Significance of calcareous algae across the Cretaceous-Tertiary sequence of Cauvery Basin in Tiruchirapalli District, Tamil Nadu

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Calcareous skeletal algae belonging to Cyanophyta (Cyanobacteria), Chlorophyta and Rhodophyta are known from Uttatur, Trichinopoly, Ariyalur and Niniyur groups of Tiruchirapalli District, Tamil Nadu. An attempt has been made to analyse the algal assemblages across the Cretaceous-Tertiary sequence in Tiruchirapalli District, Tamil Nadu. The distribution pattern of algal taxa indicates that there is a gradual change in algal flora from Cretaceous to Tertiary.

Key-words--Calcareous algae, Distribution pattern, Cretaceous -Tertiary sequence, India.

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सारांश

तमिलनाडु के तिरुचिरापल्ली जनपद में कावेरी द्रोणी के क्रीटेश्यस-टर्शियरी अनुक्रम में चूनामय शैवालों का महत्व

अमित कुमार घोष, बृजेन्द्र नाथ जाना एवं प्रभात कुमार माइती

तमिलनाडु के तिरुचिरापल्ली जनपद में उतातुर, त्रिचनापल्ली, अरियालूर एवं निनियूर नामक समूहों से सियनोजीवाणु, क्लोरोफाइटा एवं रोडोफाइटा नामक मंडलों से सम्बद्ध चूनामय मेखलीय शैवाल ज्ञात हैं। इस जनपद में क्रीटेश्यस-टर्शियरी अनुक्रम से उपलब्ध शैवालीय समुच्चयों का विश्लेषण करने का प्रयास किया गया है। शैवालीय वर्गकों के वितरण से उक्त काल में शैवालीय वनस्पतिजात में शनैः शनैः परिवर्तन प्रदर्शित होता है।

SINCE 1931, calcareous algae have been reported from the Cretaceous-Tertiary sediments of Tiruchirapalli District, Tamil Nadu. Rama Rao and Prasannakumar (1932) described *Lithothamnium* from the Kallakkudi (Dalmiapuram) limestone mines (Dalmiapuram Formation) belonging to Uttatur Group. Narayan Rao (1944, 1946) reported two new species, namely, *Solenopora coromandelensis* and *S. jurassica* and Rama Rao and Gowda (1954) described *Solenopora sahnii* and *Sporolithon* (*Archaeolithothamnium*) *lugeonii* (*sensu* Ghosh & Maithy, 1996) from the same beds. Gowda (1978) recorded *Solenopora* sp. and *Amphiroa* sp. from the Varagapaudy Limestone of Uttatur Group. Varma (1952), for the first time, reported the occurrence of *Clypenia sahnii* from the Trichinopoly Group of rocks. In recent times, Misra and Kumar (1988) investigated the Varagur limestones of Trichinopolly Group and reported 31 species of fossil algae belonging to 17 genera of Cyanophyta (Cyanobacteria), Chlorophyta and Rhodophyta. From the Ariyalur Group, Mamgain *et al.* (1968) have reported *Sporolithon* (*Archaeolithothamnium*) sp., *Lithothamnium* sp. and *Mesophyllum* sp. from south-west of Ariyalur town. Porostromata algae consisting of *Rivularia lissaviensis, R. piae, R. theodori, Rivularia* sp. cf. *R. dianae* and *Garwoodia toomeyi* have been described by Ghosh and Maithy (1995) from the Cretaceous sediments of Sendurai, Tiruchirapalli District. Rama Rao (1931) reported *Sporolithon* (*Archaeolithothamnium*) *torulosum* from Niniyur beds. In the classical contribution on fossil algae from Niniyur Group, Rama Rao and Pia (1936) described 11 taxa belonging to Dasycladaceae, Chaetophoraceae, Solenoporaceae and Corallinaceae. Rama Rao (1938, 1956, 1958) described few dasyclads

from the Niniyur Group and reviewed the previous work done on fossil algae from this group. Varma (1952, 1954) reported *Clypenia, Neomeris* and *Acicularia* (Dasycladaceae) and Gowda (1953, 1959) described *Holosporella* and *Piania niniyurensis* from the Niniyur beds. From the Palaeocene (Danian) of Niniyur Group, Rama Rao and Gowda (1954) reported *Solenopora tiruchiensis*, and Pal (1972) reported *Sporolithon (Archaeolithothamnium) pondicherriensis, S. zonatum* and *Distichoplax raoi.* In the present paper an attempt has been made to analyse the algal assemblages from different outcrop areas of Cretaceous-Tertiary sequence in Tiruchirapalli District and to ascertain the significance of calcareous algae in biostratigraphy.

