

Late Cretaceous and Early Tertiary Benthic Foraminiferal Biostratigraphy in Khuzdar District, Balochistan, Pakistan, with Special Reference to the Influence of Tethyan Sea Closure

By

Imdad Ali BROHI

with 12 Plates, 4 Tables and 22 Figures

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Abstract: The paleontological study of benthic foraminifera in relation to the Indian-Asian boundary in Khuzdar District, Balochistan, Pakistan, have been carried in three sections of the Cretaceous-Paleogene: named as 1) PAK-section, 2) MG-section and 3) HR-section (Abbr.) of Hinar. Strata of the three sections contain typical Cretaceous-lower Tertiary benthic foraminifera such as *Bolivinoidea draco*, *Coryphostoma incrassata*, *C. midwayensis*, *Gavelinella monterelensis*, *Globorotalites micheliniana*, *Stensioina beccariiiformis*, *S. excolata*, *Neoflabellina rugosa*, *Nuttallides truempyi* and *Vulvulina spinosa*. Fifteen benthic foraminiferal assemblages have been recognized from the PAK-section (seven assemblages) and MG-section (eight assemblages).

The Cretaceous-Paleogene strata are defined into three lithostratigraphic units consisting of the Mughal Kot Formation, the Pab Sandstone and the Jamburo Group in the ascending order. The age of the redefined Jamburo Group ranges from the Maastrichtian to the Middle Oligocene. The Cretaceous bearing strata of the Jamburo Group below the Pab Sandstone are correlated to the Mughal Kot Formation.

The Cretaceous-Tertiary boundary is determined above the Pab Sandstone and the base of the Jamburo Group in the PAK-section and below coarse grained brecciated limestone in the MG-section. Whereas in the Hinar section, it is located between limestone and shale of the Jamburo Group, by the disappearance of such planktonic foraminifera as *Globotruncana stuartiformis*, *G. falsostuarti*, *Gl. spp.*, *Pseudoguembelina elegans* and *Recemiguembelina fructicosa* and the appearance of the Danian *Globorotalia pseudobulloides*.

The Cretaceous specimens occurring in the lower parts of the MG-section and PAK-section indicate Maastrichtian that is the age of the above mentioned Mughal Kot Formation and Pab Sandstone. Overall the redefined Jamburo Group consists of various kinds of shale, limestone, shelly limestone and marlstone. The late Cretaceous Mughal Kot Formation reveals more distinct alternation of limestone and shale, with two to three meter thick sandstone separated as a different unit equivalent to the Maastrichtian Pab Sandstone.

Benthic foraminifera change their tests from calcareous to agglutinated across the Cretaceous-Tertiary boundary. The change is most obvious in the PAK-section. However, the frequency of agglutinated taxa shows fluctuation in the Paleogene of the HR-section, and in the MG-section the agglutinated ratio does not largely change at the K/T boundary and gradually decreases afterwards. This decreasing tendency may be associated with restriction of the bottom water circulation of deeper water which may be caused by closure of the Tethyan Sea, and supports the hypothesis of collision of Eurasian and Indian Plates near the end of the Cretaceous and the Early Paleocene to Eocene.

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I. Introduction

A. Purpose and scope of the study

The Upper Cretaceous to Lower Tertiary sequence of mixture of carbonate and siliciclastics was used to be called as the Jamburo Group. It is well exposed in the vicinity of Khuzdar district, Balochistan, between the underlying Cretaceous Parh Group (Monajhal Group) and the overlying Nari Sandstone. The benthic foraminiferal biostratigraphical studies on this sequence are carried out for the following purpose and scope.

The main purposes of this study are (1) to find out the Cretaceous-Tertiary boundary and to redefined the undifferentiated Jamburo Group either as a single depositional unit or into two or more depositional formations in terms of its exact age determination, (2) to revise the benthic foraminiferal occurrences studied previously, (3) to make correlation of the studied sections, and (4) to display change of the agglutinated and calcareous benthic foraminiferal test across the K/T boundary with reference to the plate boundaries and to reconstruction of the paleoenvironment. For achieving these objectives three sections were studied from the top of the Parh Group (Hunting Survey Corporation, 1960) and Parh Limestone (Blanford, 1879) to the base of Nari Sandstone. This study was carried out in the Department of Earth and Planetary Systems Science, Hiroshima University, Japan, under the supervision of Professor Y. Okimura.

B. Previous works

Benthic foraminiferal biostratigraphy regarding the Late Cretaceous to Early Tertiary is not well studied, in the

southern Balochistan, especially around Khuzdar area. Some works dealing with larger and planktonic foraminiferas are those of Vredenburg (1909), Williams (1959), Haque (1959), Nagappa (1959), Hunting Survey Corporation (1960; hereafter HSC for abbreviation), Dorreen (1974), Fatmi (1977) Cheema *et al.*, (1977), Baryar *et al.*, (1984), Fatmi *et al.*, (1986), Brohi and Marzaban (1986), Brohi *et al.*, (1992), Brohi (1992), Nomura and Brohi (in prep.), Brohi (in prep.). The stratigraphy of the Cretaceous Parh Group have been studied on the basis of ammonites with some modifications by Fatmi (1977) and Fatmi *et al.* (1986), the brief description of the stratigraphy in the descending order is as follows.

Jamburo Group (Fatmi *et al.*, 1986), Tertiary
----- Disconformable contact
Mughal Kot Formation (Williams, 1959),
Maastrichtian

The formation is composed of dark grey, calcareous mudstones and calcareous shale with a intercalation of quartzose sandstone. The upper contact of Mughal Kot Formation is conformable with Fort Munro Formation in the most areas of Pakistan, but not in Khuzdar area, whereas its upper contact is unconformable with the Paleocene to Eocene Dungan Formation marked by a laterite bed and disconformable with

Tertiary Jamburo Group.

----- Unconformable contact
Parh Limestone (Blanford, 1879), Late Cretaceous
The Parh Limestone is grey, white, cream, or olive green in colour, and thin to medium-bedded, porcellaneous, or argillaceous, sometimes with subordinate calcareous shale

and marl intercalations.

The reported planktonic foraminifers are *Globotruncana* spp., *G. ventricosa*, *G. lapparenti*, *G. sigali*, and *Pseudotextularia elegans* (Gigon, 1962).

-----Transitional contact

Goru Formation (Williams, 1959), Early Cretaceous

The formation consists mainly of interbedded limestone, shale and siltstone. The foraminifera reported by Fritz and Khan (1967) from this formation are *Globigerinelloides algeriana*, *G. breggiensis*, *G. caseyi*, *Ticinella roberti*, *Gavelinella lorneiana*, *Rotalipora ticinensis*, *R. appenninica*, *R. brotzeni*, *R. reicheli*, *Praeglobotruncana stephani* and *Planomalina buxtorfi*.

-----Conformable/Unconformable

Sembar Formation. (Williams, 1959), Neocomian

This formation is characterized by black silty shales with interbeds of black siltstone and nodular rusty weathering argillaceous limestone or concretions.

Haque (1959) studied some late Cretaceous smaller foraminifera from Sindh and Balochistan provinces, including northeast of Khuzdar, and described the following foraminifers: *Bolivinaoides palaeoreticulata*, *Eouvigerina* cf. *E. cretacea*, *Fronicularia goldfussi*, *Globotruncana contusa*, *G. lakrai*, *G. lapparenti*, *G. stuarti*, *Globotruncana* aff. *G. gansseri*, *G. cf. G. schnegansi*, *Globorotalites umbilicatus*, *Marginulina* sp., *Nodosaria* cf. *N. navarroana*, *Oolina apiculata*, *Pleurostomella subnodosa*, *Robulus* cf. *R. microptera*, *Rotalipora turonica*, and *Stensioina prae-exsculpta*.

Nagappa (1959) studied on the foraminiferal biostratigraphy of the Cretaceous-Eocene in the India-Pakistan-Burma region. According to him the Maastrichtian-Danian boundary was placed between the massive coarse-grained Pab Sandstone and the *Cardita beaumonti* beds in southern Balochistan, and he assigned the age of the Parh Limestone Cenomanian to Campanian.

Blanford (1879) firstly recognized the Eocene Kirthar shales underlain by Parh Group. Besides, HSC (1960) later introduced the Jamburo Group after the name of the Jamburo district, and proposed the reference locality in the western Gaj river which cuts across the Kirthar Range and exposes a good marine succession from the Cretaceous to the Oligocene (Blanford, 1879; Nagappa, 1959; HSC, 1960; Dorreen, 1974). HSC also described that this group is mainly composed of mixture of clastic and carbonate rocks with shelly or coquinoïdal limestone in the southern Balochistan. However, the subsequent studies showed that this Group is widely distributed in the adjoining areas of Khuzdar district. In some areas the Jamburo Group was clarified to be exposed in thicker sequence than that of the reference locality of HSC (1960). The larger and smaller foraminifers reported from the Jamburo Group by Blanford (1879) and HSC (1960) are listed below.

Paleocene larger foraminifera: *Alveolina* spp., *Assilina* spp., *Daviesina* sp., *Dictyoconus* sp., *Discocyclina* spp., *D.* sp. aff. *D. sowerbyi*, *Flosculina* sp. cf. *F. globosa*, *Lepidocyclina* spp., *Lokhartia* sp., *Miscellanea* sp., *M. miscella*, *Operculina* spp., *Orbitoides* sp., *Orbitolites* sp.

Paleocene smaller foraminifera: *Anomalina* sp., *Bulimina* sp., *Cassidulina subglobosa*, *Cibicides* sp. A, *Cibicides* sp. B, *Cibicides multifarius*, *Dentalina* sp. A, *Dentalina* cf. *D.*

megapolitana, *Eponides* sp. cf. *E. lotus*, *Globigerina* sp. A, *Globigerina bulloides*, *Globigerina* sp. cf. *G. pseudobulloides*, *Globorotalia* sp. A, *Globorotalia velascoensis*, *Gyroidina girardana*, *Lenticulina* sp. A, *Nodosaria* sp. A, *Nonion mexicanum*, *Robulus* sp. A, *Rotalia* sp. A, *Rotalia* sp. B, *Saracenaria* sp. A, *Verneuilina* sp. A.

Eocene larger foraminifera: *Alveolina* spp., A. sp. 7, A. *globosa*, A. *lepidula*, A. *subpyrenaica*, *Assilina* spp., A. *daviesi*, A. *exponens*, A. *granulosa*, A. *laminosa*, A. *leymeriei*, A. *mamillata*, A. *sublaminosa*, A. *subpapillata*, *Calcarina* sp. 1, *Camerina* sp. 7, C. sp. 11, C. sp. 16, C. *acutus*, C. *djokdjokartae*, C. sp. cf. C. *mamilla*, C. *subatacicus*, *Discocyclina* spp., D. sp. 6, D. *swerbyi*, *Flosculina globosa*, *Globigerina* spp., *Globorotalia* sp., *Lokhartia* sp., L. *canditi*, L. *newboldi*, L. *tipperi*, *Miscellanea miscella*, *Nummulites atacicus*, N. sp. aff. N. *atacicus*, N. sp. aff. N. *mamilla*, N. *obtusius*, *Operculinoides* sp. 1, O. *nuttalli*, *Orbitoides* sp., O. *complanatus*.

Eocene smaller foraminifera: *Robulus* sp. 1, *Ammomarginulina* sp., *Bolivina* sp. A, B. sp. B, B. sp. C, B. sp. cf. B. *beyrichi*, *Burmudezina* sp. A, *Cibicides minsilla*, C. *multifarius*, *Globigerina* sp. A, G. sp. cf. G. *compressa*, G. sp. cf. *cretacea*, G. *dubia* var. G. *lakiensis*, G. sp. aff. G. *duterie*, G. *linaperta*, G. sp. cf. G. *linaperta*, G. sp. cf. G. *pseudobulloides*, *Globigerinella* sp., *Globigerinoides* sp. cf. G. *cretacea*, *Globorotalia* sp. A, G. sp. cf. G. *crassaformis*, G. sp. cf. G. *velascoensis*, G. sp. cf. G. *willcoxensis*, *Guembelina* sp. cf. G. *trinitatensis*, G. sp. cf. G. *willcoxensis*, *Guttulina* sp. cf. G. *laetea*,

Gyroidina sp. cf. G. *girardana*, G. sp. cf. G. *globosa*, *Nodosaria* sp. A, *Rzehakina* sp. B, R. *epigona*.

Oligocene foraminifera: *Lepidocyclina* spp., *Nummulites* spp., N. *fichteli*, *Operculina* spp.

Dorreen (1974) studied the western Gaj river section including the Cretaceous Parh Group, and described some Cenomanian to Early Tertiary planktonic foraminifers. He recognized three Maastrichtian planktonic zones of *Globotruncana contusa*, *G. gansseri* and *G. falsocalcarata*, three Paleocene planktonic zones of *Globorotalia pseudobulloidis*, *G. angulata* and *Globorotalia velascoensis*, and two Lower Eocene planktonic zones of *Globorotalia rex* and *G. aragonensis*. The selected species are as under.

Planktonic species: Maastrichtian; *Globotruncana duwi*, *G. contusa*, *G. gansseri*, *G. havanensis* and *G. falsocalcarata*.

Danian; *Globorotalia compressa*, *G. pseudobulloidis*, and *Globigerina triloculinoides*.

Montian and Landenian; *Globorotalia angulata*, *G. velascoensis*, *Rzehakina epigona*, and *Spiroplectammina spectabilis*.

Eocene; *Coleites reticulosus*, *Cribohantkenina danvillensis*, *Globigerapsis kugleri*, *Globigerina inaequispira*, *Globorotalia aragonensis*, *G. formosa*, *G. rex*, *G. willcoxensis*, *G. centralis*, *G. lehneri*, *G. cerroazulensis*, *Hantkenina alabamensis*, and *H. dumblei*.

Benthic species: *Anomalina petita*, *Bolivina incrassata*, *Bolivinaoides draco*, *Bulimina kickapooensis*, *Citharina beisseli*, *Clavulina disjuncta*, *Dorothia bulletta*, *Globorotalites micheliniana*, *Marssonella oxycona*, *Neoflabellina jarvisi*, *Stensioina pommerana* and *Tritaxia insignis*.

Baryar *et al.* (1984) reported the following Paleocene-Eocene planktonic foraminifers from the Korara shale of southern Balochistan: *Globigerina* sp. aff. *G. edita*, *G. daubjergensis*, *G. trivalis*, *G. varianta*, *Globorotalia aequa*, *G. aff. G. bulbrooki*, *G. inconstants*, *G. trinidadensis*, *G. compressa*, *G. pseudobulloides*, *G. pseudomenardii*, and *G. sp. aff. G. pseudotopilensis*.

Based on the foraminifera reported by HSC (1960), Cheema *et al.* (1977) emphasized that the upper part of the Jamburo Group is equivalent to the Eocene Nisai Group of HSC (1960) in the Muslim Bagh District, and redefined the age of the Nisai Formation as Eocene-Early Oligocene. The principal reference section of this formation lies in the Kasira Jhur, a main tributary of the Hab river flowing from the east of the Pab Range. Fatmi *et al.* (1986) distinguished the undifferentiated Parh Group of HSC (1960) overlying strata of the Parh Limestone in the Mona Jhal River, north of Khuzdar, as the Mughal Kot Formation, and redefined the Parh Group into the Monajhal Group except for the Pab Sandstone. In this locality, at the top of the Mughal Kot Formation there is a brecciated limestone with larger foraminifera, showing a disconformity between the overlying Jamburo Group and the underlying Mughal Kot Formation (Fatmi *et al.* 1986). And, they suggested the age of the Jamburo Group as Tertiary.

Brohi and Marzaban (1986) studied some smaller foraminifera from the type section of the Jamburo Group and found such Cretaceous-Paleocene species as, *Bolivina incrassata*, *Globigerina globula*, *G. pseudobulloides*, *Globorotalia aqua*, *G. velascoensis*, *Globotruncana rosita*, *G. stuartiformis*, *Heterohelix reussi*, *Hedbergella herdii*, *Pseudoguembelina* sp. etc. They tentatively determined the Cretaceous-Tertiary boundary between PAK-13 and PAK-14. Moreover Brohi *et al.* (1992) reported the Cretaceous to Oligocene foraminiferal fauna of generic level from the Mai Gatti section located southeast of Khorri village, but the following Late Cretaceous and Paleogene benthic foraminifers were detected by the reexamination of the same section (Brohi, 1992): *Bolivina draco*, *Coryphostoma incrassata*, *Cibicidoides* sp., *Clavulina* sp., *Dorothia bulletta*, *Fissurina* sp., *Gaudryina* sp., *Gyroidinoides exsertus*, *G. globosus*, *Lenticulina* sp., *Nodosaria* sp., *Nuttallides truempyi*, *Oridorsalis* sp., *Oridorsalis umbonatus*, *Praebulimina navarroensis*, *P. ovulum*, *Reophax* sp., *Saracenaria* sp., *Stensioina* sp., *Stensioina beccariiiformis*.

The author in the same paper divided the Jamburo Group into two of the Cretaceous Mughal Kot and Paleogene Jamburo Formations. However, this division has a problem in the stratigraphic code, because the same name both for the group and formation is confusable and can not be used. This problem is resolved by the stratigraphical separation of the Mughal Kot Formation and Pab Sandstone from the Jamburo Group (Nomura and Brohi, in prep.). They redescribed the foraminiferal characteristics in the reference locality of this group, based on the parameters of foraminiferal No. per gram, agglutinated and calcareous foraminiferal ratio, benthic versus planktonic foraminiferal ratio and species diversity (H'), and divided into three lithostratigraphic units of Mughal Kot, Pab Sandstone and Jamburo Group in ascending order. Moreover, they recognized seven benthic foraminiferal assemblages of

Gavelinella monterelensis-*Globorotalia micheliniana*, *Trochammina*, *Praebulimina aspera*, *Praebulimina kickapooensis*, *Praebulimina ovulum*-*Lenticulina*, *Cibicidoides jamburoensis*-*Tritaxia trilatera* and unilocular taxa, and describe the representative 59 species;

Bathysiphon vernoni, *B. varans*, *B. vitta*, *Bulimina arkadelphiana* var. *midwayensis*, *Buliminella carseyae*, *Chilostomella ovoidea*, *Cibicidoides allenii*, *C. dayi*, *C. eriksdalensis*, *C. jamburoensis*, *C. subcarinatus*, *C. taylorensis*, *C. velascoensis*, *Clavulina parisiensis*, *Coryphostoma midwayensis*, *C. incrassata*, *Dentalina aculeata*, *D. colei*, *D. gracilis*, *Dorothia bulletta*, *D. cf. confraga*, *Gaudryina rugosa*, *G. pyramidata*, *Gavelinella monterelensis*, *Globorotalites micheliniana*, *Gyroidina girardana*, *G. exsertus*, *G. globosus*, *G. quadratus*, *Haplophragmoides* sp., *Lenticulina* cf. *revoluta*, *L. gunderbookaensis*, *L. navicula*, *L. rotulata*, *L. turbinata*, *Lituotuba* sp., *Marssonella oxycona*, *Neoflabellina rugosa*, *Nodosaria* cf. *fusula*, *Nuttallides truempyi*, *Oolina apiculata*, *Oolina reussi*, *Osangularia navarroana*, *Oridorsalis mariei*, *Praebulimina aspera*, *P. kickapooensis*, *P. navarroensis*, *P. ovulum*, *Pseudoclavulina amorphia*, *P. farafraensis*, *P. globulifera*, *Pullenia americana*, *Reophax globosus*, *Rzehakina epigona*, *Spiroplectammina midwayana*, *S. laevis*, *Stensioina beccariiiformis*, *S. excolata*, *Textularia plummerae*, *Tritaxia barakai*, *T. midwayensis*, *T. trilatera*, *Trochammina* cf. *texana*, *T. cf. diagonis*.

The frequency of benthic foraminifera is shown in Fig. 8, for the selected species ranging from the Late Cretaceous to the Paleocene. As shown in the Fig. 9, arranged on the basis of the different previous studies of the larger and smaller foraminifers, the age of the Jamburo Group has been decided in different ways (Cretaceous to Early Paleogene).

II. The stratigraphical succession and biostratigraphy of the studied area

A. General description of stratigraphy

The Jamburo Group is distributed in the calcareous zone of Pakistan (HSC, 1960), and is well exposed in the south and southeast of Khuzdar District, Balochistan, Pakistan (Figs. 1, 2, 3, 4), consisting of mainly limestone, but sandstone, shale, and other components are common and in places dominant. According to Nagappa (1959), the lithology of the group is well exposed especially in the western flank of ridge forming Kirthar Range whose geomorphography is profoundly influenced by the Himalayan orogeny. Mainly the lithology of the Jamburo Group is of marine variegated calcareous shale, marlstone, marly limestone, arenaceous limestone, and shelly limestone, but in some places fine to medium grained sandstone which exhibits a similar lithology to the Maastrichtian Pab sandstone exposed about 400 m thick in the Pab Range. The lower part of the Jamburo Group conformably lies on the micritic porcelaneous Campanian Parh Limestone or the top of Maastrichtian Monajhal Group (Fatmi *et al.* 1986) instead of Parh Group. While the upper contact is apparently conformable with Nari sandstone except for Gaj section where it was covered with Quaternary deposits. The Jamburo Group consisting of the latest Cretaceous and Paleogene sedimentary sequence is here

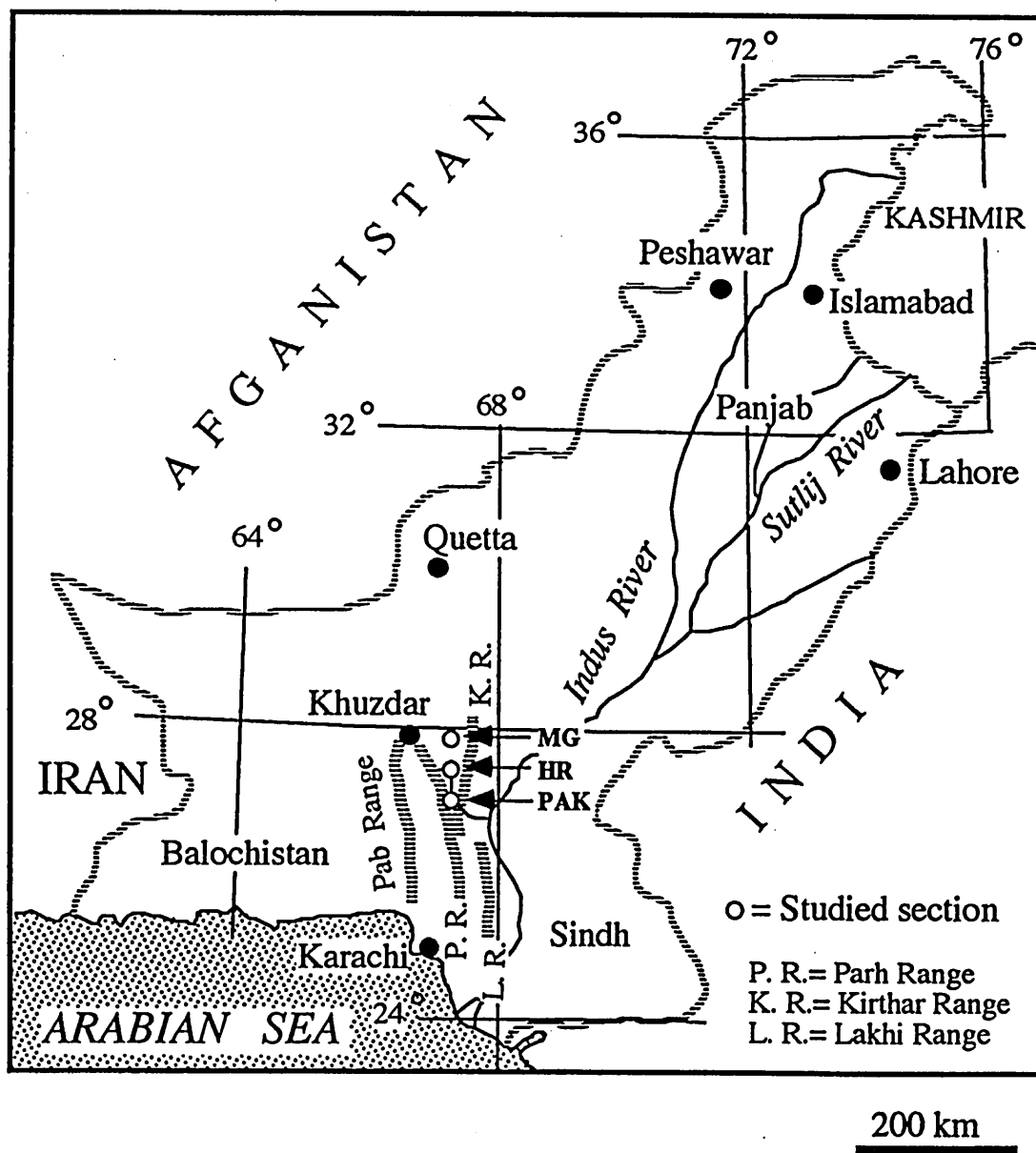


Fig. 1. Geographic map of Pakistan showing studied area.

redefined and subdivided into the Paleocene-Middle Oligocene Jamburo Group, the Cretaceous part of the Mughal Kot Formation and the Pab Sandstone. The variation in thickness found of the Pab Sandstone along the Gaj river and, in the Mai Gatti section and in the Pab Range may be related to difference in depositional setting in the shallowing Tethyan Sea.

The underlying Mughal Kot Formation of the group was introduced by Williams (1959) for the dark grey calcareous mudstone shale with intercalations of quartzose sandstone and light grey argillaceous limestone underlain by the Campanian Parh limestone. Fatmi *et al.*, (1986) recognized the Mughal Kot Formation in the Monajhal Group for the rocks overlying the Parh limestone, which equivalents to the lowermost part of the Jamburo Group in age and lithology. Furthermore, it is noticeable that the lithology of

this formation roughly resembles with the lower half of the Jamburo Group underlain by the Parh Limestone in the reference locality or the Parh Group in other sections. By the lithological succession mentioned above the Cretaceous portion of the Jamburo Group is redefined into the Mughal Kot Formation and the Maastrichtian Pab Sandstone. Although Fami *et al.*, (1986) reported the thickness of the Mughal Kot Formation to be 68 m, the present study proved that the thickness of the correlative sediments of the Mughal Kot Formation overlying the Campanian Parh Limestone reaches up to about 220 m thick. Such variations of thickness are shown in the Fig. 10.

The lithology and microfossils of this group were investigated in the three sections of PAK, MG, and HR. The individual lithology of three sections is described in the section C of this chapter in the ascending order.

