



## MIDDLE EOCENE CALCAREOUS ALGAE FROM THE PRANG FORMATION OF THE THERRIA AREA, EAST KHASI HILLS, MEGHALAYA, N. E. INDIA

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### ABSTRACT

The fossiliferous Prang Limestone which forms the uppermost stratigraphic unit of the Sylhet Limestone Group is widespread in the South Shillong Plateau and is well exposed in the Um Sohryngkew River section of the East Khasi Hills. The succession is characterized by a sequence of well-preserved calcareous algae and larger foraminifera. The 40m thick unit in this section belongs to Shallow Benthic Zones SB15 – SB18 (based on larger foraminifera) which correlate with planktic foraminifera zones P13 and P14.

The present paper reports ten species of the calcareous algae, of which eight species represent the rhodophyceean group and two species belong to the chlorophyceean group. Out of these, the occurrence of one species, *Sporolithon lauensum* is noticed for the first time from India, and two species (*Halimeda nana* and *Ovulites arabica*) are first time recorded from the study area. *Melobesia* gen. et. spec. indet. 1, a new combination, is erected on the basis of the female carposporophytic plant. The calcareous algae dominated by coralline red algae occurs in association with the poorly represented chlorophyceean algae. Associated larger foraminiferal genera are *Nummulites*, *Assilina*, *Discocyclina* and *Alveolina*.

The studied succession is suggested to have been deposited in environments ranging from shallow lagoons to inner- to upper mid-shelf with fluctuating energy conditions.

**Keywords:** Calcareous algae, Middle Eocene, Prang Formation, East Khasi Hills (Therria), Meghalaya

### INTRODUCTION

The East Khasi Hills represent the southwestern part of the Shillong Plateau, Meghalaya, N.E. India, and show excellent outcrops of Late Cretaceous and Palaeogene sedimentary successions exposed near a village Therria (Fig. 1). The Palaeogene succession is represented by carbonate deposits which range in age from the late Palaeocene to middle Eocene. They are grouped into the Sylhet Limestone Group characterized by three formations, each with a carbonate unit (Wilson and Metre, 1953). The uppermost formation of this group is designated as the Prang Formation (middle Eocene). The purpose of this paper is to describe the algal content of the Prang Formation in the Therria section, N.E. India, and to comment on its depositional environment on the basis of calcareous algae and the associated larger foraminifera.

The study area falls in the region of low palaeolatitudes near the southern part of the Tethys (Scheibner and Speijer, 2008). Because of its unique palaeogeographical position in the southern part of northern Tethys among most of the well-studied carbonate platforms situated more in the north, the data of the present study is of considerable international interest in terms of taxonomy, palaeobiogeography and palaeoenvironment. Although no formal biozonation is proposed here, a biostratigraphic correlation has been suggested on the basis of the associated larger foraminiferal biostratigraphic indices.

### PREVIOUS WORK

Calcareous algae have been reported from Meghalaya but there are a few reports from the East Khasi Hills. These include the works of Misra *et al.* (2002) and Jauhari *et al.* (2006) which report coralline and chlorophyceean algal groups from the Lakadong Formation. No information exists about the taxonomic composition of the calcareous algal assemblages

from the Prang Formation of the study area. Most published work includes reports of their occurrence from the Jaintia Hills (Sarma and Ghosh, 2006; Kishore *et al.*, 2009 and Misra *et al.*, 2011) or from the South Khasi Hills (Kishore *et al.*, 2007).

### MATERIAL AND METHODS

The present work is based on the study of outcrop samples at an interval of 3m from a 40m thick sequence of the Prang Limestone exposed in the Um Sohryngkew River section near the village Therria. The samples were processed for study of calcareous algae in random thin section as they were not suitable for separation of isolated material. Numerous thin sections were prepared, and the effort was made to obtain desired orientation by sectioning of samples along and across the bedding planes. The calcareous algae were studied under the light microscope.

Taxonomic observations were made in light of current taxonomic criteria developed through studies by Braga *et al.* (1993), Braga and Aguirre (1995), Aguirre *et al.* (1996), Basso *et al.* (1997), Bassi (1995, 1998), Rasser and Piller (1999), Harvey *et al.* (2003), Bassi *et al.* (2007) and Iryu *et al.* (2009). We also follow the recently changed taxonomic criteria given for red algae by Lee Gall and Saunders (2007) and Lee Gall *et al.* (2010).

### GEOLOGICAL SETTING AND STRATIGRAPHY

The study area is a river section in the South Shillong Plateau which is the northeastern extension of the Indian Peninsular shield (NE India). As a result of the tectonics in the neighboring regions, the Shillong Plateau appears to be the uplifted part of the basement bounded by nearly east-west aligned faults along the northern and southern boundaries of the plateau (Murty, 1983). As the geological setting of the Shillong Plateau was discussed by Jauhari and Agarwal (2001), only the stratigraphic details are briefly outlined here.

