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MICROBIOTA FROM VINDHYAN SUPERGROUP OF THE KARAULI-SAPOTRA REGION OF NORTH-EAST RAJASTHAN, INDIA

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ABSTRACT

Microbiota comprising algae, acritarcha and a few taxa of unassignable affinities from the Semri, Rewa and Bhander groups of Vindhyan Supergroup in Karauli-Sapotra area is recorded. The assemblage comprises eleven genera of algae and four genera of acritarcha. Of these, two genera, viz., *Saccifera* and *Vindhyacapsiopsis* are new. The microbiota assemblage shows gradual increase in morphological complexity from older to younger horizons, though the number of forms are scanty.

Key-words — Microbiota, Algae, Acritarcha, *Saccifera*, *Vindhyacapsiopsis*, Karauli-Sapotra area, Vindhyan Supergroup, India.

सारांश

उत्तर-पूर्व राजस्थान (भारत) में करौली-सपोत्रा क्षेत्र के विंध्य महासमूह से प्राप्त सूक्ष्मजीविता – प्रभात कुमार माइती एवं जगन्नाथ प्रसाद मंडल

करौली-सपोत्रा क्षेत्र में विंध्य महासमूह के सेमरी, रीवा एवं भन्डेर समूहों से एक्रीटार्कों, शैवालों एवं अनिश्चित सजातीयताओं के कुछ वर्गकों से युक्त सूक्ष्मजीविताएँ अभिलिखित की गयी हैं। इस समुच्चय में शैवालों के 11 वंश तथा एक्रीटार्कों के चार वंश विद्यमान हैं। इनमें से दो वंश अर्थात् सैक्किफेरा एवं विंध्यकैप्सिऑप्सिस नवीन हैं। सूक्ष्मजीविता समुच्चय में हालाँकि प्रारूपों की संख्या कम है लेकिन प्राचीनतर से लेकर कम आयु के संस्तरों तक आकारिकीय जटिलता में उत्तरोत्तर वृद्धि व्यक्त होती है।

INTRODUCTION

THE biota from the Vindhyan succession of North-east Rajasthan (Kotah-Karauli section) was reported earlier by Salujha, Rehman and Rawat (1971b). The recorded assemblage was dominated by acritarcha only. The present paper deals with the microbiota comprising mainly algae, acritarcha and other problematical remains previously unrecorded from this region.

STRATIGRAPHICAL SUCCESSION

The following is the stratigraphical succession of Vindhyans in the Karauli-Sapotra area, North-east Rajasthan (Dutta, Singh & Sinha, 1974-76 in Banerjee & Sinha, 1981).

UPPER VINDHYAN		
Bhander	{	Upper Bhander sandstone Sirbu shale Lower Bhander sandstone Semaria Shale and limestone (stromatolitic)
Rewa	{	Upper Rewa sandstone Jhiri shale (with limestone band) Lower Rewa sandstone Panna shale
Kaimur		Sandstone gritty and conglomeratic at base
---------- Unconformity ----------		
LOWER VINDHYAN		
Semri	{	Tirohan Breccia with porcellanites and conglomerate Tirohan limestone with stromatolite Basal Shale and conglomerate
---------- GWALIORS ----------		

MATERIAL AND METHODS

All the 20 samples were collected from outcrops. Organic matter was found in almost all of them. However, only 9 samples were suited better for study due to good preservation. The details of the samples is given below:

Study of samples is based on thin sections of about 30 μm thickness cut parallel to lamination, maceration residues and the residue of samples recovered after the rock in ultrasonic vibrator. For optical shaking study the method proposed by Pflug and Maithy (1977) has been followed.

No.	Sample No.	Locality	Nature of Rocks
		Upper Bhander Sandstone	
1.	16	2 km North of Karauli on Hinduan Road (Pachna Nala Section)	Siltstone and shale
		Sirbu Shale	
2.	7	Opposite to locality of sample no. 6 in Karisal Bandh	Red coloured shale
		Semaria Shale	
3.	17	Near wall of Ranipura, south-east of Karauli 26°28′40″: 77°00′40″	Stromatolitic limestone
		Lower Bhander Sandstone	
4.	14	Near Birwas Temple 26°28′55″: 76°48′30″	Red coloured sandstone
		Jhiri Shale	
5.	18	Kota Village 26°26′40″: 76°55′30″	Red coloured sandstone
6.	13	Near Birwas Temple 26°26′55″: 76°48′30″	Chokolate brown shale
7.	12	Birwas Temple in Bajna Village	Shale and limestone
		Panna Shale	
8.	11	Bapoti Village, North of Sapotra 26°18′: 76°45′50″	Shale
9.	5	South of Sapotra 26°17′15″: 76°45′50″	Shale
		Tirohan Limestone	
10.	20	North-west of Kurgaon on Kurgaon-Gangapur city Road 26°27′50″: 76°51′30″	Limestone
11.	19	Mehrauli Village near Kota 26°25′40″: 76°54′30″	Limestone
12.	15	In a well on Sapotra-Gangapur Road near Dikoli Village 26°25′24″: 76°47′30″	Limestone
13.	10	Location opposite to sample no. 9	Limestone with cherty band
14.	9	West of Sapotra on Road side (west of Tirshanpura) 26°18′24″: 76°45′	Limestone with cherty band
15.	8	Dhulwasa Village	Limestone
16.	6	Karisal Bandh near Spilway 26°16′: 76°46′30″	Stromatolitic limestone
17.	4	Jirota Village, 26°17′55″: 76°39′10″	Upper Limestone band
18.	3	do	Lower Limestone band
19.	2	Naraoli Village	Limestone band
20.	1	Naraoli Fort, 26°19′45″: 76°38′55″	Shale band below Tirohan Breccia

SYSTEMATIC DESCRIPTION

Division — Cyanophyta
Class — Cyanophyceae
Order — Chroococcales
Family — Chroococcaceae

Genus — *Myxococcoides* Schopf, 1968

Type Species — Myxococcoides minor Schopf, 1968

Myxococcoides psilata n. sp.

