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A report on the Late Cretaceous-Early Palaeocene molluscs and echinoids from the Meghalaya shelf in the vicinity of the K-Pg Mass Extinction Boundary

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A rich assemblage of molluscs (bivalves, gastropods, ammonites) and echinoids have been recorded from the Late Cretaceous-Early Palaeocene sediments of the Mahadek and Langpar formations of Meghalaya shelf, which preserve one of the best and most complete Cretaceous-Palaeogene (K-Pg) mass extinction boundary in India. The Mahadek and Langpar formations are mainly exposed in the southern part of the Meghalaya plateau and represent shelf sediments having contact with the Assam Meghalaya Gneissic Complex (AMGC), Sylhet Traps or the Shillong Group metasediments. A diverse fauna of 37 taxa has been recorded represented by 19 bivalve genera, 9 gastropod genera, 4 genera of ammonites, and 5 genera of echinoderms along with burrows (mainly *Thalassinoides* and a few *Skolithos*), shark tooth and serpulid worm tubes.

Some of the invertebrate taxa are valuable biostratigraphic tools for regional and global correlation of many Upper Cretaceous successions in the world. The heteromorph ammonite assemblage of *Nostoceras* sp., *Eubaculite* sp., *Glyptoxoceras* sp., and *Pachydiscus* sp. have been recorded from the lower part of the Langpar Formation just below the K-Pg mass-extinction boundary and probably represent the last Indian representatives of the ammonites just before their extinction. Both epifaunal and infaunal organisms in almost equal abundance and wide diversity for palaeoecological consideration noted. The assemblage is dominantly cosmopolitan with few Tethyan, European and Indo-Pacific affinities analogous to many Upper Cretaceous sections.

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INTRODUCTION

The Shillong Plateau is situated in the northeastern part of India approximately between 90°-94°E longitude and 25°-26°N latitude comprising the highlands of Garo, Khasi, Jaintia and Mikir Hills. In the southern part of the plateau, sedimentary sequences ranging in age from Late Cretaceous to Recent, volcanic rocks of Jurassic-Cretaceous age together with Proterozoic rocks are present. The Cretaceous-Palaeogene sediments of Meghalaya belong to shelf facies and are represented by the Jadukata and Mahadek formations of the Khasi Group and the Langpar, Shella, and Kopili formations of the Jaintia Group (Murthy *et al*., 1976). They unconformably overly Precambrian granite gneisses and Shillong Group of metasediments, Neoproterozoic porphyritic Granites, and Sylhet Trap rocks which form the basement of the Cretaceous Meghalaya shelf. The present study is carried out in the Mahadek Formation of Khasi Group and the Langpar Formation of Jaintia Group along the southern part of the Shillong plateau in parts of East Khasi Hills District and West Jaintia Hills District of Meghalaya (Fig.1). The Cretaceous-Palaeogene marine biota of Meghalaya is well known and studied by Bhattacharya and Bhattacharya (1987); Barman (1988); Sengupta and Mehrotra (1988); Mukhopadhyay (2008); Gertsch *et al.* (2011) and Mukherjee (2012). They have contributed considerably towards the fossil wealth of Meghalaya including molluscs, echinoderm, and foraminiferal assemblages. Detailed foraminiferal studies were carried out by Mukhopadhyay (2005) in the exposed Upper Cretaceous-Palaeogene shelf sequence of the Umsohryngkew and Umium river sections of Khasi Hills to delineate the biostratigraphic boundaries. Bhattacharya and Bhattacharya (1987) and Mukherjee (2012) reported a diverse assemblage of invertebrate fossils from the Upper Maastrichtian of Meghalaya.

Recent field investigations in the last few years have recorded highly fossiliferous units in the Mahadek and Langpar formations of the Late Cretaceous to Early Palaeocene age which have yielded abundant and rich mega invertebrates like bivalves, echinoids, gastropods, ammonites, foraminifers and other faunal elements like prolific burrows (Fig. 2), serpulid worms (Fig. 3) and shark tooth. We have

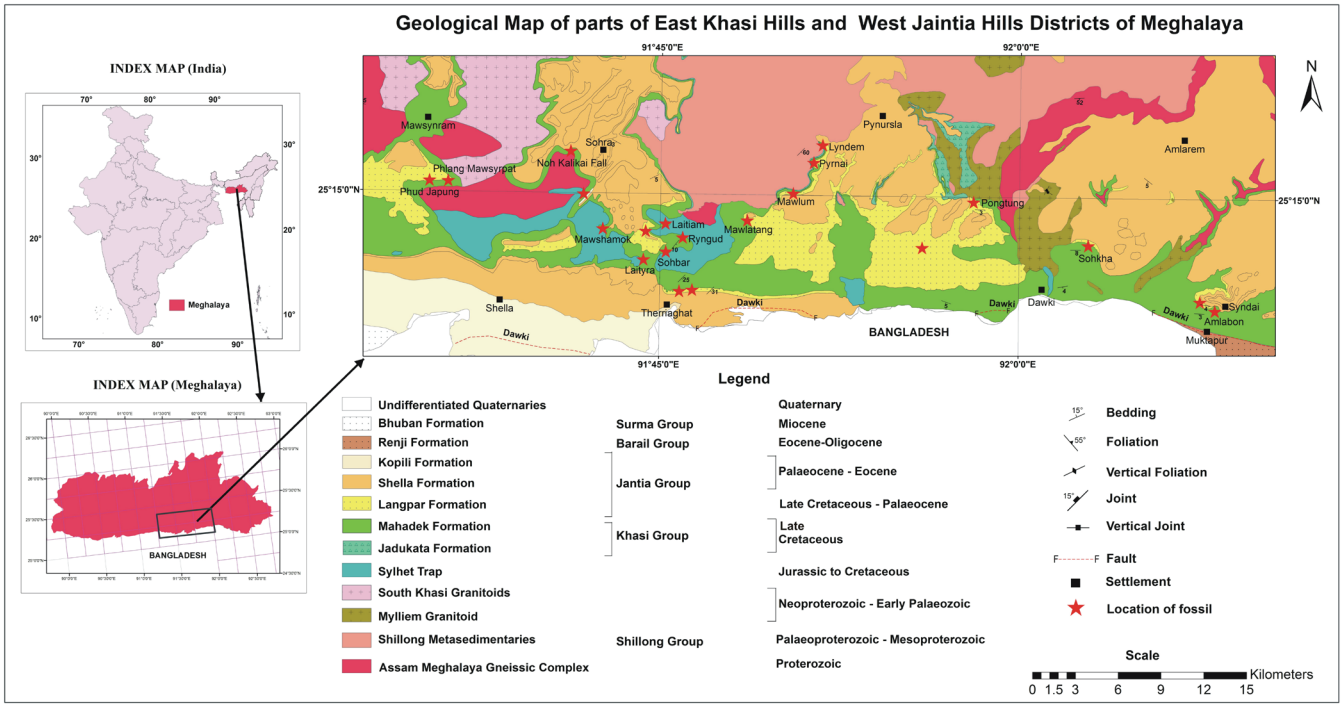


Figure 1. Geological map of the study area showing fossil sample localities

been able to record an Ammonite bearing horizon in the lower part of the Langpar Formation which lies below the Cretaceous-Palaeogene (K/Pg) boundary. Ammonites were one of the major invertebrate groups that did not survive the Cretaceous-Palaeogene mass extinction. The preservation of the faunal elements is in general very poor and they are usually preserved as steinkerns or molds. The only faunal elements with well-preserved shell structures are calcitic taxa like *Gongrochanus* and epifaunal thick-shelled oysters like *Agerostrea*.

Systematic studies of the marine invertebrates were taken up because of the proximity of the fossiliferous horizons with the mass extinction boundary. The present paper focuses on taxonomic aspects of the molluscs and echinoid fauna from mainly four sections from the different parts of East Khasi Hills District and West Jaintia Hills District of Meghalaya. Lithostratigraphic studies were carried out in detail (Dalabehera *et al.,* 2021) and fossils have been collected from well-calibrated litho-sections of the Mahadek and Langpar formations. A study of the invertebrate fauna revealed palaeo-environmental information regarding the Late Cretaceous Meghalaya shelf apart from elucidating its biotic content. Characteristic faunal assemblages have helped in identifying two marker horizons in the Mahadek and Langpar formations (Dalabehera *et al.,* 2021). The first horizon is the medium to coarse-grained calcareous sandstone of the upper part of the Mahadek Formation rich in echinoids, bivalves, and gastropods (Figs.4, 5). The nature of shell bed deposition represents sediments in fluctuating environments and bearing signs of instability- turbulence due to tide and wave actions in the shallow shelf. The local episodic storm within the shallow shelf must have played a major role in the deposition of alternating layers of shell beds (Dalabehera *et al.,* 2021). The second horizon is in the lower part of the Langpar Formation consisting of carbonaceous shale and calcareous sub-arkose with heteromorph ammonites, gastropods, and prolific burrows (Figs. 6,7). In this unit, the presence of abundant burrows along with heteromorph ammonites and typical gastropods which are borers & predators just below the K-Pg mass-extinction boundary probably points to a stressed and unfavorable condition of the environment due to the catastrophic impact, Deccan Traps large igneous province and dynamic climate instability which led to the extinction of some species. The fossils described in the present study are mainly collected from the two marker horizons and the lithological details and faunal distribution have been shown in Fig. 8.

In the present work, a documentation of the marine fauna from the Mahadek and Langpar formations has been attempted to give an overview of the rich faunal diversity in the Late Cretaceous-Early Palaeocene sediments of the Meghalaya shelf.

GEOLOGICAL SETTING

The Shillong plateau consists of the Assam Meghalaya Gneissic Complex, meta-sedimentary rocks belonging to the Shillong Group, mafic igneous rocks, granite plutons, Sylhet Traps and ultramafic-alkaline carbonatite complex covered by the Cretaceous-Palaeogene sediments in the southern part of the Meghalaya shelf. These sediments are represented by the Jadukata and Mahadek formations of the Khasi Group and the Langpar, Shella, and Kopili formations of Jaintia Group. In the present study, the emphasis is on the Mahadek Formation of Khasi Group and the Langpar Formation of the Jaintia Group in different parts of Southern Meghalaya i.e.

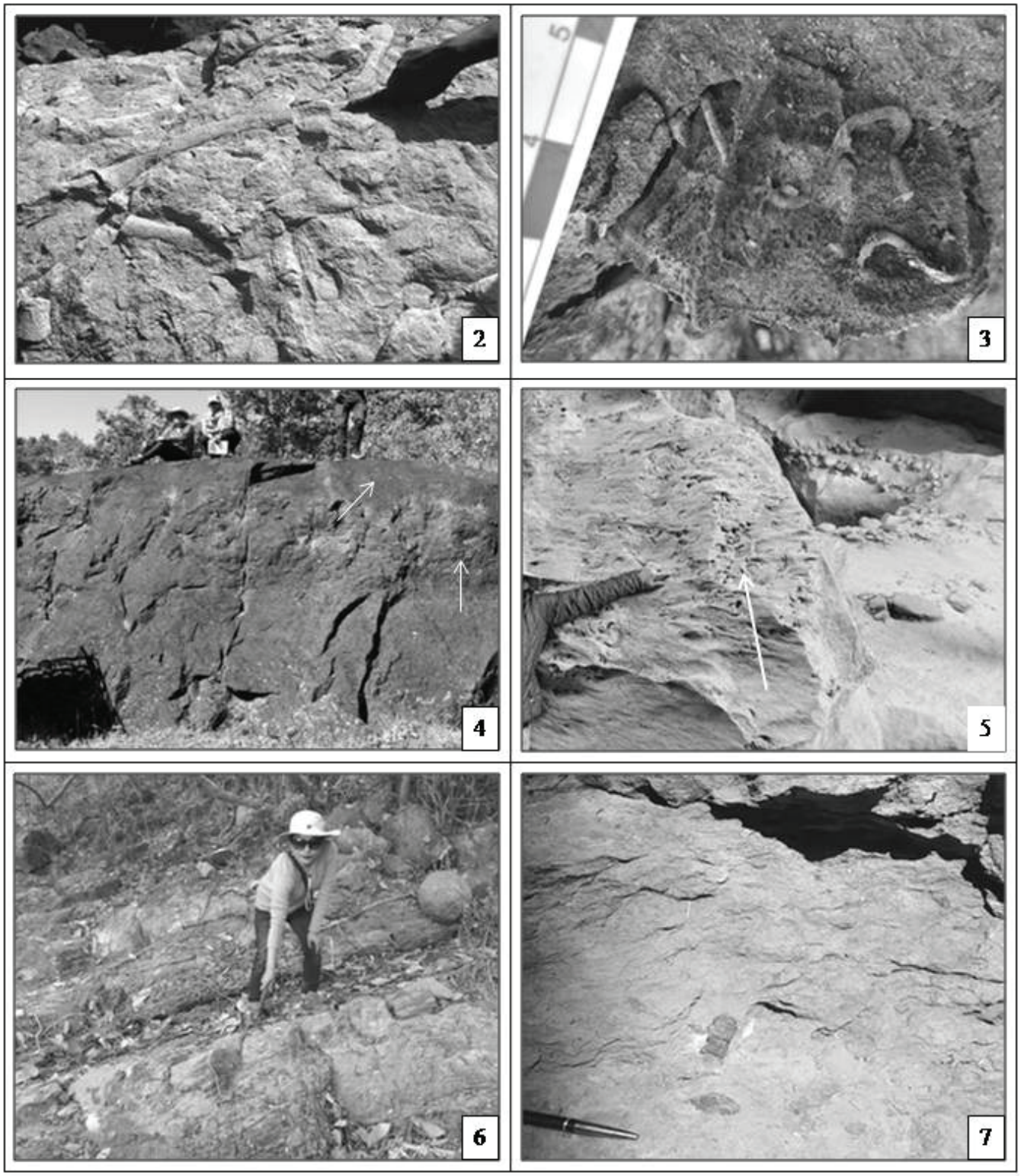


Figure 2. *Thalassinoides* observed in the Langpar Formation; **Figure 3**: Serpulid worms seen within an echinoid fossil; **Figure 4**: Echinoids rich beds observed in the calcareous sandstone of the upper part of the Mahadek Formation at Phlang Mawsyrpat; **Figure 5**: *Agerostrea* rich beds seen in the calcareous sandstone of the upper part of the Mahadek Formation at Noh Kalikai fall; **Figure 6**: Carbonaceous shale, calcareous sub-arkose, calcareous shale intercalations of the lower part of the Langpar Formation; **Figure 7**: Calcareous sub-arkose rich in heteromorph ammonites, gastropods and burrows.

