ISSN 0031-0301, Paleontological Journal, 2024, Vol. 58, No. 7, pp. 806–812. © Pleiades Publishing, Ltd., 2024.

Microfauna and Biofacies of the Jurassic of the Eastern Coast of Anabar Bay (Northern Siberia)

L. A. Glinskikh*

Trofimuk Institute of Petroleum Geology and Geophysics, Siberian Branch, Russian Academy of Sciences, Novosibirsk, 630090 Russia

**e-mail: glor@mail.ru*

Received February 2, 2024; revised February 16, 2024; accepted February 16, 2024

Abstract—The results of studying the Jurassic microfauna of the eastern shore of Anabar Bay are presented. Bajocian-Oxfordian microbenthic communities were reconstructed, characterizing two stages of foraminiferal development. The bionomic zones of the Anabar-Lena Sea in the area of the studied section are recognized.

Keywords: Foraminifera, ostracods, associations, Jurassic, Bajocian, Bathonian, Callovian, Oxfordian, Siberia

DOI: 10.1134/S003103012460046X

INTRODUCTION

A system of parallel (autonomous) zonal scales was developed, which has reliably established itself as a high-resolution stratigraphic basis for the Mesozoic reference sections of the Anabar region (north of Central Siberia)(Zakharov et al., 1997; Shurygin et al., 2000; Nikitenko et al., 2013; etc.).

However, due to intense melting of snow in the Arctic during the last decade, rock outcrops have opened up that were previously not available when describing sections, or were observed only in fragments. This allowed new collections of ammonites to be made. Based on the results of the study of this new material, as well as a revision of previously collected ammonites, changes were made to the ammonite-based zonal division of the Callovian of northern Siberia (Alifirov and Knyazev, 2020; Knyazev et al., 2020; Knyazev and Alifirov, 2024). Thus, the presence of the *Eboraciceras subordinarium* Zone in the Upper Callovian of Siberia, including on the eastern shore of Anabar Bay (Alifirov and Knyazev, 2020), was not confirmed, but a new Upper Callovian biostraton was identified based on ammonites—Beds with *Cadoquenstedtoceras begichevi* (Knyazev, Alifirov, 2024). And since the stratigraphic range of biostratigraphically important foraminifers, as well as for other parastratigraphic groups, is assessed based on the ammonites found in them, it became necessary to re-examine microfossils from the reference sections where the zonal ammonite stratigraphy had been emended. It was also important to illustrate the re-examined fossil material. Jurassic foraminifera of the eastern shore of Anabar Bay were studied by V.A. Basov (Basov et al., 1967) and Z.V. Lutova (Lutova, 1981), but were not illustrated, except for several forms in the reference book “Practical Guide…” (Azbel et al., 1991), illustrated by drawings rather than photographs. However, for correct paleogeographic reconstructions, as well as for interregional correlation of different facies, the study of bionomic differentiation of microbenthic associations is important.

MATERIAL AND METHODS

The material for the study was a collection of microfossils, comprising more than one and a half thousand specimens of foraminifers and three dozen shells and valves of ostracods, obtained as a result of processing 37 samples collected in 2015 by A.S. Alifirov and B.M. Popov of the Trofimuk Institute of petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences from the Middle-Upper Jurassic (outcrop 109) on the eastern shore of Anabar Bay (Fig. 1). The Jurassic section of the eastern coast of Anabar Bay was described in several publications (Basov et al., 1967; Meledina, 1994; Alifirov and Knyazev, 2020; Kiselev, 2022; etc.). This study uses the numbering of units and the refined stratigraphy of the section (outcrop 109) from Alifirov and Knyazev (2020) (Fig. 2). Samples for microfaunal analysis were processed using traditional methods: relatively loose rock varieties were disintegrated by simple boiling, samples of harder rocks were disintegrated using melted sodium hyposulfite (Fursenko, 1978).