Pl. 1, fig. 1

Diagnosis — Cells spherical, angular to ellipsoidal due to mutual compression, compactly aggregated in a globular colony up to 16 cells, 21-25.3 μm in diameter; cells 5.5-6.2 μm in diameter (on 6 cell count), thin-walled and smooth; extremely thin, hyaline sheath present around the colony; individual cells not ensheathed.

Etymology — With reference to smooth surface texture of cell.

Horizon — Panna Shale, Rewa Group.

Locality — Bapoti Village.

Holotype — Pl. 1, fig. 1; slide no. 6257 in macerated residues.

Comparison — *Myxococcoides psilata* n. sp. differs from all the known species of this genus due to thin-walled cells with smooth surface texture. Moreover, it is characterized by extremely thin sheath surrounding the colony. *M. konzalovae* Muir (1976) is morphologically similar to the present form in possessing nondeterminable enveloping sheath, but differs in having globular cells and the presence of common walls in between adjacent cells. *M. indicus* Venkatachala *et al.* (1974) is comparable due to its thin-walled cells but differs due to smaller size of the cells and the presence of distinct thin encircling sheath. *M. elongatus* Venkatachala *et al.* (1974) differs in having filamentous habit. *M. minor* Schopf (1968) and *M. reticulata* Schopf (1968) differ in being larger in size and the presence of thick sheath around the colony. Moreover in both species the cells have distinct ornamentation on surface. *M. inornata* Schopf (1968) agrees due to unornamented surface but differs due to large size of cells.

Genus — *Nanococcus* Oehler, 1977

Type Species — Nanococcus vulgaris Oehler, 1977.

Nanococcus vulgaris Oehler, 1977

Pl. 1, fig. 2

Description — Spherical cells, clumped irregularly in a loose colony, surrounded by a mucilagenous sheath. Cells rarely form small cluster. Up to 24 cells are counted in a colony. Cells measure 1.5-5.5 μm in diameter (16 cells counted; average 3.3 μm), surface texture smooth, margin thick; sheath around the individual cell absent.

Locality — Near Bapoti Village.

Horizon — Panna Shale, Rewa Group.

Figured Specimen — Slide no. 6258 in macerated residue.

Genus — *Corymbococcus* Awramik & Barghoorn, 1977

Type Species — C. hodgkissii Awramik & Barghoorn, 1977.

Corymbococcus vindhyanensis n. sp.

Pl. 1, fig. 3; Pl. 2, fig. 12

Diagnosis — Cells spheroidal to ellipsoidal, smooth, loosely and irregularly arranged in globular to oval colony within a non-lamellated amorphous sheath. Cells rarely arranged in diad and tetrad. Individual cells not ensheathed. Colony large, up to 50 cells in one colony. Diameter of cells 1.5-5.5 μm (commonly 1·5-2 μm), margin thick and rarely a black spot present in the centre of cell.

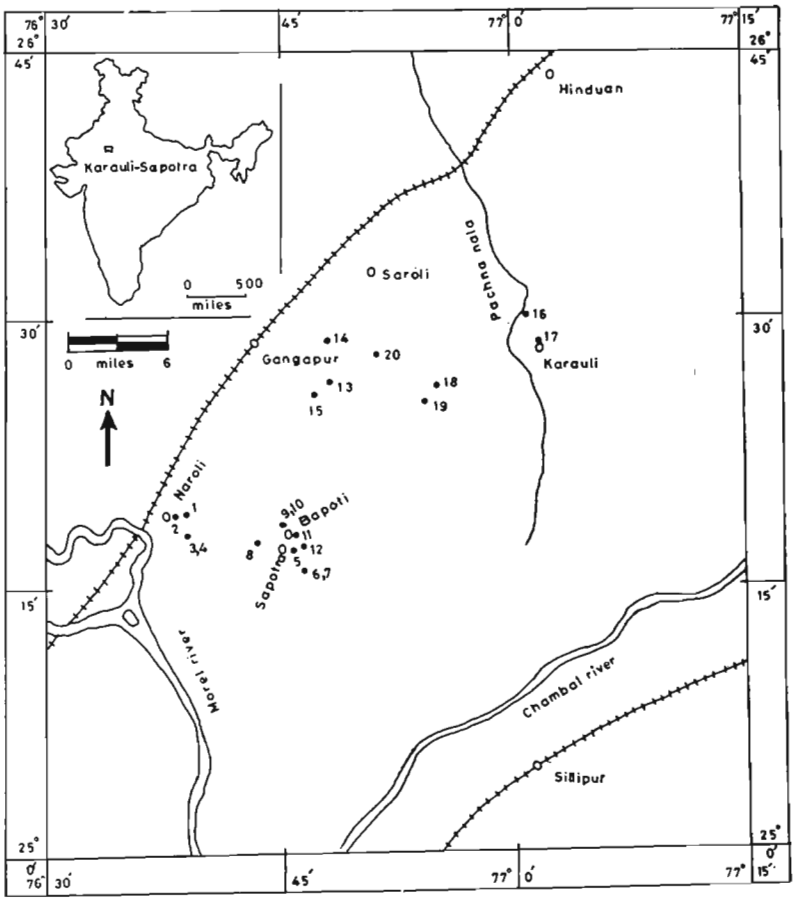
Etymology — With reference to occurrence in Vindhyan Supergroup.

