Geography in the Medieval Muslim World: Seeking a Basis for Comparison of the Development of the Natural Sciences in Different Cultures

Ralph W. Brauer
Institute for Research on the Interpretation of Science and Culture

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GEOGRAPHY IN THE MEDIEVAL MUSLIM WORLD: SEEKING A BASIS FOR COMPARISON OF THE DEVELOPMENT OF THE NATURAL SCIENCES IN DIFFERENT CULTURES

RALPH W. BRAUER

One approach to comparing cultures in an effort to identify differences in motivation, value systems, and basic attitudes, is to focus attention upon specific, isolatable aspects of the cultures in question. The body of knowledge that constituted the natural sciences in the early middle ages represents just such a complex whereby a comparison of accomplishments, methodology, and the dynamics of change might provide insight into cultural variances. As a test of this concept the present work will compare the natural sciences in the Islamic world, from the 1st quarter of the 7th to the latter part of the 15th century, with those in western Europe from about 800 to 1500 AD. These largely overlapping periods saw the scientific fortunes of the two realms start from roughly comparable low levels, and rise and fall along very different lines, but eventually intercept around the 12th century A.D. Thus, a comparison of the scientific development in these two civilizations covering seven centuries will demonstrate how the political fortunes and cultural patterns enhanced or inhibited the progress of science and science-related technology in each.

In an attempt to attain meaningful conclusions the present work will focus upon the characteristics of a single branch of the natural sciences for which adequate information can be gleaned over the entire period of interest. The present article will explore the science of geography in the medieval Muslim world and identify characteristics that need to be taken up in subsequent comparative studies. The extent to which these findings can then be generalized, will be left to a later inquiry.

General characteristics of Muslim Geography. The science of geography as it emerged in the medieval Muslim world from about the
year 800 to 1450 AD. is particularly suitable for the present inquiry for two reasons: a) the time period chosen comprises a nearly complete cycle in the productivity of the science. There is a near void from the early years of the Medinan state to the end of the Umayyad califate in the 8th century, which is followed in the early years of the Baghdad califate by a period of rapid growth that peaked in the late 10th and the first half of the 11th century, before coming to a virtual standstill toward the end of the 15th century (Figure 1). b) A substantial body of Muslim geographic literature has been preserved, representing well over fifty scholars, writing at dates so distributed over the 700 year period that hardly any 50 year interval passed unrepresented. Thus, not only can the texts serve to explore changes in the substance of the science, but insight is also provided into distributions in time as well as in space of the scholars dedicated to this field, and this information can be related to other developments in the world of medieval Islam.

Geography in the Spectrum of the Sciences and the Problem of Compartmentalization: In Muslim societies geography occupied a rather special position among the natural sciences. The subject, hardly alluded to in the Qur'an, like history, never was accepted as a part

![Figure 1. Distribution in time and space of 30 authors of Muslim geographic treatises written between ca. 850 and 1400 AD.](https://scholarsarchive.byu.edu/ccr/vol26/iss26/5)
of the sciences as defined by the 'ulama'; the all-influential scholars who were devoted to the 'Islamic sciences' (interpretation of the Qur'an, collection of the traditions of the Prophet, and the shari'a law). The earliest Muslim description of the configuration of a substantial part of the inhabited world does not appear until after the translations from the Greek (or the Syriac) of the Almagest and the Cosmographia of Claudius Ptolemaeus under the 'Abbasid khalif Ma'mun in the 9th century. Thus, from its beginning Muslim geography was linked to the assimilation and development of the geographical knowledge of the Graeco-Roman world. As such it might have formed a part of what was referred to by Muslim scholars as 'falsafa'—i.e. as philosophy in its broadest sense as conceived of by the Greeks.

The real situation is more complex. The works of the Muslim geographers can be divided into mathematical geography, and descriptive geography (cf.1). The former, closely allied to mathematical astronomy, was principally concerned with the calendar, the measurement of time, variations in the duration of the day over the course of the year, variation of the elevation of the sun with changes in one's position on the surface of the earth, the related definition of the seven (latitude-oriented) climates, the use of coordinate data to define the position of a given place on the surface of the terrestrial sphere, and methods of planisphere projection to map the features on the spherical globe onto a flat surface. The principal contribution by which Muslim scholars enriched this field was probably the development of trigonometric functions from the rudimentary concepts of the hellenistic scholars, and their application to the resolution of the spherical triangle and to the accurate translation of geodetic measurements into angular coordinates. One might thus expect that the output of the mathematical geographers might indeed have fallen within the general category of philosophic works as conceived of in medieval Muslim circles; yet the field as a whole was thought to be an applied science. In the Islamic world, as in late Antiquity, its mathematical foundations were believed to be 'contaminated' with practical considerations, and thus of limited appeal to those who conceived of 'falsafa' as 'pure science'.

The other segment of Muslim geography, descriptive geography, furnishes the bulk of the texts that have come down to us. These texts convey data concerning towns and settlements, cer-
tain characteristics of landscapes, some ethnographic information, historical descriptions, information on the history and politics of a region, and sometimes data concerning the amount of tax revenue expected. Most commonly, all this was accompanied by a wealth of data of interest to merchants, such as what merchandise was sought or available, roads and ports, and conditions of life in the principal centers. In many of the writings these data were supplemented further by anecdotal material and reports of marvelous sights or phenomena, the 'aja'ib, which made the reports attractive to the general reader. Overall, this literature tends to reflect the tastes of the "'adab culture" the culture of the refined and educated upperclass Muslim. It is broad in scope, often marked by considerable elegance in style, rich in entertainment value and of value to the conversationalist, though not overly concerned with profound scholarly inquiry. 'Adab literature was linked to the broad interests of the courts of the rulers rather than to the concerns of either the piety-minded (Hodgson's term), the 'ulama' or the philosophy-oriented falasif.

Thus, unlike mathematics, geography failed to fit neatly into any of the major categories of the intellectual domain of the medieval Muslim world. Important for geography at the time was the treatment accorded the science by the great 14th century historian, Ibn Khaldun, in the Muqaddima, the Prolegomena to his world history. Although he devoted several chapters in the first volume of his work to a description of the geography of the entire known inhabited world, based largely on the work of the 12th century geographer al-Idrisi, when he listed the "intellectual sciences," as opposed to the religious ones, he omitted geography. As pointed out by André Miquel, Muslim descriptive geography was in large measure human geography, and thus closely allied to history. They shared some of the same subject matter, and contributed mutually to the explanations of the phenomena they observed in terms of a causality, which was thought to be heretical by the 'ulama.' History, at least, was designated as 'that wretched subject' by one of the prominent religious scholars of the day despite some highly placed practitioners. Still, while events in the religio-political sphere may have been reflected in the scope of the effort, there is little evidence that the texts of Islamic geographers were substantially modified by pressure from the religious establishment. This contrasts with the situation of early
medieval European geography, as well as with that of Muslim astronomers, who were concerned with the promulgation of a more rational calendar or approaches to a less earth-centered conception of the world.

