FACIES DEVELOPMENT AND DEPOSITIONAL ENVIRONMENT OF THE MUNGRA SANDSTONE, KOLHAN GROUP, EASTERN INDIA

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Preliminary study through process-related facies analysis in late Paleoproterozoic-early Mesoproterozoic Mungra Sandstone Formation of Kolhan Group, the least studied stratigraphy in Singhbhum Geology, reveals two major facies types, viz, hummocky sandstone bodies (below fair weather wave base) and planar and cross-stratified sandstones (above fair weather wave base). From contact relations between facies types and facies succession development, a lower shoreface environment is inferred. An E-WSW paleoshoreline orientation is suggested for the Mungra Sandstone Sea.

Introduction

Intervening between the Singhbhum Granite in the north and east and the Iron Ore Group (IOG) of rocks in the west, the Kolhan Group of rocks ('Kolhan Series' of Dunn, 1940) represent the youngest and the least studied Precambrian stratigraphic unit in Singhbhum geology (Singh, 1998; Mukhopadhyay, 2001). With an unconformable relation, the low (5°-15°) westerly dipping beds of mixed siliciclastic-carbonate Kolhan succession overlies the Singhbhum granite and the IOG rocks, and can be observed as isolated outliers spread over two detached basins (*viz.* Chamakpur-Keonjhar Basin and Mankarchua Basin, cf. Saha, 1994) covering around 800 sq.km area along the western margin of the Singhbhum granite province. Broad description on lithology (Saha, 1994; Mahadevan, 2002), stratigraphic framework (viz. Mungra Sandstone, Jhinkpani Limestone and Jetia Shale; *cf.* Singh, 1988) and structural disposition (Ray and Bose, 1964) for this lithic succession is available in literature. In contrast, this Group has attracted least attention of geologists for appreciation of sedimentological attributes such as depositional structures, paleocurrent pattern etc. or for their paleoenviromental set-up. Spatial inconsistency in lithofacies development though noticed by earlier workers at different stratigraphic levels of the Kolhan succession, was never exploited in evolving spatio-temporal basin fill model for this weakly metamorphosed late Paleoproterozoic - early Mesoproterozoic (Saha, 1994) sediment package. This short discussion is a preliminary report on facies analysis carried out in parts of siliciclastic Mungra Sandstone, exposed around Lechia-Jhinkpani area, West Singhbhum (Fig.1). Detailed basin scale studies on both siliciclastic and carbonate members of this Group are in progress.

Facies Analysis

Singh (1998) divided Mungra Sandstone into two broad lithofacies, *viz.* conglomerate and sandstone. The conglomerates, occurring at the base, are thin, laterally impersistent, polymictic with basement derived clasts while the sandstones are regionally persistent and are the dominant component of the formation. This classification, however, does not provide any idea of depositional process or paleoenvironmental setting for the sediments of the siliciclastic package. Within the study area, the coarse to fine grained well-sorted feldspar rich sandstones of Mungra Sandstone were classified into two major facies types based on grain size and bedding characters. These two facies, namely the hummocky sandstone bodies and planar to cross-stratified sandstones, are described and interpreted here to infer depositional processes involved and their paleoenvironmental set-up.

Facies A: Hummocky Sandstone Bodies

These sandstone bodies are generally fine grained (0.2 mm) and continuous in the outcrop scale. Bed geometry and internal sedimentary structures of these sandstones, however, vary considerably. Lower boundaries are generally sharp and erosional with the presence of large mudstone rip-up clasts. Upper boundaries vary from sharp, erosional to gradational. The sandstone bodies show an overall hummocky topography formed either by preservation of the bedform morphology (passive variety; Bose et al. 1990) or developed through erosion of substrate (as indicated by truncation of bedding plane; Fig. 2) with subsequent draping (active variety; Harms et al. 1975). Present either as single bed (av. 0.18 m thick) or as amalgamated beds (up to 1.5 m thick) the hummocky cross-stratifications (HCS) constitute the swelling parts of these sandstone bodies. Individual beds of HCS are up to 0.42 m thick and