The southwestern part of the plateau was marked by

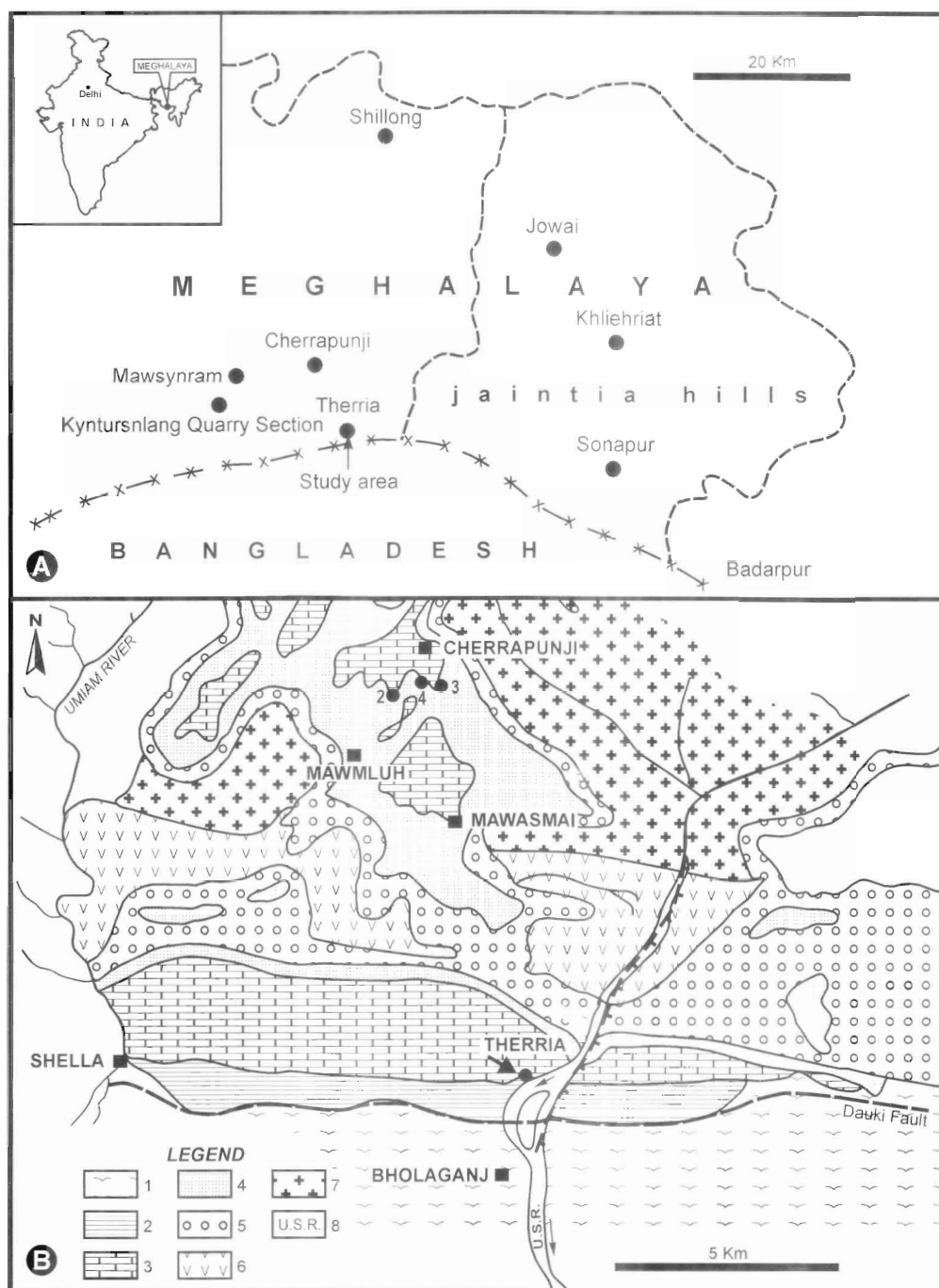


Fig. 1 A. Location of the study area B: Geological map of the area (after Jauhri and Agarwal, 2001). 1: Alluvium, 2: Kopili Formation, 3: Sylhet Limestone Group, 4: Cherra stage (Therria Formation), 5: Langpar Formation, Mahadeo Formation and Um Sohryngkew Formation, 6: Sylhet Trap, 7: Archæan, 8: Um Sohryngkew River.

several marine transgressions during the Late Cretaceous and the early Cenozoic. During the late Palaeocene-early late Eocene, carbonates were extensively deposited in the southwestern part of the plateau. They are referable to the Sylhet Limestone Group which includes three formations, each of which is characterized by a thick carbonate unit correlatable with the European chronostratigraphic stages; the carbonates are intercalated between two sandstone beds (Fig. 2, Table 1).

The Sylhet Limestone is underlain by the sandy Therria Sandstone considered to be late Palaeocene in age and overlain by the Kopili Formation of late Eocene age (Wilson and Metre, 1953; Nagappa, 1959; Chakraborty and Baksi, 1972; Dasgupta,

1977 and Samanta and Raychaudhury, 1983). The uppermost formation of this group is designated as the Prang Formation (middle Eocene). The Prang Formation is a 40 m thick carbonate unit in the study area where it is ideally exposed in a section on the eastern (left) bank of the Um Sohryngkew River near the village Therria (Fig. 1). It is underlain by the Nurpuh Sandstone of the Umlatdoh Formation and overlain by the dominantly silicistellastic unit, the Kopili Formation (Table 1). The carbonate succession shows a sequence of well-preserved calcareous algae and larger foraminifera. The lower part (PL1-PL5/DR) is dominated by wackestones, in which the miliolid foraminifera and green algae occur in large number as bioclasts.

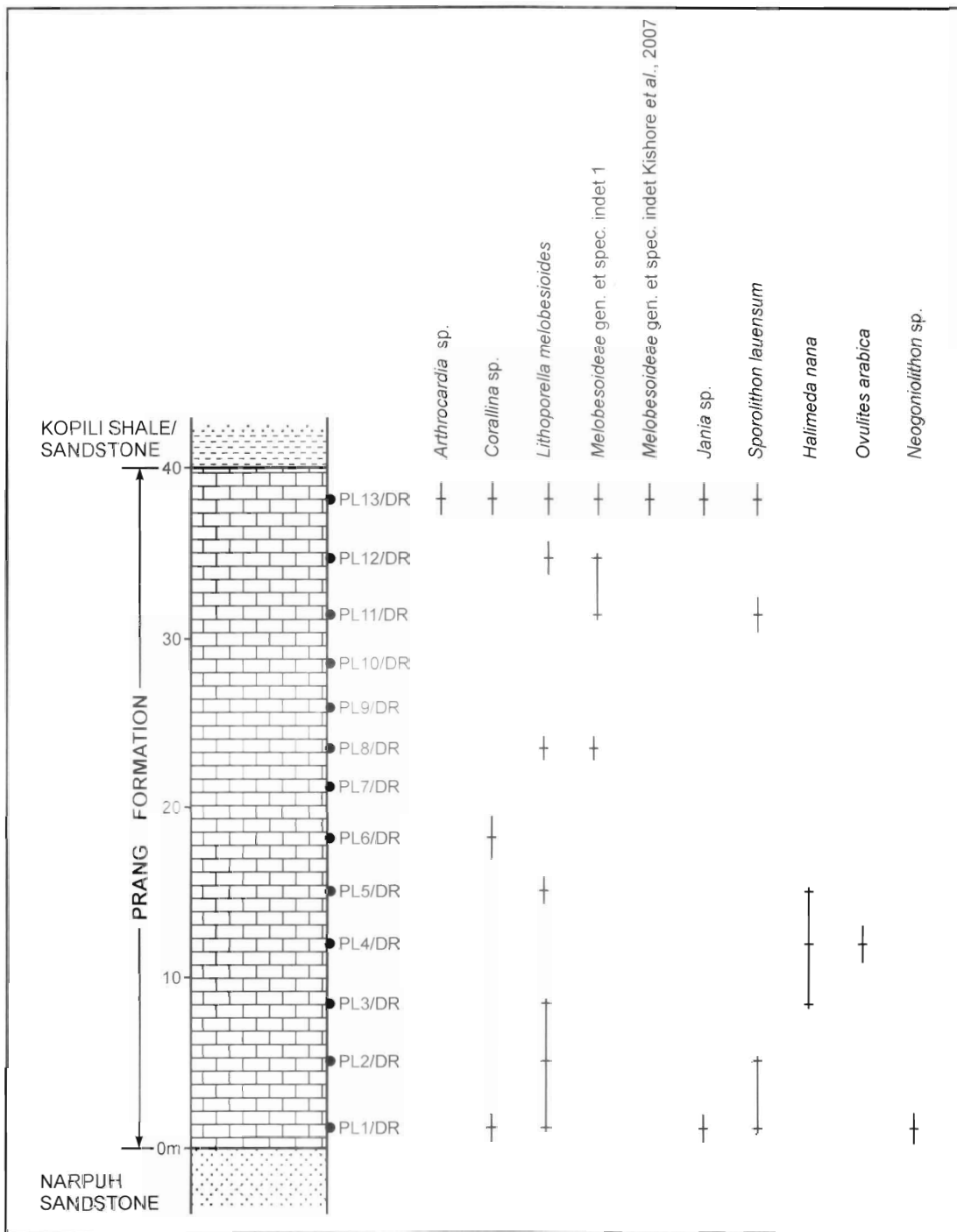


Fig. 2. Distribution of calcareous algal species in the Prang Formation, East Khasi Hills, Meghalaya.

The upper part (PL6-PL13/DR) is represented mainly by packstones and algal boundstones; the latter become dominant near the top and occur as the carbonate framework.

