DISCOVERY OF CYANOPHYCEAN ALGAL REMAINS AND CHITINOZOANS FROM THE LATE PRECAMBRIAN ARGILLACEOUS SEQUENCE OF SATPULI, GARHWAL HIMALAYA, INDIA

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ABSTRACT

The Late Precambrian argillaceous sequence of the Satpuli area (Garhwal Himalaya, India) commonly referred as Simla Slates yielded a high percentage of algal remains (phytoplanktons, filamentous algae) of living and ancient cyanophycean affinities, fungal remains and chitinozoans. The general morphological characters of these microorganisms (with *Grandiphycus satpuliensis* gen. nov., sp. nov. of nostocalean affinities) are described. Their discovery in these rocks of the area is the first find of these organic-walled microfossils known-to-date. The presence of these microorganisms in the rocks assists in the reconstruction of paleoenvirosments and dating of Precambrian sediments.

INTRODUCTION

THE fossilized forms of cyanophycean algal remains and chitinozoans from the Late Precambrian argillaceous rocks of either Satpuli or any other part of the Garhwal Himalaya (India) have not been reported so far. Chitinozoans are of very rare occurrence in the Precambrian rocks, and there is only one reported find of such definitive microfossils, according to literature survey, from the Late Precambrian Chuar Group of the Grand Canyon, Arizona (Bloeser *et al.*[2]). In India, however, Maithy and Shukla[7] have described the cyanophycean algal remains from the Late Precambrian Suket Shales of Madhya Prgdesh. In the geological and biological journals there are several interesting papers on the cyanophycean algal remains (filamentous and spheroidal) from the Late Precambrian rocks of Russia, America, Canada, Africa and India (Vologdin and Drozdova[20]; Vologdin and Strygin[21], Schopf[11], Schopf and Barghoorn[14]; Gutstadt and Schopf[4]; Schopf[12]; Schopf and Blacic[15]; Schopf[13]; McConnell[8]; Maithy[6]; Nautiyal[9]; Maithy and Shukla[7]. The present paper reports the first record of cyanophycean algal remains (filamentous and spheroidal) and chitinozoans from the Late Precambrian rocks of the Satpuli area of the Garhwal Himalaya. In addition, the occurrence of chitinozoans in these rocks of the same area is the world's second find of microfossils.

In the Garhwal Himalaya (India), the grey and purple red argillaceous sequences commonly referred as Simla Slates are of very common occurrence (Pilgrim and West[10]; Auden[1]). Auden[1] (p. 414) suggested of these slates of the area as possibly equivalent to the Chandpur Series, although different in lithology, assigning Lower Palaeozoic and Pre-Cambrian (?) age. Valdiya[17] incorporated Simla Slates of the Garhwal Himalaya at Satpuli area in the Precambrian flysch (or turbidite) sequence.

An outcrop section of these argillaceous sequences (of slate and siltstone) is well exposed along a motor roadside area, between 3 to 9 km. (approx.) distance at west of Satpuli town. At this roadside locality about 150 ft thick section of the sequence (confined between the coordinates long. 78° 38′ to 78° 41′ and lat. 29° 56′ to 30° 00′) was studied for the present investigation. About 70 ft lower part of the section is dominated by medium grey slates of non-calcareous character. The slates are enriched with black carbonaceous matter, and are appreciably fossiliferous with organic-walled microfossils. The fossils include cyanophycean algal remains (abundant spheroidal phytoplanktons, filamentous algae), fungal filament (*Eomycetopsis septata*) and spores, chitinozoans (common occurrence) having affinities of desmochitinids (*Desmochitina minor, D. minor ovulum*), and organic plates (Figs. 1–27).

The upper 80 ft thick part of the section is dominated by light olive grey slates, banded and interbedded with light olive grey to moderate brown, ferruginous siltstones. In places of the section the slates demonstrate rich concentration of spheroidal phytoplanktons with top shaly part having common occurrence of desmochitinids (*Desmochitina minor, D. minor ovulum, D. bohemica*).

