Trace fossils from the Barakar Formation (Early Permian) of Satpura Gondwana Basin, Madhya Pradesh, India

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ABSTRACT

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Well preserved trace fossils, assignable to *Palaeophycus tubularis* and *Planolites beverleyensis,* are described from the sandstone of the Barakar Formation (Early Permian) of Satpura Gondwana Basin, Madhya Pradesh, India. Occurrence of trace fossils in fine to medium grained sandstones suggests low energy condition in oxygenated lacustrine system. The animals responsible for the traces were probably soft bodied bottom dwellers, thriving in lakes.

Key-words: Non-marine trace fossils, Barakar Formation, Early Permian, Satpura Gondwana Basin, India.

INTRODUCTION

Studies on trace fossils from the continental realm of Indian Gondwana deposits received considerable attention in the last three decades (Kar & Chaudhuri 1981, Maulik & Chaudhuri 1983, De 1990, 1998, 1999, Maheshwari & Bajpai 1991, Das & Rao 1992, Mukhopadhyay 1996, Srivastava et al. 1996, Chakraborty & Bhattacharya 2005, Das & Tripathi 2008). Two species of trace fossils are recorded here from the Barakar Formation of Pench Valley and Mohpani coalfields, Satpura Gondwana Basin, Madhya Pradesh.

Satpura Gondwana Basin (Lat. 22°06' - 22°52' N: Long. 77°28' - 79°7' E) is the western most Gondwana basin of Peninsular India. It is a rhomb shaped basin and includes major coal producing areas in the central region, comprising of four coalfields, viz. Pench Valley, Kanhan Valley, Pathakhera and Mohpani. The Lower Gondwana stratigraphic succession in the basin is given in Table 1 (after Ray & Chakraborty 2002).

Different Lower Gondwana sequences of Satpura Gondwana Basin contain well preserved plant fossil assemblages (Srivastava & Ram-Awatar 2001, Srivastava & Tewari 2001, 2002, 2004, Srivastava & Agnihotri 2009, 2010). The flora, in general, is represented by *Noeggerathiopsis, Cordaites, Gangamopteris, Glossopteris, Euryphyllum, Ottokaria, Arberia, Arberiella, Buriadia, Phyllotheca, Samaropsis, Cordaicarpus, Vertebraria,* dispersed seeds, megaspores and leafless axes with ridges, furrows, nodes and internodes. These assemblages are comparable with the Karharbari and Lower Barakar floras of Raniganj Coalfield (Bharadwaj & Anand-Prakash 1972, Bharadwaj et al. 1974, Srivastava & Agnihotri 2009). During field work, several sandstone blocks were found exposed in Sitarewa River section of Mohpani coalfield, exhibiting well preserved trace fossils. In Pench Valley Coalfield, from Rawanwara underground mine, a single block of sandstone (95 x 98 cm) was also found to contain well preserved traces.

Table 1. Lower Gondwana stratigraphic succession in Satpura Gondwana Basin, Madhya Pradesh

Formation	Lithology	Thickness	Age
Bijori Formation	Fine to very coarse grained sandstone alternating with carbonaceous shale and thin coal beds. Abundant plant impressions, roots and wave-generated structures present	800 m	Late Permian (Kazanian- Tatarian
Motur Formation	Thick red mudstone dominated succession with embedded lenses and sheets of medium to very coarse grained sandstone; mudstone may be white, green or purple or dark grey; silicified wood fossils common. Crossbeds abundant in sandstones; calcareous nodules of pedogenic origin typify red mudstone	330-480 m	Early Permian (Ufimian-Kazanian)
Barakar Formation	Quartzofelspathic, medium to very coarse grained sandstone. Sandstone white to yellowish orange, three major coal seams and associated carbonaceous shales interlayer with sandstone in the upper part of the formation.	140-225m	Early Permian (Artinskian)
Talchir Formation	Boulder-pebble conglomerates, pebbly sandstone and khaki green shale	100- 250 m	Late Carboniferous(?)
---------- Unconformity ----------			
	Gneisses, quartzites, granites, etc.		Precambrian

MATERIAL

Trace fossils are recovered from the Pench Valley Coalfield (Lat. 22°09' - 22°24' N and Long. 78°38' - 79°0' E) and Mohpani Coalfield (Lat. 22°45' N: Long. 78° 50' E) of Satpura Gondwana Basin. In Pench Valley Coalfield, trace fossils were found on the micaceous sandstone overlying the coal seam no. IV of Rawanwara underground mine. In Mohpani Coalfield, trace fossils were observed over the sandstone. The Barakar Formation of Pench Valley Coalfield is primarily composed of thick sandstone alternating with carbonaceous shale and coal bands whereas in the Mohpani coalfield, it comprises of very thick sandstone bodies, mudstone units inter-layered with sandstone and carbonaceous shale and coal bands. The lithological succession of the areas indicates the position of bed containing the trace fossils (Text-figures 1, 2).

