CHAPTER 1

INTRODUCTION
CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

The State of Nagaland is located in the northeastern part of India and has a mountainous topography. It is bounded by Assam in the west, Arunachal Pradesh in the north, Manipur in the south and by Myanmar in the east. It lies between 25°60' and 27°40' latitudes north of the equator and between the longitudinal lines E 93°20' and E 95°15' having an area of 16,579 sq. km.

The geological setting and stratigraphy of this area matches in its broad aspects with that of Upper Assam. Except the alluvial plains, Ophiolite and metamorphic complexes occurring along the Indo-Myanmar border, the whole area within Nagaland is occupied by Tertiary sediments. The Tertiary sediments occur in the Central flysch zone and the Schuppen Belt. The Schuppen Belt, a highly thrusted zone is known for harboring oil and gas. The famous Digboi oil field is located within the Tertiary succession of the northeastern extremity of the Naga Hills. The presence of oil and gas in Champang and near Chumukedima in Nagaland was located by ONGC and exploration was on for a short period.

The Tertiary succession of Assam, Kutch, Cambay and Cauvery Basins has been the subject of detailed studies in view of rich oil fields found in these areas, whereas the studies pertaining to Tertiary sediments of Nagaland have received scanty attention. It may be because of the remoteness of the area and also by other factors like road, transport etc.

1.2 PHYSIOGRAPHY AND CLIMATE

The state has a picturesque landscape endowed with an enchanting landscape of green hills, valleys and rivers flowing along deep gorges. A rugged mountainous terrain characterizes most parts of the state. The Barail range in the southwest and the Patkai range in the north are the two major mountain ranges in the state. The Patkai range boasts of Mt. Saramati (3840m above MSL) which is the highest mountain peak in the state. The ridges usually trend NE-SW. The Barail range enters the state at the SW corner and runs in a northeasterly direction almost up to Kohima. Japfu peak (3015m above MSL) located southwest of Kohima town is the highest point in the Barail range. The Barail range forms the
watershed of the state, while the Patkai range forms the watershed in the easternmost part of the state bordering Myanmar. Most of the rivers emerging from these ranges drain into the Brahmaputra, except the Barak and Tizu, which drain into the Chindwin in Myanmar. The major rivers in the state are Dhansiri, Doyang, Dikhu, Tizit and Tizu.

Kohima district is basically a hilly region occupying the south-west part of the state. The town of Kohima, which is also the headquarters of the state, is located at a height of 1444.12m above MSL. It is 74 km southeast of the nearest railway station and airport of the state, which are located in Dimapur District. The exotic Dzukou Valley in the south of the district is one of the most picturesque places in the state.

Phek, one of the eleven districts of the state, lies in the south and southeastern part of the state. It forms part of the Patkai range with roughly N-E trending ridges. Pfutsero, the highest town in the state, elevated at a height of 2133m above MSL is an important town of the district. Laniye, Tizu and Sidzu are the main rivers in the district. Kaku, Kheli and Thiza are the other streams/rivers that discharge their load to Laniye and Sedzu.

The climate of the state is typical of subtropical with rather heavy rainfall. The maximum temperature during summer is 31°C and minimum is 16°C. During winter, maximum temperature is 24°C and minimum is 2°C. The monsoon starts from mid-May with an average rainfall of about 240cm.

1.3 LOCATION AND ACCESSIBILITY

The present investigation deals with the foraminiferal biostratigraphy, paleoecology and the boundary events of the Paleogene sediments of Nagaland. The present area of study is located in the extreme south of Nagaland state bordering the state of Manipur. It lies between latitude 25°30′ and 25°45′ and longitude 94°00′ and 94°45′ in the Survey of India toposheet No. 83 K/2 and No. 83 K/6 (Fig. 1.1). Pfutsero, the sub-divisional headquarter of Phek district is 70 km from state capital Kohima and is about 150 km from the nearest railway station, which is at Dimapur, and it is about 144 km from the District Headquarter Phek. For the present study the samples have been collected from different localities at Khulazu Bawe, Khulazu Basa, Phesachodu, Chobama, Zamei, Pfutsero, Pfutseromi, Glory Peak, Mesulumi, Chizami, Meluri of Phek District and Jotsoma, Kohima, New Secretariat Complex, Lalmati, Zubza, Pherima, Kigwema and Jakhama of Kohima District. The localities in Phek District yield a good number of foraminifera, whereas the locations in Kohima District are not yielding
Figure 1.1 Location Map of the Study Area
fauna. Hence, study has been concentrated in the fossiliferous localities of Phek District. Most of the study areas in and around Pfutsero are accessible by unmetalled road.

