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THE BIOSTRATIGRAPHIC BASIS OF THE PALEOGENE - NEOGENE BOUNDARY IN THE CENTRAL (UKRAINIAN CARPATHIANS) AND EASTERN (BLACK SEA DEPRESSION, NORTHERN CAUCASUS) PARATETHYS

A. S. ANDREYEVA-GRIGOROVICH and A. D. GRUZMAN

Lviv University, Geological Department, Grushevskogo 4, 290005 Lviv, Ukraine

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Abstract: The Oligocene-Miocene boundary in the Central and Eastern Paratethys is indicated by the appearance of numerous globigerinoides, Miocene nannoplankton and the disappearance of cavate cysts. In the studied sections this boundary coincides with the tops of Lower Krosno and Middle Menilite "subformations" of the Ukrainian Carpathians, Chernobayev Formation of the Northern Black Sea area and the Caucasian regional stage of the Northern Caucasus.

Key words: Paratethys, Oligocene, Miocene, foraminifera, nannoplankton, dinocysts, biostratigraphy.

Introduction

Problems in identifying the Paleogene-Neogene boundary in the Paratethys are connected with the absence of clear biostratigraphic criteria for the Chattian and Aquitanian stages. This made it necessary to establish new regional stages. In the Central Paratethys the Egerian regional stage was established (Baldi & Seneš 1975) which corresponds to Chattian and Aquitanian and in the Eastern Paratethys the Caucasian regional stage was erected (Nosovsky & Bogdanovich 1979, 1980; Nosovsky 1992) which corresponds to Aquitanian.

The present stage of investigations the Paleogene-Neogene boundary in different regions is determined in different ways: the first appearance of *Globigerinoides primordius, Globorotalia kugleri, Globoquadrina dehiscens, Globigerina woodi connecta,* the end of the acmezone of *Cyclicargolithus abisectus,* the disappearance of *Helicosphaera recta, Sphenolithus ciperoensis, Reticulofenestra bisecta.* In the Mediterranean region (sections in Italy) the boundary is proposed to be marked by the last appearance of *Reticulofenestra bisecta* and by the first appearance of *Globorotalia kugleri* (Micarelli et al. 1990).

We studied three groups of planktonic organisms (foraminifera, nannoplankton and dinocysts) from Oligocene-Miocene boundary beds of the Ukrainian Carpathians, Northern Black Sea area and the Northern Caucasus.

The Carpathians

The problem of the Oligocene upper boundary has always been connected with the age problem of the Polyanitsian-Vorotyshchian complex of sediments. It has been considered that the Oligocene ended with the Lower Vorotyshchian "subformation". Vjalov (1985) objected to this conception, he did not unite this "subformation" into a common series with the Polyanitsian Formation and attributed them to different formations. He considered that Polyanitsian Formation possesses all the signs of flysh formation, and Lower Vorotyshchian Formation - of molasse one. According to Vjalov precisely this turning-point in Carpathian geological history is the Oligocene-Miocene boundary. Some other authors (Muratov 1949; Maslakova 1955; Burov et al. 1971) thought that the molasse stage, corresponding to the Oligocene-Miocene boundary, began with sediments of Polyanitsian Formation.

But all these opinions were not supported biostratigraphically.

From the fossil content of the Polyanitsian Formation and Lower Vorotyshchian "subformation" only the foraminifera have been studied (Maslakova 1955; Subbotina 1960; Pishvanova 1960, 1972; Myatlyuk 1971). The Upper Oligocene character of the Polyanitsian foraminifera assemblage was supported on its resemblance to the Khadumian complex of the Northern Caucasus (zone of small *Globigerina, Gumbelina*). In addition, the foraminiferal *Okyktocenosis* of the Polyanitsian Formation contains a great number of foraminifera redeposited from Cretaceous and Paleogene deposits. Both circumstances hampered the determination of Polyanitsian Formation's age (Gruzman & Grigorovich 1978).

The problem of the Oligocene upper boundary in the Krosno type of section was also complex. The Upper Krosno "subformation" is considered by many investigators to be the same age as the Polyanitsian Formation, so naturally all the disagreements as to Polyanitsian Formation's age were also transferred to this part of the section.

However later investigations of the foraminiferal fauna from the Polyanitsian Formation (Pishvanova & Gruzman 1978), from Menilite and Krosno Formations (Dosin & Gruzman 1977; Gruzman 1984), nannoplankton (Andreyeva-Grigorovich et al. 1981, 1989) and dinocysts (Andreyeva-Grigorovich et al. 1986, 1993) showed a lower position for the Paleogene-Neogene boundary in the Carpathians.

The most favourable sections for recognition of the boundary are in the Ukrainian Carpathians where all the groups of planktonic microfossils are present. The Oligocene and Miocene deposits are represented there by two lithological types: Menilite and Krosno facies.

Stratigraphical distribution of planktonic foraminifera (Gruzman 1972, 1981, 1984), nannoplankton (Andreyeva-Grigorovich 1981) and dinocysts (Andreyeva-Grigorovich et al. 1986, 1989, 1990, 1993) was studied from both facies (Figs. 1 - 4).

In Krosno type sections, the Oligocene-Miocene boundary beds consists of coarse- and medium-rhythmic grey flysch deposits of the Lower and Middle Krosno "subformations".

Late Oligocene foraminiferal assemblages with *Globigerina ciperoensis* Bolli, *G. ouachitaensis* Howe & Wall., *G. praebulloides* Blow., *G. angulisuturalis* Bolli, *G. angustiumbilicata* Bolli and *Turborotalia opima opima* (Bolli) occur in the middle part of the Lower Krosno "subformation".

