4. SYSTEMATIC DESCRIPTION OF OTHER INVERTEBRATES.
4. SYSTEMATIC DESCRIPTION OF OTHER INVERTEBRATES

This chapter includes systematics of gastropods, scaphopods, echinoids and arthropods.

4.1 SYSTEMATIC DESCRIPTION OF GASTROPODS

The Summa sediments of Mizoram yielded large number of gastropods which are outnumbered by bivalves only. On the whole, preservation of gastropods is poor and, in majority of cases, only body whorls are found. These are grouped under 11 genera and 16 species, of which one is new. To describe them, the classification given by Davies (1971, pp. 280 - 444) has been followed. Measurements are given in millimetres.

<table>
<thead>
<tr>
<th>Class</th>
<th>GASTROPODA Cuvier, 1797</th>
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<tr>
<td>Subclass</td>
<td>PROSOBRANCHIA Milne Edwards, 1848</td>
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<tr>
<td>Order</td>
<td>MESOGASTROPODA Cox, 1959</td>
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<tr>
<td>Superfamily</td>
<td>CERITHIACEA Fleming, 1822</td>
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<tr>
<td>Family</td>
<td>TURRITELLIDAE Woodward, 1851</td>
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</table>
Subfamily - TURRITELLA INAE Woodward, 1851
Genus - Turritella Lamarck, 1799

Type species: Turbo terebra Linne', 1758; by monotypy. Recent; Western Pacific.

Turritella narica Vredenburg

1928. Turritella narica Vredenburg, p. 375, Pl. XVIII, figs. 13 - 17;
Pl. XIX, figs. 2 and 6.

Material: One broken specimen.

Horizon and Locality: Bed No. 6 (Upper Bhuban Formation);
Rothlang - Luangmual section.

Remarks: In the available specimen, the whorls are characterised by numerous, fine, equal to subequal spiral threads and in this respect, it approaches closely Turritella narica described and illustrated by Vredenburg (1928, loc. cit.). Its identity is further confirmed by direct comparison with G.S.I. type no. 13286.

This is the first report of the form from the Surma sediments of North Eastern region.

Turritella cf. pseudobandongensis Vredenburg

(Pl. XVII, fig. 1)

The reference for the typical form is:

1928. Turritella pseudobandongensis Vredenburg, p. 376, Pl. XIX, figs. 3 - 5, 7.

Material: One incomplete and poorly preserved conch.
Horizon and Locality: Bed No. 6 (Upper Bhuban Formation);
Pukpui - Saza section.

Dimensions: The specimen (PS/6/7) measures 29.00 in height and 15.00 in diameter of conch.

Remarks: Whorls of the specimen at hand are sculptured with numerous, fine, alternatingly unequal spiral threads. As compared to the G.S.I. type specimen no. 13301, described and figured by Vredenburg (1928, loc. cit.) as Turritella pseudobandongensis, it resembles very closely in shape and nature of ornamentation but with lesser number of threads in each whorl. Hence, it is referred here as Turritella cf. pseudobandongensis Vredenburg.

Subgenus - Torculoidella Sacco, 1895

Type species: Turbo varicosus Brochhi. Pliocene; Italy.

Turritella (Torculoidella) angulata J. de C. Sowerby
(Pl. XVII, figs. 2,3)

1840. Turritella angulata Sowerby, Pl. XXVI, fig. 7.
1840. Turritella angulata Sowerby, Pl. XXVI, fig. 8.
1853. Turritella acuticarinata Dunker, p. 132, Pl. XVIII, fig. 10.
1853. Turritella angulata Sowerby : d'Archiac and Haime, p. 294, Pl. XXVII, figs. 6 - 9.
1864. Turritella acuticarinata Dunker : Jenkins, p. 58, Pl. VII, fig. 1.
1864. Turritella acuticarinata Dunker : Jenkins, p. 58, Pl. VII, fig. 2.
1879. ? Turritella angulata Sowerby : Martin, p. 68, Pl. XII, fig. 2.
1879. Turritella duplicata Lamarck : Martin, p. 69, Pl. XI, fig. 13.
Material: One complete conch and two fragments.

Horizon and Locality: Bed Nos. 6 and 7 (Upper Bhuban Formation);
Rothlang - Luangmual section.

Dimensions: Specimen (RL/7/58) measures: Height - 30.00; Diameter of spire - 10.00; Height of body whorl - 10.00; Diameter of body whorl - 11.00.

Remarks: The complete specimen at hand has been compared with G.S.I. type no. 7682 referred as Turritella angulata Sowerby by Noetling (1901, loc. cit.) to which it is found to match well in respect of size and details of ornamentation. It also tallies well with other specimens cf this
form, i.e., (G.S.I. type no. 17433) recorded by Cox (1936 loc. cit.) and no. K-22/756 by Mukerjee (1939, loc. cit.). Hence, its identity as Turritella (Torculoidella) angulata Sowerby is well established. The specimen nos. RL/6/47 and 49, although fragments, are also assigned to this form as they possess all the essential characters of the same.

Family - ARCHITECTONICIDAE Gray, 1850
Genus - Architectonica Roeding, 1798.

Type species: Trochus perspectivus Linne; SD Gray, 1847. Recent; Indo - Pacific.

Architectonica buddha (Noetling)


Material: Two conchs of which one is partially covered by matrix.

Horizon and Locality: Bed No. 8 (Upper Bhuban Formation):
Kulikawn - Hlimen section.

Dimensions: Better preserved specimen (KH/8/33) measures as follows: Height of conch - 5.00; Height of body whorl - 2.00; Height of spire - 3.00; Diameter of body whorl - 6.00.

Remarks: The Hlimen specimens match so well with the type material housed in G.S.I. (nos. 4225 and 7664) that there is no need to qualify their identity.

This is the first record of the present form from the area under study.
Superfamily - SCALACEA
Family - SCALIDAE
Subfamily - SCALINAE
Genus Scala

Scala cf. irregularis (Noetling)

1898. Scalaria irregularis Noetling, p. 19, Pl. V, figs. 1, 2 and 2a.


Material: One broken specimen, only three whorls (LT/5/11).

Horizon and Locality: Bed No. 5 (Upper Bhuban Formation):
Serthum – Theiriat section.

Remarks: Main characters of the species are: convex whorl surfaces, channelled sutures and spire with low axial ribs separated by broad inter-spaces and closely spaced fine spiral threads. The first two characters are well marked in the present specimen while the last one is not clearly discernible due to eroded nature of surface. Therefore, it is referred as Scala cf. irregularis (Noetling).

Superfamily - STROMBACEA
Family - XENOPHORIDAE Philippi, 1853
Genus - Xenophora Fisher de Waldheim

Type species: Trochus conchyliophorus Born; SD Gray, 1847.

Xenophora birmanica Noetling

(Pl. XVII, fig. 5)

1901. Xenophora birmanica Noetling, p. 280, Pl. XVIII, fig. 21.
Material: One incomplete specimen (RL/6/50).

Horizon and Locality: Bed No. 6 (Upper Bhuban Formation):
Rothlang - Luangmual section.

Dimensions: Only the Diameter of the specimen could be made out
i.e., 25.00 mm.

Remarks: The conch in question has been compared with G.S.I. type
material no. 7690, holotype of *Xenophora bimanica* Noetling (190, loc.
cit.) to which it tallies in all respect except for its small size. Myanmar
material is also coming from Miocene beds, hence, there is no hesitation in
its specific identification.

This is reported for the first time from the Sumna sediments of
Northeastern region.

Superfamily        - NATICACEA Gray, 1847
Family             - NATICIDAE Forbes, 1848
Subfamily          - NATICINAE Forbes, 1848
Genus             - *Natica* Scopoli, 1777

Type species: *Nerita vitellus* Linne, 1758; SD Harris, 1897. Living;
Indo - Pacific.

*Natica coxi* Mukerjee


Material: One conch partly embedded in matrix.

Horizon and Locality: Bed No. 6 (Upper Bhuban Formation):
Pukpui - Saza section.

Dimensions: Specimen (PS/6/5) measures: Height of body whorl -
17.00; Diameter of body whorl - 9.00 mm.

Remarks: The present specimen, although, small in size and partially hidden under the matrix, tallies well with G.S.I. specimen no. K-22/775 in the nature of spire, depressed sutures and flattening of whorls at adapical margin. Therefore, its reference to Natica coxi Mukerjee (1901, loc. cit.) is justified.

This form was not known to occur in the present areas prior to this report.

Subfamily - AMPULLOSPIRINAE
Genus - Globularia Swainson, 1840

Type species: Globularia sigretina (Deshayes). Middle Eocene Paris basin.

Globularia callosa (Sowerby)

1840. Natica callosa Sowerby, Pl. XXVI, fig. 3.
1898. Natica callosa Sowerby : Noetling, p. 23, Pl. V, fig. 8; also 1901, p. 283, Pl. XVIII, figs. 1, a-d.
1988. Ampulina (Cernina) callosa (Sowerby) : Mathur, p. 46.

Material: Two body whorls.

Horizon and Locality: Bed No. 8 (Upper Bhuban Formation):

Kulikawn - Hlimen section.
Remarks: These two body whorls exhibit same size, shape and sculpture to that of the type specimen (G.S.I. no. 7693) referred as Natica callosa Sowerby (1901, loc. cit.). Thus, their assignment to this form is beyond doubt.

Earlier, this form was not known from present areas.

Subfamily - SININAE Woodring, 1928
Genus - Sinum "Bolten" Roeding, 1798:
   = Sigretus Lamarck.

Type species: Helix haliotoidea Linne; SD Dall.

Sinum protoneritoideum (Vredenburg)

1928. Sigretus protoneritoideum Vredenburg, p. 399, Pl. XX, figs. 8 - 9.
1939. Sinum protoneritoideum (Vredenburg) : Mukerjee, p. 43.

Material: One conch with slightly broken spire and body whorl.

Horizon and Locality: Bed No. 6 (Upper Bhuban Formation):
   Pukpui - Saza section.

Dimensions: Specimen (PS/6/6a) measures: Height of the body whorl - 7.00 (c); Diameter of body whorl - 6.00 (c).

Remarks: Recorded fragmentary specimen agrees well with the G.S.I. no. 13328 of Sinum protoneritoideum (Vredenburg) in all visible details, thus the identification. As compared to the living species Sinum neritoideum (Linne) reported by Noetling (1901, p. 286, Pl. XIX, figs. 6-7), it is smaller in size and has less rounded aperture.
Superfamily - TONNACEA Suter, 1913
Family - CYMATILIDAE
Genus - Nassaria Link

Type species: Buccinum niveum Gmelin; OD. Recent; Indian Ocean.

Nassaria birmanica (Vredenburg)

(Pl. XVII, fig. 6)

1898. Triton davidsoni d Arichi and Haime: Noetling, p. 29, Pl. VI, fig. 6.
1901. Cancellaria davidsoni d Arichi and Haime: Noetling, p. 33, Pl. XIX, figs. 23, a - b.
1921. Hindsia birmanica Vredenburg, p. 279.
1939. Nassaria birmanica (Vredenburg): Mukerjee, p. 58

Material: One conch.

Horizon and Locality: Bed No. 6 (Upper Bhuban Formation);
Rothlang - Luangmual section.

Dimensions: The conch (no. RL/6/45) measures as: Height of conch - 16.60; Height of body whorl - 11.00; Diameter of body whorl - 10.00 mm.

Remarks: Only available conch is well preserved and reveals typical sculpture of the species, i.e., strong, rounded and equidistant axial ribs crossed over by fine spiral threads. Moreover, its comparison with the material lying in G.S.I. and cited in the synonymy leaves no doubt in its specific identity as Nassaria birmanica (Vredenburg).
Family  -  FICIDAE
Genus  -  Ficus (Bolten, MS) Roeding.