Geography in the Muslim world also occupied an intermediate position between two inherited patterns of thought: that derived from the world picture of the *baduw*, the warlike nomads of the desert, and that reflecting the attitudes of the educated and sedentary urban population. In this respect the science reflects a basic paradox of Islam itself, a religion which propounds mores and beliefs bearing the imprint of bedouin nomad lifestyle, while imposing a system of law and a pattern of religious observances firmly linked to the manners and opportunities of town dwellers and merchants.¹²

Beyond doubt, Arabo-Islamic geography is to a large degree a geography of cities. Invariably the geography of a region is described primarily in terms of its urban settlements, and of such town-related facts as the location of fortifications guarding these towns, the roads between them, the water supply for them, and the like. In keeping with this urban bias and the relative disregard of the open country, the boundaries between different political units, unless marked by some inhabited place, often are described only vaguely.¹³ This is to be expected when a landscape is perceived in terms of its relation to its towns: the "fields of concern," like magnetic or electrostatic fields, decrease rapidly in intensity with increasing distance from the respective centers; this leaves a boundary region between any two of them where zones of low field intensity overlap and the resultant "field" becomes quite flat so that no sharp boundary between the two domains is recognizable.

On the other hand, in Muslim treatises of geography the actual morphology of a given country is normally represented in terms of a network made up of the lines of the routes between its cities. There is little reference to "areas" and none at all to area-related concepts, such as population density or productivity of the land. Qualitative statements regarding a district's size, when they are backed by any numbers, are supplemented by indications of distances of the routes between places separated by the length and breadth of the land in question.¹⁴ The unwillingness of Muslim geographers to conceptualize magnitudes involving length raised
to more than its first power ($L^2 = \text{area or } L^3 = \text{volume})$ finds a practical reflection in the basis used for assessment of the land tax. In the ‘Abbasid realm proper the ‘Usār (the tithe levied on Muslims) the zakat (charitable donations) and the Kharaj (the land tax imposed on unbelievers and at times persisting even after a piece of kharaj-land had been sold to a Muslim) were based on the value of crops produced rather than on the area of land tilled. Only in regions where Egyptian, Byzantine, or Sassanid taxation methods (based on area available for cultivation) had prevailed prior to the time of the Muslim conquest did these patterns of taxation sometimes persist after the Islamic conquest.

All things considered, a ‘linear geography,’ such as represented by Muslim geographical works, reflects precisely the kind of morphologic perception of a landscape one might expect among ‘hot desert’ nomads: for them the essential topographic knowledge concerning a given region consisted of the locations of water holes or springs, and of the routes that led from one of these to the next.

Muslim geography appears as an isolated subject in yet another way which becomes evident in descriptions of the Indian Ocean. The geographers’ reports from the 8th century down to the latest Muslim treatments in the 15th century persist in depicting an East African coast along Ptolemaean lines, turned sharply to the east at, or a few degrees south of, the equator, to form a land mass thought to be the southern shore of the Indian ocean (fig. 2). Latitudes of localities south of the equator on the East African coast in the tables of latitude contained in these works increase only to a few degrees south, and beyond; this remains at a constant value, while beyond this point longitudes are increased in proportion. This holds true even for places lying 25 degrees or more south of the line which had long been frequented by Arabo-Islamic sailors (fig. 3). Whoever provided the coordinate data underlying these reports by the geographers must have depended for his latitudes on astronomic observations which could be correctly accomplished only north of the equator. Almost certainly these must have been direct determinations of polestar elevations by observers ignorant of astronomic techniques for estimating their value from observations of other northern circumpolar constellations when the polestar itself had sunk below the horizon.

By contrast, treatises written by and for the use of Indian
Figure 2. Circular map of the entire inhabited world as known to al-Idrisi (from the Ms. Pococke #375, copied by courtesy of the Bodleian Library, Oxford University). Note that South is on top. The (dark) sea on the upper left hand represents the Indian Ocean, opening into the Great Surrounding Ocean. Note also the seven curved concentric dividing lines which represent the boundaries of the Seven Climates.

Ocean pilots in the 14th and 15th centuries, describe in great detail just such astronomic methods for determining southern latitudes. The texts strongly imply that this information had been available to their predecessors at least as early as the 11th century. Unlike the geographers' reports, the sailing directions of the navigators provided remarkably accurate latitudes for places along the East African coast to latitudes nearly as far as 30°S.

A number of the characteristics of this body of data leave little doubt that the geographers and the navigators did not communicate effectively with one another. On the side of the geographers,
Figure 3. Plot of modern geographical coordinate values for localities along the East African coast as a function of the values reported in the tables of Ibn Sa'id. X-localities located north of the equator, and □ for those south of it. Upper diagram-Longitudes; lower diagram-latitudes.

the southern latitude data resulted in a distortion of the longitudes for these localities, as well as a distorted picture of the supposed southern shores of the Indian Ocean that persisted to the end in the writings of the Arabo-Islamic geographers. On the side of the navigators, they failed, inconceivably, to be aware of or to use Pythagoras' theorem of the rectangular triangle. With both the geographers and navigators there is a lack of cross-referencing between their writings. It is therefore hard to escape the conclusion that, whatever the sources for the geographers' data, it
was not from navigators and they were not themselves navigators.\textsuperscript{20} The underlying cause for the mutual isolation of these two professional groups is suggested by such passages as al-Mas'udi’s in *Muruj adh-dhahab*\textsuperscript{2} which states that pilots in Siraf had told him of their “fanciful methods for determining their location in the ocean, but that, since the results did not conform with the statements of Ptolemy, he had disregarded them.”\textsuperscript{22} Other learned geographers have made similar statements which leads one to conclude that scholars tended to despise the practical knowledge of those involved in the business of steering ships safely from port to port. The pilots, conversely, may well have had a hearty contempt for the impractical book knowledge of the scholars.

Altogether then, geography in the medieval Muslim world was in a curiously isolated position. It was rejected by the learned establishment; held aloof from the learned pilots of the period; strongly influenced by the experiences of nomads and wayfarers who lacked the scholarly training which would have allowed them to assemble systematically and present the facts they encountered in their wanderings; it made use of and contributed to the concepts and techniques of the mathematical geography bequeathed to the Arabs by the Graeco-Roman scholars of the Hellenistic period, and yet it gained for itself only a marginal place in the circles of the philosophers; and it made use of the idiom of the court-oriented polite society of the times.

**Travel, Exploration, and Sources:** For their data, Muslim geographers could have recourse to three kinds of sources: the written accounts of earlier geographers, pre-Islamic as well as Arabo-Islamic, which they sometimes acknowledged, but just as often copied without reference;\textsuperscript{25} the accounts of travelers who had visited the places in question and reported their observations in writing or orally; and first-hand eye-witness accounts, derived from the writer’s own experience by some of the geographers who themselves had traveled extensively. The fact that a writer had first-hand knowledge of a region is often reflected in vivid and extensive coverage of conditions existing within the regions visited.\textsuperscript{24,25} It should be noted, however, that with one or two striking exceptions, e.g. the descriptions of the Russian steppes, or perhaps of northern Europe) such travel, while enriching the literary value
of a text, took the traveler to regions well within the orbit of Dar al-Islam, and within the ken of routine travel by Muslim merchants and pilgrims.

