JOURNAL GEOLOGICAL SOCIETY OF INDIA
Vol.81, April 2013, pp.531-542

Palaeoecological Implications of Corallinacean Red Algae and Halimedacean Green Algae from the Prang Formation of South Shillong Plateau, Meghalaya

AMIT K. GHOSH and SUMAN SARKAR
Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow – 226 007
Email: akghosh_in@yahoo.com

Abstract: The southwestern part of south Shillong plateau (Meghalaya, N-E India), designated as Sylhet Limestone Group is sub-divided into three lithounits i.e., Lakadong, Umlatdoh and Prang formations in ascending order. The Prang Formation is the youngest lithostratigraphic unit of the Sylhet Limestone Group and has been dated as Middle to early Upper Eocene based on the benthic foraminifera studies.

Thin section analysis of carbonate rocks from Prang Formation, exposed in the Bholaganj limestone quarry yielded a rich assemblage of calcareous algae. The coralline algal assemblage comprises both non-geniculate and geniculate forms. The green algae are represented by species of *Halimeda* belonging to the family Halimedaceae.

Palaeoecological interpretation based on diversity, growth-form analysis and taphonomic aspects of the algal assemblage indicate that in all probabilities the deposition of Prang Formation occurred in shallow, warm, shelf environment of normal salinity within the transgressive phase.

Keywords: Calcareous algae, Palaeoecology, Prang Formation, Sylhet Limestone Group, Meghalaya.

INTRODUCTION

Shelf carbonates dominated by calcareous algae and more specifically coralline red algae are exclusively suitable for the fabric analysis of biogenic limestones. According to Nebelsick and Bassi (2000) the fabric of biogenic carbonate sediments can be differentiated using three significant controlling factors:

a) Diversity of constituent components,
b) Features pertaining to their growth-forms, and
c) Consideration of taphonomic aspects.

Moreover, these factors also form the basis for facies differentiation and palaeoecological interpretation.

The present paper deals with the coralline algae-dominated limestones from the Prang Formation (Middle-early Upper Eocene) of south Shillong plateau, Meghalaya, NE India. Special emphasis has been given to the application of modern taxonomic concepts based on recognition of key characters used in modern palaeontological as well as phycological perspectives, growth-forms and the taphonomic features of coralline algae.

GEOLOGICAL SETTING

The study area is a part of the Assam Shelf that represents the north-eastern extension of the Indian Peninsular shield. It is situated in the southern corner of the south Shillong plateau of NE India and borders the plains of Bangladesh. Significant contributions on the geology of this area have been made by Medlicott (1871), Evans (1932), Ghosh (1940), Wilson and Metre (1953), Nagappa (1959), Biswas (1962), Chakraborti and Baksi (1972), Dasgupta (1977), Murthy et al. (1978), Samanta and Raychoudhury (1983) and Murty (1983). According to Murty (1983) this part of the Peninsular shield is dissected by a number of faults and the Shillong plateau emerged as an uplifted part of the basement bounded by the almost east-west aligned faults along the northern and southern boundaries of the plateau. It is represented by well developed carbonate rocks of Late Palaeocene to Middle Eocene age belonging to the Sylhet Limestone Group. It includes three formations viz., Lakadong, Umlatdoh and Prang (Table 1). Till date, micropalaeontological studies from the Palaeogene sequence of south Shillong plateau have revealed occurrence of very well preserved foraminifera (Pandey, 1972, 1978; Pandey and Ravindran, 1988; Jauhri, 1994, 1996, 1998;

Table 1. Generalized stratigraphic succession of the Palaeocene-Eocene sediments of South Shillong Plateau, Meghalaya

Lithostratigraphic unit			Thick-ness	Lithology	Epoch
Sylhet Limestone Group	Prang Formation		200 m	Richly fossiliferous limestone with large Discocyclinids and Nummulitids	Middle Upper Eocene
	Umlatdoh Formation	Narpuh Sandstone	20 m	Arkosic ferruginous sandstone (No algae and foraminifera)	Early Eocene
		Umlatdoh Limestone	55 m	Hard massive foraminiferal limestone	Late Palaeocene to Early Eocene
	Lakadong Formation	Lakadong Sandstone	25 m	Soft, friable, light-coloured sandstone with coaly horizons	Late Palaeocene
		Lakadong Limestone	200 m	Hard, compact fossiliferous limestone rich in larger foraminifera	
Therria Formation		Therria Sandstone	25 m	Hard, compact, coarse medium grained sandstone	
		Therria Limestone	70 m	Hard, sandy, dolomitic limestone	
Langpar Formation			200 m	Calcareous, fine shales with occasional carbonaceous bands	Early Palaeocene

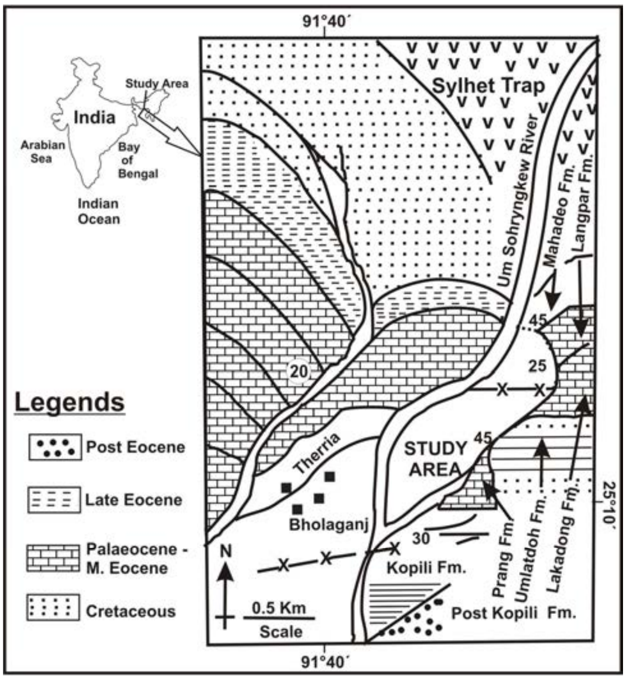

Fig.1. Part of the geological map of South Shillong Plateau showing the study area (Modified after Pandey, 1978) with map of India in the inset.

Jauhri and Agarwal, 2001), dinoflagellates (Garg and Jain, 1995; Garg and Khwaja-Ateequzzaman, 2000) and calcareous algae (Rao, 1943; Pal and Dutta, 1979; Boruah and Dutta, 2001; Misra et al. 2002; Gogoi et al. 2003; Ghosh, 2003). However, previous studies on the algal flora pertaining to this area have been mostly done from the Palaeocene rocks. Earlier, Sarma and Ghosh (2006) and Misra et al. (2011) have recorded an assemblage of calcareous algae, while Kishore et al. (2009) reported geniculate coralline algae in particular from the Prang Formation of Jaintia Group, Meghalaya. Recently Matsumaru and Sarma (2010) have carried out biostratigraphic analysis of the Lower Tertiary from the Jaintia Group based on benthic foraminifera that includes the foraminiferal assemblage from the Prang Formation. For the first time, the present study has been carried out from the Eocene of Prang Formation belonging to the Sylhet Limestone Group.

