

Silurian conodonts from Severnaya Zemlya

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FOSSILS AND STRATA



ECOS III

A contribution to the Third European Conodont Symposium, Lund, 1982

Männik, Peep 1983 12 15: Silurian conodonts from Severnaya Zemlya. *Fossils and Strata*, No. 15, pp. 111–119. Oslo. ISSN 0300-9491. ISBN 82-0006737-8.

A short description of the Silurian of Severnaya Zemlya consisting of the Vodopad, Golomyannyi, Srednii, Samoilovich, Ustspokoinaya and Krasnaya Bukhta Formations is given. The conodont fauna is discussed. The *Icriodella discreta*–*I. deflecta* and the *Icriodella inconstans* Assemblage Zones of Britain are recognizable in the lower part of the Silurian on Severnaya Zemlya. The age of the upper part of the Silurian sequence cannot be established by conodonts at the present time. The lack of the widespread species *Pterospathodus celloni* and *P. amorphognathoides* is noteworthy. Five new multielement combinations, *Oulodus?* sp. A, *Oulodus?* sp. B, *Oulodus?* sp. C, *Ozarkodina?* sp. A and *Ozarkodina?* sp. B are proposed. □ *Conodonta, biostratigraphy, Silurian, Severnaya Zemlya.*

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This paper represents a preliminary report on a study of conodonts from Severnaya Zemlya. Previous studies of the geology of this region include those by Urvantzev (1933) and Egiazarov (1959). Detailed research on paleontology and stratigraphy began in 1978, and the first results were reviewed by Menner *et al.* (1979, 1982). Klubov *et al.* (1980) first determined Silurian and Devonian conodonts from the area.

The majority of the material for this study was collected during field work in 1979. The author also had an opportunity to use the samples collected by Dr. E. Kurik in 1974 and by Dr. V. Menner in 1978. Silurian conodonts have been studied from five sections on October Revolution Island and from one on Srednii Island.

The Paleozoic section of October Revolution Island ranges from Cambrian to Upper Devonian. The oldest strata are exposed in the eastern part of the island, which is mostly covered by continental glaciers. The Cambrian–Silurian sediments in the middle and eastern parts of the island are deformed, with the Silurian outcrops situated on the limbs of a northwest–southeast trending anticline, the core of which is formed by Ordovician rocks. Lithologically the Silurian is represented by fossiliferous shallow-water carbonates with thin interbeds of sandstone at some levels. The Silurian marine carbonate rocks are underlain by variegated sandstones and siltstones of Ordovician age. The Ordovician–Silurian boundary is lithologically easily recognizable, but there is no evidence of a hiatus. The system boundary is taken at the top of the uppermost sandstone layer, which is overlain by limestone. The upper part of the Silurian was eroded before Devonian sedimentation in the central and western part of the region, but is mostly preserved in the east. The sequences available for study are exposed in river valleys perpendicular to the outcrop belts on October Revolution Island, and in the cliffs along the coast on Srednii Island (Fig. 1).

In this article a short description of the Silurian deposits is presented, and the conodont faunas recovered by dissolving 230 samples are discussed. The conodont elements are described in terms of the notation proposed by Cooper (1975).

The term s. f. (*sensu formo*) is used to denote species regarded as form taxa. The study of Silurian conodonts from Severnaya Zemlya has resulted in the recognition of faunas and zones known elsewhere; systematic descriptions will be given in future publications.

The conodont elements from Srednii Island are generally amber in color although some variation is noted. On October Revolution Island the conodonts are brown to dark brown. With reference to the conodont color alteration index, the conodonts from Srednii Island have a CAI of about 1–1.5 and those from October Revolution Island 2–3, reflecting burial temperatures of less than 90°C and of 60–200°C, respectively (see Epstein *et al.* 1977).

All the figured specimens are deposited at the Institute of Geology of the Academy of Sciences of the Estonian SSR.

Vodopad Formation

The Vodopad Formation is the lowest unit of the Silurian on Severnaya Zemlya. It was erected by Menner (Menner *et al.* 1979) and is named after the waterfall (Russian водопад) on the Matusевич River on October Revolution Island, where the type section is situated (Fig. 1). The unit, 250–300 m in thickness, is composed of sediments of a major marine transgression, comprising grey and dark grey dolomitic limestones, with siliceous nodules in the upper part. Corals (tabulates, rugosans), stromatoporoids, brachiopods, ostracodes and crinoids are numerous, particularly in the upper part. The lowermost and uppermost parts of the formation are rich in pentamerid brachiopods. The megafauna indicates a Llandovery age (Menner *et al.* 1982).

Silurian conodonts appear in the lowermost beds of the formation. *Ozarkodina oldhamensis* (Rexroad 1967), *O. aff. hassi* (Pollock, Rexroad & Nicoll 1970), *Ozarkodina* cf. sp. A Nowlan 1981, *Icriodella* cf. *deflecta* Aldridge 1972, *Oulodus?* cf. *kentuckyensis* (Branson & Branson 1947), *Distomodus* cf. *kentuckyensis* Branson & Branson 1947, *Ambalodus anapetus* Pollock, Rexroad

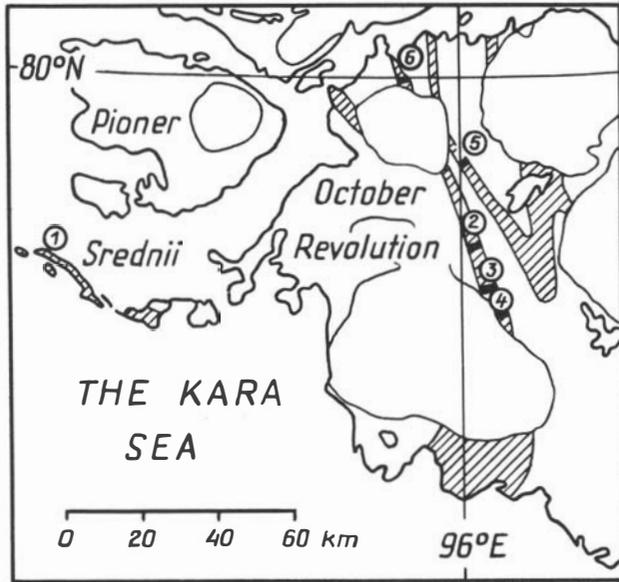


Fig. 1. Sketch map showing the locations of sections collected for conodonts. Diagonal pattern denotes Silurian rocks. 1—Srednii; 2—Matusevich River; 3—Ushakov R.; 4—Stroinaya R.; 5—Spokoinaya R.; 6—Obryvistaya R.

