receptor protein in that, while the former transports retinol from the storage site and delivers it to the cell where it is required, the latter makes retinol available to the actual site inside the cell where it is ultimately used. It would be interesting to speculate that both steriod hormone and retinol participate through the respective receptor proteins at the chromatin level of the cell nucleus in division and differentiation of cells. These considerations have led us to suggest that retinol should be called a co-steroid hormone[9].

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DISCOVERY OF THE CYANOPHYCEAN ALGAL REMAINS AND MICROPLANKTONS IN THE LATE PRECAMBRIAN SCHISTOSE PHYLLITES AND ITS BEARING ON THE AGE OF THE AMRI UNIT, GARHWAL HIMALAYA, INDIA

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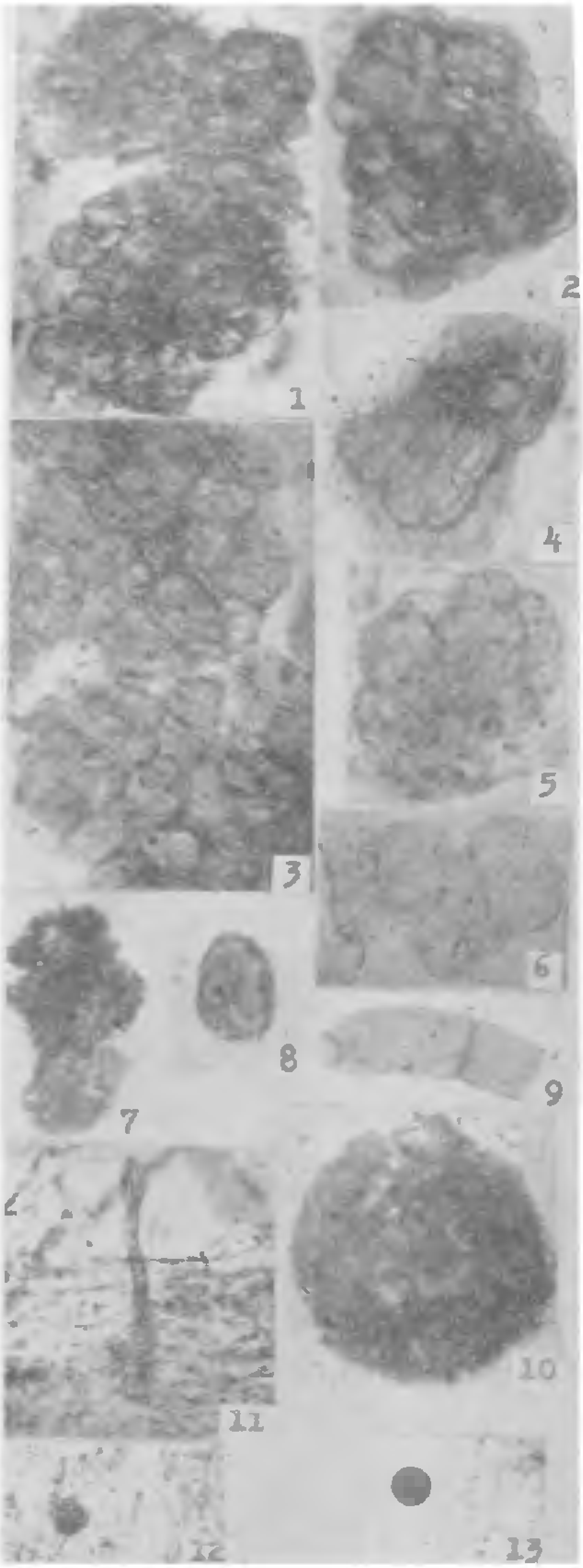
Abstract

The late Precambrian schistose phyllites (Amri Unit) of the Gahrwal Himalaya at north-eastern Dogadda yielded high concentration of spheroidal algal remains (*Myxococcoides minor*) of living Cyanophycean (Chroococcaceae) affinities. In addition, they consists of microplanktons (*Granomarginata prymitiva, Protosphaeridium volkovae*) and fungal (?) remains (*Eomycetopsis septata*). The general morphological characters of the microfossils are described. Their discovery in the rocks of the area is the first find of these microorganisms known to-date. The occurrence of microflora (microfauna) in the rocks assists in the reconstruction of the paleo-environments of the ancient Garhwal Himalayan ocean, and lating of the Precambrian phyllites of the Amri Unit.