Type species:  Bulla ficus Gmelin; SD Dall, 1906. Recent: Indo-Pacific.

Subgenus  -  Ficus s. str.

Ficus (Ficus) conditus (Brongniart)

(Pl. XVII, figs. 7,8)

1823.  Pyrula condita Brongniart, p. 25, Pl. VI, fig. 4.

1853.  Ficula condita Brongniart : Hoernes, p. 270, Pl. XXVIII, figs. 4 - 6.

1891.  Ficula condita Brongniart : Sacco, p. 23, Pl. 1, figs. 27 - 32.

1898.  Ficula theobaldi Noetling, p. 28, Pl. VI, fig. 5; also 1901, p. 298, Pl. XIX, fig. 21.

1923.  Pyrula condita Brongniart : Cossmann and Peyrot, p. 33, Pl. X, fig. 46.


1939.  Ficus conditus (Brongniart) : Mukerjee, p. 52, Pl. III, fig. 3.

1957.  Pyrula condita Brongniart : Glibert, p. 81, Pl. IV, fig. 6.


1972.  Ficus (Ficus) conditus (Brongniart) : Antunes et al., p. 489, Pl. III, fig. 31.

Material: Four fairly well preserved conchs but apertures are covered with hard matrix.

Horizons and Localities:

Bed No. 8 (Upper Bhuban Formation):

Kulikawn - Hlimen section.
Bed Nos. 6 and 7 (Upper Bhuban Formation):
   Rothlang - Luangmual section.

Bed No. 6 (Upper Bhuban Formation):
   Pukpui - Saza section.

**Dimensions:**

<table>
<thead>
<tr>
<th>Sp. No.</th>
<th>Height (body whorl)</th>
<th>Diameter (body whorl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KH/8/27</td>
<td>27.20</td>
<td>18.10</td>
</tr>
<tr>
<td>RL/7/59</td>
<td>28.00</td>
<td>18.70</td>
</tr>
<tr>
<td>RL/6/44</td>
<td>24.80</td>
<td>17.40</td>
</tr>
<tr>
<td>PS/6/4a</td>
<td>14.00</td>
<td>8.50</td>
</tr>
</tbody>
</table>

**Remarks:** General proportion, low spire, cancellate ornamentation and pyriform nature of conchs at once remind the form *Ficus conditus* (Brongniart). Identification is further confirmed by direct comparison with the Garo Hills material lying in G.S.I. (no. K-22/944), recorded by Mukerjee (1939, loc. cit.), to which these tally well.

Specimen no. RL/7/55 and 56 are also tentatively assigned to this form on account of their resemblance to it.

* *Ficus* (Ficus) *ganeshani* \* n. sp.

(Pl. XVII, fig. 4)

**Material:** One specimen.

**Horizon and Locality:** Bed No. 7 (Upper Bhuban Formation):
   Rothlang - Luangmual section.

*The species is named after Shri R. Ganeshan, Department of Geology and Mining, Directorate of Industries, Aizawl, Mizoram.*
Dimensions: Holotype (RL/7/60) measures as: Length of body whorl - 35.00; Diameter of body whorl - 14.00.

Description: The conch is pyriform with much elongated body whorl. Surface of body whorl is covered with 37 - 38 coarse, equidistant and flat spiral threads which are crossed over by very fine, equally spaced, axial striae producing reticulate pattern. All the intersections are nodose. The interspaces of spiral threads in the upper one-third of the body whorl has three secondary threads followed by one in the next one-third and succeeded by none in the rest.

Aperture could not be studied as it is covered with matrix.

Remarks: Much elongated body whorl and nature of ornamentation are sufficient to distinguish it from all other known species. A comparison is, however, made with the following:

Ficus conditus (Brongniart) Mukerjee (1939, loc. cit.) and the Japanese Palaeogene form Ficus takahasii Tam, described and figured by Kanno and Chung (1975, p. 382, Pl. II, figs. 15 - 16), approach the present form in overall configuration but differ in the nature of ornamentation. On the other hand, Ficus pellucidus Deshayes (1854, p. 184, Pl. 6, figs. 1 - 2) has uniform spiral threads throughout the body whorl whereas Ficus filosa (Tomida, 1989, p. 99, Pl. XIII, figs. 7, a - b) has altogether different configuration and ornamentation.

Superfamily - MURICACEA
Family - MURICIDAE
Subfamily - MURICINAE
Genus - Murex Linne', 1758
Type species: *Murex tribulus* Linne; SD Montfort, 1810. Recent: Indo-Pacific.

*Murex maegillivrayi* Dohrn

(Pl. XVII, fig. 9)


Material: One conch.

Horizon and Locality: Bed No. 6 (Upper Bhuban Formation):

Rothlang - Luangmual section.

Dimensions: The conch (RL/6/46) measures - Height of conch - 30.00;

Diameter of conch - 10.70; Height of canal - 14.00;

Diameter of canal - 4.25 mm.

Remarks: Present specimen tallies well with the descriptions and figures given by the workers cited in the synonymy. Also, it has been compared with the actual specimen lying in G.S.I. (no. K-24/238) from Quilon beds (Dey, 1962, loc. cit.). To this, it shows good resemblance except that its canal is little longer and spines are blunt. However, these minor differences do not warrant specific separation and are well within the limit of variation. Therefore, its identity as *Murex maegillivrayi* Dohrn is quite reasonable.

This is first report of the form from the present areas.

Superfamily - VOLUTACEA d'orbigny, 1842
Family - MITRIDAE d'orbigny, 1842
Subfamily - CYLINDROMITRINAE
Genus - *Volvaria* Lamarck (= *Volvarius* Montfort).
Type species: *Volvaria bulloides* Lamarck; SD Children, 1923

*Volvaria bimanica* Noetling

(Pl. XVII, fig. 10)

1898. *Volvaria bimanica* Noetling, p. 37, Pl. VIII, figs. 7, 7c.

1901. *Volvaria bimanica* Noetling, p. 322, Pl. XXI, fig. 11.

**Material:** Single specimen.

**Horizon and Locality:** Bed No. 7 (Upper Bhuban Formation);
   Rothlang – Luangmual section.

**Dimensions:** The lone specimen (RL/7/57) measures: Height - 13.50;
   Diameter - 6.50 mm.

**Remarks:** Recorded specimen reveals close resemblance in size, shape
and nature of ornamentation with the holotype (G.S.I. no. 4267) described
and figured as *Volvaria bimanica* Noetling (1898, loc. cit.) from Myanmar,
except for the little wider aperture which is hardly of any significance.
Hence, its identity is unquestionable.

This is the first ever record of the species from Surma sediments of
Northeastern region.

Superfamily   - CONACEA Rafinesque, 1815
Family        - COXIDAE Rafinesque, 1815
Genus         - Conus Linne', 1758

**Type species:** *Conus ramoreus* Linne'; SD Children 1823. Recent:
   Indo – pacific.

Subgenus      - Lithoconus Moerch, 1852

**Type species:** *Conus (Lithoconus) millipuncatus* Lamarck, 1822;
SD Cossmann, 1896. Recent; Indo - Pacific.

Conus (Lithoconus) ineditus Michelotti

(Pl. XVII, fig. 11)


1898. Conus (Rhizoconus) mallaconus Hwass : Noetling, p. 42, Pl. IV, figs. 4 - 7; also 1901, p. 362, Pl. XXIII, figs. 17 - 20.


1939. Conus (Lithoconus) ineditus Michelotti : Mukerjee, p. 84.

Material: Two conchs.

Horizons and Localities:

Bed No. 6 (Upper Bhuban Formation);
Rothlang - Luangmual section.

Bed No. 8 (Upper Bhuban Formation);
Haurang - Pachang section.

Dimensions:

<table>
<thead>
<tr>
<th>Sp. No.</th>
<th>Height of conch</th>
<th>Diameter of conch</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPQ/8/36</td>
<td>14.40</td>
<td>7.00</td>
</tr>
<tr>
<td>RL/6/42</td>
<td>27.20</td>
<td>12.70</td>
</tr>
</tbody>
</table>

Remarks: Owing to the features like short spire, almost smooth body whorl and few spiral threads near the lower end of the same, these two conchs are assigned to the species Conus (Lithoconus) ineditus Michelotti.
Moreover, these are found to match well with the Sind specimen lodged in G.S.I. (no. 12520), described and figured by Vredenburg (1928, loc. cit.). Thus, the identification is confirmed.

Subgenus — Leptoconus Swainson, 1840

Type species: Conus amadis Martini; SD Hermannsen, 1847. Recent: Indo - Pacific.

Conus (Leptoconus) bonneti Cossmann

(Pl. XVII, fig. 12)

1900. Conus (Leptoconus) bonneti Cossmann, p. 59, Pl. IV, figs. 15 - 16.


1921. Conus (Leptoconus) hanza (Noetling) : Vredenburg, p. 279.


Material: One specimen.

Horizon and Locality: Bed No. 6 (Upper Bhuban Formation);
Rothlang - Luangmual section.

Dimensions: Specimen (no. RL/6/43) measures: Height of spire - 8.00;
Height of body whorl - 28.00; Diameter of spire - 11.00
and Diameter of body whorl - 13.00 mm.

Remarks: The present specimen shows all the essential characters of
Conus (Leptoconus) bonneti Cossmann and agrees well with the example
(G.S.I. type no. 7758) of Conus hanza Noetling (1901, loc. cit.) which is
now a synonym of the present form. Thus, its reference to the above species
is quite justified.
4.2 SYSTEMATIC DESCRIPTION OF SCAPHOPODS

In all, two representatives constitute this class which are grouped under the genus Dentalium with two forms. These are being reported for the first time from the Upper Bhuban Formation of Surma Group in Mizoram, though, already known from the Myanmar.

The dimensions are given in millimeters.

<table>
<thead>
<tr>
<th>Class</th>
<th>SCAPHOPODA Bronn. 1862</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order</td>
<td>DENTALIODA Palmer, 1974</td>
</tr>
<tr>
<td>Family</td>
<td>DENTALIIDAE Gray, 1834</td>
</tr>
<tr>
<td>Genus</td>
<td>Dentalium Linne, 1758</td>
</tr>
</tbody>
</table>

Type species: Dentalium elephantinum Linne, 1758; SD Montfort, 1810. Recent; Philippines Islands.

Dentalium boettgeri Noetling

(Pl. XVIII, fig. 1)

1901. Dentalium boettgeri Noetling, p. 251, Pl. XVII, figs. 4, a-b.

Material: One broken specimen.

Horizon and Locality: Bed no. 8 (Upper Bhuban Formation);
Kulikawn - Hlimen section.

Dimensions: Specimen (no. KH/8/26) measures: Length - 28.00 (c);
Diameter - 4.30 near anterior end.

Remarks: In spite of slightly broken condition, it could be identified with full satisfaction as Dentalium boettgeri Noetling (1901, loc. cit.; G.S.I. type no. 7655) owing to its small size and possession of eight longitudinal primary ribs with interstices carrying a secondary.

In addition to the Myanmar, this report from Northeastern region of
India may be noted with interest.

_Dentalium junghuhni_ Martin, 1879

(Pl. XVIII, fig. 2)

1879-80. _Dentalium junghuhni_ Martin, p. 87, Pl. XII, fig. 11.

1882. _Dentalium junghuhni_ Martin: Boettger, p. 141, Pl. XII, figs. 6, a-d and 8.


1901. _Dentalium junghuhni_ Martin: Noetling, p. 250, Pl. XVII, figs. 1, a-b, 2 and 3, a-b.

1939. _Dentalium junghuhni_ Martin: Mukerjee, p. 2.

_Material_: A fragmentary specimen.

_Horizon and Locality_: Bed no. 8 (Upper Bhuban Formation):

Kulikawn - Hlimen section.