The sediment was then washed in running water through a sieve with a mesh diameter of 56 μm and dried at room temperature. Microfauna was selected from dry sediment and studied using a Carl Zeiss Stemi 2000-C stereomicroscope. Foraminifers were found in all samples, while ostracods were found in seven samples. The frequency of occurrence of each species was determined on a seven-point scale (Sachs et al., 1969). New data have been obtained on the taxonomic composition of foraminifers and ostracods in the Jurassic of the eastern shore of the Anabar Bay (Glinskikh, 2023). Based on the analysis of the distribution of foraminifers in the studied section, the following foraminiferal zones were recognized: *Trochammina jakovlevae* JF22 (upper part of the Upper Bajocian–lower part of the Upper Bathonian); *Kutsevella memorabilis, Guttulina tatarensis* JF28 (upper part of the Upper Bathonian–lower part of the Lower Callovian); *Trochammina rostovtsevi, Dorothia insperata* JF-25 (topmost Upper Bathonian–Callovian); *Ammodiscus thomsi, Tolypammina svetlanae* JF35 (Middle Oxfordian–lower part of the Upper Oxfordian). Biostratons based on foraminifera are compared with refined divisions of the ammonite zonal scale (Glinskikh, 2024). To reconstruct paleoenvironments, the dynamics of the taxonomic diversity of foraminiferal associations was analyzed (based on the construction of biodiversity curves, bar and pie charts reflecting the composition and structure of associations) and their differentiation by bionomic zones (Nikitenko, 2009). Data on ostracods were taken into account. The composition and structure of microbenthic associations can be used as indicators of abiotic environmental factors, and the nature of changes in composition over time makes it possible to reveal trends in these changes.

Foraminifers were photographed at the Trofimuk Institute of petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences, using a Carl Zeiss EVO 10 scanning electron microscope (SEM), as well as a Carl Zeiss Discovery V12 light microscope and an AxioCamMRc5 camera (Carl Zeiss).

Collections of foraminifers and ostracods nos. AZ-23, AZ-23/a, AZ-23/s are housed in the micropaleontology laboratory of the at the Trofimuk Institute of petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences (Novosibirsk).

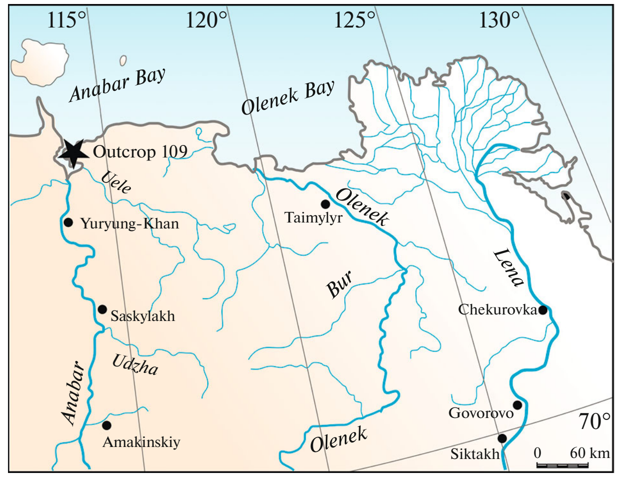
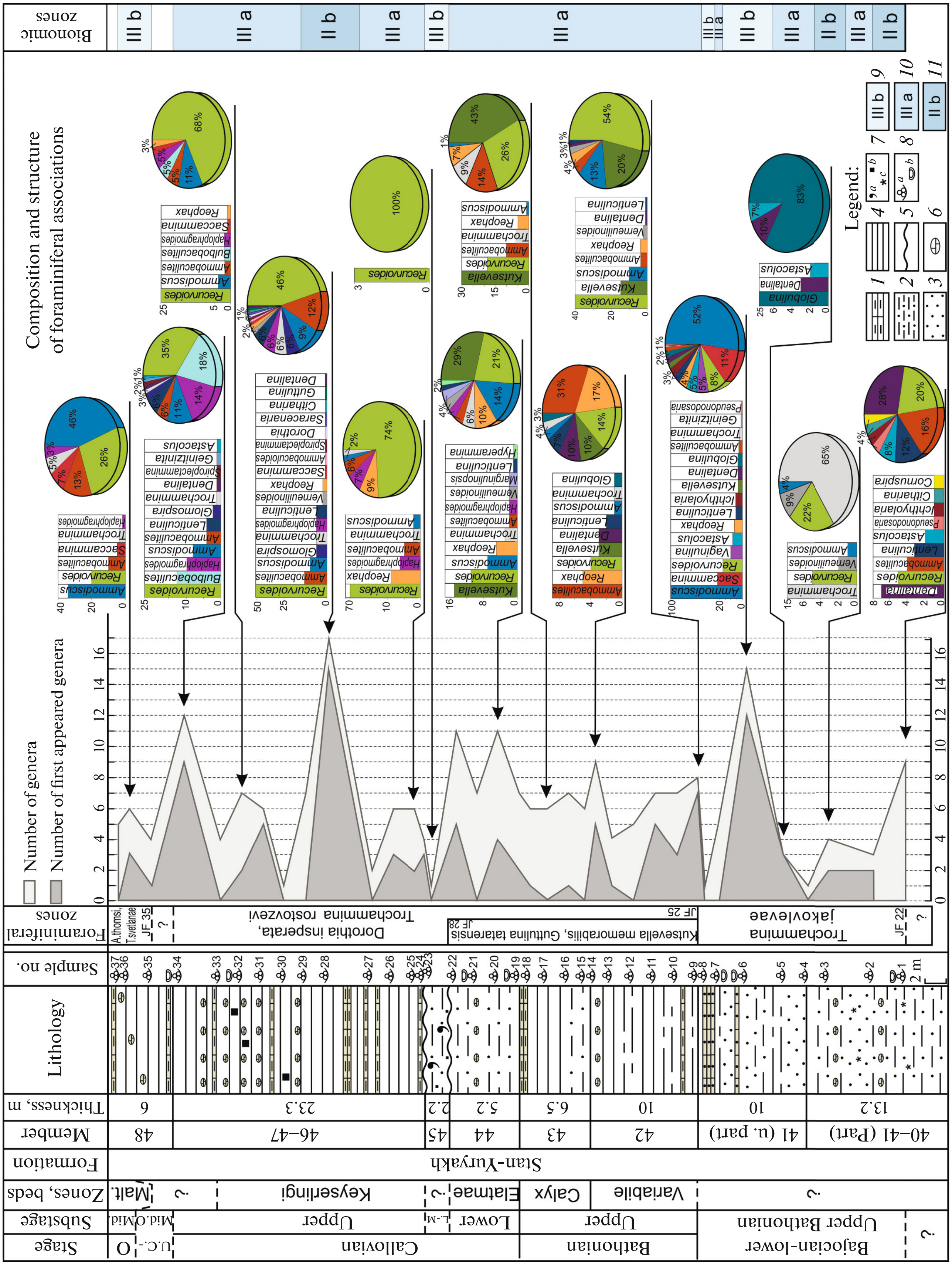


