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D. P. Plax*Belarusian National Technical University, Minsk, Belarus, e-mail: agnatha@mail.ru*

**ON THE REDEPOSITED SILURIAN ICHTHYOFAUNA REMAINS
IN THE QUATERNARY DEPOSITS OF BELARUS**

The paper presents for the first time the information on the redeposited remains (scales and tesserae) of the Silurian vertebrates found in the Quaternary deposits of Belarus. A complete systematic review and brief descriptions of the agnathan and fish taxa with the identification of their material, determination of their preservation degree, location and geographical distribution, as well as with an assumption of the age of the rock enclosing these ichthyofauna remains and their redeposition type.

Keywords: redeposited skeletal elements, Silurian ichthyofauna, Quaternary deposits, Belarus

Д. П. Плакс*Белорусский национальный технический университет, Минск, Беларусь, e-mail: agnatha@mail.ru*

**О ПЕРЕОТЛОЖЕННЫХ ОСТАТКАХ СИЛУРИЙСКОЙ ИХТИОФАУНЫ
В ЧЕТВЕРТИЧНЫХ ОТЛОЖЕНИЯХ БЕЛАРУСИ**

Впервые приводятся сведения о находке в четвертичных отложениях на территории Беларуси переотложенных остатков (чешуй и тессер) силурийских позвоночных. Дается полный систематический обзор и краткие описания таксонов бесчелюстных и рыб с указанием материала, характера его сохранности, местонахождения и географического распространения, а также высказывается предположение относительно возраста вмещающей породы, содержащей остатки ихтиофауны, и типе ее переотложения.

Ключевые слова: переотложенные скелетные элементы, силурийская ихтиофауна, четвертичные отложения, Беларусь

Дз. П. Плакс*Беларускі нацыянальны тэхнічны ўніверсітэт, Мінск, Беларусь, e-mail: agnatha@mail.ru*

АБ ПЕРАКЛАДЗЕННЫХ РЭШТКАХ СИЛУРЫЙСКОЙ ІХТЫЯФАУНЫ Ў ЧАЦВЯРЦІЧНЫХ АДКЛАДАХ БЕЛАРУСІ

Упершыню прыводзяцца звесткі аб знаходцы ў чацвярцічных адкладах на тэрыторыі Беларусі перакладзеных рэшткаў (лусак і тэсэр) сілурыіскіх хрыбетных. Даецца поўны сістэматычны агляд і кароткія апісанні таксонаў бясківічных і рыб з указаннем матэрыялу, характару захаванасці, месцазнаходжання і геаграфічнага распаўсюджвання, а таксама выказваецца меркаванне адносна ўзросту пароды, якая ўмяшчае рэшткі іхтыяфаўны, і тыпу яе перакладу.

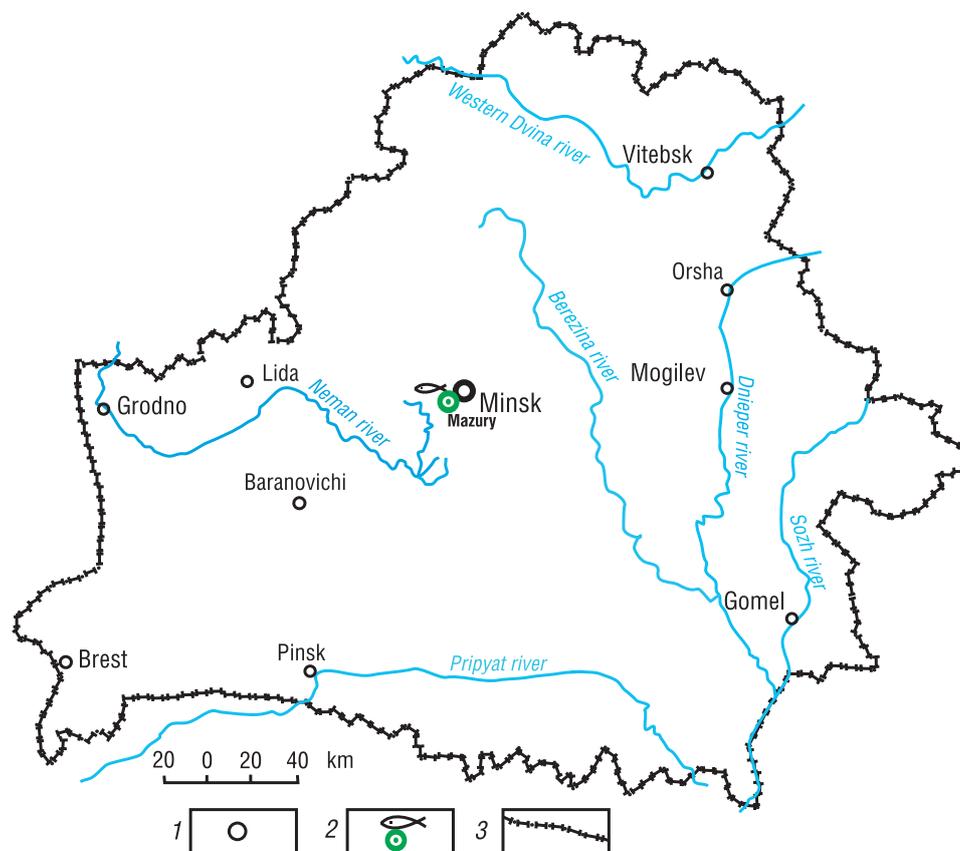
Ключавыя словы: перакладзеныя шкелетныя элементы, сілурыіская іхтыяфаўна, чацвярцічныя адклады, Беларусь

Introduction. For a long time there were no reliable evidences on the redeposited skeletal elements of the Silurian vertebrates in the Quaternary deposits found within the territory of Belarus. However, since the last century some data on the Silurian remains of the invertebrate animals occurring in the secondary bedding in the Quaternary deposits of the country became available. Findings of the redeposited Silurian corals, mollusks, brachiopods from the Quaternary deposits are mentioned in several publications by famous geologists of that time [1–4]. The author of this paper also succeeded to find

numerous redeposited remains of the Silurian invertebrate fauna in the Quaternary deposits for several years of its investigation. He found the skeletons of the sponges, stromatoporoids, corals, trilobites, ostracod valves, shells of the bivalves, gastropods, cephalopods, tentaculites and brachiopods, skeletons of the bryozoans, echinoderms and graptolites, but didn't manage to find the vertebrate remains. Only recently palaeontologist Yu.V. Zaika was lucky to find a rather large redeposited rock fragment with the Silurian vertebrate remains in one of the sandy and gravel quarries of the Minsk region. This is the first reliably established finding in the territory of Belarus and so far the only one. The preliminary results on its study were published as a short report in the proceedings of the 15th International Scientific and Technical Conference held at the Belarusian National Technical University in 2017 [5]. This paper presents a comprehensive information about this interesting finding.

