PALAEOGEOGRAPHY OF INDIA DURING GONDWANA TIMES AND ITS BEARING ON THE CLIMATE

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ABSTRACT

The three significant components of Palaeogeography, viz., Latitude, Continentality and Relief of India during Gondwana times have been reconstructed from the available information. The latitudes have been determined from the latest palaeomagnetic information for the position of South pole at different periods in the Gondwanaland, the continental fits for which have been revised by the author recently. The continentality for India has been deduced from its position with reference to ocean and continental faces. The relief over the Indian continent has been concluded upon, from the known structural, geomorphological and sedimentological features.

The climate of India, on the basis of palaeogeographic deductions has been concluded to have been mostly frigid cold and dry during Permo-carboniferous, cold or temperate with increased precipitation during the Permian, cold and dry or warm temperate and humid during the Triassic, cool or warm temperate and humid during the Jurassic and sub-tropical to warm temperate during the Lower Cretaceous time as India moved northwards separated from other continents.

INTRODUCTION

The climate of a region is made up of the temperature and humidity cycles experienced by it through a year. These cycles are dependent for their particular behaviour on the interaction of a number of factors. The temperature of a region is influenced by latitude, altitude, source and direction of winds and ocean-currents, and distance from the sea. Humidity depends upon the amount and distribution of rainfall, source of traversing winds, alignment of mountains and valleys, etc. A large number of minor factors including the soil kinds and the nature of vegetation cover, also tend to interact with the major elements modifying the climate to some extent. Hence it is presumable with fair chances of correctness that the climate during the geological history of a region must have been likewise the resultant of the above mentioned elements and their interacting factors. In short, the climate of a region is an intimate reflection of its geography which is dependant mainly upon its latitudinal position, its continentality and its relief. Evidently, for a reconstruction of the climatic history of India during Gondwana times, it is necessary to understand the above three aspects as far as one might be able to interpret the relevant data.

LATITUDINAL POSITION OF INDIA

During Gondwana times, India was part of a supercontinent, Gondwanaland, comprizing S. America, Africa alongwith Malagasy, India including Shri Lanka, Antarctica. and Australia including Tasmania and southern New Guinea. The position of India in this supercontinent has been variously postulated by the geologists and geophysicists in the past. However, recently BHARADWAJ (1976) with the help of available geological, geophysical data, has concluded upon a new fit of the constitutent continents. Accordingly,

India was flanked on its present, western boundary by Africa alongwith Malagasy and along its eastern margin was apposed to the present eastern Antarctica. On the northern margin of India which extended then significantly beyond the Himalayas, lapped the Tethys (Text-fig. 1).

