

ORIGINAL ARTICLE

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**ASSELIAN–SAKMARIAN BRACHIOPOD  
ZONATION OF THE LEFT BANK OF THE LOWER REACHES  
OF THE LENA RIVER, NORTHEAST RUSSIA**

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**Abstract**

This article summarizes the results of our study of the Early Permian brachiopods collected 5.9–6.3 km northwest of the village of Chekurovka that were used to develop the first biostratigraphic zonation of the Asselian–Sakmarian deposits on the left bank of the lower reaches of the Lena River. At the base of the Permian section, the *Jakutoproductus lenensis* Beds were identified. They are overlain by the *Jakutoproductus insignis* Zone with numerous shells of the index species. The *Jakutoproductus terechovi* and *Jakutoproductus rugosus* Zones, which are characterized by index species, occur even higher in the section. The boundary between the Khorokytian and Echian Regional Stages is defined by the first occurrence of *J. insignis* at the base of the Insignis Zone. The identified zonal sequence is identical to the previously studied Kubalakh section on the right bank of the lower reaches of the Lena River. However, the thickness of the biostratigraphic zones on the left bank is reduced by half, and a significant lower part of the Khorokytian Regional Stage (below the Lenensis Beds) is missing because it falls on the stratigraphic break between the Cambrian and Permian deposits. The zonation performed shows that there is a direct correlation between the Chekurovka section and the Asselian–Sakmarian deposits of Western Verkhoyanie and the Omolon Massif due to common index species of the biostratigraphic units.

**Keywords:** Lower Permian, biostratigraphy, brachiopods, *Jakutoproductus*, Khatystakh Formation, Bulkur structural-facies zone

**Introduction**

In the lower reaches of the Lena River, the widespread Lower Permian deposits belong to the Ust-Lena (in the north) and Bulkur (in the south) structural-facies zones which were previously considered as subzones [1]. A.A. Mezhvilk [2] originally assigned the Verkhoyanie Formation in this territory to the Lower Permian, which in the modern sense also includes the Middle–Upper Carboniferous deposits. For the entire Verkhoyanie Formation, A.A. Mezhvilk [2] cited a single brachiopod assemblage that included taxa of different ages and characteristic of different series of the Carboniferous and Permian (mixed faunal assemblages). Later, R.V. Solomina and colleagues [3], who used A.A. Mezhvilk's stratigraphic scheme, carried out a detailed study of the Lower Lena sections. A rich brachiopod assemblage dominated by *Jakutoproductus verkhoyanicus* (Fredericks) was identified in the Verkhoyanie Formation.

At that time, a team of Yakutian geologists led by A.S. Kashirtsev developed a new, more detailed stratigraphic scheme of the Upper Paleozoic of the lower reaches of the Lena River [4]: instead of the Verkhoyanie Formation proposed by A.A. Mezhvilk, it recognized the Tugasir, Kubalakh, and Tuora-Sis Formations, with stratotypes in the area of the mouth of the Kubalakh Creek on the right bank of the Lena River (Kubalakh section in our understanding). Each of these formations was characterized by brachiopod assemblages, and for the middle (Kubalakh) formation they were identified as the Late Carboniferous *Jakutoproductus protoverkhoyanicus* Kashirtsev and the Asselian–Sakmarian *Jakutoproductus verkhoyanicus* (Fredericks). Later, B.S. Abramov and A.D. Grigorjeva [5] used A.S. Kashirtsev's scheme for the lower reaches of the Lena River and clarified the paleontological characteristics of the Kubalakh and Tuora-Sis Formations.

The brachiopods zonation of the Lower Permian was first proposed for the lower reaches of the Lena River by R.V. Solomina [6], who revised her previous lists of taxa [3] from the Verkhoyanie Formation of the southern part of the Bastakh section (right bank of the Lena River near the Kubalakh and Chinka creeks = Kubalakh section). For the lower quarter of the Verkhoyanie Formation (the lower part of the Kubalakh Formation according to A.S. Kashirtsev's scheme), an assemblage of brachiopods of the *Jakutoproductus protoverkhoyanicus* Zone was reported, including the index species of the biostratigraphic unit. The second quarter of the Verkhoyanie Formation (the upper part of the Kubalakh Formation and the lower part of the Tuora-Sis Formation) was referred to the *Jakutoproductus crassus* Zone, which is characterized by a rich brachiopod assemblage in the lower reaches of the Lena River, including the index species of the zone. The third quarter of the Verkhoyanie Formation (the middle and upper parts of the Tuora-Sis Formation) belonged to the *Jakutoproductus verkhoyanicus* Zone, a section near the mouth of the Kubalakh Creek was suggested as the stratotype of this zone.

We have recently clarified and refined the zonation of the right bank of the lower reaches of the Lena River using new materials from the Kubalakh section [7]. The biostratigraphic discreteness of the species *Jakutoproductus crassus* Kashirtsev and *Jakutoproductus verkhoyanicus* (Fredericks) was not confirmed, but Insignis, Terechovi, and Rugosus Zones were identified in the middle and upper parts of the Tuora-Sis Formation. The Lenensis Beds in the upper part of the Verkhoyanicus Zone (lower part of the Tuora-Sis Formation) were established. The Carboniferous–Permian boundary was drawn inside the Kubalakh Formation, and the boundary between the Protoverkhoyanicus and Verkhoyanicus Zones was combined with it [8].

