at the observatories of Delhi and Jaipur, and travelled to distant lands at the command of the raja. They took part in just about every facet of Jai Singh's astronomical endeavor. Dayānata Khān was his most favored and honored *nujūmī*, and perhaps played an important role in his overall program. He remained associated with the raja for more than 20 years .

As the involvement of the Muslim astronomers slackened, the participation by the Europeans increased, indicating the raja's growing appreciation of the contemporary astronomy of Europe.

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APPENDIX

The Arabic and Persian books at the Sawai Man Singh II Museum, Jaipur

1. *Jamiᶜ-i Shāhī*, Persian, (astrology) No. 2 (AG).
2. *Zīj-i Sulṭānī* of Ulugh Beg with commentary by Mullāh Chānd , Persian , (acquired 1725), No. 6 (AG) .
3. *Zīj-i Sulṭānī* of Ulugh Beg with commentary by ᶜAli al-Birjāndī, Persian, No. 5 (AG).
4. *Zīj-i Sulṭānī* of Ulugh Beg, Persian, (acquired 1727), No. 11 (AG).
5. *Zīj-i Khāqānī* of Ghiyāth al-Dīn al-Kāshī, Persian, (acquired 1728), No. 9 (AG) .
6. *Zīj-i Shāhjahānī* by Farīd al-Dīn Masᶜūd ibn Ibrāhīm al-Dihlawī, Persian, No. 12 (AG) .
7. . . . . , second copy, (acquired 1725), No. 14 (AG) .
8. *Al- Tafhīm li-awā'il ṣināᶜat al-tanjīm* by Abu'l-Rayḥān al-Bīrunī, Persian, (acquired 1725), No. 7 (AG) .
9. *Almagest*, Arabic, (acquired 1725), two copies, Nos. 19 and 20 (AG) .
10. *Kitāb al-Manāẓir* of Ibn al-Haytham as contained in *Tanqiḥ al-Manāẓir* by Kamāl al-Dīn al-Fārisī, Arabic, No. 17,1 (AG) .
11. The Arabic treatise on the rainbow and lunar halo by Ibn al-Haytham, No. 17,2 (AG) .
12. *Lawā'iḥ as qamar* by Ḥusayn ibn ᶜAlī al-Bayhaqī al-Kāshifī, Persian, (astrology, acquired 1725), No. 91 (AG) .
13. *Al- Mulakhkhaṣ fi'l-hay'a* by Maḥmūd ibn ᶜUmar al-Jaghamīnī, with commentary by Qāḍīzāda al- Rūmī, Arabic, (acquired 1725), No. 18 (AG) .
14. *Sharḥ Tadhkira* by Nizāmu'd- dīn al-Nīshāpurī, Arabic, (acquired 1725), No. 21 (AG) .
15. . . . . , second copy, No. 22 (AG) .
16. *Sharḥ Shamshīya-Ḥisāb* of al-Birjandī with commentary, Nizāmu'd-dīn al-Nīshāpurī, Arabic. (acquired 1725), No. 10 (AG).
17. *Risālāh- hai'at al-Kursī* (?), Arabic, (acquired 1725). No. 90 (AG) .

Ptolemy's East Africa in Early Medieval Arab Geography

M. A. Tolmacheva*

The well- recognized debt of Arab geography to Claudius Ptolemy made a profound impression on the development of Arabic geographic science which goes far beyond mere translations of his *Geography*. From as early as the ninth century and as late as the 15th century most Arabic authors writing in the genres of descriptive and mathematical geography echoed Ptolemy as a source for systematic description of the habitable earth. The major areas in which Ptolemaic influence made an impact on Islamic scholars include(1) geographic data: description of continents and seas, and the coordinates of settlements and of topographic features,(2) geographic theory, and(3) cartography. (Ptolemaic mathematics and astronomy are not discussed here).

This paper is a re-examination of the nature and extent of the Greek influence on Arab geography traditionally ascribed to Ptolemy, limited to those early medieval Arabic works which demonstrate a recognized familiarity with Ptolemy on all three levels. These include the writings of the famous early mathematician, astronomer and geographer Muhammad ibn Musa al-Khorezmī (d. c. 232 / 846 — 847) and his less well known editor Suhrāb (the first half of the tenth century A. D.) as well as the *Kitāb al-zīj al-Ṣabī'* by the great astronomer al-Battānī (d. 317 / 929) . Their data will be explored below with a view toward certain special considerations regarding the historical geography of East Africa. In addition, some questions of general methodology of interpreting data derived from manuscript Arabic sources will be considered.