Dawki-Muktapur-Amlarem-Syndai-Sohkha of West Jaintia Hills District, Mawsynram-Janiaw-Phlang Mawsyrpat-Tyngnger, Pynursla-Lyndem-Pyrnai-Mawlatang, Ryngud-Laitiam-Sohbar-Laityra-Noh Kalikai-Mawshamok of East Khasi Hills District, Meghalaya. The stratigraphic succession of the study area is given in Table-1 (modified after Bhattacharya and Bhattacharya, 1987, and Mukhopadhyay, 2008).

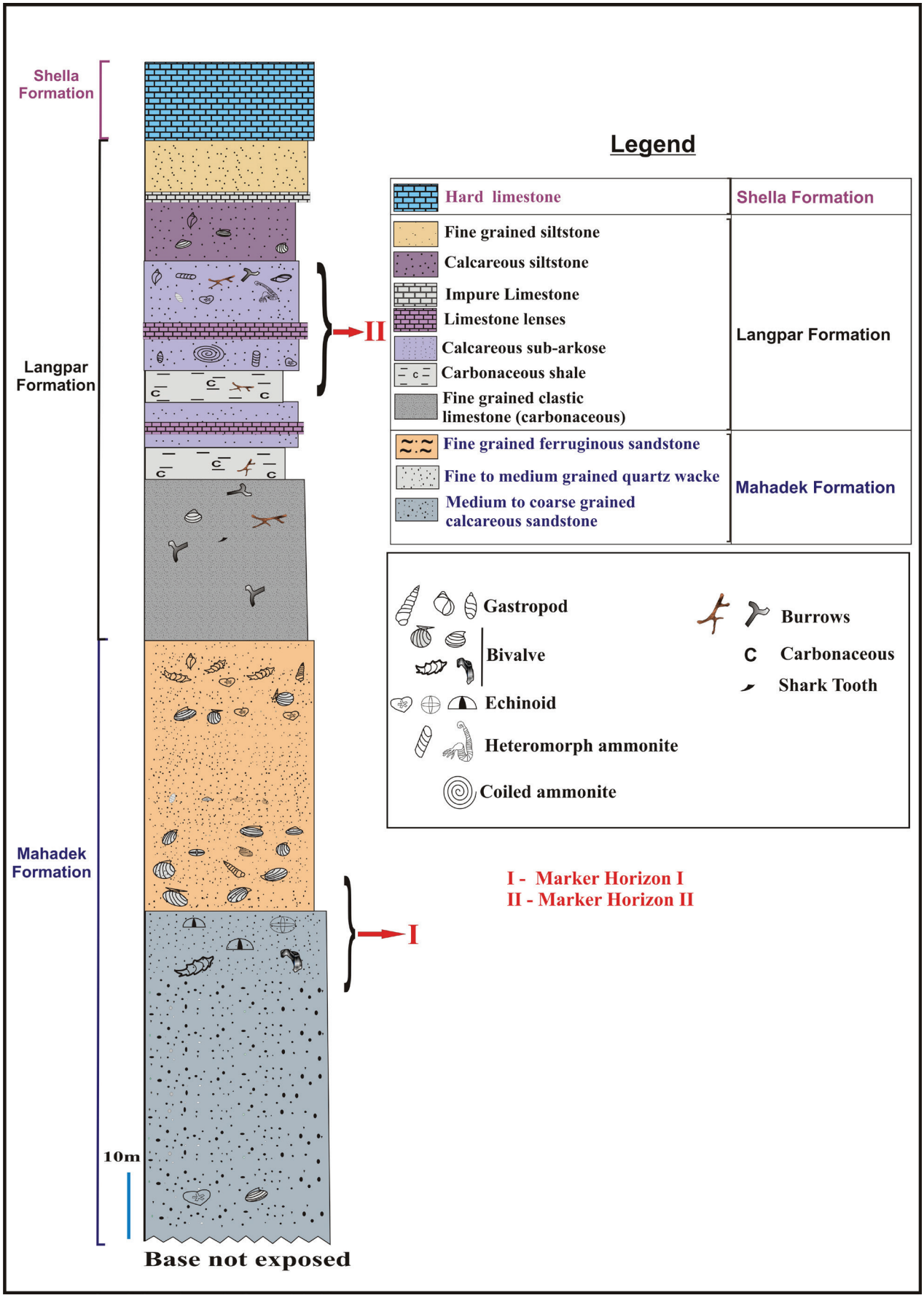


Figure 8. Composite section of the study area showing the two marker horizons recorded in the Mahadek and Langpar formations in Meghalaya.

Table- 1. Stratigraphic succession of the study area

Age	Formation	Broad lithologic character
Late Palaeocene to Middle Eocene	Shella Formation	Sandstone and limestone, in the southern part dominantly calcareous
Late Cretaceous to Palaeocene	Langpar Formation	Limestone, carbonaceous shales, sub-arkose, siltstones dominantly calcareous
Late Cretaceous	Mahadek Formation	Coarse grained gritty sandstones, glauconite bearing calcareous sandstone with thin ferruginous limonitic sandstone
Middle to Late Cretaceous	Weiloi Conglomerate/ Jadukata Formation	Bedded conglomerate, pebbly/coarse sandstone alteration
----------Unconformity----------		
Early Cretaceous	Sylhet Trap	Basalt, alkali basalt, rhyolite and tuff
Precambrian	Shillong Group	Quartzite, phyllite, quartz-sericite schist, conglomerate

Mahadek Formation

The Mahadek Formation is dominantly arenaceous which ranges from gritty sandstones in the lower part to dominantly medium to coarse grained sandstones in the upper part. The lower units in the upper part of Mahadek Formation consist of conglomerates-pebbly beds, medium to coarse-grained micaceous feldspathic sandstone which is thinly laminated with cross beddings at the bottom and gradually massive towards the top with poorly preserved molluscs. The uppermost part of the Mahadek Formation is made up of hard and massive, medium to coarse-grained greyish glauconitic calcareous sandstone intercalated with thin bands of fine to medium-grained quartz wacke and fine to medium-grained ferruginous limonitic sandstone at the top which hosts numerous molluscs and echinoids with few shark teeth. Fresh feldspars, angular to sub-angular quartz grains, gritty nature along with few pyrite nodules are some character noted in the Mahadek Formation. The Mahadek Formation is approximately 150m to 190m in thickness, well resistant, striking E-W, with sub-horizontal bedding towards the south. It is well exposed south of Sohra (Sohbar- Ryngud-Laityra-Laitiam-Mawshamok section), Mawsynram-Janiaw-Phlang Mawsyrpat- Tyngnger and Lyndem-Pyrnai-Mawlatang of East Khasi Hills District and Sohkha and Muktapur-Amlabon sections of West Jaintia Hills District. A wide diversity of molluscs were recorded in the upper part of the Mahadek Formation, viz., bivalves of the family Pectenidae, Ostreidae, Cardiidae, Trigonidae, Nuculidae, Limidae, Corbulidae, gastropods belonging to the family Turritellidae and Ampullinidae along with some heteromorph ammonites like *Eubaculite* sp. Echinoids are also a characteristic fauna, and the family Micrasteridae, Faujasiidae and Holasteridae are present.

Langpar Formation

Throughout the stretch from west to east of the study area, the Langpar Formation of Jaintia Group is approximately 80m to 100m thick and conformably overlies the Mahadek Formation. It is well exposed towards the south of Sohra (Sohbar-Therriaghat and Ryngud- Laitiam), Pyrnai-Mawlatang-Mawkliaw road sections, Janiaw near Mawsynram, East Khasi Hills District and along Muktapur-Amlarem road section and Sohkha, West Jaintia Hills District. The Langpar Formation in general has a low dip (< 4°) towards south. However, along Sohbar-Therriaghat road section, the beds have a comparatively high dip, 25°–30° towards the south due to the effect of the Dawki Fault. The Cretaceous-Palaeogene (K-Pg) boundary within the Langpar Formation was recorded from the Um Sohryngkew (Wahrew), Therriaghat river section near Sohbar, East Khasi Hills District based on foraminiferal assemblages (Mukhopadhyay, 2008). The Langpar Formation comprises calcareous units represented by clastic limestone (carbonaceous at places), carbonaceous shale, calcareous sub-arkose, calcareous shale, impure limestone, silty mudstone, calcareous siltstone, limestone lenses, etc. and occupies a major portion of the area towards the southern part of Sohra along Ryngud-Laitiam, Sohbar-Therriaghat road section and along Muktapur-Amlarem road section. Heteromorph ammonites like *Eubaculite* sp., *Glyptoxoceras* sp., and *Nostoceras* sp. with few coiled ammonites *Pachydiscus* sp., gastropods of the family Turritellidae, Fasciolaridae, Ampullinidae, Colombellinidae and Naticidae with few bivalves and echinoids Hemiasteridae were recorded from the calcareous subarkose unit. Along with these fauna, abundant burrows of variable sizes (mainly *Thalassinoides* and few *Skolithos*) were also noted. The calcareous siltstone unit hosts abundant bivalves of the family Cardiidae, Nuculidae, Crassatellidae, Lucinidae, Pholadomidae, and Mytilidae along with gastropod of the family Volutidae.

MATERIALS AND METHODS

During the present study, bivalves, gastropods, ammonites, and echinoids were systematically collected from the Mahadek and Langpar formations (Table 2). The specimens recorded are mainly internal and external molds with few having the shells preserved and therefore the internal morphological characters are mostly obscured. Specific identification is not possible since the specimens are incomplete, poorly preserved, and embedded within the matrix. Extraction is also very difficult and valve orientation could not be ascertained. From the collection, a sizable component was discarded due to poor preservation and only 19 bivalve genera, 9 gastropod genera, 4 ammonite genera and 5 genera of echinoids have been identified. A range chart of some extinct species is also shown (Fig. 9). They were brought to the laboratory, processed, and cleaned following conventional techniques. The specimens were studied and the representative fossil specimens of different genera have been described. The molluscs and echinoid fauna has been studied and identification of the fossils was made with the help of published literature like the Treatise on Invertebrate Palaeontology (Moore, R. C.; *Geol. Soc. America.* Part N. Mollusca 6: Bivalvia, Volumes 1 and 2, 1969 and Part N.

Table-2: Diverse faunal assemblages recorded across the upper part of the Mahadek Formation and the lower part of the Langpar Formation from four well calibrated litho sections of the Meghalaya shelf

Area / Formation	Lithology	Mawsynram - Janiaw - Phud Japung - Phlang Mawsyrpat - Tyngnger sections	Ryngud - Laitiam - Sohbar - Therriaghat - Laityra - Noh Kalikai- Mawshamok sections near Sohra	Lyndem-Pyrnai-Mawlum-Mawlatang sections near Pynursla	Dawki-Muktapur - Amlarem-Syndai - Sohkha Section
LANGPAR	Fine grained siltstone Calcareous siltstone Impure Limestone Limestone lenses				Bivalves like *Nucula* sp., *Nuculana* sp., *Crassetella* sp., *Pholadomya* sp., *Lucina* sp., *Mytilus* sp., carditids and limids, gastropod (*Volutocorbis* sp.) etc.
	Calcareous sub-arkose and carbonaceous shale intercalation	Heteromorph ammonites (?), few gastropods, prolific burrows	Heteromorph ammonites (*Eubaculite* sp., *Glyptoxoceras* sp. etc.), few coiled ammonite along with burrows, Gastropods like *Fasiolaria* sp., *Ampulina* sp., *Graphidula* sp., *Euspira* sp., *Pterodonta* sp. etc. Few bivalves like *Cucullae* sp.and echinoids like spatangoids.		Heteromorph ammonites (*Eubaculite* sp.) with abundant burrows and gastropods
	Fine grained clastic limestone (carbonaceous)			Prolific burrows, few shark tooth, and few bivalve	
MAHADEK	Fine grained ferruginous sandstone Fine to medium grained quartz wacke Medium to coarse grained calcareous sandstone	Prolific echinoids (*Gongrochanus* sp.), bivalves (*Agerostrea* sp., *Limea* (*Pseudolimea*) sp., *Pecten* sp.) etc, gastropods (*Turritella* sp.and *Pseudamaura* sp.)	Bivalves (Pectenids, Carditids, *Agerostrea* sp., *Cataceramus* sp.), few gastropods of the family Turritellidae and Cerithiidae), Echinoids (Cassiduloids and Spatangoids)	Heteromorph ammonites (*Eubaculite* sp.), Bivalves like, Carditids, Pectenids, *Nucula* sp., *Caestocorbula* sp., *Glycymeris* sp., *Agerostrea* sp., gastropod (*Turritella* sp. and *Ampullina* sp.). Few shark teeth. Echinoids like *Gongrochanus* sp., *Mecaster* sp.	Bivalves (*Agerostrea* sp., *Neithea* sp., *Myophorella* sp., *Granocardium* sp., pectenids), few gastropods of the family Turritellidae, *Cerithium* sp., *Graphidula* sp.), Echinoids (Cassiduloids, Holasteroids and Spatangoids)

Mollusca 6: Bivalvia, Volume 3, 1971). The present work follows the classification of the Echinoidea as suggested by Newell (in Moore *et al.,* 1969) and several other published research journals. The identification of genera and species is mainly based on external features.

SYSTEMATIC PALAEONTOLOGY

Bivalves

The Bivalves taxa include 19 genera falling into 16 families in which two were identified up to the specific level. A few species like *Cataceramus* sp., *Exogyra* sp., *Limea (Pseudolimea)* sp*., Myophorella* sp., and *Granocardium* sp. became extinct at the end of the Cretaceous period whereas *Neithea regularis* and *Agerostrea ungulata* extended up to the Lower Palaeocene age.