For the right bank of the Lena River (Kubalakh section), a detailed brachiopod biostratigraphic subdivision of the Asselian–Sakmarian interval of the Lower Permian has been carried out, but no similar work has been done for its left bank.

Traditionally, three coastal outcrops in the lower reaches of the Bulkur River, Khatystakh River, and the north of the village of Chekurovka are considered as the key sections of the Permian on the left bank of the lower reaches of the Lena River (Fig. 1). In the 1950s, these three sections were studied by T.M. Emeliantsev and colleagues [9], who found that the lithological-facies features of the Permian deposits over a huge stretch from the Chekurovka Cape (Chekurovka anticline) to the Khatystakh and Bulkur rivers (Bulkur anticline) change very little. Back then, the formation subdivision was not used

here, and the Permian deposits were divided into Lower and Upper Series with a high degree of conditionality [9, 10]. The paleontological characteristics of the basal part of the Permian were contradictory because bivalves of the genus *Kolymia* were recorded from the bottom of the section, while clusters of obviously older brachiopods “*Productus verchojanicus*” (= *Jakutoproductus verkhojanicus*) occurred in the higher beds.

After the geologists of the All-Union Aerogeological Trust had performed a medium-scale geological survey of the studied territory, they conditionally divided the Permian into two series without subdividing it into formations. The following brachiopods were reported from the Lower Permian part of the section: *Jakutoproductus verkhojanicus* (Fredericks), *Rhynchopora lobjaensis* Tolmatschew, *Rh. variabilis* Stuckenbergh, and *Rh. nikitini* Tschernyschew. Notably, no representatives of the genus *Kolymia* were found at this level.

Later, V.N. Andrianov [11] proposed using A.S. Kashirtsev’s [4] stratigraphic scheme of the Kubalakh section (the right bank of the Lena River) for the Permian deposits of the Chekurovka Cape. Thus, according to V.N. Andrianov, south of the village of Chekurovka, the Kubalakh Formation (less than 80 m thick) overlies the Cambrian limestones with a large stratigraphic break. The overlying Tuora-Sis Formation contains the Sakmarian ammonoids *Metapronorites angustus* Andrianov and *Andrianovia bogoslovskiyi* (Andrianov) [11, 12]. Regarding the subdivision of the Permian deposits for the Chekurovka Cape, B.S. Abramov also shared the same view as V.N. Andrianov [5].

In contrast to the “eastern” version of the formation subdivision of the Permian on the left bank of the lower reaches of the Lena River (A.S. Kashirtsev’s stratigraphic scheme [4]), I.V. Budnikov and colleagues [13] suggested using the Dzhargalakh and Bur Units here, established to the west – in the wells of the northeastern part of the Siberian platform. This view was approved at the last Northeastern Interdepartmental Stratigraphic Meeting [1], and the above-said strata were included in the Unified Stratigraphic Scheme of the Permian Deposits of the Verkhoyanie–Okhotsk Subregion. Accordingly, the section interval considered in this article falls on the lower part of the Dzhargalakh Unit as understood by I.V. Budnikov and colleagues.

However, in addition to the “eastern” and “western” views on the Permian stratigraphy of the left bank of the lower reaches of the Lena River, there is an opinion that for this area it is necessary to recognize its own local strata reflecting the specific features of the Permian deposits of the Tuora-Sis uplift [14]. According to the scheme used by the compilers of the Legend of the Lower Lena River series of sheets of the second edition of the medium-scale State Geological Map, the Permian deposits of the left bank of the lower reaches of the Lena River are divided into the Khatystakh and Bulkur Formations, the stratigraphic ratio of which is close to the previous conditional division of the Permian into two series. Considering that this scheme is relevant for the Permian stratigraphy of the left bank of the lower reaches of the Lena River, we must recognize the need for a thorough revision of the stratigraphic interval of the Khatystakh and Bulkur Formations and the boundary between them.

In 2010, we performed a detailed study of the three main Permian sections of the left bank of the Lena River (Fig. 1) together with our colleagues from the Siberian Research Institute of Geology, Geophysics and Mineral Resources – I.V. Budnikov, L.G. Peregoedov, and S.K. Goryaev. The Bulkur and Khatystakh sections appeared to be non-

