

## STROMATOLITES IN THE PRECAMBRIAN VINDHYAN SUPERGROUP OF CENTRAL INDIA : A REVIEW<sup>1</sup>

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**RESUME.**- Le Supergroup Vindhyan, qui occupe une superficie de 105.000 km<sup>2</sup> en Inde Centrale présente plusieurs unités carbonatées.

Les formations présentant des stromatolithes ou de manière plus générale des structures algaires sont, dans le groupe de Semri, la Formation d'Arangi, le Calcaire de Kajrahat, le Calcaire de Bhagwanpura, le Calcaire de Bargawan, le Calcaire de Rohatas et le Calcaire de Tirohan ; le Schiste de Bijaigarh dans le Groupe de Kaimur, le Schiste de Jhiri dans le Groupe de Rewa ; le Calcaire de Nagod, le Schiste de Samria, le Schiste de Sirbu et le Calcaire de Lakheri dans le Groupe de Bhandar.

Les formes rencontrées dans chaque formation sont rapidement considérées ; certaines d'entre elles ont pu être utilisées dans des corrélations mais les données à ce sujet ne sont pas satisfaisantes. De nombreuses formes ont d'autre part présenté un intérêt quant à l'interprétation lithotopique des sédiments. On peut concevoir que l'extension des recherches révélera de nombreux autres sites à stromatolithes.

**ABSTRACT.**- Several carbonate formations, members and beds occur in the Vindhyan Supergroup, which occupies an area of 105,000 sq. km. in central India. The formations which have yielded stromatolites and other algal structures are the Arangi Formation, Kajrahat Limestone, Bhagwanpura Limestone, Bargawan Limestone, Rohatas Limestone and Tirohan Limestone in the Semri Group ; the Bijaigarh Shale in the Kaimur Group ; the Jhiri Shale in the Rewa Group ; and the Nagod Limestone, Samria Shale, Sirbu Shale and Lakheri Limestone in the Bhandar Group. Brief accounts of the forms reported in each formation are given. Some of these have been used in correlation but the data are inadequate. They have been of value, though, in the interpretation of environment of deposition of the enclosing sediments. It is believed that further investigations are likely to bring to light many more stromatolite-bearing localities and horizons.

### INTRODUCTION

The Vindhyan Supergroup is a thick pile of clastic and calcareous sediments outcropping over 105,000 sq. km. area in central India. Its base is at least 1200 m.y. old and possibly 1400 m.y., and the youngest beds are around 550 m.y. old. In spite of their great antiquity they are remarkably flat-lying, except for certain marginal areas where they have been disturbed by folding and faulting. Although the Vindhyan sediments are eminently suited for the preservation of organic remains, definitive fossils have not been recovered in them so far (Mathur, In Press). However, some remains of spores, acritarchs, algal and primitive brachiopods, in addition to possible fragments of vascular plants have been recorded from time to time in various horizons of this supergroup, but there is considerable controversy

about their true nature and their stratigraphic implications. Other organic markings observed are ichnofossils, but again there is doubt in many cases about the true nature of these forms. The best studied organic structures are stromatolites and there is fair agreement about their use as indicators of environment, but conflicting opinions have been expressed about their reliability for correlation and age determination.

### STRATIGRAPHY

The Vindhyan Supergroup is divisible into four groups, which are further classified into formations as

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given below. Stromatolites and other algal structures have been observed in several carbonate horizons in the Semri and Bhandar groups, and from a single formation each in the Kaimur and Rewa. Such formations from which these have been recorded are marked by an asterisk. The generalised succession of formations given for the top three groups is standard for the entire Vindhyan basin, though the full sequence may not

always be present in certain localities. The Semri rocks are exposed only in some parts of the basin, often separated by hundreds of kilometres. Without the benefit of connected mapping and comparable succession of formations, different nomenclature has been used in this group in each part; the sequence observed for the three main regions are given here along with a rough correlation.