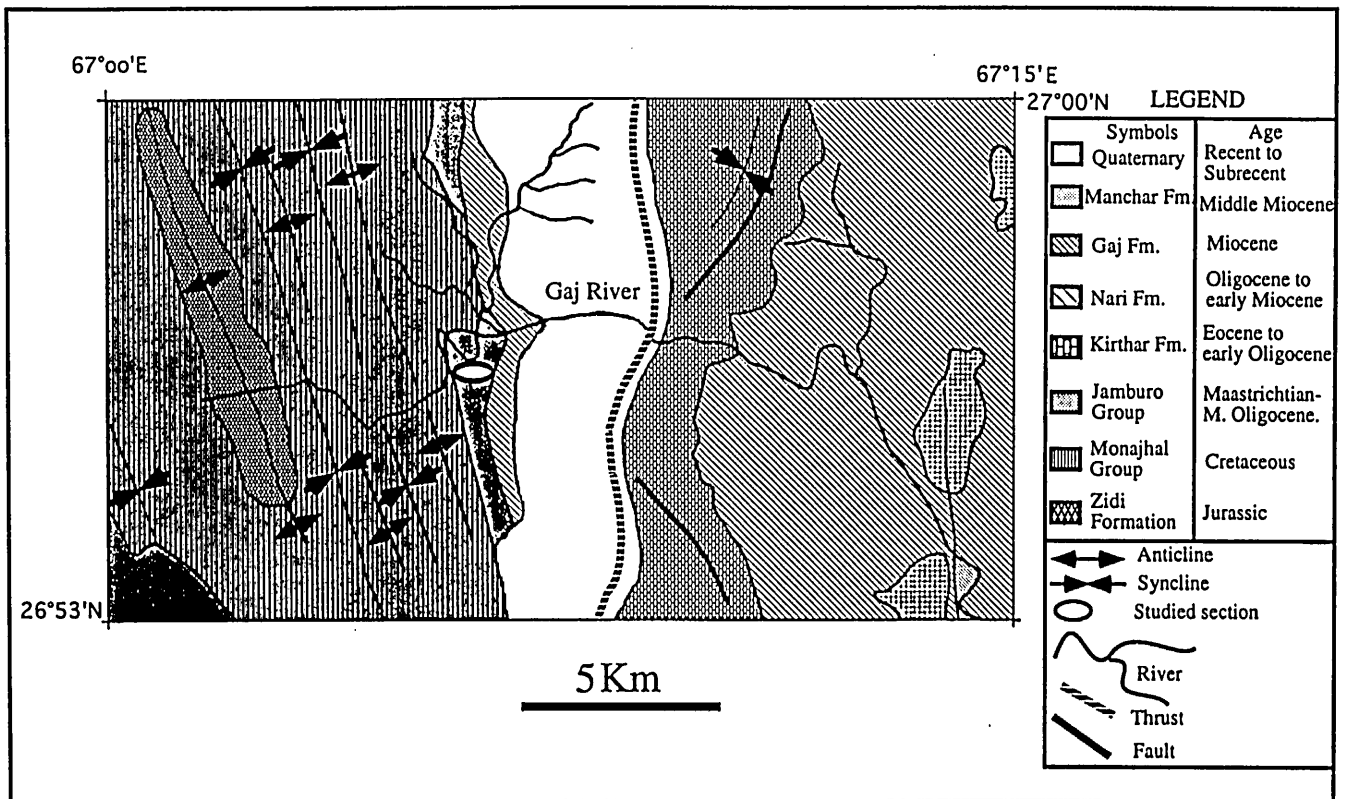


Fig. 2. Geological map around the PAK-section. (after HSC, 1960)

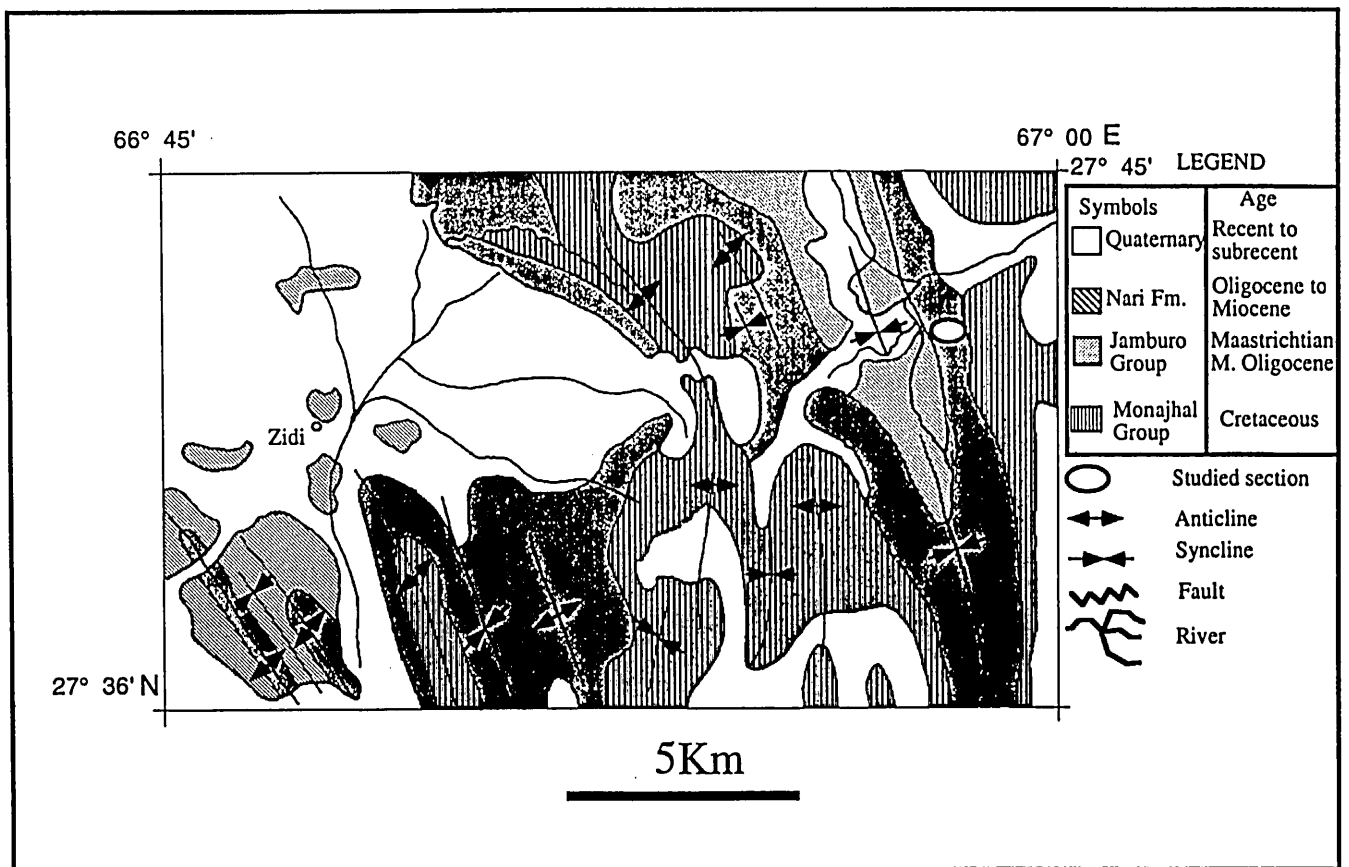


Fig. 3. Geological map around the MG-section. (after HSC, 1960)

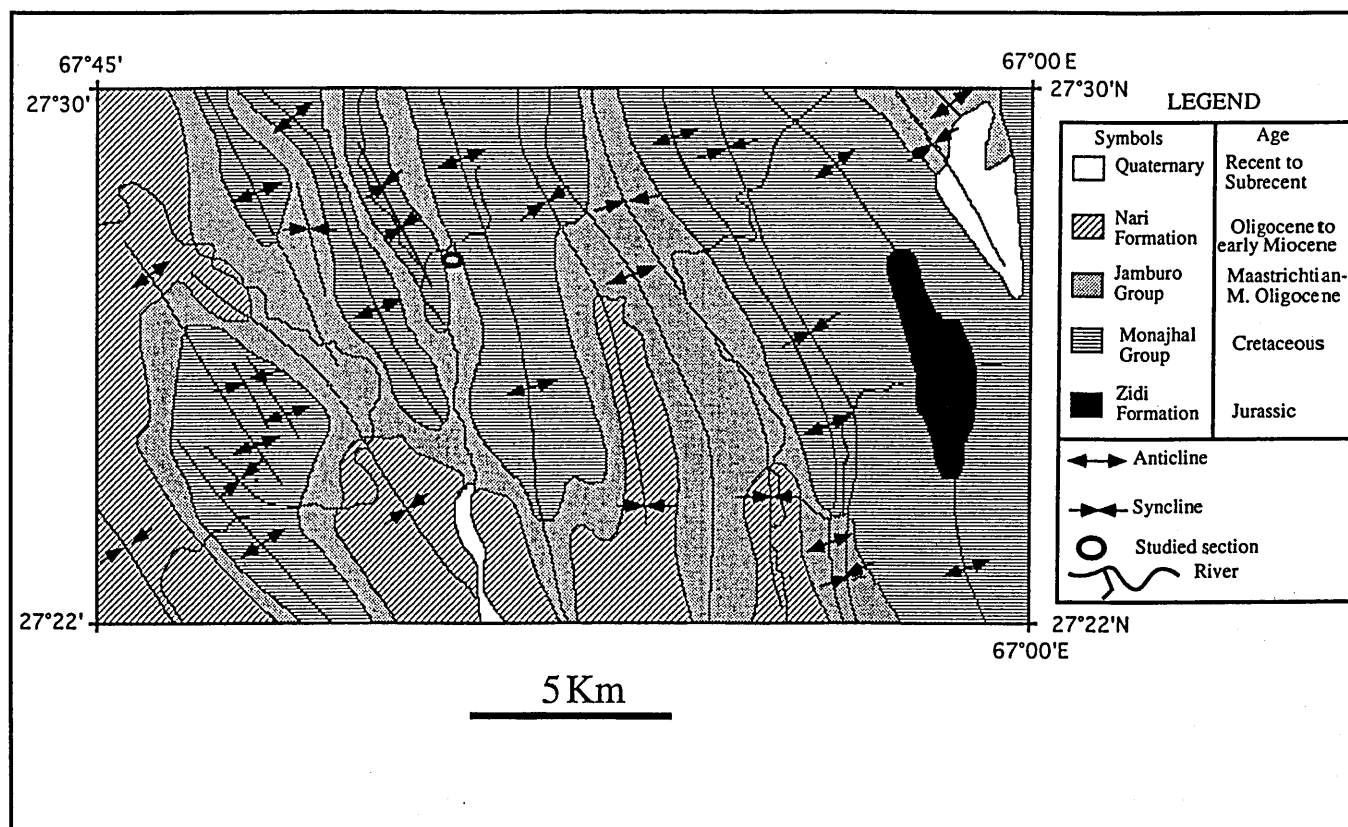


Fig. 4. Geological map around the HR-section. (after HSC, 1960)

Among these sections, only the MG section is easily accessible and motorable track can be used in fair weather up to the section, but other two sections are difficult to reach only camel tracks can approach to the sections. The local geographical names for the sections have been used. But, PAK-Section have been named after Pakistan.

B. Materials and Methods

One hundred nineteen rock samples from the three sections of the Jamburo Group were collected for the benthic foraminiferal study with an interval of two to nine meters. The collected samples were named as PAK-1 to -33, MG-1 to -60, HR-1 to -26. Mostly the collected samples were of shale lithology except for a few limestone samples.

Laboratory techniques: Each sample was broken into small fragments about 5 mm and reduced to about 80 grams (some of the samples were up to 20-25 grams, because of small quantities of available samples). The samples were dried in oven at 75°C for over night and again weighed to gain exact weight, and were processed by sodium sulfate-and naphtha-methods.

Sodium sulfate-method: After being dried in an oven, the rock samples were added in the boiling oversaturated sodium sulfate solution, and were cooled up to room temperature. The solution was decanted to get mother solution. After that the samples were left for a few days. The boiling water was added in order to remove the sodium sulfate crystals, and were washed through 200 mesh screen. The residue was redried.

Naphtha-method: After being dried in an oven, the dried

samples were added to organic solvent naphtha until room temperature. The naphtha was taken back by filtering, and the boiling water was added. The samples were boiled to remove the naphtha completely, then again washed through 200 mesh screen. The washed material was redried in the oven. In the case of hard sediments, this process was repeated for two or three times to get complete disintegration of sediments.

Besides these methods the limestone samples for the planktonic foraminiferal study were processed in 3 to 5 % of formic acid and some identifiable specimens were collected. Some of the limestone samples were studied by thin sections.

The processed and dried materials were sieved through 16 mesh screen. The residue was weighed and deducted from the initial weight of the samples for calculation of foraminiferal occurrence per gram. The sieved materials were divided into small fractions about 1/4 - 1/64 of total, by sample splitter. The fractions were observed under the binocular microscope, 200-275 benthic specimens as well as planktonic ones from each sample, whenever picking was possible. In case of poor preserved specimen, less than 8 individuals were obtained. The picked benthic foraminifers were identified but the planktonic individuals were counted only to know their occurrence ratio. 82 taxa; 40 of PAK-section (Nomura and Brohi, in prep.) and 42 of MG-section, from 76 samples; 33 of PAK-section and 43 of MG-section, 43 were analyzed for their frequency distribution, using Q-mode factor analysis with varimax rotation based on a proportional similarity (cosine theta coefficient) between samples, in order to reduce

the raw data matrix (33 samples x 40 taxa; 43 samples x 42 taxa) to a few main assemblage. The selected taxa for analysis were the taxa with the occurrence over 5 % in the total number of specimens in more than two samples. The factor loadings are used in explaining the sample contribution to any particular factor. The factors in this case are interpreted as representing assemblages. The main constituents of the assemblage are evaluated from the factor score which indicates the degree of importance in the factor. Thus, seven assemblages in PAK-section accounting for 79 % and eight assemblages in MG-section accounting for 81 % of the total variance were recognized, and their stratigraphic distribution were discussed with a species diversity and basic information, such as benthic to planktonic ratios, in order to reconstruct the paleoenvironment.

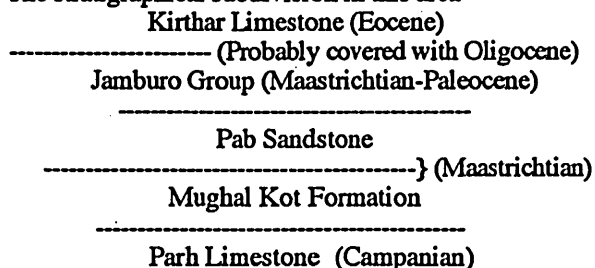
The identified specimens were coated by Platinum and photographed by using Scanning Electron Microscope.

Preservation: The benthic foraminifers obtained from PAK-section and MG-section of the Jamburo Group are moderately preserved, but in HR-section the preservation is poor.

C. Lithostratigraphy and biostratigraphy

1. PAK-SECTION (Toposheet no. 35N/1, Latitude, 26°57'N, Longitude, 67° 5'E, Fig. 2).

(1) The stratigraphical subdivision in this area



The section named after Pakistan is located in the western Gaj river. In this section the Jamburo Group contains the Maastrichtian-Paleocene sediments and lies conformably on the Parh Limestone. It consists of mainly shale, marlstone and limestone with a thin bed of sandstone which is separated as the Maastrichtian Pab Sandstone. The upper contact is not exposed in the studied area and is believed to be covered with Nari Formation of Oligocene. Based on the lithological sequences, the group is further divided into four units (Fig. 5).

Unit 1: Consists of dark grey shale, being fragments, nodular, calcareous, and associated with the grey hard limestone characterized by subconcordal fracture.

Unit 2: Purely shale with some minor gypsum flakes in places. The shale is dark grey, flaky and calcareous.

Unit 3: Dominantly shale with a thin bed of sandstone. The shale is yellowish dark grey, fragmentary and loose, while the sandstone is yellowish brown to brown, fine grained and well sorted.

Unit 4: Mainly consists of shale with intercalations of greyish marlstone at the top. The shale is dark grey to black, with calcite veins, and contains sulfide grains at some horizons.

(2) Benthic foraminiferal occurrence

In order to reconstruct the sedimentary paleoenvironment of the Jamburo Group, it is quantitatively investigated on the following four indexes, which are used to evaluate the differences among samples.

(a) Benthic foraminiferal number per gram (Fig. 11A): The most distinct change of this number is found between the PAK-13 and PAK-14. The foraminiferal number is generally high in the Maastrichtian Mughal Kot Formation (PAK-1-13 except for PAK-7). The samples from the Jamburo Group show uniformly low in the number.

(b) Agglutinated foraminifera to calcareous foraminiferal ratios (Fig. 11B): The ratios show a general increase of agglutinated foraminifera throughout the Jamburo Group, and attain over 80% in PAK-30 and 31 of the upper part. An increase of agglutinated foraminifera is probably related to the change of water properties in sediment/water interface as represented by oxygen content and/or organic supply to the sediments. Domination by agglutinated foraminifera is partly resulted from dissolution of calcite. However, high abundance of agglutinated foraminifera in this section cannot entirely attribute to this diagenetic effect because of the moderate preservation of calcareous foraminifera. Thus it is considered that this change may primarily be related to the decrease of oxygen content of the water mass.

(c) Benthic to planktonic foraminiferal ratios (Fig. 11C): The high ratios are recognized in most of the Mughal Kot Formation and the Jamburo Group, except for the former's lowermost and the limited horizons in the lower half of the latter.

(d) Species diversity (H') (Fig. 11D): Higher diversities are recognized in the lower Mughal Kot Formation. Species diversity decreases generally in the lower Jamburo Group, with fluctuations.

(3) Benthic foraminiferal assemblages

Seven benthic foraminiferal assemblages are distinguishable in the PAK-section (Fig. 12) and eight to the MG-section (Figs. 17D, 18E-F, 19G-H, 20I-J, 21K), by the results of factor analysis with varimax rotation, which explain 79 percents of the total variance in PAK-section, and 81 percents in MG-section (Table 1-4). These assemblages are named after the first and/or the second species having the higher scores for each factor.

a) *Gavelinella monterelensis*-*Globorotalites micheliniana* Assemblage, explaining 20.1 % of the total variance in the reduced data set, is represented by PAK-1-10 in the lower horizons of the lower Jamburo Group. The following species are associated with this assemblage: *Coryphostoma incrassata*, *Dentalina* spp. *Lenticulina rotulata*, Unilocular species and *Cibicides dayi*. This assemblage is characterized by high foraminiferal number and high calcareous foraminiferal diversity. Although the most main species characterize the Turonian or Campanian, there are no positive indication of these ages from the occurrence of planktonic foraminifera.

b) *Trochammina* spp. Assemblage, develops in upper horizons of the upper Jamburo group (PAK-28-33), with short peaks in the PAK-20 and the earliest Paleocene (PAK-24). This assemblage accounts for 20.8% of the total variance and almost occurs in contrast with the *Gavelinella*

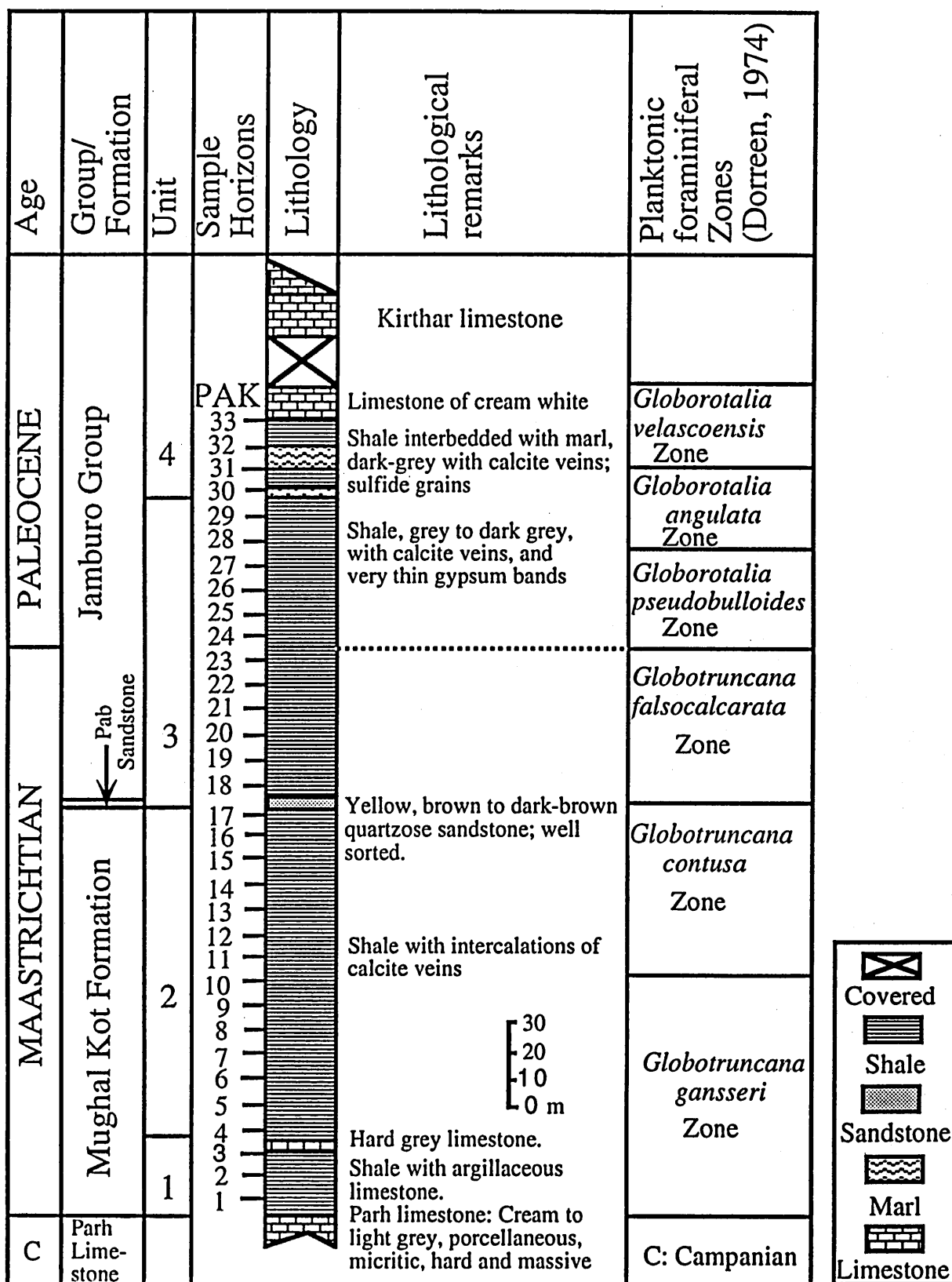


Fig. 5. Columner section of the PAK-section.

monterelensis-*Globorotalia micheliniana* Assemblage in showing lower species diversity and lower foraminiferal number. Dominance by agglutinated foraminifera attaining over 80% in PAK-30 and 31, is the most noticeable characteristics of this assemblage.

c) *Praebulimina aspera* Assemblage, accounting for 10.2% of the total variance, contains *Trochammina* sp. cf. *T. diagonis* and *Coryphostoma incrassata*. This assemblage is distributed in the middle of sequence of the Jamburo Group and the lowermost horizons of the upper Jamburo Group (PAK-15-20). Species diversity is low in general and the foraminiferal number per gram is low in this assemblage.

d) *Praebulimina kickapooensis* Assemblage, is developed in a relatively short stratigraphic interval of lower part of the upper Jamburo Group (PAK-21-23). This assemblage explains 7.6% of the total variance, along with *Cibicidoides* spp. and *Gaudryina rugosa*. Although the number of calcareous foraminiferal specimens are abundant, its diversity is low.

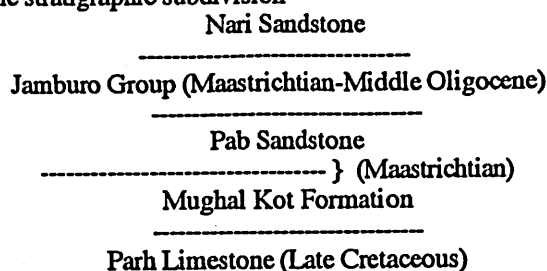
e) *Praebulimina ovulum*-*Lenticulina rotulata* Assemblage, accounting for 9.6 % of the total variance, is recognized in the upper horizon of the lower Jamburo Group (PAK-11-14). Following species such as *Trochammina* sp. cf. *T. diagonis*, *Gyroidinoides exsertus*, and *Cibicidoides subcarinatus* are characteristics in this assemblage. This Assemblage is similar to the *Gavelinella monterelensis*-*Globorotalites micheliniana* Assemblage in having a higher foraminiferal number and a higher species diversity.

f) *Cibicidoides jamburoensis*-*Tritaxia trilatara* Assemblage, accounting for 5% of the total variance, is only recognized in two separated horizons of PAK-16 and 25.

g) Unilocular taxa Assemblage, accounting for 5.6% of the total variance, consists of *Lenticulina rotulata*, *Eponides* spp. and *Nuttallides* spp. Among the unilocular taxa, the following are noted as dominant species: *Lagena hispida*, *Oolina apiculata*, *O. globulosa*. The stratigraphic distribution of this assemblage is limited in the lower Jamburo Group (PAK-26 and -27).

2. MG-SECTION (Mai Ghatti Section; Toposheet no. 35I/14, Latitude, 27°43'N, Longitude, 66°57'E, Fig. 3).

(1) The stratigraphic subdivision



This section is named after the geographic name of Mai Ghatti grave yard, south of Khorri village, Khuzdar district. Here the Jamburo Group is characterized by the shale facies which are dominant through out the section, with marl limestone, sandstone and shelly limestone. The lower contact of the Group in this section is conformable with the late Cretaceous Parh Group (Monajhal Group), and the upper contact seems to be conformable with the Oligocene

Nari Sandstone. The Jamburo Group in this locality is divided into three members (Fig. 6).

(i) The lower member consists of mainly calcareous various coloured shale, grey marl, and medium to coarse-grained poorly-sorted brown quartzitic sandstone which exhibits the similar lithology to the Maastrichtian Pab Sandstone of PAK- section. This member yields the Maastrichtian benthic foraminifera, and is correlated with the Mughal Kot Formation.

(ii) The middle member mainly consists of shale with coarse brecciated limestone in the basal part and arenaceous limestone in the upper part. This member yields the Paleocene and Eocene foraminifera. (iii) Whereas, the upper member consists of shale and marl with a intercalation of prominent coquinoïdal limestone bed, and is rich in the Oligocene larger foraminifera and molluscs. This member has yielded the Eocene to Middle Oligocene benthic foraminifera. Based on the lithological differences the middle and upper members have further been divided into following six units.

Unit 1: This unit comprises of grey coarse angular to subangular, brecciated limestone. Unit 5: This unit exhibits the prominent bed of coquinoïdal hard limestone, which is grey in colour and abounds with larger foraminifera and other molluscan fossils.

Unit 6: This unit is of purely marlstone. It is grey nodular and sandy.

(2) Benthic foraminiferal occurrences

Benthic foraminifera from MG-section are well to moderately preserved in the Maastrichtian Mughal Kot Formation and poor to very poor in the Paleogene Jamburo Group. Their occurrences are particularly sporadic in the Eocene and Oligocene. The common species in the shale of the Mughal Kot Formation are *Cibicidoides* spp., *Gavelinella monterelensis*, *Globorotalites micheliniana*, *Coryphostoma incrassata*, *Haplophragmoides* spp., and each of them occupies the 13 to 5 % of the total. But some species like *Gaudryina rugosa*, *Lenticulina* spp., *Praebulimina navarroensis*, are also abundant. The occurrences of benthic species in the Jamburo Group are characterized by *Oridorsalis* spp., *Oridorsalis umbonatus* with some sporadic occurrences of other less diversified species like *Nuttallides truempyi* and *Nodosaria* spp. This primary analysis is as below.

(a) Benthic foraminiferal number per gram (Fig. 16A).

The occurrences of benthic foraminifera are higher in the Mughal Kot Formation and making up to 3.2 individuals per gram. On the contrary their occurrence in the Jamburo Group is low and is less than 1.3 per gram.

(b) Agglutinated versus calcareous foraminifera ratios (Fig. 16B).

The agglutinated forms show an increase in the Maastrichtian, attain to 50 % at the Cretaceous-Tertiary boundary, becomes low in the Paleogene.

(c) Species diversity (Fig. 17C).

The species diversity (H') is high (3.7 to 4.2) in the Mughal Kot Formation, but in the Paleogene it is low and ranges 1.5 to 2.9 except for some horizons showing value more than 3.9.

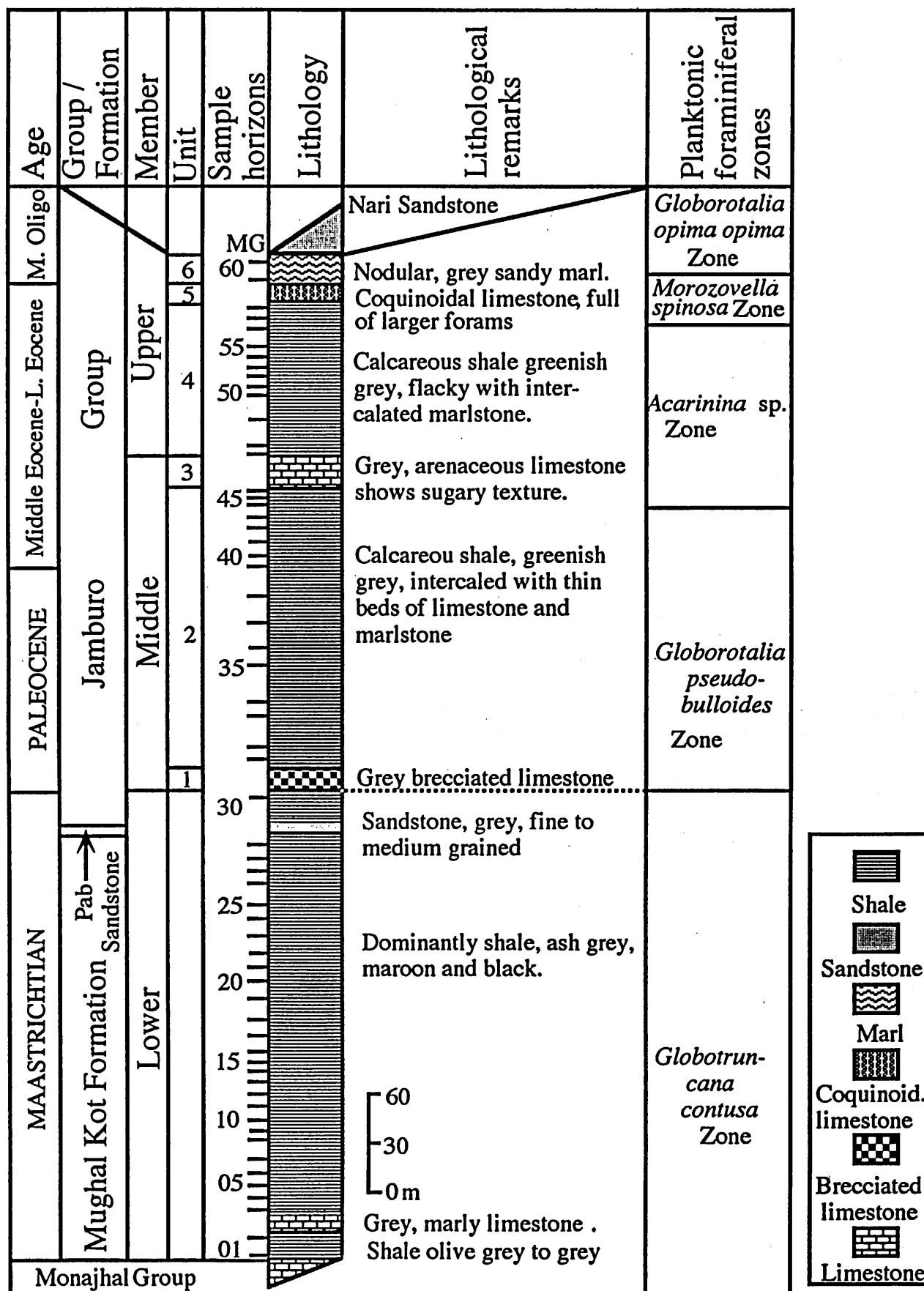


Fig. 6. Columnar section of the MG-section.

(3) Benthic foraminiferal assemblages

a) *Globorotalites micheliniana* Assemblage (Fig. 17D): This assemblage explains 13.7 % of the total variance, and is represented by a large portion from MG-9 to MG-25, except for 22 and 23. The associated foraminifers with this assemblage are *Bolivinoidea draco*, *Cibicidoides allenii*, *Cibicidoides velascoensis*, and *Gyroidinoides exsertus*. This assemblage indicates high calcareous number and high diversity.

b) *Cibicidoides* spp. Assemblage (Fig. 18E): This assemblage shows the 20.1 % of the total variance and its occurrence is noted from the Mughal Kot Formation throughout the Jamburo Group. It is found from MG-1 to MG-58 except for some horizons, and is associated with *Ammodiscus cretaceus*, *Dentalina* spp., *Dorothyia bullella* and *Dorothyia* spp.

c) *Praebulimina navarroensis* Assemblage (Fig. 18F): This assemblage accounts for 10.1 % of the total variance, and is found in the Maastrichtian especially. The common species are *Praebulimina aspera*, *P. kickapooensis*, *Reophax* spp., and *Pseudoclavulina* spp. It is common in the Lower Maastrichtian.

d) *Gaudryina pyramidata*-*G. rugosa* Assemblage (Fig. 19G): This assemblage explains 9.3 % of the total variance, and occurs from the Maastrichtian to Eocene and includes unilocular taxa and *Nodosaria* spp. The most abundant unilocular taxa are *Oolina globulosa* and *Lagena* spp.

e) *Coryphostoma incrassata* Assemblage (Fig. 19H): This assemblage associated with *Gavelinella monterelensis* explains 6.6 % of the total variance, and is common in the Mughal Kot Formation with high diversity.

f) *Lenticulina* spp. Assemblage (Fig. 20I): The occurrence of this assemblages has been noted through out the section but more frequent in Maastrichtian (MG-1 to MG-27). It accounts for the 6.9 % of the total variance.

g) *Trochammina* spp. Assemblage (Fig. 20J): This assemblage is also occurred throughout the section and explains 8.5 % of the total variance. Its occurrence is very high in the Maastrichtian and becomes low in the Paleocene, and sporadic in the Eocene to Middle Oligocene.

h) *Oridorsalis umbonatus* Assemblage (Fig. 21K): This assemblage is found from the Maastrichtian to Middle Oligocene showing high foraminiferal contents and high diversity in the Maastrichtian. This assemblage accounts for the 5.3 % of the total variance, and is associated with *Osangularia navarroana*.