Although the general extent of Arab geographical borrowing from Ptolemy has been well explored,[1] the case of East Africa deserves particu-

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1 – See, for example, I. Iu. Krachkovskii, *Izbrannye sochineniia*, vol. 4 : *Arabskaia geograficheskaia literatura* (Moscow - Leningrad, 1957), ch. III (consult also the Arabic translation by S. A. D. ᶜUthman Hashim, Cairo, 1963) , J. H. Kramers, " La littérature géographique classique des musulmans, " in J. H. Kramers, *Analecta Orientalia*, vol. I (Leiden: Brill, 1954) , pp. 172 – 204 and *Encyclopaedia of Islam* (2 nd ed.) , s. v. " Kharita, " by S. Maqbul Ahmad.

lar attention especially in view of the still unresolved cartographic convention which extends the African mainland south of the equator all the way east to form the southern shore of the Indian Ocean. The fact that Arab geographers of the Islamic era followed this convention while drawing on Ptolemy has allowed to regard Arabic geographic sources as carrying on Ptolemy's tradition during the centuries when his work was lost to Europe. Thus, the maps credited to Ptolemy which reappear in the West in the 15th century seem to agree with, and be confirmed by, medieval Arabic texts and maps.

A few preliminary observations are in order regarding the extent of Ptolemaic influence on Arab authors in general and in regard to East Africa in particular. First, a brief comment on the coordinates of latitude and longitude. To the extent that Ptolemy is regarded as the earliest geographer to apply them systematically,[2] all Muslim geographers who employ such coordinates may be considered as having experienced, and accepted, his method to some degree. It may be worth nothing that such authors represent a numerical minority in the field of Islamic geography, however significant their output. Second, the use of the coordinates by some authors does not guarantee the acceptance of Ptolemy's figures or even of his method of computing the coordinates; this especially concerns the longitude. The nature of discrepancies and some of the reasons causing them are discussed below. Third, there are authors acknowledging their debt to Ptolemy who not only do not use the degree coordinates but transform his cartographic projection while filling the map and text with contemporary data. Fourth, no " pure " Ptolemy can be found in Arabic texts. Even the works regarded as translations of *Geography*, such as al-Khorezmī's *Kitāb ṣurat al-arḍ* and Suhrāb's *Kitāb ʿadja'ib al-aqālīm al- sabʿa* do not contain a complete Arabic version of the Greek text or tables, as well as differ from the book structurally.[3] In addition, already in the ninth century al-Khorezmī is thought to have corrected and augmented Ptolemy's data with new information being then obtained through scholarly efforts sponsored by the early Abbasids. Fifth, the Greek latitudinal system of the division of habitable earth into seven zones (" climes ", Ar. *iqlīm*) is introduced into Arab geography with al - Khorezmī's reworking of Ptolemy[4] and, despite the parallel existence of at

2 – G. J. Toomer, "Ptolemy," *Dictionary of Scientific Biography*, vol. XI (New York : Charles Scribner's Sons, 1975), p. 198 .

3 – See discussion in Ernst Honigmann, *Die sieben Klimata und die* πόλειςἐπίὁημοι (Heidelberg, 1929), esp. pp. 120–125, 133, 155. *Krachkovskii.* esp. pp. 79–82, 94 and C. A. Nallino, " Al-Huwarizmi e il suo rifacimento della geografia di Tolomeo, " *Raccolta di scritti editi e inediti*, vol. *V* (Rome, 1944), 458 – 532 .

4. On *iqlīm* in Arab geography see *Encyclopaedia of Islam* (2 nd ed.) s. v. , by André Miquel, and *Honigmann.* Al-Khorezmi's manner of placing the *iqlīm* boundaries is unique : Krachkovskii, p. 95 .

least two other systems in the early centuries of Islam, becomes dominant in later sources even where no other Greek influence is noticeable. Sixth, if early on Ptolemy's impact is clearest in, and almost limited to, the works of mathematical geography, his major concepts concerning the continents and the surrounding sea, the seven climes, and the configuration of Africa penetrate the genre of descriptive geography, dictionaries and encyclopedias . Seventh, within the widely accepted cartographic and conceptual framework, the proportion of descriptive and coordinate data traceable directly to Ptolemy falls drastically from the very high in the ninth - tenth century works of the " Greek school " to very low already by about the middle of the eleventh.

