Journal of the Palaeontological Society of India
Volume 61(1), June 30, 2016: 91-97

ISSN 0522-9630

RECORD OF LATE EOCENE (PRIABONIAN) NANNOFOSSILS FROM THE LOWER PART OF THE REWAK FORMATION, GARO HILLS, MEGHALAYA, NORTHEASTERN INDIA

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ABSTRACT

We report here moderately diversified, fairly well-preserved calcareous nannofossil assemblage of Priabonian age comprising twenty three species from the Rewak Formation exposed along the Siju-Rewak road section, West Garo Hills, Meghalaya. Out of the fifty five samples, forty seven were collected from the lower part of the Rewak Formation and only one sample (SR 23) yielded identifiable calcareous nannofossils. Rare nannofossils occurring at few other levels in the profile are badly preserved precluding identification. The last occurrence (LAD) of *Cribrocentrum reticulatum* marks the zonal boundary between NNTe13 and NNTe14 zones of Varol (1998) in latest Priabonian (within NP21 Zone of Martini, 1971) and LAD of *Pemma papillatum* marks the Priabonian/ Rupelian boundary. Presence of *P. papillatum* in the recovered assemblage along with the absence of *C. reticulatum* suggests late Eocene (Priabonian) age corresponding with NP21 Zone of Martini (1971) and NNTe14 Zone of Varol (1998). Discoasters are absent in this assemblage. Reworking of Late Maastrichtian and Danian age nannotaxa is also recorded.

Keywords: Late Eocene, Priabonian, Rewak Formation, Nannofossil, Meghalaya

INTRODUCTION

The Garo Hills constitute the westernmost part of the Shillong Plateau in Meghalaya, northeastern India, where the area, lying on the south slopes of the hilly tract, represents an extension of the Assam Shelf and is characterised by a thick sedimentary succession, unconformably overlying the Precambrian basement complex, ranging in age from Paleocene to Recent (Fig. 1). The Paleogene sedimentary succession is mainly represented by thick sandstone, shales with thin interbedded coal followed by foram-rich fossiliferous limestone which in turn is overlain by a thick succession of sandstone-shale intercalations.

The pioneering studies on the geology of Meghalaya including Garo Hills have been carried out earlier by Oldham (1859), Medlicott (1868, 1869, 1874), La Touche (1882, 1883a, b, 1884, 1887, 1889, 1890a, b), Hayden (1897), Pinfold (1919), Palmer (1923), Evans (1932), Fox (in Heron 1937) and Ghosh (1954). Raja Rao (1981) provided details of coalfields of northeastern India including Garo Hills. The lithostratigraphic classification for the Tertiary sediments of northeastern India proposed by Evans (1932) is still in use, but the stratigraphic units proposed mainly for the Khasi-Jaintia Hills could not be applied to the sedimentary sequence developed in Garo Hills and western Khasi Hills. For this reason Chakraborty (1972) and Chakraborty and Baksi (1972) had proposed alternate lithostratigraphic classification scheme for the Cretaceous-Tertiary succession of Garo- West Khasi hills area. Fox (in Heron 1937), used the term "Siju Limestone" for the foraminiferal limestone of Garo Hills, which overlies the Tura Sandstones and conformably underlies the Rewak Formation (Chakraborty and Baksi, 1972).