MATERIALS AND METHODS

Samples for the present study were collected from the outcrop section in the Bholaganj Limestone Quarry near Therria village (Figs. 1 and 2). Studies have been carried out in the entire section however; the productive samples in the section have been marked by characteristic symbols in Fig.2. Thin sections were prepared following conventional method and a total of 31 productive thin sections made from the two yielding samples were analysed using microscope. Qualitative as well as quantitative assessments (especially for the growth-forms) were made for the study of coralline algal diversity. Species taxonomy is a major barrier in palaeobiological analysis based upon coralline algae (Bosence, 1991; Braga et al. 1993; Braga and Aguirre, 1995; Aguirre and Braga, 2005; Aguirre et al. 2007). In the present study, in case of some specimens an open specific nomenclature has been adopted (where no appropriate species names are available) following the systematics proposed by Woelkerling (1988), Braga et al. (1993), Aguirre and Braga (1998), Braga (2003) and Harvey et al. (2003). Coralline algal growth-form terminology follows Woelkerling et al. (1993). The cell and thallus dimensions were measured. The maximum cell diameters of peripheral filaments were measured in the sections perpendicular to the direction of filament growth. All other dimensions were measured in sections parallel to the growth direction (Rasser and Piller, 1999). At least 15 cells of each cell type have been measured. The mean (M) and standard deviation (SD) have also been calculated by the conventional biometric methods.

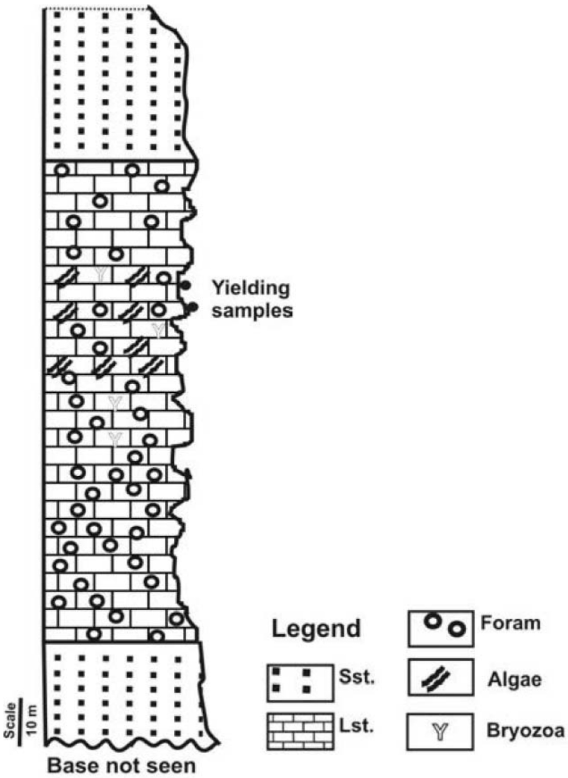

Fig.2. Litholog of the studied section.

SYSTEMATIC PALAEONTOLOGY

Division: RHODOPHYTA Wettstein 1901
Order: CORALLINALES Silva and Johansen, 1986
Family: HAPALIDIACEAE Gray 1864 emend. Harvey et al. 2003
Subfamily:MELOBESIOIDEAE Bizzozero 1885

Genus *Lithothamnion* Heydrich 1897a

Lithothamnion ramosissimum
Plate 1, Figs. 1-3

Description: Encrusting growth-form, thallus 1.2-1.545 mm long and 1.275-1.3 mm wide. Monomerous thallus composed of numerous layers of cells. Non-coaxial primigenous filaments, cell fusions present. Cells of the primigenous filaments are 22.5-25 µm in length (M=24, SD=1.37) and 12.5-17.5 µm in diameter (M=15, SD=2.5). Postigenous filaments non-coaxial, cell fusions are present. Cells of the postigenous filaments measure 15-20 µm in length (M=16.5, SD=2.24) and 12.5-15 µm in diameter (M=13.5, SD=1.37). Conceptacle bi/tetrasporangial, multiporate, height of conceptacles range from 87.5-112.5 µm in height (M= 100, SD= 10.2) and 150-350 µm in diameter (M=243.75, SD=108.73).

Remarks: Owing to monomerous thallus organization with non-coaxial primigenous filaments and multiporate conceptacles, the presently described form is assignable to the genus *Lithothamnion*. Our specimens are closely comparable to *Lithothamnion ramosissimum* (Reuss) Piller based on the dimensions and nature of the conceptacles and cells of the postigenous filaments. Conti (1946) has described similar forms as *Palaeothamnium archaeotypum* from the Leitha Limestone (Middle Miocene) of Vienna. Piller (1994) included *P. archaeotypum* in *L. ramosissimum.* Aguirre et al. (1996), however, opined that the type species of *Palaeothamnium archaeotypum* is a younger heterotypic synonym of *Lithothamnion ramosissimum* (Reuss) Piller.

Melobesioideae gen. et. spec. indet.
Plate 1, Figs. 4-6

Description: Encrusting growth-form, thallus 1.4-2.5 mm long and 1.7-2.4 mm wide. Monomerous thallus, primigenous filaments non-coaxial, cell fusions present. Cells of the primigenous filaments are 20-25 µm in length (M=22.67, SD=2.73) and 10-25 µm in diameter (M=15.33, SD=3.98). Postigenous filaments non-coaxial, cell fusions are present. Cells of the postigenous filaments measure 14-20 µm in length (M=16.5, SD=2.6) and 9-20 µm in diameter (M=14, SD=3.18). Bi/tetrasporangial multiporate conceptacle measures 175-375 µm in length and 350-800 µm in diameter.

Remarks: Owing to monomerous thallus organization with non-coaxial primigenous filaments, multiporate conceptacle and presence of cell fusions, the presently described form is assignable to the subfamily Melobesioideae. However, due to the absence of any pore canal, assignment of a generic name is difficult.

Genus *Mesophyllum* Lemoine 1928
?*Mesophyllum* sp.
Plate 1, Fig. 7

Description: Encrusting growth-form, thallus 2.6 mm long and 1.8 mm wide. Monomerous thallus composed of a numerous layers of cells. Primigenous filaments are coaxial, cell fusions present. Cells of the primigenous filaments measure 17.5-25 µm in length (M=20.5, SD=3.26) and 12.5-20 µm in diameter (M=16, SD=3.8). Postigenous filaments coaxial, cell fusions are present. Cells of the postigenous filaments measure 10-15 µm in length (M=12.5, SD=2.8) and 7.5-12.5 µm in diameter (M=9.6, SD=1.98).

Remarks: Owing to monomerous thallus organization, with coaxial primigenous filaments, the presently described form can be assigned to the genus *Mesophyllum*. However, multiporate, tetra/bisporangial conceptacles are obscure. The presently described form is not comparable to any existing species of the genus *Mesophyllum.* Moreover, characteristic conceptacles of *Mesophyllum* have not been observed. In view of this, the presently described form has been tentatively placed under the generic name *Mesophyllum.*

Family SPOROLITHACEAE Verheij 1993

Genus *Sporolithon* Heydrich 1897b

Sporolithon sp.1
Plate 1, Fig. 10

Description: Warty growth-form, thallus 3.8 mm long and 1.25 mm wide. Monomerous thallus with calcified sori, apical plugs present and spores are cruciately arranged. Primigenous filaments non-coaxial, with the cells being squarish to trapezoidal, 12.5-14 µm in length (M= 13.5, SD=1.2) and 12.5-13.5 µm in diameter (M=13, SD=1). Postigenous filaments are non-coaxial, with the cells being squarish to slightly polygonal, measuring 14-18 µm in length (M=16.5, SD= 2.5) and 14-16 µm in diameter (M=15, SD=1). Sporangia measure 35-65 µm in height (M=50, SD=13.3) and 22-30 µm in diameter (M=25.4, SD=3.39).

Remarks: Based on the available characteristic features viz., presence of monomerous thallus organization with non-coaxial primigenous filaments, calcified sori, apical plugs and cruciately arranged spores the presently described form is assignable to the genus *Sporolithon*. However, this species is not comparable to any of the previously described species of the genus.

