Calcareous algae and foraminifera of the microfaunistic horizon XIII (Visean stage) of the middle part of the central paraxial zone Dnipro-Donets Depression (Ukraine)

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Abstract. Visean deposits of exploration-production well 363 Yablunivs’ka contain predominantly carbonate and argillaceous rocks from the Pryluts’ky boundary (lower Visean). This study presents limestone microfacies and foraminiferal and calcareous algal associations of the paraxial zone in the Dnipro-Donets Depression. The foraminiferal association is represented by 26 genera, whereas the algal association is composed of 24 identified species and specimens in open nomenclature representative of 31 genera, including a new species, Atractyliopsis berezovia sp. nov., and a species of calcareous algae, Asphaltina cordillerensis. Fossil associations of calcareous algae characterize Palaeoberesella lahuseni – Exvotarisella index – Nanopora woodi zone, which correlated with the foraminiferal Uralodiscus rotundus and Paraarchaediscus koktjubensis. Green algae are predominant within the calcareous algae from carbonate deposits of the core No 3. This predominance indicates a warm and shallow-water sedimentation platform. Many archedicids indicates that the bottom substrate is represented by soft silt. Well-developed radiant layer of archaediscida indicates to the favorable habitat conditions. From the middle part of the layer, the role of red algae, whose thally has a crusty and leaf-like shape, as well as green Koninckopora sp. and Coeloporella sp., begins to grow quantitatively. This indicates an insignificant shallowing of the sedimentation basin. Visean limestones belong to the facies of the open marine platform, zone 7 (shallow undathem). According to the results of micropaleontological analysis the boundary of XIIIl and XIIIu microfaunistic subhorizon of Dnipro-Donets Basin identified at the depth of 4435.96 m. The foraminifera and algae representation is given at the 8 paleontological plates.

Keywords: calcareous algae, foraminifera, microfacies, Lower Carboniferous, Visean, Dnipro-Donets Depression.
Introduction

The question of detailed stratigraphic analysis of the Lower Carboniferous deposits of the paraxial zone of Dnipro-Donetsk Depression (DDD) becomes topical. This is due to the active exploration of deep horizons of axial fields, as well as the oil and gas prospects of Visean carbonates. Micropaleontological analysis from microfaunistic horizon (MFH) XIII was actively undertaken in the 60’s decade of the 20th century. However, the Yablunivs’ka suite was discovered only in the early 90’s. Detailed research on microfossils provides new and important information for the recognition of well stratigraphy, correlation and modeling of stratigraphy and paleoecology.

For a long time, stratigraphic characterization and correlation of carbon deposits was based on foraminifera and brachiopods, and less frequently, on corals. Calcareous algal association did not receive too much attention. Detailed analysis of calcareous algal associations provides additional tools for a more accurate and detailed environmental and paleoecological reconstructions (e.g., Ivanova, 2017). Furthermore, an algal zone has been identified, which can be used for regional correlations.

Middle Mississipian foraminiferal associations becomes mostly composed of euryhaline and euryfacial archaeids. Middle Mississipian algal associations becomes facies controlled. Green and red algae gives additional information about paleoecological understanding and paleo-environment of the basin.

Analysis of previous publications

The XIII (Pryluts’ky) MFH of the DDD is microfaunistically characterized to a greater extent by wells of the southern basinal margin. For the first time the most complete microfaunistic data were found in core materials from Radchenkivs’ke (oil and gas) and Mykhaylivs’ke (gas) fields. Investigations were mainly developed in the 50’s and 60’s decades of the 20th century. However, the volumes of deep prospecting and exploration drilling reached its maximum in the 60’s – 70’s. This material allows the study of the horizons named as Yablunivs’ka suite, including XIII and XIV MFH boundary interval.

Wells in the axial and paraxial zone from Sribnens’k Depression are the most informatively described by O. I. Berchenko (1985, 1998). He described microfacies limestones and analysed the stratigraphic correlation of the calcareous algae in this region.

A comprehensive correlation studies of productive horizons DDD and MFH were proposal in the 70’s of the 20th century. Also at this time the sub-horizons of XV, XIV, XIII MFH were identified. Strata of DDD became suites and received official names in the early 90’s (Stratygrafiya…, 2013).

The Yablunivs’ka suite is distributed mainly in the central part of the DDD and is represented by a clays and carbonates (Aizenverg et al., 1988). Foraminifera of the Yablunivs’ka suite were studied by L. V. Vinnichenko, M. V. Vdovenko, S. V. Onufrishin and V. A. Pogrebnyak.

