Burgess Shale-type fossils in Cambrian sandstones of the Holy Cross Mountains

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Impressions of a U-shaped gut are identified in discs of *Velumbrella czarnockii* from the Słowiec Sandstone Formation of the Middle Cambrian of the Holy Cross Mts. Associated discs devoid of radial ribs belonged to different species attributed to *Rotadiscus*. Fossils of both *Velumbrella* and *Rotadiscus* are sclerotized discs and are preserved randomly oriented within coarse grained sandstones. Anomalocaridid jaw apparatus has been found on the lower surface of a sandstone bed in the Late Cambrian Klonówka Shale Formation. These organisms, typical for the Burgess Shale and Chengjiang soft-bodied faunas are thus not restricted ecologically to fine clastic facies of the Cambrian.

Key words: Cambrian, Poland, Burgess Shale-type fauna.

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Introduction

Apart from a well known and recognizable fauna, the main part of which consists of trilobites, the Cambrian sequence of the Holy Cross Mountains contains also many problematic fossils. This paper contains descriptions of fossil eldonioid discs occurring in this sequence as well as a jaw-apparatus of an anomalocaridid.

Localities

The skeletal fossils described in this paper come from three localities in the Holy Cross Mountains (Fig. 1).

Among studied localities the oldest is that at the Malkowska Hill near Malkowice, about 8 km southwestwards from Iwaniska (Fig. 2) in the Wygiełzów range. One fragment of *Velumbrella* disc and one fragment of *Rotadiscus* (previously known as 'Brzechowia') have been collected in the Ociesęki Sandstone Formation of the Early Cambrian *Holmia-Schmidtiellus* Zone. They co-occur with fossils typical for the zone such as *Schmidtiellus nodosus* Orłowski 1985 and *Holmia* sp. (Orłowski 1985, 1988). All fossils have been found in slope debris.

The next place where both *Velumbrella* and *Rotadiscus* occur are heaps of stones on fields and field balks in the vicinity of Brzechów (Fig. 3A–B). The fossils are found as imprints in unbedded coarse sandstones (Słowiec Sandstone Formation), represented as randomly oriented, torn or bent fragments of discs within the sandstone. The strata represent the *Paradoxides insularis* and *Paradoxides pinus* Zones of the Middle Cambrian (Bednarczyk 1970), and contain such fossils as *Paradoxides oelandicus* Sjögren 1872, *Protolenus bodzanti* Bednarczyk 1970, *Jakutus? kielcensis* Bednarczyk 1970, *Ellipsocephalus sanctacrucensis* (Samsonowicz 1959), *Skreiaspis*? sp. and *Lingulella* sp. *Velumbrella* is very common in Brzechów whereas *Rotadiscus* is there extremely rare and usually poorly preserved. We have only 4 specimens of this fossil from this locality at our disposal, only one of which complete.

The third locality is the Wiśniówka quarries, where in the Late Cambrian Klonówka Shale Formation (*Protopeltura* Zone) an imprint of a *'Peytoia'*-type jaw apparatus has been found. This is one of the best preserved trilobite ichnocoenoses in the world (Dżułyński & Żak 1960; Radwański & Roniewicz 1960, 1963, 1967, 1972; Orłowski 1992; Orłowski *et al.* 1970). Apart from the trilobite traces, the sequence also yields traces of animals accompanying the trilobites in their biotope: anemone-like *Bergaueria perata*, a large arthropod trace *Aglaspidichnus sanctacrucensis* and various types of traces of worm-like organisms including *Planolites* and *Gordia*. They all occur in intercalations of thin to medium bedded sandstone with numerous intercalations of siltstones and shales.

Descriptions

***Velumbrella czarnockii* Stasińska 1960** (Fig. 5A–D). — The specimen was identified by Czarnocki (1927) and subsequently described as medusae by Stasińska (1960). This was a disc-like, flat, easily bending, lightly sclerotized organism. Its surface bore 28 distinct radial ribs. The disc diameter ranges from 19 to 86 mm (Fig. 4). The central parts of the discs (3–8 mm in diameter) are devoid of any features. Apart from the morpho-

