POLSKA AKADEMIA NAUK
ZAKŁAD PALEOZOOLOGII

PALAEONTOLOGIA POLONICA

REDAKTOR
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Członek rzeczywisty Polskiej Akademii Nauk

No. 28 — 1972

ORDOVICIAN INARTICULATE BRACHIOPODS FROM POLAND AND ESTONIA

(RAMIENIONOGI BEZZAWIASOWE Z ORDOWIKU POLSKI I ESTONII)

BY

GERTRUDA BIERNAT

(WITH 40 TEXT-FIGURES AND 40 PLATES)

WARSZAWA—KRAKÓW 1973

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ACADÉMIE POLONAISE DES SCIENCES
INSTITUT DE PALÉOZOOLOGIE

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Adres Redakcji — Adresse de la Rédaction
Institut de Paléozoologie
de l'Académie Polonaise des Sciences
Warszawa 22, Al. Żwirki i Wigury No. 93

Printed in Poland

Państwowe Wydawnictwo Naukowe — Warszawa

Nakład 600+90 egz. Ark. wyd. 15,5.
Arkuszy druk. $7^{10}/_{16}+40$ wkładek.
Papier rotogr. sat. kl. III 61×86 125 g.
Oddano do składania 21. II. 1972 r.
Podpisano do druku 23. I. 1973 r.
Druk ukończono w kwietniu 1973 r.

Drukarnia Uniwersytetu Jagiellońskiego w Krakowie
Zam. 183/72

To the best teacher
Professor ROMAN KOZŁOWSKI

CONTENTS

ABSTRACT

New detailed studies make revealed items of taxonomic importance about inarticulate brachiopods of five Ordovician stages: Tremadocian, Arenigian, Llanvirnian, Llandeilian and Caradocian. These studies are based on material etched from the rock of exposures in Poland (Holy Cross Mountains), in Estonia, of the cores of deep borings in north-eastern Poland, from erratic boulders of the Baltic coast and environs of Warszawa. The numerous and best preserved collections come from cores. In general, two groups of the studied inarticulates: acrotretids and siphonotretids are of special interest because of their great diversity. Presumably, they can be very useful in extended correlation. Their range in time and relative stratigraphic values are given. The described species belong to 26 genera and 9 families of the orders Lingulida and Acrotretida. Fourteen new species, 3 new genera and 1 new subfamily are proposed, based on the features of external morphology and internal structure. *Ditreta* n. gen., *Paratreta* n. gen. and *Semitreta* n. gen. are the Lowermost Ordovician acrotretids recorded in the studied collection. Myotretinae n. subfam. is erected to include forms with a distinctive laterally folded median dorsal septum. Diagnoses of many genera, subfamilies and families are emended by use of some new data obtained in the scanning electron microscope. Elements of external morphology and internal structure are analysed as important for taxonomy, some of them (such as structure of a median septum, elements of articulating mechanism, pattern of the surface ornamentation, protegular pitting) being judged as valuable for generic and familial classification. Detailed studies of the inarticulate brachiopods have shed light on the morphogeny of certain formerly obscure characters, e.g. surface concentric ornamentation (much more complicated than one could suppose), shell surface and septal spinosity, median septum, details of the hinge, shell shape and outline — these all being, in addition, considered from the point of views of their probable function and, in some cases, their evolutionary significance. Regarding the problem of growth processes in some acrotretids it appears that, in general, two quite distinct phases for the post-protegulum stage can be distinguished on the basis of the shell shape and outline and concentration of the surface lines. Shell abnormalities have not been previously discussed in inarticulate brachiopods. These are not numerous and seem to be caused by, among others, desease or the activity of predators.

INTRODUCTION

The Ordovician inarticulate brachiopods form one of the more interesting groups of fossil invertebrates. They display a very wide range of well developed forms, yielding very often extremely curious structures, illustrating the dynamic development of these animals.

In general, two groups appear to be of special interest. They are: the acrotretids, usually dominating in the number of species and genera, and the siphonotretids also diversified, but to a lesser degree. The mentioned groups are considered to be valuable for stratigraphy and some species characteristic for given horizons can be suggested. The stratigraphic range, however, of many taxa is, in general, insufficiently known. These two groups, similarly as other fossils like trilobites, graptolites or conodonts can also contribute to the correlation of Ordovician deposits over a wider area, including Scandinavia, Estonia and Poland.

The inarticulates, although they represent an important fossil assemblage, are insufficiently known, being, up to now, very neglected, so they still offer much opportunity for finding some yet unknown or not sufficiently known structural elements. Among others, the use of the scanning electron microscope can prove very valuable in a detailed investigation of these fossils.

An encouraging fact is that in recent years there has been some advance in the understanding of inarticulates in general, and although the number of papers dealing with them is still limited, many species and genera have already been described. Also the problem of

classification, functional morphology, development and lately of ultrastructure etc. have, to some extent, been discussed (among others by BELL, 1941; COOPER, 1956; PALMER, 1955; ROWELL, 1962; WRIGHT, 1963; WILLIAMS & ROWELL, 1965; GORJANSKY, 1969; BIERNAT & WILLIAMS, 1970, 1971).

The inarticulate brachiopods described in this paper derive from the Lower, Middle and Upper Ordovician deposits of: 1) an exposure in the eastern part of the Kielce region, Holy Cross Mountains, Poland; 2) a few selected bore holes recently made by the Geological Institute (Warszawa), in north-eastern Poland; 3) an exposure in West Estonia, environs of Tallinn; 4) erratic boulders scattered over the northern part of Poland. The age of these later is frequently not exactly known, very often defined only as Upper Ordovician. The collections from the first two sources are the most numerous.

For the present study approximately 1000 specimens in various state of preservation were collected during the years 1959—1969. Part of the fossil material from the Kielce region and the boulder collection was passed onto the present author by Professor ROMAN KOZŁOWSKI in 1959, the latter collection being slightly enriched as further boulders were dissolved in acid. The collection from the Holy Cross Mountains was completed by the author in 1967 (BIERNAT, 1971).

The Ordovician inarticulate brachiopods from Poland have been rarely taken into consideration by investigators, mostly only mentioned in connection with general studies on Ordovician, and very rarely described (BEDNARCZYK, 1964; BIERNAT, 1971; BIERNAT & WILLIAMS, 1970).

The collection described in the present paper is deposited in the Palaeozoological Institute of the Polish Academy of Sciences, Warszawa, Al. Żwirki i Wigury 93, for which an abbreviation Z. Pal. is used, and the numbers of specimens throughout the paper refer to this collection. The cores performed by the Geological Institute, Warszawa are abbreviated as IG.

ACKNOWLEDGEMENTS

Grateful acknowledgement is due to Professor ROMAN KOZŁOWSKI, Palaeozoological Institute, Polish Academy of Sciences, Warszawa, for kindly putting the collection of brachiopods from the Kielce region and erratic boulders at the author's disposal and for always a great interest he showed in the work, and to Professor ZOFIA KIELAN-JAWOROWSKA (the same Institute) for kindly reading the manuscript; to Professor ALWYN WILLIAMS, Queen's University of Belfast, who made it possible for the author to work with Scanning electron microscope in the Laboratory of Electromiscroscopy Geology Department, Queen's University, Belfast, and for valuable discussions on the inarticulate problems and for the micrographs; to Dr RALF MÄNNIL, Estonnian Academy of Sciences, Department of Geology, Tallinn, for providing a small collection of inarticulate brachiopods, which was very helpful in the study and was also used in the investigations by the Scanning electron miscroscope; to Dr. ZDZISŁAW MODLIŃSKI and Dr. JANINA SZTEJN, Geological Institute, Warszawa, for kindly providing the core collections (north-eastern Poland) of inarticulate brachiopods from the Geological Institute.

Many sincere thanks are also due to Dr. G. ARTHUR COOPER, Smithsonian Institution, Washington; Dr. CHARLES BELL, Austin University, Department of Geology, Texas; Prof. ALBERT ROWELL, University of Kansas, Department of Geology; Dr. ANTHONY WRIGHT, University of Belfast, Department of Geology; Dr. V. GORJANSKY, Geological Institute, Leningrad, for specimens of particular species of inarticulate brachiopods which have been used in the study by the Scanning electron microscope.

Thanks are also due to the workers of the Laboratory of Electromicroscopy of the University of Belfast for the help with the electron micrographs of the studied fossils.

The material was etched by Mrs. M. NOWIŃSKA and Mrs. M. MALECKA; some specimens cleaned in the mechanical way by Mrs. D. SŁAWIK; the ordinary photographs taken by Miss M. CZARNOCKA; the ink-drawings by Mrs. K. BUDZYŃSKA and Mrs. D. SŁAWIK who, in addition, have slightly retouched the photographs, all these persons are from the Palaeozoological Institute of the Polish Academy of Sciences, Warszawa. Mrs. E. K. DUNIN kindly corrected the English of the present paper.

Palaeozoological Institute
of the Polish Academy of Sciences
Warszawa, October 1971

GENERAL PART

MATERIAL AND METHODS

The studied collection of fossil inarticulates has been obtained from the rocks by diluted hydrofluoric and acetic acids technique. Approximately 1000 valves, more complete or less together with a great number of fragments, were picked from the residua. The state of preservation of the fossils varies greatly, in general, however, it is not satisfactory. This concerns mostly the specimens from the Tremadocian chalcedonites in the Holy Cross Mountains (see, p. 20). Many shells of particular species are in a not very advanced growth stage and therefore especially fragile. In addition, they all have undergone extensive disarticulation and, in many cases, serious fragmentation mostly due to the etching. Some dissolution phenomena also occured when hydrofluoric acid was used, changing very much the shell microstructure (BIERNAT & WILLIAMS, 1970, p. 485; see Pl. XI, Fig. 1). As a result, many specimens are incomplete to such a degree that they are almost unidentifiable not only on the specific but also often on the generic levels. Therefore, the generic and in some cases, specific status of a few species described from chalcedonites remain in doubt. Some of them represent, in all probability, new taxa.

The brachiopods from the core samples or erratics are better preserved, as a rule, much less damaged, being in general, much more thick-shelled.

All the species are represented, with a few exceptions, by disarticulated valves, in many cases almost entire, especially within acrotretaceans. This abundance of separate valves is unfortunate, as it is very difficult to find two valves belonging to one specimen, the more so, as the variation limits in the external morphology and internal structure of the shells are rather wide. Only a few acrotretaceans shells, among others of *Ephippelasma spinosum* n. sp., *Torynelasma rossicum* GORJ., *Myotreta crassa* GORJ. and *Scaphelasma subquadratum* n. sp. were preserved after etching with valves closed. However, a slight touching of the shells with a needle was sufficient to separate the valves.

It proved very helpful for identification to compare the surface ornamentation, dimensions and outline of the brachial valves with the antero-lateral margins of the pedicle ones and to treat these two valves, as, probably, belonging to one shell. The pedicle valves of some species, e.g. *Torynelasma rossicum* GORJ., *Myotreta crassa* GORJ. and *Scaphelasma subquadratum* n. sp. were much more numerous than the brachials. This was not a very satisfactory, as usually, from the pedicle valves very little information could be obtained about their interiors. This mainly concerned the highly conical pedicle valves and thin-shelled ones. Primarily, due to the valves being thin-shelled, the internal details such as e.g. muscle scars, pallial sinuses which are almost unknown, to some degree apical processes or morphological details of the internal pedicle foramen have only a slight chance of being preserved or marked. When present, their traces are extremely week and difficult to observe within the conical valves.

As has been mentioned, the specimens studied here are, in general, not in their full growth with the exception of the Estonian and erratic samples, these latter being sometimes silicified. There is often difficulty in establishing relationship to the already known species. A visual comparison of many of these specimens with those illustrated in publications, and which usually represent a very advanced individual age, reveals that in spite of the external resemblance there occur, however, some differences both in the external morphology and internal structure. As the data on such interior details as e.g. the ventral muscle scars or pallial sinuses are not very complete, they are not, or rarely, used as valuable comparable characters in the taxonomic sense.

It should be mentioned that the acrotretids are the most dominant group from the point of view of the degree of differentiation and the number of specimens for particular species being in addition, rather well preserved. Hence, many observations have been made on this group, the more so, as their morphological and internal analysis was supplemented by an examination of several species of acrotretaceans kindly received from other institutions.

In addition, after etching, it was possible, in some cases, to clean up many specimens by means of a very thin needle, especially the brachial valves of many forms such as *Ephippelasma* COOPER, *Myotreta* GORJANSKY, *Scaphelasma* COOPER or *Eoconulus* COOPER, with, in general, good results.

Many details of the shell surface and occasionally the interiors of acrotretaceans and some siphonotretaceans have been studied by using the Cambridge Stereoscan Scanning electron microscope in the Queen's University of Belfast. Shell surface studied by this microscope were coated with gold palladium.

The photographs on the plates, excluding the electron micrographs, are slightly retouched. This was necessary especially in the case of small and very translucent specimens, i.e. those coming from the Tremadocian chalcedonites or bore holes.

Many specimens, mostly those from erratic boulders and some from Estonia were coated with ammonium chloride before being photographed. The majority of the specimens have been, however, photographed, without coating, in glycerine. The Text-figures show mainly these features which were available and considered as important for the studied collection.

As in the collection, complete shells with both valves preserved together are lacking, in the case of newly proposed species, the pedicle valves have been choosen as the holotypes, and the brachial valves treated as the paratypes. Only in a few cases do the type specimens comprise the whole shell, these specimens having been found with both valves joined.

The synonymy is not given for the already known species, only the most recent papers in which the species are described and which have possibly a full synonymy, being mentioned.

The inarticulate brachiopods morphology has been discussed in general, among others, by WALCOTT (1912), BELL (1941), COOPER (1956), ROWELL (1962, 1966), WILLIAMS & ROWELL (1965), GORJANSKY (1969), BIERNAT & WILLIAMS (1970, 1971). In view of this only some characters of some inarticulate groups are here considered.

The following abbreviations of some internal structure and external morphology in Text-figures are used:

a. a. — anterior adductor
a. p. — apical process
a. w. — width anteriorly
b. th. — bulbous thickening
b. v. — brachial valve
c. m. s. — cardinal muscle scars
c. v. — calpac valve (young stage following the protegulum, young valve being superimposed on the adult valve)
d. u. — dorsal umbo
e. p. t. — external pedicle tube
f. s. p. — free septal plate

in. — interarea
i. p. t. — internal pedicle tube
it. — interthrough
l. v. — valve length
l. w. — limbus width
l. w. p. — limbus width posteriorly
m. p. — median plate
m. r. — median ridge
m. s. — muscle platform
m. w. — width medially
n. h. — height of notch
n. w. a. — notch width anteriorly
n. w. p. — notch width posteriorly
p. a. — posterior adductors
p. f. — pedicle foramen
pp. — proparea
p. v. — pedicle valve
p. w. — width posteriorly
s. c. — septum complex
s. p. — surmounting plate
s. s. — septum simple
s. sp. — septal plate
sp. — spikes
spn. — spondylium
t. p. t. — trace of pedicle tube
t. sp. — trace of spike
u. p. — upper plate
v. l. — length of valve
v. p. — vertical plate
z. s. — zigzag form of the sloping edge of septum
I — protegulum stage
II — young stage
III — adult stage.

REMARKS ON STRATIGRAPHY

The described brachiopods are of different stratigraphic age and come from Lower Ordovician deposits outcropping in the Holy Cross Mountains, Lower and Middle Ordovician bored in the north-eastern part of Poland, Lower Ordovician in the western part of Estonia and from erratic boulders, the age of which is, tentatively, defined as Middle and Upper Ordovician (Text-fig. 1).

EASTERN PART OF KIELCE REGION

In the Kielce region only some of horizons of the Ordovician outcrop in a few places. At Wysoczki, environs of Bogoria, about 5·5 kilometres south-east of Kielce, the Lower Ordovician is developed as chalcedonites defined by KOZŁOWSKI as of Upper Tremadocian age (KOZŁOWSKI, 1948, p. 5). BEDNARCZYK (1964) basing on previous investigations (MICHALSKI, 1883; GÜRICH, 1896—1901; SAMSONOWICZ, 1916—1956; CZARNOCKI, 1919—1950; KOZŁOWSKI, 1948; TOMCZYK, 1957—1962) and in particular on his own detailed studies, presented scheme of the Lower Ordovician in the Kielce region. Among others, he distinguished within the Tremadocian the Międzygórze, Zbilutka and Kozieł beds, including the chalcedonites of Wysoczki into the Zbilutka bed.

The Wysoczki exposure consists of an about 16 metres thick, sedimentary series of chalcedonites and associated rocks composed of interbedded thin layers of glauconitic sandstones, each 5—20 centimetres thick, and chalcedonites in parallel beds or lenses. These deposits contain a very well preserved fauna of graptolites (KOZŁOWSKI, 1949), extremely numerous *Acritarcha* (GÓRKA, 1969), an interesting assemblage of algae (STERMACH, 1963), very numerous spicules of sponges, some of them described. With the mentioned fauna are associated inarticulate brachiopods (BEDNARCZYK, 1964; BIERNAT, 1971). The assemblage of brachiopod species indicates the Lower Ordovician age of the chalcedonites. Among the guide species *Siphonotreta acrotretomorpha* GORJ. appears to be a very characteristic form because of its

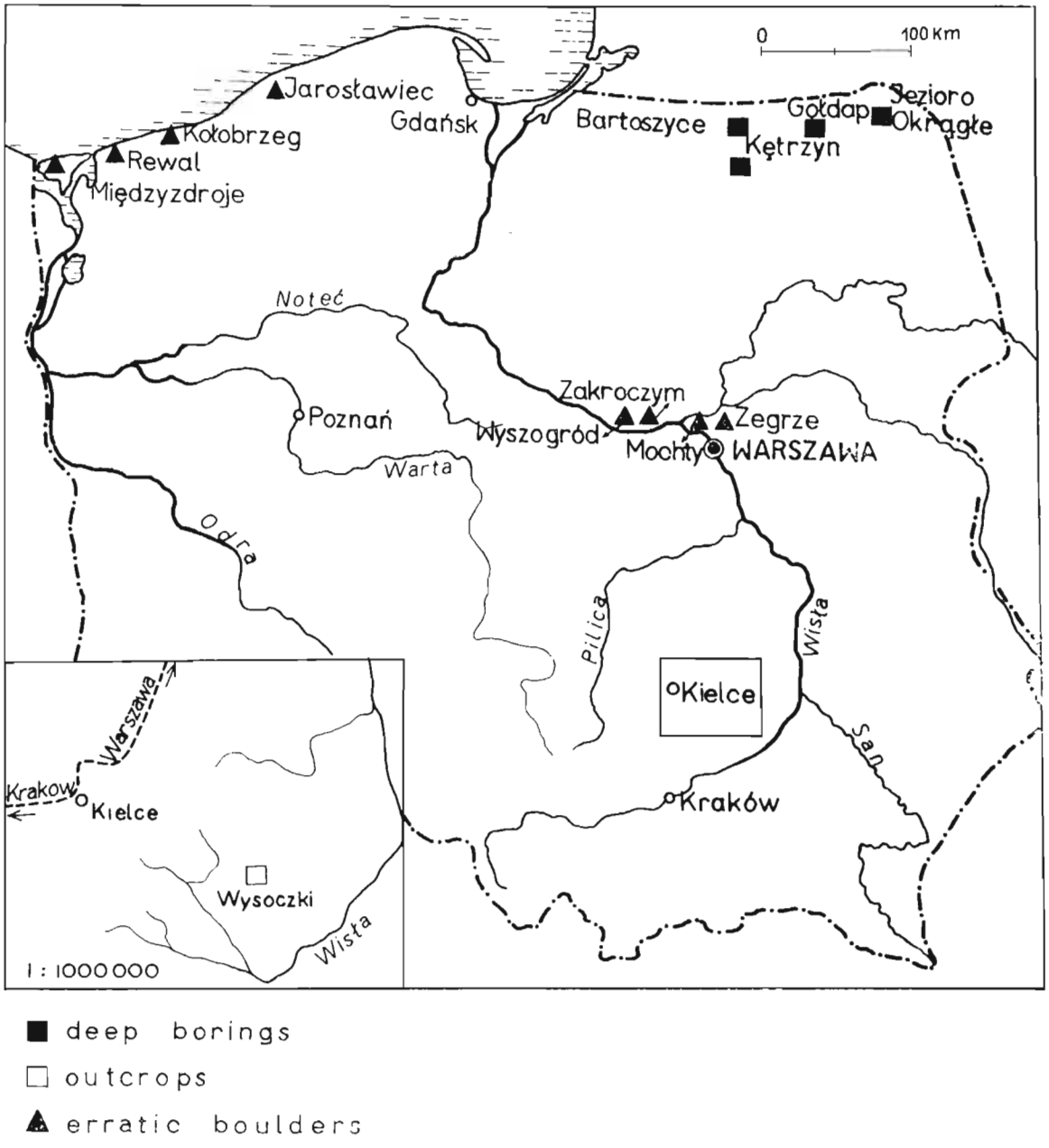

Fig. 1
Sketch-map of localities from which the inarticulate brachiopods were sampled.

limited stratigraphical range and of, probably, quite wide geographical distribution. It is known from the Lower Ordovician (*Thysanotus siluricus* Zone) in West Estonia (GORJANSKY, 1969, p. 67).

NORTH-EASTERN POLAND

The Ordovician deposits recorded in a number of bore holes were subjected to many investigations since 1959. The detailed data pertaining to the Ordovician of the whole north-east part of Poland can be found in papers of TOMCZYK (1959, 1962, 1964), TOMCZYKOWA (1962, 1966, 1968), ZNOSKO (1964), BEDNARCZYK (1966, 1971), MODLIŃSKI (1967, 1968), SZYMAŃSKI (1968), MODLIŃSKI & POKORSKI (1969).

In 1964, TOMCZYKOWA divided the Ordovician deposits of the above area into: Białowieża beds, comprising the Tremadocian and Arenigian; Pomeranian beds, including the Llanvirnian, Llandeilian and partly Caradocian; Mazurian beds with the Uppermost Caradocian (*Pleurograptus linearis* Zone) and Ashgillian.

The considered in this paper brachiopods come from a few selected borings in the extreme north-east part of Poland (Text-fig. 1): Bartoszyce IG-1, Kętrzyn IG-1, Gołdap IG-1, Jezioro Okrągłe IG-1. In the Bartoszyce, Kętrzyn, Gołdap bore holes, where there are shallow water

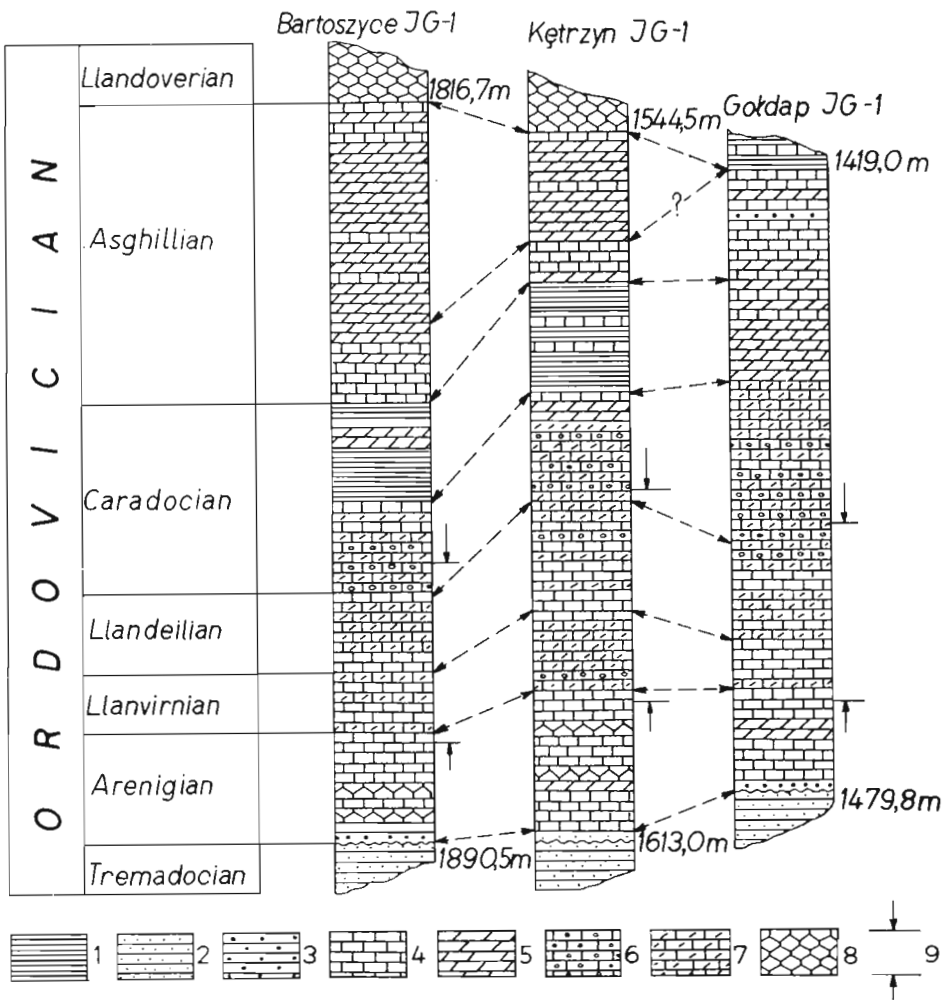

Fig. 2

Lithology and stratigraphy of the Ordovician in north-eastern Poland (after Z. MODLIŃSKI, 1967); *1* — claystones, *2* — sandstones, *3* — conglomerates, *4* — limestones, *5* — marls, *6* — oolithic limestones, *7* — marly limestones, *8* — aggregate limestones, *9* — occurrence of inarticulate brachiopods.

deposits, the general thickness of the Ordovician slightly varies for particular bore hole (Text-fig. 2). The sedimentation begins, in general, with transgressive conglomerates superimposing Cambrian sandstones. Possibly, the lowermost stratigraphic unit stated there is the Arenigian. The presence of some parts of Tremadocian is, however, not excluded, as very thin layers with *Obolus* have been recorded in bore holes in the neighbouring area of Lithuania (MODLIŃSKI, 1967). The subsequent stated stratigraphic units occurring within the bored area are: Arenigian, Llanvirnian, Llandelian, Caradocian and Ashgillian.

In the Jezioro Okrągłe IG-1 bore hole the Ordovician begins with deposits of Upper Arenigian which lie concordantly on, supposedly, Lower Cambrian (MODLIŃSKI & POKORSKI, 1969).

In general, in the above area, the Arenigian is mostly characterized by limestones and marls of changing colour, from grey to brown-cherry, often intercalated with nodular limestone. In the upper part a rich fauna of trilobites occurs including such species as: *Megistanus limbata* (BOECK), *Ptychopyge angustifrons* (DALM.), *Niobe* cf. *laevicens* DALM. and *Nileus exarmatus* (TJERN.), this corresponding to that of Volkhov horizon in Estonia (MODLIŃSKI & TOMCZYKOWA, 1968). Of the brachiopods, also indicating this horizon, can be cited *Myotreta crassa* GORJ. and *Torynelasma rossicum* GORJ.

The Arenigian-Llanvirnian boundary is marked by organodetritic limestones occurring in the Lowermost Llanvirnian, which passes into brown-cherry limestone, interbedded with marly limestone, ferrugineous small oolites often present. Found here are: *Asaphus (Asaphus)* sp., *Ampyx nasutus* DALM. accompanied by *Torynelasma rossicum* GORJ., numerous *Myotreta crassa* and *Ephippelasma spinosum* n. sp.

No lithological changes can be stated on the Llanvirnian-Llandeilian boundary. In the Upper Llandeilian, organodetritic limestone with ferrugineous oolites occurs. The fossils also have sometimes strong traces of ferrugineous impregnations. The fauna is represented by *Illaenus schroeteri* (SCHLOTH.), *Lonchodomas rostratus* (SARS), accompanied by *Scaphelasma subquadratum* n. sp., *Ephippelasma latior* n. sp. and *Torynelasma rarum* n. sp. which pass into Caradocian.

In the Caradocian, the sediments of Kętrzyn IG-1 and Bartoszyce IG-1 are comparable to the Ordovician of Sweden and Latvia, while those of Gołdap IG-1 and Jezioro Okrągłe IG-1 are closer to those of Lithuania (MODLIŃSKI, 1967). In the Lower Caradocian of Kętrzyn—Bartoszyce there occur organodetritic limestones which contain in their lower part: *Neosaphus ludibundus* TORN., *Chasmops* cf. *odini* (EICHW.), *Echinospherites* sp. and this part being correlated with the Kukruse horizon in Estonia. The upper part of these Lower Caradocian organodetritic limestones with *Illaenus fallax* HOLM., *Illaenus jevensis* HOLM., *Remopleurides wimani* THORN. can be correlated with Idavere-Jõhvi-Keila horizons in Estonia.

In Gołdap IG-1 this complex of sediments can be correlated (as a whole, without division) with the horizons from Kukruse to Keila in Estonia. In the Upper Caradocian there occur mostly marls in Kętrzyn—Bartoszyce and limestone interbedded with marls in Gołdap bore holes.

Regarding the Ashgillian, in the Gołdap IG-1 and Jezioro Okrągłe IG-1 marls with oolitic limestones pass into pelitic limestones interbedded with grey marly limestones, fauna being very poor. In Kętrzyn IG-1, occur brown-cherry limestones and marls with *Tretaspis seticornis* (HIS.), *Illaenus roemeri* VOLB., etc., and they can be correlated with the „*Tretaspis* Zone" in the Vestergotland in Sweden (MODLIŃSKI, 1967). In the upper parts of the section in Bartoszyce IG-1, Kętrzyn IG-1 occur limestones passing into sandy limestones and marls with *Dalmanitina mucronata* (BRONG). Inarticulate brachiopods are lacking.

ESTONIA

The very small collection of inarticulates comes from the locality Suhkrumägi, south of Tallinn, from the Arenigian, Volkhov horizon, which lies about 0·4—0·55 metres above the lower boundary of Viesnaski subhorizon B_{II} (MÄNNIL, 1966). There are marly limestones with fossils. The brachiopod fauna is not very numerous, represented by few genera. The shells of all species are characterized by being much larger in size and all specimens are thick-shelled. Mostly occur: *Scaphelasma septatum* COOPER (GORJANSKY, 1969), *Torynelasma rossicum* GORJ., in much less number of specimens *Myotreta estoniana* n. sp. characterized by strongly folded dorsal septum (Pl. XV, Figs. 1—17). *Eoconulus* and *Rowelella* occur rarely and mainly the latter form.

ERRATIC BOULDERS

The erratic boulders in which the inarticulate brachiopods have been found in association with e.g. algae, phosphate tubes, acritarchs, scolecodonts etc. were studied by KOZŁOWSKI (1954, 1956, 1959, 1960, 1961, 1962, 1966, 1967), KIELAN-JAWOROWSKA (1961, 1966) and GÓRKA (1969). In a particular boulder the brachiopods are often found only sporadically, represented mostly by pedicle valves of *Torynelasma* or *Eoconulus*.

An assemblage of brachiopods obtained from the erratic boulder-Jarosławiec No. O. 247 merits some mention. The fauna is not very differentiated, represented mostly by numerous eoconulids, containing few valves of *Torynelasma* sp., one complete shell (with both valves closed) of *Ephippelasma* cf. *spinosum* (Pl. XXIII, Figs. 7, 8), few valves of *Myotreta* sp. and *Scaphelasma* sp. with a characteristic lens-like pedicle foramen (Pl. XVI, Fig. 7).

Some reference is here given to those boulders in which more than one specimen has been found. Their exact age unknown, supposedly Middle and Upper Ordovician.

Characteristics of the boulders

No. O. 178. Mochty, environs of Warszawa. Grey, finely grained, compact limestone containing a number of Graptolites, polychaete jaws: *Mochtyella* sp. KIELAN-JAWOR., *Kozłowskiprion longicavernosus* KIELAN-JAWOR., *Pistoprion* sp. KIELAN-JAWOR., and a number of silicified specimens of *Craniops erratica* n. sp. and a fragment of *Rowelella* sp., *Scaphelasma* cf. *septatum* COOPER, *Torynelasma* sp. Age unknown.

No. O. 247. Jarosławiec, enviróns of Koszalin, Baltic coast. Limestone light grey, finely grained with a great number of *Eoconulus semiregularis* n. sp., rare *Ephippelasma* cf. *spinosum* n. sp., *Scaphelasma* sp., *Ectenoglossa* sp., *Glyptoglossella* sp.

No. O. 319. Mochty, environs of Warszawa. Limestone light, grey, compact with unidentified Dendroidea; Chitinozoa represented by *Cyathochitina campanulaeformis* KOZŁ., Foraminifera, spicules of sponges, polychaete jaws of *Atraktoprion maior* KIELAN-JAWOR., *Ramphoprion* sp., *Mochtyella* sp. Of the inarticulates few valves of *Eoconulus* cf. *semiregularis* n. sp. and one valve of *Ephippelasma* cf. *spinosum* n. sp. are found. Age: probably Upper Ordivician.

No. O. 349. Zakroczym, environs of Warszawa. Finely grained limestone, very similar in its lithology to the Baltic limestone, containing numerous fossils: Chitinozoa, ?*Climacograptus* sp., polychaete jaws of *Pistoprion transitans* KIELAN-JAWOR., isolated jaws of *Polychaetaspis* sp. and *Xanioprion* sp., few specimens of *Eoconulus* sp. Age unknown.

No. O. 400. Mochty, environs of Warszawa. Grey, coarse grained limestone with a rich fauna of scolecodonts (KOZŁOWSKI, 1956; KIELAN-JAWOROWSKA, 1962, 1966). Of the brachiopods single valves of *Torynelasma* sp. and *Ephippelasma* cf. *spinosum* n. sp. occur. Middle Ordovician, probably corresponding to Kukruse Stage or Idavere Stage in Estonia.

No. O. 418. Międzyzdroje, Baltic coast. Finely grained and compact limestone very similar lithologically to Baltic limestone yielding: Conodontophorida, Foraminifera, Chitinozoa, ?*Orthoretiolites* sp. polychaete jaws of *Pistoprion* sp., undescribed jaws of *Polychaetaspis* sp., *Ramphoprion* sp., few valves of *Torynelasma* sp., *T. rossicum* GOR., *Ephippelasma* sp., *Myotreta* sp. *Eoconulus* sp. Age: probably Middle Ordovician.

No. O. 461. Jarosławiec, environs of Koszalin, Baltic coast. Light, thicker grained limestone with conodonts, Chitinozoa, *Desmochimina* sp. and pirytized *Phycomyceta*, phosphate tubes: *Labirinthotuba kozlowskii* GÓRKA. Of the brachiopods are recorded few valves of *Eoconulus semiregularis* n. sp. Age unknown.

No. O. 511. Mochty, environs of Warszawa. Compact limestone, thicker grained with graptolites: *Climacograptus* sp., *Graptolodendrum* sp., Dendroidea, Hydroida, Scolecodonta, phosphate tubes: *Phosphotesta spinosa* GÓRKA. Of the brachiopods few pedicle valves of *Torynelasma* sp. occur. Age: Middle or Upper Ordovician.

No. O. 525. Międzydzroje, environs of Szczecin, Baltic coast. Grey limestone of middle sized grains, containing fragments of graptolites, numerous melanosclerits, scolecodonts, Chitinozoa, Acritarcha: *Baltispheridium digitatum* (EISEN). The inarticulate brachiopods are rarely represented by few valves of *Eoconulus semiregularis* n. sp. and two valves of *Torynelasma* sp. Age: probably Upper Ordovician.

No. O. 534. Mochty, environs of Warszawa. Organoclastic coarses grained limestone containing pedicle valves of *Torynelasma* sp., one of *Ephippelasma* cf. *spinosum*.

No. O. 535. Mochty, environs of Warszawa. Light, compact, organodetritic limestone with gastropods, scolecodonts, conodonts, phosphate tubes, few valves of *Eoconulus* cf. *semiregularis* n. sp., *Lingulella* sp., *Paterula* cf. *perfecta* COOPER, unidentified fragments. Age: probably Upper Ordovician.

No. O. 547. Mochty, environs of Warszawa. Limestone grey, compact with *Dictyonema* sp., *Diplograptus* sp., scolecodonts, conodonts, fragments of phosphate tubes, algae, two fragments of brachial valve *Torynelasma rarum* n. sp. Age: probably Middle Ordovician.

TREMADOCIAN CHALCEDONITES AND CORES BRACHIOPOD ASSEMBLAGES

The inarticulate brachiopods make up a very considerable percentage of fossils in the Tremadocian chalcedonites at Wysoczki. They are represented mainly by siphonotretaceans which prevail and the acrotretaceans. The other groups, i.e. obolinids, acrothelids, lingulellids are recorded rarely. There occur also, in the residuum, very numerous fragments of valves, evidence of a rich accumulation of forms in that environment.

Of the siphonotretaceans, especially numerous are *Siphonotreta acrotretomorpha* GORJ., varying, to some extent, in size; *Helmersenia ladogensis* JEREM. represented by a number of damaged valves: *Siphonotreta* cf. *verrucosa* (VERN.), less numerous and very fragmentary; *Alichovia analogica* n. sp. preserved, as a rule, as dichotomously bifurcated spines and small fragments of valves.

Of the acrotretaceans relatively numerous are: *Semitreta maior* n. sp., one of few species which are preserved in a wide range of shell size, discernible by its regular shape from the smallest valves to the largest (Text-fig. 27), and to a lesser degree *Eurytreta minor* n. sp. Rarely occur *Ditreta dividua* n. sp., and very rarely *Spondylotreta* sp., *Myotreta* sp., *Rowelella* sp., this latter preserved only in small fragments.

The inarticulate brachiopods show some adaptative characters, few being very specialized, e.g. spines of *Alichovia analogica* n. sp., greatly weightened apical ventral interior of *Ditreta dividua* n. sp. or well developed, widely spaced two apical processes of *Orbithele bicornis* n. sp.

The considered fauna shows general affinities mainly to the fauna of Estonia and USSR, North-west of the Russian Platform, among the common species occur: *Schmidtites obtusus* MICKW., rather abundant at Wysoczki, *Siphonotreta acrotretomorpha* GORJ., *Helmersenia ladogensis* JEREM. Genus *Alichovia* merits mention as being known only recently by two species, one from Lower Ordovician-Tremadocian in Poland and the other from Middle Ordovician, Idavere horizon in Estonia, both species having similarly ramificated surface spines (see p. 34).

The brachiopods from north-eastern Poland constitute a specific assemblage, the acrotretaceans occurring in majority, both in the number of taxa and specimens. In each of the borecores these brachiopods occur in great accumulation, usually in the lower part of the section which corresponds, to the late Lower and Middle Ordovician, i.e. Arenigian to Caradocian, in layers of different thickness. In the overlying and underlying beds the inarticulates are very scattered or lacking. The most common species is *Myotreta crassa* GORJ. recorded in number

in Kętrzyn, Bartoszyce, being less numerous in Gołdap. In Jezioro Okrągłe only a few pedicle valves of *Myotreta* sp. with a smaller cone occur. The other species which are found in association with *Myotreta crassa* are: *Ephippelasma spinosum* n. sp., *Torynelasma rossicum* GORJ., *Scaphelasma subquadratum* n. sp. represented by separate valves, the pedicle ones, as a rule, prevail. *Paratreta similis* n. sp. and *Eurytreta intermedia* n. sp. relatively large and thick-shelled in comparison to the other cited acrotretaceans are known mostly from Gołdap IG-1 (1466·9—1473 m), Kętrzyn IG-1 (1595·5—1602·5 m) being more rare in Jezioro Okrągłe IG-1. The lingulellids are preserved in small fragments.

In all the mentioned cores *Eoconulus cryptomyus* GORJ. is fairly numerous, varying in a number of specimens for particular bore holes. In Jezioro Okrągłe IG-1, in layers corresponding to the Caradocian (depth about 881·9—909·0 m) occur species much less conical, i.e. *Torynelasma rarum* n. sp., *Ephippelasma* cf. *spinosum* n. sp., but they are rather rare. The fauna of the above cores is, to a great extent, analogous to that described by GORJANSKY from West Estonia and USSR, environs of Leningrad. The stratigraphic age of the common species, in general, corresponds to the Pomeranian beds sensu TOMCZYKOWA (1964), see p. 17.

To sum up, representatives of only four genera found in the Upper Tremadocian chalcedonites of Wysoczki occur in the north-eastern Poland. These are: *Paratreta*, *Eurytreta*, *Spondylotreta*, *Myotreta*. A member of the genus *Rowelella* WRIGHT rarely occurring in the Tremadocian chalcedonites has been found in a sample from Estonia and in one erratic boulder (O. 178).

The fauna of all considered cores from north-eastern Poland shows, in general, a great constancy in its generic and specific status. The quite wide uniformity of the species in north-eastern Poland, Estonia and USSR (Russian Platform) suggests that these brachiopods can presumably be used for stratigraphy as guide fossils. The acrotretaceans regarded stratigraphically, show a tendency to become, in the younger deposits, slightly less conical, the pedicle valves being lower but wider anteriorly. This can be showed by *Torynelasma rossicum* GORJ. (Arenigian-Llanvirnian) and *T. rarum* n. sp. (Caradocian); *Ephippelasma spinosum* n. sp. (Arenigian-Llanvirnian) and *E. latior* n. sp. (Llandeilian-Caradocian), *Myotreta* sp. which preserves its quite distinct young calpac-like shell.

Within the inarticulates occur groups, restricted to a short period of time which show some specialised characters such as median septum, external and internal spines etc. The Tremadocian chalcedonites fauna shows a relatively large number of new forms — this could, probably, be greater in the case of better preserved specimens.

REMARKS ON CLASSIFICATION

As a rule, in the general and specific evaluation, every feature could be considered within the inarticulates. This, however, depends very much upon the state of preservation of specimens and mainly upon the methods used to get the fossils from the rock and to investigate them.

Most of the external and internal characters, usually preserved in the fossil state, are very helpful for the determination of the genera. In the case of e.g. obolids or paterulinids the shells are of a very simple morphology and the state of preservation is, generally, not very satisfactory. Often, only the shell outline and some traces of surface concentric lines are preserved. The number, hence, of possible features used in their classification is very limited. *Schmidtites obtusus* MICKW. is a very good example. The valves are relatively numerous and

can be grouped in growth range (Text-fig. 3). They all display a very regular shell outline, oval-elongate, narrowed posteriorly. Judging by the preserved concentric lines, not many changes or extremely few occur in their post-larval development. The features of internal morphology are, unfortunately, not preserved as the specimens are thin-shelled. The same concerns the paterulinids, lingulids and others. Even, when using every character of possible taxonomic value, defining the species and often the genera is, sometimes, extremely difficult. The

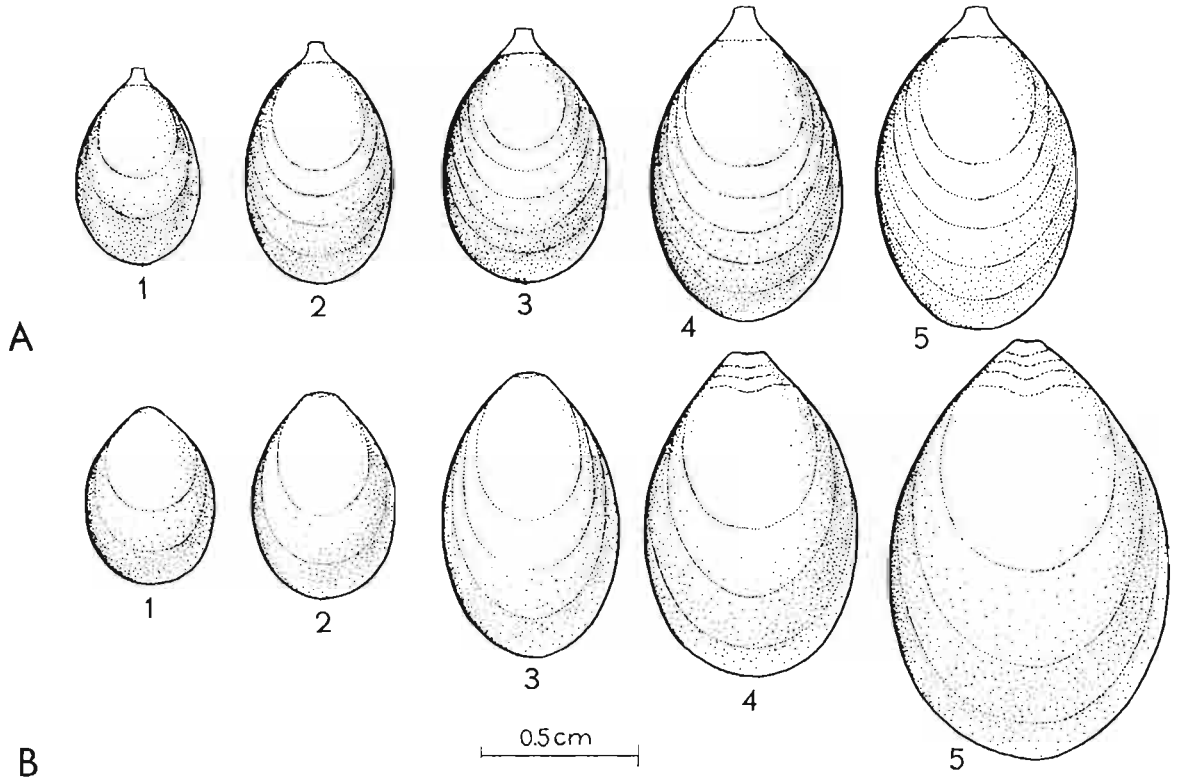

Fig. 3

Schmidtites obtusus MICKWITZ (Tremadocian chalcedonites, Wysoczki). Range of 10 specimens of different size: *A* pedicle, and *B* brachial valves.

morphological simplification is not fortunate for their classification. It is one of the reasons that these groups are very badly known. One of the more useful methods is biometry. In the case of the above forms, however, only a few measurements, such as e.g. length (maximum and minimum width rations), can be considered and sometimes, if preserved, size of propareas and pedicle groove or size of limbus for e.g. lingulellids, paterulinids (Text-fig. 4). These features, including the appearance of concentric surface lines are, as a rule, useful taxonomically. ROWELL (1966) when revising some Cambrian-Ordovician acrotretids notes the very little information available on their variation, which is usually overlooked. This is true for the inarticulates as a whole group.

The variability always occurs within the brachiopods and its limits can vary often considerably and it must be taken into consideration when dealing with these fossils. In some cases the variability is extremely small and concerns the shell outline only and in such circumstances it is still difficult to use this feature as a valuable taxonomic character for e.g. *Schmidtites*, *Pate-*

rula, *Lingulella*. To sum up, one can say that these all mentioned features are, only theoretically, very useful for defining the taxons of the above groups, not when dealing with fossils.

The acrotretaceans are rather exceptional in the great number of external and internal characters. Their brachial valves due to flattening or slight convexity are, in general, better

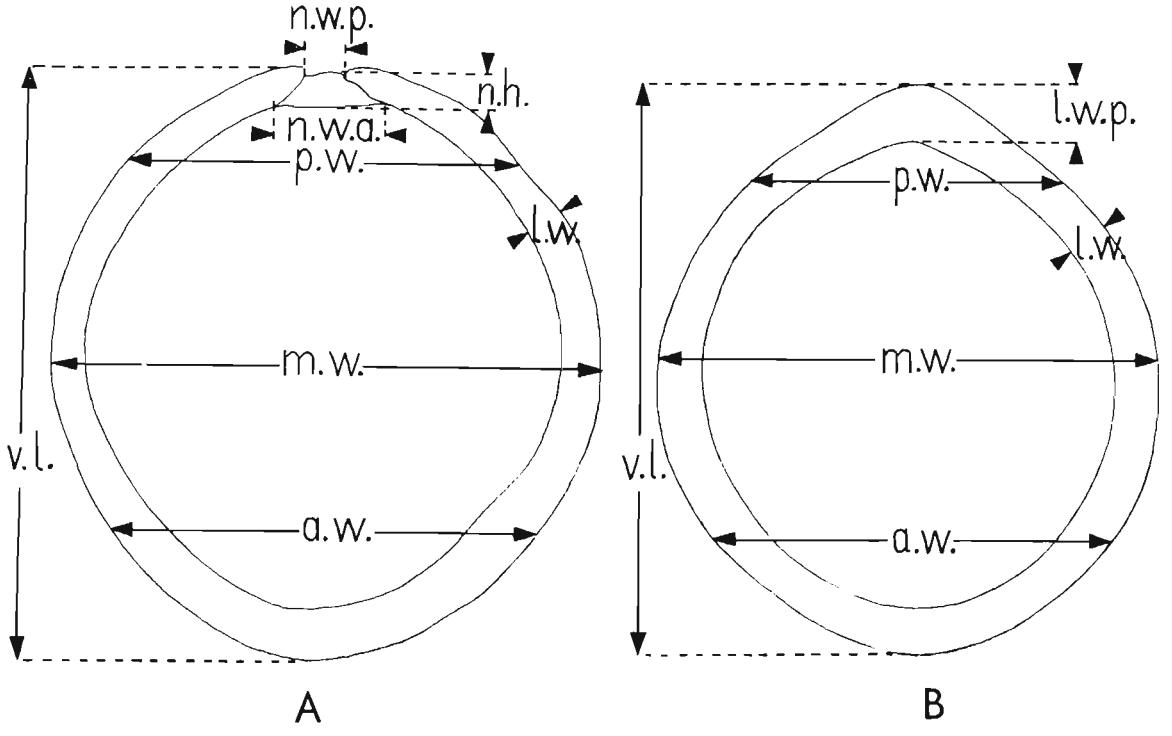

Fig. 4

Paterula cf. *perfecta* COOPER (erratic boulder, No. O. 535). *A*, *B* measurements available for pedicle and brachial valves; *a. w.* width anteriorly, *l. w.* limbus width, *l. w. p.* limbus width posteriorly, *m. w.* width medially, *n. w. a.* notch width anteriorly, *n. w. p.* notch width posteriorly, *n. h.* height of notch, *p. w.* width posteriorly, *v. l.* length of valve.

known than the pedicle ones and display more internal details which can be discussed from the taxonomic aspect. Of a great value are the structures of the posterior margin, e.g. size and shape of propareas, degree of development of median dorsal plate together with the median septum, often well developed (p. 39) and muscle scars, if these are preserved (Text-fig. 5). These features are considered as additional to the pedicle ones or are often the only features which display diagnostic value when the latter valves are not available. The considered characters are, in general, widely believed to be valuable marks for identifying the genera (BELL, 1941; COOPER, 1956; ROWELL, 1966; GORJANSKY, 1969).

The interiors of pedicle valves of some conical forms as *Myotreta* GORJ., *Torynelasma* COOPER, or *Ephippelasma* COOPER are often not very suitable for study. Hence characters which are of great importance in the generic status, such as muscle scars, pallial sinuses (for *Conotreta* WALCOTT, *Hardrotreta* ROWELL, *Eurytreta* ROWELL) or apical process for *Canthylotreta* ROWELL, *Eurytreta*, *Conotreta* are in the case of our material not/or only very slightly visible, and often not comparable. The apical process has been used by ROWELL (1966) as one of the important generic characters for the Cambrian and Early Ordovician acrotretids. Its outline, degree of development and its relation to the internal pedicle foramen (i.e. solid, knob-like boss in *Apso-*

treta BELL, or ridge-like limiting the pedicle from the interior as in *Hardrotreta* ROWELL lying dorsally in *Canthylotreta* or ventrally in *Hardrotreta* or *Apsotreta*) have been used by the above author as features which well define the genera. This internal structure, in the present fossil material, although preserved in an incomplate state, was very useful as an additional determining

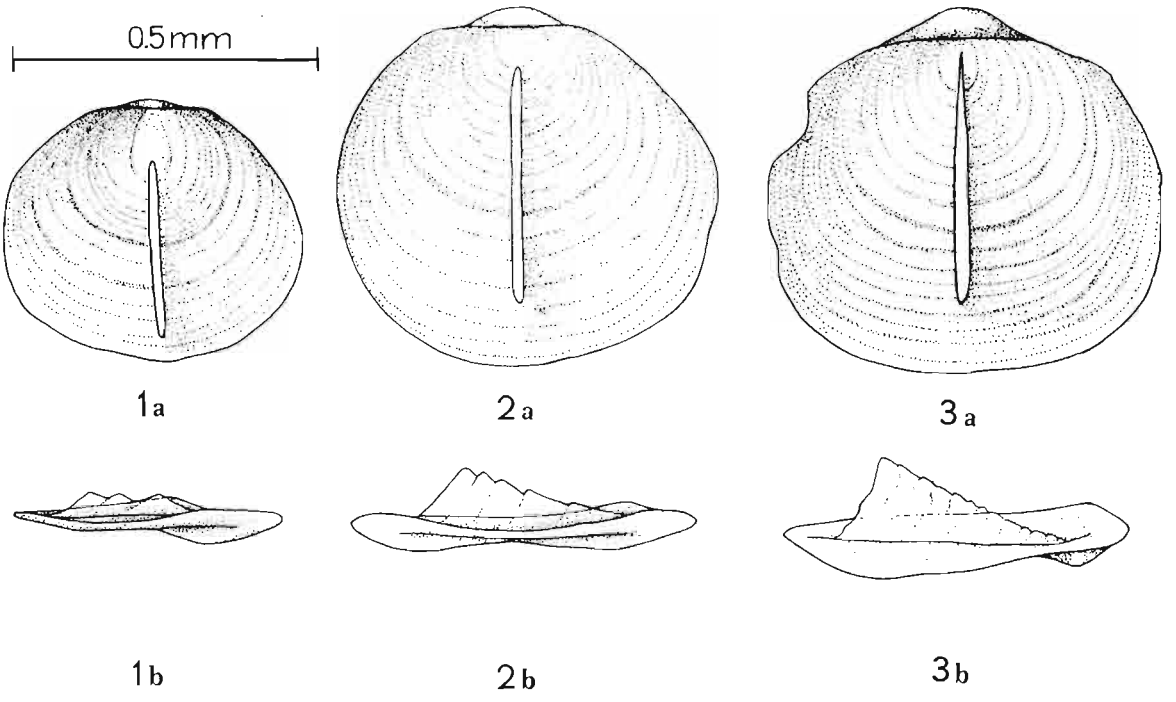

Fig. 5

Scaphelasma cf. *septatum* COOPER (erratic boulder, No. O. 478). Interior (*a*) and side view (*b*) of three different brachial valves showing length and height of septum.

feature for some species of *Eurytreta*: *E. intermedia* n. sp. (Pls. VI, IX; Text-fig. 25), *Paratreta similis* n. sp. (Text-fig. 23). As a supplement for some forms, can be used the appearance and position of the pedicle foramen, this changeable, as a result of its functioning for the pedicle emergence. It is supraapical (RUDWICK, 1970) in majority of forms being of small size and round especially in conical valves, extending outwards and forming a small tubular extention in e. g. *Torynelasma rossicum* GORJ., *Myotreta crassa* GORJ. (Pl. XIII, Figs 1—9; Text-fig. 29), or subapical in adult stage, commonly diminishing with growth, round or lens-like in pedicle valves of *Scaphelasma subquadratum* n. sp. *Scaphelasma* sp. (Pl. XVII, Figs 1—6; Pl. XVI, Fig. 7; Text-fig. 31). The difference in its size and outline can easily be discernible (individual variations and changes during the growth process excluded), and in association with the e.g. outline and size of valves they could be helpful.