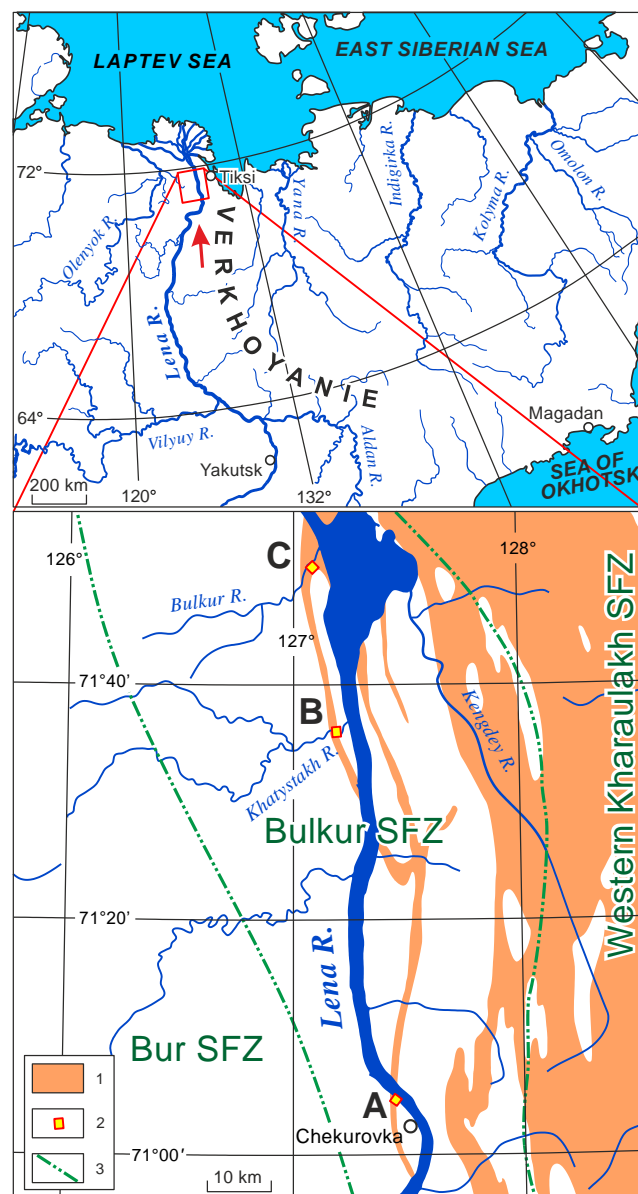


Fig. 1. The location of the studied sections of the Lower Permian on the left bank of the lower reaches of the Lena River: 1 – outcrops of the Permian sediments on the day surface, 2 – sections: **A** – Chekurovka, **B** – Khatystakh, **C** – Bulkur, 3 – boundaries of the structural and facies zones (SFZ); the zoning scheme was compiled by R.V. Kutugin

informative for biostratigraphic studies of the Lower Permian because the small fragments of the outcrops of its basal part are isolated from the main continuous sections. In this regard, the section at Chekurovka Cape proved to be the most promising for the study and substantiation of the biostratigraphic scheme. In this section, an almost continuous lithological sequence of the beds was identified and a number of levels with invertebrates were found, in which brachiopods are dominant. In 2018, this section was additionally studied by R.V. Kutugin, who created a photo panorama for the entire

Chekurovka section from the Proterozoic to the Lower Jurassic. He compiled new paleontological collections and clarified the lithological and stratigraphic structure of the section. V.I. Makoshin's monographic study of the Early Permian brachiopods collected in 2010 and 2018 made it possible to identify the biostratigraphic sequence of brachiopod assemblages considered below in the Lower Permian of the left bank of the Lena River.

### Results and Discussion

The fragment of the Chekurovka section under consideration is located on the left bank of the Lena River, 5.9–6.3 km below the village of Chekurovka (Fig. 1). Here, the Khatystakh Formation is represented by monoclinaly lying inequigranular siltstones with interbeds of fine- and medium-grained sandstones (Fig. 2, 3).

In the lower part of the Khatystakh Formation, single specimens of *Jakutoproductus* cf. *lenensis* Makoshin were found in fine-grained siltstone of Bed 30b (Fig. 4, a–b). *J. lenensis* was registered for the first time in the *Bulunites* Beds (Member 2) of the Tuora-Sis Formation of the Kubalakh section on the right bank of the lower reaches of the Lena River [15]. In addition to the Kharaulakh Ridge, we found this species in the upper part of the Khorokytian Regional Stage of the Orulgan Ridge [16] and Western Verkhoyanie [7]. A clear vertical distribution interval and a fairly wide geography of occurrence in the region allowed us to identify the Lenensis Beds in the upper part of the Verkhoyanicus Zone (Khorokytian Regional Stage) [7, 15], which probably includes Bed 30b of the Chekurovka section. At the same time, it should be noted that there is no large lower part of the Khorokytian Regional Stage in the section, which is observed in Verkhoyanie below the Lenensis Beds. From this, we can conclude that the Cambrian–Permian stratigraphic unconformity on the left bank of the lower reaches of the Lena River accounts for a significant part of the Verkhoyanicus Zone below the Lenensis Beds.

Further up along the section are coarse-grained siltstones of Bed 30a that contain a lenticular shelly interbeds with the clusters of invertebrate shells, where brachiopods prevail, gastropods and bivalves are less common, and nautiloids are extremely rare. Numerous specimens of *Jakutoproductus insignis* Abramov et Grigorjeva (fig. 4, c–f) and single specimens of *Rhynchopora* sp. have been identified among brachiopods. *Jakutoproductus insignis* is of great importance for the stratigraphy and correlation of the Lower Permian deposits of the entire Northeast Russia. Thus, based on the findings of this species at the base of the Ogonerian Regional Stage of the Kolyma–Omolon Region, V.G. Ganelin [17] identified the Insignis Lone (provincial zone), which is well traced on the Omolon Massif and beyond. In Western Verkhoyanie, when *J. insignis* occurred in the monotonous section of the Echij Formation, it became possible to draw the boundary between the Khorokytian and Echian Regional Stages [18], although there have been no ammonoid finds [19]. In the lower reaches of the Lena River, the Insignis Zone with numerous representatives of the index species contained in it was previously isolated by us in the Kubalakh section in the middle part of the Tuora-Sis Formation (Member 3) [20]. In the Chekurovka section, we refer Beds 30a, 29, and 28 to the Insignis Zone and compare the boundary between Beds 30b/30a with the boundary between the Khorokytian and Echian Regional Stages.

