ECONO-SEDIMENTOLOGICAL STUDIES OF VINDHYAN ROCKS AROUND ROHTAS, BIHAR, INDIA

Kshitij Mohan* and Ajai Srivastava**

Abstract

The present work deals with the econo-sedimentological aspects of the Vindhyan occurring around district Rohtas, Bihar. The district comes under an industrialized belt of Bihar. Vindhyans are one of the most controversial formation of Indian stratigraphy which posses a great problems regarding their age, depositional history and homotaxial position.Authors have tried to explore these challenging aspects of the Vindhyan Supergroup, especially the rocks of lower Vindhyan Group. The lithological and grain size study of vertical sections indicate a coarsening upward regressive marine deposit. An extensive deposits of limestone, sandstone and quartzite are occurring in the area; which are being utilized for the manufacture of Portland cement and as building material. A huge deposit of 11.47 million tons of geological reserves is a good sign for setting up other industries requiring limestone and sandstone.

Key words

Vindhyan Rocks, Semri and Kaimur Groups, Depositional Environment, Limestone, Sandstone

Introduction

The Vindhyan basin forms a prominent entity in the geology of India by its characteristics lithological assemblage and is also best known for its economic occurrences i.e. pyrite, limestone, sandstone etc. The Vindhyan Supergroup, represented by a thick pile of sediments belonging to the Semri, Kaimur, Rewa and Bhander Groups, is one of the largest proterozoic sedimentary basins of India. It is spread over an area of 1, 00,000 km^2, extending from Sasaram, Bihar in the east to Chittorgarh, Rajasthan in the west. The term 'Vindhyan' was first introduced by Oldham of the then Geological Survey of India in 1856 to designate the great sandstone formation of Bundelkhand and Malwa, and was later extended to cover other areas in which the same sedimentary formations are exposed. The classical works of Mallet (1869) and Auden (1933) are also noteworthy and were helpful for all subsequent research studies. The present work is concerned with the econo-sedimentological studies of the Vindhyan rocks around Rohtas, Bihar. The district of Rohtas comes under an important industrialized belt of Bihar. An extensive deposit of limestone is being frequently used as an important raw material for the manufacture of cement. Besides their economic importance, Vindhyans are one of the most controversial formations of Indian stratigraphy which possesses great problems regarding their age, depositional history and homotaxial position. In the present study, attempts have been made to delineate these challenging facts of Vindhyan Supergroup, especially the rocks of Lower Vindhyan Group and the lower part of the Upper Vindhyan Group.

** Department of Geography, Banaras Hindu University, Varanasi - 221 005, India*
*** A-2/2, Imlak Colony, Nadesar, Varanasi Cantt - 221 002*

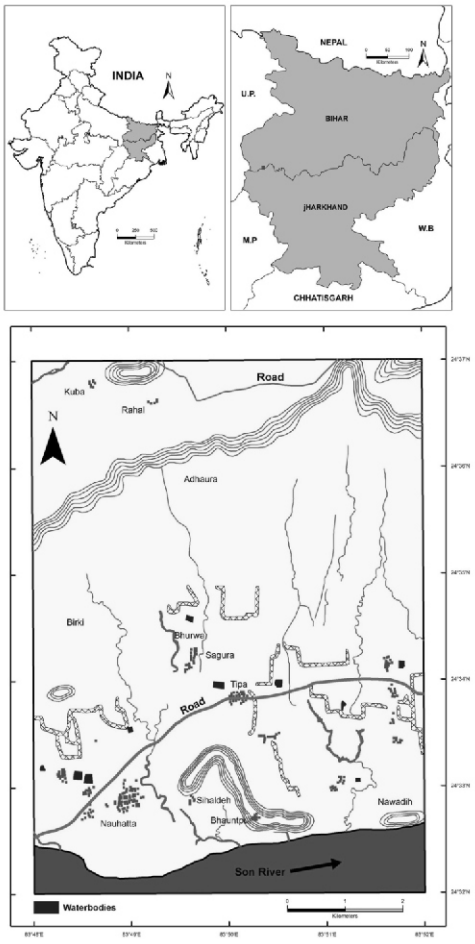

Fig. 1 Location map of the Study Area.

