



CORALLINE ALGAE FROM THE NINNIYUR FORMATION, CAUVERY BASIN, SOUTH INDIA

P. K. MISRA*, S. KISHORE*, A. K. JAUHRI** and S. K. SINGH*

* DEPARTMENT OF BOTANY AND **DEPARTMENT OF GEOLOGY, UNIVERSITY OF LUCKNOW, LUCKNOW. 226007, INDIA

ABSTRACT

Coralline red algae occur abundantly in the Ninniyur Formation of Palaeocene age (Misra *et al.*, 2001). Seven species of the coralline algae belonging to three genera are described in this paper. The assemblage includes two species of *Sporolithon*, two species of *Lithothamnion*, one species of *Hydrolithon* and two indeterminate taxa of Melobesioideae. *Sporolithon* sp.1 Bassi, 1998, *Sporolithon glangeaudii* Lemoine, 1939, *Lithothamnion* sp.1 Bassi, 1998, *Hydrolithon* sp. Bassi, 1995 are recorded for the first time from the Indian subcontinent. The genus *Hydrolithon* (Foslie) Foslie is being identified in the study area for the first time.

Key words: Coralline algae, Palaeocene, Ninniyur Formation, Cauvery Basin.

INTRODUCTION

The present paper presents stratigraphic and taxonomic account of seven taxa of the coralline algae in the Ninniyur Formation of the Cauvery Basin. These taxa are in addition to 32 taxa of red algae previously recorded by Misra, Jauhri, Chowdhury and Kishore (2001) from this formation. Following the taxonomic observations of Braga, Bosence and Steneck (1993), Braga and Aguirre (1995), Aguirre and Braga (1998), Aguirre, Braga and Piller (1996), Rasser and Piller (1999) Bassi (1995a, b, 1997, 1998), Basso, Fravega and Vanucci (1997), Basso, Fravega, Piazza and Vanucci (1998), they presented a detailed account the recovered taxa and attempted to discuss the depositional environment based on the ecological data on red algae and associated fossils, and the available information on geological aspects of the study area.

The coralline taxa studied in this paper were recovered from the samples collected from the outcrops of the Lower unit (Adanakkuruichi Limestone) and the Middle unit (Subcrystalline Shelly Limestone) exposed in the area, between Adanakkuruichi (11° 21'N: 79° 0 15'E) in the north and Sendurai (11° 15'N: 79° 0 10' E) in the south, in the Ariyalur-Pondicherry depression of the Cauvery Basin (fig. 1). These outcrops have been grouped as the Ninniyur Formation which represents the Palaeocene epoch for the geological map of the area (Misra, Jauhri, Kishore and Chawdhury, 2000, Misra *et al.* 2001).

The succession of the Ninniyur Formation

includes some fossiliferous horizons which have yielded prolific assemblages of calcareous algae, macroinvertebrates and some datable microfossils (e.g. foraminifera studied by Malarkodi and Nagaraja, 1997, 1998). Previous works on the calcareous algae of the Ninniyur Formation include Rao and Pia (1936), Rao and Gowda (1953, 1954), Chiplonkar (1944), Gowda (1953), Verma (1952, 1954), Pal (1972) besides Misra *et al.* (2000, 2001) and Kishore (2001).

GEOLOGY AND STRATIGRAPHY OF THE AREA

The detailed account of geology of the study area has been presented in recent years by Kumar (1983) and Govindan, Yadagiri, Ravindran and Kalyansunder (1998) and summarised by Misra *et al.* (2001). In the Ariyalur-Pondicherry sub-basin of the Cauvery Basin, the Late Cretaceous was followed by deposition of the shallow, neritic deposits during the lower Tertiary (Palaeocene). Extensive carbonate platform deposits, referred to as the Ninniyur Formation, accumulated because of reduction of supply of clastic material due to peneplanation of the source area as well as reduced rates of subsidence. However, fine clastics were deposited alongside the carbonates due to fluctuating conditions of local tectonics (Kumar, 1983). The Ninniyur Formation is divisible into three distinct units: lower fossiliferous limestone; middle subcrystalline shelly limestone; and the upper argillaceous gritty nodular limestone. The detailed account of the studied sections and lithological characters of these