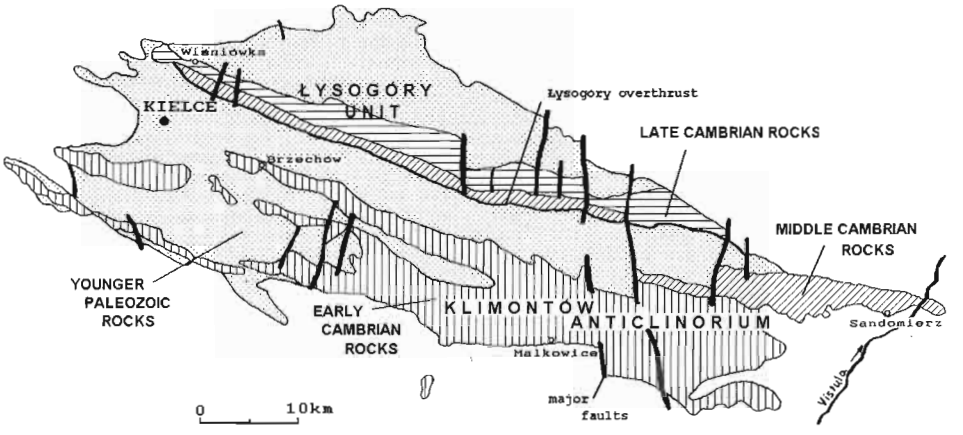

Fig. 1. Sketch geological map of the Holy Cross Mts with described localities.

logical structures identified thoroughly by Stasińska (1960) a few specimens (nos UWIPG B/II/6a, b; UWIPG B/II/18; UWIPG B/II/24b) bear a fairly distinct U-shaped depression probably extending from the central part of the disc (Fig. 5C; arrowed).

Ever since Stasińska (1960) assigned *Velumbrella* to the hydrozoan coelenterate order Trachylinida, its systematic position has been questioned by many authors (Scrutton 1979); Stanley (1986) reinterpreted these fossils as chondrophorans, together with forms like the Precambrian *Eoporpita*, Ordovician *Discophyllum*, and Devonian *Parapsonema* (see also Fedonkin 1987). Another interpretation comes from Dzik (1991), who established a new class Eldonioidea within the phylum Tentaculata for variably sclerotized, disc-shaped organisms bearing concentric or radial ridges. These include *Eldonia*, *Velumbrella*, *Yunnanomedusa*, and *Rotadiscus*. Conway Morris (1993a) stressed the resemblance of *Velumbrella* to *Eldonia*, a disc-shaped, possibly pelagic animal of unknown affinities which is abundant in the Middle Cambrian Burgess Shale faunas (Durham 1974; Conway Morris 1989a, b, 1990, 1993a, b; Conway Morris & Robison 1988) and Early Cambrian Chengjiang fauna of Yunnan, China (Sun & Hou 1987; Conway Morris 1989a; Dzik 1991).

Velumbrella is similar to *Eldonia* in shape of the disc and the presence of distinct radial ribs. Additional evidence of their close relationship is provided by a U-shaped depression, identified in some specimens of *Velumbrella*. This depression seems to be an imprint of the gut, which appears to be closely similar to that known in *Eldonia* (Durham 1974). The preservation of the gut in some specimens of *Velumbrella* could be possible when it was filled with fine sediment after the death of the organism. The infilled gut could cause deformations of the disc structure during transport and burial.

***Rotadiscus* sp.** (Fig. 6A–D). — The studied specimens are preserved in the same way as those of *Velumbrella*, also variably oriented within the