Fig. 1. Location of the studied section (Outcrop 109) (after Glinskikh, 2023; 2024).

RESULTS

At the end of the Bajocian–first half of the Bathonian in the Anabar-Lena Sea, in the area where outcrop 109 was located, clayey-silty and sandy sediments accumulated (members 40–41 and 41) (Fig. 2). Bajocian communities (Sample 1) are not numerous, but taxonomically diverse, consisting of representatives of nine genera, without clearly defined dominants: *Dentalina, Recurvoides, Ammobaculites, Lenticulina, Astacolus, Pseudonodosaria, Ichthyolaria, Citharina,* and *Cornuspira* (Fig. 2). Along with foraminifers, ostracods of the genus *Camptocythere* (*Camptocythere* (*Anabarocythere*) *spinulosa* (Sharapova, 1940) (Pl. 1, fig. 22)) are found. As the basin developed, the environment became unstable, apparently caused by a frequent change of transgressive-regressive events. The settings in the basin varied from moderately deep-water (bionomic zone IIb) to offshore shallow-water (bionomic zone IIIa) and nearshore shallow-water (bionomic zone IIIb) (Fig. 2).

The number of foraminiferal genera in associations varies from one to 15 (samples 2–8), with frequent changes in dominants (Fig. 2). A feature of the Bajocian-Bathonian associations is the presence of migrant taxa, such as *Cornuspira* sp. (Pl. 7, fig. 12) and *Vaginulina dainae* (Kosyreva in Dain, 1948) (Pl. 1, fig. 17), the index species of the foraminiferal zone of the East European Platform (Mitta et al., 2012). Along with foraminifers, microbenthic communities contain ostracods of the genus *Camptocythere (Camptocythere (Anabarocythere) arangastachiensis* Nikitenko, 1994) (samples 6, 7). A similar change in communities is observed at the end of the Bajocian—the beginning of the Bathonian in the Central Russian Sea (area of the Sokursky Quarry, Saratov) (Mitta et al., 2014), where the dominant taxa often change, and Siberian foraminifera are also present—index species: *Ammodiscus arangastachiensis* Nikitenko, 1991 (Mitta et al., 2014, text-figs. 10, 3), *Globulina praecircumphlua* Gerke, 1968 (Mitta et al., 2014, text-figs. 10, 20–22), *Trochammina jakovlevae* Glinskikh et Nikitenko, 2018 (Glinskikh and Nikitenko, 2018, pl. 2, figs. 13–15) and some other species, as well as ostracods—*Camptocythere* (*A.*) *arangastachiensis* Nikitenko (Glinskikh,


