Supplementary Material

Possible predators and prey of the angarocaridids from the of Ust'-Stolbovaya Formation

Conodonts

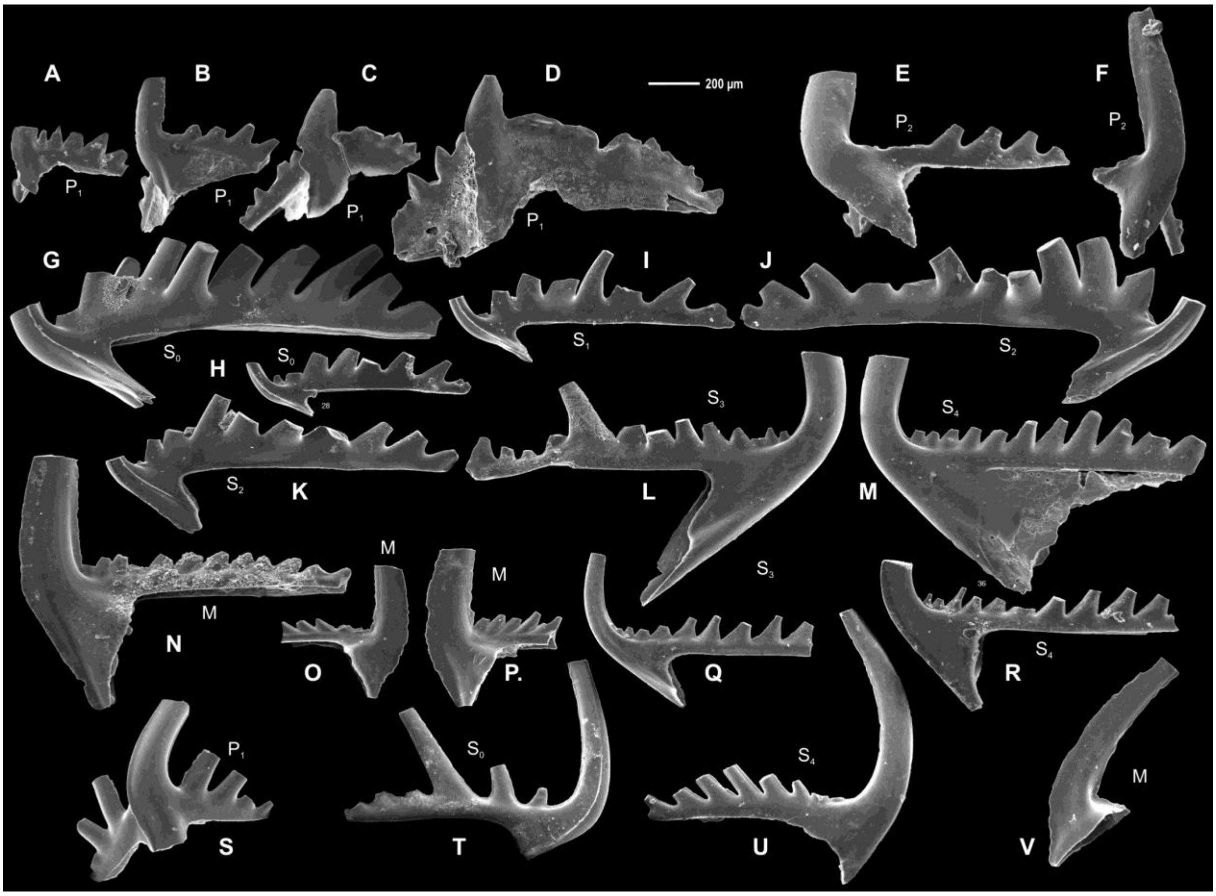
The conodonts in the sample are represented just by a few juveniles that indicates high juvenile mortality of species apparently near the limit of their area of occurrence (in biogeographic or ecological meaning). Conodonts with coniform elements in the apparatus functionally resembled the extant (as well as Cambrian) chaetognaths and possibly depended on a similar diet, that is on minute pelagic arthropods, not necessarily with mineralised cuticle. Exceptions are only *Panderodus* sp., *Ansella* sp., and perhaps also *Semiacontiodus* sp. (SMFig. 1B-G). Unlike chaetognaths, the tips of conodont elements' denticles were frequently broken and subsequently regenerated. Such phenomenon would be difficult to explain, unless durophagy is involved (e.g., SMFig. 2C, D, and L).