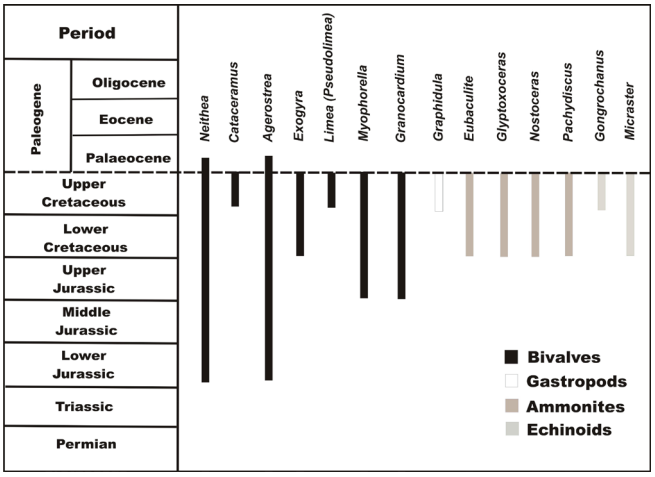
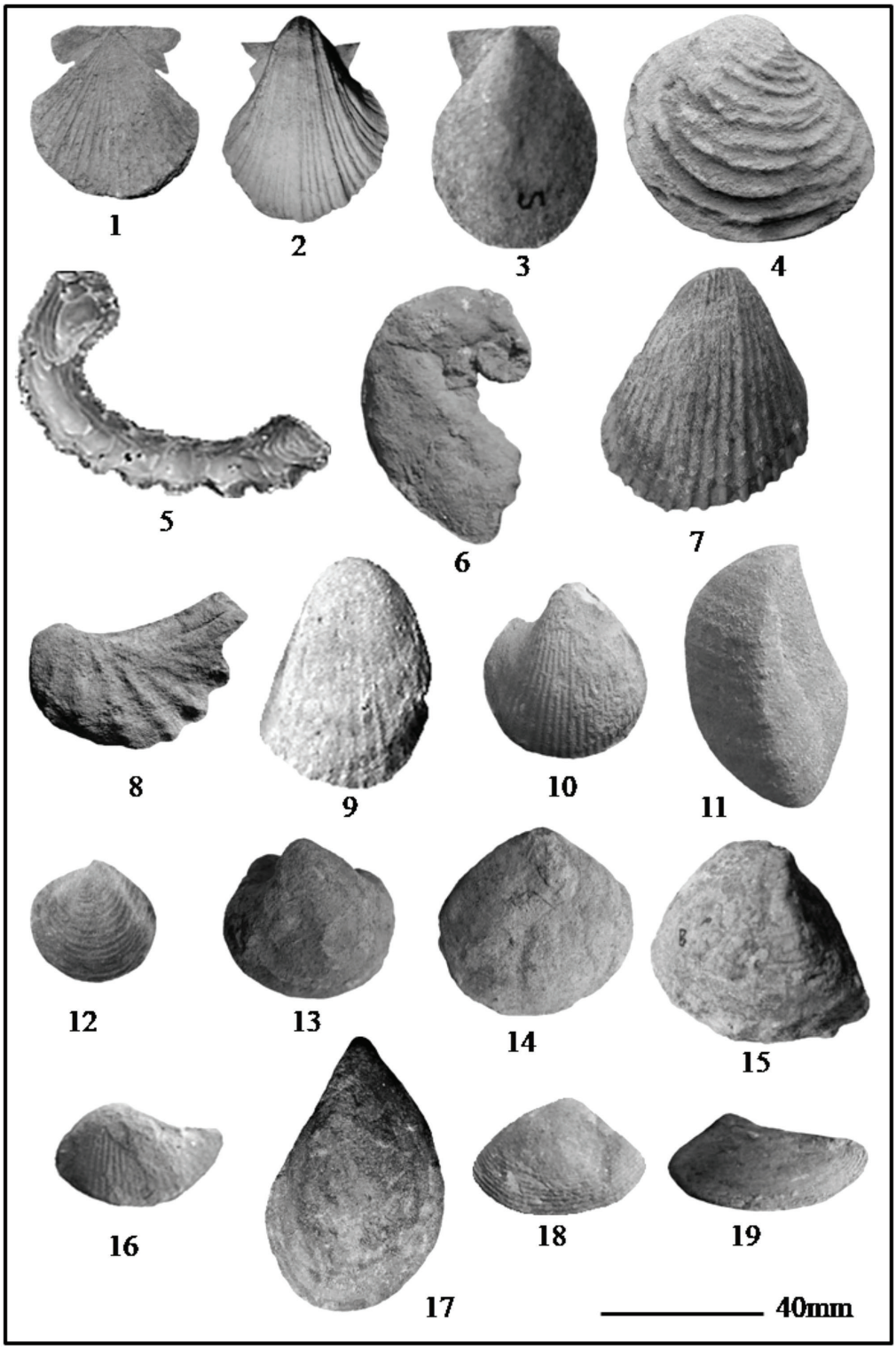


Figure 9: Range chart of some extinct taxa recorded from the Late Cretaceous- Early Palaeocene shelf sediments of Meghalaya

Order Pterioida Newell, 1965
Family Pectinidae Rafinesque, 1815
Genus *Pecten* Müller, 1776



EXPLANATION OF PLATE I

Horizontal scale bar represent the length of the specimens: 1. ***Pecten*** **sp.** (Specimen no. K-Pg/ MEG/01); **2.** ***Neithea regularis*** (40mm x1/2) (Specimen no. K-Pg/ MEG/02); **3.** ***Eburneopecten*** **sp.** (40mm x1/4) (Specimen no. K-Pg/ MEG/07); **4**. ***Cataceramus*** **sp.** (Specimen no. K-Pg/ MEG/08); **5.** ***Agerostrea ungulate*** (40mm x1/2) (Specimen no. K-Pg/ MEG/12); **6.** ***Exogyra*** **sp.** (40mm x1/4) **(**Specimen no. K-Pg/ MEG/21); **7.** ***Limea (Pseudolimea)*** **sp**. (Specimen no. K-Pg/ MEG/22); **8.** ***Myophorella*** **sp.** (40mm x1/2) (Specimen no. K-Pg/ MEG/24); **9.** ***Granocardium*** **sp.** (40mm x1/2) (Specimen no. K-Pg/ MEG/26); **10.** ***Cardium*** **sp.** (40mm x1/2) (Specimen no. K-Pg/ MEG/28);**11.*Crassatella*** **sp.** (Specimen no. K-Pg/ MEG/31); **12.** ***Lucina*** **sp.** (Specimen no. K-Pg/ MEG/36); **13.*Cucullaea*** **sp.** (Specimen no. K-Pg/ MEG/39); **14.*Glycymeris*** **sp.** (Specimen no. K-Pg/ MEG/40); **15.** ***Caestocorbula*** **sp.** (Specimen no. K-Pg/ MEG/41); **16.** ***Pholadomya*** **sp.** (40mm x1/2) (Specimen no. K-Pg/ MEG/42); **17.** ***Mytilus*** **sp.** (40mm x1/2) (Specimen no. K-Pg/ MEG/44); **18.** ***Nucula*** **sp.** (40mm x1/2) (Specimen no. K-Pg/ MEG/45); **19.** ***Nuculana*** **sp.** (Specimen no. K-Pg/ MEG/50).

Pecten sp.
[Plate-I (Fig. 1)]

Ostrea maxima Linne, 1758
Material: 1 internal mold (Specimen no.: K-Pg/ MEG/01)
Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/01	40	-	40

Description: The shell is medium to large, suboval, more or less equilateral, auriculate and ornamentation consist of principal ribs which are rounded and elevated. Auricles on both side of the valve are unequal, ornamented with fine striations. Near the umbonal region, ribs are fine and dense continuing up to the commissure with increased thickness. The ribs are smooth near the anterior and posterior margins. After a short distance from the umbonal area, the ribs become thick and separated by deep concave furrows which are characterized by fine parallel striations or secondary ribs.

Remarks: The Pectinidae family is one of the most common bivalves found in the calcarenite and medium to coarse-grained sandstones of the Mahadek Formation. However, they generally occur as internal, poorly preserved, and abraded molds. Based on the presence of strong ribs and auricles the present specimen has been kept under the genus *Pecten* which closely resembles the species reported by Kaye and Cunliffe from the Upper Cretaceous Cauvery basin of Trinchinopoly, South India (Forbes, 2013).In Meghalaya, they were earlier recorded from the Mahadek and Jadukata formations (Bhattacharya and Bhattacharya, 1987 and Mukherjee, 2012). The earliest *Pecten* are known from the Cretaceous and widely distributed in warm temperate Eurasian seas of Cenomanian to the latest Maastrichtian age, hundreds of recent species are distributed worldwide.

Horizon: Medium to coarse-grained sandstone of the upper part of the Mahadek Formation, Phlang Mawsyrpat and Sohkha, Meghalaya.

Sub Family Neitheinae Sobetskij, 1960
Genus Neithea Drouet, 1824

Neithea regularis Schlotheim, 1813
[Plate-I (Fig. 2)]

Pectinites regularis E. F. von Schlotheim, 1813, p.112.

Material: 5 external molds (Specimen nos.: K-Pg/ MEG/02 to K-Pg/ MEG/06)
Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/02	20	12	25
K-Pg/ MEG/03	18.2	9	22
K-Pg/ MEG/04	18	8	18.5
K-Pg/ MEG/05	15	10	20
K-Pg/ MEG/06	12	8	16

Description: The shells are symmetrical, and the inequivalved, right valve is moderately convex with six radiating prominent primary ribs which are high, narrow, and rounded with a variable number of secondary ribs in each interspace; the left valve is nearly flat or slightly concave, umbo incurved and auricles subequal or unequal. Three unequal secondary ribs are intercalated between each pair of principal ribs with the middle secondary rib more strongly developed. The ribs are separated by the narrow flattened depression or furrows having secondary ribs or fine striations.

Remarks: *Neithea regularis* recorded in the present study are characterized by having 21 ribs, six are more pronounced and three intercostal ribs present in between of generally equal development. They are commonly found in the ferruginous sandstone of the upper part of the Mahadek Formation. The taxa were recorded by Spengler (1923) from 'Tharria Ghat, Sokha, Assam' and later by Bhattacharya and Bhattacharya (1987). *Neithea (Neithea) quinquecostata* (Sowerby, 1816) was also recorded by Forbes (1846: 153) from Pondicherry and Verdachellum, Ariyalur Group (Maastrichtian) of South India. Forbes' specimens was re-determined as *Neithea (N.) regularis* (von Schlotheim) by Dhondt (1973: 26). *Neithea regularis* is widely distributed from the Turonian to the latest Maastrichtian; it generally occurs in coarse-grained sediments and has been found from North America (frequently found in the Campanian of the Gulf and Atlantic Coastal Plains) to the Russian Platform in uppermost Cretaceous strata. It is mainly found in the more southern parts of the temperate seas (Dhondt, 1984).

Horizon: Ferruginous sandstone of the upper part of the Mahadek Formation, Amlabon and Phud Japung, Meghalaya.

Genus Eburneopecten Conrad, 1865

Eburneopecten sp. (?) Campbell, 1993
[Plate-I (Fig. 3)]

Pecten scintillatus Conrad, 1865

Material: 1 internal mold (Specimen no.: K-Pg/ MEG/07).
Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/07	15	4	20

Description: The specimen is very poorly preserved. Shell is very small, equilateral with a circular commissure. Auricles are present which are unequal, and height is more than length showing delimited auricles.

Remarks: Poorly preserved *Eburneopecten* are quite common in the Mahadek sandstone. They were also recorded from Sohra and Sohkha areas of East Khasi Hills District, Meghalaya. However, most of the materials are broken and abraded. The present specimen was identified based on the size and unequal anterior and posterior auricles (Stilwell, 1998). They are widely distributed from the Turonian to the latest Maastrichtian with Indo-Pacific/Tethyan affinities and are more frequent in fine-grained deposits.

Horizon: Ferruginous sandstone of the upper part of the Mahadek Formation, Lyndem, Meghalaya.

Family Inoceramidae Giebel, 1852
Genus Cataceramus Heinz, 1932

Cataceramus sp.
[Plate-I (Fig. 4)]

Inoceramus balticus Böhm, 1909

Material: 3 external moulds (Specimen nos.: K-Pg/ MEG/08 to K-Pg/ MEG/10)

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/08	62	10	52
K-Pg/ MEG/09	47	14	40
K-Pg/ MEG/10	53	12.8	47

Description: The shells are suborbicular, strongly inequilateral, equivalve, small to medium size, moderately inflated and length exceeding the height. The surface is ornamented with more or less regularly spaced concentric lamellae and rugae. The beak is inclined and the umbo is slightly inflated. Toward the ventral margin, the rugae become much less regular.

Remarks: *Cataceramus* is distributed worldwide from the Late Middle Santonian to the earliest Late Maastrichtian. The supposed diagnostic feature is geniculation which occurs widely in species of *Cataceramus*, including the group of *C. balticus* (Giers, 1964). A few Campanian and Maastrichtian forms are described from eastern India (Chiplonkar & Tapasawi, 1974; Ayyasami & Rao, 1996), but their precise stratigraphical distribution is uncertain. In Meghalaya, Bhattacharya, and Bhattacharya, 1987 have recorded *Inoceramus balticus* from the Jadukata, Mahadek, and Langpar formations. The specimens in the present study are comparable with *Cataceramus balticus* and *Cataceramus* sp. based on the size, outline and ornamentation (Walaszczyk *et al.*, 2009). Few subcircular poorly preserved specimens were also recorded with weak radial ribbing but a definite conclusion on their affinities could not be established.

Horizon: Sandstone of the upper part of the Mahadek Formation, Sohbar, Meghalaya.

Order Ostreioida Ferussac, 1822
Family Ostreidae Rafinesque, 1815
Genus Agerostrea Vyalov, 1936

Agerostrea ungulate
[Plate-I (Fig. 5)]

Ostracites ungulatus von Schlotheim, 1813

Material: 10 incomplete shells (Specimen nos.: K-Pg/ MEG/11 to K-Pg/ MEG/20)

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/11	22	30	100
K-Pg/ MEG/12	20	24	45
K-Pg/ MEG/13	17	16	40
K-Pg/ MEG/14	16	20	90
K-Pg/ MEG/15	21.5	26	48
K-Pg/ MEG/16	17	10	75
K-Pg/ MEG/17	16	12	40
K-Pg/ MEG/18	20	30	85
K-Pg/ MEG/19	16.3	14	42
K-Pg/ MEG/20	18	22	54

Description: Moderately well preserved, thick, strongly ribbed shell with unequal valves. The margins of the valves have a characteristic zig-zag pattern. The lower valve shows finger-like outgrowths, by which the molluscs adhere to the substrate. Ornamentation consists of radial keel-like ribs. Ribs are thicker, and higher often with sharp crest, sometimes rounded or slightly wavy. The commissure line is sharp, zig-zag or toothed like in nature.

