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Cretaceous/Tertiary Boundary from the Koraljka-1 Off-Shore Well (SW of Zadar, Adriatic Sea)

Dubravko **LUČIĆ**[1], Josip **BENIĆ**[2], Damir **STANKOVIĆ**[1] and Danica **MILETIĆ**[1]

Key words: Stratigraphy, K/T boundary, Carbonate turbidite, Off-shore well, Adriatic Sea

Ključne riječi: stratigrafija, granica kreda/tercijar, karbonatni turbidit, pučinska bušotina, Jadransko more

Abstract

Deep exploration well Koraljka-1 in the central part of the Adriatic Sea was drilled through Neogene and Paleogene deposits and penetrated the Upper Cretaceous. In the interval from 2500 to 2230 m, the Cretaceous and Paleogene deposits consist of white to grey, mud-supported, fairly fossiliferous deeper-water, chalky limestone (wackestone-mudstone) with sporadic occurrences of chert, intercalated with bioclastic limestone packstone/rudstone to floatstone. Bioclastic limestone (calcarenite) intercalations, which yield platform-derived detritus, were redeposited seaward on the deep platform slope by a gravity mechanism. Lithostratigraphically, sedimentation was almost continuous across the Cretaceous - Tertiary boundary. The importance of these deposits and their stratigraphic interest is based on the fact that there is no on-shore equivalent of such deeper-water deposits in the Croatian part of the Outer Dinarids.

In biostratigraphic terms, the K/T boundary is marked by significant changes in the microfossil assemblages (calcareous nannofossils, plankton and benthic foraminifera), which revealed that the hiatus at the boundary is minimal.

Sažetak

Duboka, istraživačka, pučinska bušotina Koraljka-1, u središnjem dijelu jadranskog podmorja, probušila je, između ostalih, naslage gornje krede i paleogena. Od 2500 m (konačna dubina) do 2230 m, u stratigrafskom rasponu od gornjeg mastrihta do gornjeg eocena, dominiraju naslage svijetlosivog smeđastog, kredastog, mikritnog vapnenca s rožnjakom (wackestone-mudstone) bogatog planktonskim foraminiferama i vapnenačkim nanoplanktonom s proslojcima bioklastičnih (kalkarenitnih) vapnenaca. Bioklastični vapnenci (packstone/rudstone-floatstone) sadrže pretaloženi, plitkovodni platformni detritus (ostatke grebenotvoraca, bentosne foraminifere i vapnenačke intraklaste), pretpostavlja se da su gravitacijski pretaloženi u dublje dijelove taložnog prostora mutnim strujama i klizanjem.

Paleontološke analize planktonskih i bentosnih foraminifera, vapnenačnog nanoplanktona, kao i sedimentološke analize, upućuju na kontinuitet taloženja iz krede u paleocen. Ostvareni rezultati, poglavito u stratigrafskom pogledu, ističu važnost registriranja opisanih naslaga izraženih u činjenici da do sada nije poznat njihov kopneni ekvivalent (tzv. Vanjski Dinaridi, odnosno Jadranska karbonatna platforma unutar hrvatskog teritorija).

1. INTRODUCTION

The purpose of this paper is the paleogeographic reconstruction of the Outer Dinarids and their seaward counterpart in the Adriatic sea across the Cretaceous/Tertiary boundary.

In the region of the Outer Dinarids (Adriatic Plate), thick, shallow-water, carbonate beds were deposited ("carbonate-platform") during the Mesozoic. At the end of the Cretaceous, tectonic movements related to the Laramian phase led to a regional uplift with temporary emersions, karstifications, bauxite deposits, and small scale destruction of the platform. Paleogene deposits are usually transgressive on this Cretaceous relief. Lithostratigraphic continuity between the Cretaceous and Paleocene was recorded at very few localities, predominantly in shallow, restricted lagoons influenced by fresh water and interrupted by short phases of intertidal regime (DROBNE et al. 1987, 1988; GUŠIĆ & JELASKA, 1990; TRUTIN, 1992 - personal communication). The existence of Paleocene deeper marine sediments was mentioned by KALAC et al. (1991), KALAC & TARI-KOVAČIĆ (1986) and LUČIĆ et al. (1991), when interpreting the off-shore bore hole data from different localities.

This article focuses on the stratigraphic events across the K/T boundary, based on the microfossil content, which comprises calcareous nannofossils, planktonic and benthic foraminifera from the off-shore well Koraljka-1.

In lithostratigraphic terms, these deeper marine deposits define the deposition continuity from the Maastrichtian to the Upper Eocene and the obtained data open a discussion on the open marine influence on that part of the Adriatic carbonate platform during the Upper Maastrichtian and Eocene.

Koraljka-1 was drilled about 80 km southwest of Zadar (Fig.1) through clastic deposits of Lower and Upper Pleistocene, Pliocene, Miocene, Oligocene and through Eocene, Paleocene and Maastrichtian carbonate deposits.

This paper mainly concerns the interval from 2230

[1] INA-Industrija nafte, Naftaplin, Laboratory Research Dept., Lovinčićeva 1, 41000 Zagreb, Croatia

[2] University of Zagreb, Faculty of Science, Dept. of Geology and Paleontology, Ulica Kralja Zvonimira 8, 41000 Zagreb, Croatia

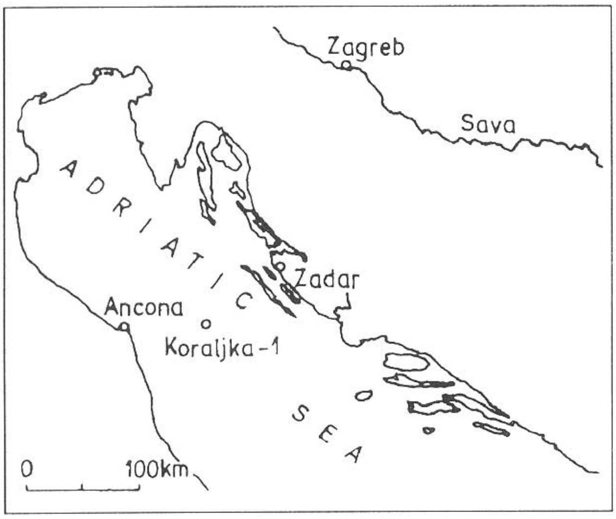

Fig. 1 Location map.

m to 2500 m (total depth), which straddles the Cretaceous/Tertiary boundary.

Calcareous nannofossil analyses were carried out by J. BENIĆ; the Cretaceous microfauna was analyzed by D. STANKOVIĆ, Paleogene microfaunas were determined by D. MILETIĆ (washed samples) and D. LUČIĆ (thin sections), who also made the sedimentological interpretation.

2. METHODS AND MATERIAL

The study was based on drill cuttings from the whole interval and on core samples from the 2500-2497 m and 2258-2254 m intervals.

The work was carried out on thin sections (mainly) and on washed samples, and more than 130 analyses were performed. Samples of approximately 100 g were collected at 5 m interval, by a well-site geologist during drilling operations. Cuttings were mixed due to the drilling technology, and it was very difficult to establish the exact sample position along the vertical sequence. Thus, especially in the case of thin intervals, it was impossible to establish biostratigraphic zonation with full precision.

In the oil industry, subsurface vertical profile interpretations are based on several wire-line logs (SELLEY, 1985; CARBONNIER & REY, 1958; PIRSON, 1970; ASQUITH, 1979). In our case, S.P. log (Spontaneous Potential) parameters were calibrated with the other logs and, along with the data obtained from the laboratory, they represent a very useful tool for defining the vertical grain-size profile. Parameters recorded by S.P. are essentially related to permeability. Mud-supported limestone have lower permeability (peaks on the right hand side) than bioclastic limestone (peaks to the left), because the amount of clay matrix blocks the passages between pores. On the log, these differences are obvious (Fig. 2). Since we are dealing mainly with cuttings, without any data on structure, texture, position or relationships between beds within the sedimentary sequence, the logs proved to be very helpful, and together with the laboratory analyses (sedimentological, paleontological and petrophysical) they provided a better understanding of subsurface relationships and aided in the identification of the bed boundaries, facilitating indeed the correlations.

3. MAASTRICHTIAN DEPOSITS

Maastrichtian sediments were identified from 2500 to 2450 m, where intercalations of pelagic mud-supported limestone (mudstone-wackestone), white to gray in colour, and skeletal, bioclastic limestone (packstone/rudstone-floatstone) predominate (Pl. X, Fig. 3). According to the S.P. log, frequent intercalations of 2 - to 5-meter-thick beds are evident. The bioclastic limestones are composed of coarse, sometimes angular to sub-angular fragments of shallow-water calcarenite, rudists, large benthic foraminifera and echinoderm,gastropod, bryozoan, coral and ostracod remains.

The following species of large benthic foraminifera were identified:

- *Orbitoides apiculata* SCHLUMBERGER, Pl. III, Fig. 5
- *Siderolites calcitrapoides* LAMARCK, Pl. III, Figs. 3, 6
- *Orbitoides media* (D'ARCHIAC), Pl. III, Fig. 4.

