

# Stratigraphical occurrence of vertebrate remains in the Upper Devonian of Severnaya Zemlya (Russia)

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## ABSTRACT:

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The stratigraphical distribution of vertebrate remains in the standard section of the Upper Devonian of October Revolution Island of the Severnaya Zemlya archipelago has been studied. Fossil fish and agnathans were collected in 1978 and 1979 from the outcrops of the Matusevich, Vavilov and Malyutka formations along the Matusevich, Bol'shaya and other rivers. The fish fauna consists of representatives of the main taxonomic groups of Devonian vertebrates, i.e., psammosteid heterostracans, placoderms, acanthodians, chondrichthyans, porolepiform and osteolepiform "rhpidistians", and dipnoans. Summarizing all available data on the distribution of vertebrates, it is possible to suggest a very late Givetian – Frasnian age for the Matusevich Formation, a late Frasnian age of the Vavilov Formation, and a latest Frasnian – early Famennian age for the Malyutka Formation of Severnaya Zemlya.

**Key words:** Biostratigraphy, Devonian, Arctic region, Vertebrates.

## INTRODUCTION

The understanding of Upper Devonian vertebrate assemblages from the Northern Hemisphere is very variable. Fish and agnathans from Scotland and the Baltic sections have been studied for almost two centuries and are well known. However, those from remote regions of the Russian Arctic were discovered only recently. Abundant remains of fossil vertebrates were collected on October Revolution Island of the Severnaya Zemlya archipelago during the study of the key section of the Silurian and Devonian in 1978-1979 (KURIK & *al.* 1982). Until now the Upper Silurian and Lower Devonian vertebrates, especially acanthodians (VALIUKEVIČIUS 1997), osteostracans (MARK-KURIK & JANVIER 1995; AFANASSIEVA & KARATAJŪTE-TALIMAA 1997; AFANASSIEVA 1998) and thelodonts (KARATAJŪTE-TALIMAA & MÄRSS 1997), have been the most

thoroughly studied groups. The distribution of fish and agnathan remains in relation to the facies changes of the basin, and the main taphonomical features of the Upper Silurian and Lower Devonian vertebrates assemblages have been described (KARATAJŪTE-TALIMAA & *al.* 1983). The Middle and Upper Devonian deposits in October Revolution Island have not been so completely studied, particularly the uppermost part of the section. Nevertheless, this part of the section is considered to be palaeontologically very important because of the abundance and good preservation of the fossil fishes (KURIK & *al.* 1982).

## MATERIAL

In the northern part of October Revolution Island, large collections of vertebrate remains from

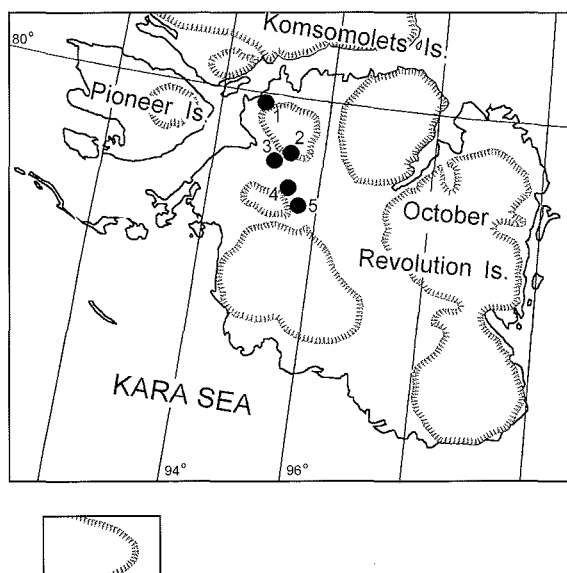


Fig. 1. Map of the central part of the Severnaya Zemlya archipelago (from the Geological Map of the USSR, reduced for this publication); numbers on the map indicate the localities: 1, October Cape, locality 139; 2, right tributary of the river Strelka, locality 12; 3, river Bol'shaya, locality 14; 4, river Bol'shaya, locality 21; 5, river Matusevich, localities 7, 17, 18, 18a, 19; Symbol in rectangle: glaciers

the the Middle and Upper Devonian sections were collected by the participants of two expeditions: mainly by V.N. KARATAJŪTE-TALIMAA and J. VALIUKEVIČUS in 1978, and by E. MARK-KURIK and A. KHAPILIN in 1979. The 1978 expedition collected fish remains mainly from the outcrops along the river Matusevich, localities 7, 17, 18, 18a, and 19 (5, Text-fig. 1). This collection is kept at the Institute of Geology of Lithuania, Vilnius. Fossil vertebrates excavated in 1979 are stored at the Institute of Geology, Tallinn Technical University, and come from several localities: site number 139 at October Cape; locality number 12, the outcrop on the right tributary of the river Strelka, sites number 14 and 21 along the river Bol'shaya. Specimen number prefixes in the text denote their respective institutions: LGI, Institute of Geology of Lithuania, Vilnius, Lithuania; Pi, Institute of Geology, Tallinn Technical University, Estonia.