Another valid generic criterion could be surface ornamentation, that means the appearance and the degree of development of its details. This can be quite differentiated within the genera, as shown by the scanning electron micrographs (Pls. VI, XXXV, XXXIX). The pattern of ornamentation being, in some cases used, among others by COOPER (1956), GORJANSKY (1969) as specifying some forms (*Scaphelasma rugosum* GORJ., 1969, Pl. 12, Figs 1—4; *Rhysotreta corrugata* COOPER, 1956, Pl. 18F). It is difficult, at present, to state to

what extent this feature can be used for specific evaluation. Apparently, the number of concentric elements, their thickness and spacing could be significant on the level of species.

ROWELL considers (1966) the statistic method as of great importance using it to supplement the description of some investigated acrotretaceans species. He measured seven available details in the dorsal interior, 6 for the ventral interior and two features of external morphology for each valve. Such a method can certainly more precisely define the taxons and it would have to be an ideal situation for it to be used to such a degree as ROWELL did, but it depends very much upon the state of preservation of fossils.

There remains another feature, protegular pits on the protegular surface of valves, highly characteristic of super-family and no doubt valuable for the lower taxonomic units (BIERNAT & WILLIAMS, 1970; see p. 35). Its precise value on generic level is not yet precisely defined. This must be investigated on a basis of a much greater number of genera and species.

Despite all these difficulties, most acrotretacean genera and, to a great extent, species appear to be rather well defined and, commonly, easily recognized, for among others, their described number is still limited. In general, one can state a significant progress in the generic and specific analysis of the considered inarticulates. This very diversified group both in the external and, to a great degree, internal morphology shows the apparent stabilization in many characters, (including, in a large sense, also the median septum), or a tendency to be stabilized.

As to the siphonotretaceans, the present material is too fragmentary to add something more to the subject of their classification. In general, the most important features are the pedicle foramen with or without an internal pedicle tube. Its size in some forms is slightly enlarging during early growth due to a gradual resorption of shell substance (ROWELL, 1962, p. 146). In the *Siphonotreta acrotretomorpha* GORJ. the pedicle foramen is relatively large in valves smaller than average. This being in agreement with ROWELL'S opinion that the resorption occurs relatively early during growth.

Further, the shell outline, details of the posterior margins morphology supplemented by the surface spines are very useful in classification of this group. With regard to the surface spines, their arrangement in quincuncial or banding pattern, general size, (all spines of the same or differentiated diameter and arrangement) as also their appearance, simple or branched, are judged to have a great taxonomic value (*S. acrotremorpha* GORJ., *Alichovia* GORJ., Pls. XXVIII, XXXI). COOPER (1969, p. 217) says that the kind of spines together with their arrangement is a generic character. This being widely used since CHAO (1927) and THOMAS (1914) for articulate brachiopods. The same can also be applied to the inarticulates. Actually, the multibifurcated surface spines have been used by GORJANSKY (1969) as a valuable generic criterion for *Alichovia*. In our specimens of that genus, the scarce arrangement of bifurcated spines, probably relatively large pedicle foramen (oral communication from Prof. R. KOZLOWSKI), elongate posterior margin of the brachial valve are, in addition, to the spines, useful features. It is a consistent difference and may be regarded as a new generic distinction. In addition, the density of single spines appears to be a valid specific criterion in the siphonotretids. As to the complex spines, their nature suggests their scarcity, a feature rather constant for the genus *Alichovia*.

Some mention merits *Eoconulus* COOPER. The height and size of the brachial valve, the only known, and, to some extent, the position of the dorsal apex are changeable, sometimes greatly. These small differences are used as specific features. Also the degree of the valve elongation although varying is usually, accentuated (*Eoconulus semiregularis* n. sp., Pl. XXXVI, Figs 1—5). No doubt, the surface ornament can have a taxonomic value on specific level, being very differentiated as shows scanning micrograph (Pl. XXXVI, Figs 9—10; Pl. XXXV). It is

necessary to establish the limits of possible variations which do occur on one valve and in specimens of one species. It is evident that the classification problem is in articulates still open and the main basis of it remains still morphology.

SOME DATA ON THE GROWTH OF SHELL

A very limited range of shell size occurs in the studied fossils as all the specimens, with some exceptions *(Schmidtites, Eurytreta, Paratreta, Myotreta)* are almost of the same individual age. The observations of the very fine surface concentric lines, which preserve the exact outline of the valve, characteristic of each growth stage, show that the developmental process in lingulellids or obolids is quite regular. No great changes are shown by the subsequent concentric outgrowths which are progressively added to the periphery of the preceding one. In every growth stage the appropriate pattern of the shell outline is preserved. As to the rate of growth and its direction they do not change or only minimally anteriorly, the young shell constituting a miniature of the adult (*Schmidtites obtusus* MICKW., Text-fig. 3; or *Semitreta maior* n. sp., Text-fig. 27).

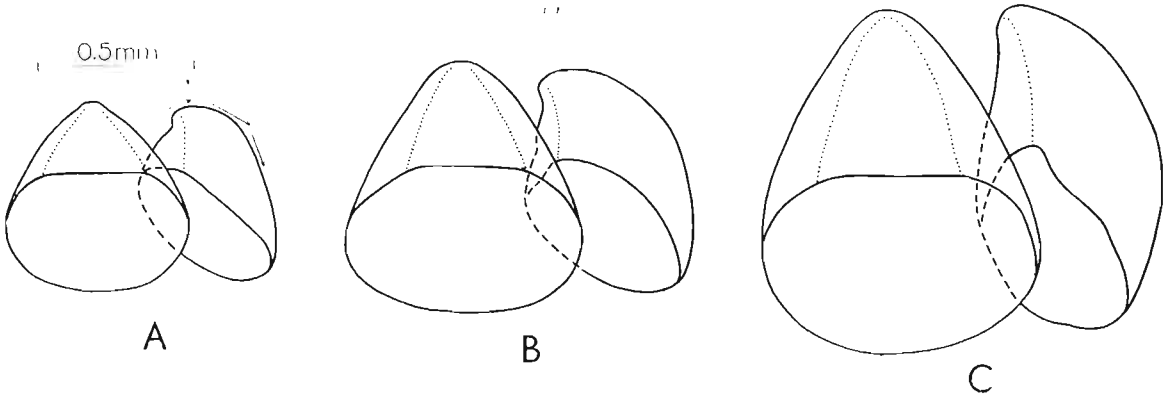

Fig. 6

Ephippelasma latior n. sp. (Kętrzyn IG-1595·5 m) *A-C* interarea and side views of three different specimens of pedicle valves, changeable in size; *A* some changes in the direction of growth marked.

Some changes in the rate of growth and direction do occur in majority of the acrotretaceans. The very young post-protegular valve is, as a result, slightly different in shape and outline from the adult one (*Myotreta crassa* GORJ., *Ephippelasma spinosum* n. sp., *E. latior* n. sp., Pl. XV, Figs 4—5; Pls. XXIII, XXIV; Text-figs 6, 10, 29). The pronouncedly unequivalved shells are, to a different degree, relatively changeable in size, much more so in their whole appearance. In general, two distinct phases of growth are always discernible which can correspond to the protegulum and post-protegular shell, the differences being related to the nature of the developmental process (BIERNAT & WILLIAMS, 1970). Due to that, the protegular part of both valves is devoid of any traces of concentric increments of growth. The protegular parts of valves are always well separated from the post-protegular parts by an especially broad but shallow deepening or by a narrow and very deep concentric furrow. These latter are, usually followed by a greatly thickened and elevated ring of shell substance which was added to the peripheral deepening encircling the protegulum or by a very broad and thick concentric band (*Torynelasma rossicum* GORJ., Pl. XXII, Fig. 1; *Scaphelasma subquadratum* n. sp., Pl. XVIII, Fig. 3). The final appearance in adult shell of the separating bands or furrows is, somewhat, changeable both intra-

specifically and/or interspecifically. It is probable that, in this way, is expressed the critical, for the animal which is newly settled, period of adaptation to changed environmental conditions. The further growth of the shell continues to be acrretionary, both valves of the shell still enlarging by subsequent additions of the marginal increments of growth. This stage applies to the whole adult shell following the protegulum stage, and seems to suggest an almost uniform rate of growth and direction. In *Torynelasma rossicum* GORJ. and others (Text-figs 7—9) there occurs

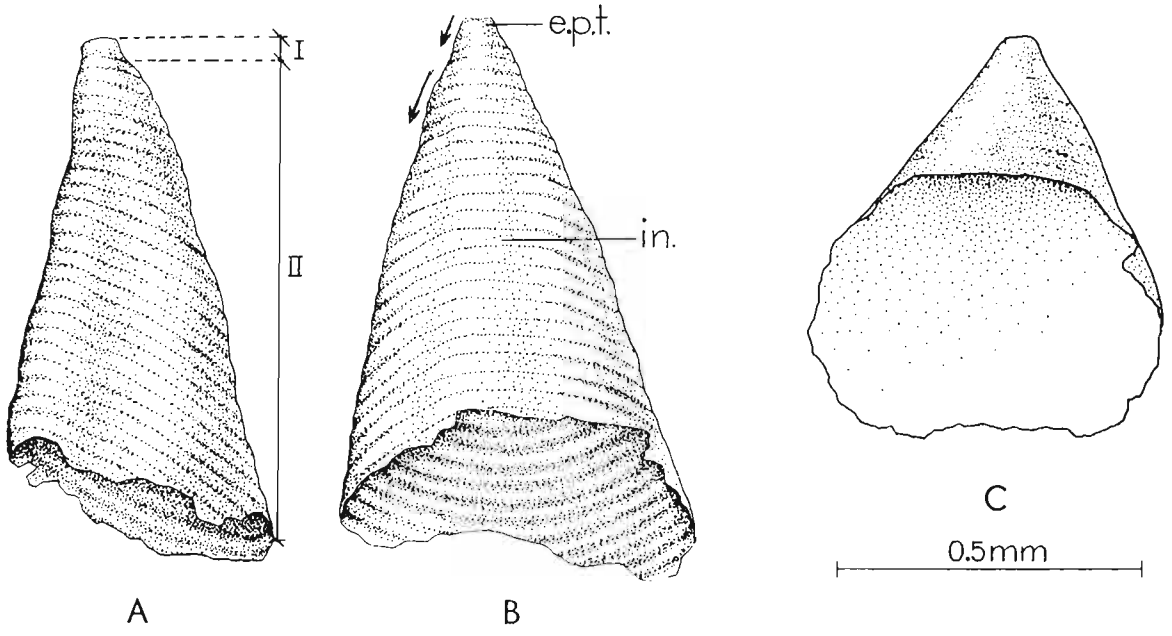

Fig. 7

Torynelasma sp. (erratic boulder, No. O. 418). One pedicle valve in three views (*A-C*), two growth stages and direction of growth marked (*A*, *B*); *e. p. t.* external pedicle tube, *in.* interarea.

gradual growth with only some changes in its rate, the valve size enlarging in the anterior direction rather regularly. This is showed by the appearance and density of concentric lines regularly arranged over the whole shell surface (Pl. XX, Fig. 11; Text-fig. 9). In some species, however, just after the protegulum stage of pedicle valves, an additional phase can be differentiated. It is quite well marked due to the changes in direction and rate of growth appearing to be responsible for the general form of the adult valve and its orientation to the brachial one. This phase comprises probably a short period, just after the settlement of the animal. The complete change in the mode of life of the animal could give rise to some disturbances in the secretion regime and could, in many cases, produce some relative retardation or acceleration in the normal outgrowth of the post-protegular shell. Very often, increased local ventral arching is formed due to the directional changes of growth (Text-fig. 23). The effects of these changes can be sometimes quite remarkable. In *Myotreta crassa* GORJ. is formed something like a calpac, the young valve being roundly outlined, looking as if superimposed on the adult valve (Text-fig. 29 B_2). In *Ephippelasma spinosum* n. sp. the post-apical valve is very arched in lateral view and the young valve being characterized by the crowded concentric lines, in *Paratreta similis* n. sp. it is vesicularly arched in side view (Text-fig. 23, 2*a*). The above —young, post-protegular valves suggest a slightly more intensive accretion in length (the concentric lines being more numerous

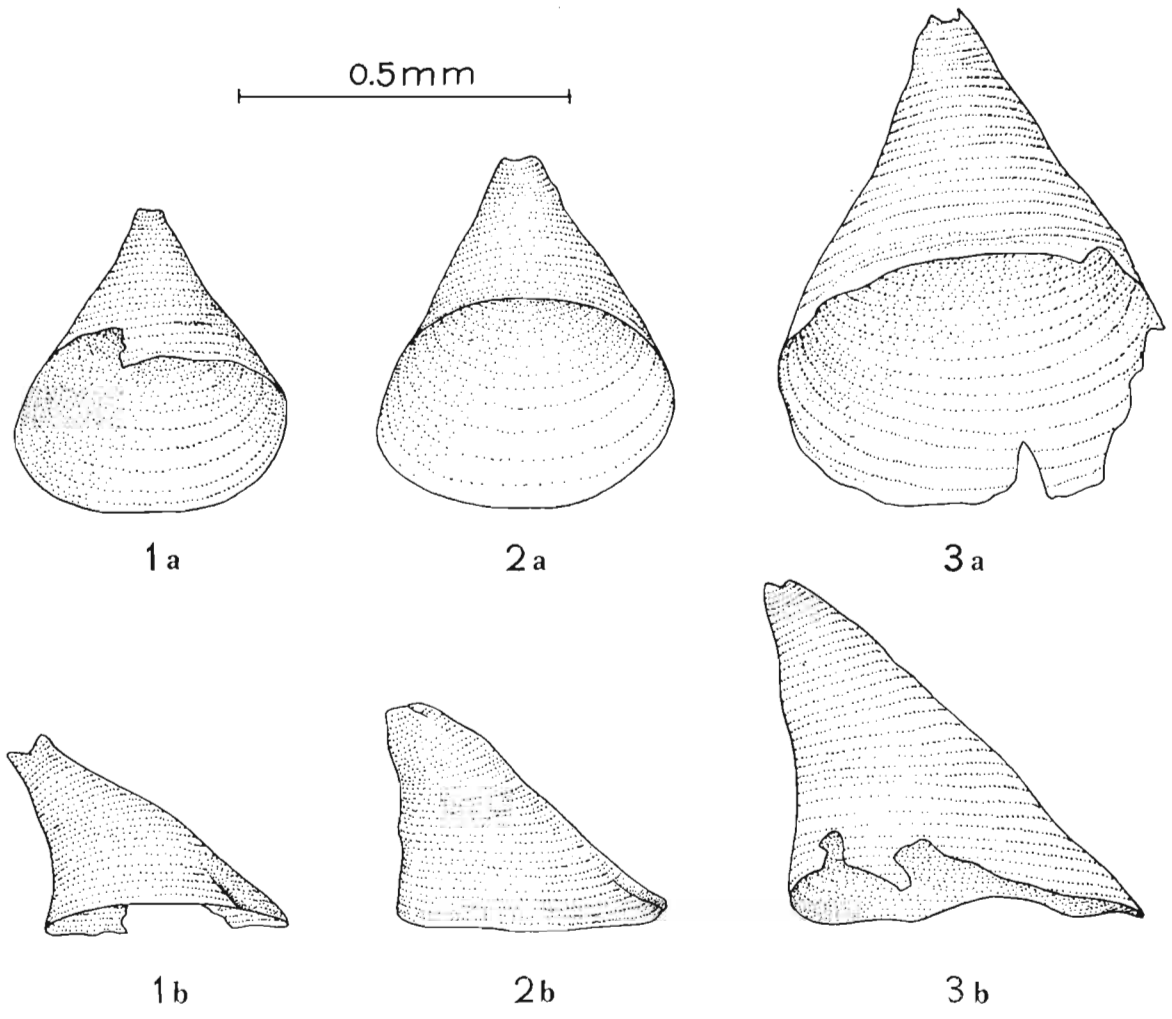

Fig. 8

Torynelasma sp. (erratic boulder, No. O. 178). *1-3* — different pedicle valves in various size: *a* interarea, and *b* side views.

as in *Ephippelasma spinosum* n. sp., Text-fig. 10) and width (the valves being more widely outlined). The total length of the anterior margins in these valves being longer in relation to those of the just following adult valve, in the latter case the total length of anterior margins usually increases gradually. *Myotreta crassa* GORJ. shows that the adult valve can grow to be a little narrower than could be suggested by the young calpac-like valve and in *Ephippelasma spinosum* n. sp. that it tends to be a little broader. Thus, with further development, some changes in growth direction do occur, but are rather minimal. As a result the two subsequent phases, the intermediate and adult can be distinguished, the boundary between them being often determined as a result of continued growth but only in thickness, the growth in length having temporarly ceased.

It is worth mentioning that all this concerns the pedicle valves displaying an external pedicle tube, which with growth becomes slightly obscured, due to the arching of the posterior half of the valve. In low valves devoid of an external pedicle tube as in *Scaphelasma subquadratum* n. sp. the protegulum and post-protegulum stages can only be discernible.

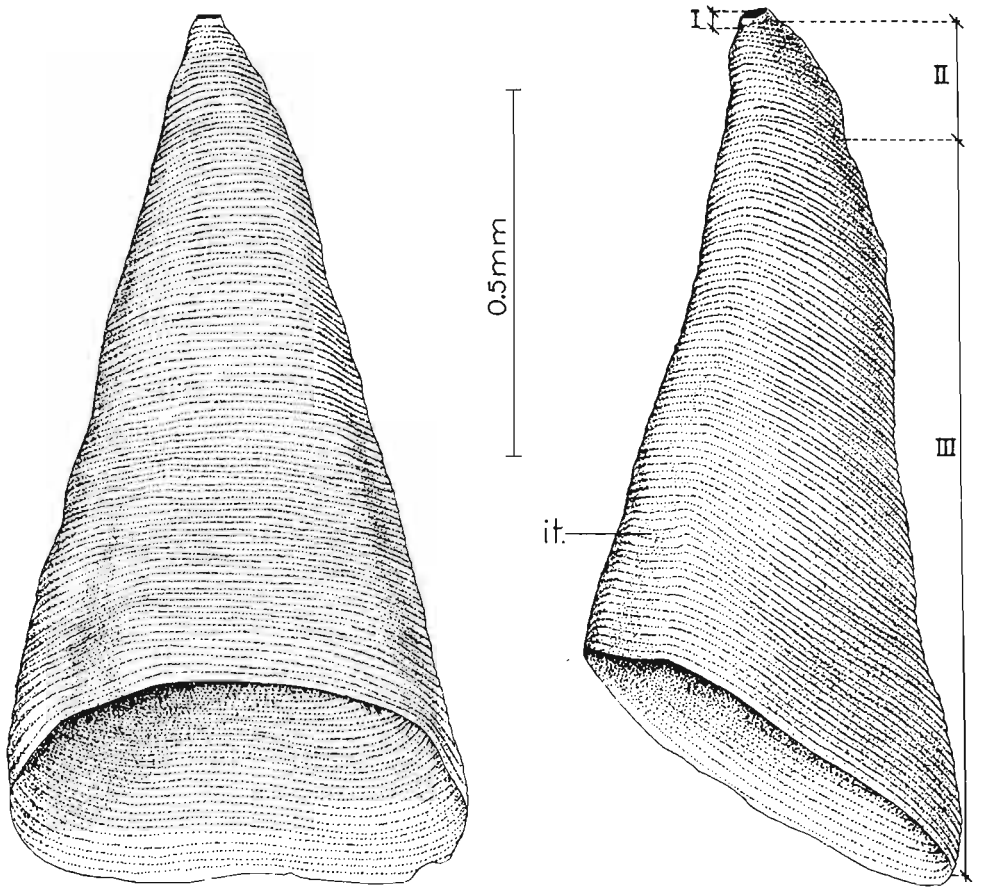

Fig. 9

Torynelasma rossicum GORJANSKY (erratic boulder, No. O. 418). *A*, *B* two views of one pedicle valve, *B* three (I—III) growth stages marked; *it.* interthrough.

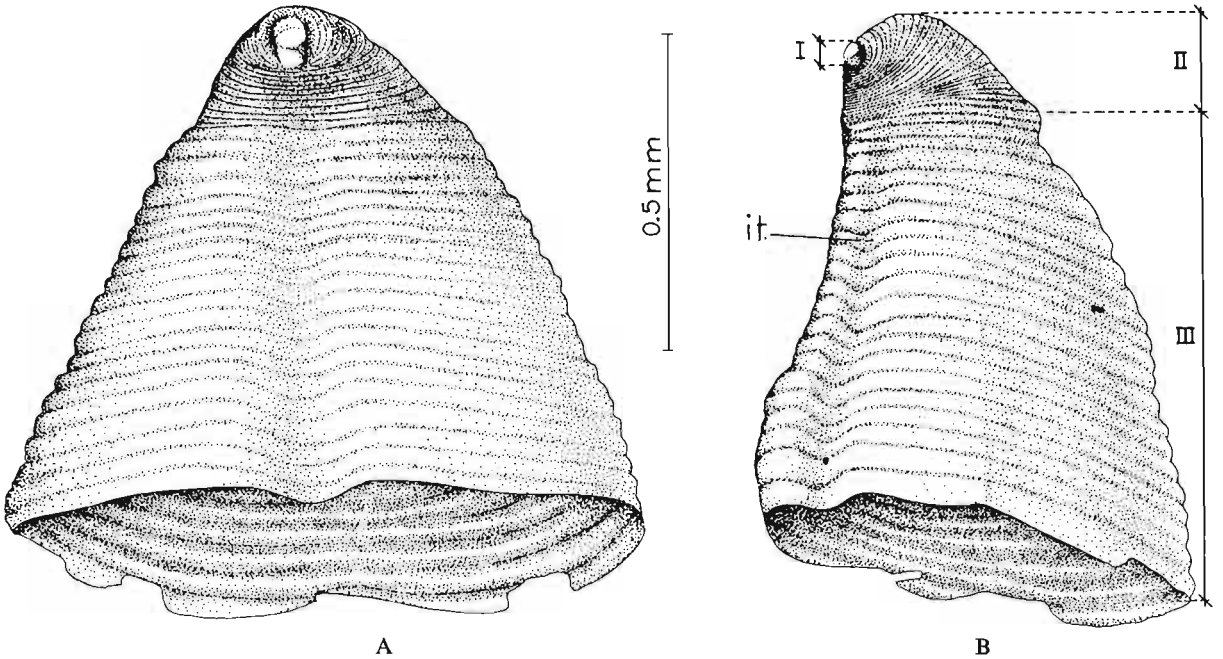

Fig. 10

Ephippelasma spinosum n. sp. (Bartoszyce IG-1, 1895·5 m). *A*, *B* interarea and side view of one adult valve, *B* three (I—III) growth stages marked; *it.* interthrough.

As to the brachial valves there always occur only two growth phases, the protegulum and adult stage.

From the above short review it is seen that the post-larval growth in inarticulate brachiopods can be defined as rather very simple.

SHELL SURFACE OF SOME INARTICULATES

Concentric ornament. Shell surface of inarticulates merits some mention from the point of view of the „ornamental" elements such as spines or, in a different way expressed, traces of concentric increments of growth. They give to the shell, sometimes, a very characteristic appearance as their pattern can be much differentiated.

These concentric outgrowths, present on the post-protegular shells occur in some variety, developed as e.g. lamellae in *Schizotreta* KUTORGA, imbrications or papillae in *Glossella* COOPER, or simply as concentric lines, bands or rugae of a few intermediate types observed in, among others, *Paterula* cf. *perfecta* COOPER and *Lingulella* SALTER. They all are, in general, rather regularly spaced all over the shell surface.

The acrotretaceans display concentric surface ornament seemingly of a quite similar appearance. It gives, as a rule, an impression of quite uniform, simple and regularly arranged lines or bands of only unmarkedly changeable thickness, which anteriorly become only sometimes more closely packed. The scanning electron microscope shows, however, that the surface ornament despite of the very small shell size is, in many forms, of a variable character.

Generally, in acrotretids a few kinds of concentric ornamental elements may be distinguished. They are developed as thinner or thicker macrolines, more pronounced or less bands with moderately rounded backs, elevated ridges usually having quite acute backs and concentric lamellae with thickened margins, sometimes bearing different proturberances. They all may appear in different growth stages and can develop at different rates (e. g. *Curticia minuta* Bell).

The simplest and the most common, recorded in the Cambrian to Silurian forms, appears to be that composed of concentric lines or bands, quite distinct, usually continuous along the whole shell width and being of almost uniform size. Some changes do occur in their thickness and height but the fluctuations usually range within rather narrow limits. As to the density of concentric elements, it tends to be almost uniform, as the new ones are added beneath each earlier one at almost the same distance. They develop by the accretionary growth of valve edges, formed by simultaneous single deflection into a wave of the correspondingly growing mantle edges (WILLIAMS & ROWELL, 1965).

The concentric elements can be single, especially in the case of bands, ribs or lamellae, that means of thicker concentric elements. This can be well illustrated by *Rhysotreta corrugata* COOPER, *Scaphelasma septatum* COOPER (COOPER, 1956, Pl. 18F, *J*), which possess very thickened and widely arranged single concentric ribs or bands of lamellar appearance, and of quite regular spacing. In the case of concentric macrolines or bands, some of them are subjected to horizontal and usually dichotomous branching. This do arise due to a periodic and localized deflection into a wave of the mantle (WILLIAMS & ROWELL, 1965).

It is difficult to define precisely the exact limits of the branching frequency. Generally speaking, some periodicity can be stated as occurring within the limits of approximately two to five or sometimes more concentric bands, depending very much upon their thickness. Thinner

elements such as concentric macrolines do, as a rule, branch more often, the thicker ones, eg. bands, more rarely. This is observed in, among others, *Torynelasma toryniferum* COOPER, *Ephippelasma minutum* COOPER (COOPER, 1956, Pls. 18I, 17B), *Myotreta crassa* GORJ. (GORJANSKY, Pl. 11, Figs 14, 18, 19; see Pl. XIII, Fig. 9). On some parts of pedicle valves, on their ventral slope, the branching can be twice to three times repeated every one to two concentric macrolines, following almost one below the other, one branching to the left, the next one to the right. An example of this can give *Ephippelasma spinosum* n. sp. (Pl. XXIV, Fig. 9).

Intercalation does occur but is extremely rare. The new bands appear independently in the concentric interbanding furrows, formed as a result of periodic deflection of the mantle edges in different places on the shell surface, beneath the existing earlier band and, in such a way, placed always midway between the two adjacent ones. This is observed in *Apsotreta expansa* PALMER (Pl. XXXVIII, Fig. 2) in which intercalation occurs rather often, which seems to be an exception. The intercalating bands are, at first, slightly lower than the remaining bands but very quickly attain almost the same thickness and height of the earlier ones. In such a way, the whole spacing of the mentioned concentric elements, including those intercalating and branching, is almost uniform, the differences in their width being small. The same concerns also the concentric furrows. This is well illustrated by *Ephippelasma spinosum* n. sp. (Pl. XXVI, Fig. 9), *Ceratreta hebes* BELL (Pl. XXXIX, Figs 1, 3), *Apsotreta expansa* PALMER (Pl. XXXVIII, Fig. 1). The concentric elements are more distant or less, some of them being somewhat lower or higher, thicker or thinner, but as a whole, their general pattern is as much uniform as is seen in *Torynelasma rossicum* GORJ. (Pl. XX, Fig. 11) or *Ceratreta hebes* BELL (Pl. XXXIX, Fig. 1). In *Myotreta crassa* GORJ. which displays much the same general pattern, the concentric macrolines and bands appear to be a little more differentiated in thickness and height, especially in the anterior direction (Pl. XIII, Figs 8, 9).

In some forms are observed, some disruptions in the continuity of the concentric macrolines or bands, being usually localized, sometimes restricted to a very small part on the shell surface. These disruptions could be a reflection of some environmental factors such as temperature, salinity and the crowded animal assemblage or predators activity which can not be excluded. In *Prototreta* sp., judging upon the pattern of these disruptions (Pl. XL, Figs 1-4) they are due to, in all probability, some injuries during the life of the animal.

The splitting of concentric elements is not a rule within the studied inarticulate brachiopods. This can be observed in some forms displaying much thicker, higher and more distant bands and seems to be characteristic of *Spondylotreta* COOPER. There can occur a simultaneous splitting of one band into three or even more thinner ones. In *Spondylotreta concentrica* COOPER (Pl. XII, Fig. 3) there occur concentric and rather wide undulations. They are covered by a few thinner macrolines which can split, intercalation does also occur, the splitted concentric lines cover, in this way, the whole of the valve surface, or a particular part of it, including the concentric undulations and the separating furrows.

A slightly peculiar pattern of the surface concentric ornamentation characterizes the genus *Scaphelasma* COOPER. The specimens of *Scaphelasma subquadratum* n. sp. bear the distinct, usually of lamellar appearance bands, usually well developed in the median part of shell, often alternately arranged. These lamellae are greatly thickened, to about 0.03 mm wide, with marginal ends rounded and step-like spacement. The lamellar surface in the majority of cases is, additionally, well ornamented, bearing ribs which are short, strongly oblique, extending from one edge of the lamella to the other, inclined to the left or right. They do occur on each lamellar extension, and are localized to some places of a particular lamella giving often a very spectacular appearance (Pl. XVI, Fig. 10; Pl. XVII, Fig. 6*b*). These lamellar ribs arise, probably, through

a localized deflection of the mantle edges at a given point. During subsequent growth these are transmitted laterally, usually in both directions, similarly as the rugae in the articulate brachiopods as is shown by the diagrammatic illustration given by WILLIAMS & ROWELL (1965, H179).

A very peculiar pattern of the external surface is seen in the members of *Eoconulus* COOPER. The valves of *Eoconulus cryptomyus* GORJ. from Estonia, usually, to a different degree, asymmetrical, bear the concentric bands, often looking as lamellose extensions, their edges being bordered by numerous thickened protuberances, these projections being very changeable in appearance. They connect the edges of the preceding lamella with the following one (Pl. XXXV, Fig. 1). The lamellar extensions are, in addition, ornamented by oblique ribs, somewhat like those in *Scaphelasma* (Pl. XVII, Fig. 6*b*), their pattern being highly unstable, very probably a reflection of the degree of the valve asymmetry.

To sum up, it could be stated that simple-single concentric bands, macrolines, ridges or undulations, with many small modifications prevail in the known Lower Palaeozoic acrotretids and mostly characterize the more conical forms. Deviations from the simple concentric pattern are observed in the *Scaphelasma* and *Spondylotreta*. In *Eoconulus* (its systematic position is not yet clear) the surface pattern of ornamentation does not resemble very much that of the other considered forms. It is much more differentiated and more complex in appearance. It may be supposed that this is related to some disturbances in the growth process of particular specimens, some evidence of this being the asymmetry of valves. May be, a more complicated surface with a greater number of thick ornamental elements like those in *Scaphelasma* or *Eoconulus* could serve to strengthen the shell and to make it heavier. Another question is the frequency of the very differentiated appearance of the concentric ornament in one shell as is shown in *Eoconulus cryptomyus* GORJ. (Pl. XXXVI, Figs 9-10), suggesting some special ornament for a particular stage. The surface ornament in inarticulates could be studied to such a degree as in articulate brachiopods.

Interarea. There remains the question of the ventral interarea ornamentation. The concentric lines disposed around the post-larval shell continue on this area sector preserving nearly the same pattern. The lines can be almost straight or slightly wavy, depending upon the degree of the interarea development. As a rule, the lines can be of a little varying appearance. Their thickness only slightly fluctuates, their spacing wider apart or less in comparison with these on the remaining valve surface. They can split more often, if this occurs on the valve surfaces, sometimes simultaneously into two to four smaller lines as in *Torynelasma rossicum* GORJ. (Pl. XXII, Fig. 4). They are, in addition, of slightly wavy appearance, forming sometimes bunch-like arrangement. In *Conotreta mica* GORJ. they can be relatively thicker, making an impression of short and discontinuous bands.

Interthrough. Its development is not clear. BELL'S suggestion that it might be related to the presence of the pedicle tube is much doubted by ROWELL (1966, p. 3), who notes this groove in the genera without a pedicle tube inside the valves of the restudied by him *Linnarsonia* WALCOTT. The interthrough comprises a narrow median part on the interarea sector and evidently, there occured some disturbances in the secretion of probably the outer layers of the shell. Evidence of this being horizontal lines traced across the interthrough, which are, however, much more fine in comparison with those crossing the remaining surface of interarea. ROWELL (1966) mentions the lack of concentric lines in the interthrough. This is a question which must be discussed, as the smooth interthrough appears to be not characteristic, however, for all the acrotretaceans.

As mentioned above, the interthrough is developed as a narrow groove, looking as

a narrow deepening of varying depth. One can observe on its both bounding margins an abrupt change in the thickness of concentric lines, but not always their complete disapearance. The lines do continue across the interthrough but are extremely fine and sometimes difficult to observe. This gives an impression of their absence in the interthrough. More light could be thrown on this question by using the scanning electron microscope in studying a larger number of different species.

Spines. In the most of the spinose inarticulate brachiopods the surface spines are single, elongate, distinctly tapering and hollow, usually arranged in concentric rows, parallel to the concentric banding. They can vary sometimes greatly in their size in particular spinose species. In *Siphonotreta verrucosa* (EICHW.) or *Multispinula* sp. they are differentiated into two sets comprising: 1) small fine spines, subcircular to oval at the base, usually to about 2 mm long, and 2) larger ones, at least to about 6 mm in length, lying, as a rule, alternatively. In *Helmersenia ladogensis* JEREM., the surface spines are of almost equal size, corresponding, in general, to the larger ones of *Siphonotreta verrucosa*, which are oval in outline at the base (BIERNAT & WILLIAMS, 1971).

The spacing and arrangement of spines change both within the species and within each particular form. Their appearance and arrangement on the shell surface have been used as a generic feature (COOPER, 1969, p. 217). Of the other spines, there are known, among others, the long hair-like spines covering the shell of *Acanthambonia* COOPER, short stubby spines of *Petrocrania* RAYMOND or the branching spines of *Alichovia* GORJANSKY (GORJANSKY, 1969; BIERNAT, 1971; see Pl. XXXI).

The branched spines are of three general kinds, the fundamental difference lying in the mode of their branching. In the two first, the branching starts on the distal end of the stem which does not continue to grow in its original form. In the third kind, the stem continues to grow, preserving its axial character, as the branches arise helicoidally from the lateral sides of the stem. The branched spines are scattered on the shell surface, arranged in concentric rows and somewhat in a radial way, the first row occurring at a distance of about 0.7 mm from the beaks. Their number, thickness and degree of branching increase with growth but their spacing probably does not change very much, however, it keeps in some relation to the degree of branching. These spines in their full development are of a complex appearance. They are always present on the anterior half of the growing shell and on the posterior half of the shell, being preserved as fragments or stumps, constituting the remnants of earlier developed spines.

With each growth stage of the shell, a proper and greater degree of spine arborescence occurs (BIERNAT, 1971). Characteristic of these spines is a great regularity in the dichotomously repeating bifurcation, the newly appearing spines are about twice as narrow and small, gradually tapering distally. The spines project at different angles from the shell surface, changing from almost perpendicular in the posterior half of the shell surface to nearly parallel in the anterior third of the shell, greatly extending anteriorly beyond the shell margins (GORJANSKY, 1969, Pl. 20, Figs 1-4; BIERNAT, 1971, Text-fig. 4*B*).

Slightly different are the spines characterized by having a comparatively thick stem from both sides of which arise, in a heliocidal way, lateral small branches, twice to three times thinner than the stem, all tapering distally but, in all probability, stopping growth rather early. This being indicated by their length and thickness as is shown by GORJANSKY (1969, Pl. 20, Fig. 4*a*). The distance between the subsequent lateral branches diminishes with growth and on the distal third or fourth of the stem the lateral branches are more densely arranged. These helicoidal spines were, probably, long judging by the thickness of many of the preserved fragments. There occur some variations in the length and thickness of these spines can oscillate. It is quite possible

that these spines found in a number in the Tremadocian chalcedonites are characteristic of *Alichovia analogica* n. sp. The same kind of spines occurs in *Alichovia ramispinosa* GORJ. from the Middle Ordovician of the Russian platform (GORJANSKY, p. 97, Pl. 20, Figs 1-4) densely covering the antero-lateral margins of the shell, extending considerably in the anterior direction.

Much less complicated are adult spines, dichotomously branched in lateral directions, or the spines with three branches, projecting in three directions (Pl. XXXI, Fig. 1). These branches arise from the distal end of the spine stem, similarly as in the case of the first cycle of the arborescent branching. They are arcuately bent downwards tapering distally like the single spines. They were, judging from the preserved fragments, quite large in adult stage, the stem being stout and long, measuring to about 3 mm in length, tapering distally but to a small degree. Their appearance does not change very much with growth. These spines are rare in the residuum and have never been found together with the shell. It is possible that they could cover the whole shell surface, may be in association with the single spines, or at least the antero-lateral or postero-lateral part of shell. In all of the mentioned spines the central canal penetrates the shell to communicate with the shell interior, and the basal part of spine is disposed almost normal to the surface of the valve similarly as in the single spines (BIERNAT & WILLIAMS, 1971, Pl. 2, Fig. 4).

All these kinds of spines grow in the same way, i.e. the central canal being lined with the outer epithelium surrounding a central core of connective tissue, the generative zone always acting (BIERNAT & WILLIAMS, 1971). In addition to the true spines, on the posterior edge of probably the pedicle valve only of some siphonotretids like *Alichovia analogica* n. sp., *Siphonotreta acrotretomorpha* GORJ. and *Helmersenia ladogensis* JEREM. a range of peripheral spike-like proturberances occurs (Pl. XXX, Figs 7, 8). These appear to be the prolongations of the shell substance — and are devoid of internal canal. These protuberances are of slightly differentiated width and length, sometimes arranged alternately, smaller — larger, almost of the same thickness and each bilaterally flattened. These elements seem to be strong or even massive. They constitute some ornamental structures and could, to some degree, strengthen the posterior margin of the valve bearing them or, in addition to the pedicle, they could be helpful in some anchoring matter.

This great differentiation of the surface spines conveys the impression that their role is also very differentiated. It could remain in some relation to the slightly fluctuating demands of the growing animals. The functional possibilities of spines could be more complex than is, up to now, supposed, and may be, for each growth stage slightly different and in old stage, probably much reduced. The spines are, at first differentiated at the margins of the growing shell, hence they constitute, as a whole, an ornamental element in every growth stage of the shell development. It is quite possible that they could serve, to some extent, as anchors, e.g. the posterior spines of *Siphonotreta* very much reminding one those in productelids, some of them being often similarly curved (Pl. XXVIII, Fig. 6). These spines may supplement the function of the still active pedicle and the others could partly serve for protection, strengthening the shell or acting as a sieve (BIERNAT & WILLIAMS, 1971; BIERNAT, 1971). It is not improbable that they had some function as sensitive organs as suggested by RUDWICK (1970), but this applies only to the spines on the newly growing part of shell.

All these suggestions appear to be quite reasonable explanations of the function of spines. One can say that the role the spines played was probably very valuable for the animals. This feature is too often repeated within the brachiopods to be accidental, appearing independently in different inarticulate and articulate groups of different geological age. Another open question is whether each kind of spines is confined to the shells of a particular species of genus. The problem is rather complicated in *Alichovia*. It is possible that while each of the mentioned kinds

of spines could characterize particular species, it is also possible that these could occur in various combinations, e.g. the arborescently or dichotomously branched alternating with the helicoidal ones and may be with simple ones. In *Alichovia ramispinosa* all kinds of spines mentioned above do occur as is mentioned by GORJANSKY (1969, p. 98).

In addition, GORJANSKY is of the opinion, that the ramificated spines could be sufficient character to erect a new family for the siphonotretids displaying this feature. He is, in all probability right, but this, at present, can not be decided until more evidence is found. As a matter of fact, the other morphological features and internal structure are not sufficiently known for specimens bearing the branched spines.

Protegular pits in acrotretaceans. This feature, in general, well preserved in fossil state, is a remarkable character quite recently observed by the scanning electron microscope (BIERNAT & WILLIAMS, 1970). The presence of pits has also been observed in unidentified acrotretacean pedicle valve from the Late Ordovician of Norway by POULSEN (1971), who mentioned the scrobulation = pitting present on the apical parts of studied valves.

The presence of pits can be observed by a normal microscope using a magnification of about ×250. As is shown, the picture of pitted protegulum in *Scaphelasma subquadratum* n. sp. is not very distinct in the ordinary microscope and the pits are marked only by an irregular pattern of dark spots. Only the sharp boundary between the immature and adult valve is well marked due to the appeared concentric band characteristic of the beginning post-protegular shell (Pl. XIX).

The pattern of pits in *Torynelasma* COOPER has been suggested to be typical of acrotretacea (BIERNAT & WILLIAMS, 1970, p. 493). It is composed of flat bottomed, mostly circular (elliptical can also occur) excavations of varying diameter comprising two well differentiated grades; the coarser pits ranging from 2 to 4·5 nm in diameter are bordered by quite distinct ridges, somewhat elevated, about 350 nm in thickness, and which can continue into a slightly raised platform bearing abundant smaller pits, to about 350 nm in diameter.

A similar pattern of protegular pits, with only very small modifications, is repeated in *Rhysotreta corrugata* COOPER. Some difference occurs mainly in the diameter and depth of the large pits and in the number of smaller ones. In general, however, the large ones are more constant in appearance remaining always roundly outlined, in contrast to the small ones which in *Rhysotreta corrugata* change in outline from more transverse to less, through slightly triangular to rounded. The limits in the size of the latter appear to be wider than in the former pits. These small differences occur, usually in somewhat different combination and, as a result, can give a picture slightly deviating from the typical one of *Torynelasma* (a feature probably of subfamily level).

The *Scaphelasma* pitting picture reminds one very much of that of *Torynelasma* (Pl. XXII, Fig. 1). However, in the former, all pits are slightly deeper, the smaller much less in number encircle the larger ones in a slightly different manner — somewhat in the form of a crown. Also the platform of Torynelasma type bearing small pits is in *Scaphelasma* less marked or much reduced.

Characteristic is the presence, in all known cases, of two grades of pits. However, the distinction between them can be, in some cases much obliterated. This can be due to the larger, sometimes, limits of variation within the smaller pits. This is well illustrated by *Myotreta crassa* GORJ. which possesses a number of pits intermediate between the large and small grades (Pl. XIII, Fig. 8). In general, the number of small pits can be reduced considerably as in the above mentioned *Scaphelasma subquadratum* n. sp. (Pl. XVIII, Figs 3-4), *Myotreta crassa* GORJ. (Pl. XIII, Fig. 8), *Prototreta* sp. (Pl. XXXIX, Fig. 4), or *Ephippelasma spinosum* (Pl. XXVI,

Fig. 3). Their diminished number seems to be associated with the deepening of both grades of pits, i.e. pits and minipits. Probably, this is not a rule, but, nevertheless, it prevails in the considered specimens.

The above mentioned typical pattern of *Torynelasma* is, to a great extent, comparable to that of *Myotreta crassa* or *Conotreta mica* GORJ. (Pl. XIII, Fig. 8). The differences which occur are much smaller than between the latter forms and *Ephippelasma spinosum*. In general, the *Scaphelasma* fabric can be supposed as a transitional type through the *Myotreta* and *Conotreta* to the different pitting of *Ephippelasma*, *Spondylotreta*, *Apsotreta*. In all these former genera, except for *Scaphelasma* and *Rhysotreta*, the large pits are relatively much smaller and deeper, being, in addition more closely packed together, due to serious reduction in number of the minipits (*Ephippelasma subquadratum* n. sp., *Prototreta* sp.). The bounding ridges are always, in the large pits usually very exposed (Pl. XXI, Fig. 4).

The fabric of pits can differ in all the considered species, to a varying degree; the limits of this variation are yet inadequately known, being in this paper only outlined. Whether this character is a valuable generic one, is too early to say with any degree of certainty. The majority of the genera, studied from the point of view of pitting, are representatives of different subfamilies. Admittedly, POULSEN'S acrotretacean specimens from the Ordovician of Norway show the same pattern of protegular pitting as that of *Myotreta* (POULSEN, 1971). This character together with the similarity in the general morphology of the pedicle valve suggest that they should be included into the mentioned genus (see p. 81). This fact appears to be of some importance but not as yet sufficiently convincing. More evidence is necessary to judge the taxonomic value of pits on the eventual generic level.

It does not seem to be a valuable specific character. This is, to some extent, indicated by two species of *Torynelasma* COOPER: *Torynelasma toryniferum* COOPER from Pratt Ferry Formation and *T. rossicum* GORJ., from the Lower-Middle Ordovician (Arenigian-Llanvirnian) of the north-eastern Poland. The pattern of their protegular pitting is almost identical. This, may be also true for other species of other genera. This can, however, support the view of some their importance on the generic level. The species are too small taxonomic units for the pits to play a taxonomic role, the more so when taking into consideration their origin and function which have already been discussed in some detail (BIERNAT & WILLIAMS, 1970, p. 495).

To sum up, it can be concluded that the pattern of pits can undoubtedly change on the subfamily or family and, in all probability, on generic levels, their presence being highly characteristic for the superfamily.

ACCOMODATION OF THE „HINGE" MECHANISM IN ACROTRETACEANS

The „hinge" morphology of this group is very simple and the valves at their posterior ends appear to be somewhat loose. The primary important elements of the internal articulation, like teeth and sockets are lacking which is why the disarticulated valves are commonly found in the residuum.

Considering the utility aspect of the hinge, comprising the valve movements, protection of animal from the external environment, it appears to be organized in such a manner, as to form a fairly functional „hinge" apparatus. Although primitive, it reminds one of the articulate pattern. There are some much favourable „hinge" accomodations which play a great role in

holding both valves of the shell together during the life of the animal, after its death and often also in fossil state. Evidence of this are the few specimens of *Torynelasma rarum* n. sp., *Myotreta crassa* GORJ., *Ephippelasma spinosum* n. sp. found with both valves closed in residuum, although etching is not a favourable operation for preserving the shells in the „articulating" state. This also suggests that the valves were not separated posteriorly, or if so, only very little from each other. They could be opened only at the antero-lateral margins, the brachial valve usually acting as an operculum.

In general, the acrotretaceans possess the posterior margins of both valves entire, relatively broad and almost straight, such margins being regarded as functioning as a „hinge" mechanism sensu that of articulate brachiopods. The posterior edge of each valve is moderately and in a rather regular way, correspondingly arched or/and undulated, a fact mentioned by BELL (1941) and PALMER (1955). Even a very weak undulation or arching at the posterior end of one valve always matches that in the corresponding valve. All this can considerably strengthen the posterior contact between the valves of a shell, limiting also possible movements. BELL (1941, p. 222) notes the lack of opening between the valves at their posterior margins, a fact also certified in the studied forms.

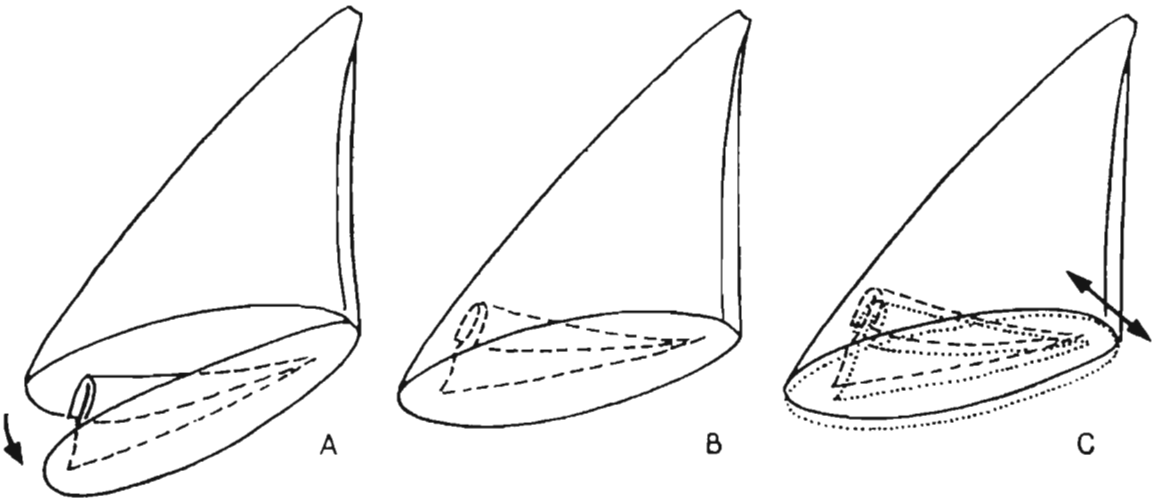

Fig. 11

Diagrammatic reconstruction of the shell with both valves closed (*B*) and with a brachial valve in movements: *A* opening--closing, *C* sliding.

The acrotretaceans show a complete absence of any opening or slit. The posterior „hinge" edges always appear to remain in exact contact during any movement of both valves. Also the size and outline of the brachial valve usually well correspond to the all margins of the pedicle valve. This is one of the very useful, for the articulating mechanism, accomodations which makes it possible for the valve edges of one shell to fit into another very precisely.

There occur some small variations in the appearance and outline of the posterior edges of valves, which, to a great extent, do reflect the changes occurring during the growth of interareas. The sector corresponding to the interarea of the pedicle valve is distinguished rather well by its marked flattening or even moderate deepening, possessing usually well pronounced postero-lateral angles (Text-figs 25, 26). This part of valve is, in general, quite easily discernible even in forms developing a highly conical valve, like *Torynelasma rossicum* GORJ. (Pl. XX,

Figs 9, 10) and *Myotreta crassa* GORJ. (Pl. XIII, Figs 5, 6, 7). It is always trigonal in outline, although the triangle can be, to a much varying degree, well defined and may be also narrower or wider as in *Paratreta similis* n. sp. (Pl. VIII, Fig. 2), *Eurytreta intermedia* n. sp. (Pl. IX, Fig. 9) and *Myotreta crassa* GORJ. (Pl. XV, Figs 4, 5). The interthrough, although sometimes very weakly marked, its deepening can be very narrow and shallow, could also give rise to some undulations of the interarea margin (Text-figs 9, 10, 19).

As to the posterior edge of the brachial valve it varies slightly and always in correspondance to that of the pedicle valve. It is, in some genera, a little more narrowly arcuate and, as a rule, only minimally extending upwards, moderately but regularly arched and raised above the dorsal posterior edge or only unmarkedly elevated above the edge. These small modifications occur in adult specimens of *Torynelasma*, *Ephippelasma* or *Scaphelasma* species. In every case the slight arcuation of the posterior edge fits into a slight identation in the ventral edge and *vice versa*. The dorsal propareas are small, sometimes very obscured as in *Scaphelasma* species, hence the variability is, in the case of their development, extremely small. Some changes can be stated in the appearance of the median plate concerning its size, outline, the degree of its deepening. The propareas are, usually, elevated above the valve floor and seem to extend somewhat into the ventral valve interior in the closed condition of the shell. Thus, it can be supposed, that these elevated elements could also serve as some kind of additional articulating elements, probably slightly reinforcing the holding together of both valves of the shell at the posterior region or they could, as suggested by BELL (1941, p. 222) take part in a weak lateral sliding of the valves over each other. This seems to be a quite reasonable supposition.

Movement of valves. The general opinion is that the movement possibilities in inarticulate brachiopods are relatively great. This can be judged from the posterior shell morphology and may be true in the case of lingulids which are completely devoid of „hinge" articulating elements observed in acrotretaceans. In the case of the latter group it seems that the movements were rather limited in their freedom. All these „hinge" small accomodations are suggestive of two possible movements, the closing-opening and the lateral sliding (Text-fig. 11). The additional role of some „hinge" elements could be defined as somewhat restraining the valves movements. The closing-opening movements of both valves of a shell are controlled by the adductors. These, in general, are rather great (judging upon the massive traces of muscle scars), especially the cardinal ones always well seen in specimens of *Myotreta crassa* GORJ. (Pl. XIII, Figs. 1-4), *Eurytreta intermedia* n. sp. and many other species. These muscle scars lie very close to the posterior edge of the brachial valve, elongate or rounded in outline, divergent or almost parallel in the anterior direction.

