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Brief report

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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 Stempień (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-

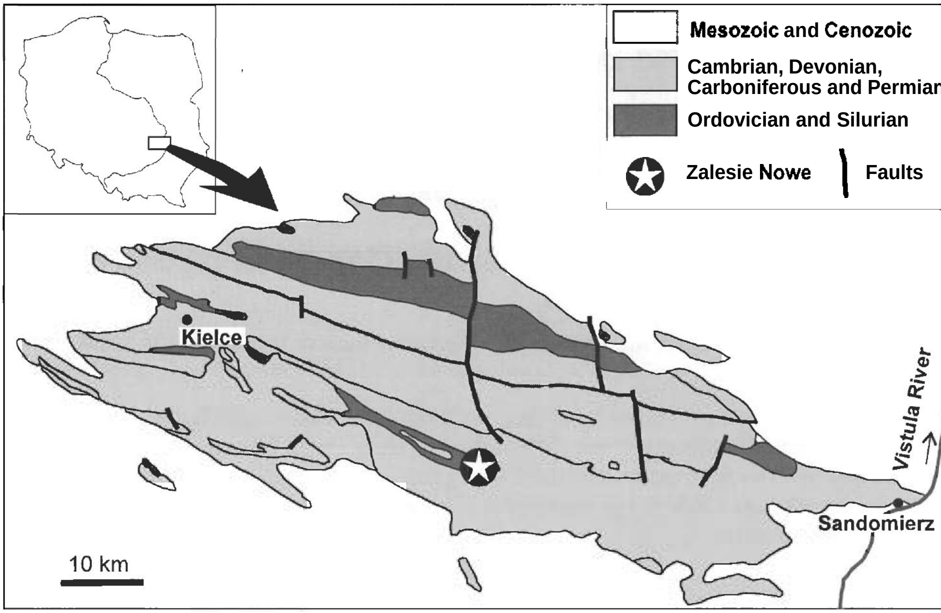

Fig. 1. Simplified geologic map of the Holy Cross Mountains with location of the studied section.

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, *Normalogrnptus 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; Štorch 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), *Baltisphaeridium* 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.