Most of the studied material comes from the Matusevich Formation, which comprises mainly red coloured and, more rarely, light grey or greenish-grey, sandstone, clay and siltstone. The vertebrate remains from outcrops along the river

Matusevich have been analysed from 19 levels within the Matusevich Formation; additional material from other sites, most probably representing the lowermost part of the same formation (KURIK, *pers. comm.*), is under study. The outcrops of the Vavilov Formation, which are composed of red-coloured sandstone, siltstone, and argillites with rare layers of grey limestone, as well as those of the Maljutka Formation, of similar composition, provided much poorer fossil material, which has been collected from only 5 levels.

The fauna of fishes and agnathans from the Upper Devonian deposits of October Revolution Island in the collections studied consists mainly of antiarchs, but contains members of all the main groups of Devonian vertebrates, such as psammosteid heterostracans, placoderms, acanthodians, chondrichthyans, porolepiform and osteolepiform "rhynchonellids", and dipnoans. Placoderms belonging to two genera of antiarchs, *Asterolepis* and *Bothriolepis*, dominate the assemblages numerically. Disarticulated bones of the head and trunk armour, plates of the pectoral fin armour and, in several cases, complete armours of various species of *Bothriolepis* make up the largest part of the vertebrate remains. The placoderms belonging to this genus are found in all stratigraphic units of the Upper Devonian of Severnaya Zemlya.

#### BIOSTRATIGRAPHY

Two assemblages, characterized by faunal elements that have been found in association with several species of *Bothriolepis*, were used as a basis for further analysis. The first assemblage, which is found throughout the Matusevich Formation, and in the lower part of the Vavilov Formation, differs from the second, younger one, which occurs in the Maljutka Formation, in the presence of psammosteid heterostracans. Everywhere on the East European Platform, the simultaneous appearance of psammosteids and bothriolepidoid antiarchs indicates a Givetian – Frasnian age (LYARSKAYA & LUKŠEVIČS, 1992), whereas psammosteids are not known in the Famennian deposits.

The oldest fish remains belonging to the family Bothriolepididae have been found in Member 2 of the Matusevich Formation (Text-fig. 2; locality 7, bed 72). These are indeterminate fragments of the pectoral fin armour plates of a bothriolepid antiarch.

The vertebrate assemblage from the upper part of Member 2 and the lower part of Member 3 of the

