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DEPOSITIONAL ENVIRONMENT AND TECTONISM DURING THE SEDIMENTATION OF THE SEMRI AND KAIMUR GROUPS OF ROCKS, VINDHYAN BASIN

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ABSTRACT

The Vindhyan Supergroup of rocks represented by the Semri and Kaimur groups, in the Chopan (Son Valley) area, Sonbhadra District comprises a thick (1500 to 3500m) sequence of rudaceous, argillaceous and chemogenic sediments and shows marked facies change both laterally and vertically. These sediments are represented by relatively thin (200 to 300 m) equivalents in the Karvi-Chitrakoot area, Banda District, Uttar Pradesh.

The lithological, sedimentological, structural and palaeontological attributes of these sequences indicate a periodically fluctuating palaeo-environmental domain restricted mainly within the limits of shallow to moderately deep continental shelf, tidal mud-flat to euxinic conditions of deposition. Bathymetric considerations were generally the controlling factors in defining the facies variation, overlapping and basinal conditions during the Semri and early Kaimur periods.

The lithofacies and isopach patterns suggest a tectonically unstable southern block, whereas the northern block remained a potentially stable platform area. The deposition of the Semri Group was punctuated by frequent and recurrent pulsating tectonism and at least three major arenite-shale-carbonate cycles of sedimentation, each culminaing in a tectonomagmatic activity.

The present studies suggest a depositional environment, wherein a recurrent sea level fluctuation continued throughout the entire period of sedimentation in response to tectonism, due to which the southern marginal parts of the Vindhyan Basin were uplifted corresponding to periodic pulsating tectonism, instead of a gradual periodic sinking and subsiding basin *pari passu* deposition under a uninformly shallow marine environment. The water body continued to move northwards transgressing the Bundelkhund basement rocks under the influence of tectonism and sediment fill, leading to northward shifting of the southern strand line and successive overlapping of younger formational units in the northern parts of the basin.

Key words: Depositional environment, tectonism, Semri and Kaimur Groups, Vindhyan Basin.

INTRODUCTION

The Vindhyan Supergroup, represented by a thick pile of sediments belonging to the Semri, Kaimur, Rewa and Bhander Groups, is one of the largest Proterozic sedimentary basins of India. It is spread over an estimated 1,00,000 Km^2 area extending from Sasaram (Bihar) in the east to Chittorgarh (Rajasthan) in the west (fig. 1). The Son valley area, in U.P. exposing Semri and Kaimur Group of Rocks has been studied for more than a century since the pioneering work by Thomas Oldham (1856). The classical work by Mallet (1869), and Auden (1933) provided the basic data for all subsequent studies. The present study is an effort to analyse and establish a probable relationship between the basin tectonism and sedimentological history and to evolve a depositional model of sedimentation.

TECTONO-SEDIMENTARY SET UP

The Bundelkhand Granitoid Complex in the north and the Pre-Vindhyan Sidhi/Mahakoshal Group along with the Granitoid-Batholithic associations towards south, controlled by the major lineament zones viz., the Narmada-Son; Amsi-Jiawan lineaments, provided the earliest Mid Proterozoic basin for the deposition of the Vindhyan sedimentary sequences. These lineaments have been considered to be ancient suture zones, which have witnessed repeated rejuvenations in the geological past and show continued reactivation till present (Naqvi and Rogers 1987; Kaila, Murthy, Mall, and Dixit, 1989). Evidences favouring reactivation and vertical movement along these fracture zones and those fractures generated subsequently have been recorded south of the Vindhyan marginal parts (Kaila *et al.* 1989).