Composition and structure of foraminiferal associations
Number of genera
Number of first appeared genera
Legend:
Bionomic zones
Foraminiferal zones
Sample no.
Lithology
Thickness, m
Member
Formation
Zones, beds
Substage
Stage
Stan-Yuryakh
Bajocian-lower Upper Bathonian
Bathonian
Callovian
Trochammina jakovleвae
Kutsevella memorabilis, Guttulina tatarensis
Dorothia insperata, Trochammina rostovzevi
Keyserlingi
Elatmae
Calyx
Variabile

2021, pl., figs. 18–20). Thus, there is a leveling out in the differences in the microfauna of the Arctic seas (including the Anabar-Lena Sea) and the Central Russian Sea, communication between which in the Bajocian-Bathonian time was possible through the Komi Strait (Dzyuba et al., 2023).

At the end of the Late Bathonian—the beginning of the Callovian, a pan-Boreal "*Cadoceras*" transgression was recorded (Glinskikh et al., 1999; Shurygin et al., 2000; Nikitenko, 2009; etc.). At that time (the late Bathonian *Variabile* and *Calyx* phases and the early Callovian *Elatmae* phase) in the Anabar-Lena Sea, in the area of the studied section (outcrop 109), clayey-silty soils are inhabited by communities characteristic of offshore shallow-water zones of the sea (bionomic zone IIIa), consisting mainly of agglutinating foraminifera (samples 9–22). The assemblage is dominated by representatives of the genera: *Recurvoides, Kutsevella, Ammobaculites*. The genus *Trochammina* is represented in smaller numbers. Calcareous foraminifera of the genera *Lenticulina, Dentalina, Globulina, Marginulinopsis*, as well as ostracods of the genus *Camptocythere*, are rare and occur sporadically (Fig. 2).

In the second half of the Early Callovian, the general boreal transgression reaches its maximum and in the Middle Callovian the regressive stage begins (Nikitenko, 2009).

It is assumed that in the Anabar-Lena Sea, in the area of the outcrop 109, Early-Middle Callovian deposits (Bed 45) accumulated in shallow water high-energy environments (Alifirov and Knyazev, 2020), apparently in a nearshore shallow water area (bionomic zone IIIb) (Fig. 2). The foraminiferal association is small and monotaxonic, represented by the genus *Recurvoides* (sample 23).

At the beginning of the Late Callovian, an extensive transgression began in the Northern Hemisphere (Nikitenko, 2009; etc.). In the Anabar-Lena Sea, in the area of outcrop 109, Late Callovian (*Keyserlingi* phase) foraminiferal associations are few in number but taxonomically diverse. The number of genera in the assemblages is mainly from four to 12 (Fig. 2). Agglutinating forms predominate. The dominant genus is *Recurvoides* (samples 24–34). The assemblages also include: *Ammobaculites, Ammodiscus, Haplophragmoides, Trochammina, Reophax, Bulbobaculites, Saccammina*, etc. Single calcareous *Dentalina, Astacolus, Geinitzinita* (sample 34) appear at this level. Such foraminiferal associations are typical of offshore shallow water zone (bionomic zone IIIa) (Fig. 2). In the middle of the *Keyserlingi* Phase, the most taxonomically diverse microbenthic assemblage is observed in this area—17 genera (sample 28), which indicates the onset of the most favorable living conditions for foraminifera at this time, which is due to an increase in the depth of the basin (bionomic zone IIb) (Fig. 2). In addition to the taxa mentioned above, there are rare representatives of the genera: *Verneuilinoides, Dorothia, Spiroplectammina*, *Ammobaculoides*—this genus characteristic of the West Siberian Jurassic Basin (Komissarenko, 1977), but first encountered in the Anabar-Lena Sea, as well as single representatives of calcareous foraminifera: *Lenticulina, Saracenaria,* and *Guttulina*.