**BHANDER GROUP**

Kuarpara Shale  
Lakheri Limestone\*  
Maihar Sandstone  
Sirbu Shale\*  
Bundi Sandstone  
Samria Shale\*  
Nagod Limestone\*  
Ganurgarh Shale

**REWA GROUP**

Karauli Quartzite  
Jhiri Shale\*  
Itwa Quartzite  
Panna Shale  
Paisuni Formation

**KAIMUR GROUP**

Dhandraul Quartzite  
Bijaigarh Shale\*  
Markundi Quartzite  
Gurma Shale  
Ghaghar Quartzite  
Pipartola Conglomerate

**SEMRI GROUP****Son valley**

Rohtas Limestone\*  
  
Basuhari Sandstone  
  
Bargawan Limestone\*  
  
Kheinjua Shale  
Chopan Porcellanite  
  
Kajrahat Limestone\*  
  
Arangi Limestone\*

**Bundelkhand**

Tirohan Limestone\*  
  
(Flaggy glauconitic  
beds)  
  
Palkawan Shale  
  
Ken Limestone  
  
Pandwa Fall Quartzite

**Western Rajasthan**

Suket Shale  
Nimbahera Limestone  
Bari Shale  
  
Jiran Sandstone  
Khori Malan Conglomerate  
  
Binota Shale  
Palri Shale  
Sawa Sandstone  
  
Bhagwanpura Limestone\*  
  
Khardeoia Sandstone

Brief descriptions of the stromatolitic structures reported from each formation are given in the following pages.

### EARLY RECORD OF STROMATOLITIC FORMS IN THE VINDHYAN

There is mention in early literature of several structures in the Vindhyan rocks which are undoubtedly algal and stromatolitic, but were not recognised as such by these pioneer workers. Probably the earliest reference to such structures dates back to 1829 when Franklin described from Nagod (in the limestone of what was later recognised as Bhandar Group) in north-central Madhya Pradesh impressions of a "gryphite shell", which presumably was a small stromatolite whose laminae looked like growth lines on a shell. Medicot (1859, p. 53) examined the same locality and observed concretionary markings having a "puzzling resemblance to organic forms". Similar concretionary structures were noted by Mallet (1869) in a limestone bed of the same affinity near Shivpuri, north-western Madhya Pradesh. In 1831 and 1833 Hardie described and illustrated structures showing a succession of cylindrical-convex forms in the Nimbahera Limestone of the Neemuch area in western Madhya Pradesh.

Concretionary markings of the same type in the Nagod Limestone (Bhandar) horizon in the Bundi area, Rajasthan, were noted by Coulson (1927) but without comment. It was Auden (1933) who observed and photographed concentric ring-like structures in the Bargawan (Fawn) Limestone in the Son valley and remarked on their striking similarity to *Cryptozoon* but thought it unwise to more than point out the resemblance. This locality became the first where proper studies of stromatolites were commenced in the Vindhyan.

Heron (1936) also described and illustrated several concretionary structures in the Bhagwanpura Limestone and some horizons of limestone in the Bhandar Group in south-eastern Mewar (Rajasthan), but dismissed the possibility of their being of organic origin.

### ARANGI FORMATION

This formation is the basal unit of the Semri Group and consists mainly of conglomerates, sandstones and shales with some lenticular beds of limestones. In one such bed exposed at Dala, in the Mirzapur district of Uttar Pradesh (Son valley), good development of colonies of *Kussiella kussiensis* has been noted; their height varies from a few centimetres to 15 cm. and the width from 1.5 to 6 cm. (Kumar, 1973).

This appears to be the only published record of a stromatolite from the oldest Vindhyan unit.

### KAJRAHAT LIMESTONE

Although the Kajrahat Limestone formation is spread over a large area and attains considerable thickness in the Son valley, only a few stromatolitic occurrences have been recorded from it. Two new species, *Colonella kajrahatensis* and *Conophyton vindhyaensis* have been described from the Dala area, from the upper part of the formation. The first form is developed extensively, and is 1 to 14 cm. high and less than 1 to 6 cm. in diameter. The development of the second form is restricted only to a few bands, the height of its columns is 12 to 17 cm. and the diameter 5 to 30 cm. (Misra *et al.*, 1977). Other forms subsequently described from this locality include *Collenia symmetrica* and *Dalaia dalensis* (new form); the *C. symmetrica* columns are 7 to 15 cm. high and 10 to 25 cm. in diameter; *D. dalensis* colonies form wall-like bodies up to 70 cm. high and 2 to 3 cm. wide (Kumar, 1973).

