

## MIDDLE-UPPER EOCENE BIOSTRATIGRAPHY OF KHASI AND JAINTIA HILLS BASED ON PLANKTONIC AND LARGER FORAMINIFERA

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### ABSTRACT

The foraminiferal biostratigraphic study of the Middle and Upper Eocene marine sequence of the Khasi and Jaintia Hills, Meghalaya has led to the recognition of two planktonic and one larger foraminiferal zones in Prang Limestone Member of the Sylhet Formation and Kopili Formation. The planktonic zones *Globigerina praebulloides oclusa*-*Globorotalia spinulosa* Assemblage Zone (Middle Eocene) in Prang Limestone Member and *Globorotalia cerroazulensis* Zone (Upper Eocene) in Kopili Formation are equivalent to *Porticulasphaera mexicana* Zone of Bolli (1957) (=Zone P. 13, *Orbulinoides beckmanni* Zone of Blow, 1969), and *Globorotalia cerroazulensis* Zone of Bolli (1957) respectively. The larger foraminiferal Zone—*Assilina spira corrugata*-*Discocyclina javana* Concurrent Range Zone, recognized in the uppermost part of Prang Limestone Member is tentatively equivalent to *Truncorotaloides rohri* Zone of Bolli (1957). These zones are systematically described with the type and typical sections and equivalent rock-stratigraphic sections in Khasi and Jaintia Hills and are correlated with well known horizons in world stratigraphy.