1.4 METHODOLOGY

1.4.1 Field Work

The geological maps prepared by Geological Survey of India, Oil and Natural Gas Commission and Directorate of Geology and Mining of Nagaland formed the basis for sample collections. Samples were collected from various litho-units and concentration was made in collecting samples from calcareous shales, siltstones, black shales and thin partings of claystone and also the sediments containing mega fossils. Very close and systematic sampling has been carried out to establish the stratigraphy of the sedimentary sequence. The standard micropaleontological techniques were adopted in the collection of samples. Very close sampling of 10-30 cm gap was carried out in the field. A total of about 500 samples were collected and studied from 10-11 sections.

Based on the absence or presence of foraminifera, the sections studied were broadly classified into two categories. They are:

A) Sections without Foraminifera
1) Kohima – Kigwema – Jakhama: Random spot sampling was carried out in this section, which lies along the Kohima-Imphal road on the National Highway No. 39. The bearings of these areas are as follows-Kigwema village (25°36'08''), Jakhama village (25°35'39'', 94°3'33'').
2) In around Kohima town: Samples were collected near Naga Students’ Federation Martyrs’ Park (25°39'23'', 94°6'11''), along the Kohima Science College road (25°40'11'', 94°4'33'') and at the New Secretariat site (25°42'24'', 94°6'31'') and processed.
3) Kohima – Chumukedima section: Random spot sample collection was carried out at Lalmati cliff (25°44'08'', 94°00'48''), Pherima village and near the Patkai Christian College, Chumukedima.
4) Chetheba – Khulazu Bawe - Phesachodu section: A traverse was made along the road that links Chetheba town (25°40'13'', 94°16'08'') and Pfutsero town and samples were collected near Khulazu Bawe village (25°38'28'', 94°16'56'').
5) Pfutsero - Mesulumi - Yoseba - Chizami section: A traverse along the state highway (Phek road) was made from Chizami to Pfutsero via Yoseba and Mesulumi. Samples were collected from every possible exposure and processed.

6) Meluri - Akhegwo section: A traverse of 12 km was taken from Meluri town (N 25° 41’23” and E 94°38’18") towards Akhegwo. Samples of siltstone and shale were collected and processed.

B) Sections with foraminifera

1) Pfutsero 1 section: This section is along the state highway that links Kohima with Pfutsero town. It is located about 200 m from Pfutseromi Village gate towards Pfutsero town. The section bears Latitude 25°34’03" and Longitude 94°17’43".

2) Pfutsero 2 section: This section is located about 2 kms from Pfutsero town towards Phek and lies opposite to Rikuzu colony. The bearings of this section are as follows: Latitude 25°34’02", Longitude 94°18’23”.

3) Leshemi Village section: This section lies above the village of Leshemi on the road towards Khezhakeno village. The bearings of this section are: Latitude 25°32’10", Longitude 94°14’05”.

4) Chobama 1 and 2 fault section: The Chobama 1and 2 sections are separated by a local fault and is about 100 m from Chobama 3 section toward Chobama village. This section bears Latitude 25°33’43" and Longitude 94°19’27”.

5) Chobama 3 apple tree section: This section is located along the road that links Pfutsero and Zamai Village. It is two kms from Chobama village towards Pfustero.' The bearings of this section are: Latitude 25°33’42" and Longitude 94°19’27”.

