PALAEOCLIMATIC VICISSITUDES IN INDIA DURING LOWER GONDWANA SEDIMENDATION

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ABSTRACT

In the present paper the lithological attributes of the Lower Gondwana Formations from Talchir to Raniganj Formations have been critically analysed and its bearing on palaeoclimate has been reviewed. The Talchir sedimentation was initiated with glacial advances, followed by periglacial sediments. The sedimentological evidences suggest that cold climate persisted even during the Karharbari times. The coal bearing Barakars experienced a damp climate, but not necessarily a hot tropical one. The post-Barakar facies of coal-less sediments—Barren Measures—testifies the progressive warning up of the climate, and also warm humid condition with seasonal dryness. The Raniganj Formation, as evident from its general calcarious nature, appears to be a product of warm humid climate.

INTRODUCTION

During the Lower Gondwana sedimentation, the Peninsular Gondwana basins of India witnessed varied climatic conditions. The variation in climatic realm in turn can be ascribed to the different geomorphic setting of the basin belts, position of the basins with reference to South rotational pole and the distance of the differnt basin belts from the sea. Therefore, palaeoclimatic conditions during the Lower Gondwana sedimentation should be viewed in conjunction with these variable factors which influenced significantly the climatic set-up of the different Gondwana basin belts. The palaeoclimatological synthesis during Lower Gondwana sedimentation has been attempted so far from floral, faunal, lithological, and geophysical view points. In the present paper the lithological attributes of the Lower Gondwana Formations from Talchir to Raniganj Formations have been critically analysed and its bearing on palaeoclimate has been reviewed.

UPPER PALAEOZOIC GLACIATION

In most minds, the Talchir Formation connotes the Lower Gondwana glaciation in the Peninsular India. The term Talchir 'stage" was first introduced by W. T. Blanford, H. F. Blanford and W. Theobold (1856) for a sequence of green sandstone, shale and 'boulder bed' occurring at the base of the Gondwanas after the name of 'Talchir', the then a feudatory State in Orissa. They were also the pioneer geologists to postulate the concept of glacial derivation of the Talchir boulder bed which culminated in the subsequent recognition of wide spread Upper Palaeozoic Gondwana glaciation in the Southern Hemisphere.

Later, Jowett (1925), Fox (1930) and Gee (1932) analysed the lithological attributes of this formation in the different Gondwana basins and made significant contribution in the advancement of our knowledge on Gondwana glaciation in India.

After a lapse of a few decades, there is a rivival of interest for the study of the Talchir glaciation in the wake of a new look into such Pre-Quaternary glacial deposits.

