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Lithostratigraphy of the Neoproterozoic Chattisgarh Sequence, its Bearing on the Tectonics and Palaeogeography

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Abstract

The Neoproterozoic Purana succession in the eastern part of Chattisgarh basin around Sarangarh has been classified into a conglomerate-sandstone-shale dominated proximal assemblage, and a lithographic limestone-shale dominated distal assemblage. The proximal assemblage constitutes the Chandarpur Group, and unconformably overlies the Archean crystalline basement complex. The Chandarpur succession has been classified into three formations that were deposited in fan-fan delta, deep water prodelta and storm- tide dominated prograding shelf environments. The distal assemblage, the Raipur Group, conformably overlies the Chandarpur Group, and may be subdivided into two shale-dominated formations separated by a limestone-dominated formation. The limestone sequence, the Sarangarh Limestone, comprises a lower member of mixed carbonate-siliciclastic succession deposited in a storm dominated shallow water platform, and an upper member of pelagic limestone that grades upward into a deep water shale, the Gunderdehi Shale. The rapid transition from shallow water platformal succession to deep-water pelagic limestone and shale points to abrupt deepening of the basin and drowning of the craton. The peak of transgression is represented by a persistent horizon of black limestone, a product of basin wide anoxia. Disposition of facies belts in proximal and distal assemblages and palaeocurrent directions measured from different facies belts point to a north-northwesterly palaeoslope of the basin. Signatures of intense storm and tidal currents in different litho-units collectively point to an open marine circulation condition. It has been inferred that the basin was connected to a major seaway that skirted the northern and north-western margin of the craton. Development of thick fan-delta sequence at the base of the succession, occurrence of felsic welded tuff within the Gunderdehi Shale, thick sandstone-mudstone cyclothems in the Chandarpur Group, and abrupt drowning of the carbonate platform leading to pelagic sedimentation collectively point to major tectonic control on basin evolution. The basin developed as a cratonic rift and evolved into a deeply subsiding one, without any major stratigraphic hiatus, through episodic tectonic pulses.

Key words: Chattisgarh, cratonic basin, lithostratigraphy and tectonics, palaeogeography, Neoproterozoic.

Introduction

The Indian Peninsula hosts several Meso-to Neoproterozoic cratonic basins, generally referred to as 'Purana basins' that preserve thick successions of mildly deformed and weakly metamorphosed/unmetamorphosed sedimentary rocks. The basins are comparable with the Proterozoic-Early Palaeozoic cratonic basins of North America, Australia and Siberian platform in respect of duration of basin history, size, sediment thickness and depositional systems. Origin of the basins, however, is still poorly constrained, though a riftogenic origin has been invoked for a few of them (Naqvi and Rogers, 1987; Chaudhuri et al., 2002).

The origin of cratonic basins, in general, has been debated for decades (Sloss, 1991; Miall, 1999). It is now considered that periods of formation of many cratonic basins are coincident with the fragmentation of supercontinents (Hartley and Allen, 1994), and a close relationship of the craton margin events with the mode of origin of the basins is now fairly well established. The origin of the basins is strongly reflected in the basin filling successions, their lithologies, depositional systems and stratigraphic architecture. The stratigraphic basin analysis appears to be the most significant tool in evaluating the tectonic history of the basin.

The Purana succession in different basins of South India consists of stacked cyclothems of different orders, and the cyclothem at the basal part of the Chattisgarh succession has been attributed to active tectonic episodes and rifting of the cratonic basement (Patranabis Deb and Chaudhuri, 2002). The Chattisgarh succession attracted the attention of geologists for last hundred years or more (Medlicott, 1866–1867; King, 1885; Ball, 1877; Dutt, 1964; Schnitzer, 1971; Murti, 1987; Das et al., 1992) and majority of the studies are focussed on the stratigraphic classification of the basin filling succession. The views on the stratigraphic classification of the Chattisgarh succession, however, vary widely. The divergence of views reflects the stratigraphic complexities, and also reflects the problems inherent to the classification and correlation of unfossiliferous Proterozoic strata, particularly when endeavours are not backed by adequate radiometric age data.

In the present paper stratigraphic classification of the Chattisgarh succession around Sarangarh in the eastern part of the basin has been re-evaluated on the basis of detailed mapping and measurement of several stratigraphic profiles. The relationships between different stratigraphic units have been critically examined to reconstruct the stratigraphic history, events of sea-level changes and palaeogeographic evolution. The recognition of stratigraphic history of the Chattisgarh basin and its bearing on palaeogeography and basin tectonics are strongly based on sedimentological aspects of the lithologies.

Chattisgarh Geology and Previous Work

The Chattisgarh is a major Neoproterozoic cratonic basin in peninsular India, which covers about 33,000 sq. km of the Chattisgarh State with a narrow extension in Orissa (Fig. 1). Majority of earlier studies on the Chattisgarh were concentrated mainly in the western and south-central parts of the basin where the succession is characterized by prolific development of algal stromatolites and mature sandstones, a characteristic stable platformal association (Dutt, 1964; Murti, 1987). The geology of the eastern part of the basin, by contrast, comprises variety of lithologies ranging from thick wedges of conglomerates and coarse feldspathic sandstones, extensive blankets of shale and lithographic limestone, and pyroclastics, deposited in widely varying conditions of sediment input, reworking, transport, and bathymetry. The sedimentary rocks are gently dipping to subhorizontal, except near major faults, and unconformably overlie Archean granite gneiss and greenstone terrain.

The age of the succession is not very precisely constrained. Kruezer et al. (1977) suggested a K-Ar date of 700–750 Ma for the basal part of the succession, whereas Schnitzer (1971) proposed that the succession may range between 800 and 1100 Ma in age. Chaudhuri et al. (1999) tentatively placed it in the Neoproterozoic Era.

Schnitzer (1971) identified five sedimentational cycles and multiple unconformities in the Chattisgarh succession and assigned Supergroup status to it. Murti (1987) subdivided the Chattisgarh Supergroup into the coarse siliciclastic dominated Chandarpur Group (ca. 400 m) and the limestone shale dominated Raipur Group (ca. 1700 m), separated by a major unconformity (Table 1). Moitra (1995) broadly followed the classification proposed by Murti (1987), though he did not unequivocally accept the unconformity between the two groups.

Das et al. (1992) considered the easternmost part of the Chattisgarh basin as a sub-basin, and designated it as the Baradwar sub-basin (Fig. 2). They defined three groups in this sub-basin, the middle and the upper one of which correspond to the Chandarpur Group and the Raipur Group respectively. They defined the basal one as the Singhora Group and proposed an unconformity between the Singhora Group and the overlying Chandarpur Group, but considered that the Raipur Group gradationally overlies the Chandarpur Group (Table 1).

The major problem in the classification of the Chattisgarh succession appears to lie in the recognition of unconformities and unconformity bounded sequences. The proposition of two unconformity bounded, coarse clastic dominated sequences, the Singhora Group and the Chandarpur Group (Das et al., 1992) if valid, would significantly change the constructional history of the basin. Likewise, the relationship between the clastic dominated Chandarpur Group and the limestone dominated Raipur Group also requires a closer scrutiny, as the nature of transition from the clastic depositional system to the carbonate depositional system would be largely controlled by basin tectonics and palaeoclimate.