Pelagic deposits include white to gray, partly marly, chalky limestone (mudstone-wackestone). Well-preserved pelagic foraminifera are scattered in a compact matrix ("pelagic rain"). In thin sections, the following species were determined:

- *Contusotruncana contusa* (CUSHMAN), Pl. I, Fig. 1
- *Globotruncanita stuarti* (DE LAPPARENT), Pl. I, Figs. 6, 8
- *Globotruncanita* cf. *stuarti* (DE LAPPARENT), Pl. I, Fig. 4
- *Globotruncanita stuarti-conica* group, Pl. I, Fig. 7
- *Contusotruncana fornicata* (PLUMMER), Pl. I, Figs. 3a, 5; Pl. II, Fig. 3
- *Globotruncanita stuartiformis* (DALBIEZ), Pl. II, Fig. 4; Pl. III, Figs. 1-2
- *Globotruncanita elevata* (BROTZEN), Pl. II, Fig. 8
- *Globotruncanella havanensis* (VOORWIJK), Pl. II, - Fig. 1
- *Contusotruncana cf. walfishensis* (TODD), Pl. II, Fig. 2
- *Globotruncana bulloides* VOGLER, Pl. II, Fig. 5
- *Globotruncana lapparenti* BROTZEN, Pl. II, Fig. 6.

In some cases, the microfossils were crushed and tightly packed. Nodular chert and stylolites are frequently visible.

The following species of calcareous nannofossils were identified (Pl. IV):

- *Micula mura* (MARTINI)
- *Micula praemurus* (BUKRY)
- *Micula decussata* VEKSHINA
- *Eiffellithus turriseiffelii* (DEFLANDRE)
- *Quadrum gothicum (DEFLANDRE)*
- *Quadrum gartneri* PRINS & PERCH-NIELSEN
- *Arkhangelskiella cymbiformis* VEKSHINA
- *Microrhabdulus decoratus* (DEFLANDRE)
- *Watznaueria barnesae* (BLACK)
- *Cribrosphaerella ehrenbergi* (ARKHANGELSKY)
- *Prediscosphaera cretacea* (ARKHANGELSKY)
- *Watznaueria biporta* BUKRY
- *Cretarhabdus angustiforatus* (BLACK).

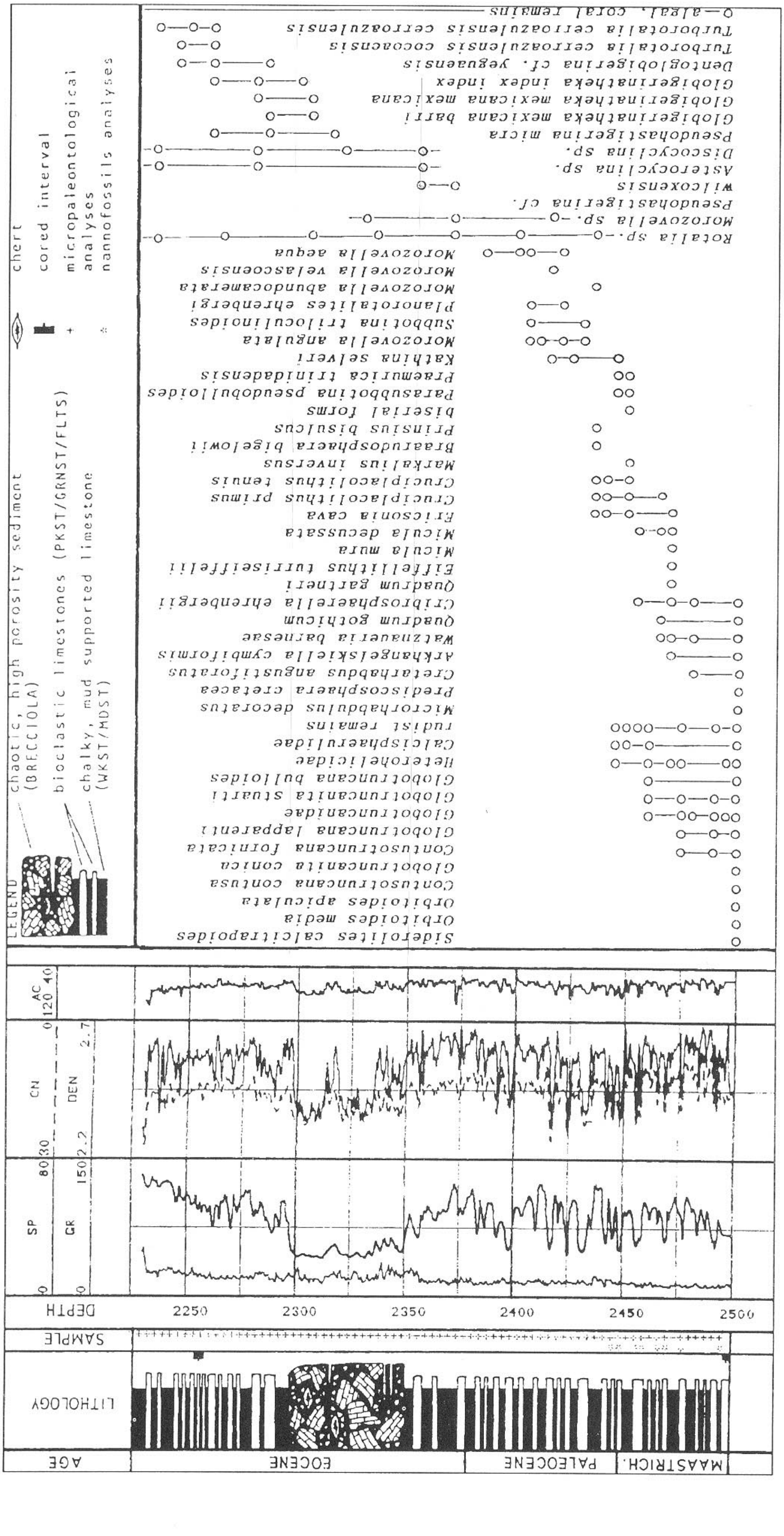

Fig. 2 Schematic stratigraphic column compared with wire-line logs (SP - Spontaneous potential, GR - Gamma ray, CN - Compensated neutron, DEN - Density, AC - Acoustic/Sonic) and distribution of some selected planktonic and benthic foraminifera, and nannofossils in Koraljka-1 well.

Age: According to various biostratigraphic classifications (HAQ, 1978; PERCH-NIELSEN, 1985; JIANG & ROBINSON, 1987; BORSETTI, 1962; BILOTTE, 1984, 1985; CARON, 1985; FLEURY, 1980; POSTUMA, 1971; SKOURTSIS-CORONEOU & SOLAKIUS, 1991; SLITER, 1989; LOEBLICH & TAPPAN, 1988a, b), the presence of *Contusotruncana contusa*, *Globotruncanita conica* as well as *Micula mura*, which define one of the latest Upper Maastrichtian nannozones (SEYVE, 1990) and the presence of *Siderolites calcitrapoides* indicates that this interval is Late Maastrichtian in age. It is necessary to add that neither *Abathomphalus mayaroensis* nor *Nephrolithus frequens* or *Noellithina prinsii* were found among the nannos and there are several reasons for that: (1) very small amount of sampled cuttings, (2) because of very thin Upper Maastrichtian biozones, or (3) easily due to bad luck in finding the typical cuts of microfossils.

4. PALEOCENE DEPOSITS

Paleocene deposits are lithologically very similar to the previously described Maastrichtian beds. In the interval from 2450 to 2380 m, the mud-supported limestone (mudstone-wackestone, Pl. X, Fig. 5), with rich planktonic and nannofossil assemblages, are interbedded with packstone-type limestone containing intraclasts of shallow-water limestone and echinoderm, benthic foraminifera, coral and algal remains (Pl. X, Fig. 2). Bed thickness of 1 to 7 m is inferred from the S.P. log, and their rhythmicity indicates turbidite sediments.

Paleocene microflora and microfauna are significantly different from the Maastrichtian, as is well-known from the literature (CANUDO et al 1991; KELLER, 1988; D'HONDT & KELLER, 1991; OLSSON at al., 1992). The lowermost Paleocene fauna is poor and consists of small globigerinids and biserial foraminifera (Pl. V, Fig. 3), whereas the first conical forms appear in the Upper Paleocene. The following species were determined:

- *Parasubbotina pseudobulloides* (PLUMMER), Pl. V, Fig. 1
- *Praemurica trinidadensis* (BOLLI), Pl. V, Fig. 2
- *P. inconstans* SUBBOTINA, Pl. V, Fig. 4
- *Morozovella angulata* (WHITE), Pl. VI, Figs. 1, 2, 3
- *M. abundocamerata* (BOLLI), Pl. VI, Fig. 2
- *M. velascoensis* group, Pl. VI, Fig. 6
- *M. aequa* (CUSHMAN & RENZ), Pl. VI, Figs. 8, 9
- *Subbotina triloculinoides* PLUMMER, Pl. VI, Figs. 1, 4
- *Planorotalites ehrenbergi* (BOLLI), Pl. VI, Fig. 7
- *Woodringina* sp. Pl. V, Fig. 3
- *Chiloguembelina* sp. Pl. V, Fig. 3.

Benthic foraminifera are rare, usually crushed and mainly found in the allochthonous bioclastic packstones with other remains of shallow-water organisms. The presence of contemporaneous shallow-marine benthic foraminifera (Pl. VII), *Rotalia* sp. *Miscellanea* sp., and *Kathina selveri* SMOUT suggests the existence of an adjacent platform.

The following nannofossil species were determined (Pl. VIII):

- *Biantholithus sparsus* BRAMLETTE & MARTINI
- *Markalius inversus* (DEFLANDRE)
- *Ericsonia cava* (HAY & MOHLER)
- *Biscutum? parvulum* ROMEIN
- *Braarudosphaera bigelowii* (GRAN & BRAARUD)
- *Cylagelosphaera reinhardtii* (PERCH-NIELSEN)
- *Cruciplacolithus tenuis* (STRADNER)
- *Cruciplacolithus primus* PERCH-NIELSEN
- *Thoracosphaera* sp.
- *Prinsius bisculus* (STRADNER)
- *Chiasmolithus danicus* (BROTZEN).

