http://doi.org/10.21440/2307-2091-2025-1-13-33

UDC 551.73(571.1)

Geological structure and correlation of upper devonian and lower carboniferous deposits of the Kurgan region (southwest of Western Siberia, Russia)

Tat'yana Ivanovna STEPANOVA[1*]
Nadezhda Aleksandrovna KUCHEVA[1**]
Gunar Andreevich MIZENS[1***]
Zoya Alekseevna TOLOKONNIKOVA[2****]
Lyudmila Vladimirovna BADIDA[1*****]

[1]The Zavaritsky Institute of Geology and Geochemistry of the Ural Branch of RAS, Ekaterinburg, Russia
[2]Kuban State University, Krasnodar, Russia

Abstract

The relevance of the work is due to the need to study the geological setting and the stratigraphy of the Pre-Jurassic basement of the Kurgan region, located at the junction of the Western Siberian Plate, the Ural fold belt and folded-block structures of Central Kazakhstan, making possible to discover new hydrocarbon deposits, confidently solve theoretical issues of the given territory geology.

The purpose of the study is stratigraphically subdivision and characterization of the Paleozoic section based on fossils: foraminifers, brachiopods and bryozoans, and data on algal and palynomorph assemblages. The study is based on cores from Kurgan-Uspenskaya-1 (KU-1) key borehole and from some other stratigraphic test boreholes.

Results and conclusions. The deposits are represented by marine shelf, lagoon and continental facies. The succession penetrated by the KU-1 borehole is divided by overlap faults into six uneven-aged blocks. For the first time in this region, the Paleozoic section has been stratigraphically subdivided based on fossils, with the Upper Devonian Famennian Stage, the lower Carboniferous (Mississippian) Tournaisian Stage and the lower substage of the Visean Stage characterized. The succession of foraminiferal assemblages is consistent with the zonal scheme of the General Stratigraphic Scale (GSS) of Russia. Several reference levels have been recognized based on bryozoans and brachiopods; those have been correlated with the foraminiferal zonation. The faunal assemblages are dominated by taxa characteristic of the coeval deposits from Central Kazakhstan and the Kuznetsk Basin in the Altai-Sayan folded area, and to a lesser degree, from the eastern slope of the Middle Urals. The formations in question were correlated with the sections from the adjacent and remote regions.

Keywords**:** geology, stratigraphy, correlation, Famennian Upper Devonian, Tournaisian and Visean Lower Carboniferous, foraminifers, brachiopods, bryozoans, Western Siberia, Russia.

Introduction

Examination of the geological structure of the Pre-Jurassic basement of the Western Siberian Plate (WSP) is aimed at discovering new hydrocarbon deposits and at solving theoretical issues of geology. Analysis of the core from the Kurgan-Uspenskaya-1 (KU-1) key borehole and additional sampling from a number of structural and exploratory boreholes (EK-30, 55, 53, 49, 44 etc.), drilled in 1970–1990s in the east of the Kurgan Region, have made it possible to reconsider the current views of the area's geological structure and to itemize the earlier [1–3] data on the stratigraphy of the Devonian and Carboniferous formations.

The study area lies within the junction zone of major geotectonic elements: the Western Siberian Plate, the Ural fold belt and the folded-block structures of Central Kazakhstan. Structurally, it lies within the Vagay-Ishim depression and the Tobol-Ubagan uplift in the Borovskoye zone (Fig. 1), pertaining to the margin of the Kazakhstan continent and adjoining the Valeryanovka zone of the Eastern Ural Subregion from the west along the Urkash fault [4]. According to the chart of structural-facies zoning for the Devonian and Carboniferous formations from Western Siberia, the Vagay-Ishim and the Tobol-Ubagan structures fall within the Uvatka structural-facies subzone [5, 6].

Geological structure of the region

The earlier geological-geophysical research results make it possible to distinguish three structural levels within the Pre-Jurassic basement over the study area; those differ in age, deformation and metamorphic degree [4, 7]. The lower level

✉stepanova@igg.uran.ru
**kucheva@igg.uran.ru
***mizens@igg.uran.ru
*****zzalatoi@yandex.ru
******kokshina.lv@gmail.com

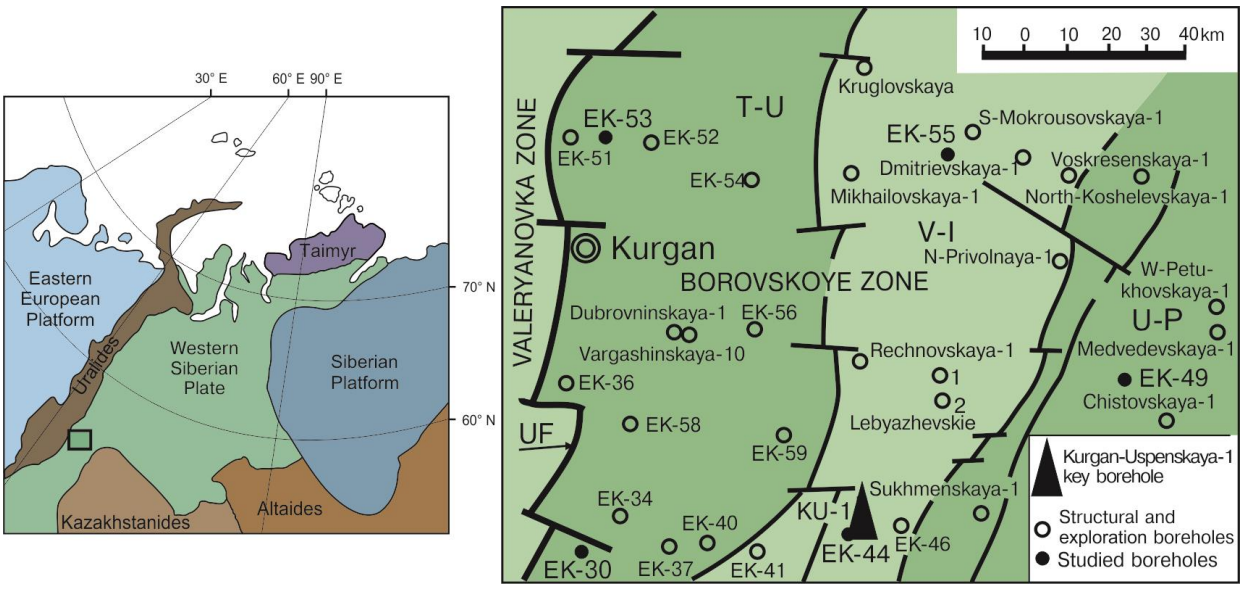

Figure 1. The main structural elements of the Ural-Siberian region [8, 9]. The location of the studied territory and the layout of wells in the southwest of the WSP (southern part of the Kurgan region, Russia): T-U – Tobol-Ubagan Uplift; V-I – Vagay-Ishim Depression; U-P – Ubagan-Petropavlovsk Synclinorium; UF – Urkash Fault

Рисунок 1. Главные структурные элементы Урало-Сибирского региона [8, 9]. Местоположение изученной территории и схема расположения скважин на юго-западе Западно-Сибирской плиты (южная часть Курганской области, Россия): T-U – Тобол-Убаганское поднятие; V-I – Вагай-Ишимский прогиб; U-P – Убаган-Петропавловский синклинорий, UF – Уркашский разлом

is composed of complexly dislocated, folded and metamorphosed pre-Middle Devonian (Riphean and lower Paleozoic) basement formations of the WSP. The middle level comprises Paleozoic and of the Lower – Middle Triassic formations; it may be divided into three structural-formation complexes: the lower volcanogenic-terrigenous complex of Middle – Late Devonian age (D_{2-3}), the terrigenous-carbonate complex of the Famennian – Visean (D_3fm–C_1v_1) and the upper volcanogenic-terrigenous complex of Middle Carboniferous (Lower Pennsylvanian) – Middle Triassic (C_2–T_{1-2}). Formations of the middle structural level unconformably overlie the folded basement. The upper level builds up sedimentary cover of the WSP formed after the Middle Triassic (Anisian) and represented by weakly lithified Mesozoic-Cenozoic deposits (Jurassic – Quaternary).

Based on the research results a composite section was made for the Famennian to early most Visean from the Kurgan region, southwest of the WSP. The most complete section is represented in the KU-1 borehole (2503.3 m deep), drilled 80 km to the southeast of the city of Kurgan. This borehole section represents a flexure broken into six uneven-aged blocks by overfaults; basalts and dolerites occur between limestones of the fifth and the sixth blocks (1177–1318 m interval), but their correlations with the carbonate rocks are obscure (Fig. 2). The stratigraphic sequence has been established based on the character of the organic faunal successions in each of the six blocks. The KU-1 borehole successions have been correlated with coeval formations from other boreholes – EK-30, EK-44, EK-49, EK-53, EK-55, Voskresenskaya-1 and Lebyazhevskaya-2 (Fig. 3).

The data obtained shows that the Famennian rocks transgressively overlie the red-bed continental formations (boreholes EK-34, EK-54), tentatively referred to the Middle (Givetian?) and the Upper Devonian (Frasnian). The Famennian and Tournaisian deposits are mostly represented open by marine shelf facies. Lagoonal carbonate-sulfate formations, however, occur in the lower Tournaisian. The lower Visean deposits were found only in the KU-1 borehole; those are represented by both, marine and continental facies.

Stratigraphy of sedimentary deposits

The Stratigraphic charts for the WSP [5, 6] specified that the Paleozoic formations from the Uvatka structural-facies subzone are practically devoid of fossils, and their assignment to the Devonian and lower Carboniferous may be regarded as highly uncertain. Our study in the southern part of the subzone revealed diverse organic remains in that stratigraphic range, which allows the succession to be dated according to the current GSS of Russia, sometimes even in finer detail.

Upper Devonian, Famennian stage

The lower part (borehole EK-30, 534.3–699.1 m interval). Consists of clayey-carbonate deposits with unilocular problematic organisms and foraminifers, Chlorophyta algae and scarce brachiopods (Table 1). In block IV, borehole KU-1, in the 1700.4–1725.4 m interval an assemblage of unilocular organisms was found in the clayey limestones in association with rare Chlorophyta algae (Table 1).

The association of unilocular foraminifers, represented by numerous forms of the *Parathuramminites suleimanovi* (Lipina) group, comprise the zonal species *Parathurammina dagmarae* Suleimanov. This allows the limestones in question to be assigned to the lower Famennian – to the Beds with *Diplosphaerina magna* – *Parathurammina dagmarae* [6].

The middle part (borehole KU-1, block I, 2420.0–2451.0 m interval; block II, 2079.8–2114.3 m interval). Clayey limestone comprising unilocular foraminifer's peculiar for wide stratigraphic ranges. In block I, interbeds of fine-bioclastic

wakestones contain numerous unilocular foraminifers, problematic organisms and rare *Septaglomospiranella* ex gr. *crassa* Reitlinger (Table 1). In block II, generally, the group *Parathuramminites suleimanovi* is dominant with rare *Parathurammina* ex gr. *dagmarae* and other species (Table 1). Sporadically, rock-forming association of cyanobacteria (*Ortonella kershopensis* Garwood) and Rhodophyta algae (*Parachaetetes* sp., *Solenopora* sp.) are observed. According to the occurrences of *Septaglomospiranella* ex gr. *crassa*, these deposits belong to the middle part of the Famennian and correspond to the Beds with *Septaglomospiranella nana* of the WSP [6].

Rare brachiopods are encountered at some levels, with the predominant Rhynchonellida (characteristic of the Famennian age, table 1). The presence of the brachiopod allows the beds to be dated to the middle Famennian and the *Dzieduszyckia baschkirica* beds to be recognized [10, 11].

The upper part. Bioclastic limestones with numerous foraminifers from the Beds with *Quasiendothyra kobeitusana – Q. communis*.

In block IV, borehole KU-1 (1580.1–1589.2 m), crinoidal limestones contain foraminifers (Table 1) corresponding to the *Quasiendothyra communis* Zone [12, 13] or to the lower Beds with *Quasiendothyra communis – Q. kobeitusana* according to [6].

In block I, borehole KU-1 (2313.4–2321.4 m), as well as in boreholes EK-55 (852.0 and 901.0 m), EK-49 (699.7–798.9 m) and EK-53 (791.6–800.0 m) numerous foraminifers occur (Table 1), characteristic of the *Quasiendothyra kobeitusana* Zone [12, 13] or the upper Beds with *Quasiendothyra communis – Q. kobeitusana* [6]. There is also an endemic algae community of Chlorophyta represented by *Kamaena tobolensis – Crassikamaena kurganensis – Menselina* [14]. Similar algae association was described at this stratigraphic level in the Voskresenskaya-1 borehole [15]. In the intervals devoid of foraminifers, this algal flora marks the above specified zone.

In borehole EK-49 (depths of 728.8–787.0 m), in the *Quasiendothyra kobeitusana* Zone a bryozoan fauna comprising a rich assemblage (Table 1) with quantitative predominance of *Rhombotrypella ancestralis* Nekhoroshev [16], allows the eponymous beds to identified at this stratigraphic level by bryozoans.

Sparse brachiopods are represented by two facies complexes. There is an association in marls (KU-1, block IV, 1525.1–1526.9 m), characteristic of the Famennian deposits, some of which pass into the Tournaisian [17]. And there is an association in crinoidal limestones (KU-1, block I, 2314.2 m, EK-49, 753.1–764.7 m, EK-53, 791.6–800.0 m) only with *Cyrtospirifer* (Table 1).

Lower Carboniferous (Mississippian), Tournaisian

The lower part is represented by marine and lagoon facies. Marine deposits of the lower Tournaisian have been penetrated only in the EK-53 borehole confined in the Tobol-Ubagan Uplift. Clayey limestones with *Earlandia elegans* (Rauser-Chernousova et Reitlinger), *Bisphaera malevkensis* Birina, *B. elegans* Vissarionova and *B. irregularis* Birina occur there stratigraphically directly above the deposits of the *Quasiendothyra kobeitusana* Zone with Cyrtospiriferidae brachiopods, in the 784.4–791.6 m interval. This corresponds to the Beds with *Bisphaera malevkensis – Earlandia minima* of the lower Tournaisian of the WSP [5].

Rare brachiopods are represented by the species *Mucrospirifer* cf. *pseudoposterus* (Besnossova), common in the Tournaisian of Kuznetsk Basin (Kuzbass) [18].

It should be noted that the section penetrated by the EK-53 borehole is the only one in the region with the Devonian–Carboniferous stratigraphic boundary established from two faunal groups [2].

In the Vagay-Ishim depression (KU-1, interval 2116–2216 m and Voskresenskaya-1) a carbonate-sulphate set was recorded, represented by dolomites, limestones and anhydrites without any organic remains. According to its position in the section, it is attributed to the lower part of the Tournaisian.

The upper Tournaisian. At the top of EK-53 borehole (the 694.3–728.6 m interval) a foraminiferal assemblage with *Chernyshinella* sp. indet. and *Palaeospiroplectammina* ex gr. *tchernyshinensis* (Lipina) has been found. It corresponds, probably, to the upper part of the Tournaisian Beds with *Chernyshinella disputabilis – Ch. glomiformis* of the of the WSP [5]. The presence of *Palaeospiroplectammina tchernyshinensis* allows this interval to be compared with the cognominal beds in the stratotype Nyurolsky district of the WSP [19, 20].