1.4.2 Laboratory Work

Standard micropaleontological techniques were adopted in the processing and preparation of the samples. A precise methodology of the laboratory works engaged in studying foraminifers is given below:

1) 50 gm weight of each sample was processed. Weighing was done using a digital balance of Aman Scales (P) Limited.
During the course of mapping in Nagaland, the workers of GSI and ONGC reported few fossiliferous horizons from Disang and Barail Groups. They stressed the need for the systematic sampling in this area to establish a detailed biostratigraphy based on microfossils. A survey of literature, field and laboratory observations by Dr. R. Venkatachalapathy (Supervisor) shows the possibility of locating many more fossil (microfossil) bearing horizons in parts of Nagaland. The absence or rarity of megafossils in some horizons has underscored the need for an alternative, if complementary, zonal scheme based on microfossils which are numerous, recurrent and can be recovered with equal facility from surface and subsurface sections. Foraminifers are ideal tool to meet such requirements.

Foraminifers are globally used for biostratigraphic subdivision and correlation of sedimentary strata. A limited work on planktic foraminiferal biostratigraphy of Nagaland has been carried out in some parts of the state on surface and subsurface (Singha and Chatterjee, 1982, Singh et al., 1986, Baruah et al., 1987 and Bhatia and Dave, 1996). Though the benthic
foraminifera are good indicators of paleoenvironment, so far, in this area, paleoenvironmental significance has not been satisfactorily studied. The present research work is therefore, made to carry out the detailed investigation on the occurrence of foraminifera, leading to the detailed biostratigraphy, paleoecology and the boundary events of the Paleogene sediments of Nagaland.

1.6 PREVIOUS WORK

A survey of literature reveals that considerable amount of work has been done on foraminifera and on other microfossils of Tertiary rocks of Assam, Kutch, Cambay, Cauvery Basin and also in Northwestern Himalayas. However, no significant work on microfauna has been carried out in Nagaland. It may be because of the remoteness of this area and by other factors like road and transport etc. Before dealing with the present investigation it would be desirable to give a chronological review of the work done by previous workers. The stratigraphy of Nagaland has been worked by the Geologists of the Geological Survey of India, Directorate of Geology and Mining, Nagaland and Oil and Natural Gas Corporation Limited.

Detailed foraminiferal biostratigraphy of the Barail and Disang Groups of all the tectonic blocks of Nagaland has not been carried out so far perhaps due to difficulty in accessibility.

Mallet (1876) was the first to work on Disang rocks on account of the coalfields of the Naga Hills and first named it as Disang series. He proposed the name Disang Group for dark grey shales and minor sandstones exposed along Disang (Dilli) river section (23°5' N: 95°23' E). Later Oldham (1883) correlated the Disang with Axials of Arakan Yoma. Maclaren (1904) followed by Pascoe (1912) considered that the ‘bulk of the Disangs has more in common with the Negrais bed of Arakan Yoma’.

Hayden (1910) suggested that the Disangs may be made up of great flysch formation and might extend up even into the Tertiary. Based on the reported find of an *Ammonite* by Hayden, the Disangs may range in age from Cretaceous to Middle Eocene (Evans, 1932). Subsequently, Evans (1932) found *Nummulites* and opined ‘that Disangs will eventually be shown to be a more altered and practically unfossiliferous equivalent of the Laungshe shales of Burma’, which are believed to range from Paleocene to Eocene. He further described Disang shales as ‘very like those of Kopili Formation’ and suggested that the Disangs include a deeper
water facies of the Jaintia Group and perhaps lower horizons equivalent to Ranikot, Laki and Kirthar and possibly the uppermost Cretaceous.

Since the inception of biostratigraphy work nearly a century ago, only a few selected sections and a few deep wells have been studied in Nagaland.

The previous workers mainly reported the occurrence of foraminifera (except Baruah et al., 1986 & Bhatia et al., 1996) from various parts of Nagaland. As the biostratigraphy data published by few authors particularly with reference to paleoenvironment is different, the present study presents a detail work of each of the previous work in detail according to different parts of Nagaland.