MORPHOLOGICAL DESCRIPTION

The cyanophycean algal remains, chitinozoans, fungal remains (in sporadic distribution) and organic plates studied mostly in thin sections

(Figs. 3–16, 18–24, 26–27) and also recovered through maceration (Figs. 1, 2 AB, 17; 25) from the medium gray to light olive gray slates and siltstones, are well preserved and mostly dark brown to black in colour. Since most of the cyanophycean algal remains are new find, still to be formally named, a general morphological description of the same with other microfossils is incorporated in the present article as first report.

Systematic Descriptions and Biological Relations of algae

Phylum : CYANOPHYTA, Class : CYANOPHYCEAE, Order : CHROOCOCCALES, Family : CHROOCOCCACEAE Nägeli, 1849

Types A, B, C, D–Algal Spherule

(Figs. 3–15)

Phytoplanktons of spheroidal nature, mostly occurring as individuals and in chains (Figs. 26, 27), may be divided into four categories. (1) *Type A spherule* (Figs. 3–5 lower part, 27), thin-walled, psilate to faintly microgranulose, showing homogeneous composition, mostly dark brown, translucent to opaque. The micro-structures occur as spheroidal aggregates, in chains of 2 to 3 or more cells, and isolated spherules (Fig. 5) are also common, with diameter range 4 to 20 μ. (2) *Type B spherule* (Figs. 5 upper part, 6) is subspherical, thin-walled, with fine reticulate ornamentation; dark brown, with diameter range, 8–10 μ. (3) *Type C spherule* (Figs. 11–15) is subpherical, moderately thick-walled, with roughened surface, dark brown; test diameter range, 14 to 25 μ, wall thickness 1 μ. (4) *Type D spherule* (Figs. 7–10, 26) is spherical to subspherical, dark brown, fairly thick-walled with roughened surface, and mostly provided with a central darker area termed "nucleiods" (McConnell[8]), test diameter range, 6 to 15 μ; wall thickness about 2 μ, size of "nucleoids" 1·50 to 4 μ.

These algal spherules (Type A) are similar as unicells (cyanophytes) (p. 74, Figs. 39–45; 47–49) of Schopf[13] from the Late Precambrian Bitter Springs Formation of Central Australia. In addition, algal remains (Types A, C, D) compare closely to the cyanophycean algal spherules (Pl. 1, *d–j*) of McConnell[8] from the Proterozoic rocks of the Mescal Formation of central Arizona. Also, some spherules (Type D) have similarity to algal unicells (Fig. 1, J, Schopf; *et al.*[16]); of blue-green algal affinities (*cf.* Chroococcaceae) from the Middle Riphean Sukhotungusin Formation of Russia.

Order : NOSTOCALES, Family : OSCILLATORIACEAE ' (S. F. Gray) Dumortier ex Kirchner, 1898.

Genus *Grandiphycus* gen. nov.

(Figs. 1, 2 AB)

Filament broad, tubular, quite long; solitary slightly bent, unbranched, partly folded; non-septate; with walls psilate to slightly roughened, collapsed and ruptured (in preservation), and tapered towards apices. One end of thallus tapered to thin end (Fig. 2 B upper) of 2 to 5 μ diameter, but other end tapered and capitate (Fig. 2 A lower) more-or-less constricted adjacent to expanded with broadly conical and bluntly pointed terminus (diameter 13 μ). Thallus up to 1035 μ long (in complete specimen), width 30 μ at central part (Fig. 2 A upper), and towards apices, 9·50 μ (thinner end) to 21 μ (capitate part). *Etymology*—Reference of algal affinities, tubular morphological structure and large size (grandis, Lt: = large size).

Grandiphycus satpuliensis sp. nov.

