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SOME ASSEMBLAGES OF PLANKTONIC FORAMINIFERA FROM THE EOCENE OF THE MAGURA SERIES (POLISH FLYSCH CARPATHIANS)

(Pl. LIV—LVI, 2 Figs.)

Niektóre zespoły otwornic planktonicznych eocenu jednostki magurskiej (polskie Karpaty fliszowe)

(Pl. LIV—LVI, 2 fig.)

Abstract: Assemblages of planktonic Foraminifera occur sporadically in Eocene beds of the Magura series. Index species of the Middle Eocene, Upper Eocene and Eocene-Oligocene boundary are present in these assemblages.

INTRODUCTION

Numerous assemblages of Foraminifera consisting exclusively of benthic, mostly arenaceous species, occur frequently in the Eocene beds of the Magura series. The arenaceous species are accompanied by rare benthic species with calcareous test. Assemblages of planktonic Foraminifera are extremely rare in these beds, and hitherto no constant zones of their occurrence were found.

The occurrence of planktonic microfauna was found at several localities during recent investigations. This microfauna represents three different zones of the Eocene: the Middle Eocene zone with mass occurrence of *Acarinina crassaformis* (S u b b o t i n a), the Upper Eocene Zone with *Globorotalia cocoaensis* C u s h m a n and *Globigerinoides index* F i n l a y, and the Uppermost Eocene — Lower Oligocene zone with *Globigerina officinalis* S u b b o t i n a and *Globigerina ampliapertura* B o l l i. These three assemblages containing widely known planktonic index species determine the area of the discussed beds much better than the long-lived assemblages of arenaceous Foraminifera.

FORMER INVESTIGATIONS

The oldest zone of planktonic Foraminifera known from the Magura series represents the lower Middle Eocene, as indicated by their index species. Three such assemblages are known of this zone.

The two assemblages found in the Eocene beds of the Beskid Niski range (A. J e d n o r o w s k a, S. W ę c ł a w i k, 1965) are described in

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detail in the present paper. The third assemblage was noted recently from the outer region of the Magura tectonic unit (A. Jednorowska, 1968), and the quoted paper contains also descriptions of the species *Globigerina inaequispira* Subbotina, *Acarinina crassaformis* (Subbotina) and *Acarinina pentacamerata* (Subbotina).

Upper Eocene planktonic Foraminifera are much more frequently found in the Magura series. They were noted from the Gorlice and Grybów area (J. Blaicher, 1958, 1962, 1963; J. Blaicher, W. Sikora, 1963). The planktonic microfauna was found in the upper part of the Variegated Shales and in the Magura Beds.

Upper Eocene zone of planktonic Foraminifera was also found in the Babia Góra region, in the upper part of the Hieroglyphic Beds (J. Blaicher, 1961), and in the Sub-Magura Beds and the Magura Beds (J. Blaicher, 1961; A. Jednorowska, 1966; F. Bieda et all., 1967; S. Geroch et all., 1967).

Besides these assemblages with numerous planktonic species a few species of planktonic Foraminifera were noted in assemblages consisting chiefly of arenaceous forms. The presence of specimens of *Acarinina crassaformis* (Subbotina) and *Acarinina pentacamerata* (Subbotina) was noted in a Lower Eocene assemblage of arenaceous Foraminifera in the Beloveza Beds in the profile of Zubrzyca Dolna in the Babia Góra region (A. Jednorowska, 1966; F. Bieda et all., 1967). In the same region single specimens of Upper Eocene planktonic species were recorded in the Magura Beds at Jabłonka and Orawka (A. Jednorowska, 1966; F. Bieda et all., 1967). Planktonic Foraminifera were also noted in the Supra-Magura Beds of the Babia Góra region (A. Jednorowska, 1966; F. Bieda et all., 1967; S. Geroch et all., 1967). Although rare, the stratigraphically important species of the genus *Globigerina* are precious index fossils in the poor assemblage of these Beds.

SELECTED ASSEMBLAGES OF PLANKTONIC FORAMINIFERA

Because of the great stratigraphic value of the assemblages of planktonic Foraminifera the localities of recent findings are briefly redescribed (Fig. 1).

The Middle Eocene assemblage was found in the lower part of the Beloveza Beds exposed in the vicinity of the Ropki village in the Beskid Niski range. The second one was found in the Lower Variegated Shales in the neighbourhood of the Hańczowa village, aslo in the Beskid Niski. The third assemblage of the same age was found in the upper part of the Variegated Shales in the vicinity of Rabka.

Assemblages of planktonic Foraminifera with index species of the Upper Eocene were found in the Sub-Magura Beds at Zembrzyce in the Babia Góra region, and in the Magura Beds at Zabełcze near Nowy Sącz.

Assemblage with rare small *Globigerina* indicating an Eocene — Oligocene boundary was found in the Supra-Magura Beds at Budzów, in the Babia Góra region.

Position of the assemblage of planktonic Foraminifera from the Ropki village (Beskid Niski range)

The discussed region lies south-east of Gorlice, in the Racza-Gorlice unit of the Magura nappe (A. Jednorowska, S. Węcławik, 1965).