The upper Tournaisian has been examined in blocks III and V of the KU-1 borehole. Clayey and bryozoan-crinoidal

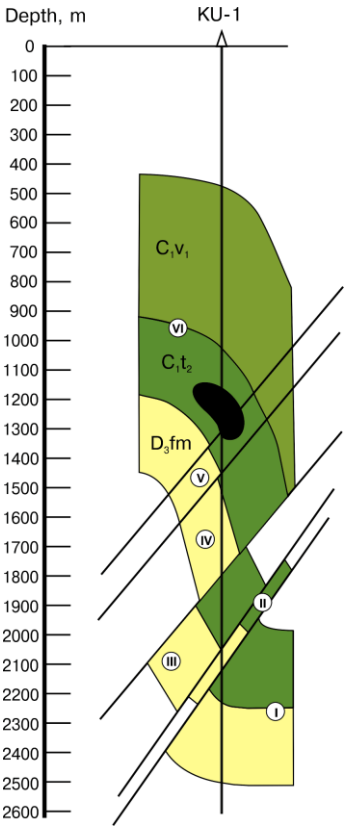

Figure 2. Schematically reconstructed tectonic structure of the section penetrated by the KU-1 borehole (by G. Mizens). The black fill marks the body of basalts and dolerites. Tectonic blocks are designated with Roman numerals

Рисунок 2. Схематическая реконструкция тектонического строения разреза, вскрытого скважиной Курган-Успенская-1 (автор Г. А. Мизенс). Черной заливкой отмечено тело базальтов и долеритов. Римскими цифрами обозначены тектонические блоки

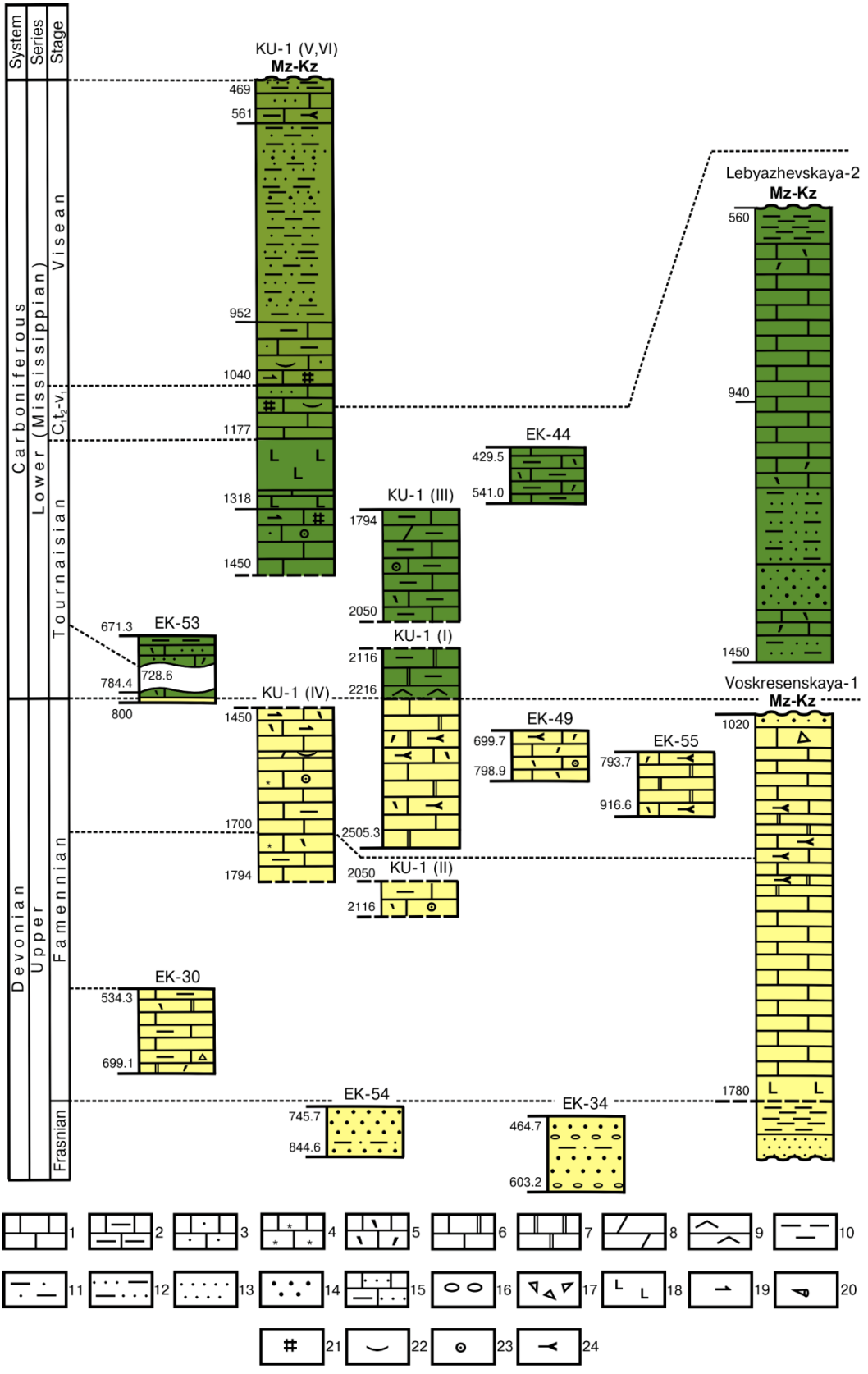

Figure 3. Correlation of the Upper Devonian and the Lower Carboniferous deposits from the south of the Uvatka structural-facies subzone: *1 – 6* – limestone: *1* – clean, *2* – clayey, *3* – sandy, *4* – peloidal, *5* – bioclastic, *6* – dolomitized; *7* – dolomite; *8* – marl; *9* – anhydrite and gypsum; *10* – argillite; *11* – silty argillite; *12–15* – sandstones: *12* – clayey, *13* – fine- and medium-grained, *14* – coarse-grained, *15* – calcareous-clayey; *16* – conglomerate; *17* – calcareous breccia; *18* – basalts, dolerites; *19–24* – organic remains: *19* – sponge spicules, *20* – rugose corals, *21* – bryozoans, *22* – brachiopods, *23* – crinoids, *24* – algae

Рисунок 3. Корреляция верхнедевонских и нижнекаменноугольных отложений южной части Уватской структурно-фациальной подзоны: *1 – 6* – известняки: *1* – чистые, *2* – глинистые, *3* – песчанистые, *4* – пелоидные, *5* – биокластовые, *6* – доломитизированные; *7* – доломиты; *8* – мергели; *9* – ангидриты и гипсы; *10* – аргиллиты; *11* – аргиллиты алевритистые; *12–15* – песчаники: *12* – глинистые, *13* – мелко- и среднезернистые, *14* – крупно- и грубозернистые, *15* – известково-глинистые; *16* – гравелиты; *17* – брекчии известняковые; *18* – базальты, долериты; *19–24* – органические остатки: *19* – спикулы губок, *20* – кораллы Rugosa, *21* – мшанки, *22* – брахиоподы, *23* – криноидеи, *24* – водоросли

limestones, spongolites and calcareous argillites represent these intervals. The upper Tournaisian has also been penetrated by EK-44. In block III (1860.0–2019.1 m), species of wide stratigraphic range prevail among foraminifers and algae; it is only at the depth of 1904.8–1910.1 m that a poorly preserved foraminiferal assemblage has been determined: *Septabrunsiina* sp., *Septaglomospiranella* sp. and *Granuliferella* cf. *latispiralis minima* (Lipina). This allows the enclosing deposits to be assigned to the upper Tournaisian.

In block III (interval of 1860.0–1869.3 m), a bryozoan association (Table 1) characteristic of the upper Tournaisian has been revealed [21, 22].

In block III (1860.0–2012.9), brachiopods have been found, characteristic of the upper Tournaisian (Table 1). In general, the brachiopod assemblage from this interval is peculiar for domination of species of *Mesochorispira*, including *M.* cf. *grimesi* (Hall) and *Marginatia* sp., which allows this interval to be recognized as the Beds with *Marginatia* sp. – *Mesochorispira grimesi.*

In block V, in the 1330.3–1331.8 m and 1358.7–1369.1 m intervals in borehole KU-1, in clayey bryozoan-crinoidal limestones, the following foraminiferal assemblages and Chlorophyta algae (Table 1) are found. The foraminiferal association contains *Neoseptaglomospiranella, Septabrunsiina* and a variety of Chernyshinellinae. Representatives of the *Granuliferella* genus prevail, with a total lack of *Spinoendothyra*. This community includes the majority of species from the characteristic association of the Beds with *Spinoendothyra costifera – Tuberendothyra tuberculata* from the Tournaisian of the WSP, but does not include any zonal species [5]. Predominance of the representatives of the *Laxoendothyra* and *Granuliferella* allowed us to distinguish the Beds with *Granuliferella latispiralis – Laxoendothyra parakosvensis*, which correspond to the Beds with *Marginatia* sp. – *Mesochorispira grimesi* in block III.

In the lower part of block V (1434.0–1435.5 m) rare bryozoans occur. This species of wide stratigraphic range: from the upper part of the Famennian to the Tournaisian Fominskian Regional Substage from Kuzbass [23–25].

Diverse and specific associations of organic remains occur in clayey limestones in the 429.5–471.4 m interval of borehole EK-44. In the upper part of the section, a peculiar association of small-size foraminifers has been discovered (Table 1), among the characteristic ones *Neoseptaglomospiranella* as well as *Pseudoplanoendothyra rotayi* (Dain in Brazhnikova) group and of *Mediendothyra. Granuliferella* occurs frequently, *Spinoendothyra* is negligible [2]. Beds with this association have been recognized as the Beds with *Pseudoplanoendothyra – Plectogyrina fomichaensis*, corresponding probably to the upper part of the Tournaisian stage.

Varied bryozoan assemblages were encountered in the 436.5–506.4 m interval in borehole EK-44 (Table 1) [16, 22]. *Rectifenestella bukhtarmensis* (497.0–506.4 m and 436.5–442.9 m intervals) is characteristic of the Tournaisian Fominskian Regional Substage from Kuzbass [23]. It may be used as an indicator for the upper Tournaisian.

The brachiopod assemblages from borehole EK-44 comprises numerous cosmopolitan *Leptagonia analoga* (Phillips) and *Megachonetes zimmermanni* (Paeckelmann), common in Late Tournaisian – Visean [26].

The member of terrigenous-carbonate rocks penetrated by borehole EK-44 is not comparable to any fragments of the KU-1. The foraminiferal and bryozoan association is indicative of the Late Tournaisian age [2, 23, 27].

The Tournaisian – Visean, boundary interval

The deposits of the lower part of block VI (KU-1, 1080.1-1098.8 m) are represented by clayey limestones and spongolites. The limestones contain rare bryozoans, brachiopods and spores (Table 1), known mainly in the upper Tournaisian – lower Visean of Kazakhstan and Kuzbass. The interval's age is accepted as late Tournaisian – early Visean by analogy with adjacent regions.

The lower Visean

In the lower Visean, three distinctive stratigraphical levels have been identified.

The lower level (borehole KU-1, block VI, 952.0–1058.5 m) is made up of organogenic limestones, calcareous sandstones and clayey spongolites. Contain diverse bryozoan assemblage at the 1009.3–1058.5 m interval (Table 1), it is Late Tournaisian – Early Visean age.

The brachiopod association occurring in the 1009.3–1058.5 m interval, inherited those encountered in the underlying deposits, but they are more numerous and diversified, and comprise the taxa from two age ranges – the Late Tournaisian-Early Visean and the Visean ones (Table 1).

The *Plicochonetes* cf. *nalivkiniformis* Aksenova and *Marginatia* ex gr. *mirabilis* Litvinovich emerging from the base of this interval, allowed us to limit the age to the earliest Visean. Occurrences of numerous *Plicochonetes* cf. *nalivkiniformis* allow distinguishing eponymous beds at this stratigraphic level.

At the depth of 1051.1 m, fine bioclastic limestones contain, single isolated fish scales of *Paleoniscus* sp. and conodonts *Idioprioniodus* cf. *cojunctus* (Gunnell), *Adetognathus* cf. *unicornis* (Rexroad et Barton) of early Carboniferous age (determined by V. V. Chernykh).

The middle level (KU-1, block VI, 561.0–952.0 m) is represented by a red-bed series of continental origin, composed of sandstones and argillites with inclusions of plant detritus. At some levels, extremely poorly preserved spore-pollen associations have been distinguished (Table 1, determined by T. V. Stukova). The spore associations allow us to make some tentative age determinations of the host terrigenous rocks: not older than the analogues from the Visean Bobrikian Regional Substage from the western slope of the Urals and the Eastern European Platform (EEP) [28–30].

The upper level, borehole KU-1, block VI. In the 548.7–557.3 m depth interval, the section is dominated by algal grainstones with abundant and diversified foraminifers assemblages (Table 1). In the algal flora community, algae of the Stacheinaceae of Rhodophyta prevail. At the depth of 551.1 m, an impoverished spore assemblage of satisfactory preservation has been encountered (Table 1), which is similar to the one found in the underlying deposits of the second level of block VI. It determines the age as being not older than the Visean Bobrikian Regional Substage from the western slope of the Urals and the EEP.

In the depth range of 540.0–548.7 m, interstratification of packstones/grainstones with fine to medium-grained sandstones is observed. The most representative foraminifers

assemblage occur in the limestones (Table 1). Algae are quite diversiform – those are representatives of the orders Dasycladales and Siphonocladales of Chlorophyta and the family Stacheinaceae of Rhodophyta.

Dominance of *Uralodiscus rotundus* and of other Archaediscidae, and species of the *Eoendothyranopsis ermakiensis* group allowing to distinguish the Beds with *Uralodiscus rotundus – Eoendothyranopsis ermakiensis* and to correlate these Beds with the *Uralodiscus rotundus – Planodiscus primaevus* Beds from the WSP [5]. It should be noted that most specimens of *Globoendothyra*, *Eogloboendothyra* and *Eoendothyranopsis* bear certain traces of redeposition: they are misshapen, micritized and recrystallized, which may indicate a somewhat younger – not older than the Ustgrekhovkian Regional Substage – age of the host rocks.

In the 548.7–557.3 m interval, scarce brachiopods occur – large Strophomenida, Productida and *Syringothyris* ex gr. *sibirica* Sokolskaja. In the limestones and calcareous sandstones from the 540.3–540.6 m interval, single *Spirifer* ex gr. *soschkini* Litvinovich and *Globosoproductus* sp. indet. occur in an unrepresentative brachiopod assemblage (Table 1).

Discussion

Depositional environments (synopsis)

The Famennian and Tournaisian marine deposits penetrated by boreholes (within the territory of Kurgan region, Uvatka structural-facies subzone) are represented by limestones and carbonate-clayey rocks, which were deposited mainly in the carbonate shelf's inner part. Secondary dolomites are widespread. The nature of the fossils and lithology indicate both an active (bioclastic limestones) and a relatively calm (algal wackestone) hydrodynamic regimes. Lagoon deposits (dolomites, limestones and anhydrites with interbeds of sandstones and clayey rocks) are found only in the Vagay-Ishim depression in the lower Tournaisian.

The expansion of the sedimentary basin occurred again in the upper Tournaisian. Open shelf facies were the most common [31]. In the lower Visean, both marine (clayey limestones and limestone sandstones) and continental (proluvial red sandstones) facies were common.

