

Fossil algae from the Cretaceous of Varagur, Tiruchirapalli District, Tamil Nadu

P. K. Misra* & Pramod Kumar

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Algal remains from the limestone deposits at Varagur area, pertaining to Trichinopolly Group in Tiruchirapalli District, Tamil Nadu have been described. The assemblage comprises 31 species of 17 genera belonging to Cyanophyceae, Chlorophyceae and Rhodophyceae, of which, *Palaeomastigocladus indicus* gen. et sp. nov. and *Amphiroa varagurensis* sp. nov. are newly proposed taxa. *Cayeuxia* sp. cf. *C. kurdistanensis* Elliott, *Pycnoporidium lobatum* Yabe & Toyama, *Cylindroporella* sp. cf. *C. sugdeni* Elliott, *Thaumatoporella incrustata* (Elliott) Johnson & Kaska, *Ethelia alba* (Pfender) Massieux & Denizot, *Ethelia* sp., *Archaeolithothamnium parisiense* (Grumbel) Lemoine, *A. rude* Lemoine, *Mesophyllum varians* Lemoine, *Archaeolithophyllum* sp., *Amphiroa* sp., *A. elliotti* Johnson and *Amphiroa* sp. cf. *A. guatemalense* Johnson & Kaska are new records for India. The Varagur algal assemblage mostly contains the forms which are known from the Upper Cretaceous. The palaeoecological interpretations of the Varagur deposits have been made and it is visualised that during Upper Cretaceous there was a shallow warm sea at the site of deposition.

Key-words—Fossil algae, Cyanophyceae, Chlorophyceae, Rhodophyceae, Palaeoecology, Upper Cretaceous (India)

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सारांश

तिरुचिरापल्ली जनपद (तमिल नाडु) में वरागुर के क्रीटेशी कल्प से अश्रित शैवाल

प्रदीप कुमार मिश्रा एवं प्रमोद कुमार

तिरुचिरापल्ली जनपद (तमिल नाडु) में त्रिचनापल्ली समूह से सम्बद्ध वरागुर क्षेत्र के चूनापत्थर निक्षेपों से प्राप्त शैवालीय अवशेषों का वर्णन किया गया है। इस समुच्चय में मिर्योनोफाइसी, क्लोरोफाइसी एवं रोडोफाइसी नामक कुलों की 17 प्रजातियाँ एवं 31 जातियाँ विद्यमान हैं जिनमें से पेलियोमेस्टीगोक्लेडस इंडिकम नव प्रजाति व जाति एवं एम्फीरोआ वरागुरेन्से नव जाति नये प्रस्तावित वर्गक हैं। कैयूक्सिया जाति सजातीय कै० कुरिस्टानेन्सिस इलियट, पिकनोपोरीडियम लोबेटम याबे व तोयामा, सिलिन्ड्रोपोरेल्ला जाति सजातीय सि० सुगडेनाइ इलियट, थोमेटोपोरेल्ला इनक्रस्टेटा (इलियट) जॉन्सन व कास्का, एथेलिया एल्बा (फेन्डर) मेसीयूक्स व डेनिजॉत, एथेलिया जाति, आर्कियोलियोथैम्नियम पेरिसीयेन्से (ग्रम्बेल) लैमांय, आ० रुडे लैमांय, मीसोफिल्लम बेरियेन्स लैमांय, आर्कियोलियोफिल्लम जाति, एम्फीरोआ जाति, ए० इलियटाई जॉन्सन एवं एम्फीरोआ जाति सजातीय ए० ग्वाटामालेन्से जॉन्सन व कास्का नामक वर्गक भारत से पहली बार अभिलिखित किये गये हैं। वरागुर शैवालीय समुच्चय में प्रायः वही प्ररूप मिले हैं जो कि उपरि क्रीटेशी कल्प से विदित हैं। वरागुर निक्षेपों की पुरापास्थितिकीय व्याख्या की गई है तथा ऐसा अनुमान है कि उपरि क्रीटेशी कल्प में इस स्थान पर छिछला गमं समुद्र विद्यमान था।

VERY little information is available on the fossil algae of Tiruchirapalli District in the Cauvery Basin of South India. Rama Rao (1956), Pascoe (1959) and Sastry *et al.* (1972) have divided the Cretaceous

rocks of Tiruchirapalli District into four divisions (Groups), viz., Utatur, Trichinopolly, Ariyalur and Niniyur. Fossil algae from the Utatur Group were reported for the first time by Rama Rao and Prasannakumar (1932) who described *Lithothamnium* from Cullygody limestone mines. Later, from these beds Narayana Rao (1944, 1946)

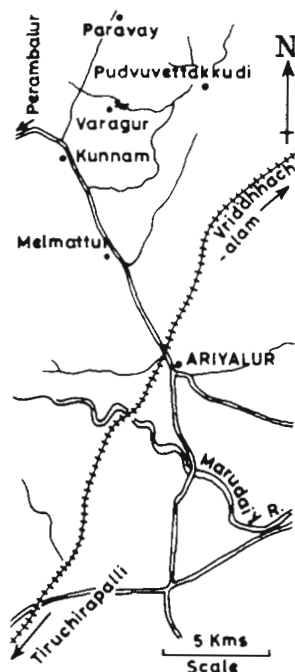
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reported two new species, namely *Solenopora coromandelensis*, *S. jurassica*, and Rama Rao and Gowda (1954) described *Solenopora sabnii* and *Archaeolithothamnium lugeonii*. The earlier phycological records from Ariyalur Group are scanty. So far, Mangain *et al.* (1968) have reported *Archaeolithothamnium* sp., *Lithothamnium* sp. and *Mesophyllum* sp. from South west of Ariyalur town. Most of the contributions on the fossil algae of Tiruchirapalli District have been made from the youngest Niniyur Group. Rama Rao (1931) recorded *Archaeolithothamnium torulosum* from Niniyur beds. Rama Rao and Pia (1936) studied fossil algae from these beds and described 11 taxa belonging to Dasycladaceae, Chaetophoraceae, Solenoporaceae and Corallinaceae. Rama Rao (1938, 1950, 1956, 1958) reported some dasycladaceous algae and reviewed the earlier work done on fossil algae of Niniyur Group. Varma (1952, 1954) described three dasycladaceous algae, viz., *Clypeina*, *Neomeris* and *Acicularia* from the Niniyur beds. Gowda (1953, 1954, 1959, 1978) further added *Holosporella*, *Piania niniyurensis*, fossil Holothuroids, *Solenopora* and *Amphiroa* to the algal flora of this group. Pal (1971a) reported *Archaeolithothamnium pondicherriensis*, *A. zonatum* and *Distichoplax raoi* from Palaeocene of Niniyur Group. Recently, Sastry and Gururaja (1980), in their catalogue of Indian fossil algae, have given a list of taxa known from South India.

Pascoe (1959) has divided the Trichinopolly Stage into lower and upper sub-stages and placed Varagur under the latter indicating Early Senonian age. Rama Rao (1956), Varadarajan and Jagtap (1968), Sastry *et al.* (1972) and Sundaram and Rao (1979) also considered that the beds exposed near Varagur Village belong to Trichinopolly Group of Late Cretaceous age. Ramanathan (1968) suggested Turonian to Senonian age for Trichinopolly Group. Sastry *et al.* (1968), Sastry and Mangain (1971) and Chiplonkar and Tapaswi (1975) have mentioned Santonian age for the Upper part of Trichinopolly Group.

Rama Rao (1956) and Sundaram and Rao (1979) described the lithology of the Trichinopolly Group which comprises conglomerates, grits, shell limestones, hard calcareous sandstones, shales, arenaceous limestones, silt, soft sandstone and numerous pebbles of the adjacent Archaean gneisses-charnockites. At Varagur the sandstone is overlain by the beds of arenaceous limestone, which is dark brown in colour with a pinkish tinge.

Present investigation on the limestones of Varagur has revealed 31 species of fossil algae belonging to following 17 genera of Cyanophyceae, Chlorophyceae and Rhodophyceae. All slides and negatives are preserved at the Birbal Sahni Institute



Map 1—Location map of Varagur showing exposures of algal limestone.

of Palaeobotany Museum and each specimen has been indicated by a mark number.

CYANOPHYCEAE

Cayeuxia Frolo (1 sp.), *Palaeomastigocladus* gen. nov. (1 sp.).