Remarks: *Agerostrea ungulata* typically occurs in marly limestones and chalk of Campanian to Maastrichtian age in Western Europe, northern Africa, Pakistan (Baluchistan), and Madagascar. In India, *Agerostrea ungulate* was reported from the Ariyalur stage of Trichinopoly and Valudavur Formation and Trigonoarca beds of Pondicherry District of Tamil Nadu. In Meghalaya, these molluscs have been recorded mostly from the medium to coarse-grained calcareous sandstone and the fine-grained ferruginous sandstone of the upper part of the Mahadek Formation. The incomplete specimens show decreasing size from older to younger unit within the Mahadek Formation ranging in height from 40 mm to 100 mm. *Agerostrea ungulata* has a smooth central field in both valves with strong plicate around the commissure which can be seen in most of the recovered specimens.

Horizon: Calcareous sandstone of the upper part of the Mahadek Formation, Nohkalikai Fall, Sohkha and Phlang Mawsyrpat, Meghalaya.

Family Gryphaeidae Vyalov, 1936
Genus Exogyra Say, 1820

Exogyra sp. (?)
[Plate-I (Fig. 6)]

Exogyra costata Say, 1820

Material: 1 poorly preserved internal mold (Specimen no.: K-Pg/ MEG/21)

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/21	10	16	17

Description: Shell is inequivalve, inequilateral, and small to medium in size. It is attached by sub umbonal or umbonal part and the beak is highly incurved and a little twisted. The attachment area is small.

Remarks: The present material is incomplete, and abraded and due to the absence of other features, a comparison was not possible. The family Gryphaeidae was recorded in abundance from the glauconitic calcareous sandstone of the Mahadek Formation but due to poor preservation, the broken and fragmentary nature of the shells' specific identity remains undetermined. In Meghalaya *Exogyra* was earlier reported from the Jadukata Formation by Bhattacharya and Bhattacharya, 1987. *Exogyra* was also reported by Stoliczka, in 1870 from the upper Cretaceous Cauvery basin of southern India. They first appeared in the lower Cretaceous and disappeared by the upper Cretaceous.

Horizon: Ferruginous sandstone of the upper part of the Mahadek Formation, Amlabon and Sokha, Meghalaya.

Order Limoida Waller, 1978
Family Limidae Rafinesque, 1815
Genus Limea Bronn, 1831

Limea (Pseudolimea)
[Plate-I (Fig. 7)]

Ostrea strigiliata Brocchi, 1814

Material: 2 external molds (Specimen nos.: K-Pg/ MEG/22 and K-Pg/ MEG/23)

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/22	40	12	50
K-Pg/ MEG/23	50	20	54

Description: The shell is relatively large, convex, suborbicular to subovate and the cardinal area is narrow. Sculptures of strong sharply triangular ribs of 21 numbers can be discerned. Fine transverse growth striae can be seen crossing the surface. Small spheres situated at the intersection of the ribs with the commarginal growth lines are present. The average apical angle is 74°.

Remarks: It was noticed that the specimens from Meghalaya are significantly large. They resemble the species *Limea* (*Pseudolimea*) *denticulate* Nilsson, 1827 which are frequent in sandy, coarse-grained sediments and only recorded from the Campanian to the latest Maastrichtian. The present record show very close similarity with the specimens recorded from the Maastricht Formation of the Netherlands based on the rib number, size, apical angle, etc. The species recorded from the Maastricht Formation, Maastricht (Late Maastrichtian) seems to reach larger dimensions like other bivalves as the ecological conditions at that time must have been exceptionally favorable (Dhondt, 1989).

Horizon: Medium to coarse-grained calcareous sandstone of the upper part of the Mahadek Formation, Phlang Mawsyrpat, Meghalaya.

Order Trigonioida Dall, 1889
Family Trigoniidae Lamarck, 1819
Genus Myophorella Bayle, 1878

Myophorella sp. Bayle, 1878
[Plate-I (Fig. 8)]

Trigonia nodulosa Lamarck, 1801

Material: 2 internal moulds (Specimen nos.: K-Pg/ MEG/24 and K-Pg / MEG/25)

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/24	25	-	50
K-Pg/ MEG/25	20	-	30

Description: The shell is thick and incomplete, inequilateral, trigonally ovate and umbo opisthogyral. The surface has diagonally arranged costae which become oblique near the dorsal margin and few tubercles can be seen. Maximum width is anteriorly displaced with the posterior part of the shell being relatively compressed and projected as a rostrum.

Remarks: Specific identification cannot be determined due to incomplete preservation and unknown internal characters. However, the shape of the shell and the ornamentation of the Meghalaya specimens are comparable to *Myophorella garatei* which bear smooth flank costae, anteriorly inflated with strong tubercles. The relative reduction in the posterior margin and elongation of the shell is one characteristic where the present study was kept under *Myophorella. Myophorella garatei* are shallow burrowers on muddy substrates, probably with the posterior margin level with the water-sediment interface and the smooth, wide ribs are interpreted as adaptations to anchor/stabilize the shell in muddy sediments and inhabited environments with low hydrodynamic energy with the most compressed shell (Echevarria, 2012b). These taxa were not recorded in the younger stratigraphic horizon and became extinct at the end of the Cretaceous period.

Horizon: Quartz wacke unit of the upper part of the Mahadek Formation, Amlabon, Meghalaya.

Order Veneroida Adams and Adams, 1883
Family Cardiidae Lamarck, 1809
Genus Granocardium Gabb, 1869

Granocardium sp. (?)
[Plate-I (Fig. 9)]

Granocardium cf. productum, J. de C. Sowerby, 1832

Material: Two moderately preserved external and internal molds (Specimen nos.: K-Pg/ MEG/26 and K-Pg/ MEG/27)

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/26	20	6	28
K-Pg/ MEG/27	14	3	23

Description: The shell is almost suborbicular, equivalved, slightly inequilateral and small in size. The length (anteroposterior diameter) is always slightly larger than the height (umbonoventral diameter); Hinge disposition is not clear but a prominent, incurved beak can be seen. Ornamentation consists of numerous, fine, spinose radial threads separated by narrow interspaces and these radial threads are better developed near the ventral margin. Smooth ribbed to spinose and internal ribs in inter costal spaces can be discerned.

Remarks: *Granocardium* is widely distributed in the (? Cenomanian), Turonian-Campanian and (? Maastrichtian) of Europe. They were reported by Stoliczka, in 1870 from the upper Cretaceous Cauvery basin of southern India. Though poorly preserved, the two specimens from Meghalaya are comparable to *Granocardium* by the presence of a prominent, pointed, incurved beak that is almost central to the axis of the shell (Bergquist, 1944). They are not recorded in the younger formations and became extinct at the end of the Cretaceous period.

Horizon: Quartz wacke unit of the upper part of the Mahadek Formation, Amlabon, Meghalaya.

Genus Cardium Linnaeus, 1758

Cardium sp. Plaziat, 1970
[Plate-I (Fig. 10)]

Cardium sp. Campbell, 1993

Material: 2 external and 1 internal mold (Specimen nos.: K-Pg/ MEG/28, K-Pg/ MEG/29 and K-Pg/ MEG/30).

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/28	20	20	19
K-Pg/ MEG/29	26	25.4	20
K-Pg/ MEG/30	25.2	25	21

Description: Shell rounded to quadrate, inflated, umbo approximately central and hinge line rather straight. Margins are rounded and deeply crenulate with a sculpture of strong radial ribs.

Remarks: The general form and sculpture of the very poorly preserved specimens from Meghalaya are comparable with *Cardium* but due to the absence of other features, specific identity remains undetermined. Also in the present study, small, relatively globose ill preserved carditids with numerous fine radial ribs were recorded from the glauconitic sandstone of the Mahadek Formation from Lyndem, East Khasi Hills of Meghalaya but are indeterminable due to fragmentary and incomplete nature. The carditids were also earlier reported from the Langpar Formation (Bhattacharya and Bhattacharya, 1987). The family Cardiidae are distributed from Upper Triassic to Recent worldwide with species in tropical, temperate and boreal waters.

Horizon: Calcareous siltstone of the Langpar Formation, Muktapur-Amlarem road section, Meghalaya.

Family Crassatellidae Ferussac, 1822
Genus Crassatella Lamarck, 1799

Crassatella sp. (?)
[Plate-I (Fig. 11)]

Mactra cygnaea Lamarck, 1799

Material: 5 incomplete internal molds (Specimen nos.: K-Pg/ MEG/31 to K-Pg/ MEG/35)

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/31	42	12	28
K-Pg/ MEG/32	32	12	20
K-Pg/ MEG/33	40	15	21
K-Pg/ MEG/34	35	12.6	25
K-Pg/ MEG/35	40	15.5	27

Description: Shell inequilateral, trapezoidal, umbo opisthogyral and the posterior end is longer. The preservation is very poor but faint radiating costae and concentric ribs can be discerned.

Remarks: In the present study, all the specimens are moulds, incomplete and very poorly preserved. Therefore further classification was not possible. However, based on the morphological characteristics of the family, all the recorded specimens are inequilateral with varying degrees of posterior elongation. In Meghalaya, *Crassatella* were also reported from the Langpar Formation (Bhattacharya and Bhattacharya, 1987).

Horizon: Calcareous siltstone of the Langpar Formation, Muktapur- Amlarem road section, Meghalaya.

Family Lucinidae Fleming, 1828
Genus Lucina Bruguiere, 1797

Lucina sp.
[Plate-I (Fig. 12)]

Venus jamaicensis Spengler, 1784

Material: 3 internal moulds (Specimen nos.: K-Pg/ MEG/36 to K-Pg/ MEG/38)

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/36	30	-	28
K-Pg/ MEG/37	23	-	22
K-Pg/ MEG/38	18	-	16

Description: The length-to-height ratio of all the specimens is nearly equal. The surface ornamented with numerous fine commarginal growth lines which are more or less equidistant and render the entire surface rough to the touch. The outline is irregularly subcircular and the shape is rather ventricose in the middle, but rapidly diminishes in convexity towards the margin.

Remarks: In the present study, the recovered specimens are incomplete and precise identification is impossible due to a lack of information about the internal features. The genus has been recorded from the Langpar Formation (Bhattacharya and Bhattacharya, 1987). The family Lucinidae have also been described from the upper Cretaceous of south India, mostly from the Ariyalur Group and the Uttattur Group by Forbes (1846), Stoliczka (1871) and Kendrick (2007).

Horizon: Calcareous siltstone of the Langpar Formation, Muktapur- Amlarem road section, Meghalaya.

Order Arcoida Stoliczka, 1871
Family Cucullaeidae Stewart, 1930
Genus Cucullaea Lamarck, 1801

Cucullaea sp.
[Plate-I (Fig. 13)]

Cucullaea auriculifera Lamarck, 1801

Material: 1 internal mold (Specimen no.: K-Pg/ MEG/39)

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/39	42	21	44

Description: The shell is sub- trigonal to sub- trapezoidal, inequilateral, and ornamented with very few widely spaced coarse radial costellae. The specific identification is impossible due to the lack of other ornamentation and internal characters are obscured.

Remarks: In Meghalaya only one poorly preserved specimen with both valves attached was recorded. *Cucullaea* is infaunal suspension feeders and burrow into unlithified sediments. Steinkerns and external molds of *Cucullaea* sp. were also recorded from the Maastricht Formation (Late Maastrichtian), Maastricht of Netherlands, Vogel (1895) which is comparable with the present record.

Horizon: Ferruginous sandstone of the upper part of the Mahadek Formation, Lyndem, Meghalaya.

Family Glycymerididae Newton, 1922
Genus Glycymeris Da Costa, 1778

Glycymeris sp.
[Plate-I (Fig. 14)]

Arca orbicularis Da Costa, 1778

Material: 1 internal mold (Specimen no.: K-Pg/ MEG/40)
Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/40	50	12	50

Description: The shell is sub-circular, and equivalved and valves are lowly inflated. The surface ornamentation is abraded but faint costae are present.

Remarks: In South India, glycymeridids were recorded from the Uttatur Group of Albian to Cenomanian age (Stoliczka, 1871, Kendrick, 2007), Trichinopoly Group of Turonian-Coniacian age (Stoliczka, 1871) and Ariyalur Group of Maastrichtian age (Stoliczka, 1871). In Meghalaya, only one poorly preserved specimen with both valves attached was recorded. It is more comparable with the glycymeridid bivalves recorded from the Northeast Pacific of the Upper Cretaceous and Palaeocene based on the size and shape which is larger and more circular than the species from South India (Squires, 2010). *Glycymeris* are shallow burrowers in fine-grained siliciclastic sediments and lived in warm-temperate, shallow-marine waters.

Horizon: Ferruginous sandstone of the upper part of the Mahadek Formation, Lyndem, Meghalaya.

Order Myoida Stoliczka, 1870
Family Corbulidae Lamark, 1818
Genus Caestocorbula Vincent, 1910

Caestocorbula sp.
[Plate-I (Fig. 15)]

Corbula henckeliusiana Nyst, 1836

Material: 1 incomplete internal mold (Specimen no.: K-Pg/ MEG/41)
Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/41	45	30	35

Description: The shell is robust, large, gibbous form, inequilateral with the posterior side slightly elongated, opisthocline/opisthogyre, and internal characters are obscured. The surface is ornamented with fine commarginal ribs and some distant concentric ornamentations/ growth lines are visible.

Remarks: Comparison with other corbulids was not possible based on one incomplete and poorly preserved specimen. The Meghalaya specimen is comparable to the *Caestocorbula* reported from south India. However it is much bigger in size compared with the specimens from the Ariyalur Group of Maastrichtian age (Stoliczka, 1870). *Caestocorbula* were also recorded from the Trichinopoly Group of Turonian- Coniacian age and the Uttatur Group of Albian to Cenomanian age (Stoliczka, 1870, Kossmat 1897 Kendrick, 2007). The earliest records of corbulids are from the Jurassic age till Recent and they are typical of environments with reduced salinity.

Horizon: Ferruginous sandstone of the upper part of the Mahadek Formation, Lyndem, Meghalaya.

