JOURNAL GEOLOGICAL SOCIETY OF INDIA
Vol. 36, Oct. 1990, pp. 383 to 402

Stratigraphy of the Late Proterozoic Rewa Group and Palaeogeography of the Vindhyan Basin in Central India during Rewa Sedimentation

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Abstract. The Rewa Group of the Son Valley has been reclassified into five formations, i.e., Panna Shale, Asan Sandstone, Jhiri Shale, Drammondganj Sandstone and Govindgarh Sandstone in the ascending order. While two basal formations are developed only in the central and eastern part of the northern outcrop belt, the upper three are much more extensive than the underlying formations. Drammondganj Sandstone and Govindgarh Sandstone are newly defined formations, and the two constitute the 'Upper Rewa Sandstone' of earlier classifications. The scarp section at Drammondganj is the type area of the former, while the latter has its type area on the northern slope of the hills south of Govindgarh.

Analysis of palaeocurrent in Drammondganj Sandstone, trend of thickness variation as well as of the regional stratigraphic relations collectively point to a northeasterly slope of the marine Rewa basin. The basin was replaced by a westerly sloping fluvial basin during the late phase of Rewa sedimentation.

Keywords: Stratigraphy, Proterozoic, Rewa Group, Palaeogeography, Vindhyan Basin, Madhya Pradesh.

INTRODUCTION

Vindhyan sequence in the Son Valley, excepting the Semri Group, is dominantly siliciclastic in nature and consists of alternating sand or sand-dominant unit and shale or mud-dominant unit. A calcareous unit is developed only towards the uppermost part of the sequence. This siliciclastic sequence has been divided into three groups, Kaimur Group, Rewa Group and Bhander Group and each group, in turn, has been classified into a number of formations (Table I). The basis for this three-fold classification, however, is somewhat obscure and the interrelationships of these groups on a basinal scale also appears to have been explored only in broad outline. The general lithostratigraphic characters of the subdivisions show extraordinary persistence and striking uniformity over the great part of the basin. Nevertheless, the seemingly monotonous sequence poses complex problems of correlation on a regional scale.

The contact between the Kaimur and the Rewa Groups is placed at the top of a thick scarp-forming sandstone, the Dhandraul Quartzite. The reasons for placing the contact along this line, however, is not very clear. This contact could be placed at the top of either the Asan Sandstone (Lower Rewa Sandstone redesignated by Shastry and Moitra, 1984) or the Jhiri Shale. The Dhandraul Quartzite is

0016-7622/90/36-4-383/$ 1.00

TABLE I. Stratigraphic classification of Vindhyan Supergroup, Son Valley.

	Banerjee and Sengupta, 1963 *		Pascoe, 1975		Shastry and Moitra, 1984		Present authors
	Bhander Series		Bhander Series		Bhander Group		Bhander Group
	∼∼∼∼		∼∼∼∼		∼∼∼∼		∼∼∼∼
REWA SERIES	Upper Rewa Sandstone	REWA SERIES	Upper Rewa Sandstone	REWA GROUP	Govindgarh Sandstone	REWA GROUP	Govindgarh Sandstone (517 m)
							Drammondganj Sandstone (59 m)
	Jhiri Shale		Jhiri Shale		Jhiri Shale		Jhiri Shale (164 m)
	Lower Rewa Sandstone		Lower Rewa Sandstone		Asan Sandstone		Asan Sandstone (33 m) **
	Panna Shale		Panna Shale		Panna Shale		Panna Shale (74 m) **
	∼∼∼∼		∼∼∼∼		∼∼∼∼		∼∼∼∼
KAIMUR SERIES	Dhandraul Quartzite	KAIMUR SERIES	Upper Kaimur Sandstone	KAIMUR GROUP	Dhandraul Sandstone		Dhandraul Quartzite
	Scarp Sandstone		Kaimur Conglomerate		Mangesar Formation		
	Bijaygarh Shale		Bijaygarh Shale		Bijaygarh Shale		
	Susnai Conglomerate breccia				Ghaghar Sandstone		
	Silicified Shale				Susnai Breccia		
	Lower Quartzite		Lower Kaimur Sandstone		Sasaram Formation		
	∼∼∼∼		∼∼∼∼		∼∼∼∼		
	Semri Series		Semri Series		Semri Group		

* This classification was a compilation from the study of earlier workers by Banerjee and Sengupta (1963, p. 142).

** Thickness data of these two formations are from Banerjee and Sengupta *(op. cit.)*.

known to imperceptibly grade upward into the Panna Shale in Eastern Rajasthan (Pascoe 1975, p. 525), and at least in one locality, i.e., (Badanpur, 24°09'N, 84°50'E) in the Son Valley, it grades into the Jhiri Shale. Likewise, the contact between the Rewa and the Bhander Groups could be placed along the boundary between the Ganurgarh Shale and the overlying Lower Bhander Limestone (Lakheri Limestone of Prasad, 1984: Shastry and Moitra, 1984) instead of along that between the 'Upper Rewa Sandstone' and the Ganurgarh Shale, which except for the local presence of diamondiferous conglomerate is gradational (Soni *et al.* 1987).

The problem is rooted to the nature of the sequence which essentially is an alternation of shale and sandstone, generally with gradational contacts. Absence of any regional unconformity or regionally correlatable key bed, along with rapid thickness variation leading to complete elimination of some of the major lithologic units at places, and number of stratigraphic overlaps compound the problem.

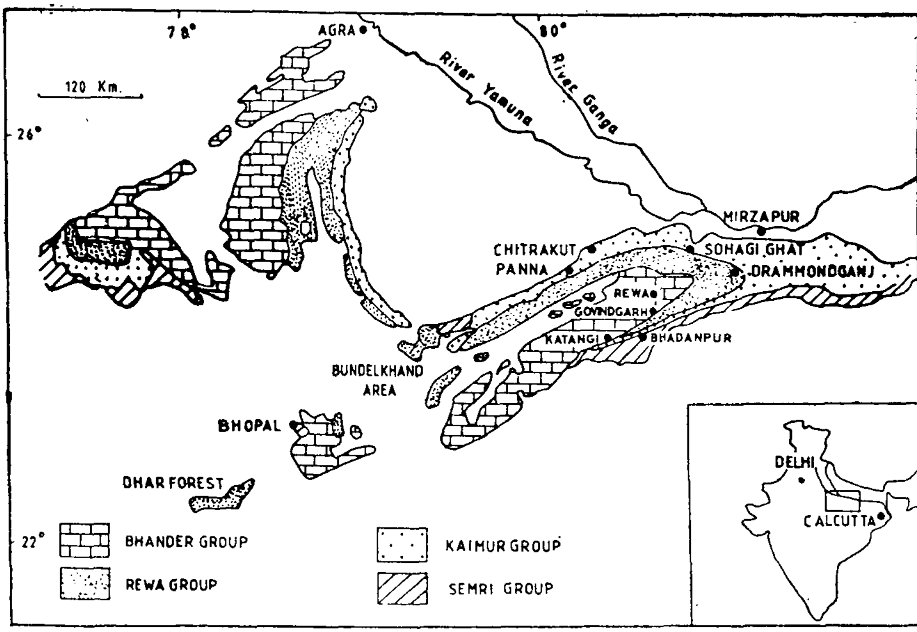


Figure 1. Location map showing outcrop distribution of Vindhyan sediments.