CHLOROPHYCEAE

Pycnoporidium Yabe & Toyama (1 sp.), *Cylindroporella* Elliott (1 sp.), *Indopolia* Pia (1 sp.), *Larvaria* Defrance (1 sp.), *Neomeris* Lamouroux (1 sp.).

RHODOPHYCEAE

Solenopora Dybowski (4 spp.), *Parachaetetes* Daninger (2 spp.), *Thaumatoporella* Pia (1 sp.), *Ethelia* Weber van Bosse (2 spp.), *Archaeolithothamnium* Rothpletz (5 spp.), *Mesophyllum* L emoine (2 spp.), *Archaeolithophyllum* Johnson (1 sp.), *Lithophyllum* Philippi (3 spp.), *Distichoplax* Pia (1 sp.), and *Amphiroa* Lamouroux (3 spp.).

Palaeomastigocladus indicus gen. et sp. nov. and *Amphiroa varagurensis* sp. nov. are being proposed as new taxa and *Cayeuxia* sp. cf. *C. kurdistanensis* Elliott, *Pycnoporidium lobatum* Yabe & Toyama, *Cylindroporella* sp. cf. *C. sugdeni* Elliott, *Thaumatoporella incrustata* (Elliott) Johnson & Kaska, *Archaeolithothamnium parisiense* (Gr ubel) L emoine, *A. rude* L emoine, *Mesophyllum varians*

Lemoine, cf. *Archaeolithophyllum* sp., *Amphiroa elliotti* Johnson and *A. guatemalense* Johnson & Kaska are new records for the Indian fossil algae.

The source of material, for the present algal studies, is from the beds exposed near Varagur Village, situated about 12-14 km north-north-west of Ariyalur town in Tiruchirapalli District, Tamil Nadu (Map 1). An outcrop of 4-5 limestone bands is exposed at 79°3' longitude and 11°5' latitude in a nala cutting at about 150-200 m north-east of the village.

All the specimens have been studied in thin sections made from the limestones by using conventional methods.

DESCRIPTION

The genera have been arranged after Wray (1977). Species under each genus are in alphabetic sequence.

Cyanophyceae

Genus—*Cayeuxia* Frollo 1938

Cayeuxia sp. cf. *C. kurdistanensis* Elliott
Pl. 1, figs 2, 3

Description—Thallus obovoid crustaceous tuft, 0.9 mm long, 0.7 mm broad; tuft composed of several loosely packed and radially arranged tubes; tubes branched, 9-12.5 μ m in diameter, branches forming an angle for some distance then abruptly turning and running more or less parallel to main tube.

Specimen—Slide no. B.S.I.P. 8513-mark 4.

Remarks—In general arrangement of tubes the present thallus resembles *C. kurdistanensis* Elliott

(1956a), but the tubes of the former are slightly narrower than those of the latter.

Elliott (1956a) has described *C. kurdistanensis* from Palaeocene of Iraq. Johnson (1969) has mentioned the occurrence of this species from Middle Jurassic to Upper Cretaceous. Frollo (1938), Elliott (1956) and Pal (1968) have treated the genus *Cayeuxia* Frollo under family Codiaceae in Siphonales of the class Chlorophyceae. But Maslov (1956) assigned this alga to the calcareous blue-green algae. This treatment was later followed by Wray (1977) and Schäfer and Senowbari-Daryan (1983). However, they did not mention the order and family of this taxon.

Genus—*Palaeomastigocladus* gen. nov.

Diagnosis—Filaments heterotrichous, long, interwoven, confluent, with true branching; branches usually arising on one side in the form of inverted-V; sheath firm and thin.

Type species—*P. indicus* sp. nov.

Comparison—The present specimen differs from the known fossil stigonematallean algae, viz., *Langiella* Croft & George (1959) and *Kidstoniella* Croft & George 1959, *Westiellopsis mahabalei* Biradar 1977 and *Ghoshia* Mandal & Maithy (in Mandal *et al.*, 1984) in having loose interwoven habit and unilateral inverted V-shaped branching pattern of filaments. These characters bring the present fossil close to recent *Mastigocladus* Cohn and nearest to its species *M. lamellosum* Cohn (Desikachary, 1959). Reproductive bodies have not been observed in the present fossil. These are also not known in modern *Mastigocladus* Cohn. However, heterocysts are reported in living algae, but they are absent in the present specimen.

PLATE 1

- 1, 6, 17. *Ethelia alba* (Pfender) Massieux & Denizot: 1. *Ethelia alba* magnified to show filaments. $\times 100$, Slide no. BSIP 8520-mark 1; 6. Showing diverging filaments. $\times 100$, Slide no. BSIP 8519-mark 1; 17. Thallus. $\times 30$.
- 2, 3. *Cayeuxia* sp. cf. *C. kurdistanensis* Elliott: 2. Thallus. $\times 50$; 3. An enlarged portion of thallus showing branching pattern of tubes. $\times 100$, Slide no. BSIP 8515-mark 4.
4. *Ethelia* sp. thallus. $\times 100$, Slide no. BSIP 8519-mark 2.
5. *Distichoplax biserialis* (Dietrich) Pia: Section of a fragment. $\times 30$, Slide no. BSIP 8511-mark 1.
- 7, 11. *Parachaetetes asvapatii* Pia: 7. An oblique section showing cross section of filaments in the centre. $\times 30$, Slide no. BSIP 8514-mark 2; 11. Longitudinal section. $\times 30$, Slide no. BSIP 8506-mark 8.
8. *Solenopora tiruchiensis* Rama Rao & Sambe Gowda: Thallus. $\times 30$, Slide no. BSIP 8514-mark 1.
- 9, 14, 15. *Pycnoporidium lobatum* Yabe & Toyama: 9, 14. Cross section of thallus. $\times 30$, Slide no. BSIP 8509-mark 1; 15. Longitudinal section of thallus. $\times 30$; 9. An enlarged portion of longitudinal section showing branched filaments, Slide no. BSIP 8506-mark 10.
10. *Archaeolithophyllum* sp.: Section of a part of thallus. $\times 100$, Slide no. BSIP 8507-mark 1.
- 12, 13. *Parachaetetes* sp.: 12. A magnified portion showing cells. $\times 50$, Slide no. BSIP 8513-mark 5; 13. Shape of thallus. $\times 30$.
16. *Neomeris cretaceae* Steinmann: Cross section of vegetative thallus. $\times 20$, Slide no. BSIP 8506-mark 11.