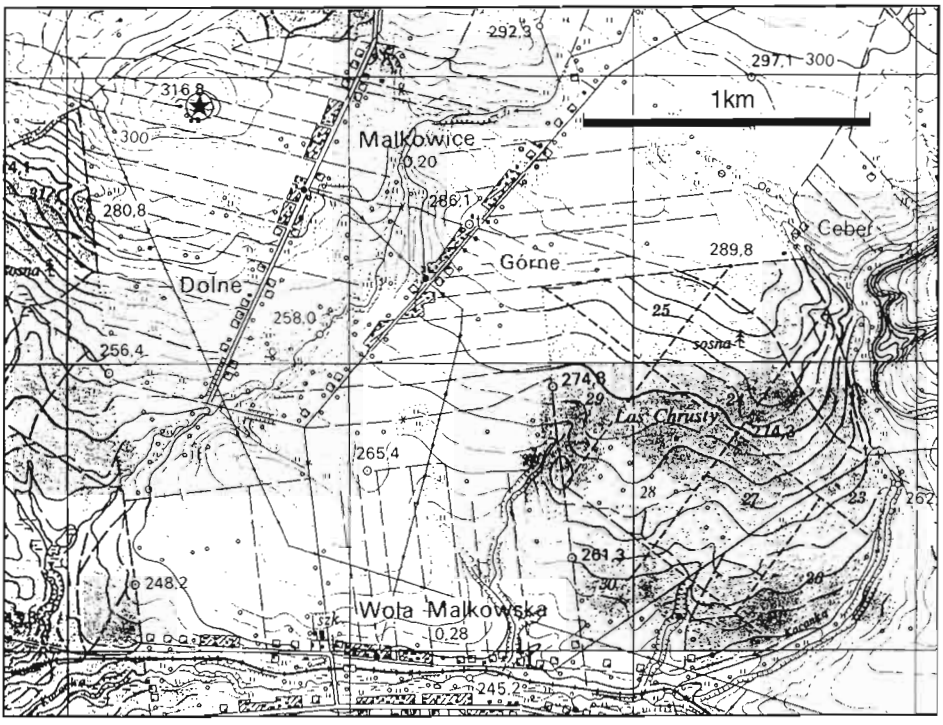

Fig. 2. Location of the exposure of the Ociesęki Sandstone Formation at Malkowska Hill near Iwaniska, eastern Holy Cross Mts, indicated with asterisk.

sandstone layers. The diameters of discs are variable: from 40 to 180 mm. The only known complete specimen (Fig. 6C) of this fossil is a poorly preserved juvenile. The central field of small specimens is surrounded by a ring of very fine radial ridges. On the periphery of larger specimens distinct concentric ridges are present. Randomly distributed radial structures within the concentric rings are of varying length and most probably originated in course of disc deformation after the death of the organism. Specimens of *Rotadiscus* (Sun & Hou 1987) from the Early Cambrian Chengjiang fauna of China have similar distinct concentric ridges on the periphery of the disc and a central field, erroneously interpreted as a trifid mouth by Sun & Hou (1987), which has been already questioned by Conway Morris (1993b), or as an attachment area for the disc by Dzik (1991).

The suggestion of Conway Morris (1993b) that *Rotadiscus* and *Velumbrella* are parts of the same animal does not find confirmation in the material from the Holy Cross Mts. As far as the Chinese material is concerned, the *Rotadiscus* specimens appear to be bilayered (Conway Morris 1993b; see Sun & Hou 1987: Pl. 3: 1), where one side of the animal is the annulated disc (interpreted as a float in the chondrophoran concept)