Voyaging was certainly an important part of both the religious and the commercial traditions of the Muslim world. The two hijras stand at its very beginning; the hajj an obligation on every Muslim and the rihla, which was for religious or legal learning or the acquisition of saintly blessing, were important means by which learning and status were acquired.26 The travels of Sinbad the Sailor stand as a highly imaginative reflection that in the medieval Muslim commercial world travel for the purpose of trading was an important part of the lives of urban merchants, deeply ingrained in commercial practices as well as in the shari‘a law. More than any other pursuit, travel for gain drew men to and beyond the limits of the Islamic territories. Some of these travelers were not mere commercial or religious wanderers but acting as spies, seeking out the kind of information that might interest a ruler or an army commander.27 In some cases, too, notably in relation to al-Idrisi’s work, it is most likely that the intelligence service of the ruler for whom they worked contributed important information to the geographical treatise.28

Yet, in all of this activity a quest for new lands, for new knowledge of the natural world, is at best secondary. Despite occasional protestations to the contrary, there is little indication that any traveler proceeded on his journey primarily for the purpose of gathering knowledge of new lands, hitherto unknown to his compatriots.29 It is likely that in part this reflects the self-centered nature of Islam which led its adherents to view as largely irrelevant, facts not connected with the religion itself, or with members of the ‘Ummah the community of believers. In addition, during much of the period here considered Islam and its culture were spread, or at least represented, over a very large part of the known inhabited earth and travelers like Ibn Battuta would feel at home in Muslim communities as remote as China or Malaya.

Beyond this, however, it is probably fair to recognize that, by the end of the third century of the hijra era religious attitudes hostile to innovation came to be felt increasingly throughout the Islamic realm.30 From an early date the term ‘bid‘a’ meant both, ‘innovation’ and ‘heresy.’ While the Prophet is supposed to have urged his followers to "seek knowledge even if it comes from
China," by the year 900 AD theologians had firmly established that the term 'knowledge' must be restricted to 'religious knowledge.' In the field of law this attitude took the form in the second half of the ninth century, as reflected in the khalifal dictum, that "the door of ijtihad (and this is best translated as 'research') is closed." While in fact some further development of shari'a law did take place, even among the orthodox, it was in the form of analogizing and legal fiction and was anathema to at least two of the four Sunnite schools of law. As applied to geography, the same general attitude prevailed with regard to those people who ventured, or were supposed to have ventured, forth into the unknown. A most striking instance of this was the case of the 'adventures of Lisbon' who were said to have sailed forth to explore 'islands in the Sea of Darkness, the Atlantic Ocean, west of the known lands.' Such references, unless applied to heroes of antiquity such as the two-horned lord, Alexander or intelligence agents like Sallam the Interpreter, tended to be critical, excoriating the travelers for their impious challenging of the unknown and well deserving of the inevitable failure of their plans.

Unlike the historians, who were influenced by the example of the isnad tradition of the hadith literature, literary custom—especially during the earlier part of the period—did not encourage authors of geography to give credit to their sources. At best one can expect an over all quote, like the list of authors whose works he had drawn upon contained in the prefatory chapter of al-Idrisi's ... Nuzha mushtaq.... The texts thus are virtually devoid of mention of specific sources other than the writer himself. Rarely is one informed specifically concerning who, or even what kind of person, gathered any part of the descriptions, or (except in the case of such a superlative scientist as al-Biruni) by what methods the measurements were made on which the numerical data are based. At times a more detailed examination of the data of the mathematical geographers can extract significant traits which may be of help in characterizing certain of these anonymous sources. Such studies reveal, for instance, that in the case of the western Sudan, distance estimates must have been based solely upon 'caravan days' of travel, presumably recorded by an educated, but non-scientific observer traveling with a trading caravan. Again, there are the latitude data for the southern reaches of the East African coast, indicating that the observers,
while probably possessed of some erudition, were neither navigators nor scholars. Even Ibn Batuta, perhaps the greatest traveler of the medieval Muslim world, was a scholar of the Islamic sciences and an astute, if biased, observer, but he was neither knowledgeable in the natural sciences nor curious about such matters in the way we would expect a modern explorer to be.

It would seem therefore, that in the medieval Muslim world the actual acquisition of geographical knowledge was incidental to travel for other purposes, and the information reported was acquired in large measure by individuals who lacked any specific scientific education. Voyages of discovery in anything like the modern sense, it would appear, did not influence the development of Arabo-Islamic geography.

The ‘Aja‘ib: Perhaps because of this vagueness in the attribution of original authorship, the literature of Muslim geography preserved until a late date a good many myths and wondrous tales. The concept of the Qubba ‘Arin, the supposed center of the world, the existence of a terra incognita forming the southern shore of the Indian Ocean, the extraordinary characteristics of the Atlantic Isles and the visit of Alexander there, the Islands of the Monkeys, the land of Gog and Magog in the extreme northeast, and Alexander the Great’s wall separating the people of Gog and Magog from their long suffering neighbors—all these are examples of geographic myths. In addition there were the ‘aja‘ib, the marvels, and strange tales, so dear to the heart of raconteurs like al-Mas‘udi and part of the material used to spice-up more prosaic accounts for the interest of readers with the tastes of the ‘adab culture. In a very general way, the frequency with which such items interrupt the flow of more scholarly geographic description tended to diminish somewhat with the years and became quite low by the time of al-Idrisi. When they occurred they tended to be concluded by some such a phrase as “... but Allah—may he be exalted—alone is (all) knowing” to reflect the author’s doubts. All told, the decreasing use of supernatural elements in the geography texts is one of the marks of scientific progress with the passage of years.

Muslim Cities and Muslim Geography: Since in considerable measure Muslim geographers of the Middle Ages described entire regions in terms of the urban settlements they contained, it is
worth considering the specific ways in which the characteristics of these towns, as seen through the eyes of the geographers, shaped geographic literature.

The towns covered a spectrum of importance and size, which was reflected in specific terminology that came to be an approximation of their importance within this scale. *Misr* (pl. *amsar*), *madina*, *kura* and *qaria* imply a descending rank: *misr* referred to a place of major administrative significance; *madina* implied the presence of a *jami’a*, or Friday mosque; *qaria*, *rustaq*, and *kura* usually referred to rural entities, villages, market villages, or even districts—places distinct from the urban settlements and often not sharply delimited from the surrounding countryside. This scale helped to separate two kinds of population: the town dwellers and the peasantry. The latter, the *felahin*, were sometimes (even in Ibn Khaldun’s writings) lumped with the nomads of the desert, the *baduw*, to form a mass of inhabitants viewed as second class members of the population.

The reasons for such distinctions are embedded in the characteristics of cities and the all-embracing religion. Geographers were frequently in accord regarding the characteristics defining a city: these included a Friday mosque, a market or markets (open air or covered suq), perhaps a *han* and a *qaisaria* (descendant of the antique porticoed market hall) baths, a source of water (‘they drink from . . .’), and some sort of administrative center (a palace or fortified citadel) that housed the local military and political representative of the ruler.41 The character of the city as such was often emphasized by the existence of a city wall. Most true cities had one or several *arbad*, suburbs, which were either separated from the countryside and protected by their own walls, or spread without any sharp break into the open country.

A substantial body of literature exists emphasizing the importance of town dwellers in the structuring of medieval Muslim populations. Because the Friday mosque and *wagf*-supported academies (*madrasas*), were limited to the towns, only town dwellers were able to live a life truly in accordance with the dictates of the *qur’an*, the *hadith* and the *shari’a*. Only towns could accommodate the required number of ‘ulama’, men learned in religion and law, needed to perpetuate the religious culture. True capital cities were also homes to rulers or their representatives, along with their courts and from a fairly early period they were the cen-
ters of the ‘adab literary culture as well as that of the philosophers. Lacking easy access to these elements, the peasant, country dweller and the nomad alike, were perceived to be imperfect followers of the religious commandments of Islam and dwellers in an intellectual desert.

