

CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF PALEOGENE SEDIMENTS OF UKRAINE (HISTORY OF STUDY AND STRATIFICATION)

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The article describes the history of nannofossil research of the Paleogene sediments in Ukraine from the beginning of the end of the XIX century. All available data concerning the significance of this ortho-stratigraphic group for detailed stratification purposes of diverse regional subdivisions and their correlation with International Stratigraphic Chart based on nannofossil biostratigraphy has also been discussed.

Key words: Paleogene, calcareous nannofossils, biostratigraphy, biozonal scales.

БІОСТРАТИГРАФІЯ ПАЛЕОГЕНОВИХ ВІДКЛАДІВ УКРАЇНИ ЗА НАНОПЛАНКТОНОМ (ІСТОРІЯ ВИВЧЕННЯ, СТРАТИФІКАЦІЯ)

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Викладено історію вивчення нанопланктону палеогенових відкладів в Україні починаючи з кінця XIX ст. Проаналізовано інформацію про значення цієї ортостратиграфічної групи для детальної стратифікації різнорангових регіональних підрозділів та їх кореляцію з Міжнародною стратиграфічною шкалою за нанопланктоном.

Ключові слова: палеоген, вапнистий нанопланктон, біостратиграфічне розчленування, біозональні шкали.

БИОСТРАТИГРАФИЯ ПАЛЕОГЕНОВЫХ ОТЛОЖЕНИЙ УКРАИНЫ ПО НАННОПЛАНКТОНУ (ИСТОРИЯ ИЗУЧЕНИЯ, СТРАТИФИКАЦИЯ)

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Изложена история изучения остатков наннопланктона из палеогеновых отложений Украины начиная с конца XIX в. Проанализирована информация о значении этой ортостратиграфической группы для детальной стратификации разноранговых региональных подразделений и их корреляции с Международной стратиграфической шкалой по наннопланктону.

Ключевые слова: палеоген, известковый наннопланктон, стратиграфическое расчленение, биозональные шкалы.

Introduction

Despite the presence of a large number of publications dedicated to the research of calcareous nanofossils biostratigraphy of Paleogene deposits of Ukraine, the degree of their study still remains different, uneven and often controversial. Especially this concerns the Carpathian-Black Sea segment of the Tethys region, in particular the Ukrainian Carpathians, North-Western Shelf, Continental slope of the Western Black Sea Depression, Kerchian Shelf of the Eastern Black Sea Depression and other structural-tectonic units of the East European Platform located within Ukraine. At present, there are many unsolved and debatable issues concerning the Paleogene stratigraphy of these regions. Namely, this is the detailed research of the paleontological age and stratigraphic position of the Dusinska, Turyska and Malovyzhenska formations and Pidgalian flysch, precise biostratigraphy and correlation of the lithostratigraphic units of the Ukrainian Carpathians with neighboring Poland, Slovakia and Romania sections based on calcareous nanofossils.

Within the Black Sea segment, the remaining issue is the detailed calcareous nanofossil biostratigraphy and biozonation of polyfacies terrigenous-carbonate Paleogene deposits of the Azov-Black Sea area, Crimea, the Black Sea region and the joining zone of the Tethys and North-Atlantic (Boreal) provinces within Ukraine and their correlation within the Alpine-Himalayan synclinal zone, with whom several mineral deposits, including hydrocarbons are related with. Subsequent calcareous nanofossil research as part of the microfossil assemblages that are contained in the Paleogene deposits is associated with the perspective of detailed stratification and the justification of the spatio-temporal patterns of their distribution in order to enhance and upgrade the existing stratigraphic schemes.

The research of microfossils has proven the orthostratigraphic importance of calcareous nanofossils assemblages of different ages and they are able to serve as reliable biostratigraphic reference levels for relative geological age dating of sedimentary rocks, regional and interregional correlations and paleobiogeographical reconstructions of relatively short periods of geological time.

Historical view of the calcareous nanofossil biostratigraphy

Calcareous nanofossils have been studied for more than 160 years. Their research is related to a wide list of World known researchers, such as, T. Huxley,

H. Lohmann, Tan Sin Hok, G. Deflandre, E. Martini, V.N. Vekshina, D. Noël, W. Hay, M. Bramlette, P. Reinhardt, S. Gartner, D. Bukry, I.A. Shamray, E.P. Lazareva, F. Sullivan, S.I. Shumenko, K. Perch-Nielsen et al. At present, the calcareous nanofossil research is performed by the effort of thousands of scientists called **nannologists**. They deal with a variety of issues that are concerned with the classification, systematic description, geographical and temporal distribution, biozonation and detailed stratification, paleoecology and biostratigraphy of calcareous nanofossils from deposits of different ages.

In Ukraine, the calcareous nanofossil research was initiated in the 1960's. Calcareous nanofossil biostratigraphy was developed by S.I. Shumenko, A.S. Andreeva-Grigorovich, S.A. Lulyeva, M.G. Muzylöv, Ye.M. Bogdanovich, N.A. Savytska, A.M. Romaniv, Dan Dyg Nga, A.V. Matveev, D.D. Waga, E.A. Solyanyk and I.S. Suprun. The main focus of their research was dedicated to study the species content, nanofossil assemblages, biozonation and the generation of biostratigraphic charts of Paleogene based on this group of microfossils.

