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Schellwienia arctica (Fusulinidae) from the Carboniferous–?Permian strata of the Treskelodden Formation, south Spitsbergen

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Abstract: The fusulinid foraminifers of *Schellwienia arctica* (Schellwien, 1908) have been investigated from Polakkfjellet Mt., south Spitsbergen, and used as biostratigraphic marker for the latest Carboniferous–?earliest Permian strata of the Treskelodden Formation. A series of thin sections enable to investigate the internal structure and growth pattern of individual specimens. The observed variation of growth suggests dynamic environmental conditions at the investigated location and most likely over one-year long life span of this foraminifer.

Key words: Arctic, Spitsbergen, Foraminifera, Carboniferous–?Permian.

Introduction

At the Carboniferous and Permian boundary, Spitsbergen was a central part of extended carbonate platform, which was located on the northwestern margin of the Pangea supercontinent (Ziegler 1988; Scotese and McKerrow 1990; Doré 1991; Stemmerik 2000). A mosaic-like structure of this platform, complicated by numerous tectonic horsts and troughs, makes it difficult to perform lithostratigraphic correlations between its different components (Harland 1997; Samuelsberg and Pickard 1999; Stemmerick 2000). Thus, biostratigraphy based on fusulinid foraminifera may play a key role in investigating the Upper Carboniferous–Lower Permian sedimentary sequence in the Arctic (Nilsson 1993; Ehrenberg *et al.* 2000; Davydov *et al.* 2001).

Fusulinids have long been known from the Upper Carboniferous and the Lower Permian of Spitsbergen. First descriptions were those by Göes (1884), who

