PALAEONTOLOGICAL STUDIES OF SOME SELECTED SECTIONS OF UPPER BHUBAN ROCKS AROUND AIZAWL, MIZORAM

By

VICTOR ZOCHHUANA RALTE

Thesis submitted in fulfillment for the award of the Degree of Doctor of Philosophy in Geology

DEPARTMENT OF GEOLOGY
MIZORAM UNIVERSITY
AIZAWL
2008

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Ph. D Regd. No. MZU/Ph. D/45/16.12.2004

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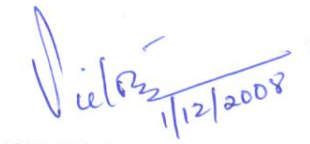
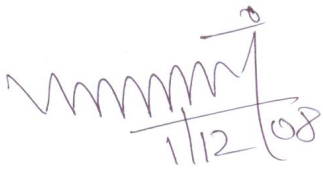
CERTIFICATE

I, Victor Zochhuana Ralte, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

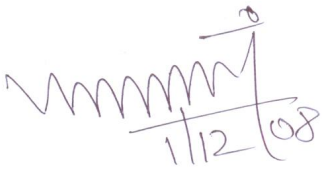
This is being submitted to Mizoram University for the degree of Doctor of Philosophy in Geology.



Aizawl (VICTOR ZOCHHUANA RALTE)



Prof. R. P. Tiwari
(Head of Department)



Prof. R. P. Tiwari
(Supervisor)

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Aizawl (VICTOR ZOCHHUANA RALTE)

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Plate No.	Description of plates
1	Field photographs of the fossil localities in the study area
2	Field photographs of the fossil localities in the study area
3.	Photographs of bivalve fossil species from the study area
4.	Photographs of bivalve fossil species from the study area
5.	Photographs of bivalve fossil species from the study area
6.	Photographs of bivalve fossil species from the study area
7.	Photographs of bivalve and gastropod fossil species from the study area
8.	Photographs of decapod fossil species from the study area
9	Photographs of foraminifer fossil species from the study area
10.	Photographs of fossil fish species from the study area
11.	Photographs of fossil fish species from the study area
12.	Photographs of fossil fish species from the study area
13.	Photographs of fossil fish species from the study area
14.	Photographs of fossil fish species from the study area
15.	Photographs of fossil fish species from the study area

CHAPTER -1

INTRODUCTION

1. INTRODUCTION

1.1 GENERAL REMARKS

Mizoram is the eastern most state of India and is sandwiched between Myanmar and Bangladesh. It covers a geographical area of about 21,081 square kilometers and exposes huge thickness of Tertiary sequences of the order of ~ 8000m. This succession has been grouped into the Barail, the Surma and the Tipam Groups. Geologically it is considered as the southern extension of Surma basin. In spite of huge thickness and good exposures, it has not yet been fully explored geologically rendering a vast scope for further researches in various aspects of earth sciences.

The State lies between 21°56'N to 24°31'N latitudes and 92°16'E to 93°26'E longitudes. It has maximum aerial dimensions of 285Km from north to south, and 115Km from east to west (Pachuau, 1994). Till 1972, it formed the southern mountain district of the Assam state and it was accorded the status of the Union Territory with capital at Aizawl in the year 1972. It became a full-fledged state in 1986. Mizoram is bounded by Chin Hills of Myanmar to the east, Chittagong Hill tracts of Bangladesh and the state of Tripura to the West, Manipur and Cachar district of Assam to the north, and again by Myanmar to the south. The tropic of cancer passes through the state, dividing it almost into two equal parts. Mizoram is connected with Assam through National Highway - 54. This highway having a total length of 572 Kms, connects Silchar (Assam) with Tuipang village in the southern corner of the state passes through Aizawl. It is also connected by air with Kolkota, Guwahati and Imphal.

The study area is around Aizawl and is covered by the Survey of India Topographic sheet Nos. 84 A/9, 84 A/10, 84 A/13 and 84 A/14 and lies within the coordinates of latitudes N 23° 42' to N 23° 47' and longitudes E 92° 39' to E 92° 46'. The location map of the study area is shown in figure 1.1.

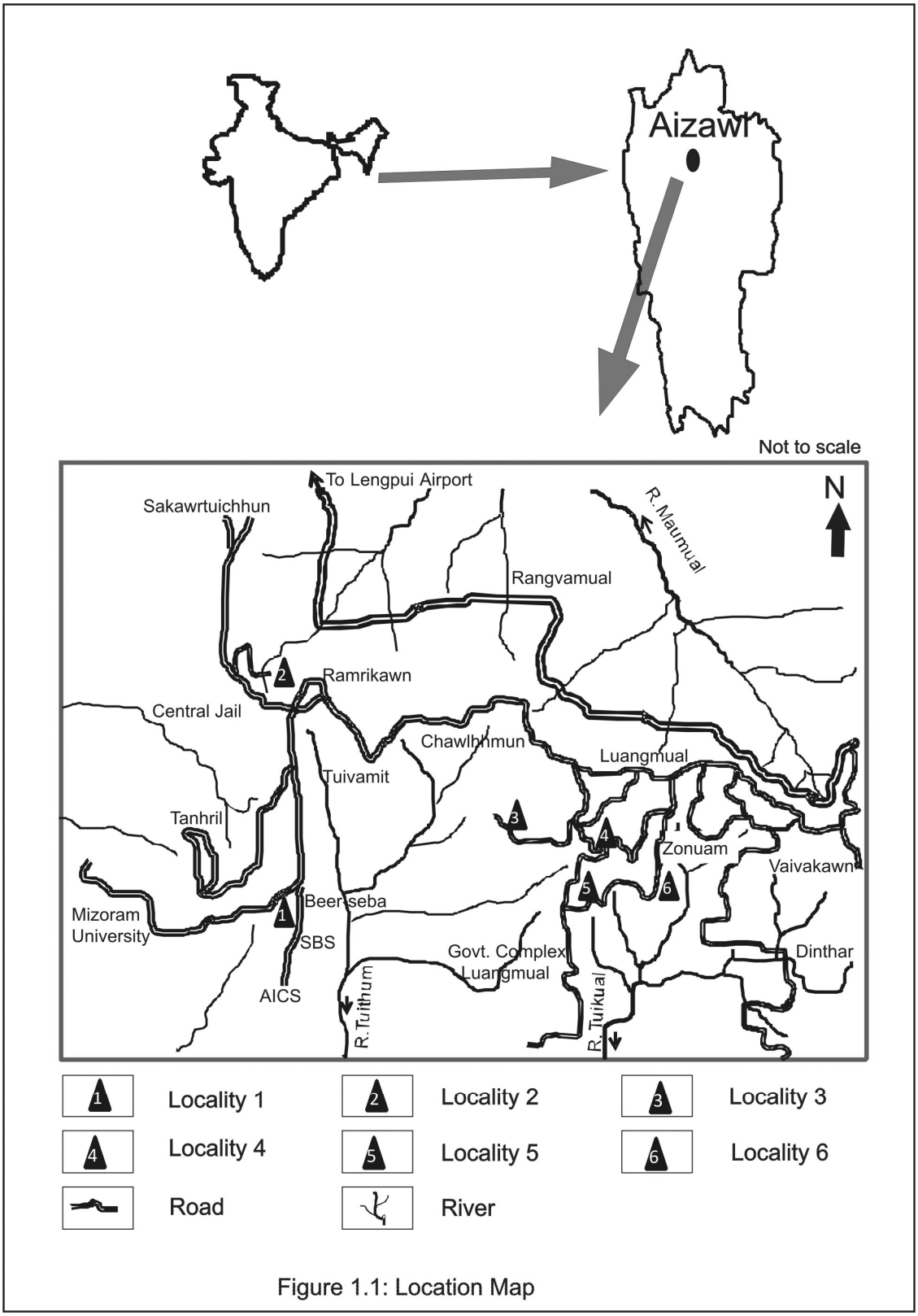


Figure 1.1: Location Map

Mizoram experiences a moderate climate owing to its location in the tropical region. It has a humid climate characterized by short winters and long summers with heavy rainfall. The temperature varies from 11°C to 23°C during winter, 21°C to 35°C during summer and 18°C to 25°C during Autumn season. The state is under the direct influence of southwest monsoon and experiences heavy rainfall. The onset of monsoon is in the month of May, lasting till late September. Mizoram has an annual average rainfall of 250 cm. The northwestern part of the state receives the highest rainfall averaging to 350 cm annually. The highest ever-recorded rainfall in Mizoram has been 602.60 cm during the month of July, 1983. Maximum rainfall generally takes place in the months of July and August while December and January are normally rain-free and form the driest months of the year (Pachuau, 1994).

1.1 FLORA AND FAUNA

The state is endowed with a very rich and diversified floral and faunal species because of the mingling of eastern floral and faunal species besides the North Indian ones. The entire state abounds in sub-tropical trees, plants, bushes, grasses and a variety of bamboos. Fern and allies, soft stemmed herbaceous plants, orchids and other epiphytes make a long list of plants endemic to this area and form a unique assemblage of non-tree floral species.

The forests in Mizoram houses a large variety of wild animals like tiger, leopard, sambhar, deer, bear, wild pig, mithun, mountain goat, flying squirrel, monkey, snakes and other reptiles.

1.2 GEOMORPHOLOGY

The hilly terrain of Mizoram is highly undulated and rugged consisting of alternating ridges and valleys that approximately trend N-S to NNE-SSW with a tendency to taper at both the ends. The terrain exhibits first order topography. The average elevation of the state is about 900 meters above Mean Sea Level. The elevation ranges from 40

meters at Bairabi (Mizoram-Assam border) to 2157 meters at Phawngpui (Blue Mountain) along the Myanmar border. Thus the general elevation increases from west to east. The hill ranges mainly comprise relatively compact and resistant older rock units exposed in the anticlinal crest, whereas the valleys are composed of younger and softer formations exposed in the synclinal troughs (Ganguly, 1983). Hills are generally characterized by steep slope, mostly anticlinal, trending approximately N – S, and are separated by synclinal narrow river valleys flowing either towards north or south forming deep gorges. These anticlines and synclines are intersected by transverse faults. The difference in elevation between valley floors and hilltops varies greatly from west to east ranging from 200m to 600m (Karunakaran, 1974).

The terrain is young and immature due to recent tectonism. It shows prominent relief and topographic features with steep slopes. The major geomorphic features are mostly erosional landforms comprising of structural and topographic 'highs' and 'depressions', 'flats' and 'slopes' that are arranged in linear fashion.

The area exhibits angular, sub-parallel, parallel and dendritic drainage patterns. Lower order streams run both parallel and across topographic 'highs' and 'depressions'. Dhaleswari (Tlawng), Sonai (Tuirial) and Tuivawl are the major rivers that flow northerly. These rivers originate in the central part of the state and drain water into the Barak Valley of Assam indicating general slope direction towards the north. The important southerly flowing rivers are Koladyne (Chhimtuipui) and Karnafuli. The former is the biggest river in the state, originates from Myanmar and flows southerly through a distance of about 500 km in Mizoram and enters Myanmar again. Karnafuli River originates at the southern tip of Mizoram, flows northerly up to the central part of the state, then takes turn towards west and enters into Bangladesh.

1.4 PREVIOUS WORK

The geological studies in Surma succession of Mizoram is not at par with the other geological terrains of the country due to its remote location, inaccessibility and highly

rugged and undulated topography coupled with dense vegetative cover. The earliest known geological field work in Mizoram was conducted by La Touche in 1891 in Lunglei area of Mizoram. Subsequently, Hayman (1937), Franklin (1948), Das Gupta (1948) and Brunnschweiler (1966) carried out geological investigations in different parts of Mizoram. However, it was only after 1970s, that the pace of detailed investigation on various geological aspects of the Tertiary succession was accelerated by several workers *viz.*, Das Gupta (1977, 1984), Ganju (1971, 1972, 1974, 1975), Ganguly (1974, 1975, 1983), Ganguly *et al.* (1973), Jokhan Ram *et al.* (1983), Nandy (1972, 1980, 1982), Nandy *et al.* (1983), Ranga Rao (1983), Sarkar *et al.* (1977), Shrivastava *et al.* (1979), Tiwari *et al.* (1989), John *et al.* (1990), Bhaskar *et al.* (1990), Purushottaman *et al.* (1990) and Tiwari *et al.*, 2007).

As far as palaeontological investigations in the Surma successions of Mizoram are concerned, no exhaustive work has been done until 1980s. Identification of fossils was preliminary, mostly up to generic level, that too without any description and illustration. The details of these investigations are given below.

La Touche (1891) while carrying out geological mapping in the Lunglei area of Southern Mizoram, reported for the first time the occurrence of an irregular echinoid genus *Schizaster* sp. Thereafter, there was a long period of quiescence in the palaeontological studies in the state. It was only in 1972 that Chatterjee reported the occurrence of ostracods and foraminifers from the Upper Bhuban Formation near Sairang. Subsequently, Mukerjee and Saxena (1973) located a few bands of shell conglomerates within Upper and Middle Bhuban rocks along Lunglei - Demagiri road between Pachang and West Rotlang. From their collection, Sinha (1973) identified some mollusks, echinoids and shark teeth.

Banerjee, Sarkar and Das Gupta (1977, in Das Gupta, 1982) located calcareous sandstone and shell limestone boulders along the narrow gorge of Ngharum Lui and Subai Lui, tributaries of Sonai river, south of the bridge on the same river, on the Aizawl – Seling Road. Mishra (1977, in Das Gupta, 1982) identified foraminifers while Bhattacharyya (1977) reported bivalves in the samples from these boulders. According to them, the

assemblage is indicative of Oligo-Miocene age. Similarly, Bhattacharyya (1977 in Das Gupta, 1982) also identified foraminifers and bivalves from the samples of shell limestone from the Koladyne river bed collected by Das Gupta (1977).

Banerjee and Das Gupta (1978 in Das Gupta, 1982) discovered three fossil localities within the rocks presumably belonging to Lower Bhuban Formation in and around Tuipang. A good number of bivalves, gastropods, foraminifers and ostracods were identified by Bhattacharyya and Sen (1978) from the collection of these localities. They suggested Eocene to Miocene age based on mega fossils and Miocene age on micro fossil assemblage (in Das Gupta, 1982).

Das Gupta (1982) reviewed the faunal records of the Surma basin and reported the occurrence of a few genera of bivalves, gastropods, foraminifers and ostracodes from different parts of Mizoram. He observed that the faunal assemblages of the Surma basin show a close affinity with those reported by Noetling (1895, 1901) and Stuart (1910) from the Kama and Pyalo beds of Myanmar. He inferred that the Lower Bhuban Formation in Mizoram may transgress Palaeogene - Neogene boundary. Similarly, Sinha *et al.* (1982) gave the status of palaeontological investigations in the northeastern region of India including Mizoram and referred to the presence of a few bivalves, gastropods and echinoids in the Surma group of rocks.

Satsangi and Mehrotra (1983) reported the occurrence of selachians (*Hemipristis serra*, *Carcharodon* cf. *carcharias*, *Carcharhinus* sp., *Odontaspis cuspidata*, *Negaprion* sp., ? *Isurus* sp.), batoid (*Dasyatis* sp.) and teleost (siluroid tooth) from the Bhuban rocks of Kolasib area. Similarly, Mehrotra (1984) reported *Alopias* sp., *Odontaspis* cf. *contortidens*, *Carcharhinus nicaraguensis* (sharks) and *Sparus cintus* (teleost) from the calcareous sandstone of Kolasib area. Satsangi (1985) reported larger and smaller foraminifers along with isolated teeth and spines of sharks and ray fishes from Bhuban Formation, South Hlimen, ~5 km south of Aizawl, and suggested shallow marine environment of deposition for the beds. However, these earlier records especially of fossil fish teeth from the Tertiary sediments of Mizoram are in the form of reporting in the News Letters of Geological

Survey of India. These reports are mostly up to generic level and are without systematic descriptions, therefore detailed comparison of the earlier reported invertebrates and vertebrates from the state could not be made with the present collections due to lack of details.

Satsangi and Mehrotra (1986) recorded the occurrence of echinoderms and arthropods in the collection of Mishra *et al.* (1986) from Upper Bhuban Formation in Aizawl District. Satsangi and Patil (1988) identified bivalves, gastropods, echinoids, corals, decapods and shark teeth from the sandstone - siltstone and mud-pellet conglomerate horizons of Upper Bhuban Formation of Aizawl and Chhimtuipui Districts. They inferred that invertebrate fauna, on the whole, shows a good resemblance to the Aquitanian – Burdigalian fauna of the Garo Hills, Meghalaya. Tiwari and Satsangi (1988) described for the first time a fossil crab *Portunus* sp. from a locality 3.5 km of Lunglei town on the Lunglei – Vanhne road within the Upper Bhuban Formation. They assigned a Lower Miocene age and shallow marine environment of deposition to the crab yielding horizon. Patil (1989 and 1990) reported a large number of bivalves, gastropods, echinoids, decapods, shark teeth and foraminifers from the samples of grey sandstone and yellow siltstone horizons of Upper Bhuban Formation from the area in and around Lunglei town. He suggested Aquitanian to Burdigalian age for the beds containing this assemblage. It is pertinent to mention here that the inferences arrived at by earlier workers regarding the age and depositional environment of Surma succession are solely based on the preliminary identification of fossils.

An important step forward in the palaeontological studies, however, was made by Tiwari (1992). He described and illustrated 125 species of bivalves, gastropods, echinoids, crabs, shark teeth and scaphopods from the Bhuban Formation of Aizawl and Lunglei areas of Mizoram. He erected three biozones – one within the Middle and two within the Upper Bhuban Formations - and assigned them to Aquitanian and Aquitanian - Burdigalian to Burdigalian respectively. Later on, Hait and Banerjee (1994), on the basis of their report on the rich and diversified tropical and subtropical palyno assemblages from the succession

suggested coastal and brackish water environment of deposition. They assigned Bhuban Formation to Lower Miocene and Tipam Group to Upper Miocene. Tiwari *et al.* (1997) reported the occurrence of four genera and five species of decapods crustaceans from the Upper Bhuban Formation and assigned it to Aquitanian - Burdigalian to Burdigalian. Subsequently, Tiwari *et al.* (1998) recorded eight species of fish teeth from the Middle and Upper Bhuban Formations in and around Aizawl and Lunglei areas. Tiwari and Kachhara (2000) described two new species of *Apolymetis* (Bivalvia: Tellinidae) from the Upper Bhuban Formation of Mizoram. Tiwari and Mehrotra (2000) described five species including a new one of wood from the Tipam Group of Mizoram and inferred prevalence of warm and humid climate during the time of deposition of these sediments. Mandaokar (2000) reported palynomorphs from the Bhuban Subgroup of Aizawl that favoured the existence of brackish water swamp and prograding delta complex with fresh water influx. Mehrotra *et al.* (2001) recorded an ichnospecies, *viz. Teredolites clavatus* Leymerie from the Upper Bhuban Formation of Aizawl and inferred shallow marine transgressive phase of deposition. Tiwari and Bannikov (2001), with the help of three new species of early Miocene marine fishes from the Upper Bhuban Formation of Aizawl and Buarpui, inferred a near-shore, shallow water, probably estuarine, marine environment of deposition. Tiwari (2001) while describing 14 species of bivalves from the Bhuban Subgroup in Mizoram inferred a shallow marine (inner neritic to littoral) environment of deposition. Tiwari and Mehrotra (2002) while working on the leaf and seed impressions from the Barails of Champhai area inferred the occurrence of tropical forest under warm and humid climate prevailing in the nearby area during the time of deposition. Mehrotra *et al.* (2003) illustrated and described a *Nypa* plant fossil from Kolasib of Mizoram and were of the opinion that the Bay of Bengal was extending northward during Miocene than its present day boundary. Tiwari and Kachhara (2003) made notable contributions in the biostratigraphic studies of the Tertiary rocks of Mizoram and established five biozones in the Barail and Surma successions of the state. These Zones are: I. *Meretrix agrestis* Zone of Late Eocene to Oligocene age, II. *Glycymeris sindiensis* - *Nuculana virgo* Zone of Aquitanian age, III. *Ostrea latimarginata* - *Natica pellis tigrina* Zone of Aquitanian to Burdigalian age, IV. *Pecten* (*Oopecten*) *gigas* Zone of Burdigalian age, and V. *Pecten* sp.

Zone of Helvetian age. Jauhri *et al.* (2003) reported an interesting assemblage of corals, foraminifers and echinoids from Upper Bhuban sediments from a locality near Zemabawk, Aizawl. Mazumder (2004), while working for his doctoral degree, identified 153 forms of which 118 belong to bivalves, 21 to gastropods, 8 to decapods, five to echinoids and one to scaphopods from the Surma rocks in and around Kolasib, Mizoram. He proposed two bio-zones in Surma rocks. These are Zone-1. *Nucula* (*Lamellinucula*) aff. *pulchra* - *Nuculana* (*Nuculana*) *virgo* of Aquitanian age in the Middle Bhuban, and Zone - 2 *Chlamys* (*Argopecten*) *senatoria* - *Tellina* (*Tellinella*) *pseudohilli* of Aquitanian – Burdigalian to Burdigalian in the Upper Bhuban. He further proposed two subzones within Zone - 2 (Subzone 2A: *Clementia* (*Clementia*) *papyracea* of Aquitanian to Burdigalian in the Upper Bhuban and Subzone 2B: *Callista* (*Costacallista*) *erycina* - *Antigona granosa* - *Trisidos semitorta* of Burdigalian in Upper Bhuban). Subzone 2A has two Zonules (Zonule 2A(a): *Conus* (*Lithoconus*) *ineditus* - *Diplodonta* (*Diplodonta*) *incerta* of Aquitanian - Burdigalian), and Zonule 2A(b): *Conus* (*Dendroconus*) *loroisii* - *Archimediella* (*Torculoidella*) *angulata* of Burdigalian. The assemblage reported here points to a shallow marine to coastal depositional environment. Palaeogeographically, the basin around Kolasib was a part of the Indo - Pacific zoogeographic province. A good number of fauna endemic to this province are recorded from the area. For example, *Fragum*, *Donax*, *Antigonia*, *Trisidos*, *Lutraria*, *Cultellus*, *Apolymetis*, *Solecurtus*, *Corbula*, *Natica*, *Conus* (*Dendroconus*), *Conus* (*Lithoconus*), *Tellina* (*Tellinella*), *Clementia* and *Architectonica* are typical faunas of the Indo - Pacific Province. Even at species level, the typical Indo - Pacific taxa, e.g. *Clementia papyracea* (Gray) (Davies, 1975; Tiwari *et al.*, 1998b), are present in the area leaving no doubt that this area was a part of palaeozoographical Indo - Pacific Province of Miocene Epoch. Lalchawimawii (2004), while working for her M. Sc. Dissertation, reported 53 forms of mega-invertebrates comprising of 47 forms of bivalves, three of gastropods, and one each of scaphopods, echinoids and decapods from the Upper Bhuban Formation of South Hlimen, Aizawl. Tiwari (2006) has described twelve species of genus *Tellina* from the area in and around Aizawl and Lunglei out of which four have been designated as new. He assigned an overall age of Aquitanian - Helvetian for the Bhuban

Formation and inferred sandy substrate with depth ranging from inter - tidal to 75 fathoms (135m), and normal salinity of sea water.

Kapesa and Raju (2007) reported the presence of varied assemblage of planktonic and benthic foraminifers comprising of six genera (*Ammonia*, *Baggina*, *Orbulina*, *Praeorbulin*, *Clavatorella* and *Lagena*) and seven species (*Ammonia umbonata*, ?*Baggina* sp, ?*Orbulina* cf. *bilobata*, *Praeorbulina glomerosa circularis*, *Praeorbulina* cf. *transitoria*, *Clavatorella* cf. *sturanii* and *Lagena* sp.) from the fossiliferous bed supposedly belonging to the Upper Bhuban Formation sequence exposed at Thuampui, Aizawl. On the basis of this foraminiferal assemblage, an early Middle Miocene age equivalent to planktonic foraminiferal zones N8 - N9 and a paleobathymetry of 50 metres is suggested for these fossiliferous horizons.

1.5 SCOPE OF PRESENT WORK

Regardless of good exposure of Tertiary succession in Mizoram, detailed geological investigations are still scanty and are not sufficient for reconstructing the geological history of the area. Thus, there is a need for more comprehensive geological studies to fill up the gaps. For instance, the criterion used for classifying the Bhuban Formation into lower sub-divisions i. e. ratio of arenaceous and argillaceous components, at times cannot be applied in the field due to large scale lateral litho-facies variations. Lithostratigraphy, therefore, it may sometimes become misleading in identifying and correlating the succession regionally as well as locally. In such situations, palaeontological studies may act as problem solving tool. Realizing this, Tiwari (1992) and Tiwari and Kachhara (2003) adopted the palaeontological approach for identification and correlations (local and regional) of isolated sections of Surma succession of Mizoram. They established five biozones in the Barail and Surma successions of Mizoram. Similarly, Mazumder (2004) also carried out biostratigraphic studies in and around Kolasib area, Mizoram and proposed two biozones along with two subzones and two zonules within the Bhuban Formation. The present work also focuses on the above theme with a view to update and supplements the existing palaeontological database of the Bhuban Formation of Mizoram. Needless to mention that,

the improved palaeontological data base will provide better interpretation in terms of age, correlation and depositional environment of the Surma succession of Mizoram. Thus, keeping these aspects in view, the present study was taken-up with the following objectives:

1. To explore the fossil wealth of the Upper Bhuban unit of Bhuban Formation (Surma Group) exposed around Aizawl, Mizoram including systematic description and illustration.

2. To use the data thus generated in constraining the age of the fossiliferous horizons, proposing bio-zones and correlating the faunal assemblage with the hitherto known assemblages from other Miocene localities in the Indian Subcontinent, and

3. To reconstruct the depositional environment.

1.6 METHODOLOGY

The present study is carried out systematically as mentioned below:

a. Literature Survey

Systematic collection of relevant literature and survey has been made from the libraries of the Geological Survey of India at Kolkata and Lucknow, Wadia Institute of Himalayan Geology, Dehradun and Department of Geology, University of Lucknow, Lucknow. Additionally, literature has also been downloaded from the internet.

b. Fieldwork

Geological map of Mizoram prepared by Ganju (1975) and Nandy (1983) has been used as a base map for field work in the study area. Extensive field work was carried out along several road and nallah sections, and quarry sites for locating fossiliferous horizons. Field data for preparation of litho-columns at the fossil localities was collected. Fossil

bearing horizons were demarcated in the litho-columns. Systematic collection of mega fossils was done along with the enclosing rock samples.

c. Laboratory work

The mega biota thus collected was brought to the laboratory. They were assigned numbers after necessary cleaning. Identification of mega-biota was done using relevant literature on fossil faunas and comparison with the specimens housed in the GSI laboratories at Kolkata and Lucknow and in the Palaeontology Laboratory, Department of Geology, Mizoram University, Aizawl. Description of the species was attempted as per the standard format used by the paleontologists. The fossils were photographed for making plates. Most of the photographs were either magnified or reduced depending on the original size in order to show morphological details necessary for their identification.

Thin sections of selected rock samples were made in order to ascertain the presence of foraminifers. Rock samples containing foraminifers were macerated by crushing down to finer sizes followed by treatment in luke warm water mixed with 5 per cent acetic acid. The residue was wet-sieved, dried and samples retained in the 40 and 35 mesh were used for the separation of foraminifers. The samples thus separated were identified and described using standard method. Better preserved foraminiferal tests were photographed under Scanning Electron Microscope in addition to the ordinary photography.

d. Analysis and Interpretation

A detailed bed-wise faunal analysis was carried out and the age of fossiliferous horizons was attempted mainly based on the entombed fossil species *vis-à-vis* their previous occurrences. The vertical distributions of all fossil species were ascertained in the litho-columns. The litho-columns were then compared with each other to work out the biozones in order to establish the biostratigraphy of the Surma sediments in the area under investigation. The biozones so established were used for correlation of the local sequences in different sections and with those of contemporaneous successions in other parts of the Indian Subcontinent. Depositional environment was deciphered from the lithological characteristics and modern ecology of the entombed fauna.

CHAPTER -2

GEOLOGICAL FRAMEWORK AND TECTONIC SETTINGS

2. GEOLOGICAL FRAMEWORK AND TECTONIC SETTINGS

2.1 REGIONAL GEOLOGICAL SET UP

Mizoram, geologically is a part of Tripura - Mizoram depositional basin and it has been considered as the southern extension of Surma Valley. It evolved after the regional uplift of Barail succession and thus, was related with the plate behaviour in the subduction zone west of Arakan - Yoma, after the spreading of Indian Ocean (Evans, 1964). Sarkar and Nandy, 1976 opined that in lithological and mineralogical characteristics, primary-sedimentary structures and degree of compaction, rock successions of Mizoram differs considerably from that of the typical Surma Valley. The entire sedimentary column of the area is a repetitive succession of Palaeogene and Neogene arenaceous and argillaceous rocks constituted of sandstone, silty-sandstone, siltstone, shale, mudstone, sand rock, silt and their admixture of varying proportions along with a few pockets of shell-limestone, calcareous sandstone and intraformational conglomerates. The entire succession is thrown into a series of approximately N-S trending, longitudinally plunging anticlines and synclines (Ganju, 1975 and Ganguly, 1983). The general strike direction of the rock formation is N-S with dip amount varying from 20°- 50° either towards east or west. The sediments are characterized by various primary-secondary structures which include Bouma's cycle of turbidite features, viz., Ta-b-c-d-e, etc. (Bouma, 1962, 1969), with structure like flutes to non-oriented dimple structures through an intermediate ridge structure as a down current varient, groove and chevron casts, load casts with flame structures and parting lineations. Besides ripple-drift cross lamination of sinusoidal type, type A, C of Jolping and Walker (1968), ripple load convolutions and ripple-trough convolutions, interference ripples with tadpole nest structure, sinuous crested linguoid ripples are not uncommon. The palaeocurrent directions shown by all the primary features reveal a mean southerly transport direction (*i.e.* south to the south-west) indicating a southerly plunging basin (Sarkar and Nandy, 1976).

Sequentially, the Tertiary rocks of Mizoram have been grouped into the Barail, the Surma and the Tipam Groups in the ascending order. The stratigraphic succession in the state as worked out by Karunakaran (1974) and Ganju (1975) with

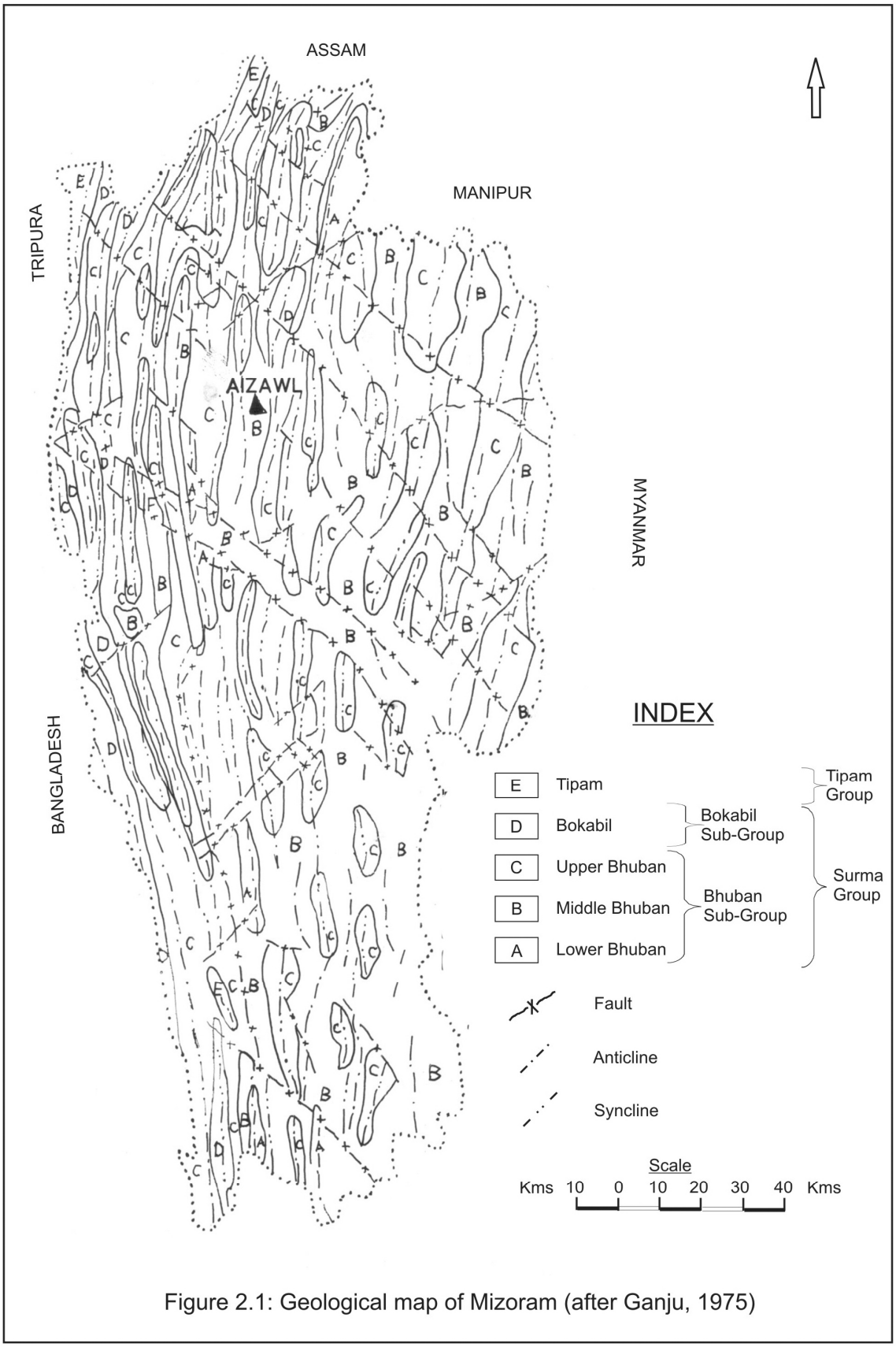


Figure 2.1: Geological map of Mizoram (after Ganju, 1975)

Table 2.1:Stratigraphic Succession of Mizoram (Modified after Karunakaran, 1974 and Ganju, 1975)

Age	Group	Formation	Unit	Generalized Lithology
Recent	Alluvium			Silt, clay and gravel
_____Unconformity_____				
Early Pliocene to Late Miocene	TIPAM (+900m)			Friable sandstone with occasional clay bands
_____Conformable and transitional contact _____				
Miocene	S	Bokabil (+950m)		Shale, siltstone and sandstone
_____Conformable and transitional contact _____				
	U	B	Upper Bhuban (+1100m)	Arenaceous predominating with sandstone,shale and siltstone
___Conformable and transitional contact _____				
to	R	H U	Middle Bhuban (+3000m)	Argillaceous predominating with shale, siltstone-shale alternations and sandstone
___Conformable and transitional contact _____				
Upper Oligocene	M	B A N	Lower Bhuban (+900m)	Arenaceous predominating with sandstone and silty-shale
	A (+5950m)			
_____Unconformity obliterated by faults _____				
Oligocene	BARAIL (+3000m)			Shale, siltstone and sandstone
_____ Lower contact not seen_____				

slight modification is given in Table 2.1 and the geological map is shown in fig. 2.1. However, the presence of Barail Group in Mizoram is debatable. Munshi (1964), Nandy (1972, 1982) and Nandy *et al.*, (1983) are of the view that the rock exposures in and around Champhai area in the eastern part of the State belong to Barail Group. Ganju (1975), Ganguly (1975), Shrivastava *et al.* (1979) and Jokhan Ram and Venkataraman (1984), on the other hand, opined that the Barails do not occur in Mizoram and the rocks around Champhai belong to Surma succession.

The Surma Group is divisible into a lower Bhuban Formation and an upper Boka Bil Formation. Bhuban Formation is further divisible into lower, middle and upper Bhuban Units. In general, Lower Bhuban succession is confined to the anticlinal cores of high amplitude folds while Middle Bhuban succession is mostly found on the limbs of folds and it also occupies the cores of low amplitude anticlines. The Upper Bhuban rocks form anticlines in western Mizoram but are confined to the synclinal cores in central and eastern Mizoram. Boka Bils and Tipams are confined to the cores of synclines in the western and northwestern parts of the State (Ram and Venkataraman, 1984).

2.2 STRUCTURE AND TECTONICS

Structurally, the Mizo Hills are considered to be forming an integral part of the mobile belt constituted of very tight, sub-parallel, elongated, doubling plunging folds. The folds are sub-meridionally trending anticlines alternating or en-echelon with broad saucer shaped synclines. The fold belt is slightly arcuate in shape with westward convexity (Srivastava *et al.*, 1979). The intensity of deformation becomes progressively lesser from east to west across the fold belt and the succession also becomes younger in the same direction. Thus, the western flanks of the State along with the neighbouring areas i.e Tripura and Cachar district of Assam are typified by younger rock formations folded into narrow, box-like anticlines in alternation with wide and flat synclines, while the eastern part of the state is characterized by relatively older rock formations folded into tight, linear anticlines and synclines (Ganguly, 1983). There are around 15 major long and arcuate anticlines and corresponding synclines in the region (Nandy *et* al., 1983). These anticlines and synclines are commonly dislocated by numerous

longitudinal faults and thrusts (Jokhan Ram and Venkataraman, 1984). These faults have maximum throws at or near the crest of an anticlines and plunge down and disappear towards the pericinal extremities. The magnitude of faulting generally increases with an increase in the intensity of folding to the east. The hill ranges mainly comprise of compact and resistant older units exposed in the anticlinal crests, whereas the valleys are composed of younger and softer formations exposed in the synclinal troughs (Ganguly, 1983). Tectonically, Mizoram forms a part of the Indo-Myanmar fold belt (Sarkar and Nandy, 1976). The arcuate shape of this fold belt is the result of the eastward subduction of the Indian plate along the Arakan - Yoma suture during Eocene time (Nandy, 1982). Neogene succession deposited in the mobile belt is deformed into a series of sub-parallel folds by both horizontal compressions as well as by vertical motion (Sarkar and Nandy, 1976).

2.3 GEOLOGY OF THE STUDY AREA

The rock succession in and around Aizawl forms an anticlinal structure referred to as Aizawl anticline that is asymmetrical and doubly plunging. Middle and Upper Bhuban units of Bhuban Formation, Surma Group constitute Aizawl anticline. Fossil localities could be delineated in the western limb of this anticline where the rock succession belonging only to Upper Bhuban unit of Bhuban Formation is exposed. The rock types in the western limb comprises of repetitive alternation of sandstones, shale, silty-sandstones and siltstone along with a sporadic occurrence of pockets of calcareous sandstones, and intraformational conglomerates. The general strike direction of these rocks is more or less N-S and the general dip is towards west with varying amount ranging from 15° - 70°. Geological map of Aizawl and its surrounding areas is given in fig. 2.2. The collection of fossils comes from the six localities out of which four are new ones. The detail lithological characteristics along with the faunal contents of each fossil locality in the study area are given below:

LOCALITY 1: Bika Quarry, University Road, Tuivamit, Aizawl.

This locality is at the quarry site located (N 23^0 45’ 184’’ –E 92^0 40’ 792’’) at about 12 kms from Aizawl on the left side of Aizawl – Mizoram University road. The litho-column of the rocks exposed at this quarry is given in fig. 2.3(A). There are two

fossiliferous beds in this locality. The lower one consists of 8.5m thick grey coloured silty-sandstone. It is a bluish grey colored, fine grained, moderately hard and compact litho-unit. Flaser beddings, interference ripples and ripple-drift cross laminations are the dominant primary-sedimentary structures of this litho-unit. Biogenic sedimentary structures like worm burrows of various kinds are also common. This bed contains two intra-formational conglomeratic bands at 0.95 to 1.30m and 8.50 to 8.65m levels respectively. These bands are calcareous and contain pebbles that are extensively bored. These bands also contain specks of pyrite minerals, coal streaks and ambers. Bulk of the fauna from this bed comes from the lower conglomeratic band and the assemblage consists of bivalves, gastropods, decapods, monogeneric form of foraminifers and fish teeth. The upper bed is 3m thick fossiliferous brown silty-sandstone. It is fine to medium grained with high proportion of argillaceous matrix. It is well bedded, moderately hard and compact in nature. The fossils within this bed occur sporadically and are poorly preserved. This bed has only yielded *Mactra* (*Mactra*) *protoreevesii* Noetling and several unidentifiable regular and irregular echinoids. Though preservation of fossils is generally poor and mostly in the form of moulds and casts of isolated valves, a few well preserved bivalved specimens have also been collected. However, the preservation of fish fauna is rather good and in majority of the cases complete teeth have been recovered. Recovery of fossils becomes difficult due to hard and indurated nature of the host rocks. Following is the list of fauna identified from this bed:

Bivalves: *Barbatia* sp., *Anadara* (*Anadara*) *craticulata* (Nyst), *Anadara* (*Anadara*) *daviesi* Mukerjee, *Anadara* (*Anadara*) *trapezoida* Tiwari, *Anadara* (*Anadara*) *garoensis* Mukerjee, *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Pecten (Pecten) mathuri* Tiwari, *Cyclocardia* sp., *Astarte* (*Bythiamena*) *striata* Tiwari, *Clinocardium* sp., *Lutraria philippinarum* Reeve, *Tellina* (*Tellinella*) *loknathi* Tiwari, *Glossus* (*Cytherocardia*) *cytheroides* (Mayer), *Callista* (*Callista*) *pseudoumbonella* Vredenburg, *Dosinia* (*Dosinia*) *peralta* Vredenburg, *Dosinia* (*Dosinia*) *subpenicillata* Vredenburg, *Clementia* (*Clementia*) *papyracea* (Gray), *Corbula* (*Corbula*) *tunicosulcata* Vredenburg, and *Corbula* (*Corbula*) *mekranica* Vredenburg.

Gastropods: *Archimediella* (*Torculoidella*) *angulata* (Sowerby), *Ficus* (*Ficus*) *kachhensis* (Vredenburg), *Ficus* (*Ficus*) *conditus* (Brongniart), *Conus* (*Leptoconus*) *bonneti* Cossmann, and *Conus* (*Dendroconus*) *loroisii* Kiener.

Decapods: *Calappa protopustulosa* Noetling, *Neptunus sindensis* Stoliczka, *Palaeocarpilius rugifer* Stoliczka, and *Xantho* sp.

Foraminifers: *Ammonia annectens concinna* Millet and *Ammonia* sp.

Fish teeth: *Lamna* sp., *Carcharodon carcharias* Linnaeus, *Carcharodon angustidens* Agassiz, *Isurus spallanzanii* Bonnaparte, *Isurus pagoda* Bonnaparte, *Alopias* sp., *Odontapis* cf. *taurus* Rafinesque, *Odontapis* cf. *tricuspidatus* Day, *Odontapis* sp., *Carcharhinus egertoni* Agassiz, *Carcharhinus priscus* Agassiz, *Carcharhinus* cf. *macloti*, *Carcharhinus bhubanicus* n. sp., *Carcharhinus* (*Prionodon*) sp., *Carcharhinus* sp. A., *Carcharhinus* sp. B, *Carcharhinus* sp. C, *Carcharhinus* sp. D, *Galeocerdo aduncus* Agassiz, *Negaprion brevirostris* Poey, *Negaprion* cf. *eurybathrodon* Blake, *Scoliodon sorrakawah* Cuvier, *Hemipristis serra* Agassiz, *Hemipristis unidenticulata* n. sp., *Sphyrna zygaena* Linneaus, *Sphyrna diplana* Springer, *Galeorhinus* sp., *Squalus* sp. (Selachians); *Myliobatis* sp., *Aetobatus* sp. (Batoids); *Diodon* sp.1, *Diodon* sp.2, *Diodon* sp.3 and *Diodon* sp.4 (Teleosts).

LOCALITY 2: Ruata Quarry near Ramrikawn, Tuivamit, Aizawl.

A quarry (N 23^0 45’ 143’’ –E 92^0 40’ 631’’) at about 12 kms from Aizawl on the right side of Aizawl – Sakawrtuichhun road exposes fossiliferous rocks belonging to Upper Bhuban unit of Bhuban Formation. The detail lithology of this fossil locality is shown in fig. 2.3 (B). This locality seems to be the strike continuation of the locality 1. Here again, fossiliferous grey coloured silty-sandstone (lower bed) and brown silty-sandstone (upper bed) are exposed but, the thickness of the lower bed is 9.00m and the exposed thickness of the upper bed is 0.71m. The lower bed at this locality also contains two intraformational conglomeratic bands, the lower one at 0 – 0.33m and the upper one at 4.5 – 4.9m stratigraphic levels. Primary-sedimentary structures like flaser beddings, ripple-drift cross laminations and wavy laminations are common in this locality. Majority of the framework grains of this conglomeratic unit are composed of calcareous pebbles. Boring within the calcareous pebbles are numerous and prominent.

The bed is highly bioturbated with a large numbers of worm burrows of different types. The bulk of the fauna from this locality has been collected from the lower bed mainly from the upper conglomeratic band and the faunal assemblage consists of bivalves, gastropods, decapods and fish teeth. No identifiable biota could be collected from the upper bed. The faunal list from this locality is given below:

Bivalves: *Barbatia* (*Barbatia*) *bataviana* Martin var**.** *carinata* Noetling, *Trisidos semitorta* (Lamarck), *Anadara* (*Anadara*) *craticulata* (Nyst), *Anadara* (*Anadara*) *daviesi* Mukerjee, *Anadara* (*Anadara*) *luangmualensis* Tiwari, *Arcopsis* sp., *Lutraria* (*Lutraria*) *saigengai* Tiwari, *Cultellus* sp., *Tellina* (*Tellinella*) *loknathi* Tiwari, *Apolymetis* (*Apolymetis*) *grimesi* Noetling, *Glossus* (*Cytherocardia*) *cytheroides* (Mayer), *Callista* (*Callista*) *pseudoumbonella* Vredenburg, *Callista* (*Costacallista*) *erycina* (Linne'), *Corbula* (*Corbula*) *tunicosulcata* Vredenburg and *Corbula* (*Corbula*) *mekranica* Vredenburg.

Gastropods: *Ficus* (*Ficus*) *ficus* (Linne'), *Murex maegillivrayi* Dohrn, *Conus* (*Leptoconus*) *bonneti* Cossmann, and *Conus* (*Dendroconus*) *loroisii* Kiener.

Decapods: *Typilobus granulosus* Stoclizka.

Fish teeth: *Carcharodon angustidens* Agassiz, *Carcharodon* sp. A, *Isurus spallanzanii* Bonnaparte, *Carcharhinus egertoni* Agassiz, *Galeocerdo aduncus* Agassiz, *Hemipristis serra* Agassiz (Selachians); *Myliobatis* sp. (Batoids) and *Diodon* sp. 4 (Teleosts).

LOCALITY 3: Near Youth Hostel, **Luangmual, Aizawl**

Small exposure just opposite to Youth Hostel, on the right side of Aizawl to Geology and Mining Office road constitutes locality 3 (N 23^0 44' 241'' – E 92^0 41' 606''). It is a road cut section and is about 6 kms from Aizawl. The litho-column of this locality is shown in fig. 2.3(C).The fossiliferous bed at this locality is represented by 27m thick brown coloured silty-sandstone. This litho-unit is sandwiched between thinly laminated splintery shale below and sandstone-shale intercalation above. Though, this bed is highly fossiliferous, recovery is poor due to fragmentary and ill-preserved nature

of the fossils. Cluster of fossils are found within this bed. This bed has yielded bivalves, gastropods and unidentifiable irregular echinoids. The faunal check-list is as follows:

Bivalvia: *Anadara* (*Anadara*) *daviesi* Mukerjee, *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Pecten* (*Pecten*) *mathuri* Tiwari, *Diplodonta (Diplodonta) incerta* d'Archiac, *Astarte* (*Bythiamena*) *striata* Tiwari, *Timoclea* (*Timoclea*) *scabra* (Hanley), and *Corbula* (*Corbula*) *tunicosulcata* Vredenburg.

Gastropods: *Archimediella* (*Torculoidella*) *angulata* (Sowerby).

Locality 4: **Near Faith Academy, Zonuam, Aizawl.**

This is a road cut section right in front of Faith Academy and is around 5.5 kms from Aizawl at the right side of Aizawl – University road (N 23^0 44' 241'' – E 92^0 41' 756''). Fossiliferous horizon at this locality consists of a nearly 20m brown coloured silty-sandstone containing fossil assemblage of bivalves, gastropods and unidentifiable irregular echinoids (Fig. 2.3 - D). The bed is highly rich in monogeneric gastropod but mostly in the form of external moulds. The bed also contains hosts of worm-burrows. The check list of the fauna recovered from this locality is as follows:

Bivalves: *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Pecten* (*Pecten*) *mathuri* Tiwari, *Gari* (*Gari*) *natensis* Noetling, *Paphia* (*Paphia*) *rotundata* (Linne'), *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg and *Corbula* (*Corbula*) *tunicosulcata* Vredenburg.

Gastropods: *Archimediella* (*Torculoidella*) *angulata* (Sowerby).

Locality 5: **Government Complex Road, Zonuam, Aizawl**

The litho-column of this locality (N 23^0 44' 121'' – E 92^0 41' 713'') is shown in Fig. 2.3 (E). The fossil yielding bed here consists of nearly 11.0m thick silty-sandstone that is fine grained, well bedded and compact. The bed is highly bioturbated and contains hosts of worm-burrows. It has yielded bivalves only. Fossiliferous bed is topped by a 0.4m thick deep brown coloured highly weathered conglomeratic band that is reported to have yielded decapods, bivalves and gastropods. Check list of fauna is given below:

Bivalvia: *Tellina* (*Angulus*) sp., *Tellina* (*Tellinella*) *loknathi* Tiwari, *Tellina* (*Eurytellina*) cf. *pilgrimi* Cox, *Tellina* (*Moerella*) *indifferens* Noetling, *Gari* (*Psammobia*) *kingi* (Noetling), *Dosinia* (*Dosinia*) *peralta* Vredenburg, *Clementia* (*Clementia*) *papyracea* (Gray), *Paphia* (*Paphia*) *rotundata* (Linne'), *Paphia* (*Paphia*) *jhai* Tiwari, *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg, *Timoclea* (*Timoclea*) *scabra* (Hanley).

Decapods: *Neptunus sindensis* Stoliczka.

Locality 6: **Government Complex Road, Zonuam, Aizawl.**

This locality is at about 7.5 kms from Aizawl on the Aizawl – Luangmual Complex road in Zonuam Locality (N 23^0 44' 006'' – E 92^0 41' 821''). The rock types exposed here are shown in Fig. 2.3 (F). A fourteen meter thick brown silty-sandstone constitutes fossiliferous bed at this locality. This bed is characterized by the primary-sedimentary structures like ripple marks, ripple-drift cross laminations and wavy laminations along with biogenic structure like worm burrows. This bed contains rounded boulders of different dimensions that are fossiliferous. Majority of the collection comes from these boulders though fossils also occur sporadically throughout the bed. Remains of bivalves and decapods including unidentifiable irregular echinoids have been collected from this bed. The following fossil species have been identified from this locality.

Bivalvia: *Nucula* (*Nucula*) *agrawali* Tiwari, *Portlandia* (*Portlandia*) *ovatoelongata* Mazumder, *Anadara* (*Anadara*) *craticulata* (Nyst), *Anadara* (*Anadara*) *daviesi* Mukerjee, *Pinna* (*Pinna*) cf. *rudis* Linné, *Diplodonta* (*Diplodonta*) *incerta* d'Archiac, *Diplodonta* (*Diplodonta*) *rotundatus* (Montagu), *Cultellus* (*Cultellus*) *zulloi* Tiwari, *Tellina* (*Angulus*) sp., *Tellina* (*Eurytellina*) cf. *pilgrimi* Cox, *Tellina* (*Moerella*) *indifferens* Noetling, *Tellina* (*Tellinella*) *loknathi* Tiwari, *Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari and Kachhara, *Apolymetis* (*Apolymetis*) *grimesi* Noetling, *Paphia* (*Paphia*) *rotundata* (Linne').

Decapods: *Ebalia tuberculata* Noetling and *Palaeocarpilius rugifer* Stoliczka.

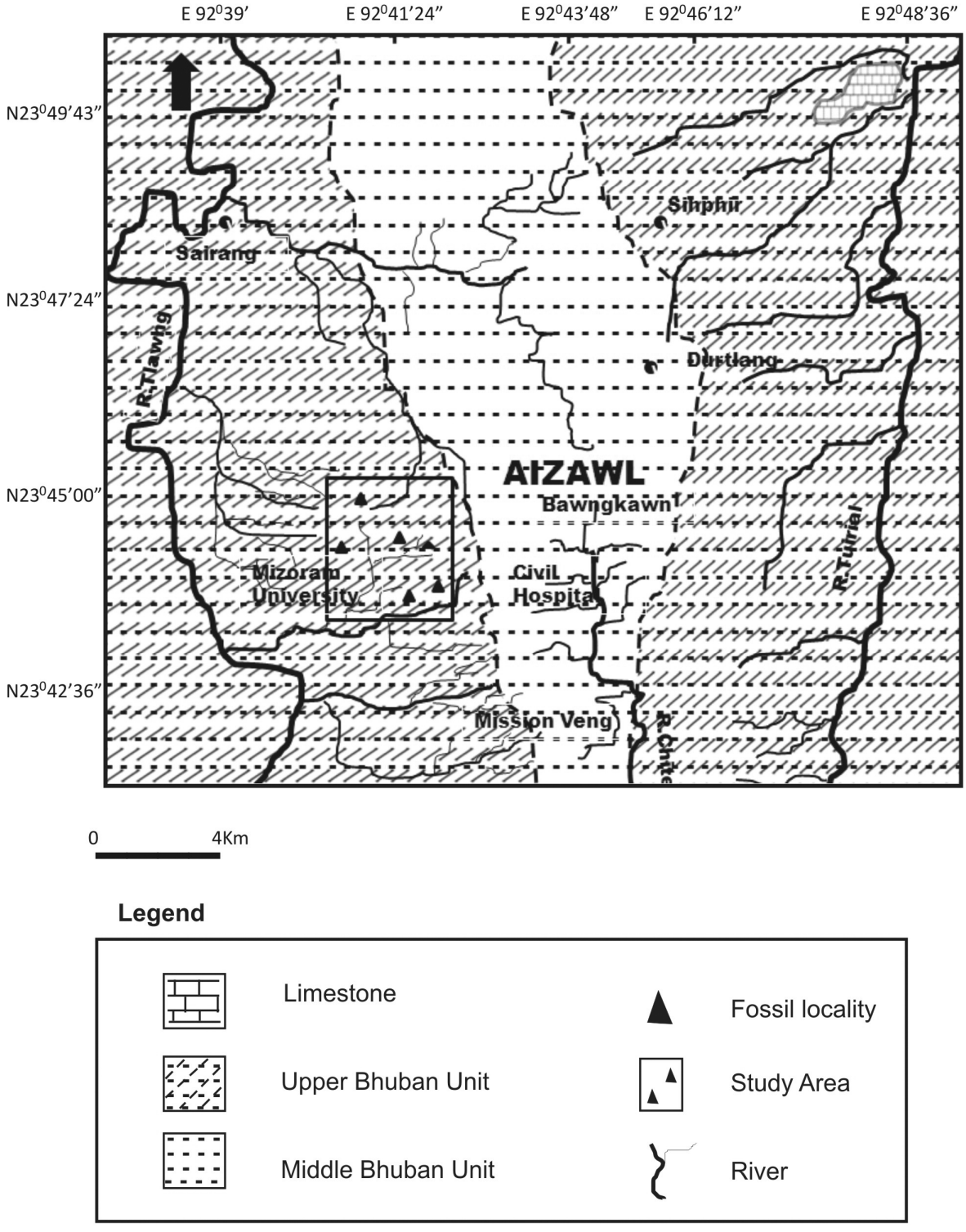


Figure 2.2: Geological map of Aizawl city and surrounding areas

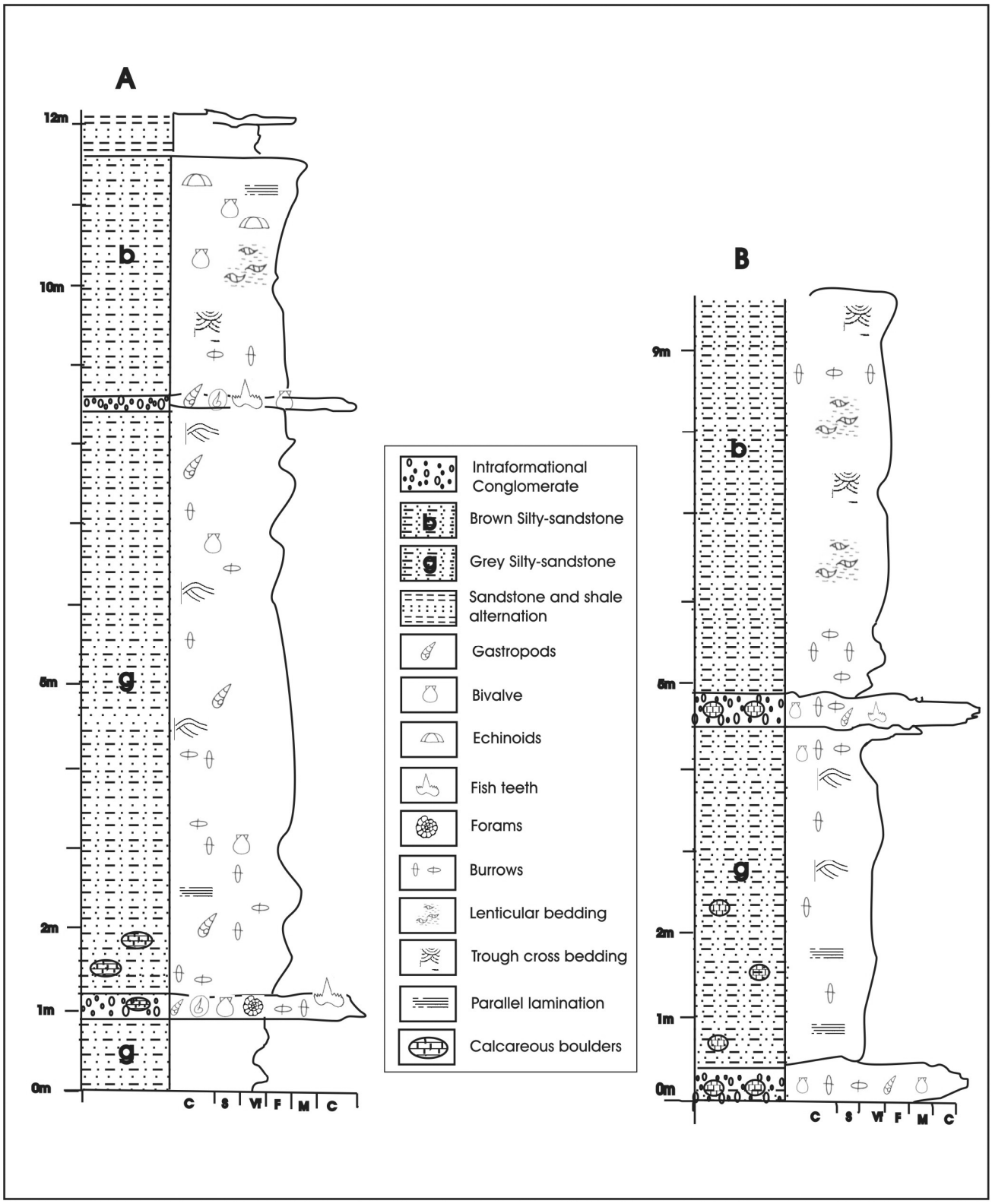


Fig.2.3: (A) Litho-column at Fossil Locality-1 (Bika Quarry, University Road, Tuivamit, Aizawl) and (B) Fossil Locality-2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl)

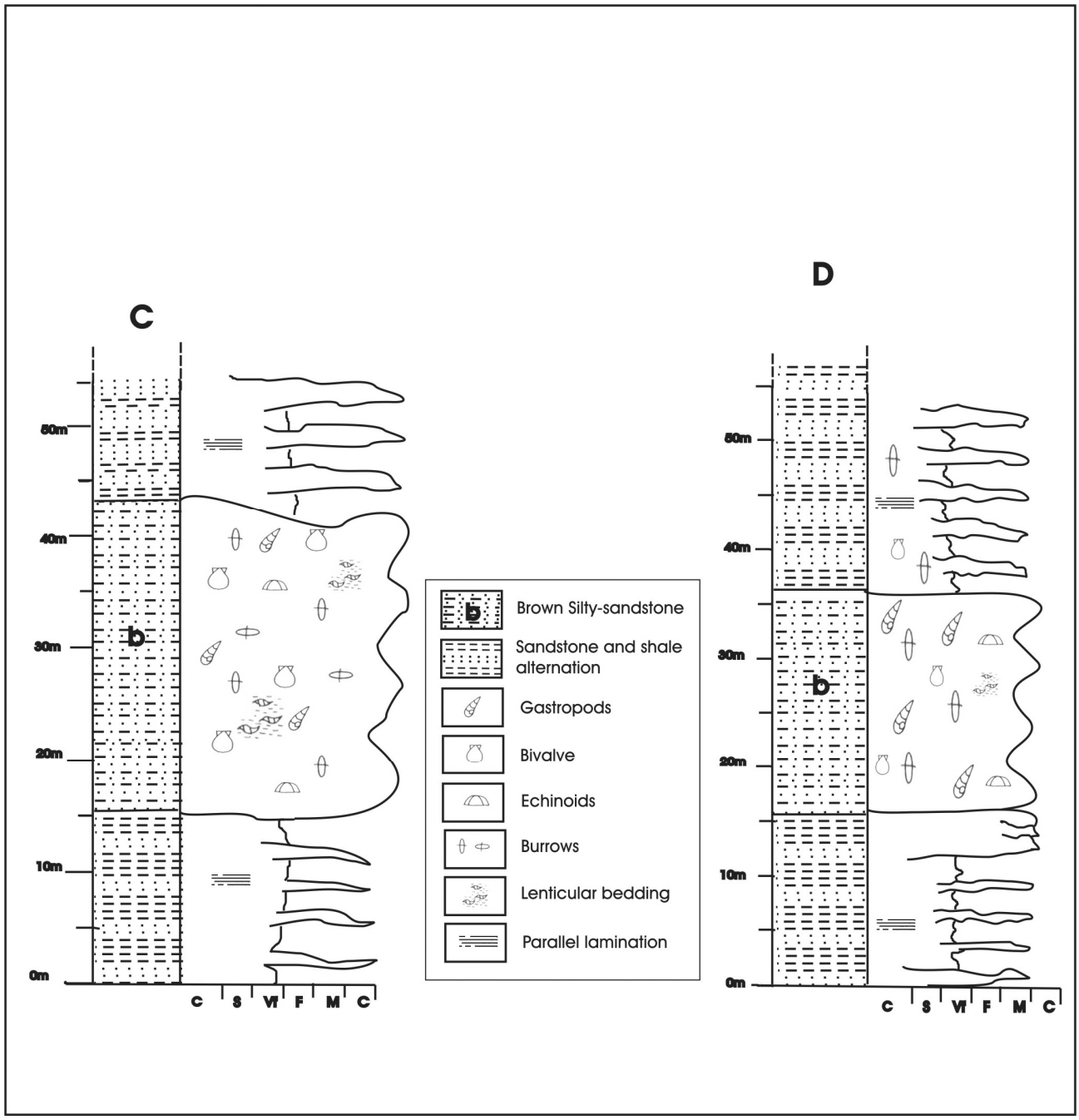


Fig.2.3: (C) Litho-column at Fossil Locality-3 (Near Youth Hostel, Luangmual, Aizawl) and (D) Locality-4 (Near Faith Academy school, Zonuam, Aizawl)

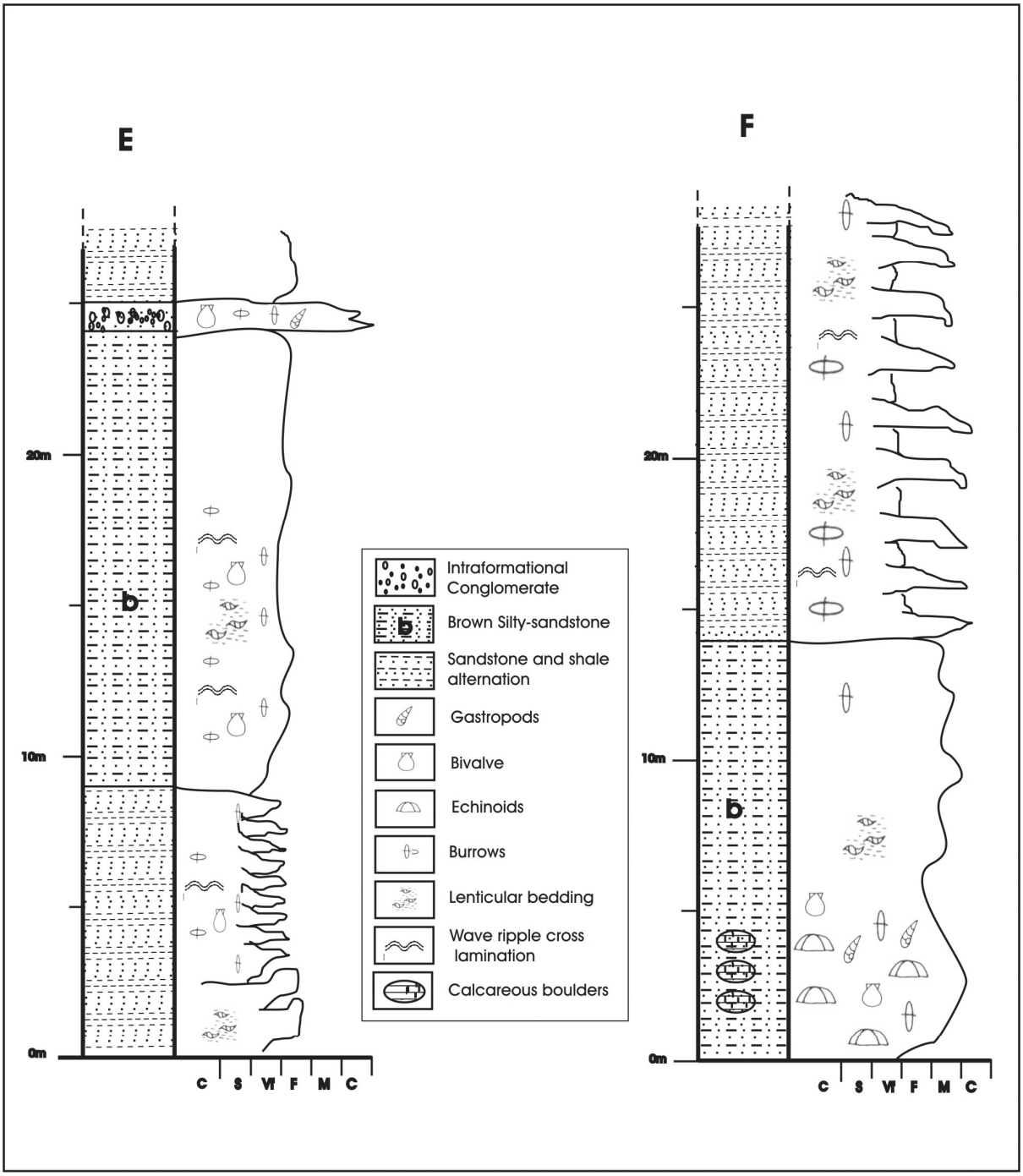


Fig.2.3: (E) Litho-column at Fossil Locality-5 (Luangmual Govt. Complex, Aizawl) and (F) Fossil Locality-6 (Govt. Complex Road, Zonuam, Aizawl)

CHAPTER -3

SYSTEMATIC DESCRIPTION

OF

VERTEBRATES

3. SYSTEMATIC DESCRIPTION OF IVERTEBRATES

3.1 SYSTEMATIC DESCRIPTION OF BIVALVIA

Bivalves represent the most abundant group of invertebrate fossils in the study area, both in number and kind. Though, the preservation of bivalves is generally poor and mostly in the form of moulds and casts of isolated valves, the essential external features are observable enough to facilitate the identification upto species level. Moreover, a few well-preserved specimens with both the valves intact have also been recovered. The identification of genera and species is mainly based on the external morphological characters and comparison with the type specimens. Internal feartures have also been considered wherever observable.