NORTH NAGALAND:

Location: North of Damchara

Nagappa (1959) recorded smaller arenaceous foraminifera Ammobaculites sp., Ammodiscus sp., Bathysiphon sp., Cyclammina sp., Gaudryina sp. and Haplophragmoides sp. from the topmost bed of the Disang Group exposed at a locality, north of Damchara, suggesting deposition under shallow marine environment.

Location: Changtongka

Micropaleontological studies carried out by Sinha (1974), have yielded reticulate Nummulites in Disang Group exposed at Changtongka (GSI, vol. 112, 1982). Reticulate Nummulites range from late Middle Eocene to Early Oligocene, but exact age cannot be given without specific identification.

Location: Champang well

Borholla field extends eastwards below the Naga thrust and that part of the structure in Nagaland is designated as Champang field (Rao and Prasad, 1982). The oil and gas pools at Champang field are in basement, Basal Sandstone, Sylhet and Kopili units and also in Tipam.
According to Singh et al. (1986) in Champang well the representative core samples from Basal Sandstone unit have not yielded foraminifera (Fig. 1.2). Hence, considering the unfossiliferous nature of the sediments and lithological association, deposition of this unit seems to have taken place in fluvial condition. The fossiliferous Sylhet Formation and lower part of the Kopili Formation seem to have been deposited in an open marine environment. In the upper part of Kopili Formation, the larger benthonic foraminifers are eliminated and in turn are taken over by smaller benthonic foraminifer.

A gradual reduction of foraminiferal assemblage is observed in this well, which indicates considerable shallowing of the sea and deposition in marginal marine environment towards the Kopili-Barail boundary the calcareous benthonic foraminifera totally disappear and a sharp reduction of faunal population is observed, suggesting setting in of regressive phase and deposition under brackish water environment.

Biostratigraphy of this well was built and published by Bhatia and Dave in 1996. The litho-column, faunal frequency, stratigraphic unit, biozones, age and paleoecology as given by Bhatia and Dave is reproduced here. There are four biozones. These are described in detail from younger to older in order as follows:

1) Barren zone: The dark grey splintery shale sequence of the upper part of Kopili Formation and the Barail Group of sandstone are devoid of foraminifera. The zone conformably overlies N. cf. N. wemmellensis Zone of Late Eocene without any sedimentation break, besides the palynofloral assemblage of Late Eocene age has been recorded from this interval. Hence, Late Eocene age has been assigned to this zone.

2) N. cf. W. wemmellensis Zone: This zone has been recorded in lower to middle part of Kopili Formation and lies above the N. discorbinitus-Assilina sp. Zone. Discontinuance occurrence of foraminifera is noticed on the top part of the zone. In this zone, Nummulite sp. A occurs commonly. Ostracodes, N. cf. N. wemmellensis, Quinqueloculina sp. are infrequent and microgastropods, Operculina sp, Rotalia sp., Elphidium sp. and Cibicides sp. are rare.

3) N. discorbinitus-Assilina sp. Zone: This zone has been recognized in upper part of Sylhet Formation. It conformably overlies N. acutus Zone. The top of the zone is marked by the discontinuance of N. pengaronensis, N. discorbinitus, Nummulites sp. B, A. praespira and
Figure 1.2 Faunal Distribution, Age and Palaeoecology of Champang Well (After Singh et al., 1986)

<table>
<thead>
<tr>
<th>STRATIGRAPHIC UNIT</th>
<th>STRATIGRAPHIC UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAMMARAY LOG</td>
<td>GAMMARAY LOG</td>
</tr>
<tr>
<td>LITHO-COLUMN</td>
<td>LITHO-COLUMN</td>
</tr>
<tr>
<td>RESISTIVITY LOG</td>
<td>RESISTIVITY LOG</td>
</tr>
</tbody>
</table>