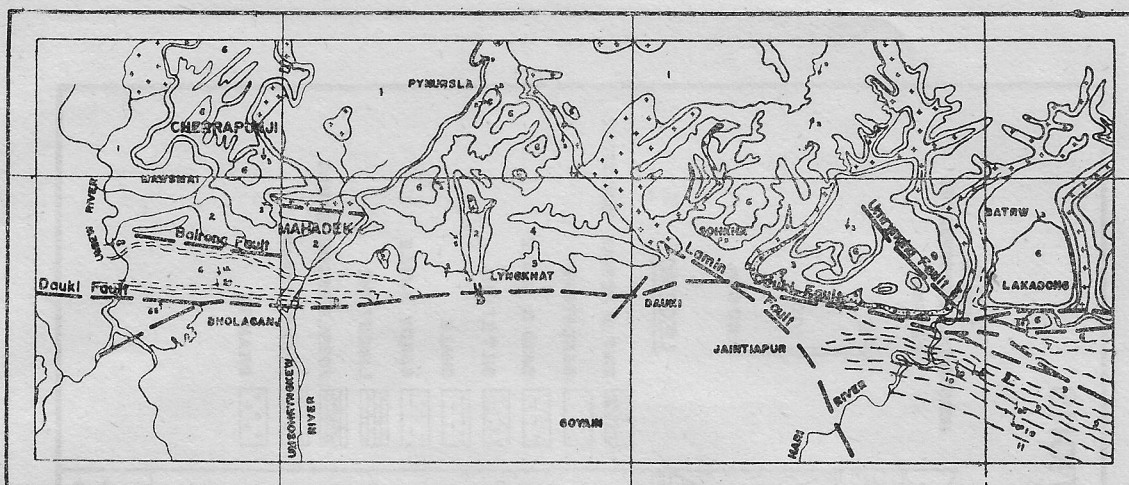
### INTRODUCTION

Planktonic foraminifera has long been considered as one of the most important and useful tool in biostratigraphic correlation of Late Cretaceous-Tertiary sequence throughout the world. In India, the application of these marine micro-organisms in biostratigraphic studies, have been utilised in several sedimentary basins and a number of unified zonations are proposed which are excellently compiled by Sastri and Datta (1972). However, in north-eastern India especially in Meghalaya and Assam, where thick marine Lower Tertiary sequence are known, such studies are still in very preliminary stage. Majority of Lower Tertiary sediments representing shelf facies, have either yielded rich benthonic larger foraminifera or are almost barren. The Middle and Upper Eocenes of Garo, Khasi, Jaintia and Miker Hills, are the only sequence having rich planktons and thus provide an opportunity for detailed biostratigraphic work in north-eastern India. The Eocene succession in Garo Hills and its planktonic foraminifera have been studied by several workers (Nagappa, 1959; Samanta, 1968, 1969), the equivalent horizons in Khasi and Jaintia Hills are still left unexplored. The purpose of this paper is to fill up this gap of knowledge about the planktonic foraminifera from Prang Limestone Member (Middle Eocene) of the Sylhet Formation and Kopili Formation (Upper Eocene) of the Khasi and Jaintia Hills, Meghalaya, and to describe the biostratigraphic zones and their correlation with Garo Hills and elsewhere.

### PREVIOUS WORK

Odham (1859) reported the presence of Eocene beds in Khasi Hills. Later several contributions by the Geological Survey of India, Burma Oil Company and Oil & Natural Gas Commission have been made especially towards the geology and structure of this region. Samanta, who made several contributions to the micropalaeontology, has given more emphasis to Garo Hills for several reasons (Samanta, 1968); the Khasi and Jaintia Hills, inspite of their rich faunal assemblage, have largely been neglected. Other recent studies includes Srinivasan and Srivastava (1967) on planktonic foraminifera of Kopili Formation in general and Ghosh (1967) on the classification of Jaintia group using larger foraminifera.

The present study is based on the outcrop samples collected by the field parties of the Oil & Natural Gas Commission (Srivastava, Asthana and Bora, 1969) from Hari, Umiew and Umsohryngkhew river sections (text fig. 1). The samples of Prang Limestone Member are mainly dark grey, massive to poorly bedded limestone and Kopili Formation are grey to dark grey and sometimes brownish grey, splintary shales with few centimetres thick fossiliferous marl bands and thin sand stone bands. The samples were processed and studied at the Institute of Petroleum Exploration, Dehra Dun. The limestone samples are generally very hard and compact, and, therefore, special technique of alternate heating and cooling in gasoline and final disintegration in ultrasonic vibrator, to extract the delicate foraminifera, were used.



GEOLOGICAL MAP OF THE PART OF KHASI AND JAINTIA HILLS

(After Shrivastava, Asthana and Bora, 1969)

SCALE 0 5 10 Kms.

INDEX

- ↖ 35 DIP NORMAL
- FORMATION BOUNDARY CERTAIN
- - - FORMATION BOUNDARY UNCERTAIN
- FAULT WITH DIRECTION OF MADE AND UPTHROWN (U) & DOWNTHROWN (D) SIDE
- 5 THERRIA
- 6 LANGPAR
- 3 MAHADEK SST.
- CONGLOMERATE SST. ALTS.
- 2 SYLHET TRAP
- BRANITE
- 1 SHILLONG SERIES WITH BASIC INTRUSIVE ROCK
- 11 TIPAM SANDSTONE
- 10 BORABE
- 9 BHUBAN
- 8 UNDIFFERENTIATED BARAL IN THE AREA WEST OF DAUKI
- 7 KOPILI FORMATION
- 6 SYLHET FORMATION

1. Geological map of the part of Khasi and Jaintia Hills.

PLANKTONIC FORMANIFERAL ASSEMBLAGE

Samples of Prang Limestone Member and Kopili Formation are not equally rich in foraminifera; planktonic foraminifera constitute on an average from 10-20% of total foraminiferal recovery. The rest comprises mostly larger and few smaller calcareous benthonic foraminifera, rare ostracode carapaces and echinoid spines. Few of the samples are devoid of foraminifera whereas some are rich in larger foraminifera. The planktonic foraminifera are in general poorly preserved, a factor which perhaps have been the cause for their being neglected in earlier studies. The marl beds of the shaly sequence of the Kopili Formation has better preservation index, whereas the limestone is the poorest.

The planktonic foraminiferal assemblage are described here according to their occurrence in two rock-stratigraphic units of three river sections in an ascending order. The stratigraphic columns are shown in text figure-2.