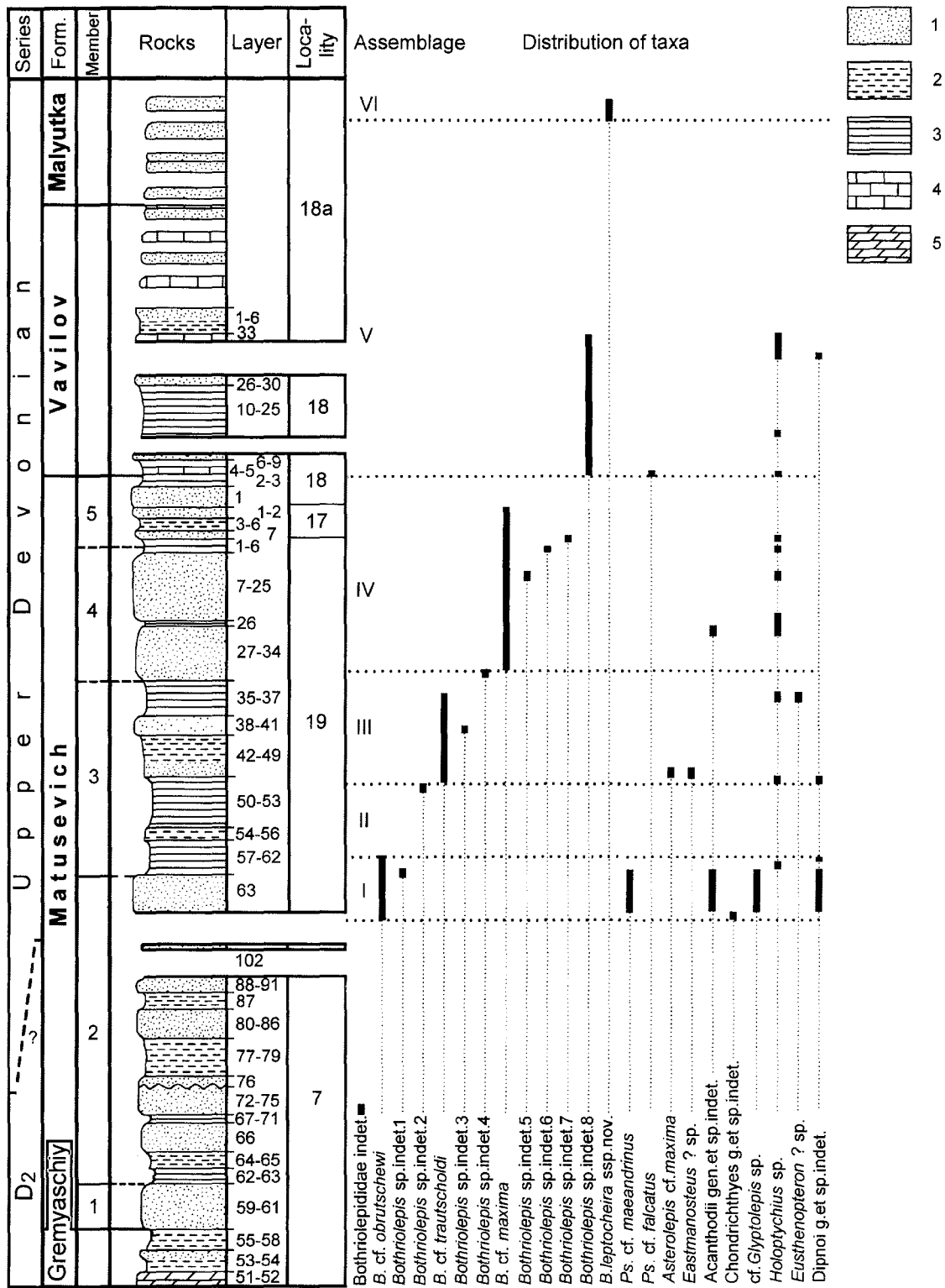


Fig. 2. Distribution of vertebrates in the section along the river Matusevich. Horizontal dotted lines separate several vertebrate assemblages; stratigraphical column simplified after KURSHS (1982) (Matusevich Formation members are given by V. KURSS, unpublished data); lithological symbols: 1 – sandstone, 2 – siltstone, 3 – clay, 4 – limestone, 5 – marl; abbreviations:

*B.* – *Bothriolepis*, Form. – Formation, *Ps.* – *Psammosteus*

Matusevich Formation (locality 19, beds 60 – 63) is richer. It comprises, in addition to abundant and well preserved skeletons of *Bothriolepis* cf. *obrutschewi* GROSS, the remains of a second representative of the same genus, *Bothriolepis* sp. 1 (single nuchal plate), the heterostracan *Psammosteus* cf. *maeandrinus* AGASSIZ, acanthodians, chondrichthyans (tooth of '*Stethacanthus*' type), the porolepiform sarcopterygians including scales of *Glyptolepis* sp., as well as indeterminable fragments of dipnoan bones.

The remaining lower part of Member 3 of the Matusevich Formation is characterized by the occurrence of indeterminable remains of *Bothriolepis* sp. 2 (locality 19, bed 50).

The upper part of Member 3 of the Matusevich Formation (locality 19, beds 33 – 49) yields a rich vertebrate assemblage characterized by the presence of a bothriolepid which closely resembles *Bothriolepis trautscholdi* JAEKEL from the Middle Frasnian of the Main Devonian Field. In addition, the assemblage contains other placoderm fishes, such as two other forms of *Bothriolepis*, *Asterolepis* cf. *maxima* AGASSIZ, known from the Nairn Sandstone of Scotland, *Eastmanosteus?* sp., as well as the sarcopterygians *Holoptychius* sp., *Eusthenopteron* sp., and dipnoans.