GEOLOGICAL SETTING

Cretaceous-Tertiary sediments in the Cauvery Basin, classified into four groups, viz., Uttatur, Trichinopoly, Ariyalur and Niniyur, occur as isolated patches outcropping in the western margin fringing the Archaean (charnokite/gneiss) basement. The first geological mapping of the area was carried out by Blanford (1862). Later, significant contributions on micropalaeontology and sedimentology (Rama Rao, 1956; Pascoe, 1959; Sastry *et al.*, 1968, 1972; Sundaram & Rao, 1966; Banerji, 1966, 1972, 1973; Chiplonkar & Tapaswi, 1975; Jain, 1977; Govindan, 1977, Govindan *et al.*, 1996, and others) along with detailed geological mapping and band-by-band aerial photomapping (Venkataraman & Rangaraju 1965, in Govindan *et al.*, 1996) gave a clear picture of the stratigraphy of Tiruchirapalli area.

The marine Cretaceous-Tertiary sequence of Cauvery Basin in Tiruchirapalli District is represented at its base by Uttatur Group which lies unconformably over the Kaolinite-Smectite dominant Therani plant beds of Upper Gondwana (Therani Bed lies unconformably over the Archaean). Lithologically the Uttatur Group comprises basal conglomerates, grey shale (Subbaraman, 1968), algal-coralline limestone (Banerji, 1972) and Karai Shale. Govindan *et al.* (1996) identified Maravathur Clay as a facies variation of Karai Shale and grouped it in Uttatur. An unconformity of small duration exists between the Uttatur Group and basal Paravay Formation of Trichinopoly Group. The Paravay Formation comprising calcareous sandstone, argillaceous limestone and limestone is overlain unconformably by the Garudamangalam Formation which consists of ferruginous sandstone, grey shale, limestone and, in turn, is followed by current bedded sandstone. The Trichinopoly Group is unconformably overlain by Ariyalur Group, consisting two sandstone bodies separated by a limestone. The basal Sillakkudi Formation of Ariyalur Group comprises ferruginous arkosic sandstone and limestone bands. The overlying Kallankurichi Formation consists of grainstone to wackestone with *Lepidorbitoides* bryozoans, echinoid and molluscan shells. The lower part of the upper sandstone body, composed of megafaunal rich buff coloured calcareous sandstone is well developed in the central part which is designated as Ottakovil Formation (Sastry *et al.*, 1972). The upper part comprising argillaceous sandstone and ferruginous claystone of continental origin is known as Kallamedu Sandstone. The topmost lithohorizon of the Cretaceous-Tertiary Sequence, conformably overlying the Ariyalur Group is represented by Niniyur Group of Danian age and is characterised by fossiliferous, white to cream coloured marls and calcareous clays.

A generalised lithostratigraphic sequence is represented in Table 1 (modified after Govindan *et al.*, 1996)

ALGAL ASSEMBLAGES FROM CRETACEOUS-TERTIARY SUCCESSION OF TIRUCHIRAPALLI AREA

A. Algal Assemblage from the Uttatur Group

Cyanophyceae (Cyanobacteria)

Rivularia (Cayeuxia) frutículosa, Rivularia sp.

Dasycladaceae

Acicularia antiqua, Larvaria occidentalis, Neomeris sp., *Halimeda* sp.

Solenoporaceae

Solenopora jurassica, S. coromandelensis, S. sahni and *Sporolithon (Archaeolithothamnium) lugeonti.*

In addition to the above listed algal taxa recorded from the Kallakkudi Limestone (Dalmiapuram Formation), from Varagapaudy Limestone of Uttatur Group Gowda (1978) reported the occurrence of

Table 1

AGE	GROUP	OUTCROP AREA / FORMATION
DANIAN	NINIYUR	NINIYUR
MAASTRICHTIAN	ARIYALUR	KALLAMEDU Sandstone
		OTTAKOVIL
		KALLANKURICHI Limestone
		SILLAKKUDI
CAMPANIAN	TRICHINOPOLY	GARUDAMANGALAM
SANTONIAN		PARAVAY
CONIACIAN		MARAVATTUR Clay
TURONIAN	UTTATTUR	KARAI Shale
CENOMANIAN		KALLAKUDDI Limestone
ALBIAN		Grey Shale
APTIAN		Conglomerate
EARLY CRETACEOUS LATE JURASSIC		THERANI PLANT BEDS
ARCHAEAN CRYSTALLINES		

Red algae *Solenopora* belonging to Solenoporaceae and *Amphiroa* belonging to Corallinaceae (Corallinoideae, articulated corallines).