Drepanoistodus sp. (SMFig. 1L–P), *Drepanodistacodus* sp. (SMFig. 1Q–V), and *Eoneoprioniodus anceps* (Moskalenko, 1970) (SMFig. 1W–AC) are conodont species with large coniform elements of the apparatus probably restricted in their distribution to the Siberian Platform and neighbouring regions. This refers as well to most conodont species with a more elaborated apparatus structure (SMFigs 2 and 3). The *Cyrtoniodus flexuosus* (Moskalenko, 1973) lineage (SMFig. 2A–R) probably had its evolutionary roots in the Australian *Cyrtoniodus spicatus* (Watson, 1988) present as early as in the Dapingian of the Canning Basin (Watson 1988). Its lineage expanded to low latitudes of Siberia with the Volginian transgression and then to the North American Midcontinent as *C. inflexus* (Stauffer, 1935) (Leslie & Bergström 1995). In the Siberian material there is a continuous transition between elements identified as P_1 and P_2, those with the P_1 morphology, there is with high angle between processes and short cusp, being disproportionately infrequent (SMTable 1). This corresponds to the observation by Bauer (1994), who identified only one type of P elements in his samples and used it as a diagnostic character of a new species.

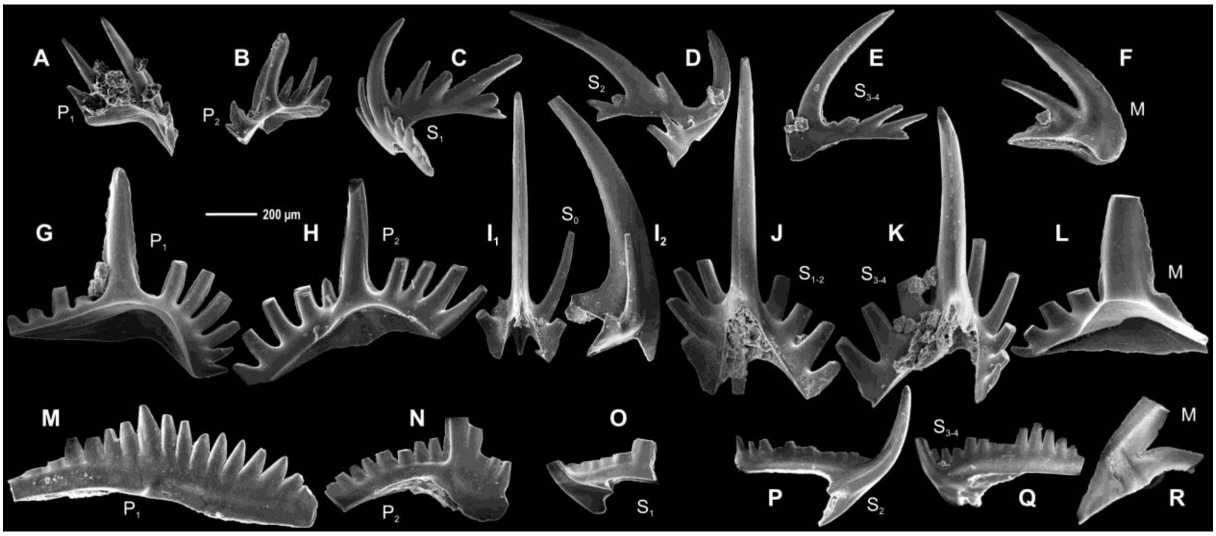
An enigmatic aspect of the basal Volginian Stolbovaya II sample is the presence of geniculate M elements with long cusp resembling those of the Australian *Phragmodus polystrophos* (Watson, 1988) and Baltic *P. polonicus* Dzik, 1978. No such elements follow *Cyrtoniodus flexuosus* in somewhat younger Siberian samples. Either this is a case of cooccurrence of *Cyrtoniodus* with *Phragmodus,* a lineage with Baltic roots (e.g., Dzik 2015), having remaining elements of the apparatus virtually identical, or these M element belong to another yet unidentified apparatus. Other elements possibly belonging to this species differ from those of typical *C. flexuosus* in longer cusp in the P elements and reclined denticles in S elements, having also somewhat stronger cusp and shorter dorsal process. The element S_0 has very short lateral processes. Because these differences are not always apparent, all elements except for theM are listed as belonging to *C. flexuosus* in SMTable 1. There were at least two episodes of biogeographic expansion of the *Phragmodus* lineage. In the North American Midcontinent warm-water environments it appeared in the Late Ordovician as *P. undatus* Branson & Mehl, 1933. These all were conodonts with a more elaborated apparatus structure (SMFig. 2 and 3) having a pair of frontal M elements of an incisor shape, a set of 11 (or 13) comb-like elements in the middle, with the medial one presumably gating the throat and two pairs of robust elements behind. They probably depended on a kind of food requiring a sophisticated apparatus enabling both grasping and crushing the prey.