Order Pholadomyoida Newell, 1965
Family Pholadomyidae Gray, 1847
Genus Pholadomya Sowerby, 1823

Pholadomya sp.
[Plate-I (Fig. 16)]

Pholadomya candida Sowerby, 1823

Material: 2 internal moulds (Specimen nos.: K-Pg/ MEG/42 and K-Pg/ MEG/43).
Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/42	20	12	11
K-Pg/ MEG/43	30	16	15

Description: The shell is strongly inequilateral, ovate to subtrigonal. Umbo is broadly rounded, more or less anteriorly placed and characteristic ornamentation consists of almost 15-18 radial ribs which are relatively wide spaced. The posterior end is distinctly longer than the anterior end and the ventral margin is rounded.

Remarks: In Meghalaya, *Pholadomya* was also reported from the Mahadek Formation (Bhattacharya and Bhattacharya, 1987). The present collections are imperfect molds, incomplete and due to the absence of other features, a comparison was not possible. *Pholadomya* was reported by Kaye and Cunliffe from the Upper Cretaceous of the Cauvery basin of Pondicherry, South India (Forbes, 2013). *Pholadomya* was initiated early in the lower Lias, and though it culminated later in the Jurassic, the decline started at the end-Cretaceous and the Palaeogene and less than half a dozen species have persisted to the present day.

Horizon: Calcareous siltstone of the Langpar Formation, Muktapur- Amlarem road section, Meghalaya.

Order Mytiloida Ferussac, 1822
Family Mytilidae Rafinesque, 1815
Genus Mytilus Linnaeus, 1758

Mytilus sp.
[Plate-I (Fig. 17)]

Mytilus edulis Linnaeus, 1758

Material: 1 internal mold (Specimen no.: K-Pg/ MEG/44)
Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/44	38	10	20

Description: Shell is of medium size, narrowly mytiliform, thin, beaks terminal, obtusely rounded to sub-angulate and merging into the short, strongly rounded ventral margin, convexly tapered toward the ventral margin. The surface is smooth with very weak radial ribs and irregular concentric growth lines are visible.

Remarks: The single specimen from Meghalaya is poorly preserved and specific identification cannot be determined. But it was comparable with the length of Mytilids recorded from the Lower Palaeocene of Denmark (Rosenkrantz, 1920). Mytilids were also reported by Kaye and Cunliffe from the Upper Cretaceous Cauvery basin of Pondicherry and Verdachellum of South India (Forbes, 2013).

Horizon: Calcareous siltstone of the Langpar Formation, Muktapur- Amlarem road section, Meghalaya.

Order Nuculoidea Dall, 1889
Family Nuculidae Gray, 1824
Genus Nucula Lamarck, 1799

Nucula sp.
[Plate-I (Fig. 18)]

Arca nucleus Linne, 1758

Material: 1 external and 4 internal molds (Specimen nos.: K-Pg/ MEG/45 to K-Pg/ MEG/49).

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/45	19	7.9	12
K-Pg/ MEG/46	20	10	13
K-Pg/ MEG/47	19.6	6	12.5
K-Pg/ MEG/48	6	1.5	3
K-Pg/ MEG/49	7	2	4

Description: The shell is small-sized, inequilateral and ovate. It is extended anteriorly but posteriorly it is short and roundly truncated. The ventral margin is convex and meeting the anterior and posterior margins in rounded curves. The inflation is moderate, umbones initially smooth, radials followed by very fine and more widely spaced, commarginal threads which pass over costellae, otherwise confined to intercostal spaces.

Remarks: In Meghalaya *Nucula* have been recorded from both the Mahadek and Langpar formations. All the specimens are poorly preserved internal moulds which lacks internal features. They show size variation ranging in length from 6 mm to 20 mm. Based on the general outline and size, the present collection resembles the genus *Nucula* which was recorded from the Early Palaeocene of Egypt (Abbass, 1962) and the Maastrichtian of Tunisia (Pervinquière 1912). *Nucula* was also reported from the Ariyalur Group of Maastrichtian age (Stoliczka, 1870) and the Uttatur Group of Albian to Cenomanian age (Stoliczka, 1870, Kendrick, 2007).

Horizon: Mahadek and Langpar formations, Lyndem and Muktapur-Amlarem road section, Meghalaya.

Family Nuculanidae Adams and Adams, 1858
Genus Nuculana Link, 1807

Nuculana sp.
[Plate-I (Fig. 19)]

Arca rostrata Chemnitz, 1774

Material: 1 incomplete internal mold (Specimen no.: K-Pg/ MEG/50)

Dimension: (mm)

Specimen no.	Length	Width	Height
K-Pg/ MEG/50	21	8	11.6

Description: The shell is thin, fragile, elongate, rostrate, longer than high, and anteriorly short. Posteriorly it is extended and the surface is ornamented with very fine concentric growth lines which are discernible towards the ventral margin.

Remarks: Comparison with other nuculids was not possible as only one poorly preserved and abraded specimen was recorded. However, it is comparable with the genus *Nuculana* which was recorded from the Early Palaeocene of Egypt (Abbass, 1962) based on the general outline and size. In south India, *Nuculana* were recorded from the Dalmiapuram Formation of Upper Albian (Stoliczka, 1871) and the Karai Formation of Cenomanian age (Stoliczka, 1870, Kendrick, 2007).

Horizon: Calcareous siltstone of the Langpar Formation, Muktapur-Amlarem road section, Meghalaya.

Gastropods

The gastropod taxa include 9 genera falling into 7 families where *Tylostoma globosum* has been identified at the specific level. *Turritella* is the most widely distributed gastropod in Meghalaya and *Graphidula* became extinct at the end of the Cretaceous period.

Order Sorbeoconcha Ponder and Lindberg, 1997
Family Turritellidae Lovén, 1847
Genus Turritella Lamarck, 1799

Turritella sp.
[Plate-II (Fig.1)]

Turritella terebra Linne, 1758

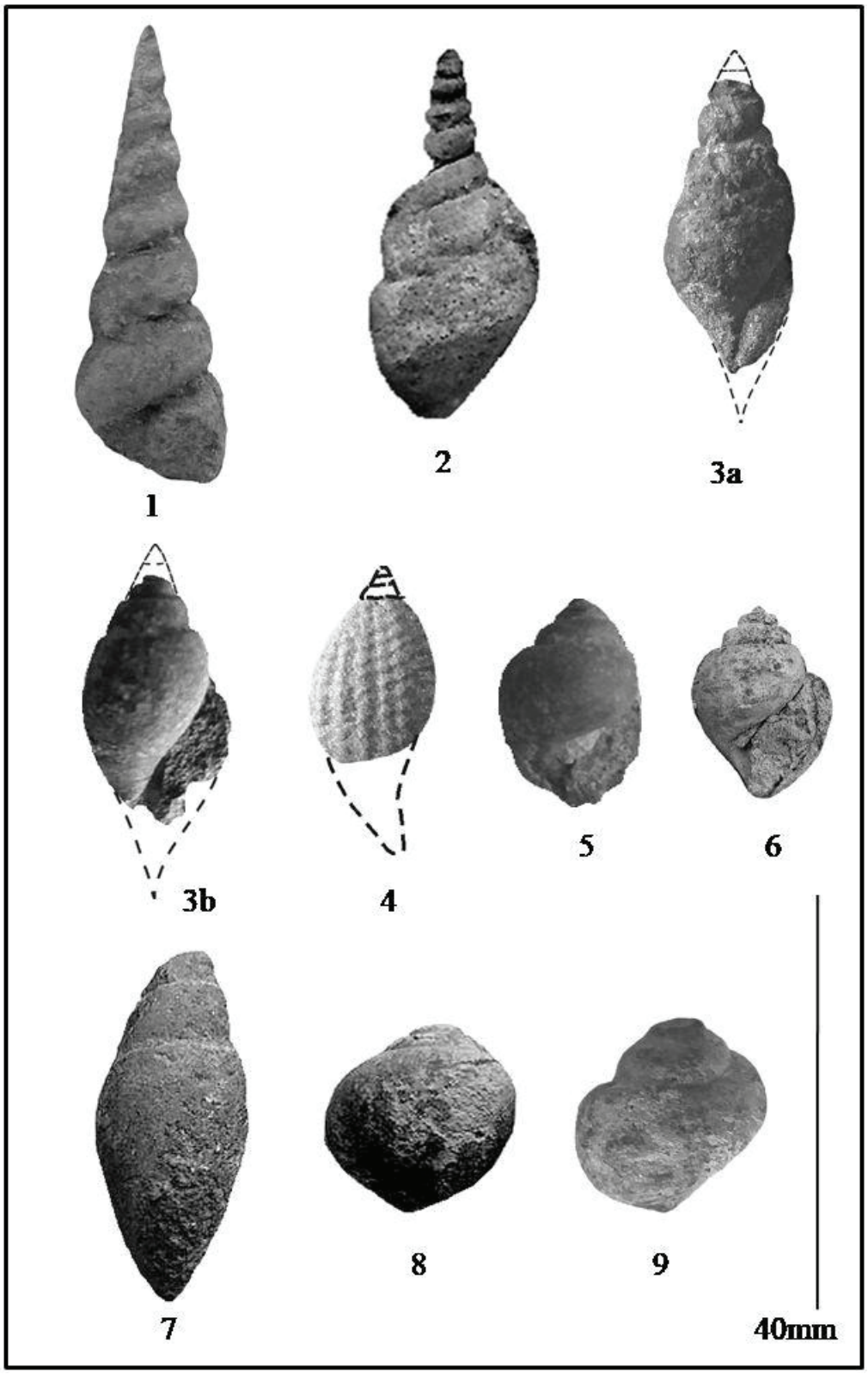
Material: 2 external molds and 1 internal incomplete mold (Specimen nos.: K-Pg/ MEG/51 to K-Pg/ MEG/53).

Dimension: (mm)

Specimen no.	Height	Maximum diameter	Apical angle (in degrees)
K-Pg/ MEG/51	40	13	30º
K-Pg/ MEG/52	50	20	28º
K-Pg/ MEG/53	12	2.5	16º

Description: Shell is elongated or turreted with an acute and long spire, dextral coiling and peristome almost circular. Apex and aperture not preserved and the body whorl is not clear. The whorls are usually straight to convex sided. Growth lines can be faintly in each whorl. Surface ornamentation is very poorly preserved.

Remarks: *Turritella* are the most widely distributed gastropods in Meghalaya. However they are mostly broken, incomplete, poorly preserved with no surface ornamentation. The specimens recorded from the Mahadek Formation ranges in height from 12 mm to 50 mm but lacks well



EXPLANATION OF PLATE II

Vertical scale bar represent the length of the specimens: **1**: ***Turritella*** **sp.** (Specimen no. K-Pg/ MEG/51); **2.** ***Graphidula*** **sp.** (Specimen no. K-Pg/ MEG/54); **3a, 3b.** ***Fasciolaria*** **sp.**(Specimen nos. K-Pg/ MEG/55 &K-Pg/ MEG/56); **4.*Volutocorbis*** **sp.** (Specimen no. K-Pg/ MEG/57); **5.** ***Ampullina*** **sp.** (Specimen no. K-Pg/ MEG/58); **6.** ***Pseudamaura*** **sp.** (Specimen no. K-Pg/ MEG/60); **7.** ***Pterodonta*** **sp.** (Specimen no. K-Pg/ MEG/62); **8.** ***Tylostoma globosum*** (Specimen no. K-Pg/ MEG/63); **9.** ***Euspira*** **sp.** (Specimen no. K-Pg/ MEG/64)

preserved original shells and are highly abraded. Based on the elongated and turreted nature of the spire most of the specimens obtained has been kept under the genus *Turritella.* The ventricose whorls divided by deep sutures of some specimens recovered are comparable to the Turritellids reported by Kaye and Cunliffe from the Upper Cretaceous of the Cauvery basin of Pondicherry and Trinchinopoly, South India (Forbes, 2013). They were also earlier recorded from the Mahadek and Langpar formations (Bhattacharya and Bhattacharya, 1987). *Turritella* ranges in age from the Cretaceous to Recent.

Horizon: Quartz wacke and ferruginous sandstone of the upper part of the Mahadek Formation, Lyndem and Amlabon nala section, Meghalaya.

Order Neogastropoda Wenz, 1938
Family Fasciolaridae Gray, 1853
Genus Graphidula Stephenson, 1941

Graphidula sp.
[Plate-II (Fig.2)]

Graphidula terebreformis Stephenson, 1941

Material: 1 external mould (Specimen no.: K-Pg/ MEG/54).

Dimension: (mm)

Specimen no.	Height	Maximum diameter	Apical angle (in degrees)
K-Pg/ MEG/54	35	16	12º

Description: Shell fusiform with length of the spire greater than that of the aperture, dextrally coiled and apical angle acute less than 45°. High spire consisting of more than 6 whorls; posteriorly angulate, sutural angle is very low in the early whorls with distinct sutural ramp and shoulder. Sculpture consists of transverse ribs commonly becoming subdued on later whorls.

Remarks: In Meghalaya *Graphidula* was recorded near the vicinity of the K-Pg boundary and became extinct at the end of the Cretaceous age. Other internal moulds and cast recovered were broken, fragmentary and incomplete. Due to the poor preservation of distinct features like protoconch, columellar folds and well preserved ribs, identification even at the family level, is difficult. *Graphidula* is common in the Campanian-Maastrichtian and became extinct in the Maastrichtian Stage (Ruban, 2013). They have been reported from the Fox Hills Formation, Upper Cretaceous (Maastrichtian) of North Dakota (Erickson, 1974) and the Maastrichtian Navarro Group of Texas, USA (Stephenson, 1941).

Horizon: Calcareous sub-arkose of the Langpar Formation, Lyngar-Ryngud-Laitiam road section, Meghalaya.

Genus Fasciolaria Lamarck, 1799

Fasciolaria sp.
[Plate-II (Fig.3a and Fig.3b)]

Fasciolaria tulipa Linnaeus, 1758.

Material: 2 internal molds (Specimen nos.: K-Pg/ MEG/55 and K-Pg/ MEG/56).

Dimension: (mm)

Specimen no.	Height	Maximum diameter	Apical angle (in degrees)
K-Pg/ MEG/55	30	17	38º
K-Pg/ MEG/56	28	12	30º

Description: The shell is fusiform, and elongated, and the spire is narrow. Four overlapping whorls with slightly convex surfaces and body whorls accounting for about 70% of the total height can be discerned. The aperture is oval and elongated, and the base is nearly sharp.