* * *

The region of East Africa was known to the Greeks, as to the Arabs , only in its coastal part . Sailing from Aromata promontory one came to Azania, traveling with the south wind as far as Rhapta and Prasum. At 83° longitude and 6° latitude N, Aromata emporium lies only 2° west of Opone, firmly identified as Ras Hafun on the Horn of Africa; Rhapta, " metropolis of Barbaria ", is placed by Ptolemy at 71° longitude and 7° latitude S. The farthest African location east and south is the island of Menuthias at 85° longitude and 12° 30′ latitude S .[5]

Of all these and other less significant and mostly unidentified locations in *Geography*, for which almost twenty sets of coordinates are provided, al-Khorezmi retains five, restructuring his table not to follow the outline of the coast as in Ptolemy but to begin with the southernmost part beyond the first clime. Thus, *Rāfāṭā* (Arabic for Rhapta) comes first, and al-*Ṭīb* (Ar. for Aromata) follows in the section on the first clime. Two out of five coastal cities are designated merely as *madīna ʿala 'l - baḥr* " town by the sea, "[6] with no transcription of the Greek toponym presumably listed in the original. Although coordinates are given, due to their significant and generally inconsistent disagreement with those of Ptolemy, no identification is possible on their basis. The fifth remaining toponym which it is possible to place on the eastern, rather than northern, coast of the Horn, is *Qanānā*. In the discussion below *Qanānā* is held to be identical with Opone.

5. Consult C. F. A. Nobbe, *Claudii Ptolemaei Geographia* (reprint Hildersheim, 1966), Bk. I, 9, 14, 17 and Bk. IV, 7 and 8. The English translation by E. L. Stevenson (New York, 1932) was used here. For identification attempts see Hans von Mžik, " Afrika nach der arabischen Bearbeitung der Γεωγραφικὴ ὑφήγησυς des Claudius Ptolemaeus von Muhammad ibn Musa al - Hwarizmi, " *We iner Zeitschrift für die Kunde des Morgenlandes*, No. 34 (1916) and Bernhard Struck, " Rhapta, Prasum, Menuthias, " *Zeitschrift der Geschichte für Erdkunde zu Berlin*, 1921, No. 517, pp. 188 – 196 .

6. See Hans von Mžik, *Das Kitab Surat al Ard des Abu Ga'far Muhammad ibn Musa al - Huwarizmi* (Leipzig, 1926), pp. 3 – 6 .

Following Ptolemy, the Arab translators of *Georgraphy* list longitude first and latitude second. Al - Khorezmi's text seems to describe a map, with the sequence of coordinates following the topography of the coast; the general direction of the narrative is toward the east and south. The tables follow the clime division south to north and west to east. The system is repeated in Suhrāb's work cited above. Al-Battānī's reworking of Ptolemy, descended from a different translation, contains a condensed introduction and tables of selected locations listed by the region rather than according to precise coor - dinates, although the west to east sequence is roughly approximated. Only one of Ptolemy's East African toponyms is retained here.[7] The combined list of named locations with their coordinates from Ptolemy and the three Arabic sources is offered in Table 1.

TABLE 1

	Aromata / Ṭīb		Opone / Qanānā		Rhapta / Rāfāṭā	
Ptolemy	83°	6°N	81°	4°15′N	71°	7°S
al- Khorezmi/table	72°	4°30′N	72°30′	2°45′N	65°	8°S
al- Khorezmi/text	69°30′	6°10′N	72°30′	2°20′N	66°	7°30′S
al-Battānī	82°	4°30′N				
Suhrāb/table			73°30′	3°45′N		
Suhrāb/text	69°30′	6°10′N	72°30′	2°20′N	65°05′	7°30′S

Certain questions arise in regard to these figures. First of all, unlike Ptolemy, the Arabic data cited by the same author in tables and in the text may not always coincide. The examined texts do not contain discussion of itineraries or distance measurements in other units which might be compared against the degrees. The nature of the narrative, which describes what appears on the map rather than unequivocally citing location coordinates, allows for some discrepancy between the table listings and data extrapolated from the text. For instance, *Kitāb ṣurat al- ārḍ* offers slight variations in the coordinates of all three named East African locations, while the literal reading of the text does not claim mathematical precision :

... حد بحر الاخدر ... يمر بأسفل مدينة عند طول سط والعرض و ى ويمر على صورة القوارة بقرب أسفل مدينة الطيب ومماس لاسفل مدينة قنانا عند طول عب ل والعرض ب ك ... ويمر إلى أسفل مدينة رافاطا عند طول سه ٥ والعرض ز ل خلف الاستوى ...[8]

7. Suhrāb's work was originally published in 1930 by Mžik, Al - Battānī's *zīj* by Nallino in 1904. Both are cited here in the edition by L. E. Kubbel' and V. V. Matveev, *Arabskie istochniki VII – X vekov* (Moscow- Leningrad, 1960), pp. 301, and 296 – 297 respectively .
8. Mžik, 1926, p. 75 .

