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 Hyrella, 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, baecocles formed within endospores by cytoplasm desmochesis and released by wall dissolution of endospores, each baecocle forms linear filament by vegetative reproduction. This new genus represents different stages of life cycle of microflora 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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सारः

भारत में लघु हिमालय में मसूरी भूलोणों के ब्लैनी शैल समूह अनुक्रम (अन्तिम नवप्रोटेरोज्योजी) से नवे फिल्टरीएडीसीय अवशेष

प्रभात कुमार माई, रुपेंद्र बाहु, गोपेन्द्र कुमार एवं वी.के. माध्युर

मसूरी भूलोणों में ब्लैनी शैल-समूह से आक्राकिरिय लक्षणों में वर्तमान रूप हिमालय से तुलनाय ब्लैनीयादल व ब्लैनीय अवशेष तक एक नया शैल अवशेषित किया गया है। इससे रेषीय तत्त्व एक दूसरे से सटी रूपान्तरण को लोगों से बना है तथा अन्त-बीजानवीकरण द्वारा प्रजनन होता है जिससे उजुम रेषा के आकार के अन्त-बीजान हटे है अथवा अन्त-बीजान जैसे अन्त-बीजान जैसे के अन्तर केबोसाइड बनता है जो अन्त-बीजानों के रूप की शैली विकसित होने के कारण एक हो जाते है। प्रत्येक कέबोसाइड से अर्थात जैसे अज्ञात प्रजनन द्वारा रेषीय तत्त्व का निर्माण होता है। इस नये प्रजनन से सुविदान्वित, जो कि इसी शैल-समूह से जोशी व अन्य (1988) द्वारा वर्णित किया गया था, के जीवन चक्र की विशिष्ट अवस्थायें निर्धारित होते है।

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., Symplasosphaeridium, Orgymatoshaeridium, Huroniospora, Myxococcoideae, and Gunjlintia, 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 Saknidihar 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.

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

<table>
<thead>
<tr>
<th>Formation</th>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infra Krol Formation</td>
<td>Bleached shale/slate</td>
<td>≥ 34 m</td>
</tr>
<tr>
<td></td>
<td>Pink Limestone</td>
<td>4 m</td>
</tr>
<tr>
<td></td>
<td>Diamictite</td>
<td>55 m</td>
</tr>
<tr>
<td></td>
<td>Slate interbedded with quartz arenite (4:1)</td>
<td>249 m</td>
</tr>
<tr>
<td></td>
<td>White quartzwacke interbedded with shale</td>
<td>342 m</td>
</tr>
<tr>
<td>Blaini Formation (2100 m)</td>
<td>Diamictite (matrix calcareous at places)</td>
<td>56 m</td>
</tr>
<tr>
<td></td>
<td>Greyish white arenite</td>
<td>106 m</td>
</tr>
<tr>
<td></td>
<td>Diamictite with calcareous bands</td>
<td>50 m</td>
</tr>
<tr>
<td></td>
<td>Purple and greenish quartzwacke with thin shales (4:1) (microbiota)</td>
<td>296 m</td>
</tr>
<tr>
<td></td>
<td>Rhytmite-greenish and grey shale</td>
<td>805 m</td>
</tr>
<tr>
<td></td>
<td>Diamictite</td>
<td>137 m</td>
</tr>
<tr>
<td>Saknidihar Formation</td>
<td>Quartz arenite with thin hands of shales</td>
<td></td>
</tr>
</tbody>
</table>

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; baecocytes formed by desmoschisis, 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.
**Etymology** — The generic name has been derived from Blaini Formation.

*Blainiella polymorpha* sp. nov.

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

**Text-figure 2** — Stratigraphic column at fossil locality.

**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...
shrunked to a dark mass (Pl. 1, fig. 13). Baeocytes within endospores are formed after desmochoesis. 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 desmochoesis 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

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

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**PLATE 1**

*Blainiella polymorpha* gen. et sp. nov.

1, 4, 14. Compactly packed baeocytes formed after desmochoesis.
2, 10. Dissolution of endospores wall and release of baeocytes.
3, 6. Darkened matter (cytoplasm) of endospore uniformly spread out indicating pre-desmochoesis.
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.
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* Börnèt & Flaggaut 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 favours 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, in fact, 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.

The work was carried out under the aegis of National Working Group of IGCP Project 303 — Precambrian-Cambrian Event Stratigraphy.

**REFERENCES**


