

Biostratigraphy of the Lower–Middle Callovian of the Saratov Area (Volga Region) Inferred from Microfauna

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Abstract—The results of micropaleontological analysis of the boundary interval of the lower–middle Callovian in the TETs-5 section (Saratov) are presented. The taxonomic composition and distribution of foraminifera and ostracods in the section are studied. The ranges of the biostratigraphic units inferred from microfauna and their correlation with the ammonite scale are refined. Two foraminiferal zones of the East European Platform are established: Haplophragmoides infracallovienensis–Guttulina tatarensis and Lenticulina cultriformis–Lenticulina pseudocrassa. The volume of the Lenticulina cultriformis–Lenticulina pseudocrassa Zone ranges from the upper part of the lower Callovian (the upper part of the Koenigi Zone and the Calloviense Zone) to the middle Callovian. Two biostratigraphic units by ostracods are established: (1) the Acanocythere milanovskyi–Procytheridea cinicinnusa Zone corresponding to the Subpatruus Zone of the lower Callovian, to the lower part of the *Ch. saratovensis* biohorizon, and (2) Beds with *Praeschuleridea wartae*–*Pleurocythere kurskensis* corresponding to the terminal part of the Subpatruus Zone (the upper part of the *Ch. saratovensis* biohorizon), the Koenigi and Calloviense zones of the lower Callovian, and the lower part of the Jason Zone of the middle Callovian. The images of typical taxa are provided.

Keywords: foraminifera, ostracods, biostratigraphy, Middle Jurassic, Callovian, Saratov area of the Volga region

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INTRODUCTION

The microfauna of the Callovian of the Volga region has been studied since the 1930s (Bykova, 1948; Dain, 1948, 1961; Khabarova, 1959, 1961; Lyubimova, 1955; Myatlyuk, 1939, 1961; Tesakova and Seltser, 2013; Ustinova and Tesakova, 2015; etc.). So, Dain (1948) outlined a scheme for the foraminiferal division of Jurassic deposits, including the Callovian, of Saratov oblast and identified layers with characteristic complexes, which later formed the basis of the subdivision of the Callovian by foraminifera not only of the Ulyanovsk–Saratov Trough (*Biostratigrafiya...*, 1982), but all central and southern regions of the East European Platform (EEP) (*Prakticheskoe...*, 1991; *Unifitsirovannaya...*, 1993, 2012). As is known, the boundaries of foraminiferal biostratigraphic units in the lectostratotype of the Callovian foraminiferal zones in the Malinovy Ravine near the village of Khlebnovka (Saratov oblast) coincide with the boundaries of substages and ammonite zones (*Biostratigrafiya...*, 1982; *Prakticheskoe...*, 1991). Thus, the foraminiferal zone

Lenticulina cultriformis–*Lenticulina pseudocrassa*, the lower and upper boundaries of which were established by the appearance of a zonal complex and by the disappearance of index species, respectively, was considered to be of the middle Callovian. The position of the lower boundary of the *Lenticulina cultriformis*–*Lenticulina pseudocrassa* Zone was, however, reconsidered in the later publication on Malinovy Ravine foraminifera (Nikiforova et al., 2001), where also new data on ammonites (Repin and Rashvan, 1996) were considered, and drawn not at the boundary of the lower and middle Callovian, but inside the lower Callovian.

Information about the appearance of the *Lenticulina cultriformis*–*Lenticulina pseudocrassa* biostratigraphic unit in the lower Callovian of the Shchigrovskii arch of the Voronezh anteclise was provided by Olferiev et al. (1992). Unfortunately, these important data were not taken into account when refining the foraminiferal zones in the stratigraphic schemes of 1993 and 2012. (*Unifitsirovannaya...*, 1993, 2012), which reflect outdated ideas about the *L. cultriformis*



Fig. 1. Map showing position of the studied Callovian TETs-5 section on the northern outskirts of Saratov, modified after (Gulyaev and Ippolitov, 2013).

formis–L pseudocrassa Zone. This, in turn, creates significant difficulties in the age interpretation of foraminiferal assemblages from the boundary interval of the lower–middle Callovian. This problem is especially acute when working with core samples where ammonite finds are rare or absent. Thus, a foraminiferal assemblage (including index species) characteristic of the “middle Callovian” L. cultratifomis–L. pseudocrassa Zone was discovered in the Fatezh Formation (Ustinova, 2017), penetrated by wells in the Maloarkhangelsk (Oryol oblast) and Fatezh (Kursk oblast) regions, together with the early Callovian ostracods (Tesakova, 2013). The stratigraphic conflict caused by outdated ideas about the zone in (*Unifitsirovannaya...*, 2012) did not allow M.A. Ustinova to distinguish this zone in the wells studied; the stratigraphic subdivision of the deposits in the wells was carried out according to foraminiferal complexes (Olferiev et al., 1992); therefore, the deposits were attributed to the lower Callovian.

Thus, there is clearly a need to clarify the zonal subdivision with respect to the microfauna, to ascer-

tain the stratigraphic position of the lower boundary of the foraminiferal zone *Lenticulina cultratifomis*–*Lenticulina pseudocrassa*, and to compare it with ostracod biostratigraphic units.

MATERIALS AND METHODS

The material for the micropaleontological study was a collection of foraminifera and ostracods from 24 samples of Callovian deposits from a quarry near the heat and electric power plant TETs-5 (hereinafter TETs-5 section, 51.623897° N, 45.989738° E) on the northern outskirts of Saratov (Fig. 1) selected by Tesakova and Seltser during the field season of 2011 and by L.A. Glinskikh and V.B. Seltser during the 2012 field party under the guidance of V.V. Mitta (Paleontological Institute Russian Academy of Sciences, Moscow). The section of the lower–middle Callovian exposed in a pocket-shaped dugout near the road leading to the territory of TETs-5 plant and reliably characterized by ammonites, belemnites, bivalves, gastropods, and other fauna has been studied since 1997 by Seltser, who also made a lithological description and stratigraphic subdivision by ammonites (Popov et al., 2004). Later, in 2012–2013, this section was reexamined by D.B. Gulyaev and A.P. Ippolitov (2013, 2021), who proposed a more detailed ammonite subdivision used in this work.

