

Late Jurassic (Volgian) radiolarians from Central Spitsbergen – a preliminary study

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Radiolarians were studied in silt and shale samples from the Upper Jurassic Volgian part of the Slottsmøya Member (Agardhfjellet Formation) of Central Spitsbergen, Svalbard. Identifications could only be made from thin-sections, which hinders precise species level identifications. Nevertheless the preservation is sufficient to reliably identify some taxa and to establish general attributes of the fauna. The overall composition of the fauna is characterised by an abundance of spongy spumellarians and a dominance of parvicingulids among the nassellarians. These attributes have also been noted in samples assignable to the bipolar Boreal and Austral Realms, and the Svalbard fauna shows all the characteristics of the Northern Boreal Province as would be expected from its high palaeolatitude in the Late Jurassic.

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Introduction

The discoveries of radiolarians in the Upper Jurassic rocks of Spitsbergen (Fig. 1) are results of fieldwork undertaken by the “Spitsbergen Jurassic Research Group” (SJRG) during the years 2004–2010. The discovery of a rich Lagerstätte with well preserved specimens of ichthyosaurs, plesiosaurs and pliosaurs in these rocks (Hurum et al. 2010) led to extensive fieldwork in the Knorringfjellet to Janusfjellet area, Sassenfjorden, Spitsbergen. As part of the project, samples were taken for sedimentological analysis and thin-sections were produced. Radiolarians were discovered in the thin-sections together with mainly benthic fossils such as echinoderms, bivalves, gastropods, scaphopods and calcareous and agglutinated foraminiferans (Rousseau & Nakrem, 2012; Collignon & Hammer, 2012).

Geological setting

The Middle Jurassic to Lower Cretaceous Agardhfjellet Formation is divided into four members in central-eastern Spitsbergen. The uppermost unit, the Slottsmøya Member, is dated as Early Volgian to latest Ryazanian (Wierzbowski et al. 2011; Mørk et al. 1999) based on ammonites, agglutinated foraminifera and palynology.

The Slottsmøya Member consists of dark grey shales with local occurrences of black paper shales containing red to yellowish siderite concretions, siderite and dolomite

interbeds, and cold seep carbonate buildups (Hammer et al. 2011). The top of the member forms a coarsening -upward shale-silt-sandstone succession. The unit is commonly rich in ammonites (distinct beds with species of *Dorsoplanites* and other well preserved ammonites in seep buildups) and bivalves (mainly species of *Buchia*). In recent years, a rich Lagerstätte with well preserved species of ichthyosaurs, plesiosaurs and pliosaurs has been documented in these rocks (Hurum et al. 2010). Based on sedimentological and micropalaeontological evidence the member was deposited in restricted to open marine shelf environments, alternating oxic to anoxic with water depths of 100–300 m (Dypvik et al. 1991; Nagy et al. 2009; Dypvik et al. 2002; Smelror et al. 2009:106).

Material and methods

Systematic collection of sand, silt and mudstones, as well as dolomite and siderite concretions, was undertaken as part of several sub-projects of the “Spitsbergen Jurassic Research Group” (SJRG) from localities in central Spitsbergen, Svalbard (Figure 1). Samples were also taken from hydrocarbon seep carbonate buildups. The siliclastic rocks and the concretions were thin-sectioned for lithological descriptions and interpretations whereas the seep carbonates were also digested in weak acetic acid. Radiolarians were discovered only in the silt and mudstone thin-sections, and radiolarians could not be found in the carefully wet sieved acid residues. The sieved fractions (90–500 μ), however, contained siliceous sponge

