

## ICHTHYOFAUNA FROM THE LOWER DEVONIAN (LOCHKOVIAN) DEPOSITS OF THE SOUTHWESTERN PART OF BELARUS

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*The paper presents the results of the palaeoichthyological study of the core samples from the Tomashovka 11 borehole drilled in the late sixties of the last century in the territory of Belarus within the northwestern part of the Volyn Monocline. Some historical evidences available of the Lower Devonian (Lochkovian) fish fauna occurrence within the southwestern part of Belarus are cited. To complete the information the author presents a Table summarizing the information of the stratigraphic distribution of all the reliably known representatives of the Lower Devonian fish fauna found within the studied area, which is based on the literature and personal data of the author. The taphonomic characteristic of the ichthyofauna remains is briefly reviewed. The Lower Devonian (Lochkovian) deposits are correlated with the synchronous sediments of Western Ukraine, the Baltic States and the Timan-Pechora region that have received the most palaeontological study. The ichthyofauna data obtained supplement the information of its taxonomic composition in the territory of Belarus.*

### INTRODUCTION

The Lochkovian deposits of the Lower Devonian are known only in the southwest of Belarus in the areas tectonically belonging to the Podlasie-Brest Depression and Volyn Monocline (Kruczek et al., 2001). The recent areas of their distribution are not vast and look like small, isolated from each other sites, which escaped destruction by erosion in Post-Devonian time (Text-Figure 1).

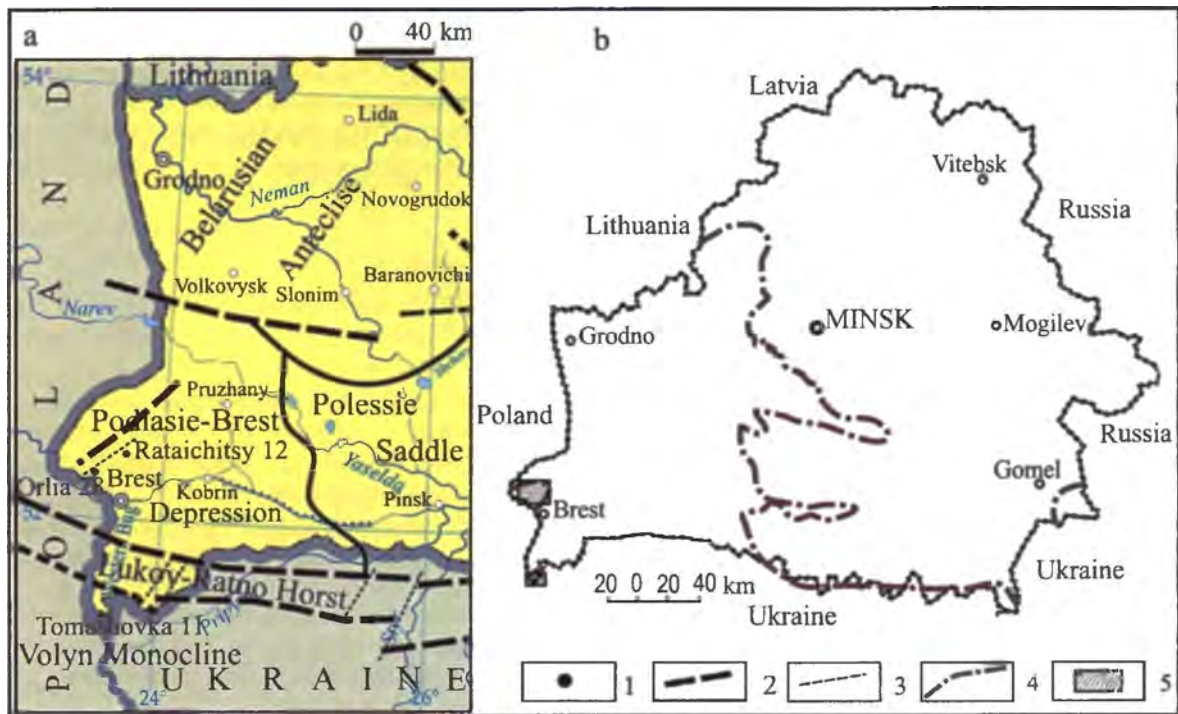
The Lochkovian Stage includes deposits of the Borshchovo and Chortkov Regional Stages distinguished in the above areas from the palaeontological data and from the correlation with the stratotype sections located in the territory of Western Ukraine (Volyn-Podolia region) (Moiseeva, Kruczek, 1969). According to the Unified Scheme of the Devonian deposits of the Russian Craton, 1988 (Decision..., 1990), as well as the last Stratigraphic Chart of the Devonian deposits of Belarus, 2010 (Obukhovskaya et al., 2010), these deposits correspond to the lower part of the Lochkovian Stage. Within the Podlasie-Brest Depression the total thickness of these deposits distinguished as the Kameniuki Formation (Kruczek et al., 2001) is 41 m, while in the Volyn Monocline these are about 85 m thick and are subdivided into the Domachevo, Dubitsa and Orkhov Formations (Pushkin, Kruczek, 1978).

The present paper is devoted to the study of the ichthyofauna microremains, that were obtained

using chemical dissolution of the fragmental core material so far remained intact in the Tomashovka 11 borehole. This borehole was drilled by the Pole-sie Exploration party of the BSSR Department of Geology in the late sixties of the last century near the village of Tomashovka of the Brest region in the far southwest of Belarus. It exposed the clayey-carbonate deposits of the Domachevo Formation and the lower part of the Dubitsa Formation of the Borshchovo Regional Stage, as well as clayey-marls deposits of the upper part of the Dubitsa and Orkhov Formations of the Chortkov Regional Stage of the Lochkovian Stage. In tectonic respect, it is located within the northwestern part of the Volyn Monocline. The palaeoichthyological study carried out by the author provided new data on the vertebrates, which supplemented the information on the taxonomic composition of agnathans and fishes earlier determined in this borehole and studied in the last century by V.N. Karatajūtė-Talimaa, J.J. Valiukevičius, S.A. Kruczek and T.I. Märss.

### HISTORY OF THE STUDY OF THE LOWER DEVONIAN ICHTHYOFAUNA IN THE SOUTHWESTERN PART OF BELARUS

The study of the ichthyofauna microremains from the Lower Devonian deposits of the southwestern part of Belarus was originated by V.N. Karatajūtė-Talimaa (Karatajūtė-Talimaa, 1976; Karatajūtė-Talimaa, 1978) in the seventies of the last



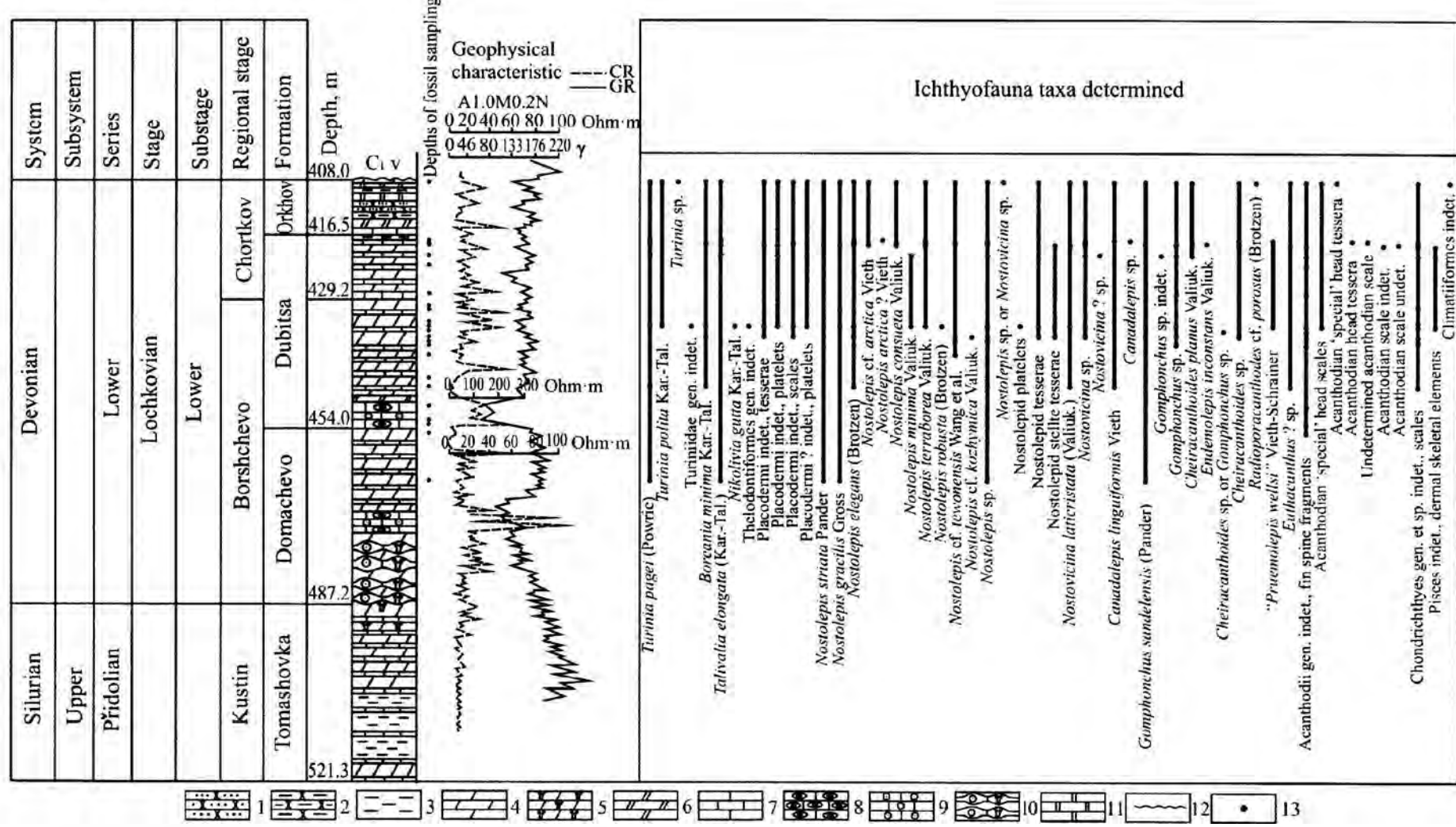
**Text-Figure 1** – Map showing the location of the borehole sections in the southwestern part of Belarus, where the Lower Devonian (Lochkovian) ichthyofauna was studied (a) and site sketch map (b). 1 – borehole sections where the ichthyofauna was studied; 2 – regional and subregional fractures; 3 – local fractures; 4 – boundary of the present-day occurrence of the Devonian deposits; 5 – outlines of the studied areas.

century. According to this author, the agnathan and fish remains represented by the thelodont scales of *Turiniasp.*, *T. pagei* (Powrie), *T. polita* Kar.-Tal., *Nikoliviagutta* Kar.-Tal., *N. elongata* Kar.-Tal. (presently *Talivalia elongata* (Kar.-Tal.)), small fragments of heterostracan plates and scales of *Anglaspis* sp., *Corvaspis* sp., *Tesseraspis* sp., «*Traquairaspis*» sp. (possibly *Phialaspis* sp.), single skeleton elements of osteostracans, acanthodian scales of *Nostolepis striata* Pander, *N. gracilis* Gross, *Gomphonchus* sp., sarcopterygian scales of *Porolepis* sp. were found within the territory of the Podlasie-Brest Depression in the Rotaichitsy 12 borehole in a depth range of 366.7 to 404.0 m. The ichthyofauna remains were determined in the carbonate greenish-grey clays and red-brown siltstones with greyish-green spots. This part of the section of the Devonian was correlated in its vertebrate composition with the Borshchovo Regional Stage of the Podolia region. The similar vertebrate assemblage was also identified by V.N. Karatajūtė-Talimaa in the Orlia 28 borehole in a depth range of 409 to 445 m.