Reassessment of the classification of the sequence at the group level is beyond the scope of this paper. We have studied the Rewa Group, which is more variable than the other two groups (Pascoe, 1975, p. 525), and have attempted reclassification, characterisation and correlation of the constituent formations in the Son Valley. Our ideas are based mainly on our observation of the Rewa sequences exposed at Drammondganj (24°52'N, 80°10'E), Govindgarh (24°22'N, 81°18'E) and Bhadanpur sections in the southern exposure belt as well as at Sohagi Ghat escarpment (25°00'N, 81°45'E) in the northern exposure belt (Fig. 1). We have also attempted palaeogeographic reconstruction of the Son Valley area of the Rewa time, based on integrated analysis of regional stratigraphic relationships. facies and sediment dispersal pattern.

REWA SEQUENCE OF THE SON VALLEY

The Rewa Group of the upper Vindhyan sequence has been traditionally subdivided into four lithostratigraphic units, namely, the Panna Shale, Lower Rewa Sandstone, Jhiri Shale and Upper Rewa Sandstone, in that ascending order (Auden, 1933; Krishnan, 1968; Mishra, 1969; Pascoe, 1975 among others). Presently, the description of Rewa stratigraphy has been somewhat complicated by the use of a large number of local names by later workers (*see Table 5 of Soni et al.* 1987) which is in total disagreement with the code of stratigraphic nomenclature. Though not very well entrenched in literature, in compliance to the code of Stratigraphic Nomenclature of India (1977), we prefer to use the names Asan Sandstone (Lower Rewa Sandstone redesignated by Shastry and Moitra, 1984). The Govindgarh Sandstone (the erstwhile Upper Rewa Sandstone redesignated by Srinivasa Rao and Neelakantam, 1978; Prasad, 1984; and Shastry and Moitra, 1984) has been subdivided into two formations, as discussed later in this paper.

But far from the simplistic layer cake stratigraphy, the Rewa sequence of the Son Valley is characterised by remarkable facies changes, rapid thickness variation and uneven development of different lithounits in different parts of the basin. The maximum development of the Rewa Group with all its four major lithounits, however, has been noted only around the eastern and central part of the northern outcrop belt, i.e., around Sohagi Ghat and Chitrakut (25°11′N; 80°52′E), while it consists of only two formations, the Jhiri Shale and the overlying Govindgarh Sandstone in the southern exposure belt stretching from Drammondganj to the east, and Katangi (23°24′N; 79°46′ E) to the west (Srinivasa Rao and Neelakantam, 1978; Soni *et al.* 1987, Table 5).

In the northern belt, Panna Shale overlies Dhandraul Quartzite both around Sohagi Ghat and Chitrakut. But Panna Shale and the overlying Asan Sandstone (' Upper Rewa Sandstone ') pinches out west of Sohagi Ghat. Similar pinch out west of Chitrakut results in Jhiri Shale coming directly over the Kaimur rocks at and around Panna (Pascoe, 1975; Banerjee and Sengupta, 1963; Soni *et al.* 1987). As observed by us, the Jhiri Shale in the southern exposure belt, overlies different stratigraphic units at different localities. Whereas it overlies Dhandraul Quartzite both in Drammondganj and Bhadanpur, it overlies the uppermost porcellanite beds (Bhagwar Shale of Srinivasa Rao and Neelakantam, 1978) of the Semri Group around Govindgarh.

THE SOUTHERN BELT

Rewa Sequence at Drammondganj : Classification and Characterization

One of the most complete sections of Rewa Group (type section) is exposed in the Drammondganj Ghat escarpment (24°52′, 82°10′) (Fig. 1). The Rewa sequence here consists of three major units, the basal shale and shale-dominant unit and the two overlying sandstone units. In the following section, we have described the lithological and sedimentological attributes of these units in detail and forms the basis for the reclassification of the Rewa Group.

Shale and Shale-dominant Unit

The sequence varies in composition from shale with intercalated sand lenticles to sandstones with thin layers and flasers of shale. The sequence is 164 m thick and is subdivided into several facies, mainly on the basis of shale-sand ratio, viz., shale facies (≮ 10% sand), shale with intercalated sand facies (10–20% sand), shale-dominant heterolithic facies (20–50% sand), sand-dominant heterolithic facies (50–90% sand) and sandstone facies (Fig. 2). The sequence shows repeated alter-

