ISSN 1810-9810 (Print)
UDC 551.734.2+551.734.3; 567 (476)

D. P. Plax[1], O. V. Murashko[2]

[1]Belarusian National Technical University, Minsk, Belarus, e-mail: agnatha@mail.ru
[2]«Institute of Geology» Branch of the State Enterprise «Research and Production Centre for Geology», Minsk, Belarus, e-mail: volum@tut.by

STRATIGRAPHY AND ICHTHYOFAUNA OF THE UPPER EMSIAN-EIFELIAN DEPOSITS IN THE BYKHOV 1 AND KORMA 1 BOREHOLE SEQUENCES IN THE EAST OF BELARUS

Abstract. The paper presents the results of a palaeoichthyological study of core samples from the Bykhov 1 and Korma 1 boreholes drilled in eastern Belarus. Based on the ichthyofaunal, lithological and geophysical data, a detailed stratigraphic division of the Upper Emsian-Eifelian deposits exposed in the studied boreholes has been performed. Their detailed description is provided. Vertebrate evidences were used to compare these deposits with the similar age formations developed within the adjacent territories of Ukraine, Russia and the Baltic States. The ichthyofauna data were used to clarify the stratigraphic distribution of some taxa in the Upper Emsian-Eifelian deposits of Belarus, to supplement their systematic composition within the studied territory, and also to complement the palaeontological characteristics of the regional stratigraphic units of the actual Stratigraphic Chart of the Devonian Deposits of Belarus (2010). The presented results should be taken into account in the future when performing large-scale geological surveys within the studied area.

Keywords: Belarus, ichthyofauna, Upper Emsian deposits, Eifelian deposits, Lower and Middle Devonian

Д. П. Плакс[1], О. В. Мурашко[2]

[1]Белорусский национальный технический университет, Минск, Беларусь, e-mail: agnatha@mail.ru
[2]Филиал «Институт геологии» государственного предприятия «НПЦ по геологии», Минск, Беларусь, e-mail: volum@tut.by

СТРАТИГРАФИЯ И ИХТИОФАУНА ВЕРХНЕЭМССКО-ЭЙФЕЛЬСКИХ ОТЛОЖЕНИЙ В РАЗРЕЗАХ СКВАЖИН БЫХОВСКАЯ 1 И КОРМЯНСКАЯ 1 НА ВОСТОКЕ БЕЛАРУСИ

Аннотация. Представлены результаты палеоихтиологического изучения керна скважин Быховская 1 и Кормянская 1, пробуренных на востоке Беларуси. На основе ихтиофауны, а также литологических и геофизических данных выполнено детальное стратиграфическое расчленение верхнеэмсско-эйфельских отложений, вскрытых вышеупомянутыми скважинами. Приведено их подробное описание. По позвоночным проведено сопоставление этих отложений с одновозрастными образованиями, развитыми на смежных территориях Украины, России и стран Балтии. Полученные данные по ихтиофауне уточняют стратиграфическое распространение некоторых таксонов в верхнеэмсско-эйфельских отложениях Беларуси, дополняют их систематический состав на территории страны, а также дополняют палеонтологическую характеристику региональных стратиграфических подразделений действующей Стратиграфической схемы девонских отложений Беларуси (2010 г.). Представленные результаты исследований в дальнейшем следует учитывать при проведении крупномасштабной геологической съемки в исследуемом районе.

Ключевые слова: Беларусь, ихтиофауна, верхнеэмсские и эйфельские отложения, нижний и средний девон

Д. П. Плакс[1], В. В. Мурашка[2]

[1]Беларускі нацыянальны тэхнічны ўніверсітэт, Мінск, Беларусь, e-mail: agnatha@mail.ru
[2]Філіял «Інстытут геалогіі» дзяржаўнага прадпрыемства «Навукова-вытворчы цэнтр па геалогіі», Мінск, Беларусь, e-mail: volum@tut.by

СТРАТЫГРАФІЯ І ІХТЫЯФАЎНА ВЕРХНЕЭМСКА-ЭЙФЕЛЬСКІХ АДКЛАДАЎ У РАЗРЭЗАХ СВІДРАВІН БЫХАЎСКАЯ 1 І КАРМЯНСКАЯ 1 НА ЎСХОДЗЕ БЕЛАРУСІ

Анатацыя. Прадстаўлены вынікі палеаіхтыялагічнага вывучэння керна свідравін Быхаўская 1 і Кармянская 1, якія былі прасвідраваны на ўсходзе Беларусі. На аснове іхтыяфаўны, а таксама літалагічных і геафізічных дадзеных выканана дэталёвае стратыграфічнае расчляненне верхнеэмска-эйфельскіх адкладаў, ускрытых вышэйзгаданымі свідравінамі. Прыведзена іх падрабязнае апісанне. Па хрыбетных праведзена супастаўленне гэтых адкладаў з утварэннямі таго ж самага ўзросту, развітымі на сумежных тэрыторыях Украіны, Расіі і краін Балтыі. Атрыманыя дадзеныя па іхтыяфаўне ўдакладняюць стратыграфічнае распаўсюджванне некаторых таксонаў у верхнеэмска-эйфельскіх адкладах Беларусі, дапаўняюць іх сістэматычны склад на тэрыторыі краіны, а таксама дапаўняюць палеанталагічную характарыстыку рэгіянальных стратыграфічных падраздзяленняў дзеючай Стратыграфічнай схемы дэвонскіх адкладаў Беларусі (2010 г.). Прадстаўленыя вынікі даследаванняў у далейшым варта ўлічваць пры правядзенні буйнамаштабнай геалагічнай здымкі ў даследаваным раёне.

Ключавыя словы: Беларусь, іхтыяфаўна, верхнеэмскія і эйфельскія адклады, ніжні і сярэдні дэвон

Introduction. The deposits of the Upper Emsian of the Lower Devonian and of the Eifelian Stage of the Middle Devonian are widespread in the eastern part of Belarus [1, 2]. These are represented by terrigenous, carbonate-terrigenous, carbonate and carbonate-sulfate rocks. The organic remains found in these rocks area carbonified plant remains, acritarchs, stromatolites, scolecodonts, conchostracans, ostracodes, inarticulate brachiopods, conodonts, ichthyofauna and miospores. The two latter groups of the organic remains are most abundant. They are also essential for the division of the Upper Emsian – Eifelian deposits. For this reason they were subject to priority study.

This paper presents the results of a palaeoichthyological study of the mentioned deposits exposed for the last years in two parametric boreholes: Bykhov 1 and Korma 1. The first one was drilled in the junction zone of the Orsha Depression and Zhlobin Saddle, and the second one – in the Zhlobin Saddle (Text-Fig. 1). The study of the ichthyofauna together with the lithology and logging data allowed the authors to determine the age of the rocks and to substantiate the regional and local stratigraphic units distinguished in these borehole sections, as well as to correlate them with the similar age different facies deposits developed within the adjacent territories of Ukraine, Russia and the Baltic States. The subdivision and comparison of deposits from some section parts that do not contain vertebrates were made using information of other fossil groups, as well as the logging data, material composition of the rocks and their stratigraphic position in the section. It is also worth to mention that the original lithostratigraphic division of the sections of these two boreholes was performed by A. G. Laptsevich, O. F. Kuzmenkova, G. D. Streltsova and N. S. Yakovleva. In this paper the authors made some refinements of the divisions of these borehole sections and proposed ichthyological complexes for the established stratigraphic units (Regional Stages, Formations).

Materials and methods. The descriptions of the Upper Emsian – Eifelian deposits, geological and geophysical materials and more than 170 samples collected for the palaeontological and stratigraphic studies from the Bykhov 1 and Korma 1 parametric boreholes served as the basis for this work. The remains of various ichthyofauna groups were identified in many collected rock samples after their technical treatment. The agnathans are represented by scattered tubercles, single tesserae, and small fragmentary skeletal elements of the heterostracans. The fishes are represented by separate fragments, more or less intact placoderm plates, some isolated scales and discrete fragments of the acanthodian fin spines, separate chondrichthyan scales, scattered scales, teeth, small fragmented jaws and bones of the sarcopterygians and some isolated scales of the actinopterygians. The identification of the skeletal remains of these vertebrate representatives was mainly based on their morphological features. Histological data were used to determine some acanthodian scales. A complex analysis of the sculpture features and the internal structure of the skeleton-forming tissues made it possible to determine the species with the greater accuracy. However, the material fragmentation and preservation degree sometimes prevented from the definition of a species. For this reason, some of the agnathan and fish definitions were left in the open nomenclature.

The ichthyofauna remains extracted from the rocks were subject to ichthyofaunistic analysis. The results of this analysis together with the lithological and geophysical (logging) data were used as the basis for both the rock age determination and identification of the regional and local stratons in the sections of the Upper Emsian – Eifelian deposits of the studied boreholes, and for their correlation with same age deposits within the transboundary territories of the adjacent countries (Ukraine, Russia and the Baltic States). The Stratigraphic Chart of the Devonian deposits of Belarus 2010 [2] was taken as the stratigraphic basis for the Upper Emsian – Eifelian sediments division within the studied area.

The pictures of the macroscopic skeletal elements of the ichthyofauna were taken using PowerShot SX130 IS and Sony A58 with lens Industar-50 cameras. The electron micrographs of the agnathan and fish remains were made with a scanning electron microscope JSM-5610 LV (JEOL, Japan). The pictures were processed using the Adobe Photoshop CS6 program, and the drawings were performed using the program CorelDRAW 2019. A microscope Axioskop 40 A Pol was used to study the internal structure of some ichthyofauna remains.

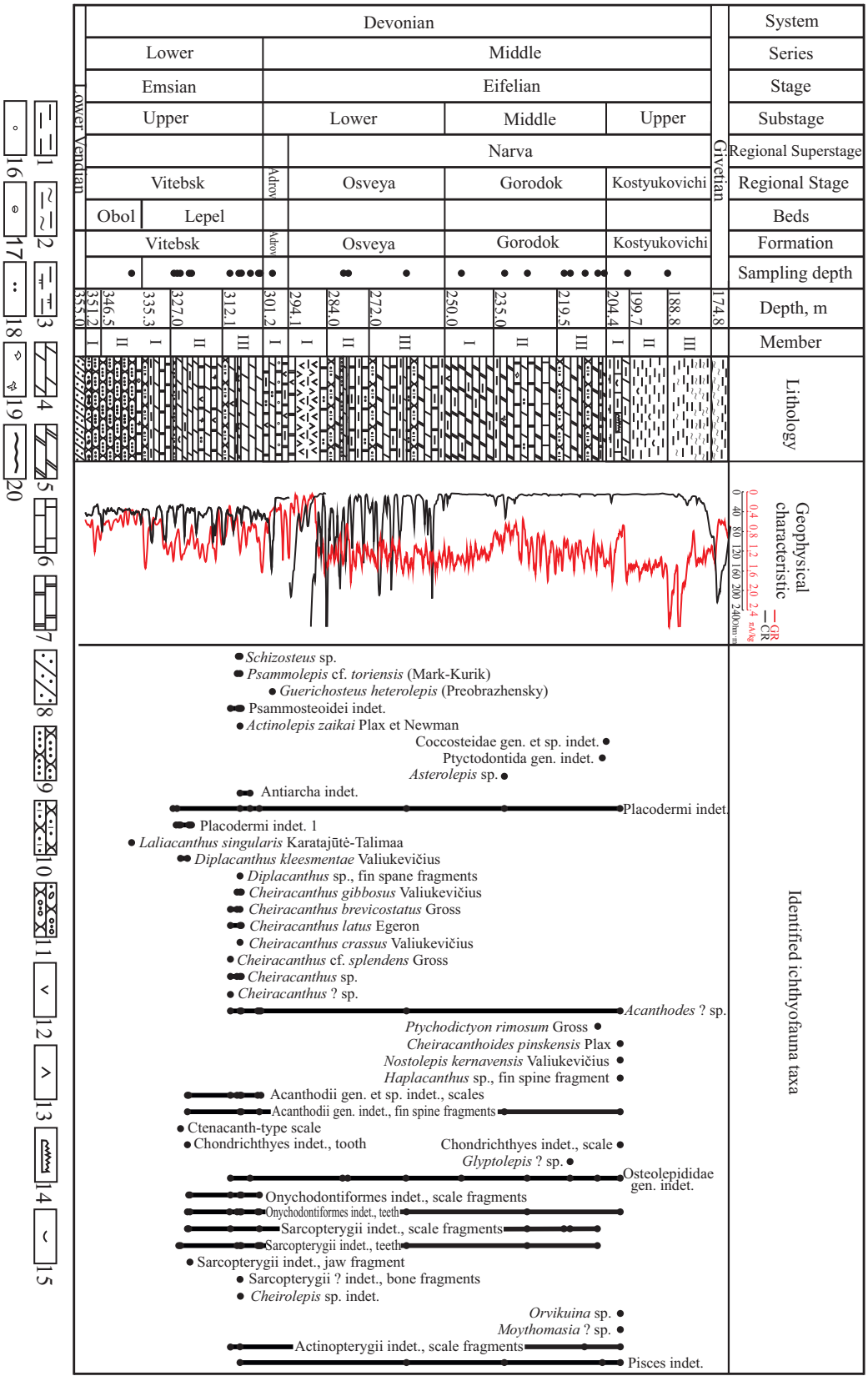
Most of the studied ichthyofauna remains are from the personal collection of one of the authors, and its smaller part is stored in the palaeontological collection of the Department of Mining, Belarusian National Technical University.

Stratigraphic subdivision of the Upper Emsian – Eifelian deposits of the studied boreholes

The Bykhov 1 borehole was drilled in the junction zone of the Orsha Depression and Zhlobin Saddle near the Bolshaya Zimnitsa village of the Slavgorod District, Mogilev Region (see Text-Fig. 1). A detailed stratigraphic division of the exposed deposits (Text-Fig. 2) was made in accordance with the results of the lithological and palaeoichthyological studies of the rocks with consideration of the geophysical data of logging diagrams and conodont evidences. A detailed lithological characteristic of the Bykhov 1 borehole sequence (from bottom to top), as well as its biostratigraphic and geophysical description are presented below. Some skeletal elements of the agnathans and fishes from the rocks of this borehole are shown in Plates I-X.

335.3–351.2 m, thickness 15.9 m – Lower Devonian (D_1), Emsian Stage (D_1e), Upper Emsian Substage (D_1e_2), Vitebsk Regional Stage (Formation) (D_1vt), Obol Beds (D_1ob). These deposits are represented by two lithological members – the sandy-gravelite and dolomite-sandstone ones. The considered interval is characterized by an increased gamma-ray logging value (1.2 πA/kg) at the bottom and a gradually decreasing GR curve as low as 0.4 πA/kg towards the roof. The values of the conventional resistivity (CR) within this interval range from 25 to 80 Ohm·m. The highest value was recorded in the lower part of the interval. Two lithological-geophysical members are distinguished in composition of these deposits on the basis of the rock material composition and geophysical logging data.

Text-Fig. 1. Map of Belarus showing the location of the borehole sections where the skeletal elements of the fish fauna were found. Boreholes: 1 – Bykhov 1; 2 – Korma 1



Text-Fig. 2. Geological section of the Upper Emsian and Eifelian deposits of the Bykhov 1 borehole with the ichthyofauna distribution. Legend. Rocks: 1 – clays, 2 – silt clays, 3 – dolomite clays, 4 – marls, 5- dolomite marls, 6 – limestones, 7 – dolomites, 8 – sandstone tillites, 9 – sandstones, 10 – carbonate sandstones, 11 – gravelites, 12 – gypsum, 13 – anhydrite. Other symbols: 14 – conodonts, 15 - shell detritus, 16 – oolites, 17 – stromatolites, 18 – sandiness, 19 – cavernosity, 20 – discontinuity surfaces

The first member (depth interval of 346.5 to 351.2 m, 4.7 m thick) is represented by the sandstones and gravelites which overlie with a large discontinuity the red-colored tillites of the Glusk Formation of the Vilchanka Series of the Lower Vendian. The sandstones are light grey with a slightly greenish tint, assorted, mainly quartzy, well cemented with clayey cement, dense, laminated, massive, platy. The gravelites are light grey, coarse-grained, with inclusions of pebbles, well cemented, with clayey-carbonate cement.

The second member (depth interval of 335.3 to 346.5 m, 11.2 m thick) is composed of mainly sandstones, but of dolomites in the roof. The sandstones are light greenish-grey, medium- and fine-grained, usually quartzy, well cemented, with carbonate-clayey cement, dense, platy, where two scales of *Laliacanthus singularis* Karatajūtė-Talimaa were found. The dolomites are light grey, cryptocrystalline, slightly cavernous, in places, with stromatolites.

301.2–335.3 m, thickness 34.1 m – Lower Devonian (D_1), Emsian Stage (D_1e), Upper Emsian Substage (D_1e_2), Vitebsk Regional Stage (Formation) (D_1vt), Lepel Beds (D_1lp). These strata are represented by interbedded sandstones, clays, marls and dolomites. The γ-activity logging diagram values range from 0.35 to 1.6 πA/kg. The values of the conventional resistivity range from 30 to 100 Ohm·m. Three lithological-geophysical members are well distinguished within these strata.