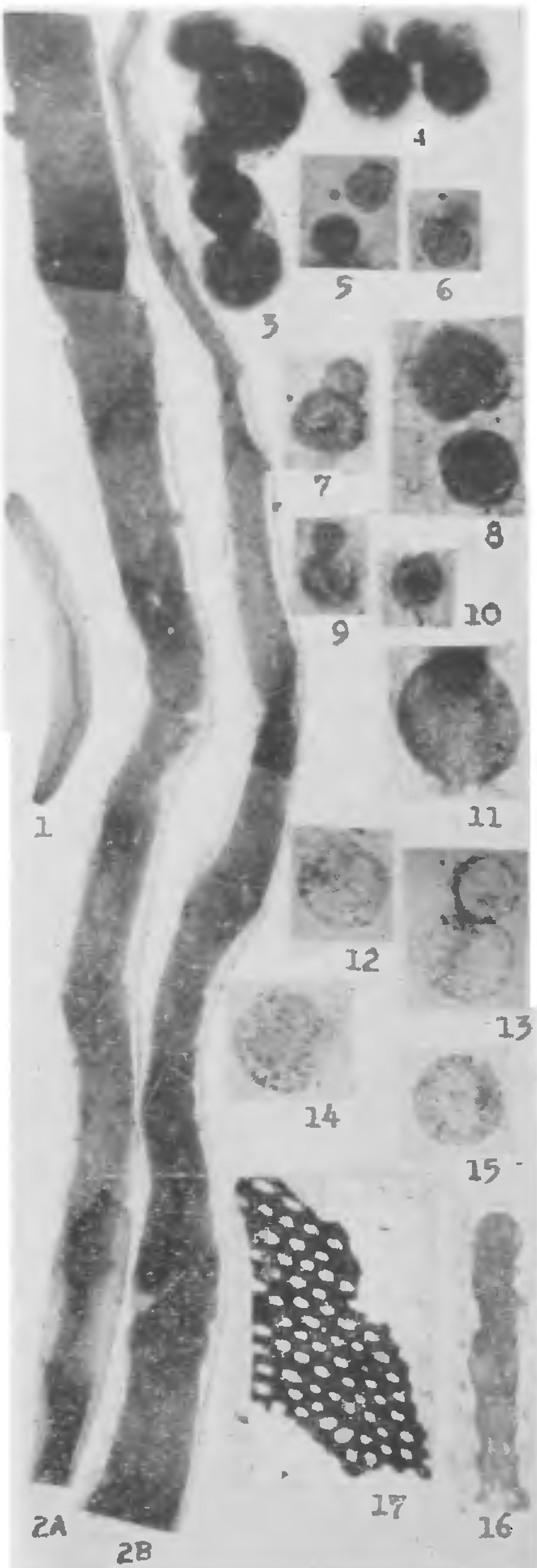
(Figs. 1, 2 AB)