The classification adopted for the systematic study of bivalves is after Newell (see Moore R. C. *et al.*, 1969). Dimensions of the specimens are given in millimeters and the figures in the parentheses are in percentages. The figured specimens are housed in the Palaeontological Laboratory, Department of Geology, Mizoram University, Aizawl, Mizoram, India. The following abbreviations have been used:

Sp. No.	=	Specimen number	SD	=	Subsequent designation
RV	=	Right valve	OD	=	Original designation
LV	=	Left valve	M	=	Monotypy
BV	=	Both valves	T	=	Tautonomy
s.s.	=	*Sensu stricto*	NR	=	Number of ribs
cf.	=	Comparable to	(c)	=	computed
aff.	=	affinity to	B/	=	Bivalves
G/	=	Gastropods	C/	=	Decapods
F/	=	Foraminifers	B	=	Bika quarry
R	=	Ruata quarry	YL	=	Youth Hostel, Luangmual
FZ	=	Faith Academy Zonuam	GZ	=	Govt. Complex Road Zonuam
LG	=	Luangmual Govt. Complex			

The specimens have been photographed mostly in natural light with orientation in the reading position. Magnification of the photographs is given in the explanation to the photoplates. In some cases, however, the measurements may not tally with the actual figures given in the text due to parallax effect during photography.

Phylum	MOLLUSCA Linne', 1758
Class	BIVALVIA Linne', 1758
Subclass	PALAEOTAXODONTA Korobkov, 1954
Order	NUCULOIDA Dall, 1889
Superfamily	NUCULACEA Gray, 1824
Family	NUCULIDAE Gray, 1824
Genus	*Nucula* Lamarck, 1799

Type species: *Arca nucleus* Linne', 1758; M. Recent; France.

Subgenus *Nucula* (*s. s.*)

Nucula* (*Nucula*) *agrawali Tiwari, 1992

(Pl - 3, figs. 1 – 2)

1992. *Nucula* (*Nucula*) *agrawali* Tiwari, p. 37, Pl. III, figs. 4 and 5.

2004. *Nucula* (*Nucula*) *agrawali* Tiwari: Mazumder, p. 32 - 33, Pl. II, fig. 5.

Material: Two complete bivalved specimens.

Location: Locality no. 6 (Govt. Complex Road, Zonuam, Aizawl).

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation.

Dimensions (mm):

Sp. no.	**Length**	**Height**	**Inflation**	
B/GZ - 216	28.00	18.00 (64.24)	10.00 (35.71)	BV
B/GZ - 217	30.00	22.00 (73.33)	16.00 (53.33)	BV

Remarks: The distinguishing characters of the species, *viz.*, sub-trigonal to transversely elongate outline, moderate inflation, small, pointed, opisthogyrous and posterior-fifth umbo are clearly discernable in the specimens at hand. Besides, the specimens closely resemble with the specimens of the same species reported by Tiwari (1992) and

Mazumder (2004) from the Upper Bhuban unit of Bhuban Formation of Mizoram. Hence, identification is confirmed. Higher inflation of specimen B/GZ – 217 may be because the valves are opened along the ventral margin.

Superfamily NUCULANACEA H. Adams and A. Adams, 1858
Family NUCULANIDAE Adams and Adams, 1858
Genus *Portlandia* Morch, 1857

Type species: *Nucula arctica* Gray, 1824; SD ICZN, 1966. Recent; North Atlantic.

Subgenus *Portlandia* (*s.s.*)

Portlandia* (*Portlandia*) *ovatoelongata Mazumder, 2004

(Pl - 3, fig. 3)

2004. *Portlandia* (*Portlandia*) *ovatoelongata* Mazumder, p. 38-39, Pl. IV, figs. 1a-b and 2.

Material: One right valve.
Localtion: Locality no. 6 (Govt. Complex road, Zonuam, Aizawl).
Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation.
Dimensions: The lone specimen numbering B/GZ - 218 has: Length – 21.00mm; Height – 15.00mm (71.42); Inflation – 11.00mm (52.38).

Remarks: The lone specimen, on direct comparison, matches well with the holotype (K17/B/98) of *Portlandia* (*Portlandia*) *ovatoelongata* of the Mazumder's collection from Kolasib in all diagnostic characters like elongate-ovate outline, thick and slightly opisthogyrate umbo, triangular umbonal profile, nature and configuration of margins, antero- and postero-ventral furrows and broad undulations with fine concentrics. Thus, it is assigned to this form. Present specimen is however, nearly half the size of the Majumder's collections.

Subclass PTERIOMORPHIA Buerlen, 1944
Order ARCOIDA Stoliczka, 1871
Superfamily ARCACEA Lamarck, 1809
Family ARCIDAE Lamarck, 1809
Sub Family ARCINAE Lamarck, 1809
Genus *Barbatia* Gray, 1842

Type species: *Arca barbatia* Linne, 1758; SD Gray, 1857: Recent; Mediterannean.

Barbatia* (*Barbatia*) *bataviana Martin var**. *carinata*** Noetling, 1939

(Pl - 3, figs. 4 – 5)

1885. *Arca bataviana* Martin, p. 253, Pl. 13, figs. 256-257

1901. *Arca* (*Barbatia*) *bataviana* Martin var. *carinata* Noetling, p. 148, Pl. 7, figs. 7- 8

1939. *Barbatia* (*Barbatia*) *bataviana* Martin var. *carinata* Noetling: Mukerjee, p. 25, Pl. I, figs. 12 and 13.

Material: Two isolated right valves.

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/R-59	27.00	28.00 (c.103.70)	9.00 (33.33)	RV
B/R-60	20.00	25.00 (c.125.00)	7.00 (35.00)	RV

Remarks: In general outline, dimensional ratios and external features, the two specimens at hand greatly resemble *Barbatia* (*Barbatia*) *bataviana* Martin var. *Carinata* Noetling reported and figured by Mukherjee (1939) from the Baghmara and Dalu localities of the Garo Hills, Meghalaya excepting for the larger size of the former. Hence, these are assigned to this form witnout any reservation.

***Barbatia* sp.**

(Pl - 3, figs. 6)

Type species: *Arca barbatia* Linne, 1758; SD Gray, 1857: Recent; Mediterannean

Material: One right valve.

Location: Locality 1 (Bika Quarry, Tuivamit, Aizawl).

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	Length	Height	Inflation	
B/B-55	31.00	13.00 (41.93)	6.00 (19.35)	RV

Description and Remarks: Valve transversely elongate, length nearly two and a half times than the height, moderately inflated maximum inflation being behind the umbo. Umbo sub-median, pointed anteriorly with a prominent umbonal profile. Dorsal margin straight and ventral margin with a median sinuosity. Anterior margin narrowly rounded whereas posterior one broadly rounded. Valve surface covered with flat radial ribs separated by the interspaces of equal width. These are crossed over by numerous concentric growth lines producing cancellate ornamentation. Internal features not discernible. Specific identification is not attempted in the absence of other details.

Genus *Trisidos* Röding, 1798

Type species: *Arca tortuosa* Linne', 1758; OD

Trisidos semitorta (Lamarck), 1819

(Pl - 3, figs. 7)

1819. *Arca semitorta* Lamarck, p. 37.

1840. *Arca tortuosa* ? J.de C.Sowerby, Pl. 25, fig. 13

1844. *Arca semitorta* Reeve, *Arca*, Pl. 13, fig. 89.

1850. *Arca kurracheensis* d'Archiac, p. 265.

1853. *Arca kurracheensis* d'Archiac and Haime, p. 263, Pl. 22, fig. 4.

1885. *Arca* (*Trisis*) *semitorta* Smith, p. 268.

1891. *Arca* (*Trisis*) *semitorta* Smith, p. 432.

1891. *Arca* (*Parallelepipedum*) *semitorta* Kobelt, *Arca*, p. 134, Pl. 35, figs. 1-2.

1901. *Arca* (*Parallelepipedum*) *semitorta* Noetling, p. 151.

1904. *Arca semitorta* Lamy, p. 150.

1907. *Arca semitorta* Lamy, p. 109.

1928. *Arca semitorta* Vredenburg, p. 417.

1939. *Trisidos semitorta* (Lamark): Mukerjee, p. 24, Pl. I, fig. 19.

1992. *Trisidos semitorta* (Lamark): Tiwari, p. 53, Pl. V, fig. 4.

2004. *Trisidos semitorta* (Lamark): Mazumder, p. 45, Pl. IV, fig. 9.

2004. *Trisidos semitorta* (Lamark): Lyngdoh, p. 32, Pl. II, fig. 2.

Material: One broken left valve

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions: Specimen no. B/R -57 has the following dimensions: Length – 34.00, Height - 15.00(44.11); Inflation – 6.00 (17.64)

Remarks: Though the specimen at hand is partially broken, it matches well with *Trisidos semitorta* (Lamarck) recorded by Vredenburg (1928) from the Gaj beds of Kachchh and Sind in respect of general proportion, in the cancellate ornamentation produced by prominent raised radial ribs traversed by fine growth lines and in twisted hinge. On these counts, it also matches well with the same species reported by Mukerjee (1939) from Garo Hills. It is a widely distributed form reported from the Oligocene of Baluchistan and Sind, Gaj of Kachchh and Sind and Lower Miocene of Meghalaya. The present specimen is however, larger than its Meghalaya counterpart.

Subfamily ANADARINAE Reinhart, 1935

Genus *Anadara* Gray, 1847

Type species: *Arca antiquata* Linne, 1758; OD. Recent; Medagascar.

Anadara* (*Anadara*) *craticulata (Nyst), 1847

(Pl - 3, figs. 8 – 9)

1844. *Arca clathrata* Reeve (non Defrance, 1816), p. 44.

1847. *Arca craticulata* Nyst, p. 22.

1853. *Arca burnesi* d'Archiac and Haime, p. 264, Pl. XXII, fig. 5.

1857. *Scapharca pygmaea* Adams, p. 2, Pl. III, fig. 5.

1885. *Arca burnesi* d'Archiac and Haime: Martin, p. 245, Pl. XII, fig. 50.

1901. *Arca burnesi* d'Archiac and Haime: Noetling, p. 131, Pl. V, figs. 6 -10.

1907. *Arca clathrata* Reeve: Lamy, p. 229.

1920. *Arca* (*Scapharca*) *burnesi* d'Archiac and Haime: Tesch, p. 97, Pl. XXXVIII, fig. 258.

1928. *Arca clathrata* Reeve Var. *burnesi* d'Archiac and Haime: Vredenburg, p. 411.

1930. *Anadara craticulata* (Nyst): Cox, p. 150.

1939. *Anadara craticulata* (Nyst): Mukerjee, p. 26, Pl. I, figs. 7 and 15.

1962. *Anadara craticulata* (Nyst): Dey, p. 39.

1973. *Anadara* (*Anadara*) *burnesi* d'Archiac and Haime: Shuto, p. 20, Pl. II, figs. 7, 8, 14.

1992. *Anadara craticulata* (Nyst): Tiwari, p. 56, Pl. V, fig. 8.

2004. *Anadara craticulata* (Nyst): Mazumder, p. 46, Pl. III, figs. 4 and 5.

2004. *Anadara craticulata* (Nyst): Lyngdoh, p. 34, Pl. II, figs. 4 and 5.

Material: Two broken left and right valves.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl); Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl); Locality 6 (Govt. Complex Road, Zonuam, Aizawl)

Horizons: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1; upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2; Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 6.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**		**NR**
B/R-71	15.00	19.00 (126.66)	8.00 (53.33)	RV	43
B/B-72	13.00	17.00 (130.76)	6.00 (46.15)	LV	30
B/GZ-220	18.00	18.00 (100.00)	9.00 (50.00)	BV	28
B/GZ-221	18.00	18.00 (100.00)	7.00 (38.88)	LV	26

Remarks: Though, the specimens under examination are poorly preserved and not complete, these show all the essential features of the species under reference like broadly elliptical outline, moderate inflation, unequal radial ribs with granulation on the anterior side and umbonal position. Hence, it is referred to as *Anadara* (*Anadara*) *craticulata* (Nyst).

Anadara* (*Anadara*) *daviesi Mukerjee, 1939

(Pl - 3, figs. 10 – 11)

1939. *Anadara daviesi* Mukerjee, p. 28, Pl. I, fig. 14; Pl. II, fig. 1.

1992. *Anadara daviesi* Mukerjee: Tiwari, p. 54, Pl. V, figs. 5 a - b, 6, 7.

2004. *Anadara daviesi* Mukerjee: Mazumder, p. 47, Pl. III, fig. 6.

2004. *Anadara daviesi* Mukerjee: Lyngdoh, p. 36, Pl. II, fig. 11.

2004. *Anadara daviesi* Mukerjee: Lalchawimawii, p. 17, Pl. I, fig. 13.

Material: Three left and right valves.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl), Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl), Locality 3 (near Youth Hostel, Luangmual, Aizawl) and Locality 6 (Govt. Complex road, Zonuam, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1; upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2; Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 3 and 6.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	**NR**
B/YL-63	17.00	11.00 (64.70)	7.00 (41.17)	LV
B/R-64	24.00	18.00 (75.00)	9.00 (37.50)	LV
B/B-68	14.00	11.00 (78.57)	8.00 (57.14)	LV
B/GZ-221	16.00	10.00 (62.50)	11.00 (68.75)	RV

Remarks: Species diagnostic characters like elongate and sub-ovate outline, height about 60 per cent of the length, moderate inflation, oblique posterior margin, broad and flattened radial ribs and distinct granulations towards anterior to anterior-third of valves are well marked in the present specimens. Hence, the assignment.

Anadara* (*Anadara*) *garoensis Mukerjee, 1939

(Pl - 3, figs. 12)

1939. *Anadara garoensis* Mukerjee, p. 26, Pl. I, figs. 6, 16, Pl. II, figs. 2 – 3.

1992. *Anadara*(*Anadara*) *garoensis* Mukerjee: Tiwari, p. 57, Pl. V, figs. 9 – 11.

2004. *Anadara* (*Anadara*) *garoensis* Mukerjee: Lyngdoh, p. 35, Pl. II, figs. 7 – 9 and 12.

Material: One left valve.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	Length	Height	Inflation		NR
B/R-86	31.00	18.00 (58.06)	8.00(25.80)	LV	28

Remarks: Though the specimen is lone and a cast of a left valve, it shows all the essential characters of the species *Anadara* (*Anadara*) *garoensis* originally described by Mukerjee (1939, *op. cit.*) from the Miocene of Garo Hills, Meghalaya *viz.*, sub-rhomboidal shape, anterior-third umbo and in the inflation, number and nature of radial ribs and in the nature of posterior carina. On account of these characters, it is assigned to the Mukerjee's species.

Anadara* (*Anadara*) *luangmualensis Tiwari, 2001

(Pl - 3, figs. 13)

2001. *Anadara* (*Anadara*) *luangmualensis*, p. 155, Pl. II, figs. 1 - 2.

Material: One left valve.

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	Length	Height	Inflation	
B/R-58	24.00	18.00 (75.00)	8.00 (33.33)	LV

Remarks: The dignostic characters of the species christened by Tiwari (2001) are sub-quadrilateral outline, strongly and evenly convex flanks, steeply inclined posterior area with wing like posterior end and thick and closely spaced radials crossed over by concentrics producing reticulate pattern of ornamentation. These characters are very well marked in the lone specimen at hand therefore it is assigned to this species without any hesitation. The only difference that can be noticed between the two is the taller nature of Tiwari's specimen in which height is nearly ninety percent of the length and it is much smaller than the present collection. The present specimen is however assigned to this species inspite of these trivial differences.

Anadara* (*Anadara*) *trapezoida Tiwari, 2001

(Pl - 3, figs. 14)

2001. *Anadara*(*Anadara*) *trapezoida* Tiwari, p. 157, Pl. II, figs. 5 – 7

2004. *Anadara* (*Anadara*) *trapezoida* Tiwari, Mazumder, p. 49, Pl. III, fig. 3.

Material: One left and right valves.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/B-62	16.00	25.00 (156.25)	9.00 (56.25)	LV
B/B-69	9.00	13.00 (144.44)	5.00 (55.55)	RV

Remarks: Tiwari (2001), while erecting a new species under the name *Anadara* (*Anadara*) *trapezoida*, stated that the diagnostic characters of the species are sub-terminal umbo, obliquely trapezoidal outline, angular posterior carina, steeply sloping posterior margin and almost parallel postero-dorsal and ventral margins. All these features are well marked in both the specimens at hand. Hence, the assignment.

Family	NOETIIDAE Stewart, 1930
Subfamily	STRIARCINAE MacNeil, 1938
Genus	*Arcopsis* Koenen, 1885

Type species: *Arca limopsis* Koenen, 18?? ; SD Reinhart, 1935

***Arcopsis* sp.**

(Pl - 3, figs. 15)

Material: One right valve

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Upper intraformational conglomeratic band of Upper Bhuban unit, Bhuban Formation.

Dimensions (mm): Specimen no. B/R-56 has: Length – 20.00; Height – 15.00 (75.00); Inflation – 5.00 (25).

Description and Remarks: The lone specimen at hand is rhomboidal in outline, moderately inflated and umbo is situated one-third from the anterior. The umbo is prosogyrate and distinct. Dorsal margin is straight, anterior and posterior margins are rounded and merge smoothly with the dorsal and ventral margins. Ventral margin is flat. It has a postro-ventral carina that is more prominent towards the dorsal margin and becomes feeble towards the ventral margin. Posterior area is small and moderately sloping. There is a feeble median sulcus running from umbo to the ventral margin. Valve surface is covered with thirty-eight fine and nearly equally spaced bifurcating ribs. These are in turn crossed over by concentric growth lines producing nodes at the intersections. The interspaces are narrower than the ribs. Specific identification is not attempted for the want of better-preserved material. This is the first report of the genus from the Miocene sediments of Mizoram.

Order	MYTILOIDA Ferussac, 1822
Superfamily	PINNACEA Leach, 1819
Family	PINNIDAE Leach, 1819
Genus	*Pinna* Linne', 1758

Type species: *Pinna rudis* Linne', 1758: SD. Children, 1823; Recent; Barbados.

Pinna* (*Pinna*) cf. *rudis Linné

(Pl - 3, figs. 16)

Synonymy of the typical form *Pinna rudis* Linné are as follows:

1969. *Pinna rudis* Linné: Cox, p. N283, and fig. C23, 2a.

1971. *Pinna rudis* Linné: Davies, p. 189, fig. 430d.

1974. *Pinna rudis* Linné: Dance, p. 229.

2004. *Pinna rudis* Linné: Mazumder, p. 58, Pl. V, fig. 4.

Material: One complete specimen.

Location: Locality 6 (Govt. Complex Road, Zonuam, Aizawl).

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation.

Dimensions: Specimen no. B/GZ-227 has: Length – 27.00; Height – 28.00 (103.70).

Remarks: General outline and radial ornamentation along with a few commarginal undulations of the present specimen at once reminds the species *Pinna* (*Pinna*) *rudis*

Linné. However, it is referred to as *Pinna* (*Pinna*) cf. *rudis* for the want of more details and better-preserved specimens.

Order	PTERIOIDA Newell, 1965
Suborder	PTERIINA Newell, 1965
Superfamily	PECTINACEA Rafinesque, 1815
Family	PECTINIDAE Rafinesque, 1815
Genus	*Chlamys* Röding, 1798

Type species: *Pecten islandicus* Müller, 1776; SD Herrmannsen, 1847; Recent; North-Atlantic.

Subgenus *Argopecten* Monterosato, 1899

Type species: *Pecten solidulus* Reeve, 1853; OD. Recent; Unknown locality.

Chlamys* (*Argopecten*) *senatoria (Gmelin), 1791

(Pl - 3, figs. 17 – 19)

1791. *Ostrea senatoria* Gmelin, p. 3327.

1840. *Pecten articulatus* J. de C. Sowerby, Pl. XXV, fig. 15.

1853. *Pecten favrei* d'Archiac and Haime, p. 270, Pl. XXIV, fig. 5.

1927. *Chlamys senatoria* (Gmelin): Cox, p. 45. Pl. VII, figs. 1 - 3; p. 75, Pl. XV, fig. 3; Pl. XXVII, fig. 10.

1928. *Pecten* (*Chlamys*) *senatoria* var. *soomrowensis* Sowerby: Vredenburg, p. 434.

1928. *Chlamys senatoria* (Gmelin): Douglas, p. 2, Pl. VIII, figs. 3 - 5.

1929-30. *Chlamys senatoria* (Gmelin): Cox, p. 191.

1930. *Chlamys senatoria* (Gmelin): Cox, p. 108, Pl. XIII, fig. 21; p. 122, 52.

1936. *Chlamys senatoria* (Gmelin): Cox, p. 54, Pl. V, fig. 18; Pl. IV, fig. 9.

1939. *Chlamys senatoria* (Gmelin): Mukerjee, p. 31, Pl. I, fig. 2; Pl. II, figs. 9-10.

1974. *Chlamys senatorius* (Gmelin): Dance, p. 234.

1992. *Chlamys* (*Chlamys*) *senatoria* (Gmelin): Tiwari MS, p. 73, Pl. VII, figs. 10, 11; Pl. VIII, figs. 1 - 3.

1997. *Chlamys* (*Argopecten*) *senatoria* (Gmelin): Jain MS, p. 72, Pl. XI, figs. 15 - 18.

2004. *Chlamys* (*Argopecten*) *senatoria* (Gmelin): Mazumder, p. 69, Pl. VIII, fig. 5.

2004. *Chlamys* (*Chlamys*) *senatoria* (Gmelin): Lyngdoh, p.52, Pl. V, fig. 1.

2004. *Chlamys* (*Argopecten*) *senatoria* (Gmelin): Lalchawimawii, p. 21-22, Pl. II, figs. 3-4

Material: One complete specimen, one left and three right valves.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl); Locality 3 (near Youth Hostel, Luangmual, Aizawl); Locality 4 (near Faith Academy, Zonuam, Aizawl).

Horizon: Lower intraformational conglomeratic band of Upper Bhuban unit, Bhuban Formation of Locality 1; Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 3 and 4.

Dimensions:

Sp. no.	Length	Height	Inflation	NR
B/B-98	15.00	15.00 (100.00)	4.00 (26.26) RV	25
B/YL-86	13.00	13.00 (100.00)	3.00 (23.07) RV	24
B/B-87	17.00	19.00 (111.76)	4.00 (23.52) RV	28
B/FZ-88	15.00	17.00 (113.33)	6.00 (40.00) LV	24
B/YL-92	21.00	22.00 (c. 104.00)	6.00 (28.50) BV	30 (C)

Remarks: Cox (1937), while commenting on the species from the Burdigalian of Persia, stated that the species in question is sub-orbicular with the height only slightly in access of the length, its surface is covered with about 24 wide radial ribs and the interspaces are occupied by the fine, closely spaced undulating sqamae. All these characters are well defined in the present specimens. Hence, the identification. The number of ribs in the present specimens however vary from 22 to 28 depending on the size. This species has also been reported from the Miocene of Garo Hills (Mukerjee, 1939; Lyngdoh, 2004) and Miocene of Mizoram (Tiwari, 1992, Mazumder, 2004 and Lalchawimawii, 2004). It is a widely distributed form reported from Asia and Africa and ranges in age from Miocene to Recent.

Genus *Pecten* Müller, 1776

Type species: *Ostrea maxima* Linne', 1758; SD Schmidt, 1818; Recent; English Channel.

Pecten* (*Pecten*) *mathuri Tiwari MS, 1992

(Pl – 3, figs. 20 a – b, Pl – 4, fig. 1)

1992. *Pecten (Pecten) mathuri* Tiwari MS, p. 78, Pl. VIII, figs. 5 - 8.

2004. *Pecten* (*Pecten*) *mathuri* Tiwari MS: Mazumder, p. 20, Pl. VIII, fig. 8.

2004. *Pecten (Pecten) mathur* Tiwari MS: Lalchawimawii, p. 23, Pl. II, figs. 5 and 6.

Material: Two bivalved specimens, two left and one right valves.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl); Locality 3 (near Youth Hostel, Luangmual, Aizawl); Locality 4 (near Faith Academy, Zonuam, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and Brown silty-sandstone, Upper Bhuban unit, Bhuban Formation of Locality 3 and 4.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/YL-90	17.00	16.00 (94.11)	3.00 (17.64)	LV
B/FZ-91	22.00	19.00 (86.36)	6.00 (27.27)	BV
B/B-93	18.00	18.00 (100.00)	3.00 (16.66)	RV
B/B-94	21.00	21.00 (100.00)	3.50 (16.66)	LV
B/B-97	18.00	16.00 (88.88)	5.00 (27.77)	BV

Remarks: Tiwari (1992), while describing the species for the first time, wrote that it is sub-orbicular in outline having evenly rounded anterior, posterior and ventral margins and its antero-dorsal is slightly more elongate than the postero-dorsal. The right valve of the species is oblique and slenderly more convex than the left one. In all these characters, the specimens at hand approach the species christened by Tiwari. Hence, it is named accordingly.

Subclass	HETERODONTA Neumayr, 1884
Order	VENEROIDA H. Adams and A. Adams, 1856
Superfamily	LUCINACEA Fleming, 1828
Family	UNGULINIDAE Adams and Adams, 1857
Genus	*Diplodonta* Bronn, 1831

Type species: *Venus lipinis* Brochhi, 1814; SD.Hermannsen, 1846; Recent; Mediterranean.

Diplodonta (Diplodonta) incerta d'Archiac, 1850

(Pl – 4, figs. 2 – 3)

1850. *Diplodanta incerta* d'Archiac, p. 259.

1853. *Lucina inflata* d'Archiac: d'Archiac and Haime, p. 240, Pl. XVI, figs. 15 - 16; Pl. XXXVI, figs. 7 - 8.

1853. *Lucina inflata* d'Archiac: d'Archiac and Haime, p. 355.

1928. *Diplodonta incerta* d'Archiac: Vredenburg, p. 441.

1939. *Taras* (*Diplodonta*) *incerta* d'Archiac: Mukerjee, p. 9, Pl. II, fig. 6.

1992. *Diplodonta incerta* d' Archiac: Tiwari, p. 86, Pl. IX, figs. 4 - 7.

2004. *Diplodonta* (*Diplodonta*) *inceta* d'Archiac: Mazumder, p. 79, Pl. IV, fig. 8.

2004. *Diplodonta* (*Diplodonta*) *inceta* d'Archiac: Lyngdoh, p.62, Pl. VIII, figs. 4 and 5.

2004. *Diplodonta incerta* d' Archiac: Lalchawimawii, P.26 Pl. III, figs. 3 and 4.

Material: Two bivalves and one right valve.

Locality: Locality 3 (near Youth Hostel, Luangmual, Aizawl) and Locality 6 (Govt. Complex road, Zonuam, Aizawl)

Horizons: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 3 and 6.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/YL-20	17.00	17.00 (100.00)	4.00 (25.00)	RV
B/GZ-231	21.00	21.50 (102.38)	9.00 (42.85)	BV
B/GZ-233	20.00	22.00 (110.00)	8.00 (40.00)	BV

Remarks: The general proportion and external characters of the ornamentation of the specimen collected from the above two fossil localities are identical with *Diplodonta incerta* reported by Vredenburg (1928) from the Gaj beds of Sind. Hence the assignment. However, the present collection is almost half the size of the Vredenburg's specimen.

Diplodonta* (*Diplodonta*) *rotundatus (Montagu), 1803

(Pl – 4, fig. 4)

1803**.** *Tellina rotundata* Montagu, p. 71, Pl. II, fig. 3.

1850. *Diplodonta rotundata* (Montagu): Wood, p. 144.

1850. *Diplodonta rotunda* (Montagu): Reevem p. 36.

1916. *Diplodonta rotunda* (Montagu): Lamy, p. 188.

1921. *Diplodonta rotunda* (Montagu): Lamy, p. 335.

1930. *Taras rotundatus* (Montagu): Steward, p. 193.

1933. *Diplodonta rotundatus* (Montagu): Cox, p. 386.

1939. *Taras* (*Diplodonta*) *rotundatus* (Montagu): Mukerjee, p. 9.

1992. *Diplodonta rotundatus* (Montagu): Tiwari, p. 87, Pl. IX, figs. 8 and 9.

2004. *Diplodonta rotundatus* (Montagu): Mazumder, p. 80, Pl. IV, fig. 7.

2004. *Diplodonta rotundatus* (Montagu): Lyngdoh, p. 64, Pl. VIII, figs. 8 and 9.

2004. *Diplodonta rotundatus* (Montagu): Lalchawimawii, p. 26, Pl. III, figs. 5a and 6.

Material: Two left valves and one right valve.

Locality: Locality 6 (Govt. Complex road, Zonuam, Aizawl).

Horizon: Brown silty-sandstone of Uppper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/GZ-232	19.00	21.00 (110.52)	7.00 (36.84)	RV
B/GZ-235	14.00	15.00 (107.14)	4.80 (34.28)	LV
B/GZ-236	27.00	23.00 (85.18)	9.00 (33.33)	LV

Remarks: On account of their small size, less prominent umbo, less oblique outline and more expanded posterior area, these specimens are assigned to *Diplodonta* (*Diplodonta*) *rotundatus* (Montagu). The species is a long ranging one (i. e. Oligocene to Recent) and has a wide geographical distribution as it is also recorded from Arabia, Mediterranean region, western Europe, east Atlantic, South Africa, Mekran Coast, Red Sea and India.

Superfamily	CARDITACEA Fleming, 1820
Family	CARDITIDAE Fleming, 1828
Subfamily	CARDITAMERINAE Chavan
Genus	*Cyclocardia* Conrad, 1867

Type species: *Cardita borealis* Conrad, 1831; SD Stoliczka, 1871. Upper Cretaceous to Recent; Cosmopolitan.

***Cyclocardia* sp.**

(Pl – 4, figs. 5 – 7)

Material: Three right valves.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**		**NR**
B/B-114	19.00	25.00 (131.57)	6.00 (31.57)	RV	16
B/B-115	20.00	22.00 (110.00)	7.00 (35.00)	RV	16
B/B-117	16.00	18.00 (112.50)	5.00 (31.25)	RV	16

Description and Remarks: Valves tall, thick, sub-trigonal in shape and strongly inflated. Umbo prosogyrous, prominent and situated anterior - third of the valve length. Dorsal margin curved, anterior margin short and concave and joins the ventral margin at an obtuse angle, posterior margin long and sloping (35^{o}) and joins ventral margin obtusely. Ventral margin obliquely rounded being larger towards antero-ventral than the postero-ventral one. A feeble carina runs from the umbo towards both the antero-ventral and the postero-ventral corners forming moderately sloping anterior and posterior areas. Anterior carina is moderately curved whereas postrior one is fairly straight. Surface ornamented with sixteen strong radial ribs. These ribs are stonger in the middle portion than in the anterior and posterior areas. Interspaces also follow the same pattern. Though the valve surface is worn out in all the specimens at hand, it seems to bear fine concentrics and nodes may be seen towards the ventral margin. Internal characters not observable. The specimens could not be identified upto the species level due to poor preservation.

Lyngdoh (2004) reported a species under the name *Cyclocardia mutabilis* from the Miocene of the Garo Hills of Meghalaya. My specimens are however, much taller than the Meghalaya couter part, hence cannot be merged. This species was originally described by Cotter (1923) and Noetling (1901) from the Eocene and Miocene of Meghalaya respectively. These are also much less in height than our specimens. This is the first report of the genus from Mizoram.

Suborder	ASTARTEDONTINA
Superfamily	CRASSATELLACEA Ferussac, 1822
Family	ASTARTIDAE d' Ordigny, 1844
Subfamily	ASTARTINAE d' Orbigny, 1844
Genus	*Astarte* J.Sowerby, 1816

Type species: *Venus scotica* Maton and Rackettm, 1807 (= *Pectunculus sulcatus* 1778); OD. Recent; Scotland.

Subgenus *Bythiamena* Gardner, 1926

Type species: *Astarte* (*Bythiamena*) *isoscleles* Gardner, 1926; OD. Miocene; U.S.A.

Astarte* (*Bythiamena*) *striata Tiwari ,1992

(Pl – 4, figs. 8 – 9)

1992. *Astarte* (*Bythiamena*) *striata* Tiwari, p. 90, Pl. IX, figs. 10 a and b.

2004. *Astarte* (*Bythiamena*) *striata* Tiwari: Majumder, p. 89, Pl. X, fig. 6.

2004. *Astarte* (*Bythiamena*) *striata* Tiwari: Lalchawimawii, p. 28, Pl. III, figs. 10 and 11.

Material: Two complete Bivalve and one left valves.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl), Locality 3 (near Youth Hostel, Luangmual, Aizawl), Locality 5 (Luangmual Govt. Complex, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality1; Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 3 and 5.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/B-10	8.00	9.00 (112.50)	5.00 (62.50)	BV
B/YL-11	15.00	16.00 (106.66)	8.00 (53.33)	BV
B/LG-234	25.00	28.00 (112.00)	14.00 (56.00)	BV

Remarks: The specimens under consideration tally well with the holotype of *Astarte* (*Bythiamena*) *striata* (Tiwari, 1992) in view of their broadly trigonal outline, slightly inequilateral valves, height slightly in excess of length, moderate inflation, curved and

pointed prosogyrous umbo that are placed at anterior-third of the shell length and surface of shell covered with dense sets of fine concentric striations. Hence, their assignment to this species is beyond doubt.

Superfamily	CARDIACEA Lamarck, 1809
Family	CARDIIDAE Lamarck, 1809
Subfamily	LAEVICARDIINAE Keen, 1936
Genus	*Clinocardium* Keen, 1936

Type species: *Cardium nuttallii* Conrad, 1837; OD. Upper Miocene to Recent; North Pacific to North-West Atlantic.

***Clinocardium* sp.**

(Pl – 4, fig. 10)

Material: One poorly preserved left valve.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions (mm):

Sp. no.	**Length**	**Height**	**Inflation**		**NR**
B/B-106	24.00	21.00 (87.50)	7.00 (29.16)	LV	9

Description and Remarks: In slightly oblique and sub-ovate outline, much asymmetrical ventral margin rising rapidly in posterior region, and flat topped radial ribs, the present specimen matches well with *Clinocardium andoi* Itoigawa and Shibata illustrated by Nagakawa (1998 p. 133, figs. 2-4, 6, 14,17 and 18). It also matches well with the specimens of the same species reported by Lyngdoh (2004, pl. X, figs. 14-15) from the Miocene of Garo Hills, Meghalaya in these respects. However, my specimen bears nine strong radial scultures as compared to numerous weak radials of the earlier reported specimens. Moreover, further comparison is not possible due to poor preservation. Hence, it is left to the open nomenclature.

Superfamily - MACTRACEA Lamarck, 1809

Family - MACTRIDAE Lamarck, 1809

Subfamily - MACTRINAE Lamarck, 1809

Genus - *Mactra* Linne,' 1767

Type species: *Cardium stultorum* Linne,' 1758; SD. Fleming, 1818. Recent: Mediterranean.

Mactra* (*Mactra*) *protoreevesii Noetling, 1901

(Pl – 4, fig. 11)

1901. *Mactra protoreevesii* Noetling, p. 236, Pl. 16, figs. 1 and 2.

1939. *Mactra protoreevesii* Noetling: Mukerjee, p.14, Pl. II, fig. 4.

1992. *Mactra protoreevesii* Noetling: Tiwari, p. 99, Pl. X, figs. 8 -10.

2004. *Harvella* (*Mactrinula*) *protoreevesii* Noetling: Lyngdoh, p. 82 Pl. X, figs. 16 – 19.

2004. *Mactra protoreevesii* Noetling: Lalchawimawii, p. 29, Pl. III, fig. 12.

Material: One left valve.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. No.	**Length**	**Height**	**Inflation**	
B/B-29	23.00	17.00 (73.91)	3.00 (13.04)	LV

Remarks: Mukerjee (1939, p.14), while describing *Mactra protoreevesii* Noetling from the Garo Hills of Meghalaya, opined that characteristic features of the species are disproportion between the size of anterior and posterior regions, the presence of a broad, flattened keel running from umbo towards the posterior margin and extremely elongate anterior and the short acuminate posterior regions. All these characters are very well-marked in the specimen at hand. Hence, the assignment. Identification is further confirmed by the direct comparison of the specimen with Tiwari's collection (*op. cit.*) particularly with Sp. No. – MT/4/8 from the Upper Bhuban Formation of Mizoram.

Subfamily LUTRATIINAE Adams and Adams, 1956

Genus *Lutraria* Lamarck, 1759

Type species: *Mya lutraria* Linne', 1758; Tautonomy. Recent; Mediterranean.

Lutraria philippinarum Reeve, 1854

(Pl – 4, figs. 12 – 14)

1854. *Lutraria philippinarum* Deshayes; Reeve, conch. Icon, VIII, *Lutraria* sp. 4.

1928. *Lutraria philippinarum*, Melvill, *Proc.* Malac. *Soc. London,* XVIII, p.116.

1932. *Lutraria philippinarum*, Prashad, *Siboga-Exped Monogr.* , L III c, p. 211(with Synonymy)

1936. *Lutratria philippinarum*, Reeve: Cox, p. 65, Pl. VIII, fig. 1.

2004. *Lutraria philippinarum* Reeve: Mazumder, p. 98, Pl. XI, fig. 9.

2004. *Lutraria philippinarum* Reeve: Lalchawimawii, p.30, Pl. IV, fig. 2.

Material: Three poorly preserved bivalved specimens.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/B-6	29.00	20.00 (68.96)	10.00 (34.48)	BV
B/B-7	32.00	26.00 (81.25)	12.00 (37.50)	BV
B/B-9	28.00	21.00 (75.00)	8.50 (30.35)	BV

Remarks: The diagnostic character of the species *Lutraria philippinarum* Reeve as stated by Cox (1936, p. 65), is compressed, elongate-ovate and somewhat arcuate outline with anterior one-sixth umbo. These characters can be clearly seen in the specimens under study inspite of their poor preservation. In addition to above, the ornamentation also seems to be similar i.e. coarse and undulating growth lines. Therefore, the identification is confirmed.

Lutraria* (*Lutraria*) *saigengai Tiwari MS, 1992

(Pl – 4, fig. 15)

1992. *Lutratria* (*Lutraria*) *saigengai*, Tiwari, p. 100, Pl. X, figs. 12-13.

2004. *Lutratria* (*Lutraria*) *saigengai*, Mazumder, p. 97, Pl. XI, fig. 1.

2004. *Lutratria* (*Lutraria*) *saigengai*, Reeve: Lyngdoh, p.83, Pl. XI, fig. 1

2004. *Lutratria* (*Lutraria*) *saigengai*, Reeve: Lalchawimawii, p.30, Pl. IV, fig. 2.

Material: One failry well preserved bivalved specimen.

Location: Locality 2 (Ruata Quarry, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/R-1	43.00	22.00 (51.16)	11.00 (25.58)	BV

Remarks: Compressed nature with gapping at both the ends, transeversely-elliptically outline, height nearly half of the length, anterior-third to anterior-fourth umbo, broad rounded margins and commarginal bands becoming wider towards ventral margin remind at ones the species newly designated by Tiwari (1992) as *Lutraria* (*Lutraria*) *saigengai.* However, the present specimen is larger in size and more inflated. Since these differences are of trivial nature, it is identified as *Lutraria* (*Lutraria*) *saigengai*.

Superfamily SOLENACEA Lamarck, 1809

Family CULTELLIDAE Davies, 1935

Genus *Cultellus* Schumacher, 1817

Type species: *Cultellus magmus (=Solen lacteus* Spengler, 1794); by monotype. Recent; East Indies.

Subgenus *Cultellus* s. str.

Cultellus* (*Cultellus*) *zulloi Tiwari MS, 1992

(Pl – 4, fig. 16)

1992. *Cultellus (Cultellus) zulloi* Tiwari, p.105, Pl. XI, figs. 3, 6.

2004. *Cultellus (Cultellus) zulloi* Tiwari: Mazumder, p. 99, Pl. XI, fig. 10.

2004. *Cultellus (Cultellus) zulloi* Tiwari: Lalchawimawii, p. 31, Pl. IV, fig. 4.

Material: One left and right valves.

Location: Locality 6 (Govt. Complex Road, Zonuam, Aizawl).

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/GZ-238	36.00	16.00 (44.44)	3.00 (8.33)	RV
B/GZ-239	39.00	14.00 (35.89)	4.00 (10.25)	LV

Remarks: These specimens have perfectly elliptical outline excepting near umbonal region, their length is about 2.3 to 2.8 times than the height, and they have a shallow groove on either side of the umbo all along the dorsal margin. These have small and low umbones placed anterior-forth of the shell-length. In all the above characters, these specimens approach very closely to *Cultellus* (*Cultellus*) *zulloi* Tiwari (1992). Hence, their assignment is justified.

***Cultellus* sp.**

(Pl – 4, fig. 17, Pl – 5, fig. 1)

Material: Two complete juvenile specimens.

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl)

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/R-200	30.00	11.00 (36.66)	3.00 (10.00)	BV
B/R-201	24.00	10.00 (41.66)	4.00 (16.66)	BV

Description and Remarks: The shell is thin, highly compressed and narrowly elongated and seems to be gaping at both the ends. Umbo is small, indistinct and situated about anterior - third to one - fourth of the shell-length. Antero-dorsal is short and gently sloping whereas postero-dorsal is long and straight. Anterior and posterior margins are narrowly rounded and ventral margin is flat. Surface appears to be smooth. Poor preservation of the

specimen does not warrant specific identification and comparison with other known forms of the species.

Superfamily	TELLINACEA de Blainville, 1814
Family	TELLINIDAE de Blainville, 1814
Subfamily	TELLININAE de Blainville, 1814
Genus	*Tellina* Linne', 1758

Type species: *Tellina radiata* Linne', 1758; SD Children, 1823. Recent; West Indies.

Subgenus - *Angulus* Megerle Von Muehlfeld, 1811.

Type species: *Tellina lanceolata* Gmelin, 1791; SD. Gray, 1847. Recent; East Indies.

***Tellina* (*Angulus*) sp.**

(Pl – 5, figs. 2 – 3)

1992. *Tellina* (*Angulus*) Tiwari, p. 106.

2004. *Tellina* (*Angulus*) Tiwari: Mazumder, p. 101, Pl. XII, fig. 1.

2004. *Tellina* (*Angulus*) Tiwari: Lalchawimawii, p. 32, Pl. IV, figs. 5, 6.

Material: Five bivalved specimens and one left and right valves each.

Locality: Locality 5 (Luangmual Government Complex, Aizawl) and 6 (Govt. Complex road, Zonuam, Aizawl).

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 5 and 6.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/GZ-241	27.00	16.00 (59.25)	7.00 (25.92)	BV
B/GZ-242	27.00	16.00 (59.25)	8.00 (29.62)	BV
B/LG-243	28.00	17.00 (60.71)	8.00 (28.57)	BV
B/LG-244	34.00	20.00 (58.82)	9.00 (26.47)	BV
B/LG-245	28.00	18.00 (64.28)	4.00 (14.28)	LV
B/LG-246	22.00	15.00 (68.18)	3.00 (13.63)	RV
B/GZ-247	20.00	14.00 (70.00)	9.00 (45.00)	BV

Remarks: All these specimens show essential characters of the subgenus *Tellina* (*Angulus*) described by Tiwari (1992) *viz.*, compressed, inequilateral, subelliptical nature of the shell and sub-median and low umbo. Further, there is a strong similarity between the two in the nature of the margins and the nature and numbers of furrows and flexures. Hence, these are identified as *Tellina* (*Angulus*) sp. Their assignment under a new species is however deferred for the want of better-preserved materials.

Subgenus - *Eurytellina* Fischer, 1887

Type species: *Tellina punicea* Born, 1790; M. Recent; West Indies.

Tellina* (*Eurytellina*) cf. *pilgrimi Cox, 1936

(Pl – 5, fig. 4)

The synonymy for the typical form is as follows:

1936. *Tellina pilgrimi* Cox, p. 37, Pl. IV, figs.11, 12 a - b.

1992. *Tellina* (*Eurytellina*) *pilgrimi* Cox: Tiwari, p.108. Pl. XI, figs. 4, 5, 7, 8, 9, 10,11; Pl. XIII, figs. 8 a - b.

2004. *Tellina* (*Eurytellina*) *pilgrimi* Cox: Mazumder, p. 103, Pl. XII, fig. 4.

2004. *Tellina* (*Eurytellina*) *pilgrimi* Cox: Lalchawimawii, p. 33, Pl. IV, fig. 7.

Material: Three bivalves and one right valve.

Locality: Locality 5 (Luangmual Government Complex, Aizawl) and 6 (Govt. Complex road, Zonuam, Aizawl).

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 5 and 6.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/LG-248	27.00	20.00 (74.07)	14.00 (51.85)	BV
B/LG-249	26.00	19.00 (73.07)	10.00 (38.46)	BV
B/GZ-250	31.00	24.00 (77.41)	9.00 (29.03)	BV
B/GZ-251	25.00	17.00 (68.00)	6.00 (24.00)	RV

Remarks: In dimensional ratios and general outline, the specimens at hand resemble paratype of *Tellina pilgrimi* originally described by Cox (1936) from Persia. Further

comparison is not possible due to poor preservation. Hence, these are referred to as *Tellina* (*Eurytellina*) cf. *pilgrimi* Cox.

Tellina* (*Moerella*) *indifferens Noetling, 1901

(Pl – 5, figs. 5 – 6)

1901. *Tellina indifferens* Noetling, p. 221, Pl. XV, figs. 3 a - b.

1939. *Tellina indifferens* Noetling: Mukerjee, p. 10.

1992. *Tellina* (*Moerella*) *indifferens* Noetling: Tiwari MS, p. 111, Pl. XIII, figs. 4, 6.

2004. *Tellina* (*Moerella*) *indifferens* Noetling: Mazumder, p. 104, Pl. XII, fig. 2.

Material: Three bivalved specimens.

Locality: Locality 5 (Luangmual Government Complex, Aizawl) and 6 (Govt. Complex road, Zonuam, Aizawl).

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 5 and 6.

Dimensions:

Sp. no.	Length	Height	Inflation	
B/LG-252	35.00	25.00 (71.42)	12.00 (24.28)	BV
B/LG-253	34.00	25.00 (73.52)	12.00 (35.29)	BV
B/G2-254	34.00	25.00 (73.52)	12.00 (35.29)	BV

Remarks: The diagnostic characters of this species are smooth and rather flat surface, elongate triangular outline, sub-terminal to sub-median umbo, narrow elongate anterior, and short and rounded posterior. All these characters are well marked in the three specimens available for study. Hence, specific assignment of these specimens is confirmed.

Tellina* (*Tellinella*) *loknathi Tiwari, 1992

(Pl – 5, fig. 7)

1992. *Tellina loknathi* Tiwari, p.117, Pl. XII, figs. 3 a - b, 9.

2004. *Tellina* (*Tellinella*) *loknathi* Tiwari: Mazumder, p. 106, Pl. XII, fig. 6.

Material: Three right valves embedded in matrix and one left valve.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl), Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) and Locality 5 (Luangmual Government Complex, Aizawl) and 6 (Govt. Complex Road, Zonuam Aizawl).

Horizon: Grey silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 1; Upper intraformational conglomerate band of Upper Bhuban unit, Bhuban Formation of Locality 2; Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 5 and 6.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/R-13	35.00	20.00 (57.14)	3.00 (8.57)	RV
B/B-15	46.00	26.00 (56.52)	3.00 (6.52)	RV
B/LG-255	23.00	11.00 (47.82)	3.00 (13.04)	LV
B/GZ-257	19.00	13.00 (68.42)	2.50 (13.15)	RV

Remarks: The specimens at hand match well with *Tellina loknathi* reported by Tiwari (1992) from Lunglei of Mizoram in dimensional ratios, nature and position of umbo, configuration of margins and nature and number of flexures and furrows. Though the surface is worn out and surface sculpture could not be clearly seen, the worn out surfaces give the feeling of growth lines that become wider towards the ventral surface like in Tiwari's collections. Thus these have been assigned to *Tellina* (*Tellinella*) *loknathi* Tiwari.

Subfamily MACOMINAE Olsson, 1961

Genus *Apolymetis* Salisbury, 1929

Type species: *Tellina meyeri* Phillipi, 1846, ex Dunker, MS; by Monotypy. Recent; East Indies.

Subgenus *Apolymetis* s.str.

Apolymetis* (*Apolymetis*) *aizawlensis Tiwari and Kachhara, 2000

(Pl – 5, figs. 8 – 9)

2000. *Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari and Kachhara, p. 84, Pl. 1, figs. 4 - 8; Pl. 2, figs. 1-7.

2004. *Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari and Kachhara: Mazumder, p. 108, Pl. XII, fig. 7.

Material: One complete specimen, one broken bivalve and one right valve

Location: Locality 6 (Govt. Complex road, Zonuam, Aizawl).

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/GZ-258	34.00	24.00 (70.58)	13.00 (38.23)	BV
B/GZ-259	31.00	19.00 (61.29)	10.00 (32.25)	RV
B/GZ-260	30.00	21.00 (70.00)	12.00 (40.00)	BV

Remarks: In trigonally-ovate outline, slightly inequivalved and strongly inequilateral character, in nature and position of umbones, in the nature and number of furrows and flexures and in ornamentation, these specimens, particularly specimen no. B/G2-258, are identical to the holotype of *Apolymetis* (*Apolymetis*) *aizawlensis* described and figured by Tiwari and Kachhara (2000). Author could not make any distinction between the two sets of specimens. Hence, the assignment.

Apolymetis* (*Apolymetis*) *grimesi Noetling, 1901

(Pl – 5, figs. 10 – 12)

1901. *Tellina* (*Metis*) *grimesi* Noetling, p. 216, Pl. 14, figs. 4 - 6.
1939. *Apolymetis grimesi* (Noetling): Mukerjee, p. 11, Pl. 1, fig. 18.
2004. *Apolymetis grimesi* (Noetling): Lyngdoh, p. 90, Pl. XI, fig. 10.
2004. *Apolymetis grimesi* (Noetling): Lalchawimawii, p. 35, Pl. IV, fig. 10; Pl. V, fig. 1.

Material: Three bivalves, one left valve embedded in the matrix and one broken right valve.

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) and Locality 6 (Govt. Complex road, Zonuam Aizawl).

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2; Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 6.

Dimensions:

Sp. no.	Length	Height	Inflation	
B/R-12	20.00	22.00 (110.00)	4.00 (20.00)	RV
B/GZ-262	33.00	31.00 (93.93)	15.00 (45.45)	BV
B/GZ-263	26.00	25.00 (96.15)	14.00 (53.84)	BV

Remarks: The specimens available for the study resemble very closely with *Apolymetis grimesi* (Noetling) reported by Mukerjee (1939) from the Miocene of Garo Hills, Meghalaya in respect of general configuration, dimensional ratios and in the nature, number and disposition of flexures and furrows. This species has also been reported by Lyngdoh (2004) from the Miocene of the Garo Hills, Meghalaya and on comaparison is found to match well with the present specimens in above characters. The present specimens however, are more or less sub-orbicular and have more pronounced concentric growth lines on both the valves than the Garo counterparts.

Family PSAMMOBIIDAE Fleming, 1828

Subfamily PSAMMOBIINAE Fleming, 1828

Genus *Gari* Schumacher, 1817

Type species: *Gari vulgaris* (= *Solen amethystus* Wood, 1815); Eocene to Recent; Cosmopolitan.

Gari* (*Gari*) *natensis Noetling, 1901

(Pl – 5, fig. 13)

1901. *Gari natensis* Noetling, p. 228, Pl. XV, figs. 6, a - e.

1992. *Gari* (*Gari*) *natensis* Noetling: Tiwari, p. 124, Pl. XII, fig. 7

2004. *Gari* (*Gari*) *natensis* Noetling: Lyngdoh, p. 91, Pl. XI, figs. 12 - 13.

Material: One right valve.

Location: Locality 4 (near Faith Academy, Zonuam, Aizawl).

Horizon: Brown-silty sandstone of Upper Bhuban unit, Bhuban Formation.

Dimensions: The lone specimen (Sp. no. B/FZ-23) has the following dimensions; Length – 15.00; Height – 8.00 (53.33); Inflation – 2.00 (13.33)

Remarks: The present specimen, though small and poorly preserved, matches well with *Gari (Gari) natensis* Noetling (1901) with respect to outline, posterior region and ornamentation. Nodes produced by the concentric lines crossing over the carina are also faintly preserved in the present specimen. Moreover, it also matches very well with the specimens of the same species reported by Lyngdoh (2004) from the Miocene of Garo Hills, Meghalaya. Hence, the assignment seems to be correct.

Gari* (*Psammobia*) *kingi (Noetling), 1901

(Pl – 5, fig. 14)

1901. *Gari kingi* Noetling, p. 232, Pl. XV, figs. 11, 11a, 12, 12a, 13, and 13a.

1939. *Psammobia kingi* (Noetling): Mukerjee, p. 12

Material: One right valve.

Location: Locality 5 (Luangmual Govt. Complex, Aizawl).

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation.

Dimensions (mm):

Sp. no.	**Length**	**Height**	**Inflation**	
B/LG-264	30.00	16.00 (48.00)	6.00 (20.00)	RV

Remarks: In general proportions, external characters of ornamentation and dimensional ratios and nature and number of posterior keels and furrows, lone specimen from Mizoram resemble very closely with the holotype of *Gari kingi* Noetling (1901). Further, it has been compared with the Mukerji's collection of the same species from the Miocene of Baghmara, Meghalaya (Sp. No. K22/876) and found to match well expecting the smaller size of the latter. Therefore, its identification is beyond doubt.

Superfamily GLOSSACEA Gray, 1847

Family GLOSSIDAE Gray, 1847

Genus *Glossus* Poli, 1795

Type species: *Glossus rubicundus* Poli, 1795 (= *Cardium humanum* Linne', 1758); M; Palaeocene to Recent; Europe, N.Atlantic, West Asia to Indo Pacific.

Subgenus *Cytherocardia* Sacco, 1900

Type species: *Isocardia cytheroides* Mayer, 1868; OD; Eocene to Miocene; Europe.

Glossus* (*Cytherocardia*) *cytheroides (Mayer), 1969

(Pl – 5, figs. 15 a – b)

1969. *Glossus* (*Cytherocardia*) *cytheroides* (Mayer): Keen and Casey, p. 657, figs. E134, 9.

2004. *Glossus* (*Cytherocardia*) *cytheroides* (Mayer): Mazumder, p. 114, Pl. XIV, fig. 12.