3. HR-SECTION (Hinar Section; Toposheet no. 35I/15, Latitude 27°27'N, Longitude, 66°, 52'E, Fig. 4)

(1) The stratigraphic subdivision

Nari Sandstone

Jamburo Group (Maastrichtian-Middle Oligocene)

Mughal Kot Formation (Maastrichtian)

Parh Limestone (Late Cretaceous)

The HR-section is named after Hinar river, which drains in the Gaj Kolachi main river, located in the south of Zidi village, Khuzdar district. The Maastrichtian-Oligocene strata exposed here lies conformably on the Parh Group (Monajhal

Group) and are conformably overlain by the Nari Sandstone. The Jamburo Group of HR-section, consists of olive grey to light green or brown calcareous shale interbedded with olive to olive grey limestone in the lower part. The middle part consists of grey marly limestone, whereas the upper part is hard, fissile and flaky calcareous shale and marl. In this locality, the Pab Sandstone is missing. This section is lithologically divided into the following 8 units (Fig. 7).

Unit 1: This unit consists of marly limestone and shale, equivalents to the upper part of the Mughal Kot Formation. The lower part of the unit is micritic limestone of light grey on fresh surface and of brownish or buff on weathered surface. The upper part of this unit is mainly of shale of dark brown to light brown in colour, and contains some nodules which breaks into sharp edged fragments.

Unit 2: It is medium to thick-bedded limestone of light brown in colour on fresh surface, but weathered rocks are light redish brown to brown in colour and break into a sharp angular fragments.

Unit 3: This unit consists of nodular shale of olive green to light green and breaks into small fragments of pencil like in shape.

Unit 4: It consists of calcareous shale with subordinate limestone. The shale is brown, soft, nodular and in places it is splintery. While the limestone is olive green, marly and thin to medium bedded.

Unit 5: This unit is characterized by micritic and thin bedded limestone which is dark grey on fresh surface but is yellowish on weathered surface.

Unit 6: This unit consists of calcareous dark grey to grey and soft marlstone.

Unit 7: It consists of grey to dark grey or soft splintery and calcareous greenish shale.

Unit 8: This unit consists of alternation of shale and marlstone. At the base of the unit, there is a thin bed of limestone resembling to unit 5 in lithological characters. The shale is light green to olive grey and contains black patches, while the marlstone is grey and nodular.

(2) Benthic foraminiferal occurrence

Benthic foraminifera of the HR-section are poorly preserved, and some layers does not yield any benthic species. In the Maastrichtian, only a few species, such as *Coryphostoma incrassata*, *Stensioina beccariformis* etc. are noted, which are abundant in other sections.

(a) Benthic foraminiferal number per gram (Fig. 22A): The benthic foraminiferal number is much higher in the Maastrichtian than in the Paleocene. The Eocene and Middle Oligocene have low species number in benthic foraminiferal fauna, but in comparison to the Paleocene it exhibits slightly higher value. The maximum value of individuals per gram is 4.9 and the minimum is less than 1.6 per gram.

(b) Agglutinated versus calcareous foraminiferal ratios (Fig. 22B): The ratios show an increase of agglutinated benthic foraminifera at the base of the Jamburo Group, and reaches to 85 % around the Cretaceous-Tertiary boundary of this section (HR-3).

III. Notes on the Cretaceous-Tertiary Boundary

It is well known that there exists a physical break in sedimentation and faunal characteristics at the Cretaceous-

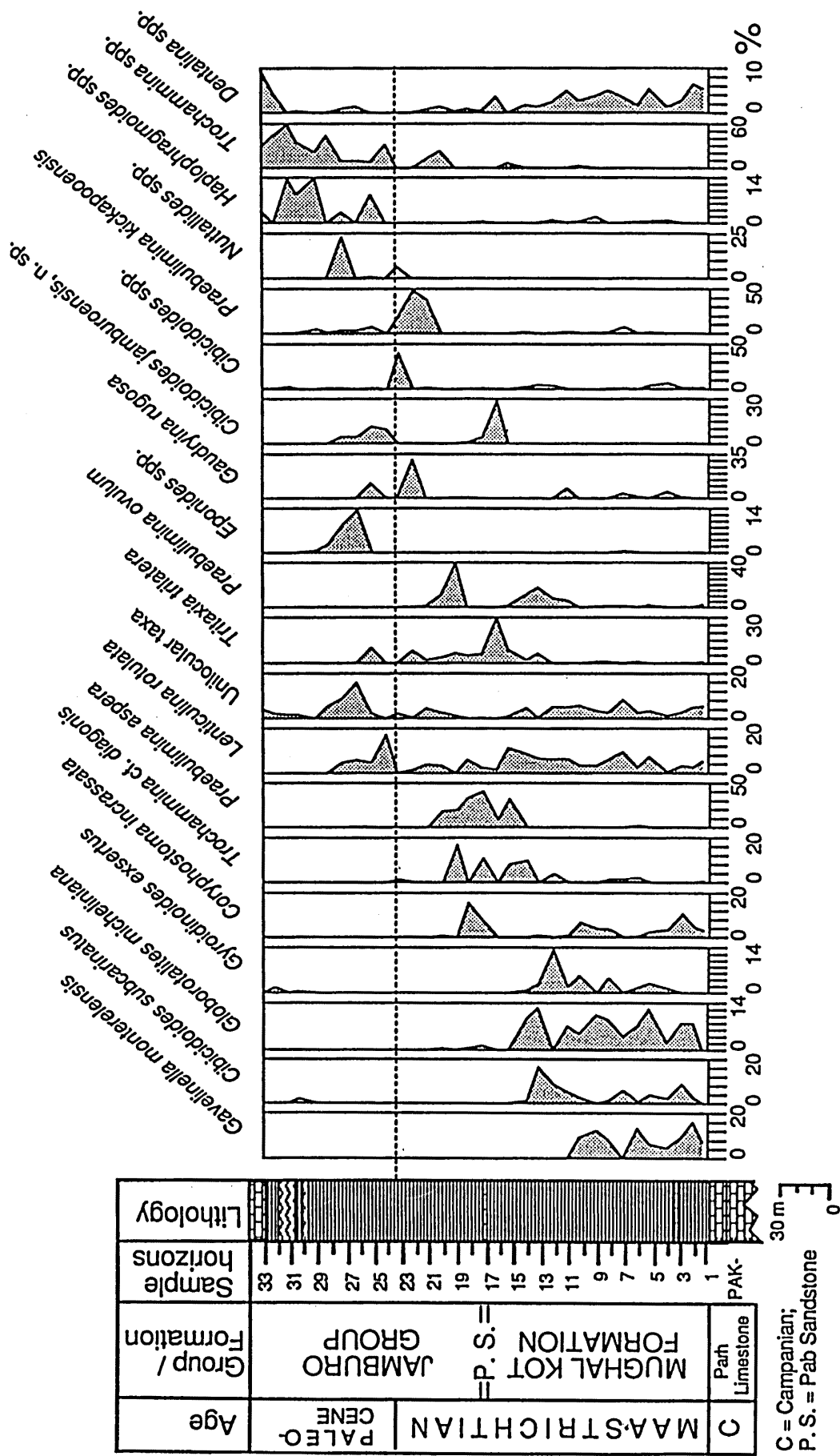


Fig. 8. Frequency chart of the selected species of the PAK-section (after Nomura & Brohi, in prep.).

Blanford (1879); Vredenburg (1909)	Vredenburg (1909)	Hunting Survey Corporation (1960)	Cheema <i>et al.</i> (1977)	Fatmi <i>et al.</i> (1986)	Brohi and Marzaban (1986)	Brohi <i>et al.</i> (1992)	Brohi (1992)	Nomura and Brohi (in prep.)																	
	Nari Fm.	Nari Fm.	Nari Fm.	Nari Fm.	Nari Fm.	Nari Fm.	Nari Fm.	Covered																	
Lower Kirthar Shales	Upper Kirthar Vredenburg (1909) = Jakkher Group HSC(1960) Paleocene- Oligocene	Paleocene-Early Oligocene	Group	Eocene-Early Oligocene	Upper parts of Jamburo and Jakkher Groups = Nisai Fm.	Tertiary	Group	Group																	
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Fig. 9. Stratigraphical nomenclature of different works on the stratigraphy of the Cretaceous to Lower Tertiary of Balochistan, Pakistan.

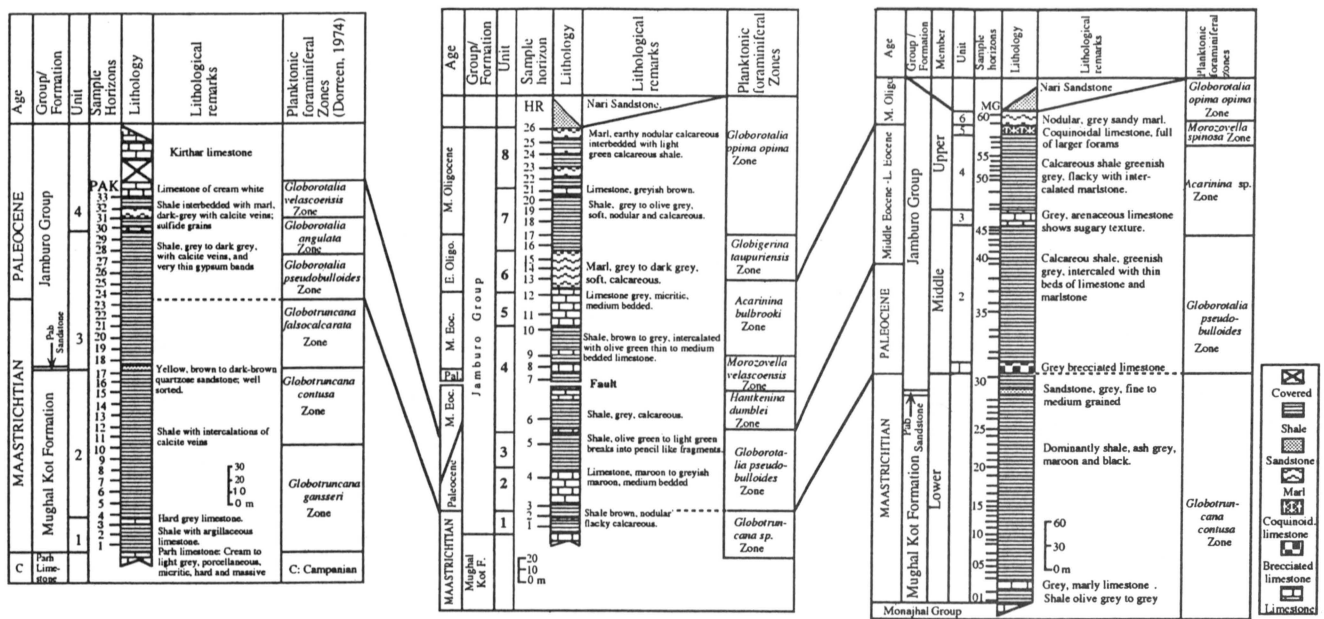


Fig. 10. Correlation of the three studied sections; PAK-, HR-, and MG-sections.

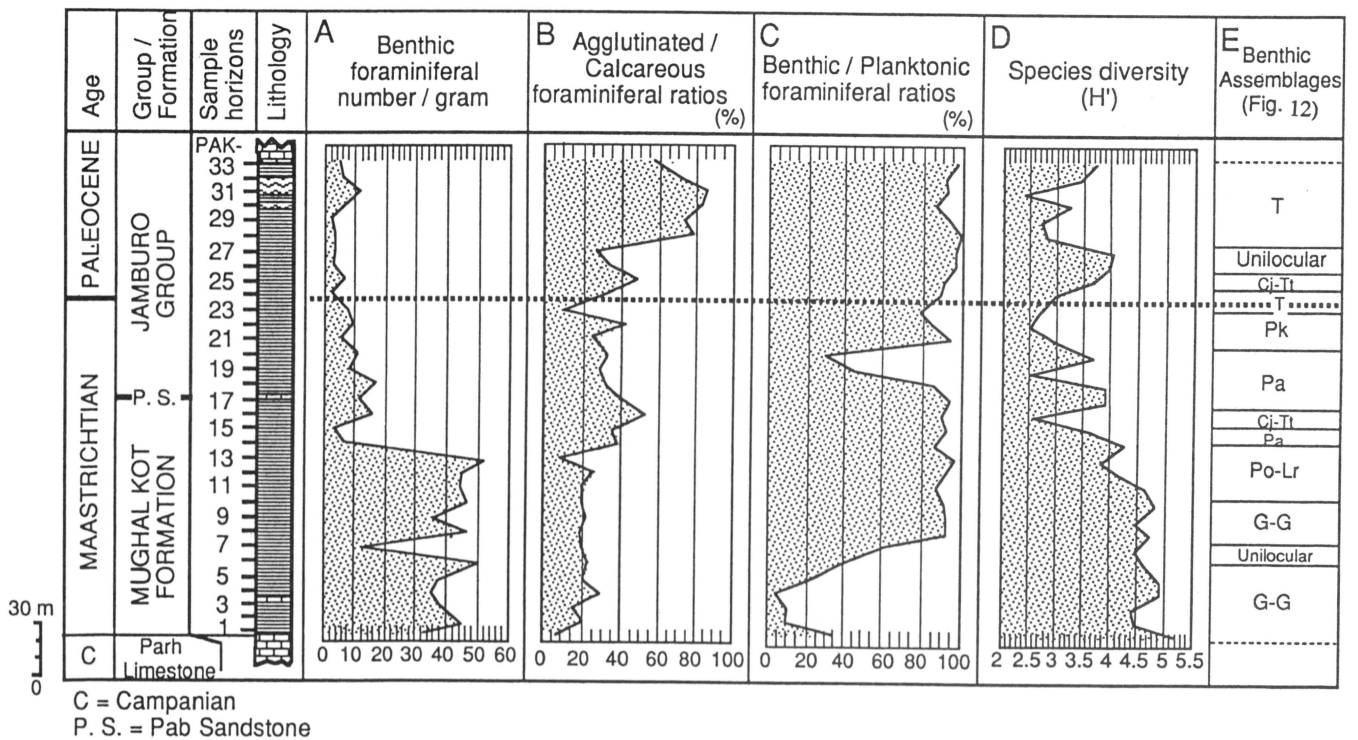


Fig. 11. Stratigraphic changes of benthic foraminiferal number per gram (A), agglutinated to calcareous ratios (B), planktonic to benthic ratios (C), species diversity based on Shannon-Wiener information index (D), frequency of low oxygen tolerant calcareous taxa (E) and stratigraphic distribution of the benthic foraminiferal assemblages (F). (after Nomura & Brohi, in prep.).

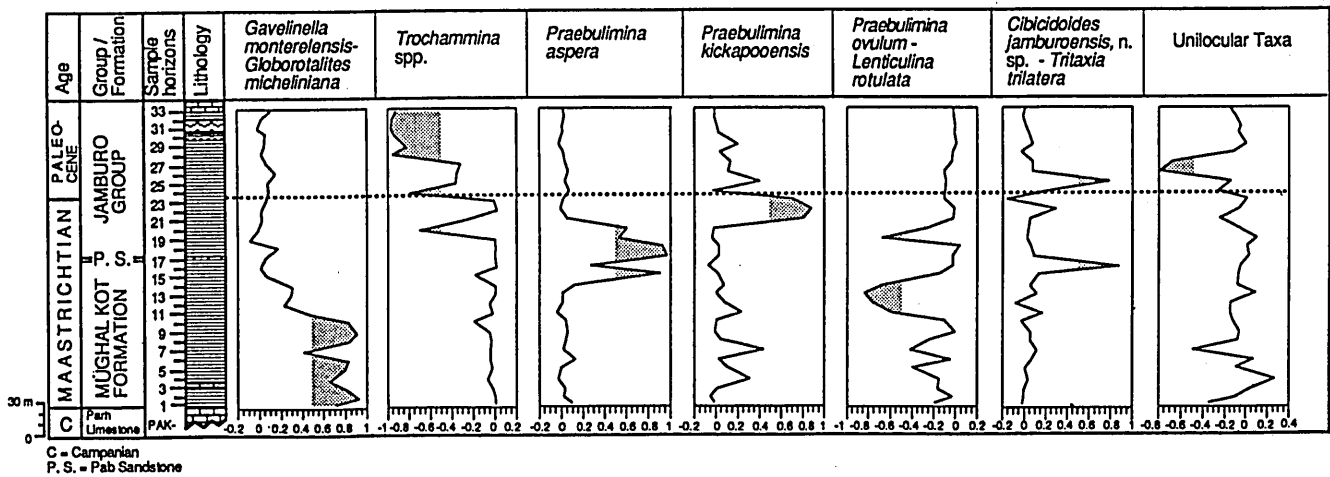


Fig. 12. Stratigraphic distribution of the assemblages recognized by factor analysis. Horizontal scale of each assemblage indicates factor loadings (after Nomura & Brohi, in prep.).

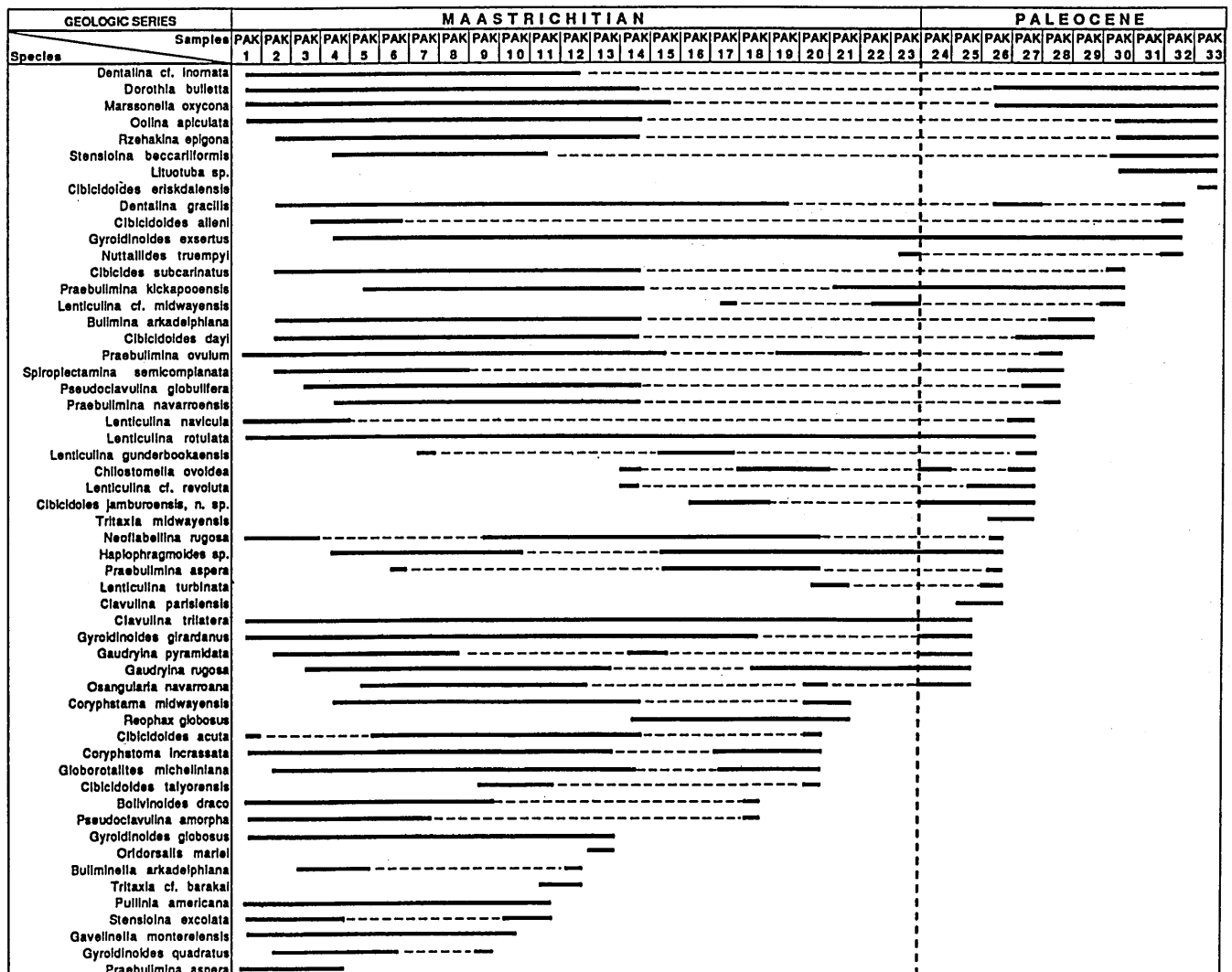


Fig. 13. Range chart of the selected species of the PAK-section (after Nomura & Brohi, in prep.).

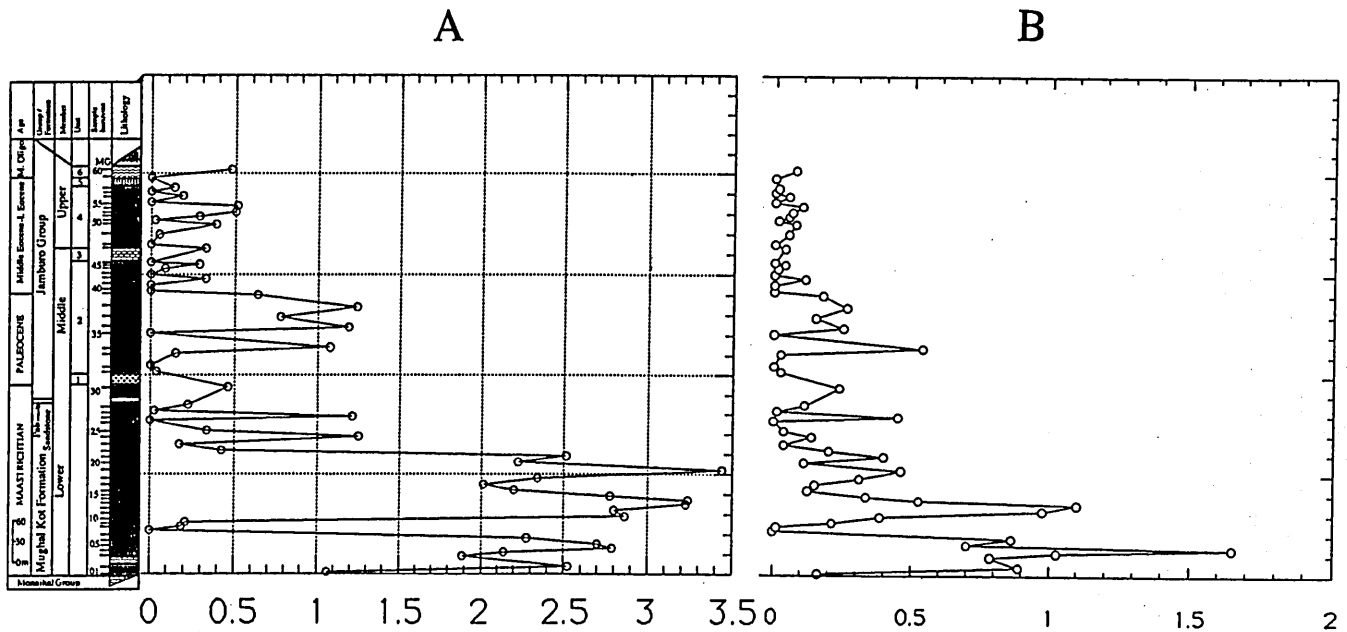


Fig. 16. Graph showing the benthic foraminiferal number per gram (A), Graph showing the agglutinated to calcareous ratios (B).

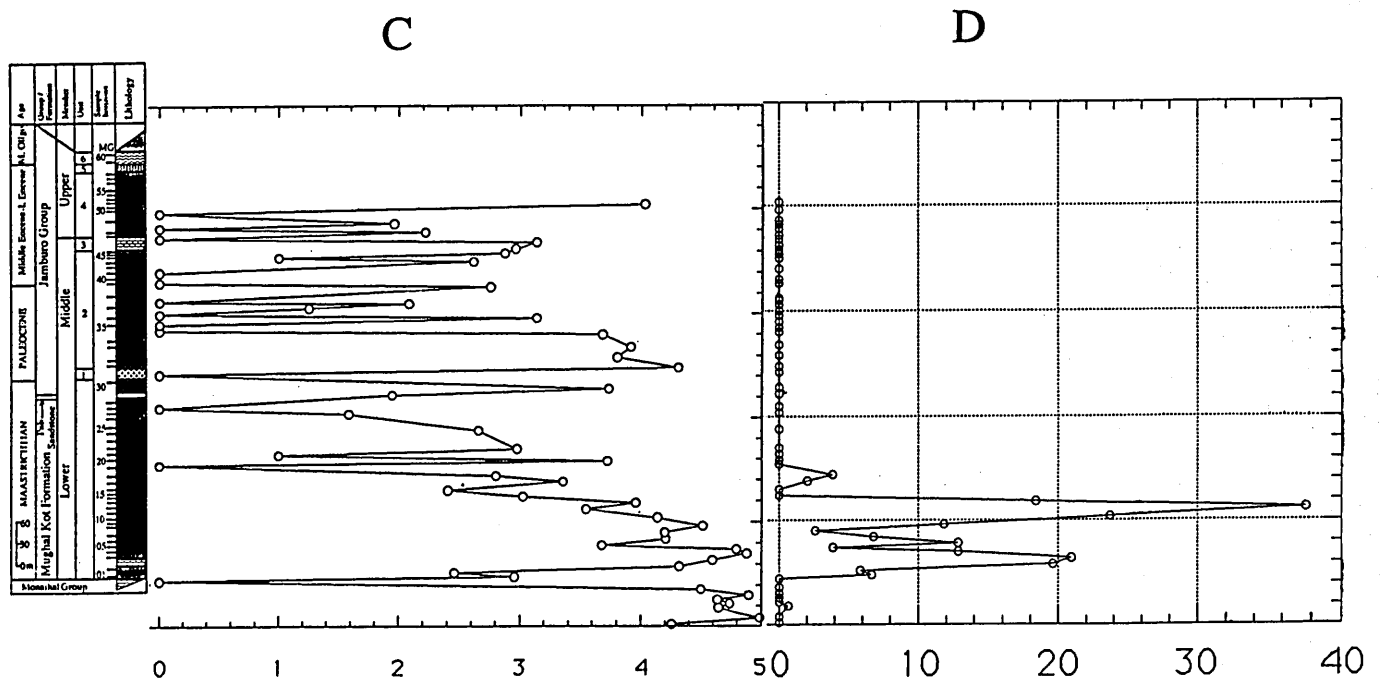


Fig. 17. Graph showing the species diversity (H') based on Shannon-Wiener index (C), Graph showing the occurrence of *Globorotalites micheliniana* Assemblage (D)

Tertiary boundary throughout the world. Examples are the rust coloured ferruginous layer in the base of clay, EL Kef, Tunisia (Keller, 1988); grayish black clay stone, Kwaruppa, Hokkaido, Japan. (Kaiho and Saito, 1986; Saito *et al.*, 1986; Kaiho, 1992); brown grey marl in Sopelana, Spain. (Lamolda *et al.*, 1983).

The Cretaceous-Tertiary boundary of the PAK-section is marked in the shale sequence between PAK-23 and 24. In the MG-section, it can be traced between the sample horizons of MG-29 and 30 which are in the base of brecciated or coarse-grained limestone. On the other hand the boundary in the HR-section has been positioned in between

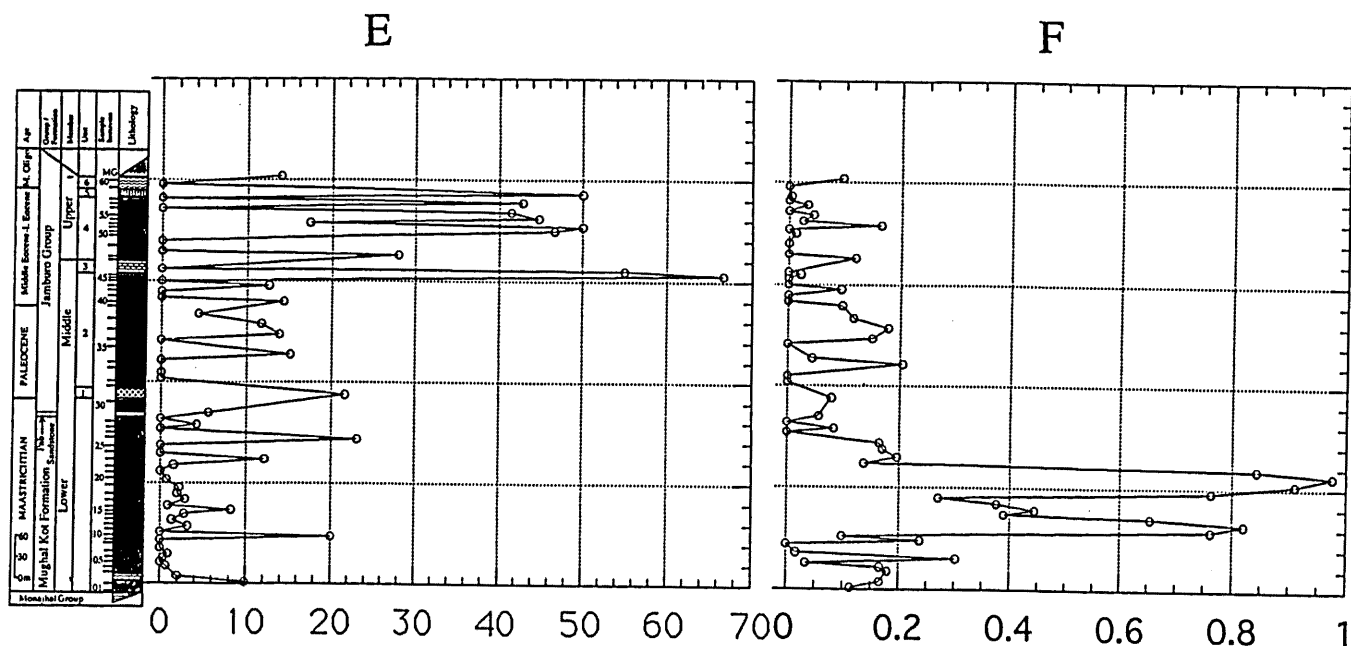


Fig. 18. Graph showing the occurrence of *Cibicidoides* spp. Assemblage (E), Graph showing the occurrence of *Praebulimina navarroensis* Assemblage (F).