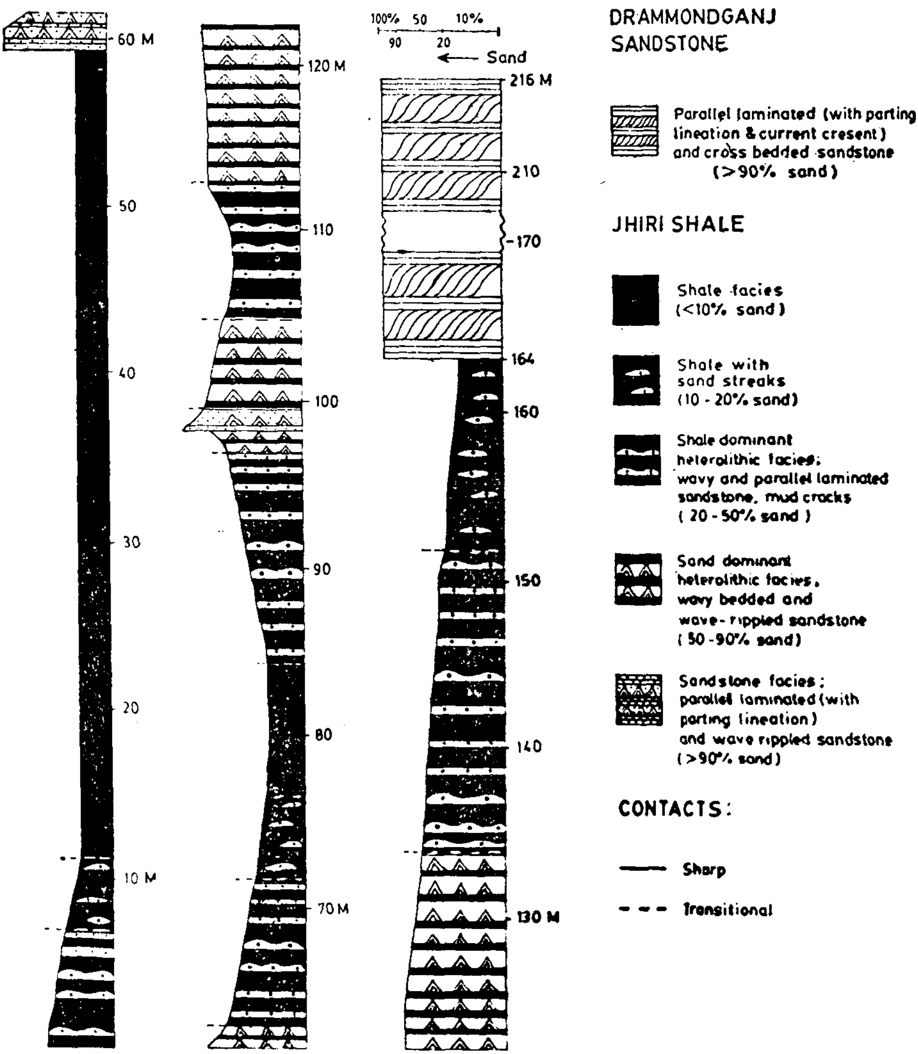
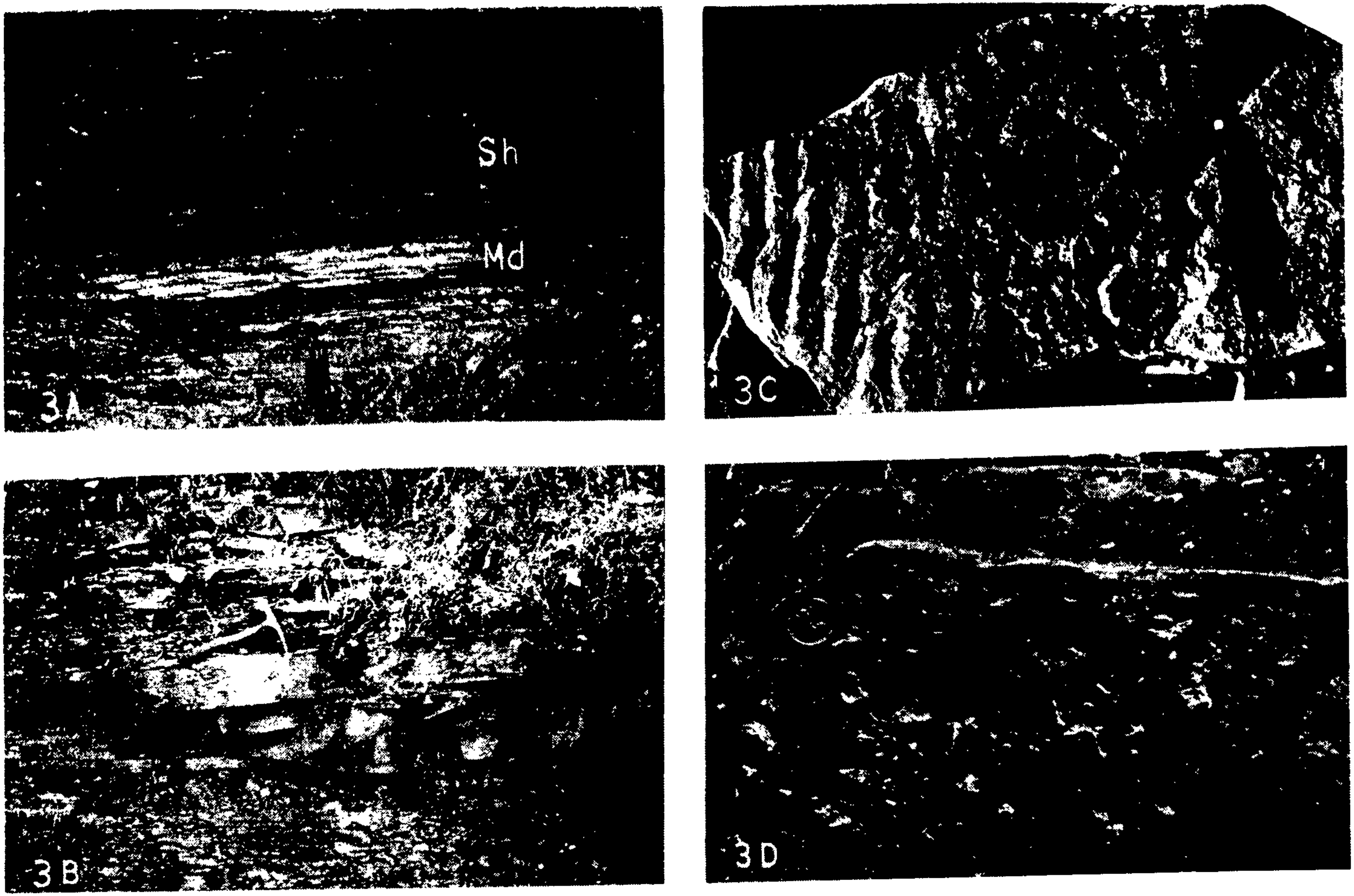


Figure 2 Measured stratigraphic column of the Rewa Group exposed in the Drammondganj escarpment. Jhiri Shale has been classified into a number of sedimentary facies based on relative content of sand and mud, shown in the horizontal scale (at the top).

nation of sand-dominant and sand-poor facies throughout its entire thickness, and all the facies occur more than once in the sequence. The complete sequence appears to exhibit cyclical coarse-to-fine (F-U) and fine-to-coarse (C-U) facies transition.


3A
Sh
Md
3B
3C
3D

However, the shale facies is better developed near the lower part of the sequence at 11 m to 59 m interval, though it occurs again at 76 m to 85 m interval.

The shale facies is red, reddish-brown to greenish-yellow and is characterised by well-developed, persistent thin laminations. In the sand-intercalated shale facies, shale is well laminated, as in the shale facies, and is intercalated with impersistent stringers and thin lenticles of fine- to medium-grained sandstone (Fig. 3a). The sandstone stringers are characterised mainly by thin, parallel lamination and ripple-like sand lenses that often show internal cross-laminations. Sand-filled mud cracks occur in a few beds.

In the heterolithic facies, both shale-dominant and sand-dominant, shale is chocolate, mauve or reddish-brown. It is gritty with poorly developed lamination that often breaks down into small splinters. Interbedded sandstones are brown to grey, medium to fine-grained, and occur as fairly continuous sheet-like bodies, with well developed wave-ripples, wavy laminations and ripple-drift laminations. Lower contacts of the beds are sharp and normally planar, though irregular contacts are not uncommon (Fig. 3b). A few of the sandstone beds in the sand-dominant heterolithic facies have well developed flutes at their soles. Upper contacts are often wavy or rippled. Sand beds in the sand-dominant heterolithic facies are, on an average, 5 cm to 10 cm thick. Mud cracks (Fig. 3c) are quite common, and are more frequent in the sand-dominant facies. Halite pseudomorphs (Fig. 3d) are locally present in the shale-dominant heterolithic facies.

Units of the sandstone facies occur at different positions in the sequence, and normally range in thickness from 85 cm to 200 cm. The facies consists of two types of sandstones. One type is medium-grained, fairly well-sorted and is characterised by parallel laminations with parting lineations, wave-ripples with mud flasers and cross-beds. This type is very similar to the parting lineated sandstone unit that overlies the shale-dominated sequence, and possibly represents tongues of the former into the latter. The other type is characterised by irregularly scoured base, and consists of poorly-sorted massive sands with large number of mud-clasts, followed upwards by large wave ripples. Straight-to-sinuous-crested ripples with highly variable crest orientation are abundant on top of many of such thicker sand bodies.

Few tens of metres away from the line of section measurement at 111 m to 135 m interval, three such sand bodies with thickness varying from 0.85 m to 1.34 m, were noted to alternate with mud-dominant heterolithic facies. Banerjee and Sengupta (1963) presumably considered one such thick sandstone as the thinned-out equivalent of Lower Rewa Sandstone exposed at Sohagi Ghat (25°N ; 81°45′E), and classified the shale sequence into two formations (Fig. 4). Appearance of multiple

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EXPLANATION OF FIGURE 3

Figure 3. Sedimentary features of Jhiri Shale at Drammondganj. (A) Shale with intercalated stringer of sand and thin laminae of sand (Sh) overlies an unit of mud-dominant heterolithic facies (Md) in the lower part of the sequence. (B) Sand-dominant heterolithic facies overlying shale with sand streaks. Note the sharp contact between the two facies and wavy base of the lowest sandstone bed. (C) Sand-filled mud cracks on the lower surface of a sandstone bed with casts of wave ripples ; specimen from sand-dominant heterolithic facies. (D) Halite pseudomorphs at the sole of a sandstone bed from an unit of mud-dominant heterolithic facies.

