

Depositional history of the basal Barakar beds—a study from Ramgarh Coalfield, Hazaribagh District, Bihar

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Bhattacharya, A. (1988). Depositional history of the basal Barakar beds—a study from Ramgarh Coalfield, Hazaribagh District, Bihar. *Palaeobotanist* 36 : 67-73.

The rock record of the basal Barakar Formation of the Ramgarh Coalfield, Hazaribagh District, Bihar has been interpreted as an ancient example of the sandur deposit, i.e., a glacial outwash plain deposit having two distinct units as—(a) channel facies divisible with riffles and pools, and (b) interchannel bar facies. Each of the facies of the environment in its stratigraphic set up, lithological attributes, sedimentary structural assemblage and palaeocurrent pattern correspond to one in the model.

The lenticular and sheet-like gravelly and pebbly sandstones with crude and sharp parallel stratifications, graded beds and scour- and fill structures characterise the bar facies whereas, coarse arkosic sandstones with ripple and megaripple bedding, lenticular to planar cross-beds, and buried megaripple trains characterise the riffles of the channel facies. Gravel lenses at regular intervals have been related to the transverse ribs of the riffle facies. The lenticular sandy shales, siltstones and carbonaceous shales within coarse sandstones have been interpreted to be the pools of the channel facies. Palaeocurrent direction within the basal Barakar beds swings between NW to NNW.

The basal Barakar beds, at the bottommost part maintain a gravel: sand ratio to the order of 40 : 60; the proportion of sand, however, increases upwards. The gravelly and pebbly sandstone are highly indurated with fresh feldspars in all cases. The gravels are rounded to well rounded with high sphericity values.

Depositional features exhibit an uninterrupted pattern of sedimentation from the glacial Talchir Formation, through the sandur basal Barakar beds to the true fluvial Middle and Upper Barakar beds till the end of the Ironstone Shale Formation. The sandur sedimentation model with channel and bar facies as identified from the basal Barakar beds of Ramgarh Basin has also been presented in a block diagram.

Key-words—Stratigraphy, Sedimentation, Depositional history, Ramgarh Coalfield, Barakar (India).

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सारांश

आधारी बराकार संस्तरों का निक्षेपणीय इतिहास—हजारी बाग जनपद (बिहार) में रामगढ़ कोयला-क्षेत्र का अध्ययन

अशोक कुमार भट्टाचार्य

हजारी बाग जनपद (बिहार) में रामगढ़ कोयला-क्षेत्र की आधारी बराकार शैल-समूह की चट्टानों के अभिलेख की व्याख्या सेन्दुर निक्षेप के एक प्राचीन उदाहरण के रूप में की गई है। इसमें (अ) कूंड प्रखारिकाओं में विभक्तनीय संलक्षणी प्रणाल, तथा (आ) भित्ति अन्तर-प्रणाल संलक्षणी नामक दो विभिन्न इकाईयाँ हैं। वातावरण का प्रत्येक प्रणाल स्तरविन्यास, शैलविन्यास, अवसादीय समुच्चय तथा पुराप्रवृत्ति के ढंग में आपस में अनुरूप हैं। स्पष्ट समानान्तर स्तरणों, क्रमिक संस्तरों एवं निर्घर्षपूर्ण संरचनाओं से युक्त मसूराकार एवं चादर के समान बजरीली तथा गुटिकामय बालुपत्थर दंड-संलक्षणी के लक्षण हैं जबकि ऊर्मिका एवं गुरुऊर्मिका वाली संस्तरों से युक्त मोटी आर्कोजी बजरी, मसूराकार और समतल क्रॉस संस्तर तथा अंतर्हित गुरुऊर्मिका श्रृंखला प्रणाल संलक्षणीयों की प्रखारिकाओं के लाक्षणिक गुण हैं। निश्चित अंतराल पर बजरीमय-लैसों को प्रखारिका संलक्षणीयों के अनुप्रस्थ भाग से सम्बद्ध किया गया है। मसूराकार बलुई शैलों, पाँशाप्रस्तरों एवं मोटे बालुपत्थरों में विद्यमान कार्बनी शैलों की व्याख्या प्रणाल संलक्षणीयों के कूंडों के रूप में की गई है। आधारी बराकार संस्तरों में पुराप्रवृत्ति की दिशा उत्तर-पश्चिम से उत्तर-उत्तर-पश्चिम के बीच प्रेक्षित की गई है। आधारी बराकार संस्तरों की निचली तली में बजरी एवं बालु 40 : 60 के अनुपात में मिलते हैं, हालाँकि बालु की मात्रा ऊपर की ओर बढ़ जाती है। बजरीमय एवं गुटिकामय बालुपत्थर साफ फेल्डस्पार