& Nicoll 1970 s. f., *Amorphognathus tenuis* Aldridge 1972 s. f., and *Pseudooneotodus beckmanni* (Bischoff & Sannemann 1958) s. f. are common (Fig. 2). This fauna is very similar to the faunal assemblage that Aldridge (1972) referred to the *Icriodella discreta* - *I. deflecta* Assemblage Zone in the Welsh Borderland. This suggests an Idwian (B₁₋₃) to early Fronian (C₁₋₂) age. The assemblage on Severnaya Zemlya is also similar to the fauna recovered from the Brassfield Limestone of Indiana and Ohio (Branson & Branson 1974; Rexroad 1967; Cooper 1975). McCracken & Barnes (1981a, b) reported similar early Silurian conodont faunas including a new species, *Oulodus? nathani*, from Member 6 of the Ellis Bay Formation, Anticosti Island. Nowlan (1981) noted that the Clemville Formation, Gaspé Peninsula, yields conodonts identical to those in the Ellis Bay fauna, together with brachiopods of Rhuddanian (Llandovery A) age. According to Nowlan, the beds containing the earliest Silurian faunas on Anticosti as well as in the Gaspé Peninsula are probably equivalent in age to the Rhuddanian Stage. The faunas described by McCracken & Barnes and by Nowlan are assigned to the *O. ? nathani* Zone, which precedes the *Distomodus kentuckyensis* Zone in North America and the *Icriodella discreta* - *I. deflecta* Assemblage Zone of Britain (Nowlan 1981). The assemblage from the lower part of the Vodopad Formation does not contain *O. ? nathani*. This fauna may be younger than that of the *O. ? nathani* Zone and belong to the *Icriodella discreta* - *I. deflecta* Assemblage Zone (Fig. 3).

In the upper part of the Vodopad Formation conodonts are rare. Samples from this interval yielded *Ozarkodina* aff. *hassi*, *O. aff. broenlundi* Aldridge 1979, *Ambalodus* sp. s. f., *Apsidognathus* sp. A s. f., *Icriodina?* sp. s. f. and gen. nov. A s. f. (Fig. 2). The main changes noted from the earlier fauna are the addition of *O. aff. broenlundi* and gen. nov. A s. f., and the absence of *I. cf. deflecta* and *O. oldhamensis*. *O. aff. broenlundi* (Fig. 5 R) is similar to the species described by Aldridge (1979) from Peary Land, eastern North Greenland. In Peary Land *O. broenlundi* occurs

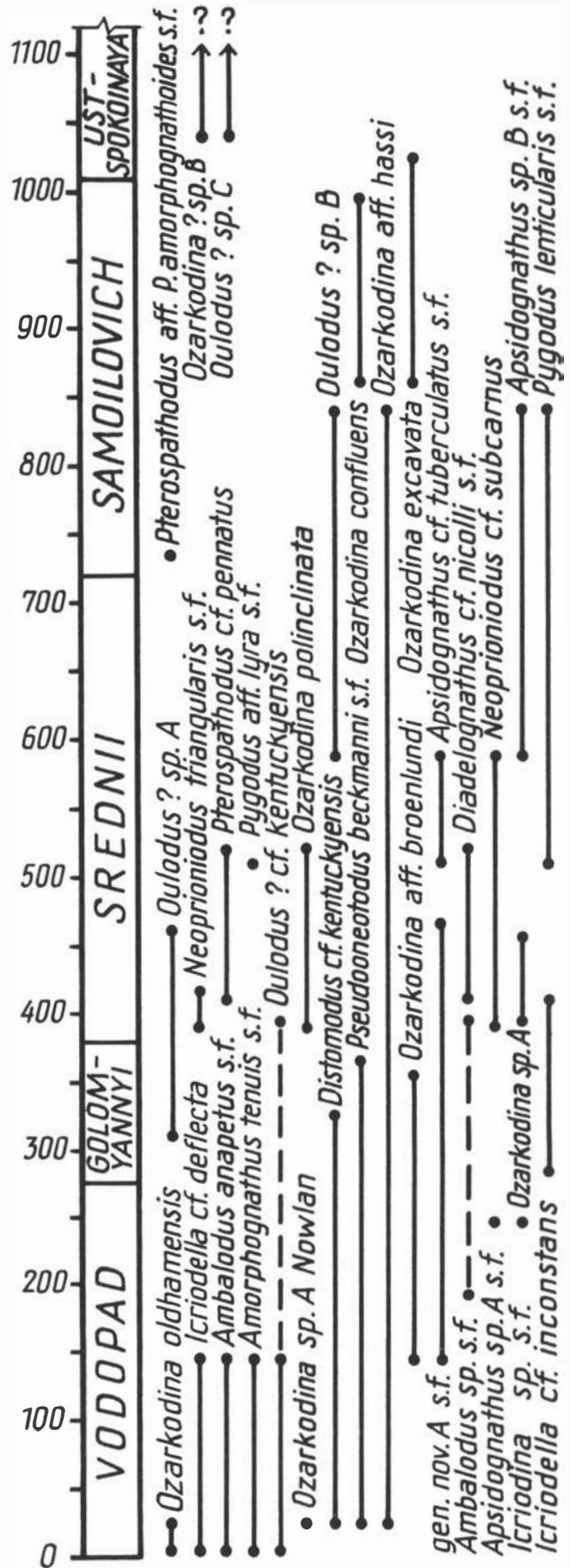


Fig. 2. Stratigraphic ranges of conodonts in the Silurian of Severnaya Zemlya.