Samples for microfaunistic analysis were processed according to the standard technique (*Osnovy...*, 1959). Samples weighing 200 g were soaked in water for 1–2 weeks and then disintegrated by several hours of plain boiling. Thereafter, the precipitate was washed in running water through a 56 µm sieve and dried at room temperature. After the processing of samples, the microfauna was taken from the dry sediment and studied under Stemi 2000-C (Carl Zeiss) and Advance ICD (Bresser) stereomicroscopes. Foraminifera were found in 22 and ostracods were found in 7 of 24 samples. The frequency of occurrence of each species of foraminifera and ostracods was determined on a scale from one to seven: very rare (1–2 specimens), rare (3–5 specimens), regular (5–10 specimens), frequent (11–15 specimens), numerous (a few tens of specimens), abundant (many tens of specimens), very abundant (hundreds of specimens) (*Oporny...*, 1969). The microfauna was photographed using scanning electron microscopes (SEM) at the Sobolev Institute of Geology and Mineralogy SB RAS (LEO-1430VP), at the Trofimuk Institute of Petroleum Geology and Geophysics SB RAS (Carl Zeiss EVO 10), or at the instrumental analytics center of the Borisyak Paleontological Institute RAS (TESCAN VEGA-II XMU).

Collections of foraminifera no. INGG TETs-5 and ostracods no. INGG TETs-5-O are stored in the Laboratory of Micropaleontology of the Trofimuk Institute of Petroleum Geology and Geophysics SB RAS (INGG SB RAS, Novosibirsk); collection of ostracods no. MGU TETs-5 is stored at the Department of

Regional Geology and History of the Earth, Moscow State University (MGU, Moscow).

RESULTS OF MICROPALAEONTOLOGICAL ANALYSIS

Biostratigraphy by Foraminifera

Forty-four taxa were identified in the studied section of the lower–middle Callovian. Foraminifera are distributed over the section unevenly. Along with numerous taxonomically diverse complexes observed in most of the samples (Fig. 2), there are levels where the microfauna was not found at all (Samples 20, 22, Fig. 2) or was represented by depleted complexes consisting only of agglutinated forms (Sample 4, Fig. 2). The preservation of foraminiferal shells was also different: from very good to the casts of calcareous foraminifera with the shells completely destroyed or represented by separate fragments (e.g., *Lenticulina* sp. ind., Fig. 2). The degree of preservation is apparently connected to the degree of weathering of the host rocks. The analysis of the stratigraphic distribution of foraminifera in the TETs–5 section allowed two successive foraminiferal zones to be identified, Haplophragmoides infracallovienensis–Guttulina tatarensis and Lenticulina cultratiformis–Lenticulina pseudocrassa (Fig. 2). An identified foraminiferal assemblage in the lower part of the section (Beds 1–4, Samples 1–9), was represented mainly by agglutinated forms consisting mainly of the following species: *Haplophragmoides infracallovienensis* Dain (Plate I, fig. 1), *Recurvoides ventosus* (Chabarova) (Plate I, fig. 2), *Trochammina* ex gr. *pileolae* Startseva (Plate I, fig. 4). There were also isolated representatives of *Ammobaculites* sp. (Plate I, fig. 3), *Paleogaudryina terra* (E. Bykova), *Epistomina elschankaensis* Mjatliuk, *E. porcellanea* Brueckmann, *E. mosquensis* Uhlig (Plate I, fig. 19), and *Globulina* sp., as well as shell casts of the genus *Lenticulina*. The taxonomic composition of the assemblage indicates the foraminiferal zone Haplophragmoides infracallovienensis–Guttulina tatarensis (upper Bathonian–lower Callovian) (*Unifitsirovannaya*..., 2012). Higher up the section (Beds 5–9, Samples 10–24), the taxonomic composition changes sharply, and the calcareous forms of foraminifera become prevalent with the addition of the small amount of *H. infracallovienensis*, *R. ventosus*, and *P. terra* occurring in the lower part of the zone, lenticulins being prevalent. The complex includes the following species: *Epistomina parastelligera* (Hofker), *E. mosquensis*, *E. porcellanea*, *Pseudolamarckina rjasanensis* (Uhlig) (Plate I, fig. 18), *Lenticulina pseudocrassa* (Mjatliuk) (Plate I, figs. 12, 13), *L. cultratiformis* (Mjatliuk) (Plate I, figs. 9–11), *L. polonica* (Wisniowski) (Plate I, fig. 14), *L. compressaeformis* (Paalzov), *L. uhligi* (Wisniowski), *L. parainflata* Grigelis, *L. spp.*, *Astacolus batrakiensis* (Mjatliuk) (Plate I, fig. 15), *A. ex gr. colligatum* (Brueckmann), *A. callovienensis* (Mjatliuk), *A. limataeformis* (Mitjanina), *A. spp.*, *Planularia* ex gr. *deekei* (Wisniowski), *Ichthy-*

