DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MICROFOSSIL ASSEMBLAGES FROM THE EOCENE SYLHET LIMESTONE AND KOPILI FORMATION, SYLHET DISTRICT, NORTHEAST BANGLADESH

by

Elisabeth M. Brouwers

U.S. Geological Survey, Mail Stop 919, Box 25046,
Federal Center, Denver, Colorado 80225

Open-File Report 92-191

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

MICROFOSSIL ASSEMBLAGES FROM THE EOCENE SYLHET LIMESTONE AND KOPILI FORMATION, SYLHET DISTRICT, NORTHEAST BANGLADESH

Elisabeth M. Brouwers
U.S. Geological Survey, MS 919, Box 25046, Federal Center,
Denver, Colorado 80225 USA

Mujibur Rahman Khan and Afia Akhtar
Geological Survey of Bangladesh, 153 Kakrail (Pioneer Road)
Segun Bagicha, Dhaka, Bangladesh

ABSTRACT

The Sylhet Limestone and the Kopili Formation in northeastern Bangladesh, of middle and late middle to late Eocene age, respectively, contain abundant microfossil faunas. The Sylhet Limestone, known regionally as the "Nummulitic Limestone", includes an abundant and diverse larger foraminifer assemblage, a moderately diverse smaller benthic foraminifer assemblage, and a sparse, low diversity ostracode assemblage. The Sylhet Limestone can be correlated with other middle Eocene formations on the basis of the larger foraminifers (*Nummulites, Assilina, Discocyclina*, and *Alveolina*). The Kopili Formation contains diverse larger foraminifer and smaller benthic foraminifer assemblages, a fairly diverse planktic foraminifer assemblage, and a sparse ostracode assemblage. The fauna of the Kopili Formation can be correlated with other late Eocene faunas on the basis of the larger foraminifers (*Nummulites, Pellatispira*) and planktic foraminifer species (*Globorotalia, Hantkenina*). The foraminifer assemblage has greater zoogeographic affinities with Eocene Indopacific assemblages than the ostracode assemblages; the ostracodes show affinities with Eocene Tethyan faunas from the Middle East. Microfossil assemblages of the Sylhet Limestone and Kopili Formation change in composition upsection in response to the shoaling trend that occurred in this region.

INTRODUCTION

The Geological Survey of Bangladesh and the U.S. Geological Survey conducted cooperative research efforts in Bangladesh between 1987 and 1990. One aspect of the field program focused on an investigation of the fossil fauna and flora of Tertiary sedimentary sequences in northeastern and southeastern Bangladesh. The objectives of these studies were to (a) construct a biostratigraphic zonation and correlate this zonation with Paleogene zonations of the Assam sequences of India, on a larger scale to correlate to the zonation of the Indopacific and Tethyan sequences based on larger foraminifers, and to correlate to the international zonation based on planktic microfossils; (b) reconstruct paleoenvironments of the Tertiary strata and tie these interpretations to the depositional history based on sedimentary structures; and (c) determine the zoogeographic affinities of the microfossil assemblages, providing some information on the nature of water mass exchange between the Indian Ocean and Tethys and the Indian Ocean and the Indopacific.

This report documents the results of a field study during 1989 in the Sylhet District, northeastern Bangladesh. Sediments of the middle Eocene Sylhet Limestone and the late middle to late Eocene Kopili Formation were sampled and analyzed for the ostracode and foraminifer assemblages. This report presents (a) a review of the stratigraphic nomenclature and biostratigraphic analyses of the Sylhet Limestone and Kopili Formation of the Jaintia Group in Bangladesh and India, (b) an analysis of the ostracode assemblage, (c) a species list of the foraminifer assemblage, and (d) scanning electron photomicrographs of the ostracode and foraminifer taxa.

ACKNOWLEDGEMENTS

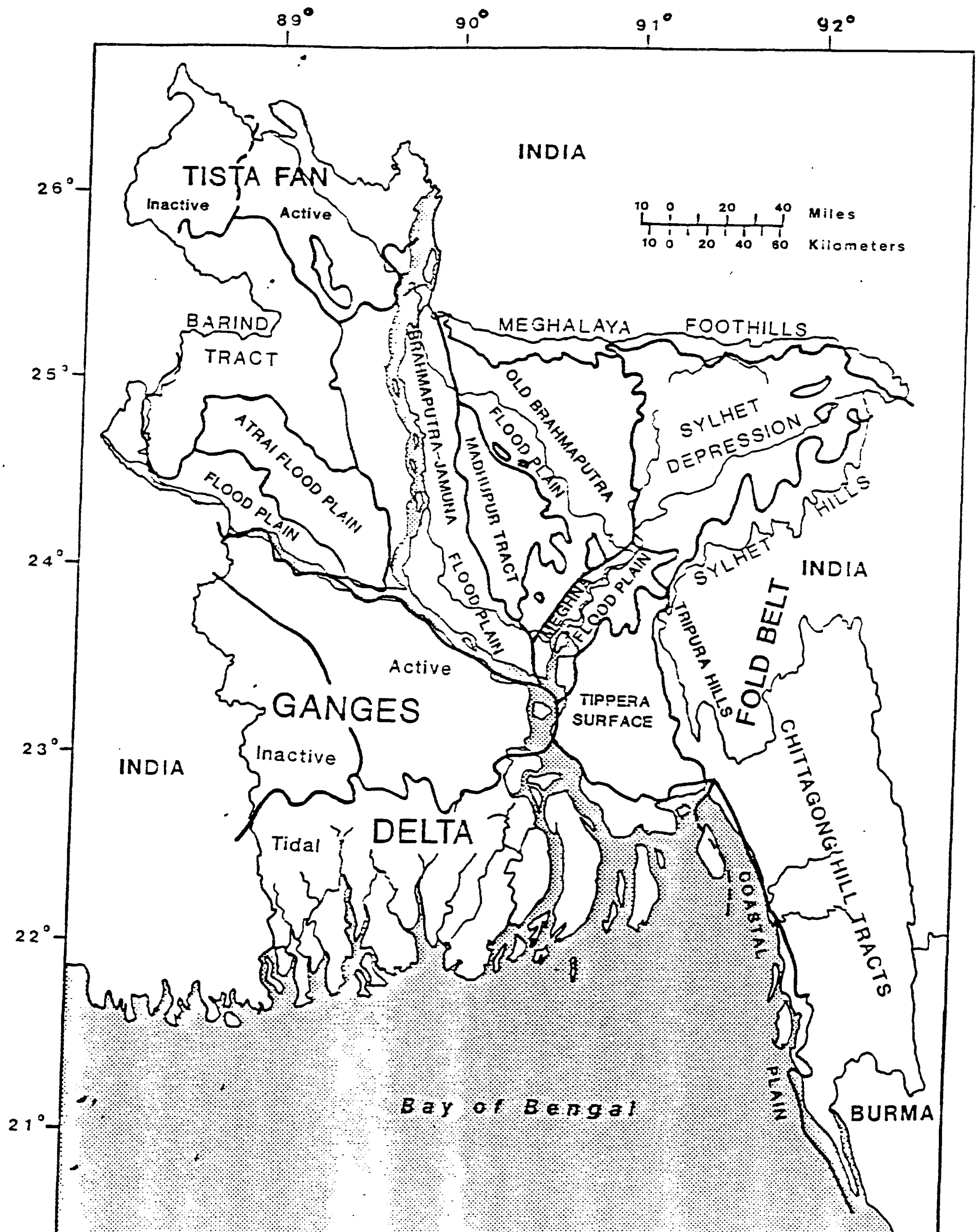
This paper is a product of the USGS project *Accelerated Exploration for Mineral Resources and Modernization of Geological Survey of Bangladesh (GSB)*, under loan agreement 450 BAN(SF) of the Asian Development Bank (ADB). The objectives of the project were to develop and implement interdisciplinary programs of geological and geophysical investigations suitable for the requirements of a modern national geological survey (Terman, 1988). Integrated field and laboratory studies in a USGS Expert-GSB Counterpart relationship were conducted throughout Bangladesh.

We gratefully acknowledge the enthusiasm and support of Mr. S.K.M. Abdullah, Director General of the Geological Survey of Bangladesh. Mrs. Nafiza Chowdhury assisted this study by examining processed residues of the Sylhet Limestone and Kopili Formation for microfossils. Mr. Nehal Uddin and Mr. Mohammed Moazzem Hossain provided valuable assistance in the field. Samuel Johnson provided observations on the sedimentary structures in the field and provided us with a draft copy of his manuscript on the Sylhet trough. We thank D.A. Coates, K. McDougall, and Qadeer Siddiqui for reviewing the manuscript.

GEOGRAPHIC SETTING

The physiography of Bangladesh consists essentially of a large delta plain rimmed by hilly regions along the northeastern, eastern, and southeastern margins (Figure 1). The topographically highest regions in Bangladesh are the Chittagong Hill Tracts, which include north-trending synclinal valleys and anticlinal ridges of Tertiary strata that range in elevation from 70-1000 m (Ministry of Irrigation, 1987).

Figure 1.--Map showing the major physiographic provinces of Bangladesh; note the Sylhet depression in northeast Bangladesh (adapted from Alam and others, 1990).



The study area is part of the Meghalaya Foothills physiographic province (Ministry of Irrigation, 1987) and consists of folded, faulted, and uplifted Tertiary rocks that form steeply dissected hills. Topography is determined by geologic structure and rock type. The area examined is between latitudes 25°0'N and 25°12.5'N and longitudes 92°0'E to 92°27.5'E, Survey of Bangladesh topographic sheet 83C/4 (scale 1:50,000).

The study area is bordered on the northeast by the abrupt scarp of the Shillong Plateau (or Shillong Massif) of India (about 1200-1800 m high), and to the north by the Khasi-Jaintia Hills (Figure 2; Khan, 1978). Hilly topography continues toward the east, and a continuous series of hills ranges southeast from Jaintiapur to the Surma River (Hossain and others, 1988). Topography south of the study area is flat, consisting predominantly of flood plains and marshes.

Outcrops in the study area are isolated and discontinuous due to dense vegetation and intense weathering. Rock exposures occur only along river banks and in fresh roadcuts. The structural complexity of the region, with many small faults and folds, together with the lack of continuous exposures, precludes definitive reconstruction of the sedimentary sequence and the total thickness.

GEOLOGIC SETTING

Bangladesh comprises the eastern half of the Bengal Basin, bordered on the west by the outcropping Precambrian Indian Shield and on the north by the Shillong Plateau of India (Acharya and others, 1986). The Dauki fault, a major east-trending tectonic lineament, separates the Shillong block from the adjacent Sylhet trough to the south (Figure 3), which in turn marks the northeastern part of the Bengal Basin. The east margin of the Bengal Basin is dominated by north-northwest and north-trending fold zones of the Indo-Burman ranges.

The study area forms the northern part of the Sylhet trough (Guha, 1978), which is bounded to the north by the Shillong massif and to the east and south by the plunging, anticlinally folded Tripura-Chittagong fold belt. The Shillong Plateau is largely composed of Precambrian metamorphic rocks which are overlain by a veneer of Cretaceous and lower Tertiary sedimentary rocks. To the south, the massif gneisses are overlain by a succession of quartzites, grits, and slates that comprise the Shillong Group. Some Mesozoic rocks, including the Middle Jurassic Sylhet Trap, are exposed along the Meghalaya Foothills. Strata of Tertiary age occur along the northern flank of the Shillong Plateau in northern Assam, and along the southern flank in central and southern Assam, India, and in northern Bangaldesh (Sah, 1974). Tertiary strata are unconformably underlain by either Precambrian basement rock or Cretaceous sediments. The lower Tertiary shelf sediments occur as discrete outliers and as a continuous narrow belt fringing the southern margin of India and the plains of northeastern Bangladesh (Murthy and others, 1976).

Figure 2.--Geologic map of Bangladesh and adjacent areas of India illustrating the distribution of Eocene rocks and the location of the Shillong Plateau (adapted from Ministry of Irrigation, 1987).