Age: Not being able to establish a precise biostratigraphic zonation, this interval is attributed to the Paleocene in general. However, planktonic assemblage may be correlated with the fauna from the Central Apennines (Italy) (LUTERBACHER & PREMOLI-SILVA, 1964; PREMOLI-SILVA et al., 1976), and according to Paleogene planktonic foraminifera biostratigraphy (BERGGREN & MILLER, 1988; TOURMARKINE & LUTERBACHER, 1985; OLSSON et al., 1992; MacLEOD & KELLER, 1991), a more detailed conclusion should be indicated (Fig. 2). In the studied material the lowermost Paleocene planktonic zone, *Parvularugoglobigerina eugubina* (LUTERBACHER & PREMOLI-SILVA, 1964) was not fully documented; there were only some evidences of the basal Paleocene biserial (*Woodringina*, *Chiloguembelina*) assemblage. *Parasubbotina pseudobulloides* and *Praemurica trinidadensis* are the first Lower Paleocene species identified (P1 zone). The Upper Paleocene fauna consists of *M.angulata* (P3) and *Subbotina triloculinoides* (P1-4). In the upper part of the Paleocene, *Planorotalites ehrenbergii* (P3-4) and *M. velascoensis* (P4-5) were determined.

In terms of nannofossil biostratigraphy, the Lower Paleocene is well documented (NP 1-4). Few species which are usually considered to be "survivors" after the K/T boundary (SEYVE,1990) were identified: *Markalius inversus* (NP 1), *Braarudosphaera bigelowii*, and *Cyclagelosphaera reinhardtii*. New Danian species were also found: *Biscutum parvulum*, *Cruciplacolithus primus* (NP 2), *Thoracosphaera* sp., *Chiasmolithus danicus* (NP 3), etc.

In the more detailed study of the distribution of the larger Paleocene foraminifera, primarily of the rotaliids in their "in situ" environment, and defining their ecology and precise biostratigraphical position, it will be possible to establish a correlation between the platform and basin succession, which is still imprecise today or even lacking in this region.

5. EOCENE DEPOSITS

Eocene deposits were identified in the interval from 2380 to 2230 m and they display the same sedimentary features as the older sediments. Stylolites and nodular chert are frequently visible in the chalky limestone. The only exception is the occurrence of a 50-meter-thick, highly porous, chaotic breccia.

Fossil assemblages were not studied in the same detail as those close to the K/T boundary. The following species of planktonic foraminifera in washed samples and in thin sections were identified (Fig. 2):

- *Pseudohastigerina* cf. *wilcoxensis* (CUSHMAN & PON TON)
- *Globigerinatheka mexicana* (CUSHMAN)
- *Globigerinatheka mexicana barri* BRONNIMAN
- *Globigerinatheka index* (FINLAY)
- *Turborotalia cerroazulensis cerroazulensis* COLE, Pl. IX, Fig. 2
- *Turborotalia cerroazulensis coacoensis* (CUSHMAN)
- *Pseudohastigerina micra* (COLE), Pl. IX, Figs. 1, 3
- *Dentoglobigerina* cf. *yeguaensis* (WEINZIERL & APPLIN),Pl. IX, Fig. 3.

Fragments of *Asterocyclina, Discocylina, Rotalia,* and other unidentified benthic fossils were mainly found in the bioclastic packstone (Pl. X, Figs. 1, 4).

Age: Due to lack of precise data, the whole interval was attributed to the Eocene. Three intervals could be differentiated:

(1) a lower part characterised by poorly preserved planktonic faunas consisting only of several specimens of conical foraminifera possibly *Morozovella,* and rare *Pseudohastigerina wilcoxensis*, coral and algal remains.

(2) a middle interval yielding several planktonic species of the genera *Globigerinatheka* and *Acarinina*.

(3) an upper part, where the core was taken, which yielded several specimens attributable to *Turborotalia cerroazulensis cerroazulensis*, *T. cerroazulensis cocoaensis*, which indicate the uppermost part of the middle Eocene or the base of the Upper Eocene. A lot of fragments of *Asterocyclina, Discocyclina, Nummulites* and *Rotalia* are usually distributed along the whole interval. According to the determined species, this part of the interval should be attributed to the Upper Eocene (P17) zone.

6. DEPOSITIONAL ENVIRONMENTS

The studied deposits are a part of the lithostratigraphic succession ranging in age from the Late Cretaceous (Maastrichtian) to Middle-Upper Eocene. The studied portion consists of deep-water, pelagic, mud supported, chalky limestone with intercalated allochthonous bioclastic packstone to rudstone. Apart from the possible correlation with the Podsabotin beds in Slovenia (PAVŠIČ, 1981), there is no on-shore equivalent in the Croatian part of the Outer Dinarids. A better correlation, because of the geographic position, can be suggested with the Apennine pelagic limestone Scaglia Formation (DOUVERNAY & REULET, 1981; ARTHUR, 1976; PREMOLI-SILVA et al., 1976; MONTANARI, 1990; ALVAREZ et al., 1985). Allochthonous bioclastic limestone was also found in the Apennines (named brecciola) (FRIEDMAN & SANDERS, 1978), and according to DUVERNOY & REULET (1981) they can be interpreted as deposited by turbidity currents. In our material the contact between the bioclastic packstones and the underlying wackestone is erosional in places, while the upper con-

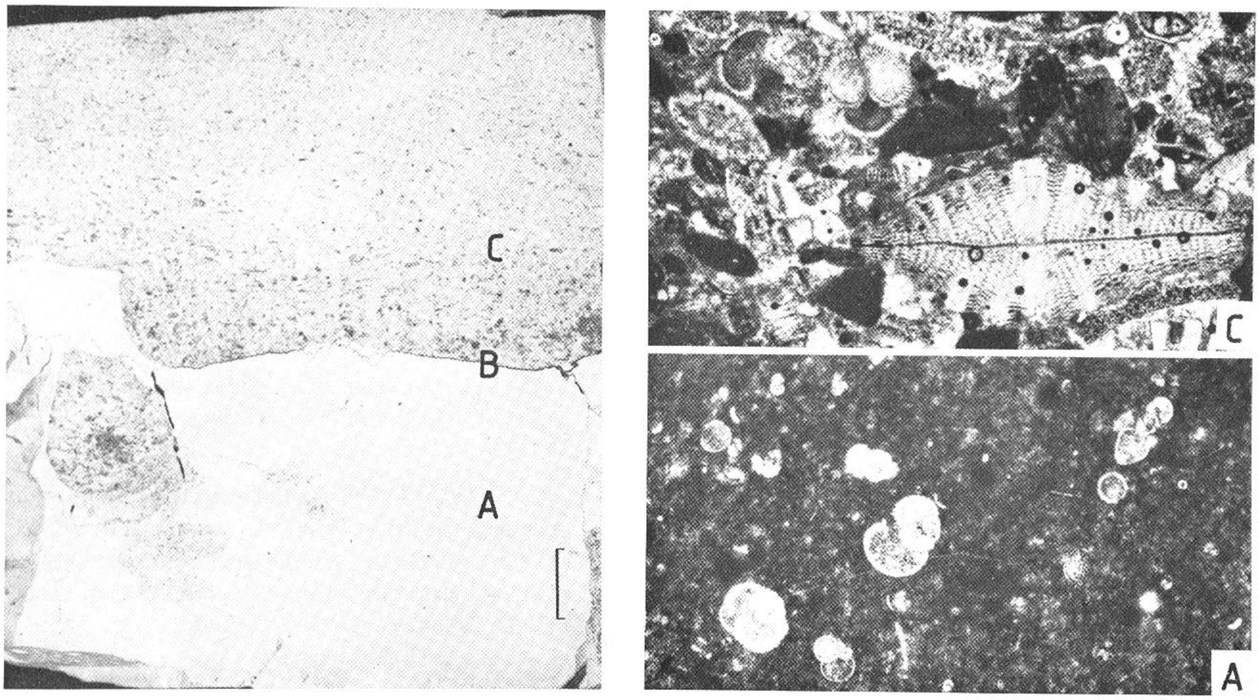

Fig. 3 Core sample with erosional contact (B) of wackestone (A) and bioclastic packstone (C):
A - Wackestone composed of planktonic foraminifera ("pelagic rain"). x 40.
B - Erosional contact, partly stilolitized.
C - Bioclastic packstone composed of benthic and planktonic foraminifera, algal remains and shell debris with visible gradation. x 30..

tact is gradational (Fig. 3).

Due to the fact that only drill cuttings were analyzed from most of the succession, a reliable sedimentological model for the entire sequence was prevented. The depth of deposition of those sediments is very difficult to estimate, because of insufficient data. The pattern of sea level changes should be inferred by comparing the planktonic/benthic ratio, planktonic diversity, and the general distribution of planktonic (keeled, unkeeled and heterohelicids) and benthic groups (SHAHIN, 1992).