Among the conodont species present in the earliest Volginian of Stolbovaya II the most robust element morphology characterizes the rare ozarkodinid *Bryantodina* (SMFig. 3M–R) with poorly known apparatus structure (element P_1 identified by Moskalenko 1984, pl. 23:25–26 as *Bryantodina* cf. *typicalis*, I suggest that here belongs also the element M identified by Moskalenko 1970, pl. 1:4 as *Oistodus linguatus*).

SMFig. 1. Conodonts with coniform elements in the apparatus from the base of Ust'-Stolbovaya Formation at exposure II on the left bank of the Stolbovaya River. Small-size letter symbols indicate inferred locations in the apparatus. A. *Pseudooneotodus* sp.; specimen ZPAL C.22/125 in lateral (A_1) and occlusal (A_2) views. B–C. *Ansella* sp. specimens ZPAL C.22/68 and 71. D–G. *Panderodus* sp., specimens ZPAL C.22/73–76. H–K. *Semiacontiodus* sp., specimens ZPAL c.22/103, 105, 106, and 104. L–P. *Drepanoistodus* sp. specimens ZPAL C.22/108–112, respectively. Q–V. *Drepanodistacodus* sp., specimens ZPAL C.22/113–118, respectively. W–AC. *Eoneoprioniodus anceps* (Moskalenko, 1970), specimens ZPAL C.22/79–85, respectively.



SMFig. 2. Prioniodontid conodonts from the base of Ust’-Stolbovaya Formation at exposure II on the left bank of the Stolbovaya River. A–R. *Cyrtoniodus flexuosus* (Moskalenko, 1973), specimens ZPAL C.22/55–63, 65, 64, 67, 70, 72, 74, 69 and 70. P–V. *Phragmodus* sp., specimens ZPAL C.22/77–78 and 86–90, respectively



