Organic Remains of Tentaculitids: New Evidence from Upper Devonian of Poland

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Organic remains of tentaculitids: New evidence from Upper Devonian of Poland

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Organic remains of tentaculitids have been recovered during palynological research on archival samples from the Dobrzyca 2 borehole (Western Pomerania). Until now tentaculitids are widely known from their abundant mineralised shells. As organic remains, on the other hand, they have only been known since 2004. The present discovery is currently the second one of this kind found in Upper Devonian strata. The shape and morphology of some recognized tentaculitid organic remains are similar to embryonic and juvenile forms of dacryoconarids belonging to orders Nowakiida and Stylionida. Based on palynomorphs, the age of the two samples investigated has been established as Frasnian, RB and RD local miospore zones.

Key words: Tentaculita, Dacryoconarida, organic remains, Frasnian, Devonian, Western Pomerania, Poland.

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Introduction

Upper Devonian sediments from the Western Pomerania (northern Poland; Fig. 1) have been investigated palynologically many times, beginning in 1970 (e.g., Turnau 1978, 1979; Clayton and Turnau 1990; Avkhimovitch and Turnau 1994). The local microfloristic scheme introduced by Turnau (1978) was finally stratigraphically extended by Stempień-Sałek (2002). Thanks to previous works, the succession of mainly land-derived microflora has been established. Meanwhile, less attention was paid to other palynomorphs in investigated samples, e.g., acritarchs and prasinophytes. Only Stempień-Sałek (1997) documented three acritarcha assemblages from the Western Pomerania area. Thanks to the present research on archival samples from the Dobrzyca 2 borehole (Jarzynka 2008) some zooclasts belonging to tentaculitid organic remains have been found among miospores and phytoplankton. This is the second record of such zooclasts among palynomorphs, having also been so far described from the Giełczew IG5 borehole in the Radom-Lublin area (Wood et al. 2004; Fig. 1).

Tentaculitids are small, enigmatic, extinct marine animals known mainly from their mineralised shells of conical shape. They were very abundant and widespread, especially in the Upper Devonian, and were a principally casualty of the Frasnian/Famennian mass extinction (Walliser 1996; Racki et al. 2002; Bond 2006). Matyja (2006), when generally characterizing fauna, mentioned tentaculitids as very abundant in the Upper Frasnian strata (Człuchów Formation) of the Western Pomerania (northern Poland).

The main aims of this paper are to describe the tentaculitid organic remains from the Frasnian of Western Pomerania and compare them to the well-known embryonic and juvenile forms of biomineralised tentaculitid skeletons, in order to find any possible taxonomic relationships. We also believe, that the described tentaculitid organic remains may help in future to resolve the problems concerning their phylogenetic affinities.

Institutional abbreviation.—GIUS, Faculty of Earth Sciences, University of Silesia, Sosnowiec, Poland.

Geological setting

Western Pomerania is located in NW Poland (Fig. 1); the Dobrzyca 2 borehole was situated in its NE part, close to the Teisseyre-Torquist Zone. The area is part of the Koszalin fault zone, which is part of transcontinental tectonic zone (Dadlez 2000). Generally, this area comprises folded and dislocated Palaeozoic sediments (Koszalin-Chojnice area, e.g., Matyja 2006).

Devonian strata are present only in the eastern, erosive border of the Koszalin-Chojnice-Toruń area (e.g., Turnau 1979; Matyja 2006). They are developed in various facies from siliciclastics in the lower and partly middle part, and carbonate rocks in the upper part of the section (Dadlez 1978). In the Late Devonian, the discussed area was inundated by marine transgression resulting in deposition of clastic and carbonate sediments (Stemipeń-Sałek 2002; Matyja 2006). The Fras-