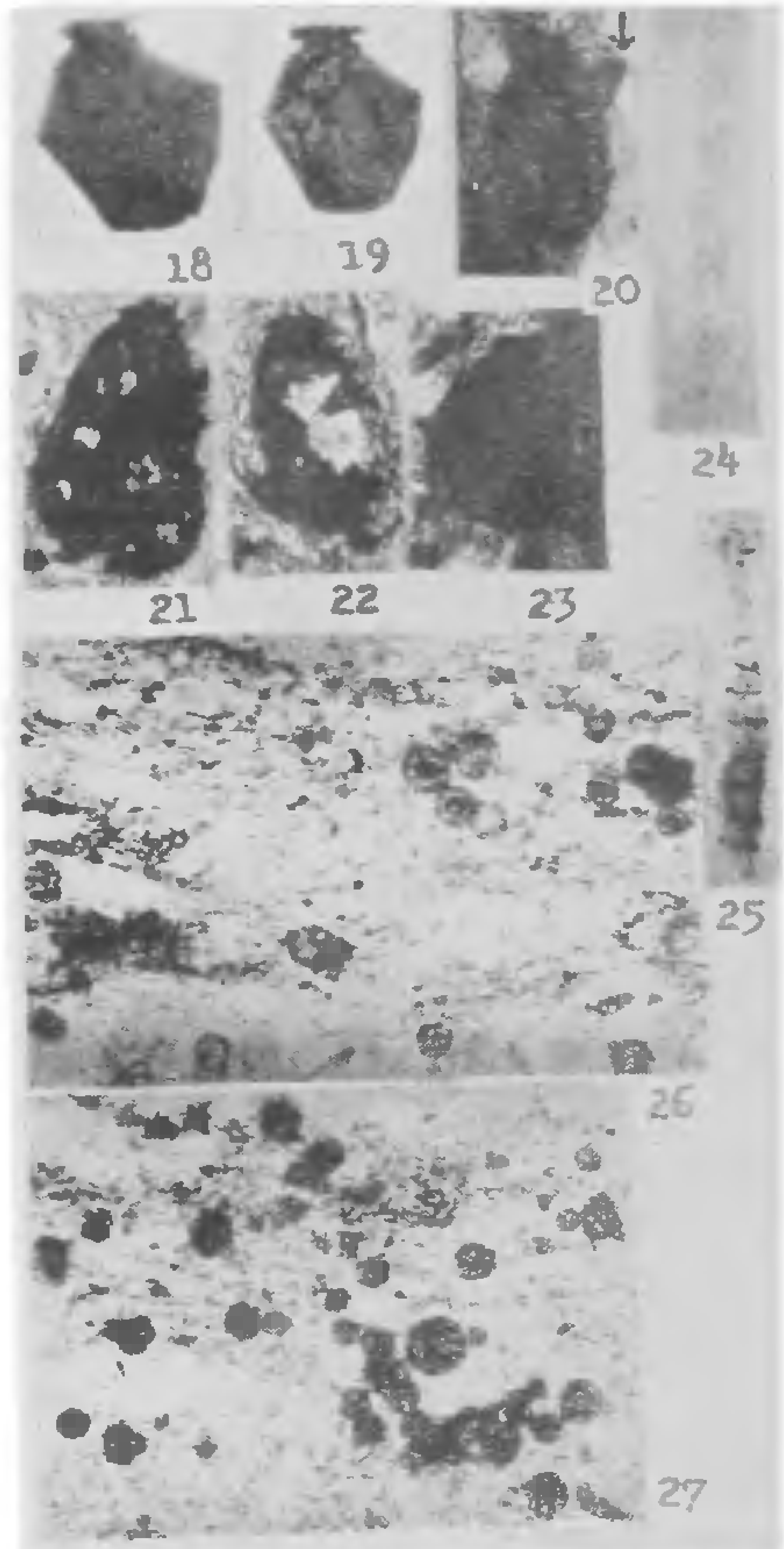
Description as for genus. Holotype specimen; Figs. 1, 2 AB. Wild microscope coordinate : Satpuli, DS 6, 111/28·5.

Discussion

Siphonophycus kestron (Pl. 80, Figs. 1–3; Schopf[11]), of the Late Precambrian sediments of central Australia differs from *Grandiphycus satpuliensis* sp. nov. in having the thallus as capitate at both apices, narrower in width (8·3–15·0 μ), ornamented and ringed by finely punctate surficial ridges. In addition, it is of very smaller in overall size (up to 185 μ long) than the new species.

Generally, the algal remains of cyanophycean (nostocalean) affinities are predominantly found in the Late Precambrian sediments of Central Australia (Schopf[11]), Zaire, Africa (Maithy[6]); and Canada (Nautiyal[9]). However, no form as new genus *Grandiphycus* or of this genus has been recorded so far from the Precambrian sediments either of Satpuli (Garhwal Himalaya) or other parts of the world. All the Late Precambrian cyanophycean (nostocalean) algal filaments (thallus) described to date are of smaller in size with entirely different morphological details (Schopf[11], Maithy[6]; Maithy and Shukla[7]). Accordingly the described form (Figs. 1, 2 AB) is regarded as a new genus, *Grandiphycus* gen. nov., with specific name *Grandiphycus satpuliensis* sp. nov.