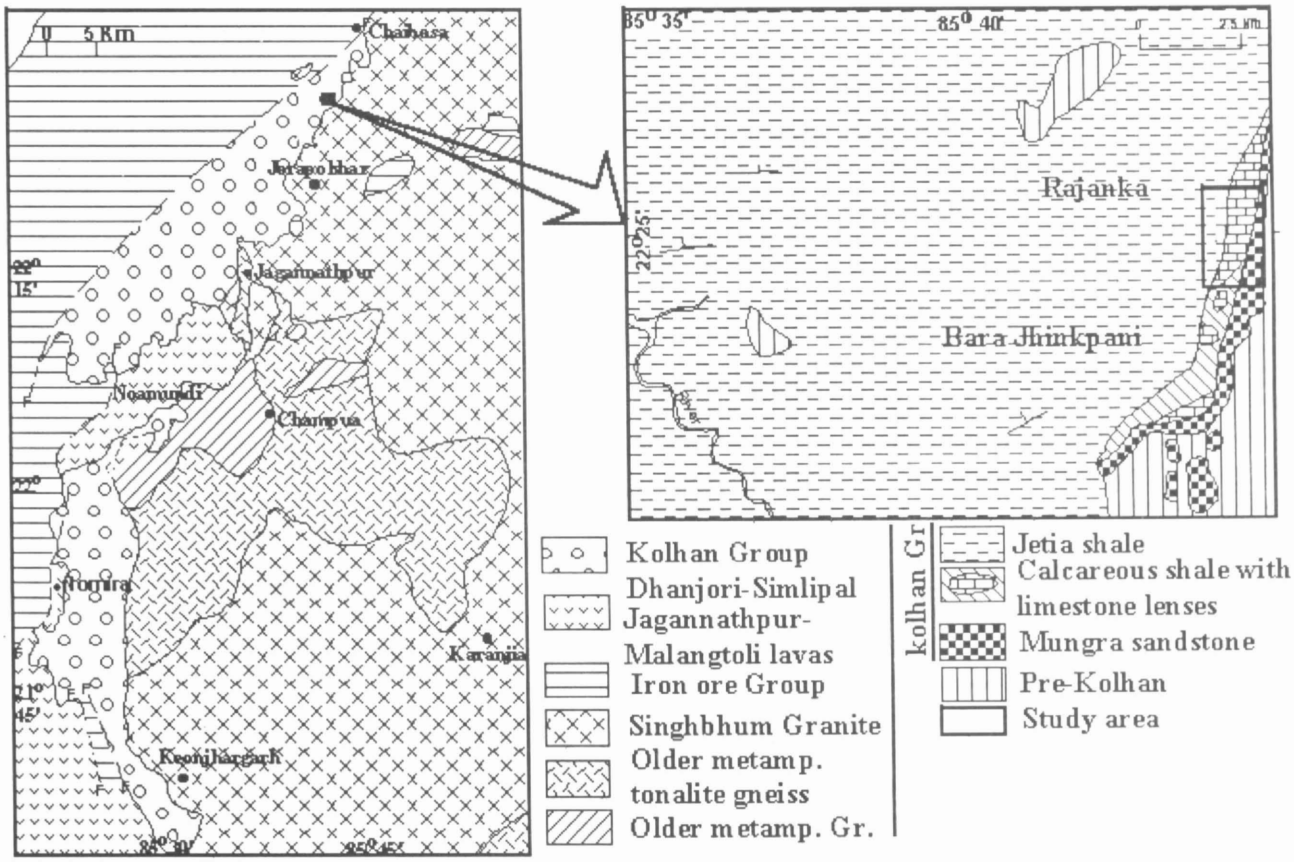

Fig.1. Geological map of parts of West Singhbhum (*after* Saha, 1992). Map of Kolhan Group around Rajanka mines, Jhinkpani is on the right (*after* Singh, 1998) with location of study area marked.

are composed of laminasets that are usually 6-15 cm thick (maximum 21 cm). Internally, the hummocky cross-stratifications are either aggradational or originate from laminae draping shallow and very low angle truncations (Fig.2). Laminae are parallel and conform to the underlying surface and show asymptotic downlap and onlapping relationships with the underlying surface with very low angles. Rarely, low-angle cross-stratifications (<12°) are recognized by the presence of tangentially downlapping foresets (Fig.3). Laterally, these cross-stratifications show transition to sets of low dipping parallel laminations. Parting lineations are present on foreset laminae and on bedding