olaria suprajurensis (Mjatliuk) (Plate I, fig. 6), *I. francoica* (Guembel) (Plate I, fig. 7), *I. sp.* (Plate I, fig. 8), *Marginulina krylovae* Mjatliuk, *M. sp.*, *Citharina mosquensis* (Uhlig), *C. sp.* (Plate I, fig. 17), *Citharinella* sp., *Dentalina* sp., *Globulina* sp. The upper part of the section (Beds 8c–9) contains representatives of the following species: *Lenticulina tumida* (Mjatliuk), *L. cata scopium* (Mitjanina), *Tristix tutkovskii* Kaptarenko, *T. nobilis* Kaptarenko (Plate I, fig. 5), *Vaginulina dimidia* Grigelis, *Saracenaria gracilis* Kosyeva in Chabarova, *S. engelsensis* Kosyeva in Chabarova (Plate I, fig. 16), *Pseudonodosaria* sp., *Bojarkaella* sp., characteristic of the Lenticulina cultratiformis–Lenticulina pseudocrassa Zone of the middle Callovian (*Prakticheskoe*..., 1991; *Unifitsirovannaya*..., 1993, 2012). The foraminiferal assemblage of the Lenticulina cultratiformis–Lenticulina pseudocrassa Zone occurs in this section (Fig. 2) together with ammonites of the lower and middle Callovian (Gulyaev and Ippolitov, 2013, 2021; Popov et al., 2004). Thus, this foraminiferal zone covers the interval of the section corresponding to the Koenigi (*Crucifer* and *Galilaeii* (s.l.) biohorizons) and Calloviense ammonite zones of the lower Callovian, as well as the Jason Zone of the middle Callovian (Fig. 2). The data obtained showed that the lower boundary of the Lenticulina cultratiformis–Lenticulina pseudocrassa foraminiferal zone turned out to be older; therefore, this zone is not limited to the middle Callovian (Jason and Coronatum zones), as was previously believed (*Biostratigrafiya*..., 1982; *Prakticheskoe*..., 1991; *Unifitsirovannaya*..., 1993, 2012). The total volume of the above foraminiferal zone should fall within the Koenigi (upper part) and Calloviense ammonite zones of the lower Callovian, as well as the Jason and Coronatum zones of the middle Callovian.

Biostratigraphy by Ostracods

Fourteen taxa identified in the section were represented by isolated specimens, with the exception of one species, and were preserved only at certain levels (Fig. 3). Such scarce material is explained by the strong weathering of the rocks available for study in the TETs–5 section and by the fragility of ostracod valves, which are prone to dissolution in rocks during weathering. The distribution of ostracods along the section made it possible to distinguish four different complexes of paleoecological nature, since the fossil state, especially in weathered rocks, could only have been achieved by dominant species, commonly used to detect the change in paleoecological conditions.

An analysis of the ostracod distribution along the section made it possible to establish two biostratigraphic units: the Acantocythere milanovskyi–Procytheridea cinicinnusa Zone and Beds with Praeschuleridea wartae–Pleurocythere kurskensis (Fig. 3). The ostracod assemblage in the interval of the section dated to the Subpatruus Zone (*Ch. saratovensis* biohorizon; Bed 1, Samples 4 and 5) consists only of index species. Rare