Sporolithon afonense
Plate 1, Fig. 11

Description: Warty growth-form, thallus 2.8 mm in length and 0.8 mm in diameter. Monomerous thallus with calcified sori, apical plugs present and spores cruciately arranged. Primigenous filaments non-coaxial with the cells squarish to slightly trpaezoidal and measuring 12.5-17.5 µm in length (M=15, SD=2.5) and 12.5-17.5 µm in diameter (M=15, SD=2.85). Postigenous filaments non-coaxial, with cells rectangular and measuring 17.5-22.5 µm in length (M=19.5, SD=2.45) and 10-15 µm in diameter (M=12.5, SD=2.5). Sporangia measure 70-110 µm in height (M=88, SD=14.5) and 40-80 µm in diameter (M=53, SD=12.5).

Remarks: Owing to the presence of monomerous thallus organization with non-coaxial primigenous filaments, calcified sori, apical plugs and cruciately arranged spores, the presently described form is assignable to the genus *Sporolithon*. This specimen resembles *S. afonense* (Maslov, 1956) Bassi et al. 2007 known from the Early Eocene sediments of Novyj Afon, Abkhazia in growth-form of the thallus, shape and dimension of cells for both primigenous and postigenous filaments as well as dimensions of the sporangia.

Sporolithon sp. cf. *S. gunteri*
Plate 1, Fig. 12

Description: Warty growth-form, thallus 850 µm in length and 950 µm in diameter. Monomerous thallus with calcified sori, apical plugs present and spores cruciately arranged. Primigenous filaments non-coaxial with the cells measuring 10-15 µm in length (M=13, SD=2.09) and 5-10 µm in diameter (M=7.5, SD=2.5). Postigenous filaments non-coaxial, with cells measuring 10-17.5 µm in length (M=14, SD=2.85) and 7.5-10 µm in diameter (M=9, SD=1.37). Sporangia measure 45-60 µm in height (M=54, SD=7.33) and 25-35 µm in diameter (M=30, SD=5).

Remarks: Based on the characteristic features viz., non-coaxial primigenous filaments, calcified sori, apical plugs and cruciately arranged spores along with a typical monomerous thallus organization the present specimen is assignable to the genus *Sporolithon.* Cell dimensions of primigenous and postigenous filaments are comparable to *S. gunteri* Johnson & Ferris (1948) reported from the Eocene of Florida, U.S.A. However, there is slight difference in the sporangial dimensions and hence, the present specimen has been treated as *Sporolithon* sp. cf. *gunteri*.

Family CORALLINACEAE Lamouroux, 1812
Subfamily MASTOPHOROIDEAE Setchell, 1943

Genus *Lithoporella* Foslie 1909

Lithoporella melobesioides (Plate 1, Figs. 8 & 9)
Lithoporella melobesioides
Plate 1, Figs. 8-9

Description: Encrusting growth-form, thallus 1.925 mm long and 1.025 mm wide. Dimerous thallus with primigenous filaments well preserved, composed of large vertically elongated mega cells having cell fusions, cells measure 27.5-37.5 µm in length (M=32.8, SD=3.17) and 20-25 µm in diameter (M=23.9, SD=3.09). Conceptacle measures 225 µm in diameter and 130 µm in height (Plate 1, Fig.9). Postigenous filaments unpreserved.

Remarks: Owing to the nature of the primigenous filaments, occurrence of megacells and overall anatomical

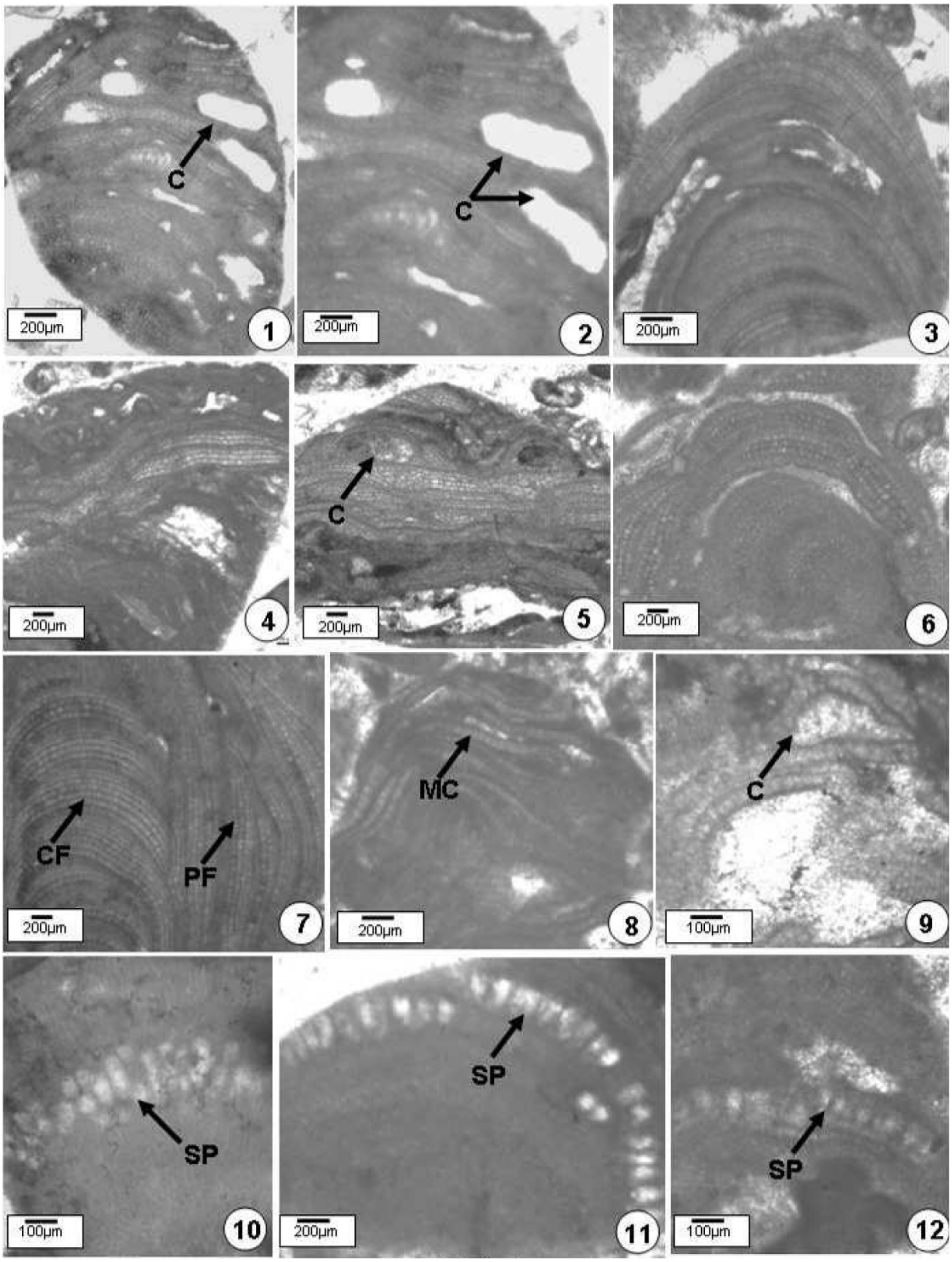

Plate 1. **(1)** *Lithothamnion ramosissimum*, Encrusting thallus with multiporate conceptacles (C), Slide No. BSIP 13995. **(2)** *Lithothamnion ramosissimum*, Magnified view of the encrusting thallus with conceptacle (C), Slide No. BSIP 13995. **(3)** *Lithothamnion ramosissimum* Slide No. BSIP 13996. **(4)** *Melobesioideae* gen. et. spec. indet., Slide No. BSIP 13997. **(5)** *Melobesioideae* gen. et. spec. indet., Thallus showing conceptacle (C), Slide No. BSIP 13997 (II). **(6)** *Melobesioideae* gen. et. spec. indet., Slide No. BSIP 13934. **(7)** ?*Mesophyllum* sp., Thallus showing core (CF) and peripheral (PF) filaments, Slide No. BSIP 13998. **(8)** *Lithoporella melobesioides,* Encrusting form with mega cells (MC), Slide No. BSIP 13994. **(9)** *Lithoporella melobesioides*, Thallus with a well-defined conceptacle (C), Slide No. BSIP 13995 (II). **(10)** *Sporolithon* sp. 1., Thallus with sporangia (SP), Slide No. BSIP 13935. **(11)** *Sporolithon afonense*, Magnified view of thallus with sporangia (SP), Slide No. BSIP 13934 (II). **(12)** *Sporolithon* sp. cf. *S. gunteri*, Thallus showing sporangia (SP), Slide No. BSIP 13992.

features of the thallus, the presently described form is assignable to the genus *Lithoporella* Foslie 1909. Our specimens are very closely comparable to *Lithoporella melobesioides* Foslie 1909 described from the Late Eocene of Austrian Molasse Zone (Rasser and Piller, 1999).