की उपस्थिति के कारण अत्यधिक कठोर हो गये हैं। इनमें विद्यमान बजरी गोलाकार है। निक्षेपणीय संलक्षणों से हिमानी तालचिर शैल-समूह के अवसादन का अर्थात् स्व रूप प्रदर्शित होता है। यह अवसादन आयरनस्टोन शैल शैल-समूह की समाप्ति तक सेन्दुर आधारी बराकार से यथार्थ नदीय, मध्य एवं उपरि बराकार तक हुआ था। प्रणाल एवं दंड संलक्षणी सहित सेन्दुर अवसादन का नमूना भी जैसा कि रामगढ़ द्रोणी के आधारी बराकार संस्तरों से अभिनिरूपित किया गया है, एक त्रिआयामी-चित्र के रूप में प्रस्तुत किया गया है।

THE sedimentary sequence of the Ramgarh Coalfield, Bihar belongs to the Gondwana Supergroup of the Koel-Damodar Valley. The basin was first discovered by D. H. Williams around 1848 and was subsequently studied by Ball (1867), Fox (1934), Ghosh (1950), Mehta and Joshi (1962), Sen (1967) and Rao *et al.* (1969).

The Gondwana Sequence covers a total 60 sq km area and occurs as an outlier of the Karanpura and Bokaro coalfields (Text-fig. 1). From the east to the west of the semi-triangular basin, three Lower Gondwana formations, viz., the Talchir, the Barakar and the Ironstone Shales grade from one to the other without any noticeable break in sedimentation. Of the three formations, both Talchir and Ironstone Shale have patchy and localized occurrences whereas, the Barakar Formation occupies the major part of the basin. The Barakar Formation, in almost all Gondwana basins, is marked by a sedimentary sequence having a general rhythmic alternation of two contrasted lithofacies which include— (a) poorly sorted coarse white arkose, interbedded with siltstone and conglomerate; and (b) well-stratified sheets of shales, siltstone and coal. The former association is related to a channel facies whereas, the latter to interchannel flood facies (Banerjee, 1963; Sengupta, 1970).

Many workers have recognised three distinct units, viz., Basal or Lower, Middle and Upper within the Barakar Formation. The basal Barakar beds have often been confused with the Karharbari Formation so far as their sedimentological characters are concerned. The basal Barakar beds or in some cases the rocks of Karharbari Formation have been supposed to be a channel or braided stream deposit (Casshyap, 1979) and piedmont alluvial plain deposit in intermontane valleys (Rao *et al.*, 1969).

Lithological and structural features of the basal Barakar beds as studied from Ramgarh Coalfield, however, suggest their generation from a sandur deposit, i.e., a glacial outwash plain deposit having many channels and interchannel bar facies in close interlacing network. Such a depositional environment for the basal Barakar beds has been suggested for the first time from the Indian Gondwana. The present paper attempts to enumerate the evidences that lead to the understanding of such a depositional environment for the basal Barakar beds of the Ramgarh Basin and

their relationship with the underlying Talchir Formation and immediately overlying the Middle and Upper units of the Barakar Formation.

THE BASIN

The Ramgarh Coalfield situated between 23°35'N to 23°42'N and 85°30'E to 85°45'E, in eastern India is a more or less triangular east-west trending sedimentary basin (Text-fig. 1) of the intracratonic type. The sedimentaries belong to the Lower Gondwana group and are divided into three formations, Talchir, Barakar, and Ironstone Shale. The greatest width is 14 km in the eastern part which tapers out to the west for an east-west extension of about 20 km, with a west-central zone of constriction of the basin where the width comes to be 1.5 km.

