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GEOLOGY

Foraminifer Zones of the Callovian Stage in the Lower Volga Region

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Callovian stratigraphy is usually based on ammonites, while foraminiferal assemblages are correlated with the ammonite scale. Precisely this approach was used for elaborating the Callovian stratigraphic scale for the Russian Platform based on the foraminifer group of microorganisms, which was proposed by a team of paleontologists at meetings in Vilnius (1982) and Tbilisi (1984) and described in [1, 2]. During recent decades, the lower Callovian ammonite scale was subjected to some changes [13, 14], which makes it necessary to revise stratification of this substage in the Russian Platform [6]. In addition, the section in the Malinovyi Ravine area north of Saratov that was accepted as a stratotype appeared to be incomplete (the *Erymnoceras coronatum* Zone is absent) and the span of the lower Callovian Substage is not quite clear [4, 8]. Nevertheless, this section was used to define formations in the North Caspian region [5] and to compile the Callovian unified stratigraphic scheme for the Russian Platform [7].

The purpose of this communication is to arrange foraminiferal assemblages of the Callovian Stage according to the specified standard ammonite scale [14] and to characterize their more complete taxonomic compositions as compared with the impoverished assemblages from the Malinovyi Ravine, although representative data on foraminifers were obtained for the Volga region long ago [9, 10, 12]. Moreover, the author attempted to consider foraminiferal assemblages for each zone and demonstrate changes in the taxonomic composition at boundaries between neighboring zones.

Materials collected during detailed description of drill cores and layer-by-layer paleontological sampling with subsequent identification of ammonite and foraminifers (determinations by E.A. Troitskaya and G.N. Startseva, respectively) served as a basis of this study. It should be noted that some samples contain both macro- and microfauna.

Figure 1 demonstrates the location of boreholes. All of them occur on external sides of flexures and include both the upper and lower boundaries of the Callovian Stage. The core recovery was 70–90%.

Several criteria were used to subdivide the section. Lithology and ammonite taxons played the main role in

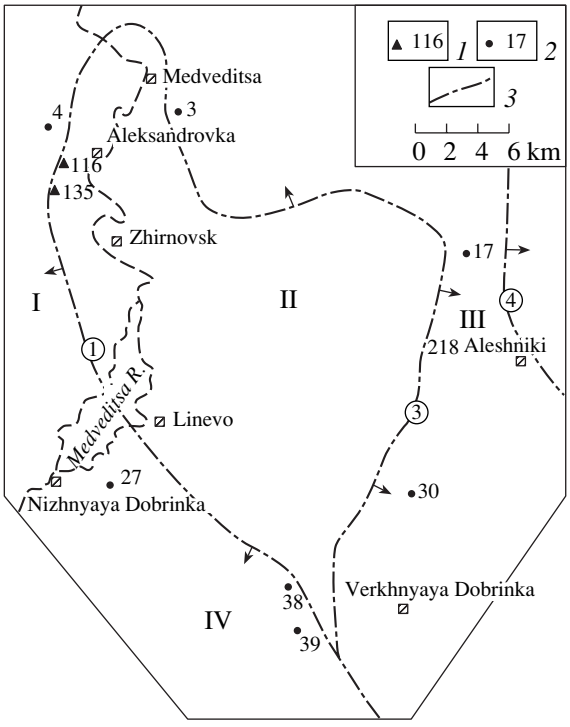

Fig. 1. Location of boreholes and outcrops with Callovian sections in the northern area of the Don–Medveditsa dislocations. (*1*) Outcrops; (*2*) boreholes; (*3*) Mesozoic flexures above Paleozoic faults; arrows show direction of fault plane dip (numbers in circles): (1) Zapadno-Zhirnovsk, (3) Sinegorsk, (4) Vostochnaya. Tectonic structures: (I) Tersin Depression; (II) Zhirnovsk–Ilovlya swell; (III) Near-Volga homocline; (IV) Netkachevo saddle.

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defining formations, while foraminifers were used for substantiating subformations. Figure 2 demonstrates the distribution of foraminifers in the averaged section, with an indication of sample location above the base of the stratigraphic unit. Such averaging is substantiated by variations in thickness of units in each borehole in the following way: 24–29 m for the middle subformation of the Khlebnoe Formation (J_2hl_2); 9–16 m for its upper subformation (J_2hl_3); 5–11 m for the lower subformation of the Dokuchaevsk Formation (J_2dk_1); and 4–6 m for its upper subformation (J_2dk_2). The Malinovyi Ravine Formation is represented only by its lower subformation (J_2mo_1) (3–5 m), which is established in boreholes 3, 17, and 30 located in the eastern part of the study region. This circumstance is responsible for the accuracy of the sample position in the interval of 1–2 m relative to each particular section. In terms of lithology, boundaries between subformations are obscure, while basal layers of formations composed usually of silty clay are enriched in sand.