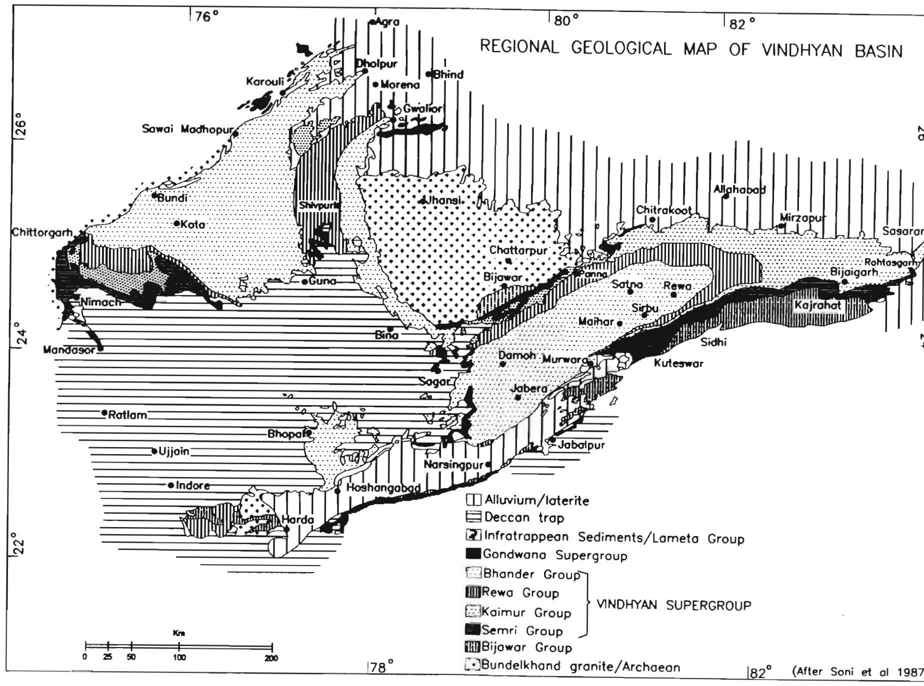

Fig.1. Regional geological map of the Vindhyan Basin (medified after Soni *et al.*, 1987).

The relationship between the tectonism and sedimentary history can be established for the Semri and Kaimur Group of rocks on critical evaluation of their repeated cyclic sedimentation around Chopan area in the Sonbhadra district and around Chitrakoot-Karvi area in Banda district of South U.P.

The thickness of extensively developed sequences of rudaceous, arenaceous, argillaceous and chemogenic sediments belonging to the Semri Group vary between 1500 to 3500 m. along the southern part of the basin i.e. around Chopan area (fig-2), while its thickness is merely 200-300 m. around Chitrakoot area in the northern part (fig-3). The lithological, sedimentological and palaeontological

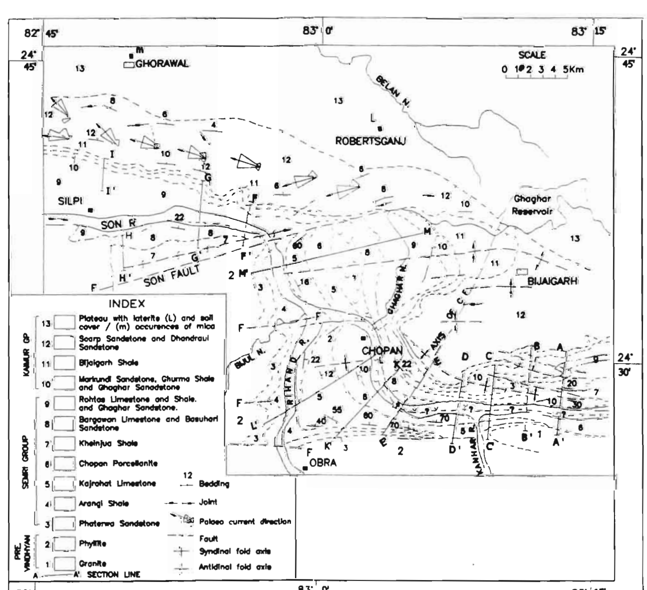

Fig. 2. Geological map of Vindhyan Supergroup in parts of Sonbhadra Distrct, Uttar Pradesh.

