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Paleontological Characteristics of Jurassic Sediments of Saratov Trans-Volga Region by Well Core, and New Data on the Biostratigraphy of the Kamennyi Ovrag Formation

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Abstract—Jurassic deposits of the Saratov Trans-Volga Region were studied in detail in the Perelyub District in sections of Boreholes 103 and 108 by paleontological and lithological methods. The ammonite Besnosovi Zone (upper part), the foraminiferal Beds with the *Lenticulina volganica–Vaginulina dainae* and the ostracod Glyptocythere bathonica lineage Zone were recognized in the Pochinki Formation (terminal Bajocian–basal Bathonian). The foraminiferal Beds with the *Ammodiscus baticus* and the ostracod Bathoniella prima lineage Zone were recognized in the Kamennyi Ovrag Formation (upper lower Bathonian–upper Bathonian). The foraminiferal Haplophragmoides infracalloviensis–Guttulina tatariensis Zone and the ostracod Bathoniella milanovskyi lineage Zone were recognized in the Khlebnovka Formation (terminal Bathonian–lower Callovian). The following zones have been identified in the Promzino Formation (middle Volgian Substage): Panderi (ammonite), Lenticulina infravolgaensis–Saracenaria pravoslavlevi (foraminifera), Cytherella–Reticythere cornulateralis (ostracods). For the first time, the Kamennyi Ovrag Formation was paleontologically substantiated on the basis of ostracods and was found to correspond to the B. prima Zone. Middle and upper Jurassic mollusks, foraminifera and ostracods and upper Jurassic nannoplankton from the Saratov Trans-Volga Region are illustrated here for the first time.

Keywords: foraminifera, ostracods, ammonites, bivalves, nannoplankton, Bajocian, Bathonian, lower Callovian, middle Volgian, East European Platform

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INTRODUCTION

Jurassic deposits are widespread in the Saratov Trans-Volga Region, but rarely come to the surface here (Kamysheva-Elpatievskaya, 1967). In natural outcrops, the most widely represented rocks are those of the Volgian age (Kamysheva-Elpatievskaya and Solov'eva, 1928; Gurvich, 1951), less often those of the Callovian age. Bajocian-Bathonian deposits in this region were established based on the results of drilling (Rozanov, 1931; Kuznetsova et al., 1964; Kamysheva-Elpatievskaya, 1967; Molostovsky et al., 2004). Kimmeridgian deposits are also known mainly from boreholes (Molostovsky et al., 2004). Rozanov (1931) recorded pyritized molds of ammonites of the Kimmeridgian and, possibly, Oxfordian age only from gray clay in outcrops in the upper reaches of the Sestra River. More commonly, Kimmeridgian and Oxfordian mollusks were recorded in the basal phosphorite conglomerate of the Panderi Zone of the Middle Volgian Substage (Kamysheva-Elpatievskaya, 1967). Since the remains of ammonites and other mollusks are rarely found in borehole cores and are often poorly preserved, microfossils, primarily foraminifers and ostracods, became very significant for biostratigraphy of the Bajocian-Bathonian interval of the Saratov Trans-Volga region. The microfaunal assemblages of the Volga Region have been most fully studied in right-bank outcrops and boreholes; those of the left-bank Jurassic outcrops are much less known (Khabarova, 1955, 1961; Lyubimova, 1955; Myatlyuk, 1961; Dain, 1970; Sarycheva, 1971; Dain and Kuznetsova, 1976; Kuznetsova, 1979; Startseva, 1986; Troitskaya and Khabarova, 1986; Saltykov et al., 2008; etc.).

During geological surveys within the onboard area of the Pre-Caspian Depression, Jurassic deposits were studied in numerous boreholes, using geophysical and paleontological methods (Khabarova and Shadrina, 1969). Many microfaunistic studies resulted in very short lists of characteristic foraminiferal species, which made it possible to identify deposits from the upper Bajocian to the middle Volgian Substage; for the upper Bajocian, guide ostracods (three species) are mentioned. The Jurassic and Lower Cretaceous mollusks, foraminifera and spore-pollen assemblages studied from borehole cores in the upper reaches of the Bolshoi and Malyi Uzen rivers were also presented as the incomplete lists of index forms; single species of ostracods were mentioned only from the upper Bajocian, the middle Volgian Virgatus Zone and the Lower Cretaceous (Valanginian and Hauterivian) (Kuznetsova et al., 1964). As a result of a monographic study of ostracods from the Mesozoic of the Volga Region (including the Saratov left-bank territory and Obshchyi Syrt, mainly from boreholes; Lyubimova, 1955), laterally well-traceable assemblages were established, characteristic of the Lower Triassic, the upper Bajocian, Bathonian, for all substages of the Callovian, Oxfordian, and Kimmeridgian, as well as for individual ammonite zones of the Volgian Stage. These assemblages generally correspond to the latest data on the distribution of ostracods in the Middle and Upper Jurassic of the East European Platform (EEP), but their level of detail compared to the currently existing zonal scheme (Tesakova, 2015, 2022d; Tesakova et al., 2017; Tesakova and Seltser, 2022) is small, and the degree of validity of the boundaries is clearly insufficient. In addition, P.S. Lyubimova's interpretation no longer corresponds to modern ideas about the composition, origin and evolution of the Jurassic ostracod fauna of the EEP (Tesakova, 2013a, 2013b, 2014a, 2022a–2022d; Tesakova and Seltser, 2022, etc.). New information on Jurassic mollusks and foraminifera was obtained during a comprehensive study of the core of reference Borehole no. 120, drilled in the north of the Saratov Trans-Volga Region in the Pugachev District (Molostovsky et al., 2004). However, the guide taxa mentioned in this work also remained unillustrated.

In all publications on the Jurassic of the Saratov Trans-Volga Region there is no information on the exact depths of the macro- and microfauna occurrences and only a brief paleontological description of the stages and substages, sometimes ammonite zones, is included. It is noteworthy that the records of Bathonian ammonites in boreholes of the Saratov Trans-Volga Region have been repeatedly mentioned in the literature (Kamysheva-Elpatievskaya et al., 1959; Kamysheva-Elpatievskaya, 1969; Kuznetsova et al., 1964; Molostovsky et al., 2004; Saltykov, 2008), but until now they were not illustrated as well as the microfauna (the exception is the drawings of ostracods from the Panderi Zone in: Lyubimova, 1955). This greatly reduces the reliability of the determinations. For these reasons, the published data at the present level cannot be reliably used for detailed stratigraphy and correlation of Jurassic deposits.

For this reason, comprehensive biostratigraphic studies of borehole cores in the Perelyub District of the Saratov Region are very relevant. In addition, the impact of salt tectonics of the Permian beds on the overlying deposits in this region leads to extreme variability of the exposed section and uneven representation of Jurassic units in it, which significantly complicates the comparison of these intervals in neighboring sections, despite the close distance between them. Hence, detailed biostratigraphy and correlation of Jurassic intervals in the sections of boreholes 103 and 108 is an urgent and rather complex task. This included: (1) identifying the composition of the faunal assemblages of macro- and microfossils of the Trans-Volga Jurassic, strictly documented by depth, and establishing their stratigraphic sequence; (2) to establish biostratons based on the distribution of mollusks, foraminifera and ostracods, allowing the sections of these boreholes to be correlated with each other and with sections of other areas, including those from the stratotype area of the right bank territory; (3) to publish figures of the studied taxa. It should be noted that although nannoplankton from the Upper Jurassic of the Saratov Region was previously known (Kuleva et al., 2004; Shchepetova, 2011; Bukina, 2013; etc.), its taxonomic definitions were previously absent in the literature and are published in this article for the first time.

Microfossils, as well as ammonites and bivalves, are distributed unevenly in the Jurassic deposits of the sections of boreholes 103 and 108. Different intervals were dated either by one of the studied groups or by their assemblage.

It is especially important to emphasize the importance of ostracods for dating the Kamennyi Ovrag Formation exposed in both boreholes, which was another objective of our study. The Kamennyi Ovrag Formation is widespread in the southeast and in the center of the EEP in the Lower and Middle Volga regions. Its age is conventionally determined as the end of the early to the beginning of the late Bathonian based on its position between the Besnosovi Zone (Pochinki Formation)[1] and Barnstoni–Infimum zones (Khlebnovka Formation) characterized by ammonites (Gulyaev, 2015, 2019). The stratigraphic range of the formation is to some extent conventional; the presence of the middle Bathonian in it has not been formally indicated by ammonite records. However, the wide distribution of the formation, its great thickness throughout its range, and usually non-contrasting boundaries with the underlying and overlying normal marine deposits allow us to conclude that there are no large-scale gaps within it, so it implicitly includes

[1] The nomenclature priority between the Pochinki and Vyazhnevka formations, which were established in the same year and have similar ages and lithology, remains ambiguous (Olferyev et al., 1993; *Unifitsirovannaya*..., 1993, 2012; Olferiev, 1997; Gulyayev, 2019). At the same time, the initial comprehensive characteristics of the Vyazhnevka Formation are quite detailed, while the characteristics of the Pochinki Formation are almost absent.

the middle Bathonian, in one range or another. The boundaries of the middle Bathonian are therefore arbitrary and are shown on the borehole logs by dotted lines.

The Formation is represented by a member of alternating light-gray clays with a characteristic yellowish tint, which they acquire during weathering, and white loose ("floury") silts; this unit contains infrequent interbeds of sand and several horizons of carbonate concretions, as well as an impoverished fossil assemblage.

Its thickness in the Trans-Volga Region is 35–51 m, and on average in the Volga Region it is about 60 m (Saltykov, 2008). The deposition took place in shallow water, in isolated or semi-isolated basins with low and variable salinity (lagoons, limans, estuaries, etc.), which excluded the presence of stenohaline marine organisms, including ammonites, belemnites, and many foraminifers (Saltykov et al., 2008; Shchepetova et al., 2021; etc.).

The Formation deposits contains euryhaline bivalves forming mono- and oligotaxonic assemblages, several species of agglutinating foraminifera of the genus *Ammodiscus*, and rare finds of poorly preserved ostracods (Khabarova, 1955, 1961; Lyubimova, 1955; etc.).

The upper part of the Formation contains marine dinocysts *Protobatioladinium elongatum* Riding et Ilyina[2], while its lower part contains monotaxonic clusters of small U-shaped spreite burrows filled with pellets, morphologically close to the ichnotaxon *Rhizocorallium commune* Schmid and considered to be a marker of tidal plain environments with variable salinity, ranging from marine to brackish and fresh waters (Shchepetova et al., 2021).

In the Kamennyi Ovrag Formation, the beds with *Ammodiscus baticus* were recognized based on frequent, sometimes abundant occurrences of *A. baticus* Dain (Dain, 1948; *Prakticheskoe*..., 1991). However, shells of this index species are also known from the boundary interval of the Bajocian and Bathonian.

Previously, Sazonova and Sazonov (1967, p. 46) wrote: "...together with *Pseudocosmoceras*, in the absence of *Parkinsonia*, the only foraminifera found is a mass accumulation of the endemic species *A. baticus*, which lived in the coastal part of the Central Russian Sea". Dain (1961) linked the distribution of massive accumulations of the foraminifera *A. baticus* in the Bathonian deposits of the Lower Volga Region with fluctuations in salinity and the possible isolation of the basin as a result of regression, while the periodic appearance and disappearance of this species was associated with fluctuations in the position of the coastline. Consequently, the mass occurrences of this species should be considered as indicators of a shallow-water, apparently lagoon-estuarine, environment, and the age of both the lower and upper boundaries of the Beds with *A. baticus* should be considered uncertain and facies-dependent. Strictly speaking, there has been no paleontological justification for the dating of the Kamennyi Ovrag Formation, which was determined only by its position between the deposits characterized by ammonites. Therefore, the ostracods *Bathoniella prima* Tesakova found in it, which appeared in the EEP at the end of the early Bathonian, can be considered as its marker taxon and define its lower boundary. In addition, the evolution of *Bathoniella* in the EEP until the end of the early Callovian (Tesakova, 2024, 2025) made it possible for the first time to correlate the Kamennyi Ovrag Formation with the beginning of a new stage in the evolution of the ostracod fauna—with the evolution of the *Bathoniella* Tesakova lineage—and to establish the corresponding lineage zones in the Bathonian and lower Callovian deposits of the studied boreholes.

The formations in both boreholes were recognized by E.V. Shchepetova. The ammonites in the lower Bathonian part of the sections were identified by D.B. Gulyaev, in the middle Volgian Substage by M.A. Rogov. The middle Jurassic bivalves were identified by O.A. Lutikov. The foraminifera and calcareous nannoplankton assemblages were studied by M.A. Ustinova, and the ostracod assemblages by E.M. Tesakova.

MATERIAL AND METHODS

The material for the study was the cores of two boreholes, nos. 103 and 108, drilled by JSC Mineral and Chemical Company EuroChem in the Perelyub District of the Saratov Region (Fig. 1). Samples for microfauna were collected by Shchepetova and Rogov in 2016. The lithological and stratigraphic characteristics of the Bajocian-Bathonian deposits studied in Borehole103 were published earlier (Shchepetova et al., 2020, 2021; in these works, Borehole 103 was designated as Borehole no. 1). The lithological log of Borehole 108 and its correlation with Borehole 103 were previously published by Tesakova et al. (2023).

The Pochinki and Kamennyi Ovrag formations were exposed by both wells, the Khlebnovka and Promzino formations are present only in well 108. All formations were dated by foraminifera and ostracods, and ammonite zones were only identified in the Pochinki (in a narrow interval) and Promzino formations (Fig. 2).

[2] In published biostratigraphic schemes, this species is considered an index of the upper Bathonian zone, but its dating is based only on data from the section near the village of Churkino on the Pizhma River, where the type series of the species originates. In this section, early Callovian ammonites (Gulyaev, 2001, 2007) were erroneously identified as early and late Bathonian (Meledina, 1994; etc.), which led to incorrect dating of the dinocysts. Thus, the age of the P. elongatum Zone remains uncertain. In the studied region, the age of the boundary interval of the Kamennyi Ovrag and Khlebnovka formations are difficult to date also because that the not always lithologically contrasting lower parts of the Khlebnovka Formation, formed during the late Bathonian boreal marine transgression in the Barnstoni and Infimum chrons, could have been erroneously attributed to the Kamennyi Ovrag Formation.