The first member (depth interval of 327.0–335.3 m, 8.3 m thick) is represented by interbedded sandstones, clays, marls and dolomites. The sandstones are light greenish-grey, medium- and fine-grained, well cemented, with clayey-carbonate cement, platy. The clays are greenish-grey, with brown-grey interlayers, lumpy, in places, platy-fragmented, dense. The marls are greenish-grey, dense, unclearly laminated, platy, in sites contain shell detritus of the lingulids.

The second member (depth range of 312.1 to 327.0 m, thickness 14.9 m) is composed of sandstones, clays, marls and dolomites. The sandstones are greenish-grey, mostly fine-grained, well cemented, with carbonate cement, platy; occur at the bottom of the member. The clays are greenish-grey, grey, brown, dense, foliated at some levels, mainly platy-comminuted, carbonate, in places, contain scarce conchostracans. The marls are greenish-grey, in places, with brown and lilac spots, dense, platy, massive, aleuritic or clayey at some levels, with numerous ostracodes, scarce shells of the conchostracans, rather numerous small shell fragments of the inarticulate brachiopods, one fragment of the Placodermi indet. plate, numerous small unidentified plate fragments, a denticle from a spinal plate and several spinal plates of Placodermi indet. 1, not very numerous scales of *Diplacanthus kleesmentae* Valiukevičius, Acanthodii gen. et sp. indet., small fin spine fragments of Acanthodii gen. indet., one Ctenacanth-type scale, numerous teeth of Onychodontiformes indet., Sarcopterygii indet., scale fragments of Onychodontiformes indet., Sarcopterygii indet., a small jaw fragment of Sarcopterygii indet. The dolomites are light grey, pelitomorphic, microcrystalline, unclearly laminated, in some sites, stromatolite-like, with rare caverns filled with clayey material and nests of pink laminar gypsum.

The third member (depth interval of 301.2–312.1 m, 10.9 m thick) consists of sandstones (the bottom of the member), dolomite clays, marls, dolomitic, silt and clayey marls. The sandstones are light grey, with a greenish tint, medium- and fine-grained, feldspar-quartzy, well cemented, with clayey-carbonate cement, platy. The clays are dolomitic, in places silty, sandy, grey, with a slightly greenish tint, with brown spots, contain fragmentary skeletal elements of *Psammolepis* cf. *toriensis* (Mark-Kurik), indefinable fragmentary skeletal element of *Schizosteus* sp., Psammosteoidei indet., scales of *Cheiracanthus* sp., *C. gibbosus* Valiukevičius, *Cheiracanthus brevicostatus* Gross, Acanthodii gen. et sp. indet., teeth of Onychodontiformes indet., Sarcopterygii indet. The marls are greenish-grey, dense, platy, in some places, with nests of orange gypsum, small pyrite crystals, rounded quartz and feldspar grains, contain a small plate fragment of Antiarcha indet., small fragments of Placodermi indet. plates, scales of *Acanthodes* ? sp., Acanthodii gen. et sp. indet., a micromeric fragment of Acanthodii gen. indet. fin spine, scale fragments of Osteolepididae gen. indet., Onychodontiformes indet., teeth of Onychodontiformes indet., Sarcopterygii indet. The marls are dolomitic, greenish-grey, clayey, dense, platy, contain isolated tubercles of *Psammolepis* cf. *toriensis* (Mark-Kurik), Psammosteoidei indet., scattered scales of *Cheiracanthus* sp., *C. latus* Egerton, *C. gibbosus* Valiukevičius, *Acanthodes* ? sp., Acanthodii gen. et sp. indet., small fragments of the fin spines of Acanthodii gen. indet., teeth of Onychodontiformes indet., Sarcopterygii indet.,

small scale fragments of Sarcopterygii indet. The marls are silty, greenish-grey, dense, platy, with small pyrite crystals, small gypsum grains, contain scarce small shell fragments of lingulids, one tubercle of *Schizosteus* sp., numerous tubercles of Psammosteoidei indet., single tesserae and small indefinable fragmentary skeletal elements of *Psammolepis* cf. *toriensis* (Mark-Kurik), small plate fragments of Antiarcha indet., Placodermi indet., two small fragments of the indefinable plates of *Actinolepis zaikai* Plax et Newman [3], small fragments of the *Diplacanthus* sp., Acanthodii gen. indet. fin spines, numerous scales of *Cheiracanthus* sp., *C. brevicostatus* Gross, *C. latus* Egerton, *C. gibbosus* Valiukevičius, *C. crassus* Valiukevičius, *Acanthodes* ? sp., Acanthodii gen. et sp. indet., numerous teeth of Onychodontiformes indet., Sarcopterygii indet., single scale fragments of Onychodontiformes indet., Sarcopterygii indet., not large bone fragments of Sarcopterygii ? indet., small bone fragments of Pisces indet., rare scales of Actinopterygii indet. The marls are clayey, greenish-grey, dense, platy, with rounded quartz grains, as well as with the scattered tubercles of Psammosteoidei indet., isolated scales of *Cheiracanthus* sp., *C. brevicostatus* Gross, *C. crassus* Valiukevičius, *C.* cf. *splendens* Gross, *C.* ? sp., *Acanthodes* ? sp., Acanthodii gen. et sp. indet., scale fragments of Osteolepididae gen. indet., teeth of Onychodontiformes indet., Sarcopterygii indet., scales of *Cheirolepis* sp. indet., Actinopterygii indet.

294.1–301.2 m, thickness 7.1 m – Middle Devonian (D_2), Eifelian Stage (D_2ef), Lower Eifelian Substage (D_2ef_1), Adrov Regional Stage (Formation) (D_2ad): a member of interbedded light grey, dense, hard, platy, unclearly layered, clayey, sandy and oolitic dolomites. At the bottom of the member, the gamma-ray logging shows a low value of 0.4 πA/kg, and the conventional resistivity curve shows there a high value of 160 Ohm·m. In the roof of the member, on the contrary: the γ-activity value is 1.4 πA/kg, and the conventional resistivity curve shows 15 Ohm·m. Among the organic remains in the rocks of this member there are very rare oogonies of the charophyte algae *Sycidium* sp. and some isolated small skeletal elements of *Guerichosteus heterolepis* (Preobrazhensky).

250.0–294.1 m, thickness 44.1 m – Middle Devonian (D_2), Eifelian Stage (D_2ef), Lower Eifelian Subtage (D_2ef_1), Osveya Regional Stage (Formation) (D_2os): these strata are composed of terrigenous-carbonate-sulfate rocks. The γ-activity logging diagram has a well-defined saw-tooth pattern with values ranging from 0.65 to 1.65 πA/kg from a depth of 284.0 m. The gamma-ray logging curve is characterized by the lower values from 0.1 to 0.7 πA/kg in the depth range from 294.1 to 284.0 m. The conventional resistivity values are mainly high and vary from 90 to 220 Ohm·m over the whole considered interval. Three lithological-geophysical members are well distinguished within these deposits on the basis of their rock material composition and geophysical logging data.

The first member (depth interval of 284.0 to 294.1 m, 10.1 m thick) is represented by clays, clayey-carbonate-sulfate rocks, gypsum, sandy dolomite. The clays are dark greenish-grey in color, slightly micaceous, dense, with uneven bedding surfaces. The clayey-carbonate-sulfate rocks are light grey in color, hard, massive, horizontally layered, with uneven, wavy, tuberous bedding surfaces. The gypsum forms the main body of this rock and is fine- to coarse-grained, sometimes, transverse fibrous. Its color varies from orange-red to light brownish-grey and dark brown. There are interlayers of white transverse columnar gypsum from 1 to 2 mm thick. The described rocks also contain interlayers of greenish-grey clays. There are also interlayers of light grey, in places, black, fine-crystalline anhydrite. The dolomite is light grey, sandy, dense, hard, massive.

The second member (depth interval of 272.0 to 284.0 m, 12.0 m thick) is composed of sandstones, clays, marls, dolomite marls, sandy and clayey dolomites. The sandstones are light grey, with a greenish tint, feldspar-quartzy, fine-grained, well cemented, with carbonate-sulfate cement, platy, massive and contain fragments of the Osteolepididae gen. indet scales. The clays are dark greenish-grey, dense usually with horizontal layering. The marls are greenish-grey, in places spotted (jasper-like), dense, unclearly layered, platy. The marls are dolomitic, greenish-grey, in places, spotted, unclearly layered, dense, solid, platy, with scale fragments of Osteolepididae gen. indet. The dolomites are sandy, light grey, slightly fractured, hard, platy. The dolomites are clayey, light grey, with a slightly greenish tint, in places with subhorizontal layering, hard, massive, platy. Throughout the section of this member there are gypsum inclusions and interlayers. The gypsum color changes from white and light grey to reddish brown.

The third member (depth interval of 250.0 to 272.0 m, 22.0 m thick) consists of interbedded sandstones, clays, marls, dolomite marls and dolomites. The sandstones are bluish-grey, feldspar-quartzy, with rounded grains of gypsum, fine-grained, well cemented, with carbonate-clayey cement, platy. The clays are bluish-grey, greenish-grey, dense, usually horizontally layered. The marls are bluish-grey, greenish-grey, in places, spotted (jasper-like), dense, massive, with gypsum grains, with small indefinable plate fragments of Placodermi indet., a scale of *Acanthodes*? sp., not numerous scale fragments of Osteolepididae gen. indet., two small tooth fragments of Onychodontiformes indet., Sarcopterygii indet., micromeric bone fragments of Pisces indet. The marls are dolomitic, greenish-grey, in places spotted, with gypsum inclusions, indistinctly laminated, dense, hard, platy. The dolomites are light grey, usually undistinctly laminated, hard, platy, clayey or sandy at some levels.

204.4–250.0 m, thickness 45.6 m – Middle Devonian (D_2), Eifelian Stage (D_2ef), Middle Eifelian Substage (D_2ef_2), Gorodok Regional Stage (Formation) (D_2gr): the strata of terrigenous-carbonate rocks. The interval is characterized by increased gamma activity values varying from 0.7 to 1.8 πA/kg and low conventional resistivity values ranging from 5 to 50 Ohm·m. These strata can be divided into three lithological-geophysical members on the basis of their material composition and geophysical logging data.

The first member (depth interval of 235.0 to 250.0 m, 15.0 m thick) is represented by clayey marls, dolomitic, sandy, grey, light grey, greenish-grey, lilac-grey, dense, mostly horizontally layered, platy, with isolated integral or fragmentary scales of Osteolepididae gen. indet., Sarcopterygii indet., teeth of Onychodontiformes indet. and Sarcopterygii indet.

The second member (depth interval of 219.5 to 235.0 m, 15.5 m thick) is composed of interbedded marls, dolomite marls, limestones and dolomites. The marls are greenish-grey, light grey, clayey, dense, sandy, with rounded quartz grains, with single scale fragments of Osteolepididae gen. indet., Sarcopterygii indet., teeth of Onychodontiformes indet. and Sarcopterygii indet. The marls are dolomitic, light grey, with light greenish tint, pelitomorphic, dense, with small plate fragment of *Asterolepis* sp., a fragment of an indefinable plate of Placodermi indet., a small fragment of the fin spine of Acanthodii gen. indet. and rare small bone fragments of Pisces indet. The limestones are light grey, fine-grained, dense, platy. The dolomites are beige-grey, beige-greenish-grey, pelitomorphic, hard, platy, massive, in places cavernous, with sulfide mineralization along subvertical cracks.

The third member (depth interval of 204.4 to 219.5 m, 15.1 m thick) consists of sandstones, marls, dolomite marls, limestones and clayey dolomites. The sandstones are light grey, with bluish-greenish tint, fine-grained, quartz, well-cemented, with clayey-carbonate cement, dense, platy. The marls are grey, bluish-green-grey, with brown and rusty spots, dense, platy, with few scolecodonts, some small shall fragments of inarticulate brachiopods, a small scale fragment of *Glyptolepis* ? sp., small scale fragments of Osteolepididae gen. indet. and Sarcopterygii indet. The marls are dolomitic, light grey, greenish grey, bluish grey, in places, spotted (jasper-like), dense, platy, with conchoidal fracture, with one small fragment of the Ptyctodontida gen. indet. triter, some scales of *Ptychodictyon rimosum* Gross, scale fragments of Osteolepididae gen. indet., Sarcopterygii indet., with very few small imprints of the Sarcopterygii indet. scales, numerous teeth of Sarcopterygii indet., indefinable small fragments of the skeletal elements of Pisces indet. The limestones are whitish, dense, pelitomorphic, platy, with single oogonies of the *Sycidium* sp. charophyte algae, some small scale fragments of Actinopterygii indet. The dolomites are clayey, grey, cryptocrystalline, dense, hard, platy.

174.8–204.4 m, thickness 29.6 m – Middle Devonian (D_2), Eifelian Stage (D_2ef), Upper Eifelian Substage (D_2ef_3), Kostuykovichi Regional Stage (Formation) (D_2ks): the strata are composed of clays, clayey siltstones, clayey marls and limestones. The gamma-ray logging curve values within these strata show a significant scatter. So, the γ-activity values vary from 0.7 to 1.8 πA/kg in the range of 204.4–199.7 m and from 0.8 to 2.8 πA/kg in the range of 188.8–174.8 m. Within this interval the conventional resistivity values are mainly low (5–30 Ohm·m) and begin to grow and reach 90 Ohm·m in the interval uppermost part only. These strata are divided into three lithological-geophysical members on the basis of their lithological and geophysical logging data.

The first member (depth interval of 199.7–204.4, 4.7 m thick) is composed of dolomite clays, clayey marls and clayey limestones. The clays are dolomitic, greenish-grey, light grey, massive, fat, heavy under wet conditions. The marls are clayey, light grey, platy, containing a fragment of an anterior medioventral plate of Coccosteidae gen. et sp. indet. The limestones are clayey, light grey, dense, platy, with pyrite inclusions, as well as with numerous small shell fragments of the inarticulate brachiopods, very scarce segments of the crinoids, scolecodonts, ostracodes, the sole fragment of the fin spine of *Haplacanthus* sp., few scales of *Cheiracanthoides pinskensis* Plax., *Nostolepis kernavensis* Valiukevičius, *Acanthodes* ? sp., one tooth of Chondrichthyes indet., few teeth of Onychodontiformes indet., isolated small plate fragments of Placodermi indet., rather abundant scale fragments of *Orvikuina* sp., *Moythomasia* ? sp., Actinopterygii indet., one indefinable bone fragment of Pisces indet., conodonts of *Icriodus stephensoni* Sparling, *Polygnathus linguiformis klapperi* Clausen, Leuteritz et Ziegler, *P. linguiformis* Hinde and *P. webbi* Stauffer (definitions of conodonts from [4]).

The second member (depth interval of 188.8–199.7 m, 10.9 m thick) is represented by grey, greenish-grey, lilac-ocher, tobacco-grey, brown-tobacco, dark grey, argillite-like, horizontally layered, dense clays.

The third member (depth interval of 174.8–188.8 m, 14.0 m thick) consists of variegated, slightly micaceous clayey siltstones and clays.

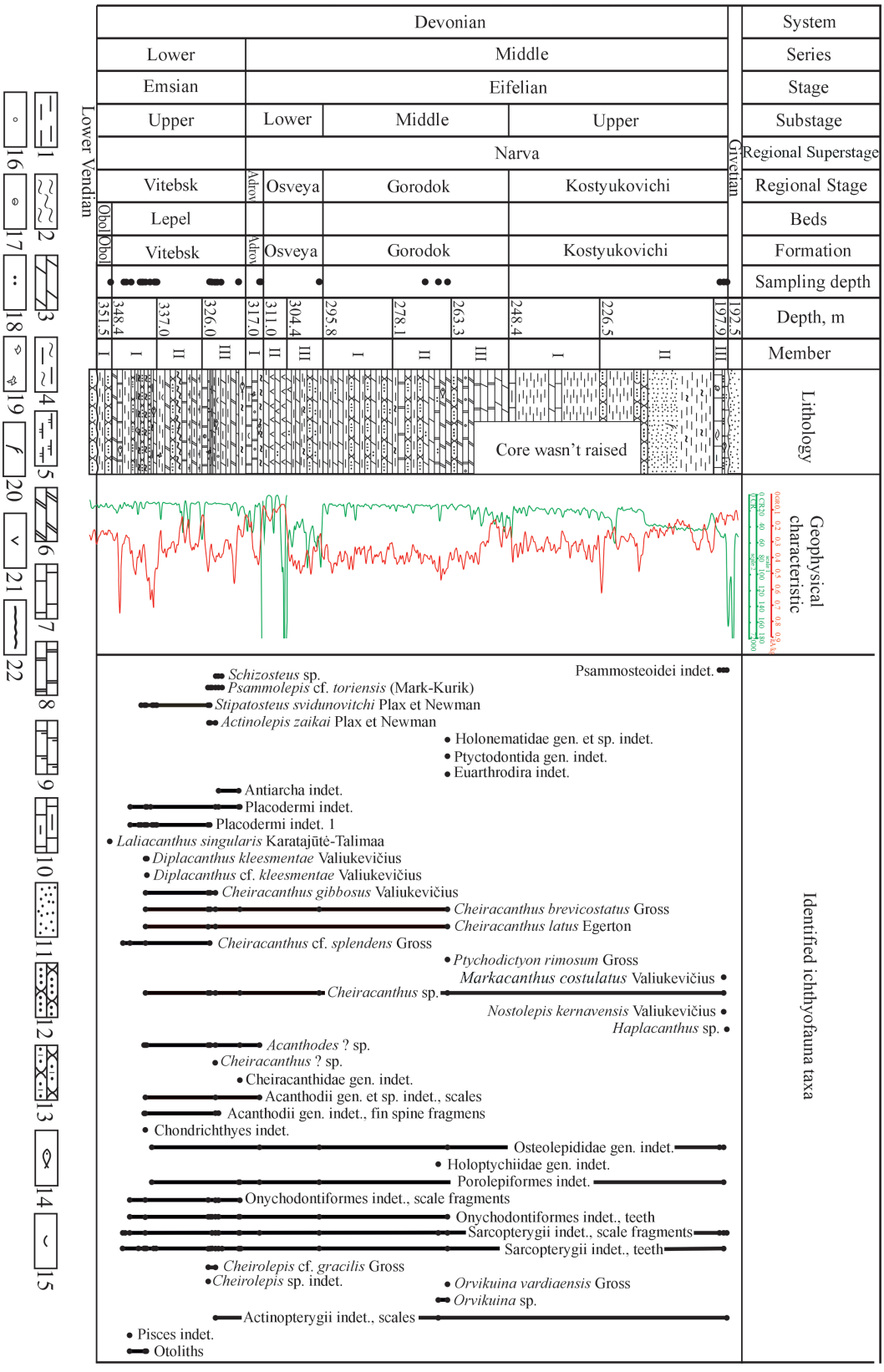
The Kostyukovichi deposits are overlain by the terrigenous rocks of the Polotsk Regional Stage (Formation) of the Givetian Stage of the Middle Devonian that were not described in this paper.