Classification of the Succession around Sarangarh

The lithostratigraphic succession around Sarangarh has been established on the basis of lithological mapping of an area of about 1000 sq. km in 1 : 50,000 scale. The mappable units of formation status had initially been designated alphabetically (North American Code of Stratigraphic Nomenclature, 1983), and were formally designated after evaluating their relationship or correlatibility with the existing formations. New formations were proposed as and when necessary. Examination of the lithological units and their mutual relationships led to the recognition of two assemblages (Patranabis Deb, 2001a). Assemblage I is dominated by conglomerate, pebbly sandstone, very coarse- to medium-grained sandstone and green shale, fine-grained sandstone and siltstone. Assemblage II is dominated by brown shale and micritic limestone, with subordinate amount of medium- to fine-grained sandstone, dolostone and green shale. Both the assemblages have been subdivided into three lithostratigraphic units (Figs. 3 and 4) of formation status (NACSN, 1983). Lithological summary of different stratigraphic units and their inferred depositional environments are given in figure 5 and table 2.

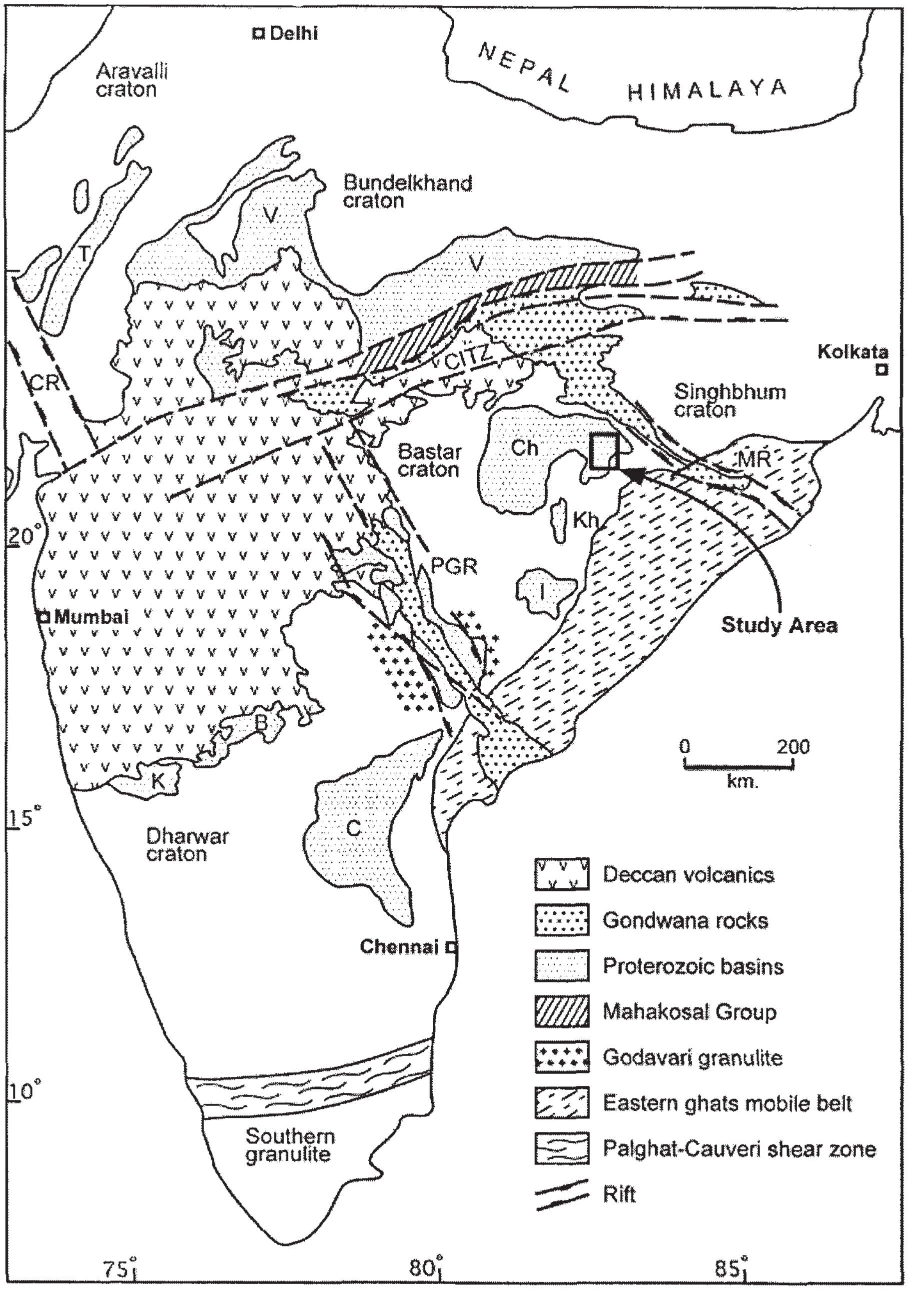

Fig. 1. Distribution of Chattisgarh and other Purana basins in Indian shield: Ch–Chattisgarh, Kh–Khariar, PGR–Pranhita-Godavari Rift, C–Cuddapah, B–Bhima, K–Kaladgi, V–Vindhyan, T–Transaravalli. CITZ, MR and CR refer to Central Indian Tectonic Zone, Mahanadi Rift and Cambay Rift respectively.

Assemblage I

Formation A

The formation comprises conglomerate, granulestone, very coarse- to coarse-grained, locally pebbly, feldspathic sandstone, and minor siltstone, often arranged in fining-upward sequences. The formation is exposed mainly in the southeastern part of the area, and unconformably overlies granites and gneisses of the basement and rocks of the Sonakhan greenstone belt. The succession is best exposed in a scarp section about 0.5 km east of the village Jognipali (21°25'N 83°18'32"E) on the Jhikipali-Jognipali road, where it is 150 m thick. It is designated as Jognipali section after the name of the village and is the type section of the formation (NACSN, 1983).

The conglomerates pass upward to coarse-grained, immature to submature, feldspathic to quartzose sandstones reflecting highly divergent depositional milieu. The sandstones in the lower part of the formation are generally coarse-grained, and feldspathic with abundant angular, cleavage blocks of fresh feldspar. The upper part of the formation is dominated by coarse- to medium-grained, submature feldspathic sandstones that alternate

Table 1. Stratigraphic classification of parts of Chattisgarh basin.