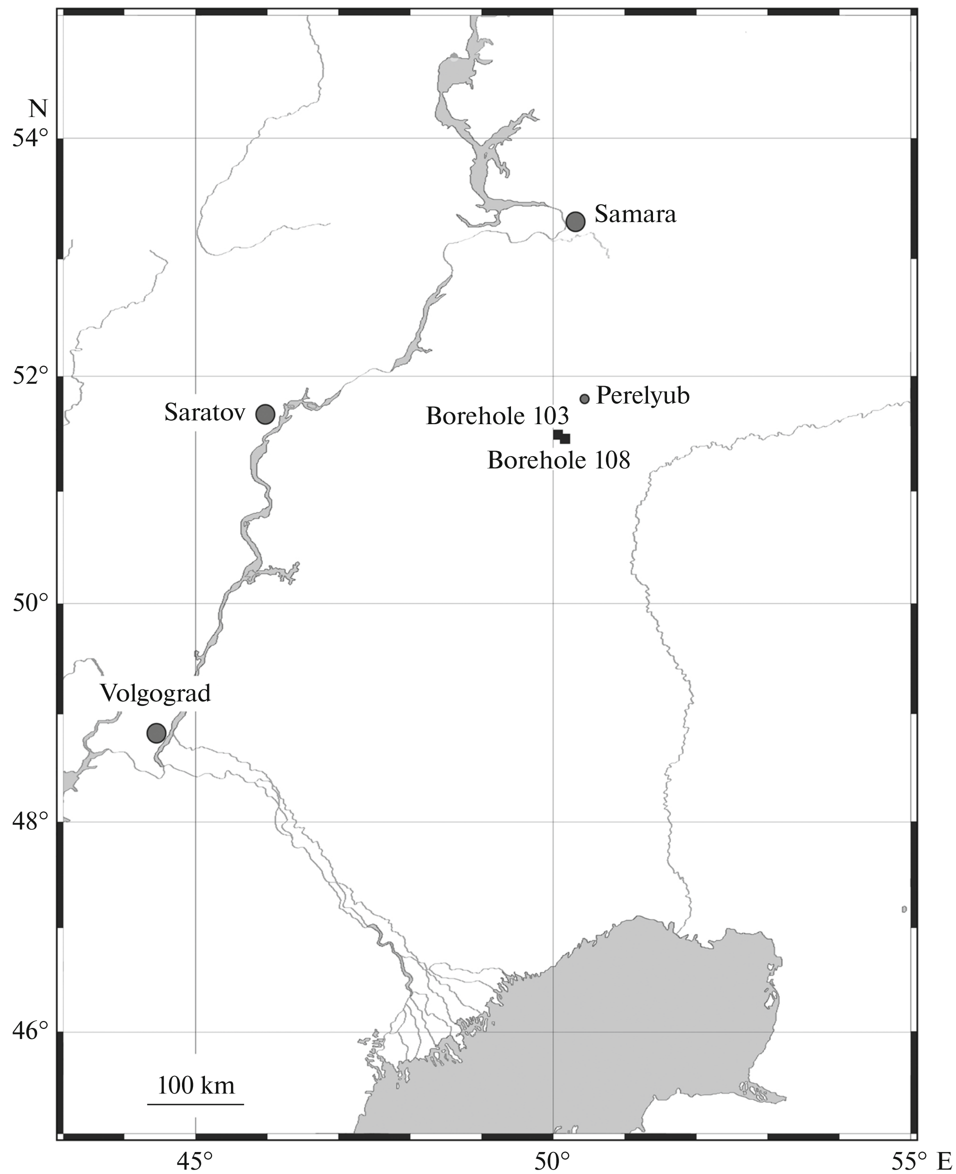

Fig. 1. Location of Boreholes 103 and 108 in the Perelyub District of the Saratov Region.

Ammonites are represented by compressed molds with a preserved nacreous layer (Pl. I). A collection of these mollusks is housed in the Aprelevka branch of VNIGNI, collection MAR5. The core of borehole 103 (at a depth of 214 m) contained scattered valves of the bivalve mollusks *Meleagrinella (M.) doneziana* (Borissjak) (Pl. II). They are housed in the Phanerozoic Stratigraphy Laboratory of the Geological Institute of the Russian Academy of Sciences, coll. no. PB-95.

Microfauna samples (30 pcs., 250–300 g each) were washed using the standard method of soaking the rock for 24 h in hot water with sodium bicarbonate and then rinsing under running water through a plankton net. After drying, the washed material was fractionated on a sieve with a mesh size of 0.315 mm, and microfauna was collected from each fraction (>0.315 and 0.315–0.01 mm) separately.

The preservation of the entire microfauna from the highly sandy Kamennyi Ovrag Formation is satisfactory or poor, and specimens from the Pochinki, Khlebnovka and especially Promzino formations clays are well and very well preserved. Photographs of fora-

Fig. 2. Stratigraphy (based on ammonites and microfossils) and correlation of cores from Boreholes 103 and 108. Here and in Figs. 3–5: (1) concretionary limestones, (2) alternating clay and oil shale sequence, (3) gray and dark gray clays, (4) light gray ("ash") silt clays and grayish-white silts, (5) jarosite nests, (6) sandstones and sands, (7) erosion, (8) bivalve shells. Black circles indicate the presence of a taxon in a sample, and the size of the circle indicates the relative abundance of the taxon: (9) single specimens, (10) tens of specimens, (11) hundreds of specimens.

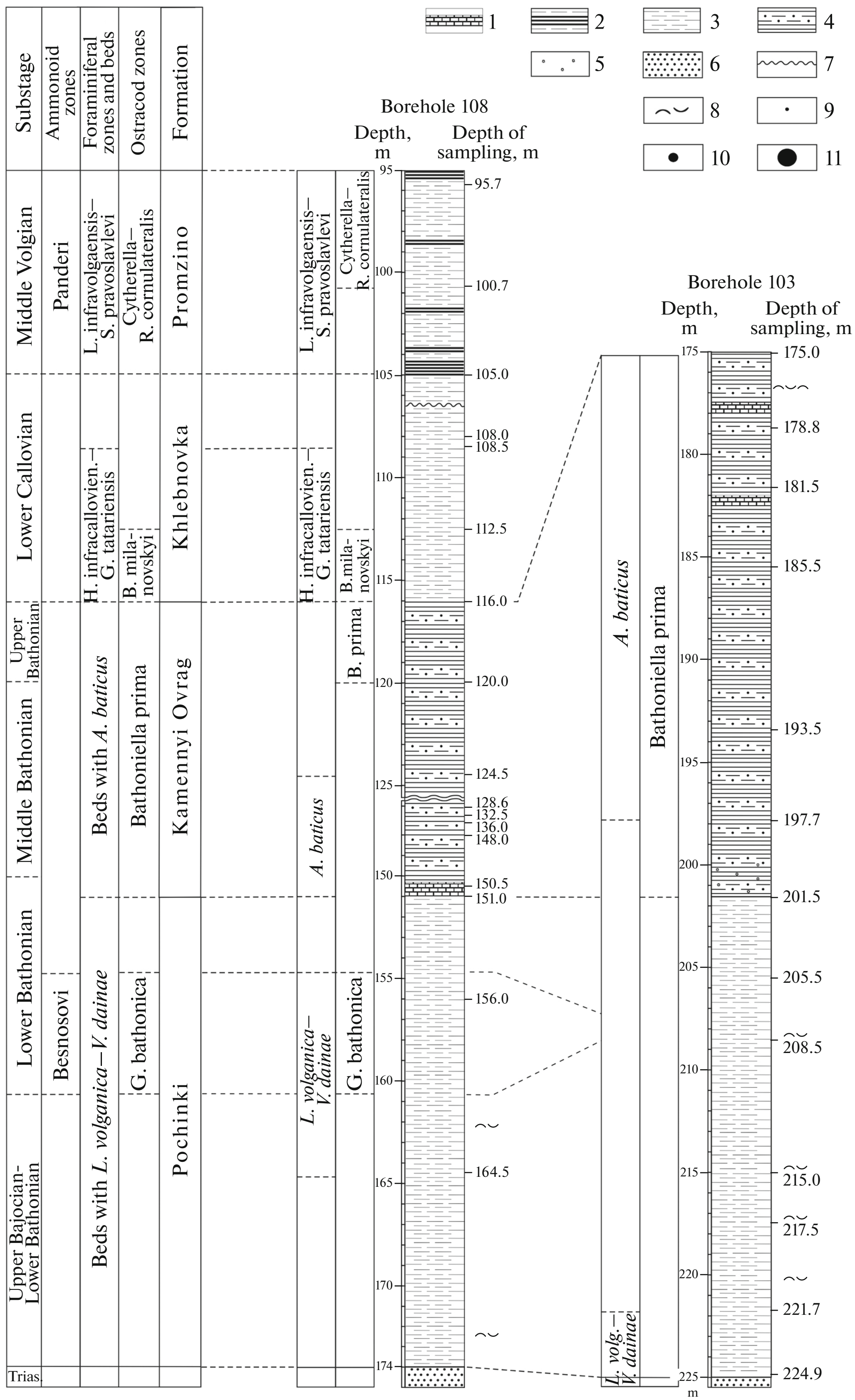
Substage
Ammonoid zones
Foraminiferal zones and beds
Ostracod zones
Formation
Borehole 108
Depth, m
Depth of sampling, m
Borehole 103
Middle Volgian
Lower Callovian
Upper Bathonian
Middle Bathonian
Lower Bathonian
Upper Bajocian-Lower Bathonian
Trias.
Panderi
Besnosovi
L. infravolgaensis–S. pravoslavlevi
H. infracallovien.–G. tatariensis
Beds with A. baticus
Beds with L. volganica–V. dainae
Cytherella–R. cornulateralis
B. mila-novskyi
Bathoniella prima
G. bathonica
Promzino
Khlebnovka
Kamennyi Ovrag
Pochinki
A. baticus
L. volganica–V. dainae
B. prima
L. volg.–V. dainae
m

Plate I

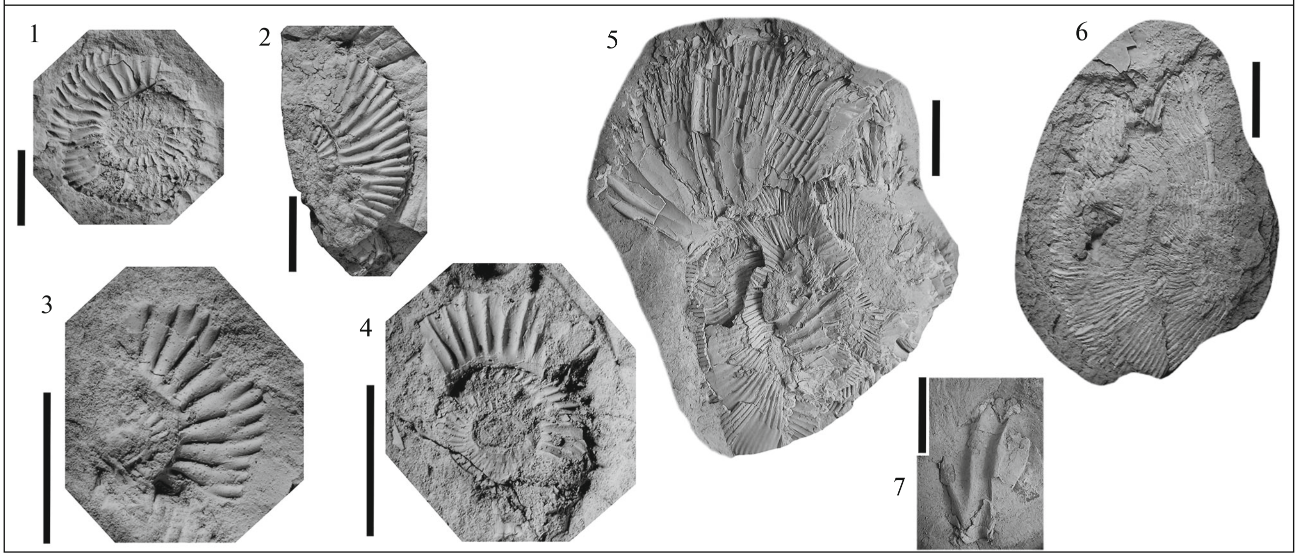

Plate I. Ammonites. (1–4) *Sokurella* cf. *elshankae* Gulyaev, 2019, lower Bathonian, Besnosovi Zone (upper part): (1) specimen no. MAR5/4, Borehole 103, depth 207.75 m; (2) specimen no. MAR5/5, Borehole 103, depth 208.1 m; (3) specimen no. MAR5/6, Borehole 108, depth 156.2 m; (4) specimen no. MAR5/7, Borehole 108, depth 156.3 m; (5) *Zaraiskites kuteki* Rogov, 2013, specimen no. MAR5/1, Borehole 108, depth 105.3 m; middle Volgian, Panderi Zone, Zarajskensis Subzone, Z. kuteki Biohorizon; (6) *Zaraiskites densecostatus* Rogov, 2014, specimen MAR5/3, Borehole 108, depth 102.2 m; middle Volgian, Panderi Zone, Zarajskensis Subzone; (7) *Dorsoplanites panderi* (Eichwald, 1840), specimen MAR5/2, Borehole 108, depth 93.85 m, middle Volgian, Panderi Zone. Scale bar 1 cm.

minifera were taken with a Levenhuk light microscope equipped with a Canon 550D digital camera in the Laboratory of Biostratigraphy and Paleogeography of the Oceans of the GIN RAS (Pls. III, IV). Ostracods were photographed using a TESCAN VEGA-II XMU SEM microscope in the instrument analysis room of the PIN RAS (Pls. V–IX). The ostracod collection under nos. MSU-Perelyub and MSU-PYU is housed in the Department of Regional Geology and History of the Earth, Geological Faculty, Moscow State University; collections of foraminifera under no. 10F-GIN-Perelyub2020 and nannoplankton no. 23N-GIN-Perelyub2020 are housed in the Laboratory of Biostratigraphy and Paleogeography of the Oceans of the GIN RAS.