Material and methods. The studied micromeric skeletal remains of the thelodonts and acanthodians were obtained from an acetic acid-treated piece of the organogenic limestone. The photographs of the agnathan and fish microremains were made with a scanning electron microscope JSM-5610 LV (JEOL, Japan). The images were processed with Adobe Photoshop CS6, the figures were created with CorelDRAW X3. The skeletal elements were studied using microscopes MBS-1 and «LOMO» Biolam au-12. The diagnostics of the skeletal elements of the agnathans and fishes were based mainly on the external morphological features. A small part of the scales, mainly those represented by more than one specimen were exposed to the histological examination.

Results of research. As a result of the research it was established that the rock containing the Silurian ichthyofauna remains is a light grey, cryptocrystalline, dense, massive, rather hard, rounded, basically fine-detrital, slightly clayey organogenic limestone. This rock piece is about 15 cm in diameter. It was found in the «Mazury» sandy and gravel quarry located near the town of Fanipol (Dzerzhinsk district, Minsk region) (Text-Figure 1). After this organogenic limestone sample dissolving with acetic



Text-Fig. 1. Location of the area of finding the redeposited Silurian vertebrates in the Quaternary deposits in the territory of Belarus: 1 – city; 2 – place of finding of the redeposited Silurian ichthyofauna in the Quaternary deposits («Mazury» sandy and gravel quarry); 3 – frontiers

acid there were found rather abundant ostracod valves, calcareous tubes of the worms, crinoid segments, some fragments of the brachiopod shells, some single conodonts, more than a dozen of discrete thelodont scales of *Thelodus parvidens* Agassiz, *T. cf. sculptilis* Gross, *T. admirabilis* Märss, numerous isolated acanthodian scales of *Nostolepis striata* Pander, *N. cf. striata* Pander, *N. cf. elegans* (Brotzen), *N. sp.*, *N. ? sp.*, *Gomphonchus sandelensis* (Pander), *G. volborthi* ? (Rohon), *G. cf. volborthi* (Rohon), *G. sp.*, *Gomphonchoporus hoppei* (Gross), *G. hoppei* ? (Gross), Ischnacanthiformes gen. et sp. indet., Acanthodii gen. et sp. indet. 1, Acanthodii gen. et sp. indet. 2, Acanthodii gen. et sp. indet. 3, one scale of probably acanthodian head sensory line and four Nostolepid stellate tesserae.

The ichthyofauna found in this organogenic limestone permits a conclusion that this rock is either Late Silurian, or Latest Ludfordian, or Earliest Pridolian in age. The similar vertebrate assemblage with an exception of some acanthodian taxa is known from both the deposits of the Kuressaare Regional Stage of the Ludfordian Stage of the Ludlowian Series, and the sediments of the Äigu Beds of the Kaugatuma Regional Stage of the Lower Pridolian of the Upper Silurian of Estonia [6, 7]. In Lithuania the similar ichthyofauna assemblage also excluding some representatives of the acanthodians is known from the deposits of the upper part of the Pagegial Regional Stage of the Ludfordian Stage and the lower strata of the Minija Regional Stage of the bottom part of the Pridolian Series of the Upper Silurian [7–9].

It should be noted that according to the classification by T.B. Yanin [10] the discovered rock containing organic remains is related to the glacial type redeposition rocks, i.e., this rock had been reburied from the more ancient deposits, in our case, from the Upper Silurian formations into the younger Quaternary formations.

Taxonomic composition and brief description of the ichthyofauna. A brief palaeontological description of the taxa of the Silurian vertebrates found in the Quaternary deposits of Belarus without specifying the synonymy is presented below. The collection of the skeleton fragments of the agnathans and fishes is a part of the author's personal collection.

Phylum CHORDATA Haeckel, 1874
Subphylum VERTEBRATA Lamarck, 1801
Superclass AGNATHA Cope, 1889
Class DIPLORHINA Kiaer, 1924
Subclass Thelodonti Jaekel, 1911
Order Thelodontiformes Kiaer, 1932
Family Coelolepididae Pander, 1856
Genus *Thelodus* Agassiz, 1839
Thelodus parvidens Agassiz, 1839
 Plate I, Figures 1a, 1b, 2a, 2b and 2c

Description. Morphology. Two cephalo-pectoral scales with the crowns about 0.55 mm and 0.85 mm long were found. The shape of the crown of the scales is rhomboid. The anterior margin is round, the lateral corners are distinct and slightly rounded. The posterior part of the crown is slightly elongated with a slightly rounded end. The crown surface is smooth, flat with a slightly lowered anterior edge. At high magnification the microscopic longitudinal scratches (grooves) are clearly observed in the anterior part of the crown. The neck is distinct, high, smooth on the anterolateral walls and with short vertical ribs on the posterior walls. The base of one scale is well defined, oval, convex and not very high (Plate I, Figure 1b), the base of second scale is diamond-shaped, high and strongly convex (Plate I, Figure 2b and 2c). The pulp opening is located in the center of the base.

The histological examination of the scales was not performed as sufficient data were available for their reliable determination by the external morphological characters, as well as because of their small number.

Material and its preservation. Two scales of very good preservation; «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region.

Geographical distribution. Russia, Estonia, Latvia, Lithuania, Belarus, Great Britain, Netherlands, Sweden, Germany, Poland.