The basin is surrounded by the Chhotanagpur Archaean metamorphites on all sides and downfaulted within them along the southern boundary. Except for a few shallow synformal and antiformal flexures the Barakar beds are generally within 30° dip. A number of oblique faults have also been reported (Mehta & Joshi, 1962).

The basin is dissected in the central part by the westerly flowing Damodar River and in the eastern part by the northerly flowing Vera River. Exposures of Gondwana rocks can be well-studied from these river sections, road and railway cuttings and on the excavation faces of the Rajrappa Colliery. The Gondwana rocks have a general dip towards west, north-west and south-west with an amount ranging mostly between 10° and 30°.

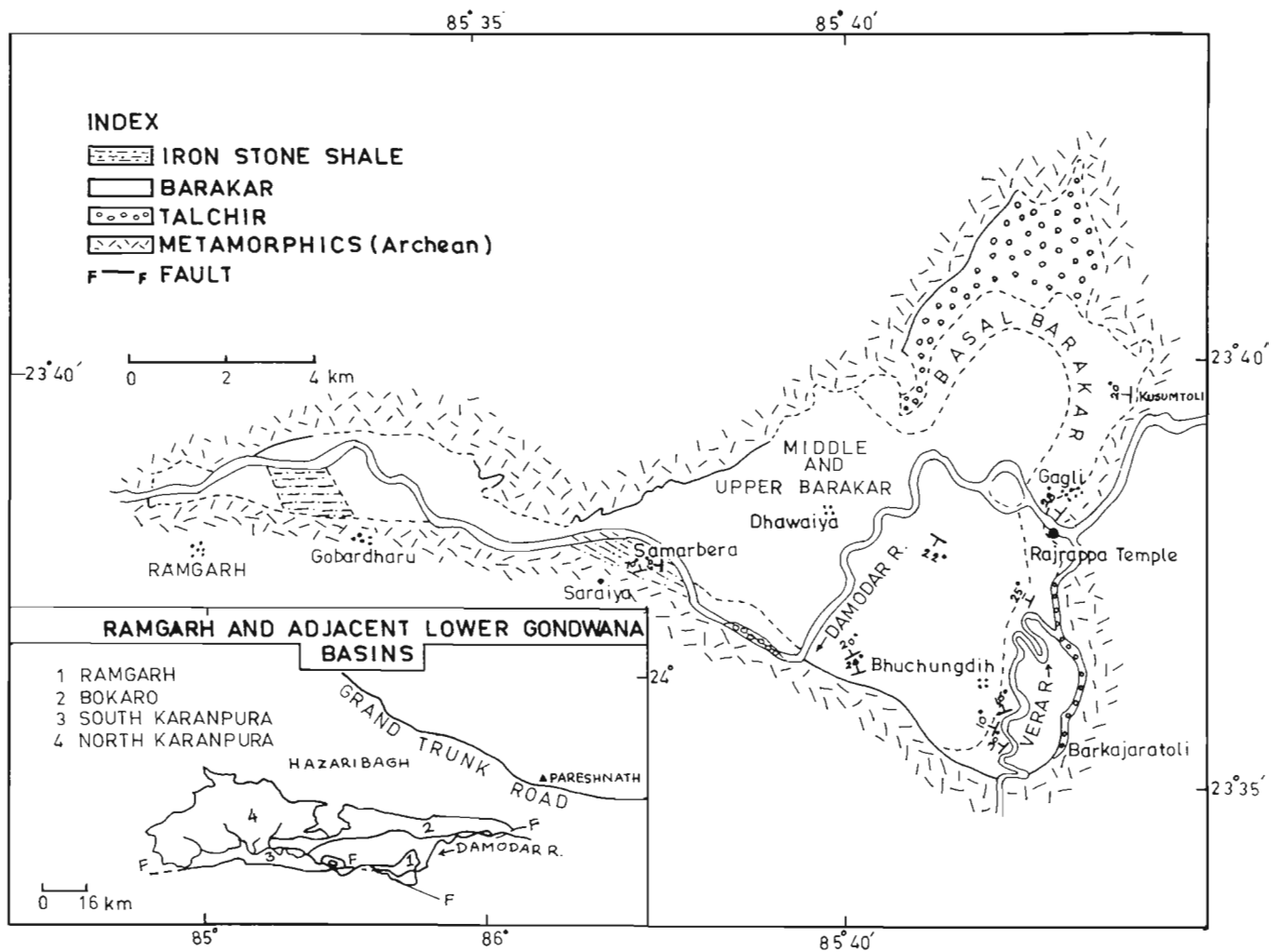
The general stratigraphy of the basin may be summarised as in Table 1.