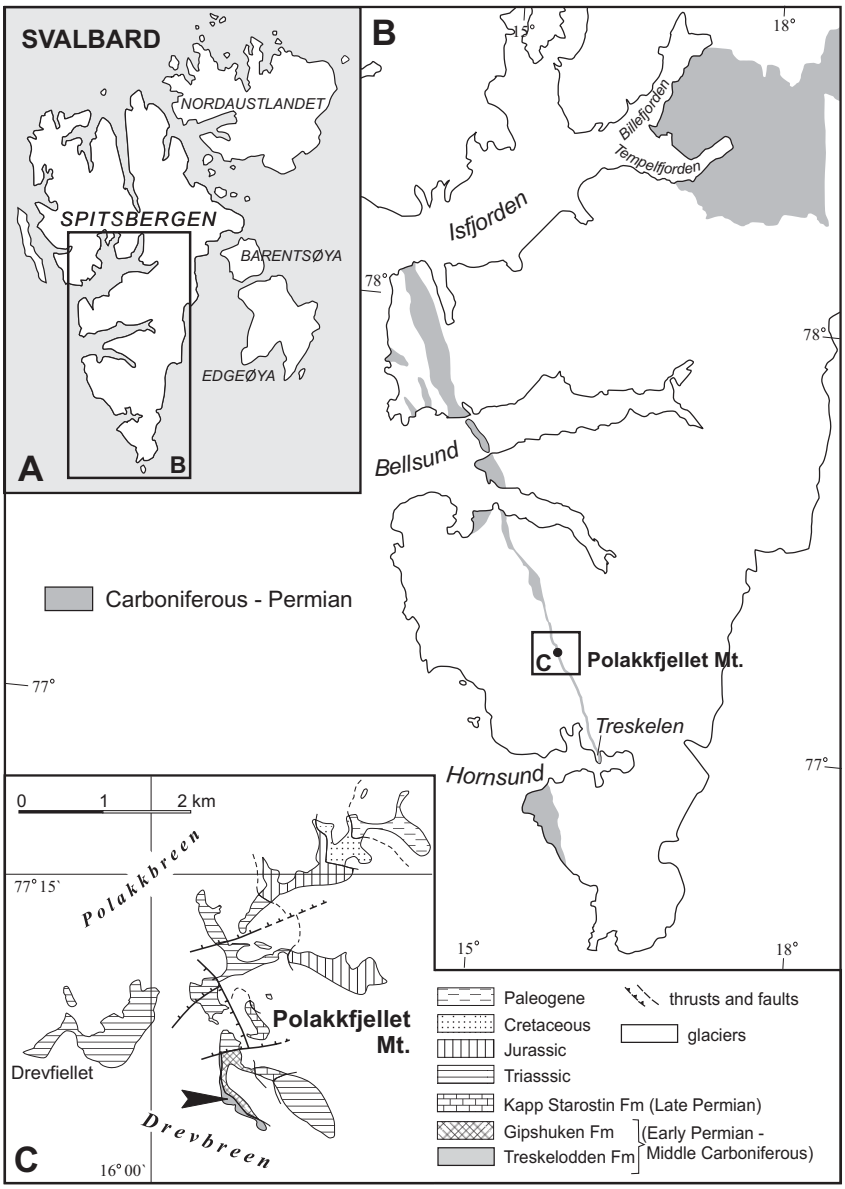

Fig. 1. **A**. Map of the Svalbard Archipelago. **B**. Sketch map of the southern and central parts of Spitsbergen showing outcrops of Carboniferous and Permian rocks after Harland (1997). **C**. Geological map of the Polakkfjellet Mt. area after Ohta and Dallmann (1999). Location of the investigated section of the Treskelodden Fm is marked by arrow.

identified *Fusulina cylindrica* in the material collected by Nathorst and de Geer in 1882 from the Wordiekammen Fm at Tempelfjorden. In the early 20th century, Schellwien (1908) described *Fusulina arctica* from Templet, Gipshuken and Billefjorden. Staff and Wedekind (1910) revised the Schellwien's work and placed

this taxon within the genus *Schellwienia*. Within the central Spitsbergen, 11 fusulinid zones were distinguished and then correlated with the Late Carboniferous and the Early Permian fusulinid zones of the Russian Platform and the Urals (Nilsson and Davydov 1992).

Most of the investigations to date were based on material collected from central Spitsbergen. The presence of fusulinids in the Permo-Carboniferous Treskelodden Fm of southern Spitsbergen has been already reported (Birkenmajer 1964; Liszka 1964; Nysæther 1977). In this paper, we present the detailed description of *Schellwienia arctica* found in two horizons (Figs 2B, 3) in the Permo-Carboniferous sequence at Polakkfjellet Mt., southern Spitsbergen. The field investigations and collecting of samples was performed by Krzysztof Michalski and Rafał Szaniawski (Institute of Geophysics, Polish Academy of Sciences) during their paleomagnetic field studies in summer 2002.

Geological and stratigraphical setting

The Permo-Carboniferous rocks, including the Treskelodden Fm are exposed between Hornsund and Bellsund along 5–10 km wide, NNW-SSE oriented belt (Nysæther 1977; Birkenmajer 1959, 1984; Dallman 1999). A few Permo-Carboniferous exposures occur south of Hornsund (Fig. 1). The Treskelodden Fm consists of alternating clastic and carbonate deposits. Most of them are good facies indicators, but only a few are stratigraphically useful (Birkenmajer 1984). Latest Carboniferous (Gzhelian) age of the formation was suggested on the basis of brachiopods (Czarniecki 1969), trilobites (Osmólska 1968) and fusulinids (Nysæther 1977). However, rugose corals and foraminifers suggest rather an Early Permian age (Asselian, Sakmarian or even Artinskian) (Birkenmajer 1964; Birkenmajer and Fedorowki 1980; Fedorowski 1964, 1965, 1967, 1982; Liszka 1964). The Treskelodden Fm seems to be coeval with the Wordiekammen Fm of central Spitsbergen, which encompasses abundant carbonates deposited in a tectonically stable part of the shelf (Dallman 1999).

The investigated section of the Treskelodden Fm is located in the south-western part of Polakkfjellet Mt. The Permo-Carboniferous deposits at Polakkfjellet Mt. were described in details by Nysæther (1977). The geological map of the area was presented by Birkenmajer (1977, 1984) and Dallman (1999), see Fig. 1.

