acta
geologica
polonica

Vol. 34, No. 1-2 Warszawa 1984

WIESŁAW BEDNARCZYK

# Biostratigraphy of the Cambrian deposits in the Łeba area

ABSTRACT: The sedimentary cover of the East European Platform in the Łeba area (north-western Poland) encloses a Cambrian sequence that comprises almost all the equivalents of the stages distinguished in the classical section of Scandinavia. On the basis of macrofossils and partly microfossils the following zones and subzones have been recognized: Mobergella, Holmia, Protolenus (Lower Cambrian), Eccaparadoxides oelandicus (E. insularis, E. pinus), Paradoxides paradoxissimus (Hypagnostus parvifrons), Paradoxides forchhammeri (Middle Cambrian), Homagnostus obesus & Agnostus pisiformis, Orusia lenticularis, Peltura minor, and Peltura scarabeoides (Upper Cambrian). The Cambrian sediments overlie here the terrigenic sediments (Smołdzino Formation) of Vendian age.

## INTRODUCTION

The paper presents the results of studies over the Cambrian fossils and sediments recognized in the oil-prospecting boreholes at the Łeba area, and partly in the Gulf of Gdańsk (western part of the Peribaltic Depression), *i.e.* from the Gardno Lake in the west to Krynica Morska in the east (*see* Text-fig. 1). It follows the papers dealing with stratigraphy of the Precambrian and Cambrian deposits pierced by the Smołdzino *1* and Łeba *8* boreholes (Bednarczyk 1972), lithostratigraphy of the Vendian and Cambrian (Bednarczyk & Turnau-Morawska 1975), Upper Cambrian conodonts and ostracodes (Bednarczyk 1978, 1979), as well as the Cambrian sedimentary environment of the Gulf of Gdańsk (Bednarczyk & Przybyłowicz 1980).

*Acknowledgements.* The Author is indebted to the manager and the staff of the Union of Petroleum Mining in Warsaw and to the petroleum enterprises at Wołomin and Piła, subordinate to this Union, for the borehole data accessible.

The paper was prepared within an inter-ministry project *MR-I-16* ("Geodynamics of the Poland territory").

## LOWER CAMBRIAN

The rocks of the Klimontów stage are the oldest sediments in the Łeba area. This stage comprises the following formations: Kluki, Nowęcin, and partly Łeba (Bednarczyk & Turnau-Morawska 1975).

A paleontologic documentation of the Klimontów Stage in the analyzed sections comprises Hyolitha, Angustiochreida, and Acritarcha. The first are represented by *Circotheca ?billingsi* (Sysoev), whereas the second ones by the pipes defined as *Anabarites sp.* But the mentioned fossils, several shells of Archaeocopida were assigned as *Indiana* sp.

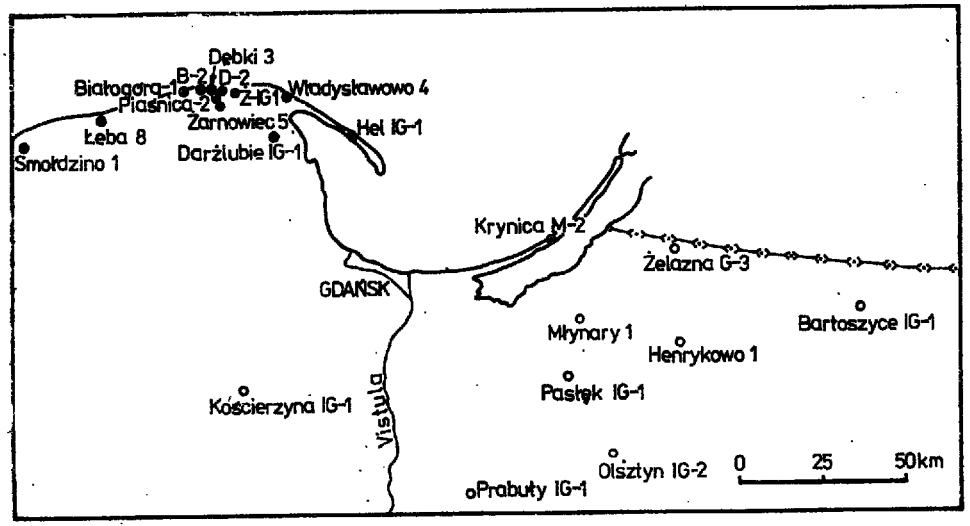



Fig. 1. Sketch-map showing location of investigated boreholes in the western part of the Peribaltic Depression

The lowermost members of the Kluki Formation should be considered as older than the Mobergella Zone and regarded as the equivalent of the Platysolenites Zone. The sediments of the Kluki Formation have been noted in the Smołdzino *1*, Łeba *8* and Kościerzyna *IG-1* boreholes (Table 6).

The Mobergella Zone has been documented only in the Kościerzyna *IG-1* borehole in which Lendzion (1976) but questionable trilobites (*Livia plana* Lendzion and *Cassubia infercambriensis* Lendzion) found *Mobergella* cf. *radiolata* Bengston. Besides, in the easternmost part of the Łeba area (Prabuty *IG-2* borehole), the Mobergella Zone was distinguished due to the presence of *Mobergella holsti* Moberg and *M. turgida* Bengston.

The thickness of the sediments of the Klimontów Stage can be evaluated in the Kościerzyna *IG-1* borehole for 143.3 m.

A paleontological documentation of the Holmia and Protolemus stages was found only in the Prabuty *IG-1* and Krynica Morska *2* boreholes. In the first one, the Holmia Stage is documented (Lendzion 1978) by

*Strenuella* cf. *polonica* Samsonowicz and *Strenuaeva primaeva* (Broegger), whereas in the second by *Holmia kjerulfi* (Linnarsson).

The Protolenus Stage was recognized in the Prabuty *IG-1* borehole due to the occurrence of *Protolenus* sp. and *Ellipsocephalus hoffi* (Schlotheim).

The most complete sequence of the Lower Cambrian is noted in the Słupsk *IG-1* borehole. The stratigraphic data and paleogeographic analysis are suggestive of a considerable reduction of the Protolenus Stage in the Łeba *8*, Smołdzino *1*, and Kościerzyna *IG-1* boreholes.

The Lower Cambrian section in the eastern part of the Peribaltic Depression suggests a sedimentary continuity, similar to that of the Łeba Formation to the east of the Łeba area, among others in the Bartoszyce *IG-1* and Olsztyn *IG-2* boreholes (Text-fig. 2; *and* Lendzion 1976, 1977).

A particular attention should be paid to sandstones and siltstones series with iron oolites. This series ranges from the Hel *IG-1* borehole to the Suwałki *IG-1* borehole, and shows lithologic similarities with iron sandstones of the Lower Cambrian Krasnoborsk Series in the Kaliningrad area (Kapłan & *al.* 1972) or with the Wergal Zone (Areń & *al.* 1978).

A fossil content of the Lower Cambrian sediments in the Peribaltic Depression, is not generally of a key type (*Torellella holmi* Kiaer, *Hyolithus*, ?*Wanneria* and Acritarcha: Lendzion 1979). For that reason the limits of the Holmia Stage are arbitrary in the investigated region and the presence of the Protolenus Stage is here only suggested by paleogeographic considerations. The zones distinguished within the Lower Cambrian of the Łeba area correlate with respective zones in the Holy Cross Mts and in the remaining parts of the East European Platform and in Scandinavia (Table 5).

A lithologic correlation is more complex because of a great variability of the Lower Cambrian sediments in the Peribaltic Depression, the Łeba area including (Bednarczyk & Turnau-Morawska 1975). Considerable differences with Scandinavia are apparent in a general thickness of the Lower Cambrian deposits as well as of its individual members (*see* Lindström & Staude 1971). They reflected various sedimentary environments of the Lower Cambrian within the East European Platform.

A correlation of the Kluki Formation (Smołdzino *1* borehole) containing a pyroclastic material (Bednarczyk 1972, Bednarczyk & Turnau-Morawska 1975) with the upper members of the Żarnowiec Series (Słupsk *IG-1*, Darżlubie *IG-1* and Kościerzyna *IG-1*) is possible. Łydka (1980) regarded sedimentation of this series as contemporaneous with the volcanic processes that accompanied sedimentation of the Sławatycze Series in the Podlasie Depression and at the Lublin slope of the Platform (Lower Vendian *after* Areń & *al. 1978*). However, paleogeographic analysis as well as a succession in the sequence do not corroborate this

opinion, though a correlative significance of the pyroclastic horizon in the lowermost Cambrian of the Łeba area should be taken into account.

