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Early Cretaceous (Albian) strata identified by palynology in the base of the Pradniprovska-2 well, Black Sea shelf, Ukraine

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Ранньокрейдові (альб) відклади, ідентифіковані за палінологією, у підошві свердловини Прадніпровська-2, шельф Чорного моря, Україна

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Ключові слова: альб, паліностратиграфія, Чорне море, свердловина Прадніпровська-2.

The borehole Pradniprovska-2, located within the inner part of the Black Sea shelf, Ukraine, intersects a sedimentary succession of which the lowermost interval (2375–2370 m) is crucial yet controversial for regional Mesozoic stratigraphy. To refine its relative geological age, a detailed palynolstratigraphical investigation of core samples was undertaken.

The palynological analysis revealed well-preserved and diverse assemblages characteristic for a near shore marine environment with pollen, spores and dinoflagellates present. The occurrence of age-diagnostic angiosperm pollen such as *Afropollis* together with abundant *Clavatipollenites* indicates an Aptian–Albian age, likewise *Asteropollis*, which first appear in the Barremian and reach a peak in the Albian, strongly indicates an Albian age for the studied deposits. The presence of early angiosperm taxa such as *Tricolpites maximus* and *Triorites* spp., widely recognized as markers for the early Albian, further supports this conclusion.

Gymnosperm pollen is present but subordinate, while fern spores and lycophytes constitute an additional minor component of the palynoflora. The taxonomic composition and proportional representation of the main pollen and spore groups show close similarity to Albian western European palynological assemblages.

The newly established Albian age for the lowermost interval of Pradniprovska-2 well is further consistent with long-term stratigraphic interpretations of Mesozoic sequences on the northwestern Black Sea shelf, previously developed by teams of the Institute of Geological Sciences of the NAS of Ukraine and SE “Naukanaftogaz”.

These findings refine the regional chronostratigraphic framework and contribute new evidence for understanding the geological evolution of this inner shelf zone during the Early Cretaceous.

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Introduction

The Mesozoic sedimentary successions of Ukraine record the long-term geological evolution of the southern margin of the East European Platform and its transition into the peri-Tethyan realm. Following Late Paleozoic tectonic reorganization, large parts of the territory were occupied by shallow epicontinental seas and marginal-marine basins that accumulated predominantly Triassic – Cretaceous siliciclastic and carbonate deposits. These successions are best developed within the Dnipro-Donets Basin, the Donets Foldbelt, the Scythian Plate, and the northwestern shelf of the Black Sea, where they form a discontinuous but regionally extensive cover above the Paleozoic basement. The Triassic and Jurassic record is characterized by alternating continental, marginal-marine, and marine facies, reflecting repeated transgressive–regressive cycles, while the Cretaceous is dominated by widespread marine sedimentation associated with the expansion of epicontinental seas across southern Ukraine. Despite their stratigraphic importance, many Mesozoic successions – particularly in deep subsurface settings of the Black Sea shelf – remain poorly constrained in age due to limited macrofossil evidence and reliance on indirect lithological or geophysical correlations. Recent syntheses emphasize the critical role of palynology and integrated biostratigraphy for resolving these uncertainties and refining regional chronostratigraphic frameworks.

One of the controversial issues in the stratigraphy of Mesozoic sediments on the northwestern shelf of the Black Sea of Ukraine is the certainty regarding the presence of Jurassic deposits in deep wells (Khryashchevskaya et al., 2009). At present, the scientific literature presents differing viewpoints on the resolution of this issue. A vivid example of such debate concerns the determination of the age of the successions at the base of the Pradniprovska-2 well. While some researchers interpret these deposits as Late Jurassic in age (Dulub et al., 1999, 2001; Oil and Gas..., 2007; Stratigraphy..., 2013) or as Late Jurassic–Early Cretaceous (Zhabina et al., 2015), others assign them to the Early Cretaceous (Albian) (Gozhyk et al., 2006).

The Pradniprovska-2 borehole was drilled in 1993, at the Pradniprovska rise on the northwestern shelf of the Black Sea, Ukraine. We performed a palynological analysis of sediment samples from the base of the core with the aim to document and interpret the age of the successions and to make correlation with strata from North Crimea, Ukraine. We further aim to clarify the potential for oil and gas deposits (Fig. 1). The Pradniprovska-2 borehole reaches a depth of 2375 m and based on the geological and geophysical characteristics of the strata within the interval 2210–2375 m, and by comparing with other well successions from the North Crimean trough, a decision was made to stop further drilling as the Paleozoic basement was thought to have been reached. However, paleontological studies of the sediments from the core have not confirmed a Paleozoic age.

The Pradniprovska-2 well is a key succession in understanding the features of the geological structure of the inner (platform) zone of the northwestern shelf of the Black Sea. Although a stratigraphical framework exists, the age of the sediments in the lower part of the well are not known. To address this issue, we carried out palynological analyses of core samples from the base of the Pradniprovska-2 well (interval 2375–2370 m). These studies included photo documentation, systematic identification, and stratigraphic interpretation based on the palynology.