Calcareous nannoplankton was found only in the Volgian deposits. Its preservation ranged from satisfactory (with partial recrystallization and dissolution of coccoliths) to good (coccoliths were not altered). Coccoliths were isolated by the standard method (Bown and Cooper, 1998) and examined using a BioPtik light polarization microscope (×1000). Photographs were taken in crossed nicols (Pl. X). The relative abundance of nannofossils was estimated by counting the number of specimens in 100 consecutive fields of view on a randomly selected area, covering both the central and marginal parts of the preparation.

The following abbreviations have been adopted for the scientific institutions mentioned in the text: VNIGNI (All-Russian Research Geological Oil Institute, Moscow (Aprelevka Branch)), GIN RAS (Geological Institute of the Russian Academy of Sciences, Moscow), MSU (M.V. Lomonosov Moscow State University), PIN RAS (Borissiak Paleontological Institute of the Russian Academy of Sciences, Moscow), YSPU (K.D. Ushinsky Yaroslavl State Pedagogical University).

AMMONITES

Rare ammonites are found only in two stratigraphic intervals—in the lower Bathonian and the middle Volgian (Figs. 3, 4).

In Borehole 103, in the interval 207.75–208.1 m, *Sokurella* cf. *elshankae* Gulyaev (Pl. I, figs. 1, 2) and *Oraniceras* sp. ind. were identified, and, on this basis, the upper part of the lower Bathonian Besnosovi Zone was recognized.

Plate II. Bivalves. All specimens come from Borehole 103, depth 214.0 m, Sample no. PB-95, Middle Jurassic, Bajocian. (1–3) *Meleagrinella (Meleagrinella) doneziana* (Borissjak, 1909): (1) specimen no. PB-95/3: (a) left valve, external view; ×1; (b) the same, scale bar 2.0 mm; (2) specimen no. PB-95/1: (a) view of the upper part of the left valve of a young specimen from the inside in the rock matrix, scale bar 0.5 mm; (b) ligament block of the left valve, scale bar 0.2 mm; (3) specimen no. PB-95/2: (a) right valve of a young specimen in hingeline view, scale bar 1.0 mm, (b) ligament area of the right valve, ligamentous pit of rectangular type, expanding subtype, scale bar 0.2 mm.

Plate II

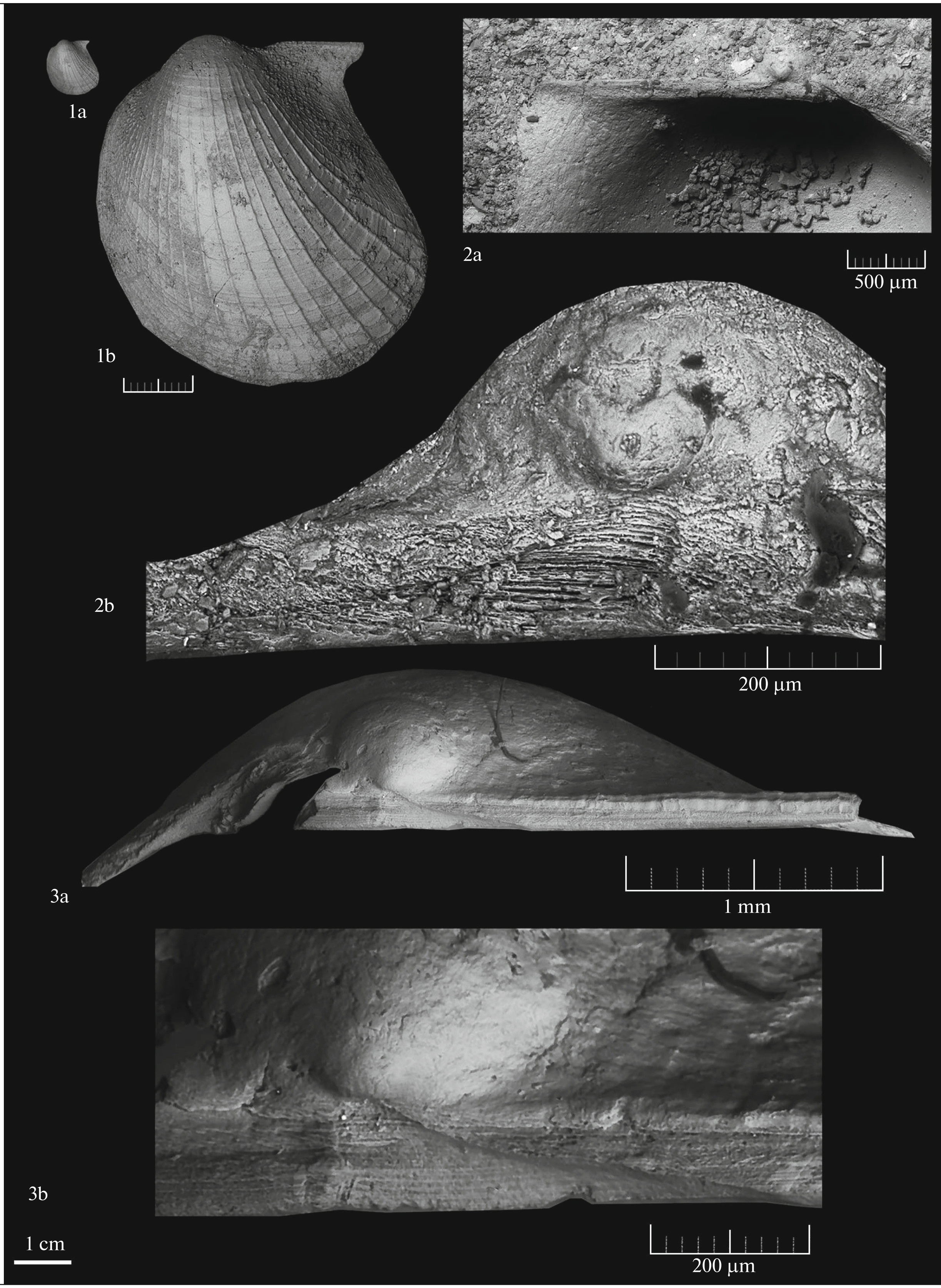

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Plate III. Foraminifera. (1) *Ammodiscus baticus* Dain, 1948, specimen 10F-GIN Perelyub2020-1, lateral view, Borehole 103, depth 175.0 m; (2) *A. crassus* (Kübl. et Zwingli, 1870), specimen 10F-GIN Perelyub2020-2, lateral view, Borehole 103, depth 175.0 m; (3) *A. varians* Kapt.-Chern., 1959, specimen 10F-GIN Perelyub2020-3, lateral view, Borehole 108, depth 124.5 m; (4) *A. pseudoinfimus* Gerke et Sosipatr, 1961, specimen 10F-GIN Perelyub2020-4, lateral view, Borehole 108, depth 116.0 m; (5) *A. graniferus* Kosyr., 1959, specimen 10F-GIN Perelyub2020-5, lateral view, Borehole 108, depth 116.0 m; (6) *A. giganteus* Myatl., 1939, specimen 10F-GIN Perelyub2020-6, lateral view, Borehole 108, depth 95.7 m; (7) *Kutsevella antiqua* Jak., 1984, specimen 10F-GIN Perelyub2020-7, lateral view, Borehole 108, depth 116.0 m; (8, 9) *Ammobaculites fontinensis* (Terq., 1870), Borehole 108, depth 116.0 m: (8) specimen 10F-GIN Perelyub2020-8, dorsal view, (9) specimen 10F-GIN Perelyub2020-9, ventral view; (10, 11) *Haplophragmoides infracalloviensis* Dain, 1948, Borehole 108, depth 116.0 m: (10) specimen 10F-GIN Perelyub2020-10, ventral view, (11) specimen 10F-GIN Perelyub2020-11, dorsal view; (12) *H. nonioninoides* (Reuss, 1863), specimen 10F-GIN Perelyub2020-12, lateral view, Borehole 108, depth 116.0 m; (13) *H. volgensis* Myatl., 1939, specimen 10F-GIN Perelyub2020-13, lateral view, Borehole 108, depth 105.0 m; (14) *Ammobaculites labythnangensis* Dain, 1972, specimen 10F-GIN Perelyub2020-14, lateral view, Borehole 108, depth 100.7 m; (15) *Haplophragmoides* cf. *H. nonioninoides* (Reuss, 1863), specimen 10F-GIN Perelyub2020-15, lateral view, Borehole 108, depth 100.7 m; (16) *Reophax* sp., specimen 10F-GIN Perelyub2020-16, lateral view, Borehole 108, depth 108.5 m; (17) *Triplasia* sp., specimen 10F-GIN Perelyub2020-17, lateral view, Borehole 108, depth 100.7 m. Scale bar 0.25 mm (15, 16); 0.5 mm (1–4, 7–9, 12, 13); 1.0 mm (5, 6, 10, 11, 14, 17).

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Plate IV. Foraminifera. (1) *Lenticulina subinvoluta* Kapt., 1961, specimen 10F-GIN Perelyub2020-18, lateral view, Borehole 108, depth 164.5 m; (2) *L. biexcavata* (Myatl., 1939), specimen 10F-GIN Perelyub2020-19, lateral view, Borehole 108, depth 105.0 m; (3, 4) *L. bella* K. Kuzn., 1976, specimen 10F-GIN Perelyub2020-20, lateral view, Borehole 108, depth 100.7 m; (5) *L. infravolgaensis* (Furs. et Pol., 1950), specimen 10F-GIN Perelyub2020-21, lateral view, Borehole 108, depth 100.7 m; (6) *L.* sp., specimen 10F-GIN Perelyub2020-22, lateral view, Borehole 108, depth 116.0 m; (7) *L.* sp. 1, specimen 10F-GIN Perelyub2020-23, lateral view, Borehole 108, depth 116.0 m; (8) *Marginulina robusta* Reuss, 1863, specimen 10F-GIN Perelyub2020-24, lateral view, Borehole 108, depth 105.0 m; (9) *M. striatocostata* Reuss, 1863, specimen 10F-GIN Perelyub2020-25, lateral view, Borehole 108, depth 105.0 m; (10) *M. kasahstanica* Kasanz., 1934, specimen 10F-GIN Perelyub2020-26, lateral view, Borehole 108, depth 100.7 m; (11, 12) *Vaginulina dainae* (Kosyr., 1948), lateral view: (11) specimen 10F-GIN Perelyub2020-27, Borehole 103, depth 124.9 m, (12) specimen 10F-GIN Perelyub2020-28, Borehole 108, depth 156.0 m; (13, 14) *Saracenaria pravoslavlevi* Furs. et Pol., 1950: (13) specimen 10F-GIN Perelyub2020-29, Borehole 108, depth 100.7 m, (14) specimen 10F-GIN Perelyub2020-30, Borehole 108, depth 105.0 m; (15) *S. triangularis* Orb., 1840, specimen 10F-GIN Perelyub2020-31, Borehole 108, depth 105.0 m; (16) *Marginulinopsis embaensis* (Furs. et Pol., 1950), specimen 10F-GIN Perelyub2020-32, lateral view, Borehole 108, depth 95.7 m; (17) *Planularia dofleini* Kasanz., 1936, specimen 10F-GIN Perelyub2020-33, lateral view, Borehole 108, depth 105.0 m; (18) *Nodosaria osynkiensis* Myatl., 1939, specimen 10F-GIN Perelyub2020-34, lateral view, Borehole 108, depth 100.7 m; (19) *N. scythicus* Furs. et Pol., 1950, specimen 10F-GIN Perelyub2020-35, lateral view, Borehole 108, depth 100.7 m; (20, 21) *Citharina raricostata* Furs. et Pol., 1950: (20) specimen 10F-GIN Perelyub2020-36, Borehole 108, depth 100.7 m; (21) specimen 10F-GIN Perelyub2020-37, Borehole 108, depth 95.7 m; (22) *C. brevis* (Furs. et Pol., 1950), specimen 10F-GIN Perelyub2020-38, lateral view, Borehole 108, depth 105.0 m; (23) *C. heteropleura* (Terq., 1868), specimen 10F-GIN Perelyub2020-39, lateral view, Borehole 108, depth 100.7 m; (24) *Citharinella* sp., specimen 10F-GIN Perelyub2020-40, Borehole 108, depth 95.7 m; (25) *C.* sp. 1, specimen 10F-GIN Perelyub2020-41, Borehole 108, depth 95.7 m; (26) *Tristix temirica* (Dain, 1934), specimen 10F-GIN Perelyub2020-42, Borehole 108, depth 95.7 m. Scale bar 0.25 mm (1); 0.5 mm (2, 5, 7–16, 18, 19, 21); 1.0 mm (4, 6, 17, 20, 22–26).

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Plate V. Ostracods. All illustrated ostracods come from Borehole 108: (2, 7–9) lower Bathonian, Besnosovi Zone, foraminiferal Beds with *L. volganica–V. dainae*, G. bathonica ostracod Zone; (1, 5, 6 and 10–13), middle Volgian, Panderi Zone, L. infravolgaensis–S. pravoslavlevi foraminiferal Zone, Cytherella–R. cornulateralis ostracod Zone. Abbreviations here and in Pls. VI–VIII: C—complete shell, RV—right valve, LV—left valve, juv.—juvenile. Scale bar 100 μm. (1) *Cytherella recta* Sharapova, 1939, MSU-Perelyub-05, C of female, left view, depth 95.7 m; (2) *Paracypris bajociana* Bate, 1963 (s.l.), MSU-PYU-11, RV of female, depth 160.5 m; (3, 4) *Procytherura didictyon rossica* Tesakova in Tesakova and Seltser, 2013, C of female, left view, lower Callovian, H. infracalloviensis–G. tatariensis foraminiferal Zone, B. milanovskyi ostracod Zone: (3) MSU-Perelyub-19, depth 112.5 m; (4) MSU-Perelyub-13, depth 116.0 m; (5, 6) *Eripleura prolongata* (Sharapova, 1939), depth 100.7 m: (5) MSU-Perelyub-24, C of female, (a) left lateral view, (b) dorsal view; (6) MSU-Perelyub-22, RV of female, (a) internal view, (b) external view; (7–9) *Plumhoffia tricostata* (Khabarova, 1955) (s.l.): (7) MSU-PYU-12, LV of female, (a) external view, (b) internal view, depth 160.5 m; (8) MSU-PYU-07, LV of female, depth 156.5 m; (9) MSU-PYU-06, LV of female, depth 156.5 m; (10–13) *Mandelstamia nikolaevi* Kolpenskaya, 1993, depth 100.7 m: (10) MSU-Perelyub-31, C of female, (a) right lateral view, (b) dorsal view; (11) MSU-Perelyub-23, C of female, left view; (12) MSU-Perelyub-30, RV of female, internal view; (13) MSU-Perelyub-28, C juv., young age stage, left lateral view; (14) *Glyptocythere* aff. *tenuisulcata* Br. et Malz in Brand and Fahrion, 1962 sensu Permj. in Pyatkova and Permjakova, 1978, MSU-Perelyub-13, C of female, depth 164.5 m, lower Bathonian, Besnosovi Zone: (a) left lateral view, (b) dorsal view.