#### FORAMINIFERAL BIOSTRATIGRAPHIC CORRELATION OF THE PRANG FORMATION

Biosratigraphic correlation of the Prang Formation is still not precisely understood. Presence of some zonal indices (e.g. *Nummulites beaumonti*, *N. millicaput* (Boubée), *N. perforatus* (Montfort), *N. gizensis* (Forskal), *Alveolina elliptica* (Sowerby), *Discocyclusina dispansa* (Sowerby), etc.) has allowed its

correlation with Shallow Benthic Zonation (Serra-Kiel *et al.*, 1998). These species suggest equivalence with zones SB15-SB18 which indicate correlation with the time scale refined by Berggren *et al.* (1995). They have also been found to be associated with planktic foraminifera of Zones P13 and P14 in the Khasi, Jaintia and Garo Hills (Samanta, 1969; Mehrotra and Banerji, 1973; Singh *et al.*, 1986), which correspond with the late Lutetian to the Bartonian, i.e. late middle Eocene. In the Garo Hills, the larger foraminifera of the equivalent Siju Limestone occur in association with the planktic foraminifera referable to Zones P13 and P14, corresponding to the late

**Table 1:** Lithostratigraphic succession in Shillong.

KOPILI FORMATION			
SYLHET LIMESTONE GROUP ↑	Prang Formation	Richly fossiliferous, light to dark grey limestone with large nummulitids (50 m)	
	Umlatdoh Formation	Nurpuh Sandstone	Arkasic, ferruginous sandstone (20 m)
		Umlatdoh Limestone	Hard, massive foraminiferal limestone (40 m)
	Lakadong Formation	Lakadong Sandstone	Soft, friable, light coloured sandstone with coaly horizons (12 m)
		Lakadong Limestone	Hard, compact, fossiliferous limestone rich in larger foraminifera (100 m)
	THERRIA FORMATION		
	Therria Sandstone	Hard, compact, burrowed, coarse to medium-grained sandstone (30 m)	
	Therria Limestone	Hard, compact, unbedded limestone (100 m)	
LANGPAR FORMATION			

Lutetian - Bartonian (Samanta, 1969).

Matsumaru and Sarma (2010) studied the faunal succession of the Palaeogene of the Jaintia Hills to provide the correlation of larger foraminifera with Far Eastern Letter stages. They suggested that the upper Palaeocene to upper Eocene formations of the Jaintia Hills correspond with the Tertiary A1 to Tertiary B of the Far Eastern Letter Stages. In this correlation, the Prang Limestone of the Therria section is considered equivalent of the Upper Tertiary a2 to Tertiary a3.

## RESULTS

The following taxa of the calcareous algae have been observed.

### SYSTEMATIC DESCRIPTION

Division **Rhodophyta** Wittstein, 1901  
 Class **Florideophyceae** Cronquist, 1960  
 Subclass **Corallinophycidae** Le Gall and Saunders, 2007  
 Order **Sporolithales** Le Gall *et al.*, 2010  
 Family **Sporolithaceae** Verheij, 1993  
 Genus **Sporolithon** Heydrich, 1897  
*Sporolithon lauensum* Johnson and Ferris 1950  
 (Pl. I, figs. 1-2)

*Achaolithothamnion lauensum* Johnson and Ferris, 1950, p. 11.

**Description:** Growth form encrusting to warty. Protuberances up to 3 mm in diameter and 5 mm long. Thickness of core portion usually 150 µm, sometimes up to 250 µm. Cell shape irregular, cell fusions present. Cell length 20-25 µm, cell diameter 8-12 µm.

Peripheral portion 550µm thick in the encrusting region. Cell shape rectangular, growth rhythms present and trichocytes absent, cell layer irregular, cell fusions present. Cell length 15-20 µm, cell diameter 8-10 µm. Epithallial cells not preserved.

Tetra/bisporangial conceptacles arranged in sori. Several consecutive sori present within one thallus, usually arising from

a layer of elongated cells. Conceptacles ovoid to egg-shaped. Tetra/bisporangial height 60-80 µm, diameter 40-50 µm. 1-3 or sometime more filaments (paraphyses) interspersed between the sporangial compartments.

**Remarks:** Following Woelkerling (1988), Moussavian and Kuss (1990) established the priority of *Sporolithon* Hydrich, 1897 over *Archaeolithothamnium* Rothpletz, 1891. Recently, Lee Gall *et al.* (2010) separated Sporolithaceae family from the order Corallinales and placed it into a separate order Sporolithales on the basis of multiple phylogenetic analysis. The present specimens are morphologically similar to *Sporolithon lauensum* (Johnson and Ferris) in general shape and arrangement of conceptacles in the protuberances. Besides, the growth forms also show similarity with the Johnson and Ferris' (1950) specimens. They reported this species from the upper Miocene of Fiji.

**Slide No.:** 91/PL1/DR; 91/PL2/DR; 91/PL11/DR; 91/PL13/DR/K/M3.

**Locality:** Therria village (Um Sohryngkew River section).

**Order** **Corallinales** Silva and Johansen, 1986

**Family** **Corallinaceae** Lamouroux, 1812

**Subfamily** **Corallinoideae** Gray, 1821

**Genus** **Corallina** Linnaeus, 1758

*Corallina* sp.

(Pl. I, figs. 5-6)

**Description:** Plant geniculate, fragments of thalli about 1.0 mm in length and 100-200 µm in diameter. Genicula not preserved. Core cells of intergenicula 50-80 µm in length and 6-10 µm in diameter. Conceptacles not preserved.

**Remarks:** The present specimen is identified as *Corallina* on the basis of its morphological characters (e.g. cell shape). Due to absence of conceptacles, its specific identification is not possible.

**Slide No.:** 91/PL1/DR; 91/PL6/DR; PL13/DR/K/M1

**Locality:** Therria village (Um Sohryngkew River section).

**Genus** **Jania** Lamouroux, 1812

*Jania* sp.

(Pl. I, fig. 3)

**Description:** Plants composed of long slender segments with diameter ranging from 160 to 180µm and length more than 1.8 mm. Cells of the intergenicula (medullary) are surrounded by a thin zone of cortical filaments. The medullary tissue consists of 'layers' of cells shaped like inverted saucer. The cells are longest at the center of the layer, becoming slightly smaller toward the margins. Cells of intergenicula 30-35 µm in length and 10-15 µm in width. Conceptacles not preserved.

**Remarks:** The present specimen is identified as *Jania* on the basis of its inverted, saucer-shaped cells in the medullary-region. Because of absence of conceptacles, its specific identification is not possible.

**Slide No.:** 91/PL1/DR; 91/PL13/DR/K/M4

**Locality:** Therria village (Um Sohryngkew River section).

**Genus** **Arthrocardia** (Harvey) Areschoug, 1852

*Arthrocardia* sp.

(Pl. I, fig. 4)

### EXPLANATION OF PLATE I

1-2. *Sporolithon lauensum*

1. Showing warty growth-form and peripheral with sporangial conceptacles

2. Showing core and peripheral filaments.

3. *Jania* sp.

