New cyanophycean remains from the Blaini Formation (Terminal Neoproterozoic sequence) of Mussoorie Syncline, Lesser Himalaya, India

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A new algal form, *Blainiella* gen. nov., comparable in its morphological aspects to the modern form *Hyella*, is recorded from the Blaini Formation, Mussoorie Syncline. The fossil shows linear filament formed of rectangular cells placed end to end; reproduction by endosporulation, thick globular endospores formed towards terminal end of linear filaments, baeocytes formed within endospores by cytoplasm desmochesis and released by wall dissolution of endospores, each baeocyte forms linear filament by vegetative reproduction. This new genus represents different stages of life cycle of microbiota reported earlier from the same formation by Joshi *et al.* (1988).

Key-words — *Blainiella*, Cyanophyceae, Mussoorie Syncline, Blaini Formation, Terminal Neoproterozoic (India).

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सारांश

भारत में लघु हिमालय में मसूरी भूद्रोणी के ब्लेनी शैल समूह अनुक्रम (अनंतिम नवप्रोटीरोजीवी) से नये सियनोफाइसीय अवशेष

प्रभात कुमार माइती, रुपेन्द्र बाबू, गोपेन्द्र कुमार एवं वी० के० माथुर

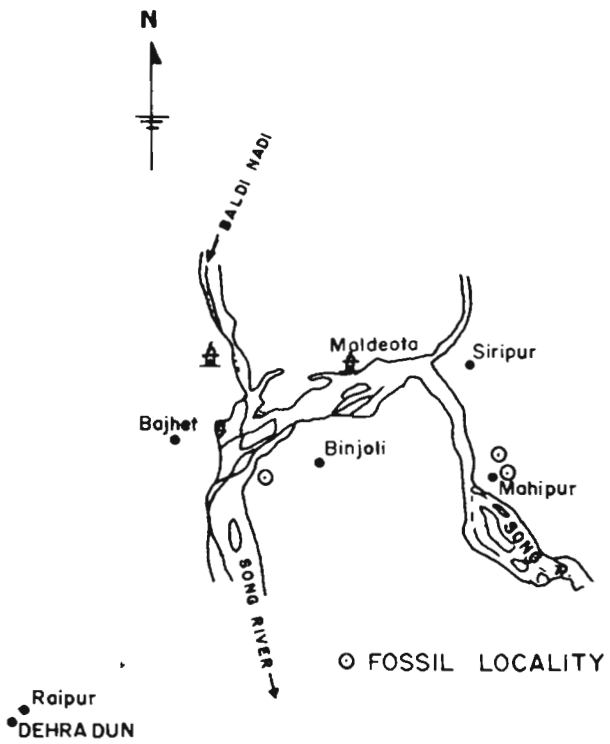
मसूरी भूद्रोणी में ब्लेनी शैल-समूह से आकारिकीय लक्षणों में वर्तमान प्ररूप *हियॅल्ला* से तुलनीय *ब्लेनियॅल्ला* नव प्रजाति नामक एक नया शैवाल अभिलिखित किया गया है। इसमें रेखीय तन्तु एक दूसरे से सटी आयताकार कोशाओं से बने हैं तथा अन्तःबीजाणवीकरण द्वारा प्रजनन होता है जिसमें मोटे ग्लोब के आकार के अन्तःबीजाणु तंतु के अन्तिम छोर पर बनते हैं। कोशाद्रव्य से अन्तःबीजाणुओं के अन्दर बेओसाइट बनते हैं जो अन्तःबीजाणुओं की भित्ति विलीन होने के कारण पृथक हो जाते हैं। प्रत्येक बेओसाइट से अलैंगिक प्रजनन द्वारा रेखीय तन्तु का निर्माण होता है। इस नई प्रजाति से सूक्ष्मजीविता, जो कि इसी शैल-समूह से जोशी व अन्य (1988) द्वारा वर्णित किया गया था, के जीवन चक्र की विभिन्न अवस्थायें निरूपित होती हैं।