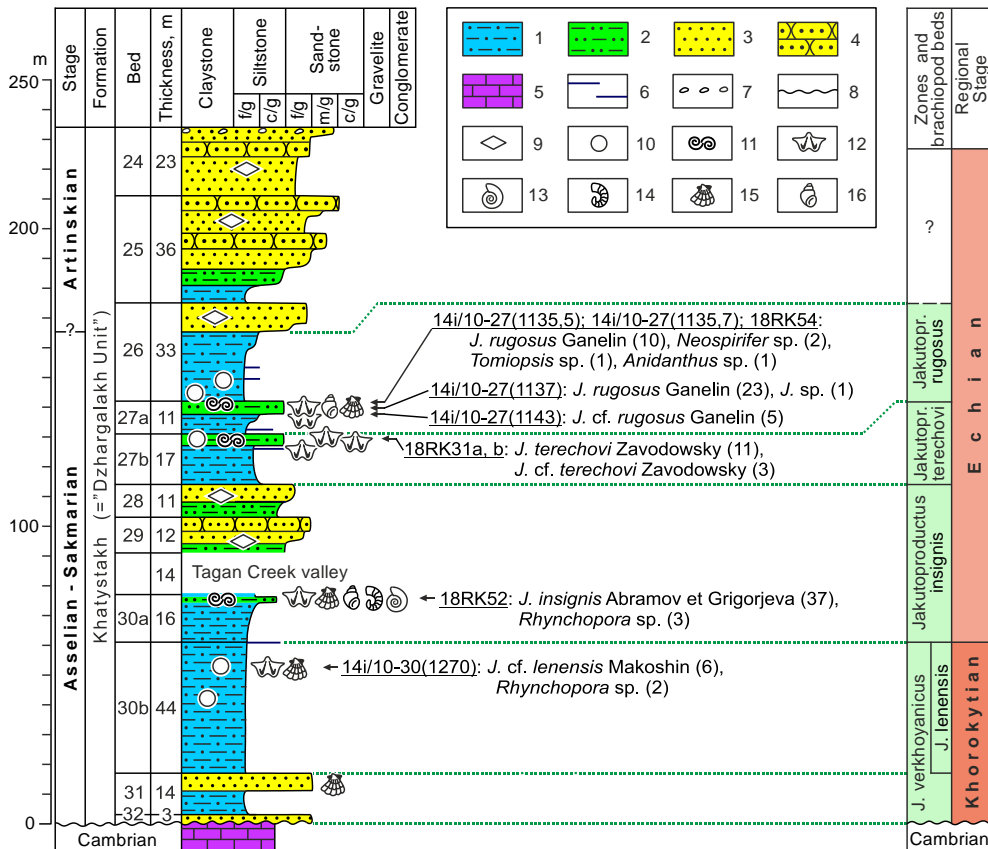


Fig. 2. Distribution of brachiopods in the Chekurovka section (outcrop 14i/10): 1 – fine-grained siltstones, 2 – coarse-grained siltstones, 3 – bedded sandstones, 4 – massive sandstones, 5 – limestones, 6 – thin rock interbeds (conventional), 7 – pebbles, 8 – stratigraphic unconformity, 9 – ripple marks, 10 – carbonate-clay and carbonate-siliceous concretions, 11 – coquina interbed, 12 – brachiopods, 13 – ammonoids, 14 – nautiloids, 15 – bivalves, 16 – gastropods; f/g – fine-grained, m/g – medium-grained, c/g – coarse-grained; the number of specimens is indicated in parentheses and comes after the taxon name

The next level with brachiopods is singled out in the upper part of Bed 27b. Here, *Jakutoproductus terechovi* Zavodowsky (Fig. 4, g–i) and *J. cf. terechovi* were discovered in clay sandstones and coarse-grained siltstones. *J. terechovi* is characterized by zonal distribution for both the Kolyma–Omolon Region (the middle part of the Ogonerian Regional Stage) [17] and Verkhoyanie (the lower part of the Echian Regional Stage) [7]. On the right bank of the lower reaches of the Lena River (Kubalakh section), the lower part of the Member 4 of the Tuora-Sis Formation rich in representatives of the index species is assigned to the Terechovi Zone. In the Chekurovka section, we compare Bed 27b with the Terechovi Zone.

The brachiopod assemblage of Bed 27a contains numerous representatives of *Jakutoproductus rugosus* Ganelin (Fig. 4, j–l), as well as single shells of *Neospirifer* sp., *Tomioopsis* sp., and *Anidanthus* sp. The Rugosus Zone was identified by V.G. Ganelin [21] on the Omolon Massif (Munugudzhak River) as the uppermost biostratigraphic unit of the Munugudzhakian Regional Stage, further considered as a superstage [1, 17].