The boundary of the Green Sea. . . passes under a city at 69° 30′ longitude and 6° 10′ latitude. Then it curves like a pot near (the place) below the city of al-Ṭib and adjoins (the place) under the city of Qanānā at 72° 30′ longitude and 2° 20′ latitude . . . It passes under the city of Rāfāṭā at 66° 00′ longitude and 7° 30′ latitude beyond the equator . . . ''

Although the seeming graphic approximation might excuse the inconsistency in the coordinates, the problem deserves further attention. To begin with, the coordinates contained in the quotation above, as well as the much longer text of nearly uniform nature from which it is excerpted, are very closely followed in Suhrāb's version. In fact, despite the distancing effect that time, editing a new version, and copying may have had on the original data, the narrative parts of al-Khorezmi's and Suhrāb's works are closer to each other than the text data of al - Khorezmi to his own tables. This kind of discrepancy has not been noted in the literature and, since it obviously does not originate in Ptolemy, requires an explanation which will take into account the nature of Arabic geographic works. It would be desirable to inquire as well into the transmission process, examining the transfer of data via different languages and numerical systems; unfortunately however, although we are fully aware that many Arabic - Greek texts were translated via Syriac or Hebrew, such intermediary versions are not extant.[9] The following comments therefore treat the data as if they were, indeed, a straightforward translation from Ptolemy; the coordinates are compared within the source, among the sources of the selected group, and between these sources and Ptolemy. The value of the coordinates, the manner and format of their presentation, and the implications of these for Greek - Arabic geographical theory and cartography as well as manuscript - derived numerical data are elaborated in the following discussion.

(1) Regarding the differences between the coordinates cited by Ptolemy and those allegedly derived from him found in Arabic sources, the prevailing explanation considers Arabic data improvements or corrections resulting from the newer independent observations and calculations made by Arab geographers and astronomers. This theory, however, does not hold for the above examples, since in the ninth century the Arabs did not have independently - obtained measurements for the old Greek toponyms in the region;[10] their post-Islamic acquaintance with the East African coast must have early revealed that names like Rhapta no longer existed there, and a new inventory of place-names began to be compiled, making Ptolemy's lists irrelevant.

9. At least two versions, in Syriac only, are hypothesized for Ptolemy. Krachkovskii, pp. 81, 86 .
10. On the early degree measurements and updating Ptolemy see Krachkovskii, pp. 82 – 88. On early Arab contact with East Africa see, e. g. , George Fadlo Hourani, *Arab Seafaring in the Indian Ocean in Ancient and Early Medieval Times* (Princeton : University Press, 1951) .

(2) It has long been observed that the greatest discrepancies among the Arabic coordinates, whether Ptolemaic in origin or not, occur in the longitudes. The discrepancies usually noted are of two kinds: one reflects the random variation in magnitude explained as mistakes occasioned by the difficulty of establishing the longitude in pre-modern times; the other originates in the differenc of 10° built into the practice of placing the prime meridian at the Canary Islands versus the western-most point of Africa. Mistakes also occur in latitude data but are usually less disparate.[11]

As Table 1 shows, in our case variations occur both in longitude and in latitude. Taking the longitude first, as the Arabs did after Ptolemy, it may appear that al-Battānī follows the prime meridian chosen by Ptolemy while al-Khorezmi's prime meridian differs from both by close to 10°; the latter manner is also seemingly adopted by Suhrāb. However, in a wider context it turns out that al-Khorezmi and al-Battānī do not diverge consistently . In fact, *Kush al - dākhila* (Ethiopia Interior) has the identical 50° longitude in both the sources. Another example from Eastern Africa (not found in Ptolemy) is *Dunqula* (Dongola) , the capital of Nubia . While al - Khorezmi gives 53° longitude, al-Battānī cites 93°.[12] Similarly, for Āswān; also not in Ptolemy, the longitude is 55° 30′ and 95°, respectively.[13] Clearly, a mistake of 40° by the author or even translator is doubtful. In surveying the sources it became apparent that in each case the discrepancy seemed significant due to positional mathematical value of the disparate decimal components; an explanation was then sought in the numerical notation used in Arabic sources.