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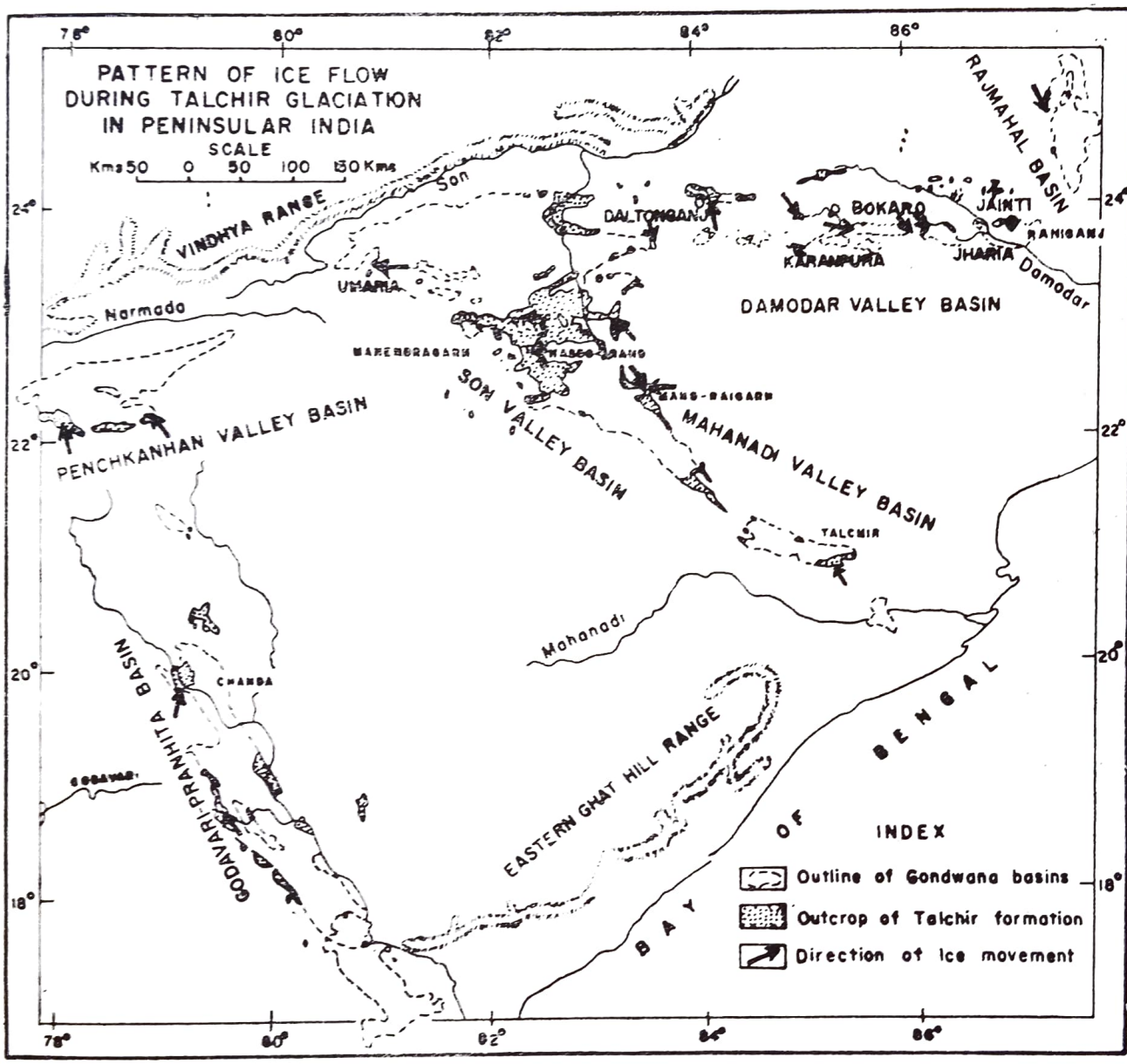
Lately with the recognition of the importance of turbidity currents or subaerial and subaqueous gravity sliding in the formation of the diamictites, there has been a growing tendency to reappriase such Gondwana diamictite (Banerjee, 1966; Frakes & Crowall 1969). Recently Ghosh and Mitra (1967, 1970) have made certain observations on the mode of origin of the Talchir diamictites, pattern of ice radiation in Peninsular India and interbasinal correlation of the glacial and periglacial deposits of the Talchir Formation (Text-fig. 1)



Text-fig. 1

The Talchir sedimentation in all the Damodr Valley basins was ushered in by glacial advances, which is evident from the occurrence of tillite at the base of the Talchir Formation, showing the typical features of ground moraine, presence of striated pavement in the Raniganj basin and association of varves with rafted pebbles, etc. The Precambrian terrain lying to the north of the Damodar Valley basins which was the gathering ground of ice, exercised dominent control on the advancement of ice lobes in the different basins (Ghosh & Mitra, 1970). This is evident from the study of dimensional fabric of the embedded clasts of the tillites and the directional sedimentary structures of the periglacial deposits. In the absence of absolute age data it is somewhat difficult to surmise whether the glacial advancements in the different isolated basins of the Damodar Valley

belt were coeval or not. However, there is no inherent improbability in considering the contemporaneity of glacial advances in the closely spaced basins of the Damodar Valley because such major change of the climatic realm in closely connected basin chain of the Damodar Valley would be a synchronous event. The withdrawal of ice during the deglaciation in the Damodar valley basins is well documented by retreated outwash sandstones with lenticular interbands of polymictic conglomerate which were laid down by braided meltwater streams.

Evidences of oscillations of the ice front are found to be well documented in the Damodar Valley particularly in the North Karanpura basin, wherein the area around the Lurunga river an upper tillite is well developed in the Talchir Formation.

The Talchir Formation has a patchy distribution pattern in the Gondwana basins of the Rajmahal hills. In Chuperbhita basin located in the central part of this basin belt a basal tillite, containing subrounded clasts of granite and quartzite testifies to the glacial advancement in this basin. The study of the dimensional fabric of the tillite indicates the movement of a lobe of glacier in this area from the north-west to south-east direction.

In Deogarh basins of Jainti, Saharjuri, Kundit and Burhai, the Talchir Formation exhibits a wide spectrum of lithofacies and comprises locally developed basal tillite, cross bedded sandstone, shales, and turbidites. In the Jainti basin the direction of ice movement is towards the north-west while in the adjoining Burhai basin the ice advanced in the northeasterly direction.