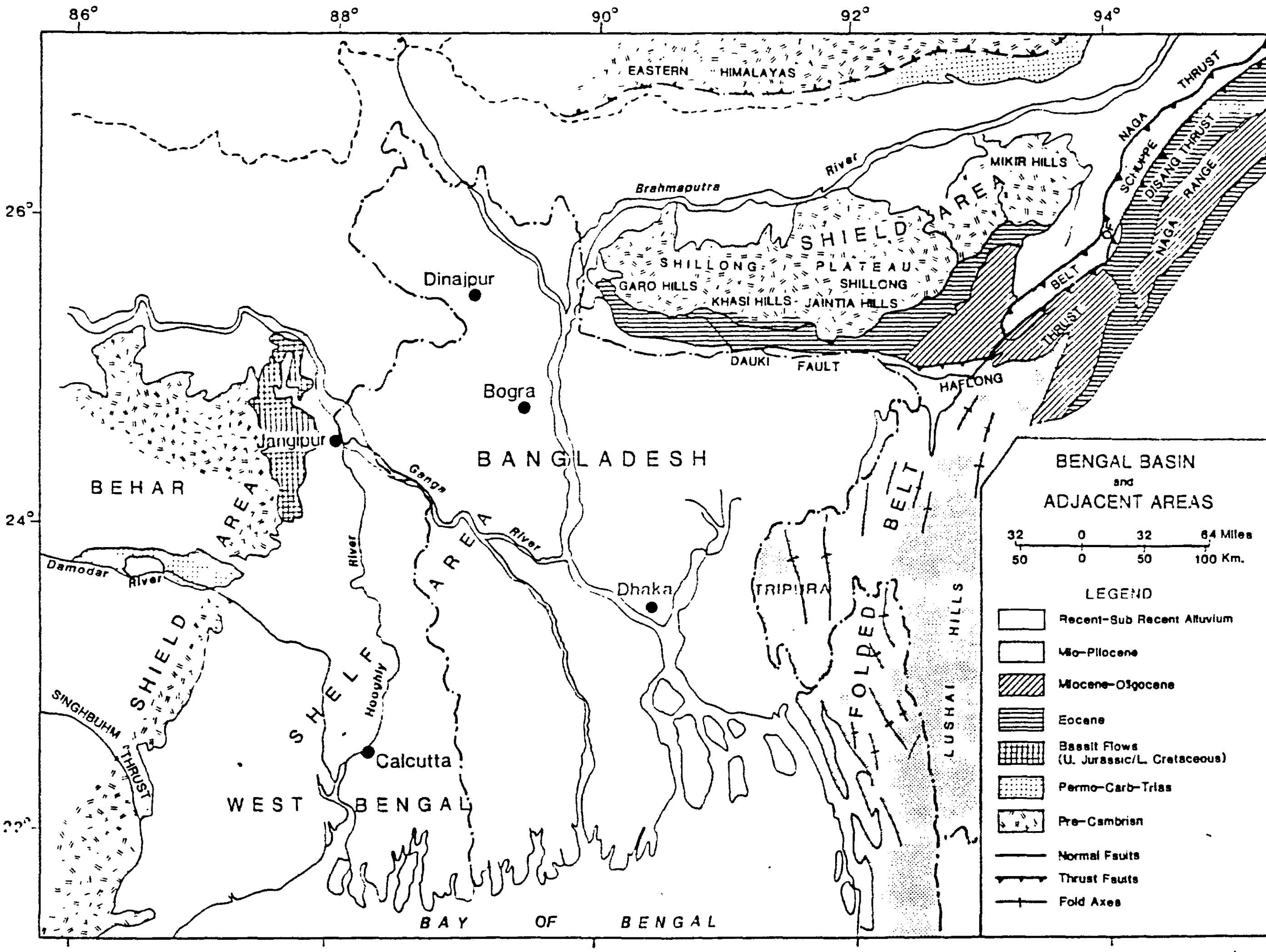
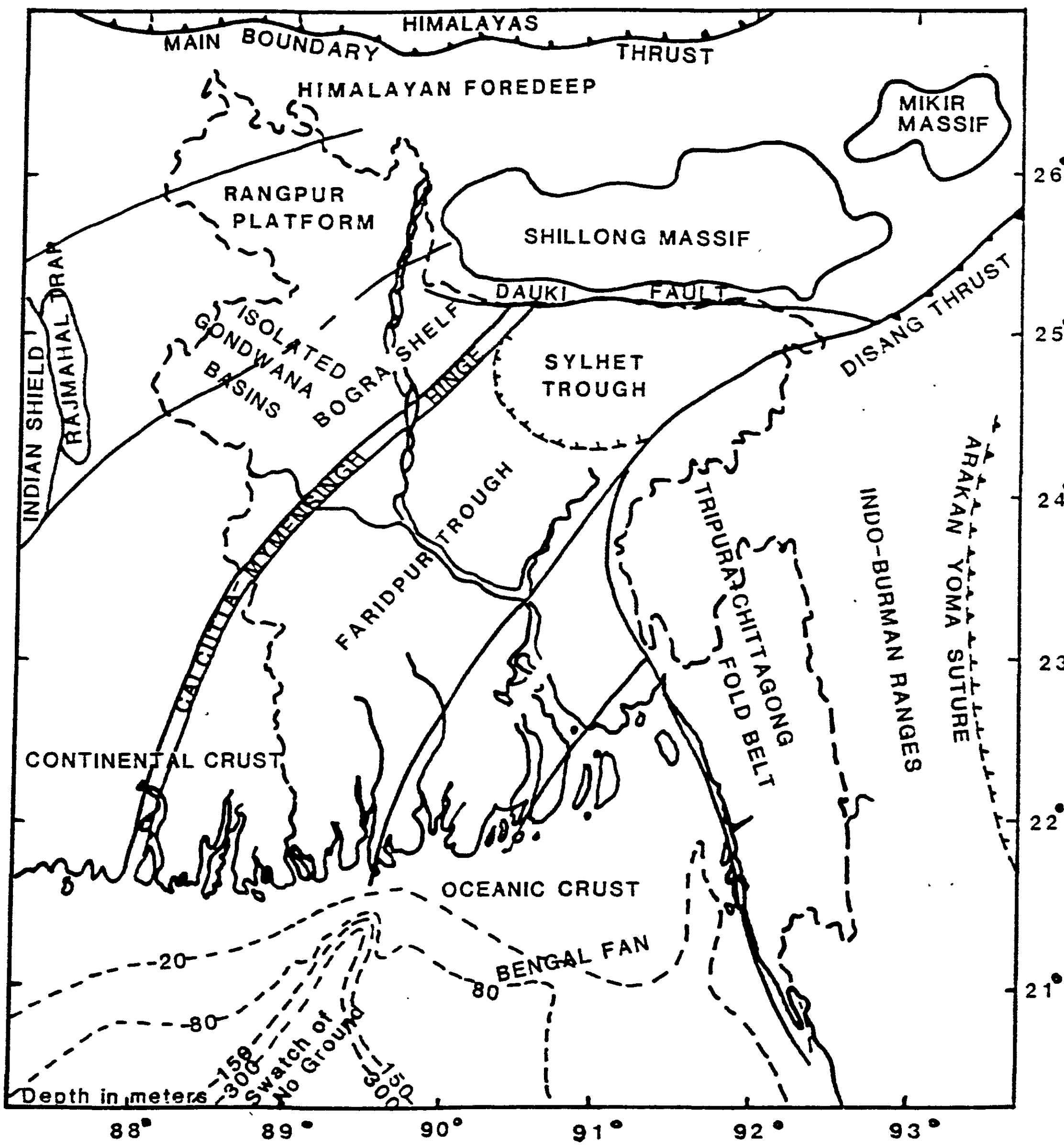


Figure 3.--Map of the major structural provinces of Bangladesh (adapted from Alam and others, 1990). Note the location of major fault zones and the Sylhet trough.



The Sylhet trough is filled with between 12,000 and 16,000 meters of sedimentary rocks above the basement, of which 600-800 m has been estimated for the Sylhet and Kopili Formation in subsurface; most of the basin fill was deposited during the Neogene (Johnson and Nur Alam, 1991). About 45 m of Sylhet Limestone and Kopili Formation are exposed in Bangladesh, trending a short distance along the southern bank of the Dauki River (Figure 4). The section studied here is located about 400 m north of Samgram Bazar and Bollaghat. The approximate strike for the Dauki River sedimentary rocks is N60^{0}W, and the dip ranges from 40^0 to 65^0 toward the northwest (Hossain and others, 1988).

METHODS

Eleven samples were collected from the Sylhet Limestone and five samples from the Kopili Formation, from outcrops along the Dauki River just south of the border with India. Samples were collected as available exposures and weathering of the strata allowed; the upper part of the Sylhet Limestone was well sampled, but the Kopili Formation could be sampled only at irregular intervals because of the discontinuous exposures.

Paleontological samples were collected in duplicate for the Geological Survey of Bangladesh and the U.S. Geological Survey, and samples were processed in both laboratories. The procedure followed in the USGS Denver Calcareous Microfossil Laboratory is as follows:

(1) 500 gm (dry weight) were precisely weighed, and the sample broken into small (< 2.5 cm) pieces.
(2) The pieces were placed into a stainless steel beaker, and about one to two tablespoons of sodium bicarbonate were added.
(3) Boiling water was added to cover the entire sample.
(4) The water was allowed to cool to room temperature, and about one tablespoon of Calgon (sodium hexametaphosphate) was added.
(5) The beaker was placed into a freezer overnight until the sample was completely frozen.
(6) The sample was allowed to return to room temperature, and the sediment was poured over a nested set of 20-mesh and 200-mesh washing sieves (850 um and 63 um, respectively).
(7) The sample fraction collected on the 200-mesh sieve was separated and allowed to air-dry. Material collected on the 20-mesh sieve was reprocessed using steps 2-6.
(8) Iterative processing was continued until the sample was completely broken down.
(9) The dried residue was separated on a set of nested sieves (20, 40, 50, 60, 80 mesh), and all fractions between the 20 and 80 sieves inclusive (e.g., all residue greater than 180 um in size) were examined. All ostracode specimens in this size range were removed and placed into micropaleontological slides.

(10) All specimens were identified to species level and counted, differentiating between adult and juvenile specimens.

Sediments of the Kopili Formation are readily disaggregated, most samples needing only one freeze-thaw cycle. The Sylhet Limestone is recrystallized and hence difficult to disaggregate, requiring 5-10 freeze-thaw cycles.

LITHOSTRATIGRAPHY

Previous Studies

Paleogene sediments exposed along the southern Shillong Plateau are divided into the Jaintia Group and the Barail Formation. The older Jaintia Group consists of three units: the lower Tura (Therria, Cherra) Formation, comprised of sandstone, claystone, limestone, and coal; the middle Sylhet Limestone, consisting of limestone, sandstone, and coal; and the upper Kopili Formation, made up of carbnaceous shale, shale, sandstone, and limestone (Figure 5).

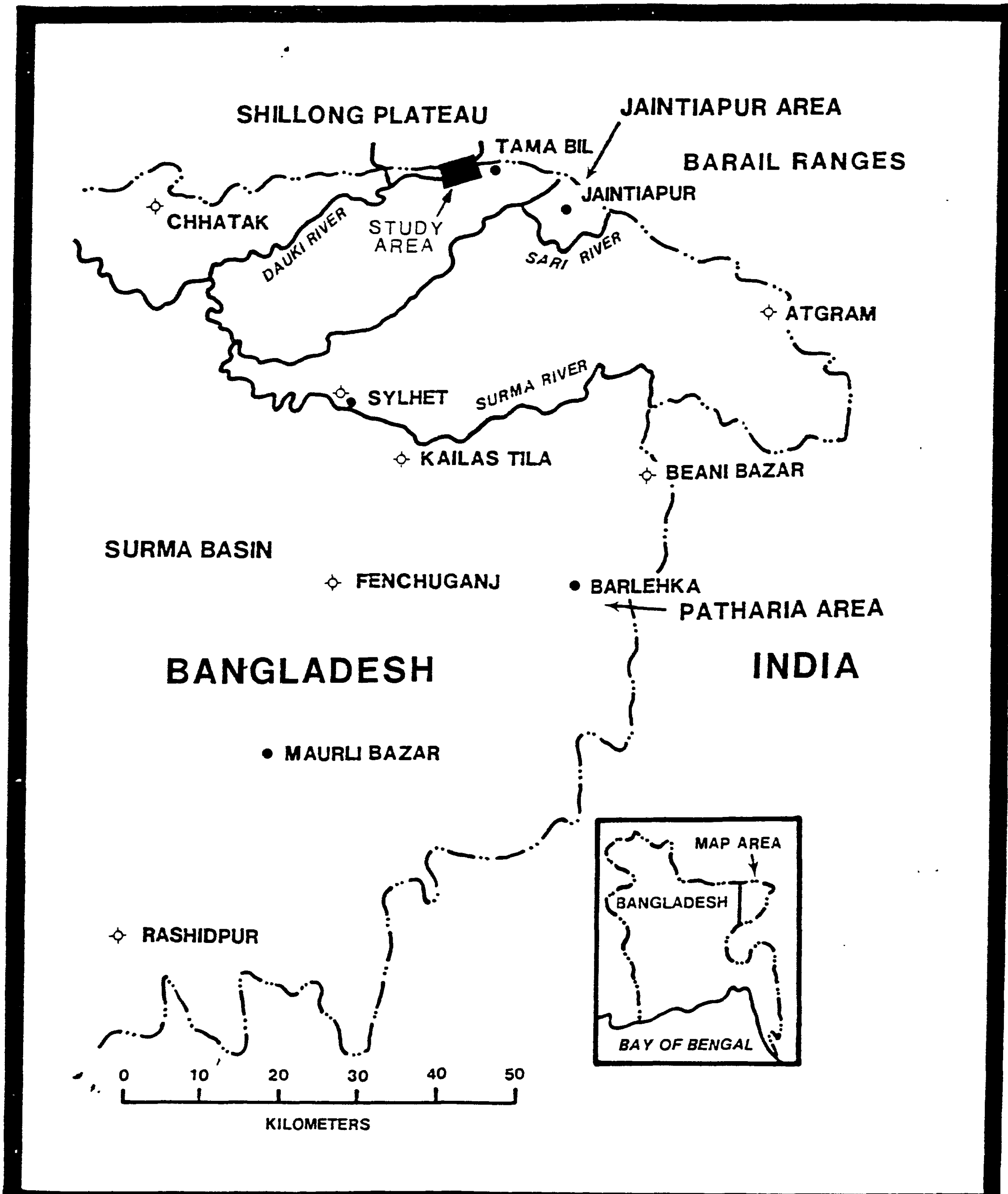
Sylhet Limestone--
The Sylhet Limestone "Stage" was first named by Evans (1932) as a conformable sequence of limestone and sandstone that constitute the middle part of the Jaintia Group. The stage was named after the district town of Sylhet along the southern Shillong Plateau. The type area is the Jaintia Hills, Assam, India, where the Sylhet Limestone attains a maximum thickness of 520 m and is divided into five members, consisting, from the uppermost to the lowermost member, of the Prang Limestone, the Nurpah Sandstone, the Umlatdoh Limestone, the Lakadong Sandstone, and the Lakadong Limestone.

Limestones referred to the Sylhet Limestone are exposed in the Jaintia Hills, Khasia Hills, and Garo Hills of India and the Takerghat area of Sylhet, Bangladesh, and in the subsurface of Rajshahi district, Bangladesh (Khan and Muminullah, 1988). In Bangladesh, the term Sylhet Limestone was first used by F.H. Khan (1963) for limestone deposits in the area of Sylhet.

The uppermost limestone horizon of the Sylhet Limestone forms a characteristic seismic reflector, recognizable as far as the Bhagirathi River but not much further downdip (Johnson and Nur Alam, 1990). The Sylhet Limestone in the subsurface in West Bengal is similar in lithology and fossil content to outcrops of the Sylhet Limestone in the Garo Hills (the Siju Limestone "Stage") and the Mikir Hills (Biswas, 1963).