The volcanic processes were activated at the end of the Precambrian (Vendian) owing to the Charnian orogeny, in result of which a complex of lavas and tuffs (Coldecote Volcanic Formation; Brassier & *al.* 1978) was formed in Central England as far as Wales. This complex is overlain with slight angular unconformity by the Hartshill Formation; in its lower part (Park Hill Member) the latter is composed of alternate arkoses, thin shales and conglomerates, with chloritic cement including also volcanic quartz and pieces of volcanic rocks. A pyroclastic material was noted in the successive Tuttle Hill Member. The Hartshill Formation represents probably, basing on the Tommotian-like fauna in its upper members, the Subholmia Stage. Thus, due to the presence of a pyroclastic horizon, it seems possible to correlate the sediments of the Kluki Formation (upper part of the Żarnowiec Series) with the lower part of the Hartshill Formation in Great Britain.

## MIDDLE CAMBRIAN

In the analyzed sections, the Middle Cambrian contains three zones with paleontologic documentation: oelandicus, paradoxissimus, and forchhammeri (*see* Text-fig. 2 and Tables 1—3 and 6).

### ECCAPARADOXIDES OELANDICUS ZONE

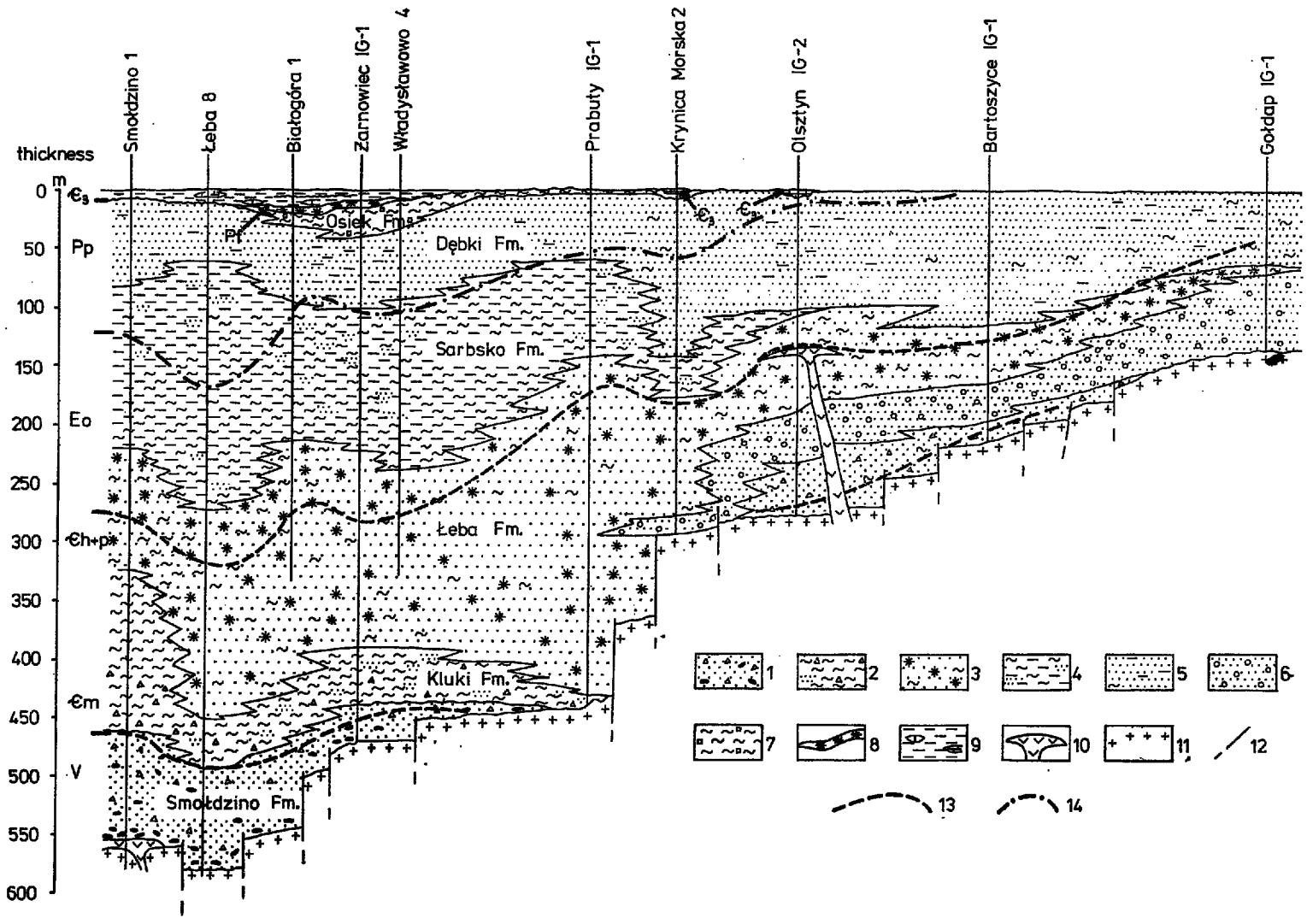
The Zone is represented by quartz-glauconitic siltstones (top members of the Łeba Formation), black claystones alternative with quartz--siltstones of the Sarbsko Formation, and quartz sandstones of the lower part of the Dębki Formation (Bednarczyk & Turnau-Morawska 1975, Bednarczyk & Przybyłowicz 1980).

In the section Smołdzino *1* a fossil assemblage is typical of the Eccaparadoxides pinus Subzone only. A similar situation appears in the Łeba *8* borehole considering a thickness of the sediments as well as a paleontologic documentation of the whole Zone. Further to the east, in the Białogóra *1* borehole, this Zone is represented by the top of the Łeba Formation and by claystones of the Sarbsko Formation. On the ground of fossils, both the Eccaparadoxides insularis and the E. pinus Subzones are here documented.

In the Białogóra *2* borehole the fauna also documents the both subzones: the E. insularis Subzone is represented by the rocks typical of the Łeba Formation and the E. pinus Subzone by black claystone of the Sarbsko Formation.

Because of a lack fossils in the Żarnowiec *5* borehole, the conclusions can be based only on lithologic similarities that suggest the presence of the equivalent of the Eccaparadoxides oelandicus Zone, represented by the Sarbsko Formation.

# Distribution of Cambrian lithofacies of the Peribaltic Depression




1 — arkose-conglomerate lithofacies of the Smołdzino Formation, 2 — arkose-siltstone lithofacies of the Kluki Formation, 3 — glauconite lithofacies of the Łeba Formation, 4 — siltstone-claystone lithofacies of the Sarbsko Formation, 5 — sandstone lithofacies of the Dębki Formation, 6 — oolite lithofacies, 7 — siltstone-carbonate lithofacies of the Osiek Formation, 8 — glauconitite lithofacies of the Białogóra Formation, 9 — claystone-carbonate lithofacies of the Upper Cambrian (Słowinia and Piaśnica) formations, 10 — diabase veins, 11 — crystalline rocks of the Precambrian, 12 — supposed faults, 13 — Lower/Middle Cambrian boundary, 14 — zone boundaries

V — Vendian, $C_m$ — Mobergella Zone, $C_{h+p}$ — Holmia and Protolenus Zone, $E_o$ — Eccaparadoxides oelandicus Zone, $P_p$ — Paradoxides paradoxissimus Zone, $P_f$ — Paradoxides forchhammeri Zone, $C_s$ — Upper Cambrian

In the Piaśnica 2 borehole the fauna documents the two subzones of the E. oelandicus Zone.

In the Władysławowo 4 borehole the E. oelandicus Zone is represented by the top members of the Łeba Formation and by the Sarbsko Formation. A rare fauna makes a subdivision into subzones impossible.

Similarly as in the Żarnowiec 5 borehole, the presence of the E. oelandicus Zone in the Krynica Morska 2 borehole is suggested from a lithostratigraphic analysis. The Zone is represented here by the sandstones of the Dębki Formation, the claystones of the Sarbsko Formation, and by glauconitic sandstones of the Łeba Formation.

