

PŘIDOLIAN ICHTHYOFAUNA OF BELARUS

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The paper presents the results of a palaeoichthyological study of the Přidolian age rocks exposed in the Komarovka 933/10 and Rataichitsy 12k boreholes located within the territory of the Volyn Monocline and Podlasie-Brest Depression in Belarus. The presented information makes it possible to clarify and supplement the ichthyofauna taxonomic composition in the above-mentioned deposits within the boundaries of the above-named tectonic structures, as well as to use it to determine the age of the rocks, their subdivision and correlation. In addition, the paper gives a description of a new acanthodian species based on some isolated scales and a brief taphonomic description of the skeletal remains of the Přidolian ichthyofauna. The data obtained supplement the information of the ichthyofauna stratigraphic and geographical distribution.

INTRODUCTION

The deposits of the Přidolian Series of the Upper Silurian have been established within the territory of Belarus in the southwestern part only, where these are developed in two separate regions tectonically corresponding to the Podlasie-Brest Depression and Volyn Monocline [26, 27]. The areas of their present distribution are small and merge with the regions in the territory of Poland, where the Přidolian sediments are widespread. In both areas of the Brest region of Belarus the Přidolian deposits occur at a considerable depth and can be studied using borehole drilling only.

According to the current Stratigraphic Chart of the Silurian deposits of Belarus of 2010, the Přidolian Series includes deposits of the Mukhavets and Kustin Regional Stages [27]. Within the Podlasie-Brest Depression the Mukhavets Regional Stage includes two Formations [25]: the Kantinovka Formation at the bottom and the Svitichi Formation at the top. The total thickness of these two formations is about 115 m. The Kustin Regional Stage corresponds to the Kustin Formation of the same name (up to 65 m thick), which completes the section of the Přidolian in the territory of the Podlasie-Brest Depression. Its deposits are overlapped here in some places by the conformable sediments of the Kameniuki Formation of the Borshchovo Regional Stage of the Lochkovian Stage of the Lower Devonian [32], and in other places – by transgressively occurring Permian and Jurassic deposits [27]. Within the Belarusian part of the Volyn Monocline the Mukhavets Regional Stage corresponds to the Gushchin Formation, and the Kustin Regional Stage corresponds to the Tomashovka Formation [14, 27]. The thickness of the Gushchin Formation is 113 m,

and the thickness of the Tomashovka Formation reaches 112 m. The deposits of the Tomashovka Formation in the considered area are either conformably overlain by the deposits of the Domachevo Formation of the Borshchovo Regional Stage of the Lochkovian Stage of the Lower Devonian [32], or by the deposits of the Dregovich Formation of the Mikhailov Regional Stage of the Visean Stage of the Lower Carboniferous with a large discontinuity in sedimentation [14].

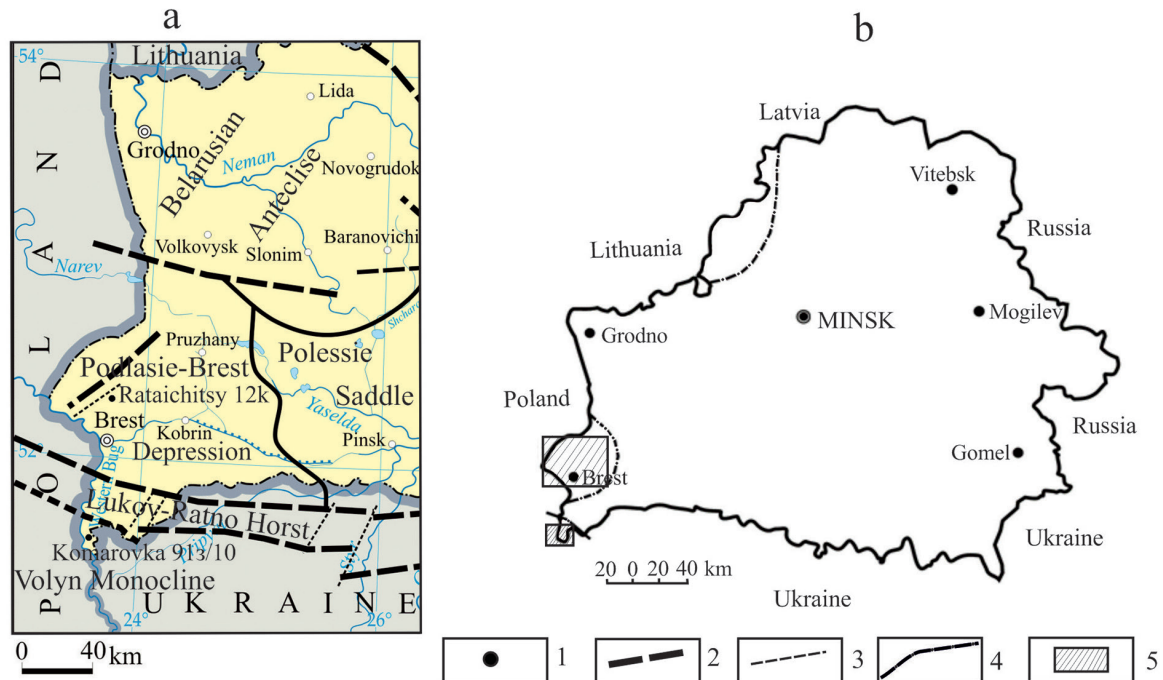
This paper provides updated generalized data on the Přidolian ichthyofauna of Belarus. Some information about the ichthyofauna findings from this age interval in the territory of Belarus have already been cited by D. P. Plax in two papers [14, 24]. However, the recent additional ichthyofaunistic studies of the core taken earlier from the Přidolian part of the sections of the Komarovka 913/10 and Rataichitsy 12k boreholes permitted us to find quite a lot of micromeric ichthyofauna remains. Their careful study made it possible to supplement the systematic composition of the Přidolian ichthyofauna of Belarus with the taxa earlier unknown in the territory of the country, to identify among them one new species of the acanthodian on the basis of some isolated scales, and, in general, to supplement the palaeontological characteristic of the regional stratigraphic subdivisions of the Přidolian in the territory of Belarus with new ichthyofauna data.

MATERIAL AND METHODS

The skeletal material of the agnathans and fishes presented in the paper comes from the core of two boreholes: Komarovka 913/10 and Rataichitsy 12k. The Komarovka 913/10 borehole was drilled within the Volyn Monocline, and the Rataichitsy 12k borehole –

in the Podlasie-Brest Depression (Text-Figure 1). The remains of the ichthyofauna obtained from the siltstones, dolomites, limestones and marls by dissolving them with 9–10 % acetic acid and 7 % formic acid are represented by micromeric skeletal elements: tesserae,

scales and fragments of fin spines of satisfactory or good preservation. Systematically, the skeletal elements mentioned above belong to the thelodonts and acanthodians.



Text-Figure 1 – Map showing the location of the borehole sections in the southwestern part of Belarus, where the Pridolian ichthyofauna was studied (a) and site sketch map (b):

- 1 – borehole sections where the ichthyofauna was studied; 2 – regional and subregional fractures; 3 – local fractures; 4 – boundary of the present-day occurrence of the Silurian deposits; 5 – outlines of the studied areas

The photographs of the agnathans and fishes microremains were taken using a JSM-5610 LV scanning electron microscope (JEOL, Japan) to illustrate the material. The pictures were processed using the Adobe Photoshop CS6 program, and the drawings were performed using the CorelDRAW 2019 graphics editor. The study of the skeletal elements was carried out using a microscopes MBS – 1 and an Axioskop 40 A Pol.

The diagnostics of the skeletal elements was based mainly on the external morphological features. The histological data were used to identify some thelodont and acanthodian scales. The fragmentation and the preservation quality of the skeletal material did not always make it possible to determine the specimen to the species; therefore, a number of definitions of the vertebrates were left in open nomenclature.

All the studied remains of the ichthyofauna with the exception of the scales of a new species of the acanthodian are kept in the author's personal collection. The scales of a new species of the acanthodian are stored at the Department of Mining of the Belarusian National Technical University (Minsk).

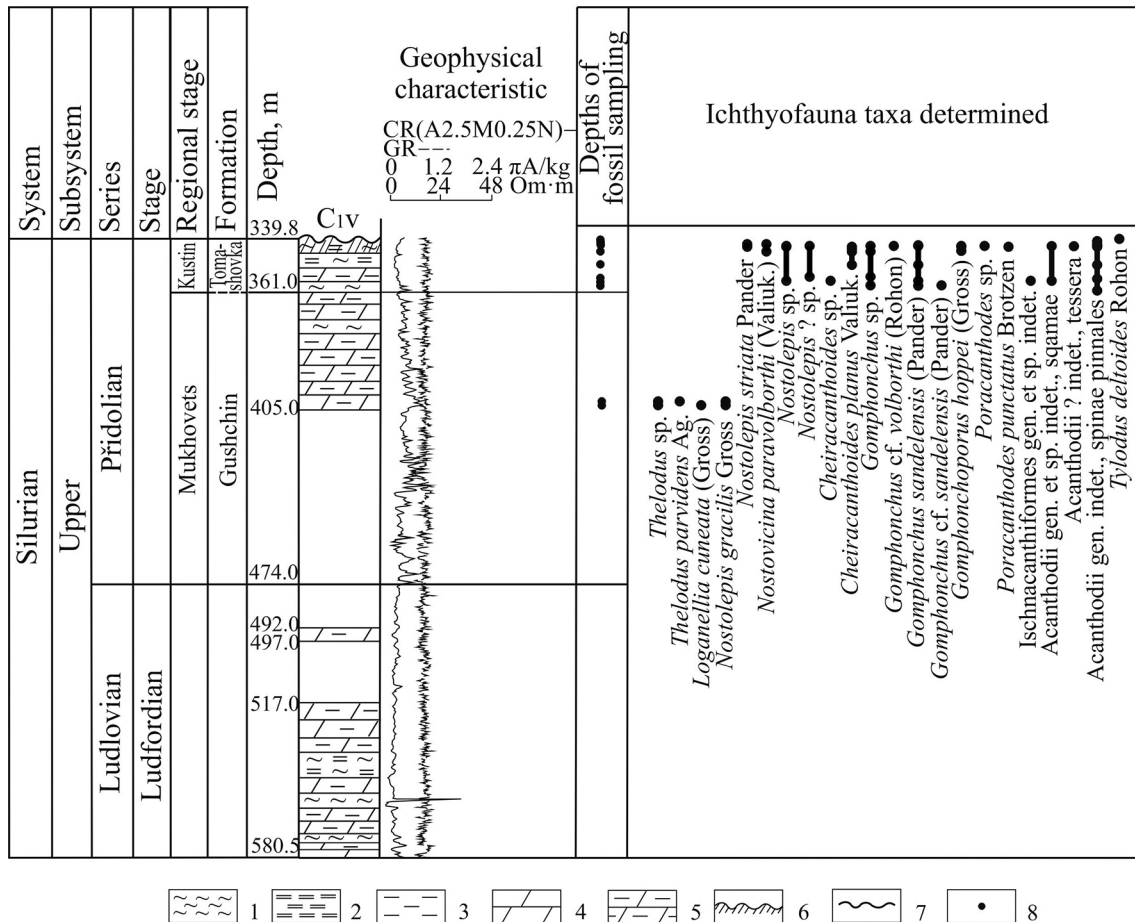
PRIDOLIAN ICHTHYOFAUNA FROM THE KOMAROVKA 913/10 AND RATAICHITSY 12K BOREHOLE SECTIONS

In this section of the paper the lithological confinement and stratigraphic distribution of the Pridolian ichthyofauna microremains determined in the Komarovka 913/10 and Rataichitsy 12k boreholes are considered in detail. In addition, the Plates I–VI are given, which show the images of most of the ichthyofauna taxa established in the Pridolian deposits of these boreholes.