Nannoplankton in this of the "subformation" is represented by *Coccolithus pelagicus* (Wall.), *Reticulofenestra bisecta* (Hay, Mohler, Wade), *R. lockeri* (Müller), *Cyclicargolithus floridanus* (Roth & Hay), *C. abisectus* (Müller), *Zygrhablithus bijugatus* Defl., *Helicosphaera recta* (Hag.), *H. bramlettei* (Müller), *Sphenolithus ciperoensis* Braml. & Wilc., *S. moriformis* Bronn. & Str. This association corresponds to the undivided Upper Oligocene *Sphenolithus distentus* and *S. ciperoensis* zone (Fig. 3).

The dinocyst assemblage includes: *Chiropteridium partispinatum* (Gerlach), *Deflandrea spinulosa* Alb., *D. phosphoritica* subsp. *phosphoritica* Eisen., *Rhombodinium draco* Gocht, *R. longimanum* Vozzhen., *Homotryblium floripes* (Cooks. & Eisen.), *Millioudodinium tenuitabulatum* (Gerlach), *Pentadinium laticinctum* Gerlach, *Thalassiphora pelagica* Eisen., *Tasmanites globulus* Gocht et al.

In the transitional part between the Lower and Middle Krosno "subformations" there is a characteristic Lower Miocene foraminiferal association with *Globigerinoides primordius* Banner & Blow., *G. trilobus* (Reuss), *G.* ex gr. *sacculifer* Brady, *Globigerina venezuelana* Hedb., *G. woodi connecta* Jenkins, *G. praebulloides* Blow., *Turborotalia obesa* (Bolli), *T. brevispira* (Subb.), *Globoquadrina dehiscens* Cushm., Paar. & Coll. (Dosin & Gruzman 1977).

The nannoplankton association from the upper part of the Middle Krosno "subformation" is characterized by *Discoaster druggii* Braml. & Wilc., *Cyclicargolithus floridanus* (Roth & Hay), *C. abisectus* (Müller), *Pontosphaera multipora* (Kamp.), *Braarudosphaera bigelowi* (Gran. & Braarud), *Helicosphaera kamptneri* Hay & Mohler and *Sphenolithus belemnos* Braml. & Wilc. et al. This assemblage corresponds to the Lower Miocene interval of the *Triquetrorhabdulus carinatus* to *Sphenolithus belemnos* zones.

Dinocysts are rather poorly represented in this part of the section, but *Spiniferites ramosus* (Ehren.), *Cordosphaeridium cantharellum* Brosius, *Millioudodinium tenuitabulatum* (Gerlach), *Tuberculodinium* sp., *Apteodinium emsladense* (Gerlach), *Deflandrea phosphoritica* subsp. *vozzhennikovae* Grig., *D. hialina* Baletes and *Thasmanites globulus* Gocht are found. The cysts in this assemblage are characteristic of Miocene deposits (Costa & Manum 1988).

Accordingly, the distribution of foraminifera, nannoplankton and dinocysts in the Krosno type sections shows that the Oligocene-Miocene boundary lies in the upper part of the coarse-rhythmic flysch of the Lower Krosno "subformation". Miocene deposits are indicated by association with *Sphenolithus belemnos* and *Globigerinoides* and also by the disappearance of cavate cysts.

In Menilite type sections the deposits around the Oligocene and Miocene boundary are represented by the Middle Menilite and Upper Menilite "subformations" (Andreyeva-Grigorovich et al. 1986).

In the upper clay part of the Middle Menilite "subformation" there are numerous *Globigerina ciperoensis* Bolli, *G. angustiumbilicata* Bolli, *G. praebulloides* Blow., *Turborotalia opima opima* (Bolli). In the "subformation" top there are single *Globigerinoides primordius* Banner & Blow. Late Oligocene nannoplankton is represented by an association of *Sphenolithus distentus* and *ciperoensis* zones. *Helicosphaera recta* Müller, *H. intermedia* Braml. & Wilc., *H. euphratis* (Hay), *Reticulofenestra lockeri* Müller, *R. bisecta* (Hay, Mohler, Wade), *Cyclicargolithus abisectus* (Müller), *Zygrhablithus bijugatus* Defl., *Sphenolithus moriformis* Bronn. & Str., *S. distentus* Martini, *S. ciperoensis* Braml. & Wilc. and *Triquetrorhabdulus carinatus* Martini were found. Dinocysts are represented by *Wetzeliella symmetrica* Weil., *W. articulata* Eisen., *Thalassiphora pelagica* Eisen., *Rhombodinium draco* Gocht, *Cyclopsiella elliptica* Drugg. & Loebl., *Deflandrea heterophlycta* (Defl. & Cooks), *D. phosphoritica* Eisen., *D. spinulosa* Alb., *Chiroptheridium* cf. *partispinatum* (Gerlach), *Cordosphaeridium cantharellum* Bros., *Millioudodinium tenuitabulatum* (Gerlach).

The Upper Menilite "subformation" (its middle part) contains a poor association of small planktonic foraminifera consisting of *Globigerina pseudoedita* Subb., *G. venezuelana* Hedb., *G. angustiumbilicata* Bolli, *Turborotalia brevispira* (Subb.), *Chiloguembelina gracillima* (Andr.) and *Cassigerinella chipolensis* (Cushm. & Ponton). By its composition this complex is similar to the characteristic assemblage of the Polyanitsian Formation.