Introduction

The occurrence of fossil spheroidal algal remains, of living cyanophycean (Chroococcaceae) affinities, and organic- walled microplanktons (acritarchs) from the late Precambrian schistose phyllites of Dogadda (Garhwal Himalaya, India) have not been reported so far. In India, however, acritarchs and cyanophycean algal remains (spheroidal, filamentous) have been recorded from North India (Kumaun and Garhwal Himalayas, Son Valley), South India (Kaladgi Basin, Karnataka State, Andhra Pradesh) and Madhya Pradesh (Rampura), ranging in age from late Precambrian to Cambrian (Salujha *et al.*[12], Salujha *et al.*[13,14], Venkatachala and Rawat[19]; Venkatachala *et al.*[20], Prakash[9], Vishwanathiah *et al.*[21], Maithy and Shukla[3], Nautiyal[5-7]). Furthermore, a considerable amount of information on the spheroidal algal remains and microplanktons from the late Precambrian rocks of the U.S.A., Canada, Australia, Africa; and Russia has been published (Vologdin and Drozdova[22]; Schopf[15]; Schopf and



FIGS. 1–13. Photomicrographs of algal (spheroidal) and fungal (?) remains from the late Precambrian schistose phyllites of the Garhwal Himalaya, India, at northeastern Dogadda. Figs. 1–6, 12, 13. *Myxococcoides minor;* Figs. 7, 8. *Granomarginata primitiva*; Fig. 9. Incertae Sedis Type 1; Fig. 10. *Photosphaeridium volkovae*; Fig. 11. *Eomycetopsis septata.* All Figs. × 2,000 approx., but Figs. 11–13 (thin section), × 900 approx.

Blacic[17]; Schopf[16]; McConnell[4]; Maithy[2]; Nautiyal[5]).

The Precambrian to Lower Palaeozoic rocks (phyllite, slate; siltstone) of the Garhwal Himalaya have considerably puzzled the European and Indian geologists for a long time. Their environment of deposition could not be deciphered with certainty owng to non-availability of fossils and have been dated dubiously on the basis of lithology (Auden[1]; Valdiya[18]; Ravi Shanker and Ganesan[10]; Pande[8]). However, the recent geological work by the author in the Garhwal (Nautiyal[5]) and Kumaun (Nautiyal[6,7]) Himalayas provides significant information of the Precambrian sequences, and suggests further investigation of the Precambrian to Lower Palaeozoic rocks. The present paper reports the first discovery of cyanophycean algal remains and microplanktons (acritarchs) from the Precambrian schistose phyllites of the Garhwal Himalaya at northeastern Dogadda, India.

The area of investigation occurs on a motor road side occupying between Dogadda and Lansdown, and the outcrop section is located at about 2½ miles distance (on straight line) from Dogadda. It is confined between long. 78° 39′ E and 78° 39·50′E and lat. 29° 49′ N and 29° 49·50′ N of the Garhwal Himalaya. At this locality; a 15·20 m. thick section of greenish gray schistose phyllites (Amri Unit) of the Garhwal Nappe was studied. The phyllites are non-calcareous, compact, hard and consist of whitt quartz lenticles (up to 3″ long). They constitute the intrusive relationship with the Lansdown Granite northwards; and have been studied earlier (Table I) as Precambrian (?) to Lower Palaeozoic rocks (Auden[1]; Ravi Shanker and Ganesan[10], Saklani *et al.*[11]).