_Dimensions_: Specimen (no. KH/8/23) measures: Length - more than 55.00; Diameter - 5.90 near the anterior end.

_Remarks_: The specimen under study is externally covered with numerous fine and raised longitudinal ribs crossed over by flat, widely spaced and equidistant concentrics. These characters lead to its identification as _Dentalium junghuhni_ Martin. Moreover, a specimen from Myanmar (Noetling, 1901, loc. cit.; G.S.I. collection no. 7657) was available to the author for direct comparison, to which it shows close resemblance. This further confirms the identity.
4.3 SYSTEMATIC DESCRIPTION OF ECHINOIDEA

Echinoids are relatively better preserved in the Surma Group of Mizoram than the other fossil groups therein. These occur in almost all fossiliferous horizons of the Upper Bhuban Formation, though less in number. Echinoids are represented by two genera, namely, Cidaris and Schizaster with one and four forms respectively. The species reported here are also known from the Tertiaries of Kachchh, Kathiawar and Sind (Pakistan).

All the measurements are in millimetres and the recorded specimens are lodged in the museum of Geology Department, Pachhunga University College, North-Eastern Hill University, Aizawl, Mizoram.

Class - ECHINOIDEA Leske, 1778
Subclass - PERISCHOECHINOIDEA M'Coy, 1849
Order - CIDAROIDA Claus, 1880
Family - CIDARIDAE Gray, 1825
Subfamily - CIDARINAE Gray, 1825
Genus - Cidaris Leske, 1778

Type species: Echinus cidaris Linne', 1758. Recent: Indian Ocean.

Cidaris granulata Duncan and Sladen

1883. Cidaris granulata Duncan and Sladen, p. 80, Pl. XIII, figs. 4 - 6.
1884. Cidaris granulata Duncan and Sladen; Fedden, p. 49.

Material: One test.

Horizon and Locality: Bed No. 9 (Upper Bhuban Formation):
Kulikawn - Hlimen section.

**Dimensions:** The specimen (no. KH/9/1) measures: Length - 20.00; Width - 18.00; Thickness - 15.00.

**Remarks:** On direct comparison, no discernible difference is noticed between the present specimen and the one from Kathiawar lodged in G.S.I. (no. 2879), illustrated and recorded by Duncan and Sladen (1883, *loc. cit.*) as *Cidaris granulata*. Hence, its identity.

Order: **SPATANGOIDA** Claus, 1876  
Suborder: **HEMIASTERINA** Fischer, 1966  
Family: **SCHIZASTERIDAE** Lambert, 1905  
Genus: **Schizaster** Agassiz, 1836

**Schizaster alveolatus** Duncan and Sladen  
(Pl. XVIII, fig. 6)

1882-86. **Schizaster alveolatus** Duncan and Sladen, p. 87, Pl. XX, figs. 10-14.  
1970 **Schizaster alveolatus** Duncan and Sladen: Sastri and Sinha, p. 62.  

**Material:** One specimen.

**Horizon and Locality:** Bed No. 3 (Upper Bhuban Formation); Chhekpuikawl - Vanhe section.

**Dimensions:** The specimen (no. GV/3/8) measures: Length - 33.00; Width - 13.00; Thickness - 20.00.

**Remarks:** The specimen is slightly deformed but cordiform and inflated nature of test, excentric and posteriorly shifted oculo-genital
system, petaloid ambulacra sunken in large groove, equal, oblong and conjugate pores in anterior ambulacra and its close matching with the type (G.S.I. no. 2585) leave no doubt about its assignment to *Schizaster alveolatus* Duncan and Sladen (1882 - 86, loc. cit.).

**Schizaster baluchistanensis** d'Archiac and Haime

(Pl. XVIII, fig. 3)

1853. *Schizaster baluchistanensis* d'Archiac and Haime, p. 221, Pl. XV, figs. 9, a-b.

1874. *Schizaster baluchistanensis* d'Archiac and Haime: Ball, p. 152.


1879. *Schizaster baluchistanensis* d'Archiac and Haime: Blanford, p. 52.

1882-86. *Schizaster baluchistanensis* d'Archiac and Haime: Duncan and Sladen, p. 224.

1883. *Schizaster baluchistanensis* d'Archiac and Haime: Duncan, Sladen and Blanford, p. 38, Pl. V, figs. 5-8.


**Material:** One test.

**Horizon and Locality:** Bed No. 8 (Upper Bhuban Formation):

Haurang - Pachang section.
Dimensions: Specimen (no. HPQ/8/38) measures: Length - 82.00;
Width - 44.00; Thickness - 18.00.

Remarks: Characters, like much elongated outline, subcentral
oculo-genital system, comparatively long anterior ambulacra in a wide and
deep groove, short and divergent antero-lateral ambulacra which are
pointed at the ends, merge it with Schizaster baluchistanensis d'Archiac
and Haime, described and figured by Duncan, Sladen and Blanford (1883,
loc. cit.).

In outline and disposition, it is similar to Schizaster
subcylindricus Cotteau, illustrated and recorded by Kier, 1984, p. 56,
Pl. XXVII, figs. 1 - 7; Pl. XXVIII, figs. 1 - 2) from Miocene of Cuba but
the later can be differentiated by its highly flared up antero-lateral
ambulacra which are shallow and have rounded tips.

Schizaster granti Duncan and Sladen
(Pl. XVIII, fig. 5)

1882-86. Schizaster granti Duncan and Sladen, p. 268, Pl. XLII, figs. 4 -
6; p. 339.

1883. Schizaster granti Duncan and Sladen : Duncan, Sladen and
Blanford, p. 70, Pl.VI, figs. 8-12; p. 88.

1884. Schizaster granti Duncan and Sladen : Fedden, p. 49.

10.


Material: Two specimens.

Horizon and Locality: Bed No. 6 (Upper Bhuban Formation);
Rothlang - Luangmual section.

Dimensions:

<table>
<thead>
<tr>
<th>Sp. No.</th>
<th>Length</th>
<th>Width</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>RL/6/51</td>
<td>18.00</td>
<td>17.00</td>
<td>16.00</td>
</tr>
<tr>
<td>RL/6/52</td>
<td>18.00</td>
<td>15.00</td>
<td>12.00</td>
</tr>
</tbody>
</table>

Remarks: Schizaster granti Duncan and Sladen is widely distributed in the Tertiary of North-Western India. It is reported from Nari (Oligocene) and Gaj beds of Sind (Duncan and Sladen, 1882-86, loc. cit.), from Kachchh and Kathiawar (Duncan, Sladen and Blanford, 1883, loc. cit.).

This form is characterised by broad and deep anterior groove, outwardly flared up and pointed antero-lateral ambulacra accommodated in deep grooves and stout postero-lateral ambulacra with sharp tips. All these are well marked in the present specimens. Further, direct comparison with the G.S.I. types (nos. 2709, 2836) under the name Schizaster granti Duncan and Sladen (1883, p. 88) reveals close similarity. Thus, the identification is beyond doubt.

Schizaster aff. symmetricus Duncan and Sladen

(Pl. XVIII, fig. 4)

Reference to the typical form is:


Material: One test.

Horizon and Locality: Bed No. 3 (Upper Bhuban Formation):
Chhekpuikawl - Vanhe section.

Dimensions: Specimen (no. CV/3/6) measures: Length - 37.00 (c):
Width - 32.00; Thickness - 15.00.

Remarks: The specimen at hand has been compared with Schizaster symmetricus Duncan and Sladen (1882-86, loc. cit.) bearing G.S.I. no. 2683 from Kirthar Group of Sind, to which it is identical in deeply excavated ambulacra, arrangement of pores and in shape. However, the oculo-genital system is shifted little more posteriorly and antero-lateral petals are more divergent. Therefore, it is referred as Schizaster aff. symmetricus Duncan and Sladen.

It also approaches Schizaster persica Clegg (1933, p. 13, Pl. I, figs. 6 and 7; G.S.I. no. 15562) from Persian Gulf in shape and nature of interambulacral areas but diverses in its relatively low posterior. On the other hand, Cuban Miocene form Schizaster Sanchez Roig (Kier, 1984, p. 55, Pl. XXVI, figs. 1 - 5) shows resemblance to the present one in overall configuration but certainly a different form because of its relatively shallow posterior ambulacra.

4.4. SYSTEMATIC DESCRIPTION OF ARTHROPODS

Arthropods in the present collection comprise cirripedians and decapods.

4.4.1 Cirripedians

Collection includes poorly preserved and crumpled isolated plates of balanoid barnacles. These may be grouped with Archeo-balanoids.
Further identification is not possible.

4.4.2 Decapods

Fossil record of decapods from Surma Group sediments of Mizoram is extremely poor. Until recently, only one individual, viz., *Portunus* sp. was known (Tiwari and Satsangi, 1988) from Upper Bhuban Formation. Subsequent collection by Satsangi and Patil (1988) includes a chela of *Callianassa* and other unspecified xanthoid crabs but their details are not worked out.

These occur as isolated fragments, complete specimens with appendages are yet to be recorded. Five genera and six species, viz., *Calappa protopustulosa* Noetling; *Typilobus granulosus* Stoliczka; *Ebalia tuberculata* Noetling, *Ebalia spinosa* n.sp.; *Xantho* sp. and *Portunus* (sp. 1 and 2) have been recognised in the present collection and described below. Except *Portunus* sp., remaining forms are going to be reported for the first time from the present areas.

Order - DECAPODA Latreille, 1803
Suborder - PLEOCYEMATA Burkenroad, 1963
Infraorder - BRACHYURA Latreille, 1803
Superfamily - CALAPPOIDEA de Haan, 1833
Family - CALAPPIDAE de Haan, 1833
Subfamily - CALAPPINAE de Haan, 1833
Genus - Calappa Weber, 1795

Type species: *Cancer granulatus* Linne, 1758; SD Latreille, 1810. Miocene; Hungary.
Calappa protopustulosa Noetling

(Pl. XIX, fig. 1)

1901. Calappa protopustulosa Noetling, p. 369, Pl. XXIV, figs. 6,a-b.

Material: A partially preserved carapace.

Horizon and Locality: Bed No. 6 (Upper Bhuban Formation);
                    Pukpui - Saza section.

Dimensions: Length and width of carapace (Specimen no. PS/6/14) are 13.00 and 21.00 mm respectively.

Remarks: In the available carapace, nearly half of the anterior portion is missing. It agrees well with the description of Calappa protopustulosa Noetling (1901, loc. cit.) from ?Miocene of Thayetmyo, Myanmar and also tallies well with G.S.I. type (no. 7768). Therefore, its reference is justified. However, due to post-depositional deformation, it has excessive width.

Family - LEUCOSIIDAE Samouelle, 1891
Genus - Ebalia Leach, 1817

Type species: Cancer tuberosus Pennant, 1777; SD Rothbun, 1922. Recent.

Ebalia tuberculata Noetling

(Pl. XIX, fig. 2)

1901. Ebalia tuberculata Noetling, p. 370, Pl. XXIV, figs. 7, 7a.

Material: A small carapace.

Horizon and Locality: Bed No. 7 (Upper Bhuban Formation);
                     Rothlang - Luangmual section.
Dimensions: The carapace (Specimen no. RL/7/65) measures:
Length - 10.00; Width - 14.00 mm.

Remarks: The present specimen, though of small size, agrees well with *Ebalia tuberculata* Noetling (1901, loc. cit.: G.S.I. type no. 7769) from ?Miocene of Thayetmyo, Myanmar, in overall configuration, surface sculpture and in the characters of gastric and cardiac regions. Hence, its identity is unquestionable.

*Ebalia spinosa* n.sp.

(Pl. XIX, fig. 3)

Material: A complete carapace.

Horizon and Locality: Bed No. 7 (Upper Bhuban Formation):
Rothlang - Luangmual section.