B. Algal Assemblage from the Trichinopoly group

Cyanophyceae (Cyanobacteria)

Rivularia sp. cf. *R. kurdistanensis*, *Palaeomastigocladus indicus.*

Siphonocladaceae

Pycnoporidium lobatum.

Dasycladaceae

Clypenia sahnii, *Cylindroporella* sp. cf. *C. sugdenii*, *Indopolia* sp. cf. *I. satyavanti*, cf. *Larvaria* sp., *Neomeris cretaceae.*

Solenoporaceae

Solenopora filiformis, *S. tiruchiensis*, cf. *Solenopora* sp. A., *Solenopora* sp., *Parachaetetes* sp., *P. asvapatii*, *Thaumatoporella incrustrata.*

Squamariaceae

Ethelia sp., *E. alba.*

Corallinaceae (Melobesoideae, Crustose Corallines)

Sporolithon (*Archaeolithothamnium*) *lugeonii*, *S. nonsteinensis*, *S. paristense*, *S. rude*, cf. *Sporolithon* sp., *Mesophyllum* sp. cf. *M. daviesi*, *M. varians*, cf. *Archaeolithophyllum* sp., *Lithophyllum* sp. A., *Lithophyllum* sp. B., cf. *Lithophyllum* sp., *Distichoplax biserialis.*

Corallinoideae, articulated coral-lines

Amphiroa elliotii, *A. guatemalense*, *A. varagurense.*

C. Algal Assemblage from the Ariyalur group

From the Ariyalur Group Rama Rao (1931) and Mamgain *et al.* (1968) reported the occurrence of *Lithothamnium*, *Sporolithon* (*Archaeolithothamnium*) and *Mesophyllum* belonging to Corallinaceae (Melobesoideae, Crustose Corallines) of Rhodophyta. Recently Porostromata algae have been recorded by Ghosh and Maithy (1995) from the Cretaceous sediments (equivalent to Ariyalur Group) of Sendurai, Tiruchirapalli District. The assemblage consists of the following taxa :

Cyanophyceae (Cyanobacteria)

Rivularia lissaviensis, *R. piae*, *R. theodori*, *Rivularia* sp. cf. *R. dianae.*

Codiaceae

Garwoodia toomeyi.

D. Algal Assemblage from the Niniyur Group

Dasycladaceae

Acicularia sp., *A. dyumatsenae*, *A. indica*, *Acitabularia* sp., *Clypenia sahnii*, *Disocladella* sp., *D. undulata*, *D. savitriae*, *Indopolia satyavanti*, *Neomeria* sp., *Orioporella malaviae* and *Piania ninlyurensis.*

Cheatophoraceae

Palaeochlya sp.

Solenoporaceae

Parachaetetes asvapatti, Solenopora tiruchiensis.

Corallinaceae (Melobesoideae, Crustose Corallines)

Sporolithon (Archaeolithothamnium) lugeonti, S. torulosum, Sporolithon sp. cf. *S. lycoperdioides, Sporolithon* aff. *provinciale, Distichoplax raoi.*

Corallinoideae, Articulated coral-lines

Corallina raoi.

DISCUSSION

It is evident from the distribution pattern (Table 2) that in the marine rocks of Tiruchirapalli District, many Cretaceous algal taxa extend up to the Tertiary (Danian) time, though apparent extinction of many algal forms is also visualised during the Cretaceous, accompanied by the appearance of new algal species in the Niniyur Group (Danian). In view of this situation it is difficult to recognise the biostratigraphic zonation on the basis of algal assemblages. Earlier it has been implied by Rama Rao and Pia (1936) that algae are most helpful in stratigraphic correlation based on index fossils. But recent analysis indicates that it is indeed very problematical to use algae as biostratigraphic marker mainly because of following two reasons :

1. the algal taxa which were used earlier as index fossils are now proved to be long ranging; and
2. many of the forms which were regarded earlier as index algal fossils are doubtful as well as controversial and in some cases are considered as animal remains.