.ck sand beds at different positions of the sequence and repetitive occurrence of .il other facies, however, make such a classification questionable. The entire sequence, on the other hand, should be treated as a single formation characterised by heterogeneous lithology dominated by shale.

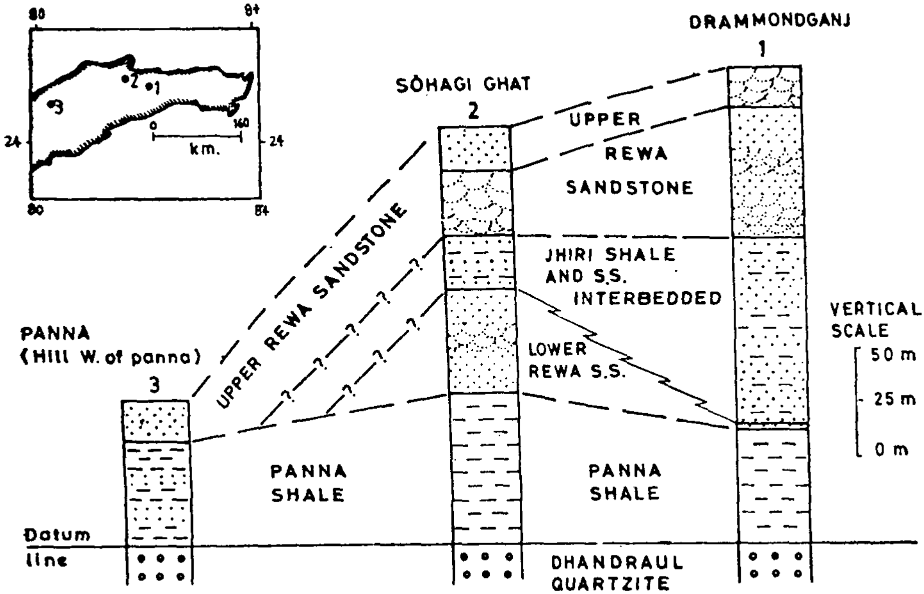

Figure 4. Stratigraphic correlation of Rewa Formation along the northern flank of Son Valley proposed earlier (after Banerjee and Sengupta, 1963). Inset map shows the location of the sections.

This shale-dominant sequence at Drammondganj, except for the presence of the thick shale facies, is lithologically nearly identical with the basal shale-dominant sequence at Govindgarh and Bhadanpur sections. Though not mapped, there is little doubt that the sequence is lithologically correlatable, and extends from Drammondganj in the east to Bhadanpur and beyond in the west, with local thickening and thinning (Figs. 5, 6).

Medium-grained Plane-bedded Sandstone

The sandstone (164 m to 216 m in Figure 2) is medium-grained, well-sorted, buff and quartzose in composition. It is texturally similar to the sandstone of heterolithic facies and the parallel laminated sandstone facies units in the underlying shale-dominant sequence. Low angle to horizontal, thin plane beds with parting lineation and well-developed current crescent on many of the parting lineated plane beds (Fig. 7a) are characteristic of this sandstone. Planar-tabular cross-beds and large accretionary sigmoidal foresets occur next in abundance to the plane beds. Very thin to 30 cm thick units of muddy sandstone or mudstone, at times, occur between plane-bedded sandstone units. Large mud clasts, concentrated along the base of certain sand beds are a characteristic component of this well-sorted sandstone.

Besides the well-sorted sandstone, medium to coarse massive sandstone and mudclast conglomerate occur as a major facies in this lower sandstone division. The conglomerates and massive sandstones occur at the base of F-U fills of shallow wide channels, and grade upward into fine, muddy wave-rippled sandstone through units of plane, parallel beds of medium sand. The channels, however, are often filled-up only with thin plane beds of well-sorted medium sand.

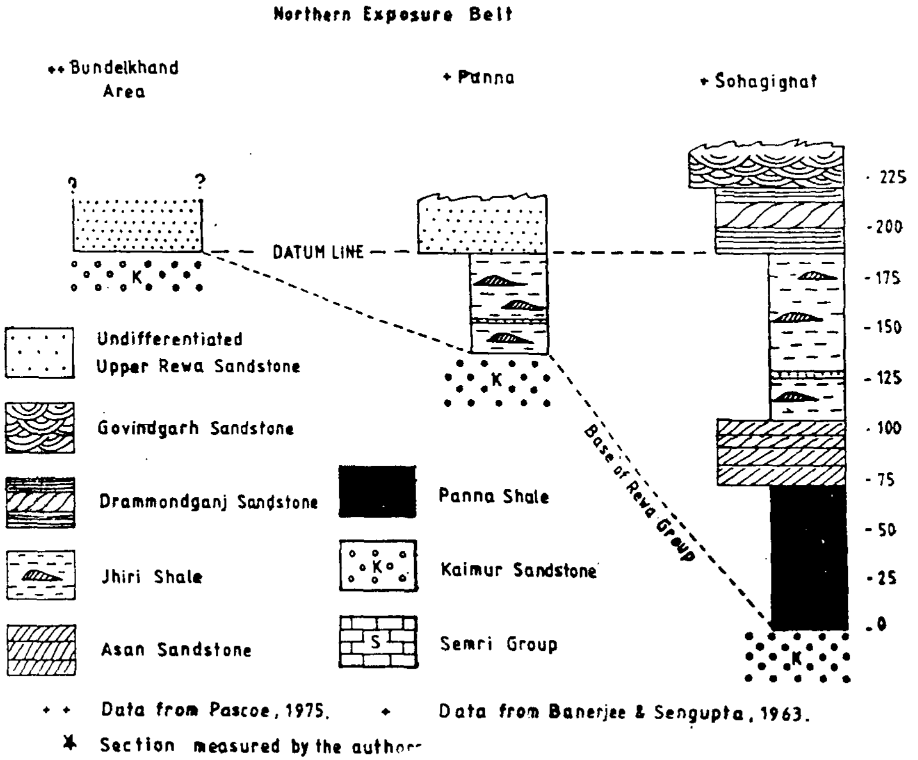

Figure 5. Revised stratigraphic correlation of the Rewa Group along the northern flank of the Son Valley. Note the overall thinning of the Rewa sequence westward from Sohagi Ghat.

Coarse-grained trough cross-bedded sandstone

This unit overlies the lower one with a sharp contact. It is brownish-grey, poorly sorted, with grain-size varying from granule to medium sand. Individual sandy beds are, however, moderately well sorted. Trough cross-bedding with set-thickness ranging from 15 cm to 65 cm and width in meter to decimeter range is the most dominant bedding type, the less common bedding types comprise planar foresets and low-angle stratification grading into small-scale cross-bed sets. Horizontal to nearly horizontal beds with parting lineation and wave ripple lamination, the hall mark of the underlying sandstone unit, is conspicuously absent in this sandstone.

