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SEDIMENTARIES OF THE ZONE OF BADOLISERA AND THE VINDHYAN SUPERGROUP, UTTAR PRADESH—A REAPPRAISAL OF CORRELATION

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ABSTRACT

On the basis of lithostratigraphic similarities and the presence of stromatolite assemblage, the Vindhyan Supergroup of U. P. and the Zone of Badolisera are correlated. It is contended that the Kajrahat Limestone and the Thalkedar Dolomite are Lower Riphean in age. The Kheinjua and Rohtas formations, and the Gangolihat Dolomite are of Middle Riphean age. The Kaimur Formation of Upper Vindhyan is correlated with the Berinag Quartzite.

INTRODUCTION

The sedimentary succession of Precambrian age occurs in widely separated regions and in contrasting tectonic setting in Uttar Pradesh (Fig. 1). In the northern Uttar Pradesh about 6000 m thick pile of sediments, designated as the Zone of Badolisera by Heim and Gansser (1939), occupies vast areas in the Lesser Himalaya in Almora and Pithoragarh districts. These are bounded in the north by the Central Thrust and in the south by the North Almora Thrust. These rocks are subjected to intense folding and to low grade of metamorphism. However, primary sedimentary structure are still discernable. No body fossil has yet been recorded from them but good development of stromatolites is documented (Valdiya, 1962, 1969; Misra and Kumar, 1968 ; Banerjee, 1970 ; Kumar and Tewari, 1977 a, b ; Kumar and Kumar, 1977 ; Bhattacharya, 1976).

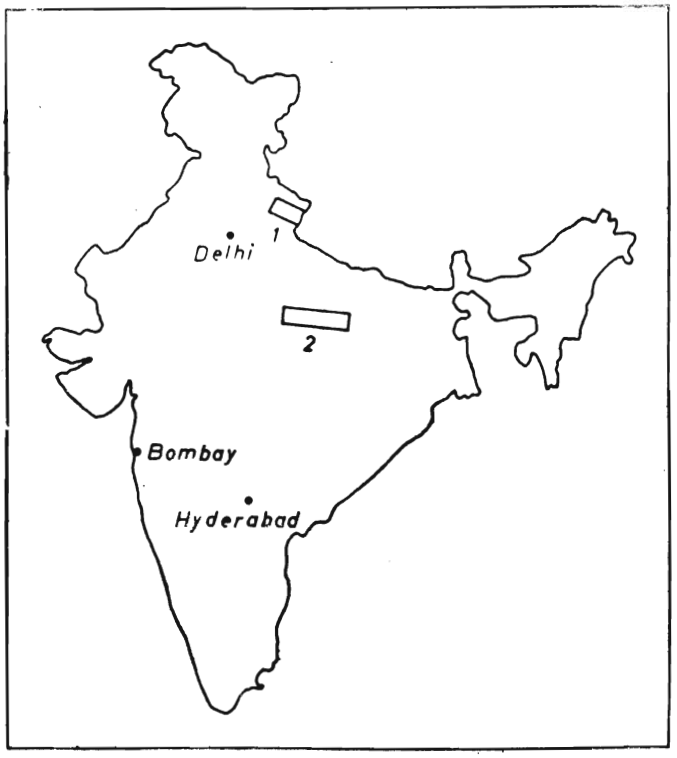

Fig. 1. Locality map of the Vindhyan Succession and the Zone of Badolisera :
1. Zone of Badolisera
2. Vindhyan rocks.

In the southern part of Uttar Pradesh, the Vindhyan rocks forming small hillocks break the monotony of Indo-Gangetic plain. The Vindhyan rocks occupy a vast area in Mirzapur, Allahabad, Banda and Lalitpur districts and attain a thickness of about 4000 meters. The rocks of the Vindhyan Supergroup are unmetamorphosed and least disturbed. Consequently these show an excellent preservation of sedimentary structures and are extensively searched for the evidences of life. Surprisingly, only a few horizons yielded fossils, majority of which are, however, of doubtful nature (Misra, 1969). Recently some primitive body fossils have been described from these rocks (Salujha *et al.*, 1971 ; Maithi and Shukla,1977 ; Tandon and Kumar, 1977 a, b). But the development of stromatolites is quite abundantly recorded from these rocks which helped in both interregional correlation and in assigning age to the different litho-stratigraphic units (Valdiya, 1969 ; Kumar, 1976 a, b).