Locality — Near Ranipura.

Horizon — Upper Bhander Sandstone, Bhander Group.

Holotype — Pl. 1, fig. 3; slide no. 6253 in thin section.

Comparison — *Corymbococcus vindhyanensis* sp. nov. differs from *C. hodgkissii* Awramik & Barghoorn (1977) recorded from the Gunflint stromatolite due to smaller size and smooth surface texture of cells.



MAP 1 — Map showing sampling localities.

Genus — *Sphaerophycus* Schopf, 1968

Type Species — Sphaerophycus parvum Schopf, 1968.

Sphaerophycus medium Horodyski & Donaldson, 1980

Pl. 2, figs 13-15

Description — Microfossils spherical to ellipsoidal, 2.2 to 6 μm without any enveloping sheath; mostly isolated, occasionally in diad, tetrad or closely and irregularly aggregate in small groups; a dark black spot 0.2 to 0.5 μm present in the centre of the cell. Surface texture smooth, marginal region thick, less than 1 μm and without any fold. In diad and tetrad position walls between the adjacent cells appear to be common.

Locality — South of Sapotra Town.

Horizon – Panna Shale, Rewa Group.

Figured Specimen — Slide no. 6255 in macerated residues.

Remark — *Sphaerophycus medium* is common in occurrence in various horizons from the Karauli-Sapotra area.

Genus — *Gloeocapsamorpha* Zalessky, 1916

Type Species — Gloeocapsamorpha prisca Zalessky, 1916.

Gloeocapsamorpha karauliensis Maithy & Mandal, 1982

Pl. 1, fig. 4

Description — Cells 2.3-7.8 μm, spherical, oval or angular due to mutual compaction, aggregated in a colony; daughter colony and cells within colony ensheathed by a non-lamellated amorphous sheath. Individual colony measuring up to 40 μm. Division of cells common and occur in two directions. Occasionally a large colony formed by a number of small groups of cells.

Locality — Near wall of Ranipura, South east of Karauli.

Horizon — Semaria Shale, Bhander Group.

Figured Specimen — Slide no. 5993 in macerated residues.

Genus — *Gloeodiniopsis* Schopf, 1968

Type Species — *G. lamellosa* (Schopf) Knoll & Golubic, 1979.

Gloeodiniopsis lamellosa (Schopf) Knoll & Golubic, 1979

Pl. 1, figs 5, 6; Pl. 2, fig. 30

Description — Cells commonly in groups, spherical to angular, measuring 1.2-6.5 μm in diameter (average 2.9 μm, 19 cells counted) surface texture psilate; groups globular or in the form of a chain, laterally flattened, 2-19 cells in each group which may be of different sizes; cells with sheath 7.5-19.8 μm in diameter (15 cells counted); sheath nearly hyaline, thin (coarsely granulated), broad and nonlamellated.

Locality — Bapoti Village.

Horizon — Panna Shale, Rewa Group.

Figured Specimens — Slide nos. 6249 and 6250 in thin section.

Remarks — Abundant and the only type of microfossils is present in the sample. The form is commonly found with distinct enveloping sheath. However, occasionally various stages of disintegration of sheath are seen. In the absence of sheath (Pl. 1, fig. 5) the form looks similar to the *Sphaerophycus* Schopf (1968). Since the transitory stages from sheath to non-sheath forms are present, therefore, the forms have been described under *Gloeodiniopsis*. However, this taxon is only found in thin section and could not be isolated by other techniques.

FAMILY — ENTOPHYSALIDACEAE

Genus — *Vindhyacapsiopsis* gen. nov.

Type Species — *Vindhyacapsiopsis bhanderensis* gen. et sp. nov.

Generic Diagnosis — Cells clumped together in a rectangular colony, ensheathed within an amorphous gelatinous mass; 4-6 cells in each vertical row arranged in opposite pairs; cells spherical or other shapes due to compression, individual cells not ensheathed.

Etymology — With reference to Vindhyan Supergroup.

Comparison — *Vindhyacapsiopsis* gen. nov. compares to *Myxococcoides* Schopf (1968), *Palaeoanacystis* Schopf (1968), *Corymbococcus* Awramik & Barghoorn (1977), *Nanococcus* Oehler (1977) and *Eoentophysalis* Hofmann (1976) due to colonial arrangement of cells enclosed in a sheath. *Myxococcoides* and *Palaeoanacystis* have globular colonies. In *Corymbococcus* the cells are loosely and irregularly arranged. *Nanococcus* is an irregularly arranged compact colony. *Eoentophysalis* differs due to palmelloid colony. Moreover, the cells are arranged in irregular clusters. In none of these genera, the arrangement of cells are in opposite pairs and in the form of rectangular colony. Hence, a new generic name is proposed here.

Similar looking form has been described earlier by Licari, Cloud and Smith (1969) as *Eucapsis* (?) from the Proterozoic of Queensland. This form was considered by them to be comparable with the modern algae *Eucapsis*. However, in *Vindhyacapsiopsis* the cells are arranged in more than one erect vertical rows and the colony is encircled by a common mucilage, however, the individual cells are uncovered. Hence, the genus has been included in Entophysalidaceae which has appearance like *Chlorogloea* Wille.

Vindhyacapsiopsis bhanderensis n. sp.

Pl. 1, fig. 7

Diagnosis — Cells arranged in vertical row in a rectangular colony, equal in size, measuring 2 to 2.5 μm in diameter (on 11 counts) surface texture smooth. Colony 16.5 μm long and 11 μm broad, up to 22 cells observed in a colony.

Etymology — With reference to the Bhander Formation from where the sample was collected.