The upper part of the Matusevich Formation, members 4 and 5 (locality 19, beds 1 – 33; locality 17), possibly contains a poor assemblage, yielding only a few taxa including *Bothriolepis* cf. *maxima* GROSS (probably a new species), three other species of *Bothriolepis*, *Holoptychius* sp. and indeterminable acanthodians.

The lower part of the Vavilov Formation (locality 18) contains a slightly different assemblage. Fish and agnathan remains recovered from a limestone (bed 5) dissolved in dilute acetic acid include tesserae of a heterostracan similar to *Psammosteus falcatus* OBRUCHEV from the East European Platform, disarticulated plates of small *Bothriolepis*, and abundant scales of *Holoptychius* sp. The last remains of psammosteids in the section occur in this bed.

Only one species of vertebrate, namely *Bothriolepis leptocheira* TRAQUAIR, represented by articulated plates of the trunk, head and pectoral fin armour, has been identified from the sandstones of the Malyutka Formation (locality 18a, upper part). This species is most probably represented in Severnaya Zemlya by a new subspecies, which differs slightly from the nominal subspecies, described from Scotland (MILES 1968), and from the other

subspecies, *Bothriolepis leptocheira curonica*, which is found in Latvia.

#### AGE AND CORRELATION WITH OTHER REGIONS

The dating of almost all the Devonian formations of Severnaya Zemlya is based on vertebrate assemblages and on correlation with the sections of the Taimyr Peninsula, Spitsbergen and the East European Platform (MATUKHIN & *al.* 1997). The position of the Givetian – Frasnian boundary is still uncertain. It was previously suggested that the Middle – Upper Devonian transition in the Severnaya Zemlya section lays within the Gremyaschiy Formation, and that the overlying deposits of the Matusevich, Vavilov and Malyutka formations, on the limited palaeontological data available, belonged to the Upper Devonian (KURIK & *al.* 1982). At the same time, the probable occurrence of Famennian deposits in Severnaya Zemlya was also suggested (KURIK & *al.* 1982). New data on the distribution of the Lower and Middle Devonian placoderms (MARK-KURIK 1998), as well as the Upper Devonian bothriolepidoid antiarchs, permits correlation of the lowermost part of the Matusevich Formation (including Member 1 and part of Member 2) with part of the Gauja Formation, and correlation of the remainder of Member 2 and the lowermost part of Member 3 of the Matusevich Formation, with the Amata Formation of the Baltic succession respectively.

Unfortunately, the data on the distribution of vertebrate assemblages are insufficient to locate the boundary between the Givetian and Frasnian in the October Revolution Island succession more precisely. The oldest placoderm remains belonging to the genus *Bothriolepis* have been reported from the Eifelian of China (PAN 1981). In Antarctica, a succession of 23 bothriolepidid taxa was recorded in the Givetian – Lower Frasnian succession (YOUNG 1988), but in Laurussia bothriolepidids appeared slightly later. The first certain remains of bothriolepidids (*Bothriolepis prima* GROSS, *B. obrutschewi*) from the Main Devonian Field occur in the Amata Regional Stage (the Amata Formation of Latvia and Estonia, the upper part of the Šventoji Formation of Lithuania, and the Staritsa Beds of the Yam-Tesovo Formation in the Leningrad Region of Russia), although questionable remains of bothriolepidids have been reported from the underlying Gauja Formation (KARATAJŪTE-

TALIMAA 1966). The age of the Gauja Formation is still under discussion and hence the Givetian – Frasnian boundary has been placed variously at the base (SOROKIN 1981), or at the top (ESIN & *al.*, in

press, IVANOV & LUKŠEVIČS 1996), of the Gauja Formation, or even at some level in the Amata Formation (see discussion in MARK-KURIK 1998). On a basis of the analysis of the distribution of ver-

Series	Stage	Baltic sequence		Placoderm zonation	Severnaya Zemlya sequence		
		Regional Stages	Beds		Formations	Members	
UPPER DEVONIAN	Famennian	Šķervelis					
		Ketleri		<i>B. ciecere</i>			
		Žagare		interzone			
		Švete					
		Mūri	Tērvete		<i>B. ornata</i>		
			Mūri				
		Akmene		<i>Phyllolepis</i>			
		Kursa					
	Joniškis		interzone				
	Eleja		<i>B. leptocheira (=curonica)</i>	Malyutka			
	Frasnian	Amula					
		Stipinai		interzone	Vavilov		
		Pamūšis				5	
		Katleši		<i>B. maxima</i>		4	
		Daugava	Al'tovo		<i>B. trautscholdi</i>	Matusevich	
Buregi							
Il'men'							
Svinord							
Porkhov							
Dubniki					3		
Pļaviņas	Chudovo		interzone				
	Pskov		<i>B. cellulosa</i>				
Snetnaya Gora							
Amata			<i>Bothriolepis prima-obrutschewi</i>		2		
D <sub>2</sub> Givetian	Gauja		<i>Asterolepis ornata</i>	?	1		
	Burtnieki	Abava*	<i>Watsonosteus</i>	Gremyaschiy			
			<i>Pycnosteus tuberculatus**</i>				
			Vatutin				

