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FIRST RECORD OF ALGAL REMAINS (FILAMENTOUS, SPHEROIDAL) AND ACRITARCHS FROM THE PRECAMBRIAN GANGOLIHAT DOLOMITES FORMATION OF PITHORAGARH, KUMAUN HIMALAYA, INDIA

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ABSTRACT

The Precambrian Gangolihat Dolomites Formation (Calc Zone) of Pithoragrah appreciably yielded algal remains (filamentous, spheroidal) of living cyanophycean (Oscillatoriaceae, Nostocaceae, Chroococcaceae) affinities. It also revealed acritarchs (organic-walled microplanktons) in common to sporadic distribution. The general morphological characters of the ancient algal and fungal (,) microfossils are described. In addition, two new species of *Baltisphaeridium* and *Schismatosphaeridium* (*Baltisphaeridium gangolihatensis* sp. nov., *Schismatosphaeridium kumauni* sp. nov.) are incorporated. Their discovery in the Calc Zone of the area is the first find of the same known to-date. The presence of these microorganisms (algal and fungal remains, incertae sedis) in the sediments assists in the reconstruction of paleoenvironments during the ancient Gangolihat oceans and dating of the Precambrian rocks.

INTRODUCTION

WITHIN the last decade substantial data on the presence of microscopic algal remains (filamentous and spheroidal) from the Precambrian sediments of the U.S.A., Canada, Australia, Russia, Africa and India have been published (Barghoorn and Tyler[1]; Vologdin and Drozdova[30]; Vologdin, 1966; Schopf[19]; Gutstadt and Schopf, 1969 ; Hofmann and Jackson[9]; Schopf, 1970; Schopf & Blacic[20] ; Schopf, 1972; Schopf *et al.*, 1973; McConnell[15]; Hofmann[6]; Maithy[13]; Nautiyal[17]; Cloud[2]; Walter *et al.*[31]; Hofmann[8]; Maithy and Shukla[14]). In India, however, reports on the algal microbiota are still scarce (Maithy, 1968; Srivastava, 1971; Sajujha *et al.*, 1971; Venkatachala *et al.*[25]; Maithy and Shukla[12]). These microorganisms from the Precambrian sequences of the Kumaun Himalaya, have not been reported so far.

In the course of investigation on the presence of microorganisms in the Precambrian Gangolihat Dolomites Formation (Calc Zone) of Pithoragarh (Kumaun Himalaya), the calcareous sediments and non-calcareous phyllites yielded microscopic algal (filamentous, spheroidal) and fungal (?) remains and acritarchs in common to sporadic distribution. However, these organic remains are not the true representative of the original microbiota at the time of deposition, as the rocks have suffered tectonic and organic metamorphism. The present paper reports the first discovery of these microfossils from the Precambrian sediments exposed at Chhera, Bans, south of Bans along the Hiunpani and Chandiak tract of Pithoragarh. These areas are confined between the coordinate 29° 36′ N to 29° 38′ N and coordinate 80° 8′ E to 80° 12′ E of the Kumaun Himalaya.

The general Precambrian geology of Pithoragarh is given by Valdiya[23-24,26]. The Precambrian Gangolihat Dolomites Formation of the Kumaun Himalaya consist predominantly of limestone, cherty limestone and dolomite, magnesite and phyllite. In the Pithoragarh region, the formation is about 700 m. thick (Valdiya[26]) and is well known for enrichment by the valuable economic deposits of magnesite. The calcareous and siliceous units of the formation are well exposed at Chhera, Bans, and areas at south of Bans. They are occasionally dominated by the organo-sedimentary structures (stromatolites) and have been assigned a Late Precambrian (Middle Riphean) age on the basis of stromatolite evidence (*e.g.*, *Baicalica* group, etc.) (Valdiya[25]). The rocks commonly display the sedimentary structures of the shallow water origin (Valdiya[24,26]) and consist of acritarchs with fungal remains. In addition, occurrence of the algal (filamentous, spheroidal) and fungal (?) remains in the stromatolitic sediments also indicates that the rocks are of marine, shallow tidal flat (intertidal to subtidal) deposit.