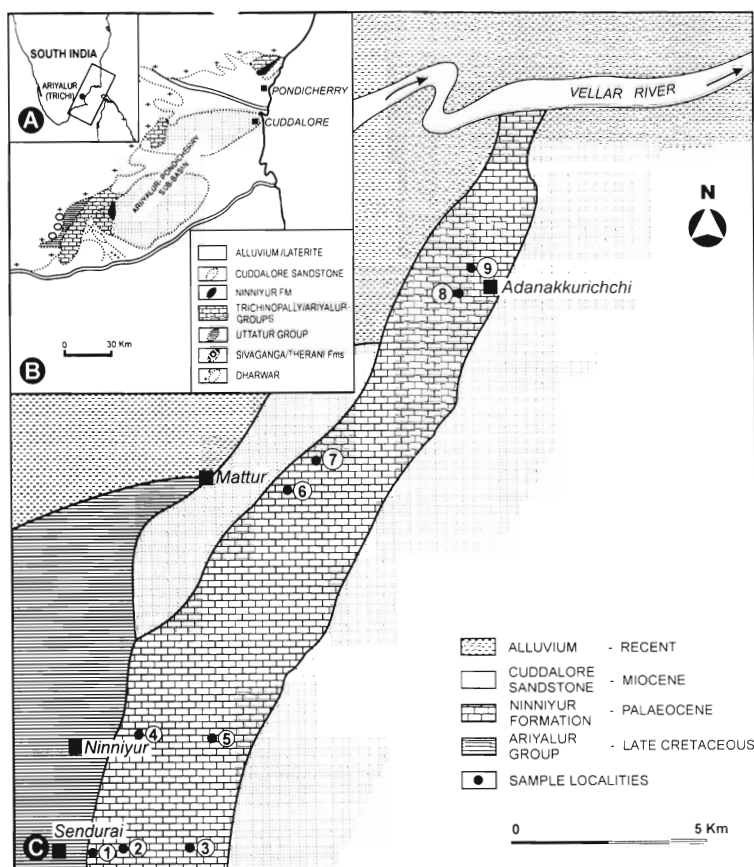


Fig. 1. Location and geological map of the area of study. A. Portion of the Cauvery Basin in India (inset) indicated by a rectangle. B. The general geological map of the Cauvery Basin showing distribution of the studied succession in the Ariyalur-Pondicherry Sub-basin. C. The geological map of the Tiruchirapalli area showing the sampled localities where the outcrops of the Ninniyur Formation are well exposed (Modified after Misra *et al.* (2000).

units has been described by Misra *et al.* (2000, 2001).

Lithologically, the lowermost unit is made up mainly of fossiliferous offwhite to yellowish limestone interbedded with marl and clay. This unit is characterised by rich megainvertebrates and miliolid assemblages in association with few elements of planktic foraminifera (Malarkodi and Nagraja, 1997). The middle unit is dominantly a hard, compact, often recrystallised limestone with several horizons of marl and clay. Though characterised by less diverse megainvertebrate fauna, of which a nautiloid *Hercoglossa danica* (Schlotheim) and a lucinoid bivalve are very common, its algal association is rich and diversified. The upper unit is an argillaceous, fine to gritty nodular limestone. It is richly fossiliferous and contains abundant corals, bivalves, gastropods, etc. *Cardita beaumonti* Douvillé is a very common bivalve found in this unit.

Associated microfossils (esp. planktic foraminifera) include some chronostratigraphic indices which suggest a precise age constraint to the members of the Ninniyur Formation. The presence in the lower unit of *Acarinina spiralis* Bolli among others indicates that this unit is equivalent of Zone P2, i.e. late Danian (early Palaeocene). The important markers of the middle unit are *Acarinina mckannai* (White) and *Planorotalites pseudomenardii* (Bolli). They indicate that the sequence of the middle unit corresponds to Zones P3-P4, i.e. Thanetian (late Palaeocene). Though upper unit does not contain any planktic zonal fossil, the important benthic forms present in this unit include a bivalve *Cardita beaumonti* Douvillé and foraminifera *Protelphidium brotzeni* (Hofker) and *Gavelinella danica* (Brotzen). *G. danica* is a widely distributed form in the lower and upper Palaeocene deposits of the Tethyan and extra-

Tethyan regions. In view of stratigraphic position in sequence, the upper unit can be considered to be Thanetian in age.

All thin sections and samples are deposited at the Algalology Laboratory, Botany Department, University of Lucknow, Lucknow.

Division Rhodophyta Wittstein, 1901
Class Rhodophyceae Rabenhorst, 1863
Order Corallinales Silva & Johansen, 1986
Family Sporolithaceae Verheij, 1993
Genus Sporolithon Heydrich, 1897
Sporolithon sp.1 Bassi, 1998
 (Pl. I, figs. 1, 2)

Sporolithon sp. 1 Bassi, 1998. p. 20, pl. 10, figs. 1-6.

Description : Growth form encrusting to warty and lumpy, thickness of encrusting thalli up to 7.5 mm. Thallus organisation monomerous. Core filaments non-coaxial, core portion 225 µm thick. Cells 16-22µm in length and 10-15 µm in width. The peripheral region of encrusting portion restricted to the dorsal part of the thallus which is usually 675 µm. Cell length 14-20 µm and cell width 10-12 µm. Cell fusions indistinct. Sporangial compartments arranged in sori. Individual sporangial compartments rounded to elliptical or ovoid corners in longitudinal section and circular in transverse section. They are 105-120 µm long and 40-50 µm wide. Sori do not arise from the basal layer of elongated cells. 1-2 filaments (paraphyses) are interspersed between the sporangial compartments. Up to 32 sporangial

