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THE PALAEOPROTEROZOIC STROMATOLITE GROUP *MISTASSINIA* FROM THE KHEINJUA FORMATION, SEMRI GROUP, CHOPAN AREA, SONBHADRA DISTRICT, UTTAR PRADESH

S. KUMAR and **Y. MISRA**

DEPARTMENT OF GEOLOGY,
LUCKNOW UNIVERSITY, LUCKNOW, U.P.
E-mail: surendra100@hotmail.com

ABSTRACT

The columnar stromatolite group *Mistassinia* Hofmann is described from the Fawn Limestone of the Kcinjua Formation from Pataudh Hill near Chopan. The form is characterized by bipartite organization and bimodal development of laminae. It is made up of vertically accreting laminae in the central part of the column, and a secondary mode of asymmetrical, steeply inclined, obliquely accreting marginal laminae forming a partial or complete encrustation on the primary central portion. All three known occurrences of this form, including the present one, are from the Palaeoproterozoic and hence it is suggested that the form can be considered as an important form of this era and can be useful both for intrabasinal and interbasinal correlation.

Keywords: Semri Group, Kheinjua Formation, Stromatolite, Central India, Palaeoproterozoic, Vindhyan Supergroup

INTRODUCTION

Stromatolites have been used for correlation and in suggesting ages for Precambrian sequences as these are considered to have a biotic origin and evolved with time. With the study of Recent stromatolites in the Bahamas, Shark Bay, Great Salt Lake, Yellowstone hot springs and the Persian Gulf etc., doubts have been raised for such attempts as it is now known that the stromatolites are environment-sensitive and the same microbial community can produce different morphologies in different environmental settings (Logan *et al.*, 1964; Monty, 1972). However, it has been noted that in Precambrian sequences hundreds of different stromatolite morphologies have been reported, whereas in the Recent only a few simple stromatolite forms have been recorded. Stromatolites lost their position as the dominant organic structures after Early Ordovician (Pratt, 1982; Monty, 1973). It is suggested that in the Precambrian microbial communities evolved without much competition and in absence of animal life. This evolution manifested itself by producing different stromatolite morphologies, some of which are very unique and nonrepetitive. This favours the assumption that there should at least be some stromatolite morphologies which are time controlled and could be useful for correlation. Here we report the unique stromatolite *Mistassinia* Hofmann from the Fawn Limestone of the Kheinjua Formation (ca. 1750 – 1650 Ma) from the Pataudh Hill, Chopan area, which shows bimodal laminae.

GEOLOGICAL SETTING

The Kheinjua Formation is a well recognizable lithologic unit of Vindhyan Supergroup in the Son Valley section, central India. The Vindhyan Supergroup occupies a large area in Central India stretching from Dehri on Son, Bihar in the east to Chittorgarh, Rajasthan in the west (Fig.1). It has been subdivided into four groups; in stratigraphic order these are the Semri Group, the Kaimur Group, the Rewa Group and the Bhander Group. The sediments of the Semri Group are commonly referred to as the Lower Vindhyans while the sediments of the Kaimur Group, the Rewa Group and the Bhander Group are traditionally designated as the Upper Vindhyans. The Semri Group has been further subdivided into four formations; in stratigraphic order, these are the Basal Formation, the Porcellanite Formation, the Kheinjua Formation and the Rohtas

Table 1: Stratigraphy of the Kheinjua Formation (the Vindhyan Supergroup) (Modified after Auden, (1933).

	Bhander Group		
	Rewa Group		
Vindhyan Supergroup	Kaimur Group		
	----------Unconformity----------		
		Rohtas Formation	
	Semri Group	Kheinjua Formation	Glauconitic Sandstone Fawn Limestone Olive Shale
		Porcellanite Formation	
		Basal Formation	
	----------Unconformity----------		
	Bijwar phyllites/Bundelkhand granites		