Thelodus cf. sculptilis Gross, 1967

Plate I, Figure 3

Description. Morphology. The cephalo-pectoral scale with a crown about 0.45 mm in length. The crown shape is elongated-rhomboid, much larger than the base. The posterior edge of the crown is slightly pointed. The crown surface is slightly convex, with a downturned anterior edge. Three segments - the medial and two lateral ones separated by two longitudinal grooves are distinctly distinguished on the crown. The medial part of the crown is the longest as compared to the two lateral ones. The crown is covered with microscopic grooves and pores which are most distinctly visible in its anterior and posterior parts. The neck is high with vertical ridges on the posterolateral walls. The base is oval, medium high. The pulp opening is located in the center of the base.

Material and its preservation. One scale of good preservation; «Mazury» sandy and gravel quarry nearby the town of Fanipol in the Minsk region.

Geographical distribution. Russia, Baltic States, Belarus, Sweden.

Thelodus admirabilis Märss, 1982

Plate I, Figures 4, 5a, 5b, 6, 7, 8, 9, 10 and 11

Description. Morphology. The rostral scales with a crown 0.3 - 0.45 mm in length. The crown is rounded, oval, rounded-rhomboid, flat or slightly convex. Numerous ridges on the crown surface converge and get narrower towards the center. They tend to bifurcate at the outer margin and are separated by steep deep furrows. The neck is not high. The base is well-defined, oval, rounded-rhomboid. A large pulp opening is located in the center of the base.

The cephalo-pectoral scales with their crown length ranging from 0.5 to 0.62 mm. Their crown is rhomboid, flat, with a downturned anterior edge. The crown sculpture consists of a series of ridges and grooves. The ridges are two to three times wider than the grooves. The ridges separated by narrow grooves usually converge nearby the posterior corner of the scale. Some shallow but steep grooves between the ridges die out in the same direction or proceed through the scale. The posterior corners of the cephalo-pectoral scales always have almost circular or pointed peg-like posterior projections. The scales have relatively long ridges anteriorly and a segmented margin posteriorly. The neck of the scales is high, distinct with short vertical ribs on the posterolateral walls. The base of the scales is almost of the same size as the crown. It is convex. The pulp opening is in the center of the base.

The postpectoral scales have a length of 0.63 to 0.65 mm. The shape of their crown is oblong-rhomboid, flat with an anterior margin curved downwards. The postpectoral scales have a length of 0.63 to 0.65 mm. The shape of their crown is oblong-rhomboid, flat with an anterior margin curved downwards. The crown sculpture consists of numerous (up to 9) longitudinal ridges and furrows directed radially to its posterior edge. Some furrows open at the posterior edge of the crown. A prong may occur in the medial distal part. The neck is distinct, relatively high. The base is well defined, with a pulp opening.

Histology. The dentine tubules are thin radially diverging from the single pulp cavity towards the surface of the crown. The dentine tubules are straight in the center of the crown. These are shorter than those rising towards the margins. The dentine tubules are branching at several levels, crowded in the central part of the crown and are fewer and sinuous within the neck. In the base these can merge with Sharpey's fibers of the basal layer.

Material and its preservation. Ten scales of good and satisfactory preservation; «Mazury» sandy and gravel quarry located nearby the town of Fanipol in the Minsk region.

Geographical distribution. Estonia, Latvia, Lithuania, Belarus, Poland, Sweden.

Infraphylum GNATHOSTOMATA Gegenbaur, 1874**Superclass Pisces Linnaeus, 1758****Class ACANTHODII Owen, 1846****Order Clamatiiformes Berg, 1940****Family indeterminate****Genus *Nostolepis* Pander, 1856***Nostolepis striata* Pander, 1856

Plate II, Figures 1, 2, 3, 4, 5 and 6

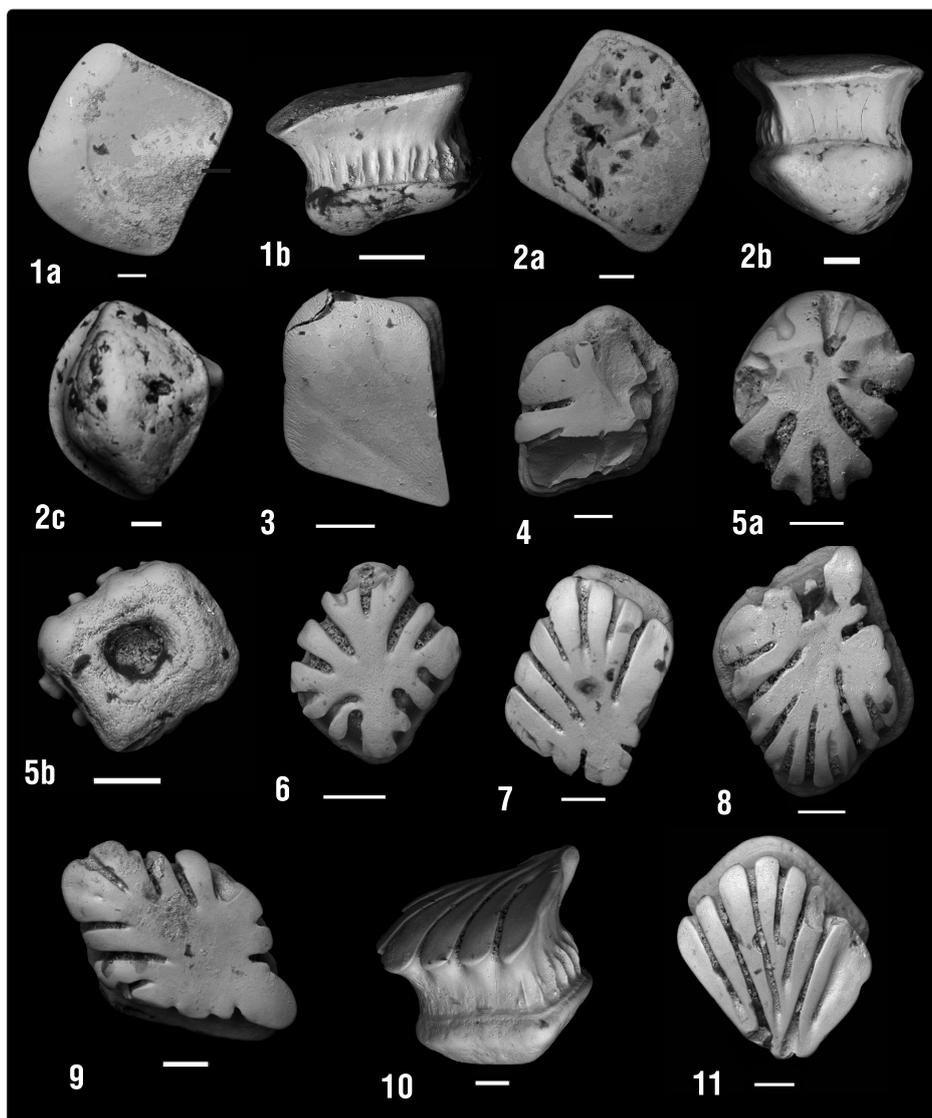


Plate I. Silurian thelodont scales found in the Quaternary deposits of the «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region. Scale bar of 50 μm for Figure 5a; 100 μm for Figures 1a, 2a, 2b, 2c, 3, 4, 5b, 6, 7, 8, 9, 10 and 11; 200 μm for Figure 1b