The Sylhet Limestone of Bangladesh has been correlated with the Prang Limestone and the Siju Limestone of central and southern Assam on the basis of lithology and foraminifer faunas (Nagappa, 1956, 1959; Zaher, 1970; Ismail, 1978; Mohan, 1979; Khan and Muminullah, 1989).

Figure 4.--Map of northeast Sylhet District, with the study area marked by a filled rectangle.



Kopili Formation--
The Kopili Formation was defined by Evans (1932) for beds that form the upper part of the Jaintia Group. The unit was named for shales outcropping near the Kopili River, draining the northern foreland shield and shelf. The type area is in the Garo Hills of Assam, India, with the best exposures in the Simsang River section (Samanta, 1968a). M.R. Khan (1982) noted that the term Kopili has been used in a lithologic sense variously as Kopili Alternations (Wadia, 1961), Kopili Series (Krishnan, 1968), and Kopili Formation (Biswas, 1963; Gupta, 1976). The Kopili Formation is about 450 m thick at the type locality and consists of alternations of carbonaceous shale and fine-grained sandstone with intercalated beds of calcareous sandstone and fossiliferous limestone. At the type locality, the Kopili Formation conformably overlies the Sylhet Limestone and is apparently conformably overlain by Barail-equivalent rocks (Samanta, 1968a). The lower part of the formation is very fossiliferous and contains abundant larger foraminifers, including stratigraphically important genera such as *Asterocyclina, Discocyclina, Nummulites*, and *Pellatispira*, with *Discocyclina* being the most abundant.

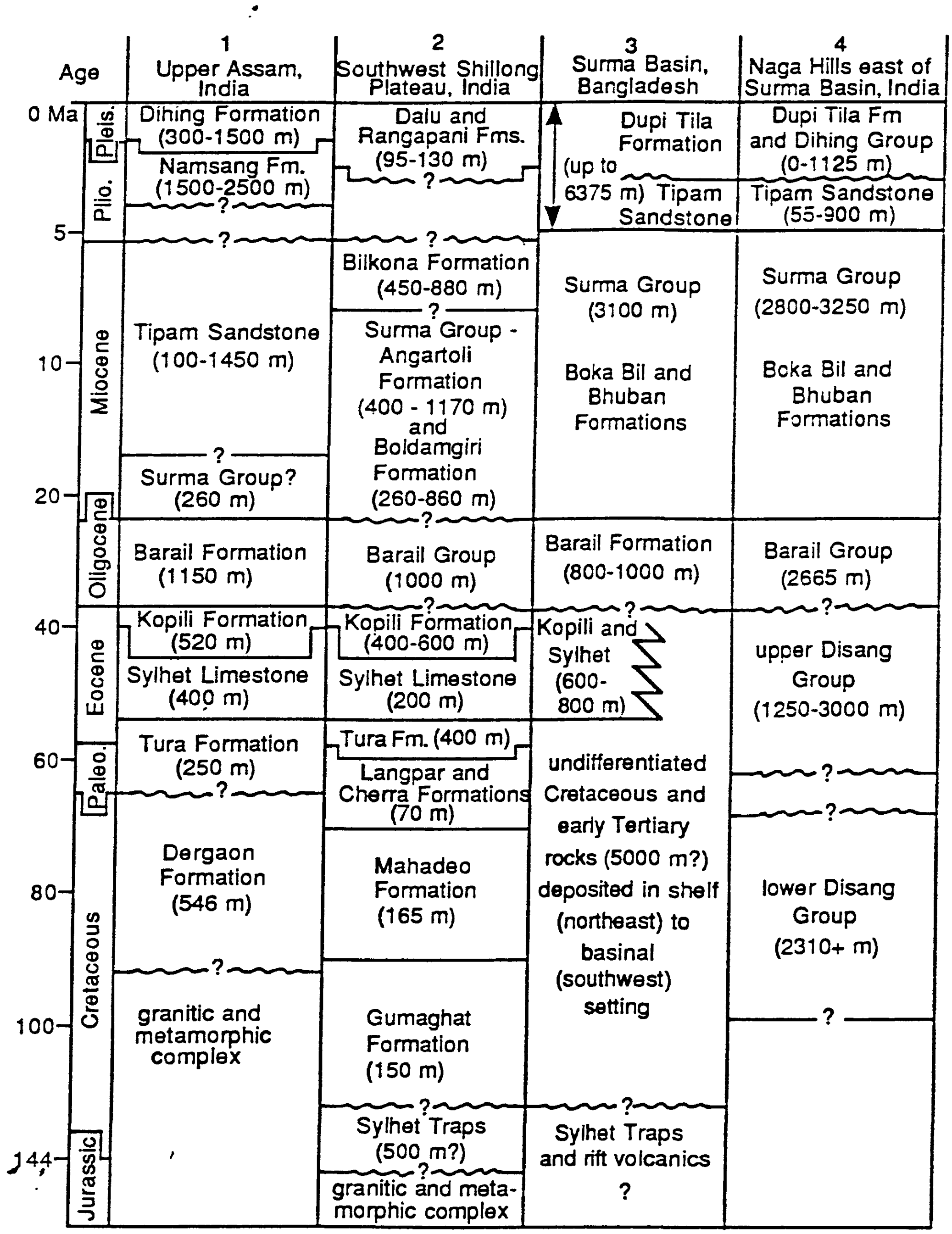
Shales referred to the Kopili have been reported from drill holes in the area of Sylhet, Bangladesh (Khan, 1963), and the northern part of Bangladesh (Ahmed and Zaher, written commun., 1965; Khan and Muminullah, 1988). In these areas, the Kopili Formation conformably overlies the Sylhet Limestone and is unconformably overlain by the undivided Surma Group. In West Bengal, the Kopili Formation is 20 m thick and conformably overlies the Sylhet Limestone.

Strata in the Garo Hills that have been interpreted as being contemporaneous with the Kopili Formation have been called the Nibgkulang Hill Series (Godwin-Austen, 1869) and the Rewak beds (Fox, 1937). The lower part of the Kopili Formation in the Garo Hills is highly fossiliferous, including many foraminifers and mollusks.

Lithologic Descriptions

The Sylhet Limestone consists of light gray to gray brown, locally massive, highly fossiliferous detrital limestone with partings of calcareous sandstone and shale near the base. The lowest part of the Sylhet Limestone in the study area (which does not include the lowest known Sylhet Limestone) is fractured, recrystallized, and fossiliferous, with numerous larger foraminifers (*Nummulites, Discocyclina*, and *Alveolina*). The middle part of the Sylhet Limestone exposed along the Dauki River consists of hard, crystalline limestone with few megafossils. Several thin beds of claystone occur near the top of the Sylhet Limestone; some of these beds are light gray and calcareous, and the remainder are dark gray to black and non-calcareous. The uppermost Sylhet Limestone exposed is not as crystalline as the middle part. The contact of the Sylhet Limestone with the overlying Kopili Formation was covered during the 1989 field season, but previous investigators reported that the contact is conformable and gradational (Hossain and others, 1987; Khan and Muminullah, 1988).

Figure 5.--Stratigraphic nomenclature of Upper Assam, the southwest Shillong Palteau, the Sylhet trough, and the Naga Hills (figure courtesy of Johnson and Nur Alam, 1990, 1991).



The Kopili Formation consists of dark gray to black siltstone and sandy siltstone interbedded with sandstone. The Kopili Formation exposed along the Dauki River includes several beds of oyster shell hash or coquina, with a high proportion of shell debris and sandy matrix and a low proportion of silt or clay. Several of the siltstone beds have symmetrical wave ripples, and some have grazing traces (Johnson and Nur Alam, 1990). The upper part of the Kopili Formation is covered in the study area and is believed to have been disturbed by intense tectonic activity related to the nearby Dauki fault zone.

The Sylhet Limestone and Kopili Formation become progressively more argillaceous downdip to the west and, to a lesser extent, to the northeast (Nagappa, 1959). In West Bengal, the Kopili Formation consists of dark gray shale with varying amounts of calcareous matter; to the northeast, the Kopili consists of thin beds of limestone, sandstone, and shale with sparse beds of carbonaceous shale, coal, and ironstone.

PREVIOUS AGE DETERMINATIONS

Sylhet Limestone--

Larger benthic foraminifers common in the Sylhet Limestone of Bangladesh include *Nummulites, Assilina, Discocyclina*, and *Alveolina* (Khan and Muminullah, 1988). A comparable assemblage of larger foraminifers indicative of a middle Eocene age is found in the Prang Limestone of the Garo Hills (Bhandari, 1981), including *Nummulites beaumonti, Discocyclina dispansa, Fasciolites sp., Operculina sp.*, and *Assilina sp.* The middle/late Eocene boundary falls within the uppermost Prang Limestone, with the first appearance datum (FAD) of *Assilina* (Mohan, 1979). In northern Assam, Mohan and Pandey (1973) recognized a *Nummulites discorbinus* abundance zone in the Sibsagar Formation (=Sylhet Limestone), which is dated as early to middle Eocene on the basis of larger benthic foraminifers.

Palynological analysis of the basal Sylhet Stage of Assam has yielded a middle Eocene age (Baksi, 1965). The Sylhet Limestone is almost barren of palynomorphs but contains many hystrichospherids (Biswas, 1963). L.E. Edwards (written commun., 1981) reported on the dinoflagellate flora from a single sample taken from the base of the Sylhet Limestone at Takerghat and described a well-preserved, distinctive assemblage that includes *Ascostomocystis, Cordosphaeridium inodes, Deflandrea dilsynense, Lentina wetzelii, Microdinium sp., Palaeocystodinium golzowense, Turbiosphaera galatea, Wetzeliella articulata, W. astra*, and *Wilsonidium cf. W. tabulaeum*. Edwards concluded that the flora is representative of an age range from early Eocene to early middle Eocene.

Kopili Formation--

Common larger benthic foraminifers reported from the lower part of the Kopili Formation in Bangladesh and the Garo Hills of southern Assam include *Asterigerina brencei, Asterocyclina latastel, Assilina daviesi, A. papillata, Nummulites spp., Alveolina elliptica,* *Discocyclina undulata, D. javana, Caneris cf. C. mauryae, Aragonella aragonensis, Operculina sp.*, and *Pellatispira crassicolumnata* (Samanta, 1965; Bhandari, 1981; Khan, 1982). The genus *Pellatispira* is indicative of a narrow stratigraphic interval in the late Eocene (Eames, 1952). A number of planktic foraminifers are associated with the larger foraminifers in the lower part of the Kopili Formation, including *Globorotalia cocoaensis, G. lehneri, G. renzi, Globigerina linaperta, G. pseudoampliapertura, G. parva, G. cf. G. trilocularis, G. trilocularis, G. triloculinoides, G. yeguensis, Hantkenina alabamensis, H. longispina*, and *H. primitiva*.

Mathur (1980, 1985) dated the Kopili Formation of the Mikir Hills as late middle Eocene (the *Discoaster saipanensis* zone) based on nannofossils; the *Discoaster saipanensis* zone marks the NP17 zone of late middle Eocene age. Based on the presence of *Discocyclina sella, Chiloguembelina spp.*, and several nannofossil species, Singh (1979) ascribed a late middle to early late Eocene age for the lower part of the Kopili Formation of the Mikir Hills.

In northeastern Bangladesh, subsurface strata assigned to the Kopili Formation contain miliolids (*Quinqueloculina* and *Triloculina*) and *Lenticulina* in the higher intervals and *Nummulites, Pellatispira, Discocyclina* and *Hantkenina alabamensis* in the lower intervals (Uddin, 1988). Samples from the subsurface Kopili contain as many as 12 species of smaller benthic foraminifers. Common benthic foraminifers include *Asterocyclina stellata, Asterigerina brencei, Uvigerina sorri, Cibicides rakhiensis, C. punjabensis*, and *C. perlucidus*.

The Kopili Formation contains common monocolpate pollen and some palms (Biswas, 1963). The paucity or absence of early Eocene marker species and the increased frequency of *Cicatricosisporites macrocostatus, Margocolporites complexum*, and *Stephanocopites tertiarus* are features that characterize the Kopili assemblage (Sah, 1974). Three species of palynomorphs (*Acoploripites spinulosa, Meyeripollis naharkotensis*, and *Monocopopites broadcopusi*) have their first appearance at the base of the Kopili Formation and can be used to delineate the Kopili from the underlying Sylhet Limestone (Sah, 1974).

FORAMINIFER FAUNA

Nagappa (1959) reported a rich larger foraminifer fauna from the Prang Limestone (*Nummulites pengaronensis, N. beaumonti, N. acutus, Calcarina, Discocyclina dispansa, D. undulata, D. sowerbyi, Alveolina*, and *Assilina papillata*) and from the lower Kopili (*Pellatispira, Discocyclina omphalus, D. dispansa, D. sowerbyi*, and *Nummulites pengaronensis*). He noted that most of the alveolines died out and assilines became extinct below the top of the Sylhet Limestone. In the Kopili Formation, these forms were replaced by *Pellatispira*, which occupies an intermediate geographic location in Bangladesh, situated between the Tethyan facies of Pakistan, where only one species is recognized over a short stratigraphic range near the top of the Eocene, and the Indopacific facies of Burma, where *Pellatispira* is represented by a number of species.

Nagappa (1959) noted that Assam had an important geographic position during the Eocene, with the larger foraminifer fauna exhibiting characters of both the Tethyan and Indopacific provinces, but with species composition showing stronger affinities with the Indopacific. Some of the characteristic Tethyan larger foraminifers occur in Assam, but they have characters that differ from the same species in Pakistan.