CLASSICAL SANDUR SEDIMENTATION MODEL

The 'sandur' deposit or glacial outwash plain deposit is a braided glaciofluvial deposit having two morphological units, each characterised by an association of sediments and sedimentary structures. The units are— (a) 'channels' which can be subdivided into— (i) 'pool' having fine silty and shaly facies with parallel stratifications, and (ii) 'riffle' of gravelly sand and pebbly sandstones with ripple- and megaripple bedding, cross-bedding, etc. Transverse ribs contribute a bed form typical of riffle portion (McDonald & Banerjee, 1971); and (b)

FORMATION	LITHOLOGY
Ironstone Shale	Highly indurated pink to reddish brown fine sandstones, silstones and shales. Small nodules of siderites and occasional streaks of carbonaceous matter.
..... Conformable	
Barakar	— Upper : Intercalated fine cross-bedded sandstones and shales with thick coal seams
	— Middle : Medium to fine cross-bedded sandstones, gritty sandstones with workable coal seams.
	— Basal : Coarse pebbly sandstones and thin intercalated shales, poorly sorted gravelly sandstones with thin local coal seams and sandy shales.
..... Conformable	
Talchir	Varved shale, green and khaki shale, Talchir Boulder Bed.
..... Unconformity	
Archaean	Granite gneiss, mica schists, quartzites, amphibolites, vein gneisses.

Table 1



Text-figure 1—The geological map of the Ramgarh Coalfield. Inset shows relation with adjacent basins. Geological map modified after Mehta and Joshi, 1962.