Taking into account all the available data (sedimentological and petrophysical characteristics), some conclusions should be pointed out. The Late Maastrichtian deposits in the Koraljka-1 well are characterized by a mixture of keeled forms (globotruncanids), heterohelicid forms and a large amount of benthic detritus. The lowermost Paleocene deposits consist of unkeeled and biserial forms without benthos. This is a significant indicator for deeper depositional environment. An interval with *Morozovella angulata* and similar keeled forms in the upper part of Paleocene deposits, occur only when water depth exceeds 500 m (PREMOLI-SILVA, personal communication). Displaced material from the carbonate platform is more abundant in the Maastrichtian than in the Paleocene-Eocene. The examined core samples (2500-2497 m), revealed relatively good preservation and the large amount of large-sized coarse shallow-water limestone fragments and "reef" and for-reef dwellers remains. So, the Late Maastrichtian is characterized by larger erosion of the adjacent platform. The presence of chalky limestone seems to collaborate a depositional environment shallower than the CCD.

Taking into consideration all the available data, although insufficient for a definite conclusion, the examined deposits can be interpreted as possibly upper bathyal or deeper slope deposits. In such environment, various gravity or tectonically forced processes could take place. ALVAREZ et al. (1985) have recognized several deformational facies in sedimentary slides in the Apennine pelagic limestone. In the case of the Koraljka-1 well, although it is not so easy to define the depositional mechanism, it can be inferred that, due to gravity influenced movements, bioclastic shallow-water sediments were redeposited into deeper water media. According to the S.P. log curve and considering onshore data, it should be said that we are dealing with a kind of turbidite deposit. The chaotic sediments recovered from 2350 to 2300 m, according to the cylindrical log curve shape and paleontological and sedimentological analyses, might be interpreted as submarine canyon or channel fill.

The average sedimentation rate for the Paleocene through the Eocene portion sequence is 7.3 m/my (approximately 220 m deposited in approximately 30 m.y., without the breccia).

7. CONCLUSIONS

The sediments from the Koraljka-1 well were interpreted as the bathyal deposits of the deeper part of the platform slope. Rhythmic intercalations of bioclastic and pelagic limestones indicate turbidite-type deposits. It is presumed that the Upper Maastrichtian is characterized by larger erosion of the platform while the shallow-water detritus were redeposited to the deeper parts. The final taphocoenosis is represented by a mixture of planktonic and redeposited benthic assemblages. During the Paleocene and Eocene displacement decreases.

For the first time, the K/T boundary is being discussed in more detail in this region, and, according to the distribution of nannofossils and planktonic foraminifera, several short hiatuses were recorded. Nevertheless, it is the most complete succession of Cretaceous to Paleocene ever found in this area. Future multidisciplinary explorations and detailed study, first of all of seismic data, sedimentological correlations and tectonical setting of the deposits, will provide a better understanding of regional geological and paleogeographical conditions as well as the lithostratigraphical evolution of the Maastrichtian-Paleocene deposits in this region.

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PLATE I

1	*Contusotruncana contusa* (CUSHMAN)
2	*Globotruncanita* sp.
3a	*Contusotruncana fornicata* (PLUMMER)
3b	*Globotruncanita* sp.
4	*Globotruncanita* cf. *stuarti* (DE LAPPARENT)
5	*Contusotruncana fornicata* (PLUMMER)
6	*Globotruncanita stuarti* (DE LAPPARENT)
7	*Globotruncanita stuarti-conica* group
8	*Globotruncanita stuarti* (DE LAPPARENT)

All figures at 100X magnification, except Fig. 5, 120X
All samples from the cored interval 2500-2497 m.
Age: Late Maastrichtian

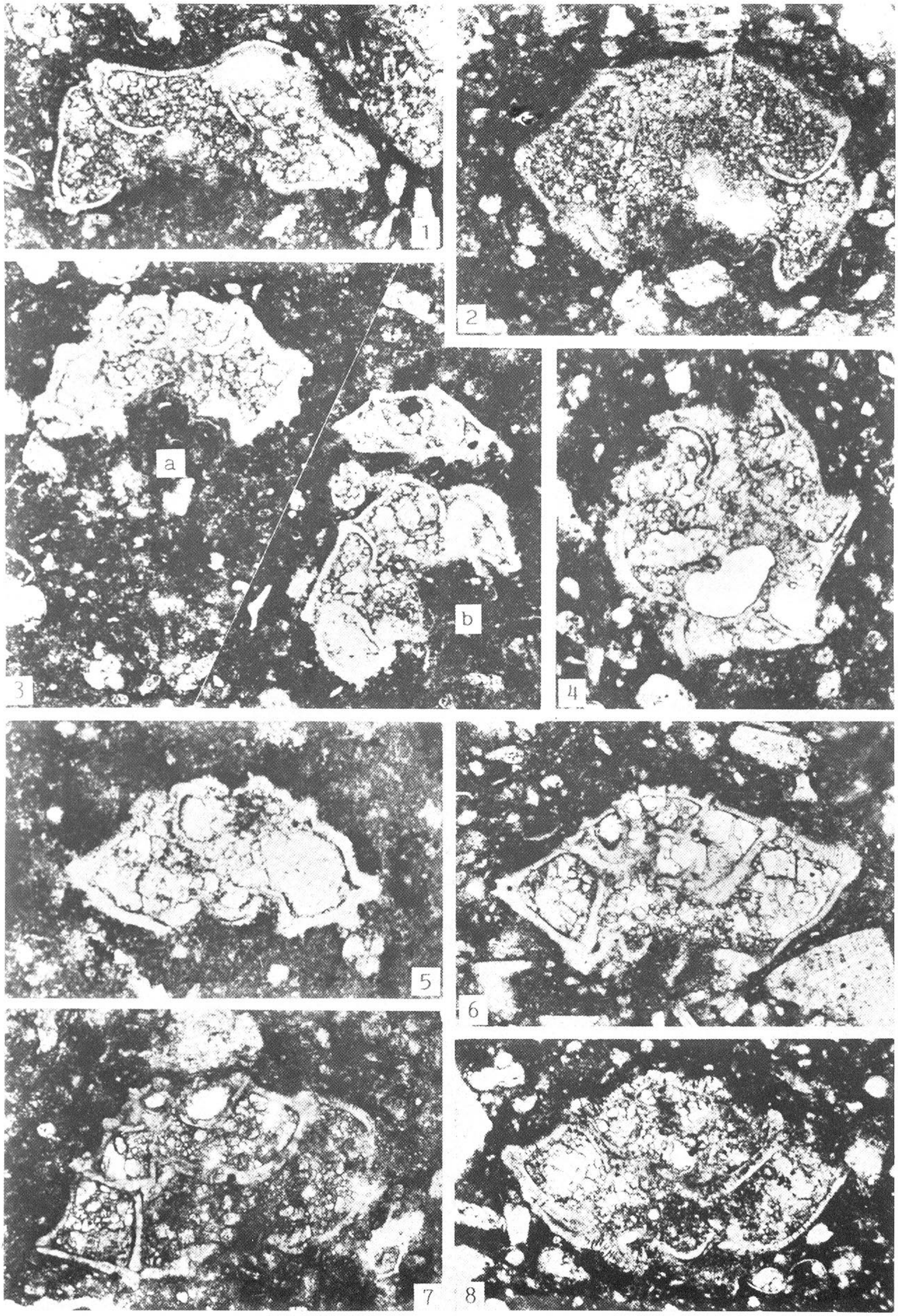
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PLATE II

1	*Globotruncanella havanensis (*VOORWIJK), 140X
2	*Contusotruncana* cf. *walfishensis* (TODD), 120X
3	*Contusotruncana fornicata* (PLUMMER), 160X
4	*Globotruncanita stuartiformis* (DALBIEZ), 100X
5	*Globotruncana bulloides* VOGLER, 170X
6	*Globotruncana lapparenti* BROTZEN, 160X
7	*Globotruncana* ?, 180X
8	*Globotruncanita elevata* (BROTZEN), 110X