We have illustrated larger and smaller benthic foraminifer taxa from the Sylhet Limestone: *Anomalina sp., Cibicidoides perlucidus, Cibicides rakhiensis, C. sp., Parafissurina sp., Pellatispira glabra, P. inflata, P. irregularis, Peneroplis sp., Quinqueloculina acuta,* and *Q. sawaensis* (Plates 1 and 2). The presence of several species of *Pellatispira* suggests that the upper part of the Sylhet Limestone in the study area is late Eocene in age. Banerji (1981) suggested that the upper part of the Sylhet Limestone is faunally inseparable from the lower part of the Kopili Formation. Based on the larger foraminifers, this appears to be true; based on the smaller benthic foraminifers, a change in abundance and species diversity is apparent.

Samanta (1968b) reported on species of *Nummulites* from the Kopili Formation of India, noting that three groups are represented. *Nummulites facianii*, a pillared form, belongs to a reticulate group of forms characteristic of late Eocene to Oligocene rocks. The assemblage of *Nummulites* in the Kopili Formation differs from those in the underlying Siju Limestone in having fewer species and in lacking large, highly evolved species.

Samples collected from the Kopili Formation in the study area contain high species diversity and abundance of larger and smaller foraminifers, including *Asterigerina sp., Asterocyclina stellata, Hanzawaia ammophela, Cibicides eocaenus, C. lobatulus, Cibicidoides perlucidus, Discorbinella sp., Eoannularia sp., Globanomalina cf. G. micra, Globigerina ampliapertura, Globorotalia sp., Lagena laevis, Lagena sp., Lenticulina sp., Nodosaria sp., Pellatispira irregularis, P. madrasizi, P. madarasizi var. idica, Planorbulina mediterranensis, Pseudophragmina (Proporocylina) sp., Pyrgo sp., Quinqueloculina acuta, Q. alabamensis, Q. compacta, Q. sp., Textularia sp., Triloculina globosa,* and *Verneulina sp.* (Plates 1-9).

PREVIOUS OSTRACODE STUDIES

A number of papers have documented the ostracode fauna from Paleogene sedimentary rocks of India. Three regions in India include fossiliferous marine rocks of Eocene age. In western and northwestern India, ostracodes have been described from Rajasthan (Lubimova and others, 1960; Singh and Misra, 1966; Khosla, 1968, 1972, 1977) and Kutch (Tewari and Tandon, 1960; Guha, 1965, 1968, 1971, 1974, 1978; Khosla and Pant, 1981). In southern India, Rajagopalan (1962) described Eocene ostracodes from

Pondicherry. From eastern India, the ostracodes from the Inter-Trappean beds at Andhra Pradesh have been noted by Bhalla (1979, 1980) and Sastri (1963).

Srivastava (1968) described three ostracode species from the Kopili Formation in the Garo Hills, Assam: *Trachyleberis sp., Cytherella protuberantis*, and *Cytherelloidea aff. C. tewarii.* These taxa were associated with a planktic foraminifer assemblage that was assigned an early late Eocene age (Srinivasan and Srivastava, 1967).

Bhandari (1981) conducted the most comprehensive study of ostracodes from the Jaintia Group, describing and illustrating a number of species from the Prang Limestone and Kopili Formation. Ostracode genera from the Prang Limestone include *Alocopocythere, Bairdia, Costa, Cytherella, Hermanites, Neonesidea*, and *Paracypris*; genera from the Kopili Formation include *Alocopocythere, Bairdia, Costa, Hermanites, Neonesidea, Pontocypris*, and *Xestoleberis.*

Most recently, Neale and Singh (1985) examined the ostracode fauna from the upper part of the middle Eocene Sylhet Formation from northern Assam, India. They described and illustrated twenty-nine species of ostracodes and noted that most of the species are provincial in distribution.

The ostracode assemblage recovered from the Sylhet Limestone and Kopili Formation of northeast Bangladesh is sparse, consisting of thirteen species and less than 100 specimens. The extensive weathering of the outcropping sedimentary rocks has resulted in destruction of the smaller fossils contained in the sediments. Therefore, based on the ostracodes, only general comments can be made concerning paleoenvironment and age.

ZOOGEOGRAPHIC AFFINITIES

The Jaintia Group represents deposition of platform carbonates and littoral clastic sediments. The highly fossiliferous Nummulitic Limestone identified as the Sylhet Limestone and its equivalents and the clastic Kopili Formation were a consequence of an extensive marine transgression that ranged over most of the Bengal-Assam shelves, depositing as much as 245 m in Bangladesh, 320 m in West Bengal, and 500 m in Assam. Northern Bangladesh had open ocean connections with both the Tethys Seaway and the Indopacific at this time, so that the Sylhet Limestone and Kopili Formation contain an admixture of species from both the Tethyan and Indopacific zoogeographic provinces. Most of the trachyleberid taxa identified (*Phacorhabdotus, Hornibrookella, Brachycythere, Paracosta*, and *Occultocythereis*) have affinities with Tethyan assemblages of the Middle East. Neale and Singh (1985) similarly documented genus-level affinities between ostracode faunas from upper Assam and from western India and Pakistan, which is particularly seen in the presence of *Cytherella, Bairdia, Paijenborchella, Schizocythere, Alocopocythere, Uroleberis*, and *Xestoleberis.*

SYSTEMATIC PALEONTOLOGY

Class OSTRACODA Latreille, 1806
Order PODOCOPIDA G.W. Mueller, 1894
Suborder PLATYCOPA Sars, 1866
Family CYTHERELLIDAE Sars, 1866
Genus *CYTHERELLA* Jones, 1849

Cytherella cf. C. protuberantis Lubimova and Guha, 1969 of Srivastava (1968)
Plate 9, figure 11

?*Cytherella protuberantis* Lubimova and Guha, Srivastava, 1968, p. 141, figs. 4-6.
Not *Cytherella protuberantis* Lubimova and Guha, 1960, p. 17-18, pl. 1, fig. 3.

Diagnosis.--Valves subovoid in lateral view, somewhat tapering at anterior and posterior ends. Dorsal and ventral margins broadly arched; anterior and posterior margins evenly and smoothly curved, with greatest width at middle of margin. Greatest length through midline of valve; greatest height through middle of valve. No ornamentation; valve surface is smooth.

Occurrence.--Samples 89-EB-5, -22, Kopili Formation.

Distribution.--Kopili Formation, Assam, India; Sylhet Limestone and Kopili Formation, Sylhet basin, Bangladesh.

Suburder PODOCOPA Sars, 1866
Superfamily BAIRDIACEA Sars, 1866
Family BAIRDIIDAE Sars, 1888
Genus *BAIRDOPPILATA* Coryell, Sample and Jennings, 1935

Bairdoppilata ?poddari Lubimova and Mohan, 1960
Plate 9, figure 7

Bairdoppilata poddari Lubimova and Mohan, 1960, p. 21-22, pl. 2, figs. 1a-1b.

Description.--Right valve forms a rounded trapezoidal shape in lateral view; no distinct cardinal angles. Dorsal margin broadly rounded, smooth; anterior margin with a short, straight, anterodorsal part and an evenly curved anteroventral part; greatest width of anterior margin dorsal of midvalve; ventral margin broadly curved, convex; posterior margin smoothly curved, with prominent caudal process located about midmargin. Greatest length through midline of valve; greatest height just posterior of midvalve. No ornamentation; valve surface is smooth.

Occurrence.--Sample 89-EB-5, Kopili Formation; samples 89-EB-11, -14, -20, Sylhet Limestone.

Distribution.--Kutch, India; Kopili Formation and Sylhet Limestone, Sylhet basin, Bangladesh.

Genus *NEONESIDEA* Maddocks, 1969

Neonesidea khoslai Bhandari, 1981
Plate 9, figure 6

Neonesidea khoslai Bhandari, 1981, p. 141, pl. 1, figs. 7-8.

Description.--Left valve forms a trapezoidal shape in lateral view; no distinct cardinal angles. Dorsal margin arched, with a straight anterodorsal part that is upwardly inclined toward midmargin and a posterodorsal part that is short and sharply inclined posteroventrally; anterior margin smoothly curved, with the greatest width dorsal of midvalve; ventral margin nearly straight, slight curvature along posteroventral part; posterior margin with a ventrally located caudal process; posterodorsal margin nearly straight, inclined sharply down toward posterior. Greatest length through midline of valve; greatest height through middle of dorsal margin. No ornamentation; valve surface is smooth.

Occurrence.--Samples 89-EB-5, -22, -24, Kopili Formation.

Distribution.--Prang Limestone and Kopili Formation, Assam, India; Kopili Formation, Sylhet basin, Bangladesh.

Superfamily CYTHERACEA Baird, 1850
Family TRCHYLEBERIDIDAE Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948
Genus *COSTA* Neviani, 1928
Subgenus *PARACOSTA* Siddiqui, 1971

Costa (Paracosta) sp. A
Plate 9, figure 10

?Trachyleberis Srivastava, 1968, p. 141, figs. 1-3.
?Hermanites wadiai Singh and Tewari, Mathur, 1977, p. 123-124, figs. 33-35.
Hermanites sp. B Bhandari, 1981, p. 142, pl. 1, fig. 15.

Description.--Right valve forms an elongate rectangular shape in lateral view. Dorsal margin straight; anterior margin smoothly and evenly curved; ventral margin very broadly curved; posterior margin with a small acute caudal process; the posterodorsal and posteroventral parts of the posterior margin angle up to the caudal process, forming a point. An extended flange along the anterior edge rims the margin and projects somewhat below the anteroventral margin. Greatest length through midline of valve; greatest height through anterior hinge element.

A strong, irregular ridge extends beyond the dorsal margin, forming a dorsal crest; low, broad, smooth rim parallels the anterior, ventral, and posterior margins. Double, overlapping rows of marginal tubercles occur along the anterior margin; fewer, larger marginal tubercles form a double row along the posterior, especially along the posteroventer. Prominent, subcircular muscle scar tubercle. Ornamentation consists of a fine reticulation pattern, arranged in a longitudinal and radial pattern. Several of the ridges of the reticulation are more strongly developed, especially the longitudinal ridges in the median part of the valve and the ridges extending in a radial pattern toward the anterior margin. Rounded, smooth, knob-like eye tubercle.

Occurrence.--Samples 89-EB-5, -22, -24, Kopili Formation; sample 89-EB-20, Sylhet Limestone.

Distribution.--?Subathu Formation, Simla Hills, India; Prang Limestone and Kopili Formation, Assam, India; Sylhet Limestone and Kopili Formation, Sylhet basin, Bangladesh.

Genus *BRACHYCYTHERE* Alexander, 1933

Brachycythere sp. A

Occurrence.--Sample 89-EB-20, Sylhet Limestone.

Subfamily BUNTONIINAE Apostelescu, 1961
Genus *PHACORHABDOTUS* Howe and Laurencich, 1958

Phacorhabdotus? sp. A
Plate 9, figure 14

Description.--Right valve forms a rounded subtriangular shape in lateral view. Dorsal margin straight, inclined downward towards posterodorsum; anterior margin smoothly and evenly rounded; ventral margin nearly straight, forming a very broad curve; posterior margin' smoothly curved, with greatest width at middle of margin; oblique, broad posterodorsal cardinal angle. Greatest length through midline of valve; greatest height through anterior hinge element.

Valve surface covered with ridges and fine pitted ornamentation. A rounded, relatively low ridge continuously parallels the anterior, ventral, and posterior margins. Irregular dorsal ridge occurs just inside the margin. Valve surface inside the marginal ridge covered by fine pitting. Anterior with about 15 prominent rounded marginal tubercles; posterior with about 10 short, blunt marginal denticles, more pronounced at posteroventer. Small, smooth eye tubercle.

Occurrence.--Sample 89-EB-22, Kopili Formation.

Family HEMICYTHERIDAE Puri, 1953
Subfamily HEMICYTHERINAE Puri, 1953
Tribe BRADLEYINI Benson, 1972
Genus *HORNIBROOKELLA* Moos, 1965

Hornibrookella arcana Lubimova and Guha, 1960
Plate 9, figure 8

Cythereis arcanus Lubimova and Guha, 1960, p. 33-34, pl. 3, figs. 1a-1b.

Description.--Left valve forms a quadrate shape in lateral view. Dorsal margin somewhat sinuous; anterior margin smoothly rounded; ventral margin with a broad, shallow concavity; posterior margin with a pronounced but short and acute caudal process located ventral of midmargin; posterodorsal margin is a distinct concave shape, with prominent, broad posterodorsal cardinal angle that forms an oblique curve. Greatest length through caudal process; greatest height through anterior hinge element.

Ornamentation consists of ridges, reticulation, and small tubercles. An irregular dorsal ridge overhangs the margin; at its posterior end the ridge forms a prominent tubercle that projects over the posterior hinge element. Prominent, thin marginal ridge parallels the anterior and ventral margins. Low, broad subcentral tubercle. Large, flattened, triangular eye tubercle. Reticulation arranged in radial pattern along the anterior and posteroventral margins and arranged in a longitudinal and concentric pattern along the median and dorsal region of the valve. Normal pores celate-type with apophysis, few in number, located on floor of reticulation pits.

Occurrence.--Samples 89-EB-5, -22, -24, Kopili Formation.

Distribution.--Kutch, India; Kopili Formation, Sylhet basin, Bangladesh.

Subfamily ORIONINAE Puri, 1973
Genus *OCCULTOCYTHEREIS* Howe, 1951

Occultocythereis sp. A
Plate 9, figure 16

Description.--Right valve elongate, subtriangular in lateral view. Dorsal margin nearly straight, inclined downward toward posteroventer; anterior margin smoothly and evenly curved; ventral margin straight; posterior margin with pronounced caudal process; posteroventral margin straight, inclined obliquely upward; posterodorsal margin forms a broad, concave shape. Acute, blunt, prominent caudal process. Distinct oblique posteroventral cardinal angle; posterodorsal cardinal angle nearly a right angle. Greatest length ventral of valve midline, through caudal process; greatest height through anterior hinge element.