Locality — North of Karauli Village.

Horizon — Upper Bhander Sandstone, Bhander Group.

Holotype — Pl. 1, fig. 7 in slide no. 6254 in macerated residue.

FAMILY — NOSTOCACEAE

Genus — *Gunflintia* Barghoorn, 1965

Type Species — *Gunflintia minuta* Barghoorn, 1965.

Gunflintia sp.

Pl. 1, fig. 8

Description — Trichome fragmentary, multicellular, uniseriate and unbranched; septae distinct, 6 μm apart, more or less uniformly placed. Cells elongated apparently without any sheath; apical cell rounded. Trichome 4.5 μm wide.

Remarks — Single well-preserved filament was observed in macerated sample of stromatolitic chert. Filament is broader than *G. minuta* Barghoorn. Furthermore, it does not show any constriction at the septae.

Locality — Near Spillway of Karisal Bandh.

Horizon — Tirohan Limestone, Semri Group.

Figured Specimen — Slide no. 6251 in macerated residues.

Division — ?Cyanophyta
Class — ?Chroococcales
Family — ?Chroococcaceae

Genus — *Palaeoglaucocystis* Maithy & Mandal 1982 emend.

Type Species — *Palaeoglaucocystis ghoshii* Maithy & Mandal, 1982.

Palaeoglaucocystis ghoshii Maithy & Mandal, 1982

Pl. 1, figs 9, 10

Emended Diagnosis — Cells spherical isolated or in loose groups; outer layer of cell uniform in thickness, lamellated and occasionally with vertical thickenings connecting inner layer; vertical thickenings may extend beyond the outer layer giving a sinuous margin; inner portion of cell thick with many short or long vertical parallel running thickenings giving reticulate appearance. Cells not enclosed within a sheath, but sometimes may be adhered to a matrix sheet. Reproduction by fission and budding (?). Cell division in single plane.

Palaeoglaucocystis was erected by Maithy and Mandal (1982). Recent examination of a large number of specimens reveals that the following characters were not observed in earlier specimen: (i) cells not enclosed within the sheath, (ii) and connection of outer layer with inner portion of cell by vertical rod-like thickenings. Therefore, the same are incorporated here.

INCERTAE SEDIS

Genus — *Archaeorestis* Barghoorn, 1965

Type Species — *A. schreiberensis* Barghoorn, 1965.

Archaeorestis sp.

Pl. 1, fig. 11

Description — Trichome slender, non-septate, tubular and possibly branched. Filament walls not parallel, occasionally lateral walls with zig-zag bulbose swellings. Filament maintains more or less constant diameter about 1 μm except at the swellings. The length extends up to 80 μm. Sheath absent.

Remarks — Single filament is recovered from the macerated residue. It is morphologically similar to *A. schreiberensis* Barghoorn, 1965 (in Tyler & Barghoorn, 1965), but is more slender. Hence, it is described as *Archaeorestis* sp.

Locality — Near Spillway of Karisal Bandh.

Horizon — Sirbu Shale, Bhander Group.

Figured Specimen — Slide no. 6260 in macerated residues.

Genus — *Saccifera* gen. nov.

Type Species — *Saccifera tirohanensis* sp. nov.

Diagnosis — Solitary or group of 2-4 cells enclosed in a broad, thick, fibrilar amorphous envelope.

Comparison— A large number of ensheathed colonial forms are known, viz., *Myxococcoides* Schopf (1968), *Palaeoanacystis* Schopf (1968), *Corymbococcus* Awramik & Barghoorn (1977), *Nanococcus* Oehler (1977), *Gloeocapsamorpha* Zalessky (1916) (see in Eisenack, 1960) and *Vindhyacapsiopsis* gen. nov. The present form differs from all of them in having a colony of only few cells enclosed in a very thick fibrilar amorphous envelope. Such form with dis inct thick fibrilar envelope has so far not been recorded from Precambrian. As such it is not referable to any known group.

Binda (1972) reported similar looking dark spheroids from Zaire, but there is no evidence of the presence of cells within the envelope. He compared the structure with *Protoleiosphaeridium*.

Saccifera tirohanensis n. sp.

Pl. 2, figs 16-18

Diagnosis — Cells dark brown, angular to spherical, psilate, 2-3.5 μm with thick margin, solitary or up to 4 cells arranged in a group; cells enclosed in a thick fibrilar amorphous sheath, 9-30 μm in diameter (commonly within 21-24 μm).

Etymology — With reference to the Tirohan Formation of Vindhyan Supergroup.

Locality — Naraoli Fort.

Horizon — Tirohan Limestone, Semri Formation.

Holotype — Pl. 2, fig. 17 in slide no. 6251 in macerated residues after shaking in ultrasonic vibrator.

Remarks — Sheath is very thick and the cells are only visible after prolong acid treatment or by breaking the fibrilar sheath with the help of vibrations of ultrasonic vibrator. Therefore, the information on the cells morphology is limited though this form is abundant.

?Germinating Cell

Pl. 2, fig. 19

A few cells are found in macerated residues from the Lower and Upper Bhander with long (about 3.5 μm) thin structure attached with a thick-walled (about 1 μm) spherical body measuring up to 5 μm. It appears that the thin-walled structure is coming out of the thick-walled structure, i.e. as germinating stage of the cell.

Remarks — Such type of structure was observed by Edhorn (1973) from the Animikie Formation of Ontario, which she described as germinating condition of akinite. Cloud, Licari, Wright and Troxel (1969) figured a specimen (Pl. 1, fig. 10) which is morphologically similar to the present form. According to them it was a Chrysophycean cyst or statospore in germinating condition. Unfortunately, the problem remains open as only a few specimens are present in our collection. However, cells with inner large spot can be superficially compared with *Caryospheroides* Schopf.