In Pench Valley Coalfield, the burrows are preserved as convex relief on the surface of grey, medium to coarse grained micaceous sandstone overlying the coal seam no. IV of Rawanwara colliery. In Mohpani coalfield, trace fossil is preserved on the surface of grey, medium grained sandstone showing cross beddings with syndepositional sedimentary structures. Exposed bedding plane view of sandstone exhibits large number of horizontal burrows. In both the areas, sandstones containing trace fossils belong to the Barakar Formation. The study aims to interpret palaeoecological conditions during their deposition.

Two species of trace fossils are recorded here from the Pench Valley and Mohpani Coalfields in Barakar Formation of Satpura Gondwana Basin, Madhya Pradesh. The trace fossil specimens are stored in the Museum of the Birbal Sahni Institute of Palaeobotany, Lucknow, India.

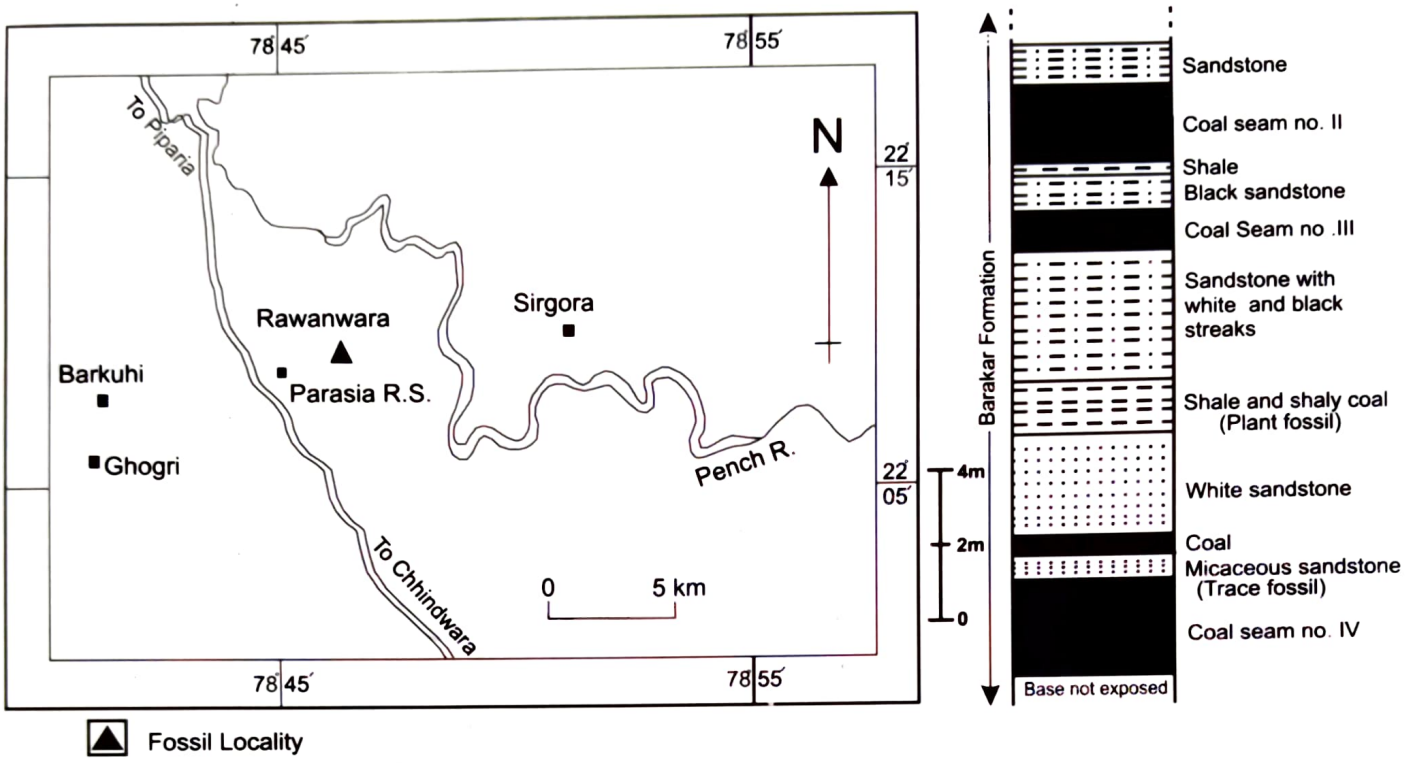
DESCRIPTION OF TRACE FOSSILS

Genus: *Palaeophycus* Hall 1847

Palaeophycus tubularis Hall 1847

Figure 1

Description: Tubular burrows randomly preserved as hypochinal epirelief (ridges), maximum length 13 cm and width 3-6 mm, parallel to the bedding plane, cylindrical to sub-cylindrical; curved to sinuous and straight, in some areas the traces appear to be suppressed or collapsed. Burrows surface simple and