Correlation with adjacent regions and remote areas

We have identified a sequence of foraminiferal assemblages in the Upper Devonian and Lower Carboniferous deposits. This succession has been established and found to be generally corresponding to the zonation accepted for the Western Siberian Plate [5, 6]; in some instances, it has been elaborated and supplemented. For the first time in the region, several reference levels have been determined from the bryozoan and brachiopod faunas; those have been recognized as "Beds with fauna" and correlated with the beds and zones recognized based on foraminifers. The examined deposits have been correlated with the coeval formations from the adjacent regions. The correlation of the recognized beds and zones is

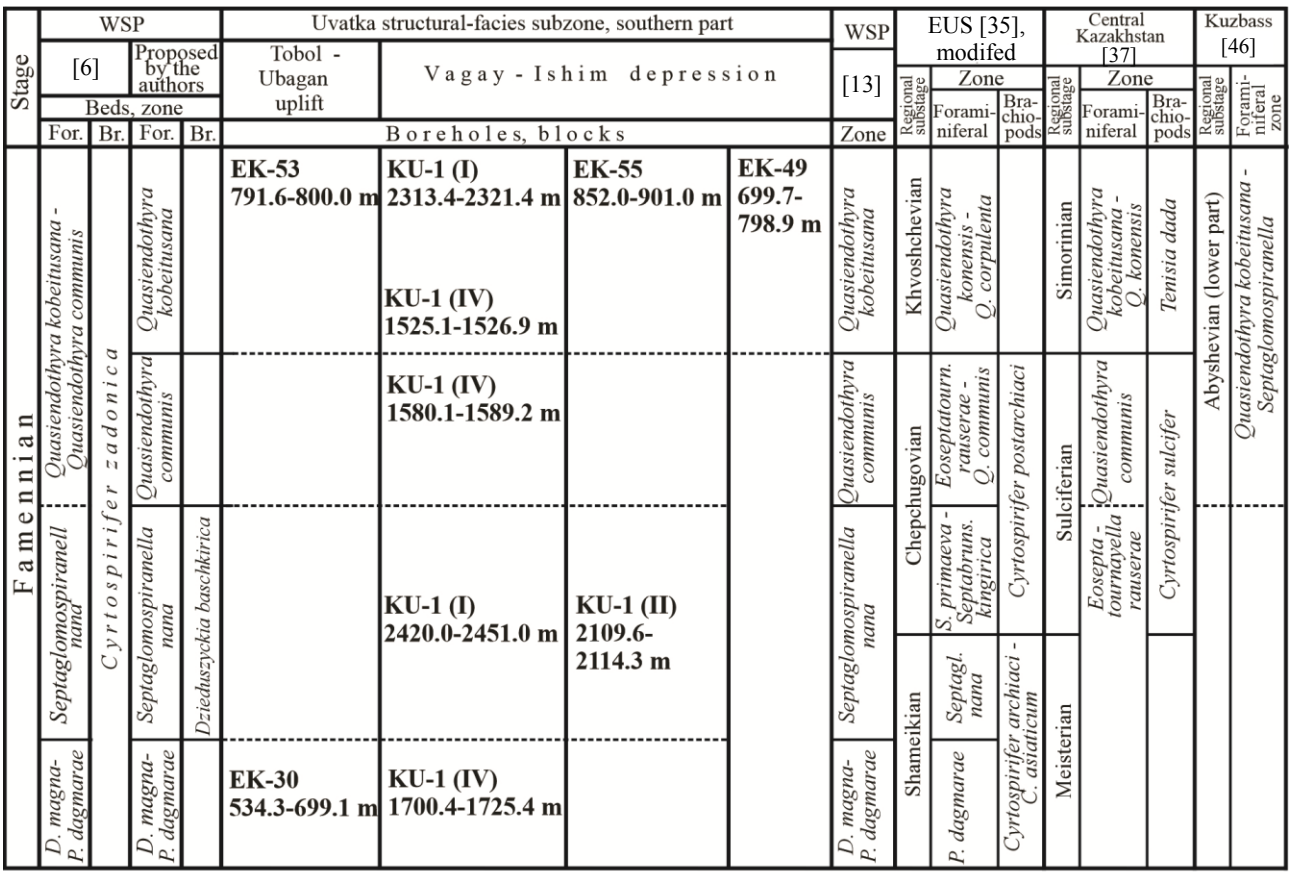

Figure 4. Division and correlation of the Upper Devonian Famennian deposits from the Uvatka structural-facies subzone. Abbreviations: WSP, Western Siberian Plate; EUS, Eastern Uralian Subregion; *C., Cyrtospirifer*; *D., Diplosphaerina*; *Eoseptatourn., Eoseptatournayella; P., Parathurammina*; *Q., Quasiendothyra; Septabruns., Septabrunsiina; S., Septagl., Septaglomospiranella*

Рисунок 4. Расчленение и корреляция отложений фаменского яруса верхнего девона Уватской структурно-фациальной подзоны. Сокращения: WSP, Западно-Сибирская плита; EUS, Восточно-Уральский субрегион; *C., Cyrtospirifer*; *D., Diplosphaerina*; *Eoseptatourn., Eoseptatournayella; P., Parathurammina*; *Q., Quasiendothyra; Septabruns., Septabrunsiina; S., Septagl., Septaglomospiranella*

tentative. These units usually cover intervals larger than in some other well-studied regions, for example, the EEP and the Urals, as part of the Eastern Uralian Subregion (EUS) and the Western Uralian Subregion (WUS), the Don-Dnieper region (DDR), the Franco-Belgian Basin (FBB) and South China.

Correlation of Famennian deposits (Upper Devonian)

The correlation of the studied Famennian deposits with the deposits of adjacent regions is shown in fig. 4.

The lower Famennian **Beds with *Diplosphaerina magna* – *Parathurammina dagmarae*** correlate with the *Parathurammina dagmarae* Zone in the lower part of the Shameikian Regional Substage from the EUS [32] and with the *Parathurammina dagmarae* – *Parathurammina breviradiosa* Zone in the Zadonskian Regional Substage of the EEP [33, 34]. Correlation of this stratigraphic level is difficult outside the territory of the Russian Federation.

The middle Famennian **Beds with *Septaglomospiranella nana*** correlate with deposits of the *Septaglomospiranella nana* Zone from the upper part of the Shameikian Regional Substage and the *Septaglomospiranella primaeva* – *Septabrunsiina kingirica* Zone from the lower part of the Chepchugovian Regional Substage from the EUS [32, 35]. In addition, these beds correlate with the upper part of the Makarovian and Murzakaevian (*Quasiendothyra bella* Zone) Regional Substages of the WUS, with the upper part of the Yeletsian and lower parts of the Lebedyanian (*Septatournayella rauserae* Zone) Regional Substage of the EEP with some degree of convention [33, 36]. Supposedly, the Beds with *Septaglomospiranella nana* are correlated with the *Septatournayella rauserae* Zone from the lower part of the Sulciferian Regional Substage in Central Kazakhstan [37], with DFZ2 and DFZ3 in the FBB [38], with the lower part of the *Quasiendothyra communis* – *Q. regularis* Interzone in Czech Republic [39, 40]. Moreover, in South China, there are zones similar to the subdivisions in the FBB [41].

The **Beds with *Dzieduszyckia baschkirica*** have been recognized as corresponding to the middle Famennian Beds with *Septaglomospiranella nana*. The Beds with *Dzieduszyckia baschkirica* are correlated with the *Dzieduszyckia baschkirica* – *Zigania ursa* Zone (the Makarovian, upper part and Murzakaevian Regional Substages) of the WUS and the Yeletsian Regional Substage of the EEP. These beds are correlated with the Shameikian (upper part) and Chepchugovian (lower part) Regional Substages of the EUS [34, 35]. Associated species are characteristic of the Meisterian (the upper part) and Sulciferian Regional Substages in Central Kazakhstan [42, 43]. In general, *Dzieduszyckia* is a cosmopolitan genus of the Famennian [11].

The ***Quasiendothyra communis* Zone** correlates with the *Eoseptatournayella rauserae* – *Quasiendothyra communis* Zone from the upper of the Chepchugovian Regional Substage of the EUS [32, 35], with the *Quasiendothyra communis* Zone from Kushelgian Regional Substage of the WUS, with the *Quasiendothyra communis* Zone from Optukhovian and Plavskian Regional Substages of the EEP [33, 36]. Moreover, this zone correlates with *Quasiendothyra communis* Zone from the upper of the Sulciferian Regional Substage in Central Kazakhstan [37], with the Beds with frequent *Q. communis, Septatournayella rauserae* in the DDR [44], with DFZ4 and DFZ5 in the FBB [38], with *Q. communis* – *Q. regularis* Zone in Czech Republic [40, 41] and with DFZ4 and DFZ5 in South China [41].

The *Quasiendothyra kobeitusana* Zone is recognized in many sections across Eurasia. In the adjacent regions, it correlates with the *Quasiendothyra konensis* – *Q. corpulenta* Zone of the Khvoshchevian Regional Substage of the EUS and the *Quasiendothyra konensis* Zone of the Lytvian Regional Substage of the WUS [32, 35, 36]. This stratigraphic interval is the most finely subdivided in the EEP [33, 45]. This zone partly corresponds to the *Quasiendothyra kobeitusana* – *Septaglomospiranella* Zone of the lower Abyshevian Regional Substage of the Kuzbass [46] or the Topkian Regional Substage of the Altai-Sayan folded region [47]; to the *Quasiendothyra kobeitusana* – *Q. konensis* Zone of the Simorinian Regional Substage in Central Kazakhstan [37]. In addition, this zone correlates with the frequent both *Quasiendothyra konensis* and *Q. kobeitusana* Zone in the DDR [45], with the DFZ6 and DFZ7 zones in the FBB [38], with the *Q. kobeitusana* – *Q. konensis* Zone in Czech Republic [39, 40, 48] and with the DFZ6 and DFZ7 zones in South China [41].

Within the range of *Quasiendothyra communis* and *Q. kobeitusana* Zones **the Beds with *Rhombotrypella ancestralis*** have been recognized based on bryozoans, which allow these deposits to be correlated with the upper Sulciferian and Simorinian Regional Substage in Kazakhstan [37]. Most species of this assemblage occur in the upper Famennian deposits in Kazakhstan and Northwest China [16, 49–52]. The brachiopod assemblage within the *Quasiendothyra kobeitusana* Zone is dominated by taxa, which appear in the upper Famennian and continue into the lower Tournaisian. Two species *Camarotoechia volucera* and *Athyris tobolica* are typical only of the upper Famennian [26, 53]. By the presence of *Orbinaria fallax*, *Camarotoechia panderi* and *Cleiothyridina tenuilineata* the host rocks are correlated with the Abyshevian Regional Substage (Kuzbass), the Tarkhan Formation (Altai-Sayan folded region), and the Zavolzhskian Regional Substage of the EEP [17, 43].

The presence of *Cyrtospirifer sibiricus* and *C. kobeitusensis* allows the deposits to be correlated with the *Tenisia dada* Zone of the Simorinian Regional Substage in Central Kazakhstan [37, 53].

Correlation of Tournaisian deposits (Lower Carboniferous). The correlation of the Tournaisian studied deposits with the deposits of adjacent regions is shown in fig. 5.

The carbonate-sulphate lagoonal facies found in the Vagai-Ishim depression above the *Quasiendothyra kobeitusana* Zone probably reflect the influence of the Hangenberg Event.

The lower Tournaisian **Beds with *Bisphaera malevkensis – Earlandia minima*** correspond to the *Bisphaera malevkensis* – *Earlandia minima* Zone of the lower part of the Rezhian Regional Substage of the EUS (according to [29], to the *Tournayellina vulgaris* – *T. intermedia* Zone [45, 54], to the *Earlandia minima* Zone of the Malevkian Regional Substage of the WUS and the EEP [36] and to the *Bisphaera malevkensis* – *Earlandia minima* Zone, according to the GSS of Russia [55].

These beds are correlated with the eponymous zone of the Kassinian Regional Substage in Central Kazakhstan, with the *Bisphaera malevkensis* Zone in the DDR [56, 57], supposedly with the *Tournayellina beata* Zone in the Czech Republic [40], with the MFZ1 in the FBB [38]. The same zone can be traced in South China [41].

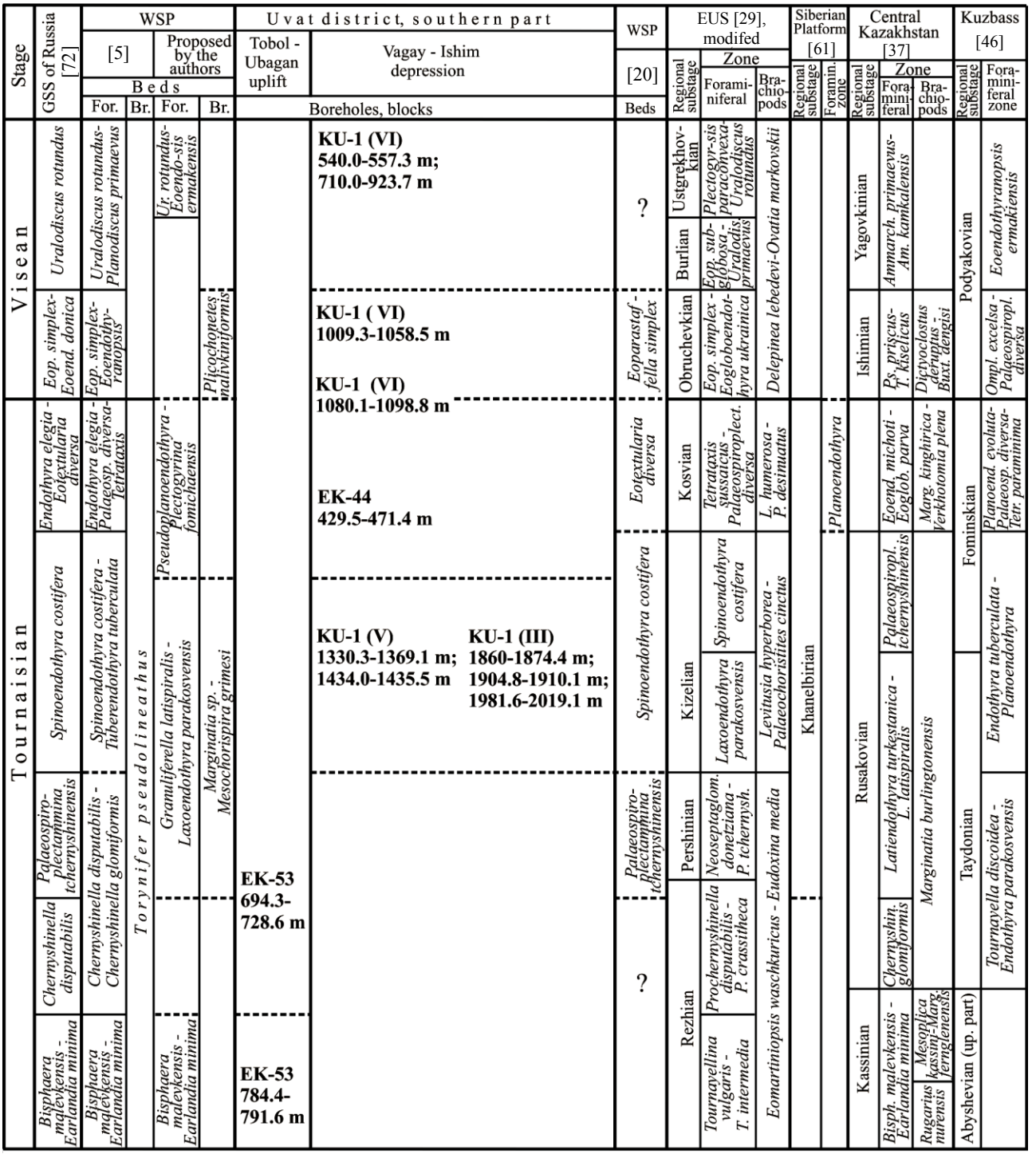

Figure 5. Division and correlation of the Lower Carboniferous Tournaisian and Visean deposits from the Uvatka structural-facies subzone.
Abbreviations: WSP, Western Siberian Plate; EUS, Eastern Uralian Subregion; *Ammarch.*, *Ammarchaediscus*; *Bisph.*, *Bisphaera*; *Buxt.*, *Buxtonia*; *Chernyshin.*, *Chernyshinella*; *Eoglob.*, *Eogloboendothyra*; *Eoend.*, *Eoendothyranopsis*; *Eop.*, *Eoparastaffella*; *L.*, *Levitusia*; *Marg.*, *Marginatia*; *Omph.*, *Omphalotis*; *P. tchernysh.*, *Palaeospiroplectammina tchernyshinensis*; *Palaeosp.*, *Palaeospiroplectammina*; *Pal.*, *Palaeochoristites*; *Planoend.*, *Planoendothyra*; *Plectogyrsis*, *Plectogyranopsis*; *Pr.*, *Prochernyshinella*; *Ps.*, *Pseudoammodiscus*; *T.*, *Tetrataxis*; *Ur.*, *Uralodiscus*

Рисунок 5. Расчленение и корреляция отложений турнейского и визейского ярусов нижнего карбона Уватской структурно-фациальной подзоны. Сокращения: WSP, Западно-Сибирская плита; EUS, Восточно-Уральский субрегион; *Ammarch.*, *Ammarchaediscus*; *Bisph.*, *Bisphaera*; *Buxt.*, *Buxtonia*; *Chernyshin.*, *Chernyshinella*; *Eoglob.*, *Eogloboendothyra*; *Eoend.*, *Eoendothyranopsis*; *Eop.*, *Eoparastaffella*; *L.*, *Levitusia*; *Marg.*, *Marginatia*; *Omph.*, *Omphalotis*; *P. tchernysh.*, *Palaeospiroplectammina tchernyshinensis*; *Palaeosp.*, *Palaeospiroplectammina*; *Pal.*, *Palaeochoristites*; *Planoend.*, *Planoendothyra*; *Plectogyrsis*, *Plectogyranopsis*; *Pr.*, *Prochernyshinella*; *Ps.*, *Pseudoammodiscus*; *T.*, *Tetrataxis*; *Ur.*, *Uralodiscus*

Brachiopods within the Beds with *Bisphaera malevkensis* – *Earlandia minima* are represented by endemic *Mucrospirifer* cf. *pseudoposterus*. This species occurs in the Taidonian and Fominskian Regional Substages of Kuzbass [18].