Occurrence — Near Birwas Temple (Lower Bhander Sandstone Formation) and from 2 km north of Karauli on Hinduan Road (Upper Bhander Sandstone Formation).

Figured Specimen — Slide no. 6259 in macerat d residues.

?Budding Cell

Pl. 2, figs 20-22

A few isolated, spherical to ellipsoidal budding cells are recorded in the Lower Bhander Sandstone Formation. These cells are 4.4-8.5 μm in diameter, smooth surface and devoid of any sheath. Each cell contains a dark body occupying ±1/2 to inner area of cells. These cells show different stages of cell division. The specimen figured in Pl. 2, fig. 21 shows a small protuberance of cell. The inner mass also expands from cell and protrudes into two cells nearly equally divided.

Remarks — Oehler (1977, Pl. 11, fig. E) reported similar type of cell division in *Bisacculoides*. Pykhova (1973) has also photographed similar structure in *Uniporata* sp. (Pl. 2, figs 16, 18).

Locality — Near Birwas Temple.

Horizon — Lower Bhander Sandstone, Bhander Group.

Figured Specimens — Slide nos. 6261 and 6263 in macerated residues.

Group — Acritarcha Evitt, 1963

Subgroup — Sphaeromorphitae Downie, Evitt & Sarjeant, 1963

Genus — *Protoleiosphaeridium* Timofeev, 1959

Type Species — Protoleiosphaeridium conglutinatum Timofeev, 1959.

Protoleiosphaeridium diatretus Salujha, Rehman & Rawat, 1971

Pl. 2, fig. 23

Description — Vesicles ash coloured, spherical to subspherical, 6.5 to 11 μm (8.4 μm average), exine smooth, wall thin with irregular folds and cracks on surface.
Locality — South of Sapotra and from near Birwas Temple.
Horizon — Panna Shale, Rewa Formation and Lower Bhander Sandstone, Bhander Formation.
Figured Specimen — Slide no. 6262 in macerated residues.

Protoleiosphaeridium cambriense Timofeev, 1959

Pl. 2, fig. 24

Description — Vesicles ash coloured, spherical, 14.3-18.7 μm, exine smooth, wall thin, folded towards margin.
Locality — South of Sapotra (near Birwas Temple).
Horizon — Panna Shale, Rewa Group.
Figured Specimen — Slide no. 6262 in macerated residues.

Protoleiosphaeridium densum Maithy, 1975

Pl. 2, fig. 25

Description — Vesicles spherical, 16.5 μm, wall thick about 0.3 μm, exine smooth.
Occurrence — (i) South of Sapotra and near Birwas Temple (Bhander Sandstone), (ii) South of Sapotra (Panna Shale and Jhiri Shale), and (iii) near Birwas Temple (Lower Bhander Sandstone).
Figured Specimen — Slide no. 6263 in macerated residues.

Genus — *Kildinella* Sepeleva & Timofeev, 1963

Type Species — Kildinella giperboreica Sepeleva & Timofeev, 1963.

Kildinella sp.

Pl. 2, fig. 26

Description — Vesicle solitary, spherical, folded, 40.5 μm; exine smooth, thin.
Locality — Near Bapoti Village (North of Sapotra).
Horizon — Panna Shale, Rewa Group.
Figured Specimen — Slide no. 6257 in macerated residue.

Genus — *Orygmatosphaeridium* Timofeev, 1959

Type Species — O. ruminatum Timofeev, 1959.

Orygmatosphaeridium plicatum Maithy & Shukla, 1977

Pl. 2, fig. 27

Description — Vesicle spherical, 66.5 μm in diameter, thin, surface pitted, pits small, closely and irregularly distributed all over, about 1-3 pits per micron, irregular folds at margin.
Locality — Near wall of Ranipura, South-east of Karauli.
Horizon — Semaria Shale, Bhander Group.
Figured Specimen — Slide no. 6265 in macerated residue.

Genus — *Granomarginata* Naumova, 1960

Type Species — Granomarginata prima Naumova, 1960.

Granomarginata minuta Maithy, 1975

Pl. 2, fig. 28

Description — Vesicles spherical, 12.2 μm, exine granulose to microbaculate, evenly distributed about 150 in number, ornamented structures less than 1 μm in height.
Locality — Near Karisal Bandh.
Horizon — Sirbu Shale, Bhander Group.
Figured Specimen — Slide no. 6260 in macerated residues.

Granomarginata prima Naumova, 1960

Pl. 2, fig. 29

Description — Vesicles in groups of 7 to 10 cells, circular, 7 to 8.5 μm in diameter

(7.7 μm in average). Exine granulose, grana small, closely set.

Locality — North of Karauli Village.

Horizon — Upper Bhander Sandstone, Bhander Group.

Figured Specimen — Slide no. 6266 in macerated residue.

DISCUSSION

The microbiota in the Karauli-Sapotra area of North-east Rajasthan are scanty. It comprises the algal remains, acritarcha and a few taxa of unassignable affinities. The algal remains are dominated by coccoid (isolated and colonial) forms. The filamentous forms are extremely rare. The isolated coccoid forms are *Sphaerophycus*, *Gloeodiniopsis* and a questionable cyanophyta *Palaeoglaucocystis*. Five genera represent the colonial forms, viz., *Vindhyacapsiopsis* n. gen., *Myxococcoides*, *Nanococcus*, *Gloeocapsamorpha*, *Corymbococcus* and *Saccifera* n. gen. The record of acritarcha is poor. Four genera and six species belonging to the subgroup 'Sphaeromorphitae' are only known.