Figure 1 – *Thelodus parvidens* Agassiz, 1839. Specimen № 111/8-3, cephalo-pectoral scale: a – scale in crown view, $\times 100$; b – scale in lateral view, $\times 95$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 2 – *Thelodus parvidens* Agassiz, 1839. Specimen № 111/8-32, cephalo-pectoral scale: a – scale in crown view, $\times 120$; b – scale in lateral view, $\times 120$; c – scale in basal view, $\times 100$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 3 – *Thelodus cf. sculptilis* Gross, 1967. Specimen № 111/8-38, cephalo-pectoral scale in crown view, $\times 200$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 4 – *Thelodus admirabilis* Märss, 1982. Specimen № 111/8-12, rostral scale in crown view, $\times 150$; the sandy and gravel quarry «Mazury» near the town of Fanipol. Figure 5 – *Thelodus admirabilis* Märss, 1982. Specimen № 111/8-1, rostral scale: a – scale in crown view, $\times 370$; b – scale in basal view, $\times 250$; the sandy and gravel quarry «Mazury» near the town of Fanipol. Figure 6 – *Thelodus admirabilis* Märss, 1982. Specimen № 111/8-2, rostral scale in crown view, $\times 200$; the sandy and gravel quarry «Mazury» near the town of Fanipol. Figure 7 – *Thelodus admirabilis* Märss, 1982. Specimen № 111/8-20, cephalo-pectoral scale in crown view, $\times 150$; the sandy and gravel quarry «Mazury» near the town of Fanipol. Figure 8 – *Thelodus admirabilis* Märss, 1982. Specimen № 111/8-23, cephalo-pectoral scale in crown view, $\times 150$; the sandy and gravel quarry «Mazury» near the town of Fanipol. Figure 9 – *Thelodus admirabilis* Märss, 1982. Specimen № 111/8-26, cephalo-pectoral scale in oblique crown view, $\times 150$; the sandy and gravel quarry «Mazury» near the town of Fanipol. Figure 10 – *Thelodus admirabilis* Märss, 1982. Specimen № 111/8-9, postpectoral scale in oblique lateral view, $\times 120$; the sandy and gravel quarry «Mazury» near the town of Fanipol. Figure 11 – *Thelodus admirabilis* Märss, 1982. Specimen № 111/8-22, postpectoral scale in crown view, $\times 130$; the sandy and gravel quarry «Mazury» near the town of Fanipol

Description. Morphology. The scales of various sizes with a crown sloping anteriorly. Subparallel ribs of different length located on the crown are often fading out, but sometimes reaching the distal section. There are scales with lateral subordinate ridges. The neck is poorly developed. The base is rhomboid, rounded-rhomboid, convex with an apex either located in the center, or shifted toward the anterior edge.

Histology. The crown is mainly formed of oriented mesodentine and in the marginal parts of the growth lamellae only is represented by simple mesodentine. The intertwined dentine tubules form a dense network on the crown. These are thin and directed upward. Strangewebe is developed in the crown posterior part and the scale primordium. This tissue occupies most of each growth lamella. Large ascending, radial and circular vascular canals form a complicated network. In the bone tissue of the base there are large cavities with bone cells.

Material and its preservation. More than a dozen of scales of good preservation; «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region.

Geographical distribution. Russia, Estonia, Latvia, Lithuania, Belarus, Ukraine, Canada, Great Britain, Sweden, Svalbard, Germany, China, India, Australia.

Nostolepis cf. striata Pander, 1856

Plate II, Figure 7

Description. Morphology. A scale with a crown about 0.4 mm long. The crown of the scale is flat, rhomboid with an elongated posterior part. In the anterior part of the crown there are about nine short, poorly visible (most probably erased) ribs. The neck is low, poorly developed. The base is large, massive, convex. The apex is in the center of the base.

Material and its preservation. One scale of satisfactory preservation; «Mazury» sandy and gravel quarry located not far from the town of Fanipol in the Minsk region.

Geographical distribution. Russia, Estonia, Lithuania, Latvia, Ukraine, Belarus, Australia, etc.

Nostolepis cf. elegans (Brotzen, 1934)

Plate II, Figures 8 and 9

Description. Morphology. The scales with the crowns 0.4 mm and 0.6 mm in length. The crowns of the scales are slightly downturned, flat, one of them is triangular-elongated in shape, the second one is rhomboid-elongated. Only the anterior part of the medial area is ornamented with several short, strongly rounded ridges. The lateral areas are outlined by inclined long neck ridges. The posterior end of the crown can go far beyond the edge of the base. The necks of the scales are low. The bases are rhomboid and slightly going beyond the anterior edge of the crown. An apex of the scales is shifted forward from the center of the base.

Material and its preservation. Two scales of satisfactory preservation; «Mazury» sandy and gravel quarry located not far from the town of Fanipol in the Minsk region.

Geographical distribution. Baltic States, Sweden, Belarus.

Nostolepis sp.

Plate II, Figures 10, 11, 12, 13 and 14

Description. Morphology. Both intact, and fragmentary scales were found. In the fragmented scales the posterior part of the crown is either not preserved, or destructed after being extracted from the rock. All the scales in the anterior part of the crown have rough, wide or sharp ridges of different length. Some of them reach the distal end of the crown. The crown of the intact specimens is elongated-rhomboid, triangular-elongated sloping with a medial depression. The neck is poorly developed. The base is rounded-rhomboid, oval, massive, convex, slightly extending beyond the anterior edge of the crown. The apex is usually slightly shifted forward.