The research performed by the author suggest that within the Komarovka 913/10 borehole the ichthyofauna remains were determined in the deposits of the **Gushchin** and **Tomashovka Formations** (Text-Figure 2). The ichthyofauna remains found in the deposits of the Tomashovka Formation are significantly more abundant than those discovered in the deposits of the Gushchin Formation. So, some discrete scales of the thelodonts of *Thelodus* sp., *Thelodus parvidens* Agassiz, 1839 [1], *Loganellia cuneata* (Gross, 1947) [10], as well

as scattered scales of the acanthodians of *Nostolepis gracilis* Gross, 1947 [10, 24] were found in the rocks of the Gushchin Formation. The latter species may be considered as the zonal one for this part of the section. Along with the ichthyofauna remains some invertebrate remains were also found there represented by isolated

scolecodonts, small pyritized shell fragments of the Orthoceratida order and scarce fragments of the graptolites. Numerous findings of the acritarchs and miospores are also known there [14]. All the identified organic remains were found in the light grey, dense, massive, platy, clayey marls.



Text-Figure 2 – Geological section of the Upper Silurian deposits in the Komarovka 913/10 borehole (from [14], Text-Figure 3), with minor changes, with the ichthyofauna distribution:

1 – siltstones; 2 – argillites; 3 – clays; 4 – marls; 5 – clayey marls; 6 – weathering crust; 7 – discontinuity surface; 8 – fossil sampling sites Remark. Lithology is not shown in those depth intervals from which no core was recovered.

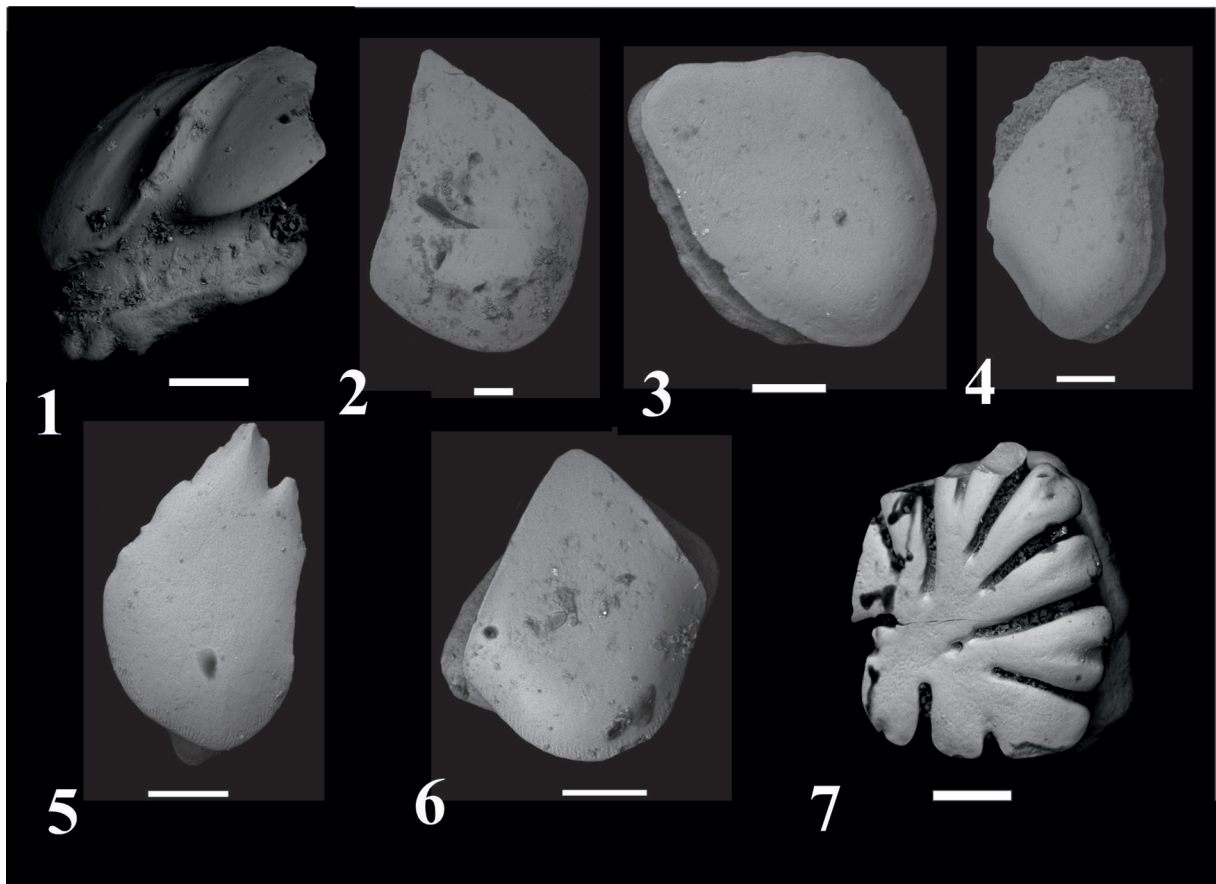


Plate I – Thelodont scales from the Rataichitsy 12k borehole.

The scales come from the Pridolian, Upper Silurian. Scale bar 100 μm for Figures 1, 2, 3, 4, 5, 6 and 7.

- Figure 1 – *Thelodus trilobatus* (Hoppe, 1931). Specimen № 122/35-6, Rataichitsy 12k borehole, depth 473.4 m, $\times 200$, trunk scale, lateral view; Svitichi Formation, Mukhavets Regional Stage. Figure 2 – *Thelodus parvidens* Agassiz, 1839. Specimen № 122/37-3, Rataichitsy 12k borehole, depth 478.0 m, $\times 100$, cephalo-pectoral scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 3 – *Thelodus parvidens* Agassiz, 1839. Specimen № 122/40-9, Rataichitsy 12k borehole, depth 483.0 m, $\times 200$, cephalo-pectoral scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 4 – *Thelodus parvidens* Agassiz, 1839. Specimen № 122/40-11, Rataichitsy 12k borehole, depth 483.0 m, $\times 120$, cephalo-pectoral scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 5 – *Thelodus parvidens* Agassiz, 1839. Specimen № 122/40-28, Rataichitsy 12k borehole, depth 483.0 m, $\times 190$, cephalo-pectoral scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 6 – *Thelodus parvidens* Agassiz, 1839. Specimen № 122/40-30, Rataichitsy 12k borehole, depth 483.0 m, $\times 200$, cephalo-pectoral scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 7 – *Thelodus admirabilis* Märss, 1982. Specimen № 122/1-1, Rataichitsy 12k borehole, depth 548.0 m, $\times 200$, rostral scale, oblique crown view; Kantinovka Formation, Mukhavets Regional Stage.

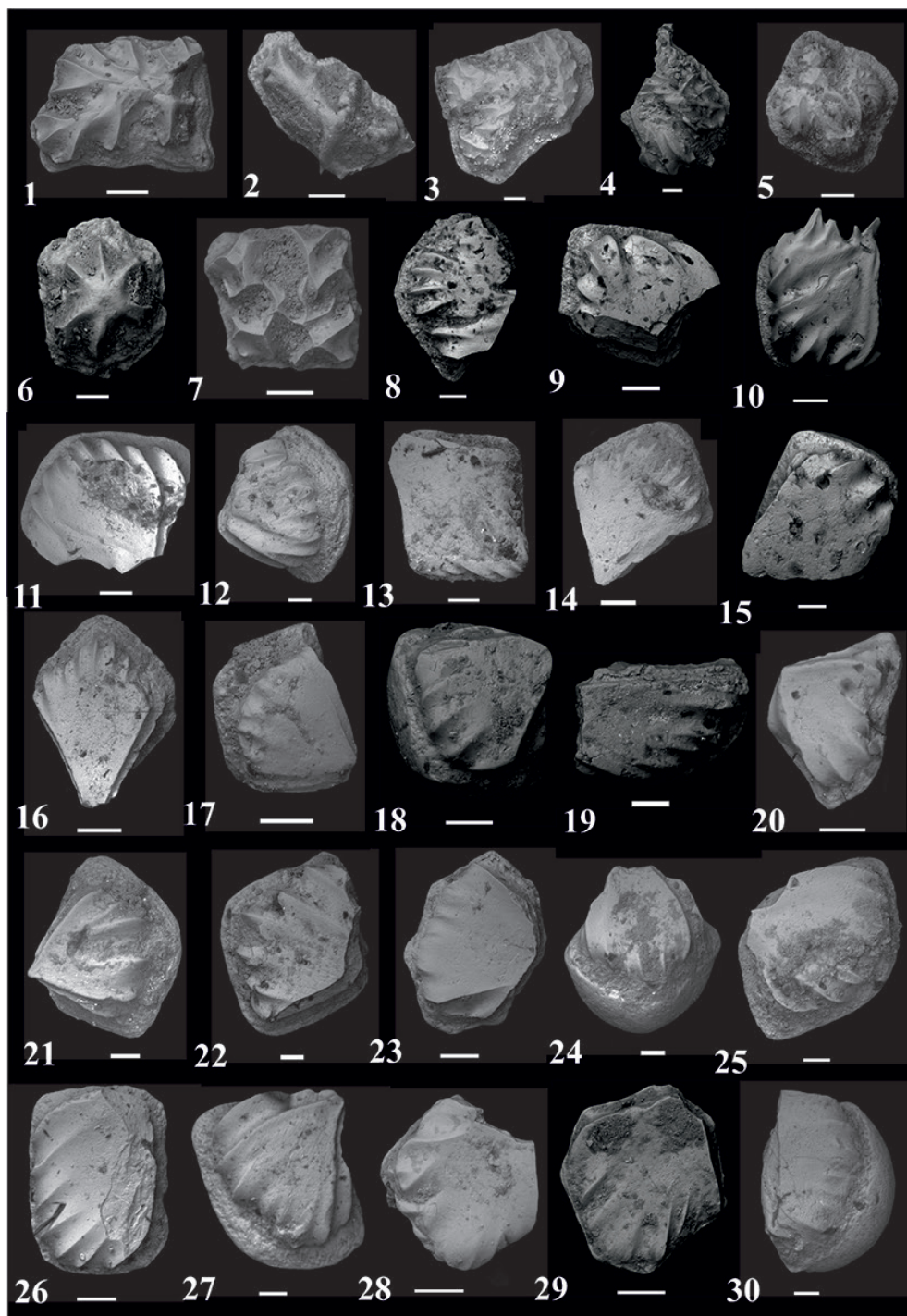


Plate II – Acanthodian tesserae and scales from the Komarovka 913/10 and Rataichitsy 12k boreholes. The skeletal elements come from the Pridolian, Upper Silurian. Scale bar 50 μm for Figure 6; 100 μm for Figures 1, 2, 3, 4, 7, 12, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30; 200 for Figures 5, 8, 9, 10, 11, 13, 14 and 16.