In actual fact the distinction between town and country may well have been much more fluid. As Lapidus indicated, Friday mosques appeared in some rural settings during the latter part of the period along with the tombs and dwellings of supposed saints, especially in North Africa. Furthermore, well-to-do town folk frequently had country estates and may have spent some of their time working these; and some country dwellers not only frequented the towns for their markets, but actually owned town dwellings. There was a measure of flux between town and country, mediated in part by the interposition of the ribad which tended to be more rustic than the city itself, and thus provided a way-station between the two environments.

While these facts are reflected in the writings of the geographers, two other important characteristics of the medieval Muslim society, are reflected in a more limited extent. First, medieval Muslim towns invariably lacked a corporate existence and were administered by the representatives of the central government. As a consequence, the individual town dweller tended to identify not with the city as a whole, but rather with his immediate neighborhood, the homogeneous harat, or quarters descended from the early tribal structure of Muslim garrison towns like Kufa. Reference to this kind of segmentation in the geographical literature of the period occurs in al-Idrisi’s work where he includes some scathing remarks concerning two facts: the water supplies to the upper and lower sections of the madina of Fes—the old town as distinct from Fes al-jadid, the later administrative town nearby—were most inequitably distributed; and the young men of different parts of the city used to mount frequent bloody battles outside its gates.

Another characteristic that finds only scarce representation in the medieval geographic literature is the important differentiation of sedentary folk from nomads; a distinction given its most incisive expression by Ibn Khaldun’s concept of a cyclic history based on the interaction of these two population elements. As it relates to the work of the geographers, this finds some implicit
expression in the general manner in which a countryside is visualized (cf. the discussion of linear geography above). It comes to the fore explicitly more rarely, as for instance in texts dealing with North Africa after about the year 1000 A.D. which lament the destruction of the sedentary society’s irrigation systems and agriculture by the devastation wrought by the incursions of the nomadic Arabic tribes of the Bani Hillal and Sulaim.

City Plans and Planning: Cities in the medieval Islamic domain can be profitably divided into ‘ancient towns,’ preexisting places, seized in the course of the wars of conquest and adapted for Muslim use; ‘spontaneously arisen towns,’ such as the madina of Fes; and ‘created towns,’ such as Kufa or Basra. Only cities belonging to this third category can be said to owe a significant part of their configuration to conscious Muslim city planning. Even here there are no documents indicating that plans were laid out in any sort of scaled drawings; rather it would appear that such plans are as recognizable may merely have involved general decisions regarding contour and location, while planning and lay-out for actual construction were performed directly on the ground to provide the outlines for public structures such as mosques or walls and major thoroughfares, and a general framework of sites for markets or of future dwelling quarters into which the living community then would proliferate with time (figure 4a). Water supply and sewage, it would appear, tended to be incorporated more or less after the town was established, plans more often than not being made one harat at a time. An example of the planning process is the description of the laying-out of al-Madina as-Salam, the (Round) City of Peace, which for a short time became the palace district of khalifal Baghdad. Here we are told that the khalif al-Mansur, having decided upon a circular ground plan, perhaps on the old Babylonian circular pattern, had a small general plan traced out in the sand before his feet. Subsequently, before ordering the beginning of actual construction, he had the principal features of the future city laid out on the actual ground by spreading oil-soaked seeds so that when these were set afire he might readily visualize the outlines.

The majority of living quarters and suqs of cities all over the medieval Muslim realm were characterized by having a highly irregular network of streets and blind alleys (figure 4b). In the
ancient towns’ important parts of these networks arose secondarily by progressive encroachment of shops and dwellings upon formerly rectangular street plans. In the other categories, while mosque sites and major thoroughfares may have been laid out deliberately, the suqs (figure 4c) and harat initially were merely determined in general outline, and the alleyways emerged in considerable part simply by juxtaposition of neighborly dwellings, adjoining as encouraged by the Qur'an, to form passages which were subsequently further encroached upon. This pattern of progressive encroachment reflects the basic tenor of the shari'a which, wherever possible, gives precedence to the rights of the individual over those of the community, and thus gave every encouragement to the individual householder to spread his use of the public ways with only the meagerest of restrictions to insure a modicum of passability. The one official who might have interposed, the muhtasib, originally the supervisor of the markets, a representative of the ruler or the central government, was not responsible to the people of the city.

**Muslim Cartography.** Given the informal character of city planning in the Muslim world it is not surprising that no drawn-out city plans are known to have been preserved, nor indeed have any other medieval Islamic plans depicting small districts. The point is of some interest in our present context: it suggests that in this culture orbit—just as in early medieval Europe—the heritage of the Roman survey techniques and the magnificent plans it produced was lost entirely. Unlike the development in the Christian world, medieval Islamic cartography, although eventually putting to use for their large scale maps the techniques and concepts set forth by geographers of the Graeco-Roman period, did not seem to have appropriated the concepts implicit in such survey plans of cities, buildings or country districts. When in the 16th century we do encounter evidence of the use of such techniques in Piri Reis' atlas, the Bahriye, they apply only to the mapping of anchorages and fortresses on islands and are almost certainly derived from 14th and 15th century 'isolaria' of Italian provenience.

The earliest world map that can properly be called Islamic was probably that prepared for the khalif al-Ma'mun in the 9th century in connection with the translation of the works of Ptolemy. The map itself has been lost for centuries, but it seems most prob-
able that it represented a revision of a world map drawn according to Ptolemy’s first projection and incorporated additional data and corrections reflecting results of the work by Arabic scholars. This beginning does not seem to have produced subsequent revisions. For the next three centuries maps showing sections of the surface of the inhabited earth or the configuration of the entire known earth were produced by the Balki school of cartography, following a style entirely unique to themselves, but assembled in the form of the so-called Atlas Islamicus. These highly schematized maps, in which land masses or oceans and seas were shown in grossly simplified geometrical outlines into which cities,
rivers, and mountains were inserted in loosely coordinated fashion, clearly were intended to supply illustrations to accompany a descriptive text (figure 5). All too obviously they could not have been used as working tools by a traveler, merchant or soldier, and, on the other hand, they were more complex than the rutters used by tax collectors or administrators, which were probably antecedents of some of the maps of the Balkhi school. The choice of simple geometrical outline elements for oceans or landmasses is said to have been determined by mystical perceptions concerning the reflection of simple geometric forms in the natural world.

A very different style of cartography came into use in the 12th century with the major work of al-Idrisi, the Cordoba-trained scholar working at the court of the Norman King, Roger II of Sicily. Maps in his *Book of Roger* (or: *Kitab nuzha al-mushtaq fi-khtiraq al-afaq*), are of two types—both of which are widely misunderstood. The first, placed at the very head of all of the known manuscripts of this work, and replicated with only the slightest of modifications in the 14th century in the beginning of Ibn Khaldun’s *Kitab al-'Ibar*, is a one page world map placed in a circular frame and probably represents a small reproduction of the great map on a silver disc of more than one meter in diameter, prepared by him for King Roger (cf. figure 2). That map, despite the appearance of its frame, is unmistakably intended to be a map of the inhabited earth according to the first Ptoleorean projection and in all reproductions, except the latest (the 16th century Ms. Greaves #42 of the Bodleian Library) indications of latitudes consist of segments of concentric circles like those prescribed by Ptolemy, and the position of the common center as well as the diameters of these circles correspond to those prescribed by Ptolemy for the circles of latitude separating the ‘seven climates’ (cf. 4).