Material: Two complete bivalves and one broken right valve.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of locality 1 and Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of locality 2.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/R-48	23.00	25.00 (108.69)	11.00 (47.82)	BV
B/R-50	14.00	14.00 (100.00)	9.00 (64.28)	BV
B/B-52	14.00	14.00 (100.00)	6.00 (42.85)	RV

Remarks: The specimens in hand, remind at once, *Glossus* (*Cytherocardia*) *cytheroides* (Mayer) reported by Mazumder (2004) from the Bhuban rocks of Kolasib, Mizoram in respect of elongate-ovate outline, prominent prosogyrous umbo placed anterior-fifth, nature of margins, a postero-ventral ridge and in ornamentation. Hence, the assignment. However, the example from Ruata Quarry, Ramrikawn, Aizawl is a taller form as compared to Kolasib. Further, comparison with the same species illustrated by Keen and Casey (1969) from the Miocene of France does not distinguish the two. Hence, the assignment is justifiable.

Superfamily	VENERACEA Rafinesque, 1815
Family	VENERIDAE Rafinesque, 1815
Subfamily	PITARINAE Stewart, 1930
Genus	*Callista* Poli, 1791

Type species: *Venus chione* Linne', 1758; SD Meek, 1876. Palaeocene toRecent; Mediterranean.

Callista* (*Callista*) *pseudoumbonella Vredenburg

(Pl – 6, fig. 1)

1928. *Cytherea* (*Callista*) *pseudoumbonella* Vredenburg, p. 450, Pl. XXIX, figs. 10 -13, Pl. XXX, figs. 1 - 3 and 5 and 6.

1964. *Cytherea* (*Callista*) *pseudoumbonella* Vredenburg: Sengupta, p. 150.

1992. *Callista* (*Callista*) *pseudoumbonella* Vredenburg: Tiwari p. 136, Pl. XV, figs. 4, 7.

2004. *Callista* (*Callista*) *pseudoumbonella* Vredenburg: Lalchawimawii p.38, Pl. V, fig. 7.

Material: One fairly preserved and two ill preserved right valves.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/R-5	25.00	20.00 (80.00)	12.00 (48.00)	RV
B/B-51	22.00	16.00 (72.72)	9.00 (40.90)	RV
B/B- 53	25.00	18.00 (72.00)	5.00 (20.00)	RV

Remarks: Tiwari (1992), while reporting *Callista* (*Callista*) *pseudoumbonella* Vredenburg from the Miocene of Hlimen, Mizoram, commented that the diagnostic characters of the species are ovate outline, strong inflation, thick umbo, produced anterior and its ornamentation. All these characters are well marked in the present specimens, particularly in Sp. No. B/R-5. Hence, the identification is beyond doubt.

Subgenus *Costacallista* Palmer, 1927

Type species: *Venus erycina* Linne,' 1758; OD. Palaeocene – Recent; America, Asia, Europe, N.Z.

Callista* (*Costacallista*) *erycina (Linne'), 1758

(Pl – 6, fig. 2)

1758. *Venus erycina* Linne', p. 686.

1901. *Cytherea erycina* Favanne: Noetling, p. 198, Pl. XII, figs. 9 – 12.

1924. *Callista erycina* (Linne'): Cossman, p. 134, Pl. VIII, figs. 1 – 3, 18.

1927. *Macrocallista erycina* (Linne'): Cox, p. 58, Pl. IX, figs. 7 – 8.

1939. *Macrocallista erycina* (Linne'): Mukerjee, p.20, Pl.I, fig. 20.

1970. *Callista* (*Costacallista*) *erycina* (Linne'): Iwasaki, p. 212. Pl. XXIII, figs. 1 – 8.

1977. *Callista* (*Costacallista*) *erycina* (Linne'): Kotada and Noda, p. 142, Pl. XXV, figs. 13-14.

1992. *Callista* (*Costacallista*) *erycina* (Linne'): Tiwari, p. 139, Pl. XV, figs. 2-3, 5 and 6.

2004. *Callista* (*Costacallista*) *erycine* (Linne'): Mazumder, p. 116, Pl. XIII, figs. 1 a - b.

2004. *Callista* (*Costacallista*) *erycina* (Linne'): Lyngdoh, p. 98, Pl. XIII, figs. 1 and 2.

2004. *Callista* (*Costacallista*) *erycina* (Linne'): Lalchawimawii, p. 39, Pl. V, figs. 8 and 9.

Material: Two incomplete right valves.

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl)

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/R- 42	30.00	23.00 (76.66)	6.00 (20.00)	RV
B/R- 42(a)	32.00	23.00 (71.87)	6.00 (18.75)	RV

Remarks: The species *Callista* (*Costacallista*) *erycina* (Linne') is known to have extremely variable form ranging from normal type to the more elongate and lanceolate types (Mukerjee, 1939; Tiwari, 1992). The present specimens are lanceolate type and match well with the general outline and external characters of ornamentation of the species under consideration. As such, these have been assigned to *Callista* (*Costacallista*) *erycina* (Linne') without any reservation.

Subfamily DOSINIINAE Deshayes, 1853

Genus *Dosinia* Scopoli, 1777

Type species: *Chama dosin* Adanson, 1757 (= *Venus concentrica* Born, 1778); M. Recent; U.S.A.

Subgenus *Dosinia s.str.*

Dosinia* (*Dosinia*) *peralta Vredenburg

(Pl – 6, figs. 3 – 4)

1928. *Dosinia* (*Dosinia*) *peralta* Vredenburg, p. 449, Pl. XXIX, figs. 1 - 6.

1992. *Dosinia* (*Dosinia*) *peralta* Vredenburg: Tiwari, p. 141, Pl. XIV, figs. 6, 7.

2004. *Dosinia* (*Dosinia*) *peralta* Vredenburg: Mazumder, p. 119, Pl. XIII, fig. 4.

2004. *Dosinia* (*Dosinia*) *peralta* Vredenburg: Lyngdoh, p. 103.

2004. *Dosinia* (*Dosinia*) *peralta* Vredenburg: Lalchawimawii, p. 41, Pl. V, fig. 11.

Material: One left and two right valves.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl) and Locality 5 (Govt. Complex road, Zonuam, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1, and brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 5.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/B-26	33.00	35.00 (106.06)	5.00 (15.15)	LV
B/B-3	21.00	23.00 (109.52)	4.00 (19.04)	RV
B/LG-4	19.00	21.00 (110.52)	3.20 (16.84)	RV

Remarks: The diagnostic characters of the species are sub-orbicular outline, height slightly more than the length, moderate inflation, symmetrical ventral margin, long and straight postero-dorsal margin, concavity at the anterior end and fine concentric growth lines. All these characters can be clearly seen in the isolated valves at hand. These also macth well with the *Dosinia* (*Dosinia*) *peralta* Vredenburg (p. 449, Pl. XXIX, figs. 1 – 6). Hence the assignment.

Dosinia* (*Dosinia*) *subpenicillata Vredenburg, 1928

(Pl – 6, figs. 5 – 6)

1928. *Dosinia subpenicillata* Vredenburg, p. 448, Pl. XXIX, figs. 7 - 9

2004. *Dosinia* (*Dosinia*) *subpenicillata* Vredenburg: Lyngdoh, p. 103, Pl. XIII, fig. 12.

2004. *Dosinia* (*Dosinia*) *subpenicillata* Vredenburg: Lalchawimawii, p. 41, Pl. V, fig. 12.

Material: Three isolated left valves.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/B-19	29.00	27.00 (93.10)	5.00 (17.24)	LV
B/B-25	39.00	36.00 (92.30)	5.00 (12.82)	LV
B/B-34	25.00	23.00 (92.00)	4.00 (16.00)	LV

Remarks: Vredenburg, while describing a new species under the name *Dosinia subpenicillata* (1928, p. 448, Pl. XXIX, figs. 7-9), remarked that this is an orbicular form expanded in an antero-posterior direction with feeble convexity, has almost horizontal ligamental margin and its surface sculpture consists of fine and numerous concentric ridges. All these characters are clearly marked in all the specimens at hand. Therefore, these can be assigned to the Vredenburg's species without any reservation.

Subfamily CLEMENTIINAE Frizzel, 1936

Genus - *Clementia* Gray, 1842

Type species: *Venus papyracea* Gray, 1825; SD Gray, 1847. Recent; Pacific.

Subgenus - *Clementia* (*s. s.*)

Clementia* (*Clementia*) *papyracea (Gray), 1825

(Pl – 6, figs. 7 – 9)

1825. *Venus papyracea* Gray, p.137.

1840. *Venus nonscripta* J.de C.Sowerby, Pl.XXV, fig.8.

1927. *Clementia papyracea* (Gray): Cox, p.54, Pl.IV, figs. 3 and 4

1928. *Clementia papyracea* (Gray): Douglas, p.10, Pl.XIII, fig. 10.

1928. *Venus* (*Clementia*) *papyracea* (Gray): Vredenburg, p.455, pl. XXXII, fig. 3.

1930. *Clementia papyracea* (Gray): Cox, p.130, Pl.XV, fig.4.

1932. *Clementia papyracea* (Gray): Prashad, p. 262

1936. *Clementia papyracea* (Gray): Cox, p.62, Pl. VIII, figs. 7 - 8

1939. *Clementia papyracea* (Gray): Mukerjee, p.23, Pl.I, fig.17.

1951. *Clementia papyracea* (Gray): Eames, p.416.

1969. *Clementia papyracea* (Gray): Myra Keen, p.N681, figs. E147, 2a-b.

1970. *Clementia papyracea* (Gray): Iwasaki, p.213, Pl.XXIII, fig. 5.

1973. *Clementia papyracea* (Gray): Shuto, p.57, Pl.X, figs. 16-18.

1982. *Clementia papyracea* (Gray): Kanno *et.al.*, p.89, Pl.XV, fig. 15.

1992. *Clementia* (*Clementia*) *papyracea* (Gray): Tiwari MS, p.142, Pl.XIV, figs. 12a-b.

1994. *Clementia* (*Clementia*) *papyracea* (Gray): Noda *et al*., P.95, fig. 6.9.

1997. *Clementia* (*Clementia*) *papyracea* (Gray): Jain MS, p.146, Pl.XXV, figs. 18-22; Pl.XXVI, fig.1.

1998. *Clementia* (*Clementia*) *papyracea* (Gray): Nakagawa, p.151, figs. 30.2, 3.

2004. *Clementia* (*Clementia*) *papyracea* (Gray): Mazumder, p.123, Pl.XIII, fig.12.

Material: One complete and one broken bivalves and one fragmentary right valve.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl), Locality 4 (near Faith Academy, Zonuam) and Locality 6 (Govt. Complex road, Zonuam, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1; brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 4 and 6.

Dimensions (mm):

Sp. no.	**Length**	**Height**	**Inflation**	
B/FZ-2	32.00	20.00 (62.5)	13.00 (40.62)	BV
B/B-8	15.00	15.00 (100.00)	7.00 (46.66)	BV
B/GZ-266	27.00	17.00 (62.96)	8.00 (29.62)	RV

Remarks: Though the species *Clementia* (*Clementia*) *papyracea* (Gray) is a variable form, it has a characteristic ornamentation i. e. coarse concentric undulations that are

inturn finely straiated. This typical surface sculpture can be clearly seen in all the specimens at hand. Therefore, these have been assigned to the species under consideration. This is a widely distributed species and has been reported from Japan, Phillipines, East Indies, Eastern Australia, Persian Gulf and Arabia. It has also been reported from the Gaj of Kachchh and Sind, Miocene of Garo Hills and Mizoram.

Subfamily TAPETINAE Adams and Adams, 1857

Genus *Paphia* Roeding, 1798

Type species: *Pahia alapapilionis* (= *Venus rotundata* Linne', 1758); SD. Dall, 1902; Recent; Western Pacific.

Subgenus *Paphia s.str*.

Paphia* (*Paphia*) *rotundata (Linne'), 1969

(Pl – 6, figs. 10 – 13)

1969. *Paphia* (*Paphia*) *rotundata* (Linne'): Myra Keen, p. 256, figs. E 149, and 2, a - c.

1971. *Paphia* (*Paphia*) *rotundata* (Linne'): Davies, p. 256, fig. 587 c.

1992. *Paphia* (*Paphia*) *rotundata* (Linne'): Tiwari, p.144, Pl. XV, figs. 13, 14, 15; Pl. XVI, figs. 1a, b, c.

2005. *Paphia* (*Paphia*) *rotundata* (Linne'): Lalchawimawii, p.43, Pl. VI, fig. 3.

Material: Two bivalves, two left and right valves each.

Location: Locality 4 (near Faith Academy, Zonuam, Aizawl), Locality 5 (Luangmual Govt. Complex, Aizawl), and Locality 6 (Govt. Complex Road, Zonuam, Aizawl)

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 4, 5 and 6.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/FZ-21	25.00	16.00 (64.00)	9.00 (36.00)	BV
B/FZ-30	30.00	17.00(56.66)	5.00 (16.66)	RV
B/LG-265	24.00	17.00 (70.83)	5.00 (20.83)	LV
B/LG-267	25.00	17.00 (68.00)	3.00 (12.00)	RV
B/GZ-268	21.00	12.00 (62.50)	4.00 (19.04)	LV
B/GZ-269	32.00	20.00 (62.50)	12.00 (37.50)	BV

Remarks: The specimens at hand have been assigned to *Paphia* (*Paphia*) *rotundata* (Linne') owing to almost total similarity with this species in respect of general outline, dimensional ratios, nature and positions of umbo and in surface ornamentation. Hence, these are assignment to the Linne' species. The identification has been further confirmed by the direct comparison of the present specimens with the Tiwari's collection (1992).

Paphia* (*Paphia*) *jhai Tiwari MS
(Pl – 6, figs. 14 – 15)

1992. *Paphia* (*Paphia*) *jhai* Tiwari MS, p. 146, Pl. XV, figs. 8, 9 and 12.
2004. *Paphia* (*Paphia*) *jhai* Tiwari MS: Mazumder p. 125, Pl. XIV, fig. 8.

Material: Two bivalved specimens.
Location: Locality 5 (Luangmual Govt. Complex, Aizawl).
Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation.
Dimensions (mm):

Sp. no.	**Length**	**Height**	**Inflation**	
B/LG-22	32.00	19.00 (59.37)	13.00 (40.62)	BV
B/LG-215	16.00	10.00 (62.50)	6.00 (37.50)	BV

Remarks: The two specimens at hand exhibits all the diagnostic characters like overall shape, dimensional ratios, position of umbo and external sculpture of the species *Paphia* (*Paphia*) *jhai* Tiwari (1992). On direct comparision, these are also found to match very closely with the holotype of Tiwari's collection. Hence the identification.

Subgenus *Callistotapes* Sacco, 1900

Type species: *Venus ventula* Basterot, 1825; OD. Oligocene to Recent; Europe, Asia and New Zealand.

Paphia* (*Callistotapes*) *pseudoliratus Vredenburg, 1928
(Pl – 6, fig. 16 – 17)

1928. *Tapes* (*Callistotapes*) *pseudoliratus* Vredenburg, p. 457, Pl. XXXI, figs. 2 - 5.
1992. *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg: Tiwari, p. 148, Pl. XVI, figs. 2- 4
2004. *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg: Lyngdoh, p.107, Pl. XIV, figs 1-2

2004. *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg: Lalchawimawii, p.44, Pl. VI, fig. 4.

Material: One bivalved specimen and two broken right valves.

Location: Locality 4 (near Faith Academy, Zonuam, Aizawl) and Locality 5 (Luangmual Govt. Complex, Aizawl)

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 4 and 5.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/FZ-40	16.00	11.00 (68.75)	3.00 (18.75)	RV
B/LG-271	25.00	17.00 (68.00)	10.00 (40.00)	BV
B/LG-272	17.00	15.00 (88.23)	3.00 (17.64)	RV

Remarks: Diagnostically compressed outline, elongate-ovate shape, narrowly rounded anterior and posterior margins; elongate ill defined lunule and prominent concentric sculpture separated by narrow interstices are satisfactorily marked in all the specimens of the present collection. On the account of the above characters, these match very well with the *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg and are accordingly assigned.

Subfamily CHIONINAE Frizzel, 1936

Genus *Timoclea* Brown, 1827

Type species: *Venus ovata* Pennat, 1777; M.Late Miocene – Recent; Europe, Mediterranean, India, Central America, Western Pacific.

Subgenus *Timoclea s.str.*

Timoclea* (*Timoclea*) *scabra (Hanley), 1844

(Pl – 6, fig. 18, Pl – 7, fig. 1)

1844. *Antigona scabra* Hanley, p. 161, 361, Pl. 16, fig. 24.

1853. *Venus scabra* (Hanley): Sowerby, p. 718, Pl. 157, figs. 101 and 102.

1864. *Venus scabra* (Hanley): Reeve, Vol. 14.

1960. *Veremolpha scabra* (Hanley): Shuto, p. 144, text fig. 10.

1974. *Timoclea scabra* (Hanley): Dance, p. 271.

2004. *Timoclea* (*Timoclea*) *scabra* (Hanley): Mazumder, p. 127, Pl. XIV, figs. 2 - 3.

2004. *Timoclea* (*Timoclea*) *scabra* (Hanley): Lalchawimawii, p.45

Material: Two fragmentary left valves.

Location: Locality 3 (near Youth Hostel, Luangmual, Aizawl) and Locality 5 (Luangmual Govt. Complex, Aizawl)

Horizon: Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 3 and 5.

Dimensions: Dimensions could not be measured due to fragmentary nature of the specimens.

Remarks: Mazumder (2004) reported this species from the Miocene of Kolasib area, Mizoram and commented that the diagnostic characters of the species in question are ovate-trigonal outline, moderate inflation, rounded posterior and ventral margins and concentric growth lines crossed over by fine radials. The radials become more prominent just anterior to the posterior slope. Though the specimens under study are fragmentary and other characters could not be ascertained, the characteristic surface sculpture i. e. concentric growth lines crossed over by the fine radials and the radial inturn becoming prominent just anterior to posterior slope, can be clearly seen in all the specimens available for the study. Thus, these can be safely merged with *Timoclea* (*Timoclea*) *scabra* (Hanley) on account of the above characters.

Order	MYOIDA Stoliczka, 1870
Suborder	MYINA Stoliczka, 1870
Superfamily	MYACEA Lamarck, 1809
Family	CORBULIDAE Lamarck, 1818
Subfamily	CORBULINAE Gray, 1823
Genus	*Corbula* Bruguiere, 1797

Type species: *Corbula sulcata* Lamarck, 1801; SD.Schmidt, 1818. Recent; Senegal (West Africa).

Corbula* (*Corbula*) *mekranica Vredenburg, 1928

(Pl – 7, fig. 2)

1928. *Corbula mekranica* Vredenburg, p. 461, Pl. XXXI, figs. 7 - 9.

1992. *Corbula mekranica* Vredenburg: Tiwari MS, p. 151, Pl.XVI, fig. 13.

2004. *Corbula mekranica* Vredenburg: Mazumder, p.130, Pl.XIII, fig.11.

Material: Two right valves and one left valve embedded in the martrix.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Foramtion of Locality 1; Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/B-203	13.00	12.00 (92.30)	3.00 (23.07)	RV
B/B-208	7.00	7.00 (100.00)	2.00 (28.57)	LV
B/R-209	6.00	6.00 (100.00)	2.00 (33.33)	RV

Remarks: Vredenburg (1928), while comparing *Corbula* (*Corbula*) *tunicosulcata* with *Corbula* (*Corbula*) *mekranica,* stated that there is no difference between the two species excepting that the former is more inequivalved and less elongate. Mizoram examples are also more inequivalved and less elongate, hence these are clubbed with *Corbula* (*Corbula*) *mekranica* (Vredenburg). These, on comparison with the Tiwari's and Mazumder's collection, are also found to match well. Hence, assignment is confirmed.

Corbula* (*Corbula*) *tunicosulcata Vredenburg

(Pl – 7, figs. 3 – 4)

1928. *Corbula tunicosulcata* Vredenburg, p. 460, Pl. XXXI, figs. 10 - 19.

1992. *Corbula tunicosulcata* Vredenburg: Tiwari, p. 150, Pl. XVI, fig. 12.

2004. *Corbula tunicosulcata* Vredenburg: Mazumder, p. 131, Pl. XIII, fig. 13.

2004. *Corbula tunicosulcata* Vredenburg: Lyngdoh, p.113, Pl. XIV, figs. 13 - 14.

2004. *Corbula tunicosulcata* Vredenburg: Lalchawimawii, p.46, Pl. VI, fig. 6.

Material: Two left valves and three right valves embedded in the matrix.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl), Locality 3 (near Youth Hostel, Luangmual, Aizawl) and Locality 4 (Faith Academy, Zonuam, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Foramtion of Locality 1; Brown silty-sandstone, Upper Bhuban unit, Bhuban Formation of Locality 3 and 4.

Dimensions:

Sp. no.	**Length**	**Height**	**Inflation**	
B/B-54	15.00	10.00 (66.66)	4.00 (26.66)	LV
B/B-204	15.00	9.00 (60.00)	5.00 (33.33)	RV
B/B-210	16.00	11.00 (68.75)	4.00 (25.00)	RV
B/FZ-212	10.00	6.00 (60.00)	2.50 (25.00)	LV
B/YL-205	12.00	8.00 (66.66)	4.00 (33.33)	RV

Remarks: Vredenburg (1928) christened a new species by the name *Corbula* (*Corbula*) *tunicosulcata* considering the dignostic characters like broadly triangular, flattened and moderately incurved umbo, high inflation, elongated and contracted posterior portion with a prominent curvilinear ridge and surface with broadly spaced angular costae. All these characters are clearly marked in all the specimens at hand. Hence, the assignment. Vredenburg (1928) considered this form as an intermediate form of *Corbula tunicata* (Hinds) and *Corbula sulcata* Lamarck because his collections showed the characters of both these species.

3.2 SYSTEMATIC DESCRIPTION OF GASTROPODA

The Bhuban sediments of the study area have yielded only a few gastropods. Overall, preservation of gastropds is poor and apertures so crucial for identification are rarely preserved. Classification given by Davies (1971, pp.280 - 444) has been followed in this work. Dimensions are given in millimeters.

Class	GASTROPODA Cuvier, 1797
Subclass	PROSOBRANCHIA Milne Edwards, 1848
Order	MESOGASTROPODA Cox, 1959
Superfamily	CERITHIACEA Fleming, 1822
Family	TURRITELLIDAE Woodward, 1851
Subfamily	TURRITELLINAE Woodward, 1851
Genus	*Archimediella* Lamarck, 1799

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

Subgenus *Torculoidella* Sacco, 1895

Type species: *Turbo varicosus* Brochhi. Pliocene; Italy.

Archimediella* (*Torculoidella*) *angulata (Sowerby), 1840

(Pl – 7, figs. 5 – 6)

1840. *Turritella angulata* Sowerby, Pl. XXVI, figs. 7 and 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, figs. 1 and 2.
1879. *Turritella simplex* Jenkins: Martin, p. 67, Pl. XI, figs. 10 – 11.
1879. ? *Turritella angulata* Sowerby: Martin, p. 68, Pl. XII, fig. 2.
1879. *Turritella duplicata* Lamarck: Martin, p. 69, Pl. XI, fig. 13.
1879. *Turritella acuticarinata* Dunker: Martin, p. 69, Pl. XII, figs. 3 – 4.
1884. *Turritella angulata* Sowerby: Fedden, p. 48.
1901. *Turritella angulata* Sowerby: Noetling, p. 272, Pl. XVIII, figs. 13 – 15.
1901. *Turritella simplex* Jenkins: Noetling, p. 272, Pl. XVIII, figs. 1 – 4.

1901. *Turritella acuticarinata* Dunker: Noetling, p. 274, Pl. XVIII, figs. 5 – 7.

1905. *Turritella simplex* Jenkins: Martin, p. 226, Pl. XXXIV, figs. 520.

1905. *Turritella djadjariensis* Martin, p. 228, Pl. XXXIV, figs. 532 – 538.

1928. *Turritella assimilis* Sowerby: Vredenburg, p. 377.

1928. *Turritella angulata* Sowerby: Vredenburg, p. 378.

1936. *Turritella angulata* Sowerby: Cox, p. 38, Pl. VIII, figs. 20 – 24.

1939. *Turritella* (*Torculoidella*) *angulata* Sowerby: Mukerjee, p. 44, Pl.II, figs. 17-21; Pl. III, figs. 1 – 2.

1964. *Turritella angulata* Sowerby: Sen Gupta, p. 148.

1973. *Turritella angulata* Sowerby: Pascoe, p. 1641, fig. 7.

1992. *Turritella* (*Torculoidella*) *angulata* J.de.Sowerby: Tiwari, p. 157, Pl. XVII, figs. 2- 3.

2004. *Turritella* (*Torculoidella*) *angulata* J.de.Sowerby: Mazumder, p. 140, Pl. XV, fig. 3.

2004. *Archimediella* (*Torculoidella*) *angulata* (Sowerby): Lyngdoh, p. 112, Pl.XV, fig. 13.

2004. *Archimediella* (*Torculoidella*) *angulata* (Sowerby): Lalchawimawii, p. 47, Pl.VI, fig. 7.

Material: Two incomplete specimens.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl), Locality 3 (near Youth Hostel, Luangmual, Aizawl) and Locality 4 (Faith Academy, Zonuam, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1, and brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 3 and 4.

Dimensions:

Sp.no.	**Height**	**Diameter of spire**
G/B-26	19.00	-
G/B-27	45.00	-

Remarks: Mukerjee (1939), while reporting the species from the Miocene of the Garo Hills, Meghalaya remarked that this species shows wide variations. He discussed four main variation of this species from A - D. My specimen belongs to A which has angular whorls marked by strong sharp spiral carina in which numerous secondary threads on the posterior part of the whorls are of nearly the same strength as the two primary ones and in which the third primary spiral forms a well defined angle.

Superfamily	CYPRAEACEA
Family	CYPRAEIDAE
Subfamily	CYPRAEINAE
Genus	*Cypraea*

***Cypraea* sp.**

(Pl – 7, figs. 7 – 8)

Material: Two specimens.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower and upper intraformational conglomeratic bands, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	Height	Diameter at the base
G/B-7	25.00	17.50
G/B-8	25.00	16.50

Remarks: Oval shape, more or less globose nature, curved, denticulate and slightly projecting and moderately wide spire, deep notch at both the ends of the two specimens remind at once the genus *Cypraea*. These specimens are thus assigned to this genus. Further description is not possible due to poor preservation. It is to be noted however, that this genus ranges from Middle Miocene to Recent and is an Indo-Pacific form found also in Indonesia and Africa (Davies, 1975). This is the first record of the genus from the Northeastern region.

Superfamily	TONNACEA Suter, 1913
Family	FICIDAE
Genus	*Ficus* (Bolten) Roeding, 1798

Type species: *Bulla ficus* Gmelin; SD. Dall, 1909. Recent; Indo - Pacific.

Ficus* (*Ficus*) *ficus (Linne'), 1767

(Pl – 7, fig. 9)

1767. *Bulla ficus* Linne', p. 1184.

1799. *Pyrula ficus* (Linne'): Lamarck, p. 73.

1822. *Pyrula ficus* (Linne'): Lamarck, Vol. VI (2), p. 141.

1847. *Ficula loevigata* Reeve, Monograph of the genus *Ficula*, sp. 4.

1885. *Pyrula ficus* (Linne'): Tryon, Vol. VII, p. 266.

1925. *Pyrula ficus* (Linne'): Vredenburg, p. 291.

1971. *Ficus ficus* (Linne'): Davies, p. 348, fig. 749.

1974. *Ficus ficus* (Linne'): Dance, p. 120.

2004. *Ficus* (*Ficus*) *ficus* (Brongniart): Mazumder, p. 145, Pl. XVI, fig. 1.

Material: One specimen is examined.

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl)

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Height**	**Diameter at the base**
G/R-3	35.00	18.00

Remarks: The diagnostic characters of this species are posteriorly expanded body whorl, almost flat spire, finely reticulated ornamentation and crowded spiral threads that are broader than the intervals. All these characters are well marked in the present collection. It has also been compared with the Mazumder's collection to which it is found to match well. Hence the assignment.

Ficus* (*Ficus*) *kachhensis (Vredenburg), 1925

(Pl – 7, fig. 10)

1925. *Pirula kachhensis* Vredenburg, p. 293, Pl. X, figs. 7 - 8.

2004. *Ficus* (*Ficus*) *kachhensis* (Vredenburg): Mazumder p. 148, Pl. XVI, fig. 5.

Material: One specimen.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band and silty-sandstone of Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Height**	**Diameter at the base**
G/B-9	30.00	-

Remarks: The essential characters of the species *Ficus* (*Ficus*) *kachhensis* (Vredenburg) like slender elongate ovoid, conoidal and slightly stepped spire and large body whorl can be easily discernable in the present specimen. Hence, the specimen is merged with this species.

Ficus (Ficus) conditus (Brongniart), 1823

(Pl – 7, fig. 11)

1823. *Pirula condita* Brongniart, p. 75, fig. 4.

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

1891. *Ficula condita* Brongniart: Sacco; p. 23, Pl. I, figs. 27 - 32.

1895. *Ficula theobaldi* Noetling, p. 28, Pl. VI, fig. 5.

1901. *Ficula theobaldi* Noetling, p. 298, Pl. XIX, fig. 21.

1923. *Pirula condita* Brongniart: Cossman and Peyrot, p. 33, Pl. X, fig. 46.

1925. *Pirula condita* Brongniart: Vredenburg, p. 292.

1939. *Ficus condita* Brongniart: Mukerjee, p. 52, pl. III, fig. 5.

1957. *Pirula condita* Brongniart: Gilbert, p.81, Pl.IV, FIG.6.

1972. *Pirula condita* Brongniart Baglioni and Poli, p. 11, Pl. III, figs. 14 - 15.

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

1992. *Ficus (Ficus) conditus* Brongniart: Tiwari, p. 165,Pl. XVII, figs. 7 - 8.

2003. *Ficus (Ficus) conditus* Brongniart: Tiwari, p. 65 - 88, Pl. VI, figs. 59.

2004. *Ficus* (*Ficus*) *conditus* Brongniart: Mazumder p. 146, Pl. XVI, fig. 2.

2004. *Ficus (Ficus) conditus* Brongniart: Lalchawimawii, p. 49, Pl. VI, figs. 8 - 9.

Material: One specimen.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

D**imensions**:

Sp. no.	Height	Diameter at the base
G/B-4	41.00	16.00

Remarks: The pyriform shape and patterns of spiral ornamentation of the species *Ficus conditus* (Brongniart) are well marked in present specimen. Hence, the identification. The identification is further confirmed by direct comparison of the specimen at hand with the one housed in the Palaeontological Laboratory, Department of Geology, Mizoram University (Tiwari, 1992) to which these are found to tally well.

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 – 7, figs. 12)

1962. *Murex maegillivrayi* Dohrn: Dey, p. 77, Pl. VII, fig. 24.

1992. *Murex maegillivrayi* Dohrn: Tiwari, p. 168, Pl. XVII, fig. 9.

Material: One nearly complete and one fragmentary conch.

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl)

Horizon: Upper intraformational conglomeratic band of Upper Bhuban unit, Bhuban Formation.

Dimensions:

Sp. no.	**Height**	**Diameter**
G/R-2	24.00	21.00

Remarks: The present specimen has been compared with *Murex maegillivrayi* Dohrn reported by Tiwari (1992) from the Miocene of Mizoram to which it has been found to match well particularly on account of long anterior canal and blunt spines. Hence the assignment.

Superfamily CONACEA Rafinesque, 1815

Family CONIDAE Rafinesque, 1815

Genus *Conus* Linne', 1758

Type species: *Conus marmoreus* Linne'; SD Children, 1823. Recent; Indo-Pacific.

Subgenus *Leptoconus* Swainson, 1840

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

Conus* (*Leptoconus*) *bonneti Cossmann, 1900

(Pl – 7, figs. 13 – 14)

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

1901. *Conus hanza* Noetling, p. 364, Pl. XXIII, figs. 24 - 26.

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

1925. *Conus* (*Leptoconus*) *bonneti* Cossman: Vredenburg, p. 285.

1939. *Conus* (*Leptoconus*) *bonneti* Cossman: Mukerjee, p. 85.

1988. *Conus* (*Leptoconus*) *bonneti* Cossman: Mathur, p. 48.

1992. *Conus* (*Leptoconus*) *bonneti* Cossman: Tiwari, p. 171, Pl. XVII, fig. 12.

2004. *Conus* (*Leptoconus*) *bonneti* Cossman: Lyngdoh, p. 174, Pl. XXII, figs. 2 and 4.

Material: Five poorly preserved specimens.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1; Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Dimensions:

Sp. no.	**Height of conch**	**Diameter of conch**
G/R-13	15.00	15.00
G/R-14	15.00	12.00
G/B-16	15.00	16.00
G/B-18	18.00	18.00
G/B-21	18.00	15.00

Remarks: The present specimens show all the essential characters of the species *Conus* (*Leptoconus*) *bonneti* Cossmann figured by Tiwari (1992). As such, these are assigned to it with least reservation.

Conus* (*Dendroconus*) *loroisii Kiener

(Pl – 7, figs. 15 – 17)

1847. *Conus loroisii* Kiener, p. 91, Pl. LXV, fig. 1.

1894. *Conus striatellus* Jenkins, p. 54, Pl. VII, fig. 3.

1879. *Conus striatellus* Jenkins: Martin, p. 9, Pl.I, figs. 2, 3 and 5.

1882. *Conus loroisii* Kiener: Martin, p. 100.

1883. *Conus loroisii* Kiener: Martin, p. 223.

1893. *Conus* (*Dendroconus*) *exloroisii* Sacco, p. 8.

1895. *Conus loroisii* Kiener: Martin, p. 21, Pl. III, fig. 52.

1925. *Conus loroisii* Kiener: Vredenburg, p. 93.

1936. *Conus* (*Dendroconus*) *loroisii* Kiener: Cox, p. 42, Pl. VIII, figs. 14 - 15.

1939. *Conus* (*Dendroconus*) cf. *loroisii* Kiener: Mukerjee, p.85.

1978. *Conus loroisii* Kiener: Kohn, p. 314, figs. 13, 52.

1999. *Conus* (*Dendroconus*) *loroisii* Kiener: Lyngdoh, Tiwari and Kachhara, Pl. IV, fig. 1.

2003. *Conus* (*Dendroconus*) *loroisii* Kiener: Tiwari and Kachhara, p. 76, Pl. VI, fig. 56.

2004. *Conus* (*Dendroconus*) *loroisii* Kiener: Mazumder, p. 153, Pl. XVII, figs. 3 - 4.

2004. *Conus* (*Dendroconus*) *loroisii* Kiener: Lyngdoh, p. 174, Pl. XXI, figs. 2 - 3.

Material: Six poorly preserved specimens.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Dimensions:

Sp. no.	**Height of conch**	**Diameter of conch**
G/R-10	20.00	9.00
G/R-12	33.00	21.00
G/B-17	38.00	23.00
G/B-19	17.00	11.00

G/B-20	19.00	11.00
G/B-22	12.00	8.00
G/B-25	25.00	14.00

Remarks: I have noted the following prominent features in these specimens: Low extraconic spire and large body whorl, protoconch followed by five to six feebly sloping spiral whorls, sulcate suture, body whorl shows numerous growth lines parallel to the outer lip. The above description of the present specimens reminds me at once *Conus* (*Dendroconus*) *loroissii* Kiener. Besides, it has also been compared with the specimens of this species reported by Mazumder (2004) from the Miocene of Kolasib area. As such, assignment is beyond question.

3.3 SYSTEMATIC DESCRIPTION OF ECHINOIDEA

Echinoids are represented by ill preserved tests of regular and irregular forms. Irregular forms have been quite often encountered in all the fossiliferous beds whereas regular one is represented by only one specimen. Though, Tiwari (1992) and Mazumder have identified these tests as belonging to the genus *Schizaster*, the preservation of the tests is so poor that I do not venture to itendify it even upto the generic level.

3.4 SYSTEMATIC DESCRIPTION OF DECAPODA

The preservation of decapod crustaceans in the Surma succession is fairly good. These are mostly in the form of dorsal sides of well-preserved carapaces, though ventral sides and appendages are also preserved in some specimens. The systematic description of the decapods from the present collection is as follows:

Suborder	PLEOCYMETA 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* Linné, 1758; SD. Latreille, 1810. Recent; Mediterranean.

Calappa protopustulosa Noetling 1901

(Pl – 8, figs. 1 – 2)

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

1997. *Calappa protopustulosa* Noetling: Tiwari *et. al*., p. 128, Pl. 1, figs. 1 and 2a.

2004. *Calappa protopustulosa* Noetling: Mazumder, p.164, Pl. XIX, figs. 3 - 4.

Material: Two carapaces, one weathered anteriorly.

Locality: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)**.**

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Foramtion

Dimensions (mm):

Sp. no.	Length	Width
C/B - 7	18.00	21.00
C/B - 9	21.00	26.00

Remarks: The carapace is subcircular in shape, length slightly less than the width, carapace more curved anterior-posteriorly than laterally, antero-lateral and postero-lateral margins form almost a semicircle, antero-lateral margin with fine compressed and a series of tubercles. Carapace covered with the longidunal ridges separared by furrows; ridges near the gastric region are more prominent than others; all the ridges are set with probably seven tubercles. The gastro-cardiac region can be delineated by the presence of the two most prominent longitudinal furrows in which the depth and width increases posteriorly. In above characters, the specimens at hand are undouptedly identical to *Calappa protopustulosa* Noetling (1901, *op. cit.*) from Miocene sediments of Myanmar (GSI type no. 7768). However, the carapace of the specimen no. C/B - 9 is slightly elongated laterally which may be due post-depositional deformation.

Genus *Typilobus* Stoclizka, 1871

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

Typilobus granulosus Stocliczka, 1871

(Pl – 8, fig. 3)

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

1997. *Typilobus granulosus* Stoclizka: Tiwari *et al*., p. 130, Pl. 1, fig. 2d.

Material: Two well-preserved carapaces.

Location: Locality 2 (Ruata Quarry, Ramrikawn, Tuivamit) and Locality 6 (Govt. Complex Road, Zonuam, Aizawl).

Horizon: Upper Intraformational conglomerate of Upper Bhuban unit, Bhuban Formation of locality 2; brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 6

Dimensions (mm):

Sp. no.	Length	Width
C/R - 8	9.00	11.00
C/GZ - 10	10.00	10.00

Remarks: The carapace is transversely ovate in shape and its entire surface is covered with fine and dense granules; the anterior is nearly semicircular and flattened, the posterior is small, gradually narrowed with a small tubercle at each end; all the regions are well defined. Cardio-gastric region delineated by a prominent furrow on either side that run upto the frontal margin. Cardiac lobe is most prominent and bears a tubercle at the middle. These specimens match very well with *Typilobus granulosus* Stoclizka (GSI type no. 2280-2281) excepting smaller size of the latter. Hence, the assignment.

Genus *Ebalia* Leach, 1816

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

Ebalia tuberculata Noetling

(Pl – 8, fig. 4)

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

1997. *Ebalia tuberculata* Noetling: Tiwari *et al*., p. 128, Pl. I, fig. 2.

2004. *Ebalia tuberculata* Noetling: Mazumder, p. 165.

Material: One carapace.

Location: Locality 6 (Govt. Complex Road, Zonuam, Aizawl).

Horizon: Brown sandstone of Upper Bhuban unit, Bhuban Formation.

Dimensions (mm): Specimen no. C/GZ - 17 measures 9.00mm in length and 11.00mm in width.

Remarks: In general outline, surface sculture, nature of the margins and lobes, the lone specimen matches well with the *Ebalia tuberculata* Noetling (1901). Besides it has also been compared with the specimen of this species reported by Tiwari (1997) from Miocene of Mizoram. Hence, identification is confirmed.

Superfamily	PORTUNOIDEA Rafinesque, 1815
Family	PORTUNIDAE Rafinesque, 1815
Genus	*Neptunus* de Haan, 1839

Neptunus sindensis Stoliczka, 1871

(Pl – 8, figs. 5 – 8)

1901. *Neptunus sindensis* Stoliczka: Noetling p. 51, Pl. X, figs. 2, 2a,b; Pl. XI, figs 1, 1a; Pl. XIII, figs. 1, 1a.

Material: Four incomplete carapaces.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 5 (Luangmual Govt. Complex, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Foramtion of Locality 1; Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 5.

Dimensions:

Sp. no.	**Length**	**Width**
C/B - 2	23.00	36.00
C/B - 3	15.00	24.00
C/LG - 4	17.00	22.00
C/B - 6	18.00	27.00

Remarks: All the prominent characters of the species *Neptunus sindensis* Stoliczka, 1871, *viz.*, carapace one-third broader than long, well defined regions including horse-shoe shaped grove defining the meta- and urogastric lobes, six orbito-frontal spines and nine antero-lateral spines are well marked in the present specimens. Sternum is preserved in one of the specimens (C/B-2) which is squarish in shape and length is little less than the width. Individual sternites tally in shape and size with the type species. On account of the above, the specimens are clubbed with the *Neptunus sindensis* Stoliczka, 1871.

Superfamily XANTHOIDEA Dana, 1815

Family XANTHIDAE Rafinesque, 1815

Genus *Xantho* Leach, 1804

Type species: *Cancer incisus*; OD. Recent.

***Xantho* sp.**

((Pl – 8, figs. 9 a – b)

Material: One carapace

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Foramtion

Dimensions (mm):

Sp. no.	Length	Width
C/B - 5	10.00	15.00

Remarks: The carapace is broader than long and hexagonal in shape, nearly flat longitudinally and transversely with wide frontal margin. Orbits are small and well separated. Regions are well defined. The specimen described and figured by Mazumder (2004) is also incomplete and matches well with our specimens in respect of the above characters. Specific indentification is not attempted due to lack of well preserved specimens.

Family HANTHIDAE Alcock, 1898

Genus *Palaeocapilius* Milne-Edwards, 1862

Palaeocarpilius rugifer Stoliczka, 1871

(Pl – 9, fig. 10)

1901. *Palaeocarpilius rugifer* Stoliczka: Noetling p. 55, Pl. XII, fig. 3; Pl. XIV, figs. 1, 1a; Pl. XV, figs. 1, 2, 3 and 4; Pl. XVI, fig. 1.

Material: Two incomplete carapace with worn out surfaces.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 6 (Govt. Complex Road, Zonuam, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Foramtion of Locality 1; Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation of Locality 6.

Dimensions: Specimen no. C/B - 11 measures 35.00mm in length and 42.00mm in width.

Remarks: The two specimens at hand, though poorly preserved, are characterized by circular and deeply indented orbits, rugosities and pits on the fresh surface of the carapace that has indistinct lobes, eight tubercles in the antero-lateral margins and long and narrow sternum. In above charcters, these match well with the *Palaeocarpilius rugifer* Stoliczka. Though other characters could not be deciphered due to poor preservation, I feel that the above similarities are enough to merge my specimens with that of Noetling's (1901). Hence, the specimens are assigned to *Palaeocarpilius rugifer* Stoliczka.

3.5 SYSTEMATIC DESCRIPTION OF FORAMINIFERA

Large numbers of foraminiferal tests have been recovered from the lower intraformational conglomeratic band of Locality 1. These however belong to monogeneric form of the genus *Ammonia*. Preservation of the tests is very poor and mostly these appear to be rolled out and deformed. The systematic description of the foraminifera from the present collection is as follows:

Phylum	PROTOZOA
Subphylum	SARCODINA
Superclass	RHIZOPODA
Class	GRANULORETICULOSEA
Order	FORAMINIFERIDA Eichwald, 1830
Suborder	ROTALIINA Delage and Herouard, 1896
Superfamily	ROTALIACEA Ehrenberg, 1839
Family	ROTALIIDAE Ehrenberg, 1839
Subfamily	AMMONIINAE Saidova, 1981
Genus	***Ammonia*** BRUNNICH, 1972

Ammonia annectens concinna Millet, 1904

(Pl - 9, figs. 1 a – b)

1981. *Ammonia annectens concinna* Millet: Jauhri, p. 70, Pl. IV, figs. 13- 16.

Material: Several specimens with weathered out tests.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Dimensions (mm):

Sp. no.	Diameter	Thickness
F/B - 1	0.27	0.12
F/B - 2	0.25	0.15

Description: Periphery of the test acute, carinate with 10 to 11 chambers in the last whorl; somewhat smooth surface, elevated, straight or slightly curved sutures on spiral side, and

open fissures in the umbilicus. Sutures on umbilical side are deeply excavated, each having two rows of beads.

Remarks: The specimens at hand can be well compared with the species *Ammonia annectens concinna* described by Jauhri (1981) from the Miocene sediments of Vinjhan-Miani area of Kachchh. These specimens also have very close affinity to the species *Ammonia annectens* (Parker and Jones) reported by Lambert (2003) from the modern Mahakam delta of East Kalimantan, Indonesia. Therefore, these can be assigned to the species *Ammonia annectens concinna* without any reservation.

***Ammonia* sp.**

(Pl – 9, figs. 2 – 3)

Material: Several specimens with weathered out tests.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic horizon, Upper Bhuban unit, Bhuban Formation

Dimensions (mm):

Sp. no.	Diameter	Thickness
F/B - 3	0.3	0.15
F/B - 4	0.32	0.15

Description: Test free, small, and carinate with 10 to 12 chambers in the last whorl; periphery rounded, slightly lobulate, smooth surface, elevated; sutures on dorsal side distinct, slightly oblique and slightly depressed, sutures on umbilical side are deeply excavated; umbilical portion of test worn out but seems to have depression or excavated.

Remarks: The specimens described above can be distinguished from the earlier one on account of the higher elevated tests at the dorsal sides and flattened ones at the ventral sides. They are somewhat similar with the species *Ammonia beccarii* Linne' reported from the upper Cenozoic sequence of Taiwan (Huang, 1964). However, detail comparison could not be made due to poor preservation of the specimen at hand. Hence, identification at a specific level has not been attempted for want of better preserved materials.

CHAPTER -4

SYSTEMATIC DESCRIPTION

OF

VERTEBRATES

4. SYSTEMATIC DESCRIPTION OF VERTEBRATES

4.1 SYSTEMATIC DESCRIPTION OF FISHES

Fish remains in the form of isolated teeth, dental plates, spines and vertebrae are the only representative of the vertebrate fossil group in the study area. These have been found in the intraformational conglomeratic bands of Upper Bhuban unit, Bhuban Formation of Locality 1 and 2 only. These two localities are very rich in the fish remains. Preservation is rather good as compared with the other associated fossils. However, the hard and compact nature of the fish yielding bands makes the recovery of the complete specimens difficult, especially of the root parts. Teeth of selachians (shark) are by far, the most abundant group of fishes in the study area and this group accounts for more than 80 per cent of the total fish fauna. Batoids (Ray-skates) and Teleosts represent the other groups of fishes.

It is pertinent to mention that the abundance of shark as fossil is due to their denseness and mineral composition and to their rapid, continual replacement in the shark's jaws. Further, the morphology of teeth exhibit several types of variation with their position in the jaws and also due to ontogenetic heterodonty and sexual heterodonty (Purdy, 1990 and 1996; Applegate, 1965). This makes the identification rather difficult. However enough care has been taken in order to avoid misleading identity arising due to differing teeth morphology in the same species.

The classification of Chondrichthyes followed in this thesis is after Cappetta (1987).

Class	CHONDRICHTHYES Huxley, 1880
Subclass	ELASMOBRANCHII Bonaparte, 1838
Cohort	EUSELACHII Hay, 1902
Subcohort	NEOSELACHII Compagno, 1977
Order	LAMNIFORMES Berg, 1958
Family	LAMNIDAE Muller and Henle, 1838
Genus	***Lamna*** Cuvier 1817

***Lamna* sp.**

(Pl – 10, figs. 1 – 2)

Material: Two isolated teeth with broken roots.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)**.**

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of crown
V/F/B - 32	9.50	-	6.50
V/F/B - 33	8.20	-	6.00

Description: Teeth medium in size; crown erect, high, narrow with pointed apex, broader at the base, sharp cutting edges without serrations, internal surface highly convex whereas external one is nearly flat or little convex; a small denticle is found on one side of the lateral cusp in specimen no. V/F/B - 33 while denticle on the other side is not preserved. Roots poorly preserved but appear to contain a median groove on the highly convex internal surface.

Remarks: The present specimens are comparable with those of the species *Lamna* sp. figured by Mishra (1980) from the Ossiferous limestones of Babia stage, Middle Eocene at Nareda, Kachchh. Due to the incomplete nature of the present specimens, the characteristic information needed for identification up to the species level is lacking. This may be the first record of *Lamna* sp. from the Tertiary rocks of the Northeastern region of India.

Genus ***Carcharodon*** Muller and Henle, 1838

Carcharodon carcharias Linnaeus, 1758

(Pl – 10, figs. 3 – 14)

The partial synonymy of the species is:

1973. *Carcharodon carcharias* Linne', 1758: Mehrotra *et al.* p.190, Pl - 2, figs. 2, 6 a - b.

1981. *Carcharodon carcharias* Agassiz: Sahni and Mehrotra p.121, Pl - 1, figs. 3 - 6.

1998. *Carcharodon carcharias* Linne', 1758: Tiwari *et al.* p.17, Pl - 1, figs. 5 - 6.

Material: Twelve isolated teeth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)**.**

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown	Height / Breath Ratio
V/F/B - 16	10.00	9.00	8.00	1.1
V/F/B -17	8.00	8.00	6.00	1
V/F/B -18	10.00	-	8.00	-
V/F/B - 19	11.00	-	8.50	-
V/F/B - 20	11.00	-	9.00	-
V/F/B - 21	10.00	-	7.00	-
V/F/B - 43	10.00	9.00	7.00	1.1
V/F/B - 44	10.00	9.00	7.00	1.1
V/F/B - 45	12.00	-	10.00	-
V/F/B - 46	11.00	11.00	8.00	1
V/F/B - 47	10.00	-	8.00	-
V/F/B - 79	15.00	-	9.00	-

Description: Teeth medium in size, nearly as high as broad; crowns compressed, triangular in outline with pointed apex, thick in the middle and becoming thinner towards the edges, erect or slightly inclined towards posterior or distal side, sharp cutting edges with fine regular serrations that are bigger at the base of the cusp, both mesial and distal margins almost straight; external surface flat, internal one slightly convex. No lateral denticles present at the cusps. Roots broader than high, basal margin of the roots feebly to moderately concave. Root canal or median furrow at the internal surface of the root is clearly visible in specimen no. V/F/B - 16.

Remarks: The present specimens are identified as *Carcharodon carcharias* by their medium sized crown, triangular shape, serrated cutting edges and moderately bilobate roots. These bear close resemblance with the specimens of the same species described from the Miocene of Kachchh (Mehrotra *et al.* 1973) and Baripada (Sahni and Mehrotra,

1981) and Pliocene of Piram Island (Prasad, 1974). This species has already been recorded from the Bhuban Formation of Mizoram (Tiwari *et al.*, 1998).

Carcharodon angustidens Agassiz, 1843

(Pl – 10, figs. 15 – 16)

1910. *Carcharodon angustidens* Agassiz, 1843: Stuart, p 300, Pl - 26, figs. 3 a - c.

1973. *Carcharodon angustidens* Agassiz, 1843: Mehrotra *et al.* p 190, Pl - 2, fig. 3.

1981. *Carcharodon angustidens* Agassiz,1843: Sahni and Mehrotra, p 121, Pl - 1, fig. 11.

Material: Two isolated fragmentary teeth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Measurements: Fragmentary nature of the teeth does not allow measurement of dimensions.

Description: Teeth large in size; crowns erect, thick, broad and having the shape of an isosceles triangle; sharp cutting edges having uniformly coarse serrations; both mesial and distal edges are straight; generally with two denticles on either side of the cusp, but only one denticle is preserved in specimen no. V/F/R - 08. This denticle is in turn finely and uniformly serrated. A series of prominent longitudinal striations extend from base to apex at the enamel surfaces of the cusps. Crown thickens or bulges at the center and gradually tapers towards edges. Internal surface strongly convex while the external one flattened or slightly convex. Collar prominent between root and cusp at the internal surface in specimen no. V/F/B - 07. Roots not well preserved but seem to be broad, low and weakly bilobate.

Remarks: The two specimens at hand show close resemblance with the *Carcharodon angustidens* described and figured by Stuart (1910) from the Miocene sediments of Pagan Hills, Burma. These can also be compared well with the species collected and figured by Mehrotra *et al.* (1973) from the Lower Miocene shales of Lakhpat (Kachchh). They are also more or less similar with the same species reported from the Miocene sediments of

Kachchh (Sahni and Mehrotra, 1981). This form is being recorded for the first time from the Northeastern India.

***Carcharodon* sp.**

(Pl – 11, figs. 1 a – b)

Material: One isolated incomplete tooth (Specimen no. V/F/R - 27).

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl)

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm): Height of tooth and crown measures 22.00mm and 18.00mm respectively, breadth of tooth could not be measured due to its incompleteness.

Description: Tooth large in size; crown thick, somewhat broad, acutely triangular in shape and directed posteriorly or distally with pointed apex; sharp cutting edges bearing serrations that are coarser towards the base and finer towards the apex; mesial edge slightly convex and distal edge straight or slightly concave; internal surface strongly convex and external surface flat; a collar preserved at the internal surface near the junction of crown and root; root low, appear to be broad and with a shallow bifurcation.

Remarks: The lone specimen at hand has a close resemblance with the species *Carcharodon carcharias* from the Upper Miocene of Senhata Formation, Boso Peninsula, Central Japan (Yabe and Hirayama, 1994, p 41, figs 8 a-c). This specimen also compares well with those illustrated as *Carcharodon* sp. by Donovan and Gunter (2001) from the unknown locality and horizon of Jamaica. The material described is too meager and incomplete to allow any detailed comparison and identification up to the species level. However, on the basis of the morphological characters and geometry of the crown, it undoubtedly belongs to the genus *Carcharodon*.

Genus ***Isurus*** Rafinesque, 1810

Isurus spallanzanii Bonaparte, 1839

(Pl – 11, figs. 2 – 4, 6 – 13)

1901. *Oxyrhina spallanzanii* Bonaparte: Noetling, p 372, Pl - 25, figs. 4 - 6.

1910. *Oxyrhina spallanzanii* Bonaparte: Stuart, Pl-25, fig. 9 and Pl - 26, figs. 1 - 2.

1973. *Isurus (oxyrhina) spallanzanii* Bonaparte: Mehrotra *et al.* p 182, Pl - 1, fig. 10a and b.

1981. *Oxyrhina spallanzanii*Bonaparte: Sahni and Mehrotra, p 120, Pl - 1, fig. 1.

1987. *Isurus (oxyrhina) spallanzanii* Bonaparte: Kumar and Loyal, p 121, Pl - 1, fig.7.

1998. *Isurus spallanzanii* Bonaparte: Tiwari *et al.*, p.17, Pl - 1, figs. 7 - 8.

Material: Thirteen isolated teeth- one complete and 12 broken ones.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown
V/F/B - 43	8.00	6.00	6.00
V/F/B - 44	-	-	9.00
V/F/B - 48	-	-	10.00
V/F/B - 49	-	-	8.00
V/F/R - 50	-	-	8.50
V/F/R - 28	-	14.00	-
V/F/B - 51	-	-	9.00
V/F/B - 52	-	-	9.00
V/F/B - 53	-	-	8.00
V/F/B - 54	-	-	7.00
V/F/B - 55	-	8.00	-
V/F/B - 56	-	7.00	-
V/F/B - 57	-	6.00	-

Description: Teeth small to medium in size; crowns erect, narrow, slender and lanceolate with pointed apex; median teeth (Sp. nos. V/F/B - 29 and 43) easily distinguished by narrow, deeply bifurcated roots, and cutting edges of crowns being sharp only for the upper two-thirds and rounded at the base; sub-rounded or almost circular shape in cross-section; cutting edges without serrations; crown slightly curved inward at the base and outwards at the apical part; internal surface convex, external one nearly flat; Roots thick

and low, externally flat, internally strongly convex. Lateral teeth (Sp. nos. V/F/R - 8 and V/F/B - 44) are characterized by broad bifurcated roots with sharp cutting edges of crowns from base to the apex; crown in general has more or less similar morphological characters with that of median teeth, but the cross-section at the base is elliptical; Roots are low but broad, forming deeply bifurcated lateral branches; externally flattened and internally strongly convex.

Remarks: These specimens can be identified as *Isurus spallanzanii* based on the above mentioned morphological features of the crown and root. They have close resemblance with *Oxyrhina spallanzanii* of Noetling (1901) and Stuart (1910) from the different localities of Miocene beds of Myanmar. These can also be compared with the same species reported by Mehrotra *et* al. (1973) and Sahni and Mehrotra (1981) from the coastal Miocene sediments of Peninsular India. This species has also been recorded and described by Tiwari *et al.* (1998) from the same formation but from a different locality.

Isurus pagoda Noetling, 1901

(Pl – 11, figs. 5a – b

1901. *Oxyrhina pagoda* Noetling: Noetling, p 372, Pl - 25, figs. 1 a-e, 2 a-e and 3 a-b.

1973. *Isurus pagoda* Noetling: Mehrotra *et al.* p 182, Pl - 1, figs. 10 a - b.

1981. *Isurus pagoda* Noetling: Sahni and Mehrotra, p 120, Pl - 1, fig. 1.

Material: One isolated tooth with partially broken root.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of crown	Height of Crown
V/F/B - 49	-	3.50	8.00

Description: Tooth small in size; crown erect, narrow, slender and lanceolate with a broad arrow-head like apex; crown much higher than root; Margins un-serrated, sharp in the apical part and rounded in basal part, internal surface strongly convex and external one somewhat flat. Root seems to be low and thick, bifurcated with short lateral branches.

Remarks: The lone specimen at hand, though smaller in size, closely resembles with the species *Oxyrina pagoda* (Noetling, 1910, pl - 25, figs. 1- 3) in its broad arrow-head shape of the upper part of the cusp. It can also be compared with the same species reported by Mehrotra *et* al. (1973) and Sahni and Mehrotra (1981) from the coastal Miocene sediments of Peninsular India. This species is being recorded for the first time from the Northeastern region of India.

Family ALOPIIDAE

Genus ***Alopias*** Rafinesque, 1810

***Alopias* sp.**

(Pl – 13, figs. 12 – 13)

Material: Two isolated crowns.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)**.**

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown
V/F/B - 86	-	-	6.00
V/F/B - 87	-	-	7.00

Description: Crowns small in size, narrow, elongated with pointed apex, oblique towards inner edge; the cutting edges are sharp and without serrations through out. Both the surfaces of crowns convex, internal one more so. Anterior edges nearly straight whereas posterior ones somewhat concave and with a notch towards the base.

Remarks: The specimens resembles *Alopias vulpes* described from the Lower Miocene shales of Matanumadh, Kachchh (Mehrotra *et al.*, 1973). However, the specimens described herein cannot be compared with the Kachchh material due to the absence of the root parts. This is the first record of genus from the Bhuban Formation of Mizoram.

Family ODONTASPIDIDAE

Genus ***Odontaspis*** Agassiz, 1843

Odontaspis* cf. *taurus Rafinesque 1810

(Pl – 11, figs. 14a – c)

1970. *Odontaspis taurus* Rafinesque: Antunes and Jonet, Pl - IV, figs. 5 - 11.

Material: One isolated tooth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)**.**

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements: Specimen no. V/F/B - 59 has the following dimension: Height of tooth - 14.00mm; breadth of tooth – 10.00 mm; Height of crown – 10.00 mm.

Description: Tooth medium in size; crown narrow, erect, elongated, slender and lanceolate with pointed apex; cutting edges sharp throughout from apex to the base of the crown and are without serrations; crown much higher than the root, curved inward at the base and outward at the apical part; internal surface highly convex and external one flat or little convex. Root broader than high, deeply forked in the middle and only one denticle could be seen on the mesial edge of the cusp.

Remarks: The lone specimen described above is comparable with the species *Odontaspis taurus* figured and described by Antunes and Jonet (1970) from the Miocene beds of Algrave Coast, Portugal. However, crown of the latter is erect and the root is strongly bifid. Hence, present specimen is referred to as the comparable form of *Odontaspis* cf. *taurus* Rafinesque.

Odontaspis* cf. *tricuspidatus Day, 1888

(Pl – 2, figs. 19 a – b)

1973. *Cacharias tricuspidatus* Day, 1888: Mehrotra *et al.* p 190, Pl - 2, fig.9.

1981. *Odontaspis tricuspidatus* Day, 1888: Sahni and Mehrotra, Pl - 1, fig.14.

Material: One isolated incomplete tooth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of crown	Height of crown
V/F/B - 61	-	7.00	21.00

Description: Tooth large; crown erect or slightly oblique towards inner edge, lanceolate, higher than broad, inner and outer margins sharp and without serrations. Internal and external surfaces of crown convex. Root seems to be low and broad with prominent medial projection on the internal side.

Remarks: The crown of the available specimen bears close resemblance with the species *Odontaspis tricuspidatus* reported and figured by Mehrotra *et al.* (1973) and Sahni and Mehrotra (1981) from the Lower Miocene shales of Matanumadh, Kachchh, Gujarat on accounts of its large size and nearly erect and lanceolate outline, unserrated cutting edges and convex internal and external surfaces. But the presence of lateral denticles and deeply forked nature of the root could not be ascertained due to the ill -preserved nature of the present specimen. Hence, it is referred to as *Odontaspis* cf. *tricuspidatus* Day.