- Figure 1 – Nostolepid. Specimen № 122/38-35, Rataichitsy 12k borehole, depth 479.0 m, $\times 200$, stellate tessera, top view; Svitichi Formation, Mukhavets Regional Stage. Figure 2 – Nostolepid. Specimen № 122/38-36, Rataichitsy 12k borehole, depth 479.0 m, $\times 180$, stellate tessera, top view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 3 – Nostolepid. Specimen № 122/39-2, Rataichitsy 12k borehole, depth 481.0 m, $\times 100$, stellate tessera, top view; Svitichi Formation, Mukhavets Regional Stage. Figure 4 – Acanthodii indet. Specimen № 122/28-2, Rataichitsy 12k borehole, depth 407.0 m, $\times 100$, tessera fragment, top view; Kustin Formation, Kustin Regional Stage.
- Figure 5 – Acanthodii indet. Specimen № 122/36-1, Rataichitsy 12k borehole, depth 474.5 m, $\times 75$, tessera, top view; Svitichi Formation, Mukhavets Regional Stage. Figure 6 – Acanthodii ? indet. Specimen № 79/18-4, Komarovka 913/10 borehole, depth 340.7 m, $\times 300$, tessera, top view; Tomashovka Formation, Kustin Regional Stage.
- Figure 7 – Acanthodii indet. Specimen № 122/38-6, Rataichitsy 12k borehole, depth 479.0 m, $\times 200$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 8 – *Nostovicina multicostata* (Vieth, 1980). Specimen № 122/32-1, Rataichitsy 12k borehole, depth 469.8 m, $\times 60$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 9 – *Nostovicina multicostata* (Vieth, 1980). Specimen № 122/32-2, Rataichitsy 12k borehole, depth 469.8 m, $\times 80$, scale fragment, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 10 – *Nostovicina multicostata* (Vieth, 1980). Specimen № 122/35-2, Rataichitsy 12k borehole, depth 473.4 m, $\times 80$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 11 – *Nostovicina multicostata* (Vieth, 1980). Specimen № 122/42-7, Rataichitsy 12k borehole, depth 484.7 m, $\times 75$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 12 – *Nostovicina multicostata* (Vieth, 1980). Specimen № 122/42-8, Rataichitsy 12k borehole, depth 484.7 m, $\times 100$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 13 – *Nostovicina multicostata* (Vieth, 1980). Specimen № 122/42-9, Rataichitsy 12k borehole, depth 484.7 m, $\times 75$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 14 – *Nostolepis striata* Pander, 1856 or *Nostovicina multicostata* (Vieth, 1980). Specimen № 122/42-6, Rataichitsy 12k borehole, depth 484.7 m, $\times 85$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 15 – *Nostolepis striata* Pander, 1856. Specimen № 122/35-1, Rataichitsy 12k borehole, depth 473.4 m, $\times 120$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 16 – *Nostolepis striata* Pander, 1856. Specimen № 122/42-4, Rataichitsy 12k borehole, depth 484.7 m, $\times 85$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 17 – *Nostolepis* cf. *striata* Pander, 1856. Specimen № 122/40-37, Rataichitsy 12k borehole, depth 483.0 m, $\times 200$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 18 – *Nostolepis* sp. Specimen № 79/33-5, Komarovka 913/10 borehole, depth 358.4 m, $\times 200$, scale, oblique crown view; Tomashovka Formation, Kustin Regional Stage. Figure 19 – *Nostolepis* sp. Specimen № 122/26-5, Rataichitsy 12k borehole, depth 405.0 m, $\times 200$, scale, crown view; Kustin Formation, Kustin Regional Stage. Figure 20 – *Nostolepis* sp. Specimen № 122/28-28, Rataichitsy 12k borehole, depth 407.0 m, $\times 200$, scale, crown view; Kustin Formation, Kustin Regional Stage. Figure 21 – *Nostolepis* sp. Specimen № 122/36-3, Rataichitsy 12k borehole, depth 474.5 m, $\times 100$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 22 – *Nostolepis* sp. Specimen № 122/37-2, Rataichitsy 12k borehole, depth 478.0 m, $\times 100$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 23 – *Nostolepis* sp. Specimen № 122/38-34, Rataichitsy 12k borehole, depth 479.0 m, $\times 150$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 24 – *Nostolepis* sp. Specimen № 122/39-3, Rataichitsy 12k borehole, depth 481.0 m, $\times 100$, scale, anterior crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 25 – *Nostolepis* sp. Specimen № 122/39-4, Rataichitsy 12k borehole, depth 481.0 m, $\times 100$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 26 – *Nostolepis* sp. Specimen № 122/42-3, Rataichitsy 12k borehole, depth 484.7 m, $\times 150$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 27 – *Nostolepis* sp. Specimen № 122/42-10, Rataichitsy 12k borehole, depth 484.7 m, $\times 100$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 28 – Nostolepid. Specimen № 122/38-13, Rataichitsy 12k borehole, depth 479.0 m, $\times 200$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 29 – Nostolepid. Specimen № 79/33-3, Komarovka 913/10 borehole, depth 358.4 m, $\times 200$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 30 – Nostolepid. Specimen № 122/40-13, Rataichitsy 12k borehole, depth 483.0 m, $\times 100$, scale fragment, crown view; Svitichi Formation, Mukhavets Regional Stage.

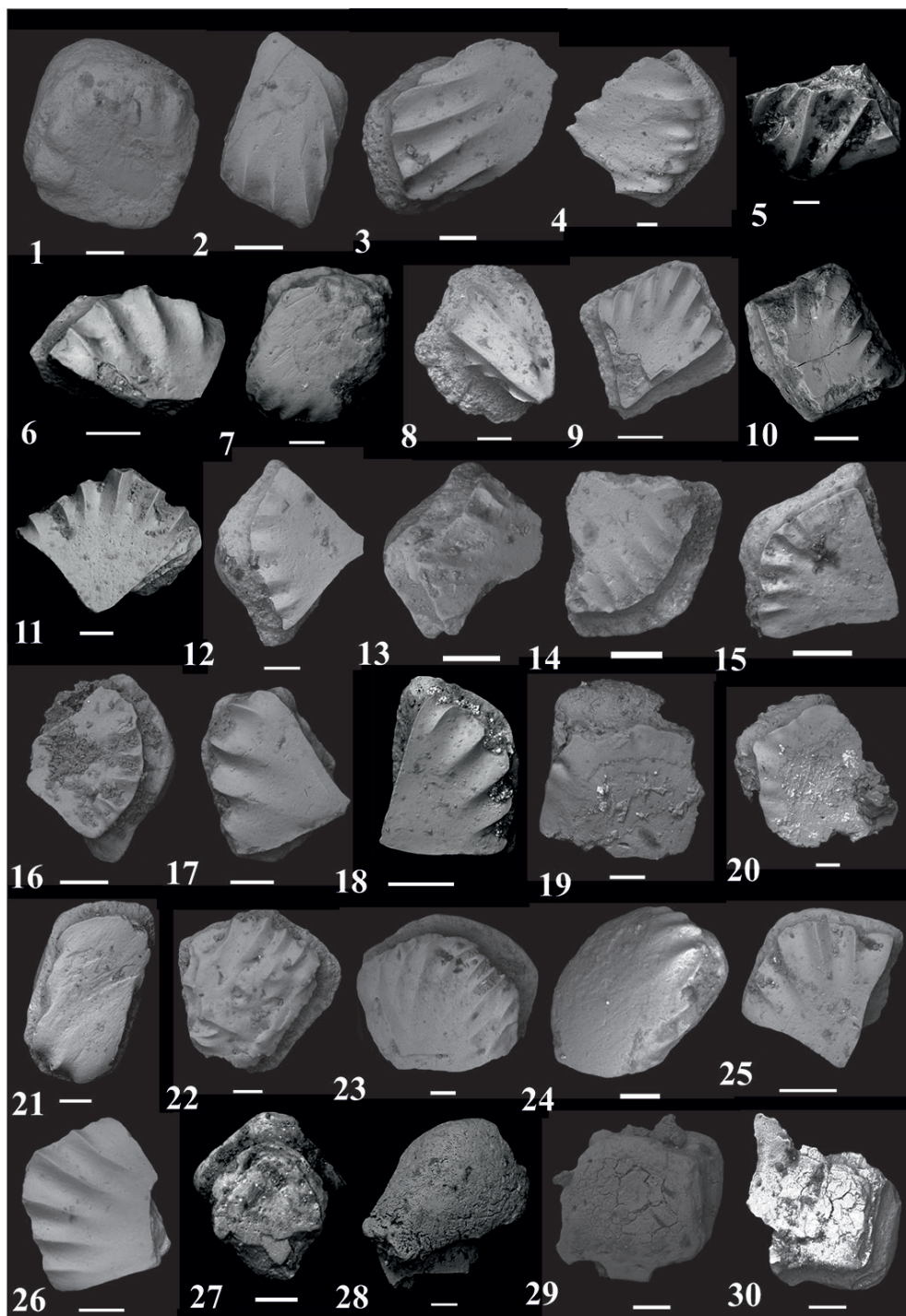


Plate III – Acanthodian scales from the Komarovka 913/10 and Rataichitsy 12k boreholes. The scales come from the Pridolian, Upper Silurian. Scale bar 50 μm for Figures 3, 6, 7, 11, 17 and 24; 100 μm for Figures 1, 2, 4, 5, 8, 9, 10, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29 and 30.