MICROFLORAL (MICROFAUNAL) DISTRIBUTION AND DESCRIPTION

The schistose phyllites were macerated (Figs. 1–10) and examined in thin sections (Figs. 11–13) and revealed abundant cyanophycean algal remains (Figs. 1–6, 12, 13) and acritarchs (Figs. 7, 8, 10) in common distribution. In addition; some fungal (?) remains were also observed (Figs. 9, 11). The rock matrix in thin sections exhibited high concentrations of black carbonaceous matter. The organic fossils are easily detached (or offset) from the matrix due to rock rupturing in thin sections (Figs. 11–13). However; they appear well preserved as dark brown to dark grey. The discovered microorganisms include: *Myrococcoides* *minor*, *Eomycetopsis septata Granomarginata primitiva*, *Protosphaeridium volkovae* and Incertae Sedis Type 1.

Systematic Descriptions and Biological Relations of Algae

Phylum: CYANOPHYTA; Class: CYANOPHYCEAE, Order: CHROOCOCCACEAE Nägeli. 1849.

Genus: *Myxococcoides* Schopf, 1968.

Myxococcoides minor Schopf, 1968

(Figs. 1–6, 12, 13)

Cells mostly spherical to subspherical; frequently ellipsoidal to slightly flattened compressional forms (Fig. 4) also occur; they occur either as solitary (Figs. 12, 13) or aggregated into ellipsoidal colony of 25 to about 40 cells (Figs. 1–6), surface ornamentation of cells, psilate to slighly punctate, dark brown; cell diameter range; 8·50 to 10·50 μ (average diameter 9·20 μ with 30 cells), cell wall distinct and thick; 0·7 to 0·8 μ, cells attached with granular; non-lamellated organic matrix (Figs. 1, 3) about 2 μ thick. This species of the Garhwal Himalaya closely compares to *M. minor* (Pl. 81, Fig. 1, Pl. 83, Fig. 10, Schopf[15]), from the late Precambrian Bitter Springs Formation of Central Australia.

"FUNGI (?)"

Phylum: EUMYCOPHYTA (?)

Genus: *Eomycetopsis* Schopf, 1968

Eomycetopsis septata Maithy, 1975

(Fig. 11)

Filaments of solitary occurrence; with smooth surface texture of walls; more-or-less cylindrical, septate, septate part of filament varying in length, filaments apparently attenuated at septa, brown; filament 43 μ long (broken specimen), diameter 6 μ, septate part of filament measured in two places, about 9 μ. *E. septata* compares to the solitary filament of the same species (Pl. 3, Fig. 24, Maithy[2]), from the late Precambrian Bushimay System of Kanshi, Zaire.

Incertae Sedis

Group: ACRITARCHA Evitt, 1963, Sub-group: SPHAEROMORPHITAE Downie, Evitt and Sarjeant, 1963.

Genus: *Granomarginata* Naumova, 1961.

Granomarginata primitiva Salujha, Rehman and Arora, 1971.

(Figs. 7, 8)

Test spherical, partly folded, exine thick about 2 μ wide peripheral thickening present, coarsely granulose, occurring as individual (Fig. 8) or in union (Fig. 7), dark greyish brown, test diameter range; 13 to 20 μ, grana 1 to 1·50 μ wide. This species of the Garhwal Himalaya is similar as *G. primitiva* (Pl. III, Figs. 18–20, Salujha *et al.*[12]), from the Lower Vindhyans (late Precambrian) of Son Valley and also compares to the form (Pl. 1. Fig. 12, Salujha *et al.*[13]) in the Bhima sediments of Karnataka State.

Genus: *Protosphaeridium* Timofeev, 1963

Protosphaeridium volkovae Maithy and Shukla, 1977

(Fig. 10)

Test circular-oval in outline, thin-walled with folds apparently visible on the margin, exine intrapunctate, partly ruptured during preservation, dark grey, overall size, about 42 μ. This species closely compares to *P. volkovae* (Pl. 2, Fig. 18, Maithy and Shukla[3]), from the late Precambrian Suket Shales (Lower Vindhyan) of Rampura in Madhya Pradesh. The Rampura specimens remarkably show almost the same pattern of folding and rupturing of test walls as that of the Garhwal Himalaya.

