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Research paper

Early Ordovician (early Arenig) radiolarians from the Cow Head Group and review of the Little Port Complex fauna, Western Newfoundland

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Abstract

Radiolarians recovered from the lower Arenig strata in the Point of Head Section, Cow Head Group, include 5 families, 9 genera, and 21 species and subspecies. Among these, seven species are new: *Antygopora littleportensis*, *Beothuka spongiosa*, *B. echinata*, *B.*? *concreta*, *Nyfrieslandia crassispinosa*, *Sphaeroentactinia*? *multiradiata*, and *Westernbrookia incohota*. The red chert of the Little Port Complex also yielded five species of radiolarians. The two faunas share three dominant species: *Antygopora ordovicica*, *Beothuka terranova*, and *B. aitchisoni.* The extremely low diversity of the Little Port Complex fauna seems to be due to selective preservation.

The isotopic age of the Little Port Complex is reported to be of the Middle Cambrian [508 and 505 ($^{+3}_{-2}$) Ma]. According to a previous radiolarian study on the red chert of the Complex, the fauna was assigned to the basal Tremadoc based on co-occurring conodonts. However, a recently recovered index fossil conodont from the Complex, *Oepikodus evae*, indicates that the fauna belongs to the *O. evae* conodont zone. The common three dominant species, as mentioned above, which make up more than 95% of the total individuals in the Little Port Complex and the strata assigned to *O. evae* conodont zone and *Pendeograptus fruticosus* graptolite zone of the Cow Head Group suggest that the two faunas are coeval in the lower Arenig.

Keywords: Radiolarians; Early Ordovician; *Pendeograptus fruticosus* graptolite Zone; *Oepikodus evae* conodont Zone; Cow Head Group; Little Port Complex

1. Introduction

A series of studies of the Middle Cambrian to latest Tremadoc (earliest Ordovician) radiolarians by Won and Below (1999), Won and Iams (2002), and Won et al. (2005, 2007) show gradual phylogenetic diversification of pre-Arenig Paleozoic radiolarians. Two other reports are purported to be of the earliest Tremadoc and early Tremadoc, one by Aitchison et al. (1998) on the Little Port Complex, Newfoundland and the other by Kozur et al. (1996) on the Windfall Formation, Nevada. The fauna from the Windfall Formation is very similar to that of the lower Tremadoc strata of the Cow Head Group. However, the Little Port Complex faunal composition shows no commonality to pre-Arenig radiolarians. Rather it appears to be very similar to the early Arenig radiolarian assemblage from the Cow Head strata studied in this paper. The biostratigraphic age for the Little Port Complex radiolarians was estimated by Aitchison et al. (1998) to be earliest Tremadoc, based on the presence of one fragment of a conodont specimen identified as *Cordylodus lindstromi*. Thus, more sampling from rocks of the Complex is needed in order to compare the radiolarians and conodonts to those obtained from the lower Arenig strata in the Cow Head Group and to establish age correlation.

Except for the earliest Arenig radiolarians studied by Won and Iams (2011), no radiolarian assemblage has been reported as early Arenig (equivalent to *P. fruticosus* zone) to date. Maletz (2007b) illustrated several radiolarian specimens from the *P. fruticosus* Biozone of the Valhallfonna Formation, Spitsbergen; unfortunately, the specimens have not been described. Maletz (2011) also reported that the specimens were obtained at 45 m from the Valhallfonna Formation. However, according to Maletz

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and Bruton (2007, fig. 1) the strata at this stratigraphic position, at 45 m, is within the *D. bifidus* Zone. Papers of early Arenig radiolarians, e.g., Nazarov (1975), Nazarov and Popov (1980), Nazarov and Ormiston (1993), and Danelian and Popov (2003), do not include any typical early Arenig radiolarians as noted by Won and Iams (2011). Thus, it is crucial to describe the radiolarian assemblage from the early Arenig Cow Head Group to clarify the characteristics of the early Arenig radiolarian faunas.

2. Location and stratigraphy

The microfossils discussed herein were found in red chert of the Little Port Complex and in grainstones from the lower Arenig strata of the Cow Head Group, Western Newfoundland. The microfauna from the Little Port Complex was formally described by Aitchison et al. (1998). Samples of red chert from the Complex were collected by us from a locality on the road side above Winter House Brook (49°25′34″N, 58°08′59″W) as noted in Fig. 1.

The radiolarians extracted from the grainstones of the Cow Head Group rocks were collected from Unit 11.4 of the Point of Head Section on the Cow Head Peninsula (Figs. 1 and 2). Locality, unit numbers from where rock samples were collected, rock description, and stratigraphic location follow the designation of James and Stevens (1986). Cow Head North — Point of Head: 44°55′N, 57°50′W.