Subfamily CORALLINOIDEAE (Areschoug) Foslie 1908

Genus *Corallina* Linnaeus 1758

Corallina kachchhensis
Plate 2, Figs. 1-2

Description: Geniculate plant, only the intergenicula are preserved. Thallus 500-700 μm in length and 237.5-300 μm in diameter. Cells of intergenicula quite distinct, measuring 27.5-55 μm in length (M=43.25, SD=11.38) and 7.5-20 μm in diameter (M=14.25, SD=3.73).

Remarks: Owing to the presence of cell fusions in intergenicula, the presently described form is assignable to the genus *Corallina*. The present specimen resembles *Corallina kachchhensis* instituted by Kundal & Humane (2003) from the Oligocene to Miocene sediments of Kachchh. However, cells of intergenicular filaments are slightly smaller in dimensions.

Corallina matansa
Plate 2, Figs.3-4

Description: Geniculate plant with only the intergenicula preserved. Dimension of thallus ranges from 550-625 μm in length and 237.5-250 μm in diameter. Cells of intergenicula are distinct, measuring 37.5-60 μm in length (M= 46.75, SD=7.17) and 10-20 μm in diameter (M=15.6, SD=2.84). Conceptacle present (Plate 2, Fig. 3), 105 μm in height and 45 μm in diameter.

Remarks: Morphology and cell dimensions of the presently described species of *Corallina* resembles *Corallina matansa* Johnson 1957 reported from the Upper Eocene of Hagman Formation and both pink and white facies of Mantasa limestone (Saipan). Later on, this species was recorded from the Eocene of Guatemala (Johnson and Kaska, 1965) and from the Oligocene to Miocene sediments of Kachchh (Kundal and Humane, 2003).

Genus *Jania* Lamouroux 1812
Jania occidentalis
Plate 2, Fig. 5

Description: Geniculate plant, thallus 725 μm long and 150 μm wide. Cells of intergenicula measure 27.5-42.5 μm in length (M=36, SD= 5.48) and 5-7.5 μm in diameter (M=6.5, SD= 1.37).

Remarks: Owing to the absence of cell fusions in the intergenciular cells, the presently described form is assignable to the genus *Jania*. The present species resembles *J. occidentalis* reported by Johnson and Kaska (1965) from the Palaeocene of Guatemala, Beckmann (1982) from the Monte Giglio, Italy; Misra et al. (2002) from the Lakadong Formation, Khasi hills, Meghalaya, India and Kishore et al. (2009) from the Prang Formation, Jaintia hills, Meghalaya, India.

Division CHLOROPHYTA
Class BRYOPSIDOPHYCEAE Round 1963
Order BRYOPSIDALES Schaffner 1922
Suborder HALIMEDINEAE Hillis-Colinvaux 1984
Family HALIMEDACEAE Link 1832

Genus *Halimeda* Lamouroux 1812

Halimeda fragilis
Plate 2, Fig. 6

Description: Longitudinal section of the segment of the thallus more or less ellipsoidal, measuring 2 mm in length and 462.5 μm in diameter. Siphons in the medullary region are ill-preserved while the utricles are well developed measuring 85-110 μm in length (M=98, SD= 10.37) and 27.5-35 μm in diameter (M=31.5, SD=3.35).

Remarks: Solitary longitudinal section of the segment described here is very closely comparable to *Halimeda fragilis* Taylor 1950 described by Dragastan and Soliman (2002) from the Palaeogene of Egypt.

Halimeda cylindracea
Plate 2, Fig.8

Description: Transverse section of the segment of the thallus more or less oval to elongate with a slight lateral compression, measuring 5.125 mm in length and 2.8 mm in diameter. Utricles in the cortical region are not very well developed but the siphons in the medullary region are well developed measuring 125-195 μm in height (M=165, SD=26.22) and 45-115 μm in diameter (M=72, SD=27.29).

Remarks: The presently described form resembles *Halimeda cylindracea* Decaisne 1842 figured by Dragastan and Soliman (2002, text-fig. 15, no. 4). *Halimeda* segments of similar affinity were earlier reported as *Halimeda nana* by Pia (1932) from the Palaeocene of Morocco and Kuss and Herbig (1993) from the Thanetian-Ypresian of NE Egypt. Dragastan & Soliman (2002) included 19 fossil species of *Halimeda* (from Late Cretaceous to Pleistocene) under the taxon *H. cylindracea* Decaisne 1842 and considered them to be synonymous.