The Islamic system for marking the numbers originating in sexagecimal computation, such as the 360° of the circle, uses Arabic characters assigned numerical value in an antiquated order which made transcribing Greek alphanumeric data both easy and convenient. However, a carelessly scripted character could be misread and incorrectly copied by another scribe; considering the graphic specificity of Arabic characters, the resulting mistake in this system could range from 1 to 59. The important point to keep in mind is that such a mistake would have nothing to do with (mis) calculation or fundamental differences in method: its origin would lie in the confusion of handwritten character contours. Once such a possibility is accepted,

11. For a concise summary of variation patterns in astronomic coordinates see Mary H. Regier, " Kennedy's Geographical Tables of Medieval Islam : An Exploratory Statistical Analysis, " *From Deferent to Equant : a Volume of Studies in the History of Science in the Ancient and Medieval Near East in Honor of E. S. Kennedy* (New York : New York Academy of Sciences, 1987), pp. 357 – 372 .
12. Mžik, 1926, p. 4 ; Kubbel' and Matveev, p. 297.
13. Mžik, 1926, p. 108 ; Kubbel' and Matveev, p. 297 .

it becomes possible to treat the disagreement between al-Khorezmi's and al-Battānī's longitude for al-Ṭīb / Aromata as a graphic mistake confusing the sources that were originally coherent with each other and with Ptolemy.

(3) Once the intrusion of the " prime meridian factor " into Greek-Arabic coordinates is eliminated, or at least suspended for sources under discussion, it becomes possible to view in the same light the disparate degrees of latitude cited for identical locations.

To offer an example of the origination of digit confusion, the letters *jīm* ج and *ḥa* ح have the same body and are distinguished only by the presence or absence of a dot ; in the sexagecimal system confusing the two means variation from 3 to 8 . Occasions have been recorded when *jīm* was scripted without a dot and moreover, with its tail left off to prevent its confusion with *ḥa*.[14] This, however, could open further possibilities of confusing the truncated, dotless *jīm* with other characters - and apparently did.

An instance of inconsistent latitude citations concerns Qanānā : al-Khorezmi gives 2° 45′ , Suhrāb's table 3° 45′ and Suhrāb's text 2° 20′ (Ptolemy's Opone is at 4° 15′) . It may be observed that the first and second measurements differ by the magnitude of 1° , the first and third differ in minutes, and the second and third in both the degree and minute components. Both the letters *ba* ب for 2 and *jīm* for 3 are normally scripted with a diacritical dot underneath, and may be corrupted or confused if carelessly written. It is more difficult to explain in graphic terms the transformation of 45′ into 20′ (*mīm – ha* / *kāf* ك / ﻙ) but it may be observed that, although separately , both the degree and minute components of all - Khorezmi's figure reappear in Suhrāb. Therefore the difference among the coordinates as cited may not be regarded as an intended correction but rather a corruption.

Support for this conclusion may be found again if we cast the net wider among non - Ptolemaic toponyms related to Eastern Africa . The capital of Nubia Dunqula has the following listings of latitude : 2° (*ba*) in al-Khorezmi, 14° 15′ (*yā - dāl yā - hā* يد يه) in al-Battānī, 14° 05′ (*ya - dāl hā* ۰ يد) in Surhrāb's text, 14° 30′ (*yā-dāl lām* ل يد) in Subrāb's table. Since al - Khorezmi's and Suhrāb's coordinates for Aswān coincide completely (55° 30′ longitude, 22° 30′ latitude), the discrepancies again do not seem intended . The latitude of 2° N is inconsistent not only with the other authors' but also with al - Khorezmi's own data for other locations as well as the place of Dunqula in the sequence of listed toponyms (generally moving north from the equator). Both numbers are commonly transcribed

14. Rida A. K. Irani, " A Sexagecimal Multiplication Table in the Arabic Alphabetical System, " *Studies in the Islamic Exact Sciences* (Beirut, 1983), pp. 511 – 512 .

with characters marked with diacritical dots underneath, and it seems legitimate to see in al-Khorezmi's published figure another instance of scribal corruption of the digit.

The discussion here is limited to the relevant group of toponyms but further examples of similar nature may be found among both Ptolemaic and non - Ptolemaic data, whether relating to Africa or elsewhere. The point is that what seems to be a mathematical discrepancy may in fact be no more than scribal error; even if the extant manuscript copies from which published editions were prepared are carefully written and appear legible with confidence,[15] the mistake may have occurred at an intermediate stage. This should be considered an important factor in the evaluation and interpretation of geographic and astronomic data, especially those derived from the same original source or, in E. S. Kennedy's words , " families of sources ". Most importantly, this is a factor operating indiscriminately in the records of latitude as well as longitude. Therefore our awareness of it should serve to temper the willingness to explain away mistakes in longitude by divorcing the numerical content from the system of notation .

(4) It will have been noticed above that the minute component of the coordinates is subject to variation and corruption no less frequently than the degree numbers. There is, however, one pattern of variation which occurs in the minute component at the rate suggesting a special vulnerability. Three types of numbers of involved: no minutes (i. e. , 00′) , tens of minutes and fractions ending in 5. Again, this discussion needs to be divorced from the modern Arabic - numeral notation and focused on sexagecimal Arabic characters. The " no minutes " notation, absent in Ptolemy, uses the Indian zero while the tens are all transcribed with a single character; therefore the mistake, if such is the cause of variation, might involve graphic confusion between the " cipher " and six numerical characters sufficient for expressing the above group of fractions.