Valve surface covered with pitting pattern, ridges, and tubercles. A smooth wide ridge parallels the anterior and anteroventral margins. Dorsum with irregular ridge that has several tubercular structures developed along its length that project over the margin; two tubercles are particularly prominent, one in the middle of the ridge and the other at the posterodorsal corner. Prominent, large, smooth subcentral muscle scar tubercle located just anterior of midvalve. Valve surface covered with fine pitting along anterior half, with pits becoming larger toward posterior. At about 3/4 of the length of the valve from the anterior margin, the pitted pattern stops and the valve surface drops to a low, smooth, irregularly shaped flattened area that extends from the end of the pitting to the posterior margin and in a zone along the length of the ventral margin. The end of the pitted pattern and the drop to the low posterior valve region is marked by two spinose structures that occur near the posterodorsal and posteroventral corners. Anterior with short, strong, blunt marginal denticles, becoming more numerous along anteroventral margin; posteroventral margin with a double row of longer denticles. Large, smooth, irregularly shaped eye tubercle.

Occurrence.--Samples 89-EB-22, -24, Kopili Formation.

Family CYTHERURIDAE G.W. Mueller, 1894
Subfamily CYTHEROPTERINAE Hanai, 1957
Genus *CYTHEROPTERON* Sars, 1866

Cytheropteron aff. C. reticuloradiata Neale and Singh, 1985
Plate 9, figure 15

Cytheropteron reticuloradiata Neale and Singh, 1985, p. 380, pl. 46, figs. 4-5.

Description.--Left valve forms an elongate ovoid shape in lateral view. Dorsal margin forms a broad curve; anterior margin drawn-out, with straight anterodorsal and anteroventral margins obliquely tapered to form an acute part of the margin; ventral margin forms a sinuous curve, with concave anteroventral part and convex posteroventral part; posterior margin with large, blunt caudal process, located dorsal of midvalve. Greatest length through caudal process; greatest height just posterior of midline of valve.

Valve surface covered with fine scale reticulation pattern, more strongly developed on posterior half of valve. Anterior half of valve surface with weak reticulation pattern, only partially developed, along anterodorsal quadrant and only a few weak ridges and some pitting developed along anteroventral quadrant. Broad, flattened rim along anterior margin. Middle of valve with a strong median sulcus that runs the height of the valve from the dorsum to the venter. A very large alar structure projects from the base of the sulcus, extending out beyond the ventral margin, forming a broad, triangular platform along the ventral surface.

Occurrence.--Sample 89-EB-22, Kopili Formation.

Distribution.--Sylhet Limestone, upper Assam, India; Kopili Formation, Sylhet basin, Bangladesh.

Family XESTOLEBERIDIDAE Sars, 1928
Genus *XESTOLEBERIS* Sars, 1866

Xestoleberis sp. A
Plate 9, figure 9

Description.--Right valve forms a rounded ovoid shape in lateral view. Dorsal margin broadly and smoothly curved; anterior margin smoothly curved, with greatest width ventral of midline; ventral margin with a broad concavity; posterior margin smoothly curved with greatest width ventral of midvalve. No cardinal angles. Greatest length just ventral of midline of valve; greatest height through middle of valve. No ornamentation; valve surface is smooth. Anterior margin with a broad, flattened area along margin.

Occurrence.--Samples 89-EB-5, -22, Kopili Formation; sample 89-EB-20, Sylhet Limestone.

Xestoleberis sp. B
Plate 9, figure 12

Description.--Right valve forms a rounded ovoid shape in latera view; no distinct cardinal angles. Dorsal margin broadly and smoothly curved; anterior margin smoothly curved;

ventral margin with a pronounced, deep concavity at mid-margin; posterior margin evenly curved. Greatest length through midline of valve; greatest height through middle of valve. No ornamentation; valve surface is smooth. Carapace is very inflated, with width nearly equal to height.

Occurrence.--Samples 89-EB-14, -24, Kopili Formation.

Xestoleberis sp. C
Plate 9, figure 13

Description.--Left valve forms a tapered ellipsoidal shape in lateral view. Dorsal margin smoothly and broadly curved; anterior margin blunt, evenly curved; ventral margin forms a convex shape, with a slight concave part near the posterior margin; posterior margin smoothly curved, with greatest width ventral of midline of valve. Greatest length just ventral of midline of valve; greatest height through middle of valve; greatest width just anterior of middle. In dorsal view, carapace is most inflated at anterior end, tapering considerably toward posterior end. In lateral view, the valve surface shows inflation nearly to the posterior margin, where a broad, flattened region parallels the margin. No ornamentation; valve surface is smooth.

Occurrence.--Samples 89-EB-5, -22, Kopili Formation.

Superfamily CYPRIDACEA Baird, 1845
Family CANDONIDAE Kaufmann, 1900
Subfamily PARACYPRIDINAE Sars, 1923
Genus *PARACYPRIS* Sars, 1866

Paracypris cf. P. meridionalis Lubimova and Mohan, 1960

Paracypris meridionalis Lubimova and Mohan, 1960, p. 23-24, pl. 2, fig. 3.

Occurrence.--Sample 89-EB-5, Kopili Formation.

Distribution.--Kutch, India; Kopili Formation, Sylhet basin, Bangladesh.

REFERENCES CITED

Acharya, S.K., Mitra, N.D., and Nandy, D.R., 1986, Regional geology and tectonic setting of northeast India and adjoining region, *in* Geology of Nagaland ophiolite: Geological Survey of India, Memoir, v. 119, p. 6-12.

Alam, M.K., Hasan, A.K.M.S., Khan, M.R., and Whitney, J.W., 1990, Geological map of Bangladesh: U.S. Geological Survey, 1:1,000,000.

Baksi, S.K., 1965, Stratigraphy of Barail Series in southern part of Shillong Plateau, Assam, India: American Association of Petroleum Geologists, Bulletin, v. 49, no. 12, p.

Banerji, R.K., 1981, Cretaceous-Eocene sedimentation, tectonism and biofacies in the Bengal Basin, India: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 34, p. 57-85.

Bhalla, S.N., 1979, A new ostracod species from Lower Eocene Inter-Trappean beds, Andhra Pradesh: Indian Geological Association, Bulletin, v. 12, no. 2, p. 145-150.

Bhalla, S.N., 1980, *Hermanites sastryi*--a new species of Ostracoda from Lower Eocene of Andhra Pradesh, India: Geological Society of India, Journal, v. 21, p. 298-300.

Bhandari, A., 1981, Ostracoda from the Jaintia Group in subsurface of Baghmara, Garo Hills, Meghalaya: Ninth Indian Colloquium on Micropaleontology and Stratigraphy, Proceedings, p. 137-145.

Biswas, B., 1963, Results of exploration for petroleum in the western part of the Bengal Basin, India, *in* Proceedings of the Second Symposium on the Development of Petroleum Resources of Asia and the Far East: United Nations, Mineral Resources Development Series 18, v. 1, p. 241-250.

Eames, F.E., 1952, A contribution to the study of the Eocene in western Pakistan and western India--Part A, The geology of the standard sections in the western Punjab and in the Kohat district: Geological Society of London, Quarterly Journal, v. 107, p. 159-171.

Evans, P., 1932, Tertiary succession in Assam, India: Mining and Geological Institute of India, Transactions, v. 27, no. 3, p. 155-260.

Fox, C.S., 1937, Director General Report: Geological Survey of India, Records, v. 72, p. 85-90.

Godwin-Austen, H.H., 1869, Notes to accompany a geological map of a portion of the Khasi Hills near longitude 9° E.: Assam Society of Bengal, Journal, v. 38, no. 2,

Guha, D.K., 1965, Palaeogene Ostracoda of the Family Cytherellidae from subsurface samples of Cambay, Gujerat State, western India: Geological Society of India, Journal, v. 6, p. 143-148.

Guha, D.K., 1968, Ostracoda from Middle Eocene of Kutch Gujerat State, western India: Oil and Natural Gas Commission, Bulletin, v. 5, no. 1, p. 83-92.

Guha, D.K., 1971, Upper Eocene Ostracoda from subcrops of Cambay, western India: Oil and Natural Gas Commission, Bulletin, v. 8, no. 1, p. 17-21.

Guha, D.K., 1974, Marine Ostracoda from Tertiary of Kutch and Cambay: Centre of Advanced Study in Geology, Publication no. 10, Panjab University, p. 156-176.

Guha, D.K., 1978, Eocene Ostracoda from Gogha wells, western India: Seventh Indian Colloquium on Micropaleontology and Stratigraphy, Proceedings, Rasheed, D.A., ed., p. 60-64a.

Guha, D.K., 1978, Tectonic framework and oil and gas prospects of Bangladesh: Geological Society of Bangladesh, Fourth Annual Conference, Proceedings.

Gupta, V.J., 1976, India Cenozoic stratigraphy: Delhi, Hindustan Publishing Corp.

Hossain, S.M., Bari, M.E., and Bashar Al-Mazi, M.A., 1988, Preliminary report on the stratigraphic sections measured along the Dauki-Sonatila, Tamabil-Kalinagar, Sripur-Ashapara and Jaintiapur area, Sylhet District: Geological Survey of Bangladesh, Data/Ur-294, 40 p.

Ismail, M., 1978, Stratigraphical position of Bogra Limestone of the Platform area of Bangladesh: Geological Society of Bangladesh, Fourth Annual Conference, Proceedings, p. 19-26.

Johnson, S.Y. and Nur Alam, A.M., 1990, Sedimentation and tectonics of the Sylhet trough, northeastern Bangladesh: U.S. Geological Survey Open File Report 90-313, p. 1-44.

Johnson, S.Y. and Nur Alam, A.M., 1991, Sedimentation and tectonics of the Sylhet trough, Bangladesh: Geological Society of America Bulletin, v. 103, p. 1513-1527.

Khan, F.H., 1963, Preliminary report on limestone, coal, and glass sand Lamakala-Bhangarghat area, Sylhet District, East Pakistan: Pakistan Geological Survey Minerals Information Circular 11.

Khan, M.A. Maroof, 1978, Geology of the eastern and northeastern part of Sadar Subdivision, Sylhet District, Bangladesh: Geological Survey of Bangladesh, Records, v. 2, pt. 4, 20 p.

Khan, M.R., 1982, A note on the biostratigraphy of Kopili Formation of the shelf facies, Bengal Basin: Bangladesh Joumal of Geology, v. 1, p. 61-64.

Khan, M.R. and Muminullah, M., 1988, Stratigraphic lexicon of Bangladesh: Geological Survey of Bangladesh, Records, v. 5, pt. 1, p. 1-67.

Khosla, S.C., 1968, A note on the occurrence of rich ostracode assemblage from the Eocene beds of Rajasthan: University of Roorkee Research Journal, v. 10, no. 3-4, p. 43-51.

Khasla, S.C., 1972, Ostracodes from the Eocene beds of Rajasthan, India: Micropaleontology, v. 18, no. 4, p. 476-507.

Khosla, S.C., 1977, Palaeoecology of the Eocene beds of Rajasthan: Centre of Advanced Study in Geology, Publication no. 11, Panjab University, p. 1-12.

Khosla, S.C. and Pant, P.C., 1981, Ostracode biostratigraphy of the Eocene and Oligocene beds of Kutch: Ninth Indian Colloquium on Micropaleontology and Stratigraphy, Proceedings, p. 167-189.

Krishnan, M.S., 1968, Geology of India and Burma: Madras, Higginbothams Ltd., 536 p.

LeFort, P., 1975, Himalayas: The collided range--present knowledge of the continental arc: American Journal of Science, v. 275A, p. 1-44.

Lubimova, P.S., Guha, D.K., and Mohan, M., 1960, On Ostracoda of Jurassic and Tertiary deposits from Kutch and Rajasthan (Jaisalmer), India: Geological, Mining and Metallurgical Society of India, Bulletin, no. 22, p. 1-61.

Mamgain, V.D. and Chatterjee, B.P., 1977, Eocene Ostracoda from Kolayatji area, Rajasthan: India Geological Survey, Records, v. 108, pt. 2, p. 42-50.

Ministry of Irrigation, Water Development, and Flood Control, 1987, Geology of Bangladesh: Master Plan Organization, Technical Report, p. 1-160.

Mohan, M., 1979, Paleoecology and age of Kopili Formation in southern Shillong Shelf, Meghalaya: Indian Geological Association, Bulletin, v. 12, no. 1, p. 63-71.

Mohan, M. and Panday, J., 1973, Early Paleogene ecostratigraphy of Upper Assam: Indian Geological Association, Bulletin, v. 6, no. 1, p. 47-62.

Murthy, M.V.N., Chakrabarti, C., and Talukdar, S.C., 1976, Stratigraphic revision of the Cretaceous-Tertiary sediments of the Shillong Plateau: India Geological Survey, Records, no. 107, pt. 2, p. 80-90.

Nagappa, Y., 1956, Foraminifera of the genera *Fabiania* and *Eorupertia* from the Sylhet Limestone of Assam: Paleontological Society of India, Journal, v. 1, no. 1, p. 191-198.

Nagappa, Y., 1959, Foraminiferal biostratigraphy of the Cretaceous-Eocene succession in India-Pakistan-Burma region: Micropaleontology, v. 5, no. 2, p. 145-192.

Neale, J.W. and Singh, P., 1985, Ostracoda from the Middle Eocene of Assam: Palaeontology, v. 28, pt. 2, p. 355-385.

Rajagopalan, N., 1962, Ostracoda from the Early Tertiary sediments of Pondicherry, South India: Geological Society of India, Journal, v. 3, p. 63-69.

Sah, S.C.D., 1974, Palaeogene biostratigraphy of Shillong Plateau, *in* Aspects and appraisal of Indian paleobotany, Surange, K.S., Lakhanpal, R.N., and Bharadwaj, D.C., eds.: Lucknow, Birbal Sahni Institute of Paleobotany, p. 525-533.

Samanta, B.K., 1968a, The Eocene succession of Garo Hills, Assam, India: Geological Magazine, v. 105, no. 6, p. 124-135.