Series	Stage	Division	CONODONT ZONES			SEVERNAYA ZEMLYA
			BRITAIN	CARNIC ALPS	N. AMERICA	
DOWN-TON						Krasnaya Bukhta
						Ustspokoinaya
LUD-LOW						Samoilovich
						Srednii
WEN-LOCK	Shein-woodian					
LLANDOVERY	Telychian	C ₆	<i>Pterospathodus amorphognathoides</i>	<i>Pterospathodus amorphognathoides</i>	<i>Pterospathodus amorphognathoides</i>	
		C ₅	<i>Icriodella inconstans</i>	<i>Pterospathodus celloni</i>	<i>Pterospathodus celloni</i>	Golomyannyi
	Fronian	C ₃₋₄	<i>Distomodus staurognathoides</i>	Bereich I	<i>Distomodus kentuckyensis</i>	Vodopad
		C ₁₋₂	<i>Icriodella discreta</i> - <i>Icriodella deflecta</i>			
	Idwian	B ₁₋₃				
Rhuddanian	A ₁₋₄			<i>Oulodus? nathani</i>	?	

Fig. 3. Correlation chart of formations on Severnaya Zemlya with the standard conodont zonal sequences of Europe and North America. Data on Britain from Aldridge (1972, 1975); on the Carnic Alps from

Walliser (1964); and on North America from Nicoll & Rexroad (1968), Pollock *et al.* (1970), Cooper (1975), McCracken & Barnes (1981 a, b), and Nowlan (1981).

together with *Pterospathodus* (Walliser 1964). The *P. celloni* Zone is approximately equivalent to the *Icriodella inconstans* Assemblage Zone defined in Britain (Aldridge 1972). The material from the upper part of the Vodopad Formation does not allow the age of this interval of the unit to be firmly established. However, the appearance higher in the section of *I. cf. inconstans* suggests that it is older in age than the *I. inconstans* Assemblage Zone of Britain, and probably equivalent to the British *Distomodus staurognathoides* Assemblage Zone (Fig. 3). The preservation of the other conodonts from this interval is too poor to give any valuable information.

Golomyannyi Formation

The formation was named by Menner (Menner *et al.* 1979) after one of the islands of the Sedov Archipelago, although the type section of the formation is situated at the Matusevich River on October Revolution Island. The Golomyannyi Formation, 95–115 m thick, represents a phase of regression in the marine basin. The formation is built up of thin-bedded clayey limestones with interbeds of sandstone, stromatolitic limestone, with dolomite at some levels. In the clayey limestones ostracodes, gastropods, small brachiopods and trilobites are abundant, whereas rugosans, tabulates and stromatoporoids are very rare. The brachiopod *Dubaria tenera* Nikiforova & Modzalevskaya indicates that the age of the formation is Llandovery. In some areas of October Revolution and on other islands of Severnaya Zemlya the Vodopad and the Golomyannyi Formations are united in Snezhnyi Formation (Menner *et al.* 1982).

The following conodonts have been identified in the

formation: *Icriodella cf. inconstans* Aldridge 1972, *O. aff. hassi*, *O. aff. broenlundi*, *Oulodus?* sp. A, *Ambalodus* sp. s. f. and gen. nov. A s. f. (Fig. 2). The new components in the fauna are *I. cf. inconstans* and *Oulodus?* sp. A. *I. cf. inconstans* (Fig. 4 T) appears in the lowermost beds of the formation. It is similar to *I. inconstans* Aldridge, although the lanceolate shape of the platform in oral view is less developed. In this formation *Oulodus?* sp. A is represented mainly by its trichonodelliform (Sa) element (Fig. 4 V), which is easily recognizable, with lateral processes that are directed only slightly downwards and are almost straight.

The occurrence of *I. cf. inconstans* in the Golomyannyi Formation confirms a Llandovery C₅ age for the unit and enables correlation with the *I. inconstans* Assemblage Zone of Aldridge (1972) in Britain (Fig. 3). *I. inconstans* occurs in Britain in association with *Pterospathodus celloni*, and the *I. inconstans* Assemblage Zone is probably equivalent to the upper part of Walliser's *P. celloni* Zone and may include the lower part of his *P. amorphognathoides* Zone (Aldridge 1972). Aldridge (1972) correlated the *I. inconstans* Assemblage Zone with the upper part of the *Neospathognathodus celloni* Assemblage Zone of North America. At present only *I. cf. inconstans* is known from Severnaya Zemlya; *P. celloni* has not been found.

Srednii Formation

The Srednii Formation (300–400 m) was named by Menner (Menner *et al.* 1979) after Srednii Island in the Sedov Archipelago. The lithology is very diverse and represents a new major transgression. In its type section on the Matusevich River the formation is comprised of intercalations of tabulate-

stromatoporoidal limestones, sometimes silicified, with stromatoporoidal bioherms and biostromes, and thick layers of brownish-grey limestones with ostracodes, gastropods, crinoids, and rare tabulates. Interbeds of greenish-grey thin-bedded dolomitic limestones lack fauna. Rare beds with stromatolites are common in the upper part of the formation. The megafauna suggests a Wenlock age, but the basal beds may still belong to the Llandovery (Menner *et al.* 1982).