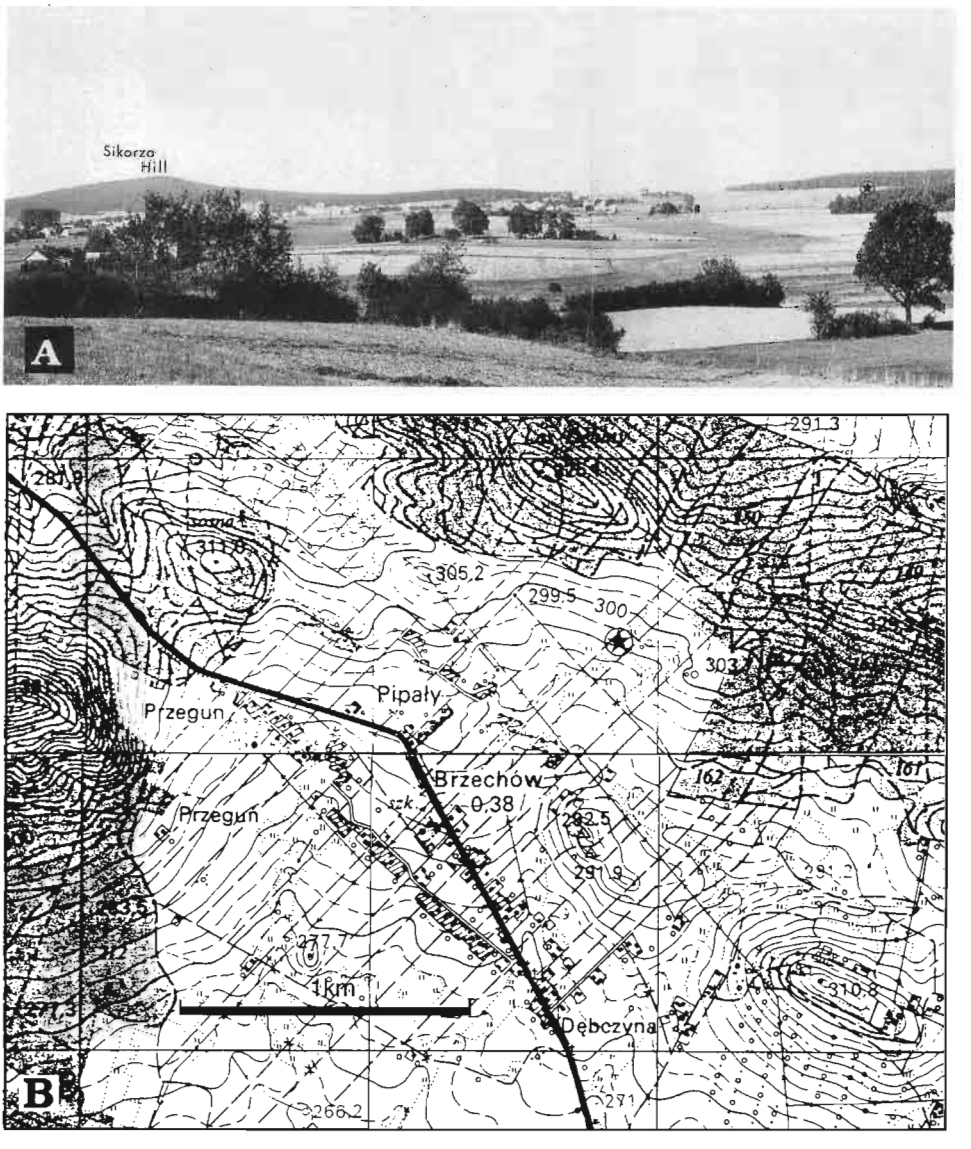

Fig. 3. ❑A. General view of the Brzechów Anticline, outcrop indicated with asterisk. ❑B. Location of the exposure of the Brzechów Sandstone Formation at Brzechów near Daleszyce, western Holy Cross Mts, indicated with asterisk.

while the other side is a disc with radial grooves synonymous with *Stellostomites* (closely related or synonymous with *Eldonia*). This is not the case in *Rotadiscus* from the Holy Cross Mountains, which has never been found superimposed on a specimen of *Velumbrella*, although discs of *Velumbrella* occasionally overlap each other (see Fig. 5B). Occurrences of *Rotadiscus* and *Velumbrella* on the same rock slab (Stasińska 1960: Pl. 1:

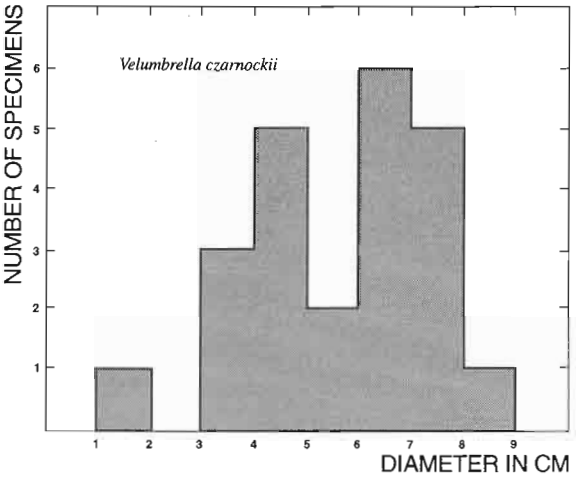

Fig. 4. Histogram of disc diameter for *Velumbrella czarnockii*. Data from all known measurable specimens (23), not occurring in one layer.

1–2; Dzik 1991: Fig. 3B) are clearly coincidental. *Velumbrella* discs never reach the diameter typical of presumably mature *Rotadiscus* discs. Also the highly uneven proportion of these two types of discs in the same outcrop testifies against their original occurrence in pairs. Nevertheless, basing upon the available data from the Holy Cross Mountains, it cannot be excluded that *Rotadiscus* was bilayered, what is more clearly evidenced by the Chinese material (Conway Morris 1993b), but the counterpart is not known. In this case the bilayered structure would testify against the chondrophore origin of *Rotadiscus*.

