ENVIRONMENTAL INTERPRETATION FROM FACIES ANALYSIS AND ROOT-BEARING BEDS OF LOWER GONDWANA SEDIMENTS FROM MERAL SUB-BASIN OF THE DALTONGANJ COALFIELD, BIHAR

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Abstract

Lower Gondwana sediments in the Daltonganj Coalfield are developed in two separate sub-basins—Rajhara in the north and Meral in the south. In the Meral subbasin, rock facies are classified as Ss, St, Sp, Fl, Fsc and C which may again be grouped into two major associations, FA I and FA II, characterizing respectively the basal and upper part of fluvial Barakar sediments. Owing to development of vegetation under a gradually ameliorating climate, the style of sedimentation of the alluvial system evolved with time from an initial low sinuousity, braided to high sinuous meandering system in later phase. Whereas sub-association (a) of FA II formed by migration of laterally adjacent facies, the facies mosaic belonging to FA II(b) reflects random superimposition of unrelated environments in a meandering setup. Root-bearing clay bed denotes bank stabilization and prolonged subaerial exposure where local calcification of roots or rootlets is related to diagenetic activity rather than to contemporaneous climate.

Introduction

Environmental interpretation of Gondwana sediments based on facies analysis has been rarely attempted. Absence of key beds, rapid lateral facies variation coupled with structural displacements, lack of suitable exposures and their poor state of preservation under the tropical climate have, no doubt, conspired together to make the task of interpretation difficult. Against this background, Jinjoli Valley in Meral sub-basin of the Daltonganj Coalfield stands as rare exception where excellent exposures of relatively undisturbed Barakar sediments provide unique opportunity to study the complex array of fluvial facies association within a small basin.

Meral Sub-basin

Gondwana sediments in the Daltonganj Coalfield are developed in two sub-basins, viz., Rajhara in the north and Meral in the south; these two sub-basins are characterized by strikingly different facies associations. The coal seams and carbonaceous strata conventionally treated as marker units though occur in both the areas their positions in sequence are mutually independent and not correlatable across the respective sub-basins. Of the marker horizons whereas the coal seams locally identified by their seam locally identified by their seam numbers (like, seam I, seam II, etc.) the carbonaceous strata are recognised as 'index horizons' and numbered accordingly with their respective positions in stratigraphic column. Gondwana formations in this coalfield (Fig. 1a), comprises glacial Talchir and coal-bearing Barakar formations (Rizvi, 1972), ofcourse, the presence of Karharbari Formation has also been suspected by Ghosh and

Basu (1967) and Maithy (1968). Notwithstanding the merits of recognition of Karharbari as biostratigraphic unit, however, its existence as separate mappable unit in this coalfield seems impractical and drawing of a synthetic boundary to demarcate Karharbari within a homogeneous and natural lithostratigraphic unit—the Barakar Formation would be highly unrealistic.

The beds in the Meral sub-basin striking mostly in E—W direction forms a synclinal flexure with a normal gravity fault along axial plane, and consequent to this the northern and southern banks of the Jinjoli expose the older and younger strata almost at the same level. Numerous satelitic oblique and parallel displacements have made the area structurally complicated and so correlation of surface exposures in this sub-basin becomes a difficult task. Therefore, while preparing vertical sequences, field observations were integrated with bore hole data.

A series of altogether seven vertical profiles presented here (Figs. 1b & 2) show every internal details of rock units, and it is emphasized that these vertical sequences taken together depict almost the entire gamut of Barakar sedimentation in the Meral sub-basin.

Facies and Facies Association

Facies codes defined by Miall (1978) have been introduced here to recognise following facies categories :

Facies S_o : Major erosional scour formed in upper flow regime and occurring at the base of a facies sequence or association.

Facies S_t : Coarse to fine grained trough cross-stratified sandstone representing dune phase of lower flow regime.

Facies S_p : Planar cross-stratified (solitary or grouped), coarse to medium grained sandstone representing migrating sand bars and flats.

Facies F_l : Medium grained to silty sandstone with ripple cross-stratifications and or parallel laminations formed in lower part of the lower flow regime.

Facies F_{sc} : Silt to mud; very finely laminated to massive; deposited from suspension fall out.

Facies C : Coal.