Conodonts are most abundant in the lower part of the formation. This interval is the richest in conodonts in the whole Silurian sequence on Severnaya Zemlya. Specimens of *Icriodella cf. inconstans* and *Oulodus?* sp. A are present in great numbers and in some samples they are the main components of the fauna. *O. aff. hassi* and gen. nov. A s. f. also occur. The new elements in the fauna are *O. polinclinata* (Nicoll & Rexroad 1968), *Ozarkodina* sp. A, *Pterospathodus cf. pennatus* (Walliser 1964), *Neoprioniodus cf. triangularis* Walliser 1964 s. f., *N. cf. subcarnus* Walliser 1964 s. f., *Diadelognathus cf. nicolli* Aldridge 1972 s. f., *Pygodus aff. lyra* Walliser 1964 s. f., *P. lenticularis* Walliser 1964 s. f. and *Apsidognathus cf. Tuberculatus* Walliser 1964 s. f. (Fig. 2). *A. cf. tuberculatus*, which is represented by broken platform elements (Fig. 4 U), was first described by Walliser 1964 s. f. and *Apsidognathus cf. tuberculatus* Walliser the *P. celloni* and *P. amorphognathoides* Zones. It was subsequently reported from Britain (Aldridge 1972), North America (Nicoll & Rexroad 1968; Helfrich 1980) and East Canada (Nowlan 1981). Specimens assigned by Helfrich (1980) and Nowlan (1981) to *A. tuberculatus* differ from those described by Walliser (1964), as they are more rounded in oral view and have one dominant straight high ridge or blade of denticles on one side of which is situated a smooth groove. *A. tuberculatus*, described by Walliser, lacks the groove and is more elongated anteriorly and posteriorly. The free blade is curved and two rows of nodes diverge from it on each side. *A. cf. tuberculatus* s. f. on Severnaya Zemlya is similar to forms described by Walliser. In the upper part of the formation a conodont herein called *Apsidognathus* sp. B s. f. (Fig. 5 Y) is found in association with *A. cf. tuberculatus*. It is identical to the form assigned by Helfrich (1980, Pl. 1:29) and Nowlan (1981, Pl. 7:7, 12, 13) to *A. tuberculatus*.

P. cf. pennatus is represented only by a few delicate specimens, none of them having an expanded blade or nodose denticles (Fig. 4 W); only the Pa element is recognised. It is similar to those described by Nowlan from the Anse à Pierre-Loiselle Formation of the Gaspé Peninsula (Nowlan 1981, Pl. 7:1, 4), although my specimens have only one or two denticles on the lateral process. *P. pennatus* ranges from late Telychian to early Sheinwoodian in Britain (Aldridge 1972, 1975) and is of similar age in North America (Nicoll & Rexroad 1968).

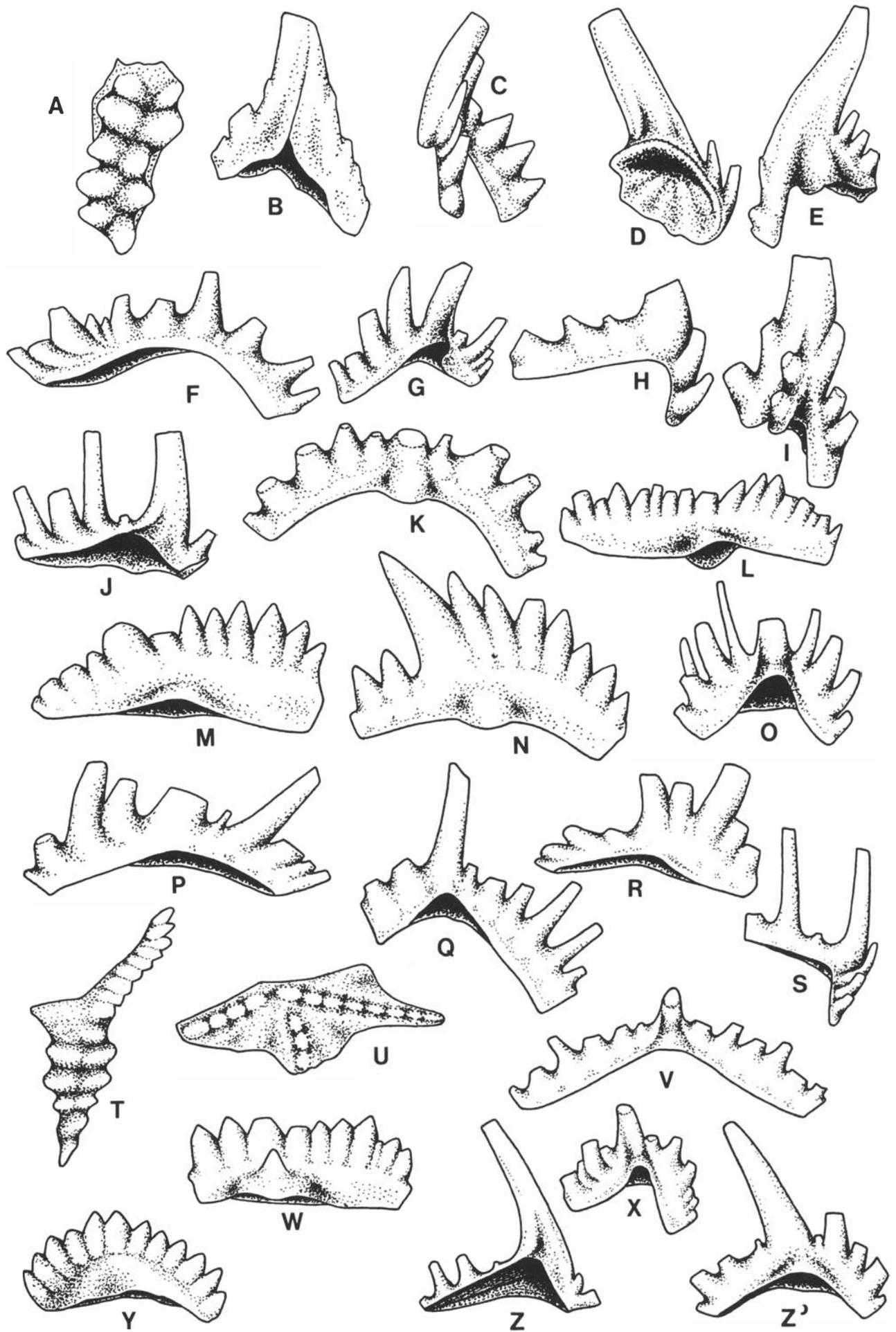
Three species assignable to the multielement genus *Ozarkodina* have been identified from the Srednii Formation. The specimens of *O. aff. hassi* are similar to those found from the Vodopad and Golomyannyi Formations (Fig. 5 I, J, K, N, Q). The Pa, Pb, and M elements of *O. polinclinata* are common and easily recognised. In *Ozarkodina* sp. A the spathognathodiform (Pa) element (Fig. 4 M) resembles the equivalent in *O. aff. hassi*, with a similar wide and rounded basal cavity, but the denticles are larger and more robust. The element has a large apical denticle, but on some specimens one or two denticles at the anterior end of the blade are of the same size as the cusp.

