

# Characterization and evolution of primary and secondary laterites in northwestern Bengal Basin, West Bengal, India

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**Abstract** It is quite impossible to travel far in India without observing the remarkable ferruginous crust to which Buchanan in 1807 gave the name of laterite. In Indian peninsula, it is a post-Cretaceous stratigraphic succession with a polycyclic nature of evolution which marks the unconformity with recent Quaternary alluvium. There are perennial problems and research gaps in the investigation of laterites in India as well as in West Bengal: (1) defining, identifying and classifying lateritic materials, (2) mode of formation of laterite and its other horizons, (3) determining the ages of laterites, (4) reliability of laterites as palaeoclimatic indicators, (5) identifying topographic requirements and pedogeomorphic processes for laterite formation, and (6) reconstructions of former lateritized landscapes. The formation of north–south lateritic hard crust (*i.e.* *Rarh* Bengal) on the Rajmahal Basalt Traps, Archean granite–gneiss, Gondwana sediments, Paleogene gravels and older deltaic alluvium is analyzed here to resolve the aforesaid problems and to depict the variable characteristics of laterites with special reference to its tectono-climatic evolution in the northwestern marginal part of Bengal Basin. This paper reveals that the low-level secondary laterites (probably the Pliocene–Early Pleistocene age) of *Rarh* Bengal are composed of heterogeneous Fe–Al rich gravelly materials which were derived from the high-level primary laterites (probably the Eocene–Miocene age) of plateau since the Paleogene Period by the peninsular river system, following the underlying structure of Bengal Basin. Alongside the roles of drifting of Indian Plate, establishment of monsoon climate, neo-tectonic uplifts and re-lateritization of ferruginous shelf deposits are determined here to unearth the palaeogenesis of primary and secondary laterites in West Bengal.

**Key words** laterite, Bengal Basin, *Rarh* Bengal, palaeogeography, monsoon, Paleogene

## 1 Introduction

The cradle of the world largest Ganga–Brahmaputra Delta is the Bengal Basin which is a structural depression (in between Indian Plate and Eurasian Plate) that the rivers filled up during the last ~150 Ma to its present configuration (Bandyopadhyay, 2007). The major peninsular river

system of Damodar, Ajay, Mayurakshi, Brahmani, Kasai and Subarnarekha *etc.* is the chief carrier of ferruginous coarse sediments into the shallow-marine shelf zone of Bengal Basin since the Paleogene, forming later a north–south undulating secondary lateritic upland due to prolonged lateritization processes and minimal upliftment (Niyogi *et al.*, 1970) (Figures 1, 2). This shelf zone of Bengal Basin is still tectonically active and since the Late Eocene, tectonic upliftment and subsidence initiated marine transgression and regression to this region, developing different

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fluvio-deltaic sedimentary units wherein the ferruginous profiles (*in situ* and *ex situ* laterites) are of the oldest formations of Bengal Basin.

The reddish-brown colour as like as brick with concentration of Fe–Al oxides has fascinated many researchers of Earth sciences about its evolution and variable occurrences on different geological formations. The tropical to sub-tropical wet–dry types of climate, mainly “rubefaction zone” of Pedro (Tardy, 1992), are allied with the ferruginous crusts which are widely recognized as the laterites or ferricretes or plinthites (McFarlane, 1976; Tardy, 1992; Bourman, 1993; Schaetzl and Anderson, 2005). In spite of numerous publications and researches on laterites, much confusion, contradictions and controversies still proliferate in the available literatures on the genesis, distribution, classification, geological age, sub-surface profiling of laterites and present day lateritization process. As the term “laterite” originated in India (Buchanan, 1807), this type of ferruginous deposits in India peninsula retains its special research interest due to its potentiality to expose the palaeogeographic environment of a region since the Paleogene Period. We are fortunate enough to have the glimpses of laterites in West Bengal. An emblematic north–south lateritic belt of West Bengal (geographically recognized as *Rarh* Bengal by Bagchi and Mukherjee in 1983) with the ferruginous gravels and kaolinite deposits (from Rajmahal Hills to Subarnarekha Basin) borders this province to make the transitional diagnostic landforms and distinct sedimentation pattern in between the Archean–Gondwana Formation at west and recent Quaternary alluvium of Bengal Basin at east (Niyogi *et al.*, 1970; Biswas, 1987; Mahadevan, 2002; Das Gupta and Mukherjee, 2006) (Figures 1, 2). The northwestern Bengal Basin, in between the western part of Bhagirathi–Hooghly River and eastern part of Chotanagpur Plateau, shows all the variations of lateritic terrain, consisting of western hilly upland, intermediate degradational plain and eastern older deltaic plain (Mukhopadhyay, 1972; Biswas, 1987). On the intermediate degradational plain (dissected by rills and gullies), a great variety of laterites (*i.e.* primary and secondary laterites) is observed, showing the sub-surface horizons of hard duricrust, mottled zone and pallid kaolinitic zone. To understand the genesis and development of this geomorphologically important material, some imperative considerations and queries are born in mind. First, there is the question of source of ferrallitic materials which contribute to the make-up of reddish-brown duricrust. Second, whether laterite and its variants are highly related to weathering on the Rajmahal Basalt Traps or shelf depos-

its of Bengal Basin. Third, whether primary (*in situ*) or secondary (*ex situ*) origin of laterites is observed in this region. Fourth, whether there is any possibility of lateritization being an ongoing process in the monsoon region or is an indicator of palaeomonsoon. Fifth question is raised about the geomorphic evolution (with respect to drifting of plate and neo-tectonic movement) of lateritic belt particularly in this zone of West Bengal. So this paper attempts to explain these queries and has provided a pedogeomorphic and palaeogeographic outlook to the laterites of northwestern Bengal Basin in relation to its geological evolution and characteristics.

## 2 Previous important work

The term “laterite” has been applied to such a diverse array of geomorphic features that it no longer has value as a precise descriptive term (Paton and Williams, 1972). Nomenclature, classification, morphological and analytical characteristics, global distribution, processes of horizon development, environmental conditions of laterites are precisely analyzed by Alexander and Cady (1962), Maignien (1966), Paton and Williams (1972), Thomas (1974), McFarlane (1976), Young (1976), Tardy (1992), Bourman (1993) and Schaetzl and Anderson (2005) *etc.* Importantly, Pascoe (1964), Roy Chowdhury *et al.* (1965), Raychaudhuri (1980), Babu (1981), Devaraju and Khanadali (1993), Wadia (1999) and Ollier and Sheth (2008) have investigated the various profiles of lateritic deposits in India peninsula and tried to solve the problems of origin of Indian laterites. The general belief is that the high-level or primary laterites were formed due to *in situ* chemical weathering of basalt plateau in the monsoon wet–dry climate, and the low-level or secondary laterites are formed by denudation and transport of primary laterites and cementation of accumulated detritus. Ollier and Sheth (2008) have mentioned the inversion of relief hypothesis in place of the ferricrete plain hypothesis to explain the origin of high Deccan duricrusts of India. The laterites of West Bengal are investigated by Morgan and McIntire (1959), Hunday and Banerjee (1967), Niyogi *et al.* (1970), Sengupta (1972), Goswami (1981), Biswas (1987), Vaidyanadhan and Ghosh (1993), Das and Bandyopadhyay (1995), Singh *et al.* (1998), Ghosh and Ghosh (2003), Chatterjee (2008), and Mukhopadhyay and Pal (2009). They have provided significant geological and geomorphological explanations of lateritic landforms which carry distinct palaeogeographic individuality of this northwestern marginal part of the Bengal Basin.

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