Plate III

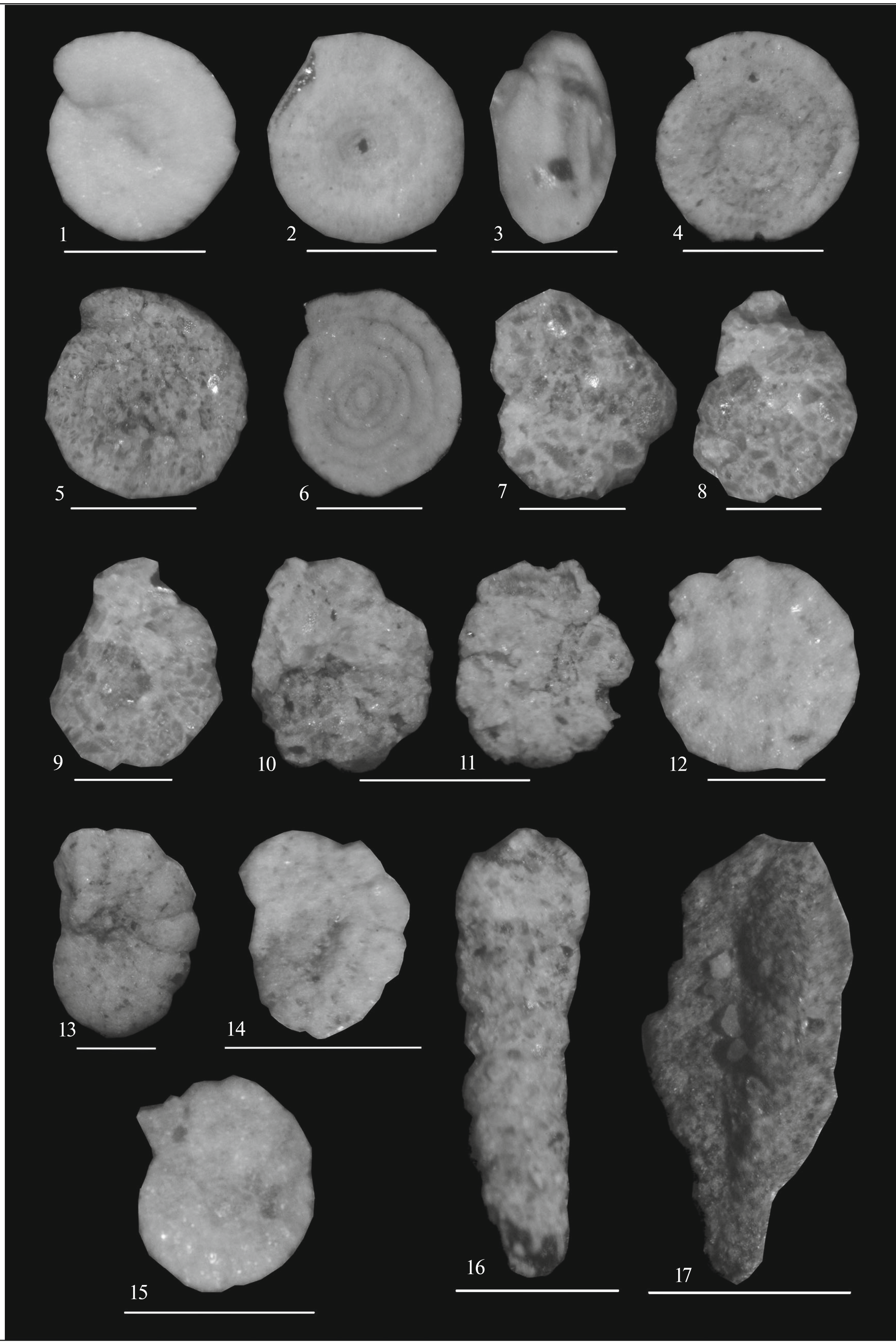

Plate IV

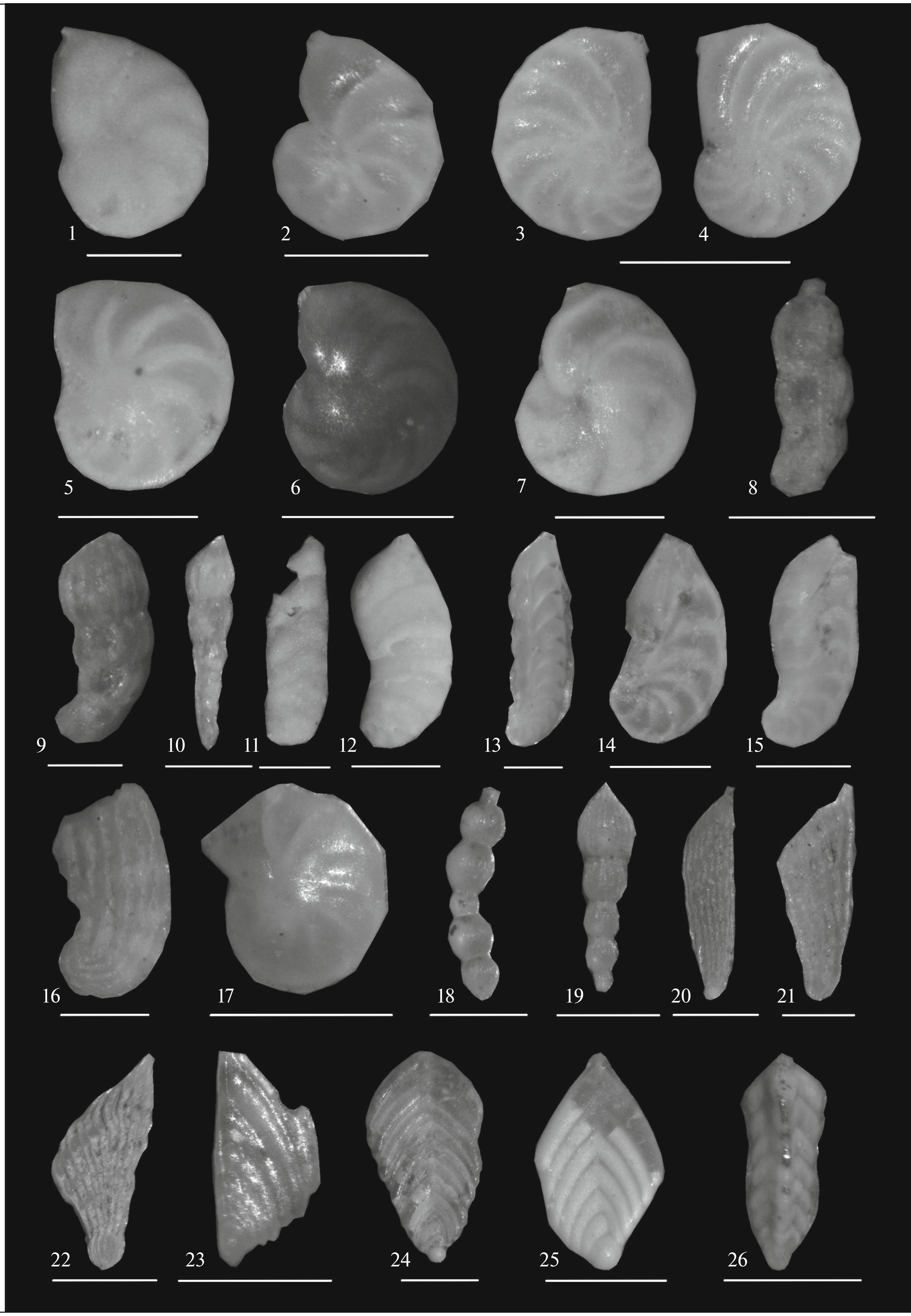

Plate V

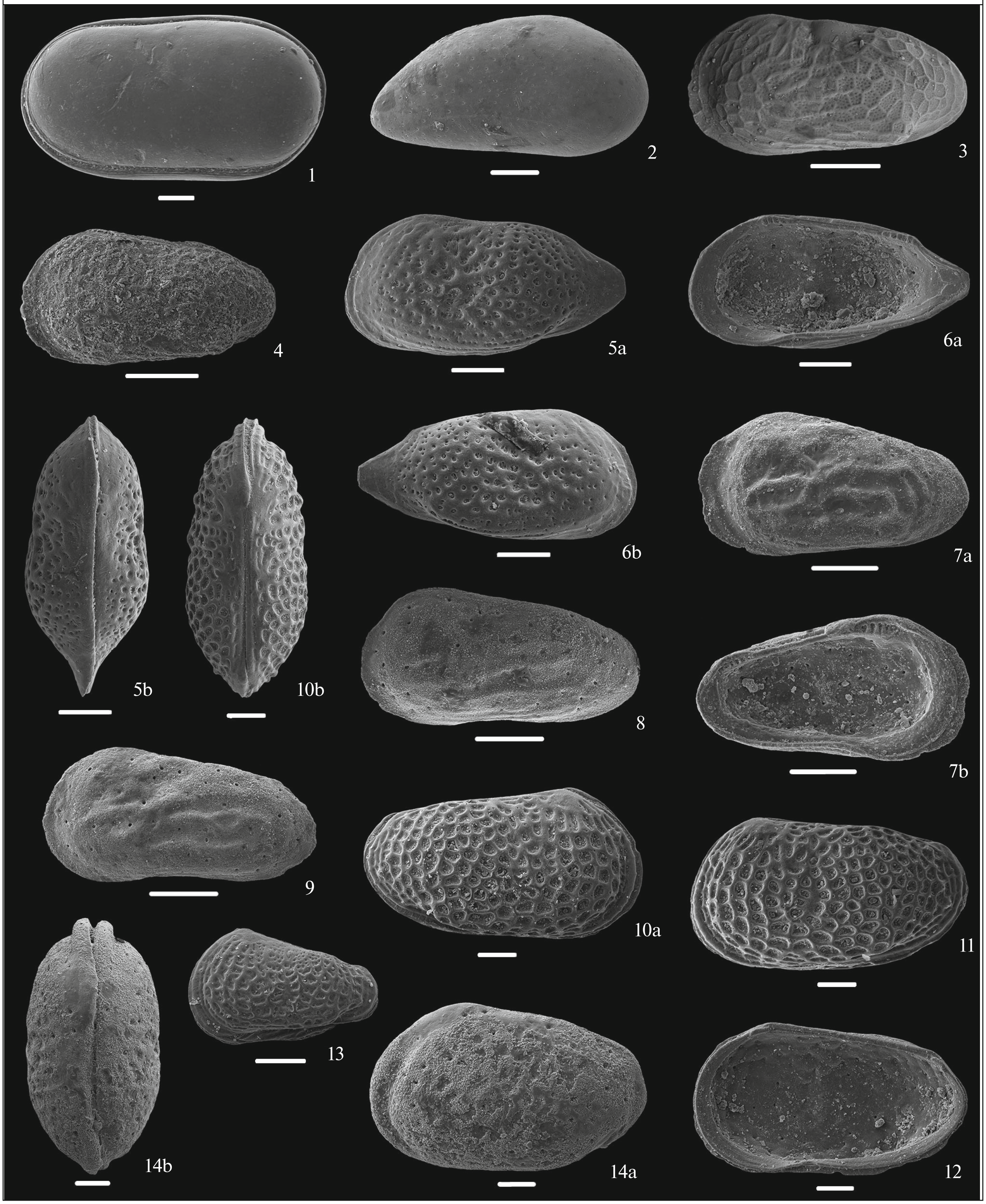

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Plate VI. Ostracods. (1–3 and 5–10) come from Borehole 108: (2, 3, 5 and 8–10) lower Bathonian, Besnosovi Zone, foraminiferal Beds with *L. volganica–V. dainae*, G. bathonica ostracod Zone; (6–7) middle Bathonian, B. prima ostracod Zone. (4, 11–12) come from Borehole 103, lower Bathonian: (4) Besnosovi Zone; (11, 12) B. prima Zone. (1) *Glyptocythere* aff. *tenuisulcata* Br. et Malz in Brand and Fahrion, 1962 sensu Permj. in Pyatkova and Permjakova, 1978, MSU-Perelyub-13, C of female right lateral view, upper Bajocian–lower Bathonian, Beds with *L. volganica–V. dainae*, depth 164.5 m; (2) *G. bathonica* Tesakova, 2022, MSU-PYU-03, RV of female, (a) external view, (b) internal view, depth 156.5 m; (3–5) *G. strigatus* (Khabarova, 1955): (3) MSU-PYU-15, LV of female, (a) external view, (b) internal view, depth 156.2 m; (4) MSU-PYU-01, LV of female, depth 208.1 m; (5) MSU-PYU-02, C of female, (a) right lateral view, (b) left lateral view, depth 156.5 m; (6, 7) *Camptocythere* cf. *scrobiculataformis* Nikitenko, 1994, depth 120.0 m: (6) MSU-Perelyub-06, C of female, left view; (7) MSU-Perelyub-08, RV juv., internal view; (8–10) *C. (Camptocythere) lateres* Tesakova et Shurupova, 2017: (8) MSU-PYU-16, LV juv., depth 156.2 m; (9) MSU-PYU-05, LV juv., depth 156.5 m; (10) MSU-PYU-17, RV juv., depth 156.2 m: (a) external view, (b) internal view; (11, 12) *C. (Anabarocythere) triangula* Tesakova, 2022, depth 201.5 m: (11) MSU-Perelyub-63, C juv., left lateral view; (12) MSU-Perelyub-61, C juv., right lateral view.