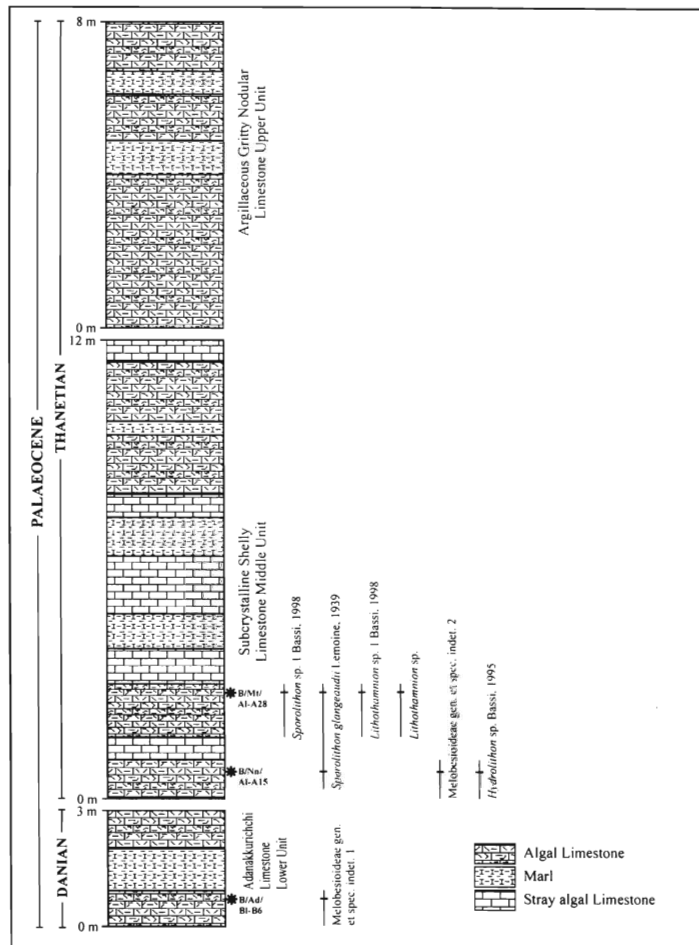


Fig. 2. The litho-biostratigraphic representation of the Ninniyur formation in the Tiruchirappalli area showing position of the fossil-yielding samples (indicated by star *) as well as the stratigraphic ranges of the species of calcareous algae based on the present study (indicated by vertical line). The horizontal bar (-) marks the actual occurrence of the algal species.

compartments can be counted in a single sorus. Old sori buried in the thallus.

Sample No.: B/Mt/A10.

Slide No.: M/CB-84, 164.

Locality: Mattur.

Horizon: Middle Unit (Subcrystalline Shelly Limestone).

Remarks: The present species resembles the Bassi's (1998) species, described as *Sporolithon* sp. 1, in growth form, cell dimensions of core and peripheral filaments of the thallus. Besides these characters, sporangial compartments also show similarity in shape, size and the fact that they do not arise from the basal layer of elongated cells. Bassi (1998) reported this species from the upper Eocene, Calcare di Nago, northern Italy.

Sporolithon glangeaudii Lemoine, 1939

(Pl. I, figs. 3, 4, 5, 7)

Sporolithon glangeaudii Lemoine, 1939. p. 102, pl. 2, fig. 15.
Sporolithon glangeaudii (Lemoine) Aguirre and Braga, 1998, p. 492, pl.1, figs. 4-6.

Description: Growth form encrusting, thickness of encrusting thalli up to 1.3 mm. Thallus organisation monomerous. Core filaments non-coaxial, core portion 120 µm thick. Cells 26-30µm in length and 12-14 µm in width. Cell filaments parallel to the substratum in the ventral part of the core, then curve upwards to give the peripheral region. The peripheral region on encrusting portion restricted to the dorsal part of the thallus which is usually 1.2 mm. Cell length 20-24 µm long and 10-14 µm wide. Cell fusions present. Sporangial compartments arranged in sori. Individual sporangial compartments with rounded to elliptical or ovoid corners in longitudinal section and circular in transverse section. They are 75-85 µm in length and 30-40 µm in width. Cells underlying the sporangial compartments longer than

other peripheral cells. Sori usually arise from a layer of elongated cells. 1-5 filaments (paraphyses) are interspersed between the sporangial compartments. Up to 16 sporangial compartments can be counted in a single sorus. Old sori buried in the thallus.

Sample No.: B/Mt/A18, B/Nin/A10.

Slide No.: M/CB-79, N/CB-105.

Locality: Mattur, Ninniyur.

Horizon: Middle Unit (Subcrystalline Shelly Limestone).

Remarks: The present specimen shows similarity with *Sporolithon glangeaudii* (Lemoine) Aguirre and Braga in shape, size of core filaments cells and also in development and nature of the peripheral cells. Lemoine (1939) reported this species from the Miocene of Algeria. Aguirre and Braga (1998) revised this species on the taxonomic criteria of sporangial compartments, growth form and core filament.