The second type of map found in the *Book of Roger* is a series of separate sheets which in all the available manuscripts appear at the end of each of the chapters and describe one of the ten longitudinal sections, *ajza‘*, of each of the seven climates. There are thus 70 such maps in all, and they reflect the major part of the specific topographic information contained in the text of the *Book of Roger* (figure 6). These maps are drawn to several different scales without any apparent order, and it can readily be shown that special features represented in any one map frequently fail to
match the appearance of the same feature in the adjoining maps. This is true of all the manuscripts I have had an opportunity to observe, including the Paris Ms., which is the oldest and most complete, the Pococke and the Greaves Mss. of the Bodleian Library, and such segments of the Cairo and Sûlamâniye manuscripts as have been available. Thus, these maps cannot be viewed as parts of a single world map drawn by a geographer unacquainted with the simplest principles of planisphere projection, as implied by Konrad Miller. Rather they represent 70 separate
sectional maps, drawn to what one may call the Marinus projection—a simple linear, rectangular coordinates in which the longitudinal angular scale does not vary in any recognizable way with the latitude so that, within the limits of random variations of scaling, sections near the equator and near 60°N are shown of equal width (figure 4). In a sense, these maps, which represent relatively small sections of the earth’s surface, can be said to revive some of the techniques of the long-forgotten Roman ground plans. They clearly make an attempt to depict accurately details of the contours of lands and seas and rivers and coastlines and they altogether eschew the use of the simple geometric outlines so characteristic of the Atlas Islamicus.

With the al-Idrisi’s and his successors’ world maps we come to the culmination of this aspect of the geographic accomplishment of medieval Muslim geography. Some of the later geographers, as well as, to a degree, al-Idrisi himself in a later work (the Uns al-muhaj) even regressed in varying degree to the simplified contours of the Atlas Islamicus tradition. On the other hand, Idrisi’s and even more Ibn Sa’id’s—maps bear remarkable resemblance to the 14th century Vesconti world map and may also have been related to the emergence of Portulan charts in the 13th and 14th centuries. Such resemblances suggest a significant degree of continuity between the work of the medieval Muslim geographers and that of the European cartographers of the 15th and 14th centuries and their efforts which led up to the extraordinary revolution in the conception of the configuration of the earth’s surface wrought by the Portuguese and Spanish voyages of discovery of the 15th and 16th centuries. In this development however, the medieval arabo-islamic geographers did not participate.

The difference in the characters of the two groups of Islamic maps bespeaks a sharp break in the post-al-Ma’mun cartographic tradition, a revolutionary change in the basic conception of the role of cartography which separated al-Balkh; and his school from al-Idrisi and post-Idrisi map-making. It contrasts sharply with the very gradual pace of change in other aspects of Muslim geography. Since al-Idrisi worked in Palermo under the auspices of the Norman court of King Roger II of Sicily, one may well wonder whether the departure of the style of the Idrisi maps from that of the earlier Islamic cartographic tradition may not reflect the constructive interaction of Muslim and western European ideas at the
Sicilian court. To anyone reading the introductory chapters of the *Book of Roger* (this is the title chosen by al-Idrisi for his *Kitasb nuzha mushtaq ji'khiraq al-'afaq*) such a view should have considerable appeal: the text bespeaks a real friendship between the Norman King and the Muslim geographer, and there are strong indications that of an active exchange of ideas between the two relating to the geography. Thus, the hurried and greatly abbreviated last chapters of the book may well be the result of the failure of this influence as King Roger lay dying. Similarly, al-Idrisi's reversion toward earlier map making styles of the cartography of the *Uns al-muhaj*, written long after the death of the king, seems well in keeping with the idea that the king's influence was important in determining the style of map making for the *Book of Roger*. If indeed such synergism can be established, this would represent one of the clearest examples of deliberate and highly constructive interaction between the two otherwise so hostile worlds of Islam and of Christendom in the Middle Ages.

In the *Book of Roger* Islamic cartography produced the earliest large-scale representation of the entire inhabited earth as known to the Middle Ages. Yet, nowhere does one encounter maps such as could have been used as precision tools in the sense of uses to which modern maps of all kinds are put. In particular, there is no reliable record of any Muslim sailing chart prior to the 16th century, i.e. prior to extensive contact with western navigation techniques after the penetration of the Indian Ocean by the Portuguese (Brauer, R. W.—discussion regarding alleged but erroneous references to such sailing charts in Marco Polo, al-Majid, al-Mas'udi—to be published). Navigation relied on verbal sailing directions, such as are preserved in the works of Ibn Majid and al-Mahri. We have already referred to the apparent lack of the use of scaled-down plans in connection with the laying out of cities. Records are very sketchy but they suggest that military campaigns, too may have relied on the same kind of linear runters as the postal service, the *barid*, rather than on detailed maps.62

**Plagiarism vs. Originality in Muslim Geography:** Before leaving this brief description of the corpus of the works of the medieval Muslim geographers the question of plagiarism vs. originality of the Muslim geographers must be addressed. It has been claimed that "on the whole this is just a bunch of writers cribbing one
from the other." Such a charge, in reference to the style of many passages, might have a point, but the issue here is the evolution of a body of science, and, however important style might be, the substantive part of the literature is its scientific content.

Since most of the earth's surface is relatively stable, even mountains, shorelines and rivers normally change their configuration only quite slowly, it is hardly surprising that a group of writers describing the same piece of land would tend to report the same facts. Differences between them can only reflect either the special stylistic tastes of a given author—e.g. al-Maqdisi's preference for rhymed prose—or special detailed knowledge, such as al-Bakri's intimate acquaintance with conditions in the Western Sudan, or al-Idrisi's references to metallurgical techniques, or al-Maqdisi's reference to the iron-clad outer gates of the Central Asian city of Tarjahara, known to him because this was the former home of his maternal uncles.

When the various reports dealt with situations involving significant change, it is possible at times to test the extent to which different authors incorporated new information into their works. We have attempted one such analysis using data for several sites in North Africa. Here some of the same localities are described in writings that cover a span of nearly 750 years and these writings reflect rich economic and political changes. By comparison the descriptions furnished in successive texts with known sequences of events, permit one to assess the degree to which the geographers' works reflect these historical events even while largely duplicating one another's discussions of those elements that were unaffected by the passage of time. The analysis is based on three such localities—the oasis Sijilmasa, Ghana, capital of the Soninke empire, and al-Wahat al-Kharija, the greatest of the western oases of Egypt. The evidence in each of these cases show that over a span of seven centuries each succeeding writer described the variable elements to reflect the conditions prevailing near his own time. The data are compatible with the view that the information used by the majority of these writers describe the situation prevailing no more than fifty years prior to the actual composition of the work in question—a trifling delay in assessing secular change in an effort extending over 750 years. Thus, these results suggest that, although the geographers often duplicated one another's texts when discussing unvarying conditions, they consistently
added their own new information where there were indications that the situation in the region had changed. This is admittedly a limited body of data, but the general conclusion is supported by glimpses of events encountered in descriptions of other places where sharply defined single events allow testing the basic concept.

Having now reviewed in very broad outlines the characteristics which mark the works of the medieval Arabo-Islamic geographers, attention may be turned toward the changes with time in the characteristics and accomplishments of medieval Muslim geography.

Changes in Muslim Geography with the Passage of Time. Once again it is useful in this connection to consider separately the subdivisions of the field, i.e. mathematical and descriptive geography and cartography.