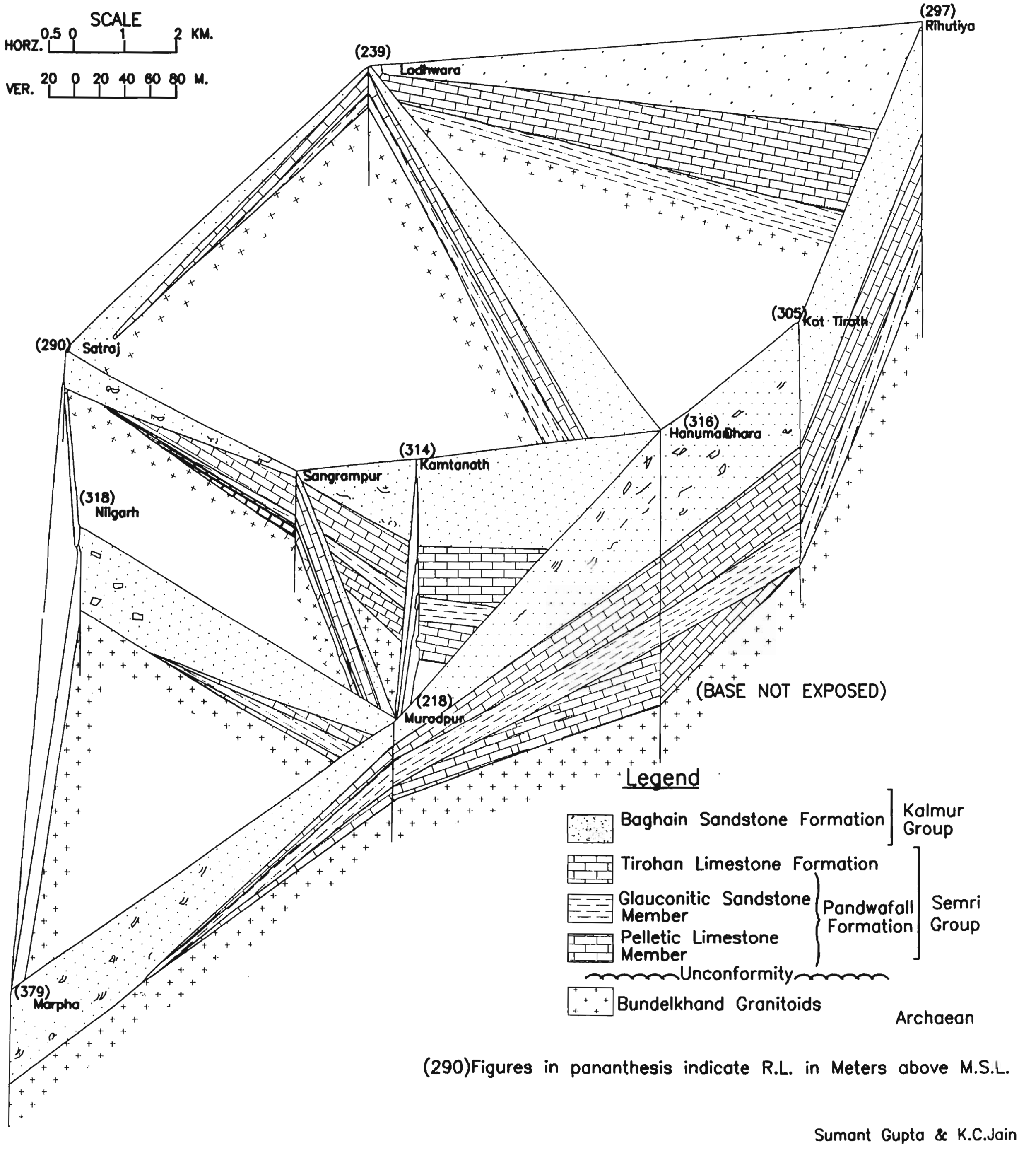

Fig. 3. Fence diagram showing the Semri-Kaimur lithofacies variation in the Chitrakoot-Karvi Area, U.P. (Figures in parenthesis indicate R.L. in metres above M.S.L).

attributes of these sequences show a marked facies change both laterally and vertically, thereby, exhibiting a highly fluctuating depositional environment which was mainly restricted within shallow to moderately deep continental shelf, tidal mud flat to euxinic lagoonal conditions of deposition. The general geological succession of the Semri and Kaimur groups in the Chopan area, Sonbhadra district and the Chitrakoot area, Banda district is given in Table 1.

The Semri Group depicts a cyclic sedimentation of a normal sedimentary sequence of rudaceous/ arenaceous, argillaceous and carbonates facies. At least, three major cycles of sedimentation, each culminating in a techno-magmatic activity, have been identified.

The first cycle of sedimentation commenced with the deposition of coarse clastic rudites, arenites and argillites as fanglomerates brought into the basin by high gradient rivers from the uplands, adjacent to the southern basin margin, and deposited in a Playa type environment. (Reading, 1978). The formational unit designated as the Patherwa Formation (Prakash, 1966), forms the basal conglomerate lithofacies of the Vindhyan Supergroup. It comprises medium to small pebbly conglomerate, gritty sandstone with sub-angular to sub-rounded clasts of smoky quartz, quartzites, chert, yellow and red jasper and tabloid fragments of slates cemented in a fine sandy matrix. Sedimentary structures such as tabular tangential cross bedding, graded cross bedding indicate turbulent conditions of deposition and shoreline accumulation. The conglomerate facies exhibit a close relationship to the system of normal faults and half grabbens, developed due to tectonic activity along Son-Narmada lineament system; immediately prceeding sedimentation along the southern margins of the Vindhyan epiric-sea, (Reading, 1987). The distribution and sedimentation of the conglomerate shows a typical proximal, medial and distal fore shore facies, while moderately stratified orthoconglomerate types exhibit fining-upward sequence resulting from sheet flow nature of deposition.

The overlying Arangi Shale (Arangi Formation) comprising fine clasts and consisting of greenish grey and khaki siltstones, fine sandstone with profuse wave-dominated ripple marks, flasser bedding indicate a typical tidal flat facies (Singh, 1973), while the silicified and cherty, black carbonaceous paper thin shales and porcellanic shales with coaly matter and pyrite dissemination suggest a back shore tidal flat to lagoonal condition of deposition.