For the most part these are easily distinguishable even in handwriting. Reviewing our selected examples, however, it will be noticed that the variation even within this limited pool of numbers is not between the " no minutes " and " tens of minutes " components but rather from " no minutes " to " n + 5 minutes " and from " tens of minutes " to " n + 5 minutes " (or vice versa) . Compare 20′ / 45′ ه / ٤٥ for Qanānā, 00′ / 05′ ٥ / ٥ for Rāfātā among the Ptolemy derived data and 00′ / 15′ / 30′ ٥ / ١٥ / ٣٠ for Dunqula from the non - Ptolemaic. The apparently Greek-derived Ptolemaic city of Tiyas (?) on the Red Sea has a latitude varying from 17° ١٧ in al - Khorezmi to

15. This writer was unable to inspect manuscript versions of the texts under discussion here.

17° 05′ ٠ ١٧ in Suhrāb's table.[16] Since Suhrāb's text mentions the integer 17° ١٧ with no reference to minutes, it may be suggested that here, again, no intended correction of data took place but rather that a mistake occurred in the process of transmitting astronomical data through alphabetic notation. The special culprit here is the " cipher, " easily confused in its medieval full-round form with the letter *ha* ه (= 5) in its unattached or final scripted form. There are no locations listed with the latitude or longitude of 0° , so confusion between the " cipher " and whole - degree coordinates is much less likely to occur and in fact, has not been observed (the tens and hundreds up to and including one thousand all require a single character) .

The above also confirms that al - Battānī and Suhrāb were editing, copying or otherwise revising Ptolemaic data from the Arabic, rather than the Greek or Syriac, since the nature of digital corruption is tied so closely to the particular script used. There is no reason to challenge the accepted view that al-Khorezmi's *Ṣurat al- arḍ* served as the source to both the authors. Moreover , the mistakes in the minute component of the coordinates were unlikely to originate in the process of translation from the Greek since Ptolemy's tables do not mark 00′ on the one hand, and on the other hand frequently use fraction designations inapplicable to the Arabic version : ½° for 30′, ¼° for 15′ and ½° + ¼° for 45′ .

(5) The sequencing of toponyms in the text and tables plays an important role in controlling the precision of transmission. The regional divisions of Africa adhered to by Ptolemy were known to his Arab editors but, as was indicated earlier, their texts seem to follow a map rather than a systematic narrative. Their tables also differ in content organization, both from Ptolemy and among each other. The most significant distinction is in the sequencing of the placenames in the tables by clime, the unit first used by Eratosthenes; it is not used by Ptolemy in the existing version of *Geography*. In this system, locations in the First Clime are generally listed beginning from the south, in the order of increasing longitude; the latitudes for the most part, but not consistently, increase as well. The lists pertaining to the Second Clime restart in the west and south and proceed toward east and north, and so on. Since al - Khorezmi's, the earliest Arabic , version offers a fully integrated and competent handling of the clime system in all three formats - texts, tables, and maps, and since the early European Ptolemaic maps retain it as well, it may be assumed that a version of Ptolemy's *Geography* incorporating the clime grid had existed prior to the ninth century and was available to early Arab scholars.

16. Mžik, 1926, p. 9; Kubbel' and Matveev , p. 302 .

(6) There are no maps of East Africa by the three authors. The sole existing manuscript of Al-Khorezmi contains four maps of which only one refers to Africa (the Nile) ; there is no world map. The precise nature of the map which the texts of al - Khorezmi and Suhrāb seem to be describing has not been established, nor its exact provenance. The theoretical discussion of the seas, continents and measurements found in Ptolemy is missing in both. The close paraphrasing of al- Khorezmi by Suhrāb suggests a possibility that his book merely repeats al-Khorezmi's description of the lost map rather than describes another map similar or identical to the former.

As distinct from these two authors, al-Battānī does include a description of the earth and particularly the seas. Although also organized as *zīj*, this work follows *Geography's* structure somewhat more faithfully, incorporating Ptolemy's system of listing the 94 inhabited areas in Bk. VIII which is missing in al-Khorezmi and Suhrāb. The text of the geographical introduction does not suggest that a related map ever existed but offers systematic comments on the location and size of the seas, division of the continents, and possibilities of navigation .