Facies, if treated individually, may vary in interpretative value but their grouping into 'association' or 'sequence' are of significant as these provide clue to determine the distribution or migration of subenvironments in time and space within a broad spectrum. Major erosional surfaces that record radical shift in depositional milieu have been considered here as bases to identify a facies sequence or association. In a sequence—facies gradually passes from one to another, whereas in association—facies occur together with sharp, nontransitional or erosive contacts; different associations or sequences obtained from grouping of different facies is shown in Table 1.

Distribution of facies and their groupings into association as represented in Figs.1b and 2 reveal preponderance of FA I in basal Barakar while succeeding younger horizons are dominated by FA II. The basal Barakar shows the large cross-beds ranging in size

Table 1—Facies associations and sequences of Meral sub-basin

1. Facies Association I (or FA I) :
   Stacked St facies intervened by erosional surfaces.

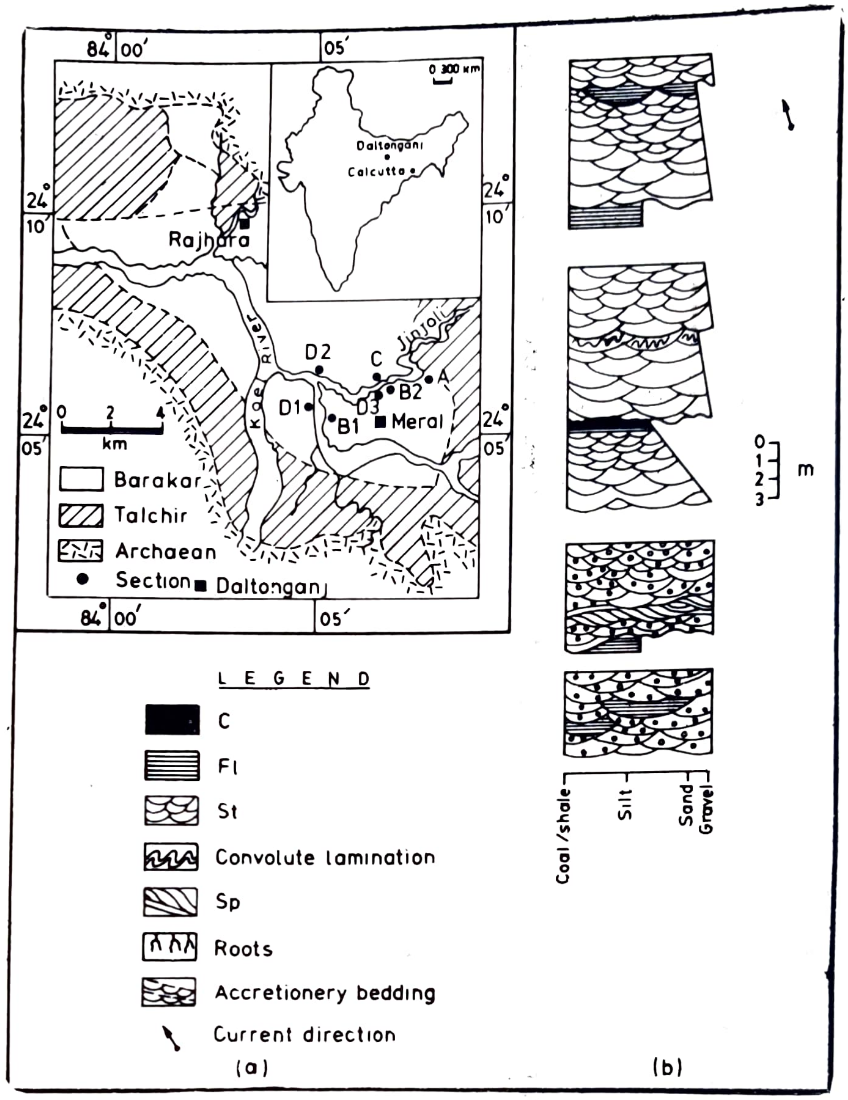
2. Facies Association II (or FA II):
   St facies overlain by finer facies (Fl or Fsc or C). According to nature of contacts between coarser and finer facies, the association can subdivided into following sub-associations:
   (i) FA II(a)
   St facies progressively grade into top stratum fine deposit and represent fining upward sequence.
   (ii) FA II(b)
   Contact between coarser and finer facies is sharp, planer and nontransitional.
   (iii) FA II(c)
   St facies overlain by Fsc facies with strongly erosive irregular contact.

