Nannoplankton and foraminifera biostratigraphy and microfacies of the Cretaceous to Cenozoic post-platform series (Mazagan Escarpment, Morocco)

Nannofossils
Foraminifera
Cretaceous
Tertiary
Mazagan Plateau (Morocco)

Nannofossiles
Foraminifères
Crétacé
Tertiaire
Plateau de Mazagan (Maroc)

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ABSTRACT

The paper summarizes the biostratigraphic results of eighteen dives of the French submersible Cyana at the Mazagan Escarpment (CYAMAZ cruise), based on calcareous nannoplankton and foraminifera. Although 130 rock samples were investigated on calcareous nannofossils in smear slides, this paper is restricted to the study of the Early Cretaceous to Quaternary post-platform series.
Most of the stratigraphical data are based on the determination of calcareous nannofossils (P. Čepek) which, however, are mostly poorly preserved and of rare occurrence (Fig.). From the 170 studied subsamples 49 are barren of calcareous nannoplankton. In the Table all identified calcareous nannofossils in all studied samples are listed according to the species epithets, separated for the Cretaceous and Tertiary.
The biostratigraphy based on foraminifera and the microfacies was studied in thin-sections (H. Hagn). Foraminiferal microfaunas of Late Cretaceous, Paleocene, Eocene-Oligocene and Quaternary age are described and shown in Plates 1-3.

Oceanol. Acta, **1984.** Submersible Cyana studies of the Mazagan Escarpment (Moroccan continental margin), CYAMAZ cruise 1982, 101-110.

RÉSUMÉ

Biostratigraphie et microfaciès des nannofossiles et des foraminifères des séries post-plateforme du Crétacé au Cénozoïque (escarpement de Mazagan, Maroc)

Cet article résume les résultats biostratigraphiques de 18 plongées du submersible français Cyana sur l'escarpement de Mazagan (campagne CYAMAZ), basés sur des nannoplanctons calcaires et des foraminifères. Bien qu'on ait observé 130 frottis de roches à nannofossiles calcaires, l'étude est limitée à des séries post-plateforme du Crétacé inférieur au Quaternaire.
La plupart des données stratigraphiques proviennent de la détermination de nannofossiles calcaires (P. Čepek), pourtant rares et médiocrement préservés (fig.). Sur 170 sous-échantillons étudiés, 49 sont dépourvus de nannoplancton calcaire. Tous les nannofossiles calcaires identifiés sont classés dans le tableau en suivant les épithètes d'espèces, séparément pour le Crétacé et pour le Tertiaire.
La biostratigraphie fondée sur les foraminifères et les microfaciès a été étudiée en lames minces (H. Hagn). Les foraminifères du Crétacé supérieur, du Paléocène, de l'Éocène-Oligocène et du Quaternaire sont décrits et présentés sur les planches 1 à 3.

Oceanol. Acta, **1984.** Études par le submersible Cyana de l'escarpement de Mazagan (marge continentale marocaine), campagne CYAMAZ 1982, 101-110.

INTRODUCTION

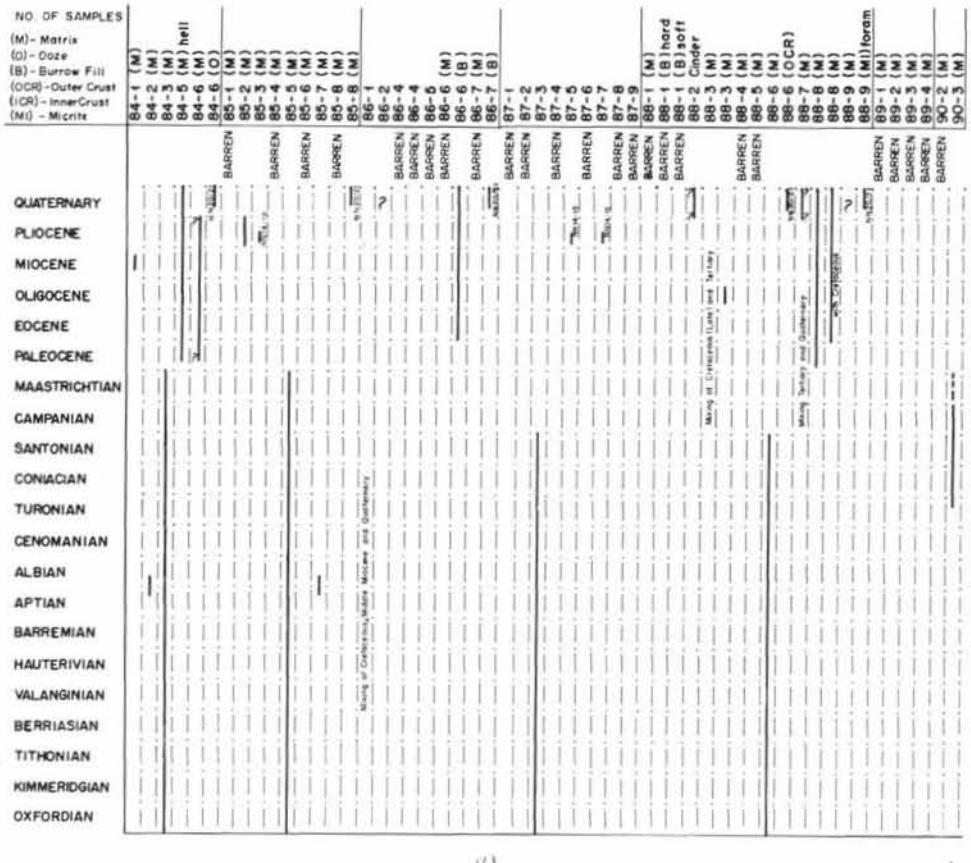
Within the last 15 years many expeditions have been working in the area of the Mazagan Escarpment, located about 200 km southwest of Casablanca in the central eastern Atlantic. These expeditions (*see* Auzende *et al.*, this vol.) resulted in new information about the structure, stratigraphy and lithology of the Mazagan Plateau area. The French-German CYAMAZ deep diving project, however, was the first expedition, which made it possible to observe and sample the almost 3 000 m high cliff of the Mazagan Escarpment directly, using the French submersible Cyana SP 3000. During eighteen dives between 3000 and 1000 m water depth, 130 rock samples were taken. In this paper we discuss only the biostratigraphical results of the Cretaceous to Cenozoic post-platform series, although the Table and the Figure contain the determinations of all CYAMAZ samples. The investigation of the calcareous nannofossils is provided by Čepek, that of the foraminifera by Hagn.

MATERIALS AND METHODS

Most of the 130 rock samples are hard, consolidated rocks and only some samples soft sediments. All samples were investigated for calcareous nannofossils by shipboard and shore-based smear slides (Čepek). The 170 smear slides were prepared by Čepek and Zika and a Zeiss microscope was used with a magnification of 1 500 x. The nannofossils are mostly poorly preserved and predominantly rare in occurrence. For the Tertiary calcareous nannoplankton stratigraphy we used the zonation of Martini (1971), for the Late Cretaceous the stratigraphy of Sissingh (1977), Perch-Nielsen (1979), and Pflaumann and Čepek (1982). The rock samples were investigated by microfacies methods (*see* Steiger, Cousin ; von Rad, this vol.). The thin-sections were provided to Hagn by Steiger and Fuchs (München) ; Höck (München) made the microphotographs.