BLAINI Formation of the Baliana Group (Shanker *et al.*, 1993) is an important lithostratigraphic marker in the Lesser Himalayan Krol Belt (Auden, 1934), representing a marine transgression related to Late Proterozoic glaciation. It unconformably rests over the Early Neoproterozoic succession of Simla-Jaunsar Group (Stack III, Shanker *et al.*, 1989) and is conformably overlain by Infra Krol of Terminal Neoproterozoic sequence. The recent palaeontological studies from the Blaini-Krol-Tal sequence have led to significant palaeontological finds which assign Late Proterozoic (Terminal Neoproterozoic) age to the Blaini succession. Important chronostratigraphic fossils from the overlying successions are the records of Ediacaran fossils from Krol Formation (Mathur & Shanker, 1989, 1990; Shanker & Mathur, 1992), small shelly fauna (Azmi, 1983; Bhatt *et al.*, 1983; Kumar *et al.*, 1987a), microgastropods and brachiopods (Kumar *et al.*, 1983), brachiopods (Tripathi *et al.*, 1984; Mathur & Joshi, 1989a) and trilobites (Kumar *et*

al., 1987b; Mathur & Joshi, 1989b) from Tal Formation. A study of the slides containing the microbiota, viz., *Symplassosphaeridium, Orygmatosbaeridium, Huroniospora, Myxococcoides* and *Gunflintia,* recorded by Joshi *et al.* (1988) from Blaini Formation, revealed that the above forms actually represent different stages of life cycle of a fossil cyanophycean algal form which is recorded for the first time in this paper.

GEOLOGICAL SETTING

The Blaini Formation is well exposed along the right bank of Song River near Maldeota (30° 21"40" : 78° 07"30"; Text-figure 1) on the southern limb of the Mussoorie Syncline. In this section it unconformably rests over the Saknidhar Formation and is conformably overlain by the Infra Krol Formation. Blaini Formation is about 2,100 m thick and consists of conglomerates with siltstone, diamictite, rhythmite, greywacke and variegated shale of grey, olive green, purple and black colours with impersistent lenticular bands of pinkish limestone.



Text-figure 1 — Locality map.

The lithostratigraphic succession recorded at the fossil locality is as under:

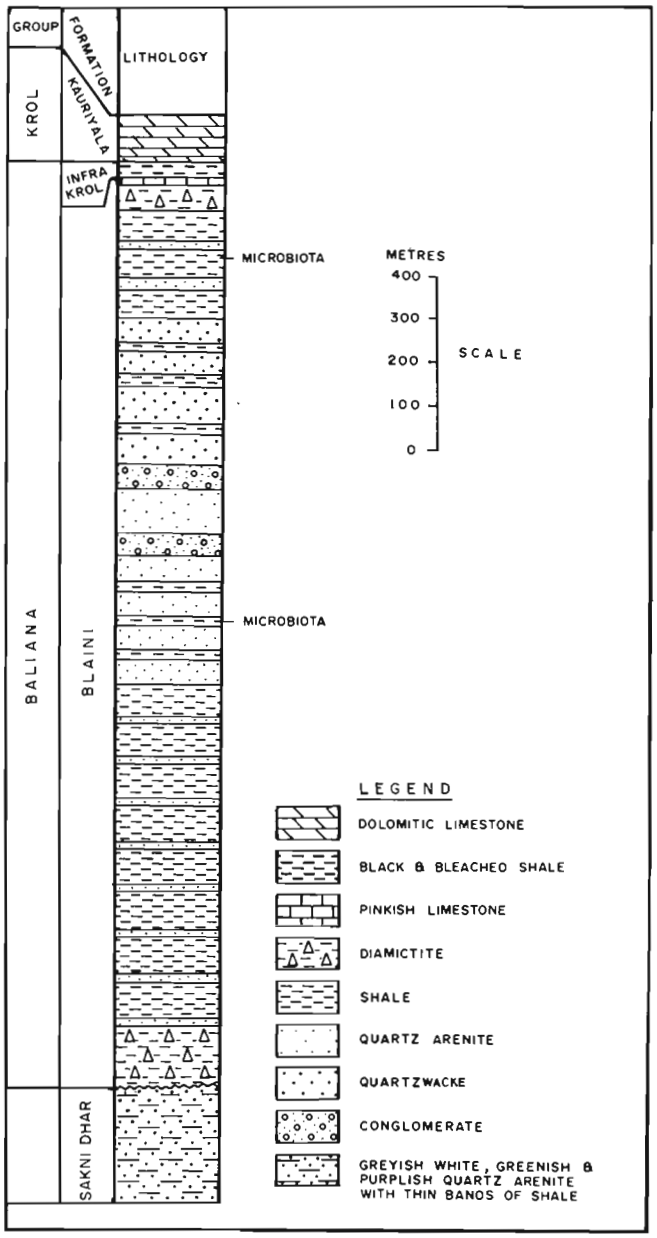
Infra Krol Formation	Bleached shale/slate	± 34 m
	Pink Limestone	4 m
	Diamictite	55 m
	Slate interbedded with quartz arenite (4:1) (microbiota)	249 m
	White quartzwacke interbedded with shale	342 m
Blaini Formation (2100 m)	Diamictite (matrix calcareous at places)	56 m
	Greyish white arenite	106 m
	Diamictite with calcareous bands	50 m
	Purple and greenish quartzwacke with thin shales (4:1) (microbiota)	296 m
	Rhythmite-greenish and grey shale interbedded with thin arenite	805 m
	Diamictite	137 m
	.....Unconformity.....	
Saknidhar Formation	Quartz arenite with thin bands of shales	

The organic-walled microfossils (OWM) yielding material consists of greyish black shale from the lower and middle part of the formation (Text-figure 2). It consists of very fine matrix of sericite, clay minerals and silica with a few silt size quartz grains and occasional muscovite flakes. The organic-walled microfossils are well preserved and golden yellow in colour. The biogenicity has been established by the presence of shrinkage in cells, organic enveloping sheath and folds.

Blainiella gen. nov.

Generic diagnosis — Linear filament formed by rectangular cells placed end to end, enveloping sheath not preserved; reproduction by endosporulation, endospores formed towards apical portion of filament; endospores commonly globular; baeocytes formed by desmochesis, which get released by dissolution of endospore wall, outline globular later becoming rectangular and forming linear filaments by vegetative reproduction.

Genotype — *Blainiella polymorpha* gen. et sp. nov.



Text-figure 2 — Stratigraphic column at fossil locality.

Etymology — The generic name has been derived from Blaini Formation.

Blainiella polymorpha sp. nov.

Pl. 1, figs 1-14; Text-figure 3

Synonymy:

1988 *Huroniospora* Barghoorn 1965 partim. Joshi *et al.*, p. 117, figs 4, 5.

1988 *Myxococcoides* Schopf 1977 partim. Joshi *et al.*, p. 117, fig. 3.

1988 *Gunflintia* Barghoorn 1965 partim. Joshi *et al.*, p. 117, fig. 1.

1988 *Leiosphaeridia* Timofeev 1956 partim. Joshi *et al.*, p. 117, fig. 6.

1988 *Lophosphaeridium* Timofeev 1956 partim. Joshi *et al.*, p. 117, fig. 2.