Somewhat later, the vertebrate remains were found by V.N. Karatajūtė-Talimaa in the Tomashovka 11 borehole (depth range of 406.2–408.3 m, 417.6–454.5 and 485.0–490.0 m) located within the northwestern part of the Volyn Monocline. She found some scales of thelodonts of *Turinia pagei*

(Powrie), *Turinia polita* Kar.-Tal., acanthodians of *Nostolepis* sp., *Gomphonchus* sp., as well as some tesserae of placoderms of *Placodermi* indet., *Radotina* ? sp. in the bottom part of a depth interval of 406.2–408.3 m, scales of the thelodonts of *Turinia pagei* (Powrie), *Turinia polita* Kar.-Tal., *Nikolivia elongata* Kar.-Tal. (now *Talivalia elongata* (Kar.-Tal.)), *Nikolivia gutta* Kar.-Tal., acanthodian scales of *Gomphonchus* sp., *Nostolepis* sp., *N. striata* Pander, fin spines of *Acanthodii* gen. indet., fragments of the heterostracan plates and scales of «*Traquairaspis*» sp. – within 417.6–454.5 m, scales of *Gomphonchus* sp. – within 485.0–490.0 m. Data on the ichthyofauna together with the invertebrate evidences (corals, bryozoans, ostracodes, brachiopods, trilobites, tentaculites, etc.) were used to date the enclosing rocks. So, the rocks containing fossils in a depth range of 408.0 to 429.2 m were assigned to the Chortkov Regional Stage, and deposits confined to a depth range of 429.2–487.2 m – to the Borshchovo Regional Stage.

In the nineties of the last century J.J. Valiukevičius, S.A. Kruchek and T.I. Märss performed an additional palaeoichthyological study of the Lower Devonian (Lochkovian) deposits exposed in the Rotaichitsy 12 and Tomashovka 11 boreholes. J.J. Valiukevičius (Valiukevičius, 1998) found the acanthodian remains represented by scales of *Nostolepis*



Text-Figure 2 – Geological section of the Lower Devonian deposits in the Tomashovka 11 borehole with the ichthyofauna distribution (from Pushkin&Kruchek, 1978, Text-Figure 1; Plax et al., 2012) with the author's refinements and additions. 1 – sandstones, 2 – clayey sandstones, 3 – clays, 4 – marls, 5 – marls with bryozoans, 6 – dolomitic marls, 7 – limestones, 8 – algal limestones, 9 – crinoidal limestones, 10 – lump crinoidal and bryozoan limestones, 11 – dolomites, 12 – discontinuity surfaces, 13 – fossil sampling sites.

Table – Stratigraphic distribution of vertebrates in the Lochkovian deposits of the southwestern part of Belarus

Taxa	System		Devonian		
	Series		Lower		
	Stage		Lochkovian		
	Substage		Lower		
	Regional stage		Borshchevo		Chortkov
	Formation	Domachevo	Dubitsa	Orkhov	
1		2	3	4	
(H) <i>Corvaspis</i> sp. ....					
(H) <i>Tesseraspis</i> sp. ....					
(H) <i>Anglaspis</i> sp. ....					
(O) <i>Osteostraci</i> indet. ....					
(H) « <i>Traquairaspis</i> » sp. ....					
(T) <i>Turinia pagei</i> (Powrie) ....					
(T) <i>Turinia polita</i> Kar.-Tal. ....					
(T) <i>Turinia</i> sp. ....					
(T) <i>Talivalia elongata</i> (Kar.-Tal.) ....					
(Ac) <i>Nostovicina laticristata</i> (Valiuk.) ....					
(Ac) <i>Nostolepis striata</i> Pander ....					
(Ac) <i>Nostolepis gracilis</i> Gross ....					
(Ac) <i>Gomphonchus sandelensis</i> (Pander) ....					
(Ac) <i>Radioporacanthodes cf. porosus</i> (Brotzen) ....					
(Ac) <i>Nostolepis minima</i> Valiuk. ....					
(Ac) <i>Nostolepis</i> sp. ....					
(Ac) <i>Cheiracanthoides planus</i> Valiuk. ....					
(Ac) <i>Nostolepis robusta</i> (Brotzen) ....					
(Ac) <i>Nostovicina cf. multicostata</i> (Vieth) ....					
(Ac) <i>Canadalepis linguiformis</i> Vieth ....					
(Ac) « <i>Pruemolepis wellsii</i> » Vieth-Schreiner ....					
(Ac) <i>Acanthodii</i> gen. indet., fragments of fin spines .					
(Ac) <i>Endemolepis inconstans</i> Valiuk. ....					
(Ac) <i>Gomphonchoporus hoppei</i> (Gross) ....					
(Ac) <i>Poracanthodes punctatus</i> Brotzen ....					
(Ac) <i>Poracanthodes subporosus</i> Valiuk. ....					
(Ac) <i>Gomphonchoporus cf. hoppei</i> (Gross) ....					
(Ac) <i>Gomphonchus sandelensis</i> (Pander) or <i>Pora-</i> <i>canthodus punctatus</i> Brotzen ....					
(T) <i>Nikolivia gutta</i> Kar.-Tal. ....					
(S) <i>Porolepis</i> sp. ....					
(Ac) <i>Gomphonchus</i> sp. ....					
(Ac) <i>Nostolepis terraborea</i> Valiuk. ....					
(T) <i>Boreania minima</i> Kar.-Tal. ....					
(Ac) <i>Euthacanthus</i> ? sp. ....					
(Ps) Pisces indet., dermal skeletal elements ....					
(Ac) <i>Nostolepis elegans</i> (Brotzen) ....					
(Ac) <i>Nostolepis cf. tewonensis</i> Wang et al. ....					
(Ac) <i>Nostolepis cf. kozhymica</i> Valiuk. ....					
(Ac) <i>Nostolepid</i> platelets ....					
(Ac) <i>Nostolepid tesserae</i> ....					
(Ac) <i>Nostolepid stellate tesserae</i> ....					
(Ac) <i>Nostovicina</i> sp. ....					
(Ac) <i>Cheiracanthoides</i> sp. or <i>Gomphonchus</i> sp. ....					
(P) Placodermi indet., tesserae ....					
(P) Placodermi indet., platelets ....					
(P) Placodermi indet., scales ....					
(P) Placodermi ? indet., platelets ....					
(Ch) Chondrichthyes gen. et sp. indet., scales ....					
(Ac) Acanthodian 'special' head scales ....					

ГЕАЛОГІЯ



Table continuation

1	2	3	4
(T) Turiniidae gen. indet. ....			
(T) Thelodontiformes gen. indet. ....			
(Ac) <i>Nostolepis</i> cf. <i>arctica</i> Vieth .....			
(Ac) <i>Nostolepis arctica</i> ? Vieth .....			
(Ac) <i>Nostolepis consueta</i> Valiuk. ....			
(Ac) <i>Gomphonchus</i> sp. indet. ....			
(Ac) <i>Nostovicina</i> ? sp. ....			
(Ac) <i>Canadalepis</i> sp. ....			
(Ac) Acanthodian head tessera .....			
(Ac) Undetermined acanthodian scale .....			
(Ac) Acanthodian scale indet. ....			
(Ac) Acanthodian scale undet. ....			
(Ac) <i>Nostolepis</i> sp. or <i>Nostovicina</i> sp. ....			
(Ac) Acanthodian 'special' head tessera .....			
(P) <i>Rodotina</i> ? sp. ....			
(Ac) <i>Climatiiformes</i> indet. ....			

Note – Zonal taxa are shown in bold italics. Ac – Acanthodii, Ch – Chondrichthyes, H – Heterostraci, O – Osteostraci, P – Placodermi, Ps – Pisces, S – Sarcopterygii. The table shows the vertebrate taxa determined by the author, as well as those found earlier by the other authors (V.N. Karatajūtė-Talimaa, J.J. Valiukevičius and T.I. Märss).

*striata* Pander, *N. minima* Valiuk., *N. robusta* (Brotzen), *Gomphonchus sandelensis* (Pander), *G. sandelensis* (Pander) or *Poracanthodes punctatus* Brotzen, «*Pruemolepis wellsii*» Vieth-Schreiner, *Endemolepis inconstans* Valiuk., *Cheiracanthoides planus* Valiuk. etc. of the acanthodian zone of *Nostolepis minima* in the Rotaichitsy 12 borehole in a depth range of 366.0–404.0 m in grey, light grey and greenish-grey clays, siltstones, marls, clayey, organogenic and dolomite limestones. The acanthodian assemblage of this part of the section enabled the author to assign it to the Borshchovo Regional Stage and to correlate it with the deposits of the lower and middle part of the Tilžė Regional Stage of the Lochkovian Stage in the Baltic States.

In the Tomashovka 11 borehole J.J. Valiukevičius, S.A. Kruchek and T.I. Märss (Valiukevičius, 1998; Kruchek et al., 1996) identified from the Borshchovo Regional Stage and the lower part of the Chortkov Regional Stage of the Lochkovian Stage the fish fauna which is generally represented by the acanthodians of *Nostolepis striata* Pander, *N. gracilis* Gross, *N. robusta* (Brotzen), *N. minima* Valiuk., «*Pruemolepis wellsii*» Vieth-Schreiner, *Canadalepis linguiformis* Vieth, *Cheiracanthoides planus* Valiuk., *Endemolepis inconstans* Valiuk., *Gomphonchus* sp., *G. sandelensis* (Pander), *G. sandelensis* (Pander) or *P. punctatus* Brotzen, *Poracanthodes subporosus* Valiuk., *P. punctatus* Brotzen etc. The specified acanthodian assemblage was assigned to the *Nostolepis minima* zone, which allowed the correlation of their enclosing deposits with the most part of the

Tilžė Regional Stage of the Lochkovian Stage of the Baltic States (Kruchek et al. 2001).

#### STRATIGRAPHIC DIVISION OF THE LOWER DEVONIAN DEPOSITS OF THE TOMASHOVKA 11 BOREHOLE ACCORDING TO NEW RESULTS OBTAINED

This part of the paper examines the lithological restrictions and stratigraphic distribution of the vertebrate microremains in the section of the Tomashovka 11 borehole (Text-Figure 2). To make the information more complete the author using the information available from the literature and his personal research data have prepared and included in the paper the Table summarizing evidences of the stratigraphic distribution of all the reliably known representatives of the Lower Devonian ichthyofauna in the southwestern part of Belarus, as well as six plates (Plates I, II, III, IV, V and VI) demonstrating some skeletal elements of the agnathans and fishes that are attached. The borehole section is considered below.