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Plate VII. Ostracods. (1–7, 10) Borehole 108: (1, 2) lower Bathonian, Besnosovi Zone, foraminiferal Beds with *L. volganica–V. dainae*, G. bathonica ostracod Zone; (3–7, 10) lower Callovian, H. infracalloviensis–G. tatariensis foraminiferal Zone, B. milanovskyi ostracod Zone; (8–9, 11) Borehole 103, lower Bathonian, B. prima Zone. (1) *Fuhrbergiella* (*Praefuhrbergiella*) *kizilkaspakensis* (Mandelstam, 1947), MSU-PYU-14, RV of female, (a) external view, (b) internal view, depth 156.2 m; (2) *Palaeocytheridea kalandadzei* Tesakova, 2013: MSU-PYU-08, fragment of RV juv., depth 156.5 m; (3–7, 10) *Bathoniella milanovskyi* (Lyubimova, 1955), depth 116.0 m: (3) MSU-Perelyub-14, LV juv., (a) external view, (b) internal view; (4) MSU-Perelyub-17, LV of female; (5) MSU-Perelyub-19, C juv., (a) right lateral view, (b) dorsal view; (6) MSU-Perelyub-18, LV of female; (7) MSU-Perelyub-15, RV of female; (10) MSU-Perelyub-20, flattened C, juv., right lateral view, depth 112.5 m; (8, 9, 11) *B. prima* Tesakova, 2024, depth 201.5 m: (8) MSU-Perelyub-66, C, (a) left lateral view, (b) dorsal view; (9) MSU-Perelyub-54, C, (a) right lateral view, (b) dorsal view; (11) MSU-Perelyub-53, C of female, left view.

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Plate VIII. Ostracods. (1–3 and 11, 12) B. prima Zone: (1, 2) Borehole 103, lower Bathonian; (11–12) Borehole 103, middle Bathonian, Beds with *A. baticus*. (4–10) Borehole 108, middle Volgian Substage, Panderi Zone, L. infravolgaensis–S. pravoslavlevi foraminiferal Zone, Cytherella–R. cornulateralis ostracod Zone. (1–3, 11, 12) *Bathoniella prima* Tesakova, 2024: (1) MSU-Perelyub-53, C of female, dorsal view, depth 201.5 m; (2) MSU-Perelyub-50, mold of C of female, left view (partly dorsal view), depth 197.7 m; (3) MSU-Perelyub-04, mold of C of male, right lateral view, Borehole 108, depth 120.0 m, middle Bathonian; (11) MSU-Perelyub-69, C, right lateral view, depth 175.0 m; (12) MSU-Perelyub-68, C, right lateral view, depth 175.0 m; (4–7) *Galliaecytheridea tatae* Kolpenskaya, 1993, depth 100.7 m: (4) MSU-Perelyub-07, C of female, right lateral view; (5) MSU-Perelyub-36, C of female, (a) right lateral view, (b) dorsal view; (6) MSU-Perelyub-34, C of female, dorsal view; (7) MSU-Perelyub-33, C of male, (a) left lateral view, (b) dorsal view; (8) *G.* cf. *perrara* Kolpenskaya, 1993, MSU-Perelyub-35, C juv., (a) left lateral view, (b) dorsal view, depth 100.7 m; (9, 10) *Exophthalmocythere affabra* Lyubimova, 1955: (9) MSU-Perelyub-36c, C of female, (a) left lateral view, (b) anterior view, depth 95.7 m; (10) MSU-Perelyub-20, C of female, (a) left lateral view, (b) dorsal view, depth 100.7 m.

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Plate IX. Ostracods. (1–4 and 7–11) Borehole 108: (7–11) lower Callovian, H. infracalloviensis–G. tatariensis foraminiferal Zone, B. milanovskyi ostracod Zone. (5–6 and 12–13) Borehole 103, lower Bathonian, B. prima Zone. (1, 2) *Galliaecytheridea tatae* Kolpenskaya, 1993, middle Volgian Substage, Panderi Zone, L. infravolgaensis–S. pravoslavlevi foraminiferal Zone, Cytherella–R. cornulateralis ostracod Zone: (1) MSU-Perelyub-34, C of female, right lateral view, depth 100.7 m; (2) MSU-Perelyub-36a, C of female, right lateral view, depth 95.7 m; (3, 4) *Aaleniella volganica* Tesakova, 2022, lower Bathonian, Besnosovi Zone, foraminiferal Beds with *L. volganica–V. dainae*, G. bathonica ostracod Zone: (3) MSU-PYU-13, RV of male, (a) external view, (b) internal view, depth 160.5 m; (4) MSU-PYU-19, RV of female, (a) internal view, (b) external view, depth 156.2 m; (5, 6) *A. franzi* Tesakova, 2022, depth 201.5 m: (5) MSU-Perelyub-62, C, right lateral view; (6) MSU-Perelyub-59, C, (a) left lateral view, (b) dorsal view; (7, 8) ?*Pyrocytheridea pergraphica* Lyubimova, 1955: (7) MSU-Perelyub-16, C, juv., left lateral view, depth 116.0 m; (8) MSU-Perelyub-21, C, left lateral view, depth 112.5 m; (9) Gen. et sp. 1 sensu Tesakova, 2013, MSU-Perelyub-71, RV, (a) lateral view, (b) internal view, depth 112.5 m; (10) Gen. et sp. 2, MSU-Perelyub-15, C, left lateral view, depth 116.0 m; (11) Gen. et sp. 3, MSU-Perelyub-10, C, (a) right lateral view, (b) dorsal view, depth 116.0 m; (12, 13) Gen. et sp. 7 depth 201.5 m: (12) MSU-Perelyub-52, C, left lateral view; (13) MSU-Perelyub-58, C, left lateral view.

In Borehole 108, ammonites of the Besnosovi Zone were found in the depth of 156.0–160.5 m (Pl. I, figs. 3, 4). Based on the assemblage containing *Zaraiskites kuteki* Rogov (Pl. I, fig. 5), *Z.* ex gr. *kuteki* Rogov, *Z. densecostatus* Rogov (Pl. I, fig. 6), *Dorsoplanites panderi* (Eichwald) (Pl. I, fig. 7), the middle Volgian Panderi Zone was recognized in the depth of 105.0–95.7 m.

BIVALVES

The representatives of the genus *Meleagrinella* (Fig. 3) found in the Pochinki Formation belong to the species *M. (M.) doneziana* Borissjak (Pl. 2, figs. 1–5), which is widespread in the Middle Jurassic deposits of the EEP. This species was first described from the upper Bajocian deposits of the Donetsk Region (Borisjak, 1909).