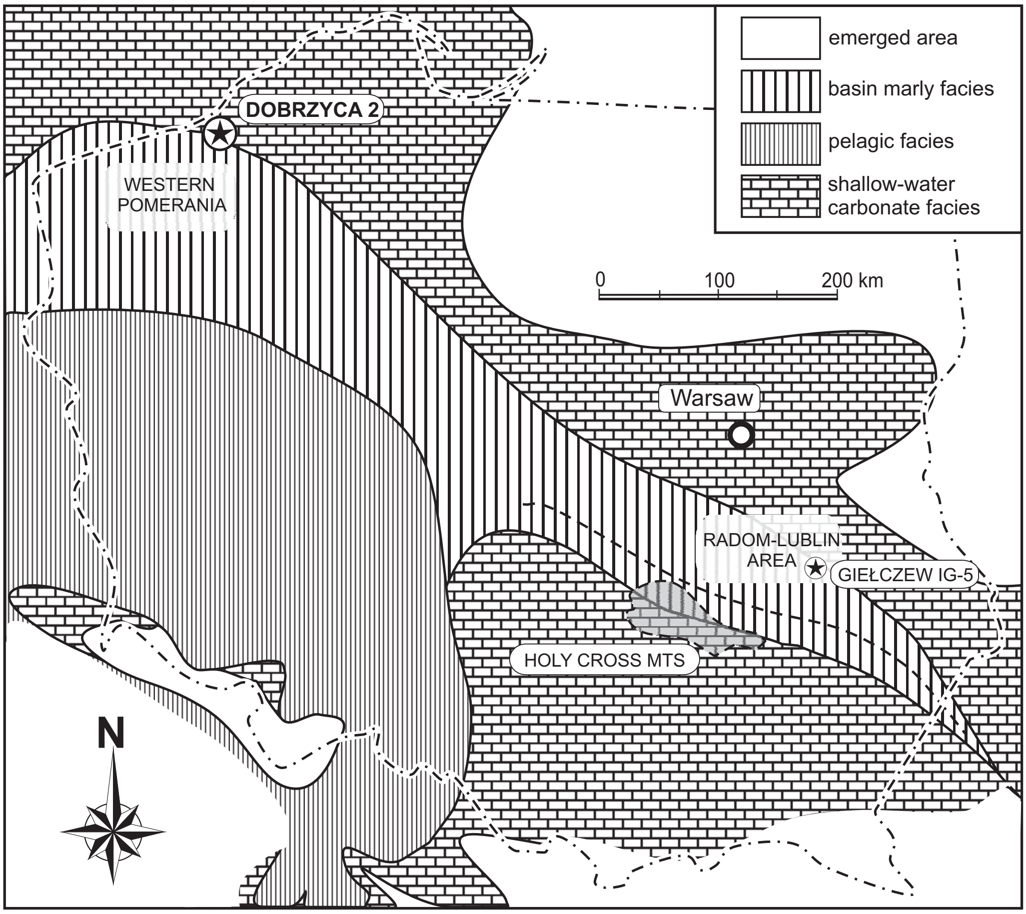

Fig. 1. Localization of the investigated Dobrzyca 2 borehole; schematic geological Upper Devonian background after Turnau and Racki (1999).

nian sediments are lithologically very differentiated, with carbonate rocks dominating, recording deposition in a rather shallow basin (Matyja 2006).

Material and methods

Standard laboratory procedures were used to remove mineral matter from five palynological samples (Wood et al. 1996). All samples contained well-preserved palynomorphs, mainly phytoplankton (acritarchs and prasinophytes), land-derived palynomorphs (miospores and plant tracheids) and zooclasts (scolecodonts and organic tentaculitids). Tentaculitid remains have been noticed in two samples from depths 4264 m and 4208 m. The preservation state of palynomorphs was very good. At least three slides were prepared from each residue. Cellosize was used as a dispersal agent to avoid organic clumping, and Peropoxy 154 was used as a mounting agent. Remaining rock samples were reviewed under the SEM microscope and normal transmitted light microscope but no other mineral traces of tentaculitids could be observed.

The palynological slides and residues are housed at GIUS. Examination and documentation was done using transmitted light microscope Olympus BX51.

Palynostratigraphy

Beside the standard miospore schemes for the Upper Devonian (e.g., Richardson and McGregor 1986; Strell et al. 1987; Avkhimovitch et al. 1993) a local miospore zonation for the Western Pomerania area (Fig. 2) was introduced by Turnau (1978) and much refined by Stempień-Sałek (2002).

Taking the presence of two index miospore species *Membrabaculisporis radiatus* and *Tholisporites densus* into account, the age of the sample from depth 4264 m was established as the RD (*Membrabaculisporis radiatus–Tholisporites densus*) local miospore Zone (Fig. 2; Stempień-Sałek 2002). Chronostratigraphically this zone belongs to the Frasnian but lithostratigraphically to the Człuchów Formation (Matyja 2006). Beside the index species, other miospores are present, such as *Corystisporites pomeranius*, *Hystricosporites multifurcatus*, *H. furcatus*, *Ancyrospora furcula*, and *A. fidus*, and species of the genera *Archaeoperisaccus* and *Geminospora*. The presence of stratigraphicaly long-ranging species like e.g., *Endoculeospora gradzinskii, Punctatisporites* spp. and *Retusotriletes* spp. is also noticed.