The valves could, to a slightly differing extent, gape apart, and as suggested by RUDWICK (1970, p. 68), a few degrees or more so. This probably depending upon the shape, dimensions of the shell and, may be, upon the degree of septum development and strength of functional muscles. In the case of forms displaying a high cone like *Torynelasma*, *Ephippelasma*, *Myotreta* species, the small brachial valves acting by right of operculum, bearing, in addition, a complicated septum, could, probably, be opened much more than in forms with less unequivalved shell having a much lower pedicle valve like *Scaphelasma* COOPER or *Hardrotreta* ROWELL. In addition, some special mention merits the extremely strong and disproportionally large, in comparison to the generally small shell size, traces of cardinal muscles in *Myotreta crassa* GORJ. or *Myotreta estoniana* n. sp. the septum of which makes an impression of extremely strong and heavy structural element (Pl. XIV, Fig. 4; Text-fig. 30). Interrelations, rather close, between the mentioned structures seem to be evident in the opening-closing

condition. In the all mentioned cases the adductors with their „quick" and „catch" role (RUDWICK, 1970) could be very efficient in action.

As to the lateral sliding, it was controlled by the oblique muscles, the traces of which are not, unfortunately, preserved in the here considered brachiopods. This lateral movement seems to be much restricted by the size and the degree of development of the hinge undulations, including the mentioned above dorsal propareas. This movement is also much related to the degree of the development of the postero-lateral angles. It is probable that this lateral sliding takes place in the limits of the width of any of the posterior margins undulations.

MEDIAN SEPTUM

Median septum is, in acrotretids, amaizing in the degree of its differentiation. It varies much in size and considerably in the degree of its complexity. A comparison of specimens of different acrotretaceans genera shows this element passing from a low median ridge through

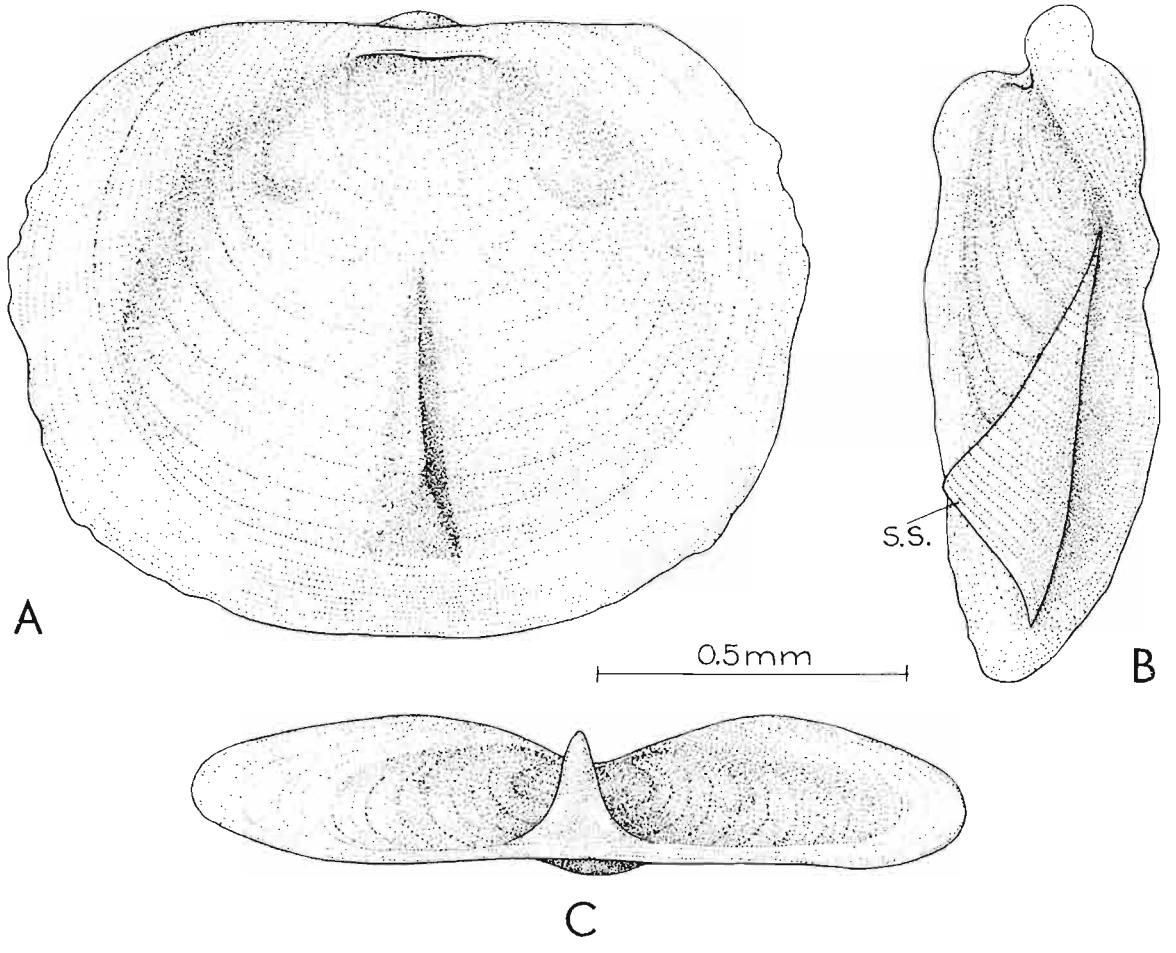

Fig. 12

Scaphelasma subquadratum n. sp. (Kętrzyn 1G-1, 1595·5 m). *A-C* one specimen of brachial valve in three different views to show the appearance of median septum; *s. s.* septum simple.

blade-like plate to a structure of complicated appearance. In general, one can differentiate two main types of septum recognized primarily by the mode of attachment as well as the general relation to the valve floor and secondarily by the whole appearance of this structure. These types comprise a vertical and an almost horizontal to the valve bottom elements. It is supposed, that they do give rise to a third one which constitutes a multi-combination of the above two (Pls. XX, XXIII; Text-figs. 12, 13, 18). The first type is the most common structure occurring in the majority of species, from Cambrian to Silurian, in a somewhat modified form. It corresponds to septum of articulate brachiopods. The two remaining types are much more rare, especially the second one which is, up to now, restricted to a few only acrotretacean species recorded in Ordovician.

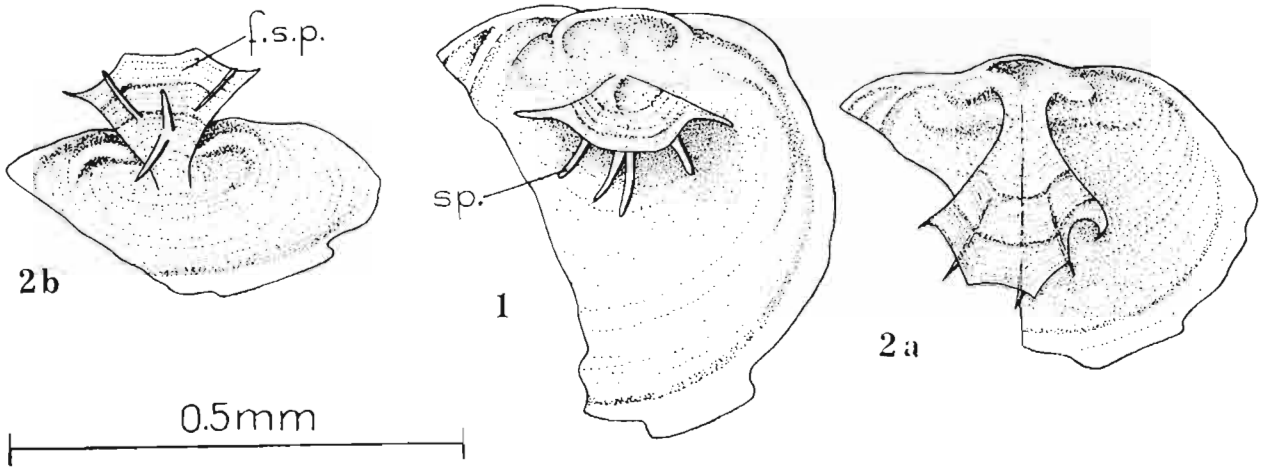

Fig. 13

?*Ephippelasma* sp. (erratic boulder, No. O. 418). *1*, *2* — two fragmentary brachial valves showing median septum like a horizontal plate with spines; *f. s. p.* free septal plate, *sp.* spike.

Type I. It comprises always a median element attached to the valve floor along its whole length simply developed as a low ridge or a raised septum much varying in length and height. In some genera it is very undifferentiated remaining, without not many changes, low well thickened at its base or looking as a thread unmarkedly elevated above the valve floor. Length and thickness vary in extremely narrow limits. In general, septum in its different form butresses a median plate or a small posterior platform-like and rather weak elevation which follows the median plate and it reaches almost to the anterior third of the valve. Examples of this can be found in *Eurytreta curvata* (WALCOTT) (*in*: ROWELL, 1966, Pl. 2, Fig. 11) or *Pegmatreta rotunda* BELL (in BELL, 1941, Pl. 30, Figs. 29, 31).

The majority of species possess a vertical septal plate, greatly changeable in its length, thickness and heigth. The highest point of this septum always lies in the anterior half or third of the valve, sloping more abruptly or less anteriorly. The changing features are few, nevertheless, their different recombinations give to the septum of many taxons a characteristic often appearance. In general, the septum is a triangular or, to a varying degree, subtriangular plate standing high above the valve bottom with a straight to concave upper edge in lateral view, raising rapidly in its anterior part, sometimes constituting a horn-like projection like in *Ceratreta hebes* BELL (BELL, 1941; Pl. 29, Fig. 10), *Undiferina rugosa* COOPER (COOPER, 1956, Pl. 18, Fig. 14) or raising gradually almost uniformly, possessing a straight, in lateral view,

upper edge as shown in *Scaphelasma septatum* COOPER (COOPER, 1956, Pl. 18, Figs. 70-72); *Canthylotreta marjumensis* (WALCOTT) (in ROWELL, 1966, Pl. 1, Fig. 17; Pl. 3, Figs. 31-32, 35); *Scaphelasma subquadratum* n. sp. (Text-fig. 12).

Attention should be paid to the septum of *Myotreta* GORJ. highly characteristic even when it occurs in its simplest form as in *Myotreta crassa* GORJ. (GORJANSKY, 1969, Pl. 11, Figs. 20-24; see Pl. XIII, Figs 1-4, Text-fig. 29*A*). This structural element is like a short and small triangular and thickened plate raised upwards anteriorly, beginning invariably about midlength

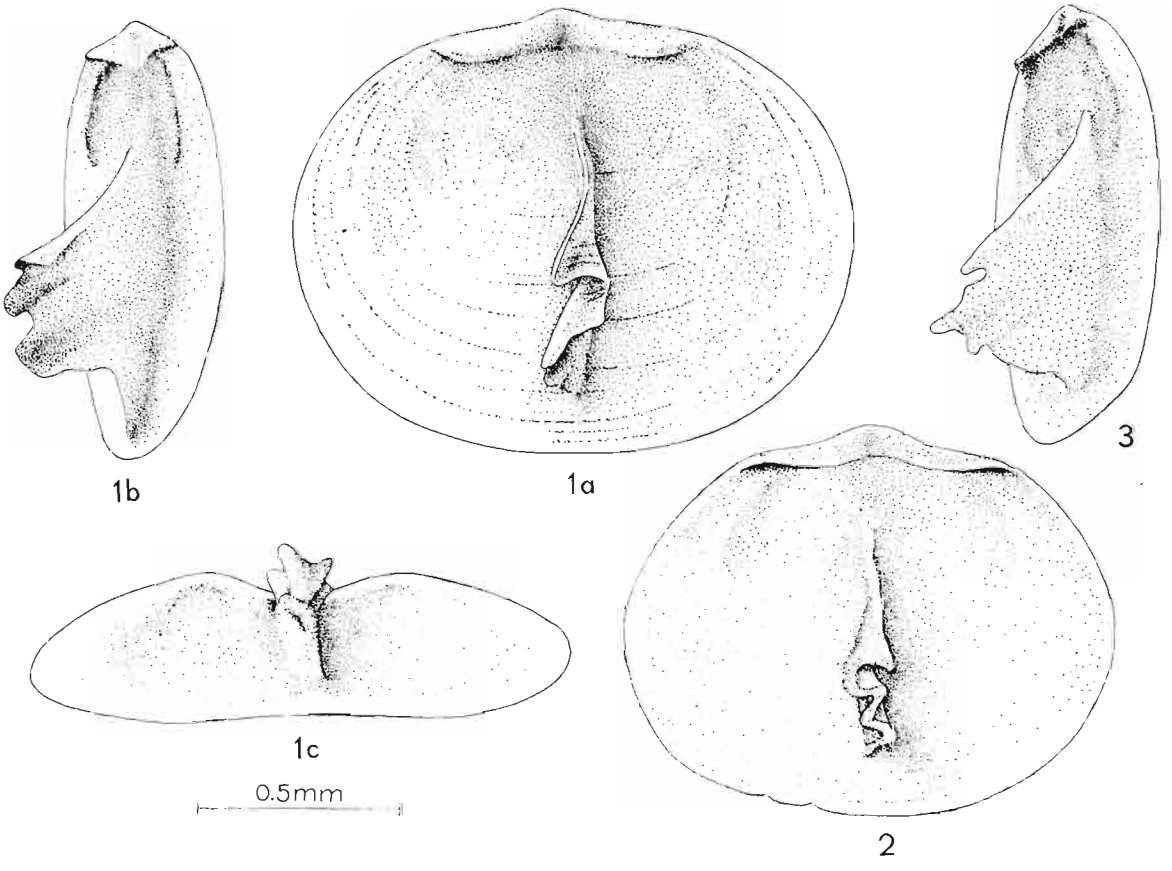

Fig. 14

Myotreta estoniana n. sp. (Suhkrumägi, Estonia). *1-3* — three different brachial valves in three views to show the folded median septum.

of the valve or a little posterior to it, never attaining the anterior margin of the valve with the highest point directed anteriorly and, in general, simply folded in lateral view in adult shell (Pl. XIII; Text-fig. 29*A*). Its very limited length in relation to the degree of raising and appearance in lateral view makes this element not very comparable, up to now, to that of the other acrotretaceans forms. Although simple, it is unique in its whole morphology.

In *Myotreta estoniana* n. sp. this septum is much more significantly folded due to the accretionary growth in length and its size in relation to the raising and degree of folding make this structure extremely peculiar (Text-figs. 14-16, 30). The total length of the folded edge of this septum increases quickly and very much with growth, for it is affected by the appearing,

with the progressing growth of shell, smaller and higher deflections. At first, these deflections are few and very indistinct, sometimes hardly marked, of wavy appearance. They, however, deepen and elongate in keeping with to the increasing size of septum. In the advanced adult

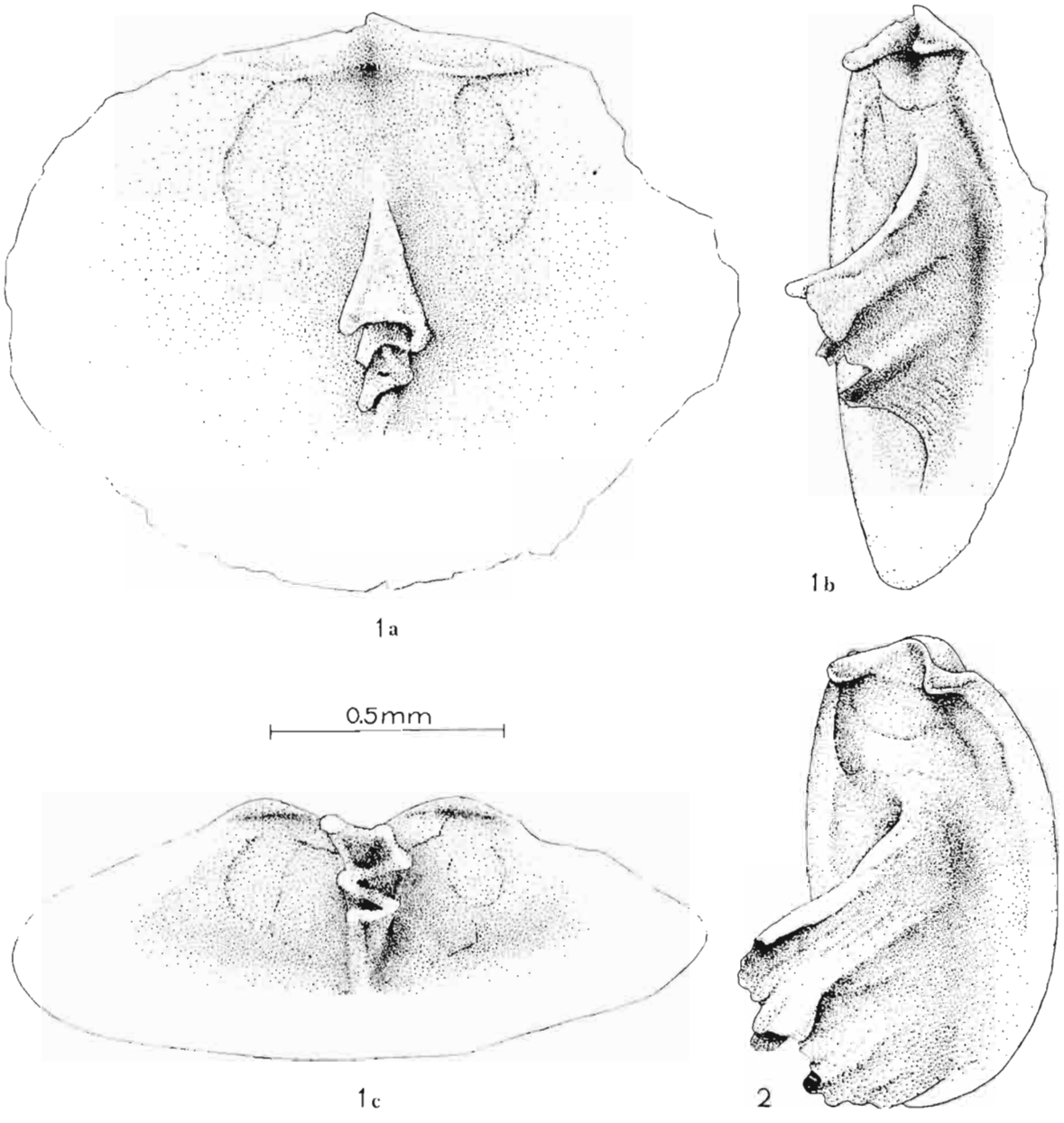

Fig. 15

Myotreta estoniana n. sp. (Suhkrumägi, Estonia). *1*, *2* — appearance of a median septum of two different brachial valves; cardinal muscle scars marked.

or old stages the anterior, sloping edge of septum is zigzag (Text-fig. 30). The number of deflections enlarges, each new one being added on the flanks (sometimes on both) of the earlier one. Their number is unstable, but usually three to six more foldings do occur. The upper

edge of septum is straight, to a varying degree, thickened, forming something like a horizontally lying narrow plate, flattened or slightly arcuate and usually moderately widening anteriorly. This septum, in its full development, is of slightly asymmetrical appearance and its sloping anterior edge can be, in old specimens, strange in its zigzag form (Pl. XIV, Fig. 4; Text-figs. 14-16, 30). There is a great variety in the appearance of these foldings in adult specimens displaying the same size. In some cases the foldings are only marked, in others pronounced to such a degree that the septum is disproportionally large in relation to the size of the whole shell, occupying over one fourth of the anterior width of the valve. In addition, one to three spinose or horn-like processes do often expand anteriorly from the upper part of the anterior sloping edge (Text-fig. 16).

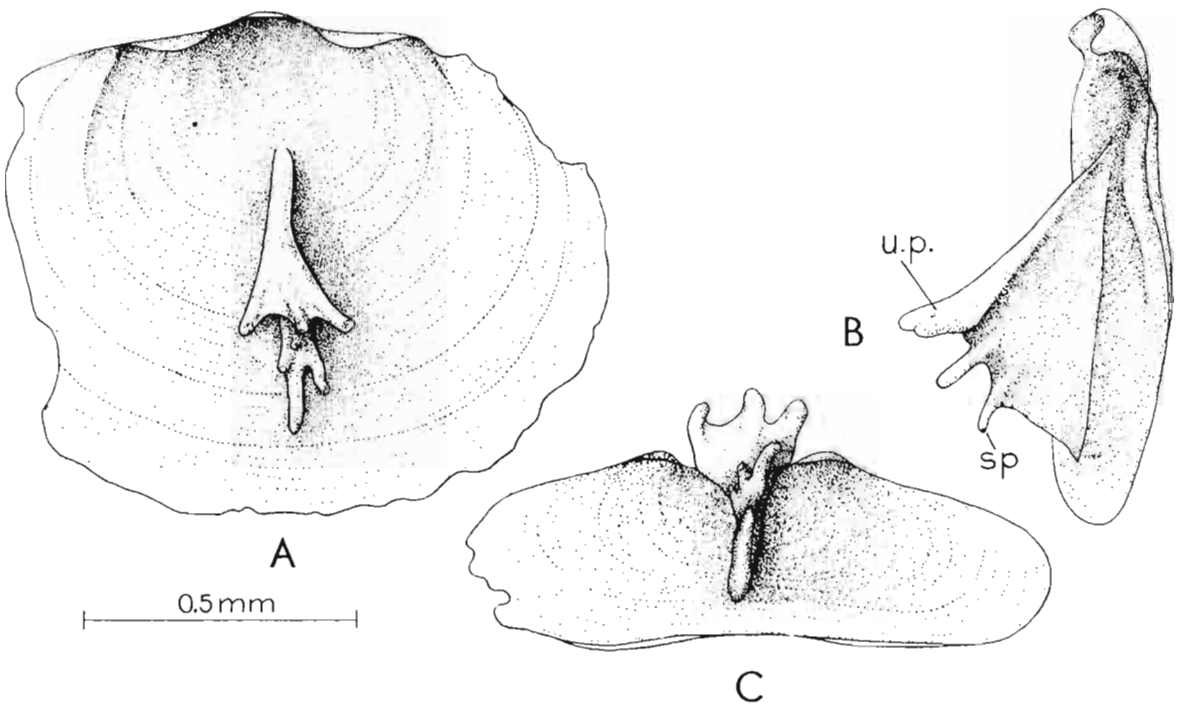

Fig. 16

Myotreta estoniana n. sp. (Suhkrumägi, Estonia). *A-C* one brachial valve showing a slightly variable median septum in three views; *u. p.* upper plate, *sp.* spike.

Type II. It is a peculiar structure, developed as a median horizontal plate of varying outline and size, greatly expanded anteriorly and somewhat laterally. It is free in its anterior and lateral parts, except for the posterior end which is attached for a short distance to the posterior third of the valve bottom (Text-fig. 13). In addition, this plate is provided with prongs, spinose protuberances or simply spines which occur along its antero-lateral margins or also covering the under side of this element. Examples of this „septal" horizontal plate are found within the *Ephippelasma* COOPER species occurring in a number of deviations. This plate is best illustrated by ?*Ephippelasma* sp. from erratic boulder No. O. 418. It is very widely expanded also laterally, slightly elevated upwards, possessing the anterior margin and underside covered with spines which appear to be hollow, relatively long, tapering anteriorly and arranged in rows (Text-fig. 13). *Ephippelasma minutum* COOPER from Pratt Ferry Formation-

Alabama, displays a digitate plate also expanded anteriorly but with its both lateral sides bent. This plate is attached to the valve bottom similarly by its posterior end, being probably, not supported at all by a vertical plate or if so, only in the, probably, very young growth stage. This plate is free, expanding anteriorly more extensively or less, preserving a triangular outline. The marginal prongs, usually five to seven in number are, to a different degree bent, sometimes almost perpendicular to the valve floor (COOPER, 1956, Pl. 17*A*, Figs. 1-14).

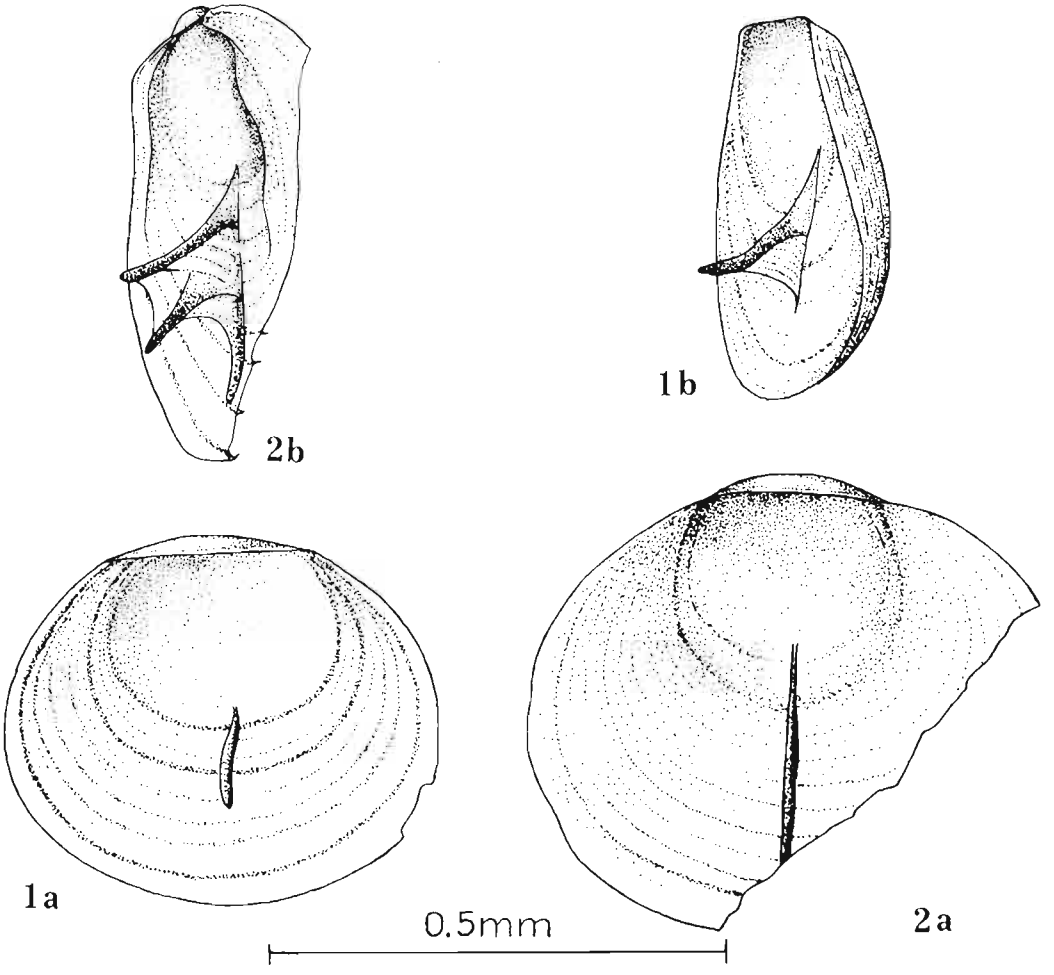

Fig. 17

Myotreta sp. (erratic boulder, No. O. 418). *1, 2* — two brachial valves in two views to show a slightly different appearance of a median septum.

Type III. A different combination of elements of the above two types can give a complex septum of a quite specific appearance. There always occurs a median vertical plate, corresponding to the above mentioned simple septum, bearing or supporting a rather horizontal, surmounting plate, very changeable in its general form, a counterpart of the septal plate, type II. The vertical plate is, in general, high, only its length changing, with the highest point lying more anteriorly or less and almost touching the ventral side of the opposite valve when the shell is closed. Also the sloping anterior edge is changeable, being sometimes slightly arcuate

or concave, supplied, in some cases, with one or two horn-like processes or spinose protuberances.

The surmounting plate is that which always varies, sometimes very much, within the genera. It can be saddle-like as in *Torynelasma minor* COOPER (COOPER, 1956, Pl. 18, Figs. 29*E*), or like a narrow elongately triangular plate, bent on both its lateral sides with flat to moderately arcuate back as *Torynelasma rossicum* GORJ., *Torynelasma rarum* n. sp.

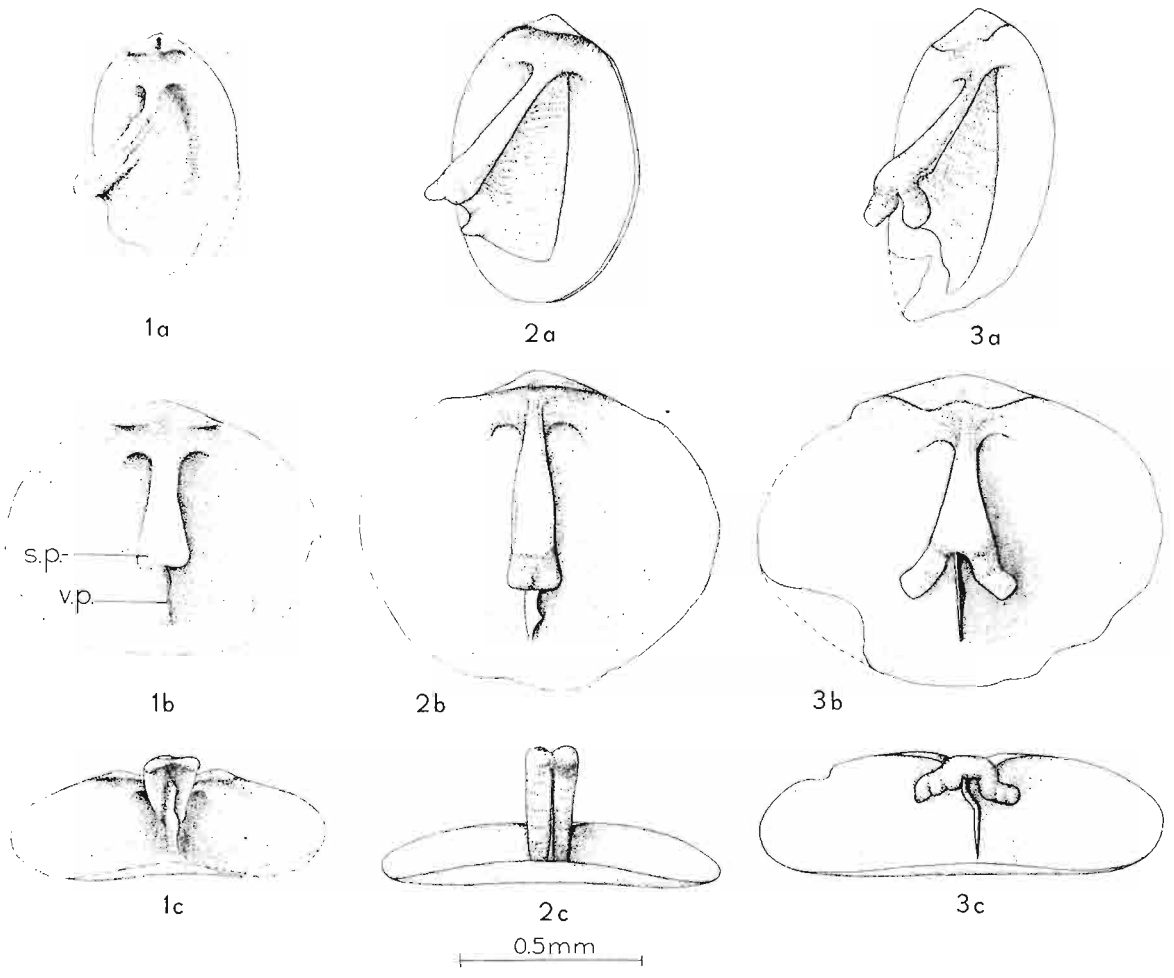

Fig. 18

Torynelasma rossicum GORJANSKY (erratic boulder, No. O. 418). *1-3* — three different brachial valves in different positions showing some variation in the appearance of a surmounting plate; *s. p.* surmounting plate, *v. p.* vertical plate.

(Pl. XXI, Fig. 6; Text-fig. 34). This plate varies in size and somewhat in outline but retaining usually the proper relations between length and height of the vertical plate, general size of the shell and the degree of the pedicle valve elongation. This is observed in *Torynelasma rarum* n. sp. A very interesting modification occurs in *Torynelasma rossicum* from erratic boulder No. O. 418, in which the surmounting plate is distally divided, the two branches diverging anteriorly are bent downwards and the vertical plate is equipped with one or two projecting spikes or somewhat bulbous processes (Text-fig. 18). It is a characteristic structure, which

could suggest an example of some anomalous development. But the three found specimens of brachial valve preserving this kind of septum and in different phases of growth, seem to illustrate another possible modification of the septum complex. The separate pedicle valves, found among others, together with the mentioned brachial ones remind one very much of those of *Torynelasma rossicum* GORJ., or *T. rarum* n. sp.

In *Ephippelasma spinosum* n. sp. the vertical plate is short and the surmounting one is well developed, much similarly as that of *Ephippelasma minutum* COOPER. It is widely expanded, equipped with marginal spines or spikes. To this group can be included the flabellate septum of the Middle Cambrian *Prototreta* BELL (BELL, 1941, Pl. 31, p. 222). The septum of the latter form is considered by BELL as the most characteristic generic feature. The same concerns also the Upper Cambrian genus *Angulotreta* PALMER (PALMER, 1955, p. 770). This structural element is highly variable even within the same species, the differences which do occur mostly concern the expanded surmounting plate and the appearance of the marginal projecting spinose processes, which are not always sufficiently well preserved in fossilized shell.

Septal spikes or spines in *Ephippelasma*. The internal septal projections of *Ephippelasma spinosum* n. sp. merit some mention — for the placement of these elements is unusual, being not recorded, up to now. The spines are fairly numerous, arranged, in addition to the marginal ones, in 3-4 rows on the under-side of the surmounting plate, 2-5 spines in each row, this depending upon the stage of growth, individual variability in their number being not excluded. The spines are slightly incurved, sometimes like a moderate arc and somewhat divergent anteriorly. Judging from their thickness and preserved fragments they, in all probability, were comparatively long. Similarly as normal surface spines, they taper distally, being hollow and circular in cross section, being secreted by the outer epithelium which lined the central spine canal. These spines seem to be very much alike the surface spines of e. g. siphonotretids, being, however, relatively a little more stronger and thicker. It is possible, that in very advanced growth, they could thicken greatly and loss, due to that, the appearance of spines *sensu stricto* (Pl. XXVI, Fig. 1; Text-figs. 13, 35).

The spines in question are, in general, different from marginal digitate projections of spikes of *Ephippelasma minutum* COOPER or *Prototreta trapeza* BELL. They could be developed in much the same way as the pseudospines of some articulate brachiopods, among others, of the Devonian *Fitzroyella* VEEVERS and of *Uncinulus* BAYLE (VEEVERS, 1959; BIERNAT, 1969).

The position of spines in *Ephippelasma spinosum* n. sp., their proximity to the anterior edge of the valves conveys the impression that they could have served as structures reinforcing the septum supporting the lophophore, or like surface spines they could have prevented harmful particles from exterior into the shell interior. To the digitate projections of the *Ephippelasma* species one could also ascribe the role both of eventual „warning" system when the valves are gaped, as also to strengthen or weighen the operculate brachial valve and thus probably slightly facilitating its opening movement.

Generally speaking, the tubular spines are confined to a few articulate and inarticulate groups of brachiopods. Very amazing is the fact of their frequent development, but in different parts of shell, exteriorly and interiorly. As far as we know, the *Ephippelasma* is the only group which has developed spines on the septal expanded plate and on its underside. COWEN and RUDWICK (1970) mentioned an unusual case of spines developed on the delthyrial region of the Triassic brachiopod *Bittnerula* HALL & CLARKE, ascribing to them a role of auxiliary attachment or stabilizing structural elements, in connection with the atrophy of pedicle. All these above mentioned examples of spines are of much interest, mainly due to their rather strange localizations inside and outside of the shell.

Remarks on the function of the dorsal septum. Although the septum, as a whole, is a distinct structure constituting an inseparable element of the shell interior within the brachiopods its exact function is not very clear. This problem remains still, to a great extent, a matter of some speculative considerations. The supposition that it could serve as a possible muscle attachment can not be ascertained also in the case of acrotretids for no traces of them on the fossilized septum are preserved in the studied forms. They have so far never been described in fossil brachiopods. All the mentioned additional modifications of the septum, sometimes very specific, are not fortuitous.

It is believed that the range of all modifications could be even greater than at present known. Taking into consideration that in the mentioned group of acrotretids the interior, with some exceptions, is in general simple, the dorsal septum appears to be the only real structure to which one could ascribe the function of a supporting element for the lophophore, the more so no other structure of a similar function are developed there. This problem has been discussed among others by WILLIAMS & ROWELL (1965, H102) and RUDWICK (1970, p. 134) who interpret the septum as a structure connected with the lophophore.

The microscopic shell size of acrotretaceans really suggests a simple lophophore, the development of which could, in all probability, stop rather early in its growth process, and only the schizolophous or may be early spirolophous stages could be attained. The recent articulate brachiopods, terebratuloid *Pumilis antiquatus* ATKINS, *Argyrotheca cordata* (RISSO) and others which are of small dimensions possess also a simple lophophore, not advanced in development beyond the schizolophous stage in adults, of relatively small shell size, 4·7 mm in length (ATKINS, 1958, p. 576 and RUDWICK, 1962, p. 599). This stage of lophophore development could be ascribed to acrotretaceans equipped with a simple septum like *Eurytreta* ROWELL, *Hardrotreta* ROWELL or *Spondylotreta* COOPER. The lophophore being adherent to the body wall and dorsal mantle and the median septum simple in its form, growing from the floor of the brachial valve in heigth, could really well support the median indentation of the schizolophous lophophore.

In the case of the early spirolophous lophophore, both of the low extensions could project freely downwards, on both sides of the upper surmounting plate of *Torynelasma* COOPER, *Ephippelasma* COOPER, *Prototreta* BELL and others, displaying the septum complex. The tips of lophophore as is shown by WILLIAMS & ROWELL (1965, H105) could also lean on both sides of the septum, in the direction of the, probably, widely gaping valves of the shell, the dorsal operculate valve being that which moved and rather rapidly. It seems to be quite probable that also in the case of a myotretid septum, which is of strange form, both arms of lophophore could similarly hang down freely on both sides of the supporting septum. The foldings could probably serve to strengthen the septum as a supporting structure. It does not seem very probable that the lophophore arms could lean on both sides of the septum very exactly, may be only on some of the more pronounced foldings.

To sum up it can be said that the septum is one of the most characteristic features of acrotretaceans and has a considerable taxonomic value (see p. 65). This highly diversified structural element remains in close relation to the general shell shape and outline. Shells very conical are usually equipped with a septum complex like in *Torynelasma* COOPER, *Ephippelasma* COOPER, lowly conical shells possess a septum simple like *Scaphelasma* COOPER and *Eurytreta* ROW. A simple septum is a stabilized feature within the Cambro-Ordovician forms, being homologous to that in articulate brachiopods.

A complex septum with a whole range of even small modifications is a newly appeared feature restricted to the acrotretaceans only of Ordovician and probably of Cambrian age.

Generally speaking, to each particular subfamily can be ascribed a special kind of septum. The function of the septum could be determined as an eventual support for the lophophore. May be, its complexity in some specialized groups, could facilitate the movement of the operculate brachial valve. However a question is whether these all sometimes very special, septal innovations can be considered as really favourable for the animals displaying them.

SOME ADAPTATIVE STRUCTURES IN ACROTRETACEANS

One of the important problems for the living brachiopods is, as suggested among others by RUDWICK (1970), the tendency to attain and maintain shell stability after settlement. This can be realized in many ways; one of these is the development of an appropriate shell shape, proper for the mode of life of the animal, the shape very much depending upon the presence of a functional pedicle and the position of the pedicle foramen. The slightly modified growth directions and rates are one of the main causes of producing differently shaped shells. Commonly known are a few main types of shell shape, each of which display a number of smaller or bigger innovations. In general, the shell biconvexity with a range of variously pronounced convexity for each valve, prevails throughout the whole history of the brachiopods, probably as one of the best relatively accomodated shapes.

The tendency to attain shell stability during life, can be also expressed by the lengthening of the pedicle valve into a cone, especially evolved in the acrotretaceans. This feature being also recorded within the articulate brachiopods like richthophenids seems to have an important value for some of the living animals. This conical form of the pedicle valves, within the considered group of inarticulates is, sometimes, accentuated by a special elongation of the valve. This is shown in *Torynelasma rossicum* (Pl. XX, Fig. 9). The conical valve bears a supraapical pedicle foramen often provided by a well developed external pedicle tube (e. g. in *Torynelasma*). Considering this lengthening of the pedicle valve from the aspect of its advantage for the animal it seems quite reasonable to suggest that it has an additional function, i. e. of helping to attain possibly greater shell stability and orientation during the life of animal.

The lengthening of the pedicle valve is, often, accompanied by an additional internal structure which, in the case of some acrotretaceans is confined to the posterior third of the cone. Its degree of development remains in some relation to the valve length. This structure is well illustrated in the Lower Ordovician *Ditreta dividua* n. sp., described from the Tremadocian chalcedonites of Wysoczki. It is developed as a horizontal platform, thickened and pierced by the internal pedicle foramen and dividing the valve interior into two unequal parts, a posterior one, which is smaller and a much larger anterior part (Pl. V, Figs. 2-4). This platform, however, constitutes the very bottom of the shell laminae which, with the subsequent growth of the shell, outcurve from the valve walls, encircling the protruding pedicle. In such a manner, the whole posterior cavity of the valve is filled in by the shell substance. The degree of the apical thickening is related to the individual age of the animal, the mantle secretion activity, and the degree of valve elongation. This filling in of the apical part of valve very much corresponds to the „cone-in-cone" structure of the shell laminae observed by BELL in the Middle Cambrian *Protreta interrupta* BELL, *P. trapeza* BELL, *P. mimica* BELL (BELL, 1941, p. 224, Figs. 1-20), also being stated in some conical valves of torynelasmatid type, recorded in erratic boulder No. O. 511 and in other conical valves of *Ditreta* type.

The above described apical interior filling may be interpreted from the point of view of its eventual function. The fact that the apical part of the valve is especially thickened,

i. e. that part of valve nearest the bottom for shell anchorage, enables it to serve as a weight for the shell. It is a second modification which, in addition to the valve elongation, could considerably help in the stabilization of the animal in its settled condition. It is supposed that also the apical process, characteristic of many, slightly less conical acrotretaceans like *Hardrotreta* ROWELL and *Eurytreta* ROWELL could also play, in addition to its main function of limiting the pedicle foramen from the interior, some role in weighing down the shell, but to a much lesser degree than the above mentioned examples of *Ditreta*.

Worth mentioning is the fact that the presence of this stabilising adaptative structure is found, up to now, only in the species from chalcedonites. This could indicate a special environment, in which were developed many other different structures such as bifurcated spines in *Alichovia*. The shortly mentioned structures are examples of the evidently great placticity of these animals which could, for survival so easily adapt to the existing environmental requirements.

ABNORMALITIES

This phenomenon is not rare within the brachiopods. Also the studied specimens of inarticulate brachiopods can show, but a very small number of specimens which somewhat deviate from the norm in the general appearance and the development of some morphological and structural features. The shell deformities are rarly recorded being, restricted mainly to a few only examples and are not so pronounced as in articulate brachiopods. Some attention should be paid to them, however, the more so as existing information is very scarce.

In the inarticulate brachiopods shell irregularities, including those of mechanical origin, appear to be much smaller than one would expect, probably due to their very limited size. This also applies to the considered collection of inarticulates which, as mentioned, is composed, to a great extent, of younger individuals, the very old stage not having been attained at all. The specimens are smaller than average, length not exceeding 1 mm and their valves are thin-shelled and transparent. One could argue that this probably shortened period of life of the animals could diminish greatly the likelihood of mechanical injuries. There could have been several causes for the very slight shell deformities stated in some specimens at hand, including disease and predator activity, the emergence of which is stated early in Ordovician. The changes deforming the shell are mostly observed in the pedicle valves, especially the very elongate ones as *Ephippelasma*, *Torynelasma* or *Eurytreta*. The brachial valves with very few exceptions are not affected.

One of the exceptions which illustrates local injuries of brachial valve is the shell of *Ephippelasma* cf. *spinosum* n. sp. Both valves show some asymmetry in outline accompanied by irregularities in the development of concentric lines (Text-fig. 19). Apparently, these are injuries which, probably, appear in the young stage of the growing shell and could have been the result of some disease, thus weakening the animal. The whole shell gives an impression of underdevelopment and bears a few local traces of damages which could reflect some disturbances in the secretory activity of the mantle, the mantle being, as is known, responsible, in general, for regular growth of shell.

A few specimens of *Paterula* cf. *perfecta* COOPER demonstrate finely preserved traces of some boring animal, the relatively large hole and much disordered arrangement of concentric lines in the vicinity of the injured part of the valve being evidence of a boring activity of some, in all probability, predators (Text-fig. 20). In general, the regular shape and outline

of highly conical acrotretacean pedicle valves is a prevailing rule, at any rate, in the present collection.

Within *Torynelasma rossicum* GORJ. occur, however, pedicle valves (very few) which are extremely elongate and, in addition, twisted to the left or right, in such a way as in some articulate brachiopods displaying very elongate ventral umbonal part and large area like *Cyrtina* on *Uncites*. The causes of this valve distortion are purely mechanical and can be explained

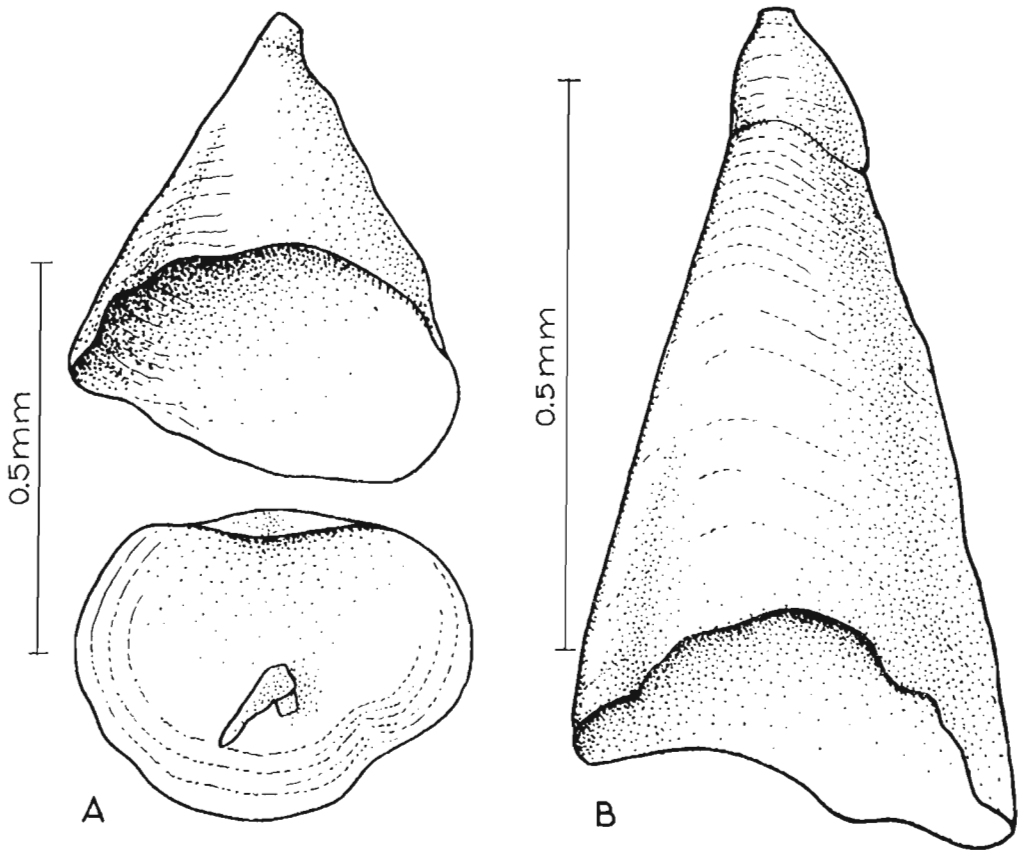

Fig. 19

Few examples of some anomaly in the external shell appearance and internal structure. *A*—*Ephippelasma* cf. *spinosum* n. sp. (Kętrzyn IG-1, 1595·5 m), asymmetry in the shell outline and shape, and in the development of a median septum; *B* — *Torynelasma* sp. (erratic boulder, No. O. 511) possessing an anomalous appearance of the posterior part of pedicle valve.

by some competition for settling space, quite like as in the case of the mentioned articulate forms. In addition, no irregularity occurs in the arrangement of the surface concentric lines.

The irregular shape and outline of the brachial valve of *Eoconulus*, the only valve which is known, is very common. Practically, no other fossilized brachiopod shells occur so often in such asymmetrical form. The changes in outline coincide, in general, with the irregular appearance of concentric lines. They are subequally arranged, often of diversified pattern even on one valve.

In the collection, only few specimens of *Eoconulus* from Estonia, which are of younger individual age, have valves regularly outlined. The others from cores (Kętrzyn IG-1, Bartoszyce

IG-1) or erratics mostly have differently changed outlines. It is implied here, that these deformations could, in some cases, be due to diagenesis. In others, however, there is no doubt that they were the result of additional environmental factors, among others, a limited living space, which affected the shell, thus producing the mentioned deformities. The crowded living space is a very probable explanation as these animals were a very proliferated group — this can be deduced from the number of occurring valves in fossil state.

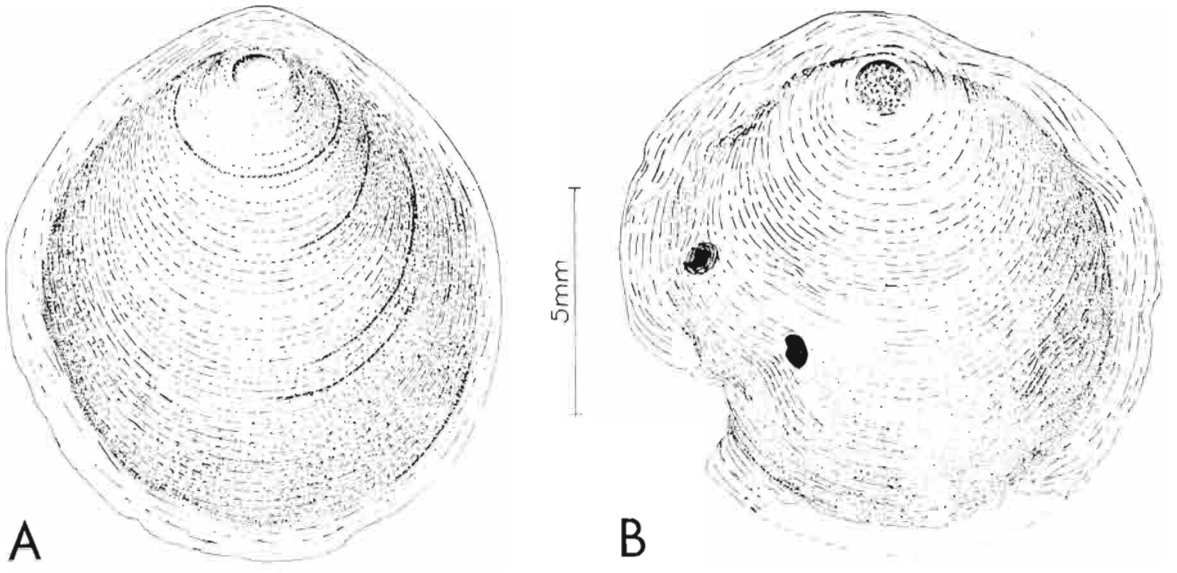

Fig. 20

Paterula cf. *perfecta* COOPER (erratic boulder, No. O. 535). *A*, *B* two pedicle valves, *B* with traces of some injuries.

As has been mentioned above, the size of the brachial valve (its operculate character being sometimes very distinct) of unequivalved acrotretaceans always corresponds to the antero--lateral margins of the pedicle valve, both valves of the shell fitting tightly together. This is a valid regularity within these brachiopods. In some, however, forms like *Myotreta crassa* GORJ. occur shells which have the brachial valve slightly smaller but which fits tightly at the posterior margin only, this valve on its anterior third being partly recessed within the conical pedicle valve without evident marks of damage. Although it is not a normal condition, it is, nevertheless, not an artificial „*post-mortem*" one. This kind of valve recession (when of course both valves of the shell fit tightly together) does not occur without a slight displacement of both valves of the shell, in relation to each other, or of some brackage of the recessed valve. In the case of *M. crassa* this slight recession of the brachial valve into the pedicle one occurs without damage and the valves are not displaced. This could suggest that really the brachial valve is smaller than average and could, as a result, move freely in one direction, somewhat similarly as in the case of richtphophenids (RUDWICK, 1970).

In general, the above shells could illustrate an example of accidental abnormality in relation to the size of one valve to the other although one could suggest that the exact fitting to the valve edges in some forms is not the rule within the inarticulate brachiopods, the more so, as we do not know very much about these animals and their modifications possibilities. To add, one illustration of *Myotreta crassa* GORJ., given by GORJANSKY (1969, Pl. 2, Fig. 10) shows

also a specimen with the brachial valve looking as slightly recessed. Unfortunately, however, the photograph is not very distinct and more detailed observations are impossible.

In specimens of *Ephippelasma spinosum* n. sp. coming from Bartoszyce IG-1 and Kętrzyn IG-1 bore holes, the brachial valves are very damaged. Of the structural elements, the septum is not in its full development, and reversely, is very often of anomalous appearance. It is seriously deformed, small, asymmetrical in appearance and changed, in many cases, to such a degree, that it is not, at all, comparable with the normal state (Text-fig. 19*A*). Some internal details as muscle scars, often both propareas or the median plate are not seen being often very obscured or, if seen, also very changed. Such an appearance of septum has not been attributed to a natural suppression of development. It is possible that the mentioned septum in the considered species has been altered in its normal development and as preserved in fossil state, is not a true „original" septum in its full state of development and state of preservation. It is, evidently, a result of a subsequnetly later secretion of inorganic origin. In addition, the shells are white and mat, this suggesting the original substance replaced by a secondary one. This was observed also by BELL (1941) in the Cambrian genus *Prototreta* with very similar to our effects.