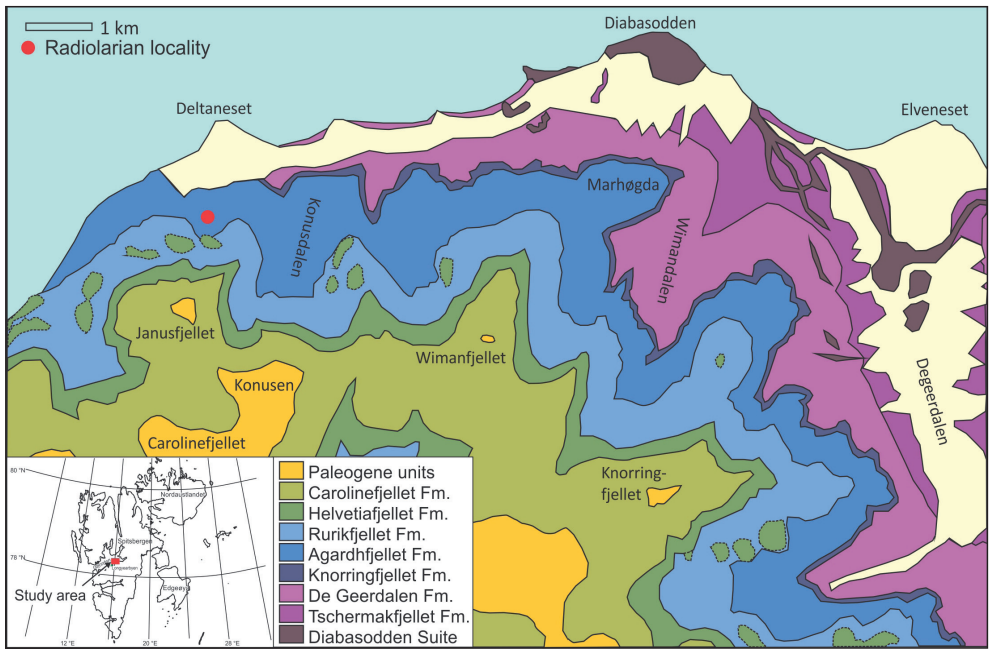


Figure 1. Geological map of the area (modified from Dallmann et al. 2001) with inset map of Svalbard indicating the study area.

spicules and it seems reasonable that any radiolarians present would also have survived the chemical and physical preparation. 300 thin-sections from the seep carbonates have also been studied, but no unequivocal radiolarians have been seen.

Thus, only thin-sections of the siliciclastic rocks were available for investigation in the current study. These derive from the Janusfjellet section, N78°20'35.4", E15°49'85.2". See Collignon & Hammer (this volume) for a lithostratigraphical discussion of the investigated

interval. The radiolarians are preserved as pyrite and appear as black opaque fossils in thin-sections.

Radiolarian taxonomy

As radiolarians could not be extracted from either the siderite nodules or the carbonate seep bodies, the descriptions are exclusively based on thin-sections. This hinders identifications at the species level and even renders identifications difficult at the genus level.

Age (Ogg 2005)		Boreal zonation	Lithostratigraphy (Mørk et al. 1999)		Revised age (Wierzbowski et al. 2011)	
Cretaceous	Early (pars.)	Hauterivian	Adventdalen Group	Rurikfjellet Fm.	Ullaberget Mbr.	
		Valanginian			Wimanfjellet Mbr.	?
		Berriasian			Myklegardfjellet Bed	Myklegardfjellet Bed
Jurassic	Late	Tithonian		Agardhfjellet Fm.	Slottsmøya Mbr.	Slottsmøya Mbr.
		Kimmeridgian			Oppdalsåta Mbr.	
		Oxfordian			Lardyfjellet Mbr.	
Middle		Callovian		Oppdalen Mbr.		
		Bathonian				
			Kapp Toscana Group			

Figure 2: Stratigraphic division of the units, showing the position of the radiolarian collection (arrow) (modified from Mørk et al. 1999).

Nevertheless, the preservation is sufficient to reliably identify some taxa and to establish general attributes of the fauna.

Spumellaria

Praeconocaryomma(?) sp. (Figure 3A)

The cortical shell is mammelate and covered with radial spines, which is a diagnostic feature of *Praeconocaryomma* (Pessagno, 1976). However, the spongy cortical shell and uncertainty about the number of medullary shells render the genus assignment doubtful. Similar specimens have been reported from Tithonian (Upper Jurassic) deposits of the Antarctic Peninsula (Kiessling

1995). Specimens of *Praeconocaryomma* sp. have also been reported from the Barents Shelf drillcore 7430/10-u-01 of Late Volgian to early Ryazanian age (Smelror & Dypvik 2005: table 9).

Staurosphaera(?) sp. cf. *S. amplissima* Foreman (Figure 3B) The cortical shell is subspherical with irregular pore frames and bears four(?) primary, triradiate spines originating from a faint medullary shell. Our specimen agrees in shape and dimensions with *Staurosphaera* sp. cf. *S. amplissima* Foreman figured by Bragin (2011) from northern Siberia. However, *Staurosphaera* Haeckel is considered a nomen dubium (O'Dogherty et al. 2009) and the resemblance to *S. amplissima* is not distinct.

