APPENDICES

Appendix 4.1: Compositional classification of limestones (after Folk, 1959)

- **Allochemical rocks**
  - Intraclastic rocks (I)
  - Oolitic rocks (II)
  - Fossiliferous rocks (III)
  - Fossiliferous pellet rocks (IV)

- **Orthochemical rocks**
  - Microcrystalline rocks (V)

---

**Legend**
- Sparry calcite cement
- Microcrystalline calcite ooze

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Appendix 4.2: Textural spectrum of carbonate sediment (after Folk, 1962)

<table>
<thead>
<tr>
<th>Over 2/3 lime mud matrix</th>
<th>Subequal spar &amp; Lime mud</th>
<th>Over 2/3 spar cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1%</td>
<td>Sorting poor</td>
<td>Sorting good</td>
</tr>
<tr>
<td>0-10%</td>
<td>Sorting good</td>
<td>Rounded &amp; abraded</td>
</tr>
<tr>
<td>10-50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micrite and Dismicrite</td>
<td>Fossiliferous micrite</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Spars</td>
<td>Poorly washed Biosparite</td>
</tr>
<tr>
<td>2</td>
<td>Biomicrite</td>
<td>Sorted Biosparite</td>
</tr>
<tr>
<td>3</td>
<td>Packed Bioticrite</td>
<td>Rounded Biosparite</td>
</tr>
<tr>
<td>4</td>
<td>Biomicrite</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Claystone</td>
<td>Sandy Claystone</td>
</tr>
<tr>
<td>6</td>
<td>Clayey or immature sandstone</td>
<td>Submature sandstone</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Mature sandstone</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Supermature sandstone</td>
</tr>
<tr>
<td>Claystone</td>
<td>Sandy Claystone</td>
<td>Submature sandstone</td>
</tr>
<tr>
<td>Clayey or immature sandstone</td>
<td>Mature sandstone</td>
<td>Supermature sandstone</td>
</tr>
</tbody>
</table>

Appendix 4.3: Classification of carbonate rocks (after Dunhum, 1962)

Appendix 5.1: Standard chemical classification of limestone (after Todd, 1966)

<table>
<thead>
<tr>
<th>Descriptive term</th>
<th>Standard ratio Ca/Mg</th>
<th>Reciprocal ratio Mg/Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure Limestone</td>
<td>100.00-39.00</td>
<td>0.00-0.03</td>
</tr>
<tr>
<td>Magnesium Limestone</td>
<td>39.00-12.30</td>
<td>0.03-0.08</td>
</tr>
<tr>
<td>Dolomitic Limestone</td>
<td>12.30-1.41</td>
<td>0.08-0.18</td>
</tr>
</tbody>
</table>
Appendix 6.1: Correlation between the “Shallow Benthic Zones” (SBZ) and the Paleocene-Eocene Time Scale. (Serra Kiel et al., 1998)

<table>
<thead>
<tr>
<th>TIME (Ma)</th>
<th>Chrons</th>
<th>Polarity</th>
<th>Epoch</th>
<th>Age</th>
<th>PLANKTON ZONES</th>
<th>Calcareous Nannoplankton</th>
<th>Larger Foraminifera Shallow Benthic Zones (SBZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>C 20</td>
<td></td>
<td>MIDDLE</td>
<td>LUTETIAN</td>
<td>P11, P11</td>
<td>NP 15</td>
<td>SBZ 14</td>
</tr>
<tr>
<td>50</td>
<td>C 21</td>
<td></td>
<td></td>
<td>P10, P10</td>
<td>NP 14</td>
<td>b, b</td>
<td>SBZ 13</td>
</tr>
<tr>
<td>55</td>
<td>C 22</td>
<td></td>
<td></td>
<td>P9, P9</td>
<td>NP 13</td>
<td>b, a</td>
<td>SBZ 12</td>
</tr>
<tr>
<td>60</td>
<td>C 23</td>
<td></td>
<td></td>
<td>P8, P8</td>
<td>NP 12</td>
<td>b, b</td>
<td>SBZ 11</td>
</tr>
<tr>
<td>65</td>
<td>C 24</td>
<td></td>
<td></td>
<td></td>
<td>NP 11</td>
<td>b, b</td>
<td>SBZ 10</td>
</tr>
<tr>
<td>70</td>
<td>C 25</td>
<td></td>
<td></td>
<td>P7, P7</td>
<td>NP 10</td>
<td>a, a</td>
<td>SBZ 9</td>
</tr>
<tr>
<td>75</td>
<td>C 26</td>
<td></td>
<td>LATE</td>
<td>SELANDIAN</td>
<td>P6, P6</td>
<td>NP 9</td>
<td>SBZ 8</td>
</tr>
<tr>
<td>80</td>
<td>C 27</td>
<td></td>
<td>DANNIAN</td>
<td>HIRIAN</td>
<td>P5, P5</td>
<td>NP 8</td>
<td>SBZ 7</td>
</tr>
<tr>
<td>85</td>
<td>C 28</td>
<td></td>
<td></td>
<td>P4, P4</td>
<td>NP 7</td>
<td>b, b</td>
<td>SBZ 6</td>
</tr>
<tr>
<td>90</td>
<td>C 29</td>
<td></td>
<td></td>
<td>P3, P3</td>
<td>NP 6</td>
<td>a, a</td>
<td>SBZ 5</td>
</tr>
<tr>
<td>95</td>
<td></td>
<td></td>
<td></td>
<td>P2, P2</td>
<td>NP 5</td>
<td>a, a</td>
<td>SBZ 4</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td>P1, P1</td>
<td>NP 4</td>
<td>b, b</td>
<td>SBZ 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NP 3</td>
<td>CP 3</td>
<td>SBZ 2</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NP 2</td>
<td>CP 2</td>
<td>SBZ 1</td>
</tr>
</tbody>
</table>

Boundary Time Span
LIST OF PUBLISHED PAPERS


FORAMINIFERAL BIOSTRATIGRAPHY OF SYLHET LIMESTONE FORMATION, SHILLONG PLATEAU, MEGHALAYA (INDIA)

ANINDITA BHATTACHARJYA and BI KASH GOGOI

DEPARTMENT OF GEOLOGICAL SCIENCES, GAUHATI UNIVERSITY, GUWAHATI 781014, INDIA

ABSTRACT

Biostratigraphy based on larger benthic foraminifera species of families Rotaliidae, Pellatispiridae, Nummulitidae, Discocyclinidae, Alveolinidae, Haueriniidae, Textulariidae, Valvulinidae and Soriidae are attempted in the three members of Sylhet Limestone Formation exposed around Mawlong village of Cherrapunji area of Shillong Plateau, NE India. Total of seven Taxon Range Zones are established in the area. For the oldest Lakadong Limestone Member of the formation, FAD and LAD of species Miscellanea miscella are considered to define Miscellanea miscella Taxon Range Zone. For biostratigraphic zonation of the intermediate Umldatoh Limestone Member, FAD and LAD of species Lockhartia conditi, Fasciolites aragonensis are considered. Two Taxon Range Zones viz. Lockhartia conditi Taxon Range Zone and Fasciolites aragonensis Taxon Range Zone are defined in stratigraphic order. However, for the Prang Limestone Member, the FAD and LAD of species Nummulites burdigalensis burdigalensis, Nummulites burdigalensis cantabricus, Nummulites lehneri and Nummulites gizehensis are used as criteria and identified four Taxon Range Zones viz. Nummulites burdigalensis burdigalensis Taxon Range Zone, Nummulites burdigalensis cantabricus Taxon Range Zone, Nummulites lehneri Taxon Range Zone and Nummulites gizehensis Taxon Range Zone in stratigraphic order. Calibration of established benthic foraminiferal biozones with the Tethyan larger benthic foraminiferal biozonation scheme (Serra-Kiel et al., 1998; Shukla, 2008) of benthic foraminifera suggests that the Sylhet Limestone Formation ranges in age from SBZ 3-SBZ 16 which is equivalent to P4-P12 Zone of planktonic foraminifera of Berggren et al., 1995.