Nannoplankton of the Lower part of the "subformation" is represented by *Triquetrorhabdulus carinatus* Mart., *Discoaster druggii* Braml. & Wilc., *Cyclicargolithus floridanus* (Roth & Hay), *C. abisectus* (Müller), *Helicosphaera kamptneri* (Hay & Müller), and of upper part by *Sphenolithus belemnos* Braml. & Wilc., *Helicosphaera ampliaperta* Braml. & Wilc. The taxonomic diversity of dinocysts of the Upper Menilite "subformation" is rather poor. There we found *Millioudodinium tenuitabulatum* (Gerlach), *Deflandrea hialina* Baletes, *D. phosphoritica* subsp. *vozzhennikovae* Grig., *Aptenodinium emslandense* (Gerlach) and *Spiniferites ramosus* (Ehren.), *Melitaesphaeridium choanophorum* (Defl. & Cooks.), *Tasmanites globulus* Gocht, *Homotryblium floripes* (Cooks. & Eisen.).

On this basis, the distribution of planktonic groups in the Menilite type sections, makes it possible to place the Oligocene-Miocene boundary on the base of the Upper Menilite "subformation".

Thus in the Ukrainian Carpathians the Oligocene-Miocene boundary is marked by the appearance of the genus *Globigerinoides, Globigerina woodi connecta*, between the disappearance of *Reticulofenestra bisecta, Zygrhablithus bijugatus, Helicosphaera recta* and the appearance of the association of zones carinatus - druggii - belemnos (nannoplankton), between the last appearance of *Chiropteridium partispinatum*, species of genera *Rhombodinium, Wetzeliella* and some *Deflandrea* and the appearance of the impoverished association of dinocysts with *Melitasphaeridium choanophorum* and *Tuberculodinium* sp. Such a positioning of the boundary is rather conditional because of the irregular distribution of microfossils in the very thick flysch complexes which exact recognition of the zones in every particular section.

Northern Black Sea region

Here the Oligocene-Miocene boundary positioning is also debatable. The Caucasian regional stage, corresponding to Aquitanian and established for southern regions, includes the Askanian and Gornostaevian Formations (Nosovsky & Bogdanovich

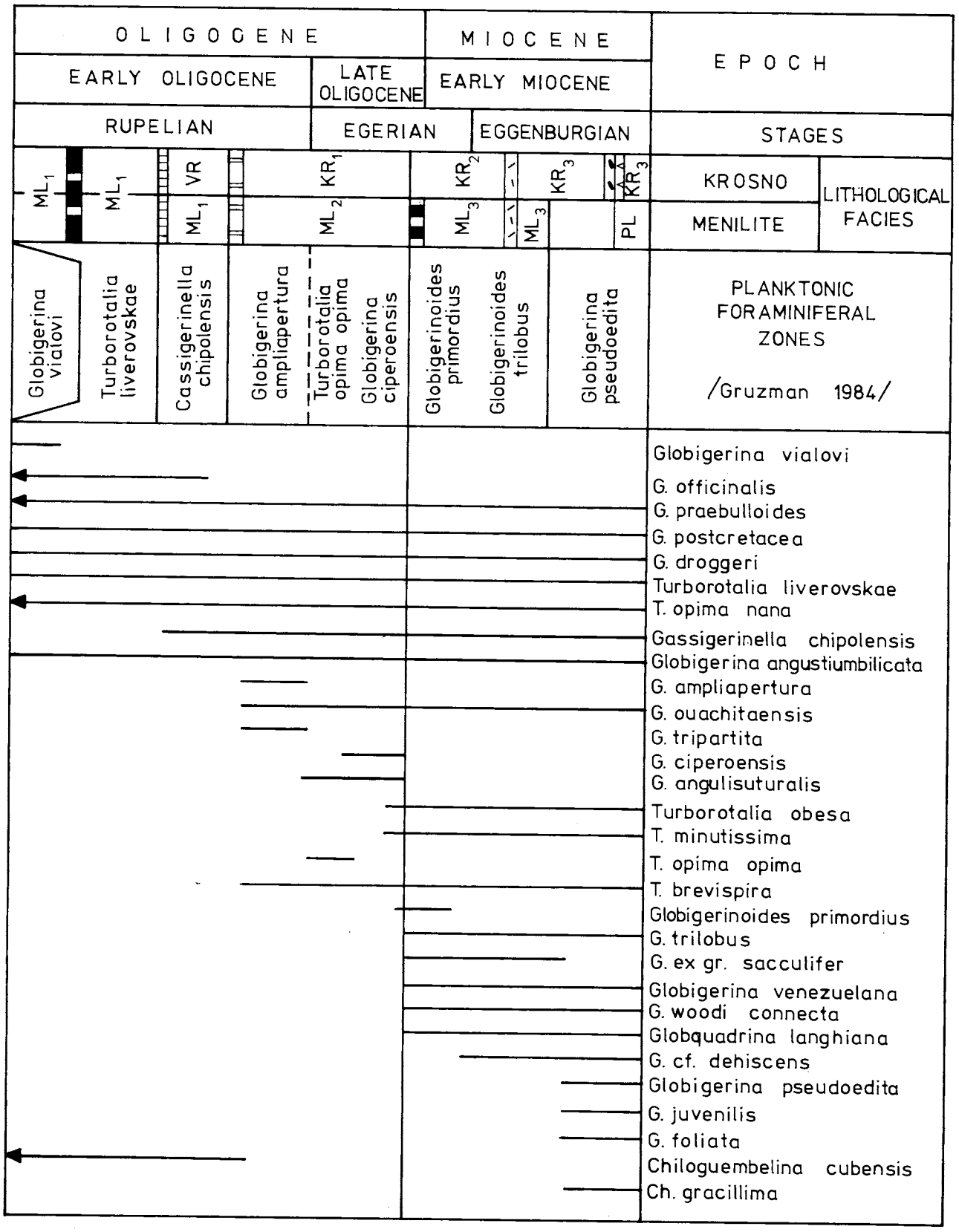

Fig. 1. Distribution of planktonic foraminifera in the Oligocene - Lower Miocene of the Ukrainian Carpathians. Legend see Fig. 2.