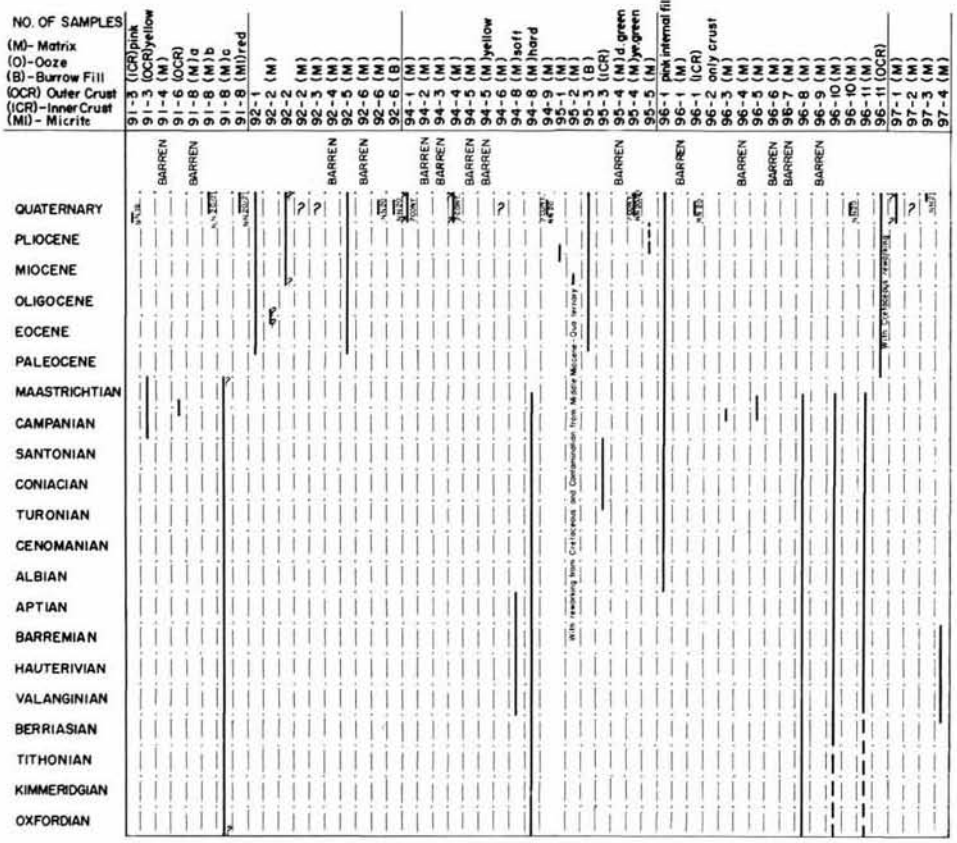
POST-PLATFORM SERIES OF CRETACEOUS TO QUATERNARY SEDIMENTS

The results are stratigraphically arranged in six paragraphs : Early Cretaceous, Late Cretaceous, Paleocene, Eocene to Oligocene, Miocene to Pliocene, and Quaternary. Most of the stratigraphical determinations indicated a Cretaceous and Quaternary age, but the Quaternary assignation is predominantely due to subrecent burrow and pocket fills or to crusts within or on older rocks.

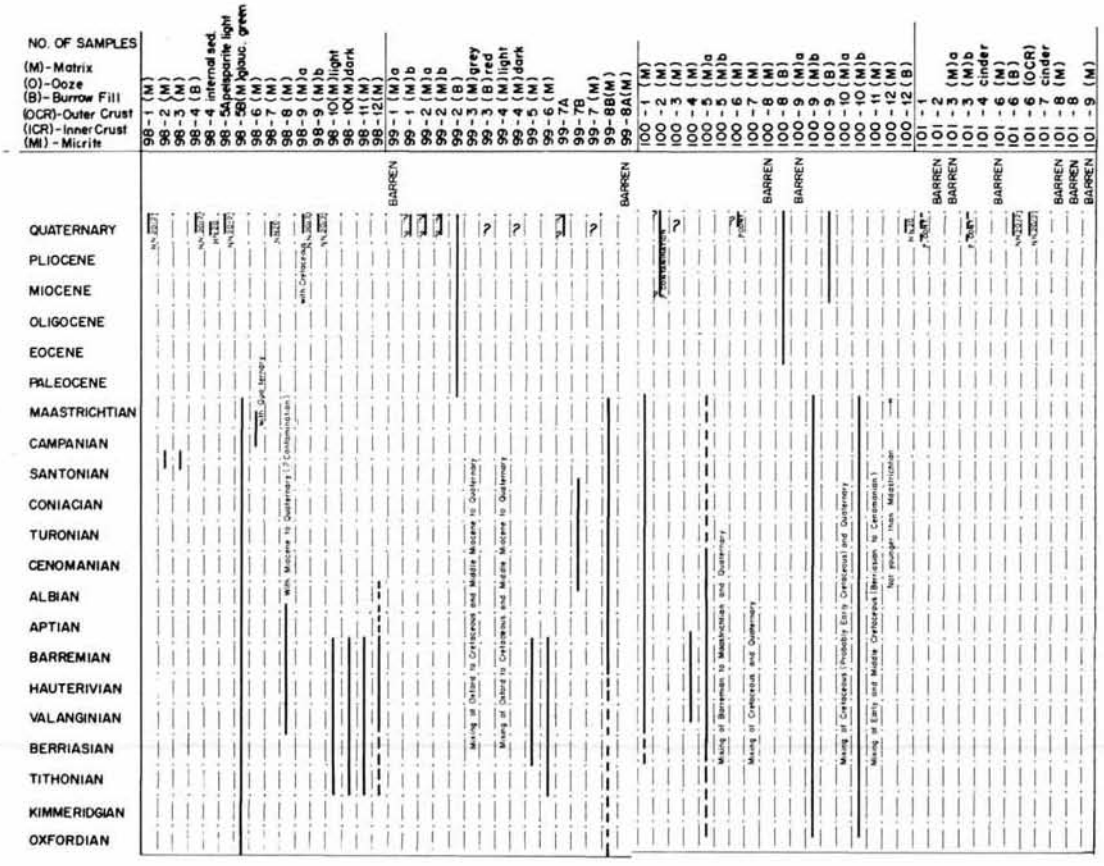


Figure

Biostratigraphical age of all CYAMAZ samples, based on calcareous nannoplankton determinations (Čepek). Cont. = contamination. NN20 etc. nannofossilzones after Martini (1971).


NO. OF SAMPLES
(M)- Matrix
(O)- Ooze
(B)- Burrow Fill
(OCR) Outer Crust
(ICR)- Inner Crust
(MI) - Micrite
QUATERNARY
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
MAASTRICHTIAN
CAMPANIAN
SANTONIAN
CONIACIAN
TURONIAN
CENOMANIAN
ALBIAN
APTIAN
BARREMIAN
HAUTERIVIAN
VALANGINIAN
BERRIASIAN
TITHONIAN
KIMMERIDGIAN
OXFORDIAN

b)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APTIAN
BARREMIAN
HAUTERIVIAN
VALANGINIAN
BERRIASIAN
TITHONIAN
KIMMERIDGIAN
OXFORDIAN

c)

Table

Calcareous nannofossil species determined in CYAMAZ samples, listed alphabetically according to the species epithets for (a) Cretaceous and (b) Tertiary.