Table 1

| Taxa | Boreholes | | | |
|---|---|---|---|---|
| | $B_1$ | $B_2$ | P | W |
| Obolus sp. | | + | | |
| Lingulella ferruginea Salter | + | + | | |
| Iphidella? sp. | | | + | |
| Linnarssonia? socialis (Seebach) | + | + | | |
| Redlichella granulata (Linnarsson) | + | + | + | |
| Hyolithes oelandicus Holm | + | + | + | |
| Linevitus obscurus (Holm) | | + | + | |
| Peronopsis? sp. | | | + | |
| Ellipsocephalus cf. lejostracus (Angelin) | | | + | + |
| Bailiella emarginata (Linnarsson) | | | + | |
| Eccaparadoxides oelandicus (Sjögren) | + | + | | |
| E. ex gr. oelandicus (Sjögren) | + | + | + | |
| E. insularis (Westergård) | + | + | | |
| Eccaparadoxides sp. | | | | + |
| Hipponicharion eos Matthew | | + | | |

Fauna of the Eccaparadoxides insularis Subzone in the western part of the Peribaltic Depression

BOREHOLES: $B_1$ — Białogóra *1*, $B_2$ — Białogóra *2*, P — Piaśnica *2*, W — Władysławowo *4*

## PARADOXIDES PARADOXISSIMUS ZONE

It comprises the top members of the Sarbsko Formation as well as the deposits of the Dębki and the Osiek Formations (Text-fig. 2).

In the Smołdzino *1* and Łeba *8* boreholes the Paradoxides paradoxissimus Zone is represented by the Dębki Formation.

In the Dębki *2* borehole the Zone is recognized in the sandstones of the Dębki Formation, whereas in the Dębki *3* borehole to the P. paradoxissimus Zone also the siltstones of the Osiek Formation were included.

In the Białogóra *1* borehole the Zone is recognized in the quartz sandstones of the Dębki Formation and quartz siltstones of the Osiek Formation, whereas in the Białogóra *2* borehole it is done by the sandstones of the Dębki Formation.

Similarly, in the Żarnowiec *5* borehole this Zone is recognized in the Dębki sandstones where the presence of Agnostidae proves an occurrence of the Hypagnostus parvifrons Subzone.

Table 2

| Taxa | Boreholes | | | | | | |
|---|---|---|---|---|---|---|---|
| | S | Ł | $B_1$ | $B_2$ | P | Ż | W |
| Lingulella ferruginea Salter | + | | + | + | + | + | |
| Lingulella sp. | | | | | + | + | |
| Iphidella? sp. | | + | | | | | |
| Linnarssonia? socialis (Seebach) | + | | + | + | | | |
| Redlichella granulata (Linnarsson) | | | + | + | + | | |
| Globorilus globiger (Saito) | + | | | | | | |
| Hyolithes oelandicus Holm | | + | + | + | | | |
| Hyolithes cf. obesus Holm | | | + | | | | |
| Hyolithes sp. | | | | + | | | |
| Peronopsis fallax (Linnarsson) | + | + | + | + | + | | |
| Triplagnostus praecurrens (Westergård) | + | + | + | + | + | | |
| Ellipsocephalus sp. | | | + | | | | |
| Burlingia sp. | | + | | | | | |
| Eccaparadoxides oelandicus (Sjörgen) | | + | + | + | | | |
| Eccaparadoxides ex gr. oelandicus (Sjögren) | | + | + | + | | | |
| Eccaparadoxides pinus (Holm) | | + | + | + | | | |
| E. cf. pinus (Holm) | + | | + | + | | | |
| E. pomeranicus (Bednarczyk) | | + | + | | | | |
| E. torelli (Holm) | | + | | | | | |
| Eccaparadoxides sp. | | + | + | + | + | + | + |
| Jincella? sp. | | + | | | | | |
| Aluta cf. flexilis Matthew | | | + | | | | |
| Hipponicharion? sp. | | | | | | + | + |

Fauna of the Eccaparadoxides pinus Subzone in the western part of the Peribaltic Depression

BOREHOLES: **S** — Smołdzino *1*, **Ł** — Łeba, *8*, **$B_1$** — Białogóra *1*, **$B_2$** — Białogóra *2*, **P** — Piaśnica *2*, **Ż** — Żarnowiec *5*, **W** Władysławowo *4*

In the Piaśnica *2* borehole this Zone includes the sandstones of the Dębki Formation and sandstone-clayey sediments with carbonates of the Osiek Formation.

Further to the east, in the Władysławowo *4* and Krynica Morska *2* boreholes the P. paradoxissimus Zone comprises the sandstones of the Osiek Formation.

## PARADOXIDES FORCHHAMMERI ZONE

According to the Author's opinion (Bednarczyk & Turnau-Morawska 1975, Bednarczyk & Przybyłowicz 1980), the P. forchhammeri Zone is represented at the Łeba area by glauconitic sandstones of the Białogóra Formation paleontologicaly documented in the Hel *IG-1* borehole. These sandstones are not always present in the boreholes, and in most cases their lack is regarded as the result of submarine erosion during the Upper Cambrian or before the Lower Ordovician (Bednarczyk 1979).

## REGIONAL CORRELATION

Besides the investigated boreholes, the Middle Cambrian deposits have been studied in several others located at the southern margin of the Łeba area (Lendzion 1976). Generally, they are represented by the rocks typi-

Table 3

| Taxa | Boreholes | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ł | D | $B_1$ | $B_2$ | P | Ż | W |
| Lingulella ferruginea Salter | | + | + | | + | + | |
| Lingulella sp. | | | + | | | + | + |
| Linnarssonia? socialis (Seebach) | + | | | | | + | |
| Peronopsis fallax (Linnarsson) | | + | | | | + | |
| Peronopsis pusilla Tullberg | | | | | | + | |
| Triplagnostus gibbus (Linnarsson) | | | + | | | | |
| Ellipsocephalus lejostracus (Angelin) | + | | | | | | |
| Paradoxides paradoxissimus (Wahlenberg) | | | | | | + | |
| Paradoxides cf. paradoxissimus (Wahlenberg) | + | | + | + | + | + | |
| Paradoxides sp. | + | + | | + | + | + | + |
| Agraulos? sp. | | | | | | + | |

Fauna of the Paradoxides paradoxissimus Zone in the western part of the Peribaltic Depression

BOREHOLES: Ł — Łeba *8*, D — Dębki *3*, $B_1$ — Białogóra 1, $B_2$ — Białogóra *2*, P — — Piaśnica *2*, Ż — Żarnowiec *5*, W — Władysławowo *4*

cal of the Łeba, Sarbsko, and Dębki formations, with predominating sandy or sandy-siltstone rocks of the Dębki and Osiek formations. A fossil list, presented by Lendzion (1976), proves the presence of the E. oelandicus and P. paradoxissimus Zones, whereas the P. forchhammeri Zone has not been recorded or got away but the Żarnowiec *IG-1* borehole (Lendzion 1976).

In the eastern part of the Peribaltic Depression the Middle Cambrian is not always fully developed (*see* Text-fig. 2 and Table 6).

In the Prabuty *IG-1* borehole, the Eccaparadoxides oelandicus Zone is represented by the glauconitic deposits of the Łeba Formation, claystones of the Sarbsko Formation, and the Dębki sandstones. A paleontologic documentation of this Zone is evidenced by the presence *i. a.* of *Ellipsocephalus* cf. *polytomus* (Linnarsson) and *Eccaparadoxides* ex gr. oelandicus (Sjögren). In other boreholes of the Peribaltic Depression the Middle Cambrian has been distinguished on the base of lithologic similarities and only in some cases its presence is proved by *Eccaparadoxides* ex gr. *oelandicus* (Sjögren) (Henrykowo *5* borehole), and *Ellipsocephalus* cf. *jugoszowi* Orłowski (Żelazna Góra *3* borehole; *see* Lendzion 1973, 1974).

The Middle Cambrian usually represented by the sandstones typical of the Dębki Formation corresponds at the Łeba area and in the Gulf of Gdańsk area mainly with the Paradoxides paradoxissimus Zone (Lendzion 1973, 1974).

The sediments of the Paradoxides forchhammeri Zone have been not reported up to now from the eastern part of the Peribaltic Depression.

The Middle Cambrian in the neighboring area of Kaliningrad in the USSR was distinguished on the base of the Acritarcha assemblages as the Krasnoborsk Series (Kaplan & *al.* 1972) which is composed of the so-called "saccharoid" sandstones (33 m thick in the east, 71.5 m in the west).