It may not be out of context to mention here that *Distichoplax bisertales*, which is still considered as an index fossil for the rocks having Palaeocene-Lower Eocene age, is present in the Trichinopoly Group (Misra & Kumar, 1988). Pal (1972) reported *Distichoplax* from the Niniyur Group (Danian) and it is stratigraphically quite justified. However, it should be mentioned here that validity of *Distichoplax* as an alga had been questioned by Lemoine (1958) and Lemoine (1961-62). They have shown analogies between chitinous parts of living and fossil Pterobranchia belonging to *Rhabdopleura*, and suggested that *Distichoplax* should not be considered as an alga. Rama Rao and Pia (1936) expressed their view that presence of *Sporolithon (Archaeolithothamnium) lugeonti* in the Niniyur Group is indicative of Tertiary age, but the taxon is now known to occur in Uttatur and Trichinoploy groups (Rama Rao & Gowda, 1954; Misra & Kumar, 1988). The genus *Corallina* which is known to be restricted to Tertiary everywhere is found in the Dalmiapuram Formation of Uttatur Group (Gowda, 1978). Eventually, it appears that no marker algal taxa in true sense is available to date the Cretaceous-Tertiary rocks of Tiruchirapalli District. However, from the distribution pattern (Table 2) it is evident that there are certain algal taxa which are significantly absent, or present or rich in any particular horizon. These are enumerated below.

The reefoidal limestone of Kallakkudi Limestone (Dalmiapuram Formation) and Varagapaudy Limestone belonging to Uttatur Group contains algae. The algal assemblage from the Dalmiapuram Formation is significantly devoid of Corallinoideae (Articulated Corallines). But the Varagapaudy Limestone which occurs at the base of Uttatur Group (Gowda, 1978) contains the articulated coralline red alga *Amphiroa* in association with *Solenopora* (Solenoporaceae). The latter genus ranges beyond Jurassic (Rama Rao & Gowda, 1954; Gowda, 1976) up to Danian (Keijzer, 1945; Rama Rao & Gowda, 1954).

Majority of the algal taxa described from the Varagur Limestone of Trichinopoly Group (Misra & Kumar, 1988) are Upper Cretaceous forms, but some of them are also known from the deposits older than Jurassic, Jurassic to Middle Cretaceous and Palaeocene to Miocene.

Rama Rao (1931) and Mamgain *et al.* (1968) reported the occurrence of crustose coralline red algae from the Ariyalur Group of rocks. Recently Ghosh and Maithy (1995) described Porostromata algae from the Cretaceous rocks of Sendurai belonging to Ariyalur Group. According to Rama Rao and Pia (1936) the Niniyur algal flora indicates a transitional position between the Cretaceous and Tertiary. The Niniyur algal assemblage (Rama Rao & Pia, 1936) is rich in well calcified Chlorophyta and coralline Rhodophyta. Majority of the algal species in the Niniyur Group are new and the preliminary indications given by their affinities are contradictory. The Niniyur Group may be included in the Mesozoic due to the presence of *Parachaetetes* and absence of specialised