**FAUNAL FREQUENCY**

- ANOMALINA SP
- CANCINUS SP
- ELPHIDINUM SP
- QUMQUECOLOQUELINA SP
- POTALIA SP
- NUMMULITES ACUTUS
- N. BEAUMONTI
- E. DISCOBULUS
- N. PENARDHUMENSIS
- N. CR. WEMMELLENSIS
- NUMMULITES SP A
- NUMMULITES SP B
- ASSILINA PRAEDIPRA
- ASSILINA SP
- OSTRACODAE
- MICROGASTROPODS

**AGE**

- EARLY LATE
- MIDDLE EOCENE
- LATE EOCENE

**PALAEOCOLOGY**

- MARINE
- INNER SHELF
- NON MARINE
1) Poorly fossiliferous Zone: This zone is represented at the depth of between 3700m and 4015m. It conformably overlies the *N. pengaronensis* Zone. The foraminiferal assemblage of upper Kopili consists of rare occurrence of arenaceous foraminifers, *Trochemmina* sp., *Haplophragmoides* sp., *Osangularia* sp., *Rotalia* sp., *Nummulites* sp. and common occurrence of *Operculina* sp. The upper part of Barail Group in this well is devoid of foraminifera. No age is assigned to this zone.

4) *Nummulites acutus* Zone: This zone lies in the lower part of Sylhet Formation unconformably overlying the basal sandstone. The base of the zone is marked by the first appearance of *N. Pengaronensis*, *N. beaumonti* and *N. acutus*. In this assemblage zone, presence of rare ostracodes, *Operculinoids* sp. *A. praespira*, *N. beaumonti*, *N. acutus*, *Rotalia* sp., *Cibicides* sp., infrequent occurrence of *Operculina* sp., *Assilina* sp., *Nummulites* sp. and common occurrence of *N. pengaronensis* is recorded. The foraminiferal assemblage recorded in this zone indicates early Middle Eocene age.

SOUTH-WEST NAGALAND:

Location: Chumukedima well

It is a part of Dhansiri valley and lies in the South west of Nagaland. The thickness of the Paleogene sequence is considerably reduced in the northeastern part of Dhansiri valley at Barpathar, where it unconformably overlies the Gondwanas. However, it attains maximum thickness at Chumukedima, suggesting a basinal slope towards Southwest (Bhatia and Dave, 1996) as in shown in Figure 1.3.

The detail biostratigraphy of this well studied by Bhatia and Dave (1996) is discussed below. The Formations encountered here are: Basal Sandstone, Sylhet, Kopili and Barail Group. Bhatia and Dave recognized five 5 biozones, which are described in detailed from top to bottom.

1) Poorly fossiliferous Zone: This zone is represented at the depth of between 3700m and 4015m. It conformably overlies the *N. pengaronensis* Zone. The foraminiferal assemblage of upper Kopili consists of rare occurrence of arenaceous foraminifers, *Trochemmina* sp., *Haplophragmoides* sp., *Osangularia* sp., *Rotalia* sp., *Nummulites* sp. and common occurrence of *Operculina* sp. The upper part of Barail Group in this well is devoid of foraminifera. No age is assigned to this zone.
Figure 1.3 Biostratigraphy of the Pre-Barail Sequence in Chumakedima Well
(After Singh et al., 1986 and Bhatia & Dave, 1996)
2) *N. pengaronensis* Zone: This zone is marked by the common occurrence of *Nummulites* sp. The zone is characterized by the dominance of *N. pengaronensis*. The other rare occurrence of foraminiferal assemblage is *Discocyclina* sp., *Assilina* sp., *N. acutus* sp., *Operculina* sp., *Uvigerina* sp and *Pararotalia* sp. The occurrence of *N. Pengaronensis* in this zone suggests an early Late Eocene age.

3) *N. discorbinus-Assilina* sp. Zone: The assemblage recorded from this zone includes rare *Discocyclina* sp., *Assilina* sp., *N. acutus*, *Cibicides* sp., *Rotalia* sp., *Uvigerina* sp., *Heterolepa* sp., *Quinqueloculina* sp., *Lagenia* sp. and common occurrence of *N. discorbinus*. A gradual reduction of fauna towards the top of this zone is observed. At Chumukedima well, this zone is recorded from the upper part of Sylhet Formation where it overlies the *N. acutus-F. elliptica* Zone. This zone is assigned as late Middle Eocene.