Keywords: Biostratigraphy, Benthic Foraminifera, Late Paleocene-Early Eocene, Larger benthic foraminiferal biozonation (SBZ), Sylhet Limestone, Shillong Plateau

INTRODUCTION

Early Paleogene involves several long and short duration palaeoclimatic changes, large scale plate reorganizations and oceanographic changes. Large scale spreading of shallow epicontinental seas in the mid latitudinal areas e.g. Tethys Sea, that covered the major areas of mid low latitude, exhibit extensive development of shallow water carbonate platform. Shillong plateau of north east India (Fig. 1) witnessed those changes as a part of globally extensive platform of carbonate distribution of the Late Paleocene - Early Eocene carbonate sedimentation phase. Fascinating occurrence of marine Eocene beds in the plateau was first reported by Oldham (1859) and occurrence of ‘Sylhet limestone stage’ was further reported by Evans (1932) from Garo Hills, near Therria Ghat and Cherrapunji area of Khasi Hills. However, Nagappa (1956, 1959) confirmed occurrence of Dianan foraminifera in the Langpar Formation of Jaintia and Khasi hills including occurrences of other foraminifera in ‘Therria stage’ and upper part of the ‘Mahadek stage’ of the places. Further, the foraminiferal assemblage of Sylhet Limestone Formation has so far been appraised by different workers (Pandey, 1981; Jauhri, 1988, 1996; Matsumaru and Jauhri, 2003; Jauhri et al., 2006; Gogoi et al., 2009; Shukla, 2009; Tiwari et al., 2010; Matsumaru and Sarma, 2010; Kalita Gogoi, 2015 and Bhattacharjya and Gogoi, 2018). Larger Foraminifers being the most common constituent of the Late Paleocene - Early Eocene shallow water carbonate platforms show a major change in morphology as well as their dominance during Paleocene - Eocene transition (Scheibner et al., 2005; Zili et al., 2009; Alegret et al., 2009).

MATERIALS AND METHODS

The study is based on observation of larger benthic foraminifera in thin sections of hard, compact limestones. The thin sections are prepared following normal procedure of thin section preparation. In order to increase good chance of encountering equatorial and vertical sections of bethic foraminifera three slides at right angle to each other are prepared from each of the samples.

GEOLOGICAL SETTING

East coast of India was developed during Late Jurassic - Early Cretaceous following separation of India from Antarctica - Australia assembly. The separation took place first in the SW part and moved gradually to its north-eastern part. In the process several sedimentary basins namely Cauvery, Pennar, Krishna- Godavari, Mahanadi, Bengal and Assam - Arakan Basin were formed closed to the newly forming east coast of India. The Shillong plateau of Meghalaya is a part of the Assam - Arakan Basin developed during Cretaceous - Tertiary time. Sedimentation in the Meghalaya basin started in Latest Campanian - Maastrichtian time depositing mainly conglomerates and sandstones of Khasi Group (Fig. 1). In Paleocene - Eocene time the basin attained passive margin condition and deposition of terrigenous clastic sediments and carbonate buildups took place on the inner shelf of the sea (Table 1). The limestone bands with intermittent clastic facies developed on the shallow shelf in this region and continued during Paleocene Eocene time (Garg and Ateequzzaman, 2000).
The purpose of the present appraisal is to provide information on foraminiferal biostratigraphy and palaeoenvironmental changes in Sylhet Limestone Formation of the plateau of Paleocene - Eocene time.

**SYSTEMATIC PALAEONTOLOGY**

**Order** Foraminiderida Eichwald, 1830  
**Suborder** Rotalina Delange and Herouard, 1896  
**Superfamily** Rotaliacea Ehrenberg 1839  
**Family** Rotaliidae Ehrenberg, 1839  
**Subfamily** Pararotaliinae Reiss, 1963  
**Genus** Kathina Smout, 1954

*Kathina* sp.  
*(Pl IV, fig. 6)*

**Remarks:** Test lenticular, low trochospiral coiling with a single spire of simple chambers with small chamber lumen, no supplementary chambers or umbilical extensions. Size of the test is (1.00x0.50) mm. Thickness of shell wall ranges from 0.03 to 0.10 mm. It is reported from Umlatdoh Limestone unit.

**Stratigraphic Range:** Late Selandian - Thanetian (*SBZ* 3 - *SBZ* 5).

*Kathina selveri* Smout, 1954  
*(Pl. I, fig. 2)*

**Remarks:** The specimen has an unequally biconical and finely perforated, lenticular test. It has a low trochospiral coiling with a single spire of simple chambers with small chamber lumen, no supplementary chambers or umbilical extensions; septa double, straight and radiate. In axial section, chambers are nearly evolute dorsally and taper ventrally towards umbilicus. Laminae can be seen around the test, thick at the dorsal fold thicker in the ventral plug and thinning out towards the margin. Size of the test is (1.45x0.77) mm. Thickness of shell wall ranges from 0.5 mm to 0.2 mm. It is reported from Lakadong Limestone unit.

**Stratigraphic Range:** Late Selandian - Thanetian (*SBZ* 3 - *SBZ* 4).

---

**EXPLANATION OF PLATE I**

Fig. 1. *Glomalveolina levis* Hottinger, 1960; axial section; Thanetian (*SBZ* 4); Slide no. AB/BG/ LKL/CSML 02. Fig. 2. *Kathina selveri* Smout, 1954; vertical axial section; Late Selandian-Thanetian (*SBZ* 3 - *SBZ* 4); Slide no. AB/BG/ LKL/CSML 08. Fig. 3. *Triloculina* sp.; axial section; Middle Eocene to Holocene; Slide no. AB/BG/ LKL/CSML 09. Fig. 4. *Biloculina* sp.; axial section; Oligocene to Holocene; Slide no. AB/BG/ LKL/CSML 03. Fig. 5. *Idalina sinjarica* Grimsdale, 1952; axial section; (Late Thanetian-Early Ilerdian) *SBZ* 3 - *SBZ* 6; Slide no. AB/BG/ LKL/CSML 03. Fig. 6. *Rotalia* sp.; axial section; Paleocene to Early Eocene; Slide no. AB/BG/ LKL/CSML 02. Fig. 7. *Textularia* sp.; axial section; Paleocene to Holocene; Slide no. AB/BG/ LKL/CSML 08. Fig. 8. *Discocyclina* sp.; vertical axial section; Middle and Upper Paleocene; Slide no. AB/BG/ LKL/CSML 08. Fig. 9. *Ranikothalia* sp.; axial section; Middle and Upper Paleocene; Slide no. AB/BG/ LKL/CSML 08. Fig. 10. *Idalina* sp.; axial section; Upper Cretaceous; Slide no. AB/BG/ LKL/CSML 08. Fig. 11. *Ranikothalia sindensis* Davies, 1927; vertical axial section; Late Selandian-Early Ilerdian (*SBZ* 3 - *SBZ* 6); Slide no. AB/BG/ LKL/CSML 02. Fig. 12. *Quinqueloculina* sp.; axial section; Cretaceous to Holocene; Slide no. AB/BG/ LKL/CSML 09.
Subfamily Lockhartiinae Hottinger, 2014

Genus Lockhartia Davies, 1932

Lockhartia conica Smout, 1954 (Pl. IV, fig.4)

Remarks: The test is strongly conical, equidimensional. Chambers are wedge shaped. Margin is acute and ventral surface plane. Umbilical area is occupied by freely developed pillars and plates. Test size is (1.02 x 0.8) mm. It is reported from Umlatdoh Limestone unit.

Stratigraphic Range: Late Selandian - Thanetian (SBZ 3 - SBZ 4).

Lockhartia condita Nuttall, 1926 (Pl. IV, fig.5)

Remarks: The test is trochospiral, conical with few huge pillars in umbilical region. Base is slightly convex. Shape of the chambers are wedge shaped. Size of the test is (1.47x 0.9) mm with shell wall size upto 0.16 mm. Proloculus is not seen. Poorly developed discontinuous radiating pillars are seen and is reported from Umlatdoh Limestone unit.