Dutt (1964) (southern part)	Schnitzer (1969) (northern part)	Murti (1987) (south central part)	Moitra (1990)	Das et al. (1992)	Patranabis Deb (present work)
Kurnool Series		Chhattisgarh Supergroup		Chhattisgarh Supergroup	Chattisgarh Supergroup
		Raipur Group		Raipur Group	
Raipur Shale-Limestone (450m)	Maniari Shale (100m) Hirri Kharkhena Dolomite (50-100 m) Belha Limestone (80 m) Patharia-Umaria Shale (50 m)	Tarenga Shale (180m)	Tarenga Shale (180m)	Maniari Formation (70m) Hirri Formation (70m) Tarenga Formation (180m?)	
Khairagarh Sandstone (variable thickness)	~Unconfirmity~ Nandini Limestone (80-100m) Bhatapara Limestone/Dolomite (50m)		Khairagarh (Deodengar) sandstone (variable thickness)		
	Lilagarh Shale (50m) Akaltara Dolomite/Siliceous Limestone and Arenite (40m)	Chandi Limestone (670m)	Raipur Limestone	Chandi Formation (670m)	
	~Unconfirmity~				Raipur Group
Gunderdehi Shale (180m)	Karuid Shale (100-150m) Karuid Bituminous/Siliceous Limestone (50m)	Gunderdehi Shale (430m)	Gunderdehi Shale (430m)	Gunderdehi Formation	Gunderdehi Shale
Charmuria Limestone (300m)	Seorinarayan Shale (100m) Sarangarh Bituminous/ Siliceous Limestone (30-50m)	Charmuria Fm. (Limestone dominated) (490m)	Charmuria Limestone (490m)		Sarangarh Limestone (150m) Bijepur Shale (100m)
	~Unconformity~	~Unconformity~	???		
		Chandarpur Group		Chandarpur Group	Chandarpur Group
Chandarpur Sandstone (300m)	Chandarpur Quartzite (200m) Conglomerate (300m)	Kansapathar/ Kondkera Formation (+125m) Chaporadih Formation (15m) Lohardih Formation (240m)	Chandarpur Sandstone	Kansapathar Formation (20-200m) Chaporadih Formation (20-200m) Lohardih Formation (20m)	Kansapathar Formation (60m) Gomarda Formation (650m) Lohardih Formation (150m)
~Unconformity~ Archean: Granite, dolerite, etc.	~Unconformity~ Crystalline Complex	~Unconformity~ Archean Basement	~Unconformity~ Precambrian Granite	~Unconformity~ Singhora Group: Chhuipali Formation (300m?) Bhalukona Formation (20m±) Saraipali Formation (60m) Rehatikhol Formation (20m+) ~Unconformity~ Archean and Lower Proterozoic Basement	~Unconformity~ Archean Greenstone Belt and Granite Gneiss

with matrix-rich greenish sandstone and siltstone. The sandstones are, at places, affected by intense soft sediment deformation, such as convolute lamination, slump folding and liquefaction (Fig. 6).

Formation B

It is characterized by extreme lithologic heterogeneity, and comprises three major lithological components namely, green mudstone and green and black shale, sandstone-mudstone heterolithic and subarkosic sandstone. The sandstone-mudstone heterolithics are the dominant constituent of the formation, and occupy almost 65% of its thickness.

The subarkosic sandstone occurs as a thick sheet at the middle of the formation, and divides the heterolithic succession into a lower 125 m thick and an upper 250 m thick unit. The sandstone separating the two heterolithic units pinches out northward where the upper and lower heterolithics merge together. The contacts between three units are gradational, though may be sharp locally.

Mudstone and shale: The green mudstone and shale are well developed at the basal part of the lower heterolithics. The shale gradationally overlies fine sandstones and mudstones of formation A, and grades upward into the heterolithic rocks. At places, the shale onlaps formation A and directly overlies the basement. The mudstone/shale attains a maximum thickness of approximately 100 m in the southwestern part of the mapped area, and becomes thicker further southwards. Small isolated lenses of sandstone, about 2 to 10 m thick, occur at different levels within the mudstone.

A 3 to 4 m thick black shale occurs in the upper part of the upper heterolithic succession, and is best exposed in well sections near the Gomarda Rest House and near the Putka reservoir. The beds exhibit small-scale slump structures and wrinkle marks.

Heterolithic unit: The heterolithic unit is well exposed in almost all the sections along the Gomarda-Baramkela ridge and in the southeastern part of the mapped area around Damdama (21°27'N 83°20'E) and the Kinkari reservoir.

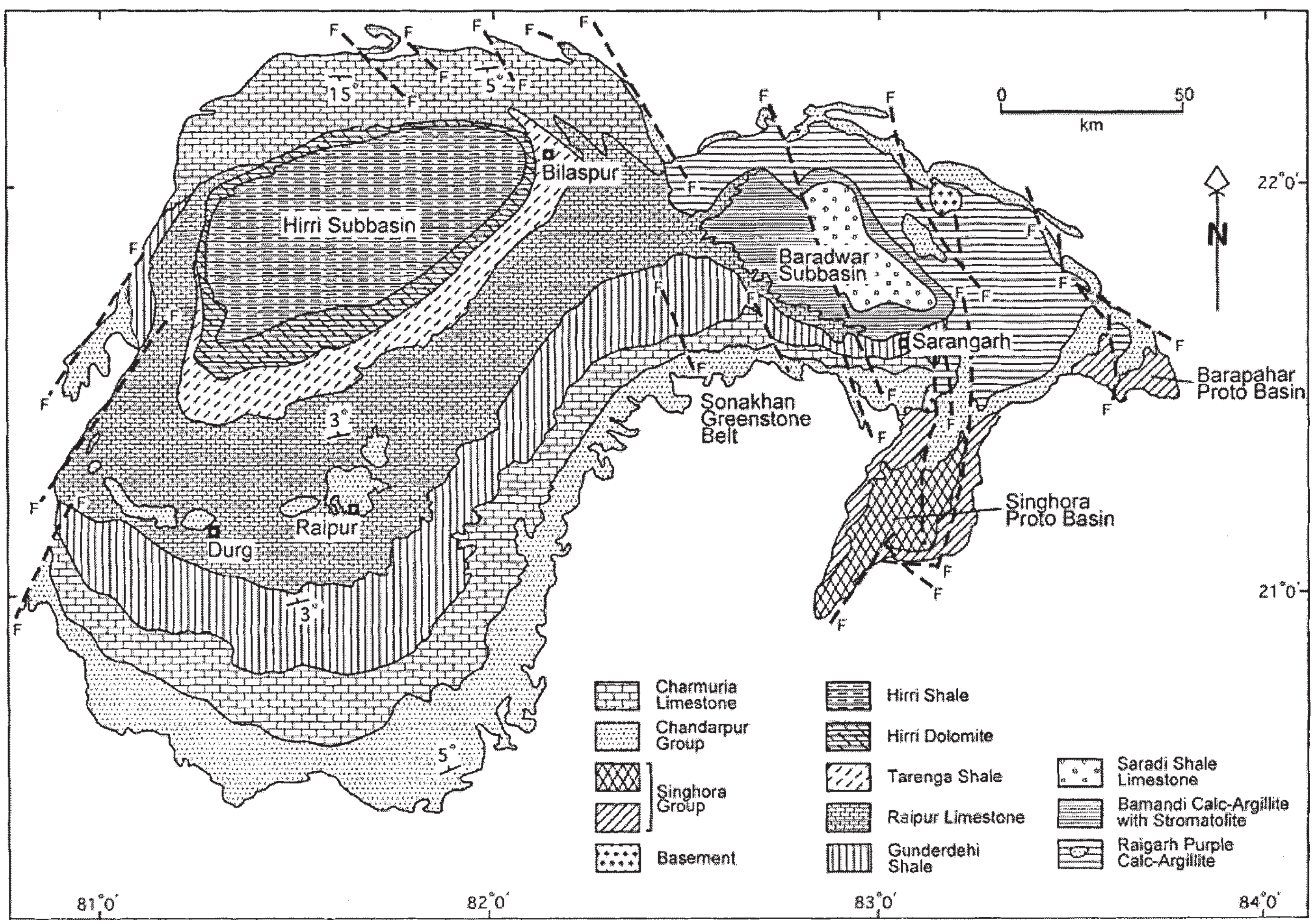

Fig. 2. Generalized geological map of the Chattisgarh basin, after Das et al (1992) and Moitra (1996).