Samanta, B.K., 1968b, *Nummulites* (Foraminifera) from the Upper Eocene Kopili Formation of Assam, India: Palaeontology, v. 11, pt. 5, p. 669-682.

Samanta, B.K., 1970, Upper Eocene planktonic foraminifera from the Kopili Formation, Mikir Hills, Assam, India: Cushman Foundation for Foraminiferal Research, Contributions, v. 21, pt. 1, p. 28-39.

Sarwar, G., 1980, Biostratigraphy and paleoecology of the subsurface Kopili Formation at Jaipurhat area, Bogra District, Bangladesh: University of Dhaka, M.S. thesis.

Sastri, V.V., 1963, A note on the Foraminifera and Ostracoda from the Inter-Trappean Beds near Rajahmundry: Geological Survey of India, Records, v. 92, no. 2, p. 299-310.

Singh, S.N. and Misra, P.C., 1966, New genus and species of ostracods from Fuller's Earth, Kolaystji area, Bikaner, Rajasthan, India: Journal Palaeontological Society of India, v. 11, p. 26-37.

Srinivasan, M.S. and Srivastava, S.S., 1967, Seminar on the geology of northeastern India: Shillong, Abstracts, v. 19, p. 14.

Srivastava, S.S., 1968, Ostracoda from the Kopili Formation (Upper Eocene) of Assam: Current Science, v. 37, no. 5, p. 141-142.

Terman, M.J., 1988, Accelerated Exploration for Mineral Resources and Modernization of the Geological Survey of Bangladesh, Phase II, Cahpter C, Review and Recommendations by U.S. Geological Survey Experts under Agreement III, Work Plan II (January-March 1988): U.S. Geological Survey Project Report, Bangladesh Investigation (IR)BG-8.

Tewari, B.S. and Tandon, K.K., 1960, Kutch microfauna--Lower Tertiary Ostracoda: National Institute of Sciences of India, Proceedings, Part B, Biological Sciences, v. 26, no. 4, p. 147-167.

Uddin, N., 1988, Foraminifera from the Kopili Formation (Eocene) of Geological Drill Hole (G.D.H.)-31 at Gaibandha, Bangladesh: Nottingham University, M.S. thesis.

Wadia, B.N., 1961, The geology of India: London, Macmillan and Co. Ltd., Third edition.

Zaher, M.A. 1970, Limestone deposits of the western part of Takerghat area, District Sylhet (Pakistan): Geological Survey of Pakistan, Records, v. 20, pt. 2.

PLATE 1

All figures are scanning electron photomicrographs.
White bar equals 100 micrometers.

Figure	
1.	*Cibicidoides sp.*, sample 45-RH-89, Kopili Formation.
2.	*Pellatispira inflata* Umbgrove, sample 36-RH-89, Sylhet Limestone.
3, 4.	*Cibicidoides perlucidus* (Nuttall), sample 36-RH-89, Sylhet Limestone.
5.	*Pellatispira irregularis* Umbgrove, sample 36-RH-89, Sylhet Limestone.
6.	*Pellatispira glabra* Umbgrove, sample 36-RH-89, Sylhet Limestone.
7.	*Quinqueloculina sawaensis* Asano, sample 37-RH-89, Sylhet Limestone.
8.	*Cibicides sp.*, sample 37-RH-89, Sylhet Limestone.
9, 10.	*Cibicides rakhiensis* Haque, sample 37-RH-89, Sylhet Limestone.
11, 12.	*Cibicides sp.*, sample 37-RH-89, Sylhet Limestone.
13, 14.	Unidentified, sample 37-RH-89, Sylhet Limestone.
15.	*Parafissurina sp.*, sample 37-RH-89, Sylhet Limestone.

Plate 1

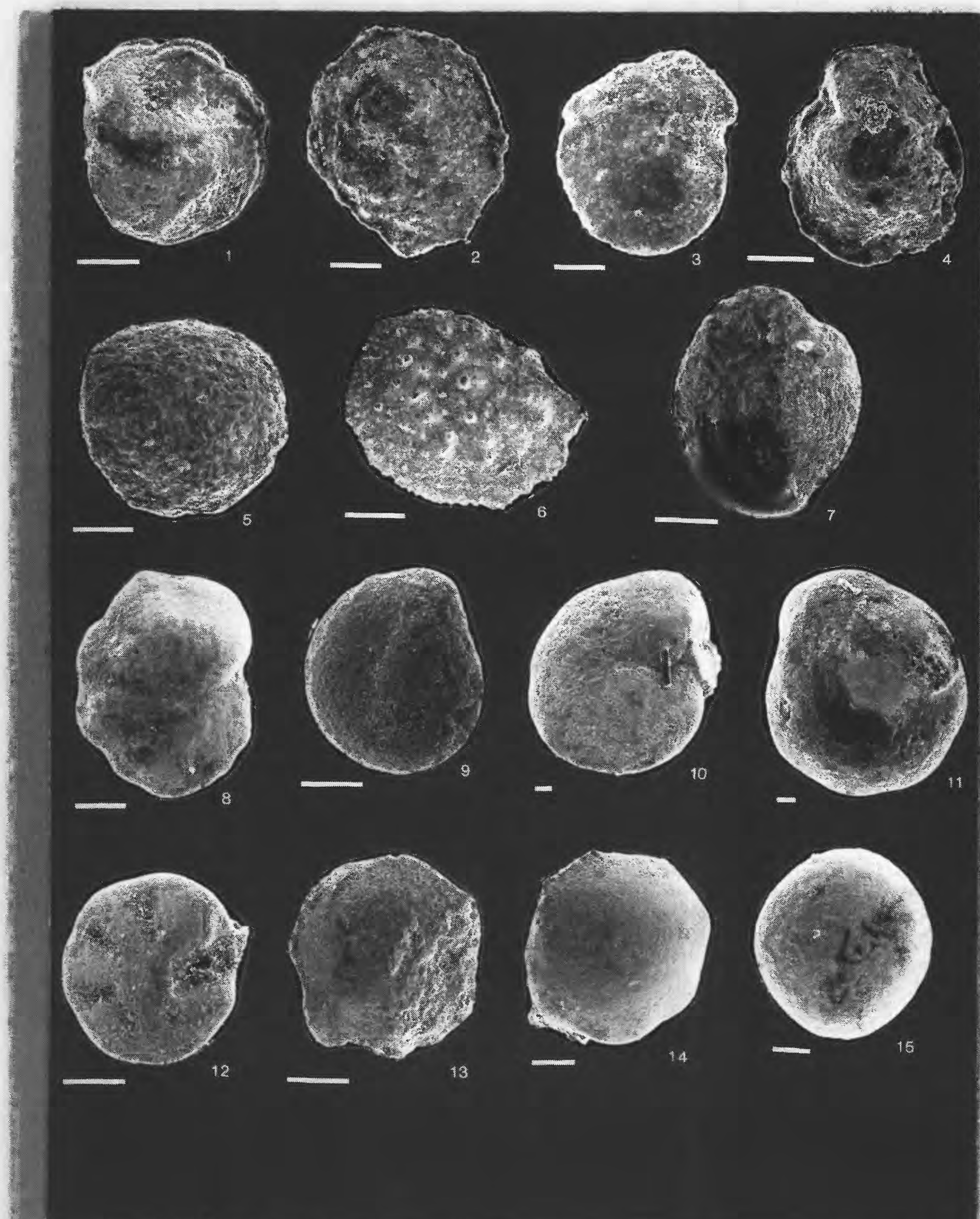


PLATE 2

All figures are scanning electron photomicrographs.
White bar equals 100 micrometers.

Figure	
1.	*Parafissurina sp.*, sample 37-RH-89, Sylhet Limestone.
2.	*Peneroplis sp.*, sample 38-RH-89, Sylhet Limestone.
3.	*Anomalina sp.*, sample 39-RH-89, Sylhet Limestone.
4, 5.	*Cibicides sp.*, sample 42-RH-89, Sylhet Limestone.,
6-10.	*Quinqueloculina acuta* Hussey, sample 43-RH-89, Sylhet Limestone.
11.	*Globigerina ampliapertura* Bolli, sample 45-RH-89, Kopili Formation.
12.	*Globorotalia sp.*, sample 45-RH-89, Kopili Formation.
13, 14.	*Lenticulina sp.*, sample 45-RH-89, Kopili Formation.
15.	*Cibicides eocaenus*, sample 45-RH-89, Kopili Formation.

Plate 2

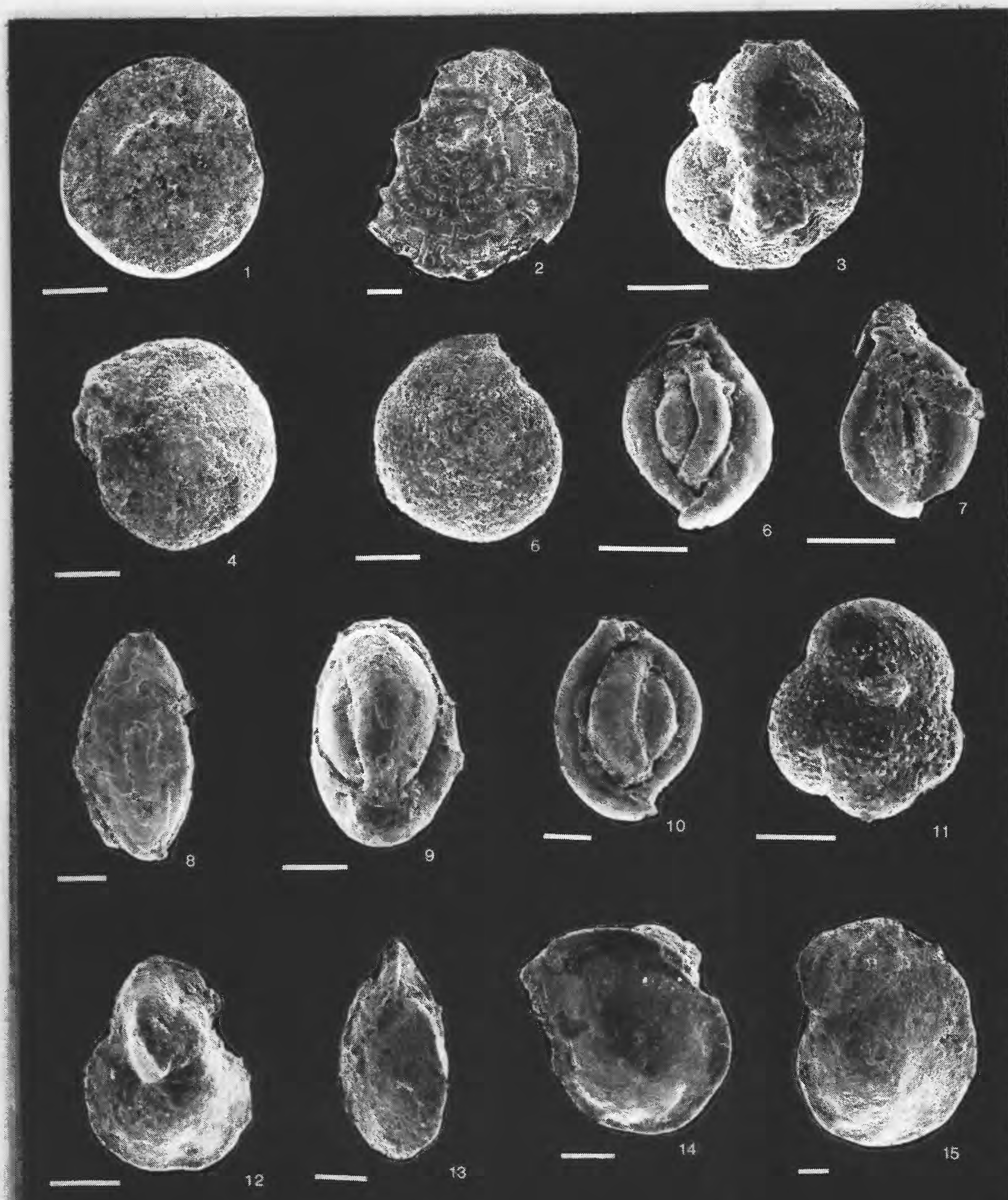


PLATE 3

All figures are scanning electron photomicrographs.
White bar equals 100 micrometers.

Figure	
1.	*Cibicides eocaenus*, sample 45-RH-89, Kopili Formation.
2, 3.	*Pellatispira madarasizi* (Hantken) *var. idica* Rao, sample 45-RH-89, Kopili Formation.
4.	*Discorbinella sp.*, sample 45-RH-89, Kopili Formation.
5-7.	*Cibicidoides perlucidus* (Nuttall), sample 45-RH-89, Kopili Formation.
8.	*Asterocyclina stellata* (d'Archiac), sample 45-RH-89, Kopili Formation.
9, 10.	*Pellatispira irregularis* Umbgrove, sample 45-RH-89, Kopili Formation.
11-14.	*Quinqueloculina sp.*, sample 45-RH-89, Kopili Formation.