Material and methods

Fusulinids presented in this paper were collected at Polakkfjellet Mt. in summer 2002. The investigated part of the Treskelodden Fm consists of alternating sandstones, shales, marls, dolomites and limestones (Fig. 3). The *Schellwienia*

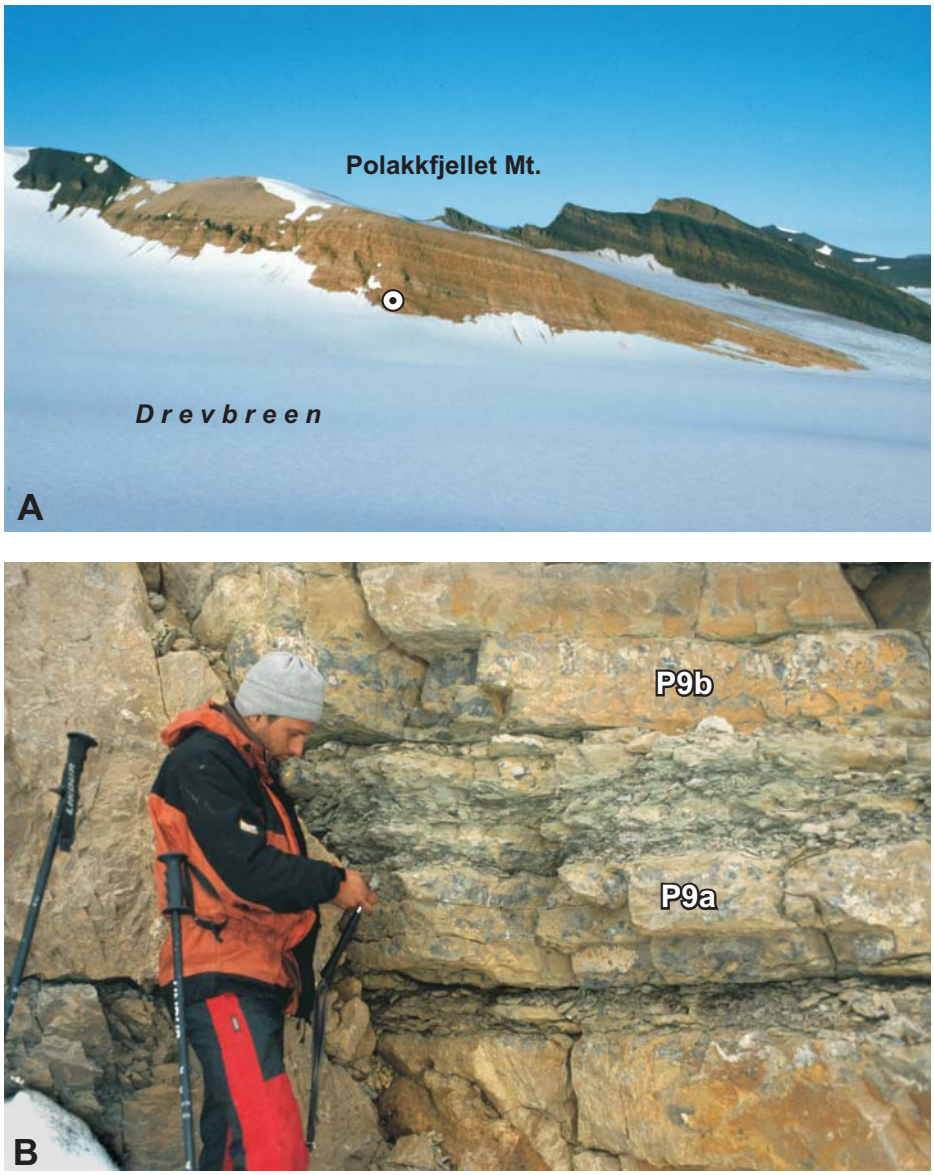

Fig. 2. **A**. A view of Polakkfjellet Mt. Location of the investigated section of the Treskelodden Fm is indicated by circle. **B**. Outcrop of the calcareous horizons P9a and P9b containing *Schellwienia arctica*.

arctica fusulinids have been found only in two limestone horizons, labeled P9a and P9b in Figs 2B and 3.