Foraminifera of the DDD were particularly studied by N. E. Brazhnikova (1952, 1967). Since the late 50’s Upper Carboniferous foraminifera of DDD were studied by L. F. Rostovtseva. In the early 21st century, foraminifera and calcareous algae of DDD were studied by V. I. Efimenko (2005, 2008). It is necessary to pay attention to the scientific work of O. I. Berchenko and O. A. Sukhov (Berchenko et Sukhov, 2013). The last study proposed a first attempt of correlation by mean of the algal associations for the boundary of XIV and XIII MFH, which are clarified and expanded in the current study.


B. Mamet, R. M. Ivanova, D. Vachard and S. Skompski studied visean calcareous algae from other regions.

In most publications of the late 20th – 21st centuries the attention was almost not paid to the correlation systematic potential of varied associations of calcareous algae. In early researches, stratigraphic subdivision in the basin was based on foraminifera, and algae mentioned only in the presence of a large number of them (1–3 species). Later publications were more paleontological in nature. However, the relationship between foraminifera and algal associations in the Donbass and DDD began to be studied only in the past 20 years.

As a result, the age of the well is dully characterized by foraminifers, whereas the algal information is scattered and covers the study area incompletely. As deep drilling in the axial zone DDD is an ongoing work, the results of micropaleontological and microfacial analysis of the core material are relevant for the lithostratigraphic correlations.

The stratigraphic breakdown by foraminifera conducted in this scientific work according to the latest schemes (Stratygrafiya…, 2013), and by calcareous algae – according to the carboniferous Urals zones (Ivanova, 2017).
Materials and methods

Microfossils researched in petrographic thin sections, from core materials of exploration-production well 363 Yablunivs’ka of Yablunivs’ke oil and gas condensate field from Poltava region of Ukraine (Fig. 1). Core material contains the following intervals:

- core No 3, interval 4424.56-4426.28 m; represented by silt argillite from gray-yellow to green-gray and black, layered-lenticular texture is emphasized by lenses and layers of siltstone material and pyrite grains.
- core No 3, interval 4426.28-4442.10 m; represented by light to dark gray organogenic-fragmentary limestone, bioturbed; black clay layers up to 2 cm occur, and light gray areas enriched with organogen-ic large detritus (brachiopod shells fragments reach 3 cm in diameter, crinoids fragments – 1.7 cm).

Samples of carbonate rocks were taken from the core material. 175 petrographic thin sections were prepared in total, oriented by layering. This research was performed using a polarizing microscope MIN-8 and microphotographs were taken with a Canon EOS 40D camera. The camera was mounted on a microscope using a universal photo nozzle in an eyepiece tube.

Results and discussion

Litology. Well 363 Yablunivs’ka contains light gray dark gray limestones with thin dark interbedded clay-carbonate detritus and curve-isometric inclusions of black argillite, and clay partings with up to 2 cm thickness.

Detailed microfacies analysis allows to distinguish twelve Visean limestone types (Fig. 2). The adopted classification is a combination of structural-genetic (Frolov, 1993) and sedimentological (Dunham, 1962) classifications. The main part of carbonate deposits is represented by polydetrital wacke-packstone (about 42 % of the total limestone content), and in a less amount, by polydetrital layered wackestone and packstone, about 11 % and 12 % respectively.

The lower part of the bed studied interval is represented by polydetrital-foraminifera wacke-packstone and wackestone. From the middle part of the interval light bioclastic polydetrital and polydetrital-algae floatstone are found, pack-floatstone occur. There are some partings of crystalline carbonate rock with preserved foraminifera and calcareous algae in these beds. From the middle part of the interval, mudstone, mude-wackstone and wack-mudestone occur. Interbedded large polydetrital packstone (with large brachiopod shells and crinoids) occur close to the top of the interval. In the uppermost part of the bed mudstone and mude-wackstone are predominant.

Micropaleontology

A diverse suite of algae is recorded, which contains 30 genera, and the foraminifera association, is representative of 26 genera (Fig. 3).

The lower part of the core No 3 contains Brunsia spirillinoaides (Grozdilova et Glebovskaya, 1948). There are many Ammarchaediscus sp. in the lower part of the studied interval. Above the interval Omphalotis sp., Lapparentidiscus sp., Pseudoammodiscus sp. are recorded, with different degree of preservation, and also the genus Earlandia including species such as Earlandia vulgaris (Rauzer-Chernousova et Reitlinger, 1937) in lower part, Earlandia minima (Birina, 1948) and Earlandia elegans (Rauzer-Chernousova et Reitlinger, 1937) in the middle part.