4) *N. acutus-F. elliptica* Zone: This zone is characterized by the first appearance of *F. elliptica* and *N. acutus* at the base. *Discocyclina* sp., *Assilina* sp., *Operculina* sp., *Cibicides* sp., *Heterolepa* sp. occurs rarely. Of common occurrence are *F. elliptica*, *N. acutus* and *N. discorbinus*. Due to the presence of *F. elliptica* (Madan Mohan, 1972), this zone is assigned early Middle Eocene age.

The Basal Sandstone which unconformable overlies the basement has been found to be unfossiliferous. The lithological association along with the occurrence of palynofossils suggests deposition in fluvial environment. The overlying Sylhet and Kopili Formations have yielded rich assemblage of larger benthic foraminifera comprising *Nummulites* sp., *Discocyclina* sp and *Assilina* sp. along with smaller benthics. The occurrence of larger benthic foraminifera in the lower part of Sylhet Formation indicates the initiation of Paleogene marine transgression (Singh et al., 1986).

The assemblage zone of *N. acutus-F. elliptica* is characterized by an abundance of larger benthics suggesting deposition in inner shelf environment. Further upward, in the Kopili Formation (*N. pengaronensis* Zone), the frequency of larger foraminifera is again increased, indicating a shallowing of sea and the deposition in inner shelf environment. The transition from Kopili to Barail is marked by the elimination of calcareous benthics and sporadic
The basal Tura Sandstone unconformably overlying the basement has been found unfossiliferous. This indicates setting in of regressive phase and the deposition of Barails in brackish water environment.

Location: Tynyphe well

This well lies in the South West of Nagaland. The section given by Bhatia and Dave (1996) showing lithology, faunal distribution, age and paleoecology is shown in Fig. 1.4.

The three biozones of this well are described in detail from top to bottom.

1) Poorly fossiliferous Zone: The poorly fossiliferous zone in Tynyphe well is represented between 3270m and 3800m. This zone is characterized by rare occurrence of Trochammina sp., Cyclammina sp., and Ammodiscus sp. Since this zone unconformably overlies the N. pengaronensis Zone of Late Eocene age without a sedimentation break and some of the arenaceous foraminiferal species recorded from this zone extend up into the Barail Group of Oligocene age, this zone is assigned as Late Eocene to Oligocene. The upper part of Barail Group of this well is devoid of foraminifera.

2) N. pengaronensis Zone: The dominance of N. pengaronensis characterizes this zone. The foraminiferal assemblage of this zone includes rare Cyclammina sp., arenaceous foraminifera, Cibicides sp., Quinqueloculina sp., Operculina sp., Discocyclina sp., N. acutus and common occurrence of N. pengaronensis and Nummulites sp. Age: The occurrence of N. pengaronensis suggests an early Late Eocene age for this zone.

3) N. acutus- F. elliptica Zone: The base of this zone is marked by the first occurrence level of larger benthics and the top is marked by the disappearance of F. elliptica, A. praespira and N. discorbinus. The foraminiferal assemblage of this zone are rare occurrence of Quinqueloculina sp., Operculina sp, Assilina sp, A. praespira, infrequent occurrence of Discocyclina sp, A. praespira, N. Pengaronensis, N. discorbinus, N. beaumonti and common occurrence of Nummulites sp, N. acutus and F. elliptica.

The basal Tura Sandstone unconformably overlying the basement has been found unfossiliferous. The overlying Sylhet and Kopili Formations have yielded good assemblage of
Figure 1.4: Faunal distribution, age and palaeoecology in Tyynhe well

(After Bhatia, M.L. and Dave, Alok, 1996)
larger benthic foraminifera comprising *N. discorbinus*, *N. acutus*, *N. beaumonti*, *N. discorbinus*, *N. pengaronensis*, *Nummulites* sp. *Discocyclina* sp. and *F. elliptica* indicating the initiation of Paleogene marine transgression and deposition in inner shelf environment.