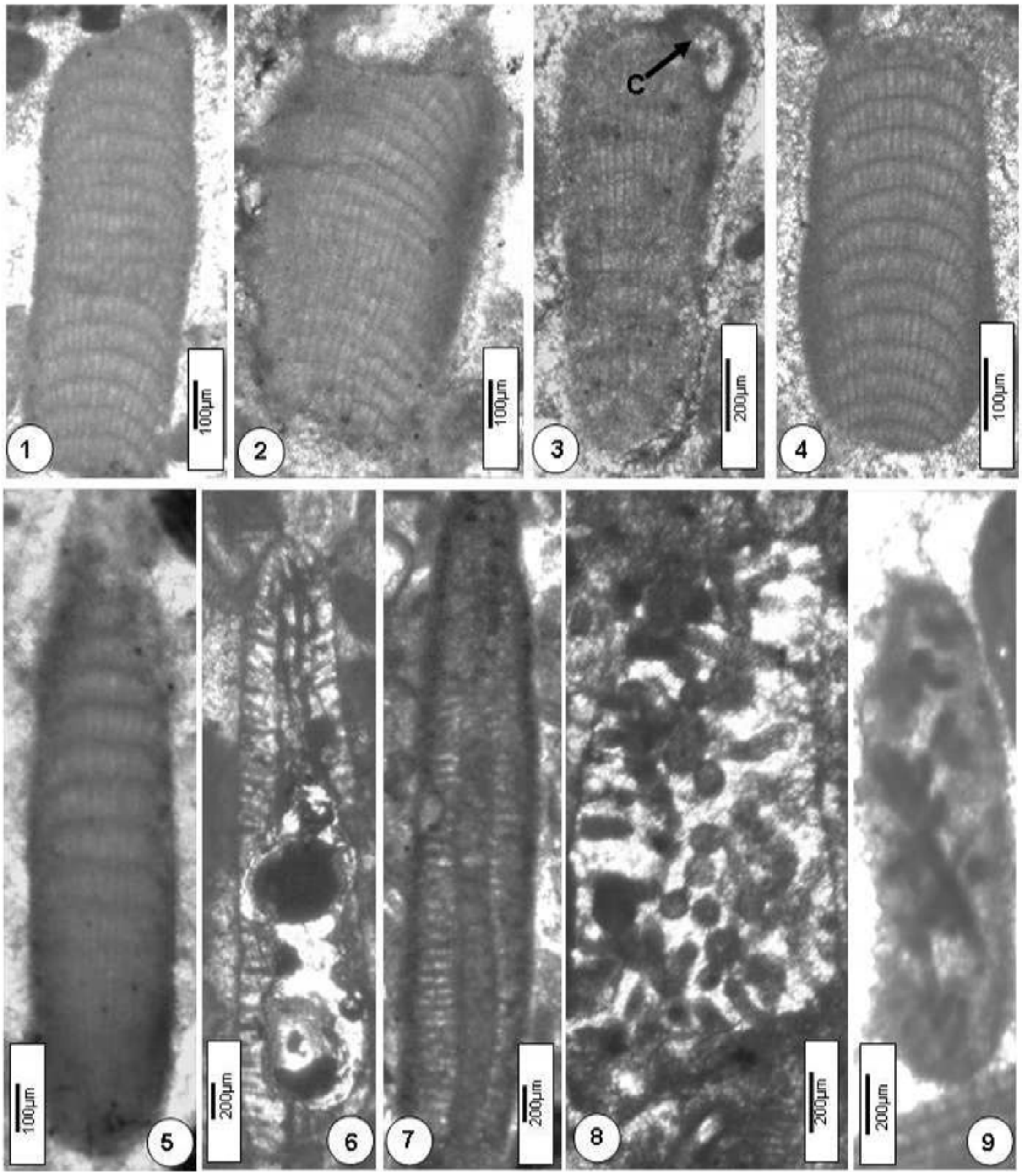

Plate 2. (1) *Corallina kachchhensis* Thallus with distinct intergenicula, Slide No. BSIP 13995 (III). **(2)** *Corallina kachchhensis*, Slide No. BSIP 13995 (IV). **(3)** *Corallina matansa*, Intergenicula with conceptacle (C), Slide No. BSIP 13997 (II). **(4)** *Corallina matansa*, Slide No. BSIP 13992 (II). **(5)** *Jania occidentalis*, Slide No. BSIP 13995 (V). **(6)** *Halimeda fragilis*, Thallus with well preserved utricles, Slide No. BSIP 13998 (II). **(7)** *Halimeda* sp. A, Slide No. BSIP 13993. **(8)** *Halimeda cylindracea*, Thallus with well developed siphons in the medullary region, Slide No. BSIP 13995 (VI). **(9)** *Halimeda* sp. B, Slide No. BSIP 13997 (III).

Halimeda sp. A
Plate 2, Fig.7

Description: Longitudinal section of the segment of the thallus more or less cylindrical, measuring 2.425 mm in length and 450 µm in diameter. Siphons in the medullary region are ill-preserved while the utricles show quite a fair degree of preservation, measuring 75-125 µm in length (M=99, SD=21.62) and 22.5-35 µm in diameter (M=27.5, SD=5). The cortical axis measures 1375 µm in length and 150 µm in diameter.

Remarks: In overall anatomical features the solitary longitudinal section of the segment described here is assignable under the genus *Halimeda*. However, the presently described form is not comparable to any known species of the genus *Halimeda.* As a matter of fact, an open specific nomenclature has been adopted and the present form has been described as *Halimeda* sp. A.

Halimeda sp. B
Plate 2, Fig.9

Description: Longitudinal section of the segment of the thallus more or less cylindrical, measuring 1.025 mm in length and 325 μm in diameter. Siphons as well as the utricles show ill preservation. Siphon tubes measure 25-30 μm in diameter (M= 28.33, SD= 2.89).

Remarks: Solitary transverse section of the segment recovered in the present study has been described here as *Halimeda* sp. B. This species is not comparable to any previously described species of *Halimeda*.

RESULTS

Growth-form Analysis

For delimitation and identification of non-geniculate coralline algal genera and species, variations of algal growth-forms have been widely used (Lemoine, 1911, 1939; Adey et al. 1982). Range of growth-forms present amongst non-geniculate coralline algae has been determined by Woelkerling et al. (1993). The variation of growth-forms within species also has been observed and this is related to differences in hydrodynamic energy and substrate morphology (Johnson, 1961; Cabioch, 1969; Adey and Adey, 1973; Bosence, 1976; Dethier, 1994). The effect of physical and environmental parameters on growth-forms of coralline algae has been specifically noted for algal ridges (Adey, 1979; Bosence and Pedley, 1982; Bosence, 1983). Two important factors can control the growth-forms of coralline algal thalli in thin sections viz., orientation of thalli in the sediment and the effect of thin sectioning. However, concept of these growth-forms has been applied to fossil coralline algae in thin section analysis (Bassi, 1998; Rasser and Piller, 1999). In the present analysis, five different growth-forms have been encountered. Irrespective of their generic and specific delimitation, qualitatively and quantitatively these are: Encrusting (10%), Warty (20%), Lumpy (15%), Layered Lamellae (5%) and Arborescent Geniculates (50%).

Taphonomic Analysis

Except in few cases, detailed taphonomic aspects of fossil coralline algae have not been considered in earlier investigations. Preservation potential of coralline algae is affected by a variety of taphonomic features. These features show a characteristic distribution with respect to the facies and palaeoecological parameters. Some of the taphonomic features can be observed directly while some are inferred. Nebelsick and Bassi (2000) recognized various taphonomic features of coralline algae viz., disarticulation, encrustation, bioerosion, fragmentation, abrasion and diagenesis in the Lower Oligocene shelf carbonates of Gornji Grad beds of Northern Slovenia. The taphonomic features observed in the present study are encrustation, fragmentation and disarticulation. Amongst these disarticulation is the dominant one. This feature is commonly observed in geniculate coralline algae in which the hard calcified intergenicula are connected by non-calcified soft genicula. Due to its fragile nature the genicula disintegrate after the organism's death.

Facies Analysis

Characterization of facies and their criteria of recognition correlate to the critical environmental thresholds e.g., rise and fall of atmospheric temperature, change of sea level, agitation and turbidity of water etc. These physical environmental parameters govern the sedimentary textures as well as biotic assemblages. Palaeoecological analysis certainly strengthens the interpretation of depositional facies reconstruction. Coralline red algae in particular are important stabilizers and secondary framebuilders in modern as well as fossil reefs. A new concept termed as 'Facies Dynamics' has been introduced recently (Nebelsick et al. 2005). It can be defined as changes of specific carbonate facies type in time and space, which are controlled by phylogenetic, ecological and geological parameters. In the present analysis only a single Major Facies Type (MFT) has been identified, which is dominated by non-geniculate and geniculate coralline red algae. The algal flora is diverse and distinct with five growth-forms. Preponderance of disarticulated, arborescent geniculates and presence of *Halimeda* is significant with abundance of small and large benthic foraminifera.

The analysis of MFT can be summarized as follows:

Dominant components – Coralline algal branches and debris, larger and smaller foraminifera.

Subordinate components – Halimedacean green algae and bryozoan fragments.

Texture – Coralline Algal - Foraminiferal Rudstone - Grainstone facies comprising of large algal and benthic foraminiferal specimens (> 2 mm size) presenting the rudstone component of the fabric grading into smaller grainstone moieties at various places supported by a matrix of packstone.

Abundance of disarticulation indicate the deposition of the sediments was not absolutely autochthonous. Rather taphonomic features viz., disarticulation, fragmentation, along with encrustation suggests a para-autochthonous depositional facies.

PALAEOENVIRONMENTAL SIGNIFICANCE

Limited environmental tolerance and spatial distribution of the algal taxa are of immense value in the reconstruction of sedimentary environments and characterization of biofacies. The establishment of depth/abundance charts (Adey, 1979) for coralline floras from the Caribbean and Pacific sites indicate the great potential of coralline algae in palaeobathymetric analysis. Since present day non-geniculate genera date back to the Tertiary period (Bosence, 1991), the bathymetric ranges should be applicable for the Tertiary coralline algae as well. Coralline algae are also known as one of the best palaeobathymetric indicators owing to their general wide depth distribution and sensitive reaction to changing light conditions. The strong relationship between the generic composition of flora and water depths has exciting potentiality for erecting quantitative bathymetric zones specifically for the Cenozoic.