Plate 3

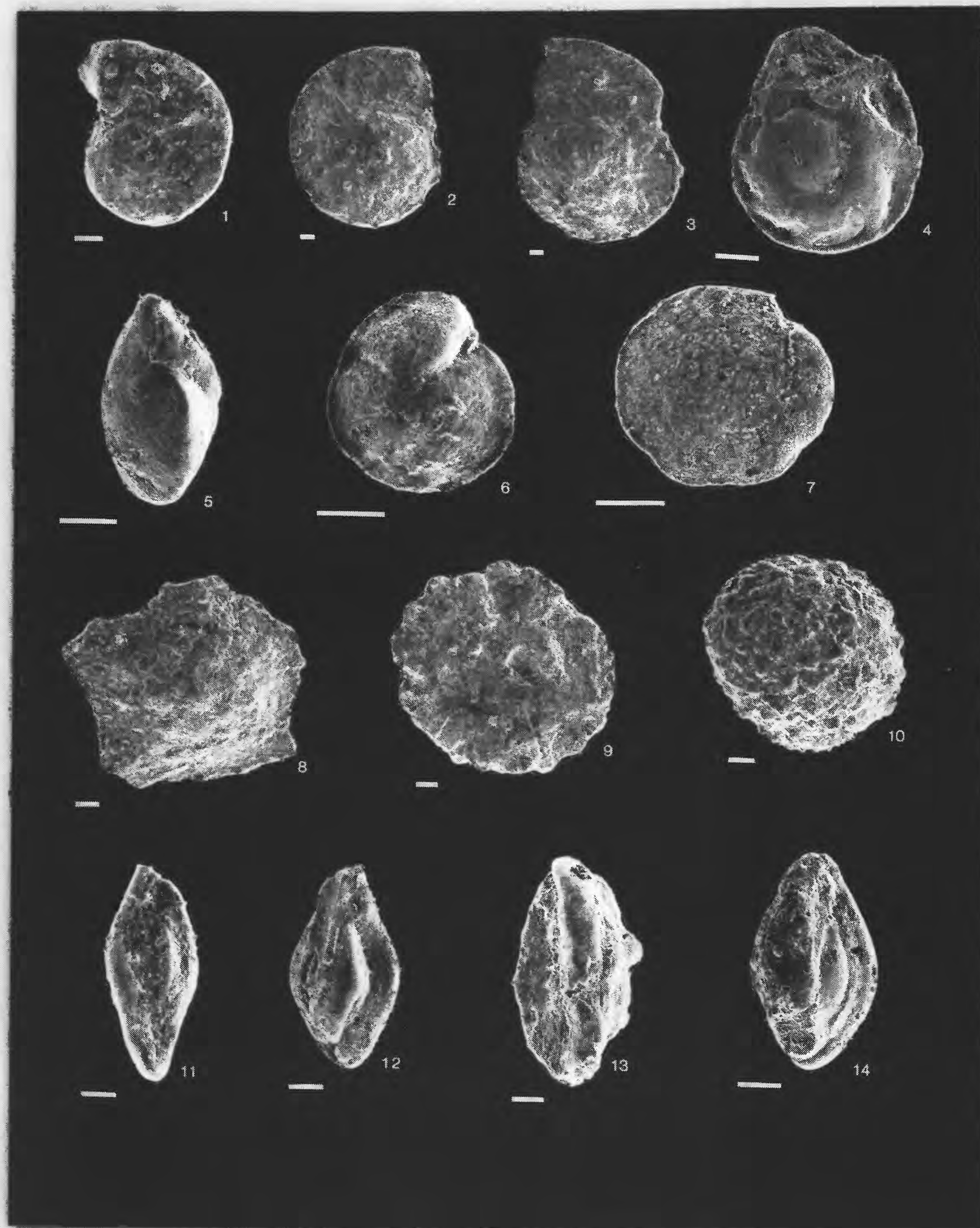


PLATE 4

All figures are scanning electron photomicrographs.
White bar equals 100 micrometers.

Figure

1. *Quinqueloculina acuta* Hussey, sample 45-RH-89, Kopili Formation.

2. *Quinqueloculina sp.*, sample 45-RH-89, Kopili Formation.

3, 4. *Lagena laevis* (Montagu), sample 45-RH-89, Kopili Formation.

5. *Planorbulina mediterranensis* d'Orbigny, sample 45-RH-89, Kopili Formation.

6-8. *Cibicides lobatulus* (Walker and Jacob), sample 47-RH-89, Kopili Formation.

9. *Pseudophragmina (Proporocyclina) sp.*, sample 47-RH-89, Kopili Formation.

10, 11. *Quinqueloculina sp.*, sample 47-RH-89, Kopili Formation.

12. *Triloculina globosa* Hanna and Hanna, sample 47-RH-89, Kopili Formation.

13. *Quinqueloculina sp.*, sample 50-RH-89, Kopili Formation.

14, 15. *Textularia sp.*, sample 45-RH-89, Kopili Formation.

Plate 4

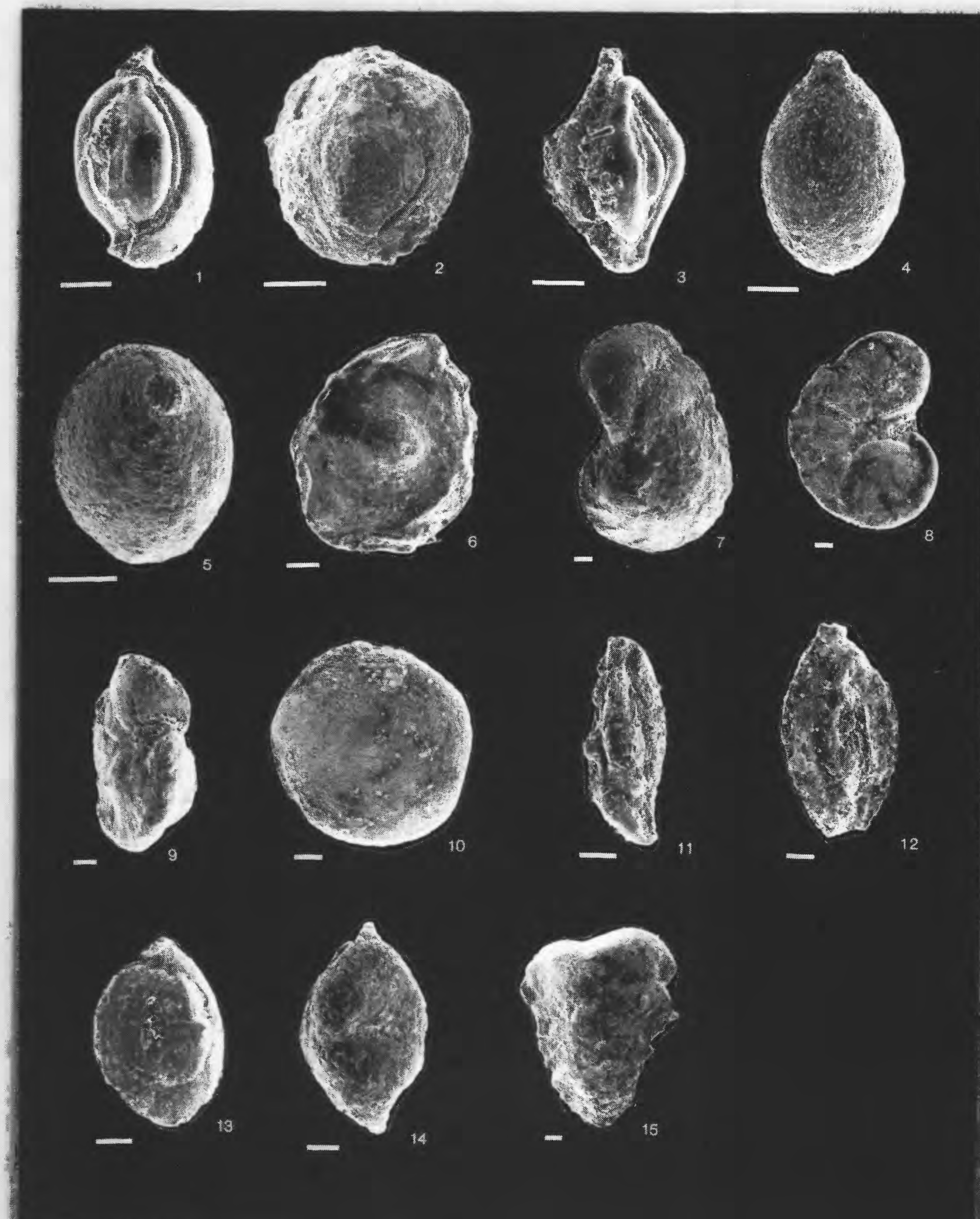


PLATE 5

All figures are scanning electron photomicrographs.
White bar equals 100 micrometers.

Figure

1. *Hanzawaia ammophela*, sample 45-RH-89, Kopili Formation.

2-9. *Quinqueloculina sp.*, sample 45-RH-89, Kopili Formation.

10. *Quinqueloculina alabamensis* Cushman, sample 45-RH-89, Kopili Formation.

11, 12. *Cibicides sp.*, sample 45-RH-89, Kopili Formation.

13, 14. *Asterigerina sp.*, sample 45-RH-89, Kopili Formation.

15. *Cibicidoides perlucidus* (Nuttall), ample 45-RH-89, Kopili Formation.

Plate 5

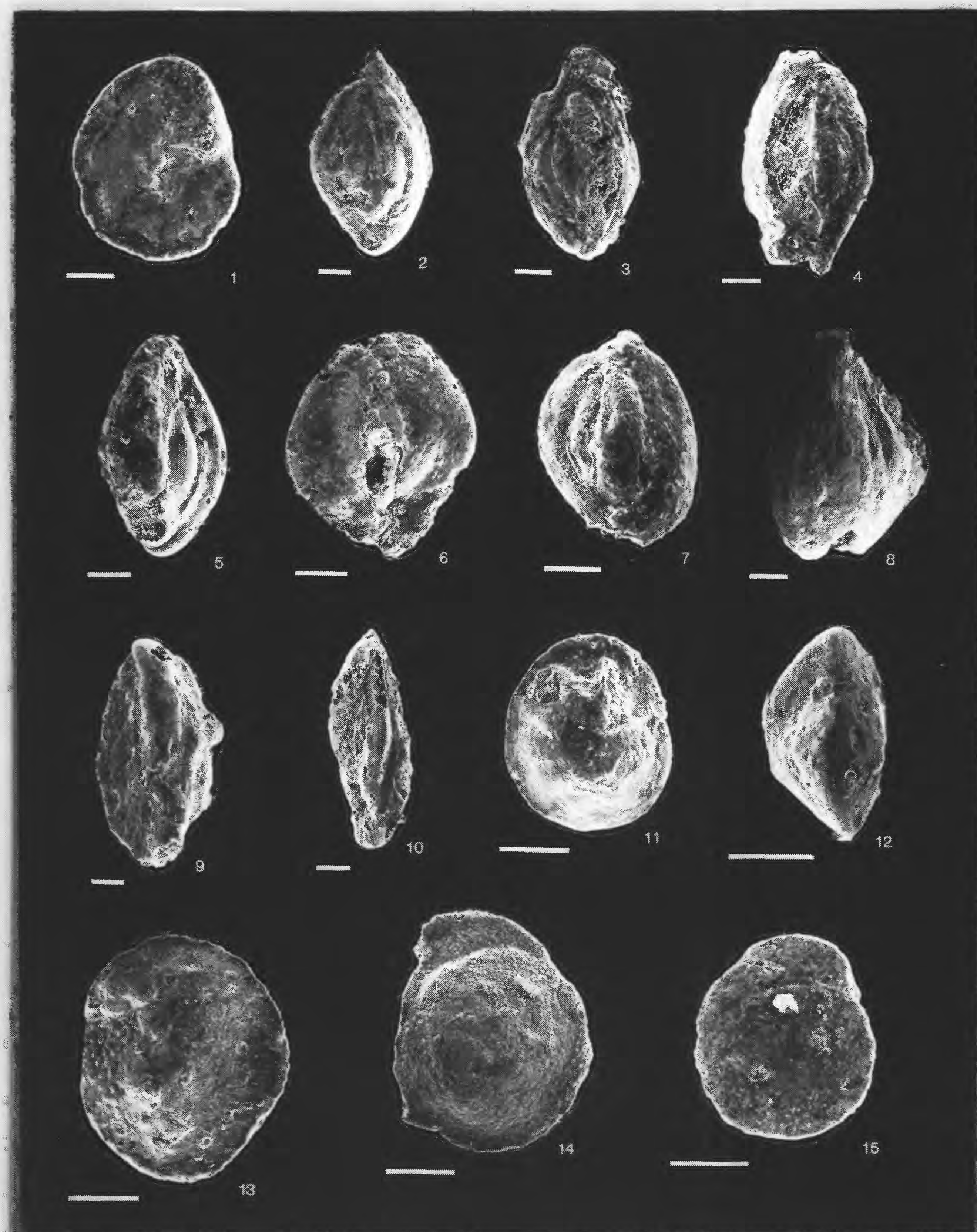


PLATE 6

All figures are scanning electron photomicrographs.
White bar equals 100 micrometers.

Figure	
1.	*Globanomalina cf. G. micra* (Cole), sample 45-RH-89, Kopili Formation.
2.	*Eoannularia sp.*, sample 45-RH-89, Kopili Formation.
3, 4.	*Lagena sp.*, sample 45-RH-89, Kopili Formation.
5.	*Nodosaria sp.*, sample 45-RH-89, Kopili Formation.
6-8.	*Globigerina ampliapertura* Bolli, sample 47-RH-89, Kopili Formation.
9, 10.	*Eoannularia sp.*, sample 47-RH-89, Kopili Formation.
11-13.	*Cibicidoides sp.*, sample 47-RH-89, Kopili Formation.
14.	*Pyrgo sp.*, sample 47-RH-89, Kopili Formation.
15, 16.	*Quinqueloculina acuta* Hussey, sample 47-RH-89, Kopili Formation.