Paleogene calcareous nanofossils from the southern part of the East European Platform and adjacent areas of the Tethys province in different times were studied by various scientists. In Crimea these are the reports made by A.S. Andreeva-Grigorovich [Андреева-Григорович, 1973, 1980], E.M. Bogdanovich (1985), D.D. Waga [Вага, 2007]; Dnieper-Donets depression – D.D. Nga (1973), S.I. Shumenko and D.D. Nga [Шуменко, Нга, 1973], S.A. Lulyeva (1974); Black Sea basin – S.A. Lulyeva (1977) [Краева, Люльева, 1976], A.S. Andreeva-Grigorovich and Ye.M. Bogdanovich (1979); Ye.M. Bogdanovich (1980, 1985) [Богданович, 1979]; Ukrainian Carpathians – A.S. Grigorovich [Григорович, 1971], A.S. Andreeva-Grigorovich [Андреева-Григорович, Музыльöv, Табачникова, 1991], A.M. Romaniv [Романив, 1991] et al. The nanofossils of Paleogene deposits were also studied by foreign scientists, including, M. Wade, H. Mohler and B. Hay (1964) which resulted in the selection of a number of standard zones in the Palaeocene-Eocene sections of the Northern Caucasus. Similarly, E. Martini and C. Ritskovsky (1970) defined the relative age of the Mandrikovka beds of south Ukraine.

The major impetus for nanofossil research within the southern regions of the Eastern European Platform and adjacent areas was contributed by the XII European Micropaleontological Colloquium that took place in Crimea in 1971. Based on the «standard»

biozonation of E. Martini and D. Bukry, the first nannofossil schemes of Paleogene deposits of Crimea, Caucasus, and the Carpathians were developed and approved by the Paleogene Commission of the Interdepartmental Stratigraphic Committee of the former USSR [Андреева-Григорович, 1973; Гавтадзе, 1986; Музыльёв, 1980; Шуменко, 1987; Андреева-Григорович, Музыльёв, Табачникова, 1991].

The intervals of calcareous nannofossil zonation NP1-NP8 and NP15-NP20 have been discovered within the Northern region of Ukraine (N.A. Savitska [Савицька, 1996] and E.M. Solyanyk (2013)).

M.G. Muzylöv published a monograph «The stratigraphy of the Paleocene of the Southern USSR based on calcareous nannofossils» in which he revised and made some supplements to the existing zonations. He also revised the relative age of the Paleogene stages and determined the stratigraphic volume of the unconformities [Музыльёв, 1980].

A comprehensive research of nannofossils from Shelf of the Black Sea was initiated in the early 1970's when the key biostratigraphic importance of this group of microfossils for biostratigraphy and correlation purposes of carbonate rock formations was realized.

In the Azov-Black Sea region studies were conducted by S.A. Lulyeva, A.V. Shumnyk, A.S. Andreeva-Grigorovich, D.D. Waga and I.S. Suprun. They were chiefly aimed at studying the calcareous nannofossils distribution within the Paleogene samples from the Black Sea shelf derived from well sections drilled at the structures of the West Olenivskaya, Krymskaya, Olympic, Stormova, Selskogo, Gamburtsevo, Golitsinska, Schmidta, Odeska, Beimenna, Subotina, and others alike. On these structures, the biozonation of the Meso-Cenozoic sediments, especially those of the Paleocene, Eocene, Oligocene, Neogene and Quaternary deposits of the Black and Azov Seas that are hydrocarbon productive [Краева, Люльева, 1976; Гожик, Маслун, Плотнікова, Іванік та ін., 2006; Маслун, Андреева-Григорович, Іванік, Мінтузова, Трофимович, 2006; Маслун, Іванік, Шумник та ін., 2007; Waga, Andreyeva-Grigorovich, Maslun, 2010; Супрун, 2017].

S.A. Lulyeva presented two monograph works – “Biozonation of the Eocene of the European part of the USSR” and “Zonal biostratigraphy of the Paleocene of the East European Platform” that included the concluding research on calcareous nannofossil biostratigraphy of the Paleocene-Eocene sediments [Зернецкий, Люльева, 1990, 1994].

The Cretaceous-Paleogene calcareous nannofossils from the Ukrainian Carpathian region were first studied by A.S. Andreeva-Grigorovich. Here, calcareous nannofossils belonging to 13 assemblages of the Barremian-Late Eocene interval were determined [Григорович, 1971].

In 1991, A.M. Romaniv [Романив, 1991] published her monograph with a title “Calcareous nannofossils of Cretaceous and Paleogene sediments of the Ukrainian Carpathians”. Here she gives the calcareous nannofossils distribution in stratotype and reference sections of the Ukrainian Carpathian region. The substantiation of the biostratigraphy of Cretaceous-Paleogene sediments applying the Standard zonation of E. Martini [Martini, 1971] was also provided.