Fig. 3. Preliminary correlation of the Baltic and Severnaya Zemlya Middle – Upper Devonian sections based on the distribution of vertebrates (correlation of the Gremyaschiy Formation after MARK-KURIK, 1998); \*Regional Substage not officially accepted by the Baltic Stratigraphic Association; \*\*Heterostracan Zone

tebrate assemblages and conodonts from South Timan, the Givetian – Frasnian boundary in the Main Devonian Field could not be traced below the base of the Amata Formation (ESIN & *al.*, in press). Therefore, it seems that bothriolepidids probably appeared on the East European Platform at the end of the Late Givetian. The Early Frasnian age of the oldest remains of bothriolepidids from North America is confirmed by their occurrence within the middle *asymmetricus* conodont Zone (SANDBERG & *al.* in YOUNG 1988).

The vertebrate assemblage of the Gremyaschiy Formation, which includes placoderms such as the antiarchs *Asterolepis* ex gr. *dellei* GROSS and *A. cf. ornata* EICHWALD sensu AGASSIZ (KURIK & *al.* 1982), and *Watsonosteus* sp.?, *Homostius* sp., *Byssacanthus?* sp. (MARK-KURIK 1998), is similar to that from the uppermost Givetian of the Baltic area.

Unfortunately, the lowermost part of the Matusевич Formation is insufficiently characterized by fossils to permit the Givetian – Frasnian boundary to be precisely located. The occurrence of *Bothriolepis* cf. *obrutschewi* in members 2 and 3 of the Matusевич Formation (see MARK-KURIK 1998) makes it possible to correlate this part of the section with the Amata Formation of the Baltic succession (Text-fig. 3), the Ust'-Chirka and the base of the Ust'-Yarega formations of Middle Timan, as well as with the Kumushka Formation of North Timan.

The distribution of the assemblage containing *Bothriolepis* cf. *trautscholdi* allows the upper part of Member 3 of the Matusевич Formation to be correlated with the Lower – Middle Frasnian interval, which corresponds to the Dubniki and Daugava Regional stages of the Main Devonian Field, and possibly to the Rassokha Formation of North Timan. However, the occurrence of another placoderm, *Asterolepis* cf. *maxima* AGASSIZ, a taxon originally described from Scotland, and closely resembling *A. radiata* ROHON from the Amata and Pļaviņas formations of the Baltic, but greatly differing from *A. syasiensis* LYARSKAYA, which occurs in the Dubniki Formation together with *B. trautscholdi*, contradicts such a correlation.

The age of the upper part of the Matusевич Formation, consisting of members 4 and 5, could be determined as late Frasnian, on the basis of an assemblage yielding *Bothriolepis* cf. *maxima*; these deposits correlate well with those of the Katleši and Pamušis regional stages of the Baltic (the Snezha and Prilovat' formations of northwestern Russia). The *Bothriolepis maxima* Zone of the vertebrate zonation of the Main Devonian Field corresponds to

the *gigas* conodont Zone of the Standard Conodont Zonation (IVANOV & LUKŠEVIČS 1996).

The next vertebrate-based zone in the sequence of the Main Devonian Field, the *Bothriolepis leptochaira* zone [previously known as the *B. curonica* zone: recent revision of the genus has shown that *B. curonica* GROSS is conspecific with *B. leptochaira* (see LUKŠEVIČS, in press)], corresponds to the *triangularis* conodont Zone. *Bothriolepis leptochaira* from the upper part of the Maljutka Formation indicates a Famennian age at least for this part of the succession. Summarizing all of the available data on the distribution of vertebrates, it is possible to suggest a very late Givetian – early Famennian age for the stratigraphical interval comprising the Matusевич, Vavilov and Maljutka formations of Severnaya Zemlya.

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