Microfloral (Microfaunal) Distribution

In the Chhera region, a section (12·16 m. thick) of phyllites (Chhera Member of Valdiya[26]) with greyish red purple to greyish purple colours (*Rock Colour Chart*, Geol. Soc. Am., 1963) was studied. The phyllites are highly siliceous and yielded algal remains: *Gunflintia grandis*, Type A—Algal filament, *Myxococcoides indicus* and *Huronispora* sp.

At the Bans locality, a section (334·40 m. thick) of limestone interbedded with phyllite, slate, and dolomitic magnesite was studied for types of stratigraphic units and algal remains. The limestones (in 9·12–39 m thick units), in ascending order, occur in varying colour patterns of medium grey, medium dark grey pale red and pale red purple and are siliceous, very fine to fine crystalline. They occasionally display ripple marks, fine laminations and stromatolites (lamellar and columnar types). Phyllites (in 21·28–60·80 m. thick units) occur in medium grey and greyish red purple colours. They are calcareous, silicious and frequently comprise bands of greyish red purple limestone. Slates (about 30·40 m. thick unit) occur in medium light grey (due to decomposition) to dark grey colours and are non-calcareous. Dolomitic magnesite and limestone (in about 106·40 m. thick units) of yellowish grey to medium grey colours constitute the topmost unit of the section. Magnesite is siliceous, recrystallized to coarser crystallinity and displays some schistosity.

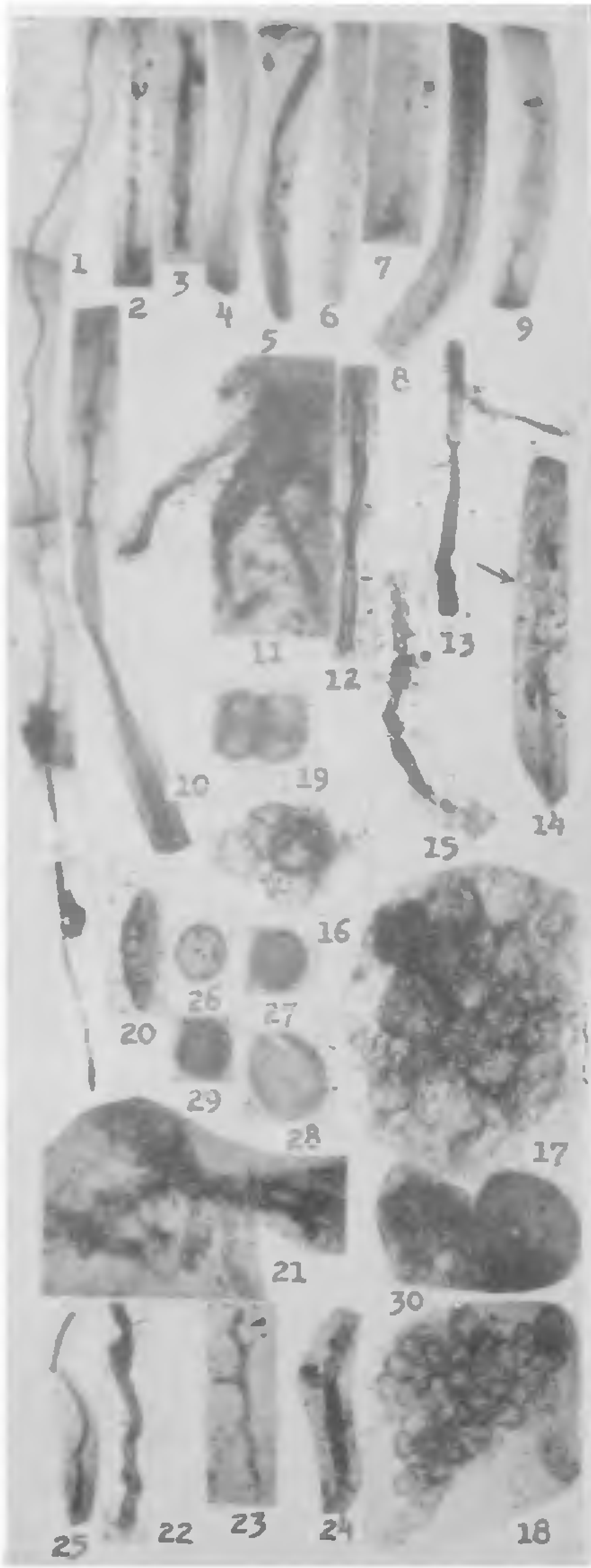
The lower 228 m. thick rock part (Nautiyal Unit) Nos. 8 to 20, in ascending order, Chhera Member consists of the following organic remains : algal microfossils, *Gunflintia grandis*, *G. minuta*, Types A, B—Algal filaments, *Siphonophycus* sp. A, *Huronispora psilata*, *H. microreticulata*, *Myxococcoides* sp., *M.* sp. A, *M. indicus*, *Eozygion minutum*, *Eosynechococcus* sp. A; fungal (?) remains, *Archaeorestis* sp. A, *Eomycetopsis filiformis* ; acritarchs, *Baltisphaeridium gangolihatensis*, *Protoleiosphaeridium problematicum*, *Schismatisphaeridium kumauni*, and *Trachysphaeridium decorum*.