(7) In the history of European cartography a controversy arose over whether Ptolemy in fact mapped the east coast of Africa as reaching far to the east opposite Asia, as late medieval maps show, and whether he conceived of the Indian Ocean as an open or closed sea. The text and tables of *Geography* do not answer these questions. On the one hand, Ptolemy's description of Ethiopia limits the extent of Barbaria to the east by the Bay of Arabia, the Red Sea and the Barbaricus Sea (IV,7). On the other hand, the land mass of Ethiopia bounded by the Great Bay of the Outer Sea is also said to be " terminated. . . by the unknown land toward the west and the south " (IV , 8).

The controversy over the closed contour of the Indian Ocean does not apply to Arab geography since neither texts nor maps currently in existence, of whatever school of thought in Islamic scholarship, ever suggested that the waters of the Indian Ocean did not communicate with the mass of the ocean. Furthermore, the suggestion that printing and color confusion may have played a role in the proliferation of European maps of the " closed - sea " pattern[17] has no bearing on Arab cartography, as the Arab medieval tradition preceded the revival of Ptolemy in Europe; the earliest extant world maps, which are first to show the Indian Ocean, or *Baḥr al-Hind*[18] beginning with al-Istakhri's (early fourth / tenth century) were not of the Greek school. From al-Khorezmi, Greek-Arabic cartography takes a leap to al-Idrīsī (mid - twelfth century) whose most detailed maps show the African mainland extended east, with the Indian Ocean open to the Surrounding Ocean (*al-Muḥīt*) to the extent of its full " width " from north to south. If, therefore, the European historians of science were to look toward Arabic sources for confirmation of the " open-sea thesis ", it may be adequately substantiated with narrative and illustrative Islamic data, both Ptolemaic and originating elsewhere .

17. Wilcomb E. Washburn, " A proposed explanation of the Closed Indian Ocean on some Ptolemaic Maps of the Twelfth - Fifteenth Centuries, " *Revista da Universidade de Coimbra*, vol. XXXIII, (1985), esp. pp. 435 – 437 .
18. *Encyclopaedia of Islam* (2nd ed.), s.v. " Baḥr al- Hind, " by D. M. Dunlop and " Djughrafiya", by S. Maqbul Ahmad.

(8) The cartographic reconstruction of the East African coastline, attempted before,[19] is difficult and involves a great deal of guesswork. However, the eastward curve of the littoral may be guessed at from al - Khorezmi's narrative. To repeat, the text represents a description of a map bearing placenames and the markings for degrees and minutes of longitude and latitude.

... حد ... يمر إلى اسفل مدينة رافاطا عند طول سء ٥ والعرض زل خلف الاستوى ويمر إلى طول سح ٥ والعرض بج ٥ وهذه العروض التي نذكرها هي خلف خط الاستوى إلى ان تجوره فنذكر ذلك يمر إلى طول عب ٥ والعرض يد ٥ يمر إلى طول قيب ٥ والعرض يد ٥ ..[20]

The coastline . . . passes below the city of Rāfāṭā at 66° 00′ longitude and 7° 30′ latitude beyond the equator, reaching to the longitude of 68° 00′ and the latitude of 13° 00′. The latitudes we refer to are beyond (i. e. south of) the equator, and if (the coastline) recrosses (the equator) we shall point that out. (The coastline then proceeds) to the longitude of 72° 00′ and the latitude of 14° 00′ and reaches the longitude of 112° 00′ and latitude of 14° 00′ . . . "

Suhrāb's text is nearly identical, differing only in slight omissions and the variation in coordinates from 00′ to 05′ as discussed above. Characteristically, nothing is described and no locations are listed for the longitudes between 72° and 112°. Thus the mainland's location so far east is implied rather than stated or substantiated.

It has been argued that Ptolemy did not make it his business to describe *unknown* places and therefore, whatever his ideas of continental contours, he was unlikely to create a visual representation of a southern *Terra Incognita*[21]. The Arabic versions seem to suggest that a Ptolemaic representation

19. By both Honigman and Mžik, 1916. See also Gabriel Ferrand, *Relations de voyages et textes géographiques arabes, persans et turks relatifs à l'Extrème- Orient du XIII - e au XVIII - e siècles*, vol. II (Paris, 1916), pp. 590 – 595.
20. Mžik, 1926, p. 75 .
21. Washburn, pp. 3 – 4 .

of an Africa distorted eastward did exist. In fact, the case would be more doubtful if the Arabic text did not base itself on a map: in the awkward phrasing of al-Khorezmi it is easy to loose track of the correct noun, and then one might read the above as a description of the sea, rather than the coast, reaching to 112° E. There are two considerations against this possibility. First, the reiteration of 14° latitude at both " ends " of the coastline suggests that *a line* was indeed drawn on the map being described between the cited meridians. Second, later works belonging to the al-Idrīsī school of geography-such as the authoritative Ibn Saʿīd al-Maghribī - return to the use of coordinates which, when superimposed on the African coast, seem to reconfirm Ptolemaic notions at a time when Arab navigation to East Africa flourished. True, Ibn Saʿīd who wrote in the latter part of the 13th century, no longer includes the Greek toponyms, but he willingly, recognizes his theoretical source in Ptolemy.