Figure 1 – *Nostolepid*. Specimen № 122/40-26, Rataichitsy 12k borehole, depth 483.0 m, $\times 150$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 2 – *Nostolepis* ? sp. Specimen № 122/40-21, Rataichitsy 12k borehole, depth 483.0 m, $\times 180$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 3 – *Nostolepis* ? sp. Specimen № 122/40-44, Rataichitsy 12k borehole, depth 483.0 m, $\times 300$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 4 – *Nostolepis* ? sp. Specimen № 122/42-2, Rataichitsy 12k borehole, depth 484.7 m, $\times 100$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 5 – *Nostolepis* ? sp. Specimen № 122/32-3, Rataichitsy 12k borehole, depth 469.8 m, $\times 130$, scale fragment, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 6 – *Nostolepis* ? sp. Specimen № 79/25-4, Komarovka 913/10 borehole, depth 342.6 m, $\times 500$, scale fragment, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 7 – *Nostolepis* ? sp. Specimen № 79/23-2, Komarovka 913/10 borehole, depth 341.7 m, $\times 350$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 8 – *Nostovicina laticristata* (Valiukevičius, 1994). Specimen № 122/42-11, Rataichitsy 12k borehole, depth 484.7 m, $\times 160$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 9 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 122/38-39, Rataichitsy 12k borehole, depth 479.0 m, $\times 200$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 10 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 79/23-6, Komarovka 913/10 borehole, depth 341.7 m, $\times 200$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 11 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 79/25-6, Komarovka 913/10 borehole, depth 342.6 m, $\times 300$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 12 – *Gomphonchoporus hoppei* ? (Gross, 1947). Specimen № 122/38-8, Rataichitsy 12k borehole, depth 479.0 m, $\times 150$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 13 – *Gomphonchoporus* cf. *hoppei* (Gross, 1947). Specimen № 122/38-28, Rataichitsy 12k borehole, depth 479.0 m, $\times 250$, scale fragment, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 14 – *Gomphonchoporus* cf. *hoppei* (Gross, 1947). Specimen № 122/40-15, Rataichitsy 12k borehole, depth 483.0 m, $\times 200$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 15 – *Gomphonchoporus* cf. *hoppei* (Gross, 1947). Specimen № 122/40-27, Rataichitsy 12k borehole, depth 483.0 m, $\times 250$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 16 – *Gomphonchoporus* cf. *hoppei* (Gross, 1947). Specimen № 122/40-41, Rataichitsy 12k borehole, depth 483.0 m, $\times 200$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 17 – *Nostovicina paravolborthi* (Valiukevičius, 2003). Specimen № 122/40-43, Rataichitsy 12k borehole, depth 483.0 m, $\times 370$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 18 – *Nostovicina paravolborthi* (Valiukevičius, 2003). Specimen № 79/18-5, Komarovka 913/10 borehole, depth 340.7 m, $\times 250$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 19 – *Poracanthodidae* gen. indet. Specimen № 122/28-18, Rataichitsy 12k borehole, depth 407.0 m, $\times 150$, scale, oblique crown view; Kustin Formation, Kustin Regional Stage. Figure 20 – *Poracanthodidae* gen. indet. Specimen № 122/28-17, Rataichitsy 12k borehole, depth 407.0 m, $\times 120$, scale, crown view; Kustin Formation, Kustin Regional Stage. Figure 21 – *Nostovicina* ? sp. Specimen № 122/42-5, Rataichitsy 12k borehole, depth 484.7 m, $\times 130$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 22 – *Nostolepid*. Specimen № 122/38-26, Rataichitsy 12k borehole, depth 479.0 m, $\times 140$, head scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 23 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 122/40-12, Rataichitsy 12k borehole, depth 483.0 m, $\times 100$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 24 – *Nostolepis* sp. Specimen № 122/38-31, Rataichitsy 12k borehole, depth 479.0 m, $\times 300$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 25 – *Gomphonchus* cf. *mediocostatus* Vergoossen, 1999. Specimen № 122/38-38, Rataichitsy 12k borehole, depth 479.0 m, $\times 250$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 26 – *Gomphonchus* cf. *mediocostatus* Vergoossen, 1999. Specimen № 122/40-14, Rataichitsy 12k borehole, depth 483.0 m, $\times 200$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 27 – *Ischnacanthiformes* gen. et sp. indet. Specimen № 122/27-3, Rataichitsy 12k borehole, depth 406.9 m, $\times 200$, scale fragment, crown view; Kustin Formation, Kustin Regional Stage. Figure 28 – *Ischnacanthiformes* gen. et sp. indet. Specimen № 122/28-14, Rataichitsy 12k borehole, depth 407.0 m, $\times 120$, scale, basal view; Kustin Formation, Kustin Regional Stage. Figure 29 – *Ischnacanthiformes* gen. et sp. indet. Specimen № 122/28-20, Rataichitsy 12k borehole, depth 407.0 m, $\times 150$, scale, crown view; Kustin Formation, Kustin Regional Stage. Figure 30 – *Ischnacanthiformes* gen. et sp. indet. Specimen № 122/28-26, Rataichitsy 12k borehole, depth 407.0 m, $\times 150$, scale, oblique crown view; Kustin Formation, Kustin Regional Stage.

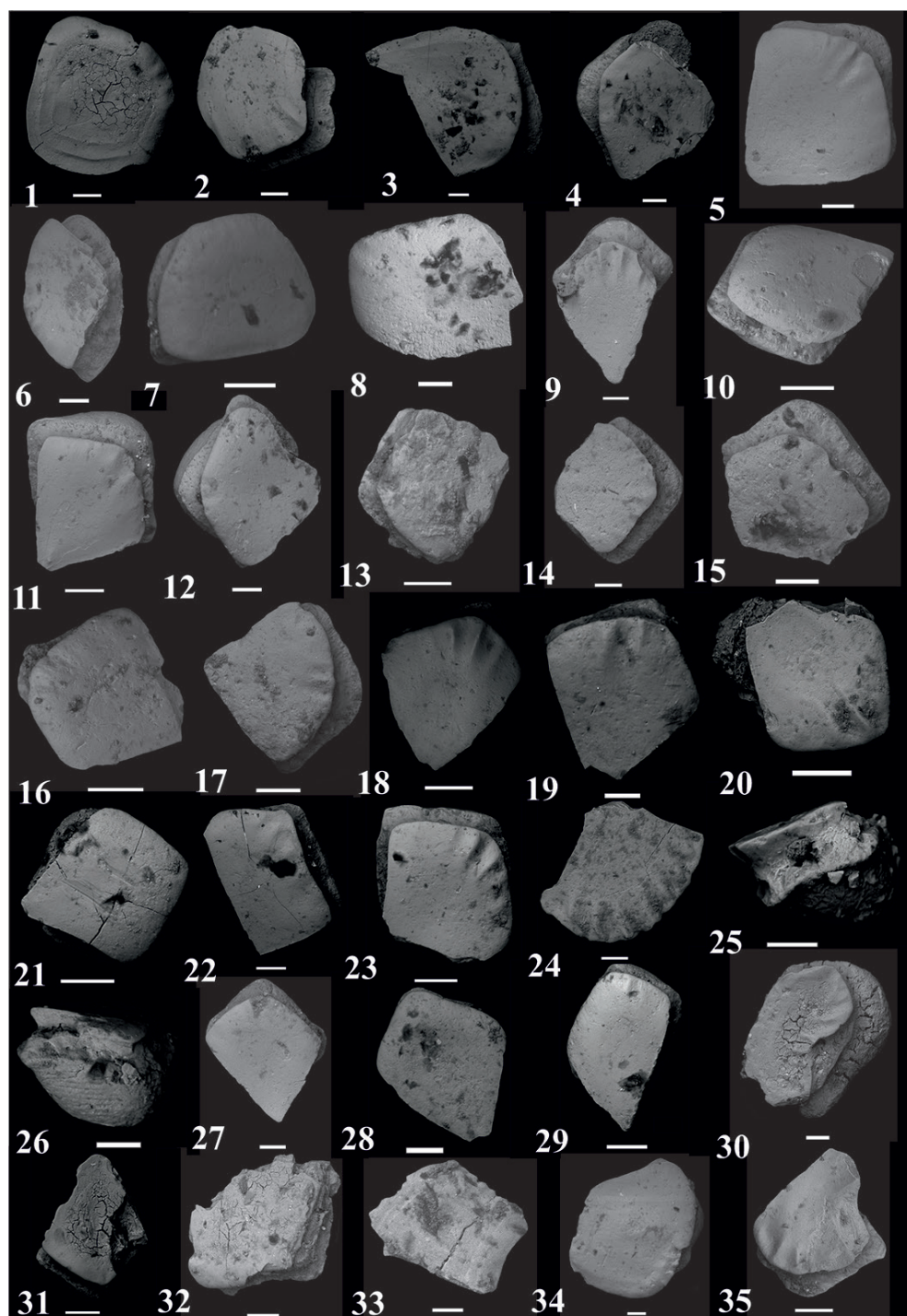


Plate IV – Acanthodian scales from the Komarovka 913/10 and Rataichitsy 12k boreholes. The scales come from the Přidolian, Upper Silurian. Scale bar 50 μm for Figure 19; 100 μm for Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34 and 35.