Diagnosis — Linear filament non-ensheathed, measuring up to 100 µm; cells rectangular, arranged end to end, corners sharp, measuring 6-10 µm in length and 3-5 µm in width, no inclusion preserved; reproduction by endosporulation, endospores formed at the apical end of the linear filament by cell wall thickening and shrinkage of cytoplasm to a globular dark structure; fully formed endospores globular in outline, thick-walled, warty, measuring 3-16 µm in dimension, occuring as distinct individual or in groups to form globular or linear colonies; baeocytes within endospores formed by cytoplasm desmochesis into small globular cells which get released by wall dissolution, baeocytes ± globular, measuring 1-2 µm; randomly distributed, often a small central vacuole preserved, individual baeocyte subsequently enlarges to a rectangular cell by vegetative cell division to form linear filament.

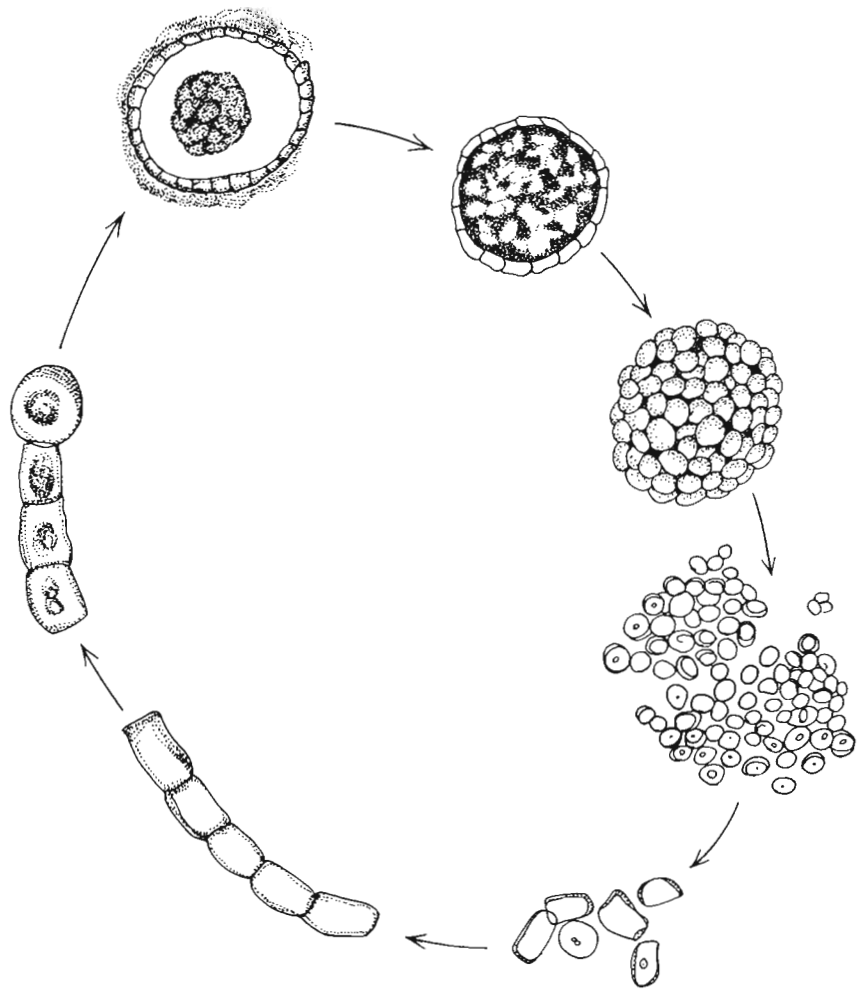
Holotype — BSIP Slide no. 11259.

Locality — Near Maldeota (Song River Section).

Horizon — Blaini Formation (Terminal Neoproterozoic).

Description — The fossil alga shows a wide morphological diversification. Filaments without gelatinous envelope, narrow linear, made up of rectangular cells, arranged end to end (Pl. 1, fig. 12). Cell wall is thin with uniformly dispersed cellular content. In certain cells (Pl. 1, figs 8, 11), oval or dumble-shaped dark structures are preserved indicating the initiation of endospore formation. Rectangular cells of filaments at the terminal region get transformed into globular-shaped structures. The end cells show thickening of outer wall indicating endospore formation (Pl. 1, fig. 9).