Plate 6

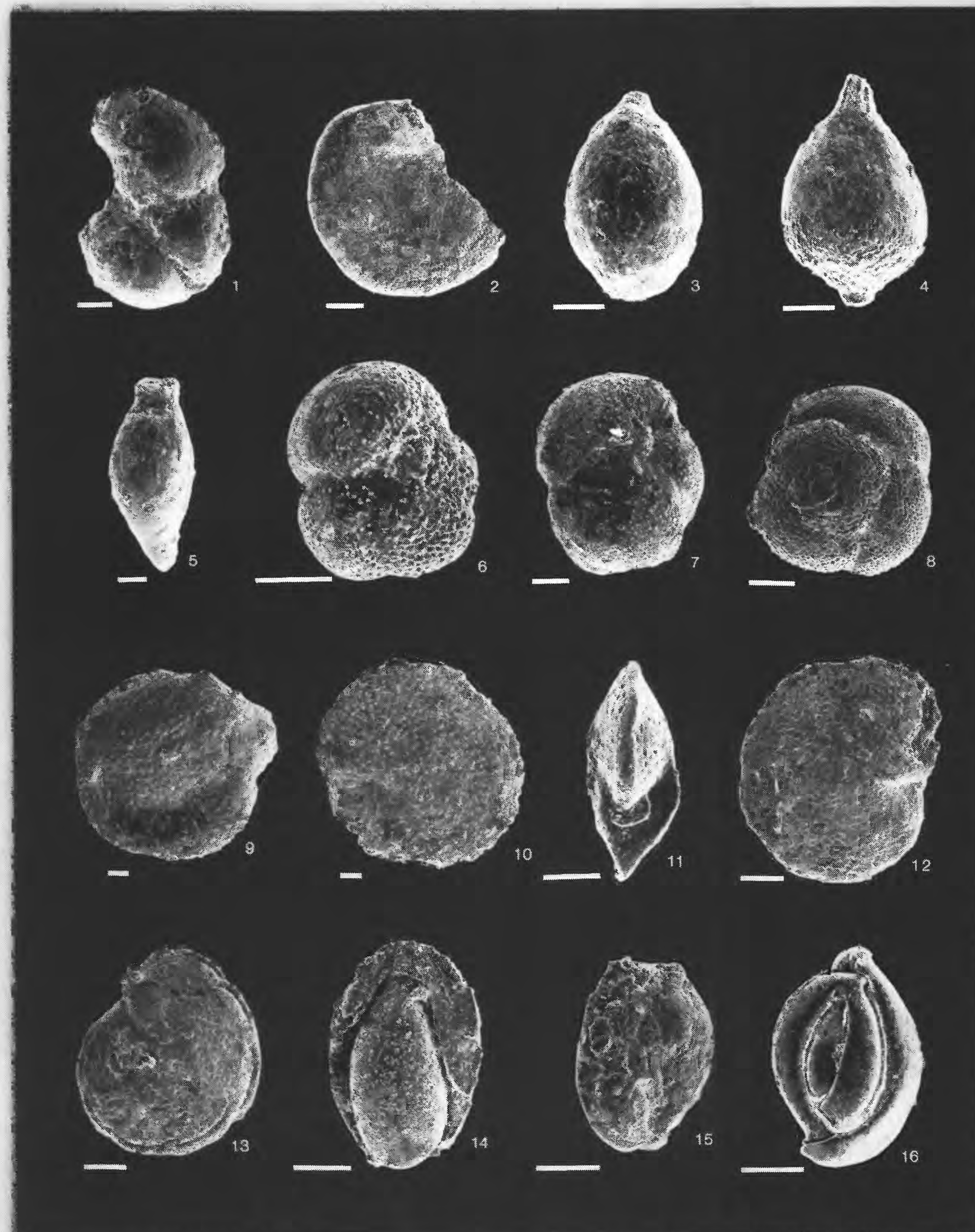


PLATE 7

All figures are scanning electron photomicrographs.
White bar equals 100 micrometers.

Figure

1.	*Quinqueloculina sp.*, sample 47-RH-89, Kopili Formation.
2.	*Lagena sp.*, sample 47-RH-89, Kopili Formation.
3, 4.	*Pellatispira irregularis* Umbgrove, sample 47-RH-89, Kopili Formation.
5.	*Asterocyclina stellata* (d'Archiac), sample 47-RH-89, Kopili Formation.
6.	*Pyrgo sp.*, sample 47-RH-89, Kopili Formation.
7.	*Eoannularia sp.*, sample 47-RH-89, Kopili Formation.
8, 9.	*Planorbulina mediterranensis* d'Orbigny, sample 47-RH-89, Kopili Formation.
10.	*Nodosaria sp.*, sample 47-RH-89, Kopili Formation.

Plate 7

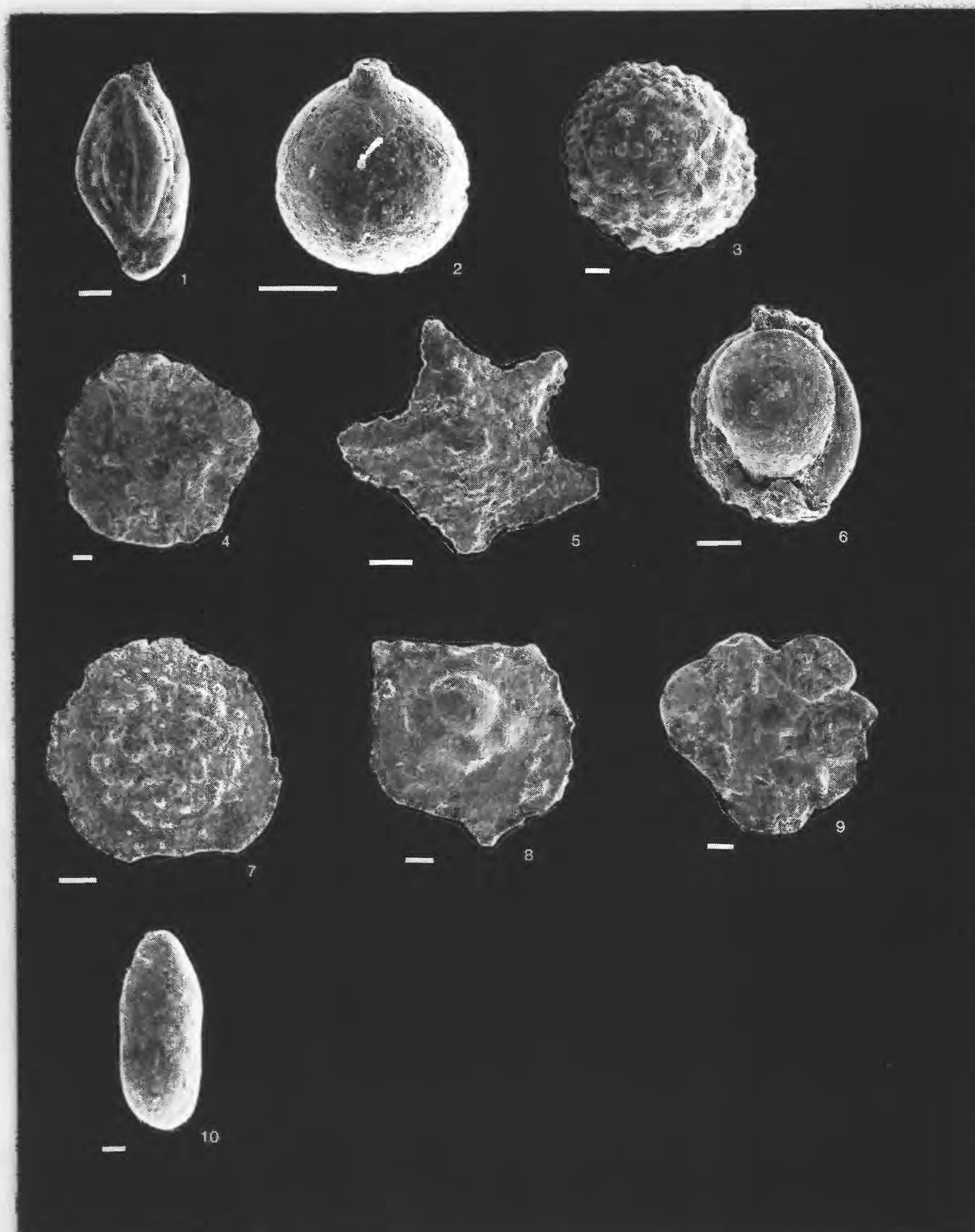


PLATE 8

All figures are scanning electron photomicrographs.
White bar equals 100 micrometers.

Figure	
1, 2.	*Verneulina sp.*, sample 47-RH-89, Kopili Formation.
3, 4.	*Globigerina ampliapertura* Bollia, sample 47-RH-89, Kopili Formation.
5.	Unidentified form, sample 47-RH-89, Kopili Formation.
6, 7.	*Pellatispira sp.*, sample 47-RH-89, Kopili Formation.
8, 9.	*Quinqueloculina sp.*, sample 47-RH-89, Kopili Formation.
10.	*Quinqueloculina compacta* Serova, samle 47-RH-89, Kopili Formation.
11.	*Discorbinella sp.*, samle 47-RH-89, Kopili Formation.
12, 13.	*Eoannularia sp.*, sample 47-RH-89, Kopili Formation.
14, 15.	*Pellatispira sp.*, sample 47-RH-89, Kopili Formation.

Plate 8

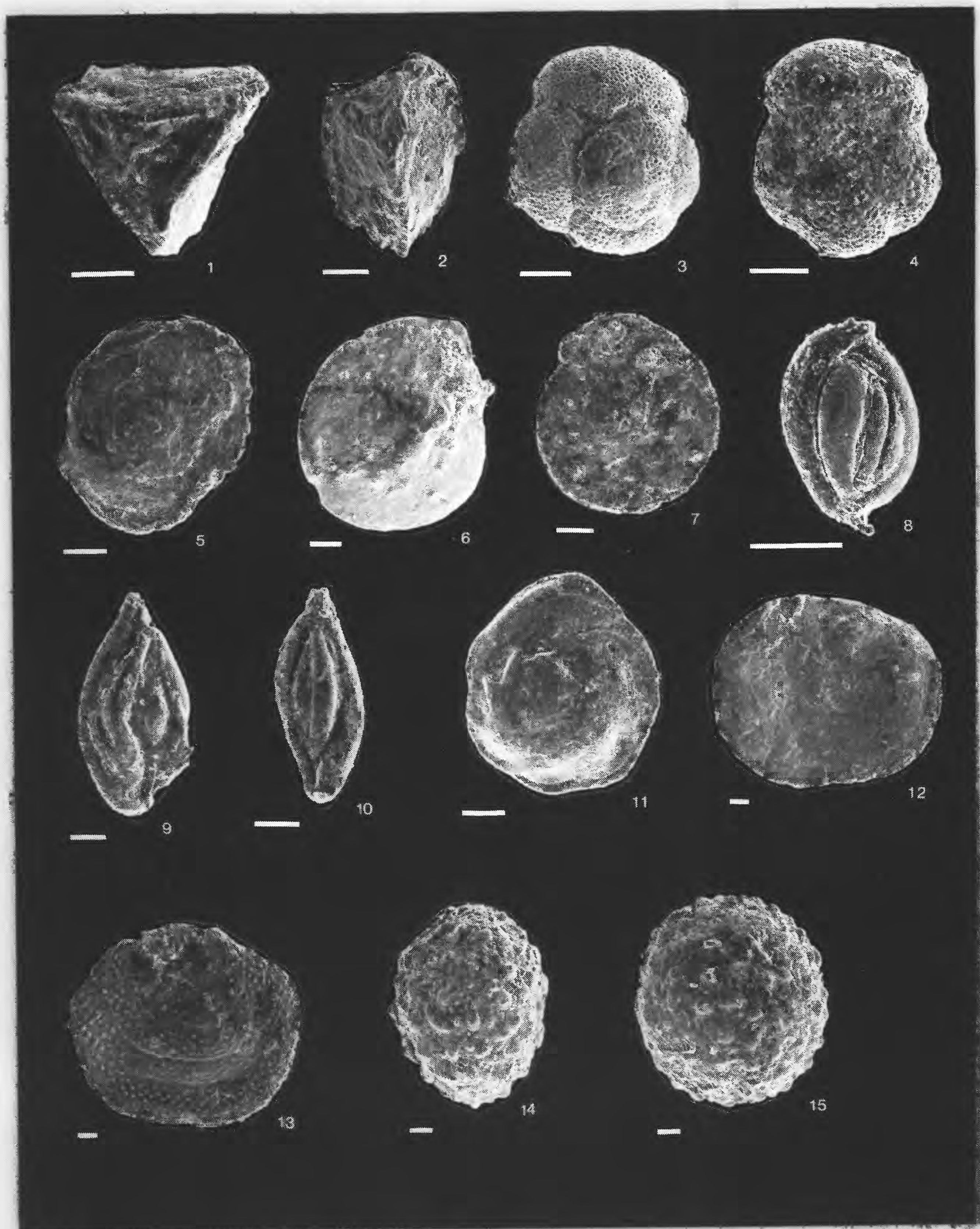


PLATE 9

All figures are scanning electron photomicrographs.
White bar equals 100 micrometers.

Figure	
1.	*Dentalina soluta*, sample 47-RH-89, Kopili Formation.
2.	*Pellatispira madarasizi* (Hantken) *var. idica* Rao, sample 47-RH-89, Kopili Formation.
3.	*Eoannularia? sp.*, sample 47-RH-89, Kopili Formation.
4, 5.	*Cibicides eocaenus*, sample 47-RH-89, Kopili Formation.
6.	*Neonesidea khoslai* Bhandari, 1981, sample 89-EB-5, Sylhet Limestone.
7.	*Bairdoppilata poddari* Lubimova and Mohan, 1960, sample 89-EB-5, Sylhet Limestone.
8.	*Hornibrookella arcanus* Lubimova and Guha, 1960, sample 89-EB-5, Sylhet Limestone.
9.	*Xestoleberis sp. A*, sample 89-EB-5, Sylhet Limestone.
10.	*Costa (Paracosta) sp. A*, sample 89-EB-5, Sylhet Limestone.
11.	*Cytherella cf. C. protuberantis* Lubimova and Guha, 1969, sample 89-EB-5, Sylhet Limestone.
12.	*Xestoleberis sp. B*, sample 89-EB-14, Sylhet Limestone.
13.	*Xestoleberis sp. C*, sample 89-EB-22, Kopili Formation.
14.	*Phacorhabdotus? sp. A*, sample 89-EB-22, Kopili Formation.
15.	*Cytheropteron aff. C. reticuloradiata* Neale and Singh, 1985, sample 89-EB-22, Kopili Formation.
16.	*Occultocythereis sp. A*, sample 89-EB-24, Kopili Formation.

Plate 9