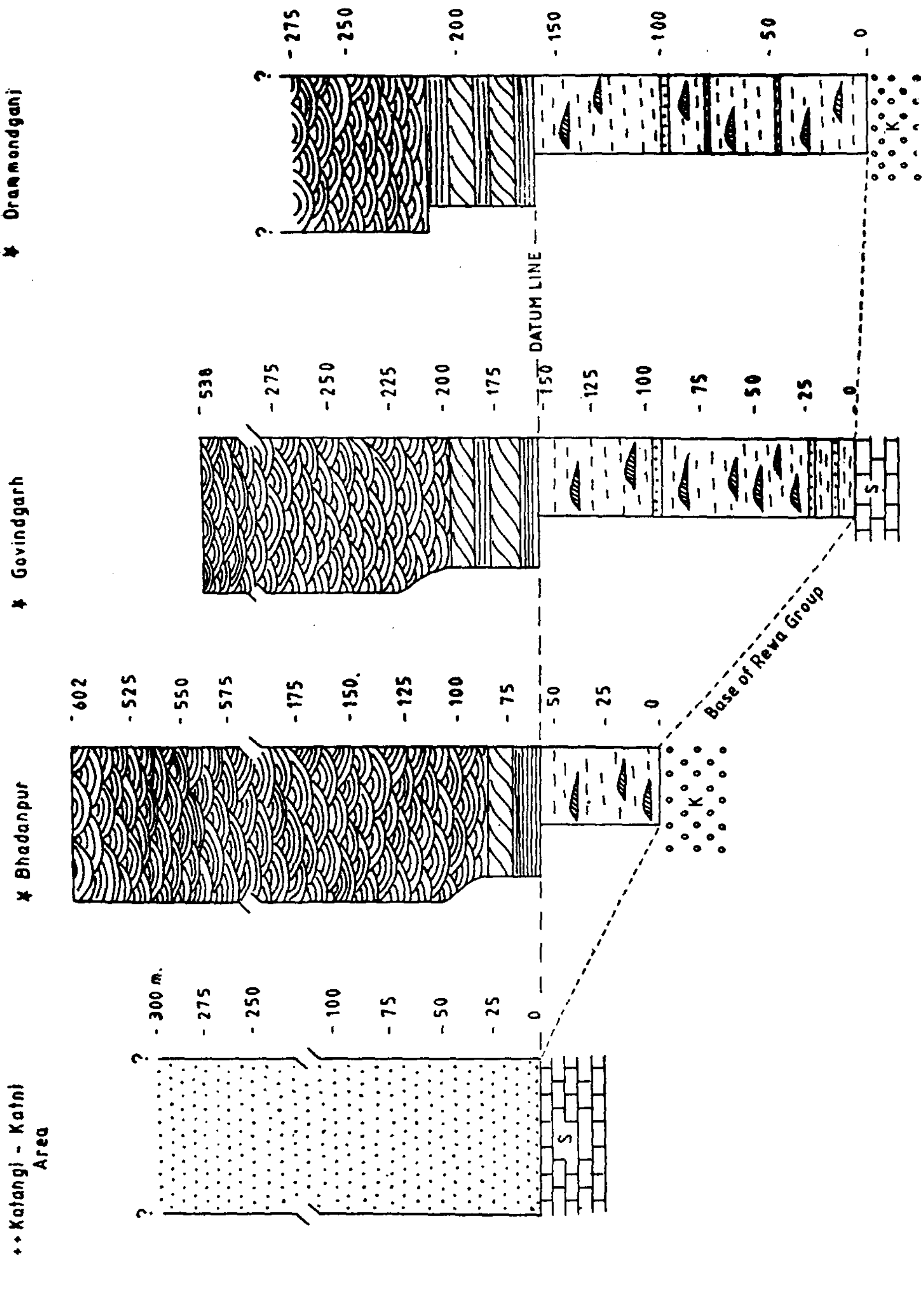

Figure 6. Revised stratigraphic correlation of the Rewa Group along the southern flank of the Son Valley. For legend *see* Figure 5.

A characteristic of this sandstone is the presence of a number of parallel to sub-parallel large planar erosion surfaces. Intervals bounded by two such surfaces sometimes show a F-U trend accompanied by decrease in the scale of cross-beds. Erosional scours of variable dimension are common on many of these surfaces. Another common feature of this unit is the development of soft sediment deformation consisting mainly of overturned cross-beds (Fig. 8) with persistent down-current overturning.

Rewa sequence at Govindgarh and Badanpur

The Rewa sequence in the hill ranges just south of Govindgarh is about 538 m thick with a thick basal shale-dominated unit overlying the porcellanite beds of Semri Group (Fig. 5). The shale is greenish-yellow to deep red, thinly laminated and with sandstone interbeds 1.5 m to .02 m thick. Thinner sand beds have a sheet-like tabular morphology and thicker ones display low angle cross-lamination, cross-beds, ripples, and mud-cracks. The shale is sharply overlain by a buff coloured, well-sorted medium sandstone with excellent development of parting-lineated plane beds and large planar cross-beds. In contrast, the uppermost 338 m of the sandstone sequence is marked by red colouration, coarser grain-size, poor sorting and dominance of trough cross-beds. Contact between two sandstone units is gradational in this section, but the two sandstone units as well as the basal shale are easily correlatable with the Rewa sequence of Drammondganj.

In the Rewa section north of Bhadanpur all these three lithological units, i.e., a shale with sand interbeds, a buff-coloured medium sandstone with plane beds and a red-coloured poorly sorted sandstone with trough cross-beds can be easily identified. The contact between the upper and lower sandstone division of the Rewa sequence is gradational but clearly distinguishable on the grounds of lithology and primary structure. The basal shale sequence conformably overlies the quartzite of the Kaimur Group. West of Bhadanpur around Katni-Katangi area, Jhiri Shale is reported to occur again in direct contact with Semri rocks (Pascoe, 1975, p. 524, Soni *et al.* 1987).

THE NORTHERN BELT

Rewa Formations at Sohagi Ghat and around Panna

A thick section of Rewa Group is well-exposed in the Sohagi Ghat escarpment (Fig. 1). This sequence has been classified into four formations by Banerjee and Sengupta (1963), which from bottom upwards are Panna Shale, Lower Rewa Sandstone (Asan Sandstone), Jhiri Shale and Upper Rewa Sandstone (Govindgarh Sandstone) (Banerjee and Sengupta, 1963 ; Soni *et al.* 1987). As described by Banerjee and Sengupta (1963) and as also noted by us, the Panna Shale that overlies the Dhandraul Quartzite of the Kaimur Group is characterised by very well-developed, rhythmic varve-type laminations. Individual laminae are extremely persistent and can be traced for over tens of metres. It is virtually devoid of sand, current or wave-formed structures and any evidence of exposure. Remarkable uniformity of its lamination style and of other physical attributes throughout its entire thickness is the characteristic of this shale at Sohagi Ghat. The Jhiri Shale, on the otherhand, is characterized by intercalation of sand layers or interbedding of sand and shale beds, with highly variable sand:shale ratio at different points. The Jhiri Shale sequence except for the occurrence of shale facies ($\leq$10% sand) is almost identical to the shale sequence at Drammondganj.

The Upper Rewa Sandstone (Govindgarh Sandstone of Srinivasa Rao and Neelakantam, 1978 among others) of Sohagi Ghat is similar to the sandstone sequence of the Drammondganj almost on all the details of the primary structures and sandbody geometry. The two sandstones recognised at Drammondganj are also easily recognisable at Sohagi Ghat. The Lower Rewa Sandstone (Asan Sandstone of Shastry and Moitra, 1984), on the otherhand, does not appear to have any correlatable counter part at Drammondganj.