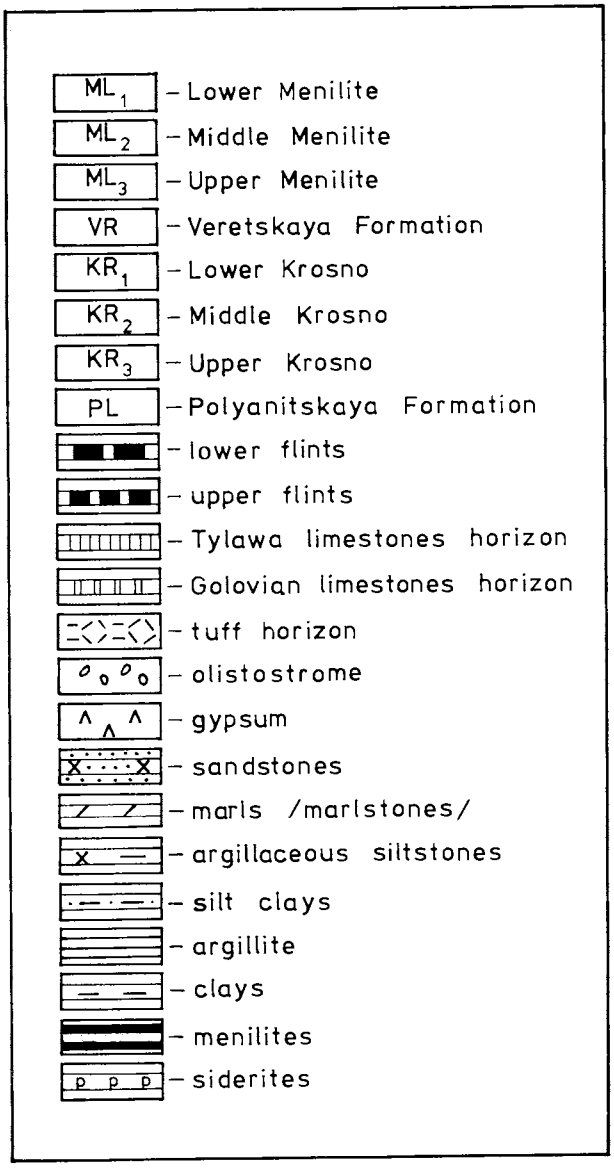

Fig. 2. Legend.

1979, 1980). But the composition of planktonic foraminifera from Askanian Formation: *Globigerina praebulloides* Blow and others corresponds to Upper Oligocene *G. ciperoensis* (Kraeva & Yartseva 1974; Andreyeva-Grigorovich et al. 1993) and, therefore, the lower part of Caucasian regional stage is Late Oligocene. Its upper part Gornostaevian Formation on the basis of the mollusc fauna, foraminifera, spores and pollen, is also Late Oligocene (Veselov et al. 1969).

Dinocysts have been studied from the borehole 1-GK Svobodny Port, 7-K Nizhnie Torgai, 12-K Chernobaevka, 8-K Ivanovka and others. They are abundant all through the section of boundary deposits. It is necessary to note that dinocyst associations from Askanian and Gornostaevian Formations practically do not differ. *Deflandrea arcuata* Vozzh., *D. phosphoritica* subsp. *phosphoritica* Eisen., *D. phosphoritica* subsp. *australis* Cooks. & Eisen., *D. granulata* Menendez, *D. elegantica* And.-Grig. & Savits., *D.* aff. *oebisfeldensis* Alb., *D. spinulosa* Alb., *Rhombodinium draco* Gocht, *R. longimanum* Vozzhenn., *Wetzeliella symmetrica* Weiler, *W. articulata* Eisen., *Chiropteridium partispinatum* (Gerlach) and *Homotryblium floripes* (Cooks. & Eisen.) et al. are found here (Fig. 5). This association corresponds to the Upper Oligocene zones of North-Western Europe D 14 and D 15 (Costa & Manum 1988).

The whole dinocysts complex mentioned above practically disappeared at the end of Gornostaevian period. In Chernobaevian Formation an impoverished association, with *Tuberculodinium vancampoae* Drugg & Loeblich, *Apteodinium emslandense* (Gerlach), *A.* cf. *spiridoides* Benedek, *Thallasiphora pelagica* Eisen., *T.* sp., *Tyttodiscus* sp., et al. green algae and *Acritarchs*, has been found. It may be compared with the Lower Miocene dinocyst association of North-Western Europe (D 16, Costa & Manum 1988).

Thus, in the Northern Black Sea region the upper part of the *Chiropteridium partispinatum* zone marks the Oligocene-Miocene boundary. It practically coincides with the upper part of Chernobaevian Formation.