In the Warsaw Synclinorium, the Middle Cambrian was partly recognized as the Paradoxides paradoxissimus Zone (Szczawno *1* borehole; Bednarczyk 1972). It comprises quartz sandstones (about 18 m thick) of the Dębki Formation, and the siltstones with claystones of irregular thickness and trilobite fragments, i. a. *Paradoxides paradoxissimus* (Wahlenberg) being probably a lithologic equivalents of the Osiek Formation.

The Cambrian deposits represented by the Eccaparadoxides oelandicus Zone occur in the Podlasie Depression (Lendzion 1974, 1975a, c) and the Lublin slope (Bednarczyk & *al. 1983*). The Zone is developed here as sandstones and siltstones, locally with fragments of trilobites, i.a. *Eccaparodoxides* ex gr. *oelandicus* (Sjögren), *Ellipsocephalus polytomus* (Linnarsson), and *Strenuella* (*Comluella*) *samsonowiczi* Orłowski. A trilobite fragment reported from the Okuniew *IG-1* borehole (Lendzion 1975)

and determined as *Solenopleura* sp. may suggest a local occurrence of the Paradoxides paradoxissimus Zone.

The whole faunistic assemblage collected in the Middle Cambrian deposits of the Podlasie Depression is relatively poor in comparison with that of the Łeba area, and it does not enable a more precise subdivision of the sequence.

The Cambrian of the Holy Cross Mts is very favorable for biostratigraphic correlations either if taking into account a differentiated faunistic assemblage that documents separate zones and subzones or/and lithologicaly differentiated sections (Orłowski 1964, 1968, 1975; Bednarczyk 1970).

In comparison with the Holy Cross Mts a paleontologic documentation of the Cambrian zones of the Łeba area is much poorer but sufficient for separating the principal zones and subzones and for a biostratigraphic correlation (Table 5). But a recognition of lithostratigraphic units from the analyzed area as far as the Holy Cros Mts is not possible because of a different development of the Holy Cross Mts Cambrian (Orłowski 1975).

In previous papers of the Author (Bednarczyk 1972, 1978, 1979; Bednarczyk & Turnau-Morawska 1975; Bednarczyk & Przybyłowicz 1980) the correlations have been done with the Cambrian sections of Scandinavia. These correlations correspond to those presented previously for the Cambrian sequences of the Holy Cross Mts by Czarnocki (1919, 1927, 1932, 1957) and Samsonowicz (1920, 1934, 1960) who pointed out the faunistic similarities of both regions, belonging undoubtedly to the same (the Scandinavia or the North-Atlantic-Baltic) zoogeographic subprovince. In this paper the similarities should be once more underlined with a remark that in spite of the same type of the Middle Cambrian fauna, particularly in the Eccaparadoxides oelandicus Zone, the assemblage that documents these zones comprises only about 25% of the species and about 40% of the genera known from Scandinavian sections.

## UPPER CAMBRIAN

The Upper Cambrian deposits of the Łeba area have been already described by the Author (Bednarczyk 1972, 1979), but some corrections and supplementary data are needed.

### HOMAGNOSTUS OBESUS & AGNOSTUS PISIFORMIS ZONE

This Zone is represented by the Słowinia Formation (Bednarczyk & Turnau-Morawska 1975), which comprises dark-gray iron claystones with inserts and interbeddings of an organogenic limestone. The fauna includes brachiopods, trilobites, ostracodes and conodonts (Table 4).

Basing on the data from other boreholes, Lendzion (1976) separated the Agnostus pisiformis Zone from the Homagnostus obesus Zone. However, neither faunistic composition nor an occurrence of the fossils allow a subdivision more detailed than presented in this paper.

## ORUSIA LENTICULARIS ZONE

This Zone comprises the upper members of the Słowinia (Fm.) claystones separated from the Piaśnica Formation by an erosion boundary. The sediments of this Zone subjected to a local washing what is proved by data from the Dębki *2* and the Piaśnica *2* boreholes in which the limestone blocks with *Orusia lenticularis* and numerous condonts were noted at the bottom of the Piaśnica Formation. An uncomplete coring of other boreholes enables to expect the presence of the zones distinguished, basing on the records of a drilling geophysics.

A direct contact of the claystone of the Homagnostus obesus & Agnostus pisiformis Zone with glauconitic laminated claystone of Arenigian age (Tetragraptus phyllograptoides Zone) proves that the erosion processes have repeated during the Upper Cambrian and before the Arenigian.

**Table 4**

| Taxa | Zones and subzones | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | H.obesus & A.pisiformis | | | | O.lenticularis | | | P.minor | | | P.scarabeoides | | | | |
| | B | D | P | Ż | B | D | P | B | D | P | B | D | P | Ż | Ł |
| Lingulella ferruginea /Salter/ | | + | | | | | | | | | | | | | |
| Orusia lenticularis /Wahlenberg/ | | | | + | + | + | + | | | | | | | + | |
| Homagnostus obesus /Belt/ | + | + | | + | | | | | | | | | | | |
| Olenus truncatus /Brünnich/ | + | + | + | + | | | | | | | | | | | |
| Sphaerophthalmus alatus /Boeck/ | | | | | | | | + | + | + | | | | + | + |
| Parabolina lobata /Broegger/ | | | | | | | | | | | | | | | + |
| Peltura acutidens Broegger | | | | | | | | | | | | | | + | |
| P.minor /Broegger/ | | | | | | | | | + | | | | | | |
| Peltura scarabeoides /Wahlenberg/ | | | | | | | | | | + | | | | | + |
| Cyclotron armatus /Groenwall/ | | + | | | | | | | | | | | | | |
| C. lapworthi /Groenwall/ | | + | | | | | | | | | | | | | |
| C. nodomarginatum Schrank | | + | | | | | | | | | | | | | |
| Hesslandona neoopina Mueller | | + | | | | | | | | | | | | | |
| Coeloecrodontus sp.s.f. | | + | | | | | | | | | | | | | |
| Furnishina alata Szaniawski | | + | | + | | | | | | | | | | | |
| F. asymmetrica Mueller | | | + | | + | + | + | | | + | | | | | |
| F. furnishi Mueller | | + | + | | + | + | + | | | | | | | | |
| F. longibasis Bednarczyk | | | + | | | | | | | | | | | | |
| F. pomeranica Bednarczyk | | | + | | | | | | | | | | | | |
| F. quadrata Mueller | | + | + | | | + | + | | | | | | | | |
| Furnishina sp. Bednarczyk | | | + | | | | | | | | | | | | |
| Gapparodus? cf. bisulcatus /Mueller/ | | | | | | | | | | + | | | | | |
| Hertzina elongata Mueller | | | | | + | | | | | + | | | | | |
| Muellerodus cambricus /Mueller/ | | | + | | + | + | + | | | | | | | | |
| M. oelandicus /Mueller/ | | + | | | + | | | | | | | | | | |
| Muellerodus pomeranicus /Szaniawski/ | | | + | | | | | | | | | | | | |
| Oneotodus cf. erectus Druce-Jones | | | | | | | | | | + | | | | | |
| Proacodus obliquus Mueller | | | | | + | | | | | + | | | | | |
| Proconectodus galatini /Mueller/ | | + | | | + | | | | | + | | | | | |
| P. tenuis /Mueller/ | | + | | + | | | | | | + | | | | | |
| Scandodus tortilis Mueller | | | + | | | | | | | + | | | | | |
| Westergaardodina amplicava Mueller | | | + | | | | | | | | | | | | |
| W. bicuspidata Mueller | | + | + | | + | + | + | | | | | | | | |
| W. bohlini Mueller | | | | | | + | + | | | | | | | | |
| W. kleva Mueller | | | | | | + | | | | | | | | | |
| W. moessebergensis Mueller | | | + | | + | + | + | | | | | | | | |
| W. muelleri Nogami | | | + | | + | | | | | | | | | | |
| W. triouspidata Mueller | | | + | | + | + | + | | | | | | | | |
| W. wimani Szaniawski | | | | + | + | | | | | | | | | | |

Upper Cambrian fauna in the western part of the Peribaltic Depression
BOREHOLES: **B** — Białogóra *1*, **D** — Dębki *2*, **P** — Piaśnica *2*, **Ż** — Żarnowiec *5*, **Ł** — Łeba *8*

The Leptoplastus Zone has not been documented in the investigated boreholes. Lendzion (1976) has not obtained any positive results in this subject. There are also no data indicative of the Protopeltura praecursor Zone.