Material and its preservation. More than a dozen of scales of good and satisfactory preservation; «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region.

Geographical distribution. Russia, Lithuania, Latvia, Estonia, Belarus, Ukraine, Poland, Great Britain, Sweden, China, Australia, etc.

Nostolepis ? sp.

Plate II, Figure 15

Description. Morphology. The scale with a crown about 0.4 mm long. The crown is oval-rhomboid, flat, in the anterior part there is a series of short, indistinctly expressed ridges. The neck is low. The base is rhomboid, large, slightly convex. The apex is indistinct, slightly shifted forward.

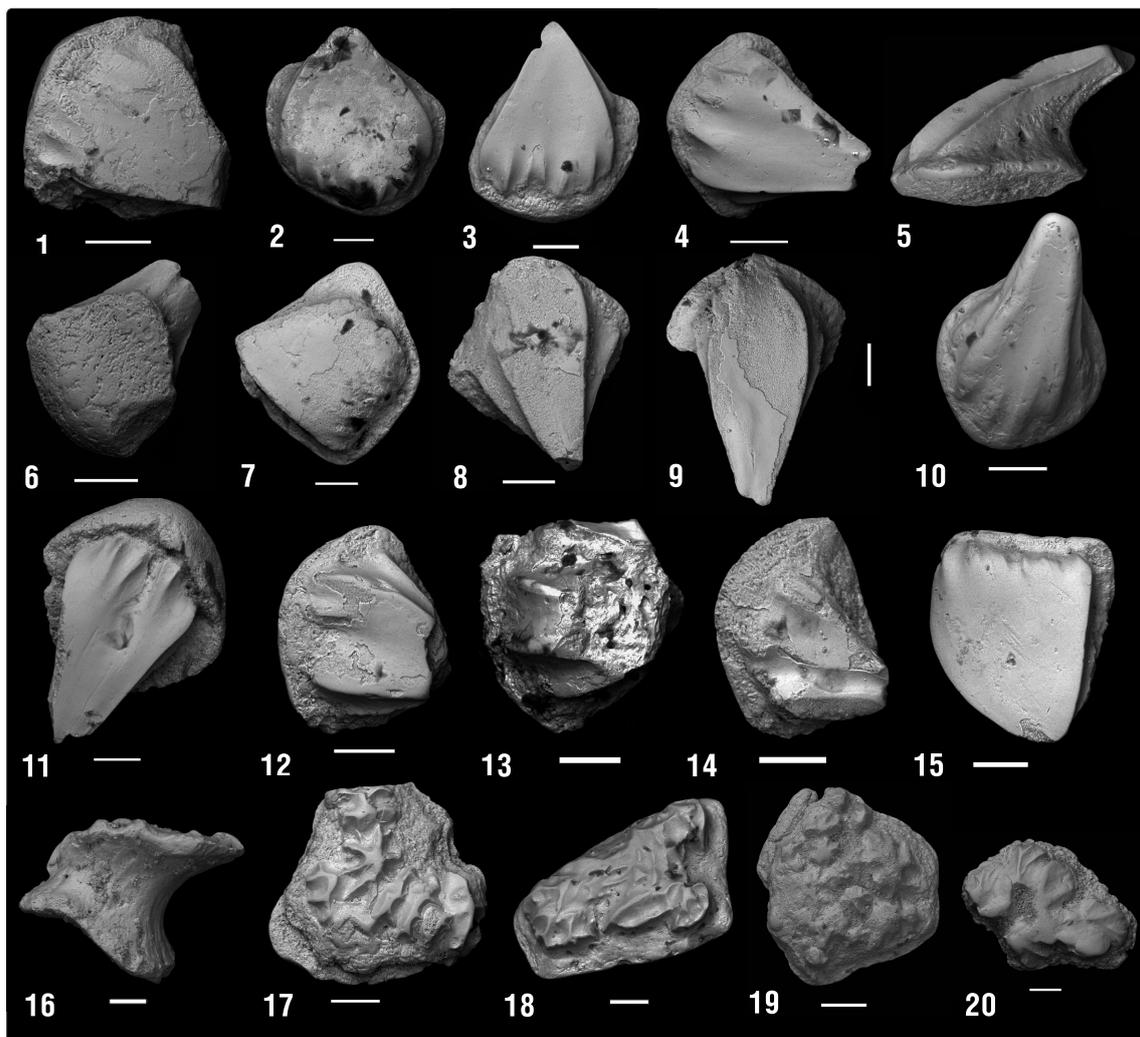


Plate II. The Silurian acanthodian scales and tesserae found in the Quaternary deposits of the sandy and gravel quarry «Mazury» located near the town of Fanipol of the Minsk region. Scale bar of 100 μ m for Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 and 20; 200 μ m for Figure 19

Figure 1 – *Nostolepis striata* Pander, 1856. Specimen № 111/8-19, scale in crown view, $\times 250$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 2 – *Nostolepis striata* Pander, 1856. Specimen № 111/8-43, scale in crown view, $\times 150$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 3 – *Nostolepis striata* Pander, 1856. Specimen № 111/8-35, scale in crown view, $\times 150$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 4 – *Nostolepis striata* Pander, 1856. Specimen № 111/8-24, scale in crown view, $\times 230$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 5 – *Nostolepis striata* Pander, 1856. Specimen № 111/8-27, scale in lateral view, $\times 200$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 6 – *Nostolepis striata* Pander, 1856. Specimen № 111/8-28, scale in basal view, $\times 230$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 7 – *Nostolepis cf. striata* Pander, 1856. Specimen № 111/8-41, scale in crown view, $\times 150$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 8 – *Nostolepis cf. elegans* (Brotzen, 1934). Specimen № 111/8-34, scale in crown view, $\times 200$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 9 – *Nostolepis cf. elegans* (Brotzen, 1934). Specimen № 111/8-39, scale in crown view, $\times 150$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 10 – *Nostolepis* sp. Specimen № 111/8-7, scale in crown view, $\times 200$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 11 – *Nostolepis* sp. Specimen № 111/8-25, scale in crown view, $\times 150$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 12 – *Nostolepis* sp. Specimen № 111/8-14, scale in crown view, $\times 200$, the posterior part of the crown is broken; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 13 – *Nostolepis* sp. Specimen № 111/8-47, scale in crown view, $\times 200$, the posterior part of the crown is broken; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 14 – *Nostolepis* sp. Specimen № 111/8-57, scale in crown view, $\times 200$, the posterior part of the crown is broken; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 15 – *Nostolepis* ? sp., Specimen № 111/8-55, scale in crown view, $\times 200$; «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 16 – *Nostolepis* sp. Pultschuppe sensu Gross 1971. Specimen № 111/8-6, scale in oblique lateral view, $\times 150$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 17 – *Nostolepid*. Specimen № 111/8-16, stellate tessera in top view, $\times 180$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 18 – *Nostolepid*. Specimen № 111/8-42, stellate tessera in oblique top view, $\times 150$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 19 – *Nostolepid*. Specimen № 111/8-10, stellate tessera in top view, $\times 90$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 20 – *Nostolepid*. Specimen № 111/8-11, stellate tessera in top view, $\times 180$, «Mazury» sandy and gravel quarry near the town of Fanipol