The upper 106·40 m. thick section of limestone and magnesite beds (Nautiyal Unit Nos. 21, 22, Hiunpani Member of Valdiya[26]) yielded the following microflora: *Gunflintia grandis*, *G. minuta*, Type C—Algal filament, *Archaeorestis* sp. A, *Eomycetopsis filiformis*, *Eomycetopsis* (?) sp. A, *Myxococcoides indicus*, *Eosynechococcus* sp. A and *Baltisphaeridium gangolihatensis*.

The calcareous and siliceous units of the Gangolihat Dolomites Formation, at a road side locality of about ½ km south of Bans, revealed the following microflora (microfauna) in the greyish red purple phyllites and pale red purple limestone interbeds (Nautiyal Unit No. 63, 15·20 m. thick, Chhera Member) : Types A, B- Algal filament and *Trachysphaeridium* sp. A; limestones (Unit No. 64, 13·04 m. thick, Hiunpani Member) : *Gunflintia grandis* and *Baltisphaeridium gangolihatensis* ; dolomitic magnesite beds (Unit No. 65, 6·08 m. thick, Hiunpani Member): *Gunflintia grandis*; non-calcareous phyllites (Unit No. 70, 6·08 m. thick, Hiunpani Member): *Gunflintia grandis*, Type B—Algal filament, *Myxococcoides* sp., Type 2 algal structure of Hofmann and Jackson[9] and *Baltisphaeridium gangolihatensis*.

Morphological Description

The cyanophycean algal and fungal (?) remains (in common to sporadic distribution) studied were recovered through maceration. Similarly acritarchs (in sporadic distribution) were also obtained through maceration. These microorganisms are also visible, with appreciable amounts of black carbonaceous matter, in thin sections of limestone and chert (Nautiyal Unit Nos. 77, 92). The organic remains occur in brown, dark brown, dark grey to black colours and are well to badly preserved (Figs. 1–35). Generally, several specimens of fungal remains and incertae sedis microfossils (Figs. 36–38) from the organic residue are well reserved and dark brown to dark




FIGS. 1–38. Photomicrographs of algal (filamentous, spheroidal) and fungal (?) remains, acritarchs and incertae sedis microfossils from the Precambrian Gangolihat Dolomites Formation of Pithoragarh (Kumaun Himalaya, India). Figs. 1–5. *Gunflintia grandis*; Figs. 6–8. *G. minuta*; Fig. 9. *Siphonophycus* sp. A; Figs. 10, 11. Type A- Algal filament; Figs. 12, 13. Type B—Algal filament; Figs. 14, 15. Type C—Algal filament; Figs. 16, 17. *Myxococcoides indicus*; Fig. 18. *Myxococcoides* sp. A; Fig. 19. *Eozygion minutum*; Fig. 20. *Eosynechococcus* sp. A; Fig. 21. *Eomycetopsis filiformis*; Figs. 22–24. *Eomycetopsis* (?) sp. A; Fig. 25. *Archaeorestis* sp. A; Figs. 26–28. *Huronispora psilata*; Fig. 29. *H. microreticulata*; Fig. 30. Type 2—microstructure; Figs. 31–33. *Baltisphaeridium gangolihatensis* sp. nov., (long process folded on test in Fig. 32, test and processes broken but with densely microgranulose ornamentation in Fig. 33); Figs. 34, 35. *Schismatosphaeridium kumauni* sp. nov.; Fig. 36. Incertae sedis Type 1; Figs. 37, 38. Fungal remains.. All figures × 2,000 approx., but Fig. 1, × 1,200 approx.