Family Corallinaceae Lamouroux, 1812

Subfamily Melobesioideae Bizzozero, 1885

Genus Lithothamnion Heydrich, 1897

Lithothamnion sp. 1 Bassi, 1998

(Pl. II, figs. 1-5)

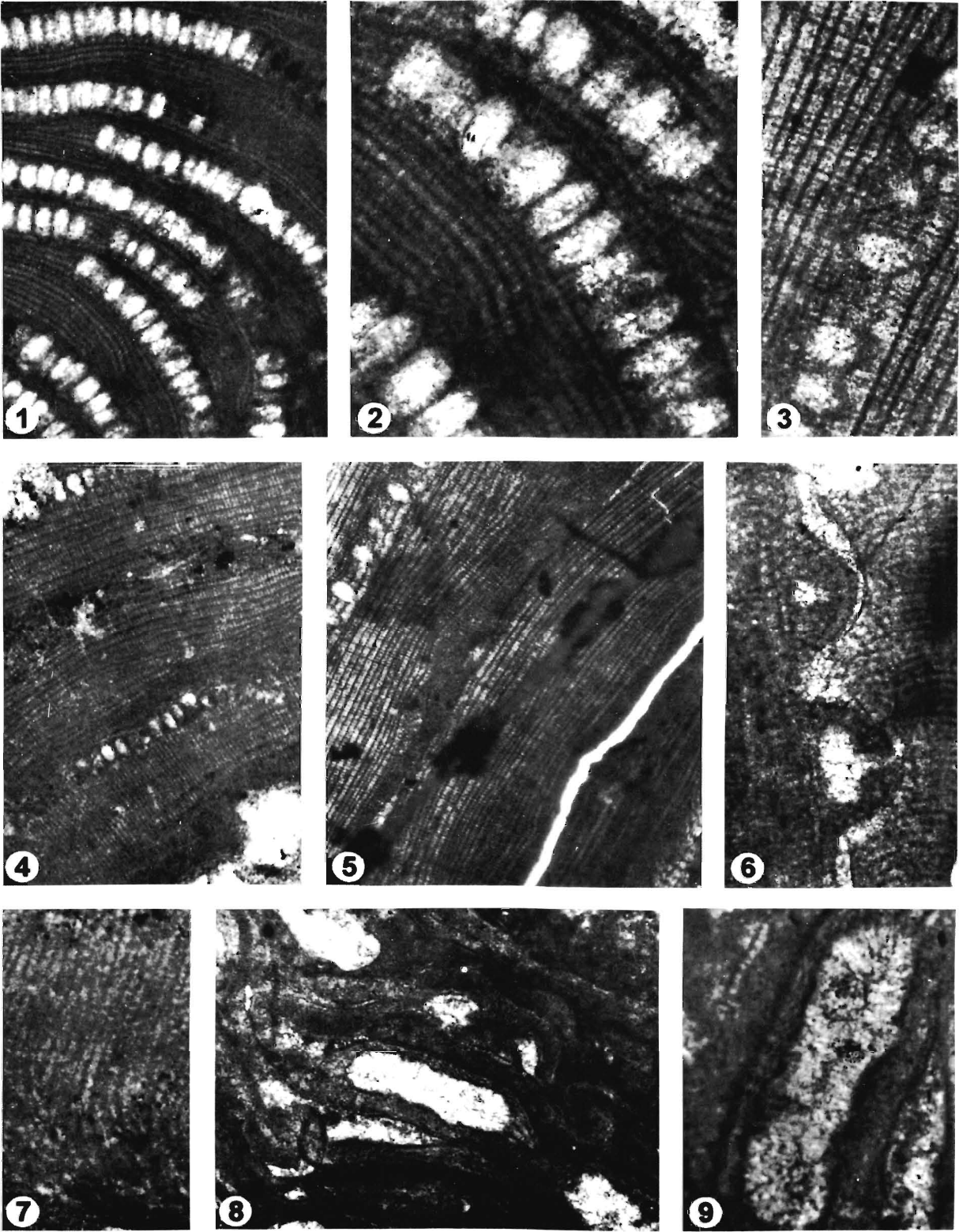
Lithothamnion sp. 1, Bassi, p.14, 1998. pl. 1, fig. 1.

Description: Growth form encrusting, layered to foliose. Thallus organisation monomerous. Core filament non-coaxial, about 225 µm in thickness, with cells 14-20 µm in length and 8-12 µm in width. Cells of the peripheral region 14-18 µm in length and 10-12 µm in width. Cell fusions present. Tetra/bisporangial conceptacles multiporate, 180-220 µm in height and 520-540 µm in width. All conceptacles are buried in the thallus.

Sample No.: B/Mt/A12, B/Mt/A8.

EXPLANATION OF PLATE I

- | | |
|---|---|
| 1, 2. <i>Sporolithon</i> sp. 1 Bassi, 1998 | 5. <i>Sporolithon glangeaudii</i> Lemoine, 1939, X 100 |
| 1. <i>Sporolithon</i> sp. 1 Bassi, 1998 X 50 | 6. <i>Hydrolithon</i> sp. Bassi, 1995, X 130 |
| 2. <i>Sporolithon</i> sp. 1 Bassi, 1998 X 130: Enlarged view of sporangia | 7. <i>Sporolithon glangeaudii</i> Lemoine, 1939, X 150. |
| 3-5,7. <i>Sporolithon glangeaudii</i> Lemoine, 1939 | 8,9. Melobesioideae gen. et spec. indet. 2. |
| 3. <i>Sporolithon glangeaudii</i> Lemoine, 1939, X 50 | 8. Melobesioideae gen. et spec. indet. 2, X 40. |
| 4. <i>Sporolithon glangeaudii</i> Lemoine, 1939, X 50 | 9. Enlarged view of conceptacle, X 110. |



Slide No.: M/CB-34, M/CB-81.