FIGS. 1–27. Photomicrographs of filamentous and spheroidal algal remains, fungal remains, chitinozoans and organic plate from the Late Precambrian shales and siltstones of Satpuli, Garhwal Himalaya, India. Figs. 1, 2 AB. *Grandiphycus sapuliensis* gen. nov., sp. nov.; Figs. 3–5 lower part, 27 (thin section of silty slate). Type A–Algal spherule; Figs. 5 upper part 6. Type B–Algal spherule; Figs. 7–10, 26 (thin section of silty slate). Type D–Algal spherule; Figs. 11–15. Type C–Algal spherule; Fig. 16. Type A–Algal filament; Fig. 17. Organic plate; Figs. 18–23. Chitinozoans with affinities of *Desmochitina minor* (Figs. 18, 19, 22), *D. minor oculum* (Figs. 20, 23), *D. bohemica* (Fig. 21); Fig. 24. *Eomycetopsis septata;* Fig. 25. fungal spore (septate). Fig. 1, × 100, Fig. 2 AB. × 1,000; Figs. 3–15, 17, 25, × 2,000; Fig. 16, × 1,800; Figs. 19, 24, 26, 27, × 900; Figs. 18, 20–23, × 450 approx.

Type A-Algal filament (Fig. 16)

Type A-algal structure is straight and composed of a chain of subspherical to subcylindrical cells with smooth surface. The filament (cell) at one end is rounded, with cell size ranging from 6 to 8 μ, and total length (broken part) 42 μ. Type A-algal filament shows closer affinities to similar structures, comparable with certain modern and fossil filamentous algae, for example Oscillatoriaceae (p. 166, Figs. 1, 2, 5) of Gutstadt and Schopf[4] from the Late Precambrian Beck Spring Dolomite of Southern California. Furthermore, the former structure also compares closely, in shape and size of cells, to similar Type A-filamentous chains, interpreted as replacement of cyanophycean algae (Pl. 1, *a–c*) of McConnell[8] from the Mescal Formation (Proterozoic) of central Arizona.

Fungal Remains

Two types of fungal remains have been discovered : fungal filament (*Eomycetopsis septata*) and septate fungal spores (Fig. 25).

FUNGI (?), Phylum : EUMYCOPHYTA (?)

Genus : *Eomycetopsis* Schopf, 1968

Eomycetopsis septata Maithy, 1975

(Fig. 24)

Filaments occur solitary and attenuated at the septa, smooth surface texture of walls, broken filament 48·50 μ long, partly regularly cylindrical, 4 to 5 μ in diameter, septate part of filament about 11 μ long. This form is comparable to similar species (Pl. 3, Fig. 24) of Maithy[6] from the Late Precambrian Bushimay System of Kanshi, Zaire.

Chitinozoans (Figs. 18–23)

The Late Precambrian chitinozoans of Arizona, as may be the Indian chitinozoans (*Desmochitina minor*, Figs. 18, 19, size 48 $\times$ 55 μ, Fig. 22, 32 $\times$ 48 μ; *D. minor ovulum*, Fig. 20, 25 $\times$ 45 μ; Fig. 23, 32 $\times$ 44 μ; *D. bohemica*, Fig. 21, 75 $\times$ 112 μ), have been compared to the Ordovician and Silurian chitinozoan, *Desmochitina* (Bloeser *et al.*[2]). However, the chitinozoans discovered in this investigation are tear- and flask-shaped having a test, short neck, and operculum. Generally, these microfossils closely compare in size, shape, and surface texture to the chitinozoans of Bloeser *et al.*[2], from the Late Precambrian Chuar Group of the Grand Canyon, Arizona (p. 677, Figs. 2 A; C, H, I; J).

Organic Plates (Fig. 17)

Black organic plates have 2 to 5 μ wide lenticular perforations. Such plates have also been reported from the Late Precambrian Dharwar sediments of Mysore State (Venkatachala *et al.*[18]), and Precambrian sediments of the Kaladgi Basin of South India (Vishwanathaiah *et al.*[19]).