grey in colour. Some forms of algal remains (Types A, B, C—Algal filament), being new, are described without assigning formal names. Furthermore, five specimens of the acritarch genus *Baltisphaeridium* and *Schismatosphaeridium* (with *Baltisphaeridium gangolihatensis* sp. nov. and *Schismatospheridium kumauni* sp. nov.) recovered of limestones and phyllites are new forms.

Systematic Descriptions and Biological Relationships

"ALGAE", Phylum : CYANOPHYTA, Class: CYANOPHYCEAE, Order : NOSTOCALES, Family : OSCILLATORIACEAE (S. F. Gray) Dumortier ex Kirchner, 1898.

Genus : *Gunflintia* Barghoorn, 1965

Gunflintia grandis Barghoorn, 1965 (Figs. 1–5): Filaments multicellular, unbranched, straight or curved, psilate, septae variably spaced, cells both equidimensional and longer than wide, individual filaments commonly of uniform diameter throughout but slightly constricted at septae, dark brown to black; filament diameter range, 2·5 to 5·5 μ, cells varying in length from 6 to 14·5 μ, overall length of filament (broken) up to 128 μ. This Kumaun Himalayan species compares to *G. grandis* (Fig. 4, pt. 4, p. 567, Barghoorn and Tyler[1]) from the Gunflint Formation (Middle Precambrian) of Canada.

Gunflintia minuta Barghoorn, 1965 (Figs. 6–8): Filaments straight to slightly curved, unbranched, septate, psilate; filament overall length up to 96 μ (broken specimen), diameter range, 1·5 to 2 μ, cell length about 6 μ in a few filaments. The recognised species closely compares to *G. minuta* (Fig. 4, pts. 6, 8, p. 567, Barghoorn and Tyler[1]) from the Gunflint Formation of Canada, and to similar species (Fig. 3 *a*, *b*, p. 222, Walter *et al.*[31]) from the Middle Precambrian stromatolitic iron formation of Western Australia.

Genus : *Siphonophycus* Schopf, 1968

Siphonophycus sp. A (Fig. 9): Thallus tubular, broad, non-septate, unbranched, fairly long, surface slightly roughened, partly folded, dark brown. Thallus cylindrical, solitary, straight up to 142 μ (incomplete specimen), 14·50 μ wide, tapering towards both ends (6 μ, 12 μ wide). *Siphonophycus kestron* (Pl. 8, Figs. 1–3 , Schopf[19]) and *Siphonophycus punctatus* (Pl. 1, Fig. 5, Maithy[13]) from the Late Precambrian of Australia and Zaire, respectively, differ from *Siphonophycus* sp. A in shape and ornamentation of filament.

Type A—Algal filament (Figs. 10, 11) : Trichomes multicellular, uniseriate, unbranched, straight to slightly bent, solitary and gregarious, loosely interlaced. Trichomes slightly to strongly constricted at septa, apices (broken part) gradually attenuated, brown to dark brown. Broader cells of trichome in places strongly constricted (commonly at septa) to long and narrow cells; the latter cells seldom with lenticular or oval cells at the central part giving a general beaded appearance to trichome. Septa well to poorly preserved, sheath absent. Trichomes upto 130 μ long (broken specimen), broad cells 6 to 8 μ wide and 14 to 40 μ long, seldom septate; narrow cells 1·5 to 2 μ wide and 5 to 26 μ long; oval cells, 6 μ wide at central part and 9·5 to 14·5 μ long, rarely with septum. Type A—Algal filament shows affinities to Oscillatoriaceae as indicated by simple morphology, growth habit. In addition, partly similar to this form, the Middle Precambrian filamentous algal specimen (of nostocalean affinities) demonstrated as *Gunflintia minuta* Barghoorn (Pl. 3, Figs. 3, 7, Cloud[2]) also has distinct constrictions at septa.