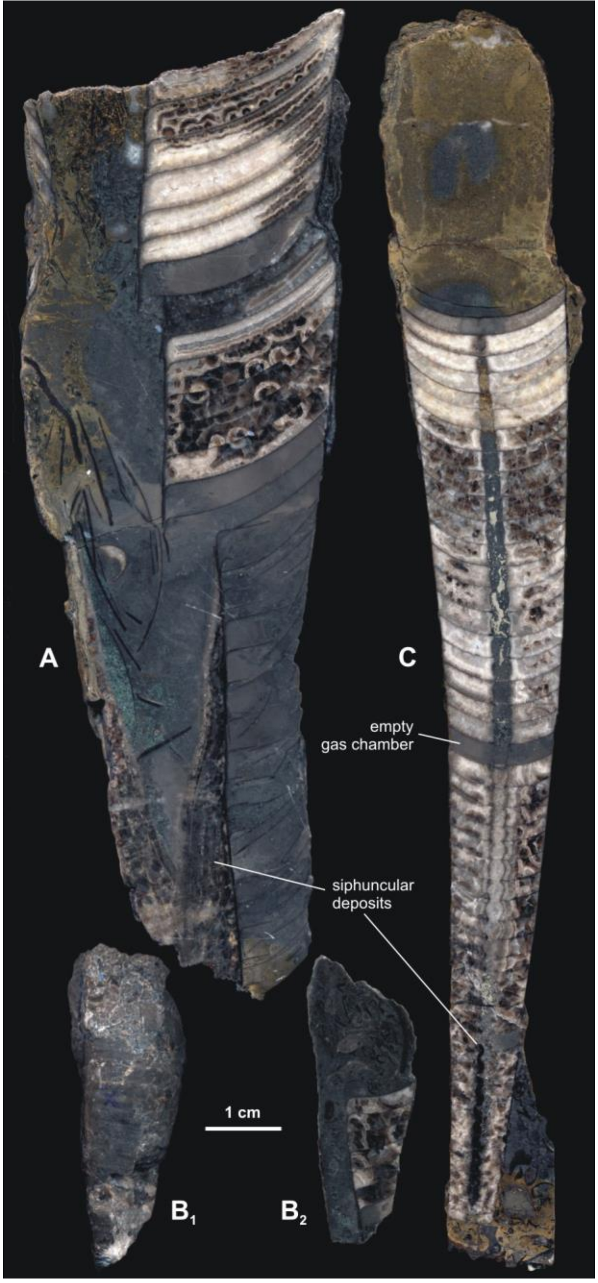
SMFig. 3. Ozarkodinid conodonts from the base of Ust’-Stolbovaya Formation at exposure II on the left bank of the Stolbovaya River. A–F. *Erraticodon alternans* (Hadding, 1913), specimens ZPAL C.22/119–124. G–L. *Microcoleodus prominens* (Moskalenko, 1973), specimens ZPAL C.22/97–102 and 107. M–R. *Bryantodina* sp., specimens ZPAL C.22/91–96, respectively.

SMTable 1. Frequencies of conodont elements in samples from the Volginian of Siberia.

Stolbovaya 2		Stolb-2
Ansella sp.	P_1	2
	S-M	2
Panderodus sp.	S	10
	M	3
Semiacontiodus sp.	P-M	63
	S_0	7
Pseudooneotodus sp.	P-M	4
Drepanoistodus sp.	P	12
	S_0	21
	S_{1-4}	129
	M	14
Drepanodistacodus sp.	P	35
	S_0	24
	S_{1-2}	21
	S_{3-4}	17
	M	37
Eoneoprioniodus anceps	P	50
	S_0	19
	S_{1-2}	32
	S_{3-4}	40
	M	49
Phragmodus polonicus?	M	119
Cyrtoniodus flexuosus	P_1	100
	P_2	379
	S_0	115
	S_{1-2}	422
	S_{3-4}	430
	M	361
Microcoleodus prominens	P	29
	S_0	16
	S_{1-4}	89
	M	13
Erraticodon alternans	P_1	1
	P_2	1
	S_1	1
	S_2	4
	S_{3-4}	3
	M	4
Bryantodina sp.	P_1	19
	P_2	6
	S	6
Plectodina? sp.	M	60
	together	2769

Cephalopods

The most complete specimen of the pseudorthoceratid ‘*Sactoceras*’ *stolbovense* Balaschov, 1962 represents probably a mature conch (SMFig. 4C), judging from the slight condensation of the last septa. Three gas chambers were apparently punctured before fossilization and they are completely filled with the sediment. Other chambers are filled with the diagenetic cement. This indicates that most of the phragmocone was probably devoid cameral deposits. Black siphuncular deposits are well visible in the proximal one-fifth of the phragmocone, only on the ventral side of the siphuncle (assuming that the conch is slightly endogastric) and they fill it completely near the phragmocone tip. The slightly swollen siphuncle segments suggest that it is a pseudorthoceratid similar to *Clinoceras* as interpreted by Dzik (1984) rather than a more advanced sactoceratid. In the acid-resistant residue 33 phosphoritic moulds of phragmocone pieces represent probably this species with moderately swollen subcentral siphuncle (they may represent just a few fragmented phragmocones). 46 pieces of phragmocones with strongly swollen subventral siphuncle may represent another species of *Sactoceras* or *Tunguskoceras*.