All samples from the cored interval 2500-2497 m.
Age: Late Maastrichtian

PLATE III

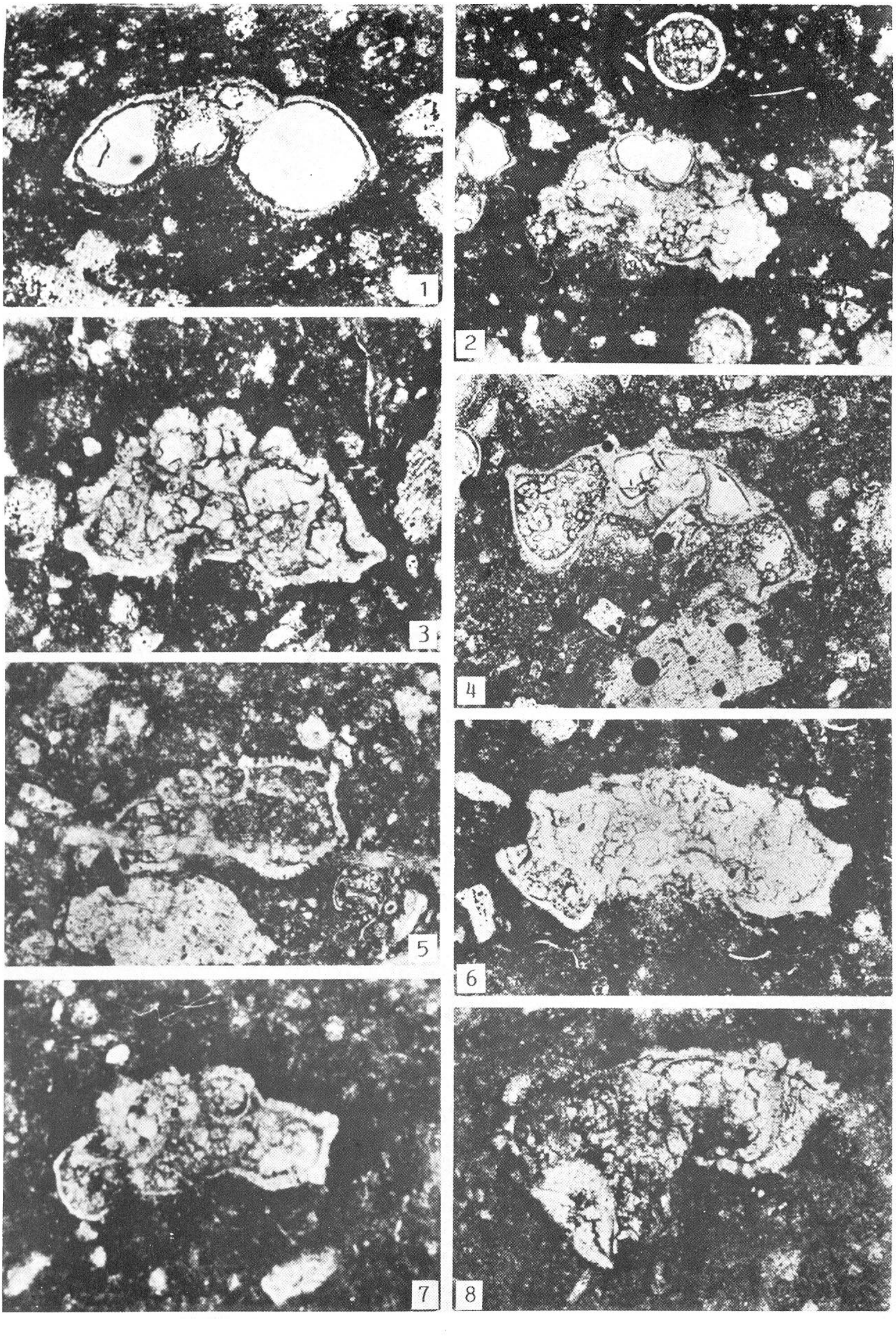
1-2	*Globotruncanita stuartiformis* (DALBIEZ), 1-100X, 2-80X
3	*Siderolites calcitrapoides* LAMARCK, 70X
4	*Orbitoides media* (D' ARCHIAC). Section through the nucleoconch, 100X
5	*Orbitoides apiculata* SCHLUMBERGER, 60X
6	*Siderolites calcitrapoides* LAMARCK, 40X

All samples from the cored interval 2500-2497 m.
Age: Late Maastrichtian

PLATE IV

1-2	*Micula mura* (MARTINI), sample Kok-1/2470m
3-4	*Micula praemurus* (BUKRY), sample Kok-1/2470m
5-8	*Micula decussata* VEKSHINA, sample Kok-1/2465m
9-10	*Eiffellithus turriseiffelii* (DEFLANDRE), sample Kok-1/2470m
11-12	*Quadrum gothicum* (DEFLANDRE), sample Kok-1/2500-2497m
13-15	*Arkhangelskiella cymbiformis* VEKSHINA, sample Kok-1/2470m
16	*Microrhabdulus decoratus* DEFLANDRE, sample Kok-1/2470m
17-19	*Watznaueria barnesae* (BLACK), sample Kok-1/2470m
20	*Cribrosphaerella ehrenbergii* (ARKHANGELSKY), sample Kok-1/2470m

All figures at 2000X magnification
Age: Late Maastrichtian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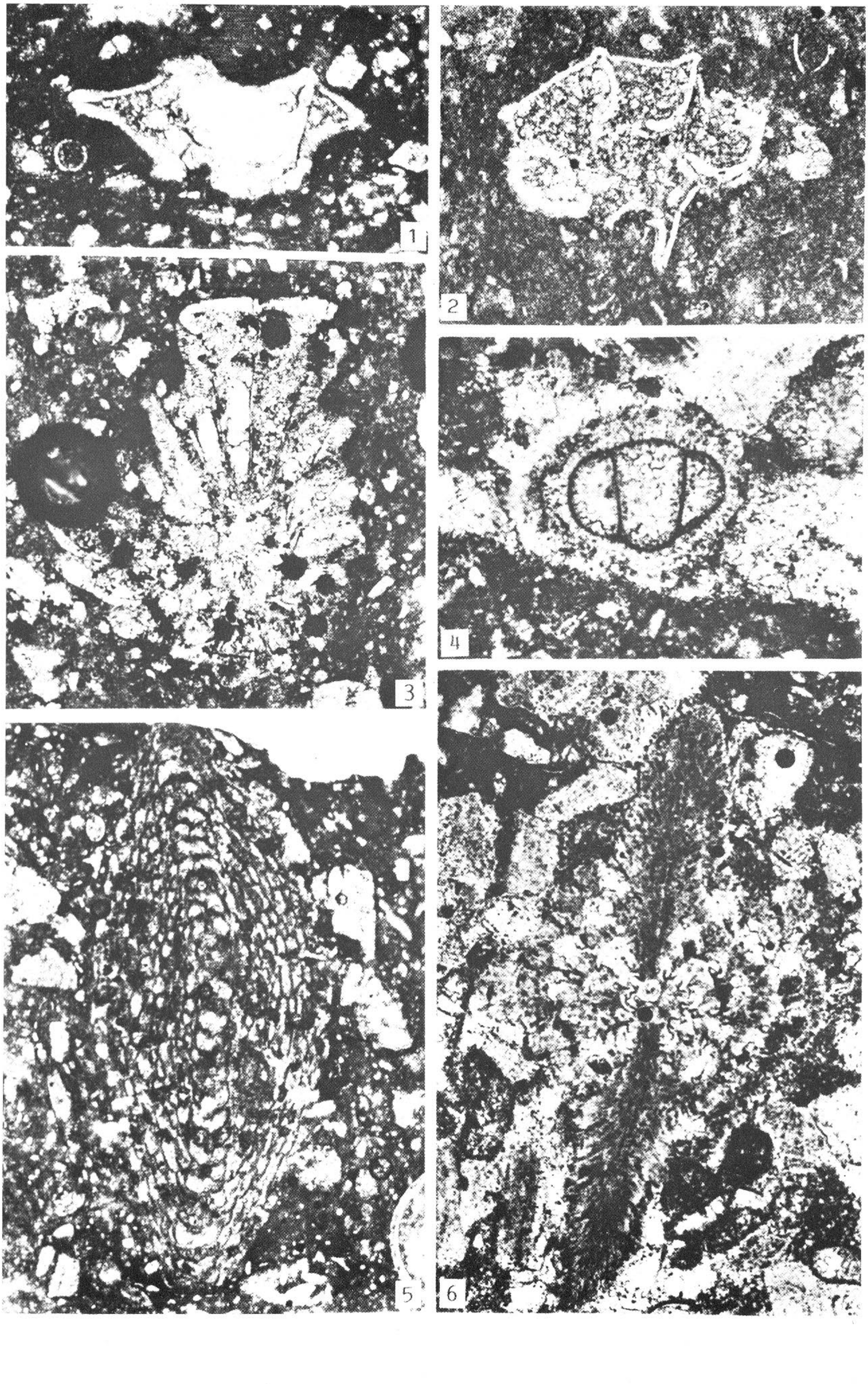
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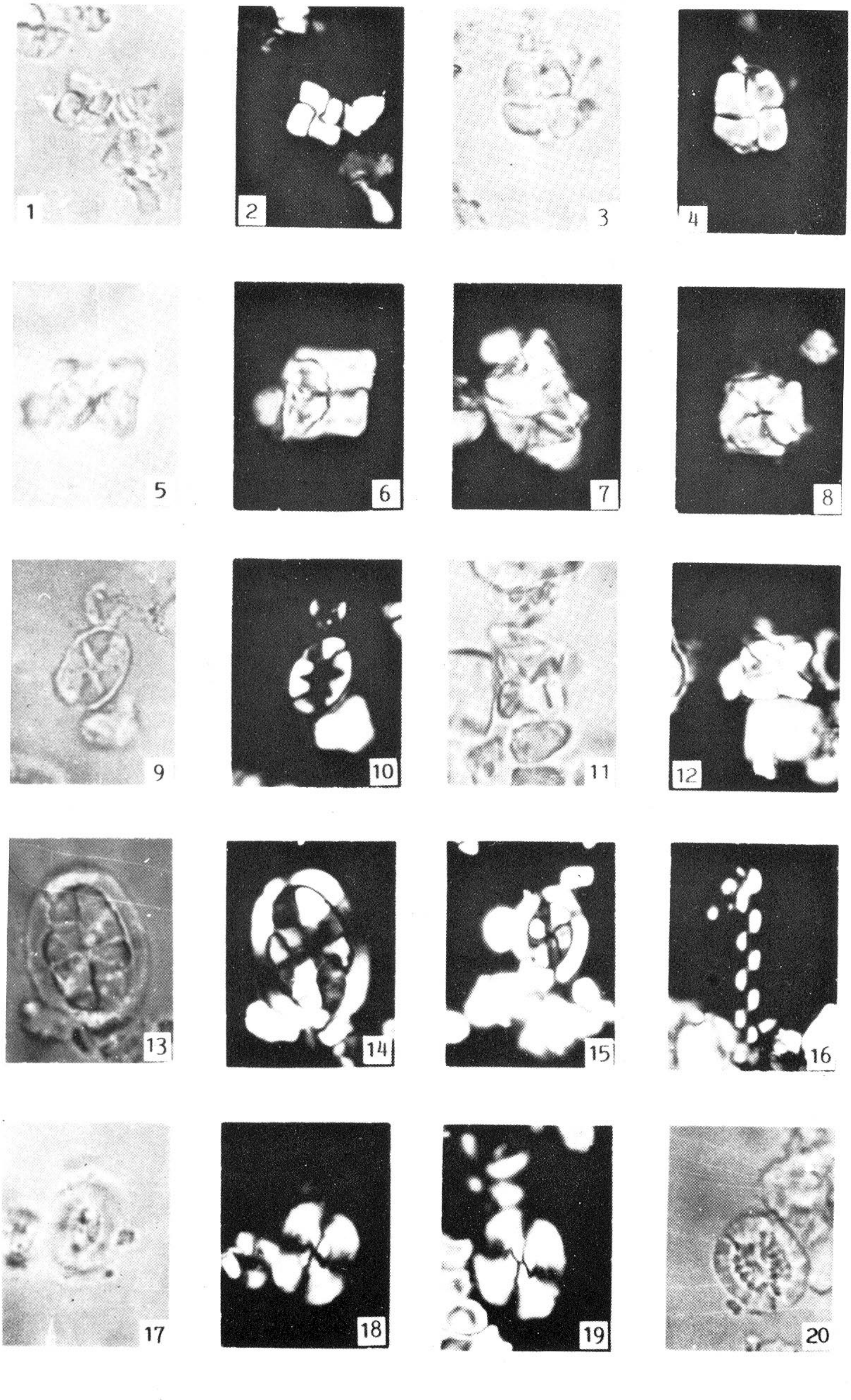
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PLATE V