The age of the sample from a depth of 4208 m has been established as the RB (*Membrabaculisporis radiatus–Cymbo-*

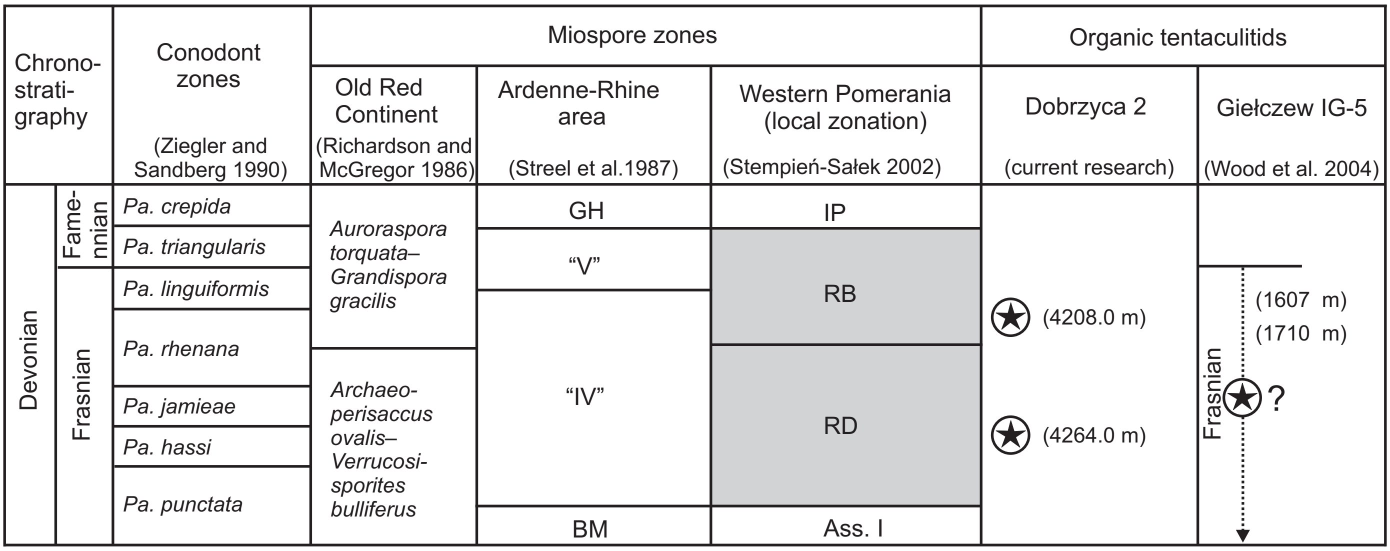

Fig. 2. Correlation among the Upper Devonian standard conodont zonation and standard miospore zonations for Old Red, Western Europe and local miospore zones for Western Pomerania. Diagonal pattern indicate recognized miospore zones. Pa, Palmatolepis.

sporites boafeticus) local miospore Zone (Stempień-Sałek 2002). Two index species *Membrabaculisporis radiatus* and *Cymbosporites boafeticus* were found among other miospores. Chronostratigraphically this belongs to the Frasnian/Famennian boundary interval (Fig. 2). According to Stemień-Sałek (2002), other characteristic miospores for this level noticed here are: *Aneurospora greggsii*, *Apiculiretusispora nitida*, and *Diducites radiatus*, along with less stratigraphically important miospores like *Stenozonotriletes conformis*, *Hystricosporites multifurcatus*, *H. furcatus*, *Ancyrospora fidus*, and *A. furcula*. Taking the presence of such miospores like *Diducites radiatus*, *Archaeoperisaccus ovalis*, and *Cristatisporites trivialis* into account, we suggest that our material belongs to the lower Frasnian part of this Zone (Fig. 2). According to Avkhimovitch et al. (1993) the species mentioned above range up to the Upper Frasnian (see also Mantsourova 2003; Filipiak and Zbukova 2006).

Summarizing, the age of the samples was established palynologically as the Middle/Upper Frasnian (Fig. 2; Jarzynka 2008) confirming the independent investigation of conodonts (*Palmatolepis rhenana* conodont Zone; see Fig. 2) by Hanna Matyja (unpublished data, with permisson).