CRETACEOUS

Corollithion achylosum (Stover)
Ceratolithoides aculeus (Stradner)
Cretarhabdus angustiforatus (Black)
Parhabdolithus cf. *angustus* (Stradner)
Reinhardtites anthophorus (Deflandre)
Parhabdolithus asper (Stradner)
Watznaueria barnesae (Black)
Watznaueria biporta Bukry
Lithraphidites carniolensis Deflandre
Cruciellipsis cf. *chiastia* (Worsley)
Watznaueria communis Reinhardt
Micula cf. *concava* (Stradner)
Biscutum constans (Gorka)
Cretarhabdus crenulatus Bramlette and Martini
Prediscosphaera cretacea (Arkhangelsky)
Arkhangelskiella cymbiformis Vekshina
Microrhabdulus decoratus Deflandre
Micula decussata Vekshina
Cyclagelosphaera deflandrei (Manivit)
Glaukolithus diplogrammus (Deflandre)
Cribrosphaerella ehrenbergi (Arkhangelsky)
Parhabdolithus embergeri (Noel)
Zygodiscus erectus (Deflandre)
Eiffellithus eximius (Gorka)
Lithastrinus floralis Stradner
Marthasterites furcatus (Deflandre)
Nannoconus globulus Bronnimann
Lithastrinus grilli Stradner
Rucinolithus hayii Stover
Parhabdolithus cf. *infinitus* (Worsley)
Nannoconus kamptneri Bronnimann
Stephanolithion laffittei Noel
Cyclagelosphaera lehmani (Noel)
Chiastozygus litterarius (Gorka)
Cretarhabdus loriei Gartner
Kamptnerius magnificus Deflandre
Cyclagelosphaera margereli Noel
Vagalapilla cf. *matalosa* (Stover)
Conusphaera mexicana Trejo
Gartnerago obliquum (Stradner)
Micrantholithus obtusus Stradner
Tranolithus orionatus (Reinhard)
Broinsonia parca (Stradner)
Manivitella pemmatoidea (Deflandre)
Tetralithus pyramidus Gardet
Prediscosphaera spinosa (Bramlette and Martini)
Nannoconus steinmanni Kamptner
Microrhabdulus stradneri Bramlette and Martini
Vagalapilla stradneri (Rood, Hay and Barnard)
Quadrum trifidum (Stradner)
Nannoconus truitti Bronnimann
Eiffellithus turriseiffeli (Deflandre)
Cretarhabdus sp.
Eiffellithus sp.
Lithraphidites sp.
Nannoconus sp.
Prediscosphaera sp.
Watznaueria sp.
Zygodiscus sp.

TERTIARY

Cyclolithella annula (Cohen)
Oolithotus antillarum (Cohen)
Gephyrocapsa aperta Kamptner
Scyphosphaera apsteini Lohmann
Discoaster asymmetricus Gartner
Braarudosphaera bigelowi (Gran and Braarud)
Reticulofenestra bisecta (Hay, Mohler and Wade)
Discoaster brouweri Tan Sin Hok
Discoaster cf. *calcaris* (Gartner)
Gephyrocapsa caribbeanica Boudreaux and Hay
Discoaster challengeri Bramlette and Riedel
Rhabdosphaera clavigera Murray and Blackman
Heliorthus concinnus (Martini)
Discoaster deflandrei Bramlette and Riedel
Amaurolithus delicatus Gartner and Bukry
Reticulofenestra dictyoda (Deflandre and Fert)
Discolithina discopora Schiller
Sphenolithus distentus (Martini)
Discolithina distincta (Bramlette and Sullivan)
Coccolithus doronicoides Black and Barnes
Discoaster cf. *druggi* Bramlette and Wilcoxon
Helicopontosphaera euphratis (Haq)
Discoaster cf. *exilis* Martini and Bramlette
Scapholithus fossilis Deflandre
Helicopontosphaera granulata Bukry and Percival
Thoracosphaera heimi (Lohmann)
Emiliania huxleyi (Lohmann)
Discolithina japonica Takayama
Helicopontosphaera kamptneri Hay and Mohler
Discoaster kugleri Martini and Bramlette
Pseudoemiliania lacunosa (Kamptner)
Cyclococcolithus leptoporus (Murray and Blackman)
Ellipsodiscoaster lidzi Boudreaux and Hay
Cyclococcolithus cf. *lusitanicus* (Black)
Umbilicosphaera mirabilis Lohmann
Sphenolithus cf. *moriformis* (Bronnimann and Stradner)
Cyclococcolithus neogammation Bramlette and Wilxocon
Coronocyclus nitescens Kamptner
Gephyrocapsa oceanica Kamptner
Coccolithus pelagicus (Wallich)
Discoaster pentaradiatus Tan Sin Hok
Sphenolithus predistentus Bramlette and Wilcoxon
Reticulofenestra pseudoumbilica (Gartner)
Syracosphaera pulchra Lohmann
Helicopontosphaera cf. *recta* (Haq)
Ceratolithus cf. *rugosus* Bukry and Bramlette
Thoracosphaera saxea Stradner
Reticulofenestra cf. *scissura* Hay, Mohler and Wade
Helicopontosphaera sellii Bukry and Bramlette
Aspidorhabdus stylifer (Lohmann)
Discoaster surculus Martini and Bramlette
Discoaster tamalis Kamptner
Cruciplacolithus tenuis (Stradner)
Discoaster cf. *variabilis* Martini and Bramlette
Helicopontosphaera wallichi (Lohmann)
Cruciplacolithus sp.
Cyclococcolithus sp.
Discoaster sp.
Discolithina sp.
Gephyrocapsa sp.
Helicopontosphaera sp.
Reticulofenestra sp.
Scyphosphaera sp.
Sphenolithus sp.
Thoracosphaera sp.

Early Cretaceous

Based on the determination of calcareous nannoplankton, there are two groups of Early Cretaceous samples :

1) (Late Berriasian) Valanginian-Barremian (to early Aptian) sandy calcarenites and belemnite-iron oolite bearing micrites (CZ 94-8, 97-4, 98-8, 98-10, 98-11, 98-12, 99-5, 99-6, 100-4) with :

Species	Sample
Cretarhabdus angustiforatus (Black)	CZ 97-4, 98-12
Zygodiscus diplogrammus (Deflandre)	CZ 94-8, 98-12 (*cf.*), 100-4
Nannoconus globulus Bronnimann	CZ 97-4
Nannoconus kamptneri Bronnimann	CZ 94-8
Conusphaera mexicana Trejo	CZ 97-4
Micrantholithus obtusus Stradner	CZ 98-8
Nannoconus steinmanni Kamptner	CZ 97-4, 98-8 (*cf.*), 98-10, 98-11, 98-12 (*cf.*), 99-5, 99-6, 100-4

2) Quartz-bearing nanno marls and claystones of late Aptian to early Albian age (84-2, 85-7) with :

Species	Sample
Corollithion achylosum (Stover)	CZ 84-2, 85-7
Parhabdolithus angustus (Stradner)	CZ 84-2 (*cf.*)
Eprolithus apertior Black	CZ 84-2
Cruciellipsis chiastia (Worsley)	CZ 84-2, 85-7 (*cf.*)
Lithastrinus floralis Stradner	CZ 85-7
Parhabdolithus infinitus (Worsley)	CZ 84-2
Chiastozygus litterarius (Gorka)	CZ 84-2, 85-7 (*cf.*)
Nannoconus truitti Bronnimann	CZ 84-2, 85-7

but without *Eiffellithus turriseiffeli* (Deflandre) and genus Prediscosphaera ; *see* also von Rad, this vol. for discussion.