It is reasonable to present a brief information on the distribution of ammonites found in drill cores. Their analysis shows that the basal part of the lower Callovian Substage comprises only the *Macrocephalites macrocephalus* Zone that was traditionally accepted for the lower part of this substage in the Russian Platform [7]. Recently, it has been established, however, that this ammonite species likely characterizes the higher *koenigi* Zone [13, 14] or the *gowerianus* Zone in the Russian scale [6]. The persistent occurrence of *M. macrocephalus* (Schloth.), *Chamoussetia chamousseti* Orb., *Kepplerites* (*Gowericeras*) *gowerianus* (Sow.) and single specimens of *Elatmites* cf. *submutatus* (Nik.) support the above statement. The finds of ammonite species *Cadoceras elatmae* (Nik.) and *Costacadoceras mundum* (Sas.) [8] suggest the presence of the uppermost part of the lower *herveyi* Zone in the Malinovyi Ravine section, which is lacking, however, a characteristic foraminiferal assemblage [4]. During geological mapping in the Don–Medveditsa dislocations area, *C. elatmae* (Nik.) and *Ch. chamousseti* Orb. were frequently found at the base of the Callovian, although the first species is missing from the examined boreholes. Exposures 116 and 135 (Kamennye Ravines) yielded rare *M. macrocephalus* (Schloth.) and *Ch. chamousseti* Orb., *K.* (*G.*) *gowerianus* (Sow.). Inasmuch as the stratigraphic position of the first species is unclear, these sediments should be placed into the middle subformation of the Khlebnoe Formation. Overlying sediments enclose the zonal ammonite form *Sigaloceras calloviense* (Sow.), which provides grounds to correlate them with the upper subformation of the Khlebnoe Formation.

Both zones have been found in the middle Callovian. The lower (*jason*) zone is characterized by diverse *Kosmoceras* genus, although abundance of each species is substantially lower as compared with the lower Callovian. Sediments of the upper (*coronatum*) zone host the zonal form and representatives of genera *Hecticoceras* and *Lunuloceras.*

The examined collection is lacking upper Callovian ammonites, but *Kosmoceras* cf. *spinosum* (Sow.) was found in hand-drilled Borehole 218 (A.F. Kuchaev, 1965). The find is confidently correlated with the upper part of the section in examined Borehole 17.

In contrast to ammonites, the identification of subformation based on microfauna is more definite (Fig. 2). The oldest *Haplophragmoides infracalloviensis–Guttulina tatariensis* foraminiferal assemblage is traditionally correlated with the entire lower Callovian Substage. Moreover, the latter is frequently united with the *Lenticulina tatariensis–L. praerussiensis* assemblage and its boundary with the middle Callovian Substage is placed at the appearance level of the *L. pseudocrassa–L. cultratiformis* assemblage [1, 2, 7]. Our data support the former suggestion [3] that two foraminiferal assemblages should be defined in the lower substage. Startseva [10, 11] made a similar conclusion for the Callovian section of Mordovia and referred sediments with these foraminiferal assemblages to the zone rank. In addition, she defined the third assemblage corresponding to the basal part of the substage.

The presented materials show that the ammonite *koenigi* Zone (J_2hl_2) is characterized by the *H. infracalloviensis–G. tatariensis* foraminiferal assemblage with some associated species. Many researchers noted that most important among them are *Ammobaculites fontinensis* (Terq.), *Recurvoides ventosus* (Chab.), *Marginulina mjatliukae* Shokh., *M. krylovae* Mjatl., *Dentalina vasta* Mjatl., and *Gaudryina* sp. All of them are agglutinated forms. This assemblage is marked by the first appearance of *L. tatariensis* (Mjatl.) and *L. praerussiensis* Mjatl., which are more typical, however, of the overlying subformation corresponding to the *calloviense* ammonite zone. The upper subformation of the Khlebnoe Formation is characterized by the *L. tatariensis–Epistomina callovica* foraminiferal assemblage with persistent species belonging to genera *Lenticulina, Epistomina, Pseudolamarckina*, and *Astacolus* and some other associated forms (Fig. 2). Most of them are secretory species.