A similar stratigraphic sequence of Rewa Group has been recorded also around Chitrakut (Soni *et al.* 1987). At around Panna, however, it comprises two units, a lower shale sequence resting directly over Dhandraul Quartzite and, an upper sandstone sequence. According to Banerjee and Sengupta (1963), the shale sequence here is interbedded with fine-grained quartz wacke with 30% clay matrix, and the overlying sandstone shows excellent development of tabular and wedge shaped cross-stratification. They correlated the shale sequence with the Panna Shale and the sandstone sequence with the Upper Rewa Sandstone of Sohagi Ghat.

CORRELATION

If the upper surface of the Dhandraul Quartzite is considered as the datum for correlation, Panna Shale at Sohagi Ghat possibly may be correlated with the shale sequence at Drammondganj or at Panna (Banerjee and Sengupta, 1963; our Fig. 4). However, we have noted that the Dhandraul Quartzite is neither always present at the base of the Rewa Group nor is it always succeeded by the same formation throughout the basin (Figs. 5, 6). At Govindgarh, the Dhandraul Quartzite is absent, and the basal shale-dominant sequence of the Rewa Group occurs directly on the Semri rocks, though it overlies the Dhandraul Quartzite at Drammondganj and Badanpur. Near Katangi and Bundelkhand, on the other hand, the Dhandrual Quartzite is directly overlain by the 'Govindgarh Sandstone' ('Upper Rewa Sandstone') which gradually comes directly over the Semri rocks further westward along both the exposure belts (Pascoe, 1975; Shastri and Moitra, 1984; Soni *et al.* 1987). Stratigraphic relationships clearly indicate that the Dhandraul Quartzite cannot be considered as a datum for correlating the Rewa Formation.

Such a correlation would also be questionable on the ground of lithology. Apart from the varve-type lamination, almost complete absence of sand, current and wave-formed structures or any evidence of exposure very clearly differentiates the lithologically uniform and homogeneous Panna Shale at Sohagi Ghat from the shale-dominant sequence at Drammondganj and Panna. Even the shale facies at Drammondganj is not completely devoid of sand. Moreover, this shale facies grades laterally and vertically into shale-dominant heterolithic facies and occurs as an integral part of a system of fining- and coarsening-upward clays. Any such variation in time and space is conspicuously absent in the Panna Shale which is very abruptly overlain by the highly mature, quartzose Asan Sandstone (Lower Rewa Sandstone).

Lithostratigraphic considerations, on the other hand, call for the correlation of Jhiri Shale at Sohagi Ghat with the similar shale-dominant sequence at Drammondganj, Govindgarh, and Bhadanpur in the southern belt and the shale sequence at

Panna in the northern belt, despite the fact the shale overlies different stratigraphic horizons at different localities (Figs. 5, 6). This shale sequence, the Jhiri Shale, occurs as a regionally extensive unit of the Rewa Group in the Son Valley, more or less with uniform physical attributes at both the southern and northern belts.

Likewise, the two subdivisions of the 'Govindgarh Sandstone' or the 'Upper Rewa Sandstone' also occur as regionally extensive sheets with extreme homogeneity of physical characters. The two subdivisions identified along the southern exposure belt are also easily recognizable at Sohagi Ghat. Though the two units were not mapped physically, their thickness and readily identifiable physical characters in widely separated sections leave little doubt about their mappability (Figs. 5, 6). We propose that these two subdivisions be treated as two separate formations in accordance with the stratigraphic code (CSNI, 1977). A very well developed section of the lower one is exposed at the Drammondganj escarpment and in the quarries on the plateau. This section may be described as the type section and we formally designate the unit as *Drammondganj Sandstone*. The upper one is very well exposed at several sections both in the southern and northern exposure belts. We, however, suggest retaining the term *Govindgarh Sandstone* for this unit, the designation which was originally proposed by Srinivasa Rao and Neelakantam (1978) and subsequently used by Prasad (1984) as well as Shastry and Moitra (1984) to formally designate the whole of the informal unit, the 'Upper Rewa Sandstone' of Mallet (1869). The hill slope immediately south of Govindgarh exposes excellent outcrops of this sandstone, and may be considered as its type area.

The Panna Shale and the Asan Sandstone do not have any lithostratigraphic equivalent either along the southern exposure belt or to the west of Chitrakoot along the northern belt. They appear to be two locally developed or preserved units around Sohagi Ghat and Chitrakoot. Stratigraphic grouping of these two units bounded by regionally extensive Dhandraul Quartzite and Jhiri Shale remains open to question. They are conventionally considered as the constituents of the Rewa Group, though imperceptible passage of the Panna Shale with the underlying Kaimur in Eastern Rajasthan (Pascoe, 1975) indicates that these two units could be considered as parts of the Kaimur Group as well.

DEPOSITIONAL ENVIRONMENT AND PALAEOCURRENT PATTERN

Jhiri Shale

Widespread development of wave ripples and wave laminations in the sandstone beds and of mudcracks suggest deposition of the heterolithic facies in periodically exposed shallow, nearshore marine environment. Absence of any evidence of appreciable sand influx or any other imprints of current or wave activity in the shale facies at Drammondganj indicates its deposition in fairly deep, quiet water, well below the wave base. Almost complete transition from shale facies to sandstone facies through heterolithic facies with variable proportions of sand points to a continuous variation of the depositional realm from shallow, wave-agitated areas with high sand influx to deeper, quiet areas without any appreciable sand influx. Presence of salt-pseudomorphs in the sequence points to a restricted, mud depositing coastal environment. The scenario possibly is that of a very large lagoon with intermittently exposed extensive flats, or more probably an extensive coastal flat-like the Rann of Kutch. Presence of flutes at the sole of many sandstone beds and parting lineation speaks for episodic development of high energy flows, possibly during exceptionally strong flood tides or storm which emplaced thin sheets of sands.

Drammondganj Sandstone

Preponderance of parting-lineated, thin plane beds in the Drammondganj Sandstone suggests deposition mainly in upper flow regime at a very shallow depth. Prevalence of high velocity flows in the depositional environment is also indicated by the presence of sigmoidal forsets which are slightly thicker and are upwardly convex near the brink point and often merge with the top set. Palaeocurrent was measured from a combination of parting lineation and current crescent as well as from cross-bedding. Both sets of measurement show a highly persistent flow direction towards northwest, both in southern and northern exposure belts (Fig. 9). Recognition of sand body geometry was attempted through examination of a number of fairly long quarry faces with different orientations on the plateau above the Drammondganj escarpment. In sections transverse to the mean flow direction, the sand bodies appear as convex-up, lens-shaped features, with widths in the range of few tens of metres (Fig. 7b).

Lengths of these lens-shaped bodies could not be properly delineated due to limited exposures and the absence of subsurface data, but their lengths are probably one order of magnitude greater than their widths. Direction of elongation of the sand bodies are parallel to the mean flow direction, and in the longitudinal sections they appear as flat-topped morphologies with well developed accretionary foresets down the current direction, i.e., northwest.