Murthy *et al.* (1976) placed foraminiferal limestone of the Garo Hills into the Upper Sylhet Limestone Member and the underlying Tura Formation (sandstone) into the Sylhet Sandstone Member of the Sylhet Formation (Table 1). A considerable amount of palynological work has been done from the Tura Formation (Baksi, 1962; Biswas, 1962; Chatterjee and Ghosh, 1963; Banerjee, 1964; Ghosh, 1969; Kar *et al*., 1972; Salujha *et al.*, 1972; Singh *et al*., 1976; Singh, 1977a, b; Sah and Singh, 1974, 1977; Singh and Singh, 1978; Tewari and Singh, 1984; Ambwani, 1993; Saxena *et al*., 1996, Tripathi *et al*., 2000) but only limited number of papers were published on the palynology of the Siju and Rewak formations (Baksi, 1962, 1974; Chakraborty and Baksi, 1972; Salujha *et al*., 1972, 1974; Sah and Singh, 1977; Saxena and Sarkar, 2000; Sarkar *et al.*, 2014). The Siju Formation is rich in foraminifera which provide the basis for Lutetian-early Bartonian age (Samanta, 1968, 1969). Nannofossils of middle-late Eocene age have earlier been reported only from the surface sediments of the Kopili Formation of Mikir Hills, Samkherjan area, Assam (Singh, 1979). In Garo Hills, Eocene (Bartonian) nannofossils have recently been recorded from the Siju Formation (Rai and Garg, 2009). The present record of nannofossils from the Rewak Formation exposed along the Siju-Rewak Road in the Garo Hills makes an important addition to our knowledge from this area which may be useful for precise age determination and correlation. The present assemblage is comparable with late Priabonian age nannofossil rich and more diversified assemblage recovered from the Surat-Bharoch area, Cambay Basin, western India (Singh *et al*., 1978; Jafar *et al.*, 1985).

STRATIGRAPHY

The sedimentary succession of the West Garo Hills, Meghalaya is deposited on Precambrian Basement complex. It is composed of mainly gneisses, meta-igneous rocks, granites and intrusive basic rocks. Its upper part is highly weathered and altered and is unconformably overlain by the Tura Formation (Table 1). The Tura Formation is composed of medium to coarse grained and gritty, non-feldspathic, current-bedded sandstone which is sandy or kaolinitic at places and intercalated with grey shale, carbonaceous shale, siltstone and coal seams. The Tura

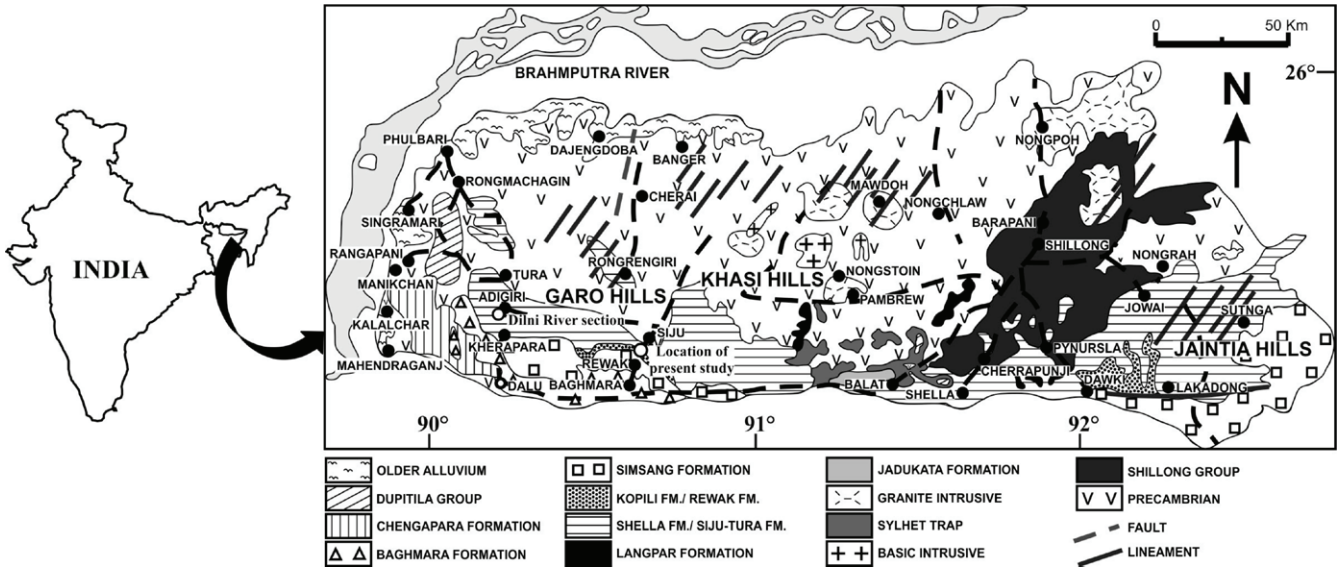


Fig. 1. Geological map of Meghalaya showing locations of the Dilni River section and present study section (adapted from website of Government of Meghalaya, Department of Mining and Geology, Directorate of Mineral Resources (https://www.megdmg.gov.in).