A. PRANG LIMESTONE MEMBER

1. UMIEV RIVER SECTION:

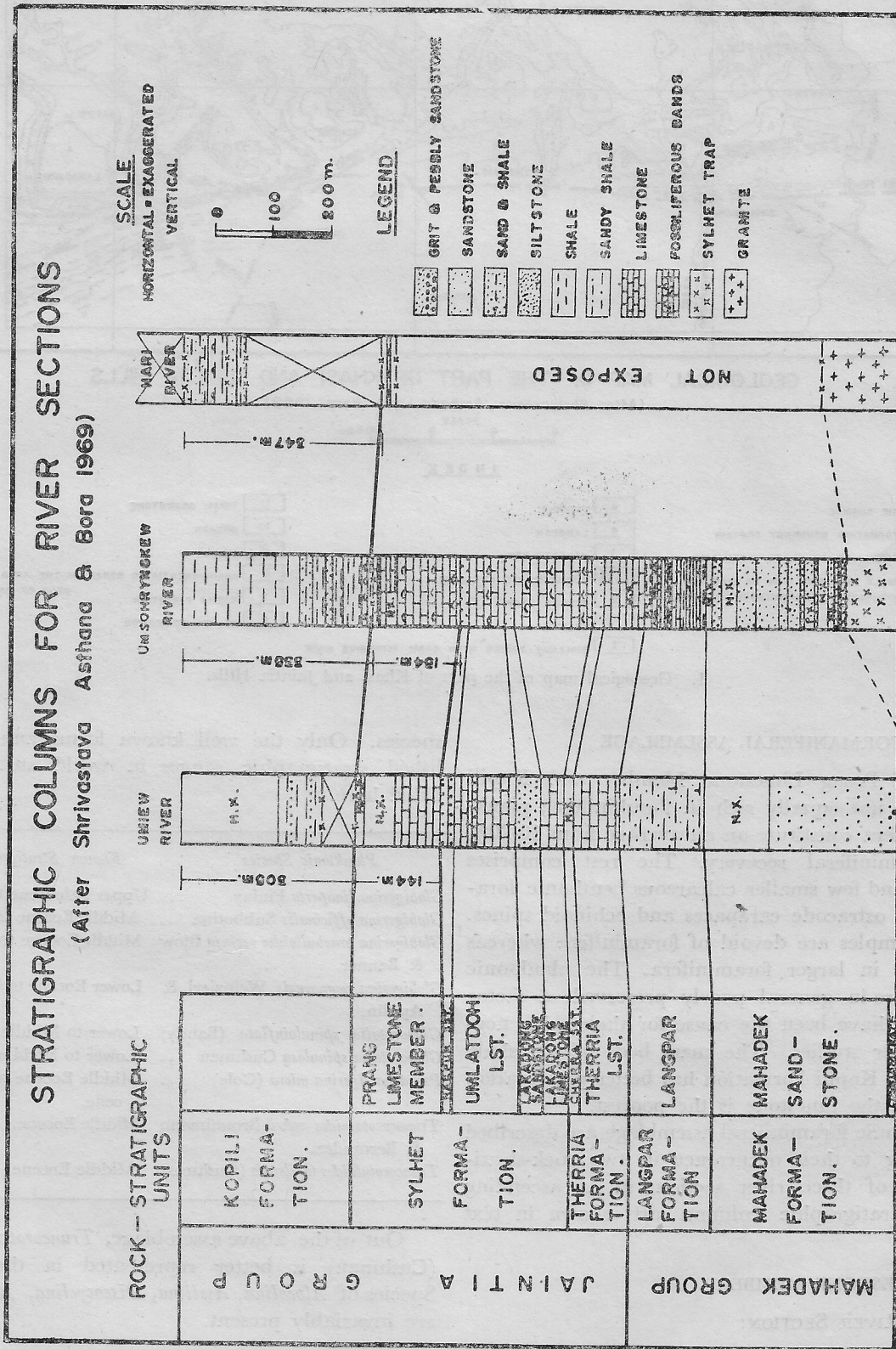
The samples from this section have yielded nine well known planktonic foraminifera and several indetermined

species. Only the well known forms and their established stratigraphic ranges in world stratigraphy are listed here.