In the Daltongunj basin of Koel Valley basin belt the glacial and periglacial sediments of the Talchir Formation attain a thickness of more than 300 meters. In the northern part of the basin the black shales are overlain by argillaceous limestones containing marine invertebrates (Dutt, 1965, 1971, 1972). The vertical organisation of the lithofacies in Daltongunj implies a progressive deepening of the basin culminating in a marine transgression of the sea during the late phase of Talchir sedimentation (Dutt, 1973). An analysis of the current vectors of the Talchir sediments indicates a west-northwesterly palaeoslope of the depositional area. It further confirms that the late Talchir marine transgression in Daltongunj basin took place from west northwesterly direction (Dutt, 1973).

The Talchir Formation covers a large tract of the Son Valley basin belt. In the southern part of this belt within the confines of the Hasdo-Arand Coalfield to the north and north-west and Korba Coalfield to the south and south-east the Talchir sediments occur as different northwest-southeast or east-west trending units within the depressions of of uneven Precambrian basement. In such a geomorphic setting, the area became locale of several interconnected basins in which a varied assemblage of lithofacies of the Talchir Formation was developed. Choudhury and Basu (1971) record a few occurrences of tillites and established the northerly direction of ice movement. The deglaciation brought widespread deposition of conglomerate and pebbly sandstones, which in turn are succeeded by ripple laminated sandstones, turbidites and varves. An analysis of the directional structures indicates that the dispersal pattern of the Talchir sediments was in response to the local palaeoslope. However, the dominant transport direction was towards the north (Choudhury & Basu, 1971).

Glacigene strata are developed in the vast area surrounding Sonhat, Sohagpur and Chirimiri basins, of which the exposure of the Talchir Formation, near Manendragarh merits special reference. In this area, the Talchir Formation is represented by a basal glacio-marine diamictite containing abundant casts of marine fossils. The prominent element of Manendragrh fauna is the Eurydesmids, comprising *Eurydesma hobartence*, *E. playforde*, *Spirifer hasdoensis*, *etc.*, which indicate a Asselian age (Sastry & Shah, 1964).

The diamictite shows an abundance of sub-rounded clasts of granite, quartzite and clasts of phyllite. Beneath the diamictite several knobs of basement display the shapes of *roches moutonnee* and indicate the advancement of ice from easterly direction to west. Thus the palaeogeographic reconstruction of Manendragarh area indicates westerly movement of ice and deposition of morainic material with the confines of a narrow area of a sea, that transgressed in this area from a westely direction.

No description of the Talchir Formation of the Son Valley belt is complete without a reference to the occurrence of Talchir beds in the Umaria Coalfield, located in the western extremity of the Son Valley belt. In this area, the base of the Talchir Formation is defined by a tillite containing angular fragments of phyllite, granite, quartizite and mica schists. This is followed upwards by a 30 metre thick unit of shales with dispersed clasts of dropstone. This is in turn followed by a buff coloured, very fine grained sandsone containing 0.5 m thick calcareous bands rich in marine fossil assemblages typified by *Products umariensis*, *P. rewahensis* and *Spirifer narsarhensis*. GEE (1928) examined the area and assigned the sandstones with marine fossil bands of Karharbari Stage. Recently some workers (AHMAD 1957; SHAH, MS) have, however, contended that these marine beds represent the uppermost unit of the Talchir Formation and as such the upper age limit of the Talchir Formation has been extended upto Artinskian.

The Talchir Formation attaining a maximum thickness of 300 m forms a vast expanse from the Pench Valley in the east to Shahpur area in the west along the southern periphery of the Pench-Kanhan-Tawa Valley Coalfields. The base of the Talchir Formation is sometimes typified by a tillite containing clasts (upto a maximum size of 3 m) of pink and black quartizite, pink, granite, phyllite, limestone, etc. Some of the boulders are striated. The periglacial deposits comprising cross bedded sandstones, turbidites and ripple laminated siltstones indicate a transport direction varying from west to north-west. The till fabric study shows a regional north to north-westerly trend of ice movement.

In the Godavari Valley area, the Talchir Formation occurs along both eastern and western peripheries of the basin belt. The evidence of the late Palaeozoic glaciation is, however, well documented in the Penganga river near Irai where the striated pavement was first reported by FEDDEN (1875). The basal unit of the Talchir Formation is defined by the outwash conglomerate containing clasts of granite, quartzite and limestones. The direction of the striae on the basement of Pakhal limestone shows a north-north-westerly to northerly direction of the ice movement.