Remarks: Several undescribed specimens of the family Fasciolaridae were recorded near the vicinity of the K-Pg boundary in Meghalaya. Due to incomplete and broken molds, identification up to a specific level was not possible. The present material lacks transverse sculpture but they closely resemble this family based on some characteristic features like fusiform nature, oval aperture, and body whorl height. They have been reported from the Fox Hills Formation, Upper Cretaceous (Maastrichtian) of North Dakota (Erickson, 1974) and the Maastrichtian Navarro Group of Texas, USA (Stephenson, 1941).

Horizon: Calcareous sub-arkose of the Langpar Formation, Lyngar-Ryngud-Laitiam road section, Meghalaya.

Family Volutidae Fleming, 1822
Genus Volutocorbis Dall, 1890 in 1890-1903

Volutocorbis sp.
[Plate-II (Fig.4)]

Volutilithes limopsis Conrad, 1860

Material: 1 poorly preserved external mold (Specimen no.: K-Pg/ MEG/57).

Dimension: (mm)

Specimen no.	Height	Maximum diameter	Apical angle (in degrees)
K-Pg/ MEG/57	24	12	-

Description: Incomplete specimen. Nodose or prickly at intersections, sculpture is reticulate, and suture is sometimes channelled. Body whorl preserved but apex and aperture are broken.

Remarks: The Meghalaya species can be compared with *Volutocorbis olssoni* (F. B. Plummer in Sellards *et al*., 1933) which has a more slender form and much more subdued ornamentation. *V. olssoni* is also marked by weaker sculpture, less numerous columellar folds and weak impressed grooves in comparison to other species like *V. limopsis, V. kerensensis* and *V. stenzeli.* The genus is well represented in the Palaeogene of Europe, the Middle and Far East and the western coast of the U. S. A. *Athleta (Volutocorbis)* is recorded in the Late Cretaceous from India and Madagascar (Stoliczka 1867; Besairie 1930) and is clearly an eastern Tethyan survivor of the K/Pg crisis.

Horizon: Calcareous siltstone of the Langpar Formation, Muktapur-Amlarem road section, Meghalaya.

Order Caenogastropoda Cox, 1960
Family Ampullinidae Cossman, 1918
Genus Ampullina Bowdich, 1822

Ampullina sp. Cox 1931
[Plate-II (Fig.5)]

Ampullina? *Abeihensis* Hamlin, 1884

Material: 2 internal molds (Specimen nos.: K-Pg/ MEG/58 and K-Pg/ MEG/59)

Dimension: (mm)

Specimen no.	Height	Maximum diameter	Apical angle (in degrees)
K-Pg/ MEG/58	20	13	40º
K-Pg/ MEG/59	22	14	58º

Description: The size of the shell is small to medium, sub-globose to sub-ovate and low-spired. Apex pointed and apical angle is obtuse. Spire is conical consisting of at least two overlapping whorls separated by moderately deep sutures. Whorls rapidly decreasing toward the apex with straight to slightly convex surfaces. Body whorl large and forming the main part of the specimen with rounded flanks. Aperture relatively large and tear drop-shaped to semi-rounded with a moderately wide umbilicus. The outer lip is strongly convex and the inner lip is slightly convex and thick.

Remarks: The sub-ovate partially preserved aperture, relatively low spire, and moderately wide umbilicus are the characteristic features of the present findings which closely resemble the *Ampullina* sp. reported from the Upper Turonian Wata Formation of Egypt (Hannaa and Fursich, 2011). The present material was recorded near the vicinity of the K-Pg boundary. In Meghalaya, *Ampullina* were earlier reported from the Langpar Formation (Mukherjee, 2012) and the Lakadong member (lower part of Shella Formation) of the Late Palaeocene to Early Eocene age (Mukherjee and Iangrai, 2018). The *Ampullina* recorded from the Lakadong limestone is much smaller in size compared to the specimen of the Langpar Formation. The finding is significant because it records the decrease in size of *Ampullina* after the K-Pg mass extinction. Bandel (2006) indicated that from the Jurassic to the Eocene, this family was common and abundant in the lagoon and near-shore settings above the fair-weather wave base in very shallow normal marine temperate waters.

Horizon: Calcareous sub-arkose of the Langpar Formation, Lyngar-Ryngud-Laitiam road section, Meghalaya.

Genus Pseudamaura Fischer, 1885

Pseudamaura sp. (?)
[Plate-II (Fig.6)]

Natica bulbiformis Sowerby, 1823

Material: 2 internal moulds (Specimen nos.: K-Pg/ MEG/60 and K-Pg/ MEG/61).

Dimension: (mm)

Specimen no.	Height	Maximum diameter	Apical angle (in degrees)
K-Pg/ MEG/60	16	9	65º
K-Pg/ MEG/61	12	6	-

Description: Egg-shaped with a spire consisting of 4 whorls. Whorls are rounded with deep and furrowed suture lines and the last whorl is large. The spire is not as high as the last whorl. The aperture is oval to spindle-shaped.

Remarks: Though poorly preserved and smaller in size, the specimens from Meghalaya resembles *Pseudamaura nobilis* (Stoliczka, 1868) recorded from the Coniacian-Santonian of South India based on the general shell shape and shape of the aperture. The collection of gastropods by Bandel from the Trichinopoly Group of Tamil Nadu, India has close relations with the species recorded from the Cretaceous Golf of Mexico of Late Campanian to Maastrichtian age (Bandel, 2006).

Horizon: Ferruginous reddish brown sandstone of the upper part of the Mahadek Formation, Phud Japung, Meghalaya.

Family Colombellinidae Fischer, 1884
Genus Pterodonta d'Orbigny, 1842

Pterodonta sp. (?)
[Plate-II (Fig.7)]

Pterodonta? cf. Deffisi Thomas & Peron, 1889

Material: 1 internal mould (Specimen no.: K-Pg/ MEG/62)

Dimension: (mm)

Specimen no.	Height	Maximum diameter	Apical angle (in degrees)
K-Pg/ MEG/62	35	20	30º

Description: The shells are large-sized, elongated conical, and moderately high-spired. The body whorl is globose and large, cylindrical, elongated, and accounting for about 70% of the total height. The spire consists of two slightly convex to flat overlapping whorls. The suture is moderately impressed. The base is narrow and nearly acute.

Remarks: Many genera of this family look very similar in the poorly preserved state making specific identification impossible. However, the present material closely resembles *Pterodonta* based on the large shell, globose last whorl, and moderately deep sutures. Even though they were recorded near the vicinity of the K-Pg boundary in Meghalaya they are comparable with the Colombellinids reported from the Cenomanian-Turonian of Tunisia, Syria, and Egypt. The Meghalaya specimens are much smaller in dimension compared to the species from the Upper Albian- Cenomanian Halal Formation of Egypt and are differentiated from *Tylostoma* in having a less plump last whorl (naticiform), a projected and incurved outer lip, deep sutures and sinuous growth lines (Hannaa and Fursich, 2011).

Horizon: Calcareous sub-arkose of the Langpar Formation, Lyngar-Ryngud-Laitiam road section, Meghalaya.

Family Tylostomatidae Stoliczka, 1868
Genus Tylostoma Sharpe, 1849

Tylostoma globosum Sharpe, 1849
[Plate-II (Fig. 8)]

Tylostoma (Tylostoma) globosum Sharpe – Mekawy & Abu Zeid, 2008

Material: 1 internal mould (Specimen no.: K-Pg/ MEG/63)

Dimension: (mm)

Specimen no.	Height	Maximum diameter	Apical angle (in degrees)
K-Pg/ MEG/63	18	18	110º

Description: Moderately large-sized, ovoid to globose, and very low-spired. Body whorl is inflated with rounded flanks, smooth, forming the greater part of the specimen (about 90% of the total height). The spire consists of 2-3 rounded and nearly smooth whorls. These whorls are wide, compressed and separated by slightly depressed sutures.

Remarks: *Tylostoma globosum* is a widespread and easily identifiable Cretaceous gastropod of the Tethyan realm. It is easily recognized by its globose to broadly oviform shape and the low spire which can be discerned in the present material. The specimen of Meghalaya closely resembles *Tylostoma globosum* recorded from the Lower Turonian Abu Qada Formation of Egypt (Hannaa and Fursich, 2011). However, it is much smaller in dimension and it is recorded near the vicinity of the K-Pg boundary.

Horizon: Calcareous sub-arkose of the Langpar Formation, Lyngar-Ryngud-Laitiam road section, Meghalaya.

Family Naticidae Gray, 1840
Genus Euspira Agassiz in J. Sowerby, 1837

Euspira sp.
[Plate-II (Fig. 9)]

Natica glaucinoides Sowerby, 1812

Material: 1 internal mold (Specimen no.: K-Pg/ MEG/64)

Dimension: (mm)

Specimen no.	Height	Maximum diameter	Apical angle (in degrees)
K-Pg/ MEG/64	18	16	55º

Description: The shell is medium in size, globose and spire is one third to one-quarter total shell height. The whorls are well rounded and surface is smooth. Apex is pointed, base rounded to nearly flat and aperture is relatively large and broad.

Remarks: The present material is an internal mould and lack important features to ascertain specific identification. They were recorded near the vicinity of the K-Pg boundary in Meghalaya. The naticid *Euspira*, is an epifaunal mobile carnivore which crawled shallowly below the sediment-water interface in search of bivalves into which it bored. *Euspira* has been reported from the Fox Hills Formation, Upper Cretaceous (Maastrichtian) of North Dakota (Erickson, 1974), the Palaeogene sediments of Texas (Garvie, 2013) and the Late Cretaceous Chatham islands of New Zealand (Stilwell, 1998).

Horizon: Calcareous sub-arkose of the Langpar Formation, Lyngar-Ryngud-Laitiam road section, Meghalaya.

Cephalopods

Four ammonoid genera falling into 4 families have been recorded during the present study and *Nostoceras* sp. has not been reported from Meghalaya by earlier workers. These ammonite assemblages were also recorded from the Terminal Maastrichtian El Kef section, Tunisia the Global Stratotype Section and Point (GSSP) of the Cretaceous-Palaeogene boundary (Eggermont, 1996 and Goolaerts *et al*., 2004).

Order Ammonoidea Zittel, 1884
Family Baculitidae Gill, 1871
Genus Eubaculites Spath, 1926

Eubaculites sp.
[Plate-III (Fig.1a and Fig.1b and Fig.2a and Fig.2b)]

Baculites vagina Forbes var. *ootacodensis* Stoliczka, 1866

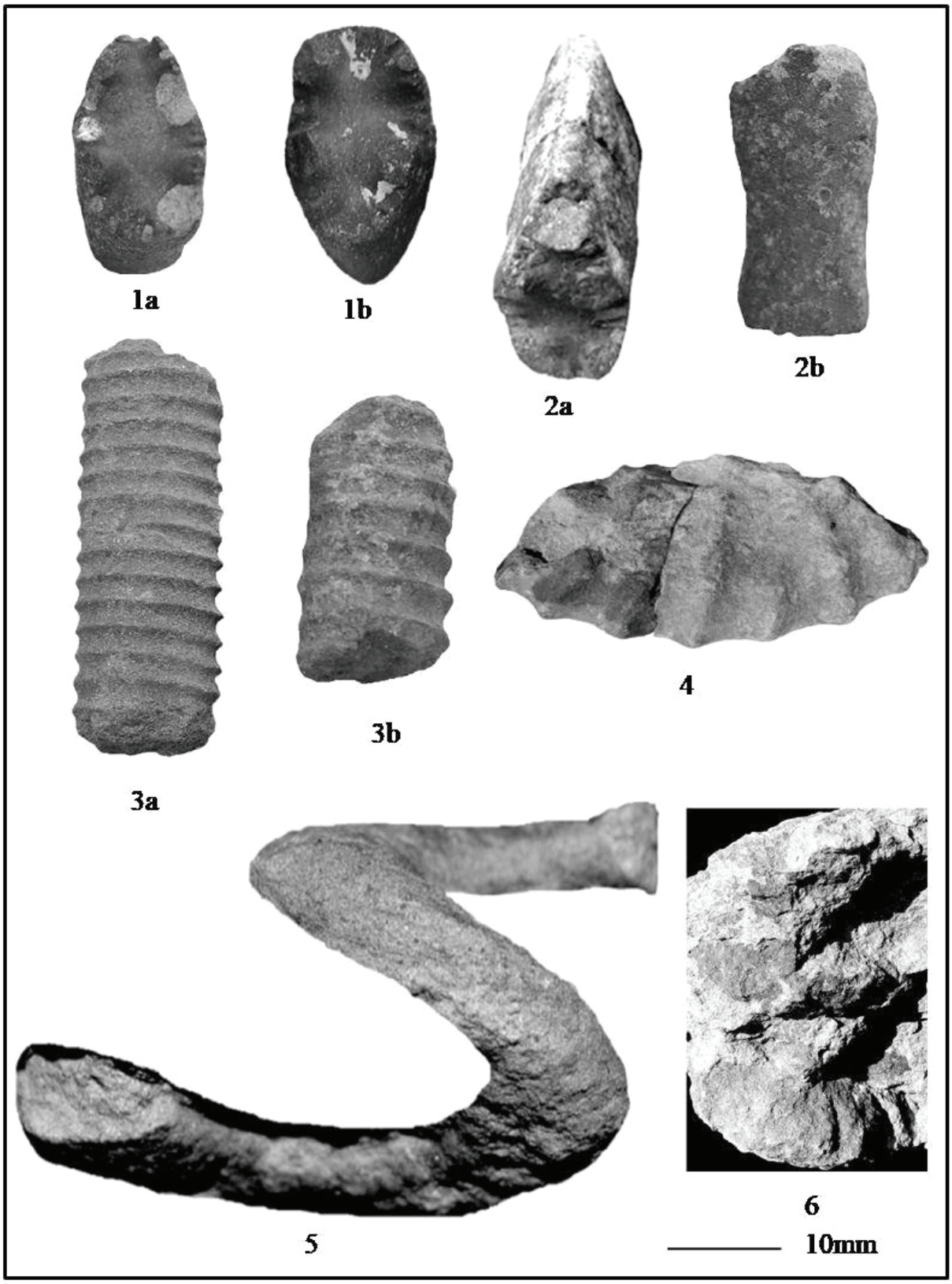
Material: 5 incomplete specimens. The uncertain dimension of most specimens is due to their broken nature and deformation (Specimen nos.: K-Pg/ MEG/65 to K-Pg/ MEG/69).

