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Organic-walled tentaculids of Late Devonian (Frasnian) deposits of the Appalachian and Michigan Basins, Laurussia (NY, MI, OH)

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ABSTRACT

This is the first report of organic-walled tentaculid remains from Givetian through Frasnian age deposits of the Michigan and Appalachian Basins in western Laurussia. This adds to the geographic scope of similar finds that have been described from the Frasnian through the Famennian in eastern Laurussia. However, those previous specimens were retrieved through palynological preparations and more closely resemble sheath structures rather than the full forms found herein, which were retrieved through complete maceration with ammonium surfactants.

KEYWORDS **Tentaculids. *Styliolina*. Organic-walled. Devonian. Michigan Basin. Appalachian Basin.**

INTRODUCTION

The low-Mg calcite shells of tentaculids are known from the Early Ordovician to the Late Devonian worldwide. These cosmopolitan zoomorphs, problematic in their phylogenic affinity (Vinn and Zatoń, 2012), have previously been considered to be victims of the Frasnian–Famennian mass extinction (Racki, 2005; Traverse, 2007; Walliser, 1996). However, there are now records of tentaculids recovered after this extinction event showing that some members of the group persisted until the end of the Devonian (Bond, 2006; Li, 2000; Marshall and Tel'nova, 2012, 2017; Niko, 2000). The late surviving forms of Laurussia appear to lack a mineralized shell (Marshall and Tel'nova 2012, 2017) according to recent reports of unique tentaculids retrieved from palynological residues from Frasnian sediments of Poland (Filipiak and Jarzynka, 2009; Kondas and Filipiak, 2021; Wood *et al.*, 2004) and the Famennian Komi Republic, Russia (Marshall and Tel'nova, 2012, 2017) suggesting that the survival of these particular tentaculids may have been achieved due to a shift from low-Mg calcite shell to existing within an organic sheath-like structures.

Recent investigations of Laurussian basins deposits conducted on sediments derived through complete maceration of whole rock samples in the Appalachian and Michigan Basins, have rendered previously unreported microtektite deposits across these basins (Lash, 2019; Meehan and Lash, 2021) and abundant microfossil assemblages that include calcareous and agglutinated foraminifera (Li *et al.*, 2021), and well-preserved marine algal material (Meehan, 2022). In addition to these microfossils, enigmatic tentaculid-like forms lacking shell material have also been retrieved from these macerated shales and limestones.

MATERIALS AND METHODS

Rock materials were collected (with permissions) at the construction site of the new Ford House Museum Visitor Center, Grosse Pointe Shores, Michigan, in the form of well spoils of the Frasnian Antrim Shale (Norwood Member) and upper-most limestone of the Traverse Group; outcrop samples from Sylvania, Ohio were taken from the Antrim