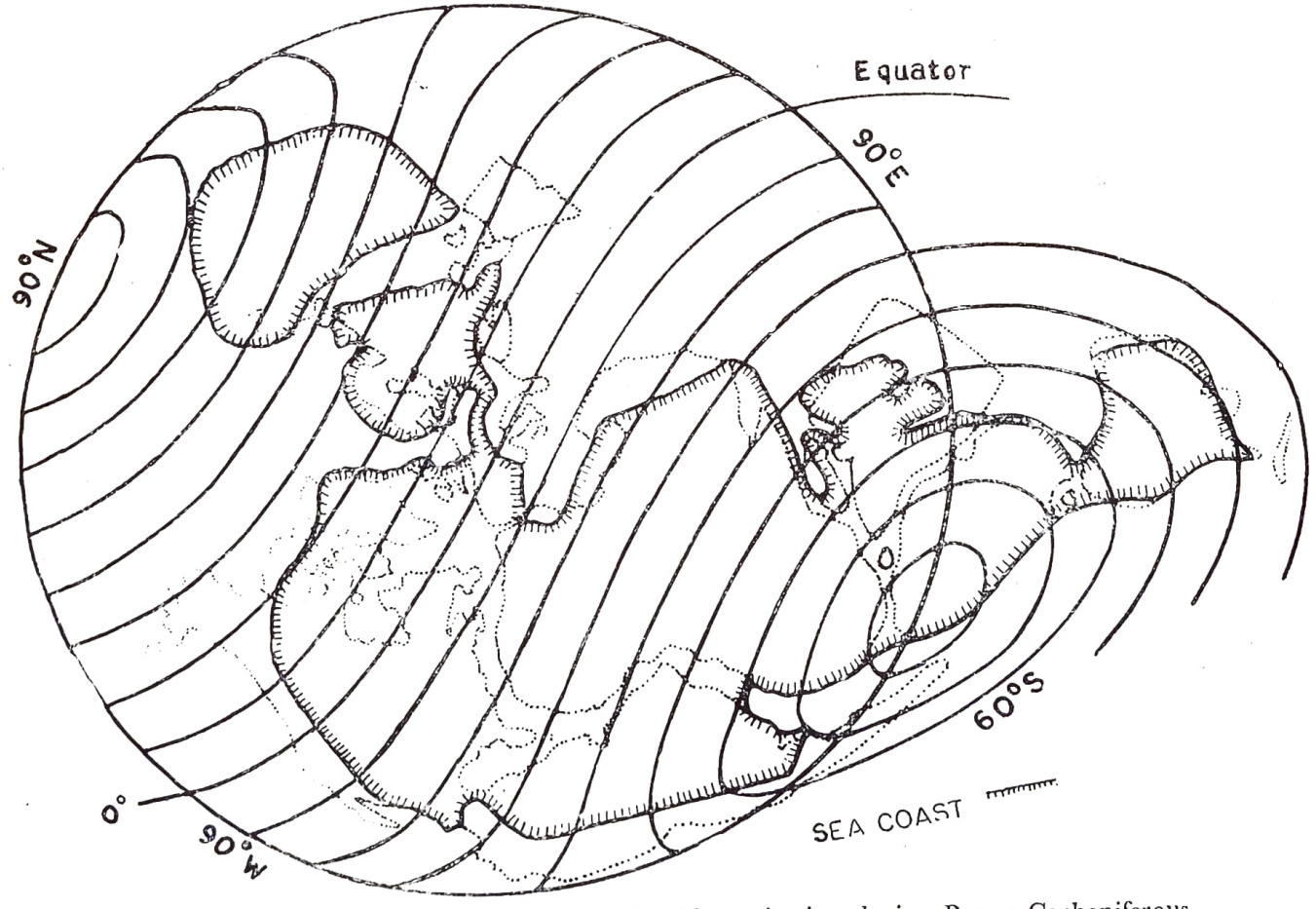
During the last couple of decades, palaeomagnetic studies of rocks have determined the position of poles during the geological periods. As recently summed up by McElhinny (1973), and also by Bhimasankaram (1975), the mean South Pole had been wandering through the continents of the Gondwanaland from Cambrian onwards till the Permo-Triassic. Thereafter, it migrated south of Antarctica-Australia during Triassic, Jurassic and Cretaceous. Combining the revised fitting of the continents in Gondwanaland (Bharadwaj, 1976) and the compromised positions of the South Pole, one gets the palaeo-latitudes for India during Permo-Carboniferous (Text-fig. 1), Permain (Text-fig. 2), Triassic (Text-fig. 3) and the Jurassic (Text-fig. 4) as follows :

Permo-Carboniferous

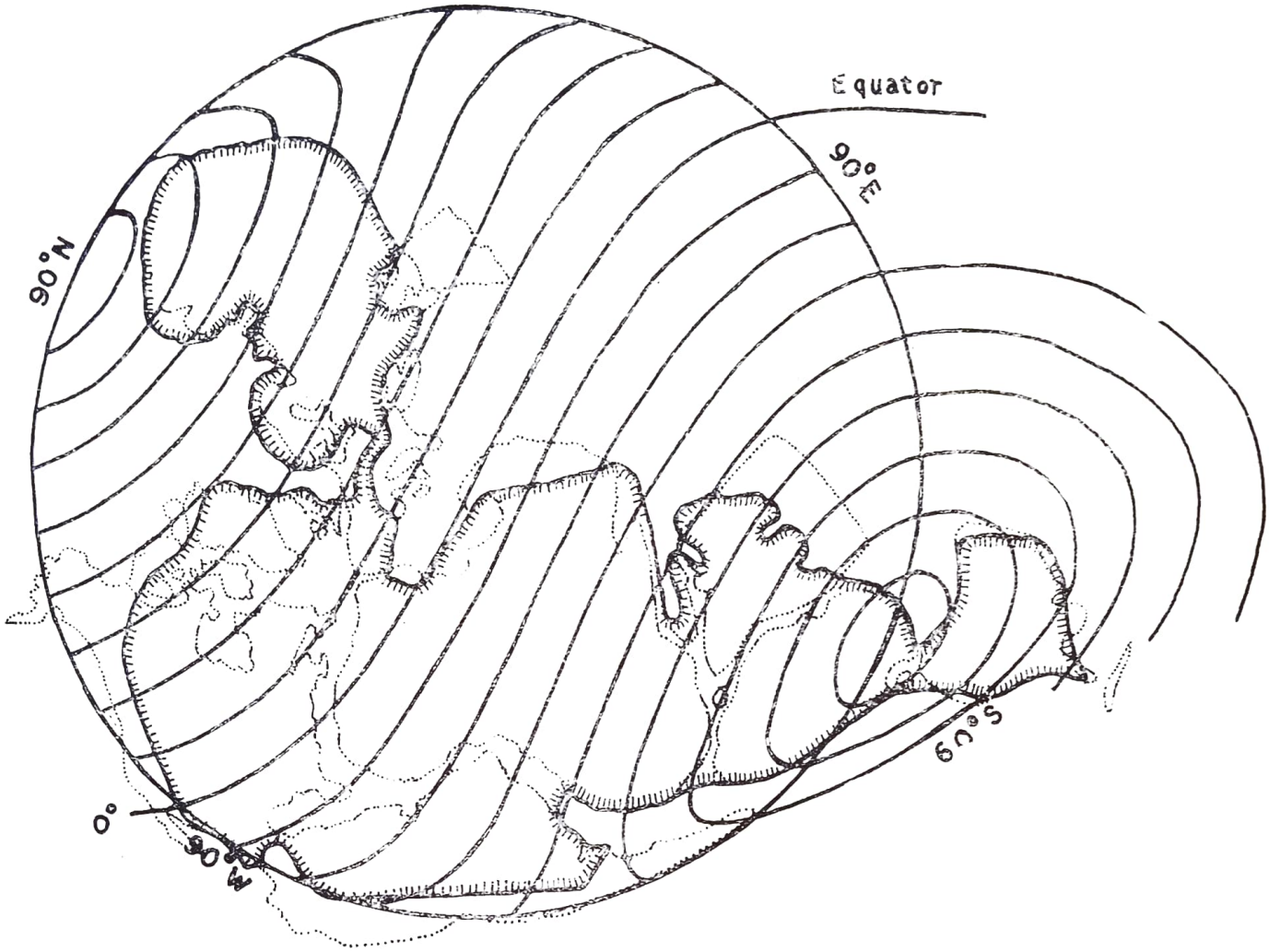
The postulated position of South Pole being in Antarctica, south-east of S. Africa, the peninsular India lay between 50° and 70 S latitude but for Panjab and Kashmir which extended beyond 50°S latitude.