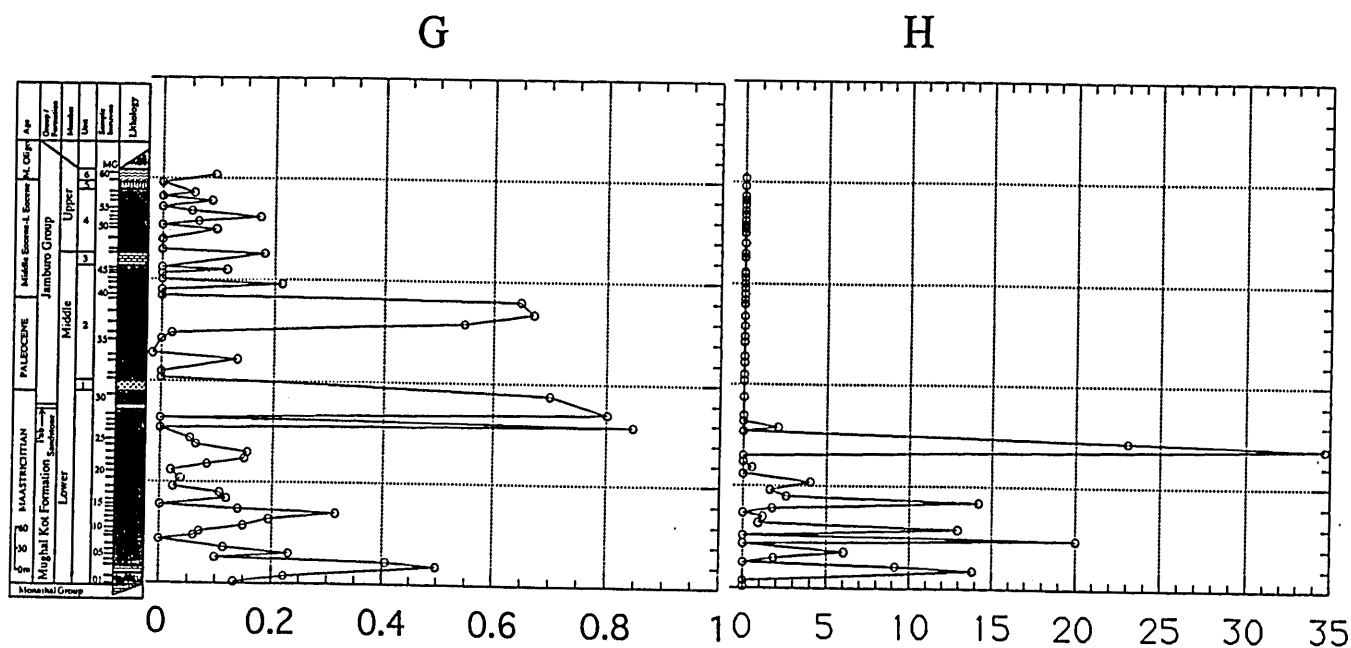


Fig. 19. Graph showing the occurrence of *Gaudryina pyramidata*-*G. rugosa* Assemblage (G), Graph showing the occurrence of *Coryphostoma incrassata* (H).

sample no. HR-2 and HR-3 in alternated shale and micritic limestone. Across the K/T boundary the nature of benthic foraminiferal test drastically changes from a calcareous to an agglutinated one. In the PAK-section the agglutinated forms occupy about 8 % of the total number, in the HR-section 80 %, and in the MG-section 50 %.

The Cretaceous-Tertiary contact in Pakistan reported by Dorreen (1974) was marked on the top of the Maastrichtian Pab Sandstone overlain by the lower Paleocene *Cardita beaumonti* shales in Sindh Province and glauconitic horizon in the Dungan Formation in Quetta region of Balochistan. Dorreen (1974) described that the case of northern Italy

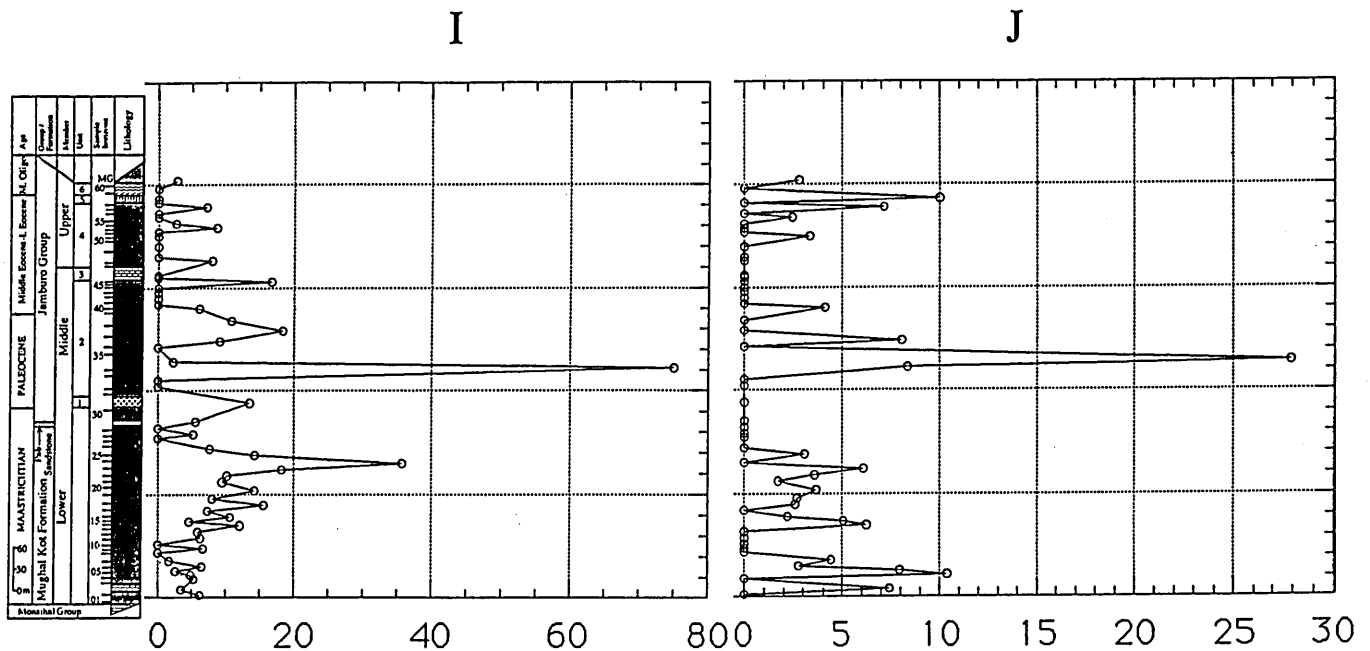


Fig. 20. Graph showing the occurrence of *Lenticulina* spp. Assemblage (I), Graph showing the occurrence of *Trochammina* spp. Assemblage (J).

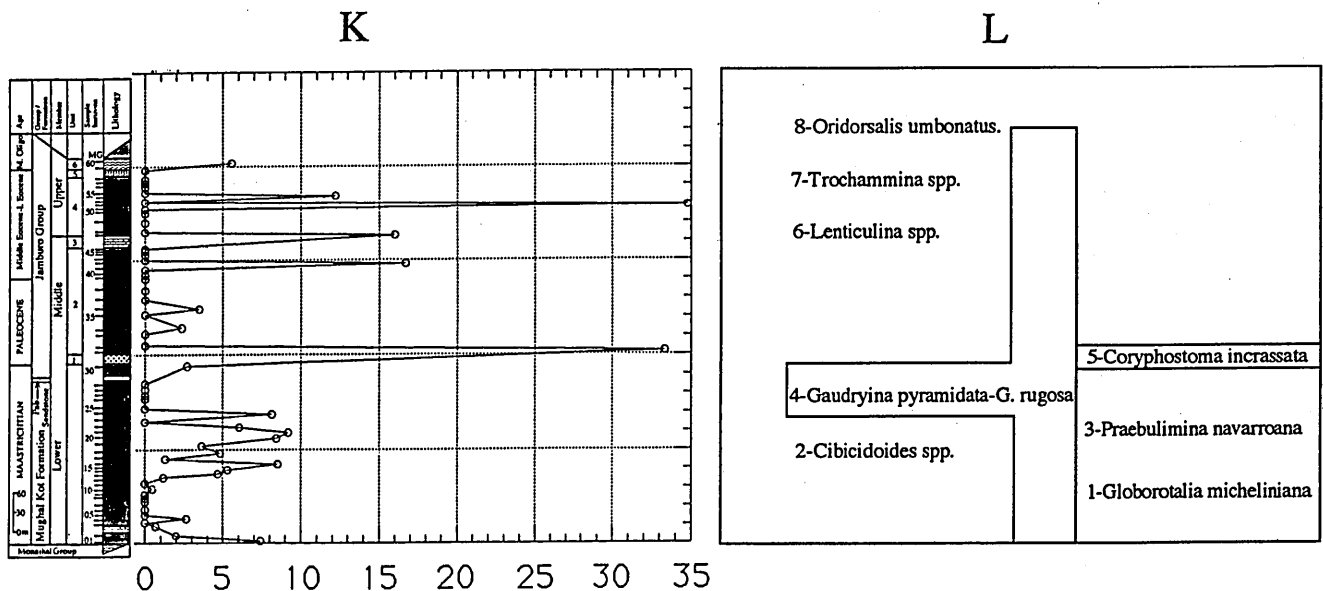


Fig. 21. Graph showing the occurrence of *Oridorsalis umbonatus* (K), figure showing the eight benthic foraminiferal assemblages, according to their stratigraphic position (L).

(Bolli and Cita, 1960) is similar to deep-water shales in Gaj river section, which he correlated with the contact of Velasco Formation and Mendez Formation in Mexico (Hay, 1960). It is difficult to discuss the Cretaceous-Tertiary boundary of Pakistan because of lack of sufficient data and it is beyond the scope of this up-to-date. The author would like to quote the continental sediments in some areas of which he is aware. The first is the laterite bed at the base of Paleocene Dungan Limestone, Ziarat District, Balochistan,

and the second is the laterite/limonitic bed developed in Panjab and north frontier Province, below the Paleocene Hangu Formation (Latif, 1976). In the studied areas mentioned above, the brecciated limestone or coarse grained limestone occurred in the boundary of the MG-section, brecciated limestone with larger foraminifera in the Monajhal section (Fatmi *et al.*, 1986), transitional contact within the deep marine shales in PAK-section, and the micritic limestone and shale in the HR-section.

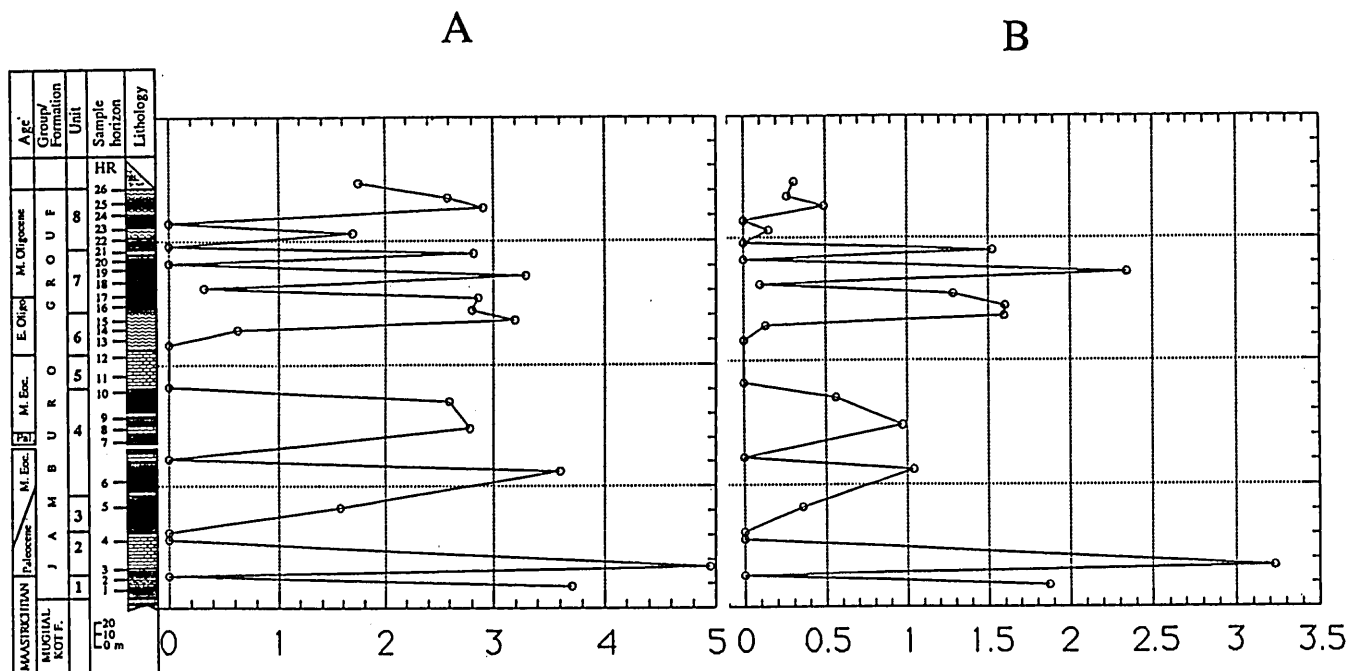


Fig. 22. Graph showing the benthic foraminiferal number per gram (A), Graph showing the agglutinated to calcareous ratios (B).

The discontinuity in lithology all over Pakistan at Cretaceous-Tertiary contact is clearly marked by either of the above mentioned lithologies. This has been described as an unconformity by the previous workers, but its details should be re-examined and proved by the geochemical and biostratigraphical evidences.

In the present study the boundaries have been decided by the disappearance of such planktonic species as *Globotruncana stuartiformis*, *G. spp.*, *Pseudoguembelina elegans* and *Racemiguembelina fruticosa*, and the appearance of *Globorotalia pseudobulloides* which indicates the P1 zone of early Paleocene. *R. fruticosa* has an established stratigraphic range of the Maastrichtian and others are rather long ranged from the Campanian to the Maastrichtian. The samples from all the sections did not contain any species showing the latest Maastrichtian (*Abathomphalus mayaroensis* Zone) or the earliest Danian (*Globigerina eugubina* Zone), but some index benthic foraminifera of late Cretaceous *Bolivinoidea draco*, *Coryphostoma incrassata*, and *Stensioina excolata* become extinct at the K/T boundary (van Morkhoven *et al.*, 1986; Nomura, 1991a). They disappeared about 50 m below the K/T boundary in PAK-section, 40 m in MG-section and at the boundary in the HR-section. The late Cretaceous to Paleocene *Cibicidoides dayi*, *Neoflabellina rugosa*, and *Stensioina beccariiiformis* are abundantly found in the PAK and MG-sections, but their occurrence in the HR-Section are common. However, Dorreen (1974) reported the developments of *Globotruncana contusa* Zone, *G. falsocalcarata* Zone, and the *G. gansseri* Zone from the western Gaj river near the PAK-section, which are considered as late to latest Maastrichtian (Caron, 1989).

The Paleocene-Eocene boundary of the studied sections have been marked by the disappearance of a benthic species

Stensioina beccariiiformis, because this species becomes extinct at the Paleocene-Eocene boundary (Tjalsma and Lohmann, 1983; Miller *et al.*, 1987). *Cibicidoides dayi* has been known from the late Cretaceous by van Morkhoven *et al.*, (1986) and Nomura (1991a), but it occurs across the boundary in the two sections of PAK and MG. The foraminiferal record of the PAK-section suggests the age of the Jamburo Group ranging from Maastrichtian to Paleocene.

In the present study, five planktonic foraminiferal zones in the MG-section have been recognized including the Maastrichtian *Globotruncana contusa* zone, and the following late Cretaceous index benthic foraminifera from this zone are similar to those of PAK-section: *Bolivinoidea draco*, *Cibicidoides dayi*, *Coryphostoma incrassata*, *C. midwayensis*, *Gavelinella monterelensis*, *Globorotalites micheliniana*, *Stensioina beccariiiformis*, and *S. excolata*, which continues up to Paleocene. Other long-ranged benthic species commonly found up to Oligocene are *Bathysiphon* spp., *Dentalina* spp., *Nodosaria* spp., *Gyroidinoides* spp., *Oridorsalis umbonatus*, *Trochammina* spp. etc.

In the Danian *Globigerina pseudobulloides* Zone occur, *Cibicidoides* spp., *Nuttallides* sp., *N. truempyi*, *Stensioina beccariiiformis*, *S. sp.*, *Cibicidoides dayi* are common, but *Nuttallides truempyi* and *Stensioina beccariiiformis* are found sporadically.

In the Middle Eocene *Acarinina* spp. Zone, *Cibicidoides subspiratus*, *C. spp.* *Oridorsalis* spp., and *O. umbonatus* occur, and in the planktonic foraminiferal zone of the Middle Oligocene *Globorotalia optima optima*, the benthic foraminifera of *Uvigerina havanensis*, *U. hispida*, *U. sp.*, and *Vulvulina spinosa* are found. The occurrence of benthic foraminifera stated above, as well as planktonic foraminifera from the MG-section, suggests that the age of the Jamburo

Table 1. Calculation of factor analysis for PAK-section.

Samples	Communality	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
PAK-1	0.67	0.71	0.01	0.09	-0.01	-0.19	-0.02	-0.35
PAK-2	0.85	0.92	0.00	0.02	-0.05	-0.03	-0.01	-0.10
PAK-3	0.71	0.83	-0.02	0.03	0.01	-0.17	0.00	0.04
PAK-4	0.61	0.65	-0.07	-0.03	0.30	-0.15	0.03	0.26
PAK-5	0.80	0.79	-0.03	0.00	0.10	-0.39	0.00	-0.09
PAK-6	0.70	0.82	-0.04	0.12	0.03	-0.05	0.06	0.06
PAK-7	0.79	0.41	-0.05	0.02	0.44	-0.42	0.11	-0.49
PAK-8	0.75	0.82	-0.04	0.04	0.05	-0.25	0.05	-0.08
PAK-9	0.83	0.90	-0.05	0.05	-0.01	-0.01	0.06	-0.06
PAK-10	0.74	0.82	-0.20	0.04	0.01	-0.11	-0.03	-0.13
PAK-11	0.68	0.48	-0.02	-0.04	0.23	-0.59	0.16	-0.15
PAK-12	0.66	0.23	-0.05	0.01	0.08	-0.76	-0.08	-0.15
PAK-13	0.80	0.29	0.00	0.01	0.01	-0.84	0.12	0.08
PAK-14	0.58	0.30	0.00	0.12	0.07	-0.68	0.05	-0.08
PAK-15	0.90	0.07	-0.18	0.90	0.02	-0.15	0.13	-0.07
PAK-16	0.84	0.01	0.01	0.27	-0.07	-0.03	0.87	-0.05
PAK-17	0.95	0.06	0.00	0.97	0.03	-0.03	0.09	0.03
PAK-18	0.89	0.17	0.00	0.92	0.03	0.04	0.06	0.01
PAK-19	0.75	-0.09	0.00	0.53	-0.04	-0.67	0.02	0.10
PAK-20	0.93	-0.01	-0.70	0.60	-0.02	-0.26	0.04	-0.07
PAK-21	0.79	0.02	-0.28	0.05	0.80	-0.02	0.05	-0.25
PAK-22	0.86	0.02	0.02	-0.01	0.88	-0.01	0.29	-0.06
PAK-23	0.53	0.06	-0.01	0.01	0.70	-0.11	-0.16	0.01
PAK-24	0.76	0.08	-0.79	0.07	-0.02	-0.10	0.21	-0.26
PAK-25	0.93	0.07	-0.37	0.03	0.40	-0.09	0.78	-0.15
PAK-26	0.80	0.15	-0.36	0.06	0.11	-0.11	0.08	-0.79
PAK-27	0.59	0.07	-0.32	0.03	0.13	-0.04	0.08	-0.68
PAK-28	0.93	0.02	-0.95	0.01	0.04	-0.03	-0.03	-0.11
PAK-29	0.73	0.05	-0.83	-0.03	0.19	0.01	0.08	0.00
PAK-30	0.89	0.06	-0.94	0.01	0.02	-0.01	0.04	-0.07
PAK-31	0.95	-0.02	-0.97	0.00	0.01	0.00	0.02	-0.05
PAK-32	0.94	0.02	-0.97	0.02	-0.01	-0.02	-0.02	-0.10
PAK-33	0.89	0.10	-0.92	0.02	-0.01	-0.02	0.01	-0.15
Variance		20.14	20.79	10.22	7.58	9.60	4.96	5.58
Cum. var.		20.14	40.92	51.14	58.71	68.31	73.28	78.86

Group ranges from the Maastrichtian to the Middle Oligocene.

In the HR-section, *Globotruncana* spp. and *Heterohelix* spp. are the only observed Maastrichtian species. The Paleocene to Middle Oligocene planktonic foraminiferal zones are similar to those of the MG-section. However, the Early Oligocene planktonic foraminiferal zone of *Globigerina tapuriensis* is present, and accompanied by such benthic foraminifers as *Anomalinoides pseudogrosserugosus*, *Cibicidoides* spp., *Cyclamina* sp.,

Uvigerina sp. cf. *U. dumblei*, *U. havanensis*, and, *Vulvulina spinosa*. The Eocene sediments contain *Cibicidoides subspiratus*, *Nuttallides truempyi* and reworked *Neoflabellina rugosa*. The Paleocene contains *Stensioina beccariiiformis*, *Nuttallides* spp., and reworked Maastrichtian *Coryphostoma incrassata*. Between the samples of no. HR-6 and HR-7, a thrust fault is inferred, because the former contains the Middle Eocene planktonic foraminifera *Hantkenina dumlei* and the latter includes the Paleocene *Morozovella velascoensis*.

IV. Discussion: On the change of foraminiferal assemblage

It is certain that the sedimentary environment is reflected in the characteristics of benthic foraminifera of the Jamburo Group from three sections of PAK, MG and HR. In addition, the benthic foraminiferal assemblages recognized in this study reveal that the southern Tethyan area has

experienced several distinct environmental changes during the Late Cretaceous to Oligocene. It is marked by the sudden change of benthic foraminiferal test from calcareous to agglutinated in the Cretaceous-Paleocene.

Kennet (1977) suggested that the Cretaceous oceans had a warmer and more uniform thermal structure than the early Cenozoic oceans. The change of the oceanic structure and circulation system produced the high thermal gradients in

Table 2. Calculation of benthic foraminiferal assemblages from common species for PAK-section.

Taxa	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
<i>Ammodiscus</i> cretaceus	0.106	-0.050	-0.011	0.006	0.004	0.004	0.039
<i>Bolivoides</i> draco	0.079	0.013	0.062	0.019	0.041	-0.005	-0.017
<i>Bulimina</i> carseyae	-0.005	0.002	-0.003	-0.003	-0.037	-0.002	-0.001
<i>Cibicidoides</i> subcarinatus	0.111	0.005	-0.089	0.011	-0.364	0.002	0.049
<i>Cibicidoides</i> allenii	0.062	-0.020	-0.008	-0.004	-0.009	-0.012	0.031
<i>Cibicidoides</i> dayi	0.152	-0.095	-0.028	0.076	-0.023	-0.014	0.144
<i>Cibicidoides</i> spp.	0.072	-0.023	0.003	0.356	-0.136	-0.185	0.161
<i>Cibicidoides</i> velascoensis	0.138	0.009	0.005	-0.030	0.039	-0.017	-0.042
<i>Cibicidoides</i> jamburoensis, n. sp.	-0.017	0.005	-0.004	-0.095	0.036	0.643	-0.132
<i>Tritaxia</i> trilatera	-0.008	0.018	0.131	-0.019	-0.060	0.621	0.079
<i>Clavulinoides</i> spp.	0.062	0.002	0.049	-0.005	0.048	-0.008	0.000
<i>Coryphostoma</i> incrassata	0.291	0.008	0.166	0.007	0.109	-0.049	0.061
<i>Dentalina</i> spp.	0.237	-0.023	-0.015	-0.043	-0.060	0.012	-0.123
<i>Eponoides</i> spp.	-0.025	0.018	0.009	-0.035	0.023	-0.033	-0.404
<i>Gaudryina</i> pyramidata	0.124	-0.006	0.021	0.019	-0.112	0.037	0.105
<i>Gaudryina</i> rugosa	0.049	0.007	-0.065	0.314	-0.055	0.313	0.113
<i>Gavelinella</i> monterelensis	0.641	0.005	0.017	-0.073	0.226	-0.023	0.056
<i>Globorotalites</i> micheliniana	0.423	0.014	-0.059	-0.028	-0.200	0.053	0.110
<i>Gyroidinoides</i> exsertus	0.069	-0.010	-0.045	-0.012	-0.228	-0.058	0.015
<i>Gyroidinoides</i> globosus	0.125	0.009	-0.020	-0.025	-0.072	0.006	0.003
<i>Haplophragmoides</i> cf. chapmani	0.028	-0.011	0.117	0.047	0.030	-0.015	-0.022
<i>Haplophragmoides</i> spp.	0.028	-0.161	-0.053	0.050	0.018	0.162	0.088
<i>Hormosina</i> spp.	0.000	-0.007	-0.001	-0.002	0.000	-0.001	0.000
<i>Unilocular</i> taxa	0.179	0.014	0.002	0.020	-0.110	-0.073	-0.600
<i>Lenticulina</i> spp	0.025	0.003	0.021	0.032	-0.037	0.035	-0.100
<i>Lenticulina</i> rotulata	0.185	0.019	0.082	0.003	-0.264	0.092	-0.370
<i>Nuttallides</i> spp.	-0.025	0.022	0.010	0.031	0.030	-0.033	-0.316
<i>Osangularia</i> navarroana	0.043	-0.029	-0.005	-0.005	0.001	0.069	-0.023
<i>Praebulimina</i> aspera	-0.018	0.003	0.931	0.021	0.032	-0.036	0.049
<i>Praebulimina</i> kickapooensis	-0.019	0.011	0.005	0.848	0.041	0.040	-0.143
<i>Praebulimina</i> navarroensis	0.140	-0.026	-0.006	0.038	0.012	-0.016	0.112
<i>Praebulimina</i> ovulum	-0.100	-0.014	0.075	-0.067	-0.721	-0.038	0.097
<i>Psammospaera</i> spp.	0.085	-0.154	0.042	-0.006	0.021	0.016	-0.050
<i>Reophax</i> spp.	0.020	-0.014	0.002	-0.005	0.010	-0.004	-0.042
<i>Spiroplectammina</i> spp.	0.026	-0.055	-0.015	0.008	-0.007	0.024	-0.104
<i>Stensioina</i> beccariiiformis	0.144	-0.039	-0.018	0.032	0.013	0.016	0.117
<i>Stensioina</i> excolata	0.116	-0.012	-0.034	0.058	-0.050	0.011	0.081
<i>Trochammina</i> cf. diagonis	-0.025	0.019	0.168	0.006	-0.213	-0.051	0.008
<i>Trochammina</i> sp. 1	0.010	-0.003	0.003	0.101	0.005	-0.023	0.051
<i>Trochammina</i> spp.	-0.041	-0.963	0.018	-0.015	0.001	-0.011	-0.057

the cold Paleogene ocean. This profound change of oceanic character and circulation may led to the turn over of the deep-sea calcareous benthic fauna (Benson, 1975, 1977; Douglas and Woodruff, 1981; Kaiho, 1989, 1991). This global turn over of calcareous fauna was probably the reason for the displacement of the calcareous tests to agglutinated found across the K/T boundary in the studied areas, as especially found in reference locality of the Jamburo Group along the western Gaj river.

If the faunal change resulted from an alteration of local circumstances, then the tectonic setting in the area affecting the condition of shallowing of Tethys must be considered. It is a well known phenomena that northward movement of the Indian plate was completed through Cretaceous and early Tertiary, which resulted the collision in early Tertiary (Pawell and Conaghan, 1973; Molnar and Tapponnier, 1975; Pawell, 1979; Patriat and Achache, 1984; Klootwijk *et al.*, 1985; Dewey *et al.*, 1989) or collision taking place during Cretaceous-Tertiary or before (Klootwijk *et al.*,

1991). Such a tectonic event probably resulted in the formation of the irregular sea-floor in or near the India-Asia convergence zone. Therefore, the closure of the Tethys may have caused the restriction of water circulation and subsequent reduction of deep-water properties, which caused the limited oxygen supply to the bottom water. In such circumstances, calcareous species had difficulty to precipitate and maintain calcareous tests, and this causes the domination by agglutinated benthic foraminifera. This agrees with the hypothesis proposed by Kaiho (1988).

According to Gradstein and Berggren (1981), in such oxygen reducing bottom conditions the foraminiferal assemblages are generally dominated by agglutinated species. These authors also described that agglutinated taxa are commonly associated with flysch deposits in various parts of the World. The agglutinated species occurred in the studied sections can be correlated with flysch-type agglutinated taxa. Some of the species can also be referable to those of Brouwer (1965) reported from turbiditic

Table 3. Calculation of factor analysis for MG-section.