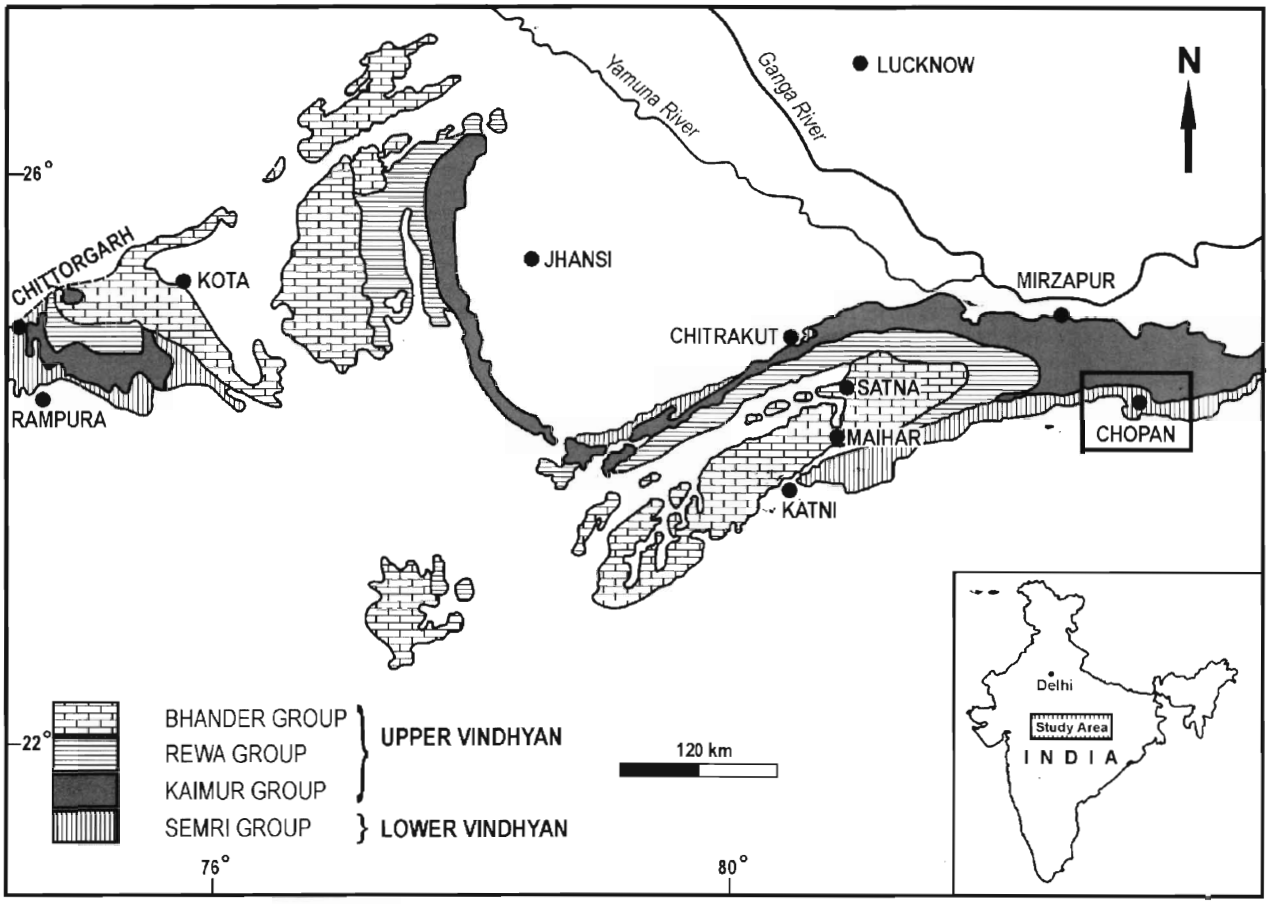

Fig. 1.Geological map of the Vindhyan Basin (after Krishnan and Swaminath, 1959). The Chopan area is marked by a window

Formation. The Kheinjua Formation conformably overlies the Porcellanite Formation. In the Son Valley section in the Chopan area, Sonbhadra district, Uttar Pradesh, the Kheinjua Formation has been subdivided into three members viz., the Olive Shale, the Fawn Limestone and the Glauconitic Sandstone (Table 1; Fig. 2). The Fawn Limestone is represented by fawn weathering siliceous and cherty dolostone with minor bedded chert. A few shale partings are also seen. The Fawn Limestone conformably overlies the Olive shales and is conformably overlain by the Glauconitic Sandstone. The rocks are unmetamorphosed and more or less undeformed.