The random distribution of these fossils within the sandstone layers, the fact that they are often bent and torn apart, as well as various sizes of discs (Fig. 4) indicates a high energy environment of sedimentation. Thin sections of sandstones from Brzechów (Słowiec Sandstone Formation) reveal that the sediment consists mainly of well rounded quartz grains with clearly recognizable syntaxial rims and sutured grains, also with an admixture of metamorphic quartz, and the sediment is petrologicaly mature. The sediment is poorly sorted and contains large clay clasts (up to 10 mm in diameter). This indicates that the sedimentation of these sandstones was current dominated, where a rip current was responsible for the transport of the sediment together with organisms and its deposition in deeper parts of the basin.

***'Peytoia'* sp.** (Fig. 7). — The specimen occurs on the lower surface of sandstone (there is a *Rusophycus* accompanying the imprint on the same slab) as a concave imprint. The specimen is slightly elliptic in outline, with a small central field and an external ring devoid of any distinctive features. It is surrounded by 28 radially arranged units, four of which are wider and radiate from the center at right angles to each other. Each of four sets has thus seven lobes (Fig. 7B). The imprint looks very much like *Astropolithon* or a *Bergaueria*-type trace fossil but since it occurs near a convex trace

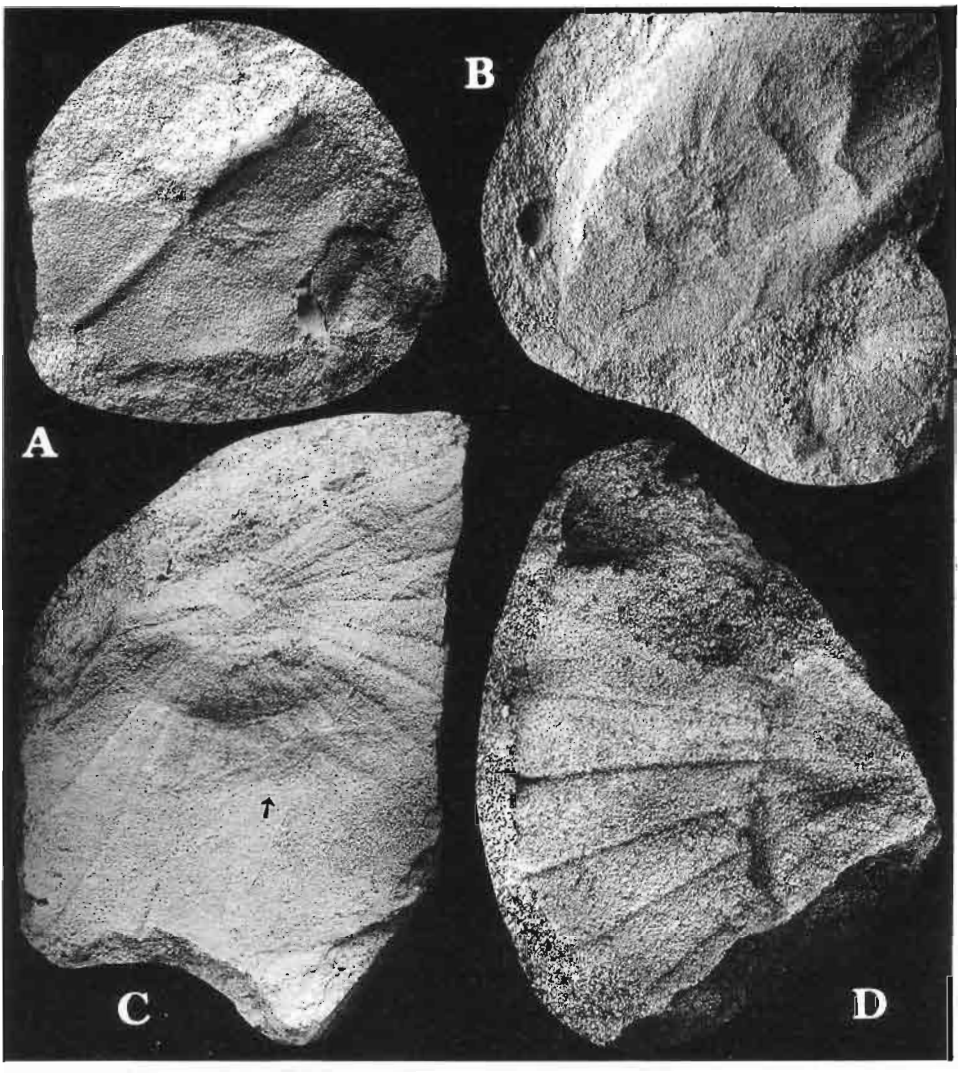

Fig. 5. *Velumbrella czarnockii* Stasińska 1960. ❑A. Specimen UWIPG B/I/1a. Early Cambrian Ociesięki Sandstone Formation, Malkowska Hill, Holy Cross Mts, Poland; × 3. ❑B. Overlapped specimens UWIPG B/II/5b. Middle Cambrian Słowiec Sandstone Formation, Brzechów, Holy Cross Mts, Poland; × 1. ❑C. Specimen UWIPG B/II/24b with gut imprint (arrowed). Middle Cambrian Słowiec Sandstone Formation, Brzechów, Holy Cross Mts, Poland; × 1.5. ❑D. Specimen UWIPG B/II/3. Middle Cambrian Słowiec Sandstone Formation, Brzechów, Holy Cross Mts, Poland; × 1.5.

fossil *Rusophycus* and is very shallow, unlike most *Astropolithon* specimens, it obviously was a thin convex element on the sea bottom at the moment of burial. Apart from that such a tetrameral arrangement of lobes is characteristic for the Middle Cambrian fossils originally described as medusoid *Peytoia nathorsti* Walcott 1911 from the Burgess Shale, British Columbia (Walcott 1911; Conway Morris & Robison 1982). *Peytoia* later

has appeared to be a circlet of sclerotized plates arming the mouth of the arthropod *Anomalocaris* (Whittington & Briggs 1985). This structure must have been held firmly together as often the circlets occur separately (Whittington & Briggs 1985). It was the only strongly sclerotized part of the body of anomalocaridids with a high preservational potential. Preservation of such a structure on the bedding plane does not seem that unlikely.