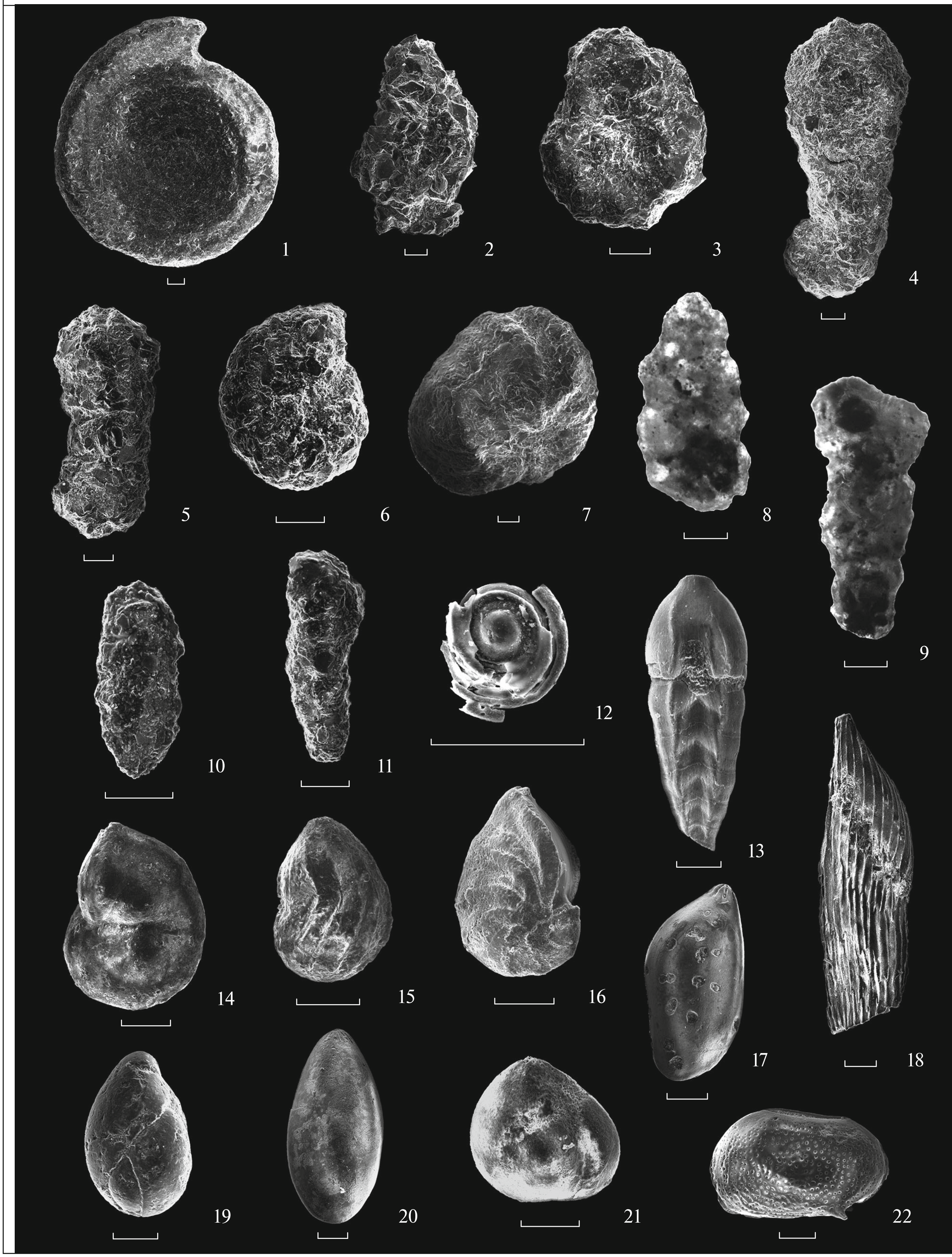
In the Middle Oxfordian (*Maltonense* Phase) in the Anabar-Lena Sea, in the area of the studied section, the foraminiferal habitats apparently deteriorated (bionomic zone IIIb), since the taxonomic diversity in foraminiferal communities is reduced (4–6 genera), *Ammodiscus*, the eurybiont genus became dominant, *Recurvoides* became subdominant; representatives of the genera *Ammobaculites, Saccammina, Trochammina, Haplophragmoides* are also found (Fig. 2).

CONCLUSIONS

The Jurassic microbenthic communities of the Anabar-Lena Sea, characteristic of different bionomic zones, living in the Bajocian-Oxfordian time in the area of the eastern coast of Anabara Bay are reconstructed. Based on the results of an analysis of the dynamics of taxonomic (generic) diversity of foraminifers, changes in the taxonomic structure of communities, and changes in dominant taxa, two stages in the development of foraminifera of the Anabar-Lena Sea are shown. The Bajocian-Bathonian stage is characterized by microbenthic associations, in which there is a frequent change in both the dominants and in taxonomic composition in general. At the Bajocian-Bathonian boundary, the differences in the taxonomic composition of the microfauna of the Arctic seas and the Central Russian Sea diminished, which can act as an interregional reference point. The Late Bathonian–Oxfordian stage is characterized by relatively stable foraminiferal communities, the structure of which is dominated by representatives of *Recurvoides*.