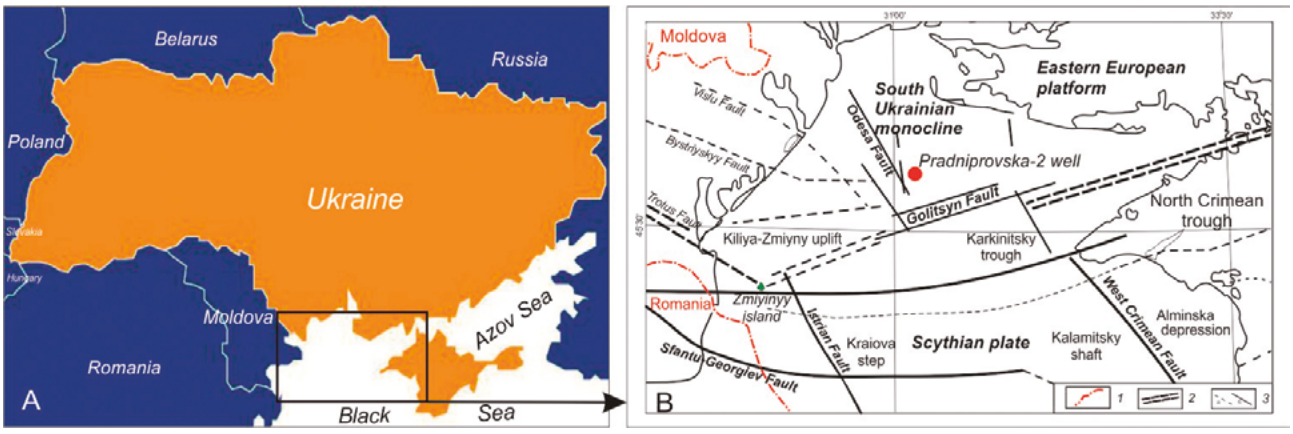

Fig. 1. A – Locality map. B – Tectonic map of the western part of the Scythian plate (Starostenko et al., 2015) modified by Farfuliak, 2016 with red dot marking the Pradniprovska-2 well. Fragment. Symbols: *1* – State border of Ukraine; *2* – southern border of the East European Platform; *3* – deep and regional faults (*a* – generally accepted, *b* – predicted)

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Geological setting

The Pradniprovska-2 well is located within the inner, platform of the northwestern Black Sea shelf, a region geologically situated at the junction between the southern margin of the East European Platform and the northern sector of the Scythian plate (see Fig. 1). This area represents a structurally heterogeneous transition that experienced long-term subsidence throughout the Mesozoic, forming a system of depressions, uplifts, and monoclines that conditioned sediment accumulation (Geological..., 2006). The well is drilled on the crest of the Pradniprovska uplift – one of a series of gently faulted structural highs that delineate the boundary between the Kiliya-Zmiinyi uplift to the west and the North Crimean trough to the southeast.

The succession in the region has been constrained by numerous geophysical investigations, including seismic profiles across the Scythian plate (Starostenko et al., 2015; Farfuliak, 2016), which reveal a relatively thin continental crust underlain by a mosaic of fault-bounded blocks. Within this framework, the northwestern shelf acted as a long-lived peri-Tethyan passive margin during the Mesozoic, receiving thick marine and marginal-marine sedimentary successions. The sedimentary cover of the platform sector is composed of an incomplete Jurassic–Cretaceous sequence unconformably overlying the Paleozoic basement.

The presence of Jurassic deposits in the deep sub surface has been a long-debated issue (Khryashchevskaya et al., 2009).

Previous stratigraphic models assigned the lowermost part of the Pradniprovska-2 section (below ~2210 m) to the Upper Jurassic or Lower Cretaceous based on correlations with borehole successions from the North Crimean trough. These interpretations were based on fragmentary macrofossil identifications and geophysical correlations, but lacked palynological documentation. More recent regional studies – including integrated seismic, lithological, and biostratigraphic analyses (Geology..., 1984, 1985, 1987; Plotnikova et al., 2003; Gozhyk et al., 2006) – suggest that Cretaceous deposits are much more widespread in this part of the shelf than previously assumed, and that Jurassic sediments may not be penetrated at all by exploratory drilling in this structural zone.

The successions representing the basal part of the Pradniprovska-2 well (2370–2375 m) comprises dark grey to black, dense siltstones and silty mudstones with localized quartzitic and carbonate intercalations. The lithology indicates deposition in a low-energy, offshore to nearshore marine environment. These fine-grained siliciclastic units form part of a thicker Mesozoic succession that accumulated within a shallow, slowly subsiding shelf basin influenced by periodic freshwater inflow from the adjacent landmass. The presence of sparse, reworked Paleozoic palynomorphs within the interval is consistent with erosion of older terranes on the East European Platform and subsequent redeposition during the Mesozoic.

The Early Cretaceous geological evolution of the region was marked by continued subsidence and the establishment of a broad epicontinental sea. During the Albian, widespread marine transgressions occurred across the northwestern Black Sea shelf, accompanied by increased clastic input from the emergent platform. Comparable lithofacies and biostratigraphic patterns have been documented in neighboring areas, including the Odesa shelf and the Karkinitsky trough (Geological..., 2006). This regional context provides a coherent geological framework for the palynostratigraphical study of the Pradniprovska-2 succession.

Tectonic framework

The decisive role in the formation of the modern geostructural plan of the northwestern shelf of the Black Sea was played by the rift and post-rift stages of the development of the territory lasting 60 million years (Early Cretaceous–Paleogene). The rift stage (the stage of extension of the territory) lasted from the Aptian (?), Albian to the Santonian, and the post-rift stage (the stage of thermal submergence) – from the Campanian to the Eocene (Late Eocene ?) (Geological..., 2006; Farfuliak, 2016; Stovba et al., 2020, 2023).

The tectonic evolution of the northwestern shelf of the Black Sea, repeated transgressions and regressions of the sea basin during the Early Cretaceous – Paleogene influenced the completeness of the geological record of the studied region, the features of sedimentation, the lithological composition of rocks, the evolution of the organic world of the specified territory and determined the sequence of geological processes (events) that led to the formation of the main elements of the hydrocarbon system: oil and gas source strata, reservoir rocks, shielding rocks and hydrocarbon traps.

The Early Cretaceous tectonic evolution of this area was governed by passive-margin dynamics along the northern Tethys. Subsidence affected

most of the Scythian plate, forming a broad epicontinental shelf (Khryashchevskaya et al., 2009). This formed accumulation-space accommodating thick marine clastic successions. Continued extensional deformation and block faulting played a key role in the differentiation of structural highs (such as the Pradniprovska uplift) and depressions (such as the Karkinitsky and North Crimean depressions) (see Fig. 1).

The structural position of the Pradniprovska uplift has important stratigraphical implications. As a gentle, long-lived high separating adjacent depocenters, it was subject to reduced sedimentation and periods of non-deposition, which partly explains the incomplete stratigraphic record and the difficulty in resolving the age of the deeper intervals. Furthermore, regional fault systems bounding the uplift facilitated selective reworking of Paleozoic units, contributing to the presence of redeposited palynomorphs in Cretaceous sediments.