Calcareous nannofossil research within the Carpathians was performed since the late 1960's enabled to substantiate the age determinations and distinguish a range of calcareous nannofossil biozonal subdivisions beginning from **NP1-Biantholithus sparsus** (lower part of the Danian stage) to **NP25-Sphenolithus ciproensis** (upper part of the Chattian stage). A vast amount of publications dedicated to the distribution of calcareous nannofossils associated with the Paleogene sediments of Skyba, Dukla, Vezhana and Monasterec nappes (thrusts) and the layers of the transitional Eocene-Oligocene boundary of most tectonic units of the Carpathians [Григорович, 1971; Романив, 1991; Супрун, 2017].

It should be noted that the biostratigraphical validation of the Paleogene scheme of the Carpathian region was performed mainly based on the foraminifera [Мятлюк, 1970; Обоснование..., 1975; Іванік, Маслун, 1977; Грузман, Дабагян, 1979], while the nannofossil biostratigraphy was much less engaged. The Cretaceous/Paleogene boundary (Middle-Striy-Upper-Striy subsuites) in the Skyba and Boryslav-Pokuttya nappes is justified according to the results of the nannofossil distribution research (Андреева-Григорович, 1994). Within the Vezhana nappe of the southern slope of the Carpathians, the calcareous nannofossil biostratigraphy proved the absence of an unconformity between the Yarmut (Maastricht) and the lower parts of the Metova suites [Андреева-Григорович, Гнилко, Гнилко, 2012; Супрун, 2017].

Paleoenvironmental research based on calcareous nannofossil assemblages was conducted by S.A. Lulyeva [Люльева, 1978], A.S. Andreeva-Grigorovich (1991), N.A. Savitska [Савицька, 1996], A.S. Andreeva-Grigorovich, N.A. Savitska [Андреева-Григорович, Савицкая, 1998].

Development of calcareous nannofossil zonal biostratigraphic scales

Calcareous nannofossils are a formal group that combines the fossil remnants of single-celled Haptophyte algae and calcareous remains (nannoliths) of unknown origin, whose size is less than 60 microns ($<60 \mu$). Their distribution and productivity depends mainly upon environmental factors, such as temperature (0-30°C) and salinity (3-36 ‰) regimes. Calcareous nannofossils are characterized by rapid evolution, cosmopolitanism and high sensitivity to environmental (climate) changes, making them indispensable for purposes of biostratigraphy and correlation of rock units, as well as, during reconstructions of paleoecological environments of the sedimentary basin.

Since the outer skeleton of the nannofossils is carbonate their maximum distribution is typical for

the low and medium geographic latitudes. Haptophyte algae are rock forming organisms (see Figure) and generate biogenic carbonate sediments. In some Cenozoic carbonate rocks, the amount of coccoliths can sometimes reach 99 %. Pure coccolith oozes are extremely rare; usually, they are form a combined component with the foraminifera and depending on the quantitative predominance form the coccolith-foraminifera or foraminifera-coccolith varieties of rocks (Лисицын, 1974). Coccoliths are an important component of marine phytoplankton in subpolar and warm waters, and it is in these waters that they are more diverse, while towards the poles this diversity is significantly reduced. Coccoliths are absent in the Arctic and Antarctic waters.

The development of nannofossil biozonation is based on the evolution of Haptophyte algae and