Samples	Communality	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
1 MG1	.6120	.1136	-.3498	.3438	.1324	-.0749	-.1320	.3900	.4073
2 MG2	.8119	.1659	-.0654	.1195	.2219	-.0835	-.0506	.7945	.2753
3 MG3	.8430	.1798	.0310	.1207	.4990	-.6429	.0716	.3063	.1839
4 MG4	.8028	.1659	.0379	.1313	.4064	-.4992	-.0650	.5808	.0255
5 MG5	.9272	.0342	-.0246	.9268	.0994	.0096	-.0541	.2094	.0982
6 MG6	.6863	.3023	-.0154	.1550	.2303	-.1111	-.1565	.6934	-.0046
7 MG7	.6968	.0174	-.0154	.7446	.1138	-.2071	.0364	.2903	-.0187
8 MG9	.7335	.2373	-.5686	.0775	.0591	-.5667	-.0040	.1017	-.1136
9 MG10	.8760	.0986	-.0620	.9112	.0702	.0509	.0666	-.0248	-.1400
10 MG11	.8526	.7622	-.1239	.1044	.1487	-.4021	.0113	.1551	-.1938
11 MG12	.7969	.8198	-.0643	.1910	.1945	-.0444	.0582	.1604	-.1237
12 MG13	.7805	.6547	-.0801	.3016	.3148	-.1126	-.2113	.2730	.1534
13 MG14	.7987	.3893	-.3750	.1742	.1389	.0175	-.1352	.6518	.1163
14 MG15	.9463	.4444	-.0166	.8359	.0013	-.0572	-.1513	-.0486	.1461
15 MG16	.9263	.3761	-.0737	.6842	.1177	-.4848	-.0886	.0139	.2332
16 MG17	.7249	.2709	-.0259	.6483	.1058	-.0840	-.3895	.2461	0.0000
17 MG18	.7691	.7630	-.0552	.1162	.0244	-.0751	-.2526	.3046	.0866
18 MG19	.9305	.9107	.0032	.0693	.0365	-.1559	-.2492	.0772	.0507
19 MG20	.9630	.9758	-.0114	.0558	.0201	.0120	-.0243	-.0252	.0754
20 MG21	.8725	.8434	-.0302	.0834	.0832	-.0812	-.2493	.1385	.2418
21 MG22	.6702	.1375	-.3743	.0543	.1499	-.2060	-.6125	.1599	.2064
22 MG23	.7627	.1956	.0151	.0230	.1556	-.0724	-.8321	.0237	.0367
23 MG24	.9196	.1694	.0089	.0708	.0628	-.8868	-.2868	.0894	.0721
24 MG25	.8581	.1634	-.5512	.2166	.0518	-.6644	-.1450	-.1201	.0325
25 MG27	.7616	.0828	-.0435	.0756	.8465	-.1021	-.0255	.0739	.1185
26 MG29	.7298	.0555	-.0366	.0456	.8011	-.1069	-.1367	.0823	.2112
27 MG30	.7222	.0783	-.3498	.0520	.6997	-.0801	-.1105	.0111	.2874
28 MG33	.8712	.2044	-.0028	.0790	.1342	-.0976	-.8803	.1438	-.0072
29 MG34	.6688	.0431	-.5331	.1348	-.0159	-.0302	-.0391	.5932	-.1001
30 MG36	.8389	.1499	-.5779	.1301	.0182	-.0409	-.2825	.6160	.0652
31 MG37	.8478	.1781	-.4088	.0926	.5467	-.0252	-.5142	.2604	-.0925
32 MG38	.6520	.1159	-.1652	.1304	.6701	.0250	-.2491	.2679	-.1040
33 MG39	.7548	.0956	-.4627	.1036	.6476	.0316	-.0938	.2046	-.2232
34 MG42	.7242	.0933	-.3533	.0413	.2131	-.0078	.1164	.1526	.7118
35 MG45	.9362	.0215	-.9565	-.0050	.1143	-.0222	.0352	.0384	.0669
36 MG47	.8450	.1183	-.6913	.0248	.1819	-.0233	-.1189	.0717	.5474
37 MG50	.8687	.0122	-.9129	-.0186	.0956	-.0265	-.0584	.0162	.1461
38 MG52	.7547	.1636	-.4016	.0538	.0638	-.0677	-.1975	.0807	.7139
39 MG53	.9349	.0251	-.9435	.0124	.1744	-.0433	.0020	.0502	.0950
40 MG54	.9516	.0433	-.9304	.0078	.0509	-.0356	-.0019	.0280	.2818
41 MG56	.8352	.0325	-.8896	.0095	.0881	-.0545	-.1218	.0843	.0997
42 MG58	.8632	.0041	-.9206	.0073	.0553	-.0797	.0049	.0776	.0128
43 MG60	.6138	.0953	-.7212	.0636	.0940	-.0263	-.0133	.2532	.0822
VARIANCE		13.701	20.135	10.177	9.355	6.629	6.931	8.551	5.304
CUM. VAR		13.701	33.837	44.013	53.368	59.997	66.928	75.479	80.782

sequences and Paleogene bathyal benthic foraminifera of Kaiho (1988).

The species diversity (H'), calculated by the Shannon-Wiener index, can be directly compared to that of the deep-sea benthic fauna, as studied by Nomura (1991a) in the Indian Ocean. As stated in the preceding Chapter, high diversities are recognized in the lower Mughal Kot Formation, with values ranging from 4.4 to 5.2 above the Parh Limestone and Parh Group (= Monajhal Group). These values are generally higher than those of Maastrichtian deep-sea fauna (1000-1500 m paleodepth) at Ocean Drilling Program Site 752, where the values range from 3.5 to 4.5. Species diversity distinctly decreases below the Pab Sandstone and the values are generally low throughout the studied Jamburo Group (3.2 in average), with distinct fluctuations ranging from 2.3 to 4.1. The species diversities of these values are lower than those of the latest

Maastrichtian and the Paleocene deep-sea fauna, except for several horizons showing over 3.5.

The difference of the species diversity between the Indian Ocean deep-sea fauna and the Tethyan fauna is thought to result from the different oceanic conditions, as represented by oxygen content and organic flux. The present author supposes that the Mughal Kot Formation and the Jamburo Group might have been deposited close to the continental margin, with an input of terrigenous sediments. However, the Mughal Kot Formation, particularly the lower part of the formation, was better circulated by open oceanic water than the Jamburo Group.

V. Conclusion

The results of study on the benthic foraminifera from the Jamburo Group in three localities of Khuzdar district,

Table 4. Calculation of benthic foraminiferal assemblages from common species for MG-section.

Taxa	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
1 Ammodiscus cretaceus	-.022	-.207	.068	-.026	-.159	-.191	.041	.485
2 Anomalinoidea sp.	.083	.009	.316	.239	.046	.358	1.319	.112
3 Bolivinoidea draco	.240	.025	.221	-.072	.128	.044	.199	.052
4 Bulimina arkadelphia	1.628	.453	-.021	-.270	.019	.168	1.176	.375
5 Cibicidoides cf. allenii	.958	-.065	.366	-.152	-.273	-.377	-.704	.064
6 Cibicidoides dayi	.100	-.036	.005	.102	.185	.006	1.775	-.074
7 Cibicidoides spp.	.017	-6.084	-.124	.529	-.203	-.054	-.284	.634
8 Cibicidoides velascoensis	.619	.097	.521	-.100	-.103	.418	.737	.400
9 Coryphostoma incrassata	.133	.145	.254	-.095	-6.045	.701	-.109	-.505
10 Dentalina spp.	.213	-1.281	.479	.788	-.088	.521	1.562	-1.806
11 Dorothia bullela	.157	-.058	.214	.235	.200	.139	.683	.343
12 Dorothia spp.	-.053	-.423	.069	.088	-.260	.393	.430	.279
13 Unilocular sp.	.411	-.150	.905	-.422	-.153	.420	1.819	0.000
14 Gaudryina pyramidata	.163	.743	.101	.103	-.295	.938	.724	2.844
15 Gaudryina rugosa	-.019	.380	.318	.921	-.185	.948	-.440	.373
16 Gaudryina sp.	.012	-.070	-.052	.055	.108	.334	-.006	1.116
17 Gavellinella monterelensis	.372	.291	.536	-.280	.087	-.178	1.435	.131
18 Globorotalites michelliniana	5.770	-.065	.073	-.232	.298	1.196	-1.132	-.672
19 Gyroldinoidea exsertus	-.345	.218	-.029	-.286	-.179	.153	1.867	.746
20 Gyroldinoidea globosus	.878	.066	-.189	-.502	.306	.123	2.051	-.242
21 Gyroldina subangulatus	-.039	-.586	.043	-.203	-.492	.020	-.300	-.021
22 Haplophragmoides spp.	.477	.009	-.083	.350	-.474	.622	.541	-.363
23 Lenticulina rotulata	.290	.119	-.247	.568	.053	-2.082	-.104	.254
24 Lenticulina spp.	1.329	.033	.387	.903	-.669	-5.545	.464	.074
25 Morssonella oxycona	-.009	.142	.479	-.012	-.382	.407	.941	.636
26 Nuttallides truempyi	.022	-.229	-.065	.136	.232	.135	.092	.775
27 Nuttallides sp.	.019	-.116	-.022	.223	.101	-.132	-.065	-.128
28 Oridorsalis spp.	.181	-.924	-.133	.152	.463	.246	.135	.672
29 Oridorsalis umbonatus	.853	-.220	.276	-.826	-.034	-.216	.243	4.433
30 Osangularia navarroana	-.066	.194	-.044	.310	-.104	.241	.555	.271
31 Praebulimina aspera	.363	-.064	.321	2.941	.509	.012	.394	-1.860
32 Praebulimina kickapoensis	-.085	.079	.241	1.839	.376	-.387	.340	-.584
33 Praebulimina navarroana	-.387	-.015	6.145	-.400	.252	.043	-1.098	.123
34 Praebulimina ovulum	.272	.079	-.028	.131	-.005	.078	.249	-.097
35 Praebulimina sp.	.030	-.446	-.088	-.254	-.727	.125	.021	-.311
36 Pseudoclavulina spp.	-.013	-.155	1.050	.021	.270	-.066	1.198	-.806
37 Spiroplectammina spp.	-.022	-.163	.123	.173	.024	.115	.223	-.314
38 Stensioina beccariformis	.013	.097	-.084	.093	-.021	.135	.644	.172
39 Stensioina excolata	.360	.247	-.026	-.025	-.379	.123	.565	.294
40 Tritaxia trilatara	-.103	.165	-.185	.393	-1.476	-.926	-.108	.523
41 Trochammina spp.	-.097	-.432	.408	-.745	-.106	-.236	3.278	-.542
42 Vulvulina spinosa	.013	-.282	-.006	-.033	.066	.095	.080	-.097

Balochistan, Pakistan are summarized as follows:

1. The lithological and biostratigraphical studies of the Jamburo Group indicate that its age is from Maastrichtian to Middle Oligocene.

2. The lower part of the section yielding the Maastrichtian foraminiferal fauna is correlated to the Mughal Kot Formation, the uppermost unit of the underlying Parh Group.

3. The sandstone occurring in two localities is defined as the referable unit to the Pab Sandstone of the type area.

4. The Cretaceous-Tertiary boundary is marked above the Pab Sandstone. Where the Pab Sandstone is not developed, the K/T boundary is positioned within the strata of the Jamburo Group.

5. The change in benthic foraminiferal tests from calcareous to agglutinated is found across the K/T boundary in the PAK and HR-sections. This suggests the paleoenvironmental changes from open to restricted basin in the Tethyan Sea.

6. The abundant occurrences of *Gavilina moterelensis* and *Globorotalites micheliniana* show the open marine conditions.

7. It is believed that the basin became shallower from Paleocene toward Middle Oligocene, because the upper strata exhibit the coquinoïdal limestone bed of larger foraminifera and other mollusc shells.

8. The benthic foraminiferal fauna from the Maastrichtian to Paleocene of studied sections indicates the paleodepth of upper bathyal to abyssal; the Middle Eocene-Middle Oligocene shows neritic to bathyal (van Morkhoven *et al.*, 1986). This confirms the shallowing idea of Tethys in the Paleogene.

VI. Systematic notes on species

The species described in this section have been identified by consulting previous published figures and descriptions. When original descriptions of species were not available, references were made to the "Catalogue of Index Smaller Foraminifera" compiled by Eliss *et al.*, (1969). Because of poor preservation, and low occurrence of specimens, some species are left unnamed or for confirmation of the further scientific examination. All the figured specimens are deposited in the Head quarter office of the Geological Survey of Pakistan.

Ammodiscus cretaceus (Reuss)

Pl. 2, fig. 52

Operculina cretacea Reuss, 1845, p. 35, pl. 13, figs. 64-65.

Ammodiscus cretaceus (Reuss). Marie, 1941, p. 18, pl. 1, figs. 5-6; Cushman, 1946, p. 17, pl. 1, fig.

35; Graham and Church, 1963, p. 17, pl. 1, fig. 17.

Involutina cretaceus (Reuss). Said and Kenawy, 1956, p. 120, pl. 1, fig. 4.

Remarks: This species resembles that of Kaihos', 1992, p. 242, pl. 1, fig. 4, but differs in having more polished and smooth surface with low cement.

Occurrence: It occurs from the Maastrichtian to Paleocene of PAK-section, and the Maastrichtian to Middle Oligocene of MG and HR-sections.

Ammodiscus glabratus Cushman and Jarvis

Pl. 2, fig. 47

Ammodiscus glabratus Cushman and Jarvis, 1928, p. 86, pl. 12, fig. 6; Cushman, 1946, p. 17, pl. 1, fig. 32; Israelsky, 1951, p. 5, pl. 2, figs. 12, 13; Slitter, 1968, p. 42, pl. 1, fig. 9; Hanzlikova, 1972, p. 35, pl. 3, fig. 7; Krashennnikov and Pflaumann, 1977, p. 569, pl. 21, figs. 8, 9; Miller, Gradstein and Berggren, 1982, p. 19, pl. 1, fig. 8.

Involutina glabratus (Cushman and Jarvis). Martin, 1964, p. 45, pl. 1, figs. 10, 11.

Involutina sp. Said and Kenawy, 1956, p. 120, pl. 1, fig. 5.

Remarks: The present form having more coarse test, closely resembles the specimens reported by Yasuda, 1986, p. 41-42, pl. 1, figs. 6a-b.

Occurrence: This species sporadically occurs in PAK-section and HR-section, but commonly occurs in MG-section from the Maastrichtian to the Middle Oligocene.

Anomalinoidea cf. pseudogrosserugosa (Colom)

Pl. 10, figs. 46a-c

Anomalina pseudogrosserugosa Colom, 1945, p. 209, pl. 31, figs. 19-30.

Remarks: A few specimens resembling the forms reported by Miller and Katz, 1987, p. 120, pl. 5, figs. 4a-c, which have been recorded from the HR-section. The present form have smaller chambers than the cited one.

Occurrence: This species occurs in the Middle Eocene to Early Oligocene of the HR-section.

Bathysiphon vernoni Hamlin

Pl. 2, fig. 30

Bathysiphon vernoni Hamlin, 1963, p. 288, pl. 11, figs. 20-22.

Remarks: Some poorly preserved specimens have a coarse surface test, which resemble the form reported by Kaiho, 1984, p. 42, Pl. 1, Fig. 4.

Occurrence: This form occurs in all the studied area from the Maastrichtian of PAK-section, the Maastrichtian to Eocene of the MG-section and from the Middle Eocene to Middle Oligocene of HR-section.

Bathysiphon varans Slitter

Pl. 2, fig. 31

Bathysiphon varans Slitter, 1968, p. 40, Pl. 1, Fig. 4.

Remarks: The present specimen resembles the holotype figure of Slitter, reported from western coast of north America.

Occurrence: Some poorly-preserved specimens, were collected from the Maastrichtian of PAK-section and Paleocene to Oligocene of HR-section.

Bathysiphon vitta Nauss

Pl. 2, fig. 32

Bathysiphon vitta Nauss, 1947, p. 334, pl. 48, fig. 4.

Remarks: This species is characterized by its large size, non constricted and parallel sized test. The reported species resembles the specimen of Slitter, 1968, p. 40-41, Pl. 1, Fig. 3. But present species have smooth test.

Occurrence: A few Poorly-preserved specimens were collected from the Maastrichtian of PAK-section and the Maastrichtian to Middle Oligocene of MG and HR-sections.

Bolivinoides draco (Marsson)

Pl. 1, figs. 6, 7

Bolivina draco Marsson, 1878, p. 157, pl. 3, fig. 25a-d.*Bolivinoides draco* (Marsson). van Morkhoven *et al.*, 1986, p. 378-380, pl. 124, figs. 1a, b, 2a, b.**Remarks:** *Bolivinoides draco* has been known as a cosmopolitan index taxon in the Upper Cretaceous (van Morkhoven *et al.*, 1986). The present species having less developed grooves resembles to ones previously reported.**Occurrence:** This species abundantly occurs in the Maastrichtian shale of PAK section and commonly in the MG-section.*Bolivina cf. tectiformis* Cushman

Pl. 8, fig. 57

Bolivina tectiformis Cushman, 1926c, p. 83, pl. 12, fig. 6a.**Remarks:** The present form has a close resemblance to the specimen reported by Tjalsma, 1983, p. 739, figs. 3a-b. This species differs from the Tjalsmas in having less-developed median ridge of the older portion of the test. This species is left for confirmation because of its poor preservation. However, it is identified as *B. cf. tectiformis*.**Occurrence:** Rarely occurs in the Middle Oligocene of HR-section.*Bulimina arkadelphiana* Cushman and Parker var. *B.**midwayensis*

Cushman and Parker

Pl. 1, fig. 1

Bulimina arkadelphiana Cushman and Parker var. *midwayensis* Cushman and Parker, 1936, p. 42, pl. 7, figs. 9, 10; Cushman, 1951, p. 40, pl. 11, figs. 25, 26.**Remarks:** The described specimen seems similar to the figured form reported by Cushman (1951). But the present form have less developed basal spines. Similar forms of this species has been reported from the Paleocene of Egypt. Said and Kenawy, 1956, p. 142, pl. 4, figs. 11.**Occurrence:** Abundantly occurred in the Maastrichtian to Early Paleocene of PAK and MG-sections.*Buliminella carseyae* Plummer

pl. 1, fig. 3

Buliminella carseyae Plummer, 1931, p. 179, pl. 8, fig. 7.**Remarks:** The present specimens look similar to that reported from Paleocene of Egypt by Said and Kenawy 1956, P. 142, Pl. 4. But this form differs from Said's by having a slightly larger aperture.**Occurrence:** Commonly found in the Maastrichtian shales of PAK-section.*Bulimina jarvisi* Cushman and Parker

Pl. 2, fig. 49

Bulimina jarvisi Cushman and Jarvis, 1936, p. 39, pl. 7, fig. 1.**Remarks:** The present specimen closely resembles the figured specimen reported by Miller and Katz, 1987, p. 125, pl. 2, figs. 6a-b.**Occurrence:** Rarely found in the Eocene of the HR-section.*Chilostomella ovoidea* Reuss

Pl. 1, fig. 17

Chilostomella ovoidea Reuss, 1850, p. 380, pl. 48, fig. 12.**Remarks:** This species is characterized by ovate test and having elevated margin at the aperture. This species is also reported by Latif, 1976, p. 27, pl. 7, figs. 5-6. The present form has a more elevated apertural face than the reported specimen.**Occurrence:** Moderately-preserved specimens occurred from the Maastrichtian to the Paleocene of PAK-section.*Cibicides cf. beumontianus* (d'Orbigny)

Pl. 6, figs. 23a-c

Cibicides beumontianus (d'Orbigny). Brotzen, 1936, p. 188; Cushman, 1946, p. 160, pl. 65, fig. 12.**Remarks:** The identified specimen, looks identical in all characters to the figured species that reported by Said and Kenawy, 1956, p. 154, pl. 7, figs. 5a-c.**Occurrence:** Commonly occurs in the Maastrichtian of PAK and MG-sections.*Cibicides subcarinatus* Cushman and Deaderick

Pl. 3, figs. 6a-b. pl. 4, figs. 8a-c

Cibicides subcarinatus Cushman and Deaderick, 1944, p. 341; Cushman, 1946, p. 159, pl. 65, figs. 8-11.**Remarks:** A large number of specimens are found in the Maastrichtian and Paleocene of the studied area. The specimens with compressed final chamber are compared to the species reported by Cushman (1946).**Occurrence:** These species occurs in the Maastrichtian to Paleocene of the PAK-section.*Cibicides cf. subcarinatus* Cushman and Deaderick

Pl. 4, figs. 9a-c

Cibicides subcarinatus Cushman and Deaderick, 1944, p. 341; Cushman, 1946, p. 159, pl. 65, figs. 8-11.**Remarks:** Some specimens found in the Maastrichtian and the Paleocene of the studied area have a more depressed ventral side and smaller chambers than that of Cushman (1946). Because of poor preservation, it is under confirmation.**Occurrence:** These species occurred in the Maastrichtian to Paleocene of the PAK-section.*Cibicidoides allenii* (Plummer)

Pl. 4, figs. 10a-c

Truncatulina allenii Plummer, 1926, p. 144, pl. 10, figs. 4a-c.**Remarks:** The present species resembles the form reported by Berggren and Aubert, 1975, p. 152-153, pl. 18, fig. 1, from the Atlantic and Mediterranean areas, except for in having more chambers and more rounded periphery.**Occurrence:** These Specimens have been reported from the Maastrichtian and Paleocene of the PAK and MG-sections. Their occurrence in the Maastrichtian is common but in the Paleocene is rare.*Cibicidoides cf. allenii* (Plummer)

pl. 5, figs. 19a-b

Truncatulina allenii Plummer, 1926, p. 144, pl. 10, figs. 4a-c.**Remarks:** The present species have close resemblance to *Cibicidoides allenii*. But it differs from that in having more chambers and bigger size.**Occurrence:** It occurs in the same horizons of the *C. allenii*.

Cibicidoides dayi (White)

Pl. 4, 11a-c

Planulina dayi White, 1928, p. 300, pl. 41, figs. 3a-c.*Cibicidoides dayi* (White). van Morkhoven *et al.*, 1986, p. 353-354, pl. 114, figs. 1a-c.**Remarks:** This species is characterized by curved-limbate sutures and having a prominent umbo. The present species is apparently similar to that reported by van Morkhoven *et al.*, (1986).**Occurrence:** This species is found abundantly from the Maastrichtian to the Early Paleocene of PAK-section and from the Maastrichtian to Paleocene of MG-section.*Cibicidoides eriksdalensis* Brotzen

pl. 5, figs. 14a-c

Cibicidoides eriksdalensis Brotzen, 1936, p. 193, pl. 14, figs. 5a-c.**Remarks:** This species is characterized by its robust test, involute umbilical side and inflated chambers. The present species resembles to that reported by Belford, 1960, p. 108-109, pl. 34, figs. 1-11, from the Upper Cretaceous of western Australia.**Occurrence:** In the studied area it occurs in the Paleocene of the PAK-section.*Cibicidoides cf. subspiratus* (Nuttall)

Pl. 6 figs. 24a-b

Cibicides subspiratus Nuttall, 1930, p. 292, pl. 25, figs. 9, 10, 14.**Remarks:** Some poorly preserved specimens have a close resemblance the figured specimens reported by van Morkhoven, *et al.* 1986, p. 314-316, pl. 102, figs. 1a-c. This species was found in the sample no. HR-7, which is the faulted horizon showing the Paleocene. However, the type specimens of *C. subspiratus* were reported from the Early Eocene.**Occurrence:** Only a few poorly-preserved specimens occurs in the HR-section.*Cibicidoides jamburoensis* Nomura and Brohi, n. sp. (MS)

Pl. 5, figs. 16a-c (Holotype), 17a-c (Paratype)

Remarks: This species resembles *Cibicidoides dayi* in having the raised sutures and boss-like umbilicus on spiral side of view, but differs in possession of distinct boss on both sides. This new species differs from *Planulina taylorensis* (Carsey) in having distinctly raised umbilicus.**Occurrence:** Occurred in the Maastrichtian to Paleocene of the PAK-section. The occurrence of this species is in sample PAK-16 is very abundant, reaching to 28 % of the total fauna. This species is named after the geographic name of the Jamburo.*Cibicidoides taylorensis* (Carsey)

Pl. 5, figs. 15a-c

Anomalina taylorensis Carsey, 1926, p. 47, pl. 6, figs. 1a, b.*Planulina taylorensis* (Carsey) Cushman, 1946, p. 158, pl. 64, figs. 14, 15.**Remarks:** Specimens with larger chambers and bigger umbo, shows close resemblance to those reported by Cushman, 1946, p. 158, pl. 64, fig. 14, 15.**Occurrence:** This species occurs in the Maastrichtian of PAK-section.*Cibicidoides velascoensis* (Cushman)

Pl. 5, figs. 18a-b

Anomalina velascoensis Cushman, 1925, p. 21, pl. 3, figs. 3a-c.*Cibicidoides velascoensis* (Cushman). van Morkhoven *et al.*, 1986, p. 371-372, pl. 121, figs. 1a-c.**Remarks:** This taxon is characterized by planoconvex test, limbate sutures and broadly rounded periphery. This species has close resemblance to that reported by van Morkhoven *et al.*, 1986, except for in test convexity. The dorsal side of the present form is more convex.**Occurrence:** Well-preserved specimens occur in the Maastrichtian of PAK and MG-sections.*Clavulina parisiensis* d'Orbigny

Pl. 2, fig. 34

Clavulina parisiensis d'Orbigny, 1826, p. 268.**Remarks:** This species is characterized by triangular or triserial coiling in early stage and uniserial in later stage. Although the internal structure could not be examined, this form is identified to *C. parisiensis*. This species looks similar to that reported by Haque, 1956, p. 48-49, pl. 5, figs. 7-9.**Occurrence:** A few poorly-preserved specimens occurred from the Paleocene of the PAK and MG-sections.*Coryphostoma midwayensis* (Cushman)

Pl. 1, fig. 11

Bolivina midwayensis Cushman, 1936, p. 50, pl. 7, fig. 12.*Coryphostoma midwayensis* (Cushman). van Morkhoven *et al.*, 1986, p. 364-366, pl. 118, figs. 1a-c.**Remarks:** *Coryphostoma midwayensis* is a cosmopolitan taxon in the Maastrichtian to the Paleocene outer neritic and bathyal depths. The present form in all respects resembles referred, specimen.**Occurrence:** Occurrence of this species is restricted in the Maastrichtian of PAK and MG-sections.*Coryphostoma incrassata* (Reuss)

Pl. 1, fig. 12

Bolivina incrassata Reuss, 1851, p. 45, pl. 5, figs. 13a-b.*Coryphostoma incrassata* (Reuss). van Morkhoven *et al.*, 1986, p. 382-384, pl. 126, figs. 1a-b, 2a-b.**Remarks:** A stout and elongate test of this species commonly found from Maastrichtian of the studied sections. Said and Kenawy (1956) also reported this species from the Maastrichtian of Egypt. van Morkhoven *et al.*, (1986) suggested this species as an index taxon of the Late Cretaceous.**Occurrence:** Common in the Maastrichtian shale of PAK, MG and HR- sections.*Dentalina aculeata* d'Orbigny

Pl. 1, fig. 16

Dentalina (Nodosaria) aculeata d'Orbigny, 1840, p. 13, pl. 1, figs. 2, 3.**Remarks:** The specimen under description seems similar to the cited one.**Occurrence:** A few specimens were found in the Paleocene sample of PAK-26.

Dentalina colei Cushman and Dusenbury

Pl. 1, fig. 13

Dentalina colei Cushman and Dusenbury, 1934, p. 45, pl. 7, figs. 10-12.**Remarks:** The present species closely resembles the specimen reported by Cushman, 1951, p. 19, pl. 6, figs. 8-10.**Occurrence:** Occurs in the Maastrichtian and Paleocene of PAK and MG-sections.*Dentalina inornata* d'Orbigny

Pl. 1, fig. 14

Dentalina inornata d'Orbigny, 1846, p. 44, pl. 1, figs. 50-51.**Remarks:** The identified species possessing smaller globular chambers, is similar to that of Belford, 1960, p. 33, pl. 9, figs. 11-15.**Occurrence:** Moderately-preserved specimens were collected from the Maastrichtian and Paleocene of PAK-section.*Dentalina gracilis* d'Orbigny, 1840

Pl. 1, fig. 15

Nodosaria (Dentalina) gracilis d'Orbigny, 1840, p. 14, pl. 1, fig. 5.**Remarks:** The species reported here is characterized by slightly inflated chambers, seems similar to the specimen discussed by Belford, 1960, p. 29, pl. 8, figs. 8-11.**Occurrence:** Moderately-preserved specimens were collected from the Maastrichtian and Paleocene of the PAK and MG-sections.*Dorothia biformis* Finlay

Pl. 1, fig. 28

Dorothia biformis Finlay, 1939, p. 313, pl. 25, figs. 26-28.**Remarks:** The identified specimen shows almost all the characters similar to the figured specimen reported from the upper Cretaceous of Australia by Belford, 1960, p. 19, pl. 4, figs. 14-18.**Occurrence:** This species occurs in the Maastrichtian of the MG-section.*Dorothia bulletta* (Carsey)

Pl. 2, fig. 39

Gaudryina bulletta Carsey, 1926, p. 28, pl. 4, fig. 4**Remarks:** The specimens resemble the species reported by Belford, 1960, p. 18, pl. 4, figs. 8-10 also reported by Said and Kenawy (1956, p. 127, pl. 1, fig. 52) from Sinai and LeRoy (1953, p. 27, pl. 2, figs. 7, 8) from Maqfi, Egypt.**Occurrence:** This species is common in the Maastrichtian to Paleocene of PAK and MG-sections, and sporadic in the Maastrichtian to Middle Eocene of the HR-section.*Dorothia cf. confragra* Belford, 1960

Pl. 2, figs. 38, 40

Dorothia confragra Belford, 1960, p. 20, pl. 5, figs. 1-7**Remarks:** The present species is referred to that of Belford, but differs in having smooth surface and regular periphery.**Occurrence:** Moderately-preserved specimens were collected from the Paleocene of the PAK-section.*Fissurina orbignyana* Seguenza

Pl. 2, fig. 53

Fissurina orbignyana Seguenza, 1862, p. 66, pl. 2, figs. 25-26.*Lagenella orbignyana* (Seguenza). Cushman, 1931, p. 39, pl. 6, figs. 2a-b.*Entosolenia orbignyana* (Seguenza). Cushman, 1946, p. 126, pl. 52, figs. 16-18.**Remarks:** The present form seems to be similar to the species reported by Kaiho, 1992, p. 251, pl. 3, figs. 3a-b.**Occurrence:** Sporadically occurs in the Maastrichtian to Paleocene of the PAK and the Maastrichtian of MG-sections.*Fronidularia inversa* Reuss

Pl. 2, fig. 50

Fronidularia inversa Reuss, 1884(inaccessible *fide* catalogue); Cushman, 1936a, p. 16, pl. 3, figs. 23, 24; Cushman, 1946, p. 86, 33, figs. 11-18; Cushman, 1949, p. 6, pl. 3, fig. 7, Frizell, 1954, p. 98, pl. 12, figs. 31, 32; Takayanagi, 1960, p. 112, pl. 6, figs. 22a-c; Skinner, 1962, p. 28, pl. 4, fig. 15; Slitter, 1968, p. 62, pl. 6, fig. 6; Slitter, 1980, pl. 7, figs. 17, 18; Yasuda, 1986, p. 63, figs. 16a, b.**Remarks:** This species is characterized by its subrhomboidal to elliptical outline, and chevron-shaped chambers. The present species closely resembles the form reported by Cushman (1946).**Occurrence:** A few specimens are recorded from the Maastrichtian of PAK and MG-sections.*Gaudryina rugosa* d'Orbigny

pl. 2, fig. 43, pl. 9, fig. 64

Gaudryina rugosa d'Orbigny, 1840, p. 44, pl. 4, figs. 20, 21; Cushman, 1937, p. 36, pl. 4, figs. 14-16, pl. 5, figs. 1, 2.**Remarks:** The specimens identified to *G. rugosa* resemble that reported by Said and Kenawy, 1956, p. 124, pl. 1, fig. 25.**Occurrence:** Well-preserved specimens occurred in the Maastrichtian and early Paleocene of PAK-section and the Maastrichtian to Eocene of MG-section.*Gaudryina pyramidata* Cushman

Pl. 2, fig. 42, pl. 11, fig. 65

Gaudryina laevigata Franke var. *pyramidata* Cushman, 1926a, p. 587, pl. 16, figs. 8a, b.*Gaudryina (Pseudogaudryina) pyramidata* Cushman, 1937, p. 87, pl. 12, fig. 13.**Remarks:** The collected specimens, having acute earlier portion of the test, closely resemble that of Beckmann, 1978, p. 766, pl. 1, figs. 9-10.**Occurrence:** Well-preserved specimens occur through the Maastrichtian to Early Paleocene samples of PAK and MG-sections.*Gavelinella monterelensis* (Marie)

Pl. 3, figs. 1a-c

Anomalina monterelensis Marie, 1941, p. 343, pl. 37, fig. 342.*Gavelinella monterelensis* (Marie). Loeblich and Tappan, 1987, p. 638, pl. 718, figs. 10-12.**Remarks:** The species identified to *G. monterelensis* resembles with that of Loeblich and Tappan (1987). *G. monterelensis* was reported from the Upper Cretaceous and

described as a limited occurrence to the upper Campanian (Hart *et al.*, 1981, p. 338, pl. 7-12, figs. 1-3), but this species is common in the Maastrichtian of the studied areas.