Materials and Methods

Materials

The study materials comprise core samples from the lower part of the Pradniprovska-2 well from the intervals: 1701–1697 m, 1717–1706 m, 2090–2093 m, and 2375–2370 m (base). The samples were collected in 2006 as part of a research project focusing on geological and geophysical exploration of oil and gas and the future potential for hydrocarbon exploration in the Ukrainian sector of the Black and Azov Seas. The samples are hosted at the Institute of Geological Sciences of the National Academy of Sciences of Ukraine by the Research Institute of Oil and Gas Industry of the National Joint-Stock Company “Naftogaz of Ukraine” (earlier – SE “Naukanaftogaz”).

Palynology Methods

Palynological processing of core samples was carried out at Global Geolab Limited (Alberta, Canada) according to standard palynological procedures where 10 grams of sediment were treated with hydrochloric acid (HCl) and then with hydrofluoric acid (HF, 30%). The organic residue was sieved through a sieve with a 5-µm mesh size (to prevent loss of small grains of angiosperms) and fixed in epoxy resin on two microscope slides. In addition, one slide with kerogen was prepared. Subsequently, palynomorphs from an entire slide were identified and the relative abundance (%) of the different groups was calculated. For detailed processing information see Vajda & Kear (Vajda, Kear, 2024).

Although this study focuses on the palynostratigraphy of the basal, unknown 2375–2370 m of the succession, samples from the intervals 1706–1697 m and 1717–1706 m were also analysed using scanning electron microscopy (SEM FEI Quanta FEG 650, Swedish Museum of Natural History) to obtain high-resolution images of dinophyte cysts and angiosperm grains, as well as other pollen, spores, and other microfossils of interest.

Palynomorphs were studied in permanent slides using an Olympus BX51 biological modular light microscope. The illustrated palynomorphs were given specimen numbers used for palaeobiology collections at the Swedish Museum of Natural History (NRM), also England Finder coordinates have been provided. The slides and residues are stored in the collections at the Department of Palaeobiology at the Swedish Museum of Natural History, Stockholm, Sweden.

Results and interpretation

The lithology of the studied interval of the Pradniprovska-2 well (2370–2375 m) is chiefly represented (according to the description of the core from the well file) by dark gray siltstones, sometimes almost black and gray, dense, strong, quartz, weakly micaceous, unevenly weakly calcareous, silty, with quartzite-like and calcitized areas with rare layers of dark gray and black, silty, weakly micaceous, dense, strong, silty argillites (Fig. 2).

General composition of the palynological assemblages

A palynological association was identified in the studied samples, characteristic of marine environments with presence of dinoflagellate cysts in all samples. The organic content is high with a varied palynofacies. Microfossils comprises spores, both gymnosperms and angiosperm pollen, as well as dinoflagellates, green alga, wood remains and plant cuticles. Spores constitute 15% of the flora; gymnosperm pollen about 25% (mainly represented by bisaccate pollen grains with a smaller portion of monosulcate pollen). Angiosperm pollen comprises slightly less than 16% of the total relative abundance. Dinoflagellates constitute approximately 38% of the total number of palynomorphs (Fig. 3).

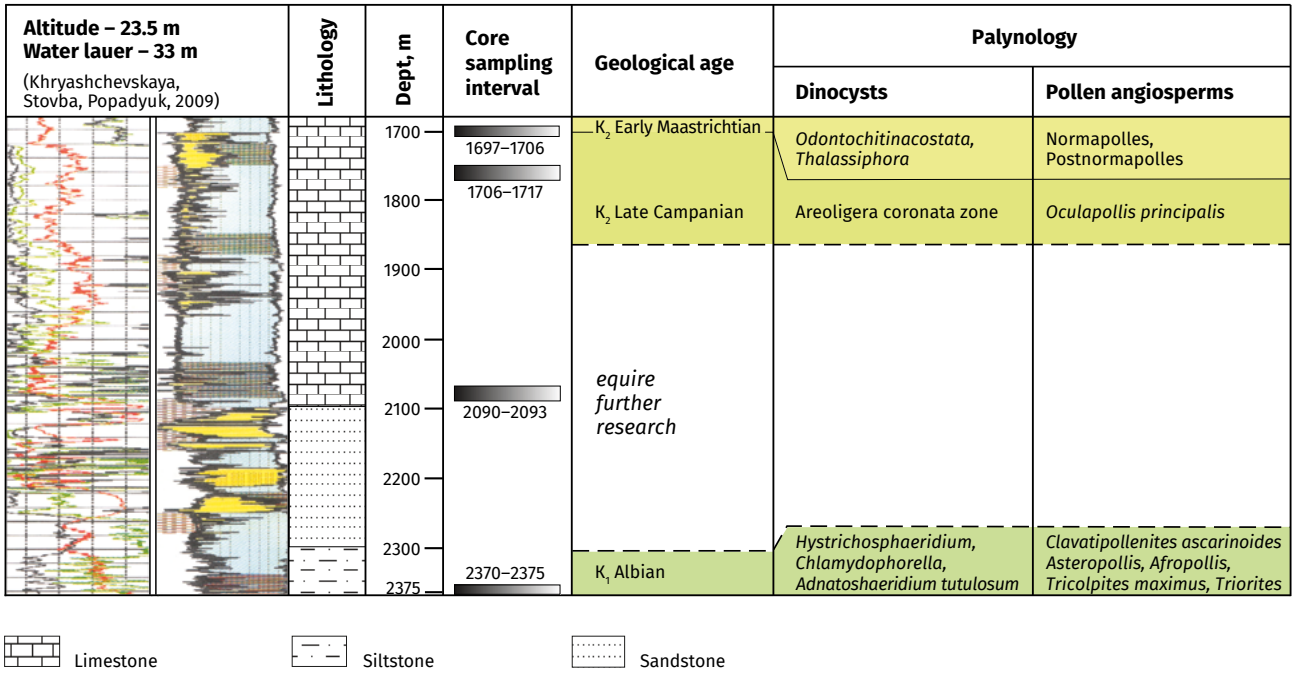

Fig. 2. Geological section of the Pradniprovska-2 well and palynological characteristics