In thin sections, endospores are generally widely dispersed and mostly seen as solitary entity (Pl. 1, figs 3, 6). However, many of them are grouped to form either globular (Pl. 1, fig. 5) or linear chained colonies (Pl. 1, fig. 12). Endospores are thick-walled, cells 2-3 layered thick. In resting endospores cytoplasm is



Text-figure 3 — Diagrammatic representation of the life cycle of *Blainiella*.

shrinked to a dark mass (Pl. 1, fig. 13). Baeocytes within endospores are formed after desmochesis. On commencement of this stage, the cytoplasm gets spread in the total area of endospore. The wall also becomes thin with an increase in the size of endospores. Endospores cytoplasm undergoes desmochesis to form globular baeocytes which are tightly packed within a fine enveloping sheath (Pl. 1, figs 1, 4, 14). They are released after dissolution of wall (Pl. 1, figs 2, 10). Cells circular in outline, wall thin

PLATE 1

(All photomicrographs are magnified x 2000 and all figures are from BSIP Slide nos. 11259 & 11260).

Blainiella polymorpha gen. et sp. nov.

1,4,14. Compactly packed baeocytes formed after desmochesis.

2, 10. Dissolution of endospores wall and release of baeocytes.

3, 6. Darkened matter (?cytoplasm) of endospore uniformly spread out indicating pre-desmochesis.