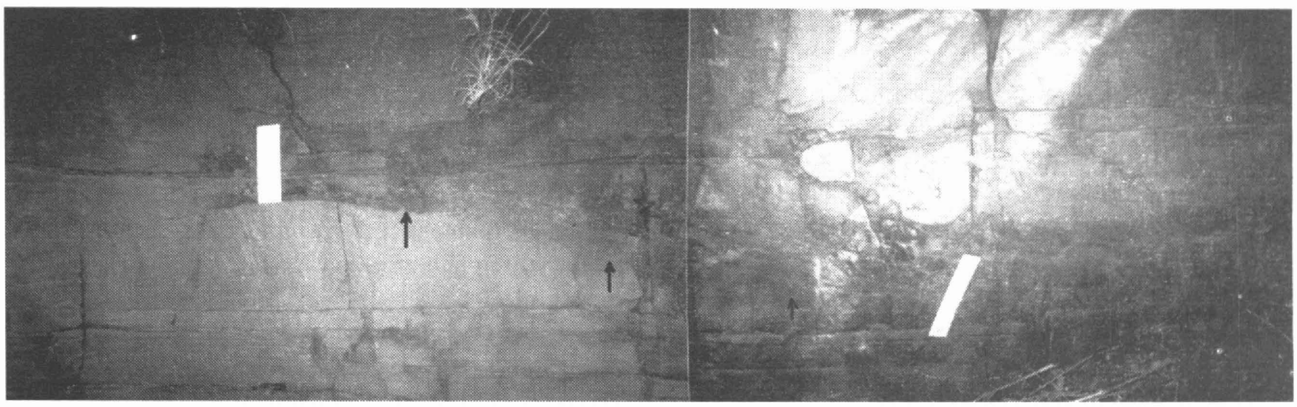

Fig.2. Hummocky sandstone beds within facies A. Note low angle truncation of laminae (marked by arrows) followed by sets of draping laminae (scale length 15 cm).

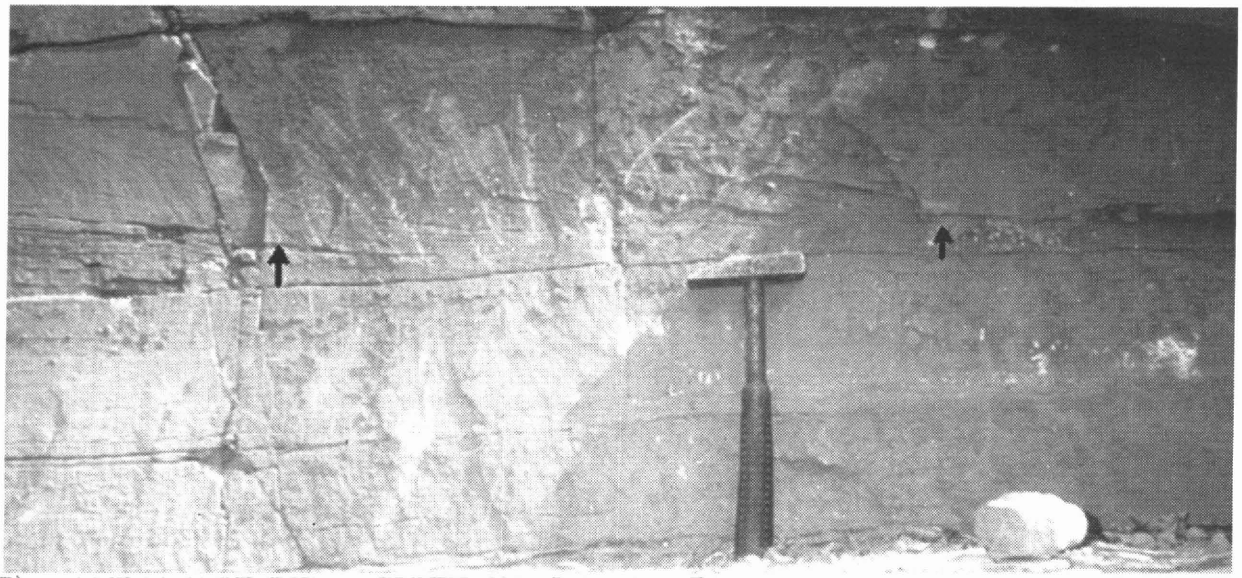

Fig.3. Low angle tangentially downlapping (arrowed) foresets within facies A. Laterally these foresets give way to low angle inclined plane laminae sets (hammer length 27 cm).

planes of low-angle plane laminations. Foreset dip azimuths are towards the northwest (Fig.4a).

The erosive bases and continuous conformable laminae draping low-angle, shallow scours are all characteristic features of hummocky cross-stratification (Harms et al. 1975; Dott and Bourgeois, 1982; Midtgaard, 1996), usually interpreted as the result of deposition under storm wave generated oscillatory flow or oscillation dominated combined flow (Bose and Chanda, 1986; Duke et al. 1991). The low-angle cross-stratifications are transitional to anisotropic HCS and interpreted as having been deposited from migrating low-amplitude bedforms. Parting lineation on foreset laminae and on bedding planes of low-angle plane laminated sandstone units suggest deposition under high boundary shear stress corresponding to upper plane bed flow conditions (Leckie and Krystinik, 1989). The unidirectional dip of foreset laminae clearly reflects the existence of a unidirectional flow component. Association of low-angle cross-stratification with HCS is interpreted as possible product of oscillatory-dominant combined flow condition (Midtgaard, 1996).