To sum up, all the above mentioned examples illustrate the possible abnormalities which can be found in inarticulate brachiopods. Their origin is disputable similarly as in the case of articulate brachiopods or the other fossil groups. Although these examples are limited and seemingly unimportant they can give some indications of the animals associations, their relations and the regime existing in the given environment — this all reflected on the shell.

REMARKS ON EVOLUTION OF ACROTRETIDS

Considering the evolution and phylogeny of acrotretids in general, one can state that this relatively well differentiated group evolved quite rapidly during the Cambrian-Ordovician time. In the Lower Cambrian the acrotretids already display true acrotretacean features, i. e. moderate or relatively moderate conus, rather weakly developed median dorsal ridge or septum as well as propareas. It is seen in the representative of this group as *Prototreta* BELL, or *Linnarsonia* WALCOTT, this latter genus being a conservative form as mentioned by WILLIAMS & ROWELL (1965).

To simplify the evolutionary scheme of acrotretids, the general outline of which was proposed by WILLIAMS & ROWELL (1965, H172), one can say that there are two main developmental lineages. The first one had a relatively longer range, from Lower Cambrian to eventually Lower Devonian, the Devonian members are only supposed, not having been recorded, up to now. The model shape of shell would be, generally speaking, defined as more transverse or less in outline, more ventribiconvex or less in profile, the ventral moderate cone being, however always preserved, with a vestigial or almost so interarea and very simple articulating mechanism. These features with small modifications and in various recombinations are repeated in all members of this stock. The way of development of this considered lineage can be traced by changes (including obsolescence or absolute disappearance) in a few features such as: median plate in the brachial valve, median septum, apical process. In general, the subfamily Acrotretinae was suggested as an initial group for the later appeared acrotretids. Among the Cambrian forms, genus *Ceratreta* could be judged as an eventual progenitor for such genera as *Rhysotreta* COOPER or *Scaphelasma* COOPER, which developed by the loss of the apical process while accepting a similar to *Ceratreta* shell shape, the pedicle valve being low. Considering the general

shell shape, the same type could be continued into the Silurian, represented by the genus *Artiotreta* IRELAND. The problem, however, of the origin and the precise affinities within this stock are still obscure as a concrete basis for explaining this question is still lacking — the documentation being still very fragmentary.

The second lineage comprises a very short ranged group somewhat conflicting from, among others, the point of view of the median septum which appears to be correlated with the pronounced ventral cone. They are well developed in the Lower and Middle Ordovician, but are judged to extend from the Cambrian into, probably, Upper Ordovician, being rather poorly represented both in Cambrian and Uppermost Ordovician. The members of the considered lineage are grouped into a few separate subfamilies, characterized mostly by a slightly different appearance of median septum in their interior — Torynelasmatinae ROWELL, Ephippelasmatinae ROWELL, Myotretinae n. subfam. They differ rather considerably, even in the general shell appearance from the members of the earlier mentioned Acrotretinae. They are always devoid of apical process, having an external pedicle tube, operculate flat, or almost so, brachial valve, weakly developed propareas and bearing a complex septum. This latter structural element was suggested as representing a „successful trend" to support the lophophore (WILLIAMS & ROWELL, 1965, H172).

The septum is really very specific in the general aspect and as a complex structure is limited mainly to the Ordovician genera, excluding, up to now, the Lower Ordovician. Despite this gap, it seems that the progenitors of the mentioned second group can be found in the Lower Cambrian. The Cambrian genera such as *Angulotreta* PALMER, *Prototreta* BELL or *Ceratreta* BELL also display a septum of a rather complex appearance, developed in a digitate form. These genera, however, preserve their rather moderate cone and well developed apical process. It is possible that the members of the second shortly lived lineage are rather close to the mentioned Cambrian forms. This lineage could deviate from, probably, *Prototreta* BELL by elaboration of a complicated septum and more conical valve and by loss of the apical process. The corresponding relatives in the Lowermost Ordovician as yet unknown, will be with time found.

This second lineage limited in time is, no doubt, very specialized and the innovations (internal and external) it displays could not have been probably very profitable for the animals — this could be one of the reasons for the extinction of this group. The interesting is also the sudden differentiation of this stock with its climax in the Ordovician.

SYSTEMATIC PART

Order **LINGULIDA** Waagen, 1885
Family OBOLIDAE King, 1840
Subfamily OBOLINAE King, 1840
Genus **OBOLUS** Eichwald, 1829

(Type species: *Obolus appolinis* Eichwald, 1829)

Obolus cf. **appolinis** Eichwald, 1829

(Pl. III, Fig. 7)

Material. — One fragment of pedicle valve (posterior half) and few very small fragments of brachial valves.

Description. — The preserved fragment of pedicle valve belongs probably to comparatively large specimen; it is to about 5 mm long, 3·5 mm wide at midlength, interarea to about 0·5 mm in height. The valve is very roundly outlined, ventral apex pointed, pedicle groove narrow, almost of the same width posteriorly and anteriorly, flexure lines only slightly marked on propareas, traces of muscle field partly preserved, but very indistinctly marked.

Discussion. — The above fragment reminds one of *Obolus appolinis*, in the shell outline, appearance of ventral interarea and traces of muscle field. Unfortunately, the specimens are fragmentary and make correct identification impossible.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland; known from Estonia and USSR (environs of Leningrad), in Lower Ordovician sandstones; Tremadocian, Pakerort horizon.

Genus **SCHMIDTITES** Schuchert & Le Vene, 1929

(Type species: *Schmidtia celata* Volborth, 1869)

Schmidtites obtusus (Mickwitz, 1896)

(Pl. I, Figs 1-5; Text-fig. 3)

1969. *Obolus (Schmidtites) obtusus* Mickwitz, 1896; V. J. Gorjansky, Bespozvonočnye brachiopody..., p. 27, Pl. 2, Figs. 11-20.

Material. — Thirty separate brachial and pedicle valves, well preserved, very small and thin-shelled.

Approximate dimensions (in mm):

Bp. XV/	Length	Width			
		maxim.	poster.	anter.	
6a	0.85	0.60	0.35	0.40	brachial valves
6b	0.80	0.53	0.30	0.33	
6c	0.86	0.56	0.40	0.46	
6d	0.64	0.45	0.27	0.37	
6e	0.54	0.38	0.25	0.35	
6f	1.05	0.71	0.45	0.55	
6g	1.36	0.87	0.60	0.70	
6h	0.60	0.36	0.22	0.26	pedicle valves
6i	0.75	0.45	0.30	0.36	
6j	0.77	0.47	0.30	0.38	
6l	0.97	0.55	0.35	0.48	
6m	1.01	0.60	0.35	0.51	

Description. — Small, the largest specimen in the collection not exceeding 1·5 mm, the smallest attaining to about 0·5 mm in length, moderately biconvex, the greatest convexity lying in the posterior third of valves just corresponding to the first, well marked concentric line (Pl. I, Figs 4, 5; Text-fig. 3), the convexity closely lowering anteriorly, shell elongate oval, always the widest about midlength, ventral apex pronounced; brachial valve with apex slightly truncate, in the smallest specimens being a little only pronounced (Text-fig. 3*B*), internally somewhat thickened, the covering horizontal lines weakly undulating.

Ornamentation consists of concentric lines, rather distinctly marked, their density on the valve surfaces changing slightly with growth process, between two concentric macrolines 4—5 very fine microlines quite regularly arranged, occur.

Internal details are not preserved, in the largest specimens in the collection, to about 1·35 mm long, a very week median ridge and some traces of probable muscle scars on both sides of the median ridge are discernible.

Discussion. — The collection comprises a range of specimens of different size, the smallest about 0·35 mm in length, the largest up to 2 mm. The specimens in question represent an early adult stage. In all the specimens the shell outline and shape are very stable. The concentric lines well reflect the very small changes in the shell outline, which occur during the growth process. The shells, in general, remain oval in outline and slightly more biconvex in their posterior third.

The above mentioned specimens are of the type of *Schmidtites obtusus* figured by MICKWITZ (1896, Pl. 2) and by GORJANSKY (1969, Pl. 2, Figs 13—20) although they represent a not advanced adult stage, contrary to specimens figured by both mentioned authors. The species is relatively numerous in the Tremadocian chalcedonites of Wysoczki. Its presence has been mentioned by BEDNARCZYK (1964, p. 36) in the upper part of Zbilutka beds, locality Kozieł in the Holy Cross Mountains, but was found there in only one very incomplete mould of the ventral valve. Due to the very bad state of preservation, this fragment has been identified as *Schmidtites* cf. obtusus (MICKWITZ).

Occurrence. — Tremadocian chalcedonites, Wysoczki and Zbilutka beds, Holy Cross Mountains, Poland; Estonia (Pakerort horizon); USSR, north-western part of Russian Platform, Pakerort horizon.

Subfamily LINGULELLINAE SCHUCHERT, 1893

Genus **LINGULELLA** SALTER, 1866

(Type species: *Lingula davisii* M'COY, 1851)

Lingulella cf. **zeuschneri** BEDNARCZYK, 1964

(Pl. II, Figs. 1-2)

1964. *Lingulella zeuschneri* n. sp.; W. BEDNARCZYK, Stratygrafia i fauna tremadoku, p. 46, Pl. 7, Figs. 1-14; Pl. 8, Figs. 1-4.

Material. — Five almost complete pedicle valves, many fragments of valves. Approximate shell dimensions (in mm):

Bp. XV/	Length	Width			Height of interarea
		poster.	median.	anter.	
22b	2.6	0.86	1.54	1.0	0.6
22g	2.0	0.75	1.4	1.0	0.4

Description. — The valves are small for the genus, oval in outline, length exceeding almost two times the maximum valves width, lateral margins moderately arcuate, antero-lateral margins and angles rounded, valves gently convex in the posterior third, a little flattening anteriorly; ventral apex pronouncedly elongate, acute; pseudointerarea occupying about one-fourth or slightly more of the whole valve length, with distinctly preserved, sometimes flexure lines on propareas, pedicle groove comparatively narrow, almost of the same width along its whole length.

Ornamentation very weakly expressed, consisting of concentric lines, more distinct and closely spaced in the anterior third of valve, rather regularly arranged on the whole shell surface.

Discussion. — The valves are thin-shelled and the traces of muscle scars or pallial sinuses are not preserved, the concentric lines being only partly visible, sometimes very delicately marked. These etched valves, however, are easily distinguishable mainly by their acute ventral apex, and arcuate lateral margins (Pl. II, Figs 1-2). In the shell outline, appearance of pedicle groove and flexure lines, the considered specimens are very much alike to *Lingulella lirata* (COOPER, 1956, Pl. 28, Figs 17-23) with the difference that the former are more roundly outlined in their anterior half. They are also very similar to *L. spicata* (COOPER, 1956, Pl. 7 *D*, Figs 23-24) differing in being more oval in outline, the greatest width about midlength of the valve. The discussed specimens appear to be the closest to *Lingulella zeuschneri*, especially to specimens figured by BEDNARCZYK on Pl. 7, Figs 1-3 (BEDNARCZYK, 1964). Some differences are seen in the more arcuate lateral margins and more roudly outlined anterior margin, also in the greatest width lying about midlength in our specimens. These differences may not have a specific value and lie in the limits of individual variability, *I. zeuschneri* BEDNARCZYK in particular is a quite variable species, the changes concern the shell outline (BEDNARCZYK, 1964, Pl. 7, Figs 1-14; Pl. 8, Figs 1-4).

Occurrence. — Tremadocian, the Zbilutka and Kozieł beds, localities: Wysoczki, Zbilutka and Kozieł, Holy Cross Mountains, Poland.

Genus **WESTONIA** WALCOTT, 1901

(Type species: *Lingula aurora* HALL, 1861)

Westonia cf. **directa** GORJANSKY, 1969

(Pl. II, Figs. 3-4)

Material. — One, almost complete (the anterior part damaged) pedicle valve, few fragments of valves.

Description. — The preserved fragments of valves are thick-shelled and belong to adult individuals, of comparatively large size; the pedicle valve is to about 1·5 mm wide at its midlength and more than 2 mm long; it is oval in outline, convex in profile, the deepest in its posterior third, ventral apex pronounced and fairly elevated, interarea comparatively high, two propareas with marked flexure lines, pedicle fissure rather wide, slightly widening anteriorly.

Ornamentation is characteristic of the genus, consisting of thickened, somewhat of lamellar appearance lines, densely and regularly spaced, which on some fragments of valves corresponding, in all probability, to the central part of specimens, are arranged in a somewhat zigzag pattern, on the lateral margins being arranged in a tile-like pattern.

Although the collection is very small and fragmentary, its generic assignment is not difficult, mostly due to the characteristic surface ornamentation (Pl. II, Figs 3-4). Until a more complete collection is obtained, the questioned fragments are identified as *Westonia* cf. *directa* GORJANSKY. The specimens of the latter species are larger, hence their outline could be slightly changed due to the more advanced individual age, also the shell convexity is much more pronounced.

Occurrence. — Arenigian, Volkhov horizon, Estonia.

Subfamily GLOSSELLINAE COOPER, 1956

Genus **GLYPTOGLOSSELLA** COOPER, 1960

(Type species: *Glyptoglossa cavellosa* COOPER, 1956)

Glyptoglossella sp.

(Pl. II, Figs. 5-6)

Material. — One complete pedicle and one brachial valve damaged at the anterior margin.

Description. — Shell gently biconvex in lateral view, the most in its posterior third, elongately oval in outline; pedicle valve about two times as long as wide, about 1·7 mm long, 1·2 mm wide at midlength, 0·56 in the posterior and 0·8 in the anterior third of valve; apex moderately pronounced, acute (Pl. II, Figs 5-6); brachial valve more roundly outlined and slightly shorter than the pedicle valve, apex very small.

Ornamentation consists of concentric lines, usually very weakly marked, more distinct and numerous on the anterior half of the shell, being there of lamellar appearance, the lamellae fairly regularly spaced anastomosing and probably frilled, the valves possessing spaced on their anterior part a characteristic surface pattern (this obtained, may be, due to the etching), very much like that of *Lingulella*? *sculptilis* described from Lower Ordovician of Nevada by ULRICH & COOPER (1938, p. 51, Pl. 3, Fig. 13). This feature being mentioned by the above authors

as unusual and of probably higher taxonomic value than on specific level. The surface ornamental pattern in our species is also very comparable to that of *Glyptoglossa cavellosa* COOPER from Shippensburg formation of Maryland (COOPER, 1956, p. 226, Pl. 3, Fig. 20) or even somewhat resembling that of *Dictyonites perforata* COOPER from Pratt Ferry fm, Middle Ordovician, Alabama (COOPER, 1956, Pl. 10, Fig. 5), this resemblance being, however, quite superficial as the shell of the latter species is perforated.

Internally, pedicle groove is of trigonal outline, greatly widening anteriorly; in the brachial valve a trace of a median ridge corresponding, in all probability, to the median septum, occurs; on both sides of septum are, but very weakly discernible, probable scars of anterior muscles. Unfortunately, the valves are thin-shelled, hence the details of internal structure are not or very obscurely marked.

Discussion. — This species is rarely found in the erratics and possesses a few only external features which could be regarded as comparable with those of other members of the genus. These are, the general shell outline and shape and surface ornamentation preserved on the anterior half of the shell as also the presence of a median septal ridge in the brachial valve. These are not really sufficient as taxonomic features, but only on their basis could above species be referred to the genus *Glyptoglossella* COOPER. In the shell outline, the discussed species is very much alike *Glyptoglossella ardmillanensis* (REED, 1917), figured by WILLIAMS (1962, Pl. 6, Fig. 22), our specimens being only a little wider and considerably smaller. In the preserved shell ornament they remind one very much of the type species of the genus *G. cavellosa* (COOPER, 1956, Pl. 3, Fig. 20), showing also a little similarity in the shell outline, the shell of our specimens being more roundly ovate and, in addition, relatively smaller.

Occurrence. — Erratic boulder, No. O. 247, Baltic coast, Poland. Middle or Early Upper Ordovician.

Genus **ECTENOGLOSSA** SINCLAIR, 1945

(Type species: *Lingula lesueuri* ROUAULT, 1850)

Ectenoglossa exunguis (EICHWALD, 1828)

(Pl. II, Figs. 7, 8)

1829. *Lingula exunguis* EICHWALD; E. EICHWALD, Zoologia specialis, p. 273, Pl. 4, Fig. 1.
1969. *Ectenoglossa exunguis* (EICHWALD, 1829); V. J. GORJANSKY, Bezzamkovye brachiopody..., p. 43, Pl. 7, Figs. 1-4.

Material. — One complete brachial valve, and few small fragments.

Description. — The brachial valve is thin-shelled small for the genus, of a length about 2·4 mm maximum width 1·54 mm, width posteriorly approximately 0·68 mm and anteriorly 1·2 mm. This is a young valve, but the older valves remain, probably, smaller than *Ectenoglossa exunguis* figured by GORJANSKY from the Leningrad environs (1969, Pl. 7, Fig. 1); lateral margins are subparallel, very weakly arcuate, anterior margin straight or almost so, anterolateral angles rounded; valve in profile convex, the most on the posterior third of the valve; shell surface is covered by concentric lines, regularly arranged, almost parallell to one another, more distantly spaced on the anterior third of the valve. Internal details not preserved.

Discussion. — On the basis of the valve outline and general appearance, the described valve is included in the genus *Ectenoglossa* ROUAULT, and treated as conspecific with the EICHWALD'S species *E. exunguis*. The shell outline and shape are exactly the same, only the con-

centric lines are, may be, slightly more distantly arranged and the size of our valve is smaller. Our valve is also very similar in its general appearance to the type species *E. lesueuri* (ROUAULT), differing somewhat in having lateral margins a little arcuate and in being more narrow in the posterior third (comp. ROWELL, 1965H, p. H268, Fig. 162·5).

Occurrence. — Erratic boulder, No. O. 247, Baltic coast, Poland; Middle Ordovician to Upper Ordovician, Caradocian (Kukruse and Idavere horizons), USSR, environs of Leningrad.

Genus **ROWELELLA** WRIGHT, 1963

(Type species: *Rowelella minuta* WRIGHT, 1963)

Species assigned to the genus: *Rowelella minuta* ROWELL, England, Upper Ordovician (Portrane limestone); *R. rugosa* GORJANSKY, USSR, Lower Ordovician (Volkhov horizon), environs of Leningrad; *Rowelella* sp. 1, Estonia, Lower Ordovician (Volkhov horizon); *Rowelella* sp. 2, Poland, Tremadocian chalcedonites of Wysoczki.

Discussion. — This is a highly characteristic genus. The shell is narrow and very elongate, its length exceeding two to three times the width, lateral margins are parallel or almost so and, to a somewhat varying degree, geniculated, converging only moderately on the posterior and anterior ends, both valves are slightly convex, the degree of convexity much depending, among others, upon the growth stage, the convexity being more marked on the posterior third of the shell; shell surface is ornamented by concentric lines or ridges, thickened to a varying degree, sometimes of lamellar appearance. Their appearance and density on the shell surface are of specific value. All these features are, in general, repeated, in the all known species of the genus, only the degree of the shell elongation and geniculation, somewhat the shell convexity, appearance of concentric ornamental elements are changeable within the genus and are taxonomically valuable. With regard to the concentric surface ornamentation, it is, in e.g. type species composed of concentric ridges, very distinct and densely arranged on the valves (WRIGHT, 1963, Pl. 1, Figs 23, 25), in *Rowelella rugosa* GORJANSKY, they are of lamellar appearance, very pronounced, only few in number (GORJANSKY, 1969, Pl. 8, Figs 4-7). In our species they are fine, probably in adults of lamellar appearance, and cover the valves surfaces in a greater number (Pl. III, Figs 1-4).

Age: Ordovician.

Rowelella sp. **1**

(Pl. III, Fig. 1)

Material. — Two fragments probably of a brachial valve.

Description. — Two preserved fragments of the valve are almost complete on their anterior third, the posterior part being damaged; the valves are very elongate, narrow, slightly convex in profile, with lateral margins almost parallel and geniculated, anterolateral angles and anterior margins rounded; on the surface occur very regularly arranged and distinctly marked concentric lines well illustrating the outline of anterior margin.

Discussion. — The described fragments possess the most characteristic features of the genus *Rowelella*. Unfortunately, the internal structure is not preserved (the valves are very thin), hence it is difficult to decide which of the valves they represent. They differ greatly in the

appearance of the surface ornamentation from the Upper Ordovician *Rowelella minuta* WRIGHT and Lower Ordovician *R. rugosa* GORJANSKY. Material is too scarce to erect new species.

Occurrence. — Lower Ordovician, Volkhov horizon, Suhkrumägi, environs of Tallinn, Estonia.

Rowelella sp. **2**

(Pl. III, Figs. 2-4)

Material. — Three fragments of valves, representing their anterior third or half, the posterior third of valve damaged.

Description. — Although the fragments are small, only one being slightly larger (Pl. III, Figs 3, 4) they preserve the characteristic for the genus shape and outline and lateral margins subparallel and geniculated, anterolateral angles are very rounded, the concentric lines delicately marked, although easily discernible on the valve surfaces and very densely arranged, this feature differing the above valves from both the *Rowelella minuta* WRIGHT (1963, Pl. 1, Figs 19, 23, 25) and *R. rugosa* GORJANSKY (1969, Pl. 8, Figs 4-7). It seems, on the basis of the described fragments, that the specimens could be slightly larger than the mentioned above *Rowelella* sp. 1 from Estonia (Pl. III, Fig. 1).

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland.

Family LINGULASMATIDAE WINCHELL & SCHUCHERT, 1893

Genus **LINGULASMA** ULRICH, 1889

(Type species: *Lingulasma schucherti* ULRICH, 1889)

Lingulasma sp.

(Pl. III, Figs. 5-6)

Material. — Three small fragments of pedicle and brachial valves.

Description. — The preserved fragments are supposed to belong to the genus *Lingulasma* ULRICH on the basis of the general appearance of preserved valves. One of them seems to represent a brachial and the second one the pedicle valve (Pl. III, Figs 5-6). The details of micro-ornamentation are not preserved.

Occurrence. — Erratic boulder, No. O. 542, Mochty, Vistula valley, Poland. Probably Upper Ordovician.

Family PATERULIDAE COOPER, 1956

Genus **PATERULA** BARRANDE, 1879

(Type species: *Paterula bohemica* BARRANDE, 1879)

Paterula cf. **perfecta** COOPER, 1956

(Pl. I, Figs. 6—8; Text-figs. 4, 20)

1956. *Paterula perfecta* COOPER n. sp.; G. A. COOPER, Chazyan and related brachiopods, p. 238, Pl. 24 *D*, Figs. 12-23.

Material. — Five brachial and pedicle valves, preserving their outline.

Approximate dimensions (in mm):

Bp. XV/	Length	Width			Width of limbus
		maxim.	poster.	anter.	
25c	1.57	1.47	0.91	1.1	0.06
26c	1.6	1.46	1.05	1.1	0.1
26d	1.9	1.7	1.1	1.4	0.1
26f	1.07	1.06	0.8	0.9	0.07
26g	1.09	1.0	0.9	0.95	0.07

Description. — Specimens are small, but attaining in adult stage probably much larger size; both valves with submarginal umbones are moderately and almost equally biconvex, the greatest convexity of the pedicle valve occurring in its posterior third, apexes small, roundly outlined; shell subcircular in outline, the widest at midlength (a feature constant for species); all specimens preserving a flattened and entire marginal limbus, usually very distinctly marked, comparatively wide, the widest posteriorly, enlarging with the progressing growth, measuring from about 0·05 mm to 0·1 mm; a notch in the pedicle valve clearly defined, deeply incised, comparatively wide (Text-fig. 4; Pl. I, Fig. 7).

Ornamentation consisting of concentric lines, well marked, densely and very regularly arranged on the whole shell surface (Pl. I, Figs 6-8). The lines are somewhat thickened, almost equally on their length. The internal structure not preserved.

Discussion. — The available material is characterized by a very thin shell, the valves being transparent. As the collection is very limited, it is not possible to state what features are exactly of specific rank. *Paterula* sp. from Lower and Middle Ordovician (Estonia and Russian Platform) is more oval in outline (GORJANSKY, 1969, Pl. 8, Figs 9-10). Judging from the very limited data on the shell morphology, our species is the closest to *Paterula perfecta* COOPER especially to some of the figured specimens which have a very similar general shell outline (COOPER, 1956, Pl. 24*D*, Figs 18-19). As shown in a range of the figured specimens of *P. perfecta* they are of quite variable outline (COOPER, 1956, Pl. 18*H*, Figs 54-56; Pl. 24*D*, Figs 19-23). The Portrane limestone *Paterula* cf. *perfecta*, described and figured by WRIGHT (1963, Pl. 2 Figs 3-5, 8-10, 13, 16) is a little more narrower in comparison with our specimens. In the shell outline our species is very much like *Paterula backlatchniensis* (DAVIDSON) figured by WILLIAMS (1962, Pl. 6, Figs 29, 30) from the Ordovician of the Girvan District. Unfortunately, no other features, except the shell outline, can be taken into consideration.

Occurrence. — Erratic boulder, No. O. 535, Mochty, Vistula valley, Poland, boring Gołdap IG-1 (1466·0 m). Middle -Upper Ordovician, north-eastern Poland. *P. perfecta* COOPER is known from Pratt Ferry Formation, Alabama, Whitesburg Arline Formation Tennessee, Botetourt Formation, Edinburg Formation, Wirginia; England, Portrane Formation.

Paterula sp.

(Pl. I, Figs. 9-11)

Material. — Three valves (two brachials and one pedicle), one of them complete.

Description. — The valves described here as *Paterula* sp. do not differ much from the specimens of *P.* cf. *perfecta* COOPER from the erratic (comp. Pl. I, Figs 8-10) or *Paterula* sp. described

by GORJANSKY (1969, Pl. 8, Fig. 9) from the Middle Ordovician of the Kaliningrad environs, USRR. The shell outline in all mentioned forms is much the same; the same concerns also the appearance of limbus and apical parts of both valves. The other features which could be important from the taxonomical point of view are not available.

Occurrence. — Middle Ordovician, Kukruse horizon, environs of Tallinn, Estonia.

Family CRANIOPSIDAE WILLIAMS, 1963

Genus **CRANIOPS** HALL, 1859

(Type species: *Orbiculoidea? squamiformis* HALL, 1843)

Remarks. — The family assignment of the genus has been a moot problem: *Craniops* was treated, among others, as a member of Paterulinidae (COOPER, 1956, p. 240, and later included into the family Craniopsidae, erected by WILLIAMS (1963). The origin of this family remains uncertain and it is suggested that it could have deviated from e.g. *Lingulops* line (ROWELL, 1965, H 273). One of the characteristic features of the genus is the calcareous shell, traces of attachment by cementation and muscle platform well developed in both valves, having, in addition, a smooth narrow limbus of almost the same width.

Age: Middle Ordovician — Lower Carboniferous.

Craniops erratica n. sp.

(Pl. IV, Figs. 1-8; Text-figs. 21, 22)

Holotype: Bp. XV/23*z*; Pl. IV, Fig. 5 (pedicle valve); paratype: Bp. XV/23*w*, Pl. IV, Fig. 7 (brachial valve).
Type horizon :Erratic boulder, No. O. 178 (Age unknown, probably Upper Ordovician).
Type locality: Mochty, environs of Warszawa.
Derivation of the name: Lat. *erraticus* — found in erratic boulder.

Diagnosis. — Medium size for the genus, roundly outlined, narrowed anteriorly and much wider posteriorly, apex slightly damaged, probably due to the cementation of valve.

Material. — Twenty valves, well preserved, all specimens silicified.

Description. — Shell biconvex, but the convexity quite limited, oval in outline with gently rounded margins, the lateral ones slightly arcuate or almost straight, shell much widened posteriorly, and greatly narrowed in the anterior direction; apex well pronounced, subcentral, sometimes with traces of cementation. The ornamentation consists of lamellar ridges, usually regularly arranged, as a rule six to eight ridges visible, more crowded around the apical part of valves.

The individual variability is limited and concerns the relation of the shell width to the shell depth and the shell width posteriorly to the shell width anteriorly. In general, however, the average shell width is to about 1.67 mm and shell depth 0.39 mm, and wider shells are less deep, in slightly more narrower valves their depth can enlarge and only in the posterior third of valves. Average shell length is about 2.06 mm and shell width 1.79 mm. In general, with the growing shell length its width slightly also enlarges. Internally, the muscular area is defined by a platform, varying in the degree of its elevation above the valve floor and somewhat in its size, occupying a limited area, usually to about the midlength of the valve; this platform

is always the widest about its midlength: in the brachial valve the posterior adductors are separated by a median long ridge like elevation (Pl. IV, Fig. 7; Text-fig. 22), on the pedicle valve the adductors are much less marked on the platform which is, usually somewhat of flabellate appearance (Text-fig. 21).

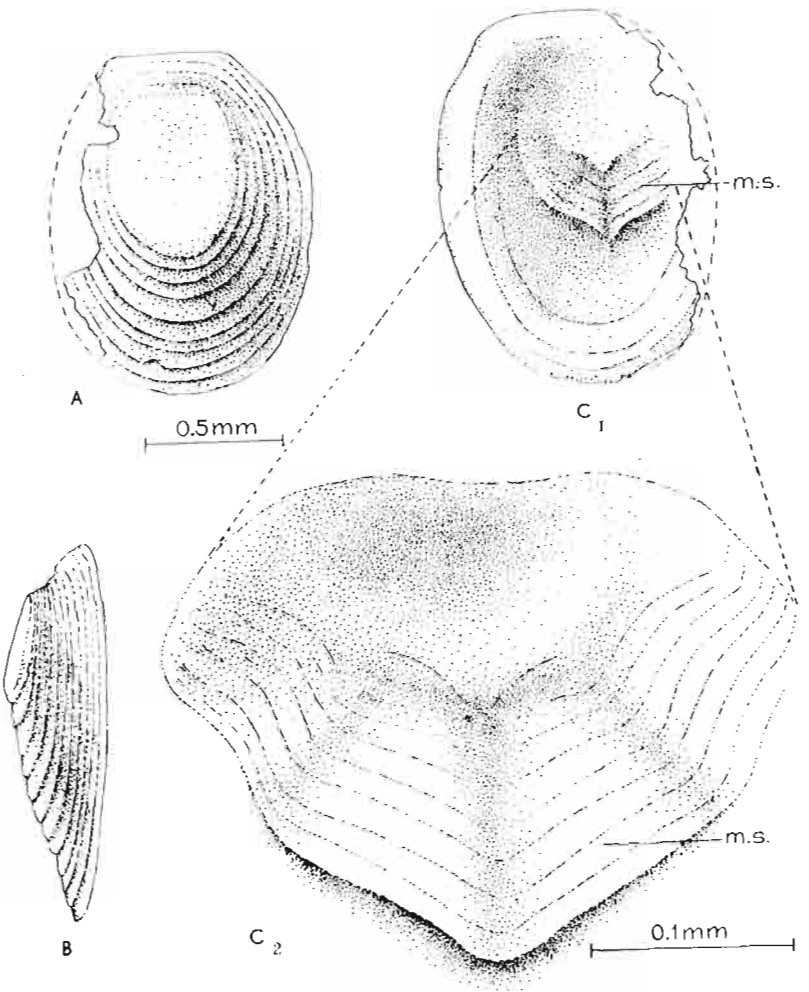

Fig. 21

Craniops erratica n. sp. (erratic boulder No. O. 178). *A-C* exterior, side and interior views of three different pedicle valves in adult stage, C_2 muscle platform.

Remarks. — All valves in the collection are almost of the same appearance, i.e. the apexes are much alike, usually looking as flattened surfaces of uneven and limited size, sometimes moderately concave, giving the impression of traces of cementation during the life of the animal. The position of apexes is constant, always lying in the posterior third of valves. Only the size and shape of the platform defining the muscles is slightly variable and on this basis one can ascribe them to the particular valve, brachial or pedicle. All of the above valves can be regarded as fully mature. The valves are thick-shelled and the preserved internal details are well developed.

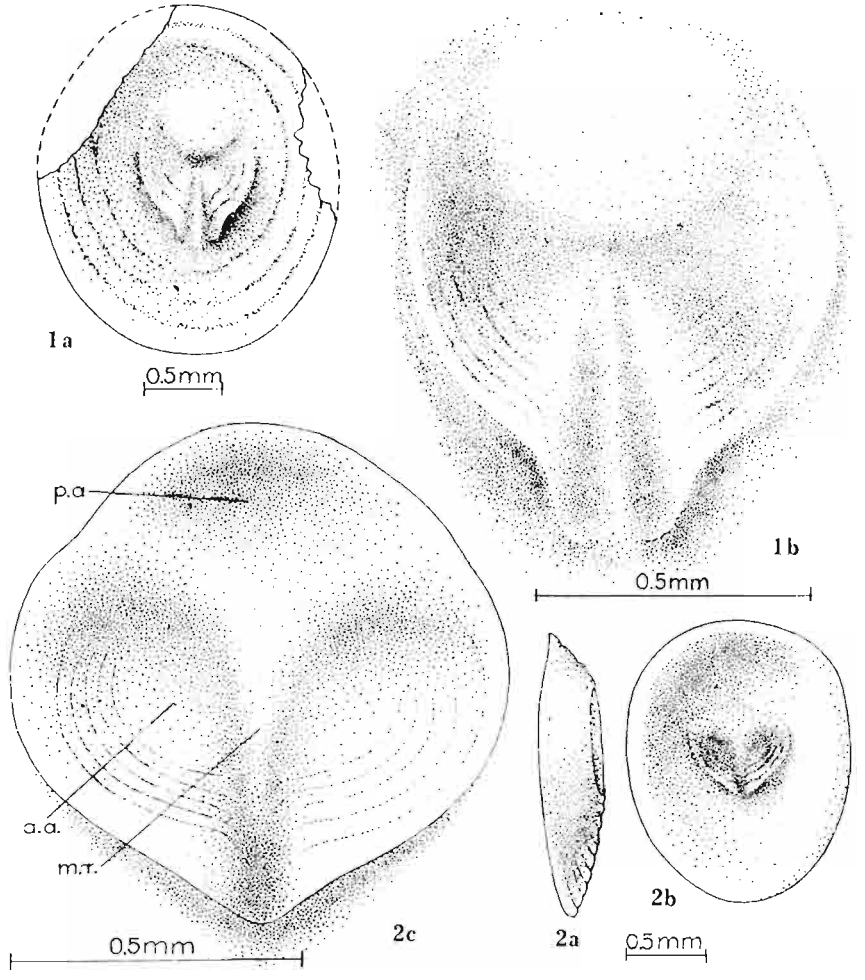

Fig. 22

Craniops erratica n. sp. (erratic boulder, No. O. 178). *1*, *2* — interior of two adult brachial valves showing muscle platform, *a* side, *b*, *c* interior views of adult valve; *a. a.* anterior adductors, *p. a.* posterior adductors, *m. r.* median ridge,

Discussion. — The above species is very close to *Paracraniops pararia* WILLIAMS (1962) described from the Caradocian of Girvan district, differing not very much in a more widely outlined shell and, above all, in having some traces of evident cementation. The absence of this latter feature characterizes the genus *Paracraniops*.

Occurrence. — Probably Upper Ordovician, erratic boulder No. O. 178, Mochty, Vistula valley, Poland.

Order **ACROTRETIDA** KÜHN, 1949
Superfamily ACROTRETACEA SCHUCHERT, 1893

Diagnosis (slightly emend.). — Unequivalved, pedicle valve to a varying degree conical, interarea developed, pedicle foramen apical or subapical, dorsal propareas of changeable appearance, median septum or ridge present; protagular parts of shell distinctly pitted.

Age: Lower Cambrian-Devonian.

Family ACROTRETIDAE SCHUCHERT, 1893

Diagnosis (slightly emend.). — Unequivalved, small, interthrough to a varying degree developed, dorsal septum simple to complex, „hinge" apparatus simple, protegular parts of shell bearing surface pits.

Discussion. — The Acrotretidae constitute a large family, occurring from Cambrian to probably Lower Devonian. They are widely and quite rapidly spread in the Cambrian-Ordovician times. Their occurrence in Silurian being very reduced and only very few forms are, up to now, described. This family is relatively very differentiated, including a great number of various forms, displaying an exceptionally great, for inarticulates, number of features of external and internal morphology and the possibilities of deviations are fairly large. Members of the family are well recognizable, some of them being highly characteristic due to their multi--modifications in the shell interior and exterior. The family comprises 7 subfamilies, including one newly proposed, Myotretinae.

Age: Cambrian - ?Lower Devonian.

Subfamily ACROTRETINAE SCHUCHERT, 1893

Diagnosis (emended). — Ventral conus low to medium in size, varying in width, internally with apical large process or spondylium, dorsal septum simple; protegular pits round, quite deep, the small ones varying in outline and somewhat in number.

Discussion. — It is the largest, up to now, subfamily comprising many genera, which appear to be closely related, showing some variability in the shell shape and outline and in some details of the internal morphology, e.g. appearance of the apical process characteristic of the subfamily, pattern of pallial sinuses, in the appearance of a median septum or septal ridge and in morphology of the posterior margin. The Cambrian Acrotretinae are believed to be ancestral to most of the Ordovician acrotretids.

Age: Cambrian-Ordovician.

Genus **DITRETA** n. gen.

Type species: *Ditreta dividua* n. sp.

Derivation of the name: *di-treta* — *Acrotreta* with umbonal part separated internally by a thickened platform.

Diagnosis. — Moderately conical acrotretoid of large size, ventral umbonal part infilled with lamellae forming anteriorly a thickened horizontal platform pierced by a pedicle foramen; dorsal septum weekly marked like a sharp and very low ridge, cardinal muscles elongate oval, distant, median plate and propareas much like those in *Eurytreta* ROWELL.

Discussion. — All the mentioned features considered together may be important in distinguishing this form within the known acrotretids. The particular features of the external morphology are distinctly acrotretid in character. The moderate but widely conical pedicle valve reminds one, to some extent, of *Ephippelasma* COOPER or *Conotreta gigantea* COOPER (1956, Pl. 16, Figs 19, 22), but the apex is much more blunt and the whole valve larger, and judging from the preserved fragments can attain more than 6 mm in length. The operculate brachial valve with its internal structure is very much alike *Eurytreta* ROWELL (1966) the dorsal

median plate being, larger and the cardinal muscle scars more distant and elongate oval. The most characteristic feature of the new genus is the thickened ventral platform, somewhat peculiar in appearance in the very advanced adult stage (Pl. V, Fig. 4). It is fairly certain, that this platform is related to the „cone-in-cone" structure of shell laminae in the apical part of *Prototreta trapeza* mentioned by BELL (1941, p. 224, Figs 1-20), preserving the pedicle tube opening to the valve interior. The functional interpretation of this platform is difficult, a reasonable explanation could be its use in weightening of the valve.

Unfortunately, no detailed study of the other internal features could be undertaken due to the fragmentary collection. Also the presence of pitted protegulum in this form could not be stated, not being preserved due to the action of hydrofluoric acid in etching the chalcedonites from which the specimens come.

Age: Lower Ordovician.

Ditreta dividua n. sp.

(Pl. V, Figs. 1-8)

Holotype: Bp. XV/37*h*; Pl. V, Fig. 2 (pedicle valve); paratype: Bp. XV/37*g*: Pl. V, Fig. 1 (brachial valves).
Type locality: Wysoczki, Holy Cross Mountains.
Type horizon: Tremadocian (chalcedonites).
Derivation of the name: Lat. *dividuum* — divided; pedicle valve internally divided into two parts.

Diagnosis. — Respectively large, pedicle valve widely conical, incurved in profile with interior infilling, internal pedicle foramen present, brachial valve flat, dorsal septum short, propareas developed.

Material. — Seven not very complete pedicle valves, three brachial ones, many fragments of shell.

Approximate dimensions (in mm):

Sp. XV/	Length	Width	
		posteriorly	anteriorly
37a	0.8	0.2	1.6
37h	6.0	holotype, pedicle valve	

Description. — Large pedicle valve developed in a wide conus, posterior margin straight, antero-lateral margins roundly outlined, valve in profile arched especially in the posterior third, external pedicle tube very short, in old stage lacking, interarea, in general, quite distinctly marked. Brachial valve roundly outlined correspondingly to the outline of the postero-lateral and anterior margins, almost flat to slightly convex in profile, width a little exceeding the length.

Ornamentation consists of concentric thickened lines, usually badly marked, and discernible as slightly more dark (being more thick) concentric bands regularly spaced on the shell surface.

Interior. Pedicle valve. Of the internal details only a peculiar horizontal thickened platform is observed and preserved. It is confined to the posterior (umbonal part) fourth of the valve interior constituting the latest phase of the projecting of the shell lamellae into the interior of

the valve. These projecting internal lamellae are just observed in the most apical part of the valve, extending to the internal pedicle tube (in some way encircling it), lying horizontally one beneath the other, forming in each subsequent growth stage a horizontal platform preserving an internal pedicle foramen. As to the internal pedicle foramen it is, in old specimens, encircled by concentric thickened bands, in a such a way the size of the pedicle foramen diminuishes with the age and, probably may dissapear — this depending much upon the secretion activity of the mantle of animal. In addition, the valve on its ventral side is slightly more thickened just in the place which corresponds to the apical process of *Conotreta* WALCOTT, *Eurytreta* ROWELL and *Linarsonella* WALCOTT.

Brachial valve is very much like other members of acrotretids, and reminds one of *Conotreta* WALCOTT and *Eurytreta* ROWELL. The propareas are quite distinct, moderately elevated anteriorly, with comparatively large and greatly depressed median plate (Pl. V, Fig. 1). The distance between the anterior end of a median plate and posterior end of the septal ridge is occupied by a slight thickening (Pl. V, Fig. 1); median ridge is short, thin and sharply ended on its upper edge; cardinal muscle scars elongate ovate, rather distinct and diverging anteriorly.

Discussion. — The species, although based on an incomplete material, from the point of view of state of preservation and number of specimens, is judged to be a quite distinct taxon. It can serve as an example of one more, and new modification in the ventral interior displayed by the inarticulate brachiopods. Externally, it is very much like the other conical acrotretoids no doubt being related with them, and probably with the Cambrian *Prototreta*. The dorsal interior of the discussed species is very comparable to that of *Conotreta* WALCOTT.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland.

Genus **CONOTRETA** WALCOTT, 1889

(Type species: *Conotreta rusti* WALCOTT, 1890)

Discussion. — It is quite possible that *Conotreta* WALCOTT is a younger synonym of *Acrotreta* KUTORGA, 1848, with the type species *Acrotreta subconica* KUTORGA, 1848, described from USSR. Unfortunately, locality and horizon of the type specimen are unknown. It probably comes from the limestone with *Echinosphaerites* ($C_1\alpha$), Popowka river (WALCOTT, 1912, GORJANSKY, 1969, p. 63). *Conotreta* and *Acrotreta* are much similar in morphology and in all probability, in the internal structure. It is impossible, without studying of topotype material of *Acrotreta subconica* and *Conotreta rusti*, to resolve this problem. As the original material of *A. subconica* KUTORGA is lacking (the specimens have been lost) and at present, one can not get the material for restudy it seems more reasonable to treat temporarily the genus *Conotreta* as a valuable taxon, as did ROWELL (1965, H 276) and GORJANSKY (1969, Pl. 63).

Age: Ordovician.

Conotreta cf. **mica** GORJANSKY, 1969

(Pl. X, Fig. 12)

Material. — Many fragments of apical parts of the pedicle valves and brachial valves.

Description. — The pedicle valves have a prominent tube-like and straight or almost so apical part which very much reminds one of *Conotreta mica* described and figured by GOR-

JANSKY (1969, Pl. 11, Fig. 2). The brachial valves possess a long median septum starting at the median plate and well marked closely placed cardinal muscle scars. The apical parts of both valves are distinctly pitted, the larger pits being much more numerous than the minute ones.

Occurrence. — Late Lower-Middle Ordovician: Bartoszyce IG-1 (1873·1 m), Gołdap IG-1 (1466·0 m), Kętrzyn IG-1 (1602·0 m), all in north-eastern Poland; Lower Ordovician--Llanvirnian, Kunda horizon, environs of Pskov, USSR and Estonia.

Genus **PARATRETA** n. gen.

Type species: *Paratreta similis* n. sp.

Derivation of the name: Lat. *par, paris* — similar; very similar to some acrotretids like *Conotreta* WALCOTT, *Eurytreta* ROWELL.

Diagnosis. — Relatively large for family, pedicle valve subconical, pseudointerarea catacline or somewhat procline, apex slightly tubular, apical part distinctly pitted, marked bulbous thickening on the ventral slope well pronounced; pedicle tube opening to the valve interior, apical process lamellose, forming anterior wall of cavity, varies in outline from broadly rounded to almost lens-like, pallial sinuses baculate, dorsal septum prominent, trigonal, tarting from the posterior third of the valve; cardinal muscle scars rounded, ver y divergent santeriorly.

Discussion. — The proposed genus resembles *Conotreta* WALCOTT, 1889 inlthe general aspect of the pedicle valve differing mainly in the appearance of the ventral apica part, in the shape and outline of the apical process which are changeable, and in having distinctly baculate pallial sinuses. It is not, at present, clear whether the pattern of pallial markings is of unstable pattern in *Conotreta* or changeable, to such a degree, as is showed by BEDNARCZYK (1959, 1964) and is supposed by GORJANSKY (1969, p. 63) or whether their pinnate pattern is characteristic of the genus (ROWELL, 1965, H 276, 1966). The proposed genus reminds one very much of *Hardrotreta* (ROWELL, 1966) in the outline of the pedicle valve and much in the appearance of the apical cavity and process, differing in the details of dorsal interior; it is similar to *Eurytreta* ROWELL (1966) in the baculate pallial sinuses, and somewhat in the outline of dorsal muscle scars.

Age: Lower to Middle Ordovician.

Paratreta similis n. sp.

(Pls. VI; VII, Figs. 1-3; Pl. VIII, Figs. 1-6; Text-figs. 23, 24)

Holotype: Bp. XV/16*x*; Pl. VIII, Fig. 2 (pedicle valve); paratype: Bp. XV/16*v*, Pl. VIII, Fig. 1 (brachial valve).
Type locality: Bartoszyce, north-castern Poland.
Type horizon: Middle Ordovician (Llandeilo), Bartoszyce IG-1 (1873·1 m), marly limestone.
Derivation of the name: Lat. *similis* — similar in the exterior to the other widely conical acrotretids.

Diagnosis. — Large, pedicle valve widely subconical, apical part arched in profile, pseudointerarea of wavy appearance interthrough slightly marked; brachial valve moderately convex, wider than long.

Material. — Ten pedicles, 20 preserved brachial valves, many fragments.

Approximate dimensions (in mm):

Bp. XV/	Length	Width
16x	1.6	1.48 (holotype, pedicle valve)
16t	1.8	1.5
16v	1.6	2.0 (paratype, brachial valve)

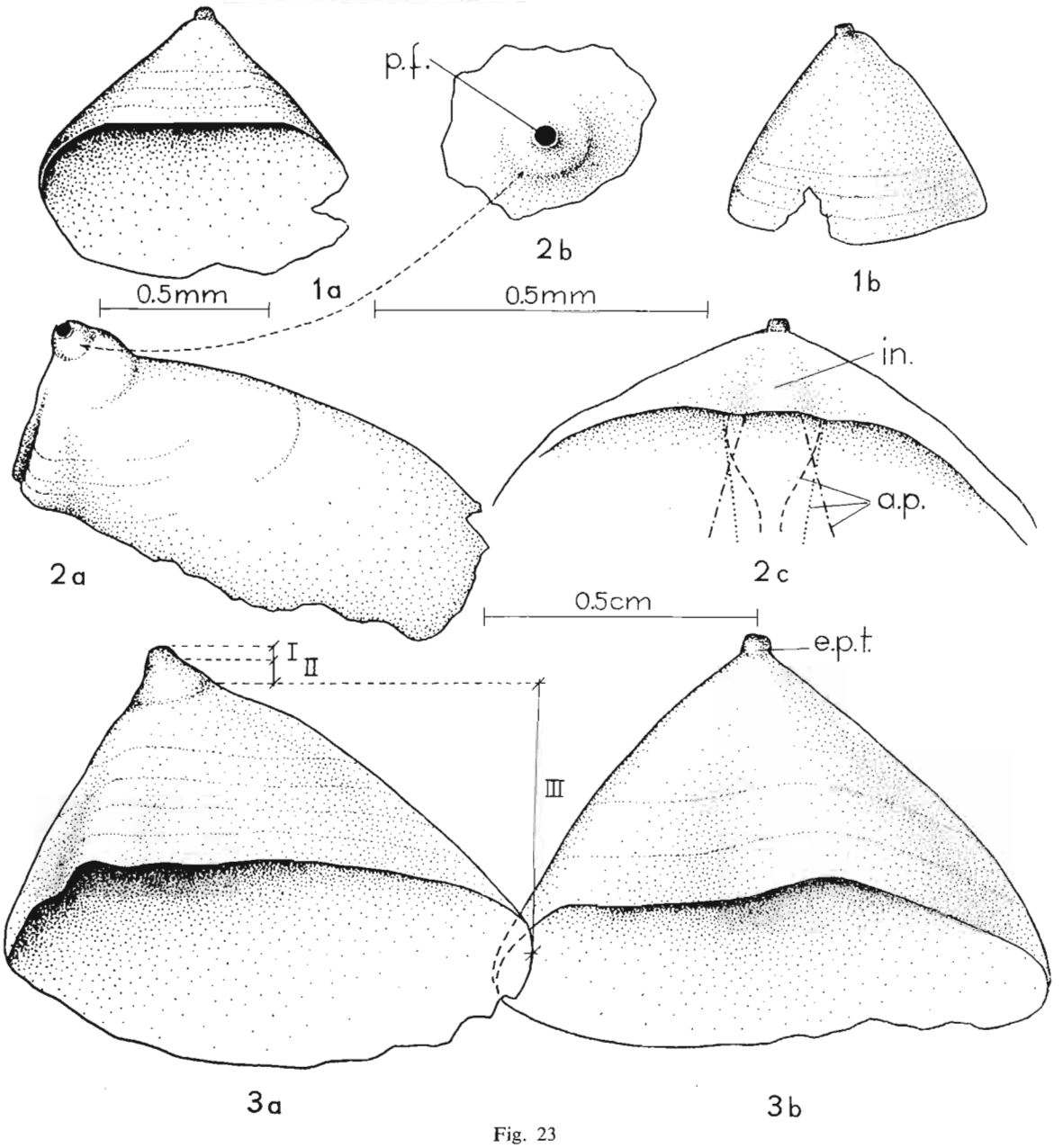

Fig. 23

Paratreta similis n. sp. (Kętrzyn IG-1, 1595·5 m). *1* — pedicle valve in *a* interarea and *b* slightly side views; *2* — adult pedicle valve in *a* side, *b* apical pedicle foramen views, *c* interior view to show different outlines of apical process: *3* — side and interarea views of adult valve, *a* I—III growth stages marked; *p. f.* pedicle foramen, *a. p.* apicai process, e. p. t. external pedicle tube.

Description. — Shell roundly to somewhat transversely outlined, comparatively large in adult stage, attaining to about 2·5 mm in length. Pedicle valve widely conical with a pronounced curvature of the ventral slope (Text-fig. 23, 2*a*), ventral umbo prominent, tube-like, slightly curved; external pedicle foramen small, round, apical; pseudodeltidium catacline to almost procline, not very well delimited from the lateral slopes of valve, distinguished by a slight flattening; intertrough practically invisible. Brachial valve roundly outlined, very moderately arched in lateral view flat or almost so in younger growth stage, dorsal umbo slightly pronounced.

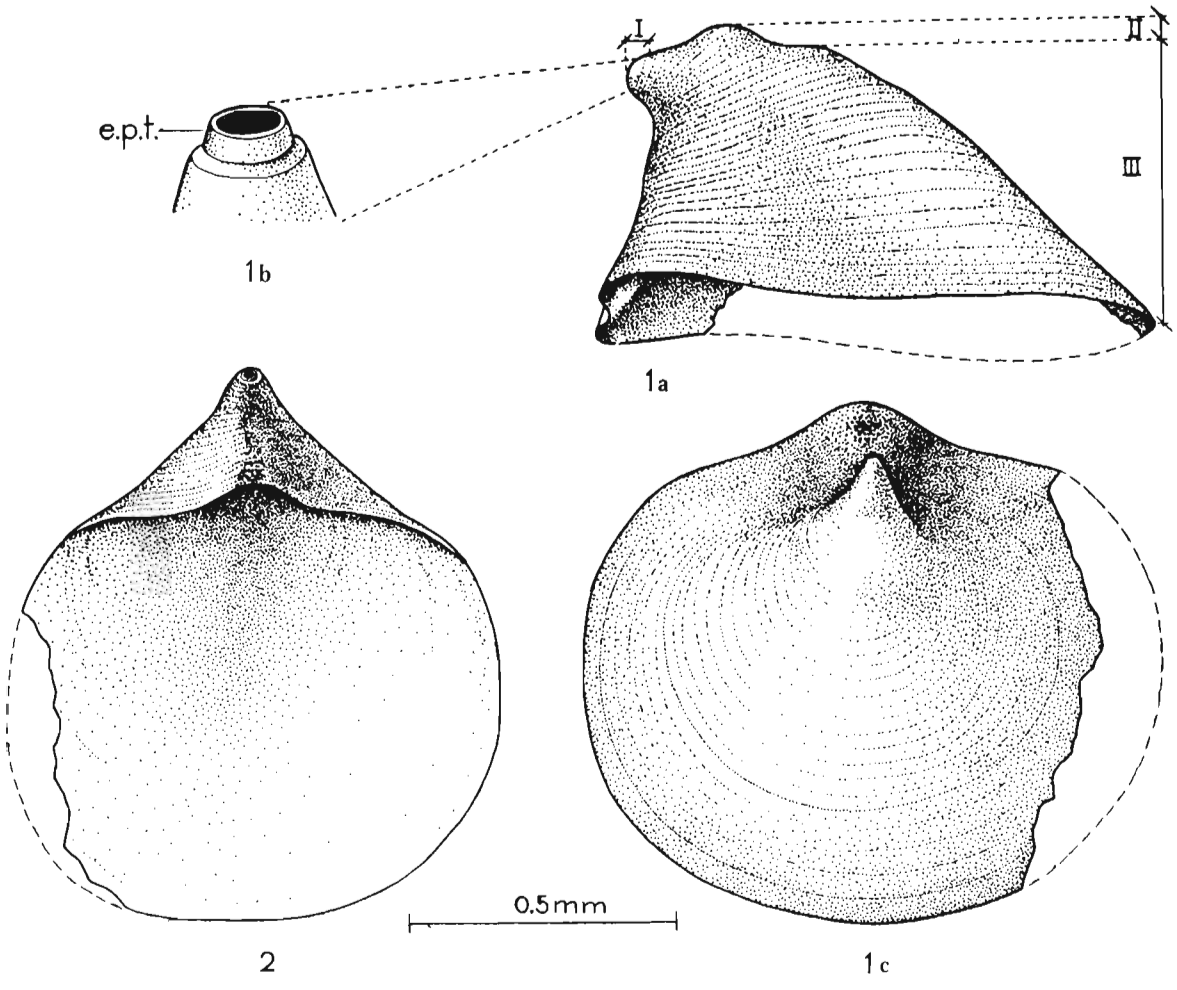

Fig. 24

Paratreta cf. *similis n.* sp. (erratic boulder, No. O. 461). *1*, *2* — two pedicle valves in different positions, *1a* — growth stages I—III showed, *1b* — appearance of external pedicle tube (*e. p. t.*).