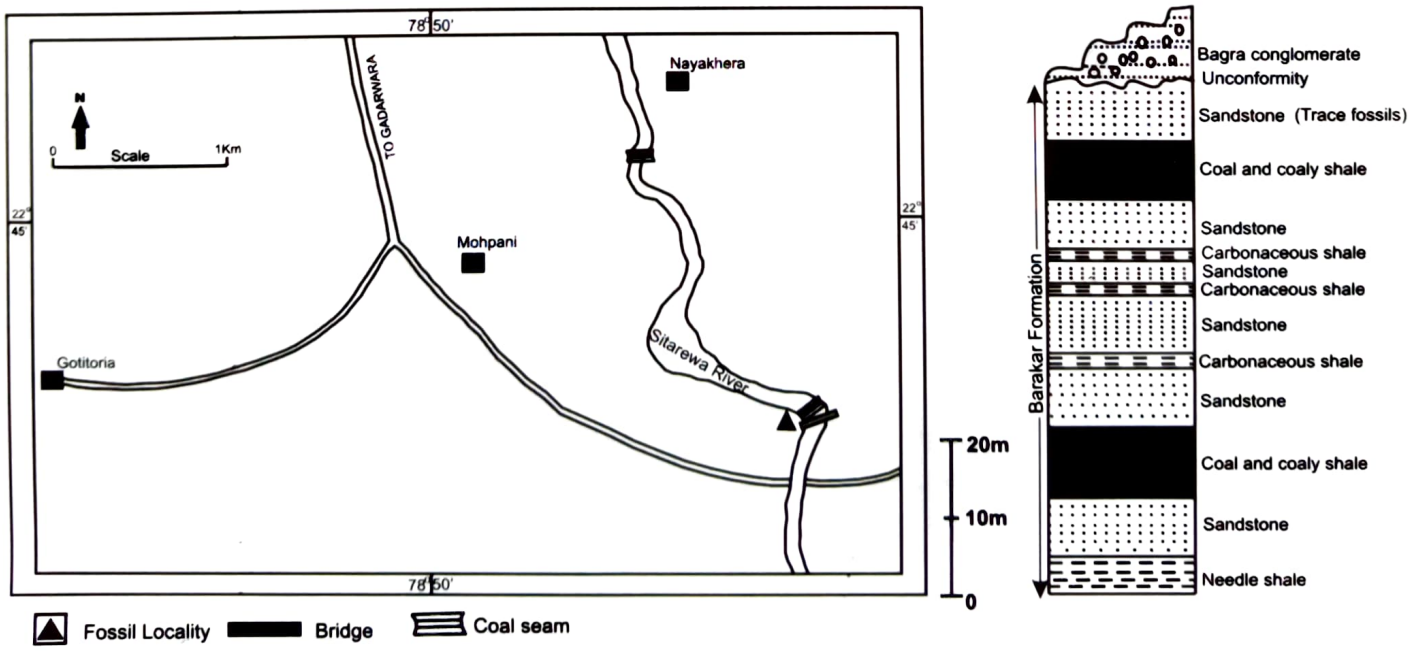


Text-figure 1. A. Map of Pench Valley Coalfield showing location of sample. B. Lithocolumn of Rawanwara colliery section, Pench Valley Coalfield.

smooth. Distinct branching pattern not observed but sometimes bifurcation discernible, frequently show intersecting and overlapping. Very fine wall lining observed at some places; infilling material identical to the host rock.

Locality: Rawanwara Colliery, Pench Valley Coalfield, Satpura Gondwana Basin, Madhya Pradesh.

Horizon and Age: Lower Barakar Formation, Early Permian.



Text-figure 2. A. Map of Mohpani Coalfield showing location of sample. B. Lithocolumn of Sitarewa River section, Mohpani Coalfield.

Figure 1. *Palaeophycus tubularis* Hall 1847, BSIP Museum No. 39801.

Figure 2. *Planolites beverleyensis* Billings 1862, BSIP Museum No. 39802. Coin diameter: 22mm.