The transition from Kopili to Barail is marked by the elimination of calcareous benthics and sporadic presence of *Trochammina* sp, *Cyclammina* sp, and *Ammodiscus* sp. indicating of regressive phase and the deposition of Barails in brackish water environment.

**Location: Heningkunglwa (Southwest of Dimapur)**

A rich foraminiferal assemblage has been recorded by Baruah et al. (1987) from an argillaceous sequence (Fig. 1.5) outcropping near Heningkunglwa village (N 93°47'2": E 25°31'41""). The study of Baruah et al. showing the litho columns, faunal distribution is discussed in detail. The foraminiferal assemblages recorded by them in the Disang rocks near Heningkunglwa are reproduced below section wise (from i through iii).

1) **Tehai Reu Section:** The siltstone sequence in this section contains mostly larger benthic foraminifera. *Nummulites* sp., *Discocyclina* sp. and *Pellatispora* sp. are common, whereas planktic foraminifers are rare and poorly preserved. The important larger foraminifera are *N. pengaronensis* (Verbeek), *N. discorbinus* (Schlotheim), *D. dispersa* (Sowerby), *D. eamesi* (Samanta), *P. madarasi* (Hantken) and *P. inflata* (Umbgrove). The planktic foraminifera are *H. alabamensis* Cushman, *Globorotalia centralis* Cushman and Bermudez, *G. cerroazulensis* (Cole) and *G. ampliapertura* (Bolli).

2) **Heina Reu Section:** A rich planktic foraminiferal assemblage has been recovered from dark grey splintery shales. Only few species of larger foraminifera are found, which include *Nummulites* and *Pellatispora*. Planktic foraminifers include *G. pseudoampliapertura* Blow and Banner, *G. yeguaensis* Weinzierl and Applin, *G. tripartita* Koch, *G. ochitaaensis* Home and Wallace, *G. cerroazulensis* (Cole) *G. centralis* (Cushman and Bermudez), *G. increbescens* (Bandy), *G. insolita* (Jenkins), *H. alabamensis* (Cushman) *C. inflata* (Howe) and *P. barbadoensis* (Blow). Few smaller benthic foraminifera viz. *Uvigerina* sp., *Marginulina* sp., *Cibicides* sp., *Dentalina* sp., *Bulimina* sp. and a few corals have been reported.
Figure 1.5 Faunal distribution and Biozones of Tehai - Heina nala section
(After Baruah et al., 1986)
3) **Manglu River Section:** In this section, a rich planktic foraminiferal assemblage has been reported from dark grey silty shales but there is no report of larger foraminifera. The assemblage is similar to that of Heina Reu section except for the common occurrence of *C. inflata* and absence of *P. barbadoensis*.

4) **Lotsu Village:** Another outcrop of silty sandstone, exposed near Lotsu village (94°5’25’’: 26°3’45’’) of Nagaland has yielded similar larger foraminiferal assemblage (Baruah et al., 1987). They have reported the larger benthic foraminifera of *P. madaraszi, Nummulites* sp. *N. orbigny* (Galeotti), *Operculina* sp., *Cibicidoides* sp., *Quinqueloculina* sp., *Lagina* sp. and *Glandulina* sp.

Based on foraminiferal assemblages recorded in the above four sections, Baruah et al. (1987) recognized four zones including two assemblage zones. These are reproduced below from top to bottom:

1. **Poorly fossiliferous Zone:** The upper part of Disang Group consists of rare occurrence of *Trochammina* sp., arenaceous foraminifera. Age is not assigned.

2. **N. pengaronensis – P. madraszi – D. dispansa Zone:** The middle and lower part of Disang group contains abundant *N. pengaronensis, P. inflata, P. madraszi*, common occurrence of *Nummulites* sp., *D. dispansa, D. eamesi* and *Globorotalia* sp. and rare occurrence of *N. discorbinus, Operculina* sp., *Marginulina* sp., *Lenticulina* sp., *G. amplipertuera, G. yeguaensis, G. centralis, H. alabamensis* and *Globigerina* sp. The foraminiferal assemblage indicates Late Eocene age for this zone.