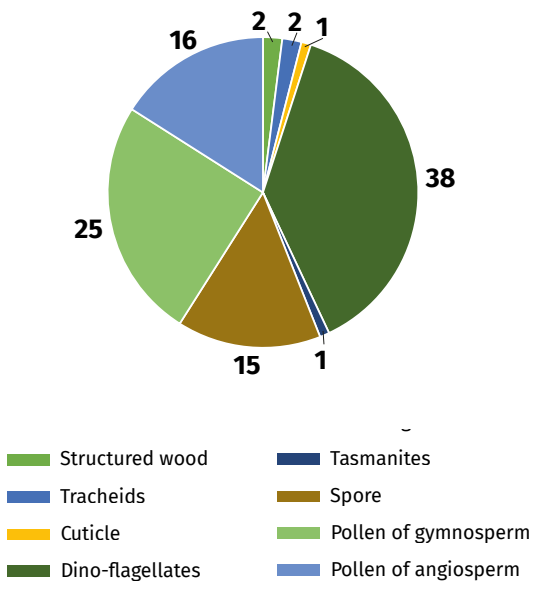

Fig. 3. Relative abundance (%) of major palynological groups in the studied samples

Taxonomic composition of the palynological assemblage

A total of 126 pollen and spore taxa were identified, below we outline selected main groups. Spores are represented by 4 number of genera including the trilete spores *Gleicheniidites* spp., *Concavisporites* sp., *Dictyophyllidites* sp., and *Leiotriletes* sp., gymnosperm pollen (5 number of genera) are mainly represented by *Araucariacites australis* Cookson, *Cedripites* sp., *Pinuspollenites* sp., and the monosulcate *Cycadopites* sp. Angiosperm pollen (5 number of genera) are mainly represented by *Clavatipollenites* spp. *Asteropollis* spp., *Afropollis* sp., *Tricolpites maximus* (Couper) Kumar, and *Triorites* sp. Marine palynomorphs include the dinoflagellate cysts (8 number of genera) *Leptodinium* sp., *Sentusidinium* sp., *Kallosphaeridium* sp., *Batiacasphaera* sp., *Ascodinium* sp., and many broken cysts belonging to *Hystrichosphaeridium* spp. Sparce *Adnatosphaeridium* spp. and *Chlamydophorella* sp. were recovered. The green algae, *Botryococcus braunii* Kützing, was also identified (Fig. 4). Additionally, reworked Paleozoic spores were identified in sediments from the interval 2375–2370 m (Fig. 5).

Age assessment

Based on key angiosperm pollen taxa, we interpret the studied interval as Early Cretaceous, Albian in age. In particular, the identification of *Afropollis*, characteristic of an Aptian to Albian age, and the significant occurrence of pollen belonging to the genera *Clavatipollenites* spp. and *Asteropollis* sp., (which both appear in the Barremian and reach their peak of distribution in the Albian, for example: *Clavatipollenites ascarinoides*) support this interpretation. Additionally, the occurrence of the pollen taxa *Tricolpites maximus* and *Triorites* sp., both belonging to ancient angiosperm lineages, point to an Albian age.