The deposits within *Chernyshinella* and *Palaeospiroplectammina tchernyshinensis* are correlated with the *Neoseptaglomospiranella donetziana* – *Palaeospiroplectammina tchernyshinensis* Zone

of the Pershinian Regional Substage of the EUS, with the *Palaeospiroplectammina tchernyshinensis – Chernyshinella glomiformis* Zone of the lower Cherepetian Regional Substage of the WUS and the EEP of the Tournaisian age [29, 36, 55, 58], as well as with the *Palaeospiroplectammina tchernyshinensis* Zone in the DDR [56, 57], supposedly with the *Chernyshinella tumulosa – Spinobrunsiia* Zone in the Czech Republic [40] and with the MFZ3 in the FBB [38].

The Beds with *Granuliferella latispiralis – Laxoendothyra parakosvensis* presumably correlate with the Kizelian Regional Substage, which is considered as part of the *Laxoendothyra parakosvensis* and *Spinoendothyra costifera* Zones of the EUS, the *Latiendothyra latispiralis* and *Spinoendothyra costifera* Zones of the WUS and corresponds to the *Spinoendothyra costifera* Zone of the GSS of Russia [28, 55, 58]. These deposits correlate with the middle part of the upper Tournaisian Rusakovian Regional Substage in Central Kazakhstan, the *Latiendothyra turkestanica – L. latispiralis* Zone [37], with *Spinoendothyra costifera – Paradainella dainelliformis* Zone in the DDR [56, 57], supposedly with the *Paraendothyra* Zone in the Czech Republic [41] and with the MFZ4 and MFZ5 in the FBB [38].

The Beds with the brachiopods *Marginatia* sp. – *Mesochorispira grimesi* are recognized within the *Granuliferella latispiralis – Laxoendothyra parakosvensis* Beds with foraminifers. They correlate with the *Marginatia burlingtonensis* Zone of the Rusakovian Regional Substage in Central Kazakhstan [37], the Taidonian and Fominskian Regional Substages of Kuzbass [18, 46]. By the presence of *Mesochorispira* ex gr. *theodorovitshi*, *Tylothyris* cf. *laminosus*, *Brachythyris* ex gr. *suborbicularis* and others, these beds are correlated with the upper Tournaisian deposits of the Urals and Mugodzhary [26] and tentatively with the EEP. The presence of the *Tylothyris* cf. *laminosus* allows these beds to be compared with the upper Tournaisian deposits of Western Europe [59].

The Beds with *Pseudoplanoendothyra – Plectogyrina fomichaensis* are probably upper Tournaisian in age. In the presence of *Pseudoplanoendothyra*, they are similar to the association of the upper Tournaisian Fominskian Regional Substage of Kuzbass [46]; *Plectogyrina* ex gr. *fomichaensis*, characteristic only of this region, were also found [60]. A similar association is cited by O. A. Bogush for the upper part of the Tournaisian Khanelbirian Regional Substage (Beds with *Pseudoplanoendothyra*) of the Norilsk region, northwest of the Siberian Platform [61].

This foraminiferal association does not contain species characteristic of the upper Tournaisian of other regions and can only partially be compared with analogues of the upper Kizelian and Kosvian Regional Substages of the Urals and the EEP, with the upper Tournaisian in the DDR and the Czech Republic, as well as with the MFZ6–MFZ8 in the FBB [38, 40, 55, 56].

Numerous bryozoans and brachiopods were found within the Beds with *Pseudoplanoendothyra – Plectogyrina fomichaensis*. Most of the bryozoans have a wide stratigraphic and geographical distribution. They are known from the upper Tournaisian – the lower Visean deposits in Kazakhstan and Kuzbass [23, 24, 62], South Caucasus, Uzbekistan, Eastern Transbaikal, Mongolia [27, 63–65]. The presence of *Rectifenestella bukhtarmensis* bryozoans in the complex limits the deposits age to the Fominskian Regional Substage of Kuzbass [23].

The brachiopod assemblage is dominated by species distributed in the upper Tournaisian – the lower Visean boundary deposits. *Leptagonia analoga* and *Megachonetes zimmermanni* are cosmopolitan, the rest of the taxa are characteristic of Kuzbass and Kazakhstan [18, 59, 66].

Correlation of Visean deposits (Lower Carboniferous). Clayey-carbonate deposits of the lower part of block VI (KU-1, 1080.1–1098.8 m) include various bryozoans, brachiopods, and single spores, which are distributed in the Tournaisian – Visean boundary deposits. Bryozoans are represented by a mixed complex of Tournaisian and early Visean forms found in Kuzbass, Eastern Transbaikal, Kazakhstan, Central Mongolia [23–25, 62]. A few brachiopods are also known in the upper Tournaisian – lower Visean deposits in Kuzbass and Central Kazakhstan [18, 59]. The spores *Punctatisporites* sp. and *Stenozonotriletes marginellus* Luber are characteristic of the Lower Carboniferous Karaganda Basin in Kazakhstan, the rest are known in the Lower Carboniferous Volga-Ural oil-and-gas province and the EEP [67, 68].

The Tournaisian – Visean boundary is in this interval, but it is not possible to indicate its specific level.

The Beds with the brachiopods *Plicochonetes nalivkiniformis* include numerous and diverse species distributed in the upper Tournaisian – lower Visean. Their distribution is limited to the Kazakhstan [59]. However, they are age-dated by the lower Visean on the appearance of a zonal species *Marginatia* ex gr. *mirabilis*. These beds are most similar to the *Dictyoclostus deruptus – Buxtonia dengisi* Zone of the lower Visean Ishimian Regional Substage in Central Kazakhstan [37].

Bryozoans found in the lower part interval are common in the upper Tournaisian – lower Visean deposits in Kazakhstan and Kuzbass [23, 24, 62]. Some taxons *Rectifenestella, Rhombopora, Sulcoretepora* are known from the upper Tournaisian – lower Visean deposits of Uzbekistan, Eastern Transbaikal, Mongolia, China [25, 63, 65].

Red bed continental formations (KU-1, block VI, 561.0–952.0 m) contain impoverished spore assemblages no older than analogues of the Visean Bobrikian Regional Substage. The *Stenozonotriletes marginellus* Luber and *Punctatisporites glabratus* (Luber) Luber are characteristic of the Lower Carboniferous deposits of the Karaganda coal basin, northern Kazakhstan [68].

The Beds with *Uralodiscus rotundus – Eoendothyranopsis ermakiensis* can be correlated with the *Plectogyranopsis paraconvexus – Uralodiscus rotundus* Zone of the Ustgrekhovkian Regional Substage of the EUS and the upper *Uralodiscus rotundus* Zone of the GSS of Russia [5, 29, 55]. The considered association is also close to the complexes described from the deposits of the Ustgrekhovkian Regional Substage in the northern part of the Borovskoye zone [69]. The presence of numerous *Eoendothyranopsis* (and *E. ermakiensis* among them) makes it possible to correlate this interval with the *E. ermakiensis* Zone of the lower Visean Podyakovian Regional Substage in the Kuznetsk Basin [46, 60].

The Beds with *Uralodiscus rotundus – Eoendothyranopsis ermakiensis* are correlated with the upper *Ammarchaediscus primaevus – A. kamkalensis* Zone of the Yagovkinian Regional Substage in Central Kazakhstan [37], with the upper part *Uralodiscus rotundus* Zone in the DDR [56], with the upper

Table 1. Intervals dated by fossils according to the KU-1 bore core
Таблица 1. Интервалы, датированные по ископаемым остаткам из керна скважины КУ-1

Borehole, block, interval, m	Organic remains	Age
ЕК-30, 534.3–699.1	Problematic: *Calcisphaera plavskensis* Reitlinger 1960, *Radiosphaera basilica* Reitlinger, 1960	D_3
	Single-chamber foraminifers: *Archaesphaera minima* (Suleimanov, 1945) *Archaesphaera magna* (Suleimanov, 1945) *Vicinesphaera squaliada* (Antropov, 1950) *Diplosphaerina minima* (Suleimanov, 1948) *Eovolutina elementa* (Antropov, 1950) *Parathuramminites suleimanovi* (Lipina, 1950) – frequently *P. scutulus* (Tchuvashov, 1965) *P. obnatus* (Tchuvashov, 1965) *Parathurammina dagmarae* (Suleimanov, 1945)	D_3fm, lower part
	Algae Chlorophyta: *Issinella* cf. *devonica* Reitlinger, 1954 (frequently) *Is. sainsii* Mamet et Roux, 1975 (frequently) *Kamaena* cf. *magna* (R. Ivanova, 1988) *K. minima* (R. Ivanova, 1990} *K. awirsi* (Mamet et Roux, 1973) *Proninella* cf. *enigmatica* (Mamet et Roux, 1978) Brachiopods (scarce): *Schuchertella* sp., *Camarotoechia* sp., undefinable Spiriferidae and Athyridida	D_3–C_1
KU-1, block IV, 1700.4–1725.4	Single-chamber foraminifers: *Diplosphaerina minima* (Suleimanov, 1948) *Eotuberitina reitlingerae* (Miklukho-Maclay, 1958), *Parathuramminites suleimanovi* (Lipina, 1950) *Parathurammina irregulariformis* (Zadorozhnyi et Juferev, 1984), *Ivanovella* sp.	D_3fm, lower part
	Algae Chlorophyta: *Proninella* sp., *Issinella sainsii* Mamet et Roux, 1975	D_3–C_1
KU-1, block I, 2420.0–2451.0	Foraminifers: *Parathuramminites cushmani* (Suleimanov, 1945) *Ivanovella luginenesis* Zadorozhnyi et Juferev, 1981 *Neoivanovella* cf. *discessa* (Tchuvashov et Juferev, 1981), *Neoarchaesphaera* sp., *Septaglomospiranella* ex gr. *crassa* Reitlinger 1961 – rare	D_3fm, middle part
KU-1, block II, 2079.8–2114.3	Foraminifers: *Parathurammina* ex gr. *dagmarae* Suleimanov, 1945 *Ivanovella* cf. *longiaculeata* (Zadorozhnyi et Juferev, 1981), *Neoivanovella discessa* Tchuvashov et Juferev 1981, *Septaglomospiranella* (?) sp. indet. (single, 2109.6–2114.3)	D_3fm, middle part
	Brachiopods: *Streptorhynchus matyricus* (Nalivkin, 1934) *Camarotoechia turanica* (Romanovsky, 1878) *C.* ex gr. *kasakhstanica* (Rozman, 1962) *C.* cf. *zadonica (*Nalivkin, 1934) *Dzieduszyckia* ex gr. *baschkirica* (Chernyshev, 1887) *Athyris* cf. *bayeti* (Rigau, 1908) Spiriferida Cyanobacteria: *Ortonella kershopensis* (Garwood, 1931) Rhodophyta: *Parachaetetes* sp., *Solenopora* sp. Problematic: *Tubus vermis* (Bogush et Juferev, 1962) *T.* cf. *agapovensis* R. (Ivanova, 1988)	
KU-1, block IV, 1580.1–1589.2	Foraminifers: *Septatournayella* ex gr. *rauserae* (Lipina, 1955), *Septaglomospiranella* cf. *kazakhstanica* Reitlinger, 1961, *Quasiendothyra (Eoendothyra)* ex gr. *communis* (Rauser-Chernousova 1948), *Q.* (*E.)* cf. *simplex* (Brazhnikova, 1962)	D_3fm, upper part
KU-1, block I, 2313.4–2321.4; ЕК-55, 852.0, 901.0; ЕК-49, 699.7–798.9; ЕК-53, 791.6–800.0	Foraminifers: *Septaglomospiranella kazakhstanica*, *Quasiendothyra (Eoendothyra) regularis* (Lipina, 1955), *Q. (Quasiendothyra) kobeitusana* (Rauser-Chernousova, 1948) *Q. (Q.) mirabilis* (N. Tchernysheva, 1952) *Q. (Q.) konensis* (Lebedeva, 1956) *Klubovella* sp.	D_3fm, upper part