Late Cretaceous

There are only 10 samples which contain Late Cretaceous nannofossils. In 15 samples the age could be determined only as " Oxfordian to Maastrichtian " and therefore it is not certain, if the samples are Late Jurassic or Cretaceous in age.

Late Cretaceous calcareous nannofossils were determined in samples CZ 90-3, 91-3, 91-6, 95-3, 96-3, 96-5, 98-2, 98-3 and 99-7B. Due to dissolution and/or recrystallization, the preservation of the nannofossils is predominantely poor. Only chalk sample CZ 98-3 and 2 from the base of the Central Mazagan Escarpment contains abundant and well preserved nannofossils of late Santonian to early Campanian age. This spectacular horizon was found for the first time in the Mazagan Plateau area. Previously, it was thought that a major hiatus spans the Santonian-Campanian. No index species were found for the Cenomanian and late Maastrichtian. We determined the following index species :

Species	Sample
Ceratolithoides aculeus (Stradner)	CZ 96-5
Arkhangelskiella cymbiformis Vekshina	CZ 91-3
Eiffellithus eximius (Gorka)	CZ 90-3, 95-3, 98-2, 98-3
Lithastrinus floralis Stradner	CZ 95-3, 99-7B
Marthasterites furcatus (Deflandre)	CZ 98-2, 98-3
Lithastrinus grilli Stradner	CZ 98-2, 98-3
Quadrum trifidum (Stradner)	CZ 91-6, 96-5

Only two of the thin-sections investigated for foraminifera gave a Late Cretaceous age. The basal part of sample CZ 84-3 (upper part of southern Mazagan Escarpment) consists of a variegated breccia (*see* von Rad, this vol.). The very fine-grained, red, unfossiliferous matrix carries numerous white limestone clasts of Late Jurassic age. They are covered or surrounded by a buff, more or less phosphatic micrite containing some small quartz grains, greenish to brown glauconite grains, as well as rare clasts of Upper Jurassic limestones (Plate 1 : Fig. 1). A small (length : 3.5 mm) sharp-edged clast proved to be a grey micrite with minute tests of the genera *Hedbergella* and *Heterohelix* (Aptian-Late Cretaceous).

The buff micrite carries one- and double-keeled Globotruncanas : *Gl.* cf. *stuarti* (De Lapp.), *Gl.* cf. *tricarinata* (Quereau) and *Gl. bulloides* Vogler. In addition *Heterohelix* cf. *reussi* (Cushm.) (Plate 1 : Fig. 2) and tests of the genera *Hedbergella, Whiteinella* and *Globigerinelloides* could be observed. The age of the micrite is Maastrichtian.

The second Late Cretaceous age was determined in one of two thin-sections of the sample CZ 92-2 (southeastern Mazagan Plateau horst). The first thin-section shows a brownish (phosphoritic ?) matrix with grains of glauconite like the sample CZ 84-3. A burrow is filled with densely packed grains of glauconite. The microfauna of the micrite consists of numerous Heterohelicidae (*Heterohelix* and *Pseudotextularia*) and the genera *Hedbergella, Whiteinella* and *Globigerinelloides*. In addition, one- and double-keeled Globotruncanas were observed. The age is Maastrichtian.

Paleocene

A Paleocene age was determined in three samples. In the fourth sample the Paleocene age is only that of a burrow fill in a Upper Jurassic limestone. The Paleocene age was only determined by foraminifera. No Paleocene index species of calcareous nannoplankton were found. There are eight samples which cover also Paleocene, but the range of the calcareous nannofossils determined in these samples is longer and passes into younger stages.

The following samples are Paleocene in age :

Sample CZ 92-4 consists mainly of a light-colored Globigerina limestone. The shells of the pelagic foraminifera are small-sized and densely packed (Plate 2 : Fig. 3). In addition to the globigerines the genera *Planorotalites, Morozovella* and *Acarinina* were observed. The species *Planorotalites ehrenbergi* (Bolli), *Pl. pusillus* (Bolli) and *Morozovella* cf. *angulata* (White) could be determined. The benthos is represented by rare *Lenticulina* and numerous Bolivinas which can be referred to *B. midwayensis* Cushm. Furthermore, fish remains are present. The age of this sample is middle Paleocene in a basinal facies.

A light-colored radiolarian limestone (sample CZ 92-5) contains numerous pelagic foraminifera (*Globigerina, Planorotalites, Morozovella* and *Chiloguembelina*). *Morozovella* cf. *angulata* (White) indicates a middle Paleocene age. In addition, numerous specimens of *Bolivina midwayensis* Cushm. and other

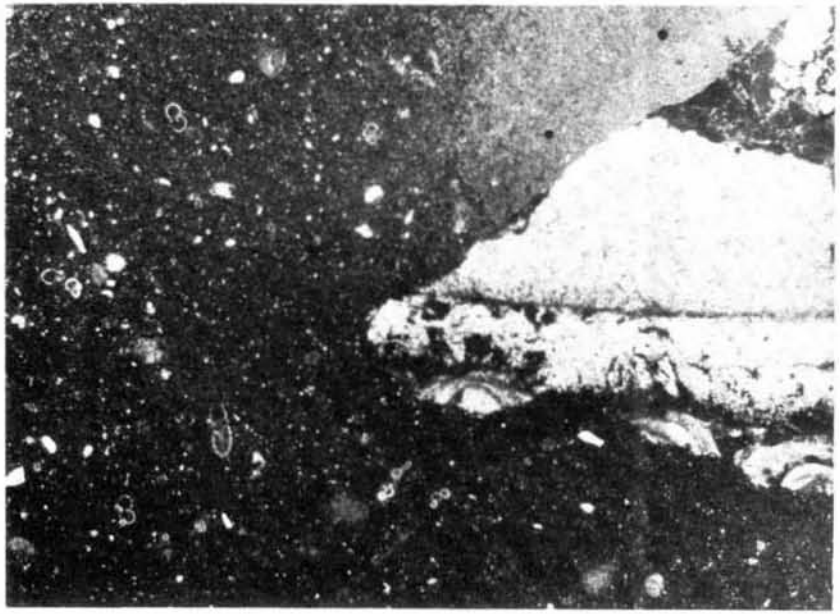

Figure 1

CZ 84-3 : Micrite (Maastrichtian) with small sized pelagic foraminifera. On the right side a clast of a limestone of Upper Jurassic (× 22,5).