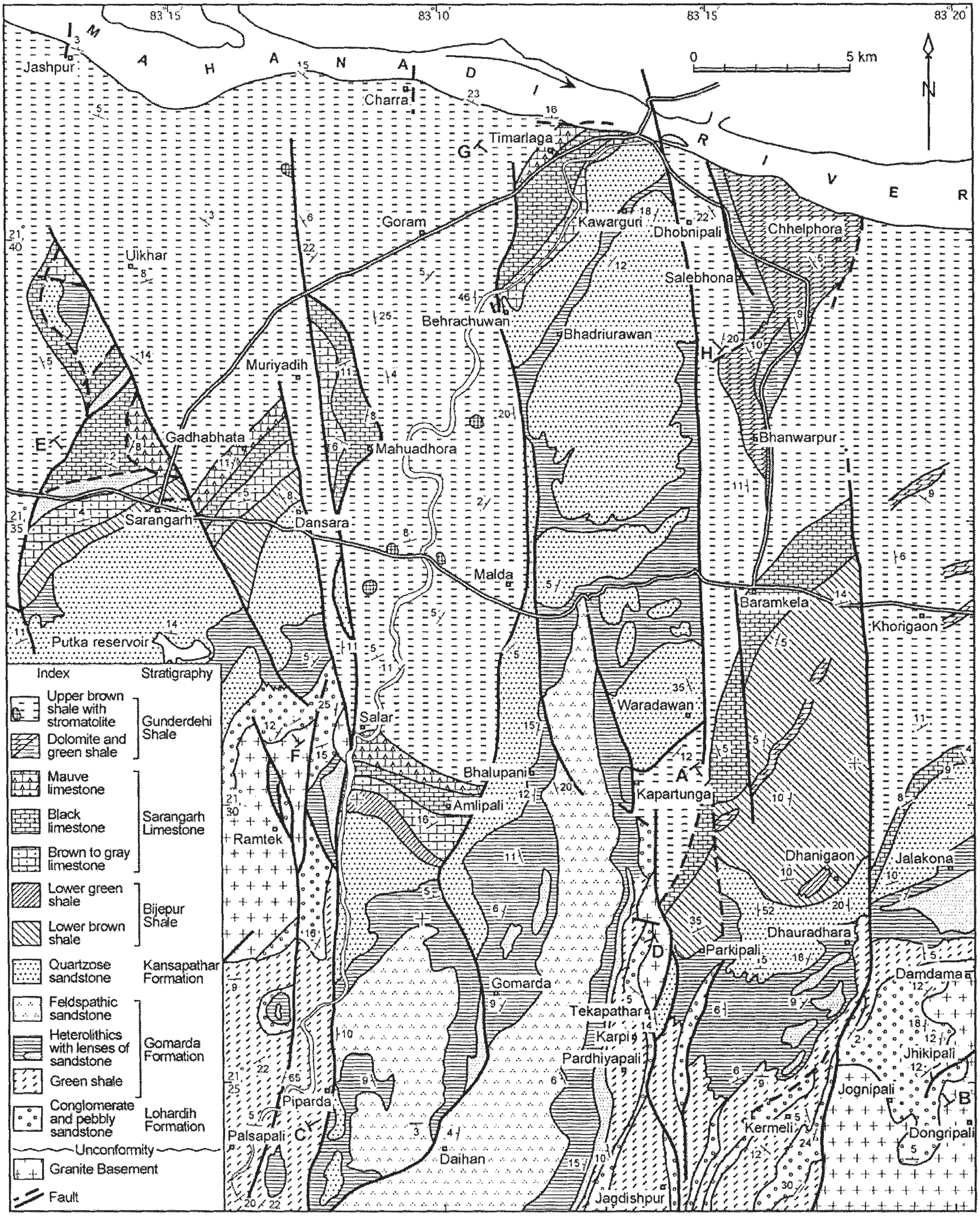

Fig. 3. Geological map of the Chattisgarh Supergroup around Sarangarh, Chattisgarh.

The heterolithic sequence compositionally varies from mud-dominated heterolithic (MDH) to sand-dominant heterolithic (SDH) through sand-mud heterolithic (SMH), and each type may recur several times in the succession.

Sandstone: This is a major scarp-forming sandstone and can be followed for about 25 km. It is thickest in the southern part of the map area (≈200 m) and pinches out north of the Baramkela-Sarangarh road. The sandstone is pink to brown, medium-grained, well sorted, subarkosic

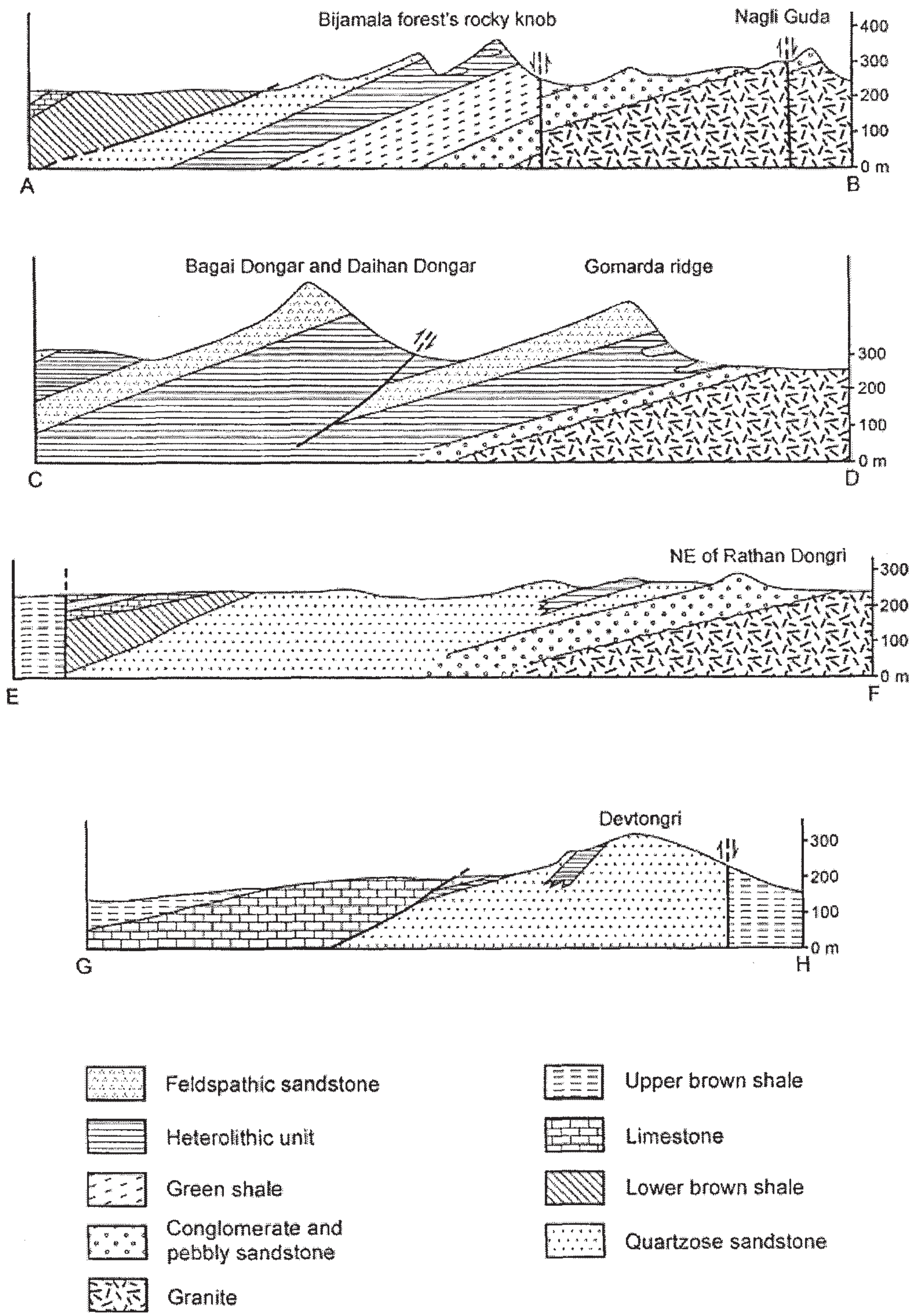

Fig. 4. Cross-section at different parts of the mapped area and the stratigraphic column of the Chattisgarh Supergroup around Sarangarh, Chattisgarh. Section lines (AB, CD, EF and GH) are marked in the geological map (Fig. 3).

and has a remarkable uniformity in composition, texture and assemblage of primary structures throughout its occurrence.