Stratigraphic Range: Late Selandian - Early Ilerdian (SBZ 3 - SBZ 4).

Lockhartia aff. hunti Ovey, 1947 (Pl. IV, fig.3)

Remarks: The test of the specimen is conical and trochospiral with strong convex base line. Poorly developed discontinuous radiating pillars, elongated slightly curved chambers. Size of the test is (1.56x0.95) mm. This species is reported from sample number CSML 1.7 of Umlatdoh Limestone.

Biostratigraphic Range: Early Eocene (?SBZ 6 - ?SBZ 7). This species is found in association with Pyrgo sp., Quinqueloculina sp., Textularia sp., Discocyclina spp., Alveolina (Fasciolites) spp., Lockhartia spp., Kathina sp., L. conditi, Idalina sinjarica, L. alveolata and underlain by L. conditi Taxon Range Zone of the present studied section. However, Hottinger, 2014 described its stratigraphic range as ?SBZ 12 - ?SBZ 14 in a book from the Western and Central Neotethys.

Lockhartia alveolata Silvestri, 1942 (Pl. IV, fig.1)

Remarks: Test conical to lenticular, trochospiral, simple spire of numerous wedge shaped chambers visible on the strongly convex spiral side. Ornamented with seven vertical pillars of varying thickness, the pillars together assume a fan like shape.
having narrow proximal and broad distal end, with numbers of tubercles in umbilical region, size of the test is (1.5x1.2) mm. Rounded proloculus of size (0.06x0.06) mm. This species is reported from CSML 1.7 of Umlatdoh Limestone unit.

**EXPLANATION OF PLATE III**

Fig. 1. *Fasciolites aragonensis* Hottinger, 1960; axial section; Ilerdian (SBZ 7 - SBZ 9); Slide no. AB/BG/UL/CSML 1. Fig. 2. *Fasciolites corbarica* Hottinger, 1960; axial section; Ilerdian (SBZ 8); Slide no. AB/BG/UL/CSML 6. Fig. 3. *Fasciolites solida* Hottinger, 1960; axial section; Ilerdian (SBZ 6); Slide no. AB/BG/UL/CSML 1.5. Fig. 4. *Fasciolites pasticillata* Schwager, 1883; axial section; Ilerdian (SBZ 6); Slide no. AB/BG/UL/CSML 1.6. Fig. 5. *Fasciolites decipiens* Schwager, 1883; axial section; Ilerdian (SBZ 7 - SBZ 9); Slide no. AB/BG/UL/CSML 1. Fig. 6. *Fasciolites* spp.; axial section; Upper Paleocene to Upper Eocene; Slide no. AB/BG/UL/CSML 3. Fig. 7. *Fasciolites subpyrenica* Leymerie, 1846; axial section; Ilerdian (SBZ 7); Slide no. AB/BG/UL/CSML 3. Fig. 8. *Nummulites* spp.; vertical section; Paleocene to Early Oligocene; Slide no. AB/BG/UL/CSML 6. Fig. 9. *Textularia* spp.; axial section; Paleocene-Holocene; Slide no. AB/BG/UL/CSML 1.7. Fig. 10. *Biloculina* sp.; axial section; Oligocene-Holocene; Slide no. AB/BG/UL/CSML 5. Fig. 11. *Idalina* sp.; axial section; Upper Cretaceous; Slide no. AB/BG/UL/CSML 3. Fig. 12. *Pyrgo* sp.; axial section; Upper Eocene to Holocene; Slide no. AB/BG/UL/CSML 3. Fig. 13. *Triloculina* sp.; axial section; Middle Eocene to Holocene; Slide no. AB/BG/UL/CSML 5. Fig. 14. *Quinqueloculina* sp.; axial section; Cretaceous to Holocene; Slide no. AB/BG/UL/CSML 1.7. Fig. 15. *Idalina sinjarica* Grimsdale, 1952; axial section; (Late Thanetian-Early Ilerdian) SBZ 3 - SBZ 6; Slide no. AB/BG/UL/CSML 1.7.
Stratigraphic Range: Early Eocene (?SBZ 6 - ?SBZ 7). This species is found in association with Pyrgo sp., Quinqueloculina sp., Textularia sp., Discocyclina spp., Alveolina (Fasciolites) spp., Lockhartia spp., Kathina sp., L. conditi, L. aff. hunti, Idalina sinjarica and underlain by L. conditi Taxon Range Zone of the present studied section. However, Dincer and Avsar 2004, described its stratigraphic range as SBZ 13 in a report from northeast and northern part of Camardi (Nigde) along the Ecemis fault zone of Turkey.

Lockhartia haimei Davies, 1927  
(Pl. II, fig. 1)

Remarks: Test conical to lenticular, trochosorial, simple spire of numerous chambers, 3 to 4 whorls with triangular spacious chambers, visible on the convex spiral side. Umbilical region showing slightly radiating pillars ornamented with convex ribs, distal ornamental ribs are longer than the proximal ribs. Size of the test is (0.98x0.55) mm. This species is reported from Lakadong Limestone unit.

Stratigraphic Range: Late Selandian - Thanetian (SBZ 3 - SBZ 4).

Genus Laffiteina Marie, 1946  
Laffiteina erki Sirel, 1969  
(Pl. II, fig.4)

Remarks: Test is strongly trochosorial with slightly convex distal side and strongly convex proximal side. Test is highly perforated, shell wall thick, umbilical area filled by numerous thin elongated pillars. It is reported from Lakadong Limestone unit and has a size of (0.6x0.8) mm. Proloculus rounded with size 0.025mm.

Stratigraphic Range: Selandian - Thanetian (SBZ 2 - SBZ5).

Genus Rotalia Lamarck, 1804  
Rotalia sp.  
(Pl. I, fig. 6; Pl. IV, fig. 2)

Remarks: Test is biconvex, trochosorial with thick lamellar pillars filling umbilical area. Shell wall perforated, thick. Septa thick, ranges from 0.25-0.02 mm, chamber spacious, rectangular to triangular, periphery acute. Size of the test is (0.90x0.60) mm to (1.00x0.80) mm. It is reported from both Lakadong Limestone and Umlatdoh Limestone unit.

Stratigraphic Range: Paleocene to Early Eocene.

Superfamily Nummulitacea de Blainville 1827  
Family Nummulitidae de Blainville, 1827  
Subfamily Nummulitinae Carpenter, 1850  
Genus Nummulites Lamarck, 1801  
Nummulites sp.  
(Pl. III, fig. 8; Pl. VI, fig. 7)

Remarks: Test globular, lenticular or discoidal. Size of tests of species reported from Umlatdoh Limestone varies from (1.0x0.55) mm to (3.0x1.5) mm and in Prang Limestone (0.9x0.5) mm to (21.0x8.0) mm. Commonly involute but some are evolute, septa thick, ranges between 0.04 - 0.08 mm, chamber less thick, alar prolongation compressed, umbilical area ornamented with wide pillars.

Stratigraphic Range: Paleocene to Early Oligocene.

Nummulites atacicus Leymerie, 1846  
(Pl. IV, fig.7)

Remarks: The specimen is vertical centered section of a megalospheric form, size of the test is (1.0x0.5) mm. Proloculus is almost rounded and size is (0.09x0.08 ) mm. Test is lenticular with prominent poles. Axial margins sub angular, sometimes rounded. There are 3.5 whorls present in the test, septal wall thick, ranges between 0.06 - 0.04 mm, chamber compressed. Height of successive whorls increases gradually, alar prolongation slightly inflated. This species is reported from Umlatdoh Limestone.

Stratigraphic Range: Ilerdian (SBZ 8).

Nummulites globulus Leymerie, 1846  
(Pl. IV, fig.12)

Remarks: The test is globular. Poles are prominent. Septa thick, ornamental pillar in umbilical area. Equatorial periphery circular, axial periphery biconvex with acute contact. Size of the test is (1.3x0.51) mm. Proloculus is rounded and is (0.14x0.15) mm in size and is reported from Umlatdoh Limestone unit.

Stratigraphic Range: Ilerdian (SBZ 8).