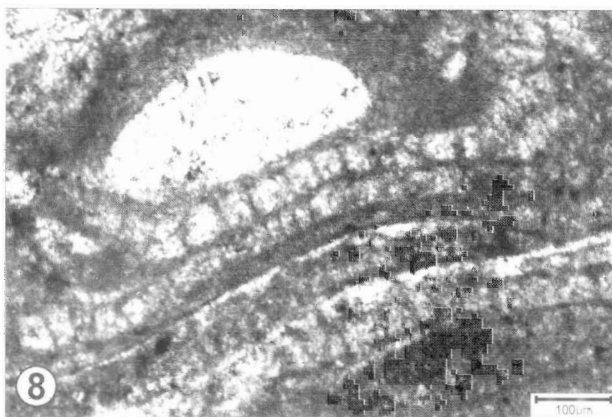
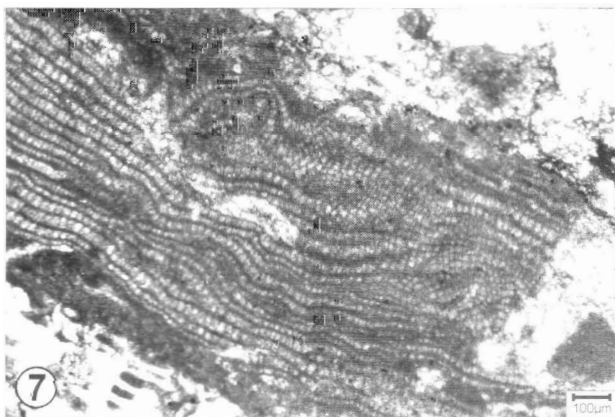
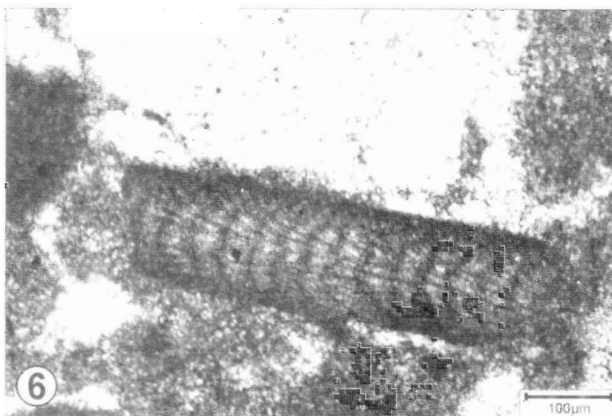
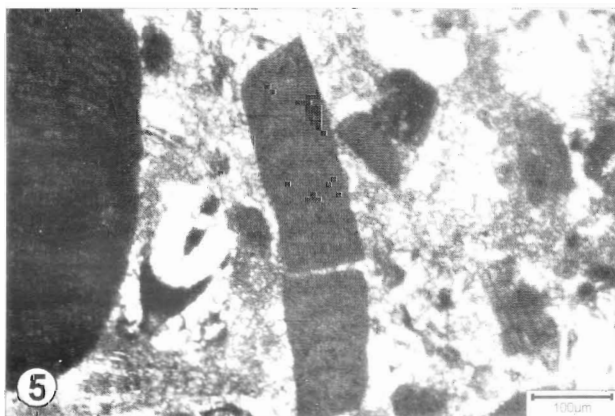
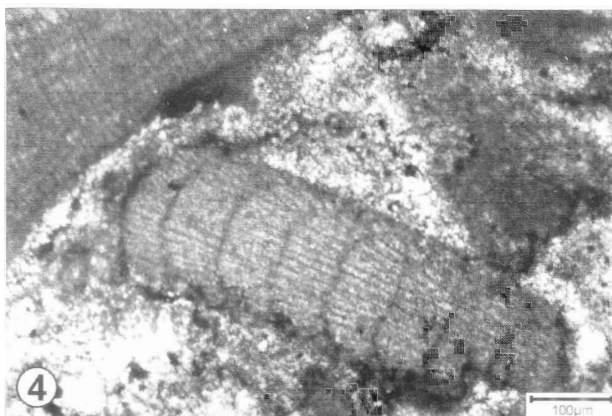
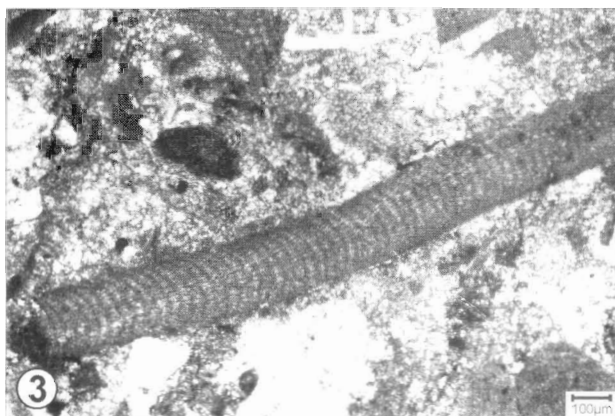
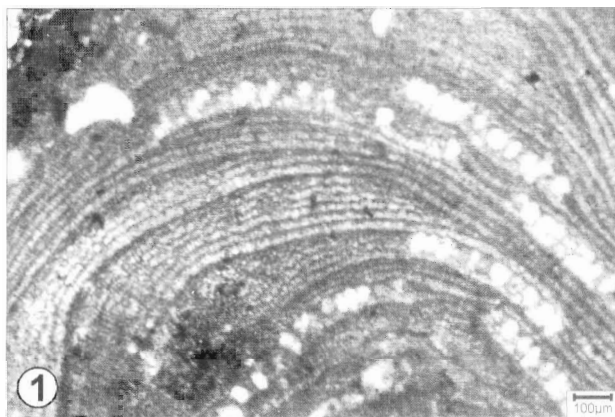
4. *Arthrocardia* sp.

5-6. *Corallina* sp.