The deposits of the **Domachevo Formation** of the Borshchovo Regional Stage of the Lochkovian Stage of the Lower Devonian overlie the sediments of the Kustin Formation of the Pridolian Stage of the Upper Silurian at a depth of 487.2 m and are covered by deposits of the lower part of the Dubitsa Formation of the same-name regional stage at a depth of 454 m. The vertebrates were determined in this part of the section in greenish-grey and light grey marls. These are few in the number of taxa

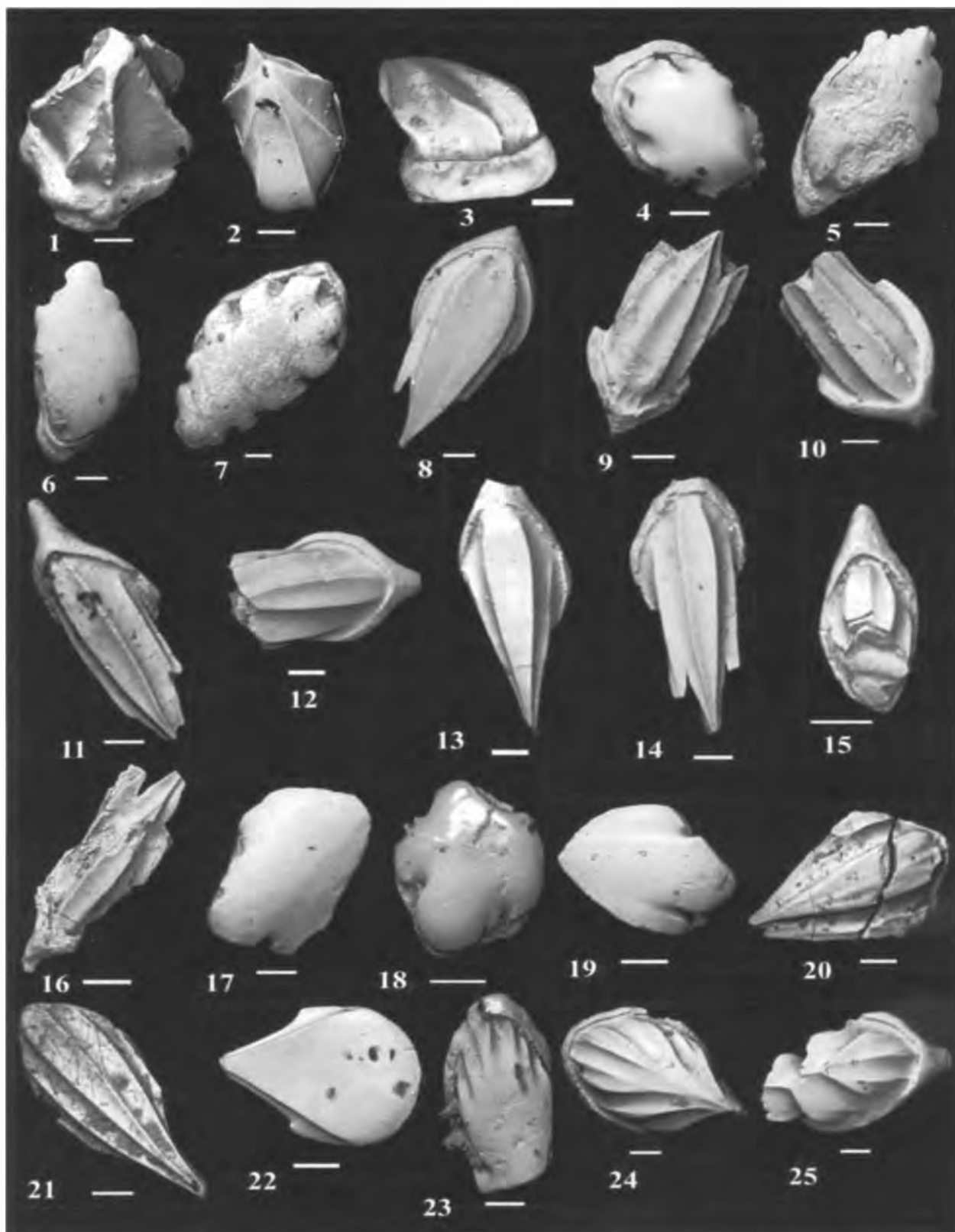


Plate I – Thelodont scales from the Tomashovka 11 borehole. The scales come from the Lochkovian Stage, Lower Devonian. Scale bar of 100  $\mu$ m for Figures 1-25.

Figure 1 – *Turinia pagei* (Powrie). Specimen N<sup>o</sup> 93/4-3, depth of 418 m,  $\times$  150, scale from the head part, oblique crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 2 – *Turinia pagei* (Powrie). Specimen N<sup>o</sup> 93/12-14, depth of 434 m,  $\times$  150, scale from the head part, oblique crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 3 – *Turinia pagei* (Powrie). Specimen N<sup>o</sup> 93/2-44, depth of 408.3 m,  $\times$  200, scale from the head part, lateral view, Chortkov Regional Stage, Orkhov Formation. Figure 4 – *Turinia pagei* (Powrie). Specimen

№ 93/12-10, depth of 434 m, × 150, cephalo-pectoral scale, oblique crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 5 – *Turinia pagei* (Powrie). Specimen № 93/19-1, depth of 445.7 m, × 130, cephalo-pectoral scale, crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 6 – *Turinia pagei* (Powrie). Specimen № 93/2-38, depth of 408.3 m, × 100, cephalo-pectoral scale, crown view, Chortkov Regional Stage, Orkhov Formation. Figure 7 – *Turinia pagei* (Powrie). Specimen № 93/4-7, depth of 418 m, × 100, cephalo-pectoral scale, crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 8 – *Turinia pagei* (Powrie). Specimen № 93/19-2, depth of 445.7 m, × 100, trunk scale, crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 9 – *Turinia pagei* (Powrie). Specimen № 93/19-3, depth of 445.7 m, × 150, trunk scale, oblique crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 10 – *Turinia pagei* (Powrie). Specimen № 93/3-8, depth of 417.6 m, × 150, trunk scale, the posterior part of the crown is broken off, crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 11 – *Turinia pagei* (Powrie). Specimen № 93/4-2, depth of 418 m, × 120, trunk scale, oblique crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 12 – *Turinia pagei* (Powrie). Specimen № 93/12-21, depth of 434 m, × 150, trunk scale, the posterior part of the crown is broken off, crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 13 – *Turinia pagei* (Powrie). Specimen № 93/12-18, depth of 434 m, × 100, trunk scale, crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 14 – *Turinia pagei* (Powrie). Specimen № 93/12-8, depth of 434 m, × 100, trunk scale, crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 15 – *Turinia pagei* (Powrie). Specimen № 93/3-13, depth of 417.6 m, × 200, trunk scale, the posterior part of the crown is broken off, crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 16 – *Turinia pagei* (Powrie). Specimen № 93/19-6, depth of 445.7 m, × 180, trunk scale, oblique crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 17 – *Boreania minima* Kar.-Tal. Specimen № 93/14-5, depth of 435.8 m, × 150, cephalo-pectoral scale, crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 18 – *Boreania minima* Kar.-Tal. Specimen № 93/2-14, depth of 408.3 m, × 200, cephalo-pectoral scale, crown view, Chortkov Regional Stage, Orkhov Formation. Figure 19 – *Boreania minima* Kar.-Tal. Specimen № 93/19-4, depth of 445.7 m, × 200, cephalo-pectoral scale, crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 20 – *Boreania minima* Kar.-Tal. Specimen № 93/4-1, depth of 418.0 m, × 150, cephalo-pectoral scale, crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 21 – *Talivalia elongata* (Kar.-Tal.). Specimen № 93/2-24, depth of 408.3 m, × 150, trunk scale, crown view, Chortkov Regional Stage, Orkhov Formation. Figure 22 – *Nikolivia gutta* Kar.-Tal. Specimen № 93/12-26, depth of 434.0 m, × 200, cephalo-pectoral scale, crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 23 – *Turinia* sp. Specimen № 93/2-4, depth of 408.3 m, × 150, trunk scale, the posterior part of the crown is broken off, crown view, Chortkov Regional Stage, Orkhov Formation. Figure 24 – *Thelodontiformes* gen. indet. Specimen № 93/12-11, depth of 434.0 m, × 150, cephalo-pectoral scale, crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 25 – *Turiniidae* gen. indet. Specimen № 93/12-23, depth of 434 m, × 150, trunk scale, crown view, Borshchovo Regional Stage, Dubitsa Formation.

and are mainly represented by the thelodont scales of *Turinia pagei* (Powrie), *Talivalia elongata* (Kar.-Tal.), as well as by acanthodian scales of *Nostolepis* sp., *N. striata* Pander, *N. gracilis* Gross, *Gomphonchus sandelensis* (Pander), separate fragments of the fin spines of *Acanthodii* gen. indet. The acanthodians form the dominant group in this vertebrate assemblage. Besides the ichthyofauna remains, the deposits of the Domachevo Formation contain some calcareous algae, isolated corals, brachiopod shells, tentaculites, numerous bryozoans which were studied by V.I. Pushkin (Pushkin, 1996) in the mid-nineties of the last century, scattered segments of crinoids, conodonts.

The deposits of the lower part of the **Dubitsa Formation** of the Borshchovo Regional Stage of the Lochkovian stage of the Lower Devonian (depth range of 429.2–454.0 m) concordantly overlie the sediments of the Domachevo Formation and contain taxonomically diverse and numerous taxa of agnathans and fishes. These are found in greenish-grey marls, clayey and biomorphic (crinoidal-algal) limestones. Thelodonts are represented by the scales of the genera and species as follow: *Turinia*

*pagei* (Powrie), *T. polita* Kar.-Tal., *Boreania minima* Kar.-Tal., *Nikolivia gutta* Kar.-Tal., *Turiniidae* gen. indet., *Thelodontiformes* gen. indet. Placoderms are represented by fragments of platelets, rare fragments of tesserae, scales of *Placodermi* indet., as well as by isolated platelets probably related to placoderms of *Placodermi* ? indet. The acanthodians determined in the rocks of this formation and represented mainly by the scales are the most taxonomically diverse vertebrates. There are scales of *Nostolepis* sp., *N. striata* Pander, *N. gracilis* Gross, *N. elegans* (Brotzen), *N. minima* Valiuk., *N. robusta* (Brotzen), *N. terraborea* Valiuk., *N. cf. tewonensis* Wang et al., *N. cf. kozhimica* Valiuk., *Nostolepid* platelets, tesserae and stellate tesserae, *Nostovicina* sp., *N. latricristata* (Valiuk.), *Canadalepis linguiformis* Vieth, *Gomphonchus* sp., *G. sandelensis* (Pander), *Cheiracanthoides* sp., *C. sp.* or *Gomphonchus* sp., «*Pruemolepis wellsii*» Vieth-Schreiner, *Euthacanthus* ? sp., discrete fragments of the fin spines of *Acanthodii* gen. indet. and Acanthodian 'special' head scale. Taxa of *Nostolepis* sp., *N. striata* Pander, *N. elegans* (Brotzen), *Gomphonchus* sp., *G. sandelensis* (Pander), *Cheiracanthoides* sp. predominate among