Upper Permian

The South Pole having migrated due east in Antarctica, closer to Australia, the 60°S latitude apparently passed close to coromandal coast and included the Son-Mahanadi and Damodar basins. The 50°S latitude obviously included most of the remaining peninsular



Text-fig. 1. Pangaea in oblique Mollweide projection during Permo-Carboniferous.



Text-fig. 2. Pangaea in oblique Mollweide projection during Permian.

India but for Kutch, Rajasthan and extra-peninsular Panjab and Kashmir which extended upto 40°S towards the equator.

Triassic

The mean position for Triassic South Pole having been conjectured to be south of the then location of Tasmania, the 50°S latituded traversed the same areas as the 60°S latitude during Upper Permian. Evidently, only the present eastern part of India lay between 60-50°S latitudes and the rest between 50-30°S.

Jurassic

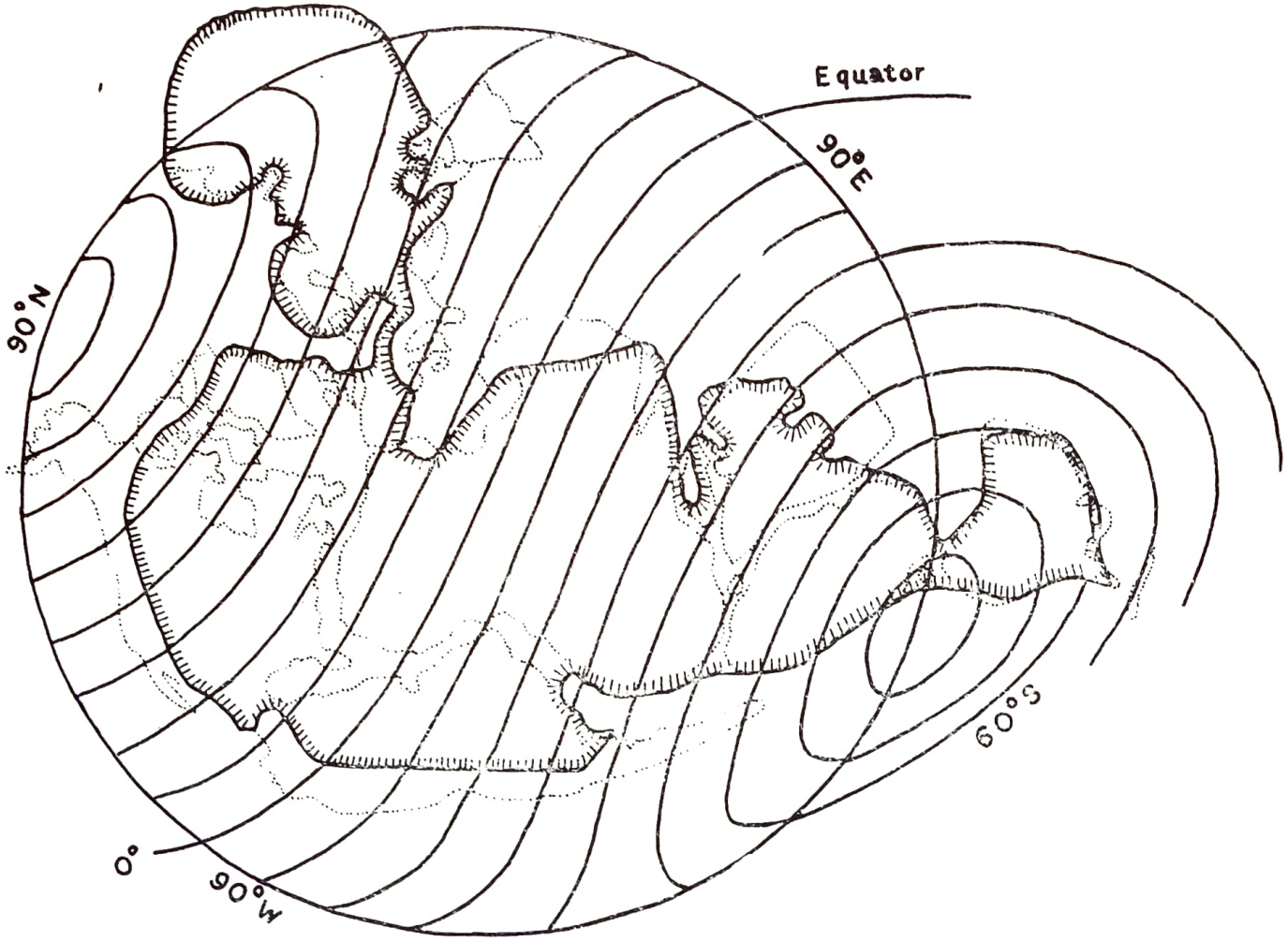
During the Jurassic, India had started moving away from Africa. The polar wandering curve for India suggests the movement of India southwards, implying thereby that presumably Antarctica and India moved together southwards. But there is a wide divergence between the Jurassic South Poles for India and Antarctica (Creer, 1971 Fig. 8, reproduced here as Text-fig. 5). So the above presumed joint movement is possible only if the Antarctican Jurassic pole is really the Triassic Pole. Considering this to be true, India-Antarctica-Australia block has been shown shifted south in Text-fig. 4. Thus, the latitudinal position of India remained the same as it was in the Triassic between 50° and 30°S latitudes but for the Assam region.

Cretaceous

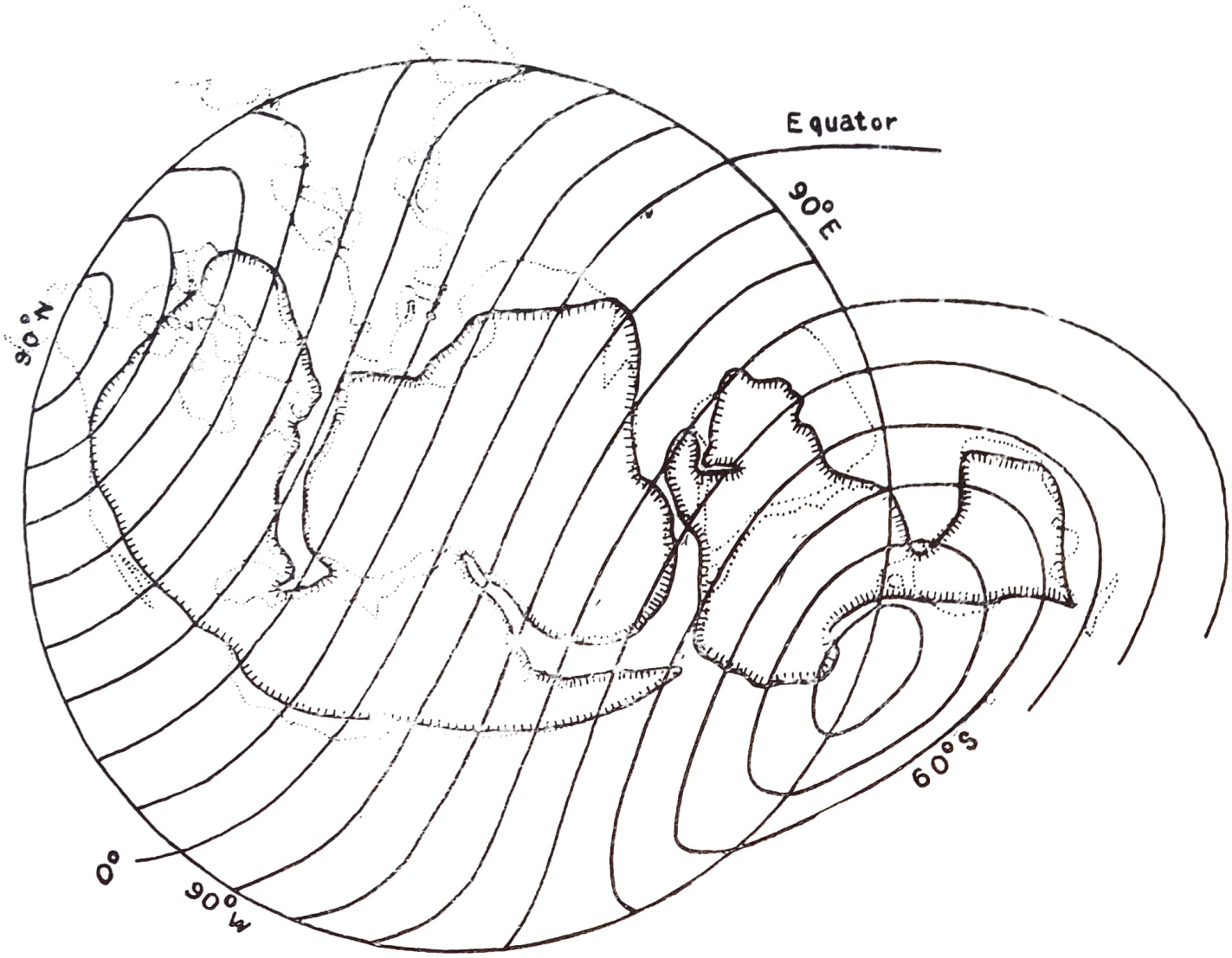
During Upp. Jurassic—Lr. Cretaceous time the direction of movement between India