Planktonic Species	Known Stratigraphic Ranges
<i>Globigerina linaperta</i> Finlay	Upper Paleocene to Upper Eocene
<i>Globigerina officinalis</i> Subbotina	Middle Eocene to Lower Miocene
<i>Globigerina praebulluoides oclusa</i> Blow & Banner.	Middle Eocene to Lower Miocene
<i>Globigerina yeguaensis</i> Weinzierl & Applin.	Lower Eocene to Oligocene.
<i>Globorotalia spinuloinflata</i> (Bandy)	Lower to Middle Eocene.
<i>Globorotalia spinulosa</i> Cushman	Lower to Middle Eocene.
<i>Pseudohastigerina micra</i> (Cole)	Middle Eocene to Middle Oligocene.
<i>Truncorotaloides rohri</i> Bronnimann & Bermudez.	Middle Eocene.
<i>Truncorotaloides topilensis</i> (Cushman)	Middle Eocene.

Out of the above assemblage, *Truncorotaloides topilensis* (Cushman) is better represented in the assemblage. Species of *Alveolina*, *Assilina*, *Discocyclina*, *Nummulites*, etc. are invariably present.

AGE AND CORRELATION: This planktonic assemblage has typical Middle Eocene affinity. Species of *Trun-*



2. Stratigraphic columns for river sections.

*corotaloides* are considered to be restricted to Middle Eocene whereas other forms are mostly long ranging. *Globorotalia spinuloinflata* (Bandy) and *Globorotalia spinulosa* Cushman are known to get extinct during Middle Eocene and *Globigerina yeguaensis* Weinzierl & Applin, *Globigerina officinalis* Subbotina, and *Globigerina praebulloides oclusa* Blow & Banner first appear in Middle Eocene. This assemblage from Prang Limestone Member is very well correlatable with *Porticulasphaera mexicana* Zone of Navet Formation (Middle Eocene), Trinidad (Bolli, 1957). Later in 1969, Blow renamed this zone as *Orbulinoedes beckmanni* Zone (Zone P. 13) based on taxonomic work of Blow & Saito (1968).

It is interesting to note that *Globigerina praebulloides oclusa* Blow & Banner first appears in Zone P13, whereas *Globorotalia spinuloinflata* (Bandy) and *Globorotalia spinulosa* Cushman become extinct at the top of Zone P. 13. As these forms are well represented in our sample, based on which a new zonal nomenclature-*Globigerina oclusa*-*Globorotalia spinulosa* Assemblage Zone is proposed, which is equivalent to P. 13 (Middle Eocene) of Blow (1969).

**CORRELATION WITH GARO HILLS:** The present assemblage of Prang Limestone Member of Khasi and Jaintia hills bears close similarity with those described from the Lower Member of the Siju Limestone of Garo Hills by Samanta (1969). Samanta has correlated this assemblage with *Globigerapsis kugleri* to the top of *Porticulasphaera mexicana* (= *Orbulinoedes beckmanni* Zone P. 13) Zone in Trinidad. In comparison to Khasi and Jaintia Hills, forms like *Globigerina linaperta* Finlay, *Globigerina officinalis* Subbotina, *Globigerina praebulloides oclusa* Blow and Banner, *Globigerina yeguaensis* Weinzierl and Applin and *Pseudohastigerina micra* (Cole), are not known to occur in Garo Hills (Samanta, 1969).