Nummulites globulus var. indicus Davies, 1927  
(Pl. IV, fig.11)

Remarks: Test is lenticular and poles are prominent. There are about 4 whorls. Size of the test is (2x0.95) mm. Test compressed, 3.5 numbers of whorls, lenticular in shape, size of proloculus is (0.2x0.15) mm. This species is reported from Umlatdoh Limestone unit.

Stratigraphic Range: Basal Ypressian (?SBZ 8). In the present studied section this species is found in association with Nummulites globulus, Nummulites atacicus, Nummulites spp., Discocyclina spp., Fasciolites (Alveolina) spp., Pyrgo sp., Triloculina sp., Biloculina sp., Textularia sp., Quinqueloculina sp., Lockhartia sp., Fasciolites aragonensis.

Nummulites burdigalensis burdigalensis, Schaub, 1981  
(Pl. VI, fig.1)

Remarks: It has a globular test with 6.5 whorls. The size of the test is (7.0x4.0) mm, chamberlets are observed, umbilical area occupied by about 16 numbers of radiating pillars, pillars

### EXPLANATION OF PLATE IV

Fig. 1. Lockhartia alveolata Silvestri, 1942; vertical axial section; Early Eocene (? SBZ 6 - ? SBZ 7); Slide no. AB/BG/ UL/CSML 1.7. Fig. 2. Rotalia sp.; axial section; Paleocene to Early Eocene; Slide no. AB/BG/ UL/CSML 4. Fig. 3. Lockhartia aff. hunti Ovey, 1947; vertical axial section; Early Eocene (? SBZ 6 - SBZ 7); Slide no. AB/BG/ UL/CSML 1.7. Fig. 4. Lockhartia conica Smout, 1954; vertical axial section; Late Selandian-Thanetian (SBZ 3-SBZ 4); Slide no. AB/BG/ UL/CSML 1.4. Fig. 5. Lockhartia conditi Nuttall, 1926; vertical axial section; Late Selandian to Early Ilerdian (SBZ 3 - SBZ 6); Slide no. AB/BG/ UL/CSML 1.6. Fig.6. Kathina sp.; vertical axial section; Late Selandian-Thanetian (? SBZ 3 - SBZ 5); Slide no. AB/BG/ UL/CSML 1.4. Fig.7. Nummulites atacicus Leymerie, 1846; vertical axial section; Ilerdian (SBZ 8); Slide no. AB/BG/ UL/CSML 5. Fig. 8. Operorbitolites sp.; axial section; Ilerdian (? SBZ 5 - SBZ 7); Slide no. AB/BG/ UL/CSML 3. Fig. 9. Discocyclina spp.; vertical axial section; Middle Paleocene to Upper Eocene; Slide no. AB/BG/ UL/CSML 1.4. Fig. 10. Juvenile Nummulites atacicus Leymerie, 1846; vertical axial section; Ilerdian (SBZ 8); Slide no. AB/BG/ UL/CSML 3. Fig.11. Nummulites globulus var. indicus Davies 1927; axial section; Basal Ypresian(?SBZ 8); Slide no. AB/BG/ UL/CSML 5. Fig.12 . Nummulites globulus Leymerie, 1846; vertical axial section; Ilerdian (SBZ 8); Slide no. AB/BG/ UL/CSML 5.
are characteristically thin, elongated, proloculus not seen, periphery less compressed, alar prolongation not inflated. It is reported from Prang Limestone.

**Stratigraphic Range:** Cuisian (SBZ 10).

*Nummulites burdigalensis cantabricus* Schaub, 1981  
(Pl. VI, fig.2)

**Remarks:** The test more or less globular in shape, composed of 8 whorls, size of the test is (6.8x4.0) mm, chamberlets present, umbilical area occupied by about 18 numbers of characteristic radiating pillars, pillars are thin, elongated. Alar prolongation not inflated.

**Stratigraphic Range:** Cuisian (SBZ 11).

*Nummulites lehneri* Hottinger, 1960  
(Pl. VI, fig. 3)

**Remarks:** Test is lenticular, compressed, size of the test is (12.5x4.5) mm, poles are prominent, chamberlets present, periphery acute. There are 8 whorls, alar prolongation not inflated. Pillars not distinct. Proloculus not seen. *Nummulites lehneri* is reported from Prang Limestone.

**Stratigraphic Range:** Lutetian (SBZ 13).

*Nummulites fossulatus* De Cizancourt, 1946  
(Pl. VI, fig. 6)

**Remarks:** It has a globular test containing 4 whorls with test size (0.55x0.35) mm. Proloculus not seen. Septal thickness varies from 0.06 mm to 0.03 mm. Umbilical region is slightly compressed. Chambers are highly compressed and acute. *Nummulites fossulatus* is reported from Prang Limestone.

**Stratigraphic Range:** Cuisian (SBZ 10)

*Nummulites gizehensis* Forskal, 1775  
(Pl. VI, fig. 4)

**Remarks:** Size of the test is (2.1x1.6) mm. Size of the proloculus is (0.25x0.20) mm. Umbilical area strongly elevated, shape of the chambers are irregular, acute. Chamberlets are seen. This species is reported from Prang Limestone unit. Septal thickness varies from very thin (0.05 mm) to very thick (0.2 mm).

**Stratigraphic Range:** Lutetian (SBZ 14 - SBZ 16).

*Nummulites djodjokartae* Martin, 1881  
(Pl. VI, fig. 9)

**Remarks:** Megalospheric test, subrounded in shape and it has a size of (2.10x1.55) mm. There are 2 whorls present in the test. Size of the proloculus is (0.6x0.5) mm, septum thick, gradual increase in thickness from initial to end whors, thickness ranges between 0.03-0.12 mm, alar prolongation slightly inflated, chamberlets present. This species is reported from Prang Limestone.

**Stratigraphic Range:** Cuisian - Lutetian (SBZ 10 - SBZ 15).

*Nummulites aff. elevata* Al Hashimi and Amer, 1985  
(Pl. VI, fig. 5)

**Remarks:** Test globular, size of the test is (2.35x1.53) mm, chambers of *Nummulites aff. elevata* are irregular, septa thick, thickness ranges between 0.10-0.15 mm, umbilical area is ornamented with 2-3 pairs prominent pillars. The test is composed of 2.5 whorls. This species is reported from Prang Limestone. Some other forms similar with *Nummulites aff. elevata* are also reported from Prang Limestone and these forms may be correlated with juvenile forms of *Nummulites aff. elevata* (Pl. VI, fig. 8).

**Stratigraphic Range:** Lutetian (SBZ 14 - SBZ 16).

*Genus* *Operculina* d' Orbigny, 1826

*Operculina* sp.  
(Pl. II, fig.8)

**Remarks:** Test planispirally coiled, size of the test is (1.63x0.37) mm, tightness of coiling is poor, evolute, compressed, whors expanding rapidly, alar prolongations inflated. Marginal cord is well developed with numerous fine canals. Outer wall is finely perforated. The genera is cosmopolitan subtropical. It is reported from Lakadong Limestone.

**Stratigraphic Range:** Oligocene to Holocene.

*Genus* *Assilina* d' Orbigny, 1839

*Assilina maxima* Pavlovec, 1969  
(Pl. V, fig. 3)

**Remarks:** Test large, flattened, commonly involute with rapidly enlarging whors, number of whors 7, periphery acute, alar prolongation inflated. Test wall finely perforate, surface smooth, septa raised, size of the test of the specimen is approximately (21x1) mm. It is cosmopolitan tropical and subtropical. It is reported from Prang Limestone.

**Stratigraphic Range:** Middle Paleocene to Holocene.

*Assilina spira abrardi* Schaub, 1981  
(Pl. V, fig. 7)

**Remarks:** It is a microspheric form of *Assilina maxima*, the test of the specimen is very large and flattened. Diameter of the test reaches up to 18.33 mm. Planispirally coiled, there are 9 whors present in the test, whorl diameter increasing gradually, test wall finely perforated, thickness increasing gradually, reaches up to 1 mm. Chamberlets are present, septal wall making about 80 - 85° with test wall. The species is reported from Prang Limestone.