The geometry of the lens-shaped sandstones shows them to be aggrading, positive depositional features, the linear-bar shoals. Close parallelism of the bars with regionally persistent, strongly unidirectional flow system suggests that they were accreted close to the coast by strong longshore currents. The facies constancy of the bars in terms of structure as well as texture, and the presence of features indicating very shallow depth all along the exposure belt of this sandstone suggests that the bars were parallel to the depositional strike rather than to the depositional slope, with no significant change in the bathymetric level. The features can be consistent only with longshore bars. Further, the juxtaposition of the bars against a mudstone with emergence and desiccation features strengthen the contention.

EXPLANATION OF FIGURES

Fig. 7. Sedimentary features of Drammondganj Sandstone at type locality. (a) Current crescents on parting lineated bedding surface. Current flow is from left to right. (b) Transverse profile of a shoal-bar. Upper surface of the composite sand body (marked by arrows) is convex up and slopes down on both sides away from the crest. Note horizontal plane beds at crestal part.

Fig. 8. Successive sets of deformed cross-beds in the Govindgarh Sandstone. Note overturning of cross-beds in the thick bed (marked A) in the middle. Foresets in the upper part of the photograph (marked B) are undeformed.

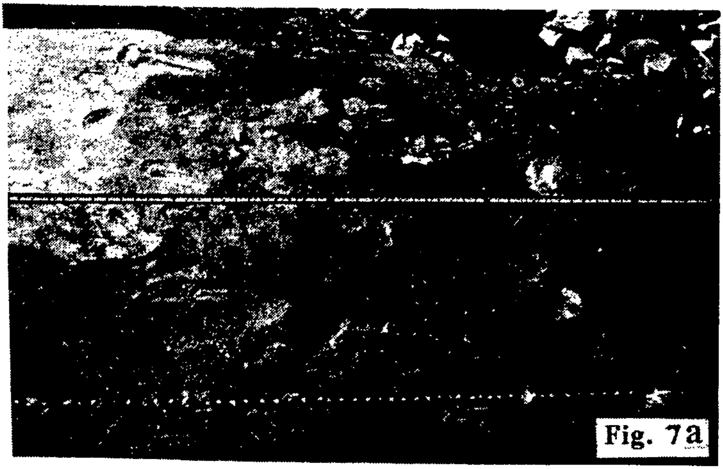

Fig. 7a

Fig. 7b

Fig. 8

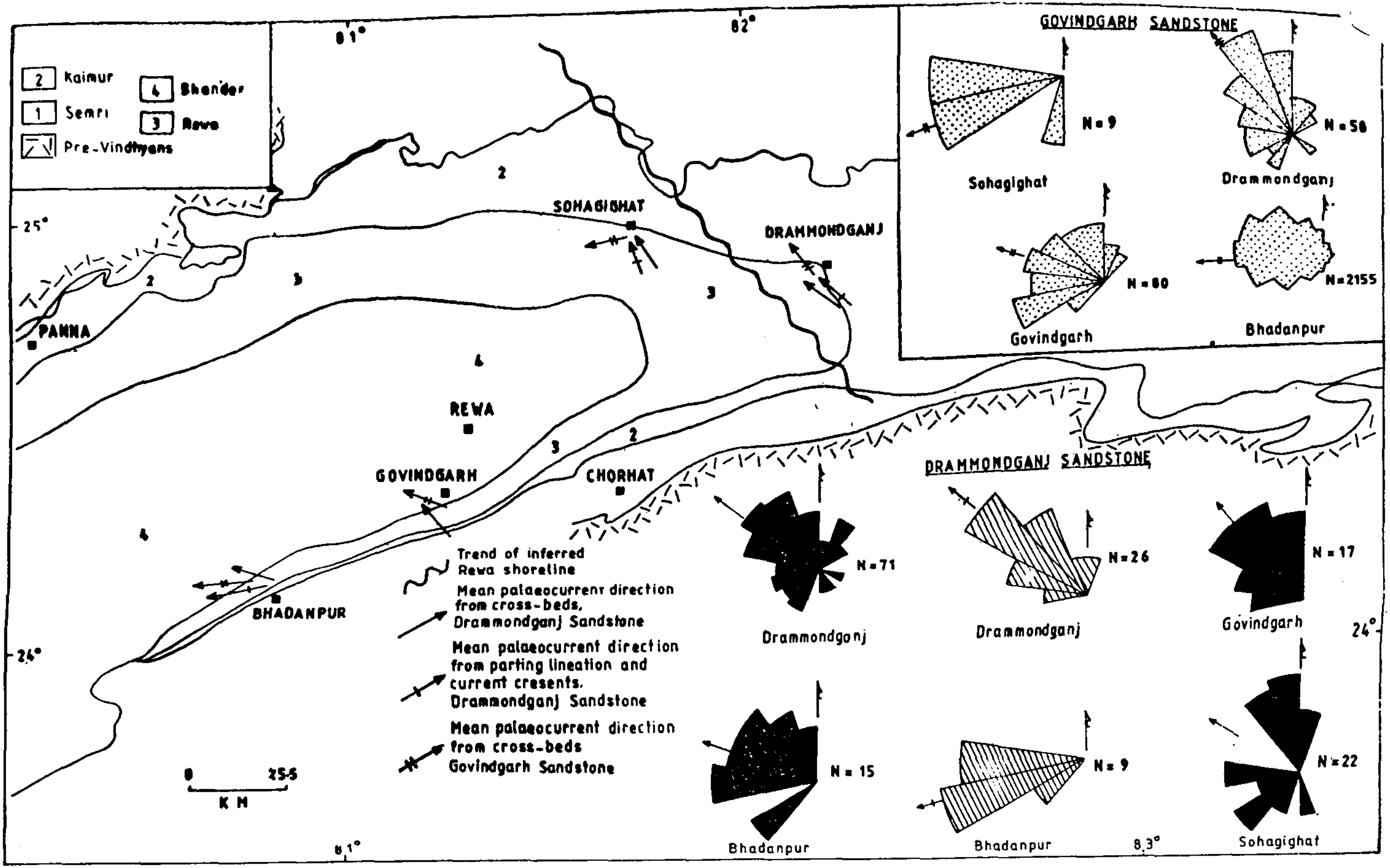

Figure 9. Map showing current flow directions in the Son Valley Vindhyan Basin during Rewa sedimentation and inferred trend of shore line of the marine basin. Rose diagrams are constructed following the method by Chenney (1983). Stippled Roses are for Govindgarh Sandstone, striped ones for parting lineation and current crescent data and dark ones for cross-bed data from Drammondganj Sandstone.

Govindgarh Sandstone

Abrupt change in texture, both in terms of size and sorting, stratification style and internal organisation of primary structures across a sharp to gradational contact between Drammondganj Sandstone and Govindgarh Sandstone indicate superposition of distinctly different, apparently unrelated depositional modes. Poor sorting, preponderance of trough cross-stratification, profusion of extensive planar erosional surfaces bounding sand bodies with fining and thinning-upward trends, collectively point to fluvial depositional mode. The absence of any wave-generated structure of granule lag surfaces apparently goes in favour of a fluvial origin. Penecontemporaneous overturning of cross-beds, so common in this sandstone (Fig. 8), also lends support to a fluvial origin. Though reported from several environments, this type of soft sediment deformation seems to be more common to the fluvial systems (Allen and Bank, 1972).

Palaeocurrent in the Govindgarh Sandstone at differant localities is much more variable compared to that in the Drammondganj Sandstone. Directional variabilities within localities are, however, quite low. Mean flow direction in widely spaced localities varies from 321 to 252 (Fig. 9) with a broad westerly trend.