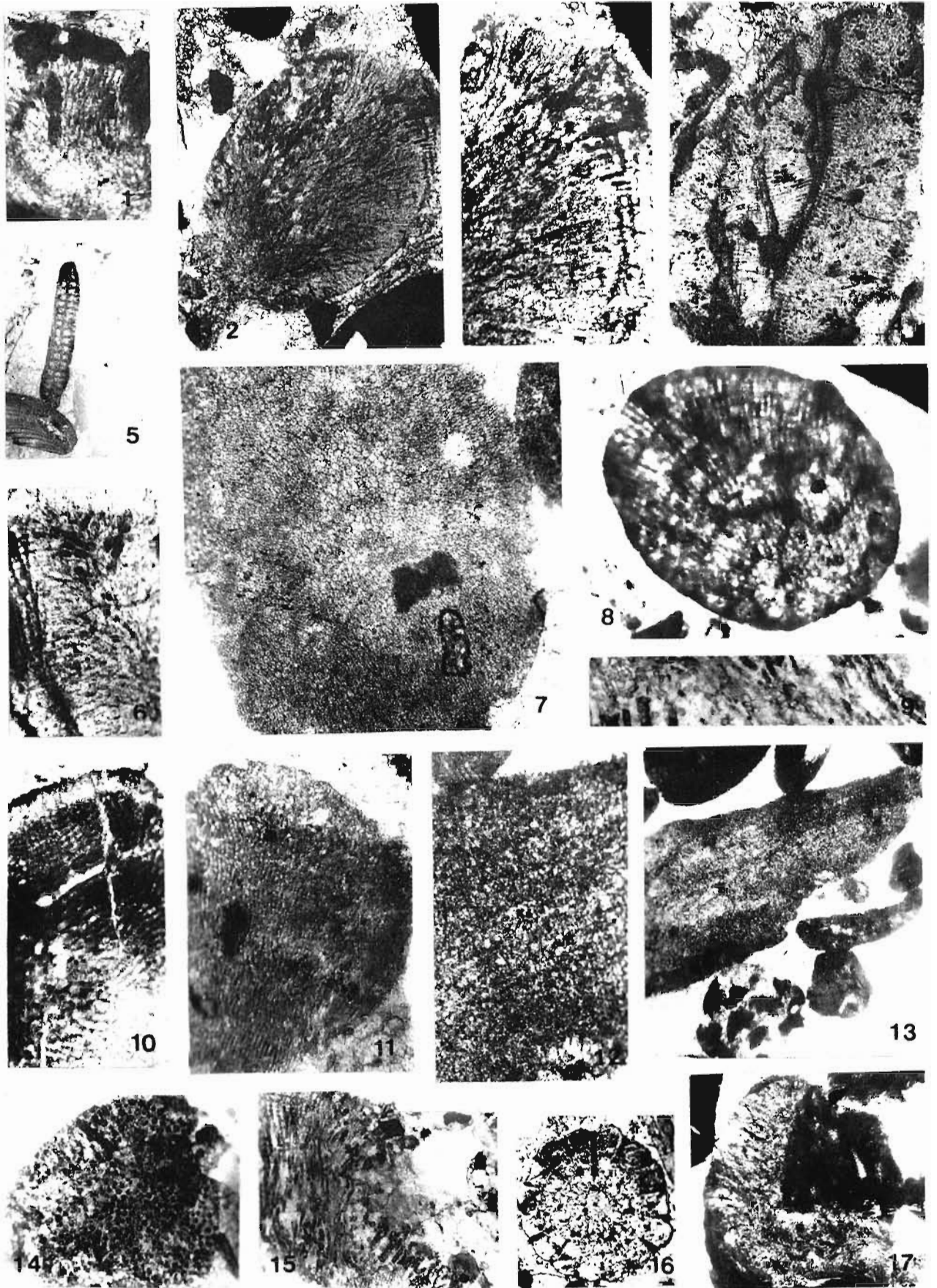


PLATE 1

Palaeomastigocladus indicus sp. nov.
Pl. 3, figs 2, 6

Diagnosis—Filaments heterotrichous, long, interwoven, confluent with true branching, branches usually arising on one side in the form of inverted-V; sheath firm and thin; filaments slightly constricted at septa; cells barrel-shaped to short cylindrical, 3.5-4.5 μm broad, 6-10.5 μm long; heterocysts not seen.

Holotype—Slide no. B.S.I.P. 8506-mark 4.

Locality—Varagur Village, Tiruchirapalli District, Tamil Nadu.

Horizon—Trichinopoly Group (Upper Cretaceous).

Genus—*Pycnoporidium* Yabe & Toyama 1928

Pycnoporidium lobatum Yabe & Toyama
Pl. 1, figs 9, 14, 15

Description—Thallus more or less rounded with irregular mass of loosely packed tubular filaments, radiating from centre to outwards and showing dichotomous branching at few places; outline of filaments circular to polyhedral in cross section, transverse partitions prominent, cells 31.0-43.5 μm broad, 37-82 μm long, cell wall 1.5-2.0 μm thick.

Specimen—Slide nos. B.S.I.P. 8506-mark 10, B.S.I.P., 8509-mark 1.

Remarks—This is the first record of this genus from India. The genus is known from Jurassic to Palaeocene (Johnson, 1969), but the species *P. lobatum* Yabe & Toyama has been recorded from Lower Cretaceous to Middle Cretaceous (Johnson & Kaska, 1965). However, the present report extends

the geologic range of this species up to Upper Cretaceous.

Johnson (1964, 1969) and Johnson and Kaska (1965) have described this genus under the family Solenoporaceae of Class Rhodophyceae while Johnson and Konishi (1960) assigned it to the order Siphonocladales of Chlorophyceae. Wray (1977) commented that this alga may belong to green algae.

Genus—*Cylindroporella* Johnson 1954

Cylindroporella sp. cf. *C. sugdeni* Elliott
Pl. 2, fig. 12

Description—Thallus large, cylindrical, 0.89-0.91 mm broad and 2.45 mm long; branches absent; sporangia large, subspherical, 185-210 μm in diameter.

Specimen—Slide no. B.S.I.P. 8510-mark 1.

Remarks—General morphology and dimensions show its close resemblance with *C. sugdeni* Elliott (Elliott, 1957; Johnson, 1968). This species was, so far, unknown from India (Sastry & Gururaja, 1980). Elliott (1957) described it from the Lower Cretaceous of Fahud, Oman. Johnson (1969) has suggested an Aptian-Albian age for this dasycladaceous alga.

Genus—*Indopolia* Pia 1936

Indopolia sp. cf. *I. satyavanti* Pia
Pl. 2, figs 2, 3

Description—Thallus broadly cylindrical, 1.7 mm long, 0.95 mm broad, central axis large, 0.4 mm in diameter; primary branches fairly regular, more or

PLATE 2



- 1, 14. *Mesophyllum* sp. cf. *M. daviesi* Narayana Rao: 1. Thallus showing biconvex conceptacle (c) in perithallus. $\times 50$, 14. A magnified portion of the same exhibiting reduction in the gap between the bands (marked by arrow). $\times 100$, Slide no. BSIP 8506-mark 1.
- 2, 3. *Indopolia* sp. cf. *I. satyavanti* Pia: 2. Longitudinal section of thallus. $\times 30$, Slide no. BSIP 8517-mark 1; 3. Cross section of thallus. $\times 30$, Slide no. BSIP 8518-mark 1
4. *Solenopora* sp.: Section through vertical axis. $\times 100$, Slide no. BSIP 8506-mark 9.
- 5, 9, 15. *Archaeolithothamnium* ? sp.: 9. An oblique section through a branch. $\times 50$, Slide no. BSIP 8510-mark 2; 5. Thallus. $\times 50$; 15. A magnified portion of same thallus showing rings (R). $\times 100$, Slide no. BSIP 8506-mark 7.
6. *Thaumtoporella incrustata* (Elliott) Johnson & Kaska, section of a fragment. $\times 30$, Slide no. BSIP 8510-mark 4.
7. *Lithophyllum* sp. A: Section of wide and platy branch segment. $\times 50$, Slide no. BSIP 8510-mark 1.
8. cf. *Solenopora* sp.: Cross section of filaments. $\times 50$, Slide no. BSIP 8508-mark 1.
10. cf. *Larvaria* sp.: Vertical section of thallus. $\times 30$, Slide no. BSIP 8517-mark 1.
11. *Amphiroa elliottii* Johnson: Section through long and slender vegetative segment. $\times 50$, Slide no. BSIP 8510-mark 3.
12. *Cylindroporella* sp. cf. *C. sugdeni* Elliott: Oblique longitudinal section of thallus showing sporangia. $\times 30$, Slide no. BSIP 8510-mark 1
13. *Neomeris cretaceae* Steinmann: Cross section of fertile thallus showing sporangia. $\times 30$, Slide no. BSIP 8510-mark 1
- 16, 18. *Lithophyllum* sp. B: 16. Section of vegetative thallus. $\times 50$; 18. A part of thallus magnified to show hypothallus. $\times 70$, Slide no. BSIP 8510-mark 4.
17. *Mesophyllum varians* L emoine: Vegetative thallus showing coaxial hypothallus. $\times 50$, Slide no. BSIP 8511-mark 2.