Locality: Mattur.

Horizon: Middle Unit (Subcrystalline Shelly Limestone).

Remarks: The present specimens agree with Bassi's (1998) *Lithothamnion* sp. 1 in growth form, general shape, size of core and peripheral filament, and arrangement of conceptacles. This species was reported from the upper Eocene, Northern Italy.

Lithothamnion sp.

(Pl. II, figs. 6, 7)

Description : Growth form encrusting with small protuberances, thallus thickness about 1.2 mm. Thallus organisation monomerous. Core filaments non-coaxial about 315 μm in thickness, with cells 14-18 μm in length and 12-14 μm in width. The peripheral region on encrusting portion is restricted to the dorsal part of the thallus which is usually 1.1 mm. Cells 15-18 μm in length and 12-15 μm width. Cell fusions present. Tetra/bisporangial conceptacles multiporate, 140-165 μm in height and 380-420 μm in width.

Sample No.: B/Mt/A 24.

Slide No.: M/CB-84.

Locality: Mattur.

Horizon: Middle Unit (Subcrystalline Shelly Limestone).

Remarks: The present specimen shows non-coaxial core filaments and tetra/bisporangial multiporate conceptacles. It is not comparable with any of the known species of the genus.

Melobesioideae gen. et spec. indet. 1

(Pl. II, fig. 8)

Description : Growth form encrusting to warty. Thallus organisation monomerous. Core filaments not preserved, the central cells of protuberance 14-28 μm in length and 10-12 μm in width. Cells of the peripheral region 14-18 μm in length and 8-12 μm in width. Cell fusions present. Tetra/bisporangial conceptacles multiporate, 330 μm in height and 105 μm in width.

Sample No.: B/Ad/B6.

Slide No.: A/CB-165.

Locality: Adanakkurichchi.

Horizon: Lower Unit (Adanakkurichchi Limestone).

Remarks : Thallus organization and conceptacle morphology of these specimens show resemblance both to genera *Lithothamnion* and *Mesophyllum*. As the present specimen lacks core filaments, its generic identification is very difficult. The nature of core filament, whether coaxial or non-coaxial, is the only character that allows genus *Lithothamnion* to be differentiated from *Mesophyllum*. Hence, the present material can be referred to the family Melobesioideae.

Melobesioideae gen. et spec. indet. 2

(Pl. I, figs. 8, 9)

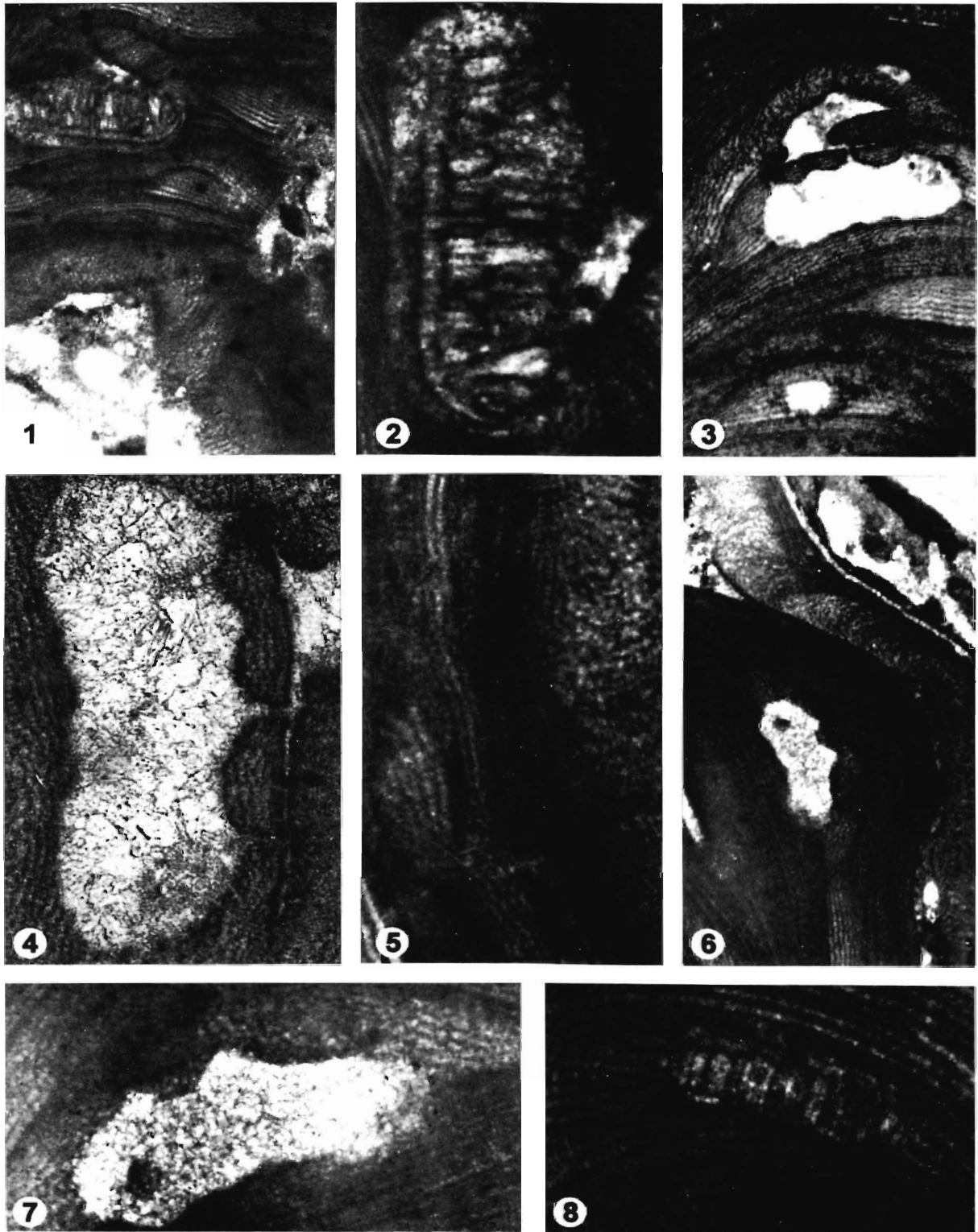
Description : Growth form encrusting to foliose, thallus thick 130 μm . Thallus organisation monomerous. Core filaments non-coaxial, 105 μm in thickness and badly preserved. Cells of the peripheral region 8-14 μm in length and 6-10 μm in width. Cell fusions present. Tetra/bisporangial conceptacles multiporate, 300-525 μm in width. 90-120 μm in length.