Dimensions: The carapace of the holotype (Specimen no. RL/7/66) measures: Length - 9.00; Width - 11.00 mm.

Description: Carapace ovate, width slightly more than the length, strongly convex longitudinally and moderately so transversely; upper surface of the carapace finely nodose and covered with small isolated tubercles. Frontal region narrow, almost straight and about one-third of the width of the carapace; orbits small, deep and closely spaced. Antero-lateral border semi-circular, dentate with four spines, and relatively longer than the distance between outer angles of the orbits; postero-lateral border with four prominent, well spaced spines.

*The specific name is derived from the spinose nature of its antero- and postero-lateral borders.*
and converge towards posterior margin making an obtuse angle.

Gastric and cardiac regions are well marked by deep and long furrow on either side, and separated from each other by a transverse furrow; both metagastric and strongly convex cardiac regions bear a prominent tubercle.

Remarks: The specimen is characterised by four prominent well separated spines on antero- and postero-lateral borders and relatively dense tuberculate sculpture on upper surface of the carapace. It differs from the only known fossil species of *Ebalia* from the Indian subcontinent, i.e. *Ebalia tuberculata* Noetling (1901, loc. cit.; G.S.I. type no. 7769) from Myanmar in which the antero- and postero-lateral borders bear few weakly developed spines and upper surface of the carapace is less tuberculate.

Genus - *Typilobus* Stoliczka, 1871

Type species: *Typilobus granulosus*; OD. Upper Eocene; Hungary.

*Typilobus granulosus* Stoliczka

(Pl. XIX, fig. 5)

1871. *Typilobus granulosus* Stoliczka, p. 15, Pl. III, figs. 3 - 5.

Material: Single carapace.

Horizon and Locality: Bed No. 6 (Upper Bhuban Formation):

Pukpui - Saza section.

Dimensions: The carapace (Specimen no. PS/6/15) measures:

Length - 8.00; Width - 10.00 mm.

Remarks: The specimen is small and well preserved, however,
frontal region and part of middle portion are weathered out. It agrees well with *Typilobus granulosus* described and figured by Stoliczka (1871, loc. cit.; G.S.I. type no. 2280) from Sind and Sahind Hill, Kachchh, in size and characters of lobes but in the former, the surface is more granulose. Sastri and Mathur (1970) have listed *Typilobus* sp. also from Miocene of Hathab, Bhavnagar, Gujarat, but without any description and figure.

<table>
<thead>
<tr>
<th>Superfamily</th>
<th>PORTUNOIDEA Rafinesque, 1815</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family</td>
<td>PORTUNIDAE Rafinesque, 1815</td>
</tr>
<tr>
<td>Subfamily</td>
<td>PORTUNINAE Rafinesque, 1815</td>
</tr>
<tr>
<td>Genus</td>
<td>Portunus Weber, 1795</td>
</tr>
</tbody>
</table>

Type species: *Cancer pelagicus* Linne, 1758; SD Rothbun, 1926. Recent; South Australia.

**Portunus** sp. 1

(Pl. XIX, fig. 4)

Material: A well preserved carapace.

Horizon and Locality: Bed No. 3 (Upper Bhuban Formation); Chhekuikaw - Vanhe section.

Dimensions: Carapace (CV/3/9) measures: Length - 19.00; Width - 40.00 mm.

Description: Carapace is transversly-ovate and surface covered with fine granules. Orbito-frontal margin slightly rounded with four small depressed spines which occupy about two-fifth of carapace width; orbits large, ovate and directed forwardly. Antero-lateral border almost semi-circular, lined with seven even-sized spines which begin from the orbit.
and end at the antero-lateral angle where a prominent lateral spine is present; postero-lateral border slightly concave, sinuous and converges rapidly to join straight posterior margin which is as wide as the orbito-frontal border. Epibranchial ridge feeble near lateral spine and becomes prominent anterior to meso-branchial lobe around which it takes a broad turn terminating near the groove posterior to gastric lobe; cervical groove shallow forming a U-shaped curve while crossing the mid-line between gastric and cardiac lobes.

The regions are well defined. Meso- and meta gastric lobes confluent and form a median shield like elevated platform with a thin ridge at the posterior margin; proto-gastric lobes large and ovate with a transverse ridge across the middle of the lobes. Cardiac region tumid, elongated and pentagonal with a median furrow separating two ovate cardiac lobes. The meso-branchial lobe prominently developed marking the highest elevation on the carapace.

Remarks: The specimen shows close similarity to the Portunus (Neptunus) arabicus (referred as Charybdis by Glaessner, 1933), described and figured by Woodward (1905, p. 307, fig. 1) from Mekran Coast, Baluchistan, with respect to the rounded frontal margin and details of the regions of carapace. However, the former differs from the latter in the nature and serrations of the margins. Also, appendeges are not available for comparison. Therefore, it is simply referred as Portunus sp.

Portunus sp. 2
(Pl. XIX, fig. 6)

Material: A ventral part of a cephalothorax.
Horizon and Locality:  Bed No. 7 (Upper Bhuban Formation):
Rothlang - Luangmual section.

Dimensions:

<table>
<thead>
<tr>
<th>Sp. No.</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>RL/7/69</td>
<td>Cephalothorax 12.00 mm</td>
<td>13.50 mm</td>
</tr>
<tr>
<td></td>
<td>Abdomen 9.00 mm</td>
<td>3.50 mm</td>
</tr>
</tbody>
</table>

Description: The specimen is of the ventral part of cephalothorax showing well preserved sternum and abdomen. The sternum is broader than long and its anterior margin is semi-circular. Out of eight thoracic sternites, first to third are fused and the fourth to eighth are separated by deep grooves. The eighth sternite is the smallest one and from seventh to fourth, the size increases gradually. Fourth one is the largest and almost squarish in shape. Sternites from fifth to eighth are almost semi-circular with their narrower end towards the abdomen which is triangular in outline.

Remarks: Nature and disposition of sternites and abdomen suggest that the species belongs to a male portunid crab. In the absence of other details, it is not possible to comment much.

Superfamily - XANTHOIDEA Dana, 1851
Family - XANTHIDAE Dana, 1851
Genus - Xantho Leach, 1804

Type species: Cancer incisus; OD. Recent.

Xantho sp.
(Pl. XIX, figs. 7,8)

Material: Two complete carapace.

Horizon and Locality:  Bed No. 7 (Upper Bhuban Formation):
Rothlang - Luangmual section.
**Dimensions:**

<table>
<thead>
<tr>
<th>Sp. No.</th>
<th>Length of Carapace</th>
<th>Width of Carapace</th>
</tr>
</thead>
<tbody>
<tr>
<td>RL/7/67</td>
<td>11.50 mm</td>
<td>16.00 mm</td>
</tr>
<tr>
<td>RL/7/68</td>
<td>11.50 mm</td>
<td>16.00 mm</td>
</tr>
</tbody>
</table>

**Description:** Carapace hexagonal, broader than long, moderately convex longitudinally and nearly flat transversely. Frontal margin wide, slightly curved and about half of the width of carapace; orbits small and widely separated. Antero-lateral margin smooth; postero-lateral straight and converges posteriorly; posterior margin about two-third of maximum width of carapace.

The regions are clearly defined; proto- and meso-gastrics well developed; urogastric and cardiac regions not clear; branchial region bears a prominent transverse ridge.

**Remarks:** This is the first record of fossil Xantho sp. from Indian-subcontinent and no form of this genus is available for comparison. The species has not been assigned by any specific name for the want of more and better preserved material.
5. SYSTEMATIC DESCRIPTION OF VERTEBRATES
5. SYSTEMATIC DESCRIPTION OF VERTEBRATES

Among vertebrate fossils, shark teeth are the only representative. These occur in intraformational conglomerate of Upper Bhuban Formation of Summa Group along Rangvamu - Sairang road section near Sairang village.

The collection includes four species, grouped in three genera of elasmobranchs, namely *carcharhinus* (Prionodon) *gangeticus* Muller and Henle, *Isurus* spallanzani (Bonnaparte), *Carcharodon* *carcharias* Linne' and *Carcharodon* sp.. All these forms are known to occur in the Miocene sediments of Myanmar (Noetling, 1901) and in Boka Bil Subgroup of Summa Group, Tripura (Das, 1938; Trivedi, 1966, 1980) but details of the latter are not available.

Shark teeth from the present areas are in the form of isolated fragments and overall preservation is not so good.
Class - CHONDRICTHYES
Subclass - ELASMOBRANCHII
Order - SELACHII
Suborder - GALEOIDA
Family - CARCHARHINIDAE
Genus - Carcharhinus Blainville, 1816
Subgenus - Prionodon

*Carcharhinus (Prionodon) gangeticus* Muller and Henle

*(Pl. XX, fig. 5)*


1981. *Carcharhinus (Prionodon) gangeticus* Muller and Henle : Sahni and Mehrotra, p. 100, Pl. II, fig. 22.

*Material:* A broken crown.

*Horizon and Locality:* Bed No. 7 (Upper Bhuban Formation):

Rangvamu - Sairang section.
Dimensions: Height of the crown (no. RS/7/3) is 7.00 mm and width-3.25 mm.

Description and Remarks: In available crown, apex is acute, external surface flat and internal one convex; the edges of crown serrated, serration on basal part being coarser than those on apical side. It is compared with Carcharias (Prionodon) gangeticus Muller and Henle described and figured by Noetling (1901, loc. cit.) from the Miocene of Myanmar (bearing G.S.I. nos. 7783 - 87) and found to match well except for its small size. Carcharias is now considered as Carcharhinus and, hence, its reference as Charcharinus (Prionodon) gangeticus Muller and Henle is quite reasonable.

Fimly - ISURIDAE
Genus - Isurus Rafinesque, 1810.

Isurus spallanzani (Bonnaparte)
(Pl. XX, figs. 1,2,3)

1901. Oxyrhina spallanzani Bonnaparte : Noetling, p. 372, Pl. XXV, figs. 4-6.
1957. Oxyrhina spallanzani Bonnaparte : Sharma, p. 104, Pl. 1, fig. 11.
1966. Oxyrhina spallanzani Bonnaparte : Trivedi, p. 68, Pl. 1, fig. 2.
1981. Isurus spallanzani (Bonnaparte) : Sahni and Mehrotra, p. 99, Pl. 1, fig. 1.
Material: Two crowns.

Horizon and Locality: Bed No. 7 (Upper Bhuban Formation):
Rangvamu - Sairang section.

Dimensions:

<table>
<thead>
<tr>
<th>Sp. No.</th>
<th>Height of crown</th>
<th>Width of crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS/7/4a</td>
<td>6.50 mm</td>
<td>3.15 mm</td>
</tr>
<tr>
<td>RS/7/4b</td>
<td>4.25 mm</td>
<td>2.10 mm</td>
</tr>
</tbody>
</table>

Description and Remarks: Tooth is slender, higher than broad. Crown lanceolate, erect; apex pointed, basal part rounded; inner surface slightly concave while outer one nearly flat; surface smooth and margins un serrated. Root not preserved.

It is found to resemble well with the form recorded from Myanmar as *Oxyrhina spallanzani* Bonaparte Noetling (1901, loc. cit.) in overall configuration and ornamentation of the crown particularly to G.S.I. type no. 9932. However, Myanmar specimen is much larger (about 22.00 mm).

Genus - *Carcharodon* Muller and Henle, 1841

*Carcharodon carcharias* Linne'

(Pl. XX, fig. 4)


Material: A broken crown.
Horizon and Locality: Bed No. 7 (Upper Bhuban Formation):
Rangvamu - Sairang section.