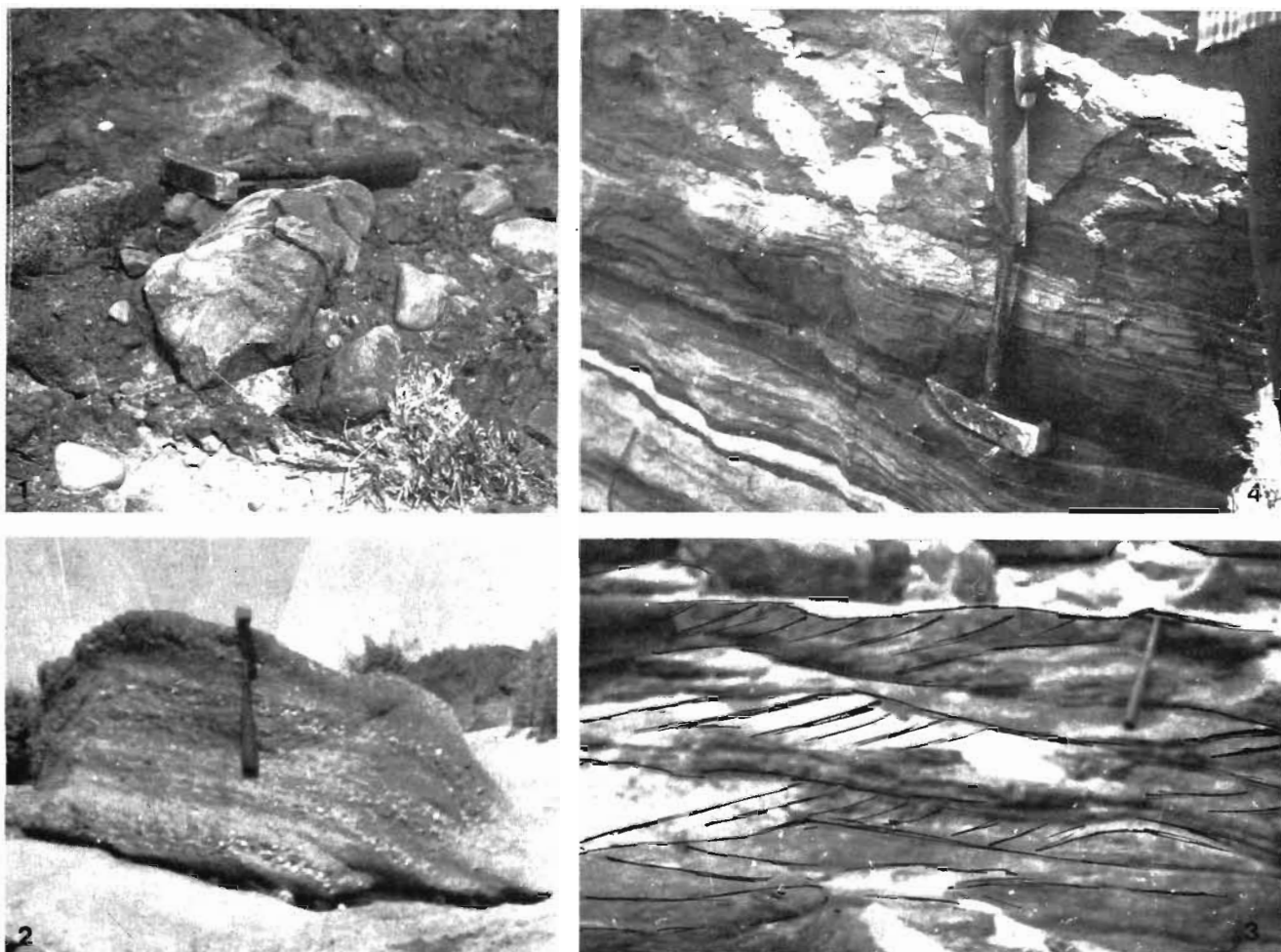


PLATE 1

1. An exposure of Talchir Boulder Bed around Sariya.
2. Graded bedding in basal Barakar beds.

3. Megaripple bedding in basal Barakar beds, hammer is 40 cm in length.
4. Ripple bedding in basal Barakar beds.

interchannel 'bars' characterised by relatively finer, poorly sorted coarse sandstones and pebbly sandstones having parallel bedding. Both channel and bar facies, however, are characterised by scour-and fill-structures (Reineck & Singh, 1980, p. 203).

THE BASAL BARAKAR BEDS

On the eastern part of the Ramgarh Coalfield the basal Barakar beds form a distinct 50 to 100 m thick lithounit having two distinctive facies and are well exposed on the Vera River Bed. These basal beds lie conformably over the Talchir Boulder Bed (Pl. 1, fig. 1) or over Talchir green or khaki shales with gradational contact. The boulders of the Boulder Bed are often faceted, iron-shaped to irregular bodies and range in size up to 5 m. Near Saraiya, on

the southern bank of Damodar River, the boulders show a crude orientation of their long axes. Compositionally the Boulder Bed is polymictic being composed of boulders of quartzites, granite gneisses, migmatites, amphibolites and vein quartz derived from Archean basement.

LITHOLOGY

The basal Barakar beds show two broad contrasted facies which alternate both in vertical and lateral senses. The sedimentary bodies are lenticular to sheet-like in geometric shapes as seen in sections. Lithologically, the beds are medium to poorly sorted gravelly sandstones or coarse pebbly sandstones. Graded bedding with grain size variations from gravel to fine sand occurring from bottom to top in