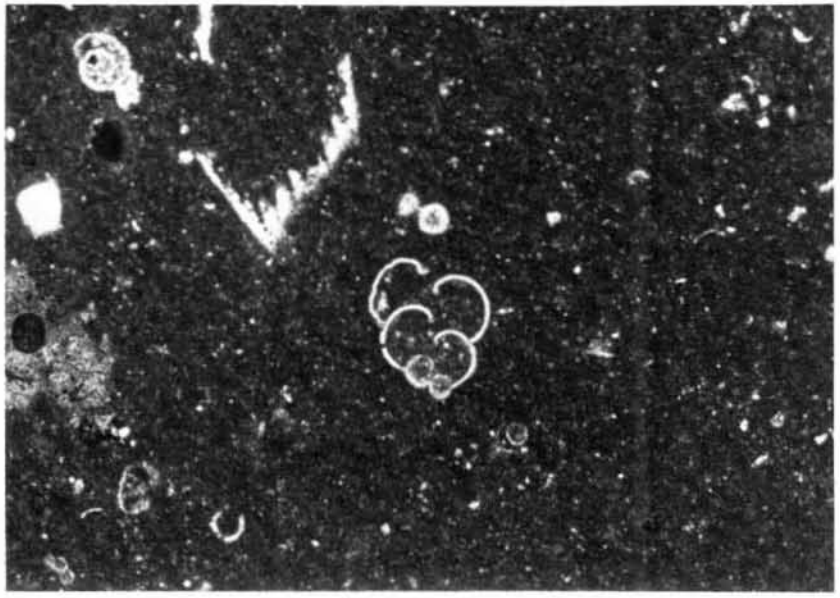

Figure 2

The same thin section. In the center Heterohelix cf. reussi (Cushm ; × 50).

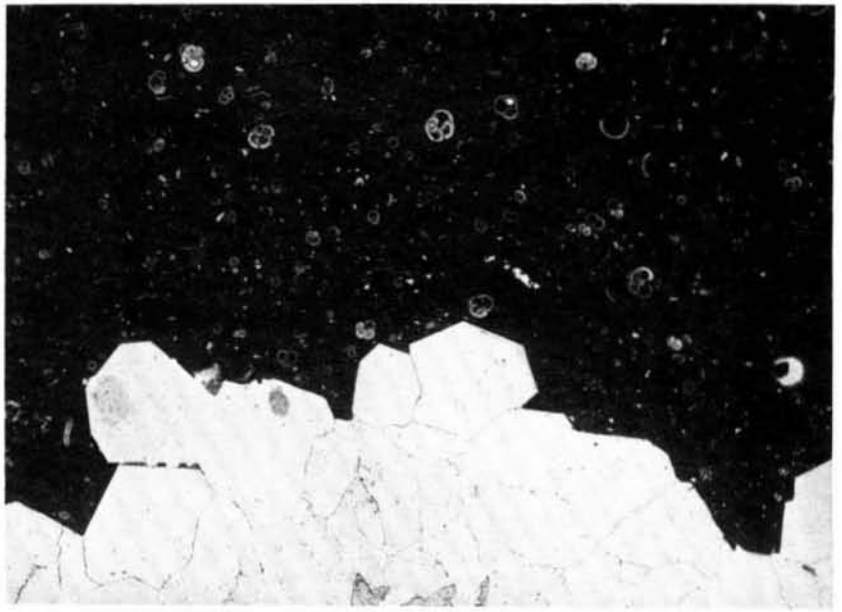

Figure 3

CZ 88-6 : In the lower part blocky cement riming a small pocket of a mesozoic limestone. On top pelite with pelagic foraminifera. Upper Paleocene (× 17).

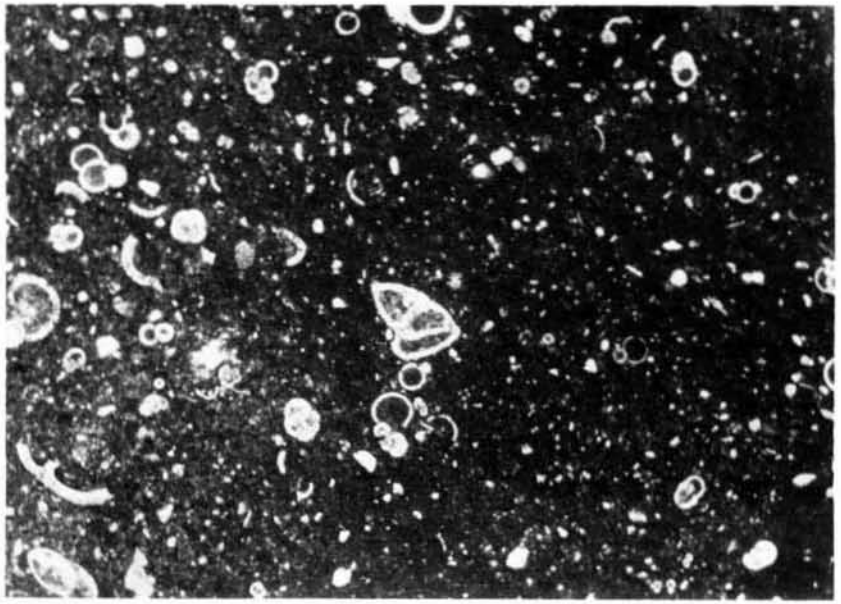

Figure 4

The same thin section. Red pelite with Globigerina and Morozovella (× 50).

Plate 1

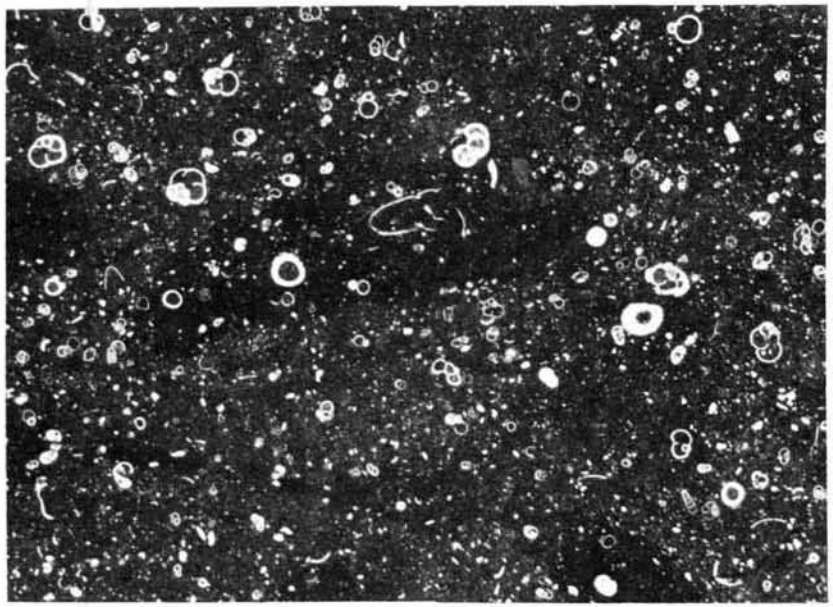

Figure 1
CZ 88-6. Red pelite with indications of bioturbation (x 22,5).