Northern Caucasus

Here the Paleogene-Neogene boundary is placed along the lower part of the Caucasian regional stage which includes Alkunian and Zelenchukian Formations and a clay part of Karadzhalginian Formation. The age of the Caucasian regional stage in the stratotypical area is based on the fauna of benthic foraminifera studied by A. K. Bogdanovich and L. S. Ter-Grigoryants. The fauna is mainly composed of endemic species (Nosovsky & Bogdanovich 1979, 1980; Nosovsky 1992). We have studied calcareous nannoplankton and dinocysts from stratotypical sections of the Caucasian regional stage - the sections along the Kuban and Belaya Rivers and borehole 4 Novopokrovskaya drilled in the Stavropol region.

Calcareous nannoplankton was found only in the Alkune Formation deposits, and is characterised by *Coccolithus pelagicus* (Wall), *C. eopelagicus* Braml. & Reidel, *Cyclicargolithus floridanus* (Roth & Hay), *C. abisectus* (Müller), *Reticulofenestra bisecta* Hay & Mohler, *R. lockeri* Müller, *Helicosphaera recta* (Hag), *H. bramlettei* Müller, *Sphenolithus moriformis* Bronn. & Str., and *Zygrhablithus bijugatus* Defl. This assemblage is correlated with the undivided interval of the Late Oligocene *Sphenolithus distentus* and *S. ciperoensis* zones.

In the whole section dinocysts are abundant and various. Association of *Chiropteridium partispinatum* zone is established from Alkunian and Zelenchukian Formations and from the lower clay part of the Karadzhalginian Formation. There are: *Chiropteridium partispinatum* (Gerlach), *Homotryblium floripes* (Cooks. & Eisen.), *Deflandrea granulata* Menen., *D. phosphoritica* subsp. *phosphoritica* Eisen., *D. phosphoritica* subsp. *australis* Cooks. & Eisen., *D. spinulosa* Alb., *Rhombodinium draco* Gocht, *R. longimanum* Vozzhen., *Wetzeliella symmetrica* Weiler, *W. articulata* Eisen., *Charlesdowniae marginata* And.-Grig. & Savits.

This complex is close to the association from the Askanian and Gornostaevian Formations of the Black Sea region and to the Upper Oligocene association of the Carpathians. The upper boundary of the partispinatum zone is marked by the last appearance of zonal species and species *R. draco* and *W. symmetrica*. This boundary does not cross all the species of the genera *Rhombodinium* and *Wetzeliella*, a lot of species of genus *Deflandrea* with some exception (Fig. 6). In the studied sections of the Northern Caucasus the upper boundary of the partispinatum zone is in the middle of Karadzhalginian Formation and almost coincides with the upper part Caucasian regional stage. Thus,