The principal achievements of Muslim science in the field of mathematical geography are expressed in terms of tables of geographic coordinates. Its success can be quantified in terms of the degree of correspondence between their values and modern coordinates for those localities that can be identified with assurance. Our analysis of the data, and of the complexities in their interpretation, will be discussed in detail elsewhere. For the present two points will be noted: 1) The correlation of ancient muslim and modern coordinate data is linear and excellent from the very earliest data series and does not show any further improvement with the passage of time. 2) The coefficient of proportionality between the modern and medieval Muslim longitude data reflects (or for geodetically derived longitude differences, determines) the length of the meridional degree. Focusing on the data for Eurasia, there is an abrupt change from the excessively short meridional degree underlying Claudius Ptolemy's data to the values implied by the data of the Arabo/Islamic geographers which deviated only insignificantly from the currently accepted length of the meridional degree. There is no consistent change in these values over the 750 year history of medieval Muslim geography. Within the individual sets of data for some of the Muslim geographers there is enough information to affirm that the coefficient of proportionality for the Eurasian longitudes is
significantly smaller than that for longitudes given for identifiable localities on the shores of the Indian Ocean. Here again no secular trend can be recognized from the limited amount of data available.

Longitudes, then as now, were expressed by reference to some arbitrarily chosen null meridian. Regression analysis of the coordinate data allows one to determine the location of this null coordinate for many of the authors of tables. Such analysis shows that three choices predominated: the longitude of the Canary Islands, that of the Acores, and some place about two thirds of the way west between the Old and the New Worlds. There appears to be no special trend to these choices, so that here again no secular trend can be discerned.

The question of the latitude determinations has already been alluded to in connection with the discussion of the conception held with regard to the Indian Ocean. In principle, these values could be readily determined on the basis of astronomic observations. We have alluded to the failure of the geographers to cope with the disappearance of the Pole Star as one proceeded below the equator, and the implications of this failure. Comparing astronomic with geodetic measurements for a given difference in latitude was used for the estimation of the length of the meridional degree and the circumference of the earth from classical times on. These measurements for a long time were based on inadequate trigonometric methods that were not fully developed until the 11th century. Even then, different authors continued to use a variety of values for this important parameter, indeed, both al-Idrisi and Ibn Sa'id, in their relatively late writings, referred to and probably employed an excessively large value for the meridional degree.

While no significant change can thus be detected over the 750 year period in the expression of Muslim mathematical geography in the works that have come down to us, it should not be assumed that there was no progress in mathematical thinking regarding these matters. Disregarding the achievements in the area of astronomy, the most important development was in the area of trigonometry. Here important strides were made in the use of trigonometric functions, and in spherical trigonometry, the very concept of which, and the implied realization of the possibility of
a non-Euclidian geometry, seems to have emerged from specula-
tions aroused in the minds of such scholars as al-Biruni by the
consideration of the fundamental problems of geodesy (cf. 5).

Cartography, the visual representation of geographic knowl-
edge, had its own history. Progression in the style of cartography
saw three stages: 1) Early assimilation of the Ptolemean writings
that produced the tables of al-Khwarizmi and the Ma‘munian
world map, a map that has been virtually lost to us but which,
according to the remaining fragments and the extant reports,
constituted essentially a revision and updating of the Ptolemean
world map, employing the concept of orthogonal coordinates to
achieve planisphere projection, probably in terms of the first
Ptolemean projection; 2) the Balkhi period of Muslim cartogra-
phy in which the principles of Ptolemean cartography came to be
neglected in favor of a schematized style using only the crudest of
geometrical simplifications to convey information on relative
positions of places to produce maps intended to illustrate an ac-
companying narrative; 3) the period inaugurated by al-Idrisi who,
working at the Sicilian court, produced the cartography of the
Book of Roger. These maps show the strong influence of Ptolemean
concepts but greatly extend the detail and the number of locali-
ties included. They clearly aimed at providing realistic contours
for shorelines, mountains, and rivers, and their style (or rather
their two styles) were adopted by al-Idrisi’s successors, notably by
Ibn Sa’id.

The part of the overall effort that proved to be most enduring,
and contained the strongest Arabic manifestation, was descriptive
geography. Muslim descriptive geography found its style and its
general pattern early. The first texts devoted to the description of
the lands of Islam showed the elements of a stylistic pattern that
would remain characteristic of Muslim geography for many cen-
turies. Wherever possible descriptions focussed on cities, the
routes connecting these cities, seas, rivers and whether a given
city was a port. The whole constituted a network illustrating the
characteristics of a given area without ever alluding to the abstract
concept of ‘area.’ Such narratives were sometimes enlivened by
the recitation of ‘marvels,’ remarkable natural features, mythical
beasts and popular legends, but the importance of this compo-
nent decreased with the passage of time. Special variants might be
the inclusion of data concerning tax yields, climatic data, and
Figure 7. Coverage of the then known inhabited world by geography texts written at various times from about 850 th 1300. The numbers are based upon the world map of al-Idrisi as reconstructed by Konrad Miller, and represent the total number of sections more or less completely described in the texts. The maximum number attainable in this system is therefore $10^7$, i.e. 70. The thinner segments extending above the heavy segments for al-Idrisi and for Ibn Sa‘id represent sections mentioned but described only rather cursorily. In the cases of the remaining authors all sections touched upon were included.

coordinates of selected places; the style might vary from the dry factual accounts of Ibn Khordadhba® to the profuse and ornate style of al-Mas‘udi or al-Muqaddasi. All of these possibilities had been explored by the 10th century and showed little development over the remainder of the medieval period.

What did vary over the centuries was the extent of the area covered by those texts aiming at inclusiveness. While the earlier works were confined in large measure to Mamlaka al-Islam, the lands conquered by and governed for Islam, as time progressed there was a systematic trend that included new detail, and replaced the astrologically based concept of climates, used in some of the early treaties, by an organization more readily adapted to a geography that recognized a wider area of concern. This was based on the notion of the Seven Climates, latitude belts based on differences in the length of the longest day of the year. In addition there was a striking expansion of the area covered (cf. figure
which, because of the methodology employed for the quantification, cuts off just before the year 1300 A.D. after which geography texts ceased to be organized around the seven climates and their longitudinal divisions). So striking and abrupt was this change that it may well be in order to speak of a revolutionary change that appears to have occurred sometime during the 11th century. It is significant that the abrupt change in cartographic technique, mentioned in the preceding paragraphs, fell into exactly the same period. Thus, while it is likely that these changes occurred partly in response to the continuing expansion of *Dur al-Islam*, and the associated increase in knowledge of remote regions, it is quite appropriate to speak here of a scientific revolution in the sense of Thomas Kuhn and to seek for more far reaching causes for such an event. Miquel in noting the discontinuity in the characteristics of his texts at that period, suggested political causes, notably the penetration of the Arabic Empire, the *Mamlaka al-Islam*, by central Asiatic Turkish tribes. In contrast to this view, as reflected in figure 7, there were geographical treatises written as much as fifty years after the establishment of the Buyids in Baghdad, showing a restricted coverage, in comparison to texts written a 100 years earlier, and dramatically below that of al-Idrisi and his successors. Earlier it was suggested that one factor in this striking change might have been that the text was written under conditions that encouraged a symbiotic interaction between the Muslim geographer and the western, Norman king. It may also be pertinent that the later geographers all originated and worked in the western ranges of the Islamic realm. Whatever the case, further exploration of this dramatic change is needed.