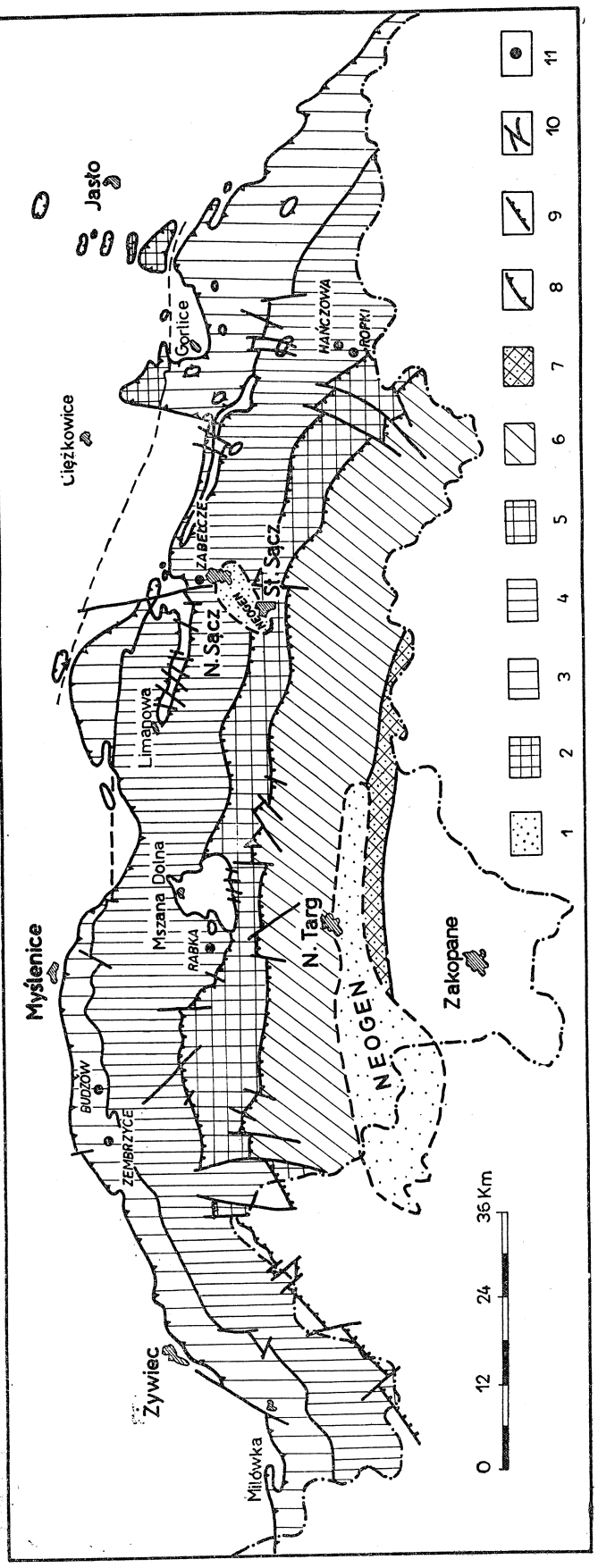
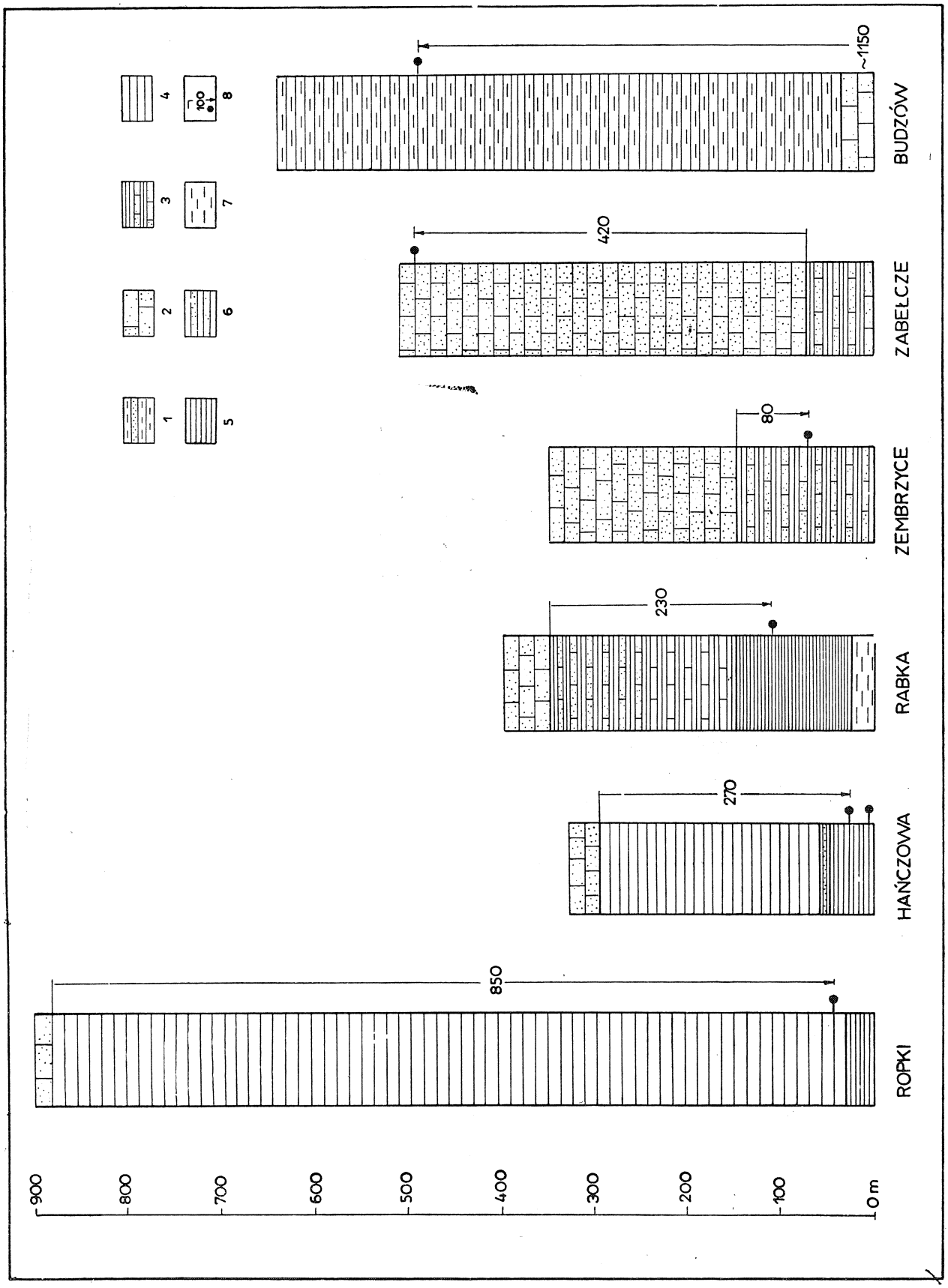


Fig. 1. Principal tectonic and facial units of the Magura nappe (after H. K o z i k o w s k i, 1958). 1 — Intracarpathian Neogene; 2 — Harklowa unit; 3 — Racza — Gorlice unit of the marginal part of the Magura nappe; 4 — Racza — Sącz unit of the marginal part of the Magura nappe; 5 — Bystrica — Rabka unit; 6 — Białe Karpaty — Rabka unit; 7 — Pieniny Klippen Belt; 8 — northern erosional borded of the Magura nappe; 9 — boundaries of the principal tectonic and facial units; 10 — principal faults; 11 — occurrences of planktonic microfauna described in the text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The profile of the Eocene begins here with Variegated Shales with a preponderance of red shales. The shales are overlain by bipartite Beloveza Beds, which are covered by the Magura Beds (Fig. 2).

The red shales contain an assemblage of microfauna characterized by mass occurrence of *Glomospira charoides* (Jones et Parker) and *Glomospira gordialis* (Jones et Parker), accompanied by single specimens of *Hormosina ovulum gigantea* Geroch, *Nodellum velascoense* (Cushman) and more numerous specimens of *Plectina lenis* (Grzybowski), *Plectina coniformis* (Grzybowski), *Lituotuba vermetiformis* (Grzybowski), *Glomospira gorayskii* (Grzybowski), *Recurvoides walteri* (Grzybowski), *Trochamminoides coronatus* (Brady), *Cystammina pauciloculata* (Brady). This is a Lower Eocene assemblage, characteristic for Lower Eocene Beds not only of the Magura unit, but also of other units in the Carpathians (F. Bieda et all., 1963).

Ca. 20 m above the Lower Eocene Variegated Shales a distinctive complex of thin-bedded flysch occurs within the lower part of the Beloveza Beds. This complex 10 m thick consists of yellowish-green pelitic marls, dark-grey and bluish silstones and fine-grained, thin-bedded calcareous sandstones which form ca. 20 per cent of the complex.

Within this complex, in the point marked in Fig. 2, occurs a rich assemblage of planktonic Foraminifera accompanied by rare specimens of arenaceous benthic species. This assemblage contains *Acarinina crassaformis* (Subbotina) which is markedly abundant, accompanied by *Acarinina triplex* Subbotina, *Globigerina inaequispira* Subbotina, *Globigerina frontosa* Subbotina, and *Globigerina linaperta* Finlay. Single specimens of the species *Globorotalia compressa* (Plummer), and *Globigerina triloculinoides* Plummer, encountered in the described assemblage, as well as single abraded specimens of the genus *Globotruncana* are considered as reworked. The assemblage of planktonic forms is accompanied by rare specimens of arenaceous benthic species: *Trochamminoides coronatus* (Brady), *Haplophragmoides walteri* (Grzybowski), *Trochammina variolaria* Grzybowski, *Dendrophrya robusta* Grzybowski, and *Plectina lenis* Grzybowski.

Samples taken from the overlying series revealed the presence of a foraminiferal assemblage characteristic for the Middle Eocene, consisting exclusively of arenaceous forms, and characterized by mass occurrence of the species *Cyclammina amplectens* Grzybowski.

Position of the assemblage of planktonic Foraminifera in the Hańczowa village (Beskid Niski range)

The beds containing the assemblage of planktonic Foraminifera are exposed in the right bank of the Ropka creek, at a distance of ca. 200 m from the road linking Wysowa and Ujście Gorlickie (A. Jednorowska, St. Węcławik, 1965). These beds belong to the Eocene Variegated Shales. The lower part of this member consists of greenish-blue marly shales, and of thin-bedded, fine-grained grey micaceous sand-

←

Fig. 2. 1 — Supra-Magura Beds; 2 — Magura Beds; 3 — Sub-Magura Beds; 4 — Beloveza Beds; 5 — bluish-green shales with intercalations of sandstones; 6 — red shales with intercalations of sandstones; 7 — red shales wtih intercalations of green shales; 8 — occurrences of microfauna described in the text, and their distance from the base of the Magura Beds (metres)

stones. The middle part consists of alternating red and green shales, and thin-bedded fine-grained green sandstones. The upper part of the series is formed of thin-bedded sandstones and greenish-blue shales, with thin intercalations of red shales (Fig. 2).

The assemblages of planktonic Foraminifera occur in two points in the lower part of the Variegated Shales. The first assemblage was found in a sample of greenish-blue marly shales, the second one in a sample taken from a 5 cm thick layer of red marly shale.