Fig. 2. Dynamics of taxonomic diversity and structure of microbenthic associations in the Jurassic of the eastern shore of Anabar Bay. Lithological column and ammonite zonation after Alifirov, Knyazev, 2020. Legend: (*1*) calcareous siltstones, (*2*) siltstones, (*3*) sandstones, (*4*) silty clays, (*5*) unconformity surface, (*6*) calcareous nodules, (*7*a) glauconite, (*7*b) pyrite, (*7*c) glendonite, (*8*a)foraminiferal occurrences, (*8*b) ostracod occurrences, (*9*) nearshore shallow water area, (*10*) offshore shallow water area, (*11*) nearshore moderately deep-water ((*9–11*) after Nikitenko, 2009).

Plate 7



Explanation of Plate 7

Jurassic foraminifers and ostracods of the eastern shore of Anabar Bay, Outcrop 109.

Scale bar 100 μm.

Fig. 1. *Ammodiscus thomsi* Chamney, 1971: specimen INGG, no. AZ-23-6, Member 48, 2 m above the base, Sample 35; Middle Oxfordian.

Fig. 2. *Reophax* sp.: specimen INGG, no. AZ-23-35, Member 44, top, Sample 22; Lower Callovian.

Fig. 3. *Kutsevella memorabilis* (Scharovskaja, 1958): specimen INGG, no. AZ-23/a-5, Member 42, base, Sample 9; Upper Bathonian.

Fig. 4. *Ammobaculites* sp.: specimen INGG, no. AZ-23-9, Member 46-47, top, Sample 34; Upper Callovian.

Fig. 5. *Bulbobaculites taigaensisi* Levina, 1990: specimen INGG, no. AZ-23-10, the same locality.

Fig. 6. *Recurvoides scherkaliensis* Levina, 1962: specimen INGG, no. AZ-23-11, the same locality.

Fig. 7. *Recurvoides singularis* Lutova, 1981: specimen INGG, no. AZ-23/a-1, Member 46-47, 1 m above the base, Sample 25; Upper Callovian.

Fig. 8. *Ammobaculoides primoris* Komissarenko, 1977: specimen INGG, no. AZ-23/s-3, Member 46-47, 9 m above the base, Sample 28; Upper Callovian.

Fig. 9. *Spiroplectammina* sp.: specimen INGG, no. AZ-23/s-2, the same locality.

Fig. 10. *Dorothia insperata* (Bulynnikova, 1962): specimen INGG, no. AZ-23-18, the same locality.

Fig. 11. *Verneuilinoides* sp.: specimen INGG, no. AZ-23-17, the same locality.

Fig. 12. *Cornuspira* sp.: specimen INGG, no. AZ-23-31, Member 40-41, Sample 1; Upper Bajocian-lower part of the Upper Bathonian.

Fig. 13. *Geinitzinita praenodulosa* Dain, 1972: specimen INGG, no. AZ-23-13, Member 46-47, top, Sample 34; Upper Callovian.

Fig. 14. *Lenticulina memorabilissima* Gerke et Scharovskaja, 1961, specimen INGG, no. AZ-23-23, Member 44, top, Sample 22; Lower Callovian.

Fig. 15. *Marginulinopsis suprajurensis* Gerke et Scharovskaja, 1961: specimen INGG, no. AZ-23-22, the same locality.

Fig. 16. *Saracenaria* sp.: specimen INGG, no. AZ-23-19, Member 46-47, 9 m above the base, Sample 28; Upper Callovian.

Fig. 17. *Vaginulina dainae* (Kosyreva in Dain, 1948): specimen INGG, no. AZ-23/a-11, Member 41, 4.5 from the top, Sample 6; Upper Bajocian-lower part of the Upper Bathonian.

Fig. 18. *Citharina* cf. *arangastachiensis* Nikitenko, 1991: specimen INGG, no. AZ-23-27, Member 40-41, Sample 1; Upper Bajocian—lower part of the Upper Bathonian.

Fig. 19. *Globulina* sp.: specimen INGG, no. AZ-23-5, Member 48, 2 m above the base, Sample 35; Upper Callovian-Middle Oxfordian.