2. UMSOHRYNKHEW RIVER SECTION:

The samples of the Prang Limestone Member from this section have not yielded any recognisable planktonic foraminifera, on the other hand the assemblage is mostly represented by larger foraminifera like *Alveolina elliptica nuttalli* Davies, *Assilina papillata* Nuttall, *A. spira corrugata* de la Harpe, *Discocyclina omphalus* (Fritsch), D. cf. *D. sella* (d'Archiac), and *Nummulites beaumonti* d'Archiac and Haime. Madan Mohan (1971, Unpublished report) has reported very similar assemblage including *Assilina* cf. *subspira*, *Discocyclina dispansa*, *D. javana*, *Nummulites discorbinus* and few species of *Operculina* and *Lokhartia*, which he has assigned as Middle Eocene age. *Fasciolites oblonga* (d'Orbigny) as recorded by him also do not occur in our samples.

**CORRELATION WITH GARO HILLS:** Samanta (1968, 1969) has described almost similar assemblage from the lower and Upper Members (=Zones I and II) of Siju Limestone Formation in Garo Hills. On the basis of Planktonic foraminiferal species, Samanta (1969) has correlated these two zones with *Orbulinoedes beckmanni* and *Truncorotaloides rohri* Zone of world stratigraphy. As the present recorded larger foraminiferal species have considerable over-lapping ranges in these two zones (of Samanta, 1968), a concurrent range zone by definition—*Assilina spira corrugata*—*Discocyclina javana* Concurrent Range Zone is proposed. *Assilina spira corrugata*—de la Harpe and *Discocyclina javana* (Verbeek) are characteristic of Zone I (= *Orbulinoedes beckmanni* Zone) and Zone II (= *Truncorotaloides rohri* Zone) respectively of Garo Hills (Samanta, 1968). This larger foraminiferal assemblage zone, therefore, tentatively ranges from the base of *Globigerina praebulloides oclusa*—*Globorotalia spinulosa* Assemblage Zone upto the top of Middle Eocene (Table-1, text fig. 3).

Table 1

Middle to Upper Eocene Biostratigraphic Zones of Khasi and Jaintia Hills (Shelf Facies)

Geologic Age	Rock-Stratigraphic Units	Biostratigraphic Zones	Correlation with Garo Hills (Samanta, 1968)
Priabonian	Kopili Formation	<i>Globorotalia Cerroazulensis</i> Zone	Zone III
Lutetian (Upper to Middle)	Sylhet Formation Prang Limestone Member	.. <i>Assilina spira corrugata</i> Discocyclina javana Concurrent Range Zone	? (= <i>Truncorotaloides rohri</i> Zone of Bolli, 1957).  Zone II  Zone I
		<i>Globigerina praebulloides oclusa</i> - <i>Globorotalia spinulosa</i> Assemblage Zone.	

RANGE TABLE FOR PLANKTONIC FORAMINIFERA IN KHASI AND JAINTIA HILLS.				PLANKTONIC FORAMINIFERA																					
GEOLOGIC AGE		ROCK UNITS	BIOSTRATIGRAPHIC ZONES	<i>Globigerina praebuloides occulosa</i>	<i>Globorotalia spinuliflata</i>	<i>Globorotalia spinulosa</i>	<i>Truncorotaloides rohri</i>	<i>Truncorotaloides topilensis</i>	<i>Globigerina linaperta</i>	<i>Globigerina officinalis</i>	<i>Globigerina yeguaensis</i>	<i>Pseudohastigerina micra</i>	<i>Globigerina ampliapertura</i>	<i>Globigerina eocaena</i>	<i>Globigerina tripartita tripartita</i>	<i>Globigerinata unicava</i>	<i>Globorotalia centralis</i>	<i>Globorotalia cerroazulensis</i>	<i>Globorotalia gemma</i>	<i>Globorotalia opima nana</i>	<i>Chiloguembelina cubensis</i>	<i>Chiloguembelina tenuis</i>	<i>Hantkenina alabamensis</i>	<i>Hantkenina brevispira</i>	
E O C E N E	PRIABONIAN	KOPILI FORMATION	Globorotalia cerroazulensis Zone																						
	LUTETIAN	SYLHET FORMATION PRANG LIMESTONE	( <i>Truncorotaloides rohri</i> Zone of Samanta, 1969)  Asellina spira corrugata-Discocyclina javana Concurrent Range Zone  Globigerina praebuloides occulosa - Globorotalia spinulosa Assemblage Zone																						

3. Range table for planktonic foraminifera in Khasi and Jaintia Hills.

## B. KOPILI FORMATION:

## 1. UMSOHRYNGKHEW RIVER SECTION:

The Kopili shale samples collected from this section are also rich in planktonic foraminifera, however, their distribution has not been observed to be uniform. In all thirteen well known planktonic species are recorded.