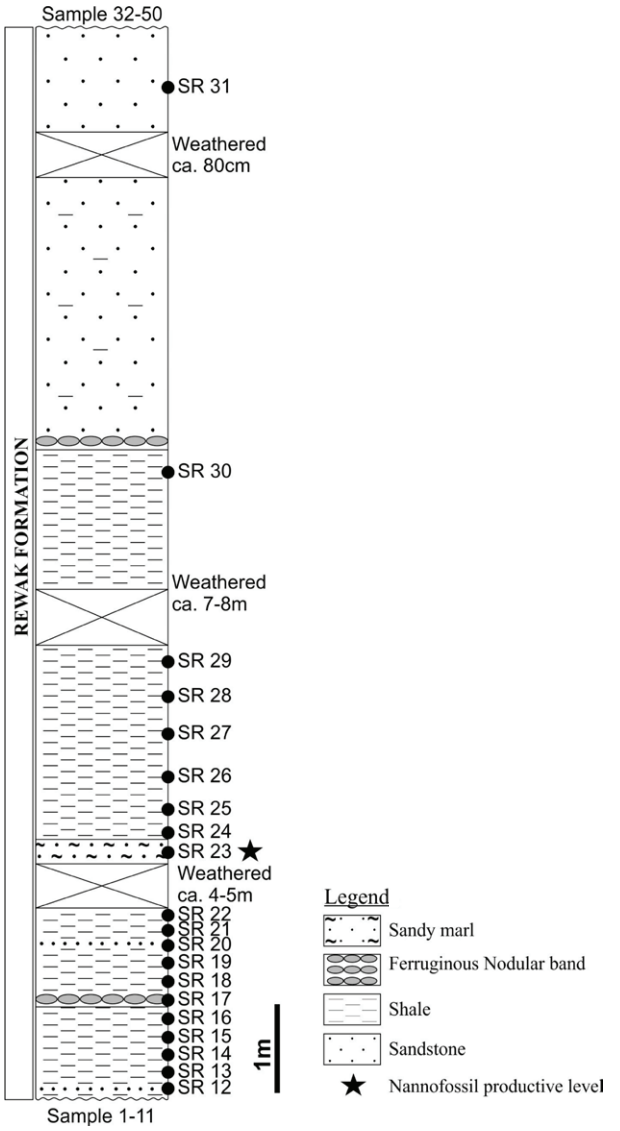


Fig. 2. Litholog of the studied section showing nannofossil productive level.