### BHAGWANPURA LIMESTONE

This formation was considered for a long time as belonging to the Raijalo Group (Delhi Supergroup, Middle Proterozoic) but a re-examination on the basis of the stromatolites occurring in them and formational association with the typical Semri sediments lead me in 1963 to include it in the Vindhyan. Subsequent work has amply demonstrated the correctness of this stratigraphic allocation. The most important form recognised in this formation is *Conophyton cylindricus*, which measures up to 1.75 metre in height and 35 cm. in diameter, the largest known from the Vindhyan rocks (Barman, 1976). Other forms recorded are *Collenia frequens*, *Cryptozoon* and *Gymnosolen* (Raja Rao & Mahajan, 1965).

### BARGAWAN LIMESTONE

The algal structures occurring in this formation (informally referred to in earlier literature as Fawn Limestone) have possibly received the greatest attention of any studied in the Vindhyan since F.J. Pettijohn during a visit in 1958 to the Son valley, Mirzapur district, for the first time identified the concentric markings positively as stromatolites. The forms seen

in the Patwadh hill were assigned by Mathur *et al.* (1962) to the group *Collenia*, which was later given the specific name of *C. columnaris* by Valdiya (1969) and *Colonella (Collenia) columnaris* by Kumar (1973). These columns are 60 to 150 cm. high and 10 to 15 cm. in diameter.

Prominent structures exposed in Salkhan hill in this district were judged by Mathur (1965) as a new form and called *Indophyton*, which are cylindrical bodies (and not conical like *Conophyton*) with laminae or layers occurring in the form of annular tubes or cylinders, 18 to 45 cm. long and 5 to 15 cm. in diameter. *Indophyton* is regarded as an analogue of *Conophyton* by Mohan (1968); Valdiya (1969) has called this form as *Conophyton cylindricus*, but Kumar (1973) names it as *C. garganicus*. This type of structure has been observed in several other localities as well.

Algal mats and *Colonella (Collenia) clappii* have also been reported from the same horizon further west on the border of this district (Kumar, 1974).

A remarkable form is seen near Bargawan in the Son valley, it is dome-shaped, semispheroidal, up to 2.5 metres in diameter at the base and up to 1.8 metres in height above the bed level, though it must actually be much longer if the whole section could be seen through the stratum; each structure is made up of concentric domal layers or hemispheroids and is topped by a nipple-like protuberance. I have called it "mammicus" because of its resemblance with a human breast (in keeping with my view that stromatolites being in the nature of sedimentary structures should not be given names according to Linnean system), but it could be a very large *Conophyton* according to the votaries of the Linnean nomenclature.

### ROHTAS LIMESTONE

This formation consists of a pile of limestone 125 to 200 metres thick with some shale beds and is exposed over a large area in the Son valley. Strangely enough, few occurrences of algal structures have been recorded from this vast store of calcareous sediments. Some structures found in dolomitised micrite in the lower part of the formation in the Basuhari area, Mirzapur district, are circular, oval, ellipsoid and elongated bodies, 2.5 to 5.5 cm. across, but have not been identified by name (Srivastava & Zaidi, 1975). These could possibly be oncolites, since Kumar (1977b) has also recorded oncolites, 1 to 4 cm. in diameter, from the nearby Dala area. Kumar (1974) has also noted algal

mats in the same horizon in the Newari area of this district, and has provisionally identified them as *Collenia clappii*.

### TIROHAN LIMESTONE

This formation of the Semri Group is developed in Bundelkhand (Central India) and some parts of Rajasthan, and is considered as equivalent of the Rohtas Limestone of the Son Valley on stratigraphic grounds. The Tirohan Limestone exposed at Lodhwara hill near Karwi, in the Banda district of Uttar Pradesh, contains forms closely resembling *Collenia kusiensis* according to Valdiya (1969). From the same locality Kumar (1974) has recorded a number of other species: *Collenia symmetrica* has height of up to 17 cm. and diameter at base of 25 cm. and at top of 36 cm.; *Kussiella kussiensis* of this locality resembles the same species described from the Kajrahat Limestone of the Son valley; and *Colonella lodhwarensis* (new form) is 7 to 35 cm. high with the diameter at the base of 1 to 7 cm. increasing at top to a maximum of 21 cm. In the nearby area of Janki Kund falling in the Satna district of Madhya Pradesh, Kumar (1977a) has also observed some oncolites and stromatolites identified as *Baicalica baicalia* and *Collenia columnaris*, which are covered by thin, dark-coloured phosphatic encrustations (collophane).