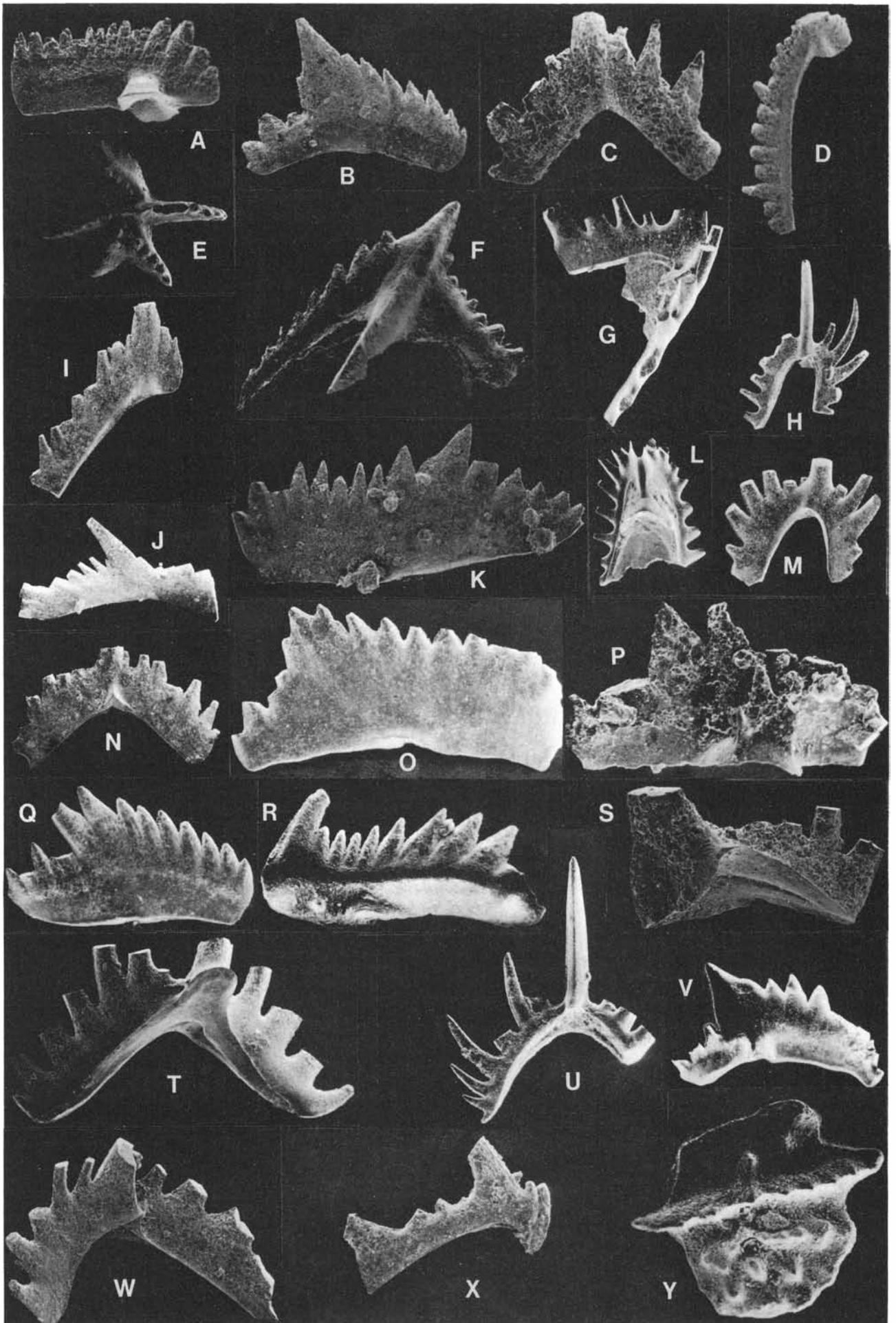
The Pb element (Fig. 4 N) has a large cusp and the denticles on the anterior blade are much higher than those on the posterior. The basal cavity is wide and rounded beneath the cusp. The possible Sa, Sb, Sc elements of the apparatus (Fig. 4 O, P, Q) are common.

The Sa elements of *Oulodus?* sp. A appear in the Golomyannyi Formation, but the species is most numerous in the lower part of the Srednii Formation, where all the elements have been found. The first P (Pa?) element (Fig. 4 R) is somewhat similar to its equivalent in *Oulodus? nathani* McCracken & Barnes 1981b, but differs in being shorter and in having distinct denticles fused only in their lower parts. The posterior blade is twisted to the outer side. The P (Pb?) elements (Fig. 4 Z') are similar to specimens referred to *Lonchodina walliseri* Ziegler 1960 s. f., but they are very varied. The M element has not been positively identified. Probably, some specimens in my material similar to P (Pb?) elements might occupy the M position in the apparatus. They have a very short anterior process with two or three small discrete denticles (Fig. 4 Z). The Sc element (Fig. 4 S) resembles *Ligonodina kentuckyensis* Branson & Branson 1947 s. f. The elements assumed to be Sb (Fig. 4 X) are somewhat similar to *Lonchodina greilingi* s. f., described by Walliser (1964).