Occurrence: Well-preserved specimens abundantly occur in the Maastrichtian of PAK and MG-sections.

Globorotalites micheliniana (d'Orbigny)

Pl. 3, figs. 3a-b

Rotalina (*Rotalina*) *micheliniana* d'Orbigny, 1840, p. 31, pl. 3, figs. 1-3.

Globorotalites micheliniana (d'Orbigny). Martin, 1964, p. 99, pl. 14, fig. 4.

Remarks: This species is characterized by a trochospiral test with steeply conical umbilical side, is similar to the form described by Slitter, 1968, p. 119, pl. 22, figs. 1a-c. *G. micheliniana* was originally described from the Upper Cretaceous. Hart *et al.* (1981) noted the stratigraphic occurrence of this species from the Turonian to the Campanian.

Occurrence: In studied areas, it commonly occurs in the Maastrichtian samples of the PAK and MG-sections.

Glomospira gordialis (Jones and Parker)

Pl. 9, figs. 36a-c

Trochammina squamata Jones and Parker var. *gordialis* Jones and Parker, 1860, p. 300 (Inaccessible *fide* Cat. Foram.).

Glomospira gordialis (Jones and Parker). Cushman and Jarvis, 1928, p. 87, pl. 12, figs. 7, 8; Cushman, 1946, p. 18, pl. 1, figs. 38-40; Said and Kenawy, 1956, p. 120, pl. 1, fig. 7; Yoshida, 1963, pl. 1, fig. 8; Webb, 1974, p. 834, pl. 1, figs. 13, 14; Slitter, 1977, pl. 1, fig. 7; Sigal, 1979, pl. 1, fig. 10; Gradstein and Berggren, 1981, p. 204, pl. 3, figs. 2, 3.

Remarks: This species is characterized by its irregular coiling of the test. The present species closely resembles that reported by Yasuda, 1986, p. 42, pl. 1, figs. 8a-b. However, the identified specimen differs from that of Yasuda (1986) by having less irregularity in the coiling of the test.

Occurrence: In the studied areas it occurs in the Paleocene of the PAK-section the Middle Oligocene of the MG-section and the Maastrichtian to Middle Oligocene of the HR-section.

Gyroidinoides exsertus (Belford)

Pl. 8, figs. 37a-c

Gyroidina exserta Belford, 1960, p. 80-81, pl. 22, figs. 1-6

Remarks: The specimen under the report has similar characters, to the holotype and paratype figured species reported by Belford, (1960) from the Upper Cretaceous of western Australia.

Occurrence: This species was found from the Maastrichtian to Paleocene of the PAK and MG- sections.

Gyroidina girardana (Reuss)

Pl. 8, figs. 38a-c

Rotalina girardana Reuss, 1851, p. 73, pl. 5, fig. 34.

Remarks: Well-preserved specimens having a trochoid test, resemble in all respects to the figured forms reported by Belford, 1960, p. 78, pl. 21, figs. 4-9, from the Upper Cretaceous of western Australia.

Occurrence: Occurs in the Maastrichtian to Early Paleocene samples of PAK-section.

Gyroidinoides globosus (Hagenow)

Pl. 3, figs. 5a-c

Nonionella globosa Hagenow, 1842, p. 574

Gyroidinoides globosus (Hagenow). van Morkhoven *et al.*, 1986, p. 329-330, pl. 107, figs. 1-3

Remarks: This species is characterized by its globular test with broadly rounded periphery. This taxon is cosmopolitan and is known from upper bathyal to abyssal depths in the Late Cretaceous to the Early Eocene (van Morkhoven *et al.*, 1986).

Occurrence: In the studied areas it occurs in the Maastrichtian of PAK samples, the Maastrichtian to Paleocene of MG-section and Maastrichtian to Middle Oligocene of the HR-section.

Gyroidinoides quadratus Cushman and Church

Pl. 8, figs. 39a-c

Gyroidinoides quadratus Cushman and Church, 1929, p. 516, pl. 41, figs. 7-9.

Remarks: The present species has close resemblance to that reported by Cushman and Church (1929). However, slight difference is found in having larger chambers.

Occurrence: Well-preserved specimens occur in the Maastrichtian of the PAK-section.

Gyroidinoides soldanii (d'Orbigny)

Pl. 10, figs. 47a-c

Gyroidinoida soldanii d'Orbigny, 1826, p. 278, model no. 36

Gyroidinoides soldanii (d'Orbigny). Belanger and Berggren, 1986 p. 344, pl. 6, figs. 3a-c.

Remarks: The present specimen looks similar in all characters to the forms, reported by Belanger and Berggren (1986).

Occurrence: Commonly occurs in the Early to Middle Oligocene of the HR-section.

Haplophragmoides sp.

Pl. 11, figs. 51a-c

Remarks: Poorly-preserved specimens, of *H. sp.*, which are usually deformed and compressed, are left for their species level.

Occurrence: It occurs through out the Maastrichtian to Early Paleocene shale, of the PAK-section.

Lagena gracillima (Seguenza)

Pl. 7, fig. 56

Amphorina gracillima Seguenza, 1862, p. 51, pl. 1, fig. 37.

(Inaccessible *fide* Cat. Foram.)

Lagena gracillima (Seguenza). Brady, 1884, p. 456, pl. 56, figs. 19-20.

Remarks: The present species looks similar to the form reported by Kaiho, 1984, p. 51, pl. 3, figs. 10a-b. But the present specimens have a larger inflated chamber.

Occurrence: Occurred rarely in the Eocene and Early Oligocene of the HR-section.

Lagena sulcata (Walker and Jacob)

Pl. 2, fig. 46

Surpula (*Lagena*) *sulcata*, Walker and Jacob. Walker and Jacob, 1798, in Kanmacher, F., Adams' *Essays on the Microscope*, 2nd Edition, p. 63, pl. 14, fig. 5.

Lagena sulcata (Walker and Jacob). Cushman, 1929, *Contr. Cushman Lab. Foram. Res.* vol. 5, p. 70, pl. 11, fig. 5;

LeRoy, 1953, p. 37, pl. 7, fig. 28; Said and Kenawy, 1956, p. 136-137, pl. 3, fig. 6.

Remarks: The species discussed here shows almost all the characters smaller to the form reported by Belford, 1960, p. 55, pl. 14, fig. 12-13, from the Upper Cretaceous of western Australia.

Occurrence: In the studied sections, found in the Maastrichtian.

Lenticulina cf. revoluta (Israelsky)

Pl. 6, figs. 21a-c

Robulus revolutus Israelsky, 1955, p. 49, pl. 72, fig. 5.

Lenticulina revoluta (Israelsky). Slitter, 1968, p. 67, pl. 7, fig. 11.

Remarks: This species is characterized by its strongly curved sutures. The reported species has a close resemblance to that of Slitter (1968).

Occurrence: In the studied sections it occurs in the Maastrichtian to Paleocene of the PAK and MG-sections.

Lenticulina gunderbookaensis Crespin

Pl. 6, figs. 20a-c, pl. 9, figs. 32a-c

Lenticulina gunderbookaensis n sp., Crespin, 1944, p. 21, pl. 1, fig. 9.

Remarks: This species is characterized by somewhat compressed test with nine chambers, resembles that reported by Scheibnerová, 1976, p. 62-63, pl. 24, figs. 1-4.

Occurrence: Moderately-preserved specimens were found from the Maastrichtian to Paleocene of PAK-section.

Lenticulina navicula (d'Orbigny)

Pl. 9, figs. 33a-c

Cristellaria navicula d'Orbigny, 1840, p. 27, pl. 2, figs. 16, 19, 20.

Remarks: The present specimen looks similar to the forms reported by Said and Kenawy (1956, p. 131, pl. 2, fig. 9).

Occurrence: It was collected from the Maastrichtian and Paleocene of the PAK-section.

Lenticulina rotulata (Lamark)

Pl. 9, figs. 34a-b, pl. 10, figs. 43a-b

Lenticulites rotulata Lamark, 1804, p. 188, pl. 62, fig. 11.

Lenticulina rotulata (Lamark). Frizzell, 1943, p. 341, pl. 56, fig. 2.

Remarks: The large test with distinct keel, identified to *L. rotulata*, is similar to the form reported from the Upper Cretaceous of Egypt (Said and Kenawy, 1956, p. 131, pl. 2, fig. 10).

Occurrence: Collected from the Maastrichtian to Early Paleocene of the PAK, the Maastrichtian-Eocene of the MG, and the Paleocene-Middle Oligocene of the HR-sections.

Lenticulina turbinata (Plummer)

Pl. 9, figs. 35a-c

Cristellaria turbinata Plummer, 1926, p. 93, pl. 7, figs. 4a, b, pl. 13, fig. 2.

Lenticulina turbinata (Plummer). Berggren and Aubert, 1975, pl. 1, figs. 3a-b.

Remarks: This specimen has close resemblance to the figured forms reported by Berggren and Aubert (1975) from the Atlantic Tethyan Regions.

Occurrence: Collected from the Maastrichtian to Early Paleocene of PAK-section and rarely found in the Paleocene of the MG-section.

Lituotuba sp.

Pl. 6, figs. 22a-b

Remarks: Some specimens were mostly deformed, are assigned to *L. sp.*

Occurrence: The occurrence of this species is limited in the Paleocene of the PAK-section (PAK-30 to -33).

Marssonella oxycona (Reuss)

Pl. 1, fig. 29

Gaudryina oxycona Reuss 1860, p. 229, pl. 12, fig. 3.

Marssonella oxycona (Reuss). Belford, 1960, p. 16-17, pl. 4, figs. 1-3.

Remarks: This species is characterized by its conical test with early trochospiral stage. This species has a close resemblance to that of Belford (1960, p. 16-17, pl. 4, figs. 1-3).

Occurrence: Occurs from the Maastrichtian to Paleocene of PAK, the Maastrichtian-Eocene of MG, and the Maastrichtian-Middle Oligocene of the HR-sections.

Neoflabellina rugosa (d'Orbigny)

Pl. 1, fig. 21, pl. 6, fig. 25

Flabellina rugosa d'Orbigny, 1840, p. 23, pl. 2, figs. 4-5, 7.

Neoflabellina rugosa (d'Orbigny). Said and Kenawy, 1956, p. 135, pl. 2, fig. 43.

Remarks: The present species is quite similar to that reported by Said and Kenawy (1956, p. 135, pl. 2, fig. 43) from the Maastrichtian to the Danian of Egypt.

Occurrence: *N. rugosa* occurs in the Maastrichtian to Paleocene of the PAK and MG-sections. But some reworked specimens were found from the Eocene of the HR-section.

Nodosaria affinis Reuss

Pl. 8, fig. 60

Nodosaria affinis Reuss, 1845, p. 26, pl. 13, fig. 16; Cushman, 1946, p. 70-71, pl. 25, figs. 8-23.

Remarks: The present form resembles the figured specimen reported by Kaiho, 1992, p. 247-248, pl. 2, fig. 7. However, the specimen in this study is larger than the referred one.

Occurrence: It occurs in the Maastrichtian to the Paleocene of the PAK-section, the Maastrichtian to Middle Oligocene of the MG-section, and the Middle Eocene-Middle Oligocene of the HR-section.

Nodosaria cf. limbata d'Orbigny

Pl. 2, fig. 48

Nodosaria limbata d'Orbigny, 1840, p. 12, pl. 1, fig. 1.

(Inaccessible *fide* Cat. Foram.); Cushman and Jarvis, 1932, p. 32, pl. 10, fig. 5; Cushman, 1946, p. 74, pl. 27, figs. 1, 2; Said and Kenawy, 1956, p. 133, pl. 2, fig. 32; Belford, 1960, p. 38, pl. 11, figs. 7-9; Slitter, 1968, p. 53, pl. 4, fig. 15; Yasuda, 1986, p. 58, pl. 5, figs. 2a, b.

Remarks: This species is characterized by having two inflated subglobular chambers. The present form seems identical to the form reported by Yasuda (1986).

Occurrence: In the studied areas, it occurs in the Maastrichtian to Paleocene of the PAK, the Maastrichtian of MG, and the Paleocene of the HR-sections.

Nodosaria cf. fusula Reuss

Pl. 1, fig. 18

Nodosaria fusula Reuss, 1874, p. 82, pl. 20, fig. 9.**Remarks:** This Specimen resembles the form reported by Cushman, 1946, p. 71, pl. 26, fig. 5.**Occurrence:** Rarely found from the Maastrichtian of the PAK-section.*Nuttallides* sp.

Pl. 10, figs. 42a-b

Remarks: Somewhat compressed form of this species is assigned to the genus *Nuttallides*.**Occurrence:** Collected from the Paleocene of the PAK and the Maastrichtian to Paleocene of MG-section*Nuttallides truempyi* (Nuttall)

Pl. 11, figs. 52a-c

Eponides truempyi Nuttall, 1930, p. 287, pl. 24, figs. 9, 13, 14.*Nuttallides truempyi* (Nuttall). van Morkhoven *et al.*, 1986, p. 288-292, pl. 96 A, figs. 1-4b.**Remarks:** This species is characterized by its rotaliform test with distinct central boss, though the central boss of this species from the Jamburo Group is less developed in test thickness, but could be comparable to the cited one. This taxon is a cosmopolitan in the Paleocene and Eocene bathyal to abyssal depths. van Morkhoven *et al.* (1986) described its occurrence from late Cretaceous to early Eocene.**Occurrence:** In the studied sections, it was found in the Paleocene of the PAK, the Maastrichtian to Paleocene of the MG, and the Middle Eocene of the HR-sections.*Oolina apiculata* Reuss

Pl. 4, fig. 13, pl. 7, fig. 55

Oolina apiculata Reuss, 1851, p. 22, pl. 1, fig. 1.**Remarks:** This species seems to be very close to the form reported by Slitter 1968, p. 80, pl. 10, fig. 13 from Baja California.**Occurrence:** Found from the Maastrichtian to Paleocene samples of the PAK and MG-sections, and the Middle Eocene-Middle Oligocene of the HR-section.*Oolina reussi* Said and Kenawy.

Pl. 4, fig. 12

Oolina reussi Said and Kenawy, 1956, p. 145, pl. 7, fig. 15.**Remarks:** The present specimen has all the characters similar to the referred one.**Occurrence:** Occurs from the Maastrichtian samples of the PAK-section.*Operculina* sp.

Pl. 11, figs. 53a-c

Remarks: Some moderately-preserved specimens are assigned to genus *Operculina*.**Occurrence:** Collected from the Middle Oligocene of the HR-section.*Oridorsalis mariei* (Said and Kenawy)

Pl. 8, figs. 40a-c, pl. 11, figs. 50a-c

Eponides mariei Said and Kenawy, 1956, p. 148, pl. 5, figs. 2a-c.**Remarks:** This species was originally reported from the Maastrichtian and Danian of Sinai. The characters of this species such as globular, nearly radial sutures on spiral side, and acute periphery of the test are assignable this taxon to the genus *Oridorsalis*. Said and Kenawy (1956) does not mentioned about the ventral sutures, but the specimens from the Mughal Kot Formation have slightly raised sutures near the umbilicus.**Occurrence:** Collected from the sample PAK-13.*Oridorsalis umbonatus* (Reuss)

Pl. 10, figs. 41a-c

Rotalina umbonata Reuss, 1851a, p. 75, pl. 5, fig. 35.*Eponoides umbonatus* (Reuss). Bermudez, 1949, p. 249, pl. 17, figs. 22-24.**Remarks:** The specimen identified as *O. umbonatus*, resembles to the form reported by Kaiho, 1991, p. 76, figs. 10-12. But the present species differs from the Kaihos' in having depression on the ventral side, and the dorsal sutures are less curved.**Occurrence:** In the studied sections it occurs commonly from the Maastrichtian to Paleocene in PAK, the Maastrichtian to Middle Oligocene in MG, and the Middle Eocene-Middle Oligocene in HR-sections.*Osangularia navarroana* (Cushman)

Pl. 3, figs. 2a-c, pl. 7, figs. 26a-c

Pulvinulinella navarroana Cushman, 1938, p. 66, pl. 11, fig. 5.**Remarks:** Typical specimens of this species, as described from the Upper Cretaceous of Texas by Cushman. (1938, 1946), are similar to the present forms. Some forms having less than ten chambers are also included in this species.**Occurrence:** Its occurrence is abundant in the Maastrichtian and Paleocene of the MG-section, the Maastrichtian to Middle Eocene of the HR-section, but common in the Maastrichtian to Paleocene samples of PAK-section.*Osangularia cf. navarroana* (Cushman)

Pl. 4, figs. 7a-c

Pulvinulinella navarroana Cushman, 1938, p. 66, pl. 11, fig. 5.**Remarks:** This species is similar to *O. navarroensis*. It only differs from that in having less chambers. However it is difficult to differentiate, and is kept under confirmation for further detailed study.**Occurrence:** It occurs in the Maastrichtian to Paleocene of the PAK-section.*Pleurostomella* sp.

Pl. 11, fig. 66

Remarks: Some poorly-preserved specimens are identified as *P. sp.***Occurrence:** A few specimens were found from the Maastrichtian of PAK, the Maastrichtian-Eocene of MG, and the Eocene and Early Oligocene of the HR-sections.*Praebulimina aspera* (Cushman and Parker).

Pl. 1, figs. 8, 19

Bulimina aspera Cushman and Parker, 1940, p. 44, pl. 8, figs. 18, 19.

Remarks: This species is characterized by occurred having a blunt initial portion of test without spines. The present form closely resembles the cited one.

Occurrence: Its occurrence is abundant in the Maastrichtian to Paleocene of the PAK and MG-sections.

Praebulimina kickapooensis (Cole)

Pl. 1, figs. 9, 10, 20

Bulimina kickapooensis Cole, 1938, p. 45, pl. 3, fig. 5.

Praebulimina kickapooensis (Cole). Slitter, 1986, p. 84, pl. 11, figs. 17-19.

Remarks: The present specimen is quite similar to the forms, reported by Slitter (1968), from the Upper Cretaceous of Baja California.

Occurrence: Occurs abundantly from the Maastrichtian to Paleocene of the PAK and MG-sections.

Praebulimina navarroensis (Cushman and Parker)

Pl. 1, figs. 2, 5

Bulimina reussi Morrow var. *navarroensis* Cushman and Parker, 1935, p. 100, pl. 15, fig. 11.

Remarks: The specimen under report is apparently similar to *P. cf. navarroensis* of Beckmann, 1978, p. 768, pl. 2, figs. 7, 8, reported from the Late Cretaceous of the Southeast Atlantic Ocean.

Occurrence: Well-preserved specimens occur from the Maastrichtian to Paleocene shale of the PAK-section, and the Maastrichtian of the MG-section.

Praebulimina ovulum (Reuss)

Pl. 1, fig. 4

Bulimina ovulum Reuss, 1844, p. 215.

Praebulimina ovulum (Reuss). Belford, 1960, p. 64, pl. 16, figs. 7-9.

Remarks: The present form resembles the Belford's specimens reported from the Upper Cretaceous of western Australia, but differs in having a larger test size and more inflated chambers.

Occurrence: Occurs from the Maastrichtian to Paleocene samples of the PAK and the Maastrichtian of the MG-section.

Pseudoclavulina amorphia (Cushman)

Pl. 2, fig. 37

Clavulina amorphia Cushman, 1926a, p. 589, pl. 17, fig. 5.

Pseudoclavulina amorphia (Cushman). Said and Kenawy, 1956, p. 124, pl. 1, fig. 32.

Remarks: The present species is characterized by more-developed uniserial portion and has close resemblance to that reported by Said and Kenawy (1956).

Occurrence: A few poorly-preserved specimens occur in the Maastrichtian samples of PAK-section.

Pseudoclavulina farafraensis LeRoy

Pl. 2, fig. 35

Pseudoclavulina farafraensis LeRoy, 1953, p. 44, pl. 2, fig. 9; Said and Kenawy, 1956, p. 125, pl. 1, fig. 29.

Remarks: This form was originally described by LeRoy from the lower Tertiary of Maqfi, Egypt. Said and Kenawy (1956) reported it from the Maastrichtian to Paleocene of Sinai,

Egypt. The specimen under identification is similar to the form reported by Said and Kenawy (1956).

Occurrence: Occurred in the Maastrichtian of the PAK and MG-sections.

Pseudoclavulina globulifera ten Dam and Sigal

Pl. 2, fig. 36

Pseudoclavulina globulifera ten Dam and Sigal, 1950, p. 32, pl. 2, figs. 5-7; Said and Kenawy, 1956, p. 125, pl. 1, fig. 30.

Remarks: Moderately-preserved specimens occur from the PAK section resemble the form reported by Said and Kenawy (1956) from the Danian of Egypt.

Occurrence: Occurred in the Maastrichtian to Paleocene of PAK-section.

Pullenia americana Cushman, 1936

Pl. 7, figs. 27a-c

Pullenia americana Cushman, 1936, p. 76, pl. 13, figs. 41-b, 5a-b; Beckmann, 1978, p. 768, pl. 3, fig. 22.

Remarks: The present species is close to that reported by Beckmann (1978, p. 768, pl. 3, fig. 22) from the Late Cretaceous of South Atlantic Ocean. The similar form has also been described by Belford (1960) from the Upper Cretaceous of Western Australia.

Occurrence: Occurs in the Maastrichtian of the PAK and MG-sections.

Pullenia quinqueloba (Reuss)

Pl. 10, figs. 48a-b, 49a-b

Nonionina quinqueloba Reuss, 1851, p. 71, pl. 5, fig. 31; Bermudez, 1949, p. 276, pl. 21, figs. 32-33; Plummer, 1927, p. 136, pl. 8, fig. 12.

Remarks: This species shows nearly all the characters similar to the form reported by Thomas, 1982, p. 678, pl. 4, figs. 1-2.

Occurrence: Specimens rarely occur in the Middle Eocene to the Early Oligocene of the HR-section.

Pullenia sp.

Pl. 10, figs. 44a-c

Remarks: Some specimens are assigned to this genus.

Occurrence: It occurs in the Eocene to Middle Oligocene of the HR-section.

Reophax duplex Grzybowski

Pl. 2, fig. 51

Reophax (Reophax) duplex Grzybowski, 1896, p. 276, pl. 8, figs. 23-25 (Inaccessible *vide* Cat. Foram.).

Reophax duplex (Grzybowski). Webb, 1974, p. 834, pl. 1, fig. 3;

Reophax duplex Grzybowski. Gradstein and Berggren, 1982, p. 20, pl. , fig. 22.

Remarks: This species is characterized by two globular chambers and closely resembles to the specimens reported by Yasuda, 1986, p. 48, pl. 1, figs. 17a-b. But the species under report has smoother globular chambers, than the referred ones.

Occurrence: It is found in the Maastrichtian of the MG-section.

Reophax globosus Slitter

Pl. 2, fig. 33

Reophax globosus Slitter, 1968, p. 43, pl. 1, fig. 12**Remarks:** Some specimens closely resemble that of Slitters' cited above. But the collected specimens are usually compressed.**Occurrence:** Recorded from the Maastrichtian and Paleocene of the PAK and MG-sections.*Rzehakina epigona* (Rzehak)

Pl. 1, fig. 22

Silicina epigona Rzehak, 1895, p. 214, pl. 6, figs. 1a-c.*Rzehakina epigona* (Rzehak). van Morkhoven *et al.*, 1986, p. 317-318, pl. 103, figs. 1-3.**Remarks:** This species is characterized by elliptical, compressed, and flattened ovate test. This form has a close resemblance to bathyal and abyssal specimen reported by van Morkhoven *et al.*, (1986).**Occurrence:** Recorded from the Maastrichtian to Paleocene of PAK-section and the Middle Oligocene of HR-section.*Saracenaria cf. kattarensis* Ludbrook

Pl. 2, fig. 54

Saracenaria kattarensis Ludbrook 1966, p. 126, pl. 8, figs. 11-13.**Remarks:** This species closely resembles the form reported by Scheibnerova', 1974, p. 77, pl. 36, figs. 5,6.**Occurrence:** A few specimens occur in the Maastrichtian of the PAK-section.*Saracenaria triangularis* (d'Orbigny)

Pl. 2, fig. 44

Cristellaria triangularis d'Orbigny 1840, p. 27, pl. 2, figs. 21, 22,*Saracenaria triangularis* (d'Orbigny). Cushman, 1946, p. 58, pl. 25, figs. 1-3.**Remarks:** The identified specimen shows close resemblance to that reported by Said and Kenawy, 1956, p. 131, pl. 3, fig. 1.**Occurrence:** Occurs in the Maastrichtian of the PAK and MG-sections.*Stilostomella cf. lepidula* (Schwager)

Pl. 2, fig. 45

Nodosaria lepidula Schwager, 1986, p. 210, pl. 5, figs. 27-28. (Inaccessible fide Cat. Foram.).*Ellipsonodosaria lepidula* (Schwager). Ishizaki, 1943, p. 680, text figs. 3, 4.**Remarks:** The studied species has close resemblance to the forms reported by Kaiho, 1984, p. 62, pl. 5, figs. 9a-b. The present form differs from the referred one in lack of spines on the chambers.**Occurrence:** In the studied areas, sporadic specimens occur in the Paleocene of the PAK and the Middle Oligocene of the HR-sections.*Spiroplectammina midwayana* (Lalicker)

Pl. 1, fig. 24

Textularia midwayana Lalicker, 1935, p. 49, pl. 6, fig. 7-9.**Remarks:** This species is characterized by having, planispiral chamber arrangement in early portion of the test. The present

specimen resembles the form reported by Cushman, 1951, p.7, pl. 1, figs. 28a-b, 29, 30.

Occurrence: Occurs in the Paleocene of the PAK-section.*Spiroplectammina laevis* (Roemer) var. *cretosa* Cushman

Pl. 1, figs. 25, 26.

Spiroplectammina laevis (Roemer) var. *cretosa* Cushman, 1932, p. 87, pl. 11, figs. 3a, b.**Remarks:** This species is characterized by subtriangular compressed test. The present form closely resembles that of Cushman, 1946, p. 27, pl. 6, figs. 1-3 reported from the Upper Cretaceous of Gulf Coastal region. This specimen is larger in size and tapering more upwards and broader.**Occurrence:** Occurs in the Maastrichtian of the PAK, MG and HR-sections.*Stensioina beccariiiformis* (White)

Pl. 7, figs. 28a-c

Rotalia beccariiiformis White, 1928, p. 28, pl. 39, figs. 2a-4c.*Stensioina beccariiiformis* (White). van Morkhoven *et al.*, 1986, p. 346-353, pl. 113C, figs. 1a-1d, 2-3b.**Remarks:** *S. beccariiiformis* is characterized by planoconvex test with smooth dorsal side and broadly rounded periphery. The present species resembles deep-water morphotype discussed by van Morkhoven *et al.* (1986).**Occurrence:** The present species occurs through the Maastrichtian to Paleocene of the PAK, MG and HR-sections.*Stensioina excolata* (Cushman)

Pl. 7, figs. 29a-c

Truncatulina excolata Cushman, 1926b, p. 22, pl. 3, fig. 2.*Stensioina excolata* (Cushman). Said and Kenawy, 1956, p. 150, pl. 6, figs. 2a-c.**Remarks:** The general morphology of this species is apparently similar to that of *Stensioina beccariiiformis* but differs in possessing irregular costae on planoconvex dorsal side. *Stensioina excolata* has been reported from the Maastrichtian of Egypt (Said and Kenawy, 1956). van Morkhoven *et al.* (1986) discussed the occurrence of this species and recognized the stratigraphic range limited to the Late Cretaceous.**Occurrence:** Moderately-preserved specimens were collected from the Maastrichtian of the PAK and MG-sections.*Textularia plummerae* Lalicker, 1935, p. 50, pl. 6, figs. 10.

Pl. 1, fig. 23

Textularia plummerae Lalicker. Cushman, 1951, p. 7-8, pl. 2, figs. 2a-b.**Remarks:** This species is characterized by elongate test with depressed sutures. Cushman's forms have a rough test surface and less no of chambers in comparison with the present form. However, such difference fall within the range of variation.**Occurrence:** Moderately preserved specimen occurred in the Maastrichtian to Early Paleocene of the PAK-section.*Tritaxia cf. barakai* Said and Kenawy

Pl. 9, fig. 63

Tritaxia barakai Said and Kenawy, 1956, p. 123, pl. 1, fig. 18.

Remarks: The specimens characterized by having the acute periphery are identified to *T. barakai*, and seems similar to that of Said and Kenawy (1956).

Occurrence: Occurs in the Maastrichtian of the PAK-Section.