Both these assemblages have a composition similar to that of the assemblage of planktonic Foraminifera from the area of the Ropki village. They are characterized (Pl. LIV, Fig. 1) by the presence of numerous specimens of *Acarinina crassaformis* (Subbotina) accompanied by specimens of *Acarinina pentacamerata* (Subbotina), *Acarinina triplex* Subbotina, *Globorotalia aragonensis* Nuttal, *Globigerina inaequispira* Subbotina, *Globigerina frontosa* Subbotina, *Globigerina linaperta* Finlay, *Chiloguembelina martini* (Pijpers). Besides the planktonic species the following benthic Foraminifera with calcareous test are present: *Nodosarella advena* Cushman et Siegfus, *Glandulina eliptica* Reuss, *Anomalinoides granosus* (Hantken), *Cibicides* cf. *cushmani* Nuttal. Benthic arenaceous forms are represented by: *Rhabdammina linearis* Brady, *Dendrophrya excelsa* Grzybowski, *Trochamminoides coronatus* (Brady), *Ammodiscus angygyrus* Reuss, *Glomospira charoides* (Jones et Parker), *Trochamminoides lituiformis* (Brady), *Lituotuba vermetiformis* (Grzybowski), *Reophax splendidus* Grzybowski, *Thalmannammina subturbinata* (Grzybowski), *Cribrostomoides subglobosus* (Sars), and single specimens of *Cyclammina amplectens* Grzybowski.

Position of the assemblage of planktonic Foraminifera from the profile of Rabka

The next assemblage of planktonic Foraminifera was found in the top part of the Variegated Shales exposed in the vicinity of Rabka (Fig. 2). The Variegated Shales consist predominant of red shales and less abundant green shales (H. Kozikowski, 1956; A. Jednorowska, 1968). The red shales are alternating with rare thin-bedded fine-grained green sandstones. The green shales consist of green, olive-green and bluish-grey shales, alternating with thin-bedded flaggy sandstones, gray-green or gray in colour. Thick-bedded sandstones of the Ciężkowice sandstone type are present locally.

The upper part of the profile of the Variegated Shales contain a Lower Eocene assemblage composed exclusively of arenaceous Foraminifera, with a distinct predominance of *Glomospira charoides* (Jones et Parker) and *Glomospira gordialis* (Jones et Parker).

A sample of olive-green marly shales collected in the top part of the profile (Fig. 2), contained an assemblage consisting almost exclusively of Foraminifera with calcareous test, including numerous planktonic Globigerinidae and Globorotalidae (Pl. LIV, Fig. 2). Numerous specimens of *Acarinina crassaformis* (Subbotina) are accompanied in this assemblage by specimens of *Acarinina pentacamerata* (Subbotina), *Globorotalia aragonensis* Nuttal, *Globigerina inaequispira* Subbotina, *Globigerina linaperta* Finlay and *Chiloguembelina wilcoxensis* (Cushman et Ponton). Calcareous benthic species are represented

by: *Lagena amphora* Reuss, *Eponides umbonatus* (Reuss) and *Cibicides cushmani* Nuttal.

The Variegated Shales are overlain in the described profile by the Sub-Magura Beds. Samples collected in the lower part of these Beds contain an assemblage consisting exclusively of arenaceous Foraminifera, with abundant specimens of *Cyclammina amplectens* Grzybowski, indicating a Middle Eocene age.

Position of the assemblage of planktonic Foraminifera from the Sub-Magura Beds at Zembrzyce (Babia Góra region)

The samples of the Sub-Magura Beds containing the assemblage of planktonic Foraminifera were collected in the profile of Zembrzyce-Pilchówka, situated in the marginal part of the Babia Góra region (Fig. 2). The Sub-Magura Beds exposed in the stream-bed of the creek flowing from Pilchówka and joining the Paleczka River at Zembrzyce, are underlain by Variegated Shales (M. Książkiewicz 1966; F. Bieda et all., 1967).

The Sub-Magura Beds exposed in the lower part of the stream valley, consist of thin-bedded sandstones (bed thickness ranges from 10 to 20 cm) alternating with greenish and brown marls which form beds 2—3 m thick.

The samples taken in the lower part of the Sub-Magura Beds contain exclusively arenaceous Foraminifera. The large number of specimens of the species *Reophax pillulifera* Brady is characteristic.

The upper part of the Sub-Magura Beds contain a rich assemblage of Foraminifera (Fig. 2) consisting of benthic species with arenaceous and calcareous tests, as well as of stratigraphically important planktonic species.

An especially rich assemblage was found in a sample collected at a distance of c. 120 m from the road curve. The following benthic arenaceous species represented by few specimens were found: *Rhabdammina linearis* Brady, *Dendrophrya excelsa* Grzybowski, *Glomospira gorayski* (Grzybowski), *Haplophragmoides walteri* (Grzybowski), *Haplophragmoides lamella* (Grzybowski), *Haplophragmoides scitulus* (Brady). The calcareous benthic forms are represented by the following species: *Stilostomella consobrina* (d'Orbigny), *Marginulina subbullata* Hantken, *Discorbis biapertura* (Pokorný), *Halkyardia radiata* var. *minima* (Liebus),*Oolina orbignyana* (Seguenza), *Nuttalides truempyi* (Nuttal), *Globulina gibba* d'Orbigny, *Eponides umbonatus* (Reuss), *Nonionella mauricensis* Howe, *Pullenia quinqueloba* (Reuss), *Cibicides dampelae* Bykova et Chramaja, *Cibicides grimsdalei* Nuttal, *Cibicides rzehaki* (Grzybowski), *Gyroidinoides girardanus* (Reuss), *Rotalia lithothamnica* Uhlig and *Planulina jabacoensis* Bermudez. The planktonic species (Pl. LVI, Fig. 1) are following: *Globorotalia cocoaensis* Cushman, *Globigerina corpulenta* Subbotina, *Globigerina ampliapertura* Bolli, *Globigerina yeguaensis* Weinzierl et Applin, *Globigerina venezuelana* Hedberg, *Globigerina linaperta* Finlay, *Globigerina* cf. *eocaena* Guembel, *Catapsydrax dissimilis* (Cushman et Bermudez), *Catapsydrax unicavus* Bolli, Loeblich et Tappan, *Globigerinoides index* Finlay, *Globigerinatheca* cf. *barri* Brönnimann, *Globigerapsis cf. kugleri* Bolli, Loeblich et Tappan.

Upper Eocene planktonic index species: *Globorotalia cocoaensis*, Cushman, *Globigerina corpulenta* Subbotina, *Turborotalia centralis* Cushman et Bermudez, *Globigerinoides index* Finlay, and *Globigerina ampliapertura* Bolli known from the Upper Eocene and Oligocene, determine the age of the Sub-Magura Beds in the discussed profile.

Position of the assemblage with planktonic Foraminifera from the Magura Beds at Zabełcze near Nowy Sącz

The assemblage was found in Magura Beds exposed at Zabełcze near Nowy Sącz (Fig. 2). In the lower part of the exposure beds of light-green sandstones of medium thickness are alternating with greenish-grey clayey shales a few cm thick. Higher occur thin-bedded sandstones alternating with hard black and grey shales. This sandstone-shale complex is overlain by sandstones and thin-bedded shale similar to those present in the lower part of the exposure.

Samples collected in the upper part of the exposure contain an assemblage of Foraminifera, in which, besides long-living arenaceous species: *Dendrophrya robusta* Grzybowski, *Dendrophrya excelsa* Grzybowski, *Saccammina placenta* (Grzybowski), *Glomospira charoides* (Jones et Parker), *Glomospira irregularis* (Grzybowski) and *Trochamminoides lituiformis* (Brady) occur numerous specimens of *Sphaerammina subgaleata* (Vašiček), and fairy numerous specimens of benthic calcareous species. The latter are represented by: *Nodosaria calomorpha* Reuss, *Lenticulina unica* Maslakova, *Lagena amphora* Reuss, *Globocassidulina subglobosa* (Brady), *Nuttalides truempyi* (Nuttal), *Eponides umbonatus* (Reuss), *Cibicides hantkeni* (Grzybowski) and *Rotalia lithothamnica* Uhlig. The planktonic species (Pl. LV): *Globorotalia cocoaensis* Cushman, *Globigerina corpulenta* Subbotina, *Globigerina yeguaensis* Weinzierl et Applin, *Globigerina eocaena* Guembel, *Globigerinoides index* Finlay and *Turborotalia centralis* (Cushman et Bermudez) indicate the Upper Eocene age of this assemblage.