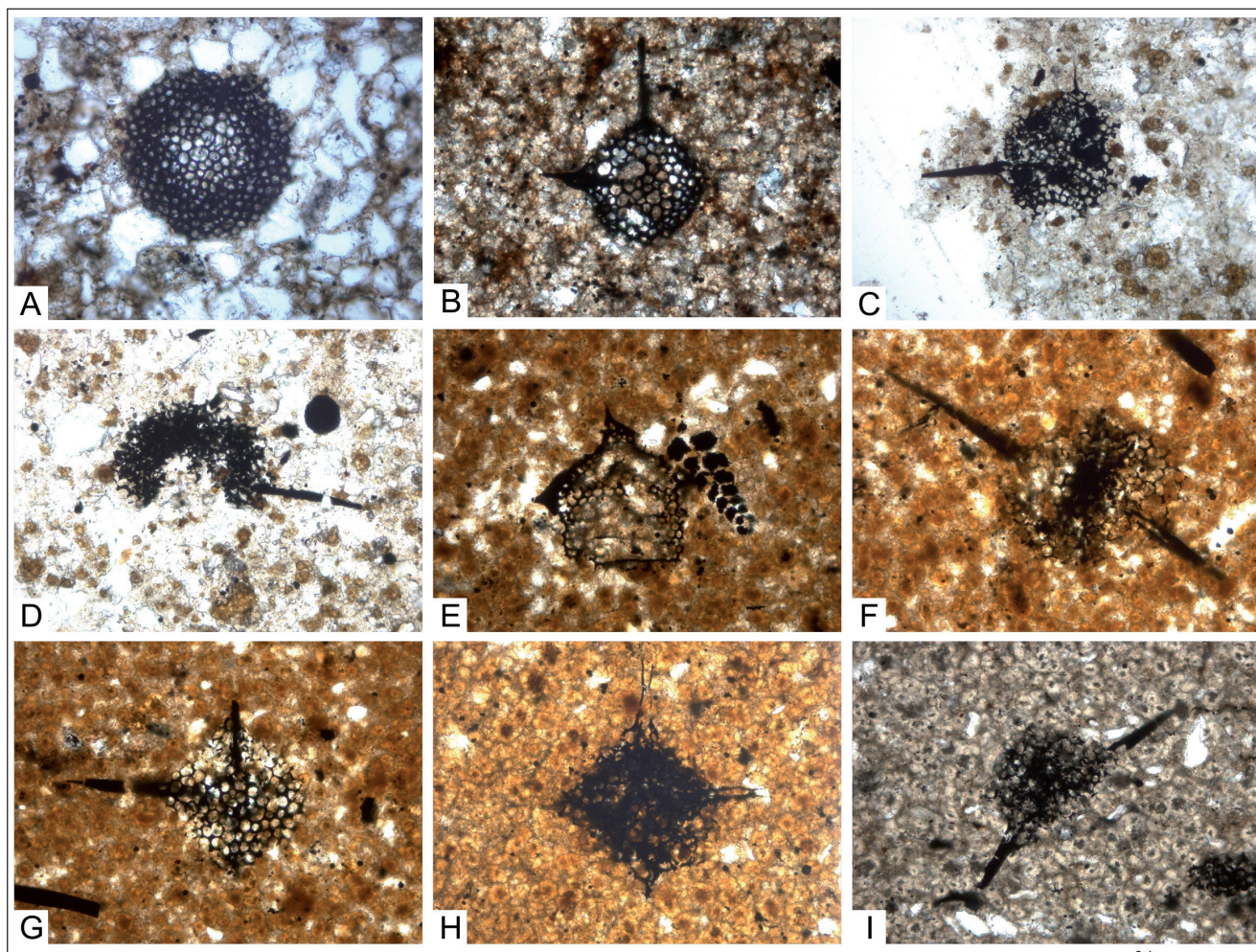


Figure 3: Radiolarians in petrographic thin-sections. The illustrated specimens are deposited in the Palaeontological Collections of the Natural History Museum (PMO), University of Oslo.

3A: *Praeconocaryomma*(?) sp. PMO 214.922, latest Early Volgian, near the base of the Slottsmøya Member, Janusfjellet.

3B: *Staurosphaera*(?) sp. cf. *S. amplissima* Foreman. PMO 214.926, Middle Volgian, 37 m above the base of the Slottsmøya Member, Janusfjellet.

3C, D: *Gen. et sp. indet.* PMO 214.928, earliest Middle Volgian, 24 m above the base of the Slottsmøya Member, Janusfjellet.