**Stratigraphic Range:** Lutetian (SBZ 13 - SBZ 14).

*Assilina spira abrardi* Schaub, 1981  
(Pl. V, fig.7)

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**EXPLANATION OF PLATE V**

Fig. 1. *Fasciolites aff. palermitana* Hottinger, 1960; axial section; Late Cuisian-Lutetian (SBZ 12 - SBZ 14); Slide no. AB/BG/PL/CSML 30. Fig.2. *Fasciolites azzarolii* Drohne, 1977; axial section; Cuisian (SBZ 12); Slide no. AB/BG/PL/CSML 24. Fig. 3. *Assilina maxima* Pavlovec, 1969; horizontal equatorial section; Lutetian, (SBZ 13-SBZ14); Slide no. AB/BG/PL/CSML 25. Fig. 4. *Fasciolites bayruntensis* Sirel, 1976; axial section; Cuisian (SBZ 11 - SBZ 12); Slide no. AB/BG/PL/CSML 20. Fig. 5. *Fasciolites spp.*; axial section; Upper Paleocene to Upper Eocene; Slide no. AB/BG/PL/CSML 30. Fig. 6. *Assilina spp.*; vertical section; Middle Paleocene to Holocene; Slide no. AB/BG/PL/CSML 20. Fig. 7. *Assilina spira abrardi* Schaub, 1981; vertical axial section; Lutetian (SBZ 13), Slide no. AB/BG/PL/CSML 26. Fig. 8. *Discocyrtinaforitis d’Archiac*, 1850; off centered axial section; Cuisian (SBZ 10); Slide no. AB/BG/PL/CSML 18. Fig. 9. *Discocyrtina ephippium* Schlotheim, 1820; axial section; Cuisian (SBZ 11); Slide no. AB/BG/PL/CSML 22. Fig. 10. *Discocyrtina* spp.; vertical axial section; Middle Paleocene to Upper Eocene; Slide no. AB/BG/PL/CSML 18. Fig. 11. *Quinqueloculina* sp.; axial section; Cretaceous to Holocene; Slide no. AB/BG/PL/CSML 24.
Remarks: The test is large and flattened, involute. Size of the test is (18.02x1.8) mm, proloculus not seen. There are six whorls present in the test, size of the last two whorls increased abruptly, test wall thick, reaches up to 0.6 mm and finely perforated. Alar prolongation slightly inflated, it is reported from Prang Limestone.

Stratigraphic Range: Lutetian (SBZ 13).

Genus Ranikothalia Caudri, 1944

Ranikothalia spp. (Pl. I, fig. 9)

Remarks: The test is flattened lenticular with central boss. The test is compressed and involute. The axial section showing long, thin alar prolongations but continued to umbilical area. Wall calcareous and structure is not coarsely perforated except at the marginal cord. Marginal cord thick and perforate. It is tropical and subtropical cosmopolitan. Size of the test is (1.86x0.40) mm, proloculus is not seen. It is reported from Prang Limestone.

Stratigraphic Range: Middle and Upper Paleocene.

Ranikothalia sindensis Davies, 1927 (Pl. I, fig. 11)

Remarks: The test is compressed and involute. The axial section showing very long thin alar prolongations but continued to umbilicus, inflated. Wall calcareous and structure is not coarsely perforate except at the marginal cord. Marginal cord thick. Size of the test is (1.19x0.21) mm, proloculus not seen and is reported from Lakadong Limestone.

Stratigraphic Range: Late Selandian - Early Ilerdian (SBZ 3 - SBZ 6).

Ranikothalia sahni Davies, 1952 (Pl. II, fig. 3)

Remarks: The test is megalospheric with lenticular outline and initial thick involute. Periphery is rounded and crowded granules are seen on poles. Septal filaments are strong with relatively thick marginal cord and coarse canals. It is reported from Lakadong Limestone and size of the test is (1.41x0.45) mm, size of proloculus (0.14x0.12) mm

Stratigraphic Range: Late Selandian - Early Ilerdian (SBZ 3 - SBZ 6).
Remarks: Size of the test is (2.22x1.33) mm. The ornamental pillars are not only restricted to the umbilical area, but also scattered over the lateral shell surface. It is reported from Lakadong Limestone and both microspheric and megaspheric forms of this species is observed.

Stratigraphic Range: Late Thanetian - Early Ilerdian (SBZ 4 - SBZ 5).

Suborder Millolina Delange and Herouard, 1896
Superfamily Alveolinacea Ehrenberg 1839
Family Alveolinidae Ehrenberg, 1839
Genus Glomalveolina Hottinger, 1962
Glomalveolina levis Hottinger, 1960
(Pl. I, fig. 1)

Remarks: Test small, globular to slightly ovate. The axial section of the specimen is almost rounded with 7 whorls. The height of spire increases very gradually. Chamberlets are circular to elongate in nature. The proloculus is also rounded and has an internal diameter of (0.14x0.11) mm. The size of the test is (0.60x0.45) mm. It is reported from Lakadong Limestone unit.

Stratigraphic Range: Thanetian (SBZ 4).

Genus Alveolina d’Orbigny, 1826
Alveolina (Fasciolites) spp.
(Pl. III, figs. 6; Pl. V, fig. 5)

Remarks: Test ellipsoidal to fusiform or cylindrical, rarely spherical. Coiling irregular in early stage of microspheric generation but regular throughout megaspheric generation. Chambers rapidly increasing in width in successive whorls to result in progressive elongation of the test. The axial section of the specimen is almost rounded with 15 whorls. The height of spire increases very rapidly in the first three whorls, in between 4th and 5th whorl the height increases very slowly. Again from 6th to 11th whorl it starts to increase rapidly. The size of the proloculus is (0.6x0.5) mm. Chamberlets are elongated in the first five whorls, after that they become circular to subcircular in nature. The species is reported from Umlatdoh Limestone.

Stratigraphic Range: Ilerdian (SBZ 7 - SBZ 9).

Alveolina (Fasciolites) aragonensis Hottinger, 1960
(Pl. III, fig. 1)

Remarks: The test of this form is oval containing 11 numbers of whorls and size of the test is (2.40x1.85) mm. The height of spire increases very rapidly in the first three whorls, in between 4th and 5th whorl the height increases very slowly. Again from 6th to 11th whorl it starts to increase rapidly. The size of the proloculus is (0.6x0.5) mm. Chamberlets are elongated in the first five whorls, after that they become circular to subcircular in nature. The species is reported from Umlatdoh Limestone.

Stratigraphic Range: Ilerdian (SBZ 7 - SBZ 9).

Alveolina (Fasciolites) subpyrenica Leymerie, 1846
(Pl. III, fig. 7)

Remarks: Microspheric form, Test is oval shaped, Size of the test is (2x1.12) mm. There are 8 whorls where height of the spire increases very rapidly. Chamberlets are more or less circular and smaller in the first whorls. Towards the outer whorls the chamberlets increases in size. Size of chamberlets ranges from (0.04x0.03) mm to (0.08x0.06) mm and is reported from Umlatdoh Limestone unit.

Stratigraphic Range: Ilerdian (SBZ 7).

Alveolina (Fasciolites) corbarica Hottinger, 1960
(Pl. III, fig. 2)

Remarks: Size of the test is (4.48x3.18) mm. There are 17 whorls, height of spire increases gradually. Chamberlets are circular in the early whorls then it becomes elongated. Size of chamberlets ranges from (0.01x0.02) mm to (0.12x0.58) mm. The species is reported from Umlatdoh Limestone.

Stratigraphic Range: Ilerdian (SBZ 8).

Alveolina (Fasciolites) aff. palermitana Hottinger, 1960
(Pl. V, fig. 1)

Remarks: Size of the test is (3.37x2.75) mm. The test is composed of 3 tight inner coiling followed by 3 much looser coils which are again followed by 5 tight outer coils. The species is reported from Prang Limestone.

Stratigraphic Range: Late Cuisian-Lutetian (SBZ 12 - SBZ 14).