The distribution of biota in the succession is presented in Table 1. Most of the algal genera are restricted to a particular formation in the succession, except *Sphaerophycus medium* which has been recovered in the entire succession. In contrast, the acritarcha have been recorded only in Upper Vindhyan.

Salujha *et al.* (1971b) recorded the microbiota from the Kota-Karauli area of Rajasthan, which is dominated by acritarcha. Besides, the other elements are two genera of Chlorophyceae, trilete spores and a few fungal spores. However, the present assemblage differs in the dominance of algal remains and rarity of acritarcha. Salujha

TABLE 1 — DISTRIBUTION OF MICROBIOTA IN THE DIFFERENT SUCCESSION STUDIED

Taxon	Lower Vindhyan	Upper Vindhyan					
	Tirohan	Panna Shale	Jhiri Shale	Semaria	Lower Bhander	Sirbu Shale	Upper Bhander
Saccifera tirohanensis n. gen. n. sp.	*						
Gloeodiniopsis lamellosa (Schopf) Knoll & Golubic		*					
Myxococcoides psilata n. sp.		+					
Sphaerophycus medium Horodyski & Donaldson	+	+	+	+			+
Nanococcus vulgaris Oehler		+					+
Vindhyacapsiopsis bhanderensis n. gen. n. sp.							+
Corymbococcus vindhyanensis n. sp.				*			
Gloeocapsamorpha karauliensis Maithy & Mandal				*			
Palaeoglaucocystis ghoshi Maithy & Mandal (emend.)							•
Gunflintia sp.	+						
Archaeorestis sp.						+	
Protoleiosphaeridium diatretus Salujha, Rehman & Rawat		+			+		
P. cambriense Timofeev		+					
P. densum Maithy		+	+		+		
Orygmatosphaeridium plicatum Maithy & Shukla				+			
Granomarginata minuta Maithy						+	
G. prima Naumova							+
Kildinella sp.		+					

(*=common; +=rare).

et al. (1971a) recorded interesting microbiota from the Vindhyans of Son Valley. Their assemblage contains only acritarchs and unidentifiable remains. Therefore, a detailed comparison of both the assemblages is not possible as the algae are lacking. Maithy (1969) and Shrivastava (1972) reported microbiota from the Suket Shale Formation of Ramapura. It contains a few acritarchs and an alga. Later, Maithy and Shukla (1977) described a rich assemblage containing algae (both coccoid and filamentous) and acritarcha from the Suket Shale Formation of Ramapura. *Myxococcoides*, *Protoleiosphaeridium*, *Orygmatosphaeridium* and *Kildinella* are common in both the assemblages. The present assemblage is, however, not comparable as it represents the total Vindhyan succession of the Karauli-Sapotra area whereas the Suket Shale assemblage belongs to only one particular formation of the Lower Vindhyan.

Ghosh and Bose (1950), Jacob *et al.* (1953), Bose (1956) and Mathur (1964) described the recovery of spores and woody tissues from the Vindhyans. These records are controversial as the possibility of the occurrence of vascular plants in such older rocks is remote. However, there are more possibilities that they are either contamination from the atmosphere or from younger strata. Further, we are also of the opinion that some of the woody tissue-like elements may be animal plates (see Sah, Maithy & Bhargava, 1977, pl. 1, fig. 10).

A comparison of the microbiota recovered from the equivalent Precambrian rocks of other countries shows that the biota recorded earlier mostly contain either algae (Schopf, 1968; Schopf & Blacic, 1971; Oehler, 1977; Barghoorn & Tyler, 1965; Licari, 1978; Muir, 1976, etc.) or acritarcha (Timofeev, 1959, 1969, 1973; Timofeev *et al.*, 1976; Vidal, 1976; Binda, 1972, etc.). However, some assemblages are known with both algae and acritarcha. Maithy (1975) recorded algae and acritarchs from the BIIC of Bushimay Supergroup, Zaire. This assemblage cannot be compared in detail with the Vindhyan assemblage of Karauli-Sapotra area as the microbiota is recorded from the entire succession, whereas in Bushimay it is from only one formation. Peat *et al.* (1978) reported the assemblage containing algae and acritarcha from the Roper Group (1300 m.y.), Australia. A detailed comparison with this assemblage too is not possible as the details of biota are lacking.

REMARKS ON THE AGE OF VINDHYAN

Several opinions have been given in past regarding the age of Vindhyan. Salujha (1973) on the basis of the acritarch assemblage proposed that Upper Vindhyan extends up to Lower Palaeozoic (Early Silurian). Venkatachala and Rawat (1973) declined to accept the Cambrian-Silurian age assigned by Salujha (1973) due to (i) simplicity of morphology of the acritarcha, (ii) absence of complex spinose acritarchs, (iii) absence of true Chitinozoa, and (iv) absence of true trilete spores with morphological complexities. They suggested a Precambrian-Cambrian age to the Vindhyan sediments.

Radiometric data on the rocks of Semri and Kaimur groups are also available. Mathur (1964) by Rb-Sr method reported an age 1130 ± 20 m.y. for the Majhagawan diamond bearing pipe rock which is a intrusive into the Kaimur. Vingradov *et al.* (1964) on the basis of K-Ar method estimated that the Semri Group (Lower Vindhyan) may be between 1400 and 1100 m.y. whereas the Kaimur Group (lower part of Upper Vindhyan) to be between 940 and 910 m.y. On the basis of Rb-Sr method Crawford and Compston (1970) proposed that the age of the Vindhyan Supergroup extends over a long period from at least 1200 m.y. and possibly 1400 m.y. to perhaps 550 m.y. or even later. The base of the Upper Vindhyan is dated to about 1150 m.y. or more. Balasundaram and Balasubramanyam (1973) gave a date, i.e. 940 m.y. for Lower Kaimur host rock of Panna Kimberlite.