The Arangi shales are in turn overlain by 600-800m thick sequence of chemogenic sediments belonging to the Kajrahat Limestone which comprises thickly bedded dolmicrite, argillaceous limestone with interbedded shale and siltstone lenticles, representing the carbonate facies of 1st cycle of sedimentation. Penecontemporaneous slumping and mass deformational structures at the base observed in certain localities such as Sinduriya suggests local syndepostional gravity slides, possibly triggered by mild tectonism.

Stormatolites are profusely developed at the terminal phase of carbonate deposition, indicating shallowing upward cycle of sedimentaton. Presence of stromatolite forms like *Colonella columnaris, Omechtenia* sp; *Conophyton garganicus* and ripple-like forms *Platella* sp; exhibiting pustular mat structures (Gupta and Jain, 1997), and associated sedimentary structures intra-formational conglomerate, ripple marks, channel cut suggest moderately deep, intertidal to shallow sub-tidal carbonate mud flat environment.

The presence of basic intrusives near Dala and north of Kuchari Pahar (320m) within the Kajrahat Limestone and emplacement of granitoid bodies as seen around Darhyia-Lauva areas further south indicate widespread magmatic activity and tectonic upheaval in the southern marginal parts at the close of the first cycle of sedimentation. The post Kajrahat volcanism is also evident from the presence of a thick pile of volaniclastic and volcanogenic sediments comprising green coloured and greenish black tuff, agglomerates, lapille, ignembrite and associated arkosic sandstone, conglomerates (Oligomictic) and argillites termed the Chopan Porcellanite. Suspected volcanic vents have also been identified around Amiliya–Sehawal areas (Bhattacharjee, Mukherjee and Banerjee, 1964).

Table 1: Stratigraphic Succession with Litho Assemblage of the Vindhyan Supergroup in Parts of South U.P.

		CHOPAN AREA (Gupta & Jain 1997)			**CHITRAKOOT AREA** (Modified after Sanyal & Chakraborty 1982)		
Super Group	**Group**	**Formation**	**Lithology**	**Thick-ness in meters**	**Form-ation**	**Lithology**	**Thick-ness in meters**
		Dhandraul Sabdstone	Milky white, compact medium to fine grained sandstone & orthoguartzite.	90-100	Baghain Sandstone	Medium grained, reddish and pink coloured current bedded sandstone with lenticular siltstone and shale interbeds.	10 -100
		Scarp Sandstone	Red, pink, compact, blocky sandstone. Khaki & greenish grey; micaceous siltstone and sandstone.	100-200			
		Bijaigarh Shale	Grey mecaceous siltstone, red & yellow olive shale & siltstone black carbonaceous shale & ferruginous sandstone.	50-90			
	KAIMPUR GROUP	Markundi Sandstone with Susnai breccia at the base.	Light geryish white, medium to fine grained micaceous sandstone and breccia conglomerate with angular to sub-angular clasts at base	15-45			
		Ghurma Shale	Micaceous, yellow, brown and light grey porcellanic shale with interbeds of black carbonaceous shale and siltstone.	30 – 70			
		Ghaghar Sandstone	Coarse to medium grained pinkish sandstone	30			
			DISCONFORMITY			**DISCONFORMITY**	
VINDHYAN		Rohtas Limestone	Flaggy limestone with Cherty parting	70 -120	Tirohan Limestone	Massive dolomitic limestone exhibiting Stylolites, Stratifera and chert beccia towards top.	40 – 65
			Black paper-thin shale, Porcellanic shale with calcareous nodules.	60-350			
			Blocky, massive, light grey, brown, fawn coloured stylolitic limestone.	80-200			
		Basuhari Sandstone	Greenish grey, khaki green, olive green and porcellanic shales with siltstone interbeds.	60-125	Pandwafall Sandstone	Glauconite bearing flaggy sandstone, dolomite limestone, glauconitic sandstone alternations, pelletic, oolitic and stromatolitic limestone.	5-25
			Glauconitic sandstone, silty sandstone, greenish grey and khaki to brown quartz arenite.	80-150		Gritty glauconitic sandstone and conglomerate with pebbles of granite and vein set in dolomitic matrix	0.25- 2
		Bargawan Limestone	Fawn coloured cherty limestone with quartz veins and black chert bands.	20-25			
	SEMRI GROUP		Fawn to light grey coloured compact cherty limestone with stromatolites bands.	40-80			
			Argillaceous flaggy limestone with siltstone interbeds.	15-30			
		Kheinjua Shale	Olive to greenish grey khaki splintery shale with calcareous inter-beds and partings.	350-600			
		Chopan Porcellanite	Light gery, greenish porcellanic shales, ash, tuff, agglomerate beds with arkosic sandstone.	400-900			
		Kajrahat Limestone	Siliceous, cherty, dolomitic limestone with stromatolites.	40-200			
			Blocky and slabby limestone and dolarentie with argillite interbeds.	200-350			
			Light grey, black, slabby limestone, stylolitic	30-350			
		Arangi Shale	Bleached, purplish porcellanic shales and black carbonaceous shales.	70-200			
		Phaterwa Sandstone	Gritty to pebbly sandstone, medium grained sandstone and siltstone.	20-60			
			Conglomerate with cobbles, pebbles and clasts of quartz, quartzite, chert, yellow and red jasper set in a sandy matrix.	40-50			
		ANGULAR UNCONFORMITY/FAULTED CONTACT					
SIDHI/ MAHAKOSHAL GROUP			Phyllite		Bungelkhand Granitoid Complex		