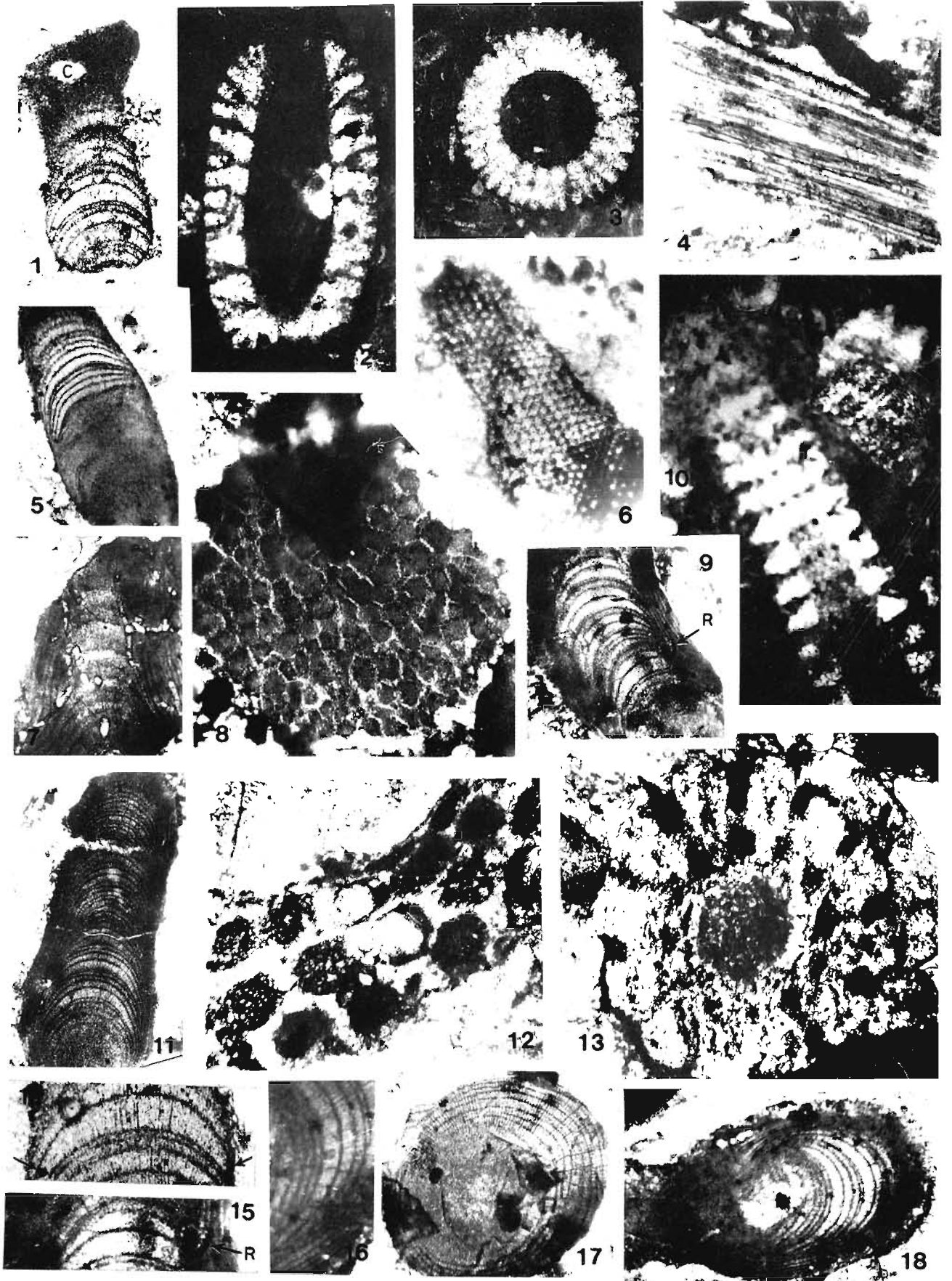


PLATE 2

less oppositely arranged (22 in a whorl); secondary branches slightly inclining and diverging with swollen ends, primary branches equal to secondary branches meeting with external surface at right angle, sporangia not seen.

Specimen—Slide nos. B.S.I.P. 8517-mark 1; B.S.I.P. 8518-mark 1.

Remarks—Vegetative morphology of the studied specimen agrees with *Indopolia* Pia, but due to absence of fertile structures it is regarded as *Indopolia* sp. cf. *I. satyavanti* Pia. The genus *Indopolia* Pia has been described from the uppermost Cretaceous of Niniyur, South India.

Genus—*Larvaria* Defrance 1822

cf. *Larvaria* sp.
Pl. 2, fig. 10

Description—Thallus fragmentary, cylindrical with acuminate end, 2.83 mm long, 0.65 mm broad in the middle; primary branches in regular whorls, short and straight, each dividing into V-shaped secondary branches; sporangia not seen.

Specimen—Slide no. B.S.I.P. 8517-mark 2.

Remarks—Only one longitudinal section of the vegetative fragment is available, hence, the number of primary branches in a whorl and arrangement of sporangia could not be observed. However, this segment resembles *Larvaria* Defrance (Johnson & Kaska, 1965) in vegetative characters. According to Johnson and Kaska (1965), the occurrence of this genus is recorded in Middle to Upper Cretaceous. Sastry and Gururaja (1980) have mentioned that Morellet (1916) has recorded *Larvaria* from Cretaceous of central Tibet. No record of this genus has been made from India.

Genus—*Neomeris* Lamouroux 1816

Neomeris cretaceae Steinmann
Pl. 1, fig. 16; Pl. 2, fig. 13

Description—Cross sections circular, 1.7-2.2 mm in diameter, central axis 0.8-0.95 mm broad bearing a whorl of considerably elongated primary branches; primary branches divided into short secondary branches near the outer surface, secondary branches overlap or lie close to each other; sporangia apparently stalked, usually present at junction of primary and secondary branches, oblong or subspherical, 110-145 μm long, 95-120 μm broad.

Specimen—Slide no. B.S.I.P. 8506-mark 10, 11.

Remarks—The specimens resemble illustrations given by Johnson (1969, pl. 50, figs 3-5) in having similar outline of cross sections, branching pattern and shape, size and position of sporangia. This is the first report of this species from India. According to

Johnson (1969) the stratigraphic distribution of this species is from the Lower Cretaceous only.

Rhodophyceae

Genus—*Solenopora* Dybowski 1877

Solenopora filiformis Nicholson
Pl. 3, fig. 7

Description—Thallus obovoid, nodular mass of radiating filaments, filaments branched at few places, cross partitions inconspicuous, filaments rounded to polygonal in cross section, 35-37 μm in diameter.

Specimen—Slide no. B.S.I.P. 8513-mark 3.

Remarks—This specimen agrees well with the forms described as *Solenopora filiformis* Nicholson by Rothpletz (1913) and Johnson *et al.* (1959). Occurrence of this species in the Upper Cretaceous of Varagur appears to be interesting because its known stratigraphic range is from Silurian to Ordovician (Johnson, 1960).

Solenopora tiruchiensis Rama Rao & Sambe Gowda
Pl. 1, fig. 8

Description—Thallus broad, fan-like, filaments unbranched, closely placed and diverging from centre to periphery; cross partitions indistinct, cells 33-36 μm broad and 62-132 μm long.

Specimen—Slide no. B.S.I.P. 8514-mark 1.

cf. *Solenopora* sp. A
Pl. 2, fig. 8

Description—Cross section of thallus showing filaments in the form of nodular mass of closely packed polyhedral cells with undulating margin and 60-85 μm diameter.

Specimen—Slide no. B.S.I.P. 8508-mark 1.

Remarks—The present specimen compares well with *Solenopora compacta* Rothpletz (1908) in outline, compactness and width of filaments. Since the longitudinal section of this specimen was not observed, the nature of septation and the arrangement of filaments could not be studied.

Solenopora sp.
Pl. 2, fig. 4

Description—Thallus flat, ribbon-shaped with loosely arranged narrow filaments ranging 5-6.5 μm in width; cross partitions indistinct and irregularly placed.

Specimen—Slide no. B.S.I.P. 8506-mark 9.

Remarks—Few ill-preserved thalli were observed. Morphologically these longitudinal sections are assignable to the genus *Solenopora* Dybowski, but due to lack of good preservation of