Plate VI

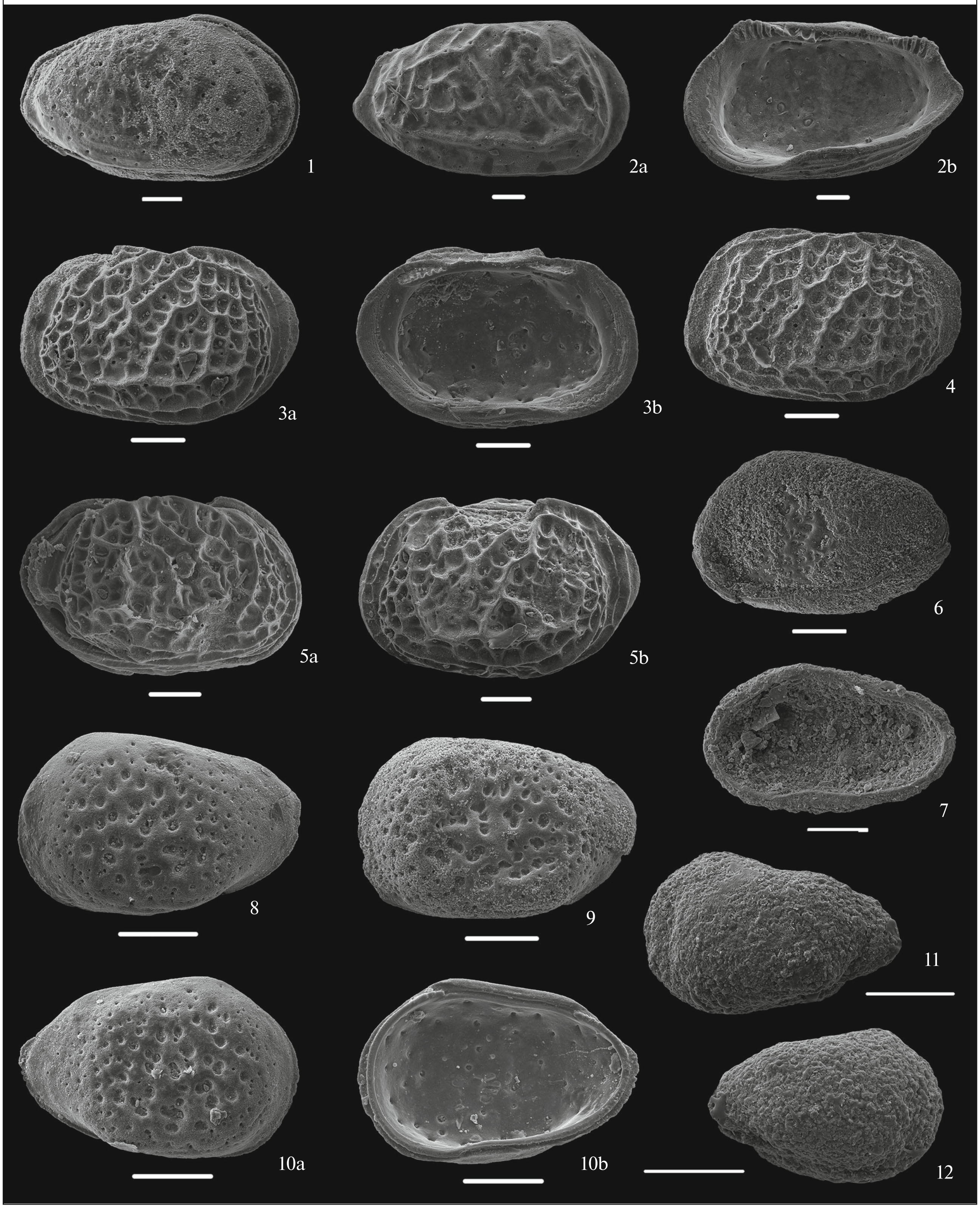

Plate VII

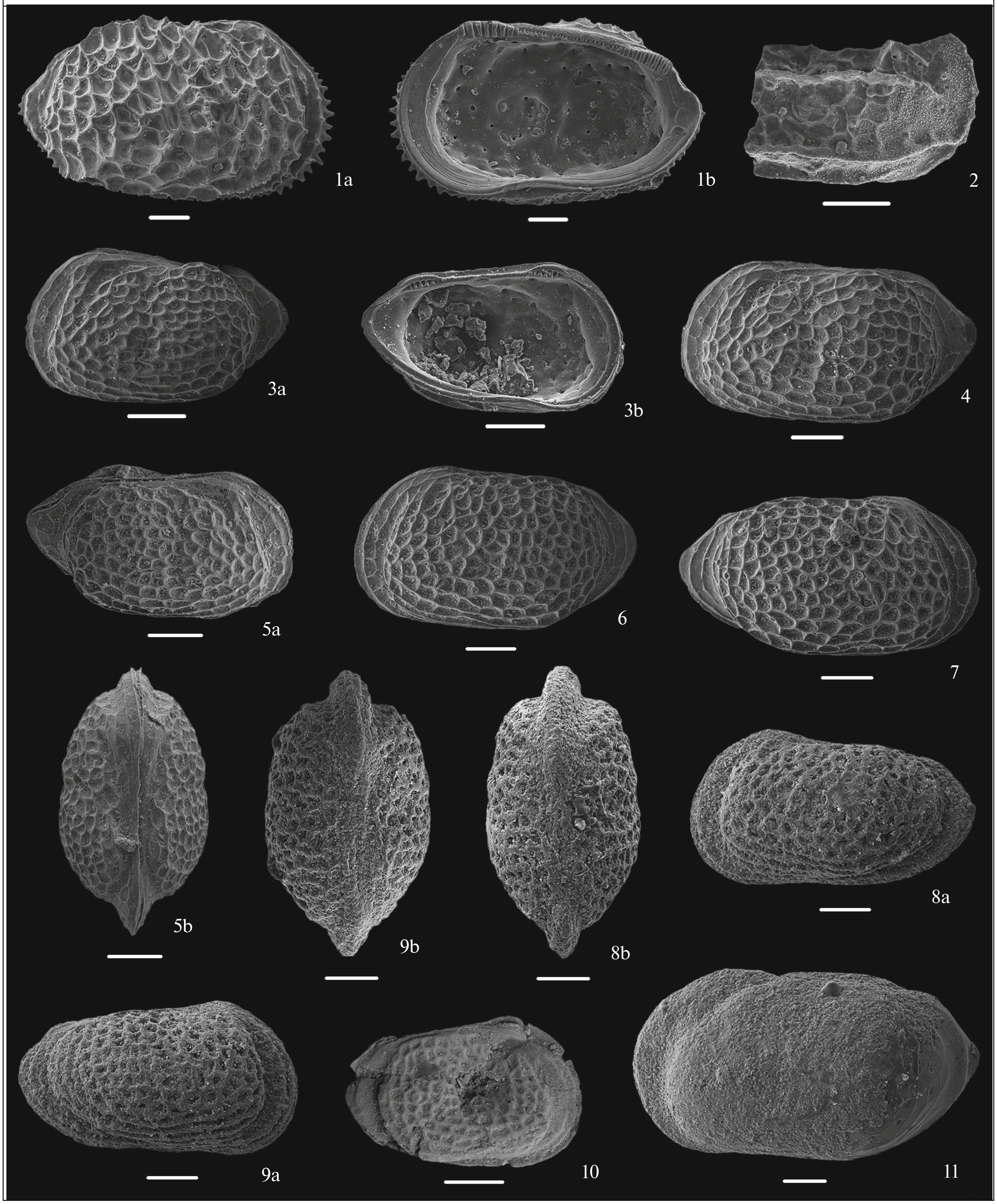

Plate VIII

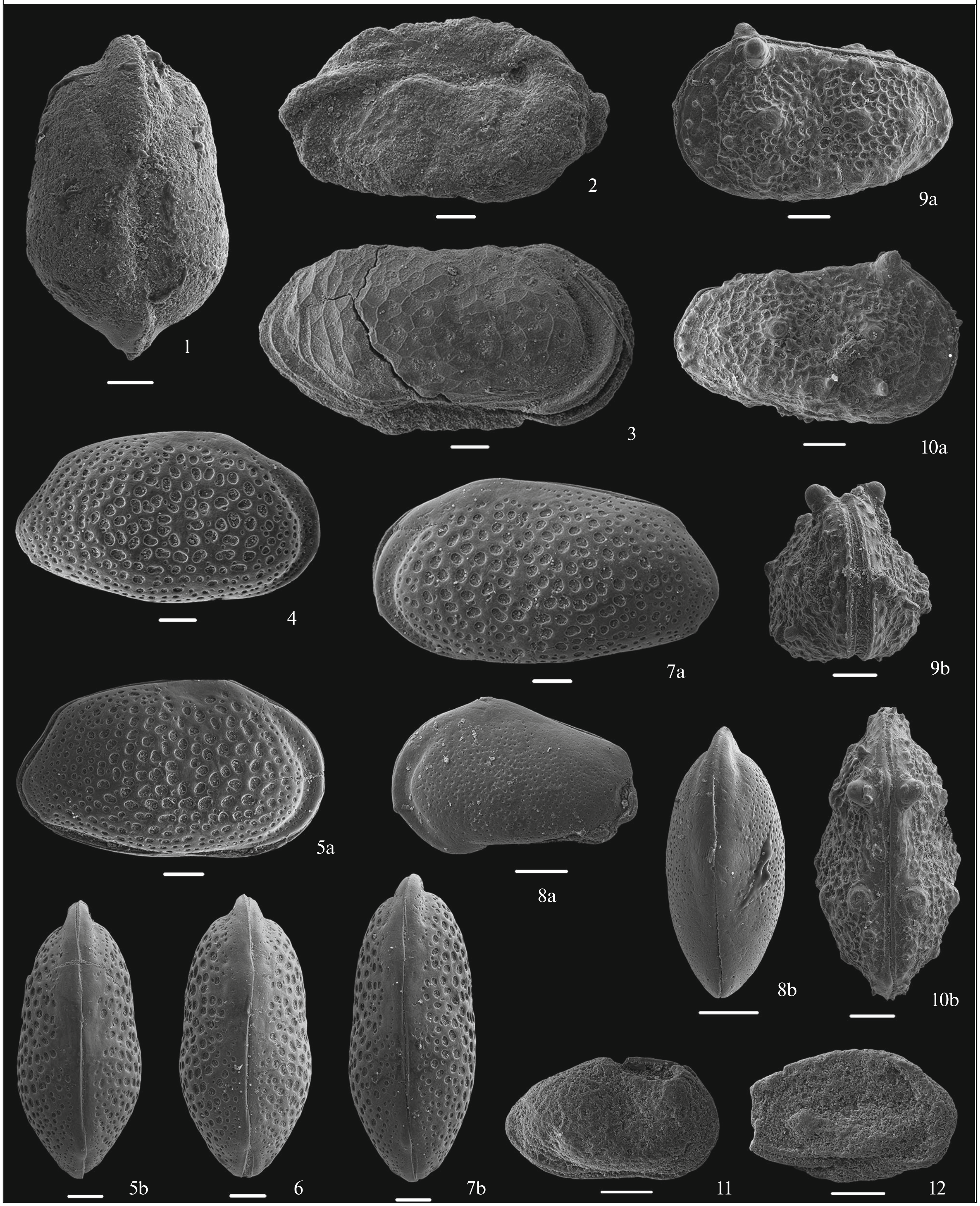

Plate IX

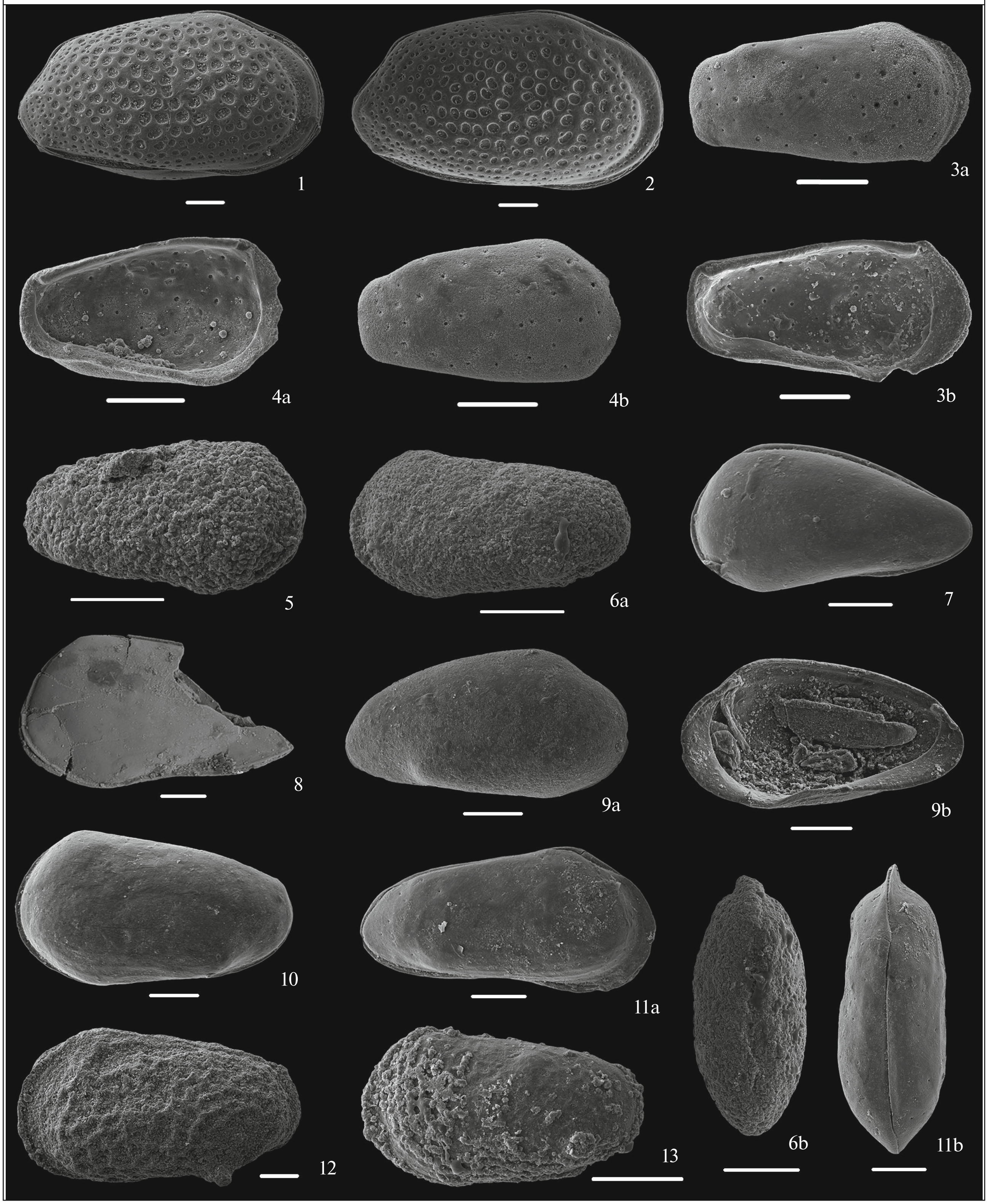

Plate X

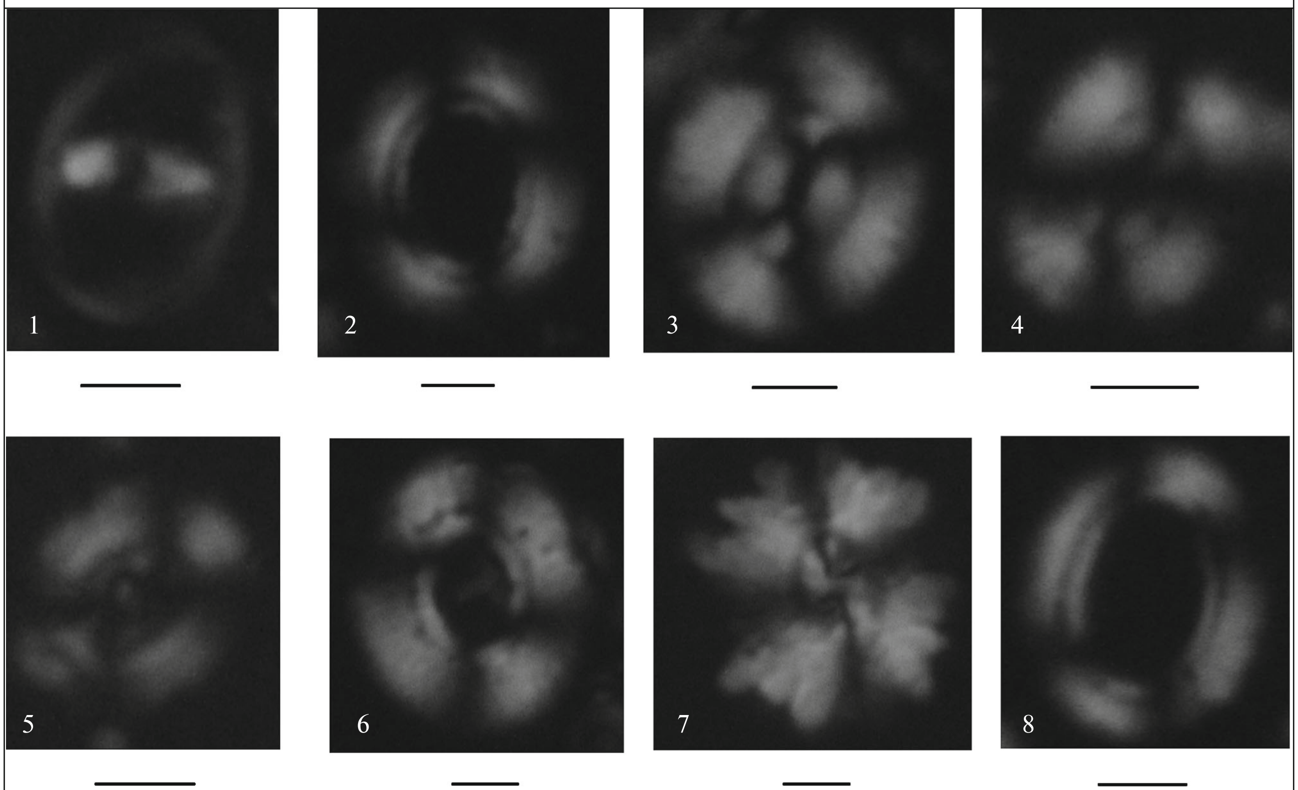

Plate X. Calcareous nannoplankton from the middle Volgian (Panderi Zone) Borehole 108. All photographs were taken in crossed nicols. Scale bar 2 μm. The specimen in Fig. 7 has signs of secondary alterations. (1) *Zeugrhabdotus erectus* (Deflandre in Deflandre and Fert) Reinhardt, depth 105.4 m; (2) *Manivitella pemmatoidea* (Deflandre in Manivit) Thierstein, depth 105.7 m; (3) *Watznaueria fossacincta* (Black) Bown in Bown and Cooper, depth 105. 4 m; (4) *W. barnesiae* (Black in Black and Barnes) Perch-Nielsen, depth 105.7 m; (5, 6) *W. britannica* (Stradner) Reinhardt: (5) depth 105.7 m, (6) depth 105.4 m; (7) *W. biporta* Bukry, depth 105.4 m; (8) *W. ovata* Bukry, depth 105.7 m.

It was recorded from the lower part of the Pochinki ("Zhirnovsk") Formation in the Malyi Kamenniy Ovrag Section, where it is associated with beds with presumably late Bajocian ammonites (Pervushov et al., 2011), but no images of the fossils from this section were published. In the higher part of the Pochinki Formation in the Pletnevka Quarry (lower Bathonian, Besnosovi Zone), another species of *Meleagrinella* is found, which has not yet been unambiguously identified (Gulyaev and Ippolitov, 2017). In the middle Volgian interval, a shell of the bivalve *Buchia mosquensis* (Buch) was found (identification by V.A. Zakharov).

FORAMINIFERA

The most widespread and representative group of fossils in the Jurassic deposits studied in Boreholes 103 and 108 are foraminifera, but their distribution across the sections is very uneven (Figs. 3, 5). A total of 57 taxa have been identified (Pls. III, IV).

Interval 175.0–224.9 m in Borehole 103 and interval 124.5–164.5 m in Borehole 108 contained extremely taxonomically sparse assemblages. In borehole 108 at depth 164.5 m, one specimen of *Lenticulina subinvoluta* Kaptarenko-Chernousova was found, first described from the upper Bajocian of the southwestern part of the Dnieper-Donets Depression and the northwestern edge of the Donets Basin (Kaptarenko-Chernousova, 1961), which made it possible to attribute the enclosing deposits to this substage. This species is also found in the upper Bajocian of Moldova and the Bajocian of the Northeastern Caucasus (Pyatkova and Permyakova, 1978). At depth 156.0 m in Borehole 108 and in the interval 221.7–224.9 m of Borehole 103, single specimens of *Vaginulina dainae* (Kosyreva) were found—a species characteristic of the Beds with *Lenticulina volganica*–*Vaginulina dainae*, recognized in the upper Bajocian–lower Bathonian of the Saratov Volga Region (Azbel et al., 1991; *Unifitsirovannaya*..., 2012).