3. Facies Association III (or FA III)
   Grouped Sp facies bounded within St facies.

from 0.65 to 0.50 m and sand with very coarse grade size incorporate pebbles that usually cluster at trough base or occasionally fine upward. Cross-stratifications in FA II with set thickness ranging from 0.30 to 0.25 m, at places undergo upward fining due to gradual elimination of coarser populations and addition of fine materials. Only in two instances, sigmoidal sets of accretionery surface are found to develop in FA II of Section D1 (Figs. 2 & 3) where one of these forms the basal unit of a complete fining upward sequence below seam III whereas partially preserved unit. Planar cross-beds, occurring in places within S_t facies, vary in thickness from 0.65 to 0.50 m and vertically stacked sets of planar cross-stratifications (FA III) exposed in section B 2 above coal seam I vary in thickness from 0.15 to 0.10 m and are draped with silt laminae along planes separating the planar cosets. This facies association together with sub-associations (a) and (c) of FA II are too rare to affect the depositional motif. The current direction in this area is unidirectional and persistently plunging northerly with low variance.

Roots Beds

Several discrete occurrences of roots or rootlets are recorded from sandy and clayey rock layers lying between coal seams I and III while Choudhuri (1985) has reported rootlets from still lower horizon (location 3b in Table 1.). However, the section D 3 where the fire clay unit lying above seam III contain erect roots or rootlets in such profusion that they may be treated as root beds (Fig.4) The unit comprising interlayered Fl and C and resting above the root beds with sharp and non-transitional planar contact is devoid of rootlets even though succeeding S_t facies is locally root bearing. Conspicuously, the seam III and associated units exposed elsewhere (in sections D1 & D 2) apparently do not contain any visible existence of rootlets. The rootlets, usually 0.50 to 0.25 m in length, tend to spread downward in all directions from a trunk root with increasing number of off-shoots. A few erect roots that pierce through several cosets in overlying S_t facies range in length from 1.5 to 1.0 m and similar situation also prevails in the coarse sandy member above seam I, exposed as cliff at the confluence of Jinjoli and Amanat rivers. Rootlets that ramify in the host beds in section D 3 era