Ornamentation consists of concentric wide and elevated macrolines, looking as ridges with rounded backs, of somewhat differentiated thickness, densely and rather regularly spaced all over the valve surfaces, the new ones appearing by splitting or more rarely by intercalation (Pl. VI, Fig. 2).

Internally, pedicle tube opening to the valve interior the foramen being relatively large, bordered at its ventral edge by a lamellose process of varying size outline and shape, being lens-like to almost quadrangular or elongately triangular, posteriorly terminating abruptly

at apical cavity and gradually lowering anteriorly. Its growth changes are much related with the position and appearance of the tubular external apex. It is straight with a more central position in the younger stage, comprising valve length to about 1.2 mm, and the apical process being developed at apical cavity as a distinct bounding ridge-like in *Hardrotreta primaeva* ROWELL (1966, Pl. 1, Fig. 5) of slightly varying sharpness and thickness (Text-fig. 23, 2*c*; Pl. VIII, Figs 5, 6). With advanced growth the external pedicle tube is displaced more dorsally and steeply incurved forming a rather conspicuous external bulbous hump (Pl. VIII, Fig. 3*b*), internally, the ridge-like apical process developes into a thickening, extending anteriorly, unstable in outline marging steeply with floor of the valve.

Dorsal interior possesses a well developed pseudointerarea, moderately concave, propareas anteriorly elevated, median plate slightly extending forward; median septum highly pointed anteriorly of trigonal outline in profile, extending to the anterior third of the valve, its upper edge distinctly concave in side view like *Undiferina rugosa* COOPER (1956, Pl. 18, Fig. 14), the highest point of septum lying in the anterior half of the valve, often thickened, its height and length somewhat changing, the posterior end of septum placed on the posterior third of the valve but never reaching the small median thickening lying just anterior to the median „hinge" plate (Pl. VIII, Fig. 1), cardinal muscle scars large, well pronounced, roundly outlined, distant each from the other and divergent anteriorly (Pl. VII, Fig. 1; Pl. VIII, Fig. 1).

Discussion. — The species, although in many cases fragmentary is quite distinguishable by its incurved dorsally pedicle tube and transverse shell. It reminds much one, especially in the external appearance and some features of the dorsal interior, that of *Conotreta mica* GORJANSKY (1969, Pl. 11, Figs 1-3) differing in the shape of the apical process, appearance of the median „hinge" plate, median septum and cardinal muscles (Pl. VI, VIII, Fig. 1). It also is close to *Hardrotreta primaeva* (WALCOTT), and *Eurytreta curvata* (WALCOTT) figured by ROWELL (1966, Pl. 1, Figs 1-12; Pl. 2, Figs 8-18) in the general appearances of the exterior and some features of the internal structure. To this species are tentatively included two pedicle valves of *Paratreta* cf. *similis* n. sp. from erratic boulder No. O. 461. They are lower in comparison with *Paratreta similis* n. sp., but have similarly developed bulbous thickening well discernible in profile (Text-fig. 24).

Occurrence. — Late Lower-Middle Ordovician, Bartoszyce IG-1 (1873.1—1879.1 m), Gołdap 1G-1 (1466·0 m), Kętrzyn 1G-1 (1595.5—1602.5 m), Jezioro Okrągłe 1G-1 (940.2—941·0 m), north-eastern Poland, erratic boulder, No. O. 461, Jarosławiec, Baltic coast. Age unknown.

Paratreta sp.

(Pl. VII, Figs. 4-5)

Material. — Few pedicle valves, partly damaged.

Discussion. — The few, thin-shelled specimens of pedicle valves (one almost complete), remind very much one of *Paratreta similis* n. sp. The valves in question are more conical, being quite wide anteriorly, the external pedicle tube is slightly longer, but possesses a hump-like curvature on the ventral slope of the valve, just beneath the external pedicle tubs (Pl. VII, Fig. 5), this feature being, among others, characteristic of the genus. Internally, on the ventral side, beneath the internal pedicle tube a trace of apical process like a thickening occurs. It is similarly outlined as in *Paratreta similis*. The interarea is quite well defined and the valve surface is covered by very distinct concentric lines, regularly spaced.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland.

Genus **EURYTRETA** ROWELL, 1966

(Type species: *Acrotreta curvata* WALCOTT, 1902)

Discussion. — Generic features of *Eurytreta* are sufficiently important to distinguish it from the all known acrotretids. *Eurytreta* is large similarly as *Conotreta* WALCOTT, the Cambrian *Canthylotreta* ROWELL, or *Hardrotreta* ROWELL, resembling them also, in the shell shape and outline, as also in the appearance of the ventral interarea. The main differences lie, among others, in the ventral beak not thickened internally (characteristic of *Conotreta*) which is more sharply and less pointed, in the apical process moderately elevated and widening anteriorly and in the baculate pattern of pallial sinuses, in the low ridge-like median dorsal septum and the dorsal cardinal muscle scars being relatively distantly spaced and sometimes very deep, not very divergent anteriorly (comp. Pl. X, Fig. 13). Protegulum pitted, the pattern of pits being very much like that in *Conotreta*.

Species assigned: *Acrotreta curvata* WALCOTT, Lower Ordovician, Nevada, USA; *Eurytreta intermedia* n. sp., Middle Ordovician, north-eastern Poland; *Eurytreta minor* n. sp., Lower Ordovician, Holy Cross Mountains, Poland.

Age: Lower-Middle Ordovician.

Eurytreta intermedia n. sp.

(Pl. IX, Figs. 7-11; Pl. X, Fig. 13; Text-fig. 25)

Holotype: Bp. XV/41*t*, Pl. IX, Fig. 9 (pedicle valve); paratype: Bp. XV/41*o*, Pl. IX, Fig. 8 (brachial valve).
Type locality: Bartoszyce, north-eastern Poland.
Type horizon: Bartoszyce IG-1 (1873.1 m), marly limestone, Llanvirnian-Llandeilo.
Derivation of the name: Lat. *intermedia* — intermediate in its morphology and structure between *E. curvata* and *E. minor*.

Material. — Ten pedicle valves and 3 brachial ones, many fragments.

Approximate dimensions (in mm):

Bp. XV/	Ventral side length	Dorsal side length	Width	
			anteriorly	posteriorly
11t	1.8	?0.6	1.85	0.4

Description. — Pedicle valve of slightly varying length, very widened anteriorly; apical part sharply outlined, pedicle foramen apical, round and small; pseudointerarea moderately concave, apsacline to catacline. Brachial valve weakly convex, apex slightly pronounced.

Ornamentation consists of concentric macrolines, somewhat like concentric bands, rather of equal size, bifurcation or intercalation of new ones sometimes occurs. Internally — ventral beak is not thickened, internal pedicle foramen only slightly smaller than the external one, apical process marked, beginning at the anterior edge of the internal foramen (Text-fig. 25, 1*c*), extending and slightly widening anteriorly (Text-fig. 25), traces of cardinal muscle scars on the dorsal slope of the valve roundly marked, relatively obscured. In the brachial valve pseudointerarea well developed, a little concave in profile, in general almost procline, both propareas slightly elevated on their anterior end, median plate distinctly concave, somewhat extending anteriorly, cardinal muscle scars relatively large, usually rounded or elliptical a little

diverging anteriorly, anterior muscle scars indistinctly marked; median septum ridge like, low but thickened never reaching the anterior margin and the anterior end of the median hinge plate (Pl. IX, Fig. 8).

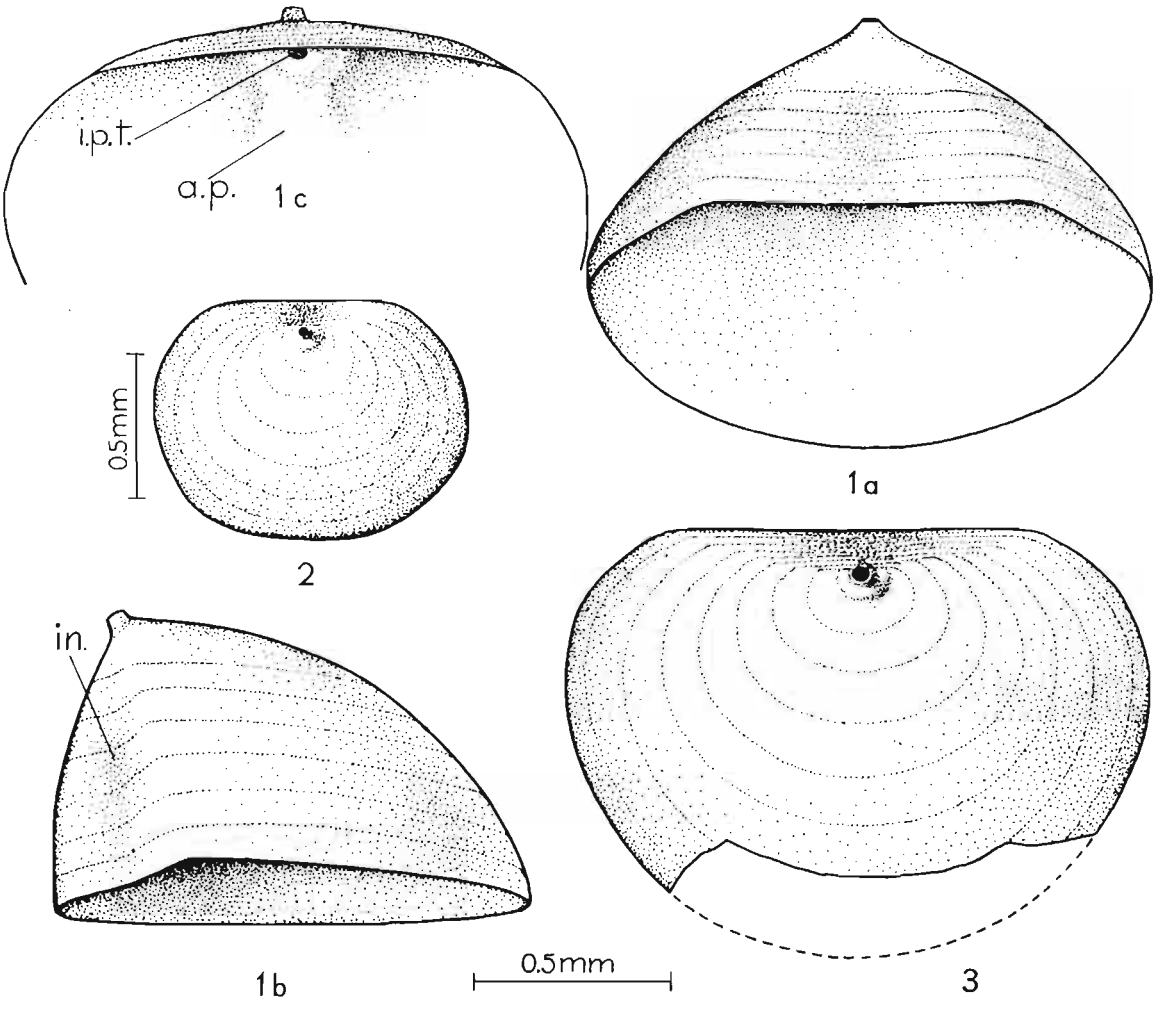

Fig. 25

Eurytreta intermedia n. sp. (Bartoszyce IG-1, 1873·1 m). *1* — pedicle valve, *a* interarea, *b* side, *c* interior views; *2*, *3* — apical views of adult specimen; *i. p. t.* internal pedicle tube, *a. p.* apical process, *in.* interarea.

Discussion. — The species is externally very close to the Lower Ordovician *Eurytreta curvata* (WALCOTT), figured and described in detail by ROWELL (1966, p. 11, Pl. 2, Figs 8-18). The shall outline, appearance of the ventral beak and ventral interarea are much the same. Our specimens seem to be wider, dorsal beak slightly more marked, and the ventral interarea less apsacline.

Occurrence. — ?Late Lower-Middle Ordovician, Bartoszyce IG-1 (1871.1 m), Kętrzyn IG-1, Gołdap IG-1 (1466.5 m), north-eastern Poland.

Eurytreta minor n. sp.

(Pl. IX, Figs. 1-6; Text-fig. 26)

1964. *Acrotreta* (cf. *inchoans*, BARRANDE, 1868) sp.; W. BEDNARCZYK, Stratygrafia i fauna, p. 50, Pl. 9, Fig. 1; (Pl. 12, Figs. 12-14).

Holotype: Bp. XV/16*n*: Pl. IX, Fig. 6 (pedicle valve), paratype: 16*g*, Pl. IX, Fig. 1 (brachial valve).
Type locality: Wysoczki, Holy Cross Mountains, Poland.
Type horizon: Tremadocian (chalcedonites).
Derivation of the name: Lat. *minor* — smaller in comparison to the other members of the genus.

Diagnosis. — Like *Eurytreta intermedia* n. sp., but smaller, ventral interarea more catacline, apical part wider posteriorly, dorsal cardinal muscles a little more elliptical.

Material. — Ten brachial and pedicle valves, mostly broken.
Approximate dimensions (in mm):

Bp. XV/	Length ventral side	Width	
		poster.	anter.
16n	0.6	0.3	0.87 holotype, pedicle valve
16_9	length 0.8	width 1.0	brachial valve

Description. — Small for the genus, pedicle valve widely conical, relatively low, interarea trigonal, a little only concave, intertrough absent or obscured; pedicle foramen small, round, pedicle tube very short, ventral beak not thickened internally. Brachial valve slightly convex in profile, median septum low, ridge like, thickened along the valve floor, its posterior end lying some distance from the median plate; extending anteriorly and never attaining the anterior margin of the valve (Pl. IX, Figs 1, 2), interarea correspondingly small, propareas almost only marked; cardinal muscle scars weekly defined, elliptical in outline and slightly divergent anteriorly (Text-fig. 26).

Ornamentation consists of delicate concentric lines fairly regularly spaced all over the shell surface. In some cases they are very distinct, developed as greatly thickened lines or ridges.

Discussion. — The collection is poor mainly from the aspect of state of preservation and not very suitable due to the early adult stage of specimens. The valves are very translucent, thin-shelled, and no details of internal structure are marked. The apical cavity from the interior shows no traces of the apical process- this element is developed comparatively late in ontogeny, and is an adult feature — hence it is absent in the specimens in question. All valves in the collection are slightly differentiated in size but preserve almost the same shape and outline, the pedicle valve always remaining widely and relatively lowly conical, the brachial valve possessing the similar ratio of the length to the width.

The species in question is here considered as a member of the genus *Eurytreta* ROWELL. This is based, among others, on the general shell shape and outline not thickened ventral beak from the interior, and the general appearance of the brachial valve exteriorly and interiorly, and the degree of the median septal ridge development. The considered species is very easily

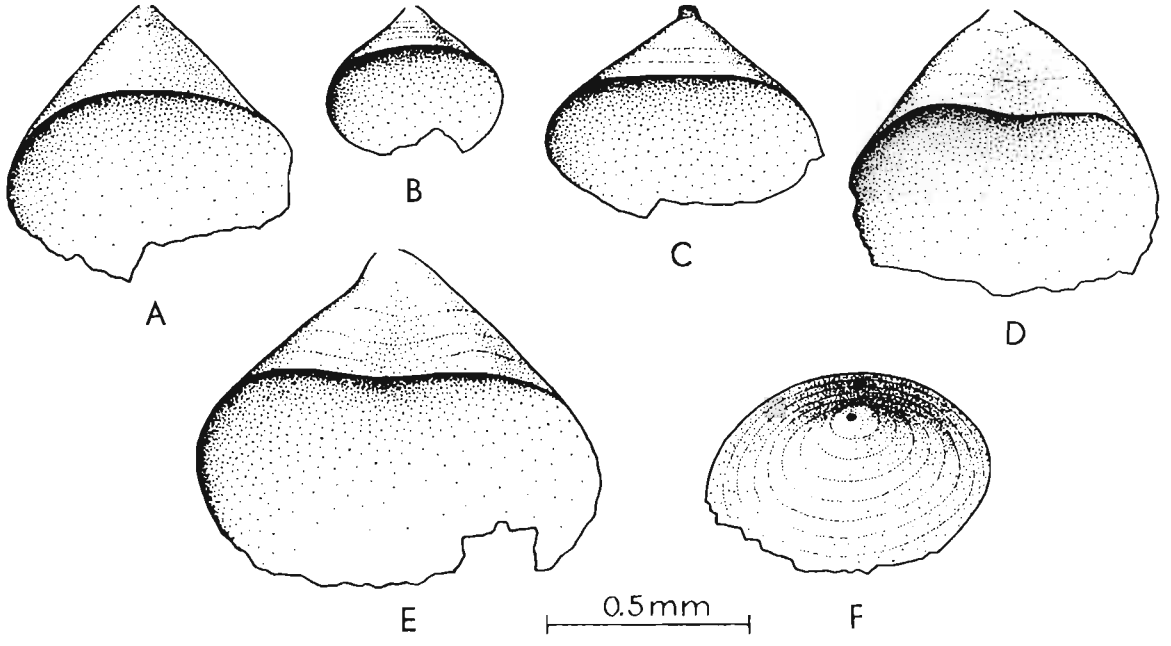

Fig. 26

Eurytreta minor n.sp. (Tremadocian chalcedonites, Wysoczki). *A-E* interarea view of five pedicle valves of different size, *F* apical view of adult specimen.

distinguishable from the other acrotretids which occur in the Tremadocian chalcedonites. The shortly described and figured by BEDNARCZYK *Acrotreta* cf. *inchoans* BARRANDE (1964, Pl. 12, Figs 12-14) from the Tremadocian of Pułaczów and Wysoczki in the Holy Cross Mountains is judged to be conspecific with the above described *Eurytreta minor* n. sp.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland.

Genus **SEMITRETA** n. gen.

Type species: *Semitreta maior* n. sp.
Derivation of the name Lat. *semi* — a half; very close to the members of *Conotreta* WALCOTT.

Diagnosis. — Highly conical acrotretoid with a short external pedicle tube, elongate and widening anteriorly apical process, dorsal septum like a very low but broad septal middle elevation, and reniform, distantly divergent cardinal muscle scars.

Discussion. — Externally, the genus resembles very much the conical acrotretoids like *Torynelasma* COOPER (1956, Pl. 18, Figs 31, 33-34), *Myotreta* GORJANSKY (1969, Pl. 11, Figs 15-16), some members of *Spondylotreta* (*S. faceta* GORJANSKY, 1969, Pl. 10, Fig. 7; present paper: Pl. XI, Fig. 1), or *Conotreta*? *altirostra* COOPER (1956, Pl. 18-G) in its highly conical pedicle valve, but differs in being larger, pedicle valve much widening anteriorly and in the lamellose apical process, which, in its outline, reminds one very much of *Eurytreta* ROWELL (1966, p. 11). The Tremadocian form is, if all its characters are considered together, a quite distinctive taxon.

Age: Lower Ordovician.

Semitreta maior n. sp.

(Pl. X, Figs. 1-11; Text-fig. 27)

Holotype: Z. Pal. Bp/XV/11*u*, Pl. X, Fig. 10 (pedicle valve); paratype: Bp. XV/11*z*, Pl. X, Fig. 11 (brachial valve)
Type locality: Wysoczki, eastern region of Kielce, Holy Cross Mountains, Poland.
Type horizon: Tremadocian (chalcedonites).
Derivation of the name: Lat. *maior* — larger in size in comparison to the other acrotretaceans occurring in the Tremadocian chalcedonites.

Diagnosis. — Relatively large, pedicle valve highly conical greatly widened anteriorly, only slightly incurved in profile; brachial valve with small propareas and median plate, cardinal muscle scars divergent anteriorly, median septum small.

Material. — Thirty pedicle and 10 brachial valves in different size, the pedicle ones almost complete, the brachial valves, usually very damaged; the specimens are thin-shelled, transparent, internal characters badly preserved.

Approximate dimensions (in mm):

Bp. XV/	Length	Width			Length
		poster.	anter.	median	dorsal septum
11k	0.22	0.1	0.2	—	—
11m	0.5	0.12	0.3	—	—
11u	1.3	0.15	1.1	(holotype, pedicle valve)	1
11z	0.9	—	—	1.1	0.45 (paratype, brachial valve)

Description. — Large, pedicle valve developed as a wide conus, posterior end straight or almost so, antero-lateral margins widely rounded, valve slightly arcuate in profile (Text-fig. 27), external pedicle tube thin and short, much like that in *Torynelasma rossicum*, interarea not very distinct. Brachial valve roundly outlined, operculate, almost flat to weakly convex in profile, width slightly exceeding the length or equal to it.

Ornamentation consists of concentric thickened lines, in general weakly preserved, quite regularly spaced on the shell surface (Pl. X, Fig. 7).

Interior. Pedicle valve. Of the internal details only apical process is partly preserved. It is confined to the posterior third of the ventral side of the valve, more extending and widening or less anteriorly. It occurs in larger specimens being an adult feature. A range of smaller specimens of slightly differing size do not show it — this however, may be a question also of the state of preservation after the used etching in the hydrofluoric acid. Brachial valve is like, in general, other members of acrotretoids mainly in the appearance of the posterior region of the valve; the propareas distinct, slightly elevated anteriorly like in *Eurytreta* ROWELL (1966, p. 11) but with a median plate much less depressed, from the anterior edge of which a small and, only slightly marked, platform occurs corresponding to that in *Conotreta* WALCOTT (COOPER, 1956, Pl. 17, Fig. 59); median septal elevation poorly developed in height, but greatly broaded, its posterior end lying some distance from the above mentioned platform (Pl. X, Fig. 11), extending anteriorly but never reaching the anterior margin of the valve; cardinal muscle scars distant, slightly divergent anteriorly, reniform in outline.

Individual variability is limited. Some small changes occur in the outline of the valve and internally in the width of the septal elevation.

Growth changes are also very small. A range of valves both pedicle and brachial ones shows a great regularity in the enlargement of the shell, the same shape and outline being preserved (Pl. X, Figs 1-10; Text-fig. 27).

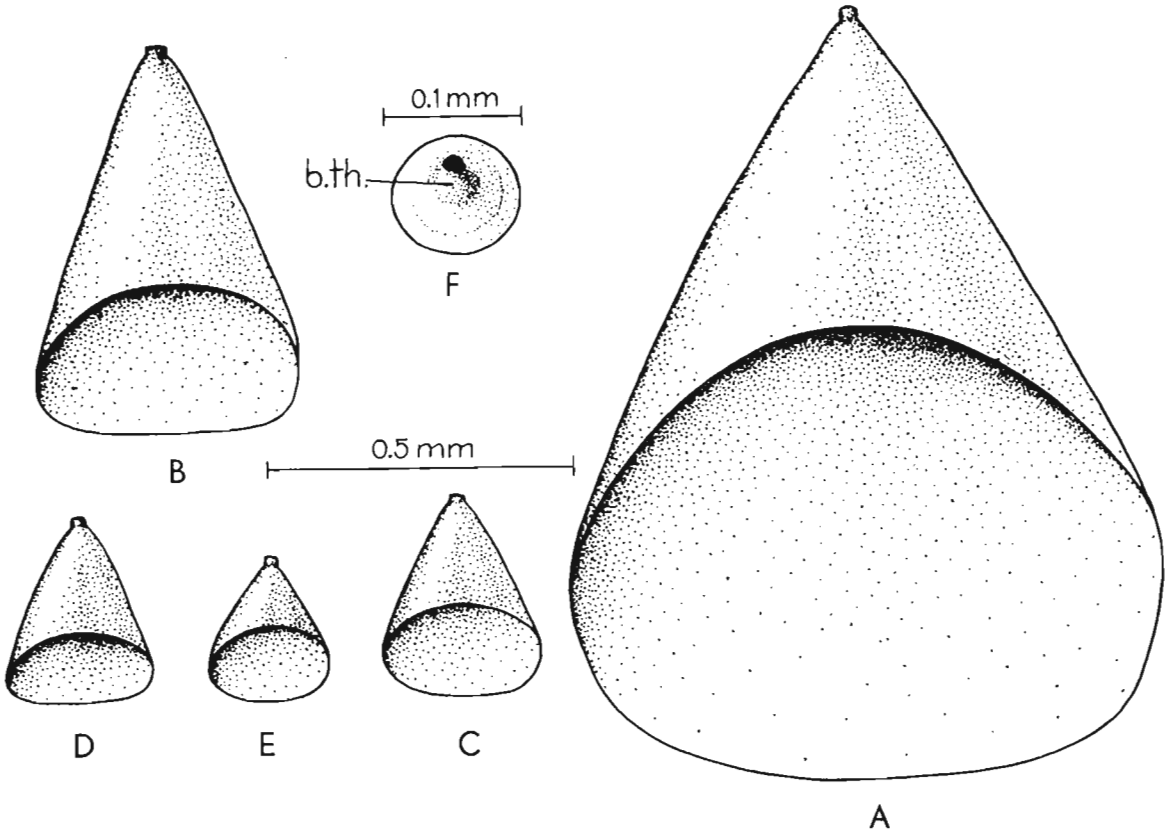

Fig. 27

Semitreta maior n. sp. (Tremadocian chalcedonites, Wysoczki). *A-E* range of five pedicle valves of different size, *F* external pedicle foramen view, bulbous thickening (*b. th.*) present.

Discussion. — The Tremadocian chalcedonite form is considered to be a sufficiently distinct species. The main differences lie in the brachial valve, e. g. lower but much wider median septum, smaller median dorsal plate, and these character together with the conical pedicle valve differ it from the other acrothretoids. Unfortunately, the interior of the pedicle valve, except for the apical process can not be sufficiently known, for some important characters such as pallial sinuses or muscle scars are not preserved. The valves are, all, thin- shelled, only few fragmentary valves are slightly thicker.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland.

Genus **SPONDYLOTRETA** Cooper, 1956

(Type species: *Spondylotreta concentrica* Cooper, 1956)

Diagnosis (emend). — Small, pedicle valve conical, with a distinct septum and pedicle tube, brachial valve with a low median septum starting almost from the anterior end of the median hinge plate, long and triangular in profile; protegula of both valves distinctly pitted, the pits being round, quite deep, the smaller ones encircling the larger are numerous.

Age: Ordovician.

Spondylotreta dissimilis n. sp.

(Pl. XI, Figs. 2-9; Pl. XII, Figs. 1-2)

Holotype: Bp. XV/10*d*, Pl. XI, Fig. 3 (pedicle valve), paratype: Bp. XV/10*k*, Pl. XI, Fig. 5 (brachial valve).
Type locality: Wysoczki, Holy Cross Mountains.
Type horizon: Tremadocian (chalcedonites).
Derivation of the name: Lat. *dissimilis* — not very similar to the type species.

Diagnosis. — Relatively large, ventral conus wide, slightly arched in lateral view, brachial valve almost flat, concentric lines like thickened and broad ridges.

Material — Three not very complete pedicle valves, six brachial valves, many small fragments of valves.

Approximate dimensions (in mm):

Bp. XV/	Length	Width	
		at midlength	anteriorly
10k	0.72	0.84 (brachial valve)	—
10d	1.1 (pedicle valve)	—	1.3

Description. — Pedicle valve widely conical, interarea sufficiently defined due to its flattening, pedicle foramen apical, small, round, opening into the interior; valve in profile moderately arched. Brachial valve roundly outlined, almost circular, width not or only slightly exceeding the length, flat or very gently convex. Shell surface covered with concentric ridges, somewhat thickened, unfortunately not very well preserved due to the etching. The protegular pits are not preserved in these etched shells. Internally, both plates in the ventral cavity form a spoon-like structure slightly anchylosed to each other in their upper side and coalesced on their underside, in addition both plates widen anteriorly being in profile a little crushed (Pl. XI, Fig. 3).

The interarea of the brachial valve is small, both propareas marked, slightly elevated at their anterior ends, median plate narrow, slightly concave medially; median septum in general of moderate height, extending anteriorly but not attaining the anterior margin of the valve, developed as a thin, trigonal in side view plate with a highest point in the anterior half of the valve; cardinal muscle scars elongate oval, divergent anteriorly and distant (Pl. XI, Figs. 5-6).

Discussion. — The species is rare and the specimens although not so thin-shelled as the other acrotretids from the chalcedonites, are not complete and uncrushed valves are lacking.

All this fragmentary collection is not sufficient to give further information about the internal structure. However, all of the preserved and considered features, especially these in the ventral and dorsal interior appear to be so characteristic as to justify the above species as a member of the genus *Spondylotreta* COOPER.

The newly proposed species differs from the other known members of the genus, known from the Middle and Upper Ordovician, in having a wider pedicle valve, less pronounced dorsal septum with its highest point about its midlength, the hinge median plate is marked and the dorsal pseudointerarea smaller. The cardinal muscle scars of the brachial valve agree, to a great extent, with those of the type species *Spondylotreta concentrica* COOPER.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland.

Spondylotreta faceta GORJANSKY, 1969

(Pl. XI, Fig. 1; Text-fig. 28)

1969. *Spondylotreta faceta* GORJANSKY sp. nov.; V. J. GORJANSKY, Bezzamkovye brachiopody... p. 66, Pl. 10, Figs. 7-12.

Material. — One pedicle valve almost complete and 1 fragmentary brachial valve.

Description. — Pedicle valve sufficiently well preserved shows all features of the pedicle valve of *Sp. faceta* GORJANSKY, 1969 (Pl. 10, Figs. 7-12) being similarly conical, possessing marked pseudointerarea defined by a flattened dorsal region of valve, valve being slightly arched in lateral view. Internally, the ventral internal structure is greatly thickened, septum high and both supported plates are well arched (Text-fig. 28, 1). The only small difference is, that the

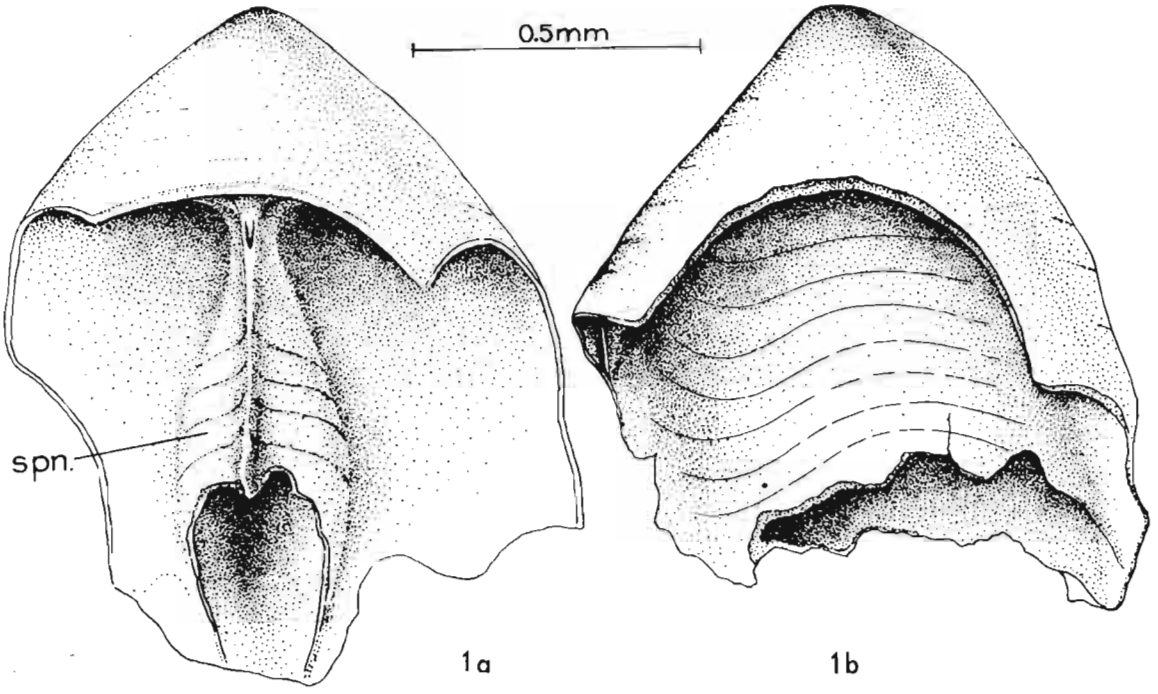

Fig. 28

Spondylotreta faceta GORJANSKY (Suhkrumägi, Estonia). *1* — interior of pedicle valve with a spondylium-like structure (*spn.*).

discussed specimen is slightly more widened in its anterior third (Pl. XI, Fig. 1). Brachial valves are too fragmentary and show a preserved small interarea and a small posterior part of the dorsal septum only.

Occurrence. — Lower Ordovician (Arenigian, Volkhov horizon), locality Suhkrumägi, environs of Tallinn, Estonia. The species occurs in the Lower Ordovician, the uppermost part of Letskij horizon layers with *Pliomeroides primigenus* var. *lamanskij* and *Megalspides (Poporkites) inostrancevi*, occurring, in all probability, also in the upper part of Volkhov horizon in West Estonia and in the upper part of Letskij horizon in east part of Leningrad environs, Russian Platform.

Subfamily MYOTRETINAE n. subfam.

Derivation of the name: ex genus *Myotreta* GORJANSKY, 1969.

Diagnosis. — Shells small, narrowly conical, ventral apex tubular, pedicle foramen opening into the valve cavity, round; protegulum pitted, the pits are round, the large and the small ones separated by distinctly thickened ridges; dorsal septum short, trigonal, simple to very folded, apical process in the pedicle valve lacking.

Remarks. — This is a significant taxon distinguishable and readily separated from the others by a combination of features of external morphology and internal structure. The shells are small, in general smaller than in the other acrotretids, the dorsal median septum appearing relatively late in ontogeny, similarly as in e.g. scaphelasmatids, is one of the characteristic features. It is, in comparison to the general shell size, thick with a tendency to form a high, conspicuous and complicated element, not very comparable with that of the others acrotretids; pedicle valve is much like that of *Ephippelasma* COOPER. To this subfamily is included only one genus — *Myotreta* GORJANSKY.

Age: Ordovician.

Genus **MYOTRETA** GORJANSKY, 1969

(Type species: *Myotreta crassa* GORJANSKY, 1969)

Diagnosis (emend.). — Small to medium size, pedicle valve narrowly conical, to a slightly varying degree widening anteriorly, distinctly arched umbonally in profile, internally without apical process, dorsal median septum simple or, to a different degree folded, always starting about midlength or posterior third of the valve, cardinal muscle scars elongate, protegular pits deep and circular both the large and the small ones.

Discussion. — The genus is one of the acrotretoids very characteristic in its external morphology and internal structure of brachial valve. It is, in general, of the type of *Torynelasma* COOPER or *Ephippelasma* COOPER (COOPER, 1956) in having a conical pedicle valve and operculate brachial valve. The morphological differences are quite considerable and concern mainly the ratio $\frac{\text{pedicle valve width posteriorly}}{\text{pedicle valve width anteriorly}}$, the characteristic arching in profile of the pedicle valve in its posterior third which can somewhat remind one of that in *Paratreta* (Text-fig. 23, 2*a*), the appearance of the cardinal muscle scars which are large in comparison to the general valve size and the median septum in the brachial valve.

Age: Lower-Middle Ordovician.

To that genus are included three, up to now, valuable species, one not defined: *Myotreta crassa* GORJANSKY, Lower Ordovician, USSR, Estonia, Poland *Myotreta estoniana* n. sp., Lower Ordovician (Arenigian), Poland; Estonia; *Myotreta* sp., Lower Ordovician, Poland. In addition, to that genus could be included specimens of pedicle valves described from the Lower and Middle Ordovician, Oslo region, Norway (POULSEN, 1971).

Myotreta crassa GORJANSKY, 1969

(Pl. XIII, Figs. 1-9; Pl. XIV, Figs. 6-7; Pl. XV, Figs. 1-5; Text-fig. 29)

1969. *Myotreta crassa* GORJANSKY sp. nov.; V. J. GORJANSKY, Bezzamkovye brachiopody..., p. 67, Pl. 11, Figs. 10-27.

Material. — Fifty separate pedicle and brachial valves, all well preserved. Approximate dimensions (in mm):

Bp. XV/	Length	Width		
		poster.	anter.	
40c	0.50	0.14	0.39	pedicle valves
40d	0.60	0.15	0.38	
40f	0.68	0.20	0.50	

Bp. XV/	Length	Width of septum	Length of septum	Distance from septum poster.	Distance from septum anter.	
35c	0.27	0.30	0.10	0.11	0.06	brachial valves
35d	0.30	0.35	0.11	0.13	0.06	
35f	0.28	0.31	0.09	0.10	0.09	
35g	0.28	0.32	0.06	0.14	0.06	
35h	0.28	0.30	0.07	0.16	0.05	

Description. — Small, pedicle valve narrowly elongate, slightly widening anteriorly, the apical part like a small calpac imposed on the adult valve (Text-fig. 29, B_2), very arched in side view, pedicle foramen round, minute, pedicle tube very small; pseudodeltidium apsacline to slightly anacline, flattened with a slight intertrough (Text-fig. 29, *B*); brachial valve roundly outlined, slightly arched along midline. Ventral interior with a small pedicle tube opening in the deep ventral cavity, apical process lacking; brachial valve with two small propareas, relatively well marked, only a little elevating upwards at their anterior end, median plate well depressed; median septum starting about midlength of the valve just near the anterior end of the cardinal muscle scars, developed as a small, triangular, simple or a little folded plate, very limited in height, upper margin thickened, extending anteriorly but never reaching the anterior margin of the valve (Pl. XIII, Figs 1-4), cardinal muscle scars distinct, lying on both sides of a median depression, elongate, sometimes reniform in outline, divergent anteriorly, placed on small shell elevations (Pl. XIII, Figs 3-4).

Ornamentation consists of concentric macrolines, to a much degree thickened, ridge-like with backs more rounded or less, much less distinct on the anterior part of the pedicle valve and on the lateral slopes of the brachial valve being of somewhat lamellar appearance; the new concentric lines appearing by division or rarely by intercalation; in general they are regularly arranged, usually 4-6 lines occurring at a distance of about 0·08 mm.

Growth changes. All specimens at hands are represented by individuals of two different growth stages, easily recognized. There occur the younger, characterised by a thin shell, more equally conical, i.e. narrowed posteriorly with a pedicle tube almost straight, the apical arching of the ventral valve in side view not at all or only a little accentuated (Text-fig. 29; Pl. XIII, Fig. 6); the dorsal median septum very small, usually only marked about midlength of the

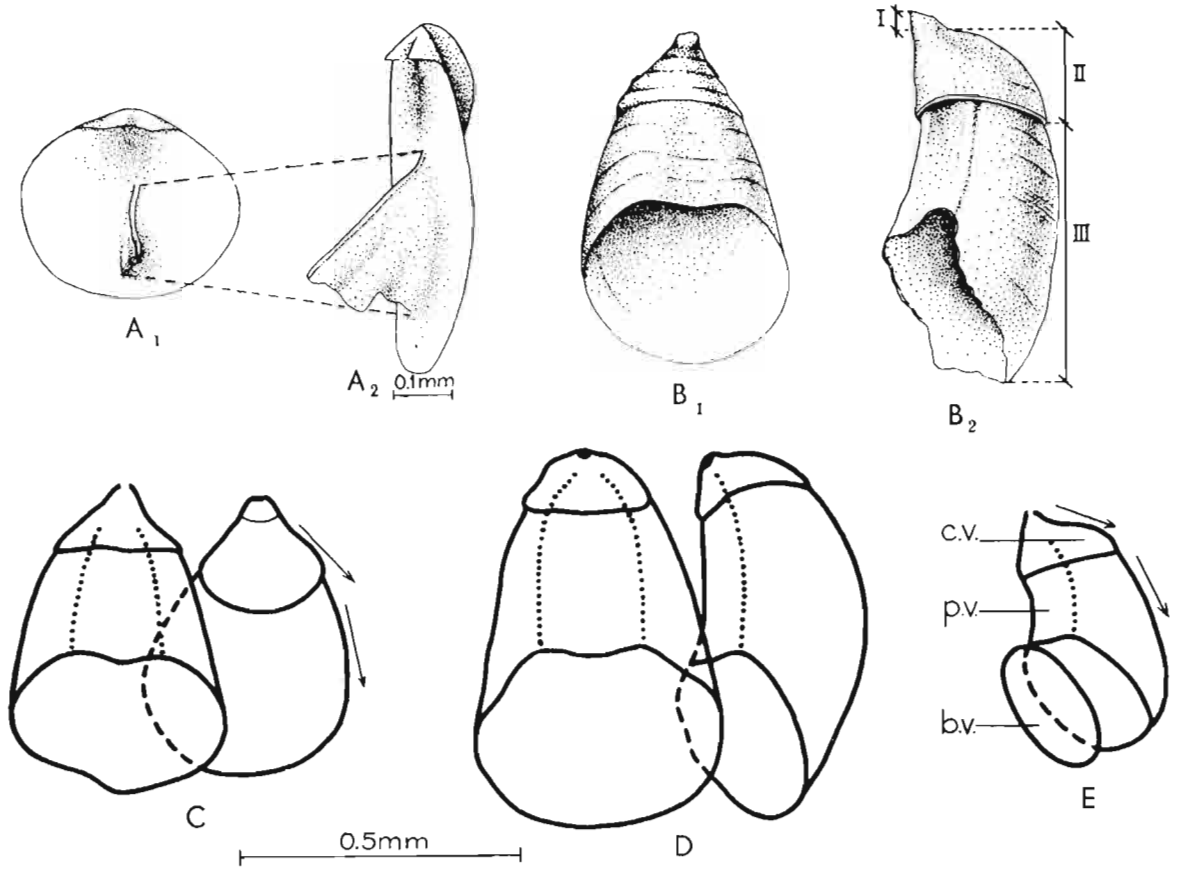

Fig. 29

Myotreta crassa GORJANSKY (Bartoszyce IG-1, 1878·1 m). *A* interior of one brachial valve with a median septum; *B* interarea and side views of pedicle valve, three (I—III) growth stages marked, calpac-like stage corresponding to the IInd one, very extremely distinct; *C*, *D* two different pedicle valves in area and side views; *E* side view of adult pedicle and brachial valves; *c. v.* calpac valve, *b. v.* brachial valve, *p. v.* pedicle valve.

valve (Pl. XIII, Fig. 1). The adult stage starts at the length of about 0·29 mm for the brachial valve and 0·48 mm for the pedicle valve. The pedicle valve is narrowly conical (a feature characteristic for the species), the apical part becoming arched, in side view having a calpac appearance, without distinct concentric ornament which, among others, distinguishes it from the adult valve. The dorsal septum is longer, thicker and in the valves of about 0·3 mm can become slightly folded (Text-fig. 29; Pl. XIII, Fig. 4), usually one small folding appears. These adult features accompanied by a relatively thick valve but very diminutive shell size make this species extremely characteristic and easily recognisable.

Individual variability in this species is very limited, and can only concern the degree of depth in the posterior third of the brachial valve, to a lesser degree the length and height of

the median septum. As to the external morphology, both valves preserve their similar outline and shape.

Discussion. — No differences occur between the specimens described by GORJANSKY from the Middle and Lower Ordovician of USSR (GORJANSKY, 1969, p. 67, Pl. 11, Figs 10-27) and ours. The shell dimensions, shape and outline are the same, also the other features of external morphology and internal structure are almost identical. The acrotretacean brachiopod from the Lower and Middle Ordovician of the Oslo region, Norway described and figured by POULSEN (1971) unfortunately known only from the pedicle valves is very close to M. crassa in the general appearance, differing somewhat in having a longer and more elongate valve. The most posterior part of the pedicle valve is similarly distinguishable from the adult parts of the valve.

Occurrence. — Late Lower-Middle Ordovician, Bartoszyce IG-1 (1873 m), Gołdap IG-1 (1473.6 m), Kętrzyn IG-1 (1595.5-1602 m), north-eastern Poland; Estonia — Volkhov horizon at the Paldiski locality; USSR — Kundskij horizon, near Petchora river, environs of Leningrad.

Myotreta estoniana n. sp.

(Pl. XIII, Figs. 10-13; Pl. XIV, Figs. 1-5; Text-figs. 14-16, 30)

Holotype: Bp. XV/11*y*, Pl. XIV, Fig. 5 (pedicle valve); paratype: Bp. XV/40*z*, Pl. XIII, Fig. 12 (brachial valve).
Type locality: Kętrzyn IG-1, north-eastern part of Poland.
Type horizon: Uppermost Arenigian, Kętrzyn IG-1 (1602·5 m).
Derivation of the name: Lat. *estoniana* — occurring in Estonia.

Diagnosis. — Externally very much like *Myotreta crassa* GORJ. but larger, pedicle valve wider anteriorly, arched umbonally in side view; median dorsal septum considerably folded.

Material. — A number of brachial valves and only 2 pedicle, valves, many fragments of particular valves.

Approximate dimensions (in mm):

Bp. XV/	Length	Width	
		anter.	poster.
11y	0.51	0.23	0.69
	holotype, pedicle valve		
29d	0.57	0.6	0.35

Description. — Median size for the genus; pedicle valve with a relatively greater width anteriorly, arched in side view, especially much in the posterior third of the valve, the posterior part of the valve corresponding to the protegulum and the calpac structure of *Myotreta crassa* GORJ. very small and slightly moved dorsally, pedicle foramen apical, small and round, pseudointerarea apsacline to slightly anacline, flattened. Brachial valve wider than long, roundly outlined, slightly arched umbonally (Pl. XIII, Figs 10-13).

Ornamentation consists of concentric, ridge-like lines, distinctly thickened, regularly spaced on the shell surface; intercalation and bifurcation occurring from time to time. Ventral interior with a very small pedicle tube opening into the deep valve cavity; no apical process. Brachial valve deepened apically, both propareas usually narrow, their anterior margin often linear, only a little elevated; median plate concave, well marked. Median septum beginning at the

posterior valve third, anterior to the posterior concavity; in this latter, in addition, in gerontic valves appear thickenings sometimes forming a small elevation (Pl. XIV, Fig. 4), like a platform, as in *Conotreta*, *Torynelasma* and other forms, to the anterior margin of which the posterior

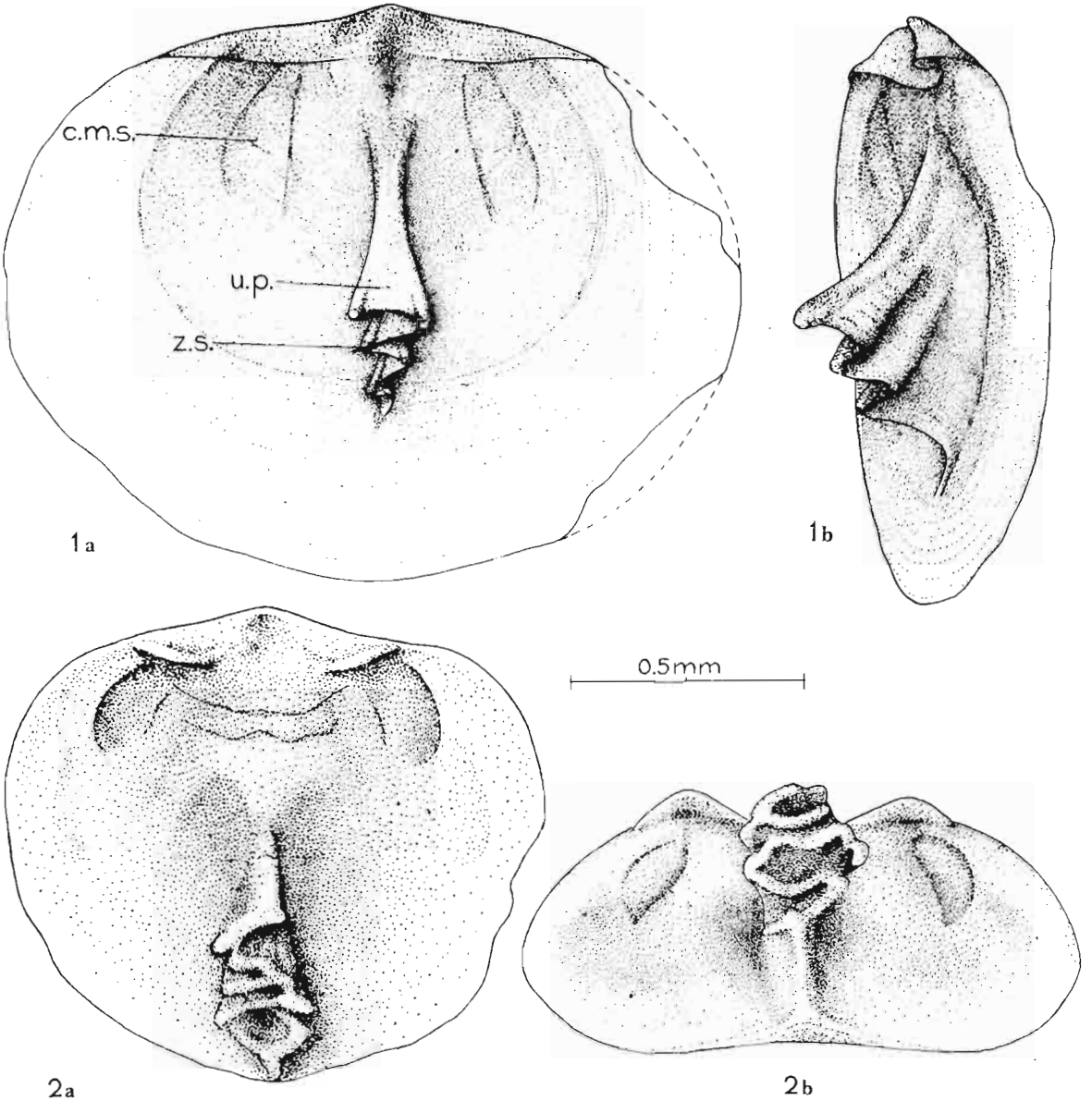

Fig. 30

Myotreta estoniana n. sp. (Suhkrumägi, Estonia). *1, 2* — two brachial valves with a median septum very strongly folded; 2 — internal view of extremely old brachial valve.

end of median septum seems to be „attached". The septum is high, its upper edge thickened and widened, to a varying degree folded (in lateral view), the number of folds depending upon the growth stage showing also some individual variability mainly in the degree of their development;

the folds being more deep or less, sometimes only marked; septum can start to be folded to the left or right, and no regularity is stated, this feature being unstable (Text-figs 14, 30). Cardinal muscle scars large, occupying one third or more of the valve length, elongate oval or reniform in outline (Pl. XIV, Figs 1-4), only a little divergent anteriorly, their appaerance is suggestive of strong muscles; in old valves one could observe traces of probably adductor anterior muscles lying on both side of the median septum, which are smaller and roundly outlined.

Discussion. — The species is characteristic and distinguished from *M. crassa* GORJ. by its larger size, more widely outlined pedicle valve and much more folded dorsal septum.

Occurrence. — Late Lower-Middle Ordovician, Bartoszyce IG-1 (1873 m), Kętrzyn IG-1 (1595·5 m), north-eastern Poland; Suhkrumägi, Estonia, Volkhov horizon; erratic boulder No. O. 178, Mochty, Vistula Valley, Poland.

Myotreta sp.

(Pl. XV, Figs. 6-8)

Description. — In the collection from the Tremadocian chalcedonites there is one incomplete pedicle valve and many fragments, smaller or larger, and incomplete brachial valves. The specimens are extremely thin and transparent. Although the pedicle valve is broken it preserves, however, the general appearance characteristic of *Myotreta crassa* GORJ. (comp. Pl. XIII, Fig. 6) or, to a great degree *M. estoniana* n. sp. (Pl. XIV, Fig. 5) differing in being not or only very little incurved dorsally. It also reminds one very much of acrotretacean pedicle valve (MMH No. 11024) from the *Ceratopyge Limestone* Slemmestadt from the Oslo region, figured by POULSEN (1971, Pl. 1, Fig. 2*a*; Pl. 2, Fig. 3) which, no doubt, is a member of the genus *Myotreta*. As to the brachial valves they are also badly preserved. The appearance of the cardinal muscle scars, median septum and to a great extent, the interarea are also of *Myotreta* character. There is some reason to believe that the discussed specimens are members of the genus *Myotreta* and in all probability, represent a new species which unfortunately can not be defined at present.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland.

Subfamily SCAPHELASMATINAE ROWELL, 1965

Diagnosis. (slightly emend.).— Lowly conical, interthrough well developed, pedicle foramen posterior to the apex; apical process, if present, very small, median septum simple and high, propareas small; protegulum pitted, pits of both size — the larger and smaller round and relatively deep.

Age: Middle Ordovician-Upper Silurian.