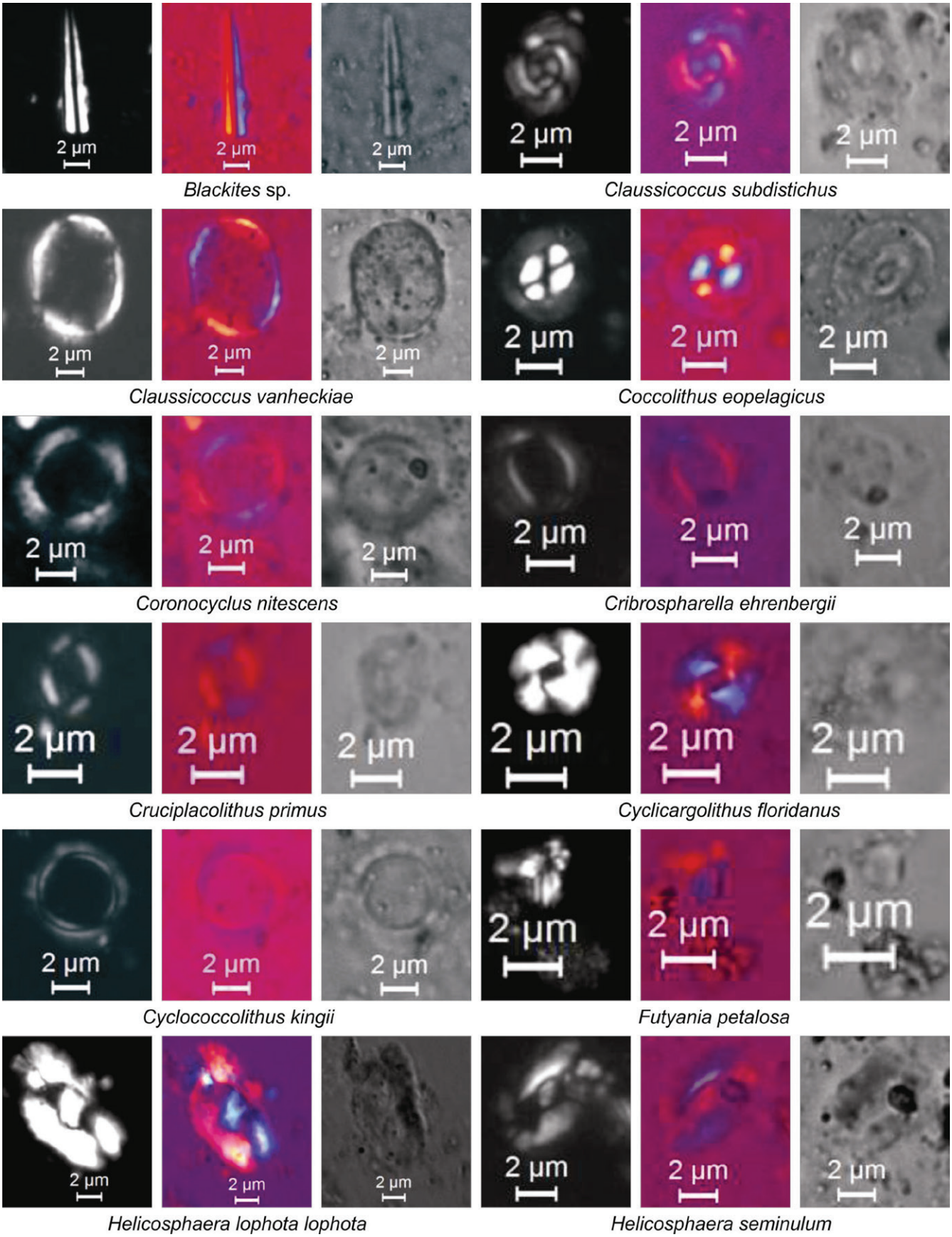
Formation is conformably overlain by the Siju Formation which consists of alternations of arenaceous limestone and calcareous shale or marl at the base and hard, massive buff coloured limestone in the upper part. The Siju Formation is overlain by the predominantly argillaceous Rewak Formation. The Rewak Formation is composed of thinly bedded, splintery, grey shales with streaks of coal and leaf impressions interspersed with fine-grained, current-bedded sandstones and black shale with phosphatic nodules and ferruginous nodular bands at the base. The Rewak Formation is conformably overlain by the Kherapara Formation which in turn is unconformably overlain by the Boldamgiri Formation and followed by Angartoli, Bilkona and Dalu formations in ascending order (Chakraborty and Baksi, 1972). The stratigraphic succession of the Garo Hills, Meghalaya is summarized in Table 1 (after Chakraborty and Baksi, 1972).

The studied section (~150 m) displays massive cliff-forming foram- rich, bedded to massive limestone on the west side of the Siju-Rewak-Baghmara road representing upper part of the Siju Limestone, well exposed in the nearby Siju Cave. The limestone is highly fossiliferous containing several shell rich bands including larger foraminifera along with corals and bivalves at few levels. The Siju–Rewak contact is exposed almost at the road level. The overlying Rewak Formation exposed along the Siju-Rewak-Baghmara road contains calcareous sandstone, grey to black splintery shales and sandstone/shale alternations with several Fe-rich nodular bands and bioturbated horizons (Fig. 2).