Hummocky cross-stratified beds (Fig. 7), planar parallel beds with parting lineation, and structureless massive beds with local abundance of mud flakes are common. In the uppermost part of the interval, the sandstone exhibits a variety of wave and current ripples with different types of interference pattern, locally with late stage run-off features. Spindle-shaped linear and polygonal shrinkage cracks also occur on the bedding plane surfaces at places.

Consideration of the sheet sandstone as a formation would make it imperative to assign formation status to both lower and upper heterolithic intervals, and also to the amalgamated heterolithics to the north where the sandstone is absent. The classification of the total ensemble into four different formations would only create problems in identification in a terrain affected by large number of faults, and also enhance complexities in regional correlation. The ensemble, so, has been considered as a single formation, and the sandstone has been treated as a member (NACSN, 1983).

Formation C

The upper heterolithic unit conformably grades upwards into a sand-dominated unit with a maximum thickness of 60 m. Well sorted, medium-grained, subarkosic to quartzose sandstone forming small lenticular shoaling up bodies, and poorly sorted fine-grained sandstone and siltstone occuring in the lows between the lenticular bodies are the two major facies. The sandstone beds preserve profusely developed symmetric to slightly asymmetric, slightly sinuous to straight crested 3D dunes (cf. Ashley, 1990). Stringers of very well-rounded, very coarse sand and granules mantle the bedding plane surfaces at places.

The east-facing escarpment along the Chandarpur-Baramkela road near its intersection with the Lath nala

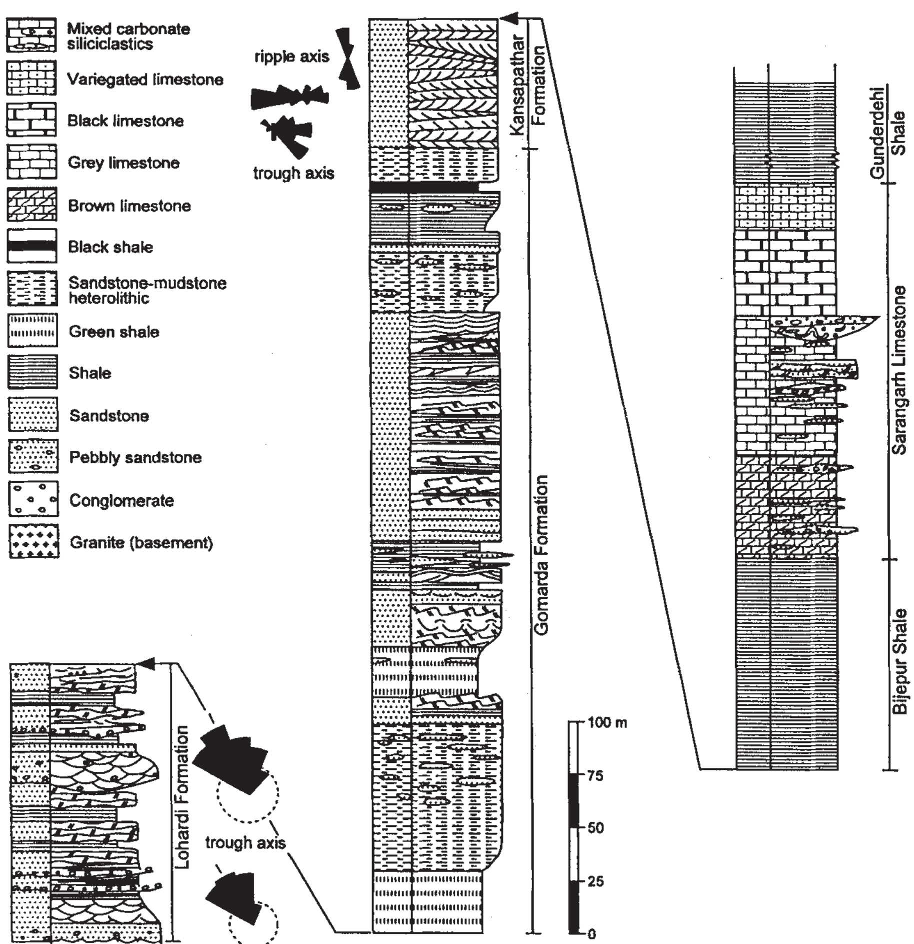

Fig. 5. Stratigraphic column (composite) of the Chattisgarh Supergroup around Sarangarh.

Table 2. Stratigraphy in the eastern Chattisgarh.

Chattisgarh Supergroup	Raipur Group	Gunderdehi Shale		Brown calcareous shale, green shale, dolomite, small stromatolitic mounds at the base	Platform margin, slope to basin
		Sarangarh Limestone (150m)	Timarlaga Member	Black, mauve and brown flat bedded micritic limestone (without any sand)	Slope to basin
			Gadhabhata Member	Brown and grey micritic limestone with sand sheets and lenses	Platform
		Bijepur Shale (100m)		Green and brown calcareous shale, thinly laminated, locally with sandy graded beds, sole marks	Muddy shelf and shelf lagoon
	Chandarpur Group	Kansapathar Formation (60m)		Subarkosic and quartzose sandstone, and shale	Storm-tide influenced shelf – shoreface bar, and wind flats
		Gomarda Formation (650m)	Daihan Sandstone Member	Sandstone, sandstone-mudstone heterolithic, shale	Prodelta and prograding shelf
		Lohardih Formation (150m)		Conglomerate, pebbly sandstone, coarse sandstone	Fandelta

(21°37' 28"N 83°14'20"E) exposing a linear sandstone bar may be treated as the type section. The section exhibits an exhumed north-south trending bar, about 200 m long, 77 m wide, and 10 m thick.

Assemblage II

Formation D

This is the basal unit of Assemblage II and consists mainly of brown calcareous shale and green shale. It overlies the sandstone of formation C with a sharp contact, and grades upwards to the limestones of formation E. The maximum preserved thickness of the formation is about 100 m. The shale is very well exposed in the Putka nala section near Bijepur village (21°34'53"N 83°6'24"E).

Formation E

The formation comprises micritic limestone with subordinate amount of glauconitic sandstone. It generally overlies the brown shale of formation D with a gradational contact, though at certain profiles it overlaps the sandstones of formation C with a sharp contact. The formation has a preserved thickness of 150 m, and it can be classified into two members on the basis of presence or absence of siliciclastics.

The lower member: The basal part of the member consists of brown limestone that grades upward into an interval of gray limestone. The thickness of the brown interval varies between 15 to 40 m and the gray limestone is about 60 m thick. These limestones are best exposed in along a stream passing through the Saradih (21°36'N 83°7'E) and Gadhabhata (21°36'16"N 83°7'16"E) villages. The limestones include stringers, discrete layers, or thick beds of medium to fine-grained subarkosic glauconitic sandstone at different levels. Coarse sands occur locally. The relatively thicker sandstones occur as sheet-like bodies, or as small positive relief bar like feature and are characterized by plane lamination, hummocky cross stratification, combined flow ripples and thin plane parallel laminae sets separated by low angle discordance surfaces. This interval also contains locally developed small pockets or thin sheets of autoclastic lime-clast conglomerate with highly disorganised clasts.