The volcaniclastics and clastics of Chopan Procellanite show the fine-laminated bedding, while the associated arkosic sandstone, conglomerate exhibit lenticular bedding, cross bedding and graded bedding. Presence of flat pebble, conglomerate, mud balls and turbidity structures suggest a foreshore subtidal marine environment and represents the onset of second cycle of deposition.

The volcanicity during this period, perhaps, was also responsible for a widespread appearance of glauconite-bearing sediments in the subsequent deposits which are represented by the Kheinjua Subgroup comprising the Kheinjua Shale (Olive Shale of Auden) and the Bargawan Limestone (= Fawn Limestone).

The Kheinjua Shales are finely laminated and evenly bedded, greenish grey, dark grey and olive in colour. Fine varve-like laminated nature of shales and presence of fine glauconitic clasts suggest a warm moderately deep, calm foreshore to shoreface environment.

Presence of glauconite-bearing sediment and glauconite rich oolitic limestone and shales, overlying the Bundelkhand basement in the northern limb of the Vindhyan syncline, as seen in the Chitrakoot-Karvi area along with columnar stromatolites shows close resemblance to the Kheinjua Subgroup assemblage. The widespread appearance of glauconite during Kheinjua period is remarkable. This situation, when viewed in a regional perspective, also points towards a significant fact that during 1st cycle of sedimentation when the basal conglomerate (Patherwa Formation), Kajrahat Limestone and Chopan Porcellanite sediments were accumulating in the south, there was no sedimentation along the northern sector around the Chitrakoot area, which remained a positive land. The Vindhyan Sea, which was probably limited towards south, surged northwards during the Kheinjua period and covered the Bundelkhand basement with development of Kheinjua and younger sedimentary sequence simultaneously in the both the areas.

Presence of Andesite dyke intruding the Kheinjua shales as seen in the Patwadh area, indicates yet another syndepositional volcanicity and magmatism which led to the shallowing of the basin with the developing stromatolite-bearing limestone unit designated as the Bargawan Limestone.

Profuse development of reefal stromatolites such as *Conophyton cylindricus, Jacutophyton* (large domical forms) (Kumar, 1976; Gupta and Jain, 1997) are biostratigraphically significant. Presence of these stromatolites in association with interstratified clastic carbonate conglomerates, wave ripples and mud cracks suggest protected lagoonal, intertidal to shallow subtidal environmental domain.

The siliciclastic sediments belonging to the Basuhari Formation represent the third sedimentary cycle of deposition. It comprises glauconite-bearing coarse sandstone, with thinly laminated fine siltstone and shale interbeds. The bedding is lenticular to sub parallel showing profuse development of asymmetrical, symmetrical, rhomboid, lunate and ladder ripples, mud cracks and synaeresis cracks, rain prints, rill marks and trail and track marks. A shallow marine supratidal mudflat to intertidal backshore environment has been interpreted for this sequence. In the northern limb of the Vindhyan Sea, around Chitrakoot area, the sequence is well represented by glauconite-bearing sandstone horizon designated as the Pandwafall Sandstone Formation (Sanyal and Chakraborty, 1982).

The Chemogenic sequence belonging to this cycle is represented by the Rohtas Limestone Formation, overlying the Basuhari Sandstone Formation with a gradational contact.

The Rohtas Limestone comprises i) basal, thickly bedded, slabby to blocky limestone and dolomitic limestone, ii) middle black finely laminated paper-thin shales, cherty nodular limestone and iii) an upper flaggy limestone, shaly limestone, litho assemblage. A shallow subtidal euxinic lagoonal, foreshore carbonate mudflat environment is suggested for the chemogenic sequence.