The sediments of the middle Callovian *jason* Zone (subformation J_2dk_1) enclose the *L. pseudocrassa*–L. cultratiformis*–L. cidaris–L. praepolonica–Ep. mosquensis–Ep. ukrainica–Pseudolamarckina orbiculata* (hereafter, asterisk designates index species). The assemblages of this zone, particularly subordinate forms, are highly diverse.

The overlying *coronatum* Zone (subfromation J_2dk_2) shows substantial impoverished taxonomic composition of its foraminiferal assemblage. The latter includes species *L. cidaris* Kosyr., *Saracenaria gracilis* Kosyr., *Ep. mosquensis* Uhlig typical of the middle Callovian and first representatives of *L. tumida* Mjatl. and *L. polonica* (Wisn.), which are more characteristic of the upper Callovian, where they serve as guide spe-

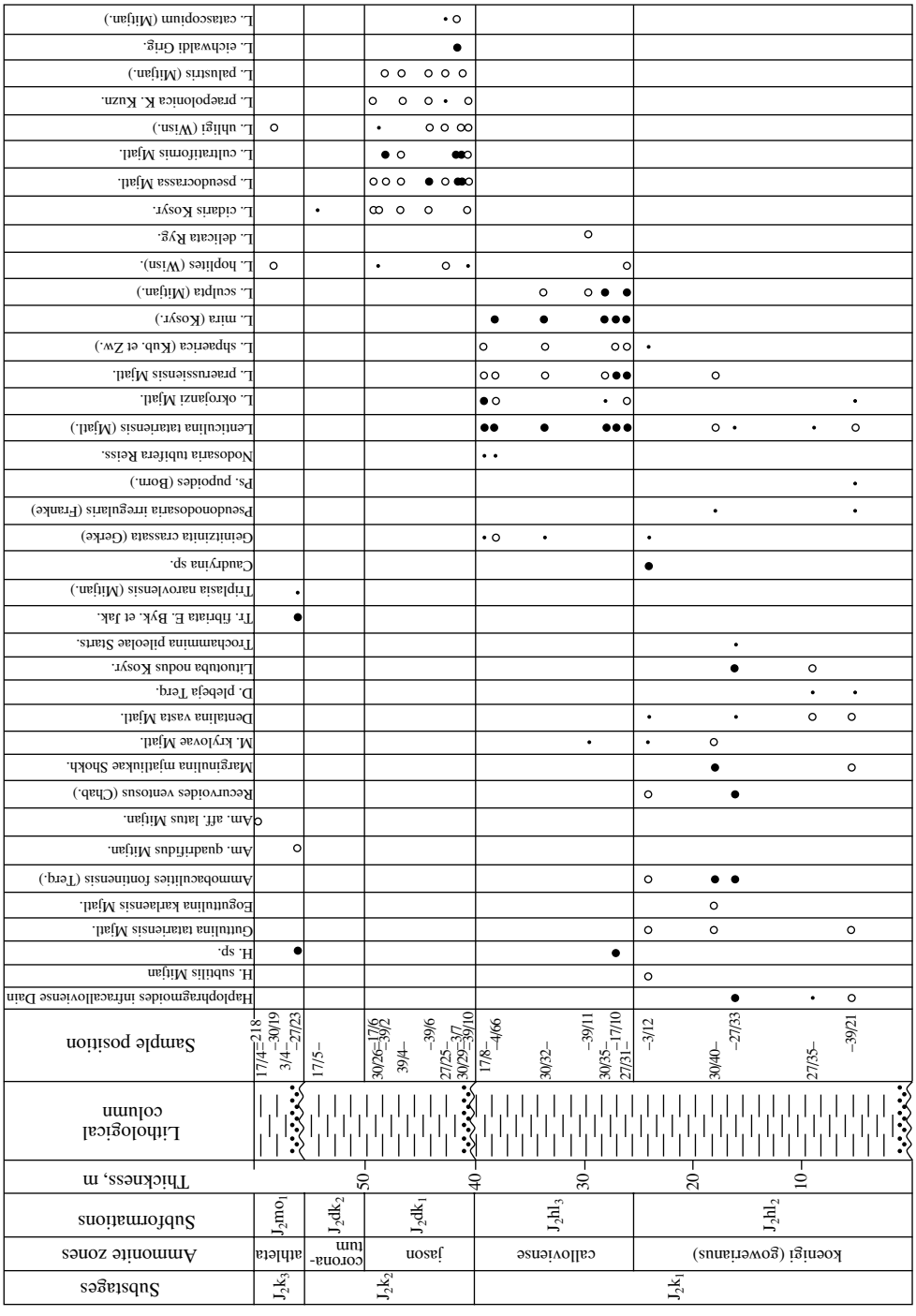

Fig. 2. Distribution of foraminiferal species in the averaged Callovian section of boreholes in the northern area of the Don–Medveditsa dislocations. Numbers designate boreholes (left) and samples (right). (*1*) Clay; (*2*) sandy clay; (*3–5*) abundance of foraminifers: (*3*) rare (up to 5 specimens), (*4*) common (up to 10 specimens), (*5*) abundant (>10 specimens).