Thus, as the stromatolites are common in both the successions of the Zone of Badolisera and the Vindhyan Supergroup, and are also well documented by several workers, in the present paper an attempt has been made to review the correlation with special reference to the evolution of sedimentation basin.

GEOLOGICAL SETTING AND STROMATOLITES OF THE ZONE OF BADLISERA

The lithostratigraphic subdivisions of the sedimentary Zone of Badolisera is given in Table 1. However, the stratigraphic position of the different litho-units is a matter of debate. Misra and Valdiya (1961), Valdiya (1962, 1964, 1969), Misra and Kumar (1968), Misra and Banerjee (1968) and Bhattacharya (1976,) consider the entire sedimentary zone as inverted while Heim and Gansser (1939), Gansser (1964), Banerjee and Bisaria (1975), Ram Ji (1976), Kumar and Tewari (1977) maintain that the entire sedimentary pile is in normal position except for some locally inverted sequences. Considering the whole gamut of tectonic implications, it is however, logical to consider the entire sedimentary zone as normal. Thus, what is physically at the top is taken as the youngest and vice versa. With this view, the Berinag Quartzite becomes the younger and the Calc Zone of Pithoragarh as the older group of the Zone of Badolisera.

The stromatolites are developed in the Calc Zone of Pithoragarh in both the carbonate formations viz., the Thalkedar Dolomite and the Gangolihat Dolomite (Table1).

Table 1—Lithostratigraphic Succession of the Calc Zone of Pithoragarh

	Group	Formation	Lithology	Stromatolites
ZONE OF BADOLISERA	Berinag Quartzite		Orthoquartzites and amphibolites	
	Calc Zone of Pithoragarh	Gangolihat Dolomite	Dolomites and dolomitic limestones, lentiform deposits of magnesite, tuffaceous purple phyllites.	*Baicalia baicalica* *Colonella columnaris* *Kussiella kussiensis* *Minjaria uralica* *Collenia symmetrica* *Conophyton garganicus* *Conophyton misrai*
		Sor Slate	Olive, green, brown, grey and black slates with orthoquartzites and subordinate argillaceous dolomitic limestone	
		Thalkedar Dolomite	Siliceous dolomite, dolomitic limestone and slates.	*?Jurasania* *Colonella thalkedarensis* *Gongylina* *Stratifera* *Colonella columnaris*
		Rautgara Quartzite	Brown and greyish pink proto-quartzite, orthoquartzite and purple green and brown slates.	
.....		North Almora Thrust		
		Crystalline Zone of Almora.	Porphyries, schists, quartzites and gneisses	

THALKEDAR DOLOMITE

The Thalkedar Dolomite is characterised by stratified, domal as well as columnar stromatolites. Misra and Kumar (1968) for the first time recorded stromatolites from this horizon. Valdiya (1969) recorded the occurrence of two forms *?Jurasania* and *Collenia symmetrica*. Misra and Kumar (1969) have reported the occurrence of *Colonella thalkadarensis* from Raintola. The identification of *Jurasania* is doubtful as the form lacks well developed wall structure. The form in question needs redescription and reidentification. The identification of *Collenia symmetrica* described from Raintola is also incorrect. It has now been identified as *Colonella thalkedarensis* and the photograph in Valdiya (1969), Plate III-3 is nothing but the transverse section of *Colonella thalkedarensis*.

Recently, Kumar and Kumar (1977) have recorded two stratified stromatolites *Stratifera* and *Gongylina*.

GANGOLIHAT DOLOMITE

The youngest formation of the Calc Zone of Pithoragarh, the Gangolihat Dolomite, shows better development of stromatolites in comparison to the Thalkedar Dolomite. Valdiya (1969) has recorded *Collenia baicalica* (*Baicalia baicalica*), *Collenia columnaris* (*Colonella columnaris*), *Collenia symmetrica*, *Collenia kussiensis* (*Kussiella kussiensis*), and *Minjaria uralica*. Recently Kumar and Tewari (1977, 1978) have recorded two forms *Conophyton garganicus* and *Conophyton misrai*.

