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GEOGRAPHY
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iv. Geography

Bīrūnī's conceptions of the spherical shape of the earth and of the distribution of geographical features on its surface are those of Greek scientists, and especially of Ptolemy, as modified by earlier Muslim geographers. Thus he explains the Greek astronomers' theory of the earth in his *al-Qānūn al-masʿūdī* (1/2, pp. 24-54), but adds to his discussion of the distribution of land and sea over its surface much new information and some arguments of his own devising (*Tafhīm*, secs. 210-12, pp. 120-25; *Taḥdīd*, pp. 41-64, tr. pp. 15-32; *India*, chap. 18, pp. 155-57, tr. vol. 1, pp. 196-98). In the course of these discussions especially in that in the *Taḥdīd* he has much to say about changes in climate and of terrain that is based on a close examination of fossils, seashells, and stratigraphy. In India he describes the theories of the earth both of the *Purāṇa*s (chap. 221, pp. 185-91, tr. vol. 1, pp. 228-33) and of the Indian astronomers (chap. 26, pp. 219-32, tr. vol. 1, pp. 263-77).

Moreover, he accepts the need to determine anew the dimensions of the earth. In this connection he records the story of the ascertainment by the astronomers of al-Maʾmūn of the length of a degree as 56 2/3 miles in three works: the *Taḥdīd* (pp. 213-14, tr. pp. 178-79), the *Tafhīm* (sec. 208, pp. 118-19),

and the *Qānūn* (bk. 5, chap. 7, pp. 529-30; see Barani, pp. 11-22). Bīrūnī also devised his own method of determining the radius of the earth by means of the observation of the height of a mountain and carried it out at Nandana in India (*Taḥdīd*, pp. 221-26, tr. pp. 187-89; *Qānūn*, bk. 5, chap. 7, pp. 530-31); he determined that the length of a degree is 55;53,15 miles in the *Taḥdīd*, 56;5,50 miles in the *Qānūn* (see Barani, pp. 35-44, and *Taḥdīd* comm. p. 143).

In speaking of the inhabited part of the world Bīrūnī follows the Greek tradition of the seven climes, whose limits are determined by increments of half an hour in the lengths of longest daylight (*Taḥdīd*, pp. 138-41, tr. pp. 103-06; comm. pp. 77-78; *Tafhīm*, secs. 236-38, pp. 138-40; *Qānūn*, bk. 5, chap. 9, pp. 536-45). But he also describes in considerable detail the seven *kešvar*s (climes) of traditional Persian geography (*Taḥdīd*, pp. 134-36, tr. pp. 101-02; and *Tafhīm*, sec. 240, pp. 141-142) and the seven *dvīpa*s of the Indian *Purāṇa*s (*India*, chaps. 21 and 24, pp. 191-96, 207-12, tr., vol. 1, pp. 233-38, 251-56), as well as the Indian traditions concerning the geography of Bharatavarṣa (*India*, chaps. 25 and 29, pp. 212-19, 246-50, tr., vol. 1, 257-62, 294-305). He adds as well an account of the Hindu *tīrtha*s (places of pilgrimage) based on the *Purāṇa*s (*India*, chap. 66; pp. 461-66, tr., vol. 2, pp. 142-48).

But Bīrūnī's main concern in the domain of geography lay in the location of places relative to each other, the determination of their latitudes and longitudes, and the computation of their azimuths of the *qebla* (direction of Mecca). For the first purpose he records a number of routes in India, emanating primarily from Kanawj (Kānyakubja), the then capital of the Pratīhāras, and branching out from nodes along the direct routes from that city; to this system he appends descriptions of Kashmir and the source of the Indus, of the east and west coasts of the peninsula, and of Ceylon and other islands in the Bay of Bengal (*India*, chap. 18, pp. 157-70, tr., vol. 1, pp. 198-211). In most cases Bīrūnī gives the distance in parasangs between the major towns on these routes.

Bīrūnī does not attempt to construct a map of India on the basis of these itineraries as, for instance, Ptolemy had done with similar material. But he has compiled from various earlier authorities and his own observations and computations a list of the geographical coordinates of about 600 localities, arranged according to the seven climes (*Qānūn*, bk. 5, chap. 10, pp. 546-79; these places are included in Kennedy and Kennedy); some indication of his innovations with respect to localities in the east is given in Haddad and Kennedy (pp. 99-100). He himself had made observations of the latitudes of

various places in Ḵʷārazm, Khorasan, Jorjān, Afghanistan (see Bivar), the Punjab, and northern Sind; many other observations made by his predecessors among Muslim astronomers were known to him from the literature.

The methods of determining local latitude are relatively straightforward (*Taḥdīd*, pp. 63-87, tr. pp. 34-57; *Qānūn*, bk. 4, chaps. 7-9, pp. 402-11). The more difficult problem was to determine the longitudinal difference between two localities. The preferable solution was to compute this from simultaneous observations of a lunar eclipse (*Taḥdīd*, pp. 167-206, tr. pp. 130-72; *Qānūn*, bk. 5, chap. 1, pp. 507-11); but, lacking the possibility of doing that in most cases, Bīrūnī devised a method of approximating the longitudinal difference through a modification of the itinerary distance between two localities, a knowledge of the latitude of each, and a determined value for the circumference of the earth (*Taḥdīd*, pp. 227-72, tr. pp. 192-240, with a number of worked examples; *Qānūn*, bk. 5, chaps. 2-4, pp. 512-22; see Schoy and Kramers); in the course of his discussion of the second method in the *Taḥdīd* he describes and criticizes a related Indian method which he deals with more extensively in India (chap. 31, pp. 265-69, tr. vol. 1, pp. 311-16). Finally, when the longitudinal difference between any locality of known latitude and Mecca has been determined, it is possible to compute accurately the azimuth of the *qebla* (*Taḥdīd*, pp. 272-89, tr. pp. 241-59; *Qānūn*, bk. 5, chaps. 5-6, pp. 522-28).

Bīrūnī composed a number of works on geography besides the *Taḥdīd* before 427/1036; they are listed as nos. 20-33 in his *Fehrest* (Boilot, pp. 183-87). We also know of his *Ketāb taqāsīm al-aqālīm* from the same source (Boilot, pp. 229-30). Still extant are his *Maqāla fī tasṭīḥ al-ṣowar wa tabṭīḥ al-kowar* on projecting the points on the surface of a sphere onto a plane (see Berggren and Richter-Bernburg) and his *Ketāb Abī Rayḥān elā Abī Saʿīd* on Ḥabaš's analemma for finding the azimuth of the *qebla* (see Kennedy).

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