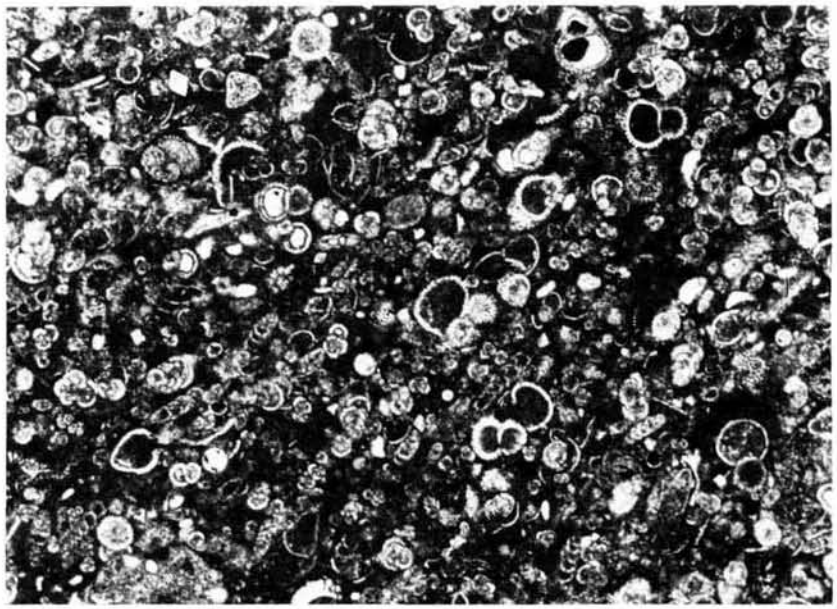

Figure 3
CZ 92-4. Globigerina limestone. Middle Paleocene (x 50).

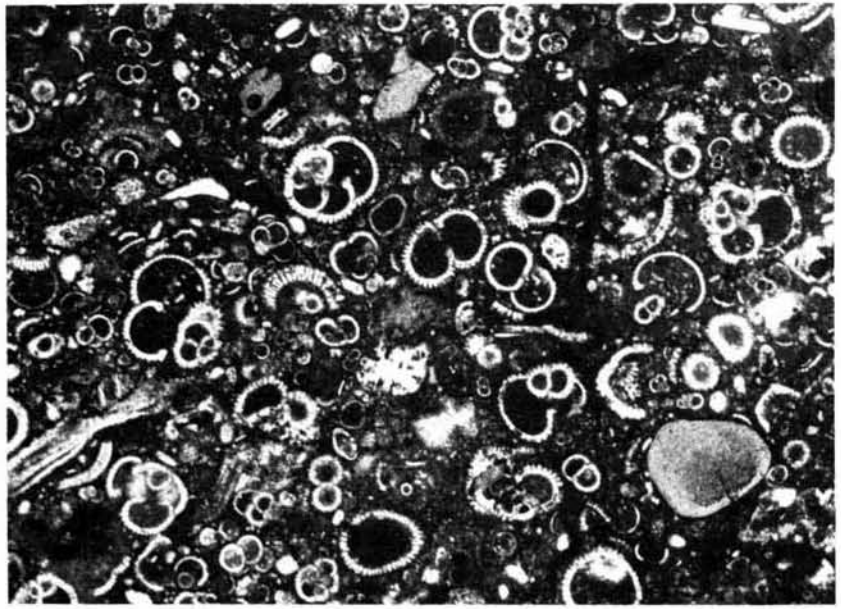

Figure 2
CZ 88-9 : Red Globigerina limestone. Middle — to Upper Eocene (x 50).

Plate 2

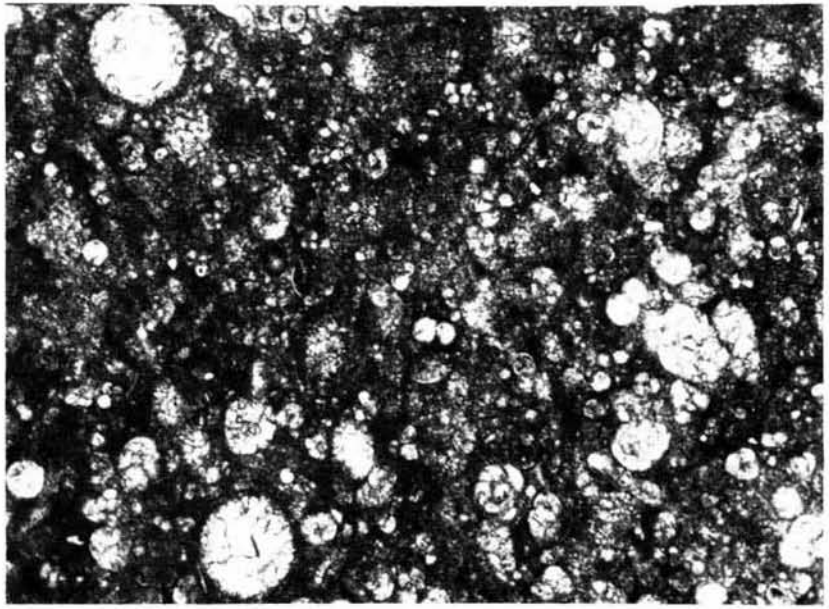

Figure 4
CZ 92-6. Radiolaria — Globigerina limestone. Lower Paleocene (x 50).

representatives of the family Buliminidae (*Bulimina, Uvigerina, ?Siphogenerinoides*) were observed.

Sample CZ 92-6 consists of a light-colored, strongly recrystallized radiolarian limestone (Plate 2 : Fig. 4). In addition to the radiolarians very minute tests of *Globigerina* were observed, furthermore the genera *Globoconusa* and *Planorotalites*. The genus *Morozovella* could not be found. In the benthic fauna the genus *Bolivina* predominates. The sample is of early Paleocene age.

In sample CZ 88-6, the surface of a light-colored Upper Jurassic limestone has a small pocket which is covered by large blocky cement (Plate 1 : Fig. 3). The pocket was subsequently filled by red pelite with indications of the genera *Globigerina, Planorotalites* and *Morozovella,* including *M. velascoensis* (Cushm.) and *M.* cf. *aegua* (Cushm. and Renz) ; Plate 1 : Fig. 4). The age of the filling is therefore late Paleocene.

Eocene to Oligocene

Only three samples contain fossils of this age. The second thin-section of sample CZ 92-2 proved to be of middle Eocene age according to the foraminifera. Its matrix is full of tests of the genera *Globigerina* and *Globigerinatheka.* A stratigraphic marker is *Morozovella* cf. *spinulosa* (Cushm.). The benthos is represented by the family Lagenidae (genus *Lenticulina*), *Buliminidae* (genera *Bolivina, Uvigerina*), as well as by rotaliids.

For the investigation of calcareous nannofossils from this sample three slides were studied. One of them is probably late Eocene to early Oligocene in age. But the *Cyclococcolithus* which was determined in this slide is attached only with reservation, by reason of preservation, to *Cyclococcolithus* cf. *lusitanicus* (Black).