The upper member: A very persistent horizon of black limestone constitutes the basal part of the upper member that overlies the gray limestone with a sharp contact. The maximum thickness of the unit is 40 m. It is well exposed in Timarlaga (21°41'36"N 83°12'E) limestone quarry on the Raigarh-Sarangarh road. A large channel-fill body of lime-clast debris-flow conglomerate occurs at the interface of gray limestone and black limestone at Gadhabhata. The channel is incised within the gray limestone, and the conglomerate is made up of platy clasts of gray limestone and a few boulder size clasts of black chert. The clasts are either framework supported, or float within micritic or mixed siliciclastic-micritic matrix with very coarse and extremely well rounded sands (Fig. 8). The black limestone is characterized by thick, laterally persistent beds, profuse development of pyrite, and complete absence of siliciclastic grains. It grades upward to a variegated brown and mauve limestone which, by turn, is gradationally overlain by the brown shale of formation E. The variegated limestone is best exposed in the Ghogra nala section north of Amlipali (21°29'N 58" 83°10'E) village.

Fig. 6. Sandstone with well preserved soft sediment deformation.

Fig. 7. Hummocky cross-stratified sandstone beds.

Fig. 8. Conglomerate with platy clasts of gray and black limestone floating in very coarse sandstone matrix. The conglomerate occurs as channel-fill deposit.

Formation F

The formation is dominated by brown shale. Green shale occurs as a subordinate constituent. Dolomite, small bioherm of stromatolitic limestone, and sandstone occur in minor quantities. Fairly persistent welded and non-welded tuff horizons occur at different levels within the shale. Nodules of authigenic barite occur at several places at the basal part of the shale. The brown shale overlies the variegated limestone of formation E through a narrow trinsition zone of shale-limestone heterolithics, best exposed near Mahuadhora (21°36'8"N 83° 9'36"E).

Relationship between Assemblage I and Assemblage II

The relationship between the two assemblages is well exposed in the southern bank of Lath nala near Behrachuwan village (21°38'44"N 83°11'8"E), in the Mahanadi bed section near Lath nala-Mahanadi confluence, and in the Lath nala section near Salar village (21°31'24"N 83°8'44"E). The sections exhibit that different units, either shale or brown limestone of Assemblage II overlies the formation C of Assemblage I at different points. The contact, though sharp at most places, is conformable and there is no evidence of any discernible break in deposition. The stratigraphic relationship further indicates a possible lateral variation between the two lithologies of Assemblage II dictated by highly variable parameters of shallow marine environments.

The relationship between the two assemblages presented here makes a major departure from several earlier postulations. It supports the views (Dutt, 1964; Moitra, 1990; and Das et al., 1992) that the limestone-shale dominated succession overlies the coarse clastic dominated succession without any major break or hiatus (Tables 1 and 2). Further, evidence for any major unconformity to subdivide Assemblage I into two groups could not be found even with assiduous search. The sedimentary package in the study area, from formation A to formation F represents a continuous succession without any major hiatus. The sedimentary package overlies crystalline rocks of the Archean basement with a profound unconformity. On the basis of lithologic composition and organization, Assemblage II may be correlated with the lower part of the Raipur Group where Assemblage I is equated with the Chandarpur Group.

Comments on Correlation

Assemblage I

Formation A and formation C may be equated with the Lohardih and Kansapathar Formation respectively, on the basis of lithological similarities. By contrast, formation B is distinctly different from the Chaporadhi Formation in terms of thickness, lithologic and facies assemblage. The differences point to significant variations in the rate and nature of sediment input, hydrodynamic conditions as well as subsidence rate in the eastern part of the basin.

Formation B is a stratigraphic equivalent of the

Chaporadih Formation though, in view of significant lithological differences between the two, the formation B has been formally defined as a new formation (cf. NACS, 1983). It is best developed and exposed along an E-W traverse from Tekapathar to Gomarda (Fig. 3), and has been designated as Gomarda Formation after the name of the village Gomarda (21°26'32"N 83°11"E). The Tekapathar-Gomarda section may be considered as the type section. The thick sandstone member of the Formation has been formally designated as the Daihan Member, after the name of the Daihan Range.

Assemblage II

The limestone succession around Sarangarh (formation E) was designated as Sarangarh Limestone (cycle I) by Schnitzer (1971). The limestone also appears to correspond to the limestones of the Charmuria Formation of Dutt (1964) and Murti (1987). The lithologic characterization of the Charmuria Formation, or vertical and lateral changes within it, however, are not well documented. Murti (1987) noted that major part of the Charmuria Limestone corresponds to the Sarangarh Limestone of Schnitzer (1971). The limestone (Formation E) at and around Sarangarh has been designated here as Sarangarh Limestone. The stream section at the Gadhabhata (21°36'16"N 83°7'16"E) village, about 3 km northeast of Sarangarh exposes a well preserved section of brown, gray, and black limestone intervals, and may be considered as the type section of the formation. The north-south section through the village Amlipali (21°29'58"N 83°10'E) may be considered as an additional reference section.

The lower member has been designated as Gadhabhata Member, after the name of the village Gadhabhata. The upper member has been designated as the Timarlaga Member, and the Timarlaga quarry section may be considered as its type section.

The brown and green shale of formation D, that underlies the Sarangarh limestone with a gradational contact, has a thickness of ≈100 m at well preserved profiles, and has been raised to the status of a formation. It is formally designated here as the Bijepur Shale, named after the village the Bijepur. The section along the Putka nala in the east of Bijepur preserves the type section.

The upper shale, formation F, that gradationally overlies the Sarangarh Limestone, closely corresponds to the Gunderdehi Shale (Murti, 1987, 1996) both in terms of stratigraphic position and lithologic assemblage.

Stratigraphical Evolution and Palaeogeographic Implications

The Chattisgarh Supergroup in the eastern part of the basin has a cumulative thickness up to 2000 m (Fig. 5) that was deposited in wide ranging environments from alluvial fan to deep marine through coastal marine and shelf. Table 2 lists facies and interpreted environments of deposition of different stratigraphic units. The conglomerate and pebbly sandstones of the Lohardih Formation represent the alluvial fan and associated braided fluvial deposits dominantly with north-west palaeoflow (Fig. 5). The conglomerates with quartz pebbles and coarse-grained feldspathic sandstone of the Lohardih Formation were derived from the uplifted fault blocks of the granitic basement. The alluvial fan and fan deltas represent tectonically active stage of basin formation and episodic uplift of the basement. Rapid transition of coarse-grained delta deposits to deep-water mud-dominated prodelta sequence further indicates that the initial stage of basin development was marked by a narrow coastal zone with steep gradient (Galvin, 1968; Frostick and Steel, 1993). The coastal zone gradually evolved into a low gradient wide shelf that hosted a thick storm dominated prograding shelf sequence of the Gomarda Formation and the tide dominated large bars of the Kansapathar Formation. The large dimension of the tide-generated bars and storm-generated structures, such as large wave ripples and hummocky cross stratification in the shelf deposits, indicate a wide shelf with open marine circulation condition. The Sarangarh Limestone Formation records the development of a shallow water carbonate platform (the Gadhabhata Member) in the seaward margin of the shelf. The carbonate platform developed as an isolated one, separated from the sand depositing inner shelf by a strait (Chaudhuri and Patranabis Deb, 2002), the loci of deposition of the Bijepur Shale (Fig. 9). Coarser sands were episodically transported to the platform by high intensity storm currents generating the mixed carbonate-siliciclastic succession.