The non-geniculate corallines (*Lithothamnion, Mesophyllum, Sporolithon, Lithoporella*) construct the reef core together with foraminifers and their abundance increases towards the outer edge of the reef. The genera *Lithothamnion* and *Mesophyllum* are excellent indicators of 20-40 m bathymetric zone (Bosence, 1991). Sporolithaceans (Genus *Sporolithon*) also thrive at ~40 m water depth. On the other hand, the geniculate corallines (*Corallina* and *Jania*) are associated with reef complexes and their presence in moderate number indicates an environment prevailing in the inner margin of the reef flat or shallow back-reef region near the reef core.

The genus *Halimeda* is common in Cenozoic reefoidal limestones. *Halimeda* is more abundant in somewhat sheltered parts of the reef complex such as the inner part of the reef flat or the adjoining shallower portion of the lagoon, where water is moderately agitated and clear. Its abundance in the sediments indicates the advent of reef environment along with a tropical climate and shallow water condition.

The palaeoecological interpretation based on benthic foraminiferal study from the Prang Formation (Matsumaru and Sarma, 2010) of Jaintia Group also complements the algal data recovered from the Prang Formation of Sylhet Limestone Group in the present study. In general larger benthic foraminifera occur in warm waters and exist in the photic zone. Species of nummulitid (*Nummulites* and *Assilina*), orthophragminid (*Discocyclina*) and alveolinid (*Alveolina*) larger benthic foraminifera have been recorded earlier from the Prang Formation and also have been observed during the present study. Large, flat-shaped *Assilina* are generally prevalent in deep, oligotrophic water and also in much shallower, open marine, high-energy settings. Occurrence of *Nummulites* indicates that the deposition was autochthonous. Smaller, lenticular *Nummulites* occur in shallower, inner ramp/shelf settings and often coexists with *Alveolina.* Species of *Alveolina* are abundant in moderate energy shallow water conditions with significant movement and reworking of bioclasts (Boukhary et al. 2005; Adabi et al. 2008).

CONCLUSION

The coralline algal - foraminiferal rudstone - grainstone facies is composed of diverse calcareous algae viz., non-geniculate corallines, geniculate corallines and *Halimeda.* The rudstone-grainstone facies supported by packstone matrix indicates a grain-supported fabric in the studied samples. Five different types of growth-forms i.e., encrusting, warty, lumpy, layered lamellae and arborescent have been recorded in the present study. Amongst the taphonomic features, disarticulation is the most dominant feature followed by fragmentation and encrustation. Dominance of the taphonomic features like, disarticulation and fragmentation of the geniculate corallines suggests a para-autochthonous facies. These taphonomic features also indicate that the energy was moderately high. Non-geniculate corallines *Lithothamnion, Sporolithon, Mesophyllum* and *Lithophyllum* thrive at water depth of about 20-40 m in normal salinity. The genus *Sporolithon* also prefers to thrive at ~40 m water depth. A perusal of the foregoing account reveals that in all probabilities the deposition of Prang Formation occurred in shallow, warm, shelf environment of normal salinity within the transgressive phase in a moderately high energy condition.

Acknowledgements. The authors are thankful to Dr. N.C. Mehrotra, Director, Birbal Sahni Institute of Palaeobotany, Lucknow for his kind permission to publish this work. The authors are also highly indebted to the anonymous reviewer for valuable suggestions and comments. One of us (S. Sarkar) is thankful to CSIR for the award of JRF (NET) Grant No. 09/528(0016)/2009-EMR-I.

References

ADABI, M.H., ZOHDI, A., GHABEISHAVI, A. and AMIRI-BAKHTIYAR, H. (2008) Applications of nummulitids and other larger benthic foraminifera in depositional environment and sequence stratigraphy: an example from the Eocene deposits in Zagros Basin, SW Iran. Facies, v.54, pp.499-512.

ADEY, W.H. (1979) Algal ridges of the Caribbean sea and West Indies. Phycologia, v.17, pp. 361-367.

ADEY, W.H. and ADEY, P.J. (1973) Studies on the biosystematics and ecology of the epilithic crustose corallines of the British Isles. British Phycological Jour., v.8, pp.343-407.

ADEY, W.H., TOWNSEND, R.A. and BOYKINS, W.T. (1982) The crustose coralline algae (Rhodophyta; Corallinaceae) of the Hawaiian Islands. Smithsonian Contrib, Marine Sci,, v.15, pp.1-74.

AGUIRRE, J., BRAGA J.C. and PILLER, W.E. (1996) Reassessment of *Palaeothamnium* Conti, 1946 (Corallinales, Rhodophyta). Rev. Palaeobot. Palynol., v. 94, pp. 1-9.

AGUIRRE, J. and BRAGA, J.C. (1998) Redescription of Lemoine's (1939) types of coralline algal species from Algeria. Palaeontology, v.41, pp. 489-507.

AGUIRRE, J. and BRAGA, J.C. (2005) The citation of nongeniculate fossil coralline red algal species in the twentieth century literature: an analysis with implications. Revista Espaoola de Micropalaeontologica, v.37 (1), pp. 57-62.

AGUIRRE, J., BACETA, J.I. and BRAGA, J.C. (2007) Recovery of marine primary producers after the Cretaceous-Tertiary mass extinction: Paleocene calcareous red algae from the Iberian Peninsula. Palaeogeog, Palaeoclimatol, Palaeoecol., v.249, pp.393-411.

BASSI, D. (1998) Coralline red algae (Corallines, Rhodophyta) from the Upper Eocene Calcare di Nago (Lake Garda, Northern Italy). Annali dell' Universita di Ferrara 7, supplemento, pp.1-51.

BASSI, D., BRAGA, J.C., ZAKREVSKAYA, E. and PETROVNA RADIONOVA E. (2007). Redescription of the Type Collections of Maslov's Species of Corallinales (Rhodophyta). II. Species Included by Maslov in *Archaeolithothamnium* Rothpletz, 1891. Revista Espanola de Paleontologia, v.22(2), pp.115-125.

BECKMANN, J.P. (1982). Displaced Late Cretaceous and Palaeocene microfossils. *In:* J.P. Beckmann et al. (Eds.), Micropalaeontology and Biostratigraphy of the Campanian to Palaeocene of the Monte Giglio, Bermago Province, Italy. Memoire Di Scienze Geologiche, Padova, Società Cooperativa Tipografica, v.35, pp.120-141.

BISWAS, B. (1962) Stratigraphy of the Mahadeo, Langpur, Cherra and Tura Formation, Assam, India. Bull. Geol. Met. Soc. India, v.25, pp.1-28.

BIZZOZERO, G. (1885) Flora Veneta Crittogamica. Parte II. Seminario, Padova I, v.1, pp.255.

BORUAH, P.K. and DUTTA, S.K. (2001) Palaeocene calcareous algae from Khasi Hills, Meghalaya. Geophytology, v.31, pp.19-29.

BOSENCE, D.W.J. (1976) Ecological studies on two unattached coralline algae from western Ireland. Palaeontology, v.19(2), pp.365-395.

BOSENCE, D.W.J. (1983) Coralline algal reef framework. Jour. Geol. Soc. London, v.140, pp.365-376.

BOSENCE, D.W.J. (1991) Coralline algae: mineralization, taxonomy and palaeoecology. In: R. Riding (Ed.) Calcareous Algae and Stromatolites. Springer, Berlin, pp.98-113.

BOSENCE, D.W.J. and PEDLEY, H.M. (1982) Sedimentology and palaeoecology of a Miocene coralline algal biostrome from the Maltese islands. Palaeogeog, Palaeoclimatol, Palaeoecol., v.38, pp.9-43.