Planktonic Foraminifera in the Supra-Magura Beds

Occurrences of planktonic Foraminifera were noted near Budzów (Fig. 2) in the Babia Góra region (A. Jednorowska, 1966; F. Bieda et all., 1967). A full profile of the Magura series of this region, from the Palaeocene to the Upper Eocene is exposed in the Droździna stream (M. Książkiewicz, 1966). The Supra-Magura Beds containing the planktonic microfauna are overlying the glaukonitic sandstones of the Magura Beds. Shale intercalations in the Magura Beds did not yield microfauna. The Supra-Magura Beds contain an assemblage of calcareous Foraminifera, not very rich, but comprising index species. Planktonic species in this assemblage are represented by: *Globigerina officinalis* Subbotina, *Globigerina ampliapertura* Bolli, *Globigerina yeguaensis* Weinzierl et Applin and *Globigerina triloculinoides* d'Orbigny (Pl. LVI, Fig. 2). The presence of *Globigerina officinalis* Subbotina and *Globigerina ampliapertura* Bolli determine the age of this assemblage as the Eocene — Oligocene boundary. The same age is suggested by the presence of the benthic species *Cibicides lopianicus* Miatluk in the same assemblage.

STRATIGRAPHIC POSITION OF THE DESCRIBED ASSEMBLAGES OF PLANKTONIC FORAMINIFERA

The first three assemblages of planktonic Foraminifera i. e. the assemblage from the lower part of the Beloveza Beds at Ropki, and the assemblages from the Variegated Beds at Hańczowa and at Rabka occupy the same stratigraphic position.

The marly intercalations containing these assemblages are underlain by strata assigned to the Lower Eocene on the basis of foraminiferal fauna. Above these intercalations Middle Eocene foraminiferal assemblages with abundant *Cyclammina amplectens* Grzybowski were found at Ropki and at Rabka.

Among the planktonic species of Foraminifera present in these assemblages *Acarinica crassaformis* (Subbotina) has a great stratigraphic value, and moreover occur abundantly. Both the generic and the specific name adopted for this form is a matter of discussion. W. A. Krasheninnikov (1964) regarded the species described by N. N. Subbotina (1953) as *Acarinina crassaformis* as a synonym of the species *Globorotalia bullbrooki* Bolli. The same was suggested already by V. Pokorný (1960).

W. A. Berggren (1965) noted several synonyms for the species described by N. N. Subbotina: *Globorotalia bullbrooki* Bolli; *Globorotalia densa* (Cushman); *Globorotalia spinuloinflata* (Bandy). Numerous Soviet authors (among others: O. K. Kaptarenko-Chernousova, 1960; E. K. Shuckaja, 1960; W. P. Alimarina, 1963) recognizing the genus *Acarinina* established by N. N. Subbotina, identify, following the suggestions of that author, the Eocene species with *Globorotalia crassaformis* described from the Pleistocene by Galloway et Wissler (1927 — fide Ellis et Messina: Catalogue of Foraminifera). The name *Globorotalia crassaformis* (Galloway et Wissler) is used, probably for the same species, by E. Hanzlíková (1965), and E. Bratu (1967). Also Polish authors working in the Carpathians used the name *Globorotalia crassaformis* (Galloway et Wissler) describing the form characteristic for Eocene assemblages (F. Bieda et all., 1963; A. Jednorowska, S. Węcławik, 1965; A. Jednorowska, 1966).

In a later paper, N. N. Subbotina (1960) writing on the species *Acarinina crassaformis* states that this species has been established by her, thus stressing upon the difference between the species she described from the Palaeogene of the Northern Caucasus, and the species described by Galloway et Wissler.

On the other hand, the western authors do not recognize the genus *Acarinina* established by N. N. Subbotina (1953). They place this genus among the synonyms of the genus *Globorotalia* (H. Bolli, A. Loeblich, H. Tappan, 1967), or *Turborotalia* (K. Gohrband, 1963; A. Loeblich and H. Tappan, 1964). Still others, e.g. A. Hillebrandt (1962) use the name *Acarinina* as a sub-generic name. However, spherical tests entirely devoid of keel, covered by numerous spines, which, according to the definition of N. N. Subbotina (1953) should be assigned to the genus *Acarinina*, are distinctly differing from the delicate tests provided with a sharp keel of typical specimens of the genus *Globorotalia* (according to the definition of A. Loeblich and H. Tappan, 1964). The covered umbilicus and the delicate wall of

the test distinguish forms belonging to the genus *Turborotalia* from the *Acarinina*. According to N. N. Subbotina (1960) the Turborotalidae form a later developed phyllogenetic branch of Acarininae.

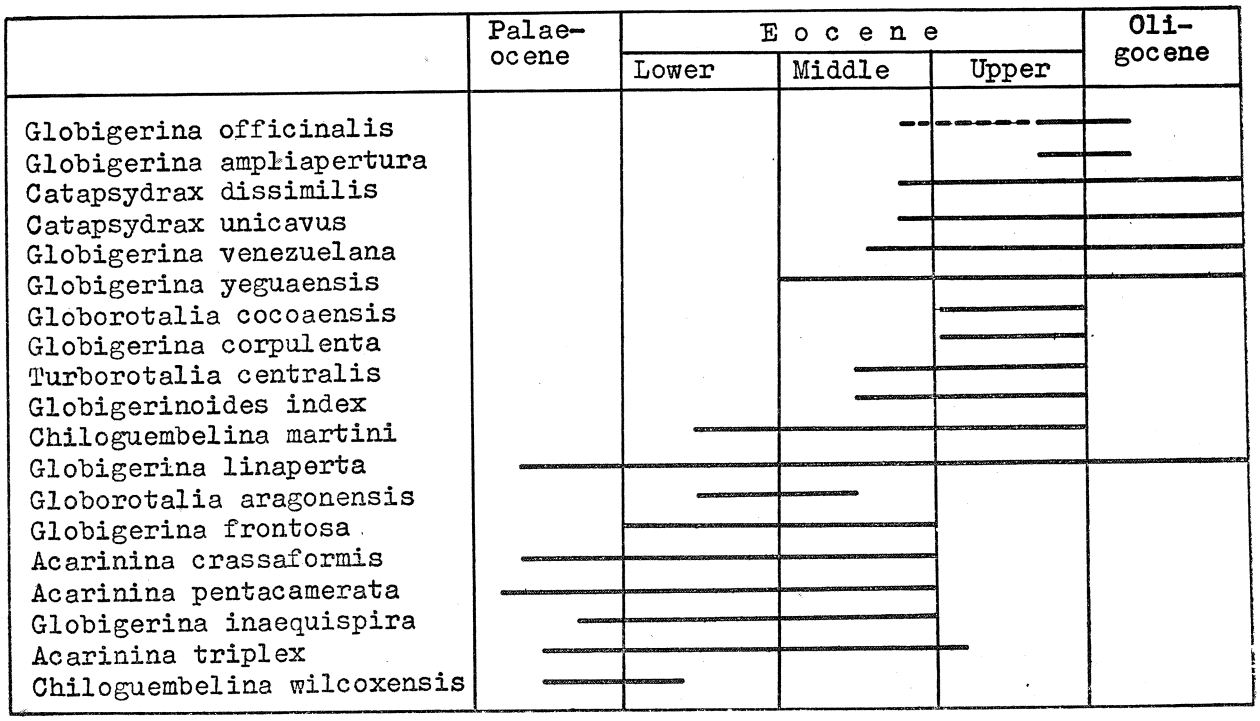
W. A. Berggren (1966) was right stressing upon the distinct features permitting to discdiminate between specimens of Acarininidae and phylogeneticall closely related Globorotalidae and Turborotalidae. This author regarded *Acarinina* as a fully justified generic name.

As the specimens occurring very abundantly in the assemblages of planktonic Foraminifera from Ropki, Hańczowa and Rabka are closely similar to the species described by N. N. Subbotina (1953), the name *Acarinina crassaformis* introduced by this author is used in the present paper.