Sample No.: B/Nin/A14.

Slide No.: N/CB- 191.

EXPLANATION OF PLATE II

- | | |
|---|--|
| <p>1-5. <i>Lithothamnion</i> sp. 1 Bassi, 1998.</p> <p>1. <i>Lithothamnion</i> sp. 1 Bassi 1998, X 50.</p> <p>2. <i>Lithothamnion</i> sp. 1 Bassi, 1998 : showing conceptacle with Sporangia, X 140.</p> <p>3. Thallus showing conceptacle and peripheral filaments, X 60.</p> <p>4. Enlarged view of conceptacle, X 150.</p> | <p>5. Showing non-coaxial core filaments, X 100.</p> <p>6, 7. <i>Lithothamnion</i> sp.</p> <p>6. <i>Lithothamnion</i> sp., X 50.</p> <p>7. <i>Lithothamnion</i> sp. : showing multiporate conceptacle, X 135.</p> <p>8. Melobesioideae gen. et spec. indet. : 1, showing conceptacle with sporangia X 70.</p> |
|---|--|



Locality: Ninniyur.

Horizon: Middle Unit (Subcrystalline Shelly Limestone).

Remarks: The core filaments of this specimen are non-coaxial and epithallial cells are not preserved. Hence, it can be referred either to *Lithothamnion* or to *Phymatolithon*. The taxonomic assignment of present form is based on the work of Rasser and Piller (1999) from the Austrian Molasse zone.

Subfamily Mastophoroideae Setchell, 1943

Genus Hydrolithon (Foslie) Foslie, 1909

Hydrolithon sp. Bassi, 1995

(Pl. I, fig. 6)

1995b. *Hydrolithon* sp., Bassi, p. 20, fig. 6A, B.

Description : Plant non-geniculate, attached to the substratum ventrally and lacking protuberances, thallus pseudoparenchymatous, usually 370 µm thick. The cells of the postigenous filaments 20-26 µm in length and 12-20 µm in width. Primigenous composed of one or more layers of filaments oriented more or less parallel to thallus surface; rectangular cells 14-18 µm in length and 10-15 µm in width. Cell fusions present. Tetra/bisporangial conceptacles uniporate, 120-150 µm in width and 75-90 µm in height. Conceptacles with a single aperture.

Sample No.: B/Nin/A9.

Slide No.: N/CB-104.

Locality: Ninniyur.

Horizon: Middle Unit (Subcrystalline Shelly Limestone).

Remarks: Thallus organisation, the nature of pore canals of conceptacles and rectangular cells of primigenous filaments allow the present specimens to be identified as *Hydrolithon*. The present specimens agree with Bassi's (1995b) *Hydrolithon* sp. in growth form, general shape; size of primigenous and peripheral filament cells. Though the Bassi's (1995b) specimens lack conceptacles, that from the Ninniyur area shows uniporate conceptacles. Bassi (1995b) reported *Hydrolithon* sp. from the upper Eocene, Northern Italy.

DISCUSSION

As previously noted (Misra *et al.*, 2001), the coralline red algae are abundantly represented in the Ninniyur Formation as fragments, crusts, and rhodoliths along with other fossil groups. Based on the currently employed taxonomic criteria (e.g. Braga *et al.*, 1993; Aguirre and Braga, 1998), seven more species of the coralline algae can be added to the inventory of Misra *et al.* (2001). These include two species of *Sporolithon*; two species of *Lithothamnion*; one species of *Hydrolithon* and two indeterminate taxa of the family Melobesioideae. Of these, *Sporolithon* sp.1 Bassi, 1998, *Sporolithon glangeaudii* Lemoine, 1939, *Lithothamnion* sp.1 Bassi, 1998 and *Hydrolithon* sp. Bassi, 1995 are recorded for the first time from the Indian subcontinent.