Conodonts assignable to *Oulodus?* cf. *kentuckyensis* are found together with *I. cf. inconstans* in the lowermost beds of the Srednii Formation (Figs. 2, 4 F, G, H, J, K). On the Gaspé Peninsula, Canada, Nowlan (1981) described *O?* cf. *kentuckyensis* from the Clemville Formation, assigned to the successive *O?* *nathani* and *D. kentuckyensis* Zones (Llandovery A₂-C₂) of the North American continent and to the *Icriodella discreta* - *I.*

Fig. 4. □A, B, C. *Icriodella cf. deflecta* Aldridge. □A. Oral view of Pa element, ×75, Cn 5000, Vodopad Formation, Srednii Island. □B. Lateral view of M element, ×80, Cn 5001. □C. Lateral view of S element, ×75, Cn 5002. B and C from the Vodopad formation, October Revolution Island, Stroinaya River. □D, E, I. *Distomodus cf. kentuckyensis* Branson & Branson. All specimens from the Golomyannyi Formation, Srednii Island. □D. Lateral view of Pb element, ×40, Cn 5003. □E. Lateral view of Sc element, ×45, Cn 5004. □I. Posterior view of Sa element, ×70, Cn 5005. □F, G, H, J, K. *Oulodus?* cf. *kentuckyensis* (Branson & Branson). All specimens from the Srednii Formation, Srednii Island. □F. Lateral view of first P (Pa?) element, ×75, Cn 5006. □G. Posterior view of Sb element, ×50, Cn 5007. □H. Lateral view of Sc element, ×80, Cn 5008. □J. Lateral view of P (Pb?) element, ×85, Cn 5009. □K. Posterior view of Sa element, ×80, Cn 5010. □L. *Ozarkodina* sp. A Nowlan; lateral view of Pa element, ×75, Cn 5011, Vodopad Formation, Srednii Island. □M, N, O, P, Q. *Ozarkodina* sp. A. All specimens from the Srednii Formation, Srednii Island. □M. Lateral view of Pa element, ×40, Cn 5012. □N. Lateral view of Pb element, ×45, Cn 5013. □O. Posterior view of Sb element, ×55, Cn 5014. □P. Lateral view of Sc element, ×55, Cn 5015. □Q. Posterior view of Sa element, ×40, Cn 5016. □R, S, V, X, Z, Z'. *Oulodus?* sp. A. All specimens from the Srednii Formation, Srednii Island. □R. Lateral view of first P (Pa?) element, ×50, Cn 5017. □S. Lateral view of Sc element, ×45, Cn 5018. □V. Posterior view of Sa element, ×55, Cn 5019. □X. Posterior view of Sb element, ×50, Cn 5020. □Z. Lateral view of M(?) element, ×50, Cn 5021. □Z'. Lateral view of P (Pb?) element, ×55, Cn 5022. □T. *Icriodella cf. inconstans* Aldridge; oral view of Pa element, ×45, Cn 5023, Srednii Formation, Srednii Island. □U. *Apsidognathus cf. tuberculatus* Walliser s. f.; oral view, ×45, Cn 5024, Srednii formation, October Revolution Island, Ushakov River. □W. *Pterospathodus cf. pennatus* (Walliser); lateral view of Pa element, ×85, Cn 5025, Srednii Formation, Srednii Island. □Y. gen. nov. A s. f.; lateral view, ×50, Cn 5026, Golomyannyi Formation, October Revolution Island, Ushakov River.





deflecta Assemblage Zone of Britain. On Severnaya Zemlya *O.*? cf. *kentuckyensis* is found together with forms characteristic of the *Icriodella discreta* – *I. deflecta* Assemblage Zone in the Vodopad Formation, but also occur in the lower part of the Srednii Formation. The age of this horizon may be late Llandovery, as it contains *Apsidognathus* cf. *tuberculatus* s. f. Several other taxa, *P.* cf. *pennatus*, *O. polinclinata* and *Pygodus* species, indicate a late Llandovery – earliest Wenlock age. According to Menner (Menner *et al.* 1982) the megafauna indicates a late Llandovery or earliest Wenlock age for the lower part of the formation.

The upper part of the Srednii Formation has yielded few conodonts (Fig. 2). *Ozarkodina* aff. *hassi* is still the dominant species. The main new multielement component is *Oulodus*? sp. B (Fig. 5 S, T, W, X) and the fauna also includes some specimens of *Neoprioniodus* cf. *subcarnus* s. f., *Apsidognathus* cf. *tuberculatus* s. f. and *Apsidognathus* sp. B s. f. Only one P (Pb?) element of *Oulodus*? sp. B has been recognised; it is very similar to *Lonchodina detorta* Walliser 1964 s. f. and is characteristic. The M, Sc, Sb and Sa elements of the apparatus are common. Walliser (1964) described *L. detorta* s. f. as an Upper Silurian species, occurring in the Ludlow *Polygnathoides siluricus* Zone and higher levels in the Carnic Alps. The other elements assigned to *Oulodus*? sp. B are known from Wenlock strata in the Carnic Alps (Walliser 1964). Aldridge (1972) has recorded similar conodonts from the Idwian and lower Wenlock. On Severnaya Zemlya *Oulodus*? sp. B is found together with a megafauna regarded as Wenlock in age (Menner *et al.* 1982). *Neoprioniodus* cf. *subcarnus* s. f. and *Apsidognathus* cf. *tuberculatus* s. f. are common in the upper Llandovery and lower Wenlock

(Walliser 1964; Nicoll & Rexroad 1968; Aldridge 1972). *Apsidognathus* sp. B s. f. is known at present only from the upper Llandovery (Helfrich 1980; Nowlan 1981).