- Figure 1 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/28-1, Rataichitsy 12k borehole, depth 407.0 m, $\times 140$, scale, crown view; Kustin Formation, Kustin Regional Stage. Figure 2 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/35-3, Rataichitsy 12k borehole, depth 473.4 m, $\times 110$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 3 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/35-4, Rataichitsy 12k borehole, depth 473.4 m, $\times 100$, scale fragment, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 4 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/35-5, Rataichitsy 12k borehole, depth 473.4 m, $\times 100$, scale; oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 5 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/35-9, Rataichitsy 12k borehole, depth 473.4 m, $\times 150$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 6 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/36-2, Rataichitsy 12k borehole, depth 474.5m, $\times 130$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 7 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/37-4, Rataichitsy 12k borehole, depth 478.0 m, $\times 250$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 8 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/37-7, Rataichitsy 12k borehole, depth 478.0 m, $\times 130$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 9 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/38-9, Rataichitsy 12k borehole, depth 479.0 m, $\times 110$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 10 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/38-14, Rataichitsy 12k borehole, depth 479.0 m, $\times 220$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 11 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/38-23, Rataichitsy 12k borehole, depth 479.0 m, $\times 190$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 12 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/38-33, Rataichitsy 12k borehole, depth 479.0 m, $\times 120$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 13 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/38-42, Rataichitsy 12k borehole, depth 479.0 m, $\times 200$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 14 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/40-16, Rataichitsy 12k borehole, depth 483.0 m, $\times 120$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 15 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/40-20, Rataichitsy 12k borehole, depth 483.0 m, $\times 200$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 16 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/40-35, Rataichitsy 12k borehole, depth 483.0 m, $\times 250$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 17 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/40-42, Rataichitsy 12k borehole, depth 483.0 m, $\times 200$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 18 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 79/18-2, Komarovka 913/10 borehole, depth 340.7 m, $\times 250$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 19 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 79/20-2, Komarovka 913/10 borehole, depth 341.2 m, $\times 300$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 20 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 79/23-4, Komarovka 913/10 borehole, depth 341.7 m, $\times 250$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 21 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 79/23-5, Komarovka 913/10 borehole, depth 341.7 m, $\times 250$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 22 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 79/23-8, Komarovka 913/10 borehole, depth 341.7 m, $\times 150$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 23 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 79/23-7, Komarovka 913/10 borehole, depth 341.7 m, $\times 200$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 24 – *Gomphonchus cf. sandelensis* (Pander, 1856). Specimen № 79/33-2, Komarovka 913/10 borehole, depth 358.4 m, $\times 150$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 25 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/28-7, Rataichitsy 12k borehole, depth 407.0 m, $\times 250$, scale, lateral view; Kustin Formation, Kustin Regional Stage. Figure 26 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/28-13, Rataichitsy 12k borehole, depth 407.0 m, $\times 200$, scale, lateral view; Kustin Formation, Kustin Regional Stage. Figure 27 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 122/37-1, Rataichitsy 12k borehole, depth 478.0 m, $\times 120$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 28 – *Gomphonchus sandelensis* (Pander, 1856). Specimen № 79/35-3, Komarovka 913/10 borehole, depth 358.8 m, $\times 200$, scale, crown view; Tomashovka Formation, Kustin Regional Stage. Figure 29 – *Gomphonchus* sp. Specimen № 122/32-4, Rataichitsy 12k borehole, depth 469.8 m, $\times 200$, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 30 – *Gomphonchus* sp. Specimen № 122/28-22, Rataichitsy 12k borehole, depth 407.0 m, $\times 100$, double scale, oblique crown view; Kustin Formation, Kustin Regional Stage. Figure 31 – *Gomphonchus* sp. Specimen № 122/28-3, Rataichitsy 12k borehole, depth 407.0 m, $\times 170$, scale, crown view; Kustin Formation, Kustin Regional Stage. Figure 32 – *Gomphonchus* sp. Specimen № 122/28-27, Rataichitsy 12k borehole, depth 407.0 m, $\times 150$, scale, oblique crown view; Kustin Formation, Kustin Regional Stage. Figure 33 – *Gomphonchus* sp. Specimen № 122/28-25, Rataichitsy 12k borehole, depth 407.0 m, $\times 150$, scale, crown view; Kustin Formation, Kustin Regional Stage. Figure 34 – *Gomphonchus* sp. Specimen № 122/38-1, Rataichitsy 12k borehole, depth 479.0 m, $\times 100$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 35 – *Gomphonchus* sp. Specimen № 122/40-19, Rataichitsy 12k borehole, depth 483.0 m, $\times 200$, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.

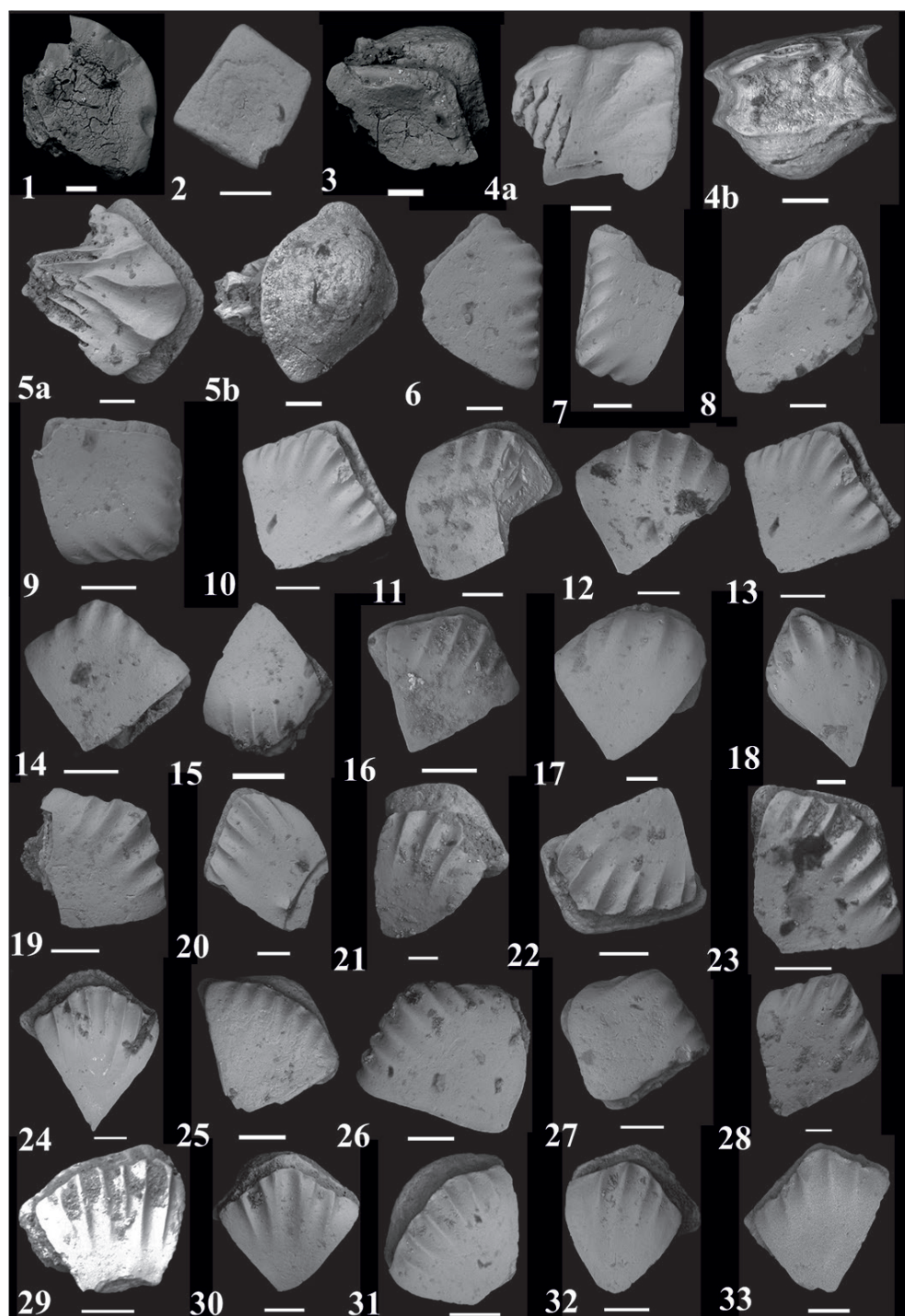


Plate V – Acanthodian scales from the Rataichitsy 12k boreholes. The scales come from the Přidolian, Upper Silurian.
 Scale bar 50 μm for Figures 17, 18, 21 and 28; 100 μm for Figures 1, 2, 3, 4a, 4b, 5a, 5b, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 22, 23, 24, 25, 26, 27, 29, 30, 31, 32 and 33.

Figure 1 – *Gomphonchus* sp. Specimen № 122/28-15, Rataichitsy 12k borehole, depth 407.0 m, × 150, scale fragment, crown view; Kustin Formation, Kustin Regional Stage. Figure 2 – *Gomphonchus* sp. Specimen № 122/28-24, Rataichitsy 12k borehole, depth 407.0 m, × 250, scale, crown view; Kustin Formation, Kustin Regional Stage.

Figure 3 – *Gomphonchus* sp. Specimen № 122/28-12, Rataichitsy 12k borehole, depth 407.0 m, × 180, scale fragment, anterior crown view; Kustin Formation, Kustin Regional Stage. Figure 4 – *Poracanthodes rataichitsyensis* sp. nov. Specimen № 122/39-1, Rataichitsy 12k borehole, depth 481.0 m, scale: a – crown view, × 170; b – lateral view, × 200; Svitichi Formation, Mukhavets Regional Stage. Figure 5 – *Poracanthodes rataichitsyensis* sp. nov. Specimen № 122/42-1, Rataichitsy 12k borehole, depth 484.7 m, scale: a – crown view, × 150; b – basal view, × 150; Svitichi Formation, Mukhavets Regional Stage. Figure 6 – *Cheiracanthoides* sp. Specimen № 122/38-5, Rataichitsy 12k borehole, depth 479.0 m, × 150, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 7 – *Cheiracanthoides* sp. Specimen № 122/38-37, Rataichitsy 12k borehole, depth 479.0 m, × 150, scale fragment, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 8 – *Cheiracanthoides* sp. Specimen № 122/38-43, Rataichitsy 12k borehole, depth 479.0 m, × 150, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 9 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-2, Rataichitsy 12k borehole, depth 479.0 m, × 250, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 10 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-7, Rataichitsy 12k borehole, depth 479.0 m, × 200, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 11 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-10, Rataichitsy 12k borehole, depth 479.0 m, × 200, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.

Figure 12 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-11, Rataichitsy 12k borehole, depth 479.0 m, × 200, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 13 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-12, Rataichitsy 12k borehole, depth 479.0 m, × 200, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 14 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-15, Rataichitsy 12k borehole, depth 479.0 m, × 250, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 15 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-16, Rataichitsy 12k borehole, depth 479.0 m, × 250, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.

Figure 16 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-18, Rataichitsy 12k borehole, depth 479.0 m, × 250, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 17 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-19, Rataichitsy 12k borehole, depth 479.0 m, × 300, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 18 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-21, Rataichitsy 12k borehole, depth 479.0 m, × 350, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 19 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-22, Rataichitsy 12k borehole, depth 479.0 m, × 250, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.

Figure 20 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-24, Rataichitsy 12k borehole, depth 479.0 m, × 150, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 21 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-25, Rataichitsy 12k borehole, depth 479.0 m, × 300, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 22 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-27, Rataichitsy 12k borehole, depth 479.0 m, × 250, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 23 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-30, Rataichitsy 12k borehole, depth 479.0 m, × 250, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.

Figure 24 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-32, Rataichitsy 12k borehole, depth 479.0 m, × 150, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 25 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-40, Rataichitsy 12k borehole, depth 479.0 m, × 200, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 26 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-41, Rataichitsy 12k borehole, depth 479.0 m, × 200, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 27 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-45, Rataichitsy 12k borehole, depth 479.0 m, × 200, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.