EK-49, 728.8–787.0	Bryozoans: *Streblascopora devonica* (Tolokonnikova, 2012) *Rhombotrypella ancestralis* (Nekhoroshev, 1977) *Fistulipora praetubulosa* (Lu, 1999) *Spinofenestella ischimica* (Troizkaya, 1968) *S. undulata* (Troizkaya, 1975) *Cheilotrypa kurganica* (Tolokonnikova, 2012) *Intrapora kasakhstanica* (Nekhoroshev, 1960) *Minilya* cf. *nurensis* (Nekhoroshev, 1977)	D_3fm, upper part
KU-1, block IV, 1525.1–1526.9	Brachiopods (scarce): *Orbinaria fallax* (Pander, 1862) *Semiproductus amplus* (Bublichenko, 1956) *Schuchertella* sp. *Dalejina* (?) sp. *Camarotoechia panderi* (Semenov and Moeller, 1864) *C. volucera* (Nalivkin, 1979) *Athyris tobolica (*Nalivkin, 1937) *Cleiothyridina tenuilineata* (Rowley, 1900) *Cl.* ex gr. *pectinata* (Semenov and Moeller, 1864) *Retzia* (?) sp.	D_3fm, upper part
KU-1, block I, 2314.2	*Cyrtospirifer* sp.	D_3fm
EK-49, 753.1–764.7	Brachiopods (scarce): *Cyrtospirifer* ex gr. *sibiricus* (Lebedev, 1916)	D_3fm, upper part
EK-53, 791.6–800.0	Brachiopods (scarce): *Cyrtospirifer sibiricus*, *C. kobeitusensis* (Martynova, 1975)	D_3fm, upper part
EK-53, 784.4–791.6	Foraminifers: *Earlandia elegans* (Rauser-Chernousova et Reitlinger, 1940) *Bisphaera malevkensis* (Birina, 1948) *B. elegans* (Vissarionova, 1950) *B. irregularis* (Birina, 1948) Brachiopods (scarce): *Mucrospirifer* cf. *pseudoposterus* (Besnossova, 1963)	C_1t, lower part C_1t
EK-53, 694.3–728.6	Foraminifers: *Chernyshinella* sp. indet. *Palaeospiroplectammina* ex gr. *tchernyshinensis* (Lipina, 1948)	C_1t, lower part
KU-1, block III, 1904.8–1910.1	Foraminifers: *Septabrunsiina* sp. *Septaglomospiranella* sp. *Granuliferella* cf. *latispiralis minima* (Lipina, 1955)	C_1t, upper part
KU-1, block III, 1860.0–1869.3	Bryozoans: *Crustopora elegans* (Tolokonnikova, 2014) *Eostenopora carbonica* (Tolokonnikova, 2014) *Primorella variata* (Tolokonnikova, 2015) *Triznotrypa tenuilignata* (Trizna, 1958) *Tr. uvatica* (Tolokonnikova, 2014) *Nikiforovella tobolensis* (Tolokonnikova, 2015)	C_1t, upper part
KU-1, block III, 1860.0–2012.9	Brachiopods (scarce): *Orbiculoidea* (?) sp. *Marginatia* sp. indet. *Schuchertella* sp. *Camarotoechia* cf. *tersiensis (*Sokolskaja, 1963) *C.* ex gr. *elegantula* (Rowley, 1900) *Cleiothyridina kusbassica (*Besnossova, 1963) *Tulathyris* cf. *subpyriformis* (Semenov and Moeller, 1864) *Spirifer missouriensis* (Swallow, 1860) *Mesochorispira* ex gr. *theodorovitshi* (Fotieva, 1972) *M.* cf. *grimesi* (Hall, 1858) *Brachythyris* ex gr. *suborbicularis* (Hall, 1858) *Tylothyris* cf. *laminosus* (M'Coy, 1844) *Phricodothyris* (?) sp. *Punctospirifer* (?) sp.	C_1t, upper part

KU-1, block V, 1330.3–1331.8; 1358.7–1369.1	Foraminifers: *Earlandia moderata* (Malakhova, 1954) *E. minor* (Rauser-Chernousova, 1948) *Septabrunsiina* cf. *krainica* (Lipina, 1948) *S.* cf. *kingirica* (Reitlinger, 1961) *Neoseptaglomospiranella* cf. *quadriloba* (Dain, 1953) *N.* ex gr. *karakubensis* (Brazhnikova et Vdovenko, 1971), *Chernyshinella (Chernyshinella)* ex gr. *glomiformis* (Lipina, 1948), *Endochernyshinella* cf. *gelida* (Durkina, 1959) *Rectochernyshinella* cf. *distorta* (Lipina, 1965) *Granuliferella latispiralis* (Lipina, 1955) *Gr.* cf. *borealis (*Bogush, 1980) *Latiendothyranopsis grandis* (Lipina, 1955) *Laxoendothyra parakosvensis* (Lipina, 1955) *L. antiqua* (Rauser-Chernousova, 1948) Algae Chlorophyta: *Issinella devonica* (Reitlinger, 1954) *Kamaena awirsi* (Mamet et Roux, 1973) *Kamaenella tenius* (Moeller, 1880) *Exvotarisilla index* (Ehrenberg, 1854 emend. Moeller, 1880)	C_1t, upper part
KU-1, block V, 1434.0–1435.5	Bryozoans: *Fenestella* sp., *Rectifenestella* sp., *Klaucena* sp. *Nicklesopora simulatrix* (Ulrich, 1884)	C_1t, upper part
EK-44, 429.5–449.2	Foraminifers: *Earlandia moderata* (Malakhova, 1954) *E. elegans* (Rauser-Chernousova et Reitlinger, 1940) *Neoseptaglomospiranella* cf. *rauserae* (Dain, 1953) *N.* cf. *quadriloba* (Dain, 1953) *Pseudoplanoendothyra* cf. *rotai* (Dain in Brazhnikova, 1962) *Inflatoendothyra* sp. *Laxoendothyra* sp. *Granuliferella latispiralis* (Lipina, 1955) *Gr. latispiralis minima* (Lipina, 1955) *Mediendothyra posneri* (Ganelina, 1956) *M.* cf. *wjasmensis* (Ganelina, 1956) *Latiendothyranopsis* (?) sp., *Plectogyrina* ex gr. *fomichaensis* (Lebedeva, 1954)	C_1t, upper part
EK-44, 436.5–506.4	Bryozoans: *Polyporella spininodata* (Ulrich, 1890) *P. biseriataformis* (Nekhoroshev, 1956) *Rectifenestella bukhtarmensis* (Nekhoroshev, 1956) *R. cesteriensiformis* (Nekhoroshev, 1956) *R.* aff. *nododorsalis* (Ulrich,1890) *Sulcoretepora toimensis* (Tolmachev, 1924) *S. altaica* (Nekhoroshev, 1956) *S. nurensis* (Nekhoroshev, 1953) *S. regularis* (Tolokonnikova, 2015) *Pseudonematopora sibirica* (Tolokonnikova, 2012) *Nikiforovella ulbensis* (Nekhoroshev, 1956) *Mackinneyella maccoyana* (Ulrich, 1890) *Cystodictya* aff. *lineata* (Ulrich, 1884) *Minilya triangularis* (Nekhoroshev, 1956)	C_1t, upper part
EK-44, 429.5–541.0	Brachiopods: *Leptagonia analoga* (Phillips, 1836) *Megachonetes zimmermanni* (Paeckelmann, 1930) *Plicochonetes* cf. *kingiricus* (Nalivkin, 1937) *Dictyoclostus* ex gr. *deruptus* (Romanovsky, 1878) *Mesochorispira* ex gr. *subgrandis* (Rotai, 1938)	C_1t, upper part – C_1v, lower part

KU-1, block VI, 1080.1-1098.8	Bryozoans: *Sulcoretepora* cf. *minor* (Nekhoroshev, 1956) *Nikiforovella multipitata* (Trizna, 1958) *Polyporella radialis* (Ulrich, 1890) *Minilya triangularis* (Nekhoroshev, 1953) *Triznotrypa lamosa* (Balakin, 1975) Brachiopods: *Schuchertella* sp., *Rugosochonetes* aff. *illinoisensis taidonensis* (Sokolskaja, 1962) *Marginatia* sp., *Rhynchopora* aff. *coopensis* (Shumard, 1855) *Eumetria* cf. *kasachstanica* (Simorin, 1949), *Spirifer* cf. *aschliariki* (Simorin, 1941) *Unispirifer* sp. indet. Spores: *Punctatisporites* sp., *Stenozonotriletes* sp., *S. marginellus* (Luber, 1938) *S.* aff. *limbosus* ((Andreeva) Ischenko, 1952) *Vallatisporites* sp., *Lophozonotriletes curvatus* (Naumova, 1953)	C_1t, upper part – C_1v, lower part
KU-1, block VI, 1009.3–1058.5	Bryozoans: *Dyscritella* aff. *tenuata* (Dunaeva, 1964) *Rhombopora novitia* (Trizna, 1958) *Pseudopolypora karakingirensis* (Nekhoroshev, 1953) *Sulcoretepora altaica* (Nekhoroshev, 1956) *Tabulipora corticosa* (Nekhoroshev, 1956) *Crustopora* aff. *lubrica* (Trizna, 1958) *Rectifenestella* cf. *simulans* (Nekhoroshev, 1953) *R. cesteriensiformis* (Nekhoroshev, 1956) *R. cesteriensis* (Ulrich, 1890) *R. triserialis* (Ulrich, 1890) Brachiopods: *Rugosochonetes* cf. *ischimicus (*Nalivkin, 1937) *Plicochonetes* cf. *nalivkiniformis* (Aksenova, 1969) *Dictyoclostus deruptus*, *Marginatia* ex gr. *mirabilis* (Litvinovich, 1969) *Spirifer* ex gr. *kasachstanensis (*Simorin, 1936) *Syringothyris* sp. indet., *Unispirifer* sp. indet.	C_1t, upper part – C_1v, lower part
KU-1, block VI, 1051.1	Fishes *Paleoniscus* sp. Conodonts: *Idioprioniodus* cf. *cojunctus* (Gunnell, 1931), *Adetognathus* cf. *unicornis* (Rexroad et Barton, 1961)	C_1
KU-1, block VI, 887.9–923.6	Spores: *Punctatisporites platyrugosus* ((Waltz) Sullivan, 1964) *Punctatisporites glabratus* ((Luber) Luber, 1955) *P.* aff. *rauserae* ((Naumova) Byvscheva, 1985) *Stenozonotriletes marginellus (*Luber, 1938) *Triguitriletes* sp., *Auroraspora* aff. *granulatipunctata* ((Hoffmeister, Staplin et Malloy) Turnau, 1975)	C_1v
KU-1, block VI, 710.0–718.8	Spores: *Punctatisporites platyrugosus* ((Waltz) Sullivan, 1964) *Lycospora* aff. *pusilla* ((Ibrahim) Somers, 1972) *Euryzonotriletes planus (*Naumova, 1941) *Simozonotriletes minutus (*Ischenko, 1956) *Acantotriletes parvispinus (*Naumova, 1953) *Stenozonotriletes* sp.	C_1v

KU-1, block VI, 548.7–557.3	Foraminifers: *Earlandia moderata* (Malakhova, 1954) *E. minor* (Rauser-Chernousova, 1948) *Donodiscus explanatus* (Vdovenko, 1970) *Ammarchaediscus eospirillinoides* (Brazhnikova, 1967), *Planoarchaediscus spirillinoides* (Rauser-Chernousova, 1948), *Uralodiscus* cf. *rotundus* (N. Tchernysheva, 1948), *Paraarchaediscus dubitabilis* (Orlova, 1955) *P.* ex gr. *regularis* (Brazhnikova, 1973) *Glomodiscus* sp., *Omphalotis minima* (Rauser-Chernousova et Reitlinger, 1936), *Globoendothyra (Eogloboendothyra) ukrainica* (Vdovenko, 1967) *Globoendothyra numerabilis* (Vissarionova, 1948), *Gl.* cf. *globulus* (Eichwald, 1878), *Eoendothyranopsis* sp., *Palaeotextularia* sp. Brachiopods: Strophomenida, Productidina, *Syringothyris* ex gr. *sibirica* (Sokolskaja, 1963)	C_1v, lower part
KU-1, block VI, 551.1	Spores: *Punctatisporites glabratus (*(Luber) Luber 1955) *Vallatisporites* sp., *Auroraspora* aff. *granulatipunctata* ((Hoffmeister, Staplin et Malloy) Turnau, 1975) *Lycospora* sp., *L.* aff. *pussilla* ((Ibrahim) Somers, 1972) *Granulatisporites arcuatus (*Oschurkova, 1976) *Stenozonotriletes marginellus* (Luber, 1938)	C_1v
KU-1, block VI, 540.0–548.7	Foraminifers: *Ammarchaediscus eospirillinoides* (Brazhnikova, 1967) *Planoarchaediscus spirillinoides* (Rauser-Chernousova, 1948) *Viseidiscus primaevus* (Pronina, 1963) *Uralodiscus rotundus* (N. Tchernysheva, 1948) *U. rotundus elongatus* (Conil et Lys, 1964) *U. rotundus inflatus* (Conil et Lys ,1964) *Paraarchaediscus dubitabilis* (Orlova,1955) *P. oblongus* (Conil et Lys, 1964) *Glomodiscus spira* (Conil et Lys, 1964) *Gl. pseudoinfantus* (Brazhnikova, 1973) *Gl. spiroides* (Popova, 1970) *Gl. infera* (Brazhnikova, 1973) *Archaediscus pauxillus* (Schlykova, 1951) *Pseudoplanoendothyra* cf. *rotai* (Dain in Brazhnikova, 1962), *Dainella* cf. *elegantula* (Brazhnikova, 1962) *D. micula* (Postojalko, 1970) *Endothyra prisca* (Rauser-Chernousova et Reitlinger, 1936), *Omphalotis frequentata* (Ganelina, 1956), *Globoendothyra (Eogloboendothyra)* ex gr. *ukrainica* Vdovenko 1967, *Globoendothyra* sp. indet., *Plectogyranopsis* cf. *regularis* (Rauser-Chernousova, 1948), *Eoendothyranopsis* ex gr. *donica* (Brazhnikova et Rostovzeva, 1967), *E.* cf. *ermakiensis* (Lebedeva, 1954) *E.* ex gr. *subtilis* (M. F. Solovjeva, 1967) *E.* cf. *rara* (Grozdilova, 1954) *E.* cf. *pressa* (Grozdilova) *Eoparastaffella* ex gr. *simplex* (Vdovenko, 1954) *Eostaffella* (?) sp.	C_1v, lower part
KU-1, block VI, 540.3–540.6	Brachiopods: *Plicochonetes* sp. indet. *Pustula* sp. indet. Dictyoclostinae Linoproductidae *Globosoproductus* sp. indet. *Composita* sp. *Spirifer* ex gr. *soschkini* (Litvinovich, 1962) *Phricodothyris* sp. indet.	C_1v, lower part

part *Viseidiscus eospirillinoides – Glomodiscus oblongus* Zone in the Czech Republic [41] and with the MFZ11 in the FBB [38].