Samoilovich Formation

The Samoilovich Formation, erected by Menner (Menner *et al.* 1979), was named after Samoilovich Island. This formation and both the succeeding formations are composed of regressive sediments. The unit is 260–320 m thick and consists of a rhythmic intercalation of stromatolitic, oolitic and oncolitic limestones with greenish-grey thin-bedded clayey limestones. In the latter lithology gastropods, brachiopods, ostracodes and trilobites are numerous. The boundary with the underlying unit is placed at the top of the uppermost thick (2–3 m) layer of limestones with abundant stromatoporoids characteristic of the Srednii Formation. In the lower part of the formation brachiopods *Hyattidina parva* Nikiforova, *Anabaria rara* (Nikiforova) and *Protatrypa lepidota* Nikiforova & Modzalevskaya have been found that indicate a Wenlock age. The number of megafossils decreases towards the top of the sequence, but an interval rich in tabulates of Ludlow age occurs in the upper part of the formation. On the Ushakov River at the same level the vertebrates *Logania* ex. gr. *ludlowensis* Gross, *Thelodus* sp. nov. and *Darthmutia* have been found. The upper limit of the formation is taken at the basal layer of the greenish-grey sandstones of the overlying Ustspokoinaya Formation. The position of the Lower–Upper Silurian boundary is unclear at present (Menner *et al.* 1982).

The lower part of the Samoilovich Formation yields a conodont fauna similar to that of the upper part of the Srednii Formation (Fig. 2). *Ozarkodina* aff. *hassi*, *Oulodus*? sp. B, *Apsidognathus* sp. B s. f. and *Pygodus* cf. *lenticularis* s. f. are common. A new component is *Pterospathodus* aff. *P. amorphognathoides* (Pa element) Walliser 1964 (Fig. 5 P), which is identical to the forms illustrated by Nowlan (1981, Pl. 7:2, 5) from the Anse à Pierre–Loiselle Formation. Nowlan remarked that *Pterospathodus* aff. *P. amorphognathoides* probably represents a separate species that may be an ancestor of *P. amorphognathoides*, which was found in the overlying La Vieille Formation. *Pterospathodus* aff. *P. amorphognathoides* is of latest Llandovery age on the Gaspé Peninsula. *Apsidognathus* sp. B s. f., described by Nowlan from the Anse à Pierre–Loiselle Formation as platform element of *Apsidognathus tuberculatus*, is also of the same age. *Pygodus* cf. *lenticularis* s. f. is found from the Telychian in Britain (Aldridge 1972, 1975) and is of the same age in the Carnic Alps (Walliser 1964). All these taxa indicate a late Llandovery age. Only *Oulodus*? sp. B has elements, similar to those known from beds younger than Llandovery. It is noteworthy that Llandovery conodonts here range into strata that may be of late Wenlock age and occur with forms of megafauna known from Wenlock and younger beds. A similar phenomenon, where *O. hassi* ranges up to the Lower–Upper Silurian boundary is known from the Timan–Petchora Province (S. V. Melnikov, personal communication).

Samples from the upper part of the formation yielded only *Ozarkodina confluens* (Branson & Mehl 1933) and *O. excavata* (Branson & Mehl 1933). *O. confluens* ranges elsewhere from late Sheinwoodian to Downtonian (Aldridge 1975), but here

Fig. 5. □A, B, C, D. *Ozarkodina oldhamensis* (Rexroad). All specimens from the Vodopad Formation, October Revolution Island, Stroinaya River. □A. Lateral view of Pa element, ×75, Cn 5027. □B. Lateral view of Pb element, ×80, Cn 5028. □C. Posterior view of Sb element, ×140, Cn 5029. □D. Lateral view of M element, ×55, Cn 5030. □E. *Amorphognathus tenuis* Aldridge s. f.; oral view, ×40, Cn 5031, Vodopad Formation, October Revolution Island, Spokoinaya River. □F. *Ambalodus anapetus* Pollock, Rexroad & Nicoll s. f.; lateral view, ×75, Cn 5032, Vodopad Formation, October Revolution Island, Spokoinaya River. □G, H, L, M, U. *Oulodus*? sp. C. All specimens from the Ustspokoinaya Formation, October Revolution Island, Matushevich River. □G. Lateral view of Sc element, ×75, Cn 5033. □H. Posterior view of Sb element, ×40, Cn 5034. □L. Posterior view of Sb element, ×40, Cn 5035. □M. Posterior view of Sb element, ×50, Cn 5036. □U. Posterior view of Sa element, ×40, Cn 5038. □O, V. *Ozarkodina*? sp. B. Both specimens from the Ustspokoinaya Formation, October Revolution Island, Matushevich River. □O. Lateral view of Pa element, ×80, Cn 5037. □V. Lateral view of Pb element, ×40, Cn 5038. □I, J, K, N, Q. *Ozarkodina* aff. *hassi* (Pollock, Rexroad & Nicoll). All specimens from the Srednii Formation, October Revolution Island, Ushakov River. □I. Lateral view of M element, ×75, Cn 5040. □J. Lateral view of Sc element, ×75, Cn 5041. □K. Lateral view of Pa element, ×75, Cn 5042. □N. Posterior view of Sa element, ×80, Cn 5043. □Q. Lateral view of Pb(?) element, ×80, Cn 5044. □P. *Pterospathodus* aff. *amorphognathoides* Walliser s. f.; lateral view, ×155, Cn 5045, Samoilovich Formation, October Revolution Island, Matushevich River. □R. *Ozarkodina* aff. *broenlundii* Aldridge; lateral view of Pa element, ×85, Cn 5046, Golomyannyi Formation, October Revolution Island, Ushakov River. □S, T, W, X. *Oulodus*? sp. B. All specimens from the Srednii Formation, October Revolution Island, Ushakov River. □S. Lateral view of M element, ×155, Cn 5047. □T. Lateral view of P (Pb?) element, ×80, Cn 5048. □W. Posterior view of Sb element, ×85, Cn 5049. □X. Lateral view of Sc element, ×70, Cn 5050. □Y. *Apsidognathus* sp. B s. f.; oral view, ×85, Cn 5051, Samoilovich Formation, October Revolution Island, Matushevich River.

the megafauna indicates a Ludlow age (Menner *et al.* 1982). *O. excavata* is known as a widespread species ranging from Fronian to Downtonian (Aldridge 1975).