Glacial advances in the different Peninsular basins at the dawn of Gondwana sedimentation left undisputable record in the deposition of tillites. The patchy distribution pattern of tillites in various Gondwana basins can be ascribed to their deposition in the bed rock depressions and their wedging out over basement prominences. From this mode of occurrence of the tillites, it can be surmised that these were laid down by the different lobes of valley glacier than by a continuous ice sheet and the relief of Pre-Talchir topography imposed a dominant control on the lobatioh and extent of the different glaciers.

In the absence of absolute age data it is somewht difficult to surmise whether the glacial advancements in the widely separated Peninsular basin belts were coeval or not.

A brief reference to the Talchir seqence of Manendragarh area in the Sonhat basin and the Daltonganj basin in Koel Valley is sufficient to bring out the inherent inconsistency in acceptng the base of the boulder bed as an isochronous surface. Near Manendragarh in the Sonhat basin, the basal boulder bed is associated with an *Eurydesma* assemblage of Lower Sakmarian age which represents a temporary incursion of sea during Talchir sedimentation. In the Daltonganj basin similar *Eurydesma* assemblage (Lr. Sak-

marian) occurs 300 meters above the basal boulder bed, near the top of the Talchir Formation suggesting that the basal boulder bed of Daltonganj is somewhat younger than that of Manendragarh (Ghosh & Mitra, 1957). It further suggests that the glacial advances in these two widely separated basins are separate both in time and space. However, the probability of contemporaneous marine transgression in these two widely separated basins from Son-Narmada lineament controlling the marine incursion is also open to question. In the absence of other marine fossils or any other data, the age of the tillites in the different Gondwana basins cannot be precisely stated.

It can, however, be indicated that the timing of glacial advances in some of the Peninsular Gondwana basins coincides with late Carboniferous Period and the periglacial sediments were continued to be deposited till the late Sakmarian period.

PALAEOCLIMATIC INTERPRETATION OF KARHARBARI AND BARAKAR COAL MEASURES

The Karharbari Formation, the basal coal measures of Peninsular Gondwana sesequence, exhibits a varied array of lithofacies including cross stratified sandstone, conglomerates, carbonaceous shale and siltstone, fire clay and coal seams. In most of the Gondwana basins the Karharbari Formation has a transitional contact with the underlying Talchir Formation. In some of the basins as Deogarh, Giridih etc., the lithological attributes of the Karharbari Formation are strikingly similar to that of Talchir Formation. In these basins the development of coal seam is the main feature which distinguishes lower sections of the Karharbari Formation from the underlying Talchir Formation. In other words, but for the absence of coal seams, the lower members of the Karharbari Formation are indistinguishable from the Talchir Formation in certain basin belts. If the lithological parameters are an index to the climatic condition, the logical conclusion that emanates is that cold climatic condition persisted even during the Karharbari sedimentation.

CLIMATIC FLUCTUATIONS AND LOWER GONDWANA COAL SWAMPS

The idea is widely held that warm humid tropical climate prevailed during Karharbari and Barakar sedimentation with unbounded luxuriant swamp vegetation. Based on available lithological data and palaeogeographic fit of the Indian subcontinent, it is a prime necessity to modify this old concept. There is no doubt that the Gondwana basins during Barakar and Karharbari sedimentation witnessed prolific vegetal growth to provide the basic raw material of coal. If present is the key to the past then it is found that in recent years peat which is precursor for coal, is formed both under hot humid tropical climate as well as in cold and temperate regions. But the most important prerequisite for coal formation is the abundant precipitation, where the rainfall exceeds potential evaporation or evapo-transpiration. Evidently the coal flora had lived in a damp climate, but not necessarily in the hot tropical climate. It has been pointed out that coal forming forest depended less on the high temperature than on equable climate with little change of precipitation and temperature (Kräusel, 1963).