7-8. *Lithoporella melobesioides* (Foslie), Foslie, 1909

7. Showing primigenous filaments

8. Enlarge view of primigenous filaments and conceptacles.





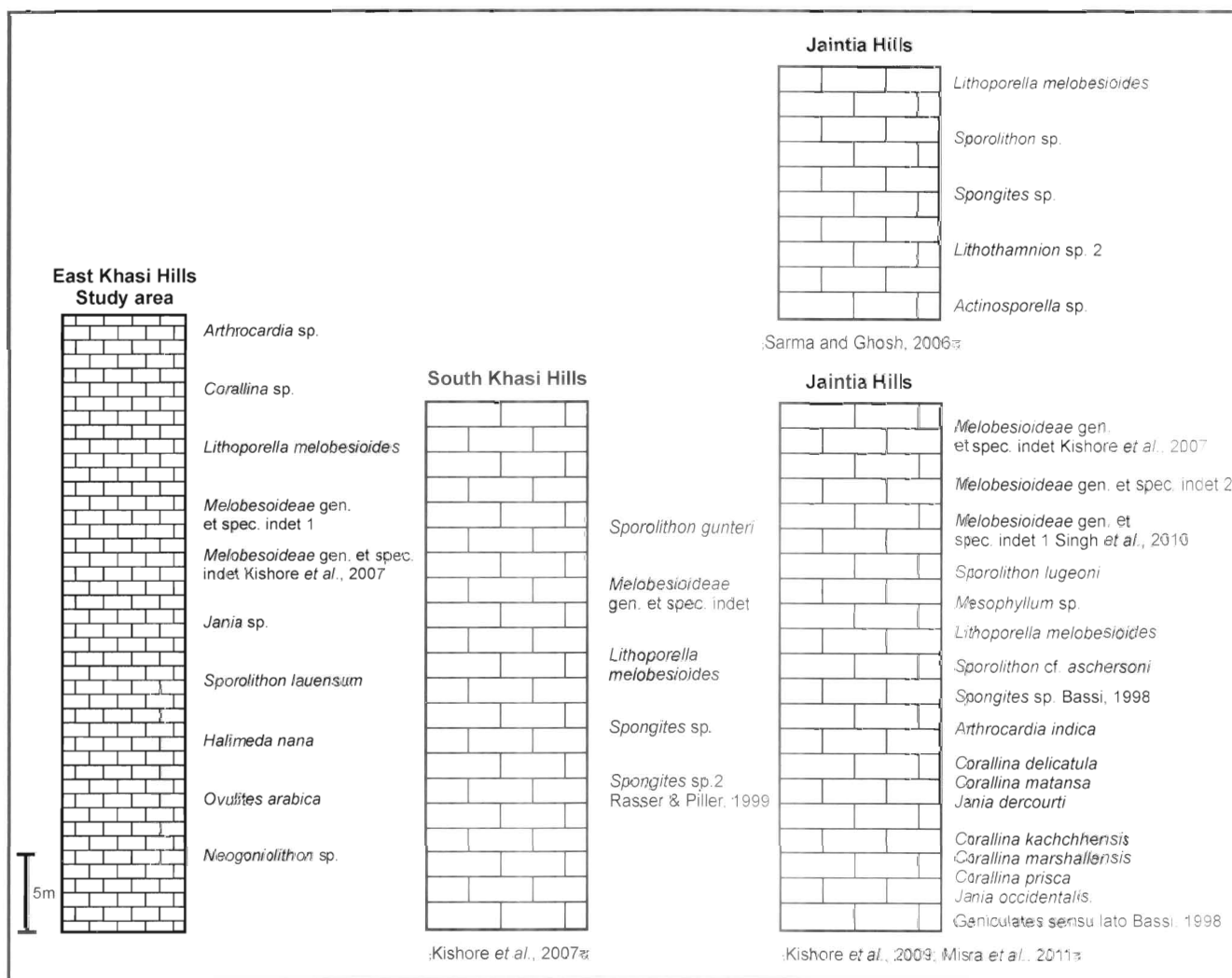


Fig. 3. Comparison of algal flora of the study area and other sections exposing the Prang Formation in Meghalaya

**Description:** Thallus segmented, about 0.55 mm in length and 150-170 µm in diameter. Genicula not preserved, medullary filaments comprising unequal cells. Cells 70-80 µm in length and 10-12 µm in width. Conceptacles not preserved.

**Remarks:** The present specimen is identified as *Arthrocardia* on the basis of its shape and size of cells in the medullary region. Because of absence of conceptacles, its specific identification is not possible.

**Slide No.:** 91/PL13/DR/K/M4

**Locality:** Therria village (Um Sohryngkew River section).

**Subfamily** *Mastophoroideae* Setchell, 1943

**Genus** *Lithoporella* (Foslie) Foslie, 1909

*Lithoporella melobesioides* (Foslie) Foslie, 1909

(Pl. I, figs. 7-8; Pl. III, fig. 7)

*Lithoporella melobesioides* (Foslie) Foslie: Johnson and Ferris,

1950, p. 18-19. - Bosence, 1983, p. 165-166. - Bassi, 1998, p. 19.

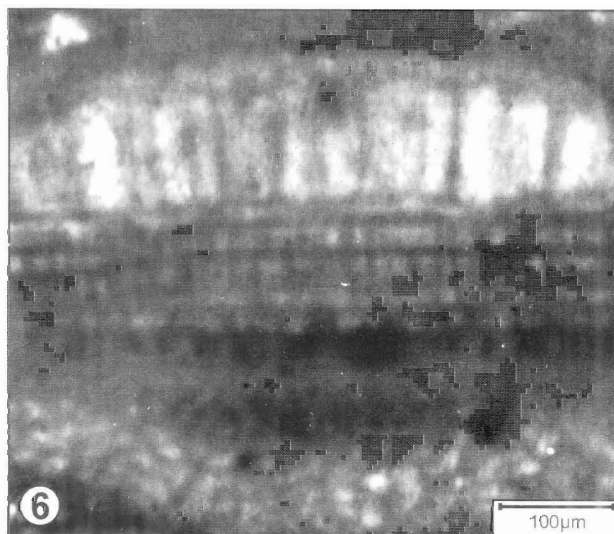
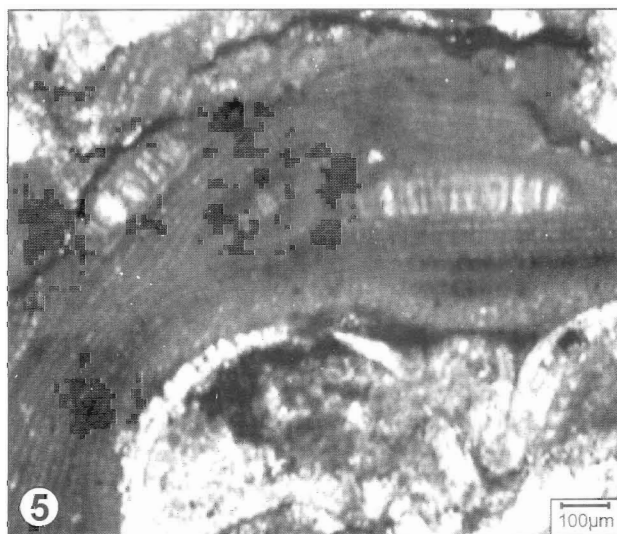
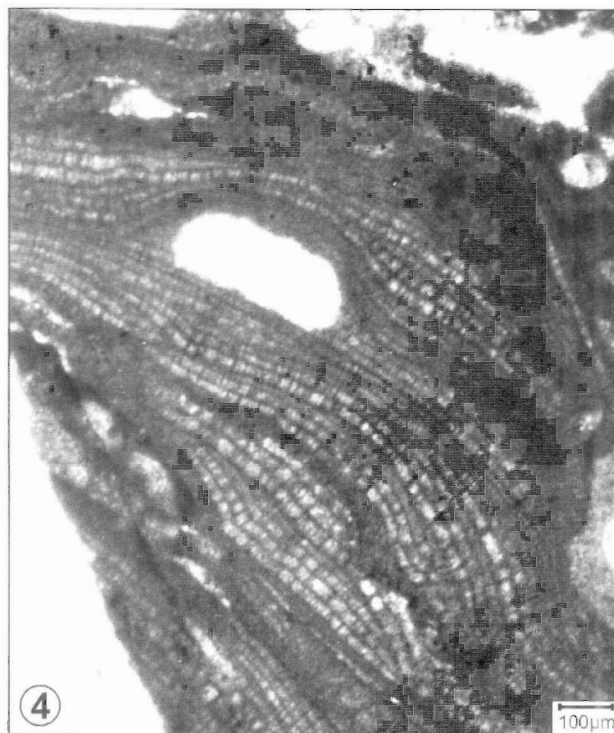
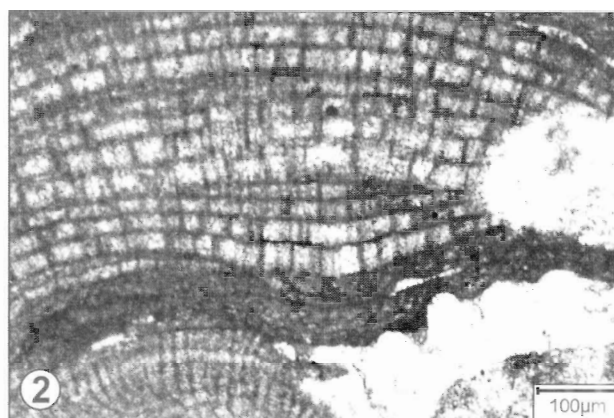
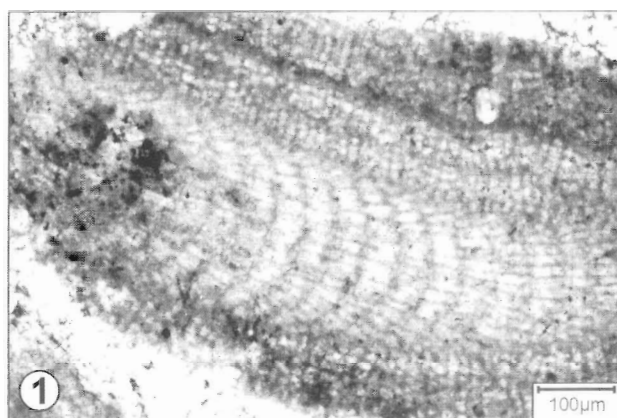
**Description:** Growth form encrusting, thallus either single or multiple (overgrowth), often encrusting on other coralline algae and skeletal material.