Alveolina (Fasciolites) azzarolii Drobske, 1977
(Pl. V, fig. 2)

Remarks: Test is ellipsoidal which is characterized by 2 tight inner coiling followed by 3 much looser coils and again 7 outer tight coiling. Size of the specimen is (4.51x3.50) mm. Chamberlets are almost rounded but towards the initial whorls they are somewhat smaller and towards outer whorls they gradually become larger. The species is reported from Prang Limestone unit of the Sylhet Limestone Formation.

Stratigraphic Range: Cuisian (SBZ 12).
Alveolina (Fasciolites) bayburtensis Sirel, 1976  
(Pl. V, fig. 4.)

Remarks: The test is ellipsoidal with size (4x3.5) mm. Proloculus is rounded with size (0.15x 0.1) mm. The initial 5 whorls of the test are much looser than the outer 4 whorls. Chamberlets are circular in the early whorls but becomes elongated in the outer whorls. It is reported from Prang Limestone unit.

Stratigraphic Range: Cuisian (SBZ 11 - SBZ 12).

Superfamily Soritacea Ehrenberg 1839  
Family Soritidae Ehrenberg, 1839  
Subfamily Operorbitolitinae Loeblich and Tappan, 1986  
Genus Operorbitolites Nuttall, 1925  
Operorbitolites sp.  
(Pl. IV, fig. 8)

Remarks: The test is lenticular, with cyclic chambers subdivided into numerous small chamberlets. Test consists of median chamber, extending along the whole test length, shape of which is elongate, cylindrical; covered with successive laminae on both above and below. Median layer is thicker towards the peripheral part and thinner towards the central part of the test. Proloculus not distinct, Large and Spherical. Test wall is calcareous, imperforate and porcelaneous. Size of the test is approximately (2.00x1.20) mm. It is recorded from Umlatdoh Limestone.

Stratigraphic Range: Ilerdian (?SBZ 5 - SBZ 7).

Superfamily Miliolacea Ehrenberg 1839  
Family Hauerinidae Schwager, 1876  
Subfamily Siphonapertinae Saidova, 1975  
Genus Quinqueloculina d’Orbigny, 1826
Quinqueloculina sp.  
(Pl. I, fig.12; Pl. III, fig. 14; Pl. V, fig. 11)

Remarks: The ovate test of Quinqueloculina sp. is composed of chambers a half coil in length and added successively in planes 144° apart. Five chambers completing a cycle, each chamber 72° from its next adjacent one. Equatorial diameter of the specimen observed in the sample number CSML 1.7 is 1 mm. Test wall thick, thickness of shell wall ranges from 0.2 mm to 0.8 mm. Chambers simple and large. Quinqueloculina sp. is cosmopolitan and is reported from all the three limestone units of Sylhet Limestone Formation.

Stratigraphic Range: Cretaceous to Holocene

Genus Pyrgo Defrance, 1824
Pyrgo sp.  
(Pl. III, fig.12)

Remarks: The test of the specimen is ovate in outline, rounded through the midpoint of the opposing chambers. Chambers one half coil in length, microspheric generation with early quinqueloculine to cryptoquinqueloculine arrangement. Size of the test is (0.35x0.44) mm. Pyrgo sp. is present in Umlatdoh Limestone.

Stratigraphic Range: Upper Eocene to Holocene.

Subfamily Milliolinellinae Vella, 1957  
Genus Triloculina d’Orbigny, 1826
Triloculina sp.  
(Pl. I, fig. 3; Pl. III, fig. 13)

Remarks: It is a cosmopolitan species with test ovate in outline, equilaterally or subtriangular in section. Chambers are one half coil in length, elongated, slightly curved to straight, early stage cryptoquinqueloculine, at least in the microspheric generation. Later it becomes pseudotriquiloculine or triloculine. Only three chambers are visible from the exterior, chambers without a floor. Test wall calcareous, imperforate, porcelaneous. Aperture rounded. Size of the test is approx. (0.45x0.48) mm. It is reported from Both Lakadong Limestone and Umlatdoh Limestone.

Stratigraphic Range: Middle Eocene to Holocene

Genus Idalina Schlumberger and Munier-Chalmus, 1884
Idalina sp.  
(Pl. I, fig. 10; Pl. III, fig. 11)

Remarks: The test of the specimen is ovoid to fusiform. Consists of a calcareous and imperforate wall. The proloculus is followed by chambers one half coil in length. In axial section chambers are arranged in a biloculine manner. Early stage of the genus generally quinqueloculine, later triloculine, biloculine and in the adult with completely enveloping chambers, some of which may be lacking in some specimens. Size of the test of the specimen found in sample no. CSML 09 is (0.71x0.5) mm. Idalina sp. is reported from both Lakadong and Umlatdoh Limestone.

Stratigraphic Range: Upper Cretaceous.

Idalina sinjarica Grimsdale, 1952  
(Pl. I, fig. 5; Pl. III, fig. 15)

Remarks: The test of the specimen has ovloid test where the proloculus followed by chambers are one half coil in length. Test wall calcareous and imperforate. In axial section chambers are arranged in a biloculine manner. Length of the specimen found in sample no. CSML 03 of Lakadong Limestone is 1.21 mm and breadth at the middle part of the specimen is 1 mm. It is reported from both Lakadong and Umlatdoh Limestone.

Stratigraphic Range: Late Thanetian - Early Ilerdian (SBZ 3 - SBZ 6)

Genus Bilnoculina Wiesner, 1931
Biloculina sp.  
(Pl. I, fig. 4; Pl. III, fig. 10)

Remarks: The test of the specimen is ovate in outline. The chambers are simple, large and one half coil in length. In the microspheric generations early chambers arrangement quinqueloculine then cryptoquinqueloculine and finally biloculine. The megalospheric generations are biloculine throughout. Test wall is calcareous, imperforate and porcelaneous. Bilnoculina sp. is reported from both Lakadong and Umlatdoh Limestone unit. Size of the test of the specimen found in sample no. CSML 03 is (0.36x0.5) mm.

Stratigraphic Range: Oligocene to Holocene.

Suborder Textulariina Delange and Herouard, 1896
Superfamily Textulariacea Ehrenberg 1838  
Family Textulariidae Ehrenberg, 1838  
Subfamily Textularinae Ehrenberg, 1838  
Genus Textularia Defrance, 1824
Textularia sp.  
(Pl. I, fig. 7; Pl. III, fig. 9)
ANINDITA BHATTACHARYA AND BIKASH GOGOI

Table 2. Table showing characteristic assemblage of Shallow Benthic Zones (SBZ) reported from studied section of Sylhet Limestone Formation, Meghalaya (India).

<table>
<thead>
<tr>
<th>Series/Epoch</th>
<th>Stage/Age</th>
<th>Shallow Benthic Zone (SBZ, Serra-Kiel et al. 1998)</th>
<th>Assemblage reported from the studied section of Sylhet Limestone Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eocene</td>
<td>Lutetian</td>
<td>SBZ 16: Fascioolites spp., Discocyclina spp., Assilina spp., Nummulites aff. elevata, N. gizehensis</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SBZ 15: Fascioolites spp., Discocyclina spp., Assilina spp., Nummulites aff. elevata, N. djodjokartae, N. gizehensis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cuisian</td>
<td>SBZ 12: Fascioolites bayburtenis, Quinqueloculina sp., Fascioolites sp., Discocyclina epiphium, Discocyclina spp., Assilina spp., N. djodjokartae, N. burdigalensis burdigalensis</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SBZ 11: Quinqueloculina sp., Fascioolites spp., Discocyclina fortilis, Discocyclina spp., Assilina spp., N. djodjokartae, N. fossulatus, N. burdigalensis burdigalensis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ilerdian</td>
<td>SBZ 8: Operorhibolites sp., F. subpyronica, F. aragonensis, F. decipiens, Textularia sp., Biloculina sp., Triloculina sp., Pyrgo sp., Quinqueloculina sp., Fascioolites spp., Discocyclina spp., Rotalia sp., Lockhartia alveolata, Lockhartia aff. hunti</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SBZ 4: Idalina sinjarica, Textularia sp., Biloculina sp., Idalina spp., Triloculina sp., Quinqueloculina sp., Fascioolites spp., Discocyclina spp., Nummulites aff. elevata, Assilina maxima, Assilina spp., N. djodjokartae, N. lehneri</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Late Selandian-Thanetian</td>
<td>SBZ 3: Idalina sinjarica, Clavulina sp., Textularia sp., Idalina spp., Biloculina sp., Triloculina sp., Pyrgo sp., Quinqueloculina sp., Fascioolites spp., Discocyclina spp., Nummulites aff. elevata, Assilina maxima, Assilina spp., N. djodjokartae, N. lehneri</td>
<td></td>
</tr>
</tbody>
</table>