The increase in knowledge of distant territories is especially noticeable in relation to the lands bordering the Indian Ocean. This is readily illustrated by the changes in the perception of the southern shore of the Indian Ocean. Based on information inherited from antiquity, predominantly that purveyed by Ptolemy, the Indian Ocean appeared as an enclosed lake with a vaguely defined eastern barrier separating it from the great surrounding ocean, and an assumed landmass, the Terra incognita australis, constituting its southern shore. Islamic geographers almost from the start dispensed with the eastern barrier. In the sequel there was a gradual progression in which the Terra incognita, without changing its shape or position, slowly gave way to a better known
African landscape that was inhabited by an increasing number of settlements located along the East African coast. In the last stages the size of the southern landmass shrank and extended eastward only half way across the Indian Ocean while an open sea passage between the Indian and the Atlantic Oceans came to be accepted in the far south. This configuration existed virtually unchanged until the 15th century when the Cape of Good Hope was rounded by the Portuguese.

Islamic medieval geography did not share in the next phase of development which took place in the hands of western European cartographers, as a result of the maritime discoveries of the Spanish and Portuguese in the late 15th and 16th centuries.

In light of the above comments, it is clear that medieval geography in the Muslim world was neither static, nor were Islamic scholars merely the passive transmitters of knowledge received from the Hellenistic, Roman, and Byzantine worlds to an emergent western Europe. Rather, the picture presented is that of a discipline appropriated from antiquity, naturalized in its new setting, and developed, albeit unevenly, to a new and richer form in the course of the first seven centuries following the Islamic Revelation. It was certainly no accident that the cartography of western Europe in the 14th century carried a distinct Muslim imprint. It would appear rather that such similarities reflect the extent to which European interest in these fields was inspired by 13th century Muslim scholars. In this sense, and only this sense, it is correct to speak of the great contribution of the Islamic world in transmitting the ancient learning to the west.

In Place of a Summary: A word is in order regarding the actual time sequence that produced this Muslim development. It is clear that the development was not uniform. At the very beginning of this essay attention was called to the pronounced rise and fall of the numbers of scholars contributing written works to the field of geography. The peak period of contribution, the 10th/11th centuries A.D., has been called the Islamic Renaissance, a period characterized by a marked resurgence of religious enthusiasm, that subjected the faithful to a renewed rigidity of doctrine and, in the mind of some critics, resulted in a reduction of creativity and originality in numerous fields. In actual fact, however, while the volume of writings decreased during this age the quality of
the manuscripts actually improved. The improved quality is reflected in the works of al-Idrisi, Ibn Sa‘id, Ibn Batuta, Ibn Jubair, al-Mahri, Ibn Majid and others. As was shown in the preceding section, progress in the different segments of the field followed very different courses: in mathematical geography an initial period of considerable activity and creativeness was followed by near stagnation for the remaining centuries; in the domain of descriptive geography there was an abrupt step increase in the scope of the matter covered sometime between the end of the 10th and the middle of the 12th century; in cartography there was a curious saltatory series of changes beginning at a high initial level, retrogressing markedly after a short period of fluorescence in the 9th century, followed by an abrupt step upward, again falling sometime between the end of the 10th and the middle of the 12th century, and thereafter persisting without much change until at least the end of the 13th century.

This brief treatise will refrain from speculating as to the driving forces behind these complex changes, but it should be noted, that most of the changes had in fact been played out before the middle of the 13th century. This may be a remote consequence of the fate of the ‘Abasid califate, and its lapse into near impotence, or the difficulties experienced by the successive Egyptian rulers during the 10th century. In any event, it seems clear that these events preceded the disaster of the Mongol invasions of the second half of the 13th century. With regard to further analysis it may well prove true that the time course in the expression of this branch of the natural sciences may reflect a degree of interaction with other cultures, and it seems likely that comparison of the chain of events in the Muslim world with those at comparable stages of development in the western European theater may shed additional light upon the complex forces giving rise to the changes we have described.

A Basis for Future Comparative Studies: At the outset of this communication it was established that one of the objectives was to suggest a basis for a future comparison of the scientific development specifically in geography, between the Islamic and the Western European civilizations during the Middle Ages. Surely, a hint that there were profound differences between the spirit or the contents of geographical thought as it existed in Western and
Southern Europe and in Muslim Maghrib and al-Andalus in the 12th century is contained in the symbiotic effect of the collaboration of representatives of the two domains which we encountered in the Book of Roger by al-Idrisi. From what has been said above, it is evident that there are numerous detailed features that invite comparison. Two obvious areas of comparison would be the structure of the learned society that gave rise to geographical inquiry and the characteristics of the science itself.

One gets the impression that much of the early work, especially the early days of fluorescence under the ‘Abbasid khalifs, was undertaken in relative isolation: scholars may have read each others works, but there is scarcely any record of direct verbal contact. Even at the later courts, the geographers were usually represented by no more than one scholar at a time. With the possible exception of the cartographers of the Balkhi school, and it was early, I am unaware of any succession of master and pupil who both addressed the science of geography. In this respect, it seems that Muslim geography tended to differ from astronomy or mathematics.

A previous section documented another kind of isolation, that being the self-imposed isolation of geographers from those individuals who ought to have been the immediate beneficiaries of their efforts. This, perhaps, reflects a social prejudice whereby the bold seafarer held contempt for the housebound scholar. Whatever the cause, the result was, as we have seen, highly detrimental for much of the period. It may well have been at the base of the failure of the science in the Arabo-Islamic realm to participate early on in the revolution in geography as well as in cartography brought about in Western Europe by the Iberian discoveries of the late 15th century. The Ottomans, Turks with very different preoccupations and attitudes, were the ones who did pick up the new concepts, but they were relatively late and in any event represented a new start in the development of Muslim culture.

Here we can only allude briefly to two other potentially fruitful areas of discussion toward which the preceding pages have contributed in an incidental way. In the first place there is the question of who constituted the audience to whom these works were addressed? There are at least indications in what has been stated that, these writings addressed princes and their immediate environment. The style chosen, the ‘adab style, suggests a desire to
reach an audience of the educated and well-to-do. In this sense there may be a difference between some of the earlier works which may well have been designed for the use of lesser officials—such as postmasters and tax collectors—and the later literature which was addressed to a less specifically interested audience.

In the second place, there is the question of the influence of the all-pervasive religion on the shaping and the development of the science. While one may read encouragement for inquiry into the natural sciences out of the Qur'an, initially this encouragement was confined to the religious sciences. Accordingly, as was noted earlier, there are indications that the piety-minded had little use for a science devoted to describing the physical make-up of this world yet little evidence exists that they actively interfered with geographic pronouncements. In this respect it would seem that geography fared better than astronomy.

Andre Miguel has argued convincingly that Muslim geography has had a pronounced impact on human geography. This was expressed in the present work through the use of cities as the primary defining entity of many landscapes. The result is what has been called ‘linear geography’ whereby a countryside is pictured in terms of a network of lines linking cities, with supplementary descriptions of various landmarks. One result of this approach was that authors on the whole did not include area-linked concepts. Attention has also been drawn to the vagueness with which boundaries between realms were described and it was suggested that this characteristic, too, may be linked closely to the town-centered perception of the country. This point can be expanded to suggest that Muslim geographers often fell short of any kind of generalizations as there was no recognition of continents and their boundaries, river systems rarely emerge with any clarity, mountains rarely form part of recognizable systems, and outlines of lands abutting the seas were extremely vague. It is uncertain whether these scholars used their coordinates to orient their localities on the map or whether conversely they used a combination of preconceived ideas and real travel distances to reconstruct fitting coordinates.