**Dimension:** Height of the crown (no. RS/7/5) is 9.00 mm (c) and width - 5.50 mm.

**Description and Remarks:** Crown erect, edges sharp and coarsely serrated, margins nearly straight and apex acute. Crown is slightly thicker in the middle and becomes thinner towards edges. The present specimen agrees so well with the *Carcharodon carcharias* Linne described and figured by Mehrotra *et al.* (1973, loc. cit.), that its identification is beyond doubt.

This form flourishes in the present day waters of Atlantic and Pacific Oceans and no record of it is available from the Indian Ocean (Mishra, 1969 in Mehrotra, 1988, p. 128).

*Carcharodon* sp.

**Material:** A broken crown.

Horizon and Locality: Bed No. 7 (Upper Bhuban Formation);
Rangvamu - Sairang section.

**Dimension:** Crown's height is 7.00 mm and width - 2.90 mm.

**Description:** Available fragment of crown shows slightly obtuse apex, serrated margins, serrations nearly of equal size throughout, internal surface concave, more so near the base, and external one flat. Further details could not be made out due to fragmentary nature of the specimen.
Remarks: Specimen differs from the preceding one, viz., *Carcharodon carcharias* Linne' in having slightly obtuse apex and concave internal surface. Its specific identification is deferred for the want of more details.
6. FAUNAL ANALYSIS AND AGE OF BEDS
6. FAUNAL ANALYSIS AND AGE OF BEDS

6.1 ANALYSIS OF FAUNA

Marine Miocene fauna are known to occur in various parts of the country mainly along the coastal regions. From west to east, these are reported from Kachchh, Kathiawar and Surat - Broach in Gujarat; Quilon in Kerala; Baripada in Orissa; Garo Hills in Meghalaya; Kanchanpur in Assam; and Mizoram. These fauna belong to Indo-Pacific province which includes Persia, Pakistan, Sri Lanka, Myanmar, Java, Philippines and Japan beside India.

Faunal record from Mizoram is very poor. Among earlier workers, no one has made systematic collection of the fossil fauna with a view to describe them. These people, while working out geology of the state, collected few forms here and there and listed them without any details. Keeping this in view, the present author took the task of collecting available mega-fauna systematically bed by bed. For this purpose,
sections around Aizawl and Lunglei towns are selected and studied. In all, more than one thousand five hundred individuals were collected taking traverses along and across the strike of the beds. These were cleaned and prepared for the identification and around five hundred were found suitable for systematic description. Their overall preservation is not very satisfactory and all the beds are not fossiliferous.

The Middle and Upper Bhuban Formation of Bhuban Subgroup (Surma Group) altogether yielded 125 forms belonging to bivalves, gastropods, decapods, echinoids, shark teeth and scaphopods in decreasing order of abundance. The fossiliferous horizons are Bed Nos. 6 and 7 of Rothlang - Luangmual section (Fig. 2.4); Bed No. 7 of Rangvamu - Sairang section (Fig. 2.5); Bed Nos. 1, 8, and 9 of Kulikawn - Hlimen section (Fig. 2.6); Bed No. 4 of Maubawk - Tuikual Lui section (Fig. 2.7); Bed No. 8 of Haurang - Pachang section (Fig. 2.8); Bed Nos. 3 and 5 of Lunglei - Zothlang section (Fig. 2.9); Bed No. 6 of Pukpui - Saza section (Fig. 2.10); Bed No. 5 of Lunglein - Sazaikawn section (Fig. 2.11); Bed No. 1 of Ghhekpuikawl - Vanhe section (Fig. 2.12); and Bed Nos. 1 and 5 of Serthum - Theiriat section (Fig. 2.13). The bulk of the fauna comes from Bed Nos. 6 and 7 of Rothlang - Luangmual section, Bed No. 8 of Kulikawn - Hlimen, and Haurang - Pachang sections. These beds together contributed about three-fifth of the total collection.

Out of 125 identified forms, 91 are assigned to bivalves, 16 to gastropods, seven to decapods, five to echinoids, four to sharks and two to scaphopods. Around one-sixth forms are still surviving and a few appear to be premutations of the existing ones.

Bivalves are grouped into 41 genera (and 20 subgenera) which in
hierarchy belong to 24 families (and 21 subfamilies), 19 superfamilies, and seven orders distributed to four subclasses. Family-wise, Veneridae has the largest number of genera, i.e., seven, namely, Antigona, Meretrix, Pitar, Callista, Dosinia, Clementia and Paphia. Generically, however, only eleven namely, Nucula, Anadara, Pinna, Chlamys, Pecten, Astarte, Tellina, Apolymetis, Arctica, Callista, and Paphia have large number of individuals and diversified species. The remaining ones commonly have single taxon based on one representative. It is worth mentioning that the oysters, which are so common in other areas, are almost missing from the present one.

Sixteen forms of gastropods reported here are clubbed into 12 genera (and three subgenera) distributed in 10 families (seven subfamilies) referred to eight superfamilies ranking into one order of the one subclass. Overall, there is paucity of forms and numbers to the genera leaving aside Turritella, Ficus, and Conus which are represented by numerous examples.

Decapods, on the other hand, have only five genera which belong to four families of three superfamilies. Portunus is the only genus having large number of individuals.

Cidaris and Schizaster comprise the class Echinoidea, each one belong to a family and an order. In all, five species are recognised, i.e., one of Cidaris and four of Schizaster.

Shark teeth constitute the vertebrates. These are assigned to three genera (one subgenus) of two families.

Genus Dentaliun is the only representative of class Scaphopoda.
Out of total 64 genera recorded in the present work, the following 27 are already known to occur in the studied areas as these have been listed by earlier workers:

- Nucula, Yoldia, Arca, Barbatia, Trisidos, Anadara, Glycymeris, Pinna, Chlamys, Pecten, Ostrea, Cardium, Mactra, Tellina, Apolymetis, Meretrix, Dosinia, Paphia, Corbula, Turritella, Ficus, Conus, Schizaster, Portunus, Carcharodon, Carcharhinus and Isurus.

Remaining ones are reported here for the first time from Mizoram. Following 14 genera/subgenera (without asterisks) are even not known even from the Miocene of India:

- Acila* (Truncacila), Yoldia* (Megayoldia), Anadara* (Lunarca), Brachidontes* (Austromytilus), Limaria* (Limatulella), Astarte* (Bythiamena), Astarte* (Digitariopsis), Salaputininum, Solena* (Plectosolen), Vepricardium* (Hedecardium), Tellina* (Angulus), Tellina* (Eurytellina), Tellina* (Oudardia), and Xantho.

Following 23 genera, previously listed by various workers are, however, missing from the present collection:

- Spondylus, Fossularia, Glossus, Donax, Venus, Unio, Batissa, Septifer, Lima, Varicorbula, Trachycardium, Terebra, Rimella, Siphonalia, Cerithium, Volutospina, Opissaster, Eupatagus, Callianassa, Hemipristis, Odontapsis, Sparus and Myliobatis.

A new subgenus, i.e., Indometis under the genus Apolymetis Salisbury is erected with stable characters like trigonal to quadrate and compressed shell, left valve slightly more convex and larger than the right one, umbones much posterior to mid-line, posterior half of shell flexured, atleast two folds and two furrows in left valve and one fold
and two furrows in right valve and surface sculpture of spaced commarginal growth lines. Two earlier known forms, namely *Tellina* (*Metis*) *grimesi* Noetling and *Tellina* (*Arcopagia*) *tazuensis* Cotter along with two new ones, viz., *Apolymetis* (*Indometis*) *rambalaki* and *Apolymetis* (*Indometis*) *ramashrayi* are included in new subgenus as they show these characters.

Myra Keen (in Moore et al., 1969, p. N677) has considered *Antigona* Schumacher as a subgenus of *Venus* Linne, with restricted range of Recent. However, it has been reported from Oligo-Miocene beds by number of earlier workers and even *Antigona granosa* (Sowerby) is considered as an index form of Lower Miocene in Myanmar, Kenya, Pemba, Java, Sri Lanka, beside India. Therefore, the author preferred to retain its generic status.

On the basis of the present findings, the range of some genera and subgenera, which are known to occur in the older or younger horizons, has been extended. For instance, range of the genus *Meretrix* (Upper Miocene to Recent) and subgenera *Austromytilus* (Pliocene to Recent), *Hemimetis* (Recent), and *Angulus* (Recent) is to be lowered down to lower Miocene. On the other hand, for the subgenus *Plectosolen* (Lower Eocene to Middle Eocene), it is to be extended upward to Lower Miocene.

Out of 125 forms described in chapters three, four and five, the following 35 species, one variety and a subgenus have been designated as new:

- *Nucula* (*Nucula*) *agrawali*
- *Nucula* (*Nucula*) *sahnii*
- *Nucula* (*Nucula*) *tewarii*
- *Acila* (*Truncacila*) *kachharai*
Yoldia (Yoldia) satsangii
Barbatia (Barbatia) duttai
Anadara (Anadara) barmani
Anadara (Anadara) narayanai
Anadara (Anadara) babui
Anadara (Lunarca) singhi
Pinna (Pinna) choudhuryi
Pinna (Pinna) vermai
Pecten (Pecten) mathuri
Limaria (Limatulella) mukerjeei
Lucina (Lucina) vredenburghi
Anodontia noetlingi
Astarte (Astarte) deyi
Astarte (Bythiamena) striata
Astarte (Bythiamena) striata var. eamesi n. var.
Astarte (Digitariopsis) coxi
Salaputinum evansi
Vepricardium (Hedecardium) kobayashii
Lutraria saingengai
Solena (Plectosolen) singhi
Cultellus (Cultellus) zulloi
Tellina (Hemimetis) bimlae
Tellina (Oudardia) binodi
Tellina (Tellinella) loknathi
Apolymetis (Apolymetis) amreshi
Apolymetis (Indometis n. subgen.) rambalaki
Apolymetis (Indometis n. subgen.) ramashrayi
Solecurtus karunae
Out of the remaining, the following five taxa were reported from the present areas by the workers noted against each, but their description has not been published so far:

- *Chlamys (Chlamys) senatoria* (Gmelin) Bhattacharyya (1978) in Das Gupta (1982)
- *Carcharodon carcharias* (Linne) Satsangi and Mehrotra (1983)

Under mentioned forms, although, said to occur in the present areas, but are missing from this collection. Name/s of worker/s who recorded these taxa are given in parentheses.

- *Lima protosquimosa* Noetling Bhattacharyya in Das Gupta (1982)
- *Trachycardiun minbuense* Noetling Bhattacharyya in Das Gupta (1982)
- *Venericardia noetlingi* Cotter Bhattacharyya in Das Gupta (1982)
Meretrix protophilippinarum Noetling Bhattacharyya in Das Gupta (1982)

Corbula socialis Martin Bhattacharyya in Das Gupta (1982)

Turritella noetlingi Vredenburg Bhattacharyya in Das Gupta (1982)

Conus decollatus Linne Bhattacharyya in Das Gupta (1982)

Carcharodon nicaraguensis Agassiz Mehrotra (1984)

Sparus cintus Agassiz Mehrotra (1984)

Odontapsis cuspidata Agassiz Sinha and Mehrotra (1984)

Hemipristis serra Agassiz Satsangi and Mehrotra (1983)

In all, 64 species are being reported for the first time from the areas under investigation in addition to the earlier referred 36 new ones. Of these, following 36 are not known even from the Northeast India:

Nucula warsarensis Eames

Arca feddeni Vredenburg

Arca newtoni Vredenburg

Glycymeris sindiensis Vredenburg

Chlamys (Chlamys) quilonensis Dey

Pecten (Pecten) pascoei Cox

Tellina (Eurytellina) pilgrimi Cox

Tellina (Tellinella) hilli Noetling

Tellina (Tellinella) pseudohilli Noetling

Tellina salinensis Cotter

Gari (Gari) natensis Noetling

Arctica islandica (Linne)
**Meretrix persica** Cox

**Pitar altoumbonata** (Nagao)

**Callista** (Callista) **pseudoumbonella** Vredenburg

**Dosinia** (Dosinia) **perlata** Vredenburg

**Clementia** (Clementia) **protopapyracea** Vredenburg

**Paphia** (Paphia) **rotundatus** (Linne)

**Paphia** (Paphia) **persica** Cox

**Paphia** (Callistotapes) **pseudoliratus** Vredenburg

**Corbula mekranica** Vredenburg

**Dentalium boettgeri** Noetling

**Turritella pseudobandongensis** Vredenburg

**Turritella narica** Vredenburg

**Architectonica buddha** (Noetling)

**Xenophora birmamica** Noetling

**Globularia callosa** (Sowerby)

**Murex maegillivrayi** Dohrn

**Volvaria birmamica** Noetling

**Cidaris granulata** Duncan and Sladen

**Schizaster alveolatus** Duncan and Sladen

**Schizaster baluchistanensis** d'Archiac and Haime

**Schizaster granti** Duncan and Sladen

**Calappa protopustulosa** Noetling

**Ebalia tuberculata** Noetling

**Typilobus granulosus** Stoliczka

Range of several taxa has been extended upward/downward (table no. 6.1) in the light of their earlier records either from older or younger horizons and present occurrence.
Table - 6.1 List of forms with extended Range.