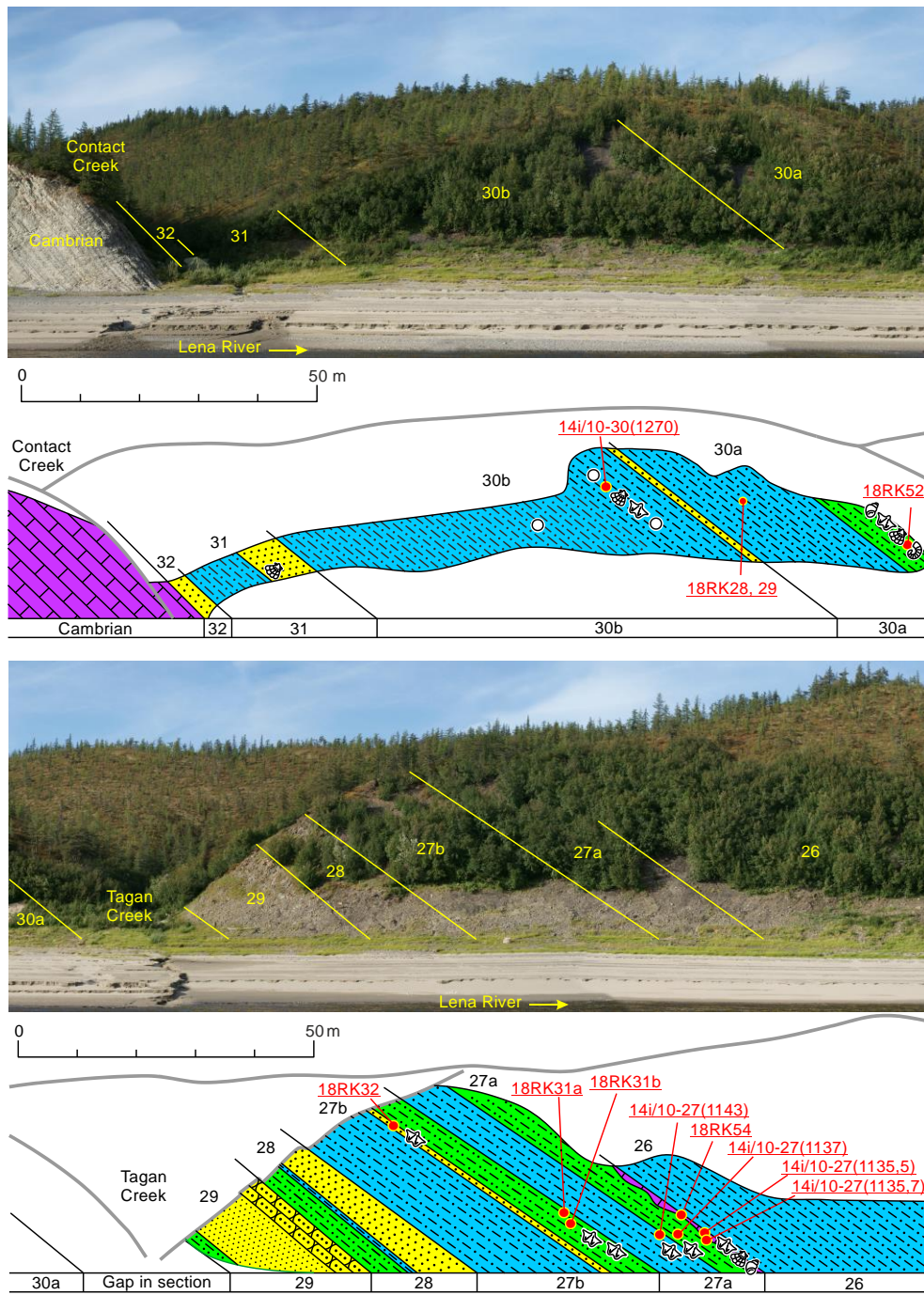


Fig. 3. A fragment of the photo panorama of the Chekurovka section. Compiled by R.V. Kutugin in 2018. See Fig. 2 for legend details

In Verkhoyanie, the representatives of *J. rugosus* were recorded in the Echij Formation of the Orulgan Ridge (upper reaches of the Sobolokh-Mayan River) and in the upper part of the Tuora-Sis Formation (upper part of the Member 4) [7].