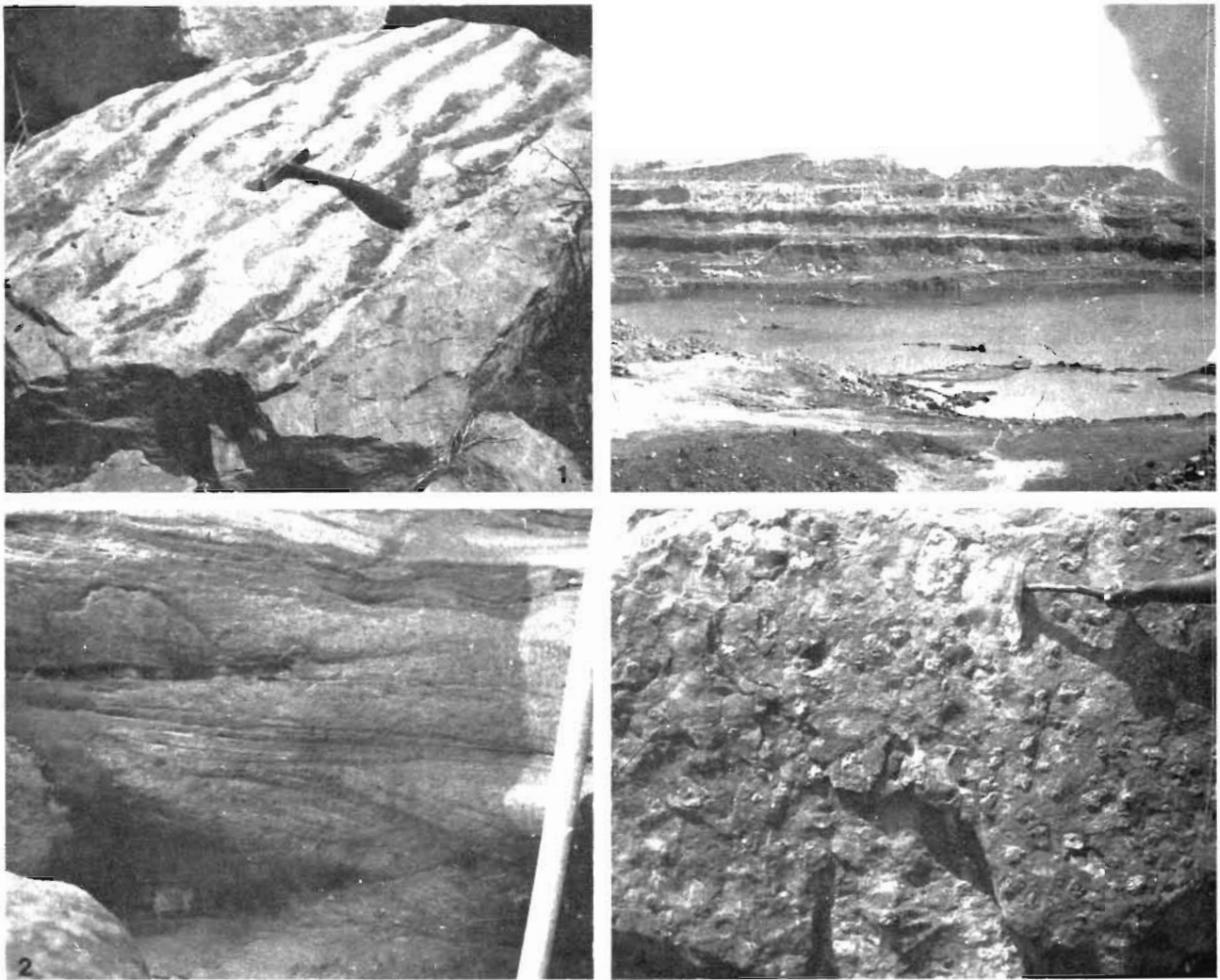


PLATE 2

1 Wavy ripple marks on the surface of the basal Barakar beds
 2. Scour-and fill structure in the basal Barakar beds

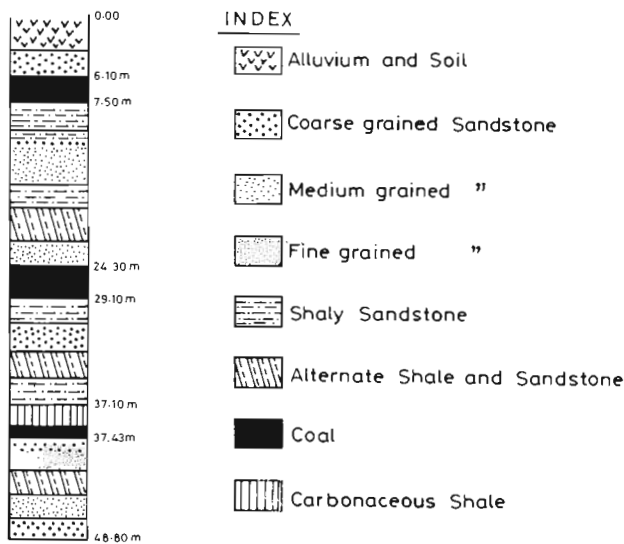
3. Three different coal seams in alternations in the sandstones and shales as exposed in a mining face.
 4. Pyrite nodules in sandstones

individual sedimentation unit (Pl. 1, fig. 2) is well-registered in many cases. This coarse gravelly and pebbly sandstone facies may be related to the bar facies of glacial outwash plains.