ACKNOWLEDGEMENTS

The authors express a deep sense of gratitude to the Heads of the Departments of Botany and Geology, University of Lucknow, Lucknow for encouragement and library and laboratory facilities. Prof. J.C. Braga (Granada, Spain), Dr. M. Rasser (Vienna, Austria) and Dr. Davide Bassi (Universita di Ferrara, Italy) are gratefully thanked for sending useful literature and providing valuable advice through correspondence on matters pertaining to taxonomy and interpretive aspects of the coralline algae. Dr. J. Aguirre (Granada, Spain) is thanked for reviewing the original manuscript and offering helpful comments. This work was supported by the Department of Science and Technology, New Delhi, Project (SERC FAST Track Scheme) No. SR/FTP/ESA-01/2002 sanctioned to S. Kishore.

REFERENCES

- Aguirre, J. and Braga, J. C. 1998. Redescription of Lemoine's (1939). Types of coralline algal species from Algeria. *Palaeontology*. **41** (3): 489-507.
- Aguirre, J., Braga, J. C. and Piller, W. E. 1996. Reassessment of *Palaeothamnium* Conti, 1946 (Corallinales, Rhodophyta). *Rev. Palaeobotany and Palynology*. **94** :1-9.
- Bassi, D. 1995a. Crustose Coralline Algal Pavements from Late Eocene Colli Berici of Northern Italy. *Rivista Italiana di Palaeontologia e Stratigrafia*. **101**(1): 81-92.
- Bassi, D. 1995b. *Sporolithon*, *Hydrolithon*, *Corallina* and *Halimeda* in the Calcare di Nago (Eocene, Trento, Northern Italy). *Annali dell' Universita di Ferrara*. **6** (2): 11-25.
- Bassi, D. 1997. Vegetative anatomy and palaeoecology of