***Odontaspis* sp.**

(Pl – 2, figs. 15 – 18)

Material: Four isolated broken teeth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)**.**

Horizon: Lower intraformational conglomeratic horizon, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of crown	Height of Crown
V/F/B - 58	-	-	8.00
V/F/B - 30	-	-	10.00
V/F/B - 60	-	-	6.00
V/F/B - 31	-	-	6.50

Description: Teeth small in size; crowns narrow, erect, elongated, slender and lanceolate with pointed apex, edges of the crown sharp throughout and without serrations; crowns curved inward at the base and outward at the apical part; lateral denticles not preserved;

internal surface highly convex and external one flat or a little convex. Roots not preserved.

Remarks: The morphological features and outline of the crowns is typical of the Odontaspids. But the incomplete materials especially the root parts do not allow precise determination of the specimens.

Family CARCHARHINIDAE Jordan and Everymann 1896

Genus ***Carcharhinus*** Blainville, 1816

Carcharhinus egertoni *Aga*ssiz, 1843

(Pl – 12, figs. 1 – 4)

1910. *Carcharias (Prionodon) egertoni* Agassiz: Stuart, p 300, Pl - 26, figs. 8 and 8a.
1981. *Carcharhinus egertoni* Agassiz: Sahni and Mehrotra, p 122, Pl - 2, figs.4 - 5.
1981. *Carcharhinus egertoni* Agassiz: Antunes *et al.* Pl - 2, figs. 14 and 16.
1989. *Carcharhinus egertoni* Agassiz: Karasawa, p 55, Pl - VII, figs. 12, 13, 14 and 15.

Material: Four isolated teeth.
Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).
Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.
Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of crown	Height/Breath Ratio
V/F/B - 64	24.00	22.00	20.00	1.09
V/F/R - 4	-	-	18.00	-
V/F/B - 24	13.00	16.00	11.00	0.80
V/F/B - 35	-	-	10.00	-

Descriptions: Teeth medium to large in size; crowns with pointed apex, obliquely triangular in outline, broad, slightly oblique towards distal side, cutting edges sharp with

fine serrations at the apex becoming slightly coarser towards the base, mesial or outer margins moderately convex and distal margins straight or slightly concave; internal surfaces or lingual faces moderately convex and external surfaces or labial faces nearly flat or little convex, collar present between root and cusp in specimen no. V/F/B - 64. Roots broader than high with moderately bilobed nature.

Remarks: Specimen numbers V/F/R - 4 and V/F/B - 64 have close resemblance with the upper tooth of *Carcharhinus egertoni* described and figured by Karasawa (1989) from the Miocene sequences of Hokuriku district, Central Japan excepting that the former are slightly larger in size. These are also more or less similar with the same species described and illustrated by Antunes and Jonet (1970) from the Miocene Formations of Algarve coast, Portugal. These also tally well with the species under consideration described and figured by Stuart (1910) from the Pegu beds exposed in the Singu Oilfield (Miocene), Pakokku district, Myanmar. Specimen no. V/F/B - 24 can be well compared with the lower tooth of the same species described and illustrated by Karasawa (1989) from the Miocene beds of Hokuriku district, central Japan. It also has a close affinity to the *Carcharhinus egertoni* described by Antunes *et al.* (1981) from the Miocene beds of Algarve coast, Portugal. Hence, these specimens are unhesitatingly assigned to *Carcharhinus egertoni*.

Carcharhinus priscus Agassiz 1843

(Pl – 12, figs. 5 – 8)

1970. *Carcharias priscus,* Agassiz: Antunes and Jonet, Pl - XVII, figs. 120 - 131.
1981. *Carcharhinus priscus* Agassiz: Antunes *et al.* Pl - II, figs. 18 a - b.
1989. *Carcharhinus priscus* Agassiz: Karasawa, p 55, Pl - VII, figs. 9 - 11.

Material: Four isolated teeth.
Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)**.**
Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown	Height/Breath Ratio
V/F/B - 65	-	-	7.00	-
V/F/B - 66	9.00	8.00	9.50	1.1
V/F/B - 25	11.00	-	9.50	-
V/F/B - 26	8.00	9.00	6.50	0.88

Description: Teeth medium in size; crown narrow with pointed apex, acutely triangular, oblique distally or posteriorly; cutting edges sharp bearing fine and uniform serrations at the base of cusps while upper part of cusps are with a few or no serrations; mesial or outer margins moderately convex and distal or inner margins straight or little concave; internal surface convex and external one flat; crowns slightly higher than roots and cover entire roots. Roots broader than high and the lateral branches of roots moderately bifurcated.

Remarks: The specimens presently described can be compared reasonably well with the upper tooth of the same species described and figured by Karasawa (1989) from the Miocene sequences of Hokuriku district, central Japan (Plate VII, figures 9 and 11). This species has also been described and figured by Antunes and Jonet (1970) and Antunes *et al.* (1981) from the Miocene Formations of Algarve coast, Portugal to which collection at hand matches well.

Carcharhinus* cf. *macloti Muller and Henle 1873

(Pl – 13, figs.15 a – b)

Material: One isolated tooth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm)**:**

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown	Height/Breadth Ratio
V/F/B - 78	12.00	12.00	8.00	1.00

Description: Tooth small; crown thick, oblique posteriorly with pointed apex, both inner and outer edges straight and without serrations, moderately deep notch near the base of cusp. Internal surface strongly convex while external one flattened. Root low, broader than high, internal surface convex, external one flat, basal margin of root slightly concave.

Remarks: The specimen resembles *Hypoprion macloti* (which has been redesignated as *Carcharhinus macloti*) reported from the Lower Miocene sediments of Baripada, Orissa and Matanumadh of Kachchh (Sahni and Mehrotra, 1981). However, the specimen at hand is not sufficient for precise specific assignment. Hence, it has been considered as the comparable form of *Carcharhinus* cf. *macloti*.

***Carcharhinus bhubanicus* n. sp.**

(Pl – 14, figs. 9 a – b)

Material: One tooth (Specimen no. V/F/R - 77).

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements: A single but well preserved specimen measures 12.00 mm in height, 14.00 mm in breadth and height of crown is ~ 7.00 mm.

Diagnostic characters: Strongly convex outer edge, strongly concave inner cutting edge and more or less rectangular unlobed root.

Descriptions: Tooth medium in size, thick at the centre and becoming thinner towards the edges as well as the apex and base; crown broad, strongly oblique distally with pointed apex, cutting edges sharp with fine and more or less uniform serrations from apex to base, outer edge strongly convex, inner edge strongly concave; internal surface highly convex, external surface flattened. Root low, broader than high, internal surface convex while external one flattened. Basal margin of root straight or little concave.

Remarks: The lone but well preserved specimen undoutedly belong to the genus *Carcharhinus* owing to the overall geometry of the tooth and prominent and uniform serrations at both the margins. It can be easily distinguished from the other species of *Carcharhinus* hitherto reported on account of higher convexity of the outer edge and strongly concave nature of the inner cutting edge. In addition, its root is more or less

rectangular and is without bifurcation. Therefore, it is given a new name from its occurrence in the Bhuban Formation.

***Carcharhinus* (*Prionodon*) sp.**

(Pl – 14, figs.1 – 4)

Material: Four isolated teeth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm)**:**

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown
V/F/B - 83	8.00	9.00	5.50
V/F/B - 84	6.00	9.00	4.50
V/F/B - 85	8.00	-	5.50
V/F/B - 90	-	-	7.00

Description: Teeth medium in size, broader than high; crowns compressed, sub - triangular in outline, directed posteriorly with pointed apex, outer edges slightly convex, inner edges straight or little concave, cutting edges sharp bearing fine serrations, somewhat coarser at the base. Internal surface slightly convex while external surface flattened. Root low, broader than high, internal surface weakly convex, external one flat, basal margin of root straight or slightly concave.

Sp. no. V/F/B - 90 differs from the other specimens of the present collection in the erect nature of the crown, triangular outline and somewhat blunt apex.

Remarks: The material described above has close resemblance with the *Prionodon* sp. described and illustrated by Hora (1939) from the Eocene sediments of Balasore, Orissa. However, the genus *Prionodon* was latter on considered as the sub-genus of the genus *Carcharhinus* under the family Carcharhinidae by Ghosh (1967). Hence, it has been named accordingly.

Carcharhinus sp. A (indet)

(Pl – 12, figs.9 – 13)

Material: Five isolated incomplete teeth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown
V/F/B - 42	-	-	13.00
V/F/B - 74	20.00	-	15.00
V/F/B - 107	12.00	-	8.50
V/F/B - 108	11.50	-	8.00
V/F/B - 109	-	-	8.00

Descriptions: Teeth medium to large in size; crowns erect or slightly oblique towards the posterior, sub-triangular in shape with pointed apex, higher than broad; sharp cutting edges bearing fine serrations throughout; serrations coarser at the base becoming finer towards the apex, crowns thicker in the middle and thinner towards the edges; outer margins slightly convex and distal or inner margins somewhat straight or fairly concave; Surface strongly convex internally and flattened externally. Roots ill preserved.

Remarks: Specimen no. V/F/B - 42 from the present collection can be compared well, on the basis of the morphological features and geometry of the crown, with the upper tooth of the species *Charcharhinus egertoni* (Plate - 2, fig. 10) described and figured by Stuart (1910) from the Miocene sediments of Myanmar. Another specimen (V/F/B - 74) also bears a close resemblance with the upper tooth of the species *Charcharhinus egertoni* (Plate - XV, fig. 111) described and illustrated by Antunes and Jonet (1970) from the Miocene beds of Algrave coast of Portugal. Specimen nos. V/F/B - 107, 108 and 109 are more or less similar with the previously described specimens (Nos. V/F/B - 24 and 35) under the species *Carcharhinus egertoni*. Since the present specimens are incomplete and poorly preserved, specific assignment is not attempted and these are referred to as *Carcharhinus* sp. indet.

Carcharhinus sp. B (indet)

(Pl – 12, fig.14 a – b)

Material: One complete tooth (Specimen no. V/F/B - 88).

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm)**:** Height of tooth- 6.00mm, breadth – 8.00mm, height of crown- 4.50mm.

Description: Tooth small; crown erect, triangular in shape with somewhat blunt apex, broader than high, sharp cutting edge with fine serrations only at the base of the crown; crown runs all over along the root, outer edge moderately convex, inner edge straight or slightly concave; internal surface convex while external surface flat. Root low, broad and weakly bifid with a median groove in its inner surface.

Remarks: The lone specimen at hand can be grouped under the genus *Carcharhinus* on the basis of morphological characteristics of the tooth and geometry of the crown. This can be distinguished from *Carcharhinus* sp. A described above on account of its small size, erect nature, serrated margins at the base only, somewhat blunt apex and weakly bifid root.

Carcharhinus sp. C

(Pl – 12, fig.15 – 16)

Material: Two isolated teeth; one complete and another with broken root.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown	Height/Breadth Ratio
V/F/B - 75	24	18	16	1.33
V/F/B - 76	14	-	10	-

Description: Specimen no. V/F/B - 75 is large in size; crown directed posteriorly with pointed apex, sharp cutting edges with fine and more or less uniform serrations from base to apex, outer or distal margin convex and inner or mesial margin straight; crown curved inward at the base and outward at the tip; internal surface strongly convex while the external one flattened. Root high, broad and thick, internally strongly covex and externally flattened with strong bifid nature.

Specimen no. V/F/B -76 is medium in size; crown erect, thick, higher than broad, apex pointed, cutting edges sharp, fine and uniformly serrated throughout, both outer and inner margins slightly convex; Internal surface strongly convex while external one flattened. Root broader than high, internal surface strongly convex, external surface flat, lateral branches of root weakly bifurcated.

Remarks: On account of medium to large size, almost equilateral triangular outline, regularly serrated margins and thick and bifurcated root, these specimens are assigned to *Carcharhinus* sp. However, additional specimens and information would be desirable in order to have a precise determination. These specimens differ from the species described above as *Carcharhinus* sp. A and B on account of slender nature of crown and more bifid root.

***Carcharhinus* sp. D**

(Pl – 13, figs.16 a – b)

Material: One isolated tooth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm)**:**

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown
V/F/B - 80	12.00	-	08.00

Description: Tooth small to medium; crowns thick and erect with pointed apex, both inner and outer edges straight or little convex, cutting edges sharp bearing fine and uniform serrations from base to the tip of the cusp. Internal surface strongly convex while external surface flattened; no lateral denticles observed at the base of cusp. Root low,

broader than high, internal surface convex, external one flat, basal margin of root slightly concave.

Remarks: The specimens, inspite of their smaller size, are somewhat similar with *Hypoprion minidenticulata* described and figured by Sahni and Mehrotra, (1981) from the Lower Miocene gypseous shales of Matanumadh, Kachchh and unconsolidated conglomerates of Akwara, Bhavnagar in the shape of crown and root. The only discernible difference is the absence of small denticles on the lateral cusp of the present specimen. *Hypoprion* is now considered as the synonym of *Carcharhinus.* Specific assignment is deferred for the want of more and better preserved materials.

Genus ***Galeocerdo*** Muller and Henle, 1873

Galeocerdo aduncus Agassiz 1843

(Pl – 13, figs. 1 – 4)

1970. *Galeocerdo aduncus* Agassiz: Antunes and Jonet, Pl - XI, figs. 59 - 62.

1981. *Galeocerdo aduncus* Agassiz: Antunes *et al.* Pl - II, figs. 10 and 13.

1981. *Galeocerdo aduncus* Agassiz: Sahni and Mehrotra. Pl - 2, fig. 15.

1989. *Galeocerdo aduncus* Agassiz: Karasawa, p 55, Pl - VII, figs. 7- 8.

Material: Four isolated teeth; two complete and two broken and are embedded in the matrix.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown	Height/Breadth Ratio
V/F/R - 09	10.00	16.00	9.00	0.62
V/F/B -10	10.00	-	9.00	
V/F/B - 67	12.00	16.00	9.00	0.75
V/F/B - 68	11.00	-	9.00	

Description: Teeth medium in size; upper part of the crowns obliquely triangular with pointed apex and thicker at the centre, lower part compressed and broad covering entire roots, strongly oblique posteriorly; cutting edges sharp with fine and uniform serrations at the mesial or outer margin excepting near the apex that is smooth, serrations prominent at the inner margin with largest ones in the proximity of the notch thereafter gradually becoming smaller towards the posterior end of the crowns, serration absent from the notch towards the apical end; outer margins moderately convex and distal or inner margins strongly concave giving a V-shaped geometry with a deep notch at the centre. External surface nearly flat and internal one moderately convex. Root low and broad, strongly bilobed excepting in Sp. nos. 9 and 10, and sub- rectangular in outline.

Remarks: *Galeocerdo aduncus* Agassiz has been recorded and described by many workers from within the country and abroad. The specimens described herein can be compared reasonably well with the collections made by Antunes and Jonet (1970) and Antunes *et al.* (1981) from the Miocene beds of Portugal. Sahni and Mehrotra (1981) also described and figured this species from the Miocene sediments of Gogha coast of Orissa. Karasawa (1981) has also reported the occurrence of this species from the Miocene sequences at Hokuriku district of central Japan.

Genus ***Negaprion*** Whitley, 1940

Negaprion brevirostris Poey, 1868

(Pl – 13, figs. 10 a – b)

1970. *Negaprion brevirostris* Poey, 1868: Antunes and Jonet, Pl - XIII, fig. 80.

Material: One isolated tooth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm)**:**

Sp. no.	Height of Tooth	Breadth of Tooth	Height of crown	Height/Breadth Ratio
V/F/B - 71	06	7.5	05	0.80

Description: Tooth small, broader than high; crown oblique posteriorly with pointed apex, nearly as high as broad, outer margin slightly convex and inner margin straight, cutting edges sharp and without serrations excepting few ones at the base of the cusp. Internal surface convex and external surface flattened. Root low, straight or feebly bilobed, broader than high, convex on internal side while little concave on external side.

Remarks: Though, the specimen presently described is smaller, it can be compared reasonably well with the one described and figured by Mehrotra *et al*. (1973) under the name *Negaprion brevirostris* from the Lower Miocene shales of Lakhpat and Matanumadh, Kachchh.

Negaprion* cf. *eurybathrodon Blake

(Pl – 13, figs. 11 a – b)

Material: One isolated tooth with broken apical part.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm)**:**

Sp. no.	Height of Tooth	Breadth of Tooth	Height of crown
V/F/B - 72	-	24.00	-

Description: Tooth medium sized; crown erect or slightly oblique posteriorly, broader than high, outer cutting edge convex and inner one straight or slightly concave, irregularly serrated, serrations bigger at the middle and decrease in size towards the basal and apical portions of the cusp, crown goes all over along the root. Internal surface convex and external surface flattened or little convex. Root low, broader than high, internal surface convex while external one concave. Basal part of root straight or feebly bilobed.

Remarks: The specimen at hand has a close affinity with the species *Negaprion* cf *eurybathrodon* described and figured by Antunes *et al.* (1981) from the Miocene beds of Algarve coast, Portugal. Though the appearance and geometry of the above two are quite similar, the serrated margins and smaller size of the present specimen distinguishes it from the species described by Antunes *et al.* (1981). It cannot be compared very well with

the *Negaprion* sp. reported from the conglomeratic horizon of Upper Bhuban unit of Bhuban Formation, Lunglei by Tiwari *et al* (1998), because the latter is much smaller in size and its cutting edges are not serrated.

Genus ***Scoliodon*** Muller and Henle, 1837

Scoliodon sorrakawah Cuvier, 1829

(Pl – 13, figs.14 a – b)

1973. *Scoliodon sorrakawah* Cuvier: Mehrotra *et al*. p 182, Pl - 1, figs.9 a - b.

Material: One isolated tooth with parts of root broken.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm)**:**

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown
V/F/B - 73	7.00	-	5.50

Description: Tooth small; crown narrow, oblique posteriorly with pointed apex. Inner and outer edges straight and without serrations, moderately deep notch near the base of cusp. Internal surface convex while external surface flattened. Root low, broader than high and its basal margin is weakly concave.

Remarks: The specimen resembles *Scoliodon sorrakwah* reported from the Lower Miocene shale and limestone of Matanumadh, Kachchh and Bariapad, Orissa respectively (Mehrotra *et al.* 1973). The distinctive characters such as its small size, posteriorly oblique crown, unserrated cutting edges and low root allow it to be assigned to the species *Scoliodon sorrakawah.*

Order CARCHARINIFORMES Compagno, 1973

Family HEMIGALEIDAE Hasse, 1879 (1885)

Genus ***Hemipristis*** Agassiz, 1843

Hemipristis serra Agassiz, 1843

(Pl – 13, figs.5 – 8)

1901. *Hemipristis serra* Agassiz, 1843: Noetling, p. 83, Pl - XXV, figs. 9 a-e and 10.

1910. *Hemipristis serra* Agassiz, 1843: Stuart, p 300, Pl - 26, fig. 14.

1959. *Hemipristis serra* Agassiz, 1843: Gosh, p Pl - 88, fig. 1.

1973. *Hemipristis serra* Agassiz, 1843: Mehrotra *et al.*, p 182, Pl - 1, fig. 5.

1981. *Hemipristis serra* Agassiz, 1843: Antunes *et al.* Pl - II, figs. 7 - 9.

1981. *Hemipristis serra* Agassiz, 1843: Sahni and Mehrotra p 122, Pl - 2, figs. 16 - 17.

1998. *Hemipristis serra* Agassiz, 1843: Tiwari *et al.* p17, Pl - 1, fig. 1.

Material: Four isolated teeth; two specimens with broken apex and two with parts of the root embedded in the matrix.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown	Height/Breadth Ratio
V/F/R - 01	17.00	14.00	15.00	1.2
V/F/R - 02	15.00	14.00	13.00	1.1
V/F/R - 03	-	20	-	-
V/F/B - 69	-	-	-	-

Description: Teeth large and broad; crowns obliquely triangular to lanceolate, higher than broad with pointed apex and directed towards posterior end, thicker at the base and center portions, thinning out towards apex and edges. Internal surfaces of crowns strongly convex, external surfaces flat or little convex. Both the edges sharp, bearing irregular and obtuse serrations excepting near the apex where they end abruptly; serrations at the inner margin smaller at the base and become larger towards the apex whereas at the outer edges these are smaller and somewhat uniform. Inner edges strongly concave, outer edges convex. Roots very low, swollen in the middle forming prominent bilobed structure on

the internal side that is more prominent in Sp. nos. V/F/R - 03 and V/F/B - 69.

Remarks: The specimens under study resemble *Hemipristis serra* reported and described by many workers from within and outside the country. Specimen nos. V/F/R - 01 and 02 can be compared reasonably well with the same species reported and described by Stuart (1910) from the Pegu beds exposed in the Singu Oilfield of Burma. Sp. nos. V/F/R - 03 and V/F/B - 69 bear close resemblance with the *Hemipristis serra* recorded and figured by Sahni and Mehrotra (1981) from the Miocene sediments of Kachchh (Gujarat) and Gogha coast (Orissa). They can also be compared well with the same species collected and described by Tiwari *et al* (1998) from the Middle Bhuban Formation of Mizoram (Lower Miocene).

The present specimens are identified as *Hemipristis serra* on account of their large size, stout and awl-shaped crown, differently serrated margins i. e. serrations smaller at the base, becoming larger towards apex and abruptly ending a little before reaching the apex, and low, swollen and bifid root.

***Hemipristis unidenticulata* n. sp.**

(Pl – 13, figs. 9a – c)

Material: One complete isolated tooth (Specimen no. V/F/B - 70).

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements: Height of tooth – 10 mm, Breadth of tooth – 8 mm; Height of crown – 8 mm.

Diagnostic characters: Somewhat blunt apex, 5 – 6 serrations in the inner margin, unserrated outer margin with a prominent denticle, and weakly bilobed root.

Description: Tooth medium in size; crown triangular in shape with somewhat blunt and posteriorly directed apex, higher than broad, thicker at the base and central portion, thinning towards the apex and edges. Internal surface strongly convex, external surface flat or with slight convexity. Internal edge bears 5 – 6 obtuse serrations which are smaller at the base and larger towards apex and end abruptly leaving nearly one-third of crown unserrated. Only one large serration or denticle present near the base of the cusp at the

outer edge. Inner margin slightly concave, outer margin straight or slightly convex. Root low and thick, swollen in the middle, and the lateral branches weakly bilobed.

Remarks: The lone but well preserved specimen at hand is distinct from the *Hemipristis serra* in less number of serrations in the inner margin and in the unserrated outer margin bearing a prominent denticle near the base of the cusp. It also differs from *Hemipristis simplex* Stuart (1901, Pl - 26, figs. 13a - b) that has un-serrated marginal edges, stout and narrow outline and convex outer and inner faces. Other forms of *Hemipristis* are not available for comparison. Hence, present specimen is assigned to a new species. It is named as *Hemipristis unidenticulata* n. sp. due to the presence of a prominent denticle near the base of the cusp at the outer cutting edge.

Family SPHYRNIDAE Gill, 1872

Genus ***Sphyrna*** Rafinesque, 1810

Sphyrna diplana Springer, 1941

(Pl – 14, fig. 5)

1973. *Sphyrna diplana* Springer, 1941: Mehrotra *et al.* p 192, Pl - 2, fig. 8 a - b.

1981. *Sphyrna diplana* Springer, 1941: Sahni and Mehrotra, p 192, Pl - 2, fig. 8 a - b.

1982. *Sphyrna diplana* Springer, 1941: Mehrotra, p 402, Pl - 1, fig. 1 a - b.

Material: One isolated tooth with external surface embedded in matrix (Specimen no. V/F/B - 40).

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Description: Tooth small, about 7.00 mm in height and 9.00 mm in breadth; crown as high as root with pointed apex and is strongly directed posteriorly, apical portion of the cusp narrow and the base goes all along over the root; cutting edges without serrations; inner cutting edge straight, outer cutting edge little convex; internal surface somewhat convex, external surface not observable. Root as high as broad, internal surface strongly convex with prominent bilobed structure. It is bifurcated by a deep median furrow at the internal surface.

Remarks: A single but well preserved specimen described herein is more or less similar with the one figured by Sahni and Mehrotra (1981) from the Miocene sediments of Baripada, Orissa and Kachchh.

Sphyrna zygaena Linneaus, 1758

(Pl – 14, fig. 6)

1981. *Sphyrna zygaena* Linneaus, 1758: Antunnes *et al*. Pl - III, fig. 16.

1981. *Sphyrna zygaena* Linneaus, 1758: Sahni and Mehrotra, p 122, Pl - 2, fig. 21.

1998. *Sphyrna zygaena* Linneaus, 1758: Tiwari *et al*. p 17, Pl - 1, fig. 4.

Material: One isolated tooth with external surface embedded in matrix (Specimen no. V/F/B - 39).

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements: Height of tooth – 6.00 mm; Breadth of tooth – 7.00; Height of crown – 4.50 mm.

Description: Tooth small; crown narrow, sharp, slightly oblique with pointed apex. Inner margin nearly straight while outer margin slanted with slight convexity. Edges are without serrations. Base of the crown goes all along over the root. Crown much higher than the root. Internal surface slightly convex, thickened in the middle and becoming thinner towards the edges. Root low, broader than high and sub-rectangular in shape.

Remarks: The present specimen compares well with the collection and description made by Tiwari *et al*. (1998) from the Upper Bhuban Formation of Mizoram. It also has a close resemblance with the lower lateral anterior tooth of *Sphyrna zygaena* described and figured by Antunnes and Jonet (1981) from the Miocene beds of Algarve Coast, Portugal.

Family TRIAKIDAE

Genus ***Galeorhinus*** Blainville, 1816

***Galeorhinus* sp.**

(Pl – 14, figs.7 a – b)

Material: One incomplete isolated tooth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Height of Tooth	Breadth of Tooth	Height of Crown
V/F/B -23	-	-	6.00

Description: Tooth though slightly broken, appears to be very small. Crown thick, as high as broad, sub-triangular in shape, labiolingually compressed with pointed apex and slightly directed distally; four to five obtuse serrations at the inner or distal cutting edge, serrations decrease in size form the apex to the base of crown; mesial margin smooth and little convex; internal surface more convex than the external one.

Remarks: Tooth is incomplete and the root part is not fully preserved. It belongs to the genus *Galeorhinus* on account of its small size, well developed cusp, absence of mesial serrations and sub-erect mesial margin. It has close resemblance with the species *Galeorhinus* sp. described and figured by Kumar and Loyal (1987) from the Subathu Formation of Lower Eocene age, Northwestern Himalaya. It also has considerable similarity with the same species described and reported by Yabe and Hirayama (1994) from the Upper Miocene sediments of Sehhata Formation, Boso Peninsula, Central Japan. Incomplete nature of the specimen, however, does not warrant specific identification.

Order SQUALIFORMES Goodrich, 1909

Family SQUALIDAE

Genus ***Squalus*** Linnaeus, 1758

***Squalus* sp.**

(Pl – 14, fig. 8)

Material: Isolated tooth with external surface embedded in the matrix (Specimen no. V/F/B - 91).

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Description: Tooth small, about 3.50 mm in height and 8.50 mm in breadth; crown as high as root and strongly inclined towards the inner edge, apical portion of the cusp narrow and the base goes all along over the root; cutting edges without serrations, inner cutting edge straight, outer cutting edge little convex; internal surface slightly convex,

external surface embedded in the matrix. Root much broader than high, basal margin not observable.

Remarks: The specimen resembles with *Squalus* sp. reported and figured by Sahni and Mehrotra (1981) from the Miocene sediments of Baripada, Orissa. Specific identification is however deferred for the want of additional material.

Carcharhinidae gen. et sp. indet.

(Pl – 14, figs. 12 a – b)

Material: One vertebra (Specimen no. V/F/R - 105).

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Descriptions: Cranial and caudal surfaces of vertebral column with scripted ring groups, column nearly rounded and concave; canals of haemal arches at dorsal surface and neural arches at ventral surface not observable; lateral faces nearly flat; vertebral plate 15 mm in thickness, 40 mm in diameter or breadth.

Remarks: The specimen under consideration belongs to the family Carcharhinidae because cranial and caudal surfaces are rounded with concentric ring groups and its lateral surface is nearly flat. The same species is reported from the Miocene sediments of the Hokuriku district, central Japan by Karasawa (1989). The features of this specimen is also similar to the one of *Carcharhinus egertoni* from the Higashibessho Formation (Nishimoto *et al.* 1980 as *C.* aff. *egertoni*). Specific identification is not being attempted because the available specimen is only a small part of the vertebral column.

Indeterminate vertebral centra of selachians

(Pl – 14, figs. 11 a – b)

Material: One vertebra (Specimen no. V/F/R - 104).

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Descriptions: Vertebra small in size; both its cranial and caudal surfaces are concave with numerous concentric growth lines whereas lateral and dorsal surfaces are concave

and smooth. It has a thickness of about 10 mm and diameter of about 8mm.

Remarks: The described specimen is too meager and poorly preserved to allow precise determination. No form of this genus is available to the author for comparison.

Superorder	BATOIDEA
Order	MYLIOBATIFORMES Compagno 1973
Superfamily	MYLIOBATOIDEA Compagno 1973
Family	MYLIOBATIDAE Bonaparte 1838
Genus	***Myliobatis*** Cuvier, 1817

***Myliobatis* sp.**

(Pl – 14, figs. 13 – 17; Pl – 15, figs. 1 a – b)

Material: Five isolated median teeth; three complete and two broken, and one fragmentary caudal spine.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Measurements (mm):

Sp. no.	Length of Tooth	Breadth of Tooth
V/F/B - 05a	4.00	22.00
V/F/B - 91	5.00	19.00
V/F/B - 92	5.00	-
V/F/B - 93	4.00	25.00
V/F/R - 94	5.00	-
V/F/R - 5b	-	-

Description: The described specimens belong to the median teeth of *Myliobatis*. They are medium in size, transversely elongated, more or less straight, hexagonal in out line; the coronal surface of crown is smooth, the basal surface of root is divided into 19-20 ridges and grooves at right angle to the transverse axis of crown as observed in sp. no. V/F/B - 05a. A straight ridge or shelf-like projection is present at the junction of crown and root on both the anterior and posterior sides.

Specimen no. V/F/R - 05b is the claudal spine. Its dimensions could not be measured due to fragmentary nature of the material. The spine is narrow, about 5 mm in breadth, longitudinally striated, some of the striations being deep enough to form grooves. The anterior is straight with denticles on the lateral edges which are directed distally making an angle of 30 to 40 degrees from the central axis. The presence of these denticles imparts a saw-tooth appearance.

Remarks: These specimens have a clear resemblance with the *Myliobatis* sp. described and reported by Sahni and Mishra (1975) from Lower Miocene of Matanomadh, and Lakhpat, Kachchh, Gujarat. These also resemble well with the same species from the Eocene sediments of Subathu Formation, Northwestern Himalaya (Loyal, 1987). Identification of *Myliobatids* spines at a specific level seems difficult, as all of them are nearly alike. Moreover, the present specimen is poorly preserved. Thus no specific name has been proposed.

Genus ***Aetobatus*** Muller and Henle, 1841

***Aetobatus* sp.**

(Pl – 15, figs. 2 – 3)

Material: Two poorly preserved isolated teeth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Length of Tooth	Breadth of Tooth
V/F/B - 95	7.00	21.00
V/F/B - 96	6.00	21.00

Description: Teeth medium in size, hexagonal in shape and arched laterally which is well-exhibited in the basal view. The occlusal surface is smooth. The root is divided longitudinally into 20 to 25 ridges and grooves, which continue from the under side to the posterior boarders of the enameled surface. Further details could not be deciphered.

Remarks: The present specimens can be compared reasonably well with the species *Aetobatus* (= *Aetobatis*) *arcuatus baripadensis* reported from the Tertiary deposits of Mayurbhanj by Ghosh (1959). The species reported by Sahni and Mishra (1975) from the gray colored gypseous shales of Khari Series, Matanomadh, Kachchh is slightly smaller than the present one. However, the materials at hand are poorly preserved and their specific assignment is not possible.

Class OSTEICHTHYES
Subclass ACTINOPTERYGII
Infraclass TELEOSTEI
Superorder ACANTHOPTERYGII
Order TETRADONTOIDEI
Family DIODONTIDAE
Genus ***Diodon*** Linnaeus 1758

***Diodon* sp. 1**

(Pl – 15, figs. 4 – 8)

Material: Five isolated dental plates.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Breadth	Length	Thickness	No. of Lamellar Plates
V/F/B - 12	12.7	18.00	6.00	09
V/F/B - 97	10.00	14.50	5.00	08
V/F/B - 98	11.00	15.00	4.00	06
V/F/B - 99	7.00	8.50	2.50	04
V/F/B - 100	6.00	9.50	3.00	04

Description: Dental plates are medium to large, oval to sub-rounded and consist of 4 to 10 lamellar plates. The individual lamellar plates have different shapes - ranging from oval to sub-angular- and sizes and are piled up one over another. The first plate on the apical side is the smallest and the sizes of the subsequent plates increase towards the base. All the dental plates are cut into two more or less similar halves by a vertical plane.

Remarks: The record of the fossil diodontids from India is meager and the present specimens could not be well compared with any of the collections made by the earlier workers. Based on the shape and the arrangement of the lamellar plates, the present specimens undoubtedly belong to the genus *Diodon.* These cannot be identified at the specific level due to inadequate details.

***Diodon* sp. 2**

(Pl – 15, figs. 9 – 10)

Material: Two complete dental plates.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Breadth	Length	Thickness	No. of Lamellar Plates
V/F/B - 101	3.00	5.50	1.50	04
V/F/B - 102	5.50	4.60	1.50	04

Description: The dental plate is small in size and sub-triangular in shape. Lamellar plates are piled up on top of one another and vary in shapes and sizes. The sizes of the individual plates progressively increases from the apex to the base. A vertical line divides the dental plate into two symmetrical halves.

Remarks: The present speimens differ widely in shape, size and over all geometry from the earlier known species of *Diodon* and also from the *Diodon* forms described herewith. However, christening is deffred for the want of more material and information.

***Diodon* sp. 3**

(Pl – 15, figs.11 a – b)

Material: One complete isolated dental plate.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

Sp. no.	Breadth	Length	Thickness	No. of Lamellar Plates
V/F/B -13	16.00	20.00	4.00	06

Description: Dental plate medium in size and 'heart shaped'. It consists of 6 lamellar plates. The lamellar plates at the apex and base are very thin while the four lamellae in between these are comparatively thicker. These plates have more or less equal size from the apex to the base. A vertical line divides the plates into two asymmetrical halves. The outer edge of the plate is somewhat crenulated. The dental plate is slightly concave at the apex and slightly convex at the base.

Remarks: The present specimen is markedly different from all other specimens on account of its shape, size, number of lamellar plates and slightly crenulated plate margin. However, a new species is not christened owing to solitary specimen.

***Diodon* sp. 4**

(Pl – 15, fig. 12 – 13)

Material: Two dental plates.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

Measurements (mm):

Sp. no.	Breadth	Length	Thickness	No. of Lamellar Plates
V/F/B - 103	9.00	20.00	6.00	06
V/F/R - 15	10.00	22.00	6.00	07

Description: The dental plate is medium in size, laterally elongated, sub-rectangular to sub-oval in shape; dental plates are formed by more or less oblique piles of 6 to 7 lamellae of unequal sizes; the biggest one lies at the base and the smallest one at the apex. The lamellar plates are divided by a median vertical line into two similar halves. Margins of the plates are not crenulated.

Remarks: The transversely elongated nature of the dental plates of the present specimens distinguishes these from the previously described species. Though *Diodon* is reported from several fossil localities from the Eocene and Miocene sediments of the Indian sub-continent, the material described here is too meager to allow any detailed comparison and identification at the specific level.

Indeterminate tooth of Crocodylidae

(Pl – 14, figs. 10 a – b)

Material: One isolated incomplete tooth (Sp. no. V/C/R - 90).

Location: Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

Horizon: Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements: The specimen has the following dimensions: Height of crown - 16.00, breadth of crown – 8.00 mm; height and breadth of tooth cannot be measured because the root is embedded in the matrix.

Description: Tooth medium in size; crown narrow, thick and erect with arc-shaped apex, cutting edges sharp with fine and uniform serrations throught out, both the inner and outer edges little convex; internal surface highly convex, external surface flattened with slight depression near the junction of crown and root. Root seems to be very low, and could not be described further due to poorly preserved material.

Remarks: The specimen at hand completely differs from the teeth of the elasmobranch forms on account of its blunt apex and almost an arc-shaped crown. Furthermore, the internal surface of the crown is highly convex while the outer surface is flat. Owing to the possession of these morphological features, it may be a tooth of Crocodylidae. The identification is not ascertained due to the lack of enough details.

CHAPTER -5

ANALYSIS OF FAUNA
AND
AGE OF BEDS

5. FAUNAL ANALYSIS AND AGE

5.1 ANALYSIS OF FAUNA

In spite of a huge thickness and good exposures, the shallow marine Surma sequence of Mizoram has not been fully explored for its fossil contents. The earlier published literatures on the palaeontological aspects of this sequence were contributed mainly by the geologists of Burmah Oil Company, Geological Survey of India and Oil and Natural Gas Corporation of India. The first detailed study on the palaeontological aspect of this succession was carried out by Tiwari (1992) who reported 125 forms of bivalves, gastropods, decapods, echinoids, shark teeth and scaphopods from the rocks exposed in and around Aizawl and Lunglei, Mizoram. Subsequently, Mazumder (2004) described and illustrated 153 forms of bivalves, gastropods, decapods, echinoids and scaphopods from the Bhuban Formation of Kolasib, Mizoram. Lalchawimawii (2004), while working for her M. Sc Dissertation, reported 53 forms of bivalves, gastropods, echinoids and decapods from the South Hlimen locality, Aizawl District, Mizoram.

The present work is an attempt to explore the fossil contents of the Upper Bhuban Unit of Bhuban Formation, Surma Group from the area in and around Aizawl, Mizoram. Fossil collection has been made from the six localities of the study area out of which four localities are new ones. The fossil assemblage from these localities consists of bivalves, gastropods, decapods and foraminifers in descending order of abundance amongst the invertebrates and fish teeth amongst the vertebrates. One tooth has been tentatively assigned to crocodylidae as it strikingly differs from the elasmobranchs teeth. Though some specimens of regular and irregular echinoids have also been collected from these localities, these are mostly unidentifiable. Out of the total 98 taxa, 58 belong to mega-invertebrates, 2 to foraminifers, 37 to fishes and one to crocodylidae?. The 58 taxa of mega-invertebrates include 44 of bivalves, 8 of gastropods and 6 of decapods. The 37 taxa of fishes are distributed to 33 of elasmobranchs and 4 of teleosts. Among the elasmobranches, 31 taxa belong to selachians (sharks) and two to batoids (rays).

Bivalves are represented by 26 genera, gastropods by 5, decapods by 6, foraminfers by one genus, selachians by 13 genera, batoids by 2 genera and teleosteans

by one genus. Two vertebrae of selachians, and one tooth of crocodylidae could not be identified up to the generic level because of the lack of adequate details. Twenty-six genera (11 subgenera) of bivalves have been grouped into 17 families (16 subfamilies), 16 superfamilies and 6 orders (4 suborders) belonging to 3 subclasses. Five genera (3 subgenera) of gastropods belong to 5 families (3 subfamilies), 5 superfamilies and one order and subclass each. Decapods are distributed to 6 genera grouped into 5 families, 3 superfamilies and one infraorder and suborder each. Family-wise, Veneridae of the class Bivalvia contains largest number of genera, *i.e.* five, namely, *Callista*, *Dosinia*, *Clementia*, *Paphia* and *Timoclea* followed by Arcidae that has three genera viz., *Barbatia*, *Trisdos* and *Anadara*. Other families are represented by either one or two genera. *Anadara* has maximum number of species, *i.e.* 5, closely followed by *Tellina* – 4 and *Paphia* – 3. Other genera have less than three representative taxa. Individual-wise, the following species are abundant: *Conus* (*Dendroconus*) *loroisii* – 7, *Paphia* (*Paphia*) *rotundata* (Linne') – 5, *Chlamys* (*Argopecten*) *senatoria* (Gmelin) – 5, *Pecten* (*Pecten*) *mathuri* Tiwari – 5 and *Conus* (*Leptoconus*) *bonneti* Cossmann – 5. The species with four individuals are *Anadara* (*Anadara*) *craticulata* (Nyst), *Anadara* (*Anadara*) *daviesi* Mukerjee, *Diplodonta* (*Diplodonta*) *incerta* d'Archiac, *Tellina* (*Eurytellina*) cf. *pilgrimi* Cox, *Tellina* (*Tellinella*) *loknathi* Tiwari and *Corbula* (*Corbula*) *tunicosulcata* Vredenburg. Rests of the species are represented by less than 4 individuals.

The elasmobranch fauna is represented by 4 orders *viz.* Lamniformes, Carcharhiniformes, Squaliformes and Myliobatiformes. Lamniformes is represented by four families such as Lamnidae, Alopiidae, Odontaspididae and Carcharhinidae; Carcharhiniformes by three families – Hemigaleidae, sphyrnidae and Triakidae; both Squaliformes and Myliobatiformes by only one family each namely, Squalidae and Myliobatidae respectively. Teleosts is represented only by the family Diodontidae belonging to the order Tetradontoidei. A close study of the fish fossil in the present work reveals that selachians are the dominant fish group in both the localities from where collection of fishes has been made and accounts for more than 80 % of the total fish assemblages. The shark species are dominated by the families Lamnidae and Carcharhinidae. The genera namely *Carcharodon, Isurus, Carcharhinus, Galeocerdo* and *Hemipristis* occur frequently in the two localities.

Out of the total of 37 fish fauna identified in this study, only four species *viz*. *Hemipristis serra, Sphyrna zygaena, Carcharodon carcharias* and *Isurus spallanzanii* are common with the previously known fish assemblage from Mizoram (Tiwari *et al*., 1998). The remaining twenty-nine fish forms *viz*. *Lamna* sp., *Isurus pagoda, Alopias* sp., *Carcharodon angustidens*, *Carcharodon* sp., *Odontaspis* cf. *taurus, Odontaspis* cf. *tricuspidatus, Odontaspis* sp., *Carcharhinus egertoni, Carcharhinus priscus, Carcharhinus* cf. *macloti, Carcharhinus* (*Prionodon*) sp., *Carcharhinus* sp. A, B, C, and D, *Galeocerdo aduncus, Negaprion brevirostris, Negaprion* cf. *eurybathrodon, Scoliodon sorrakawah, sphyrna diplana, Squalus* sp., *Galeorhinus* sp., *Myliobaties* sp., *Aetobatus* sp., *Diodon* sp.1, 2, 3 and 4 are being reported for the first time from Bhuban Formation of Mizoram. In addition to this, two vertebrae of selachians and one tooth of crocodylidae are also being recorded for the first time. However, three genera namely *Pristiphorus, Dasyatis,* and *Dentex,* though reported previously from the Bhuban Formation are surprisingly absent from the present collection.

Among the total faunal assemblage from the present collection, only two are the new species. These are: *Carcharhinus bhubanicus* n. sp. and *Hemipristis unidenticulata* n. sp. *Carcharhinus priscus* and *Galeorhinus* sp. are reported for the first time from the Miocene beds of Indian subcontinent. Two species, namely, *Odontapis* cf. *taurus* and *Negaprion* cf. *eurybathrodon* Blake are being reported for the first time from the Miocene of Northeastern region.

The present collections along with the ones reported by Tiwari (1998) from the Bhuban Formation of Mizoram represent almost 40 % of the total fish assemblages previously reported from the other Miocene beds of the Indian subcontinent.

The fish fauna described in the present study bears a close relationship to the present day fauna of the Indian Ocean. Almost all the genera of fossil sharks from Miocene of Indian subcontinent still inhabit the Indian Ocean except *Carcharodon* and *Lamna.* It can be reasonably surmised that the sharks underwent only a minimal structural change from the Miocene and are the direct ancestors of Recent Indian sharks (Sahni and Mehrotra, 1981). *Carcharodon* is very common in Indian Miocene beds but surprisingly absent in the present day Indian Ocean (Mehrotra *et al*., 1973).

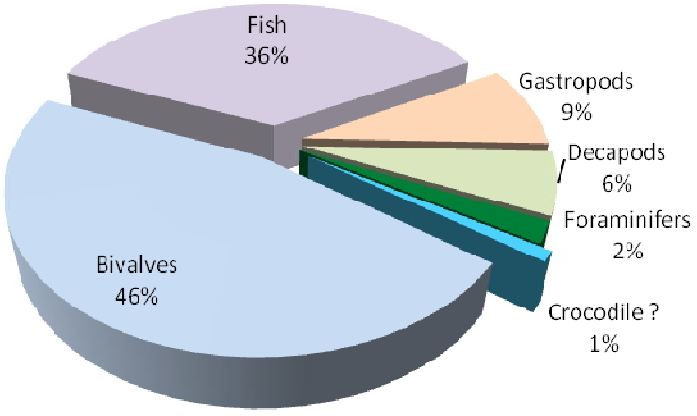


Figure 5.1: Percentage composition of faunal assemblage in the study area

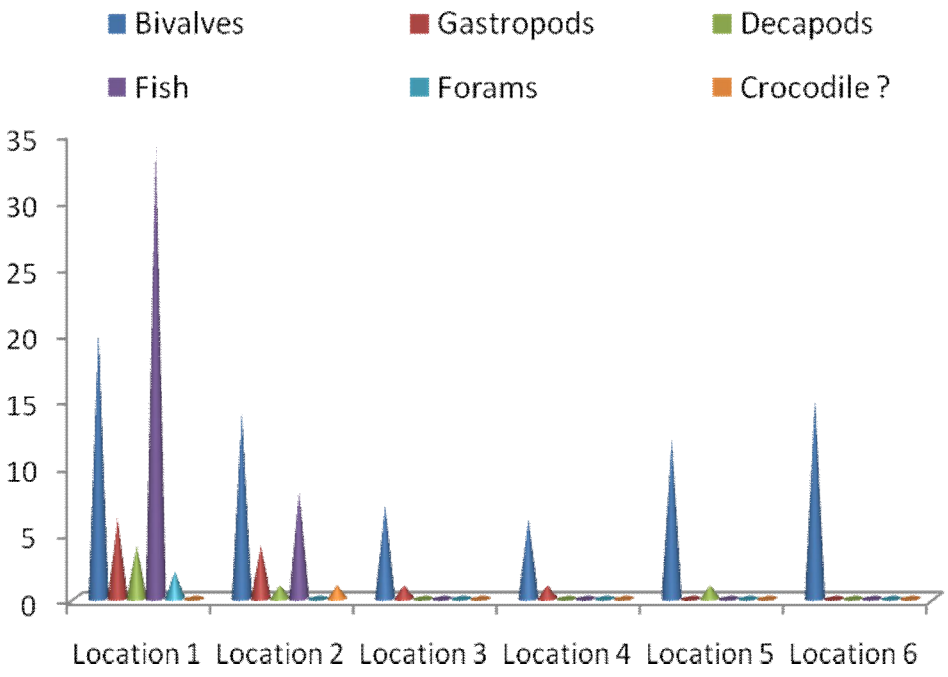


Figure 5.2: Locality-wise distribution of fauna in the study area

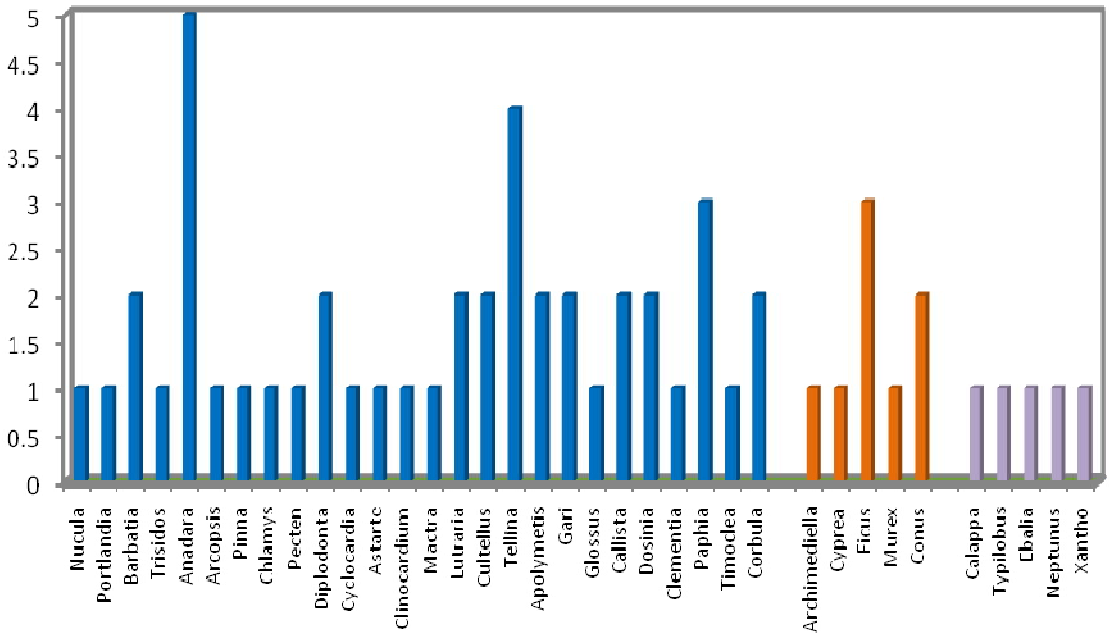


Figure 5.3: Family-wise relative abundance of mega-invertebrate fauna in the study area

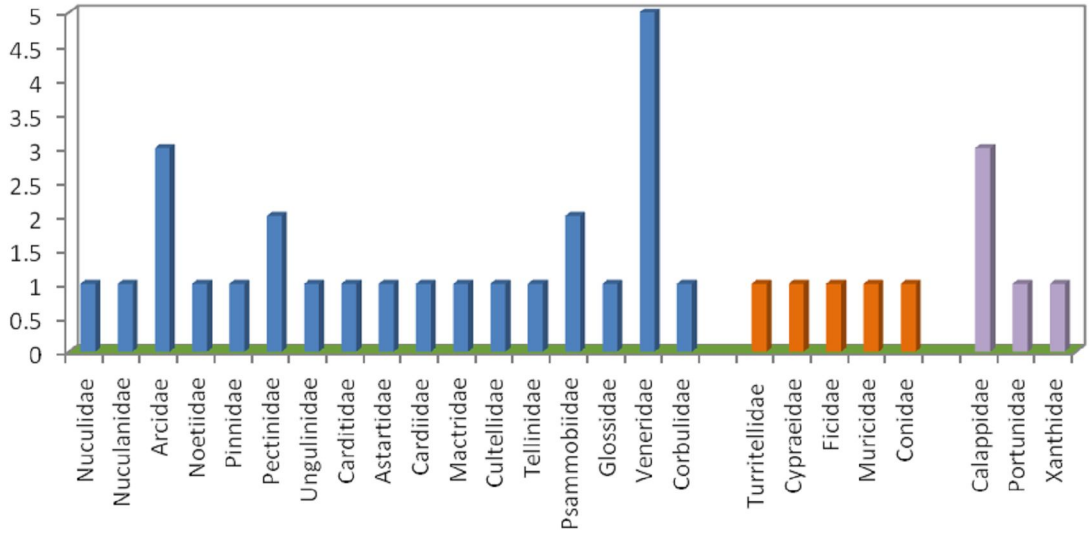
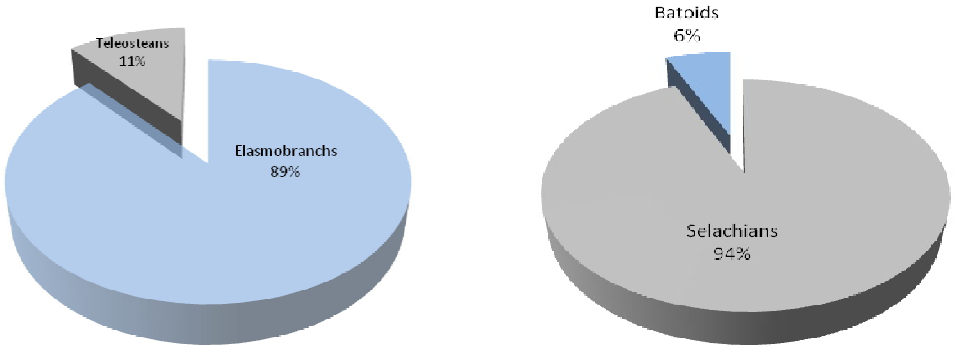
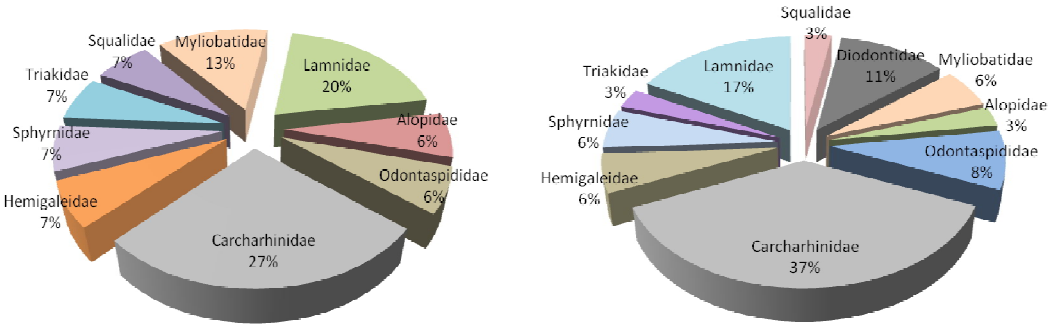


Figure 5.4: Genera-wise relative abundance of mega-invertebrate species in the study area



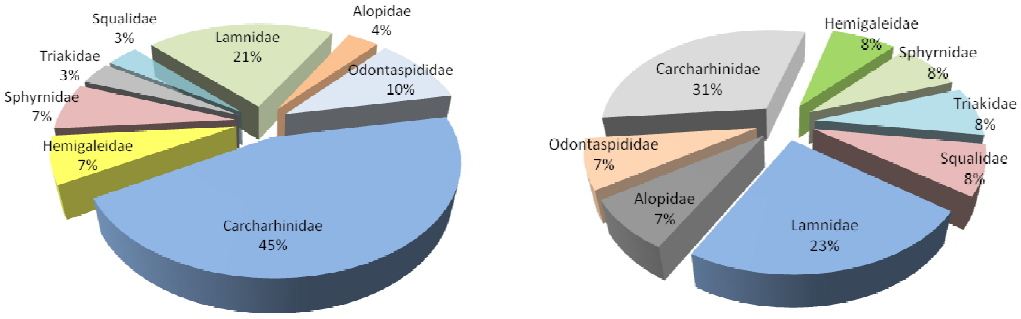
A B

Figure 5.5: (A) Group-wise relative abundance of fish fauna in the study area, (B) Species-wise relative abundance of Elasmobranch fauna in the study area



A B

Figure 5.6: (A) Family-wise relative abundance of Elasmobranch genera in the study area, (B) Family-wise relative abundance of Elasmobranch species in the study area



A B

Figure 5.7: (A) Family-wise relative abundance of shark genera in the study area, (B) Family-wise relative abundance of shark species in the study area

5.1.1 GENERIC RECORD FROM THE STUDY AREA

In the present work a total of the following 54 genera are recorded:

Bivalves: *Nucula*, *Portlandia*, *Barbatia*, *Trisidos*, *Anadara*, *Arcopsis*, *Pinna*, *Chlamys*, *Pecten*, *Diplodonta*, *Cyclocardia*, *Astarte*, *Clinocardium*, *Mactra*, *Lutraria*, *Cultellus*, *Tellina*, *Apolymetis*, *Gari*, *Glossus*, *Callista*, *Dosinia*, *Clementia*, *Paphia*, *Timoclea* and *Corbula*.

Gastropods: *Archimediella*, *Cypraea*, *Ficus*, *Murex* and *Conus*.

Decapods: *Calappa*, *Typilobus*, *Ebalia*, *Neptunus*, *Palaeocarpilius*, and *Xantho*.

Foraminifers: *Ammonia*.

Fishes: *Lamna*, *Carcharodon*, *Isurus*, *Alopias*, *Odontaspis*, *Carcharhinus*, *Galeocerdo*, *Negaprion*, *Scoliodon*, *Hemipristis*, *Sphyrna*, *Galeorhinus*, *Squalus*, *Myliobatis*, *Aetobatus*, and *Diodon*.

Twelve genera, namely, *Arcopsis*, *Cypraea*, *Lamna*, *Alopias*, *Odontaspis*, *Galeocerdo*, *Scoliodon*, *Galeorhinus*, *Squalus*, *Myliobatis*, *Aetobatus* and *Diodon* are being reported for the first time from the Miocene of Mizoram whereas two genera, namely, *Cyclocardia* and *Clinocardium* are being reported for the first time from the Miocene sediments of the Northeastern region.

5.1.2 SUBGENERIC RECORD

The following fifteen subgenera are recorded in the present study:

Bivalves: *Chlamys* (*Argopecten*), *Astarte* (*Bythiamena*), *Lutratria* (*Lutraria*), *Tellina* (*Angulus*), *Tellina* (*Eurytellina*), *Tellina* (*Moerella*), *Tellina* (*Moerella*), *Tellina* (*Tellinella*), *Gari* (*Psammobia*), *Glossus* (*Cytherocardia*) and *Callista* (*Calistotapes*).

Gaspropods: *Archimediella* (*Torculoidella*), *Conus* (*Leptoconus*) and *Conus* (*Dendroconus*).

Fishes: *Carcharhinus* (*Prionodons*).

5.1.3 RECORD OF SPECIES FROM THE STUDY AREA

Bivalves: *Nucula* (*Nucula*) *agrawali* Tiwari, *Portlandia* (*Portlandia*) *ovatoelongata* Mazumder, *Barbatia* (*Barbatia*) *bataviana* Martin var. *carinata* Noetling, *Barbatia* sp., *Trisidos semitorta* (Lamarck), *Anadara* (*Anadara*) *craticulata* (Nyst), *Anadara* (*Anadara*) *daviesi* Mukerjee, *Anadara* (*Anadara*) *garoensis* Mukerjee, *Anadara* (*Anadara*) *luangmualensis* Tiwari, *Anadara* (*Anadara*) *trapezoida* Tiwari, *Arcopsis* sp., *Pinna* (*Pinna*) cf. *rudis* Linné, *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Pecten* (*Pecten*) *mathuri* Tiwari, *Diplodonta* (*Diplodonta*) *incerta* d'Archiac, *Diplodonta* (*Diplodonta*) *rotundatus* (Montagu), *Cyclocardia* sp., *Astarte* (*Bythiamena*) *striata* Tiwari, *Mactra* (*Mactra*) *protoreevesii* Noetling, *Clinocardium* sp., *Lutraria philippinarum* Reeve, *Lutratria* (*Lutraria*) *saigengai* Tiwari, *Cultellus* (*Cultellus*) *zulloi* Tiwari, *Cultellus* sp., *Tellina* (*Angulus*) sp., *Tellina* (*Eurytellina*) cf. *pilgrimi* Cox, *Tellina* (*Moerella*) *indifferens* Noetling, *Tellina* (*Tellinella*) *loknathi* Tiwari, *Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari, *Apolymetis* (*Apolymetis*) *grimesi* Noetling, *Gari* (*Psammobia*) *kingi* (Noetling, *Gari* (*Gari*) *natensis* Noetling, *Glossus* (*Cytherocardia*) *cytheroides* (Mayer), *Callista* (*Callista*) *pseudoumbonella* Vredenburg, *Callista* (*Costacallista*) *erycina* (Linne'), *Dosinia* (*Dosinia*) *peralta* Vredenburg, *Dosinia* (*Dosinia*) *subpenicillata* Vredenburg, *Clementia* (*Clementia*) *papyracea* (Gray), *Paphia* (*Paphia*) *rotundata* (Linne'), *Paphia* (*Paphia*) *jhai* Tiwari, *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg, *Timoclea* (*Timoclea*) *scabra* (Hanley), *Corbula* (*Corbula*) *tunicosulcata* Vredenburg and *Corbula* (*Corbula*) *mekranica* Vredenburg.

Gastropods: *Archimediella* (*Torculoidella*) *angulata* (Sowerby), *Cypraea* sp., *Ficus* (*Ficus*) *ficus* (Linne'), *Ficus* (*Ficus*) *kachhensis* (Vredenburg), *Ficus* (*Ficus*) *conditus* (Brongniart), *Murex maegillivrayi* Dohrn, *Conus* (*Leptoconus*) *bonneti* Cossmann, and *Conus* (*Dendroconus*) *loroisii* Kiener.

Decapods: *Calappa protopustulosa* Noetling, *Typilobus granulosus* Stocliczka, *Ebalia tuberculata* Noetling, *Neptunus sindensis* Stoliczka, *Palaeocarpilius rugifer* Stoliczka and *Xantho* sp.

Foraminifers: *Ammonia annectens concinna* and *Ammonia* sp.

Fishes: *Lamna* sp., *Carcharodon carcharias* Linnaeus, *Carcharodon angustidens* Agassiz, *Carcharodon* sp., *Isurus spallanzanii* Bonnaparte, *Isurus pagoda* Bonnaparte, *Alopias* sp., *Odontapis* cf. *taurus* Rafinesque, *Odontapis* cf. *tricuspidatus* Day, *Odontaspis* sp., *Carcharhinus egertoni* Agassiz, *Carcharhinus priscus* Agassiz, *Carcharhinus* cf. *macloti***,** *Carcharhinus bhubanicus* n. sp., *Carcharhinus* (*Prionodons*) sp., *Carcharhinus* sp. A., *Carcharhinus* sp. B, *Carcharhinus* sp. C, *Carcharhinus* sp. D, *Galeocerdo aduncus* Agassiz, *Negaprion brevirostris* Poey, *Negaprion* cf. *eurybathrodon* Blake, *Scoliodon sorrakawah* Cuvier, *Hemipristis serra* Agassiz, *Hemipristis unidenticulata* n. sp., *Sphyrna zygaena* Linneaus, *Sphyrna diplana* Springer, *Galeorhinus* sp., *Squalus* sp., Carcharhinidae gen. et sp. indet, indeterminate vertebral centra of selachian, *Myliobatis* sp., *Aetobatus* sp., *Diodon* sp.1, *Diodon* sp.2, *Diodon* sp.3 and *Diodon* sp.4.