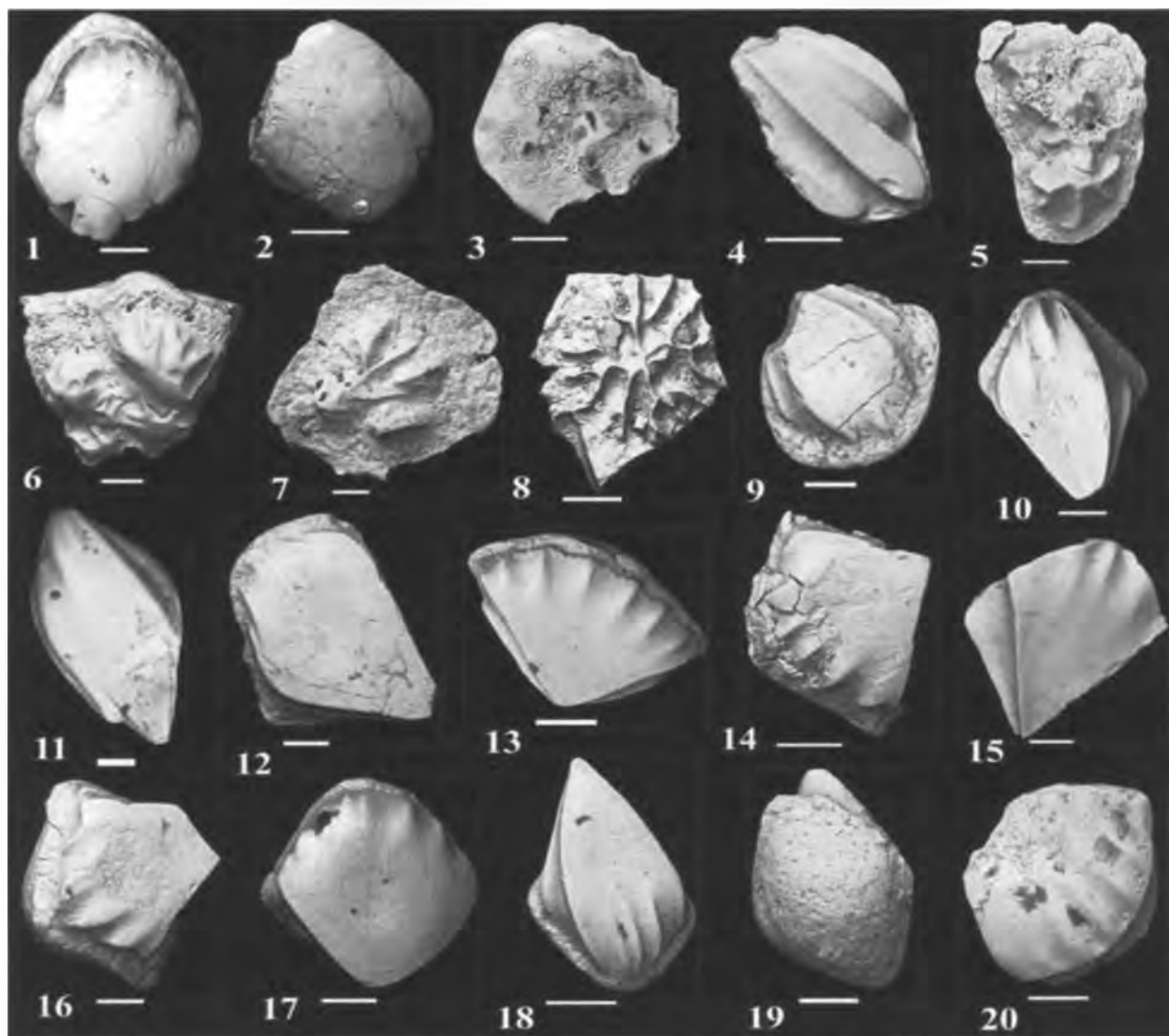


Plate II – Thelodont scales, acanthodian scales and placoderm skeletal elements from the Tomashovka 11 borehole. The skeletal elements of the agnathans and fishes come from the Lochkovian Stage, Lower Devonian. Scale bar of 50  $\mu\text{m}$  for Figure 15; 100  $\mu\text{m}$  for Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19 and 20. Figure 1 – *Turinia pagei* (Powrie). Specimen N<sup>o</sup> 93/4-17, depth of 418.0 m,  $\times$  150, scale from the head part, crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 2 – *Turinia polita* Kar.-Tal. Specimen N<sup>o</sup> 93/2-51, depth of 408.3 m,  $\times$  200, cephalo-pectoral scale, crown view, Chortkov Regional Stage, Orkhov Formation. Figure 3 – *Turinia polita* Kar.-Tal. Specimen N<sup>o</sup> 93/12-54, depth of 434.0 m,  $\times$  200, cephalo-pectoral scale, crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 4 – *Boreania minima* Kar.-Tal. Specimen N<sup>o</sup> 93/12-53, depth of 434.0 m,  $\times$  250, cephalo-pectoral scale, oblique crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 5 – Placodermi indet. Specimen N<sup>o</sup> 93/12-37, depth of 434.0 m,  $\times$  150, tessera, top view, Borshchovo Regional Stage, Dubitsa Formation. Figure 6 – Placodermi indet. Specimen N<sup>o</sup> 93/12-35, depth of 434.0 m,  $\times$  150, a fragment of platelets, top view, Borshchovo Regional Stage, Dubitsa Formation. Figure 7 – Placodermi indet. Specimen N<sup>o</sup> 93/6-7, depth of 420.0 m,  $\times$  100, a fragment of platelets, top view, Chortkov Regional Stage, Dubitsa Formation. Figure 8 – *Climatiiformes* indet. Specimen N<sup>o</sup> 93/2-54, depth of 408.3 m,  $\times$  200, a small fragment of tessera, top view, Chortkov Regional Stage, Orkhov Formation. Figure 9 – *Nostolepis striata* Pander. Specimen N<sup>o</sup> 93/2-49, depth of 408.3 m,  $\times$  200, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 10 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/12-32, depth of 434.0 m,  $\times$  200, scale in crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 11 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/2-52, depth of 408.3 m,  $\times$  100, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 12 – *Nostolepis striata* Pander. Specimen N<sup>o</sup> 93/2-50, depth of 408.3 m,  $\times$  150, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 13 – *Nostolepis terraborea* Valiuk. Specimen N<sup>o</sup> 93/3-19, depth of 417.6 m,  $\times$  200, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 14 – *Nostolepis terraborea* Valiuk. Specimen N<sup>o</sup> 93/12-33, depth of 434.0 m,  $\times$  200, scale in crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 15 – *Nostolepis terraborea* Valiuk. Specimen N<sup>o</sup> 93/12-39, depth of 434.0 m,  $\times$  350, scale in crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 16 – *Nostolepis consueta* Valiuk. Specimen N<sup>o</sup> 93/4-16, depth of 418.0 m,



× 170, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 17 – *Nostolepis terraborea* Valiuk. Specimen № 93/4-18, depth of 418.0 m, × 200, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 18 – *Nostolepis* sp. Specimen № 93/3-17, depth of 417.6 m, × 200, scale in anterior crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 19 – *Nostolepis* sp. Specimen № 93/12-44, depth of 434.0 m, × 200, scale, base view, Borshchovo Regional Stage, Dubitsa Formation. Figure 20 – *Cheiracanthoides* sp. Specimen № 93/5-26, depth of 418.2 m, × 200, scale, oblique crown view, Chortkov Regional Stage, Dubitsa Formation.

the others representatives of the acanthodians. The chondrichthyan scales of *Chondrichthyes* gen. et sp. indet. are rarely found. The rocks in this part of the section often contain small indefinable dermal skeletal elements of *Pisces* indet. The zonal species of the above vertebrate assemblage are *Turinia pagei* (Powrie), *Nikolivia gutta* Kar.-Tal., *Nostolepis minima* Valiuk. Together with the agnathans and fishes the rocks of this part of the formation contain shells of gastropods, bivalves, tentaculites, numerous fragments of brachiopod shells, bryozoan colonies, numerous segments and stems of crinoids, calcareous algae, conodonts.

The deposits of the Domachevo Formation and the lower part of the Dubitsa Formation of the Borshchovo Regional Stage correspond to the lower part and the lower half of the middle part of the Tilžė Regional Stage of the Lochkovian Stage of the Lower Devonian of the Baltic States, the Borshchovo Regional Stage of the Volyn-Podolia region and the lower part of the Ovinparma Regional Stage of the Timan-Pechora region (Valiukevičius, Kruczek, 2000; Valiukevičius, 2003; Plax, 2011).

The deposits of the upper part of the **Dubitsa Formation** of the Chortkov Regional Stage of the Lochkovian Stage of the Lower Devonian (depth range of 416.5–429.2 m) are also rich in the vertebrate microremains. These were established in greenish-grey marls and organogenic limestones and are represented by the thelodonts, placoderms, acanthodians and chondrichthyans. The thelodonts are represented by discrete scales of the following species: *Turinia pagei* (Powrie), *Talivalia elongata* (Kar.-Tal.), *Boreania minima* Kar.-Tal.; placoderms – by rare tesserae, platelets and scales of *Placodermi* indet. There are several platelets of *Placodermi* ? indet. The acanthodians are represented by isolated scales of the following taxa: *Nostolepis* sp., *N. striata* Pander, *N. gracilis* Gross, *N. elegans* (Brotzen), *N. cf. arctica* Vierth, *N. arctica* ? Vierth, *N. consueta* Valiuk., *N. minima* Valiuk., *N. terraborea* Valiuk., *N. cf. tewonensis* Wang et al., *Nostolepis* stellate tesserae, *Nostovicina* sp., *N. laticristata* (Valiuk.), *Nostovicina* ? sp., *Canadalepis* sp., *C. linguiformis* Vieth, *Gomphonchus* sp., *G. sandelensis* (Pander), *G. sp. indet.*, *Cheiracanthoides* sp., *C. planus* Valiuk., *Endemolepis inconstans* Valiuk., «*Pruemolepis wellsi*» Vieth-Schreiner, *Euthacanthus* ? sp., scattered fragments of fin spines of *Acanthodii* gen.

indet., head tesserae, indefinable acanthodian scales. There are scattered scales of *Chondrichthyes* gen. indet. and separate small indefinable skeletal elements of *Pisces* indet. The most numerous species in the above assemblage of agnathans and fishes are thelodonts of *Turinia pagei* (Powrie) and acanthodians of *Nostolepis* sp., *N. striata* Pander, *N. gracilis* Gross, *N. elegans* (Brotzen), *Gomphonchus* sp., *G. sandelensis* (Pander), *Cheiracanthoides* sp., the other taxa are essentially inferior in number. Along with the agnathans and fishes the deposits in this part of the section contain rather rare shells of gastropods, few shells of tentaculites, many fragments of brachiopod shells, isolated bryozoans, not numerous segments of crinoids, as well as conodonts.