The Korma 1 borehole was drilled in the territory of the Zhlobin Saddle near the Barsuki village of the Korma district, Mogilev region. The stratigraphic division of the exposed-deposits (Text-Fig. 3) was performed using the same research methods as for the borehole described above. A detailed lithological description of this borehole sequence (from bottom to top) with palaeontological and geophysical characteristics is presented below. Some skeletal elements of the vertebrates from the rocks of this borehole are shown in Plates I-X.

348.4–351.5 m, thickness 3.1 m – Lower Devonian (D_1), Emsian Stage (D_1e), Upper Emsian Substage (D_1e_2), Vitebsk Regional Stage (Formation) (D_1vt), Obol Beds (D_1ob). This member is represented by an alternation of light grey, mostly fine-grained, quartzy, with carbonate cement, dense, fairly hard, platy sandstones containing scarce scales of *Laliacanthus singularis* Karatajūtė-Talimaa and greenish-grey, dense, argillite-like clays. There are also interlayers of pelitomorphic, platy, beige dolomites. The rocks of this member occur with a large discontinuity in sedimentation on pink sandstones of the Glusk Formation of the Vilchanka Series of the Lower Vendian. A high γ-activity value up to 0.75 πA/kg is observed at the bottom of this member. The conventional resistivity values are moderate.

317.0–348.4 m, thickness 31.4 m – Lower Devonian (D_1), Emsian Stage (D_1e), Upper Emsian Substage (D_1e_2), Vitebsk Regional Stage (Formation) (D_1vt), Lepel Beds (D_1lp). These strata are composed of terrigenous-carbonate rocks. The studied interval is characterized by sharp changes in the gamma-ray values from 0.12 to 0.7 πA/kg. The values of the conventional resistivity are slightly increased in the middle part of the interval only (50 and 60 Ohm·m). These strata can be divided into three lithological-geophysical member on the basis of their material composition and geophysical logging data.

The first member (depth interval of 337.0 to 348.4 m, 11.4 m thick) is represented by sandstones, siltstones, aleuritic and argillite-like clays, as well as by marls, dolomite marls and clayey dolomites. The sandstones are light grey, greenish grey, fine- and medium-grained, with carbonate cement, well cemented, unclearly layered, at some levels horizontally layered and slightly cavernous, massive, platy, with small fragments of plates, two incomplete spinal plate of *Stipatosteus svidunovitchi* Plax et Newman [3]. The siltstones are light grey, with greenish tint, in places with brown spots, sometimes, clayey, dense, fine-grained, unclearly layered, quartzy, with clayey-carbonate cement, well cemented, with ostracodes, rare small shell fragments of lingulids, numerous small indefinable plate fragments of *Stipatosteus svidunovitchi* Plax et Newman, one small plate fragment of Placodermi indet. 1, scales of *Diplacanthus kleesmentae* Valiukevičius, *D.* cf. *kleesmentae* Valiukevičius, *Acanthodes* ? sp., one fragment of a fin spine of Acanthodii gen. indet., isolated teeth of Sarcopterygii indet. and otoliths. The clays are silty, dark grey, dark greenish-grey, variegated (grey, red, brown, greenish), lumpy, dense,



Text-Fig. 3. Geological section of the Upper Emsian and Eifelian deposits of the Korma 1 borehole with the ichthyofauna distribution. Legend. Rocks: 1 – clays, 2 – siltstones, 3 – marls, 4 – silt clays, 5 – dolomite clays, 6 – dolomite marls, 7 – limestones, 8 - dolomites, 9 – dolomite limestones, 10 – clayey limestones, 11 – sands, 12 – sandstones, 13 - carbonate sandstones. Other symbols: 14 – ichthyofauna, 15 – shell detritus, 16 – oolites, 17 – stromatolites, 18 – sandiness, 19 – cavernosity, 20 – carbonified plant remains, 21 – gypsum, 22 - discontinuity surfaces

weakly carbonate, with small shell fragments of the inarticulate brachiopods, scarce small plate fragments of Placodermi indet., isolated small indefinable plate fragments, a left posterior ventrolateral plate of *Stipatosteus svidunovitchi* Plax et Newman, a spinal plate of Placodermi indet. 1 [3], scales of *Diplacanthus kleesmentae* Valiukevičius, *Cheiracanthus* sp., *C. gibbosus* Valiukevičius, *C. brevicostatus* Gross, *C. latus* Egerton, *C.* cf. *splendens* Gross, *Acanthodes* ? sp., Acanthodii gen. et sp. indet., small fragments of the Acanthodii gen. indet. fin spine, scales of Chondrichthyes indet., scale fragments of Sarcopterygii indet., Onychodontiformes indet., teeth of Onychodontiformes indet., Sarcopterygii indet., small indefinable skeletal element of Pisces indet. and otoliths. The clays are argillite-like, greenish-grey, dense, platy, with numerous small indefinable plate fragments, a right anterior lateral plate, a right anterior ventrolateral plate with an attached right spinal plate of *Stipatosteus svidunovitchi* Plax et Newman [3], small scale fragments of Osteolepididae gen. indet. and Porolepiformes indet. The marls are greenish-grey, brown, with light grey and greenish spots, sandy or clayey at some levels, dense, platy, non-layered, with very rare small plate fragments of Placodermi indet. The marls are dolomitic, light greenish-grey, dense, unclearly layered, relatively hard, massive, in places, with rare small caverns, platy. The dolomites are light grey, with greenish tint, pelitomorphic, dense, hard, in places, with small caverns, platy.

The second member (depth interval of 326.0 to 337.0 m, 11.0 m thick) is composed of sandstones, siltstones, argillite-like and dolomite clays, dolomites. The sandstones are greenish-grey, fine- and medium-grained, quartzy, with carbonate cement, well cemented, unclearly layered, massive, platy. The siltstones are greenish-grey, at some levels variegated, fine-grained, quartzy, well cemented, with carbonate cement, platy. The clays are argillite-like, greenish-grey, dark gray, dense. Clays are dolomitic, greenish-gray, gray, lumpy. Marls are dolomitic, greenish-grey, sandy, dense, unclearly layered, platy, in some places with slickensides. The dolomites are stromatolithic, whitish, beige-grey, dense, slightly cavernous.

The third member (depth interval of 317.0 to 326.0 m, 9.0 m thick) consists of argillite-like and silty clays, clayey marls, dolomite limestones and dolomites. The clays are argillite-like, greenish-grey, with brown spots, dense, contain small fragmentary skeletal elements and isolated tubercles of *Psammolepis* cf. *toriensis* (Mark-Kurik), small plate fragments of *Stipatosteus svidunovitchi* Plax et Newman, small plate fragments of *Actinolepis zaikai* Plax et Newman, Placodermi indet., scales of *Cheiracanthus* sp., *C. brevicostatus* Gross, *C. gibbosus* Valiuk., *Acanthodes* ? sp., teeth of Onychodontiformes indet., Sarcopterygii indet., small scale fragments of Sarcopterygii indet. The clays are argillite-like, silty, greenish-grey, dense, platy, thin-plate at some levels, with a left anterior ventrolateral plate of Antiarcha indet., one small fragment of an articular process and small plates of Antiarcha indet., small plate fragments of Placodermi indet., spinal plate of Placodermi indet., scales of *Cheiracanthus* sp., *C. brevicostatus* Gross, Cheiracanthidae gen. indet., *Acanthodes* ? sp., scale fragments of Porolepiformes indet., Onychodontiformes indet., Sarcopterygii indet., numerous teeth of Onychodontiformes indet., Sarcopterygii indet. The marls are clayey, greenish-grey with brown spots, dense, platy, with slickensides, with scarce ostracodes, conchostracans, single shell fragments of inarticulate brachiopods, tubercles and small fragmentary skeletal elements of *Schizosteus* sp., *Psammolepis* cf. *toriensis* (Mark-Kurik), small plate fragments of Placodermi indet., small indefinable plate fragments and a spinal plate of Placodermi indet. 1, one plate fragment of *Stipatosteus svidunovitchi* Plax et Newman, seven small indefinable plates and the right anterior ventrolateral plate with the inner part of a spinal plate of *Actinolepis zaikai* Plax et Newman, one small fragment of an articular process of Antiarcha indet., scales of *Cheiracanthus* sp., *C. gibbosus* Valiukevičius, *C. latus* Egerton, *C. brevicostatus* Gross, *C.* cf. *splendens* Gross, *C.* ? sp., *Acanthodes* ? sp., Acanthodii gen. et sp. indet., a small fragment of the Acanthodii gen. indet. fin spine, scale fragments of Onychodontiformes indet., Sarcopterygii indet., Onychodontiformes indet., Sarcopterygii indet., three scales of *Cheirolepis* cf. *gracilis* Gross, two scale of *Cheirolepis* sp. indet., a fragment of one scale of Actinopterygii indet. The limestones are dolomitic, light grey, whitish, dense, porous, hard, stromatolithic at some levels. The dolomites are whitish, beige, pelitomorphic, dense, unclearly laminated, platy.

311.0–317.0 m, thickness 6.0 m – Middle Devonian (D_2), Eifelian Stage (D_2ef), Lower Eifelian Substage (D_2ef_1), Adrov Regional Stage (Formation) (D_2ad)): a member of interbedded clays, silt-

Plate I

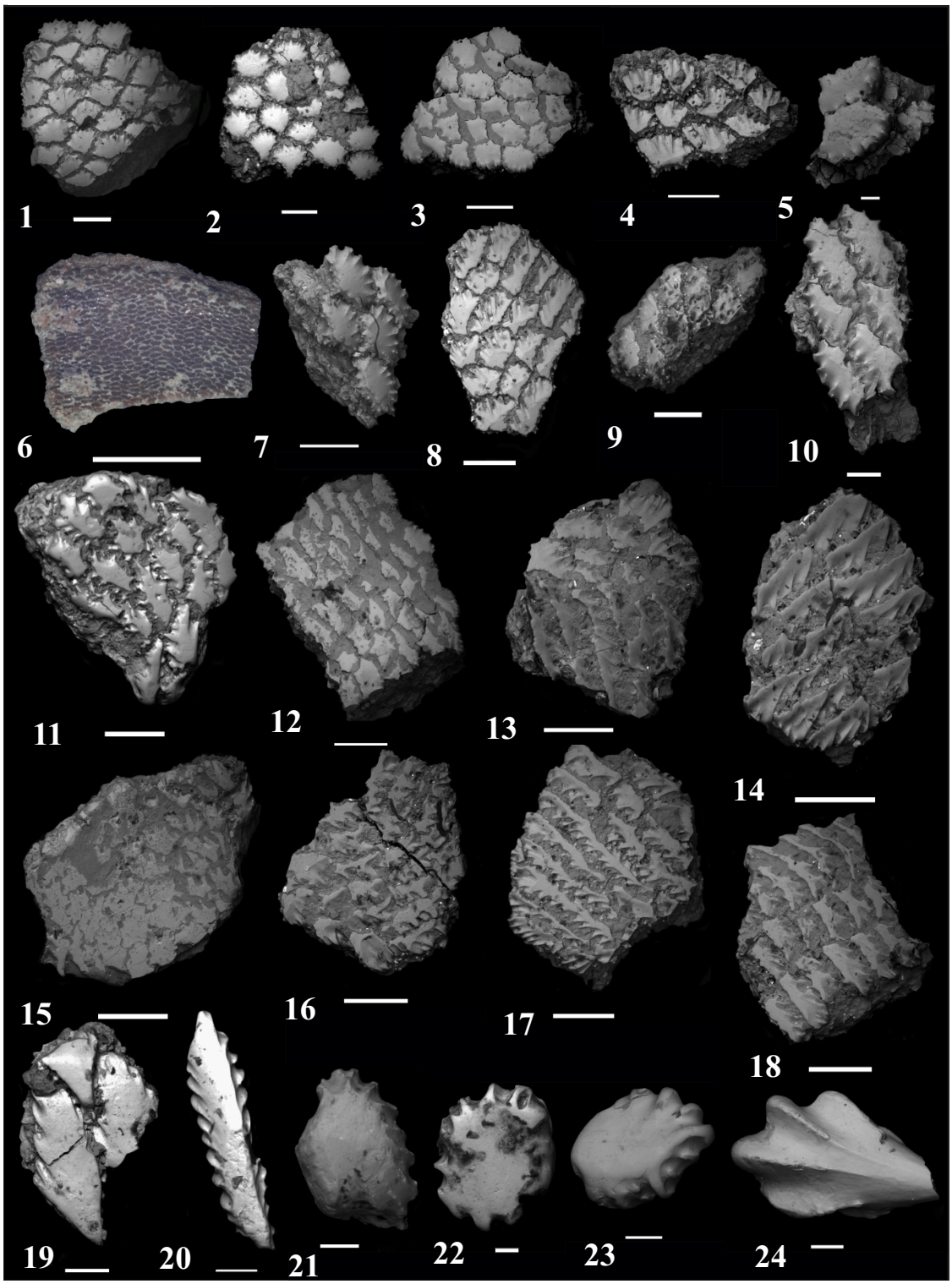


Plate I. Heterostracan remains from the studied boreholes. Skeletal elements of the heterostracans from the Upper Emsian and Eifelian. Scale bar 100 μm for Figures 5, 22, 23 and 24; 200 μm for Figures 10, 19, 20 and 21; 500 μm for Figures 1, 2, 3, 4, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17 and 18; 5 mm for Figure 6