Remarks: Textularia sp. is a cosmopolitan species which has a tapering, elongated test with leaf or wedge shape. The specimen has biserial test but uniserial tests are also common. Chambers are simple and convex downward. They are not labyrinthic. The measured length of the specimen observed in CSML 02 of Lakadong Limestone is 0.6 mm and breadth is 0.33 mm. Thickness of shell wall ranges from 0.02 mm to 0.04 mm. Both uniserial and biserial forms are reported from both Lakadong and Umlatdoh Limestone.

Stratigraphic Range: Paleocene to Holocene.

Family Valvulinidae Berthelin, 1880
Subfamily Valvulininae Berthelin, 1880
Genus Clavulina d’Orbigny, 1826
Clavulina sp.
(Pl. II, fig. 7)

Remarks: Clavulina sp. has elongated test with triserial and triangular early stage which becomes uniserial and rectilinear at the later stage. The test becomes somewhat angular to rounded at the later stage. Wall is agglutinated with considerable calcareous cement, canaliculated, fine canaliculi bifurcation within the wall, openings of the canaliculi sealed internally by inner organic lining and externally by the imperforate surface layer of the wall. The chambers present in the test are simple and large which contains comparatively thick cell wall. Size of the test is (0.45x 0.31) mm. It is a cosmopolitan species and it is reported from Lakadong Limestone.

Stratigraphic Range: Paleocene to Holocene.

BIOSTRATIGRAPHIC ZONATION

The distribution range of species of benthic foraminifera of the studied section are shown in Fig. 2. The distribution pattern suggests occurrences of both short and long ranging species of foraminifera. Biostatigraphical appraisal in the present work is attempted with the species association of the larger benthic foraminifera families Rotaliidae Ehrenberg, 1839; Pellatspiridae Hanzawa, 1937; Nummulitidae Blainville, 1827; Discocyclinidae Galloway 1928; Alveolinidae Ehrenberg, 1839; Hauerinidae Schwager, 1876; Textulariidae Ehrenberg, 1838;
Valvulinidae Berthelin, 1880 and Soritidae Ehrenberg, 1839. The study establishes seven Taxon Range Zones viz. Miscellanea miscella Taxon Range Zone, Lockhartia conditi Taxon Range Zone, Fasciolites aragonensis Taxon Range Zone, Nummulites burdigalensis burdigalensis Taxon Range Zone, Nummulites burdigalensis cantabricus Taxon Range Zone, Nummulites lehneri Taxon Range Zone and Nummulites gizehensis Taxon Range Zone of benthic foraminifera in the studied section of Sylhet Limestone Formation. For biostratigraphic zonation of lower most lithounit Lakadong Limestone Member FAD and LAD of species M. miscella was considered as criteria and based on that Miscellanea miscella Taxon Range Zone was identified. For Umlatdoh Limestone Member FAD and LAD of species Lockhartia conditi, Fasciolites aragonensis were considered and identified Lockhartia conditi Taxon Range Zone and Fasciolites aragonensis Taxon Range Zone. However, for the uppermost member Prang Limestone, FAD and LAD of species Nummulites burdigalensis burdigalensis, Nummulites burdigalensis cantabricus, Nummulites lehneri and Nummulites gizehensis were used as criteria and established Nummulites burdigalensis burdigalensis Taxon Range Zone, Nummulites burdigalensis cantabricus Taxon Range Zone, Nummulites lehneri Taxon Range Zone and Nummulites gizehensis Taxon Range Zone (Bhattacharyya and Gogoì, 2018).

Miscellanea miscella Taxon Range Zone

**Definition:** Total stratigraphic range of Miscellanea miscella represented in the upper part of the Lakadong Limestone Member which ranges between sample numbers CSML 01 - CSML 09 (Fig. 2). The zone is overlain by clastic facies of Lakadong Sandstone however the underlying biozone could not be described due to sampling constrain.

**Characteristics:** The Miscellanea miscella Taxon Range Zone is characterized by occurrence of Miscellanea miscella along with species association of Triloculina sp., Biloculina sp., Quinqueloculina sp., Textularia sp., Fasciolites spp., Discocyclina spp., Idalina sp., Kathina sp., Glomalveolina levis, Lockhartia spp., Lockhartia haimei, Idalina sinjarica, Rotalia sp., Clavulinia sp., Ranikothalia sindensis, Ranikothalia sahni, Miscellanea sp., Miscellanea juliettae, Operculina sp. and Lafiíteína erki.

**Age:** The age of the Miscellanea miscella Taxon Range Zone is Late Paleocene (Late Selandian – Thanetian) (SBZ 3 - SBZ 4).

Lockhartia conditi Taxon Range Zone

**Definition:** Total stratigraphic range of Lockhartia conditi is represented in the lower part of the Umlatdoh Limestone Member which is distributed from the sample number CSML 1.1 to CSML 1.7 (Fig. 2). The biozone is overlain by clastic facies of Lakadong Sandstone Member and overlain by Fasciolites aragonensis Taxon Range Zone.

**Characteristics:** The Lockhartia conditi Taxon Range Zone is characterized by occurrence of Lockhartia conditi along with species association of Pyrgo sp., Triloculina sp., Biloculina sp., Quinqueloculina sp., Textularia sp., Fasciolites spp., Nummulites spp., Discocyclina spp., Lockhartia spp., Idalina sinjarica, Fasciolites solida, Fasciolites pascicillata, Idalina sp., Kathina sp., Lockhartia aff. hunti, Lockhartia alveolata and Lockhartia conica.

**Age:** The age of the Lockhartia conditi Taxon Range Zone is Thanetian - Ilerdian (SBZ 4 - SBZ 6).

Fasciolites aragonensis Taxon Range Zone

**Definition:** Total stratigraphic range of Fasciolites aragonensis is represented in the upper part of the Umlatdoh Limestone Member which is distributed between the sample numbers CSML 1 to CSML 17B (Fig. 2). The biozone is overlain by Lockhartia conditi Taxon Range Zone and overlain by clastic facies of Nurpuh Sandstone Member.

**Characteristics:** The Fasciolites aragonensis Taxon Range Zone is characterized by presence of Fasciolites aragonensis along with species of Pyrgo sp., Triloculina sp., Biloculina sp., Quinqueloculina sp., Textularia sp., Fasciolites spp., Nummulites spp., Discocyclina spp., Lockhartia spp., Fasciolites decipiens, Fasciolites corbarica, Fasciolites subpyrenica, Operorbitolites sp., Nummulites atacicus, Nummulites globulus, Juvenile Nummulites atacicus and Nummulites globulus var. indicus.

**Age:** The age of the Fasciolites aragonensis Taxon Range Zone is Early Eocene (Ilerdian) (SBZ 7 - SBZ 9).

Nummulites burdigalensis burdigalensis Taxon Range Zone

**Definition:** Total stratigraphic range of Nummulites burdigalensis burdigalensis and is distributed between the sample numbers CSML 18 to CSML 19 (Fig. 2) of lower part of the Prang Limestone Member. The biozone is overlain by clastic facies of Nurpuh Sandstone Member and overlain by Nummulites burdigalensis cantabricus Taxon Range Zone.

**Characteristics:** The Nummulites burdigalensis burdigalensis Taxon Range Zone is characterized by occurrence of Nummulites burdigalensis burdigalensis along with appearance of the species of Fasciolites spp., Nummulites spp., Discocyclina spp., Assilina spp., Quinqueloculina sp., Nummulites fossulatus, and Discocyclina fortisi.