The horizon P9a (Fig. 3) is organodetritic, sandy limestone with numerous *S. arctica*, small foraminifers as well as fragments of crinoids, mollusks and brachiopods. The fusulinid tests are often incompletely presented, with outer whorls lack-

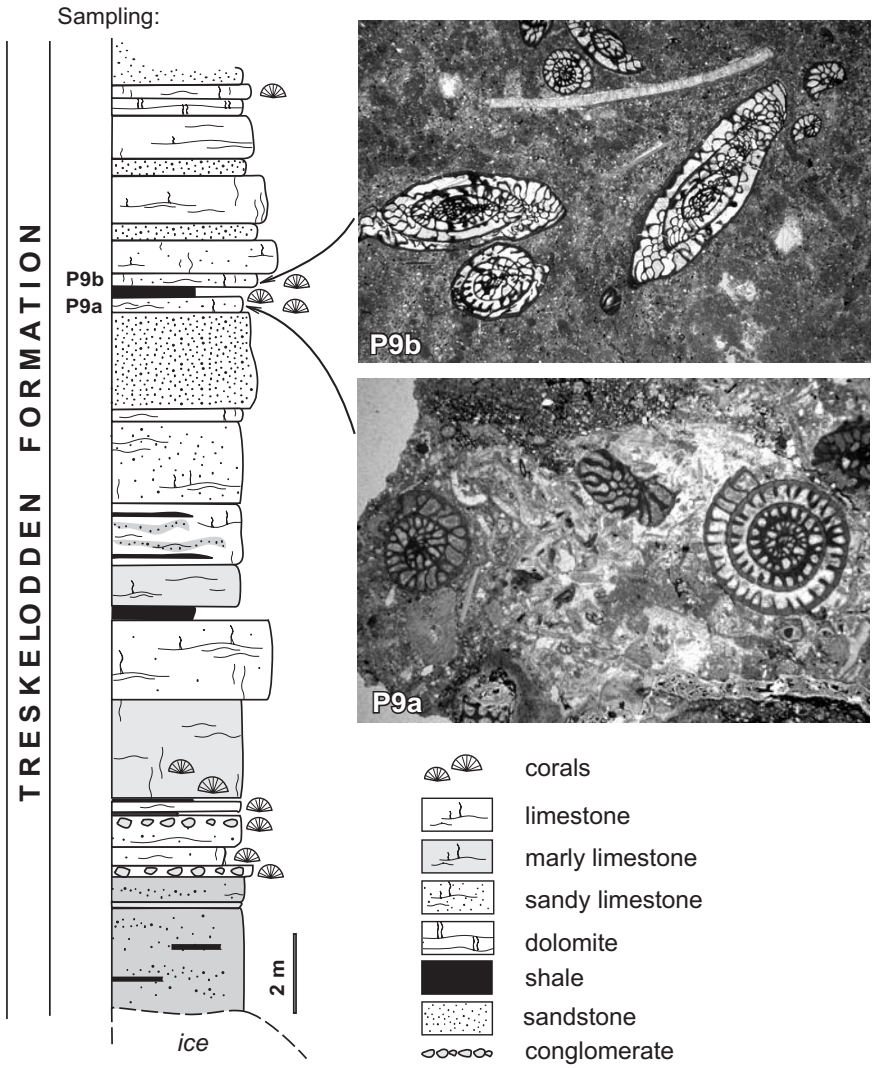

Fig. 3. Geological section of the lowermost part of the Treskelodden Fm at Polakkfjellet Mt., and microscopic photographs of the P9a and P9b limestone horizons containing *Schellwienia arctica.*

ing. However, central whorls are well preserved. The horizon P9b (Fig. 3) consists of micritic limestone with numerous *S. arctica* and sparse fragments of brachiopods. Other fossils are lacking. In contrast to P9a, the P9b horizon contains complete and very well preserved tests of *S. arctica*.

Thirty thin sections were prepared from the horizons P9a and P9b. Nine individual specimens of *S. arctica* were isolated from P9a horizon by mechanical maceration. Five specimens were cut into sets of thin sections parallel and perpendicular to the axis test in the attempt to determine their internal structure. Polished cross sections from the P9b horizon were etched with 1% ortophosphoric acid for ~ 1

minute, as recommended by Wood (2000), and coated with platinum for SEM imaging. All the illustrated specimens are housed at the Institute of Paleobiology, Polish Academy of Sciences, Warszawa, (abbreviated ZPAL F.53).