Type B—Algal filament (Figs. 12, 13) : Trichomes multicellular, uniseriate, unbranched, straight, fairly narrow, occurring individually. Trichomes conspicuosly constricted at septa, apices (broken part) finely and gradually attenuated, dark brown. Longer cells and few subspherical cells connected in a row with fine, long and narrow cells, psilate. Septa rather poorly preserved, sheath absent. Trichomes up to 80 μ long (broken specimen), longer cells 1·8 to 2·5 μ wide and 12 to 14 μ long; subspherical cells, 2 to 2·4 μ in diameter; connecting long and narrow cells, 1 μ wide, about 5 μ long. Type B—Algal filament exhibits affinities of Oscillatoriaceae as indicated by lack of reproductive structures and presence of simple morphology.

Family : NOSTOCACEAE Kutzing, 1843 (?)

Type C—Algal filament (Figs. 14, 15) : Trichomes multicellular, branched (falsely) in two, straight parts. Trichomes strongly constricted at septa, apices very slightly and gradually attenuated, brown to dark brown. All cells more-or-less barrel-shaped, but cell at bifurcated filament broader, terminal (apical) cell with remnants of organic coating (dark brown), longer than barrel-shaped. Septa well preserved, sheath absent, psilate. Trichomes up to 90 μ long (complete specimen), commonly occurring as broken and isolated filament up to 68 μ long, cell commonly 3·6 to 6 μ wide and 5 to 8 μ long, cell at bifurcating filament 6 μ wide. Type C—Algal filament has some morphological similarity (in shape and size of cell, ornamentation) to moddern nostocalean algae of the genus *Nostoc*. However, the branching (see arrow in Fig. 14) in the former species may be false as seldom found in the filamentous Nostocales (Fritsch[4]).

Order : CHROOCOCCALES

Family : CHROOCOCCACEAE Nägeli 1949

Genus : *Myxococcoides* Schopf, 1968

Myxococcoides indicus Venkatachala, Bhandari, Chaube and Rawat (Figs. 16, 17) : Colonies consisting of 5 to 25 cells; cells circular, oblong and angular due to crowding of neighbouring cells, psilate, cell wall thin, dark brown, broken and thin sheath of the colony attached with the cell appearing granulose due to agglutination of organic and mineral particles. cell 7 to 10 μ, wide. This species closely compares to *M. indicus* (Pl. 1, Figs. 17–19, Venkatachala *et al.*[28]) from the Dharwar sediments of Karnataka State.

Myxococcoides sp. A. (Fig. 18) : Cells commonly spherical to subspherical, contained in a more-or-less ellipsoidal colony (rarely occurring as solitary cells) provided with few to 45 cells. Colony enveloped by thin, psilate sheath. Cell surface psilate to slightly roughened, dark brown, with diameter range, 4·5 to 6 μ. *M. indicus* Venkatachala *et al.*[28] differs from *M.* sp. A in having larger cells of different shape. *Myxococcoides minor* Schopf[19], from the Late Precambrian rocks of Australia also has larger cells (8·8–10·5 μ) embedded in a thick, granular and non-lamellated organic matrix.

Genus : *Eozygion* Schopf and Blacic, 1971

Eozygion minutum Schopf and Blacic, 1971 (Fig. 19): Cells occurring in pairs, spheroidal to hemispheroidal, colonial, dark brown, enveloped by a common, thick, organic sheath; cell surface finely microogranulose; each cell size 7 × 4 μ, organic sheath 1 μ thick. This species closely compares to *E. minutum* of Schopf and Blacic[20] from the Late precambrian rocks of Australia and to similar species of Hofmann[8] from the Middle Precambiran rocks of Belcher Island, Canada.