SMFig. 4. Nautiloid cephalopods from the base of Ust'-Stolbovaya Formation. A–B. Endoceratid *Endoceras pseudoseptum* Balaschov, 1962, medial section of crushed phragmocone ZPAL V.29/92 (A); external view and medial section through the juvenile specimen ZPAL V.29/93 (B). C. Pseudorthoceratid '*Sactoceras*' *stolbovense* Balaschov, 1962 medial section of almost complete conch ZPAL V.29/94.

Another common nautiloid species in the Ust'-Stolbovaya Formation is the endoceratid *Endoceras pseudoseptum* Balaschov, 1962. The largest specimen photographed at the locality was of 76.0 mm diameter at the base of the body chamber. It shows no condensation in spacing of septa, the individual was thus still not mature. The specimen collected as a part of the conodont sample (SMFig. 4A) shows septal necks extending throughout the whole gas chamber. This apparently prevented exchange of the cameral liquid, which resulted in the lack of cameral deposits in the endoceratids. Instead, the conical end of the sipho, while retreating from the apical part of the shell and leaving behind diaphragms in its narrow terminal spiculum, secreted solid siphuncular deposits. Such deposits are well developed in the specimen. which means that this is a proximal portion of the phragmocone. Its complete size was thus similar to the specimen photographed in the field. Probably the embryonic conch morphology is the character of highest value in the endoceratid taxonomy above the species level.

The endoceratids, with a large conch diameter already at the embryonic stage, are unlikely to be represented in acid-resistant residues. Fortunately, a juvenile specimen found in the sample preserved most of its embryonic part (SMFig. 4B, C). Its diameter decreases rapidly towards the tip but the siphuncle slightly increases its diameter at the cost of gas chambers.

Bellerophontid molluscs

A relatively large *Sinuites*-like globular bellerophontid mollusk, 27.0 mm in diameter was extracted from the sample before being put in acetic acid. The residue has yielded 12 small internal moulds of such bellerophontids with relatively wide umbo, no one representing the larval stage. Another bellerophontid with even wider umbo and transversely expanded coils is represented by 17 specimens, mostly larval. The conch apex in these two species is of rather large size and consequently number of coils low.

The most numerous among molluscs (276 specimens) are discoidal conchs with acute venter probably representing the bellerophontid *Trematodiscus* (SMFig. 5A). Very few juvenile postlarval specimens.

52 specimens of another species with similar population dynamics co-occur. Its larval conch had a flat dorsum; the early postlarval stage had flattened flanks but acute venter. The coils have much higher whorl expansion rate than in the preceding species. These specimens may belong to *Tropidodiscus*.

The limpet-like *Pterotheca* is the bellerophontid second in number of specimens in the sample, represented by 146 moulds of various ontogenetic age (SMFig. 5B).

Yet another species of bellerophontids with a very small apex of a globular conch, similar to the Baltic species of *Kokenospira,* is represented by only a single larva. An enigmatic bellerophontid with coiled larval conch and high pyramidal postlarval conch with triangular cross section yielded 9 juvenile specimens. Adult conchs were probably of the *Hypseloconus* shape. One incomplete specimen with probably coiled larval and limpet-like postlarval stage is hard to classify at the genus level.