### PELTURA SCARABEOIDES ZONE

This Zone comprises claystones and recrystallized black limestones that are included into the Piaśnica Formation (Bednarczyk & Turnau-Morawska 1975), the best documented in the Łeba *8* borehole. Lendzion (1976) evaluated the thickness of this Zone for about 1.6 m. The Author's observations suggest that a separation from the under- and overlying zones is impossible because of the scarce occurrence of fossils in the sequence.

### ACEROCARE ZONE

This Zone is represented by black limestones without fossils that pass concordantly into the glauconitic claystones of Tremadocian age (Bednarczyk 1979). It was analyzed in a single borehole (Białogóra *1*) as the others have not been sampled at the Cambrian/Ordovician boundary, or the Cambrian sequence is separated from the Ordovician one by a distinct erosion surface (Dębki *2* and Dębki *3* boreholes).

## REGIONAL CORRELATION

An occurrence of the Upper Cambrian sediments in the areas neighboring to the Łeba area was reported by Lendzion (1976) and Szymański (1976). The first author documented the Upper Cambrian deposits in the Kościerzyna *IG-1* and Młynary *1* boreholes; their thickness is extremely small (0.8 m and 0.5 m, respectively).

The Upper Cambrian deposits in the Białogóra *1* borehole are 13.7 m thick, whereas in the other boreholes they are usually incomplete and thus of a reduced thickness.

In the Kaliningrad area, the Upper Cambrian is represented (Kaplan & *al.* 1972) by the Ladushkino sequence of the limestones with *Orusia lenticularis* Wahlenberg and *Homagnostus* sp..

In their lithology, the Upper Cambrian deposits of the Łeba area are very similar to those of Scandinavia. Similarly as the island of Bornholm (V. Poulsen 1966), it is composed of the alum shales and the anthraconites. Greater thickness of the Upper Cambrian deposits in Bornholm

## Table 5

Correlation of the Cambrian sequences of Scandinavia, the Łeba area (the Peribaltic Depression including) and other parts of Poland

| Scandinavia (after Martinsson 1974 and Dergström 1980) | | Łeba area and Peribaltic Depression | | NE Poland Podlasie Depression (after Areń, Lendzion 1978) | Central Poland Holy Cross Mts (after Orłowski 1975) |
|---|---|---|---|---|---|
| Zones | Subzones | Zones | Subzones | Zones | Zones |
| Acerocare<br>P.scarabeoides<br>P.minor<br>P.praecursor<br>Leptoplastus<br>P.spinulosa<br>H.obesus<br>A.pisiformis | | Acerocare<br>P.scarabeoides<br>P.minor<br>hiatus<br>O.lenticularis<br>H.obesus<br>A.pisiformis | hiatus | hiatus | Parabolina<br>Paltura<br>Protopeltura<br>Olenus |
| P.forchhammeri | L.laevigata<br>J.brachymetopa | P.forchhammeri | | | (no fossils) |
| P.paradoxissimus | T.lundgreni<br>G.nathorsti<br>P.punctuosus<br>H.parvifrons<br>T.fissus<br>P.atavus<br>T.gibbus | P.paradoxissimus | H.parvifrons<br>T.gibbus | | (no fossils)<br>P.polonicus |
| E.oelandicus | E.pinus<br>E.insularis | E.oelandicus | E.pinus<br>E.insularis | E.oelandicus | E.pinus<br>E.insularis |
| Lower/Middle Cambrian hiatus | | | | | |
| Proampyx, Comluella<br>Holmia kjerulfi group,<br>Calodiscus lobatus<br>Holmia sp.<br>Schmidtiellus mickwitzi,<br>Holmia mobergi, Mobergella<br>Platysolenites antiquissimus<br>hyolithids | | Protolenus<br>Holmia<br>Mobergella | hiatus | Protolenus<br>Holmia<br>Mobergella<br>Platysolenites<br>Sabelliditos | Protolenus<br>Holmia<br>Platysolenites<br>Sabelliditos |

## Table 6

Stratigraphic subdivision and thickness of the Cambrian deposits in the Peribaltic Depression

| Boreholes | Upper Cambrian | Middle Cambrian | | | | Lower Cambrian | Vendian |
|---|---|---|---|---|---|---|---|
| | Thickness | Thickness | Thickness of the zones | | | Thickness | Thickness |
| | | | P.forchhammeri | P.paradoxissimus | E.oelandicus | | |
| Bartoszyce IG-1[x] | - | 130.7 | - | - | - | 100.8 | - |
| Białogóra 1 | 13.5 | 257.9 | 3.8 | 83.0 | 171.5 | >84.6 | - |
| Białogóra 2 | 20.5 | >258.0 | - | 97.0 | >161.0 | - | - |
| Dębki 2 | 8.7 | > 78.0 | - | >78.0 | - | - | - |
| Dębki 3 | 9.9 | >112.0 | - | >112.0 | - | - | - |
| Gołdap IG-1[x] | - | 41.7 | - | - | - | 107.9 | - |
| Hel IG-1[x] | 4.8 | 242.6 | 1.2 | 86.8 | 154.6 | 190.1 | 4.4 |
| Krynica Morska 2 | 0.5 | 165.5 | - | - | - | 130.0 | - |
| Kościerzyna IG-1[x] | 0.8 | 322.9 | - | 129.8 | 193.1 | 278.7 | 117.1 |
| Łeba 8 | 15.0 | 315.0 | - | 165.0 | 150.0 | 160.0 | 83.6 |
| Olsztyn IG-2[x] | 0.3 | 125.8 | - | - | 125.8 | 129.7 | 148.2 |
| Piaśnica 2 | 11.6 | >281,2 | 4.2 | 108.5 | >168.5 | - | - |
| Prabuty IG-1[x] | 0.05 | 179.05 | - | 62.35 | 116.7 | 303.9 | - |
| Słupsk IG-1[x] | - | 93.8 | - | - | 93.8 | 362.9 | 103.0 |
| Smołdzino 1 | 20.0 | 252.5 | - | 102.5 | 150.0 | 255.0 | 87.6 |
| Władysławowo 4 | 11.0 | 261.0 | - | 86.0 | 175.0 | >83.3 | - |
| Żarnowiec IG-1[x] | 8.4 | 274.8 | 1.2 | 97.7 | 175.9 | 196.1 | 35.4 |
| Żarnowiec 5 | 11.0 | >142.2 | 2.3 | 132.2 | >7.7 | - | - |

[x] after Lendzion (1974-1976).

results from their more complete sedimentation where no hiatus within shales is known (*see also* C. Poulsen 1923). Greater thicknesses (40 to 55 m) of the Upper Cambrian were also observed (Westergård 1944) of the boreholes drilled in the south-eastern Scania.

Much smaller thickness of the Upper Cambrian deposits was noted in the Oeland Island, and in Öster- and Västergotland (14—14.8 m at Kinnekulle; Martinsson 1974) where the sequence is reduced due to numerous sedimentary gaps.

Outside the Łeba area and the Peribaltic Depression, the Upper Cambrian deposits in Poland are known only in the Holy Cross Mts (*see* Tomczykowa 1968; Orłowski 1968, 1975), where the Wiśniówka Sandstone Formation and the Klonówka Shale Formation are about 400 m thick each. A rich trilobite fauna enabled to distinguish (Orłowski 1968) the four zones (Olenus, Protopeltura, Peltura, and Parabolina) and six subzones within the latter two. The Upper Cambrian sequence of the Holy Cross Mts does not comprise the carbonate rocks, so typical of the Baltic region. The dark shales predominating particularly in the upper parts of the sequence have been correlated previously with the alum shales (Samsonowicz 1952; Czarnocki 1919, 1957) but this opinion has not been supported by later investigations.

## FINAL REMARKS

The study of the Cambrian sediments in northern Poland enables to draw the following conclusions.

The Lower Cambrian shows quite a great lithologic differentiation in the Łeba area, and a variable thickness of its individual members in the whole territory of northern Poland. A borehole-core analysis proves that the sediments are thinning eastwards what can suggest a direction of the Lower Cambrian transgression (*cf.* Jaworowski 1979) from the west or from the south-west eastwards and north-eastwards.