The gravelly sandstone beds are well stratified to crudely stratified and exhibit rapid alternation of well sorted and moderately sorted cross-bedded arkosic sandstone of the riffle facies of the channels. Small lenses (length within 1 m and thickness 10 cm) of gravels at more or less regular intervals in lateral and vertical sequences may reflect sectional manifestations of the gravelly 'transverse ribs' of the riffle portions of channels of the outwash plains

(McDonald & Banerjee, 1971). At the bottommost part of the beds the gravel: sand ratio is of the order of 40 : 60; the proportion of sand, however, increases towards the upper part of the basal beds.

In contrast to the gravelly and pebbly sandstone facies, sandy silts, silty shales and fissile carbonaceous shales have very local occurrences. These bodies are elongated lenticular both in plan and section and merge laterally into gravelly and coarse sandstones. This finer facies may be related to the pool facies of the channels. The carbonaceous shales contain impressions of *Vertebraria*, *Glossopteris* and *Gangamopteris* (?) in abundance



Text-figure 2—Representative sedimentary sequence of the Barakar Formation of the Ramgarh Coalfield as obtained from bore-hole data.

and in all cases are sandwiched between underlying 1 to 5 m thick lenticular coal seams and overlying lenticular gravelly sandstones.

Unlike the Middle and Upper Barakar beds, the basal beds, sometimes are devoid of any definite cyclic pattern of sedimentation as marked by alternation of sand, shale and coal facies. The Barakar beds are better sorted and relatively finer sized than that of underlying Talchir Boulder Bed but poorer in sorting and coarser sized than the succeeding Middle and Upper Barakar beds.

The pebbly and gravelly sandstones of the basal beds are very indurated with the presence of fresh feldspars in all cases. The gravels are found to be well rounded (av. roundness 0.8) with high sphericity (sphericity between 0.7 and 0.9); size ranges between 0.5 to 3 cm with the commonest size around 1.5 cm. Compositionally the gravels are of quartz, feldspar, quartzite, granite and gneisses and are supposed to be derived from underlying formations.

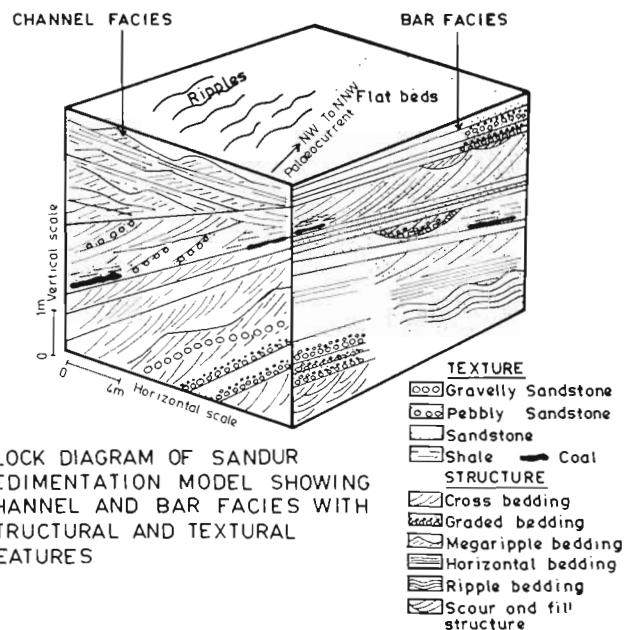
SEDIMENTARY STRUCTURES

The gravelly and pebbly sandstones, representative of the bar facies are crudely or sharply parallel-stratified and grade both laterally and vertically to profusely cross-bedded coarse pebbly sandstones to coarse sandstones of the channel facies. The bedding thickness ranges between 15 cm and 2 m. The cross-bedded units are mostly of trough-lenticular type with planar erosional bounding surfaces. In many cases, megaripple

beddings (Pl. 1, fig. 3) with wavelength ranging between 1 and 4 m and height between 30 cm and 1 m register non-erosional upper bounding surfaces. Cosets of trough-lenticular cross-beds and composite sets composed of alternation of tabular and lenticular sets can be seen in 5 to 10 m vertical sections exposed on Vera River banks. These cross-bedded units often with alignment of pebbles along foreset laminae are supposed to be resultant from megaripple migration along with subsidence. The megaripples can be inferred to be generated in the upper part of the lower flow regime of the outwash plain channels.

