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Cornulitids from the Upper Ordovician of northwestern Russia

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Abstract: Four cornulitid species occur in the Rakvere Regional Stage in NW Russia. The new species *Conchicolites rossicus* is here described; it is the earliest known *Conchicolites* from the Ordovician of Baltica. The new species has very small tubes with sharp, strong and regular annulations. The diversity of cornulitids in the Rakvere Regional Stage at the Pechurki quarry is usual for the Upper Ordovician of Baltica. The cornulitids of Pechurki quarry encrusted hard organic substrates in a mud bottom (clay and carbonate clay) environment. *Cornulites sterlingensis* occurs both in the Upper Ordovician of North America and Baltica, which suggest a short distance between these two paleocontinents and/or similar environmental conditions.

Key-words:

- tubeworms;
- tentaculitoids;
- Katian;
- Baltica;
- shallow shelf;
- paleobiogeography

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Résumé : ***Cornulitidés de l'Ordovicien supérieur du nord-ouest de la Russie.-*** Quatre espèces de cornulitidés sont présentes dans l'Étage Régional de Rakvere dans le nord-ouest de la Russie. La nouvelle espèce *Conchicolites rossicus* est décrite ici ; c'est le *Conchicolites* le plus ancien connu dans l'Ordovicien de Baltica. Il correspond à des tubes de très petite taille avec des anneaux, aigus et saillants, agencés à intervalles réguliers. La diversité des cornulitidés de l'Étage Régional de Rakvere dans la carrière de Pechurki est assez classique pour l'Ordovicien supérieur de Baltica. Les cornulitidés de la la carrière de Pechurki ont encroûté des supports organiques rigides dans un environnement de fond boueux, argileux et argilo-calcaires. *Cornulites sterlingensis* est connu dans l'Ordovicien supérieur de l'Amérique du Nord et de Baltica, ce qui suggère un faible éloignement de ces deux paléocontinents et/ou des conditions environmentales similaires.

Mots-clefs :

- tubes de vers ;
- tentaculitoïdes ;
- Katien ;
- Baltica ;
- plateau peu profond ;
- paléobiogéographie

1. Introduction

Cornulitids are a group of encrusting tentaculitoid tubeworms evolutionarily closely related to free-living tentaculitids (VINN & MUTVEI, 2009). The zoological affinities of cornulitids have long been debated, but they most likely belong to the Lophothrochozoa (VINN & ZATOŃ, 2012) and presumably represent stem group phoronids (TAYLOR *et al.*, 2010). Their fossils are important tools in palaeoecology because as hard substrate encrusters they generally retain their original position on the substrate after fossilization (TAYLOR & WILSON, 2003). Cornulitids lived only in marine

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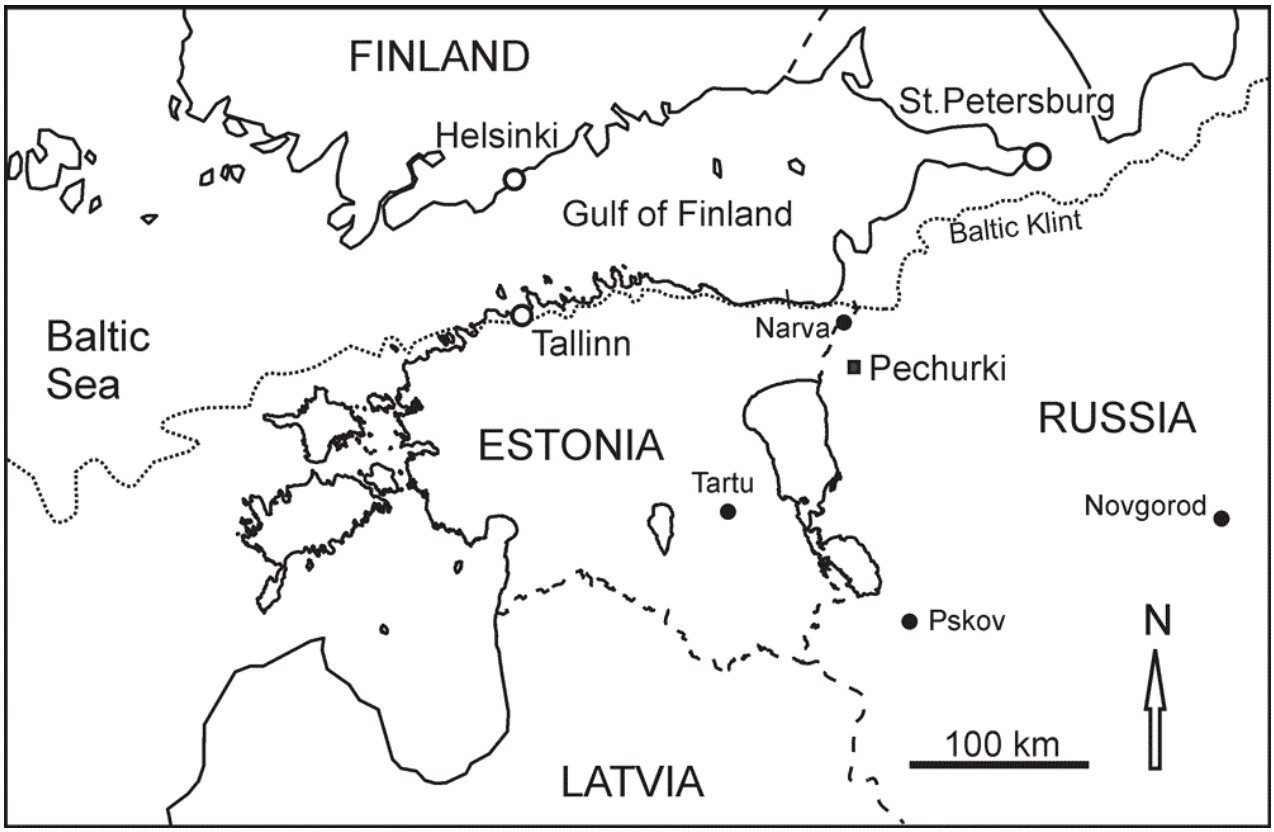