Genus **SCAPHELASMA** COOPER, 1956

(Type species: *Scaphelasma septatum* COOPER, 1956)

Discussion.— *Scaphelasma* is a very characteristic genus, very stable in its external morphology and internal structure. The most characteristic and important features are: 1) the dorsal median septum starting almost at midlength or anterior third of the brachial valve and never exactly reaching the anterior valve margin, its height, length and outline show some small

intra- or interspecific variations; 2) the dorsal beak relatively wide and blunt well marked in side view; 3) the pedicle valve lowly conical with the pedicle foramen constantly posterior to the apex, usually round, sometimes lens-like; size of the pedicle foramen depending much upon the growth stage; 4) interthrough marked, usually distinctly; 5) propareas wide, rather well delimited.

Such external features as: the shell ornamentation — including the density and thickness of the concentric thickened lines or lamellae, some differences in the shape and outline of the shell, the degree of distinctness of the interthrough, appearance of the pedicle foramen are the main-specific features, which can change, to some degree and the appearing morphological differences can be well discernible. *Scaphelasma* shows a great similarity to the Silurian genus *Artriotreta* IRELAND, 1961 especially in some details of the internal morphology of both valves. In *Artriotreta* the median septum is shorter, its maximum height lying more anteriorly, the median plate being much narrower, pedicle valve less conical, interthrough deeper and better marked, the „hinge" posterior margin of the pedicle valve being relatively very distinctly incised (IRELAND, 1961, Pl. 137, Figs. 1-4, 7, 8, 10-11).

Age: Late Lower, Middle and Upper Ordovician.

Species assigned: *Scaphelasma septatum* COOPER, Middle Ordovician, U. S. A.; *Scaphelasma rugosum* GORJANSKY, Middle Ordovician, USSR; *Scaphelasma subquadratum* n. sp., Late Lower and Middle Ordovician, Poland; *Scaphelasma* sp., probably Upper Ordovician, erratic boulder, No. O. 247, Jarosławiec, Poland.

Scaphelasma subquadratum n. sp.

(Pl. XVI, Figs. 1-6, 8-10; Pl. XVII, XVIII, XIX; Text-figs. 31, 32)

Holotype: Bp. XV/8*v*, Pl. XVII, Fig. 5 (pedicle valve); paratype; Bp. XV/8*r*, Pl. XVII, Fig. 3 (brachial valve).
Type locality: Kętrzyn; north-eastern part of Poland.
Type horizon: Llanvirnian, Kętrzyn IG-1 (1595 m).
Derivation of the name: Lat. *subquadratum* — subquadrate outline prevailing.

Diagnosis. — Like *Scaphelasma septatum* COOPER (type species), but more transverse in outline, external concentric lines much finer, dorsal septum shorter.

Material. — Twenty pedicle, 35 brachial valves, all well preserved.
Approximate dimensions (in mm):

Bp. XV/	Length	Width	Length of septum	
1c	0.68	0.99	0.37	brachial valve
2c	0.92	1.02	0.57	
3c	0.55	0.67	0.24	
4c	0 88	1.0	0.43	
5c	0.64	0.84	—	pedicle valve
6c	0.86	1.03	—	
7c	0.58	0.78	—	
8c	0.40	0.50	—	

Description. — Shell usually subquadrate in outline very rarely almost quadrate; pedicle valve lowly conical; pseudointerarea trigonal, slightly concave, interthrough marked, pedicle foramen small, round; brachial valve almost flat, slightly arched umbonally (Text-figs. 31, 32).

Ornamentation consisting of concentric macrolines regularly outlined, well distinguishable, densely arranged, looking as thickened concentric ridges with thickened backs (Pl. XVII, Fig. 6). At higher magnification (under scanning electron microscope) the surface ornamentation is, to some extent, differentiated all over the shell surface. The concentric ridges around the protegulum are thicker, distinctly elevated, the new ones appearing by intercalation (Pl. XVII, Fig. 6*b*), on the median part of particular valve they are almost regularly arranged, separated usually by one to three thinner ones, which, however, are not continued along the valve's width (Pl. XVII, Fig. 6). On the anterior part of the shell, mostly on lateral slopes the ridges are of somewhat lamellar appearance, the lamellar surfaces being covered by short oblique thickened wrinkles (Pl. XVII, Fig. 6*b*) of slightly changeable pattern (see p. 31).

Internally, pedicle foramen is surrounded by a slight rim with a shortly extending spike on the ventral side of the valve interior. The dorsal median plate is, very changeable in its outline, being usually in the younger growth stage lens-like, slightly extending anteriorly, with the progressing age it is less lens-like, sometimes its anterior edge being almost linear, as this plate is more transversely or less transversely elongate (Text-fig. 32); medium septum is much of stable appearance, starting always about midlength of the valve, extending anteriorly, never reaching the anterior valve margin; it is, in side view of a trigonal outline with a highest point in the anterior fourth of the valve length, its upper and sloping edges always straight; muscle scars very indistinct, sometimes weak traces of cardinal muscles can be observed, usually roundly outlined (Pl. XVII, Fig. 3).

Growth changes. In the growth process some changes in the general appearance of the shell occur. The pedicle valve almost flat in the younger stage deepens with time, the pedicle foramen in specimens to about 0·27 mm long is round to slightly elongate, relatively large (Text-fig. 31 *D-E*). In much smaller specimens the posterior edge is only inclined, samewhat like in *Orbiculoidea.* In adult stage the pedicle foramen is round but to about two times smaller. Internally, only the rim encircling the pedicle foramen appears and thickens with growth. Brachial valve is, in younger stage (valves to about 0·26 mm long) pentagonal in outline, the dorsal apex being pronounced (Pl. XVI, Figs 2-3). With growth, the posterior edges becomes straight, apex less pronounced, the valves becoming subquadrate in outline (Pl. XVI, Fig. 3).

Internally, the apical cavity is deep and possess (in the length of valve to about 0·25 mm) a distinct median plate, of lens-like appearance, the largest in its middle, narrowing laterally, no propareas or extremely very small are present (Pl. XV, Fig. 1; Text-fig. 32); the posterior margin of both sides of the median plate being slightly elevated and roundly outlined (Pl. XVI, Fig. 3). In general, with growth, when the median septum starts to develop, two small propareas usually appear, remaining, in adult stage very reminiscent.

Median plate is somewhat of variable appearance in adults being linear or preserving the lens-like outline (Text-fig. 32). Median septum, an interesting internal element, appears late in the growth process similarly as in *Myotreta* (Pl. XV, Figs 1-3). Usually, valves of about 0.42 mm long possess extremely faint and short median thickening in the anterior third of the valve at a distance of about 0.24-0.3 mm from the apex (Pl. XVI, Fig. 1).

Some valves about 0.4—0.60 mm long have a median septum looking as a weak median ridge a little only elevated anteriorly. In general, in valves of about 0·84 mm long and 1·00 mm wide the median septum is well developed as a trigonal plate, slightly thickened along its base and highly, to a different degree, elevated anteriorly (Pl. XVII, Fig. 3).

Discussion. — The species is quite characteristic in its external morphology, mostly in being transversely outlined and in having regularly and densely arranged thickened concentric

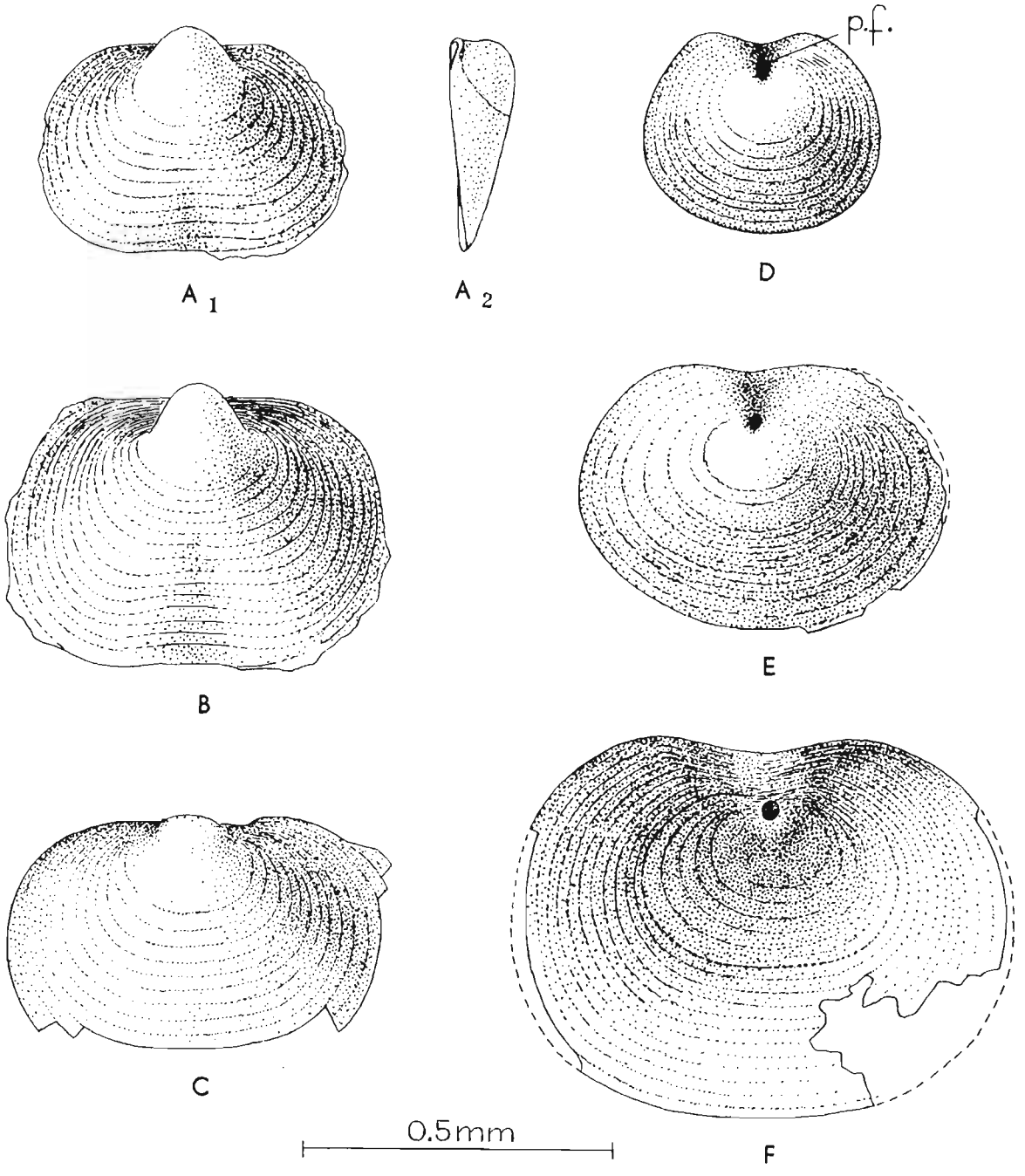

Fig. 31

Scaphelasma subquadratum n. sp. (Kętrzyn 1G-1, 1602·0 m). *A-C* exterior of three different brachial valves, A_2 side view; *D. E* exterior of two different pedicle valves; *F* interior of adult pedicle valve; *p. f.* pedicle foramen.

lines. These are the features mostly differing our species from *Scaphelasma septatum* COOPER, Pratt Ferry Formation (COOPER, 1956, Pl. 18, Figs 70-72) or from Leningrad and Pskov environs — Volkhov and Kunda horizons (GORJANSKY, 1969, p. 70, Pl. 12, Figs. 10-11).

Scaphelasma rugosum GORJANSKY, environs of Pskov, Tallinn horizon, in comparison with our species, is more roundly outlined and the shell surface is ornamented by thick, concentric rugae (GORJANSKY, 1969, p. 71, Pl. 12, Figs. 2, 4), internally the median septum being also longer.

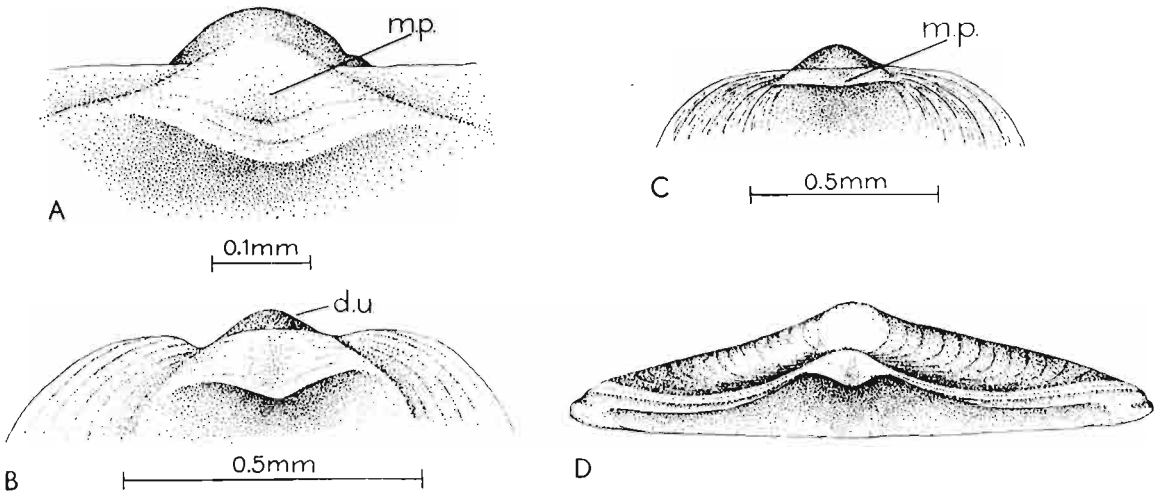

Fig. 32

Scaphelasma subquadratum n. sp. (Gołdap IG-1, 1466·0 m). *A-D* posterior view of four different brachial valves showing variations in the appearance of a median plate; m. p. median plate, d. u. dorsal umbo.

Occurrence. — Late Lower-Middle Ordovician, Kętrzyn IG-1 (1595·5-1602·5 m), Bartoszyce IG-1 (1873·1-1879·1 m), Gołdap IG-1 (1466·9 m), north-eastern Poland; Estonia, environs of Tallinn, Suhkrumägi, Volkhov horizon.

Scaphelasma cf. **septatum** COOPER, 1956

(Text-figs. 5, 33)

Material. — Two brachial valves with well preserved median septum.

Description. — Two specimens, although not very complete, preserve the median septum well developed, standing high above the valve floor. It is in contrary to *Scaphelasma subquadratum* n. sp. (Pl. XVII, Fig. 3), relatively much longer, occupying more than three fourth of the whole valve length, with the highest point near the anterior valve margin. Median plate small, slightly concave, cardinal muscle scars slightly visible.

Ornamentation consists of concentric lines of slightly thickened appearance, regularly arranged.

Discussion. — The specimens in the appearance of the median septum are very close to *Scaphelasma septatum* COOPER from PRATT Ferry Formation, Alabama (COOPER, 1956, Pl. 18, Figs. J, 65-73) and to specimens described by GORJANSKY from Kunda horizon (corresponding to Llanvirnian), environs of Pskov, USSR (GORJANSKY, 1969, Pl. 12, Fig. 10). The only difference

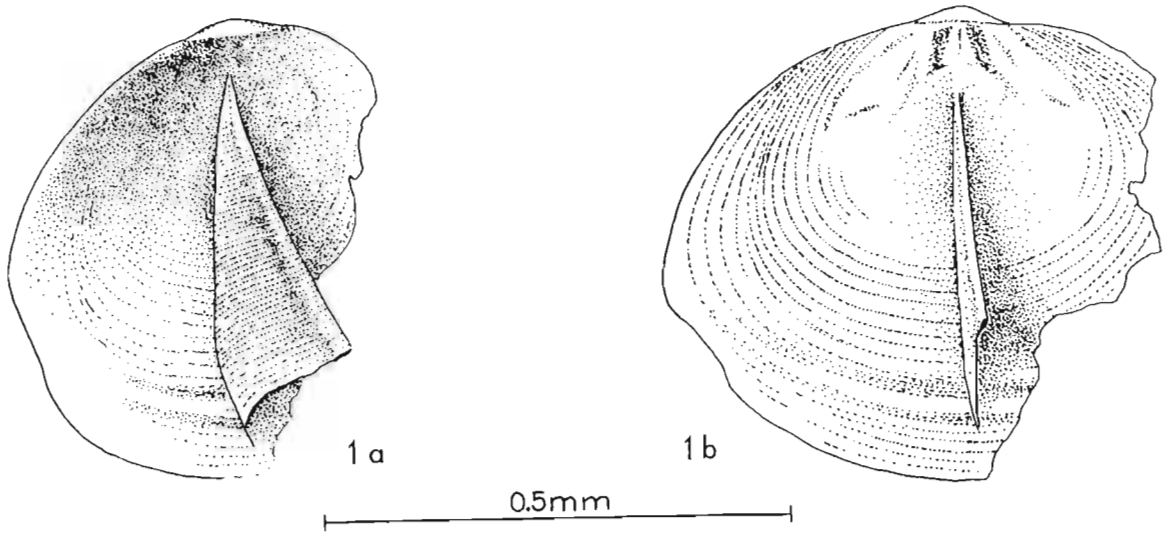

Fig. 33

Scaphelasma cf. *septatum* COOPER (erratic boulder, No. O. 178). *1* — dorsal interior view showing well preserved median septum.

in comparison with our specimens are small variations in the density of concentric surface lines which are more closely spaced in the considered valves, and seem to be slightly thinner.

Occurrence. — Erratic boulder No. O. 178, Mochty, Vistula valley, Poland; Middle Ordovician, North America, Pratt Alabama, Pratt Ferry formation; USSR, environs of Pskov.

Scaphelasma sp.

(Pl. XVI, Fig. 7)

Material. — One complete pedicle valve, one fragment and one brachial valve, fairly well preserved.

Description. — Although the specimens are, in general aspect, extremely similar to the known species of *Scaphelasma*, they possess some differing features which could be of specific rank. The interarea of the pedicle valve is better outlined and larger, the pedicle foramen is quite large, lens-like in outline (Pl. XVI, Fig. 7); the concentric lines are like rugae quite distinct and thickened in the anterior half of the shell, much thicker than in *Scaphelasma subquadratum* n. sp. (Pl. XVI, Fig. 6; Pl. XVII, Fig. 4). The shell is more transverse, both lateral margins are rather moderately arcuate and posterior margin longer. As to the dorsal septum it is similar to that in *Sc. subquadratum* being only slightly longer. The mentioned differences appear to be relatively great but the material is to scarce, hence it is impossible to state whether they are fairly stable and are the specific features or whether these differences lie in the limits of individual variability. It seems, basing on the available material, that the scaphelasmatids are characterized by a great constancy in the external morphology and internal details, and are changing mostly in the direction of widening ventral interarea (elongation of the posterior margin) and probably in a slighty different developing of some structures of the dorsal posterior margin, e. g. median dorsal plate (Text-fig. 32).

Occurrence. — Erratic boulder No. O. 247, Jarosławiec, Poland (Caradocian, Ashgillian?).

Subfamily TORYNELASMATINAE Rowell, 1965

Diagnosis (emend.). — Pedicle valve conical; protegulum of both valves pitted, the larger pits round and shallow surrounded by a number of smaller ones; dorsal pseudointerarea undivided, medium septum arising slightly anteriorly or some distance to beak, bearing a concave, flat or slightly arched plate on its posteroventral edge.

Discussion. — One of the internal changeable features is the dorsal septum, well developed of complex type (vide p. 45) in the genus *Torynelasma* Cooper and much reduced in the Silurian genus *Acrotretella* Ireland. This latter genus, although, to some extent, controversial, possesses a median septum weakly developed, which can, however, remind one of *Torynelasma*. This structure in the Silurian form could represent an advanced stage of development, attaining considerable simplicity in the shape of this element as also loosing its distinctness. Another feature which could support the including of this genus to the subfamily is the character of the protegular pits- they, however, have not yet been studied in *Acrotretella*.

Age: Ordovician — Silurian.

Genus **TORYNELASMA** Cooper, 1956

(Type species: *Torynelasma toryniferum* Cooper, 1956)

Diagnosis (slightly emend.). — Small, pedicle valve widely to narrowly conical, cone higher or shorter, median septum complex, long or relatively short, saddle like or with surmounting plate triangular, to a different degree, bent along its both lateral sides. Protegulum pitted.

Discussion. — The genus comprises a small group of species externally very alike, but differing somewhat in the appearance of a median septum. It is always of a complex type (vide p. 45) but, in general, distinctly saddle-spoon like as is shown by the type species *Torynelasma toryniferum* (Cooper, 1956, Pl. 18*E*, I) or the surmounting plate is flat to slightly arcuate on its back as is illustrated by *T. rossicum* Gorjansky (*vide* Pls. XX, XXI). The latter type of septum, as far as is known, constantly occurs in the European species. It includes a number of smaller variants, as the length, degree of flattening or arching of the surmounting plate are somewhat changeable. This differing feature could be considered as valuable on the generic level. It seems, however, very probable that the torynelasmatids described by Cooper from Pratt Ferry Formation could also develop a similar structure to ours. A range of illustrated brachial valves shows in a few cases, a septum suggesting a flat or slightly arched surmouting plate (Cooper, 1956, Pl. 18, Figs. I, 61-62). The other available external features are the same both in our forms and those from Alabama. Also the pattern of protegular pitting is identical. Thus, the here considered species are judged to be members of a genus *Torynelasma* Cooper which displays a septum much varying in appearance.

Species assigned: *Torynelasma toryniferum* Cooper, Middle Ordovician, N. America; *T. minor* Cooper, Middle Ordovician, N. America; *T. rossicum* Gorjansky, Lower and Middle Ordovician, West USSR; *T. (?) magnum* Gorjansky, Lower Ordovician, Estonia; *T. rarum* n. sp., Middle Ordovician, Poland; *Torynelasma* sp., Lower Ordovician, Estonia.

Age: Lower and Middle Ordovician.

Torynelasma rarum n. sp.

(Pl. XX, Figs. 12, 13)

Type specimen: Bp. XV/5, Pl. XX, Fig. 12*a*, *b*.
Type locality: Jezioro Okrągle, north-eastern Poland.
Type horizon: Caradocian, Jezioro Okrągle IG-1 (depth 909 m).
Derivation of the name: Lat. *rarum* — rare, rarely found in the studied deposits.

Diagnosis. — Small, pedicle valve widely conical, brachial valve roundly outlined, surmounting plate of the dorsal septum long with arched upper back.

Material. — One complete shell with both valves preserved, few small fragments of pedicle valves, rare.

Approximate dimensions (in mm):

			Width	
Bp. XV/5	Holotype, ventral valve	Length 1.0	anter. 0.86	poster. 0.2
Bp. XV/6b	brachial valve	0.83	0.86	—

Description. — Small, pedicle valve widely conical, pedicle foramen apical, brachial valve roundly outlined, apex slightly pronounced. Surface ornamentation consists of concerntric, thickened macrolines fairly regularly arranged all over the shell surface.

Interior. Pedicle valve without apical process, brachial valve with a small pseudointerarea, undivided, median plate slightly concave; median septum long, starting some distance from the beak, high, its highest point lying on fourth anterior of the valve, bearing a long, to a varying degree, convex plate with comparatively large lateral walls.

Discussion. — It is a distinct species and although represented by a very limited number of specimens, much differing from the other members of the genus. One of the external differences is the relatively low and wide conus due to which the pedicle valve makes an impression of a slightly shortened valve, but of a very regular triangular outline. The concentric lines are thickened and less densely outlined. The dorsal median septum is also very characteristic in its outline; much narrowed posteriorly and widened anteriorly, the upper back of the surmounting plate is arcuate, this plate being, in addition, very long. All these mentioned features differ *T. rarum* from the other known species. To mention, the brachial valve is very regularly rounded and the platform between the anterior edge of the median „hinge" plate and posterior end of the median septum is less developed and of slightly different appearance (Pl. XX, Fig. 13). Unfortunately, no observations on the protegular pits could be made. Supposedly, the pattern of pits is of *Torynelasma* type.

Occurrence. — Late-Middle Ordovician, Jezioro Okrągle IG-1, Gołdap IG-1, north-eastern Poland.

Torynelasma sp.

(Pl. XXI, Figs. 1, 6; Text-fig. 8)

Material. — One complete brachial valve and few fragmentary pedicle valves.

Remarks. — The mentioned specimens show some features of *Torynelasma rarum* n. sp., mainly in having a long septum, the surmounting plate is, however, more flat, the platform

at the posterior end of the septum not marked, median „hinge" plate smaller. As to the pedicle valve, it is very much between e.g. *Torynelasma rossicum* GORJ. (Pl. XX, Figs. 8-9) and *T. rarum* n. sp. (Pl. XX, Fig. 12*a*). The conus is widened anteriorly but it is still narrower and longer in comparison to the latter species. These all differences could be of specific value but must be ascertained on larger number of specimens.

Occurrence. — Arenigian, Volkhov horizon, Suhkrumägi, environs of Tallinn, Estonia; erratic boulder No. O. 178, Mochty, Vistula valley, Poland.

Torynelasma rossicum GORJANSKY, 1969

(Pl. XX, Figs. 1-11; Pl. XXI, Figs. 2-5; Pl. XXII; Text-figs. 9, 18, 34)

1969. *Torynelasma minor rossicum* GORJANSKY, subsp. nov.; V. GORJANSKY, Bezzamkovye brachiopody..., p. 71, Pl. 12, Figs. 15-21.

Material. — Thirty brachial and 50 pedicle valves, majority of pedicle valve damaged. Approximate dimensions (in mm):

Bp. XV/	Length	Width	Length of septum	
44a	0.33	0.40	0.23	brachial valves
45a	0.38	0.40	0.28	Bartoszyce
51	0.35	0.38	0 27	Kętrzyn
56a	0.40	0.45	0.30	

Bp. XV/	Length	Width		
		poster.	anter.	
46a	0.50	0.1	0.38	pedicle valves
48a	0.65	0.09	0.33	Bartoszyce
49a	0.45	0.08	0.38	
50a	0.33	0.07	0.36	
60a	0.53	0.11	0.38	Kętrzyn
62a	0.45	0.07	0.38	
63a	0.47	0.07	0.30	
66a	0.35	0.06	0.30	

Description. — Small, pedicle valve narrowly conical, pseudointerarea flattened, with a very slight trace of interthrough; brachial valve slightly convex in profile, roundly outlined, apex weakly pronounced. Concentric lines are thickened, densely covering the whole shell surface, not always very distinct, on the pseudointerarea sector often spliting two to three times, being in a such a way more distinct and narrower (Pl. XXII, Figs. 3, 4). Interior of the pedicle valve not studied. The dorsal pseudointerarea, sometimes weakly marked, very small; median septum starting from the marked area (Pl. XXI, Fig. 2; Text-fig. 34) as a thickened platform, lying anteriorly to pseudodeltidium; septum high, extending anteriorly, the highest point anterior to midlength of the valve, bearing a short plate, to a varying degree convex, sometimes almost flat, its lateral walls slightly varying in size.

Variability. — The variations concern mainly the appearance of the median dorsal septum, its height and position of the highest point, size of the upper plate and the degree of its arching. Very unimportant variations are marked in the degree of the pedicle valve elongation.

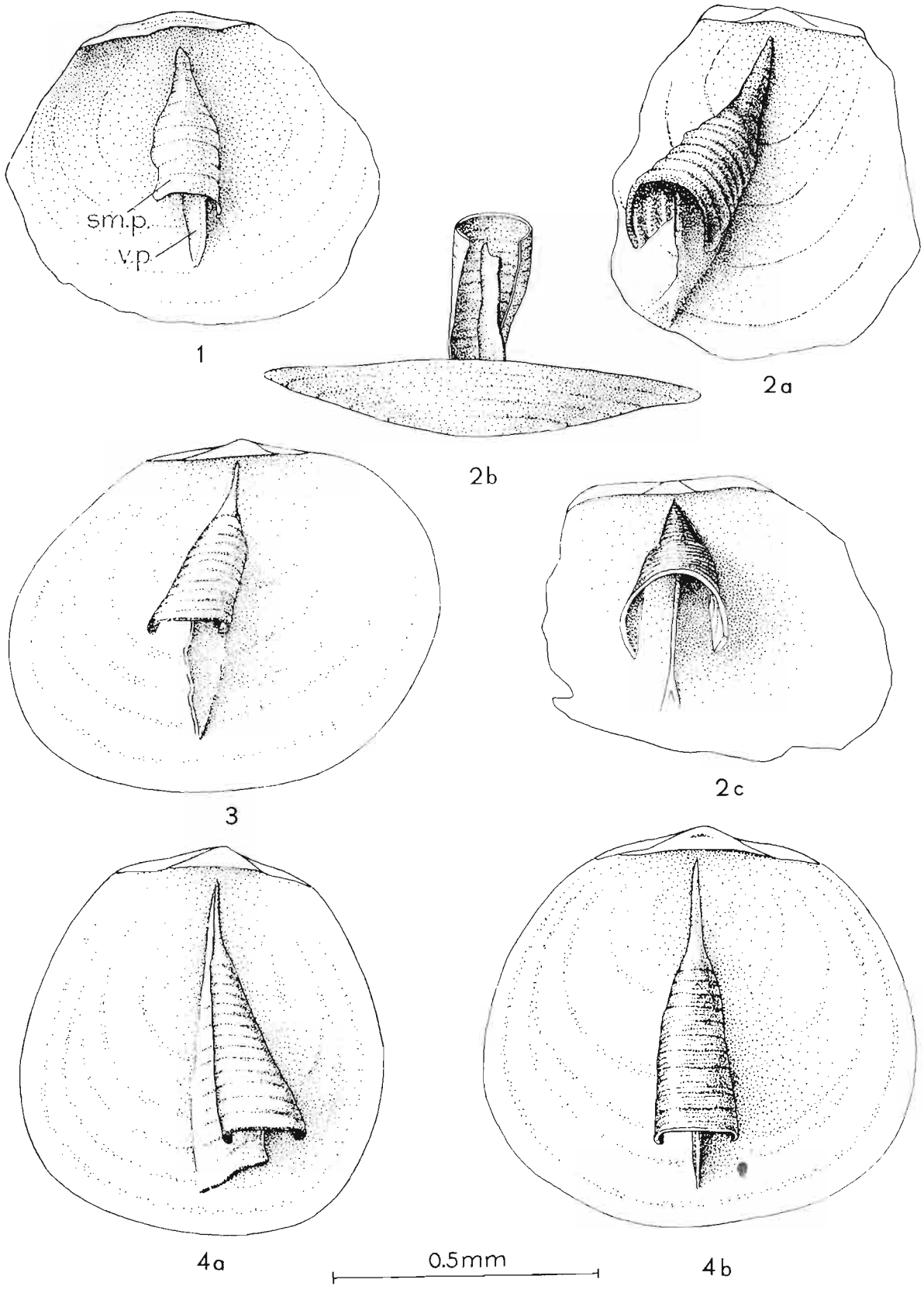

Fig. 34

Torynelasma rossicum GORJANSKY (erratic boulder No. O. 418). *1-4* — dorsal complex septum in different views, *2b* — anterior view showing a degree of septum elevation; *sm. p.* surmounting plate, *v. p.* vertical plate.

Discussion. — The collection is quite numerous, the most numerous specimens come from Kętrzyn, much less from Bartoszyce, or Estonia. One of the negative features of the whole collection is that the specimens are of not very advanced adult age hence the shells are usually very thin, their dorsal septum being, however, well developed (Pls. XX, XXI; Text-fig. 34). In addition, to the mentioned species are tentatively, included three brachial valves the surmounting septal plate of which is distinctly divided into two parts, these latter very diverge anteriorly and are bent to the valve bottom. The pedicle valves are unknown (vide p. 45, Text-fig. 18). Our specimens are of the type of the GORJANSKY's species from the Lower and Middle Ordovician of the Pskov environs (1969, Pl. 12, Figs. 15-21) and practically no important differences occur. Exterior of both valves is the same, also variations in the length of the dorsal septum are similar.

Occurrence. — Late Lower-Middle Ordovician; Kętrzyn IG-1 (1595.5-1602.5 m), Bartoszyce IG-1 (1873.1-1879.1 m), Gołdap IG-1 (1466.9-1473.6 m), north-estern part of Poland, erratic boulder No. O. 417, Międzyzdroje, Baltic coast; Lower and Middle Ordovician, environs of Pskov, USSR, Estonia.

Subfamily EPHIPPELASMATINAE ROWELL, 1965

Diagnosis (emend.). — Pedicle valve conical, apical process lacking, pedicle foramen small, round, apical, dorsal propareas small and median plate concave; dorsal saddle like plate digitate or spinose, attached by its posterior end to the posterior third of the valve floor or supported by a vertical plate; protegula of both valves pitted, pits round and comparatively deep, the encircling smaller pits of a limited number.

Discussion. — The subfamily is small, comprising, up to now, one genus, displaying rather simple external morphology and complex median septum, the surmounting plate being rather very variable. The subfamily constitutes one of isolated groups within the acrotretids. This group of acrotretids could probably deviate from the acrotretinae and seems to be very close to the Cambrian genus *Prototreta* BELL (1941, p. 221) mainly by realizing, to some extent, more complicated appearance of the median septum.

Age: Ordovician.

Genus **EPHIPPELASMA** COOPER, 1956

(Type species: *Ephippelasma minutum* COOPER, 1956)

Diagnosis (emend.). — Small, pedicle valve widely conical, varying in its length, apically arched in side view, interarea relatively well delimited; brachial valve with a septum complex, with or without supporting vertical plate, surmounting plate of variable appearance, spinose marginally or/and on the under side, often displaying the spikes; protegular pits round, distinct.

Age: Late Lower-Middle Ordovician-?Upper Ordovician.

Discussion. — Our forms are very much like *Ephippelasma* COOPER in the general appearance of the pedicle valve, the detailed morphology of the dorsal posterior margin, in the outline of the cardinal muscle scars and in the general appearance of the median septum. In our case, however, the vertical supporting plate always occurs, developed to a different degree, and in old individuals being often extremely short and very weakly marked. The surmounting

plate is very variable in its general appearance, being wider, or more elongate, bearing the spines on its under side together with the marginal ones, or only spikes. Their appearance in the fossil state much depends upon the state of preservation (vide p. 50) of these structures.

The septum externally can, to a great extent, be compared to that of the Middle Cambrian *Prototreta* BELL (1941, Pl. 31, Figs 44-48) or *Angulotreta* PALMER in which the upper plate being digitate or flabellate is also supported by a vertical plate. Also the propareas of the dorsal interarea vary somewhat, being slightly larger or smaller, but rather well preserved. As to the pedicle valves there occur some variations in length. They can be more elongate or with length greatly reduced however, the width at the anterior valve margin remains almost unchangeable (Pls. XXIII, XXIV). Despite of the mentioned differences our form is included to the genus *Ephippelasma* COOPER, and interpreted as a quite variable taxon.

Age: Ordovician.

Ephippelasma spinosum n. sp.

(Pl. XXIII; Pl. XXIV, Fig. 9; Pl. XXV; Pl. XXVI; Text-figs. 10, 19*A*, 35)

Holotype: Bp. XV/12z, Pl. XXIII, Fig. 11 (pedicle valve); paratype: Bp. XV/11z, Pl. XXIII, Fig. 10 (brachial valve).

Type locality: Kętrzyn, north-eastern part of Poland.

Type horizon: Llanvirnian, Kętrzyn IG-1 (1595.5 m).

Derivation of the name: Lat. *spinosum* — because of spinose dorsal septum.

Diagnosis. — Small, widely conical, brachial valve with a septum of complex type, supporting plate short, the surmounting plate spinose.

Material. — Sixty pedicle and brachial valves, separated; two complete shells with both valves closed; all specimens, in general, well preserved.

Approximate dimensions (in mm):

Bp. XV/	Length	Width			Length of septum
		poster.	anter.	median	
12z	1.2	1.3	1.0	— (holotype, pedicle — valve)	—
9b	0.61	—	—	0.98	0.28 brachial
9c	0.65	—	—	0.80	0.26 valves

Description. — Small, pedicle valve widely conical; interarea flattened with a weak trace of ?interthrough, pedicle foramen small, round, marked by a slight thickening (Text-fig. 10), opening to the valve cavity by a short tube ended with a small rim, brachial valve flat or a little concave, apex weakly pronounced, arching in the lateral view.

Ornamentation consists of concentric thick, and almost regularly spaced lines--like ridges, with rounded backs, well pronounced being separated by relatively deep furrows; the new concentric lines appearing mostly by bifurcation which is not rare (Pl. XXIV, Fig. 9). Internally, pseudodeltidium in the brachial valve small, both propareas elongate transversely, narrow and a little elevated above the valve floor (Pl. XXIII, Figs 1-10); median plate medially deepened, its anterior edge unmarkedly thickened; median septum of complex type, very

unstable in its appearance, composed of a median, thickened vertical plate, occupying usually, about a half of the valve length or slightly more, sometimes being very short; it bears a surmounting plate of a varying appearance. A typical form of this plate is like a trigonal entire or flabellate plate, greatly widening anteriorly, with spinose (in old specimens spikose marginal ends, and/or a few of ranges on the under side (Pl. XXVI, Fig. 1; Text-fig. 35). Septum starting some distance from the beak, in the posterior third of the valve, sometimes, a thickened platform like small elevation at the posterior end of septum occurs (Pl. XXIII, Fig. 8). Often very great deformations of septum are observed. Muscle scars practically not visible, sometimes only the very weak traces of the cardinal muscles can be discernible, being elongate and slightly divergent anteriorly (Pl. XXIII, Fig. 8).

Variability. — The shape and outline appear to be stable, only some variations occur in the shell size, degree of pedicle valve arching in side view, depth of the brachial valve. Internally, as mentioned, the median septum is quite changeable, usually in the number of spines, and the degree of expansion of the septal plate. The species in easily discernible. Some variations occur in the appearance of dorsal small propareas, which can be unmarkedly more elongate or less.

Discussion. — The species is characteristic in its external morphology, distinguished by the shape and outline of the pedicle valve, and internally by the structure of the „hinge" margin and septum. It is much like *Ephippelasma minutum* COOPER, but the pedicle valve is wider and shorter and the dorsal expanded septal plate is attached by its posterior end to the dorsal third of the valve floor and supported by a vertical septal plate.

Occurrence. — Late Lower-Middle Ordovician; Kętrzyn IG-1 (1595.5—1602.5 m), Bartoszyce IG-1 (1873.1—1879.1 m), occurring in a great number of specimens, much rarely recorded in Gołdap bore-hole IG-1 (1466.9—1473.6 m), north-eastern part of Poland.

Ephippelasma latior n. sp.

(Pl. XXIV, Figs. 1-8; Text-fig. 6)

Holotype: Bp. XV/13*t*, Pl. XXIV, Fig. 8 (pedicle valve); paratype: Bp. XV/13*v*, Pl. XXIV, Fig. 4 (brachial valve)
Type locality: Kętrzyn, north-eastern of Poland.
Type horizon: Llanvirnian, Kętrzyn IG-1 (1595.5 m).
Derivation of the name: Lat. *latior* — broader in comparison to *Ephippelasma spinosum* n. sp.

Diagnosis. — Like *Ephippelasma spinosum* n. sp. but much lower and wider, dorsal propareas smaller.

Material. — Eight pedicle and two brachial valves, separate, well preserved.
Approximate dimensions (in mm):

Bp. XV/	Length	Width		
		anter.	poster.	
13t	1.4	1.4	0.5	holotype (pedicle valve)
Bp. XV/	Midlength	Width		
13v	1.0	0.8	paratype (brachial valve)	

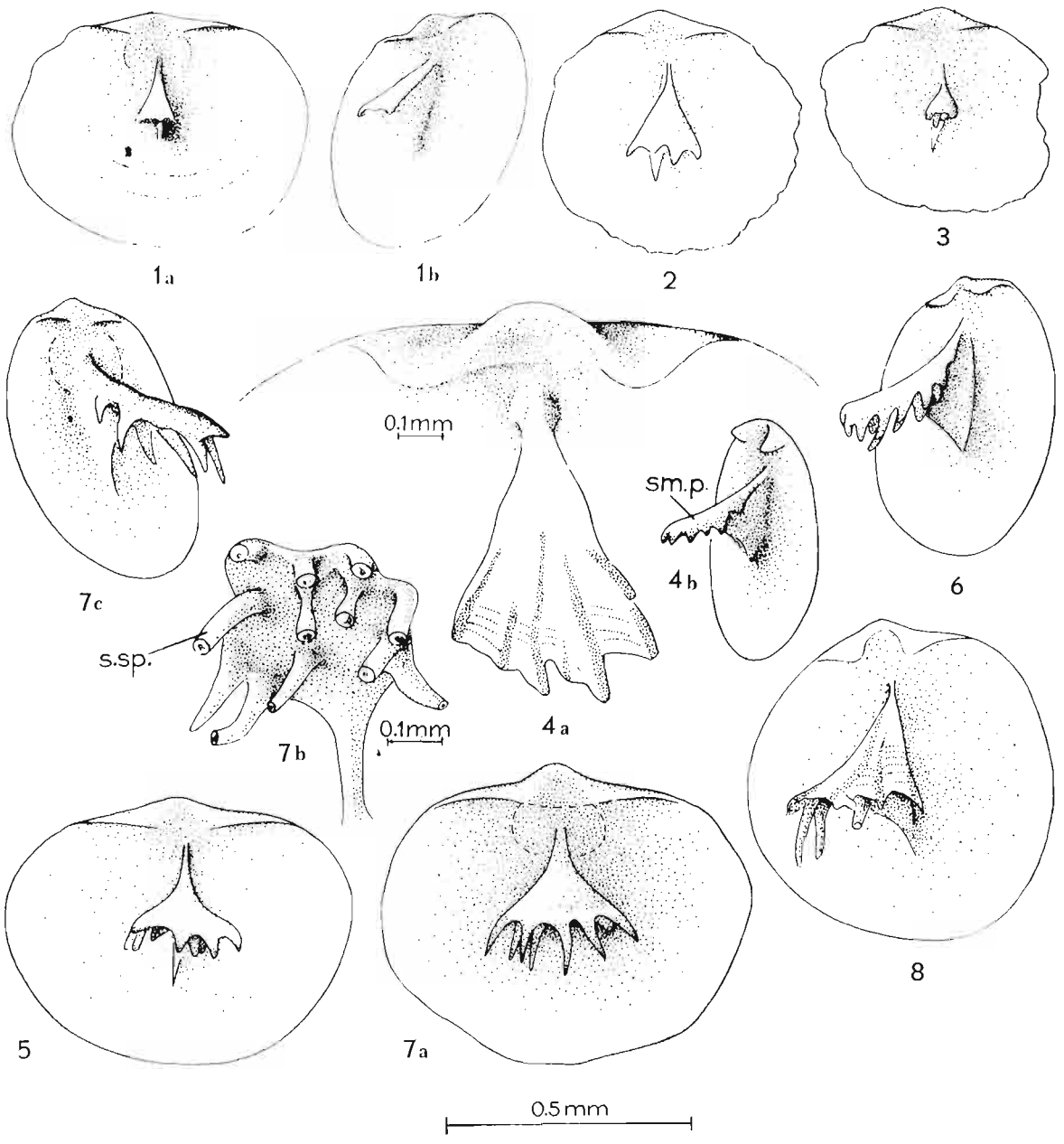

Fig. 35

Ephippelasma spinosum n. sp. (Kętrzyn IG-1, 1595·5 m). *1-7* — internal view of seven brachial valves, some variability of a median septum showed, *4a* — surmounting, plate view, *7a* — surmounting plate well preserved, *7b* — underside view of surmounting plate showing many spines (*s. sp.*).

Description. — Pedicle valve in the outline of short but wide conus; interearea marked by its slight flattening and somewhat wavy appearance, valve moderately arched in side view, umbo pronounced a little incurved (Pl. XXIV, Figs. 7, 8); pedicle foramen small, round, in younger growth stage preserving an external pedicle tube somewhat elongated: brachial valve

weakly arched, the deepest about midlength. Shell surface covered by quite distinct, thickened and regularly spaced concentric macrolines.

Interior. Ventral interior without traces of internal details. In the brachial valve both propareas small, trigonally outlined; median plate concave, relatively large (Pl. XXIV, Fig. 4); median septum beginning in the posterior third of valve, slightly merging at its posterior end in a somewhat thickened platform, separating the median plate from septum; median septum rather large, the surmounting plate of flabellate appearance with deep incisions, the marginal digitate processes quite thick, no underside processes are observed; vertical supporting plate short, extending to about half length of the surmounting plate; traces of muscle scars not visible, some very weak deepenings could suggest the cardinal muscles.

Discussion. — The collection includes a few pedicle valves of slightly differentiated size (Pl. XXIV, Figs. 5-8), they all preserve, independently of the general valve dimensions, the same shape and outline, this suggesting that the relatively short but wide cone is a stable feature characterizing the newly erected species. In addition, the arching in posterior third of valve, occurring also in *Ephippelasma spinosum* n. sp., is well marked in the considered specimens, and it seems to start usually in valves about a half of the average adult valve length. The reduced pedicle valve length almost equal to the greatest valve width in the anterior part of valve is a distinct feature, distinguishing quite well the above specimens from the other members of *Ephippelasma*. It is, in all probability, a good taxonomic difference.

Occurrence. — Late Lower-Middle Ordovician; Kętrzyn IG-1 (1595.5-1602.1 m), Bartoszyce IG-1 (1873.1-1879.1 m), Jezioro Okrągłe IG-1 (940.1 m), north-eastern Poland.

The specimens have been found at a depth of about 1595.5 m together with rare *Myotreta crassa* GORJ. and *Scaphelasma subquadratum* n. sp. Similarly shaped and outlined pedicle valves have been also found in the erratic boulder from Jarosławiec (No. O. 247), the exact age of which is unknown, supposedly can be Late Middle or Early Upper Ordovician judged to be Caradocian or ?Ashgillian.

Ephippelasma cf. **spinosum** n. sp.

(Pl. XXV; Text-fig. 36)

Material. — One pedicle valve, one brachial valve and one incomplete shell with both valves closed, but pedicle valve damaged in its posterior half.

Description. — The pedicle valve is similarly conical as that in *Ephippelasma spinosum* (Pl. XXIII, Fig. 11), differing somewhat in having less wavy interarea and the young valve is similarly superimposed on the adult valve as in *Myotreta crassa* GORJ. (Pl. XV, Fig. 5). The concentric macrolines are very distinct, like concentric ridges, and very regularly spaced (Pl. XXV, Fig. 1*b*). The brachial valve is rather flat, the dorsal umbo a little incurved, propareas small and the cardinal muscle scars well marked, elongate and slightly divergent anteriorly. Median septum of complex type, the supporting plate appears to be quite long, the surmounting one a little asymmetrical in outline, with marginal spinose processes, a few occurring on the under side (Pl. XXV, Figs 5-6), extending very far anteriorly.

Discussion. — There are similarity and some small differences between the above mentioned forms and *Ephippelasma spinosum* sp. nov. The differences concern the ventral interarea, which is narrower in *E.* cf. *spinosum*, the superimposed young valve a little larger and the cardinal

muscle scars elongate and well marked, those in *E. spinosum* not observed (Pl. XXV, Fig. 5). Also the median septum is slightly different but it is not possible to state whether its appearance is a constant feature. This element is, in general, very variable and can not be, unfortunately,

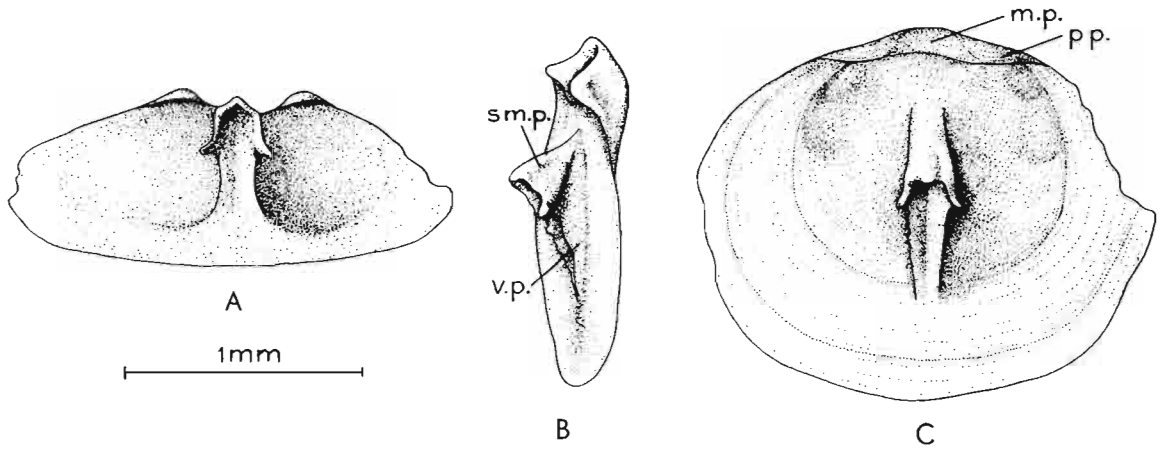

Fig. 36

Ephippelasma cf. *spinosum* n. sp. Erratic boulder, No. O. 247) *A-C* interior view of one adult brachial valve to show median septum with partly preserved surmounting plate; *m. p.* median plate, *pp.* proparea.

choosen as a highly typical septum for the species. It is very possible that the discussed specimens represent a new species, this can not be, however, decided at present.

Occurrence. — Erratic boulder No. O. 247, Jarosławiec, Baltic coast, Poland. The age not exactly known, ?Late Middle or Early Upper Ordovician.

?**Ephippelasma** sp.

(Text-fig. 13)

Material. — Two minute brachial valves, preserving median septal plate.

Description. — These valves illustrate the interesting modification of the median plate (vide p. 40). The valve is thin-shelled, — calcareo-phosphatic; median septal plate well developed in comparison to the whole size of the valve, expanded anteriorly and laterally, bearing spine-like marginal and underside processes. These are quite long, arranged in three to four rows, and divergent in different directions. This plate is unsupported and can represent the second differentiated type of septum (vide p. 41), being attached to the valve floor only at its posterior end (Text-fig. 13). It is probable, that the spines, which are here supposed to be hollow are characteristic of younger growth stage and with progeressing individual age become digitate as in sensu *Ephippelasma minutum* COOPER (1956, Pl. 17*A*, Figs. 12-14). Pedicle valve is unknown.

Occurrence. — Erratic boulder No. O. 418, Międzyzdroje, Baltic coast, Upper Ordovician, Ashgillian age.

Family ACROTHELIDAE Walcott & Schuchert, 1908

Genus **ORBITHELE** Sdzuy, 1955

(Type species: *Discina contraria* Barrande, 1868)

Orbithele bicornis n. sp.

(Pl. XXVII, Figs. 1-3; Text-fig. 37)

Holotype: Bp. XV/1*k*, Pl. XXVII, Fig. 1 (pedicle valve).
Type locality: Wysoczki, Holy Cross Mountains, Poland.
Type horizon: Tremadocian (chalcedonites).
Derivation of the name: Lat. *bicornis* — two horned.

Diagnosis. — Small, almost quadrate to subpentagonal in outline, with two long spike-like processes on the apex.

Material. — Four pedicle valves, one probably brachial, very thin and partly damaged. Approximate dimensions (in mm):

Bp. XV/	Length		Width of pedicle foramen	Length of pedicle foramen
	apex to dorsal margin	apex to ventral margin		
1k	0.48	0.48	0.03	0.1
1p	0.40	0.50	0.02	0.1

Description. — Small, very widely subconical, almost quadrate to nearly subpentagonal in outline, anterolateral margins very rounded, posterior margin almost straight (Pl. XXVII, Fig. 1), posterolateral angles well marked, anterolateral only sometimes distinguished, pseudointerarea deltoid, flattened, in general not very distinctly defined, straight or moderately concave in profile; ?pedicle foramen lens-like, of slightly varying length, occupying about two-fourths to one-third of the pseudointerarea height, starting slightly beneath the apex, opening to the valve cavity by a small internal tube occupying about two posterior thirds or a half of the pedicle foramen length (Text-fig. 37). One of the characteristic features of the species are the spike-like long processes, more divergent or less distally, sometimes very much (Pl. XXVII, Fig. 3; Text-fig. 37), placed on two small apical elevations, constituting the highest points of the valve, on both sides of posterior end of the pedicle slite, some distance posteriorly and laterally from it. These spikous processes seem to be quite long, judging upon their thickness (Pl. XXVII, Fig. 3*b*), serving, in all probability, to anchor the shell. The distance between the spikes is changeable and appears to be related to the individual age of specimen, being larger in younger growth stage. This being evidenced by the outline of pedicle foramen which is, in specimen possessing widely placed spikes, slightly larger and oval in outline (Pl. XXV, Fig. 3*a*).

Ornamentation consists of quite distinct concentric lines, very regularly arranged on the valve surfaces, more densely spaced on the apical part of the pedicle valve, accumulating around two spikes, the concentric lines being straight, only sometimes slightly wavy in appearance. Interior of the shell not studied, the details of internal structure being not preserved.