GEOLOGICAL SETTING AND STROMATOLITES OF THE VINDHYAN SUPERGROUP

The Vindhyan succession in Uttar Pradesh is represented by the Semri Group (Lower Vindhyan) and the Kaimur Formation of the Upper Vindhyan. It unconformably overlies the Bijawar Formation. The contact

between the Semri Group and the Kaimur Formation is also unconformable. Stromatolites are seen only in the Semri Group in which these are recorded from all the carbonate horizons (Table 2).

Basal Formation

The Basal Formation is characterised by dominance of *Kussiella* group. The Basal Conglomerate (Member) shows poor development of *Kusiella kussiensis* (Kumar, 1976a). The Kajrahat Limestone shows development of stromatolites only in the upper part of the succession. It has yielded *Colonella kajrahatesnsis*, *Kussiella dalaensis*, *Kussiella kussiensis*, *Collenia symmetrica* and *Conophyton vindhyansis* (Kumar, 1976 a, b ; Misra *et al.*, 1977).

Kheinjua Formation

The Fawn Limestone member of the Kheinjua Formation shows good development of *Conophyton garganicus* and *Colonella columnaris* and domal form *Collenia clappii* (Kumar, 1976 a, b).

Rohtas Limestone

The Rohtas Limestone, the youngest formation of the Semri Group, shows poor development of stromato lites. Only ill developed algal mats are recorded in Son Valley. Recently, oncolites have also been recorded from these limestones (Kumar, 1977 a). However, in the Chitrakut area, where the Semri Group shows a condensed sequence, columnar stromatolites show good development. In the Tirohan Limestone (=Rohtas Limestone) of Chitrakut area, Kumar (1977b) has recorded *Colonella* and *Baicalia* and oncolites. These are associated with phosphorite. However, the identification of *Baicalia* could not be confirmed as the description of the form has not been published.

CORRELATION

The correlation of such sequences which attain great thicknesses but are more or less destitute of body fossils even of debatable nature is largely a matter of speculation. In such unfossiliferous sequences of widely separated regions the correlation is generally based on

Table 2—Stratigraphic Succession of Vindhyan Supergroup (After Auden, 1933)

Group	Formation	Member	Stromatolites
	Bhander Formation	Maihar Sandstone Sirbu Shale	
			Baicalia baicalica
		Bhander Limestone	*Maiharia maiharensis* ? *Tungussia* Oncolites
UPPER VINDHYAN	Rewa Formation	Upper Rewa Sandstone Jhiri Shales Lower Rewa Sandstone	
	Kaimur Formation	Dhaundhraul Quartzite Scarp Sandstone Bijaigarh shales Upper Quartzite Silicified shales Lower Quartzite	
.....	.....	Unconformity	.....
	Rohtas Formation	Limestone and Shales	*Colonella columnaris* ? *Baicalia* and oncolites
SEMRI GROUP	Kheinjua Formation	Glauconitic Sandstone Fawn Limestone Olive Shale	*Conophyton garganicus* *Colonella columnaris* *Collenia clappii*
(Lower Vindhyan)	Porcellenite Formation	Porcellenites	
	Basal Formation	Kajrahat Limestone	*Kussiella kussiensis* *Kussiella dalaensis* *Colonella kajrahatensis* *Collenia symmetrica* *Conophyton vindhyaensis*
		Basal Conglomerate	*Kussiella kussiensis*
.....	.....	Unconformity	.....
	Bijawar Formation	Phyllites	

lithologic anology even though it is unreliable because of the facies changes and lack of time control. The radiometric age determinations of authigenic minerals in the sedimentary rocks and also of the associated igneous rocks can be used for correlation but such data is most often not available or there is altogether lack of such material which can be used for determination of radiometric age in the succession in question.