MATERIAL AND METHODS

The samples for the present study were collected by RG from the Siju and Rewak formations exposed along the Siju-Rewak-Baghmara Road in the West Garo Hills, Meghalaya (Fig. 1). In all, fifty five samples were collected from the massive limestone of the Siju Formation and shales, silty shales and sandy marls of the Rewak Formation (Fig. 2). Two permanent smear slides of each sample were prepared for the nannofossil study following Bown and Young (1998).

Plate I


2 µm
Blackites sp.
Claussicoccus subdistichus
Claussicoccus vanheckiae
Coccolithus eopelagicus
Coronocyclus nitescens
Cribrospharella ehrenbergii
Cruciplacolithus primus
Cyclicargolithus floridanus
Cyclococcolithus kingii
Futyania petalosa
Helicosphaera lophota lophota
Helicosphaera seminulum

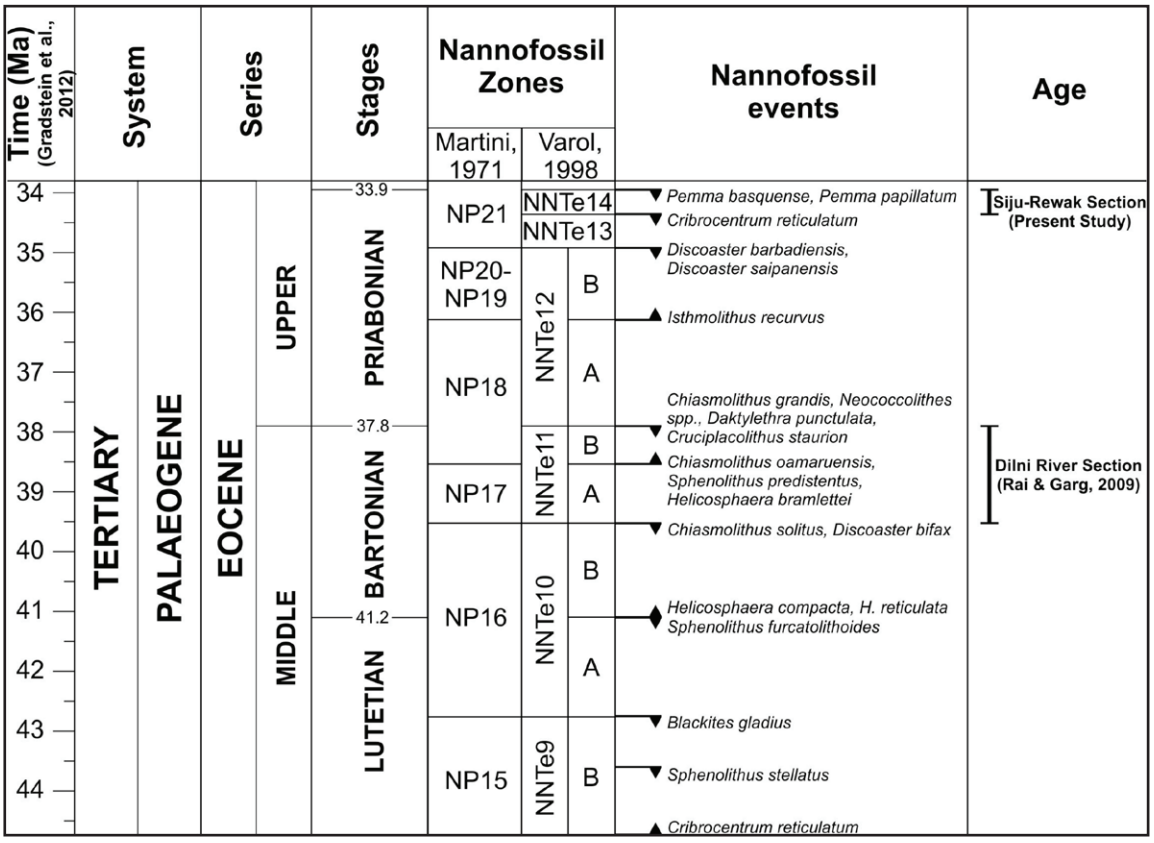


Fig. 3. Chart showing calibration of nannofossil records and bioevents from Garo Hills with standard Palaeogene Nannofossil Zonation Schemes.