Systematic paleontology

Order Foraminiferida Eichwald, 1830
Family Fusulinidae von Moeller, 1878
Genus *Schellwienia* Staff and Wedekind, 1910
Schellwienia arctica (Schellwien, 1908)
(Figs 4–6)

1908. *Fusulina arctica* Schellwien, p. 173, pl. 16, figs 3–9.

1910. *Schellwienia arctica* (Schellwien); Staff and Wedekind, p. 115–118, pl. 4, figs 4–6.

1960. *Triticites arcticus* (Schellwien); Forbes, p. 216, pl. 32, figs 10–17.

1962. *Pseudofusulina* (Rugosofusulina) *arctica* (Schellwien); Ross and Dunbar (part), p. 41, pl. 6, figs 1–7.

1965. *Triticites arcticus* (Schellwien); Ross, p. 78, pl. 10, figs 14–21.

1967. *Triticites arcticus* (Schellwien); Sosipatrova, pl. 8, figs 4, 8, 9; pl. 9, fig. 20.

1992. *Schellwienia arctica* (Schellwien); Igo and Okimura, pl. 7, figs 1–3.

1994. *Schellwienia arctica* (Schellwien); Nilsson, p. 49, pl. 3, figs 6–9, 11.

Material. — Nine complete specimens macerated from rock samples, then investigated in the series of thin sections. About 30 more specimens in rock thin-sections.

Description. — Fusiform tests usually about 5 mm long, moderately slender, with flanks curving evenly convex from the equator to the slightly rounded poles (Fig. 4A–D). Proloculus small to medium (up to 0.2 mm in diameter – Fig. 4A). Septa deeply folded, especially when away from midplane; high and generally irregular, but sometimes in part regular; in axial parts of the shells forming continuous zones of cellular networks (Fig. 4). Septal pores closely spaced, often not seen at all. Angle of tunnel irregular, ranging from about 30° in the first, inner whorl, then increasing. Number of whorls not exceeding 5. Secondary deposits weakly developed, but still recognizable on SEM (Fig. 6A_1, B_1). Wall composed of tectum and keriotheca with medium sized alveoli (Figs 4, 5). The last volution in polar regions slightly extended.

Remarks. — Fusulinids described from Polakkfjellet Mt. resemble that described by Schellwien (1908: pl. 16, figs 3–9) from Tempelfjorden area, central Spitsbergen. *Schellwienia arctica* was considered as a marker of Kasimovian stage on the Russian Platform and the Urals (Rauser-Chernousova *et al.* 1979). Recent revisions (Davydov *et al*. 1990) questioned the taxonomical position of the specimens from Russia, and classified them as the more primitive *Rauserites quasiarcticus* (Solovieva 1987).