Presence of clastic dykes in the basal lithounit exposed in the Ghurma area, indicate syndepositional tectonism. Reported occurrence of basic intrusives around Bakhia-Baghawar and Manchi near the top of Rohtas (Auden 1933) and recorded occurrence of a basic dyke intruding black silicified shales of the Rohtas Formation (Rudauli Shale Member) near the prominent N-S bend of Son River, south of Gardha, affirms the continuity of syndepositional tectonism during the entire Rohtas period in a pulsating and phased manner.

The close of Semri sedimentation was marked by a brief period of non-deposition. The Rohtas Formation was subsequently overlain disconformably by coarse gritty, saccharoidal sandstone belonging to the Ghaghar Formation, the basal most lithounit of the Kaimur Group in the Chopan area.

The coarse gritty, thickly cross-bedded Ghaghar Formation exhibits a marked change in the hydrodynamic conditions, with palaeocurrent direction towards SSE and SSW, as deduced from trough cross bedding, present in the basal units. Interference ripples, asymmetrical and ladder ripples indicating regression of the sea in the southern sector. The deposition look place in backshore beach environment.

The Ghaghar Formation is overlain by light grey, greyish black silicified shales and porcellanites, designated as the Ghurma Shale formation. These exhibit yellowish brown and limonitic shales. The bedding is fine and exhibit rhomboidal jointing and fracturing to cuboidal fragments. Flaser bedding, ripple drift cross lamination, symmetrical ripples and mud cracks indicate wave-dominated backshore to shoreface environment.

Lenticular and cuboidal autoclastic conglomerate/breccia with over 50% clast-dominated lithology overlies the Ghurma Shale Formation. Conglomerate clasts are angular to subangular, with pebble to cobble-sized fragments occurring at basal lithofacies of the Markundi Sandstone Formation. This conglomerate/breccia has been named as the Susnai Breccia (Auden 1933) from the locality north of Susnai village the in Sonbhadra area. The lithounit is lenticular with limited areal extent in the strike continuity. Close resemblance of clasts to the porcellanic and silicified shale of the Ghurma Formation is remarkable. The angularity and size of the clasts, their tabular nature, together with imbrication and palaeocurrent dirtection exhibited by the cross bedded, graded bedded structures, suggest proximity to high gradient hinterland towards south.

Post-Ghurma tectonism along the southern boundary, leading to the upheaval of part of the Ghurma Shale above the level of active erosion has been envisaged resulting in rapid erosion and swift short drifted deposition of the weathered material as Susnai Breccia. The temporal position of the Susnai Breccia clearly establishes northward drift of the southern strandline, rise in the sea level and northward migration of the basin in response to the tectonogeomorphic changes.

Deposition of younger formational units of the Kaimur Group viz. Markundi Sandstone; Bijaigarh shale, Scarp Sandstone and Dhandraul Sandstone took place in varied environmental domains between beach, tidal to lagoonal euxinic conditions.

The Vindhyan Sea by this time had potentially established in the northern area with deposition of younger formational units of the Vindhyan sequence.

The lithology of the various formational units of the Semri and Kaimur groups in the northern sector and their temporal distribution suggests that the bathymetric configuration of the basisn was in general a major controlling factor in defining the facies variations, overlapping and basinal conditions of deposition.

As has already been discussed, the basal formations of the Semri Group, i.e. the Patherwa Formation, Arangi shale and Chopan Porcellanite are conspicuous by their absence in the northern sector. The overlying Kheinjua Subgroup of rocks termed the Pandwafall Sandstone Formation has developed fairly well in the Chitrakoot area though with a marked reduction in thickness and lateral extent (fig-3). It comprises glauconite-bearing flaggy snadstone, dolomitic limestone with glauconite and exhibits pelletic, oolitic, and stromatolitic structures (Sanyal and Chakraborty 1982).

In the Panna area, again in the northern sector, the Ken Limestone overlying the Pandwafall Sandstone and the Palkawan Shale are exposed. The limestone is stromatolitic, exhibiting laterally linked hemispheroid types and resembling nodular Rohtas limestone of the Sonbhadra area; and the overlying black, finely laminated, flaggy shales bearing resemblance to the Rudauli Shale member (Rohtas

Formation) are probably lateral facies variants, while the upper Flaggy Limestone Member of the Rohtas Formation is missing in the northern sector.

Similarly, the rocks of the Kaimur Group also exhibit the northward facies variation of rocks. The Ghaghar Sandstone of the Sonbhadra area overlying the Rohtas Formation disconformably, the Ghurma Shale, Markundi Sandstone and Bijaigarh Shale (pyritiferous) formations of the Chopan area are represented by the Dulchipur Conglomerate, Bhaghain Sandstone, Sanodha Shale (pyriutiferous) members (Das *et al.*, 1975), respectively as their facies variants. The Vindhyan Sea during the onset of Kaimur period had again transgressed under the influence of syndepositional tectonism due to uplift in the southern sector resulting in overlapping of the basal Kaimur over the Bundelkhand Granite as seen in the Lalitpur area where the former rests directly over the basement granites. The Sanodha Shale overlying the Dulchipur conglomerate is probably a facies variant of the Bijaigarh Shale.