Material and its preservation. One scale of satisfactory preservation; «Mazury» sandy and gravel quarry located not far from the town of Fanipol in the Minsk region.

Geographical distribution. Belarus.

Nostolepis sp. Pultschuppe sensu Gross, 1971
Plate II, Figure 16

Description. Morphology. The scales with a crown measuring about 0.5 mm. The crown is oval-elongated, not smooth. The anterior part of the crown is gently sloping, downturned anteriorly, the posterior part is raised. The neck is distinct, high. The base is oval, flattened, with weak concavity in the anterior part.

Remark. In the report [5] these scales were initially identified as Chondrichthyes indet.

Material and its preservation. Two scales of satisfactory preservation; «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region.

Geographical distribution. Belarus and some other countries.

Nostolepid stellate tesserae
Plate II, Figures 17, 18, 19 and 20

Description. Morphology. Four polygonal tesserae from 0.45 to 1.2 mm in size were found in the rock. Their outer surface is covered with branched or stellate tubercles covering not the entire surface area. The tessera base is massive, flat or slightly convex.

Material and its preservation. Four tesserae of good and rather good preservation; «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region.

Geographical distribution. Russia, Baltic States, Belarus, Sweden, Australia, etc.

Order Ischnacanthiformes Berg, 1940
Family Ischnacanthidae Woodward, 1891
Genus *Gomphonchus* Gross, 1971

Gomphonchus sandelensis (Pander, 1856)

Description. Morphology. The scales with their crowns measuring 0.5 mm and 0.8 mm. The crown is rhomboid, oval-rhomboid, flat, usually smooth or with short ridges in the proximal part. The anterior margin of the crown is circular and slightly downturned. The neck is distinct, high, with vertical ribs posteriorly. The neck rim is sharp. The base is rhomboid, massive, strongly convex jutting slightly out of the crown. The apex is shifted slightly forward.

Histology. The crown is composed of dentine and enamel-like dentine. Long narrow ascending vascular canals containing many lateral branches and located in the basis parts of each of the growth lamellae are clearly expressed in the neck. The growth lamellae are penetrated by dense ascending vascular canals. No lacunae are presented. The radial canals occur above the base surface and consist of many long branches. The acellular bone tissue of the base is penetrated by numerous narrow, short tubules and Sharpey's fibers.

Material and its preservation. Two scales of good and satisfactory preservation; «Mazury» sandy and gravel quarry in the vicinity of the town of Fanipol in the Minsk region.

Geographical distribution. Russia, Lithuania, Latvia, Estonia, Belarus, Ukraine, Poland, Central Asia, Sweden, Great Britain, China.

Gomphonchus volborthi ? (Rohon, 1893)
Plate III, Figures 1 and 2

Description. Morphology. The scales with their crowns ranging from 0.3 to 0.35 mm in length. The crown shape is almost triangular with a circular or straight anterior edge. The posterior part of the crown is rounded and extends slightly behind the base. Most part of the crown surface of the scales is flat and smooth. The anterior part of the crown is covered with distinct radial ridges, that quickly fade away not reaching the side corners. The neck is well defined, relatively not high. The base is rhomboid, large, strongly convex and is larger in size than the crown. The apex is slightly shifted forward from the base center.

Material and its preservation. Two scales of good preservation; «Mazury» sandy and gravel quarry in the area of the town of Fanipol in the Minsk region.

Geographical distribution. Belarus.