<table>
<thead>
<tr>
<th>Species Name</th>
<th>Original Range</th>
<th>Extended Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arca newtoni Vredenburg</td>
<td>Upper Miocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Chlamys (Chlamys) quilonensis Dey</td>
<td>Middle Miocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Pecten (Pecten) pascoei Cox</td>
<td>Pliocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Tellina (Eurytellina) pilgrimi Cox</td>
<td>Oligocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Tellina salinensis Cotter</td>
<td>Eocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Meretrix persica Cox</td>
<td>Middle Miocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Pitar altoubonata (Nagao)</td>
<td>Oligocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Clementia (Clementia) protopapyracea</td>
<td>Oligocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Vredenburg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dosinia (Dosinia) perlata Vredenburg</td>
<td>Upper Miocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Paphia (Paphia) rotundata (Linne')</td>
<td>Pliocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Paphia (Paphia) persica Cox</td>
<td>Middle Miocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Turritella narica Vredenburg</td>
<td>Oligocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Murex maegillivrayi Dohrn</td>
<td>Middle Miocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Schizaster alveolatus Ducan &amp; Sladen</td>
<td>Oligocene</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td>Schizaster baluchistanensis Duncan</td>
<td>Upper Eocene</td>
<td>Lower Miocene</td>
</tr>
</tbody>
</table>

The check list of the forms in the present collection together with their vertical distribution is given in table 6.2 (see infra).
Table - 6.2 Distribution of the forms

First horizontal row at the top indicate the two studied areas, second one measured sections while the third one with figures represent fossiliferous Bed Nos. in them. (X) indicates occurrence of species in the concerned bed(s). Besides, following symbols are used: (a) - Forms new to the area; (b) - Forms already known from the area; (c) - Forms new to Miocene of India; (d) - First record of genus from Miocene of India; (e) - First record of subgenus from Miocene of India; (f) - First record of genus from the area; (g) - First record of the subgenus from the area; (h) - Vertical range extended upward; and (i) - Vertical range extended downward.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Species</th>
<th>Bed Nos.</th>
<th>Alzawil</th>
<th>Lunglei</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rothlang</td>
<td>Rangvam-</td>
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<td></td>
<td></td>
<td></td>
<td>Llungnal</td>
<td>Sairang</td>
</tr>
<tr>
<td>1.</td>
<td>Nucula alcocki Noetling</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Nucula warsarensis Eames</td>
<td></td>
<td>X</td>
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<tr>
<td>3.</td>
<td>Nucula cf. pulchra Hinds</td>
<td>X</td>
<td></td>
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<tr>
<td>4.</td>
<td>Nucula (Nucula) agrawali n. sp.</td>
<td>X</td>
<td>X</td>
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<tr>
<td>5.</td>
<td>Nucula (Nucula) sahnii n. sp.</td>
<td>X</td>
<td></td>
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<tr>
<td>6.</td>
<td>Nucula (Nucula) tewarii n. sp.</td>
<td>X</td>
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<tr>
<td>7.</td>
<td>Acila (Truncacila) kachharai n. sp.</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>8.</td>
<td>Nuculana virgo (Martín)</td>
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Remarks:
a, b, e, f
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<tr>
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<th>Species</th>
<th>Bed Nos.</th>
<th>AIZAWL</th>
<th>LUNGLEI</th>
<th>Remarks</th>
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<td>Rothlang-</td>
<td>Lunglei-</td>
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<td></td>
<td>Liangmu-</td>
<td>Zoithlang</td>
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<td></td>
<td>Sairang</td>
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<td>Kulikom-</td>
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<td>Hliren</td>
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<td>Muosie-</td>
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<td>Tuinal</td>
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<td></td>
<td>Lui</td>
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<td>9.</td>
<td>Portlandia? sp.</td>
<td></td>
<td>X</td>
<td></td>
<td>f</td>
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<tr>
<td>10.</td>
<td>Yoldia (Yoldia) satsangii n. sp.</td>
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<td>11.</td>
<td>Yoldia (Megayoldia) sp.</td>
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<td>12.</td>
<td>Arca feddeni Vredenburg</td>
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<td>13.</td>
<td>Arca newtoni Vredenburg</td>
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<td>X</td>
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<td>14.</td>
<td>Barbatia (Barbatia) duttai n. sp.</td>
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<td>15.</td>
<td>Barbatia sp.</td>
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<td>16.</td>
<td>Trisidos cf. semitorta (Lamarck)</td>
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<td>17.</td>
<td>Anadara daviesi Mukerjee</td>
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<td>X</td>
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<td>18.</td>
<td>Anadara craticulata (Nyst)</td>
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<td>19.</td>
<td>Anadara garoensis Mukerjee</td>
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<td>20.</td>
<td>Anadara cf. gourae Dey</td>
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205
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<td>Measured Sections</td>
<td>Rothlang—Lungla</td>
<td>Rangvan—Sairang</td>
<td>Kulisem—Hilien</td>
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<td>21.</td>
<td>Anadara aff. gourae Dey</td>
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<td>6 7 7 8 9 4</td>
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<td>22.</td>
<td>Anadara (Anadara) barmani n. sp.</td>
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<td>23.</td>
<td>Anadara (Anadara) narayanai n. sp.</td>
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<td>24.</td>
<td>Anadara (Anadara) babui n. sp.</td>
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<td>25.</td>
<td>Anadara (Lunarca) singhi n. sp.</td>
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<td>X X</td>
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<td>26.</td>
<td>Gyxymeris sindiensis Vredenburg</td>
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<td>27.</td>
<td>Brachidontes (Austroroytilus) sp.</td>
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<td>28.</td>
<td>Pinna (Pinna) choudhuryi n. sp.</td>
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<td>X X X X</td>
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<td>29.</td>
<td>Pinna (Pinna) verma n. sp.</td>
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<td>30.</td>
<td>Pinna sp. indet.</td>
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<td>31.</td>
<td>Chlamys (Chlamys) senatoria (Gmelin)</td>
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<td>32.</td>
<td>Chlamys (Chlamys) guilonensis Dev</td>
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Table 6.2 (Contd.)
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<th>Remarks</th>
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<td>Rothlang</td>
<td>Luangmal</td>
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<td>33</td>
<td>Chlamys cf. jamviniensis Cox</td>
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<td>7</td>
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<tr>
<td>34</td>
<td>Pecten (Pecten) pascoei Cox</td>
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<td>8</td>
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<td>Pecten (Pecten) mathuri n. sp.</td>
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<td>Limaria (Limatulella) mukerjeei n. sp.</td>
<td>X</td>
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<td>37</td>
<td>Ostrea latimarginata Vredenburg</td>
<td>X</td>
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<td>Lucina (Lucina) vredenburgi n. sp.</td>
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<td>Anodontia noetlingi n. sp.</td>
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<td>Diplodonta incerta d Archiac</td>
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<td>Diplodonta rotundatus (Montagu)</td>
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<td>Astarte (Astarte) deyi n. sp.</td>
<td>X</td>
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<tr>
<td>43</td>
<td>Astarte (Bythiamena) striata n. sp.</td>
<td>X</td>
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Table 6.2 (Contd.)
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<td><strong>Astarte (Bythiamena) striata</strong> n.sp.</td>
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<td>var. eamesi n. var.</td>
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<tr>
<td>45</td>
<td><strong>Astarte (Digitariopsis) coxi</strong> n. sp.</td>
<td>X</td>
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<td>46</td>
<td><strong>Salaputinum evansi</strong> n. sp.</td>
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<tr>
<td>47</td>
<td><strong>Cardiun (s.l.) juven. guilonense</strong> Dey</td>
<td>X</td>
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<td>48</td>
<td><strong>Cardiun</strong> sp.</td>
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<td>49</td>
<td><strong>Vepricardium</strong> (Hedecardium) kobayashii n. sp.</td>
<td>X</td>
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Scaphopods:

| 108.  | Dentalium boettgeri Noetling         |          | X      |         | c,f       |
| 109.  | Dentalium junghunhi Martin           |          | X      |         | a         |

Echinoids:

<p>| 110.  | Cidarisa granulata Duncan &amp; Sladen   |          | X      |         | a         |
| 111.  | Schizaster alveolatus Duncan and Sladan |      | X      |         | a,h       |</p>
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<td><strong>Shark Teeth:</strong></td>
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<td>122. Carcharhinus (Prionodon)</td>
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<td></td>
<td><em>gangeticus</em> Muller and Henle</td>
<td>X</td>
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<td>123. Isurus spallanzani (Bonaparte)</td>
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<td>X</td>
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<td>124. Carcharodon carcharias Linné</td>
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<td>X</td>
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<tr>
<td>125. Carcharodon sp.</td>
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<td>X</td>
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6.2 AGE OF BEDS

6.2.1 General Remarks

Faunally, bivalves and gastropods are widely distributed and have been encountered in almost all fossiliferous beds of the measured sections in the studied areas. Other fossil groups are confined to few horizons only. Bivalves and gastropods are not found suitable for age determination and correlation purpose due to their long range and limited value as time indicator. However, majority of the forms found in the present areas are also known to occur in the Lower Miocene sediments of Garo Hills, Meghalaya; Cachar Valley, Assam; Kachchh and Kathiawar, Gujarat; Sind, Pakistan; and Myanmar, where the ages of beds have been fixed to a great extent. Therefore, an attempt has been made here to date and correlate the various fossiliferous horizons of the Bhuban Subgroup (Surma Group). The stratigraphic conclusions are obviously broad.

6.2.2 Overall Age

An important characteristic of the Miocene fauna of the Indo-Pacific province is the occurrence of large number of long ranging species which are still in existence. Lyell (in Dey, 1962) proposed a method for the subdivision of Tertiary on the basis of percentage composition of Recent species. Dall (1904) commented that Miocene contains from 17 to 20 per cent of species which survive to the Recent. Martin (in Van Der Vlerk et al., 1931) established percentage number for the Tertiary faunas of Indo-Pacific province which are as under:

- Pliocene - 50 to 70 per cent
- Upper Miocene - 20 to 50 "
- Lower Miocene - 8 to 20 "
- Eocene - 0 "
Vredenburg (1921) said that Upper and Lower Gaj of Northwestern India (Lower Miocene) together have 17.30 per cent of Recent species. Mukerjee (1939) mentioned that the percentage composition of Lower Miocene molluscan faunas of Myanmar, Western India and Java varies from 7 to 25 depending on the horizon, facies and generic constitution. He worked out 21 per cent composition of Recent molluscs for Lower Miocene sediments of Garo Hills, Meghalaya.

