Acritarchs from the Upper Ordovician of southern Holy Cross Mountains, Poland

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Acritarchs and prasinophyceans belonging to eleven genera have been found in the Upper Ordovician (Ashgill) deposits from Zalesie Nowe (Holy Cross Mountains, southern Poland). They are the first representatives of organic-walled plankton described thus far from the uppermost Ordovician/lowermost Silurian strata in the southern part of the Holy Cross Mountains.

The studied acritarchs and prasinophyceans derive from two different lithofacies comprising shallow-water mudstones (Dalmanitina beds) overlain by grey and black graptolites shales (Bardo beds). Previously, the Ordovician acritarchs from the Holy Cross Mountains were described by Jagielska (1962) from the Arenig and Caradoc strata. Gorka (1967, 1969, 1974) reported acritarchs from Tremadoc deposits, while Stępień (1990) described Ordovician and Silurian acritarchs. In the present paper, the new record of the latest Ordovician acritarchs from the Zalesie Nowe section in the Bardo syncline is reported. The material studied is housed in the Institute of Paleobiology, Polish Academy of Sciences, Warsaw (abbreviated ZPAL).

Material and methods

Twelve samples of mudstones and siliceous shales were taken from the uppermost part of the Ordovician section at Zalesie Nowe in the Holy Cross Mountains. Standard palynological techniques were employed for the recovery of acritarchs. (These involved dissolving about 10 grams of rock from each sample in hydrochloric acid followed by hydrofluoric acid and finally nitric acid. The macerated material was washed several times with distilled water and subsequently treated with heavy liquid to separate the organic fraction from the residue).

Geological setting

The sampled Ordovician deposits are exposed at Zalesie Nowe near Łagów in the southern part of the Holy Cross Mountains (Fig. 1). The Ordovician succession at Zalesie Nowe is stratigraphically almost complete (Czarnocki 1928; Dzik & Pisera 1994; Bednarczyk 1996), however, the boundaries of the series have not yet been precisely determined. The Ordovician is here unconformable to the Cambrian. The lower part of the Ordovician deposits (Tremadoc and Arenig) is composed of sandstones, which are partly glauconitic (Bednarczyk 1996). The fossils are rare and represented mostly by inarticulate brachiopods (Czarnocki 1928; Bednarczyk 1988). Spicules of sponges, graptolites and conodonts were also recovered from the cherty interlayers (Kozłowski 1948; Szaniawski 1980). The middle part of the Zalesie Nowe section is condensed and composed mainly of dolomites and limestones. Conodont assemblages indicate a Llanvirn to Ashgill age for these deposits (Dzik 1996). The uppermost part of the section is divided into two informal units. The lower unit (Dalmanitina beds) consists of mudstones and marly mudstones with brachiopods (Temple 1965). trilobites (Kielan 1959) and numerous bur-
Mesozoic and Cenozoic
Cambrian, Devonian, Carboniferous and Permian
Ordovician and Silurian
Zalesie Nowe
Faults

Fig. 1. Simplified geologic map of the Holy Cross Mountains with location of the studied section.

rows. Its age is well defined by the trilobite *Mucronaspis mucronata* (Brongniart, 1822) as latest Ashgill (Owen 1981), and by the brachiopod fauna (Temple 1965), which indicates a Hirnantian age (Poulsen 1978; Rong & Harper 1988). Black shales and lydites of the upper unit (Bardo beds) contain different faunas. Graptolites and scolecodonts occur in the grey and black siliceous shales, whereas graptolites, radiolarians, chitinozoans and several fragments of phragmocones of orthoconic nautiloids in lydites. Based on the graptolites *Normalograptus normalis* Lapworth, 1877, *Normalograptus angustus* (Perner, 1895), and poorly-preserved forms assigned to *Glyptograptus* Lapworth, 1873, which indicate age of latest Ordovician–earliest Silurian (Melchin & Mitchell 1991), as well as on lithological character (usually the beginning of the Silurian is associated with the start of lydite deposition, see Brenchley 1988; Jaeger 1988; Storch 1988), the author suggests a late Ordovician (Ashgill)–early Silurian age for the Bardo beds at Zalesie Nowe.

**Acritarchs from Zalesie Nowe**

The acritarchs from the Upper Ordovician deposits at Zalesie Nowe are of low diversity and rare. Eleven acritarch and prasinophycean genera and 20 species were identified from the samples taken from the Dalmanitiiza beds and Bardo beds (Fig. 2). Some of the most characteristic and common forms are shown in Fig. 3 and Fig. 4.