Genus : *Eosynechococcus* Hofmann, 1976

Eosynechococcus sp. A (Fig. 20) : Cell oblong, without distinct envelope, solitary, psilate, medium grey, consisting of 7 minute spherical structures in a row inside on the cell wall; cell 7·2 μ wide and 19 μ long, diameter of spherical structure 2 to 2·5 μ.

"FUNGI" (?), Phylum: EUMYCOPHYTA (?)

Genus : *Eomycetopsis* Schopf, 1968

Eomycetopsis filiformis Schopf, 1968 (Fig. 21) : Filaments with almost uniform diameter, non-septate, unbranching, commonly gently curved, mostly clustered to rarely solitary, light brown, psilate to slightly microgranulose (?); up to 120 μ long, 1·5 to 3·8 μ across, average 2·0 μ wide (25 filaments measured), less than 0·5 μ thick. This species closely resembles to *E. filiformis* of Schopf[19] from the Late Precambrian rocks of Australia and to the same species of Hofmann and Jackson[9] and Hofmann[8] from the Middle Precambrian rocks of Belcher Island, Canada. *Eomycetopsis* (?) sp. A (Figs. 22–24) : Filaments tubular, slightly varying diameter, solitary, indistinctly and irregularly septate, branching into two, partly curved, psilate, brown to dark brown; filaments up to 79 μ long (broken specimen), width varying from 3 to 4·8 μ, cell size from 8·4 to 12 μ long, short branch of the filament 4·8 to 7·2 μ long. Schopf *et al.* (1977, p. 281, Figs. 3 A, B) also reported *Eomycetopsis*—like organic, branched and septate filament (of fungal ? affinities) from the Late Precambrian rocks of Russia.

Genus : *Archaeorestis* Barghoorn, 1965

Archaeorestis sp. A. (Fig. 25) : Filament tubular, non-septate, occasionally branched, curved, psilate to irregular surface, uneven diameter due to slightly widening of walls at random intervals; filament up to 64 μ long (broken specimen), width varying from 1·5 to 2·5 μ. *Archaeorestis schreiberensis* Barghoorn[1] from the Middle Precambrian Gunflint rocks of Canada differs from this species in having filaments of constant diameter except at bulbose swellings, with rugose walls.

INCERTAE SEDIS

Genus : *Huronispora* Barghroorn, 1965

Huronispora psilata Barhoorn, 1965 (Figs. 26–28): Test sphreroidal, relatively thin-walled, wall psilate, dark brown; diameter range, 8 to 15 μ. This species of Pithoragarh compares to *H. psilata* (Fig. 5, pl. 4, p. 568, Barghoorn and Tyler, 1967) from the Gunflint Formation (Middle Precambrian) of Ontario, Canada. The Himalayan species is also similar to spherical body of *Huronispora* (Pl. 4, Fig. 1, p. 339, La Berge[12]) from Middle Precambrian chert of the Gunflint District (Canada), *Huronispora* sp. (Fig. 3 *h*, p. 222, Walter *et al.*[31]) from the Middle Precambrian Iron Formation of Western Australia and to spheroidal *Huronispora* sp. (Pl. 3, Fig. 8, Cloud[2]) of the Gunflint Formation of Canada.

Huronispora microreticulata Barghoorn, 1965 (Fig. 29): Test spheroidal, moderately thick-walled, wall finely reticulate (muri about 0·7 μ high), dark brown; diameter (overall size) 12 μ. This Himalayan species compares closely to similar species (Fig. 5, pl. 1, p. 568, Barghoorn and Tyler[1]) from the Gunflint Formation of Ontario, and to *Huronispora* sp. (pl. 4, Fig. 2, p. 339, La Berge[12]), with fine reticulate ornamentation, from the Canadian Gunflint Formation.

Type 2 microstructure (Fig. 30) : Spheroidal tests similar to Type 2 microstructure of Hofmann and Jackson[9], from the Middle Precambrian rocks of Belcher Island, occur either individually, or often attached to organic matter (Fig. 30). Test is psilate, dark brown, and a dark circular spot having opening (1–3·5 μ) is located near the test margin. Test diameter range, 7 to 20·4 μ, wall thickness range, 0·1 to 0·5 μ.