The present assemblage from the Vindhyan succession of Karauli-Sapotra area shows the absence of Acanthomorph acritarch which are commonly present in the Cambrian and younger sediments. The acritarch recorded from this assemblage belong to the group Sphaeromorphitae. These forms are dominant only in the Late Precambrian (Timofeev, 1973). Moreover, the recorded algal forms are so far known from Middle and Late Proterozoic. Thus the present record of biota favours the age of Vindhyan in this area not to be younger than Cambrian and possibly to be Late Proterozoic.

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EXPLANATION OF PLATES

(All the photographs are. × 1000 unless otherwise stated. All the figured slides are preserved at the Museum, Birbal Sahni Institute of Palaeobotany, Lucknow).

PLATE 1

1. Two globular colonies of *Myxococcoides psilata*. Compactly arranged thin-walled cells surrounded by very thin sheath (pointed by arrow), slide no. 6257.
2. *Nanococcus vulgaris*, a colony of small spheroids surrounded by sheath, slide no. 6258.
3. *Corymbococcus vindhyanensis*, colony of irregularly arranged cells within a thick sheath, slide no. 6253.
4. *Gloeocapsamorpha karauliensis* showing arrangement of cells, slide no. 5993.
5, 6. *Gloeodiniopsis lamellosa* showing arrangement of cells. Isolated cell at left side of fig. 5 shows degraded sheath; fig. 6 shows small cell with thick sheath pointed by arrow, slide no. 6249.
7. *Vindhyacapsiopsis bhanderensis*, a group of colony showing vertical arrangement of cells in more than one rows and thick sheath around the colony, slide no. 6254.
8. *Gunflintia* sp. showing the trichome, slide no 6251.
9, 10. *Palaeoglaucocystis ghoshii* showing different exomorphic characters; fig. 9 — slide no. 5992; fig. 10 — slide no. 6264.
11. *Archaeorestis* sp., slide no. 6260.

PLATE 2

12. Grouping of cells in *Corymbococcus vindhyanensis*, slide no. 6253.
13-15. *Sphaerophycus medium* showing the different modes of arrangement and occasional dark spot at the centre, slide no. 6255.
16-18. *Saccifera tirohanensis*; fig. 16 showing the fibrilar nature of sheath and two cells at the centre, slide no. 6257; fig. 17 amorphous sheath broken after vibration following prolonged acid treatment showing three cells (arrow pointed), slide no. 6251; fig. 18 — Arrow pointing to a single cell at the centre, slide no. 6252.
19. ?Germinating cell. × 2000, slide no. 6259.
20-22. Different stages of probable budding cells, slide nos. 6162 and 6263.
23. *Protoleiosphaeridium diatretus* showing fold on surface, slide no. 6262.
24. *P. cambriense* showing irregular folds on the surface, slide no. 6262.
25. *P. densum* showing thick wall (crack at the centre), slide no. 6263.
26. *Kildinella* sp. folded specimen, slide no. 6257. × 500.
27. *Orygmatosphaeridium plicatum* showing folds at marginal region and pitted surface, slide no. 6265. × 450.
28. *Granomarginata minuta*, slide no. 6260.
29. *G. prima*, slide no. 6266.
30. *Gloeodiniopsis lamellosa*, cells arranged in chain, slide no. 6250.