and Antarctica changed. While Antarctica moved south-westwards India adopted an east-northly course. At this time the rift between India and Antarctica occurred causing marine transgression into lower lying parts of the east coast of India for which there is positive evidence. Palaeomagnetic results from India suggest its position during Mid-Cretaceous at about 45°S (McElhinny, 1973). As deduced from magnetic anomalies in the Indian Odean by McKenzie and Sclater (1971), 75 million years ago, i.e. by the late Cretaceous, India was almost beyond 30°S latitude, towards Equator and 36 million years ago (Oligocene) the Equator is said to have been passing close to Madras.

According to Dietz and Holden (1970), India had separated from Africa-Malagasy in the West and Antarctica in the South, by the end of Triassic, 180 m. y. ago, and by the late Jurassic, it lay between 10° and 30°S latitudes. Smith and Hallam (1970) concluded that much of the dispersal occurred in Upper Cretaceous times although the initial rifting had occurred in Jurassic and Lower Cretaceous. However, the time of rifting and drifting of east Gondwanaland comprising Antarctica, Australia, India and Malagasy from west Gondwanaland is stated to be Middle Jurassic by McElhinny (1973) and that of India from Antarctica in Upp. Jurassic to Low. Cretacous and from Malagasy at the end of Cretaceous. While Dietz and Holden (*loc. cit.*) have based their conclusions on North Atlantic magnetic and geological evidences, those by Smith and Hallam and by McElhinny, rest upon the continuity of geological features across the Gondwanaland and the different South pole positions in time, as suggested by palaeomagnetic studies. The latter have been accepted to be true for the present although it is possible that the final



Text-fig. 3. Pangaea in oblique Mollweide projection during Triassic.



Text-fig. 4. Pangaea with separated eastern Gondwanaland in oblique Mollweide projection during Jurassic.

position might be still different which the more recent palaeomagnetic and ocean floor studies might suggest.

CONTINENTALITY OF INDIA

During the Permian to Jurassic time span, most of the Indian continent but for a part of its western and eastern fringes and the whole of northern margin were lapped by the Tethys. The effect of marine proximity must have been appreciable in the northern region especially because, warm ocean currents starting from the equator in the Tethys must have reached the western and the northern coasts directly and ameliorated the high latitude colder conditions. But this may not have been true for the eastern fringe because the sea arm might have been lapped by a compensatory cold current arising from the coast of east Antarctica between India and Australia. The climate of this region might be conjectured to be similar to the western North Atlantic near Labrador and New Foundland with planty of fog. Evidently most of the peninsular India must have had cold, continental climate during the Permian but a little less cold during Triassic. There must have been distinct alternation of well-warmed Summer and frosty Winter.