There are many Uralodiscus in the middle part of the interval, which are assigned to the Uralodiscus rotundus zone. In the same levels, Valvalinella sp., Globoendothyra sp., Omphalotis sp., Mediocris sp., Forschiiella sp., Eoforschia sp., Lituotubella sp. are recorded. Other
genera recorded in the older zone are still present, such as *Brunsia* (*Brunsia ovalis* (Malakhova, 1956)), *Glomodiscus* sp., *Conilidiscus* sp., *Ammarchaediscus* sp. There are many *Paraarchaediscus* cf. *stilus* (Grozdilova et Lebedeva, 1953) and *Paraarchaediscus koktubensis* (Rauzer-Chernousova, 1948) in the middle part of the interval. According to the micropaleontological research on the territory of DDD it is the norm, because the similar foraminiferal assemblages have been recorded in other boreholes in the DDD.

At the top of the studied interval *Glomospiranella* sp., *Quasiendothyra* sp., *Pseudolituotuba enormica* (Brazhnikova et Rostovtseva, 1967), *Tolypammina pseudospiralis* Malakhova, 1980, *Baituganella* sp. are identified, and *Archaediscus krestovnikovi* Rauzer-Chernousova, 1948 is first recorded.

There are many *Endothyra* spp. and *Tetrataxis* spp. all over the carbonate beds.


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**Fig. 2.** Microfacies types of limestones. Core No 3, well 363 Yabluniv’s ka. Scale bar – 500 μm: A – detrital wack-mudstone (sampling depth 4425.10 m); B – detrital laminated mudstone (sampling depth 4425.30 m); C – detrital-foraminifera wacke-packstone (sampling depth 4426.39 m); D – detrital-algae packstone (sampling depth 4426.57 m); E – detrital packstone (sampling depth 4426.86 m); F – detrital floatstone (sampling depth 4427.61 m); G – detrital-shell laminated packstone (sampling depth 4428.30 m); H – detrital-foraminifera pack-floatstone (sampling depth 4428.48 m); I – detrital pack-floatstone (sampling depth 4428.56 m); J – detrital-algae wacke-packstone (sampling depth 4428.83 m); K – detrital laminated wackestone (sampling depth 4432.67 m); L – crystalline carbonate rock with foraminifera (sampling depth 4432.91 m).
The green algae from the middle and upper parts of the interval are composed of *Koninckopora tenuiramosa* Wood, 1942, *Koninckopora inflata* (de Koninck, 1842), *Nanopora* cf. *woodi* Berchenko, 1981, *Coelosporella* sp., *Kulikia* sp., *Sphaeroporella* sp., *Cuzbassia botryosa* R. Ivanova, 1990, and *Asphaltina cordillerensis* Mamet, 1972, which is described for the first time for DDD. *Aphralysia carbonaria* Garwood, 1914 and *Ortonella* sp. are the cyanobacteria recorded in this study.

There are many large stacheiids among the red algae all over the layer: *Pseudostacheoides loomisi* Petryk et Mamet, 1972, *Pseudostacheoides* sp., and *Epistacheoides* sp., identified at the upper part of the interval as *Epistacheoides nephroformis* Petryk et Mamet, 1972, *Epistacheoides connorensis* Mamet et Rudloff, 1972. In middle parts, which belong to XIII MFH, a new species of calcareous algae is identified: *Atractyliopsis berezovia* sp. nov. In the upper part of the interval *Nostocites* sp. and *Fourstonella* sp. are recorded.

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**Fig. 3.** Expansion of foraminifera in sediments of the Visean stage in the well 363 Yabluniv’ska. 1 – limestone, 2 – argillite.
Identification of representatives of the genus *Uralodiscus* Malakhova, 1973 and *Paraarchaeodiscus koktjubensis* (Rauzer-Chernousova, 1948) in carbonate core material allows us to identify the foraminiferal biostratigraphic *Uralodiscus rotundus* and *Paraarchaeodiscus koktjubensis* zones (Hozhyk et al., 2013), which correlated with MFZ11 Belgium and France, and with Bobrikovian horizon of Eastern European Platform and Eastern Ural Subregion.

The predominance of green siphonocladales algae in the calcareous algae association indicates a calm hydrodynamic regime below the tidal level, as well as...
the depth of the sedimentation basin. From the middle part of the layer, the role of red algae, whose thallus has a crusty and leaf-like shape, as well as green *Konineckopora* sp. and *Coeloporella* sp., begins to grow quantitatively. This indicates an insignificant shallowing of the sedimentation basin, up to the first tens of meters. Visean limestones belong to the facies of the open marine platform, zone 7 (shallow undathem) (Wilson, 1980), namely the sea bay with limited water exchange in front of the outer boundary of the platform.