The deposits of the **Orkhov Formation** of the Chortkov Regional Stage of the Lochkovian Stage of the Lower Devonian (depth range of 408.0–416.5 m) terminate the Lower Devonian section in the territory of the Volyn Monocline. They concordantly overlie the rocks of the Dubitsa Formation and are discordantly overlain by the rocks of the Visean Stage of the Lower Carboniferous. The vertebrate remains were found in greenish-grey marls. These are slightly inferior in the number and diversity of taxa to the ichthyofauna found in the deposits of the upper part of the Dubitsa Formation of the Chortkov Regional Stage. The established vertebrates are mostly represented by the acanthodians in the deposits of the Orkhov Formation. The others representatives of the ichthyofauna, namely, thelodonts, placoderms and chondrichthyans are not abundant, chondrichthyan scales of *Chondrichthyes* gen. et sp. indet are especially few in number. The thelodonts are represented by the scales of *Turinia* sp., *T. pagei* (Powrie), *T. polita* Kar.-Tal., *Talivalia elongata* (Kar.-Tal.), *Boreania minima* Kar.-Tal., including the scales of *T. pagei* (Powrie) that predominate over the scales of the others thelodont taxa. It should also be noted that this species is found throughout the section and is considered as a zonal species for the deposits of the Borshchovo and Chortkov Regional Stages of the Lochkovian Stage (Karatajūtė-Talimaa, 1978; Talimaa, 2000). The placoderms are represented by rare fragments of the platelets, tesserae and scales of *Placodermi* indet. in the deposits of the Orkhov Formation. There are rare problematic plate-

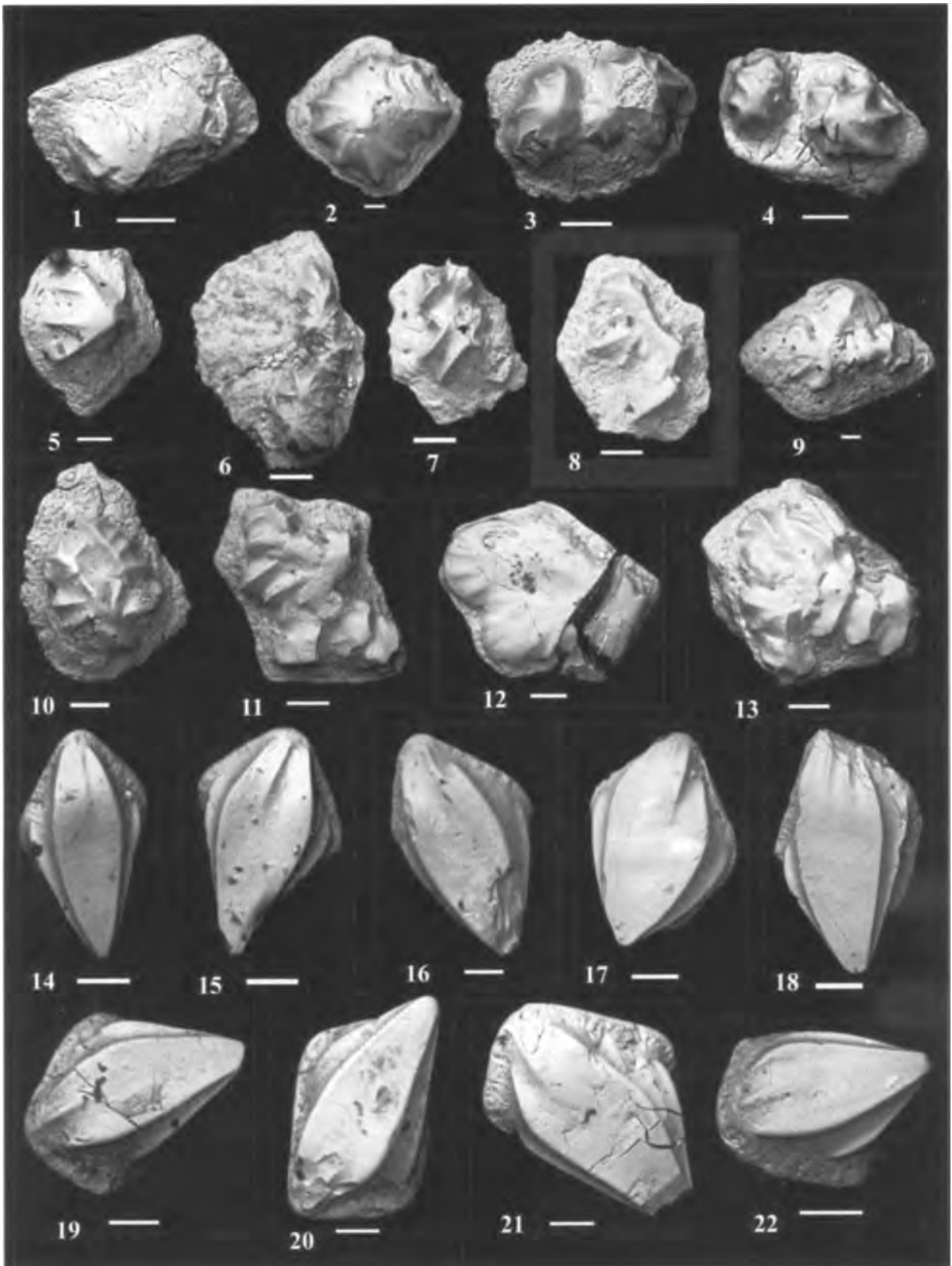


Plate III – Placoderm and acanthodian skeletal elements from the Tomashovka 11 borehole. The skeletal elements of fishes come from the Lochkovian Stage, Lower Devonian. Scale bar of 100  $\mu\text{m}$  for Figures 1–5 and 7–22; 200  $\mu\text{m}$  for Figure 6. Figure 1 – Placodermi indet. Specimen N<sup>o</sup> 93/14-7, depth of 435.8 m,  $\times 200$ , tessera, top view, Borshchovo Regional Stage, Dubitsa Formation. Figure 2 – Placodermi indet. Specimen N<sup>o</sup> 93/4-10,

depth of 418.0 m,  $\times 100$ , scale, top view, Chortkov Regional Stage, Dubitsa Formation. Figure 3 – Placodermi indet. Specimen N<sup>o</sup> 93/12-15, depth of 434.0 m,  $\times 190$ , platelet, top view, Borshchovo Regional Stage, Dubitsa Formation. Figure 4 – Placodermi indet. Specimen N<sup>o</sup> 93/5-8, depth of 418.2 m,  $\times 200$ , tessera, top view, Chortkov Regional Stage, Dubitsa Formation. Figure 5 – Placodermi indet. Specimen N<sup>o</sup> 93/12-13, depth of 434.0 m,  $\times 150$ , scale, top view, Borshchovo Regional Stage, Dubitsa Formation. Figure 6 – Placodermi ? indet. Specimen N<sup>o</sup> 93/2-34, depth of 408.3 m,  $\times 70$ , platelet, top view, Chortkov Regional Stage, Orkhov Formation. Figure 7 – Placodermi ? indet. Specimen N<sup>o</sup> 93/12-25, depth of 434.0 m,  $\times 150$ , platelet, top view, Borshchovo Regional Stage, Dubitsa Formation. Figure 8 – Placodermi ? indet. Specimen N<sup>o</sup> 93/4-20, depth of 418.0 m,  $\times 150$ , platelet, top view, Chortkov Regional Stage, Dubitsa Formation. Figure 9 – Nostolepid. Specimen N<sup>o</sup> 93/5-10, depth of 418.2 m,  $\times 100$ , stellate tessera, top view, Chortkov Regional Stage, Dubitsa Formation. Figure 10 – Acanthodian 'special' head scale. Specimen N<sup>o</sup> 93/12-22, depth of 434.0 m,  $\times 130$ , 'special' head scale, top view, Borshchovo Regional Stage, Dubitsa Formation. Figure 11 – Nostolepid. Specimen N<sup>o</sup> 93/14-2, depth of 435.8 m,  $\times 150$ , stellate tessera, top view, Borshchovo Regional Stage, Dubitsa Formation. Figure 12 – Acanthodian head tessera. Specimen N<sup>o</sup> 93/3-1, depth of 417.6 m,  $\times 150$ , head tessera, top view, Chortkov Regional Stage, Dubitsa Formation. Figure 13 – Nostolepid. Specimen N<sup>o</sup> 93/14-6, depth of 435.8 m,  $\times 150$ , tessera, top view, Borshchovo Regional Stage, Dubitsa Formation. Figure 14 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/2-2, depth of 408.3 m,  $\times 150$ , scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 15 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/2-1, depth of 408.3 m,  $\times 150$ , scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 16 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/2-6, depth of 408.3 m,  $\times 100$ , scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 17 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/12-20, depth of 434.0 m,  $\times 150$ , scale in crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 18 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/14-1, depth of 435.8 m,  $\times 150$ , scale in crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 19 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/2-20, depth of 408.3 m,  $\times 150$ , scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 20 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/2-30, depth of 408.3 m,  $\times 150$ , scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 21 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/2-37, depth of 408.3 m,  $\times 150$ , scale in posterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 22 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/3-3, depth of 417.6 m,  $\times 200$ , scale in anterior crown view, Chortkov Regional Stage, Dubitsa Formation.

lets of Placodermi ? indet. The acanthodians are represented by the scales of *Nostolepis* sp., *N. striata* Pander, *N. gracilis* Gross, *N. elegans* (Brotzen), *N. cf. arctica* Vierth, *N. consueta* Valiuk., *N. teraborea* Valiuk., *N. cf. tewonensis* Wang et al., *N. sp.* or *Nostovicina* sp., Nostolepid tesserae, *Nostovicina* sp., *N. laticristata* (Valiuk.), *Canadalepis linguiformis* Vieth, *Gomphonchus* sp., *G. sandelensis* (Pander), *Cheiracanthoides* sp., *C. planus* Valiuk., *Radioporacanthoi des cf. porosus* (Brotzen), *Euthacanthus* ? sp., discrete fragments of the fin spines of Acanthodii gen. indet., 'special' head scale and tessera of the acanthodians. Among the above-named taxa of the acanthodians the dominant species are *Nostolepis* sp., *N. striata* Pander, *Gomphonchus* sp., *G. sandelensis* (Pander), Acanthodii gen. indet. Besides the vertebrates, the rocks of this Formation also contain brachiopods and conodonts.

The deposits of the Dubitsa Formation upper part and the Orkhov Formation of the Chortkov Regional Stage are correlated with the upper half of the middle part and the upper part of the Tilžė Regional Stage of the Lochkovian Stage of the Baltic States, with the most part (except the uppermost one) of the Chortkov Regional Stage of the Volyn-Podolia region and with the upper part of the Ovinparma Regional Stage of the Timan-Pechora region (Valiukevičius, Kruczek, 2000; Valiukevičius, 2003; Plax, 2011).