The genus *Globosoproductus* appears within the Beds with *Uralodiscus rotundus – Eoendothyranopsis ermakiensis*. Its occurrence limits the age of the deposits to the upper lower Visean. This genus the most ancient representative of the Gigantoproductini, and it occurs chiefly in the lower upper Visean in the EEP, Urals, Kazakhstan and Central Asia

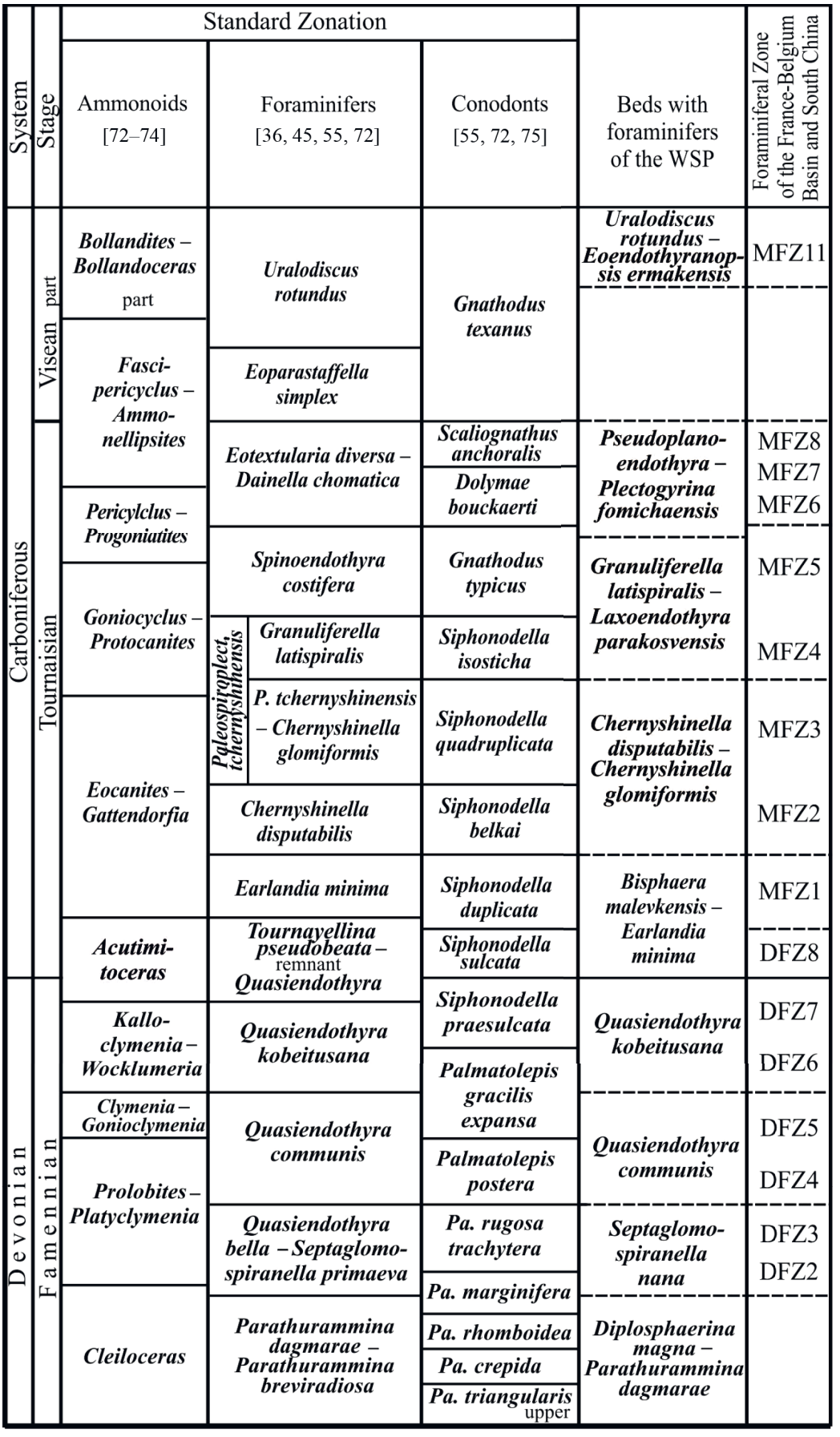

Figure 6. Comparison of foraminiferal zones of the WSP with remote regions. Abbreviations: WSP, Western Siberian Plate; *P.*, *Palaeospiroplect.*, *Palaeospiroplectammina*; *Pa.*, *Palmatolepis*

Рисунок 6. Корреляция фораминиферовых зон Западно-Сибирской плиты с удаленными регионами. Сокращения: WSP, Западно-Сибирская плита; *P.*, *Palaeospiroplect.*, *Palaeospiroplectammina*; *Pa.*, *Palmatolepis*

[70]. In single locations of the EUS, it appears in the upper Ustgrekhovkian Regional Substage, lower Visean [29, 71].

Conclusions

The results of the study of Kurgan region sedimentary formations allowed us to revise ideas about the geological structure, lithological-facial features and stratigraphy of the WSP basement within the Uvatka structural-facies subzone. For the first time in this area, the widespread distribution of deposits of the Famennian stage (the Upper Devonian), Tournaisian stage and Lower Visean substage (the Lower Carboniferous) characterized by organic remains was established. The Famennian and most of the Tournaisian deposits are represented by marine shelf facies. Lagoon formations are found in the lower Tournaisian deposits. The lower Visean deposits are represented by alternating marine and continental facies.

Dating, stratigraphic subdivision and correlation of deposits are based on foraminifera, bryozoans, brachiopods, algae and spore-pollen complexes. The sequence of foraminiferal assemblages corresponds to the zonation adopted for the WSP and the zonal scheme of the General Stratigraphic Scale (GSS) of Russia (Fig. 6). Based on bryozoans and brachiopods, reference "Beds with fauna" have been recognized, which are linked to foraminiferal zones and beds. Associations of foraminifera, bryozoans and brachiopods are most similar to the communities of the Kazakhstan continent's shelf and the Kuznetsk Basin of the Angarides. Spore-pollen assemblages are typical of the Lower Carboniferous of the EEP, the Urals and the Karaganda Basin of Kazakhstan. The foraminiferal zones were correlated with coeval formations in remote areas – the EEP, the DDR, the FBB and Southern China. The research results will make it possible to further detail the stratigraphic schemes of the WSP. This information significantly complements the international database of Upper Devonian and Lower Carboniferous deposits and provides a global correlation of deposits in this stratigraphic range.

Acknowledgements

First of all, the authors are deeply grateful to the late co-author Larisa Ivanovna Mizens (IGG UB of RAS). She did a lot of work to create this paper: from identifying brachiopods to writing some parts of the text. Unfortunately, shortly before the paper was submitted for publication, Larisa Ivanovna passed away.

The authors are grateful to T. V. Stukova for the assistance in determining the systematic affiliations of palynologic associations in accord with the current classification and in elaborating the age determinations for the continental deposits. We are also grateful to V. V. Chernykh for identification of conodonts and for a number of valuable comments that have helped to improve the quality of the manuscript.

Funding Information

This work was supported by the State Programs of IGG UBR RAS, Russia: 123011800010-5, 123011800013-6.

REFERENCES

1. Yekhlakov Yu. A., Ugryumov A. N., Sanfirova S. S. 2010, New data on geological structure of the Paleozoic basement of south of Kurgan region (according to the study of Kurgan-Uspenskaya borehole). *Gornye vedomosti* [Mining Statements], no. 5, pp. 34–51. (*In Russ.*)
2. Mizens G. A., Kucheva N. A., Stepanova T. I., Mizens L. I., Tolokonnikova Z. A., Ivanova R. M., Ryl'kov S. A. 2011, Stratigraphy and sedimentary environments of Devonian and Carboniferous deposits in Tobol-Ubagan uplift and Vagay-Ishim depression (south-western districts of Western Siberia). *Litosfera* [Lithosphere], no. 4, pp. 20–44. (*In Russ.*)
3. Stepanova T. I., Kucheva N. A., Mizens G. A., Ivanova R. M., Mizens L. I., Tolokonnikova Z. A., Ryl'kov S. A. 2011, Stratigraphy of Paleozoic section uncovered by Kurgan-Uspenskaya-1 key borehole (Western Siberia south-west margin). *Litosfera* [Lithosphere], no. 3, pp. 3–21. (*In Russ.*).
4. Ivlev A. I. 2008, Magmatism and geodynamics of the junction area of the Urals and Kazakhstan. Rudnyy; Kostanay, 500 p. (*In Russ.*)
5. 1999, Decisions of the Interdepartmental Meeting on the review and adoption of a regional stratigraphic scheme of the Paleozoic formations of the West Siberian Plain. V. I. Krasnov (ed.). Novosibirsk, 80 p. (*In Russ.*)
6. Krasnov V. I. et al. 2012, Regional stratigraphic scheme of the Devonian formations of the West Siberian oil and gas province. Novosibirsk, 43 p. (*In Russ.*)
7. Mazina Ye. A., Ovechkin N. K. 1961, Tectonics. N. K. Ovechkin (ed.). Geological structure of the Turgai trough: Proceedings VSEGEI, vol. 53, pp. 223–258. (*In Russ.*)
8. Puchkov V. N. 2010, Geology of the Urals and Cis-Urals (actual problems of stratigraphy, tectonics, geodynamics and metallogeny). Ufa, 280 p. (*In Russ.*)
9. Puchkov V. N. 2018, Plumes – a new word in Geology of the Urals. *Litosfera* [Lithosphere], no. 4, pp. 483–499. (*In Russ.*) https://doi.org/10.24930/1681-9004-2018-18-4-483-499
10. Nalivkin D. V. 1947, Class Brachiopoda. D. V. Nalivkin, V. N. Weber (eds.). Atlas of the main forms of fossil faunas of the USSR. Vol. 3, Devonian system. Leningrad, pp. 63–134. (*In Russ.*)
11. Mizens A. G. 2012, Brachiopods and biostratigraphy of the Upper Devonian of the Middle and Southern Urals. Ekaterinburg, 324 p. (*In Russ.*)
12. Bogush O. I., Juferev O. V. 1990, Division and correlation of boundary sediments of the Devonian and Carboniferous of Siberia and the North-East according to foraminifers. New in paleontology and stratigraphy of the Paleozoic in the Asian part of the USSR. Novosibirsk, pp. 111–119. (*In Russ.*)
13. Timokhina I. G., Klets A. G., Bochkarev V. S. 2002, Foraminifers of the Famennian Stage on the West Siberian Plate. Yelkin Ye. A., Kanygin A. V., N. V. Sennikov (eds.). News of paleontology and stratigraphy: Supplement to the Journal of Geology and Geophysics, vol. 43, issue 5, pp. 123–135. (*In Russ.*)
14. Ivanova R. M., Stepanova T. I. 2011, Upper Devonian calcareous algae of the southern Western Siberia (*Quasiendothyra kobeitusana* Zone). *Litosfera* [Lithosphere], no. 3, pp. 22–38. (*In Russ.*)
15. Bogush O. I., Ivanova R. M., Luchinina V. A. 1990, Calcareous algae of the Upper Famenian and Lower Carboniferous of the Urals and Siberia. Novosibirsk, 202 p. (*In Russ.*)
16. Tolokonnikova Z. A. 2012, Late Devonian bryozoans of the Borovskoye zone (southwest of Western Siberia). *Litosfera* [Lithosphere], no. 3, pp. 22–30. (*In Russ.*)
17. Mizens A. G., Mizens L. I. 2021, Upper Devonian brachiopods from the core of the Kurgan-Uspenskaya-1 key borehole (South-Western outlying areas of Western Siberia). *Litosfera* [Lithosphere], vol. 21, no. 4, pp. 560–573. (*In Russ.*) https://doi.org/10.24930/1681-9004-2021-21-4-560-573
18. Sarycheva T. G., Sokol'skaya A. N., Beznosova G. A., Maksimova S. V. 1963, Carboniferous brachiopods and paleogeography of the Kuznetsk bassin. T. G. Sarycheva (ed.). Proceedings of PIN AN SSSR, vol. XCV, 548 p. (*In Russ.*)
19. Bogush O. I. 1985, Foraminifers and stratigraphy of the Carboniferous of the West Siberian Plate. Biostratigraphy of the Paleozoic of Western Siberia. V. N. Dubatolov, A. V. Kanygin (eds.). Novosibirsk, pp. 49–68 (*In Russ.*)