Facies B: Planar and Cross-stratified Sandstone

Alternation between two units, viz., plane lamination and chevron cross-stratification constitute this well-sorted coarse sandstone facies. Sandstone beds in this facies tend to be sheet like with constant bed thicknesses along-strike on the outcrop scale. Bedding surfaces of the parallel laminated sheet sandstones are even, sharp, parallel, parting lineated and rarely scoured. The chevron cross-stratifications of this facies are present in coset (av. set thickness 7 cm; Fig. 5). Paleocurrent azimuth obtained from these cross-

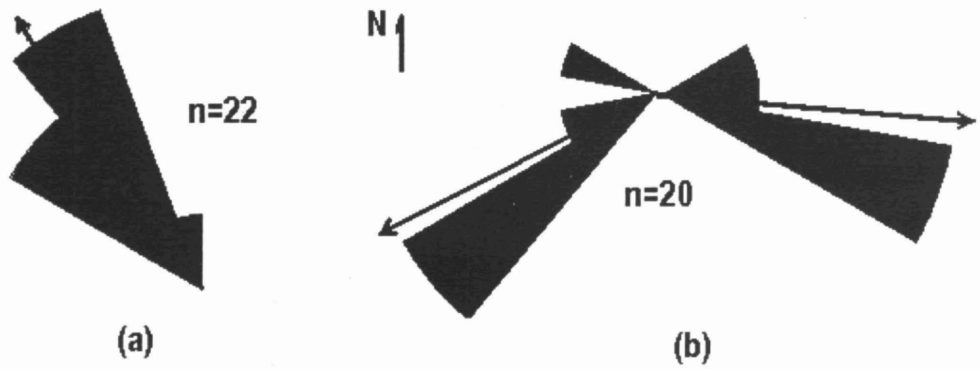

Fig.4. Paleocurrent directions from large low-angle foresets in facies A (a) and chevron cross-stratifications in facies B (b).

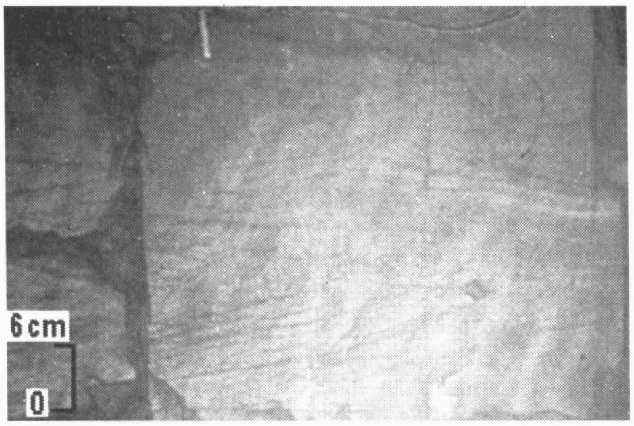

Fig.5. Chevron cross-stratification in facies B.

stratifications reveals E-WSW bimodal pattern (Fig.4b). On bedding planes there is a rare preservation of straight crested, near symmetric ripple like forms whose wavelength and amplitude are 7.8 cm and 0.8 cm respectively. In vertical section, sets of chevron cross-stratification of this facies is found erosionally overlying the hummocky sandstone bodies of facies A. Upward, this facies shows a coarsening-up tendency until getting mantled by thin bedded rippled fine sandstone units (av.18 cm thick) with sharp, planar contact.

Presence of wavy and chevron cross-stratification indicates dominance of oscillatory flow (Chakraborty et al. 1999). The broad ripple like forms with straight and occasionally bifurcated crests and wavelength: amplitude ratio more than 8 possibly replicate shore parallel swash ripples or antidunes, commonly present in wave dominated shoreface (Sarkar et al. 1996). Close association with plane lamination also strengthens this contention. Chevron cross-stratifications in this facies are interpreted as products of fair weather wave ripples. Considering shore-parallel character of fair weather ripple trains on wave dominated coastlines, the paleocurrent patterns derived from cross-stratifications of these ripples are commonly taken as proxy for paleoshoreline orientation (Sarkar et al. 1996; Chakraborty et al. 1999; Chakraborty, 2004). Paleocurrents from chevron cross-stratifications in facies B provide undoubted indication for E-WSW paleoshoreline orientation.