The occurrence of large numbers of specimens of *Acarinina crassaformis* (Subbotina) in the discussed assemblages suggest an analogy between the assemblage present in the Magura series, and the assemblage with *Acarinina crassaformis* described by N. N. Subbotina (1953, 1960) from the Eocene of Northern Caucasus. According to the latter author, this assemblage appears in the Middle Eocene (part of the F 1 zone — N. N. Subbotina 1960). W. A. Krasheninnikov (1964) reports the occurrence of this assemblage in the lower zone of the Middle Eocene. W. A. Berggren (1966) suggested that the zone with *Acarinina crassaformis*, covering the upper part of the zone of conical *Globorotalia* (N. N. Subbotina, 1953, 1960), corresponds partly to the *Globorotalia palmerae* zone, to the *Hantkenina aragonensis* zone and to a part of the *Globigerapsis kugleri* zone, established by H. Bolli (1957) in Trinidad. According to Bolli, the *Globorotalia palmerae* zone forms the boundary between the Lower and Middle Eocene (Table 2). The

Table 1

Stratigraphic ranges of planktonic Foraminifera in the Magura Series, according to the literature



same have been suggested by M. B. Cita et all. (1968) who parallelised the assemblage of planktonic Foraminifera from the section of Padermo d'Adda (Northern Italy) occurring in beds regarded as representing in age the Lower Eocene — Middle Eocene boundary, with the assemblage with *Acarinina crassaformis* of the Soviet authors.

The same age of the described assemblages is suggested by other planktonic index species (Table 1).

The species *Globorotalia aragonensis* Nuttal described from the Lower Eocene Aragon formation of Mexico, occurs, according to Bolli (1957) in the upper part of Lower Eocene and in the lower part of Middle Eocene (from the *Globorotalia formosa formosa* zone up to the *Globigerapsis kugleri* zone). A similar range of this species is reported by N. N. Subbotina (1960). According to the latter author specimens of *Globorotalia aragonensis* Nuttal appear in her zones *d* and *c* (Table 1).

The next two index species: *Acarinina pentacamerata* (Subbotina) and *Globigerina inaequispira* Subbotina were noted by many authors. Their age range covers the Palaeocene — Middle Eocene. N. N. Subbotina (1953, 1960) described these species from the Palaeocene — Middle Eocene strata of the Northern Caucasus. Czechoslovakian authors (V. Pokorný, 1960; E. Hanzlíková, 1965) described them from the Lower Eocene of Western Carpathians. A. v. Hillebrandt (1962) noted them from the Palaeocene of the Reichenhall and Salzburg areas. In Hungary they were described from the Ypresian and Lutetian of the Dorog basin (L. Vitalis-Zilahy, 1968). *Acarinina pentacamerata* (Subbotina) occurs in the Ypresian and Lower Lutetian of Belgium and of the Paris basin (P. Brönnimann et all., 1968) (Table 1).

Acarinina triplex Subbotina, described from the Lower and Middle Eocene of the Northern Caucasus (N. N. Subbotina, 1953) is present also in the Upper Ypresian and in the Lower Lutetian of the Paris basin (P. Brönnimann et all., 1968). *Globigerina frontosa* Subbotina described from beds of the same age (N. N. Subbotina, 1953) is present in the Middle Eocene of the Western Carpathians (E. Hanzlíková, 1965) and in the Lower Eocene and Middle Eocene of the Eastern Carpathians (E. Bratu, 1967).

The assemblages described above are considered as typical for the Middle Eocene, on account of the similarity to the assemblage with *Acarinina crassaformis* (Table 2). They are stratigraphically corresponding to the assemblages with numerous Globorotalidae and *Globigerina,* described from the Silesian series and the Sub-Silesian series of the Polish Flysch Carpathians (F. Bieda et all., 1963).

The assemblage of planktonic Foraminifera from the Sub-Magura Beds at Zembrzyce, and the assemblage from the Magura Beds at Zabełcze near Nowy Sącz are coeval, as the same index species occur in both. The age of the assemblages is determined by the presence of *Globorotalia cocoaensis* Cushman, an exclusively Upper Eocene species. According to H. Bolli (1957) this species appears in the lower part of the Upper Eocene and is an index form of the upper part of the Upper Eocene in Trinidad. Also in the Atlantic-Meditteranean realm it is an index form of the Priabonian (P. Brönnimann et all., 1968). A. W. Krasheninnikov (1964) described it as an index form of the Upper Eocene in Syria (Table 1).

Globigerina corpulenta Subbotina is another Upper Eocene

species present in the discussed assemblages. This species described as an index form of the Upper Eocene strata of Caucasus (N. N. Subbotina, 1953, 1960) forms part of the assemblage of „large *Globigerina*". W. A. Krasheninnikov (1964) considered this species as an index form for the zone with Upper Eocene nummulites: *Nummulites chavanesi* de la Harpe, *N. fabiani* (Prever), *N. incrassatus* de la Harpe. *Globigerina corpulenta* Subbotina occurs together with *Globorotalia cocoaensis* Cushman in the assemblage described by the above mentioned author.

Krasheninnikov (l. cit.) considered the *Globigerina corpulenta* zone as equivalent to the Upper Eocene *Globigerapsis semiinvoluta* and *Globorotalia cocoaensis* zones established by H. Bolli in Trinidad. The occurrence of this species in the Upper Lutetian strata of the Dorog basin in Hungary, where according to L. Vitalis-Zilahy (1968) it is an index species for a zone, is probably exceptional.

Turborotalia centralis (Cushman et Bermudez) is the third species typical for the Upper Eocene. Although it has a somewhat wider range of occurrence (H. Bolli reports it occurrence from the Middle Eocene *Globigerapsis kugleri* zone up to the Upper Eocene *Globorotalia cocoaensis* zone), but it is very characteristic for Upper Eocene assemblages and is reported by many authors. It occurs, among others, in Upper Eocene assemblages in Trinidad (H. Bolli, 1957) and in Northern Caucasus (N. N. Subbotina, 1953, 1960) (Table 1).

The presence of specimens of *Globigerina ampliapertura* Bolli precises even more exactly the age of the assemblage occurring in the Sub-Magura Beds at Zembrzyce.

According to H. Bolli (1957) this species appears first in the Upper Eocene, accompanying often specimens of *Globorotalia cocoaensis* Cushman and *Turborotalia centralis* (Cushman et Bermudez) (Table 1).

Also the presence of *Globigerinoides index* Finlay is important for the determination of age of the discussed assemblage. According to H. Bolli (1957) this species has the same stratigraphic range as *Turborotalia centralis* (i.e. from the *Globigerapsis kugleri* zone to the *Globorotalia cocoaensis* zone). It occurs often in the Upper Eocene assemblages in the Carpathians (V. Pokorný, 1960; F. Bieda et all., 1963; E. Hanzlíková, 1965). It occurs probably also in the Upper Eocene beds of the Northern Caucasus, determined here by N. N. Subbotina as *Globigerinoides conglobatus* Brady.

The presence of the index forms described above lead to the conclusion that the assemblages of Foraminifera from Zembrzyce and from Zabełcze are equivalent to the Upper Eocene zone of „large *Globigerina*" described from the Northern Caucasus and Crimea (N. N. Subbotina, 1963) (Table 2).

The Supra-Magura Beds at Budzów in the Babia Góra region contain an assemblage including two index species: *Globigerina officinalis* Subbotina and *Globigerina ampliapertura* Bolli. The first is an index species for the Uppermost Eocene and Lower Oligocene (N. N. Subbotina, 1953, 1960). This species is noted by many authors, among others V. A. Krasheninnikov (1964) reports its presence in the Uppermost Eocene and Oligocene of Syria, R. A. Mc Tavish from the same stratigraphic position in the Solomon Islands, L. Vitalis-Zilahy (1968) from the Upper Eocene of the Dorog basin in Hungary.