For the present areas out of 109 molluscan forms, 22 range up to the Recent and constitute 20.56 per cent. This figure approximately fits in the Martin's table of percentage composition for the Lower Miocene, and as such, the Bhuban sediments are assigned the same overall age.

Amongst the recorded forms from the present areas, 26 are common to the Aquitanian - Burdigalian sediments of Garo Hills, Meghalaya; 22 to Kama (Aquitanian) and Pyalo (Burdigalian) Formations of Pegu Group, Myanmar; and 15, 14 and 13 to Gaj beds of Kachchh, Sind and Kathiawar respectively. This further confirms a Lower Miocene (Aquitanian - Burdigalian) age for the Bhuban sediments. This is also in accordance with the age assigned to these sediments by earlier workers cited under previous work in chapter one.

6.2.3 Age of Fossiliferous Beds

After going through the literature, it has been found that Miocene sections of Sind (Pakistan) and Myanmar are fully described. In the former, Gaj beds are divided into Lower and Upper of Aquitanian and Burdigalian age respectively. The index fossils shown for each division are found to be of immense value for dating the beds in the present areas. The taxa taken into consideration are: Ostrea latimarginata
Vredenburg and Diplodonta incerta d'Archiac of Upper Gaj i.e. Burdigalian and Glycymeris sindiensis of Lower Gaj i.e., Aquitanian (Vredenburg, 1928; Pascoe, 1973).

In the Pegu Group of Myanmar, the three Formations namely Singu (Oligocene), Kama (Aquitanian), and Pyalo (Burdigalian) are considered for the purpose. Bulk of the fauna come from the first two Formations and majority of them are common to both. However, certain forms, viz., Nuculana virgo (Martin), Mactra protoreevesii Noetling, Tellina (Tellinella) foliacea Reeve, Tellina (Tellinella) pseudohilli Noetling, Gari (Gari) natensis Noetling and Conus (Leptoconus) bonneti Cossmann are exclusively confined to Kama Formation and considered as Aquitanian. Rest of the forms which are coming from the older horizons and encountered in Kama Formation are also taken into account while discussing age of the beds. Typical oyster form from Pyalo Formation, i.e., Ostrea latimarginata Vredenburg and decapod crustaceans, viz., Calappa protopustulosa Noetling and Ebalia tuberculata Noetling do not occur in older horizons and considered as time indicator of Burdigalian age (Noetling, 1898, 1901; Stuart, 1910; Pascoe, 1973; and Sastry and Mathur, 1970. Raju et al. (1974), however, reported the occurrence of Ostrea latimarginata Vredenburg from the Oligocene of Kachchh. Mathur (1988) commented that this discovery does not reduce the importance of this form as an index fossil of Lower Miocene as the flaring up of taxa has taken place during this period.

Similarly, Diplodonta rotundatus (Montagu) is known to occur in the Burdigalian of Persia, Garo Hills and Mekran beds of Pakistan. In view of this, the referred form is also taken as Burdigalian (Cox, 1936; Mukerjee, 1939 and Vredenburg, 1928).
Gaj beds of Kachchh and Kathiawar (= Khari Formation) are assigned to Aquitanian - Burdigalian by Biswas (1965) and Pascoe (1973) and are considered accordingly. The fauna of the Garo Hills represent Aquitanian-Burdigalian or Burdigalian age as assigned by Mukerjee (1939).

In the following pages, fossil forms referred from Gaj of Sind, Kachchh and Kathiawar; Garo Hills; Singu, Kama and Pyalo Formations of Myanmar; and Persia are in accordance with the references cited above.

6.2.3.1 Rothlang - Luangmual Section

Middle and Upper Bhuban sediments constitute this section (Fig. 2.4) where the sequence is divided into eight beds. Bed Nos. 6 and 7 are fossiliferous and contain bivalves, gastropods, echinoids and crabs. Bed-wise age of these is discussed below;

Bed No. 6: This is exposed near Luangmual Village, Aizawl. The stratigraphic and temporal distribution of identified forms from this bed are shown in table 6.2. In all, there are 26 forms of bivalves, eight of gastropods and one of echinoids. Of these, 12 forms are n. sp., cf., aff. and sp. juv., thus excluded from the discussion.

From the remaining 22 forms, the following six namely, Anadara craticulata (Nyst), Tellina (Moerella) indifferens Noetling, Tellina (Tellinella) pseudohilli Noetling, Conus (Lithoconus) ineditus Michelotti, Conus (Leptoconus) bonneti Cossmann and Xenophora birmanica Noetling are also recorded from Kama Formation of Myanmar and, thus indicate Aquitanian age.

As compared to Garo Hills, there are 10 commonly occurring forms which include first, second and fifth of aforesaid ones. Remaining forms are: Nucula alcocki Noetling, Anadara daviesi Mukerjee, Anadara
garoensis Mukerjee, Callista (Costacallista) erycina (Linné), Turritella (Torculoidella) angulata Sowerby, Nassaria birmanica (Vredenburg), Ficus (Ficus) conditus (Brongniart). As pointed out earlier, Garo Hills sediments are dated as Aquitanian - Burdigalian, obviously the assemblage is of the same age.

Only echinoid namely Schizaster granti Duncan and Sladen occurs in the Gaj beds of Kachchh and Kathiawar and does not pass into younger horizons.

A few forms of this bed are also reported from the Tertiary sediments of other parts of India. To cite, Chlamys (Chlamys) quilonensis Dey, Murex maegillivrasi Dohrn from Quilon beds of Kerala and Arca newtoni Vredenburg and Paphia (Callistotapes) pseudoliratus Vredenburg from Mekran beds of Pakistan are slightly younger in age. Contrary to this, Tellina (Eurytellina) pilgrimi Cox (Persia), Tellina salinensis Cotter (Myanmar), Turritella narica Vredenburg and Clementia (Clementia) protopapyracea Vredenburg (Sind) are coming from older horizons of Tertiary. This is not surprising as certain percentage of fauna of a Tertiary subdivision always transgress into the others. Similarly, the occurrence of Mediterranean form Arctica islandica (Linné) (Pliocene to Recent) should not be taken as an exception.

In view of the above, Aquitanian - Burdigalian age is inferred for the bed in question with affinity towards Aquitanian as it contains more than 60 per cent of the fauna of this age.

Bed No. 7: It is highly fossiliferous and exposed near Luangmual Govt. complex, Aizawl. Forty four identified forms from this bed belong to bivalves (36), gastropods (four) and crabs (four). Only 15 already
known forms could be identified from the assemblage, rest being n. sp., cf., aff. and spp.

The bed has yielded four taxa which are also reported from Sind namely Diplodonta incerta d'Archiac, Diplodonta rotundatus (Montagu) of Upper Gaj; and Chlamys (Chlamys) senatoria (Gmelin) and Clementia (Clementia) papyracea (Gray) of Gaj beds. Pascoe (1973) has opined that Lower and Upper Gaj of Sind are of Aquitanian and Burdigalian age respectively. Thus, the fauna cited above heavily favour Burdigalian age.

As compared to Myanmar, the bed under discussion has the following common elements with Kara Formation (Aquitanian): Anadara craticulata (Nyst), Tellina (Tellinella) hilli Noetling, Gari (Gari) natensis Noetling, Turritella (Torculoidella) angulata Sowerby, Ficus (Ficus) conditus (Brongniart); and Ebalia tuberculata Noetling of Burdigalian age. Obviously, this assemblage indicates Aquitanian - Burdigalian age.

Amongst the above mentioned forms, leaving aside Tellina (Tellinella) hilli Noetling, Gari (Gari) natensis Noetling and Ebalia tuberculata Noetling, all others are also found in Garo Hills. The three additional Garo forms are: Anadara daviesi Mukerjee, Anadara garoensis Mukerjee and Corbula tunicosulcata Vredenburg. Following Mukerjee (1939), these reflect Aquitanian - Burdigalian age. The last mentioned form together with Clementia (Clementia) papyracea (Gray) are also known to occur in Gaj beds of Kachchh and Kathiawar respectively.

One taxon each from Oligocene beds of Persia - Tellina (Eurytellina) pilgrimi Cox and Myanmar - Volvaria birmanica Noetling have also been obtained from this bed and may be taken within the limit of extended range of the forms concerned.
As the bed contains more than 85 per cent fauna of Aquitanian - Burdigalian affinity, the same age can be assigned to the bed concerned. Moreover, occurrence of forms like *Diplodonta incerta* d'Archiac, *Diplodonta rotundatus* (Montagu) and *Ebalia tuberculata* Noetling indicate an age more towards Burdigalian as these were not reported from the horizons older to it.

### 6.2.3.2 Rangvamu – Sairang Section

Upper Bhuban succession in this section (Fig. 2.5) is 1200 m thick and comprises nine beds. Bed Nos. 1 to 6 are unfossiliferous as far as mega-biota are concerned and, thus these can not be dated. In Bed No. 7, fossils are confined to 1.0 m thick intraformational conglomerate.

**Bed No. 7:** Faunally, it is a unique bed as it entombs mainly fossils of pisces and a few molluscs. The taxa are in the form of shark teeth - *Carcharhinus* (*Prionodon*) *gangeticus* Muller and Henle, *Isurus spallanzani* (Bonaparte) *Carcharodon carcharias* Linné and *Carcharodon* sp; and only bivalve - *Anadara garoensis* Mukerjee. The first two are also known to occur in the Kama Formation (Aquitanian) of Myanmar; these along with the third one, from the Tertiary sediments of Kolasib area, Mizoram (Satsangi and Mehrotra, 1983) and Middle Miocene of Orissa (Baripada beds). The last one was originally described from the Aquitanian - Burdigalian of Garo Hills. *Carcharodon carcharias* (Linné) is said to occur in Upper Burdigalian and younger beds only (Sahni and Mehrotra, 1981; Satsangi and Mehrotra, 1983). Obviously, one can not assign an age other than the Burdigalian to the concerned bed.

### 6.2.3.3 Kulikawn – Hlimen Section

Middle and Upper Bhuban sediments are exposed along this section
(Fig. 2.6). In all, nine litho-units are recognised, first two belonging to Middle and rest to Upper Bhubans. Bed No. 1, although is highly bioturbiditic, has not yielded any identifiable taxa while Bed Nos. 2 to 7 are devoid of Mega-biota and the top two beds are fossiliferous. Their age is discussed below:

Bed No. 8: The bed is exposed at South Hlimen village, Aizawl. The identified taxa include 25 forms of bivalves, three of gastropods and two of scaphopods. Of these, 22 forms are considered for determining the age of the bed and the rest are left out because of being n. sp., aff. and sp.

The bivalve forms include Ostrea latimarginata Vredenburg and Diplodonta incerta d'Archiac which are characteristic Burdigalian species of Upper Gaj in Sind. Moreover, former also occurs in the Pyalo Formation (Burdigalian) of Myanmar. These two forms, therefore, favour Burdigalian age. The two forms namely Chlamys (Chlamys) senatoria (Gmelin) and Clementia (Clementia) papyracea (Gray) come from the Gaj beds of Sind, while Mactra protoreevsi Noetling, Dentalium boettgeri Noetling, Dentalium junghuhni Martin and Globularia callosa (Sowerby) from Kama Formation (Aquitanian) of Myanmar. All but number four of the above mentioned forms are also identified from Garo Hills (Mukerjee, 1939). Additional Garo forms are: Anadara craticulata (Nyst), Diplodonta rotundatus (Montagu), Callista (Costacallista) erycina Linne', Architectonica buddha Noetling and Ficus (Ficus) conditus (Brongniart). This assemblage is indicative of Aquitanian - Burdigalian age, the only exception being Diplodonta rotundatus (Montagu) of Burdigalian age.