Stromatolites are widespread in the upper part of this formation in the Karauli, Sapotra and Sherpur sections of the Bharatpur and Sawai Madhopur districts of Rajasthan (Maharaja Singh and Banerjee, 1978). Among the forms recognised are *Collenia* and *Baicalica* (Bakliwal & Dwivedi, 1978). Presence of *Conophyton cylindricus* has also been reported from this area (Barman, 1976).

### BIJAIGARH SHALE

This is the only formation in the Kaimur Group from which an occurrence of stromatolite has been reported so far. Schnitzer (1971, p. 13) in a table of stromatolite-bearing formations mentions the name of Bijaigarh Shale, but does not give any particulars or illustration, although photographs of stromatolites from several other formations appear in his paper.

### JHIRI SHALE

Calcareous beds occur in two formations in the

Rewah Group ; a narrow band of limestone is found at the base of the Jhiri Shale in some parts of its outcrop. Prasad (1978) mentions this limestone horizon as one of the five in the Vindhyan Supergroup in south-eastern Rajasthan in which algal structures have been recorded, but no details or particulars are given in the published abstract of his paper.

### NAGOD LIMESTONE

This formation, which is sometimes informally referred to variously as "Bhander Limestone" or "Lower Bhander Limestone", is exposed at several localities in the Satna-Maihar area of Madhya Pradesh and in south-eastern Rajasthan. Widespread occurrences of stromatolites have been reported from the first area, while the second one has yielded few forms.

Luxuriant development of stromatolites is known in the Maihar area, where numerous outcrops and quarries show several types of algal structures. The main forms recognised are *Baicalia baicalica*, whose columns attain heights of 50 cm. and width of 9 cm., and *B. satnensis* (new form) which reaches heights up to 25 cm. and diameter up to 10 cm. (Kumar, 1973). *Collenia baicalica* has also been noted in this area (Valdiya, 1969); it is 7 to 30 cm. high and 5 to 6 cm. wide.

Several forms of stromatolites have also been noted in the Satna area (Srinivasa Rao *et al.*, 1977). They include the following forms : *Colonella* having columns up to 60 cm. high and 8 cm. in diameter ; *Collenia symmetrica* with 5-18 cm. high columns which are up to 12 cm. in diameter ; *Baicalia* whose columns are 10 to 30 cm. high and 5-12 cm. in diameter ; *Boxonia* with short and stubby columns ; *Tungussia* having columns up to 40 cm. high ; *Stratifera* whose ripple-like laminae have "wave lengths" of 5 to 20 cm. ; and large oncolites of 20-60 cm. size.

### SAMRIA SHALE

Thin bands of limestone occur in this formation. In some parts of the south-eastern Rajasthan some of these beds show faintly developed algal structures at a few places (Prasad and Ramaswamy, 1978). Details are not given in the published abstract of their paper.

### SIRBU SHALE

A calcareous horizon, called the Magardaha

Limestone Member occurs within this shale formation in the Satna-Maihar area of Madhya Pradesh (Srinivasa Rao *et al.*, 1977). It is generally only one to two metres in thickness and is found sandwiched between shales in widely scattered outcrops of small size.

Some extraordinary circular, cushion-like algal bodies were noted by me near Maihar in 1961. These are 0.5 metres to 2 metres across and 25 to 40 cm. thick in the centre. They occur stacked one upon the other without any apparent connection in a bed of limestone hardly one metre thick. They are not reefs, but each is made up of concentric laminae without any perceptible attachment to the substratum. They appear to be detached bodies like oncolites, but are much too large to be classed as such. I have not come across description of a similar body in the available literature, and in the absence of a comparable form I have named it "coxinumalus" after its cushion-like shape. Since I consider stromatolites as biogenic sedimentary structures I do not subscribe to the view that they should be given Linnean names, and therefore this name is not italicised or the first letter capitalised.