Figure 1: Locality map.

environments with normal salinity, which differs from their close relatives the microconchids that lived in waters of various salinities (ZATOŃ *et al.*, 2012). Fossils of cornulitids are common in shallow marine sediments, especially those associated with carbonate platforms. Cornulitids have a stratigraphic range from the Middle Ordovician to the Late Carboniferous (VINN, 2010). They had a diverse ecology with six adaptive strategies thus far described (VINN, 2010).

Cornulitids of NW Russia are essentially unstudied, mostly due to their minor stratigraphical importance caused by taxonomic uncertainties. Recently Ordovician cornulitids from nearby Estonia were systematically studied in several occasions (VINN & MÕTUS, 2012; VINN, 2013). Some of the cornulitid species here are described in open nomenclature because of the small number of well-preserved specimens available for study. The Ordovician cornulitid species of North America are better studied than those of Baltica. Many 19th Century species need to be revised before one can identify them in the Ordovician of NW Russia with certainty, but an attempt has been made.

The aims of this paper are to: 1) systematically describe fauna of small cornulitid tubeworms from the NW Russia for the first time, and 2) discuss the diversity, ecology and paleobiogeographic distribution of Ordovician cornulitid tubeworms.

2. Geological background and locality

A shallow epicontinental sea covered what will become modern NW Russia during the Ordovician (Fig. 1). The Ordovician of sequence of NW Russia is relatively complete and represented mostly by carbonate rocks except for the terrigenous Lower Ordovician sequence. Ordovician limestones are exposed in NW Russia as a wide belt from the Narva River in the west to Ladoga Lake in the east (NESTOR & EINASTO, 1997). The climate changed drastically during the Ordovician when Baltica drifted from the southern high latitudes to the tropical realm (TORSVIK *et al.*, 2012). The warming of the climate caused an increase in the sedimentation rate of carbonates. Finally, deposits that are characteristic of an arid and tropical climate appeared in the sequence (NESTOR & EINASTO, 1997). The first signs of tropical climate (appearance of tabulate corals, stromatoporoids) are early Katian, but it was not until Hirnantian that they became prevalent (NESTOR & EINASTO, 1997).

The huge quarry in Pechurki is the main source of pure limestone for the concrete factory in Slantsy (DRONOV *et al.*, 2005). The Rakvere Regional Stage (Katian) in the Pechurki quarry is composed of very massive pale grey micritic limestone, without obvious layers. The limestone contains a few extremely thin clayey interbeds. Brachiopods and bryozoans are the dominant fossil groups (DRONOV *et al.*, 2005).