Tritaxia midwayensis (Cushman)

Pl. 2, fig. 41

Clavulinoides midwayensis Cushman, 1936, p. 21, pl. 3, figs. 9, 15.

Tritaxia midwayensis (Cushman). Berggren and Aubert, 1975, p. 142, pl. 1, figs. 1a-c.

Remarks: *T. midwayensis* is characterized by elongate triserial and triangular test. The present species shows close resemblance to that of Berggren and Aubert, (1975), reported from Atlantic Tethyan region but slightly differs in having less elongated and more uniform triangular test.

Occurrence: Moderately-preserved specimens were recorded from the Paleocene of the PAK-section.

Tritaxia trilatera (Cushman)

Pl. 1, fig. 27

Clavulina trilatera Cushman, 1926b, p. 558, pl. 17, fig. 2

Clavulinoides trilaterus (Cushman). LeRoy, 1953, p. 26, pl. 1, figs. 9, 10.

Remarks: The holotype of this species is reported by Cushman (1926) from the Upper Cretaceous of Mexico. The present form is characterized by elongate triangular test and closely resembles the referred one.

Occurrence: Occurs in the Maastrichtian to Paleocene of the PAK and MG-sections.

Trochammina cf. diagonis (Carsey) Cushman and Waters.

Pl. 10, figs. 45a-c

Haplophragmoides cf. diagonis Carsey, 1926, p. 22, pl. 3, fig. 1.

Trochammina cf. T. diagonis (Carsey). Cushman and Waters, 1927, p. 84, pl. 10, figs. 7a, c.

Remarks: Compressed and deformed specimens are referred to this species.

Occurrence: Sporadically found in the Maastrichtian of the PAK-section.

Trochammina cf. texana Cushman and Waters

Pl. 7, figs. 30a-c, 31a-c

Trochammina cf. T. texana Cushman and Waters, 1927, p. 85, pl. 11, fig. 8.

Remarks: The present specimens having a deformed test with five chambers in the last whorl are conferred to *T. texana* which originally reported from the Cretaceous of Texas.

Occurrence: Poorly-preserved specimens occur in the Maastrichtian to Paleocene of the PAK-section.

Trochammina sp.

Pl. 3, figs. 4a-c

Remarks: Usually compressed and deformed forms of the *Trochammina* sp., is common. However, from the top of the Maastrichtian to the Paleocene, its occurrence is abundant.

Occurrence: In the studied areas it was found in the Maastrichtian to Middle Oligocene of the PAK, MG and HR-sections.

Uvigerina havanensis Cushman and Bermudez

Pl. 9, fig. 61, pl. 11, figs. 64, 67

Uvigerina havanensis Cushman and Bermudez, 1936, p. 59, pl. 10, figs. 19, 21.

Remarks: This species is characterized by having slender and elongate test. The present form seems to be identical to the figured specimens reported by Tjalsma, 1983, p. 747, pl. 10, figs. 8-10.

Occurrence: In the studied areas it occurs in the Eocene to Middle Oligocene of the HR-section and the Middle Oligocene of the MG-section.

Uvigerina cf. hispida Schwager

Pl. 9, fig. 62

Uvigerina hispida Schwager, 1866, p. 249; Belanger and Berggren, 1986, p. 386, pl. 2, fig. 8-9.

Uvigerina cf. hispida Schwager. Nomura, 1991b, p. 71, pl. 1, fig. 8.

Remarks: The present species slightly resembles to the form reported by Belanger and Berggren (1986), however, the identified specimens have smaller spines. It is more closer to the Nomura's specimens. The discussed form has more regular spines developed on the test. However, this specimen is left for confirmation for further investigation.

Occurrence: Some poorly-preserved specimens have been collected from the Middle Oligocene of the HR, and MG-sections.

Uvigerina spinulosa Hadley

Pl. 6, fig. 22

Uvigerina canriensis d'Orbigny var. *spinulosa*, Hadley, 1934, p. 18, pl. 2, fig. 17.

Remarks: This species has close resemblance to that reported by van Markhoven *et al.*, 1986, p. 219-220, pl. 75. But, the present form differs from the referred one in having smaller tubular neck.

Occurrence: A few specimens occurred in the Middle Oligocene of the HR-section.

Vulvulina spinosa Cushman

Pl. 8, figs. 58, 59

Vulvulina spinosa Cushman, 1927, p. 111, pl. 23, fig. 1.

Vulvulina jarvisi Cushman, 1932, p. 84, pl. 10, fig. 20.

Vulvulina spinosa Cushman and Stainforth, 1945, p. 15-16, pl. 1, fig. 28; Wood *et al.*, 1985, p. 184, pl. 1, figs. 1, 2 and 5.

Remarks: The present species seems identical in all characters to the specimen reported by Saunders *et al.*, 1984, p. 404-405.

Occurrence: Rarely found in the Eocene-Middle Oligocene of the MG and the Middle Oligocene of the HR-sections.

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Imdad Ali BROHI

Geological Survey of Pakistan, Quetta,
P. O. Box no. 15, Sariab Road, Quetta,
Pakistan.

Plate 1 (Bar=100 µm)

- Fig. 1. *Bulimina arkadelphia* var. *midwayensis* Cushman and Parker, sample PAK-12
 Figs. 2, 5. *Praebulimina navarroensis* (Cushman and Parker), sample PAK-6
 Fig. 3. *Buliminella carseyae* Plummer, sample PAK-8
 Fig. 4. *Praebulimina ovulum* (Reuss), sample PAK-13
 Figs. 6, 7. *Bolivina draco* (Marsson), sample PAK-18 (Fig. 6) sample MG-5 (Fig. 7)
 Figs. 8, 19. *Praebulimina aspera* (Cushman and Parker), sample PAK-17
 Figs. 9, 10, 20. *Praebulimina kickapoensis* (Cole), sample PAK-7
 Fig. 11. *Coryphostoma midwayensis* (Cushman), sample PAK-13
 Fig. 12. *Coryphostoma incrassata* (Reuss), sample PAK-18
 Fig. 13. *Dentalina colei* Cushman and Dusenbury, sample PAK-11
 Fig. 14. *Dentalina inornata* d'Orbigny, sample PAK-2
 Fig. 15. *Dentalina gracilis* d'Orbigny, sample PAK-26
 Fig. 16. *Dentalina aculeata* d'Orbigny, sample PAK-4
 Fig. 17. *Chilostomella ovoidea* Reuss, sample PAK-20
 Fig. 18. *Nodosaria fusula* Reuss, sample PAK-5
 Fig. 21. *Neoflabellina rugosa* (d'Orbigny), sample PAK-11
 Fig. 22. *Rzehakina epigona* (Rzehak), sample PAK-30
 Fig. 23. *Textularia plummerae* Lalicker, sample PAK-27
 Fig. 24. *Spiroplectammina midwayana* Lalicker, sample PAK-33
 Figs. 25, 26. *Spiroplectammina laevis* (Roemer), sample PAK-7 (Fig. 25) sample HR-1 (Fig. 26)
 Fig. 27. *Tritaxia trilatera* (Cushman), sample PAK-15
 Fig. 28. *Dorothia bifurcata* Finlay, sample MG-13
 Fig. 29. *Marssonella oxycona* (Reuss), sample PAK-6

Plate 2 (Bar=100 µm)

- Fig. 30. *Bathysiphon vernoni* Hamlin, sample PAK-30
 Fig. 31. *Bathysiphon varans* Slitter, sample PAK-17
 Fig. 32. *Bathysiphon vitta* Nauss, sample PAK-2
 Fig. 33. *Reophax globosus* Slitter, sample PAK-16
 Fig. 34. *Clavulina parisiensis* d'Orbigny, sample PAK-26
 Fig. 35. *Pseudoclavulina farafraensis* LeRoy, sample PAK-11
 Fig. 36. *Pseudoclavulina globulifera* ten Dam and Sigal, sample PAK-9
 Fig. 37. *Pseudoclavulina amorpha* (Cushman), sample PAK-5
 Fig. 39. *Dorothia bullella* (Carsey), sample PAK-1
 Fig. 38, 40. *Dorothia* cf. *confraga* Belford, sample PAK-25
 Fig. 41. *Tritaxia midwayensis* (Cushman), sample PAK-27
 Fig. 42. *Gaudryina pyramidata* Cushman, sample PAK-2
 Fig. 43. *Gaudryina rugosa* d'Orbigny, sample PAK-22
 Fig. 44. *Saracenaria triangularis* (d'Orbigny), sample MG-11
 Fig. 45. *Stilostomella* cf. *lepidula* (Schwager), sample HR-9
 Fig. 46. *Lagena sulcata* (Walker and Jacob) sample HR-1
 Fig. 47. *Ammodiscus glabratus* Cushman and Jarvis, sample HR-3
 Fig. 48. *Nodosaria* cf. *limbata* d'Orbigny, sample HR-3
 Fig. 49. *Bulimina jarvisi* Cushman and Parker, sample HR-6
 Fig. 50. *Fronclularia inversa* Reuss, sample MG-1
 Fig. 51. *Reophax duplex* Grzybowski, sample MG-4
 Fig. 52. *Ammodiscus cretaceus* (Reuss), sample HR-3
 Fig. 53. *Fissurina orbignyana* Seguenza, sample MG-3
 Fig. 54. *Saracenaria* cf. *kattarensis* Ludbrook, sample MG-12

Plate 3 (Bar=100 µm)

- Figs. 1a-c. *Gavelinella monterelensis* (Marie), sample PAK-2
 Figs. 2a-c. *Osangularia navarrana* (Cushman), sample PAK-1
 Figs. 3a-b. *Globorotalites micheliniana* (d'Orbigny), sample PAK-5
 Figs. 4a-c. *Trochammina* sp. sample HR-13
 Figs. 5a-c. *Gyroidinoides globosus* (Hagenow), sample PAK-13
 Figs. 6a-b. *Cibicides subcarinatus* Cushman and Deaderic, sample PAK-12

Plate 4 (Bar=100 µm)

- Figs. 7a-c. *Osangularia* cf. *navarroana* (Cushman), sample PAK-25
 Figs. 8a-c. *Cibicides subcarinatus* Cushman and Deaderic, sample PAK-13
 Figs. 9a-c. *Cibicides* cf. *subcarinatus* Cushman and Deaderic, sample PAK-12
 Figs. 10a-c. *Cibicidoides allenii* (Plummer), sample PAK-3
 Figs. 11a-c. *Cibicidoides dayi* (White), sample PAK-4
 Fig. 12. *Oolina reussi* Said and Kenawy, sample PAK-2
 Fig. 13. *Oolina apiculata* Reuss, sample PAK-7

Plate 5 (Bar=100 µm)

- Figs. 14a-c. *Cibicidoides eriksdalensis* Brotzen, sample PAK-33
 Figs. 15a-c. *Cibicidoides taylorensis* (Carsey), sample PAK-20
 Figs. 16-17a-c. *Cibicidoides jamburoensis* Nomura and Brohi, n. sp. sample PAK-16
 Figs. 18a-b. *Cibicidoides velascoensis* (Cushman), sample PAK-1
 Figs. 19a-b. *Cibicidoides* cf. *allenii* (Plummer), sample PAK-4

Plate 6 (Bar=100 µm)

- Figs. 20a-c. *Lenticulina gunderbookaensis* Crespin, sample PAK-27
 Figs. 21a-c. *Lenticulina* cf. *revoluta* (Israelsky), PAK-27
 Figs. 22a-b. *Lituotuba* sp., sample PAK-30
 Fig. 22. *Uvigerina spinulosa* Hadley, sample HR-24
 Figs. 23a-c. *Cibicides* cf. *beaumontianus* (d'Orbigny), sample MG-5
 Figs. 24a-b. *Cibicidoides* cf. *subspiratus* (Nuttall), sample HR-7
 Fig. 25. *Neoflabellina rugosa* (d'Orbigny), sample HR-6

Plate 7 (Bar=100 µm)

- Figs. 26a-c. *Ossangularia navarroana* (Cushman), sample PAK-7
 Figs. 27a-c. *Pullenia americana* Cushman, sample PAK-8
 Figs. 28a-c. *Stensioina beccariiiformis* (White), sample HR-1
 Figs. 29a-c. *Stensioina excolata* (Cushman), sample MG-3
 Figs. 30-31a-c. *Trochammina* cf. *texana* Cushman and Waters, sample PAK-15
 Fig. 55. *Oolina apiculata* Reuss, sample HR-3
 Fig. 56. *Lagina gracillima* (Seguenza), sample HR-3

Plate 8 (Bar=100 µm)

- Figs. 37a-c. *Gyroidinoides exsertus* (Belford), sample PAK-4
 Figs. 38a-c. *Gyroidina girardana* (Reuss), sample PAK-4
 Figs. 39a-c. *Gyroidinoides quadratus* Cushman and Church, sample PAK-2
 Figs. 40a-c. *Oridorsalis mariei* (Said and Kenawy), sample PAK-13
 Fig. 57. *Bolivina* cf. *tectiformis* Cushman, sample HR-24
 Figs. 58, 59. *Vulvulina spinosa* Cushman, sample HR-14 (Fig. 58) sample MG-60 (Fig. 59)
 Fig. 60. *Nodosaria affinis* (Reuss), sample MG-11

Plate 9 (Bar=100 µm)

- Figs. 32a-c. *Lenticulina gunderbookaensis* Crespin, sample PAK-15
 Figs. 33a-c. *Lenticulina navicula* (d'Orbigny), sample PAK-27
 Figs. 34a-b. *Lenticulina rotulata* (Lamarck), sample PAK-5
 Figs. 35a-c. *Lenticulina turbinata* (Plummer), sample PAK-26
 Figs. 36a-c. *Glomospira gordialis* (Jones and Parker), sample HR-9
 Fig. 61. *Uvigerina havanensis* Cushman and Bermudez, sample HR-16
 Fig. 62. *Uvigerina* cf. *hispida* Schwager, sample HR-25
 Fig. 63. *Tritaxia* cf. *barakai* Said and Kenawy, sample PAK-12
 Fig. 64. *Gaudryina rugosa* d'Orbigny, sample MG-3

Plate 10 (Bar=100 µm)

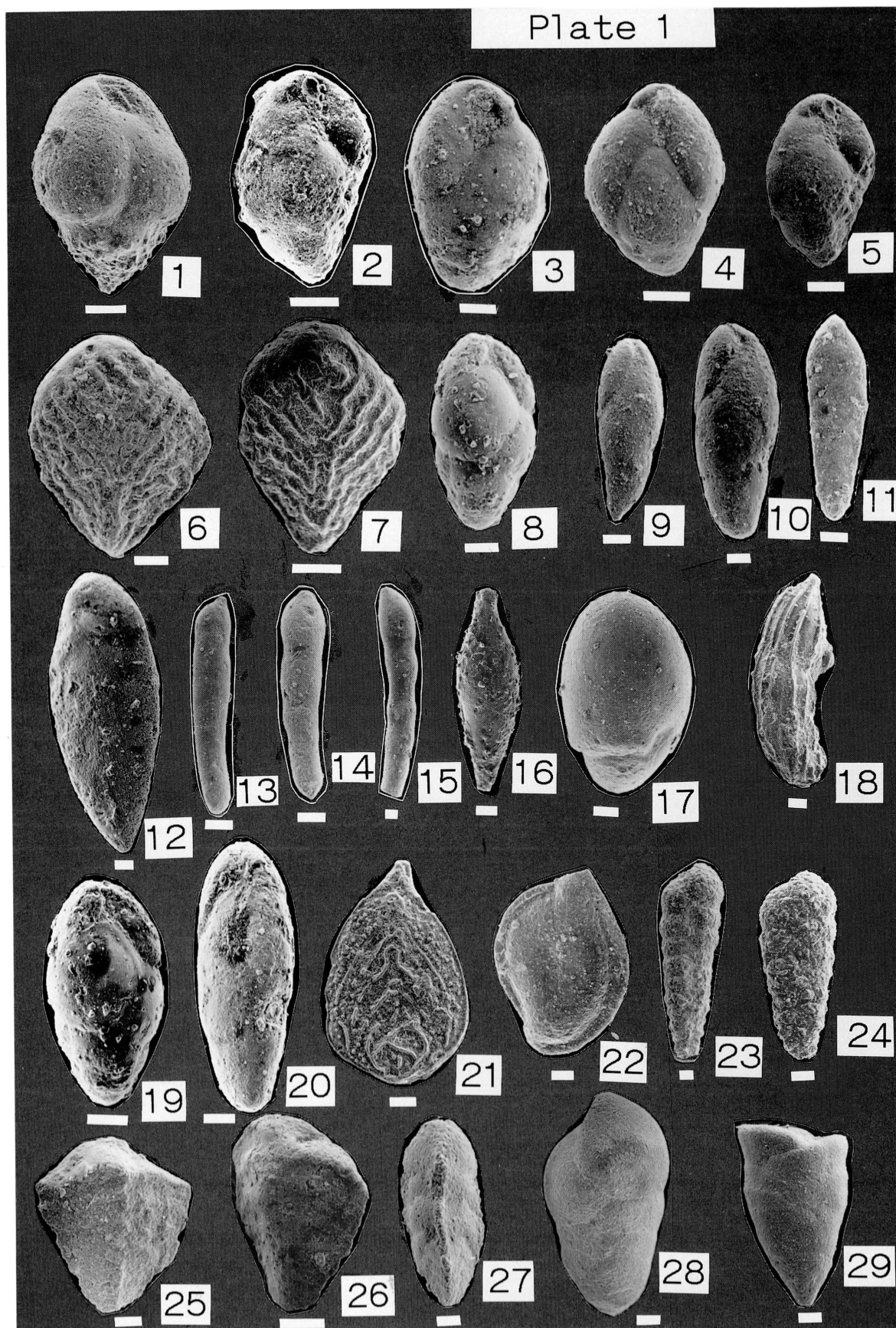
- Figs. 41a-c. *Oridorsalis umbonatus* (Reuss), sample HR-10
 Figs. 42a-b. *Nuttallides* sp., sample PAK-23
 Figs. 43a-b. *Lenticulina rotulata* (Lamarck), sample HR-6
 Figs. 44a-c. *Pullenia* sp. sample HR-6
 Figs. 45a-c. *Trochammina* cf. *diagonis* (Carsey), Cushman and Waters sample PAK-26
 Figs. 46a-c. *Anomalinoidea* cf. *pseudogrosserugosus* (Colom), sample HR-7
 Figs. 47a-c. *Gyroidina soldanii* (d'Orbigny), sample HR-14
 Figs. 48a-49c. *Pullenia quinqueloba* (Reuss), sample HR-16

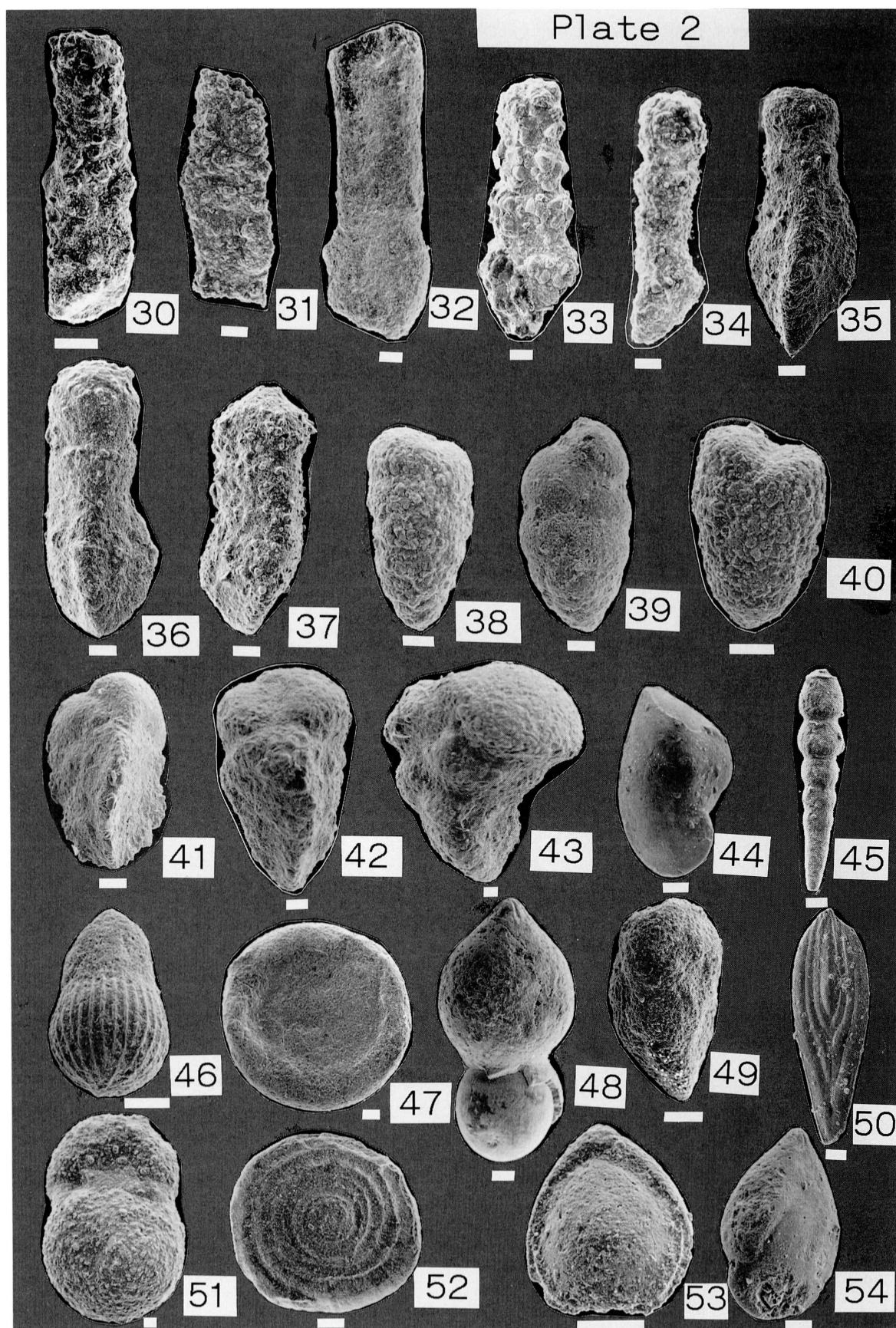
Plate 11 (Bar=100 μ m)

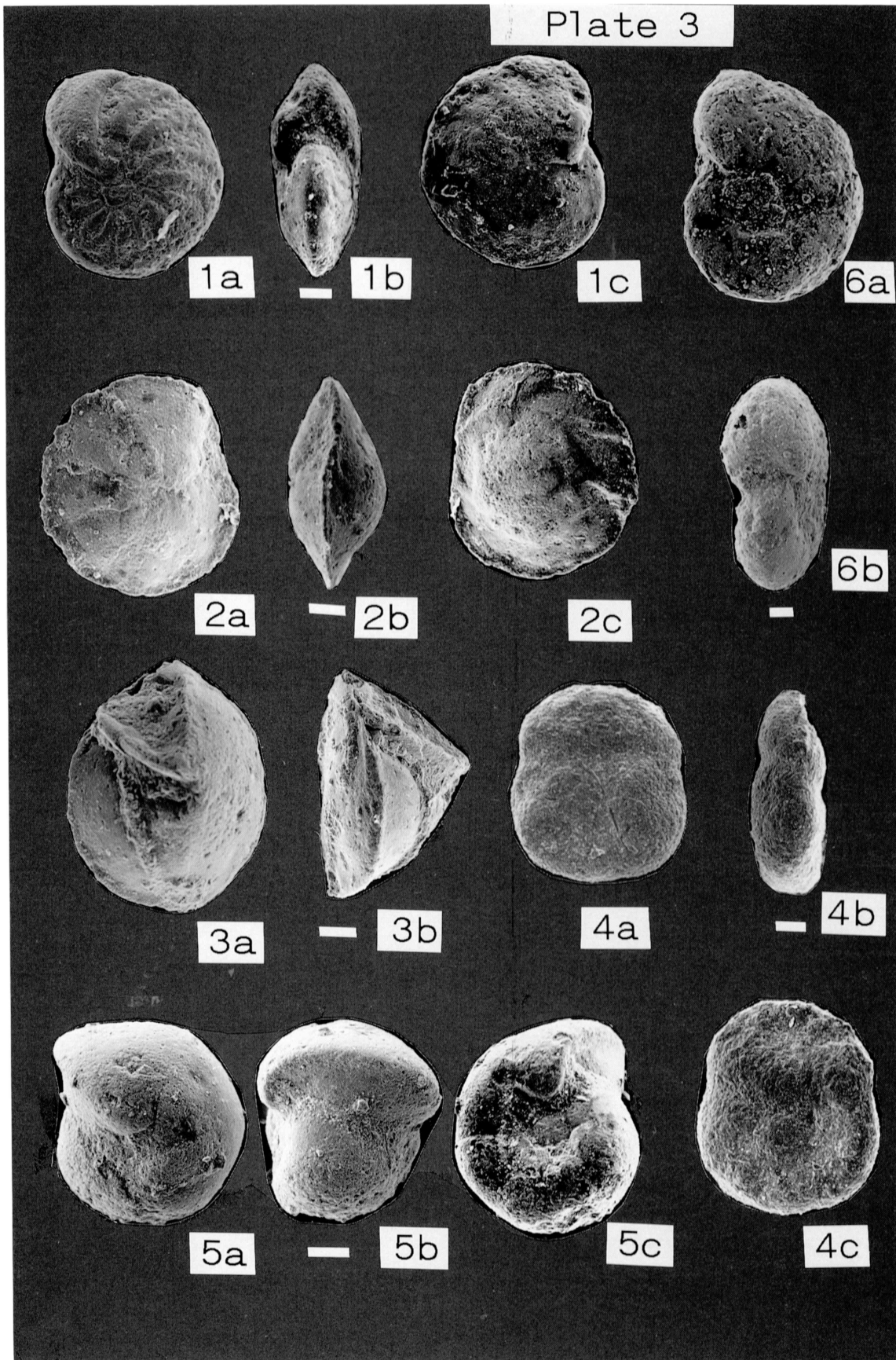
- Figs. 50a-c. *Oridorsalis mariei* (Said and Kenawy), sample PAK-13
Figs. 51a-c. *Haplophragmoides* sp., sample PAK-18
Figs. 52a-c. *Nuttallides truempyi* (Nuttall), PAK-32
Figs. 53a-c. *Operculina* sp., sample IIR-24.
Figs. 64, 67. *Uvigerina havanensis* Cushman and Bermudez, sample IIR-20
Fig. 65. *Gaudryina pyramidata* Cushman, sample MG-2
Fig. 66. *Pleurostomella* sp., sample IIR-7

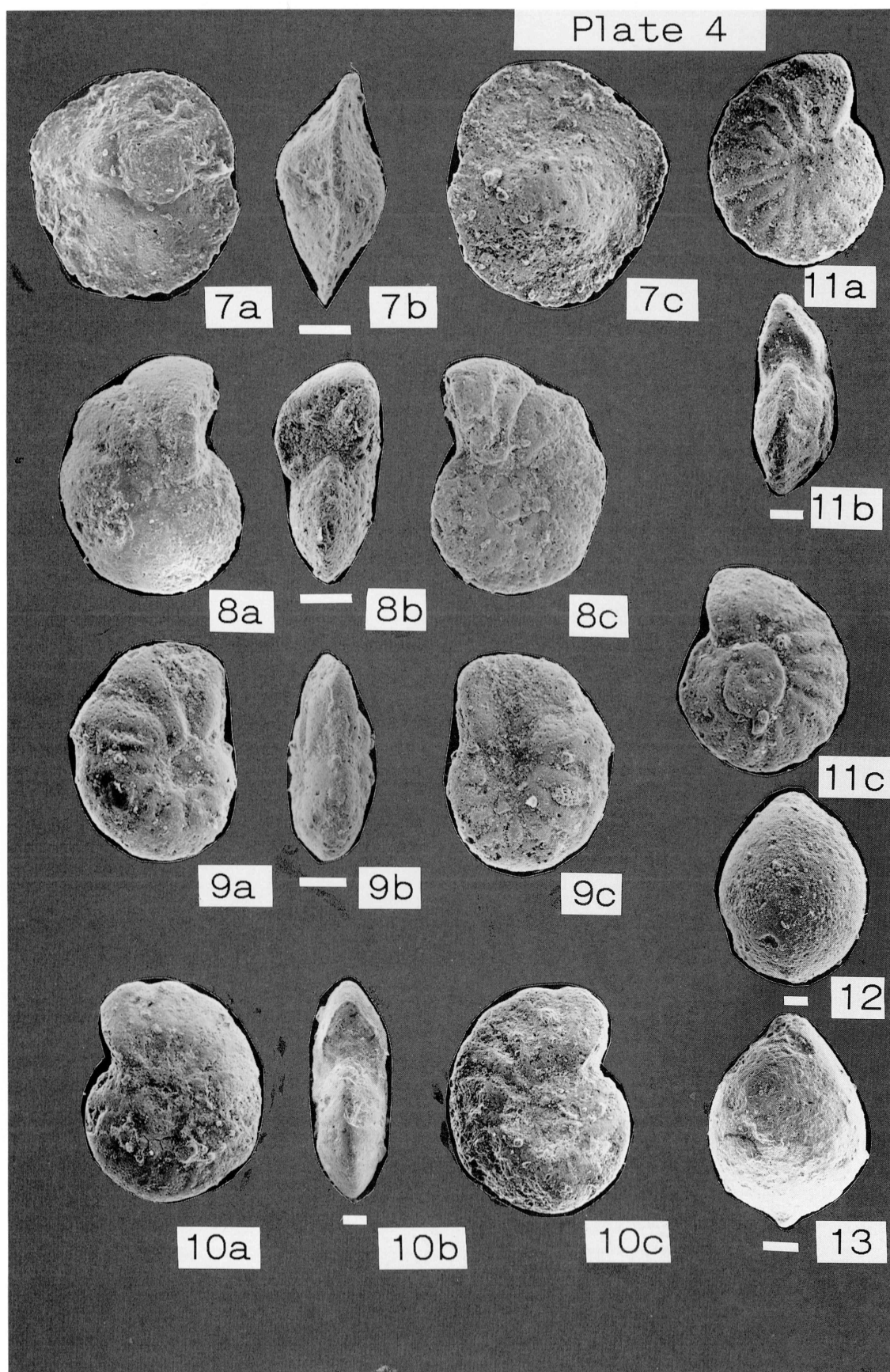
Plate 12

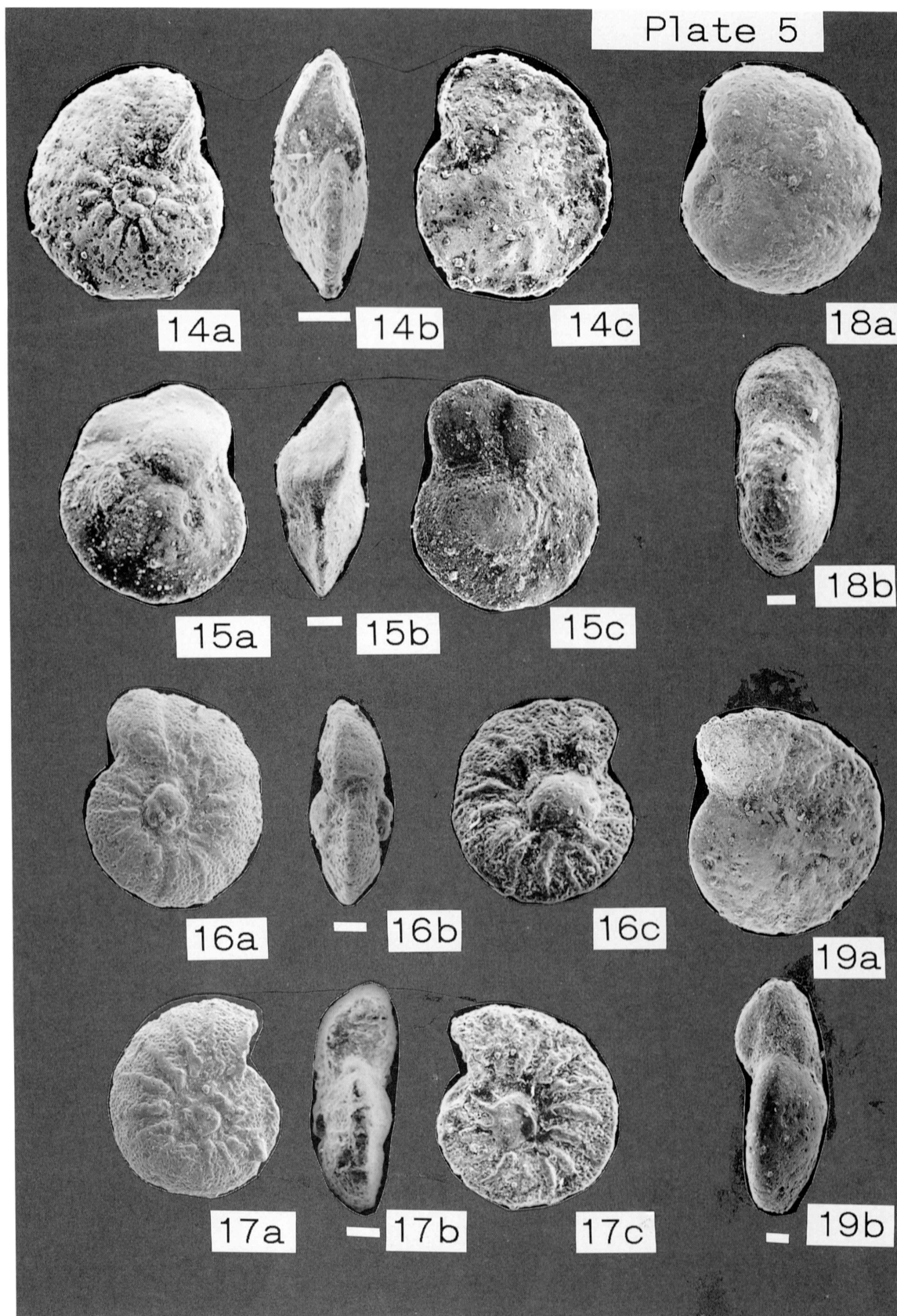
- Figs. 1a-d. *Globotruncana* spp., sample HR-2
Fig. 2. *Heterohelix* sp., Sample HR-2
(studied by thin sections).