Organic remains of tentaculitids

The main palynological remains are small, usually acid-resistant and mostly of plant origin (e.g., Tyson 1993; Batten 1996; Traverse 2007). Most of them belong to the plant kingdom, but there exists a large group of particles probably of animal origin. Depending on age of the sediment analyzed, there are sometimes very common remains of graptoloids, scolecodonts (Szaniawski 1996), arthropod cuticles (Miller 1996a), or in younger strata foraminiferal internal organic linings (Stancliffe 1996). Common chitinozoa probably are of animal origin, as well (Miller 1996b). Generally, palynomorphs are rather cosmopolitan and their concentration in sediments varies, but in some cases even a few thousand of fossils per gram of rock can be retrieved.

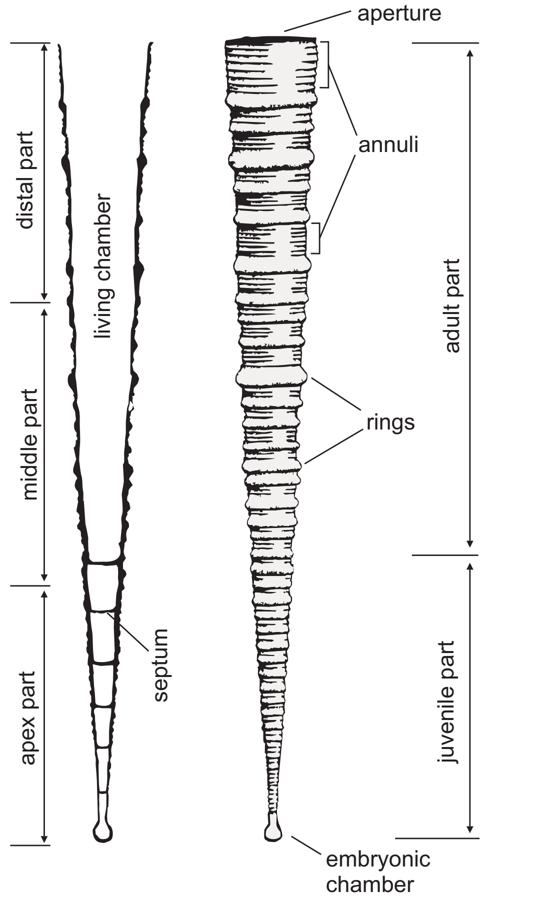

Fig. 3. Inner and outer structure of mineral tentaculite shell (from Larsson 1979 and Wood et al. 2004, modified).

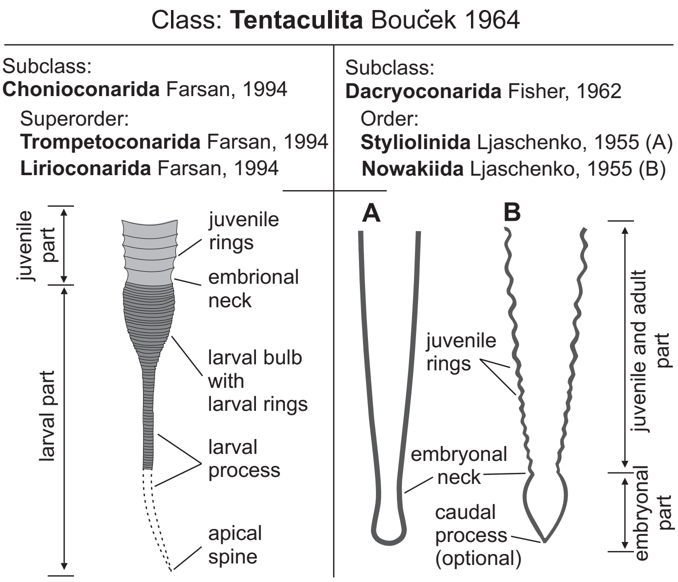

Fig. 4. The different shape, size and microstructure of the early ontogenetic parts of mineral tentaculitids and the taxonomic consequence (from Farsan 2005, modified).

Organic remains of tentaculitids have not been known until 2004 despite an extensive published record of Palaeozoic palynomorphs. Wood et al. (2004) were the first to describe and connected organic Frasnian particles with tentaculitid mineral shells. Their findings were derived from the Giełczew IG 5 borehole in the Radom-Lublin area (central Poland) (Fig. 1; Wood et al. 2004). It has been known that these enigmatic invertebrates possessed a multi-layered conch, consisting of rather thick mineral calcite and two thin, external and internal, organic layers (e.g., Blind 1969; Larson 1979). Commonly, their adult size was between several dozen of micrometers to several dozen of millimeters. Generally speaking, tentaculitids possessed gradually tapering conical shells with proximal growth angle of 2–10°, and were smooth or covered with dense rings and annuli (Fig. 3; e.g., Buček 1964). Inside the proximal part of the shell some of them (Trompetoconarida) possessed mineral septa (Larsson 1979; Farsan 2005). On the early developmental stage tentaculitids possessed two different modes of construction (Fig. 4) that are the basis for their classification at higher taxonomic level. The juvenile representatives of the subclass Chonioconarida possess a larval bulb with a succeeding long needle-like process (see Fig. 4). The representatives of the subclass Dacryoconarida, on the other hand, possess a drop-shaped embryonic chamber which may have a caudal process additionally (see also Farsan 1994, 2005).