Above the Bed with *L. volganica*–*V. dainae* in the Bathonian of the European part of the former USSR, the Beds with *Ammodiscus baticus* are recognized (Azbel et al., 1991; etc.). In them, *Saccammina compacta* Gerke, *Ammodiscus crassus* Kubler et Zwingli, and *A. varians* Kaptarenko-Chernousova are found together with the index taxon; their distribution in the Middle

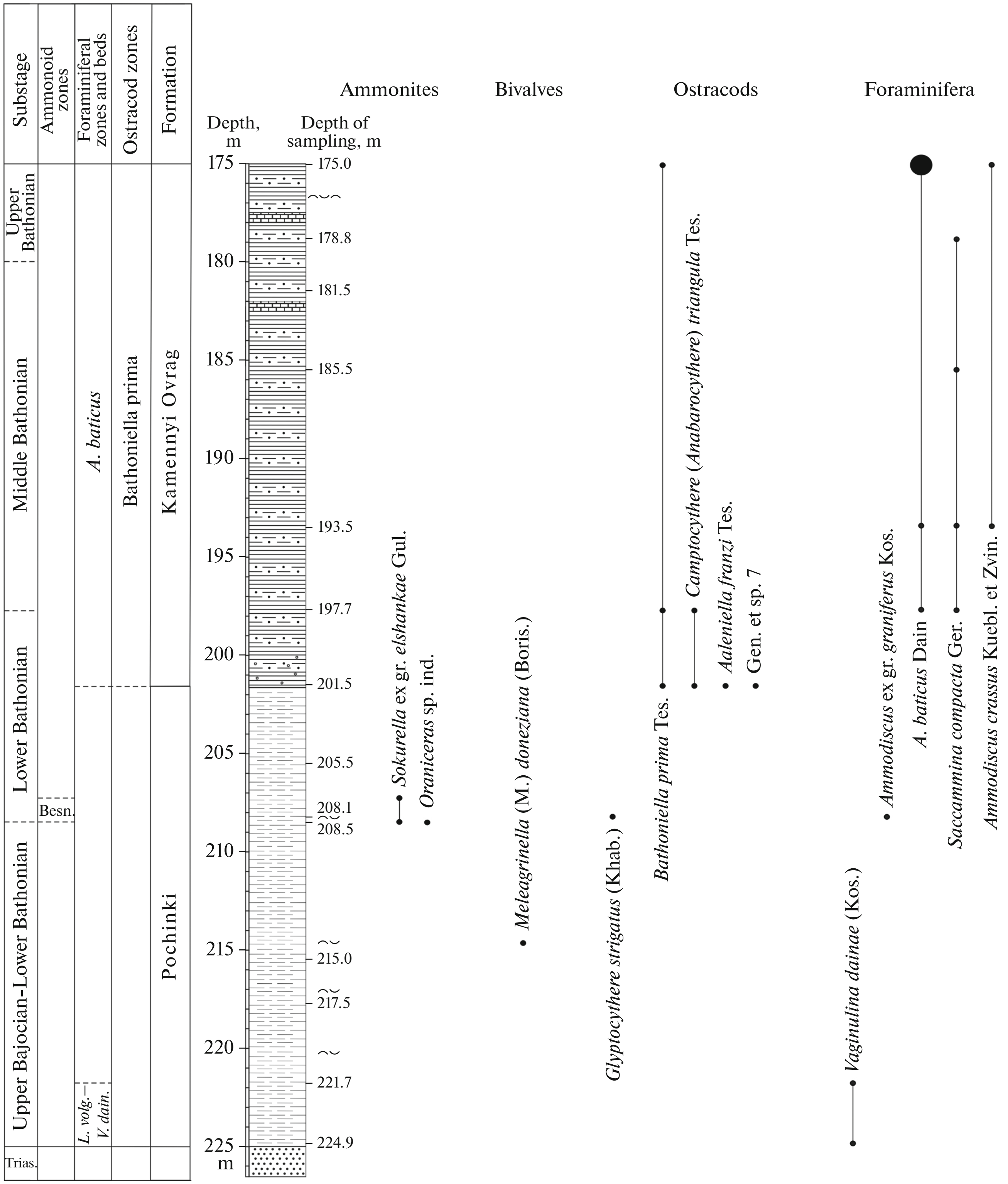

Fig. 3. Distribution of ammonites, bivalves, foraminifera and ostracods in the studied interval of Borehole 103.

Jurassic is not limited to the Bathonian (Kaptarenko-Chernousova, 1959). The Beds with *A. baticus*, associated in the Lower Volga Region with the Kamennyi Ovrag Formation, were found in Boreholes 103 and 108 in the interval 175.0–197.7 and 124.5–151.0 m, respectively.

Above lies the lower Callovian, established in Borehole 108 in the 108.5–116.0 m interval based on the

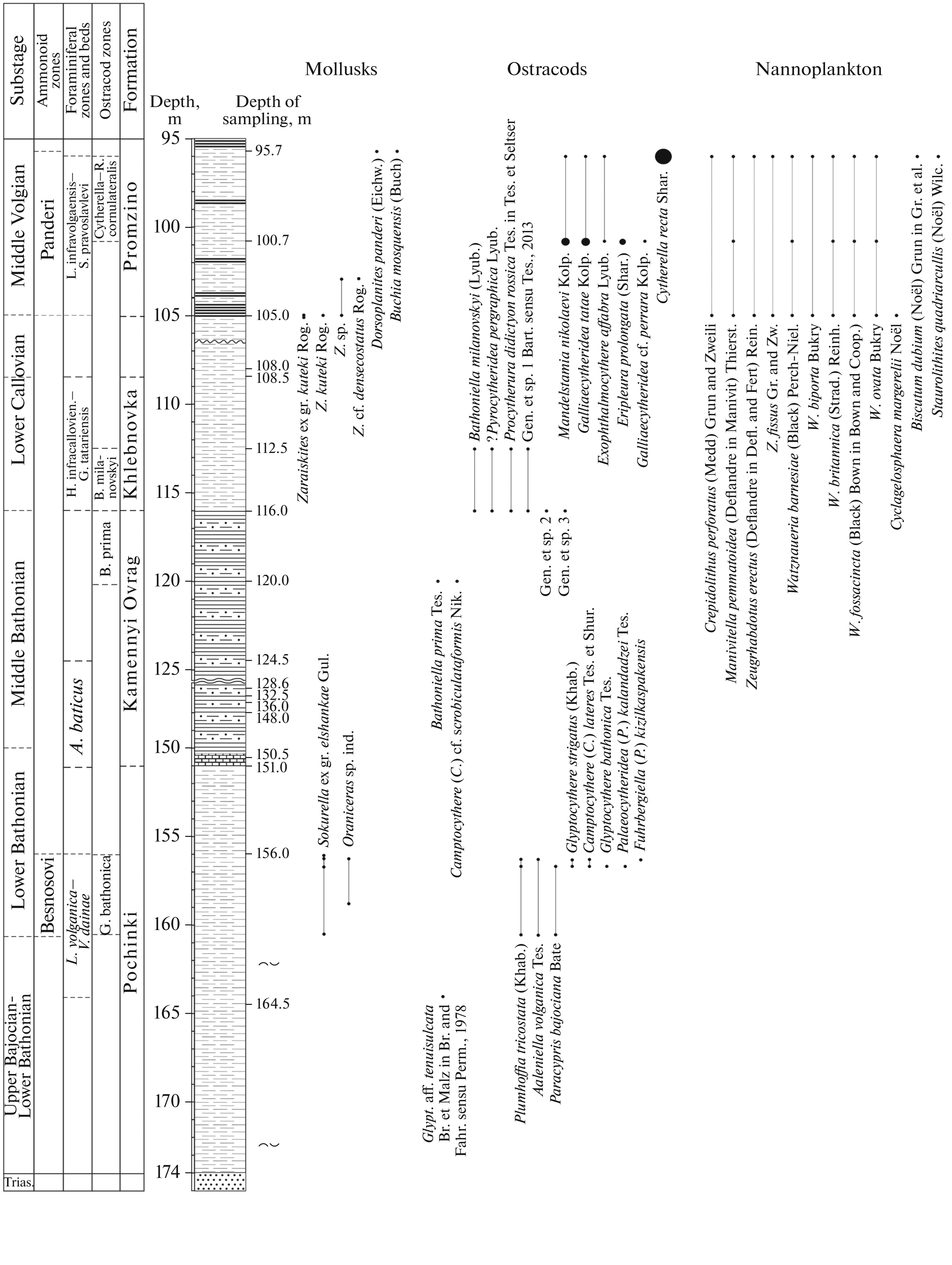

Fig. 4. Distribution of ammonites, ostracods and nannoplankton in the studied interval of Borehole 108.

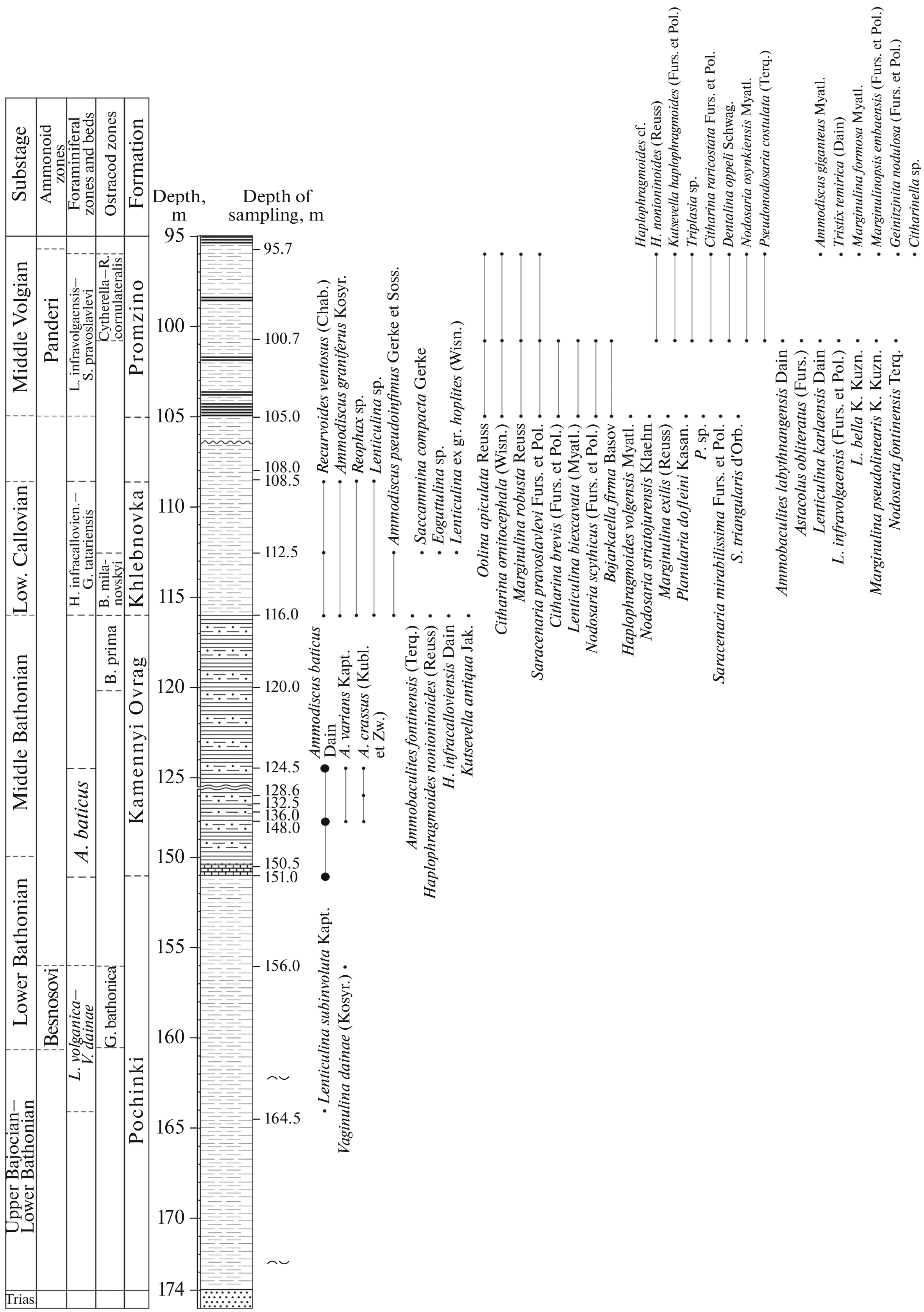

Fig. 5. Distribution of benthic foraminifera in the studied interval of Borehole 108.

findings of *Ammodiscus graniferus* Kosyreva, *Haplophragmoides infracalloviensis* Dain, *Recurvoides ventosus* (Chabarova)—species characteristic of the lower Callovian Haplophragmoides infracalloviensis–Guttulina tatariensis Zone (Azbel et al., 1991). The most representative foraminiferal assemblage was encountered in borehole 108 in the interval of 95.7–105.0 m. Based on the presence of species characteristic of the middle Volgian Lenticulina infravolgaensis–Saracenaria pravoslavlevi Zone: *Ammodiscus giganteus* Myatliuk, *Haplophragmoides volgensis* Myatliuk, *Lenticulina biexcavata* (Myatliuk), *Saracenaria pravoslavlevi* Fursenko et Polenova, etc., the host rocks can be attributed to the middle Volgian. A total of 55 species have been identified in this interval.

OSTRACODS

In total, 28 ostracod taxa were identified in both boreholes, seven of which—in the open nomenclature.

In Borehole 103 (Fig. 3) in the Pochinki Formation at a depth of 208.1 m, one specimen of the species *Glyptocythere strigatus* (Khabarova) s.l. (Pl. VI, fig. 4) was found. This species is characteristic of the upper Bajocian and lower Bathonian of the Lower Volga and Obshchyi Syrt regions (Khabarova, 1955, 1961), the northwestern outskirts of the Donets Basin (Katz, 1957; Permyakova, 1970) and the central regions of Russia (Penza Region, in Tesakova's collection). In the Sokur Section (outskirts of Saratov), where this species was initially defined in open nomenclature as *Glyptocythere* sp. 1 morpha 1 and *G.* sp. 1 morpha 2 (Shurupova et al., 2016; Shurupova and Tesakova, 2017), is widespread in the Michalskii and Besnosovi ammonite zones and is characteristic of the zonal assemblages of the ostracod G. aspera and G. bathonica lineage zones (Tesakova, 2022d).

In the Kamennyi Ovrag Formation, four taxa have been noted, represented by poorly preserved specimens of different age stages: *Bathoniella prima* Tesakova (Pl. VII, figs. 8, 9, 11; Pl. VIII, figs. 1, 2, 11 and 12), *Camptocythere (Anabarocythere) triangula* Tesakova (Pl. VI, figs. 11, 12), *Aaleniella franzi* Tesakova (Pl. IX, figs. 5, 6) and Gen. et sp. 7 (Pl. IX, figs. 12, 13). Altogether they were found only at a depth of 201.5 m, and higher up the section the diversity decreases. The most frequently found and relatively abundant species in the Kamennyi Ovrag Formation in Borehole 103 is *B. prima* (thus, five specimens were found at a depth of 201.5 m, six at a depth of 197.7 m, and three at a depth of 175.0 m), while the other species are represented singly. Based on the distribution of *B. prima*, an eponymous Zone is established (Tesakova, 2025), also recognized in Borehole 108.