5. Several endospores forming globular mass.

7. Vegetative division of globular baeocytes and formation of linear tubular filaments by vegetative reproduction.

8. Initiation of endospore formation in the rectangular cells of tubular filaments.

9. Tubular filament showing rounded endospores at terminal end.

11. Narrow tubular filament composed of rectangular cells with mucilaginous sheath.

12. Endospores arranged in linear chains.

13. Individual thick-walled endospores with dark condensed matter in the centre.

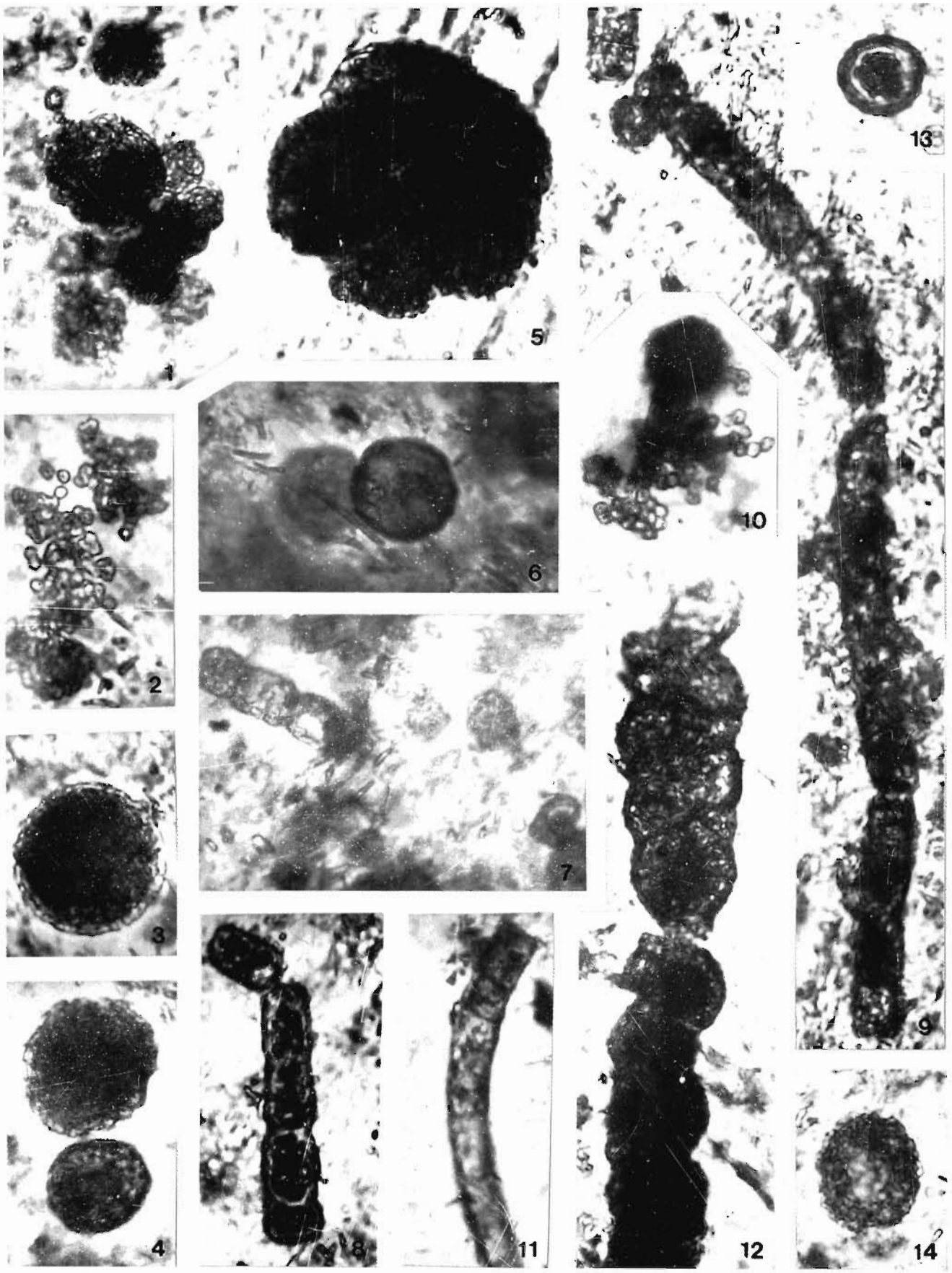


PLATE 1

with a dark spot (Pl. 1, fig. 2). Later, the cells enlarge in size into rectangular cells (Pl. 1, fig. 7) and subsequently form linear filament by vegetative division.

Thus, the different morphological entities recovered represent the complete life cycle of alga, which has been shown in Text-figure 3.

DISCUSSION

Though in the past several algal forms have been reported from the Precambrian sediments of the world (Schopf & Klein, 1992), the present form, however, remains unrecorded. The endospores of *Blainiella* compare well with those of the form *Sphaerocongregus (Bavlinella) variabilis* Moorman 1974 reported from the Vendian (Zang *et al.*, 1992; Maithy & Babu, 1994). But *Sphaerocongregus* is represented only by endospores and the filaments are not known. The filamentous form in association of globular endospores and later germinating into filamentous form favours a close comparison of *Blainiella* to the extant algal forms belonging to the genus *Hyella* Börnet & Flaghaut 1888. In *Hyella*, the filamentous part generally grows endolithically in the substratum and the endospores are formed towards the terminal end, which in turn release baeocytes to form new mat. This life cycle is best detailed in *H. caespilosi* (fig. 198 in Geitler, 1932). Rare occurrence of filamentous forms and frequent presence of globular endospores in fossilised state in Blaini rocks favour endolithic growth of the filament and formation of endospores similar in habitat and life cycle as in the case of extant *Hyella*. Joshi *et al.* (1988) described five different forms, *viz., Huroniospora, Myxococcoides, Gunflintia, Leiosphaeridia* and *Lophosphaeridium* from the same locality. The present study indicates that all these forms, infact, represent part of the life cycle of *Blainiella*. The globular endospore stage is represented by the identified forms — *Huroniospora, Leiosphaeridia* and *Lophosphaeridium*. Endospores are compactly packed into globular mass as *Myxococcoides* and the filamentous part as *Gunflintia*. Thus considering this fact the above mentioned forms described by Joshi *et al.* (1988) are placed under synonymy.

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