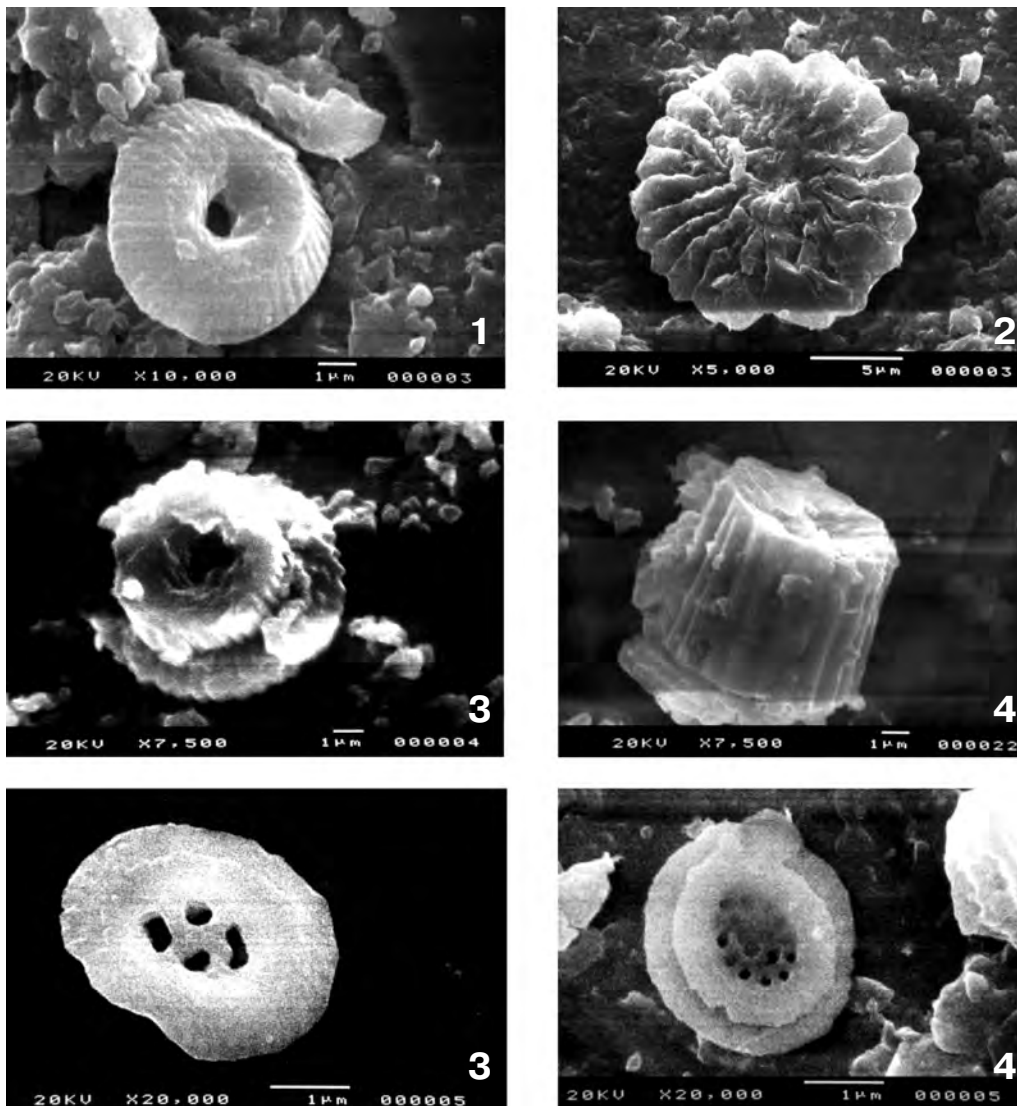


Figure. Typical representatives of Paleogene rock-forming nannofossils:

1 — *Coccolithus pelagicus*, NP2-Extant; 2 — *Discoaster multiradiatus*, NP9-NP11; 3 — *Heliolithus kleinpellii*, NP6-NP8; 4 — *Fasciculolithus tympaniformis*, NP5-NP10; 5 — *Chiasmolithus bidens*, NP6-NP11; 6 — *Toweius pertusus*, NP4-NP14. Photo by I.S. Suprun

their relation to the changes of hydrological and paleoenvironmental conditions in the Paleogene basins. Paleogene sediments are subdivided into number of nannozones based on which diverse stratigraphic units can become subject for further detailed stratification. A *biostratigraphic zone* – is a group of rocks containing an assemblage of fossil organisms (zonal assemblage) that differs from other assemblages specific to the underlying and covering sediments [Стратиграфічний..., 2012].

The most reliable calcareous nannofossil biozonations were developed as a result of the research performed onboard of the scientific vessel «Glomar Challenger» within the Deep Sea Drilling Project (DSDP) and the Ocean Drilling Project (ODP) from the JOIDES Resolution drilling research vessel. Numerous offshore well sections encountered Paleogene deposits which formed under different depths and climatic zones in the Atlantic, Pacific and Indian Oceans and in inland seas enabled to identify each of the selected nannofossil zone. The detail and thoroughness of the correlations of biozonation charts developed on the basis of this group of microorganisms are equivalent to those biozonation charts for planktonic foraminifera, and in some cases they even supplement and detail them.

Local and regional stratigraphic schemes for Paleogene sediments of different areas of the US and Europe based on calcareous nannofossil biostratigraphy have been established (Bronnimann, Stradner, 1960; Bramlette, Sullivan, 1961; Sullivan, 1964, 1965 et al.) This zonation was later included into the biozonation of the Cenozoic of W. Hay, H. Mohler, P. Roth, R. Schmidt and J. Boudreaux (Hay et al., 1967). The Danian-Eocene section of the scheme was developed by H. Mohler and W. Hay (Hay, Mohler, 1967, 1969), while the Lower Oligocene section – by P. Roth and W. Hay. Thus, all known at that time data on the stratigraphic distribution of nannofossils of the Danian-Eocene interval coming from numerous European stratotype sections of Denmark, France, Switzerland, Italy, Austria, Crimea, North Caucasus and United States of America (California, Texas, Mississippi, Alabama), Mexico, Barbados, Trinidad, Cuba were analyzed.

The scheme developed by W. Hay and H. Mohler from the very start had not only a regional, but an intercontinental importance. Due to this, the distribution of nannofossils from many sections of the various regions was examined.

In the zonation proposed by W. Hay and H. Mohler most nannozones had been characterized by representative nannofossil assemblages. However, in all cases the boundary limits of the zones were determined not by general changes in the nannofossils assemblage, but only based on formal levels of first occurrences (FO) or last occurrences (LO) of some index-species.

Subsequently, this approach in establishing biozonal boundaries proposed by W. Hay and H. Mohler, was applied predominantly in all of the next nannofossil biozonal scales: D. Bukry, M. Bramlette (1970), E. Martini [Martini, 1970, 1971], D. Bukry (1971, 1973, 1975), S. Gartner (1971), A. Edwards (1971), P. Roth (1971) which is a reflection of the concept of «datum-levels» («dated levels»). In a sequence of changes in levels established in separate sections, stratification and correlation of Paleogene deposits are performed. It is supposedly assumed that the same name «dated levels» are synchronous within the studied region or regions, but in reality their stratigraphic position in different regions and even in different sections of one region is heavily controlled by many factors, such as, climatic, ecological, facial, palaeobathymetry, structural and tectonic, morphometric, diagenesis et al.