Area under Study

The area under investigation (Fig.1) falls between the latitude 24°32' to 24°37' N and longitude 83°48' to 83°52' E as appeared in the Survey of India toposheet no. 83P/14. The Figure shows the location of 9 representatives samples taken for the grain size analyses. The total area covered is about 23 sq. miles and is a part of Rohtas district; it is known as Tipa. The area covers small hillocks along Son valley near (1) Bhaunathpur, Shiladih and Nawadih areas (2) area near Rahal village situated at the hill of Kaimur range. (3) Bhurwa-Birki area situated at the foothill of Kaimur range.

The area lies along the left side of course of Son River and situated 60-70 km away from Dehri-on-Sone Railway Station. It is approachable from Dehri-on-Sone and Sasaram by buses or taxies. Nauhatta is a big village where Police station and Block office is present. On the way to the area, the excellent exposure of sandstone, limestone and shale are frequently met with, which are observable around Banjari, Murli, Rohtasgarh, Bhaunathpur and Chunhatta.

Geological Setting

The area under present investigation belongs to the Vindhyan Supergroup comprising mainly the lithounits like sandstone, limestone and shale. The 'Vindhyan Supergroup' can be defined as the sequence of rocks comprising mainly of sandstone, limestone and shale; occupying a large basin extending from Dehri-on-Sone to Hoshangabad and from Chittorgarh to Agra. It has been named as the 'Vindhyan Supergroup' after the Vindhyan Range in central India.

The small hillocks along the Son-river are mainly comprised of sandstone, siltstone limestone and shale. The general strike direction of the area is nearly eastward, dip direction towards north with a variable angle of 5-12 degrees. Few local folds and minor faults are present at places. In the area only Kaimur and upper part of Semri Group, i.e. Rohtas subgroup are well exposed. Calcareous formation occurs in the area belonging to the Rohtas Subgroup of Semri Group in Lower Vindhyan. Rohtas Subgroup mainly consists of intercalated shale and limestone bands which overlie the glauconitic sandstone of Khenjua stage. This stage is overlain by Kaimur Group consisting mainly of sandstone, quartzite and shale (Figure 2). In the present area, no complete