The absence of fossils, if it is not due to environmental factors like high salinity or deficiency of oxygen in the basin of deposition, can be ascribed to the antiquity of the rocks when the life was either absent or was in a very primitive state of evolution which could not get preserved.

The general absence of body fossils in the rocks of the Vindhyan Supergroup and the Zone of Badolisera except for a few record of a very primitive life in the former, suggests Precambrian age to both of them.

The profuse development of stromatolites in the two sequences is also indicative of their antiquity. Though, the stromatolites are basically organosedimentary structures produced by organic activity of micro-organisms, but they have been quite successfully used in the inter-regional correlation in U.S.S.R., Australia and India in the Precambrian sequences on this presumption that they show time controlled evolutionary trends in the form morphology. Their luxuriant growth in the Precambrian sedimentary sequences are indicative of the fact that algal activity was most dominant during this period. Subsequently, during early Palaeozoic, the algal activity relegated to secondary role due to the emergence of animals whose browsing activity hindered the development of stromatolites in the post Precambrian period. Undoubtedly the stromatolites have been reported in the Palaeozoic to Recent only in the areas where browsing activity was not possible perhaps due to some unusual chemical milieu in the sedimentation basin. Thus, the profuse development of stromatolites and near absence of body fossils in the Vindhyan Supergroup and the Zone of Badolisera confirm that their age is Precambrian.

Holland (see Wadia, 1957) was the first who considered the unfossiliferous sediments of the Lesser Himalaya to be the northern outliers of the sedimentary group of Purana age of the Peninsular India. He even regarded them as the prolongation of the Peninsular Purana which were continuous and connected before the divorce of the Himalaya and Peninsula. His correlation was simply on the basis of the lithological similarity and unfossiliferous nature of both the successions of the Lesser Himalaya and the Puranas. Similar suggestions also came from Pascoe (1950). Later on Boileau (1954, in Krishnan and Swaminath) correlated the Upper Vindhyan with Shali succession in the Simla hills which is considered to be homotaxial with Infra Krol—Krol succession of Garhwal. He also correlated the Khaira quartzite of Dharamshala, Mandi and Bilaspur areas with Tanakki quartzites of Hazara and the Kaimur Formation. Krishnan and Swaminath (1959) have contended that the shape of the Vindhyan basin suggest that the northern ridge should have extended well into the Sub-Himalayan Zone and that its western boundary was marked by the extension of the Aravalli mountain axis into the Simla-Garhwal region.

Valdiya (1964, 1969) was the first who attempted correlation of these rocks on the basis of the stromatolite assemblage. Since the work of Valdiya (*op. cit.*) considerably more data is available on the structure, lithostratigraphy and stromatolites of the Lesser Himalaya of Almora and Pithoragarh, U. P., a more precise correlation can now be attempted. A detailed correlation Table is given in Table 3.

Table 3

Vindhyans of U.P.		Zone of Badolisera	
Kaimur Formation		Berinag Quartzite	
.....Unconformity.....			
Semri Group: Rohtas Formation		Calc Zone of Pithoragarh: Gangolihat Dolomite	
Semri Group: Kheinjua Formation		Calc Zone of Pithoragarh: Sor Slate	
Semri Group: Porcellenite Formation			
Semri Group: Basal Formation	Kajrahat Limestone	Calc Zone of Pithoragarh: Thalkedar Dolomite	
	Basal Conglomerate	Calc Zone of Pithoragarh: Rautgara Quartzite	
.....Unconformity.....		.....North Almora Thrust.....	
Bijawar Formation		Crystalline Zone of Almora	

DISCUSSION

The Basal Formation of the Semri Group shows profuse development of *Kussiella*, *Conophyton*, *Collenia symmetrica* and *Colcnella*. Kumar (1976) has assigned Lower Riphean age to the Basal Formation. In the Thalkedar Dolomite there is no stromatolite assemblage which can be used as an age indicator. Valdiya (1969) has identified *Jurasania* with a question mark. The form in question does not show presence of wall structure and this makes identification doubtful. The presence of *Colonella*, *Stratifera* and *Gongylina* does not indicate any age. Since the Thalkedar Dolomite underlies the Sor Slate which in turn is overlain by the Gangolihat Dolomite of Middle Riphean age, the age of the Thalkedar Dolomite has been taken as Lower Riphean. However, Valdiya (1969) has suggested Upper Riphean age to the Thalkedar Dolomite.