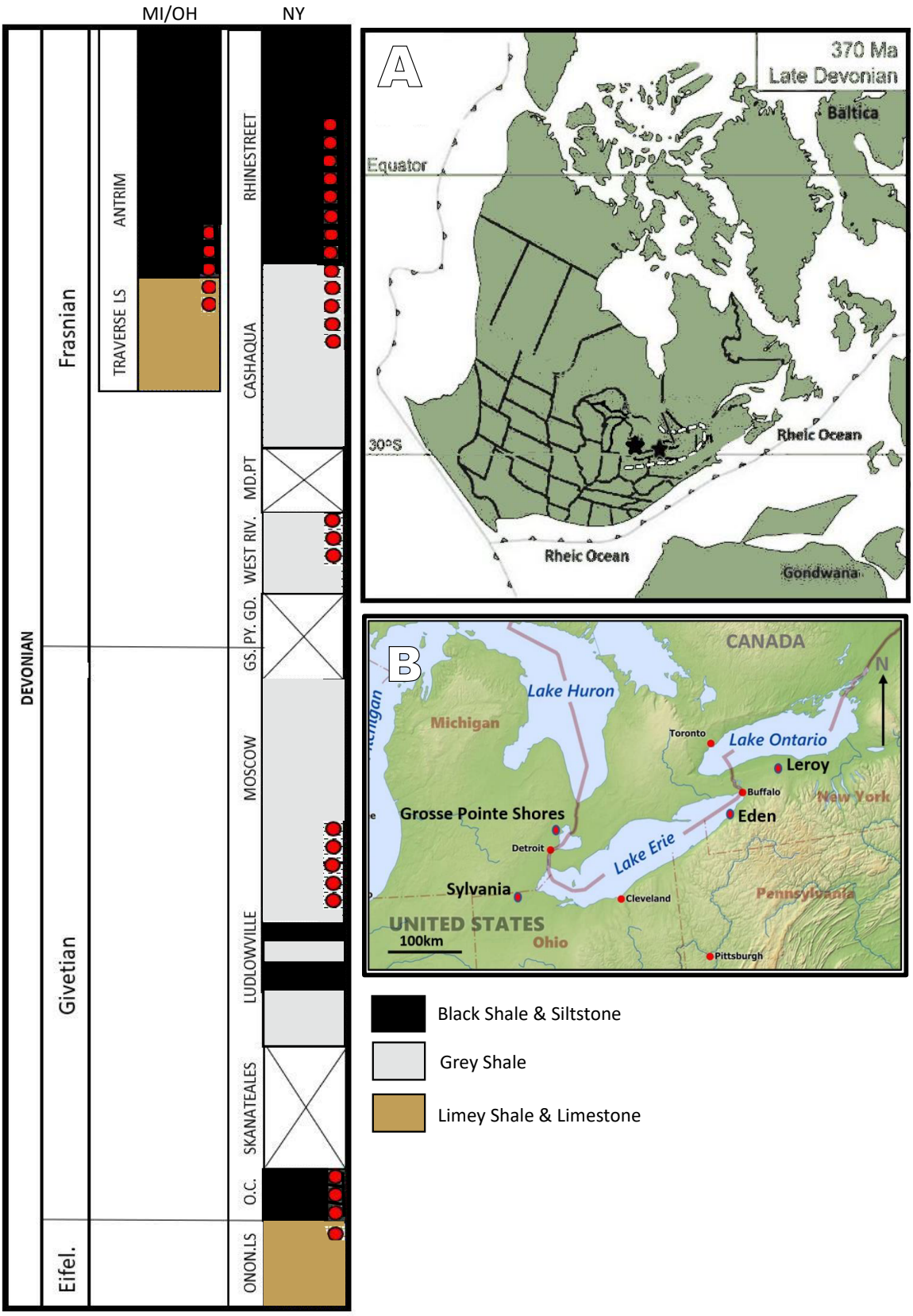

FIGURE 1. General stratigraphy of southeast Michigan/northwest Ohio (left column), and western New York (right column), red dots denote the approximate location within the column from which the samples were taken; A) paleogeography of Laurasia in the Late Devonian adapted from Cocks and Torsvik (2011); B) locations of material collected.