Planktonic Species	Known Stratigraphic Ranges
<i>Chiloguembelina cubensis</i> (Palmer)	.. Middle Eocene to Middle Oligocene.
<i>Chiloguembelina tenuis</i> Todd	.. Upper Eocene.
<i>Globigerina ampliapertura</i> Bolli	.. Upper Eocene to Lower Oligocene.
<i>Globigerina eocaena</i> Guembel	.. Upper Eocene to Lower Oligocene.
<i>Globigerina linaperta</i> Finlay	.. Upper Paleocene to Upper Eocene.
<i>Globigerina officinalis</i> Subbotina	.. Middle Eocene to Lower Eocene.
<i>Globigerina yeguaensis</i> Weinzierl & Applin.	.. Lower Eocene to Oligocene.
<i>Globorotalia centralis</i> Cushman & Bermudez.	.. Middle to Upper Eocene.
<i>Globorotalia cerroazulensis</i> (Cole)	.. Upper Eocene.
<i>Globorotalia gemma</i> Jenkins	.. Upper Eocene to Oligocene.
<i>Globorotalia opima nana</i> Bolli	.. Upper Eocene to Oligocene.
<i>Hantkenina brevispira</i> Cushman	.. Upper Eocene.
<i>Pseudohastigerina micra</i> (Cole)	.. Middle Eocene to Middle Oligocene.

This assemblage has restricted Upper Eocene species like *Chiloguembelina tenuis* Todd, *Globorotalia cerroazulensis* (Cole), and *Hantkenina brevispira* Cushman. Other species are long ranging. Species which get extinct during Upper Eocene are *Globigerina linaperta* Finlay, and *Globorotalia centralis* Cushman and Bermudez, and forms which first appear during Upper Eocene are *Globigerina ampliapertura* Bolli and *Globorotalia gemma* Jenkins.

## 2. HARI RIVER SECTION:

The planktonic assemblage has close similarity with those recorded from Umsohryng khew River samples. Forms like *Globigerina tripartita tripartita* Koch (Middle Eocene to Lower Miocene), *Globigerinita unicava* (Bolli, Loeblich & Tappan) (Middle Eocene to Lower Miocene) and *Hantkenina alabamensis* Cushman (Middle to Upper Eocene) has also been recorded from these samples.

The planktonic foraminifera of the Kopili Formation as recorded from Umsohryngkhew and Hari River sections, have definite Upper Eocene affinity and may be correlated with *Globorotalia cerroazulensis* Zone of Bolli (1957). Similar zonal name is also proposed for the present studied sequence.

CORRELATION WITH GARO HILLS: The planktonic assemblage for Kopili Formation from Khasi and Jaintia

Hills bear close resemblance with the counterparts described from Garo Hills. All the forms from Khasi and Jaintia Hills are known from Garo Hills. Samanta (1969) has described twenty one species, out of which *Cribrohantkenina inflata* (Howe), *Globigerina angioporides* Hornibrook, *Globigerina angustumbilicata* Bolli, *Globigerina pseudoampliapertura* Blow and Banner, *Globigerinita howei* Blow and Banner, *Hantkenina liebusi* Shokhina, *Hantkenina primitava* Cushman and Jervis and *Hantkenina suprasuturalis* Bronnimann, however, do not occur in Khasi and Jaintia Hills. He also correlated the assemblage with *Globorotalia cerroazulensis* Zone of Bolli (1957).