Two different lithofacies of the Fawn Limestone are developed; one is characterized by the development of fawn coloured dolomite with abundance of chert bands while the other shows absence of chert bands. The chert-dominated facies is developed in the northern part of the area in Newari, Bargwan and Salkhan, while latter is seen in the central eastern part of the area at Pataudh Hill (Fig.2). A thickness of about 20 m is recorded at Newari where coniform stromatolites *Siren, Cyathotus* and *Ephyaltes* are well developed while eastwardly, at Salkhan Hill, the best development of *Ephyaltes* is seen (Misra and Kumar, 2005). Further south from Pataudh Hill, Kumar (1976, 1978) has reported *Colonnella columnaris* from these dolostones. The present form *Mistassinia* is associated with this horizon. Here chert is absent. The dolomite shows parallel bedding with development of fenestral fabric. Penecontemporaneous breccia has also been recorded.

From the chert dominated facies both from the Salkhan and Newari areas, well preserved microbiota, dominated by cyanobacteria has been described from the black bedded chert from the Salkhan and Newari areas (McMenamin *et al.*, 1983; Kumar and Srivastava, 1995).

AGE OF THE SEMRI GROUP

About forty years back, Russian workers dated the Kheinjua glauconites by the K/Ar method (Vinogradov *et al.*, 1964). The data was reinterpreted by Kreuzer *et al.* (1977) by using a later recommended constant, and suggested the age of the Glauconitic Sandstone as 1080 ± 80 Ma. In recent years the SHRIMP method of dating of zircon and Pb-Pb dating of

EXPLANATION OF PLATE I

A. Longitudinal section of ***Mistassinia*** sp. Arrow marks the encrusting laminae around the main column. Scale = 1 cm.

B. Longitudinal section of ***Mistassinia*** sp. showing development of conical laminae. Scale = 1 cm

C. Photomicrograph showing fan fabric within the encrusting laminae. Scale = 5 mm

D. Photomicrograph showing dark and light laminae with in the main column. Scale = 5 mm

E. Photomicrograph showing dark and light inclined encrusting laminae. Scale = 5 mm

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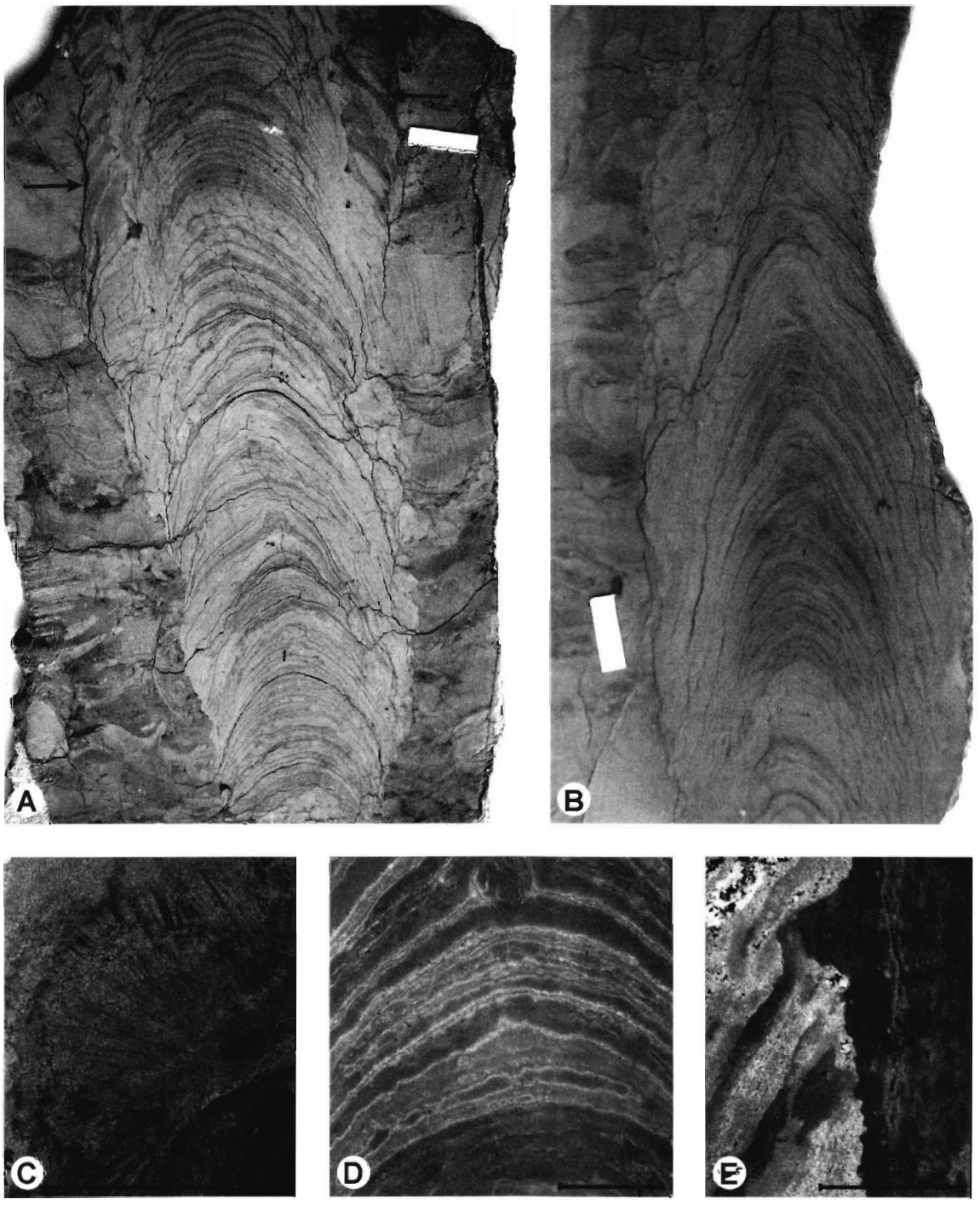
Plate I