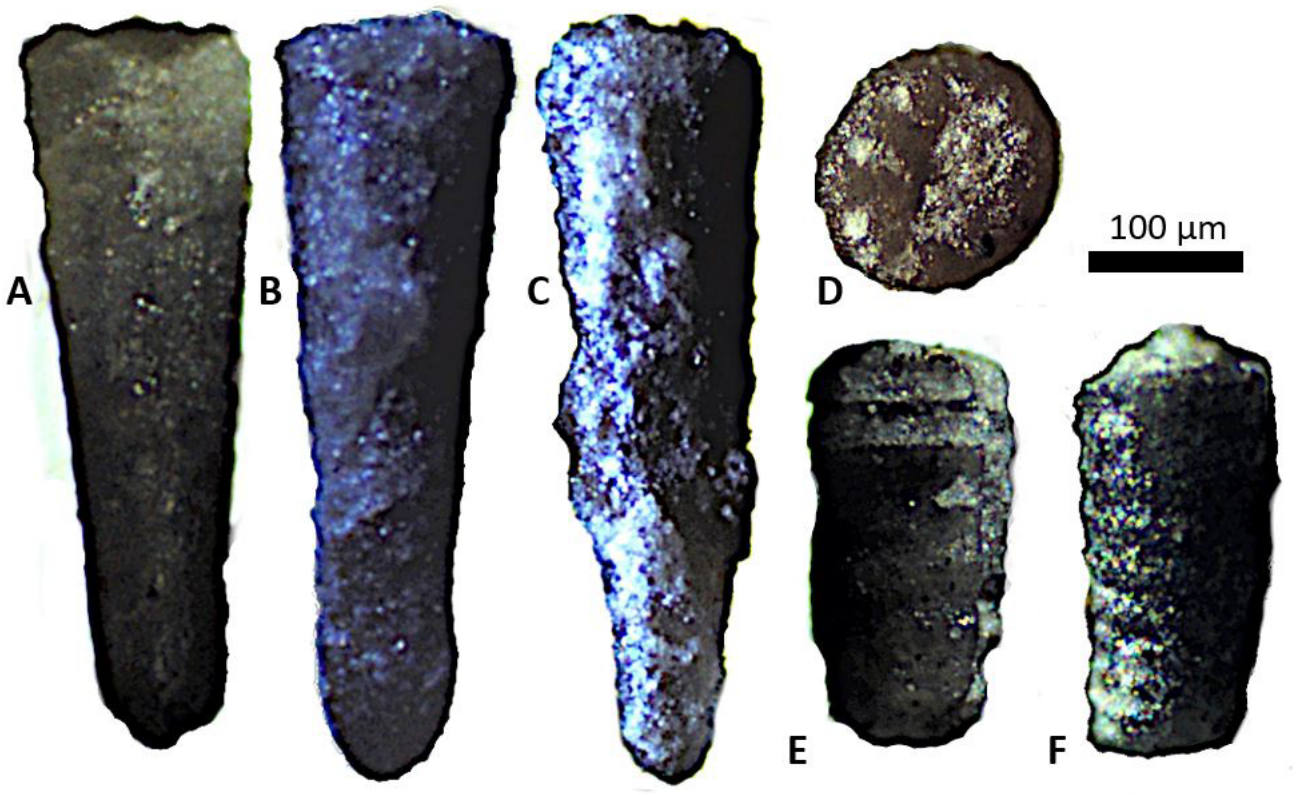

FIGURE 2. Stereoscope images of tentaculid fossils: A–C) lateral view of septum and embryonic chambers of smooth textured Styliolina indet. A) Traverse Group (Sylvania, OH), B) Cashaqua Formation (Eden, NY), C) Ludlowville Formation (Eden, NY); D) top view of Styliolina septum fragment from the Moscow Formation (Eden, NY); E–F) Viriatellina indet., E) Traverse Group (Grosse Pointe Shores, MI), F) Oatka Creek Formation (LeRoy, NY).

Shale and Dundee Limestone; Eden and LeRoy, New York outcrops of the uppermost meter of the Onondaga Limestone and 9m of the Oatka Creek Formation, (LeRoy); select members of the Ludlowville Formation (Wanakah Shale Member; Eden); Moscow Formation (Windom Shale Member; Eden); Genesee Formation (West River Shale Member; Eden); Cashaqua Formation (Eden), and the Rhinestreet Formations (Eden). These samples ranged in age from upper Givetian to middle Frasnian (Fig. 1). Whole rock samples were processed through a quaternary surfactant-based complete digestion methodology detailed in Meehan *et al.* (2020). Macerated shale materials left suspended in surfactant were run through a series of nested sieves (500, 355, 212, 90, and 63μm) and dried at room temperature (~20ºC). The remaining sediment was sifted through, and then imaged using simple transmitted light microscopes and stereoscopes. To confirm that the translucent specimens were of carbonaceous or kerogenic origin rather than matrix-filled casts, several tentaculid-like forms, and agglutinated and calcareous foraminifera, all from the same deposits, were placed on a porcelain spot plate (reaction plate), weighed for Loss On Ignition (LOI) calculations, and then heated at 200°C for 2 hours and finally 2 hours at 500°C in a muffle furnace.