The fauna also include a few forms from Gaj of Kachchh namely Arca feddeni Vredenburg, Callista (Callista) pseudomobonella Vredenburg,
Globularia callosa (Sowerby); and also from Kathiawar - Ostrea latimarginata Vredenburg, Globularia callosa (Sowerby) and Clementia (Clementia) papyracea (Gray). These favour Aquitanian - Burdigalian or Burdigalian age for the bed under discussion.

Remaining six forms are those which have been considered to transgress boundaries of sub-divisions of Tertiary. These are: Arca newtoni Vredenburg and Paphia (Callistotapes) pseudoliratus (Vredenburg) from Mekran; Arctica islandica (Linné); & Paphia (Paphia) rotundatus (Linné), Paphia (Paphia) persica Cox and Tellina (Eurytellina) pilgrimi Cox from Persia.

From the above, it can be observed that a few forms from this bed favour Burdigalian age, a handful of these Aquitanian and about 50 per cent Aquitanian - Burdigalian. Hence, the concerned bed may be broadly dated as Aquitanian - Burdigalian. It is pertinent to mention that the said bed has two fossiliferous intercalations also, the upper and lower ones. These contain characteristic Burdigalian and Aquitanian forms respectively besides Aquitanian - Burdigalian ones. To be precise, therefore, the upper part of the bed may have close affinity with the Burdigalian while the lower one with Aquitanian.

Bed No. 9: This has yielded the only echinoid form Cidaris granulata Duncan and Sladen which is also known to occur in Gaj beds of Kathiawar. Its precise age could not be inferred in the absence of other characteristic forms. However, sequentially, it immediately overlies preceding bed and may be younger in age.

6.2.3.4 Maubawk - Tuikual Lui Section

Top most bed of this section (Fig. 2.7) is fossil yielding out of
the four beds in the Upper Bhuban Formation.

**Bed No. 4**: This bed has yielded the following taxa: *Pinna (Pinna) choudhuryi* n. sp., *Chlamys (Chlamys) senatoria* (Gmelin), *Mactra protoreeesii* Noetling, *Tellina (Hemimetis) bimlae* n. sp. and *Arctica islandica* (Linné).

From the known forms, *Chlamys (Chlamys) senatoria* (Gmelin) comes from Gaj of Sind, Kachchh and Kathiawar; Aquitanian - Burdigalian of Garo Hills; Aquitanian (*Kama Formation*) of Myanmar; and *Mactra protoreeesii* Noetling from Aquitanian (*Kama Formation*) of Myanmar and Aquitanian - Burdigalian of Garo Hills. Thus, this bed may be assigned to Aquitanian - Burdigalian with more affinity towards Aquitanian.

### 6.2.3.5 Haurang - Pachang Section

Altogether, 10 beds have been identified along this section (Fig. 2.8), first five belonging to Middle while the rest to Upper Bhubans. Bed No. 1 to 7 and 9 to 10 are barren, hence can not be dated. Bed No. 8 has yielded large number of identifiable taxa.

**Bed No. 8**: Out of 21 forms reported from this bed, only 14 are known ones the rest being n. sp., cf. and sp. juv.

To start with, *Chlamys (Chlamys) senatoria* (Gmelin) and *Antigona granosa* (Sowerby) are known from Gaj beds of Sind; second one from Kathiawar; *Nucula warsarensis* Eames and *Dosinia (Dosinia) perlata* Vredenburg from Kachchh. Occurrence of these forms in the referred bed points out Aquitanian - Burdigalian age.

Three forms, namely *Mactra protoreeesii* Noetling, *Tellina (Tellinella) hilli* Noetling and *Conus (Lithoconus) ineditus* Michelotti
come from Aquitanian of Myanmar beside Antigona granosa (Sowerby). This assemblage suggest Aquitanian age.

A large number of Garo forms of Aquitanian - Burdigalian affinity occur in this bed. They are: Anadara garoensis Mukerjee, Mactra protoreevesii Noetling, Antigona granosa (Sowerby), Chlamys (Chlamys) senatoria (Gmelin) and conus (Lithoconus) ineditus Michelotti.

Besides, the bed also contains such taxa which have already been considered to occur in various subdivisions of Tertiary. These are: Tellina (Eurytellina) pilgrimi Cox (Oligocene) and Meretrix persica Cox (Vindobonian) of Persia; Chlamys (Chlamys) quilonensis Dey and Murex meagillivrayi Dohrn (Middle Miocene) of Quilon bed; and Clementia (Clementia) protopapyrus (Gray) (Oligocene) and Schizaster baluchistanensis Duncan and Sladen from Sind (Eocene). Moreover, the stratigraphic status of last one is doubtful (Pascoe, 1973).

The above scrutiny of the fauna from this bed tilts the balance in favour of Aquitanian - Burdigalian age with leaning towards the former, more so in the absence of any characteristic Burdigalian form.

6.2.3.6 Lunglei - Zothlang Section

Bed Nos. 1, 2 and 4 in this section (Fig. 2.9) are devoid of fossils while 3 and 5 have yielded few bivalve forms.

Bed No. 3: It is exposed at Serkawn village, Lunglei. The taxa of this bed are: Anadara garoensis Mukerjee, Diplodonta incerta d'Archiac and Diplodonta rotundatus (Montagu). Amongst these, first one is reported from Aquitanian - Burdigalian of Garo Hills; second one from Upper Gaj (Burdigalian) of Sind and third one from Burdigalian of Persia and Mekran beds. The last two forms are also known to come from Aquitanian -
Burdigalian of Garo Hills.

The assemblage referred above definitely points out Aquitanian - Burdigalian or Burdigalian age for the bed under discussion.

Bed No. 5: Stratigraphically, this bed is younger to the preceding one and is exposed at Zothlang village, Lunglei. The bed has yielded few well preserved bivalves, viz., Anadara (Anadara) narayanai n. sp., Anadara (Anadara) babui n. sp., Diplodonta incerta d'Archiac and Pholadomya sp. 1.

The only known form of this bed, i.e., Diplodonta incerta d'Archiac is quoted from Upper Gaj (Burdigalian) of Sind, and Aquitanian - Burdigalian of Garo Hills. Hence, the bed in question, like the preceding one, is assigned Aquitanian - Burdigalian or Burdigalian age.

6.2.3.7 Pukpui - Saza Section

 Altogether, eight beds are delineated along this section (Fig. 2.10) which belong to Upper Bhuban Formation. Of these, only Bed No. 6 is fossiliferous and the rest, by and large, lack in mega-biota.

Bed No. 6: The check list of the taxa from this bed and their occurrence in different areas is as under:

<table>
<thead>
<tr>
<th>Gastropods</th>
<th>Localities</th>
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<tbody>
<tr>
<td>1. Turritella cf. pseudobandongensis Vredenburg</td>
<td>Sind</td>
</tr>
<tr>
<td>2. Natica coxi Mukerjee</td>
<td>Garo Hills</td>
</tr>
<tr>
<td>3. Sinum protoneritoideum</td>
<td>- do -</td>
</tr>
<tr>
<td>4. Ficus (Ficus) conditus (Brongniart)</td>
<td>Garo Hills, Kama Formation of Myanmar and Gaj of Sind</td>
</tr>
<tr>
<td>5. Nassaria birmanica (Vredenburg)</td>
<td>- do -</td>
</tr>
</tbody>
</table>
6. **Anadara daviesi** Mukerjee  
7. **Chlamys cf. jamviniensis** Cox.  
8. **Pecten (Pecten) pascoei** Cox  
9. **Tellina (Oudardia) binodi** n. sp.  
10. **Pitar altoumononata** (Nagao)  
11. **Corbula mekranica** Vredenburg

**Crabs**

12. **Calappa protopustulosa** Noetling  
13. **Typilobus granulosus** Stoliczka

As indicated earlier, Kama and Pyalo Formations of Myanmar are Aquitanian and Burdigalian respectively while Garo Hills sediments and Gaj beds of Sind are Aquitanian - Burdigalian.

It may not be out of context to mention that **Calappa protopustulosa** Noetling and **Typilobus granulosus** Stoliczka are purely Burdigalian forms (Sastry and Mathur, 1970). The remaining forms are rather long ranging, therefore, the bed under discussion may be assigned to Burdigalian.

6.2.3.8 Lunglawn - Sazaikawn Section

The section (Fig. 2.11) is unique in the sense that it contains seven beds of Middle Bhuban Formation only. Leaving aside Bed No. 5, rest are devoid of Mega-biota, hence can not be dated.

**Bed No. 5:** It has yielded nine bivalved taxa in which four are new to science and one cf. The remaining four forms are: **Nucula warsarensis** Eames, **Nuculana virgo** (Martin), **Anadara craticulata** (Nyst) and **Glycymeris**
sindiensis Vredenburg. The first one has been reported from Gaj beds of Kachchh and Quilon beds of Kerala; second one from Kama Formation of Myanmar and Garo Hills; third one is widely occurring form both geographically as well as stratigraphically and last one is so far known to occur in Lower Gaj of Sind only.

The occurrence of Nuculana virgo (Martin) and Glycymeris sindiensis Vredenburg in this bed strongly favour Aquitanian age as these are characteristic form of this period.

6.2.3.9 Chhekpuikawl - Vanhe Section

This section (Fig. 2.12) exposes seven beds of Upper Bhuban Formation. In the lower part of the sequence, Bed No. 3 is fossiliferous, however, fossils are difficult to extract because of indurated nature of associated rocks.

Bed No. 3: It has yielded few well preserved bivalves, echinoids and crabs. Among the various species identified from this bed, only Schizaster alveolatus Duncan and Sladen has also been reported from Ecocene of Sind, rest of the forms being n. sp., cf. and sp. indet. Due to this, it is rather difficult to precisely date this bed. The only clue which is of some use is the occurrence of bivalve genus Pinna which in other sections is encountered along with Diplodonta incerta d'Archiac and Diplodonta rotundatus (Montagu) and chlamys (Chlamys) senatoria (Gmelin). The former two are mainly Burdigalian while the last one is Aquitanian - Burdiganlian.

In the light of the above, the bed under discussion has been correlated with other beds containing various forms of genus Pinna and roughly falls at par with Aquitanian - Burdigalian, more akin to the
Serthum - Theiriat Section

The section (Fig. 2.13) constitutes Upper Bhuban succession and divisible into five beds. Bed Nos. 1 and 5 are fossil yielding while three intervening beds are barren.

Bed No. 1: Bivalve forms collected from this bed are: Nucula (Nucula) agrawali n. sp., Anadara (Anadara) babui n. sp. and Diplodonta rotundatus (Montagu).

As mentioned earlier, the form cited last is mainly Burdigalian (Persia), though recorded from Aquitanian - Burdigalian of Garo Hills. Thus, the concerned bed may be safely assigned Aquitanian - Burdigalian age with more affinity towards the latter.

Bed No. 5: It is exposed at Theiriat village in the outskirt of Lunglei town. Altogether, eight species of bivalves and one of gastropod are recovered from this bed and out of these, only three are known forms, rest being n. sp., cf. and spp.

The three known taxa are: Chlamys (Chlamys) senatoria (Gmelin). Diplodonta rotundatus (Montagu) and Tellina (Eurytellina) pilgrimi Cox. The first one is common with the Gaj of Sind, Kachchh and Kathiawar, lower Miocene of Garo Hills, and Kama Formation of Myanmar; second one with the Burdigalian of Persia, and Aquitanian - Burdigalian of Garo Hills; and the last one with the Oligocene of Persia but long ranging in present areas.

In the present context, this bed may be dated as Aquitanian - Burdigalian with more affinity towards the latter. Moreover, this bed is stratigraphically younger to the preceding one.