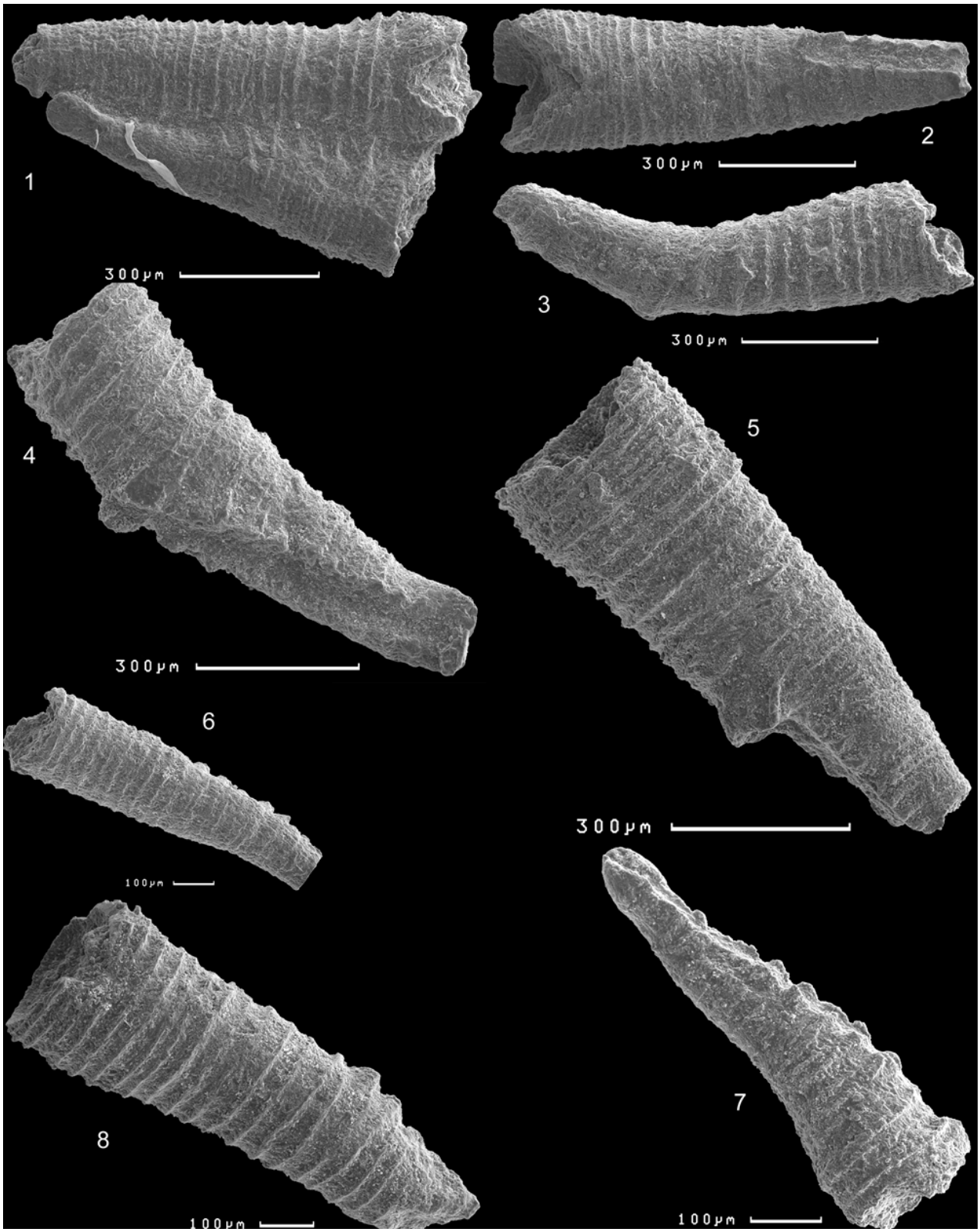

Figure 2: *Conchicolites rossicus* sp. nov. from the Rakvere Regional Stage (Katian) of Pechurki quarry, NW Russia. 1, Holotype (lower specimen with embryonic shell preserved) PIN 5601/3, 2, specimen PIN 5601/1, 3, specimen PIN 5601/7, 4, specimen PIN 5601/9, 5, specimen PIN 5601/11, 6, specimen PIN 5601/13, 7, specimen PIN 5601/19, 8, specimen PIN 5601/16.