Discussion. — All valves are young, evidence of this are the very small size of valves which, in addition, are thin-shelled, and the appearance of pedicle foramen and tube. Pedicle foramen is, in young specimens, large, lens-like, being with progreessing growth steeply sealed

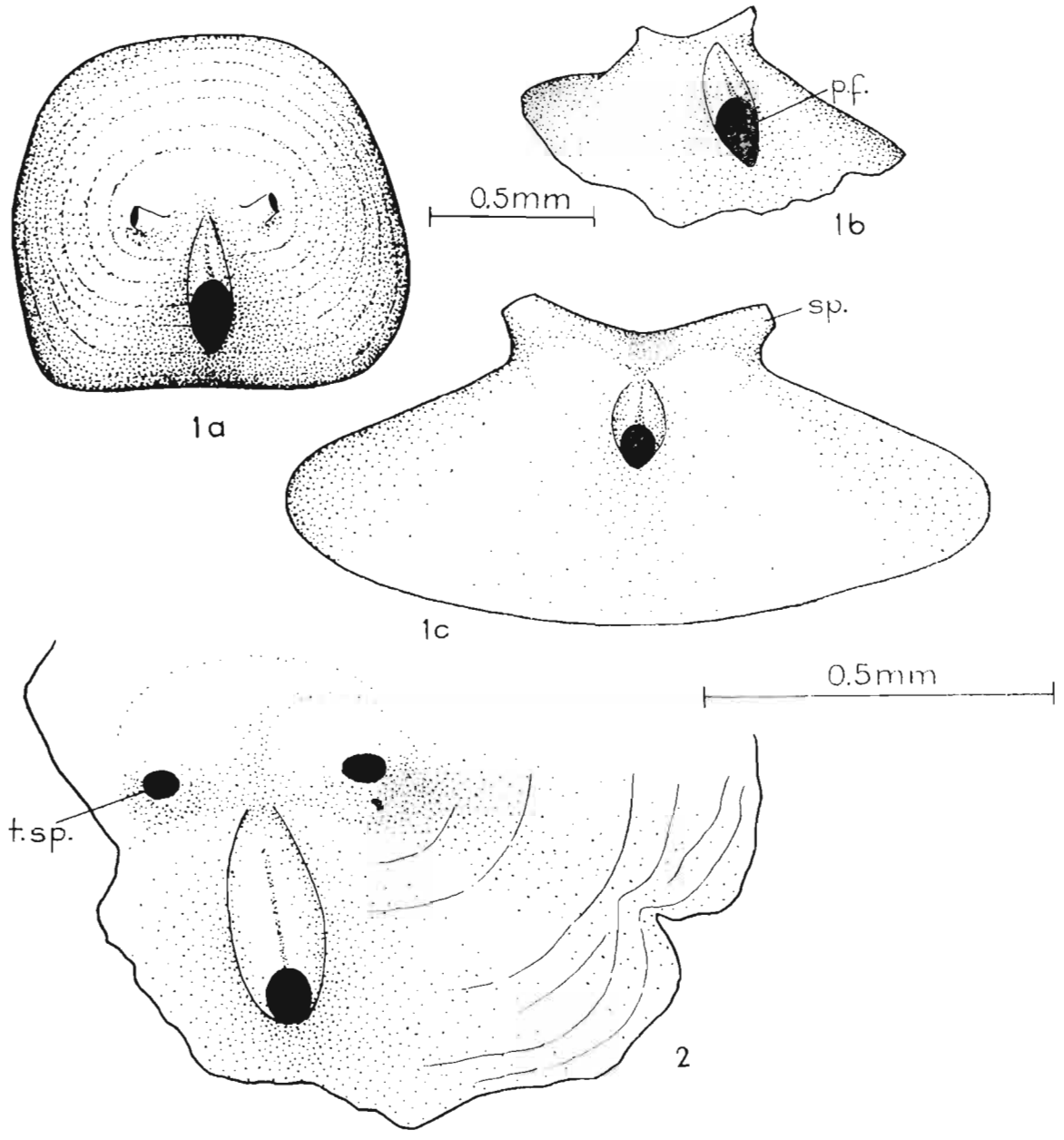

Fig. 37

Orbithele bicornis n. sp. (Tremadocian chalcedonites, Wysoczki). 1, 2 — two specimens of pedicle valve from exterior to show two spinose protuberances and subapical foramen; *p. f.* ?pedicle foramen, *t. sp* trace of spike.

on the posterior half or third by an appearing tube (listrium). In consequence, it is smaller and much less elongate, occupying in adults the anterior half or third of the former foramen. It seems that atrophy of pedicle, in full adult age or in senility, could not occur, and the pedicle remains comparatively thick and short. Although the specimens are not adult, they are of very characteristic appearance, being intermediate between the genus *Acrothele* LINNARSON and *Orbithele* SDZUY. They are very close to the first genus in having the apical external processes

(a feature of generic rank for *Acrothele*; ROWELL, 1965, p. 280), these in our specimens being more pronounced, distantly placed and distinctly divergent anteriorly. The valve outline, the marked flattening of the interarea in the pedicle valve and the developed pedicle tube (listrium) make our specimens very close to *Orbithele*. Although the collection is very poor, the discussed specimens are judged to represent a new species, the more so, as the differences are quite distinct and can be of specific rank. In comparison to *Orbithele contraria* (BARRANDE), described from the Lower Tremadocian of Czechoslovakia (BARRANDE, 1868, p. 104, Fig. 72), our species is of smaller size, ventral apex lies slightly more centrally being supplied by two distinct, quite long spikes at some distance from one another. Similarly, two fragments of pedicle valves of *Orbithele* from the Tremadocian (*Thysanotos siluricus* Zone) of Estonia, figured by GORJANSKY (1969, Pl. 13, Figs. 8, 9), preserve the lens-like track of the ?pedicle foramen and traces of concentric lines, the valves are, however, thick-shelled and the apical processes smaller and closer to one another.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland

Superfamily DISCINACEA GRAY, 1840
Family DISCINIDAE GRAY, 1840
Subfamily ORBICULOIDEINAE SCHUCHERT & LE VENE, 1929
Genus **ORBICULOIDEA** D'ORBIGNY, 1847

(Type species: *Orbicula forbesi* DAVIDSON, 1848)

Orbiculoidea? subovalis n. sp.

(Pl. III, Figs. 8—14; Text-fig. 38)

Holotype: Bp. XV/65m, Pl. III, Fig. 14 (brachial valve).
Type locality: Wysoczki, Holy Cross Mountains, Poland.
Type horizon: Tremadocian (chalcedonites).
Derivation of the name: Lat. *subovalis* — suboval in outline.

Diagnosis. — Almost oval in outline with a beak lying posteriorly, almost submarginal in position.

Material. — Eight almost complete brachial valves and two very small fragments of valves; valves phosphate, translucent, very thin.

Approximate dimensions (in mm):

Bp. XV/	Length	Width	
		poster.	anter.
65n	2.0	1.8	1.3

Description. — The valves are thin-shelled, small, to about 2 mm long, elongate-oval in outline, more narrowed anteriorly than posteriorly (the valves being somewhat egg-like), beak submarginal, distinctly posterior to the middle of the valve; valve only moderately convex in profile, the most pronounced convexity in the umbonal region (Text-fig. 38).

Ornamentation consists of concentric lines, weakly preserved, rather regularly spaced all over the valve surface, except for the umbonal parts which are smooth. In the dorsal interior are faintly marked two diverging lines (pallial sinuses?), arising at the apex of the valve continuing anteriorly, in general slightly arcuate in appearance.

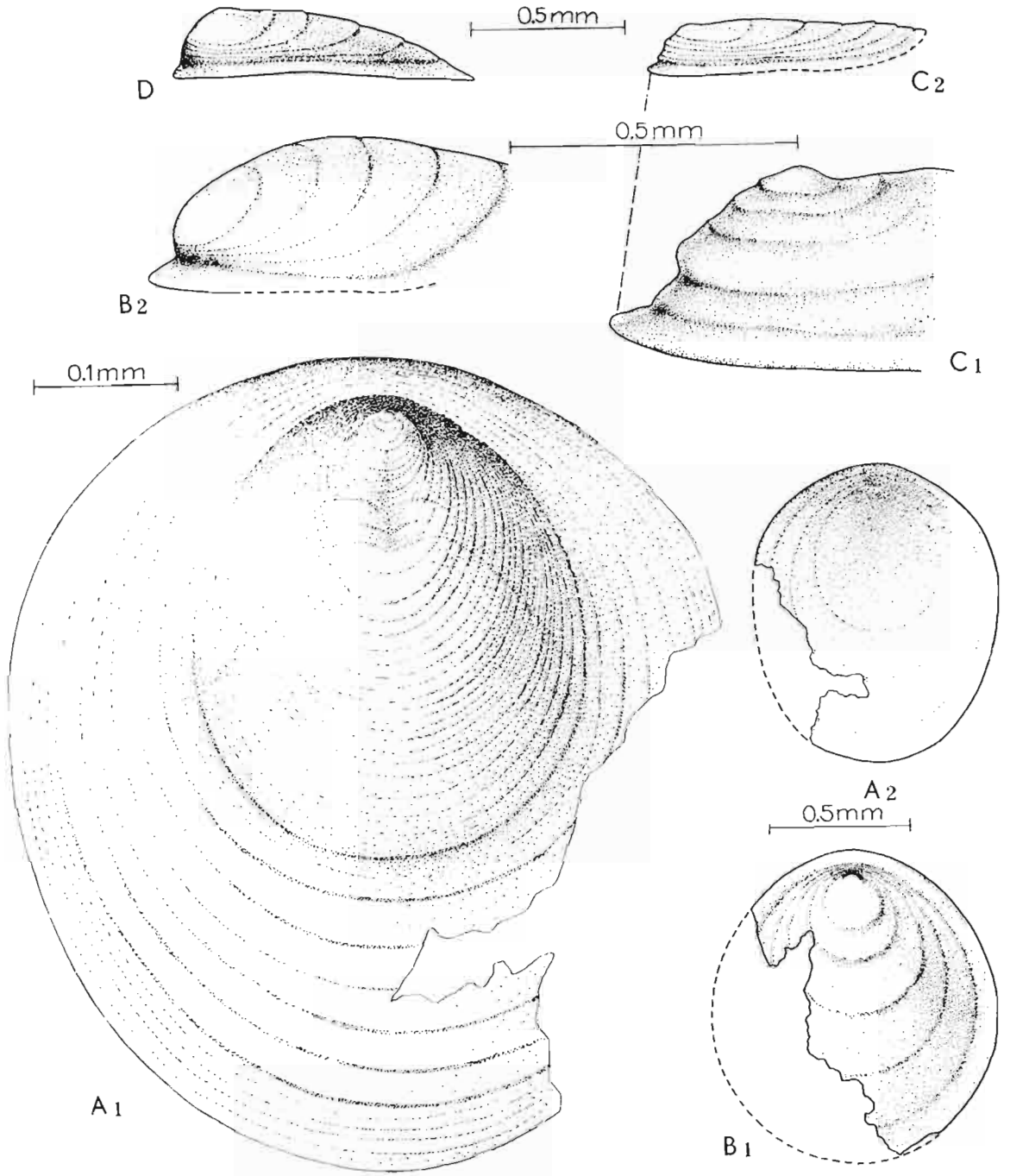

Fig. 38

Orbiculoidea ?subovalis n. sp. (Tremadocian chalcedonites, Wysoczki). *A-D* exterior, interior (A_2) and side views of four different specimens partly preserved.

Discussion. — The discussed valves have a characteristic appearance, the marginal limbus marked in the posterior third of the valve and the apex constantly submarginal. Unfortunately, the pedicle valve is not preserved (not found after etching) and no details are seen in the interior of the thin dorsal valves. In addition, under the apex something like a narrow, short furrow is marked, seen due to the accumulation of concentric lines (Text-fig. 38A_1). The concentric lines rather thick, well marked, but after etching not well preserved. They seem to be of lamellar appearance. The generic status of the above specimens remains doubtful; on the base of the general outline and submarginal dorsal beak, they are tentatively assigned to the genus *Orbiculoidea*. The Tremadocian chalcedonite valves are similar to the still badly known genus *Oxlosia* ULRICH & COOPER (1938, p. 69, Pl. 6*B*, Figs. 9, 10; Text-fig. 2), reminding one of *O. perplexa* ULRICH & COOPER, particularly in the elongate valve and submarginal apex, differing in some details of the surface ornament and smaller size. Our valves in profile are very close to the *Glossella*? *umbonata* described by GORJANSKY from the Middle Ordovician of the Leningrad environs (GORJANSKY, 1969, Pl. 8, Figs. 1, 1*a*), differing in not having a radially ornamented surface which characterizes the GORJANSKY's species.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland.

Orbiculoidea sp.

(Pl. IV, Fig. 9)

Material. — One fragmentary brachial valve.

Description. — The valve is small, length slightly exceeding 1 mm. It is roundly oval in outline, with apex submarginal, valve very moderately convex in profile. On the surface there occur quite regularly spaced, rather distant concentric strong lines of a somewhat lamellar appearance (Pl. IV, Fig. 9). No more details of the external morphology or internal structure are preserved. The general outline and appearance of the surface concentric lines suggest the genus *Orbiculoidea*. In comparison to the *Orbiculoidea*? *subovalis* from the Tremadocian chalcedonites, the considered valve differs in having more distantly spaced and thicker concentric lines all over the valve surface and in being wider in the anterior half and narrowed posteriorly, which is the reverse of the Tremadocian chalcedonite valves (comp. Pl. III, Figs. 8-14).

Occurrence. — Lower Ordovician, Volkhov horizon, Suhkrumägi, environs of Tallinn, Estonia.

Superfamily SIPHONOTRETACEA KUTORGA, 1848
Family SIPHONOTRETIDAE KUTORGA, 1848

Genus **SIPHONOTRETA** VERNEUIL, 1845

(Type species: *Crania unguiculata* EICHWALD, 1829)

Siphonotreta acrotretomorpha GORJANSKY, 1969

(Pl. XXVII, Figs. 4-10; Pls. XXVIII, XXIX, XXX, Figs. 6-8; Text-fig. 39)

1969. *Siphonotreta acrotretomorpha* GORJANSKY sp. nov.; V. GORJANSKY, Bezzamkovye brachiopody..., p. 85, Pl. 14, Figs. 6—9.

Material. — Thirty pedicle and brachial valves, not complete, many fragments.

Approximate dimensions (in mm):

Bp. XV/	Length	Width			
		midlength	poster.	anter.	pedicle valves
1f	0.91	1.17	0.7	0.86	
1g	1.0	1.22	0.97	0.98	
1h	1.0	1.0	0.75	0.86	

Bp. XV/	Length	Width			Size of pedicle foramen	
		midlength	poster.	anter.		brachial valves
1i	0.7	0.97	0.7	0.75	0.08	
1m	0.6	0.8	0.6	0.66	0.1	

Description. — Small, length not exceeding 3 mm, ventri-biconvex, roundly subconical in outline, wider than long; lateral, postero-lateral margins and antero-lateral angles well rounded. Pedicle valve moderately subconical, apically arched in profile, moderately lowering anteriorly, pedicle foramen apical, opening by a short tube to the valve cavity (Text-fig. 39), remaining round or slightly elongating and changing in size during the growth, as a rule boundered on the ventral side by semiround, slightly bulbous thickening; this thickening in smaller

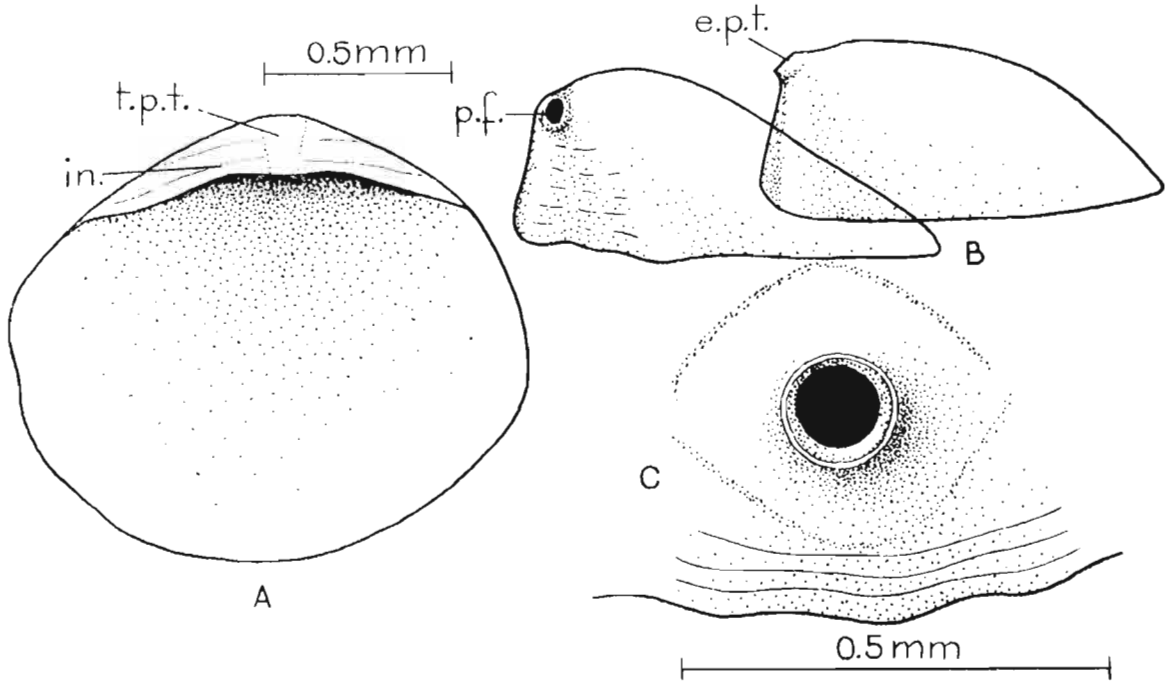

Fig. 39

Siphonotreta acrotretomorpha GORJANSKY (Tremadocian chalcedonites, Wysoczki). *A*, *B* pedicle valve interior and in profiles; *C* appearance of pedicle foramen; *e. p. t.* external pedicle tube, *in.* interraea, *p. f.* pedicle foramen, *t. p. t.* trace of pedicle tube marked due to the transparent interarea.

valves is often marked as a more distinct or less line encircling the ventral side of the thin apiral part of the valve (Pl. XXVIII, Fig. 6); the external edge of the foramen usually only a little projecting upwards and thickening with time; pseudointerarea nearly apsacline to procline, flattened, high in comparison to the general shell size, constituting about one-third to one-fourth of the whole valve length, the covering horizontal lines thickened, to a varying degree, continue on the remaining valve surface. Brachial valve is, in general, moderately convex, with the greatest convex ity on the posterior valve third; pseudointerarea low, occupying almost two-thirds of the whole valve width, overhanging the posterior margin of the valve, slightly concave in its median part.

Ornamentation. All shell surface is covered by concentric lines, partially thickened, looking somewhat as discontinuous. The surface spines are hollow, arranged alternatively in rows, occurring also at the postrior margin of the shell (Pl. XXVII, Figs. 9, 10; Pl. XXVIII; Pl. XXIX, Fig. 3), where they are often curved like in productellids. In addition, at the posterior margin of both valves can occur few flattened and elongate protuberances of differentiated length and thickness (Pl. XXX, Figs. 7, 8). On the remaining shell surface the hollow spines are almost straight, as can be judged from their fragments preserved in different length. In smaller (younger) shells to about 1·3 mm long the spines are almost regularly spaced, their diameter being much the same for all on the whole shell surface (Pl. XXVII, Fig. 8). With progressing growth the arrangement of spines is less regular and their diameter varying.

Discussion. — The collection comprises specimens ranging in length from 1·3 to 3 mm. Smaller valves (both pedicle and brachial) are circular, the length being equal to the width (Pl. XXVII, Figs. 3, 4). The larger specimens are wider, subtransverse in outline, the ventral apical part slightly arched in profile and the surface spines anteriorly slightly differentiated in their diameter. The pedicle foramen relatively large in small specimens, remains with growth round and proportionally large (Pl. XXVII ,Figs. 4, 6; Text-fig. 39). In the available specimens some variability occurs in the size of the pseudointerarea, size of the pedicle foramen and in the height of the pedicle valve. Our form is very close to *Siphonotreta acrotretomorpha* GORJANSKY (1969, p. 85, Pl. 14, Figs. 6-9) in its general appearance, especially in the shell outline and shape of the pedicle valve. The differences lie in the much smaller size of our species, round foramen which, with progressing age, becomes much smaller, shell width greater than length. It is also near „*Acrotreta*" *spinosa* WALCOTT (1912, Pl. 39, Fig. 4). WALCOTT's species possesses thread-like radiating striae, more or less irregular, bearing on their backs the elevated, elongate and very fine spinous protuberances. The general shell size is similarly minute and the pedicle foramen roundly outlined.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland; West Estonia, environs of Paldiski (*Thysanotos siluricus* Zone).

Siphonotreta cf. **verrucosa** (EICHWALD, 1840)

(Pl. XXX, Figs. 1-5)

1969. *Siphonotreta verrucosa* (EICHWALD, 1840); V. J. GORJANSKY, Bezzamkovye brachiopody..., p. 87, Pl. 15, Figs. 1, 2.

Material. — Twenty fragmentary pedicle and brachial valves, many small fragments of valves with preserved surface spines.

Approximate dimensions (in mm):

Bp. XV/	Length	Width	
8e	1.5	1.4	brachial
8a	2.0	1.9	valves
8d	1.8	1.4	pedicle
8c	2.0	1.8	valves

Description. — The incomplete valves are moderately convex in profile, round in outline, length to a varying degree exceeding width; apex of both valves slightly pointed, that of the pedicle valve a little more; dorsal pseudointerarea from the interior slightly concave, with horizontal growth lines; pedicle pseudointerarea larger two or three times, similarly covered with horizontal lines; pedicle foramen circular or almost circular, apical, continuing antero-dorsally as a tube, this being of different length, usually slightly narrowing anteriorly. Shell surface covered by spines of two sizes — the larger ones arranged in a somewhat quincuncial pattern on the younger part of shell, and the smaller ones forming the concentric arrays, the first usually appearing at a distance of about 1·5 mm from the beaks.

Discussion. — The specimens from Tremadocian chalcedonites are extremely close to those of *Siphonotreta verrucosa* (EICHW.), figured by GORJANSKY (1969, Pl. 15, Figs. 1, 2) and may belong to this species. This similarity is mainly expressed in the outline of shell, pattern of surface spines as also in the appearance of the pedicle foramen and the pedicle tube. The exact, however, assignment of our specimens must remain in doubt as it lacks complete shells in more advanced adult stage. Not very much information is obtainable from the collection at hand, especially about the shell interior of the considered species and also about more details of the morphology in adult stage.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland; Lower Ordovician, USSR, north-eastern part of the Russian Platform, environs of Leningrad (Kunda horizon); Estonia (Volkhov horizon, rather rare); Czechoslovakia.

Genus **ALICHOVIA** GORJANSKY, 1969

(Type species: *Alichovia ramispinosa* GORJANSKY, 1969)

Discussion. — The genus was erected by GORJANSKY (1969) for the spiphonotretids which possess thin shell and multibifurcated surface spines, the spines being very scattered, arranged in quincuncial pattern on the shell surface. This peculiar feature has been recently stated in two species of Middle and Lower Ordovician age (GORJANSKY, 1969; BIERNAT, 1971). Unfortunately, the whole material concerning the genus is very poor, it does not illustrate sufficiently the external morphology and gives no information on the interior of the shell. It is a rare genus (GORJANSKY, 1969, p. 97), in addition poorly preserved, mostly in fragments (BIERNAT, 1971) and displays a very thin shell. The available characters of the external morphology such as shell outline and shape, appearance of the ventral apical part and pseudointerarea of both valves, make the genus very close to the other members of siphonotretids. The multibifurcated surface spines are one of the valuable differing characters on the generic level.

Age: Lower-Middle Ordovician.

Species assigned: *Alichovia ramispinosa* GORJANSKY, Middle Ordovician, Estonia, USSR, Russian Platform; *A. analogica* n. sp., Lower Ordovician, Holy Cross Mountains, Poland.

Alichovia analogica n. sp.

(Pl. XXXI, Figs. 1-6; Pl. XXXII)

1971. ?*Siphonotreta* sp.; G. BIERNAT, On branched surface spines..., p. 83, Pls. 1, 2, Figs. 2-5.

Holotype: Bp. XIII/12, figured on Pl. 1, Fig. 1 (BIERNAT, 1971).

Type locality: Wysoczki, Holy Cross Mountains, Poland.

Type horizon: Tremadocian (chalcedonites).

Derivation of the name: Lat. *analogicus* — analogous to the type species *Alichovia ramispinosa* GORJANSKY, 1969.

Diagnosis. — Small, thin-shelled, phosphatic siphonotretid, gently biconvex, with a small dorsal overhanged pseudointerarea, widely rounded, wider than long, surface spines scattered, multibranched.

Material. — Four almost complete brachial valves with preserved bifurcating spines, a number of fragments of valves or separated multibifurcated spines.

Approximate dimensions (in mm):

Bp. XIII/	Length	Width	
12	1.5	2.0	holotype

Description. — The available brachial valves are incomplete and not in full adult stage. The valves are of small size, not exceeding 1·5 mm in length, extremely thin, their pseudointerarea in this stage is narrow, slightly concave medianly, thickened, covered by lines parallel to the posterior end, usually occupying a half or more of the whole valve width, overhanging the posterior margin of the valve (this is especially well marked as the valve is comparatively deep on its posterior third), the propareas slightly marked being somewhat elevated upwards.

Ornamentation is characteristic of the genus, composed of surface hollow spines very scattered and arranged in a quincuncial pattern, ramifying to a varying degree, depending much upon the growth stage of shell. The spines are lacking on the most posterior part of the valve, corresponding to the protegulum. In general, they are straight, only slightly at first anchylosed to the valve surface, their diameter, length and the degree of inclining (bending) enlarging progressively with the advancing growth (comp. p. 33, Pl. XXXI, Figs. 1-6; Pl. XXXII; BIERNAT, 1971, Pls. 1, 2, Text-figs. 3, 4). Although the spines vary somewhat in size and, to some extent, in mode of their ramification in specimens of the almost the same individual age, they preserve almost the same character — this is also observed in *Alichovia ramispinosa* (GORJANSKY, 1969, p. 98). The pattern of spines in *Alichovia* differs from that in the other siphonotretids, as *Siphonotreta verrucosa* (EICHWALD) or *Multispinula* ROWELL, 1962, in which the spines are usually differentiated into two distinct size and form arrays of fine and larger spines. In addition to the surface spines, there occur usually two marginal ones at the postero-lateral angles of the valve, slightly convergent or divergent, curved and directed upwards, somewhat like in productellids or productids (MUIR-WOOD & COOPER, 1960).

Discussion. — Our species is, in the appearance of the surface spines, very close to *Alichovia ramispinosa* GORJANSKY which, in addition to their multiramification, are very scattered on the shell surface. More detailed comparison in the other features of the external morphology and internal structure can not be made due to the scarce material, its unfortunately bad state of preservation, lack of the pedicle valves and, generally, young individual age of the available brachial valves. The nature of the shells from Tremadocian chalcedonites shows that they are

members of the genus *Alichovia* GORJANSKY. Although more complete material is lacking, the discussed specimens are considered here as representing a new species, which differs from *A. ramispinosa* GORJANSKY in the stratigraphical age and in being probably of smaller size in adult stage. There also can occur some differences in the mode of the spine ramification.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland.

Genus **HELMERSENIA** PANDER, 1860

(Type species: *Siphonotreta ladogensis* JEREMEJEV, 1856)

Helmersenia cf. **ladogensis** (JEREMEJEV, 1856)

(Pl. XXXIII, Figs. 1-7; Text-fig. 40)

1969. *Helmersenia ladogensis* (JEREMEJEV, 1856); V. J. GORJANSKY, Bezzamkovye brachiopody..., p. 99, Pl. 19, Figs. 1-21.

Material. — One almost complete pedicle and two brachial valves, many fragments of particular valves.

Approximate dimensions (in mm):

Bp. XV/	Length	Width	
2a	4.8	?5.0	pedicle valve
2c	3.8	4.2	brachial valve

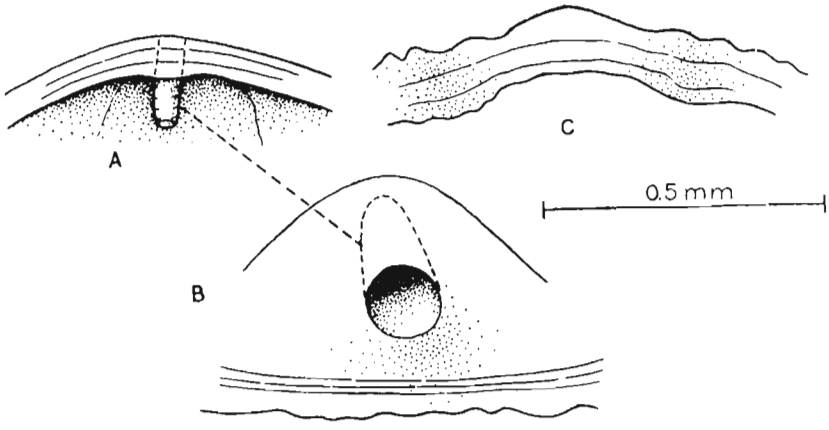

Fig. 40

Helmersenia cf. *ladogensis* (JEREMEJEV) (Tremadocian chalcedonites, Wysoczki). *A-C* details of the posterior part of shell; *A* interior view of pedicle tube; *B* exterior view to show pedicle foramen; *C* appearance of dorsal propareas.

Description. — The material is scarce and poorly preserved. The appearance of the valve, its transversely elongate outline, irregularly spaced hollow spines, slightly elongate pedicle foramen with posterior part lying at the apex of the valve, the most posterior end of the apex forming something like a lip to foramen, slightly curving dorsally make this specimen quite characteristic; pedicle foramen opening to the valve cavity, its internal walls slightly thickened, being sealed by the later shell material; pseudointerarea small, slightly apsacline, with

horizontal covering lines. Dorsal beak small, marginal weakly incurved, pseudointerarea small with lines parallel to the posterior margin. All shell surface covered by small fragments of small hollow spines, rather densely spaced, all of almost equal diamater at their basis.

Discussion. — Externally, the above specimens are very close to the Lower Ordovician *H. ladogensis* (JEREMEJEV), with the difference that our specimens are comparatively much smaller as they represent a not advanced individual age, pedicle foramen being larger, probably due to the growth stage which they attained and the shell outline is slightly less transverse.

Occurrence. — Tremadocian chalcedonites, Wysoczki, Holy Cross Mountains, Poland; USSR (Pakerort horizon), environs of Leningrad; Estonia; *Thysanotos siluricus* Zone.

Superfamily CRANIACEA MENKE, 1928
Family EOCONULIDAE ROWELL, 1965

Discussion. — The family still remains, from the aspect of its systematical position, much controversial. It was regarded by, among others, COOPER (1956, p. 282) and ROWELL (1965, p. H291), as a member of the superfamily Craniacea, being on the other hand treated by GORJANSKY (1969, p. 107) as a family of *incertae sedis*. There is still not enough data to finely discuss this problem in detail. The specimens of the above family are known from the brachial valve only and these occur, as a rule, in a great number. The pedicle valves not found, up to now, could possibly be entirely organic as in some craniids, e.g. *Philledra* KOKEM. This is one of the reasons for including the above family into the craniaceans. The relationships of eoconulids to the other Inarticulates are still unclear. The protegular portions of valve of *Eoconulus* displae surface excavations, but their pattern appears to be not comparable to that of acrotretaceans, the origin of the protegular elements being different (BIERNAT & WILLIAMS, 1970, p. 499). This fact excludes these fossils from the acrotretaceans. GORJANSKY (1969, p. 108), on the basis of the eventual differences in the shell structure, was inclined to interpret the very similar shape and outline of eoconulids to that of craniids as a matter of convergence; this is very possible. In this paper, the family Eoconulidae is only tentatively included into the Craniacea.

Age: Ordovician.

Genus **EOCONULUS** COOPER, 1956

(Type species: *Eoconulus rectangularis* COOPER, 1956)

Discussion. — The most changeable features are the shape and outline of the valve and, to a lesser degree, the appearance of the umbo. The pattern of the surface ornamentation can have also, in all probability, some value as a specific feature (vide p. 32). The few known members of the genus are quite well defined and are distinct species. This is due to the many combinations of the few above mentioned features. The type species of the genus — *E. rectangularis*, is characterized by well marked marginal angles (COOPER, 1956, Pl. 10*h*, Figs 11-13); *E. transversum* described by WRIGHT is very subquadrate in outline (WRIGHT, 1963, Pl. 3, Figs 4, 8); *E. cryptomyus* GORJANSKY possesses valves almost quadrate and umbo straight; *E. semiregularis* n. sp. has an umbo much pointed, well incurved posteriorly.

Age: Ordovician.

Eoconulus cryptomyus GORJANSKY, 1969

(Pls. XXXIV, XXXV; Pl. XXXVI, Figs. 9, 10)

1969. *Eoconulus cryptomyus* GORJANSKY sp. nov.; V. J. GORJANSKY, Bezzamkovye brachiopody..., p. 108, Pl. 20, Figs. 5-8.

Material. — Ten valves well preserved, majority of them with the apical part damaged, many larger or smaller fragments of valves.

Description. — Small, length and width of specimens in the available collection not exceeding 1·4 mm. Valves are widely conical, with umbo placed almost centrally, sometimes posterior to midvalve, their outline commonly guadrate or almost so; posterior margin usually more straight or less, anterolateral and posterolateral margins and extremities rounded.

Ornamentation consisting of concentric thickened lines of almost equal thickness and wavy appearance, as a rule, densely arranged and especially distinctly marked on the boundary of the most apical part of valve, corresponding to the protegulum and the adult valve (Pl. XXXV, Figs. 2, 3); the pattern of surface ornamentation is not the same in different parts of valve. On its posterior third of the valve they are quite regularly arranged around the apex, being in moderate way a little wavy. On the more adult part of the valve the concentric lines occur in distinct strips (arrays), only a little varying in width, two strips connected by a range of small processes (Pl. XXXV, Fig. 1). The concentric lines on each strip are usally discontinuous, not parallel one to the other, arranged in something like short bundles (Pl. XXXIV, Fig. 5; Pl. XXXV, Fig. 1), in which the new ones appear mostly by branching, much rarely by intercalation. In some parts of valve the pattern of ornamentation is highly irregular, making an impression of some disturbation which could have place during the life of animal. In addition, macroscopically, the surface ornament looks rather regular, the concentric lines being almost of the same thickness. The all mentioned details of ornamentation have been stated by the electron microscope (comp. p. 32). The apical part is in well preserved specimens, covered by very regular, extremely shallow and flatbottomed circular pits bounded by the thickened ridges; these pits being not comparable with the pits in acrotretids (BIERNAT & WILLIAMS, 1970, p. 499).

Variability. — The specimens of this species are of almost stable appearance, even the small valves being almost of the same outline and shape as the larger ones. Some small variations concern the outline of the valve and, to some extent, the appearance of the apex, which can be more pronounced or less, sometimes considerably widened and low.

Discussion. — The specimens of this species are smaller, have much thinner shell in comparison with the type species — *Eoconulus rectangularis* COOPER, and differ from *E. transversum* WRIGHT in being more quadrate in outline.

Occurrence. — Lower Ordovician, Volkhov horizon, Suhkrumägi, West Estonia; Middle Ordovician (Tallinn horizon), North-west of the Russian Platform.

Eoconulus semiregularis n. sp.

(Pl. XXXVI, Figs. 1-8)

Holotype: Bp. XV/6*s*, Pl. XXXVI, Fig. 1.
Type locality: Jarosławiec, Baltic coast.
Type horizon: Probably Upper Ordovician, erratic boulder No. O. 247.
Derivation of the name: Lat. *semi* — a half, *regularis* — regular; almost regular in outline.

Diagnosis. — Small, roundly outlined, length not/or a little only exceeding the width, umbo much pronounced, placed more centrally.

Material. — Twenty valves, well preserved, entire.
Approximate dimensions (in mm):

Bp. XV/	Length	Width	Umbo distance from posterior valve end
6s	1.3	1.1	0.3
6t	1.3	1.3	0.2
6u	1.3	1.35	0.36

Description. — Small, roundly outlined, length equal or only slightly less than width; umbo pronounced, slightly incurved, placed very near to the central part of valve, lateral margins more arcuate or less, the posterior margin almost straight.

Ornamentation consists of widely arranged, concentric, distinct lines, sometimes thickened, of somewhat lamellar appearance, quite regularly spaced. No internal details are preserved.

Discussion. — The specimens are characterized by the valve margins rounded, the lateral ones being, to a slightly varying extent, arcuate. The umbo is well marked, being thickened, slightly incurved posteriorly. The variability occurs but in a very limited degree and concerns mainly the appearance of the lateral valve margins which can be more arcuate or less, and somewhat in the degree of the umbonal part elevation. The species is characteristic although it displays only a few features. The roundly outlined valve with length almost equal to the width and the pronounced and slightly incurved posteriorly umbo differs from the other known species of *Eoconulus*. In comparison with *E. cryptomyus* GORJ. from Arenigian, environs, of Leningrad, USSR, our species possesses more roundly outlined valve margins and the umbonal part less pronounced, umbo being not incuvred (GORJANSKY, 1969, Pl. 20, Figs. 5—8; *vide* Pl. XXXVI, Figs. 1-5); *E. rectangularis* COOPER from Pratt Ferry Formation has the marginal angles quite well marked (COOPER, 1956, Pl. 10*b* Figs. 11-13); *E. transversum* WRIGHT from Portrane Limestone is of irregular outline and very transversely elongate (WRIGHT, 1963, Pl. 3, Figs. 4, 8, 12, 13).

Occurrence. — Erratic boulder No. O. 247, Jarosławiec, Poland, Baltic coast, probably Upper Ordovician age.

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ALPHABETICAL INDICES

I. INDEX OF AUTHORS

II. PALAEONTOLOGICAL INDEX

Systematic names cited only are indicated by *italic*, and names accompanied by descriptions are indicated by roman letters.

Numerals which indicate the page, on which the species is cited only, are standart; numerals, which indicate pages with descriptions, are **bold**.

Numerals denoted with asterisks (*) indicate pages with figures.

PLATES

G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE I

Page

Schmidtites obtusus (MICKWITZ) 54

Tremadocian chalcedonites, Wysoczki

Figs. 1-3. Three complete or fragmentary brachial valves (Bp. XV/66 o-r); Fig. 1 — approx. ×22, Fig. 2 — ×55, Fig. 3 — ×34.

Figs. 4, 5. Pedicle and brachial valves of two different specimens (Bp. XV/66*s-t*), representing the early adult stage, concentric lines partly preserved; approx. ×62.

Paterula cf. *perfecta* COOPER 60

Erratic boulder No. O. 535, Mochty, environs of Warszawa

Figs. 6-8. One pedicle valve (Fig. 7) and two brachial valves almost complete (Bp. XV/67*u, v, z*); all approx. ×30.

Paterula sp. 61

Middle Ordovician, Kukruse horizon, Estonia

Figs. 9-11. Two brachial valves and one pedicle valve almost complete (Bp. XV/66*u, v, z*), the concentric lines partly preserved; approx. ×28.

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PLATE II

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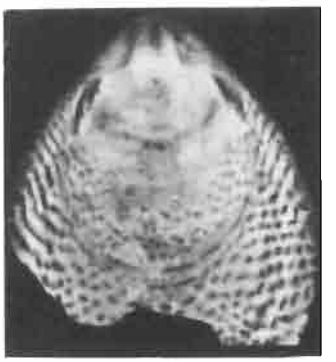

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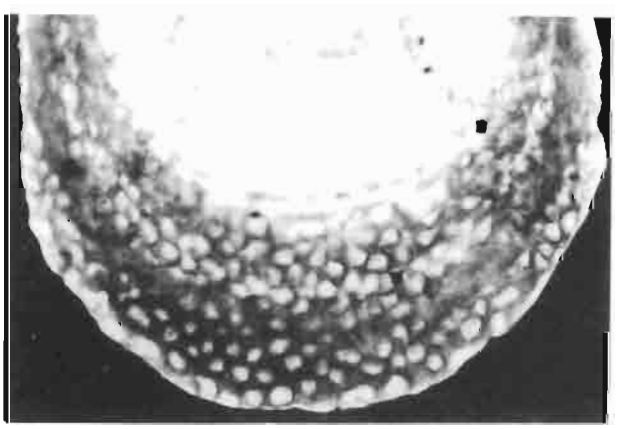

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PLATE III

Page

Rowelella sp. *1* 59

Volkhov horizon, Suhkrumägi, Estonia

Fig. 1. Fragment of brachial valve (Bp. XV/63*s*), concentric lines regularly disposed, approx. ×18.

Rowelella sp. *2* 60

Tremadocian chalcedonites, Wysoczki

Figs. 2-4. Three fragments of valves (Bp. XV/63*z, p, t*); Figs. 2, 3 — approx. ×20, Fig. 4 — approx. ×48.

Lingulasma sp. 60

Erratic boulder No. O. 542, Mochty, environs of Warszawa

Figs. 5-6. Two fragmentary valves of different specimens (Bp. XV/63*u, y*) representing, in all probability, a brachial and pedicle valves, approx. ×34.

Obolus cf. *appolinis* EICHWALD 54

Tremadocian chalcedonites, Wysoczki

Fig. 7. Fragment of a pedicle valve preserving a ventral interearea and some traces of pallial sinuses (Bp. XV/64*y*); approx. ×54.

Orbiculoidea? subovalis n. sp. 103

Tremadocian chalcedonites, Wysoczki

Figs. 8-14. Seven fragmentary or complete brachial valves (Bp. XV/65*g-m*), umbonal part marked, concentric lines partly preserved; Fig. 14 type specimen, Figs. 10-12 — approx. ×22, Fig. 13-14 — approx. ×25, Figs. 8-10 — approx. ×20.

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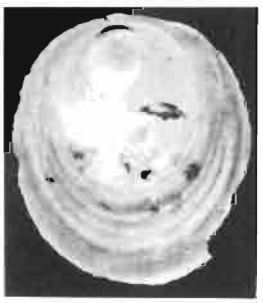

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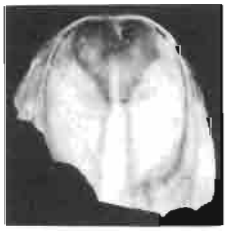

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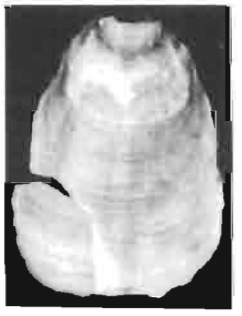

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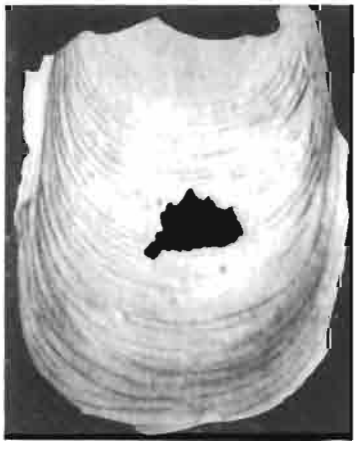

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE IV

Page

Craniops erratica n. sp. 62

Erratic boulder No. O. 178, Mochty, environs of Warszawa

Figs. 1-6. Six pedicle valves of slightly different size (Bp. XV/23*s*, *t*, *u*, *v*, *z*, *x*), exterior view; Fig. 5 — type specimen; approx. ×40.

Figs. 7-8. Interior view of two valves (Bp. XV/23*w*, *y*); Fig. 7 — brachial valve (paratype), Fig. 8 — pedicle valve, approx. ×42.

Orbiculoidea sp. 105

Volkhov horizon, Suhkrumägi, Estonia

Fig. 9. Incomplete brachial valve (Bp. XV/54), *a* exterior, *b* interior views; approx. ×65.

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

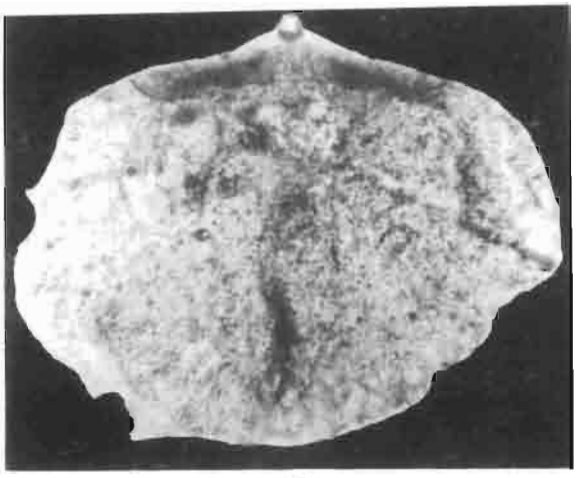
PLATE V

Fig. 1. Brachial valve almost complete but with badly preserved internal details; interarea and median septal ridge partly preserved (Bp. XV/37*g*), paratype; approx. ×62.

Figs. 2-3. Two partly preserved pedicle valves of slightly different size showing through at the transparent valve the infilled by the shell substance apical part of the valve (Bp. XV/37*h*, *g*); Fig. 2 — type specimen; approx. ×40.

Fig. 4. Interior of the pedicle valve with a horizontal platform and an internal pedicle foramen (Bp. XV/37*i*); approx. ×60.

Figs. 5-8. Apical parts of a few younger pedicle valves in slightly different positions, showing the infilled apical parts, transparent and preserving the internal pedicle foramen which comunicates with the external one (Bp. XV/37*j*, *k*, *l*, *m*); Fig. 5 — approx. ×55, Figs. 6-8 — approx. ×40.



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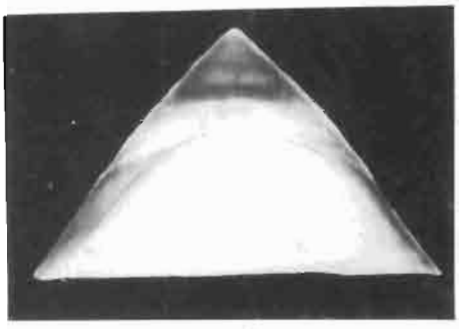

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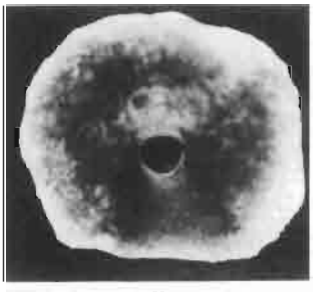

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PLATE VI

Page

Paratreta similis n. sp. 68

Bartoszyce IG-1 (1873.1 m), north-eastern Poland

Figs. 1-2. Surface ornamentation view; Fig. 1 — ×2350, Fig. 2 — ×1100.
Fig. 3. Junction-protegulum and adult shell view; ×1300.
Fig. 4. Protegular pits view; ×2400.

Scanning electron micrographs.

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PLATE VII

Page

Paratreta similis n. sp. 68

Bartoszyce IG-1 (1873·1 m), north-eastern Poland

Fig. 1. Internal view of adult brachial valve (paratype), (Bp. XV/16*v*); approx. ×22.

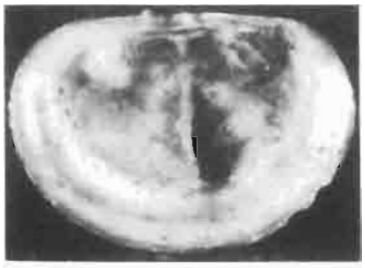
Fig. 2. Adult pedicle valve (type specimen, Bp. XV/16*x*); *a* interarea view, approx. ×20; *b* ventral slope view, approx. 27; *c* interior view, × approx. 27.

Fig. 3. Scanning electron micrograph of adult pedicle valve; *a* interarea, *b* side views; × approx. 65.

Paratreta sp. 71

Tremadocian chalcedonites, Wysoczki

Figs. 4-5. Two adult valves (Bp. XV/16*y, i*), almost complete; Fig. 4 — interarea view, × approx. 45; Fig. 5 — side view, × approx. 65.



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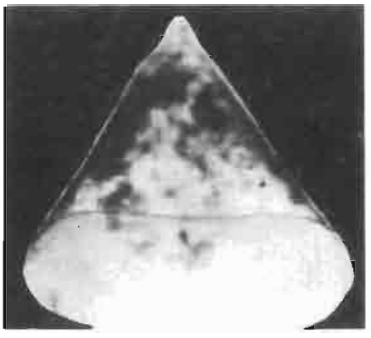

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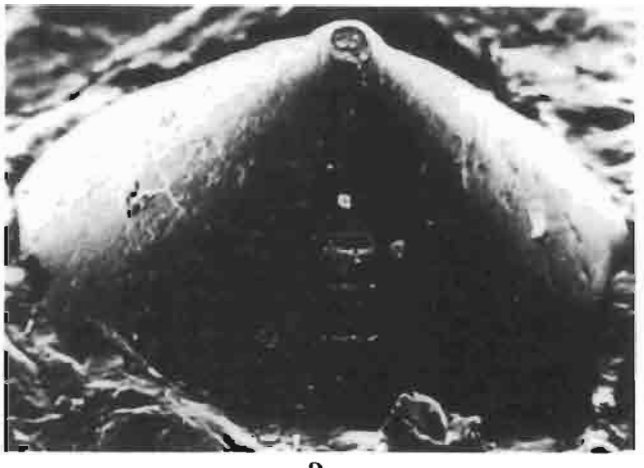

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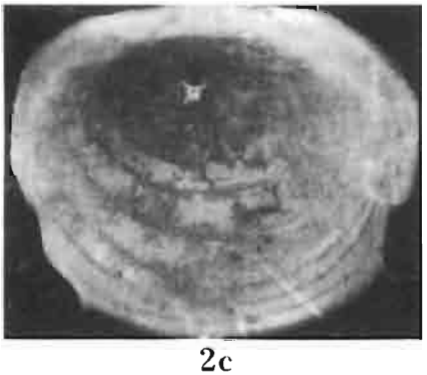

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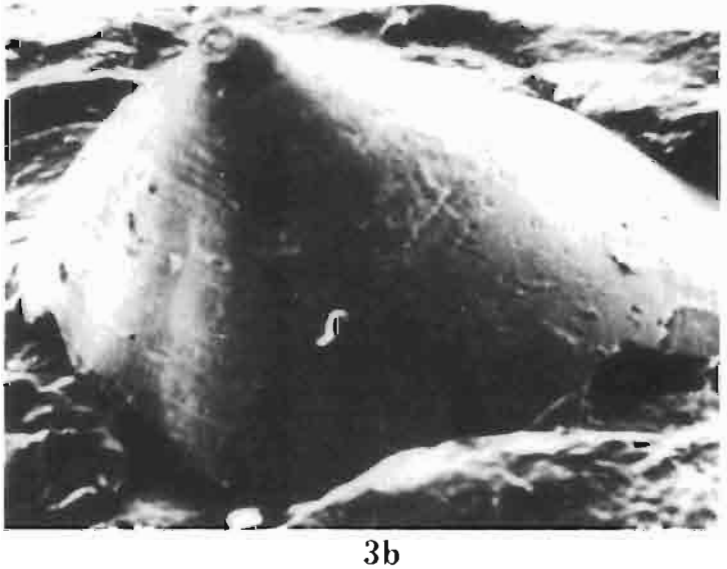

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

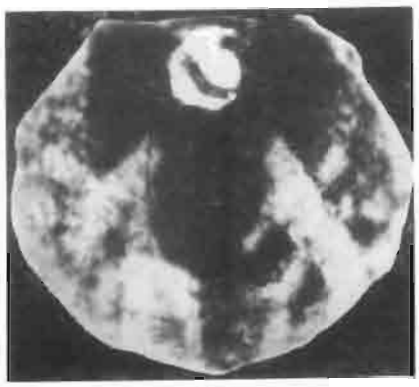
PLATE VIII

Fig. 1. Interior view of adult brachial valve (paratype, Bp. XV/16*v*), Bartoszyce IG-1 (1873·1 m); × approx. 27.

Figs. 2-3. Two adult pedicle valves (Bp. XV/16*x*, *u*); Fig. 2 — type specimen, approx. × 37; Fig. 3 — apical view, approx. ×42; Bartoszyce, IG-1 (1873·1 m).

Fig. 4. Adult pedicle valve (Bp. XV/16*k*) with traces of pallial sinuses preserving a baculate pattern: *a* interior view, *b* exterior view; approx. ×42; Kętrzyn IG-1 (1595·5 m).

Figs. 5-6. Two adult pedicle valves (Bp. XV/16*n*, *p*); Fig. 5 — a fragment of apical process, Fig. 6 — interior view of apical cavity; approx. ×42; Kętrzyn IG-1 (1595·5-1602·1 m).



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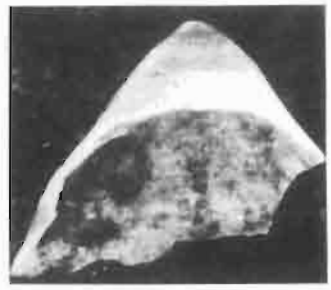

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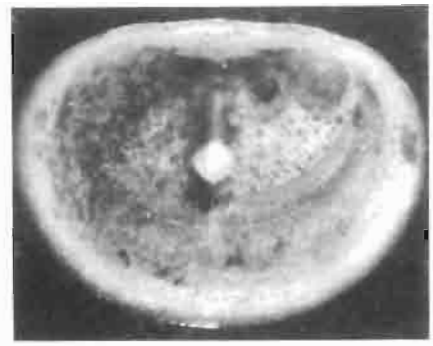

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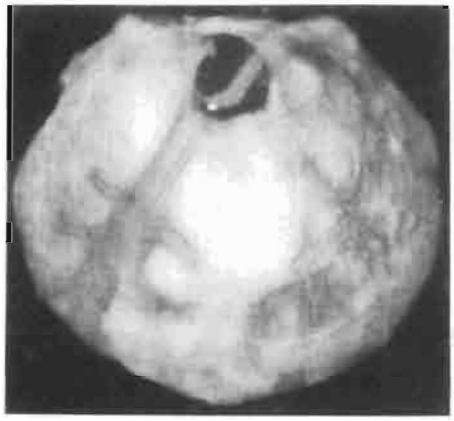

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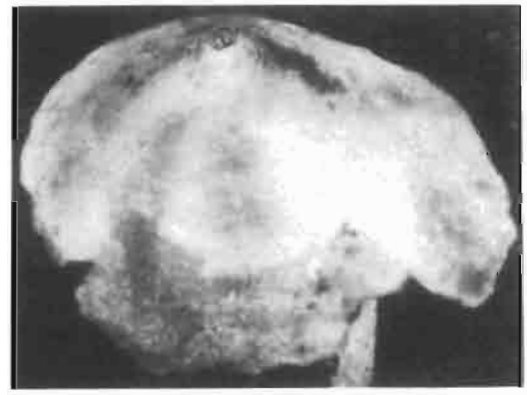

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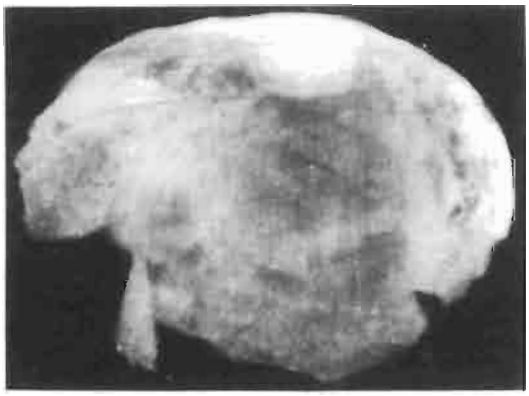

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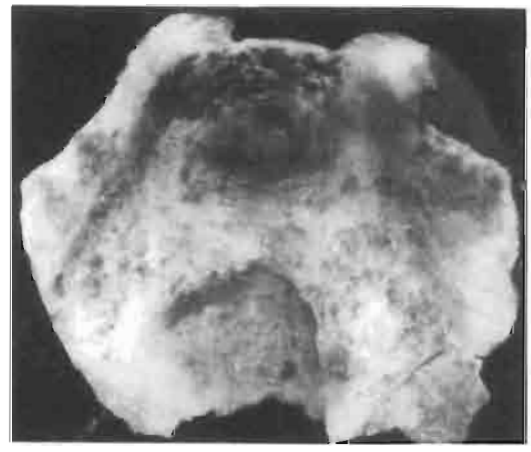

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PLATE IX

Page

Eurytreta minor n. sp. 74

Tremadocian chalcedonites, Wysoczki

Figs. 1-2. Two brachial valves of slightly different size with a preserved median septal ridge (Bp. XV/16*g*, *h*); Fig. 1 (paratype) — approx. ×30, Fig. 2 — approx. ×24.