Paleoenvironment

Detailed basin-scale paleoenvironmental study is in progress. The preliminary observation, however, suggests lower shoreface depositional set up for the above described facies variants. Characteristics such as broad lenticular bed geometries, scoured bed bases with occurrence of rip-up mud clasts and hummocky cross-stratification within facies A are features expected from deposition below the effects of all but the largest storm waves. Occurrence of these event beds is consistent with lower shoreface setting outside the reach of day-to-day waves. Facies B, containing smaller scale wave ripples and associated plane laminations, bears definite clue for deposition above fair weather wave base. Amalgamated character of the hummocky sandstone bodies together with evidence of reworking of hummocky sand bodies by fair weather wave ripples of facies B, however, indicates that the depositional area of facies A was very close to fair weather wave base.

The common facies succession in the study area constitutes facies A erosionally overlain by Facies B that finally is topped by tens of cm thick thin bedded rippled fine sandstone. Recurrent development of this stacked, shallowing-upward facies succession possibly resulted from repeated progradation of the shoreline, alternating with abrupt transgression.

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References

Bose, P.K. and Chanda, S.K. (1986) Storm deposits and hummocky cross-stratification: A geological viewpoint. Quart. Jour. Geol. Min. Met. Soc. India, v.58, pp.53-68.

Bose, P.K. and Chaudhuri, A.K. (1990) Tide versus storm in epiric coastal deposition: two proterozoic sequences, India. Geol. Jour., v.25, pp.81-101.

Chakraborty, P.P., Pal, T., Dutta Gupta, T. and Gupta, K.S., (1999) Facies pattern and depositional motif in an immature trench-slope basin, Eocene Mithakhari group, Middle Andaman, India. Jour. Geol. Soc. India, v.53, pp.271-284.

Chakraborty, P.P. (2004) Facies architecture and sequence development in a Neoproterozoic carbonate ramp: Lakheri Limestone Member, Vindhyan Supergroup, Central India. Precambrian Research (*in press*)

Dott, R.H. Jr. and Bourgeois, J. (1982) Hummocky stratification: significance of its variable bedding sequence. Geol. Soc. Am. Bull., v.93, pp.663-680.

Dunn, J.A. (1940) The stratigraphy of north Singhbhum. Mem. Geol. Surv. Ind., v.63, Pt.3, pp.303-369.

Duke, W.L., Arnott, C.W.C and Cheel, R.J. (1991) Storm sandstones and hummocky cross-stratifications: New evidence on a stormy debate. Geology, v.19, pp.625-628

HARMS, J.C., SOUTHARD, J.B., SPEARING, D.R. and WALKER, R.G. (1975) Depositional environments as interpreted from primary sedimentary structures and stratification sequences. Soc. Econ. Paleont. and Mineral., Short course 2, 161p.

LECKIE, D.A. and KRYSTINIK, L.F. (1989) Is there evidence of geostropic currents preserved in the sedimentary record? Jour. Sed. Pet., v.59, pp.862-870.

MAHADEVAN, T.M. (2002) Geology of Bihar and Jharkhand. Geol. Soc. India, Bangalore, 564p.

MIDTGAARD, H.H. (1996) Inner shelf to lower shoreface hummocky sandstone bodies with evidence for geostropic influenced combined flow, Lower Cretaceous, west Greenland. Jour. Sed. Res., v.66, pp.343-353

MUKHOPADHYAY, D. (2001) The Archaean nucleus of Singhbhum: the present state of knowledge. Gondwana Research, v.4, No.3, pp.307-318.

RAY, S. and BOSE, M.K. (1964) Unique fold pattern in a shallow basin. Rept 22nd Session, Int. Geol. Cong., Pt.IV, pp.163-170.

SAHA, A.K. (1994) Crustal evolution of Singhbhum North Orissa, Eastern India. Mem. Geol. Soc. India, no.27, 338p.

SARKAR, S., CHAKRABORTY, P.P. and BOSE, P.K. (1996) Proterozoic Lakheri Limestone, central India: Facies, paleogeography and physiography. *In:* A. Bhattacharya (Ed.), Recent advances in Vindhyan Geology. Mem. Geol. Soc. India, no.36, pp.5-26.

SINGH, S.P. (1998) Precambrian stratigraphy of Bihar- An overview. *In:* B.S. Paliwal, (Ed.), The Indian Precambrian, Scientific Publ., Jodhpur, pp.376-408

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