3E: *Tertonium* sp. PMO 217.937, earliest Middle Volgian, 22 m above the base of the Slottsmøya Member, Janusfjellet.

3F: *Archaeospongoprunum*(?) sp. PMO 217.937, earliest Middle Volgian, 22 m above the base of the Slottsmøya Member, Janusfjellet.

3G: *Emiluvia*(?) sp. PMO 217.937, earliest Middle Volgian, 22 m above the base of the Slottsmøya Member, Janusfjellet.

3H: *Emiluvia*(?) sp. PMO 217.987, earliest Middle Volgian, 22 m above the base of the Slottsmøya Member, Janusfjellet.

3I: *Alievium*(?) sp. PMO 217.986, earliest Middle Volgian, 22 m above the base of the Slottsmøya Member, Janusfjellet.

Gen. et sp. indet. (Figures 3C, D)

The large spherical test with a thick cortical shell of loose spongy meshwork is reminiscent of *Octodendron(?) superfragilis* described by Kiessling (1999) from Tithonian (Upper Jurassic) deposits of the Antarctic Peninsula. However, the uncertainties regarding the internal structure make any reliable identification impossible. The shells in our material are also somewhat smaller than the *O.(?) superfragilis* in Antarctica.

Archaespongoprunum(?) sp. (Figure 3F)

The two specimens are characterised by a cylindrical test with a spongy meshwork and two long, triradial, polar spines. These characters agree well with the original diagnosis of the genus (Pessagno 1973). However, the size of our specimens (c. 620 µm) is significantly larger than any known species in this genus. The largest specimens of the type species (*A. venadoensis*) have a total size of 360 µm.

Emiluvia(?) sp. (Figures 3G, H)

Typical for *Emiluvia* Pessagno is a flattened rectangular shell with four three-bladed spines emerging from the corners of the shell. The absence of nodes on the surface renders the identification doubtful, although weakly developed nodes have been marked in high-palaeolatitude occurrences of this genus (Kiessling, 1999). The specimens could alternatively be assigned to *Spongostaurus*.

Alievium(?) sp. (Figure 3I)

Alievium(?) sp. B – Kiessling 1999, p. 39, pl. 8, fig. 15

This specimen is characterised by a flattened triangular shell with irregular, almost spongy pore frames and three, triradial, primary spines. Although the resemblance to *Alievium(?)* sp. B of Kiessling (1999) is striking, the specimen might also be assignable to *Tripocyelia* Haekel as emended by Kiessling (1999).

Praeconosphaera sp. (Figure 4K)

The tubercles (mammellae) on the cortical shell and the absence of medullary shells allow a reliable assignment of this specimen to *Praeconosphaera* (Yang 1993).

Nassellaria

Tertonium sp. (Figure 3E)

The tent-shaped test with spines that are prolonged downward along the thorax and extended outward can reliably be assigned to the genus *Tertonium* (Dumitrica & Zügel 2003), which is known from uppermost Jurassic sediments in Germany (Dumitrica & Zügel 2003), California (Hull 1997) and North Siberia (Bragin 2011). The figured specimen differs from the two known species of *Tertonium* (*T. curvicornum* and *T. rectum*) in possessing less pronounced spines and a much smaller apical horn.

Toritenum sp. (Figure 4H)

Typical for the genus (Dumitrica & Zügel 2003) is a large cephalis with apical horn but lacking additional spines, the presence of circumferential ridges separated by depressionary intervals bearing transverse rows of pores and a widely open thorax.

Praeparvicingula rotunda Hull (Figure 4D)

Praeparvicingula rotunda n. sp. – Hull 1995, p. 40, pl. 7, figs. 14-16, 21

Praeparvicingula rotunda Hull – Kiessling 1999, p. 53, pl. 12, fig. 20

Praeparvicingula rotunda Hull – Bragin 2011, pl. 4, fig. 10-11

This specimen is the only one that can be reliably assigned to a species. This is known from California, the Antarctic Peninsula and northern Siberia and appears to be constrained to the Kimmeridgian to Berriasian.

Praeparvicingula sp. (Figures 4A-C, E, F)

As typical for the genus (Pessagno et al., 1993), the specimens are conical to cylindrical in shape, possess three rows of pores between joints and bear an apical horn. Different species are probably assembled under this name, but limited preservation hinders a clear separation. Specimens illustrated as Figures 4A and E are, however, similar to *Parvicingula genriettae* and *P. antoshkinae*, described from the Domanikoid facies of the Pechora Basin (Vishnevskaya 1998). Specimens of *Praeparvicingula* sp. have also been reported from the Barents Shelf drillcore 7430/10-u-01 of Late Volgian to Early Ryazanian age (Smelror & Dypvik 2005: table 9).