Dimension: (mm)

Specimen no.	Whorl height	Whorl breadth
K-Pg/ MEG/65	18	12
K-Pg/ MEG/66	26	12
K-Pg/ MEG/67	11	7
K-Pg/ MEG/68	20	10
K-Pg/ MEG/69	7	5

Description: More than 20 broken specimens were recorded in clusters where the body chambers are fragmented. The whorl cross section is compressed ovoid and the whorl breadth to height ratio is 0.34- 0.84 [PLATE-III (Fig.1a and Fig.1b)]. The dorsum is almost flat to broadly rounded. The outer flanks converge to a fastigiated to tabulate venter. The nodate swelling is relatively strong on the inner flank. The venter is nearly smooth to faintly ornamented with transverse ribs that cross the venter producing a serrated appearance [PLATE-III (Fig-2a)]. Lateral sections show sutures [PLATE-III (Fig-2b)] while in some specimens the suture is faintly preserved.

Remarks: In Meghalaya *Eubaculites* were earlier reported from both the Mahadek and Langpar formations (Bhattacharya and Bhattacharya, 1987). Mukherjee in 2012 recorded *Eubaculites vagina* and *Eubaculites simplex* from the Mahadek Formation. In the present study, the specimens were recovered from the Langpar Formation near the vicinity of the K-Pg boundary. Most of the specimens show a close resemblance to the Maastrichtian *Eubaculites carinatus* recorded from the Manasquan River Basin, Monmouth County, New Jersey, USA (Klinger *et al*., 2001), Quiriquina Formation of central Chile and Ariyalur Group, South India based on the pattern of ornamentation, shape, and size. In some cases, a few *Eubaculites vagina* (?) were also noted. They are correlatable with *Eubaculites vagina* recorded from the Upper Maastrichtian Valudavur Formation beds of Pondicherry District, South India.



EXPLANATION OF PLATE III

Horizontal scale bar represent the whorl breadth of the specimens: **1a, 1b and 2a, 2b**: ***Eubaculite*** **sp.** (Whorl section and lateral view; Specimen nos.: K-Pg/ MEG/65 and K-Pg/ MEG/66; **3a, 3b.** ***Glyptoxoceras*** **sp.** (Specimen nos.:K-Pg/ MEG/70 and K-Pg/ MEG/71); **4.** ***Pachydiscus*** **sp.**(10mm x10) (Specimen no.: K-Pg/ MEG/74); **5.** ***Nostoceras*** **sp.** (Specimen no.: K-Pg/ MEG/75

Horizon: Calcareous sub-arkose of the Langpar Formation, Lyngar-Ryngud-Laitiam road section, Meghalaya.

Family Diplomoceratidae Spath, 1926
Genus Glyptoxoceras Spath, 1925

Glyptoxoceras sp.
[Plate-III (Fig.3a and Fig.3b)]

Hamites rugatus Forbes, 1846

Material: 4 internal moulds (Specimen nos.: K-Pg/ MEG/70 to K-Pg/MEG/73)
Dimension: (mm)

Specimen no.	Whorl height	Whorl breadth
K-Pg/ MEG/70	20	10
K-Pg/ MEG/71	15	15
K-Pg/ MEG/72	12	10
K-Pg/ MEG/73	6	6

Description: One specimen is flattened while the other three are evenly rounded in cross section. Whorl section of one specimen is compressed, oval where ribbing is oblique on the venter rather than being transverse [PLATE-III (Fig-3a)]. Among the sub circular, one specimen is evenly ribbed [PLATE-III (Fig-3b)].

Remarks: The specific identification of *Glyptoxoceras* recovered from Meghalaya is difficult due to incomplete preservation. However the equal and even spacing of the ribs are comparable with *Glyptoxoceras rugatum and Glyptoxoceras largesulcatum* recorded from the Upper Maastrichtian Valudavur Formation beds of Pondicherry District, Tamil Nadu, India (Kennedy and Henderson, 1992). *Glyptoxoceras* were earlier recorded from the Mahadek Formation (Mukherjee, 2012) while the present specimens were collected from the Langpar Formation near the vicinity of the K-Pg boundary. *Glyptoxoceras* is part of a diverse, nearshore community that extended along the Gulf and Atlantic Coastal Plains during the late Maastrichtian (Kennedy *et al.,* 2001).

Horizon: Calcareous sub-arkose of the Langpar Formation, Sohbar-Therriaghat road section, Meghalaya.

Family Pachydiscidae Spath, 1922
Genus Pachydiscus Zittel, 1884

Pachydiscus sp.
[Plate-III (Fig.4)]

Ammonites neubergicus Von Hauer, 1858

Material: 1 incomplete internal mould (Specimen no.: K-Pg/ MEG/74)
Dimension: Uncertain values due to incomplete preservation.
Description: This specimen has a completely septate internal mould which is broken and incomplete. It is compressed, primary ribs are thick, strong and ridge-like elongated umbilical tubercles preserved partially. Suture lines are very poorly preserved.
Remarks: In Meghalaya, *Pachydiscus* was earlier recorded from both the Mahadek and Langpar formations (Bhattacharya and Bhattacharya, 1987). The specimen in the present study was collected from the Langpar Formation near the vicinity of the K-Pg boundary. Henderson *et al.*, 1992 noted that this species was widely distributed but did not generally range beyond low to mid latitudes. They are useful indicator of middle to late Maastrichtian age and represent the last widely distributed heteromorph taxon to appear in the stratigraphic record. *Pachydiscus* ranges from the upper lower to the upper upper Maastrichtian (Klinger *et al.,* 2001). In India, they were recorded from the Upper Maastrichtian Valudavur Formation beds of Pondicherry District, Tamil Nadu (Kennedy and Henderson, 1992).
Horizon: Calcareous sub-arkose of the Langpar Formation, Sohbar-Therrighat road section, Meghalaya.

*Sub*order Ancyloceratina Wiedmann, 1966
Family Nostoceratidae Hyatt, 1894
Genus Nostoceras Hyatt, 1894

Nostoceras sp.
[Plate-III (Fig.5 and Fig.6)]

Nostoceras stantoniretrorsum Hyatt, 1894

Material: 2 internal moulds (Specimen nos.: K-Pg/ MEG/75 and K-Pg/ MEG/76)
Dimension: (mm)

Specimen no.	Whorl height	Whorl breadth
K-Pg/ MEG/75	20	12
K-Pg/ MEG/76	18	8

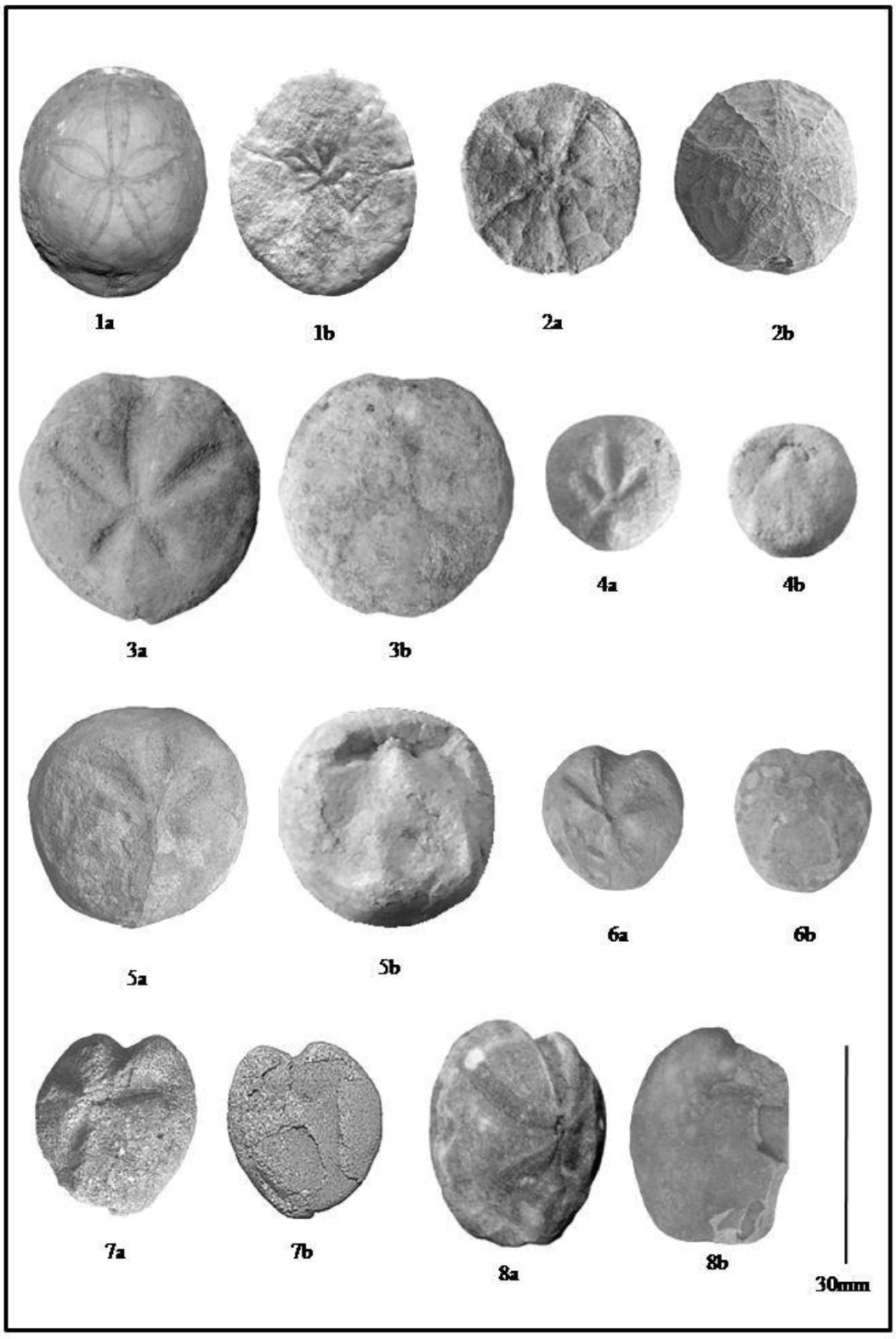
Description: Incomplete and poorly preserved. One a half whorl volutions are preserved where the helical whorls are not in contact, penultimate limb and body chamber are not preserved [Plate-III (Fig. 5 and Fig. 6)]. Transverse costae on the helical whorls are very faintly raised and sharp. Helical whorls and ribs are weak on the upper whorl face. Two tubercles or spines typically occur on alternating costae linked across the venter by one. A single row of tubercles or spines faintly occurs along the ventrolateral margin distal to the apex of the helical whorls [Plate-III (Fig.6)].

Remarks: In Meghalaya, *Nostoceras* was recorded for the first time from the Langpar Formation near the vicinity of the K-Pg boundary and became extinct at the end of the Cretaceous age. They are characterized by a dextral or sinistral helical spire of whorls mostly in tight contact and a partly to wholly uncoiled body chamber. Even though specific identification and comparison with other species were not possible, the widely-spaced ribs seen in the present findings [Plate-III (Fig.6)] resemble *Nostoceras collignoni* sp. nov. reported from the Maastrichtian of Belo Sur Tsiribihina of Madagascar (Klinger *et al.,* 2007).

Horizon: Calcareous sub-arkose of the Langpar Formation, Lyngar-Ryngud-Laitiam and Sohbar- Therriaghat road sections, Meghalaya.

Echinoids

The echinoid taxa include 5 genera falling into 4 families which *Gongrochanus* sp. and *Micraster* sp. became extinct at the end of the Cretaceous period.



EXPLANATION OF PLATE IV

Vertical scale bar represent the length of the specimens: **1a, 1b**: ***Gongrochanus ariyalurensis n. sp.*** (x 2) (Aboral view and oral view; Specimen no.: K-Pg/ MEG/78) **2a, 2b**: ***Gongrochanus herschelianus*** (x 2) (Oral view and aboral view; Specimen no.: K-Pg/ MEG/79); **3a, 3b and 4a, 4b** : ***Hemiaster*** **sp.** (Aboral view and oral view; Specimen nos.: K-Pg/ MEG/85and K-Pg/ MEG/86); **5a, 5b**: ***Hemiaster bexari*** (Aboral view and oral view; Specimen no.: K-Pg/ MEG/88); **6a, 6b**: ***Mecaster*** **sp.** (Aboral view and oral view; Specimen no.: K-Pg/ MEG/89); **7a, 7b**: ***Micraster*** **sp.** (Aboral view and oral view; (Specimen no.: K-Pg/ MEG/91); **8a, 8b**: ***Cardiaster*** **sp.** (Aboral view and oral view; Specimen no.: K-Pg/ MEG/92)

Order Cassiduloida Claus, 1880
Family Faujasiidae Lambert, 1905
Genus Gongrochanus Kier, 1962

Gongrochanus sp.
[Plate-IV (Fig. 1a & Fig. 1b and Fig. 2a & Fig. 2b)]

Cyrtoma herschelianus M'Clelland, 1840

Material: Few well preserved specimens with internal molds and numerous incomplete, broken shells (Specimen nos.: K-Pg/ MEG/77 to K-Pg/ MEG/84).

Dimension: (mm)

Specimen no.	Length	Breadth	Height
K-Pg/ MEG/77	60	50	20.6
K-Pg/ MEG/78	50	45	28
K-Pg/ MEG/79	37	31	12
K-Pg/ MEG/80	50.5	40	20.5
K-Pg/ MEG/81	49	41	25
K-Pg/ MEG/82	50	45	23
K-Pg/ MEG/83	37	31	12
K-Pg/ MEG/84	20.5	20	5

Description: Shape oval to sub-pentagonal in outline, test is medium, aboral surface highly inflated and oral surface flat. Peristome excentric anteriorly, broader than long and lies in depression. Anteriorly the shell is broadly rounded and the anterior slope is steeper than the posterior. Ambulacra is subpetaloid and unequal in length with ambulacra III longest, and ambulacra I and V narrowest and shortest. Periproct is supra-marginal and interambulacral area is widest. Tubercles are not preserved. Prominent bulge in median area of each ambulacrum in phyllode can be discerned.