Table 2—Distribution pattern of calcareous algae

TAXA	DISTRIBUTION IN DIFFERENT GROUPS			
	UTTATUR	TRICHINOPOLY	ARIYALUR	NINIYUR
Clypenia sahnii	—			—
Neomeris sp.	—			—
Sporolithon lugeonii	—	—		—
Sporolithon nonsteinensis	—	—		—
Acicularia antiqua	—	—		—
Halimeda sp.	—			
Larvaria occidentalis	—			
Rivularia fruticulosa	—			
Rivularia sp.	—			
Solenopora jurassica	—			
Solenopora coromandelensis	—			
Solenopora sahnii	—			
Amphiroa sp.	—			
Solenopora sp. A	—			
Solenopora sp. B	—			
Amphiroa elliottii		—		
Amphiroa guatemalense		—		
Amphiroa varagurense		—		
Cylindroporella sp. cf. *C. sugdeni*		—		
Rivularia sp. cf. *kurdistanensis*		—		
Ethelia alba		—		
Ethelia sp.		—		
Indopolia sp. cf. *I. satyavanti*		—		
cf. *Larvaria* sp.		—		
Lithophyllum sp. A		—		
Lithophyllum sp. B		—		
cf. *Lithophyllum* sp.		—		
Neomeris cretaceae		—		
Mesophyllum sp. cf. *M. daviesi*		—		
Mesophyllum varians		—		
Palaeomastigocladus indicus		—		
Pycnoporidium lobatum		—		
Solenopora filiformis		—		
Solenopora sp.		—		
cf. *Solenopora* sp. A		—		
Sporolithon paristense		—		
Sporolithon rude		—		
Thaumatoporella incrustata		—		
Parachaetetes sp.		—		
Distichoplax biseriales		—		
Parachaetetes asvapatii		—		
Lithothamnium sp.			—	
Lithophyllum sp.			—	
Mesophyllum sp.			—	
Sporolithon sp.			—	
Rivularia sp. cf. *Rivularia dianae*			—	
Rivularia lissaviensis			—	
Rivularia piae			—	
Rivularia theodori			—	
Garwoodia toomeyi			—	
Acicularia dyumatsenae				—
Acicularia indica				—
Acicularia sp.				—
Acitabularia sp.				—
Corallina raoi				—
Disocladella savitriae				—
Disocladella sp.				—
Disocladella undulata				—
Distichoplax raoi				—
Indopolia satyavanti				—
Orioporella malaviae				—
Piania niniyurensis				—
Solenopora tiruchiensis				—
Sporolithon aff. *provinciale*				—
Sporolithon pondicherriensis				—
Sporolithon sp. cf. *lycoperdioides*				—
Sporolithon torulosum				—
Sporolithon zonatum				—
Palaeochlya sp.				—

Melobesoideae in the Niniyur assemblage. On the other hand, presence of *Sporolithon* (*Archaeolithothamnium*) *lugeonii* and *Orioporella* would point to a Tertiary age of the Niniyur Group.

Therefore, Rama Rao and Pia (1936) expressed that algae can not play any significant role in the stratigraphic zonation in south India. However, the authors while discussing the age of Niniyur Group based on fossil algal assemblage stated that the Niniyur rocks must be given an age towards the close of Upper Cretaceous, for they overlie the Ariyalur Group.

A perusal of the foregoing discussion reveals that algae can not be used as an important tool to demarcate the K/T boundary. However, a critical evaluation of the distribution pattern of calcareous algae from the Cretaceous-Tertiary sediments of Tiruchirapalli District allows us to draw the following conclusions :

1. The Cretaceous algal assemblages consist of Cyanophyta or Cyanobacteria (10%), Chlorophyta (20-25%) and Rhodophyta (60-65%), whereas, the Tertiary assemblages consist of Chlorophyta (40-45%) and Rhodophyta (50-55%).

2. Calcified Cyanophyta (Cyanobacteria) which are frequent forms in the Cretaceous, are not present in the Tertiary algal assemblage recovered from the Niniyur Group.

3. The green algae like *Acicularia, Disocladella, Orioporella* and *Pianta* are only known from the Niniyur Group, whereas, forms like *Cylindroporella, Clypenia, Halimeda*, etc. are only recorded from the underlying Cretaceous deposits. Codiaceae are poorly represented in the Tertiary deposits.

4. Gymnocodiaceae and Solenoporaceae (Rhodophyta) significantly contribute to the algal assemblages of Cretaceous deposits, whereas, their presence in the Tertiary deposits is unimportant. Among the crustose corallines, frequency of occurrence and morphological variations of the alga *Sporolithon* (*Archaeolithothamnium*) increases in the Tertiary sediments in comparison to those of Cretaceous.

5. In the Tertiary deposits (Niniyur Group, Danian) a majority of the algal species are new (viz., *Acicularia dyumatsenae, A. indica, Disocladella savitriae, Indopolia satyavanti, Pianta ninityurensis*). Apparent extinction of many algal forms (viz., *Halimeda* sp., *Lithophyllum* sp., *Lithothamnium* sp., *Mesophyllum* sp., *Larvaria occidentalis, Rivularia* spp. and *Amphiroa* spp.) is also noticed from Cretaceous to Tertiary. These are indicative of the fact that there is a gradual change in algal flora from Cretaceous to Tertiary, due to which preponderance of new species is visualised in the algal assemblage of Niniyur Group (Danian).

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