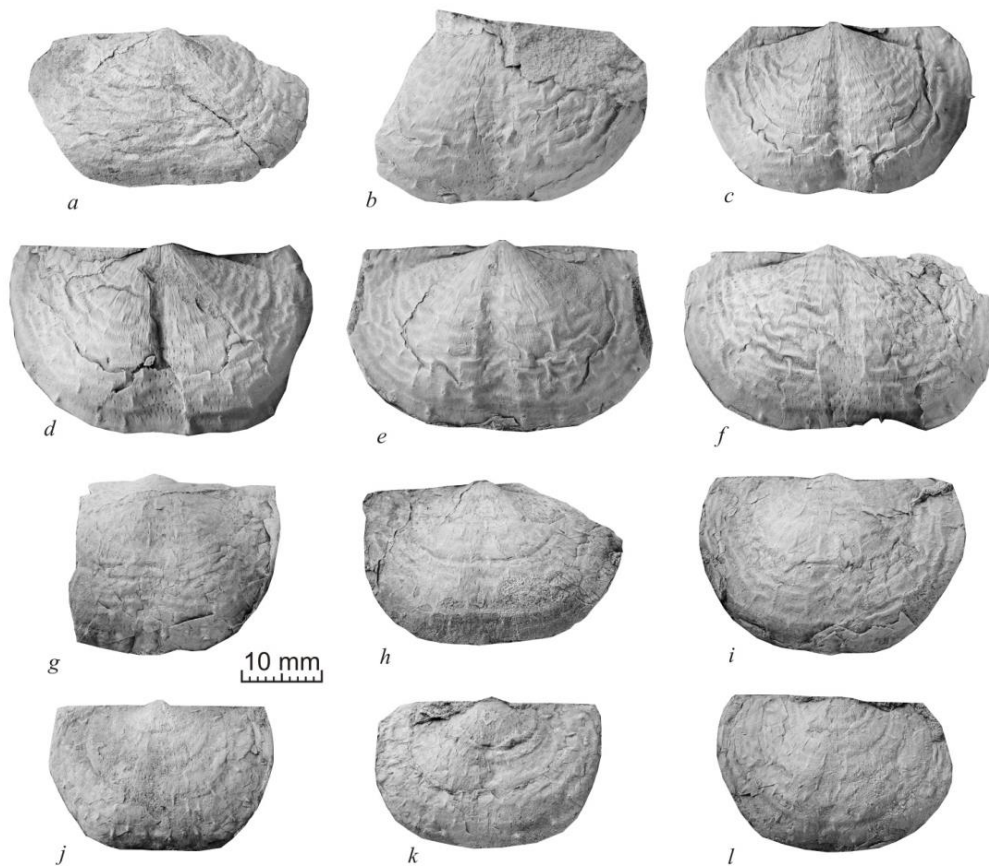


Fig. 4. Brachiopods of the Khatystakh Formation of the Chekurovka section: *a–b* – *Jakutoproductus* cf. *lenensis* Makoshin, DPMGI nos. 202/600-4 and 202/600-5, natural casts of a ventral valves; *c–f* – *Jakutoproductus insignis* Abramov et Grigorjeva, DPMGI nos. 202/610-1, 202/610-3, 202/610-4, and 202/610-11, natural casts of a ventral valves; *g–i* – *Jakutoproductus terechovi* Zavodowsky, DPMGI nos. 202/612-1, 202/612-2, and 202/612-3, ventral valves; *j–l* – *Jakutoproductus rugosus* Ganelin, DPMGI nos. 202/602-1, 202/602-2, and 202/602-4, ventral valves

For a long time, the Rugosus Zone was confidently dated to Artinskian due to the findings of the goniatites *Neoshumardites triceps* Ruzhencev and *Uraloceras* aff. *fedorowi* (Karpinsky) on the Munugudzhak River [21]. However, the subsequent revision of the Munugudzhakian goniatites by R.V. Kutygin [22] showed that *Neoshumardites* have primitive characters that link them with the Permian somoholitids. Therefore, they do not belong to the Lower Artinskian *N. triceps*, but rather to two new, older (pre-Artinskian) species *Neoshumardites munugudzhensis* Kutygin et Ganelin and *N.? nassichuki* Kutygin et Ganelin. Numerous Munugudzhakian *Uraloceras*, originally belonging to *U. aff. fedorowi*, were described by M.F. Bogoslovskaya and M.S. Boiko [23] as *U. omolonense* Bogoslovskaya et Boiko, a new endemic species, and *U. kolymense* Bogoslovskaya et Boiko. According to R.V. Kutygin [22], these two northeastern species have the Sakmarian morphotype, not the Artinskian one. Based on the above data, we assigned the Rugosus Zone to the Upper Sakmarian [7, 24, 25].



The biostratigraphic subdivision of the Asselian–Sakmarian deposits of the Chekurovka (left bank) and Kubalakh (right bank) sections is identical, however, the thickness of each biostraton in the direction from the right-bank section to the left-bank section is reduced by half, which should be considered when conducting sedimentological reconstructions and lithological-stratigraphic comparisons.

### Conclusions

As a result of our study of the Early Permian brachiopods collected by us in the Chekurovka section, we were able to identify for the first time the sequence of Asselian–Sakmarian zonation for the left bank of the lower reaches of the Lena River. In the studied section, the Permian terrigenous deposits of the Khatystakh Formation with stratigraphic unconformity lie on the Cambrian limestones. Previously, it has been impossible to determine the completeness or probable absence of the lower part of the Permian. In addition, the Lower Permian of the Chekurovka section has never been compared with the Lower Permian section of the right bank of the lower reaches of the Lena River near the mouth of the Kubalakh Creek (Kubalakh section). Moreover, the boundary between the Khorokytian and Echian Regional Stages has not been specified thus making it more difficult to capture a correlation between the Asselian–Sakmarian deposits of the left bank of the lower reaches of the Lena River and the typical sections of the territory in Western Verkhoyanie.

The data obtained and discussed here made it possible to solve the problems outlined above. The Lenensis Beds containing *Jakutoproductus* cf. *lenensis* Makoshin were identified at the base of the Permian. The level with numerous representatives of *Jakutoproductus insignis* Abramov et Grigorjeva, indexing the zone of the same name, was traced above in the section. The occurrence of this species defines for the first time the paleontological boundary between the Khorokytian and Echian Regional Stages on the left bank of the Lena River. Two biostratigraphic units occur above: Terechovi and Rugosus Zones, both characterized by the index species.