Crocodylidae: Indeterminate tooth of Crocodylidae.

The following twelve species are being reported for the first time from the Miocene of Mizoram: *Gari* (*Psammobia*) *kingi* (Noetling), *Neptunus sindensis* Stoliczka, *Palaeocarpilius rugifer* Stoliczka, *Carcharodon angustidens* Agassiz, *Isurus pagoda* Bonnaparte, *Odontapis* cf. *tricuspidatus* Day, *Carcharhinus egertoni* Agassiz, *Carcharhinus* cf. *macloti* Muller and Henle, *Galeocerdo aduncus* Agassiz, *Negaprion brevirostris* Poey, *Scoliodon sorrakawah* Cuvier, and S*phyrna diplana* Springer.

The age range of the following forms has been extended either downward or upward as shown against their names:

Name of species	From	to
Ficus (*Ficus*) *conditus* (Brongniart)	Rupelian to Aquitanian	Rupelian to Burdigalian

5.1.4 SPECIES COMMON BETWEEN THE PRESENT AREA AND PREVIOUSLY REPORTED FOSSIL LOCALITIES OF MIZORAM

Thirty-seven species of bivalves, 7 of gastropods, 3 of decapods and 4 of fishes are common between the study area and other parts of Mizoram. These are as follows:

Bivalves: *Nucula* (*Nucula*) *agrawali* Tiwari, *Portlandia* (*Portlandia*) *ovatoelongata* Mazumder, *Barbatia* (*Barbatia*) *bataviana* Martin var. *carinata* Noetling, *Trisidos semitorta* (Lamarck), *Anadara* (*Anadara*) *craticulata* (Nyst), *Anadara* (*Anadara*) *daviesi* Mukerjee, *Anadara* (*Anadara*) *garoensis* Mukerjee, *Anadara* (*Anadara*) *luangmualensis* Tiwari, *Anadara* (*Anadara*) *trapezoida* Tiwari, *Pinna* (*Pinna*) cf. *rudis* Linné, *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Pecten* (*Pecten*) *mathuri* Tiwari, *Diplodonta* (*Diplodonta*) *incerta* d'Archiac, *Diplodonta* (*Diplodonta*) *rotundatus* (Montagu), *Astarte* (*Bythiamena*) *striata* Tiwari, *Mactra* (*Mactra*) *protoreevesii* Noetling, *Lutraria philippinarum* Reeve, *Lutratria* (*Lutraria*) *saigengai* Tiwari, *Cultellus* (*Cultellus*) *zulloi* Tiwari, *Tellina* (*Eurytellina*) cf. *pilgrimi* Cox, *Tellina* (*Moerella*) *indifferens* Noetling, *Tellina* (*Tellinella*) *loknathi* Tiwari, *Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari, *Apolymetis* (*Apolymetis*) *grimesi* Noetling, *Gari* (*Gari*) *natensis* Noetling, *Glossus* (*Cytherocardia*) *cytheroides* (Mayer), *Callista* (*Callista*) *pseudoumbonella* Vredenburg, *Callista* (*Costacallista*) *erycina* (Linne'), *Dosinia* (*Dosinia*) *peralta* Vredenburg, *Dosinia* (*Dosinia*) *subpenicillata* Vredenburg, *Clementia* (*Clementia*) *papyracea* (Gray), *Paphia* (*Paphia*) *rotundata* (Linne'), *Paphia* (*Paphia*) *jhai* Tiwari, *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg, *Timoclea* (*Timoclea*) *scabra* (Hanley), *Corbula* (*Corbula*) *tunicosulcata* Vredenburg and *Corbula* (*Corbula*) *mekranica* Vredenburg.

Gastropods: *Archimediella* (*Torculoidella*) *angulata* (Sowerby), *Ficus* (*Ficus*) *ficus* (Linne'), *Ficus* (*Ficus*) *kachhensis* (Vredenburg), *Ficus* (*Ficus*) *conditus* (Brongniart), *Murex maegillivrayi* Dohrn, *Conus* (*Leptoconus*) *bonneti* Cossmann and *Conus* (*Dendroconus*) *loroisii* Kiener

Decapods: *Calappa protopustulosa* Noetling, *Typilobus granulosus* Stocliczka and *Ebalia tuberculata* Noetling.

Fishes: *Carcharodon carcharias* Linnaeus, *Isurus spallanzanii* Bonnaparte, *Hemipristis serra* Agassiz and *Sphyrna zygaena* Linneaus.

5.2 AGE OF BEDS

5.2.1 INTRODUCTORY REMARKS

Bivalves are widely distributed and have been encountered in all the fossiliferous beds in the study area. A large number of bivalves taxa reported here may not be suitable for age determination and correlation due to their long ranges and thus are of limited significance as age indicator. However, majority of the forms recorded from the study area are also known to occur in the Miocene sediments of Aizawl, Lunglei and Kolasib areas of Mizoram (Tiwari, 1992, 2001 and 2007; Tiwari and Kachhara, 2003; Mazumder, 2004; Lalchawimawii, 2004), Garo Hills of Meghalaya (Mukerjee, 1939; Lyngdoh, *et. al*., 1999; Lyngdoh, 2004); Barak Valley (old 'Cachar District' of Assam; Pascoe, 1972), Dey (1962), Kachchh and Kathiawar (Gujarat; Vredenburg, 1925 and 1928, Jain 1997), Sind (Pakistan; Vredenburg, 1928) and Myanmar (Noetling, 1898 and 1901; Pascoe, 1972) and Persia (Cox, 1936). The ages of fossiliferous beds in these localities have been fixed to a great extent. Therefore, an attempt has been made here to date the fossiliferous beds of the study area based on the age-ranges of these taxa as deduced from their previous occurrences in the known fossiliferous localities referred to above.

5.2.2 OVERALL AGE

The ratio of the living to fossil component of the assemblage has been considered as the basis by the earlier workers for classifying the Tertiary strata of the Indo-Pacific region because a good percentage of the fauna from this province are extant. Lyell (refer to Dey, 1962) was the first to propose a method for classifying the Tertiary rocks on the basis of the per cent composition of Recent species in the fossil records. Dall (1904) opined that the Miocene sediments contain roughly 17 to 20 per cent of living species. Martin (Van Der Vlerk, 1931, p. 291) established the following percent component of extant taxa among the Tertiary faunas of the Indo-Pacific province:

Pliocene	50 to 70 %
Upper Miocene	20 to 50 %
Lower Miocene	8 to 20 %
Eocene	0 %

According to Vredenburg (1921) the per cent composition of living fauna in the Upper and Lower Gaj of Northwestern India (Lower Miocene) together is 17.30. Mukerjee (1939) commented that the percent living component of Lower Miocene molluscan faunas of Myanmar, Western India and Java vary from 7 to 25 depending on the horizon, facies and generic constitution. Further, he estimated 21 per cent composition of Recent molluscs species for the Lower Miocene sediments of the Garo Hills, Meghalaya.

Out of 52 molluscan forms described and figured in the present work, 12 range up to the Recent as shown in Table 5.1. Thus the percentage of living component in the present fossil assemblage is 23.07. Though this figure is slightly in the higher side with the Martin's figure for the Lower Miocene, it is well within the range of the figure proposed by Mukerjee (1939) for the Lower Miocene. Hence, the Bhuban rocks of the study area may be assigned to Lower Miocene.

Fourty-three molluscan fossils forms from amongst the 52 discussed in this work are respectively common to the Lower Miocene of Kolasib, Aizawl and Lunglei areas of Mizoram. Twenty-six taxa are common to the Aquitanian - Burdigalian of the Garo Hills of Meghalaya, 9 to Kama (Aquitanian) and 8 to Pyalo (Burdigalian) Formations of Pegu Group, Myanmar, and 14, 10 and 8 are common to Gaj (Lower Miocene) of Kachchh, Kathiawar and Sind respectively. This data also confirms a Lower Miocene (Aquitanian - Burdigalian) age for the Bhuban rocks and agrees with the age as proposed by the earlier workers. It is to be pointed out here that Eames (in Davis, 1975) considered Aquitanian as Lower Miocene and Burdigalian as Middle Miocene. However, in this work, both Aquitanian and Burdigalian are considered as belonging to Lower Miocene.

5.2.3. AGE OF FOSSILIFEROUS BEDS BASED ON RECORDED TAXA

Miocene successions of the Indian subcontinent have been studied in reasonable details by the various workers as mentioned in the preceding section. These studies have shown that a few taxa could be considered as index fossils. These are found to be quite suitable for dating the beds in the present area especially *Diplodonta* (*Diplodonta*) *incerta* d'archiac and *Diplodonta* (*Diplodonta*) *rotundatus* (montagu) of Gaj beds (Aquitanian to Burdigalian). The latter is also known to occur in the Garo Hills, Mekran Bed and Iran (Aquitanian - Burdigalian). Though, *Ostrea latimarginata* has been widely considered as an index species of Aquitanian - Burdigalian age, it is conspicuously absent in the fossil

assemblage available for the study. Locality wise occurrence of fossils collected in the study area along with their age range is given in Table 5.2.

5.2.3.1 Grey Silty-sandstone bed at Bika Quarry, University Road, Tuivamit, Aizawl

A total of 66 forms have been identified from this bed including 20 forms of bivalves, 6 of gastropods, 4 of decapods, one of foraminifers and 34 of fishes out of which 21 are left to open nomenclature.

Out of 25 species of mega-invertebrates from this locality one ranges from Rupelian - Aquitanian [*Ficus* (*Ficus*) *conditus* (Brongniart)] and another form *Clementia* (*Clementia*) *papyracea* (Gray) from Rupelian - Recent. Eight species namely, *Anadara* (*Anadara*) *daviesi* Mukerjee, *Anadara* (*Anadara*) *trapezoida* Tiwari, *Pecten (Pecten) mathuri* Tiwari, *Mactra* (*Mactra*) *protoreevesii* Noetling, *Tellina* (*Tellinella*) *loknathi* Tiwari, *Glossus* (*Cytherocardia*) *cytheroides* (Mayer), *Callista* (*Callista*) *pseudoumbonella* Vredenburg, and *Ficus* (*Ficus*) *kachhensis* (Vredenburg) are confined to Aquitanian - Burdigalian. *Astarte* (*Bythiamena*) *striata* Tiwari and *Corbula* (*Corbula*) *tunicosulcata* Vredenburg range in age from Aquitanian - Helvetian whereas four forms range from Aquitanian - Lower Pliocene. These are: *Lutraria philippinarum* Reeve, *Dosinia* (*Dosinia*) *peralta* Vredenburg, *Dosinia* (*Dosinia*) *subpenicillata* Vredenburg and *Conus* (*Leptoconus*) *bonneti* Cossmann and three forms from Aquitanian - Recent [*Anadara* (*Anadara*) *craticulata* (Nyst), *Chlamys* (*Argopectecn*) *senatoria* (Gmelin) and *Archimediella* (*Torculoidella*) *angulata* (Sowerby)]. Two forms i. e. *Neptunus sindensis* Stoliczka and *Palaeocarpilius rugifer* Stoliczka are confined to Burdigalian. The four forms that make appearance in Burdigalian are *Anadara* (*Anadara*) *garoensis* Mukerjee, *Corbula* (*Corbula*) *mekranica* Vredenburg, *Calappa protopustulosa* Noetling, *Conus* (*Dendroconus*) *loroisii* Kiener but the first three ranges up to Helvetian and the last one up to the Recent. Thus, eight Aquitanian - Burdigalian forms are confined to this bed and another nine forms appeared for the first time during Aquitanian. Additionally, four forms make their first appearance during Burdigalian and two forms have restricted age range of Burdigalian hence, this bed is assigned to Aquitanian – Burdigalian to Burdigalian.

The age deduced is also supported by the fish assemblage recovered from this bed. The presence of *Galeocerdo aduncus* in the intraformational conglomeratic bands of the study area along with other typical Miocene forms like *Hemipristis serra, Sphyrna*

zygaena, Sphyrna diplana and *Isurus spallanzanii* suggests a Lower Miocene (Aquitanian - Burdigalian) age to these horizons whereas the occurrence of *Carcharodon carcharias* indicates that the bed is not older than the Burdigalian (Sahni and Mehrotra, 1981). *Carcharhinus egertoni* has been reported only from the upper Burdigalian of Portugal and is conspicuously absent in the Helvetian (Sahni and Mehrotra, 1981). Further, the presence of *Ammonia annectens* broadly indicates Miocene age for the bed (Singh and Nayak, 2004).

5.2.3.2 Grey Silty-sandstone bed at Ruata Quarry, Near Ramrikawn, Tuivamit, Aizawl

Out of 28 forms being reported from this bed, 13 are bivalves, 4 are gastropods, one decapod, 9 fishes and one crocodylidae. Five are left to open nomenclature.

Nearly thirty-eight per cent out of 16 invertebrate species from this bed range from Aquitanian to Burdigalian. These are *Anadara* (*Anadara*) *luangmualensis* Tiwari, *Lutraria* (*Lutraria*) *saigengai*, Tiwari, *Tellina* (*Tellinella*) *loknathi* Tiwari, *Apolymetis* (*Apolymetis*) *grimesi* Noetling, *Glossus* (*Cytherocardia*) *cytheroides* (Mayer), *Callista* (*Callista*) *pseudoumbonella* and Vredenburg. Another twenty five per cent appeared for the first time during Aquitanian and range up to Helvetian, Lower Pliocene and Recent. These include *Typilobus granulosus* Stoclizka, *Murex maegillivrayi* Dohrn, *Conus* (*Leptoconus*) *bonneti* Cossmann and *Anadara craticulata* (Nyst) respectively. Another six percent i. e. *Barbatia* (*Barbatia*) *bataviana* Martin var**.** *carinata* Noetling is a typical Burdigalian species from this bed. This bed has also yielded Rupelian – Recent species *Trisidos semitorta* (Lamarck), Burdigalian to Helvetian species like *Corbula* (*Corbula*) *mekranica* Vredenburg) and Burdigalian – Recent species like *Callista* (*Costacallista*) *erycina* (Linne'), *Ficus* (*Ficus*) *ficus* (Linne') and *Conus* (*Dendroconus*) *loroisii* Kiener. It is evident from the above, thus that out of a total of sixteen species from this bed, fifteen have Aquitanian to Burdigalian affinity and one form having restricted age range of Burdigalian. Thus the bed is assigned to Aquitanian – Burdigalian to Burdigalian.

Hemipristis serra, *Isurus spallanzanii*, *Carcharhinus egertoni* and *Galecerdo aduncus* are the species of fishes reported from this bed and indicate Aquitanian to Burdigalian age .

5.2.3.3 Brown silty-sandstone bed at Youth Hostel, Luangmual, Aizawl

A total of eight molluscan species have been identified from this bed. Out of this, seven species of bivalves and one of gastropods have Aquitanian – Burdigalian affinity because two are Aquitanian – Burdigalian forms [*Pecten* (*Pecten*) *mathuri* Tiwari and *Diplodonta (Diplodonta) incerta* d'Archiac], two are Aquitanian – Helvetian form [*Astarte* (*Bythiamena*) *striata* Tiwari and *Corbula tunicosulcata* Vredenburg], three are Aquitanian – Recent form [*Anadara* (*Anadara*) *daviesi* Mukerjee, *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Timoclea* (*Timoclea*) *scabra* (Hanley) and *Archimediella* (*Torculoidella*) *angulata* (Sowerby)]. As such, this bed may be assigned to Aquitanian – Burdigalian.

5.2.3.4 Brown silty-sandstone bed at Faith Academy, Zonuam, Aizawl

Four out of six bivalve species reported from this bed, namely, *Pecten* (*Pecten*) *mathuri* Tiwari, *Gari* (*Gari*) *natensis* Noetling, *Paphia* (*Paphia*) *rotundata* (Linne') and *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg range from Aquitanian – Burdigalian, one taxa namely, *Corbula* (*Corbula*) *tunicosulcata* Vredenburg range from Aquitanian - Helvetian and the remaining bivalve i. e *Chlamys* (*Argopecten*) *senatoria* (Gmelin) and one form of gastropods namely, *Archimediella* (*Torculoidella*) *angulata* (Sowerby) ranges from Aquitanian – Recent. Therefore, this bed has a very strong affinity to Aquitanian – Burdigalian and is assigned to this age accordingly.

5.2.3.5 Brown silty-sandstone bed at Luangmual Govt. Complex, Aizawl

Twelve forms of bivalves and one of decapods has been identified from this bed out of which five range from Aquitanian – Burdigalian. These are: *Tellina* (*Moerella*) *indifferens* Noetling, *Tellina* (*Tellinella*) *loknathi* Tiwari, *Paphia* (*Paphia*) *rotundata* (Linne'), *Paphia* (*Paphia*) *jhai* Tiwari and *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg. Only one form i. e. *Neptunus sindensis* Stoliczka is Burdigalian. Three species *viz.*, *Astarte* (*Bathiamena*) *striata* Tiwari, *Dosinia* (*Dosinia*) *peralta* Vredenburg and *Timoclea* (*Timoclea*) *scabra* (Hanley) though appear during Aquitanian time but continue up to Helvetian, Lower Pliocene and Recent respectively. Again, three species namely, *Gari* (*Psammobia*) *kingi* (Noetling), *Tellina* (*Eurytellina*) cf. *pilgrimi* Cox and *Clementia* (*Clementia*) *papyracea* (Gray), though appear during Rupelian time but

continue up to Burdigalian, Helvetian and Recent respectively. Therefore, this bed may also be assigned to Aquitanian – Burdigalian to Burdigalian.

5.2.3.6 Brown silty-sandstone bed at Govt. Complex Road, Zonuam, Aizawl

Eight forms from this bed have been considered to range from Aquitanian – Burdigalian. These include *Portlandia* (*Portlandia*) *ovatoelongata* Mazumder, *Diplodonta (Diplodonta) incerta* d'Archiac, *Cultellus* (*Cultellus*) *zulloi* Tiwari, *Tellina* (*Moerella*) *indifferens* Noetling, *Tellina* (*Tellinella*) *loknathi* Tiwari, *Apolymetis* (*Apolymetis*) *grimesi* Noetling, *Paphia* (*Paphia*) *rotundata* (Linne') and *Ebalia tuberculata* Noetling. Lone form i. e. *Palaeocarpilius rugifer* Stoliczka from this bed has restricted age of Burdigalian. Another five forms, namely, *Nucula* (*Nucula*) *agrawali* Tiwari, *Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari and Kachhara, *Anadara craticulata* (Nyst), *Anadara* (*Anadara*) *daviesi* Mukerjee, and *Pinna* (*Pinna*) cf. *rudis* Linné have been considered to have appeared during Aquitanian but the first two range up to Helvetian and the last three up to Recent. Another form [*Diplodonta* (*Diplodonta*) *rotundatus* (Montagu)] ranges from Burdigalian – Recent. The remaining one [*Diplodonta* (*Diplodonta*) *rotundatus* (Montagu)] is considered to range from Burdigalian to Recent. Thus, the mega-invertebrate fauna from this bed show very strong affinity to Aquitanian – Burdigalian to Burdigalian and have been assigned to the same age.

Table- 5.1: Check list, geographic distribution and age range of mega-invertebrate species from the study area, Mizoram

Name of species	Mizoram (Tiwari 1992, 2001, 2006; Tiwari and Kachhara, 2003; Mazumder 2004 and Lalchawimawii 2004)	Garo Hills (Mukerjee 1939 and Lyngdoh, 2004)	Gaj Beds (Vredenburg, 1925, 1928 and Jain, 1997)			Myanmar (Noetling, 1895, 1901)		Quilon Bed (Dey, 1960)	Persian Bed (Cox, 1936)	Oligocene				Miocene				Pliocene			Recent
			Kachchh	Kathiawar	Sind	Kama Formation	Pyalo Formation			Sannoisian	Rupelian	Chattian	Stampian	Aquitanian	Burdigalian	Helvetian	Tortonian	Plaisancian	Astian	Sicilian	
Nucula (*Nucula*) *agrawali* Tiwari	√													—	—	—					
Portlandia (*Portlandia*) *ovatoelongata* Mazumder	√													—	—						
Barbatia (*Barbatia*) *bataviana* Martin var. *carinata* Noetling	√	√					√								—						
Barbatia sp.																					
Trisidos semitorta (Lamarck)	√	√	√	√	√						—	—	—	—	—	—	—	—	—	—	—
Anadara (*Anadara*) *craticulata* (Nyst)	√	√	√			√	√	√						—	—	—	—	—	—	—	—
Anadara (*Anadara*) *daviesi* Mukerjee	√	√												—	—						
Anadara (*Anadara*) *garoensis* Mukerjee	√	√													—	—					

Contd…

Name of species	Mizoram (Tiwari 1992, 2001, 2006; Tiwari and Kachhara, 2003; Mazumder 2004 and Lalchawimawii 2004)	Garo Hills (Mukerjee 1939 and Lyngdoh, 2004)	Gaj Beds (Vredenburg, 1925, 1928 and Jain, 1997)			Myanmar (Noetling, 1895, 1901)		Quilon Bed (Dey, 1960)	Persian Bed (Cox, 1936)	Oligocene				Miocene				Pliocene			Recent
			Kachchh	Kathiawar	Sind	Kama Formation	Pyalo Formation			Sannoisian	Rupelian	Chattian	Stampian	Aquitanian	Burdigalian	Helvetian	Tortonian	Plaisancian	Astian	Sicilian	
Anadara (*Anadara*) *luangmualensis* Tiwari	√													—	—						
Anadara (*Anadara*) *trapezoida* Tiwari	√													—	—						
Arcopsis sp.																					
Pinna (*Pinna*) cf. *rudis* Linné	√													—	—	—	—	—	—	—	—
Chlamys (*Argopecten*) *senatoria* (Gmelin)	√	√	√	√	√	√	√		√					—	—	—	—	—	—	—	—
Pecten (*Pecten*) *mathuri* Tiwari	√													—	—						
Diplodonta(*Diplodonta*) *incerta* d'Archiac	√	√	√	√	√									—	—						
Diplodonta (*Diplodonta*) *rotundatus* (Montagu)	√	√													—	—	—	—	—	—	—
Cyclocardia sp.																					
Astarte (*Bythiamena*) *striata* Tiwari	√													—	—	—					

Name of species	Mizoram (Tiwari 1992, 2001, 2006; Tiwari and Kachhara, 2003; Mazumder 2004 and Lalchawimawii 2004)	Garo Hills (Mukerjee 1939 and Lyngdoh, 2004)	Gaj Beds (Vredenburg, 1925, 1928 and Jain, 1997)			Myanmar (Noetling, 1895, 1901)		Quilon Bed (Dey, 1960)	Persian Bed (Cox, 1936)	Oligocene				Miocene				Pliocene			Recent
			Kachchh	Kathiawar	Sind	Kama Formation	Pyalo Formation			Sannoisian	Rupelian	Chattian	Stampian	Aquitanian	Burdigalian	Helvetian	Tortonian	Plaisancian	Astian	Sicilian	
Mactra (*Mactra*) *protoreevesii* Noetling	√	√												—	—						
Clinocardium sp.																					
Lutraria philippinarum Reeve	√			√					√					—	—	—	—	—			
Lutratria (*Lutraria*) *saingengai* Tiwari	√	√												—	—						
Cultellus (*Cultellus*) *zulloi* Tiwari	√													—	—						
Cultellus sp.																					
Tellina (*Angulus*) sp.																					
Tellina (*Eurytellina*) cf. *pilgrimi* Cox	√								√		—	—	—	—	—	—					
Tellina (*Moerella*) *indifferens* Noetling	√	√				√	√							—	—						
Tellina (*Tellinella*) *loknathi* Tiwari	√													—	—						

Name of species	Mizoram (Tiwari 1992, 2001, 2006; Tiwari and Kachhara, 2003; Mazumder 2004 and Lalchawimawii 2004)	Garo Hills (Mukerjee 1939 and Lyngdoh, 2004)	Gaj Beds (Vredenburg, 1925, 1928 and Jain, 1997)			Myanmar (Noetling, 1895, 1901)		Quilon Bed (Dey, 1960)	Persian Bed (Cox, 1936)	Oligocene				Miocene				Pliocene			Recent
			Kachchh	Kathiawar	Sind	Kama Formation	Pyalo Formation			Sannoisian	Rupelian	Chattian	Stampian	Aquitanian	Burdigalian	Helvetian	Tortonian	Plaisancian	Astian	Sicilian	
Apolymetis (*Apolymetis*) *aizawlensis* Tiwari	√													—	—	—					
Apolymetis (*Apolymetis*) *grimesi* Noetling	√	√		√										—	—						
Gari (*Psammobia*) *kingi* (Noetling)		√									—	—	—	—	—						
Gari (*Gari*) *natensis* Noetling	√	√												—	—						
Glossus (*Cytherocardia*) *cytheroides* (Mayer)	√													—	—						
Callista (*Callista*) *pseudoumbonella* Vredenburg	√													—	—						
Callista (*Costacallista*) *erycina* (Linne')	√	√				√									—	—	—	—	—	—	—
Dosinia (*Dosinia*) *peralta* Vredenburg	√	√	√											—	—	—	—	—			

Name of species	Mizoram (Tiwari 1992, 2001, 2006; Tiwari and Kachhara, 2003; Mazumder 2004 and Lalchawimawii 2004)	Garo Hills (Mukerjee 1939 and Lyngdoh, 2004)	Gaj Beds (Vredenburg, 1925, 1928 and Jain, 1997)			Myanmar (Noetling, 1895, 1901)		Quilon Bed (Dey, 1960)	Persian Bed (Cox, 1936)	Oligocene				Miocene				Pliocene			Recent
			Kachchh	Kathiawar	Sind	Kama Formation	Pyalo Formation			Sannoisian	Rupelian	Chattian	Stampian	Aquitanian	Burdigalian	Helvetian	Tortonian	Plaisancian	Astian	Sicilian	
Dosinia (*Dosinia*) *subpenicillata* Vredenburg	√	√	√	√										—	—	—	—	—			
Clementia (*Clementia*) *papyracea* (Gray)	√	√	√	√	√	√	√		√		—	—	—	—	—	—	—	—	—	—	—
Paphia (*Paphia*) *rotundata* (Linne')	√													—	—						
Paphia (*Callistotapes*) *pseudoliratus* Vredenburg	√	√	√											—	—						
Paphia (*Paphia*) *jhai* Tiwari	√													—	—						
Timoclea (*Timoclea*) *scabra* (Hanley)	√													—	—	—	—	—	—	—	—
Corbula (*Corbula*) *mekranica* Vredenburg															—	—					
Corbula (*Corbula*) *tunicosulcata* Vredenburg	√	√	√	√										—	—	—					

Name of species	Mizoram (Tiwari 1992, 2001, 2006; Tiwari and Kachhara, 2003; Mazumder 2004 and Lalchawimawii 2004)	Garo Hills (Mukerjee 1939 and Lyngdoh, 2004)	Gaj Beds (Vredenburg, 1925, 1928 and Jain, 1997)			Myanmar (Noetling, 1895, 1901)		Quilon Bed (Dey, 1960)	Persian Bed (Cox, 1936)	Oligocene				Miocene				Pliocene			Recent
			Kachchh	Kathiawar	Sind	Kama Formation	Pyalo Formation			Sannoisian	Rupelian	Chattian	Stampian	Aquitanian	Burdigalian	Helvetian	Tortonian	Plaisancian	Astian	Sicilian	
Archimediella (*Torculoidella*) *angulata* (Sowerby)	√	√	√	√	√	√	√		√					—	—	—	—	—	—	—	—
Cypraea sp.																					
Ficus (*Ficus*) *conditus* (Brongniart)	√	√				√					—	—	—	—							
Ficus (*Ficus*) *ficus* (Linne')	√	√				√									—	—	—	—	—	—	—
Ficus (*Ficus*) *kachhensis* (Vredenburg)	√	√	√	√										—	—						
Murex maegillivrayi Dohrn	√							√						—	—	—	—	—	—	—	—
Conus (*Leptoconus*) *bonneti* Cossmann	√	√				√								—	—	—	—	—			
Conus (*Dendroconus*) *loroisii* Kiener	√	√	√						√						—	—	—	—	—	—	—
Calappa protopustulosa Noetling	√						√								—	—	—				

Name of species	Mizoram (Tiwari 1992, 2001, 2006; Tiwari and Kachhara, 2003; Mazumder 2004 and Lalchawimawii 2004)	Garo Hills (Mukerjee 1939 and Lyngdoh, 2004)	Gaj Beds (Vredenburg, 1925, 1928 and Jain, 1997)			Myanmar (Noetling, 1895, 1901)		Quilon Bed (Dey, 1960)	Persian Bed (Cox, 1936)	Oligocene				Miocene				Pliocene			Recent
			Kachchh	Kathiawar	Sind	Kama Formation	Pyalo Formation			Sannoisian	Rupelian	Chattian	Stampian	Aquitanian	Burdigalian	Helvetian	Tortonian	Plaisancian	Astian	Sicilian	
Typilobus granulosus Stocliczka	√		√		√									—	—	—					
Ebalia tuberculata Noetling	√						√							—	—						
Neptunus sindensis Stoliczka					√										—						
Palaeocarpilius rugifer Stoliczka			√		√										—						
Xantho sp.																					

Table 5.2: Locality-wise occurrence of invertebrate and vertebrate taxa in the study area along with their age range

Name of species	**Locality 1** (Bika Quarry, Tuivamit)	**Locality 2** (Ruata Quarry, Tuivamit)	**Locality 3** (Youth Hostel, Luangmual)	**Locality 4** (Faith Academy, Zonuam)	**Locality 5** (Luangmual Govt. Complex**)**	**Locality 6** (Govt. Complex Road, Zonuam)	**Age Range**
Bivalves:							
1. *Nucula* (*Nucula*) *agrawali* Tiwari						√	Aquitanian - Helvetian
2. *Portlandia* (*Portlandia*) *ovatoelongata* Mazumder						√	Aquitanian - Burdigalian
3. *Barbatia* (*Barbatia*)*bataviana* Martin var. *carinata* Noetling		√					Burdigalian
4. *Barbatia* sp.	√						
5. *Trisidos semitorta* (Lamarck)		√					Rupelian - Recent
6. *Anadara* (*Anadara*) *craticulata* (Nyst)	√	√				√	Aquitanian - Recent
7. *Anadara (Anadara) daviesi* Mukerjee	√	√	√			√	Aquitanian - Recent
8. *Anadara* (*Anadara*) *garoensis* Mukerjee	√						Burdigalian - Helvetian
9. *Anadara* (*Anadara*) *luangmualensis* Tiwari		√					Aquitanian - Burdigalian
10. *Anadara* (*Anadara*) *trapezoida* Tiwari	√						Aquitanian - Burdigalian
11. *Arcopsis* sp.		√					
12. *Pinna* (*Pinna*) cf. *rudis* Linné						√	Aquitanian - Recent
13. *Chlamys* (*Argopecten*) *senatoria* (Gmelin)	√		√	√			Aquitanian - Recent
14. *Pecten* (*Pecten*) *mathuri* Tiwari	√		√	√			Aquitanian - Burdigalian

Contd….

Name of species	Locality 1 (Bika Quarry, Tuivamit)	Locality 2 (Ruata Quarry, Tuivamit)	Locality 3 (Youth Hostel, Luangmual)	Locality 4 (Faith Academy, Zonuam)	Locality 5 (Luangmual Govt. Complex)	Locality 6 (Govt. Complex Road, Zonuam)	Age Range
15. *Diplodonta*(*Diplodonta*) *incerta* d'Archiac			√			√	Aquitanian - Burdigalian
16. *Diplodonta* (*Diplodonta*) *rotundatus* (Montagu)						√	Burdigalian - Recent
17. *Cyclocardia* sp.	√						
18. *Astarte* (*Bythiamena*) *striata* Tiwari	√		√		√		Aquitanian - Helvetian
19. *Mactra* (*Mactra*) *protoreevesii* Noetling	√						Aquitanian - Burdigalian
20. *Clinocardium* sp.							
21. *Lutraria philippinarum* Reeve	√						Aquitanian – Lower Pliocene
22. *Lutratria* (*Lutraria*) *saingengai Tiwari*		√					Aquitanian - Burdigalian
23. *Cultellus* (*Cultellus*) *zulloi* Tiwari						√	Aquitanian - Burdigalian
24. *Cultellus* sp.		√					
25. *Tellina* (*Angulus*) sp.					√	√	
26. *Tellina* (*Eurytellina*) cf. *pilgrimi* Cox					√	√	Rupelian – Helvetian
27. *Tellina* (*Moerella*) *indifferens* Noetling					√	√	Aquitanian - Burdigalian
28. *Tellina* (*Tellinella*) *loknathi* Tiwari	√	√			√	√	Aquitanian - Burdigalian
29. *Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari						√	Aquitanian - Helvetian
30. *Apolymetis* (*Apolymetis*) *grimesi* Noetling		√				√	Aquitanian - Burdigalian

Contd….

Name of species	Locality 1 (Bika Quarry, Tuivamit)	Locality 2 (Ruata Quarry, Tuivamit)	Locality 3 (Youth Hostel, Luangmual)	Locality 4 (Faith Academy, Zonuam)	Locality 5 (Luangmual Govt. Complex)	Locality 6 (Govt. Complex Road, Zonuam)	Age Range
31. *Gari* (*Psammobia*) *kingi* (Noetling)					√		Rupelian - Burdigalian
32. *Gari* (*Gari*) *natensis* Noetling				√			Aquitanian - Burdigalian
33. *Glossus* (*Cytherocardia*) *cytheroides* (Mayer)	√	√					Aquitanian - Burdigalian
34. *Callista* (*Callista*) *pseudoumbonella* Vredenburg	√	√					Aquitanian – Burdigalian
35. *Callista* (*Costacallista*) *erycina* (Linne')		√					Burdigalian - Recent
36. *Dosinia* (*Dosinia*) *peralta* Vredenburg	√				√		Aquitanian- Lower Pliocene
37. *Dosinia* (*Dosinia*) *subpenicillata* Vredenburg	√						Aquitanian-Lower Pliocene
38. *Clementia* (*Clementia*) *papyracea* (Gray)	√				√		Rupelian - Recent
39. *Paphia* (*Paphia*) *rotundata* (Linne')				√	√	√	Aquitanian - Burdigalian
40. *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg				√	√		Aquitanian - Burdigalian
41. *Paphia* (*Paphia*) *jhai* Tiwari					√		Aquitanian - Burdigalian
42. *Timoclea* (*Timoclea*) *scabra* (Hanley)			√		√		Aquitanian – Recent
43. *Corbula* (*Corbula*) *mekranica* Vredenburg	√	√					Burdigalian - Helvetian
44. *Corbula* (*Corbula*) *tunicosulcata* Vredenburg	√		√	√			Aquitanian - Helvetian
B. Gastropods							
45. *Archimediella* (*Torculoidella*) *angulata* (Sowerby)	√		√	√			Aquitanian - Recent

Contd…

Name of species	Locality 1 (Bika Quarry, Tuivamit)	Locality 2 (Ruata Quarry, Tuivamit)	Locality 3 (Youth Hostel, Luangmual)	Locality 4 (Faith Academy, Zonuam)	Locality 5 (Luangmual Govt. Complex)	Locality 6 (Govt. Complex Road, Zonuam)	Age Range
46. *Cypraea* sp.	√						
47. *Ficus* (*Ficus*) *conditus* (Brongniart)	√						Rupelian - Aquitanian
48. *Ficus* (*Ficus*) *ficus* (Linne')		√					Burdigalian - Recent
49. *Ficus* (*Ficus*) *kachhensis* (Vredenburg)	√						Aquitanian - Burdigalian
50. *Murex maegillivrayi* Dohrn		√					Aquitanian - Recent
51. *Conus* (*Leptoconus*) *bonneti* Cossmann	√	√					Aquitanian - Lower Pliocene
52. *Conus* (*Dendroconus*) *loroisii* Kiener	√	√					Burdigalian - Recent
C. Decapods:							
53. *Calappa protopustulosa* Noetling	√						Burdigalian - Helvetian
54. *Typilobus granulosus* Stocliczka		√					Aquitanian - Helvetian
55. *Ebalia tuberculata* Noetling						√	Aquitanian - Helvetian
56. *Neptunus sindensis* Stoliczka	√				√		Burdigalian
57. *Palaeocarpilius rugifer* Stoliczka	√					√	Burdigalian
58. *Xantho* sp.	√						
D. Foraminifer							
59. *Ammonia annectens concinna* Millet	√						Miocene - Recent
60. *Ammonia* sp.	√						
E. Fishes							
61. *Lamna* sp.	√						

Contd…

Name of species	Locality 1 (Bika Quarry, Tuivamit)	Locality 2 (Ruata Quarry, Tuivamit)	Locality 3 (Youth Hostel, Luangmual)	Locality 4 (Faith Academy, Zonuam)	Locality 5 (Luangmual Govt. Complex)	Locality 6 (Govt. Complex Road, Zonuam)	Age Range
62. *Carcharodon carcharias* Linnaeus	√						Eocene- Recent
63. *Carcharodon angustidens* Agassiz.	√	√					
64. *Carcharodon* sp.		√					
65. *Isurus spallanzanii* Bonnaparte	√	√					Eocene - Recent
66. *Isurus pagoda* Bonnaparte.	√						
67. *Alopias* sp.	√						
68. *Odontapis* cf. *taurus.*	√						
69. *Odontaspis* cf. *tricuspidatus*	√						
70. *Odontapis* sp.	√						
71. *Carcharhinus egertoni* Agassiz:	√	√					Eocene - Recent
72. *Carcharhinus priscus* Agassiz.	√						
73. *Carcharhinus* cf. *macloti*	√						
74. *Carcharhinus bhubanicus* n. sp.							
75. *Carcharhinus* (*Prionodon*)sp.	√						
76. *Carcharhinus* sp. A	√						
77. *Carcharhinus* sp. B	√						
78. *Carcharhinus* sp. C	√						
79. *Carcharhinus* sp. D	√						
80. *Galeocerdo aduncus* Agassiz	√	√					Eocene - Recent

Contd…

Name of species	Locality 1 (Bika Quarry, Tuivamit)	Locality 2 (Ruata Quarry, Tuivamit)	Locality 3 (Youth Hostel, Luangmual)	Locality 4 (Faith Academy, Zonuam)	Locality 5 (Luangmual Govt. Complex)	Locality 6 (Govt. Complex Road, Zonuam)	Age Range
81. *Negaprion brevirostris* Poey.	√						
82. *Negaprion* cf. *eurybathrodon* Blake	√						
83. *Scoliodon sorrakawah* Cuvier	√						
84. *Hemipristis serra* Agassiz:	√	√					Eocene - Recent
85. *Hemipristis unidenticulata* n. sp.	√						Eocene - Recent
86. *Sphyrna zygaena* Linneaus	√						Miocene to recent
87. S*phyrna diplana* Springer.	√						Miocene to recent
88. *Galeorhinus* sp.	√						
89. *Squalus* sp.	√						
90. *Myliobatis* sp	√	√					
91. *Aetobatus* sp.	√						
92. *Diodon* sp.1	√						
93. *Diodon* sp.2	√						
94. *Diodon* sp.3	√						
95. *Diodon* sp.4	√	√					
96. Carcharhinidae gen. et sp. indet.		√					
97. Indeterminate vertebral centra of selachians	√						
F. Crocodylidae							
Indeterminate tooth of Crocodylidae	√	√					

CHAPTER -6

BIOSTRATIGRAPHY AND CORRELATION

6. BIOSTRATIGRAPHY AND CORRELATION

6.1 BIOSTRATIGRAPHY

6.1.1 INTRODUCTION

Lyell (1830-33) was the first to introduce the concept of molluscan biostratigraphy. He, for the first time divided, the Cenozoic Era into Eocene, Miocene, Pliocene and Recent on the basis of the ratio of extinct versus living molluscan species. Oligocene epoch in the Tertiary period was introduced much later by Beyrich (1854) based on the same criterion. Nicol (1953) studied in detail the life span of several bivalve species and proposed that the average life span of a bivalve species is 6.5 million years and a short-lived species have duration of 1 to 2 million year(s). The species in question may either become extinct or change over to a distinct form after completing this life span. There are several examples where mollusks have been successfully used for local biostratigraphic zonations as well as regional correlations. This clearly demonstrates the potential of molluscan species as an alternative for biostratigraphic classification of those sedimentary successions that lack in age-diagnostic microfossils. The mega invertebrates have been used with a fair success by earlier workers (Tiwari, 1992, 2001; Mazumder, 2004; Lalchawimawii, 2004) in biostratigraphic classification and stratigraphic correlation of Tertiary succession of Mizoram. Furthermore, Surma sequence of Mizoram are surprisingly devoid of planktic foraminifers and nanno-planktons, at least in the exposed sections, which have been used world over for biozonations and correlations of the Palaeogene and Neogene successions (Tiwari and Kachhara, 2003; Mathur, 1988). It is in this background that the biostratigraphy and correlation of the Bhuban Formation of the study area is being attempted. Other fossil group available in the area has also been considered while proposing bio-zones and attempting correlation.

6.1.2 BIOSTRATIGRAPHIC ZONATION

Only one biozone is being proposed in the Bhuban Formation of the study area (Table 6.1). *Paphia* (*Paphia*) *rotundata* (Linne') and *Palaeocarpilius rugifer* Stoliczka are the frequently occurring species with restricted age range of Aquitanian to Burdigalian and Burdigalian respectively in the study area. The former is found in three

localities and the later in two localities. Therefore, this zone has been named as *Paphia* (*Paphia*) *rotundata* - *Palaeocarpilius rugifer Zone* of Aquitanian – Burdigalian to Burdigalian age. Additionally, two Subzones are being proposed within Zone - 1. These are: *Gari* (*Gari*) *natensis* Subzone (Subzone - 1A) and *Barbatia* (*Barbatia*) *bataviana* var. *carinata* - *Neptunus sindensis* Subzone (Subzone - 1B). The distribution of the taxa in the two Subzones is given in table 6.2.

Table 6.1: Biostratigraphic Zonations in the study area

Epoch	Age	Formation	Faunal Zone	
L O W E R M I O C E N E	Aquitanian - Burdigalian to Burdigalian	Upper Bhuban Unit, Bhuban Formation	**Zone – 1.** *Paphia* (*Paphia*) *rotundata* - *Palaeocarpilius rugifer* Zone	**Subzone - 1B** *Barbatia* (*Barbatia*) *bataviana* var. *carinata* - *Neptunus sindensis* Subzone
	Aquitanian - Burdigalian	Upper Bhuban Unit, Bhuban Formation		**Subzone - 1A** *Gari* (*Gari*) *natensis* Subzone

ZONE-1. *Paphia* (*Paphia*) *rotundata* - *Palaeocarpilius rugifer* Zone

This zone is proposed within the Upper Bhuban unit of Bhuban Formation. Though, the zonal taxa are encountered only at three and two fossil localities respectively out of the total of six, the zone is extended in the remaining localities also in view of the fact that these localities contain several biota of Aquitanian to Burdigalian age. *Paphia* (*Paphia*) *rotundata* (Linne') and *Palaeocarpilius rugifer* Stoliczka of Aquitanian - Burdigalian and Burdigalian ages respectively are confined to this zone, hence the name of the zone. Further, *Gari* (*Gari*) *natensis* Noetling having restricted range of Aquitanian - Burdigalian is confined to Locality 4. Thus this locality along with the Locality 3 is assigned to Subzone - 1A and is named accordingly. *Barbatia* (*Barbatia*) *bataviana* Martin var. *carinata* Noetling and *Neptunus sindensis* Stoliczka of Burdigalian age are confined to the other localities. Hence, these localities are assigned to Subzone 1B with the same nomenclature and age.

Subzone - 1A: *Gari* (*Gari*) *natensis* Subzone

Gari (*Gari*) *natensis* (Noetling) of Aquitanian – Burdigalian age is confined to this Subzone, hence the name. This Subzone is exposed at Locality 3 (near Youth Hostel, Luangmual) and Locality 4 (near Faith Academy, Zonuam). At Locality 3, it is represented by 27m thick brown coloured silty-sandstone bed yielding bivalves, gastropods and unidentifiable irregular echinoids whereas at Locality 4 it consists of nearly 20m brown coloured silty - sandstone containing fossil assemblage of bivalves, gastropods and unidentifiable irregular echinoids.

The other fossil species having restricted age range of Aquitanian - Burdigalian found in this Subzone are *Anadara* (*Anadara*) *daviesi* Mukerjee, *Pecten* (*Pecten*) *mathuri* Tiwari, *Diplodonta* **(***Diplodonta***)** *incerta* d'Archiac, *Paphia* (*Paphia*) *rotundata* (Linne') and *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg.

The following species, though, long-ranging elsewhere are also found in this Subzone: *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Astarte* (*Bythiamena*) *striata* Tiwari, *Timoclea* (*Timoclea*) *scabra* (Hanley), *Corbula* (*Corbula*) *tunicosulcata* Vredenburg and *Archimediella* (*Torculoidella*) *angulata* (Sowerby).

This Subzone is devoid of decapods and fish fauna thus the age assigned to it is solely based on the molluscan assemblage.

Subzone - 1B: *Barbatia* (*Barbatia*) *bataviana* var. *carinata* – *Neptunus sindensis* Subzone

Barbatia (*Barbatia*) *bataviana* Martin var. *carinata* Noetling and *Neptunus sindensis* Stolickza of Burdigalian age are restricted to this Subzone. Besides, thirteen taxa of Aquitanian - Burdigalian age are also confined to this Subzone. Thus this Subzone is assigned to Aquitanian - Burdigalian to Burdigalian age. This Subzone is confined to the four localities in the area west of Aizawl City i.e Bika Quarry, University Road, Tuivamit, Aizawl (Locality 1); Ruata Quarry, Near Ramrikawn, Tuivamit, Aizawl (Locality 2); Luangmual Govt. Complex, Zonuam, Aizawl (Locality 5) and Govt. Complex Road, Zonuam, Aizawl (Locality 6). At Locality 1 it consists of 8.5m thick grey coloured silty-sandstone. This bed contains intra-formational conglomeratic bands at 0.95

to 1.30m and 8.50 to 8.65m levels respectively. Bulk of the fauna from this bed comes from the lower intra-formational conglomeratic band and the assemblage consists of bivalves, gastropods, decapods, foraminifers and fish teeth. Though, a 3m thick fossiliferous brown silty-sandstone bed overlies the above sequence, it has only yielded *Mactra* (*Mactra*) *protoreevesii* Noetling and several unidentifiable regular and irregular echinoids. As such the age of this bed and its relationship with the Subzone could not be ascertained. Locality 2 seems to be the strike continuation of the locality 1. Here again, grey coloured silty-sandstone (lower bed) and brown silty-sandstone (upper bed) occur but, the thickness of the lower bed is 9.00m and the exposed thickness of the upper bed is 0.71m. The lower bed also contains two intra-formational conglomeratic bands, the lower one at 0 – 0.33m and the upper one at 4.5 – 4.9m stratigraphic levels. The bulk of the fauna from this locality has been collected from the lower bed mainly from the upper conglomeratic band and the faunal assemblage consists of bivalves, gastropods, decapods and fish teeth. No identifiable biota could be collected from the upper bed as such its age and relationship with the Subzone in question could not be constrained. This Subzone at Locality 5 consists of nearly 11.0m thick silty-sandstone bed yielding bivalves only. Fossiliferous bed here is topped by a 0.4m thick deep brown coloured highly weathered conglomeratic band that is reported to have yielded decapods, bivalves and gastropods (Tiwari *et al.*, 1997). At Locality 6, fourteen meter thick brown silty-sandstone constitutes this Subzone. Bivalves, decapods and unidentifiable irregular echinoids have been collected from this locality.

Palaeocarpilius rugifer Stoliczka and *Carcharodon carcharias* Linneaus are the other taxa of Burdigalian age confined to this Subzone. Besides Burdigalian taxa, species having restricted age range of Aquitanian - Burdigalian in this Subzone are: *Anadara* (*Anadara*) *luangmualensis* Tiwari, *Anadara* (*Anadara*) *trapezoida* Tiwari, *Cultellus* (*Cultellus*) *zulloi* Tiwari, *Mactra* (*Mactra*) *protoreevesii* Noetling, *Lutraria saigengai* Tiwari, *Tellina* (*Tellinella*) *loknathi* Tiwari, *Tellina* (*Moerella*) *indifferens* Noetling, *Apolymetis* (*Apolymetis*) *grimesi* Noetling, *Glossus* (*Cytherocardia*) *cytheroides* (Mayer), *Callista* (*Callista*) *pseudoumbonella* Vredenburg, *Paphia* (*Paphia*) *jhai* Tiwari, *Ficus* (*Ficus*) *kachhensis* (Vredenburg) and *Ebalia tuberculata* Noetling. Additionally, the following forms, though long ranging elsewhere, are confined to this Subzone: *Nucula* (*Nucula*) *agrawali* Tiwari, *Trisidos semitorta* (Lamarck), *Anadara* (*Anadara*) *craticulata*

(Nyst), *Anadara* (*Anadara*) *garoensis* Mukerjee, *Pinna* (*Pinna*) cf. *rudis* Linné, *Diplodonta* (*Diplodonta*) *rotundatus* (Montagu), *Lutraria philippinarum* Reeve, *Tellina* (*Eurytellina*) cf. *pilgrimi* Cox, *Dosinia* (*Dosinia*) *subpenicillata* Vredenburg, *Clementia* (*Clementia*) *papyracea* (Gray), *Corbula* (*Corbula*) *mekranica* Vredenburg, *Ficus* (*Ficus*) *conditus* (Brongniart), *Ficus* (*Ficus*) *ficus* (Brongniart), *Murex maegillivrayi* Dohrn, *Conus* (*Leptoconus*) *bonneti* Cossmann, *Conus* (*Dendroconus*) *loroisii* Kiener, *Calappa protopustulosa* Noetling and *Typilobus granulosus* Stoclizka.

The taxa ranging from Subzone - 1A to Subzone - 1B are: *Anadara daviesi* Mukerjee, *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Pecten (Pecten) mathuri* Tiwari, *Diplodonta (Diplodonta) incerta* d'Archiac, *Astarte* (*Bythiamena*) *striata* Tiwari**,** *Paphia* (*Paphia*) *rotundata* (Linne'), *Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg, *Timoclea* (*Timoclea*) *scabra* (Hanley), *Corbula* (*Corbula*) *tunicosulcata* Vredenburg and *Archimediella* (*Torculoidella*) *angulata* (Sowerby).

Though a large number of fish fauna are known to occur within this Subzone, most of these are long-ranging and thus are not useful in constraining the age of the Subzone. However, bulk of the fish assemblage from this Subzone is also known to occur in the other localities of Miocene epoch viz., Myanmar (Noetling, 1901; Stuart, 1910), Baripada bed, Orissa (Sahni and Mehrotra, 1981; Bhalla, 1985), Kachhch (Sahni and Mehrotra 1981; Mehrotra, Mishra and Srivastava, 1973), Piram Island (Sahni and Mehrotra1981; Mehrotra, Mishra and Srivastava, 1973) and Gogha Coast (Sahni and Mehrotra, 1981; Mehrotra, Mishra and Srivastava, 1973). Besides, the presence of *Galeocerdo aduncus* Agassiz along with other typical Miocene forms like *Hemipristis serra* Agassiz, *Sphyrna zygaena* Linneaus and *Isurus spallanzanii* Bonnaparte etc. suggests a Lower Miocene (Aquitanian-Burdigalian) age for this Subzone.

Table - 6.2: Zonal distribution of fossils in the study area

Sl. no.	SPECIES / FREQUENCY / ZONE	A = Abundant F = Frequent R = Rare	
		ZONE - 1	
		SUBZONE- 1A	SUBZONE -1B
	Bivalves		
1	*Nucula* (*Nucula*) *agrawali* Tiwari		R
2	*Portlandia* (*Portlandia*) *ovatoelongata* Mazumder		R
3	*Barbatia* (*Barbatia*) *bataviana* Martin var. *carinata* Noetling		R
4	*Barbatia* sp.		R
5	*Trisidos semitorta* (Lamarck)		R
6	*Anadara* (*Anadara*) *craticulata* (Nyst)		F
7	*Anadara* (*Anadara*) *daviesi* Mukerjee	R	F
8	*Anadara* (*Anadara*) *garoensis* Mukerjee		R
9	*Anadara* (*Anadara*) *luangmualensis* Tiwari		R
10	*Anadara* (*Anadara*) *trapezoida* Tiwari		R
11	*Arcopsis* sp.		R
12	*Pinna* (*Pinna*) cf. *rudis* Linné		R
13	*Chlamys* (*Argopecten*) *senatoria* (Gmelin)	F	F
14	*Pecten* (*Pecten*) *mathuri* Tiwari	F	F
15	*Diplodonta*(*Diplodonta*) *incerta* d'Archiac	R	F
16	*Diplodonta* (*Diplodonta*) *rotundatus* (Montagu)		R
17	*Cyclocardia* sp.		A
18	*Astarte* (*Bythiamena*) *striata* Tiwari	R	R
19	*Mactra* (*Mactra*) *protoreevesii* Noetling		R
20	*Clinocardium* sp.		F
21	*Lutraria philippinarum* Reeve		F
22	*Lutratria* (*Lutraria*) *saingengai* Tiwari		R
23	*Cultellus* (*Cultellus*) *zulloi* Tiwari		R
24	*Cultellus* sp.		R
25	*Tellina* (*Angulus*) sp.		A
26	*Tellina* (*Eurytellina*) cf. *pilgrimi* Cox		F
27	*Tellina* (*Moerella*) *indifferens* Noetling		F
28	*Tellina* (*Tellinella*) *loknathi* Tiwari		F
29	*Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari		F
30	*Apolymetis* (*Apolymetis*) *grimesi* Noetling		F
31	*Gari* (*Psammobia*) *kingi* (Noetling)		R
32	*Gari* (*Gari*) *natensis* Noetling	R	
33	*Glossus* (*Cytherocardia*) *cytheroides* (Mayer)		F

Contd…

Sl. no.	SPECIES / FREQUENCY / ZONES	A = Abundant F = Frequent R = Rare	
		ZONE - 1	
		SUBZONE - 1A	SUBZONE- 1B
34	*Callista* (*Callista*) *pseudoumbonella* Vredenburg		F
35	*Callista* (*Costacallista*) *erycina* (Linne')		R
36	*Dosinia* (*Dosinia*) *peralta* Vredenburg		F
37	*Dosinia* (*Dosinia*) *subpenicillata* Vredenburg		F
38	*Clementia* (*Clementia*) *papyracea* (Gray)		F
39	*Paphia* (*Paphia*) *rotundata* (Linne')	R	A
40	*Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg	R	R
41	*Paphia* (*Paphia*) *jhai* Tiwari		R
42	*Timoclea* (*Timoclea*) *scabra* (Hanley)	R	
43	*Corbula* (*Corbula*) *mekranica* Vredenburg		A
44	*Corbula* (*Corbula*) *tunicosulcata* Vredenburg	F	A
	Gastropods		
45	*Archimediella* (*Torculoidella*) *angulata* (Sowerby)	A	F
46	*Cypraea* sp.		R
47	*Ficus* (*Ficus*) *conditus* (Brongniart)		R
48	*Ficus* (*Ficus*) *ficus* (Linne')		R
49	*Ficus* (*Ficus*) *kachhensis* (Vredenburg)		R
50	*Murex maegillivrayi* Dohrn		R
51	*Conus* (*Leptoconus*) *bonneti* Cossmann		A
52	*Conus* (*Dendroconus*) *loroisii* Kiener		A
	Decapods		
53	*Calappa protopustulosa* Noetling		R
54	*Typilobus granulosus* Stocliczka		R
55	*Ebalia tuberculata* Noetling		R
56	*Neptunus sindensis* Stoliczka		F
57	*Palaeocarpilius rugifer* Stoliczka		F
58	*Xantho* sp.		R
	Fishes		
59	*Lamna* sp.		R
60	*Carcharodon carcharias* Linnaeus		A
61	*Carcharodon angustidens* Agassiz		R
62	*Carcharodon* sp.		R
63	*Isurus spallanzanii* Bonnaparte		A

Contd…

Sl. no.	SPECIES / FREQUENCY / ZONES	A = Abundant F = Frequent R = Rare	
		ZONE - 1	
		SUBZONE - 1A	SUBZONE -1B
64	*Isurus pagoda* Bonnaparte		A
65	*Alopias* sp.		R
66	*Odontapis* cf. *taurus* Rafinesque		R
67	*Odontapis* cf. *tricuspidatus* Day		R
68	*Odontapis* sp.		A
69	*Carcharhinus egertoni* Agassiz:		F
70	*Carcharhinus priscus* Agassiz.		F
71	*Carcharhinus* cf. *macloti* Muller and Henle		F
72	*Carcharhinus* (*Prionodon*) sp.		F
73	*Carcharhinus* sp. A		R
74	*Carcharhinus* sp. B		R
75	*Carcharhinus* sp. C		R
76	*Carcharhinus* sp. D		R
77	*Galeocerdo aduncus* Agassiz		F
78	*Negaprion brevirostris* Poey.		R
79	*Negaprion* cf. *eurybathrodon* Blake		R
80	*Scoliodonsorrakawah* Cuvier		R
81	*Hemipristis serra* Agassiz:		A
82	*Hemipristis unidenticulata* n. sp.		R
83	*Sphyrna zygaena* Linneaus		R
84	S*phyrna diplana* Springer		R
85	*Galeorhinus* sp.		R
86	*Squalus* sp.		R
87	*Myliobatis* sp		A
88	*Aetobatus* sp.		F
89	*Diodon* sp.1		F
90	*Diodon* sp.2		F
91	*Diodon* sp.3		F
92	*Diodon* sp.4		F
	Foraminifers		
93	*Ammonia annectens concinna* Millet		A
94	*Ammonia* sp.		A

6.2 CORRELATION OF BEDS

Conventionally, biostratigraphic zones along with the entombed faunal assemblages have been extensively used for local as well as regional correlations. To accomplish this, attempt is made first to establish the relationship amongst the fossiliferous horizons of the study area with a view to know the local composite faunal and stratigraphic sequences. The correlation of the local sequences is then carried out with those from the other areas of the Indo-Pacific province where fossiliferous strata of the corresponding ages have been studied in detail.

6.2.1 CORRELATION OF THE LOCAL SEQUENCE

Fossil species considered for age determination, biostratigraphy and correlation in the present study have been collected from the six beds out of the total of eight as the remaining two have not yielded any age-diagnostic fauna. The bed-wise faunal contents and age has been discussed in the preceding chapter. These six beds have been biostratigraphically grouped into two Subzones in a zone. The correlation of these fossiliferous beds in the study area has been attempted and is given in Table 6.3. Proposed biostratigraphic zonations in the six fossil localities of Upper Bhuban unit, Bhuban Formation of the study area is given in fig. 6.1.

Table 6.3 Correlation of fossil localities of the study area

Zone	Subzone	Locality					
		1	2	3	4	5	6
Zone – 1 *Paphia* (*Paphia*) *rotundata* – *Palaeocarpilius rugifer* Zone	**Subzone – 1B** ***Barbatia* (*Barbatia*) *bataviana* var. *carinata* – *Neptunus sindensis* Stoliczka Subzone** (Aquitanian – Burdigalian to Burdigalian)	Bed no. 2	Bed no. 1	Bed not exposed	Bed not exposed	Bed no. 2	Bed no. 1
	Subzone – 1A ***Gari* (*Gari*) *natensis* Subzone** (Aquitanian – Burdigalian)	Bed not exposed	Bed not exposed	Bed no. 2	Bed no. 2	Bed not exposed	Bed not exposed

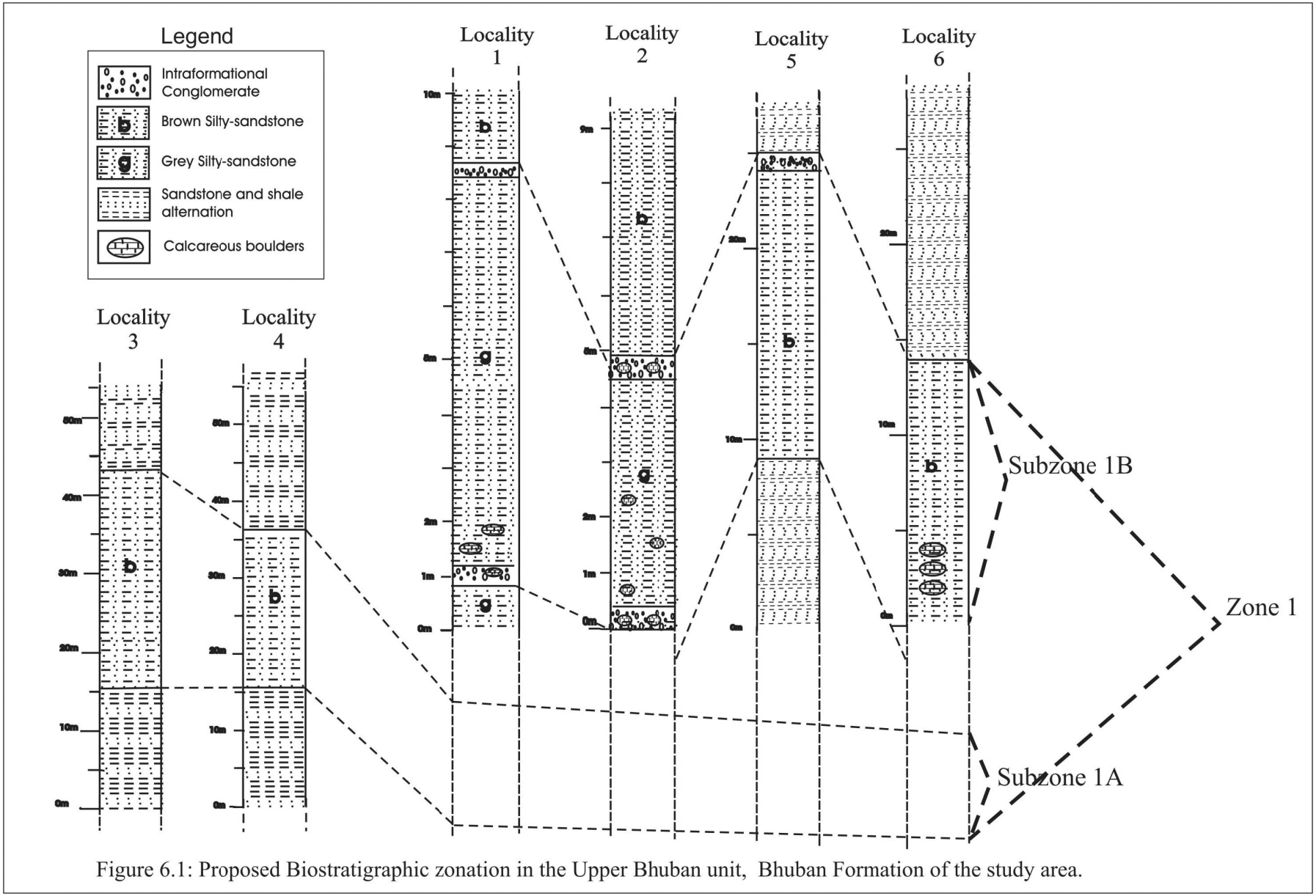


Figure 6.1: Proposed Biostratigraphic zonation in the Upper Bhuban unit, Bhuban Formation of the study area.