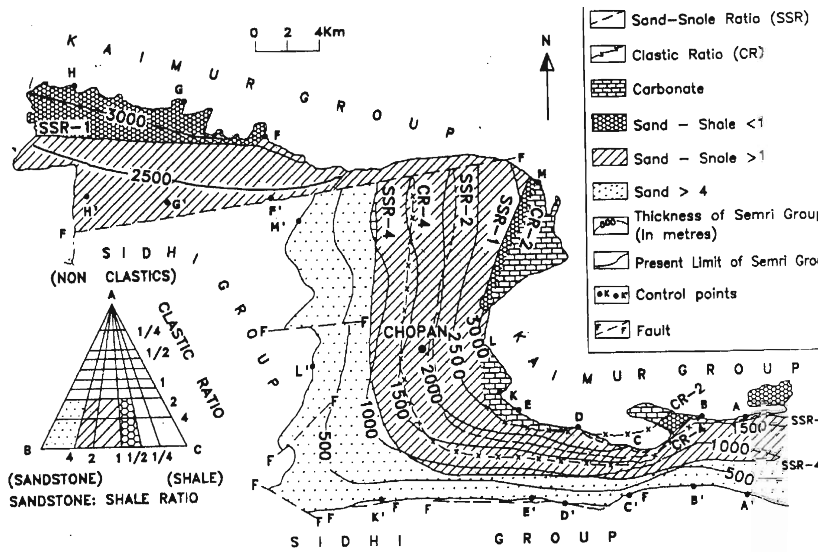

Fig.5. Isopach-lithofacies map of the Semri Group in parts of Sonbhadra District, U.P.

ISOPACH AND LITHOFACIES INTERPRETATION

Detailed section measurements were carried out along a series of sections across the Semri and Kaimur Groups from east of Hardi to Newari in the west in Son valley area. The thickness, lithological and associated sedimentary and biosedimentary attributes of varous formational units were recorded to identity the vertical as well as lateral facies variation in this segment of the Vindhyan Basin. (Fig. 4).

Isopach and lithofacies maps were prepared computing the sum total of the lithological characteristics and the dominant lithologies grouped into clastic and non-clastic components were resolved. In evaluating the data for facies interpretation, sandstone, volcanic tuff and conglomerate were included as coarse clastics. Claystone, mudstone, siltstone and all varieties of shales were included as fine clastics. Dolomites and limestones form the non-clastic components. The thickness, clastic ratio, and sand – shale

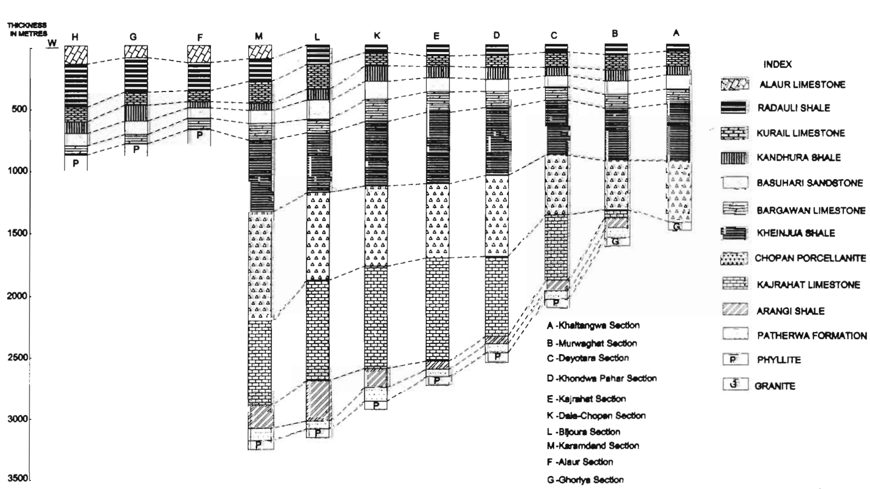

Fig.4. Thickness of lithostratigraphic units along the measured sections of the Semri Group in the Son Valley Area, U.P.

ratio at each control point were plotted for projection of isopach and lithofacies contour lines (fig. 5).

The parallelism of isopach and lithofacies lines and the prevalence of north and northwestelry palaeocurrent direction, throughout the Vindhyan sedimentation imply a predominance of a southerly and southeasterly source area during the entire Vindhyan period.