The Gangolihat Dolomite shows presence of *Conophyton garganicus*, *Baicalia* and *Colonella*. This assemblage is taken as characteristic assemblage of the Middle Riphean. The Kheinjua Formation shows development of *Conophyton garganicus*, *Colonella columnaris* and *Collenia clappii*. However, in the Tirohan Limestone (=Rohtas Limestone) *Colonella—?Baicalia* has been recorded. Thus, the upper part of the Semri Group (Kheinjua Formation and Rohtas Formation) shows presence of *Conophyton garganicus—Colonella—?Baicalia* assemblage which has been assigned Middle Riphean age. This correlation is in agreement with the radiometric age of 1110 ± 60 my given to the Kheinjua Formation (see Misra, 1969) and thus, the upper part of the Semri Group can be correlated with the Gangolihat Dolomite. However, Valdiya (1969) has correlated the Gangolihat Dolomite with the Bhander Limestone of the Bhander Formation of the Upper Vindhyan.

Association of phosphorite and stromatolite is a characteristic feature of the Indian Precambrian sequences. It has been recorded from the Gangolihat Dolomite, Tirohan Limestone and Aravali Formation. All the three formations have been assigned Middle Riphean age (Valdiya, 1972, Kumar, 1977 ; and Banerjee, 1971). Thus, the common occurrence of phosphorite in the Tirohan Limestone and the Gangolihat Dolomite is an additional basis for their correlation.

If this correlation of the Gangolihat Dolomite and upper part of the Semri Group holds good then there will be a very clear anology between sedimentational history of the Vindhyan of the Son Valley-Chitrakut area and the sedimentaries of the Zone of Badolisera of the Lesser Himalaya.

(1) It is contended that the sedimentation in both the areas started synchronously.

(2) In both the areas the sedimentaries attain huge thicknesses of several thousand meters.

(3) The sedimentation kept pace with the sinking so that the thick sequences of the same environment could develop.

(4) The Semri Group of the Vindhyan Supergroup and the Calc Zone of Pithoragarh of the Zone of Badolisera show more or less similar lithostratigraphic attributes. There are two thick carbonate sequence in the Semri Group, i.e., the Kajrahat Limestone and the Rohtas Limestone and in the Calc Zone also there are two thick carbonate horizons viz., the Thalkedar Dolomite and the Gangolihat Dolomite.

(5) The Semri Group is unconformably succeeded by a purely arenaceous facies represented by the Kaimur Formation. The Calc Zone is overlain by a thick succession of purely arenaceous rocks of the Berinag Quartzite (Group).

(6) The Kaimur Formation and the Berinag Quartzite represent very shallow marine coastal deposits. The Kaimurs, however, represent deposits of a transgressive sea while the Berinag Quartzite indicates a platform deposit on a stable platform area and is the product of a regressive sea (Kumar, 1978).

However, there is an important difference between the Berinag Quartzite and the Kaimur Formation. The Berinag Quartzite is characterised by penecontemporaneous volcanic activity while no such activity is reported in the Kaimur Formation.

(7) No horizon younger than the Berinag Quartzite and Kaimur Formation has been recorded in both the areas.

(8) It is suggested that there were two separate basins during Lower Riphean time ; one in the Himalaya which witnessed the deposition of the rocks of the Zone of Badolisera and the other in the south in which the Vindhyan rocks were deposited. Both the basins were homotaxial. Another possibility is that both the sedimentary successions were part of the same basin, whose southern side remained stable during the entire sedimentational history of the Vindhyan Supergroup while the northern side during the deposition of the Berinag Quartzite became unstable which resulted in the volcanic erruptions which occur as sills within the Berinag Quartzite. After the regression of the sea at the close of the deposition of the Berinag Quartzite, the area was uplifted and sedimentation ceased.

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