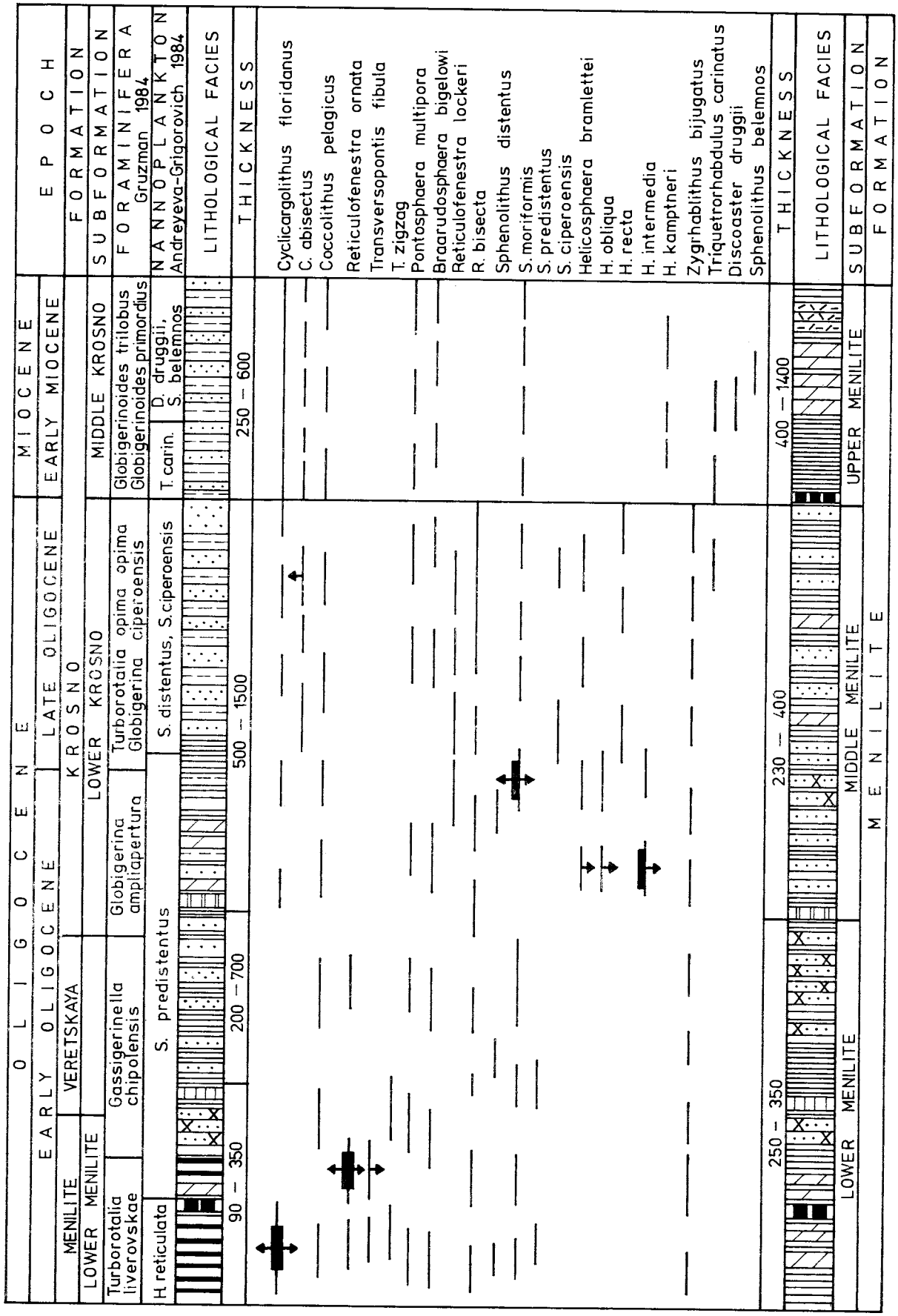

Fig. 3. Distribution of nannoplankton in the Oligocene - Lower Miocene of the Ukrainian Carpathians. Legend see Fig. 2.

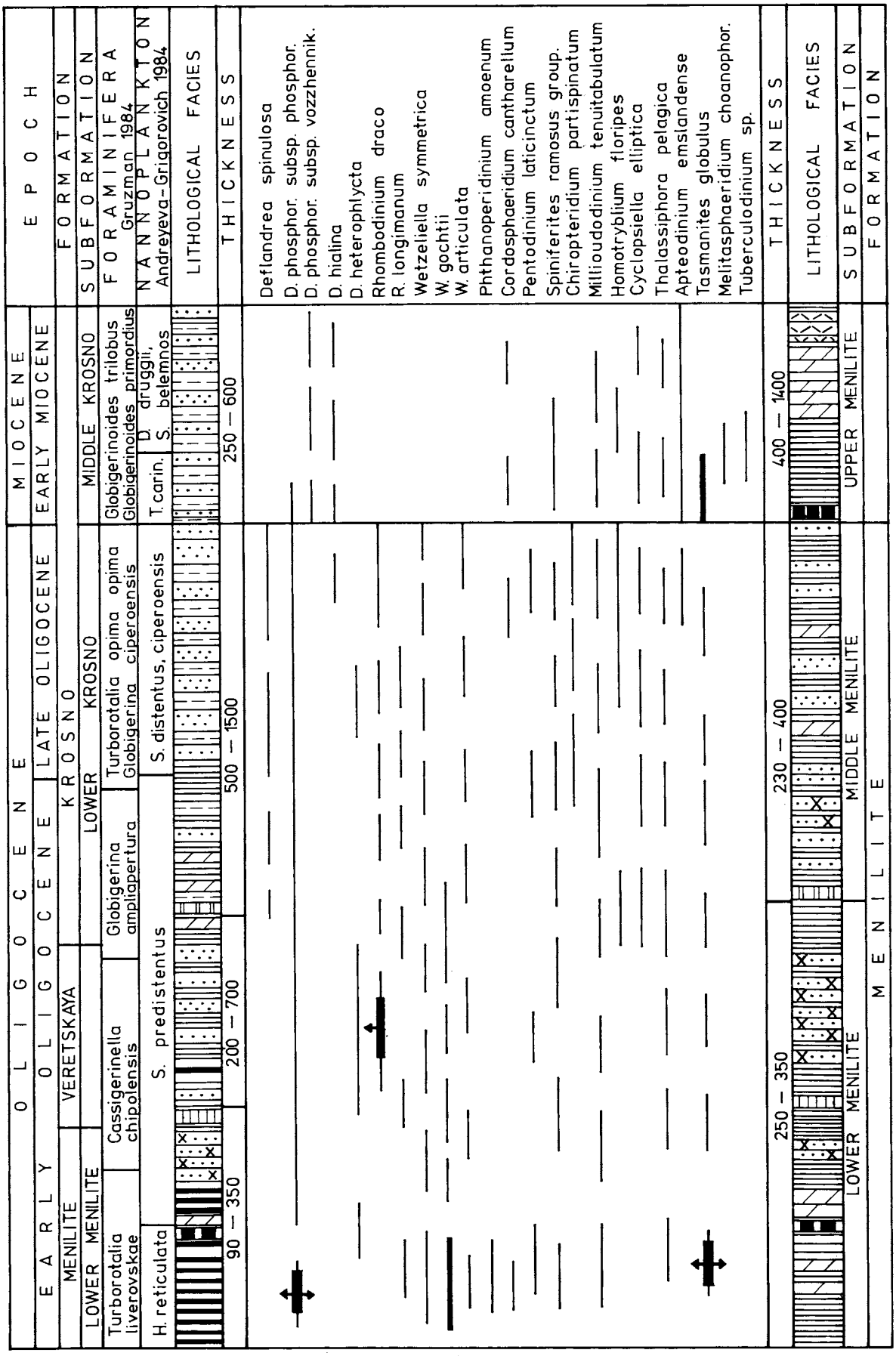

Fig. 4. Distribution of dinocysts in the Oligocene - Lower Miocene deposits of the Ukrainian Carpathians. Legend see Fig. 2.