#### BRIEF TAPHONOMIC DESCRIPTION OF THE LOCHKOVIAN ICHTHYOFAUNA MICROREMAINS FROM THE BELARUSIAN PART OF THE VOLYN MONOCLINE

The micromeric skeletal elements of the ichthyofauna (thelodont scales, as well as scales and fragments of the fin spines of the acanthodians) determined in the deposits of the Domachevo Formation of the Borshchovo Regional Stage of the Tomashovka 11 borehole occur only at a depth of 465.3 m, where some fragments of brachiopod shells, tentaculites and segments of crinoids were also found in the greenish-grey and light grey marl strata. In the lower part of this formation, where crinoid-bryozoan and crinoid-algal limestone interlayers occur, the ichthyofauna remains have not been determined. The absence of vertebrates in this part of the section can be apparently explained by an imperfect knowledge of this depth interval because of a scarcity of rock samples available for palaeo-ichthyological studies. The vertebrate remains found at a depth of 465.3 m generally show a rather good safety (poor preservation is mainly characteristic of the fin spines as among them there are no intact specimens). These belong to individuals of different age and are light cream, yellow, orange, light brown, rarely, dark brown in color. The internal and external structure details are well preserved. The fossilization degree of the majority

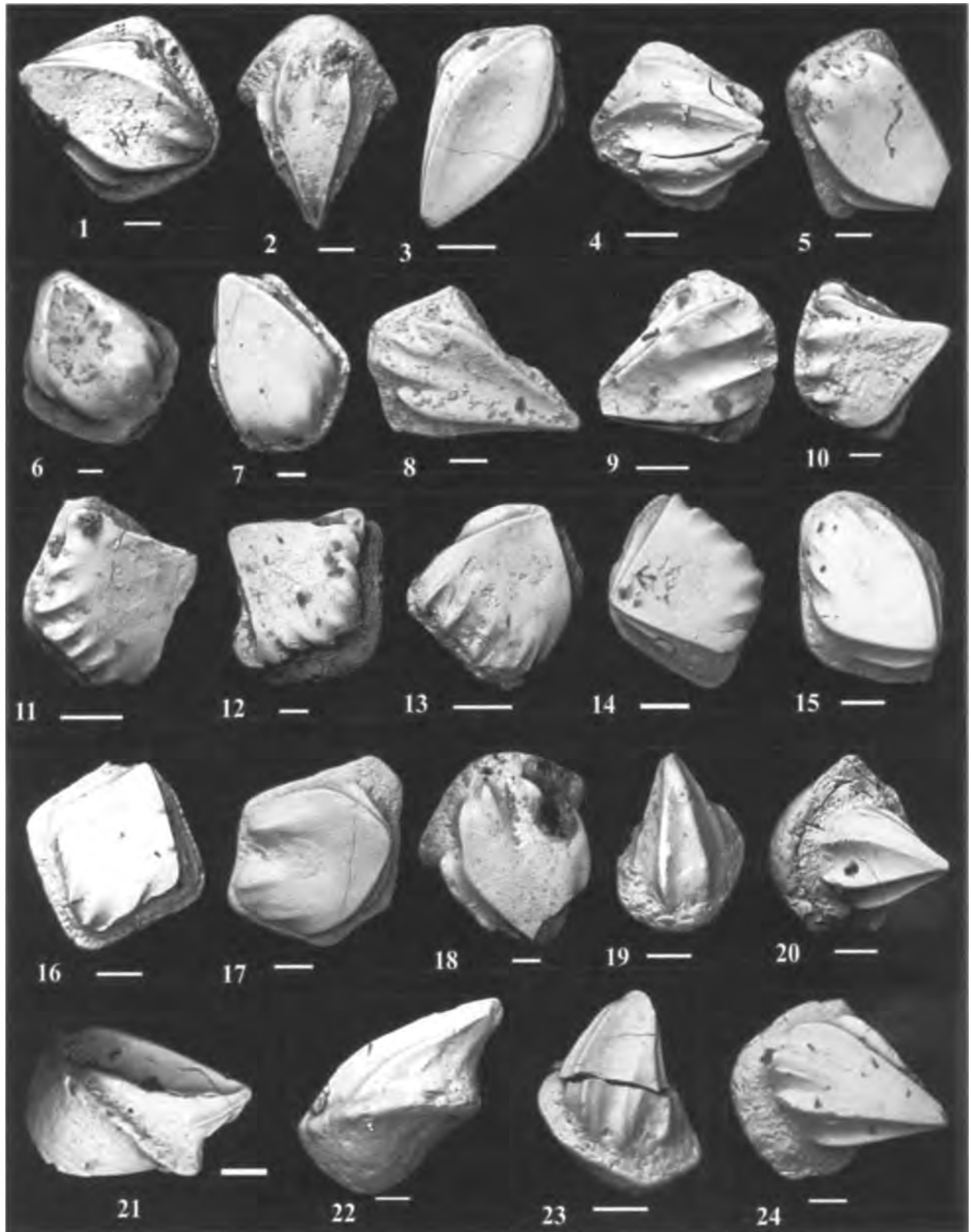


Plate IV – Acanthodian scales from the Tomashovka 11 borehole. The scales come from the Lochkovian Stage, Lower Devonian. Scale bar of 50  $\mu\text{m}$  for Figure 22; 100  $\mu\text{m}$  for Figures 1-21 and 23-24. Figure 1 – *Nostolepis elegans* (Brotzen). Specimen N<sup>o</sup> 93/3-9, depth of 417.6 m,  $\times$  150, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 2 – *Nostolepis* sp. Specimen N<sup>o</sup> 93/2-23, depth of 408.3 m,  $\times$  150, scale in posterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 3 – *Nostolepis arctica* ? Vieth. Specimen N<sup>o</sup> 93/3-4, depth of 417.6 m,  $\times$  200, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 4 – *Nostolepis gracilis* Gross. Specimen N<sup>o</sup> 93/12-6, depth of 434.0 m,  $\times$  200, scale in crown view, Borshchovo Regional

Stage, Dubitsa Formation. Figure 5 – *Nostolepis striata* Pander. Specimen № 93/2-8, depth of 408.3 m, × 150, scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 6 – *Nostolepis striata* Pander. Specimen № 93/2-16, depth of 408.3 m, × 100, scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 7 – *Nostolepis striata* Pander. Specimen № 93/2-31, depth of 408.3 m, × 100, scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 8 – *Nostolepis striata* Pander. Specimen № 93/5-21, depth of 418.2 m, × 150, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 9 – *Nostolepis striata* Pander. Specimen № 93/2-32, depth of 408.3 m, × 200, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 10 – *Nostolepis striata* Pander. Specimen № 93/4-6, depth of 418.0 m, × 150, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 11 – *Nostolepis consueta* Valiuk. Specimen № 93/2-21, depth of 408.3 m, × 200, scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 12 – *Nostolepis consueta* Valiuk. Specimen № 93/2-25, depth 408.3 m, × 100, scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 13 – *Nostolepis terraborea* Valiuk. Specimen № 93/2-39, depth 408.3 m, × 200, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 14 – *Nostolepis terraborea* Valiuk. Specimen № 93/5-25, depth of 418.2 m, × 200, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 15 – *Nostolepis striata* Pander. Specimen № 93/2-47, depth of 408.3 m, × 150, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 16 – *Nostolepis* sp. or *Nostovicina* sp. Specimen № 93/2-40, depth of 408.3 m, × 150, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 17 – *Nostolepis* cf. *tewonensis* Wang et al. Specimen № 93/14-9, depth of 435.8 m, × 150, scale in crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 18 – *Nostolepis* cf. *tewonensis* Wang et al. Specimen № 93/4-8, depth of 418.0 m, × 100, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 19 – *Nostolepis* sp. Specimen № 93/2-9, depth of 408.3 m, × 150, scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 20 – *Nostolepis* sp. Specimen № 93/4-11, depth of 418.0 m, × 150, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 21 – *Nostolepis* sp. Specimen № 93/2-22, depth of 408.3 m, × 200, scale in lateral view, Chortkov Regional Stage, Orkhov Formation. Figure 22 – *Nostolepis* sp. Specimen № 93/2-42, depth of 408.3 m, × 300, scale in lateral view, Chortkov Regional Stage, Orkhov Formation. Figure 23 – *Nostolepis* sp. Specimen № 93/3-2, depth of 417.6 m, × 200, scale in anterior crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 24 – *Nostolepis* sp. Specimen № 93/12-29, depth of 434.0 m, × 150, scale in crown view, Borshchovo Regional Stage, Dubitsa Formation.

of skeletal elements is identical. All of them are of secondary mineralization. Within the rock strata these are scattered (dispersed), scanty, do not form accumulations, all the fin spines are broken, unlike the scales. A coastal-sea shallow-water basin with the normal salt content of water, where the clayey-carbonate sedimentation mainly took place, was most likely the habitat of the vertebrates identified.

The remains of the vertebrates determined in the deposits of the lower part of the **Dubitsa Formation** of the Borshchovo Regional Stage are much more abundant and diverse than the fish fauna found in the deposits of the Domachevo Formation. The skeletal elements of vertebrates (scales, tesserae, platelets, ichthyodorulites) within the lower part of the Dubitsa Formation were found at 9 levels in greenish-grey marls, as well as in clayey and crinoidal-algal limestones. They occur within these rocks mainly subhorizontally, rather randomly and generally show a rather good safety with no evidences of obvious roundness. This fact may suggest that these were buried rather quickly and, most likely, not subject to a very long transportation. All of them are of secondary mineralization. They are mostly yellowish-orange, light cream, light brown, sometimes, dark brown and black in color. The largest number of scales was found in marls and clayey limestones, they are much less abundant in crinoidal-algal limestones. They belong to individuals of different age. An analysis of the taxonomic

composition of the vertebrates found in this part of the section indicates the predominance of scales and fragments of the fin spines of the acanthodians, thelodont scales are less abundant and the skeleton remains of placoderms and chondrichthyans occur very rarely. The invertebrates found in this part of the section are represented by gastropods, bivalves, tentaculites, numerous fragments of shells of brachiopods, bryozoan colonies, numerous segments and stems of crinoids, and the flora is represented by calcareous algae. The conodonts were also determined in this part of the formation. From the above discussion it appears that the habitat of the vertebrates could be a non-deep-water coastal-sea basin with the normal salt content of water, where mainly clayey-carbonate sedimentation took place.

The deposits of the upper part of the **Dubitsa Formation** of the Chortkov Regional Stage are also rich in the vertebrate microremains (scales, platelets, fin spines, tesserae). These were determined mainly in the upper part of the formation in greenish-grey marls and organogenic limestones and are represented by the thelodonts, placoderms, acanthodians, chondrichthyans. The location of the skeletal elements in the rocks of this part of the section is almost similar to the location of the ichthyofauna remains in the rocks of the lower part of the Dubitsa Formation. The skeletal elements are mainly yellowish-orange, pale cream and light brown in color. All the skeletal elements are well minerali-