The zonation developed by us is identical to that in the previously studied Kubalakh section of the right bank of the lower reaches of the Lena River, but the thickness of the biostratigraphic zones identified in the left bank is reduced by half and a significant lower part of the Khorokytian Regional Stage (below the Lenensis Beds) is missing because it falls on the stratigraphic break between the Cambrian and Permian deposits. The identified biostratigraphic units indicate a direct correlation between the Chekurovka section and the Asselian–Sakmarian deposits of the Western Verkhoyanie and the Omolon Massif with the same zonal index species.

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### References

1. Koren T.N., Kotlyar G.V. (Eds.) *Resheniya Tret'ego mezhdomeystvennogo regional'nogo stratigraficheskogo soveshchaniya po dokembriyu, paleozoyu i mezozoyu Severo-Vostoka Rossii* [Resolution of the Third Interdepartmental Regional Stratigraphic Meeting on the Precambrian, Paleozoic, and Mesozoic of Northeastern Russia]. St. Petersburg, Izd. VSEGEI, 2009. 268 p. (In Russian)
2. Mezhevik A.A. Stratigraphy of the Northern Kharaulakh. *Sov. Geol.* 1958, no. 7, pp. 43–61. (In Russian)
3. Solomina R.V., Lungersgauzen G.F., Zakharov V.V. Carboniferous and Permian sections of the Kharaulakh Range. *Stratigrafiya kamennougol'nykh i permskikh otlozhenii Severnogo Verkhoyan'ya* [Stratigraphy of the Carboniferous and Permian Deposits of Northern Verkhoyanie]. Leningrad, Nedra, 1970, pp. 8–20. (In Russian)
4. Kashirtsev A.S., Kashirtsev V.A., Safronov A.F., Semenov V.P. Key section of the Carboniferous and Lower Permian sediments in the estuary of the Lena River. *Trudy IX nauch. konf. inzh.-tekh. fak.: Tez. dokl.* [Proc. IX Sci. Conf. Eng.-Tech. Fac.]. Yakutsk, 1966, pp. 54–58. (In Russian)
5. Abramov B.S., Grigorjeva A.D. *Biostratigrafiya i brachiopody permi Verkhoyan'ya* [Biostratigraphy and Brachiopods of the Permian in the Verkhoyanie]. Moscow, Nauka, 1988. 204 p. (In Russian)
6. Solomina R.V. Biostratigraphic scheme of Permian deposits of Verkhoyanie. *Otechestvennaya Geol.*, 1997, no. 3, pp. 37–43. (In Russian)
7. Makoshin V.I., Kutygin R.V. Asselian–Sakmarian (Lower Permian) brachiopod zonation of the Verkhoyansk Region, Northeast Russia. *Stratigr. Geol. Correl.*, 2020, vol. 28, no. 7, pp. 716–744. doi: 10.1134/S0869593820040061.
8. Makoshin V.I., Kutygin R.V. Biostratigraphy of the terminal Carboniferous of the lower reaches of the Lena River (Kubalakh section, Russia). *Uchenye Zapiski Kazanskogo Universiteta. Seriya Estestvennye Nauki*, 2021, vol. 163, no. 3, pp. 406–413. doi: 10.26907/2542-064X.2021.3.406-413. (In Russian)
9. Emel'yantsev G.M., Kravtsova A.I., Puk P.S. *Geologiya i perspektivy neftegazonosnosti nizov'ev r. Leny* [Geology and Prospects of the Oil and Gas Reservoirs in the Lower Reaches of the Lena River]. Leningrad, Gos. Nauchno-Tekh. Izd. Neft. Gorno-Topl. Lit. Leningr. Otd., 1960. 146 p. Tr. Nauchno-Issled. Inst. Geol. Arkt. Minist. Geol. Okhr. Nedr, vol. 108. (In Russian)
10. Bidzhiev R.A., Groshin S.I., Gorshkova E.R., Gogina N.I. *The State Geological map of USSR, Scale 1:200 000. Lower Lena River Series. Sheet R-52-VII, VIII. Explanatory note.* Moscow, Aerogeologiya, 1977. 80 p. (In Russian)
11. Andrianov V.N. *Permskie i nekotorye kamennougol'nye ammonoidy Severo-Vostoka Asii* [Permian and Some Carboniferous Ammonoids of Northeastern Asia]. Novosibirsk, Nauka, 1985. 180 p. (In Russian)
12. Kutygin R.V. Permian ammonoid associations of the Verkhoyansk Region, Northeast Russia. *J. Asian Earth Sci.*, 2006, vol. 26, nos. 3–4, pp. 243–257. doi: 10.1016/j.jseaes.2005.10.004.