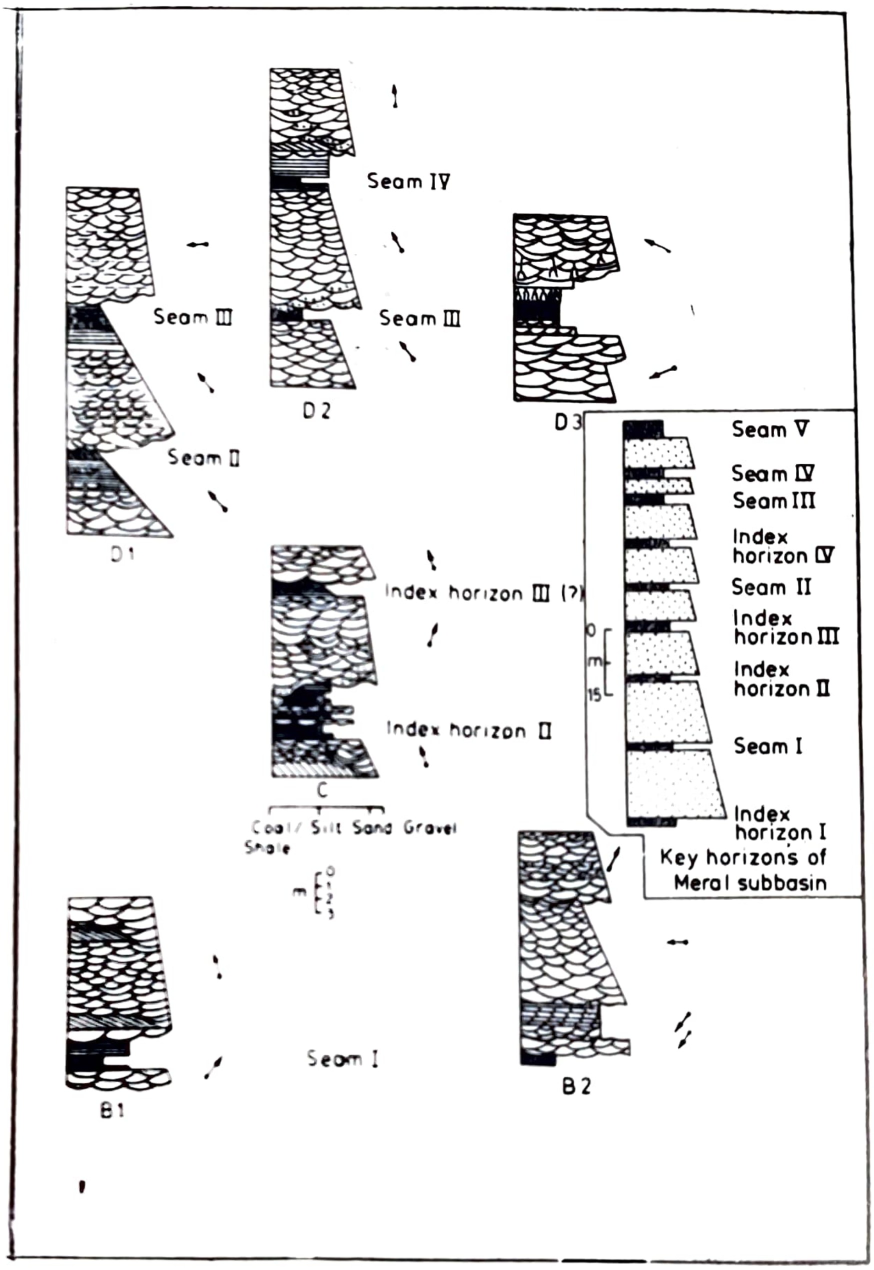


Text-fig. 1 **a**, Geological map of the Daltonganj Coalfield, Palamau District, Bihar; **b**, Facies sequence associated with the lower part of the Barakar Formation in the Meral sub-basin.

either ferruginous or calcareous (Fig 5). Megascopically the host rock is soft, massive to finely bedded and dominantly made up of clay of mixed layer group and kaoloinite and other inorganic constituents are largely mixed up with degraded phytological hash (Bandyopadhyay *et al.*, 1985).

Interpretation

Thick lenticular bodies of coarse sands and thinner ribbons of finer sand set in matrix of overbank fines constituting respectively the basal and upper parts of the fluvial Barakar sediment amply demonstrate gradual evolution of the style of the alluvial system from an initial low sinuosity braided to a later high sinuosity style in the Meral sub-basin. It is apparent that the initiation of Barakar sedimentation witnessed a transitional phase between glacial and nonglacial climate—a condition not congenial for abundant plant growth. Lack of bank stability in absence of vegetative cover apparently facilitated the braiding of Early Barakar river system. Extremely pebbly nature of the sandy facies and re-occurrences of erosive junctions may owe their deposition to



Text-fig. 2 Facies sequence associated with the upper part of the Barakar Formation in the Meral sub-basin. The insertion in the middle of right hand side, displays the stratigraphic positions of the coal seams and 'index horizons' in the sub-basin.

1. Downstream view of the fining upward sequence ending with coal seam III (marked C III). The sequence is resting over the seam II (marked C II) with erosional contact. Mark P within arrows, shows the development of a point bar. The height of the section is abou 6 m.
2. View of the root-bed lying above seam III (Section D 3 in Fig. 2). The unit above the root-bed rests with irregular erosive contact. The coal seam III is resting over the underlying sandy unit with non-transitional, sharp planar contact. The section is nearly 3 m thick.
3. Fragments of calcified rootlets recovered from the root-bed (the bar is in cm).

a system of laterally multiplying broad and deep channel system. The sandy facies being predominantly through cross-stratified denote a situation analogous to Saskatchewan River that did not support development of cross-channel bars (Cant, 1978). Presumably, the bars were mantled with sinuous-crested dunes that had low palaeocurrent variance points to their origin as longitudinal bars. The rare occurrences of solitary planar cross-beds and with azimuth oblique to local current direction possibly reflects deposition in transverse bars, equivalent to oblique bars of Cant (op.cit) and side bars of Allen (1966) and Collinson (1970). The unique occurrence of a coset of small scale cross-stratification with silt drape along the planar set boundary surfaces punctuated within S_t facies above the coal seam I are comparable to deposits of sand flats developed on the shales of the channel bars.

The occurrence of fining-upward sequence ending with a thin coal layer at the basal part of the Barakar (Fig. 2) records an event that marks gradual deceleration of flow velocity within the general background of rapidly fluctuating flow regime and —in turn denote a temporary change in geomorphic setup leading to consequent change in slope and discharge. Alternatively, flow separation beyond large channel bars might have induced the deposition of finer units, above the former, with transitional characters. Stacked sets of large scale cross-bedded coarse sands intervened by major erosional surfaces and slump structures near the truncated top of the succeeding facies suggest the revival cf rapid deposition and as well as higher flow regime in subsequent phases.