Parvicingula sp. (Figure 4G)

This is the only specimen that can reliably be assigned to *Parvicingula* (Pessagno 1977). It bears a short apical spine and exhibits a final postabdominal neck.

Echinocampe(?) sp. (Figure 4I)

This specimen is reliably assignable to the Echinocampidae, a typical high-latitude family (Bragin 2009). The diagnostic characters are the multicyrtrid shell and several external horns, diverging in various directions from the apical part of the shell. The well developed horns and circumferential ridges separate this specimen from the other two genera currently assigned to the family.

Perispyridium(?) sp. (Figure 4J)

Although doubts remain about the internal structure of this specimen, it does resemble *Perispyridium* Dumitrica. If true, the sample containing this specimen (PMO 214.928) cannot be younger than the Early Tithonian (=Mid Volgian in the Boreal stratigraphic scheme) (Pessagno et al. 1993; Kiessling 1999). This age is in accord with ammonite and foraminiferan dating of this interval (Nagy & Basov 1998).

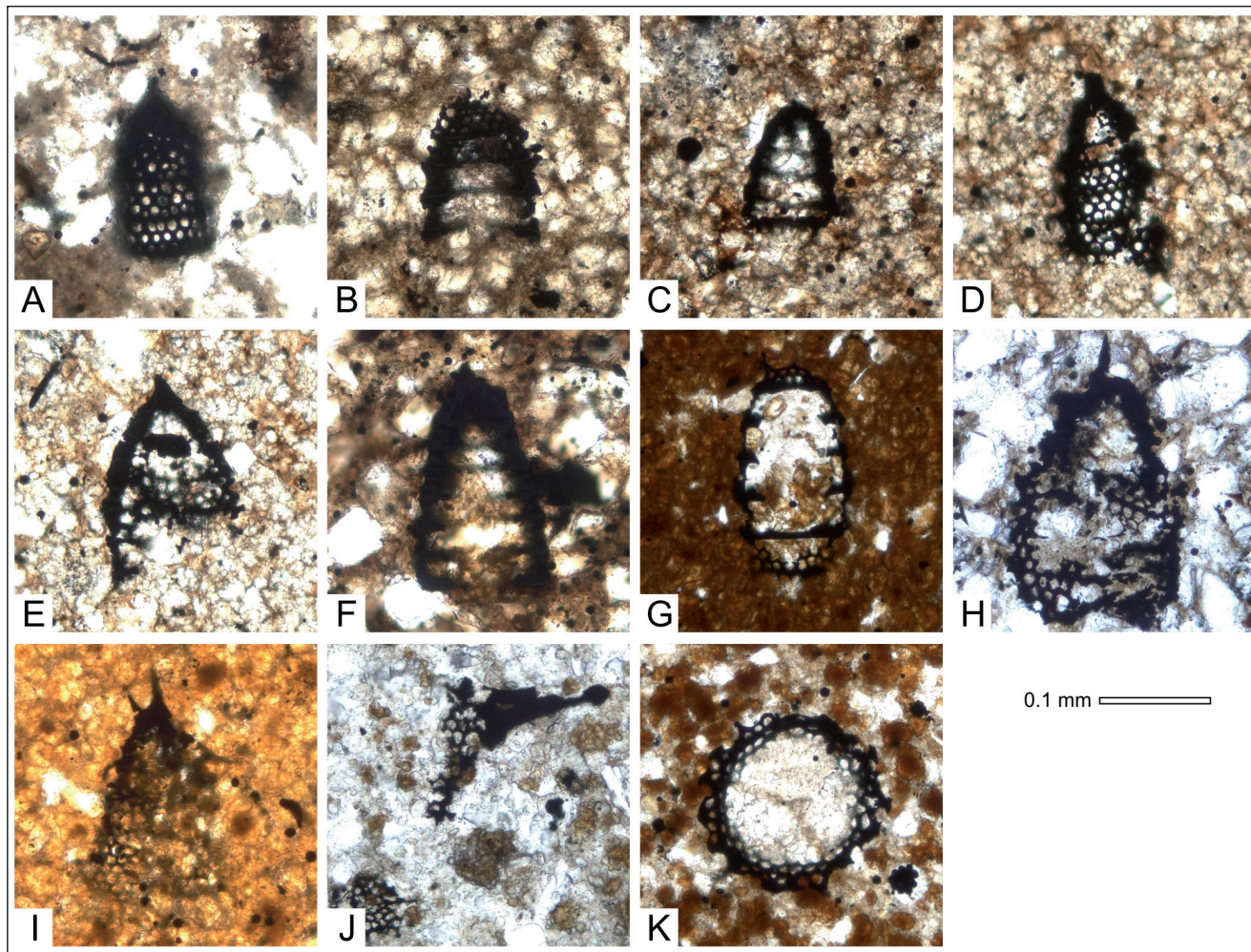


Figure 4: Radiolarians in petrographic thin-sections. The illustrated specimens are deposited in the Palaeontological Collections of the Natural History Museum (PMO), University of Oslo.

4A-C, E, F: *Praeparvingula* sp.

A: PMO 214.924, Early Volgian, 5 m above the base of the Slottsmøya Member, Janusfjellet.

B: PMO 217.985, earliest Middle Volgian, 22 m above the base of the Slottsmøya Member, Janusfjellet.

C, E: PMO 214.926, Middle Volgian, 37 m above the base of the Slottsmøya Member, Janusfjellet. F: PMO 214.922, latest Early Volgian, near base of the Slottsmøya Member, Janusfjellet.

4D: *Praeparvingula rotunda* Hull. PMO 214.926, Middle Volgian, 37 m above the base of the Slottsmøya Member, Janusfjellet.

4G: *Parvingula* sp. PMO 217.986, earliest Middle Volgian, 22 m above the base of the Slottsmøya Member, Janusfjellet.

4H: *Toritenum* sp. PMO 214.922, latest Early Volgian, near the base of the Slottsmøya Member, Janusfjellet.

4I: *Echinocampe*(?) sp. PMO 217.987, earliest Middle Volgian, 22 m above the base of the Slottsmøya Member, Janusfjellet.

4J: *Perispyridium*(?) sp. PMO 214.928, earliest Middle Volgian, 24 m above the base of the Slottsmøya Member, Janusfjellet.