Primigenous filaments show cell fusions. Cell length 25-30 µm, cell diameter 20-25 µm. Postigenous filaments poorly preserved around tetrasporangial conceptacles, trichocytes absent. Epithallus not preserved. Tetra/biosporangial conceptacles completely raised above the thallus surface. Conceptacle pores indistinct, conceptacle height 100-130 µm, diameter 250-280 µm.

**Remarks:** The thallus morphology, cell dimensions of primigenous filaments and shape and size of conceptacles indicate affinity of the present specimen with *Lithoporella melobesioides* (Foslie). It has been reported by Bassi (1998)

## EXPLANATION OF PLATE II

1. *Neogoniolithon* sp.
- 2-4. *Melobesioidae* gen. et spec. indet 1
2. Showing core and peripheral filaments with distinct cell fusions.
3. Warty growth-form with multiporate conceptacle
4. Showing encrusting growth-form with conceptacles and peripheral filaments.
- 5-6. *Melobesioidae* gen. et spec. indet Kishore et al., 2007
5. Showing encrusting growth-form with conceptacles
6. Showing enlarged view of conceptacle and non-coxial core filaments



from the late Eocene of Northern Italy, by Rasser and Pillner (1999) from the late Eocene of Austrian Molasse zone, by Kishore *et al.* (2007) from the Prang Formation (middle Eocene) of the South Khasi Hills, Meghalaya, and by Singh *et al.* (2009, 2010) from the middle Eocene and the lower Oligocene of Kachchh, India.

*Slide No.:* 91/PL1/DR; 91/PL2/DR; 91/PL3/DR; 91/PL5/DR; 91/PL8/DR; 91/PL12/DR; 91/PL13/DR/K

*Locality:* Therria village (Um Sohryngkew River section).

*Genus* *Neogoniolithon* Setchell and Mason, 1943

*Neogoniolithon* sp.

(Pl. II, fig. 1)

*Description:* Growth form encrusting. Thallus organisation monomerous. Thallus about 350 µm thick, core filaments coaxial, core portion 200 µm thick, filaments curved both towards ventral and dorsal surfaces; cell fusions abundant, cells 30-35 µm in length and 10-14 µm in width. Peripheral filaments restricted to dorsal and ventral surfaces. Peripheral portion 150 µm thick, cells 8-12 µm in length and 10-12 µm in width. Conceptacles not preserved.

*Remarks:* The present specimen is without reproductive structures but growth form and predominantly the coaxial morphology and abundant cell fusions of core filaments indicate affinity with *Neogoniolithon* Setchell and Mason. Because of absence of conceptacles, it is not presently possible to determine its specific status. Misra *et al.* (2002) reported a relatively similar form as *?Neogoniolithon* sp. from the Lakadong Limestone, East Khasi Hills, Shillong.

*Slide No.:* 91/PL1/DR/A2

*Locality:* Therria village (Um Sohryngkew River section).

*Family* *Hapalidiaceae* Gray, 1864

*Subfamily* *Melobesioideae* Bizzozero, 1885

*Melobesioideae* gen. et spec. indet Kishore *et al.*, 2007 (Pl. II, figs. 5-6)

*Melobesioideae* gen. et spec. indet Kishore *et al.*, 2007, p. 619, pl. 1, fig. 3.

*Description:* Growth form encrusting, thallus thickness of usually 350-400 µm. Thallus organisation monomerous.

Core filaments non-coaxial, predominantly curved towards the dorsal surface, sometimes towards the ventral thallus surface. Core portion usually 80-100 µm thick. Cell fusions present. Cell length 18-20 µm, cell diameter 10-12 µm. The peripheral region (in encrusting portion) restricted to the dorsal part of the thallus; it is usually 350 µm. Growth rhythms absent. Cell length 16-20 µm, cell diameter 20-20 µm. Peripheral cells rectangular or squarish, distinct, arranged in somewhat undulating rows. In the peripheral region, the horizontal walls more distinct than the vertical zones. The epithallial cells not preserved.

Tetra/bisporangial conceptacles immature, showing various developmental stages. Conceptacles distinctly raised above the thallus surface, with a floor of usually six layers (sometimes 8-12 layers) below the thallus surface. Height 120-130 µm, diameter 550-600 µm.

*Remarks:* The present specimen is comparable with a morphologically similar specimen of Kishore *et al.*, 2007

(*Melobesioideae* gen. et spec. indet) in the characteristic shape of its conceptacles. Kishore *et al.* (2007) reported this species from the Prang Formation of the South Khasi Hills, India.

*Slide No.:* 91/PL13/DR/LM2

*Locality:* Therria village (Um Sohryngkew River section).

*Melobesioideae* gen. et spec. indet 1 n. Comb.

(Pl. II, figs. 2-4; Pl. III, figs. 1-4)

*Description:* Growth form encrusting or warty, with branched protuberances, mostly 2.2 mm in height and 0.8-1.0 mm in width. Thallus organisation monomerous.

Core filaments non-coaxial, predominantly curved towards the dorsal surface. Core portion usually 50-60 µm thick. Cell length 16-20 µm, cell diameter 6-10 µm. The peripheral region in the encrusting portion restricted to the dorsal part of the thallus, usually 300-350 µm in size. Cell length 20-25 µm, cell diameter 10-15 µm. Cell fusions present abundant. Growth zones present. The epithallial cells not preserved.

Plant is dioecious. Tetra/bisporangial conceptacles are developed on asexual plant, conceptacles multiporate, with rim (Pl. II, fig. 3), distinctly raised above the thallus surface, with a floor of usually five layers below the thallus surface. Height 100-120 µm, diameter 300 µm. Thickness of roof 30-35 µm, conceptacle pore indistinct (Pl. II, fig. 4).