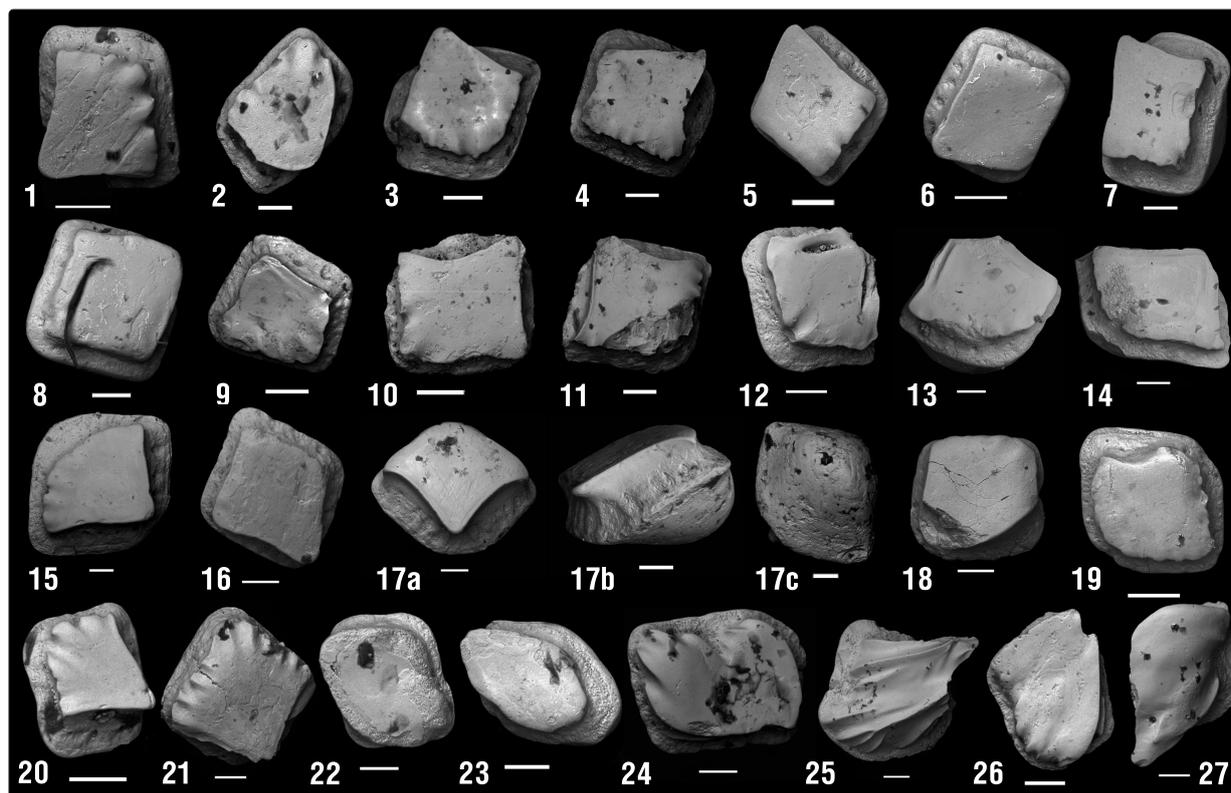


Plate III. Silurian acanthodian scales found in the Quaternary deposits of the «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region. Scale bar of 100 μ m for Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17a, 17b, 17c, 18, 19, 20, 21, 22, 23, 24, 26 and 27; 200 μ m for Figure 25

Figure 1 – *Gomphonchus volborthi* ? (Rohon, 1893). Specimen № 111/8-30, scale in crown view, $\times 250$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 2 – *Gomphonchus volborthi* ? (Rohon, 1893). Specimen № 111/8-61, scale in crown view, $\times 150$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 3 – *Gomphonchus* cf. *volborthi* (Rohon, 1893). Specimen № 111/8-45, scale in crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 4 – *Gomphonchus* cf. *volborthi* (Rohon, 1893). Specimen № 111/8-46, scale in crown view, $\times 150$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 5 – *Gomphonchus* cf. *volborthi* (Rohon, 1893). Specimen № 111/8-51, scale in crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 6 – *Gomphonchus* cf. *volborthi* (Rohon, 1893). Specimen № 111/8-59, scale in oblique crown view, $\times 250$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 7 – *Gomphonchus* cf. *volborthi* (Rohon, 1893). Specimen № 111/8-49, scale in crown view, $\times 150$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 8 – *Gomphonchus* sp. Specimen № 111/8-18, scale in crown view, $\times 190$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 9 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-48, scale in crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 10 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-17, scale in crown view, $\times 250$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 11 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-44, scale in crown view, $\times 150$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 12 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-15, scale in oblique crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 13 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-4, scale in oblique crown view, $\times 140$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 14 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-5, scale in oblique crown view, $\times 150$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 15 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-13, scale in crown view, $\times 120$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 16 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-8, scale in crown view, $\times 190$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 17 – *Gomphonchoporus hoppei* (Gross). Specimen № 111/8-36, scale: a – scale in anterior crown view, $\times 150$; b – scale in lateral view, $\times 130$; c – scale in basal view, $\times 130$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 18 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-50, scale in oblique crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 19 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-53, scale in crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 20 – *Gomphonchoporus hoppei* (Gross, 1947). Specimen № 111/8-58, scale in crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 21 – *Gomphonchoporus hoppei* ? (Gross, 1947). Specimen № 111/8-40, scale in crown view, $\times 150$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 22 – *Ischnacanthiformes* gen. et sp. indet. Specimen № 111/8-52, scale in crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 23 – *Ischnacanthiformes* gen. et sp. indet. Specimen № 111/8-54, scale in crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 24 – *Acanthodii* gen. et sp. indet. 1. Specimen № 111/8-29, scale in crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 25 – *Acanthodii* gen. et sp. indet. 2. Specimen № 111/8-37, scale in crown view, $\times 65$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 26 – *Acanthodii* gen. et sp. indet. 3. Specimen № 111/8-62, scale in crown view, $\times 200$, «Mazury» sandy and gravel quarry near the town of Fanipol. Figure 27 – Possibly acanthodian head sensory line scale. Specimen № 111/8-31, scale in crown view, $\times 150$, «Mazury» sandy and gravel quarry near the town of Fanipol

Gomphonchus cf. volborthi (Rohon, 1893)

Plate III, Figure 3, 4, 5, 6 and 7

Description. Morphology. The scales are 0.3-0.5 mm long. Their crown is diamond-shaped with a slightly elongated posterior edge. The posterior edge is usually sharp. Most of the crown surface is flat. Its anterior part is smooth or covered with short radial ridges. The neck is clear, not high. The base is rhomboid, rounded-rectangular, massive, large, strongly convex, larger than the crown. The apex of the scales is slightly displaced forward from the center of the base.

Material and its preservation. About a dozen of scales of good and satisfactory preservation; «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region.

Geographical distribution. Belarus, Great Britain, Sweden, Poland.

Gomphonchus sp.

Plate III, Figure 8

Description. Morphology. The scales with their crowns ranging from 0.4 to 0.7 mm in length. The crowns of the scales are rhomboid, flat, smooth. The posterior edge of the crowns is circular, obtuse. The neck is well defined, not very high. The base is diamond-shaped, massive, strongly convex, slightly larger than the crown with the apex slightly shifted toward the anterior edge of the scale.

Material and its preservation. Three scales of satisfactory preservation; «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region.

Geographical distribution. Russia, Lithuania, Latvia, Estonia, Belarus, Ukraine, Poland, the USA, Great Britain, Sweden, Svalbard, Greenland, India, Australia.