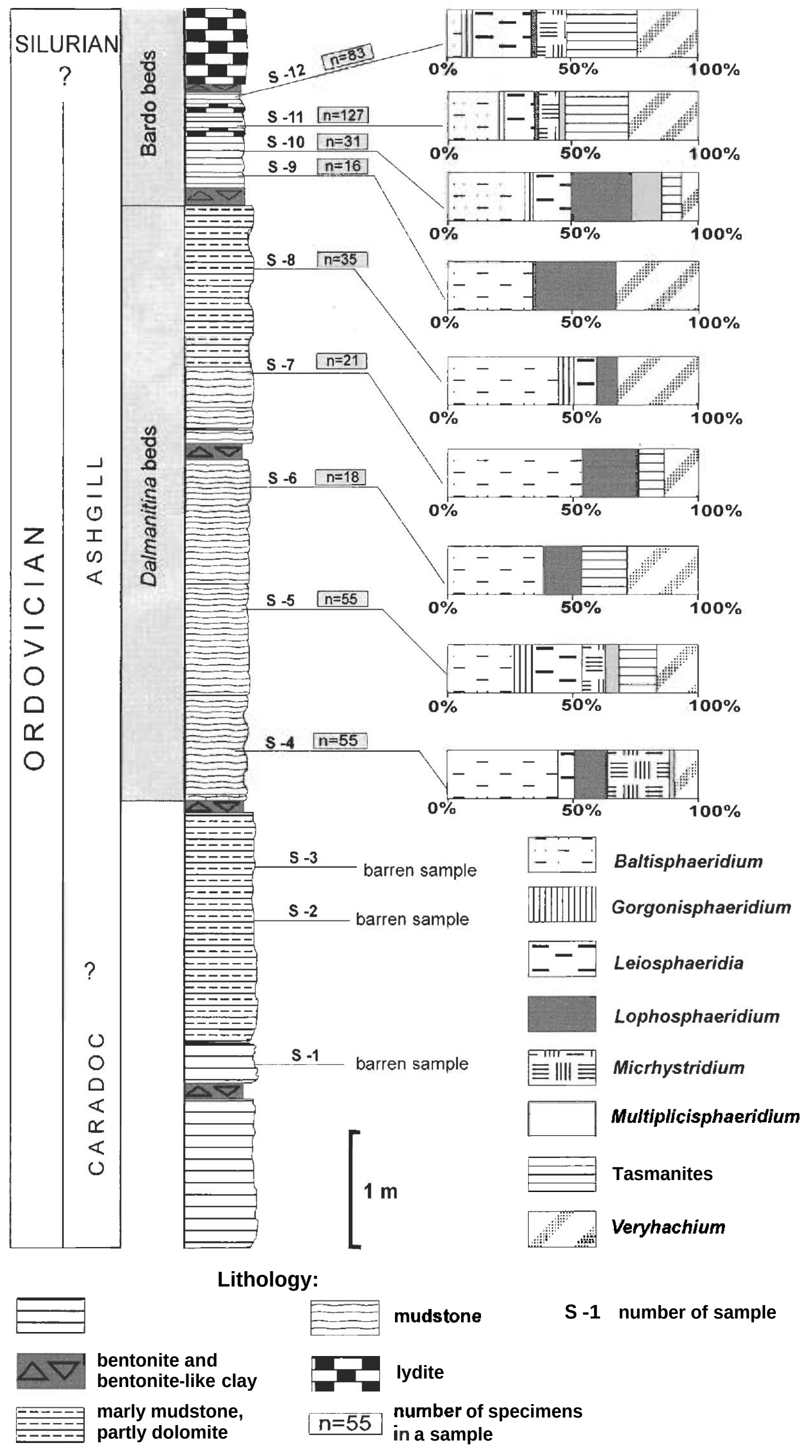

Fig. 2. Stratigraphic section of Upper Ordovician deposits at Zalesie Nowe showing frequency of acritarchs and percentage of genera in analyzed samples (S-1–S-12).