Group	:	ACRITARCHA Evitt, 1963
Sub-group	:	ACANTHOMORPHITAE Downie, Evitt and Sarjeant, 1963
Genus	:	*Baltisphaeridium* (Eis.) Downie and Sarjeant, 1963

Baltisphaeridium gangolihatensis sp. nov.
(Figs. 31–33)

Test spherical to sub-spherical, moderately thick-walled, densely microgranulose (appearing darker due to agglutination of mineral particles), rarely with few folds, provided with 5 to 6 thick, long and stout processes tapering distally to blunt tip; processes psilate to densely microgranulose, mostly broken in specimen observed, dark grey to black; test diameter range, 33·50 to 50 μ, wall thickness about 1·20 μ; process length up to 30 μ, diameter at base 6 to 7·20 μ; spacing between two processes in a specimen 18 μ; microgranules diameter about 0·50 μ. Holotype specimen (Fig. 31), test 48 × 50 μ (Wild microscope coordinate: Pithoragarh 70/3, 111·4/44·3); Locality: about ½ km. south of Bans (Gangolihat Dolomites Formation), Pithoragarh, Kumaun Himalaya, India.

Species of *Baltisphaeridium* occur very rarely in the Precambrian sediments. *Baltisphaeridium scitulum* (Pl. II, Figs, 26, 27, Salujha *et al.*[18]), from the Bijaigarh Shales (Upper Vindhyan) of Són Valley, differs from *B. gangolihatensis* sp. nov. in having smaller test (25·20–31·40 μ) with shorter and sharp tipped spines (2·50–3·50 μ long). *Baltisphaeridium* (*Arhaeohystrichosphaeridium*) *bohemicum* Konzalová, 1972 (Pl. V, 12, Konzalová[11]), of the Upper Proterozoic grywacke of Bohemia, also has shorter, thinner and more number of psilate spines (processes).

Sub-group : Sphaeromorphitae Downie, Evitt, and Sarjeant, 1963

Genus : *Schismatosphaeridium* Staplin, Jansonius and Pocock, 1965

Schismatosphaeridium kumauni sp. nov. (Figs. 34, 35)

Test spherical to sub-spherical, moderately thick-walled, finely punctate, rarely with folds; with a circular pylom bounded by a thin rim, brown in colour; test diameter range 69·50 × 80·50 μ to 69·50 × 83 μ, wall thickness, more than 1 μ; pylom 18 to 19 μ, rim around pylom 0·70 μ; diameter of pits 0·50 μ, spacing between pits about 0·70 μ. Holotype specimen (Fig. 34) test 69·50 × 83 μ (Wild microscope coordinate: Pithoragarh 8/2, 111·8/37·80); Locality: Bans (Gangolihat Dolomites Formation), Pithoragarh Kumaun Himalaya, India.

Schismatosphaeridium bhimai Venkatachala and Rawat, 1872 (Pl. 1, Figs, 11, 12, Venkatachala *et al.*[27]), from the Bhima sediments (Late Cambrian) of Karnataka State, differs from *S. kumauni* sp. nov. in having smaller size (test 16 × 18 μ) with a small pylom (6–10 μ) and smooth test wall. *Schismatosphaeridium* sp. (Pl. I, Fig. 12, Vishwanathiah *et al.*[29]), of the Kaladgi Basin sediments (Late Proterozoic to Lower Cambrian), also differs in having smaller test (10–12 μ), smaller pylom (2 μ) and granulose test wall.

Inceratae sedis Type-1 (Fig. 36): Test more or less flask-shaped, thin-walled, densely microgranulose, wall with folds; size of main body, 45·50 × 50·50 μ; length of extension, 48 μ, diameter at base and top, 21·50 μ; diameter of microgranules, less than 0·50 μ.

Fungal remains (Figs. 37, 38): Several oval (fungal spores, Fig. 38) and long, filament-like (Fig. 37), septate, bodies suspected as fungal in origin were recorded. Measurement of a fungal remain (Fig. 37): oval size, 98·50 μ, length of septate body, 68 μ, maximum 10·80 μ across; size of constricted thin tube, 1·20 × 13·20 μ: size of oval body, 6 × 15·60 μ.