Within the Eccaparadoxides oelandicus Zone of the Middle Cambrian there are two lithofacies types connected with the Łeba and the Gdańsk regions. The first is typical of the predominance of clays and siltstones (Sarbsko Formation), the second one of sands with glauconite (top members of the Łeba Formation).

The Paradoxides paradoxissimus Zone usually comprises uniform sandy lithofacies (Dębki Formation) and sandy-siltstone one with carbonate concretions (Osiek Formation).

At the end of the Middle Cambrian the sedimentary basin became shallow and the equivalents of the Paradoxides forchhammeri Zone are only several metres thick if preserved in spite of either pre-Upper Cambrian or pre-Ordovician erosion.

In the Upper Cambrian, due to erosive hiatus, only several trilobite zones known from Scandinavia have been distinguished. The Upper Cambrian sequence comprises a clayey-carbonate lithofacies, quite monotonous due to the development of darkgray claystones with limestone inserts typical of the Słowinia and Piaśnica formations. The latter passes (Bednarczyk 1979, Topulos 1979) into the lowermost Lower Ordovician. At the Cambrian/Ordovician boundary glauconite appears within the claystones. In the eastern part of the Peribaltic Depression the pre-Ordovician erosion reached locally the sediments of the Eccaparadoxides oelandicus Zone and for that reason the Upper Cambrian deposits have been preserved in thin patches.

*Laboratory of Paleozoic Stratigraphy,*
*Institute of Geological Sciences*
*of the Polish Academy of Sciences,*
*Al. Żwirki i Wigury 93,*
*02-089 Warszawa, Poland*

## REFERENCES

AREŃ B. & LENDZION K. 1978. Stratigraphic-lithological characteristics of the Vendian and Lower Cambrian. *Prace I. G.*, **90**, 8—49. Warszawa.

BEDNARCZYK W. 1968. The Ordovician in the region of Kętrzyn, NE Poland. *Acta Geol. Polon.*, **18** (4), 707—749. Warszawa.

— 1970. Trilobite fauna of the Lower Paradoxides oelandicus stage from the Brzechów area in the Western part of the Holy Cross Mts. *Bull. Acad. Polon. Sci., Sér. Sci. Géol., Géogr.*, **18** (1), 29—35. Warszawa.

— 1978. On the occurrence of *Bradorina* Raymond, 1935, ostracods in the Upper Cambrian of NW Poland. *Bull. Acad. Polon. Sci., Sér. Sci. de la Terre*, **16** (3—4), 215—219. Warszawa.

— 1979. Upper Cambrian to Lower Ordovician conodonts of Łeba elevation, NW Poland, and their stratigraphic significance. *Acta Geol. Polon.*, **29** (4), 409—442. Warszawa.

— & Turnau-Morawska M. 1975. Cambrian formations in the Łeba area (northern Poland). *Acta Geol. Polon.*, **25** (4), 537—566. Warszawa.

— & Przybyłowicz T. 1980. On development of Middle Cambrian sediments in the Gdańsk Bay area. *Acta Geol. Polon.*, **30** (4), 391—415. Warszawa.

— , Korejwo K., Matyja H., Podhalańska T., Prejbisz A. & Żbikowska B. 1983. Stratygrafia paleozoiku Lubelszczyzny w świetle nowych danych. *Archiwum Inst. Nauk Geol. PAN.*

BRASIER M. D., HEWITT R. A. & BRASIER C. J. 1978. On the Late Precambrian-Early Cambrian Hartshill Formation of Warwickshire. *Geol. Mag.*, **115** (1), 21—26. Hertfort.

CZARNOCKI J. 1919. Stratygrafia i tektonika Gór Świętokrzyskich. *Prace Tow. Nauk. Warsz. Wydz. Nauk (Mat.-Przyr.*, **28**, 1—172. Warszawa.

CZARNOCKI J. 1927. Le Cambrien et sa faune dans la partie centrale du massif de S-te Croix *Spraw. P. I. G.*, **4** (1—2), 189—208. Warszawa.

— 1932. Sur la stratigraphie et la tectonique du Cambrien des environs d'Ociesęki et d'Orłowiny. *Pos. Nauk. P. I. G.*, **33**, 76—78. Warszawa.

— 1957. Tectonics of the Holy Cross Mountains *Prace I. G.*, **18** (3), 11—95. Warszawa.

JAWOROWSKI K. 1979. Cambrian marine transgression in northern Poland. *Prace I. G.*, **94**, 5—80. Warszawa.

KAPLAN A. A., FANDERFLIT E. K. & GORYANSKY W. J. 1972. Kembriskye otlozhenlya Yuzhnoy Pribaltiki. *Izv. Akad. Nauk SSSR, Ser. Geol.*, **6**, 112—122. Moskva.

LENDZION K. 1973. Kambr. Profile głębokich otworów wiertniczych, Inst. Geol. (9. Pasłęk *IG-1*). Warszawa
— 1974. Kambr. Profile głębokich otworów wiertniczych Inst. Geol. (14. Bartoszyce *IG-1*, Gołdap *IG-1*). Warszawa.
— 1975a. Kambr. Profile głębokich otworów wiertniczych Inst. Geol. (28. Żebrak *IG-1*). Warszawa.
— 1975b. Kambr (27. Prabuty *IG-1*). Warszawa.
— 1975c. Kambr (29. Okuniew *IG-1*) Warszawa.
— 1976. Stratigraphy of the Cambrian in the western part of the Peribaltic syneclise. *Biul. I. G.*, 270 (2), 59—76. Warszawa.
— 1977. First gastropod fauna from the Klimontów Stage (Lower Cambrian) of the south-eastern Poland. *Kwart. Geol.*, 21 (2), 240—243. Warszawa.
LINDSTRÖM M. & STAUDE H. 1971. Beitrag zur Stratigraphie der unterkambrischen Sandsteine des südlichsten Skandinaviens. *Geologica et Palaeontologica*, 5, 1—6. Marburg.
ŁYDKA K. 1980. Litologicheskaya kharakteristika verknego dokembriya i nizhnego kembriya Baltijskoj sineklizy. *In*: Paleogeografiya i litologiya venda i kembriya zapada Vostochno-Evropejskoj platformy, 71—78. Moskva.
MARTINSSON A. 1974. The Cambrian of Norden. *In:* C. H. Holand (*Ed.*), Cambrian of the British Isles, Norden and Spitsbergen, 185—283. *Wiley;* London.
ORŁOWSKI S. 1964. Middle Cambrian and its fauna in the eastern part of the Holy Cross Mts. *Studia Geol. Polon.*, 16, 547—560. Warszaw.
— 1968. The Cambrian stratigraphy in the Holy Cross Mts (Poland). *XXIII Intern. Geol.*, 9, 127—131.. Praha.
— 1975. Cambrian and Upper Precambrian lithostratigraphic units in the Holy Cross Mts. *Acta Geol. Polon.*, 25 (3), 431—448. Warszawa.
POULSEN C. 1923. Bornholms Olenuslag og deres Fauna. *Danmarks Geol. Unders. II*, 40, 8—230. København.
POULSEN V. 1966. Cambro-Silurian stratigraphy of Bornholm. *Medd Dansk Geol. Fören.*, 16 117—136. København.
SAMSONOWICZ J. 1920. Sur la stratigraphie du Cambrien et l'Ordovicien dans la partie centrale des montagnes de Święty Krzyż, Pologne centrale. *Spraw. P. I. G.*, 1, 53—67. Warszawa.
— 1934. Objaśnienia arkusza Opatów, 1—97. Warszawa.
— 1960. The Lower Cambrian of the Klimontów anticlinorium. *XXI Intern. Geol., Part* 8, 86—92. Copenhagen.
SZYMAŃSKI B. 1976. The outline of petrography of the Upper Cambrian of eastern Peribaltic Depression. *Kwart. Geol.*, 20 (4) 702—718. Warszawa.
TOMCZYKOWA E. 1968. Stratigraphy of the uppermost Cambrian deposits in the Holy Cross Mountains. *Prace I. G.*, 54, 5—60. Warszawa.
TOPULOS T. 1979. Geological interpretation of the results of geophysical well logging of the Łeba elevation Paleozoic rocks. *Biul. I.G.*, 134, 5—48. Warszawa.
WESTERGÅRD A. H. 1944. Borrningar genom Skånes alunskiffer 1941—1942. *Sver. Geol. Unders., C*, 459, 1—45. Stockholm.