A final point that seems worthy of mention is the absence in Muslim literature of any reference to what might be called a voyage of exploration. While the records of Ibn Batuta's travels re-
reflect a genuine spirit of adventure, unlike the European literature of the period, there is no indication that Muslim travelers were inspired by a comparable thirst for knowledge of the unknown. Traveler after traveler assures us that he is sallying forth in search of learning to be acquired from learned and pious men, but there is hardly any reference to gathering knowledge by seeing previously unseen sights with one's own eyes. However, marvelous stories enter this literature second hand, as travelers hear tales that are repeated for the entertainment of others. One rare exception might be al-Biruni's voyage to India, that resulted in a wealth of often carefully scrutinized information being brought back, but it could be argued that much of the country visited by this time was safely included in Dar al-Islam. On the other hand there are reports of travelers who deliberately set out toward the unknown, but whose deeds, far from drawing praise were condemned as manifestations of unseemly pride and mere curiosity. All around, it seems that the travel recorded in connection with the geographers' treatises contrasts vividly with patterns of exploratory voyaging in other societies.

Hopefully, these suggestions reflect the rich opportunities that exist for comparisons to be drawn between medieval Muslim and European geographers. Future comparative studies need to determine the extent to which it would be appropriate to pursue a comparison of the two cultures. Whatever work in this direction will prove practicable, it will have to be aimed at further defining differences in the time course of development of the science in the two societies, and the contribution to be expected from such comparison toward the understanding of the forces underlying whatever link may be revealed between the history and the history of science in each.

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NOTES


10. In his classification the traditional sciences (which include religion, jurisprudence, hadith, dream interpretation etc.) are opposed to the philosophical sciences (these include the study of logic, of elemental substances, of metaphysics, as well as the science of quantities). The list, presented on pages 111 to 148 of volume 3 of F. Rosenthal’s translation of the work (Pantheon Books, New York, 1958), includes “the sciences concerned with numbers, the geometrical sciences, astronomy, and logic,” as well as physics, medicine, and agriculture and a number of others not properly forming part of the intellectual sciences, but there is no mention of geography as a science in any form.
11. The Imam abu hamid muhammad al-ghazali (12th century).
13. For example cf. descriptions of the relations among Ethiopia, Nuba, Baija, Berberland (Somalia), and the Suaheli Coast.
14. Despite this linear character, which clearly derives from the early rutter and in some ways is a bit reminiscent of modern railroad schedules, it should be noted that at times the insertion of terms describing the character of the agriculture or horticulture, mention of landscape features, in particular those associated with water (rivers, lakes, swamps), reference to the difficulty or ease of particular routes, and perhaps more general terms referring to a countryside as ‘ruinous’ or ‘flourishing,’ and other descriptive details of the kind, can result in conveying to the reader a remarkably vivid impression of the appearance of the region being described.

18. e.g. al-Mahri, Sulaiman. Kitab al-minhaj al-fakhar fi 'ilm al-jara al-zakhir (Ms.)


20. This despite occasional claims (such as in al-Istakhri i or al-Mas'udi) that “for years they had frequented Indian Ocean (or Persian Gulf) ports, and had spent a great deal of time congregating with ship owners and pilots, and inquiring into all aspects of their craft.”


23. We hardly ever hear of direct oral contact between scholars, of debates or discussions, and in geography, but perhaps not in mathematics or astronomy, even mention of being someone's student is exceedingly rare.


27. The addendum entitled Masahat badh al-balad travels in divers countries) p. 149-165 of Reinaud's edition of Sulaiman the sailor's salsala at-tawarikh. Otto Zeller Verlag, Osnabrück, 1988, is perhaps the clearest example; the tale of Sallam the interpreter and his trek to the wall of Gog and Magog, though in large measure fictitious, is another well known instance cited in at least two of the geographers' treatises (Ibn Khordadhba and al-Idrisi).

28. re al-Idrisi cf. Konrad Miller. Die grosse Rogerkarte des Idrisi in Konrad Miller. Mappae Arabicae, H. Gaube ed., Reichert Verlag, Wiesbaden, 1986, Section A. Note also that Ibn Khordadhba combined his activity as a geographer with a position as head of the Barid, the Postal service which at the same time was a key part of the Intelligence service of the 'Abbasid caliphs.

29. Ibn Battuta may be such an exception, yet he was a qadhi who started his voyages as a pilgrim on the way to mecca.


32. Cf. e.g. 9 Climate I, section 1 and Climate IV, section 1.
33. Cf. 9 Climate II, section 1.
35. Cf. 9 Praefatio.
37. These comprise a large company of strange plants and animals, numbers of more familiar animals like the crocodile but surrounded by strange tales concerning their manners and characteristics, a whole company of strangely distorted man-like creatures, as well as inclusion of ancient tales, like that of the thirteen sleepers in the cave in Anatolia.
38. al-Maqdisi, Shams ad-din abu'abd allah muhammad-Kitab ahsan at-taqasim fi-ma-'arifa 'l-agalim-vol III of Biblioteca Geographicorum Arabicorum- M.J. de-Goeje ed.- almost any place e.g, in the section entitled 'janub khorasan', subsection juml shu'un hadha 'liqlim. p.24.
39. cf. - Introd. section: dhikr 'l-asma 'l-ikhtilafha
40. Within the towns classes tend to be distinguished by wealth and occupation: rich merchants tending to form the upper class, poor merchants and craftsmen a lower stratum, the latter group being further separated by dignity and perhaps qualification of the trade. The representatives of the central government and the military tend to fall outside of this class structure, as do the peasants of the surrounding countryside who tend to be viewed as falling below any of the city classes. Nomads, not being residents of the lands pertaining to the city also have no place in the society of any but the military towns. Cf. e.g. 11 and Goitein, S.D. A mediterranean society. Univ. of California Press, 1967. Vol. I. Economic Foundations, c. 1. Introduction.
41. qadhi and muhtasib are representatives of the ruler in direct touch with the people and are embedded in the general population. They commonly reside and have their courts among the dwellings or markets-cf. Durand, Bernard- Histoire comparative des institutions- les Nouvelles Éditions Africaines, Dakar, 1983- titre II, section III Les structures gouvernementales et administratives.
44. Cf. 9. Climate III Section 1.
46. Cf. e.g. 9. The geographic literature of the time constitutes an important component of the debate concerning the real impact of these incursions and may have contributed importantly to the point of


56. In this respect I take issue with K. Miller; a detailed exposition of my reasoning in this matter will be published elsewhere.


59. Cf. 9.


62. This seems less than certain to me, since it is reasonably well documented that in the 13th century Mongol war leaders like Subotai
Bahadur are reputed to have made use of scaled maps in their campaigns for the conquest of Russia.

63. al-maqdisi, abu' abd Allah Muhammad-ahsan al-taqasim—fi-'ma'arifa 'l-qa'lam-BGA-Brill, Leiden 1968- many places, e.g. in the section entitled janib khurasan',
64. cf. 64 p. 358
67. Brauer, R. W. Correlation of geographical coordinates in the Arabo/Islamic literature with modern coordinates for the same localities. (to be publ.)