6.2.2 CORRELATION OF LOCAL SEQUENCE WITH OTHER AREAS

The lower Miocene mega-invertebrates have been extensively studied from several localities from the Indian Sub-continent. These localities are: Mizoram (Tiwari, 1992; Tiwari and Kachhara, 2003; Mazumder, 2004; Lalchawimawii, 2004), Kanchanpur, Assam (Mukerjee, 1929 in Das Gupta, 1982), Garo Hills, Meghalaya (Vredenburg, 1921; Mukerjee, 1939; Lyngdoh *et al*., 1999; Lyngdoh, 2004), Sind (Pakistan), Kachchh and Kathiawar in Gujarat (Vredenburg, 1925, 1928; Jain, 1997) and in Myanmar (Noetling, 1895, 1901; Vredenburg, 1921 and Pascoe, 1973). An attempt has been made here to correlate the Bhuban Formation of the study area with the above-mentioned Lower Miocene localities from the Indian Sub-continent.

6.2.2.1. Lower Miocene of Mizoram (Tiwari and Kachhara, 2003)

Tiwari and Kachhara (2003) proposed five bio-zones in the Tertiary succession of Mizoram. These are: *Meretrix agrestis* Zone (I) of Late Eocene - Oligocene age within the Barail Group; *Glycymeris sindiensis* - *Nuculana virgo* Zone (II) of Aquitanian age within the lower and middle units of Bhuban Formation; *Ostrea latimarginata* - *Natica pellis tigrina* Zone (III) of Aquitanian - Burdigalian age within the lower part of Upper Bhuban unit; *Pecten* (*Oopecten*) *gigas* Zone (IV) of Burdigalian age within the middle part of the Upper Bhuban unit; and *Pecten* sp. Zone (V) of Helvetian age within the upper part of Upper Bhuban unit of Bhuban Formation.

The list of common taxa between the present Subzones and the five Zones of Tiwari and Kachhara (2003) from Mizoram is given in Table 6.4.Thirty-four and 33 taxa from the proposed Zone - 1 of the study area are also known to occur in the Zone - III and Zone - IV respectively of Tiwari and Kachhara (2003). Hence, this zone is broadly correlatable with the Zone - III (*Ostrea latimarginata* - *Natica pellis tigrina* Zone) of Aquitanian - Burdigalian age) and Zone - IV [*Pecten* (*Oopecten*) *gigas* Zone] of Burdigalian age respectively of Tiwari and Kachhara (2003).

Detailed comparison of Subzone - 1A with the zones of Tiwari and Kachhara (2003) revealed that 3, 10, 9 and 4 taxa from this Subzone are also known to occur in the Zone - II, Zone - III, Zone - IV and Zone - V of Tiwari and Kachhara (2003) respectively. Though maximum numbers of common taxa are from Zone - III and Zone - IV, the zonal

taxa of Subzone - 1A i. e. *Gari* (*Gari*) *natensis* Noetling is confined to Zone - III. As such, proposed Subzone - 1A is equivalent to Zone - III of Tiwari and Kachhara (2003).

It can also be concluded from the table that, 33 and 34 taxa are common with the Zone - III and Zone - IV respectively. Therefore, this Subzone is correlatable with Zone - III in part and Zone - IV of Tiwari and Kachhara (2003).

6.2.2.2. Lower Miocene of Kolasib, Mizoram (Mazumder, 2004)

Mazumder (2004) studied the Lower Miocene fauna from the Bhuban Formation of Kolasib area, Mizoram and erected two zones, namely, *Nucula* (*Lamellinucula*) aff. *pulchra* – *Nuculana* (*Nuculana*) *virgo* Zone - I of Aquitanian age within middle unit of Bhuban Formation, and *Chlamys* (*Argopecten*) *senatoria* - *Tellina* (*Tellinella*) *pseudohilli* Zone - II of Aquitanian – Burdigalian to Burdigalian age within the Upper Bhuban unit of Bhuban Formation. He further proposed two subzones within Zone - II. These are *Clementia* (*Clementia*) *papyracea* Subzone - IIA and *Callista* (*Costacallista*) *erycina* – *Antigona granosa* - *Trisidos semitorta* Subzone - IIB. The former is within the Upper Bhuban unit of Bhuban Formation and is of Aquitanian – Burdigalian to Burdigalian age whereas the latter is also within the Upper Bhuban unit of Bhuban Formation but of Burdigalian age. Zone - IIA has further been divided in to a lower *Conus* (*Lithoconus*) *ineditus* - *Diplodonta* (*Diplodonta*) *incerta* Zonule (IIA-a) of Aquitanian to Burdigalian age and an upper *Conus* (*Dendroconus*) *loroisii* – *Achimediella* (*Torculoidella*) *angulata* Zonule (IIA-b) of Burdigalian age.

The detailed comparison of the fauna from the proposed Subzone - 1A and - 1B has been worked out and is presented in table 6.5. This indicates that the maximum number of common taxa from Subzone - 1A is with the Zone - IIA (a) of Mazumder (2004). Hence, these two are correlatable. Similarly, proposed Subzone - 1B has 22, 8 and 18 taxa common with the IIA-(a), IIA-(b) and IIB of Mazumder (2004) respectively. Therefore, it has been correlated with Zone - IIA (a) in part to Zone - IIA (b) and Zone - IIB.

6.2.2.3 Kanchanpur Bed, Hailakandi District, Assam (Mukerjee, 1939)

A thin bed of sandy and pebbly mudstone is highly fossiliferous in this locality. Mukerjee (1929 in Das Gupta, 1982) studied the faunal content of this bed. Das Gupta (1982) proposed a Miocene age for this bed and further commented that it bears a close correlation with the faunal assemblage of the Gaj Beds, Northwestern India. The characteristic forms from this bed are *Nucula alcocki* Noetling, *Nuculana virgo* (Martin), *Mactra protoreevesii* Noetling and *Ficus* (*Ficus*) *dussumieri* (Valenciennes).

Out of the above, only *Mactra protoreevesii* Noetling has been found in Subzone - 1B i. e. *Barbatia* (*Barbatia*) *bataviana* var. *carinata* - *Neptunus sindensis* Subzone of Aquitanian - Burdigalian to Burdigalian age. Hence, Kanchanpur bed may be correlatable with this Subzone.

6.2.2.4. Lower Miocene of Garo Hills, Meghalaya

A. Dalu and Baghmara Localities (Mukerjee, 1939)

Pinfold (1919) discovered two fossil localities near Dalu and Baghmara of Garo Hills, Meghalaya. He made collection of a few mega-invertebrates from these two localities. Pinfold's collection was studied by Vredenburg (1921). Later on, Mukerjee (1939) made an exhaustive collection from these two localities and gave a comprehensive account of a large number of bivalves and gastropods and a few scaphopods. Based on his findings, he assigned these rocks to Lower Miocene, *i.e.* Aquitanian - Burdigalian or Burdigalian.

Table 6.8 shows that the following 18 species are common between the study area and Dalu and Baghmara of Garo Hills: *Trisidos semitorta* (Lamarck), *Anadara* (*Anadara*) *craticulata* (Nyst), *Anadara* (*Anadara*) *daviesi* Mukerjee, *Anadara* (*Anadara*) *garoensis* Mukerjee, *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Diplodonta (Diplodonta) incerta* d'Archiac, *Diplodonta* (*Diplodonta*) *rotundatus* (Montagu), *Mactra* (*Mactra*) *protoreevesii* Noetling, *Tellina* (*Moerella*) *indifferens* Noetling, *Apolymetis* (*Apolymetis*) *grimesi* Noetling, *Gari* (*Psammobia*) *kingi* (Noetling), *Callista* (*Costacallista*) *erycina* (Linne'), *Dosinia* (*Dosinia*) *subpenicillata* Vredenburg, *Clementia* (*Clementia*) *papyracea* (Gray), *Corbula* (*Corbula*) *tunicosulcata* Vredenburg, *Archimediella*

(*Torculoidella*) *angulata,* Sowerby), *Ficus* (*Ficus*) *conditus* (Brongniart), *Conus* (*Leptoconus*) *bonneti* Cossmann.

Further scrutiny indicates that the number of common taxa with the proposed Subzone - 1A and Subzone - 1B are 5 and 18 respectively. Hence, the Lower Miocene fossil horizons of Garo Hills are more akin to the present Subzone - 1B. This is also confirmed by the age proposed by Mukerjee to the Garo Hills fossil localities.

B. Lyngdoh *et al.*, 1999; Lyngdoh, 2004

Lyngdoh *et al*., (1999) and Lyngdoh (2004), while describing the mega-invertebrates from the Lower Miocene of Garo Hills Meghalaya, established two bio-zones within these successions. These are *Ostrea latimarginata* Zone - I and *Crassostrea gajensis- Conus* (*Dendroconus*) *loroisii* Zone - II. Zone - I contains two subzones, namely, *Anadara submultiformis – Turritella narica baluchistanensis* Subzone - 1A and *Mactra* (*Eomactra*) *protoreevesii – Turritella pinfoldi* Subzone - 1B. Subzone - 1A occurs within Baghmara Formation and is of Aquitanian – Burdigalian age; Subzone - 1B is near the base of Chengapara Formation of Burdigalian age whereas Zone - II is within the Chengapara Formation of Burdigalian to Helvetian age.

The list of common taxa between the proposed zone and Zones of Lyngdoh *et al*., (1999) is given in Table 6.6. The list shows that common taxa between Subzone - 1A of the present area and Subzone - 1A, Subzone - 1B and Zone - II of the Garo Hills are 5, 4 and 2 respectively. Since maximum number of common taxa including the zonal taxa from this Subzone i. e. *Gari* (*Gari*) *natensis* Noetling are in the Subzone - 1A of Garo Hills, hence the correlation. The number of common taxa between Subzone - 1B and the zones of Garo Hills are 11, 15 and 9 respectively. Thus the maximum numbers of common taxa are between the present Subzone - 1B and the Subzone - 1B of Lyngdoh *et al*., (1999). As such, these are correlatable.

6.2.2.5. Kama Formation, Myanmar (Noetling, 1895, 1901)

Blue shales and sandstones constitute fossiliferous lithic units within Kama Formation. Noetling (1895, 1901) studied Kama fauna in great detail that included a large number of bivalves and gastropods and a few scaphopods, decapods and fishes. Pascoe

(1973) assigned Aquitanian age for this Formation. *Barbatia* (*Barbatia*) *bataviana* Martin var. *carinata* Noetling, *Anadara* (*Anadara*) *craticulata* (Nyst), *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Tellina* (*Moerella*) *indifferens* Noetling, *Callista* (*Costacallista*) *erycina* (Linne'), *Clementia* (*Clementia*) *papyracea* (Gray), *Archimediella* (*Torculoidella*) *angulata* (Sowerby) and *Conus* (*Leptoconus*) *bonneti* Cossmann from the study area have also been reported by Noetling (1898, 1901) from the Kama Formation of Myanmar (Table 6.8). Thus, a fair degree of correlation exists between the two.

6.2.2.6. Pyalo Formation, Myanmar (Noetling, 1895, 1901)

This formation has been assigned Burdigalian age (Pascoe, 1973). The main litho-units of this formation are sandstone, shale and pebble beds. The following forms reported by Noetling (1898, 1901) from the Pyalo Formation of Myanmar have also been encountered in the present area indicating good degree of correlation between the two (Table 6.8): *Anadara* (*Anadara*) *craticulata* (Nyst), *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Tellina* (*Moerella*) *indifferens* Noetling, *Clementia* (*Clementia*) *papyracea* (Gray), *Archimediella* (*Torculoidella*) *angulata* (Sowerby), *Calappa protopustulosa* Noetling and *Ebalia tuberculata* Noetling

6.2.2.7 Persian Bed (Cox, 1936)

Table 6.8 shows that six species from the Lower Miocene of Persian bed have also been encountered in the present area. These are: *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Lutraria philippinarum* Reeve, *Tellina* (*Eurytellina*) cf. *pilgrimi* Cox, *Clementia* (*Clementia*) *papyracea* (Gray), *Archimediella* (*Torculoidella*) *angulata* (Sowerby) and *Conus* (*Dendroconus*) *loroisii* Kiener. Hence, a good degree of correlation exists between the two.

6.2.2.8. Gaj Beds

Gaj Beds (Lower Miocene) are exposed in Sind (Pakistan), Kachchh and Kathiawar (Gujarat) and the fauna of these beds were studied by Stoliczka (1871), Duncan and Sladen (1882-86), Duncan, Sladen and Blanford (1883); Fedden (1884), Vredenburg (1906, 1908, 1921, 1925 and 1928), Sen Gupta (1964), Biswas (1965), Chatterjee and Mathur (1966), Mathur (1988) and Jain (1997). Correlation of Bhuban with Gaj Beds is dealt with herein:

A. Gaj Bed of Kachchh (Vredenburg, 1925, 1928)

Khari Formation (Lower Gaj) of Kachchh is composed of sandstone, marly limestone, shales, clays and marls. The rich fossiliferous horizons are the marly limestone and shales. The taxa common between the two localities as shown in table 6.8 are: *Trisidos semitorta* (Lamarck), *Anadara* (*Anadara*) *craticulata* (Nyst), *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Diplodonta* (*Diplodonta*) *incerta* (d'Archiac), *Clementia* (*Clementia*) *papyracea* (Gray), *Corbula* (*Corbula*) *tunicosulcata* Vredenburg, *Archimediella* (*Torculoidella*) *angulata* (Sowerby), *Ficus* (*Ficus*) *kachhensis* (Vredenburg), *Typilobus granulosus* Stocliczka and *Palaeocarpilius rugifer* Stoliczka. Hence good degree of correlation exists between the two.

B. Gaj Bed of Kathiawar (Jain, 1997)

Lithologically, the Gaj Formation (referable to Gaj Beds) of Kathiawar comprises limestones, marls, grey clay, variegated clays, silty calcareous clay and clay stones. Basal part of the succession is richly fossiliferous. Jain (1997) erected *Ostrea protoimbricata – Diplodonta incerta naricum- Aturia aturi* Zone (I) in the Lower Miocene of Kathiawar with which the following ten taxa are common (Table 6.7): *Trisidos semitorta* (Lamarck), *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Diplodonta* (*Diplodonta*) *incerta* d'Archiac, *Lutraria philippinarum* Reeve, *Dosinia* (*Dosinia*) peralta Vredenburg, *Dosinia* (*Dosinia*) *subpenicillata* Vredenburg *Clementia* (*Clementia*) *papyracea* (Gray), *Corbula* (*Corbula*) *tunicosulcata* Vredenburg, *Archimediella* (*Torculoidella*) *angulata* (Sowerby) and *Ficus* (*Ficus*) *kachhensis* (Vredenburg). Most of these taxa are found in Subzone - 1B. Hence Zone I of Jain (1997) is corretable with the present Subzone - 1A.

C. Gaj Bed of Sind (Vredenburg, 1925, 1928)

Taxa like *Trisidos semitorta* (Lamarck), *Chlamys* (*Argopecten*) *senatoria* (Gmelin), *Diplodonta* (*Diplodonta*) *incerta* d'Archiac, *Clementia* (*Clementia*) *papyracea* (Gray), *Archimediella* (*Torculoidella*) *angulata* (Sowerby), *Typilobus granulosus* Stocliczka, *Neptunus sindensis* Stoliczka and *Palaeocarpilius rugifer* Stoliczka from the Gaj bed of Sind have also been encountered in the present area (Table 6.8). Hence, good degree of correlation exists between the two.

In summary, it may be stated that Subzone - 1A [*Gari* (*Gari*) *natensis* Subzone] of the present area is correlatable with Zone III (*Ostrea latimarginata - Natica pellis tigrina* Zone) of Tertiary succession of Mizoram (Tiwari and Kachhara, 2003); Zonule II A-a (*Conus* (*Lithoconus*) *ineditus – Diplodonta* (*Diplodonta*) *incerta* Subzone) of Mazumder (2004), Subzone - IA (*Anadara submultiformis – Turritella narica baluchistanensis* Subzone) of Lyngdoh *et al*., (1999) from the Garo Hills, Kanchanpur Bed and upper part of Kama Formation of Myanmar. Subzone - 1B [*Barbatia* (*Barbatia*) *bataviana* var. *carinata - Neptunus sindensis* Subzone] is correlatable with Zone - III in part and Zone - IV [*Pecten* (*Oopecten*) *gigas* Zone of Burdigalian age] of Tertiary succession of Mizoram (Tiwari and Kachhara, 2003), Zonule IIA-a in part to Zonule IIA-b [*Conus* (*Dendroconus*) *loroisii – Achimediella* (*Torculoidella*) *angulata* Subzone] to Sub Zone IIB [*Callista* (*Costacallista*) *erycina – Antigona granosa - Trisidos semitorta* Subzone] of Mazumder (2004), Subzone - 1B [*Mactra* (*Eomactra*) *protoreevesii – Turritella pinfoldi* Subzone] of Garo Hills (Lyngdoh *et al.*, 1999), Pyalo Formation of Myanmar and Zone - I (*Ostrea protoimbricata – Diplodonta incerta naricum- Aturia aturi* Zone) of Kathiawar (Jain, 1997). The overall correlation so attempted in the preceding pages is summarized in the Table 6.9.

Table - 6.4: List of taxa common between the proposed Subzones and Zones of Mizoram (Tiwari and Kachhara, 2003)

Subzone - 1A **(Ralte, 2008)**	**Zone**				
	I	**II**	**III**	**IV**	**V**
Anadara (*Anadara*) *daviesi* Mukerjee	**x**	**x**	√	√	√
Chlamys (*Argopecten*) *senatoria* (Gmelin)	**x**	**x**	√	√	√
Pecten (*Pecten*) *mathuri* Tiwari	**x**	**x**	√	√	**x**
Diplodonta **(***Diplodonta***)** *incerta* d'Archiac	**x**	√	√	√	**x**
Astarte (*Bythiamena*) *striata* Tiwari	**x**	√	**x**	√	√
Gari (*Gari*) *natensis* (Noetling)	**x**	**x**	√	**x**	**x**
Paphia (*Callistotapes*) *pseudoliratus* Vredenburg	**x**	**x**	√	√	**x**
Paphia (*Paphia*) *rotundata* (Linne')	**x**	**x**	√	√	**x**
Timoclea (*Timoclea*) *scabra* (Hanley)	**x**	**x**	√	**x**	**x**
Corbula tunicosulcata Vredenburg	**x**	√	√	√	√
Archimediella (*Torculoidella*) *angulata* (Sowerby),	**x**	**x**	√	√	**x**
Subzone - 1B					
Nucula (*Nucula*) *agrawali* Tiwari	**x**	**x**	√	**x**	**x**
Portlandia (*Portlandia*) *ovatoelongata* Mazumder	**x**	**x**	**x**	**x**	**x**
Trisidos semitorta (Lamarck)	**x**	√	√	**x**	**x**
Anadara (*Anadara*) *craticulata* (Nyst)	**x**	√	√	√	**x**
Anadara (*Anadara*) *daviesi* Mukerjee	**x**	**x**	√	√	√
Anadara (*Anadara*) *garoensis* Mukerjee	**x**	**x**	**x**	√	√
Anadara (*Anadara*) *luangmualensis* Tiwari	**x**	**x**	**x**	√	**x**
Anadara (*Anadara*) *trapezoida* Tiwari	**x**	**x**	√	√	**x**
Pinna (*Pinna*) cf. *rudis* Linné	**x**	**x**	√	√	**x**
Chlamys (*Argopecten*) *senatoria* (Gmelin)	**x**	**x**	√	√	√
Pecten (Pecten) mathuri Tiwari	**x**	**x**	√	√	**x**
Diplodonta (Diplodonta) incerta d'Archiac	**x**	√	√	√	**x**

Contd…

Subzone - 1B (Ralte, 2008)	Zone				
	I	II	III	IV	V
Invertebrates					
Diplodonta (*Diplodonta*) *rotundatus* (Montagu)	**x**	√	√	√	**x**
Astarte (*Bythiamena*) *striata* Tiwari	**x**	√	**x**	√	√
Mactra (*Mactra*) *protoreevesii* Noetling	**x**	√	√	√	**x**
Lutraria philippinarum Reeve	**x**	**x**	√	**x**	**x**
Lutratria (*Lutraria*) *saingengai* Tiwari	**x**	√	√	√	**x**
Cultellus (*Cultellus*) *zulloi* Tiwari	**x**	√	√	√	**x**
Tellina (*Eurytellina*) cf. *pilgrimi* Cox	**x**	√	√	√	√
Tellina (*Moerella*) *indifferens* Noetling	**x**	**x**	√	√	**x**
Tellina (*Tellinella*) *loknathi* Tiwari	**x**	**x**	**x**	√	**x**
Apolymetis (*Apolymetis*) *aizawlensis* Tiwari	**x**	**x**	**x**	√	√
Apolymetis (*Apolymetis*) *grimesi* Noetling	**x**	**x**	√	**x**	**x**
Gari (*Psammobia*) *kingi* (Noetling)	**x**	**x**	**x**	**x**	**x**
Glossus (*Cytherocardia*) *cytheroides* (Mayer)	**x**	**x**	√	**x**	**x**
Callista (*Callista*) *pseudoumbonella* Vredenburg	**x**	**x**	√	**x**	**x**
Callista (*Costacallista*) *erycina* (Linne')	**x**	**x**	√	√	**x**
Dosinia (*Dosinia*) *peralta* Vredenburg	**x**	√	**x**	√	√
Dosinia (*Dosinia*) *subpenicillata* Vredenburg	**x**	**x**	√	**x**	**x**
Clementia (*Clementia*) *papyracea* (Gray)	**x**	**x**	√	√	√
Paphia (*Paphia*) *rotundata* (Linne')	**x**	**x**	√	√	**x**
Paphia (*Paphia*) *jhai* Tiwari	**x**	**x**	√	√	**x**
Paphia (*Callistotapes*) *pseudoliratus* Vredenburg	**x**	**x**	√	√	**x**
Timoclea (*Timoclea*) *scabra* (Hanley)	**x**	**x**	√	**x**	**x**
Corbula (*Corbula*) *mekranica* Vredenburg	**x**	**x**	**x**	√	√
Corbula (*Corbula*) *tunicosulcata* Vredenburg	**x**	√	√	√	√
Archimediella (*Torculoidella*) *angulata*, Sowerby	**x**	**x**	√	√	**x**
Ficus (*Ficus*) *ficus* (Brongniart)	**x**	**x**	√	√	**x**

Contd…

Subzone - 1B **(Ralte, 2008)**	**Zone**				
	I	**II**	**III**	**IV**	**V**
Ficus (*Ficus*) *kachhensis* (Vredenburg)	**x**	**x**	√	**x**	**x**
Ficus (*Ficus*) *conditus* (Brongniart)	**x**	√	√	√	**x**
Murex maegillivrayi Dohrn	**x**	**x**	√	√	**x**
Conus (*Leptoconus*) *bonneti* Cossmann	**x**	**x**	**x**	√	**x**
Conus (*Dendroconus*) *loroisii* Kiener	**x**	**x**	**x**	√	**x**
Calappa protopustulosa Noetling	**x**	**x**	**x**	**x**	√
Typilobus granulosus Stoclickza	**x**	**x**	**x**	**x**	√
Ebalia tuberculata Noetling	**x**	**x**	**x**	√	**x**
Vertebrates (Fishes)					
Carcharodon carcharias Linnaeus	**x**	**x**	**x**	**x**	√
Isurus spallanzanii Bonnaparte	**x**	**x**	**x**	**x**	√
Hemipristis serra Agassiz	**x**	√	**x**	**x**	**x**
Sphyrna zygaena Linneaus	**x**	**x**	**x**	√	**x**

Table - 6.5: List of taxa common between the proposed Subzones and Zones of Kolasib, Mizoram (Mazumder, 2004)

Subzone - 1A (Ralte, 2008)	**ZONE I**	**ZONE II**		
		IIA		**IIB**
		IIA (a)	**IIA (b)**	
Anadara (*Anadara*) *daviesi* Mukerjee	**x**	√	**x**	**x**
Chlamys (*Argopecten*) *senatoria* (Gmelin)	**x**	√	√	√
Pecten (*Pecten*) *mathuri* Tiwari	**x**	**x**	**x**	√
Diplodonta **(***Diplodonta***)** *incerta* d'Archiac	**x**	√	**x**	**x**
Astarte (*Bythiamena*) *striata* Tiwari	**x**	√	**x**	**x**
Timoclea (*Timoclea*) *scabra* (Hanley)	**x**	**x**	**x**	√
Corbula tunicosulcata Vredenburg	**x**	√	**x**	**x**
Archimediella (*Torculoidella*) *angulata* (Sowerby),	**x**	√	√	**x**
Subzone - 1B				
Nucula (*Nucula*) *agrawali* Tiwari	**x**	√	**x**	**x**
Portlandia (*Portlandia*) *ovatoelongata* Mazuder	**x**	√	**x**	**x**
Trisidos semitorta (Lamarck)	**x**	**x**	**x**	√
Anadara (*Anadara*) *craticulata* (Nyst)	**x**	√	**x**	**x**
Anadara (*Anadara*) *daviesi* Mukerjee	**x**	√	**x**	**x**
Anadara (*Anadara*) *trapezoida* Tiwari	**x**	√	**x**	**x**
Pinna (*Pinna*) cf. *rudis* Linné	**x**	**x**	√	**x**
Chlamys (*Argopecten*) *senatoria* (Gmelin)	**x**	√	√	√
Pecten (Pecten) mathuri Tiwari	**x**	**x**	**x**	√
Diplodonta (Diplodonta) incerta d'Archiac	**x**	√	**x**	**x**
Diplodonta (*Diplodonta*) *rotundatus* (Montagu)	**x**	√	**x**	**x**
Astarte (*Bythiamena*) *striata* Tiwari	**x**	√	**x**	**x**
Lutraria philippinarum Reeve	**x**	√	**x**	√

Contd…

Subzone - 1B (Ralte, 2008)	**ZONE I**	**ZONE II**		
		IIA		**IIB**
		IIA (a)	**IIA (b)**	
Lutratria (*Lutraria*) *saingengai* Tiwari	**x**	√	**x**	√
Cultellus (*Cultellus*) *zulloi* Tiwari	**x**	√	**x**	**x**
Tellina (*Eurytellina*) cf. *pilgrimi* Cox	**x**	√	**x**	√
Tellina (*Moerella*) *indifferens* Noetling	**x**	√	**x**	**x**
Tellina (*Tellinella*) *loknathi* Tiwari	**x**	√	**x**	**x**
Apolymetis (*Apolymetis*) *aizawlensis* Tiwari	**x**	√	**x**	√
Glossus (*Cytherocardia*) *cytheroides* (Mayer)	**x**	**x**	**x**	√
Callista (*Costacallista*) *erycina* (Linne')	**x**	**x**	**x**	√
Dosinia (*Dosinia*) *peralta* Vredenburg	**x**	**x**	**x**	√
Clementia (*Clementia*) *papyracea* (Gray)	**x**	√	√	**x**
Paphia (*Paphia*) *jhai* Tiwari	**x**	**x**	**x**	√
Timoclea (*Timoclea*) *scabra* (Hanley)	**x**	**x**	**x**	√
Corbula (*Corbula*) *mekranica* Vredenburg	**x**	**x**	**x**	√
Corbula (*Corbula*) *tunicosulcata* Vredenburg	**x**	√	**x**	**x**
Archimediella (*Torculoidella*) *angulata*, Sowerby	**x**	√	√	**x**
Ficus (*Ficus*) *ficus* (Brongniart)	**x**	**x**	√	√
Ficus (*Ficus*) *kachhensis* (Vredenburg)	**x**	√	**x**	**x**
Ficus (*Ficus*) *conditus* (Brongniart)	**x**	√	**x**	√
Conus (*Dendroconus*) *loroisii* Kiener	**x**	√	√	**x**
Calappa protopustulosa Noetling	**x**	**x**	√	**x**
Ebalia tuberculata Noetling	**x**	**x**	√	**x**

Table - 6.6: List of taxa common between the proposed Subzones and Zones of Garo Hills, Meghalaya (Lyngdoh *et al.*, 1999; Lyngdoh 2004).

Subzone - 1A (Ralte, 2008)	**ZONE I**		**ZONE II**
	Subzone IA	**Subzone IB**	
Anadara (*Anadara*) *daviesi* Mukerjee	√	**x**	**x**
Chlamys (*Argopecten*) *senatoria* (Gmelin)	√	√	**x**
Pecten (*Pecten*) *mathuri* Tiwari	**x**	**x**	√
Diplodonta **(***Diplodonta***)** *incerta* d'Archiac	√	**x**	**x**
Gari (*Gari*) *natensis* (Noetling)	√	**x**	**x**
Paphia (*Callistotapes*) *pseudoliratus* Vredenburg	**x**	√	**x**
Corbula (*Corbula*) *tunicosulcata* Vredenburg	√	√	**x**
Archimediella (*Torculoidella*) *angulata* (Sowerby)	**x**	√	√
Subzone - 1B			
Barbatia (*Barbatia*) *bataviana* Martin var. *carinata* Noetling	√	**x**	**x**
Trisidos semitorta (Lamarck)	√	**x**	**x**
Anadara (*Anadara*) *craticulata* (Nyst)	**x**	√	**x**
Anadara (*Anadara*) *daviesi* Mukerjee	√	**x**	**x**
Anadara (*Anadara*) *garoensis* Mukerjee	**x**	√	√
Chlamys (*Argopecten*) *senatoria* (Gmelin)	√	√	**x**
Pecten (*Pecten*) *mathuri* Tiwari	**x**	**x**	√
Diplodonta (Diplodonta) incerta d'Archiac	√	**x**	**x**
Diplodonta (*Diplodonta*) *rotundatus* (Montagu)	**x**	√	**x**
Mactra (*Mactra*) *protoreevesii* Noetling	**x**	√	**x**
Lutratria (*Lutraria*) *saingengai* Tiwari	√	√	**x**
Tellina (*Moerella*) *indifferens* Noetling	**x**	**x**	√
Apolymetis (*Apolymetis*) *grimesi* Noetling	**x**	√	**x**
Callista (*Costacallista*) *erycina* (Linne')	√	**x**	**x**

Contd…

Subzone - 1B (Ralte, 2008)	**ZONE I**		**ZONE II**
	Subzone IA	**Subzone IB**	
Dosinia (*Dosinia*) *subpenicillata* Vredenburg	√	√	√
Clementia (*Clementia*) *papyracea* (Gray)	√	**x**	**x**
Paphia (*Callistotapes*) *pseudoliratus* Vredenburg	**x**	√	**x**
Corbula (*Corbula*) *tunicosulcata* Vredenburg	√	√	**x**
Archimediella (*Torculoidella*) *angulata*, Sowerby)	**x**	√	√
Ficus (*Ficus*) *ficus* (Brongniart)	**x**	√	**x**
Ficus (*Ficus*) *kachhensis* (Vredenburg)	√	**x**	**x**
Ficus (*Ficus*) *conditus* (Brongniart)	**x**	√	**x**
Conus (*Leptoconus*) *bonneti* Cossmann	**x**	√	**x**
Conus (*Dendroconus*) *loroisii* Kiener	**x**	**x**	√
Carcharodon carcharias Linnaeus	**x**	**x**	√
Isurus spallanzanii Bonnaparte	**x**	√	**x**
Scoliodon sorrakawah Cuvier	**x**	**x**	√
Sphyrna diplana Springer	**x**	**x**	√

Table - 6.7: List of taxa common between the proposed Subzones and Zones of Kathiawar, Gujarat (Jain 1997).

Subzone - 1A (Ralte, 2008)	**ZONES**	
	I	**II**
Chlamys (*Argopecten*) *senatoria* (Gmelin)	√	**x**
Diplodonta **(***Diplodonta***)** *incerta* d'Archiac	√	**x**
Corbula tunicosulcata Vredenburg	√	√
Archimediella (*Torculoidella*) *angulata* (Sowerby)	√	**x**
Subzone -1B		
Trisidos semitorta (Lamarck)	√	**x**
Chlamys (*Argopecten*) *senatoria* (Gmelin)	√	**x**
Diplodonta **(***Diplodonta***)** *incerta* d'Archiac	√	**x**
Lutraria philippinarum Reeve	√	**x**
Apolymetis (*Apolymetis*) *grimesi* Noetling	**x**	√
Dosinia (*Dosinia*) *peralta* Vredenburg	√	**x**
Dosinia (*Dosinia*) *subpenicillata* Vredenburg	√	**x**
Clementia (*Clementia*) *papyracea* (Gray)	√	**x**
Corbula (*Corbula*) *tunicosulcata* Vredenburg	√	**x**
Archimediella (*Torculoidella*) *angulata* (Sowerby)	√	**x**
Ficus (*Ficus*) *kachhensis* (Vredenburg).	√	**x**

Table 6.8 : List of taxa common between the study area and other Miocene fossil localities

Name of species	Study Area (Ralte, 2008)		Dalu and Baghmara, Garo Hills (Mukerjee, 1939)	Myanmar, (Noetling, 1895, 1901)		Persian Bed (Cox, 1936)	Gaj Beds (Vredenburg, 1925, 1928)	
	ZONE 1							
	Subzone 1A	Subzone 1B		Kama Formation	Pyalo Formation		Kachchh	Sind
Nucula (*Nucula*) *agrawali* Tiwari		√						
Portlandia (*Portlandia*) *ovatoelongata* Mazumder		√						
Barbatia (*Barbatia*) *bataviana* Martin var. *carinata* Noetling		√		√				
Barbatia sp.		√						
Trisidos semitorta (Lamarck)		√	√				√	√
Anadara (*Anadara*) *craticulata* (Nyst)		√	√	√	√		√	
Anadara (Anadara) daviesi Mukerjee	√	√	√					
Anadara (*Anadara*) *garoensis* Mukerjee		√	√					
Anadara (*Anadara*) *luangmualensis* Tiwari		√						
Anadara (*Anadara*) *trapezoida* Tiwari		√						

Name of species	Study Area (Ralte, 2008)		Dalu and Baghmara, Garo Hills (Mukerjee, 1939)	Myanmar, (Noetling, 1895, 1901)		Persian Bed (Cox, 1936)	Gaj Beds (Vredenburg, 1925, 1928)	
	ZONE 1							
	Subzone 1A	Subzone 1B		Kama Formation	Pyalo Formation		Kachchh	Sind
Arcopsis sp.		√						
Pinna (*Pinna*) cf. *rudis* Linné		√						
Chlamys (*Argopecten*) *senatoria* (Gmelin)	√	√	√	√	√	√	√	√
Pecten (*Pecten*) *mathuri* Tiwari	√	√						
Diplodonta(*Diplodonta*) *incerta* d'Archiac	√	√	√				√	√
Diplodonta (*Diplodonta*) *rotundatus* (Montagu)		√	√					
Cyclocardia sp.		√						
Astarte (*Bythiamena*) *striata* Tiwari	√	√						
Mactra (*Mactra*) *protoreevesii* Noetling		√	√					
Clinocardium sp.		√						

Name of species	Study Area (Ralte, 2008)		Dalu and Baghmara, Garo Hills (Mukerjee, 1939)	Myanmar, (Noetling, 1895, 1901)		Persian Bed (Cox, 1936)	Gaj Beds (Vredenburg, 1925, 1928)	
	ZONE 1							
	Subzone 1A	Subzone 1B		Kama Formation	Pyalo Formation		Kachchh	Sind
Lutraria philippinarum Reeve		√				√		
Lutratria (*Lutraria*) *saingengai* Tiwari		√						
Cultellus (*Cultellus*) *zulloi* Tiwari		√						
Cultellus sp.		√						
Tellina (*Angulus*) sp.		√						
Tellina (*Eurytellina*) cf. *pilgrimi* Cox		√				√		
Tellina (*Moerella*) *indifferens* Noetling		√	√	√	√			
Tellina (*Tellinella*) *loknathi* Tiwari		√						
Apolymetis (*Apolymetis*) *aizawlensis* Tiwari		√						
Apolymetis (*Apolymetis*) *grimesi* Noetling		√	√					

Name of species	Study Area (Ralte, 2008)		Dalu and Baghmara, Garo Hills (Mukerjee, 1939)	Myanmar, (Noetling, 1895, 1901)		Persian Bed (Cox, 1936)	Gaj Beds (Vredenburg, 1925, 1928)	
	ZONE 1							
	Subzone 1A	Subzone 1B		Kama Formation	Pyalo Formation		Kachchh	Sind
Gari (*Psammobia*) *kingi* (Noetling)		√	√					
Gari (*Gari*) *natensis* Noetling	√							
Glossus (*Cytherocardia*) *cytheroides* (Mayer)		√						
Callista (*Callista*) *pseudoumbonella* Vredenburg		√						
Callista (*Costacallista*) *erycina* (Linne')		√	√	√				
Dosinia (*Dosinia*) *peralta* Vredenburg		√						
Dosinia (*Dosinia*) *subpenicillata* Vredenburg		√	√					
Clementia (*Clementia*) *papyracea* (Gray)		√	√	√	√	√	√	√
Paphia (*Paphia*) *rotundata* (Linne')	√	√						

Name of species	Study Area (Ralte, 2008)		Dalu and Baghmara, Garo Hills (Mukerjee, 1939)	Myanmar, (Noetling, 1895, 1901)		Persian Bed (Cox, 1936)	Gaj Beds (Vredenburg, 1925, 1928)	
	ZONE 1							
	Subzone 1A	Subzone 1B		Kama Formation	Pyalo Formation		Kachchh	Sind
Paphia (*Callistotapes*) *pseudoliratus* Vredenburg	√	√						
Paphia (*Paphia*) *jhai* Tiwari		√						
Timoclea (*Timoclea*) *scabra* (Hanley)	√	√						
Corbula (*Corbula*) *mekranica* Vredenburg		√						
Corbula (*Corbula*) *tunicosulcata* Vredenburg	√	√	√				√	
Archimediella (*Torculoidella*) *angulata* (Sowerby)	√	√	√	√	√	√	√	√
Cypraea sp.		√						
Ficus (*Ficus*) *conditus* (Brongniart)		√	√					
Ficus (*Ficus*) *ficus* (Brongniart)		√						

Name of species	Study Area (Ralte, 2008)		Dalu and Baghmara, Garo Hills (Mukerjee, 1939)	Myanmar, (Noetling, 1895, 1901)		Persian Bed (Cox, 1936)	Gaj Beds (Vredenburg, 1925, 1928)	
	ZONE 1							
	Subzone 1A	Subzone 1B		Kama Formation	Pyalo Formation		Kachchh	Sind
Ficus (*Ficus*) *kachhensis* (Vredenburg)							√	
Mure maegillivrayi Dohrn								
Conus (*Leptoconus*) *bonneti* Cossmann			√					
Conus (*Dendroconus*) *loroisii* Kiener				√		√		
Calappa protopustulosa Noetling					√			
Typilobus granulosus Stocliczka							√	√
Ebalia tuberculata Noetling					√			
Neptunus sindensis Stoliczka								√
Palaeocarpilius rugifer Stoliczka							√	√
Xantho sp.								

Table 6.9: Correlation of Upper Bhuban unit, Bhuban Formation of the study area with other fossiliferous Miocene localities from the Indian Subcontinent

Study Area (Ralte, 2008)	**Upper Bhuban Unit, Bhuban Formation**	
	Zone - 1	
	Subzone - 1A	**Subzone - 1B**
Aizawl & Lunglei, Mizoram (Tiwari, 1992; Tiwari & Kachhara, 2003)	Zone III	Zone III in part to Zone IV
Kolasib, Mizoram (Mazumder 2004)	Subzone II A(a) of Sub Zone II A	Zonule IIA(a) in part to Zonule IIA(b) to Sub Zone IIB
Garo Hills, Meghalaya (Lyngdoh *et al.*, 1999, Lyngdoh, 2004)	Zone IA	Zone IB
Myanmar (Noetling, 1895, 1901; Pascoe, 1973)	Kama Formation (upper part)	Pyalo Formation
Sind (Vredenburg, 1928; Pascoe, 1973)		
Kachchh (Vredenburg, 1928; Pascoe, 1973)	Gaj beds	
Kathiawar (Jain, 1997)		Zone I

6.3 CORRELATION BASED ON FISH FAUNA

Fish fauna have been extensively studied from the several Neogene fossil localities of the Indian Sub-continent. These localities are: Myanmar (Noetling, 1901; Stuart, 1910), Baripada bed, Orissa (Sahni and Mehrotra, 1981; Bhalla, 1985), Kachhch (Sahni and Mehrotra 1981; Mehrotra, Mishra and Srivastava, 1973), Piram Island (Sahni and Mehrotra1981; Mehrotra, Mishra and Srivastava, 1973) and Gogha Coast (Sahni and Mehrotra, 1981; Mehrotra, Mishra and Srivastava, 1973). The list of genera common between the present area and above localities from the Indian Subcontinent is given in Table 6.10. A check list of fish fauna from the study area along with their geographic distribution has been given in table 6.11.

It is found that all the seven fish genera reported from Myanmar have also been found in the present collection. However, nine genera from the study area, namely, *Lamna*, *Odontaspis*, *Negaprion*, *Scoliodon*, *Sphyrna*, *Galeorhinus*, *Squalus*, *Ateobatus* and *Diodon* have so far not been recorded from the Miocene succession of Myanmar. Species wise, six are found to be common between the two areas. Ten species reported from Myanmar are missing in the present collection whereas thirty-two from the present area are found to be missing in Myanmar. Hence, a good degree of correlation exists between the two.

Comparison between the present area and Baripada beds of Orissa provides interesting inferences. Here, twelve out of sixteen genera are known to be present in the Miocene sediments of Baripada. Four genera such as *Lamna*, *Hemipristis*, *Galeorhinus* and *Diodon* are found to be absent in the Baripada beds. On the other hand, six genera *viz. Dasyatis*, *Nacrine*, *Pristis*, *Rhinobatos*, *Raja* and *Rhinoptera* have not been recorded in the present assemblage. Out of these six genera, the first five forms belong to teleosteans group of fishes. The genus *Dasyatis* has been reported from the Upper Bhuban unit, Bhuban Formation of Mizoram (Tiwari, 1998). Species-wise, nine taxa are common between the two areas. Twenty-nine taxa found in the present collection are absent from the Baripada beds whereas twenty-eight species from Baripada beds are yet to be found in the study area. From the above, it can be safely concluded that the two areas have very high degree of correlation.

Similarity between the fish fauna of the present assemblage and that of Kachchh is to the extent that out of sixteen genera described in the present work twelve have also been recorded from Kachchh. The four genera namely, *Lamna*, *Galeorhinus*, *Squalus* and *Diodon* are absent in the Miocene beds of Kachchh whereas only one genus *Raja* belonging to teleosts is unavailable in the present collection. Out of the thirty-seven species described in the present work, only ten are common with the Kachchh. Inversely, eleven species from Kachchh are missing in the present collection. Therefore, a good degree of correlation exists between the two localities.

Fifty per cent of fish genera are common between the study area and Gogha coast (Kathiawar). The following eight genera constituting the present assemblage have not being reported from the Gaj bed of Gogha coast: *Lamna*, *Negaprion*, *Scoliodon*, *sphyrna*, *Galeorhinus*, *Squalus*, *Ateobatus* and *Diodon*. Only the genus *Raja* present in the Gogha coast has so far not been reported from the Bhuban Formation of Mizoram. Eight species are found to be common between the two localities. Twenty-nine taxa found in the present collection have not being reported from the Gaj bed of Gogha coast. On the other hand, eight species known to occur in Gogha coast are not present in the study area or elsewhere in the Bhuban Formation of Mizoram.

Only four genera and species are common between the study area and the Pliocene beds of Piram Island. These are: *Carcharodon carcharias*, *Isurus spallanzanii*, *Isurus pagoda* and *Myliobatis* sp.

Table - 6.10: List of fish genera common between the study area and the other Neogene localities of Indian Subcontinent

Name of Genera	**Piram Island** (Mehrotra *et al.* 1973; Sahni & Mehrotra, 1981)	**Gogha Coast** (Mehrotra *et al.* 1973; Sahni & Mehrotra, 1981)	**Kachhch** (Mehrotra *et al.* 1973; Sahni & Mehrotra, 1981)	**Baripada** (Mehrotra *et al.* 1973; Sahni & Mehrotra, 1981)	**Myanmar** (Noetling, 1901 & Stuart, 1910)
Lamna					
Carcharodon	√	√	√	√	√
Isurus	√	√	√	√	√
Alopias		√	√	√	√
Odontaspis		√	√	√	
Carcharhinus	√	√	√	√	√
Galeocerdo		√	√	√	√
Negaprion			√	√	
Scoliodon			√	√	
Hemipristis		√	√		√
Sphyrna			√	√	
Galeorhinus					
Squalus				√	
Myliobatis	√	√	√	√	√
Aetobatis			√	√	
Diodon					

Table 6.11: Check list with geographic distribution of fish species from the study area, Mizoram

Families, genera and species	**STUDY AREA**		**Mizoram** (Tiwari, 1992; Tiwari *et al*., 1998)			**Piram Island** (Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	**Gogha Coast** (Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	**Kachhch** Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	**Baripada** Mehrotra *et al*. 1973; Sahni and Mehrotra1981)	Myanmar (Noetling, 1901 and Stuart, 1910)
	Bika Quarry, University Road, Aizawl	**Ruata Quarry, Ramrikawn, Aizawl**	**Chanmari Aizawl**	**Sairang Aizawl Dist.**	**Zotlang Lunglei Dist.**					
A. Selachians										
Family LAMNIDAE										
1. *Lamna* sp.	√									
2. *Carcharodon carcharias*	√			√	√	√	√	√	√	
3. *Carcharodon angustidens*	√	√								√
4. *Carcharodon* sp.		√								
5. *Isurus spallanzanii*	√	√		√	√	√	√	√		√
6. *Isurus pagoda*	√					√	√		√	√
Family ALOPIIDAE										
1. *Alopias* sp.	√									
Family ODONTASPIDIDAE										
1. *Odontaspis* cf. *taurus*	√									
2. *Odontaspis* cf. *tricuspidatus*	√						√	√		
3. *Odontaspis* sp.	√									
Family CARCHARHINIDAE										
1. *Carcharhinus egertoni*	√	√					√			√
2. *Carcharhinus priscus*	√									
3. *Carcharhinus* cf. *macloti*	√							√	√	

Families, genera and species	**STUDY AREA**		**Mizoram** (Tiwari, 1992; Tiwari *et al*., 1998)			**Piram Island** (Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	**Gogha Coast** (Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	**Kachhch** Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	**Baripada** Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	Myanmar (Noetling, 1901 and Stuart, 1910)
	Bika Quarry, University Road, Tuivamit, Aizawl	**Ruata Quarry, Ramrikawn, Tuivamit, Aizawl**	**Chanmari Aizawl**	**Sairang Aizawl Dist.**	**Zotlang Lunglei Dist.**					
4. *Carcharhinus bhubanicus* n. sp	√									
5. *Carcharhinus* (*Prionodon*) sp.	√									
6. *Carcharhinus* sp.A	√									
7. *Carcharhinus* sp.B	√									
8. *Carcharhinus* sp.C	√								√	
9. *Carcharhinus* sp.D	√									
10. *Galeocerdo aduncus*	√	√					√			
11. *Negaprion brevirostris*	√							√	√	
12. *Negaprion* cf. *eurybathrodon*	√									
13. *Scoliodon sorrakawah*	√							√	√	
Family HEMIGALEIDAE										
1. *Hemipristis serra*	√	√	√				√	√	√	√
2. *Hemipristis unidenticulata* n. sp	√									
Family SPHYRNIDAE										
1. *Sphyrna diplana*	√							√	√	
2. *Sphyrna zygaena*	√	√						√		
Family TRIAKIDAE										
1. *Galeorhinus* sp.	√									
Family SQUALIDAE										
1. *Squalus* sp.										

Families, genera and species	**STUDY AREA**		**Mizoram** (Tiwari, 1992; Tiwari *et al*., 1998)			**Piram Island** (Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	**Gogha Coast** (Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	**Kachhch** Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	**Baripada** Mehrotra *et al*. 1973; Sahni and Mehrotra 1981)	Myanmar (Noetling, 1901 and Stuart, 1910)
	Bika Quarry, University Road, Aizawl	**Ruata Quarry, Ramrikawn, Aizawl**	**Chanmari Aizawl**	**Sairang Aizawl Dist.**	**Zotlang Lunglei Dist.**					
Family INDETERMINATE										
1. Carcharhinidae gen. et sp. indet.		√								
2. Indeterminate vertebral centra of selachians										
B. Batoids (Ray-Skates)										
Family MYLIOBATIDAE										
1. *Myliobatis* sp.	√					√	√	√	√	
2. *Aetobatus* sp.	√									
C. Teleosteans										
Family DIODONTIDAE										
Diodon sp.1	√									
Diodon sp.2	√	√								
Diodon sp.3	√									
Diodon sp.4	√	√								
Family CROCODYLIDAE										
Indeterminate tooth of Crocodylidae	√	√								

CHAPTER 7

PALAEOECOLOGY
AND
DEPOSITIONAL ENVIRONMENT

7. PALAEOECOLOGY AND DEPOSITIONAL ENVIRONMENT

7.1 GENERAL REMARKS

Palaeoecology is the study of the habitat of ancient organisms in environmental context. Palaeoecology is extrapolated from conclusions drawn from the observations on the ecology of the modern counterparts of fossils. Palaeoecology thus utilizes the concept and methods of ecology. This concept is however, frequently debated but, it remains irreplaceable as yet. It has now become an important tool for palaeoenvironmental reconstructions that in turn help establish the evolutionary history of fossiliferous sedimentary basins. Since the marine benthic organisms strongly interact with the environment, their fossils provide useful information about depositional environments of the geological past (Fursich, 1995). Out of the five categories proposed by Fursich (1995), the integrated approach provides maximum information preserved in sediments and fossils and has been considered the most ideal method for palaeoenvironmental interpretations. It takes into account the petrographic, geochemical and sedimentological characteristics of the rocks and taphonomic, ichnological and palaeoecological aspects of fossils. The distribution of organisms in the aquatic environment is strongly influenced by the environmental parameters *viz*., light, temperature, salinity, rate of sedimentation, water energy (waves, currents), and substrate. For a palaeoecologist, the substrate is the most readily available parameter in shal1ow environments. The substrate, in turn, may provide useful information related to rate of sedimentation and environmental energy. The substrate further may yield information on oxygenation, stability, degree of consolidation, grain-size, sorting and the organic contents (Fursich, 1976; Jaitly and Mishra, 2007).

It is quite obvious that the degree of probability of the reconstruction of depositional environment decreases with the increasing age. The problem is further complicated due to increase in the number of groups without their extant representatives and the evolution of communities to which these organisms belonged. Since the Cenozoic fossil records have advantage over the fossils of older ages on these two counts, this technique of palaeoecology using the concept of modern ecology is fairly dependable for this era (Ager, 1963; Roup and Stanley, 1971).

Interpretation of depositional environment, palaeoecology and palaeogeography in the present work is mainly based on the available biota, and lithological characteristics and primary-sedimentary structures of the fossil yielding horizons. It may be mentioned in this context, however, that entire faunal wealth of the Bhuban formation from the study area is yet to be fully explored and sedimentological characteristics are yet to be worked out in detail. Therefore, it is difficult to work out the accurate depositional environment. In spite of these limitations, author has made a modest attempt to deduce the depositional environment and palaeoecology based largely on entombed fossil assemblages consisting of bivalves, gastropods, unidentifiable regular and irregular echinoids, foraminifers and fishes on the one hand and preliminary studies of the lithic-units and primary-sedimentary structures on the other. Decapods, though recovered, but do not through much light on the depositional conditions and palaeoecological attributes. The present assemblage is dominated by bivalves and fishes and gastropods and foraminifers constitute a small component of the total faunal assemblage. Fish teeth occur in a large numbers in two localities only.

7.2 BHUBAN FORMATION IN GENERAL

Tiwari *et al*. (1998b), Mazumder (2004) and Lalchawimawii (2004) attempted the depositional environment of the Bhuban Formation based on the entombed fauna, preliminary lithological characteristics and primary-sedimentary structures. They stated that this formation comprises a hybrid association of sandstone, siltstone, shale, mudstone and their admixtures in various proportions. The shales and siltstones grade into mudstones and argillaceous alternations consisting of interlaminations of shales, ripple laminated siltstones and silty-sandstones. Sandstones are generally hard, fine grained, ill sorted, immature and richly micaceous. These are lenticular in geometry and are characterized by lateral litho-facies changes. The characteristic feature of Bhuban sediments is rhythmic alternations of argillaceous and arenaceous strata. Prominent primary-sedimentary structures are current and interference ripples, ripple-drift laminations, lenticular and flaser beddings, cross and wavy laminations, slump structures, and pinch and swell structures. Worm burrows are the major biogenic sedimentary structures.

Alternate regular and irregular beddings of sands or silts and shales indicate rough water environment. Thin nature of the coset of cross-lamination/stratification indicates shallow depth. Small scale cross laminations are produced due to rippling of the sand-water interface under faster movement of sediments in slightly higher energy regime with frequent variations in the direction of water current (Collinson and Thompson, 1982). Parallel laminations in the siltstones or thin beddings results from gradational change in grain size suggesting long term fluctuations in the sedimentary load. Interference ripples are indicative of fluctuations in the current direction. Presence of pyrite at places points to a reducing environment (Pettijohn, 1963).

The entombed marine crabs, echinoids and fishes inhabit shallow open sea. Presence of fish skeleton in large numbers reported by Tiwari and Bannikov (2002) in the Upper Bhuban unit of Bhuban Formation is suggestive of their mass death and rapid burial. Echinoids are mostly irregular shallow burrowers preferring soft substrate and regular echinoids inhabit a rocky floor. Among the molluscs, shallow to deep burrowers, semi-infaunal, byssate nestlers, cemented and thick shelled and detritus feeder forms are common. Disarticulated and fragmentary fossil record of bivalves indicates strong bottom currents. Preservation of delicate worm trails and similar structures suggest feeble bottom current. Vertical burrows are quite common and point to fast rate of sedimentation. The process of burrowing kept pace with the fast rate of sedimentation perhaps in deltaic regime. According to Mazumder (2004), these burrows may probably belong to *Skolithos, Glossifungites* and *Cruziana* association. This is the typical association of tidal – outer neritic environment as envisaged by Collinson and Thompson (1982).

Above observations may lead to the inference that Upper Bhuban sediments were deposited in an unstable quickly subsiding basin with a high rate of sedimentation under rapidly fluctuating conditions of deltaic to inner neritic environment with fluviatile phases intermittently. This Formation thus represents a complex interfingering of deltaic to marine environment and interruption in sedimentation has been rare. Thickness of this formation in Mizoram is of the order of 5000m while in Tripura and Surma Valley, it is less than 3000m. It suggests that the linear Mizo fold belt extending

north and southwards to Manipur and Arakan coast formed the site of a rapidly subsiding furrow within a generally subsiding and tectonically active depositional basin during the Miocene Epoch (Mazumder, 2004).

7.3 UPPER BHUBAN UNIT, BHUBAN FORMATION OF THE STUDY AREA

The Upper Bhuban unit of Bhuban Formation of the study area comprises three fossiliferous litho-units namely, Grey silty-sandstone, Brown silty-sandstone and Intraformational conglomeratic bands. Two intraformational conglomeratic bands occur within the grey silty-sandstone bed at locality 1 and 2 whereas one band occurs at the top of the brown silty-sandstone bed at locality 5.

7.3.1 Grey silty-sandstone bed

This constitutes the lower bed in localities 1 and 2. It is grey coloured, fine grained, silty and micaceous. Fossils in this bed are scattered and difficult to extract due to hard and indurated lithology. Grey colour is indicative of deposition of bed in reducing environment however burrows and borings in clastic sequence indicate well aerated nature of the sediments (Clarkson, 1984). Borings have been observed only in indurated sediments and cross-laminations are above the borings. This may be due minor hiatus in sedimentation (Clarkson, 1984). At places there are sand-shale alternations suggesting fluctuating conditions of deposition. Thereafter, the basin became shallow as indicated by the presence of ripple marks, flaser beddings, lenticular beddings and ripple cross laminations in the upper part. The upper part is also characterized by the presence of simple vertical burrows suggestive of shallow turbulent water with a high concentration of suspended food. On the basis of lithology, it is possible to infer that at the time of deposition of this bed, in early phase, basin was deep enough to support different kinds of biota. Borings made by *Teredolites clavatus* Leymerie- a wood borer- was reported by Mehrotra *et al.* (2001) from Ramrikawn stone quarry very close to locality 2 from the lower part of the grey silty-sandstone. The overcrowded nature of these borings suggests that the substrate was infested by a large number of bivalves and that is why no xylic material remained. Although, *Teredolites* - infested log grounds are found in a wide range of facies ranging from non-marine to marine, many are linked with transgressive events (Bromley *et al.*, 1948). Medium- to coarse-grained substrate that gradually passed over to mud- and grain- supported

carbonate with micritic matrix provided plenty of substrate for cementing to the epibenthos and and also explains the dominance of infaunal bivalves, mainly suspension-feeders. General dominance of suspension-feeding bivalves may reflect scarcity of the detrital organic matter in the sediment, which apparently was kept suspended in the water column. Medium- to coarse-grained sediments further encouraged the colonization of the suspension feeders.

7.3.1.1 Invertebrate fossils

Bulk of the collection from this locality comes from the lower conglomeratic band at Locality 1 and from the upper conglomeratic band at Locality 2. The collection consists of bivalves, gastropods, decapods and foraminifers in decreasing order of abundance. The fossil community indicates a shallow inner-shelf habitat with silty-sand substrate. Overall this assemblage indicates that the depth of the basin was shallow throughout. All the gastropods from this bed belong to order Mesogastropoda which thrive only in marine water. These are represented by genera like *Ficus* and *Conus*. *Conus* is a carnivorous and mainly feeds on infaunal polychaetes whereas *Ficus* prefers to eat echinoderms. *Archimediella* sp. lives at depth shallower than 300m. Additionally, nektonic fishes and active epifaunal crabs, epifaunal and infaunal echinoids and annelids have also flourished. It is to be noted that there are no boreal or cold-water species in the present collection.

Among bivalves, genera like *Barbatia*, *Trisidos*, *Anadara*, *Chlamys*, *Arcopsis*, *Pecten*, *Cyclocardia*, *Astarte*, *Clinocardium*, *Lutraria*, *Cultellus*, *Tellina*, *Apolymetis*, *Glossus*, *Callista*, *Dosinia*, *Clementia*, and *Corbula* are commonly represented. The epifaunal animals include the suspension feeder and byssate free swinging *Chlamys*, a warm water scallop *Pecten* and byssally attached *Anadara* (Noda, 1961). Infaunal forms, both shallow and deep burrowers, are present - *Diplodonta*, *Clementia*, *Corbula* and *Astarte* as shallow burrowers and *Lutraria*, *Cultellus*, *Tellina*, *Apolymetis*, *Dosinia* and *Clementia* as deep burrowers with long siphons. These characteristically inhabit soft substratum. Stationery burrowers like *Callista* is also found. Among infaunal compressed forms both elongated ones (*Cultellus*) and suborbicular forms (*Apolymetis*) are present. The substrate also supported thick-shelled *Corbula* and warm water fauna

Clementia. Thus bivalve genera are mainly infaunal ones moderately deep-to-deep burrowers and permanent burrowers and all of them are known to occur in warm water.