- Polystrata alba* (PFENDER), 1968 (Cryptonemiales, Peyssonneliaceae) from the Upper Eocene of northern Italy. *Rev. Paléo. Genève*. **16**(2): 309-320.
- Bassi, D.** 1998. Coralline red algae (Corallinales, Rhodophyta) from the upper Eocene Calcare di Nago (Lake Garda, Northern Italy). *Annali dell' Università di Ferrara*. **7**:1-50.
- Basso, D., Fravega, P. and Vanucci, G.** 1997. The Taxonomy of *Lithothamnium ramosissimum* (GÜMBEL non REUSS) CONTI and *Lithothamnium operculatum* (CONTI) CONTI (Rhodophyta, Corallinaceae). *Facies*. **37**: 167-182.
- Basso, D., Fravega, P., Piazza, M. and Vanucci, G.** 1998. Revision and re-documentation Of M. Airoidi's species of *Mesophyllum* from the Tertiary Piedmont Basin (NW Italy). *Rivista Italiana di Paleontologia e Stratigrafia*. **104**(1):85-93.
- Beckmann, J. P.** 1982. Displaced Late Cretaceous and Palaeocene microfossils. p. 120-141. In : *Micropalaeontology and biostratigraphy of the Campanian to Palaeocene of the Monte Giglio, Bergamo Province, Italy.* (Beckmann, J. P., Bolli, H. M., Kleboth, P. and Proto Decima, F.), *Memoire Di Scienze Geologiche* , XXXV, Padova.
- Bizzozero, G.** 1885. *Flora Veneta Crittogammica*. Part 2. Seminario, Padova, 255pp.
- Braga, J. C., Bosence, D. W. J. and Steneck, R. S.** 1993. New anatomical characters in fossil coralline algae and their taxonomic implications. *Palaeontology*. **36**: 535-547.
- Braga, J. C. and Aguirre, J.** 1995. Taxonomy of fossil coralline algal species: Neogene Lithophylloideae (Rhodophyta, Corallinaceae) from southern Spain. *Review of Palaeobotany and Palynology*. **86**: 265-285.
- Chiplonkar, G. W.** 1944. Algae in the Cretaceous of the Narbada Valley. *Sci. Cult.* **10**: 130-131.
- Foslie, M.** 1909. Algologiske notiser. VI. *K. norske Vidensk. Selsk. Skr.* **1909**(2): 1-63.
- Ghose, B. K.** 1977. Palaeoecology of the Coenozoic reefal foraminifers and algae- a brief review. *Palaeogeog, Palaeoclimatol, Palaeoecol.* **22**: 231-256.
- Govindan, A., Yadagiri, K., Ravindran, C.N. and Kalyansunder, R.** 1998. *A field guide on Cretaceous sequences of Tiruchirapalli area, Cauvery Basin.* O.N.G.C., Chennai.
- Gowda, S. S.** 1953. Occurrence of *Holosporella* in the Niniyur (Danian) group of the Trichinopoly Cretaceous, S. India. *Curr. Sci.* **22**: 169-170.
- Heydrich, F.** 1897. Corallinaceae, insbesondere Melobesieae. *Ber. Deutsch. Bot. Ges.* **15**(1): 34-70.
- Johnson, J. H.** 1965. Coralline algae from the Cretaceous and early Tertiary of Greece. *Jour. Pal.* **39**(5): 802-814.
- Johnson, J. H. and Stewart, W. A.** 1953. Eocene Coralline Algae from the Meganos Formation , California. *Jour. Pal.* **27**(1): 130-136.
- Kishore, S.** 2001. A Study of Calcareous Algae from the Ninniur Formation(Palaeocene) of the Tiruchirapalli area, Cauvery Basin, South India. *Unpublished Ph. D. thesis, Lucknow University, Lucknow.*
- Kumar, S. P.** 1983. Geology and Hydrocarbon prospects of Krishna, Godavari and Cauvery Basin. In: *Petroliferous Basins of India* (eds. Bhandari, L. L. et al.), *Petroleum Asia Journal*, **6**(4): 57-65.
- Kützing, F. T.** 1841. über die 'Polypiers calciferes' des Lamouroux. Thiele, Nordhausen, 34pp.
- Lamouroux, J. V. F.** 1812. Extrait d'un mémoire sur la classification des polypiers coralligènes non entièrement pierreux. *Nouv. Bull. Sci. Soc. Philomath.* Paris. **2**: 38-44.
- Lemoine, M. P.** 1939. Les algues calcaires fossiles de l'Algérie: Matériaux pour la Catre géol. de l' Algérie,ser. 1, *paleontology.* **9**: 128.
- Malarkodi, N. and Nagaraja, H. M.** 1997. Palaeocene foraminifera from the Ariyalur area, Southern India. *Palaeobot.* **46**(1, 2): 177-185.
- Malarkodi, N. and Nagaraja, H. M.** 1998. Genus *Thalmanita* (Foraminifera) from the Ninniur Formation (Palaeocene), Ariyalur area, South India. *Jour. Geol. Soc. India* **50**: 361-366.
- Misra, P. K., Jauhri, A. K., Kishore, S. and Chowdhury, A.** 2000. Calcareous algae (Dasycladaceans and Gymnocodiacean) from the Palaeocene deposits of the Tiruchirapalli (= Trichinopoly) area, Tamil Nadu, India. *Jour. Pal. Soc. India*, **45**: 151-164.
- Misra, P. K., Jauhri, A. K., Chowdhury, A. and Kishore, S.** 2001. Palaeocene Rhodophyceean algae from the Ninniur Formation of the Cauvery Basin, southern India. *Palaeobot.* **50**(2&3): 311-339.
- Pal, A. K.** 1972. Further discovery of fossil algae in the Ninniur group (Palaeocene) of the type area, p. 243-247. In: *Proceedings of the Seminar on Palaeopalynology and Indian stratigraphy* (Eds. Ghosh A. K. et al.), Calcutta University, Calcutta University, Calcutta.
- Rabenhorst, L.** 1863. *Kryptogamen-Flora von Sachsen, der Ober-Lausitz, Thüringen und Nordbohmen.* Abteilung I.E. Krummer, Leipzig.
- Rao, L. R. and Pia J.** 1936. Fossil algae from the uppermost Cretaceous beds (The Ninniur Group) of the Trichinopoly District, S. India. *Mem. Geol. Surv. India, Pal. Ind.* **XXI**, (4): 13-40, Calcutta.
- Rao, L. R. and Gowda, S. S.** 1953. Occurrence of *Clypeina* (Dasycladaceae) in the Niniyur group of the south Indian Cretaceous. *Curr. Sci.* **22**: 322-323.
- Rao, L. R. and Gowda, S. S.** 1954. Solenoporaceae in the Cretaceous rocks of south India. *Curr. Sci.* **23**: 177-178.
- Rasser, M. and Piller, W. E.** 1999. Application of neontological Taxonomic concepts to the Late Eocene coralline algae (Rhodophyta) of the Austrian Molasse Zone. *Jour. Micropalaeont.* **18**: 67- 80.
- Setchell, W. A.** 1943. *Mastophora* and Mastophoreae: Genus and subfamily of Corallinaceae. *Proc. Natl. Acad. Sci.* **29**: 127-135.
- Silva, P. C. and Johansen, H. W.** 1986. A reappraisal of the order Corallinales (Rhodophyceae). *Br. Phycol. Jour.* **21**:245-254.
- Varma, C. P.** 1952. *Clypeina* (Dasycladaceae) from the Cretaceous of S. India. *Palaeobot.* **1**: 439-441.
- Varma, C. P.** 1954. On the algal genera *Neomeris* and *Acicularia* from the Niniyur (Danian) beds, Trichinopoly (S. India). *Proc. Natn. Inst. Sci. India*, **20**: 298-304.
- Verheij, E.** 1993. The genus *Sporolithon* (Sporolithaceae fam. Nov., Corallinales, Rhodophyta) from the Spermonde Archipelago, Indonesia. *Phycologia*, **32**: 184-196.
- Wettstein, R. R.** 1901. *Handbuch der Systematischen Botanik, Vol. I.* Deuticke, Leipzig.