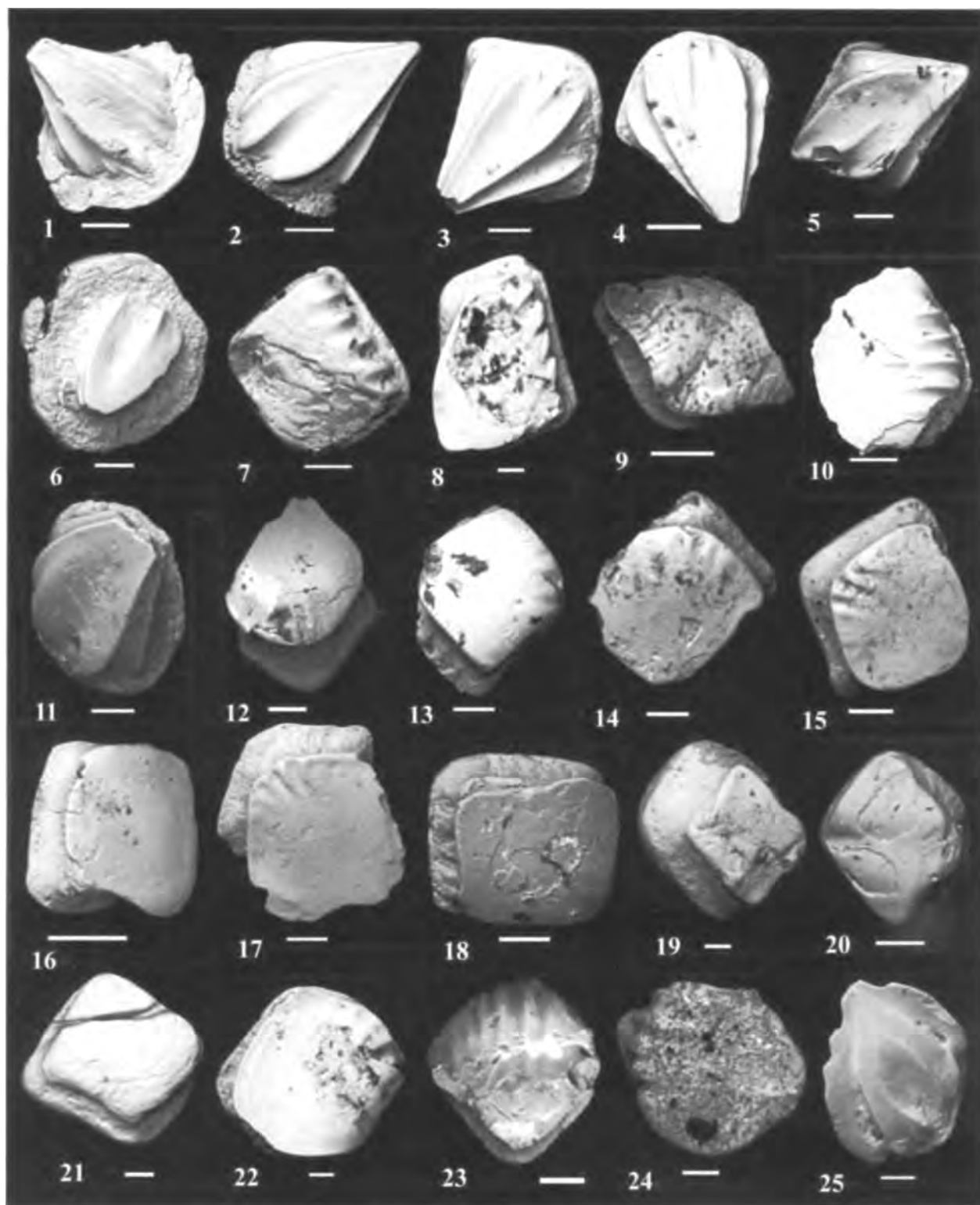


Plate V – Acanthodian scales from the Tomashovka 11 borehole. The scales come from the Lochkovian Stage, Lower Devonian. Scale bar of 50  $\mu\text{m}$  for Figure 11; 100  $\mu\text{m}$  for Figures 1-8, 10, 13, 14, 17-23 and 25; 200  $\mu\text{m}$  for Figures 12, 15 and 24; 500  $\mu\text{m}$  for Figures 9 and 16. Figure 1 – *Nostolepis* sp. Specimen N<sup>o</sup> 93/12-27, depth of 434.0 m,  $\times$  200, scale in anterior crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 2 – *Nostolepis* sp. Specimen N<sup>o</sup> 93/5-2, depth of 418.2 m,  $\times$  200, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 3 – *Nostolepis* sp. Specimen N<sup>o</sup> 93/2-35, depth of 408.3 m,  $\times$  150, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 4 – *Nostolepis* sp. Specimen N<sup>o</sup> 93/12-30, depth of 434.0 m,  $\times$  200, scale in crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 5 – *Nostolepis* sp. Specimen N<sup>o</sup> 93/2-3, depth of 408.3 m,  $\times$  150, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 6 – *Canadalepis*

sp. Specimen № 93/3-5, depth of 417.6 m, × 150, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 7 – *Nostovicina* sp. Specimen № 93/4-4, depth of 418.0 m, × 190, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 8 – *Nostovicina* sp. Specimen № 93/3-7, depth of 417.6 m, × 100, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 9 – *Radioporacanthodes* cf. *porosus* (Brotzen). Specimen № 93/2-15, depth of 408.3 m, × 50, scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 10 – *Euthacanthus* ? sp. Specimen № 93/5-19, depth of 418.2 m, × 200, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 11 – *Nostolepis* sp. Specimen № 93/3-6, depth of 417.6 m, × 300, scale in oblique crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 12 – *Gomphonchus sandelensis* (Pander). Specimen № 93/12-17, depth of 434.0 m, × 70, scale in anterior crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 13 – *Gomphonchus sandelensis* (Pander). Specimen № 93/2-17, depth of 408.3 m, × 150, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 14 – *Gomphonchus sandelensis* (Pander). Specimen № 93/2-19, depth of 408.3 m, × 150, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 15 – *Gomphonchus sandelensis* (Pander). Specimen № 93/2-28, depth of 408.3 m, × 85, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 16 – *Gomphonchus sandelensis* (Pander). Specimen № 93/5-20, depth of 418.2 m, × 50, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 17 – *Gomphonchus sandelensis* (Pander). Specimen № 93/14-11, depth of 435.8 m, × 150, scale in crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 18 – *Gomphonchus* sp. Specimen № 93/5-5, depth of 418.2 m, × 200, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 19 – *Gomphonchus* sp. Specimen № 93/2-36, depth of 408.3 m, × 100, scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 20 – *Gomphonchus* sp. Specimen № 93/2-33, depth of 408.3 m, × 200, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 21 – *Gomphonchus* sp. Specimen № 93/14-4, depth of 435.8 m, × 100, scale in crown view, Borshchovo Regional Stage, Dubitsa Formation. Figure 22 – *Gomphonchus* sp. indet. Specimen № 93/6-4, depth of 420.0 m, × 100, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 23 – *Cheiracanthoides planus* Valiuk. Specimen № 93/2-11, depth of 408.3 m, × 150, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 24 – *Nostovicina* ? sp. Specimen № 93/6-3, depth of 420.0 m, × 75, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 25 – *Nostolepis* cf. *kozhyrnica* Valiuk. Specimen № 93/14-3, depth of 435.8 m, × 150, scale in crown view, Borshchovo Regional Stage, Dubitsa Formation.

zed. An analysis of the taxonomic composition of the ichthyofauna found in this part of the section suggests the predominance of the scales and fragments of the fin spines of the acanthodians, the thelodont scales and the scales, platelets and tesseræ of the placoderms are less abundant, and the chondrichthyan scales are found very rarely. Along with the vertebrates the rocks contain rather rare shells of gastropods, few shells of tentaculites, many fragments of brachiopod shells, isolated bryozoans, segments of crinoids and conodonts. All of them are rather safe, but scattered. It is believed that the remains of the vertebrates and invertebrates were not subject to a very long transportation during their burial, however, their fragmentary occurrence could be an evidence of their transportation to short distances. In other words, a minor mechanical differentiation of the skeleton material due to different force bottom currents and wave movements in the basin could take place. A burial like this could occur in the shallow coastal-sea environment.

The ichthyofauna remains found in the clayey-marl deposits of the **Orkhov Formation** of the Chortkov Regional Stage are also represented by scattered parts of the skeletal elements – fragments of platelets, tesseræ, ichthyodorulites, scales of various sizes. They are confined to a member of greenish-grey marls, which occur in the upper part of the formation. Most of the skeletal elements are rather well preserved, all of them are scattered, i. e., not

articulated skeletons and some of them are slightly rounded. The remains are unevenly distributed. Their accumulations were not noted. They usually occur in a steady position. A fossilization degree of the majority of skeletal elements is similar. All of them are of the secondary mineralization, are mostly light cream, yellow, orange, light brown in color. Dark brown and black remains are less common. The lithification processes of the enclosing sediments favored a good fossilization of the buried remains of vertebrates. Like as in the above-mentioned case, it can be assumed that in the process of burial their remains were not subject to a very long transportation, however, the fragmentation of the skeletal elements and a slight roundness of some of them can, however, be an evidence of their transportation to short distances. The determined vertebrates could most likely inhabit a coastal-sea shallow basin. An analysis of the skeletal elements of the vertebrates from this part of the section suggests the predominance of mainly isolated acanthodian scales and to a lesser extent thelodont scales over the remains of the other ichthyofauna groups. Together with the vertebrate remains some scattered fragments of brachiopod shells, as well as conodonts are buried there.

## CONCLUSIONS

The study of the micromeric skeletal elements of the Lower Devonian (Lochkovian) vertebrates obtained by dissolving the core samples from the