The biostratigraphic age of Unit 11.4 of the Point of Head Section of the Cow Head Group is referred to the *Pendeograptus fruticosus* graptolite Zone and *Oepikodus evae* conodont Zone by Williams and Stevens (1988) and by Stouge and Bagnoli (1988), respectively. Co-occurring conodonts found with radiolarians from our samples from the Unit 11.4 are typical for the *O. evae* Zone, comprising *Oepikodus evae* Lindström, 1955 (Fig. 9A, C, E–G, I–L, Q), *Paraoistodus paralellus* Pander, 1856, *P. proteus* (Lindström, 1955), *Bergstromeognathus extensus* Graves and Ellison, 1941 (Fig. 9S), *Oistodus* aff. *O. lanceolatus* Pander, 1856 (Fig. 9R), and *Acodus gladiatus* Lindström, 1955 (Fig. 9T).

U/Pb age data obtained by Jenner et al. (1991) indicate that the age of the pillow lavas of the Little Port Complex is 505 ($^{+3}_{-2}$) Ma. According to the chronostratigraphic unit proposed in 2007 by the Stratigraphic Commission of the Geological Society of the UK, this isotopic age corresponds to the Middle Cambrian. Aitchison et al. (1998) reported that the conodonts occurring with the radiolarians included a possible specimen of *Cordylodus lindstromi* indicative of basal Tremadoc age. The specimen illustrated by Aitchison et al. (1998, fig. 2x) is not *C. lindstromi*, but a fragment of *Oepikodus evae* whose anterior and lateral processes are broken. *C. lindstromi* is characterized by one main cusp and a posterior process with denticles which are not attached at their lower part, unlike those of *O. evae*. We also obtained specimens of conodonts from the Little Port Complex, all of which appear to be fragments of *Oepikodus evae* elements (Fig. 9B, D, H, M–P). Furthermore, as suggested by Won et al. (2005, 2007) and Won and Iams (2011), the radiolarian fauna from the red chert of the Complex is very similar to that from the early Arenig strata of the Cow Head Group. Most importantly, all radiolarian and conodont species from the Complex occur in the early Arenig Cow Head Group (Table 1) and the same three dominant radiolarian species make up more than 95% of the total specimens in both faunas. Thus, we argue that the fauna from the Complex and fauna from the early Arenig strata of the Cow Head Group are coeval.

The difference in age between the radiometrically-dated lava (Middle Cambrian) and the fossil dated red chert (early Arenig) cannot, at present, be explained.

The Little Port Complex fauna was assigned to late Floian by Maletz (2011) by the presence of *Beothuka terranova*. However, *B. terranova* is not an index fossil for the *Didymograptellus bifidus* graptolite Zone of late Floian and is even absent in *Isograptus victoriae lunatus* Zone of late Floian. *B. terranova* occurs from the earliest to lower/middle Arenig, is much more abundant in the *Pendeograptus fruticosus* graptolite Zone (see Table 1), becomes much reduced in number in the *D. bifidus* graptolite Zone, and disappears in the *I. v. lunatus* Zone of Cow Head Group.

3. Characteristics of the early Arenig radiolarian faunas

The early Arenig radiolarian faunas from the Little Port Complex and from the Cow Head Group are not as well preserved as the extremely well-preserved radiolarian faunas previously reported from the Cow Head Group. Unlike the earliest Arenig radiolarian assemblages from the Cow Head Group that consist of "pre-Arenig dominant", "earliest Arenig dominant", and "Arenig dominant taxa" (Won and Iams, 2011, table 1), the early Arenig faunas described in this paper are characterized only by the "Arenig dominant taxa", in which antygophorids and beothukids apparently flourished.

The early Arenig Cow Head Group fauna contains more than 21 species and subspecies excluding unidentified taxa, whereas that of the Little Port Complex fauna consists of up to 5 species, all of which also occur in the early Arenig Cow Head fauna. Regardless of this difference, both faunas share three dominant species, i.e., *Antygopora ordovicica* Maletz and Bruton, 2005, *Beothuka terranova* Aitchison et al., 1998, and *B. aitchisoni* Won and Iams, 2011, which make up more than 95% of the total specimens, probably due to selective preservation because all three species have stout skeletal elements. However, it may also partly reflect biostratigraphic range; the three species were recovered from the earliest Arenig (Won and Iams, 2011) and have also been observed in the unreported early/middle Arenig Cow Head faunas. These species are very rare in the earliest Arenig, are most plentiful in early Arenig, and then gradually decrease in abundance in the early/middle Arenig faunas of the Cow Head Group.

The differences between the Little Port Complex fauna and the early Arenig fauna of the Cow Head Group may be due to both selective preservation and different ecologic conditions. The early Arenig Cow Head Group fauna shows diversity not only in species composition but also in the number and the size of the spines in all three of the *Beothuka* species, i.e., *B. robusta* Maletz, 2007a, *B. spongiosa* n. sp., and *B. terranova* Aitchison et al., 1998. In contrast, the species obtained from the Little