3. Material and methods

A huge limestone block with some clay on its surface was found near the Pechurki quarry wall. The clay was scraped and then washed with water and specimens were mechanically picked from the washing residue. A peculiar feature is the numerous pentamerids in the sample. After washing, 58 complete small tubes or fragments of larger tubes of cornulitids were found. Later specimens were coated with platinum and photographed using a scanning electron microscope (SEM). The studied collection is stored at the Paleontological Institute of the Russian Academy of Sciences (PIN), Moscow, collection number 5601.

4. Systematic palaeontology

Phylum *Incertae sedis*

Class Tentaculitida BOUČEK, 1964

Order Cornulitida BOUČEK, 1964

Family Cornulitidae FISHER, 1962

Genus *Conchicolites* NICHOLSON, 1872

***Conchicolites rossicus* sp. nov.**

(Fig. 2)

Type: Holotype specimen PIN 5601/3 (lower tube)

Material: PIN 5601/1 - PIN 5601/11, PIN 5601/13, PIN 5601/14, PIN 5601/16 - PIN 5601/19, PIN 5601/26 - PIN 5601/28, PIN 5601/33, PIN 5601/35, PIN 5601/38, PIN 5601/39, PIN 5601/41, PIN 5601/42, PIN 5601/44, PIN 5601/45, PIN 5601/48, PIN 5601/49 - PIN 5601/54.

Locality and stratigraphy: Pechurki quarry, Rakvere Regional Stage (Katian), Upper Ordovician.

Derivation of name: After the Russia, country of type locality of *Conchicolites rossicus* sp.nov.

Diagnosis: Minute straight to slightly curved shells expanding distally very slowly in diameter. Tubes perpendicularly covered with sharp, strong and regular annulations.

Description: Minute straight to slightly curved shell usually attached to substrate only in its proximal part, sometimes up to half to full length. The tube length is 0.6-1.3 mm (N=13, Mean 0.87 mm, standard deviation 0.18) and diameter of the aperture is 0.20-0.35 mm (N=13, Mean 0.25 mm, standard deviation 0.05). Tubes grew very slowly in diameter. Tube divergence angle is about 9 to 12º, but usually 10º. Tube base is not widened at the attachment to substrate, but has a wavy appearance due to strong annulation. Most attachment scars are elongate and concave consistent with the attachment to a straight stem-like substrate with circular cross section. Some tubes can be attached to each other. In the substrate cemented part, tubes have their maximal diameter at the contact with the substrate. External surface of the tube is covered with strong well-developed, mostly regular perpendicular annulations, but distance between different annular crests varies up to two times. The annular crests are sharp, about four times as wide as interspaces between the crests. Some annular crests are not continuous around the tube's circumference. The interspaces between annular crests are moderately concave and smooth. Fine perpendicular growth lines and longitudinal striae are absent. There are four to five annuli per 0.1 mm near the aperture. The tube lumen appears to be smooth as far as can be detected from broken tube parts. Embryonic chamber bulbous. There is no distinct constriction between embryonic chamber and the juvenile tube part. The juvenile tube gains diameter very slowly after the embryonic chamber. Strong annulation is absent in the most juvenile part of the tube. Tube wall is thin. Tube wall is devoid of vesicular structure. Tube structure is crystalline, homogenous without lamination probably due to diagenetic changes to the tube fabric.

Comparison: This new species is assigned to *Conchicolites* because of its regular strong perpendicular ornamentation and small tube divergence angle. It also presumably has a smooth tube lumen characteristic to the genus. *Conchicolites rossicus* sp. nov. resembles *Cornulitella minor* NICHOLSON, 1872 (p. 57, Fig. 3a-3b) in its small size and regular perpendicular annulation, but differs in having smaller tubes and stronger annulation. This new species resembles somewhat *Conchicolites hosholmensis* VINN & MÕTUS, 2012 (p. 3-4, Fig. 2.A-D) from the Katian of Estonia by its smooth tube lumen, but differs in having strong perpendicular ornamentation.

Genus *Cornulites* SCHLOTHEIM, 1820

***Cornulites* cf. *sterlingensis* MEEK & WORTHEN, 1866**

(Fig. 3)

1888 *Cornulites sterlingensis*- HALL, Pl. CXV, fig. 7

Material: Two partially preserved tubes PIN 5601/57 and PIN 5601/58.

Locality and stratigraphy: Pechurki quarry, Rakvere Regional Stage (Katian), Upper Ordovician.