W. BEDNARCZYK

# BIOSTRATYGRAFIA OSADÓW KAMBRYJSKICH W PROFILACH WIERCEŃ OBSZARU ŁEBY

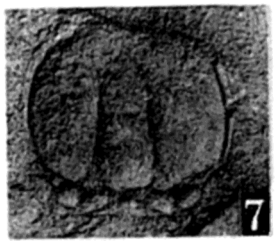
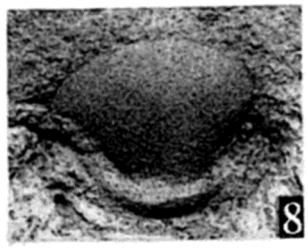
## (Streszczenie)

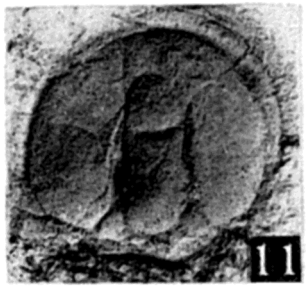
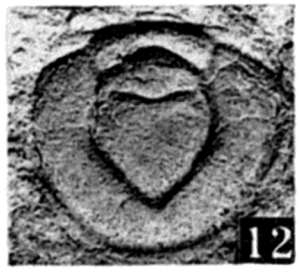
Praca przedstawia biostratygrafię osadów kambryjskich z 10 wierceń usytuowanych na obszarze zachodniej części obniżenia perybałtyckiego, od jeziora Gardno na zachodzie po Krynicę Morską na wschodzie (*patrz* fig. 1—2). Przy ustalaniu zasięgu biozon (*patrz* tab. 6) nawiązano do publikacji, w których omówiono stratygrafię osadów kambryjskich w sąsiednich otworach (Lendzion 1976, 1978). Podstawą przyjętego podziału biostratygraficznego są głównie trylobity, w niektórych przypadkach brachiopody i małżoraczki, a w górnym kambrze także konodonty (*patrz* tab. 1—4 oraz pl. 1—6). Syntetyczny profil stratygraficzny osadów kambru obszaru Łeby skorelowano z profilami pozostałej części obniżenia perybałtyckiego, obniżenia podlaskiego, Gór Świętokrzyskich oraz Skandynawii (*patrz* tab. 5).







1 — *Bailiella emarginata* (Linnarsson); cephalon, × 3; Piaśnica *2* (depth 2938-2939 m), E. insularis Subzone

2, 5 — *Lingulella ferruginea* Salter; 2 — ventral valve, × 8; Dębki *2* (2663-2664 m), H. obesus & A. pisiformis Zone; 5 — dorsal valve, × 6; Piaśnica *2* (2813-2815 m), E. pinus Subzone

4 — *Eccaparadoxides insularis* (Westergard); cranidium, × 2; Białogóra *1* (2904-2905 m), E. insularis Subzone

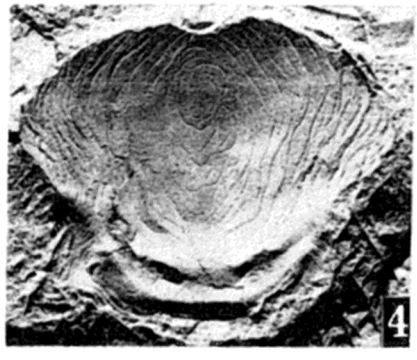
6, 9 — *Peronopsis fallax* (Linnarsson); 6 — pygidium, × 8; Piaśnica *2* (2829-2830 m), E. pinus Subzone; 9 — cephalon, × 7; Białogóra *1* (2903—2904 m), E. pinus Subzone

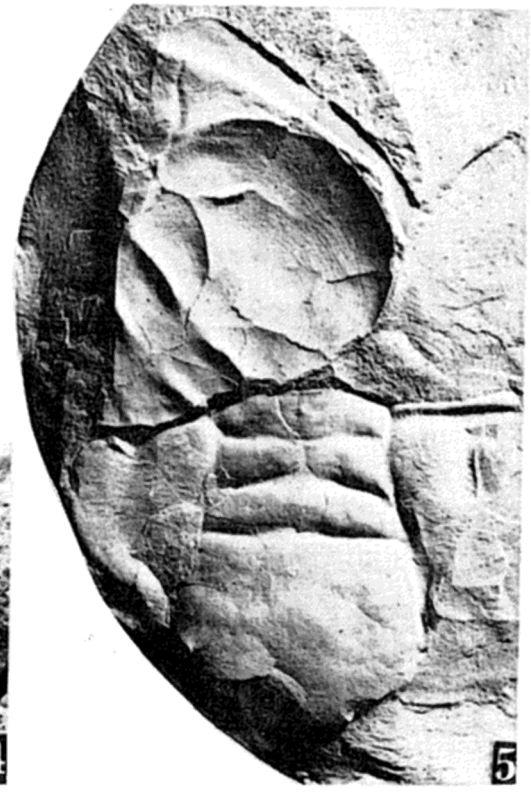
7, 11 and 12 — *Triplagnostus praecurrens* (Westergard); 7 — cephalon, × 6; Białogóra *1* (2784—2787 m), E. pinus Subzone

8 — *Eccaparadoxides* sp.; hypostoma, × 9; Białogóra *1* (2963-2964 m), E. insularis Subzone

10 — *Eccaparadoxides* cf.*pinus* (Holm); specimen at a late meraspid stage, × 2; Białogóra *1* (2355-2858 m), E. pinus Subzone