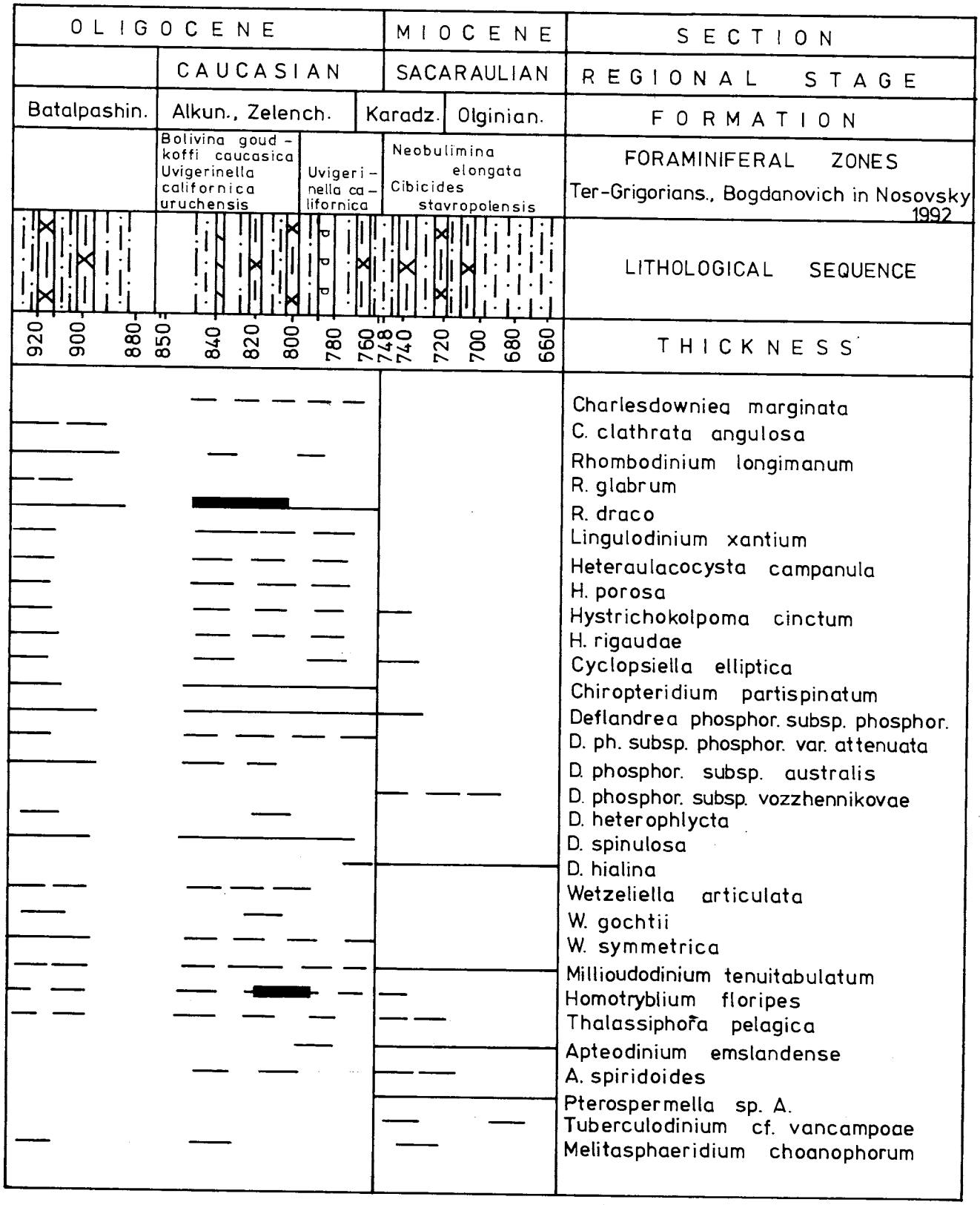

Fig. 5. Distribution of dinocysts in the Upper Oligocene - Lower Miocene of Black Sea area depression. Legend see Fig. 2.