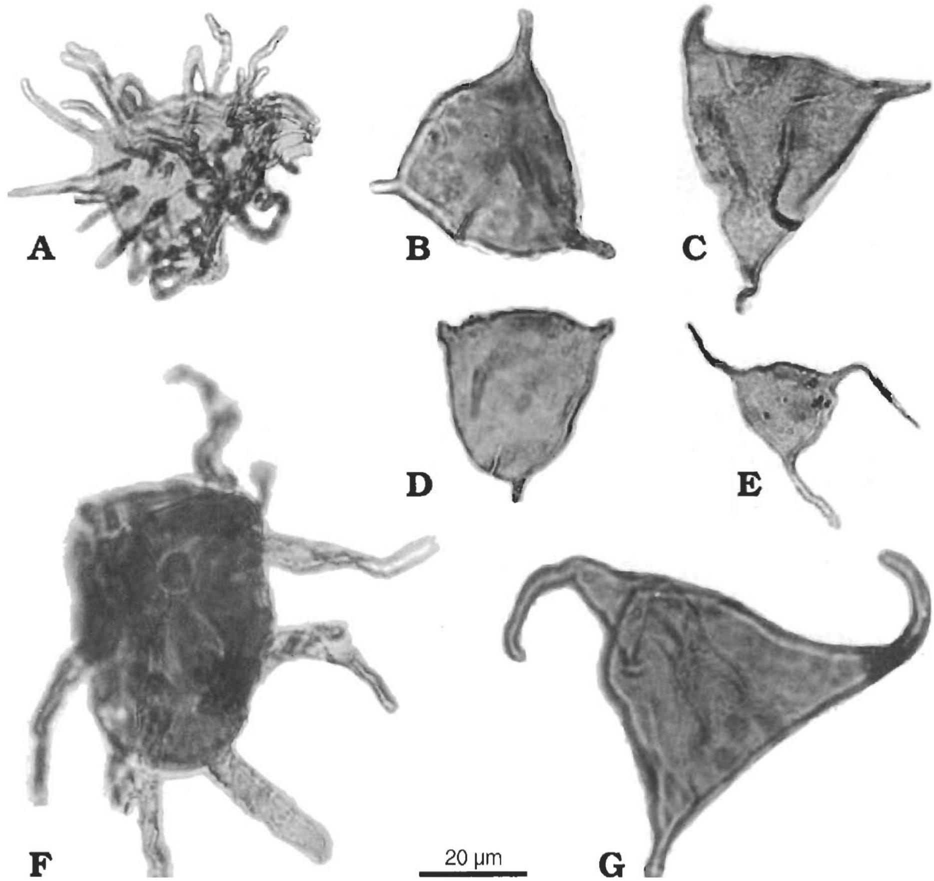

Fig. 3. Examples of the most characteristic and common acritarchs in the Upper Ordovician deposits at Zalesie Nowe. *A. Bnltisphaeridium* sp. A (S-8, ZPAL Ak.I/PR.8/3). B. *Veryhachium reductum* (S-6. ZPAL Ak.I/PR.5/1). **C.** *Veryhachium* sp. (S-8, ZPAL Ak.I/PR.8/1). D. *Veryhachium* cf. *V. reductum* (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 modem prasinophycean alga *Halosphaera* Schmitz, 1878 (Wall 1962). Riegel (1974) considered *Leiosphaeridia* to be a neritic form, while Jacobson (1979). to the contrary, considered it to be a shallow water form. At Zalesie Nowe succession, *Leiosphaeridia* is abundant in sediments characteristic of both shallow-, as well as a 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 modem analogue of *Tasmanites* is probable *Pachysphaera* Ostenfeld, 1899 (Wall 1962; Boalch & Parke 1971) and similarly as its possible modem 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 very 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

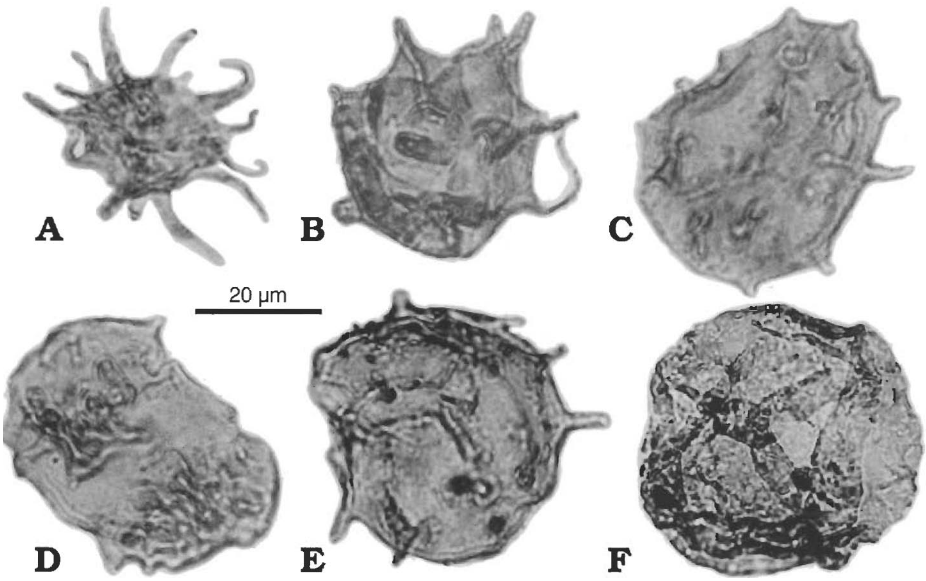

Fig. 4. Examples of the most characteristic and common acritarchs in the Upper Ordovician deposits at Zalesie Nowe. **A.** *Micrhystridium* cf. *M. stellatum* (S-11, ZPAL Ak.I/PR.1113). B. *Micrhystridium* sp. (S-6, ZPAL Ak.I/PR.6/1). **C.** *Goniosphaeridium* sp. (S-8, ZPAL Ak.I/PR.8/1). D. *Acanthodiacrodium* 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.

lowermost and uppermost part of the studied interval. Genera *Multiplicisphaeridium* Staplin, 1961, restricted Staplin, Jansonius & Pocock, 1965, emend. Eisenack, 1969, *Gorgonisphaeridium* Loeblich & Tappan, 1978 and *Goniosphaeridiuin* Eisenack, 1969, emend. Kjellstrom, 1971 are not common and were only found in several samples. Acritarchs classified as *Acanthodiacrodium* Timofeev, 1958 and *Deunffia* Downie, 1960 were found only in sample S-8.