(9) The very different narrative of al-Battānī focusing on the seas and the equator, rather than continents or the coastline, also suggests a system where the Asian landmass north of the equator is symmetrically faced across the sea by another landmass south of the equator, and that this landmass is Africa :

...وذكروا ان خط الاستواء من الأرض يقطع من المشرق إلى المغرب فيما بين الهند والحبش ...[22]

" It is claimed that the equator crosses east to west the space between India and Ethiopia... "

Al - Battānī gives the Indian Ocean an elongated contour, citing a length west to east of 8,000 miles and a width of 2,700 miles.

(10) Nevertheless, al-Battānī also includes statements which imply a much greater southward extent of the Indian Ocean than either Ptolemy or other Greek-Arabic geographers indicate:

... وقدروا بحر الهند وقالوا ان ... يجاوز من جزيرة استواء الليل والنهار إلى ناحية الجنوب الفا وتسعمائة ميل ...[23]

" They have measured Baḥr al-Hind and stated that it. . . stretches beyond the island where night equals day (i. e., beyond the equator) in the direction of the south for one thousand and nine hundred miles. . . "

If measured in degrees at the so-called al-Ma'mun equivalent of 1° = 56 2/3 miles,[24] this would allow a southward depth of the ocean to the latitude approximating 34°. Even if other equivalents are used (Ptolemy's

22. Kubbel' and Matveev, p. 296 .
23. Ibid.
24. Krachkovskii, p. 84 .

66 2/3 miles or even the Syrian 75 miles per degree which seems to have been used by al-Idrīsī,[25] the difference as compared to 14°S in al - Khorezmi is dramatic and Suhrāb, whose texts (as indicated above) do not contain mile measurement which otherwise might allow a comparison with or verification of al-Battānī's figures. Al-Idrīsī, on the other hand, cites distances in cubits, miles and *farsakhs* (unit equalling 3 miles) but has no corresponding figures in degrees. Although citing Ptolemy for his description of the seas, he quotes no dimensions for the whole of the Indian Ocean (the length of the Red Sea is estimated by him at 1,400 miles) .[26]

While this limited evidence is inconclusive, it would be difficult to dismiss al-Battānī's figures altogether: the numbers, however round and therefore easily suspect, are carefully written in words and thus cannot be explained away by corruption of the digits. Although the dimensions as found tend to contradict al-Battānī himself as discussed in (9), it is important to admit that Greek-Arabic geography may have allowed for a more realistic conceptualization of the Indian Ocean, however imperfectly measured and visualized cartographically.

(11) To limit the discussion of Ptolemy's influence on Arab geographers to three early works may seem to constrict the pool of data unnecessarily. However, the sources we have chosen represent not only the most complete and faithful exposition of Ptolemy's information in Arabic, but also are among the most carefully edited and extensively examined pieces in all of medieval Arabic geographic writing. Not only the later Muslim authors but also those of medieval Europe, especially in the case of Al-Battānī,[27] drew on the tables and descriptions they had provided. Under the name *Kitāb rasm al - rubᶜ al - maʿmūr* (" Design of the Inhabited Quarter ") al-Khorezmi's *Kitāb ṣurat al-arḍ* (" Geography ", or " Image of the Earth ") is quoted in the 14th century by Abu 'l - Fidā' who also cites al-Khorezmi's coordinates anonymously.[28] However, by that time the toponyms known to the Arabs in East Africa are no longer those transcribed or translated from Ptolemy. The coordinates, when provided, are attached to new and different names; the continuity is broken. The cartographic tradition, although forever inclined to imitate old authorities, undergoes a dramatic transformation at the hands of al-Idrīsī and it is he who is imitated from then on by descriptive geographers. Although in the wider context of Islamic geography new translations of Ptolemy are made in the late 15th century, these are occasioned by the new Turkish access to Greek manuscripts and bypass the medieval Arabic tradition.

25. Al-Idrīsī, *Opus geographicum sive " Liber ad forum delectationem qui terras peragrare studeant "*, *fasc.* 1 (Naples - Rome, 1970), p. 8.
26. Ibid. , p. 10 .
27. Krachkovskii, pp. 100 – 101 .
28. Ibid. , p. 93 .