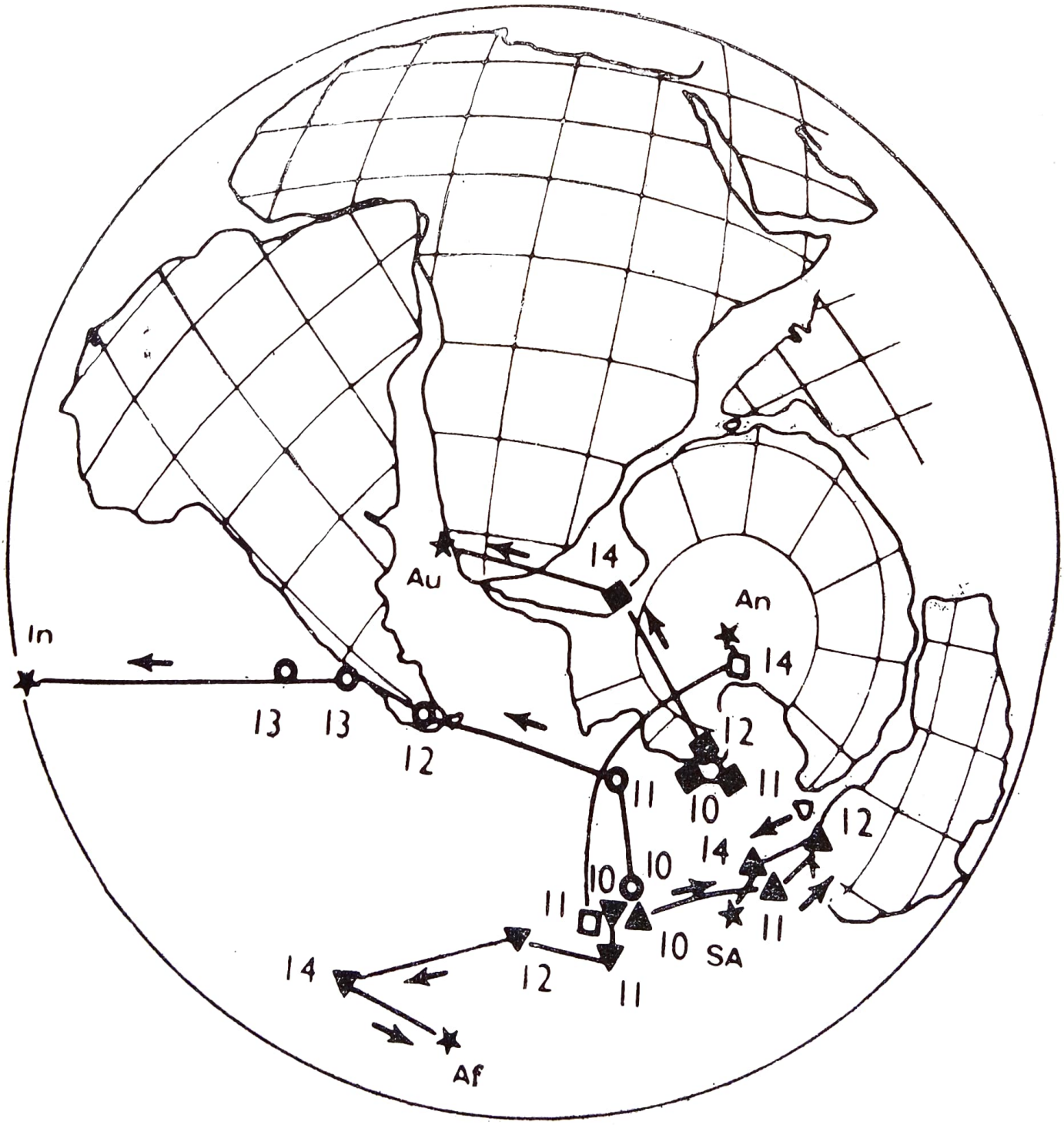
THE RELIEF IN INDIA

The relief features in a country are made up of the high and lowlands. Both of these can be conjectured by reconstructing the folding movements resulting into moun-

tains and the sedimentological studies elucidating the basinal structure circumscribing the extent and configuration of lowland. The determination of the direction of sediments-inflow indicates the position of a highland provenance *vis-a-vis* the basin of deposition.

From the information available about the pre-Gondwana geological events, it is mostly believed that at the commencement of the Talchir deposition, India had a number of highlands distributed as follows :

N-W Highland—The area North of Narbada river and West of Delhi what is represented by Rajasthan and Panjab, was a highland with a SW-NE trended Aravalli range. The region SE of this, extending upto Narbada and Chambal rivers, a part of Vindhyans, was also raised. It seems that the renewed folding movement of the Aravalli range after the Erinpura Granite intrusion, which continued till the end of Uper Vindhyans, also effected the upheaval of the adjoining, older Vindhyan sediments. These along their



Text-fig. 5. Palaeomagnetic South poles obtained from Mesozoic and Tertiary rocks of Gondwanaland (after Creer, 1971).

boundary with the Aravallis and Delhis, show unmistakable disturbance such as folding, faulting and to some extent also metamorphism (PASCOE, 1959, p. 560) The North-western extent of this highland touched the region of the Salt Range where the Talchir boulder bed contains boulders of origin in the granites and rhyolites of Erinpura and Malani adjescent to the Aravallis. Westward, Jaisalmer area appears to have been the margin. AHMAD (1961) has named this highland as the Aravalli nucleous. In view of recent deep drilling by the ONGC near Ujhani in West Uttar Pradesh, where Vindhyan sediments have been accosted, this nucleus might have encompassed western U.P. as well.