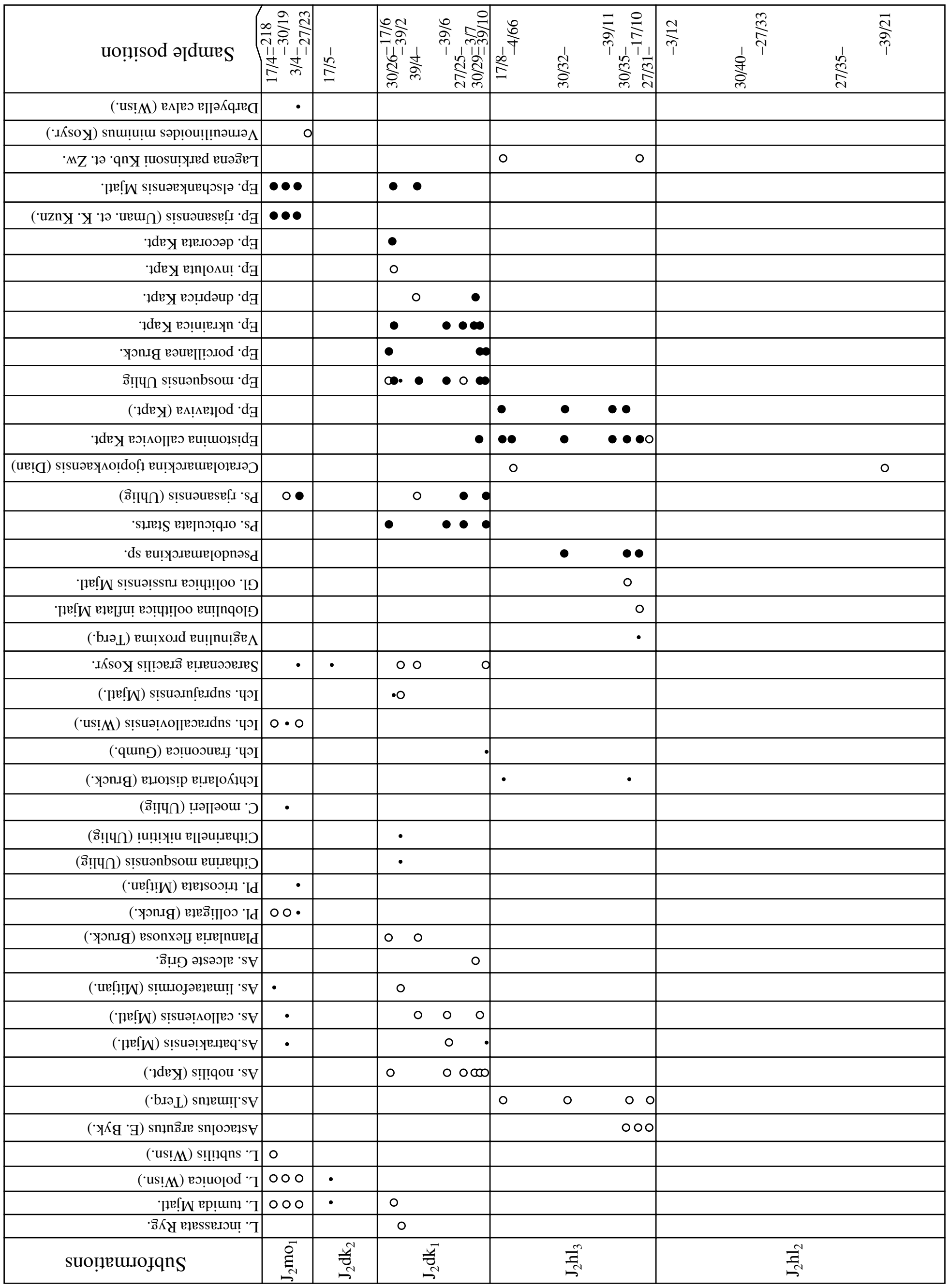
Sample position
Darbyella calva (Wisn.)
Verneuilinoides minimus (Kosyr.)
Lagena parkinsoni Kub. et. Zw.
Ep. elschankaensis Mjatl.
Ep. rjasanensis (Uman. et. K. Kuzn.)
Ep. decorata Kapl.
Ep. involuta Kapl.
Ep. dneprica Kapl.
Ep. ukrainica Kapl.
Ep. porcillanea Bruck.
Ep. mosquensis Uhlig
Ep. poltavira (Kapl.)
Epistomina callovica Kapl.
Ceratolamarckina tjopiovkaensis (Dian)
Ps. rjasanensis (Uhlig)
Ps. orbiculata Starts.
Pseudolamarckina sp.
Gl. oolithica russiensis Mjatl.
Globulina oolithica inflata Mjatl.
Vaginulina proxima (Terq.)
Saracenaria gracilis Kosyr.
Ich. suprajurensis (Mjatl.)
Ich. supracalloviensis (Wisn.)
Ich. franconica (Gumb.)
Ichtyolaria distorta (Bruck.)
C. moelleri (Uhlig)
Citharinella nikitini (Uhlig)
Citharina mosquensis (Uhlig)
Pl. tricostata (Mitjan.)
Pl. colligata (Bruck.)
Planularia flexuosa (Bruck.)
As. alceste Grig.
As. limataeformis (Mitjan.)
As. calloviensis (Mjatl.)
As.batrakiensis (Mjatl.)
As. nobilis (Kapl.)
As.limatus (Terq.)
Astacolus argutus (E. Byk.)
L. subtilis (Wisn.)
L. polonica (Wisn.)
L. tumida Mjatl.
L. incrassata Ryg.
Subformations
J2mo1
J2dk2
J2dk1
J2hl3
J2hl2