20. Timokhina I. G. 2008, Significance of foraminifers for Carboniferous biostratigraphy of West-Siberian geosyneclise. N. V. Sobolev (ed.). News of paleontology and stratigraphy: Supplement to the journal Geology and Geophysics, vol. 49, issue 10-11, pp. 170–172. (*In Russ*.)
21. Tolokonnikova Z. A. 2014, Trepostome bryozoans from the Lower Carboniferous deposits of the southwestern part of the West Siberian Plain. *Geologiya i mineral'nye resursy Sibiri* [Geology and mineral resources of Siberia], no. 3(19), pp. 18–24. (*In Russ*.)
22. Tolokonnikova Z. A. 2015, New Tournaisian bryozoans (Mississippian, Lower Carboniferous) of Kurgan region, Russia. *Paleontologicheskiy zhurnal* [Paleontological journal], no. 6, pp. 43–47. (*In Russ*.)
23. Nekhoroshev V. P. 1956, Lower Carboniferous bryozoans of the Altai and Siberia. Proceedings of VSEGEI, vol. 13, 418 p. (*In Russ*.)
24. Trizna V. B. 1958, Early Carboniferous bryozoans of the Kuznetsk basin. Proceedings of VNIGRI, issue 122, 433 p. (*In Russ*.)
25. Goryunova R. V., Morozova I. P. 1979, Late Paleozoic bryozoans of Mongolia. Proceedings of Joint Soviet-Mongolian expedition, issue 9, 139 p. (*In Russ*.)
26. Nalivkin D. V. 1979, Tournaisian brachiopods of the Urals. Leningrad, 248 p. (*In Russ*.)
27. Tolokonnikova Z. A. 2016, New data on Tournaisian bryozoans (Lower Carboniferous) of Azerbaijan and Armenia. *Paleontologicheskiy zhurnal* [Paleontological journal], no. 4, pp. 68–75. (*In Russ*.)
28. Oshurkova M. V., Dryagina L. L., Shvartsman Ye. G. 1990, Palynostratigraphy of Carboniferous deposits. Practical Palynostratigraphy. L. A. Panova, M. V. Oshurkova, G. M. Romanovskaya (eds.). Leningrad, pp. 33–59. (*In Russ*.)
29. Shcherbakov O. A., Postoyalko M. V., Shcherbakova M. V., Chuvashov B. I., Kucheva N. A., Stepanova T. I. 1993–1994, Stratigraphy scheme of the Urals' coal deposits. N. Ya. Antsygin, K. K. Zoloyev, M. L. Klyuzhina, V. A. Nasedkina, B. A. Popov, B. I. Chuvashov, M. V. Shurygina, O. A. Shcherbakov, V. M. Yakushev (eds.). Explanatory note to the stratigraphic schemes of the Urals (Precambrian, Paleozoic). Ekaterinburg, p. 97–127. (*In Russ*.)
30. Oshurkova M. V. 2003, Morphology, classification and description of late Paleozoic myospore form-genera. St. Petersburg, 377 p. (*In Russ*.)
31. Klets A. G. 2005, Upper Paleozoic of marginal seas of Angarida. Novosibirsk, 240 p. (*In Russ*.)
32. Mizens G.A., Stepanova T. I., Kucheva N. A., Sapurin S. A. 2014, Geochemical features of limestones and sedimentation conditions on an isolated carbonate platform in the late Devonian and early Carboniferous on the eastern margin of the Urals. *Litosfera* [Lithosphere], no. 6, pp. 53–76. (*In Russ*.)
33. Rzhonsnitskaya M. A., Kulikova V. F. 1990, Decision of the Interdepartmental Regional Stratigraphic Meeting on the Middle and Upper Paleozoic of the Russian Platform with regional stratigraphic schemes. Devonian system (Leningrad, 1988). Leningrad, 58 p. (*In Russ*.)
34. Fortunatova N. K., Zaytseva Ye. L., Bushuyeva M. A., Shvets-Teneta-Guriy A. G., Baranova A. V., Kononova L. I., Rakhimova Ye. V., Mikheyeva A. I., Oleneva N. V., Avdeyeva A. A. 2018, Unified subregional stratigraphic scheme of the Upper Devonian deposits of the Volga-Ural Subregion: Explanatory note. Moscow, 63 p. (*In Russ*.)
35. Nasedkina V. A., Maslov V. A., Zenkova G. G., Artyushkova O. V., Segedin R. D. 1993–1994, Scheme of stratigraphy of the Devonian deposits of the Urals. N. Ya. Antsygin, K. K. Zoloyev, M. L. Klyuzhina, V. A. Nasedkina, B. A. Popov, B. I. Chuvashov, M. V. Shurygina, O. A. Shcherbakov, V. M. Yakushev (eds.). Explanatory note to the stratigraphic schemes of the Urals (Precambrian, Paleozoic). Ekaterinburg, pp. 72–90. (*In Russ*.)
36. Kulagina E. I., Stepanova T. I., Zaytseva Ye. L., Gorozhanina Ye. N., Gibshman N. B., Ivanova R. M., Vevel' Ya. A., Ponomarova G. Yu., Filimonova T. V. 2018, Atlas of Upper Devonian and Lower Carboniferous foraminifers and microfacies of northern Eurasia. Famennian and Tournaisian. E. I. Kulagina, T. I. Stepanova (eds.). Moscow, 221 p. (*In Russ*.)
37. Nikitin I. F. 1991, Decisions of the III Kazakhstan Stratigraphic Conference on the Precambrian and Phanerozoic. Part I. Precambrian and Paleozoic. Alma-Ata, pp. 3–7, 110–135. (*In Russ*.)
38. Poty E., Devuyst F.-X., Hance L. 2006, Upper Devonian and Mississippian foranimiferal and rugose coral zonations of Belgium and northern France: a tool for Eurasian correlations. *Geological Magazine*, vol. 143, issue 6, pp. 829–857. https://doi.org/10.1017/S0016756806002457
39. Kalvoda J. 1990, Foraminiferal zonation of the Upper Devonian and Lower Carboniferous in Moravia (Czechoslovakia). *Acta Musei Moraviae, scientiae naturales*, vol. 75, pp. 71–93.
40. Kalvoda J. 2002, Late Devonian – Early Carboniferous Foraminiferal Fauna: Zonation, Evolutionary Events, Paleobiography and Tectonic Implications. Brno: Masaryk University, Czech Republic, 217 p.
41. Hance L., Hou H., Vachard D., Devuyst F.X., Kalvoda J., Poty E. & Wu X. 2011, Upper Famennian to Visean Foraminifers and some carbonate Microproblematica from South China – Hunan, Guangxi and Guizhou. Beijing: Geological Publishing House, 359 p.
42. Martynova M. V. 1961, Stratigraphy and brachiopods of the Famennian stage of the western part of Central Kazakhstan. A. A. Bogdanova (ed.). Moscow, 211 p. (*In Russ*.)
43. Rozman Kh. S. 1962, Stratigraphy and brachiopods of the Famennian Mugodzhary and adjacent areas. Moscow, issue 50, 228 p. (*In Russ*.)
44. Brazhnikova N. Ye, Ayzenverg D. Ye., Berchenko O. I., Vinnichenko L. V., Poletayev V. I. 1988, Devonian and Carboniferous boundary deposits of the Donets Basin. V. K. Golubtsov (ed.). The Devonian-Carboniferous boundary in the USSR. Minsk, pp. 70–78. (*In Russ*.)
45. Kulagina E. I., Zaytseva E. L., Vevel Y. A., Stepanova T. I., Gibshman N. B., Nikolaeva S. V., Kononova L. I., Plotitsyn A. N. 2021, The foraminiferal zonal scale of the Devonian-Carboniferous boundary beds in Russia and Western Kazakhstan and its correlation with ammonoid and conodont scales. *Palaeobiodiversity and Palaeoenvironments*, vol. 101, no. 2, pp. 561–588. https://doi.org/10.1007/s12549-020-00439-y; https://www.elibrary.ru/fghkjp
46. Krasnov V. I. 1982, Decisions of the All-Union Conference on the development of unified stratigraphic schemes for the Precambrian, Paleozoic and Quaternary systems of Central Siberia. Part II. Middle and Upper Paleozoic. Novosibirsk, 130 p. (*In Russ*.)
47. Gutak Ya. M., Rodygin S. A., Peregoyedov L. G., Makarenko S. N., Antonova V. A. 2018, Regional Devonian Stratigraphic Scale for the Western Part of the Altai-Sayan Fold Region (new edition). *Geologiya i mineral'no-syr'evye resursy Sibiri* [Geology and mineral resources of Siberia], no. 1(33), pp. 3–13. (*In Russ*.)
48. Kalvoda J., Kumpan T., Bábek O. 2015, Upper Famennian and Lower Tournaisian sections of the Moravian Karst (Moravo-Silesian Zone, Czech Republic): a proposed key area for correlation of the conodont and foraminiferal zonations. *Geological Journal*, vol. 50, issue 1, pp. 17–38. https://doi.org/10.1002/gj.2523
49. Nekhoroshev V. P. 1960, Some types of Paleozoic cryptostomata. New species of ancient plants and invertebrates of the USSR. Moscow, pp. 268–283 (*In Russ*.)
50. Nekhoroshev V. P. 1977, Devonian bryozoans of Kazakhstan. Moscow, 192 p. (*In Russ*.)
51. Troitskaya T. D. 1968, Devonian bryozoans of Kazakhstan. Moscow, 237 p. (*In Russ*.)
52. Lu L. 1999, Famennian-Tournaisian bryozoans of the Aergati Mt., NW Xinjiang. Palaeozoic fossils of northern Xinjiang, China. Nanjing: Nanjing Institute of Geology and Palaeontology, Academia Sinica, vol. 37–47, pp. 142–186.
53. Litvinovich N. V., Aksenova G. G., Martynova M. V. 1975, Brachiopods. Fauna of Devonian and Carboniferous boundary deposits of Central Kazakhstan. Materials on Geology of Central Kazakhstan. Moscow, vol. XVIII, pp. 50–96. (*In Russ*.)
54. Kulagina E. I., Vevel' Ya. A., Stepanova T. I., Zaytseva Ye. L. 2016, Foraminifera Tournayellina Lipina, 1955. *Paleontologicheskiy zhurnal* [Paleontological journal], no. 6, pp. 19–32. (*In Russ*.)
55. Alekseev A. S., Nikolaeva S. V., Goreva N. V., Donova N. B., Kossovaya O. L., Kulagina E. I., Kucheva N. A., Kurilenko A. V., Kutygin R. V., Popeko L. I., Stepanova T. I. 2022, Russian Regional Carboniferous Stratigraphy. Geological Society, London, Special Publications, pp. 49–117.
56. Vdovenko M. V. 2009, Foraminiferal zones of the Lower Carboniferous of Don-Dnieper region. *Geologicheskiy zhurnal* [Geological journal], no. 4, pp. 75–86. (*In Russ*.)

57. Gozhik P. F. 2013, Stratigraphy of Upper Proterozoic and Phanerozoic of Ukraine. Vol. 1. Stratigraphy of Upper Proterozoic, Paleozoic and Mesozoic of Ukraine. Kyiv, 637 p. (*In Ukrain.*).
58. Stepanova T. I., Kucheva N. A. 2007, Refinement of the subregional stratigraphic scheme of the Lower Carboniferous of the eastern slope of the Urals. V. V. Silant'yev, G. M. Sungatullina (eds.). Upper Paleozoic of Russia: Stratigraphy and Paleogeography: Proceedings of the All-Russian Scientific Conference. Kazan, pp. 325–330. (*In Russ.*)
59. Litvinovich N. V., Aksenova G. G., Razina T. P. 1969, The stratigraphy and lithology of the Lower Carboniferous deposits of the western part of Central Kazakhstan. L. V. Vlasova (ed.). Moscow, 448 p. (*In Russ.*)
60. Bushmina L. S., Bogush O. I., Kononova L. I. 1984, Microfauna and biostratigraphy of the Lower Carboniferous. O. A. Betekhtina (ed.). Moscow, 128 p. (*In Russ.*)
61. Bogush O. I. et al. 1980, Stratigraphy of the Lower Carboniferous deposits of Central Siberia. Siberian platform. Northwestern, western, southeastern, eastern and northeastern parts of the platform. V. N. Dubatolov (ed.). Lower Carboniferous of Central Siberia. Novosibirsk, pp. 6–19. (*In Russ.*)
62. Nekhoroshev V. P. 1953, Lower Carboniferous bryozoans of Kazakhstan. Moscow, 236 p. (*In Russ.*)
63. Mikhno N. M., Balakin G. V. 1975, Foraminifers and bryozoa of the Lower Carboniferous of Chatkal mountains. T. A. Sikstel' (ed.). Tashkent, 126 p. (*In Russ.*)
64. Morozova I. P. 1981, Late Paleozoic bryozoans of north-east of the USSR. Proceedings PIN AN SSSR. Moscow, vol. 188, 120 p. (*In Russ.*)
65. Popeko L. I. 2000, Carboniferous of Mongol-Okhotsk orogenic belt. Vladivostok, 124 p. (*In Russ.*)
66. Nalivkin D. V., Fotieva N. N. 1973, Brachiopods of the Tournaisian and Visean boundary deposits of the western slope of the Urals. Moscow, 118 p. (*In Russ.*)
67. 1985, Atlas of spores and pollen of oil and gas bearing strata of the Phanerozoic of the Russian and Turan plates. V. V. Menner, T. V. Byvsheva (eds): Proceedings of VNIGNI, Moscow, vol. 253, 264 p. (*In Russ.*)
68. Goganova L. A., Lopatina A. I., Mamutova S. B. 2002, Atlas of the Carboniferous Flora and Fauna of the Ekibastuz Coal Basin. Karaganda, 150 p. (*In Russ.*)
69. Ivanova R. M. 2008, Lower Carboniferous of the Tyumen-Kustanai trough's Borovskoye subzone. *Litosfera* [Lithosphere], no. 2, pp. 3–24. (*In Russ.*)
70. Litvinovich N. V., Vorontsova T. N. 1991, Giagantoid brachiopods of the USSR, their distribution and stratigraphic significance. G. A. Afanas'yeva (ed.). Moscow, 61 p. (*In Russ.*)
71. Kucheva N. A., Stepanova T. I. 1999, Stratigraphy of the Carboniferous deposits of the Smolino region. *Ural'skiy geologicheskiy zhurnal* [Uralian Geological Journal], no. 3, pp. 13–46 (*In Russ.*)
72. Alekseev A. S. 2008, The Carboniferous system. Investigation of the state of precambrian and phanerozoic stratigraphy in Russia. Tasks of scientific research. Resolutions of the MSK and its commission. St. Petersburg, issue 38, pp. 61–68. (*In Russ.*)
73. Nikolaeva S. V., Bogoslovsky B. I. 2005, Late Famennian Ammonoids from the Upper Part of the Kiya Formation of the South Urals. *Paleontological Journal*, vol. 39, suppl. 5, pp. 527–537.
74. Nikolaeva S. V. 2016, Ammonoid Carboniferous Genozones: Current State and Prospects. T. Yu. Tolmacheva (ed.). General stratigraphic scale and methodological problems of development of regional stratigraphic scales of Russia: Materials of the Interdepartmental Workshop. St. Petersburg, pp. 115–117. (*In Russ.*)
75. 2004, A Geologic Time Scale 2004. F. M. Gradstein, J. G. Ogg, A. G. Smith (eds). Cambridge: Cambridge University Press, 589 p.

The article was received on December 12, 2024

УДК 551.73(571.1) http://doi.org/10.21440/2307-2091-2025-1-13-33

Геологическое строение и корреляция отложений верхнего девона и нижнего карбона Курганского региона (юго-запад Западной Сибири, Россия)

Татьяна Ивановна СТЕПАНОВА[1*]
Надежда Александровна КУЧЕВА[1**]
Гунар Андреевич МИЗЕНС[1***]
Зоя Алексеевна ТОЛОКОННИКОВА[2****]
Людмила Владимировна БАДИДА[1*****]

[1]Институт геологии и геохимии им. акад. А. Н. Заварицкого УрО РАН, Екатеринбург, Россия
[2]Кубанский государственный университет, Краснодар, Россия

Аннотация

Актуальность работы обусловлена необходимостью изучения структурно-тектонической позиции и стратиграфии доюрского фундамента Курганского региона, расположенного в зоне сочленения Западно-Сибирской плиты, Уральского складчатого пояса и складчато-глыбовых структур Центрального Казахстана, позволяющих обнаружить новые месторождения углеводородов, а также более уверенно решать теоретические вопросы геологии данной территории.

Цель исследования – расчленение и характеристика палеозойского интервала разреза по органическим остаткам – фораминиферам, брахиоподам и мшанкам (с привлечением данных по водорослям и спорово-пыльцевым комплексам) на основании изучения керна параметрической скважины Курган-Успенская-1 (КУ-1) и ряда структурно-поисковых скважин.

Методы исследования – описание и изучение литологии керна скважин, микропалеонтологические и микрофациальные исследования коллекций шлифов, изучение макромерных органических остатков.

Результаты и выводы. Рассматриваемые отложения представлены морскими шельфовыми, лагунными и континентальными фациями. Толща осадочных пород, вскрытая скважиной КУ-1, разбита взбросами на шесть разновозрастных блоков. Впервые для данной территории по органическим остаткам выполнено расчленение палеозойской части разреза и охарактеризованы фаменский ярус верхнего девона, турнейский ярус и нижняя часть визейского яруса нижнего карбона. Установлена последовательность комплексов фораминифер, в целом соответствующая зональным подразделениям Общей стратиграфической шкалы России. По мшанкам и брахиоподам выявлено несколько реперных уровней, которые выделены как слои с фауной и увязаны со слоями и зонами по фораминиферам. В составе фаунистических комплексов по систематическому составу преобладают таксоны, характерные для одновозрастных отложений Центрального Казахстана и Кузнецкого бассейна Алтае-Саянской складчатой области, в меньшей степени восточного склона Среднего Урала. Выполнена корреляция рассматриваемых образований с подразделениями смежных и удаленных регионов.

***Ключевые слова*:** геология, стратиграфия, корреляция, фаменский ярус верхнего девона, турнейский и визейский ярусы нижнего карбона, фораминиферы, брахиоподы, мшанки, Западная Сибирь, Россия.

ЛИТЕРАТУРА

1. Ехлаков Ю. А., Угрюмов А. Н., Санфирова С. С. Новые данные о геологическом строении палеозойского фундамента юга Курганской области (по данным изучения Курган-Успенской параметрической скважины) // Горные ведомости. 2010. № 5. С. 34–51.
2. Мизенс Г. А., Кучева Н. А., Степанова Т. И., Мизенс Л. И., Толоконникова З. А., Иванова Р. М., Рыльков С. А. Стратиграфия и условия образования девонских и каменноугольных отложений Тобол-Убаганского поднятия и Вагай-Ишимской впадины (юго-западная окраина Западной Сибири) // Литосфера. 2011. № 4. С. 20–44.
3. Степанова Т. И., Кучева Н. А., Мизенс Г. А., Иванова Р. М., Мизенс Л. И., Толоконникова З. А., Рыльков С. А. Стратиграфия палеозойского разреза, вскрытого параметрической скважиной Курган-Успенская-1 (юго-западная окраина Западной Сибири) // Литосфера. 2011. № 3. С. 3–21.
4. Ивлев А. И. Магматизм и геодинамика области сочленения Урала и Казахстана. Рудный; Костанай. 2008. 500 с.
5. Решения Межведомственного совещания по рассмотрению и принятию региональной стратиграфической схемы палеозойских образований Западно-Сибирской равнины / под ред. В. И. Краснова. Новосибирск: СНИИГГиМС, 1999. 80 с.
6. Региональная стратиграфическая схема девонских образований Западно-Сибирской нефтегазоносной провинции / В. И. Краснов [и др.]. Новосибирск: СНИИГГиМС, 2012. 43 с.