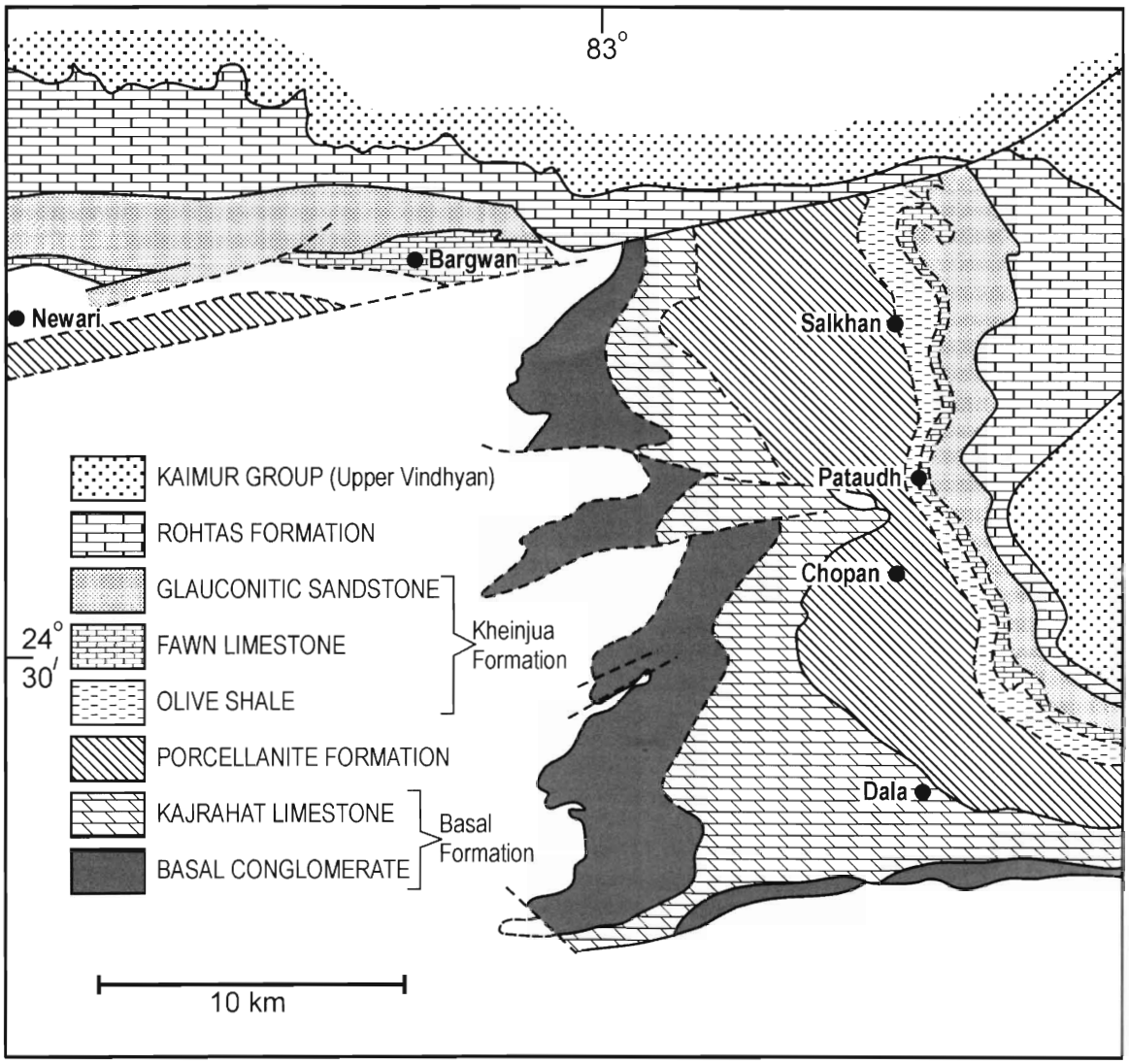


Fig. 2.Geological map of the Chopan area, Son Valley section, Sonbhadra District, Uttar Pradesh (after Auden , 1933).

carbonates have been used for the Semri Group (Rasmussen *et al*, 2002; Ray et al., 2002; Sarangi *et al*., 2004). Pb – Pb isochron age of 1599 ± 48 Ma has been suggested for the *Grypania*-bearing Rohtas Limestone by Sarangi *et al*.(2004) while 1601 ± 130 Ma age has been given by Ray *et al*. (2003) for the Rohtas Formation. Rasmussen *et al*. (2002) have dated the Chorhat Sandstone (= Glauconitic Sandstone) as between 1628 ± 8 and 1599 ± 8 Ma, based on U – Pb dating of zircon. Rasmussen et al. (2002) have dated the Deonar Porcellanite (= Porcellanite Formation) and the Rampur Shale (=Kheinjua Formation) as 1628 ± 8 and 1599 ± 8 Ma respectively