Remarks: Five species of *Palaeophycus* are considered to be valid and are discussed in detail by Pemberton and Frey (1982). The present specimen is similar with *P. tubularis* Hall 1847. It is distinguished from other species of *Palaeophycus* in having smooth surface and thin wall lining. The similarity of infilling of the burrows with host rock indicates that *Palaeophycus* was probably not sorted or processed by trace maker (Pemberton & Frey 1982). The collapsed nature of the burrows is attributed to soft filling material which escaped lithification. The horizontal nature of the burrows suggests their formation on relatively stable part of the depositional regime. *Palaeophycus* represents passive infilling of open dwelling burrows of predaceous or suspension-feeding organism (Pemberton & Frey 1982). It is reported from a wide variety of environmental setting ranging from shallow marine, fluvial to lacustrine environment. However, its occurrence in coal bearing sequences, in association with plant fossils, favours the fresh water channel of deposition.

Genus: *Planolites* Nicholson 1873

Planolites beverleyensis Billings 1862

Figures 2, 3

Description: More than 30 specimens of burrows are preserved on fine to medium grained sandstone as convex and concave reliefs, maximum length 5 cm and thickness 4 to 7 mm. Burrows horizontal, fusiform, often branched in Y-shaped pattern, cylindrical to subcylindrical, curved to sinuous and straight in some segments. Burrow surface simple and smooth, at places

Figure 3. An enlarged portion of the specimen (shown in Figure 2) to show the fusiform nature of branched and unbranched burrows. Coin diameter: 22mm.

slightly irregular, overlapping, crossing over and interpenetration of burrows common; walls without lining, internal fill coarser and harder than host rock.

Locality: Sitarewa River section, Mohpani Coalfield, Satpura Gondwana Basin, Madhya Pradesh.

Horizon and Age: Lower Barakar Formation, Early Permian

Remarks: *Planolites* is distinguishable from *Palaeophycus* in having an unlined wall and a fill contrasting with the host rock (Pemberton & Frey 1982) and from *Macaronichnus* by the presence of a lined wall in the latter (Curran 1985, Mangano et al. 1996). Pemberton and Frey (1982) revised the morphological characteristics of *Planolites* and identified three species. The present specimen is similar with *Planolites beverleyensis* Billings 1862 in showing large size straight

to gently curved smooth surface burrows. The other two species, viz. *P. monatus* Richter and *P. annularis* Walcot are distinct in their small sized tortuous burrows having transverse annulations over the surface. *Planolites* burrows are formed due to active backfilling of sediment in an ephemeral burrow constructed by a mobile deposit feeding animal.

DISCUSSION

Palaeophycus tubularis and *Planolites beverleyensis* occur in a wide variety of environmental settings. In their model for non-marine ichnofacies, Buatois and Mangano (1995, 1998) incorporated *Palaeophycus* and *Planolites* as the component of *Scoyenia* ichnofacies. This ichnofacies is characteristic of transitional terrestrial/ non-marine aquatic substrates, periodically inundated or desiccated and therefore, commonly present in lake margin facies. The horizontal nature of both these burrows also suggests more stable and low energy conditions at the time of their formation and subsequent preservation.

Ray and Chakraborty (2002) discussed sedimentological framework and depositional regime of the Barakar Formation of Satpura Gondwana Basin. The location of trace fossils is correlated with the BFA-II facies of coal-carbonaceous shale association alternating with sandstone bodies. They argued that deposition of such type of facies must have taken place in a low gradient extensively vegetated marshland with small channels and lakes and were temporally and spatially unrelated to the braided river system. The occurrence of *Palaeophycus* and *Planolites* at sandstone and carbonaceous shale interface suggests change in depositional regime, from moderate energy to low energy environment. Animal fossils are not known from the Barakar Formation of Pench and Mohpani coalfields. However, annelid-like fossils are known from adjoining Mahanadi basin (Chandra & Singh 1996). The tubular traces recovered from Satpura Gondwana Basin probably belong to soft bodied bottom dwellers of annelid group.

It is ironical that all the trace fossils recovered from Indian Gondwana are considered marine (Goswami 2008 and reference cited therein). Chakraborty et al. (2003) expressed their opinion about presence of sea shore condition in Satpura Gondwana Basin. However, recovery of a variety of plant fossil assemblages in Talchir, Barakar, Motur, Bijori, Denwa and Bagra formations in Satpura Gondwana Basin strongly rules out marine condition and indicates the continental facies (Srivastava & Agnihotri 2009). Chakraborty et al. (2003) also recognized Barakar Sandstone as fluviatile deposit coinciding with the present observation.

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