The genus *Anadara* is a large species group of bivalvia and represents an internationally well-known taxonomic group occurring in the Neogene shallow marine sediments. Since the genus has a wide geographical distribution and rather short geological range and a narrow range of ecological adaptation from tropical to warm temperate and embayment to shallow sea, it has contributed considerably for the stratigrphic correlation and palaeoenvironmental reconstruction (Noda, 1991). *Anadara* is a warm water genus and is attached to the substrate by means of byssus situated in middle, preferring mainly the crevices or debris of dead shells. It, though belongs to byssate nestler arcids, is an exception to adapt partially to wholly infaunal conditions.

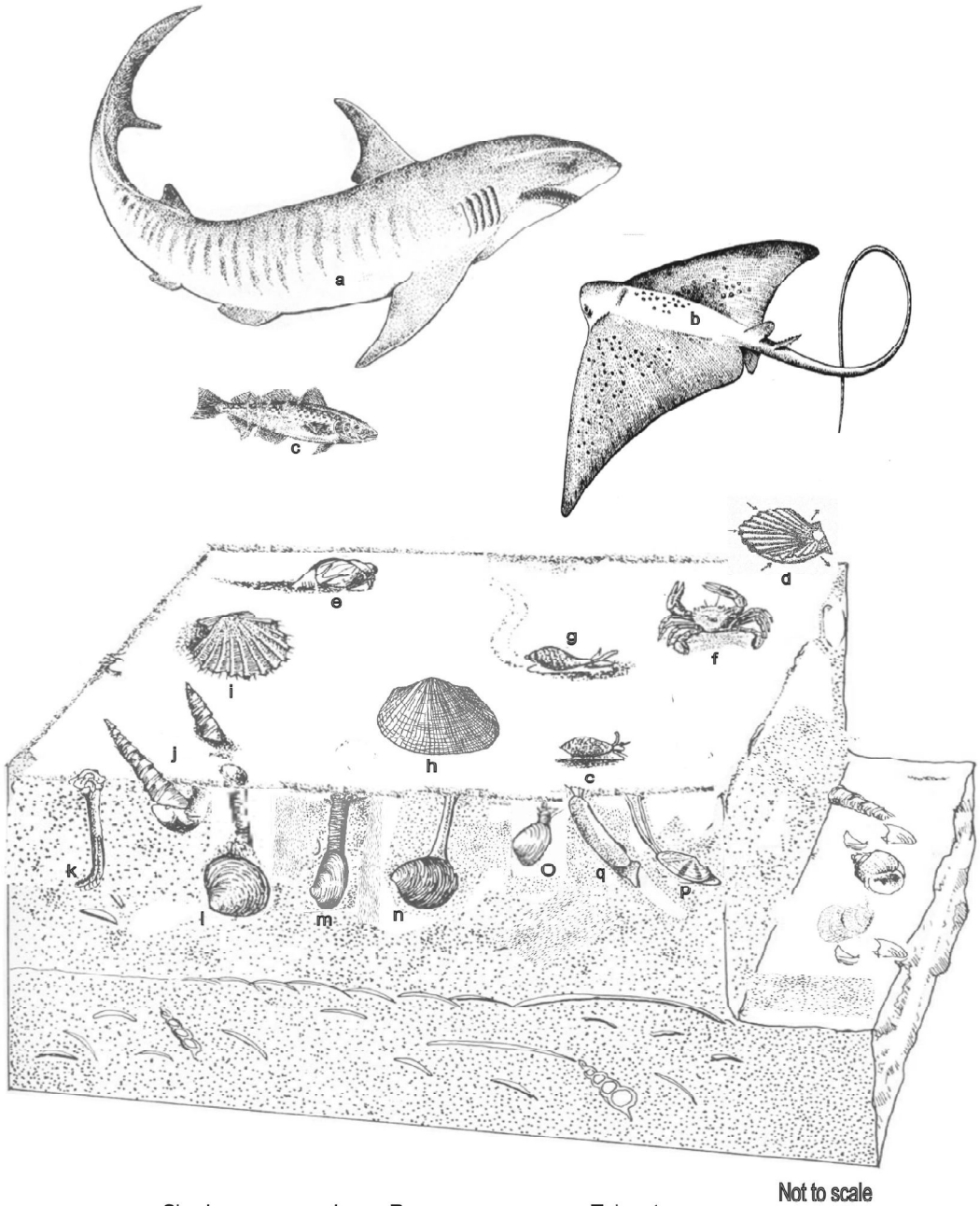
The bivalve community consists of thick-shelled genera like *Corbula*, which reflect shallow water environment. *Chlamys* is inter-tidal genus and lives in depth between inter-tidal to 150 fathoms on gravel bearing rocky bottoms. It can swim easily on interference; otherwise it is a free- lying on the substratum. The presence of *Chlamys* in the assemblage indicates that it is an indigenous one not transported far from its original habitat after death. *Cultellus* is inter-tidal to euneritic mollusk (Mesuda, 1989). *Dosinia* and *Tellina* are frequently found buried shallowly in muddy to sandy bottoms of lower to sub-tidal zones. *Cyclocardia* inhabits lower tidal to 1000 fathoms and *Tellina* inter-tidal to 75 fathoms. The living species of *Clementia* (*Clementia*) *papyracea* occupy the littoral zone above 20m on fine-grained sand to muddy bottoms in subtropical to tropical regions (Kanno, Amano and Noda, 1988). Extant genera like *Conus, Archimediella, Callista* (*Costacallista*) and *Corbula* indicate transgressive phase and would most commonly occur today in the seas between 10 - 45m depth (Squires, 1984). These along with *Barbatia* are known to occur in tropical to subtropical waters (Squires, 1987). *Barbatia* is byssaly attached and is usually wedged in among rocks or colonial corals (Stanley, 1970). It, although commonly occurs in inter-tidal depths, could also occur in waters as deep as 65m (Abbott and Dance, 1982). *Apolymetis*, a Miocene marine fauna, the index species for the tropical (20m depth) environment, is a mangrove fauna and early Middle Miocene age (Noda, Kikuchi and Nikaido, 1994).

Strangely, representatives of *Ostrea* which can sustain strong currents, is altogether missing from the present collection.

All the infaunal elements are compressed indicating unconsolidated substrate. Based on the composition of the molluscan fauna, it may be inferred that fauna grew in the shallow sea water region mainly in the shelf under the influence of warm water. Most of the bivalves occur as detached valves suggesting that the assemblage is an allochthonous one. A very few of the fossils retain their original shell covering. The molluscan fauna consists of infaunal, epifaunal, swimming and sessile forms, the majority of which are known to live in the inter-tidal to lower tidal zones and even though their bathymetric distribution extends down to greater depth, most of the identified species are shallow water forms. Dwarfed forms and unusually thickened forms are missing from the present collection. This indicates faunal association lived in water with normal salinity.

Amber has also been discovered from the lower intraformational conglomeratic band at locality 1 suggesting that the site of deposition was not too far from the hinterland.

Considering all the observations it can be inferred that an open shallow, warm sea with fluctuations from inner neritic to littoral water with depth less than 45m meter existed during deposition of these sediments. The substrate was soft but firm at places to support epifaunal byssate forms. So, the overall picture from this assemblage comes to be of inner-shelf sand and silt community (Figure 7.1), representing a fluctuating shoreline because of the presence of cross-bedding and disarticulated bivalve shells. At the same time, it can also be inferred that fossils were perhaps intra-basinally transported by the bottom currents from a variety of communities of the inter-tidal to near shore shelf, evidenced by infaunal elements characteristics of soft substratum occurring in sandy bottom.



a	Shark	b	Ray	c	Teleosts
d	Pecten	e	Conus	f	Crab
g	Ficus	h	Anadara	i	Chlamys
j	Archimediella	k	Burrow	l	Clementia
m	Lutraria	n	Dosinia	o	Corbula
p	Tellina	q	Culltelus		

Figure 7.1: Inner-shelf silt and sand community of grey silty-sandstone bed, Upper Bhuban Unit of the study area (diagram based on Mc Kerrow, 1978)

7.3.1.2 Vertebrate (fish) Fossils

The natural home of the present day sharks are the seas and estuarines of the tropical regions where they are abundantly present. They also commonly occur in the temperate and arctic regions. Many of the sharks are pelagic in habit and restricted within the range of 2l°C isotherms. All the genera of sharks from the Miocene of Indian subcontinent excepting *Carcharodon* and *Lamna* are found in the present day Indian Ocean.

Table 7.1 shows the climate and bathymetric distributions, and the mode of life of the living shark genera. The palaeoenvironment and palaeoecology of the Neogene elasmobranch assemblages can be inferred, referring to the climatic and bathymetric distribution of the recent elasmobranches. *Carcharodon*, a neritic nekton, is a cosmopolitan fish inhabiting the seas around the globe ranging from tropical to temperate regions. The typical *Carcharodon carcharias* found in other parts of globe is an active and strong swimming species found in tropical to hot temperate belts of all oceans excepting the Indian Ocean. It prefers surface waters but descends to considerable depths. *Carcharodon* was very common during the Miocene period, but is surprisingly absent in present day Indian waters (Mishra, 1969). *Lamna* is also not found presently in Indian Ocean. It is widespread in boreal to warm temperate belts of both the hemispheres and not known from tropical seas. It is an active, strong swimming fish in a depth range from surface to 70 – 80 fathoms. *Isurus*, an epipelagic to neritic nekton, is a cosmopolitan fish inhabiting the seas around the globe ranging from tropical to temperate regions. *Alopias* represented by *Alopias vulpinus* in the Indian Ocean is a common thresher shark and occurs in warm temperate and subtropical areas. It is practically absent in very warm waters. The typical pelagic species is found a few kilometers off shore. *Odontaspis* is a nekton shark dwelling in the neritic zone of the tropical and subtropical seas and is found in the Indo-Pacific and Atlantic Ocean. *Odontaspis tricuspidatus*, found in present day waters, is a typical temperate water species. It is generally found near the coast in warm and shallow waters. Bigelow and Schroeder (1948) stated that *Odontaspis tricuspidatus* and *Odontaspis taurus* of Atlantic withdraws from the area where temperature falls below 19° - 20°C. *Galeocerdo*, the tiger shark is also a nekton shark dwelling in the neritic zone of the

tropical and subtropical seas. It is pelagic and found in the mean annual isotherm of 20°C. *Carcharhinus* is neritic to epipelagic nekton in the tropical to subtropical seas. It is one of the most common sharks found all along the Indian coast line. A typical neritic nekton – *Hemipristis*, is widely distributed in the tropical seas around the globe. *Scolidon*, the typical Indian shark, is found all along the east and west coasts. *Scoliodon sorrakawah*, the most common species is always found up to a few kilometers from the land. *Negaprion* though not present in the recent fish fauna of Indian region (Mishra, 1969) is represented equally on the shores of Atlantic Ocean and warm water of Pacific and Indian Oceans (Antunes and Jonet, 1970). *Negaprion brevirostris* is typical of very warm waters of tropical and subtropical seas and it is strictly an inshore species. *Sphyrna* is represented by four species in Indian waters. The most common species *Sphyrna zygaena* is found in tropical to warm temperate water of Pacific, Atlantic and Indian Oceans. It does not prefer temperatures below 20^0C. *Sphyrna* is presently found in Bay of Bengal and off Bombay Coast. *Galaeorhinus* is found in open pelagic conditions.

Rays are mainly sluggish and bottom dwelling forms and well represented in Indian Ocean. *Myliobatis* is a benthic form found in littoral conditions in both east and west coasts of Indian subcontinent. It is presently found in India at the mouth of Ganges, Chhilka Lake and along east and west coasts of India in mean annual isotherm of about 20^0C. *Ateobatus* is also a benthic form dwelling in the tropical shallow sea. The genus *Diodon*, belonging to teleostean group of fishes, is also nekton forms inhabiting warm waters of tropical and subtropical seas and is presently found in Indian Ocean.

A close study of these fossil fishes reveals that all the shark species found in the present study are nekton forms, dwelling mainly in the neritic to epipelagic regions of the tropical to subtropical seas having mean annual isotherm of about 20^0C. On the basis of the above ecological framework, it can also be inferred that bed yielding these fossil fishes might have deposited in near-shore shallow marine environment. The sedimentation must have occurred in a warm, shallow marine basin, near to the shore line in a high energy environment. This inference is also supported by the presence of bored pebbles indicating shallow marine high-energy environment. Presence of hard

grounds containing calcareous and siliceous pebbles that are extensively bored by organisms indicate transgressive phase of deposition. Transgressive event is also inferred from the presence of *Teredolites clavatus* Leymerie in the grey silty-sandstone bed below this band. However, the foraminiferal assemblage dominated by *Ammonia annectens* associated with the fish fauna in these bands suggested their deposition during regressive phase under reducing environment with reduced salinity (Purdy, 1970; Bhalla and Dev, 1975). It further supports deposition in shallow marine set-up with palaeobathymetric fluctuations from 5m – 20m (Singh and Nayak, 2004). The tests of *Ammonia* are however, highly deformed due to rolling and indicate that these might have been transported to their present site of occurrence. On the whole, the palaeoenvironment of the depositional basin inferred from the selachian faunas agrees well with the environment indicated by the associate invertebrate fossils.

Table 7.1: The climatic and bathymetric distribution, and the mode of life of the recent elasmobranches (after Bigelow and Schroeder 1948; Compagno 1984a, and 1984b and Last and Stevens 1994.)

Genus	**Climate**			**Bathymetry**			**Mode of Life**		
	Tropical	Subtropical	Temperate	Neritic	Epipelagic	Mesopelagic	Benthons	Nekton	Plankton
Carcharodon	√	√	√	√	√			√	
Isurus	√	√	√		√			√	
Odontaspis	√	√		√				√	
Alopias	√	√			√			√	
Carcharhinus	√	√		√	√			√	
Galeocerdo	√	√		√				√	
Hemipristis	√			√				√	
Squalus	√	√	√	√	√			√	
Myliobatis	√	√		√			√		
Aetobatus	√			√			√		

7.3.2 Brown Silty-sandstone bed

This bed is brown coloured with high silt content and micaceous. The bed is normally massive but primary-sedimentary structures like ripple-marks, ripple cross laminations, sole marks along with biogenic structure like worm burrows of different varieties are also developed at places. This bed was deposited in oxygen sufficient environment as indicated by its reddish-brown colour.

The collection from this bed consists of bivalves, gastropods and decapods. The fossil community indicates a shallow sub-littoral habitat with a silt and sandy substrate. Here also, the only gastropod *Archimediella* from this bed belong to order Mesogastropoda which thrive only in marine water at depth less than 300m.

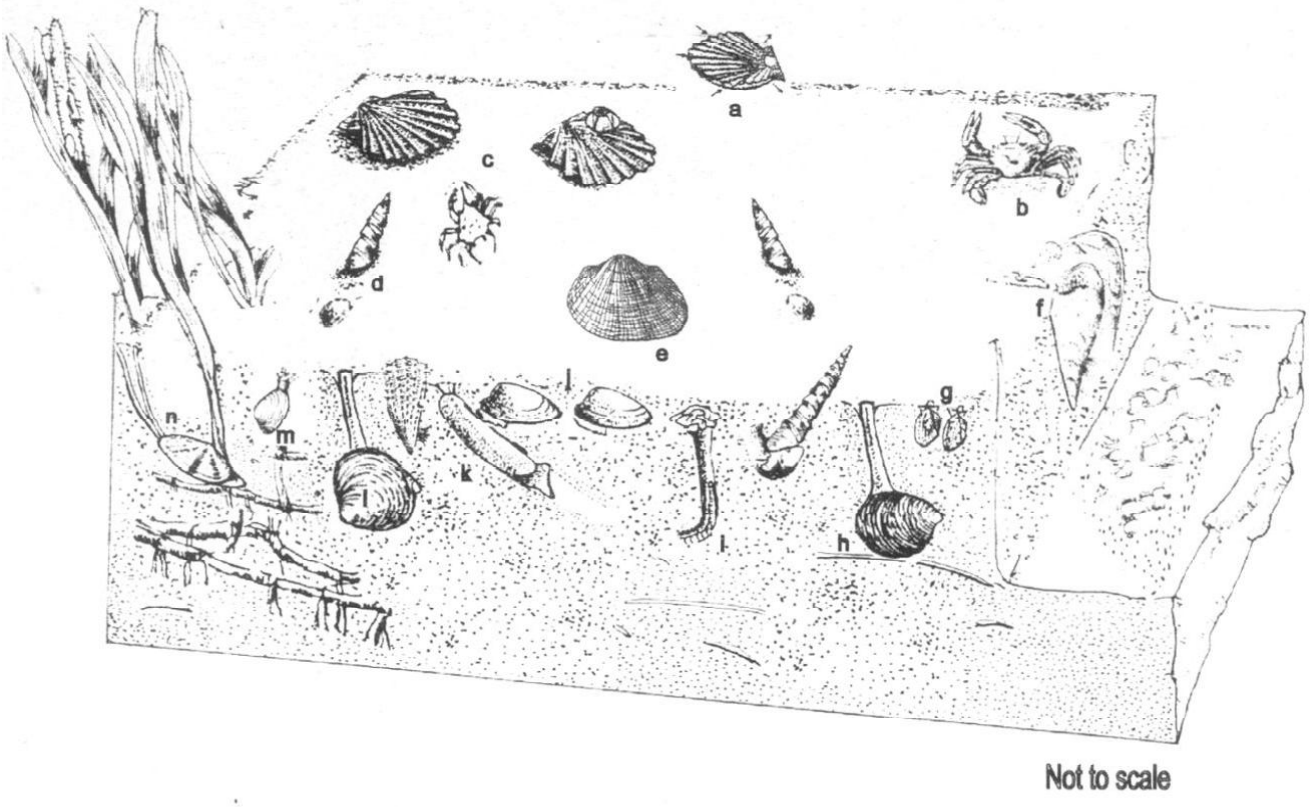
The following eleven genera are common between the grey silty-sandstone bed and brown silty-sandstone bed. These are: *Anadara*, *Chlamys*, *Pecten*, *Cultellus*, *Astarte*, *Corbula*, *Tellina*, *Dosinia*, *Clementia*, *Apolymetis* and *Archimediella*. The palaeoecology of these eleven genera has been discussed under the palaeoecology of grey silty-sandstone bed. Thus the ecology the following eight genera that are confined to the brown silty-sandstone bed is discussed herewith: *Nucula*, *Portlandia*, *Diplodonta*, *Timoclea*, *Gari*, *Paphia*, *Pinna* and *Mactra*.

Nucula is a deposit palp feeder and generally used to live on black mud of continental shelf. The semi-infaunal *Pinna* is a byssate and habitat of sheltered stable substrate, particularly those colonized by marine grasses. *Diplodonta* and *Mactra* belong to shallow burrower infaunal community and are characteristically habitat of soft substratum. *Diplodonta* has semi-permanent burrows connected to the surface by an inhalent tube. *Conus* is a carnivorous and mainly feeds on infaunal polychaetes. *Portlandia* is siphonal suspension feeder, more mobile and prefers to live on soft sediments. The genus *Gari* is restricted to subtropical to tropical seas. It generally inhabits sandy bottoms from the inter-tidal zone to 10m depth (Tiwari, 2006).

So, the overall picture from this assemblage comes to be of sub-littoral sand community (Figure7.2), representing a retreating shoreline because of presence of cross-bedding and disarticulated bivalves shells. This bed represents siliciclastic facies.

The assemblage is generally dominated by epibenthos. Infaunal bivalves prevail over their epifaunal counterparts. Silty-sandstone dominated by relatively coarse angular quartz grains are marked by a considerable decrease in the faunal content. It may imply further shallowing sea during the deposition of these beds. Absence of calcareous sediments may indicate a short-lived regression. It may be the result of basin uplift. Alternatively, it may correspond to the major sea-level falls during Burdigalian-Langhian time (Haq *et al*. 1987).

Palaeogeographically, the basin around western part of Aizawl was a part of the Indo-Pacific Zoogeographical Province. This inference is based on the occurrence of a good number of taxa at the generic level and a few at the species level in the study area that are endemic to Indo-Pacific Province of Miocene Epoch. These are: *Trisidos*, *Lutraria*, *Cultellus*, *Apolymetis*, *Corbula*, *Conus* (*Dendroconus*), *Conus* (*Lithoconus*), *Tellina* (*Tellinella*) and *Clementia papyracea* (Gray).



a	Pecten	b	Crab	c	Chlamys
d	Archimediella	e	Anadara	f	Pinna
g	Timoclea	h	Dosinia	i	Burrow
j	Nucula	k	Cuttellus	l	Clementia
m	Corbula	n	Tellina		

Figure 7.2 : Sub-littoral silt and sand community of brown silty-sandstone bed, Upper Bhuban Unit of the study area (diagram based on Mc Kerrow, 1978)

CHAPTER – 8

SUMMARY

AND

CONCLUSIONS

8. SUMMARY AND CONCLUSIONS

A thick (~8000m) and monotonous shallow marine sedimentary succession belonging to Palaeogene and Neogene are well exposed in Mizoram. This entire sedimentary column is a repetitive succession of arenaceous and argillaceous rocks comprising sandstone, silty-sandstone, siltstone, shale, shaly-sandtones, silty-shale, mudstone and their admixture in varying proportions along with random pockets of shell-limestone and intraformational conglomerates. Sequentially, this succession is grouped in to the Barail, Surma and Tipam Groups. Surma Group covers major portion of the state and is classified in to a lower Bhuban and an upper Boka Bil Formations. The Bhuban Formation is further subdivided into Lower, Middle and Upper Bhuban units solely based on the lithological characteristics *i. e.* ratio of argillaceous and arenaceous components. Barail Group rocks are supposed to occupy the area in and around Champhai bordering Myanmar whereas Tipam Group rocks are known to cover the western and north-western parts of the state (Chapter 2).

It is evident from the survey of the existing literature that the palaeontological wealth of the Surma Group rocks in Mizoram is yet to be fully explored. The present study was taken-up in order to carry out detailed palaeontological investigation in the unexplored areas in and around Aizawl with a view to supplement and up-date the existing palaeontological database of the Upper Bhuban unit of Bhuban Formation (Chapter 1).

Though, the area selected for the present study exposes rock successions belonging to middle and upper units of Bhuban Formation, fossiliferous horizons could be located only in the western part of the study area where Upper Bhuban rocks are exposed. During the course of extensive fieldwork, a number of traverses were made to locate fossiliferous horizons and litho-columns of these fossiliferous localities were prepared. In all, six fossil localities could be delineated out of which four are new ones. Two of these fossil localities are the stone quarries in Tuivamit – a locality nearly 12Km in the western outskirt of Aizawl city whereas the other four occur along the road cut sections in Zonuam and Luangmual localities. The gross lithology and fossil contents of each locality is described in detail in Chapter 2.

The fossils thus collected for systematic studies include mega- and micro-invertebrates and vertebrates. Mega-invertebrates are mainly represented by bivalves, gastropods and decapods. Monogeneric form of foraminifers represents the only micro-fossil whereas as fish remains in the form of teeth, dental plates, spines and parts of vertebral column and presumably one tooth of crocodile belonging to the class Reptilia represent the vertebrate fauna. In addition to this, regular and irregular echinoids have often been encountered in almost all the fossiliferous beds of the study area. But, due to ill-preservation and fragmentary nature of tests, these could not be studied.

Overall mode of preservation of fossils is not so good and these are mostly in the form of moulds and casts. However, a few well-preserved specimens with both the valves intact have also been recovered among the bivalves. The preservation of fish teeth is rather good as compared to the other associated fauna.

The identification of genera and species is mainly based on the external morphological characters and comparison with the description and illustration available in the existing literature. It is also based on the direct comparison with the type specimens housed in the laboratory of Palaeontological Division, Geological Survey of India, Kolkata and Lucknow; Palaeontological Laboratory, Department of Geology, Mizoram University, Aizawl and Department of Geology, Pachhunga University College, Mizoram University, Aizawl.

A total of 98 taxa have been described and illustrated in chapters 3 and 4 and their faunal analysis is provided in chapter 5. Out of these, 58 forms belong to mega-invertebrates, 2 to foraminifers, 37 to fishes and one to crocodylidae?. Fifty-eight species of mega-invertebrates include 44 species of bivalves belonging to 26 genera (11 subgenera) and 17 families, 8 species of gastropods belonging to 5 genera (3 subgenera) and 5 families, and 6 forms of decapods are grouped in to 6 genera and 5 families. Nearly 77 per cent of the forms belonging to mega-invertebrates are found to be extinct.

The 37 species of fishes are distributed to 33 of elasmobranchs and 4 of teleosteans. 31 species of elasmobranches belong to selachians (sharks) and are grouped in to 13 genera belonging to 8 families and 4 orders, whereas the remaining 2 species

are batoids (rays) which are grouped in to 2 genera belonging to one family and order each. *Diodon* is the only genus that represents teleost group of fishes.

A close study of the data reveals that twelve genera, namely, *Arcopsis*, *Cypraea*, *Lamna*, *Alopias*, *Odontaspis*, *Galeocerdo*, *Scoliodon*, *Galeorhinus*, *Squalus*, *Myliobatis*, *Aetobatis* and *Diodon* are being reported for the first time from the Miocene of Mizoram whereas one genus namely, *Clinocardium* is being reported for the first time from the Miocene sediments of Northeastern India. In addition, the subgenus *Carcharhinus* (*Prionodons*) is also being reported for the first time from Miocene beds of Mizoram as well as from the northeastern region of India

The following twelve species are being reported for the first time from the Miocene of Mizoram: *Gari* (*Psammobia*) *kingi* (Noetling), *Neptunus sindensis* Stoliczka, *Palaeocarpilius rugifer* Stoliczka, *Carcharodon angustidens* Agassiz, *Isurus pagoda* Bonnaparte, *Odontapis tricuspidatus*, *Carcharhinus egertoni* Agassiz, *Carcharhinus* cf. *macloti*, *Galeocerdo aduncus* Agassiz, *Negaprion brevirostris* Poey, *Scoliodon sorrakawah* Cuvier, and S*phyrna diplana* Springer.

Two species, namely, *Odontapis* cf. *taurus* and *Negaprion* cf. *eurybathrodon* Blake are being reported for the first time from the Miocene of Northeastern region. A mentioned can also be made here that *Carcharhinus priscus* Agassiz and *Galeorhinus* are being reported for the first time form the Miocene successions of Indian subcontinent.

Among the total faunal assemblage from the present collection, only the following two species are new to science: *Carcharhinus bhubanicus* n. sp. and *Hemipristis unidenticulata* n. sp.

In the light of present record, the age range of *Ficus* (*Ficus*) *conditus* (Brongniart) has been extended upward from Rupelian - Aquitanian to Rupelian - Burdigalian.

Geographical distribution and age range of mega-invertebrate taxa is shown in Table 5.1. Locality-wise occurrence of fossils with their age range has been given in

Table 5.2 of Chapter 5. Overall age of the succession in the study area as well as bed-wise age has also been discussed in the same chapter. By and large, the Bhuban successions of the study area are inferred to be of Aquitanian - Burdigalian age.

Based on some age diagnostic fauna, one Biozone with two Subzones have been proposed in the Upper Bhuban unit of Bhuban Formation in the study area (Chapter 6). These are as follows:

Epoch	Age	Formation	Faunal Zone	
L O W E R M I O C E N E	Aquitanian - Burdigalian to Burdigalian	Upper Bhuban Unit, Bhuban Formation	**Zone – 1.** *Paphia* (*Paphia*) *rotundata* - *Palaeocarpilius rugifer* Zone	**Subzone-1B** *Barbatia* (*Barbatia*) *bataviana* var. *carinata* - *Neptunus sindensis* Subzone
	Aquitanian - Burdigalian	Upper Bhuban Unit, Bhuban Formation		**Subzone-1A** *Gari* (*Gari*) *natensis* Subzone

These biozonations prove to be useful in local as well as regional correlation. Correlation of the Upper Bhuban rocks of the study area has been attempted with those of other areas from Mizoram, and these rocks have also been correlated with the other Miocene localities of the Indian Subcontinent (Chapter 6). It has been found that Subzone - 1A [*Gari* (*Gari*) *natensis* Subzone] of the present area is correlatable with Zone III (*Ostrea latimarginata* - *Natica pellis tigrina* Zone) of Tertiary succession of Mizoram (Tiwari and Kachhara, 2003); Zonule II A-a (*Conus* (*Lithoconus*) *ineditus* – *Diplodonta* (*Diplodonta*) *incerta* Subzone) of Mazumder (2004), Subzone - IA (*Anadara submultiformis* – *Turritella narica baluchistanensis* Subzone) of Lyngdoh *et al*., (1999) from the Garo Hills, Kanchanpur Bed and upper part of Kama Formation of

Myanmar. Subzone - 1B [*Barbatia* (*Barbatia*) *bataviana* var. *carinata* - *Neptunus sindensis* Subzone] is correlatable with Zone - III in part and Zone - IV [*Pecten* (*Oopecten*) *gigas* Zone of Burdigalian age] of Tertiary succession of Mizoram (Tiwari and Kachhara, 2003), Zonule IIA-a in part to Zonule IIA - b [*Conus* (*Dendroconus*) *loroisii – Achimediella* (*Torculoidella*) *angulata* Subzone] to Sub Zone IIB [*Callista* (*Costacallista*) *erycina – Antigona granosa* - *Trisidos semitorta* Subzone] of Mazumder (2004), Subzone - 1B [*Mactra* (*Eomactra*) *protoreevesii – Turritella pinfoldi* Subzone] of Garo Hills (Lyngdoh *et al.*, 1999), Pyalo Formation of Myanmar and Zone - I (*Ostrea protoimbricata – Diplodonta incerta naricum- Aturia aturi* Zone) of Kathiawar (Jain, 1997).

The total number of common taxa between the study area and other Miocene fossil localities of Indian subcontinent along with their respective formations and areas are shown below:

Area	**Formation**	**Number of common taxa**
Aizawl, Lunglei and Kolasib, Mizoram	Bhuban	47
Kanchanpur, Assam	Bhuban	01
Garo Hills, Meghalaya	Dalu, Baghmara and Chengapara	26
Myanmar	Kama	09
Myanmar	Pyalo	08
Kachchh, Gujarat	Gaj	14
Kathiawar, Gujarat	Gaj	10
Sind, Pakistan	Gaj	08

Palaeoecology and depositional environment of the succession based on gross lithology and fossils contents has been dealt with in Chapter 7. It has been inferred that the Upper Bhuban sediments were deposited in an unstable quickly subsiding basin with a high rate of sedimentation under rapidly fluctuating conditions of deltaic to inner neritic environment with fluviatile phases intermittently. This Formation thus represents a complex interfingering of deltaic to marine environment and interruption in sedimentation is rare.

The Upper Bhuban unit of Bhuban Formation of the study area comprises three fossiliferous litho-units namely, Grey silty-sandstone, Brown silty-sandstone and Intraformational conglomeratic bands. Since intraformational conglomeratic bands occur within the grey silty-sandstone bed at locality 1 and 2 and at the top of the brown silty-sandstone bed at locality 5, depositional environment of these have been considered along with the sandstone beds.

Based on overall lithology and palaeoecology of the entombed fauna, it can be inferred that an open shallow, warm sea with fluctuations from inner neritic to littoral water with depth less than 45m meter existed during deposition of grey silty-sandstone bed. The overall picture from this assemblage comes to be of inner-shelf sand and silt community (Figure 7.1), representing a fluctuating shoreline because of the presence of cross-bedding and disarticulated bivalve shells. At the same time, it can also be inferred that fossils were perhaps intra-basinally transported by the bottom currents from a variety of communities of the inter-tidal to near shore shelf, evidenced by infaunal elements characteristics of soft substratum occurring in sandy bottom. A close study of fossil fishes from this bed reveals that all the shark species are nekton forms, dwelling mainly in the neritic to epipelagic regions of the tropical to subtropical seas having mean annual isotherm of about 20^0C. The ecological framework of these fossil fishes also points to the deposition in a warm shallow marine set-up near to the shore line in a high energy environment.

The faunal assemblage of brown silty sandstone bed resemble sub-littoral sand community (Figure7.2), representing a retreating shoreline. This bed represents siliciclastic facies. The assemblage is generally dominated by epibenthos. Infaunal bivalves prevail over their epifaunal counterparts. Silty-sandstone dominated by relatively coarse angular quartz grains are marked by a considerable decrease in the faunal content. It may imply further shallowing sea during the deposition of these beds. Absence of calcareous sediments may indicate a short-lived regression. It may be the result of basin uplift. Alternatively, it may correspond to the major sea-level falls during Burdigalian-Langhian time (Haq *et al*. 1987).

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REFERENCES

REFERENCES

Abbott, R. T. and Dance, S. P. 1982. Compendium of sea-shells. *E. P. Dutton, New York*, 411p.

Adams, A. 1857. The genera of Recent Molluscs, **2**: 2

Ager, D. V. 1963. Principles of Palaeoecology, *Mc Graw Hill Book Co. Inc.*

Antunes, M. T., and Jonet, S. 1970. Requins de' L'Helvetien Supe'rieur et du Tortonien de Lisbonne. *Rev.Fac Cien Lisboa, 2a, Sérié* - C **XVI(1)**: 119 - 280.

Antunes, M. T., Fonseca, B. and Rocha, R. B. 1972. Notes Sur La Géologie Et La Paléontologie Du Miocéne De Lisbonne - XXII, Coupe De L'avenid Paulo VI, Lumiar: *Stratigraphie et Paléontologie Sérié* - C, **17(2)**: 459 - 514.

Antunes, M. T, Jonet, S. and Nascimento, A. 1981. Vertebre (Crocodiliens, Poissons) du Miocene marin de l'algrave occidentale. *Ciencias da Terra (UNL), Lisboa,* 9 - 38p.

Applegate, S. P. 1965. Tooth terminology and variation in sharks with special reference to the sand shark, *Carcharias taurus Rafinesque*. *Los Angeles County Museum Contributions in Science*, **86**: 18

Archiac, d' V. 1850. Hist. Prog. *Géol. Soc. Geol. France*, **3**: 1 - 305.

Archiac, d' V. and Haim, J. 1853. Description des Animaux Fossiles du Groupe Nummulitique de l'Inde., *Proc. Res. Geol. et d'une Monog. des Nummulities*, Paris, 1 - 373p.

Baglioni, A. R. and Piccoli, G. 1972. Aggior namento Delle Conoscenze Sulla Malaco Fauna Miocenica dei Lessimi Vicentini. *Cons. Nazion. del R. icerche*, Mollusca, **28**: 1 - 28.

Bhalla, S. N. and Dev, P. 1975. *Ostrea* in the Miocene Beds of Mayurbhanj, Orissa. *Jour. Geol. Soc. India*, **16(1)**: 93 - 97.

Bhalla, S. N. and Dev, P. 1984. Stratigraphy and micro fauna of the Baripada beds (Middle Miocene), Orissa. *Bull. Ind. Geol. Assoc.*, **17**(**2**): 123 - 132.

Bhalla, S. N. and Dev, P. 1988. Palaeontology of Baripada beds (Middle Miocene), East coast of India. *Bull. Ind. Geol. Assoc.*, **21**(**2**): 141 - 153.

Bhaskar, A. A., Ramamurthy, S., Beeraiah, M. B. and Khalkho, K.B. 1990. Geology of parts of the Aizawl District, Mizoram. *Recent. Geol. Surv. Ind.*, **123**(**4**): 77 - 79.

Bhattacharyya, A. and Sen, M. 1978. In Banerjee, S. P. and Das Gupta, S. Geological mapping in Tuipang area. *Geol. Surv. Ind. Progress Report* (Unpublished).

Bigelow, H. B. and Schroeder, W. C. 1948. Fishes of the Western North Atlantic. part **1**, *Yale University, Connecticut,* 576p.

Biswas, S. K, 1965. A new classification of the Tertiary rocks of Kutch, Western India. *Bull. Geol. Min. Met. Soc. Ind.,* **35**: 1 - 6.

Bouma A. H, 1962. Sedimentology of some flysch deposits: A graphic approach to facies interpretation. *Elsevier, Amsterdam,* 168p.

Bouma A. H, 1969. Methods for the study of Sedimentary structures. *Wiley Interscience, New York,* 458: 6.

Bromley, R. G., Pemberton, S. G. and Rahmani, R. A. 1984. A Cretaceous woodground: the *Teredolites* ichnofacies. *Jour. Paleont.*, **58**: 488 - 498

Brongniart, A. 1823. Mem. térr. séd. *Sup. Vicentin,* 75p, pl. VI

Brunnschweiler, R. O. 1966. On the Geology of the Indo - Burman Range (Arakan Coast and Yoma Chin Hills, Naga Hills). *Jour. Geol. Soc. Australia,* **13**(**1**): 137 - 194.

Cappetta, H. 1987. Chondrichthyes II, Mesozoic and Cenozoic Elasmobranchii in Handbook of Paleoichthyology, (ed.H. P. Schultze). *Gustav Fischer Verlag. Stuttgart. New York,* **3**(**B**): 1 - 193.

Chatterjee, A. K. and Mathur, U. B. 1966. A note on the Nari Series of Kutch, Gujarat. *Bull. Geol. Soc. Ind.,* **3**(**1**): 9 - 11.

Chatterjee, B. P. 1972. In Nandy, D. R. and Mukerjee, R. N.: Geological mapping in parts of Aizawl District, Mizoram. *Geol. Surv. India. Progress Report,* (unpublished).

Clarkson, E. N. K. 1984. Invertebrate Palaeontology and Evolution, (7^{th} ed.), *George Allen & Unwin Ltd., London,* 323p.

Collinson, J. G. and Thompson, D. B. 1982. Sedimentary structures, *George Allen & Unwin Ltd.,* 149p.

Compagno, L. J. V. 1984a. FAO species catalogue. Sharks of the world. An annoteded and illustrated catalogue of shark species known to date, Part 1 – Hexanchiformes to Lamniformes. FAO *Fisheries synopsis,* 125: 1 -249.

Compagno, L. J. V. 1984b. FAO species catalogue. Sharks of the world. An annoteded and illustrated catalogue of shark species known to date, Part 2 – Carcharhiniformes. FAO *Fisheries synopsis*, 125: 251 - 655.

Cossmann, M. 1900. Faune Pliocenique de Karikal. *Jour. de Conch.*, **48**; 14 - 66.

Cossmann, M. and Peyrot, A. 1923. A Brief Sketch of the Tertiary Geology of Burma. *Proc. Pan-Pacific Science Congress* (Australia), **I**: 942 - 949.

Cotter, G. de P. 1923. The Lamellibranchiata of the Eocene of Burma. *Pal. Ind., N. S.*, **7(2)**: 1 - 24.

Cox, L. R. 1927. Neogene and Quarternary Mollusca from the Zanzibar Protectorate. *Rept. Pal. Zanzibar Protectorate,* 13 – 102p, pls. III – XIX.

Cox, L. R. 1930a. Miocene, Pliocene and Post-Pliocene Mollusca in 'Reports on Geological collections from the Coastlands of Kenya Colony' by Miss M. McKinnon. *Monogr. Geol. Dept. Hunterian Mus. Glassgow Univ.*, **4**: 103-130.

Cox, L. R. 1930b. Notes on the Post-Miocene Ostreidae and Pectinidae of the Red Sea Region with remarks on the Geological significance of their distribution. *Proc. Malac. Soc. Lond.*, **18**: 165 - 209.

Cox, L.R. 1933. Miocene Rocks of Arabia. *The Empty Quarter by H. St. J. B. Philby.*, 386 - 387.

Cox, L. R. 1936. Fossil Mollusca from Southern Persia (Iran) and Bahrein Island. *Pal. Ind., N. S.*, **22(2**): 1 - 69.

Cox, L. R. and Hertlein, L. G. 1969. In R. C. Moore *et al*. Treatise on Invertebrate Palaeontology, Bivalvia – Superfamily Pinnacea,. *Geol. Soc. of America and Univ. of Kansas*, (**N**): 281 - 285.

Dall, W. H. 1904. Relation of the Miocene of Maryland to that of other regions and to the Recent fauna. *Maryland Geol. Surv., Miocene*, 139 - 155p.

Dance, S. P. 1974. The Encyclopedia of Shells. Blandford Press, 288p.

Das Gupta, A. B. 1948. Review of the prospects of Lushai Hills structures. *Letter to A.B.D.G.9, B.O.C. Report* (Unpublished).

Das Gupta, A. B. 1977. Geology of Assam - Arakan Region. *Quart. Jour. Geol. Min. Met. Soc. India*, **49**: 1 - 54.

Das Gupta, A. B. and Biswas, A. K. 2000. Geology of Assam. *Geol. Soc. India*, 170p.

Das Gupta, S. 1982. Synthesis and review of the faunal records from the Surma Basin. *Rec. Geol. Surv. India*, **112(IV)**: 31 - 38.

Das Gupta, S. 1984. Tectonic trends in the Surma Basin and possible genesis of folded belt. *Rec. Geol. Surv. Ind.*, **113(IV)**: 58 - 61.

Davies, A. M. 1971. Tertiary Faunas. The composition of the Tertiary Faunas – I (Revised by F. E. Eames and R. J. G. Savage). *George Allen & Unwin Ltd.*, London, 571p.

Davies, A. M. 1975. Tertiary Faunas - II. The sequence of Tertiary Faunas (Revised by F. E. Eames), *George Allen & Unwin Ltd.*, London, 447p.

Dey, A. K. 1962. The Miocene mollusca from Quilon, Kerala (India). *Mem. Pal. India, N. S.*, **36**: 1 - 129.

Donovan, S. K. and Gunter, G. C. 2001. Fossil sharks from Jamaica. *Bull. Mizunami Fossil Museum.* **28**: 211 - 215, pl. 1.

Douglas, J. A. 1928. Contributions to Persian Palaeontology, London, **1 - 3**.

Duncan, P. M. and Sladen, W. P. 1882-86. Fossil Echinoidea of Western Sind and the Coast of Baluchistan and of the Persian Gulf, from Tertiary Formations. *Pal. Ind., Ser. Ser.* 14, **1**(**3**): 392, pl. 58.

Duncan, P. M., Sladen, W. P. and Blanford, W. T. 1883. The Fossil Echinoidea from Kutch and Kathiawar. *Pal. Ind., Ser.* 14, **1**(**3**): 4 - 9, pls. I – XIII.

Dunker, G. 1853. Index Molluscorum quae in itinere ad Guineam inferiorem collegit G. Tams., cassellis a Cattorum; *Navitates conchologiae, supplement* II and III, 132p, pl. 18.

Eames, F. E. 1950a. 'The Pegu System of central Burma', *Rec. Geol. Surv. India*, **81**(**2**): 377 - 388.

Eames, F. E. 1950b. On the age of certain Upper Tertiary beds of Peninsular India and Ceylon. *Geol. Mag. Lond.*, **34**(**4)**: 233 - 252.

Eames, F. E. 1951. A contribution to the study of the Eocene in Western Pakistan and Western India: B. The Description of the Lamellibranchia from standard sections in the Rakhi Nala and Zinda Pir areas of the Western Panjab and in the Kohat District. *Phil. Trans. R. Soc.*, (B), **235**(**627**): 311 - 382.

Eames, F. E. 1952. A contribution to the study of the Eocene in Western Pakistan and

Western India: C. The description of the Scaphopoda and Gastropoda from standard sections in the Rakhi Nala and Zinda Pir areas of the Western Panjab and in the Kohat District. *Phil. Trans. R. Soc.*, (B), **236**(**631**): 1 - 168.

Evans, P. 1932. Tertiary succession in Assam, *Trans.Min. Geol. Inst. Ind.*, **27**(**3**): 155 - 260.

Evans, P. 1964. Tectonic Framework of Assam, *Jour. Geol. Soc. Ind.*, **5**: 80 - 96.

Fedden, F. 1884. The Geology of the Kathiawar Peninsula in Gujarat, India. *Mem. Geol. Surv. Ind.*, **21**(**2**): 1 - 108.

Franklin, W. A. 1948. Photogeological map of Assam and Tripura. *A.O.C. Letter* (unpublished)

Fursich F. T. 1976. Fauna-substrate relationship in the Corallian of England and Normandy. *Lethaia,* **18**: 343 - 356.

Fursich F. T. 1995. Approaches to Palaeoenvironmental reconstructions. *Geobios.*, **18**: 183 - 195.

G.S.I, 1974. Geology and Mineral Resources of the North Eastern States of India, *Misc. Publ., Geol. Surv. India,* **30** (**4**): 93 - 101.

Ganguly, S. 1974. Note on the Structure and Tectonics of Mizoram. *Proc.* 61st *Ind. Sci. Cong. Assoc.*, (III), 132p (Abs.).

Ganguly, S. 1975. Tectonic Evolution of Mizo Hills, *Bull. Geol. Min. Met. Soc. India*, **48**: 28 - 40.

Ganguly, S. 1983. Geology and Hydrocarbon prospects of Tripura - Cachar - Mizoram region. *Jour. Petrol. Asia*, **6**(**IV**): 105 - 109.

Ganguly, S., Dhar, P. C. and Ali, S. R. 1973. Traverses in Mizoram – field season 1972 - 73, *O.N.G.C. Report* (unpublished).

Ganju, J. L. 1971. Report on the Photogeological study of a part of Tripura and Lushai Hills between latitudes 24º - 23º and longitudes 91º 30´ - 83º 20´. *ONGC Report* (unpublished).

Ganju, J. L. 1972. Report on the Photogeological study of a part of Tripura and Lushai Hills (Mizoram). *ONGC Report* (unpublished).

Ganju, J. L. 1974. Report on the detailed Photogeological study of Mizoram between latitudes 22º - 24º 30´ and longitudes 92º 10´- 93º 25´ (with limited field check). *ONGC Report* (unpublished).

Ganju, J. L. 1975. Geology of Mizoram. *Bull. Geol. Min. Met. Soc. Ind.*, **48**: 17 - 26.

Ghosh, B.K. 1959. Some Fossil Fish teeth from Tertiary Deposits of Mayurbhanj, India, *Jour. Pal.*, **33**(**4**): 675 - 679.

Glibert, M. 1957. Pélécypodes et Gastropodes du Rupélian Supérieur et du Chattian de la Belgique. *Mém. inst. r. Sci. Nat. Belg.*, **137**: 1 - 98.

Gmelin, J. F. 1791. Caroli a Linné. *Systema Naturæ*, **1**(**6**): 3327 - 3328.

Hait, A. K. and Banerjee, M. 1994**.** Palynology of lignite sediments from Mizoram, Eastern India with remarks on age and environment of deposition. *Jour. Palynology*, **30**: 113 - 135.

Hanley, C. 1844-1856. Illustrated and descriptive catalogue of recent bivalve shells.

Haq, B. U., Hardenbol, J. and Vail, P. R. 1987. Chronology of fluctuating sea-levels since the Triassic. Science, **235:** 1156 - 1167.

Hayman, R. J. 1937. Reconnaissance map of part of the Lushai Hills. *Report R. J. H.*, BOC, (unpublished), II.

Hoernes, M. 1853. Foss. Moll. Tert. Beckens Wien, Abhand. *K. K. geol. Reich - Sanst, Band*, **III**(**5, 6**): 270.

Hora, S. L. 1939. On two small collections of fossil fish-remains from Balasore, Orissa. *Rec. G. S. I.*, **74**: 199 - 215.

Huang, T. 1964. "Rotalia" group from the upper Cenozoic of Taiwan. Micropaleontology, **10**(**1**): 49 - 62.

Iwasaki, Y. 1970. A Miocene Molluscan Fauna in the Philippines. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, **77**: 205 - 228.

Jain, R. L. 1997. A Study of the Miocene Mollusca from Jamnagar District, Gujarat. *Unpubl. Ph. D. Thesis, M. L. Sukhadia Univ.*, **I** and **II**.

Jaitly, A. K. and Mishra, S. K. 2007. Approaches to Palaeoecology: Acase study from the late Cretaceous (Campanian-Maastrichtian) Benthic Bivalves of Ariyalur, Tamil Nadu. **69**: 97 - 120.

Jauhari, A. K. 1981. Early-middle Miocene benthonic Foraminifera from the Vinjhan-Miani area of Kutch, Western India. *Pal. Soc. Ind.* **26**: 54 - 76.

Jauhari, A. K., Mandaokar, B. D., Mehrotra, R. C., Tiwari, R. P. and Singh, A. P. 2003. Corals and Foraminifera from the Miocene (Upper Bhuban Formation) of Mizoram, India. *Jour. Pal. Soc. Ind.* **48**: 135 - 138.

Jenkins, H. M. 1864. On some Tertiary Mollusca from Mount Séla, Java. *Qurt. Jour. Geol. Soc. Lond.*, **20**: 58.

John, M. K., Chattopadhyaya, G., Singh, G. S. and Patel, N. P. 1990. Systematic Geological mapping in parts of Chhimtuipui District, South Mizoram. *Rec. Geol. Surv. Ind.*, **123**(**4**): 72 - 76.

Jokhan Ram and Venkataraman, B. 1983. Landsat Analysis of Mizoram. *O.N.G.C. Report* (unpublished).

Jokhan Ram and Venkataraman, B.1984. Tectonic frame work and Hydrocarbon Prospects of Mizoram. Proceeding of the symposium on the Petroliferous basions of India, *Petro. Asia Jour.*, **2**: 60 - 65.

Jolping, A. V. and Walker, R. G. 1968. Morphology and origin of ripple drift cross-lamination, with examples from the Pleistocene of Massachusetts. *Jour. Sed. Petrology*, **38**: 971 - 984.

Kanno, S., O'hara, S. and Caagusan, N. L. 1982. Molluscan Fauna from the Tartaro Formation (Upper Miocene) of Central Luzon, Philippines. *Geol. Pal. Southeast Asia*, (Kobayashi *et al.*, eds.), **24**: 51 - 128.

Kanno, S., Amano, K and Noda, H. 1988. Vicarya and its associated molluscan fauna from the Kunnui Formation in Oshamanbe, Southwest Hokkaido. *Saito Ho-on, Kai Spec. Pub*. (Prof. T. Kotaka Commem. Vol): 373 - 389.

Kapesa, L., and Raju, D. S. N. 2007. Langhian (early Middle Miocene) Foraminiferal Assembalge from Bhuban Formation, Mizoram, N E India, *Jour. Geol. Soc. Ind.* **70**: 933 - 938.

Karasawa, H. 1989. Late Cenozoic Elasmobranchs from the Hokuriku district, Central Japan. *Sci. Rep. Kanazawa Univ.*, **34**(**1**)**:** 1 - 57.

Karunakaran, C. 1974. Geology and Mineral resources of the states of India, *Misc. Publ. Geol. Surv. Ind.*, **30**(**IV**): 93 - 101.

Kiener, L. C. 1845-1850. *Species Générale et Iconographie des Coquilles Vivantes.* Paris, Rousseau, **2**.

Kobelt, W., 1891. *Syst. Conch. Cab.*

Kohn, A. J. 1978. The Conidae (Mollusca: Gastropoda) of India. *Jour. Nat. Hist.*, **12**: 295 - 335.

Kotaka, T. and Noda, H. 1977. Additional notes on the Miocene Pitogo fauna of the Bondoc Peninsula, the Philippines. Part 1. Systematic description of Pelecypoda. *Geol. Palaeont. Southeast Asia* (Kobayashi *et al.*, eds.), **18**: 133 - 148.

Kumar, K. and Loyal, R. S. 1987. Eocene Ichthyofauna from the Subathu Formation, North Western Himalaya, India, *Jour. Pal. Soc. Ind*., **32**: 60 - 84.

Lalchawimawii. 2004. Palaeontogical study of the Bhuban Formation at South Hlimen Quarry, Aizawl District, Mizoram. *Unpubl. M.Sc. Dissertation Thesis of Mizoram University*.

Lakhanpal, R. N. 1970. Tertiary flora of India and their bearing on the historical geology of the region. *Taxon*, **19**(**5**): 675 - 694.

Lamarck, J. B. de. 1799. Prodrome Nouvelle Classification des Coquilles. *Mem. Soc. Hist. Nat. Paris*, **I**(**1**): 73.

Lamarck, J. B. de. 1819. *Histoire naturelle des animaux sans Vertèbres*, **9**: 97, (Paris).

Lamarck, J. B. de. 1822. *Histoire naturelle des animaux sans Vertèbres*, 2nd ed. **VI**(**2**): 141p, (Paris).

Lamarck, J. B. de. 1843. *Histoire naturelle des animaux sans Vertèbres*, **VI**(**2**).

Lambert, B. 2003. Micropalaeontological invesrigation in the modern Mahakam delta, East Kalimantan (Indonesia). *Total Fina Elf, manuscript online since March 8, 2003*.

Lamy, E. 1907. Revision des *Arca. Jour. de Conch.*, **55**: 109p.

Lamy, E. 1916. Lucines et Diplodontes de la mer Rouge. *Bull. Mus. Hist. Nat.* Paris, 188p.

Lamy, E. 1921. Revision des Lucinacea. *Jour. de Conch.*, **64**: 335 - 336.

Last, P. R. and Stevens, J. D. 1994. Sharks and rays of Australia. *CSIRO, Australia*, 513p, pl. 84.

La Touche, T. H. D. 1891. Note on the geology of the Lushai Hills. *Rec. Geol. Surv. India*, **24**(**2**): 83 - 141.

Linnaeus, K. 1758. Systema Naturae, ed. 10: 824

Linnaeus, K. 1767 - 68. Systema Naturae, ed. **12**: 1184 - 1327.

Lyell. 1830 - 33. Principles of Geology, **1** - **3**.

Lyngdoh, B. C. 2004. Palaeontological and biostratigraphic studies of Garo Hills, Meghalaya. North east India. *Unpubl. Ph. D. Thesis of Gauhati University*: 287p.

Lyngdoh, B. C., Tiwari, R. P. and Kachhara, R. P. 1999. Miocene Molluscan Biostratigraphy of the Garo Hills, Meghalaya, India. *Jour. Pal. Soc. Ind.*, **44**: 55 - 67.

Mandaokar B. D. 2000. Palynology and palaeoenvironment of the Bhuban Formation (Early Miocene) of Ramrikawn, near Aizawl, Mizoram, India. *Palaeobotanist*, **49**: 317 - 324.

Martin, K. 1879-1880. Die Tertiarschichten auf Java: 67 - 87, pls. XI - XII.

Martin, K. 1883-1887. Tiefbohrungen auf Java. *Samm1.Geol. Reichsmus.*, Leiden, Ser. 1, Bd. III, 1 - 373p.

Martin, K. 1905. Die Fossilien von. Java. *Samm1.Geol. Reichsmus.*, Leiden, N. F. Bd. 1, 221 – 281p, pl. XXXIV.

Mathur, U. B. 1988. Marine Tertiary Larger Invertebrates Fauna of India - A review. *Proc. Symp. on Three decades of Devel. Paleont. Strat.*, Hyderabad, 1980. *Geol. Surv. Ind. Spl. Publ.*, **2**(**II**): 63 - 162.

Mazumder B. I. 2004. A Study of Miocene Invertebrates from the area around Kolasib, Mizoram. *Unpubl. Ph. D. Thesis of Nagaland University, Kohima*, 259p.

Mehrotra, D. K. 1981. Micro Teleost Remains from the Miocene of India, *Jour. Pal. Soc. Ind.*, **25**: 76-84.

Mehrotra, D. K. 1982. On the occurrence of fish remains form the Quilon beds of Kerela Coast, *Jour. Geol. Soc. Ind.*, **23**: 408 - 410.

Mehrotra, D. K. 1984. Additional Fossil Fishes from Mizoram, *Newsletter, Geol. Surv. Ind., N.E.Region*, **3**(**1**)**:** 22.

Mehrotra, D. K., Mishra, V. P., and Srivastava, S. 1973. Miocene Sharks from India, *Rec. Res. Geol. Hind. Publ. Corpn., New Delhi*, **1**: 180 - 200.

Mehrotra, R. C., Mandaokar, B. D., Tiwari, R. P. and Rai, V. 2001. *Teredolites clavatus* from the Upper Bhuban Formation of Aizawl District, Mizoram, India. *Ichnos*, **8**(**1**): 63 - 68.

Mehrotra, R. C., Tiwari, R. P. and Mazumder, B. I. 2003. *Nypa* megafossils from the Tertiary sediments of Northeast India. *Geobios*, **36**: 83 - 92.

Mishra, K. S. 1969. The Fauna of India and Adjacent Countries, Pisces, Elasmobranchii and Holocephalii, *Zool. Sur. India, Calcutta*, 1-276.

Mishra, V. P. 1980. A new species of *Myliobatis* and some shark teeth from the middle Eocene of Kutch, western India., *Jour. Pal. Soc. Ind.*, **23** and **24**: 81 - 85.

Mishra, V. P. 1985. On the occurrence of the Teleost fish *Cybium* in Baripada Beds, Orissa. *Current Trend in Geology – IV Indian Geological Congress*. **7**: 89- 92.

Montagu, G. 1803. *Test. Brit.*, 71p.

Moore, R. C. ***see treatise*** 1969-71. Treatise on Invertebrate Paleontology, Pt. N, Moollusca 6, Bivalvia. *Geol. Soc. America & Univ. Kansas*, **1-3**: N1 - N1224.

Mukerjee, P. N. 1928. General Report for the year 1928. *Rec. Geol. Surv. Ind.*, **61**: 20.

Mukerjee, P. N. 1929. General Report for the year 1929. *Rec. Geol. Surv. Ind.*, **62**: 23 - 25.

Mukerjee, P. N. 1939. The fossil fauna of the Tertiary of Garo Hills, Meghalaya. *Pal. Ind., N. S.*, **28**(**1**): 1-101.

Mukerjee, R. N. and Saxena, A. 1973. Systematic Geological mapping in parts of Lunglei District, Mizoram. *Geol. Surv. Ind. Prog. Rep.*, (unpublished).

Munshi, M. M. 1964. Geological mapping in parts of Mizo Hills, Assam. *Geol. Surv. Ind. Prog. Report*, (unpublished).

Myra Keen 1969. In R. C. Moore *et al*. (eds.). Treaties on Invertebrate Palaeontology, pt. N, Bivalvia-Superfamily, Mactracea, N595 – 619p; Solenacea, N610 - 613p; Tellinacea, N613 - 640p; Arcticacea, N644 - N650p and Veneracea, N670 - 690p. *Geol. Soc. America and Univ. of Kansas.*

Nair. K. K. 1945. On fossil fish-teeth from the Nicobar Island, *Proc. Nat. Inst. Sci. Ind.*, **11**: 149-151.

Nakagawa, T., 1998. Miocene Molluscan Fauna and Paleoenviornment in the Niu Mountains, Fukui Prefecture, Central Japan. *Sci. Rep. Univ. Tsukuba*, Section B, **19**: 61 - 185.

Nandy, D. R. 1972. Style of folding in the Mio-Pliocene of Tripura and Mizoram area and possible role of Basement dislocation fabrics. *Misc. Publ. Geol. Surv. Ind.*, 31p.

Nandy, D. R. 1980. Tectonic Pattern in North – East India. *Indian Jour. Earth Science,* **7** (**1**): 103 - 107.

Nandy, D. R. 1982. Geological Set Up of the Eastern Himalayas and the Patkai-Naga-Arakan-Yoma (India – Burma) Hill ranges in relation to the Indian Plate Movement. *Misc. Publ. Geol. Surv. Ind.*, **41**: 205 - 213.

Nandy, D. R. 1983. The Eastern Himalayas and the Indo-Burman Orogen in relation to the Indian Plate Movement. *Misc. Publ. Geol. Surv. Ind.*, **13**: 153 - 159.

Nandy, D. R., Gupta, S. D., Sarkar, K. and Ganguly, A. 1883. Tectonic Evolution of Tripura - Mizoram Fold Belt., Surma Basin, North East India. *Quart. Jour. Geol. Min. Met. Soc. Ind.*, **35**(**4**): 186 - 194.

Nicol, D.1953. Period of existence of some late Cenozoic pelecypods. *Jour. Pal.* **27**(**5**): 706 - 707.

Nishimoto, H., Tatemastu, M. and Sawada, H. 1980. Fossil skull of Elasmobranch from the Miocene Hokuriku Group, Central Japan. *Ibid.*, 7: 113 - 115, pl. 2.

Noda, H. 1961. The geological significance of the genus *Pecten* from the Pliocene Haizume Formation, Niigata Prefecture, Japan. *Jap. Geol. Geogr.*, **32**(**1**)**:** 9 - 17.

Noda, H. 1991. Biogeographic distribution of the genus Anadara (Mollusca; Bivalvia). *Saito Ho-on, Kai Spec. Pub.*, **3**: 283 - 293.

Noda, H., Kikuchi, Y. and Nikaido, A. 1994. Middle Miocene Molluscan Fauna from the Tamagawa Formation in Ibaraki Prefecture, northern Kanto, Japan. *Sci. Rep. Univ. Tsukuba*, Section B, **15**: 81 - 102.

Noetling, F. 1895. On some marine fossils from the Miocene of Upper Burma. *Mem. Geol. Surv. India*, **27**(**1**): 1 - 45.

Noetling, F. 1898. On some marine fossils from the Miocene of Upper Burma. *Mem. Geol. Surv. Ind.*, 27(1): 1 - 45, pls. I - IX.

Noetling, F. 1901a. Miocene fauna of Burma, *Mem. Pal. Ind.*, **1(3)**: 1 - 378.

Noetling, F. 1901b. Fauna of the Miocene beds of Burma, *Pal. Indica, N S,* **1**(**3**): 372 - 377.

Nomura, S. 1935b. Miocene Mollusca from Shiogama, northeast Honshu, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, **6**: 193 - 234.

Nyst, P. H. 1847. Notice sur deux coq. nouvelles de genre *Crassatella. Bull. Acad. Roy. Belgique*, 2nd ed., **14**: 22p.