1 *Parasubbotina pseudobulloides* (PLUMMER), sample Kok-1/2450m
2 *Praemurica trinidadensis* (BOLLI), sample Kok-1/2450m
3 *Woodringina* sp., *Chiloguembelina* sp., sample Kok-1/2450m
4 *Praemurica inconstans* SUBBOTINA, sample Kok-1/2445m
5 *Praemurica* sp., sample Kok-1/2450m

All figures at 150X magnification
Age: Paleocene, except Fig. 3 - Lowermost Paleocene?

PLATE VI

1 *Morozovella angulata* (WHITE), (upper part) and *Subbotina triloculinoides* PLUMMER (lower part), sample Kok-1/2425m
2 *Morozovella abundocamerata* (BOLLI) and fragment of *M. angulata* (WHITE), sample Kok-1/2430m
3 *Morozovella angulata* (WHITE), sample Kok-1/2430m
4 *Subbotina triloculinoides* (PLUMMER), sample Kok-1/2425m
5 *Morozovella* sp., sample Kok-1/2400m
6 *Morozovella velascoensis* group, sample Kok-1/2410m
7 *Planorotalites ehrenbergi* (BOLLI), sample Kok-1/2430m
8-9 *Morozovella aequa* (CUSHMAN & RENZ), sample Kok-1/2400m

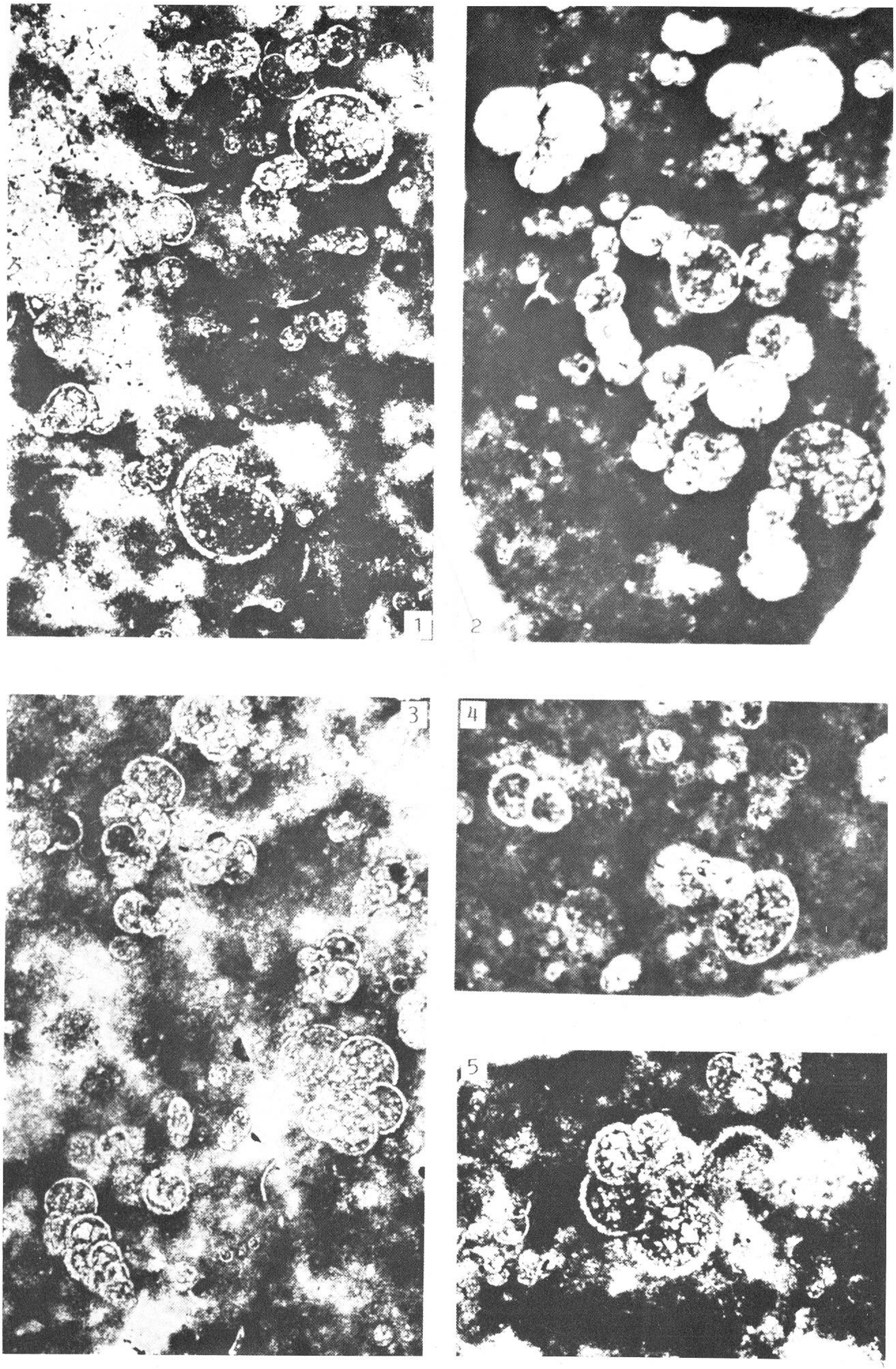
All figures at 150X magnification
Age: Paleocene