Incertae Sedis Type 1

(Fig. 9)

Elongated oblong filament (broken part), psilate, septate, constriction at septum apparent, narow end with an opening (?) surrounded by a curved septum, brown; overall size, 37 μ (broken specimen), 12 μ wide at center, filament, part between two septa, 24 μ, narrow end 6 μ wide, septa about 2 μ thick. Incertae sedis Type 1 is suspected as fungal remain.

Paleoenvironment and Age Assignment

The schistose phyllites (Amri Unit) of the Garhwal Himalayan Nappe at northeastern Dogadda are dominated by the colonial form of fossil blue-green algae, referable to the modern Cyanophycean order Chrodcoccaceae, in the microflora (microfauna). The development of benthic, colonial blue-green algae requires the process of photosynthesis in shallow water environments. Its high concentration in the phyllites is associated with the organic-walled microplanktons (*Granomarginata primitiva*, *Protosphaeridium volkovae*) to planktonic habitat of shallow marine environment. Generally, these microfossils are suggestive of existence of extensive, shallow, ancient Garhwal Himalayan oceans that provided a very suitable environment (littoral photic zone) for colonial algal growth (Schopf[15], Schopf and Blacic[17], Nautiyal[5]). The microorganisms were preserved in

TABLE I

Lithotectonic sequence of Garhwal Nappe (a part) and age of rock runits

Auden[1]			Ravi Shanker and Ganesan[10]				Saklani *et al.*[11]			Present work		
				Tectonic units	Lithology	Probable age	Tectonic units	Lithology	Probable age	Tectonic units	Lithology	Age
Garhwal Nappe	Amri Nappe	Chandpur, metamorphosed	Garhwal Nappe	Amri unit	Schistose phyllite with Lansdown granite	Lower palaeozoic to precambrian (?)	Amri unit	Schistose phyllite	Lower Palaeozoic to precamb.	Amri unit	Greenish grey schistose phyllites: *M. minor*, *G. primitiva*, *P. volkovae*, *E. septata*, Incertae sedis type 1	Late precamb.
	.... Thrust			.... Amri Thrust			.... Amri (Garhwal) Thrust			.... Amri Thrust		
	Bijni Nappe	Nagthat, Chandpur, boulder beds, slate and limestone		Upper Bijni unit	Purple, green, white quartzite with subordinate green, grey slate		Tal	Shelly limestone	Upper cretac.	Units not studied		
	...... Garhwal Thrust			.... Bijni Thrust			.... Krol Thrust					

the marine, greenish grey mud before the sediment was consolidated and metamorphosed to schistose phyllites.

The schistose phyllites of the Garhwal Himalaya have been equated to the Chandpur Series, assigning Pre-Cambrian (?) and Lower Palaeozoic as probable ages (Auden[1]; Ravi Shanker and Ganesan[10]; Saklani *et al.*[11]) (Table I). The author's discovered microfloral (microfaunal) assemblage predominantly consists of the late Precambrian microorganisms (*Myxococcoides minor, Eomycetopsis septata, Granomarginata primitiva, Protosphaeridium volkovae*) that have been reported from Australia, Africa, and India (*see* systematic part). Therefore, a late Precambrian age is proposed to the schistose phyllites of the Garhwal Himalayan Nappe, at the northeastern Dogadda region, on the basis of microfloral (microfaunal) assemblages. In addition, it is suggested that these phyllites may be correlated with the late Precambrian Lower Vindhyans Semri Series) of Son Valley (Mirzapur) and Rampura (Madhya Pradesh) on the presence of the diagnostic microplanktons, *Granomarginata primitiva* and *Photosphaeridium volkovae*.

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