Predominance of silty-shale facies in the southern sector close to the southern bounday suggests active denudation and recycling of earlier deposited sedimentaries along the marginal part in response to periodic and pulsating tectonism which resulted in deposition of younger facies in northward prograding basin. The isopach map suggests a tectonically unstable southern block.

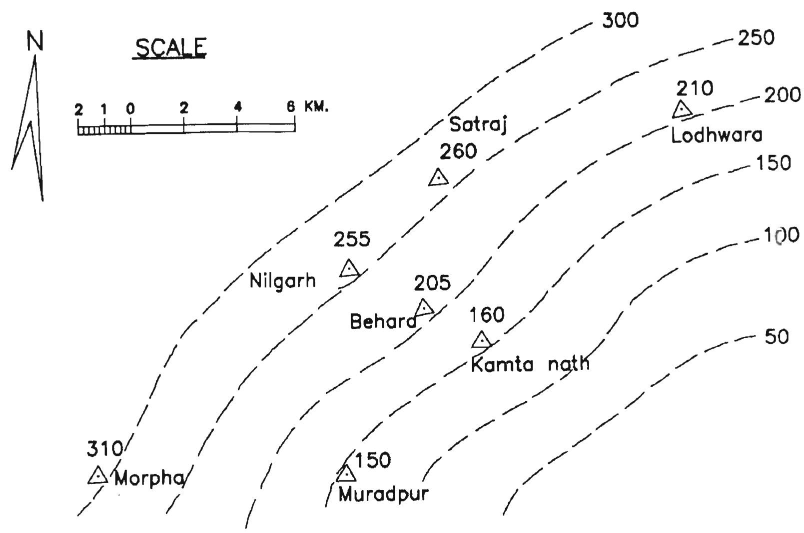

Fig.6. Palaeoslope contour map of the Vindhyan Basin, Chitrakoot area, U.P.

The isopach and stratum contour maps prpeared on the basis of available sections in the Chitrakoot area show an even slope of 1 in 30^0 due south for the basement granite which parallels the dip of the overlying sediments (fig. 6), suggesting a potentially stable northern block. The Semri and Kaimur sediments depositied subsequently, overlapped the basement towards north. This is a significant feature pointing towards a northward transgressive sea. The earlier concept of correlation of the basal conglomerate obseved in the northern flanks of the Vindhyan basin to the Basal conglomerate of the southern flank is not sustainable. In fact, due to the trangression of the sea northward, the constitutent fragments of the conglomerate were contributed from the Bundelkhand granite in the north and got accumulated as marginal detritus.

A shallow water marine environment during the entire Vindhyan period is ubiquitous and unique and a periodic sinking and subsiding basin *pari passu* deposition had been postulated by earlier workers (Auden 1933). The present model of deposition is a corollary to the one given above according to which a sea with recurrent sea level fluctuations throughout deposition is envisaged and the sea level rise corresponding to periodic pulsating tectonics is proposed, wherein the southern marginal part of the Vindhyan basin were uplifted in response to tectonics and the water body moved northwards, transgressing the Bundelkhand basement rocks towards north under the influence of tectonism and the southern standline shifted towards the central part of the basin.

CONCLUSIONS

1. The Semri and Kaimur Groups of rocks overlying the basement of Sidhi/Mahakoshal group in the Son Valley area towards the south are 1500 to 3500 m thick and exhibit a marked vertical as well as lateral facies variation in response to periodically pulsating tectonism. Overlapping of younger formational units on to the Bundelkhund basement with reduced thickness (200 to 300m) towards north has been recorded in the Chitrakoot-Karvi area.
2. Three distinct cycles of sedimentation of rudaceous, arenaceous, argillaceous and chemogenic sequences have been recorded each culminating in a tectono-magmatic activity in the form of volcaniclastic and volcanogenic deposits, acidic and basic intrusives and effusives.

3. The lithological, sedimentological, structural and palaeontological (stromatolites) attributes, and critical evaluation of isopach, lithofacies and stratum contour maps suggest a depositional environment under recurrent fluctuating sea level conditions. Besides ubiquitous northwesterly palaeocurrent direction throughout the period of deposition suggests a southerly to southeastery source area.

4. The southern marginal parts of the Vindhyan Basin, marked by major lineament zones *viz.*, Narmada-Son and Amsi-Jiawan lineament system, witnessed a periodically pulsating tectonism throughout the entire period of sedimentation. Under the influence of this tectonism, the southern part of the basin continued to be uplifted spasmodically, resulting in sea level rise, northward movement of the water body onto the Bundelkhund basement, leading to north ward shifting strandline and successive overlapping of younger formational units in the northern part of the basin.

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