Many archedicids indicates that the bottom substrate is represented by soft silt. Well-developed radiant layer of archedicida indicates favorable habitat conditions.

**SYSTEMATIC DESCRIPTION**

**CHLOROPHYTA** Division

**DASYCLADALE** Pascher Order, 1931

**DASYCLADACEAE** (Kutzing, 1843) Stizenberger, 1860

Tribe Aciculelleae Bassoullet et al., 1979

Genus *Atractyliopsis* Pia, 1937

**Typical species** — *Atractyliopsis lastensis* Accordi, 1956; Upper Permian shallow-sea sediments from North-Western Caucasus to Hungary, Croatia, western part of Slovenia, Greece.

**Description.** Tallus subcylindrical, composed of a single layer of calcified ovoid cells, which are adjacent to each other pointwise or partially.

**Comparison.** Individuals of this genus are similar to *Archaeolithophyllum* Johnson, 1956. They also can be confused with individuals of the genus *Coelosporella* Wood, 1940. However, in both cases it is distinguished by uniform, ordered ovoid cells, which are separated by clear intercellular pillars. The genus is differed from *Hypocaustella* Elliott, 1980 by the size, form and cell interconnection of ovoid cells. Ovoid cells of the genus *Hypocaustella* tightly pressed together, as a result – the hexagonal shape of the outer edge of cell wall. Also, in contrast to the species of this genus, it is accepted that the individuals of the genus *Hypocaustella* have a lamellar form of thallus, rather than subcylindrical.

**Remarks.** Species classification of this genus is based mainly on the size and correlation of ovoid cells. The author did not find sources in free access, which would give a description of all species of the *Atractyliopsis* Pia, 1937. Below you can find the table, which contains the name of the species and the size of the ovoid cells as a species trait (Fig. 4).

**Species and stratigraphic spreading.** There are eleven species from the Famennian to Moscovian stages. *Atractyliopsis puryformis* Anfimov, 2010 (eastern slope of the Middle Urals) is common in the Famennian deposits; species *A. cumberlandensis* Rich, 1974 is described from the Upper Tournaisian – Visean deposits of Tethys and North America; there are three species from Visean deposits: *A. weyanti* Mamet, Mortelmanns et Roux, 1979 (Visean stage of Montmartin-sur-Mer (Manche, France) and Belgium), *A. foerei* Mamet et Roux, 1975 (France, Belgium, Australia), *A. minima* Mamet et Roux, 1978; there are five species from Permian: *A. lastensis* Accordi, 1956 (Italy), *A. darariensis* Elliott, 1968 (Iraq), *A. quadratus* Endo, 1956 (Japan), *A. fecundus* Korde, 1965 (Transcaucasia), *A. tezakensis* Vachard, 1980 (Afghanistan); *A. nurataensis* Mamet et Khodjanyazova, 2005 (Republic of Uzbekistan) is diagnosed in the limestones from Moscovian stage.

<table>
<thead>
<tr>
<th>Species</th>
<th>d_{ovoid cell} (µm)</th>
</tr>
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<tbody>
<tr>
<td><em>Atractyliopsis puryformis</em></td>
<td>0.040-0.060</td>
</tr>
<tr>
<td><em>A. cumberlandensis</em></td>
<td>0.050-0.120</td>
</tr>
<tr>
<td><em>A. weyanti</em></td>
<td>0.130-0.145</td>
</tr>
<tr>
<td><em>A. foerei</em></td>
<td>0.095-0.165</td>
</tr>
<tr>
<td><em>A. minima</em></td>
<td>0.060-0.048</td>
</tr>
<tr>
<td><em>A. berezovia Gusarova, sp. nov.</em></td>
<td>0.027-0.029</td>
</tr>
<tr>
<td><em>A. lastensis</em></td>
<td>0.020-0.025</td>
</tr>
<tr>
<td><em>A. darariensis</em></td>
<td>0.130</td>
</tr>
<tr>
<td><em>A. quadratus</em></td>
<td>?</td>
</tr>
<tr>
<td><em>A. fecundus</em></td>
<td>?</td>
</tr>
<tr>
<td><em>A. tezakensis</em></td>
<td>?</td>
</tr>
<tr>
<td><em>A. nurataensis</em></td>
<td>0.025</td>
</tr>
</tbody>
</table>

Fig. 5. Species of *Atractyliopsis* Pia genus, 1937 with size of ovoid cells.
**Atractyliopsis berezovia** sp. nov.