Figure 1 – *Psammolepis* cf. *toriensis* (Mark-Kurik). Specimen № 116/43 – 11, Bykhov 1 borehole, depth of 307.9 m, x 35, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 2 – *Psammolepis* cf. *toriensis* (Mark-Kurik). Specimen № 116/42 – 27, Bykhov 1 borehole, depth of 307.3 m, x 35, indefinable fragmentary skeletal

element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 3 – *Psammolepis* cf. *toriensis* (Mark-Kurik). Specimen № 121/21 – 1, Korma 1 borehole, depth of 321.5 m, x 45, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 4 – Psammosteoidei indet. Specimen № 116/43 – 8, Bykhov 1 borehole, depth of 307.9 m, x 50, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 5 – *Psammolepis* cf. *toriensis* (Mark-Kurik). Specimen № 121/21 – 4, Korma 1 borehole, depth of 321.5 m, x 100, dentine tubercles, top view; Vitebsk Regional Stage, Lepel Beds. Figure 6 – *Psammolepis* cf. *toriensis* (Mark-Kurik). Specimen № 121/23 – 8, Korma 1 borehole, depth of 322.3 m, plate fragment, external view, Vitebsk Regional Stage, Lepel Beds. Figure 7 – *Psammolepis* cf. *toriensis* (Mark-Kurik). Specimen № 116/43 – 12, Bykhov 1 borehole, depth of 307.9 m, x 50, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 8 – *Schizosteus* sp. Specimen № 121/22 – 5, Korma 1 borehole, depth of 322.0 m, x 35, plate fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 9 – *Schizosteus* sp. Specimen № 116/43 – 9, Bykhov 1 borehole, depth of 307.9 m, x 50, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 10 – *Schizosteus* sp. Specimen № 121/23 – 23, Korma 1 borehole, depth of 322.3 m, x 55, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 11 – *Psammolepis* cf. *toriensis* (Mark-Kurik). Specimen № 116/42 – 24, Bykhov 1 borehole, depth of 307.3 m, x 40, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 12 – *Schizosteus* sp. Specimen № 121/21 – 3, Korma 1 borehole, depth of 321.5 m, x 35, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 13 – *Schizosteus* sp. Specimen № 121/22 – 12, Korma 1 borehole, depth of 322.0 m, x 45, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 14 – *Schizosteus* sp. Specimen № 121/22 – 10, Korma 1 borehole, depth of 322.0 m, x 45, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 15 – *Schizosteus* sp. Specimen № 121/21 – 2, Korma 1 borehole, depth of 321.5 m, x 45, indefinable fragmentary skeletal element with heavily worn surface, external view; Vitebsk Regional Stage, Lepel Beds. Figure 16 – *Schizosteus* sp. Specimen № 121/22 – 11, Korma 1 borehole, depth of 322.0 m, x 45, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 17 – *Schizosteus* sp. Specimen № 121/22 – 7, Korma 1 borehole, depth of 322.0 m, x 40, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 18 – *Schizosteus* sp. Specimen № 121/22 – 9, Korma 1 borehole, depth of 322.0 m, x 43, indefinable fragmentary skeletal element, external view; Vitebsk Regional Stage, Lepel Beds. Figure 19 – *Schizosteus* sp. Specimen № 116/42 – 28, Bykhov 1 borehole, depth of 307.3 m, x 75, dentine tubercles, top view; Vitebsk Regional Stage, Lepel Beds. Figure 20 – *Schizosteus* sp. Specimen № 116/42 – 25, Bykhov 1 borehole, depth of 307.3 m, x 65, dentine tubercle, top view; Vitebsk Regional Stage, Lepel Beds. Figure 21 – Psammosteoidei indet. Specimen № 121/1 – 1, Korma 1 borehole, depth of 192.7 m, x 85, dentine tubercle, top view; Kostyukovichi Regional Stage. Figure 22 – Psammosteoidei indet. Specimen № 116/41 – 8, Bykhov 1 borehole, depth of 307.2 m, x 120, dentine tubercle, top view; Vitebsk Regional Stage, Lepel Beds. Figure 23 – Psammosteoidei indet. Specimen № 116/42 – 14, Bykhov 1 borehole, depth of 307.3 m, x 200, dentine tubercle, top view; Vitebsk Regional Stage, Lepel Beds. Figure 24 – Psammosteoidei indet. Specimen № 121/2 – 2, Korma 1 borehole, depth of 193.5 m, x 150, dentine tubercle, top view; Kostyukovichi Regional Stage

stones, marls, clayey dolomites and dolomites. The clays are argillite-like, brownish-brown, dark grey, black, thin-plate, dense, with thin horizontal layering. The siltstones are greenish-grey, fine-grained, carbonate, well cemented, horizontally layered, platy. The marls are light grey with a greenish tint, with numerous inclusions of rounded and slightly angular quartz grains, contain rare scales of *Acanthodes* ? sp., Acanthodii gen. et sp. indet., micromeric scale fragments of Osteolepididae gen. indet., Porolepiformes indet., small indefinable scale debris of Sarcopterygii indet. The dolomites are clayey, greenish-grey, light brown, algal, hard, horizontally layered, platy. The dolomites are white, beige, brownish-grey, crystalline, with occasional and undistinct horizontal lamination, hard, at some levels, organogenic, porous and oolitic. For this member the lowest GR value is 0.1 πA/kg, and the highest value is 0.45 πA/kg. The lowest value of the conventional resistivity is 10 Ohm·m, and the highest one reaches 50 Ohm·m.

295.8–311.0 m, thickness 15.2 m – Middle Devonian (D_2), Eifelian Stage (D_2ef), Lower Eifelian Substage (D_2ef_1), Osveya Regional Stage (Formation) (D_2os): the strata are represented by terrigenous-carbonate-sulfate and sulfate-clayey-carbonate rocks. The studied strata are characterized by the lower gamma-activity values in the lower part from 0.5 to 1.7 πA/kg (the first member) and increased values in the upper part of the section from 0.25 to 0.5 πA/kg (the second member). The conventional resistivity values are quite opposite.

The first member (depth interval of 304.4 to 311.0 m, 6.6 m thick) is represented by horizontally layered, hard terrigenous-carbonate-sulfate rocks. Gypsum is the main mineral of the sulfate portion of this member. It is represented by two modifications: long-fiber selenite, white in color, up to 5 cm in thickness, and coarse-grained, scaly gypsum up to 1.5 cm in thickness. The clayey-carbonate rocks (marls) are light grey in color, dense, platy, contain gypsum; greyish-brown sedimentary crushed breccia lie below. At the base of this member there is a 10 cm thick interlayer of light grey limestone with bedded stromatolites.

Plate II

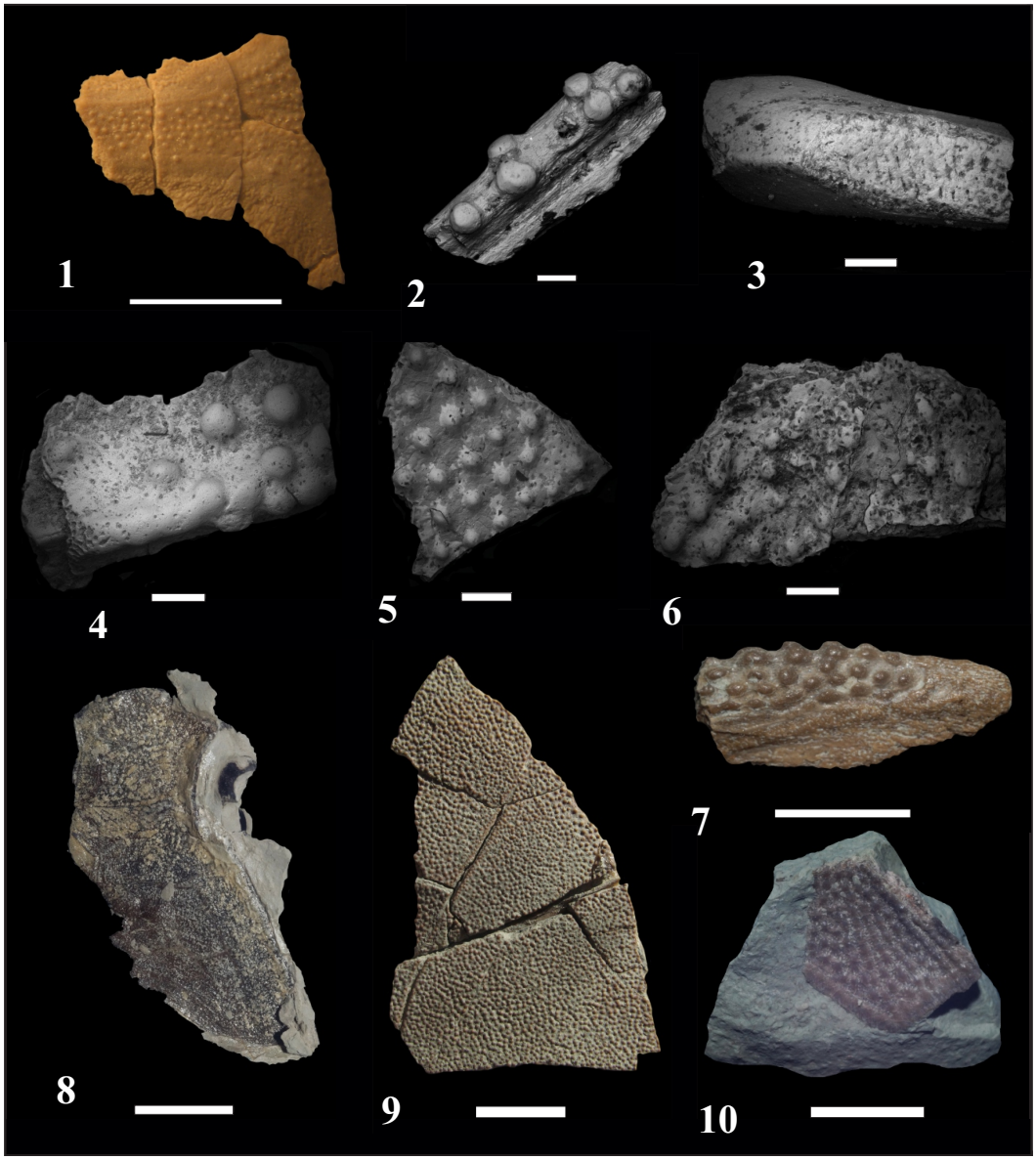


Plate II. Placoderm remains from the studied boreholes. Skeletal elements of the placoderm fishes from the Upper Emsian and Eifelian. Scale bar 200 μm for Figure 2; 500 μm for Figures 3, 4, 5 and 6; 5 mm for Figures 1, 7 and 10; 1 cm for Figures 8 and 9

Figure 1 – Coccosteidae gen. et sp. indet. Specimen № 116/17a – 1, Bykhov 1 borehole, depth of 204.4 m, fragment of the anterior medioventral plate, external view; Kostyukovichi Regional Stage. Figure 2 – Placodermi indet. Specimen № 116/16 – 5, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 65, spinal plate fragment, external view; Kostyukovichi Regional Stage. Figure 3 – Ptyctodontida gen. indet. Specimen № 116/18 – 1, Bykhov 1 borehole, depth of 205.1 m, x 35, fragment of a tritor, top view; Gorodok Regional Stage. Figure 4 – Placodermi indet. Specimen № 116/24 – 2, Bykhov 1 borehole, depth of 231.9 m, x 35, indefinable plate fragment, external view; Gorodok Regional Stage. Figure 5 – Placodermi indet. Specimen № 116/57 – 1, Bykhov 1 borehole, depth of 326.0 m, x 35, indefinable plate fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 6 – Placodermi indet. Specimen № 121/44 – 17, Korma 1 borehole, depth of 340.2 m, x 35, indefinable plate fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 7 – Placodermi indet. Specimen № 116/42 – 41, Bykhov 1 borehole, depth of 307.3 m, spinal plate fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 8 – Antiarcha gen. indet. Specimen № 121/20 – 1, Korma 1 borehole, depth of 317.5 m, the left anterior ventrolateral plate, external view; Vitebsk Regional Stage, Lepel Beds. Figure 9 – Holonematidae gen. et sp. indet. Specimen № 121/10 – 1, Korma 1 borehole, depth of 264.2 m, plate fragment, external view; Gorodok Regional Stage. Figure 10 – Antiarcha indet. Specimen № 116/40 – 1, Bykhov 1 borehole, depth of 304.8 m, indefinable plate fragment, external view; Vitebsk Regional Stage, Lepel Beds

The second member (depth interval of 295.8 to 304.4 m, 8.6 m thick) is composed of sulfate-clayey-carbonate rocks mixed with terrigenous material or of marls in composition including of sandstone, clay, gypsum and dolomite interlayers. The sandstones are light grey, spotted, fine- and medium-grained, massive, with sulfate-carbonate-clayey cement. The clays are grey, greenish-grey, dense, platy, contain two scales of *Cheiracanthus* sp., *C. brevicostatus* Gross, scarce fragments of scales of Osteolepididae gen. indet., Porolepiformes indet., Sarcopterygii indet. and two teeth fragments of Onychodontiformes indet. and Sarcopterygii indet. The marls are light grey, greenish-grey, sandy, clayey at some levels, with gypsum interlayers, lenses, streaks and nests. The gypsum is represented by white, orange, thin-fiber selenite, as well as tabular, lamellar, columnar gypsum of brown color. The dolomites are light grey, beige, pelitomorphic, hard, platy and include gypsum layers. Well pronounced slickensides are observed over the entire interval of the considered member.

248.4–295.8 m, thickness 47.4 m – Middle Devonian (D_2), Eifelian Stage (D_2ef), Middle Eifelian Substage (D_2ef_2), Gorodok Regional Stage (Formation) (D_2gr): the strata of terrigenous-carbonate rocks. For this interval the logging diagrams show a saw-tooth pattern. The maximum values of the conventional resistivity (20 to 40 Ohm·m) were recorded in the uppermost part of the strata. The highest gamma-activity values are observed in the depth range of 263.3 to 278.1 m (from 0.4 to 0.55 πA / kg). Three lithological-geophysical members are well distinguished within these strata on the basis of the lithological and logging data.

The first member (depth interval of 278.1 to 295.8 m, 17.7 m thick) is represented by interbedded sandstones, clays, marls and dolomites. The sandstones are grey, greenish-grey, fine-grained or medium-coarse-grained, quartzy-feldspar, with carbonate cement, massive, undistinctly laminated, platy. The clays are light grey, red, brown, greenish-grey, green, brown, lumpy, foliated at some levels, platy, carbonate. The marls are light grey, greenish-grey, with brown, lilac, brown spots (jasper-like), in places with slickensides, in sites fractured, dense, massive, platy. The dolomites are light grey, dense, pelitomorphic, hard, at some levels fissured and slightly cavernous, platy.

The second member (depth interval of 263.3 to 278.1 m, 14.8 m thick) is composed of sandstones, clays, marls, dolomite marls, limestones and dolomites. The sandstones are light grey, mostly coarse- and medium-grained, feldspar-quartz, with carbonate cement, unclearly layered, massive, platy. The clays are grey, dark grey, dense. The marls are grey, light grey, greenish-grey, with lilac, brown spots (jasper-like), dense, with conchoidal fracture, dolomitic at some levels, with clastic material, usually undistinctly laminated, in places fissured, platy, contain a large plate fragment of Holonematidae gen. et sp. indet., small plate fragments of Euarthrodira indet., small fragments of triters of Ptyctodontida gen. indet., scales of *Cheiracanthus* sp., *C. brevicostatus* Gross, *C. latus* Egerton, *Ptychodictyon rimosum* Gross, small scale fragments of Osteolepididae gen. indet., Sarcopterygii indet., teeth of Onychodontiformes indet., Sarcopterygii indet., two scales of *Orvikuina vardiaensis* Gross, five fragments of scales of *Orvikuina* sp. The limestones are light grey, dense, pelitomorphic, platy, with some few micromeric fragments of the ichthyofauna: small scale fragments of Holoptychiidae gen. indet., Sarcopterygii indet., scale fragments of *Orvikuina* sp. and Actinopterygii indet. The dolomites are grey, dense, pelitomorphic, in places fractured, mainly hard, platy.

The third member (depth interval of 248.4 to 263.3 m, 14.9 m thick) consists of sandstones, marls, dolomite marls, limestones and dolomites. The marls are light grey, dark grey, in places with brown and rust spots, dense, unclearly layered, platy, in some places silty. The marls are dolomitic, light grey, in places with brown and purple spots, dense, in sites with conchoidal fractures, unclearly layered, platy. The limestones are light grey, greenish grey, pelitomorphic, cavernous, hard, massive, platy, with pyrite and calcite in caverns. The dolomites are light grey, pelitomorphic, at some levels oolitic, cavernous, fractured, hard, non-layered, platy.