Remarks: The genus *Gongrochanus* was proposed by Kier (1962).In Meghalaya, Bhattacharya and Bhattacharya (1987) reported *Gongrochanus herschelianus* M' Clelland, 1840 as *Stigmatopygus elatus* (Forbes) from the Mahadek Formation and Stolickza (1873a) described them from the Senonian rocks of the Ariyalur Group of Tamil Nadu. Kier (1962) considered *Stigmatopygus elatus* (Forbes) to be a junior synonym of *Gongrochanus herschelianus. Stigmatopygus* was also reported from the Langpar Formation (Mukherjee, 2012). *Gongrochanus* can easily be distinguished from *Stigmatopygus* by its supramarginal periproct situated in a longitudinal groove, the presence of three gonopores (four gonopores in *Stigmatopygus*), and presence of a prominent bulge on the median area of each phyllode. In the present study, most of the recorded specimens are comparable with the genus *Gongrochanus.* They were recorded in huge numbers from the medium to coarse-grained calcareous sandstone of the upper part of the Mahadek Formation from both East Khasi Hills and West Jaintia Hills Districts. They bear resemblance to both *Gongrochanus herschelianus* and *Gongrochanus ariyalurensis n.* sp. which was reported from the Kallankurichchi and Ottakovil formations of the Ariyalur Group of Tamil Nadu of Maastrichtian age. Based on the anteriorly excentric peristome, interpetaloid angle between the petals I and V which is minimum (ranging from 45°- 60° with an average angle of 53.5°), and petals I and II and IV and V which is maximum (ranging from 75°- 87° with an average angle of 83°), the major component of the collected specimens are comparable with *Gongrochanus ariyalurensis n.* sp. Srivastava, 2003. However few specimens in the present study also show broader test and centrally located peristome which can be correlated with *Gongrochanus herschelianus* [Plate-IV (Fig. 2a & Fig. 2b)]. *Gongrochanus* are large, infaunal, deposit-feeding cassiduloids confined to beds of unconsolidated sands of well-sorted calcarenites.

Horizon: Calcareous sandstone of the upper part of the Mahadek Formation, Phlang Mawsyrpat-Phud Japung section, Meghalaya.

Order Spatangoida Claus, 1876
Family Hemiasteridae Clark, 1917
Genus Hemiaster Agassiz, 1847

Hemiaster sp.
[Plate-IV (Fig. 3a & Fig. 3b and Fig. 4a & Fig. 4b)]

Spatangus bufo Brongniart, 1822

Material: 3 internal moulds (Specimen nos.: K-Pg/ MEG/85 to K-Pg/ MEG/87).

Dimension: (mm)

Specimen no.	Length	Breadth	Height
K-Pg/ MEG/85	35	32	18
K-Pg/ MEG/86	45	43	20
K-Pg/ MEG/87	17	17	6

Description: Shell is almost bilaterally symmetrical, ovate to rounded, the anterior margin smoothly rounded in profile, the posterior margin slightly oblique. Size ranges from 17mm to 45mm in length [Plate-IV (Fig.3a & 3b and Fig.4a & 4b)]. The apical system is slightly anterior and petals are unequal in size. Paired ambulacra form moderately sunken petals in few specimens. The periproct is situated relatively high on the posterior surface. The peristome has a suboval outline and occurs close to the anterior border.

Remarks: Amongst the spatangoids, *Hemiaster* is the most recorded taxa in the present study with variable lengths ranging from 17 mm to 45 mm. Even though many specimens were discarded due to poor preservation, some of the Meghalaya species are comparable with *Hemiaster rana* recorded from the Ariyalur Group of Pondicherry District, Tamil Nadu of Maastrichtian age while few others resemble *Hemiaster subsimilis* reported from the Bagh Beds of Madhya Pradesh of Turonian age (Chiplonkar & Badve, 1974) and *Hemiaster dalli* from the Upper Cretaceous of U.S.A (Cooke, 1953). The size recorded in the Langpar Formation is much smaller than the taxa recorded from the Mahadek Formation. *Hemiaster* was earlier reported from both the Jadukata and Mahadek formations (Bhattacharya and Bhattacharya, 1987). These spatangoids appeared in the central Tethys in the Aptian (Neraudeau, 1994) developed and diversified in Tethyan regions in the Late Cretaceous and Cenozoic, and are still found in the Mediterranean today.

Horizon: Mahadek and Langpar formations, Ryngud, Sohkha and Sohbar, Meghalaya.

Hemiaster bexari (?) Clark & Twitchell, 1915
[Plate-IV (Fig. 5a andFig. 5b)]

Hemiaster wetherbyi de Loriol, 1887

Material: 1 internal mould (Specimen no.: K-Pg/ MEG/88)

Dimension: (mm)

Specimen no.	Length	Breadth	Height
K-Pg/ MEG/88	25	24	13

Description: Test is small, plump and margin rounded. Paired petals are wide, straight and moderately sunken. Anterior pair is twice as long as posterior pair. The peristome occurs very close to the anterior border.

Remarks: Only one specimen was recorded from Meghalaya near the vicinity of the K-Pg boundary. The present specimen has been kept under *Hemiaster bexari* based on the size and morphology of the petals. *Hemiaster bexari* are widely distributed in the Upper Cretaceous of U.S.A (Cooke, 1953).

Horizon: Calcareous sub-arkose of the Langpar Formation, Lyngar-Ryngud-Laitiam section, Meghalaya.

Genus Mecaster Pomel, 1883

Mecaster sp.
[Plate-IV (Fig. 6a and Fig. 6b)]

Hemiaster texanus Roemer, 1849

Material: 2 internal molds (Specimen nos.: K-Pg/ MEG/89 and K-Pg/ MEG/90).

Dimension: (mm)

Specimen no.	Length	Breadth	Height
K-Pg/ MEG/89	15.2	14	7
K-Pg/ MEG/90	13	11	6

Description: Test is ovate with a distinct anterior sulcus. Posterior face truncate, ambulacrum III sunken from apex to peristome (deepest aborally). Pore-pairs differentiated with faint interporal ridge. Paired ambulacra is petaloid and petals sunken and bowed. Peristome is pentagonal and tilted slightly towards anterior. Periproct is obscured.

Remarks: *Mecaster* was originally included in the Hemiasteridae on the basis of globular shape, high test and anterior notch. However in *Hemiaster* the posterior petals are shorter than the anterior petals whereas the petals of *Mecaster* are subequal (Smith and Bengtson 1991). Also *Mecaster* differs from *Hemiaster* in having an ethmolytic (or hemiethmolytic) apical disc. Therefore the specimens from Meghalaya with sub-equal petals have been kept under the genus *Mecaster.* They are typical of the Tethyan region with its highest diversity in the upper Cretaceous (Upper Cenomanian to Maastrichtian) from Europe, Africa, North and South America, India, Madagascar etc.

Horizon: Ferruginous sandstone of the upper part of the Mahadek Formation, Lyndem, Amlarem-Muktapur road section, Meghalaya.

Family Micrasteridae Lambert 1920
Genus Micraster Agassiz, 1836

Micraster sp. d'Orbigny, 1855
[Plate-IV (Fig.7a and Fig.7b)]

Spatangus coranguinum var. Aanglicum Leske, 1778

Material: 1 internal mould (Specimen no.: K-Pg/ MEG/91)

Dimension: (mm)

Specimen no.	Length	Breadth	Height
K-Pg/ MEG/91	20	16	8

Description: Very poorly preserved, mainly deformed cordiform mold with anterior sulcus. Posterior face truncate. A apical disc is slightly off-centered with sunken paired petals. The peristome is close to the anterior margin.

Remarks: The present material was identified as *Micraster* based on the position of the peristome which faces anteriorly and the heart shape of the mold. They were also reported from the Langpar Formation by Mukherjee, 2012. The genus *Micraster* first occurs in the Cenomanian and ranges through Palaeocene (Danian) in Europe, North Africa, and the former Soviet Union.

Horizon: Calcareous sub-arkose of the Langpar Formation, Lyngar-Ryngud-Laitiam section, Meghalaya.

Order Holasteroida Durham and Melville, 1957
Family Cardiasteridae Lambert, 1917
Genus Cardiaster Forbes, 1850

Cardiaster sp.
[Plate-IV (Fig.8a and Fig.8b)]

Spatangus cordiformis Woodward, 1833= *Spatangus granulosus* Goldfuss, 1826

Material: 3 incomplete moulds (Specimen nos.: K-Pg/ MEG/92 to K-Pg/ MEG/94).

Dimension: (mm)

Specimen no.	Length	Breadth	Height
K-Pg/ MEG/92	31	30	12
K-Pg/ MEG/93	28	34	11
K-Pg/ MEG/94	31	36	13

Description: The shell is incomplete, mainly deformed and broken. Shape is cordiform with anterior sulcus deep and the apical disc is centred. Weak paired ambulacra with conjugate and elongate pore-pairs. Columns of pore-pairs in anterior paired ambulacra are markedly narrower in width than those forming the posterior column.

Remarks: The present materials from Meghalaya recorded are mostly broken, incomplete and partially preserved. Therefore specific identification was not possible. However they resemble *Cardiaster* where the anterior depression is commonly deeper and the anterior end wider with strong cordate horizontal outline as compared to *Holaster* with a nearly oval horizontal outline. The difference between *Cardiaster* and *Holaster* is the presence of a marginal fasciole in *Cardiaster* which passes under the periproct. *Cardiaster* was earlier reported from the Jadukata Formation (Bhattacharya and Bhattacharya, 1987). They are found in deep water shelf chalks or slope deposits and are widely distributed in the Upper Cretaceous (Turonian to Maastrichtian) of U.S.A, Europe, Cuba, and the former Soviet Union.

Horizon: Quartz wacke unit of the upper part of the Mahadek Formation, Amlabon nala section, Meghalaya.

REPOSITORY

All the specimens are kept in the repository of Palaeontology Division, Geological Survey of India, North Eastern Region, Shillong.

CONCLUSIONS

The Cretaceous-Palaeogene sediments of the Meghalaya shelf are represented by the Jadukata and Mahadek formations of Khasi Group and the Langpar, Shella, and Kopili formations of Jaintia Group and the Cretaceous-Palaeogene (K-Pg) mass extinction boundary has been recorded within the Langpar Formation. In the present study, emphasis has been given to document the fauna from the Mahadek Formation and the Langpar Formation in the East Khasi Hills District and West Jaintia Hills District of Meghalaya. The Mahadek Formation is represented by coarse gritty sandstone and glauconite bearing medium to coarse-grained arkosic sandstone, hard and massive grey medium to coarse-grained calcareous sandstone, ferruginous sandstone, etc., and the Langpar Formation comprises calcareous units represented by clastic limestone (carbonaceous at places), carbonaceous shale, calcareous subarkose, calcareous shale, impure limestone, silty mudstone, calcareous siltstone, siltstone, and limestone lenses, etc. Two marker horizons in the Mahadek and Langpar formations were identified based on characteristic faunal and litho assemblages. The first horizon comprises medium to coarse-grained calcareous sandstone of the upper part of the Mahadek Formation rich in echinoids, bivalves, and gastropods and the second horizon is the calcareous sub-arkose and carbonaceous shale intercalation of the lower part of the Langpar Formation rich in heteromorph ammonites, gastropods, and prolific burrows. A wide faunal diversity and variation in the taxonomic richness of 37 taxa comprising 19 bivalve genera, 9 gastropod genera, 4 genera of ammonites, and 5 genera belonging to echinoderms were recorded throughout the Mahadek and Langpar formations of Late Cretaceous- Early Palaeocene age from east to west of the study area. The bivalve families include Pectenidae, Ostreidae, Cardiidae, Trigonidae, Nuculidae, Limidae, Corbulidae, Inoceramidae, Crassatellidae, Lucinidae, Pholadomidae, Gryphaeidae, Cucullaeidae, Glycymerididae and Mytilidae and gastropod families consist of Turritellidae, Fasciolaridae, Ampullinidae, Volutidae, Tylostomatidae, Colombellinidae, and Naticidae. The heteromorph ammonites include *Eubaculite* sp., *Glyptoxoceras* sp., *Nostoceras* sp., and *Pachydiscus* sp. and echinoid families comprise Faujasiidae, Hemiasteridae, Micrasteridae, and Holasteridae. Interestingly most of the ammonite faunal assemblages recorded in the present study have also been reported from the Terminal Maastrichtian El Kef section of Tunisia which is the Global Stratotype Section and Point (GSSP) of the Cretaceous-Palaeogene boundary. Along with these faunas, abundant burrows of variable sizes (mainly *Thalassinoides* and a few *Skolithos*) were also noted. The record of abundant and diverse mega invertebrates like bivalves, gastropods, ammonites, and echinoids with prolific burrows, shark teeth, and few serpulid worm tubes in Meghalaya with an extensive increase in borers and burrowers and heteromorphs just below the K-Pg mass-extinction boundary probably points to a stressed and unfavorable condition of the environment due to the catastrophic impact, Deccan Traps large igneous province and dynamic climate instability, which led to the extinction of some species. In the present study, some of the taxa that became extinct at the K-Pg boundary or in the Early Palaeocene are *Neithea*, *Cataceramus*, *Agerostrea*, *Exogyra*, *Limea (Pseudolimea), Myophorella, Granocardium, Graphidula*, *Eubaculite*, *Glyptoxoceras, Nostoceras*, *Pachydiscus*, *Gongrochanus* and *Micraster*. In Meghalaya, the gastropods of the families Fasciolaridae, Volutidae, Aporrhaidae, and Tylostomatidae, bivalve taxa like *Myophorella*, *Granocardium*, *Limea (Pseudolimea), Mytilus*, heteromorph ammonite like *Nostoceras* and echinoid like *Mecaster* have been recorded for the first time from the Mahadek and Langpar formations, but are left in open nomenclature owing to the inadequate preservation. Based on the faunal assemblages, palaeo-ecologically major parts of these faunas are interpreted as typical for an argillaceous to the sandy environment in an open marine shallow inner shelf environment. The fauna recorded from the Late Cretaceous-Early Palaeocene sediments of the Mahadek and Langpar formations of Meghalaya shelf display a wide diversity in palaeoecology: suspension feeders, deposit feeders, predators, borers, and swimmers concerning life habit. Both epifaunal and infaunal organisms are nearly equally abundant pointing to an open shallow shelf environment and warm marine habitat. The faunal assemblages show cosmopolitan and Tethyan affinities with a few European and Indo-Pacific links analogous to many Upper Cretaceous sections like South India, Madagascar, New Zealand & Australia, North and South Africa, Saudi Arabia, Poland, Belgium and Netherlands, Upper Cretaceous of USA, United Arab Emirates-Oman, Mediterranean Europe, Pakistan, etc.

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