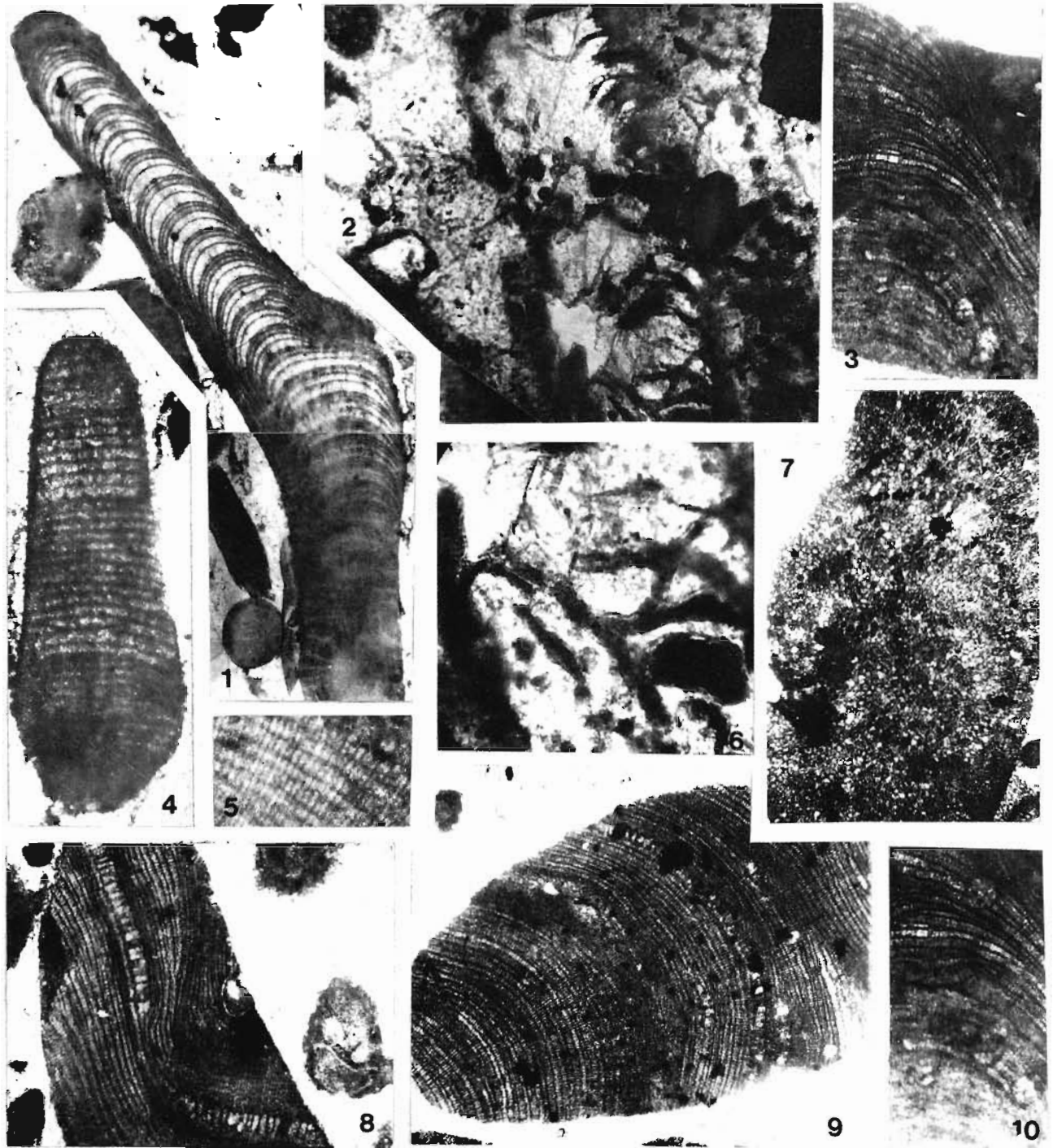


PLATE 3

1. *Amphiroa varagurens* sp. nov.: Section of branch segment showing alternation of 2 rows of short cells with 2 rows of long cells in medullary hypothallus. $\times 30$, Slide no. BSIP 8506-mark 3.
- 2, 6. *Palaeomastigocladus indicus* gen. et sp. nov.: 2. Habit. $\times 30$; 6. Branching of the filaments. $\times 100$, Slide no. BSIP 8506-mark 4.
4. cf. *Lithophyllum* sp.: Section through cylindrical segment. $\times 100$, Slide no. BSIP 8506-mark 5.
- 5, 9, 10. *Archaeolithobamnium nongsteinensis* Sripada Rao: A part of same thallus enlarged to show rectangular cells. $\times 100$, Slide no. BSIP 8512-mark 3; 9. Section of fertile thallus. $\times 50$, Slide no. BSIP 8512-mark 1; 10. A fragment showing arrangement of sporangia. $\times 50$.
7. *Solenopora filiformis* Nicholson: Oblique longitudinal section. $\times 30$, Slide no. BSIP 8513-mark 3.
- 3, 10. *Archaeolithobamnium parisiense* (Grümbel) Lemoine: Thallus with scattered sporangia. $\times 50$, 10. A portion of thallus showing morphology of tetrasporangia. $\times 75$, Slide no. BSIP 8516-mark 1

septa and cross section of filaments, their specific identification is not possible.

Genus—*Parachaetetes* Daninger 1906

Parachaetetes asvapatii Pia

Pl. 1, figs 7, 8

Description—Thallus oblong to hemispherical, cushion-like with shallow marginal fissures, 3-7.5 mm long and 2.5-4 mm broad, perithallus and hypothallus indistinguishable; cellular filaments regular, compactly arranged, radiating towards periphery, vertical walls of cells thicker than cross walls; cells 31-37 μm broad, 62-114 μm long.

Specimen—Slide no. B.S.I.P. 8506-mark 8; B.S.I.P. 8514-mark 2.

Remarks—*Parachaetetes asvapatii* Pia (Rama Rao & Pia, 1936) was described from the Uppermost Cretaceous beds of Niniyur. Elliott (1956b) and Johnson (1964a) recorded this species from Palaeocene of Iraq. Johnson and Kaska (1965) reported this taxon from uppermost Cretaceous as well as Palaeocene of Guatemala.

Parachaetetes sp.

Pl. 1, figs 12, 13

Description—Thallus broad with a gradually narrowing end; filaments ill-preserved, apparently closely packed; cells more or less rectangular, 11-13 μm broad and 15-30 μm long.

Specimen—Slide no. B.S.I.P. 8513-mark 5.

Remarks—In the arrangement of filaments and shape and size of cells the present species compares well with *Parachaetetes* sp. of Johnson (1964a) reported from the Palaeocene of Iraq. However, the latter has a circular outline while the present specimen possesses an acuminate thallus.

Genus—*Tbaumatoporella* Pia 1927

Tbaumatoporella incrustata (Elliott)

Johnson & Kaska

Pl. 2, fig. 6

Description—Thallus thin monostromatic crust containing more or less polygonal-prismatic cells measuring 45-70 μm in diameter.

Specimen—Slide no. B.S.I.P. 8510-mark 4.

Remarks—The cells of the present specimen are slightly narrower than those of the holotype (65 to 104 μm in diameter). Johnson and Kaska (1965) and Johnson (1969) included the genus *Polygonella* Elliott (1957) in the synonymy of *Tbaumatoporella* Pia (1927) on the basis of similar morphology and the priority. Elliott (1957) has recorded it from the Upper Jurassic of Middle East. Johnson (1963) has given the stratigraphic range of this taxon from Upper Jurassic to Lower Palaeocene. This is the first record of the genus from the Upper Cretaceous of Varagur.

Genus—*Ethelia* Weber van Bosse 1913

Ethelia alba (Pfender) Massieux & Denizot

Pl. 1, figs 1, 6, 17

Description—Thallus small, ribbon-shaped, more or less curved; 330-520 μm broad; hypothallus with closely packed cellular filaments lying parallel to axis in the centre and curved outwards to meet the edges perpendicularly; filaments 9-11.5 μm broad, cells of the filaments gradually becoming smaller from center towards the margin of thallus and forming indistinct and thin layer of perithallus.

Specimen—Slide no. B.S.I.P. 8519-mark 1; B.S.I.P. 8520-mark 1.

PLATE 4



- 1, 2. *Archaeolithothamnium* ? sp.: Section through branched segments. $\times 50$, Slide no. BSIP 8510-mark 2, Slide no. BSIP 8506-mark 6.
- 3, 4. *Mesophyllum varians* L moine: 3. Enlarged portion of coaxial hypothallus. $\times 50$, Slide no. BSIP 8506-mark 10; 4. Thallus showing conceptacle (c) and initiation of branch (B). $\times 30$, Slide no. BSIP 8510-mark 5.
- 5, 10, 12. *Amphiroa guatemalense* Johnson & Kaska: 5, Thallus. $\times 50$; 10. Same magnified to show alternation of one row of short cells with 2 rows of long cells in hypothallus. $\times 100$; 12. Enlarged view of hypothallus and perithallus. $\times 100$, Slide no. BSIP 8510-mark 3.
- 6, 8, 16. *Archaeolithothamnium rude* L moine: 6. A thallus containing flattened pear-shaped sexual conceptacles. $\times 100$, Slide no. BSIP 8515-mark 1; 8. Section of fertile thallus. $\times 30$; 16. A portion of same magnified to show serrate outline of tetrasporangia. $\times 100$, Slide no. BSIP 8513-mark 2.
- 7, 9, 11, 14, 17. *Archaeolithothamnium lugeoni* Pfender: 7 Section of thallus under low magnification. ($\times 5$); 9. An enlarged portion of thallus exhibiting sporangia in series. $\times 50$; 11. Oval shape of sporangia—some with an acuminate end. $\times 100$; 14. Magnified view of thallus showing hypothallus, perithallus and sporangia arranged in clusters. $\times 50$; 17. Serial sporangia in oblique section. $\times 50$, Slide no. BSIP 8512-mark 2.
13. *Archaeolithothamnium nongsteinensis* Sripada Rao: Magnified view of rectangulo-ovoid sporangia. $\times 100$, Slide no. BSIP 8513-mark 1.