Isolated buried megaripples without any evidence of erosion of crestal profiles are noticed in many sections. Ripple-bedded sandstones (Pl. 1, fig. 4) sometimes alternate with megaripple bedding in sections. Scour and fill structures (Pl. 2, fig. 2) with poorly sorted gravel lags at the base of the scours are most common structures of both channel and bar facies of the sandur deposits. Rao *et al.* (1969) also noticed occurrences of excellent channel sand grading to silt in the Ramgarh Basin. Small wavy ripples marks (Pl. 2, fig. 1) having wavelengths less than 30 cm and height around 2 cm are present in few places as surface beds forms.

Palaeocurrent measurements in the field were done from foresets of cross-beds, foresets of ripple bedding and trends of ripple trains in plan. The overall palaeocurrent direction swings between NW to NNW.



Text-figure 3—Block diagram to represent the sandur sedimentation model showing channel and bar facies as identified from the basal Barakar beds of Ramgarh Coalfield.

Text-figure 3 illustrates a block diagram to represent the sandur sedimentation model with channel and bar facies as identified from the basal Barakar beds of Ramgarh Coalfield.

MIDDLE TO UPPER BARAKARS AND IRONSTONE SHALES

The basal Barakar beds grade further west of the basin to Middle and Upper Barakar beds that truly represent a cyclic pattern of sedimentation with medium to fine sandstones, shales and coal seams (Pl. 2, fig. 3). All gradations exist between sandstones to siltstones and shales. Shales are mostly associated with coal-bearing portions. Lenticular cross-stratifications of medium to small scale are very common. Apart from cross-laminations, convolute laminations and load casts are also present occasionally. A representative sedimentary sequence of the Middle and Upper Barakar beds of the Ramgarh Coalfield as obtained from bore-hole data is shown in Text-figure 2.

Such a cyclic sedimentation may be related to fluvial cycle caused by shift in the channel alignment and environmental boundaries simultaneous with subsidence (Banerjee, 1978, fig. 8). A fining upward fluvial cycle of a different type related to annual flood cycle over river point bars and flood basins has been described by Allen (1965), Visher (1965) and Casshyap (1970).

In rare cases, Middle Barakar fine sandy beds contain nodules of pyrites having 2 to 10 cm diameter (Pl. 2, fig. 4). These pyritiferous sandstones might reflect an euxinic environment of their formation perhaps in certain arrested pools of the river flood plains.

The Ironstone Shale Formation is well-bedded and cross-bedded fine sandstones, siltstones and shales having a general pink to pinkish red colour. They are of local occurrences and seen to maintain a graded contact with the Barakar Formation.

CONCLUSION

The basal Barakar beds of the Ramgarh Coalfield with their textural and structural attributes and facies relations indicate deposition on gently sloping glacial outwash plain cut through by many channels, i.e., in a sandur environment.

The sandur deposits have two distinct facies—(i) channel facies with riffles and pools, and (ii) inter-channel bar facies having gradational contacts in both lateral and vertical senses. The basal beds register deposits of both the facies as has been illustrated with textural and structural parameters, geometric shape of sand bodies and geomorphic-

geologic framework of sedimentation. The gravelly and pebbly sandstones with crude or sharp parallel stratifications, graded beds and scour and fill structures characterise the bar facies whereas, coarse sandstones with ripple and megaripple bedding, lenticular and planar cross-bedding, buried megaripple trains, scour and fill structures and gravel lenses characterise the riffles of the channel facies. The lenticular sandy shales and siltstones within coarse pebbly sandstones may be related to the pools of the channel facies.

Such a depositional environment has been supposed to have graded uninterruptedly from true glacial Talchir deposits and has led to the true fluvial model sedimentation commencing from the Middle Barakar upwards.

ACKNOWLEDGEMENTS

The author expresses his great sense of appreciation for the co-operation and hospitality offered by the officers of the Rajrappa Colliery, Hazaribagh District, Bihar.

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