PALAEOGEOGRAPHY

The contact of the Jhiri Shale and the Drammondganj Sandstone though sharp (Fig. 2), intertonguing as well as interbedding characterise the relationship between the two in the Drammondganj escarpment. Some of the sandstone interbeds of the Jhiri Shale is correlatable with the Drammondganj Sandstone in terms of structure, texture and composition and they apparently represent the tongue of the Drammondganj Sandstone within the Jhiri Shale. Further, the sandstone interbeds of the Jhiri Shale are laterally gradational to the intervals of sand-dominant or the shale-dominant heterolithic facies at several points on the escarpment. The stratigraphical relationship as well as the lithological similarity suggest that the sands in the Jhiri Shale are the wedges of the sandbody forming the Drammondganj bar complex. The bar complex apparently acted as the barrier to open marine circulation and led to the development and maintenance of the low energy mud depositing environment. The superposition of the Drammondganj Sandstone over the Jhiri Shale was caused through the extensive transgression of the bar complex. Regionally persistent orientation of the shoal-bars developed parallel to long shore current in the Drammondganj Sandstone (Fig. 9) point to a very stable configuration of the basin with NW-SE trending shoreline.

Majority of the formations thin out in a southwesterly to south-southwesterly direction both along the southern and northern exposure belts. In the southern exposure belt, the thickness of the Jhiri Shale decreases from 164 m at Drammondganj to 154 m at Govindgarh and to 57 m at Bhadanpur. Thickness of the Drammondganj Sandstone decreases from 52 m at Drammondganj to 45 m at Govindgarh and to 26 m at Bhadanpur (Fig. 6). Along the northern exposure belt, thickness of the Jhiri Shale decreases from 75 m at Sohagi Ghat to 50 m at Panna (Fig. 5). A marked thinning of the total Rewa section is also noted from Sohagi Ghat towards Panna (Banerjee and Sengupta, 1963) and beyond.

Besides the thinning, many of the formations pinch out and are stratigraphically overlapped by the immediately overlying one in the same general trend. Along the southern exposure belt, each of the Kaimur Formations as well as the Jhiri Shale successively pinches out, and is overlapped by the succeeding one in the direction from Drammondganj to Katangi where the erstwhile upper Rewa Sandstone overlaps on to the Lower Vindhyan rocks (Pascoe, 1975). Similarly, the 'Upper Rewa Sandstone' in the northern exposure belt comes over the Dhandraul Quartzite at Bundelkhand, while further west, it comes directly over the Lower Vindhyan rocks (Shastry and Moitra, 1984).

The Panna Shale and the Asan Sandstone ('Lower Rewa Sandstone') have developed only at Chitrakoot and Sohagi Ghat in the eastern and central part of the northern belt. Apparently, these two formations have pinched out towards south as well as towards west.

Fullest development of the Rewa Group with four formations and general trend of increasing thickness of the marine Rewa Formation towards the northeastern part around Sohagi Ghat suggests that the marine Rewa basin had its margin towards the southwest and had a northeasterly paleoslope. Visualisation of a northeasterly sloping basin finds expression also in the:

1) southwesterly direction of truncation of each formation by the successive higher ones;
2) southwesterly direction of overlap of the Semri rocks by the successively younger formations; and
3) increasing stratigraphic hiatus between the Semri rocks and the upper Vindhyan Formations towards the southwest.

The interpretation of the northeasterly paleoslope conforms to our interpretation of NW-SE trend of the basin margin, arrived through the integrated analysis of paleocurrent and sandbody orientation around Drammondganj and Sohagi Ghat. Our interpretation of the basin configuration contradicts a commonly held notion that the Son Valley Vindhyan Basin opened towards west or northwest (cf. Ahmed, 1962; Banerjee and Sengupta, 1963; Banerjee, 1974; Singh, 1985). In our interpretation, the basin opened towards northeast and extended further beyond the northern and northeastern limit of the present day exposure limit, beneath the alluvium of the Ganga Valley (also *see* Krishnan and Swami Nath, 1959; Mishra, 1969; Hari Narain and Kaila, 1982; Srivastava *et al.* 1983). Persistence of northwesterly longshore current at Sohagi Ghat in the northern margin of the Rewa exposures corroborates the interpretation.

The northeasterly sloping marine basin was replaced by a westerly sloping fluvial basin towards the later phase of Rewa sedimentation. Westerly palaeoslope is clearly indicated by the westerly palaeocurrent of the fluvial Govindgarh Sandstone. Rapidly increasing thickness of the poorly sorted, gritty, red 'Rewa Sandstone', apparently the Govindgarh Sandstone, towards Bhopal and Dhar forest (Pascoe, 1975; Shastry and Moitra, 1984) possibly is a response of this westerly basin slope.

The change of the northeasterly slope during the marine phase of the early Rewa time to westerly direction during the late Rewa period of fluvial sedimentation suggest contemporaneous tectonism. The contemporaneous tectonism is perhaps also reflected in the development of the several localised sites of subsidence and deposition both during Rewa and Kaimur time, viz., around Bijoygarh (Banerjee and Sengupta, 1963); Drammondganj and Sohagi Ghat (present study); Dhar forest area (Pascoe, 1975). The signatures of contemporaneous deformation suggest the Vindhyan Basin was not as passive as has been conceived (cf. Chanda and Bhattacharya, 1982).

CONCLUSIONS

1. The 'Upper Rewa Sandstone' has been classified into two distinctly different types of sandstone, each of a formation status. The lower sandstone has been formally designated as the Drammondganj Sandstone and the upper one has been designated as Govindgarh Sandstone. The Drammondganj escarpment is the type section for the Drammondganj Sandstone, while the northern slope of hill range just south of Govindgarh is the type section for the Govindgarh Sandstone.
2. The Rewa Group in the Son Valley is redefined to consist of three regionally extensive formations, the Jhiri Shale, the Drammondganj Sandstone and the Govindgarh Sandstone in an ascending order. The Asan Sandstone and the Panna Shale have developed locally.
3. The Drammondganj Sandstone and the Jhiri Shale intertongue, and are interrelated to each other. The former developed as a complex of linear, shore-parallel bars under the influence of strong, unidirectional longshore currents, while the latter developed in vast, protected mud flat/lagoon environments, landward of the bar complex. The Govindgarh Sandstone, by contrast, has signatures of fluvial sedimentation.
4. The shore line of the marine Rewa basin marked by very persistent longshore current system had a NW-SE trend. The basin sloped down towards northeast, and probably extended much further northeastward beneath the alluvium of the Ganga basin.
5. The basin was much more extensive than the area defined by the limits of present day outcrops, and the outcrop pattern does not reflect the original basin geometry.
6. The palaeocurrent from the Govindgarh Sandstone indicates westerly palaeoslope of the fluvial basin, and attests to the marked change in basin configuration at the later stage of Rewa sedimentation.

ACKNOWLEDGEMENTS

We thank S. K. Chanda of Jadavapur University for his critical reading of several versions of the manuscript, and greatly appreciate his moderating comments. We thank our colleague Soumen Sarkar for his assistance in the fieldwork and for permitting us to use his unpublished palaeocurrent data from Maihar. Thanks are also due to A. K. Das for drafting the diagrams and to D. K. Saha for preparing the typescript.

Indian Statistical Institute funded the field research programme and provided all facilities for the work.

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(Received: Oct. 25, 1988; Revised form accepted: Jan. 27, 1990)