Pl. VIII, fig. 1–5

Species name – berezovia (lat.) – associated with the Berezivs’ke gas field, where the species was first found.

Holotype – Complex Core Laboratory, JSC UkrGasVydobuvannya, sample No 57167; Poltava Oblast, Sencha village area, exploration-production well 363 Yablunivs’ka, sampling depth 4433.55 m, Visean stage, XIII MFH DDD.

Description. Thallus subcylindrical, represented by one long tube, straight or slightly curved. The wall is weakly calcified, finely porous. The calcareous algae membrane is composed of one simple row of ovoid cells, which separated by thin pillars. Intercellular pillars well differed in color, adjoin each other pointwise and partially, but not along the entire length of the cells. In diagonal-longitudinal sections, it is observed that the internal cavities of ovoid cells are directed perpendicular to the central axis of the thallus.

Dimensions (mm): observable outer diameter of thallus – from 0.292 to 0.502, inner diameter of thallus – from 0.214 to 0.274, visible length of the thally – 0.550, wall thickness – from 0.025 to 0.030 outer diameter of ovoid cells – from 0.027 to 0.029, inner diameter – from 0.022 to 0.023, width of intercellular pillar – from 0.001 to 0.003.

Comparison. The new species differs from other species in the size of ovoid cells, wall thickness. Species differs from neighbor *Atractyliopsis lastensis* Accordi, 1956 and *A. nuratauensis* Mamet et Khodjanyazova, 2005 by other age interval of distribution and, to a greater extent, by a larger size of ovoid cells.

Remarks. A comparative scheme of the genus *Atractyliopsis* Pia, 1937 and *Hypocaustella* Elliott, 1980, is necessary for minimizing the most common misidentification in the micropaleontological study of DDD and Donbass deposits (Fig. 5).

Occurrence. Visean stage, XIII–XIIa microfaunistic horizons of Dnipro-Donets Depression (Ukraine).

Material: two intersections of good preservation and three fragments of sections are of satisfactory quality, sampling depth 6034.38 m, 5879.72 m, well 203 Berezivs’ka; two intersections of good preservation, two intersections of average quality, three fragments of sections, sampling depth 4429.60 m, 4433.55 m, well 363 Yablunivs’ka.

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**Fig. 6.** Comparison of the ratio of ovoid cells of species *Atractyliopsis berezovia* (1) and *Hypocaustella cartimandue* (2). Well 363 Yablunivs’ka. The red outline shows the contours of ovoid cells, yellow - the space between the cells of *Atractyliopsis berezovia*. 
**WETHEREDLACEAE** Vachard, 1976, emend. Shuysky, 1987

Tribe Wetheredlæae Berchenko, 1987

Genus *Asphaltina* Mamet, 1972

*Asphaltina cordillerensis* Mamet, 1972

P l. V, fig. 1

1972 *Asphaltina cordillerensis* Mamet; Petryk et Mamet, p. 792, 797, pl. 10, fig. 3–6.

1972 *Asphaltina cordillerensis* Mamet; Rudloff, 1972, p. 88, pl. 10, fig. 8–11.

1974 *Asphaltina cordillerensis* (pars) Rich, p. 373, pl. 11, fig. 3–6 (only).

1975 *Asphaltina cordillerensis* Armstrong, Mamet, p. 15, fig. 11G.

1975b *Asphaltina cordillerensis* Mamet, Roux, p. 164, pl. 12, fig. 2.

1976 *Asphaltina cordillerensis* Mamet; Petryk and Mamet, pl. 87, fig. 2.

1976 *Asphaltina cordillerensis* Mamet, pl. 87, fig. 2.

1976 *Asphaltina cordillerensis?* Bogush et Juferev, pl. 6, fig. 7.

1977 *Asphaltina cordillerensis* Brenkle, pl. 4, fig. 8, 21.

1977 *Asphaltina cordillerensis* Armstrong et Mamet, p. 109, pl. 39, fig. 12–14.

1978 *Asphaltina cordillerensis* Jurkewiecz et Zakowa, p. 30, pl. 6, fig. 7.

1978 *Asphaltina cordillerensis* Mamet et Roux, p 78, pl. 4, fig. 8–10.

1980 *Asphaltina cordillerensis* Vachard et Montenat, p. 183, pl. 11.


P. 204, pl. 26, fig. 9–10.

1981 *Asphaltina cordillerensis* Zeller, pl. 3, fig. 2.