A rich and moderately preserved calcareous nannoplankton flora was determined in sample CZ 88-3. The assemblage with *Sphenolithus distentus* (Martini) and *Sphenolithus predistentus* Bramlette and Wilcoxon gave a middle Oligocene to early late Oligocene age.

A neritic intrabiosparite (sample CZ 88-9) of Late Jurassic to early Neocomian age is covered by a limonitic crust. It is covered by a hemipelagic, red, limonitic micrite with numerous coarse grains of glauconite (Plate 2 : Fig. 2). In the microfauna large-sized Globigerinas dominate which can be associated with *Gl. eocaena* Gümbel, *Gl. cryptomphala* Glaessner and *Gl. linaperta* Finlay. In addition the genera *Globigerinatheka* and *Turborotalia* could be observed. The Turborotalias can be compared with representatives of the group of *T. cerroazulensis* (Cole). The benthic fauna consists of the genera *Lenticulina, Bolivina, Eponides* and *Heterolepa.* The age of the hemipelagic micrite can be determined as middle to late Eocene.

Also the age of the burrow fill of sample CZ 100-9 could be Oligocene, although a younger age cannot be excluded with certainty. The sediment corresponds to sample CZ 100-8. It shows a burrow covered by a rim of limonite (Plate 3 : Fig. 4). The centre of the burrow is filled by a grey pelite. A narrow fissure of the limestone is also filled by the same pelite (Plate 3 : Fig. 5) and contains a microfauna of minute specimens, among which *Globigerina* and *Turborotalia ?opima* (Bolli) could be observed.

Miocene to Pliocene

Evidence of these stages is only by calcareous nannofossils. The matrix of sample CZ 95-2 is probably of early Miocene age. The poorly preserved assemblage with *Cyclococcolithus neogammation* Bramlette and Willcoxon, *Helicopontosphaera granulata* Bukry and Percival and *Discoaster* cf. *druggi* Bramlette and Wilcoxon determined the age of this sample. The sample contains also reworked Cretaceous coccoliths and also calcareous nannoplankton of late Miocene and Pliocene age. But these younger nannofossils are probably due to contamination.

The assemblage with *Discoaster challengeri* Bramlette and Riedel and *Discoaster kugleri* Martini and Bramlette but without *Discoaster hamatus* Martini and Bramlette and *Discoaster pentaradiatus* Tan Sin Hok gave sample CZ 84-1 a middle Miocene age.

In the assemblage of sample CZ 95-1 *Discoaster pentaradiatus* Tan Sin Hok and *Reticulofenestra pseudoumbilica* (Gartner) were observed. According to the known range of these species, the age of this sample is restricted to late Miocene to early Pliocene.

A rich and well preserved calcareous nannoplankton flora of late early Pliocene with *Discoaster asymmetricus* Gartner and *Reticulofenestra pseudoumbilica* (Gartner) was studied in samples CZ 85-3, 87-5, 87-7 and — partly questionable — in sample CZ 95-5. Sample CZ 85-2 belongs probably to the Pliocene with *Discoaster pentaradiatus* Tan Sin Hok and *Discoaster* cf. *surculus* Martini and Bramlette.

Quaternary

A Quaternary age was determined in many samples. But in most of these determinations this young age is due to subrecent contamination in pockets, burrow fills, or crusts within or on older sediments. This has to be also kept in mind for the following foraminiferal determinations :

A light pelmicrite (sample CZ 86-7) with rare ooids carries burrows filled with a reddish pelite. Locally, thin crusts of limonite can be observed. The pelagic microfauna in the burrows consists of the genera *Globigerina, Globorotalia* and *?Orbulina.* The age of the filling is Pleistocene. The middle Paleocene *Globigerina* limestone (sample CZ 92-4) is covered by a red pelite with grains of glauconite and locally penetrated by burrows (Plate 3 : Fig. 1). The plankton is characterized by the genera *Globigerina, Globigerinoides, Globorotalia* and *Orbulina* (Plate 3, Fig. 2-3). Especially mentioned are the species *Globorotalia inflata* (d'Orb), *Gl. truncatulinoides,* (d'Orb) and *Orbulina universa* d'Orb. The benthos contains large-sized tests of the genus *Pyrgo.* In addition debris of shallow-water organisms (corals, bryozoans, lamellibranchs and echinoderms) were observed. The age of the red pelite is Pleistocene.

The lower Paleocene limestone (sample CZ 92-6) is penetrated by burrows filled by a reddish pelite. Its

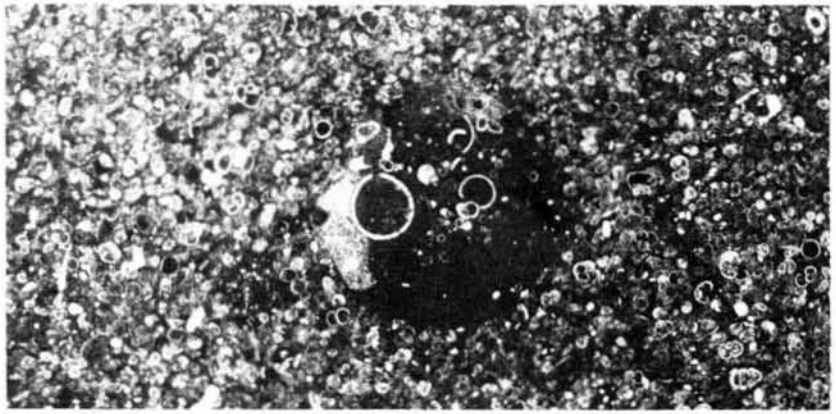

Figure 1 *CZ 92-4. Burrow (Pleistocene) with* Globigerina *and* Orbulina universa *d'Orb in Globigerina limestone of Middle Paleocene (× 17).*

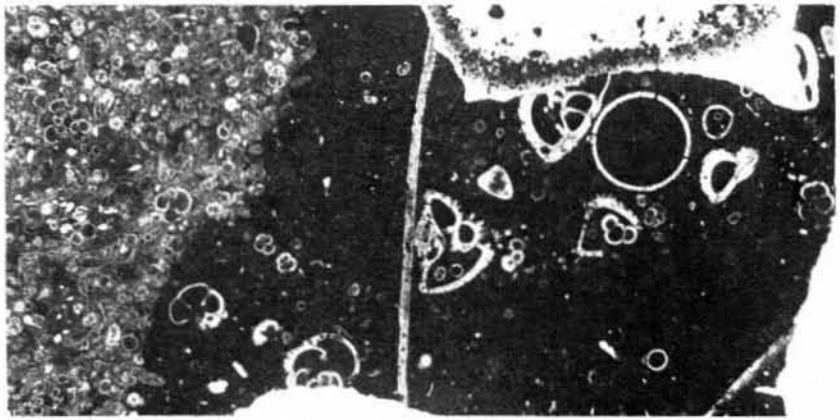

Figure 2 *CZ 92-4. On the left side Globigerina limestone of Middle Paleogene age. On the right side red pelite of the Pleistocene with* **Globigerina,** Globorotalia *and* Orbulina universa *d'Orb (× 22,5).*