Currently, there are two commonly used calcareous nannofossil standard zonations that have a global status. The first one – the zonation of E. Martini [Martini, 1970, 1971] – is based on the results of the study of sections located on the continents. According to this zonation, the Paleogene is divided into 25 nannozones (NP), of which 9 are of the Paleocene, 11 are Eocene and 5 are Oligocene. The second – the biozonation of D. Bukry (1973) that was developed on the basis of deep-water drilling materials, where 24 zones were selected from the study of the Paleogene from oceanic sections, and subsequently a number of these nannozones were subdivided into subzones (Okada, Bukry, 1980). These zonations intercorrelate well with each other and with the foraminifera zonal divisions, and also with the paleomagnetic scales of the International Stratigraphic Scheme.

The standard zonation of E. Martini [Martini, 1970, 1971] is widely used for biostratigraphic purposes of the Paleogene. Compared with the zonation of W. Hay and H. Mohler (1967) its resolution is much higher as a result of the selection of new units in the Danian stage and in the upper sections of the Middle and Upper Eocene. The succession of zones in the Lower Paleocene and lower portion of the

Eocene was left unmodified. However, the Martini zonation comes with some significant disadvantages, mainly associated with the interpretation of sample data originated from incomplete sections. The conclusions done by E. Martini are based primarily on data from numerous onshore sections located in Europe. These sections are usually presented by an incomplete stratigraphy and those sections that are not always properly correlated, of shallow facies that often display unfavorable conditions for nannofossil preservation. In addition, the nannofossil study was conducted mainly on separate individual samples [Музылѐв, 1980].

The zonation proposed by D. Bukry (1973, 1980) is based on a much wider data of calcareous nannofossils distribution obtained from numerous sections of deep wells located and drilled in low latitudes of the Atlantic and Pacific Oceans.

The major advantage of tropical oceanic sections is that they represent open ocean settings and are characterized by constant bionomic environments and facies conditions. Here the stratigraphic distribution of nannofossils in sediments is hardly affected by the influence of local environmental and facies conditions. The latter one is typical for sediments of epicontinental basins.

It is here, in sediments that are developed in low latitudes that a detailed nannofossil biozonation is performed and where the systematic assemblages are dominated by warm-water species (except for a small group of cold-water species). This distribution is associated with the stratification of warm- and cold-water currents. Thus, the Paleogene oceanic sediments can be considered as an ideal research polygon for estimating the spatial and temporal patterns of the nannofossil distribution.

Stratigraphic significance of calcareous nannofossils

The biostratigraphic value of calcareous nannofossils is extremely important, especially for Mesozoic and Cenozoic sediments. The group had its most intensive development during the Late Cretaceous and Eocene Epochs. The rapid change of species assemblages was caused by high rate of evolution. This enabled the application of calcareous nannofossils for biostratigraphic and stratigraphic correlation of sequences. Dramatic changes in the species assemblages took place at the Mesozoic and Cenozoic boundary, i.e., at the Maastrichtian/Danian stages. Significant rates of nannofossil evolution enabled to justify the biostratigraphy of deposits ranging from

the Upper Jurassic. Biostratigraphic (zonal) units are subdivisions of the stages and based on the vertical diversity of species, genera and even larger taxa. The taxa of lower level, namely species, and rarely families are applied.

Given the spatial-temporal distribution of microfossils, and calcareous nannofossils in particular, the detailed stratification of regional and local stratigraphic units (regional stages, suites/members, strata, layers, horizon-markers) was performed, as well as their boundaries and diachroneity were substantiated.

Calcareous nannofossils are widely used in generating various stratigraphic models of the Paleogene deposits of Ukraine during various scale mapping of open (outcrop) and closed (borehole) sections. Stratigraphic and sedimentary models, as well as stratigraphic schemes of the Paleogene for Western (Carpathian) and Southern (Black Sea, Crimea, Azov-Black Sea water area) oil and gas regions were also constructed.

Today three regional stage charts for the Paleogene sediments of Ukraine have been developed. Two of these charts are for the Tethyan Province (Carpathian and Southern regions) and one chart is for the North Atlantic Boreal Province (Northern Ukraine) in which the major biostratigraphic group are the calcareous nannofossils by which the several correlation levels are selected.

An integrated biostratigraphical research of sediments (foraminifera, calcareous nannofossil, dinocysts, sponge spicules) provided a interregional correlation of Paleogene sections of various facies that are developed in the Northern, Southern and Carpathian regions. It also enabled to correlate the developed regional scheme with units of the International Stratigraphic Chart [Vandenberghe et al., 2012].

Conclusions

Calcareous nannofossils are one of the ortho-stratigraphic groups that are actively used for biostratigraphy and correlation of Paleogene sediments. One of the most reliable global scales has been developed based on this group of microorganisms. Calcareous nannofossils species, including those of the Paleocene are characterized by rapid evolution, cosmopolitanism, and sensitivity to ecological changes which makes them irreplaceable for biostratigraphy and paleoecological reconstructions of the sedimentary basins. The limits and volumes of the stages of the International Stratigraphic Chart,

regional and local stratigraphic units of remote sections have been substantiated based on this group of microfossils.