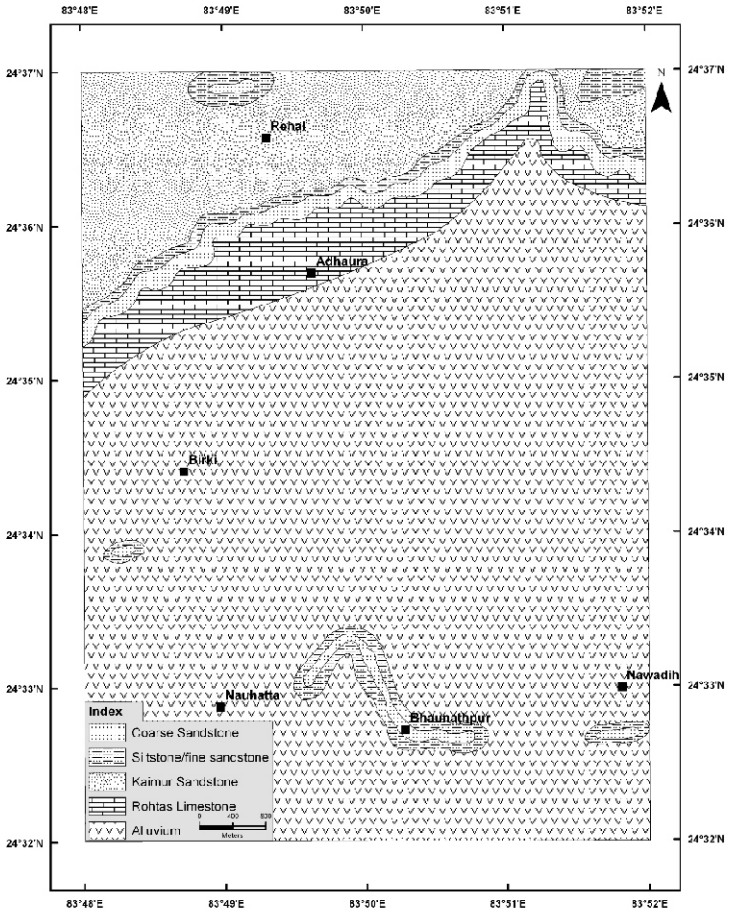

Fig. 2 Geology of the Study Area.

succession of Rohtas and Kaimur Formations are exposed. The limestones are more or less light grey to dark grey in colour with partings of yellowish grey shale and calcareous nodules. Kaimur Sandstones is found at the top and other Formations like Kheinjua, Porcellanite and Basal are absent in the present area. As per the principle laid down in the American code and that of stratigraphic nomenclature of India, 1971; Vindhyan System can be termed as 'Vindhyan Supergroup' and Semri Series termed as 'Semri Group' and the Stages which are included into each series can be termed as Subgroup.

Keeping the above in view, the following classification has been made in the investigated area.

Upper Vindhyan	Kaimur Group	-	Lower Kaimur Sanstone
----------Unconfirmity----------			
Lower Vindhyan	Semri Group		Rohtas Subgroup-
			- Rohtas limestone & shale

In the study area, only upper portion of the Semri Group, i.e Rohtas Subgroup and lower portion of the Kaimur Group is visible.

The sedimentary sequences comprising limestone and shale, termed as Rohtas Subgroup, forms the upper most unit of Semri Group. The Rohtas Subgroup was named after the ancient fort of Rohtasgarh in Rohtas District of Bihar. At Rohtasgarh, the limestones are about 200 m thick. The limestone are more or less light grey to dark grey in colour with partings yellowish grey shale and calcareous nodules. The bedding in both limestone and shale is mostly thin and markedly parallel. Towards the top of this Subgroup, silcification of limestone is markedly noticed. The Rohtas Subgroup has conformable contact with the underlying Kheinjua Subgroup. The 'Nodular', 'Banded Shale Limestone' (Auden, 1933, Mallet, 1869) have been clubbed as the Rohtas limestone (Rao and Neelkantam, 1978) which has further been modified as the Rohtasgarh Limestone. In the area, Kaimur Group is characterized by an assemblage of sandstone, shale, flagstone and Porcellanite overlying the Semri Group, being the lowest unit of the Upper part of the Vindhyan Supergroup. Thickness of the Kaimur varies enormously from a few metre to 400 metre. At Rohtasgarh, it is estimated to have gone up to 400 meter (Pascoe, 1968). The sandstones of the area are of horizontal nature and suffered a long course of weathering. The general strike direction is almost east-west and the dip towards north and at variable angle of 5 to 12 degrees towards hill due north. Kaimur sandstones are found at the top and other formations like Kheinjua, Porcellanite and basal stages are absent in the area. Besides, depositional and post-depositional structures can well be observed in both the formations i.e. Rohtas and Kaimur formations in the area. Beddings, laminations, lineations, graded beddings, cross beddings, ripple marks, mud cracks and desiccation cracks, rain prints, stylolites and dentrites have been observed. Whereas, post-depositional structures includes folds, faults and joints in the area. In the present area, authors have also found the algal structures from the Rohtas Limestone, which owe the origin of their lives during the Vindhyan period. These evidences are very helpful in demarcating the Pre-Cambrian/ Cambrian boundary.