BOUKHARY, M., ABDELGHANY, O., BAHR, S., HUSSEIN-KAMAL, Y. (2005) Upper Eocene larger foraminifera from the Dammam formation in the border region of United Arab Emirates and Oman. Micropaleontology, v.51, pp.487-504.

BRAGA, J.C. (2003) Application of botanical taxonomy to fossil coralline algae (Corallinales, Rhodophyta). Acta Micropalaeontologica Sinica, v.20, pp.47-56.

BRAGA, J.C., BOSENCE, D.W.J. and STENECK, R.S. (1993) New anatomical characters in fossil coralline algae and their taxonomic implications. Palaeontology, v.36, pp. 535-547.

BRAGA, J.C. and AGUIRRE, J. (1995) Taxonomy of fossil coralline algal species: Neogene Lithophylloideae (Rhodophyta, Corallinaceae) in Southern Spain. Rev. Palaeobot. Palynol., v.86, pp.265-285.

CABIOCH, J. (1969) Les fonds de maerl de la Baie de Morlaix et leur peuplement vegetal. Vahiers Biologique Marine, v.9, pp.33-55.

CHAKRABORTI, A. and BAKSI, S. (1972) Stratigraphy of the Cretaceous-Tertiary sedimentary sequence, southwest of Shillong Plateau. Quart. Jour. Geol. Min. Metal. Soc. India, v. 44, pp. 109-127.

CONTI, S. (1946) Revisione critica di *Lithothamnium ramosissimum* Reuss. Publ. Ist. Geol. Univ. Genova, Ser. A (Paleontol.), v.1-2, pp.3-29.

DASGUPTA, A.B. (1977) Geology of the Assam-Arakan region. Quart. Jour. Bull. Geol. Met. Soc. India, v.49, pp.1-54.

DECAISNE, J. (1842) Mémoire sur les corallines ou polypiers calcifères [la seconde partie du "Essais sur une classification des algues et des polypiers calcifères de Lamourous"]. Annales des Sciences Naturelles, Botanique, Second Série, v.18, pp.96-128.

DETHIER, M.N. (1994) The ecology of intertidal algal crusts: variation within a functional group. Jour. Experimental Marine Biology and Ecology, v.177, pp.37-71.

DRAGASTAN, O. and SOLIMAN, H.A. (2002) Palaeogene calcareous algae from Egypt. Micropaleontology, v.48, pp.1-30.

EVANS, P. (1932) Explanatory notes to accompany a table showing the Tertiary succession in Assam. Trans. Min. Met. Geol. India, v.27, pp.155-260.

FOSLIE, M. (1908) Algologiske notiser VK Norske Videnskabus Selskals Skrifter, pp.1-20.

FOSLIE, M. (1909) Remarks on two fossil Lithothamnia. Algologiske notiser VI. Det Kongelige Norske Videnskabus Selskals Skrifter, v.2, pp.1-63.

GARG, R. and JAIN, K.P. (1995) Significance of the terminal

Cretaceous calcareous nannofossil marker *Micula prinsii* at the Cretaceous - Tertiary boundary in the Um Sohrynkew section, Meghalaya, India. Curr.Sci., v.66(12), pp.1012-1017.

Garg, R. and Khwaja-Ateequzzaman (2000) Dinoflagellate cysts from the Lakadong Sandstone, Cherrapunji area: Biostratigraphical and Palaeoenvironmental significance and relevance to sea level changes in the Upper of the Khasi Hills, South Shillong Plateau, India. Palaeobotanist, v.45, pp.461-484.

Ghosh, A.K. (2003) Late Palaeocene coralline algal buildup in the Lakadong Formation of South Shillong Plateau, Northeast India. 8th International Symposium on Fossil Algae, (Abstract) Granada, Spain, pp.20.

Ghosh, A.M.N. (1940) The stratigraphical position of the Cherra Sandstone, Assam. Rec. Geol. Surv. India, v.75, pp.1-19.

Gogoi, B., Borgohain, R. and Deka, K.K. (2003) Petrography, palaeontology and depositional environment of Lakadong Limestone of Mawsynram area, Meghalaya. Jour. Indian Assoc. Sed., v.22, pp.133-149.

Gray , J.E. (1864) Handbook of British Water-Weeds or Algae. R. Hardwicke, London, 123p.

Harvey, A.S., Broadwater, S.T., Woelkerling, W.J. and Mitrovski, P.J. (2003) *Choreonema* (Corallinales, Rhodophyta): 18Sr DNA phylogeny and resurrection of the Hapalidiaceae for the subfamilies Choreonematoideae, Austrolithoideae and Melobesioideae. Jour. Phycol., v.39, pp.988-998.

Heydrich, F. (1897a) Corallinaceae, insbesondere Melobesieae. Berichte der Deutschen Botanischen Gesellschaft, v.15, pp.34-71.

Heydrich, F. (1897b) Über die weiblichen Conceptakeln von *Sporolithon*. Bibliotheca Botanica, v. 49, pp. 1-25.

Hillis-Colinvaux, L.W. (1984) Systematics of the Siphonales. In: D.E.G. Irvine and D.M. John (Eds.), Systematics of the green algae, pp.271-296. Academic Press, London.

Jauhri, A.K. (1994) Carbonate buildup in the Lakadong Formation of the South Shillong Plateau, NE India: A micropalaeontological perspective, *In:* R. Matteucci et al. (Eds.), Studies on Ecology and Palaeoecology of Benthic communities. Bull. Soc. Paleon. Ital., Spec. v.2, Mucchi, Modena, pp.157-169.

Jauhri, A.K. (1996) *Ranikothalia nuttali* (Davies), a distinctive early Ilerdian marker in the South Shillong Plateau, N.E. India, *In:* J. Pandey et al. (Eds.), Contributions to XV Indian Colloquium on Micropalaeontology and Stratigraphy, 1996 Dehra Dun, pp.209-218.

Jauhri, A.K. (1998) *Miscellanea* (Foraminiferida) from the South Shillong Region, NE India. Jour. Pal. Soc. India, v.43, pp.73-83.

Jauhri, A.K. and Agarwal, K.K. (2001) Early Palaeogene in the South Shillong Plateau, NE India: local biostratigraphic signals of global tectonic and oceanic changes. Palaeogeogr, Palaeoclimatol, Palaeoecol., v.168, pp.187-203.

Johnson, J.H. (1957) Geology of Saipan, Marina Islands, Pt.3, Palaeontology: Calcareous Algae. USGS Prof. Paper, 280 E, pp. 209-246.

Johnson, J.H. (1961) Limestone-building Algae and Algal Limestones. Colorado School of Mines, Boulder.

Johnson, J.H. and Ferris, B.J. (1948) Eocene Algae from Florida. Jour. Palaeontology, v.22, pp.762-766.

Johnson, J.H. and Kaska, H.V. (1965) Coralline algae from the Guatemala. Professional contribution of the Colorado school of Mine, v.1, pp.1-152.

Kishore, S., Singh, A.P., Singh, S.K., Tiwari, R.P., Jauhari, A.K. and Misra, P.K. (2009) Geniculate coralline algae from the Prang Formation (Eocene) of the Jaintia Hills, Meghalaya, India. Jour. Palaeont. Soc. India, v.54, pp.189-195.

Kundal, P. and Humane, S.K. (2003) *Corallina*, a geniculate Coralline alga from Middle Eocene to Miocene of Kachchh, Gujarat, India. Gond. Geol. Mag., v.6, pp.261-275.

Kuss, J. and Herbig, H.G. (1993) Biogeography, facies and taxonomy of early Tertiary green algae from Egypt and Morocco. *In:* F. Barattolo et al. (Eds.), Studies on Fossil Benthic Algae- Proceedings of the 5th International Symposium on Fossil Algae, Bolletino della Societa Paleontologica Italiana, v.1, pp.249-280.