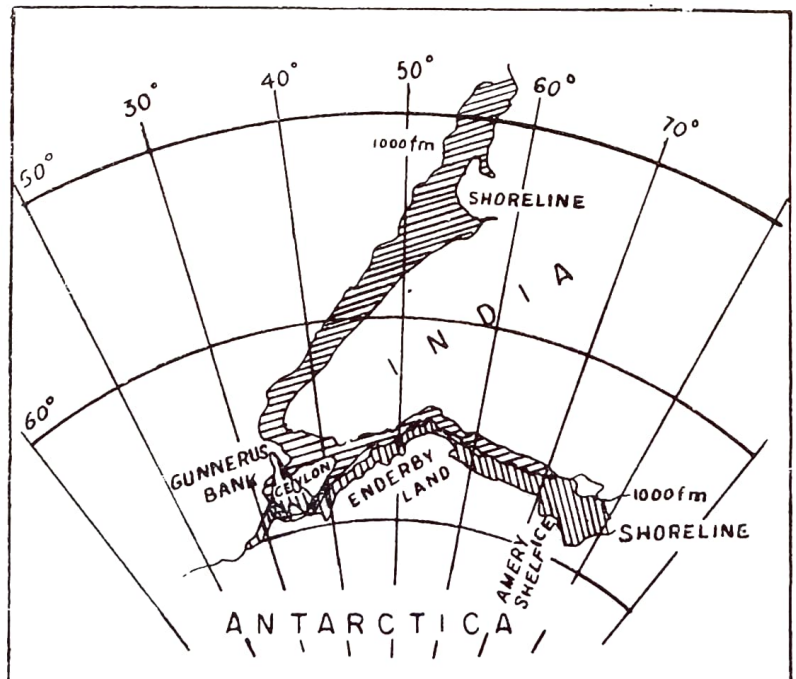
The lithological similarity of some members of Karharbari Formation to that of the underlying Talchir Formation and th transitional contact between the two formations clearly demonstrates that a cold climate was still prevalent during the formation of Karharbari coal measures. The greyish black carbonaceous sandstone facies with fresh feldspar of Karharbari Formation is typically cold temperate. In agreement with this is the fact that *Glossopteris* and *Gangamopteris* floras associted with the formation lack the characters of those of a warm humid environment. The cool to temperate condition prevailed during

the Karharbari and probably the early phase of Barakar sedimentation. Gradually the climate became warmer during the deposition of younger members of Barakar Formation. The climate during Barakar sedimentation was, however, humid and equable and does not need to have been tropical at all.

CLIMATIC SIGNIFICANCE OF BARREN MEASURES /IRON STONE SHALE FORMATION/ MOTUR FORMATION

After cessation of Barakar sedimentation, the different Peninsular basins witnessed deposition of a varied array of lithofacies. In the Damodar and Son Valley basins, thick sequences of carbonaceous shales with ironstone bands and interbanded cross stratified sandstones were deposited. In the Pench Valley, on the other hand, the Motur Formation with its characteristic red and mottled clays typify this post-Barakar sequence. There was, however, a return to coal forming environment not only in the Damodar Valley basins during Raniganj sedimentation but also in Pench Valley where the coal bearing Bijori Formation succeeds the Motur Formation. The Pench Valley basin thus displays the unique occurrence of a red bed sequence sandwiched between the two coal measures. This, therefore, testifies to the progressive warming up of the climate during the late phase of Barakar sedimentation from the cold temperate climate and the red facies of Motur Formation documents definite warm humid condition with seasonal dryness. The associtation of red bed facies between two coal measures can be ascribed to local oxidising condition.

The Raniganj Formation and its equivalent horizon yield no clearly diagnostic evidence of depositional climate. However, the general calcareous nature of Raniganj Formation is likely to be a product of warm humid climate.



The best-fit position of India relative to Antarctica, a continental drift reconstruction (After Dietz et. al)

Text-fig. 2

PALAEOCLIMATIC ANALYSIS IN THE FRAMEWORK OF CONTINENTAL FITS

No palaeoclimatic synthesis is complete unless it is viewed in the framework of the continental fits and palaeolatitudinal position. Palaeomagnetic data indicate that the eastern part of Indian subcontinent was at approximately 60° south latitude during the early Permian Period (Text-fig. 2). Such a reconstruction is in conformity with palaeoclimatic analysis made earlier because the occurrence of glacial sediments of Talchir Formation and Karharbari sediments showing the characteristics of deposition under cold temperate conditions in Peninsular Gondwana basins, are in harmony with the high palaeolatitude of the Indian subcontient at the Permian Period. But the Indian shield was so oriented that the different basins of Damodar Valley, parts of Mahanadi Valley and Godavari Valley had similar palaeolatitude and climatic zones in these basins were aligned approximately parallel to this palaeolatitude. It is, therefore, evident that the basin in Pench Valley was at a lower palaeolatitude than in the Damodar, Godavari and Mahanadi Valleys. This, therefore, explains advent of red bed facies in Middle Permian time in Pench Valley area. However, a greater amount of palaeo-magnetic information from Indian subcontinent is required for revealing the climates of the past.

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