The interface between the mixed carbonate-siliciclastic deposits of the shallow water carbonate platform and the deep-water, sand free black limestone represents a sharp change in basin palaeography and bathymetry. The interface records an event of abrupt drowning of the platform and expansion of the basin, the black limestone representing the peak of transgression. The large submarine channel filled up with debris-flow lime-clast conglomerates at the interface of the gray and black limestone near Gadhabhata appears to represent a tectonic triggering that heralded the changes in the basin configuration and drowning of the basin. Furthermore, very coarse, well-rounded sands in the matrix of the debris-flow conglomerate and occurrence of very coarse-grained sandstone beds immediately below the black limestone point to an event of sea-level fall and progradation. The sea-level fall was followed by rapid sea-level rise when the black limestone was deposited and a regional euxinic condition was generated. With the drowning of the platform, the siliciclastic generating environments were severely restricted. The sand-free, deep-water limestones (black grading up into mauve) covered the platform and also onlapped over the preexisting siliciclastics with a sharp contact. Development of stromatolite mounds at the basal part of the upper red shale (Gunderdehi shale) points to sea-level fall and an event of shallowing.

The palaeoflow direction in alluvial fan and fluvial deposits (Fig. 5) point to northwesterly palaeoslope. The disposition of the facies belts, and occurrences of deeper water deposits north/northwestward of the proximal siliciclastic deposits also corroborate that the marine basin was opening towards north to northwest. The tidal bars of the Kansapathar Formation show a well defined east-west to northwest-southeast bimodal-bipolar current pattern which may related to flood and ebb tidal currents (Fig. 5) (Patranabis Deb, 2001a), and indicates north-south to northeast-south west orientation of the linear bars. Combining the palaeocurrent pattern and the disposition of the facies belt, a northwesterly palaeoslope and SE-NW orientation of the shoreline is inferred (Patranabis Deb, 2001a).

The stratigraphic relationship indicates that the basin was opening and deepening towards northwest. The palaeogeographic reconstruction thus, suggests the presence of a major Neoproterozoic seaway skirting the north and northwestern margin of the Southern Indian craton, along the Central Indian Tectonic Zone (Fig. 10), a probable suture between north and south India (written comm., J.J.W. Rogers). The marine incursion in the Chattisgarh may have come from this direction.

Tectonic Implication

The stratigraphic classification and inferred relationship between different stratigraphic units as presented here attest that the entire succession of the eastern Chattisgarh was deposited in a continually subsiding basin that evolved from a narrow, shallow water basin to fairly deep, wide sea through time (Patranabis Deb, 2001a). The subsidence history of the basin, particularly in the eastern part of the basin, was punctuated by episodic events of shallowing and progradation, though the depositional interface was never exposed above the base level, into the erosional regime to generate any stratigraphically significant hiatus.

The inferred amplitude of subsidence and creation of accommodation space to accommodate about 2000 m thick succession is well beyond the range of glacio-eustatically controlled sea-level rise and fall, and suggests tectonically induced movement of the basin floor (cf. Sloss, 1984). The subsidence was accompanied and caused by high angle faults that propagated from the basement, and ultimately fractured and displaced the overlying sedimentary rocks. The faults, as manifested in the geological map (Fig. 2) have an overall north-south trend, that followed the north-south grain of the underlying Sonakhan greenstone belt of Archean age (Chaudhuri et al., 2002).

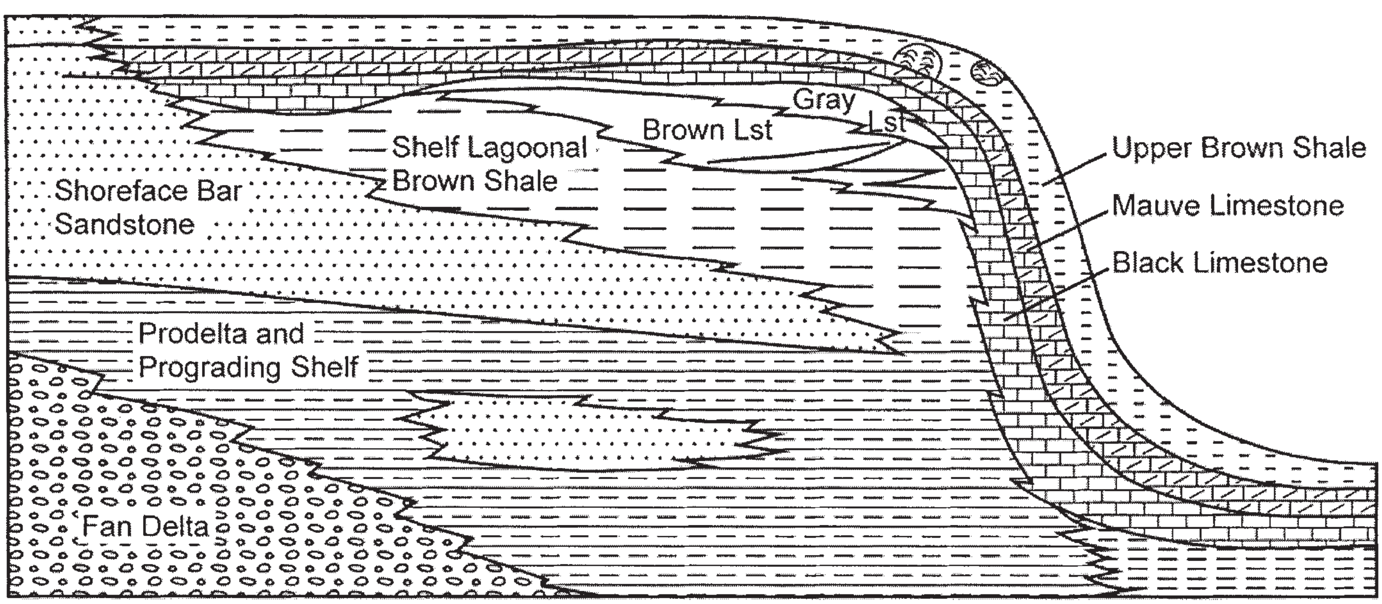

Fig. 9. Cartoon diagram (not in scale) showing the palaeogeography.