on the basis of U – Pb zircon (TIMS) method. Considering the above dates the youngest horizon of the Semri Group, the Rohtas Formation can be taken as ~ 1600 Ma old. As the Kheinjua Formation underlies the Rohtas Formation, it can be taken as ca. 1750 - 1650 Ma old. The Fawn Limestone is about 300 m below the dated horizon of the Rohtas Formation.

TAXONOMY

Group ***Mistassinia*** Hofmann, 1978

Diagnosis: Concentric, bipartite organization and strong bimodal development of lamina shape.

Type species: *Mistassinia wabassinon* Hofmann 1978.

Content: Only type form is known.

Distribution: Lower Albanel Formation, Mistassini Group, Quebec, Canada, Hutuo Group, China.

Age: Palaeoproterozoic.

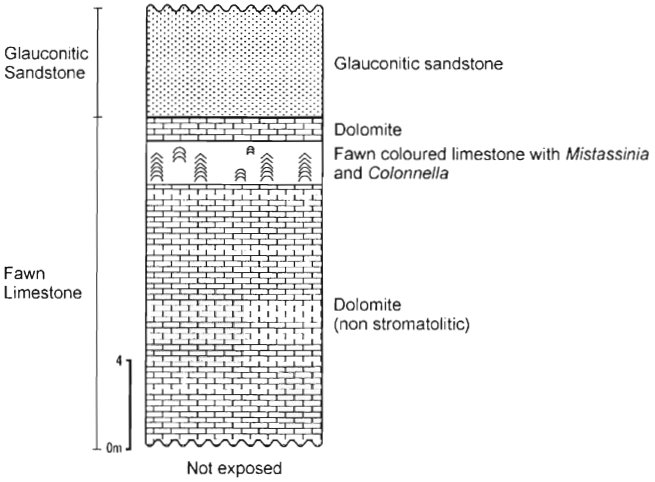
Mistassinia sp. Hofmann 1978

(Pl. I, figs. A,B,C,D, & E; Fig. 4)