Figure 28 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/38-46, Rataichitsy 12k borehole, depth 479.0 m, × 300, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 29 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-1, Rataichitsy 12k borehole, depth 483.0 m, × 250, scale fragment, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 30 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-2, Rataichitsy 12k borehole, depth 483.0 m, × 200, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 31 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-3, Rataichitsy 12k borehole, depth 483.0 m, × 250, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.

Figure 32 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-4, Rataichitsy 12k borehole, depth 483.0 m, × 250, scale, crown view; Svitichi Formation, Mukhavets Regional Stage. Figure 33 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-6, Rataichitsy 12k borehole, depth 483.0 m, × 200, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.

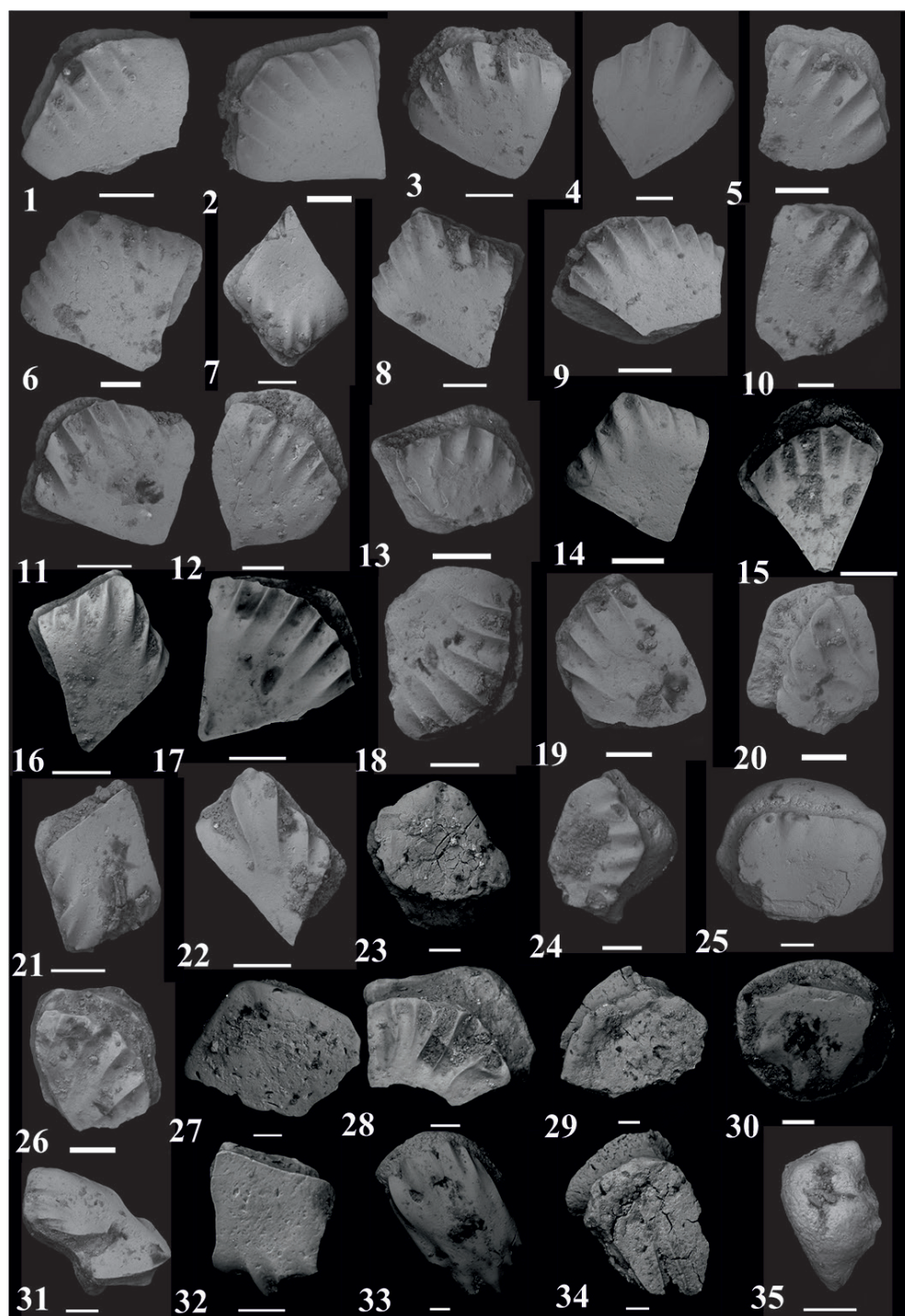


Plate VI – Acanthodian scales from the Komarovka 913/10 and Rataichitsy 12k boreholes.
The scales come from the Pridolian, Upper Silurian. Scale bar 50 μm for Figures 10, 28 and 32; 100 μm for Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 33, 34 and 35.

- Figure 1 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-7, Rataichitsy 12k borehole, depth 483.0 m, × 250, scale fragment, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 2 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-10, Rataichitsy 12k borehole, depth 483.0 m, × 200, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 3 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-22, Rataichitsy 12k borehole, depth 483.0 m, × 220, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 4 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-23, Rataichitsy 12k borehole, depth 483.0 m, × 180, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 5 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-24, Rataichitsy 12k borehole, depth 483.0 m, × 250, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 6 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-25, Rataichitsy 12k borehole, depth 483.0 m, × 150, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 7 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-29, Rataichitsy 12k borehole, depth 483.0 m, × 190, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 8 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-31, Rataichitsy 12k borehole, depth 483.0 m, × 200, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 9 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-33, Rataichitsy 12k borehole, depth 483.0 m, × 230, scale fragment, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 10 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-34, Rataichitsy 12k borehole, depth 483.0 m, × 300, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 11 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-38, Rataichitsy 12k borehole, depth 483.0 m, × 250, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 12 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-40, Rataichitsy 12k borehole, depth 483.0 m, × 200, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 13 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 122/40-47, Rataichitsy 12k borehole, depth 483.0 m, × 250, scale fragment, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 14 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 79/1a-1, Komarovka 913/10 borehole, depth 351.5 m, × 250, scale, crown view; Tomashovka Formation, Kustin Regional Stage.
- Figure 15 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 79/18-3, Komarovka 913/10 borehole, depth 340.7 m, × 250, scale, crown view; Tomashovka Formation, Kustin Regional Stage.
- Figure 16 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 79/25-2, Komarovka 913/10 borehole, depth 342.6 m, × 250, scale, crown view; Tomashovka Formation, Kustin Regional Stage.
- Figure 17 – *Cheiracanthoides planus* Valiukevičius, 1998. Specimen № 79/29a-1, Komarovka 913/10 borehole, depth 357.5 m, × 250, scale, crown view; Tomashovka Formation, Kustin Regional Stage.
- Figure 18 – *Cheiracanthoides* ? sp. Specimen № 122/38-3, Rataichitsy 12k borehole, depth 479.0 m, × 220, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 19 – *Cheiracanthoides* ? sp. Specimen № 122/40-17, Rataichitsy 12k borehole, depth 483.0 m, × 220, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 20 – *Cheiracanthoides* ? sp. Specimen № 122/38-17, Rataichitsy 12k borehole, depth 479.0 m, × 200, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 21 – *Rohonilepis breviornatus* Valiukevičius, 2004. Specimen № 122/38-20, Rataichitsy 12k borehole, depth 479.0 m, × 250, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 22 – *Rohonilepis breviornatus* Valiukevičius, 2004. Specimen № 122/40-36, Rataichitsy 12k borehole, depth 483.0 m, × 250, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 23 – *Gomphonchus* ? sp. Specimen № 122/28-4, Rataichitsy 12k borehole, depth 407.0 m, × 150, scale fragment, oblique crown view; Kustin Formation, Kustin Regional Stage.
- Figure 24 – *Gomphonchus* ? sp. Specimen № 122/28-19, Rataichitsy 12k borehole, depth 407.0 m, × 160, scale, oblique crown view; Kustin Formation, Kustin Regional Stage.
- Figure 25 – *Gomphonchus* ? sp. Specimen № 122/38-44, Rataichitsy 12k borehole, depth 479.0 m, × 130, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 26 – *Gomphonchus* ? sp. Specimen № 122/40-18, Rataichitsy 12k borehole, depth 483.0 m, × 220, scale fragment, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 27 – *Poracanthodes punctatus* Brotzen, 1934. Specimen № 122/28-10, Rataichitsy 12k borehole, depth 407.0 m, × 120, scale fragment, crown view; Kustin Formation, Kustin Regional Stage.
- Figure 28 – *Nostovicina paravolborthi* (Valiukevičius, 2003). Specimen № 79/27-2, Komarovka 913/10 borehole, depth 344.1 m, × 300, scale fragment, crown view; Tomashovka Formation, Kustin Regional Stage.
- Figure 29 – *Poracanthodes* sp. Specimen № 122/28-9, Rataichitsy 12k borehole, depth 407.0 m, × 100, scale fragment, crown view; Kustin Formation, Kustin Regional Stage.
- Figure 30 – *Nostovicina* ? sp. Specimen № 122/35-7, Rataichitsy 12k borehole, depth 473.4 m, × 150, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 31 – *Acanthodii* gen. et sp. indet. Specimen № 122/38-29, Rataichitsy 12k borehole, depth 479.0 m, × 180, scale, oblique crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 32 – *Acanthodii* gen. et sp. indet. Specimen № 79/25-3, Komarovka 913/10 borehole, depth 342.6 m, × 500, scale, oblique crown view; Tomashovka Formation, Kustin Regional Stage.
- Figure 33 – *Acanthodii* gen. et sp. indet. Specimen № 122/35-8, Rataichitsy 12k borehole, depth 473.4 m, × 100, scale, crown view; Svitichi Formation, Mukhavets Regional Stage.
- Figure 34 – *Acanthodii* gen. et sp. indet. Specimen № 122/26-3, Rataichitsy 12k borehole, depth 405.0 m, × 110, scale, oblique crown view; Kustin Formation, Kustin Regional Stage.
- Figure 35 – *Acanthodii* gen. et sp. indet. Specimen № 122/40-32, Rataichitsy 12k borehole, depth 483.0 m, × 250, scale, basal view; Svitichi Formation, Mukhavets Regional Stage.