The Cystocarpic conceptacles are developed on the female gametophytic (i.e. carpogonium) plant, Cystocarpic conceptacles urn-shaped with a distinct opening (ostiole) situated on its distal ends (Pl. III, figs. 1-4). It is parasitic on the female gametophytic plant and is developed from female conceptacle after fertilization to form a diploid structure (i.e. Cystocarp) without columella (Pl. III, figs. 1-4). Height 250-300 µm, diameter 500-550 µm. Pore length 150 µm, diameter 40 µm. Shape of pore canal possibly conical (Pl. I, fig. 5). Cell filaments around conceptacle pores subparallel to the roof measuring 10-15 µm in length and 8-10 µm in diameter.

*Slide No.:* 91/PL13/DR/ML2

*Locality:* Therria village (Um Sohryngkew River section).

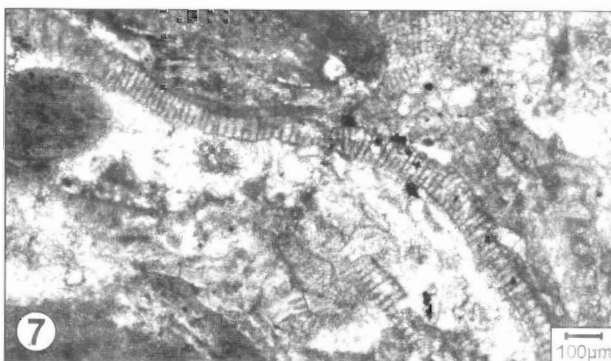
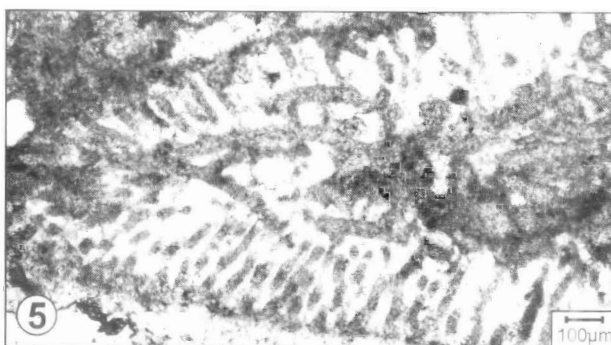
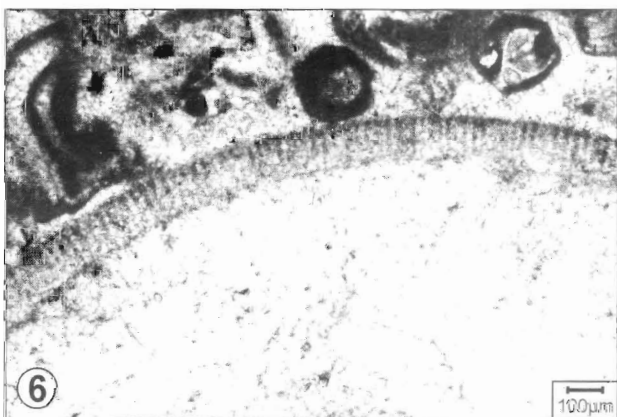
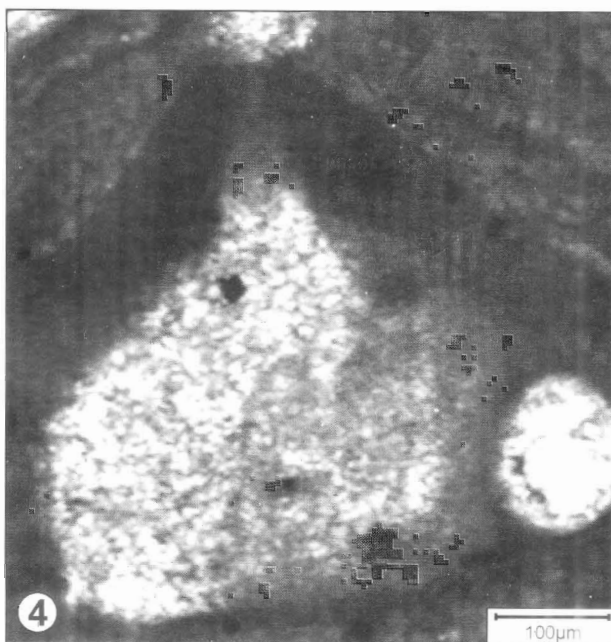
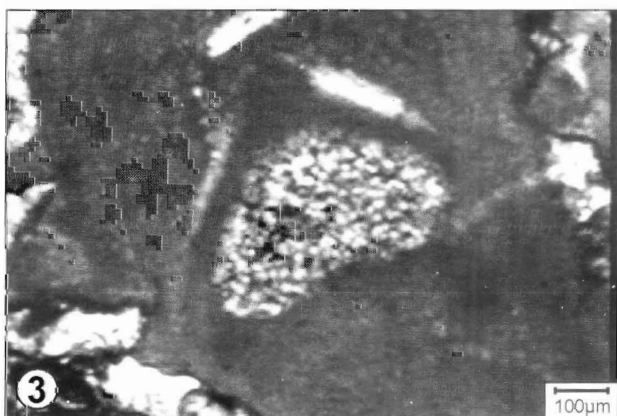
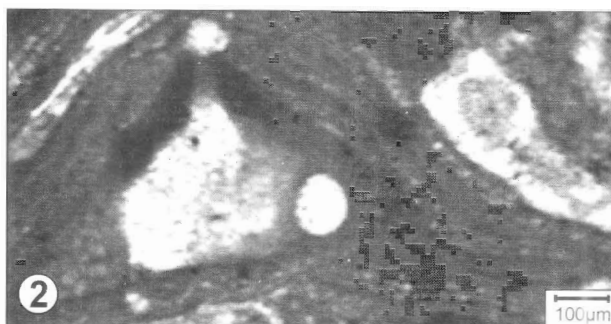
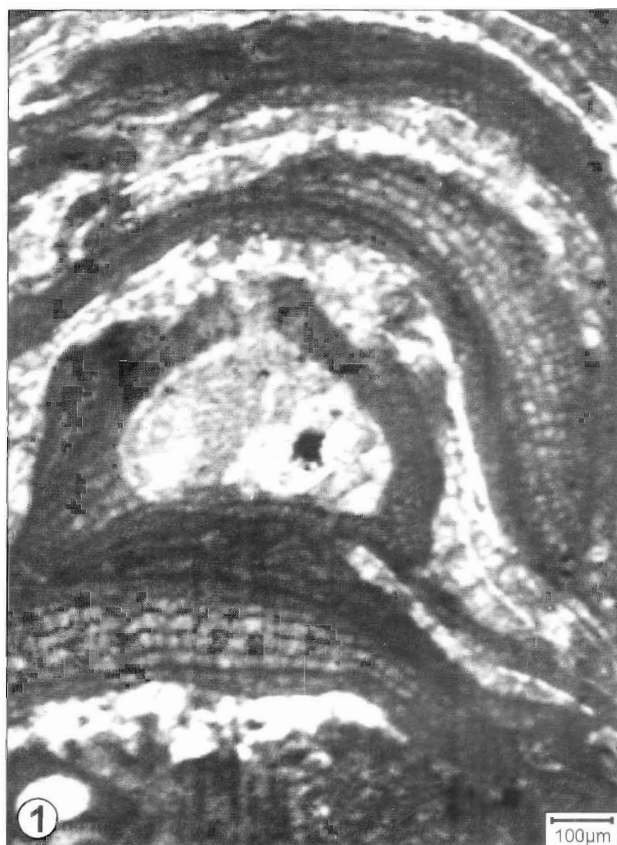
*Remarks:* The present specimens compare well with the genus *Spongites* on the basis of its uniporate nature of conceptacle, but the conceptacles in the present case are much different not only in shape and size but also lack columella. Besides, the shape of pore canal and cells around conceptacle pores are also different. In view of above, the present specimens are compared with the cystocarpic plant of recent material not known in fossil forms. It has an urn-shaped body with a distinct ostiole (i.e. Cystocarp), a feature more closely related to our fossil specimens (Pl. III, figs. 1-4). It is possibly because of this character that we cannot compare our material to any known fossil species. It seems that it is a new species from the study area, though its exact generic identification cannot be made due to absence of epithallial cells. The presence of cell fusions in thallus and multiporate conceptacle indicates its relationship with subfamily *Melobesioideae*. It is therefore kept in open taxonomic nomenclature.