Eames et all. (1962) found it somewhat earlier, i.e. in the uppermost part of the Middle Eocene of Tanganica (*Truncorotaloides rohri* zone). In the Carpathians *Globigerina officinalis* was found in the Uppermost Eocene of the Western Carpathians (E. Hanzlíková, 1965; Z. Stra-

Table 2

Comparison of zones established on the basis of planktonic Foraminifera in the Eocene and Lower Oligocene

Age		Trinidad – H.Bolli 1957 supplemented by J.A.Berggren 1966	Caucasus and Crimea soviet authors compiled by W.A.Berggren 1966 and N.N. Subbotina 1953, 1960		Assemblages from the Magura series of the Polish Flysch Carpathians
Oligocene		Globigerina ampliapertura zone	Zone of small Globigerina /N.N.Subbotina 1953/		Assemblage with Globigerina officinalis Globigerina ampliapertura
EOCENE	Upper	Globorotalia cocoaensis zone	Globigerina officinalis zone /N.N. Subbotina 1960/		
		Globigerapsis semiinvoluta zone	Zone of Globigerinoides conglobatus and large Globigerina /N.N.Subbotina 1953, 1960/		Assemblage with Globorotalia cocoaensis and Globigerinoides index
	Middle	Truncorotaloides pseudodubia zone	Zone of thin-walled pelagic Foraminifera /N.N.Subbotina 1953/		
		Porticulasphaera mexicana zone			
		Globorotalia lehneri zone	Acarinina rotundimarginata zone		
		Globigerapsis kugleri zone			
		Hantkenina aragonensis zone	Acarinina crassaformis zone		Assemblage with Acarinina crassaformis
		Globorotalia palmerae zone			
	Lower	Globorotalia aragonensis zone	Truncorotalia aragonensis zone	Truncorotalia caucasica subzone	
		Globorotalia formosa formosa zone		Truncorotalia lensiformis subzone	
		Globorotalia subbotinae /G.rex/ zone	Acarinina subsphaerica G.aequa zone	Globorotalia marginodentata subzone	

nik and E. Hanzlikovà, 1967) and of the Eastern Carpathians (E. Bratu, 1967). It occurs also in the Uppermost Eocene and Oligocene of the Polish Flysch Carpathians (F. Bieda et all., 1963; S. Geroch et all., 1967).

The species *Globigerina ampliapertura* according to Bolli (1957), has a stratigraphic range from the Uppermost Eocene *Globorotalia cocoaensis* zone to the Lower Oligocene for which this form is an index species (*Globigerina ampliapertura* zone).

The assemblage from Budzów is regarded, on the basis of the occurrence of the two above species, as equivalent partly to the assemblage with *Globigerina officinalis* described by N. N. Subbotina (1960) in the Uppermost Eocene, and partly to the assemblage of small *Globigerina* described by the same author on the Uppermost Eocene-Lower Oligocene boundary (Table 2).

Future research will probably result in finding new occurrences of planktonic microfauna, which will contribute to the age determination of beds of the very interesting and complicated Magura series.

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STRESZCZENIE

Warstwy jednostki magurskiej zawierają liczne zespoły otwornic aglutynujących. Bentoniczne gatunki wapiennoskorupowe są zwykle nieliczne. Zespoły otwornic planktonicznych znajduje się w warstwach tej jednostki bardzo rzadko. Bardziej szczegółowe badania jednostki magurskiej prowadzone w latach ostatnich pozwoliły na wykrycie punktów z fauną planktoniczną reprezentującą trzy różne poziomy eocenu: poziom środkowoeoceński z masowo występującym gatunkiem *Acarinina crassaformis* (Subbotina), poziom górnoeoceński z *Globorotalia cocoaensis* Cushman i *Globigerinoides index* Finlay oraz poziom wieku najwyższy eocen- oligocen z *Globigerina officinalis* Subbotina i *Globigerina ampliapertura* Bolli.

Najstarszymi zespołami planktonicznymi znanymi dotychczas z warstw eocenu jednostki magurskiej są trzy zespoły, których wiek wyznaczony przy pomocy występujących w nich form przewodnich ustalić można na dolną część eocenu środkowego. Są to zespoły występujące w dolnej części warstw beloweskich z Ropek oraz w warstwach pstrych z Hańczowej w rejonie Beskidu Niskiego. Trzeci analogiczny zespół wykryto w górnej części pstrych łupków z Rabki. Cechą charakterystyczną wszystkich trzech zespołów jest masowe występowanie gatunku *Acarinina crassaformis* (Subbotina). Występowanie w omawianych zespołach dużej ilości okazów tego gatunku pozwala na przyrównanie zespołów z jednostki magurskiej do zespołu z *Acarinina crassaformis* opisanego przez N.N. Subbotinę (1953, 1960) z warstw środkowoeoceńskich

północnego Kaukazu. W tym samym interwale czasowym umieszcza omawiany zespół W. A. Kraszeninnikow (1964) twierdząc, że poziom, w którym zespół ten występuje, odpowiada częściowo strefie z *Globorotalia palmerae*, strefie *Hantkenina aragonensis*, i częściowo strefie z *Globigerapsis kugleri* wydzielonym przez Bollego w warstwach dolnej części eocenu środkowego Trinidadu. Te same sugestie wysuwają autorzy Cita M. B et all. (1968) paralelizując zespół otwornic planktonicznych występujący w warstwach, których wiek umieszczają na granicy eocenu dolnego z eocenem środkowym z zespołem z *Acarinina crassaformis* autorów radzieckich.

Zespoły otwornic planktonicznych, wśród których notuje się gatunki przewodnie dla zespołów eocenu górnego pochodzą z warstw podmagurskich z Zembrzyc w rejonie Babiej Góry oraz z warstw magurskich z Zabełcza koło Nowego Sącza. Wskaźnikiem wieku dla tych zespołów jest obecność wyłącznie górnoeoceńskiego gatunku *Globorotalia cocoaensis* Cushman oraz gatunku *Globigerinoides index* Finlay występującego często w górnoeoceńskich zespołach znanych z warstw Karpat. Innymi formami wskaźnikowymi w tych zespołach są gatunki *Globigerina corpulenta* Subbotina opisana z górnoeoceńskich warstw Kaukazu (N. N. Subbotina 1953) oraz *Turborotalia centralis* (Cushman et Bermudez) towarzysząca zwykle zespołom górnoeoceńskim.

W warstwach nadmagurskich z Budzowa w rejonie Babiej Góry stwierdzono występowanie niezbyt licznego zespołu zawierającego gatunki globigerin przewodnich dla wieku najwyższy eocen- dolny oligocen. Są to gatunki *Globigerina officinalis* Subbotina opisane z tego interwału z warstw Kaukazu (N. N. Subbotina 1953), oraz z tego samego interwału opisana *Globigerina ampliapertura* Bolli 1957).

EXPLANATION OF PLATES

Plate LIV

Fig. 1 — Species of planktonic Foraminifera from the Variegated Beds at Hańczowa. 1, 2, 3, 4 — *Acarinina pentacamerata* (Subbotina); 5, 6 — *Globorotalia aragonensis* Nuttal; 7 — *Acarinina triplex* Subbotina; 8, 9, 10, 11, 12 — *Acarinina crassaformis* (Subbotina); 13, 14, 15, 16, 19 — *Globigerina inaequispira* Subbotina; 17, 18 — *Globigerina frontosa* Subbotina; 20 — *Chiloguembelina martini* (Pijpers). ×50

Fig. 2 — Species of planktonic Foraminifera from the Variegated Beds at Rabka. 1, 2 — *Acarinina pentacamerata* (Subbotina); 3, 4 — *Globigerina inaequispira* Subbotina; 5 — *Chiloguembelina wilcoxensis* (Cushman et Ponton); 6, 7 — *Acarinina crassaformis* (Subbotina). ×50