In the deposits of the Svitichi Formation not numerous scattered scales of *Thelodus* sp., *T. trilobatus* (Hoppe, 1931) [11], *Thelodus parvidens*, numerous isolated scales of *Nostolepis* sp., *N. gracilis* Gross, 1947 [10], *N. striata*, *N. cf. striata*, *N. ?* sp., *Nostovicina multcostata* (Vieth, 1980) [41], *N. paravolborthi*, *N. laticristata* (Valiukevičius, 1994) [34], *N. ?* sp., *Nostolepis striata* or *Nostovicina multcostata*, *Rohonilepis breviornatus* Valiukevičius, 2004 [37], *Gomphonchus* sp., *G. sandelensis*, *G. cf. mediocostatus* Vergoossen, 1999 [40], *G. ?* sp., *Cheiracanthoides* sp., *C. planus* Valiukevičius, 1998 [35], *C. ?* sp., *C. sp.* or *Nostolepis* sp., *Gomphonchoporus hoppei*, *G. cf. hoppei*, *G. hoppei ?*, *Poracanthodes rataitchitsyensis* sp. nov., *Ischnacanthiformes* gen. et sp. indet., some single stellate nostolepid tesserae, unidentified nostolepid scales, one tessera of *Acanthodii* indet. and indefinable scales of *Acanthodii* gen. et sp. indet. were established in the light grey with greenish tint, cryptocrystalline, indistinctly laminated, sometimes, with weakly expressed thin wavy layering, dense, rather strong, massive, thick-platy, in some areas, slightly lumpy, clayey limestones. Along with the ichthyofauna remains very scarce scolecodonts, some single ostracod valves, not numerous small fragmentary and intact brachiopod shells, numerous segments of the crinoids, single skeletons of the bryozoans, some few conodonts were also found in the clayey limestones. The ostracods from this part of the section were previously studied by A. F. Abushik and T. I. Moiseeva [30], and the brachiopods – by T. L. Modzalevskaya and V. I. Pushkin [26, 30].

In the deposits of the Kustin Formation the ichthyofauna remains were found both in the clayey dolomites and dolomitic marls. The scales of *Gomphonchus* sp., *G. sandelensis*, *G. ?* sp., *Nostolepis* sp., *Poracanthodes* sp., *P. punctatus*, *Poracanthodidae* gen. indet., *Ischnacanthiformes* gen. et sp. indet., the tessera fragments of *Acanthodii* indet. and *Acanthodii ?* indet. were determined in the light grey, dense, strong, cryptocrystalline slightly cavernous, platy, clayey dolomites with thin wavy lamination. Of all the above-listed ichthyofauna taxa the only species of *Poracanthodes punctatus* was not found in the underlying deposits. Hence, this species can be used as a zonal one for this stratigraphic level. Together with the above-mentioned ichthyofauna remains some single scolecodonts, very rare small fragments of the brachiopod shells were also found in the Kustin deposits. The scales of *Nostolepis* sp., *Gomphonchus sandelensis*, *Ischnacanthiformes* gen. et sp. indet., *Acanthodii* gen. et sp. indet. and *Acanthodii* indet. were determined in grey with a greenish tint, dense, strong, platy, dolomitic marls without obvious layering, with a conchoidal fracture. Some scarce scolecodonts, few ostracods, infrequent microgastropods, single brachiopod

shells and very few crinoid segments were found along with them. The ostracods from this part of the section were also previously studied by A. F. Abushik and T. I. Moiseeva [30], and the brachiopods – by T. L. Modzalevskaya and V. I. Pushkin [26, 30].

CORRELATION OF THE PŘIDOLIAN DEPOSITS OF BELARUS BASED ON THE ICHTHYOFAUNA

The deposits of the Kantinovka and Svitichi Formations in the section of the Rataichitsy 12k borehole drilled in the territory of the Podlasie-Brest Depression correspond in their volume to the Mukhavets Regional Stage of the Přidolian Series [27]. In the territory of the Volyn Monocline the Mukhavets Regional Stage corresponds in its volume to the Gushchin Formation in the section of the Komarovka 933/10 borehole [14]. According to the ichthyofauna remains the deposits of the Mukhavets Regional Stage correspond approximately to the upper part of the thelodont zone of *Thelodus admirabilis* and the acanthodian zone of *Nostolepis gracilis*, earlier accepted for the Kaugatuma deposits in the territory of the Baltic States [19]. According to the ichthyofauna remains the deposits of the Mukhavets Regional Stage can be compared with the sediments of the Minija Regional Stage and the rocks of the lower part of the Jūra Regional Stage of Lithuania [12, 29, 38], the deposits of the Kaugatuma Regional Stage of Estonia [19], the Ludlow Bone Bed Member, the Downton Castle Sandstones and the Temeside Shale Formation of Great Britain [19] and, probably, with deposits of the lower part of the Krasnaya Bukhta Formation of the Severnaya Zemlya [13, 17].

The deposits of the Kustin Formation of the same name Regional Stage in the section of the Rataichitsy 12k borehole correspond to the Tomashovka Formation identified in the sections of the Tomashovka 11 [27] and Komarovka 933/10 boreholes [14]. These deposits complete the section of the Přidolian in the territory of the Podlasie-Brest Depression and Volyn Monocline. According to the ichthyofauna remains these deposits correspond to the Trimerolepis timanica – *Poracanthodes punctatus* zone earlier identified in the Baltic States for Ohesaare deposits [19], and correlate rather well with the sediments of the upper part of the Jūra Regional Stage of Lithuania [12, 29, 38], the deposits of the Ohesaare Regional Stage of Estonia [16, 19], the rocks of the most part of the Ledbury Formation of Great Britain [19, 20], the deposits of the Holmestrand Formation of Norway [31], the rocks of the lower part of the Reliktovoe Formation of Novaya Zemlya [5], deposits of the upper part of the Krasnaya Bukhta Formation of Severnaya Zemlya [13, 17] and deposits of the Barlow Inlet Formation of Arctic Canada [8, 18, 19].

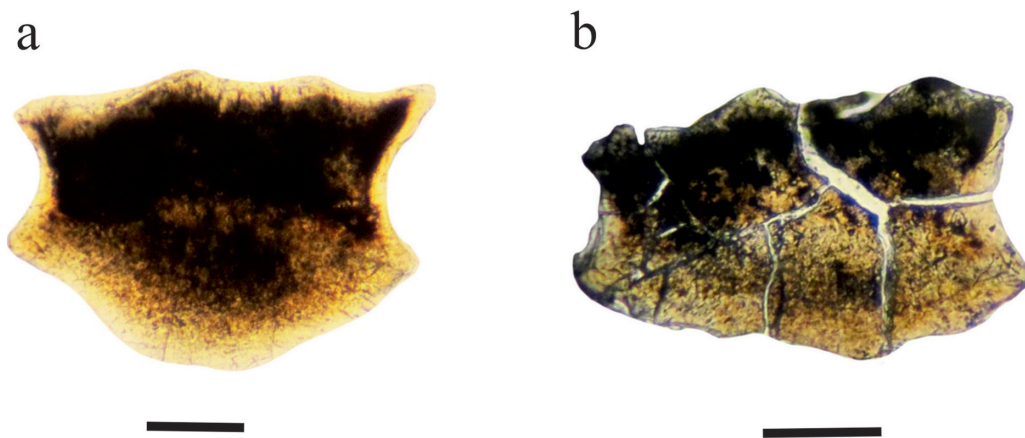
SYSTEMATIC PALAEONTOLOGY
Class ACANTHODII Owen, 1846
Order Ischnacanthiformes Berg, 1940
Family Poracanthodidae Vergoossen, 1997
Genus *Poracanthodes* Brotzen, 1934

Diagnosis. See R. H. Denison [7] and C. J. Burrow [6].

Type species. *Poracanthodes punctatus* Brotzen, 1934 [4].

Remark. According to the results of the recent studies, for example, C. J. Burrow [6], the acanthodians belong to the stem group of the class of Chondrichthyes. In this paper, the acanthodians are still considered traditionally in a class rank, i. e., as an Acanthodii Owen Class, 1846 [22].

Poracanthodes rataitchitsyensis sp. nov.
Plate V, figures 4a, 4b, 5a and 5b; Text-Figure 4



Text-Figure 4 – Microstructure of a scale of *Poracanthodes rataitchitsyensis* sp. nov.
a – scale vertical section; b – scale vertical section in anise oil (scale slightly cracked). Specimen № 122/39-1, Rataitchitsy 12k borehole, depth 481.0 m; Svitichi Formation, Mukhavets Regional Stage.
Scale bar 100 µm for Figures a and b.

Etymology. The name of the species is derived from the name of the village of Rataichitsy, near which a borehole was drilled, in the core of which the scales of this new species of the acanthodians were found for the first time.

Holotype. Belarusian National Technical University (BNTU). Department of Mining. Specimen № 122/42-1, scale (Plate V, fig. 5).

Type locality and horizon. Rataichitsy 12k borehole, depth 484.7 m; Belarus, Kamenets district, Brest region; Upper Silurian, Přidolian, Mukhavets Regional Stage, Svitichi Formation.

Material. 9 scales.

Diagnosis. The scales are small, up to 0.7 mm long. The crown is rhomboid, rounded-rhomboid. On the crown there are no more than four large, slightly curved, radially located ridges situated at a distance from each other, clearly expressed in its anterior part and gradually fading towards the middle part of the crown. Within the posterior part of the crown there are usually from five to

seven V-shaped arcade canals with small pores penetrating the crown and opening on its surface. The neck is high, thick. The base is moderately or strongly convex, rounded-rhomboid, elongated-oval, with a slightly expressed apex, usually slightly shifted forward. There are at least five growth lamellae in the crown. The anterior part of the crown is pierced by narrow, branching dentine tubules. The ascending and radial vascular canals are rather well expressed. In the neck there are large osteocytes with short processes. The base is characterized by an average amount of the osteocyte cavities. The Sharpey's fibers are narrow, not very distinct.

Description. *Morphology.* Small scales are 0.4 to 0.7 mm long, usually 0.4 to 0.5 mm wide and usually not more than 0.35 mm high. The crown of the scales is slightly flattened. The shape of the crown of the scales is rhomboid, rounded-rhomboid. The anterior part of the crown is usually rounded, but can also be angular, often slightly curved down. The sculpture of the crown is represented by 3–4 well-expressed, high,

slightly sinuous, fan-shaped ridges with wide elongated depressions located between them. At the anterior part of the crown, the ridges are very well expressed and gradually decrease and fade towards the middle part or going slightly beyond the middle part. The thin posterior section of the crown is usually pierced by 5–7 V-shaped arcade canals and not numerous small pores. The neck of the scales is well-expressed. It is rather high, thick, relatively smooth, rhomboid in plan. The rim outlining the junction of the neck and base is clear and well-developed. The base is moderately or strongly convex, rounded-rhomboid, elongated-oval, usually slightly protruding from the anterior margin of the crown. The apex of the base is weakly expressed, slightly shifted forward.