Fig. 2. (Contd.)

cies. Precisely these facts provide grounds for uniting both assemblages into a single community. Nevertheless, the low taxonomic diversity and mixed assemblage of middle and upper Callovian species emphasize the necessity to define an autonomous assemblage that reflects the change in the foraminiferal fauna at the boundary between substages.

In addition to the last two species, the Malinovyi Ravine Formation yields abundant *Ep. rjasanensis* (Uman. et K. Kuzn.), *Ep. elschankaensis** Mjatl., *Ichtyolaria supracalloviensis* (Wisn.), *Ammobaculites* aff. *latus* Mitjan., and *Planularia colligata* (Bruck.). Here, *Pseudolamarckina rjasanensis* (Uhlig), a proxy of the middle Callovian, is present, but *L. cidaris* Kosyr. is missing.

The taxonomic composition of studied foraminiferal assemblages is consistent almost completely (except for the lower Callovian) with data of many other researchers who studied the Callovian stratigraphy of the Russian Platform [1, 2, 4, 9, 10, 12]. They demonstrate distinct correlation with the ammonite scale. The defined foraminiferal assemblages demonstrate distinct succession through the section (Fig. 2) and more detailed stratification of the Callovian than in the available scale [1, 2]. The study of continuous sections in other regions with the exact position of samples can confirm the validity of proposed foraminiferal assemblages typical of corresponding ammonite zones. This is particularly true of the upper Callovian, which is insufficiently substantiated by paleontological materials.

Another important point not considered here is the lower Callovian boundary, which is actively discussed in recent years. The author of the present communication attempted to estimate the stratigraphic position of beds with *Ammodicus colchicus* Thodr. and *Glomospirella tsessiensis* Thodr., which were placed, by analogy with Georgia, at the base of the lower Callovian in the Mordovia sections (without ammonites) [10]. The preliminary analysis of this problem suggests that these beds should likely be attributed to the upper Bathonian. The overlying layers contain mass accumulations of *Reephax scabrosus* Srarts., scarce *Haplophragmoides* sp., and new foraminiferal species [11]: *Trochammina pileolae* Starts., *Nodosaria villosa* Starts., *N. costulata* Starts., and *N. insigne* Starts. These sediments can correspond to the lower zone of the lower Callovian (the first subformation of the Khlebnoe Formation). This assumption should be substantiated, however, by ammonite finds and tested in other areas.

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