✉stepanova@igg.uran.ru
**kucheva@igg.uran.ru
***mizens@igg.uran.ru
*****zzalatoi@yandex.ru
******kokshina.lv@gmail.com

7. Мазина Е. А., Овечкин Н. К. Тектоника // Геологическое строение Тургайского прогиба: труды ВСЕГЕИ. 1961. Новая серия. Т. 53. С. 223–258.
8. Пучков В. Н. Геология Урала и Приуралья (актуальные вопросы стратиграфии, тектоники, геодинамики и металлогении). Уфа: «ДизайнПолиграфСервис», 2010. 280 с.
9. Пучков В. Н. Плюмы – новое слово в геологии Урала // Литосфера, 2018. № 4. С. 483–499. https://doi.org/10.24930/1681-9004-2018-18-4-483-499
10. Наливкин Д. В. Класс Brachiopoda. Атлас руководящих форм ископаемых фаун СССР. Т. 3. Девонская система. Л.: ВСЕГЕИ, Госгеолтехиздат, 1947. С. 63–134.
11. Мизенс А. Г. Брахиоподы и биостратиграфия верхнего девона Среднего и Южного Урала. Екатеринбург: ИГГ УрО РАН. 2012. 324 с.
12. Богуш О. И., Юферев О. В. Расчленение и корреляция пограничных отложений девона и карбона Сибири и Северо-Востока по фораминиферам // Новое в палеонтологии и стратиграфии палеозоя азиатской части СССР. Новосибирск: Наука. Сибир. отд-ние, 1990. С. 111–119.
13. Тимохина И. Г., Клец А.Г., Бочкарев В. С. Фораминиферы фаменского яруса Западно-Сибирской плиты // Новости палеонтологии и стратиграфии: приложение к журналу «Геология и геофизика». 2002. Т. 43. Вып. 5. С. 123–135.
14. Иванова Р. М., Степанова Т. И. Известковые водоросли верхнего девона юга Западной Сибири (зона Quasiendothyra kobeitusana) // Литосфера. 2011. № 3. С. 22–38.
15. Богуш О. И., Иванова Р. М., Лучинина В. А. Известковые водоросли верхнего фамена и нижнего карбона Урала и Сибири. Новосибирск: Наука. Сибир. отд-ние, 1990. 202 с.
16. Толоконникова З. А. Позднедевонские мшанки Боровской зоны (юго-запад Западной Сибири) // Литосфера. 2012. № 3. С. 22–30.
17. Мизенс А. Г., Мизенс Л. И. Верхнефаменские брахиоподы из керна скважины Курган-Успенская-1 (юго-западная окраина Западной Сибири) // Литосфера. 2021. № 4. С. 560–573. https://doi.org/10.24930/1681-9004-2021-21-4-560-573
18. Сарычева Т. Г., Сокольская А. Н., Безносова Г. А., Максимова С. В. Брахиоподы и палеогеография карбона Кузнецкой котловины // Труды ПИН АН СССР. 1963. Т. XCV. 548 с.
19. Богуш О. И. Фораминиферы и стратиграфия нижнего карбона Западно-Сибирской плиты // Биостратиграфия палеозоя Западной Сибири. Новосибирск: Наука. Сибир. отд-ние, 1985. С. 49–68.
20. Тимохина И. Г. Значение фораминифер для биостратиграфии карбона Западно-Сибирской геосинеклизы // Новости палеонтологии и стратиграфии: приложение к журналу «Геология и геофизика». 2008. Т. 49. Вып. 10-11. С. 170–172.
21. Толоконникова З. А. Трепостомные мшанки из отложений нижнего карбона юго-западной части Западно-Сибирской равнины // Геология и минерально-сырьевые ресурсы Сибири. 2014. № 3(19). С. 18–24.
22. Толоконникова З. А. Новые турнейские мшанки (миссисипий, нижний карбон) Курганской области, Россия // Палеонтологический журнал. 2015. № 6. С. 43–47.
23. Нехорошев В. П. Нижнекаменноугольные мшанки Алтая и Сибири // Труды ВСЕГЕИ. Новая серия. 1956. Т. 13. 418 с.
24. Тризна В. Б. Раннекаменноугольные мшанки Кузнецкой котловины // Труды ВНИГРИ. Новая серия. 1958. Вып. 122. 433 с.
25. Горюнова Р. В., Морозова И. П. Позднепалеозойские мшанки Монголии // Труды Совместной Советско-Монгольской палеонтологической экспедиции. 1979. Вып. 9. 139 с.
26. Наливкин Д. В. Брахиоподы турнейского яруса Урала. Л.: Наука, 1979. 248 с.
27. Толоконникова З. А. Новые данные о турнейских мшанках (нижний карбон) Азербайджана и Армении // Палеонтологический журнал. 2016. № 4. С. 68–75.
28. Ошуркова М. В., Дрягина Л. Л., Шварцман Е. Г. Палиностратиграфия каменноугольных отложений // Практическая палиностратиграфия. Л.: Недра, 1990. С. 33–59.
29. Щербаков О. А., Постоялко М. В., Щербакова М. В., Чувашов Б. И., Кучева Н. А., Степанова Т. И. Схема стратиграфии каменноугольных отложений Урала: объяснит. записка к стратиграфическим схемам Урала (докембрий, палеозой). Екатеринбург: УГСЭ, 1993–1994. С. 97–127.
30. Ошуркова М. В. Морфология, классификация и описания форма-родов миоспор позднего палеозоя. СПб: ВСЕГЕИ, 2003. 377 с.
31. Клец А. Г. Верхний палеозой окраинных морей Ангариды. Новосибирск: Гео, 2005. 240 с.
32. Мизенс Г. А., Степанова Т. И., Кучева Н. А., Сапурин С. А. Геохимические особенности известняков и условия осадконакопления на изолированной карбонатной платформе в позднем девоне и начале карбона на восточной окраине Урала // Литосфера. 2014. № 6. С. 53–76.
33. Ржонсницкая М. А., Куликова В. Ф. Решение Межведомственного Стратиграфического Совещания по среднему и верхнему палеозою Русской платформы с региональными стратиграфическими схемами. Девонская система (Ленинград, 1988 г.) Л.: ВСЕГЕИ, 1990. 58 с.
34. Фортунатова Н. К., Зайцева Е. Л., Бушуева М. А., Швец-Тэнэта-Гурий А. Г., Баранова А. В., Кононова Л. И., Рахимова Е. В., Михеева А. И., Оленева Н. В., Авдеева А. А. Унифицированная субрегиональная стратиграфическая схема верхнедевонских отложений Волго-Уральского субрегиона: объяснит. записка. М.: ВНИГНИ, 2018. 63 с.
35. Наседкина В. А., Маслов В. А., Зенкова Г. Г., Артюшкова О. В., Сегедин Р. Д. Схема стратиграфии девонских отложений Урала: объяснит. записка к стратиграфическим схемам Урала (докембрий, палеозой). Екатеринбург: УГСЭ, 1993–1994. С. 72–90.
36. Кулагина Е. И., Степанова Т. И., Зайцева Е. Л., Горожанина Е. Н., Гибшман Н. Б., Иванова Р. М., Вевель Я. А., Пономарёва Г. Ю., Филимонова Т. В. Атлас фораминифер и микрофаций верхнедевонских и нижнекаменноугольных отложений Северной Евразии. Фаменский и турнейский ярусы. М.: ПИН РАН, 2018. 221 с.
37. Никитин И. Ф. Решения III Казахстанского стратиграфического совещания по докембрию и фанерозою. Ч. I. Докембрий и палеозой. Алма-Ата: Казахгеология, Ин-т геол. наук, 1991. С. 3–7, 110–135.
38. Poty E., Devuyst F.-X., Hance L. Upper Devonian and Mississippian foranimiferal and rugose coral zonations of Belgium and northern France: a tool for Eurasian correlations // Geological Magazine. 2006. Vol. 143. Issue 6. P. 829–857. https://doi.org/10.1017/S0016756806002457
39. Kalvoda J. Foraminiferal zonation of the Upper Devonian and Lower Carboniferous in Moravia (Czechoslovakia) // Acta Musei Moraviae, scientiae naturals. 1990. Vol. 75. P. 71–93.
40. Kalvoda J. Late Devonian – Early Carboniferous Foraminiferal Fauna: Zonation, Evolutionary Events, Paleobiography and Tectonic Implications. Brno: Masaryk University, Czech Republic, 2002. 217 p.
41. Hance L., Hou H., Vachard D., Devuyst F. X., Kalvoda J., Poty E., Wu X. Upper Famennian to Visean Foraminifers and some carbonate Microproblematica from South China – Hunan, Guangxi and Guizhou. Beijing: Geological Publishing House, 2011. 359 p.
42. Мартынова М. В. Стратиграфия и брахиоподы фаменского яруса западной части Центрального Казахстана. М.: МГУ, 1961. Т. II. 212 с.
43. Розман Х. С. Стратиграфия и брахиоподы фаменского яруса Мугоджар и смежных районов. М.: ГИН АН СССР, 1962. Вып. 50. 228 с.
44. Бражникова Н. Е., Айзенверг Д. Е., Берченко О. И., Винниченко Л. В., Полетаев В. И. Пограничные отложения девона и карбона Донбасса // Граница девона и карбона на территории СССР. Минск: Наука и техника, 1988. С. 70–78.
45. Kulagina E. I., Zaytseva E. L., Vevel Y. A., Stepanova T. I., Gibshman N. B., Nikolaeva S. V., Kononova L. I., Plotitsyn A. N. The foraminiferal zonal scale of the Devonian-Carboniferous boundary beds in Russia and Western Kazakhstan and its correlation with ammonoid and conodont scales // Palaeobiodiversity and Palaeoenvironments. 2021. Vol. 101. No. 2. P. 561–588. https://doi.org/10.1007/s12549-020-00439-y; https://www.elibrary.ru/fghkjp

46. Краснов В. И. Решения Всесоюзного совещания по разработке унифицированных стратиграфических схем докембрия, палеозоя и четвертичной системы Средней Сибири. Ч. II. Средний и верхний палеозой. Новосибирск: СНИИГГиМС, 1982. 130 с.
47. Гутак Я. М., Родыгин С. А., Перегоедов Л. Г., Макаренко С. Н., Антонова В. А. Региональная стратиграфическая шкала девона западной части Алтае-Саянской складчатой области (новая редакция) // Геология и минерально-сырьевые ресурсы Сибири. 2018. № 1 (33). С. 3–13.
48. Kalvoda J., Kumpan T., Bábek O. Upper Famennian and Lower Tournaisian sections of the Moravian Karst (Moravo-Silesian Zone, Czech Republic): a proposed key area for correlation of the conodont and foraminiferal zonations // Geological Journal. 2015. Vol. 50. Issue 1. P. 17–38. https://doi.org/10.1002/gj.2523
49. Нехорошев В. П. Некоторые виды палеозойских криптостомат // Новые виды древних растений и беспозвоночных СССР. М.: Недра, 1960. С. 268–283.
50. Нехорошев В. П. Девонские мшанки Казахстана. М.: Недра, 1977. 192 с.
51. Троицкая Т. Д. Девонские мшанки Казахстана. М.: Недра, 1968. 237 с.
52. Lu L. Famennian-Tournaisian bryozoans of the Aergati Mt., NW Xinjiang // Palaeozoic fossils of northern Xinjiang, China. Nanjing: Nanjing Institute of Geology and Palaeontology, Academia Sinica, 1999. Vol. 37–47. P. 142–186.
53. Литвинович Н. В., Аксенова Г. Г., Мартынова М. В. Брахиоподы // Фауна пограничных отложений девона и карбона Центрального Казахстана: материалы по геологии Центрального Казахстана. М.: Недра, 1975. Т. XVIII. С. 50–96.
54. Кулагина Е. И., Вевель Я. А., Степанова Т. И., Зайцева Е. Л. Фораминиферы рода Tournayellina Lipina, 1955 // Палеонтологический журнал. 2016. № 6. С. 19–32.
55. Alekseev A. S., Nikolaeva S. V., Goreva N. V., Donova N. B., Kossovaya O. L., Kulagina E. I., Kucheva N. A., Kurilenko A. V., Kutygin R. V., Popeko L. I., Stepanova T. I. Russian Regional Carboniferous Stratigraphy // Geological Society, London, Special Publications. 2022. P. 49–117.
56. Вдовенко М. В. Фораминиферовые зоны нижнего карбона Доно-Днепровского региона // Геологический журнал. 2009. № 4. С. 75–86.
57. Гожик П. Ф. Стратиграфія верхнього протерозою та фанерозою України. Т. 1. Стратиграфія верхнього протерозою, палеозою та мезозою України. Київ: ІГН НАН України, 2013. 637 с.
58. Степанова Т. И., Кучева Н. А. Уточнение субрегиональной стратиграфической схемы нижнего карбона восточного склона Урала // Верхний палеозой России: стратиграфия и палеогеография: материалы Всерос. науч. конф. Казань: КГУ, 2007. С. 325–330.
59. Литвинович Н. В., Аксенова Г. Г., Разина Т. П. Стратиграфия и литология отложений нижнего карбона западной части Центрального Казахстана. М.: Недра, 1969. 448 с.
60. Бушмина Л. С., Богуш О. И., Кононова Л. И. Микрофауна и биостратиграфия нижнего карбона (юг Западной Сибири). М.: Наука, 1984. 128 с.
61. Стратиграфия нижнекаменноугольных отложений Средней Сибири. Сибирская платформа. Северо-западная, западная, юго-восточная, восточная и северо-восточная части платформы / О. И. Богуш [и др.] // Нижний карбон Средней Сибири. Новосибирск: Наука. Сибир. отд-ние, 1980. С. 6–19.
62. Нехорошев В. П. Нижнекаменноугольные мшанки Казахстана. М.: АН СССР, 1953. 236 с.
63. Михно Н. М., Балакин Г. В. Фораминиферы и мшанки нижнего карбона Чаткальских гор. Ташкент: ФАН, 1975. 126 с.
64. Морозова И. П. Позднепалеозойские мшанки северо-востока СССР // Труды ПИН АН СССР. 1981. Т. 188. 120 с.
65. Попеко Л. И. Карбон Монголо-Охотского орогенного пояса. Владивосток: Дальнаука, 2000. 124 с.
66. Наливкин Д. В., Фотиева Н. Н. Брахиоподы пограничных отложений турнейского и визейского ярусов западного склона Урала. М.: Наука, 1973. 119 с.
67. Атлас спор и пыльцы нефтегазоносных толщ фанерозоя Русской и Туранской плит / ред. В. В. Меннер, Т. В. Бывшева // Труды ВНИГНИ. М.: Недра, 1985. Вып. 253. 264 с.
68. Гоганова Л. А., Лопатина А. И., Мамутова С. Б. Атлас каменноугольной флоры и фауны Экибастузского угольного бассейна. Караганда, 2002. 150 с.
69. Иванова Р. М. Нижний карбон Боровской подзоны Тюменско-Кустанайского прогиба // Литосфера. 2008. № 2. С. 3–24.
70. Литвинович Н. В., Воронцова Т. Н. Гигантоидные брахиоподы СССР, их распространение и стратиграфическое значение. М.: Наука, 1991. 61 с.
71. Кучева Н. А., Степанова Т. И. Стратиграфия каменноугольных отложений Смолинского района // Уральский геологический журнал. 1999. № 3. С. 13–46.
72. Алексеев А. С. Каменноугольная система // Состояние изученности стратиграфии докембрия и фанерозоя России. Задачи дальнейших исследований: постановления МСК и его постоянных комиссий. СПб: ВСЕГЕИ, 2008. Вып. 38. С. 61–68.
73. Nikolaeva S. V., Bogoslovsky B. I. Late Famennian Ammonoids from the Upper Part of the Kiya Formation of the South Urals // Paleontological Journal. 2005. Vol. 39. Suppl. 5. P. 527–537.
74. Николаева С. В. Аммоноидные генозоны карбона: современное состояние и перспективы // Общая стратиграфическая шкала и методические проблемы разработки региональных стратиграфических шкал России: материалы Межвед. рабочего совещ. (Санкт-Петербург, 17–20 окт. 2016 г.). СПб: ВСЕГЕИ, 2016. С. 115–117.
75. A Geologic Time Scale 2004 / ed. by F. M. Gradstein, J. G. Ogg, A. G. Smith. Cambridge: Cambridge University Press, 2004. 589 p.

Статья поступила в редакцию 12 декабря 2024 года