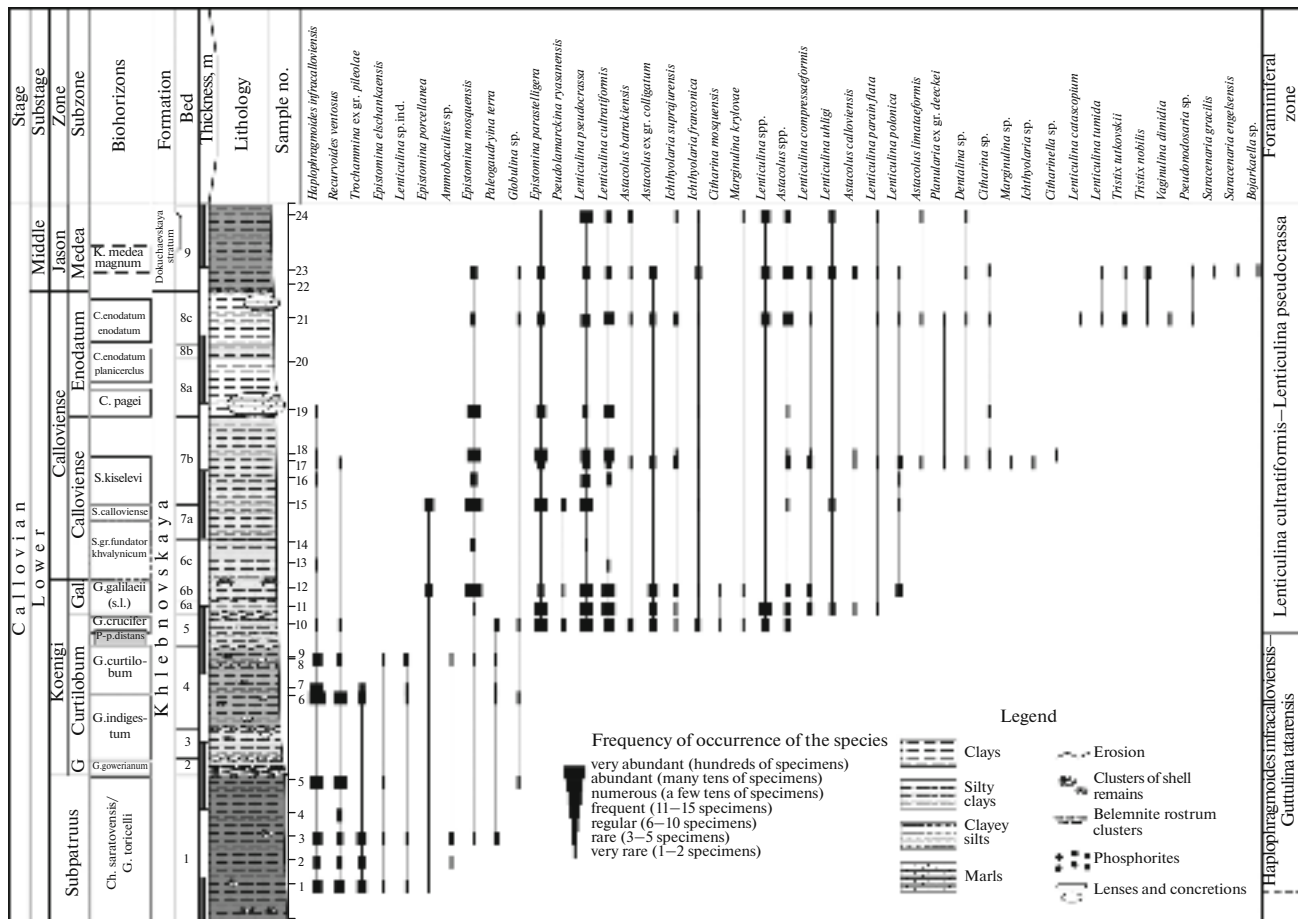


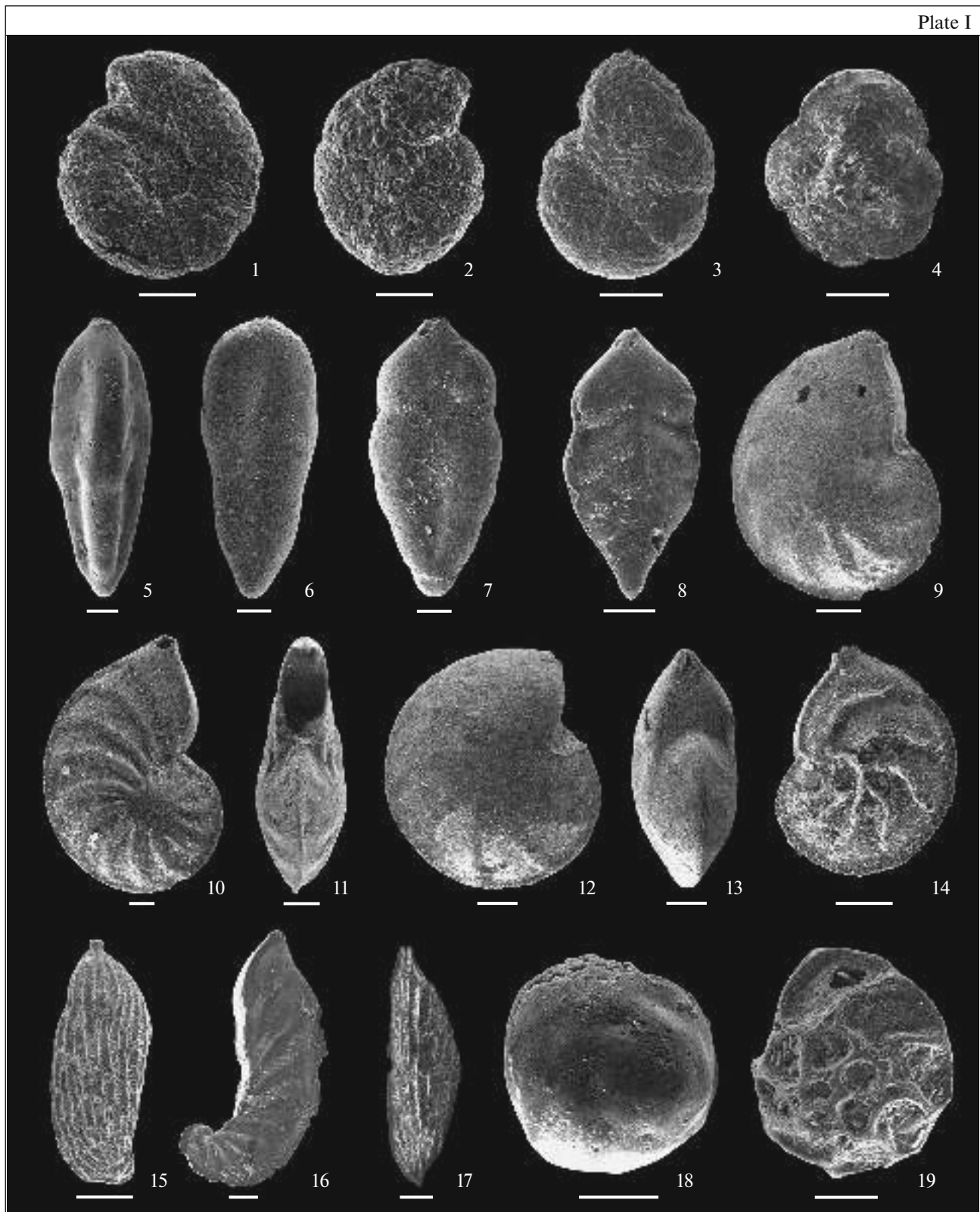
Fig. 2. Distribution of foraminifera in the lower Callovian–lower part of the middle Callovian of TETS-5 section on the northern outskirts of Saratov. Lithological column and subdivision by ammonites, modified after (Gulyaev and Ippolito, 2021). G, subzone Gowerianum.

specimens of *Procytheridea cinicinnusa* (Mandelstam in Lyubimova) are represented only by the cores of whole shells; the valves have not been preserved (Plate II, figs. 1, 4). A single shell of *Acanocythere milanovskiyi* (Lyubimova) is strongly deformed (Plate II, fig. 14), but is well recognized by its characteristic reticular ornamentation. It has already been shown that both of

these species have a narrow stratigraphic distribution in the lower Callovian Subpatruus Zone in the ammonite-dated sections Bartolomeevka of Saratov oblast (Tesakova and Seltser, 2013) and Pochinki of Nizhny Novgorod oblast (Tesakova et al., 2020), where they dominated at certain levels. At the same time, *P. cinicinnusa* appears at the very bottom of the zone, in the