Description: Small tubes which expand slowly to moderately in diameter. Better preserved tube has diameter of 1.3 mm. Tubes free parts relatively long. Tubes covered with regular strong annulation with sharp crests. Interspaces between annuli deep and concave. Deepest immediately

after the preceding annular crest. There are three annuli per 1 mm in a tube fragments studied. Tubes covered with well developed strong longitudinal striae. There are five to six striae per 0.3 mm

Remarks: Studied specimen closely resembles *Cornulites sterlingensis* MEEK & WORTHEN, 1866 (HALL, 1888, Pl. CXV, fig. 7) from Cincinnatian (Late Ordovician) of Ohio, but has slightly smaller size.

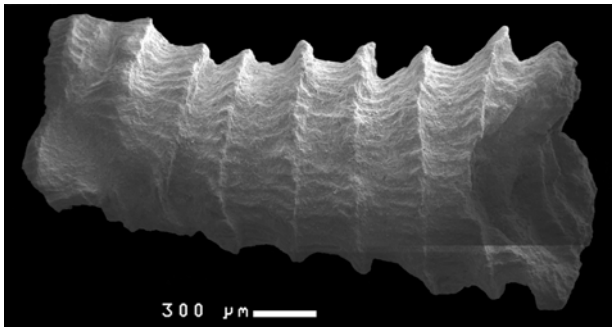

Figure 3: *Cornulites* cf. *sterlingensis* MEEK & WORTHEN, 1866, from Rakvere Regional Stage (Katian) of Pechurki quarry, NW Russia, specimen PIN 5601/58.

Cornulites sp. A

(Fig. 4)

2013 *Cornulites* sp. C - VINN, p. 110-111, Fig. 8.

Material: PIN 5601/15, PIN 5601/56.

Locality and stratigraphy: Pechurki quarry, Rakvere Regional Stage (Katian), Upper Ordovician.

Description: Straight to moderately curved small tubicolous shell. Tubes covered externally with relatively regular moderately developed annulation. The tubes ornament is composed of well-developed regular longitudinal striae and smaller number of well-developed relatively regular perpendicular growth lines. The growth lines are slightly coarser than the striae. There are seven to eight striae per 0.3 mm and three to six growth lines per 0.3 mm. The interior of tubes is covered with well-developed regular annulation with sharp crests. The distance between annular crests is about 0.3-0.5 mm at the tubes diameter >0.7 mm.

Remarks: Studied tube fragments closely resemble *Cornulites* sp. C (VINN, 2013, p. 110-111, Fig. 8) from the Rakvere Regional Stage (Katian) of Estonia, but are slightly smaller presumably due to juvenile age of studied specimens.

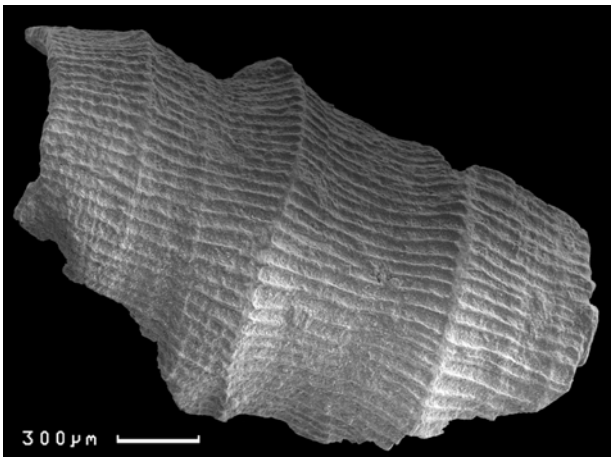

Figure 4: *Cornulites* sp. A from Rakvere Regional Stage (Katian) of Pechurki quarry, NW Russia, specimen PIN 5601/56.

Cornulites ? sp. B

(Fig. 5)

Material: Single poorly preserved tube PIN 5601/55.

Locality and stratigraphy: Pechurki quarry, Rakvere Regional Stage (Katian), Upper Ordovician.

Description: Straight small tubicolous shell with somewhat quadrate cross section, covered with fine perpendicular growth lines and few sharp spine-like appendixes. Annulation not observable. Tubes expand distally moderately in diameter.

Remarks: It is possible that studied specimen may not belong to cornulitids due to its somewhat quadrate cross section, but it is tentatively assigned to *CORNULITES* because of conical shape of the tube and its moderate divergence angle.