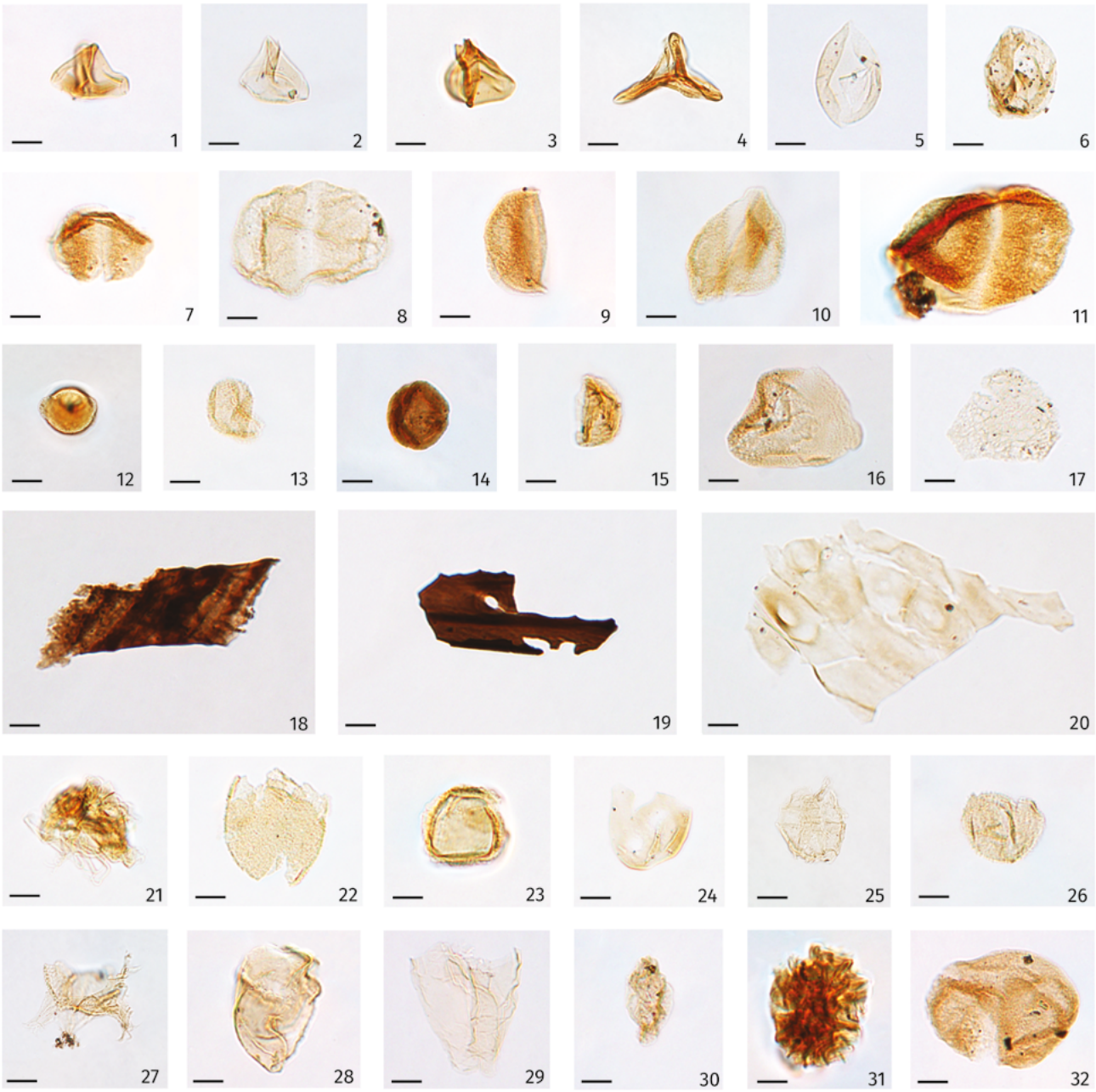

Fig. 4. ***Selected palynomorphs from the interval 2370–2375 m.*** Taxon, England Finder Reference. Scale bar = 10 µm. ***Fern spores*** (1–4): 1 – *Concavisporites* sp., L30-4; 2 – *Gleicheniidites* sp., H31-3; 3 – *Dictyophylliidites* sp., S10-2; 4 – *Gleicheniidites toriconcavus,* S18; ***Gymnosperm pollen*** (5–11): 5 – *Cycadopites* sp., U27-4; 6 – *Araucariacites australis,* T29; 7 – *Cedripites* sp., L21-4; 8 – *Pinuspollenites* sp., J29-4; 9 – Pinaceae, L20; 10 – *Pinuspollenites* sp., Q29; 11 – *Cedripites* sp., S21-4; ***Angiosperm pollen*** (12–17): 12 – *Triorites* sp., H28-3; 13 – *Clavatipollenites ascarinoides* McIntyre, O37; 14 – *Clavatipollenites* sp., Q30; 15 – *Asteropollis* sp., Q41-2; 16 – *Tricolpites* cf. *maximus,* O44-4; 17 – *Afropollis* sp., T36-3; ***Plant matter*** (18–20): 18 – Wood fragment, D23; 19 – wood fragment F23-1; 20 – Cuticle with stomata, O42; ***Dinocysts*** (21–30): 21 – *Adnatoshaeridium* cf. *tutulosum* Cookson and Eisenack, F24-4; 22 – *Sentusidinium* sp., G42-1; 23 – *Chlamydophorella* sp., H25-3; 24 – *Kallosphaeridium* sp., H26-3; 25 – *Leptodinium* sp., K39-3; 26 – *Batiacasphaera* sp., N27; 27 – *Hystrichosphaeridium* sp., L21; 28 – *Batioladinium* sp.? L22-3; 29 – *Tubotuberella* sp., M33-2; 30 – *Ascodinium* sp., H29-3; ***Green algae*** (31–32): 31 – *Botryococcus braunii*, J29, 32 – Sp. indet. L30-3

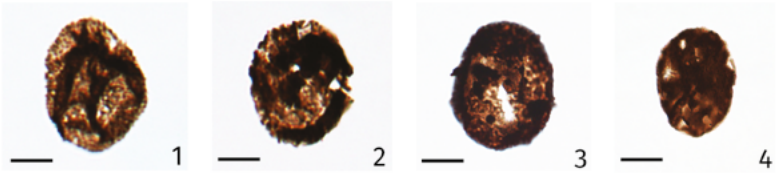

Fig. 5. Example of reworked, Permian to Late Devonian spores, from the interval 2375–2370 m. Taxon, England Finder Reference, Scale bar = 10 µm. 1 – *Spinosisporites* sp., N37-3; 2 – *Apiculatisporis* sp., B15, N17; 3 – *Tuberculispora* sp.; 4 – *Reticulatisporites* sp., F13-1

Although the oldest record of hysrichospheridian dinocysts is in the Late Jurassic (Oxfordian–Tithonian), the abundance and diversity of this group in the studied samples indicates a Cretaceous age. Particularly, the occurrence of *Adnatoshaeridium* cf. *tutulosum* Cookson and Eisenack indicate an age younger than Aptian (119.82–94.12 Ma (Ogg et al., 2008)).

Discussion

Dating and comparison with other areas

Our results from the Pradniprovska-2 well are consistent with results from previous studies of Albian sediments in Ukraine and adjacent regions (Voronova, 1972, 1975, 1983, 1984, 1994; Shevchuk et al., 2021; Shevchuk, Pustovoitova, 2021), corroborating our stratigraphical assessment of an Albian age. A similar ratio of spore-pollen assemblages, dominated by *Clavatipollenites* spp., *Asteropollis* spp., *Afropollis* sp., and the presence first appearance datum of *Tricolpites maximus* and *Triorites* sp., was noted in sediments of both the northern and southern regions of Ukraine, which indicates the regional stability of this pollen-complex within the Albian time interval (Voronova, 1994).

The obtained results are also in agreement with the latest European palynological data (Shevchuk, Vajda, 2024), where similar associations of angiosperm pollen and dinocysts are considered characteristic of the Albian age. The consistent recurrence of assemblages with a similar composition hosting the palynocomplex; *Clavatipollenites* + *Asteropollis* + *Afropollis* + associated forms, from sections of sedimentary basins of Europe, the Middle East, and North America (Tanrikulu, Cornet, 2014; Barrón et al., 2015; Schrank et al., 2017) indicates the reliability of these angiosperm forms as markers for determining Albian sediments. This provides the basis to consider this palynological assemblage established in the section of the Pradniprovska-2 well in the depth interval of 2370–2375 m as a reliable stratigraphic Albian age-indicator.

Comparison with marine macro- and microfossil data

Macrofossil remains, including fragments and steinkerns of bivalves, *Pseudolimea alternicostata* (Buvign.), *Aulacomiella problematica* (Furl.), *Radulopecten (Radulopecten) indequicostatus* (Phil.), and *Plagiostoma (Aequipecten) laurae* (Etall.) has been reported from the depth interval 2242–2233 m (Dulub et al., 1999).