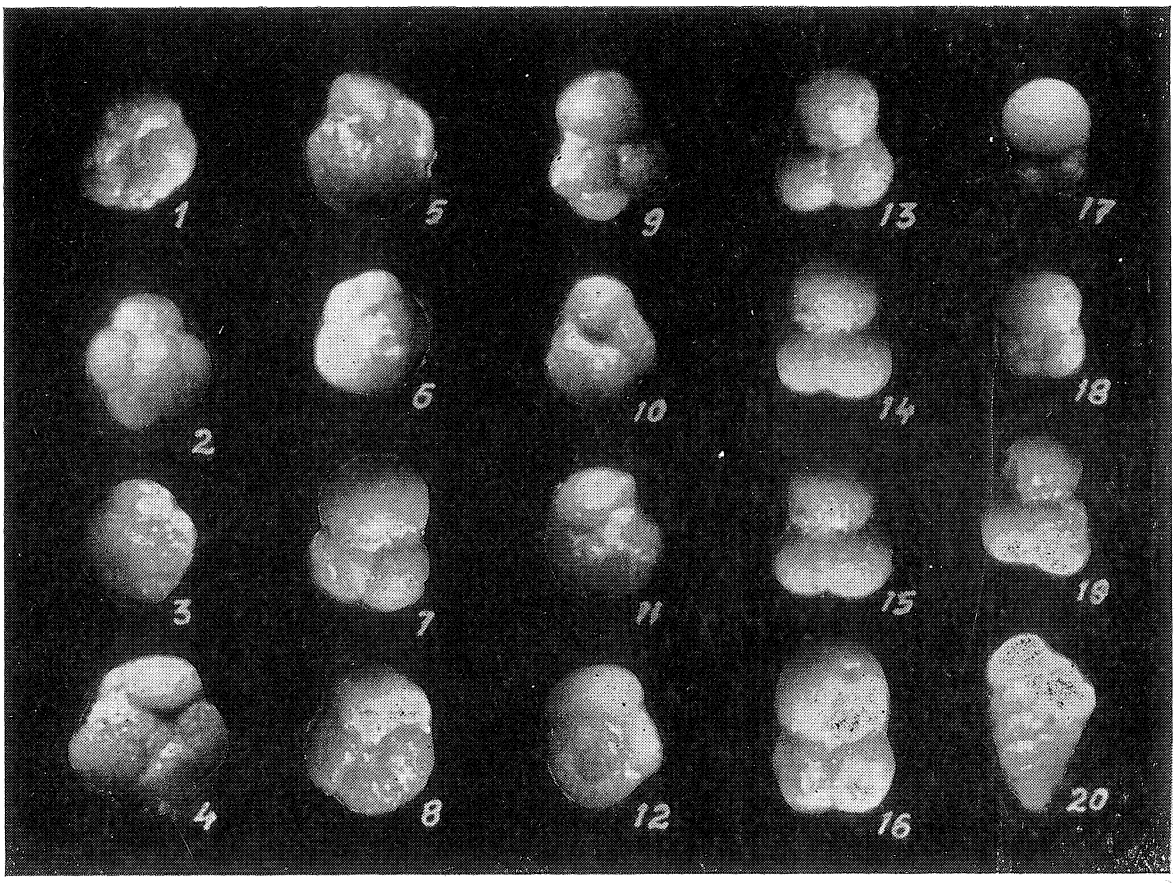
Plate LV

Species of Calcareous planktonic and benthic Foraminifera from the Magura Beds at Zabełcze near Nowy Sącz. 1, 2 — *Rotalia lithothamnica* Uhlig — ×65; 3, 4 — *Nuttallides truempyi* (Nuttall) — ×60; 5, 11, 12 — *Globigerina yeguaensis* Weizierl et Applin — ×60; 6 — *Globigerinoides index* Finlay — ×65; 7 — *Turborotalia centralis* (Cushman et Bermudez) — ×60; 8, 9 — *Globigerina corpulenta* Subbotina — ×65; 10 — *Globigerina eocena* Gümbel — ×60; 13 — *Lagena amphora* Reuss — ×60; 14 — *Nodosaria calomorpha* Reuss ×60

Plate LVI

Fig. 1 — Planktonic species from the Sub-Magura Beds at Zembrzyce. 1, 2, 3 — *Globigerina corpulenta* Subbotina; 4, 5 — *Turborotalia centrails* (Cushman et Bermudez); 6, 14 — *Globigerinatheca* cf. *barri* Brönnimann; 7 — *Catapsydrax dissimilis* (Cushman et Bermudez); 8, 12 — *Catapsydrax unicavus* Bolli, Loeblich, Tappan; 9, 16 — *Globigerina yeguaensis* Weinzierl et Applin; 10, 13 — *Globigerinoides index* Finlay; 11 — *Globigerina venezuelana* Hedberg; 15 — *Globorotalia cocoaensis* Cushman. ×50

Fig. 2 — Planktonic species from the Supra-Magura Beds at Budzów. 1, 2, 5 — *Globigerina yeguaensis* Weinzierl et Applin; 3 — *Globigerina* cf. *trilocularis* d'Orbigny; 4 — *Globigerina venezuelana* Hedberg; 6 — *Globigerina ampliapertura* Bolli; 7, 8, 9 — *Globigerina officinalis* Subbotina. ×50



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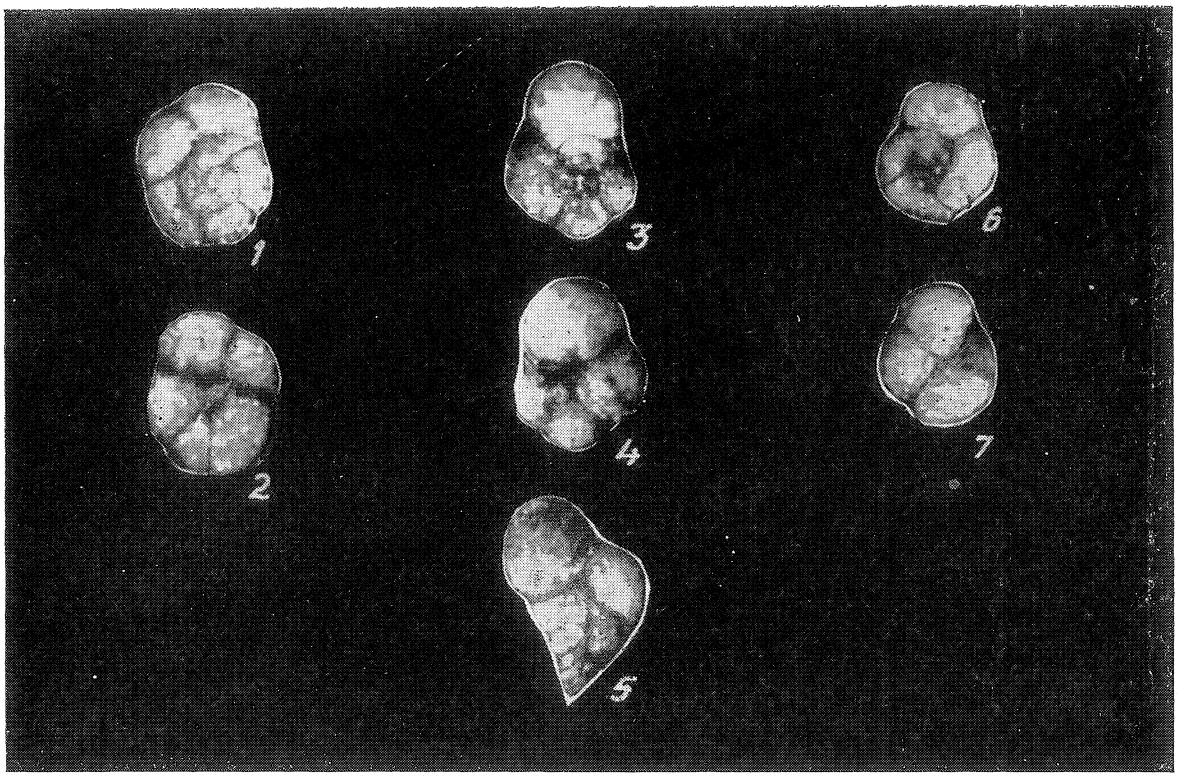
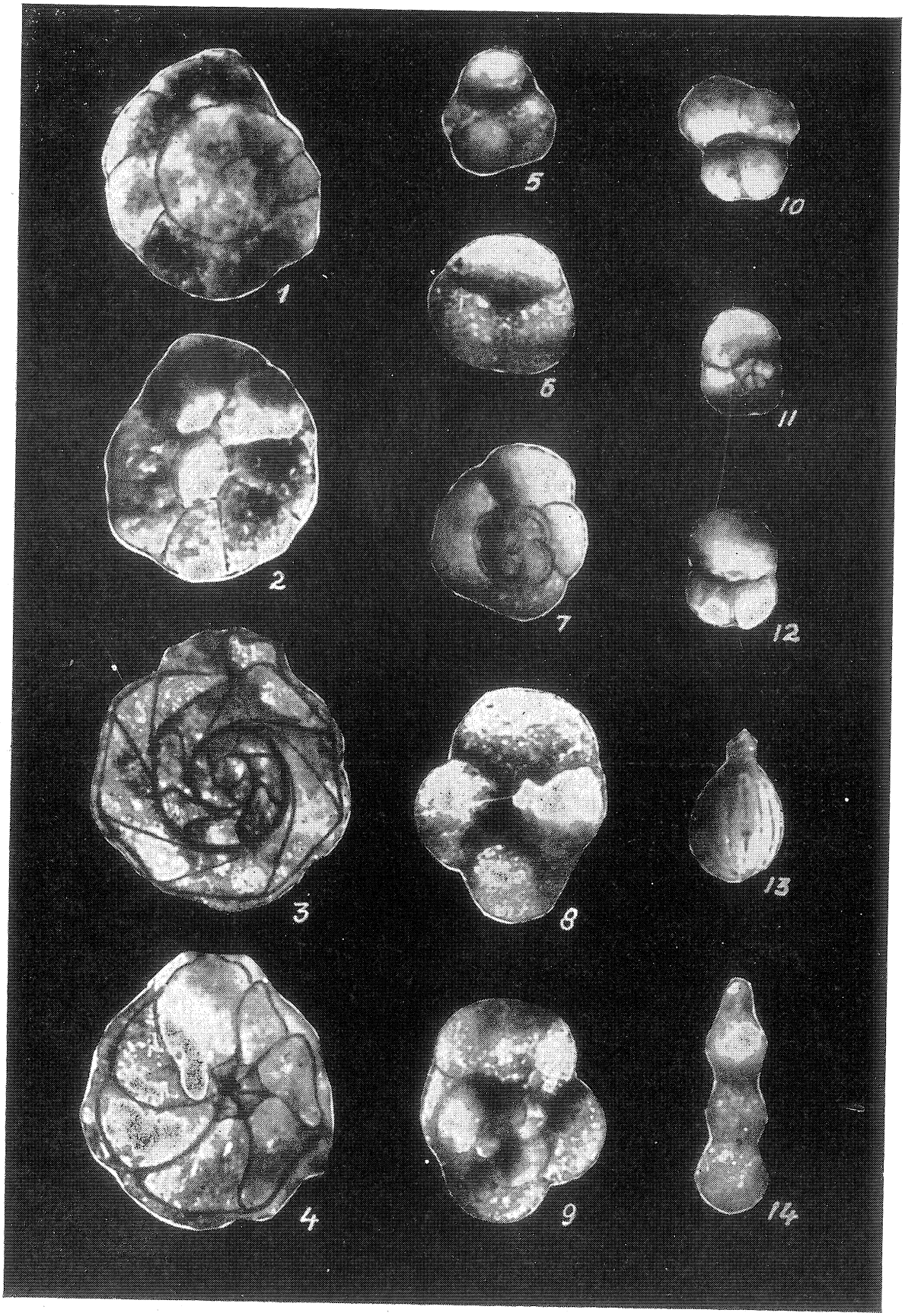