1982 *Asphaltina cordillerensis?* Brenckle et al., p. 63, 64, pl. 10, fig. 1–4, 6–8, 10–12, 13, 15.


1985 *Asphaltina cordillerensis* Mamet et Pinard, pl. 1, fig. 7.

1986 *Asphaltina cordillerensis* Groves, p. 492, fig. 8, 10–13.

1986 *Asphaltina cordillerensis* Rich, pl. 9, fig. 3, 8, 11.

1988 *Asphaltina cordillerensis* Chuvashov, Anfimov, p. 57, pl. XXII, fig. 1.

1990 *Asphaltina cordillerensis* Ivanova; Ivanova et Bogush, p. 117, fig. 3–5.

1995 *Asphaltina cordillerensis* Forke, pl. 15, fig. 6.

1996 *Asphaltina cordillerensis* Sebbar, Mamet, pl. 1, fig. 13.

1996 *Asphaltina cordillerensis* Mamet, pl. 3, fig. 8–11.

1997 *Asphaltina cordillerensis* Harris et al., fig. 9.24.

1997 *Asphaltina cordillerensis* Brenckle et al., pl. 2, fig. 23.

2006 *Asphaltina cordillerensis* Mamet, p. 347, pl. 7, fig. 13.

2013 *Asphaltina cordillerensis* Ivanova, p. 218, pl. 20, fig. 5.

**Description.** Thallus is composed by tubes, that are segmented by clamps into a number of flattened hemispherical segments. Thallus looks like a single-layer crust or multi-layer formation. Two-layer wall: the inner layer is larger, composed of radial transparent calcite, the inner wall is much thinner, composed of dark pelitomorphic calcite.

**Dimensions (mm):** observable outer diameter of thallus – 0.455–0.486, inner diameter of thallus – 0.181–0.197, wall thickness – 0.049–0.105, outer dark layer thickness – 0.011–0.013.

**Comparison.** The identified forms are similar in structure to the typical species *Asphaltina cordillerensis* Mamet, however, they are slightly larger, closer to the described Ural forms (Ivanova, 2013). Individuals of this genus are similar to *Sphaeroporella* Antropov, 1967.

**Occurrence.** Cosmopolitan. Visean, Serpukhovian stages and Lower Bashkir of Tethys realm, Urals and Magadan region (Russian Federation), Arctic Canada; Upper Tournaisian of Altai and Kuzbass (Russian Federation), Lower Tournaisian Ural-Kazakh Depression (Russian Federation), Tourmaisian – Visean of Bolivia; Visean stage of Rocky Mountains (Alberta, Canada); Upper Visean of Moscow Synclise (Russian Federation), Sakmarian stage of Central Afghanistan; Artinskian stage of Ural (river Ay, Usva, Yayva, Russian Federation); Namurian limestone Wahoo (North Slope Borough, Alaska, USA), Peratrovich Formation (southeastern Alaska, USA); Pennsylvanian of New Mexico and Arkansas (USA).

**Material:** two large and two small intersections of good preservation, sampling depth 4425.84 m, 4426.24 m and 4429.08 m, well 363 Yablunivs’ka.
Plate I.
Fig. 1–3, 7. *Uralodiscus rotundus* (Chernysheva, 1948), 1 – axial section, sampling depth 4440.75 m; 2 – axial section, sampling depth 4428.48 m; 3 – axial section, sampling depth 4428.05 m; 7 – axial section, sampling depth 4437.21 m.
Fig. 4–6, 8, 12-16. *Paraarchaediscus koktubensis* (Rauzer-Chernousova, 1948b), 4, 5 – axial section, sampling depth 4428.48 m; 6, 13-15 – axial section, sampling depth 4428.05 m, 8 – axial section, sampling depth 4429.08 m; 12 – axial section, sampling depth 4431.26 m; 16 – axial section, sampling depth 4429.08 m.
Fig. 10. *Archaediscus* aff. *krestovnikovi* Rauzer-Chernousova, 1948, axial section, sampling 4426.57 m.
Fig. 9, 11. *Paraarchaediscus* aff. *stilus* (Grozdilova et Lebedeva, 1953), 9 – axial section, sampling depth 4426.39 m, 11 – axial section, sampling depth 4431.31 m.
Fig. 17–20, 23–24. *Paraarchaediscus* sp., 17 – axial section, sampling depth 4427.37 m, 18-19, 24 – axial section, sampling depth 4427.44 m, 20 – axial section, sampling depth 4427.37 m; 23 – axial section, sampling depth 4426.57 m.
Fig. 21. *Glomodiscus rigens* (Conil et Lys, 1964), axial section, sampling depth 4427.37 m.
Fig. 22. *Lapparentidiscus* sp., axial section, sampling depth 4427.37 m.
Fig. 25–26, 31–32, 36–40. *Ammonarchaediscus* sp., 26 – axial section, sampling depth 4440.30 m; 32 – axial section, sampling depth 4440.69 m; 36 (median section)-37 – axial section, sampling depth 4441.89 m; 38-40 – median section, sampling depth 4440.75 m.
Fig. 27. *Brunsia* sp. (*increased size variety*), median section, sampling depth 4441.89 m.
Fig. 28–29. *Pseudoammodiscus* sp., axial section, sampling depth 4441.89 m.
Fig. 30, 33–34. *Brunsia* sp., 30 – axial section, sampling depth 4435.96 m; 33–34 – axial section, sampling depth 4441.89 m.
Fig. 35. *Eoforschia* sp., axial section, sampling depth 4435.96 m.
Plate II