192.5–248.4 m, thickness 55.9 m – Middle Devonian (D_2), Eifelian Stage (D_2ef), Upper Eifelian Substage (D_2ef_3), Kostuykovichi Regional Stage (Formation) (D_2ks): the strata of interbedded sands, sandstones, clays and limestones. The GR curve shows the highest values in the middle part of the strata (0.48 and 0.62 πA/kg). The value of the conventional resistivity gradually grows towards the roof of the strata, then slightly drops and gradually increases to the maximum values in the uppermost

Plate III

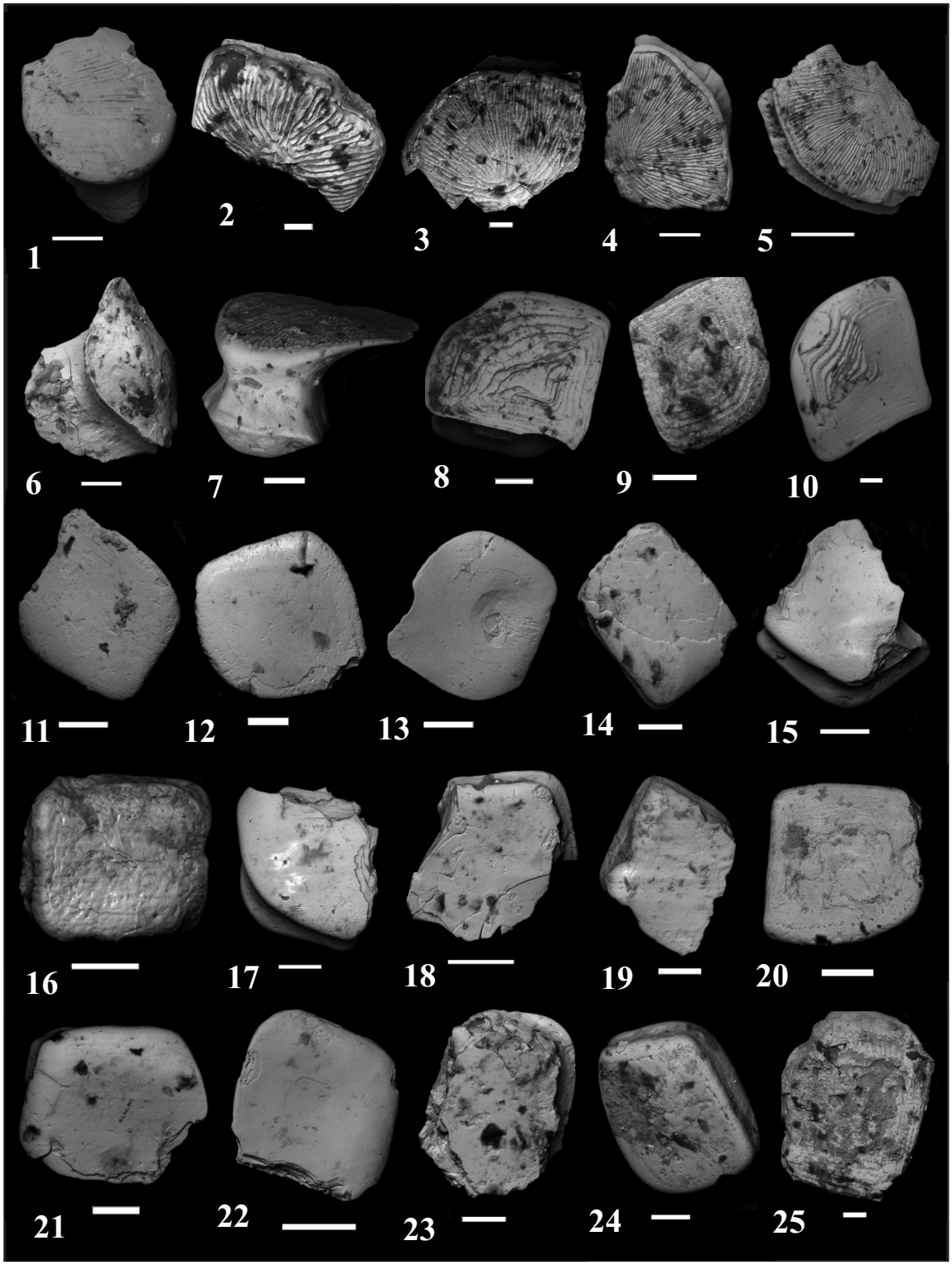


Plate III. Acanthodian scales from the studied boreholes. Scales of acanthodians from the Upper Emsian and Eifelian. Scale bar 100 μm for Figures 2, 3, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24 and 25; 200 μm for Figures 1, 4, 6, 7, 8 and 15; 500 μm for Figure 5

Figure 1 – *Diplacanthus* cf. *kleesmentae* Valiukevičius. Specimen № 121/43 – 1, Korma 1 borehole, depth of 340.1 m, x 95, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 2 – *Diplacanthus kleesmentae* Valiukevičius. Specimen № 116/53 – 1, Bykhov 1 borehole, depth of 324.2 m, x 140, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 3 –

Diplacanthus kleesmentae Valiukevičius. Specimen № 116/51 – 1, Bykhov 1 borehole, depth of 321.5 m, x 100 scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 4 – *Diplacanthus kleesmentae* Valiukevičius. Specimen № 121/44 – 6, Korma 1 borehole, depth of 340.2 m, x 85, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 5 – *Diplacanthus kleesmentae* Valiukevičius. Specimen № 121/44 – 3, Korma 1 borehole, depth of 340.2 m, x 50, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 6 – *Diplacanthus kleesmentae* Valiukevičius. Specimen № 121/44 – 1, Korma 1 borehole, depth of 340.2 m, x 75, scale, basal view; Vitebsk Regional Stage, Lepel Beds. Figure 7 – *Diplacanthus kleesmentae* Valiukevičius. Specimen № 121/44 – 5, Korma 1 borehole, depth of 340.2 m, x 70, scale, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 8 –Acanthodii gen. et sp. indet. Specimen № 116/50 – 3, Bykhov 1 borehole, depth of 321.3 m, x 75, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 9 – Acanthodii gen. et sp. indet. Specimen № 116/41 – 7, Bykhov 1 borehole, depth of 307.2 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 10 – Acanthodii gen. et sp. indet. Specimen № 121/44 – 9, Korma 1 borehole, depth of 340.2 m, x 100, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 11 –*Acanthodes* ? sp. Specimen № 116/44 – 12, Bykhov 1 borehole, depth of 310.0 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 12 – *Acanthodes* ? sp. Specimen № 116/44 – 7, Bykhov 1 borehole, depth of 310.0 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 13 – *Acanthodes* ? sp. Specimen № 116/39 – 1, Bykhov 1 borehole, depth of 302.4 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 14 – *Acanthodes* ? sp. Specimen № 116/16 – 11, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 180, scale, crown view; Kostyukovichi Regional Stage. Figure 15 – *Acanthodes* ? sp. Specimen № 116/42 – 15, Bykhov 1 borehole, depth of 307.3 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds.Figure 16 – Acanthodii gen. et sp. indet. Specimen № 116/16 – 1, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 250, scale, crown view; Kostyukovichi Regional Stage. Figure 17 – *Acanthodes* ? sp. Specimen № 116/42 – 13, Bykhov 1 borehole, depth of 307.3 m, x 150, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 18 – *Acanthodes* ? sp. Specimen № 116/16 – 10, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 250, scale, crown view; Kostyukovichi Regional Stage. Figure 19 – *Acanthodes* ? sp. Specimen № 116/16 – 4, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 180, scale, crown view; Kostyukovichi Regional Stage. Figure 20 – Acanthodii gen. et sp. indet. Specimen № 116/42 – 12, Bykhov 1 borehole, depth of 307.3 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 21 – *Acanthodes* ? sp. Specimen № 116/42 – 7, Bykhov 1 borehole, depth of 307.3 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 22 – *Acanthodes* ? sp. Specimen № 121/44 – 15, Korma 1 borehole, depth of 340.2 m, x 250, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 23 – *Acanthodes* ? sp. Specimen № 116/16 – 13, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 170, scale, crown view; Kostyukovichi Regional Stage. Figure 24 – Acanthodii gen. et sp. indet. Specimen № 116/42 – 11, Bykhov 1 borehole, depth of 307.3 m, x 150, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 25 – Acanthodii gen. et sp. indet. Specimen № 116/37 – 2, Bykhov 1 borehole, depth of 302.0 m, x 100, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds

part of the strata. The considered strata can be divided into three members in accordance its material composition and logging data.

According to the logging data the first member (depth interval of 226.5 to 248.4 m, 21.9 m thick) is composed of clays, marls and limestones.

The second member (depth interval of 197.9 to 226.5 m, 28.6 m thick) is represented by sands, sandstones and clays. The sands are coarse- and medium-grained, quartz, with carbonified plant remains. The sandstones are variegated, medium- and coarse-grained, platy. The clays are variegated (ochreous, greenish, lilac, brown), micaceous, layered.

The third member (depth interval of 192.5 to 197.9 m, thick 5.4 m) consists of sandstone and limestones. The sandstones is pale-yellow, fine-grained, quartz, slightly cemented, platy, carbonate, with single tubercles of Psammosteoidei indet., scales of *Cheiracanthus* sp., *Markacanthus costulatus* Valiukevičius, *Nostolepis kernavensis* Valiukevičius, small scale fragments of Osteolepididae gen. indet., Porolepiformes indet., Sarcopterygii indet., tooth of Sarcopterygii indet. The limestone is light grey, dense, platy, clayey, unclearly laminated, hard, with small shell fragments of the lingulids, with some isolated tubercles of Psammosteoidei indet., some scale fragment of Osteolepididae gen. indet., teeth of Sarcopterygii indet. The limestone is light grey, fine-crystalline, sandy, cavernous, platy, with scarce ostracode valves, with isolated tubercles of Psammosteoidei indet., small fragments of a fin spine of *Haplacanthus* sp., sparse scale fragments of Osteolepididae gen. indet., Sarcopterygii indet., a scale of Actinopterygii indet. The Kostyukovichi deposits are overlain by clayey-silty-sandy rocks of the Polotsk Regional Stage (Formation) of the Givetian Stage of the Middle Devonian that are not described in this paper.

Correlation of the distinguished stratigraphic units in the studied boreholes. The deposits of the Obol and Lepel Beds of the Vitebsk Regional Stage (Formation) of the Upper Emsian determined in two studied boreholes correspond to the Skamolepis fragilis zone in their content of thelodonts, and to the Laliacanthus singularis zone – in the acanthodians [5–9]. The ichthyofauna contained in these deposits allows their correlation with the sediments of the Rezēkne Regional Stage (Formation) of the Baltic States [10–12] and the Novobasovo Beds of the Ryazhsk Regional Stage (Formation) of the central part of the East European Platform [12–14].

Plate IV

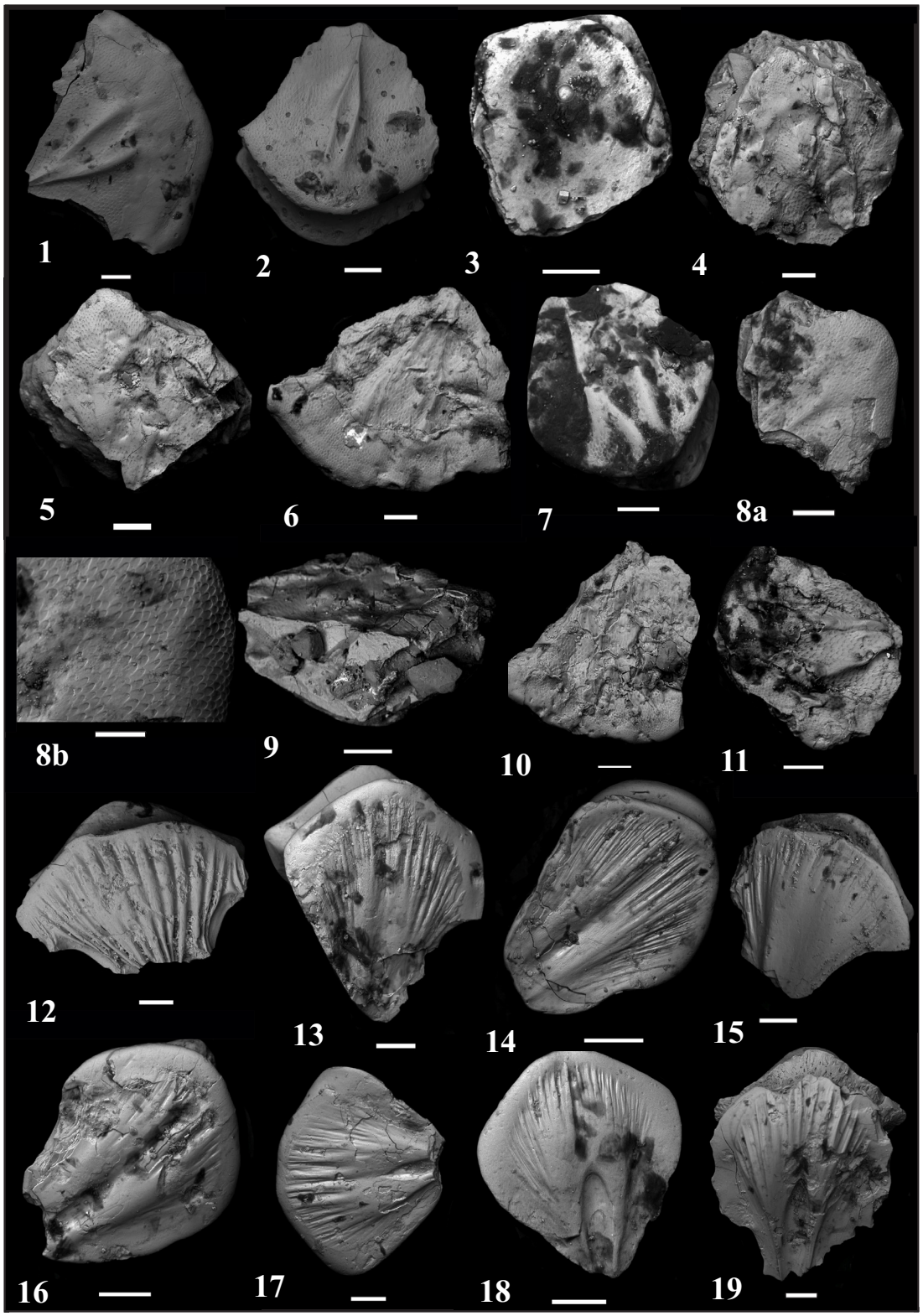


Plate IV. Acanthodian scales from the studied boreholes. Scales of acanthodians from the Upper Emsian and Eifelian. Scale bar 50 μm for Figure 8b; 100 μm for Figures 1, 2, 3, 4, 5, 6, 7, 8a, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 and 19

Figure 1 – *Cheiracanthus* cf. *splendens* Gross. Specimen № 121/44 – 10, Korma 1 borehole, depth of 340.2 m, x 100, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 2 – *Cheiracanthus* cf. *splendens* Gross. Specimen № 121/44 – 4, Korma 1 borehole, depth of 340.2 m, x 120, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 3 – *Cheiracanthus*

cf. *splendens* Gross. Specimen № 116/44 – 5, Bykhov 1 borehole, depth of 310.0 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 4 – *Cheiracanthus* cf. *splendens* Gross. Specimen № 121/50 – 1, Korma 1 borehole, depth of 345.5 m, x 100, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 5 – *Cheiracanthus* cf. *splendens* Gross. Specimen № 121/50 – 6, Korma 1 borehole, depth of 345.5 m, x 120, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 6 – *Cheiracanthus* cf. *splendens* Gross. Specimen № 121/50 – 2, Korma 1 borehole, depth of 345.5 m, x 100, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 7 – *Cheiracanthus* cf. *splendens* Gross. Specimen № 121/48 – 2, Korma 1 borehole, depth of 343.5 m, x 150, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 8 – *Cheiracanthus* cf. *splendens* Gross. Specimen № 121/27 – 2, Korma 1 borehole, depth of 323.3 m, scale: a – crown view, x 150, b – increased crown view, x 500; Vitebsk Regional Stage, Lepel Beds. Figure 9 – *Cheiracanthus* cf. *splendens* Gross. Specimen № 121/50 – 3, Korma 1 borehole, depth of 345.5 m, x 150, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 10 – *Cheiracanthus* cf. *splendens* Gross. Specimen № 121/50 – 4, Korma 1 borehole, depth of 345.5 m, x 120, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 11 – *Cheiracanthus* cf. *splendens* Gross. Specimen № 121/50 – 5, Korma 1 borehole, depth of 345.5 m, x 150, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 12 – *Markacanthus costulatus* Valiukevičius. Specimen № 121/2 – 1, Korma 1 borehole, depth of 193.5 m, x 100, scale, crown view; Kostyukovichi Regional Stage. Figure 13 – *Cheiracanthus latus* Egerton. Specimen № 121/23 – 20, Korma 1 borehole, depth of 322.3 m, x 120, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 14 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 116/42 – 9, Bykhov 1 borehole, depth of 307.3 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 15 – *Cheiracanthus latus* Egerton. Specimen № 121/10 – 6, Korma 1 borehole, depth of 264.2 m, x 150, scale, crown view; Gorodok Regional Stage. Figure 16 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 121/23 – 19, Korma 1 borehole, depth of 322.3 m, x 180, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 17 – *Cheiracanthus latus* Egerton. Specimen № 116/42 – 8, Bykhov 1 borehole, depth of 307.3 m, x 100, scale, crown view; Vitebsk Regional Stage, Lepel Beds.Figure 18 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 116/41 – 6, Bykhov 1 borehole, depth of 307.2 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 19 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 121/44 – 7, Korma 1 borehole, depth of 340.2 m, x 100, scale, crown view; Vitebsk Regional Stage, Lepel Beds

The rocks of the Adrov Regional Stage (Formation) of the Lower Eifelian Substage of the Eifelian Stage distinguished in the studied boreholes correspond to the Guerichosteus heterolepis zone in the heterostracans found there [15] and to the Laliacanthus singularis zone – in the acanthodians [5, 6, 16]. The ichthyofauna determined in the deposits of this Regional Stage allows their correlation with the sediments of the Pärnu Regional Stage (Formation) of the Main Devonian Field [11, 12, 17, 18] and with the deposits of the Osetrov Beds of the Ryazhsk Regional Stage (Formation) in the territory of the Central Devonian Field [13].

Unfortunately, no remains of a zonal taxon of the acanthodians were found in any of the studied boreholes in the deposits of the Osveya Regional Stage of the Lower Eifelian Substage of the Eifelian Stage, therefore, their Osveya age was determined from the rock occurrence in the section, their material composition and correlation with the deposits from the other boreholes drilled earlier within the territory under study. Within Belarus, the deposits of the Osveya Regional Stage (Formation) correspond to the Cheiracanthoides estonicus zone in the acanthodians [6–9, 16]. These are well correlated with the sediments of the Vadja Regional Substage (Formation) of the Narva Regional Stage of Lithuania [5, 12, 18, 19], and are also well correlated with the rocks of the Dorogobuzh Regional Stage (Formation) of the central part of Russia [13].