From the depth interval 2265–2272 m, V.G. Dulub identified foraminiferal remains including *Epistomina* cf. *stellicostata* Biel. et Paz., *Belorussiella volinianensis* Biel., *Verneulina* sp., and *Dentalina* sp. Additional foraminiferal assemblages were reported from the interval 2375–2370 m, comprising *Anchispirocyclina* cf. *lusitanica* (Egger), *Anchispirocyclina* (?) sp., *Rectocyclammina chouberti* Hoff., *Placopsilina* sp., *Pseudospirocyclina* sp., *Pseudospirocyclina* (?) sp. indet., *Haplophragmium* sp., and *Bramkampella* sp. indet. On the basis of the occurrence of representatives of the genus *Anchispirocyclina,* which are known from coeval deposits of southeastern Crimea, these sediments were interpreted as Tithonian in age (Dulub et al., 1999). At the same time, the authors noted that the preservation of the identified forms was significantly poorer than that of comparable taxa described by G.M. Voloshyna from well sections in the Tambov area (Voloshyna, 1977).

The same bivalve and foraminiferal taxa were subsequently cited in the characterization of Upper Jurassic deposits of the Black Sea region in Volume 1 of the monograph *Stratigraphy of the Upper Proterozoic and Phanerozoic of Ukraine,* where they were assigned a Kimmeridgian–Tithonian age (Stratigraphy..., 2013).

Based on a retrospective analysis of the stratigraphic distribution of faunal remains identified by R.Y. Leshchuk and V.G. Dulub, as well as drilling materials from the Pradniprovska-2 well (Dulub et al., 1999, 2001; Leshchuk et al., 1999; Oil and Gas..., 2007), Zhabina et al. (2015) concluded that the succession in the base of the well are of Tithonian–Berriasian age.

It should be emphasized, however, that the above-mentioned publications do not provide photographic documentation of the fossil material, which is an essential component of substantiated paleontological and biostratigraphic interpretation. The absence of such visual evidence limits the possibility of independent taxonomic verification and complicates stratigraphic correlation.

In contrast, during the geological and geophysical assessment of hydrocarbon potential in the Ukrainian sector of the Black and Azov Seas (2004–2006), conducted by the State Enterprise “Naukanaftogas”, L.F. Plotnikova, analyzing the foraminiferal assemblage identified by N.A. Trofymovych from the depth interval 2129–2375 m, noted a strong similarity to assemblages from the Odeska-2 and Bezimenna-2 wells. On this basis, it was suggest-

ed that sediments of both Albian and Cenomanian age may be present within this interval, with the Albian–Cenomanian boundary tentatively placed at approximately 2210 m according to geophysical data (Gozhyk et al., 2006).

Paleoenvironmental interpretation

The palynological assemblage recovered from the 2370–2375 m interval of the Pradniprovska-2 well provides important insights into the vegetation and depositional environment of the region during the Albian. The dominance of gymnosperms and ferns, together with a diverse dinoflagellate component, suggests that sedimentation occurred in a coastal or near-shore marine setting receiving continuous influx of terrestrial material from a well-vegetated hinterland.

The terrestrial vegetation was markedly diverse and stable, consisting mainly of conifers represented by Araucariaceae (pollen genus *Araucariacites),* Pinaceae (*Pinuspollenites, Cedripites),* and members of Cycadales *(Cycadopites).* Ferns were also prominent, indicated by the presence of *Concavisporites, Gleicheniidites, and Dictyophyllidites,* pointing to humid and warm conditions that favored dense understory fern communities. These data correspond to Albian floras reconstructed from macrofossil evidence in other regions, where conifer-dominated forest canopies coexisted with extensive fern-rich understories.

Angiosperm pollen grains are well represented and show moderate diversity, with key Albian taxa such as *Clavatipollenites, Asteropollis, Afropollis, Tricolpites maximus*, and *Triorites*. Their relative abundance (≈16%) is consistent with a phase of early angiosperm expansion characteristic of the Albian, when flowering plants began to diversify and spread into coastal and fluvial environments. These early angiosperms likely occupied a range of ecological niches, including shrub-level vegetation on floodplains and possibly aquatic or semi-aquatic habitats.

The presence of abundant marine dinocysts (≈38%), including *Hystrichosphaeridium, Kallosphaeridium, Batiacasphaera, Leptodinium,* and *Sentusidinium,* indicates deposition in a marine setting with normal salinity. The high diversity and excellent preservation of hystrichosphaerid forms are consistent with fully marine conditions typical of the Cretaceous. At the same time, the occurrence of freshwater–brackish green algae such as *Botryococcus braunii* suggests periodic freshwater influx into the basin. This combination infers a coastal shelf or lagoonal environment influenced by river discharge, where terrestrial plant material was efficiently transported into the marine system.

Vegetation signals show no sharp changes throughout the studied interval, suggesting stable ecological conditions during the deposition of these sediments. The balance between terrestrial and marine palynomorphs implies a long-lived, stable interaction between land and sea, perhaps reflecting a broad coastal plain with adjacent shallow marine embayments.

Comparable Albian palynofloras from other regions, such as the northern Black Sea shelf, the Middle East, and western Europé, show a similar dominance of conifers and ferns, accompanied by the characteristic *Clavatipollenites–Asteropollis–Afropollis* angiosperm complex. Such similarities underscore the regional climatic stability and widespread distribution of these plant communities across the northern margin of the Tethys Ocean during the Albian.

The preservation of organic material, including delicate cuticles and plant tracheids, suggests low levels of oxidation on the seafloor, consistent with dysoxic bottom waters. The dark, dense siltstones and mudstones support this interpretation, indicating sedimentation in a low-energy environment with periodically restricted circulation. However, the presence of diverse and abundant dinocysts implies that surface waters remained oxygenated and biologically productive.

Conclusions

When integrating and comparing our results from the detailed palynological analyses of both marine and continental palynomorphs with previous results from local and regional studies we conclude that the base of the Pradniprovska-2 well is Early Cretaceous in age, indicating that the core only reached Albian sediments. Our study further shows that the succession in the base of the Pradniprovska-2 well reflects sedimentation in a shallow-marine, nearshore environment influenced by influx of freshwater. This sea was bordered by conifer-dominated forests with expanding angiosperm communities growing in a relatively humid environment. The palynological signatures confirm a stable, warm-temperate to subtropical climate and provide a coherent picture of Albian paleoenvironmental conditions that agrees with regional and intercontinental data.