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

Bednarczyk, W. 1988. Rola brachiopodów Inarticulata w stratygrafii najnizszego ordowiku Gór Świętokrzyskich. — *Przegląd Geologiczny* **1,** 17–23.

Bednarczyk. W. 1996. Zalesie. *In:* M. Szulczewski & S. Skompski (eds.), *Sixth European Conodont Symposium (ECOS VI), Excursion Guide.* 18–21. Warszawa.

Boalch, G.T. & Parke, M. 1971. The Prasinophycean genera (Chlorophyta) possibly related to fossil genera, in particular the genus *Tasmanites*. *Proceedings of the II Planktonic Conference.* Roma 1970.99–105.

Brenchley, P.J. 1988. Environmental changes close to the Ordovician–Silurian boundary. *In:* L.R.M. Cocks & R.B. Rickards (eds.), A Global Analysis of the Ordovician–Silurian Boundary. — *Bulletin of the British Museum of Natural History (Geology)*43, 377–385.

Czarnocki, J. 1928. Profil dolnego i górnego ordowiku w Zalesiu pod Eagowem w porównaniu z ordowikiem innych miejscowości Srodkowej części Gór Świętokrzyskich. — *Sprawozdania Państwowego Instytutu Geologicznego* **4**, 555–568.

Dzik. J. 1996. Mójcza quarry. *In:* M. Szulczewski & S. Skompski (eds.), *Sixth European Conodont Symposium ECOS VI, Excursion Guide,* 22–26. Warszawa.

Dzik. J. & Pisera, A. 1994. Sedimentation and fossils of the Mójcza Limestone. *In:* J. Dzik, *E.* Olempska, & A. Pisera (eds.), Ordovician Carbonate Platform Ecosystem of the Holy Cross Mountains. — *Palaeontologica Polonica* 53, 5–41.

Gorka, H. 1967. Quelques nouveaux Acritarches des silexites du Trkmadocien supérieur de la région de Kielce (Montagne de Ste Croix, Pologne). — *Cahiers de Micropaleontologie* 1, 1–1 1.

Górka, H. 1969. Microorganismes de l'Ordovicien de Pologne. — *Palaeontologia Polonica* 22. 1–100.

Górka, H. 1974. Les Acritarches de concretions calcaires du Famennien Superieur de Łagów (Monts de Sainte Croix, Pologne). — *Acta Palaeontologica Polonica* 19, 225–250.

Guy-Ohlson, D. 1996. Green and blue-green algae. *In:* J. Jansonius & D.C. McGregor (eds.), Palynology: Principles and Applications. — *American Association of Stratigraphic Palynologists Foundation 1*, 181–189.

Jacobson, S.R. 1979. Acritarchs as paleoenvironmental indicators in Middle and Upper Ordovician rocks from Kentucky, Ohio and New York. — *Journal of Paleontology* **53**, 1197–1212.

Jaeger, H. 1988. The Ordovician–Silurian boundary in the Saxothuringian Zone of the Variscan Orogen. *In:* L.R.M. Cocks & R.B. Rickards (eds.), A Global Analysis of the Ordovician–Silurian Boundary. — *Bulletin of the British Museum of Natural History (Geology)*43, 101–106.

Jagielska, L. 1962. Wstppne opracowanie mikrospor z ordowiku Brzezin i Zbrzy w Górach Świętokrzyskich. — *Biuletyn Instytutu Geologicznego* 174, 51–63.

Kielan, Z. 1959. Upper Ordovician trilobites from Poland and some related forms from Bohemia and Scandinavia. — *Palaeontologica Polonica* 11, I–199.

Kozłowski, R. 1948. Les Graptolites et quelques nouveaux groupes d'animaux du Tremadoc de la Pologne. — *Palaeontologica Polonica* 3, 1–236.

Melchin. M.J. & Mitchell, Ch.E. 1991. Late Ordovician extinction in the Graptoloidea. *In:* C.R. Barnes & S.H. Williams (eds.), Advances in Ordovician Geology. — *Geological Survey of Canada* 90-9, 143–156.