Plate I. Foraminifera from the lower and middle Callovian TETS-5 section, Saratov oblast. (figs. 1, 2) From the Koenigi Zone, Curtilobum Subzone, *G. indigestum* biohorizon, Sample 6; (fig. 3) from the Koenigi Zone, Curtilobum Subzone, *G. curtilobum* biohorizon, Sample 8; (fig. 4) from the Subpatruus Zone, *Ch. saratovensis* biohorizon, Sample 1; (figs. 5, 16, 17) from the Jason Zone, Medea Subzone, Sample 23; (figs. 6, 7, 9–14, 19) from the Koenigi Zone, Galilaei Subzone, *G. galilaei* biohorizon, Sample 12; (figs. 8, 15) from the Calloviense Zone, Calloviense Subzone, *S. kiselevi* biohorizon, Sample 17; (fig. 18) from the Koenigi Zone, Curtilobum Subzone, *G. crucifer* biohorizon, Sample 10. The length of the scale bar is 100 μm. (1) *Haplophragmoides infracallovienensis* Dain, specimen INGG TETS-5-01; (2) *Recurvoides ventosus* (Chabarova), specimen INGG TETS-5-02; (3) *Ammobaculites* sp., specimen INGG TETS-5-15; (4) *Trochammina* ex gr. *pileolae* Startseva, specimen INGG TETS-5-19; (5) *Tristix nobilis* Kaptarenko, specimen INGG TETS-5-03; (6) *Ichthyolaria suprajurensis* (Mjatliuk), specimen INGG TETS-5-04; (7) *Ichthyolaria franconica* (Guembel), specimen INGG TETS-5-16; (8) *Ichthyolaria* sp., specimen INGG TETS-5-05; (9–11) *Lenticulina cultratiformis* (Mjatliuk): (9) specimen INGG TETS-5-06, side view; (10) specimen INGG TETS-5-07, side view; (11) specimen INGG TETS-5-08, edge view; (12, 13) *Lenticulina pseudocrassa* (Mjatliuk): (12) specimen INGG TETS-5-09, side view; (13) specimen INGG TETS-5-10, edge view; (14) *Lenticulina polonica* (Wisniowski), specimen INGG TETS-5-17; (15) *Astacolus batrakiensis* (Mjatliuk), specimen INGG TETS-5-11; (16) *Saracenaria engelsensis* Kosyreva in Chabarova, specimen INGG TETS-5-14; (17) *Citharina* sp., specimen INGG TETS-5-18; (18) *Pseudolamarckina rjasanensis* (Uhlig), specimen INGG TETS-5-12; (19) *Epistomina mosquensis* Uhlig, specimen INGG TETS-5-13.