The validity of our new conclusions about the geological age of the studied section of the Pradniprovska-2 well is first confirmed by photo documentation of the studied microfossils in accordance with accepted international standards. The correlation of the composition of the identified palynological assemblage with assemblages from other intervals of the lower part of the Cretaceous system of the territory of Ukraine and adjacent regions indicates its regional stability within the Albian time interval.

This new information revealing an Albian age of these deposits is the result of many years of comprehensive stratigraphic studies of the sedimentary succession of the northwestern shelf of the Black Sea, obtained by specialists of the Institute of Geological Sciences of the NAS of Ukraine and the Research Institute of Oil and Gas Industry of the National Joint-Stock Company "Naftogaz of Ukraine".

In addition to their stratigraphic significance, the Mesozoic successions of southern Ukraine and the northwestern Black Sea shelf are of considerable interest for hydrocarbon exploration. Numerous Triassic – Cretaceous intervals contain elevated amounts of dispersed organic matter deposited under low-energy marine to marginal-marine conditions, providing favourable prerequisites for hydrocarbon source rock development.

The results obtained are an important step towards ant understanding of the geological structure of the northwestern shelf of the Black Sea and further qualitative interpretation of seismic survey materials.

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Свердловина Прадніпровська-2 розташована в межах українського сектору північно-західного шельфу Чорного моря. З метою встановлення відносного геологічного віку вибійної частини розрізу (інтервал глибин 2370–2375 м), що має ключове значення для регіональної стратиграфії мезозою цього регіону, виконано палінологічні дослідження кернового матеріалу, які включали фотофіксацію, таксономічну ідентифікацію та стратиграфічну інтерпретацію всіх груп мікрофітофосилій. За допомогою палінологічного аналізу встановлено наявність добре збережених і таксономічно різноманітних комплексів, характерних для прибережно-морських умов осадонакопичення, за участю пилку, спор і диноцист. Виявлення віково-діагностичних таксонів покритонасінних, зокрема *Afropollis* у поєднанні з численними *Clavatipollenites*, свідчить про апт-альбський вік. Присутність *Asteropollis*, перша поява яких приурочена до барему, а максимум поширення – до альбу, обмежує вік відкладів альбом. Наявність *Tricolpites maximus* і *Triorites* spp., які розглядаються як маркери раннього альбу, додатково підтверджує таку інтерпретацію. Пилок голонасінних має підпорядковане значення, тоді як спори папоротей і лікофітів формують незначний компонент паліноспектра. Таксономічна структура і співвідношення основних груп пилку та спор демонструють високу подібність до альбських палінологічних комплексів Західної Європи. Отримані палінологічні дані дозволяють датувати вибійну частину свердловини Прадніпровська-2 альбом. Встановлений вік узгоджується з результатами попередніх стратиграфічних досліджень мезозойських відкладів північно-західного шельфу Чорного моря, що були отримані співробітниками Інституту геологічних наук НАН України та ДП «Науканафтогаз» протягом багаторічних комплексних досліджень осадового чохла цього регіону. Отримані результати уточнюють регіональну хроностратиграфічну модель осадового чохла та надають нові дані для розуміння геологічної еволюції цієї внутрішньої зони шельфу впродовж крейдового періоду.

References

Barrón E., Comas-Rengifo M.J., Rodríguez-Lázaro J., Najarro M. 2015. Palynology of Aptian and upper Albian (Lower Cretaceous) amber-bearing outcrops of the southern margin of the Basque–Cantabrian Basin (northern Spain). *Cretaceous Research,* 52, 292–312. http://doi.org/10.1016/j.cretres.2014.09.003

Dulub V.G., Leshchukh R.Y., Melnichuk P.M., Polukhtovych B.M., Turkevych Ye.V. 2001. New materials on Jurassic formations in the Black Sea area. *Tectonics and oil and gas potential of the Azov-Black Sea region in connection with the oil and gas potential of the passive margins of continents:* Materials Conference. Simferopol, pp. 41–46 (in Ukrainian).

Dulub V.G., Leshchukh R.Y., Melnychuk P.M. Polukhtovych B.M., Turkevych Ye.V. 1999. Jurassic sediments of the northwestern shelf of the Black Sea. *Geology and geochemistry of fossil fuels,* 4, 101–110 (in Ukrainian).

Farfuliak L.V. 2016. Deep structure of the western part of the Scythian microplate according to modern seismic data: Dissertation of Candidate of Geological Sciences. Kyiv. (in Ukrainian).

Geology of the shelf of the Ukrainian SSR. Stratigraphy. 1984. Kyiv: Naukova Dumka. (in Ukrainian).

Geology of the shelf of the Ukrainian SSR. Lithology. 1985. Kyiv: Naukova Dumka. (in Ukrainian).

Geology of the shelf of the Ukrainian SSR. Tectonics. 1987. Kyiv: Naukova Dumka. (in Ukrainian).

Geological and geophysical assessment of oil and gas potential and allocation of priority hydrocarbon exploration sites for the Ukrainian sector of the Black and Azov Seas. Report. (Scientific Supervisor S.M. Stovba). 2006. Kyiv: State Enterprise "Naukanaftogas". (in Ukrainian).

Gozhyk P.F., Maslun N.V., Ivanik M.M., Plotnikova L.F., Yakushyn L.M. Ishchenko I.I. 2006. Stratigraphy of Meso-Cenozoic sediments of the northwestern shelf of the Black Sea. Kyiv: Lohos. (in Ukrainian).

Khryashchevskaya O.I., Stovba S.N., Popadyuk I.V. 2009. Stratigraphic basis of geological and geophysical studies of the Odessa shelf (northwestern part of the Black Sea): status, problems and solutions. *Geophysical Journal,* 31 (3), 17–31 (in Russian).

Leshchukh R.Y. Permyakov V.V., Polukhtovych B.M. 1999. Jurassic deposits of southern Ukraine. Lviv: Eurosvit. (in Ukrainian).

Oil and gas prospective objects of Ukraine. Scientific and practical foundations of the search for hydrocarbon deposits in the northwestern shelf of the Black Sea. (Ed. Gozhyk P.F.). 2007. Kyiv: EKMO. (in Ukrainian).