Pascoe, E. H. 1908. Marine Fossils in the Yenangyaung Oil Field, Upper Burma. *Rec. Geol. Surv. India*, **36**(**3**): 135 - 240.

Pascoe, E. H. 1973. A Manual of the Geology of India and Burma. *Geol. Surv. India*, (3rd ed.), **3**: 1345 - 2017.

Patil, R. S. 1989. Faunal assemblage from Lunglei area, Mizoram. *News Letter, Geol. Surv. Ind., North Eastern Region*, 8: 6p

Patil, R. S. 1990. Palaeontology of the Upper Bhuban Formation of Lunglei District, Mizoram. *Rec. Geol. Surv. India*, **123**(**IV**): 168 - 169.

Pettijohn, E. J. 1963. Sedimentary Rocks. *CBS Publ. & Distr.*, (3rd ed.): 628p.

Pinfold, E. S. 1919. Two new fossil localities in the Garo Hills. *Rec. Geol. Surv. India*, **50**(**II**): 126 - 129.

Prasad K.N., 1974. Vertebrate fauna from Piram island, Gujrat. *Pal. Indica N S*, **41**: 1-23.

Prashad, B. 1923. Pelecypoda, *Siboga – Expeditie Monogr*., LIIIC(II), 262p.

Purdy, E. G. 1964. Sediment as substrates: In approaches to palaeecology, *Ed. John Imbrie and Norman Newell*, 238 - 269p.

Purdy, R. W. 1990. A key to the common genera of Neogene Shark Teeth, *Nat. Museum Nat. Hist, Washington D. C*, 1-16.

Purdy, R. W. 1996. A key to the common genera of Neogene Shark Teeth, *http:// www. Nmnh. Si. Edu/paleo/shark.html.*

Purushottaman, M. and Vidyasagar, G. 1990 Systematic Geological mapping in parts of Lunglei District, Mizoram. *Recent. Geol. Surv. Ind.*, **123**(**IV**): 80 - 82.

Ram, J. and Venkataraman, B. 1984. Tectonic Framework and Hydrocarbon prospects of Mizoram. *Petrol. Asia Jour.*, **2**: 60 - 65.

Rao, R. A. 1983. Geology and Hydrocarbon potential of a part of Assam - Arakan basin and its Adjacent Region. *Petrol. Asia Jour.*, **6**(**4**): 127 - 158.

Reeve, L. A. 1844. *Conchologia Iconica.*, **2**: 44p.

Reeve, L. A. 1847. Monograph of the genus *Ficula*, sp. 4, *Conchologia Iconica.*, IV.

Reeve, L. A. 1850. *Conchologia Iconica.*, **6**: 36p.

Reeve, L. A. 1864. *Conchologia Iconica.*, **14**.

Pachuau, R. 1994. Geography of Mizoram (1st ed.), *New Aizawl Press, Chanmari, Aizawl,* 54p.

Roup, D. M. and Stanley, S. M. 1971. Principles of Palaeontology, *W. S. Freeman and Co., San Francisco,* 388p.

Sacco, F. 1891. *Moll. Terr. Terz. Piemonte e Della Liguria*, **VIII**: 23p, pl. 1.

Sacco, F. 1893. *Moll. Terr. Terz.Piemonte e Della Liguria,* **VIII**: 23p and **XIII**: 26p.

Sahni, A. and Mehrotra, D. K. 1981. The Elasmobranch Fauna of Coastal Miocene Sediments of Peninsular India. *Biol. Mem.,* **5**(**2**): 83 - 121.

Sahni, A. and Mishra, V. P. 1975. Lower Tertiary Vertebrates from Western India, *Monograph Pal. Soc. Ind. Lucknow,* **3**: 1 - 48.

Sarkar, K. and Nandy, D. R. 1977. Structures and Tectonics of Tripura - Mizoram area, India. *Geol. Surv. India. Misc. Publ.,* **34**(**1**): 141 - 148.

Satsangi, P. P. 1985. A new fossil Finds. *News Letter, Geol. Surv. India* (*NER*), **4**(**1,2**): 5.

Satsangi, P. P. and Parida. K. 1980. A new fossil crab from Garo Hills, Meghalaya. *Jour. Geol. Soc. Ind.,* **21**: 302 - 305.

Satsangi, P. P. and Mehrotra, D. K. 1986. New Fossil Finds. *News Letter, Geol. Surv. India* (*NER*), **5**(**1**): 9.

Satsangi, P. P. and Patil, R. S. 1988. Mega Fossils from Bhuban Formation of Mizoram. *News Letter, Geol. Surv. India* (*NER*), **7**: 11p.

Sengupta, B. K., 1964. Tertiary Biostratigraphy of a part of North Western Kutch. *Jour. Geol. Soc. Ind.,* **5**: 138 - 158.

Shrivastava, B. P., Ramachandran, K. K. and Chaturvedi, J. G. 1979. Stratigraphy of Eastern Mizo Hills. *Bull. ONGC,* **16**(**2**): 87 - 94.

Shuto, T. 1960. On some Pectinids and Venerids from the Miyazaki Group. *Mem. Fac. Sci. Kyushu University.*, Ser. D. **9**(**3**): 119 - 149.

Shuto, T. 1973. Neogene Bivalves from Panay Island, the Philippines. *Geol. Pal. Southeast Asia,* (Kobayashi *et al.*, eds.), **11**: 1 - 74.

Singh, J. and Nayak, K. K. 2004. Biostratigraphy and Palaeoenvironmental Analysis of Subsurface Tertiary Sedimentary Sequences in Navsari Area, Narmada Block. *2nd APG Conference and Exhibition,* 1 - 4p (Abs).

Sinha, N. K. 1973. In systematic geological mapping in parts of Lunglei district, Mizoram. *Prog. Report. Geol. Surv. India* (Unpublished).

Sinha, N. K., Chatterjee, B. P. and Satsangi, P. P. 1982. Status of Palaeontological researches in the North-east States of India. *Rec. Geol. Surv. India,* **112**(**IV**): 66 - 88.

Smith, E. A. 1885. Report on the Lamellibranchiata collected: the Challenger. *Zoology,* XII.

Smith, E. A. 1891. On the collection of Marine Shells from Aden……etc. *Proc. Zoo. Soc. Lond.*: 390 - 436.

Sowerby, J. de C. 1840. Appendix to Capt. Grant on the Geology of Cutch. *Trans. Geol. Soc. Lond.*, Series 2. **5:** 327, pl. XXI – XXVI.

Squires, R. L. 1984. Megapalaeontology of the Eocene Llajas Formation, Simi Valley, Calofornia, *Los Angeles County Natural History Museum, Contributions in Science,* **350**: 76p.

Squires, R. L. 1987. Eocene mollusca palaeontology of the Whitaker peak area, Los Angeles and Ventura Counties, California. *Los Angeles County Natural History Museum, Contributions in Science,* **388**: 93p.

Srivastava, B. P., Ramachandran, K. K. and Chaturvedi, J. G. 1979. Stratigraphy of Eastern Mizo Hills. *Bull. O. N. G. C.*, **16**(**2**): 87 - 94.

Stanley, S. M. 1970. Relation of shell form to life habits in the bivalvia (Mollusca). *Mem. Geol. Soc. Amer.* **125**: 1 - 296.

Stewart, R. B. 1930. Gibb's Californian Fossil Type Gastropoda. *Proc. Acad. Nat. Sci. Philadelphia,* **78**: 193 - 194.

Stoliczka, F. 1871. On some Tertiary Crabs from Sind and Kutch. *Pal. Ind.*, **I**(**1**): 15 - 16, pl. III

Stuart, M. 1910. Fossil fish teeth from Pegu System of Burma. *Rec. Geol. Surv. Ind.*, **38**(**IV**): 292 - 301.

Taki, I. 1951. Handbook of Illustrated Shells.

Tesch, P. 1920. Jungtertiare Und Quartare Mollusken Von Timor. *Pal. Von. Timor,* **14**: 97, pl. CXXXVIII.

Tewari B. S., Chaturvedi, M. N. and Singh M. P. 1964. Two new species of shark teeth from Gaj beds of Matanumarh, Kutch. *Jour. Pal. Soc. Ind.,* **5** (**10**): 74 - 76.

Tiwari, R. P. 1992. Palaeontological and biostratigraphic studies of the Surma Group rocks around Aizawl and Lunglei, Mizoram, India. *Unpubl. Ph. D. Thesis of Gauhati University,* 287p.

Tiwari, R. P. 2001. Neogene Palaeontology of the Surma Group, Mizoram, India. 1 - The Arcoida (Mollusca : Bivalvia), *Jour. Pal. Soc. India,* **46**: 147 - 160.

Tiwari, R. P. 2006. Neogene Palaeontology of the Surma Group, Mizoram, India. 2- The Tellinoidea (Mollusca: Bivalvia), *Jour. Pal. Soc. India,* **51** (1): 33 - 42.

Tiwari, R. P. and Bannikov, A. F. 2001. Early Miocene marine fishes from the Surma Group, Mizoram India. *Bollettino del Museo Civico di Storia Naturale di Verona, Geologia Paleontologia Preistoria,* **25**: 11 - 26.

Tiwari, R. P. and Kachhara, R. P. 2000. Two new species of *Apolymetis* (Bivalvia: Tellinidae) from the Miocene of Mizoram, India, *Tertiary Research*, **20**(**1-4**): 79 - 84.

Tiwari, R. P. and Kachhara, R. P. 2003. Molluscan Biostratigraphy of the Tertiary sediments of Mizoram, India. *Jour. Pal. Soc. Ind.*, **48**: 65 - 88.

Tiwari, R. P. and Mehrotra, R. C. 2000. Study of fossil wood from the Tipam Group (Neogene) of Mizoram, India, *Tertiary Research*, **20**(**1-4**): 85 - 94.

Tiwari, R. P. and Mehrotra, R. C. 2002. Plant Impressions from the Barail Group of Champhai – Aizawl Road section, Mizoram, India. *Phytomorphology*, **52**(**1**): 69 - 76.

Tiwari, R. P. and Satsangi, P. P. 1988. Fossil crab from Mizoram, *Curr. Sci.*, **57**(**7**): 956 - 958.

Tiwari R. P., Khare, P., Barman, G. and Rao, M. N. 1989. Geology and Structures along Sairang – Tuirial road section. *Proc. 76th Ind. Sci. Cong.*, **III**.

Tiwari, R. P., Barman, G. and Satsangi, P. P. 1997. Miocene crabs from Mizoram, India, *Jour. Pal. Soc. India*, **42**: 127 - 132.

Tiwari, R. P., Mishra, V. P. and Lyngdoh, B. C. 1998a. Lower Miocene fish teeth from Mizoram, India, *Geosci. Jour.*, **19**(**1**): 9 - 17.

Tiwari, R. P., Kachhara, R. P. and Lyngdoh, B. C. 1998b**.** Palaeontological and Sedimentological studies (in Mizoram and Meghalaya) for documenting collision of East Indian and South China - Myanmar block. *DST Project report* (unpublished), 84p.

Tiwari, R. P., Lalchawimawii & Ralte, V. Z. 2005. Neogene Palaeontology of South Hlimen Quarry, Aizawl, Mizoram. *Proc. Nat. Sem. Geology & Energy Resources of NE India*: Process and Perspective, 2 - 3p.

Tiwari, R. P., Malsawma, J., Sangode, S. J. and Arora, B. R. 2007. Magnetostratigraphy of a part of Middle Bhuban sequence (Surma Group), Aizawl, Mizoram, *Jour. Geol. Soc. of India,* **70** (**4**): 667 - 674.

Trivedi, A.N., 1966. A note on the Finding of Vertebrate fauna in the Surma Series of Tripura and its bearing on the stratigraphy of the area, *Curr. Sci.,* **3**: 68 - 69.

Tryon, G. W. 1880-1890. Manual of Concology, *Philadelphia*, 2 - 12.

Van Der Vlerk, I. M. 1931. The Tertiary. *Leidsche Geologische Mededeelingen, Deel*. **5**: 611 - 648.

Vredenburg, E. W. 1906. Classification of Tertiary System in Sind with reference to zonal distribution of Echinoidea . *Rec. Geol. Surv. India,* **34**(**3**): 303 - 337.

Vredenburg, E. W. 1908. Preliminary note on the Indian occurrence of *Ostrea latimarginata. Rec. Geol. Surv. India*, **36**(**4**): 317 - 324.

Vredenburg, E. W. 1921a. Results of the Revision of Dr. Noetling's second monograph on the Tertiary Fauna of Burma. *Rec. Geol. Surv. India*, **51**(**3**): 224 - 302.

Vredenburg, E. W. 1921b. Note on the marine fossils collected by Mr. Pinfold in the Garo Hills. *Rec. Geol. Surv. India,* **51**(**3**): 303 - 337.

Vredenburg, E. W. 1925. Description of the Mollusca from the post-Eocene Tertiary Formation of north-western India: Cephalopoda, Opisthobranchiata, Siphonostomata. *Mem. Geol. Surv. India*, **50**(**1**): 1 - 322.

Vredenburg, E. W. 1928. Description of Mollusca from the post-Eocene Tertiary Formation of north-western India: Gastropoda (in part) and Lamellibranchiata. *Mem. Geol. Surv. India,* **50**(**2**): 351 - 506.

Wood, W. V. 1850. Crag Mollusca, **2**(**2**): 144p.

Yabe, H. and Hirayama, R, 1994. Selachian Fauna from the Upper Miocene Senhata Formation, Boso Peninsula, Central Japan, *Nat. His. Museum Inst. Chiba, Jap.*, 33 - 59p.

Alphabetic index of species

93	*Trisidos semitorta* (Lamarck)	31
94	*Typilobus granulosus* Stocliczka	79
95	*Xantho* sp.	82
96	Carcharhinidae gen. et sp. indet.	113
97	Indeterminate vertebral centra of selachians	113
98	Indeterminate tooth of Crocodylidae	119

PLATES

Plate 1

Locality 1: Bika Quarry, University road, Tuivamit, Aizawl

Locality 2: Ruata Quarry, Near Ramrikawn, Tuivamit, Aizawl

Locality 3: Near Youth Hostel, Luangmual, Aizawl

Locality 4: Near Faith Academy, Zonuam, Aizawl

Locality 5: Luangmual Govt. Complex, Aizawl

Locality 6: Govt. Complex Road, Zonuam, Aizawl

EXPLANATION OF PLATE 2

Figure	Explanation
1.	Boring within the calcareous boulder in lower intraformational conglometaric band at Locality 1
2.	Boring within the calcareous boulder in lower intraformational conglometaric band at Locality 2
3.	Worm burrows (branched) within grey silty-sandstone bed at Locality 2
4.	Worm burrows (horizontal) within brown silty-sandstone bed at Locality 5
5.	Lower intraformational conglometaric band (weathered) along the nallah at Locality 2.
6.	External moulds of gastropods within brown sily-sandstone bed at Locality 4
7.	Amber within grey sily-sandstone at Locality 1.
8.	Flaser bedding overlain by parallel bedding and ripple-drift cross lamination in grey silty-sandstone at Locality 2.

Plate 2

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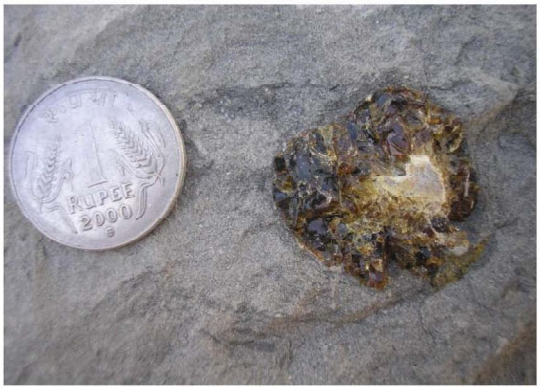

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EXPLANATION OF PLATE 3

Figure	Explanation	Page
1a	*Nucula* (*Nucula*) *agrawali* Tiwari - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality no. 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 216, exterior of left valve. (X 1.20)	28
1b	*Nucula* (*Nucula*) *agrawali* Tiwari - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality no. 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 216, exterior of right valve. (X 1.20)	28
2a	*Nucula* (*Nucula*) *agrawali* Tiwari - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality no. 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 217, exterior of leftt valve. (X 1.00)	28
2b	*Nucula* (*Nucula*) *agrawali* Tiwari - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality no. 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 217, exterior of right valve. (X 1.00)	28
3	*Portlandia* (*Portlandia*) *ovatoelongata* Mazumder - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality no. 6 (Govt. Complex road, Zonuam, Aizawl). Sp. no. B/GZ - 218, exterior of right valve. (X 1.50)	29
4	*Barbatia* (*Barbatia*) *bataviana* Martin var**.** *carinata* Noetling - Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no.B/R - 59, exterior of right valve. (X 1.20)	30
5	*Barbatia* (*Barbatia*) *bataviana* Martin var**.** *carinata* Noetling - Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no.B/R - 60, exterior of right valve. (X 1.20)	30
6	*Barbatia* sp.- Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. no. B/B - 55, exterior of right valve. (X 1.00)	30
7	*Trisidos semitorta* (Lamarck) - Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 57, exterior of left valve. (X 1.00)	31
8a	*Anadara* (*Anadara*) *craticulata* (Nyst) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp.no. B/GZ - 220, exterior of right valve. (X 1.20)	32

Plate 3

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EXPLANATION OF PLATE 3

Figure	Explanation	Page
8b	*Anadara* (*Anadara*) *craticulata* (Nyst) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp.no. B/GZ - 220, exterior of left valve. (X 1.20)	32
9	*Anadara* (*Anadara*) *craticulata* (Nyst) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp.no. B/GZ - 221, exterior of right valve. (X 1.50)	32
10	*Anadara* (*Anadara*) *daviesi* Mukerjee - upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 64, exterior of left valve. (X 1.20)	33
11	*Anadara* (*Anadara*) *daviesi* Mukerjee - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 3 (near Youth Hostel, Luangmual, Aizawl). Sp. no. B/YL - 63, exterior of left valve. (X 1.50)	33
12	*Anadara* (*Anadara*) *garoensis* Mukerjee - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. B/R - 86, exterior of left valve. (X 1.00)	34
13	*Anadara* (*Anadara*) *luangmualensis* Tiwari - Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 58, exterior of left valve. (X 1.50)	35
14	*Anadara* (*Anadara*) *trapezoida* Tiwari - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 62, exterior of left valve. (X 1.00)	36
15	*Arcopsis* sp. - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 56, exterior of right valve. (X 1.50)	36
16	*Pinna* (*Pinna*) cf. *rudis* Linné - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 227, exterior of left valve. (X 1.00)	37
17	*Chlamys* (*Argopecten*) *senatoria* (Gmelin) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 3 (near Youth Hostel, Luangmual, Aizawl). Sp. no. B/YL - 86, exterior of right valve. (X 2.00)	38

EXPLANATION OF PLATE 3

Figure	Explanation	Page
18	*Chlamys* (*Argopecten*) *senatoria* (Gmelin) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. B/B - 87, exterior of right valve. (X 1.50)	38
19	*Chlamys* (*Argopecten*) *senatoria* (Gmelin) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 3 (near Youth Hostel, Luangmual, Aizawl). Sp. no. B/FZ - 88, exterior of left valve. (X 1.50)	38
20a	*Pecten* (*Pecten*) *mathuri* Tiwari MS - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 3 (near Youth Hostel, Luangmual, Aizawl). Sp. no. B/YL - 91, exterior of left valve. (X 1.20)	39
20b	*Pecten* (*Pecten*) *mathuri* Tiwari MS - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 3 (near Youth Hostel, Luangmual, Aizawl). Sp. no. B/YL - 91, exterior of right valve. (X 1.20)	39

EXPLANATION OF PLATE 4

Figure	Explanation	Page
1	*Pecten* (*Pecten*) *mathuri* Tiwari MS - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 93, exterior of right valve. (X 1.50)	39
2	*Diplodonta (Diplodonta) incerta* d'Archiac - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 3 (near Youth Hostel, Luangmual, Aizawl). Sp. no. B/YL - 20, exterior of right valve. (X 1.20)	41
3a	*Diplodonta (Diplodonta) incerta* d'Archiac - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 233, exterior of left valve. (X 1.00)	41
3b	*Diplodonta (Diplodonta) incerta* d'Archiac - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 233, exterior of right valve. (X 1.00)	41
4	*Diplodonta* (*Diplodonta*) *rotundatus* (Montagu) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 232, exterior of right valve. (X 1.20)	41
5	*Cyclocardia* sp. - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 114, exterior of right valve. (X 1.00)	43
6	*Cyclocardia* sp. - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B-117, exterior of right valve. (X 1.20)	43
7	*Cyclocardia* sp. - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 115, exterior of right valve. (X 1.00)	43
8a	*Astarte* (*Bythiamena*) *striata* Tiwari - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 3 (near Youth Hostel, Luangmual, Aizawl). Sp. no. B/YL-, exterior of left valve. (X 1.50)	44
8b	*Astarte* (*Bythiamena*) *striata* Tiwari - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 3 (near Youth Hostel, Luangmual, Aizawl). Sp. no. B/YL - 11, exterior of right valve. (X 1.50)	44
9a	*Astarte* (*Bythiamena*) *striata* Tiwari - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 234, exterior of right valve. (X 1.00)	44

Plate 4

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EXPLANATION OF PLATE 4

Figure	Explanation	Page
9b	*Astarte* (*Bythiamena*) *striata* Tiwari - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 234, exterior of left valve. (X 1.00)	44
10	*Clinocardium* sp. - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 106, exterior of left valve. (X 1.00)	45
11	*Mactra* (*Mactra*) *protoreevesii* Noetling - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 29, exterior of left valve. (X 1.50)	46
12a	*Lutraria philippinarum* Reeve - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 7, exterior of left valve. (X 1.00)	47
12b	*Lutraria philippinarum* Reeve - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B-7, exterior of right valve. (X 1.00)	47
13a	*Lutraria philippinarum* Reeve - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 9, exterior of right valve. (X 1.00)	47
13b	*Lutraria philippinarum* Reeve - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 9, exterior of left valve. (X 1.00)	47
14a	*Lutraria philippinarum* Reeve - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 6, exterior of right valve. (X 1.00)	47
14b	*Lutraria philippinarum* Reeve - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 6, exterior of left valve. (X 1.00)	47
15	*Lutraria saigengai* Tiwari - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 1, exterior of left valve. (X 1.00)	48
16	*Cultellus* (*Cultellus*) *zulloi* Tiwari - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 238, exterior of right valve. (X 1.00)	48
17	*Cultellus* sp. - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 200, exterior of left valve. (X 1.00)	49

EXPLANATION OF PLATE 5

Figure	Explanation	Page
1	*Cultellus* sp. - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 200, exterior of right valve. (X 1.00)	49
2a	*Tellina* (*Angulus*) sp. - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 242, exterior of right valve. (X 1.00)	50
2b	*Tellina* (*Angulus*) sp. - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 242, exterior of left valve. (X 1.00)	50
3a	*Tellina* (*Angulus*) sp. - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ-241, exterior of left valve. (X 1.00)	50
3b	*Tellina* (*Angulus*) sp. - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 241, exterior of right valve. (X 1.00)	50
4	*Tellina* (*Eurytellina*) cf. *pilgrimi* Cox - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 251, exterior of right valve. (X 1.20)	51
5a	*Tellina* (*Moerella*) *indifferens* Noetling - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 252, exterior of left valve. (X 1.00)	52
5b	*Tellina* (*Moerella*) *indifferens* Noetling - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 252, exterior of right valve. (X 1.00)	52
6a	*Tellina* (*Moerella*) *indifferens* Noetling - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 253, exterior of right valve. (X 1.00)	52
6b	*Tellina* (*Moerella*) *indifferens* Noetling - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 253, exterior of left valve. (X 1.00)	52
7	*Tellina* (*Tellinella*) *loknathi* Tiwari - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 15, exterior of right valve. (X 1.00)	52

Plate 5

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EXPLANATION OF PLATE 5

Figure	Explanation	Page
8a	*Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari & Kachhara - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ-258, exterior of left valve. (X 1.00)	53
8b	*Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari & Kachhara - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ-258, exterior of right valve. (X 1.00)	53
9	*Apolymetis* (*Apolymetis*) *aizawlensis* Tiwari & Kachhara - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ-259, exterior of left valve. (X 1.00)	53
10a	*Apolymetis* (*Apolymetis*) *grimesi* Noetling - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ-263, exterior of right valve. (X 1.00)	54
10b	*Apolymetis* (*Apolymetis*) *grimesi* Noetling - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 263, exterior of left valve. (X 1.00)	54
11	*Apolymetis* (*Apolymetis*) *grimesi* Noetling - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R-12, exterior of right valve. (X 1.00)	54
12a	*Apolymetis* (*Apolymetis*) *grimesi* Noetling - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 262, exterior of right valve. (X 1.00)	54
12b	*Apolymetis* (*Apolymetis*) *grimesi* Noetling - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 262, exterior of left valve. (X 1.00)	54
13	*Gari* (*Gari*) *natensis* Noetling - Brown-silty sandstone of Upper Bhuban unit, Bhuban Formation; Locality 4 (near Faith Academy School, Zonuam, Aizawl). Sp. no. B/FZ - 23, exterior of right valve. (X 2.50)	55
14	*Gari* (*Psammobia*) *kingi* (Noetling) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 264, exterior of right valve. (X 1.00)	56
15a	*Glossus* (*Cytherocardia*) *cytheroides* (Mayer) - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 48, exterior of right valve. (X 1.20)	57
15b	*Glossus* (*Cytherocardia*) *cytheroides* (Mayer) - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 48, exterior of left valve. (X 1.20)	57

EXPLANATION OF PLATE 6

Figure	Explanation	Page
1	*Callista* (*Callista*) *pseudoumbonella* Vredenburg - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 5, exterior of right valve. (X 1.20)	58
2	*Callista* (*Costacallista*) *erycina* (Linne') - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. B/R - 42(a), exterior of right valve. (X 1.00)	59
3	*Dosinia* (*Dosinia*) *peralta* Vredenburg - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 3, exterior of right valve. (X 1.20)	60
4	*Dosinia* (*Dosinia*) *peralta* Vredenburg - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 4, exterior of right valve. (X 1.50)	60
5	*Dosinia* (*Dosinia*) *subpenicillata* Vredenburg - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 19, exterior of left valve. (X 1.00)	61
6	*Dosinia* (*Dosinia*) *subpenicillata* Vredenburg - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 25, exterior of left valve. (X 1.00)	61
7	*Clementia* (*Clementia*) *papyracea* (Gray) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 266, exterior of right valve. (X 1.50)	61
8a	*Clementia* (*Clementia*) *papyracea* (Gray) - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 8, exterior of right valve. (X 2.00)	61
8b	*Clementia* (*Clementia*) *papyracea* (Gray) - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 8, exterior of left valve. (X 2.00)	61
9a	*Clementia* (*Clementia*) *papyracea* (Gray) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 2, exterior of right valve. (X 1.00)	61

Plate 6

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EXPLANATION OF PLATE 6

Figure	Explanation	Page
9b	*Clementia* (*Clementia*) *papyracea* (Gray) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 2, exterior of left valve. (X 1.00)	61
10a	*Paphia* (*Paphia*) *rotundata* (Linne') - Brown-silty sandstone of Upper Bhuban unit, Bhuban Formation; Locality 4 (near Faith Academy School, Zonuam, Aizawl). Sp. no. B/FZ - 21, exterior of left valve. (X 1.50)	63
10b	*Paphia* (*Paphia*) *rotundata* (Linne') - Brown-silty sandstone of Upper Bhuban unit, Bhuban Formation; Locality 4 (near Faith Academy School, Zonuam, Aizawl). Sp. no. B/FZ - 21, exterior of right valve. (X 1.50)	63
11	*Paphia* (*Paphia*) *rotundata* (Linne') - Brown-silty sandstone of Upper Bhuban unit, Bhuban Formation; Locality 4 (near Faith Academy School, Zonuam, Aizawl). Sp. no. B/FZ - 30, exterior of right valve. (X 1.00)	63
12a	*Paphia* (*Paphia*) *rotundata* (Linne') - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 269, exterior of left valve. (X 1.00)	63
12b	*Paphia* (*Paphia*) *rotundata* (Linne') - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 269, exterior of right valve. (X 1.00)	63
13	*Paphia* (*Paphia*) *rotundata* (Linne') - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. B/GZ - 268, exterior of right and left valve. (X 1.00)	63
14a	*Paphia* (*Paphia*) *jhai* Tiwari MS - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 215, exterior of left valve. (X 2.00)	61
14b	*Paphia* (*Paphia*) *jhai* Tiwari MS - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 215, exterior of right valve. (X 2.00)	61
15a	*Paphia* (*Paphia*) *jhai* Tiwari MS - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 22, exterior of right valve. (X 1.00)	61
15b	*Paphia* (*Paphia*) *jhai* Tiwari MS - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 22, exterior of left valve. (X 1.00)	61

EXPLANATION OF PLATE 6

Figure	Explanation	Page
16	*Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 272, exterior of right valve. (X 1.50)	64
17	*Paphia* (*Callistotapes*) *pseudoliratus* Vredenburg - Brown-silty sandstone of Upper Bhuban unit, Bhuban Formation; Locality 4 (near Faith Academy School, Zonuam, Aizawl). Sp. no. B/FZ-40, exterior of right valve. (X 2.00)	64
18	*Timoclea* (*Timoclea*) *scabra* (Hanley) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. B/LG - 273, exterior of left valve. (X ~ 2.50)	65

EXPLANATION OF PLATE 7

Figure	Explanation	Page
1	*Timoclea* (*Timoclea*) *scabra* (Hanley) - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 3 (near Youth Hostel, Luangmual, Aizawl). Sp. no. B/YL - 83, exterior of left valve. (X 2.50)	65
2	*Corbula* (*Corbula*) *mekranica* Vredenburg - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 203, exterior of right valve. (X 2.50)	67
3	*Corbula tunicosulcata* Vredenburg - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 54, exterior of right valve. (X 2.50)	67
4	*Corbula tunicosulcata* Vredenburg - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. B/B - 204, exterior of right valve. (X 2.50)	67
5(a)	*Archimediella* (*Torculoidella*) *angulata* (Sowerby) - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. G/B - 26, apertural view. (X 2.00)	69
5(b)	*Archimediella* (*Torculoidella*) *angulata* (Sowerby) - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. G/B - 26, apertural view. (X 2.00)	69
6	*Archimediella* (*Torculoidella*) *angulata* (Sowerby) - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. G/B - 27, apertural view. (X 2.00)	69
7	*Cypraea* sp. - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. G/B - 7, apertural view. (X 2.00)	71
8	*Cypraea* sp. - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. G/B - 8, apertural view. (X 2.00)	71
9	*Ficus* (*Ficus*) *ficus* (Linne') - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. G/R - 3, abapertural view. (X 1.50)	71
10	*Ficus* (*Ficus*) *kachhensis* (Vredenburg) - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. G/B - 9, abapertural view. (X 1.50)	72

Plate 7

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EXPLANATION OF PLATE 7

Figure	Explanation	Page
11	*Ficus (Ficus) conditus* (Brongniart) - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. G/R - 4, abapertural view. (X 1.20)	73
12	*Murex maegillivrayi* Dohrn - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. G/R - 2, abapertural view. (X 1.50)	74
13	*Conus* (*Leptoconus*) *bonneti* Cossmann - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. G/B - 16, abapertural view. (X 2.00)	75
14	*Conus* (*Leptoconus*) *bonneti* Cossmann - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. G/R - 13, abapertural view. (X 2.00)	75
15	*Conus* (*Dendroconus*) *loroisii* Kiener - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. G/R - 10, abapertural view. (X 2.00)	76
16(a)	*Conus* (*Dendroconus*) *loroisii* Kiener - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. G/R - 12, abapertural view. (X 1.00)	76
16(b)	*Conus* (*Dendroconus*) *loroisii* Kiener - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. G/R - 12, apical view. (X 1.50)	76
17	*Conus* (*Dendroconus*) *loroisii* Kiener - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. G/R - 25, abapertural view. (X 1.50)	76

EXPLANATION OF PLATE 8

Figure	Explanation	Page
1	*Calappa protopustulosa* Noetling - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. C/B - 7, dorsal view of the carapace. (X 2.00)	78
2	*Calappa protopustulosa* Noetling - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. C/B - 9, dorsal view of the carapace. (X 1.50)	78
3	*Typilobus granulosus* Stocliczka - Upper Intraformational Conglomerate of Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. no. C/R - 8, dorsal view of the carapace. (X 4.00)	79
4	*Ebalia tuberculata* Noetling - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 6 (Govt. Complex Road, Zonuam, Aizawl). Sp. no. C/GZ - 17, dorsal view of the carapace. (X 4.00)	78
5(a)	*Neptunus sindensis* Stoliczka - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. C/B - 2, ventral view of cephalothorax. (X 1.50)	81
5(b)	*Neptunus sindensis* Stoliczka - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. C/B-2, dorsal view of the carapace. (X 1.50)	81
6	*Neptunus sindensis* Stoliczka - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. C/B - 6, dorsal view of the carapace. (X 2.00)	81
7	*Neptunus sindensis* Stoliczka - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. C/B - 3, dorsal view of the carapace. (X 2.00)	81
8	*Neptunus sindensis* Stoliczka - Brown silty-sandstone of Upper Bhuban unit, Bhuban Formation; Locality 5 (Luangmual Govt. Complex, Aizawl). Sp. no. C/LG - 4, dorsal view of the carapace. (X 2.00)	81
9(a)	*Xantho* sp. - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. C/B - 5, dorsal view of the carapace. (X 3.00)	82
9(b)	*Xantho* sp. - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. C/B - 5, ventral view of cephalothorax. (X 3.00)	82
10.	*Palaeocarpilius rugifer* Stoliczka - Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl). Sp. no. C/B - 11, dorsal view of the carapace. (X 1.20)	82

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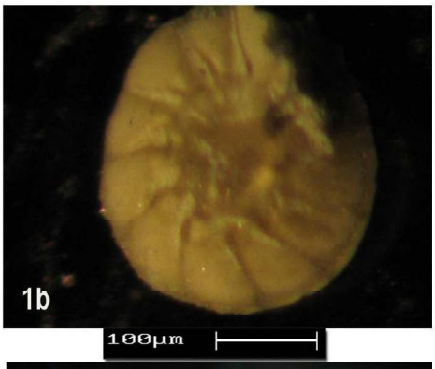
EXPLANATION OF PLATE 9

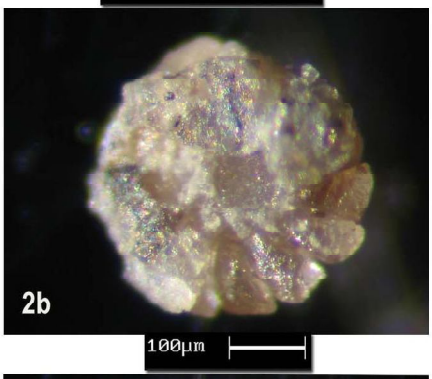
Figure	Explanation	Page
1a	*Ammonia annectens concinna* Millet-Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. F/B - 1, spiral view. (X 150.00)	84
1b	*Ammonia annectens concinna* Millet-Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. F/B - 1, umbilical view. (X 150.00)	84
2a	*Ammonia* sp.- Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. F/B - 3, spiral view. (X 150.00)	85
2b	*Ammonia* sp.- Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. F/B - 3, umbilical view. (X 150.00)	85
3a	*Ammonia* sp.- Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. F/B - 4, spiral view. (X 150.00)	85
3b	*Ammonia* sp.- Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. F/B - 4, umbilical view. (X 150.00)	85
4	*Ammonia* sp.- Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. F/B - 5, Thin section. (X 150.00)	85
5	*Ammonia* sp.- Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. F/B - 6, Thin section. (X 150.00)	85
6	*Ammonia annectens concinna* Millet-Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. F/B - 7, umbilical view under SEM. (X 63.00)	84
7	*Ammonia annectens concinna* Millet-Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl). Sp. no. F/B - 7, spiral view under SEM. (X 90.00)	84

Plate 9


1a
100µm


1b
100µm


2a
100µm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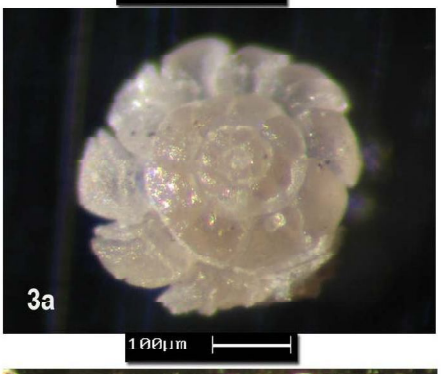
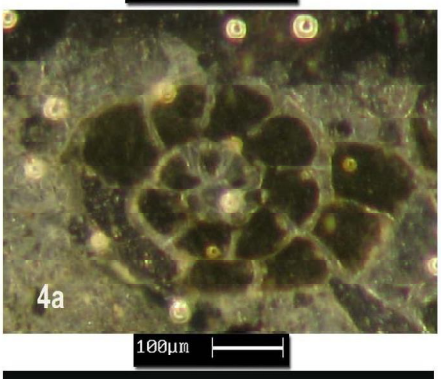
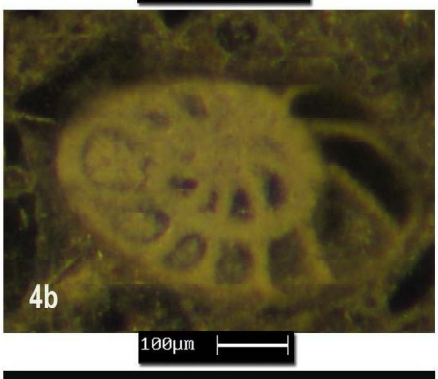
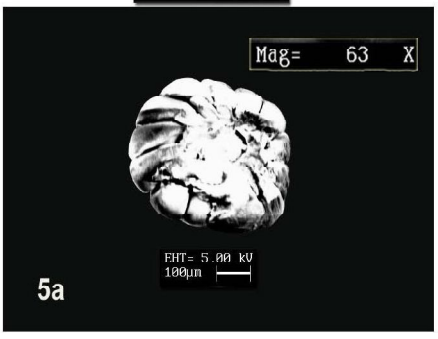

3a
100µm


3b
100µm


4a
100µm


4b
100µm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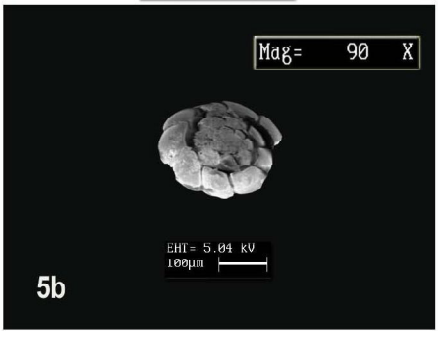
EHT= 5.00 kV
100µm
5a


Mag= 90 X
EHT= 5.04 kV
100µm
5b

EXPLANATION OF PLATE 10

Figure	Explanation	Page
1a	*Lamna* sp. - Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B - 32, Internal view X 2.00	87
1b	*Lamna* sp. -Upper intraformational conglomeratic band, Upper Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B - 32, External view X 2.00	87
2a	*Lamna* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -33, External view X 2.00	87
2b	*Lamna* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B - 33, Internal view X 2.00	87
3a	*Carcharodon carcharias* Linnaeus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -16, External view X 2.00	87
3b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -16, Internal view X 2.00	87
4a	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -17, External view X 2.00	87
4b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -17, Internal view X 2.00	87
5a	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -20, External view X 2.00	87
5b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -20, Internal view X 2.00	87

Plate 10


1a


1b


2a


2b


3a


3b


4a


4b


5a


5b


6a


6b


7a


7b


8a


8b


9a


9b


10a


10b


11a


11b


12a


12b


13a


13b


14a


14b


15


16

EXPLANATION OF PLATE 10

Figure	Explanation	Page
6a	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -19, External view X 2.00	87
6b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -19, Internal view X 2.00	87
7a	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -18, Internal view X 2.00	87
7b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -18, External view X 2.00	87
8a	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -22, Internal view X 2.00	87
8b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -22, External view X 2.00	87
9a	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -43, Internal view X 2.00	87
9b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -43, External view X 2.00	87
10a	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -44, External view x 2.00	87
10b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -44, Internal view X 2.00	87
11a	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -45, Internal view X 2.00	87

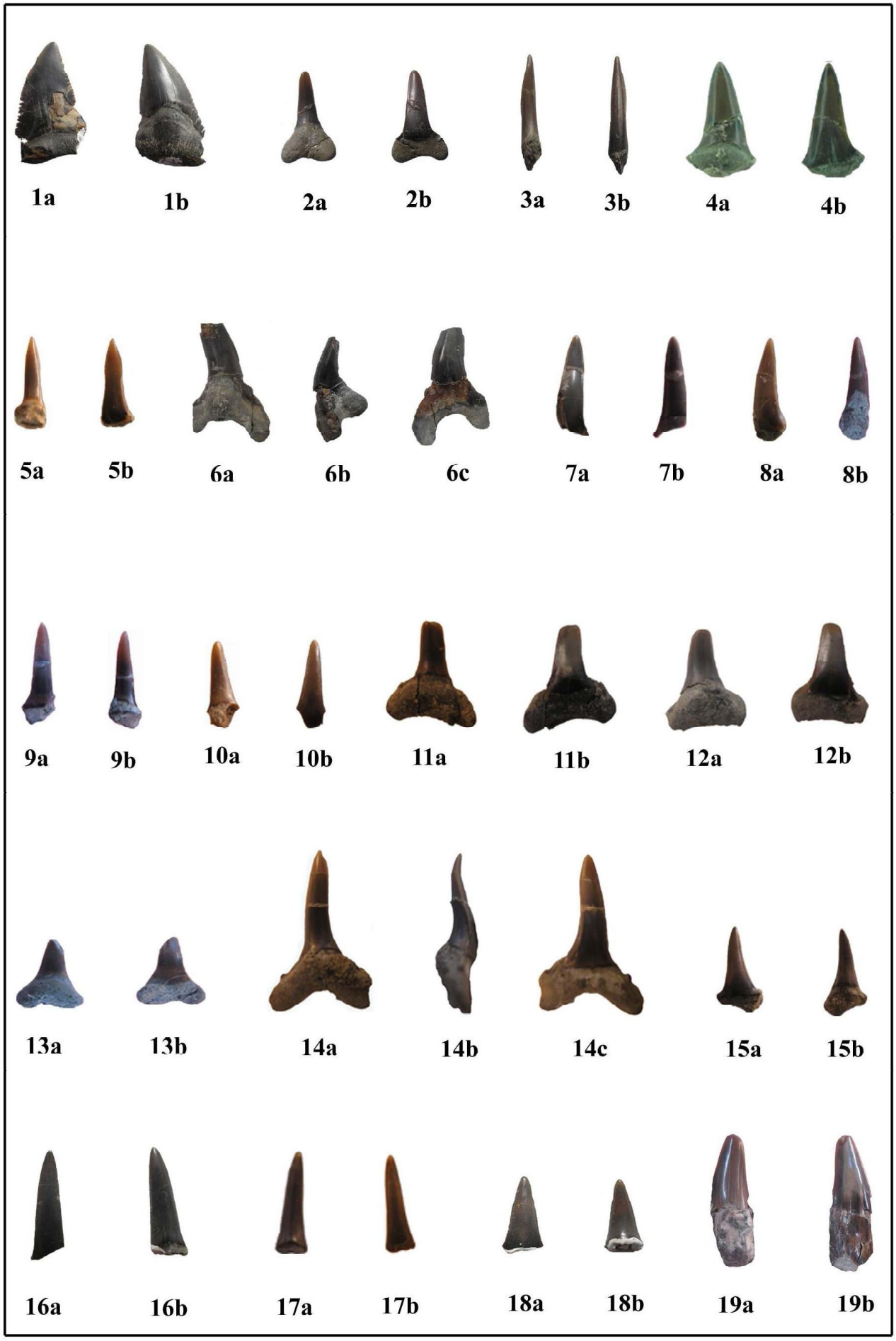
EXPLANATION OF PLATE 10

Figure	Explanation	Page
11b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -45, External view X 2.00	87
12a	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -46, External view X 2.00	87
12b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -46, Internal view X 2.00	87
13a	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -47, Internal view X 2.00	87
13b	*Carcharodon carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -47, External view X 2.00	87
14a	Carcharodon *carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -79, External view X 1.00	87
14b	Carcharodon *carcharias* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -79, Internal view X 1.00	87
15	*Carcharodon angustidens* Agassiz, - Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl). Sp. No. V/F/R -7, Internal view X 1.00	89
16	*Carcharodon angustidens* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -8, Internal view X 1.00	89

EXPLANATION OF PLATE 11

Figure	Explanation	Page
1a	*Carcharodon* sp. A, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R-27, External view X 1.00	90
1b	*Carcharodon* sp. -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.A, V/F/R -27, Internal view X 1.00	90
2a	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -43, Internal view X 2.00	90
2b	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -43, External view X 2.00	90
3a	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -44, Internal view X 2.00	90
3b	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -44, External view X 2.00	90
4a	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -48, External view x 2.00	90
4b	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -48, Internal view X 2.00	90
5a	*Isurus pagoda* Neotling, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -49, Internal view X 2.00	92
5b	*Isurus pagoda* Neotling, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -49, External view X 2.00	92

Plate 11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8b
9a
9b
10a
10b
11a
11b
12a
12b
13a
13b
14a
14b
14c
15a
15b
16a
16b
17a
17b
18a
18b
19a
19b

EXPLANATION OF PLATE 11

Figure	Explanation	Page
6a	*Isurus spallanzanii* Bonnaparte, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -28, Internal view X 1.00	90
6b	*Isurus spallanzanii* Bonnaparte, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -28, Profile view X 1.00	90
6c	*Isurus spallanzanii* Bonnaparte, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -28, External view X 1.00	90
7a	*Isurus spallanzanii* Bonnaparte, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -51, External view X 2.00	90
7b	*Isurus spallanzanii* Bonnaparte, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -51, Internal view X 2.00	90
8a	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -52, External view X 2.00	90
8b	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -52, Internal view X 2.00	90
9a	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -53, Internal view X 2.00	90
9b	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -53, External view X 2.00	90
10a	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -54, Internal view X 2.00	90

EXPLANATION OF PLATE 11

Figure	Explanation	Page
10b	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -54, External view X 2.00	90
11a	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -55, Internal view X 2.00	90
11b	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -55, External view X 2.00	90
12a	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -56, Internal view X 2.00	90
12b	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -56, External view X 2.00	90
13a	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -57, External view X 2.00	90
13b	*Isurus spallanzanii* Bonnaparte, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -57, Internal view X 2.00	90
14a	*Odontapis* cf. *taurus*, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -59, Internal view X 2.00	94
14b	*Odontapis* cf. *taurus*, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -59, Profile view X 2.00	94
14c	*Odontapis* cf. *taurus*, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -59, External view X 2.00	94

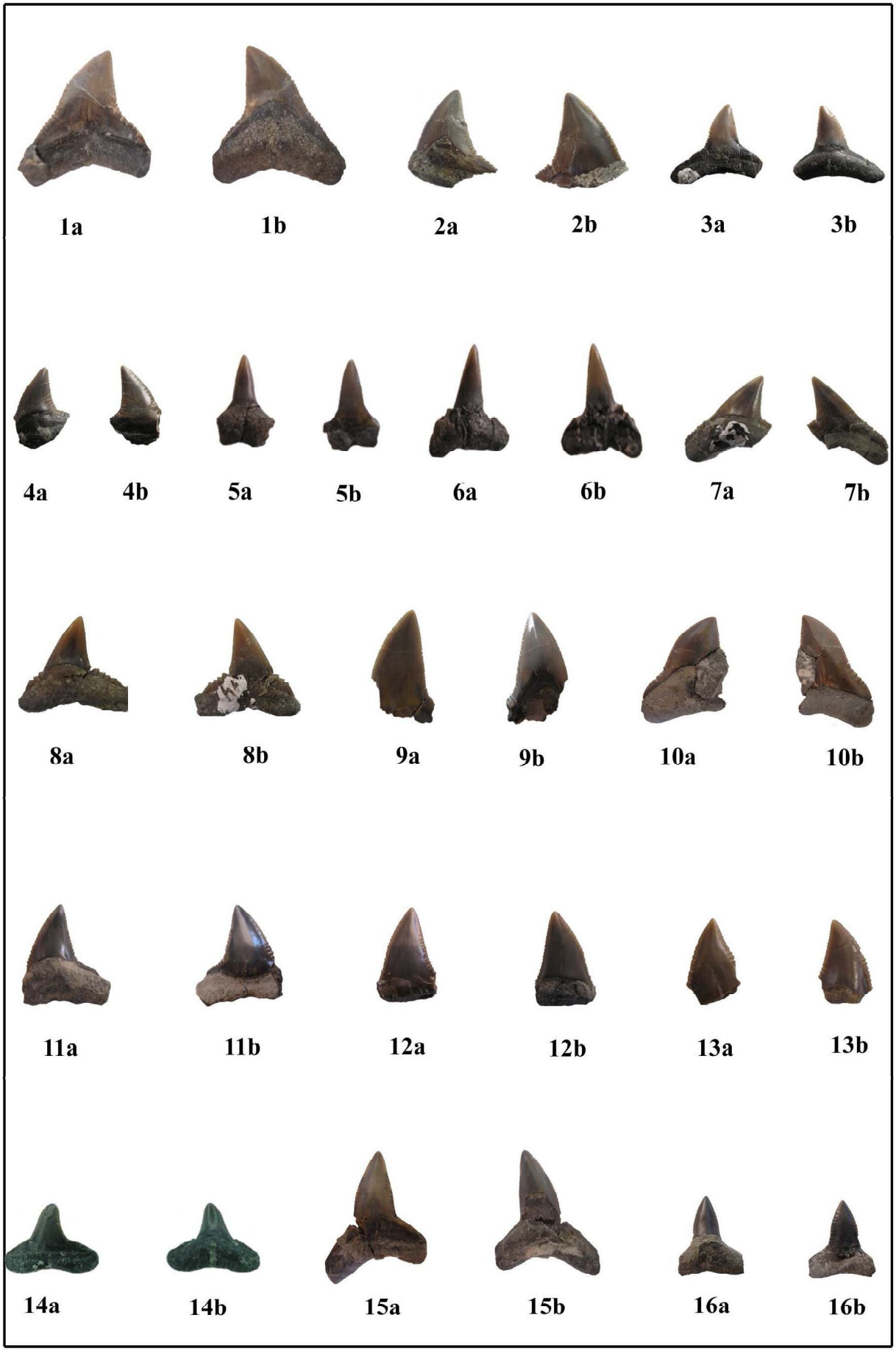
EXPLANATION OF PLATE 11

Figure	Explanation	Page
15a	*Odontapis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -58, Internal view X 2.00	95
16a	*Odontapis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -30, Internal view X 2.00	95
16b	*Odontapis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -30, External view X 2.00	95
17a	*Odontapis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -60, Internal view X 3.00	95
17b	*Odontapis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -60, External view X 3.00	95
18a	*Odontapis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -31, External view X 2.00	95
18b	*Odontapis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -31, Internal view X 2.00	95
19a	*Odontapis tricuspidatus*, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -61, Internal view X 1.00	94
19b	*Odontapis tricuspidatus*, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -61, External view X 1.00	94

EXPLANATION OF PLATE 12

Figure	Explanation	Page
1a	*Carcharhinus egertoni* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -64, External view X 2.00	96
1b	*Carcharhinus egertoni* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -64, Internal view X 2.00	96
2a	*Carcharhinus egertoni* Agassiz, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -4, Internal view X 2.00	96
2b	*Carcharhinus egertoni* Agassiz, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R-4, External view X 2.00	96
3a	*Carcharhinus egertoni* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -24, External view X 1.00	96
3b	*Carcharhinus egertoni* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -24, Internal view X 1.00	96
4a	*Carcharhinus egertoni* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -35, Internal view X 1.00	96
4b	*Carcharhinus egertoni* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -35, External view X 1.00	96
5a	*Carcharhinus priscus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -65, External view X 1.00	97
5b	*Carcharhinus priscus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -35, Internal view X 1.00	97

Plate 12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16b

EXPLANATION OF PLATE 12

Figure	Explanation	Page
6a	*Carcharhinus priscus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -66, Internal view X 1.00	97
6b	*Carcharhinus pricus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -66, External view X 1.00	97
7a	*Carcharhinus priscus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -25, Internal view X 2.00	97
7b	*Carcharhinus priscus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -25, External view X 2.00	97
8a	*Carcharhinus priscus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -26, Internal view X 2.00	97
8b	*Carcharhinus priscus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -26, External view X 2.00	97
9a	*Carcharhinus* sp. A, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -42, Internal view X 1.00	101
9b	*Carcharhinus* sp. A, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -42, External view X 1.00	101
10a	*Carcharhinus* sp. A, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -74, Internal view X 1.00	101
10b	*Carcharhinus* sp. A, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -74, External view X 1.00	101
11a	*Carcharhinus* sp. A, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -107, Internal view X 1.5	101

EXPLANATION OF PLATE 12

Figure	Explanation	Page
11b	*Carcharhinus* sp. A, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -107, External view X 1.5	101
12a	*Carcharhinus* sp. A, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -108, External view X 1.5	101
12b	*Carcharhinus* sp. A, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -108, Internal view X 1.5	101
13a	*Carcharhinus* sp. A, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -109, External view X 1.5	101
13b	*Carcharhinus* sp. A, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -109, Internal view X 1.5	101
14a	*Carcharhinus* sp. B, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -88, External view x 2.00	102
14b	*Carcharhinus* sp. B, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -88, Internal view X 2.00	102
15a	*Carcharhinus* sp. C, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -75, External view X 1.00	102
15b	*Carcharhinus* sp. C, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -75, Internal view X 1.00	102
16a	*Carcharhinus* sp. C, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -76, Internal view X 1.00	102
16b	*Carcharhinus* sp. C, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -76, External view X 1.00	102

EXPLANATION OF PLATE 13

Figure	Explanation	Page
1a	*Galeocerdo aduncus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -67, External view X 1.00	104
1b	*Galeocerdo aduncus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -67, Internal view X 1.00	104
2a	*Galeocerdo aduncus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -68, External view X 1.00	104
2b	*Galeocerdo aduncus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -68, Internal view X 1.00	104
3	*Galeocerdo aduncus* Agassiz, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R-9, Internal view X 1.00	104
4	*Galeocerdo aduncus* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -10, Internal view X 1.00	104
5a	*Hemipristis serra* Agassiz, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -1, External view X 1.00	108
5b	*Hemipristis serra* Agassiz, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -1, Internal view X 1.00	108
6a	*Hemipristis serra* Agassiz, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -2, Internal view X 1.00	108
6b	*Hemipristis serra* Agassiz, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -2, External view X 1.00	108

Plate 13

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EXPLANATION OF PLATE 13

Figure	Explanation	Page
7a	*Hemipristis serra* Agassiz, - Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -3, External view X 1.00	108
7b	*Hemipristis serra* Agassiz, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -3, Internal view X 1.00	108
8a	*Hemipristis serra* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -69, Internal l view X 1.00	108
8b	*Hemipristis serra* Agassiz, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -69, External view X 1.00	108
9a	*Hemipristis unidenticulata* n. sp. – Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -70, Internal l view X 1.50	109
9b	*Hemipristis unidenticulata* n. sp..- Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -70, Profile view X 1.50	109
9c	*Hemipristis unidenticulata* n. sp..- Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -70, External view X 1.50	109
10a	*Negaprion brevirostris* Poey, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -71, Internal view X 2.00	105
10b	*Negaprion brevirostris* Poey, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -71, External view X 2.00	105
11a	*Negaprion* cf. *eurybathrodon* Blake -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -72, Internal view X 1.00	106

EXPLANATION OF PLATE 13

Figure	Explanation	Page
11b	*Negaprion* cf. *eurybathrodon* Blake -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -72, External view X 1.00	106
12a	*Alopias* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -86, Internal view X 2.00	93
12b	*Alopias* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -86, External view X 2.00	93
13a	*Alopias* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -87, Internal view X 2.00	93
13b	*Alopias* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -87, External view X 2.00	93
14a	*Scoliodon sorrakawah* Cuvier, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -73, Internal view X 2.00	107
14b	*Scoliodon sorrakawah* Cuvier, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -73, External view X 2.00	107
15a	*Carcharhinus* cf. *Macloti* Muller and Henle -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -78, Internal view X 1.00	98
15b	*Carcharhinus* cf. *Macloti* Muller and Henle -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -78, External view X 1.00	98
16a	*Carcharhinus* sp. D, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -80, External view X 1.00	103
16b	*Carcharhinus* sp. D, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -80, Internal view X 1.00	103

EXPLANATION OF PLATE 14

Figure	Explanation	Page
1a	*Carcharhinus* (*Prionodon*) sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -83, Internal view X 2.00	100
1b	*Carcharhinus* (*Prionodon*) sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -83, External view X 2.00	100
2a	*Carcharhinus* (*Prionodon*) sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -84, Internal view X 2.00	100
2b	*Carcharhinus* (*Prionodon*) sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -84, External view X 2.00	100
3a	*Carcharhinus* (*Prionodon*) sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -85, External view X 2.00	100
3b	*Carcharhinus* (*Prionodon*) sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -85, Internal view X 2.00	100
4a	*Carcharhinus* (*Prionodon*) sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -90, Internal view X 2.00	100
4b	*Carcharhinus* (*Prionodon*) sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -90, External view X 2.00	100
5	S*phyrna diplana* Springer, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -40, Internal view X 2.00	110
6	*Sphyrna zygaena* Linneaus, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -39, External view X 2.00	111

Plate 14

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EXPLANATION OF PLATE 14

Figure	Explanation	Page
7a	*Galeorhinus* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -23, External view X 2.00	111
7b	*Galeorhinus* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -23, Internal view X 2.00	111
8	*Squalus* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -91, Internal view X 2.00	112
9a	*Carcharhinus bubanicus* n. sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B-77, External view X 1.00	99
9b	*Carcharhinus bubanicus* n. sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No V/F/B-77, Internal view X 1.00	99
10a	Indeterminate tooth of Crocodylidae, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/C/R-90 External view X 1.5	119
10b	Indeterminate tooth of Crocodylidae, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/C/R-90, Internal view X 1.5	119
11a	Indeterminate vertebral centra of selachians, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -104 Cranial or Caudal view X 1.5	113
11b	Indeterminate vertebral centra of selachians, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -104 Dorsal or Lateral view X 1.5	113
12a	Carcharhinidae. Gen. et sp. indet.(Vertebra), -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -105 Cranial or Caudal view X 1.00	113

EXPLANATION OF PLATE 14

Figure	Explanation	Page
12b	Carcharhinidae. Gen. et sp. indet.(Vertebra), -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -105dorsal or lateral view X 1.00	113
13a	*Myliobatis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No. V/F/B -5a, Basal view X 1.00	114
13b	*Myliobatis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -5a, Oral view X 1.00	114
14a	*Myliobatis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -91, Oral view X 1.00	114
14b	*Myliobatis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -91, Basal view X 1.00	114
15a	*Myliobatis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -92, Oral view X 1.00	114
15b	*Myliobatis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -92, Basal view X 1.00	114
16	*Myliobatis* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -93, Oral view X 1.00	114
17	*Myliobatis* sp. -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R-94, Oral view X 1.00	114

EXPLANATION OF PLATE 15

Figure	Explanation	Page
1a	*Myliobatis* sp. -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -5b, Caudal spine X 1.00	114
1b	*Myliobatis* sp. -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -5b, Caudal spine X 1.00	114
2a	*Aetobatus* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -95, Basal view X 1.00	115
2b	*Aetobatus* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -95, Oral view X 1.00	115
3	*Aetobatus* sp. -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -96, Basal view X 1.00	115
4a	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -12, Anterior view X 1.00	116
4b	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -12, Posterior view X 1.00	116
4c	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -12, Side view X 1.00	116
5a	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -97, Anterior view X 2.00	116
5b	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -97, Posterior view X 2.00	116

Plate 15

1a

1b

2a

2b

3

4a

4b

4c

5a

5b

6a

6b

7a

7b

8a

8b

9a

9b

10a

10b

11a

11b

12a

12b

12c

13

EXPLANATION OF PLATE 15

Figure	Explanation	Page
6a	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -98, Anterior view X 2.00	116
6b	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -98, Posterior view X 2.00	116
7a	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -99, Anterior view X 2.00	116
7b	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -99, Posterior view X 2.00	116
8a	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -100, Anterior view X 2.00	116
8b	*Diodon* sp.1, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -100, Posterior view X 2.00	116
9a	*Diodon* sp.2, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -101, Anterior view X 3.00	117
9b	*Diodon* sp.2, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -101, Posterior view X 3.00	117
10a	*Diodon* sp.2, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -102, Anterior view X 3.00	117
10b	*Diodon* sp.2, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -102, Posterior view X 3.00	117

EXPLANATION OF PLATE 15

Figure	Explanation	Page
11a	*Diodon* sp.3, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -13, Anterior view X 1.00	117
11b	*Diodon* sp.3, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -13, Posterior view X 1.00	117
12a	*Diodon* sp.4, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -103, Anterior view X 1.5	118
12b	*Diodon* sp.4, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -103, Side view X 1.5	118
12c	*Diodon* sp.4, -Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 1 (Bika Quarry, Tuivamit, Aizawl). Sp. No.V/F/B -103, Posterior view X 1.5	118
13	*Diodon* sp.4, -Upper Intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation; Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl) Sp. No.V/F/R -15, Anterior view X 1.00	118