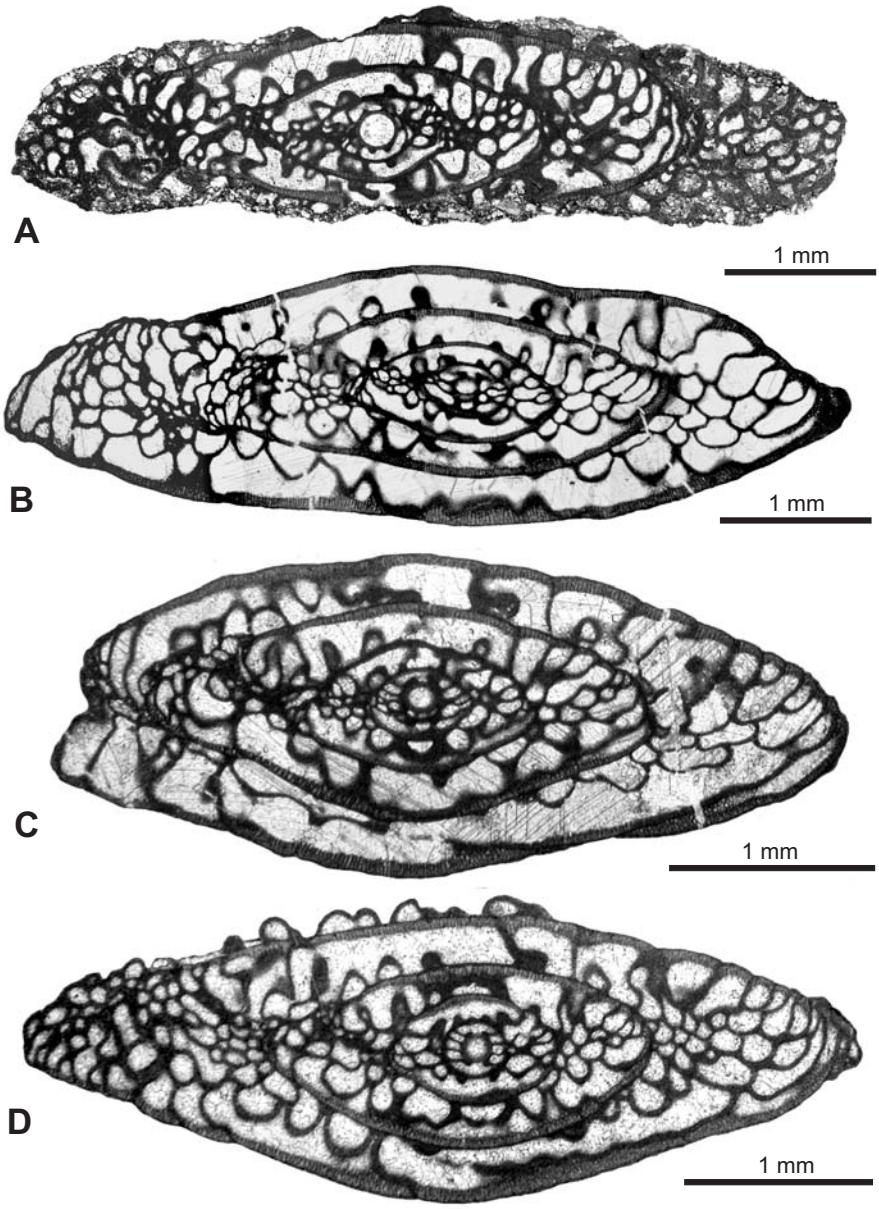

Fig. 4. *Schellwienia arctica* (Schellwien, 1908). **A**–**D**. Axial sections, collection ZPAL F.53/1. Treskelodden Fm, late Gzhelian–?early Asselian, Polakkfjellet Mt.

Stratigraphical distribution. — *Schellwienia arctica* occurs in central Spitsbergen within the *Daixina sokensis* Zone and *Schwagerina robusta* Zone (both late Gzhelian), within the Nordensköldbreen Formation (Nilsson and Davydov 1997). *Schellwienia arctica* has been reported also from the *Zigarella anderssoni* Zone