Paleoenvironment

The limestones of the Gangolihat Dolomites Formation are occasionally dominated by stromatolites. In addition, fossil blue-green algae, referable to two of the five modern Cyanophycean orders are well represented in the micoflora of Pithoragarh. These microorganisms represent the photosynthetic nature and their association with the algal-stromatolite-bearing calcareous units indicates that the microbiota represents a shallow water assemblage, possibly preserved close to the sediment-water interface (Schopf,[19]; Nautiyal[17]). In addition, the reddish colour in limestones (pale red to pale red purple) and phyllites (red purple to greyish purple) of the Calc Zone is due to presence of ferric iron oxide or hydroxide, suggesting partly oxidising conditions (Grim[5]) in the photosynthetic environment at the time of deposition.

Age Assignment

The Gangolihat Dolomites Formation has been assigned a Late Precambrian (Middle Riphean) age on the basis of Indian stromatolites' correlation with that of Russia (Valdiya[25–26]), although Valdiya[25] acknowledged the dating of sediments by stromatolites as disputive subject. Moreover, the North American geologists have expressed doubts in world-wide correlation of Proterozoic rocks using stromatolites (Cloud and Semikhatov,[3]; McConnell[16]; Hofmann[7]). However, it is interesting to note that the microflora of the Calc Zone is dominated by the filamentous and spheroidal procaryotic microorganisms commonly referred to cyanophycean families (Oscillatoriaceae, Nostocaceae, Chroococcaceae), like the Middle Precambrian microbiota of the Gunflint Formation (2,000 m.y.) and Belcher Island (1,700 m.y.) of Canada, and of the stromatolitic Iron Formation (2,000 m.y.) of Western Australia (Barghoorn and Tyler[1]; Hofmann,[6] Walter *et al.*[31]). A good number of microorganisms reported in this paper are either new genera and species or long time ranging (Middle to Upper Precambrian) forms and cannot be used for dating of Proterozoic rocks (upper sequence). However, the Middle Precambrian microorganisms (*Gunflintia grandis*, *G. minuta*, *Huronispora psilata*, *H. microreticulata, Myxococcoides indicus, Protoleiosphaeridium problematicum, Trachysphaeridium decorum*) occur appreciably in the Gangolihat Dolomites Formation. In addition, the genera *Archaeorestis* and *Eosynechococcus* have been reported from the Middle Precambrian rocks of southern and northern Canada. Furthermore, the Calc Zone microfloral assemblage of Pithoragarh does not compare with the Lower and Upper Precambrian assemblage reported from Africa, U.S.A., Australia, Russia, western Europe, China and India. It is certainly more advanced than the Lower Precambrian (Fig Tree Formation) microbiota of Africa (3,200 m.y.) but less advanced than the Upper Precambrian (1,000 m.y.) microflora of Australia (Schopf[19]; Schopf and Blacic[20]). It seems that the Gangolihat Dolomites Formation falls somewhere between these two time periods, and may be of Middle Precambrian age on the basis of microfloral assemblages.

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INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

International Newsletter of Chemical Education—Newsletter No. 8 is in the press for publication in April 1978 and will be available free of charge from the Secretariat: Dr. P. D. Gujral, Assistant Secretary; Publications, Bank Court Chambers, 2–3 Pound Way, Cowley Centre, Oxford OX 4, 3 YF, UK.

Highlights of Newsletter No. 8—A major part of this issue of the Newsletter is devoted to reporting the outcome of a preliminary Survey of Chemical Education in 23 developing countries carried out by Prof. C. N. R. Rao, Chairman of IUPAC Committee on Teaching of Chemistry. Chemistry is highly popular amongst college/university level students in most developing countries—first choice in 12 countries and second choice in 5 countries. However, lack of trained teachers; and training facilities for them; and of equipment and chemicals for undergraduate students results in inadequate laboratory training of students. Chemistry courses in most countries are undergoing a certain degree of modernization but international cooperation is needed in the training of teachers in modern teaching methods. The report was discussed at the UNESCO–IUPAC International Symposium on Chemical Education (Ljubljana, Yugoslavia: August 1977) and the recommendations emerging are also included.