Family Poracanthodidae Vergoossen, 1997**Genus *Gomphonchoporus* Vergoossen, 1999***Gomphonchoporus hoppei* (Gross, 1947)

Plate III, Figures 9, 10, 11, 12, 13, 14, 15, 16, 17a, 17b, 17c, 18, 19 and 20

Description. Morphology. The scales are from small to relatively large ones in size (0.3-0.8 mm). The crown is rhomboid or almost triangular, with angular or rounded anterior edge. The posterior edge of the crown is sharp or obtuse (rounded). The anterior part of the crown up to the lateral corners is either smooth, or with prominent, sharp radial ridges, that may extend beyond the lateral corners or may be short. The surface of the crown between the ridges can be concaved rather deeply, especially in the anterior part. One narrow deep groove can be observed on each side in the posterior part of the crown. The neck is well-defined, not very high. Its posterolateral areas are lowered with ribs or without them. The base is oval, rhomboid, massive, strongly convex, exceeds the size of the crown. The apex is shifted forward.

Histology. The crown of the scales consists of dentine located in numerous thin growth lamellae. The posterior part of the crown contains the pore canals or can be without them. There is a well-defined network of thin sinuous branching and ascending vascular canals. The radial canals located in the neck do not usually form long branches. They may be exposed on some scales. The dentine tubules in the crown surface layer are short in length. Their centripetal orientation is well observed. The base of the scales is represented by the acellular bone tissue, which is penetrated by numerous narrow and short tubules and well-defined long Sharpey's fibers.

Material and its preservation. About fifteen scales of good and satisfactory preservation; «Mazury» sandy and gravel quarry in the vicinity of the town of Fanipol in the Minsk region.

Geographical distribution. Russia, Estonia, Latvia, Lithuania, Belarus, the Netherlands, Germany, etc.

Gomphonchoporus hoppei ? (Gross, 1947).

Plate III, Figure 21

Description. Morphology. The scale shows a crown measuring 0.45 mm in length. The crown is rhomboid in shape. The posterior edge of the crown is slightly broken. The anterior part of the crown is covered by short distinct radial ridges. The neck is not very high. The base is oval-rhomboid, massive, convex, slightly larger than the crown. The crown is slightly shifted anteriorly.

Material and its preservation. One scale of relatively good preservation; «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region.

Geographical distribution. Belarus.

Ischnacanthiformes fam. gen. et sp. indet.

Plate III, Figures 22 and 23

Description. Morphology. The scales with a crown measuring about 0.4 mm in size. Their crown is rounded-rhomboid, oval-elongated, flat, without sculpture. The neck of the scales is high, well-defined. The base of the scales is rounded-rhomboid, ellipsoidal, large, convex, slightly larger than the crown. The apex is located either in the center of the base, or slightly shifted forward.

Material and its preservation. Seven scales of which four are fairly well-preserved and three are slightly rounded; «Mazury» sandy and gravel quarry in the area of the town of Fanipol in the Minsk region.

Geographical distribution. Besides Belarus, the acanthodian scales belonging to this order are widely distributed throughout the world.

Acanthodii gen. et sp. indet. 1

Plate III, Figure 24

Description. Morphology. A small scale with a crown slightly concave in the middle part and flattened on each side, as well as with several short vanishing ridges on the proximal edge. The neck is low. The base is rounded-rectangular, large, massive, strongly convex, larger than the crown.

Remarks. This scale is somewhat similar to the scales of *Canadalepis linguiformis* Vieth [9, 11, 12]. However, the scales of this species are characteristic of the deposits of the upper part of the Pridolian Series of the Upper Silurian and the Lochkovian Stage of the Lower Devonian. The scale described here is more ancient, according to dating of the rock sample from which it originates. The presence of an abundant scale material would allow the more detailed study and the more accurate species determination.

Material and its preservation. One scale of good preservation; «Mazury» sandy and gravel quarry located nearby the town of Fanipol in the Minsk region.

Geographical distribution. Belarus.

Acanthodii gen. et sp. indet. 2

Plate III, Figure 25

Description. Morphology. The scale is large, the crown is about 1.4 mm in length. The crown is steeply downturned forward. The sculpture consists of three distinct large ribs running from the posterior section of the crown to the anterior one. In the anterior part of the crown they break up into 2 - 3 short ridges. The base is large, angular-oval, very massive, strongly convex and protrudes anteriorly and on each side of the crown edges. The apex is in the center of the base.

Material and its preservation. One scale of good preservation; «Mazury» sandy and gravel quarry located near the town of Fanipol in the Minsk region.

Geographical distribution. Belarus.

Acanthodii gen. et sp. indet. 3

Plate III, Figure 26

Description. Morphology. The scales with a crown measuring about 0.4 mm in length. The crown is flat with small depressions on each side and with short poorly expressed ridges along the anterior margin. The neck is low. The base is large, improperly rhomboid, convex, slightly larger than the crown. The apex is well-defined, slightly moved forward.

Material and its preservation. One scale of good preservation; «Mazury» sandy and gravel quarry in the vicinity of the town of Fanipol in the Minsk region.

Geographical distribution. Belarus.

Possible acanthodian head sensory line scale

Plate III, Figure 27

Description. Morphology. Small scale with a slightly destroyed crown. The crown is thin, smooth; the surface is uneven with a gently sloping circular anterior edge. The neck is poorly developed and smoothly passing into the crown. The base is rounded-rhomboid, flattened, slightly extending beyond the crown edges.

Material and its preservation. One scale of good preservation; «Mazury» sandy and gravel quarry located near the town of Fanipol of the Minsk region.

Geographical distribution. Belarus.

CONCLUSIONS

Micromeric skeleton elements (scales and tesserae) of the redeposited Silurian ichthyofauna represented by thelodonts and acanthodians were revealed for the first time in the Quaternary deposits of the territory of Belarus, namely, in the Minsk region, and their descriptions and photographs are presented. Unfortunately, due to a small number of some skeletal remains found or to their not perfect preservation, the significant part of this ichthyofauna representatives could not be accurately identified to a species. The author believes that in the future the task-oriented searches for the skeletal elements of the Silurian vertebrates, which occur in the secondary bedding in the Quaternary deposits, will nevertheless permit discovering their abundant remains. This will provide an opportunity to perform the more accurate taxonomic definitions and to supplement their systematic composition in the territory of Belarus, as well as to find out the ways of their skeletal element transportation by glaciers together with their enclosing rocks within the country.

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