In Borehole 108 (Fig. 4) in the Pochinki Formation at a depth of 164.5 m (undifferentiated deposits of the upper Bajocian–lower Bathonian; Beds with *L. volganica–V. dainae*) single shell of average preservation was found, in size, outline and fine ornamentation most similar to *Glyptocythere* aff. *tenuisulcata* Brand et Malz in Brand and Fahrion from the upper Bajocian of the Dnieper-Donets Depression (Pyatkova and Permyakova, 1978, p. 141, pl. 58, fig. 1). The specimen found has a reticulate ornamentation with small loops, the thin walls of which are low, smoothed and poorly distinguishable due to the accreted micrite (Pl. V, fig. 14; Pl. VI, fig. 1). The bottom of the cells is covered with small simple pores (often arranged along the walls); the surface of the valve is also perforated by small round sieve pores (Pl. VI, fig. 1).

Above, in the depth interval of 156.2–160.5 m, an ostracod assemblage typical of the G. bathonica Zone was established from the deposits of the Besnosovi Zone and the Beds with *L. volganica–V. dainae*. In its lower part, the following species are present: *Plumhoffia tricostata* (Khabarova) (Pl. V, figs. 7–9), *Paracypris bajociana* Bate (Pl. V, fig. 2), and *Aaleniella volganica* Tesakova (Pl. IX, figs. 3, 4); at the top, to them are added: *Glyptocythere bathonica* Tesakova, the index species of this zone (Pl. VI, fig. 2), *G. strigatus* (Pl. VI, figs. 3, 5), *Camptocythere (C.) lateres* Tesakova et Shurupova (Pl. VI, figs. 8–10), *Fuhrbergiella kizilkaspakensis* Mandelstam (Pl. VII, fig. 1) and *Palaeocytheridea (P.) kalandadzei* Tesakova (Pl. VII, fig. 2).

The next ostracod finds in Borehole 108 were made in the Kamennyi Ovrag Formation. At a depth of 120.0 m, one specimen of *B. prima* (Pl. VIII, fig. 3) and one specimen of *Camptocythere (C.)* cf. *scrobiculataformis* Nikitenko (Pl. VI, figs. 6, 7) were noted, both poorly preserved. The interval of the section 116.0–120.0 m is assigned to the B. prima Zone (before the first finds of the index species *Bathoniella milanovskyi* (Lyubimova) of the next Zone (Tesakova, 2025)). The species *C. (C.) scrobiculataformis* is an index of a Zone that covers the lower and probably middle Bathonian and can be traced in Northern Siberia, on the shelf of the Barents Sea and in the Timan-Pechora Region (Basov et al., 2009; Nikitenko, 2009).

The transition between the Kamennyi Ovrag and Khlebnovka formations in the section is lithologically quite smooth and indistinct. Early Callovian ostracods of the B. milanovskyi Zone from the Khlebnovka Formation (int. 112.5–116.0 m) are represented by a poor but very characteristic assemblage: *B. milanovskyi* (Pl. VII, figs. 3–7, 10), *?Pyrocytheridea pergraphica* Lyubimova (Pl. IX, figs. 7, 8), *Procytherura didictyon rossica* Tesakova in Tesakova and Seltser (Pl. V, figs. 3, 4), Gen. et sp. 1 sensu Tesakova, 2013 (Pl. IX, fig. 9), Gen. et sp. 2 (Pl. IX, fig. 10) and Gen. et sp. 3 (Plate IX, fig. 11).

In the Promzino Formation, ostracods of excellent preservation have been identified: *Cytherella recta* Sharapova (Pl. V, fig. 1), *Eripleura prolongata* (Sharapova) (Pl. V, figs. 5, 6), *Mandelstamia nikolaevi* Kolpenskaya (Pl. V, figs. 10–13), *Galliaecytheridea tatae* Kolpenskaya (Pl. VIII, figs. 4–7), *G.* cf. *perrara* Kolpenskaya (Pl. VIII, fig. 8) and *Exophthalmocythere affabra* Lyubimova (Pl. VIII, figs. 9, 10). The taxonomic composition of this assemblage is impoverished (only six species), but the abundance of some of its components is quite significant. The listed taxa are widespread in the middle Volgian–upper Volgian substages of the Russian Plate (Sharapova, 1939; Lyubimova, 1955; Kolpenskaya, 1993, 1999; Tesakova, 2014b). In the Gorodishchi Section (Ulyanovsk Region), in the interval of Z. scythicus–Z. regularis ammonite biohorizons, the Cytherella–R. cornulateralis ostracod Zone was identified on the basis of the pronounced dominance of *Cytherella* and the distribution of the species *Reticythere cornulateralis* (Lyubimova). *E. affabra* and *Mandelstamia abdita* Lyubimova appear at its lower boundary (Tesakova, 2014b). The species *E. prolongata* in the Gorodishchi Section was found in the upper Kimmeridgian Fallax Subzone and the lower Volgian Klimovi Zone (Tesakova, 2014b), and in Obshchyi Syrt it is common in the Panderi and Virgatus zones of the middle Volgian Substage (Lyubimova, 1955). Based on the fine-pitted ornamentation, we have tentatively identified the deformed juvenile shell as *G.* cf. *perrara*, known from the middle-upper Volgian deposits of the Pechora River basin (Kolpenskaya, 1993). Thus, the interval of the section, different levels of which either are dominated by *C. recta* or *G. tatae* or (to a lesser extent) by *M. nikolaevi,* while *E. affabra*, characteristic of the zonal assemblage in present, can be assigned to the Cytherella–R. cornulateralis Zone.

NANNOPLANKTON

Calcareous nannoplankton was found in small quantities (Fig. 4) in the Middle Volgian interval Borehole 108. A total of 12 species have been identified, represented by cosmopolitan species of wide stratigraphic distribution: *Crepidolithus perforatus* (Medd) Grün et Zweili, *Cyclagelosphaera margerelii* Noël, *Biscutum dubium* (Noël) Grün in Grün et al., *Manivitella pemmatoidea* (Deflandre in Manivit) Thierstein, *Staurolithites quadriarcullus* (Noël) Wilcoxon, *Watznaueria barnesiae* (Black in Black and Barnes) Perch-Nielsen, *W. biporta* Bukry, *W. britannica* (Stradner) Reinhardt, *W. fossacincta* (Black) Bown in Bown and Cooper, *W. ovata* Bukry, *Zeugrhabdotus erectus* (Deflandre in Deflandre and Fert) Reinhardt, *Z. fissus* Grün et Zweili (Pl. X, figs. 1–8).

It is impossible to judge the age of the enclosing sediments based on the species listed, but their presence in the section suggests normal salinity of the mobile waters. In addition, the quantitative predominance of *W. barnesiae* and *W. fossacincta*, as well as *Z. erectus*, is a sign of mesotrophy or the initial stage of eutrophication of the environment (Lees et al., 2004; Kedzierski, 2012).

RESULTS AND DISCUSSION

Ostracods from the Kamennyi Ovrag Formation are shown to be quite remarkable. Among them, taxa characteristic of the underlying G. bathonica Zone (Tesakova, 2022) continue into these beds: *C. (A.) triangula, C. (C.) scrobiculataformis, A. franzi* (Figs. 3, 4). The same was shown by other authors. For example, Khabarova (1955) wrote that in this formation, along with *A. baticus*, there are rare specimens of ostracods that came from the Bajocian, and in the article by Saltykov et al. (2008), the Bajocian species are listed: *Glyptocythere praerimosa* (Khabarova), *Procytheridea? bajociensis* (Khabarova), *Pseudohutsonia clivosa* (Khabarova), and *Paracypris bajociana* Bate. But they did not dominate the assemblages at all. From the end of the early Bathonian, this role was played by representatives of the genus *Bathoniella*, which flourished in the early Callovian in the Subpatruus Phase and survived until the end of the Calloviense Phase (Tesakova, 2024, 2025). The Bathonian representatives of *Bathoniella* were so similar to their Callovian descendants that, given the poor state of preservation of the fossils from the Kamennyi Ovrag Formation, they could easily have been confused. This explains the opinion of Lyubimova (1955, p. 124) about the impossibility of distinguishing between the Bathonian and Callovian based on ostracods: "In the Bathonian deposits of the Samarskaya Luka, a few ostracods have been identified (*Protoargilloecia impurata* sp. n., *Paracypris* sp. n.[3] and indeterminate species of the genus *Palaeocytheridea*). These species also occur in the overlying Callovian sediments and therefore do not provide an indication of the age of the host rocks."

The genera *Protoargilloecia* Mandelstam in Lyubimova and *Paracypris* Sars include smooth, poorly identifiable taxa, apparently composite, which, indeed, makes them of little use for stratigraphy. Lyubimova erroneously attributed many species to *Palaeocytheridea* Mandelstam, which were subsequently transferred to other genera and even families (Tesakova, 2013a). The Bathonian "*Palaeocytheridea*", which Lyubimova considered as Callovian, could only be early *Bathoniella*, namely the species *B. prima*, the ancestor of the early Callovian species *B. milanovskyi* (Tesakova, 2024, 2025).

The Jurassic deposits studied in Boreholes 103 and 108 contain impoverished fossil assemblage and only at certain levels. Stratons established on the basis of different groups (ammonites, foraminifera and ostracods) in Borehole 103 allowed the deposits in the interval 175–225 m to be assigned to the upper Bajocian–upper Bathonian (Fig. 3). Within the interval, from bottom to top, the Beds with *L. volganica*–

[3] It is difficult to interpret what Lyubimova (1955) meant by an unnamed new species. Her monograph described two new species of the genus *Paracypris*, but neither of them originated from the Bathonian. Most likely, she referred to another new, Bathonian, species of this genus which she intended to describe in the future.

V. dainae (221.7–224.9 m, upper Bajocian–lower Bathonian) were recognized. Above (206.0–208.5 m), the upper part of the lower Bathonian Besnosovi Zone was established based on ammonite finds. Based on ostracods in the interval, 175.0–201.5 m, the Bathoniella prima lineage Zone is defined. Its association with the Bathonian Kamennyi Ovrag Formation allows the B. prima Zone to be provisionally correlated with the interval between the lower part of Ishmae and Barnstoni or lower part of Infimum ammonite zones. Approximately in the same interval (175.0–197.7 m), the corresponding beds are established based on the foraminiferal assemblage characteristic of the Beds with *A. baticus*.

It is noteworthy that the stratigraphic subdivision of the Bajocian-Bathonian interval of Borehole 103 was made possible by three different groups that were almost never found in the same core samples.

Borehole 108 (Fig. 4) contains a section of Jurassic deposits from the undifferentiated upper Bajocian–lower Bathonian to the middle Volgian, overlying Callovian deposits with a significant gap. The lower part of the borehole section (int. 156.0–164.5 m) contains a foraminiferal assemblage of the Beds with *L. volganica–V. dainae*, dating these rocks as late Bajocian–early Bathonian. The basal horizons of this interval yielded ostracods of the genus *Glyptocythere*, not identified to species, which also indicates a late Bajocian–early Bathonian age, since from the end of the early Bathonian this genus was succeeded by the descendant genus *Bathoniella* (Tesakova, 2025). Ostracods from the upper part of the interval under discussion (156–160 m) it to be confidently dated as the early Bathonian and assign it to the G. bathonica lineage Zone. The ammonites found here allowed narrowing the stratigraphic range to the upper part of the lower Bathonian Besnosovi Zone. The interval 124.5–151.0 m is characterized only by foraminifera allowing the recognition of the Beds with *A. baticus*. The interval 116.0–120.0 m is assigned to the B. prima Zone based on ostracods, and the higher part of the section (112.0–116.0 m) is assigned to the lower Callovian B. milanovskyi Zone. It is very likely that the lower part of the Khlebnovka Formation and the mentioned zone should be attributed here, as well as in the vicinity of Saratov, including the stratotype of the formation (Malinovyi Ovrag Section), to the upper part of the Bathonian (Gulyaev, 2013, 2015). The foraminiferal assemblage of the H. infracalloviensis–G. tatariensis Zone is found in a wider interval of the section 108.5–116.0 m.

In the Promzino Formation, at a depth of 102–106 m, the middle Volgian Panderi Zone (Zarajskensis Subzone) has been established based on ammonites, as well as the L. infravolgaensis–S. pravoslavlevi Zone based on foraminifera (95.7–105.0 m) and the Cytherella–R. cornulateralis ostracod Zone (95.7–100.7 m).

CONCLUSIONS

A comprehensive study of the Jurassic deposits of the Saratov Trans-Volga Region, exposed by Boreholes 103 and 108, revealed the following: in the Pochinki Formation (terminal Bajocian–basal Bathonian) the lower Bathonian ammonite Besnosovi Zone, the foraminiferal Beds with *L. volganica–V. dainae* and the ostracod Glyptocythere bathonica Zone; in the Kamennyi Ovrag Formation (terminal lower Bathonian–basal upper Bathonian) the foraminiferal Beds with *A. baticus* and the ostracod Bathoniella prima Zone; in the Khlebnovka Formation (terminal Bathonian–lower Callovian) the foraminiferal H. infracalloviensis–G. tatariensis Zone and the ostracod Bathoniella milanovskyi Zone; in the Promzino Formation (middle Volgian) the ammonite Panderi ammonite Zone, the Zarajskensis Subzone, the foraminiferal L. infravolgaensis–S. pravoslavlevi Zone and the ostracod Cytherella–R. cornulateralis Zone.

In the Kamennyi Ovrag Formation, the appearance of *Bathoniella* marks the beginning of a new stage in the development of the ostracod fauna in the middle Jurassic basins of the EEP. Therefore, it is here proposed to consider the beginning of the Kamennyi Ovrag stage precisely from this bioevent, thanks to which it is possible to distinguish ostracod assemblages from the Kamennyi Ovrag and Pochinki formations (since other ostracods are common in them). The entire range of the Kamennyi Ovrag Formation corresponds to the B. prima ostracod Zone, and its lower boundary, which for the first time received a paleontological definition, corresponds approximately to the middle of the lower Bathonian.

Here publishes for the first time photographs of ammonites, bivalves, foraminifera, ostracods and nannoplankton from the Jurassic deposits of the Saratov left bank of the Volga. The depth in the studied boreholes of all the listed groups of fossils are strictly documented.

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CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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