Owen, A.W. 1981. The trilobite *Mucronaspis* in the uppermost Ordovician of the Oslo Region, Norway. — *Norsk Geologisk Tidsskrift* 61,271–279.

Poulsen, V. 1978. *Dalmanitina* beds (late Ordovician) on Bornholm. — *Danmarks Geologiske Undersøgelse, Årbog* **1976**, 53–87.

Prauss, M. & Riegel, W. 1989. Evidence from phytoplankton associations for causes of black shale formation in epicontinental seas. — *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte* 11, 671–682.

Riegel, W. 1974. Phytoplankton from the upper Emsian and Eifelian of the Rhineland, Germany – a preliminary report. — *Review of Palaeohotany and Palynology* 18, 29–39.

Rong, Jia-yu & Harper, D.T. 1988. A global synthesis of the Ordovician Hirnantian brachiopod faunas. — *Transactions of the Royal Society of Edinburgh: Earth Sciences* 79, 383-402.

Stempień, M. 1990. Ordovician and Silurian acritarchs of the Niestachów Sandstone Formation (Góry Świętokrzyskie Mountains). — *Annales Societatis Geologorum Poloniae* **60**, 59–74.

Štorch, P. 1988. The Ordovician–Silurian boundary in the Prague Basin, Bohemia. *In:* L.R.M. Cocks & R.B. Rickards (eds.), A Global Analysis of the Ordovician–Silurian Boundary. — *Bulletin of the British Museum of Natural History (Geology)*43, 95–100.

Szaniawski. H. 1980. Conodonts from the Tremadocian chalcedony beds. Holy Cross Mountains, Poland. — *Acta Palaeontologica Polonica* 25. 101–121.

Temple, J.T. 1965. Upper Ordovician brachiopods from Poland and Britain. — *Acta Palaeontologica Polonica 10.* 379427.

Wall, D. 1962. Evidence from recent plankton regarding the biological affinities of *Tasmanites* Newton 1875 and *Leiosphaeridia* Eisenack 1958. — *Geological Magazine* **99,** 353–363.

Wall, D. 1965. Microplankton, pollen, and spores from the Lower Jurassic in Britain. — *Micropaleontology* **11.** 151–190.

Appendix

List of identified taxa:

Acritarcha. — *Acanthodiacrodium* sp., *Baltisphaeridium brevifilicum* Kjellstrom, 1971, *Baltisphaeridium filosum* Kjellstrom, 1971, *Baltisphaeridium* cf. *B. hirsutoides* (Eisenack. 1931), *Baltisphaeridium magnoporatum* Kjellstrom, 1971, *Baltisphaeridium microspinosum* (Eisenack, 1954), *Baltisphaeridium multipilosum* (Eisenack, 1931), *Baltisphaeridium* cf. B. *nanninum* (Eisenack, 1965). *Baltisphaeridium psilatum* Kjellstrom, 1971, *Baltisphaeridium* cf. *B. ritvae* Kjellstrom, 1971, *Baltisphaeridium* sp. *A*, *Baltisphaeridium* sp. *B*, *Deunffia* sp., *Goniosphaeridium* sp.. *Gorgonisphaeridium* sp., *Lophosphaeridium* sp., *Micrhystridium* cf. *M. cleae* Martin, 1972. *Micrhystridium robustum* Downie, 1958. *Micrhystridiurn* cf. *M. stellatum* Deilandre. 1945, *Micrhystridiurn* sp., *Multiplicisphaeridium brevifurcatum* (Eisenack, 1954), *Multiplicisphaeridium* cf. *M. irregulcrre* Staplin, Jansonius & Pocock, 1965. *Multiplicisphaeridium* sp., *Veryhachium downiei* Stockmans & Williere, 1962, *Veryhachium hamii* Loeblich, 1970, *Veryhachium reductum* Deunff, 1958, *Veryhachium trispinosum* Eisenack. 1938, *Veryhackium* sp.

Prasinophyceae.— *Leiosphaeridia wenlockia* Downie, 1959. *Leiosphaeridia* sp., *Tasmanites* sp.

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