13. Budnikov I.V., Budnikov V.I., Grausman V.V., Danilov V.I., Mikhailova T.E. Lithostratigraphy of the Upper Paleozoic marginal troughs of the northeast of the Siberian Platform. In: *Stratigrafiya i litofatsial'nyi analiz verkhnego paleozoya Sibiri* [Stratigraphy and Lithofacial Analysis of the Upper Paleozoic of Siberia]. Novosibirsk, SNIIGiMS, 1991, pp. 5–14. (In Russian)
14. Andreev V.S., Kirichenko V.G., Shumov V.V., Panfilov A.N., Fedoseeva L.N., Selivanova V.V., Ivanenko G.V. *The State Geological Map of the Russian Federation, Scale 1:200 000. Lower Lena River Series. Legend.* Moscow Aerogeologiya, 2000. 134 p. (In Russian)
15. Makoshin V.I. New species of *Jakutoproductus* from the Lower Permian of Verkhoyansk Region. *Paleontol. J.* 2016, vol. 50, no. 5, pp. 463–470. doi: 10.1134/S0031030116050087.
16. Kutygin R.V., Makoshin V.I., Budnikov I.V., Peregoedov L.G. Biostratigraphy of the Asselian–Sakmarian deposits of the upper reaches of the Sobolokh-Mayan River of the Orulgan Range. *Otechestvennaya Geol.*, 2018, no. 5, pp. 74–80 (In Russian). doi: 10.24411/0869-7175-2018-10018.
17. Ganelin V.G., Biakov A.S., Karavaeva N.I. Some questions of stratigraphic theory and Permian stratigraphic scale of Northeastern Asia. In: Gladenkov Yu.B., Kuznetsova K.I. (Eds.) *Puti detalizatsii stratigraficheskikh skhem i paleogeograficheskikh rekonstruktsii* [Ways of Refinement of Stratigraphic Schemes and Paleogeographic Reconstructions]. Moscow, GEOS, 2001, pp. 194–209. (In Russian)
18. Makoshin V.I., Kutygin R.V. Correlation of the Asselian-Sakmarian deposits of Northern and Western Verkhoyanie by brachiopods. *Prir. Resur. Arkt. Subarkt.*, 2019, vol. 24, no. 3, pp. 5–22 (In Russian)
19. Kutygin R.V., Biakov A.S., Makoshin V.I., Budnikov I.V., Peregoedov L.G., Krivenko O.V. Biostratigraphy and important biotic events in the Western Verkhoyansk Region around the Sakmarian–Artinskian boundary. *Palaeoworld*, 2020, vol. 29, no. 2, pp. 303–324. doi: 10.1016/j.palwor.2018.10.001.
20. Makoshin V.I., Kutygin R.V. Biostratigraphy and brachiopods of the Asselian–Sakmarian of the Kubalakh section (lower reaches of the Lena River). *Otechestvennaya Geol.*, 2014, no. 4, pp. 17–21. (In Russian)
21. Ganelin V.G. Taimyr-Kolyma subregion. In: *Osnovnye cherty stratigrafii permskoi sistemy SSSR* [Main Stratigraphic Features of the Permian System of the USSR]. Leningrad, Nedra, 1984. pp. 111–123. (In Russian)
22. Kutygin R.V., Ganelin V.G. Permian ammonoids of the Kolyma-Omolon region: Ogonerian association. *Paleontol. J.*, 2013, vol. 47, no. 1, pp. 1–10. doi: 10.1134/S003103011301005X.
23. Bogoslovskaya M.F., Boiko M.S. The evolution and distribution of the Early Permian genus *Uraloceras* (Ammonoidea). *Paleontol. J.*, 2002, vol. 36, no. 6, pp. 598–605.
24. Kutygin R.V., Budnikov I.V., Sivtchikov V.E. The main features of the Kasimovian–Gzhelian and Permian stratigraphy in the Siberian platform and adjacent fold belts. *Prir. Resur. Arkt. Subarkt.*, 2020, vol. 25, no. 4, pp. 5–29. doi: 10.31242/2618-9712-2020-25-4-1. (In Russian)
25. Budnikov I.V., Kutygin R.V., Shi G.R., Sivtchikov V.E., Krivenko O.V. Permian stratigraphy and paleogeography of Central Siberia (Angaraland) – A review. *J. Asian Earth Sci.*, 2020, vol. 196, art. 104365, pp. 1–21. doi: 10.1016/j.jseaes.2020.104365.

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ОРИГИНАЛЬНАЯ СТАТЬЯ

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**Зональное деление ассельско-сакмарских отложений  
левобережья низовьев реки Лены по брахиоподам**

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**Аннотация**

В результате изучения раннепермских брахиопод, собранных севернее села Чекуровка, впервые для левобережья низовьев реки Лены выполнено зональное деление ассельско-сакмарских отложений. В основании перми установлены слои с *Jakutoproductus lenensis*, выше которых прослеживается уровень с многочисленными представителями вида *Jakutoproductus insignis* Abramov et Grigorjeva, индексирующего одноименную зону. По появлению вида *J. insignis* (в основании зоны *insignis*) палеонтологически обоснована граница хорокытского и эчийского региональных горизонтов. Еще выше в разрезе выделены зоны *Jakutoproductus terechovi* и *Jakutoproductus rugosus*, охарактеризованные соответствующими видами-индексами. Выявленная зональная последовательность идентична ранее изученному Кубалахскому разрезу правобережья низовьев реки Лены, однако мощности установленных в левобережье биостратиграфических зон сокращаются в два раза, а значительная нижняя часть хорокытского регионального горизонта (ниже слоев с *J. lenensis*) выпадает, так как приходится на стратиграфический перерыв между кембрийскими и пермскими отложениями. Проведенное зональное деление позволяет сделать прямую корреляцию Чекуровского разреза с ассельско-сакмарскими отложениями Западного Верхоянья и Омолонского массива по общим видам-индексам.

**Ключевые слова:** нижняя пермь, биостратиграфия, брахиоподы, *Jakutoproductus*, хатыстахская свита, Булкурская структурно-фациальная зона

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