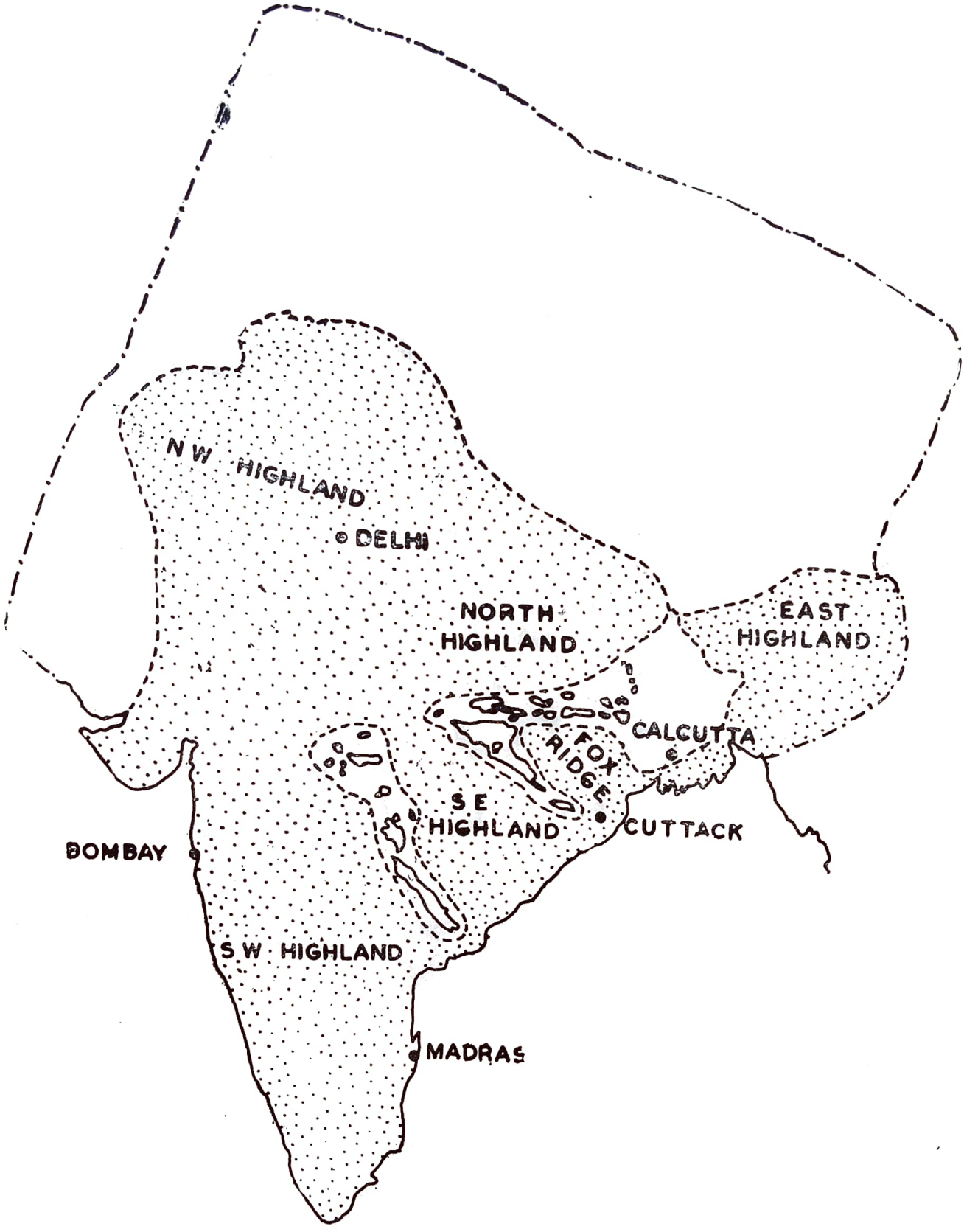
S-W Highlands—On the basis of available geological evidences, there is a consensus about the occurrence of a highland south-west of Godavari River. It seems that the region traversed by Godavari River today, was a longish lake in which sedimentation commenced from Talchir time. These sediments were received not only from the SW but also from NE. AHMAD (1961) has figured and named this highland as *Charnockia*. This highland was formed mainly by gneissic Archaean rocks such as Charnokites in the southern part and the Bengal gneisses in south-western part, alongwith the metamorphosed sedimentaries of the Dharwar System.