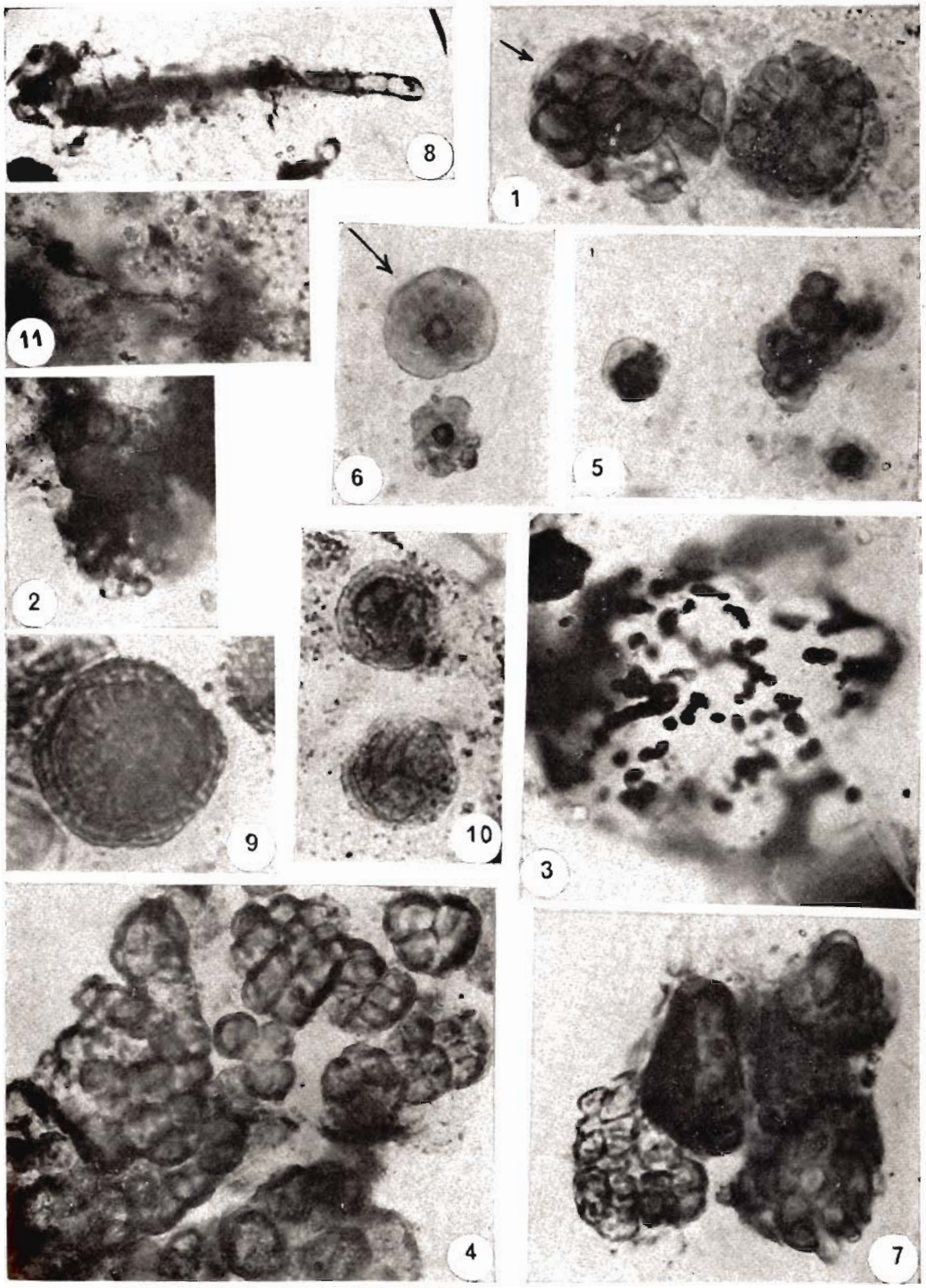

PLATE 1

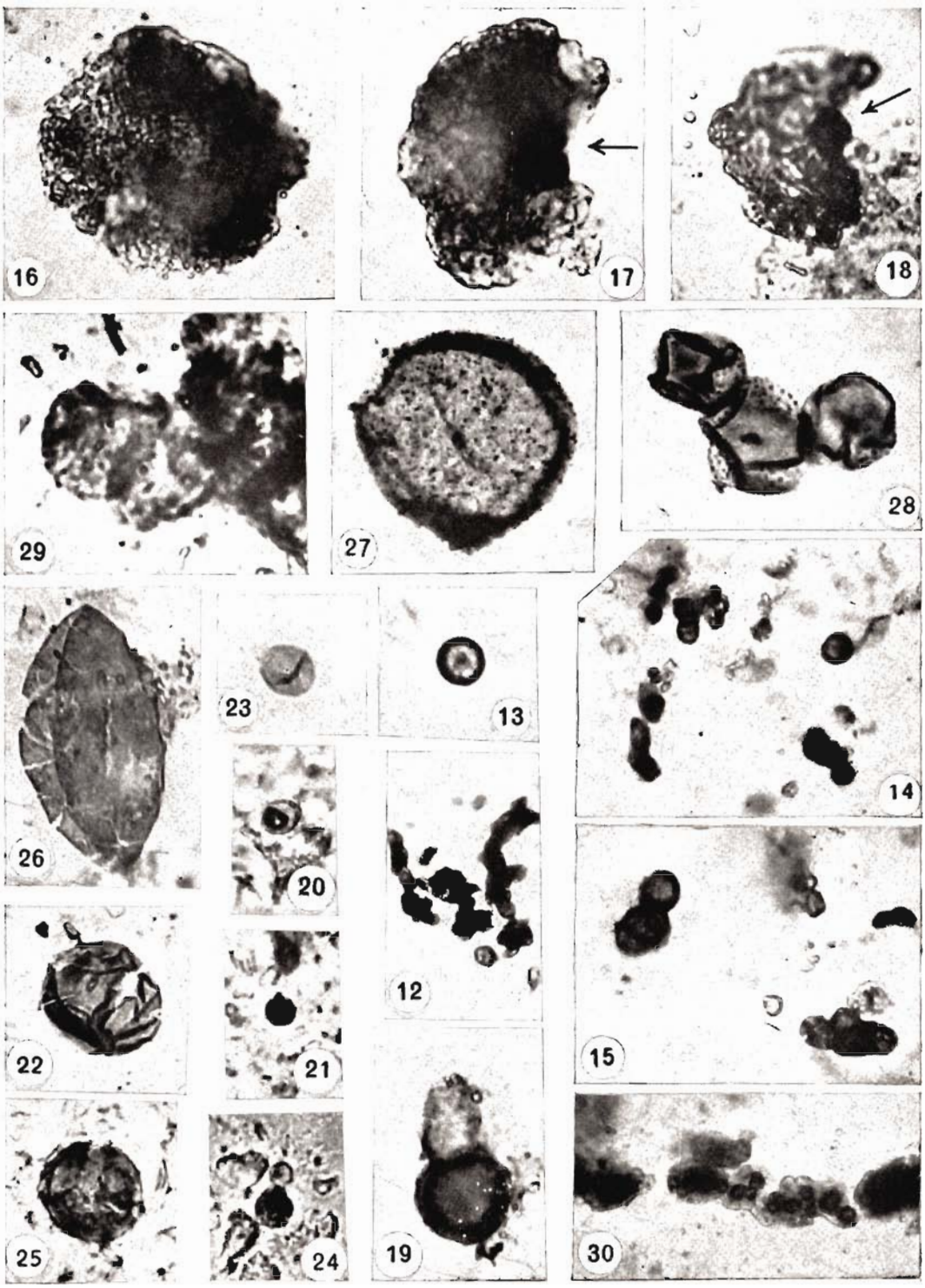

PLATE 2