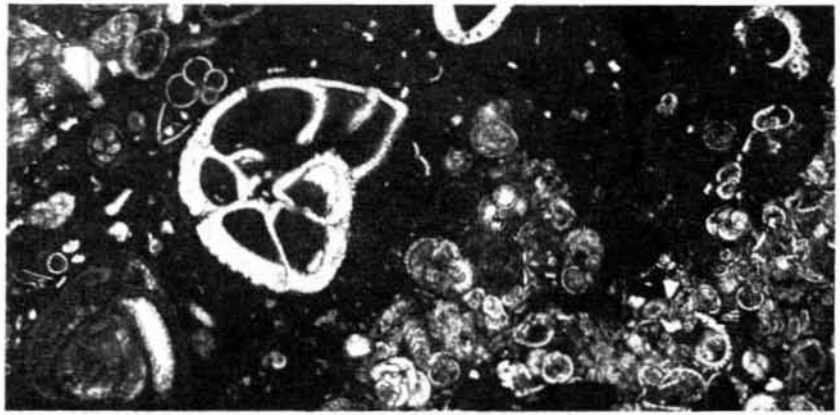

Figure 3 *CZ 92-4. Red pelite (Pleistocene) with* Globorotalia truncatulinoides *(d'Orb) (oblique section) in the filling of a burrow in a limestone of Middle Paleocene age (× 50).*

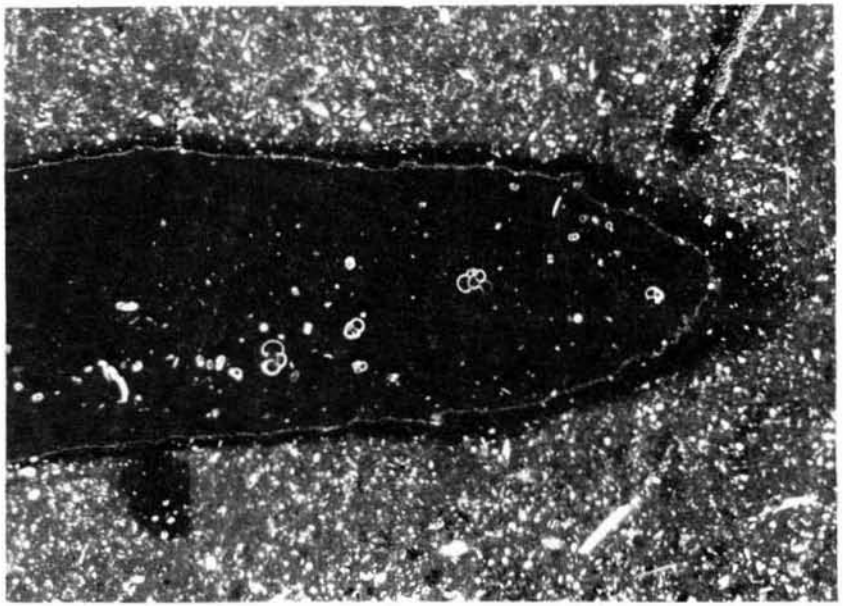

Figure 4

CZ 100-9. Burrow in a Lower Cretaceous limestone rimed by limonite. The grey filling shows a scarce and smallsized microfauna (Oligocene and younger, × 17).

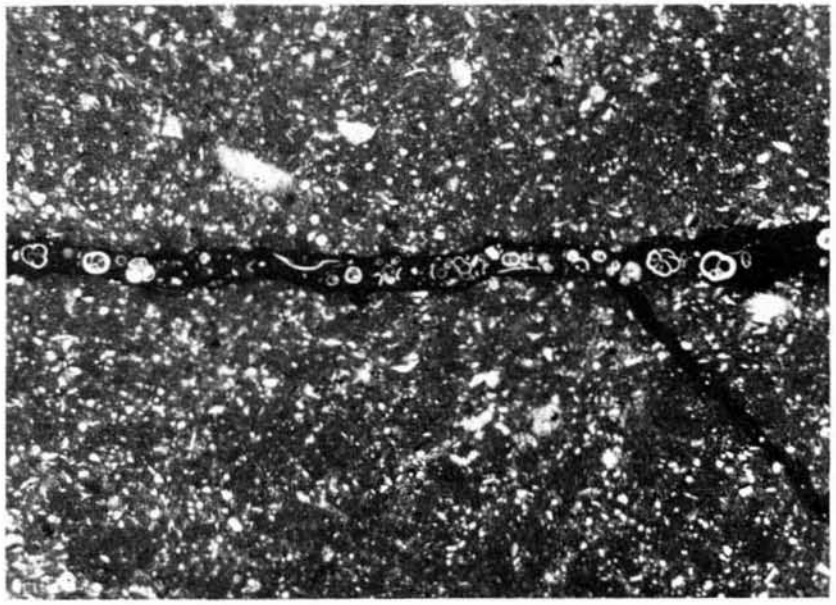

Figure 5

CZ 100-9. A fissure is filled by grey pelite containing small sized pelagic foraminifera (× 22,5).

Plate 3

microfauna consists of the genera *Globigerina*, *Globigerinoides*, *Globorotalia (inflata* and *truncatulinoides* group) and *Orbulina universa* d'Orb. Age : Pleistocene.

A fissure of a sandy limestone (sample CZ 99-6) is filled by a buff pelite with an association of *Globigerina*, *Globorotalia* and *Pyrgo* which indicates a Pleistocene age. The surface of the sample is covered by corals, tubes of *Serpula* and thalli of red algae *(Lithophyllum)* which grew on a manganese crust. The Lower Cretaceous sediment of sample CZ 100-8 shows a burrow (7 × 4 mm), filled by a red sediment of Pleistocene age. The microfauna consists of *Globigerina*, *Globigerinoides*, *Globorotalia* and *Orbulina universa* d'Orb.

Quaternary calcareous nannofossils were determined in 37 slides (Fig. 1). Only a few of these samples are probably Quaternary sediments and not fillings or crusts in or on older rocks. On the base of calcareous nannoplankton we distinguish three stratigraphical levels.

The oldest level of the Quaternary is the horizon with *Pseudoemiliania lacunosa* (Kamptner), but without *Discoaster* sp. According to Martini (1971) this level belongs to the *Pseudoemiliania lacunosa* Zone (NN 19 ; Martini, 1971) and was observed in the inner crust of sample CZ 91-3.

The coocurrence of *Gephyrocapsa oceanica* Kamptner and *Gephyrocapsa caribbeanica* Boudreaux and Hay without *Pseudoemiliania lacunosa* (Kamptner), identified in samples CZ 92-6 and 98-7, indicate the *Gephyrocapsa oceanica* Zone (NN20 ; Martini, 1971). The same age was observed also in burrow fills of samples CZ 92-6 and 100-2.

The youngest level belongs to the *Emiliania huxley* Zone, (NN21 ; Martini, 1971), which is defined by the total range of species *Emiliania huxleyi* (Lohmann), which was observed only in the matrix of sample CZ 97-3.

Most of the Quaternary samples could be only attached to the horizon which includes the last two stratigraphical levels (*Gephyrocapsa oceanica* Zone, NN20 ; and *Emiliania huxleyi* Zone, NN21), because the species *Emiliania huxleyi* (Lohmann) is very difficult to recognize under the light-microscope.

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