Lamouroux, J.V.F. (1812) Extrait d'une mémoire sur la classification des polypiers coralligènes non entièremen pierreux. Noveau Bulletin des Sciences par la Société Philomatique de Paris, v.3, pp.181-188.

Lemoine, M.P. (1911) Structure anatomique des Melobesiess. Application a la classification. Annales de l' Institute de Oceanographie de Monaco, v.2, pp.1-213.

Lemoine, M.P. (1928) Un noveau genre de Mélobésiées: *Mesophyllum.* Bulletin de la Société botanique de France, v.75, pp. 251-254.

Lemoine, M.P. (1939) Algues calcaires fossiles de l' Algerie. Materiaux pour la Carte Geologique d' Algerie, serie 1a, Paleontologie, v.9, pp.1-128.

Link, H.F. (1832) Über die Pflanzenthiere überhaupt und die dazu gerechneten Gewächse besonders. – Abh. Königl. Acad. Wiss. Berlin, Phys. Kl., v.1830, pp.109-123, Berlin.

Linnaeus, C. (1758) Tomus I. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Editio decima, reformata. Holmiae. (Laurentii Salvii), v.1-4, pp.1-824.

Maslov, V.P. (1956) Fossil calcareous algae of USSR. Trudy Instituta geologicheskh Nauk SSSR, v.160, pp.1-301 (in Russian).

Matsumaru, K. and Sarma, A. (2010) Larger foraminiferal biostratigraphy of the lower Tertiary of Jaintia Hills, Meghalaya, NE India. Micropaleontology, v.56(6), pp.539-565.

Medlicott, H.B. (1871) Geological sketch of the Shillong Plateau in north-eastern Bengal. Mem. Geol. Surv. India, v.7, pp.151-207.

Misra, P.K., Jauhri, A.K., Kishore, S. and Singh, S.K. (2002) Calcareous algae from the Lakadong Formation of the South Shillong Plateau, NE India. Revue Paléobiol. Genève, v.21, pp.717-734.

Misra, P.K., Jauhri, A.K., Tiwari, R.P., Kishore, S., Singh, A.P.

and SINGH, S.K. (2011) Coralline algae from the prang formation (middle-late Eocene) of the Lumshnong Area, Jaintia Hills, Meghalaya. Jour. Geol. Soc. India, v.78, pp.355-364.

MURTHY, M.V.N., CHAKRAVORTY, C. and TALUKDAR, S.C. (1978) Stratigraphic revision of the Cretaceous-Tertiary sediments on the Shillong Plateau. Rec. GSI, v.107, pp.80-90.

MURTY, K.N. (1983) Geology and hydrocarbon prospects of Assam shelf: recent advances and present status. *In:* L.L. Bhandari et al. (Eds.), Petroliferous Basin of India. Petrol. Asia Jour., v.1, pp.1-14.

NAGAPPA, Y. (1959) Foraminiferal biostratigraphy of Cretaceous-Eocene succession in the India-Pakistan-Burma region. Micropaleontology, v.5(2), pp.141-181.

NEBELSICK, J.H. and BASSI, D. (2000) Diversity, growth forms and taphonomy: key factors controlling the fabric of coralline algae dominated shelf carbonates. From: E. Insalaco et al. (Eds.), 2000. Carbonate Platform Systems: components and interactions. Geol. Soc. London Spec. Publ., v.178, pp.89-107.

NEBELSICK, J.H., RASSER, M.W. and BASSI, D. (2005) Facies dynamics in Eocene to Oligocene circumalpine carbonates. Facies, v.51, pp.197-216.

PAL, A.K. and DUTTA, S.K. (1979) A study of fossil algae from Sylhet Limestone Formation of Meghalaya and Mikir Hills, Assam. Geophytology, v.9, pp.144-155.

PANDEY, J. (1972) Palaeocene/Eocene boundary in Indian subcontinent. *In:* S.N. Singh (Ed.), Proc. II Indian Colloq. Micropalaeont. Stratigr., Lucknow, pp.77-78.

PANDEY, J. (1978) Palaeocene smaller foraminifera of Um Sohryngkew River, Meghalaya. *In:* D.A. Rasheed (Ed.), Proc. VII Indian Colloq. Micropalaeont. Stratigr., Madras, pp.70-152.

PANDEY, J. and RAVINDRAN, C.N. (1988) Foraminiferal control in the Indian Palaeocene. *In:* H.K. Maheshwari (Ed.), Palaeocene of India, I.A.P. Publ., v.4, pp.124-184.

PIA, J. (1932) Remaques sur les Algues calcaires. In: J. Pia et al. (Eds.), tudes géologiques sur les calcaires des Bekrit et de Tmhadit (Moyen Atlas). Notes et Mémoires de la Service Mineralogique et de la carte géologique Maroc, v.20, pp.13-18.

PILLER, W.E. (1994) *Nullipora ramosissima* Reuss, 1847- a rediscovery. Beiträge zur Paläontologie, v.19, pp.181-189.

RAO, K.S. (1943) Fossil algae from Assam: 1. The Corallinaceae Proc. Natn. Acad. Sci. India, v.13(5), pp.265-299.

RASSER, M. and PILLER, W.E. (1999) Application of neontological taxonomic concepts to Late Eocene coralline algae (Rhodophyta) of the Austrian Molasse Zone. Jour. Micropaleontology, v.18, pp.67-80.

ROUND, F.E. (1963) The taxonomy of the Chlorophyta. Br. Phyc. Bull, v.2, pp.224-235.

SAMANTA, B.K. and RAYCHOUDHURY, A.K. (1983) A revised lithostratigraphic classification of the Cretaceous-Lower Tertiary shelf sediments of the Eastern Khasi and Jaintia Hills, Meghalaya. Quart. Jour. Bull. Geol. Met. Soc. India, v.55(3), pp.101-129.

SARMA, A. and GHOSH, A.K. (2006) A new record of calcareous algae from Shella Formation (Jaintia Group) of South Jaintia Hills, Meghalaya, India. Curr. Sci., v.90(9), pp.1276-1281.

SCHAFFNER, J.H. (1922) The classification of plants. XII. Ohio Jour. Sci., v.22, pp.129-139.

SETCHELL, W.A. (1943) *Mastophora* and the Mastophorsae: genus and subfamily of Corallinaceae. Proceedings of the National Academy of Sciences of the United States of America, v.29, pp. 127-135.

SILVA, P.C. and JOHANSEN, H.W. (1986) A reappraisal of the Order Corallinales (Rhodophyceae). British Phycological Jour., v.21, pp. 245-254.

TAYLOR, W.R. (1950) Plants of Bikini and other northern Marshall Islands. Pp. Xv + 227, 79 pls. Ann. Arbor. University of Michigan Press.

VERHEIJ, E. (1993) The genus *Sporolithon* (Sporolithaceae fam. nov., Corallinales, Rhodophyta) from the Sporomonde Archipelago, Indonesia. Phycologia, v.32, pp.84-196.

WETTSTEIN, R.R. (1901) *Handbuch der systematischen Botanik*. Vol. 1 Deuticke, Leipzig v + 201 pp.

WILSON, C.E. and METRE, W.B. (1953) Assam and Arakan. *In:* V.C. Illing (Ed.), World's Oil Field: The Eastern Hemisphere. The Science of Petroleum. London, Oxford University Press, v.6, pp.119-123.

WOELKERLING, W.J. (1988) The Coralline Red Algae: An analysis of the genera and subfamilies of nongeniculate Corallinaceae. British Museum (Natural History), Oxford University Press, London and Oxford, pp.268.

WOELKERLING, W.J., IRVINE, L.M. and HARVEY, A.S. (1993) Growth-forms in non-geniculate coralline red algae (Corallines, Rhodophyta): Australian Systematic Botany, v.6, pp.277-293.

(Received: 25 July 2011; Revised form accepted: 29 February 2012)