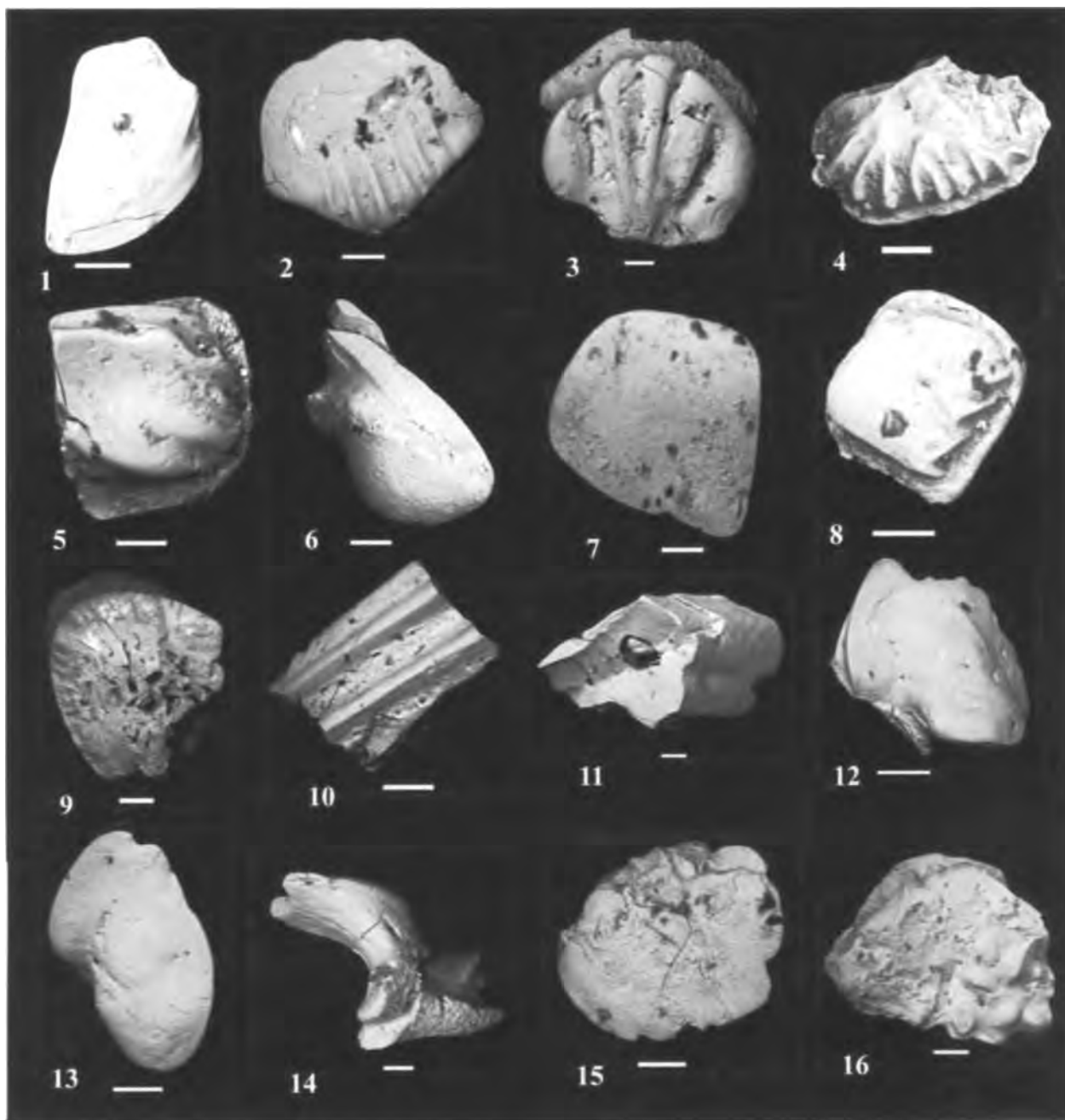


Plate VI – Acanthodian and chondrichthyan scales, as well as acanthodian fin spines from the Tomashovka 11 borehole. The scales and fin spines of fishes come from the Lochkovian Stage, Lower Devonian. Scale bar of 100  $\mu\text{m}$  for Figures 2-8, 14 and 15; 200  $\mu\text{m}$  for Figures 1, 9-13 and 16. Figure 1 – Undetermined acanthodian scale. Specimen N<sup>o</sup> 93/3-12, depth of 417.6 m,  $\times$  95, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 2 – Acanthodian scale indet. Specimen N<sup>o</sup> 93/5-3, depth of 418.2 m,  $\times$  150, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 3 – Acanthodian scale undet. Specimen N<sup>o</sup> 93/4-9, depth of 418.0 m,  $\times$  100, scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 4 – Acanthodian 'special' head scale. Specimen N<sup>o</sup> 93/2-45, depth of 408.3 m,  $\times$  150, scale in anterior crown view, Chortkov Regional Stage, Orkhov Formation. Figure 5 – *Nostolepis striata* Pander. Specimen N<sup>o</sup> 93/2-29, depth of 408.3 m,  $\times$  150, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 6 – *Nostolepis* sp. Specimen N<sup>o</sup> 93/4-5, depth of 418.0 m,  $\times$  150, scale posterior part with offset, scale in lateral view, Chortkov Regional Stage, Dubitsa Formation. Figure 7 – *Gomphonchus sandelensis* (Pander). Specimen N<sup>o</sup> 93/2-27, depth of 408.3 m,  $\times$  130, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 8 – *Nostovicina* sp. Specimen N<sup>o</sup> 93/2-46, depth of 408.3 m,  $\times$  200, scale in crown view, Chortkov Regional Stage, Orkhov Formation. Figure 9 – Acanthodii gen. indet. Specimen N<sup>o</sup> 93/2-12, depth of 408.3 m,  $\times$  55, fragment of the fin spine in cross section, Chortkov Regional Stage, Orkhov Formation. Figure 10 – Acanthodii gen. indet. Specimen N<sup>o</sup> 93/6-1, depth of 420.0 m,  $\times$  90, fragment of the fin spine, lateral view, Chortkov Regional Stage, Dubitsa Formation. Figure 11 – Acanthodii gen. indet. Specimen N<sup>o</sup> 93/12-2,

depth of 434.0 m,  $\times 100$ , fragment of the fin spine in cross section, Borshchovo Regional Stage, Dubitsa Formation. Figure 12 – Chondrichthyes gen. et sp. indet. Specimen № 93/5-15, depth of 418.2 m,  $\times 95$ , scale in anterior crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 13 – Chondrichthyes gen. et sp. indet. Specimen № 93/5-12, depth of 418.2 m,  $\times 75$ , scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 14 – Chondrichthyes gen. et sp. indet. Specimen № 93/5-16, depth of 418.2 m,  $\times 100$ , scale in lateral view, Chortkov Regional Stage, Dubitsa Formation. Figure 15 – Chondrichthyes gen. et sp. indet. Specimen № 93/5-14, depth of 418.2 m,  $\times 150$ , scale in crown view, Chortkov Regional Stage, Dubitsa Formation. Figure 16 – Pisces indet. Specimen № 93/12-5, depth of 434.0 m,  $\times 70$ , dermal skeletal element in external view, Borshchovo Regional Stage, Dubitsa Formation.

Tomashovka 11 borehole, as well as of the data available on the agnathans and fishes from the considered time interval of the studied area allowed the author to make a more comprehensive analysis and to describe with the vertebrate findings some local (Domachevo, Dubitsa and Orkhov Formations) and regional stratigraphic units (Borshchovo and Chortkov Regional Stages) of the Lower Devonian. At the same time it became possible to present a brief taphonomic description of the vertebrate remains, to generalize data on their stratigraphic distribution, slightly replenish their list and to get new data about them from the Lower Devonian deposits of the studied area. The palaeoichthyological data presented in the paper supplement the information of the vertebrate palaeogeographical and stratigraphic distribution in the Lower Devonian deposits of the southwestern part of Bela-

rus, their taxonomic composition and allow their correlation with the synchronous sediments from the adjacent territories (Western Ukraine and the Baltic States), as well as from the more distant areas, for example, the Timan-Pechora region.

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### REFERENCES

- DECISION of the Interdepartmental Regional Stratigraphic Meeting on the Middle and Upper Paleozoic of the Russian Craton (Leningrad, 1988). The Devonian system. The Carboniferous system. The Perm system (with regional stratigraphic schemes). – Moscow, 1990 (in Russian).
- KARATAJÜTË-TALIMAA V.N. The Silurian and Devonian thelodonts from the USSR and Spitsbergen / Abstract of the Thesis for doctor in geol. and mineral: 04.00.09; Moscow State University. – Moscow, 1976. – 44 p. (in Russian).
- KARATAJÜTË-TALIMAA V.N. The Silurian and Devonian thelodonts from the USSR and Spitsbergen. – Vilnius: Mokslas, 1978. – 336 p. (in Russian).
- KRUCHEK S., VALIUKEVIČIUS J., MÄRSS T. Vertebrate microremains from the Lower Devonian (Lochkovian) deposits of Belarus / The Third Baltic Stratigraphic Conference (Abstracts). – Tartu, 1996. – P. 34.
- KRUCHEK S.A., MAKHNACH A.S., GOLUBTSOV V.K., OBUKHOVSKAYA T.G. The Devonian system / Geology of Belarus // National Acad. Sci. of Belarus, Institute of Geological Sciences; ed. by A.S. Makhnach. – Minsk, 2001. – P. 186–236 (in Russian).
- MOISEEVA T.I., KRUCHEK S.A. Preliminary data on the age of the rocks of the Upper Silurian of the Brest Depression (from microfauna data) / Materials of the Third Scientific Conference of Young Geologists of Byelorussia. – Minsk, 1969. – P. 5–6 (in Russian).
- OBUKHOVSKAYA T.G., KRUCHEK S.A., PUSHKIN V.I., NEKRYATA N.S., PLAX D.P., SACHENKO T.Ph., OBUKHOVSKAYA V.Yu., ANTIPENKO S.V. The Devonian system / Stratigraphic Chart of Precambrian and Phanerozoic deposits of Belarus: Explanatory note. – Minsk: State Enterprise «BelNGRI», 2010. – P. 98–114 (in Russian).
- PLAX D.P. Devonian ichthyofauna of the Volyn Monocline/ Lithosphere. – 2011. № 2(35). – P. 12–21.
- PLAX D.P., KUZMENKOVA O.F., OBUKHOVSKAYA V.Yu., SACHENKO T.Ph., VOSKOBOINIKOVA T.V., KLIMENKO Z.M., BIBIKOVA Ye.V., KARIMOVA L.A. Lithological and stratigraphic characteristics of Precretaceous deposits of the platform cover of southwestern Belarus (from the results of studying the Komarovka 913/10 borehole) / Lithosphere. – 2012. № 2(37). – P. 3–21 (in Russian).
- PUSHKIN V.I., KRUCHEK S.A. Position of the Silurian-Devonian boundary and the stratigraphy of the Lower Devonian of Byelorussia / Dokl. Acad. Nauk Belarusi. 1978. – Vol. XXII, № 11. – P. 1013–1016 (in Russian).
- PUSHKIN V.I. Bryozoan bioherms and «overgrowths» of the Early Devonian of Belarus and the adjacent regions / Lithosphere. – 1996. – № 4. – P. 62–73 (in Russian).

- TALIMAA V.N. Significance of thelodonts (Agnatha) in the correlation of the Upper Ordovician to Lower Devonian of the northern part of Eurasia / Courier Forschungsinstitut Senckenberg (Final Report of IGCP 328 project). – Vol. 223. 2000. – P. 69–80.
- VALIUKEVIČIUS J. Acanthodians and zonal stratigraphy of the Lower and Middle Devonian in East Baltic and Byelorussia / Palaeontographica. – Stuttgart, 1998. Abt. A. – S. 1–53.
- VALIUKEVIČIUS J., KRUCHEK S. Acanthodian biostratigraphy and interregional correlations of the Devonian of the Baltic States, Belarus, Ukraine and Russia / Courier Forschungsinstitut Senckenberg (Final Report of IGCP 328 project). – Vol. 223. 2000. – P. 271–289.
- VALIUKEVIČIUS, J. New Silurian to Middle Devonian acanthodians of the Timan-Pechora region / Acta Geologica Polonica. – 2003. – Vol. 53, № 3. – P. 209–245.

Рецензент С.А. Кручек

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ІХТЫЯФАЎНА З НІЖНЕДЭВОНСКІХ (ЛОХКАЎСКІХ) АДКЛАДАЎ  
ПАЎДНЁВА-ЗАХОДНЯЙ ЧАСТКІ БЕЛАРУСІ  
Дз.П. Плакс

У артыкуле прыводзяцца вынікі палеаіхтыялагічнага вывучэння керну свідравіны Тамашоўка 11, прабуранай у канцы 60-х гадоў мінулага стагоддзя на тэрыторыі паўночна-заходняй часткі Валынскай монакліналі ў межах Беларусі. Даны гістарычныя звесткі па вывучэнні ніжнедэвонскай (лохкаўскай) іхтыяфаўны ў межах паўднёва-заходняй часткі Беларусі. Для паўнаты інфармацыі прыводзіцца табліца, у якой на аснове літаратурных крыніц і ўласных даследаванняў аўтара зведзены абагульненыя даныя па стратыграфічным распаўсюджванні ўсіх дакладна вядомых прадстаўнікоў ніжнедэвонскай іхтыяфаўны на даследуемай тэрыторыі. Кратка разгледжана тафанамічная характарыстыка рэштак іхтыяфаўны. Таксама прыведзена супастаўленне ніжнедэвонскіх (лохкаўскіх) адкладаў з утварэннямі таго ж самага ўзросту найбольш добра вывучаных у палеанталагічным дачыненні рэгіёнаў Заходняй Украіны, краін Балтыі, Цімана-Пячорскай правінцыі. Атрыманыя даныя па іхтыяфаўне некалькі дапаўняюць інфармацыю аб таксанамічным складзе яе на тэрыторыі краіны.

ИХТИОФАУНА ИЗ НИЖНЕДЕВОНСКИХ (ЛОХКОВСКИХ) ОТЛОЖЕНИЙ  
ЮГО-ЗАПАДНОЙ ЧАСТИ БЕЛАРУСИ  
Д.П. Плакс

В статье приводятся результаты палеоихтиологического изучения керна скважины Томашовка 11, пробуренной в конце 60-х годов прошлого столетия на территории северо-западной части Волынской моноклинали в пределах Беларуси. Даны исторические сведения по изучению нижнедевонской (лохковской) ихтиофауны в пределах юго-западной части Беларуси. Для полноты информации, приводится таблица, в которой на основе литературных данных и собственных исследований автора сведены обобщенные данные по стратиграфическому распределению всех достоверно известных представителей нижнедевонской ихтиофауны на исследуемой территории. Рассмотрена кратко тафономическая характеристика остатков ихтиофауны. Также приведено сопоставление нижнедевонских (лохковских) отложений с одновозрастными образованиями наиболее хорошо изученных в палеонтологическом отношении регионов западной Украины, стран Балтии, Тимано-Печорской провинции. Полученные данные по ихтиофауне несколько дополняют информацию о таксономическом составе ее на территории страны.