Plate I



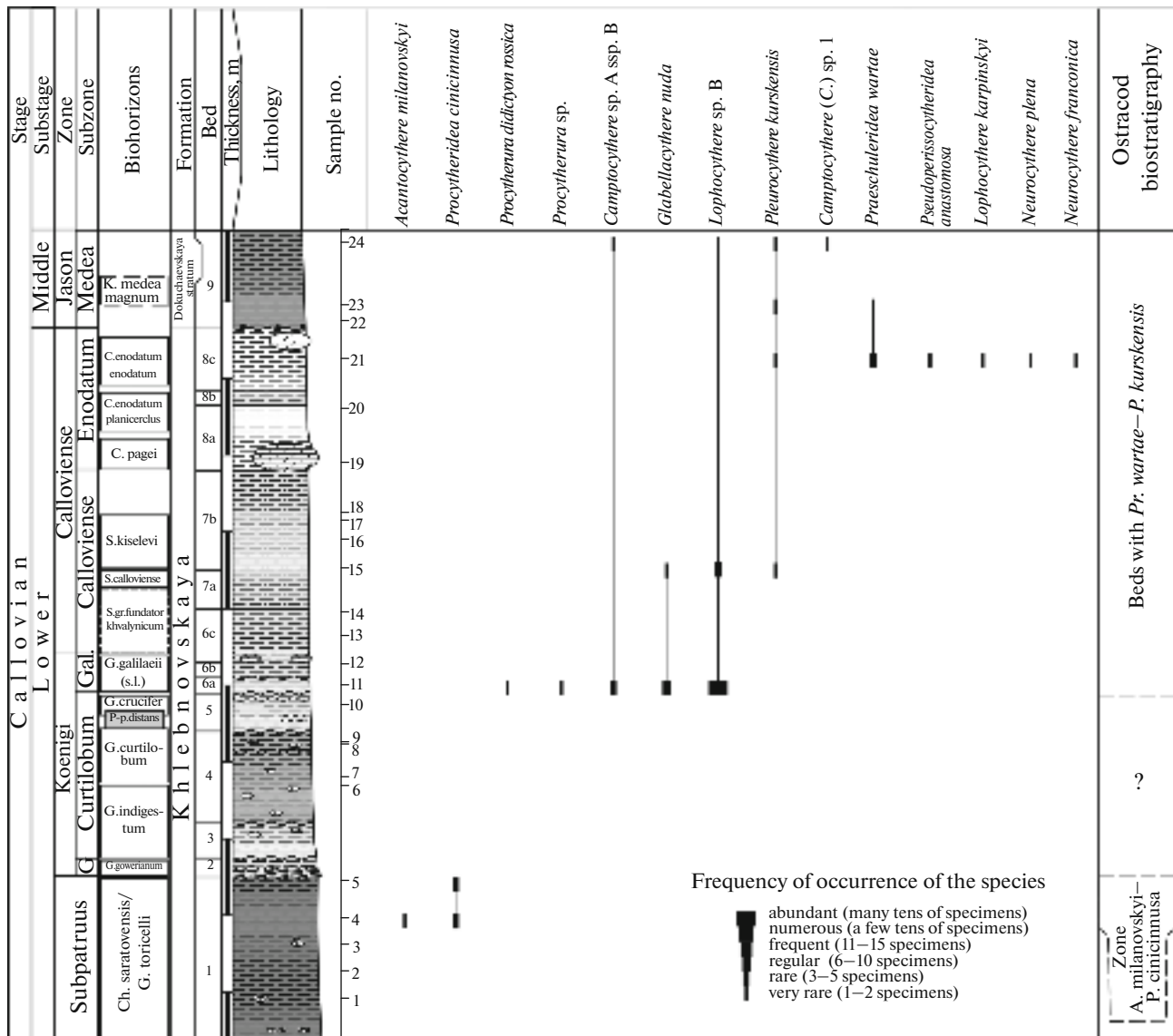
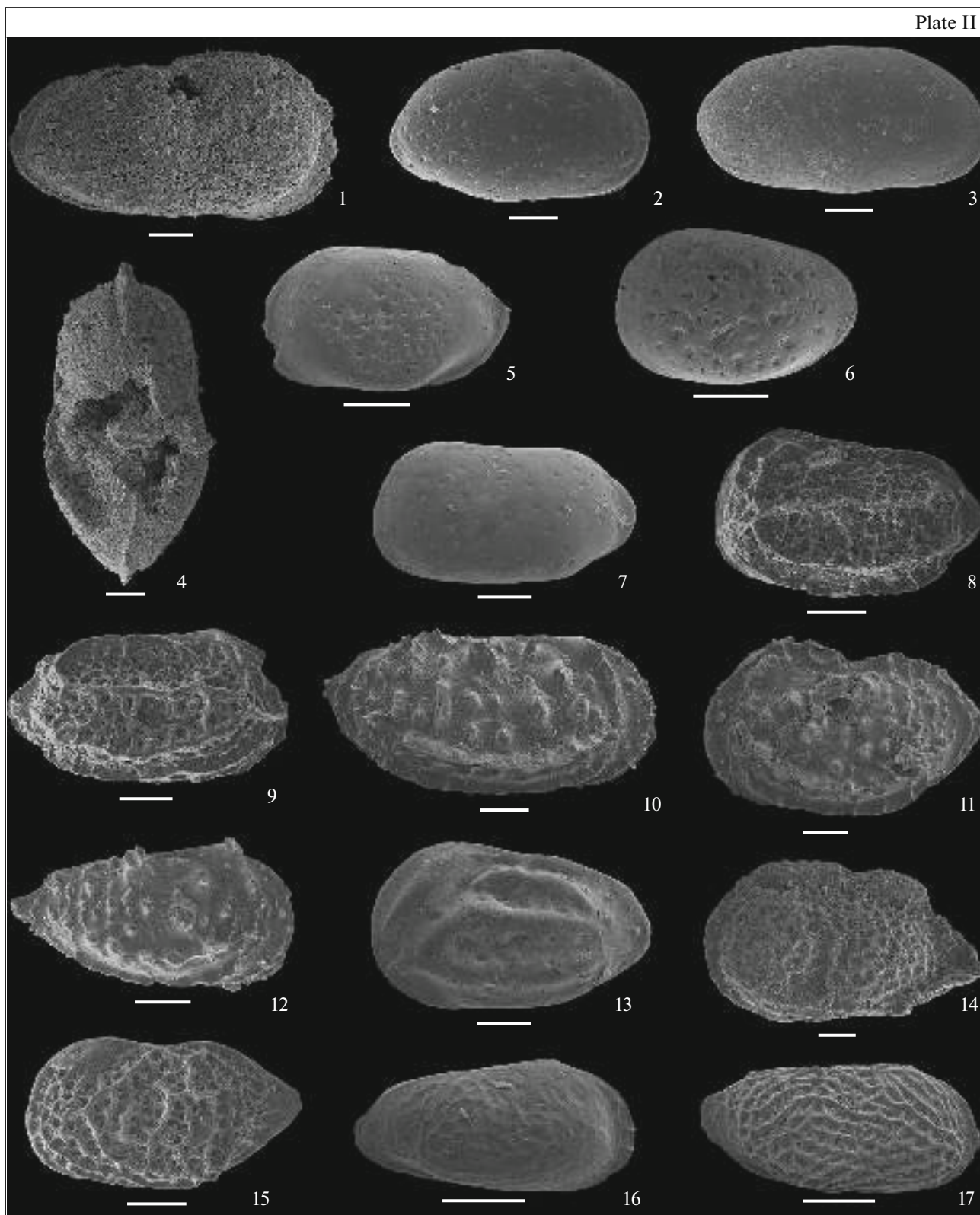


Fig. 3. Distribution of ostracods in the lower Callovian–lower part of middle Callovian of the TETS-5 section on the northern outskirts of Saratov. Lithological column and subdivision by ammonites, modified after (Gulyaev and Ippolitov, 2021). For legend see Fig. 2.

