CLIMATE DURING UPPER GONDWANA SEDIMENTATION IN PENINSULAR INDIA

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ABSTRACT

An attempt has been made to reveal the climate in the Peninsular India during Upper Gondwana, solely from sedimentary studies. The Mesozoic climate commences with a warm semi-arid condition during which extensive red beds were formed. Then there was break in sedimentation and the climate changed to warm humid, similar to the present day tropics.

INTRODUCTION

There are still certain limitations in our understanding the attributes of 'Palaeoclimatology'. This is primarily due to the nature of the problem the palaeoclimatologists are dealing with. Climate is a very complex phenomenon, as it is the combined effect of number of variables, viz., heat budget of the earth including its albedo, temperature, precipitation, evapotranspiration, humidity, altitude, land-sea distribution, ocean and wind currents, etc. These variables are very difficult to determine indepedently and their combined effect in shaping the climate, particularly in the geological past, is a difficult task indeed.

However, the present day analogy and not too distant geological phenomena like the formations of tillite, varve, peat, evaporite, red bed, degree of geochemical weathering of rocks and minerals to name a few, point towards certain climatically significant factors that influence in shaping the sediment characters. Under these limitations the interpretation of the past climate is possible only in terms of certain qualitative statements. Fossils and palaeomagnetic evidences are not in a position, either, to interpret the past climate in more quantitative terms.

In this paper an attempt has been made to reveal the climate in the Peninsular India during Mesozoic solely from sediment characters.

Gondwana sequence in Peninsular India shows a wide variation in facies development. Such variations are mainly due to three important factors, viz., provenance, tectonism and climate. An analysis of the sedimentary structures of directional significance of the Mesozoic sequence proves that the source area of the entire peninsular basins, with a rare exception in the Satpura region, did not change appreciably, and the materials were mainly derived from the granitic country. Contributions from rocks, other than granites, as source materials were very local in nature and insignificant in the regional context. Sedimentary parameters inicate that the subsidence of the basinal area went *pari-passu* with sedimentation. Pulsations of varying intensity from time to time rejuvinated and made necessary re-adjustment of the structural frame of the entire area in an otherwise monotonous tectonic history. It is, thus, apparent that provenance and tectonism alone cannot explain the wide variations in rock characteristics, and so the onus rests on the third parameter, i.e. climate.

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LITHOLOGY OF THE MESOZOIC SEQUENCE

Mesozoic sequence in Peninsular India is broadly divisible into two distinct lithic associations. The lower one is characterised by a alternation of arkosic sandstone and brick-red mudstone while the upper unit is typified by quartz-arenite, conglomerate and a subordinate fraction of red siltstone, variegated silt and clay, and white clay.

Arkose-Red Mudstone Association

Above the carbon bearing drab colour formation of Permain age, lies the arkose-red mudstone ranging in age from Lower Trias to Upper Trias. This lithological association is represented by Panchet Formation in the Damodar-Koel Valley Coalfield, Pali-Tiki Formation in the South-Rewa, Pachmari-Denwa in the Satpura and Maleri Formation in the Godavari Valley Coalfied. The arenaceous part is represented by coarse to medium grained sandstone, poorly to moderately well sorted. Sedimentary structures like cross-bedding, ripple mark, convolute bedding, parting lineation, scouring and mud-cracks are common. Mineralogically the sandstones are immature and contain considerable amount of feldspar. Thse feldspars are generally fresh and gain the pink colour and somtimes even the vitreous lustre. The mudstones are composed essentially of silt size particles and clay content varies considerably both laterally and vertically. Individual grains are red in colour but when treated with dilute HCl, they leave a white residue suggesting that the detrital grains are coated with red pigmenting materials. Chemical and X-ray study confirms that the red pigmenting materials are hematite in composition.

Sedimentary structures, facies organisation and other sedimentary parameters indicate that this arkose-red bed association is a product of fluvial regime.

Quartz-Arenite-Conglomerate-Siltstone-Clay Association

Immediate above the red bed sequence following a straitigraphic break, a remarkable change in lithology can be recognised. This association spans from Rhaetic through Jurassic and Lower Cretaceous period and is designated as Mahadevas in the Damodar -Koel Valley, Parsora-Chandia beds in the South Rewa, Jabalpur bed in the Satpura, Kota-Chikiala in the Godavari Valley, etc. Deposition of this lithic association of quartz-arenite, conglomerate, siltstone and clay took place intermittently with a number of hiatuses within a fluvial regime. The above mentioned stratigraphic break is not an isochronous datum and the dividing line goes down below the Triassic-Jurassic boundary at many places.

Disappearance of feldspar from the sandstone framework is the most noteworthy character of this facies. Argillaceous beds in shades of violet and pink towards the base and buff to white clay beds of commercial variety towards the top of the sequence are also characteristics of this facies association. Thick conglomerate beds varying in thickness from few centimeters to more than 100 m are interspersed throughout the sequence but they come in force more towards the top of the sequence as in the Godavari Valley area represented by Chikiala Formation. These conglomerate beds are generally wedge-shaped and they are composed mostly of quartz, quartzite and chert pebbles. Labile constituents are mostly absent in these conglomerate beds except in the Satpura region where the Bagra Conglomerate is a polymictic one. The sandstones are medium to coarse grained. Fine grained sandstones are present at places but they are generally not very common. Medium to large scale cross-stratifications are common but some of the multi-storeyed sandstones are devoid of any sedimentary structure. Other sedimentary structures developed in the sandstone are ripple mark, convolutes, scouring, etc. Sorting varies widely from poor to well sorted. Siltstone and clay beds are volumetrically significant and would not be more than 5 per cent of the total lithic fill. Thin, impersistent coal seams are present in the Satpura region and significant amount of fresh water limestone and a little gypsum are found to be present only in the Godavari Valley area.