A form outwardly similar to coxinumalus has been described as *Maiheria maiharensis* by Kumar (1973) from the Nagod (Bhander) Limestone, which, from the locality mentioned by the author, appears in fact to be the Magardaha Limestone Member. According to him it occurs as large domal colonies made up of intersecting columns of 0.5 to 4 cm. high and 0.2 to 1.4 cm. wide ; size of the colonies varies from 10 to 150 cm. across and up to 30 cm. high.

Other forms noted by me from this locality belong to "stratifera" and "irregularia" and "colleniella" types. "Stratifera" has also been recorded by Srinivasa Rao *et al.*, (1977) from this member from the Magardaha valley in the Satna district. They have also noted the presence of oncolites, 2 x 4 cm. to 12 x 20 cm in size at a single locality in this area.

Profilic development of stromatolites, mostly *Collenia baicalica*, has taken place in this member in some parts of the Kota, Bundi and Sawai Madhopur districts of Rajasthan, while in the Pali area of the same state *Collenia columnaris* has been observed in it (Prasad & Ramaswamy, 1978).

### LAKHERI LIMESTONE

This limestone has been referred to informally as the Upper Bhander Limestone, and is of restricted occurrence in the Bundi district of Rajasthan. Prolific

development of mostly *Collenia baicalica* has been noted in it, but details are not available (Prasad & Ramaswamy, 1978).

### MARWAR SUPERGROUP

The sequence of formations known for a long time as the Trans-Aravalli Vindhyan has now been reorganised as the Marwar Supergroup, newly created by the Geological Survey of India. It is composed of three groups, of which the middle Bilara Group contains limestone and dolomite which show plentiful occurrences of stromatolites as isolated reef masses. In the Bilara type area, Jodhpur district of Rajasthan, the main forms studied are of LLH and SH types; another type is discoidal with flattened top and subcircular outline (Khilnani, 1968).

An assemblage of *Weedia*, *Conophyton*, *Collenia* and *Minjaria* has been noted from the limestone around Badi Khatu in Nagaur district. The structures are mostly phosphatic having a coating of collophane around the columns as well on the laminae (Paliwal, 1975).

### DISCUSSION

Several calcareous formations, members and beds occur in the Vindhyan Supergroup, and their outcrops cover large areas and sometimes large thicknesses. Stromatolites and other algal structures have been recorded from several of these horizons and localities, but vast stretches still remain to be studied. In several cases the investigations are inadequate or incomplete, but whatever work has been done so far is of considerable value or significance in the study of these Precambrian sediments.

The stromatolites have been used by some workers for dating of the Vindhyan formations by comparing only a few forms with the Riphean of the U.S.S.R., and correlating some formations in the Himalayan region with those of this Supergroup (Valdiya, 1969). Other correlations have also been attempted. Firstly, the conclusions seem to be based on inadequate data, and, secondly, the limitations inherent in the use of stromatolites for correlation purposes, have not been kept in view (Mathur, 1979).

A perusal of the foregoing account shows that in some cases different authors have given different "generic" and "specific" identifications of the same form from the same stratigraphic horizon and in the

same locality; and this has led to some confusion and doubts about the correctness of some identifications. If the discrepancies are due to differences in interpretation of the morphology of the particular forms, it shows that diagnostic characters of the "species" have not been assessed properly by some workers. Naturally, then, to use such identifications for correlative purposes would be risky, especially in the cases of unconnected and widely separated areas even in the same Vindhyan basin. The study of stromatolites and algal structures in this Supergroup can be considered still in its infancy, and unless more systematic and thorough studies are made it would be premature to use them for correlative purposes even if stromatolites could be employed as index fossils.

The stromatolites, of course, have served to shed a lot of light on environment of deposition of the enclosing sediments, and those in the Vindhyan have admirably proved of great value in this direction. They have also served to determine the correct disposition of beds in a rare case of overturned strata.

The stromatolites in the Vindhyan Supergroup have lately been attracting attention from several groups of workers, and it is hoped that the time will not be far off when detailed and thorough accounts from certain critical areas will become available. It can confidently be predicted that further search will bring to light many other horizons and localities in the Vindhyan where stromatolites and other algal structures occur.

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