Shaly sediments in the basal Barakar are ill preserved; abundance of angular mud chips in sands at this part, is apparently derived from mud that were deposited from suspension during slack waters. The zone consisting of laterally arranged clay lentiles enclosed within the erosive surfaces is traceable for nearly half a kilometer in the upper part of the basal Barakar (section A) and the clayey sediment reflects deposition during the falling stage of a river flood in a braided framework. The flood water while receding back to the trunk channel in the initial phase of falling stage apparently decapped the channel bars and the truncated bed forms ultimately got burried under suspension fall out in final waning phase (Coleman, 1969). The tendency of amalgamation at places of the S_t facies in the overlying unit implies the begining of a fresh cycle of sedimentation. This style of deposition was subsequently followed by couplets of coarser and finer sediments resting on each other with either gradational or sharp planar contacts (sub-associations (a) and (b) of FA II). This change in facies association where finer sediments started to dominate points to enhanced bank stability that in most likelihood was the direct consequence of development of vegetative cover under gradually ameliorating climate. Subfacies association (FA IIa) comprising coarser sands fining upward to shale were deposited in laterally adjacent subenvironments in the same cycle, whereas the corresponding units in nontransitional coarse-fine facies sub-associations (FA IIb) were deposited in unrelated geomorphic units belonging to different cycles.

Larger trough cross-stratifications in FA II range in heights from 0.3 to 0.25 m and usually show progressive reduction in the scale of troughs accompanied by elimination of coarser fractions and thus are consistent with deposition under gradual waning of current on modern point bar sequence (McDowell, 1960). Units with seam III exposed in sections D 1 and D 2 provide a scope to understand the genesis of coal bearing strata in two differing set ups within meandering reaches. Sigmoidal sets of accretionary beds normal to directions of flow in sandy units of section D 1 bear a definite stamp of their growth as point bars; their gradation into top stratum fine deposits through cross-laminated silty units suggests their development in proximity to an active channel where flood water could also move with appreciable velocity. The top stratum (coal seam III) deposit in section D 2 lying with sharp planar contact above sandy unit interpreted to be channel deposit, had been formed as clay plug over a completely abandoned meander lying far away from an active channel. In this isolated pool, flood water could reach only by overtopping the banks of active channel and stagnate there to deposit silt and plant materials. The coal seam III together with its underlying finer units exposed in section D 3 also mimicing clay plug deposits. The index horizon (II section C) is also a clay plug deposit and sandy unit in its middle appears to have been deposited through temporary opening of entrance and exit of an abandoned loop.

Profuse development of fairly long rootlets in clay bed above seam III in section D 3 suggests growth of strong and stout plants above it and thus correspond to a prolonged period when the clay plugged abandoned loop remained subaerially exposed to form soil before being truncated by an extensive flood of much later date. The calcification of rootlets is apparently unrelated with syndepositional climate. In the context of the position of palaeopole during Permian and prevailing cold temperate climate (G. S. I., 1977) therein it is evident that this extremely localised calcification is in all probability not the manifestation of any aridity or local noise in the climate. More plausibly, the phenomenon might be related to the diagenetic changes where highly decomposed vegetable materials resulted in the increased alkalinity of groundwater that under reducing condition had precipitated as carbonates. Isolated occurrences of roots piercing through trough cosets or planer cross-beds in coarse sandy channel members do also imply subaerial exposures of some of the aggrading channel bars that supported plants on their surface for appreciably longer periods so that the plants could develop extensive downward growing root systems through bar sediments.

Conclusions

From foregoing descriptions and discussions, following conclusions can be drawn regarding depositional history of Barakar sediments in the Meral sub-basin:

1. River pattern progressively changed from an initial low sinuous to highly sinuous channel system in later phase.
2. Change of channel style through time might be linked with the enhanced plant activity under gradually ameliorating climate.
3. Nature of mutual contacts between facies in the meandering sequences had been determined by their relative positions with respect to the active channel.
4. Roots or rootlets denote subaerial exposure and bank stabilization for considerably long period; calcification around and within the roots or rootlets is in all probability related to diagenetic activity, rather than to the contemporaneous climate.

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