According to numerous geological and paleontological data, calcareous nannofossil biostratigraphy enables to perform a wide spectrum of tasks. These include: a) elaboration of the relative geological age; b) substantiation of the diachroneity of the boundaries of diverse stratigraphic units; c) clarifi-

cation of the biozonal subdivision; d) clarification of the geological position and the conditions of the sediment accumulation of the Paleogene formations; e) The correlation levels that have been allocated from planktonic microorganisms enabled to conduct a direct correlation between the Paleogene deposits of the Carpathian-Crimean and Caspian regions and also with the International Stratigraphic Scale Chart [Vandenbergh et al., 2012].

Список літератури / References

1. **Андреева-Григорович А.С.** Зональний поділ за нанопланктоном палеогенових відкладів Бахчисарая. Докл. АН УРСР. Сер. Б. 1973. № 3. С. 195-197.

Andreeva-Grigorovich A.S., 1973. Zonal division of the Paleogene deposits of Bakhchisarai based on calcareous nannofossils. *Doklady AN URSS. Seriya B*, No. 3, p. 195-197 (in Ukrainian).

2. **Андреева-Григорович А.С.** Зональное деление палеогеновых отложений Бахчисарая по наннопланктону. Стратиграфия кайнозоя Северного Причерноморья и Крыма. Днепропетровск: Изд-во Днепропетр. ун-та, 1980. С. 52-60.

Andreeva-Grigorovich A.S., 1980. Zonal division of the Paleogene deposits of Bakhchisarai based calcareous nannofossils. *Stratigraphy of the Cenozoic of the Northern Black Sea and Crimea*. Dnepropetrovsk: Izdatelstvo Dnepropetrovskogo Universiteta, p. 52-60 (in Russian).

3. **Андреева-Григорович А.С., Музыльев Н.Г., Табачникова И.П.** Зональная шкала палеогена юга СССР по наннопланктону. Зональная стратиграфия фанерозоя СССР. Москва: Недра, 1991. С. 134-135.

Andreeva-Grigorovich A.S., Muzylov N.G., Tabachnikova I.P., 1991. Biozonation of the Paleogene of the south of the USSR based on nannoplankton. *Zonal stratigraphy of the Phanerozoic of the USSR*. Moscow: Nedra, p. 134-135 (in Russian).

4. **Андреева-Григорович А.С., Савицкая Н.А.** Ископаемые кокколитофориды (Coccolithophorales) – индикаторы климатических изменений эоценовых палеобассейнов южных регионов СНГ. *Альгология*. 1998. Т. 8, № 4. С. 411-418.

Andreeva-Grigorovich A.S., Savitska N.A., 1998. Fossil Coccolithophores (Coccolithophorales) — Indicators of Climate Changes in the Eocene Paleobasins of the Southern Regions of the CIS. *Algology*, vol. 8, No. 4, p. 411-418 (in Russian).

5. **Андреева-Григорович А.С., Гнилко О.М., Гнилко С.Р.** Межа крейди – палеогену у відкладах Вежанського покриву (зона Мармороських скель) Внутрішніх Українських Карпат. *Матеріали XXXIV сес. Укр. палеонтол. т-ва*. Київ, 2012. С. 66-67.

Andreeva-Grigorovich A.S., Hnylko O. M., Hnylko S.R., 2012. The Cretaceous – Paleogene boundary in the Vezhana nappe (Marmoros zone) of the Inner Ukrainian Carpathians. *Materials of the XXXIVth session of the UPS*. Kyiv, p. 66-67 (in Ukrainian).

6. **Богданович Е.М.** Стратиграфия датских, палеоценовых и эоценовых отложений Северного Причерноморья по нанопланктону: дис. ... канд. геол.-минерал. наук. Днепропетровск, 1979. 164 с.

Bogdanovich Ye.M., 1979. Stratigraphy of the Danian, Paleocene and Eocene deposits of the Northern Black Sea Depression based on calcareous nannofossils. Candidate geol.-mineral. sci., diss. Dnepropetrovsk, 164 p. (in Russian).

7. **Вага Д.Д.** Нанопланктон палеоцен–еоцену Південної периферії Східно-Європейської платформи: автореф. дис. ... канд. геол. наук. Київ, 2007. 28 с.

Waga D.D., 2007. Paleocene-Eocene calcareous nannofossils of the southern periphery of the East European Platform: avtoref dis. ... candidate geol. sci. Kyiv, 28 p. (in Ukrainian).

8. **Гавтадзе Т.Т.** Наннопланктонные комплексы палеоцена Абхазии и его биостратиграфическое значение. *Тр. ГИН АН ГССР*. 1985. Вып. 89. С. 79-85.

Gavtadze T.T., 1985. Nannofossil assemblages of Paleocene of Abkhazia and their biostratigraphic importance. *Trydy GIN AN GSSR*, iss. 89, p. 79-85 (in Russian).

9. **Гожик П.Ф., Маслун Н.В., Плотникова Л.Ф., Іванік М.М. та ін.** Стратиграфія мезокайнозойських відкладів північно-західного шельфу Чорного моря. Київ, 2006. 171 с.