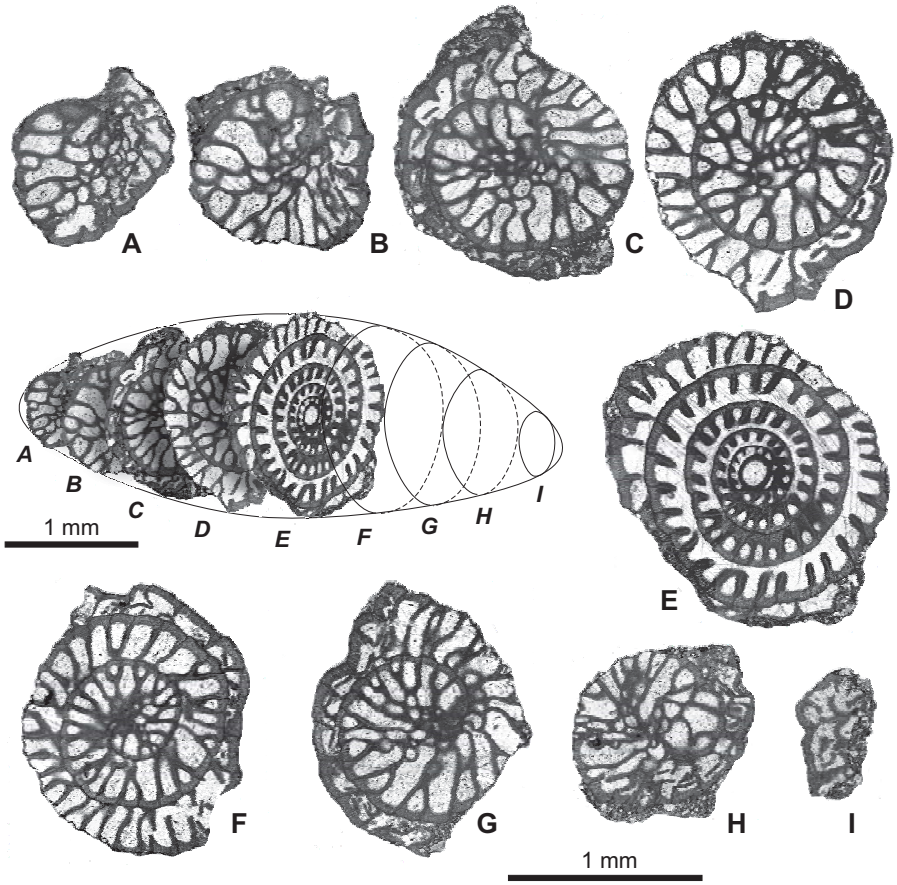

Fig. 5. *Schellwienia arctica* (Schellwien, 1908). **A–I**. Series of sagittal thin sections, collection ZPAL F.53/2.

(early Asselian) by Nilsson and Davydov (1997). The fauna, assigned to the above mentioned units, correlates well with the transitional fauna of the Finnmark Platform of Gzhelian/Asselian age (*Zigarella paraanderssoni–Schellwienia arctica* Zone), recognized as belonging to shallow-water environments of the marine shelf (Nilsson and Davydov 1992). In the Arctic Canada, fusulinid assemblages of the latest Gzhelian/earliest Asselian (*Pseudofusulina plana–Pseudofusulinella* Zone) were described by Nilsson (1992). It is possible to correlate those zones with the uppermost Gzhelian fauna of the *Ultradaixina bosbytauensis–Schwagerina robusta* Zone in the Urals and Central Asia (Davydov *et al.* 1990; Nilsson and Davydov 1992, 1997). In Northern Greenland, the sediments with *Schellwienia arctica*, previously considered as early Permian, appear in the lower part of the "*Pseudoschwagerina*" Zone where no typical specimens of Asselian fauna has been found. Thus the age of the latest Gzhelian–?earliest Asselian was suggested (Nilsson 1994).