4K: *Praeconosphaera* sp. PMO 217.988, earliest Middle Volgian, 22 m above the base of the Slottsmøya Member, Janusfjellet.

General attributes

The overall composition of the fauna is characterised by an abundance of spongy spumellarians and a dominance of parvingulids among the nassellarians. These attributes have also been noted in samples assignable to the Boreal and Austral Realms (Kiessling 1999). The commonness of parvingulids, including forms with external apophyses (now assigned to the family Echinocampidae, Bragin 2009), and the absence of pantanelliids, *Podocapsa* and *Eucyrtidiellum* was deemed characteristic of the Northern Boreal Province by Kiessling (1999). Thus, the Svalbard fauna shows all the characteristics of the

Northern Boreal Province as would be expected from its high palaeolatitude in the Late Jurassic. We have to admit that sampling and preservation is rather incomplete at this point, such that some taxa that are typical of high palaeolatitudes in the latest Jurassic have not yet been found in our material. Examples are *Orbiculiforma* and *Higumastra*. Otherwise, the Svalbard fauna appears quite similar to the excellently preserved material reported from Volgian-Berriasian strata of the Nordvik Peninsula along the Laptev Sea coast of northern Siberia (Bragin 2009; 2011). In addition, the Svalbard fauna is similar to the radiolarian assemblages reported from Volgian strata of the Peshva Peninsula and Pechora Basin along

the Barents Sea coast (Kozlova 1976; Vishnevskaya 1998; Vishnevskaya 2001; Vishnevskaya & Murchey 2002). In both the Siberian and the Svalbard material, the diversity of radiolarians appears high considering the high-palaeolatitude setting and inferred palaeotemperature (5–10°C, mean 8°C) (Ditchfield 1997) from a belemnite oxygen isotope study in Kong Karls Land, Svalbard, but see Hammer et al. (2011) where temperatures between 13 and 16°C have been proposed from a study of Late Volgian-Early Ryazanian seep carbonates of the Janusfjellet area), as well as the moderate waterdepth during deposition. Finally, the similarity of high-latitude faunas between the northern and southern hemispheres is striking. Inter-hemispheric faunal exchange may have been facilitated along connecting deep-water marine systems (Kiessling 1999).

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