S-W Highland—Between the three NW-SE trending valley systems of peninsular India namely those of the Godavari, Son-Mahanadi and Damodar rivers along which Gondwana sediments are known to have been deposited, there occur even today two highlands of the Archean basement complex and the same appears to have been true at the commencement of Gondwana sedimentation. FOX (1931, Pl. 10) recognized both of them, however AHMAD (1961, Pl. 1) has stipulated a lowland with marine conditions in the region between Godavari and Mahanadi rivers and a highland, *Fox Ridge*, between Mahanadi and Damodar rivers.

East Highland—The Garo, Khasi and Jaintia hills in eastern India have a basement complex of gneisses ad schists of Archaean-Dharwar affinities. This region but for its western fringes lacks Gondwana sediments and was evidently a raised area not unlike the other highlands of similar origin.

North Highland—FOX (*loc. cit.*) has shown a land slice north-west of Son river which obviously represents the Bundelkhand gneisses and Vindhyans. Moreover, CROWELL AND FRAKES (975) have depicted the direction of till fabrics, erratic trains and striated pavements from WNW in Damodar basin, evidently indicating a highland northwards. The northern limit of this high region might have been lying beyond the central himalayan cristaline axis where from LE FORT (1975) has reported occurrence of Gondwana sediments. In view of the probable extension of Aravalli nucleous eastwards into W. Uttar Pradesh, it is not unlikely that the same might have extended further eastward including what has been separately described here as the North Highland.

Lowlands—The valley systems of Godavari, Mahanadi and Damodar rivers have already been referred to. The former two were narrow and linear in their southern reaches but expanded into very extensive lowlands. The Godavari valley was connected to the vast Tawa-Narbada basin in the Satpura region. This basin received sediments in the Pench valley from the south east (QIDWAI & CASSHYAP, 1975) which obviously means, from the S-E Highland between Godavari and Mahanadi valleys. In the Tawa valley, the Bagra detritus came from the north. The northtern reaches of the Mahanadi valley expanded in the South-Rewa region. The direction of the tillite fabrics in this region (CROWELL & FRAKES, *loc. cit.*) is from SW and W. This indicates that possibly the S-E High land between Godavari and Mahanadi rivers might have continued right into the Aravalli nucleous. The Damodar valley might have been connected with the Rangit



Map 1. Distribution of high-and lowlands in India during Permo-Carboniferous.

valley northwards and extended eastwards into what is now Bangaladesh. This vast basin alongwith the Beaver Lake in East Antarctica, against which it is presumed to have lain (BHARADWAJ, 1976), must have formed a huge fresh water reservoir in Gondwana-land. Map 1 depicts the approxmate distribution and extent of high-and lowlands in India during Permo-Carboniferous as discussed above.

RECONSTRUCTION OF THE CLIMATE

Permo-Carboniferous (Text-fig. 1) : Most of India having been situated between70 -40°S latitudes, the Westerlies must have been the prevailing winds. Most of the region lying west of India having being land, these winds must have been low in moisture content but for those going across northern part having surfaced over the narrow arm of sea touching Malagasy. But due to the Aravalli range running along them, precipitation might not have been significant. The Westerlies as well as the high latitude must have made most of the Indian plate forozen during winter but for the north-eastern coastal region which due to the postulated lapping by warm equatorial current might have had ameliorated temperature gradient. However, during summers the tropical temperature conditions must have extended deeper in India in view of its continentality. But due to high latitude, the summer must have been rather short and scarcely effective to melt all the ice but for the icy cover in the fresh water lowlands.

Permian (Text-fig. 2)—India is presumed to have been still between 70°-40°S latitudes however, its slightly changed inclination must have increased precipitation by the Westerlies.

Triassic (Text-fig. 3)—During the Triassic time most of India is supposed to have lain between 60-30°S latitudes. Whereas, eastern India might have continued in the belt of westerlies and thus maintained cold and dry conditions, the region west of Aravalli range must have come under the influence of semi-continental trade winds during Winter coming from East Africa over the sea-arm extended to Malagasy.

Jurassic (Text-fig. 4)—India having moved south, alongwith Antarctica, its latitudinal position remained the same as during the Triassic. But the sea between East Africa and India having windened and the southern sea having come nearer because of separation of Antarctica from S. Africa, India must have lost some of its continentality resulting into more humid climate. Temperature-wise, India must have continued to have a cool temperate eastern part and a warm temperatre western part separated by 40°S latitude running along Aravalli range.

Lower Cretaceous—As accepted here, India separated from Antarctica and started moving northwards along the 90°E longitude. This separation is likely to have brought in marine condition all round, which, along with the drift towards the equator, must have brought about a sub-tropical to warm temperate climate in the continent.

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