The Wiśniówka specimen differs from that from the Burgess Shale in number of radial units — seven instead of eight in each set. It is thus at least specifically distinct from the only known anomalocaridid jaw apparatus of *Anomalocaris nathorsti*, which has an additional medial lobe in each set. As it is not certain that the type species of *Anomalocaris* — *A. pennsylvanica* (Resser 1929) had its oral apparatus of *'Peytoia'*-type, we prefer to use informally the latter generic name for the Wiśniowka specimen, in which the number of lobes can be placed within the range of the number of lobes suggested by Conway Morris & Robison (1982) for Middle Cambrian *'Peytoia'* specimens from Utah. The latter specimens possibly belong to anomalocaridids, but their generic affinities are unknown.

Anomalocaridids were probably the largest predators in the Cambrian seas (Whittington & Briggs 1985) although some of them may have been filter feeders (Dzik & Lendzion 1988).

Anomalocaridids widely occur in Early and Middle Cambrian strata (Conway Morris 1989a; McHenry & Yates 1993). The earliest specimen is *Cassubia infercambriensis* (Lendzion 1975) from the Early Cambrian of the Polish part of the East European Platform (Dzik & Lendzion 1988). The new finding of *'Peytoia'* extends the range of occurrence of anomalocaridids to the Late Cambrian which is unique for Burgess Shale fauna, thought to be exclusive for the Early and Middle Cambrian (Conway Morris 1989a). *Goticaris* and *Cambropachycope* from the Late Cambrian Orsten fauna of the Baltic Region, known only from juveniles (Walossek & Müller 1990), bear some similarities to the anomalocaridids (Dzik 1993). The Wiśniówka specimen may have belonged to an adult of a related form.

Conclusions

Velumbrella czarnockii discs are skeletal fossils and are related to *Eldonia*. Like *Eldonia* it probably had a U-shaped gut, a feature documented by newly collected specimens. Most probably *Velumbrella* is not exclusive for the Middle Cambrian. Its probable occurrence in the Ociesęki Sandstone Formation near Malkowska Hill extends its range as low as to the *Holmia-Schmidtiellus* Zone of the Early Cambrian.

It is proposed to classify specimens previously informally named 'Brzechowia' to *Rotadiscus*. A complete juvenile specimen is described. *Rotadiscus* discs are skeletal fossils like *Velumbrella*, but they definitely belonged to different organisms, distinct at generic level. *Rotadiscus* cooccurs with *Velumbrella* mainly in the vicinity of Brzechów, although a probable