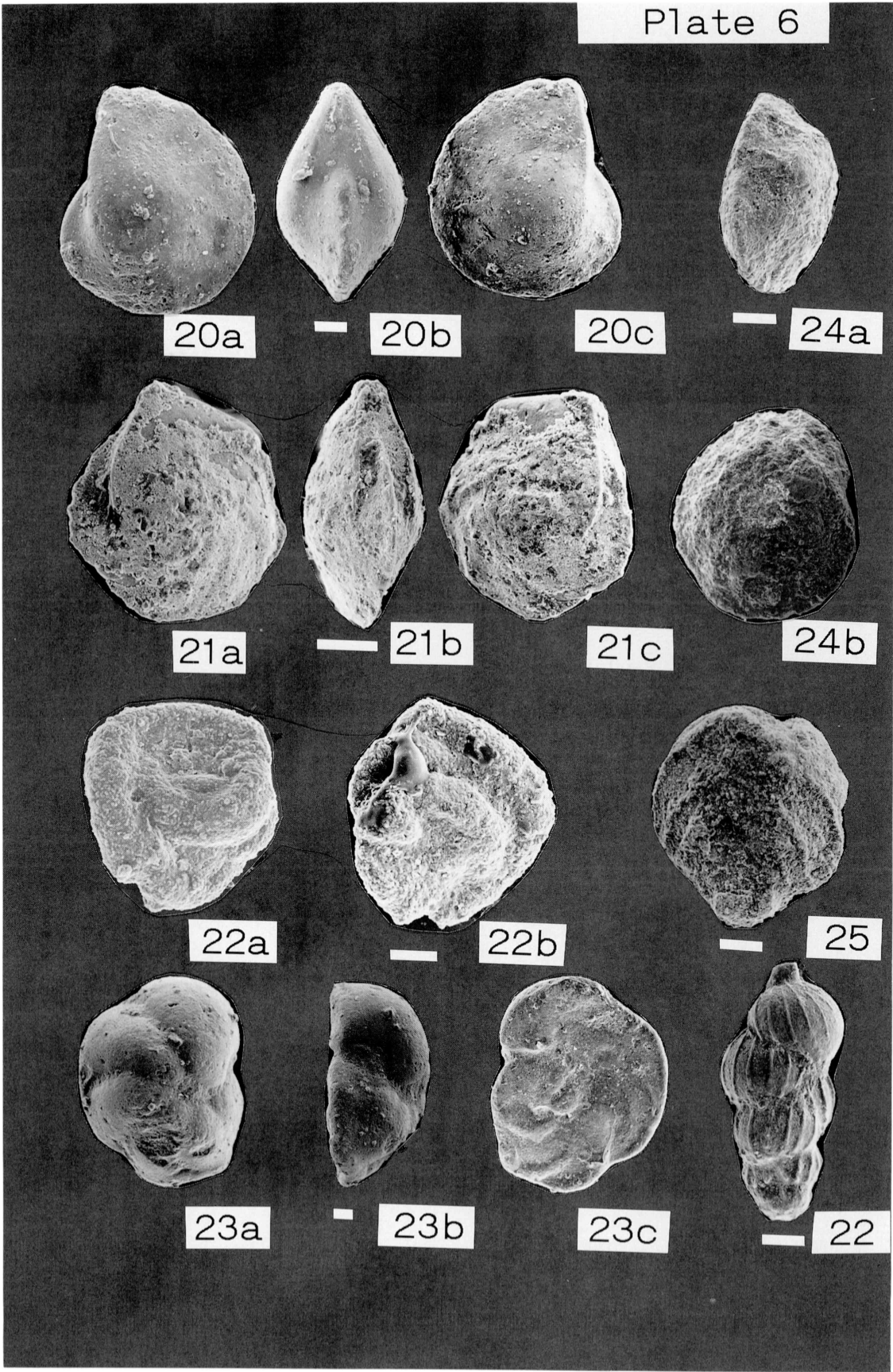


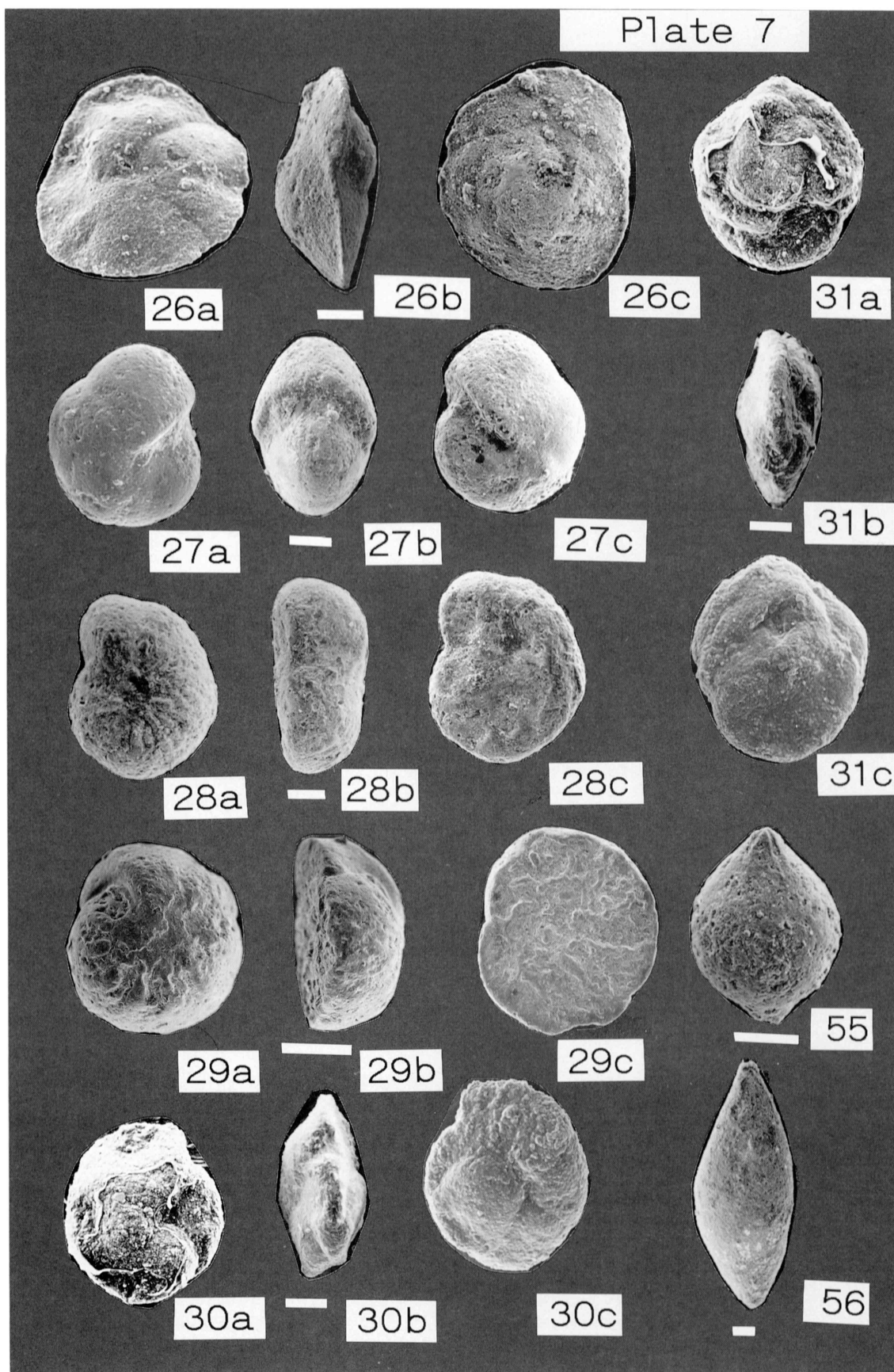


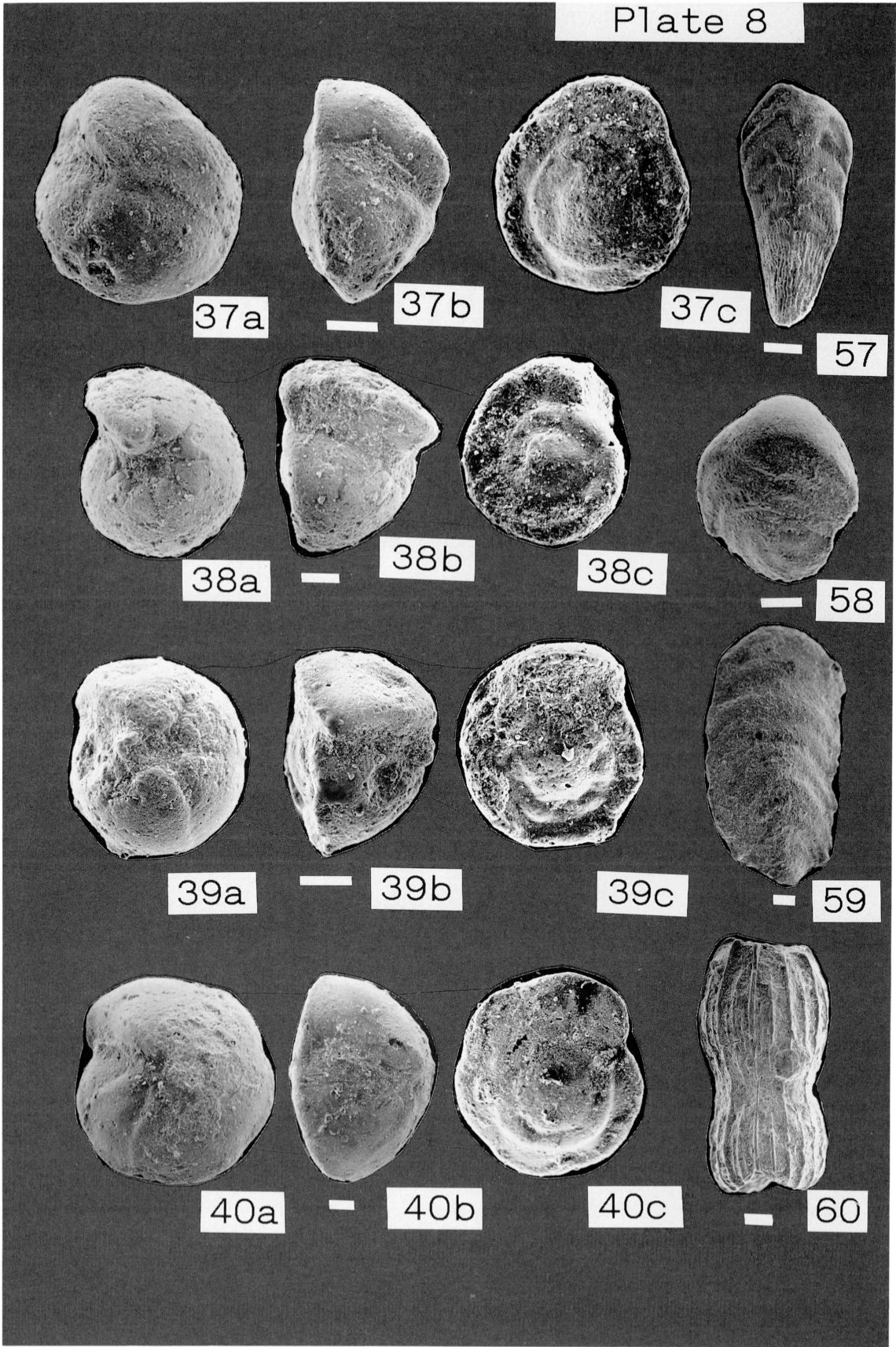


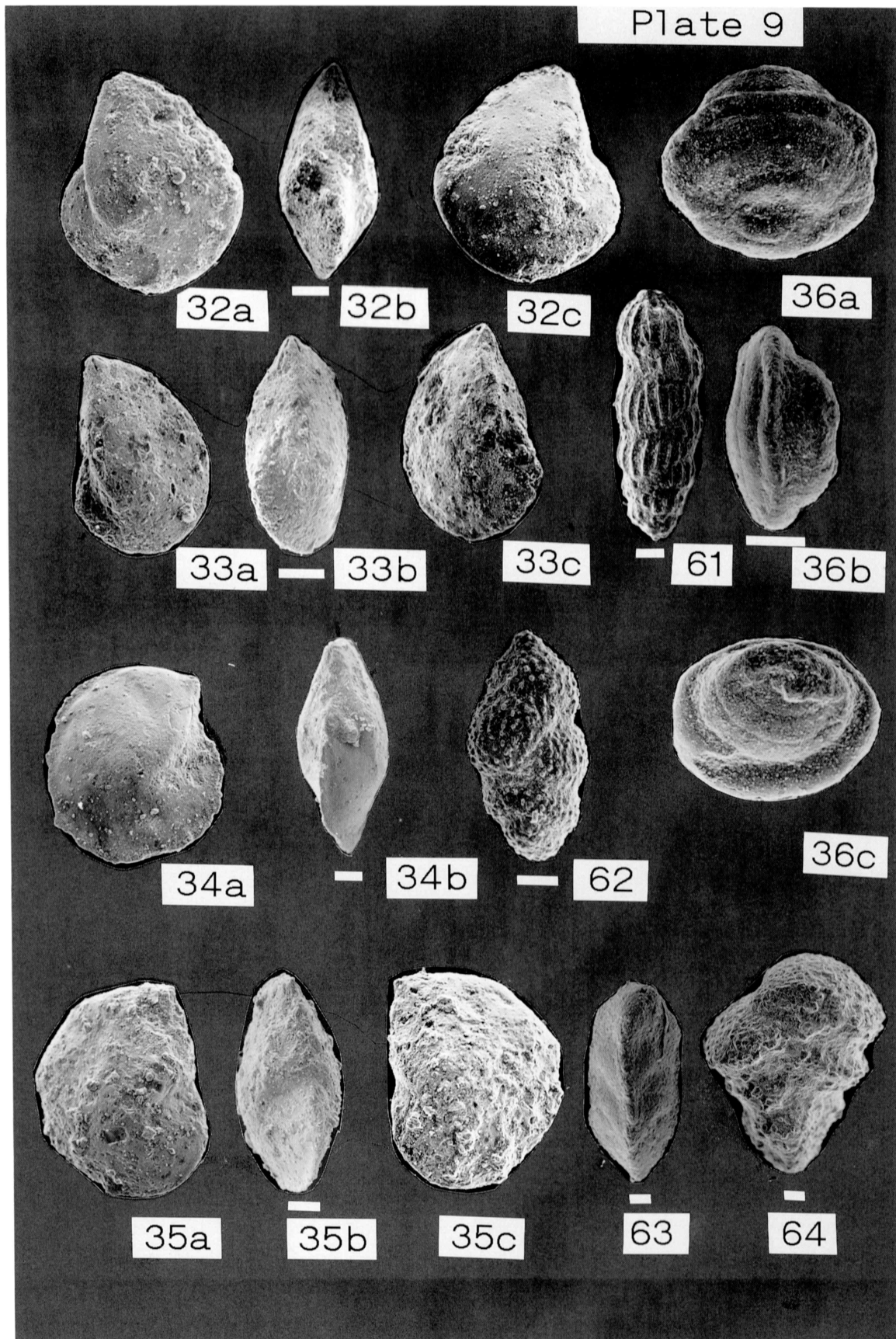


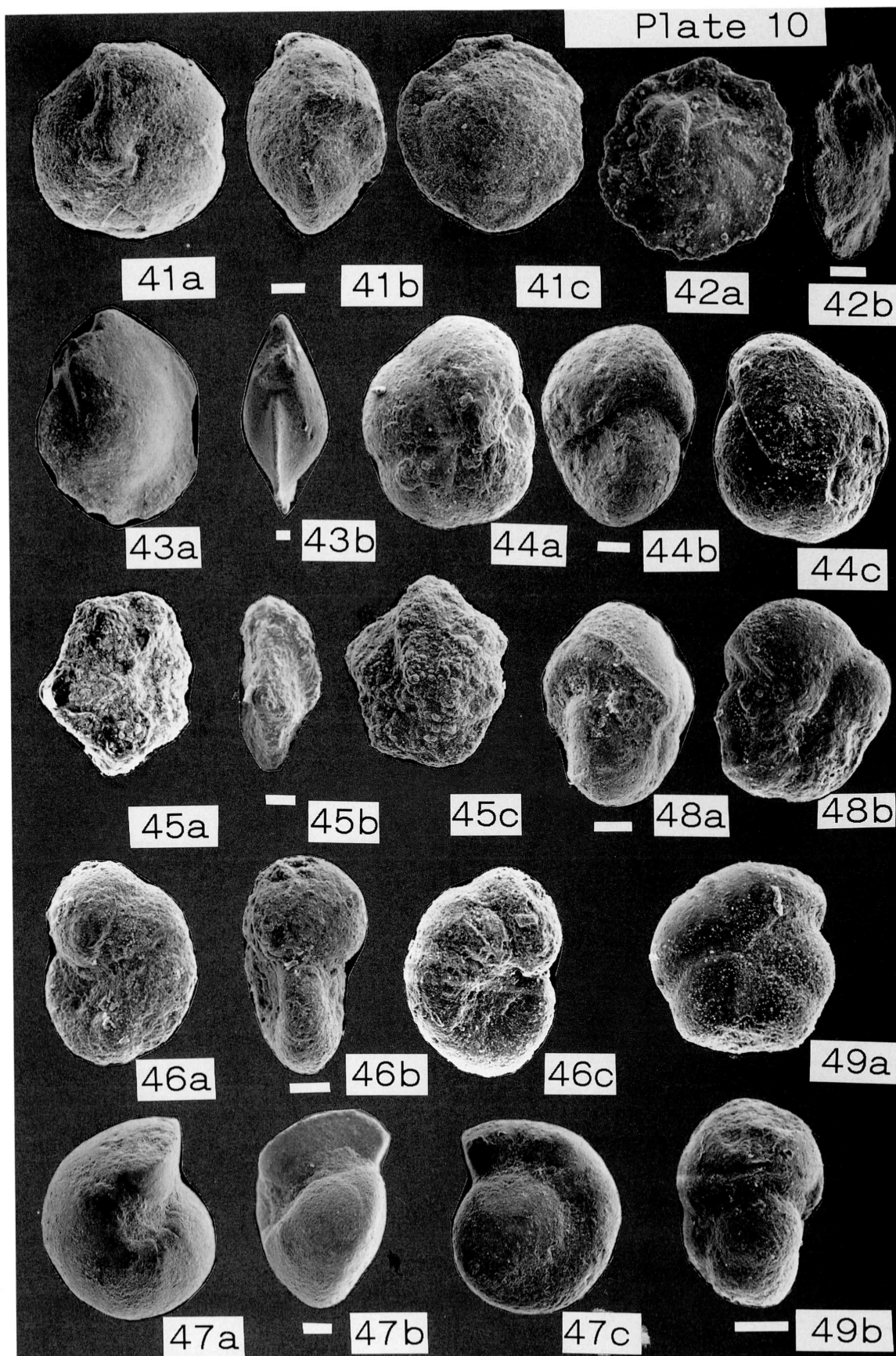


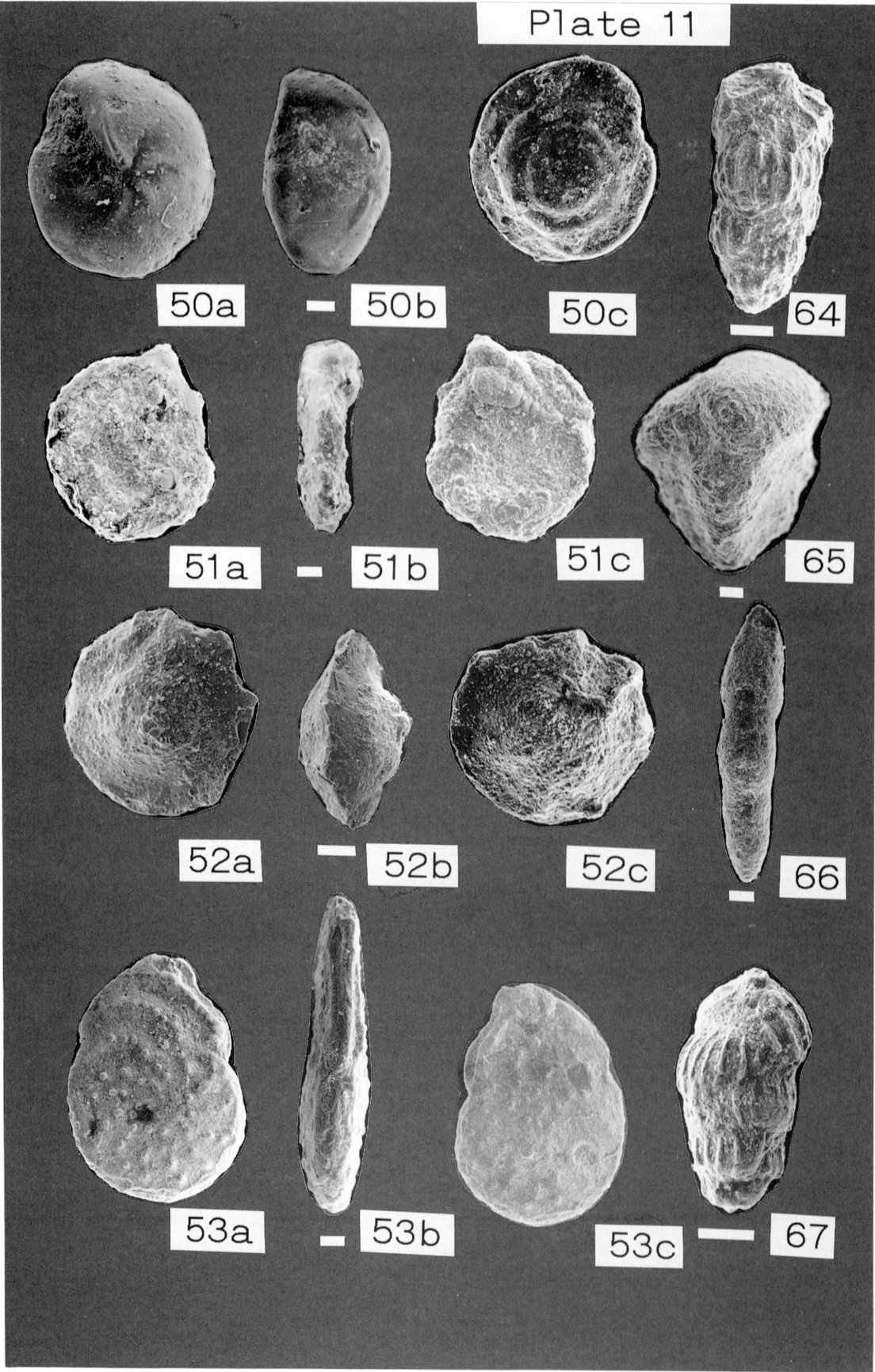


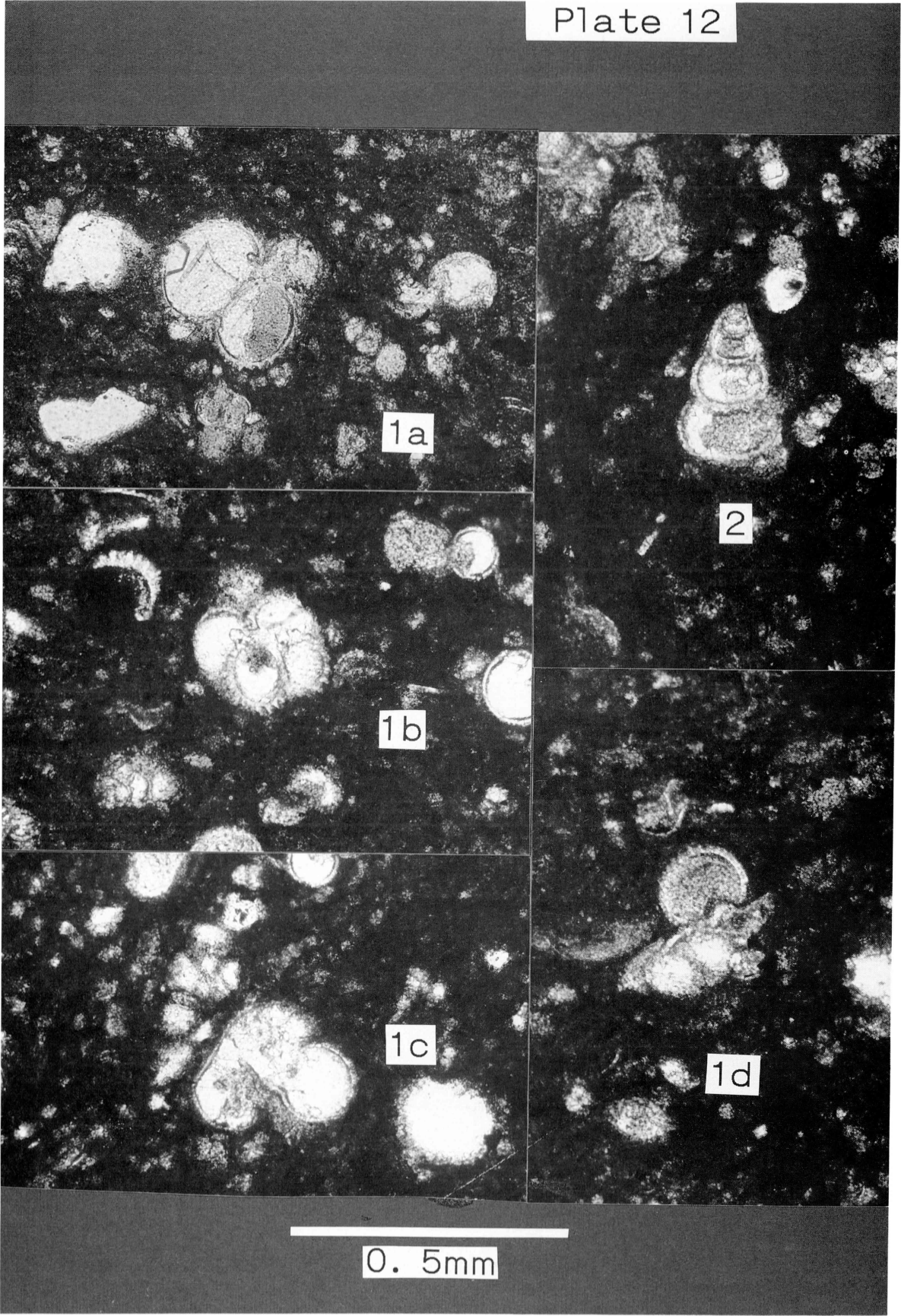












SPECIES OCCURRENCE LIST OF PAK-SECTIN

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SPECIES OCCURRENCE LIST OF MG- SECTION

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SPECIES OCCURRENCE LIST OF HR-SECTION

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