The rocks of the Gorodok Regional Stage (Formation) of the Middle – Eifelian Substage of the Eifelian Stage distinguished in the studied boreholes correspond to the Ptychodictyon rimosum acanthodian zone [5–9, 16] and are correlated with the deposits of the Leivu Regional Substage (Formation) of the Narva Regional Stage of Lithuania, as well as with the Klintsov and Mosolovo Regional Stages (Formations) in the territory of the central part of Russia [5, 12, 13, 17, 18].

The deposits of the Kostyukovichi Regional Stage (Formation) of the Upper Eifelian Substage of the Eifelian Stage established in the studied boreholes correspond to the Schizosteus striatus zone in their content of heterostracans, to the Coccosteus cuspidatus zone – in the placoderms, and to the Nostolepis kernavensis zone – in the acanthodians [7–9, 12, 16]. These are correlated by their ichthyofauna composition with the sediments of the Kernavė Regional Substage (Formation) of the Narva Regional Stage of the Baltic States [5, 11, 17, 18], with deposits of the Veliky Most Subformation of the lower part of the Lopushany Formation of the Eifelian Stage in the Volyn-Podolia Region [20], with the rocks of the Chernyi Yar Regional Stage (Formation) of the central part of the East European Platform [12, 13], and the Kolva Regional Stage (Lekeiyaga Formation) of the Timan-Pechora Region [12, 21]. It is also worth to note that conodonts were also found in the Bykhov 1 borehole within the Kostyukovichi Regional

Plate V

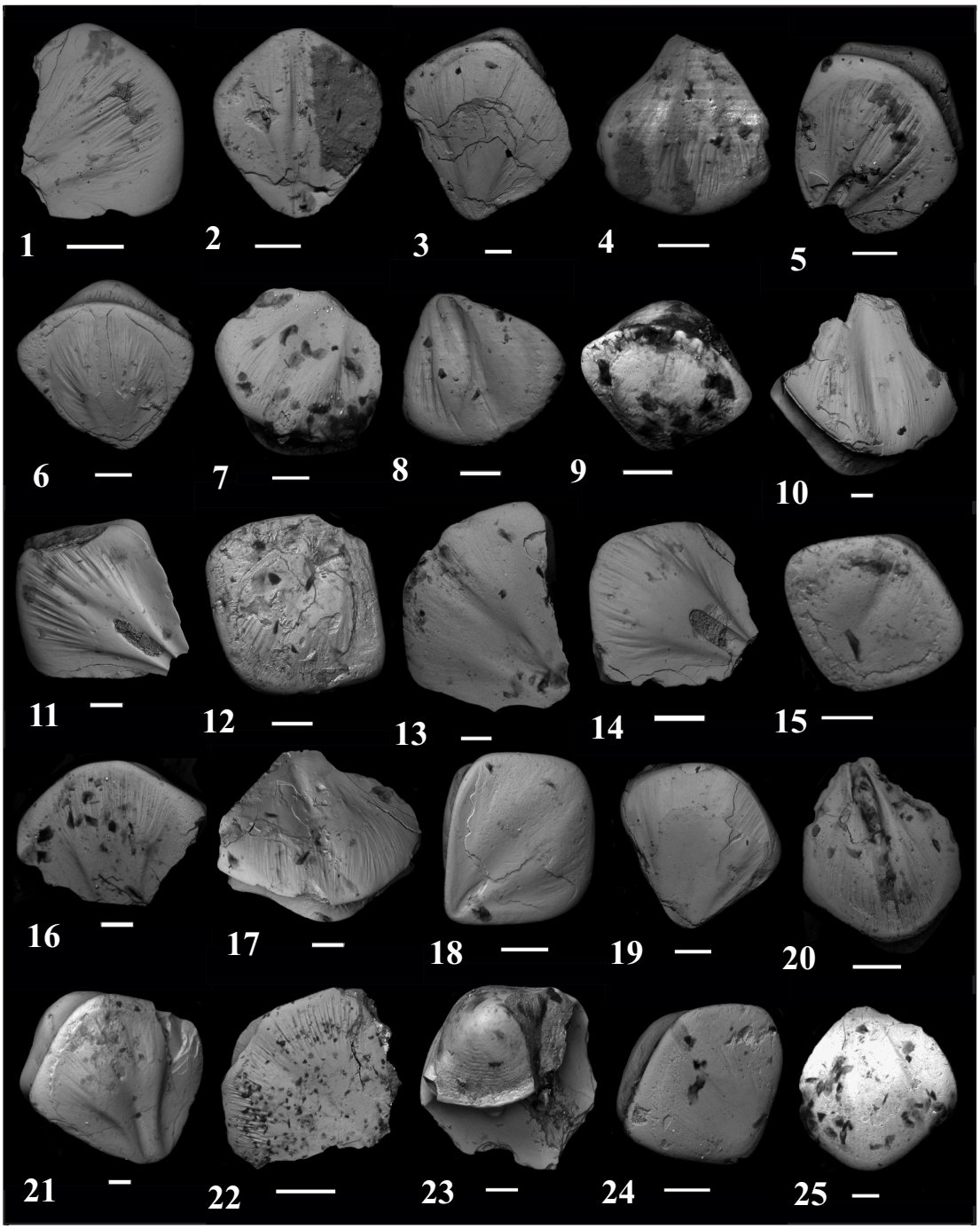


Plate V. Acanthodian scales from the studied boreholes. Scales of acanthodians from the Upper Emsian. Scale bar 100 μm for Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 23, 24 and 25; 200 μm for Figure 20; 500 μm for Figure 22

Figure 1 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 116/42 – 19, Bykhov 1 borehole, depth of 307.3 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 2 – *Cheiracanthus crassus* Valiukevičius. Specimen № 116/42 – 2, Bykhov 1 borehole, depth of 307.3 m, x 180, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 3 – *Cheiracanthus* sp. Specimen № 116/42 – 3, Bykhov 1 borehole, depth of 307.3 m, x 100, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 4 – *Cheiracanthus* sp. Specimen № 116/42 – 4, Bykhov 1 borehole, depth of 307.3 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 5 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 116/42 – 10, Bykhov 1 borehole, depth of 307.3 m, x 180, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 6 – *Cheiracanthus* sp.

Specimen № 116/42 – 5, Bykhov 1 borehole, depth of 307.3 m, x 150, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 7 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 116/43 – 6, Bykhov 1 borehole, depth of 307.9 m, x 150, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 8 – *Cheiracanthus* sp. Specimen № 116/42 -6, Bykhov 1 borehole, depth of 307.3 m, x 200, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 9 – Acanthodii gen. et sp. indet. Specimen № 116/41 – 2, Bykhov 1 borehole, depth of 307.2 m, x 250, scale with worn crown, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 10 – *Cheiracanthus brevicostatus* Gross. Specimen № 116/42 – 18, Bykhov 1 borehole, depth of 307.3 m, x 100, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 11 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 121/23 – 12, Korma 1 borehole, depth of 322.3 m, x 150, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 12 – *Cheiracanthus* sp. Specimen № 121/23 – 13, Korma 1 borehole, depth of 322.3 m, x 160, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 13 – *Cheiracanthus* sp. Specimen № 116/43 – 4, Bykhov 1 borehole, depth of 307.9 m, x 100, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 14 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 116/42 – 21, Bykhov 1 borehole, depth of 307.3 m, x 200, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 15 – *Cheiracanthus crassus* Valiukevičius. Specimen № 116/44 – 13, Bykhov 1 borehole, depth of 310.0 m, x 200, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 16 – *Cheiracanthus* sp. Specimen № 116/43 – 3, Bykhov 1 borehole, depth of 307.9 m, x 150, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 17 – *Cheiracanthus brevicostatus* Gross. Specimen № 121/23 – 16, Korma 1 borehole, depth of 322.3 m, x 120, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 18 – *Cheiracanthus* sp. Specimen № 121/23 – 15, Korma 1 borehole, depth of 322.3 m, x 200, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 19 – *Cheiracanthus brevicostatus* Gross. Specimen № 116/42 – 1, Bykhov 1 borehole, depth of 307.3 m, x 150, scale, crown view; Vitebsk Regional Stage, Lepel Beds.Figure 20 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 121/23 – 25, Korma 1 borehole, depth of 322.3 m, x 95, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 21 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 121/23 – 27, Korma 1 borehole, depth of 322.3 m, x 100, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 22 – *Cheiracanthus brevicostatus* Gross. Specimen № 121/19 – 2, Korma 1 borehole, depth of 317.4 m, x 50, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 23 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 121/23 – 14, Korma 1 borehole, depth of 322.3 m, x 140, scale, basal view; Vitebsk Regional Stage, Lepel Beds.Figure 24 – Acanthodii gen. et sp. indet. Specimen № 116/43 – 16, Bykhov 1 borehole, depth of 307.9 m, x 200, scale with worn crown, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 25 – *Cheiracanthus* sp. Specimen № 116/43 – 1, Bykhov 1 borehole, depth of 307.9 m, x 100, scale with worn crown, oblique crown view; Vitebsk Regional Stage, Lepel Beds

Stage deposits [4] that made it possible to additionally confirm the age of these deposits and to correlate them with the coeval Chernyi Yar deposits in central part of Russia [14].

Conclusions. 1. A detailed stratigraphic subdivision of the Bykhov 1 and Korma 1 borehole sections was made on the basis of their lithological, palaeoichthyological, geological and geophysical data. The lithological and geophysical members were also distinguished in each section of these boreholes.

2. Several ichthyofauna taxa previously unknown from the Upper Emsian-Eifelian deposits of the country were found in the rocks of the studied boreholes. This allowed the authors to complement the palaeontological characteristics of the regional stratigraphic units of the actual Stratigraphic Chart of the Devonian Deposits of Belarus 2010.

3. The correlation of the deposits from the established regional and local stratigraphic units with well-studied synchronous deposits in western Ukraine, Russia and the Baltic States is presented.

4. The results obtained in this research have to be used in future during large-scale geological surveys within the studied area.

Acknowledgements. The authors of the paper are sincerely grateful to Dr. O. F. Kuzmenkova and Dr. S. A. Kruchek (The “Institute of Geology” Branch of the State Enterprise “Research and Production Centre for Geology”, Minsk, Belarus) for the geological and geophysical information about the studied boreholes and some core material provided, the authors express their deep gratitude to Dr. C. Burrow (University of Queensland, Queensland, Australia), Prof. Dr. E. Lukševičs (University of Latvia, Riga, Latvia), Dr. O. A. Lebedev (Orlov Palaeontological Museum of the Borissiak Palaeontological Institute of Russian Academy of Sciences) for the helpful discussions on some ichthyofauna taxa definitions, as well as to V. G. Lugin (Belarusian State Technological University, Center for Physical and Chemical Investigations) for his help with the electron microscope photography, to D. A. Stepanenko for taking pictures of some macroremains of the vertebrates, and to V. G. Filippova for her help in editing the English version of the paper.

Plate VI

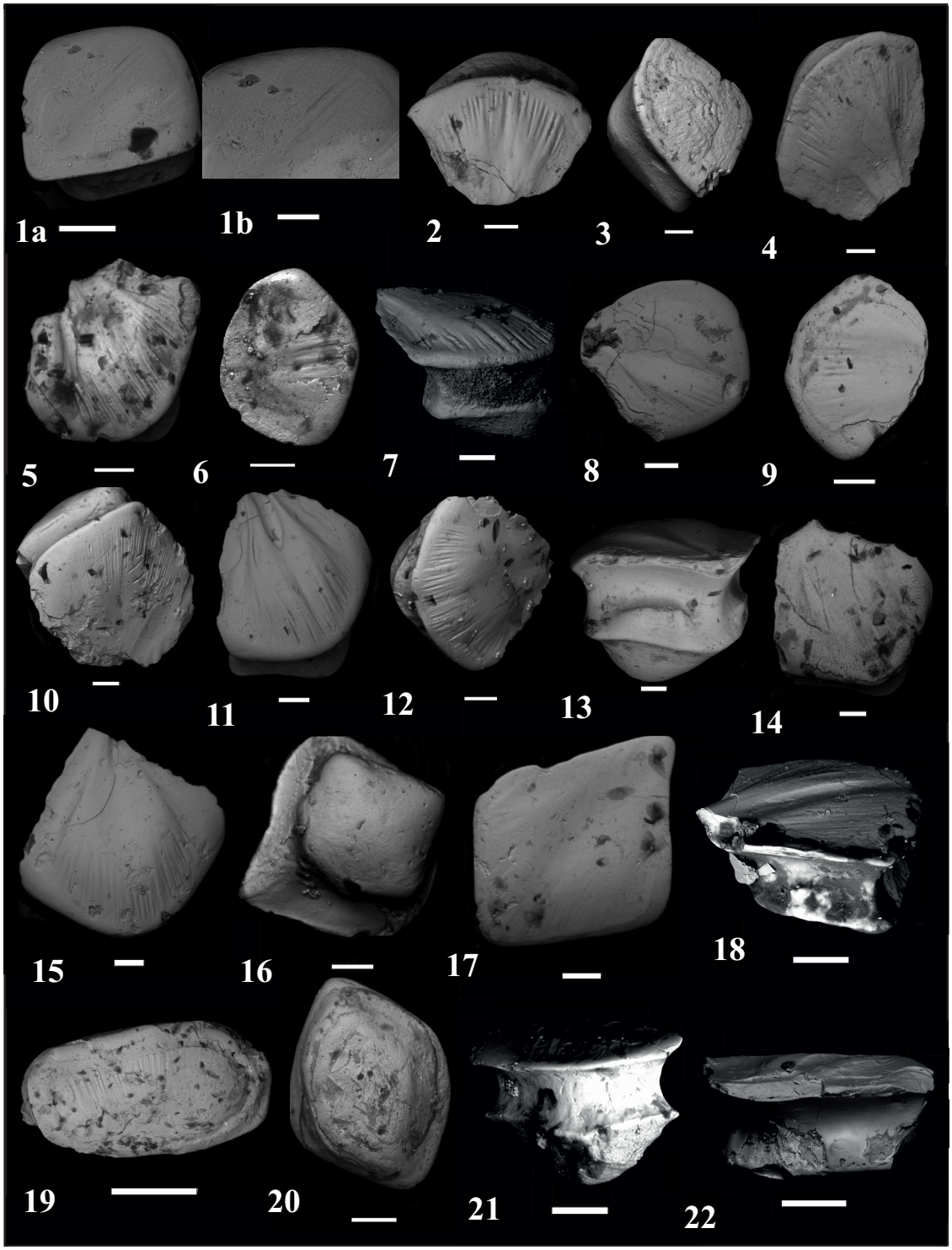


Plate VI. Acanthodian scales from the studied boreholes. Scales of acanthodians from the Upper Emsian and Eifelian. Scale bar 50 μm for Figures 1b and 16; 100 μm for Figures 1a, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 21 and 22; 200 μm for Figure 20; 500 μm for Figure 19.