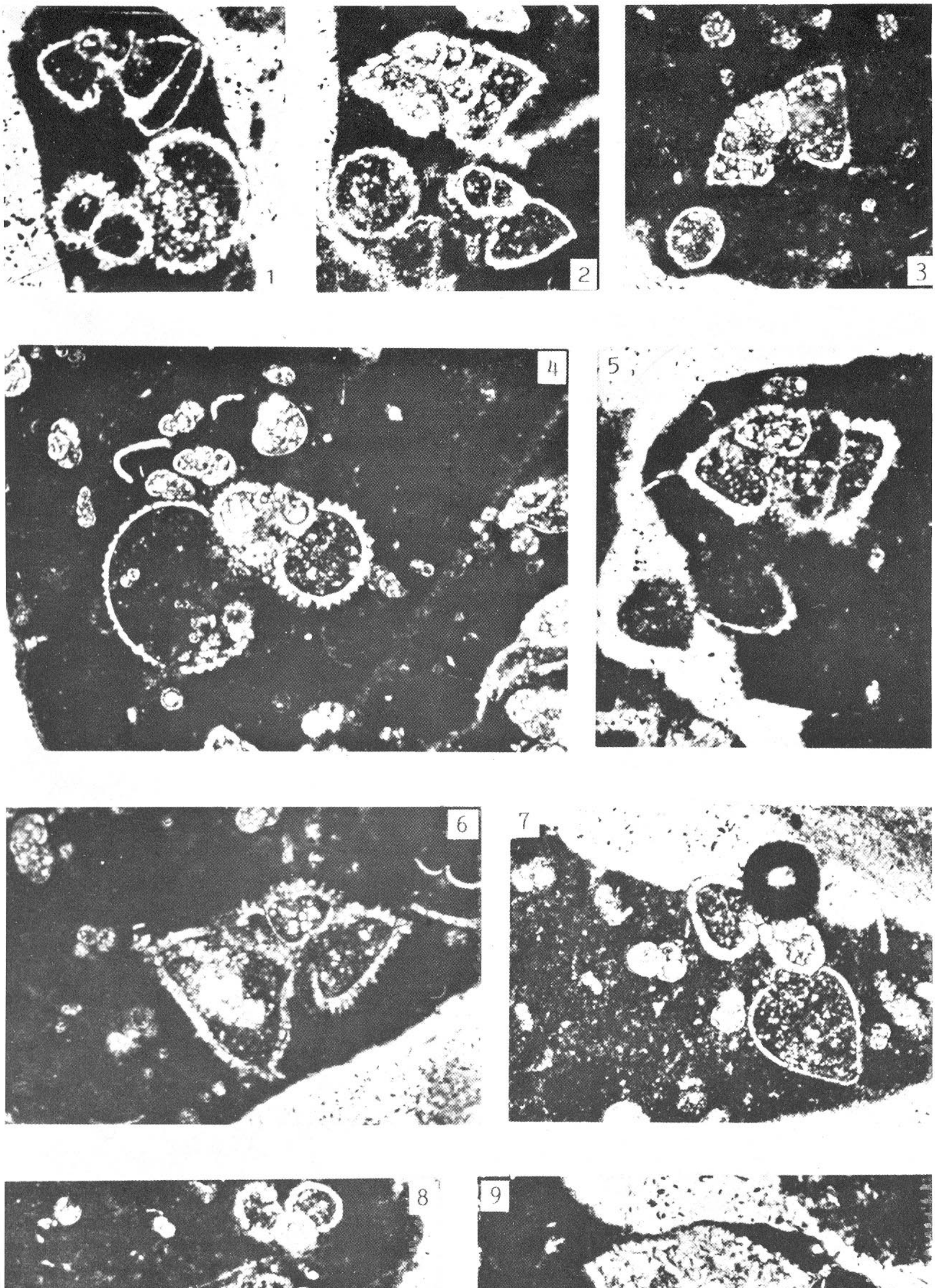
PLATE VII

1 *Miscellanea* sp., sample Kok-1/2420m, 60X
2 *Kathina selveri* SMOUT, sample Kok-1/2420m, 95X
3-4 *Rotalia* sp., sample Kok-1/2410m, 95X
5 *Miscellanea* sp., sample Kok-1/2420m, 60X
6 *Kathina selveri* SMOUT, sample Kok-1/2445m, 90X
7 *Rotalia* sp. and *Kathina selveri* SMOUT, sample Kok-1/2420m, 60X

Age: Paleocene

PLATE V

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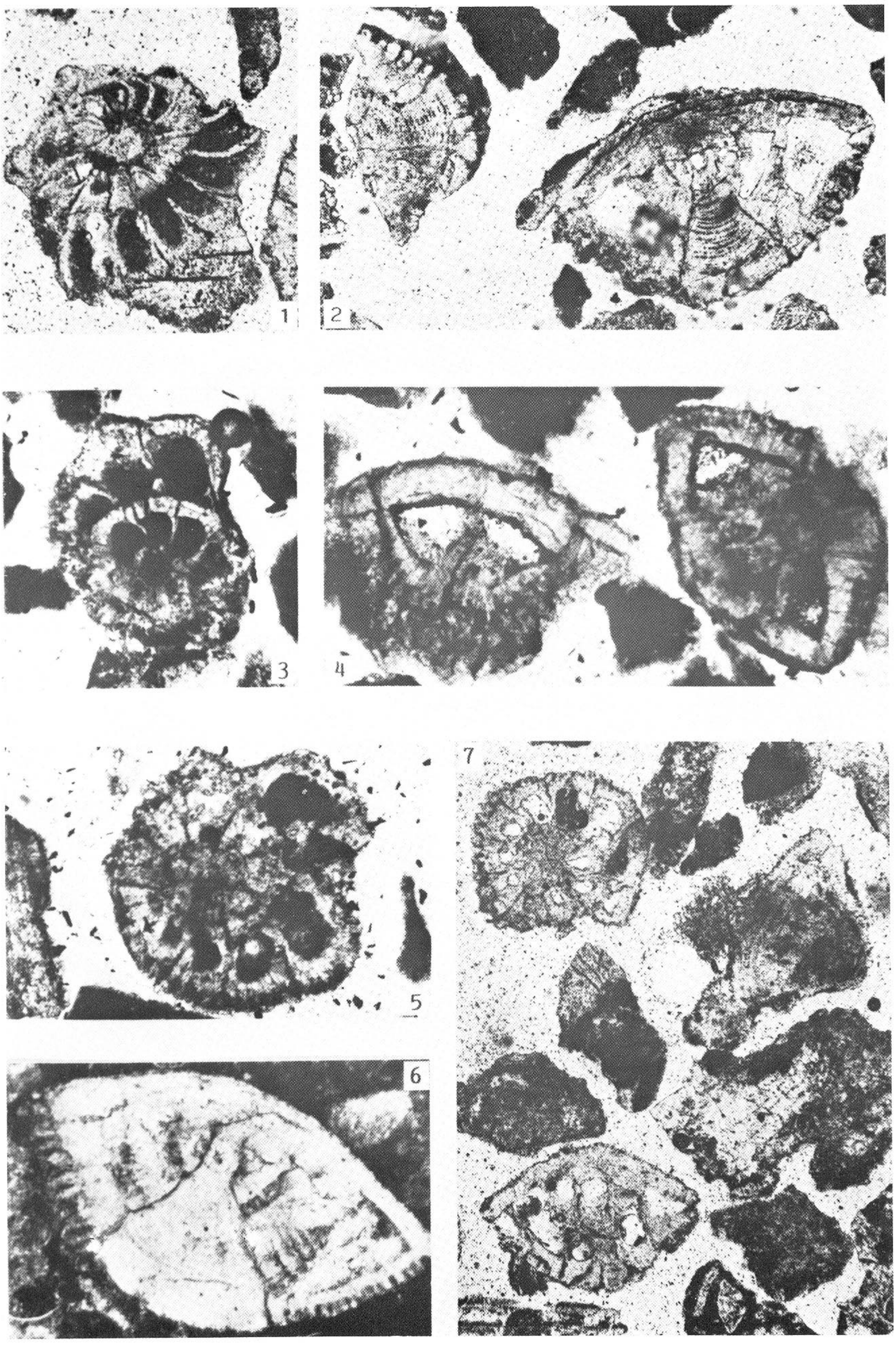


PLATE VIII

1-2	*Markalius inversus* (DEFLANDRE), sample Kok-1/2450m
3-4	*Biantholithus sparsus* BRAMLETTE & MARTINI, sample Kok-1/2450m
5-6	*Ericsonia cava* (HAY & MOHLER), sample Kok-1/2440m
7	*Biscutum? parvulum* ROMEIN, sample Kok-1/2440m
8	*Braarudosphaera bigelowii* (GRAN & BRAARUD), sample Kok-1/2435m
9-10	*Cyclagelosphaera reinhardtii* (PERCH-NIELSEN), sample Kok-1/2435m
11-13	*Cruciplacolithus tenuis* (STRADNER), sample Kok-1/2435m
14-16	*Cruciplacolithus primus* PERCH-NIELSEN, sample Kok-1/2435m
17-18	*Cruciplacolithus tenuis* (STRADNER), sample Kok-1/2435m
19	*Thoracosphaera* sp., sample Kok-1/2435m

All figures at 2000X magnification
Age: Paleocene

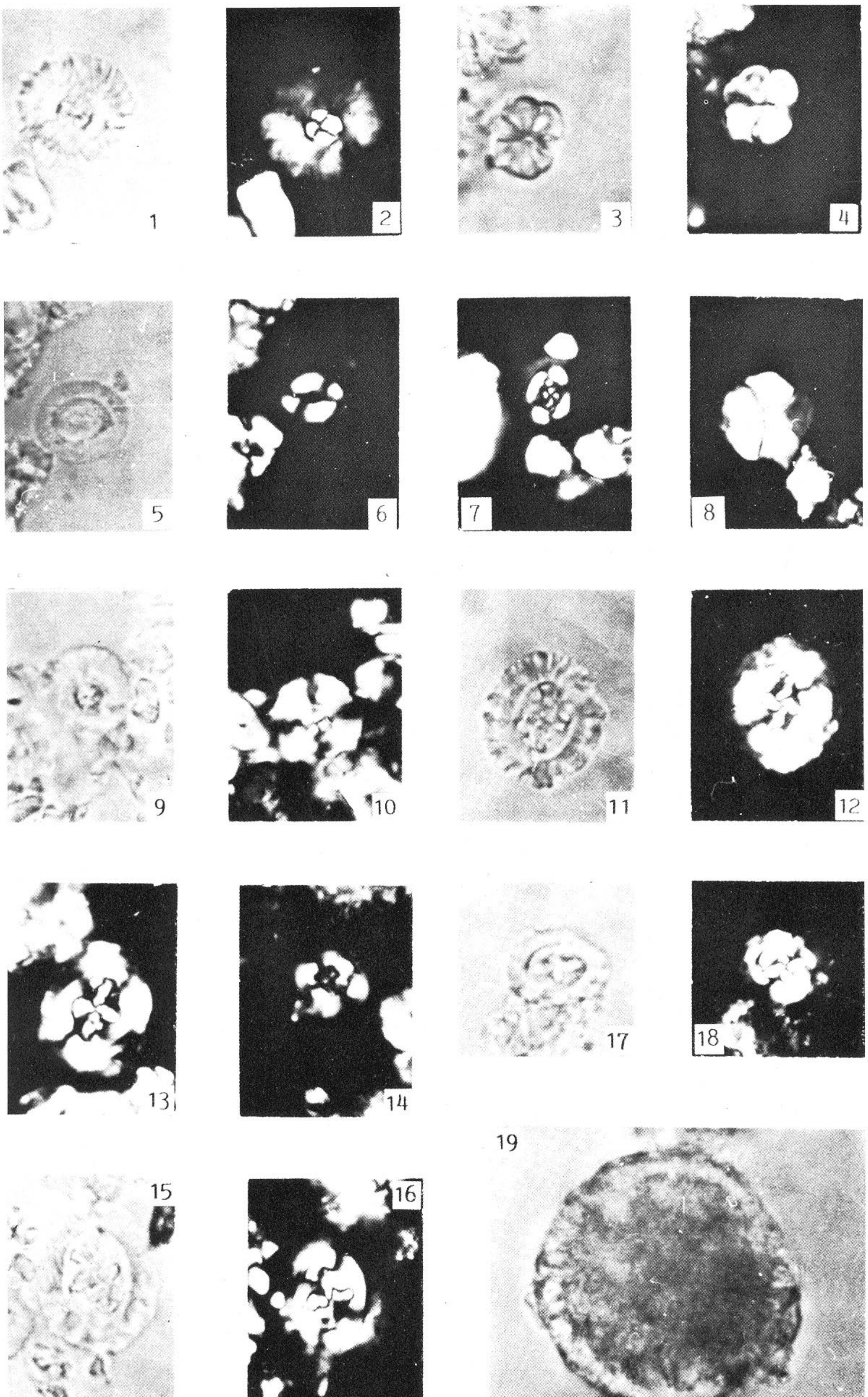
PLATE IX

1	*Turborotalia*? sp. and *Pseudohastigerina micra* (COLE), left corner
2	*Turborotalia cerroazulensis cerroazulensis* (COLE)
3	*Dentoglobigerina* cf. *yeguaensis* (WEINZIERL & APPLIN), *P. micra* (COLE) (upper part).
4	*Acarinina* sp., possibly *A. rohri* group (BOLLI)
5-6	*Globigerinatheka* sp.