Gozhyk P.F., Maslun N.V., Plotnikova L.F., Ivanik M.M. et al., 2006. Stratigraphy of Mesozoic and Cenozoic deposits of the Black Sea Northwestern Shelf. Kyiv, 171 p. (in Ukrainian).

10. **Григорович А.С.** Микрофитопланктон меловых и палеогеновых отложений северного склона Украинских Карпат. *Бюл. Моск. о-ва испытателей природы. Отд. геол.* 1971. № 2. С. 83-98.

Grigorovich A.S., 1971. Microphytoplankton of the Cretaceous and Paleogene deposits of the northern slope of the Ukrainian Carpathians. *Bulleten Moskovskogo Obschestva Ispytateley Prirody. Otdelenie geologicheskoye*, No. 2, p. 83-98 (in Russian).

11. **Грузман А.Д., Дабагян Н.В.** Зональная стратиграфия по планктонным фораминиферам палеоцена и эоцена южного склона Украинских Карпат. *Палеонтол. сб.* 1979. № 16. С. 30–34.

Gruzman A.D., Dabagyan N.V., 1979. Planktonic foraminifera biozonal stratigraphy of the Paleocene and Eocene of the southern slope of the Ukrainian Carpathians. *Paleontologicheskii sbornik*, № 16, p. 30–34 (in Russian).

12. **Зернецкий Б.Ф., Люльева С.А.** Зональная биостратиграфия палеоцена Восточно-Европейской платформы. Киев: Наук. думка, 1994. 74 с.

Zernetsky B.F., Lulyeva S.A., 1994. Zonal biostratigraphy of the Paleocene of the Eastern European Platform. Kyiv: Naukova Dumka, 74 p. (in Russian).

13. **Зернецкий Б.Ф., Люльева С.А.** Зональная биостратиграфия эоцена европейской части СССР. Киев: Наук. думка, 1990. 102 с.

Zernetsky B.F., Lulyeva S.A., 1990. Zonal biostratigraphy of the Eocene of the European part of the USSR. Kyiv: Naukova Dumka, 102 p. (in Russian).

14. **Иваник М.М., Маслун Н.В.** Кремнистые микроорганизмы и их использование для расчленения палеогеновых отложений Предкарпатья. Киев: Наук. думка, 1977. 118 с.

Ivanik M.M., Maslun N.V., 1977. Siliceous microorganisms and their biostratigraphical application for Paleogene sediments of the Carpathian Foredeep. Kyiv: Naukova Dumka, 118 p. (in Russian).

15. **Краева Е.Я., Люльева С.А.** Фораминиферы и зоны известкового нанопланктона палеогеновых отложений шельфа северо-западной части Черного моря. *Изв. АН СССР. Сер. геол.* 1976. № 10. С. 133-139.

Kraeva E.Ya., Lulyeva S.A., 1976. Foraminifera and calcareous nannofossil zonation of the Paleogene sediments of the northwestern part of the Black Sea shelf. *Izvestiya AN SSSR. Seriya geologicheskaya*, № 10, p. 133-139 (in Russian).

16. **Люльева С.А.** Экологические факторы формирования и тафономия известкового нанопланктона. *Вопросы тафономии и палеонтологии.* Душанбе: Дониш, 1978. С. 158-165.

Lulyeva S.A., 1978. Environmental factors affecting the generation and taphonomy of calcareous nannofossils. *Issues of Taphonomy and Paleontology.* Dushanbe: Donish, p. 158-165 (in Russian).

17. **Маслун Н.В., Андреева-Григоревич А.С., Иваник М.М., Минтузова Л.Г., Трофимович Н.А.**

Биостратиграфичне обґрунтування розчленування кайнозойських відкладів прикерченського шельфу Чорного моря. *Проблеми палеонтології та біостратиграфії протерозою і фанерозою України.* Київ, 2006. С. 172-178.

Maslun N.V., Andreeva-Grigorovich A.S., Ivanik M.M., Mintuzova L.G., Trofimovich N.A., 2006. Biostratigraphic basis of zonation of the Cenozoic deposits of Near-Kerch Black Sea Shelf. *Paleontological and biostratigraphic problems of the Proterozoic and Phanerozoic of Ukraine.* Kyiv, p. 172-179. (in Ukrainian).

18. **Маслун Н.В., Иваник М.М., Шумник А.В. та ін.** Біолітостратиграфична будова підняття Олімпійське — складова геологічної моделі Крайового уступу північно-західного шельфу Чорного моря. *Палеонтологічні дослідження в Україні: історія, сучасний стан та перспективи: Зб. наук. пр. ІГН НАН України.* Київ, 2007. С. 206-210.

Maslun N.V., Ivanik M.M., Shumnyk A.V., Tsychochotskaya N.N., Kliushyna G.V., 2007. Biolithostratigraphic structure of the Olimpiyskaya uplift as a constituent of a geological model of the marginal bench of the Black Sea northwestern shelf. *Paleontological studies in Ukraine: history, present-day state and prospects: Collection of scientific works of the Institute of Geological Sciences of NAS of Ukraine.* Kyiv, p. 206-210.

19. **Музыльов Н.Г.** Стратиграфія палеогена юга СССР по нанопланктону. Москва: Наука, 1980. 94 с. (Тр. ГИН АН СССР; Вып. 348).