DISCUSSION

Moderately well preserved nannofossils were recovered from only one sample (greenish-grey mudstone; Sample SR 23; Slide No. BSIP museum no. 15557) from the lower part of the Rewak Formation (Plate I, II). Rare nannofossils recorded at few other levels (SR 12) are badly preserved precluding identification (Fig. 2). The assemblage contains twenty three nannofossil species represented by *Blackites* sp., *Claussicoccus subdistichus*, *Claussicoccus vanheckiae*, *Coccolithus eopelagicus*, *Coronocyclus nitescens*, *Cyclicargolithus floridanus*, *Cyclococeolithus kingii*, *Helicosphaera lophota lophota*, *Helicosphaera seminulum*, *Markalius astroporus*, *Pemma basquense*, *Pemma papillatum*, *Pontosphaera multipora*, *Pontosphaera pectinata*, *Reticulofenestra dictyoda*, *Sphenolithus moriformis*, *Thoracosphaera* sp., *Toweius* sp. and *Umbilicosphaera* sp. alongwith the reworking of some Danian (*Cruciplacolithus primus*, *Futyania petalosa* and *Neocrepidolithus neocrassus*) and Cretaceous taxa (*Cribrospharella ehrenbergii*) from older horizons.

The last Appearance Datum (LAD) of *Pemma basquense* and *Pemma papillatum* (total range zone is NP14b-NP21) indicates terminal Priabonian (Late Eocene) NP21 Zone of Martini (1971) and it equates with the zonal boundary of NNTe14 (Varol, 1998). Rai and Garg (2009) recorded nannofossils from the Siju Formation of Dilni River section, Tura-Dalu road (Fig. 3). With regard to abundant presence of *Cribrocentrum reticulatum* they assigned NP17 Zone of Martini (1971) of late Middle Eocene (Bartonian) age to the assemblage. The last occurrence of *C. reticulatum* marks the late Eocene zonal boundary between NNTe13 and NNTe14 zones of Varol (1998). *C. reticulatum* is not recorded in the present assemblage and indicates a younger age. The presence of *P. papillatum* and absence of *C. reticulatum* confirms NP21 Zonal assignment of Martini (1971) of Late Eocene (Priabonian) age corresponding with NNTe14 Zone of Varol (1998).

Record of helicoliths (*Helicosphaera lophota lophota* and *Helicosphaera seminulum*) pentaliths and *Coccolithus eopelagicus* in the present assemblage suggests deposition under hemipelagic, nearshore, warm water setting.

Nannofossils of middle-late Eocene age are recorded from the Kopili Formation of Mikir Hills, Samkherjan area, Assam. The assemblage is more diverse than the present assemblage and contains variety of pentaliths, helicoliths and discoasters. *C. reticulatum* is also present in this assemblage (Singh, 1979). The present assemblage is also comparable with late Priabonian age nannofossil assemblage recovered from Surat-Bharoch area, Cambay Basin, western India (Singh *et al*., 1978; Jafar *et al.*, 1985). The western Indian assemblage is, however, rich and more diversified.