Figure 1 – *Cheiracanthus* sp. Specimen № 116/43 – 15, Bykhov 1 borehole, depth of 307.9 m, scale with worn crown: a – oblique crown view, x 250, b – increased crown view, x 500; Vitebsk Regional Stage, Lepel Beds. Figure 2 – *Cheiracanthus brevicostatus* Gross. Specimen № 121/10 – 5, Korma 1 borehole, depth of 264.2 m, x 150, scale, crown view; Gorodok Regional Stage. Figure 3 – Acanthodii gen. et sp. indet. Specimen № 121/23 – 18, Korma 1 borehole, depth of 322.3 m, x 130, scale with worn crown, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 4 – *Cheiracanthus* sp. Specimen № 121/10 – 4,

Korma 1 borehole, depth of 264.2 m, x 100, scale, crown view; Gorodok Regional Stage.Figure 5 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 121/23 – 17, Korma 1 borehole, depth of 322.3 m, x 160, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 6 – Acanthodii gen. et sp. indet. Specimen № 116/44 – 9, Bykhov 1 borehole, depth of 310.0 m, x 200, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 7 – *Cheiracanthus latus* Egerton. Specimen № 121/10 – 3, Korma 1 borehole, depth of 264.2 m, x 120, scale, anterolateral view; Gorodok Regional Stage. Figure 8 – *Cheiracanthus* sp. Specimen № 116/42 – 22, Bykhov 1 borehole, depth of 307.3 m, x 150, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 9 – *Cheiracanthus* sp. Specimen № 116/43 – 13, Bykhov 1 borehole, depth of 307.9 m, x 180, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 10 – *Cheiracanthus* sp. Specimen № 121/23 – 22, Korma 1 borehole, depth of 322.3 m, x 120, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 11 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 121/23 – 26, Korma 1 borehole, depth of 322.3 m, x 130, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 12 – *Cheiracanthus brevicostatus* Gross. Specimen № 121/23 – 21, Korma 1 borehole, depth of 322.3 m, x 140, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 13 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 121/23 – 28, Korma 1 borehole, depth of 322.3 m, x 120, scale, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 14 – *Cheiracanthus* sp. Specimen № 116/43 – 2, Bykhov 1 borehole, depth of 307.9 m, x 100, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 15 – *Cheiracanthus gibbosus* Valiukevičius. Specimen № 121/23 – 24, Korma 1 borehole, depth of 322.3 m, x 100, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 16 – Acanthodii gen. et sp. indet. Specimen № 116/42 – 23, Bykhov 1 borehole, depth of 307.3 m, x 300, scale, basal view; Vitebsk Regional Stage, Lepel Beds. Figure 17 – *Cheiracanthus* ? sp. Specimen № 116/43 – 5, Bykhov 1 borehole, depth of 307.9 m, x 150, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 18 – *Cheiracanthus* sp. Specimen № 116/43 – 7, Bykhov 1 borehole, depth of 307.9 m, x 150, scale, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 19 – Cheiracanthidae gen. indet. Specimen № 121/19 – 1, Korma 1 borehole, depth of 317.4 m, x 50, scale with worn crown, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 20 – Acanthodii gen. et sp. indet. Specimen № 121/17 – 2, Korma 1 borehole, depth of 312.4 m, x 80, scale, crown view; Adrov Regional Stage. Figure 21 – *Cheiracanthus* sp. Specimen № 116/41 – 1, Bykhov 1 borehole, depth of 307.2 m, x 200, scale, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 22 – *Cheiracanthus* sp. Specimen № 116/42 – 20, Bykhov 1 borehole, depth of 307.3 m, x 250, scale, lateral view; Vitebsk Regional Stage, Lepel Beds

Plate VII

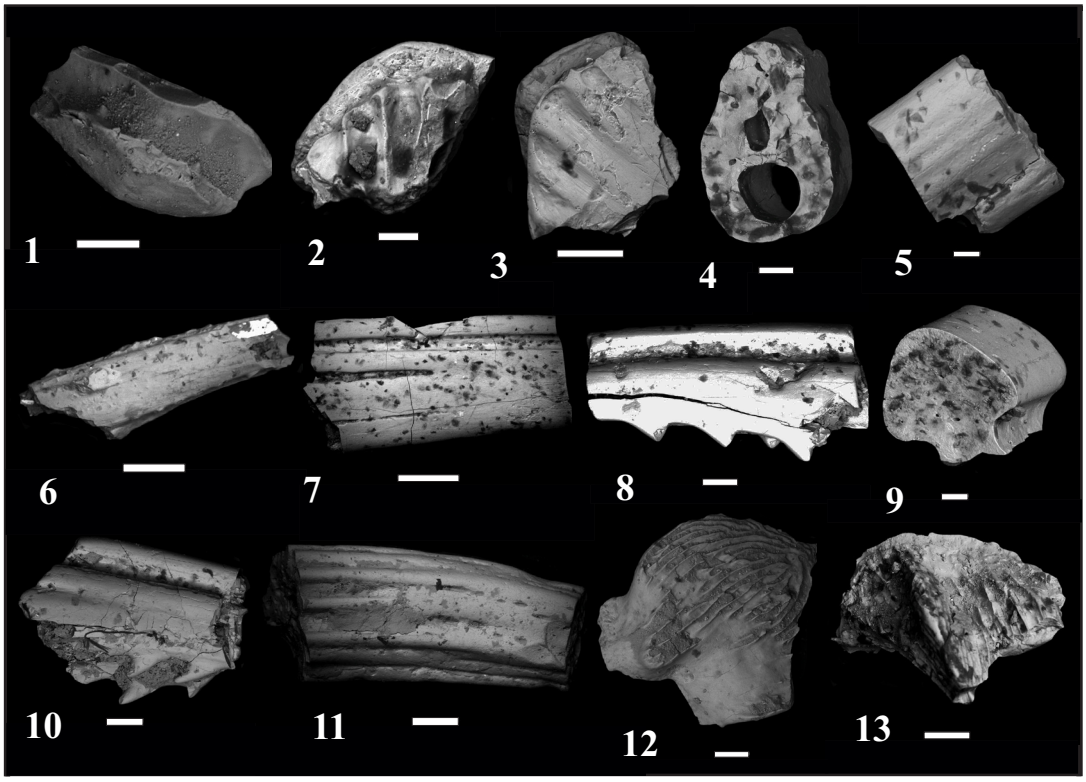


Plate VII. Acanthodian and chondrichthyan remains from the studied boreholes. Skeletal elements of fishes from the Upper Emsian and Eifelian. Scale bar 50 μm for Figure 2; 100 μm for Figures 1, 3, 4, 5, 9 and 12; 200 μm for Figures 8, 10 and 13; 500 μm for Figures 6, 7 and 11

Figure 1 – Acanthodii gen. et sp. indet. Specimen № 116/39 – 5, Bykhov 1 borehole, depth of 302.4 m, x 200, scale, oblique lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 2 – *Nostolepis kernavensis* Valiukevičius. Specimen № 116/16 – 12, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 300, scale, crown view; Kostyukovichi Regional Stage. Figure 3 – *Cheiracanthoides pinskensis* Plax. Specimen № 116/16 – 15, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 250, scale, oblique crown view; Kostyukovichi Regional Stage. Figure 4 – *Haplacanthus* sp. Specimen № 121/1 – 2, Korma 1 borehole, depth of 192.7 m, x 150, fragment of the fin spine, cross section view; Kostyukovichi Regional Stage. Figure 5 – *Haplacanthus* sp. Specimen № 121/1 – 3, Korma 1 borehole, depth of 192.7 m, x 100, fragment of the fin spine, lateral view; Kostyukovichi Regional Stage. Figure 6 – Acanthodii gen. indet. Specimen № 121/22 – 6, Korma 1 borehole, depth of 322.0 m, x 35, fragment of the fin spine, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 7 – Acanthodii gen. indet. Specimen № 116/41 – 3, Bykhov 1 borehole, depth of 307.2 m, x 50, fragment of the fin spine, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 8 – *Diplacanthus* sp. Specimen № 116/42 – 37, Bykhov 1 borehole, depth of 307.3 m, x 65, fragment of the fin spine, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 9 – Acanthodii gen. indet. Specimen № 116/41 – 5, Bykhov 1 borehole, depth of 307.2 m, x 100, fragment of the fin spine, cross section view; Vitebsk Regional Stage, Lepel Beds. Figure 10 – *Diplacanthus* sp. Specimen № 116/42 – 36, Bykhov 1 borehole, depth of 307.3 m, x 75, fragment of the fin spine, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 11 – Acanthodii gen. indet. Specimen № 116/42 – 38, Bykhov 1 borehole, depth of 307.3 m, x 30, fragment of the fin spine, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 12 – Ctenacanth-type scale. Specimen № 116/53 – 4, Bykhov 1 borehole, depth of 324.2 m, x 120, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 13 – Chondrichthyes indet. Specimen № 121/44 – 8, Korma 1 borehole, depth of 340.2 m, x 75, scale, crown view; Vitebsk Regional Stage, Lepel Beds

Plate VIII

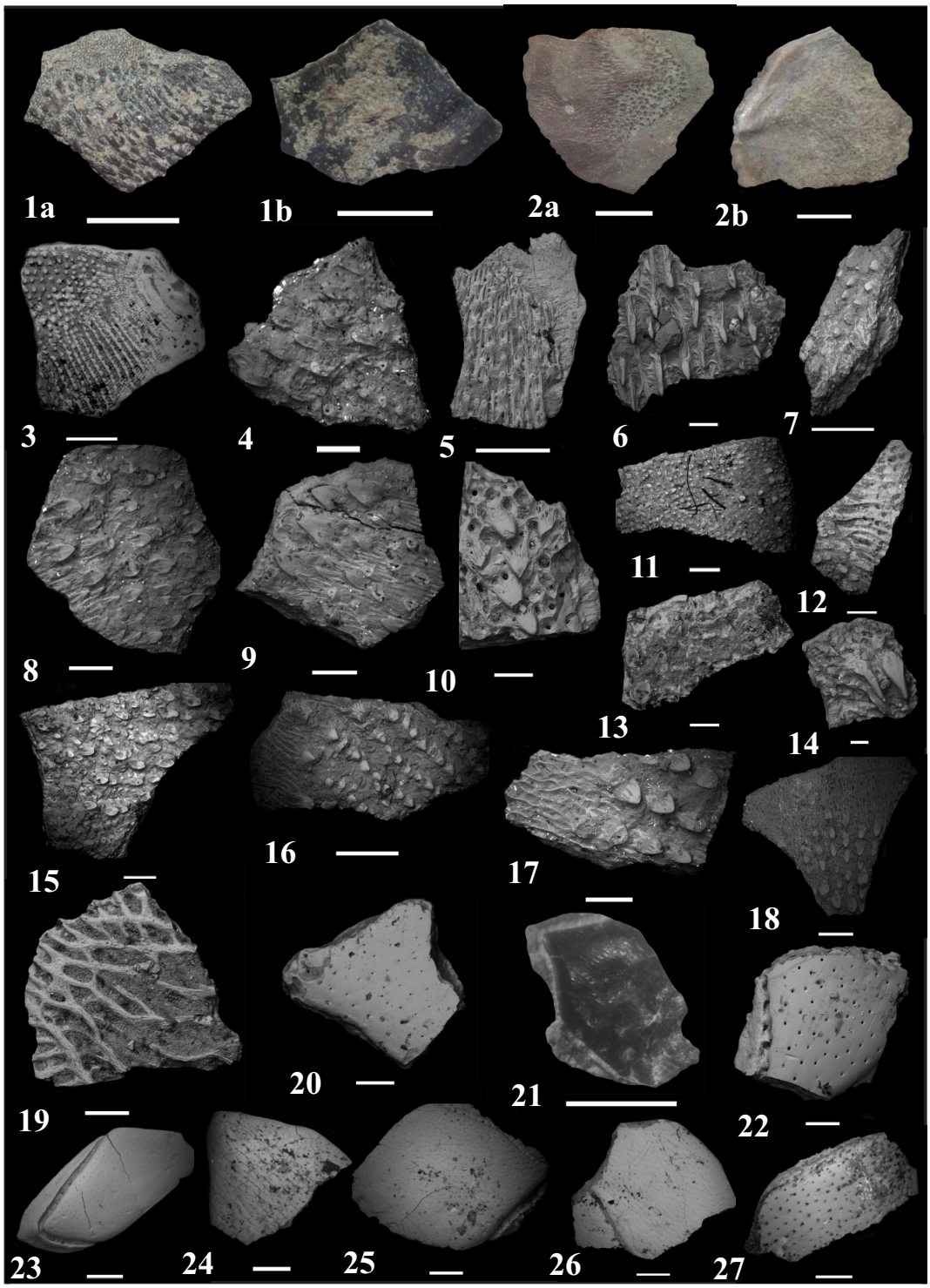


Plate VIII. Sarcopterygian scale fragments from the studied boreholes. Scale fragments of fishes from the Upper Emsian and Eifelian. Scale bar 200 μm for Figures 6, 10, 13, 14, 19, 20, 22; 500 μm for Figures 3, 4, 5, 8, 9, 11, 12, 15, 17, 23, 24, 25, 26 and 27; 1 mm for Figures 7, 16 and 18; 5 mm for Figures 1, 2 and 21.

Figure 1 – Onychodontiformes indet. Specimen № 121/20 – 2, Korma 1 borehole, depth of 317.5 m, scale fragment: a – external view; b – internal view; Vitebsk Regional Stage, Lepel Beds. Figure 2 – Onychodontiformes indet. Specimen № 121/23 – 5, Korma 1 borehole, depth of 322.3 m, scale fragment: a – external view; b – internal view; Vitebsk Regional Stage, Lepel Beds. Figure 3 – Sarcopterygii indet. Specimen № 116/42 – 33, Bykhov 1 borehole, depth of 307.3 m, x 45, scale fragment, external view; Vitebsk

Regional Stage, Lepel Beds. Figure 4 – Onychodontiformes indet. Specimen № 121/22 – 1, Korma 1 borehole, depth of 322.0 m, x 35, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 5 – Onychodontiformes indet. Specimen № 121/44 – 13, Korma 1 borehole, depth of 340.2 m, x 50, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 6 – Sarcopterygii indet. Specimen № 121/44 – 11, Korma 1 borehole, depth of 340.2 m, x 70, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 7 – Sarcopterygii indet. Specimen № 116/38 – 3, Bykhov 1 borehole, depth of 302.3 m, x 25, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 8 – Onychodontiformes indet. Specimen № 121/22 – 2, Korma 1 borehole, depth of 322.0 m, x 35, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 9 – Onychodontiformes indet. Specimen № 121/22 – 3, Korma 1 borehole, depth of 322.0 m, x 35, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 10 – Sarcopterygii indet. Specimen № 121/2 – 3, Korma 1 borehole, depth of 193.5 m, x 80, scale fragment, external view; Kostyukovichi Regional Stage. Figure 11 – Sarcopterygii indet. Specimen № 116/50 – 1, Bykhov 1 borehole, depth of 321.3 m, x 30, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 12 – Onychodontiformes indet. Specimen № 116/38 – 2, Bykhov 1 borehole, depth of 302.3 m, x 30, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 13 – Sarcopterygii indet. Specimen № 121/11 – 1, Korma 1 borehole, depth of 266.4 m, x 85, scale fragment, external view; Gorodok Regional Stage. Figure 14 – Sarcopterygii indet. Specimen № 121/2 – 5, Korma 1 borehole, depth of 193.5 m, x 65, scale fragment, external view; Kostyukovichi Regional Stage. Figure 15 – Onychodontiformes indet. Specimen № 116/42 – 35, Bykhov 1 borehole, depth of 307.3 m, x 30, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 16 – Sarcopterygii indet. Specimen № 116/38 – 1, Bykhov 1 borehole, depth of 302.3 m, x 25, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 17 – Onychodontiformes indet. Specimen № 121/22 – 4, Korma 1 borehole, depth of 322.0 m, x 35, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 18 – Onychodontiformes indet. Specimen № 121/22 – 8, Korma 1 borehole, depth of 322.0 m, x 18, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 19 – Holoptychiidae gen. indet. Specimen № 121/11 – 2, Korma 1 borehole, depth of 266.4 m, x 85, scale fragment, external view; Gorodok Regional Stage. Figure 20 – Porolepiformes indet. Specimen № 121/17 – 3, Korma 1 borehole, depth of 312.4 m, x 90, scale fragment, external view; Adrov Regional Stage. Figure 21 – Osteolepididae gen. indet. Specimen № 116/23 – 3, Bykhov 1 borehole, depth of 227.5 m, scale, external view; Gorodok Regional Stage. Figure 22 – Porolepiformes indet. Specimen № 121/2 – 4, Korma 1 borehole, depth of 193.5 m, x 80, scale fragment, external view; Kostyukovichi Regional Stage. Figure 23 – Osteolepididae gen. indet. Specimen № 121/3 – 2, Korma 1 borehole, depth of 194.5 m, x 40, scale, external view; Kostyukovichi Regional Stage. Figure 24 – Sarcopterygii indet. Specimen № 116/23 – 2, Bykhov 1 borehole, depth of 227.5 m, x 40, scale fragment, external view; Gorodok Regional Stage. Figure 25 – Osteolepididae gen. indet. Specimen № 121/3 – 1, Korma 1 borehole, depth of 194.5 m, x 35, scale, external view; Kostyukovichi Regional Stage. Figure 26 – Sarcopterygii indet. Specimen № 116/21 – 1, Bykhov 1 borehole, depth of 215.7 m, x 35, scale fragment, external view; Gorodok Regional Stage. Figure 27 – Porolepiformes indet. Specimen № 121/41 – 3, Korma 1 bo rehole, depth of 337.9 m, x 35, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds

Plate IX

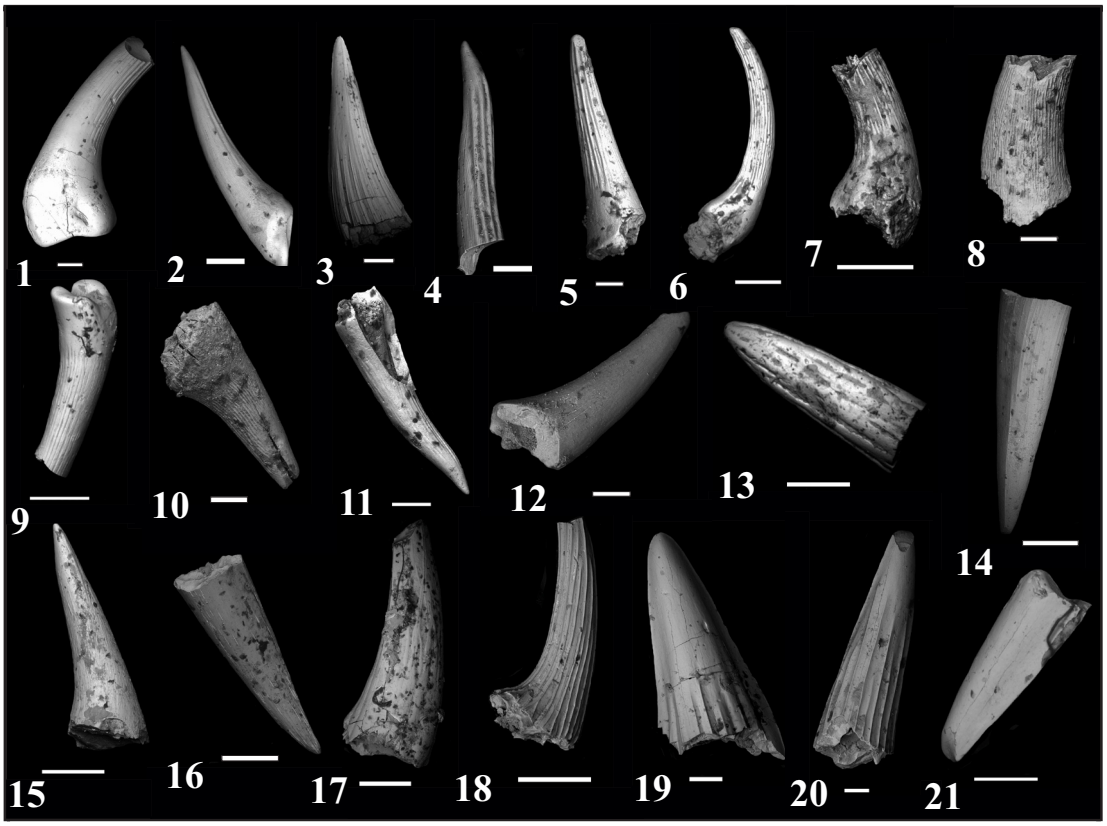


Plate IX. Sarcopterygian teeth from the studied boreholes. Teeth of fishes from the Upper Emsian and Eifelian. Scale bar 100 μm for Figures 4, 12 and 20; 200 μm for Figures 1, 2, 5, 8, 10, 11 and 19; 500 μm for Figures 3, 6, 7, 9, 14, 15, 16, 17, 18 and 21; 1 mm for Figure 13.