3. **C. inflata – H. alabamensis Zone:** This zone is recognized on the basis of the occurrence of *C. inflata* and *H. alabamensis* on the lower boundary and the upper limit is delineated on the basis of poor frequency of planktic foraminifera. The other foraminifers include an abundant occurrence of *Globorotalia* sp. and *Globigerina* sp. and common occurrence of *Gr. centralis, Uvigerina* cf. *jacksonensis, Lenticulina* sp. and *Marginulina* sp. and rare occurrence of coral, *P. barbadoensis, H. alabamensis, Gr. insolita, Gr. increbescens, G. cerroazulensis, GG. yeguaensis, GG tripartita, GG ouachitaeensis, GG. amplipertuera, G. amplipertuera, Trochammina* sp., *Cyclammina* sp., *Haplophragmoides* sp., *Gumbelitria* sp., *Bulimina* sp.,
Anomalina sp., Operculina sp., *P. madraszi* and *N. pengaronensis*. They assigned middle part of Late Eocene age to this zone.

4. **Sporadic arenaceous foraminiferal Zone**: This zone is confined to Laisong Formation (Barail Group). Foraminiferal assemblage in this zone includes a sporadic occurrence of arenaceous foraminifera, *Trochammina* sp., *Cyclammina* sp. and *Haplophragmoides* sp. Age is not assigned to this zone.

The paleoecology of Disang and Barail Groups studied by Baurah et al. is reproduced here. The foraminiferal assemblage recorded from the Disang and Barail Group represents deposition in shallow marine environment with oscillations in bathymetry. Heina Reu and Manglu sections are rich in planktic foraminiferal assemblage with *Uvigerina* sp. and *Bulimmina* sp., corresponding to middle to outer shelf zones and indicating bathymetry between 100 to 150m. Scanty occurrence of arenaceous foraminiferal assemblage on top part of Disang Group and in Barail Group suggests a brackish water environment of deposition.

**Location: Manglu River, Tehai Heina Reu and Lotsu village**

Singh and Rao (1998) reported the occurrence of foraminifera from Manglu River, Tehai Heina Reu and Lotsu village sections of Nagaland and Homo Nala section of Assam. The samples have yielded a rich microfaunal assemblage, which includes both planktic and benthic foraminifera. The larger foraminifera constitute the dominant element of the fauna and are widely distributed in the area. The detailed study of the assemblage led to recognition of thirteen species of the genera *Biplanispira*, *Pellatispira*, *Nummulites*, *Discocyclina* and *Heterostegina*.

The rich presence of *Biplanispira mirabilis* (Umbgrove), a rare occurring species, in the above assemblage was noted to be interesting. Based on larger benthic foraminifera *N. pengaronensis*-*P. madraszi* biozone has been recognized out of the above assemblage which could be dated Middle – Late Eocene equivalent to Zone P16 on planktic scale.
Sinha et al. (1982) recorded the occurrence of *Nummulites* sp. and *Dictyoconoides* sp. from the Disang Group of rocks exposed around Pfutsero and Meluri in Phek districts. The list of fossils reported are Bivalves: *Barbatia* sp., *Corbula* sp., *Nemocardium* sp., *Solen* sp., *Tellina* sp., *Venericardia* sp.; Gastropods: *Lymnaea* sp., *Turritella* sp. Foraminifera: *Nummulites* sp.

The above assemblage together with the fauna recorded at various times consist of molluscan taxa, which are cosmopolitan in nature, long ranging i.e., upper Cretaceous to Recent and indicative of marine shallow water deposition.

The presence of characteristic bivalves suggests the lower age limit of the fossiliferous members of the Upper Formation of the Disang Group as Paleocene. They have also further confirmed by the presence of larger foraminifera cf. *Nummulites* sp., which first appears in Paleocene. They reported that the record of Eocene index form *Dictyoconoides* suggests the age of the Disang Group may extend at least up to Middle Eocene.