Muzyl'ov N.G., 1980. The stratigraphy of the Paleogene of the Southern USSR based on calcareous nannofossils. Moscow: Nauka, 94 p. (Trydy GIN AN SSSR; Iss. 348) (in Russian).

20. **Мятлюк Е.В.** Фораминиферы флишевых отложений Восточных Карпат (мел–палеоген). Ленинград: Недра, 1970. 360 с.

Myatlyuk E.V., 1970. Foraminifera of Flysch sediments of the Eastern Carpathians (Cretaceous–Paleogene). Leningrad: Nedra, 360 p. (in Russian).

21. **Обоснование** стратиграфических подразделений мезо-кайнозой Украины по микрофауне: Дидковский В.Я. (ред.). Киев: Наук. думка, 1975. 231 с.

Substantiation of the stratigraphic units of the Mesozoic and Cainozoic of Ukraine based on microfossils: Didkovskiy V.Ya. (Ed.), 1975. Kyiv: Naukova Dumka, 231 p. (in Russian).

22. **Романив А.М.** Известковый нанопланктон меловых и палеогеновых отложений Украинских Карпат. Киев: Наук. думка, 1991. 148 с.

Romaniv A.M., 1991. Calcareous nannofossils of the Cretaceous and Paleogene sediments of the Ukrainian Carpathians. Kyiv: Naukova Dumka, 148 p. (in Russian).

23. **Савицька Н.А.** Нанопланктон і диноцисти середньо-верхньоеоценових відкладів платформеної України: автореф. дис. ... канд. геол. наук. Київ, 1996. 22 с.
- Savytska N.A.**, 1996. Calcareous nannofossils and dinocysts of the Middle- Upper Eocene sediments of the platform areas of Ukraine: avtoref. dis. ... candidate geol. sci. Kyiv, 21 p. (in Ukrainian).
24. **Стратиграфічний** кодекс України: Гожик П.Ф. (відп. ред.). Київ: Нац. стратигр. ком. України, 2012. 66 с.
- Stratigraphic** Code of Ukraine: Gozhyk P.F. (Editor-in-Chief), 2012. Kyiv: National Stratigraphic Committee of Ukraine, 66 p. (in Ukrainian).
25. **Супрун І.С.** Зонування за нанопланктоном палеоценових відкладів Карпатсько-Чорноморського сегменту Тетису. *40 років Палеонтологічному товариству України*: Матеріали XXXVIII сес. Палеонтол. то-ва України (Канів, 23-26 трав. 2017 р.). Київ, 2017. С. 109-110.
- Suprun I.S.**, 2017. Calcareous nannofossil biozonation of the Paleocene sediments of the Carpathian-Black Sea segment of Tethys. *40 years for the Paleontological Society of Ukraine*: Materials of the XXXVIII session of the Paleontological Society of Ukraine (Kaniv, May 23-26, 2017). Kyiv, p. 109-110 (in Ukrainian).
26. **Шуменко С.И.** Практическое руководство по микрофауне СССР. *Известковый наннопланктон*. Ленинград: Недра, 1987. 240 с.
- Shumenko S.I.**, 1987. Practical guide on the microfauna of USSR. *Calcareous nannofossils*. Leningrad: Nedra, 240 p. (in Russian).
27. **Шуменко С.И., Данг Дик Нга.** Вапняний нанопланктон та стратиграфічне положення київської світи. *Доп. АН УРСР. Сер. Б.* 1973. № 10. С. 900-903.
- Shumenko S.I., Dang Dik Nga**, 1973. Calcareous nannofossils and the stratigraphic position of the Kiev Formation. *Dopovidi AN URSS. Seriya B*, № 10, p. 900-903 (in Ukrainian).
28. **Martini E.** Standard Paleogene calcareous nannoplankton zonation. *Nature*. 1970. Vol. 226, № 5245. P. 560-561.
- Martini E.**, 1970. Standard Paleogene calcareous nannoplankton zonation. *Nature*, vol. 226, № 5245, p. 560-561 (in English).
29. **Martini E.** Standard Tertiary and Quaternary calcareous nannoplankton zonation. *Proc. II. Plankt. Conference*. 1971. Vol. 2. P. 739-785.
- Martini E.**, 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *Proc. II. Plankt. Conference*, vol. 2, p. 739-785 (in English).
30. **Vandenbergh N., Hilgen F.J., Speijer R. P. et al.** The Paleogene Period. *The Geological Time Scale*. Published by Elsevier B.V., 2012. p. 855-921.
- Vandenbergh N., Hilgen F.J., Speijer R.P. et al.**, 2012. The Paleogene Period. *The Geological Time Scale*. Published by Elsevier B.V., p. 855-921 (in English).
31. **Waga D.D., Andreyeva-Grigorovich A.S., Maslun N.V.** Calcareous nannofossil biostratigraphy of the Paleocene sediments of the Odessa Gas Field (NW Black Sea). *Geobios*. 2010. Vol. 43. P. 33-43.
- Waga D.D., Andreyeva-Grigorovich A.S., Maslun N.V.**, 2010. Calcareous nannofossil biostratigraphy of the Paleocene sediments of the Odessa Gas Field (NW Black Sea). *Geobios*, vol. 43, p. 33-43 (in English).

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