## EXPLANATION OF PLATE III

- 1-4. *Melobesioideae* gen. et spec. indet. 1: Cystocarpic female plant.  
1. Encrusting growth-form of thallus with cystocarp conceptacles  
2-4. Showing cystocarp conceptacles with ostiole

5. *Halimeda nana* Pia, 1932  
6. *Ovulites arabica* (Pfender, 1939), Massieu, 1966  
7. *Lithoporella melobesioides* (Foslie), Foslie, 1939 showing primigenous filaments





Slide No.: 91/PL8/DR; 91/PL11/DR; 91/PL12/DR; 91/PL13/DR/K/G1,M6

Locality: Therria village (Um Sohryngkew River section).

Division **Chlorophyta** Papenfus, 1946

Class **Chlorophyceae** Kützinger, 1843

Order **Siphonales** Blackman and Tansley, 1902

Family **Udoteaceae** Feldman, 1946

Genus **Halimeda** Lamouroux, 1812

*Halimeda nana* Pia, 1932

(Pl. III, fig. 5)

*Halimeda nana* Pia: Elliott, 1955, p. 126. - Kuss and Herbig, 1993, p. 277. - Pia: Kishore, 2004, p. 41.

**Description:** Thallus up to several millimeters, 1.5 mm in length, 0.6 mm in diameter. Medulla composed of a few filaments subparallel to the axis of the thallus. Pores on the outer surface, approximately 25-30 µm in diameter.

**Remarks:** The present specimen is comparable with *Halimeda nana* Pia on the basis of general morphology of the thallus. Kuss and Herbig (1993) reported *Halimeda nana* from the early Tertiary of Egypt and Morocco. Kishore (2004) reported *H. nana* from the Palaeocene of the Cauvery Basin, South India.

Slide No.: 91/PL3/DR; 91/PL4/DR/D2; 91/PL5/DR

Locality: Therria village (Um Sohryngkew River section).

Genus **Ovulites** Lamarck, 1816

*Ovulites arabica* (Pfender, 1939) Massieux, 1966

(Pl. III, fig. 6)

*Ovulites arabica* (Pfender) Massieux: Kuss and Leppig, 1989, p. 323. - Kuss and Herbig, 1993, p. 277. - Kishore, 2004, p. 41.

**Description:** Thallus fragmented, 1.8 mm long, 0.8 mm in diameter, thin calcified, wall perforated by perpendicular crossing, with constant tiny canals, 15-20 µm in length.

**Remarks:** This specimen is comparable with *Ovulites arabica* Massieux on the basis of general morphology of the thallus. Kuss and Herbig (1993) reported *Ovulites arabica* from the early Tertiary of Egypt and Morocco. Kishore (2004) recorded this species from the Palaeocene of the Cauvery Basin, South India.

Slide No.: 91/PL4/DR/D1

Locality: Therria village (Um Sohryngkew River section).

## DISCUSSION AND CONCLUSIONS

The present paper records ten species of calcareous algae from the Prang Limestone which is well exposed in the Um Sohryngkew River section of the East Khasi Hills. These include *Sporolithon lauensum*, *Corallina* sp., *Jania* sp., *Arthrocardia* sp., *Lithoporella melobesoides*, *Neogoniolithon* sp., *Melobesioideae* gen. et spec. indet Kishore et al., 2007, *Melobesioideae* gen. et spec. indet 1, *Halimeda nana* and *Ovulites Arabica* (Fig. 2). Out of these, the occurrence of one species (*Sporolithon lauensum*) is the new record from India, and two species (*Halimeda nana* and *Ovulites Arabica*) are first time recorded from the study area. Except *Melobesioideae* gen. et spec. indet 1 which is a new combination on the basis of its female/carposporophytic plant (i.e. cystocarpic plant), the remaining species are known from different horizons and locations of Meghalaya, India. Of the ten species, eight belong to the division Rhodophyta, five of which are grouped under the family Corallinaceae, two assigned to the family Hapalidiaceae and one to the family

Sporolithaceae. The remaining two species belong to the division Chlorophyta.

The middle Eocene algal taxa present in the Prang Formation of the study area, when compared with those of other sections of Meghalaya (South Khasi Hills and Jaintia Hills), show that the algal flora is well developed in the Prang Formation (Fig. 3), with only some common elements and there is marked differentiation of taxa both at generic and specific levels. When the total (37) species recorded from the three sections of Meghalaya are considered, only two taxa are common at specific level and five taxa at generic level. It seems that despite similar depositional facies of the Prang Formation in these areas, there was little floral similarity and the sequences supported different algal flora.

Biostratigraphically, the algal flora in these areas is coeval. Associated larger foraminifera (e.g. *Nummulites perforatus*, *Alveolina elliptica* and *Discocyclusa dispasa*) suggest a late middle Eocene age to the Prang Formation.

The present algal association comprises two groups, one major group of red algae and the other a minor group of chlorophycean algae. The foraminifera are rich in the lower part and less developed in the upper part. Calcareous algae (e.g. *Melobesioideae*, *Sporolithon*, etc.), on the other hand, are abundant in the upper part, especially in the topmost interval and less represented in the lower part. Associated miliolids and nummulitids suggest shallow, warm water conditions. *Lithoporella* and *Sporolithon* present almost throughout the succession also indicate warm climate (Adey and Macintyre, 1973; Vannucci et al., 2006).

Foraminifera (miliolids, etc.)-dominated lower part with chlorophyceae (e.g. *Halimeda* and *Ovulites*) in good number may have been deposited in the shallow (lagoonal) marine, low-energy environment (Flügel, 1988). The upper part dominated by *Melobesioideae* and *Sporolithaceae* indicates a relatively deep environment (Vannucci et al., 2006 and others cited in it). However, the associated *Mastophoroideae* and geniculate coralline forms (e.g. *Corallina* and *Jania*) in the upper part suggest that the bathymetric interval was near the boundary of inner- and upper mid-shelf (Consigliere et al., 2004-2007). The upper part is thus representative of inner- to mid-shelf environment with fluctuating energy conditions.

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