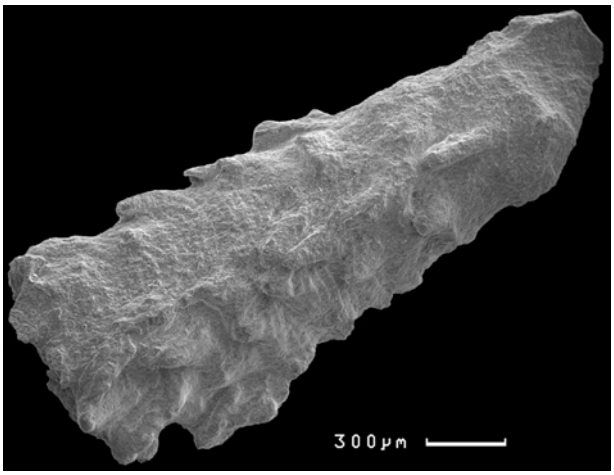

Figure 5: *Cornulites* ? sp. B from Rakvere Regional Stage (Katian) of Pechurki quarry, NW Russia, specimen PIN 5601/55.

5. Discussion

Diversity

The fossils of cornulitids have been reported from the Uhaku Stage (Darriwilian) to Pirgu Stage (late Katian) in Baltica (VINN, 2013). Six cornulitid species are known from the Katian of Baltica (VINN, 2013). There was a rapid diversification of cornulitids in the Late Ordovician of Baltica (VINN, 2013). The diversity of cornulitids (*i.e.*, three or four species) in Rakvere Stage of Pechurki quarry is usual for the Ordovician of Baltica and similar to that of Rakvere Stage in Estonia (VINN, 2013). However, the other Ordovician records of cornulitids of similar age from Baltica contain only *Cornulites* and no *Conchicolites*. The hitherto earliest known *Conchicolites* from Baltica is *Conchicolites hosholmenis* VINN & MÕTUS, 2012, from Adila Formation (Vormsi Regional Stage) of Vormsi Island, Estonia. The latter species was a specialized symbiont in tabulate corals (VINN & MÕTUS, 2012). Thus, two genera of cornulitids occurred earlier in the Katian of Baltica than previously known. The diversity data on cornulitid tubeworms from the Late Ordovician of Baltica are poor. However, data collected by VINN (2013) are consistent with the rapid global generic diversification of cornulitid tubeworms in the Late Ordovician. In general, cornulitids seem to be rarer in the Late Ordovician of Baltica than in the Late Ordovician of North America (VINN, 2013). It is likely that diversity and number of cornulitids was not actually higher in North America than in Baltica during the Late Ordovician and the difference is due to a study bias.

Palaeoecology

All the studied cornulitids from the Rakvere Stage of Pechurki quarry occur in normal marine shelf sediments of a carbonate platform. It is difficult to reconstruct the depth distribution of the cornulitids in the Katian of Pechurki quarry in NW Russia because exact data on palaeodepth are absent. However, the studied material is derived from NW Russia, which was covered with a relatively shallow sea during the Late Ordovician. The cornulitids of Pechurki quarry encrusted hard organic substrates in a mud bottom (clay and carbonate clay) environment. As far it can be detected from attachment scar morphology *Conchicolites rossicus* sp. nov. was attached to straight stem-like structures, presumably to stems of crinoids. In the Late Ordovician of North America, cornulitids attached to stems of living crinoids (MORRIS & FELTON, 2003). This is also possible for *Conchicolites rossicus* sp. nov. from Pechurki quarry. However, no specimen was found to be attached to remains of crinoid columnals. Thus, an alternative explanation is also possible. *C. rossicus* sp. nov. may have been attached to some organic stem-like structures, some algae perhaps, which did not fossilize. Some attachment scars in *C. rossicus* sp. nov. are slightly concave in longitudinal direction, which could indicate attachment to a convex shell such as in many brachiopods.

Palaeobiogeography

Cornulites sterlingensis occurs both in the Late Ordovician of North America and Baltica (HALL, 1888; VINN, 2013). Similarly, *Cornulites* sp. A resembles closely some forms figured by HALL (1888) from the Late Ordovician of North America. During the Late Ordovician North America (Laurentia) was not very distant from NW Russia (Baltica) and it is likely that both continents shared some fauna. In the Late Ordovician, Baltica and North America were also in a tropical climatic zone which probably facilitated migration of species between two continents. In contrast, there are no reports of forms similar to *Conchicolites rossicus* from the Late Ordovician of North America. It is possible that *Conchicolites* originated from Baltica or alternatively North American small cornulitids are not well enough documented.

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