The currently obtained material consists of thirteen organic remains of tentaculitids. Ten of them possess natural ending of apical ends, sometimes with well-defined embryonic chambers. However, the remaining three specimens possess only broken tubes without chambers (Fig. 5). Generally, some of them possess more or less gradually tapering conical shells, ornamented by dense rings and annuli. Other specimens are only slightly wrinkled without well-defined rings. The size of the tubes are different, ranging from 100 µm to 300 µm. Some specimens possess almost spherical embryonic chambers (e.g., Fig. 5F, G, M); the other ones have only elongate shape, slightly broader when compared to the rest of the tubes (e.g., Fig. 5B, D, I, K). The diameter of the spherical chambers is between 8 and 20 µm, while the diameter of the narrower apical endings is 5–7 µm (see Fig. 5) and very close to the tube diameter. Annuli and transverse rings are not always preserved in the same way. They are very distinct on some of the specimens (see Fig. 5E, G, H, L, M); however, on the others they are hardly visible (Fig. 5B, D, K). It is a rule in this material that forms with big spherical embryonic chambers generally possess more ornamented surface of their tubes. The ring density is also different in specimens with greater diameter (22–27 per 100 µm; see Fig. 5E, L, M) than in those of smaller diameter (approx. 38 per 100 µm; see Fig. 5A). The degree of broadening of organic remains varies as well. Because we have not observed long larval processes (Fig. 4), or even their traces, we believe that those organic remains (especially with chambers preserved) belong to the subclass Dacryoconarida. Moreover, it seems that these tentaculitid organic remains can be classified in two groups. The first with well-defined embryonic part as spherical chambers and more visible rings (Fig. 5A, E–H, M) may represent the order Nowakiida, and the second one with slightly broader apical parts and smoother surface (Fig. 5B, D, I–K) may represent order Styliolinida (see Fig. 4). It is difficult to univocally classify some of the organic remains into these two orders because they are poorly preserved (Fig. 5C) or possess both features—rather small chamber and well defined rings (Fig. 5L). Probably, those tentaculitids with big embryonic chambers, greater diameter and visible rings and annuli (Fig. 5A, E–H, M), represent external layers. However, we cannot preclude that specimens without bulbous chambers, with smaller diameter and wrinkled organic surface represent internal(?) organic layers (Fig. 5B, D, J, K). Some researchers (Olev Vinn, personal communication 2008) doubt that they at all had an inner organic shell layer. Lack of such layer in mollusks and lophophorates to which tentaculitids have most often be affiliated support this hypothesis.

According to Wood et al. (2004), the Frasnian organic remains from the Radom-Lublin area represent the outer organic layers of tentaculitid shells. Their conclusions were based on distinctive morphology, general shape, divergence angle of the tube and the presence of distinct embryonic chambers (see Wood et al. 2004: 255, fig. 3). Wood at al. (2004) tentatively classified their specimens to the genus *Nowakia* (Dacryoconarida). But it seems that the organic material presented here from the Western Pomerania is much more complex taxonomically. The tubes often differ from each other and in many cases possess different features when compared to the material from the Radom-Lublin area (general shape, size, shape of embryonic chamber, rings). There is no extensive data in the literature concerning tentaculitids