Material: (YMPC 15/94) five specimens from Pataudh Hill, Sonbhadra District, Uttar Pradesh.

Description: Slender, erect columns with digitate branching and tuberculate surface composed of two types of laminae, vertically accreting laminae in the central part of the column, and a secondary mode of asymmetrical, steeply inclined, obliquely accreting marginal laminae forming a partial or complete encrustation on the primary central portion. Both types of laminae are even to slightly wrinkled, cross-sections are round to brevilobate, diameters centimetric.

Mode of occurrence: It occurs as a biostrome exposed at Pataudh Hill about 1 km from Dala-Chopan road in the Fawn Limestone (Fig.3). The stromatolite-bearing horizon is developed in the upper part of the succession made up of white/yellow coloured dolostone. Generally the form occurs



Generalised litholog of Pataudh Hill, Sonbhadra district U.P.

Fig. 3.Litholog of Pataudh Hill showing the position of the *Mistassinia* bearing horizon.

as isolated colonies. Weathering of stromatolitic and non-stromatolitic dolostone is more or less same because of which relief of stromatolites is not well marked even on the weathered surface.

Column shape and arrangement: The columns are in the shape of cylinders with smooth margins, erect and almost parallel to each other. They are about 25 cm in height and 2-6 cm in diameter. Their bipartite arrangement of columns is best seen on weathered surface. It comprises an axial region of vertically accreting, more or less symmetrical, convex laminae of high relief. Around this column a partial or complete encrustation is seen with oblique laminae. The columns in the biostrome are slender, erect and unlinked, with a tuberculate walled surface.

Branching: The columns show passive branching in which the daughter branches are poorly developed. The daughter branches are only 1-2 cm in height . The daughter branch does not show bipartite organization of column i.e., only an axial column is present with convex laminae.

Margin structure: The margin or periphery of main axial column is encrusted by steeply inclined, obliquely accreting slightly convex laminae. These laminae completely or partially encrust the main axial column wherever they are present. The margin of the main column is slightly wavy.

Lamina shape: In an entire column three types of laminae are found.

Conical Laminae: They are found at the middle portion of axial column. They are about 1 mm thick in the crestal zone but becomes thinner at the margins. They are slightly wavy but less wrinkled in comparison to convex laminae.

Convex laminae: These are found at the upper and lower portions of axial column and are clearly visible in hand specimens or slabs. They are thicker in the crestal zone in comparison to the margins. They are slightly wavy and wrinkled.

Encrusting laminae: Steeply inclined obliquely accreting laminae forming encrustation to main column. These laminae are almost 40-50^0 inclined to the main column laminae. They are less wavy and wrinkled in comparison to other two types of laminae. Only convex laminae are found in daughter branches. Alternate light and dark coloured laminae are present

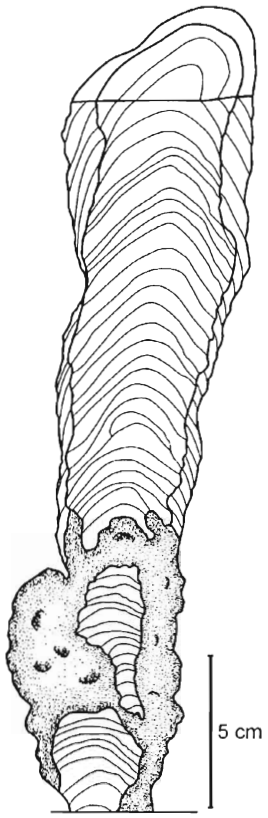


Fig. 4. 3D reconstruction of *Mistassinia* sp.

which can be best studied only under the microscope. Both axial and peripheral laminae are even or slightly wrinkled and have the same texture. Generally they are about 1 mm thick.