**Age:** The age of the Nummulites burdigalensis burdigalensis Taxon Range Zone is Early Eocene (Cuisian) (SBZ 10).

Nummulites burdigalensis cantabricus Taxon Range Zone

**Definition:** Total stratigraphic range of Nummulites burdigalensis cantabricus and is distributed between the sample numbers CSML 20 to CSML 22 (Fig. 2). The biozone is overlain by Nummulites burdigalensis burdigalensis Taxon Range Zone and overlain by Nummulites lehneri Taxon Range Zone.

**Characteristics:** The Nummulites burdigalensis cantabricus Taxon Range Zone is characterized by occurrence of Nummulites burdigalensis cantabricus along with appearance of the species of foraminifera Fasciolites spp., Nummulites spp., Discocyclina spp., Assilina spp., Quinqueloculina sp., Fasciolites bayburtensis and Discocyclina ephippium.

**Age:** The age of the Nummulites burdigalensis cantabricus Taxon Range Zone is Early Eocene (Cuisian) (SBZ 11).

Nummulites lehneri Taxon Range Zone

**Definition:** Total stratigraphic range of Nummulites lehneri and is distributed between the sample numbers CSML 23 to CSML 27 (Fig. 2) of middle part of the Prang Limestone Member. The biozone is overlain by Nummulites burdigalensis burdigalensis Taxon Range Zone and overlain by Nummulites gizehensis Taxon Range Zone.

**Characteristics:** The Nummulites lehneri Taxon Range Zone is characterized by appearance of Nummulites lehneri along with species of foraminifera Quinqueloculina sp., Fasciolites spp., Nummulites spp., Assilina spp., Fasciolites aff. palermiana, Assilina maxima, Assilina spira, Fasciolites azzaroli, Nummulites djodjokartae, Nummulites aff. elevata.
**Age**: The age of the *Nummulites lehneri* Taxon Range Zone is Early Eocene (Cuisian) - Middle Eocene (Lutetian) (SBZ 12 - SBZ 13).

**Nummulites gizehensis** Taxon Range Zone

**Definition**: Total stratigraphic range of *Nummulites gizehensis* and is represented in the upper part of the Prang Limestone Member which ranges between the sample numbers CSML 28 to CSML 30 (Fig. 2). The biozone is underlain by *Nummulites lehneri* Taxon Range Zone and is representing the uppermost part of the studied section.

**Characteristics**: The *Nummulites gizehensis* Taxon Range Zone is characterized by occurrence of *Nummulites gizehensis* in association with *Fasciolites* spp., *Nummulites* spp., *Assilina* spp., *Fasciolites* aff. palermiana, *Assilina maxima* and Juvenile *Nummulites* elevata.

**Age**: The age of the *Nummulites lehneri* Taxon Range Zone is Middle Eocene (Lutetian) (SBZ 14 - SBZ 16).

**CORRELATION OF BIOZONES WITH SBZ ZONAL SCHEME**

The established biozones in the present work can be closely correlated with the standard Shallow Benthic Zone (SBZ) of Serra-Kiel et al., 1998 (Fig. 2 and Table 2). The *Miscellanea miscella* Taxon Range Zone of Lakadong Limestone Member can be correlated with the SBZ 3 - SBZ 4 (Late Selandian - Thanetian) of Serra-Kiel et al., 1998; which is equivalent to P4a - P4c Zone of planktonic foraminifera of Berggren et al., 1995. The *Lockhartia conditi* Taxon Range Zone of lower part of Umlatdoh Limestone Member is comparable with SBZ 4 - SBZ 6 (Thanetian - Ilerdian) of Serra-Kiel et al., 1998; which is equivalent to P4c - P5 Zone of planktonic foraminifera of Berggren et al., 1995. The *Fasciolites aragonensis* Taxon Range Zone of upper part of Umlatdoh Limestone Member may be calibrated with SBZ 7 - SBZ 9 (Ilerdian) of Serra-Kiel et al., 1998; which is equivalent to P5 - P6b Zone of planktonic foraminifera of Berggren et al., 1995. Amongst the Taxon Range Zones of Prang Limestone Member the *Nummulites budrigalenis budrigalenis* Taxon Range Zone of the lower part of the lithounit is comparable with SBZ 10 (Cuisian) of Serra-Kiel et al., 1998; which is equivalent to P6b - P7 Zone of planktonic foraminifera of Berggren et al., 1995. The *Nummulites budrigalenis cantabricus* Taxon Range Zone is comparable with SBZ 11 (Cuisian) of Serra-Kiel et al., 1998; which is equivalent to P8 - P9 Zone of planktonic foraminifera of Berggren et al., 1995. The *Nummulites lehneri* Taxon Range Zone of middle part of the Prang Limestone Member is closely comparable with SBZ 12 - SBZ 13 of Serra-Kiel et al., 1998; which is equivalent to P9 - P10 Zone of planktonic foraminifera of Berggren et al., 1995 of Cuisian - Lutetian age. The youngest *Nummulites gizehensis* Taxon Range Zone of upper part of the Prang Limestone Member is well comparable with SBZ 14 - SBZ 16 of Serra-Kiel et al., 1998; which is equivalent to P11 - P12 Zone of planktonic foraminifera of Berggren et al., 1995.

**CONCLUDING REMARKS**

1. On the basis of the species association of foraminifera in Lakadong Limestone Member *Miscellanea miscella* Taxon Range Zone has been identified and is calibrated with SBZ 3 - SBZ 4 of Serra-Kiel et al., 1998; which is equivalent to P4a - P4c Zone of planktonic foraminifera of Berggren et al., 1995 of Late Selandian - Thanetian age.
2. In Umlatdoh Limestone Member of the studied section *Lockhartia conditi* Taxon Range Zone and *Fasciolites aragonensis* Taxon Range Zone have been established.
3. The *Lockhartia conditi* Taxon Range Zone of the lower part of the member is well comparable with SBZ 4 - SBZ 6 of Serra-Kiel et al.1998 and equivalent to P4c - P5 Zone of planktonic foraminifera of Berggren et al., 1995 of Thanetian - Ilerdian age. The uppermost part of the member is represented by the *Fasciolites aragonensis* Taxon Range Zone of SBZ 7 - SBZ 9 equivalent zone of Serra-Kiel et al., 1998; which is comparable to P5 - P6b Zone of planktonic foraminifera of Berggren et al., 1995 of Ilerdian age.
4. In Prang Limestone four Taxon Range Zones viz. *Nummulites budrigalenis budrigalenis* Taxon Range Zone, *Nummulites budrigalenis cantabricus* Taxon Range Zone, *Nummulites lehneri* Taxon Range Zone and *Nummulites gizehensis* Taxon Range Zones have been identified.
5. The oldest biozone of the Prang Limestone Member is represented by the *Nummulites budrigalenis budrigalenis* Taxon Range Zone which is comparable with SBZ 10 of Serra-Kiel et al.1998 and equivalent to P6b - P7 Zone of planktonic foraminifera of Berggren et al., 1995 of Cuisian age. The *Nummulites budrigalenis cantabricus* Taxon Range Zone is comparable with SBZ 11 (Cuisian) of Serra-Kiel et al., 1998; which is equivalent to P8 - P9 Zone of planktonic foraminifera of Berggren et al., 1995. The *Nummulites lehneri* Taxon Range Zone of middle part of the Prang Limestone Member is closely comparable with SBZ 12 - SBZ 13 of Serra-Kiel et al., 1998; which is equivalent to P9 - P10 Zone of planktonic foraminifera of Berggren et al., 1995 of Cuisian - Lutetian age. The youngest *Nummulites gizehensis* Taxon Range Zone of upper part of the Prang Limestone Member is well comparable with SBZ 14 - SBZ 16 of Serra-Kiel et al., 1998; which is equivalent to P11 - P12 Zone of planktonic foraminifera of Berggren et al., 1995 of Lutetian age.

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