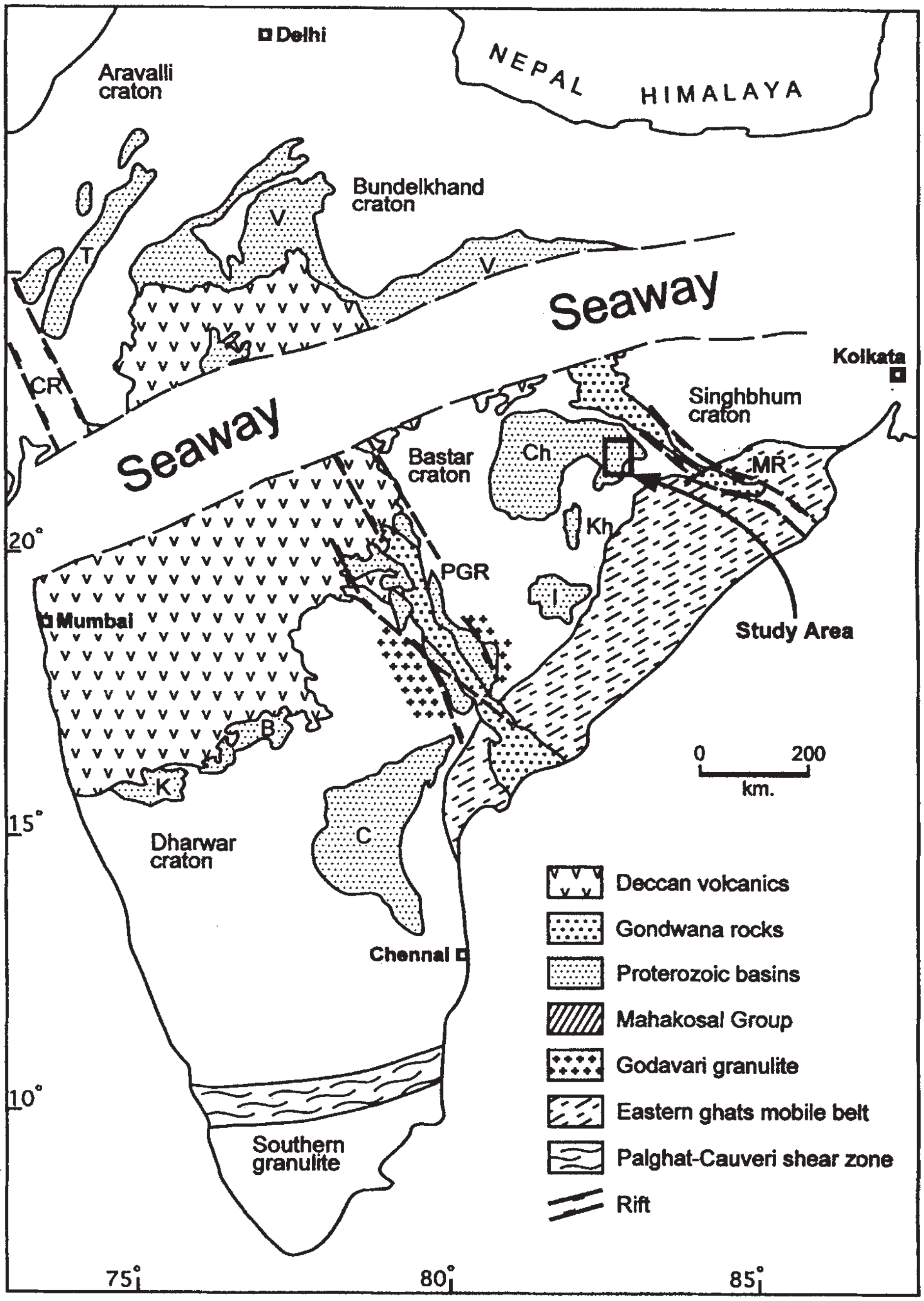

Fig. 10. Schematic diagram showing the Neoproterozoic seaway skirting northern and northwesterm margin of South Indian craton.

In the Chandarpur succession, the shales and the mud-dominant intervals developed during transgressions when generation of sands decreased substantially, or when the coarser clastics were trapped in the fluvial systems or in the coastal area (Allen, 1974). The sandstones, on the otherhand, were related to relative sea-level fall and indicate shoreline progradation as well as uplift of the hinterland. The large order cycles of sand deposition represented by the Lohardih Sandstone, Daihan Sandstone and Kansapathar Sandstone, each followed by a thick shale-mud dominated sequence, point to major changes in terms of base level, basinward shift of coastal facies belts and uplift of the hinterland leading to generation of large volumes of coarse clastics. The changes collectively point to pulsating active tectonic episodes.

The development of the Lohardih Sandstone as a thick wedge of fan and fan delta complexes strongly suggests basin-margin faulting and fault controlled deposition. The abundant feldspathic sandstones were generated from uplifted craton blocks, and may be related to syn-rift stage of basin opening (Erriksson et al., 1993). The overall similarity of the Daihan and Kansapathar depositional events in terms of sand influx and progradation supports emplacement of sandstones by tectonically controlled events as well.

The deposition of the calcareous shale (Bijepur Shale), the carbonates (Sarangarh Limestone) and the overlying shale (Gunderdehi Shale) may be related to the post-rift subsidence stage of basin opening. However, the sudden upward change from shallow water carbonate depositional system (Gadhabhata Member) to the deep water, carbonate (Timarlaga Member) depositional system suggests a rapid tectonic control of the process. Ash flow tuffs, intercalated with Gunderdehi Shale also point to intra-basinal volcanism and overall basin instability (Patranabis Deb, 2001a, Patranabis Deb, 2001b).

Conclusions

(1) The conglomerate-shale-sandstone assemblage in the eastern part of the Chattisgarh basin unconformably overlies the basement complex and is designated as the Chandarpur Group. The group has been classified into three formations. The lower and the upper formations are equated respectively with the Lohardih Formation and the Kansapathar Formation of earlier workers. The middle one, stratigraphic equivalent of the Chaporadhi Formation, has been defined as a new one, and designated as the Gomarda Formation.

(2) The shale-limestone-dominated assemblage corresponds to the Raipur Group. The basal shale may attain a thickness of over 100 m, and has been defined as a new formation, the Bijepur Shale. The limestone at the middle of the sequence, designated as the Sarangarh Limestone, has been classified into two formal members, the lower Gadhabhata Member, and the upper Timarlaga Member. The brown shale that conformably overlies the Sarangarh Limestone has been correlated with the Gunderdehi Shale, both in terms of lithologic character and stratigraphic position. The Raipur Group conformably overlies the Chandarpur Group without any stratigraphically significant hiatus.

(3) The Lohardih Formation was originated in alluvial fan and fan delta environments in a narrow coastal zone with steep gradient, representing a tectonically active stage of the basin formation and episodic uplift of the basement. On the other hand, the overlying Gomarda and Kansapathar formations represent a storm and tide-dominated, prograding shelf sequence and indicate that the coastal zone gradually evolved into a low gradient, wide shelf.

(4) The Bijepur Shale was abruptly superposed on the Kansapathar Sandstone of the Chandarpur Group, and represents deposition in a strait or bay that separated the clastic-depositing, mainland coastal areas from the carbonate platform to the north.

(5) The Gadhabhata Member of the Sarangarh Limestone represents a shallow water platform, whereas the Timarlaga Member comprises pelagic carbonates deposited in deep water shelf and slope. The interface between the two members is marked by a sharp contact with a large submarine channel filled up with slumped beds of gray limestone and lime-clast debris-flow conglomerates which represents a forced regression followed up by a rapid transgression.

(6) The stratigraphic variations in time and space, together with the palaeocurrent data speak for northwesterly slope of the basin, with a broadly north-south trending axial zone. The welded felsic tuffs in the Gunderdehi Shale and the basal alluvial fan-fan delta complex of the Lohardih Formation indicate that the basin developed as a cratonic rift.

(7) The complete succession, from the Lohardih Formation to Gunderdehi Shale, preserves signatures of multiple events of major sea-level change, with consanguineous basin subsidence. The succession was deposited in several episodes of progradation, agradation and retrogration that resulted with formation of a shallow water basin to fairly deep, wide continental sea through time.

(8) The paleogeographic reconstruction suggests the presence of a major Neoproterozoic seaway skirting the north and the northwestern margin of the South Indian craton that hosted the Chattisgarh basin.

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