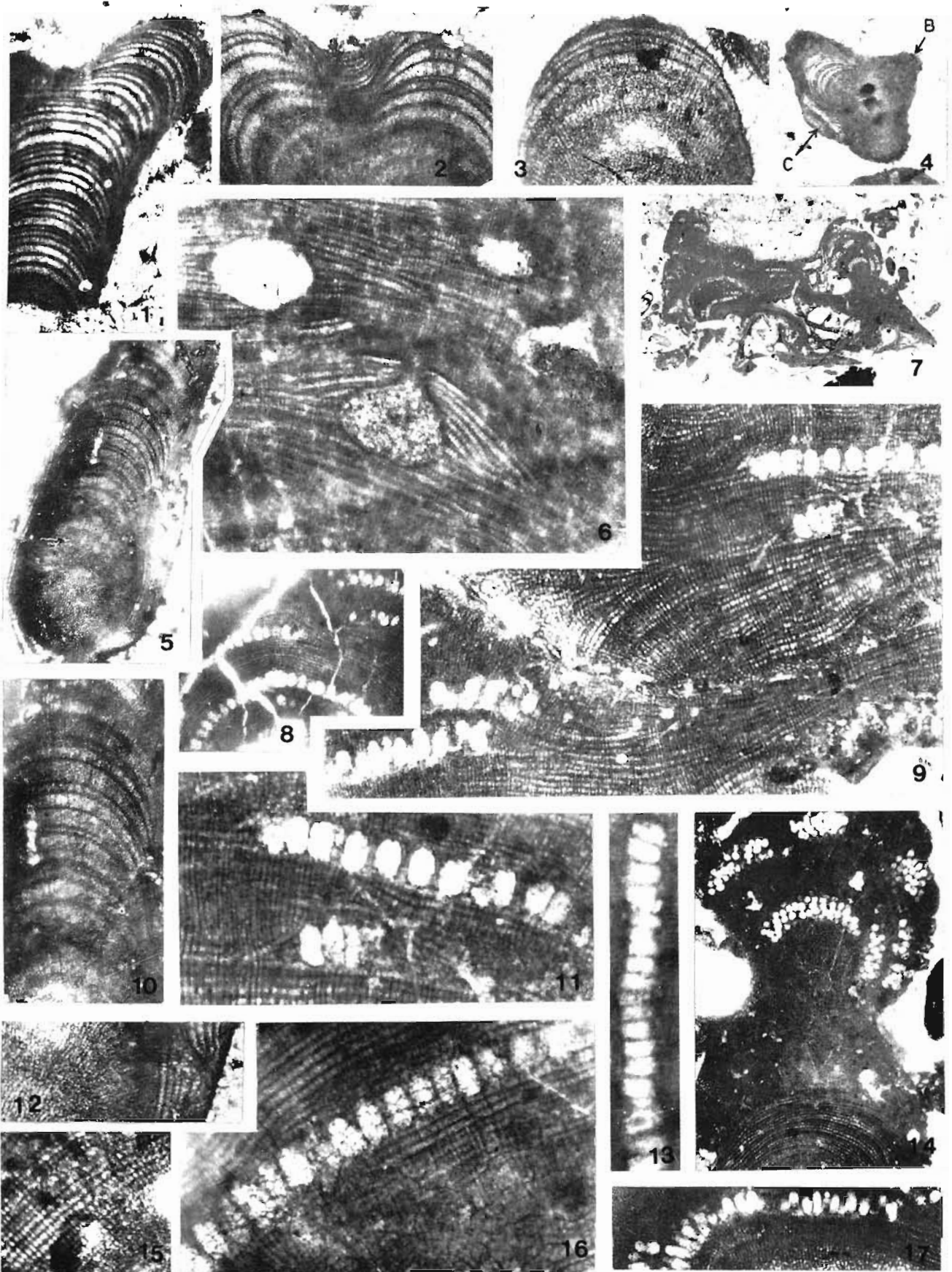


PLATE 4

Remarks—Morphologically, the fossils closely resemble the specimens reported by Johnson and Kaska (1965) and Orszag-Sperber *et al.* (1977) from the Upper Cretaceous-Palaeocene of Guatemala and Miocene beds of Turkey. Johnson and Kaska (1965) have discussed the taxonomy of this species and treated *Pseudolithothamnium album* Pfender as a synonym of the former. Orszag-Sperber *et al.* (1977) retained the specific name given by Pfender without any proper reasons. However, the views of Johnson and Kaska (1965) have been followed here.

Ethelia sp.
Pl. 1, fig. 4

Description—Thallus bladdered, crustose, 450 μm broad, 700 μm long; central hypothallial area possessing indistinct straight filaments meeting the edge perpendicularly; filaments 12-14 μm broad.

Specimen—Slide no. B.S.I.P. 8519-mark 2.

Genus—*Archaeolithothamnium* Rothpletz 1891

Archaeolithothamnium lugeoni Pfender
Pl. 4, figs 7, 9, 11, 14, 17

Description—Thallus crustose and lobate, 8 mm long, 4.5 mm broad; hypothallus with regular superimposed layers of cells, hypothallial cells 15-24 μm long, 10-12 μm broad, medullary hypothallus absent in protuberances of thallus; perithallus compact, consisting of fairly uniform lattice of polygonal cells; sporangia loosely arranged in linear rows, oval, some of them exhibiting acuminate ends, 60-75 μm long, 30-40 μm broad, in tangential section appearing in groups of various clusters.

Specimen—Slide no. B.S.I.P. 8512-mark 2.

Remarks—Johansen (1969) points "the name *Archaeolithothamnium* was used only provisionally by Rothpletz (1891) and therefore Heydrich's (1897) generic epithet *Sporolithon* should be applied. Thus Littler (1972), Dixon (1973) and Johansen (1976) have followed the same treatment and described the recent species of this extant genus under the generic name *Sporolithon* Heydrich. However, Orszag-Sperber *et al.* (1977), Wray (1977) and Bosence (1983) have retained the name *Archaeolithothamnium* Rothpletz for the fossil specimens, and the same has been adopted here.

Rao and Pia (1936) have mentioned that in this species the appearance of sporangia in the form of cluster is because of the tangential cutting of thallus. However, in one of the thin sections of presently studied specimens, sporangia were seen to be arranged in series as well as in clusters. Beak-like projection of sporangial-end has been illustrated by Lemoine (1928). This is also perceptible in Varagur specimen. Johnson (1963) has enlisted *A. lugeoni*

Pfender with Upper Jurassic species of this genus. However, Rao and Pia (1936) recorded this alga from the Upper Cretaceous of Niniyur in Tiruchirapalli District.

Archaeolithothamnium nongsteinensis Sripada-Rao
Pl. 3, figs 5, 9, 10; Pl. 4, fig. 13

Description—Thallus encrusted and mamillated, perithallus compact with curved layers of cells; cell-wall generally even but at places cross walls slightly thicker than vertical walls; cells 15-21 μm long, 7-9.5 μm broad; sporangia rectangulo-ovoid, arranged in concentric rows, 40-58 μm long and 15-22 μm broad.

Specimen—Slide nos. B.S.I.P. 8509-mark 2; B.S.I.P. 8512-marks 1, 3; B.S.I.P. 8513-mark 1.

Remarks—Johnson (1963) recorded the occurrence of this species from Palaeocene to Eocene.

Archaeolithothamnium parisiense (Grümbel)
Lemoine
Pl. 3, figs 3, 10

Description—Thallus fragmentary and crustose, somewhat mammilated; hypothallus not preserved; perithallus composed of irregular layers of 17-32 μm long and 8-10.5 μm broad cells; sporangia ovoid to obovoid, irregularly distributed; 0.86-1.2 mm long, 0.8-0.92 mm broad.