Drainage Pattern, Topography and Physiography

The river Son flows 4 km. away from the Bhurwa-Birki limestone quarry area and it the

plateau has its drainage towards the south by some seasonal drains and streams. Son river valley which is lying south of the area is the only perennial water course. Previously, the Bhurwa-Birki area was the lease area of 80,937 hectare, totally lying in the forest area and mostly covered with small thorny trees and bushes. Now-a-days agricultural land exists in some portion of land between lease area and Son river valley.

History of Sedimentation

An attempt has been made to derive the probable provenance on the basis of the mineralogy of the rocks. For the determination of provenance, it is much obvious to know that the detrital sediments present in the area, are of the first cycle of erosion i.e. derived from a crystalline rocks or whether it is second cycle sediments derived from earlier sediments. Roundness of grain is the main indication of the cycle of origin. The immature sediments having a little roundness indicate their origin in first cycle whereas the mature grains with a certain degree of roundness is indicative of second cycle of origin. The following evidences could be cited for deciphering the provenance for the Kaimur sandstone of the present area. Mineral logically, the sandstones are mainly constituted of quartz, rock fragments, feldspar, mica and clay minerals. The quartz is the most stable mineral in the nature in respect of its chemical and physical characteristics. The quartz forms about 70-95% of the total rocks in the litho units of the present area. The abundance of quartz signifies the maturity of these rocks. The quartz of these rocks is mostly detrital. Inclusions of very minute mineral grains are also found in the quartz. Such quartzs are characteristics of crystalline and/or preexisting sedimentary rocks in the provenance. However, feldspars are also present in the rocks of the present area, but percentage is much low (1-2%). The presence of feldspars indicates the metamorphic and igneous provenance. On the other hand, the detrital grains of muscovite and clay minerals are common in the arenaeceous lithounits, but they are in very minor amount. The clay minerals form the argillaceous matrix, and iron-oxide is dominating cementing material. Cherty and ferruginous rock fragments are present which indicate the mixed sources. In limestone calcite as a rock fragment is common.

Heavy minerals can be employed in provenance studies in a general way to recognize broad categories of possible parent rocks. A few species of heavy minerals are diagnostic of a particular kind of parent rocks and helpful in an identification to determine provenance. A variety of heavy minerals e.g. tourmaline, garnet, kyanite, sillimanite, zircon and opaque are found in the sandstone of the present area. The following Table –1 shows the probable source for the heavy minerals as suggested by Pettijohn (1975).

Table - 1 Heavy minerals and their probable sources (Pettijohn, 1975)

Heavy Minerals	Source rock
Tourmaline	Reworked sediments, acid igneous rocks, low grade metamorphic rocks, pegmatites
Garnet	Pegmatite, High grade metamorphic rocks
Zircon	Acid igneous rocks
Kyanite, sillimanite	High grade metamorphic rocks

The heavy minerals are both quantitatively and qualitatively not so significant in case of Kaimur sandstone. Tourmaline, garnet, kyanite, sillimanite and zircon are found, but their percentage is much less in comparison with opaque heavies. However, the presence of zircon indicates the igneous source while tourmaline, garnet, kyanite and sillimanite are indicative of metamorphic source. It may be concluded that that both igneous and metamorphic sources are responsible for the Vindhyan sedimentation.

The proterozoic Vindhyan sediments represent a classic example of platform sequence developed in the intracratonic embayment opening towards west. Recent studies have demonstrated that the environment of sedimentation, though remain largely in shallow marine realm, shifted periodically from beach to tidal shelf through tidal flat lagoonal complex. The association of shore parallel elongate sand bodies with tidal flat lagoonal facies no doubt suggests that these sand bodies could possible represent barrier-beach-dune complexes, yet absence of both typical beach structures and evidence of emergence cast doubt on the validity of barrio- bar origin.