#### BIOSTRATIGRAPHIC ZONES

Two planktonic and one concurrent larger foraminiferal zones are worked out in Middle to Upper Eocene sequence of Khasi and Jaintia Hills. These are described in ascending order:

1. *Globigerina praebulloides oclusa*-*Globorotalia spinulosa* Assemblage Zone.

*Definition:* Interval with the first appearance of *Globigerina praebulloides oclusa* Blow and Banner and extinction of *Globorotalia spinulosa* Cushman and *Globorotalia spinuloinflata* Bandy.

*Type section:* Umiew River (text figs. 1 & 2).

*Rock-stratigraphic Unit:* Lower part of Prang Limestone Member of Sylhet Formation (Evans, 1932).

*Age and correlation:* Upper part of Middle Eocene, correlated with *Porticulasphaera mexicana* Zone of Bolli (1957), *Orbulinoides beckmanni* Zone, P. 13 of Blow (1969).

2. *Assilina spira corrugata*-*Discocyclusina javana* Concurrent Range Zone (informal zone).

This zone is characterised by the paucity of planktonic foraminifera and abundance of larger foraminifera as recorded in Umsohryngkhew river section.

It is tentatively correlated with *Porticulasphaera mexicana* and *Truncorotaloides rohri* Zone (Middle Eocene) of Bolli (1957). This zone is also correlated with Zone I and II, (based on larger foraminifera) of Garo Hills (Samanta, 1968).

3. *Globorotalia cerroazulensis* Zone.

*Definition:* Range with zonal marker.

*Type section:* Near San Fernando Railway station, Trinidad (Bolli, 1967).

*Typical section:* Umsohryngkhew River section, Meghalaya (text figs. 1 & 2).

*Rock-stratigraphic Unit:* Kopili Formation, *nom. correct.* Kopili Alternations Stage of Evans (1932).

*Age and Correlation:* Upper Eocene age, correlatable with *Globorotalia cerroazulensis* Zone of Bolli (1957).

#### CONCLUSIONS

Planktonic foraminiferal study helps in identifying two biostratigraphic Zones, in the Middle to Upper Eocene of shelf sediments in Khasi and Jaintia Hills. Precise correlation of these zones with other unified zonation scheme in world's Eocene stratigraphy is thus possible. *Globigerina praebulloides oclusa*-*Globorotalia spinulosa* Assemblage Zone is better defined and easily identifiable than the equivalent *Orbulinoides beckmanni* Zone of Blow (= *Proticulasphaera mexicana* Zone of Bolli), as the taxonomic status of the latter species has been matter of controversy and its being rare in occurrence in this part of world. This study also helps to identify *Assilina spira corrugata*-*Discocyclusina javana* Concurrent Range Zone, based on larger foraminifera within Middle Eocene sequence. As most of the horizons in Meghalaya are rich in larger foraminifera, the recognition of this larger foraminiferal Zone will be useful for biostratigraphic work and precise correlation in north-eastern India.

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The views expressed in this paper are those of the authors and not necessarily of the Oil and Natural Gas Commission.

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*Globobulimina aculeata* Zone  
 Definition: Interval with the first appearance of *Globobulimina aculeata* section Bow and Suter and extinction of *Globobulimina spinosa* and *Globobulimina spinosa* section Bawa.

The name: Umie River (see fig. 1 & 2).

Geographical limit: Lower part of the Umie River Member of the Kopili Formation (Crane, 1912).

The zone is characterized by the presence of planktonic foraminifera and abundance of larger foraminifera as recorded in Umie River section.

It is stratigraphically correlated with the *Globobulimina aculeata* Zone (Middle Eocene) of Bolla and Suter (1908). The zone is also correlated with Zone I and II (1937) based on large foraminifera of the Umie Hills (Sastri, 1972).

*Globobulimina aculeata* Zone  
 Definition: Range with small number.

The name: Umie River (see fig. 1 & 2).

Geographical limit: Umie River section, Assam (see fig. 1 & 2).

Geographical limit: Kopili Formation, Assam (1937).

The name: Umie River (see fig. 1 & 2).

Geographical limit: Kopili Formation, Assam (1937).