Fig. 20. *Globulina praecircumphlua* Gerke, 1968: specimen INGG, no. AZ-23/a-7, Member 41, 2 m above the base, Sample 5; Upper Bajocian—lower part of the Upper Bathonian.

Fig. 21. *Guttulina tatarensis* Mjatliuk, 1959, specimen INGG, no. AZ-23-20, Member 46-47, 9 m above the base, Sample 28; Upper Callovian.

Fig. 22. *Camptocythere (Anabarocythere) spinulosa* (Sharapova, 1940), specimen INGG, no. AZ-23-30, Member 40-41, Sample 1; Upper Bajocian—lower part of the Upper Bathonian.

ACKNOWLEDGMENTS

The author is grateful to A.S. Alifirov, B.M. Popov and B.L. Nikitenko for providing samples, as well as T.V. Gonta for his help in photographing foraminifers.

FUNDING

The study was supported by the Russian Science Foundation grant no. 23-27-00058 https://rscf.ru/project/23-27-00058/ Callovian—Oxfordian foraminifers, funded from the budget of the Trofimuk Institute of petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences (project FWZZ-2022-0005) Bajocian—Bathonian foraminifers and ostracods.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This work does not contain any studies involving human or animal subjects.

CONFLICT OF INTEREST

The author of this work declares that she has no conflict of interest.

REFERENCES

Alifirov, A.S. and Knyazev, V.G. The Upper Callovian ammonites Cardioceratidae from Northern Siberia, *Stratigr. Geol. Correl.*, 2020, vol. 28, no. 5, pp. 493–513.

Azbel, A.Ya., Akimets, V.S., Alekseeva, L.V., et al., *Prakticheskoye rukovodstvo po mikrofaune SSSR. T. 5. Foraminifery mezozoya* (Practical Guide to the Microfauna of the USSR, Vol. 5. Foraminifera of the Mesozoic), Leningrad: Nedra, 1991.

Basov, V.A., Velikzhanina, L.S., Dzhinoridze, N.M., et al., New data on the Jurassic stratigraphy of the Lena–Anabar region, in Problems of Paleontological Substantiation of the Detailed Stratigraphy of the Mesozoic of Siberia and the Far East, Leningrad: Nauka, 1967. pp. 74–94.

Dzyuba, O.S., Shurygin, B.N., Izokh, O.P., Kuznetsov, A.B., and Kosenko, I.N., Isotopes of C, O and Sr in belemnite rostra from the Bajocian–Bathonian of Arctic Siberia and their significance for global correlation and paleogeographic reconstructions, *Russ. Geol. Geophys.*, 2023, vol. 64, no. 11, pp. 1304–1322.

Fursenko, A.V., *Vvedeniye v izucheniye foraminifer* (Introduction to the Study of Foraminifers), Novosibirsk: Nauka, 1978.

Glinskikh L.A. Ostracodes and biostratigraphy of the Lower–Middle Jurassic deposits of Yamal (north of Western Siberia), *Geologiya i Mineral'no-Syr'yevyye Resursy Sibiri,* 2021, no. 3 (47), pp. 12–20.

Glinskikh, L.A., New data on the Jurassic microfauna of the eastern shore of Anabar Bay (northern Siberia), in *Mikropaleontologiya: fundamental'nyye problemy i vklad v regional'noye geologicheskoye izucheniye nedr. Trudy XVIII Vseross. mikropaleontol. soveshch. (g. Sankt-Peterburg, 30 oktyabrya–3 noyabrya 2023)* (Micropaleontology: Fundamental Problems and Contribution to the Regional Geological Study of the Subsoil. Proc. XVIII All-Russ. Micropaleontol. Meet. (St. Petersburg, October 30–November 3, 2023)), St. Petersburg: Vseross. Nauchno-Issled. Geol. Inst., 2023, pp. 32–35.

Glinskikh, L.A., Jurassic foraminifera of the eastern shore of Anabar Bay (northern Siberia), *Geologiya i Mineral'no-Syr'yevyye Resursy Sibiri,* 2024, no. 1 (56), pp. 24–31.

Glinskikh, L.A. and Nikitenko, B.L., Representatives of the Genus *Trochammina* (Foraminifera) from the Middle Jurassic of the Arctic and Boreal Regions, *Paleontol. J.*, 2018, vol. 52, no. 3, pp. 221–230.

Glinskikh, L.A., Nikitenko, B.L., and Shurygin, B.N., Jurassic of Western Siberia – Abalak Formation (paleontological characteristics, litho- and biostratigraphy), *Geol. Geofiz.*, 1999, vol. 40, no. 3, pp. 1059–1078.