Contribution of Banerjee (l964) was the trend settler for the modem studies in Vindhyan Sedimentology. It was Banerjee (l974) who made an attempt to reconstruct a sedimentation model for the Vindhyan basin. More recently, Gupta et al. (2003) worked on the depositional environment and tectonics during the sedimentation of Semri and Kaimur Groups of rocks of Vindhyan basin. He suggested a depositional environment under recurrent fluctuating sea level conditions 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 uniformly shallow marine environment.

Our Observations

In the present study, we found that lower Kaimur sandstones are generally quartz wacke, quartz arenite, lithic arenite, having angular to subangular quartz grains, which are frequently enlarged due to the secondary overgrowths. Ripple marks, dessication cracks and mud cracks are present with locally raindrops impression. The Kaimur quartz arenite would have been deposited in fluviodeltaic or subtidal to intertidal environment as evidenced by ripple marks and cross beddings. The quartz wacke would have deposited under low energy conditions as winnowing of the fine material is lacking. A total of 9 representative samples were subjected to grain size analyses to assess the sedimentary processes. The results of grain size analyses are shown in the Table 2. The lithological and grain size study of vertical sections indicate a coarsening upward regressive marine deposit. The Rohtas limestone is predominantly of micritic size. It is compact and fine grained with thin laminations. It is usually interbedded with fine-grained, thinly laminated shale. This suggests the precipitation of calcium carbonate under suitable physico-chemical conditions when the sea water would have covered more or less the flat areas.

Table - 2 Grain size analysis

Sl. No.	Class interval (in ϕ)	Sample No.1		Sample No. 2		Sample No. 3		Sample No. 4		Sample No. 5		Sample No. 6		Sample No. 7		Sample No. 8		Sample No. 9	
		Frequency %	Cumulative %	Frequency %	Cumulative %	Frequency %	Cumulative %	Frequency %	Cumulative %	Frequency %	Cumulative %	Frequency %	Cumulative %	Frequency %	Cumulative %	Frequency %	Cumulative %	Frequency %	Cumulative %
1	0.00-0.50	-	-	-	-	-	-	-	-	0.78	0.78	-	-	-	-	-	-	2.76	2.76
2	0.50-1.00	-	-	1.2	1.2	-	-	-	-	0.78	1.56	2.64	2.64	-	-	-	-	13.83	16.59
3	1.00-1.50	3.63	3.63	8.8	10.0	1.19	1.19	-	-	10.15	11.71	8.30	10.94	2.0	2.0	-	-	50.59	67.18
4	1.50-2.00	9.09	12.72	9.6	19.6	12.74	13.93	6.81	6.81	14.84	26.55	5.28	16.22	17.6	19.6	4.19	4.19	20.94	88.12
5	2.00-2.50	22.45	38.17	30.4	50.0	21.51	35.44	17.04	23.85	28.12	54.67	23.39	39.61	33.6	53.2	25.19	29.38	7.50	95.62
6	2.50-3.00	22.54	60.17	27.6	77.6	27.88	63.44	25.75	49.60	23.82	78.49	21.13	60.74	26.0	79.2	25.95	55.33	1.97	97.59
7	3.00-3.50	22.54	83.25	18.8	96.4	23.10	86.42	32.95	82.55	18.35	96.84	26.03	86.77	16.4	95.6	30.91	86.24	2.37	99.96
8	3.50-4.00	9.01	92.96	2.8	99.2	9.96	96.38	13.63	96.18	1.95	98.79	8.67	95.44	1.2	96.8	8.39	94.63	-	-
9	4.00-4.50	7.63	99.89	-	-	3.58	99.96	3.78	99.96	1.17	99.96	4.52	99.96	1.2	98.0	5.34	99.97	-	-
										Total	99.96		99.96		98.0		99.97		99.96

Economic Significance of depositing rocks:

An attempt has been made to assess the economic viability of the depositing rocks of the area. The most important lithounits dominating in the area are limestone, shale and sandstone belonging to the Rohtas subgroup and Kaimur group respectively. The present area consists of large deposits of Rohtas limestone. The limestone of the ea is suitable for the manufacture of cement and lime. The limestone of the area is querried out for the manufacturing of cement by Kalyanpur cement Ltd. ,Banjari, District Rohtas, Bihar. The Japla Cements Ltd, also quarries out the Rohtas limestone of the area, situated across the Son-river valley. Limestone is also quarried out at Chunhatta. An assessment has been made for the quality and reserve of the cement produced. For the calculation of reserves, the area has been divided into two blocks viz. east and west. There are 5 limestone beds varing from 0.91 to 9.14 metres. The total reserve has been estimated 11.47 million tons, on the basis of true thickness of beds; amongst this, proved reserve is 5.19 million tons, whereas the probable and mineable reserves are 3.25 and 3.02 millions tons respectively. The limestone of the area can be utilized in other industries as Iron-steel industry, manufacture of chemical fertilizers and lime, alkali, bleaching power and ceramic. Production of one ton of steel requires about half ton of limestone. Limestones are in great demand in the paper, sugar, textile and glass industries. It is also used as a constituent of pottery, glazes for textiles, soap and toilet powders. In this way, the limestone of the area could occupy a good place in the aforesaid industries.

Apart from limestone, sandstone also occurs in more than half of the area of lower Kaimur region. These sandstones are very hard and compact, less jointed, fine to medium grained and possess brown, red and greyish yellow colours. These may be used for building as well as road materials as sandstones of the area fulfils most of the requirements needed for building materials i.e. quarrying, strength and durability, hardness and workability, colour, fabric, texture, porosity and permeability. These sandstones could be used in so many ways like, for the construction of houses, pillars, for roofing, ceiling and as road material. The cost of quarrying method is less because they can be separated out easily along their bedding plane. Vindhyan sandstones furnish all the qualities which are required for building purposes. Some of the finest models of Indian architecture such as famous stupas of Sanchi and Sarnath, the famous Ashokan monolithic columns of Sarnath and Mughal palaces and mosques of Delhi and Agra and the modern government buildings in New Delhi have been constructed from Vindhyan sandstones. The local Rohtasgarh Fort situated at the top of the Kaimur hill, has also been constructed from the Vindhyan sandstones. Besides, shales of the present area might be used together with limestone in the manufacturing of cement.

Conclusion

It is concluded that the main lithounits of the present area are mainly limestone, sandstone and shale. The Kaimur plateau is entirely made up of sandstones which are hard and compact and commonly rich in ferruginous material. The Rohtas limestone and shale are found interbedded in the area. They show moderate to thin bedding and laminations. Lower Kaimur sandstones overlying Rohtas limestones are hard, compact and fine to medium grained quartz arenites. The shape of quartz grains varies from angular to subangular and rounded to subrounded and due to

secondary overgrowth few grains exhibit faceted out lines. The sandstones are supermature quartz arenitic consisting more than 75% quartz detritals. It has syndeposition structures too, like cross beddings, ripple marks, mud cracks or dessication cracks and rainprints indicating intertidal nature of deposition. Usually the size of the sandstones ranges from fine to coarse grain from bottom to top of the Kaimur plateau. The siltstone is found to be exposed in the lower part of the hillocks. In general the rocks of the area show the mixed provenance as evaluated from the heavy mineral suits. The study of heavies of Kaimur sandstones shows that metamorphic and igneous, both the type of sources may be responsible for the sedimentation. The large deposits of Rohtas limestone are suitable for the manufacture of cement, lime, iron-steel industry, manufacture of chemical fertilizers. Whereas the Lower Kaimur sandstones found in more than half of the present investigated area, fulfils most of the requirements needed for building material. These sandstones can be used in so many ways like, for construction of houses and pillars, for roofing and ceiling and as road material. The total geological reserves have been estimated as 11.47 million tons. These huge reserves are a good sign for setting up new industries requiring sandstone and limestone.

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