All figures at 150X magnification, except Fig. 4, 75X
All samples from the cored interval 2258-2254m, except Fig. 6, sample Kok-1/2205m
Age: Eocene

PLATE X

1	Mudstone and packstone in contact, sample Kok-1/2258-2254m, 30X Age: Eocene
2	Packstone to wackestone, sample Kok-1/2245m, 30X Age: Paleocene
3	Packstone (rudstone)-floatstone, sample Kok-1/2500-2497m, 50X Age: Maastrichtian
4	Packstone (calcarenite), sample Kok-1/2258-2254m, 50X. Age: Eocene
5	Wackestone (pelagic rain), sample Kok-1/2430m, 100X. Age: Paleocene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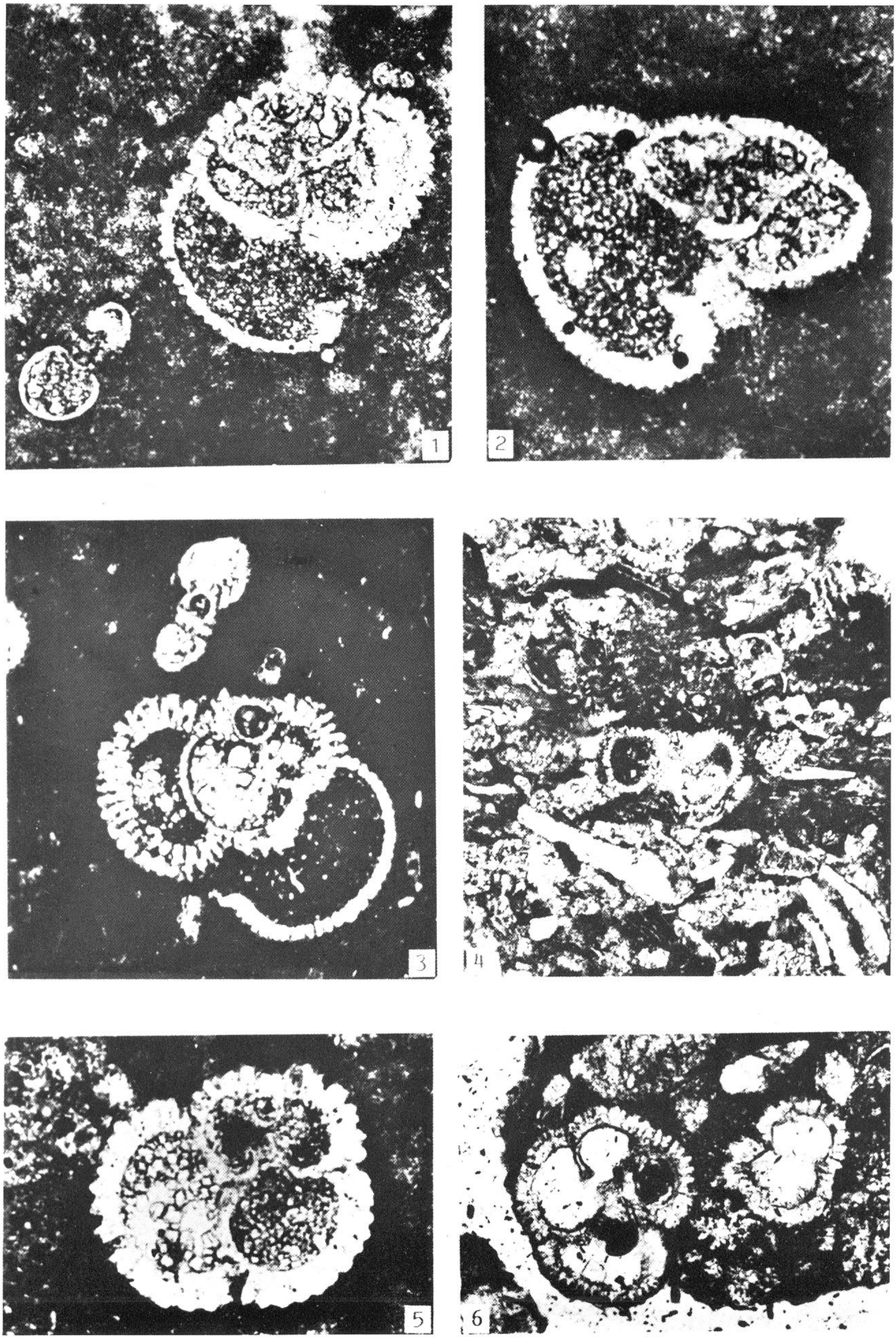
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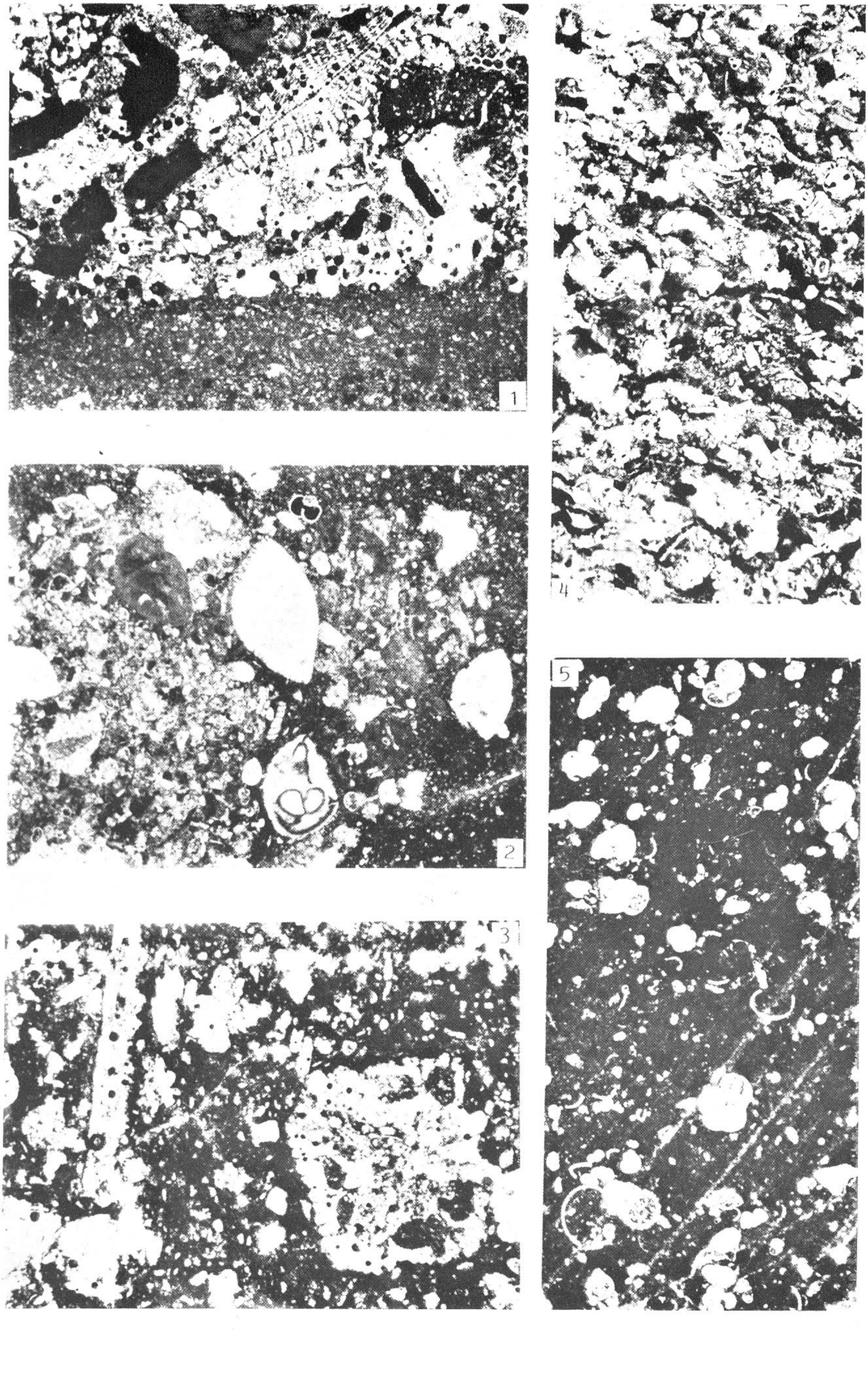
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