Plate II. Ostracods from the lower and middle Callovian TETS-5 section, Saratov oblast. (figs. 1, 4) from the Subpatruus Zone, *Ch. saratovensis* biohorizon, Sample 4; (figs. 2, 3, 8, 9, 12, 15) from the Calloviense Zone, Enodatum Subzone, *C. enodatum* biohorizon, Sample 21; (figs. 5, 7, 16, 17) from the Koenigi Zone, Galilaei Subzone, *G. galilaei* biohorizon, Sample 11; (fig. 6) from the Jason Zone, Medea Subzone, Sample 24; (figs. 10, 11) from the Calloviense Zone and Subzone, *S. kiselevi* biohorizon, Sample 15; (fig. 13) from the Jason Zone, Medea Subzone, Sample 24; (fig. 14) from the Subpatruus Zone, *Ch. saratovensis* biohorizon, Sample 4. The length of the scale bar is 100 μm. (1, 4) *Procytheridea cinicinnusa* (Mandelstam in Lyubimova), specimen MGU TETS-5-06, the core of a whole female shell: (1) view from the right, (4) dorsal view; (2, 3) *Praeschuleridea wartae* Błaszczak: (2) specimen INGG TETS-5-01, right valve of female; (3) specimen INGG TETS-5-03, right valve of male; (5) *Campocythere* sp. A ssp. B sensu Tesakova, 2013, specimen MGU TETS-5-27, left valve of a juvenile specimen; (6) *Campocythere (C.)* sp. 1, specimen MGU TETS-5-17, left valve of a juvenile specimen; (7) *Glabbellacythere nuda* Wienholz, specimen MGU TETS-5-29, left valve of a juvenile specimen; (8) *Neurocythere plena* (Triebel), specimen INGG TETS-5-012, left valve of female; (9) *Neurocythere franconica* (Triebel), specimen INGG TETS-5-010, right valve of female; (10, 11) *Lophocythere* sp. B: (10) specimen MGU TETS-5-37, right valve of male; (11) specimen MGU TETS-5-11, left valve of female; (12) *Lophocythere karpinskyi* (Mandelstam in Lyubimova), specimen INGG TETS-5-09, right valve of a late-stage juvenile specimen; (13) *Pleurocythere kurskensis* Tesakova, specimen MGU TETS-5-15, left valve of female; (14) *Acantocythere milanovskiyi* (Lyubimova), specimen MGU TETS-5-01, whole shell of female, left-side view; (15) *Pseudoperissocytheridea anastomosa* Whatley, Ballent et Armitage, specimen INGG TETS-5-04, left valve of female; (16) *Procytherura didictyon rossica* Tesakova, specimen MGU TETS-5-23, right valve of female; (17) *Procytherura* sp., specimen MGU TETS-5-22, right valve of female.

Plate II



Surensis biohorizon, and *A. milanovskyi* was observed later in the *Subpatruus* biohorizon. Their co-occurrence made it possible to establish a zone of the same name corresponding to the *Subpatruus*–*Saratovensis* ammonite biohorizons (Tesakova et al., 2020). Thus, a part of the TETs-5 section, including the first complex, can be attributed to the *A. milanovskyi*–*P. cinicinnusa* ostracod Zone.

The ostracod assemblage in the interval of the section corresponding to the upper part of the Koenigi Zone, the Galilaei Subzone, the lower part of the Calloviense Zone and Subzone (biohorizons *G. galilaeii* (Bed 6a, Sample 11)–*S. calloviense* (Bed 7a, Sample 15)) is represented by completely different taxa: *Procytherura didictyon rossica* Tesakova (Plate II, fig. 16), *P. sp.* (Plate II, fig. 17), *Camptocythere* sp. A ssp. B sensu Tesakova, 2013 (Plate II, fig. 5), *Glabella-cythere nuda* Wienholz (Plate II, fig. 7), *Lophocythere* sp. B (Plate II, figs. 10, 11), and *Pleurocythere kurskensis* Tesakova (Plate II, fig. 13). All of the above taxa are characteristic of the ostracod beds with *Praeschuleridea wartae*–*Pleurocythere kurskensis*, established from the joint occurrence of index species in Kursk oblast and corresponding to the *Subpatruus* ammonite zone and the lower part of the Koenigi Zone (Gowerianus and Curtilobus subzones) (Tesakova, 2003; Tesakova et al., 2009). This interval of the section can therefore be safely attributed to the *Pr. wartae*–*P. kurskensis* Beds, despite the fact that the index species *P. kurskensis* and *Praeschuleridea wartae* Błaszyk (Plate II, figs. 2, 3) were found much higher than the lower boundary of the biostratigraphic unit. Moreover, the distribution of *P. kurskensis* covers the interval from the upper part of the lower Callovian *Subpatruus* Zone to the Middle Jurassic Jason Zone (Tesakova, 2003; Tesakova et al., 2009), while *Pr. wartae* also appears in the Bathonian (Błaszyk, 1967). Apart from the ubiquitous *P. kurskensis*, there are other species characteristic of the *Pr. wartae*–*P. kurskensis* Beds: *Pr. wartae*, *Pseudoperissocytheridea anastomosa* Whatley, Ballent et Armitage (Plate II, fig. 15), *Lophocythere karpinskyi* (Mandelstam in Lyubimova) (Plate II, fig. 12), *Neurocythere plena* (Triebel) (Plate II, fig. 8), and *N. franconica* (Triebel) (Plate II, fig. 9) were found in the upper part of the section, in the upper part of the Calloviense Zone, in the Enodatum Subzone, and in the lower part of the middle Callovian Jason Zone, Medea Subzone (biohorizons *C. enodatum enodatum* and *K. medea magnum*; Bed 8c and lower part of Bed 9; Samples 21 and 23). All these species, except for *P. kurskensis*, are widespread in Western, Central, and Eastern Europe (Błaszyk, 1967; Tesakova, 2003; Tesakova and Glinskikh, 2020; Triebel, 1951; Lutze, 1960; Whatley et al., 2001; etc.), which indicates their free migration within the entire specified territory. *Lophocythere* sp. B, *P. kurskensis*, *C. sp. A ssp. B* sensu Tesakova, 2013, and *Camptocythere* (*C.*) sp. 1 (Plate II, fig. 6) were encountered at the very top of the section, at the bottom Medea Sub-

zone of the Jason Zone (Bed 9, Sample 24). The first three are background taxa of the *Pr. wartae*–*P. kurskensis* Beds, which substantiate the assignment of this part of the section to the respective biostratigraphic unit. Thus, the Beds with *Pr. wartae*–*P. kurskensis* cover the interval of the section studied corresponding to the upper part of the Koenigi Zone–lower part of the Jason Zone (Fig. 3).