The most common genera in the studied material are *Baltisphaeridiuin* Eisenack, 1958 *ex* Eisenack, 1959, emend. Staplin, Jansonius, & Pocock, 1965, emend. Eisenack, 1969 and *Veryhachium* Deunff, 1954, emend. Downie & Sarjeant, 1963, emend. Turner, 1984. According to *Wall* (1965), *Baltisphaeridiuin* occurred predominantly in a near-shore, partly restricted environments. At Zalesie Nowe, the genus occurs indeed in relatively shallow-water sediments, but in the upper part of the section it also occurs in black shales representing a deeper water facies, *Veryhachium*, found in all analysed samples is considered to be characteristic of offshore open-marine environment (Jacobson 1979). At Zalesie Nowe *Veryhachium* occurs, however, both in shallow- (*Dalmanitiiza* beds) and open-marine (*Bardo* beds) environment.
Fig. 2. Stratigraphic section of Upper Ordovician deposits at Zalesie Nowe showing frequency of acritarchs and percentage of genera in analyzed samples (S-1–S-12).
Fig. 3. Examples of the most characteristic and common acritarchs in the Upper Ordovician deposits at Zalesie Nowe. A. *Baltisphaeridium* sp. A (S-8, ZPAL Ak.I/PR.8/3), B. *Veryhachium reductum* (S-6, ZPAL Ak.I/PR.5/1), C. *Veryhachium* sp. (S-8, ZPAL Ak.I/PR.8/1), D. *Veryhachium* cf. *V. reductum* (S-8, ZPAL Ak.I/PR.8/3), E. *Veryhachium* cf. *V. downiei* (S-11, ZPAL Ak.I/PR.11/1), F. *Baltisphaeridium* sp. B (S-8, ZPAL Ak.I/PR.8/3), G. *Veryhachium hamii* (S-8, ZPAL Ak.I/PR.8/1). Scale bar 20 μm.

*Leiosphaeridia* Eisenack, 1958, common at the Zalesie Nowe succession, is compared with modern prasinophycean alga *Halosphaera* Schmitz, 1878 (Wall 1962). Riegel (1974) considered *Leiosphaeridia* to be a neritic form, while Jacobson (1979) considered it to be a shallow water form. At Zalesie Nowe succession, *Leiosphaeridia* is abundant in sediments characteristic of both shallow- and open-marine environments. This record supports the idea that *Leiosphaeridia* comprises cysts of eurytopic phytoplankters (Jacobson 1979). A common form at Zalesie Nowe is the prasinophycean alga *Tasmanites* Newton, 1875. The modern analogue of *Tasmanites* is probable *Pachysphaera* Ostenfeld, 1899 (Wall 1962; Boalch & Parke 1971) and similarly as its possible modern relatives, the fossil *Tasmanites* is a cosmopolitan phytoplankter. These fossil algae are found in various environments, both shallow and deep-water sediments and also in brackish and freshwater sediments. Mass occurrence of *Tasmanites* is often associated with black shales (Guy-Ohlson 1996). Prauss & Riegel (1989) also noted common occurrence of phytoplankton in black shales in which prasinophyte phycomata are often the most abundant forms. *Micrhystridium* Deflandre, 1937, emend. Sarjeant, 1967, is restricted to the
Fig. 4. Examples of the most characteristic and common acritarchs in the Upper Ordovician deposits at Zalesie Nowe. A. *Micrhystridium* cf. *M. stellatum* (S-11, ZPAL Ak.I/PR.1113). B. *Micrhystridium* sp. (S-6, ZPAL Ak.I/PR.6/1). C. *Goniosphaeridium* sp. (S-8, ZPAL Ak.I/PR.8/1). D. *Acanthodiacrodim* sp. (S-8, ZPAL Ak.I/PR.8/1). E. *Goniosphaeridium* sp. (S-8, ZPAL Ak.I/PR.8/3). F. *Leiosphaeridia wenlockia* (S-8, ZPAL Ak.I/PR.8/3). Scale bar 20 μm.


The distinct change in depositional environments between the *Dalmanitina* beds and Bardo beds is not clearly reflected in acritarch succession. All the analyzed species occur throughout the whole studied interval showing only differences in their abundance. The acritarch succession shows a gradual change from a *Baltisphaeridium-Micrhystridium* dominated assemblage at the base of the *Dalmanitina* beds, through an upward increasing *Baltisphaeridium-Lophosphaeridium-Veryhachium* assemblage, to an assemblage dominated by *Tasmanites-Leiosphaeridia-Veryhachium* at the top.

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References


Appendix

List of identified taxa:


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