Fig. 1, 4, 11. *Omphalotis aff. minima* (Rauzer-Chernousova et Reitlinger, 1936), 1 (median section), 4 (axial section) – sampling depth 4437.11 m; 11 – median section, sampling depth 4438.77 m.

Fig. 2. *Globoendothyra* sp., 2 – axial section, sampling depth 4439.90 m.

Fig. 3. *Omphalotis frequentata* (Ganelina, 1956), 3 – median section, sampling depth 4434.23 m.

Fig. 5–9. *Spinoendothyra* sp., 5 – axial section, sampling depth 4433.18 m; 6 – median section, sampling depth 4435.96 m; 7 – median section, sampling depth 4434.23 m; 8 – median section, sampling depth 4430.18 m; 9 – median section, sampling depth 4435.34 m.

Fig. 10, 12–14. *Endothyra* sp., 10 – axial section, sampling depth 4429.48 m; 12 – axial section, sampling depth 4435.34 m; 13 – median section, sampling depth 4432.40 m; 14 – median section, sampling depth 4430.18 m.

Fig. 15. *Omphalotis cf. frequentata* (Ganelina, 1956), axial section, sampling depth 4434.01 m.

Fig. 16. *Earlandia vulgaris* (Rauzer-Chernousova et Reitlinger, 1937), incomplete longitudinal section, sampling depth 4433,30 m.

Fig. 17–19. *Earlandia minima* (Birina, 1948), 17–18 – longitudinal section, sampling depth 4433.18 m; 19 – longitudinal section, sampling depth 4437.11 m.
Plate III

Fig. 1–7, 11. *Valculinella* spp., 1, 2, 4 – longitudinal section, sampling depth 4426.39 m; 3 – longitudinal section, sampling depth 4427.37 m, 5 – longitudinal section, sampling depth 4426.57 m; 6–7 – longitudinal section, sampling depth 4427.44 m, 11 – longitudinal section, sampling depth 4428.05 m.

Fig. 8–10, 12–14. *Tetrataxis* spp., 8–9, 13 – longitudinal section, sampling depth 4427.44 m; 10 – longitudinal section, sampling depth 4430.86 m; 12, 14 – longitudinal section, sampling depth 4427.37 m.
Plate IV

Fig. 1-2. *Epistacheoides connorensis* Mamet et Rudloff, 1972, 1 – sampling depth 4439.28 m; 2 – sampling depth 4428.30 m.

Fig. 3, 5. *Pseudostacheoides loomisi* Petryk et Mamet, 1972, 3 – sampling depth 4428.05 m; 5 – sampling depth 4431.31 m.

Fig. 4, 6, 8. *Epistacheoides nephroformis* Petryk et Mamet, 1972, sampling depth 4431.31 m.

Fig. 7. *Stacheoides polytrematoides* (Brady, 1876), sampling depth 4438.77 m.
Plate V

Fig. 1–3. Asphaltina cordillerensis Mamet, 1972, 1 – sampling depth 4426.24 m; 2–3 – sampling depth 4430.86 m.
Fig. 4. Pseudostacheoides sp., sampling depth 4426.39 m.
Fig. 5–6. Epistacheoides sp., 5 – sampling depth 4434.69 m; 6 – sampling depth 4434.95 m.
Fig. 7. Pseudolituotuba enormica (Brazhnikova et Rostovtseva, 1967), sampling depth 4426.39 m.
Fig. 8. Tolypammina pseudospiralis Malakhova, 1980, sampling depth 4426.57 m.
Plate VI

Fig. 1, 3, 7, 16-17. Palaeoberesella lahuseni (Moeller, 1880), 1 – sampling depth 4440.75 m; 3 – sampling depth 4439.28 m; 7 – sampling depth 4428.30 m; 16 – sampling depth 4438.96 m; 17 – sampling depth 4441.37 m.