CONCLUSIONS

1. The moderately diverse nannofossil assemblage contains twenty three species. The last Appearance Datum (LAD) of *P. basquense* and *P. papillatum* indicates terminal Priabonian (Late Eocene) NP21 Zone of Martini (1971) and it equates with the zonal boundary of NNTe14 (Varol,

Plate II

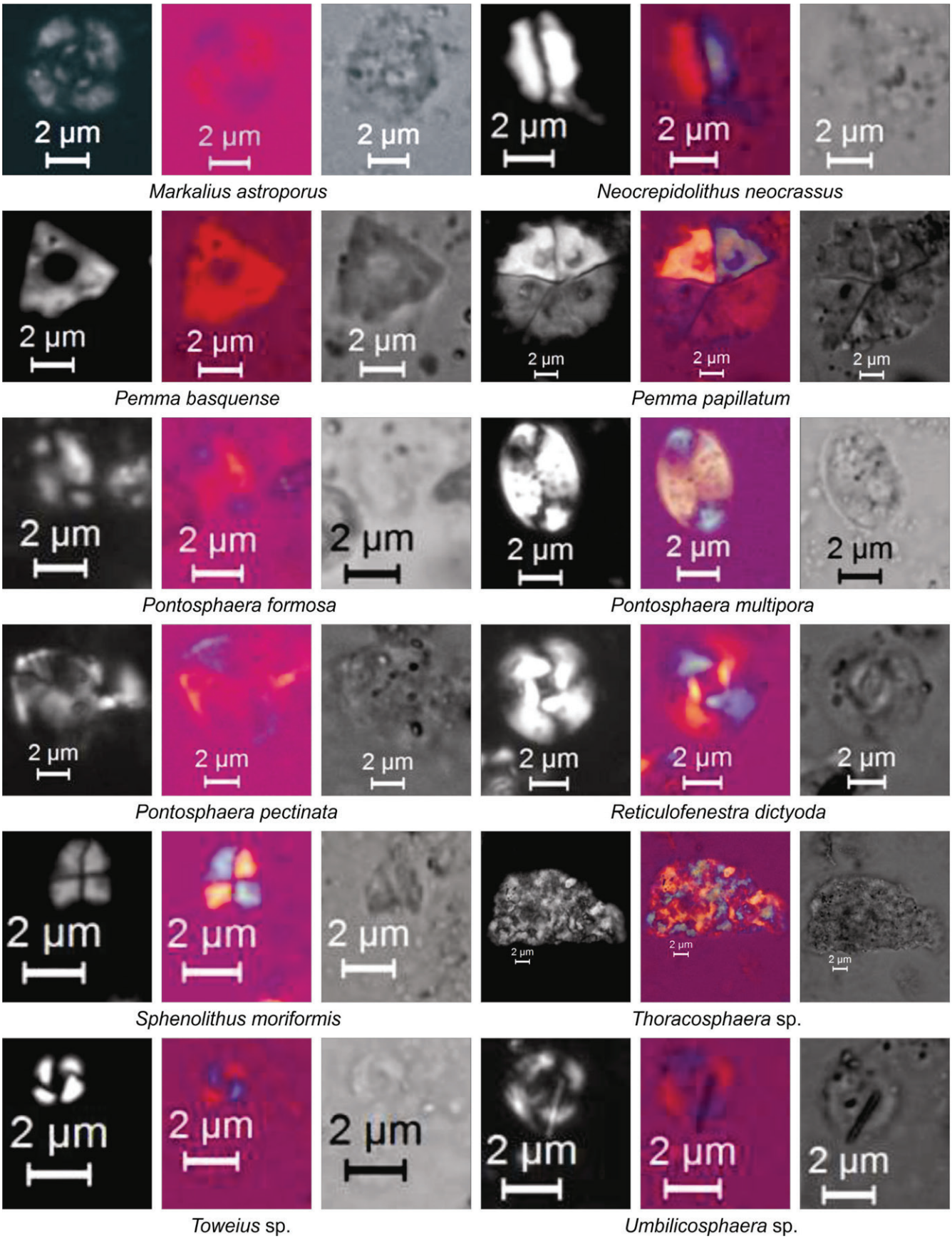

2 µm
Markalius astroporus
Neocrepidolithus neocrassus
Pemma basquense
Pemma papillatum
Pontosphaera formosa
Pontosphaera multipora
Pontosphaera pectinata
Reticulofenestra dictyoda
Sphenolithus moriformis
Thoracosphaera sp.
Toweius sp.
Umbilicosphaera sp.