Specimen—Slide no. B.S.I.P. 8516-mark 1.

Remarks—Some sporangia of the present specimen are slightly longer, otherwise it agrees well with *A. parisiense* (Grümbel) Lemoine (in Johnson & Ferris, 1948). Johnson (1963) has mentioned the occurrence of this species from Palaeocene to Eocene. This is the first record of *A. parisiense* (Grümbel) Lemoine from the Upper Cretaceous. This species is a new record from India.

Archaeolithothamnium rude Lemoine
Pl. 4, figs 6, 8, 16

Description—Thallus crustose with apparently short protuberances; hypothallus poorly developed, consisting of few layers of ill-preserved cells; perithallus with compactly arranged irregular layers of cells, whose wall being evenly thickened; perithallial cells 12-23 μm long, 11-14 μm broad; asexual tetrasporic sporangia arranged in curved rows, oblong to sub-spherical with faintly serrate margin, 63-98 μm long, 40-75 μm broad; sexual conceptacles of cystocarps irregularly scattered in the tissue, slightly flattened pear-shaped with a large apical pore, 240-310 μm in diameter, 150-180 μm in length.

Specimen—Slide nos. B.S.I.P. 8513-mark 2; B.S.I.P. 8515-mark 1.

Remarks—Flat, conical and large conceptacles, similar to the present fossil have also been reported in leafy-plate like crustose thallus of *Litbophyllum indicum* Sastry *et al.* (1963), but the latter shows coaxial hypothallus and lacks apical pore in the conceptacles. Moreover, these conceptacles are asexual while those of *A. rude* L emoine are sexual. This species has been earlier recorded from Upper Jurassic to Lower Cretaceous of France, Spain and Algeria by Pfender (1926), L emoine (1939) and Johnson (1969), respectively. The present record extends its stratigraphic distribution up to Upper Cretaceous. However, this species is being reported for the first time from India.

cf. *Archaeolithothamnium* sp.

Pl. 2, figs 5, 9, 15; Pl. 4, figs 1, 2

Description—Thalli represented by short, stubby branches with rounded ends; hypothallus coaxial and medullary, hypothallial cells 20-42 μm long, 6-8.5 μm broad; marginal perithallus thin or thick, perithallial cells 11-13.5 μm long, 9 μm broad, junction of hypothallus and perithallus in one specimen exhibiting ring-like structure on either side in the form of 'inverted-P', reproductive bodies not seen.

Specimen—Slide nos. B.S.I.P. 8506-mark 6, 7; B.S.I.P. 8510-mark 2.

Remarks—In the genus *Archaeolithothamnium* Rothpletz, the hypothallus is generally non-coaxial (Wray, 1977). Johnson (1963) has mentioned that in certain branched forms of this genus, particularly those from Cretaceous, the medullary hypothallus is coaxial. Rama Rao and Pia (1936) have reported a vegetative thallus as *Archaeolithothamnium* sp. from uppermost Cretaceous of Niniyur, district Tiruchirapalli. Their specimen also shows coaxial hypothallus. However, the ring-like structures seen in one specimen are hitherto unknown in this genus. Because of the absence of reproductive organs the final specific placement of the thalli is questionable.

Genus—*Mesophyllum* L emoine 1928

Mesophyllum varians L emoine

Pl. 2, fig. 17; Pl. 4, figs 3, 4

Description—Thalli crustose, 1.3 mm long, 0.7-1.03 mm broad, some of them showing branched habits, hypothallus coaxial, growth zones generally irregular, cells of the same layer vary in length; cells 18-34 μm long, 16-19 μm broad; conceptacle oblong, poorly preserved, 335 μm long, 100 μm broad.

Specimen—Slide nos. B.S.I.P. 8506-mark 10; B.S.I.P. 8510-mark 5; B.S.I.P. 8511-mark 2.

Remarks—L emoine (1934) reported this species from the Lower Cretaceous of France while Johnson

(1965a) recorded this taxon from Palaeocene of Greece. This is the first record of this species from the Upper Cretaceous of India.

Mesophyllum sp. cf. *M. daviesi* Narayana Rao

Pl. 2, figs 1, 14

Description—Thallus crustose with coaxial hypothallus showing concentric bands at different intervals, hypothallial cells 14-30 μm long, 10-13.5 μm broad; perithallus homogeneous with more or less polygonal cells, perithallial cells 14-17 μm in diameter; conceptacle biconvex 150 μm long, 75 μm broad.

Specimen—Slide no. B.S.I.P. 8506-mark 1.

Remarks—The hypothallial cells of the present specimen are larger in dimensions as compared to those of the species described by Narayana Rao (which measure 18.6 \times 7.7 μm). The hypothallus of the latter also shows zig-zag growth zones which are not prominent in the Varagur fossil. However, the biconvex conceptacle of the present studied specimen resembles the conceptacle of *M. daviesi* Narayana Rao. This species has been originally described from Palaeocene of Upper Ranikot Series of the Samana range (N.W. India).

Genus—*Archaeolithophyllum* Johnson 1956

cf. *Archaeolithophyllum* sp.

Pl. 1, fig. 10

Description—Thallus fragmentary, crustaceous and rectangular, measuring 0.47 mm in length and 0.35 mm in breadth; hypothallus composed of arcuate rows of large polygonal cells showing thick walls, hypothallial cells 18.5-37 μm long, 9-14 μm broad; perithallus poorly preserved, consisting of regular rows of small, rectangular, thin-walled 6-8.5 μm long, 4-5 μm broad cells; conceptacles not seen.

Specimen—Slide no. B.S.I.P. 8507-mark 1.

Remarks—The present vegetative thallus is comparable to *Archaeolithophyllum* Johnson (Johnson, 1960; Wray, 1979) but in the absence of conceptacle, the present specimen can not finally be assigned to it. Wray (1977) has given the stratigraphic range of this genus from Lower Carboniferous to Upper Permian.

Genus—*Litbophyllum* Philipp 1837

Litbophyllum sp. A

Pl. 2, fig. 7

Description—Branch encrustated, coaxial medullary hypothallus showing faint growth zones, hypothallus gently tapering upwards and consisting of alternate layers of short, dark cells and long, light-coloured cells; hypothallial cells 25-50 μm long, 12 μm broad; perithallus equally broad, width gradually

increasing upwards, perithallus separated from hypothallus by a row of wide cells, ranging 20-40 μm in length and 12-28 μm in breadth, perithallial cells 11-23 μm long, 10 μm broad; reproductive structures not seen.

Specimen—Slide no. B.S.I.P. 8510-mark 8.

Remarks—The coaxial medullary hypothallus does not show strong growth-zones and comprises alternate layers of dark and light-coloured cells, hence it is suggested that this specimen belongs to *Lithophyllum* Philippi (Johnson, 1965b). Since the present fragment is wide and platy, it has not been considered as a remain of *Amphiroa* Lamouroux.

Lithophyllum sp. B
Pl. 2, figs 16, 18

Description—Thallus fragmentary, short, rounded plate-like branch; hypothallus coaxial with irregular alternate layers of short and long cells; hypothallial cells 10.5-29 μm long, 11 μm broad; perithallus less than half of the width of hypothallus, perithallial cells 8 μm broad, 12-16 μm long.

Specimen—Slide no. B.S.I.P. 8510-mark 4.

Remarks—The reasons for assigning the present specimen to the genus *Lithophyllum* Philippi, are based on the observations made by Johnson (1965b).

cf. *Lithophyllum* sp.
Pl. 3, fig. 4

Description—Segment crustose, cylindrical with a rounded end, medullary hypothallus quite regular with rectangular cells arranged in horizontal rows, transverse walls of cells more prominent than vertical, cells 12.5-18 μm long, 11-14.5 μm broad; perithallus and conceptacles not present.

Specimen—Slide no. B.S.I.P. 8506-mark 5.

Remarks—Because of the lack of perithallus and conceptacle, the placement of fossil in the genus *Lithophyllum* is doubtful. However, the general construction of the hypothallus and the rounded tip of the thallus are very similar to a sterile branch specimen of *Lithophyllum* Lemoine, reported from the Miocene of Iraq by Johnson (1964b).