RESULTS

All localities and samples noted on Figure 1 contained varying abundances of tentaculid specimens. There is no statistical significance between specimen abundances and lithology. It should be noted that samples were taken from the Rhinestreet Formation from its base through the formation's lowermost 12m and the upper-most 6m, the Angola was sampled at its lower-most 6m and upper-most the entire Pipe Creek Formation, and the lowermost 8m of the Hanover Formations along Eighteenmile Creek, and none of these samplings yielded tentaculid specimens. The apparent loss of these tentaculid forms coincides with the termination of a ^{13}C excursion identified as a muted North American expression of the *punctata* Event (Lash, 2019) at 1m above the Rhinestreet-Cashaqua contact.

No carbonate tentaculid or stylinoid shells were found on whole rock samples prior to maceration or within the resulting macerated sediments. All tentaculid-like specimens were translucent and amber to gray in color. All specimens were diminutive in size, ranging from 75μm to 225μm in length and with an average width of 65μm at their widest point. About 15% of specimens examined

retained their initial bulbous chambers (Fig. 2A–C); 85% of specimens, though all kerogenic material, were the proximal portion of tentaculid juvenile shells (Fig. 2E–F). Cross sections of specimens (Fig. 2D) reveal notch-like patterning similar to that of baculite and ammonite suture patterns. Approximately 75% of specimens examined lack texture and ornamentation (Fig. 2A–D) and ~25% of specimens have transverse ring ornamentation with consistent interspacing (Fig. 2E–F). The specimens imaged in Figure 2A–C bear strong resemblance to *Styliolina* as identified and reconsidered by Yolchenson (1986). Figure 2E–F bear strong resemblance in external texture, ornamentation, and general shell shape and tapering to the Givetian genera *Viriatellina* (Dacryoconarida) identified by Lindemann and Yolchenson (1992), however, no material beyond what is perceived to be the original septum or juvenile form were recovered, thus we cannot identify these specimens beyond the genus-level with any certainty.

Initial weight of muffled furnace materials was 0.23g, post processing weight of materials was 0.19g; LOI was 0.04g for temperatures set to 200°C. After this initial LOI run, visual analysis with a stereomicroscope showed that the agglutinated and calcareous foraminifera maintained their original white to cream coloring, however, the tentaculid specimens were charred having neared complete combustion. Final LOI run, at 500°C, left sample at 0.18g. Total LOI for both temperature runs were 0.05g. Visual inspection of the foraminifera show charring of calcareous foraminifera at 500°C. Given the temperature of charring of translucent tentaculid specimens recovered at lower temperature, we suspect that these forms are most likely kerogenic in nature and the specimens are not matrix-filled casts.

DISCUSSION

The specimens in Figure 2 are the first records of smooth-walled tentaculids that do not have a traditional carbonate shell, and are similar to those reported in Eastern Europe and Russia (Filipiak and Jarzynka, 2009; Kondas and Filipiak, 2021; Marshall and Tel'nova 2012, 2017; Wood *et al.*, 2004). These previous reports have suggested that the sheath-like remnant found in Eurasia may be reflective of a terminal line of tentaculids where at an earlier point in the Devonian a shift between shelled organisms to sheathed organisms evolved.

It is evident that the specimens recovered were soft-bodied portions of styliolinids and dacryoconarids. As to whether these organisms lived without shells or that taphonomic conditions led to only the soft-tissue being preserved is yet to be determined. Considering that the same samples yielded calcareous foraminiferal assemblages, a taphonomic explanation is highly unlikely. Nonetheless, these specimens present a unique opportunity to study these enigmatic organisms' internal forms and may provide unprecedented detail in geochemical analysis.

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