Microstructure: Microstructure is basically banded type and laminae are well differentiated into dark and light coloured laminae.

Dark coloured laminae: They are usually 1 mm thick but thickness varies from 0.1 to 2.25 mm The thickness is maximal at the center. The laminae are wavy to occasionally smooth, often crenulations can be seen on the upper boundary. The lower boundary in contact with light laminae is usually smooth and sharp, however at places this contact can be gradational also. These laminae hang at the margins covering many lower laminae but usually they do not form any wall. Conical laminae in the crestal zone become thick up to four times the convex laminae. The laminae are usually fine grained micritic, equigranular, polygonal to xenotopic made up of dolomite, occasionally with numerous inclusions up to 0.05 mm wide, occasional patches of dolomite rhombs are also seen.

Light-coloured laminae: They range from 0.1 to 2.0 mm thick but generally they are 0.6 mm thick. The thickness gradually diminishes towards the margins. The laminae are wavy with occasional sinuosity. Crenulation is also seen. Contact with the dark laminae is smooth and sharp as well, occasionally there is a gradational contact. Light coloured laminae gradually grade into dark laminae. At the margins they become very thin and overhang on the lower laminae. At places, they are totally obliterated by dark laminae. The texture of light laminae is very similar to that of the dark coloured laminae, they are slightly coarse grained and xenotopic to hypidiotopic. However, there are numerous inclusions of dark patches which very rarely form lenses of dark laminae within

the light laminae.

Interspaces: Interspaces are filled with broken pieces of stromatolites, peloids and micrite. Dolomite grains ranging in size from 20-40 μm are also seen.

Secondary alterations: Neomorphism is distinct in light coloured laminae at various places and micrite is seen changing into sparite. Calcite is almost totally altered into the dolomite. The dolomite grains are about 20-40 μm in light coloured laminae whereas 10-15 μm in dark coloured laminae. Radiating crystals forming fan fabric are developed in the encrusting laminae at a number of places which may be due to replacement of aragonite crystal by dolomite (Plate I – C).

Comparison: The form shows bipartite organization and strong bimodal development of laminae that is they are convex in the lower part and then become conical in the upper part. This is the typical form which can only be compared with the *Mistassinia* described from Palaeoproterozoic Mistassini Group, Quebec by Hofmann (1978). *M. wabassinon* shows larger thickness in light-coloured laminae but has thinner dark-coloured laminae in comparison to the present form. The most striking feature of *Mistassinia* which separates it from the other known columnar forms is the bimodal nature of the laminae that corresponds to a bipartite zonal arrangement within the columns. *Jacutophyton* differs from *Mistassinia* in having multiple structures with nonconical convex laminae surrounding the central column beginning at the *Conophyton* and spreading sideward and upwards.

DISCUSSION

Hofmann (1978) described *Mistassinia* from the Lower Albanel Formation of the Mistassini Group, Quebec, Canada whose age can be considered as Palaeoproterozoic on the basis of the Rb-Sr isochron age of 1787 ± 55 Ma of the Temiscamie Formation, the youngest formation of the Mistassini Group. Subsequently, *Mistassinia* has also been reported from the Hutuo Group of China, which has been considered also as Palaeoproterozoic (Zhu Shixing, 1982; Zhu Shixing and Huiheng, 1992). Since the upermost part of the Rohtas Formation has now been dated as ca. 1600 Ma (Sarangi *et al.*, 2004), the *Mistassinia*-bearing horizon of the Fawn Limestone which is ca. 300 m below this horizon can be bracketed between 1650 – 1750 Ma. Misra and Kumar (2005) have suggested the age of the Kheinjua Formation as ca. 1650 – 1700 Ma on the basis of the coniform stromatolites such, as *Siren, Cyathotes* and *Ephyaltes*. Thus, *Mistassinia* appears to be restricted only in the Palaeoproterozoic. *Mistassinia-Siren, Cyathotes - Ephyaltes* assemblage can be used as a diagnostic assemblage for the Palaeoproterozoic and can also be used with a fair degree of confidence for interbasinal correlation and in suggesting age.

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