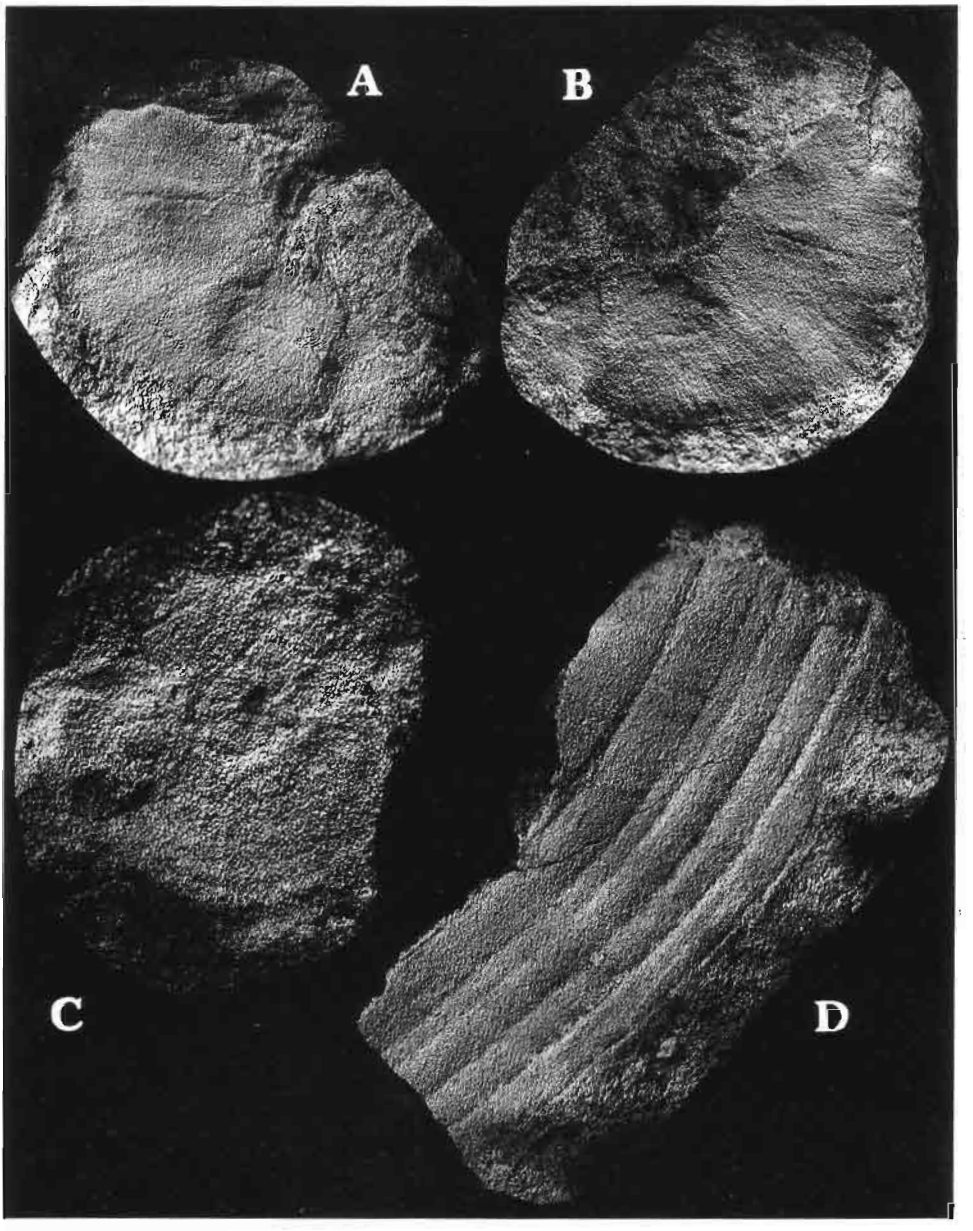

Fig. 6. *Rotadiscus* sp. ❑A–B. Specimens UWIPG B/I/2a and UWIPG B/I/2b, part and counterpart. Early Cambrian Ociesięki Sandstone Formation, Malkowska Hill, Holy Cross Mts, Poland; × 2. ❑C. Peripheral fragment of mature specimen UWIPG B/II/23a. Middle Cambrian Słowiec Sandstone Formation, Brzechów, Holy Cross Mts, Poland; × 1.5. ❑D. Juvenile specimen UWIPG B/II/24b. Middle Cambrian Słowiec Sandstone Formation, Brzechów, Holy Cross Mts, Poland; × 2.

fragment of disc has been found on the Malkowska Hill in strata of Early Cambrian age.