Histology. Because of the paucity of the found scales of the described species, only two scales were histologically studied. Unfortunately, their preservation turned out to be not very good, but despite this, some important features of the internal structure were still found out. There are at least five growing lamellae in the crown. The ascending canals are located in each lamella; they are long, sinuous, with quite numerous branches on top. The radial canals are wide, long, located above the surface of the base. There are V-shaped arcade canals with small pores. The pore canals are few, relatively small, uneven, penetrate the crown and open on its surface. In the neck there are large osteocytes which are supplied with short processes. The base is composed of the bone tissue and is characterized by an average amount of the osteocyte cavities. The Sharpey's fibers are narrow, relatively long, not very distinct.

Variability. The scales of this species vary in their crown shape, base configuration and the degree of its convexity – from strong to moderately convex. The crown sculpture varies in the number of ridges. A number of V-shaped canals in the posterior part of the crown section is also variable.

Comparison. In the morphological features the scales of the new species differ significantly from the scales of *Poracanthodes punctatus* Brotzen, 1934 [4, 16] by the different sculpture on the crown surface, crown shape, fewer pores on the crown, morphological features of V-shaped arcade canals on the crown, as well as the character of the branching of the radial and pore canals. The scales of the described species *Poracanthodes rataitchitsyensis* sp. nov. differ from those of *Poracanthodes menneri* (Valiukevičius, 1992) [33] by the presence of distinct ridges in the anterior section of the crown, a number of V-shaped canals in the posterior section of the crown, the height of the neck and the absence of large openings on its posterior side, and the internal structure. The scales of *Poracanthodes rataitchitsyensis* sp. nov. differ well from the scales of

Poracanthodes exaratus Valiukevičius, 1994 [34] in their crown sculpture, location of the pores, their number and size, the presence of V-shaped canals on the crown and slightly in the base shape. Due to the fact that the histology of the scales of *Poracanthodes exaratus* has not been done, it is impossible to say anything about how the internal structure of the scales of this species differs from the internal structure of the scales of the new species. Morphologically, the scales of the new species differ from the scales of *Poracanthodes canadensis* Burrow et Vergoossen, 1999 [21] in a much smaller number of the ridges on the crown surface and their appearance, crown shape, configuration and number of V-shaped arcade canals in the posterior section of the crown, the absence of clear rows of openings on the neck, a somewhat less expressed apex of the base, the number of growth lamellae of the crown, the nature of branching of the ascending and radial canals, a number of the osteocyte cavities at the base and the expressiveness of the Sharpey's fibers. The scales of the new species clearly differ from the scales of the species of *Poracanthodes marssae* Valiukevičius, 2004 [37] in a peculiar crown sculpture, its size and shape, a large number of the pores on the crown surface and their location, the presence of V-shaped arcade canals on the crown, the absence of numerous pores on the neck, the shape of the base and a position of the apex on it, as well as in some details of the microstructure. On the basis of the scale morphology of the new species differ from those of *Poracanthodes sulcatus* Valiukevičius, 2004 [37] in the sculpture on the crown surface represented by 3–4 well-defined, high, slightly curved ridges with wide and long depressions located between them, the nature of the pore canals, the more massive base and features of the internal structure.

Geological age and geographical distribution. Upper Silurian, Pridolian, Mukhavets Regional Stage, Svitichi Formation; Belarus, Kamenets district of the Brest region.

Occurrence. Belarus, Kamenets district, Brest region, Rataichitsy 12k borehole, depths – 484.7 and 481.0 m.

BRIEF TAPHONOMIC DESCRIPTION OF THE PŘIDOLIAN ICHTHYOFAUNA REMAINS

The ichthyofauna remains originating from the deposits of the Gushchin Formation of the Komarovka 933/10 borehole were found in the clayey marls. They are represented there only by some isolated scales of the thelodonts and acanthodians. The thelodont scales are better preserved than those of the acanthodians. The thelodont scales are more abundant than the

acanthodian scales. These are located randomly in the rocks, do not form group accumulations and have no signs of obvious roundness. The color of the scales is light brown, dark brown and black. Due to their fragmentation and strong scattering in the rock it is possible that before burial they were subject to mechanical displacement over a certain distance. It is also worth noting that together with the ichthyofauna scales few remains of the invertebrates of relatively good and satisfactory preservation were also found. It can be concluded that the habitat of the discovered animals was a shallow coastal zone of the shelf, where mainly carbonate sedimentation took place [14].

The skeletal elements of the ichthyofauna originating from the deposits of the Tomashovka Formation of the same borehole were found in the siltstones and clayey marls. Within these rocks they are mainly represented by numerous discrete scales of the acanthodians and, to much smaller degree, by some small fragments of the acanthodian fin spines. These micromeric remains are randomly located in the rocks; they do not form rather large group accumulations. Some of the found remains show obvious signs of roundness. The color of the ichthyofauna remains is light brown, dark brown, brown, dark grey and black. In addition to the ichthyofauna remains, various remains of the invertebrates were also found in the rocks of the formation under consideration, that are represented by broken calcareous tubes of the worms, scolecodonts, ostracod valves, fragmentary shells of brachiopods and cephalopods, tentaculite shells, fragments of crinoid stems and some small fragments of the graptolites. These are generally characterized by satisfactory preservation. Based on the preservation and features of the distribution of the fossils in the rocks, it can be concluded that all of them undoubtedly experienced transportation over some distance under the influence of the hydrodynamic processes in the water basin. It can be concluded from the above data that the habitat of the discovered vertebrates and invertebrates could be a coastal-shallow area of the sea where mainly terrigenous-carbonate sedimentation took place [14].

The ichthyofauna remains established in the deposits of the Katinovka Formation of the Rataichitsy 12k borehole were found in the marls and are represented by some single scales of the thelodonts and acanthodians. The scales are very unevenly distributed in the rock and are strongly scattered. These scales are yellowish-orange, light brown and dark brown. Along with the scales of the agnathans and fishes rather abundant remains of the invertebrates, as well as few conodonts were found there. Their preservation is mostly satisfactory. The habitat of the discovered fossils was the marine shallow-water open shelf [9].

The skeletal elements of the ichthyofauna originating from the deposits of the Svitichi Formation

of the Rataichitsy 12k borehole were found in clayey limestones and are mainly represented by some isolated acanthodian scales, to a lesser extent, by the thelodont scales and rarely found acanthodian tesserae. The remains of the ichthyofauna in the clayey limestones are very unevenly distributed, they do not have a clear orientation and expressed confinement to the bedding planes. Some scales are slightly rounded. In general, most of the remains are fairly well-preserved. In color these scales are mainly light brown, brown, dark brown and black. The preservation of the remains, their fragmentation, scattering, roundness of some of them testifies to their allochthonous nature. Along with the ichthyofauna remains some scattered remains of various invertebrates and conodonts were also found in the clayey limestones, which preservation is generally quite good. The habitat of the discovered fossils was the marine shallow open shelf [9].

The ichthyofauna remains established in the deposits of the Kustin Formation of the Rataichitsy 12k borehole were found in the clayey dolomites and dolomitic marls. An analysis of the skeletal material of the vertebrates found in this part of the section indicates the predominance of the acanthodian scales over the findings of their tesserae. The remains of the acanthodians in these rocks are very unevenly distributed. Their preservation is relatively good or satisfactory. These scales are of different color – light grey, grey, dark grey, light brown, brown, dark brown and black. The invertebrates are represented there by the scolecodonts, ostracods, microgastropods, small fragments of the brachiopod shells and segments of the crinoids. The preservation of invertebrate and vertebrate remains is partly good and partly satisfactory. The fragmentation, isolation and separation of the remains in size and weight in the rocks may, to some extent, be evidence of their mechanical transportation by the bottom currents and wave movements. It can be concluded from all the above that the habitat of the discovered animals was the marine shallow-water open shelf [9].

CONCLUSIONS

1. The paper provides updated information of the ichthyofauna of the Pridolian age established in the deposits of the Gushchin and Tomashovka Formations in the territory of the Volyn Monocline, as well as in the sediments of the Katinovka, Svitichi and Kustin Formations within the Podlasie-Brest Depression (Komarovka 93s/10 and Rataichitsy 12k boreholes).

2. The lithological description of the above-mentioned formations earlier identified in the Komarovka 93s/10 and Rataichitsy 12k boreholes is given.

3. The considered deposits are correlated by their ichthyofauna remains with the well-studied synchronous deposits in the territory of the Baltic States, Great Britain, Sweden, Norway, Canada and Russia.

4. The data obtained of the Pridolian fish fauna identified in the Komarovka 933/10 and Rataichitsy 12k boreholes made it possible to significantly replenish its systematic composition in the territory of Belarus, to distinguish and describe a new species, to supplement the evidences of the geographical distribution of the ichthyofauna, as well as to consider the taphonomic characteristics of its vertebrate remains.

5. In addition, a number of skeletal elements of the Pridolian agnathans and fishes are presented in the paper as attached Plates.

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ПРЖЫДОЛЬСКАЯ ІХТЫЯФАЎНА БЕЛАРУСІ

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У артыкуле прыводзяцца вынікі палеаіхтыялагічнага вывучэння парод пржыдольскага ўзросту, ускрытых свідравінамі Камароўка 93з/10 і Ратайчыцы 12к на тэрыторыі Валынскай манакліналі і Падляска-Брэсцкай упадзіны ў межах Беларусі. Прадстаўленая інфармацыя па іхтыяфаўне дазваляе ўдакладніць і дапоўніць таксанамічны склад яе ў вышэйзгаданых адкладах у межах названых тэктанічных структур, а таксама выкарыстоўваць яе для вызначэння ўзросту парод, іх расчленення і карэляцыі. Асобна ў артыкуле прыводзіцца апісанне новага віду акантода на аснове ізаляваных лусак і разглядаецца кароткая тафанамічная характарыстыка шкідных рэшткаў пржыдольскай іхтыяфаўны. Атрыманыя дадзеныя па іхтыяфаўне дапаўняюць інфармацыю аб яе стратыграфічным і геаграфічным распаўсюджванні.

ПРЖИДОЛЬСКАЯ ИХТИОФАУНА БЕЛАРУСИ

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В статье приводятся результаты палеоихтиологического изучения пород пржидольского возраста, вскрытых скважинами Комаровка 93з/10 и Ратайчицы 12к на территории Волынской моноклинали и Подляско-Брестской впадины в пределах Беларуси. Представленная информация по ихтиофауне позволяет уточнить и дополнить данные о таксономическом составе в вышеупомянутых отложениях в границах названных тектонических структур, а также использовать ее для определения возраста пород, их расчленения и корреляции. Отдельно в статье приводится описание нового вида акантода на основе изолированных чешуй и рассматривается краткая тафономическая характеристика скелетных остатков пржидольской ихтиофауны. Полученные данные по ихтиофауне дополняют информацию о ее стратиграфическом и географическом распространении.