Table 1. Stratigraphic succession in the Garo Hills (after Chakraborty and Baksi, 1972).

Age	Stratigraphic Unit	Lithology
Post-Eocene	Post-Rewak (Kherapara, Boldamgiri Angartoli, Bilkona, Rangapani and Dalu formations)	
Late Eocene	Rewak Formation	Thinly bedded, splintery, grey shales and carbonaceous shales with interbeds of fine grained, ferruginous, current bedded sandstone and coal streaks. Thin foraminiferal limestone beds occur in the upper part.
Middle Eocene	Siju Formation	Banded alternations of hard, greyish yellow and yellow, arenaceous foraminiferal limestone and calcareous shales or marl. Hard massive limestone occurs in the upper part.
Palaeocene Early Eocene	Tura Formation	Medium to coarse grained and gritty, clayey, dirty white, yellow and reddish, nonfeldspathic, frequently current bedded sandstone intercalated with thin argillaceous beds and coal seams.
Precambrian	Basement Complex	Granite and granite gneisses

1998). *P. papillatum* has earlier been recorded from middle-late Eocene age Kopili Formation in Mikir Hills (Singh, 1979).

2. The presence of helicoliths (*Helicosphaera lophota lophota* and *Helicosphaera seminulum*) and *Coccolithus eopelagicus* indicates hemipelagic, nearshore, warm water environment of deposition.
3. Absence of open ocean discoasters is noticeable.

LIST OF TAXA

1. *Blackites* sp.
2. *Claussicoccus subdistichus* (Roth & Hay *in* Hay *et al.*, 1967) Prins, 1979
3. *Claussicoccus vanheckiae* (Perch-Nielsen, 1986)
4. *Coccolithus eopelagicus* (Bramlette & Riedel, 1954) Bramlette & Sullivan, 1961
5. *Coronocyclus nitescens* (Kamptner, 1963) Bramlette and Wilcoxon, 1967
6. *Cribrospharella ehrenbergii* (Arkhangelsky, 1912) Deflandre in Piveteau, 1952
7. *Cruciplacolithus primus* Perch-Nielsen, 1977
8. *Cyclicargolithus floridanus* (Roth & Hay, *in* Hay *et al.*, 1967) Bukry, 1971
9. *Cyclococcolithus kingii* Roth (1970)
10. *Futyania petalosa* (Ellis and Lohmann, 1973) Varol, 1989
11. *Helicosphaera lophota lophota* (Bramlette & Sullivan, 1961) Locker, 1973
12. *Helicosphaera seminulum* Bramlette & Sullivan, 1961
13. *Neocrepidolithus neocrassus* (Perch-Nielsen, 1968) Romein, 1979
14. *Pemma basquense* (Martini, 1959) Báldi-Beke, 1971
15. *Pemma papillatum* Martini, 1959
16. *Pontosphaera formosa* (Bukry & Bramlette, 1969) Romein, 1979
17. *Pontosphaera multipora* (Kamptner, 1948 ex Deflandre in Deflandre & Fert, 1954) Roth, 1970
18. *Pontosphaera pectinata* (Bramlette & Sullivan, 1961) Sherwood, 1974
19. *Reticulofenestra dictyoda* (Deflandre *in* Deflandre & Fert, 1954) Stradner *in* Stradner & Edwards, 1968
20. *Sphenolithus moriformis* (Brönnimann and Stradner, 1960) Bramlette and Wilcoxon, 1967
21. *Thoracosphaera* sp.
22. *Toweius* sp.
23. *Umbilicosphaera* sp.

ACKNOWLEDGEMENTS

The authors are thankful to Prof. Sunil Bajpai, Director Birbal Sahni Institute of Palaeobotany, Lucknow for the encouragement and kind permission to publish this work (Permission no. BSIP/RDCC/Publication No. 46/2015-16). Dr. Vandana Prasad, BSIP and lab mates are duly thanked for their support.

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Manuscript Accepted December 2015