It is questionable whether the boundary drawn between the *Acantocythere milanovskyi*–*Procytheridea cinicinnusa* Zone and the *P. wartae*–*P. kurskensis* Beds is justifiable. The index taxa of the lower biostratigraphic unit (*A. milanovskyi*–*P. cinicinnusa* Zone) were observed in the lower part of the *Saratovensis* biohorizon of Bartolomeevka and TETs-5 sections (while its upper part was not represented there (Gulyaev and Ippolitov, 2013, Fig. 5; 2021, Fig. 13; Gulyaev, 2015, Fig. 2; Gulyaev and Ippolitov, 2021, Fig. 13)), as well as in all biohorizons of the *Subpatruus* Zone in the Pochinki section, including the lower part of the *Saratovensis* biohorizon, while the very presence of the latter in this section is ambiguous (Gulyaev, 2015; Tesakova et al., 2020). Other index species, such as *Acantocythere nikitini* (Lyubimova) and *P. kurskensis* were found in the upper part of the same biohorizon (while its lower part was absent) in the sections of the Kanev dislocations (Gulyaev and Ippolitov, 2013, Fig. 2; 2021, Fig. 9; Tesakova et al., 2015, Fig. 1) and Kursk oblast (Tesakova et al., 2009, pp. 26 and 29, Fig. 2). It should be borne in mind that both of these species are an integral part of Beds with *Pr. wartae*–*P. kurskensis*, also identified in the TETs-5 section.

This distribution of ostracod index species in time and space may be interpreted in two ways: one may consider them as either stratigraphic markers of the lower and upper parts of the *Saratovensis* biohorizon or ecological markers of two water masses, one of which (the western one, Kanev and Kursk sections) gradually shifted eastward (Saratov and Nizhny Novgorod sections) during the *Subpatruus* phase. An unambiguous interpretation would take the study of ostracods from the entire section of the *Saratovensis* biohorizon. So far, the author (E.M. Tesakova) does not have such material; nevertheless, the published data on the presence of both mutually exclusive pairs in the same section both in Ukraine (Pyatkova and Permyakova, 1978, p. 144) and on Samarskaya Luka (section Repyevka; Lyubimova, 1955, pp. 125–127, Tables 1, 2, 5) support the stratigraphic sequence and allow the boundary between the *A. milanovskyi*–*P. cinicinnusa* Zone and the Beds with *P. wartae*–*P. kurskensis* within the *Saratovensis* biohorizon to be assumed (Fig. 4; boundary is shown as a dotted line).

CONCLUSIONS

The study revealed the complete systematic composition of assemblages of foraminifera and ostracods and their distribution in the lower Callovian and at the

Stage	Substage	Zone	Foraminiferal zones			Ostracod zones and beds
			<i>Biostratigrafiya...</i> , 1982; <i>Prakticheskoe...</i> , 1991; <i>Unifitsirovannaya...</i> , 1993; 2012	Nikiforova et al., 2001	this work	
C a l l o v i a n	Middle	Coronatum	Lenticulina pseudocrassa– Lenticulina cultratiformis	Lenticulina pseudocrassa– Lenticulina cultratiformis	Lenticulina pseudocrassa– Lenticulina cultratiformis	Beds with Praeschuleridea wartae– Pleurocythere kurskensis
		Jason				
	Lower	Calloviense	Haplophragmoides infracalloviensis– Guttulina tatarensis	Haplophragmoides infracalloviensis– Guttulina tatarensis	Haplophragmoides infracalloviensis– Guttulina tatarensis	Acantocythere milanovskyi– Procytheridea cinicinnusa
		Koenigi				
	Subpatruus					

Fig. 4. Scheme of comparison of biostratons based on foraminifers and ostracods for the boundary interval of the lower–middle Callovian of the East European Platform.

base of the middle Callovian in the TETs-5 section on the northern outskirts of Saratov. The obtained results of micropaleontological analysis for foraminifera and ostracods were compared with data on ammonites (Gulyaev and Ippolitov, 2021; Popov et al., 2004; Repin and Rashvan, 1996), as well as with published data on microfauna (Nikiforova et al., 2001; Olfer'ev et al., 1992; Ustinova, 2017) and with each other (Fig. 4). The analysis of the distribution of foraminifera in the studied section revealed two zones: Haplophragmoides infracalloviensis–Guttulina tatarensis and Lenticulina cultratiformis–Lenticulina pseudocrassa; the stratigraphic volume and the position of the lower boundary of the latter have been refined. It has been substantiated that the Lenticulina cultratiformis–Lenticulina pseudocrassa Zone of the East European Platform is not limited only to the middle Callovian, as was thought previously (*Biostratigrafiya...*, 1982; *Unifitsirovannaya...*, 1993, 2012; etc.), but covers the upper part of the lower Callovian (within the scope of the Koenigi (upper part) and Calloviense ammonite zones) and the middle Callovian (Jason and Coronatum zones). Its lower boundary, therefore, should be drawn in the upper part of the Koenigi Zone. The analysis of the distribution of ostracods in the section studied allowed two biostratons to be distinguished, the Acantocythere milanovskyi–Procytheridea cinicinnusa Zone and the Praeschuleridea wartae–Pleurocythere kurskensis Beds. The A. milanovskyi–P. cinicinnusa Zone of the East European Platform covers the upper half of the lower Callovian Subpatruus Zone without the terminal part of the *Saratovens* biohorizon (Tesakova and Seltser, 2013; Tesakova et al., 2020) and corresponds to the middle part of the H. infracalloviensis–G. tatarensis foraminiferal zone. Beds with *Ps. wartae*–*P. kurskensis* correlate with the terminal part of the Subpatruus ammonite zone (terminal part of the *Saratovens* biohorizon) and the Koenigi and Calloviense zones of the lower Callovian, as well as with the lower part of the Jason Zone of the middle Callovian (Tesakova et al., 2009, 2015); they also correspond to the upper part of the H. infracalloviensis–G. tatarensis and the lower part of the L. cultratiformis–L. pseudocrassa foraminiferal zones.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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