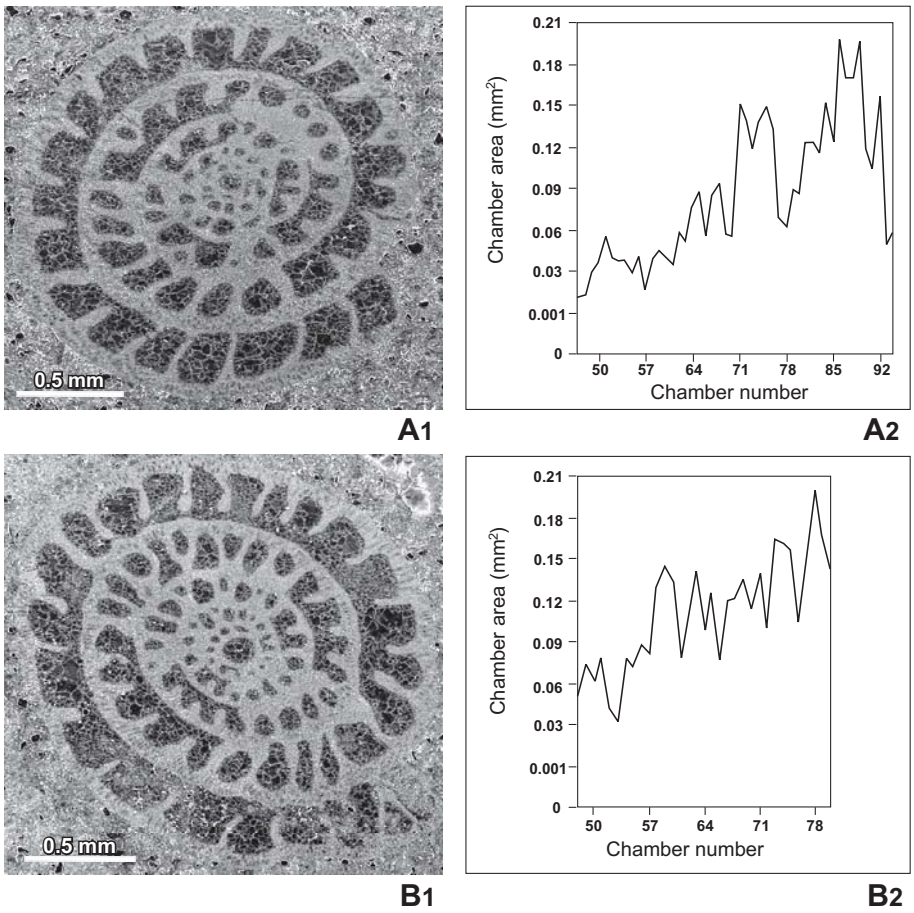

Fig. 6. Growth data for *Schellwienia arctica* (Schellwien, 1908), Treskelodden Fm, late Gzhelian–?early Asselian, Polakkfjellet Mt. **A_1**, **B_1**. Sagittal sections, collection ZPAL F.53/3. **A_2**, **B_2.** Variations in chamber areas.

Occurrence. — Treskelodden Formation, (latest Gzhelian–?earliest Asselian): south Spitsbergen (Polakkfjellet Mt.).

Growth patterns in *Schellwienia arctica*

Nine specimens had been macerated from the carbonate matrix. Five of them were cut and polished in saggital sections through the initial chamber (proloculus), and then photographed (Figs 5E; 6A_1, B_1). The areas of consecutive chambers, excluding early chambers altered by diagenesis, were measured for all specimens. The consecutive chambers show significant periodical-like variation in size (see examples in Figs 6A_2, B_2).

According to Małkowski (1998), the climate of Spitsbergen during the late Paleozoic was humid and hot. Recent foraminifer *Marginopora vertebralis* living in shallow waters in the frontal and central regions of tropical reef moat (Wefer and Berger 1980; Hohenegger 1994; Renema and Troelstra 2001) may experience similar environmental conditions as those of *Shellwienia arctica*. In this Recent foraminifer, it is possible to distinguish two unequal seasons of intense growth per year (Ross 1972). This feature, as well as oxygen and carbon stable isotope analysis conducted on laboratory cultured specimens (Wefer and Berger 1980), allowed to estimate the life span of *M. vertebralis* to be of a few years.

The ontogenic variations in the volume of *S. arctica* chambers could have resulted from seasonal changes in food supply, water temperature and/or other ecological conditions. Ross (1982) suggested that growth variations may be also due to a presence of photosynthetic symbionts. Unfortunately, it is impossible to perform isotopic studies on our material, because of its diagenetic changes. Thus, we can neither trace eventual changes of $d^{13}C$ and $d^{18}O$ within *S. arctica* tests, nor determine the presence of photosynthetic symbionts.

Our observations of test morphology remain the only crude insight into variable life history of *S. arctica*. Its growth-rate variations may suggest domination of dynamic environmental conditions close to Carboniferous–Permian boundary at the Polakkfjellet Mt., and most likely over one-year long life span of this foraminifer.

Conclusions

First detailed description of fusulinid foraminifers from the Treskelodden Formation at Polakkfjellet Mt. allows us to establish the latest Carboniferous (Gzhelian)–?earliest Permian (Asselian) age of the studied beds.

The observed variations in growth rate of the fusulinid foraminifers are likely to reflect various ecological factors, such as changes in nutrients level, light, temperature and presumable presence of photosynthetic symbionts. The presence of growth variation suggests dynamic environmental conditions at the investigated location and seems to indicate over one year life span of this foraminifer.

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