Palaeoenvironment and Age Assignment

The occurrence of filamentous, benthic algal remains in the sediments is significant and the same are comparable to the living and ancient cyanophycean (blue-green) algae (Schopf[11]; Gutstadt and Schopf[4]; McConnell[8]; Nautiyal[9]). They occur associated with profuse concentrations of spheroidal algal remains; phytoplanktons (of cyanophycean affinities) of planktonic habitat (Figs. 26, 27). In addition, chitinozoans, which are considered of planktonic and benthonic habitat (Jenkins[5]), also occur commonly associated with the algal remains.

The development of benthic, filamentous blue-green algae and phytoplanktons requires the process of photosynthesis. Their occurrence, with rich concentration of spheroidal phytoplanktons, in the sediments is indicative of the presence of the extensive shallow ocean that provided a highly favourable environment (littoral photic zone) for algal growth (Schopf and Blacic,[15]; Nautiyal[9]). In addition, presence of primary, sedimentary, hematitic bands (of ferric iron oxide or hydroxide) in appreciable amounts in moderate brown siltstones (upper section), with poor preservation of phytoplanktons, supports the oxidising conditions possibly in the near shore (or protected tidal mud flat) environment of deposition (Grim[3]). Bloeser *et al.*[2] also reported microbiotas of benthic algal filaments and small unicells from the Late Precambrian Chuar Group of the Grand Canyon of Arizona, suggesting the relatively nearshore, more shallow conditions for the sediments.

The discovered microfossils as algal remains (filamentous, spheroidal phytoplanktons), fungal remains (*E. septata*), chitinozoans, and organic plates of the argillaceous sequence of Satpuli (Garhwal Himalaya) are closely comparable to similar microorganisms from the Late Precambrian to Precambrian sediments of America, Australia, Africa, and India; as mentioned earlier (Schopf[11]; Gutstadt and Schopf[4]; Schopf and Blacic[15]; McConnell[8]; Venkatachala *et al.*[18]; Vishwanathiah *et al.*[19]; Maithy[6]; Bloeser *et al.*[2]). These microfossils have not been recorded from the post-

Precambrian sediments of any part of the world to-date. In addition, the lowest time range of desmochitinids, similarly as in the Satpuli sediments, has been reported from the Late Precambrian Chuar Group of the Grand Canyon, Arizona. All these evidences support the suggestion that the Garhwal Himalayan argillaceous sequence (at Satpuli) is of Late Precambrian age.

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INTERNATIONAL SYMPOSIUM ON THE LATE BIOLOGICAL EFFECTS OF IONIZING RADIATION, VIENNA

In an International Symposium on the Late Biological Effects of Ionizing Radiation which was organized by the International Atomic Energy Agency (IAEA) in Vienna from 13 to 17 March 1978 the late somatic effects which might appear at considerably later stages after exposure to ionizing radiation from external and internal exposure were discussed by 250 experts from 33 IAEA Member States as well as 9 International Organizations. The effects discussed included induction of benign or malignant tumors, various types of degenerative diseases, disturbances in growth, development and physiological or behaviour responses, impairment of fertility, chromosome aberrations and others observed both in experimental animals and human populations.

Reports on atomic bomb survivors showed that epidemiological studies are still providing so far the extensive and dependable data such as dose-related excess infant mortality, among others, and that work should be continued. The symposium revealed the need for consensus on the methods to be employed in the interpretation of data. It was however noted that establishment of national registry system regarding dosimetry and medical record of radiation workers and its international coordination is essential in order to facilitate any reliable epidemiological surveillance. As far as medical exposure is concerned, the current practices involving radiation exposure seems generally well justified except in some cases where radiation is used of diagnostic purposes on benign disorders.

Of interest and importance was the combined effect of smoking and radon-222 in lung cancer induction. Lung cancer incidence was significantly elevated by combination of the two in the rat, which was also substantiated by the observation in the Hiroshima-Nagasaki study where incidence of lung cancer in the smoking population was shown to be higher than in the non-smoking population.