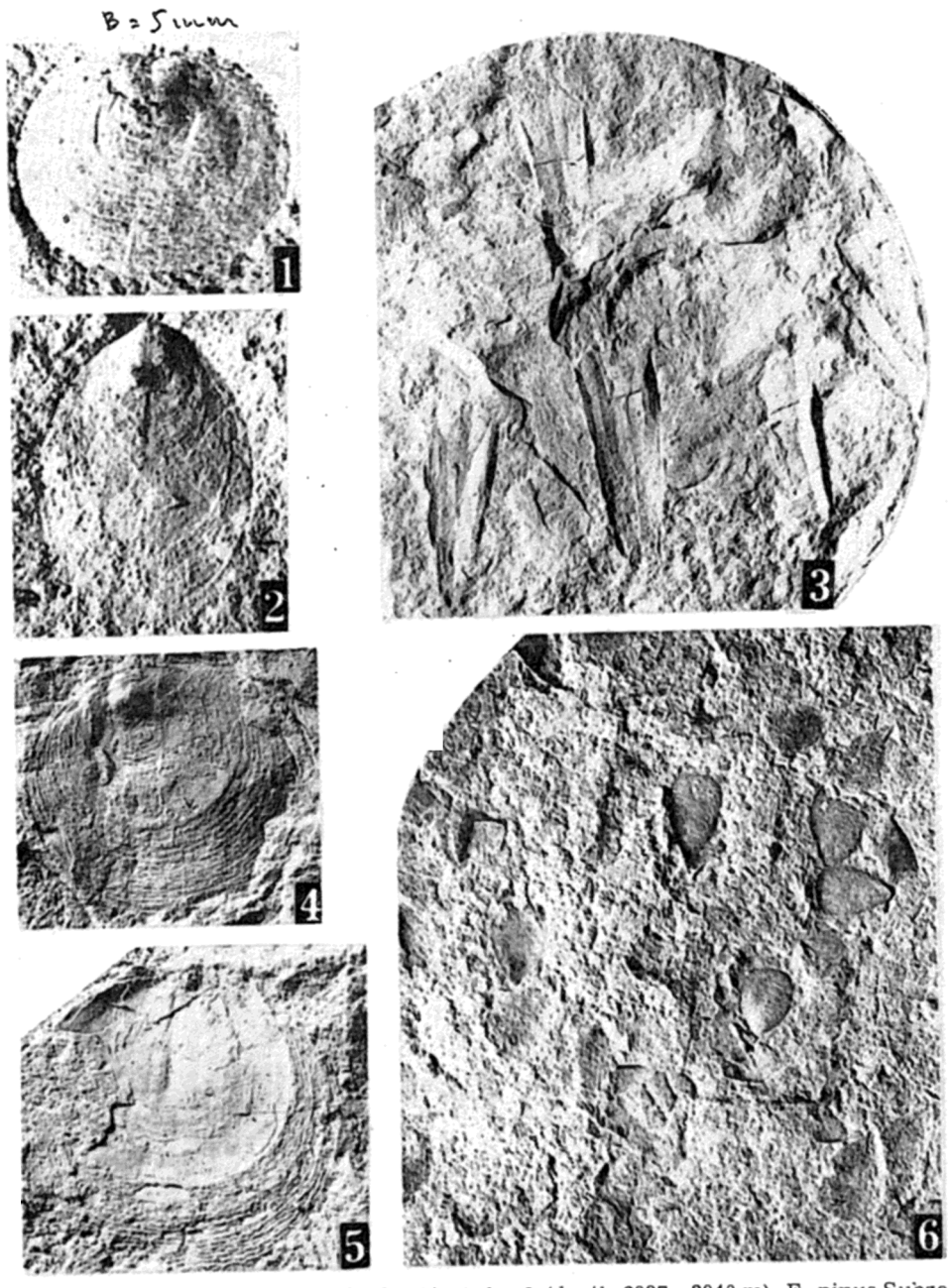




**1, 3** and **4** — *Eccaparadoxides pinus* (Holm); 1 — pygidium, × 7; Białogóra *1* (depth 2903—2904 m), E. pinus Subzone; 3 — cranidium, × 2; Białogóra *2* (2817—2822 m), E. pinus Subzone; 4 — hypostoma, × 3; Białogóra *1* (2903—2904 m), E. pinus Subzone

**2** — *Eccaparadoxides pomeranicus* Bednarczyk; cranidium, × 3; Białogóra *1* (2874—2877 m), E. pinus Subzone

**5** — *Eccaparadoxides* ex gr. *oelandicus* (Sjögren); Białogóra *1* (2874—2877 m), E. pinus Subzone, × 2.5

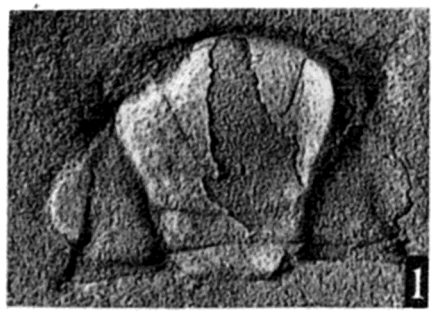



1 — *Linnarssonia ? socialis* (Seebach); Łeba *8* (depth 2937—2940 m), E. pinus Subzone, × 7

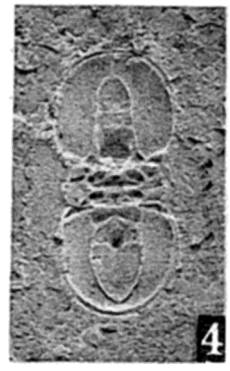
2, 6 — *Lingulella ferruginea* Salter; 2 — dorsal valve, × 12; Smołdzino *1* (2953—2956 m), E. pinus Subzone; 6 — another specimen, × 2; Białogóra *2* (2721—2723 m), P. paradoxissimus Zone

3 — *Hyolithes oelandicus* Holm; Białogóra *1* (2832—2835 m), E. pinus Subzone, × 1.5

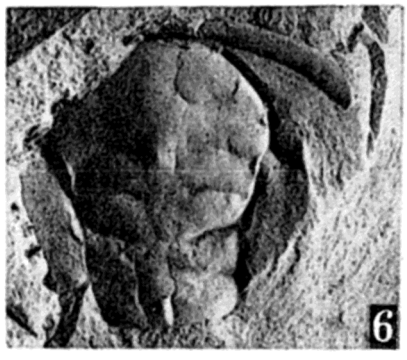
4-5 — *Redlichella granulata* (Linnarsson); 4 — ventral valve, × 5; Białogóra *1* (2933—2937), E. insularis Subzone; 5 — dorsal valve, × 5; Białogóra *1* (2943—2945 m), E. insularis Subzone

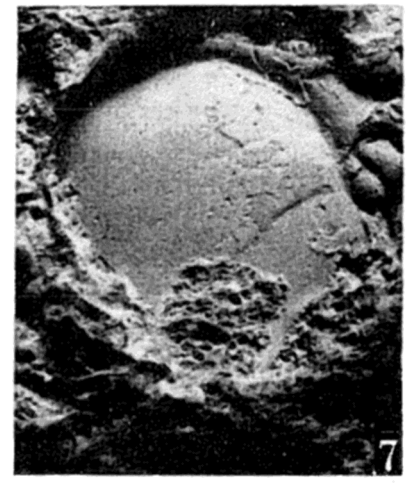









**1-2** — *Paradoxides paradoxissimus* (Wahlenberg); 1 — cranidium, × 3; Białogóra *1* (depth 2725—2726 m), P. paradoxissimus Zone; 2 — another specimen, × 1; Białogóra *1* (2724—2725 m), P. paradoxissimus Zone

**3** — *Triplagnostus* sp.; Białogóra *1* (2721—2723 m), P. paradoxissimus Zone, × 7

**4** — *Triplagnostus praecurrens* (Westergård); Białogóra *2* (2842—2846 m), E. pinus Subzone, × 6

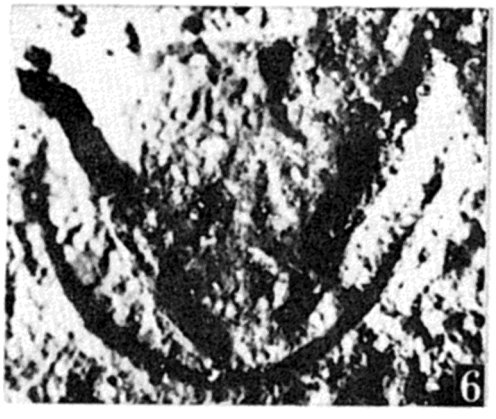
**5** — *Eccaparadoxides* ex gr. *oelandicus* (Sjögren); Białogóra *1* (2855—2858 m), E. pinus Subzone, × 8

**6** — *Eccaparadoxides insularis* (Westergård); Białogóra *1* (2903—2905 m), E. insularis Subzone, × 4

**7** — *Peltura minor* Brögger; glabella, × 8; Dębki *2* (2660—2661 m), Peltura minor Zone






1 — *Triplagnostus praecurrens* (Westergård); pygidium, × 10; Piaśnica *2* (depth 2813—2815 m), E. pinus Subzone

2-3 — *Eccaparadoxides* ex gr. *oelandicus* (Sjögren); 2 — hypostoma, × 2; Piaśnica *2* (2938—2939 m), E. insularis Subzone; 3 — cranidium, × 2; Piaśnica *2* (2938—2939 m), E. insularis Subzone; 3 — cranidium, × 2; Piaśnica *2* (2939—2940 m), E. insularis Subzone

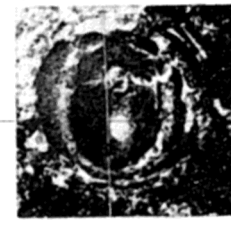
4-5 — *Sphaerophthalmus alatus* (Boeck); 4 — cranidium, × 5; Dębki *2* (2660—2661 m), Peltura Zone; 5 — another specimen, × 8; Piaśnica *2* (2679—2680 m), Peltura Zone

6 — *Hipponicharion* cf. *eos* Matthew; Białogóra *1* (2945—2947 m), E. insularis Subzone, × 30

7 — *Orusia lenticularis* Wahlenberg; Dębki *2* (2660—2661 m), O. lenticularis Zone, × 5









1 — *Sphaerophthalmus alatus* (Boeck); cranidium × 8; Piaśnica *2* (depth 2679—2680 m), Peltura Zone

2, 6 — 7 *and* 9 — *Olenus truncatus* (Brünnich); 2 — cranidium, × 5; Piaśnica *2* (2680—2685 m), H. obesus & A. pisiformis Zone; 6 — another specimen, × 7; 7 — pygidium of another specimen, × 7; 9 — cranidium of another specimen, × 7

3 — ?*Hipponicharion* sp.; Białogóra *1* (2943—2947 m), E. insularis Subzone, × 15

4 — *Peltura scarabeoides* Wahlenberg; cranidium, × 10; Piaśnica *2* (2678—2680 m), Peltura Zone

5, 8 — *Homagnostus obesus* (Belt); 5 — pygidium, × 10; 8 — cephalon, × 10; Dębki *2* (2661—2662 m), H. obesus & A. pisiformis Zone