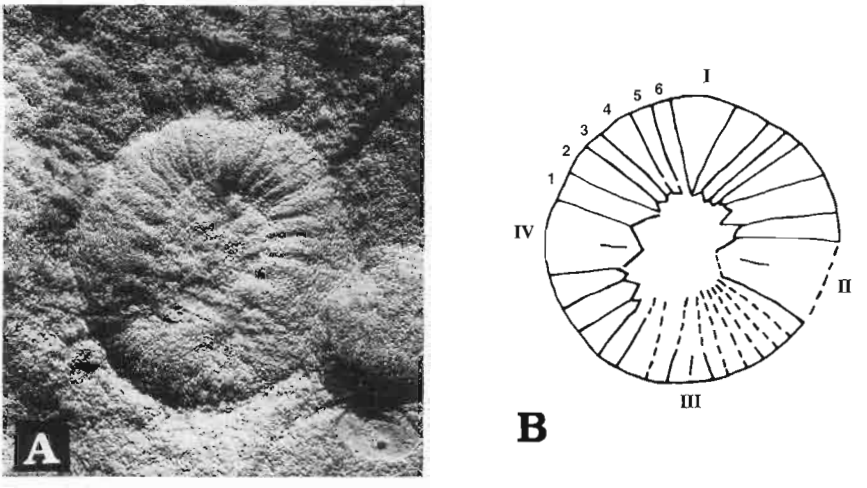

Fig. 7. *'Peytoia'* sp., Late Cambrian Klonówka Shale Formation, Wiśniówka, Holy Cross Mts, Poland; × 3. Specimen no. UWIPG B/III/1. Photograph of the rock slab (A) and interpretive drawing (B). I–IV are wide lobes, 1–6 are narrow lobes of the jaw apparatus.

A *'Peytoia'*-type anomalocaridid jaw — apparatus identified in the Holy Cross Mountains belonged to an anomalocaridid possibly related to adult forms of *Goticaris* and *Cambropachycope*, known from juvenile specimens in the Late Cambrian Orsten fauna. Some trace fossils within the Wiśniówka ichnocoenose may belong to the anomalocaridids.

The above described fossils are typical for both the Early Cambrian Chengjiang and the Middle Cambrian Burgess Shale soft bodied faunas but are preserved in completely different sediments in the Holy Cross Mountains, mainly sandstones, including coarse grained sandstones.

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Streszczenie

Z trzech stanowisk fauny kambryjskiej w Górach Świętokrzyskich tj. z Brzechowa, Góry Malkowskiej i z Wiśniówki Dużej pochodzą okrągłe odciski organizmów o nieustalonej pozycji systematycznej. W Brzechowie i na Górze Malkowskiej znaleziono dyski o zróżnicowanych rozmiarach (2–8 cm), które wykazują podobieństwo do dysków *Eldonia ludwigi* Walcott 1911. Odciski te znane pod nazwą *Velumbrella czarnockii* Stasińska 1960 wielokrotnie opisywane były jako przedstawiciele jamochłonów (*Hydrozoa* lub *Chondrophora*). Występowanie na kilku okazach U-kształtnego śladu w obrębie dysku, być może odcisku jelita, potwierdza wcześniejsze twierdzenia o pokrewieństwie *Velumbrelli* i *Eldonii*.

Rotadiscus, znany wcześniej pod nieformalną nazwą „Brzechowia", współwystępuje z rodzajem *Velumbrella* zarówno w Brzechowie jak i na Górze Malkowskiej. Obserwacje jedynego całkowicie zachowanego młodocianego okazu oraz nielicznych fragmentów form dojrzałych wskazują na to, iż *Velumbrella* i *Rotadiscus* były odrębnymi organizmami. Znaleziska z Góry Malkowskiej obniżają dolną granicę zasięgu obydwu rodzajów.

Znany z górnokambryjskich piaskowców z Wiśniówki aparat szczękowy typu *'Peytoia'* należał do przedstawiciela *Anomalocarididae*. Nie wyklucza się pokrewieństwa tej formy z dorosłymi osobnikami *Goticaris* i *Cambropachycope*, znanych z juwenilnych okazów w późnokambryjskiej faunie z Orsten.

Omówione wyżej formy są typowe dla wczesnokambryjskiej fauny z Chegjiang (*Rotadiscus*) oraz środkowokambryjskiej fauny z Burgess (*Velumbrella* i *Peytoia*). Różnią się jednak zarówno sposobem zachowania jak i typem osadu, w którym występują.