Fig. 2, 12. Issinella grandis Tchuvashov, 1965, 2 – sampling depth 4438.96 m; 12 – sampling depth 4427.44 m.

Fig. 4-5. Exvotarisella maponi Elliott, 1970, 4 – sampling depth 4427.61 m; 5 – sampling depth 4427.44 m.

Fig. 6, 8-11, 14–15. Palaeoberesella scalaris R. Ivanova, 1988, 6 – sampling depth 4441.37 m; 8 – sampling depth 4438.82 m; 9-10, 11, 14 – sampling depth 4426.86 m; 15 – sampling depth 4427.44 m.

Fig. 13. Kamaena delicata Antropov, 1967, sampling depth 4440.75 m.
Plate VII

Fig. 1–4, 6–7, 9–10, 17, 24. *Exvotarisella index* (Ehrenberg em. Moeller, 1880), 1–4, 10 – sampling depth 4426.86 m, 6, 7 – sampling depth 4427.44 m, 9 – sampling depth 4428.30 m, 17 – sampling depth 4427.77 m; 24 – sampling depth 4426.86 m.

Fig. 5, 12, 21. *Kamaena awirsi* Mamet et Roux, 1974, 5, 12 – sampling depth 4426.86 m, 21 – sampling depth 4426.86 m.

Fig. 8. *Kamaena itkillikensis* Mamet et Rudl., 1972, sampling depth 4426.86 m.

Fig. 11. *Kamaena delicata* Antropov, 1967, sampling depth 4426.86 m.

Fig. 13–14. *Kataepella* cf. *denbighi* Mamet et Roux, 1974, 13–14 – sampling depth 4427.44 m; 16 – sampling depth 4425.84 m; 18 – sampling depth 4427.77 m.

Fig. 19, 25. *Palaeoberesella lahuseni* (Moeller, 1880), 19 – sampling depth 4427.44 m, 25 – sampling depth 4433.48 m.

Fig. 20. *Subkamaena* sp., sampling depth 4426.86 m.

Fig. 23, 30. *Crasikamaena* sp., sampling depth 4424.63 m.

Fig. 26. *Pseudokamaena armstrongi* Mamet, 1972, sampling depth 4427.44 m.

Fig. 27, 31. *Parakamaena irregularis* Berchenko, 1981, 27 – sampling depth 4434.56 m; 31 – sampling depth 4425.11 m.

Fig. 28. *Kamaenid transversal section*, sampling depth 4426.57 m.

Fig. 29, 32–33. *Pseudokamaena* sp., 29, 32 – sampling depth 4425.11 m; 33 – sampling depth 4434.95 m.
Plate VIII

Fig. 1–5. *Atractyliopsis berezovia* sp. nov., 1, 5 – sampling depth 4433.55 m; 2-3 – sampling depth 4429.60 m; 4 – sampling depth 4438.96 m.

Fig. 6–11. *Hypocaustella cartimandue* Elliott, 1980, 6, 10 – sampling depth 4437.97 m, 7 – sampling depth 4438.37 m; 8 – sampling depth 4438.56 m; 9 – sampling depth 4436.67 m; 11 – sampling depth 4441.37 m.

Fig. 12–13. *Hypocaustella* cf. *cartimandue* Elliott, 1980, sampling depth 4430.42 m.

Fig. 14–16. *Hypocaustella* aff. *cartimandue* Elliott, 1980, 14 – sampling depth 4430.25 m; 15 – sampling depth 4429.60 m; 16 – sampling depth 4432.05 m.
Conclusions

The next conclusions can be drawn:
1. Core materials of exploration-production well 336 Yablunivs'ka, represented by the upper part of the lower Visean mainly composed of carbonate and clay rocks, embracing the XIII (Pryluts'kyy) and XIV (Khorol's'kyy) MFH DDD.
2. Foraminiferal association, represented by individuals of 26 genera, calcareous algae association represented by individuals of 30 genera, including 1 species of calcareous algae, which are described for the first time for DDB: Asphaltina cordillerensis; and new species Atractyliopsis berezovia sp. nov.
3. The species guides of the Tulian substage: Paraarchaediscus koktjubensis has been identified.

Lower Visean calcareous algal associations of the central paraxial zone DDD differ from the coeval association of Donbass zone by the absence taxonomically diverse palaeoberesellides (Sukhov, 2012), as well as more types of red algae.

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References