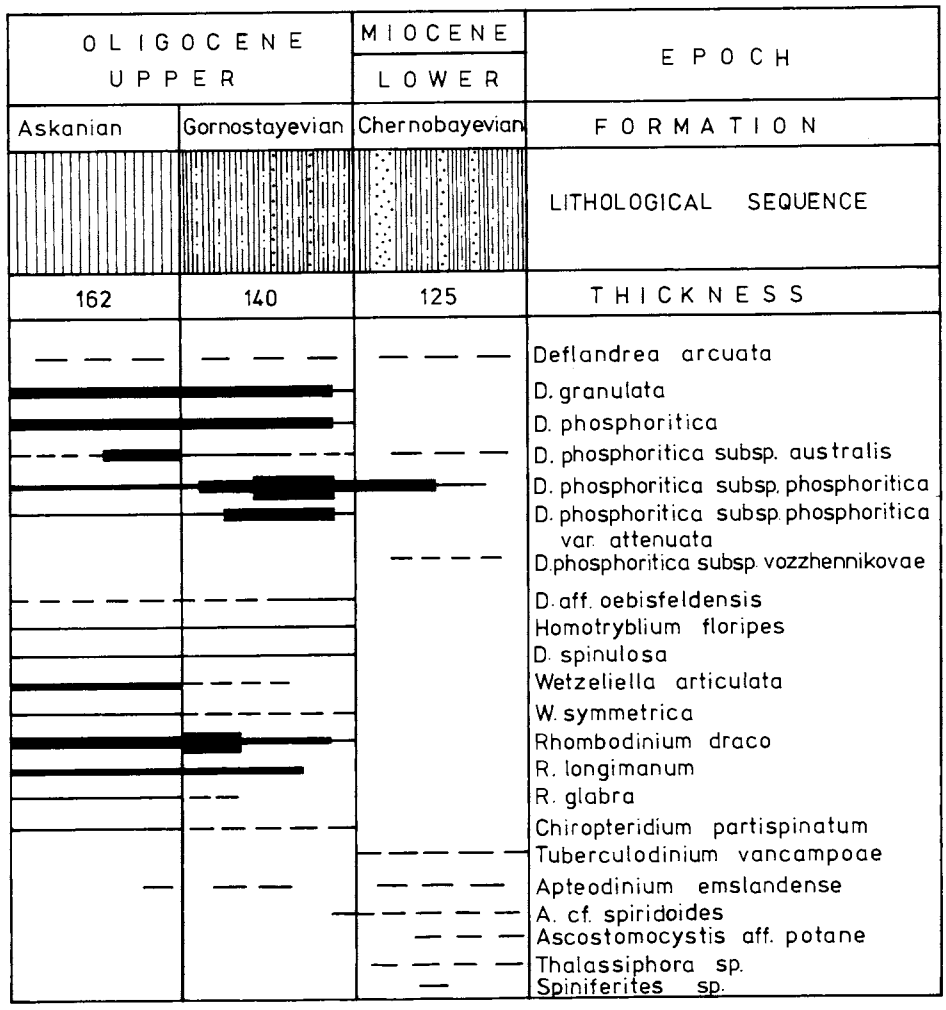

Fig. 6. Correlation of the Oligocene - Miocene boundary deposits of the Ukrainian Central and Eastern Paratethys. Legend see Fig. 2.

in the borehole 4 (by Nosovsky and Bogdanovich) the top of the Caucasian regional stage is at 750 m depth, and the top of the partispinatum zone is at 748 m depth (Andreyeva-Grigorovich 1980).

The Lower Miocene association with *Tuberculodinium vancampoae* Drugg & Loeblich, *Apteodinium* cf. *spiridoides* Bened., *A. emslandense* (Gerlach), *Deflandrea phosphoritica* subsp. *phosphoritica* Eisen., *D. phosphoritica* subsp. *vozzhennikovae* Grig., *Ascostomocystis* aff. *potane* Drugg & Loebl., *Thalassiphora* sp., *Spiniferites* sp. has been found in the deposits of the upper part of the Karadzhalginian and in the Olginian Formations, and it is close to the association from the Chernobaevian Formation of the Black Sea region, the Upper Menilite and Middle Krosno "subformations" of the Carpathians.

Accordingly, the dinocyst assemblage makes it possible to put the Oligocene-Miocene boundary only at the top of the Caucasian regional stage.

It is to be noted that the only group of planktonic microorganisms occurring throughout all the section of the Oligocene-Miocene boundary posits of all the facial rocks of the Carpathians, the Black Sea region and the Northern Caucasus are dinocysts. Their characteristic feature is impoverishment of their qualitative and quantitative composition at the transition from Oligocene to Miocene. The same is observed with foraminifera and calcareous nannoplankton.

In addition, with rare exception, the lithological boundaries of the formations practically do not coincide in any section with the boundaries of the micropaleontologic zones.

Conclusions

Thus, complex analysis of data comparison on planktonic foraminifera and calcareous nannoplankton and data on dinocysts makes possible to establish Oligocene-Miocene boundary position in the studied regions of Central and Eastern Paratethys of Ukraine and Russia. This boundary is placed along the assemblages *Turborotalia opima opima - Globigerina ciperoensis* zones, *Sphenolithus ciperoensis* (at the end of *Reticulofenestra bisecta* occurrences) and the upper part of *Chiropteridium partispinatum* zone, which are established in Lower Krosno and Middle Menilite "subformations" of the Ukrainian Carpathians, in Askanian and Gornostaevian Formations of the Black Sea region and in Caucasian regional stage of the Northern Caucasus.

EPOCH		Planktonic foraminiferal zones Gruzman 1984	Nanoplankton zones Andreyeva – Grigorovich 1984	Dinocysts zones Andreyeva – Grigorovich 1993	Central Paratethys regional stages	LITHOSTRATIGRAPHIC UNITS				Eastern Paratethys regional stages
						Central Paratethys		Eastern Paratethys		
						Ukrainian Carpathians		Northern Black sea area	Northern Caucasus	
						Krosno type	Menilite type			
MIOCENE	EARLY MIOCENE	Globigerina pseudoedita	Sphenolithus belemnos		EGGENBURGIAN	Upper Krosno Subformation	Polyanits. Formation			SAKARAULIAN
			Discoaster druggii	Tuberculodinium vancampoae		Middle Krosno Subformation	Upper Menilite Subformation	Cherno-baevian Formation	Olginian Formation	
		Globigerinoides trilobus G. primordius	Triquetrorhabdulus carinatus	Apteodinium emslandense					Upper Karadz. Subformation	
OLIGOCENE	LATE OLIGOCENE	Globigerina ciperoensis Turborotalia opima opima	Sphenolithus ciperoensis	Chiropteridium partispinatum s.l.	EGERIAN	Lower Krosno Subformation	Middle Menilite Subformation	Gornostayev. Formation	Lower Karadz. Subformation	CAUCASIAN
									Zelench. Formation	
								Askanian Formation	Alkune Formation	

Fig. 7. Correlation of the Oligocene - Miocene boundary deposits of the Ukrainian Central and Eastern Paratethys.

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