Figure 1 – Onychodontiformes indet. Specimen № 121/23 – 31, Korma 1 borehole, depth of 322.3 m, x 55, tooth; lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 2 – Onychodontiformes indet. Specimen № 121/23 – 29, Korma 1 borehole, depth of 322.3 m, x 70, tooth, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 3 – Sarcopterygii indet. Specimen № 121/23 – 32, Korma 1 borehole, depth of 322.3 m, x 30, tooth; Vitebsk Regional Stage, Lepel Beds. Figure 4 – Onychodontiformes indet. Specimen № 116/16 – 19, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 130, tooth, lateral view; Kostyukovichi Regional Stage. Figure 5 – Onychodontiformes indet. Specimen № 116/41 – 4, Bykhov 1 borehole, depth of 307.2 m, x 60, tooth, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 6 – Onychodontiformes indet. Specimen № 116/42 – 32, Bykhov 1 borehole, depth of 307.3 m, x 30, tooth, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 7 – Onychodontiformes indet. Specimen № 116/38 – 4, Bykhov 1 borehole, depth of 302.3 m, x 50, tooth fragment, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 8 – Onychodontiformes indet. Specimen № 116/16 – 2, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 85, tooth fragment; Kostyukovichi Regional Stage. Figure 9 – Onychodontiformes indet. Specimen № 116/42 – 30, Bykhov 1 borehole, depth of 307.3 m, x 45, tooth; Vitebsk Regional Stage, Lepel Beds. Figure 10 – Onychodontiformes indet. Specimen № 116/23 – 1, Bykhov 1 borehole, depth of 227.5 m, x 70, tooth; Gorodok Regional Stage. Figure 11 – Onychodontiformes indet. Specimen № 116/44 – 10, Bykhov 1 borehole, depth of 310.0 m, x 70, tooth, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 12 – Onychodontiformes indet. Specimen № 116/39 – 3, Bykhov 1 borehole, depth of 302.4 m, x 150, tooth; Vitebsk Regional Stage, Lepel Beds. Figure 13 – Sarcopterygii indet. Specimen № 116/42 – 29, Bykhov 1 borehole, depth of 307.3 m, x 25, tooth; Vitebsk Regional Stage, Lepel Beds. Figure 14 – Sarcopterygii indet. Specimen № 116/43 – 14, Bykhov 1 borehole, depth of 307.9 m, x 50, tooth, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 15 – Sarcopterygii indet. Specimen № 116/38 – 5, Bykhov 1 borehole, depth of 302.3 m, x 45, tooth, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 16 – Sarcopterygii indet. Specimen № 116/43 – 10, Bykhov 1 borehole, depth of 307.9 m, x 45, tooth; Vitebsk Regional Stage, Lepel Beds. Figure 17 – Sarcopterygii indet. Specimen № 121/19 – 3, Korma 1 borehole, depth of 317.4 m, x 43, tooth; Vitebsk Regional Stage, Lepel Beds. Figure 18 – Sarcopterygii indet. Specimen № 121/44 – 14, Korma 1 borehole, depth of 340.2 m, x 50, tooth, lateral view; Vitebsk Regional Stage, Lepel Beds. Figure 19 – Sarcopterygii indet. Specimen № 121/44 – 12, Korma 1 borehole, depth of 340.2 m, x 70, tooth; Vitebsk Regional Stage, Lepel Beds. Figure 20 – Sarcopterygii indet. Specimen № 116/53 – 3, Bykhov 1 borehole, depth of 324.2 m, x 100, tooth; Vitebsk Regional Stage, Lepel Beds. Figure 21 – Sarcopterygii indet. Specimen № 116/42 – 31, Bykhov 1 borehole, depth of 307.3 m, x 50, tooth, lateral view; Vitebsk Regional Stage, Lepel Beds

Plate X

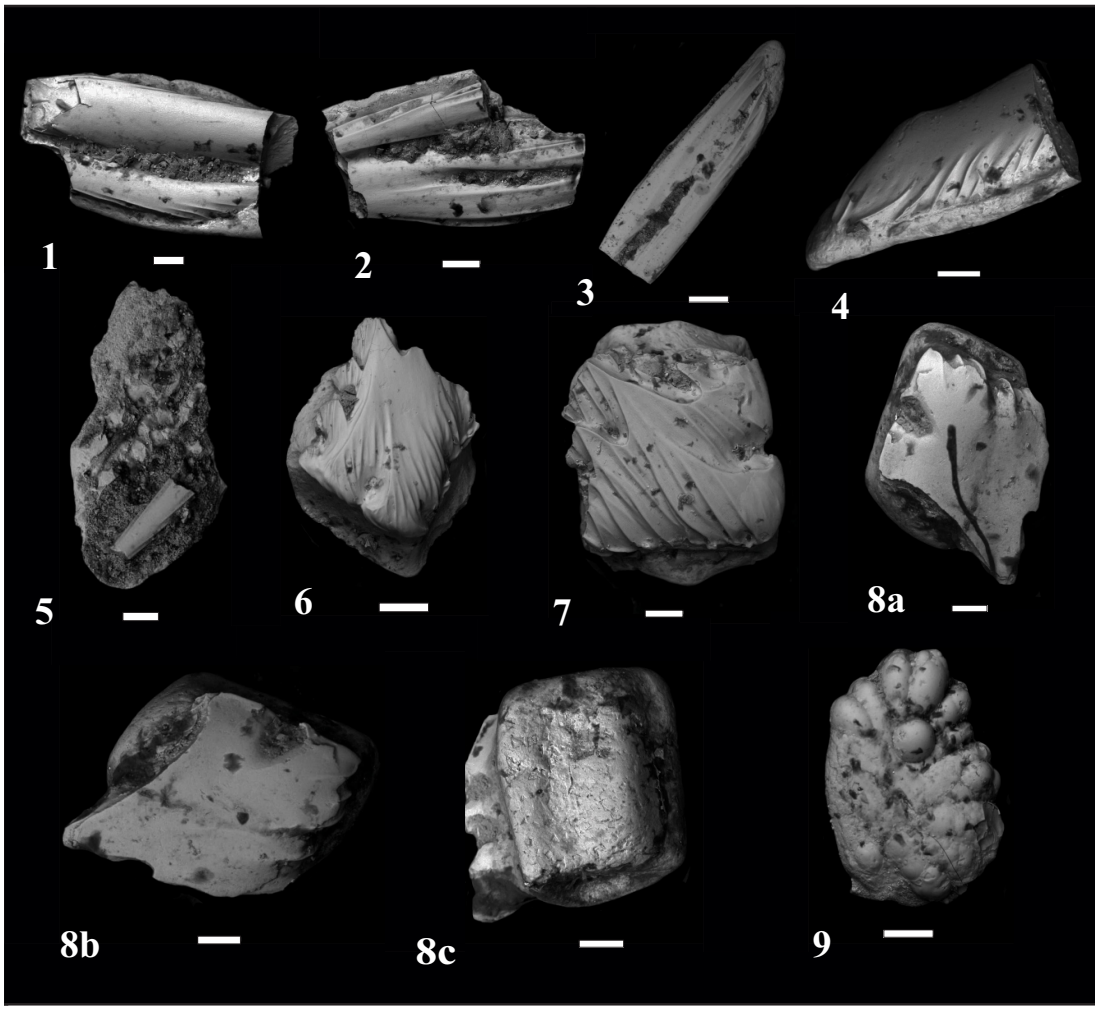


Plate X. Actinopterygian scales and one fish otolith from the studied boreholes. Fish remains from the Upper Emsian and Eifelian. Scale bar 100 μm for Figures 1, 2, 4, 5, 7, 8a, 8b and 8c; 200 μm for Figures 3, 6 and 9

Figure 1 – *Orvikuina* sp. Specimen № 116/16 – 9, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 100, scale fragment, external view; Kostyukovichi Regional Stage. Figure 2 – *Orvikuina* sp. Specimen № 116/16 – 17, Bykhov 1 borehole, depth of 201.4 – 202.4 m, x 140, scale fragment, external view; Kostyukovichi Regional Stage. Figure 3 – *Orvikuina* sp. Specimen № 121/10 – 2, Korma 1 borehole, depth of 264.2 m, x 75, scale fragment, external view; Gorodok Regional Stage. Figure 4 – Actinopterygii indet. Specimen № 116/44 – 11, Bykhov 1 borehole, depth of 310.0 m, x 150, scale fragment, external view; Vitebsk Regional Stage, Lepel Beds. Figure 5 – Actinopterygii indet. Specimen № 121/11 – 3, Korma 1 borehole, depth of 266.4 m, x 120, scale, external view (with worn external surface); Gorodok Regional Stage. Figure 6 – *Cheirolepis* cf. *gracilis* Gross. Specimen № 121/23 – 33, Korma 1 borehole, depth of 322.3 m, x 75, scale, crown view; Vitebsk Regional Stage, Lepel Beds. Figure 7 – *Cheirolepis* cf. *gracilis* Gross. Specimen № 121/23 – 34, Korma 1 borehole, depth of 322.3 m, x 100, scale, oblique crown view; Vitebsk Regional Stage, Lepel Beds. Figure 8 – *Cheirolepis* sp. indet. Specimen № 116/44 – 8, Bykhov 1 borehole, depth of 310.0 m, scale: a – crown view, x 100; b – oblique crown view, x 100, c – basal view, x150; Vitebsk Regional Stage, Lepel Beds. Figure 9 – Otolith. Specimen № 121/44 – 2, Korma 1 borehole, depth of 340.2 m, x 75, otolith; Vitebsk Regional Stage, Lepel Beds

References

1. *Kruchek, S. A., Makhnach A. S., Golubtsov V. K., Obukhovskaya T. G.* The Devonian system // Geology of Belarus. Ed. by A. S. Makhnach [et al.]. – Minsk: National Acad. Sci. Belarus, Institute of Geological Sciences, 2001. – P. 186–236 (in Russian).

2. The Devonian system / Stratigraphic Chart of the Precambrian and Phanerozoic deposits of Belarus: Explanatory Note / T. G. Obukhovskaya [et al.]. – Minsk: State Enterprise «BelNIGRI», 2010. – P. 98–114 (with Stratigraphic Chart of the Devonian deposits of Belarus in 2 sheets) (in Russian).

3. *Plax, D. P.* New Early Devonian (Late Emsian) placoderms from Belarus / D. P. Plax, M. J. Newman // Journal of Paleontology. – 2020. – Vol. 94(4). – P. 773–787.

4. *Murashko, O. V.* A finding of the Middle Devonian conodonts in the Bykhovskaya parametric borehole section in the eastern part of Belarus / O. V. Murashko, D. P. Plax // Problems of Geology of Belarus and Adjacent Territories: Materials of the International Scientific Conference Dedicated to the 100th Anniversary of A.S. Makhnach, Academician of the NAS of Belarus (Minsk, November 21–22, 2018) / Institute for Nature Management of the National Academy of Sciences of Belarus. Eds.: A. A. Makhnach [et al.]. – Minsk: StroyMedia Project Publ., 2018. – P. 138–139 (in Russian).

5. *Valiukevičius, J.* Acanthodian zonal sequence of Early and Middle Devonian in the Baltic basin // Geologija, 17. Vilnius, 1994. – P. 115–125.

6. *Valiukevičius, J.* Acanthodians and zonal stratigraphy of Lower and Middle Devonian in East Baltic and Byelorussia / J. Valiukevičius // Palaeontographica. – Stuttgart, 1998. – Abt. A. – S. 1–53.

7. *Plaksa, D. P.* Devonian (Late-Emsian – Frasnian) fish fauna of Belarus and its stratigraphic importance. – Candidate's Thesis. Institute of Geochemistry and Geophysics of the National Academy of Sciences of Belarus / D. P. Plax. – Minsk, 2007. – 23 p. (in Russian with Belarusian and English summary).

8. *Plaksa, D. P.* Introduction of vertebrate zonal scales into the Stratigraphic Chart of Devonian deposits of Belarus / D. P. Plaksa // Dokl. Acad. Nauk Belarusi. – 2008. – Vol. 52, N 4. – P. 83–88 (in Russian).

9. *Plax, D. P.* Devonian fish fauna of Belarus / D.P. Plax // Lithosphere. – 2008. – N 2 (29). – P. 66–92 (in Russian).

10. *Lyarskaya, L. A.* The Rēzekne Formation and its age equivalents / L. A. Lyarskaya // The Stratigraphy of the Phanerozoic of the Baltic States. – Riga: Zinātne Publ., 1978. – P. 22–39 (in Russian).

11. The Devonian and Carboniferous of the Baltic States / V. S. Sorokin, L. A. Lyarskaya, A. S. Savvaitova [et al.]. – Riga, 1981. – 502 p. (in Russian).

12. *Valiukevičius, J.* Acanthodian biostratigraphy and interregional correlations of the Devonian of the Baltic States, Belarus, Ukraine and Russia / J. Valiukevičius, S. Kruchek // Courier Forschungsinstitut Senckenberg (Final Report of IGCP 328 project). – 2000. – Vol. 223. – P. 271–289.

13. The Devonian of the Voronezh Anteclise and the Moscow Syneclise // G. D. Rodionova, V. T. Umnova, L. I. Kononova [et al.]. – Moscow, 1995. – 265 p. (in Russian).

14. *Vorotnikova, G. V.* State geological map of the Russian Federation. Scale 1:1,000,000 (third generation). Central European Series. Sheet N-36 (M-36). – Smolensk, Explanatory Note / G. V. Vorotnikova, E. A. Gavryushova, S. V. Drutskoy, A. V. Zhuravlev [et al.]. – St. Petersburg, VSEGEI Cartographic Factory, 2011. – 267 p. (in Russian).

15. *Glinskiy, V. N.* New data on psammosteid heterostracans (Pteraspidomorpha) and acanthodians (Acanthodii) from the Pärnu Regional Stage (Lower Eifelian, Middle Devonian) of Estonia / V. N. Glinskiy, D. V. Pinakhina // Estonian Journal of Earth Sciences. – 2018. – Vol. 67 (1). – P. 76–87.

16. *Valiukevičius, J.* Complexes of vertebrate microremains and correlation of terrigenous Devonian deposits of Belarus and adjacent territories / J. Valiukevičius, V. Talimaa and S. Kruchek // Ichthyolith Issues. Special Publication 1 Socorro. – New Mexico, 1995. – P. 53–59.

17. *Valiukevičius, J.* The Devonian system // Geological map of the USSR. Scale of 1:1,000,000 (new series). Explanatory Note. Sheet N-(34), (35) / J. Valiukevičius, V. K. Golubtsov. – Vilnius; Leningrad, 1986. – P. 53–68 (in Russian).

18. *Mark-Kurik, E.* The Middle Devonian fishes of the Baltic States (Estonia, Latvia) and Belarus / E. Mark-Kurik //Courier Forschungsinstitut Senckenberg (Final Report of IGCP 328 project). – 2000. – Vol. 223. – P. 309–324.

19. *Valiukevičius, J.* Acanthodians from the Narva Regional Stage of the Main Devonian Field / J. Valiukevičius. – Vilnius, 1985. – 144 p. (in Russian).

20. *Plax, D. P.* Devonian ichthyofauna of the Volyn Monocline / D. P. Plax // Lithosphere. – 2011. – N 2 (35). – P. 12–21.

21. *Valiukevičius, J.* New Silurian to Middle Devonian acanthodians of the Timan-Pechora Region / J. Valiukevičius // Acta Geologica Polonica. – 2003. – Vol. 53, N 3. – P. 209–245.

Received 16.09.2020