Gastropods

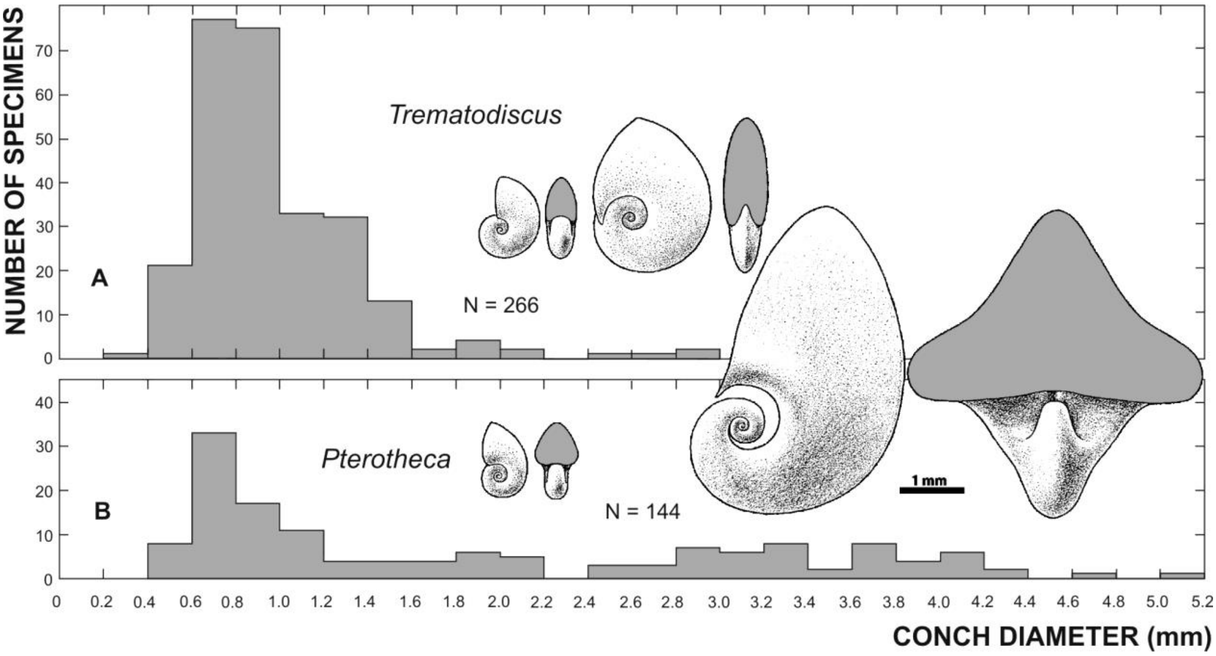
The most common gastropod species in the Stolbovaya II sample counts 110 specimens. Most of them are conchs with a relatively low coil, a rather narrow umbo, and high whorl expansion rate. Perhaps this is a species of *Holopea* but more than one taxon may be there represented. Relatively few specimens are of size suggesting that these are larvae at hatching or immediately after it. The size frequency distribution resembles that of *Pterotheca,* unlike the bellerophontids and Ordovician ‘small shelly fossils’ assemblages from the Baltic region or Argentina (Dzik 2020).

The second in number, 60 specimens, is a gastropod with relatively high coils and angulation of flanks possibly connected with the selenizone. Most are at post-larval stages, the largest one of near centimetre size. More than one species may be represented by these high-spired moulds.

24 specimens of gastropods with a very low coil, relatively open umbo and low expansion rate of various but early postlarval size; this may be a *Raphistoma*-related species. The largest specimen with diameter of 12 mm has been extracted from the sample before being dissolved.

Probably the most unusual gastropod species in the assemblage, of shape unknown among Ordovician gastropods from other regions of the world, is an extremely tall *Subulites* with openly coiled low-spired larva represented by 8 specimens at postlarval stages of development. Of other gastropods known to have an openly coiled embryonic conch, only one juvenile *Platyceras*-like form has been found. The apex is missing which does not allow to determine whether the first coil was loose, as typical for gastropods of this group.

Some specimens of at least the most common among gastropod species listed above show densely distributed diaphragms in the apex. Usually diaphragms develop only in mature gastropod conchs. Unfortunately, the aperture in internal moulds is rarely preserved well enough to be sure that the conch is complete. From the same reason it is not clear whether these are conchs of predated mollusks or of individuals died from other cause.



SMFig. 5. Size frequency distribution of the two most common species of bellerophontids in the basal layer of the Ust'-Stolbovaya Formation and semi-diagrammatic drawings of internal moulds of a specimen immediately after metamorphosis and the largest one in the sample. A. *Trematodiscus* sp. B. *Pterotheca* sp.

Bivalves and scaphopods

All 37 tubular moulds of the probable scaphopod *Rhytiodentalium* are of similar, presumably mature size. The same refers to 25 moulds of juvenile nuculid bivalves, all preserved as articulated shells.

Only six moulds of isolated valves represent postlarval thin-shelled modiolopsid(?) bivalves. Disarticulation and fragmentation of shells of these presumably byssus-attached animals may be as well a result of predation or action of the turbulent water.

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