Ogg J.G., Ogg G., & Gradstein F.M. 2008. The Concise Geologic Time Scale. 177. Cambridge, New York, Melbourne: Cambridge University Press.

Schrank E., Kuss J., Ouda K. 2017. Palynology and stratigraphy of the Albian–Cenomanian succession in Makhtesh Qatan, northern Negev, Israel. *Review of Palaeobotany and Palynology*, 235, 73–95. http://doi.org/10.1016/j.revpalbo.2016.09.008

Plotnikova L.F., Maslun N.V., Ivanik M.M., Tsyhotska N.N., Shumnyk A.V. 2003. Stratigraphy of Cretaceous-Paleocene deposits and features of the geological development of the western part of the northwestern shelf of the Black Sea. *Geologičnij žurnal,* 2 (304), 27–38. (in Ukrainian).

Schrank E., Kuss J., Ouda K. 2017. Palynology and stratigraphy of the Albian–Cenomanian succession in Makhtesh Qatan, northern Negev, Israel. *Review of Palaeobotany and Palynology*, 235, 73–95. http://doi.org/10.1016/j.revpalbo.2016.09.008

Shevchuk O.A., Mcloughlin S., Vajda V. 2021. The first Cretaceous megaspores from Ukraine. *Cretaceous Researc.,* 118, 104649. https://doi.org/10.1016/j.cretres.2020.104649

Shevchuk O., Pustovoitova D. 2021. Stratification of Cretaceous deposits of the section No. 29 – Zakhidnooktyabrska (Karkinitsko-North Crimean trough) by palynological data. *Bulletin of the Taras Shevchenko National University of Kyiv. Geology,* 3 (94), 27–36. http://doi.org/10.17721/1728-2713.94.03 (in Ukrainian).

Shevchuk O., Vajda V. 2024. Cretaceous (Albian–Coniacian) dinoflagellate biostratigraphy of the Vomb Trough, southern Sweden. *GFF,* 145, 3–4, 165–176. https://doi.org/10.1080/11035897.2024.2312575

Starostenko V.I., Janik T., Yegorova T., Farfuliak L., Czuba W., Środa P., Thybo H., Artemieva I., Sosson M., Volfman Yu., Kolomiyets K., Lysynchuk D., Omelchenko V., Gryn D., Guterch A., Komminaho K., Legostaeva O., Tiira T., Tolkunov A. 2015. Seismic model of the crust and upper mantle in the 675 Scythian Platform: the DOBRE-5 profile across the northwestern Black Sea and the 676 Crimean Peninsula. *Geophys. J. Int.,* 201, 406–428. http://doi.org/10.1093/gji/ggv018

Stovba S.M., Popadyuk I.V., Fenota P.O., Khriachtchevskaia O.I. 2020. Geological structure and tectonic evolution of the Ukrainian sector of the Black Sea. *Geophysical Journal,* 42, 5, 53–106. https://doi.org/10.24028/gzh.0203-3100.v42i5.2020.215072

Stovba S., Stephenson R., Tyshchenko A., Fenota P., Vengrovych D., Mazur S. 2023. History of the geological development of the Ukrainian sector of the Black Sea from the middle of the Early Cretaceous to the beginning of the Late Miocene. *Geophysical Journal,* 45, 3, 3–49. https://doi.org/10.24028/gj.v45i3.282411 (in Ukrainian).

Stratigraphy of the Upper Proterozoic and Phanerozoic of Ukraine. 1: Stratigraphy of the Upper Proterozoic, Paleozoic and Mesozoic of Ukraine. (Cor. ed. Gozhyk P.F.). 2013. Kyiv: Lohos. (in Ukrainian).

Tanrikulu O., Cornet B. 2014. Early Cretaceous (Albian) spores and pollen from the Glen Rose Formation, Texas, USA. Berkeley eScholarship Repository, University of California Publications in Geological Sciences. 146. P. 1–70. https://escholarship.org/uc/item/7z38083b

Vajda V., Kear B.P. 2024. An earliest Triassic riparian ecosystem from the Bulgo Sandstone (Sydney Basin), Australia: palynofloral evidence of a high-latitude terrestrial vertebrate habitat after the end-Permian mass extinction. *Alcheringa*, 48, 483–494. https://doi.org/10.1080/03115518.2024.2392489

Voloshyna G.M. 1977. Microfauna and stratigraphic division of Upper Jurassic and Lower Cretaceous sediments in two wells of Eastern Crimea. *Reports of the Academy of Sciences of Ukrainian SSR. Ser. B,* 3, 195–198 (in Ukrainian).

Voronova M.A. 1972. On the stratigraphic significance of spores and pollen of the Lower Cretaceous sediments of the East European Platform and its margins. *Tectonics and stratigraphy.* 1, 60–69 (in Ukrainian).

Voronova M.A. 1975. To the issue of the evolution of the vegetation cover of Ukraine in the Albian-Cenomanian time and the problem of the Lower and Upper Cretaceous boundary. *Fossil fauna and flora,* 3, 122–126 (in Ukrainian).

Voronova M.A. 1983. Changes in the structure of ancient phytocenoses in connection with the Albian-Cenomanian transgression in the south of Ukraine. Paleontology and reconstruction of the geological history of paleobaseins. *Theses of the XXIX session of the All-Union Paleontological Society*. Leningrad, pp. 12–13 (in Russian).

Voronova M.A. 1984. Miospores of the Early Cretaceous of Ukraine. Kyiv: Naukova Dumka. (in Russian).

Voronova M.A. 1994. Palynostratigraphy of the Lower Cretaceous and development of Early Cretaceous floras of Ukraine. Kyiv: Naukova Dumka (in Russian).

Zhabina N., Anikeeva O., Kolodiy I., Mintuzova L. 2015. New data on sediment stratigraphy and hydrogeochemical conditions of the Pradniprovska area (northwestern shelf of the Black Sea). *Bulletin of the Taras Shevchenko National University of Kyiv. Geology,* 3 (70), 18–22. https://doi.org/10.17721/1728-2713.70.03 (in Ukrainian).