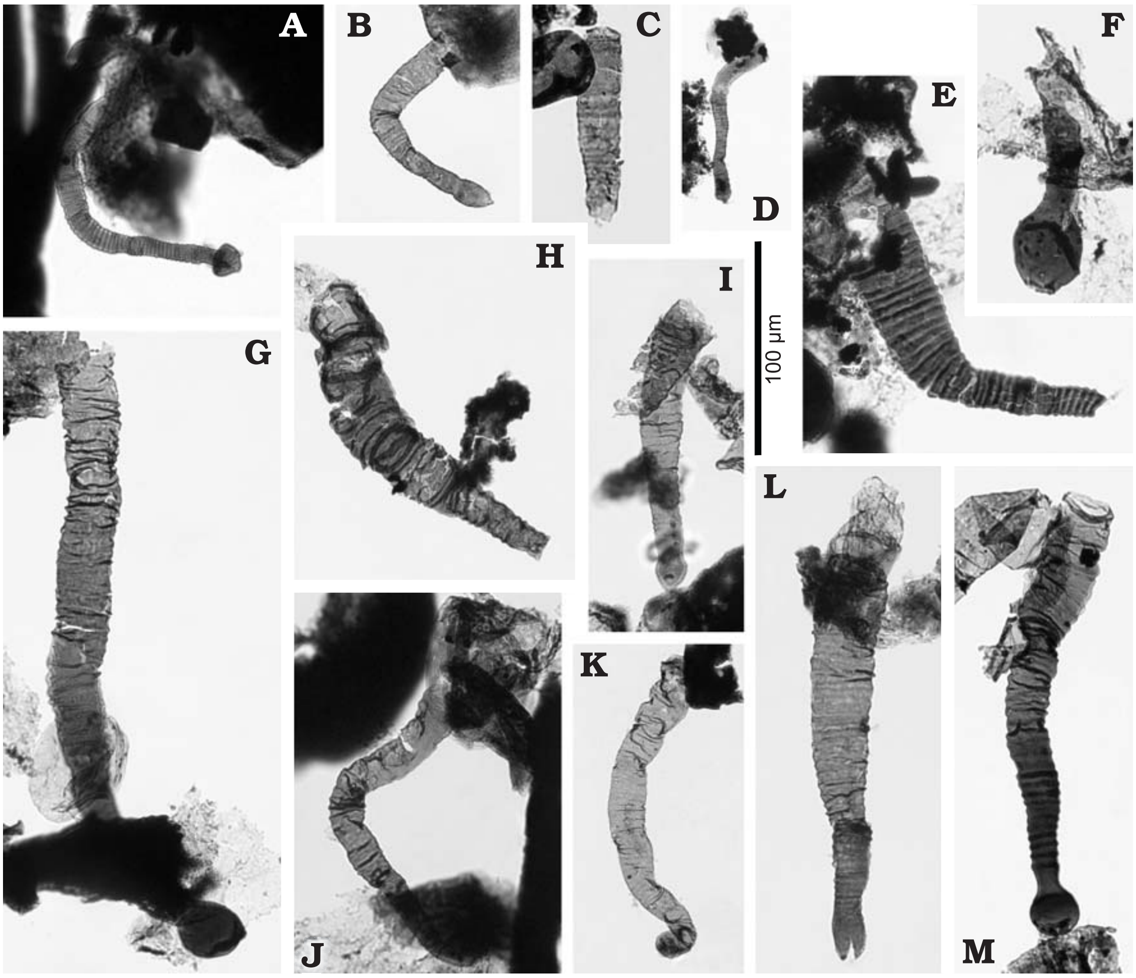

Fig. 5. Organic tentaculite remains. **A**, **E**?, **F**–**H**?, **L**?, **M**. Nowakiida. **B**, **D**, **I**–**K**. Styliolinida. **C**. Problematic. A, D–G, J, M, depth 4208 m, GIUS 4-3510 Do4208; B, C, H, I, K, L, depth 4264 m, GIUS 4-3511 Do4264.

from the Frasnian of Western Pomerania. Abundant tentaculitid groups described from the Polish Frasnian deposits, especially of the Holy Cross Mountains (central Poland), are represented by the species belonging to the genus *Homoctenus* (Homoctenida) (e.g., Hajłasz and Sarnecka 2003; Bond 2006), but the latter belongs to the subclass Chonioconarida. Only Hajłasz and Sarnecka (2003) showed three genera belonging to the subclass Dacryoconarida from the Polish Frasnian deposits. These are *Nowakia*, *Styliolina*, and *Viriatellina*. It is probable that among these genera possessing mineral shells, the representatives of presently described organic remains may belong to. However, precise and certain relationship of these organic remains with mineralised tentaculitids genera/species require more observations on numerous specimens, especially juvenile forms, representing both mineralised shells and organic remains.

Our present discovery of tentaculitid organic remains in palynological material confirms the presence of these palynomorphs in the Upper Frasnian of Western Pomerania (northern Poland). We believe that finds of tentaculitids preserved as an organic layer will help in future resolve the problems concerning their phylogenetic affinities.

Acknowledgments

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