Kiselev, D.N., *Ammonity i infrazonal'naya stratigrafiya boreal'nogo i subboreal'nogo bata i kelloveya* (Ammonites and Infrazonal Stratigraphy of the Boreal and Subboreal Bathonian and Callovian), Moscow: GEOS, 2022.

Knyazev, V.G. and Alifirov A.S. The Middle–Upper Jurassic Boundary in the north of Siberia: Problems of the evidence, *Stratigr. Geol. Correl.*, 2024, vol. 31, Suppl. 1, pp. S17–S28.

Knyazev, V.G., Meledina, S.V., and Alifirov, A.S. The Middle Callovian of Siberia: Ammonites and zonal division, *Stratigr. Geol. Correl.*, 2020, vol. 28, no. 3, pp. 263–280.

Komissarenko, V.K., Finds of the genus Ammobaculoides Plummer from the Upper Jurassic of the West Siberian Plain, in *Trans. West-Siberian Institute of Oil and Gas Geology "Biostratigraphic Characteristics of Jurassic and Cretaceous Oil and Gas Deposits of Western Siberia,"* 1977, vol. 119, pp. 58–65.

Lutova, Z.V., *Stratigrafiya i foraminifery kelloveya severa Sredney Sibiri* (Stratigraphy and Foraminifera of the Callovian of the North of Central Siberia), Moscow: Nauka, 1981.

Meledina, S.V., *Boreal'naya srednyaya yura Rossii (ammonity i zonal'naya stratigrafiya bayosa, bata i kelloveya)* (Boreal Middle Jurassic of Russia (Ammonites and Zonal Stratigraphy of the Bajocian, Bathonian, and Callovian). Novosibirsk: Nauka, 1994.

Mitta, V., Kostyleva, V., Dzyuba, O., et al., Biostratigraphy and sedimentary settings of the Upper Bajocian–Lower Bathonian in the vicinity of Saratov (Central Russia), *Neues Jahrb. Geol. Palaontol., Abh.*, 2014, vol. 271, no. 1, pp. 95–121.

Mitta, V.V., Vuks, V.Ya., Glinskikh, L.A., et al., *Unifitsirovannaya regional'naya stratigraficheskaya skhema yurskikh otlozheniy Vostochno-Yevropeyskoy platformy. Ob''yasnitel'naya zapiska* (Unified Regional Stratigraphic Scheme of Jurassic Deposits of the East European Platform. Explanatory Note), Moscow: Paleontol. Inst. Ross. Akad.–Vseross. Nauchno-Issled. Geol. Neft. Inst., 2012.

Nikitenko, B.L., *Stratigrafiya, paleobiogeografiya i biofatsii yury Sibiri po mikrofaune (foraminifery i ostrakody)* (Stratigraphy, Paleobiogeography, and Biofacies of the Jurassic of Siberia by Microfauna (Foraminifera and Ostracods)), Novosibirsk: Parallel, 2009.

Nikitenko, B.L., Shurygin, B.N., Knyazev, V.G., et al., Stratigraphy of the Jurassic and Cretaceous of the Anabar region (Arctic Siberia, the coast of the Laptev Sea) and the boreal zonal standard, *Russ. Geol. Geophys.*, 2013, vol. 54, no. 8, pp. 808–837.

Saks, V.N., Ronkina, Z.Z., Basov, V.A., et al., Bed-by-bed description of the reference section, in *Opornyy razrez verkhneyurskikh otlozheniy r. Khety (Khatangskaya vpadina)* (Reference Section of the Upper Jurassic Deposits of the Kheta River (Khatanga Trough)), Leningrad: Nauka, 1969, pp. 14–63.

Shurygin, B.N., Nikitenko, B.L., Devyatov, V.P., et al., *Stratigrafiya neftegazonosnykh basseynov Sibiri. Yurskaya Sistema* (Stratigraphy of Oil and Gas Basins of Siberia. Jurassic System), Novosibirsk: Sib. Otd. Ross. Akad. Nauk, 2000.

Zakharov, V.A., Bogomolov, Yu.I., Ilyina, V.I., et al., Boreal zonal standard and biostratigraphy of the Mesozoic of Siberia, *Geol. Geofiz.*, 1997, vol. 38, no. 5, pp. 927–956.

Translated by S. Nikolaeva

Publisher's Note. Pleiades Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.
AI tools may have been used in the translation or editing of this article.