Genus—*Distichoplax* Pia 1934

Distichoplax biserialis (Dietrich) Pia
Pl. 1, fig. 5

Description—Thallus showing two rows of cells in section, cells oppositely arranged and disposed at right angle to central axis, rectangular to slightly polygonal, 58-67 μm long, 27-29.5 μm broad.

Specimen—Slide no. B.S.I.P. 8511-mark 1.

Remarks—The specimen exhibits relatively thicker cell walls, otherwise it agrees well with

Distichoplax biserialis (Dietrich) Pia (in Elliott, 1956b; Johnson, 1966). According to Johnson (1966) this is a very widespread fossil taxon which was more developed during the Palaeocene and Lower Eocene. This species has been recorded in India from Palaeocene of Andaman Islands, Nerinia beds and Vridhachalam areas of Tamil Nadu and Middle to Upper Eocene of Assam (Sastry & Gururaja, 1980). Pal (1968a) has reported this taxon from the Upper Cretaceous of Bagh beds in Madhya Pradesh. Pal and Dutta (1979) have reported it from the uppermost Palaeocene (Landenian) of Lakadong Member in Jaintia Hills, Assam. Johnson (1966) believed that *Distichoplax biserialis* is an index fossil of Palaeocene to Early Eocene age but Pal (1968b) has described it from Late Cretaceous of Bagh beds. The present finding is also from the Upper Cretaceous deposits; this discourages the use of this taxon as an Index Fossil of Palaeocene-Early Eocene age.

Genus—*Amphiroa* Lamouroux 1812

Amphiroa elliottii Johnson
Pl. 2, fig. 11

Description—Segment long, slender, more or less cylindrical, 1.9 mm long and 0.4 mm broad; medullary hypothallus surrounded by thin marginal perithallus; hypothallus showing irregular alternate layers of long and short cells, marginal cells diverged outward, hypothallial cells 30-40 μm long, 9-11 μm broad; marginal perithallus consisting of 3-4 rows of cells, measuring 15-18 μm in length, 11-12.5 μm in breadth.

Specimen—Slide no. B.S.I.P. 8510-mark 3.

Remarks—The present specimen is slightly shorter and narrower than the *Amphiroa elliottii* Johnson (1964a, 1965a) but it shows close resemblance with Johnson's specimen in having similar outline of thallus, shape, size and arrangement of cells.

Johnson (1964a, 1965a) described this species from the Palaeocene deposits of Rayat in Iraq and Akros in Greece. Sastry *et al.* (1963) have described *Amphiroa* sp. from Upper Cretaceous of Nerinia beds of Pondicherry. Their specimen lacks perithallus and conceptacles and shows hypothallus having alternation of five long cells with one short cells. Johnson (1965a) mentioned that the specimens from Iraq and Greece were fragmentary and possibly they were the remains of those *Lithophyllum* Philippi which usually possessed long spine-like branches.

Amphiroa guatemalense Johnson & Kaska
Pl. 4, figs 5, 10, 12

Description—Segment broadly cylindrical, 1.08 mm long and up to 0.5 mm broad, medullary

hypothallus shows two rows of long cells alternating with one row of short cells, long cells 20-35 μm long, 7-8.5 μm broad, short cells 11-19 μm long, 7-8 μm broad; perithallus consisting of 6-8 rows of cells measuring 7 μm in length and 6 μm in breadth.

Specimen—Slide no. B.S.I.P. 8510-mark 3.

Remarks—This species was described from the Upper Palaeocene and the Lower Eocene of Guatemala by Johnson and Kaska (1965). It is a new record for India.

Amphiroa varagurens sp. nov.

Pl. 3, fig. 1

Diagnosis—Branch segment long and slender, measuring 3.1 mm in length, 0.5-0.6 mm in breadth; medullary hypothallus coaxial with deep curved rows of cells, two rows of short cells alternating with two rows of long cells; long cells 36-66 μm long, 12-14 μm broad, short cells 23-30 μm long, 11-16 μm broad; perithallus thin, comprising 2-3 layers of cells and measuring 95 μm in breadth; perithallial cells poorly preserved, distinct cells 17-25 μm long, 15 μm broad; conceptacle not seen.

Holotype—Slide no. B.S.I.P. 8506-mark 3.

Locality—Varagur Village, Tiruchirappalli District, Tamil Nadu.

Horizon—Trichinopoly Group (Upper Cretaceous).

Remarks—The studied specimen differs from all the other known fossil species of *Amphiroa* Lamouroux in having extremely long cylindrical thallus, which shows alternation of two long and two short cells in the medullary hypothallus.

DISCUSSION AND CONCLUSION

A review of the previous data on the stratigraphic distribution of various taxa, similar to or closely comparable with those encountered in the Varagur limestones, reveals that the majority of the taxa is known from Upper Cretaceous. Some of them have been reported either from the sediments of Palaeocene to Miocene age or from the Jurassic to Middle Cretaceous, or even older deposits.

The presence of certain species, viz., *Indopolia satyavanti* Pia, *Larvaria* sp., *Ethelia alba* (Pfender) Massieux & Denizot, *Solenopora tiruchiensis* Rama Rao & Sambe Gowda, *Parachaetetes asvapatii* Pia, *Archaeolithothamnium lugeoni* Pfender and a vegetative thallus of *Archaeolithothamnium* Rothpletz similar to one described by Rama Rao and Pia (1936) suggests Late Cretaceous age for Varagur beds. It is further supported by the occurrence of three species of the genus *Lithophyllum* Philippi, because Johnson (1965b) mentioned that such algae had a greater development during Maestrichtian.

Distichoplax biserialis (Dietrich) Pia is known from Palaeocene to Eocene (Johnson, 1966). The report of this alga from Upper Cretaceous of Bagh beds by Pal (1971) and present findings from Varagur beds indicates that this taxon might have evolved in Late Cretaceous but could flourish only during Palaeocene to Eocene.

Specimens denoting Palaeocene-Eocene age to Varagur beds are *Archaeolithothamnium nongsteinensis* Sripada Rao, *A. parisiense* (Grümbel) Lemoine, *Amphiroa elliotii* Johnson and *A. guatemalense* Johnson & Kaska.

While discussing stratigraphic implication of Niniyur algae, Pia (in Rama Rao & Pia, 1936) pointed out a transitional position of that flora between Cretaceous and Tertiary periods and suggested that these algae could not be employed to make any stratigraphic conclusions for South India, particularly when many of them were new.

The diverging recommendations of the present algal assemblage regarding the age reveal that most of the taxa suggest a Late Cretaceous age for the beds exposed near Varagur Village. All the specimens of older age, except *Solenopora filiformis* Nicholson, have been found to occur up to Lower or Middle Cretaceous and now it appears that these algae have extended up to Upper Cretaceous. The fossils suggesting Palaeocene-Eocene age might have originated in Late Cretaceous but they bloomed up during favourable conditions of Early Tertiary period.

According to Rama Rao (1956) the rocks of Trichinopoly Group, to which Varagur beds belong, are essentially littoral deposits. Palaeoecological interpretations of Varagur area with respect to fossil algae are based on information on growth habit and ecological conditions of modern representatives of these taxa.

Dasycladaceous algae, represented by *Cylindroporella* Johnson, *Larvaria* Defrance, *Indopolia* Pia and *Neomeris* Lamouroux, are tropical or subtropical plants inhabiting shallow marine warm waters (Wray, 1977). Species of *Ethelia* Weber van Bosse occur at shallow depth, from just-below tide level in tropical or subtropical marine waters (Wray, 1977). The same habitat is preferred by *Archaeolithothamnium* Rothpletz, which is generally found at 12-60 m depth (Johnson, 1963). Chiplonkar and Borkar (1972) have suggested shallow marine conditions in the Middle-Upper Cretaceous of Wadhwan Formation in Gujarat on the basis of the presence of three species of *Archaeolithothamnium* Rothpletz. Greater development of the taxa belonging to genus *Lithophyllum* Philippi is also in the tropical seas, where they inhabit tidal or intertidal pools in depth ranging from 10 to 33 m.

According to Phansalkar and Kumar (1983) the shell limestone of Trichinopoly Group as well as the fauna contained in it is suggestive of infraneritic depths; the wood logs, most of them arranged parallel to each other, indicate a near-shore, possibly littoral conditions.

The present interpretations, as also supported by other studies, help us in visualising that during the Upper Cretaceous, a shallow warm sea was prevailing at the depositional site of Varagur beds. Presently the coastal line has shifted about 150 km towards east from this place.

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