CLIMATIC INTERPRETATION

In the arkose-red bed association, feldspar is the second most important constituent, next to quartz, in the sandstone and the argillites are composed mainly of silt size material. All these are a product of primarily, mechanical disintegration of a granitic country. Petrographic, chemical and X-ray analyses of the red beds show that the red colour is due to a red pigmentary material present either as finely powdered detritus distributed throughout the sediments or as thin coatings on the clastics. Recent red beds are being formed particularly in two distinctly different climatic zones, viz., in warm humid zone and in the warm arid to semi-arid conditions. Red beds are being formed in the Brahmputra Valley in Assam in the tropical climatic belt as a result of ageing of the hydrated ferric oxide in a oxidising environment (personal comm., B. C. PODDAR). Red beds are also being formed today in the arid to semi-arid zones of Australia and Africa. Both ageing and dehydration of the hydrated ferric oxides into red hematite in a warm oxidising environment are responsible for the formation of red beds.

Presence of high percentage of fresh feldspars in the sandstones, retaining their original colour and lustre, cannot be expected in a warm humid condition as in the tropical region, unless there is a very rapid burial of sediments. But such rapid burial is generally absent during Mesozoic sedimentation except in the Satpura region when Bagra Conglomerate was formed. So, it is more probable that the feldspars were not subjected to geochemical alteration due to non-availability of much water as a geochemical reagent either in the provenance or in the basin of deposition, though the sedimentary parameters at the same time suggest the presence of a considerable amount of water in the depositional area. It is possible that the total annual precipitation was less than the annual evaporation resulting in an overall partially dry climate. Equating the above observations it is reasonable to suggest that the climate during the sedimentation of red bed and associated sediments covering most of the Triassic Period was essentially warm and semi-arid.

Above the arkose- -red bed sequence there are evidences of a break in sedimentation manifested by angular unconformity, overlap and erosional surfaces. This break indicates a period of peneplanation and geochemical weathering of the granitic provenance. Absence of feldspar in the sandstone and presence of kaolinitic clay bed within this Jurassic-Cretaceous sequence suggest chemical weathering of the granitic country. Subsequent transport and differentiation of coarser and finer fractions gave rise to quartz rich sandstone-conglomerate facies and siltstone-clay association. Degree of chemical weathering, however, increased in the sequence where at many places the products are glass sand of commercial variety and thick beds of china clay. Complete chemical weathering is most preferred when the rock is exposed to the surface for considerable time and where the surface and ground water play an important role in the process of kaolinization. Rainfall and ground water also play an important part in chemical weathering and formation of soil profile. There is also a close interrelation between the rainfall and formation of different clay minerals. It is found that within the intertropical regions, weathering of the granitic country yields mainly kaolin where the annual rainfall varies between 100 mm and 1200 mm. Soil profile of a granitic terrain in the tropics shows complete absence of feldspar and high concentration of kaolinite towards the top. However, the feldspar content inreases with depth and correspondingly kaolin decreases. Thus it is clear rom present day analogy and other sedimentary attributes that the quartz rich arenite and kaolinitic clay bed association is the product of a warm humid climate.

The argillites in this facies show different colours in shades of red, violet, buff and white. The brighter colours as indicated earlier are due to the presence of iron oxides in its dehydrated form, formed due to ageing, in this case in a warm humid condition. On the other hand, the white colour of the china clay bed is probably due to complete leaching of the hydrated iron oxide by acidic water.

Occurrence of coal within this facies association is significant only academically, otherwise it has no commercial importance. Bands of jet black coal, very different in character from thick coal seams of Permain age, are never more than a few centimeters thick. Formation of coal needs humid condition. A narrow range in temperature variation decays vegetal matter. But within tropics, the range in temperature variation within 24 hours is very high which hinders the decay of organic material and consequently the formation of thick coal seams. During Quaternary time, thick peat beds have been reported from cool temperate climatic zones. Comparatively the peats in the tropical zones are thin. Likewise, the tropical warm humid climate might have been responsible for the development of thin impersistent coal seams. Thick beds of freshwater limestone in the Godavari Valley also suggest a warm climate during this period. Formation of evaporites, locally in the Godavari Valley, indicates a climatic history different from warm humid climate. Evaporites are formed in a warm dry climate. Such dry spell within a broad humid condition is not uucommon in the geological past. The advent of aridity may be due to a little change in the wind distribution system caused by the upward air masses.

Thus it is coucluded that the Mesozoic climate commences with a warm semi-arid condition during which extensive red beds were formed and this continued till the end of Trias. Then there was a break in sedimentation and the climate changed to warm humid, similar to the present day tropics. This climate, except local departures in the Godavari Valley, prevailed throughout Jurassic and Lower Cretaceous till the cessation of Gondwana sedimentation.

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