Ustspokoinaya Formation

Menner erected the Ustspokoinaya (Menner *et al.* 1982), formerly the Izluchina (Menner *et al.* 1979), Formation, for a sequence of violet-grey, green-grey and red-brown marlstones and clayey limestones with numerous ostracodes. The lowermost part of the formation contains interbeds of sandstone. Thin beds of dolomite are common. The red colour of the sediments increases up the sequence. Only in the eastern part of October Revolution Island, near the mouth of the Spokoinaya River, is the whole sequence of the formation (200–250 m) available for study. On the Matusевич and Ushakov Rivers the upper part of the formation was eroded before Devonian sedimentation. The vertebrates *Tremataspis* sp. nov., *Thelodus* cf. *schmidti* (Pander), *Logania martinsoni* Gross, indicating a Ludlow age, have been found in this formation.

The conodonts in the Ustspokoinaya Formation are known only from the sequences on the Matusевич and Spokoinaya Rivers. On the Matusевич River the lowermost beds of the formation contain some elements of *Ozarkodina excavata*. Two undescribed species designated *Ozarkodina?* sp. B and *Oulodus?* sp. C (Fig. 2) appear higher in the sequence. A few elements of these species have also been recovered from the sequences on the Spokoinaya River. *Ozarkodina?* sp. B is in majority represented by Pa and Pb elements. A few Sc and M elements occur on the Matusевич River. The anterior denticles of the Pa element of *Ozarkodina?* sp. B (Fig. 5 O) are fused nearly to their apices and form a gradually deepening row to the cusp, which is situated near the posterior. At the posterior end the height of the denticles fall rapidly. The basal cavity has flared lips at the midlength of the unit under the posteriorly inclined cusp. The arched Pb element (Fig. 5 V) has a strong cusp situated posterior of midlength and inclined posteriorly. The denticles of the posterior blade are much lower than those of the anterior. The posterior blade is turned outwards and strongly twisted inwards. The basal cavity is widest beneath the cusp. The M element has a long downwards directed posterior process. The anterior one is shorter and twisted to the outer side. The Sc element is hindeodelliform.

The first P (Pa?) element of *Oulodus?* sp. C has laterally compressed and nearly to their apices fused denticles on its anterior blade. The posterior process is laterally bowed and aborally arched. Denticles on this process are discrete with U-shaped interspaces and twisted outwards. The basal cavity is widely flared, aboral surfaces of processes are widely excavated or inverted. The Sc element (Fig. 5 G) is ligonodiform, and somewhat similar to that of *Ligonodina elegans* Walliser 1964, *sensu* Jeppsson 1969. The asymmetrical Sb element is represented by two forms. They are similar, but one of them has a very strongly posteriorly expanded basal cavity beneath the cusp (Fig. 5 L). The cusp itself is also strongly inclined. The other Sb element has a less expanded basal cavity and its cusp is straighter (Fig. 5 M). A gradual transition between

these different forms may be observed (Fig. 5 L, H, M). The Sa element (Fig. 5 U) has two bars which form a deep symmetrical arch. The basal cavity is strongly expanded under the posteriorly inclined cusp and continues as a wide groove on the aboral surfaces of the processes.

The uppermost Silurian formation on Severnaya Zemlya, the Krasnaya Bukhta Formation, has a megafauna indicative of Downton age (Menner *et al.* 1982). The few samples from this formation did not yield conodonts.

Summary and conclusions

This study is based on the examination of 230 samples from the Srednii and October Revolution Islands of Severnaya Zemlya that collectively yielded over 11,000 conodont elements. Conodonts have been recovered from each of the formations studied, except the uppermost Krasnaya Bukhta Formation. Some units have been sampled in much more detail than others, so additional collecting is needed. Future publications will detail the taxonomy of the conodont faunas. On the basis of the information recovered so far several conclusions can be made.

- (1) The lower part of the Vodopad Formation yields a conodont fauna that may be assigned to the *Icriodella discreta*–*I. deflecta* Assemblage Zone (Llandovery B_{1–3}, C_{1–2}) of Britain and *Distomodus kentuckyensis* Zone of North America.
- (2) Conodonts from the Golomyannyi Formation suggest a Telychian (Llandovery C₅) age, based on the presence of *Icriodella* cf. *inconstans*.
- (3) Conodonts from the lower part of the Srednii Formation are abundant and similar to those known from the late Llandovery (Telychian C_{5–6}) and earliest Wenlock (Sheinwoodian) elsewhere. The age of the upper part of the formation, based on the presence of *Oulodus?* sp. B and on the megafauna, is probably Wenlock.
- (4) The absence of *Pterospathodus celloni* and *P. amorphognathoides*, widespread in Europe, America and Asia, is noteworthy.
- (5) The lower part of the Samoilovich Formation is dated as Wenlock by megafauna, but yields typical Llandovery conodonts together with *Oulodus?* sp. B. The upper part of the formation contains *Ozarkodina confluens* and *O. excavata*, and the megafauna indicates a Ludlow age.
- (6) Conodonts from the Ustspokoinaya Formation do not allow determination of its age. The megafauna indicates a Ludlow age.

Acknowledgments. – I would like to thank Drs. Elga Kurik and Vladimir Menner (junior) for making their samples available for examination; Drs. Elga Kurik, Einar Klaamann and Viive Viira for criticism of the text; Mr. Udo Veske and Mr. Jevgeni Klimov for the photographs and Miss Kaie Vallimäe for the figures.

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