2

A. Jednorowska



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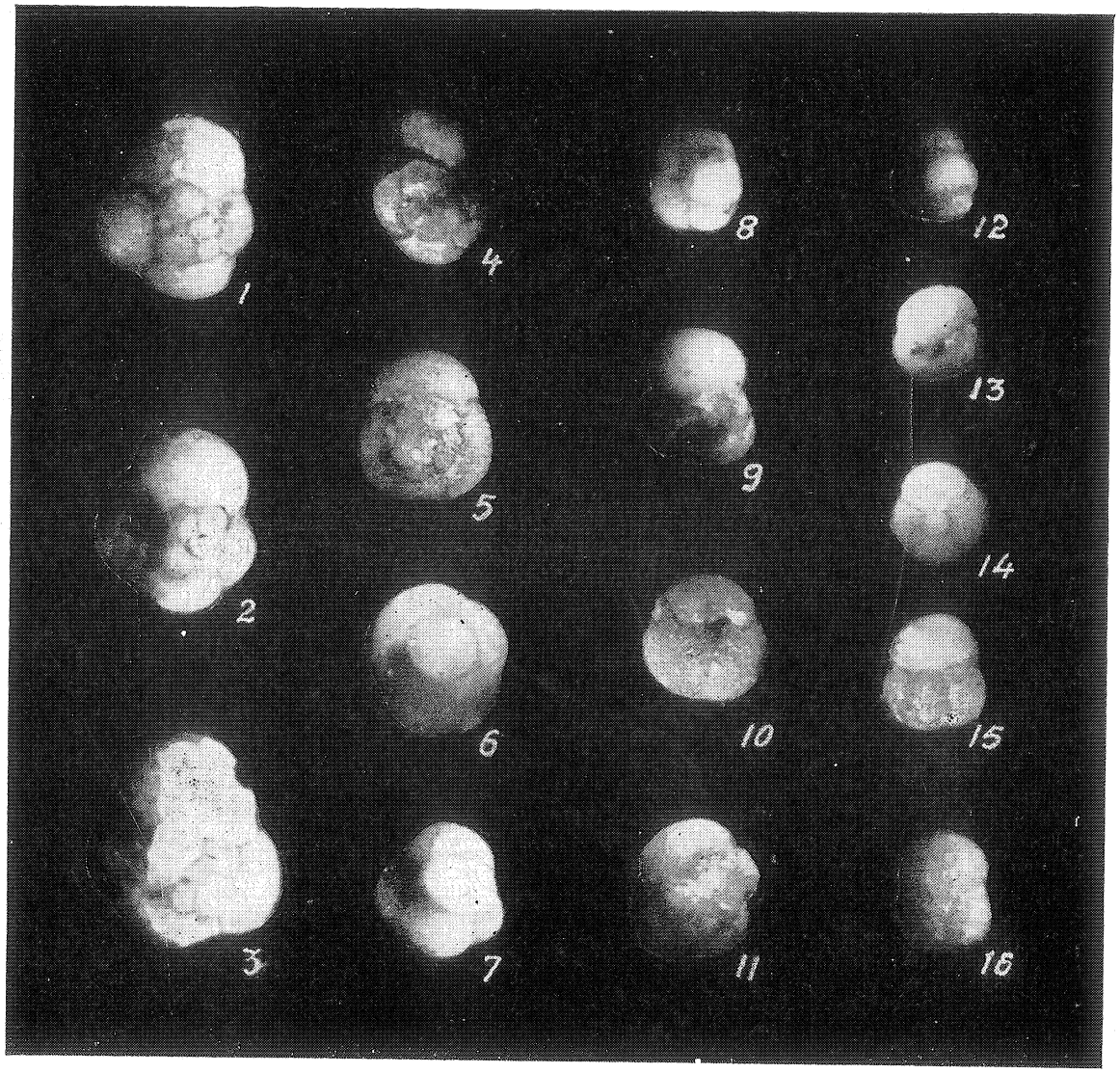

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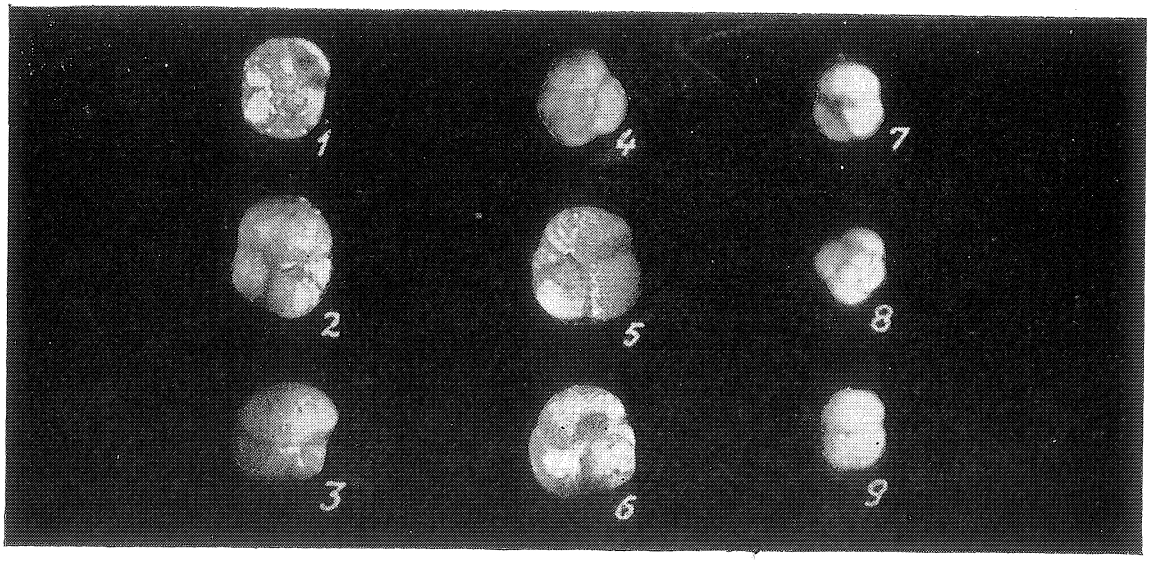

2

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