Figs. 3-6. Four different pedicle valves of not very adult specimens (Bp. XV/16*o*, *r*, *j*, *n*); Figs. 3-5 — approx. ×24, Fig. 6 (type specimen) — approx. ×62.

Eurytreta intermedia n. sp. 72

North-eastern Poland

Figs. 7-8. Two different brachial valves from exterior and interior (Bp. XV/41*k*, *o*); median septum, two propareas and median plate present; Fig. 8 — paratype, approx. ×28. Bartoszyce IG-1 (1873·1 m).

Fig. 9. Pedicle valve (Bp. XV/41*t*, type specimen) in three slightly different positions; approx. ×28. Bartoszyce IG-1 (1873·1 m).

Figs.10-11. Two pedicle valves (Bp. XV/42*u*, *s*), approx. ×20, Fig. 10 — Bartoszyce IG-1 (1873·1 m), Fig. 11 — Goldap IG-1 (1466·1 m).

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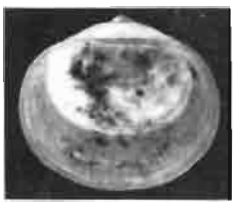

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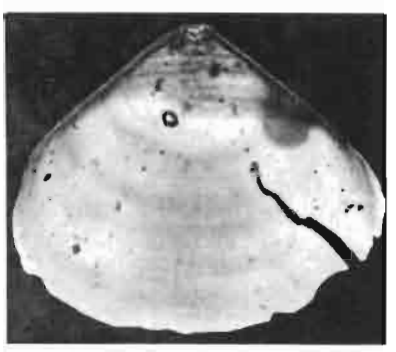

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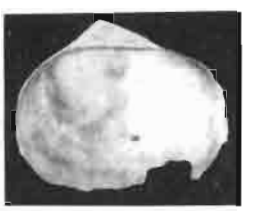

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PLATE X

Page

Semitreta maior n. sp. 76

Tremadocian chalcedonites, Wysoczki

Figs. 1-10. A range of pedicle valves in different size showing a very limited variability in the valve outline (Bp. XV/11*k*, *l*, *m*, *n*, *o*, *p*, *r*, *s*, *t*, *u*); Fig. 10 — type specimen; Figs. 1-6, 8-10 — approx. ×40, Fig. 7 — approx. ×62.

Fig. 11. Brachial valve partly preserved (Bp. XV/11*z*), paratype, approx. ×55.

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Conotreta cf. *mica* GORJANSKY . . . . . .

Bartoszyce IG-1 (1873·1 m), north-eastern Poland

Fig. 12. Apical part of the pedicle valve (Bp. XV/11*w*); approx. ×25.

Eurytreta intermedia n. sp. 72

Kętrzyn IG-1 (1595·5 m), north-eastern Poland

Fig. 13. Brachial valve of adult specimen (Bp. XV/42*y*); approx. ×42.

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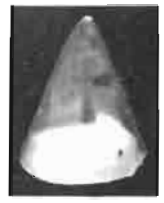

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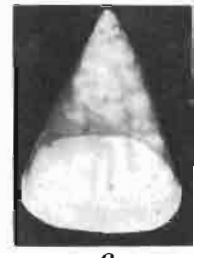

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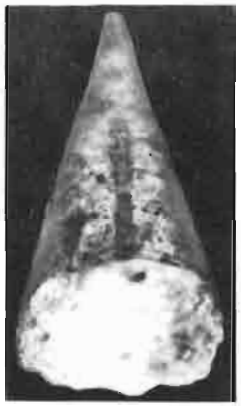

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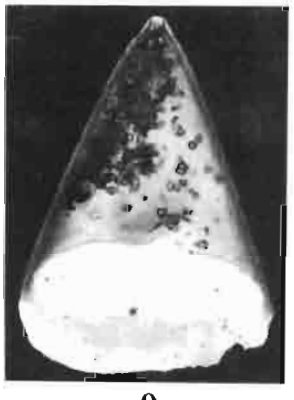

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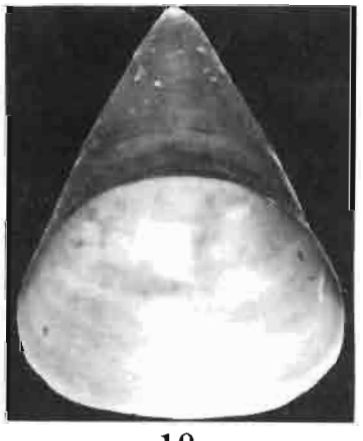

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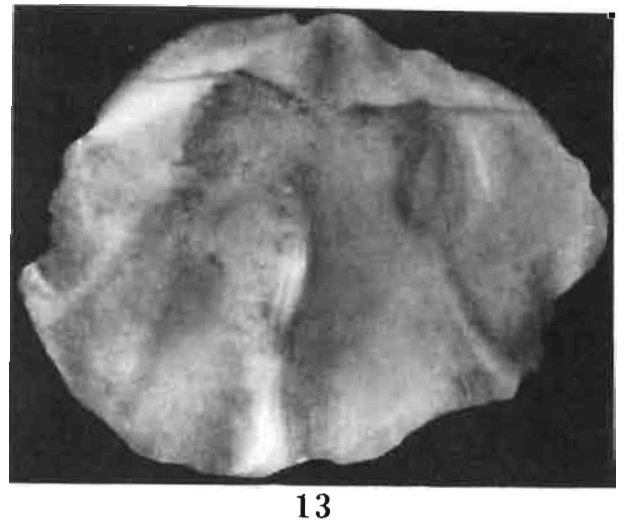

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XI

Page

Spondylotreta faceta GORJANSKY 79
Volkhov horizon, Suhkrumägi, Estonia

Fig. 1. Pedicle valve of adult specimen, approx. ×30.

Spondylotreta dissimilis n. sp. 78
Tremadocian chalcedonites, Wysoczki

Figs. 2-4. Three pedicle valves, damaged (Bp. XV/10*a*, *b*, *d*), Fig. 3 (type specimen) preserving spondylium, Figs. 1, 3 — approx. ×40, Fig. 2 — approx. ×30.

Figs. 5-7. Three brachial valves (Bp. XV/10*k*, *l*, *m*), interarea and median septal ridge preserved; Fig. 5 — paratype, all figs. approx. ×62.

Figs. 8-9. Scanning electron micrographs: Fig. 8 — view of the dorsal shell surface etched in hydrofluoric acid, ×2400; Fig. 9 — exterior of the brachial valve, ×140.

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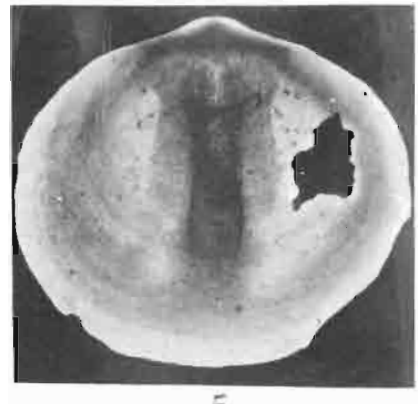

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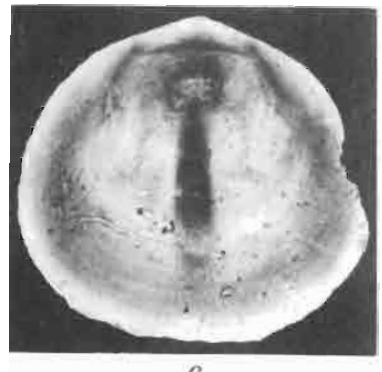

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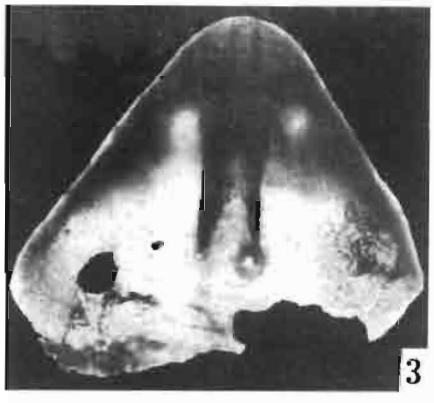

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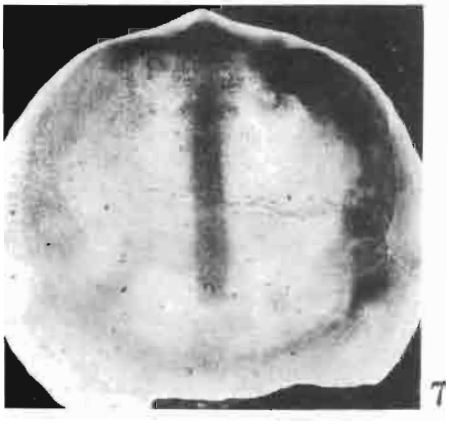

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XII

Page

Spondylotreta dissimilis n. sp. 78
Tremadocian chalcedonites, Wysoczki

Figs. 1-2. Two brachial valves partly preserved showing cardinal muscle scars, septum and interarea (Bp. XV/10*s*, *t*); Fig. 1 — approx. ×23, Fig. 2 — ×40.

Spondylotreta concentrica COOPER 78
Pratt Farry fm., Alabama, USA

Figs. 3-5. Scanning electron micrographs: Fig. 3 — fragment of concentric surface ornament, the splitting ribs in the ventral interarea region, approx. ×1450; Fig. 4 — view of the ventral protegulum pits, approx. ×6·500, Fig. 5 — junction protegulum and adult valve, approx. ×2600.

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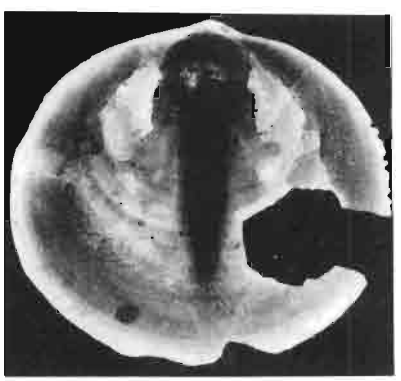

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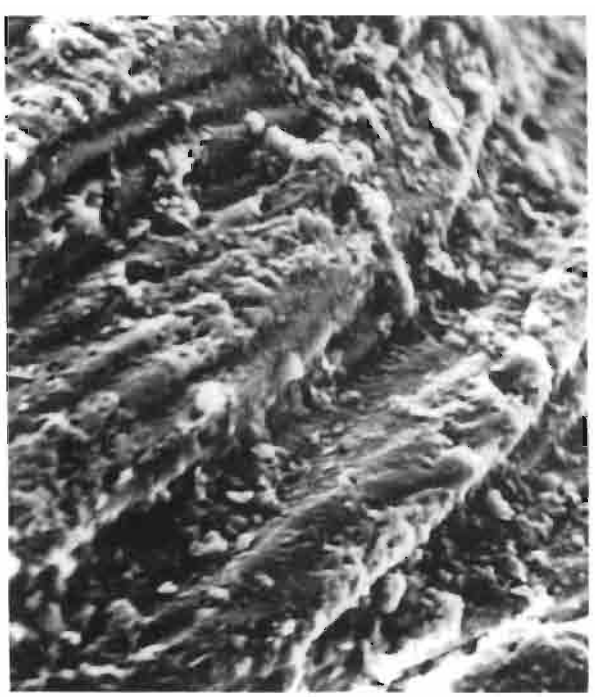

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XIII

Page

Myotreta crassa GORJANSKY 81
North-eastern Poland

Figs. 1-4. Four adult brachial valves preserving a median septum, interarea and a weak cardinal muscle scars (Bp. XV/40*a*, *t*, *u*, *v*); Fig. 1 — Goldap IG-1 (1475·6 m), Figs. 2-3 Kętrzyn IG-1 (1602·1 m); Figs. 1-3 — approx. ×50, Fig. 4 — approx. ×30.

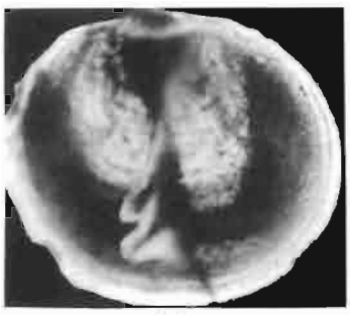
Figs. 5-7. Three pedicle valves of a slightly different size (Bp. XV/35*s*, *t*, *v*); Kętrzyn IG-1 (1602·1 m); Fig. 5 — approx. ×10, Figs. 6, 7 — approx. ×40.

Figs. 8-9. Scanning electron micrographs. Fig. 8 — external view of the brachial valve, Kętrzyn LG-1 (1602·1 m), ×240; Fig. 9 — external view of pedicle valve, Bartoszyce IG-1 (1879·5 m), ×210.

Myotreta estoniana n. sp. 83
Volkhov horizon, Suhkrumägi, Estonia

Figs. 10, 11, 13. Three adult brachial valves with distinctly folded median septum (Bp. XV/40*o*, *r*, *p*); approx. ×65.

Fig. 12. Brachial valve with a weakly folded septum (Bp. XV/40*z*, paratype), Kętrzyn IG-1 (1602·1 m); approx. ×57.



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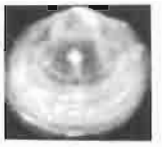

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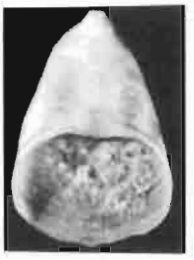

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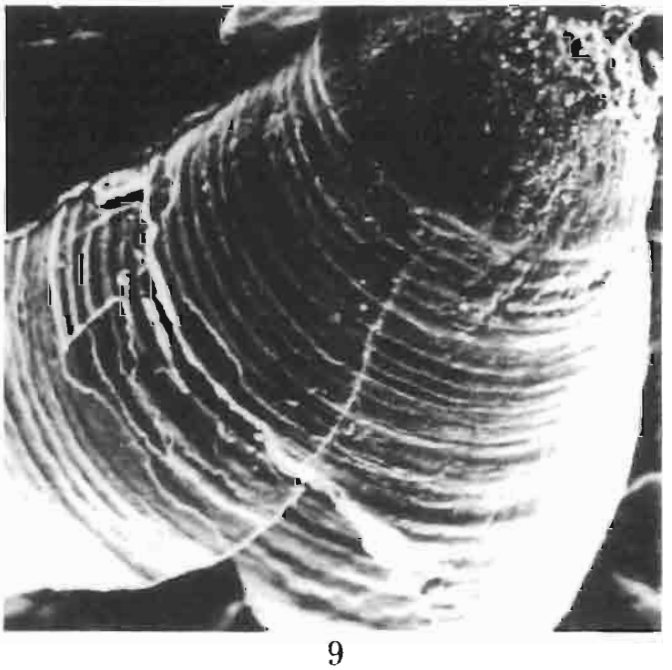

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XIV

Page

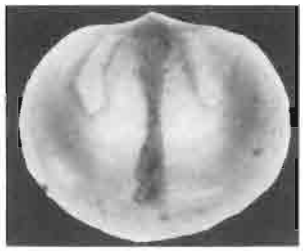
Myotreta estoniana n. sp. 83
North-eastern Poland

Figs. 1-4. Four brachial valves in different size (Bp. XV/11*s,t, u, v*), median septum folded, to a varying degree. Figs. 1, 2 — Kętrzyn IG-1 (1602·1 m), approx. ×90, Figs. 3-4 — Estonia, Volkhov horizon. Fig. 3 — approx. ×62, Fig. 4 illustrating an extremely old stage, approx. ×65.

Fig. 5. Pedicle valve (Bp. XV/11*y*, type specimen), Kętrzyn IG-1 (1602·1 m); approx. ×90.

Myotreta crassa GORJANSKY 81
Kętrzyn IG-1 (1602·1 m), north-eastern Poland

Figs. 6-7. Scanning electron micrographs: Fig. 6 — fragment of the surface concentric ornamentation on the anterior third of the brachial valve, ×1200; Fig. 7 — junction of protegulum and adult shell on the brachial valve, ×1300.



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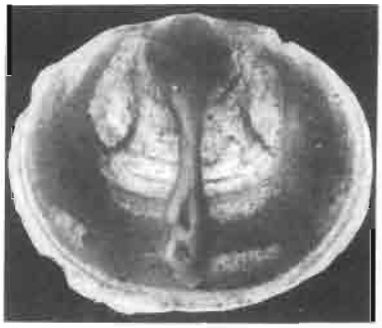

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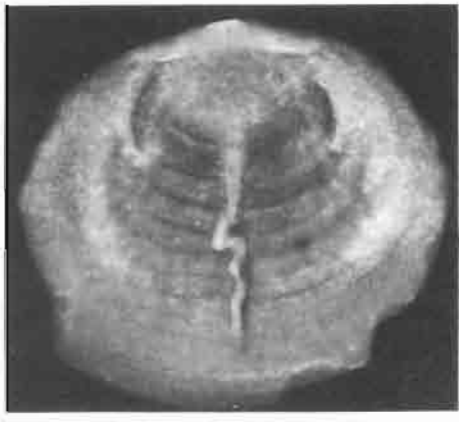

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PLATE XV

Page

Myotreta crassa GORJANSKY 81
North-eastern Poland

Figs. 1-3. Three brachial valves (Bp. XV/12*t*, *u*, *v*). Figs. 1, 3 — Kętrzyn IG-1 (1602·1 m), Fig. 2 — Gołdap IG-1 (1473·6 m); approx. ×55.
Figs. 4-5. Two pedicle valves (Bp. XV/12*x*, *y*) in side views, showing preserved calpac-like young shell; Kętrzyn IG-1 (1602·1 m).

Myotreta sp. 85
Tremadocian chalcedonites, Wysoczki

Fig. 6. Pedicle valve with preserved external pedicle tube, valve very damaged (Bp. XV/35*z*), approx. ×71.
Figs. 7-8. Two brachial valves partly preserved bearing an interarea, divergent cardinal muscle scars and a short median septum (Bp. XV/35*v*); approx. ×55.

Eoconulus cryptomyus GORJANSKY 112
Volkhov horizon, Suhkrumägi, Estonia

Fig. 9. Scanning electron micrograph. Apical view of adult specimen; ×1400.

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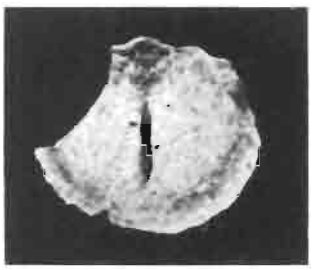

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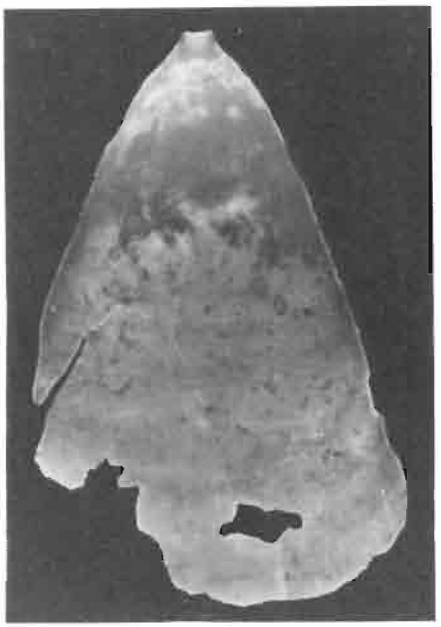

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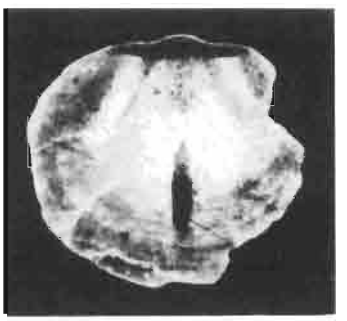

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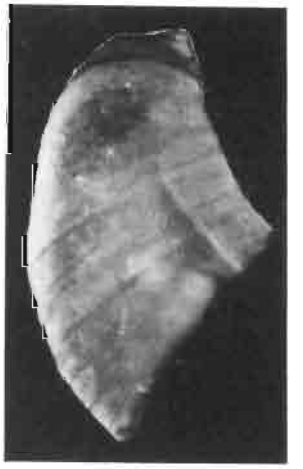

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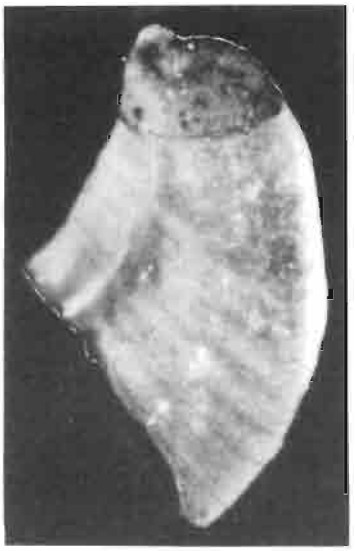

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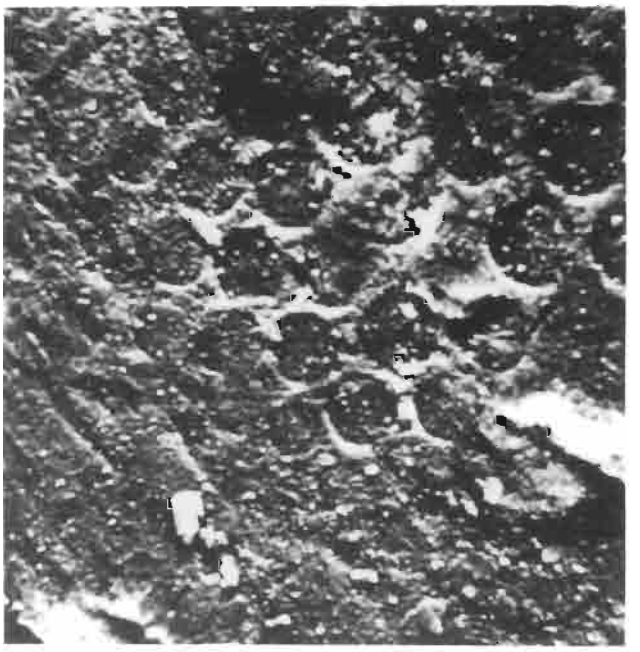

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PLATE XVI

Page

Scaphelasma subquadratum n. sp. 86
North-eastern Poland

Figs. 1-5. Five brachial valves (Bp. XV/10*c*, *o*, *s*, *t*, *u*, *v*) from exterior and interior; Figs. 1, 4, 5 — Kętrzyn IG-1 (1602·1 m), Figs. 2, 3 — Gołdap IG-1 (1473 m); Figs. 1-4 — approx. ×50, Fig. 5 — approx. ×60.

Figs. 6, 8-10. External view of three pedicle valves showing weakly marked interthrough and pedicle foramen (Bp. XV/9*o*, *r*, *c*), Goldap IG-1 (1473 m). approx. ×50. Fig. 10 — Scanning electron micrograph, exterior view of brachial valve, ×114.

Scaphelasma sp. 90
Erratic boulder No. O. 247, Jarosławiec, Baltic coast

Fig. 7. Exterior view of pedicle valve showing a lens-like pedicle foramen (Bp. XV/9*p*), Fig. 7*a* — approx. ×22, Fig. 7*b* — approx. ×50.

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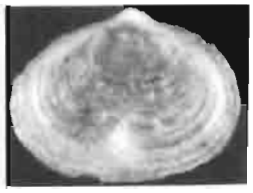

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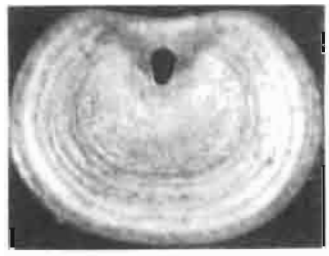

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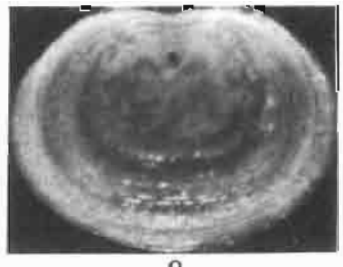

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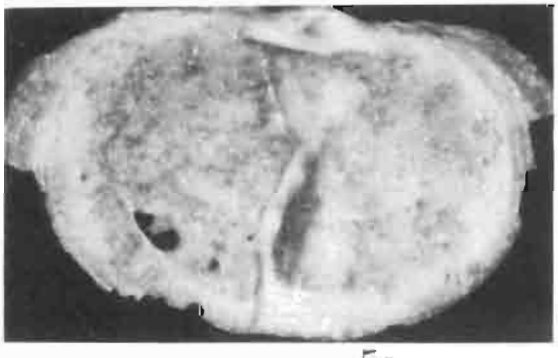

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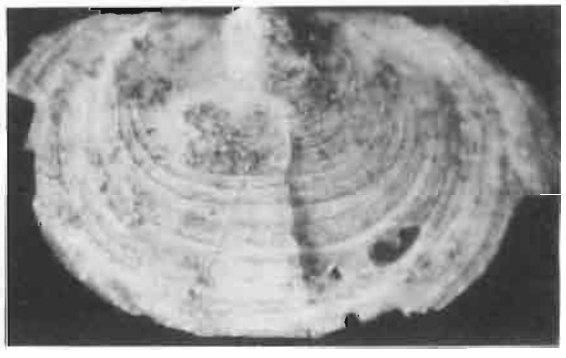

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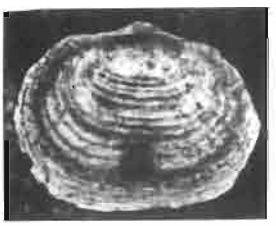
PLATE XVII

Figs. 1-3. Three brachial valves (Bp. XV/8*o*, *p*, *r*) in slightly different individual age, exterior and anterior views; Fig. 3 — paratype, Kętrzyn IG-1 (1595·5 m); Figs. 1, 2 — Gołdap IG-1 (1466·0 m); approx. ×60, Fig. 3 — approx. ×50.

Figs. 4-5. Two pedicle valves (Bp. XV/8*t*, *v*), Kętrzyn IG-1 (1595·5 m); Fig. 5 — type specimen, approx. ×60.

Fig. 6. Scanning electron micrograph: Fig. 6*a* — external view of brachial valve, ×124; Fig. 6*b* — detail of the surface concentric ornamentation; ×1300; Volkhov horizon, Estonia.



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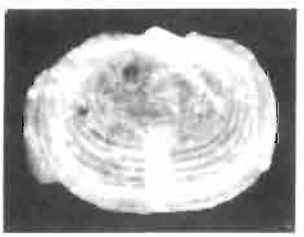

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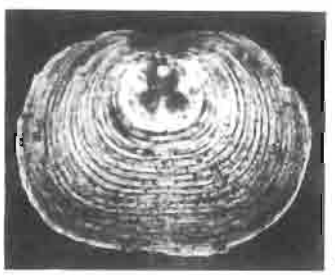

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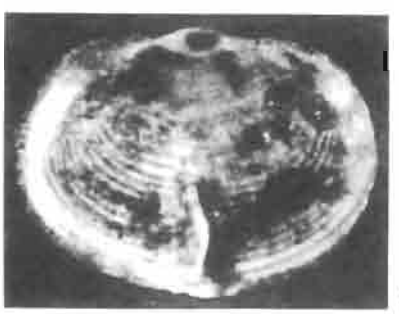

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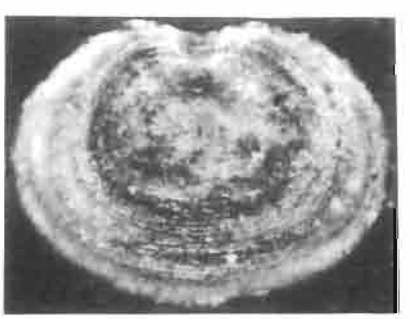

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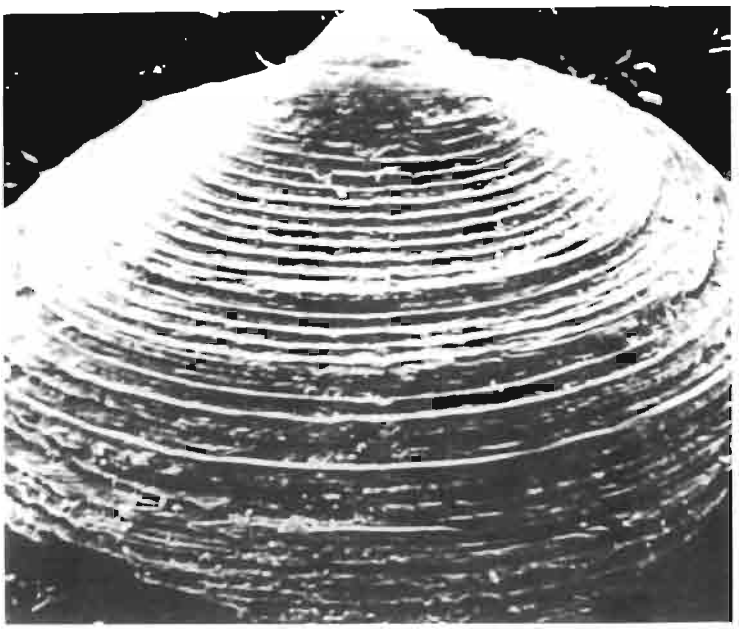

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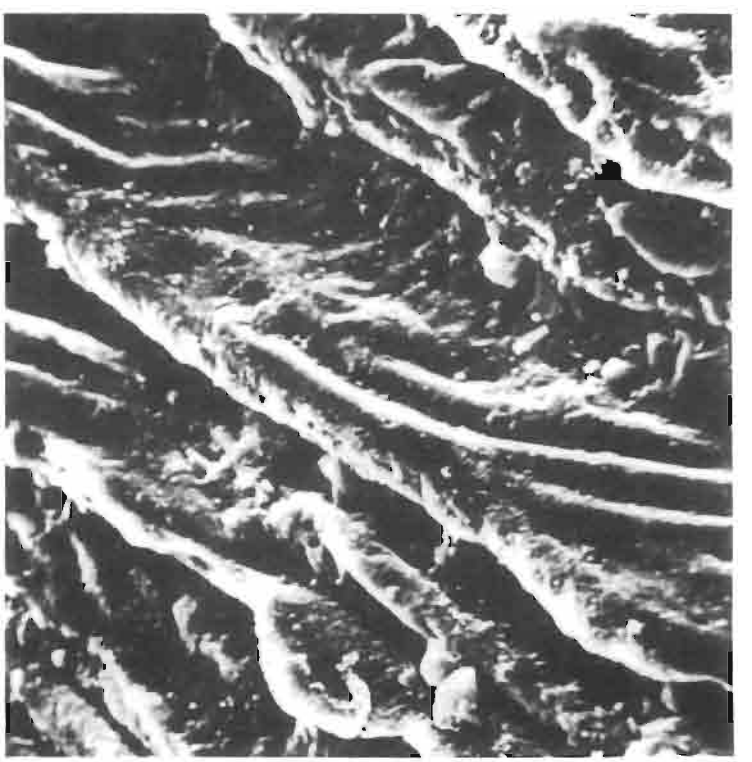

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XVIII

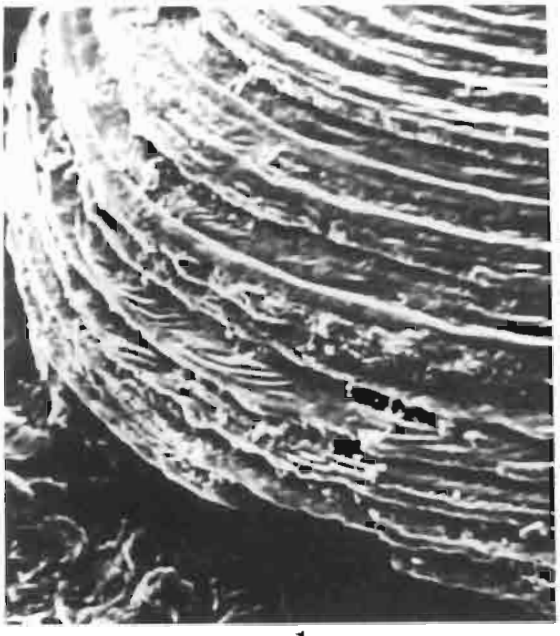
Page

Scaphelasma subquadratum n. sp. 86

Scanning electron micrographs

Figs. 1, 2. Details of adult specimen, Volkhov horizon, Suhkrumägi, Estonia; Fig. 1 — ×250, Fig. 2 — ×1200.

Figs. 3, 4. Junction of protegulum and adult valve; Fig. 3 — Kętrzyn boring, ×1100; Fig. 4 — Volkhov horizon, Suhkrumägi, Estonia, ×600.



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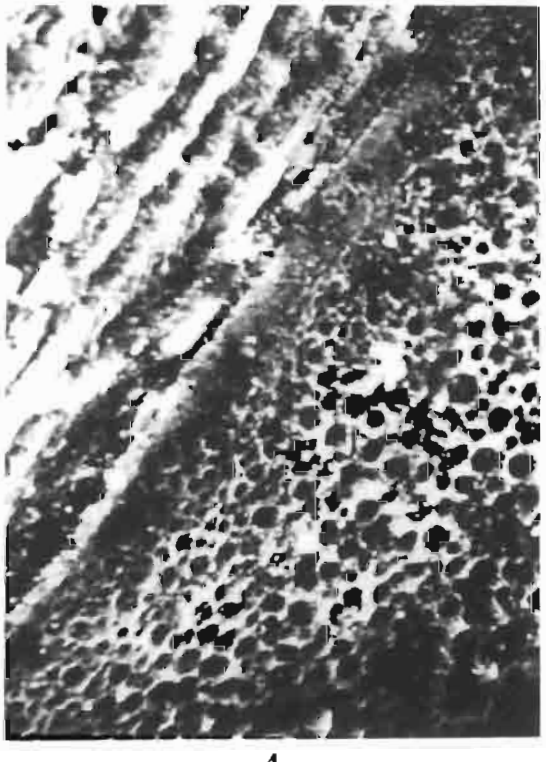

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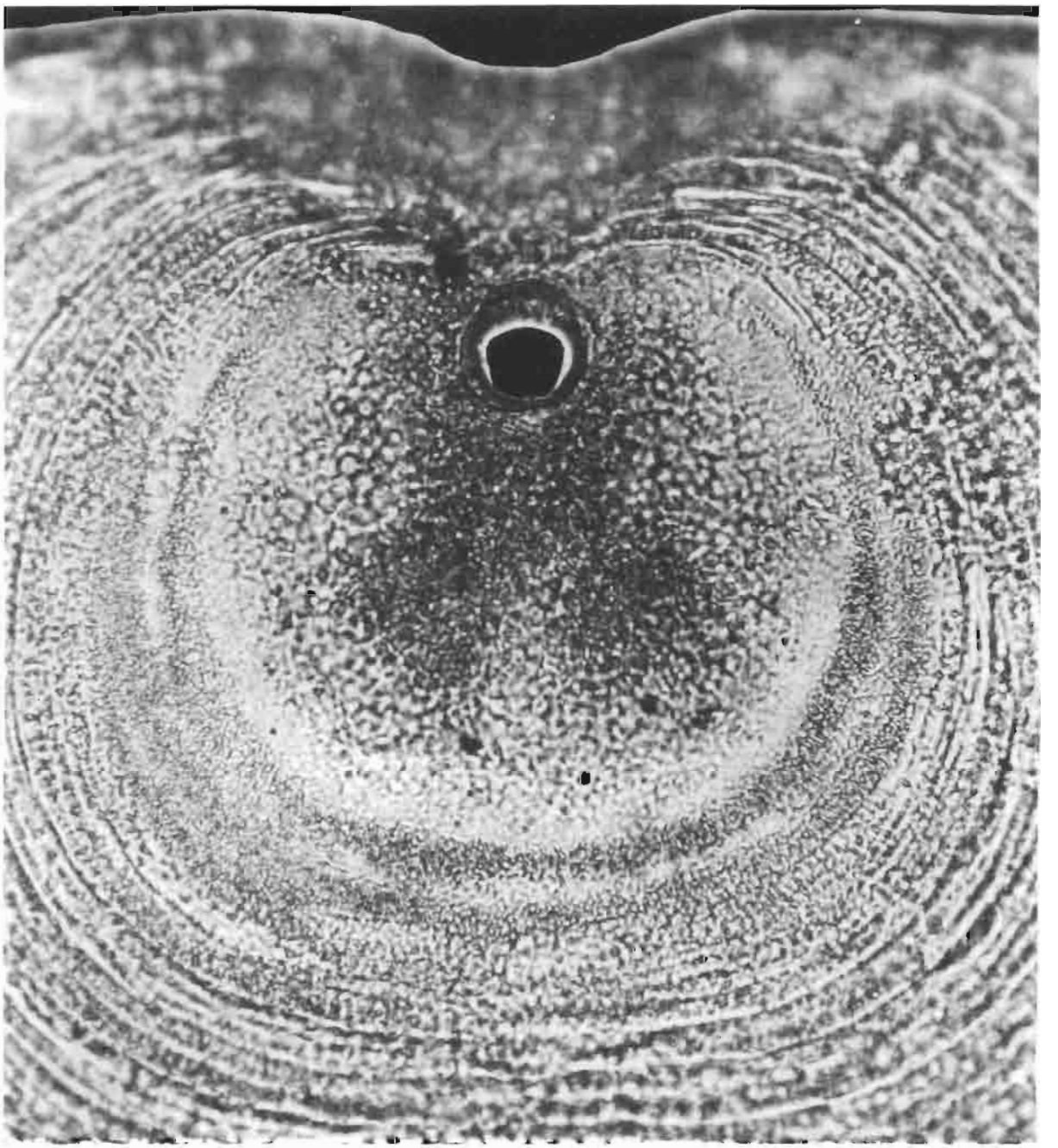
G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XIX

Kętrzyn IG-1 (1602·1 m), north-eastern Poland

Fig. 1. Apical view of adult pedicle valve showing traces of pitted protegulum and junction of protegulum with adult valve; approx. ×250.



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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XX

Page

Torynelasma rossicum GORJANSKY 93
North-eastern Poland

Figs. 1-7. A range of brachial valves slightly varying in size with a median septum in a different state of preservation (Bp. XV/44*n,o, p, r, s, t, u*); Fig. 1 — side view, approx. × 60, Voikhov horizon, Estonia; Figs. 2-7 — Kętrzyn IG-1 (1602·1 m); Figs. 2-5 — approx. × 28; Figs. 6, 7 — approx. ×40.

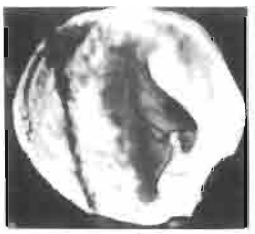
Figs. 8-10. Three pedicle valves in slightly different views (Bp. XV/45*o, r, s*), Bartoszyce IG-1 (1879 m); Figs. 8, 10 — approx. ×40, Fig. 9 — approx. × 42.

Fig. 11. Scanning electron micrograph. Posterior half of adult pedicle valve, Bartoszyce IG-1 (1879 m), a detail of protegulum and adult valve showed: × 240.

Torynelasma rarum n. sp. 92
Jezioro Okrągłe IG-1, north-eastern Poland)

Fig. 12. A specimen (Bp. XV/5) found in the residuum with both valves closed, type specimen, approx. ×30, Jezioro Okrągłe IG-1 (909 m).

Fig. 13. Brachial valve of adult specimen with only partly preserved dorsal septum (Bp. XV/6*z*); approx. ×40.



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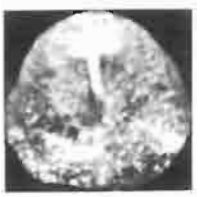

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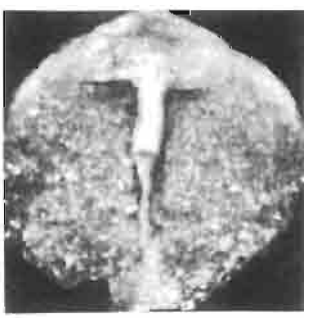

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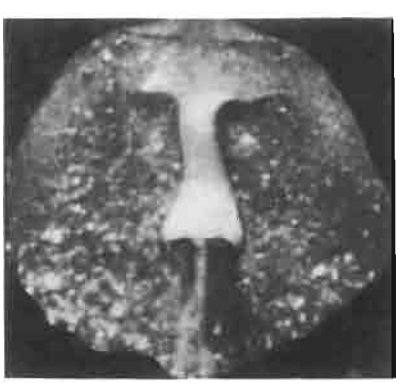

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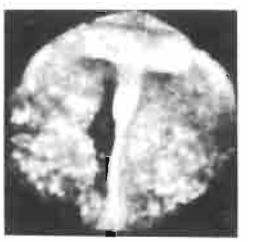

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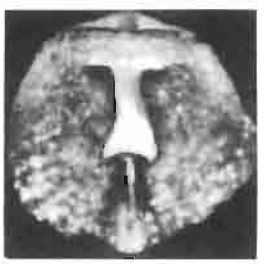

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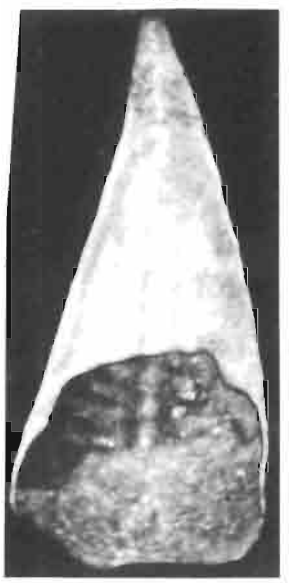

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPOD

PLATE XXI

Page

Torynelasma sp. 92

Volkhov horizon, Suhkrumägi, Estonia

Fig. 1. Pedicle valve slightly damaged (Bp. XV/45*t*), approx. ×45.

Fig. 6. Internal view of adult brachial valve (Bp. XV/44*w*); approx. ×100.

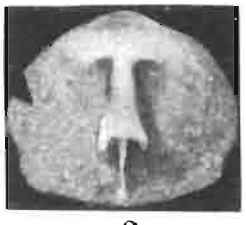
Torynelasma rossicum GORJANSKY 93

Bartoszyce IG-1 (1879 m), north-eastern Poland)

Figs. 2-3. Two brachial valves with well preserved internal details (Bp. XV/44*v*, *y*); Fig. 2 — approx. ×50, Fig. 3 — approx. ×62.

Figs. 4-5. Scanning electron micrographs. Fig. 4 — view of a pitted protegulum, ×1200; Fig. 5 — surface ornamentation composed of concentric lines in the anterior third of pedicle valve, ×1200.

1



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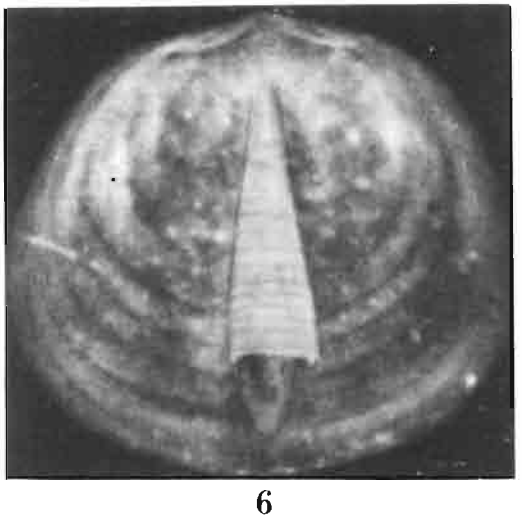

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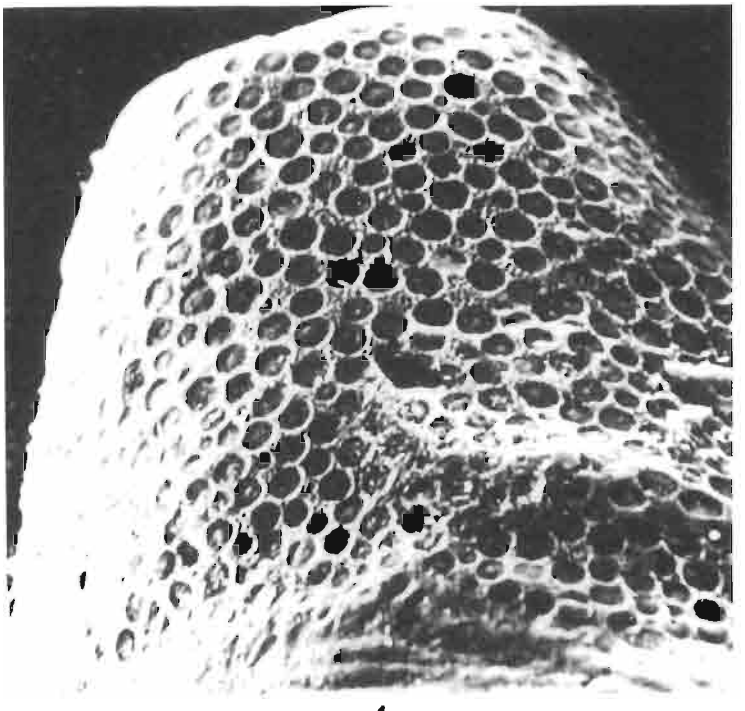

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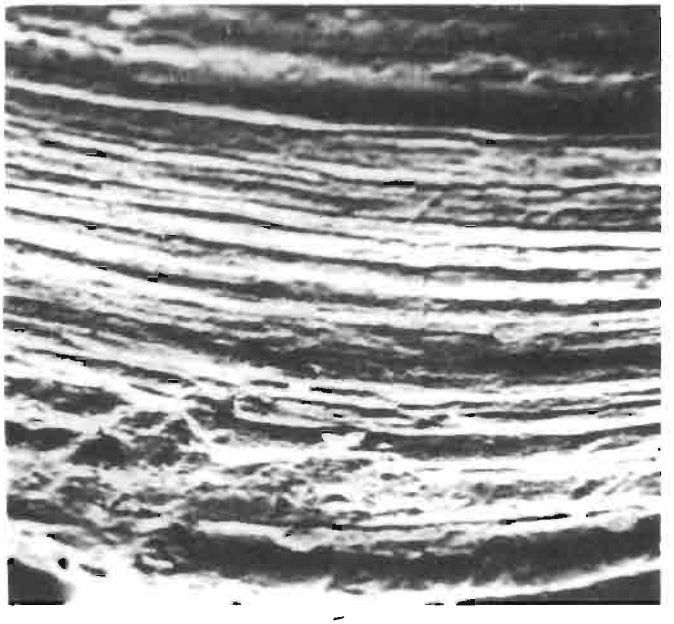

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXII

Page

Torynelasma rossicum GORJANSKY 93

Bartoszyce IG-1 (1893·0 m), north-eastern Poland

Scanning electron micrographs

Fig. 1. Junction of protegulum and adult valve; ×2400.
Fig. 2. View of right side of the pedicle valve surface; ×1200.
Figs. 3-4. Details of interarea; Fig. 3 — ×600, Fig. 4 — × 2300.

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXIII

Figs. 1-10. A range of brachial valves of varying size and appearance of the median septum (Bp. XV/11 *m*, *n*, *o*, *p*, *r*, *s*, *t*, *u*, *v*, *z*); Fig. 10 — paratype, Figs. 1-3 — Jezioro Okrągłe IG-1 (941 m), Figs. 4-5 — Gołdap IG-1 (1466·2 m), Figs. 6-10 — Kętrzyn IG-1 (1602·1 m); Figs. 1-5 — approx. ×27, Figs. 6-10 — approx. ×50.

Fig. 11—13. Three pedicle valves, interarea view (Bp. XV/12 *z*, *n*, *v*,); Fig. 11 — type specimen, Fig. 12 — adult valve Suhkrumägi, Estonia, Volkhov horizon approx. ×60; Figs. 11, 13-14 — Kętrzyn IG-1 (1595·5 m), Figs. 11*a*-13 — approx. ×27, Fig. 11*b* — approx. ×50.

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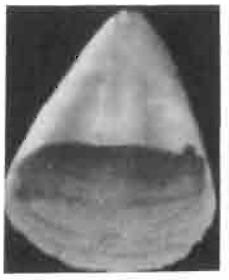

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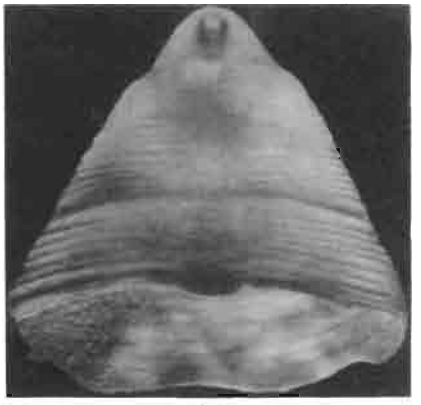

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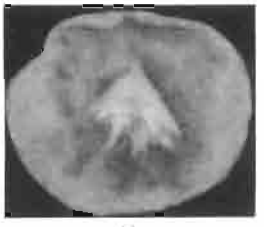

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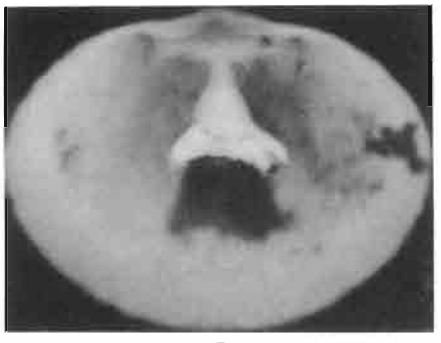

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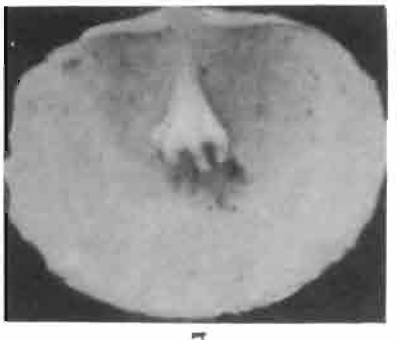

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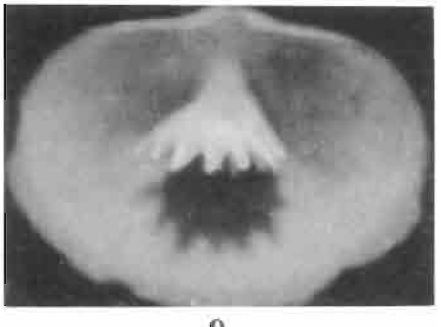

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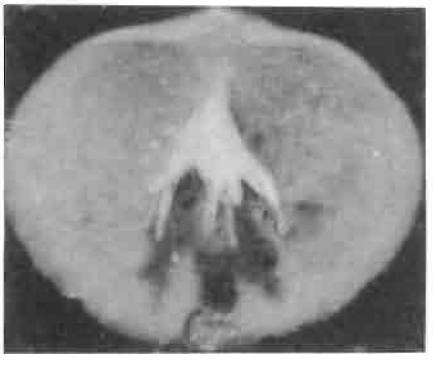

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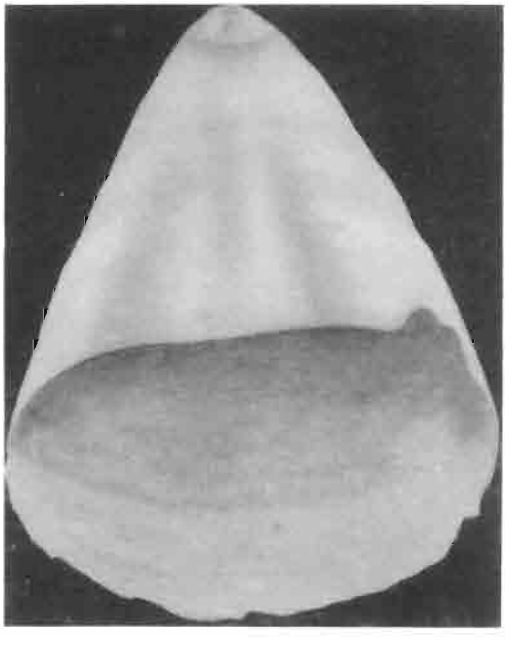

11b

G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXIV

Page

Ephippelasma latior n. sp. 97
North-eastern Poland

Figs. 1, 3. Two brachial valves showing a median septum (Bp. XV/13*z*, *x*), Kętrzyn IG-1 (1595·5-1602·1 m); approx. ×42.
Fig. 2. Dorsal interior with a slightly change median septum (Bp. XV/13*u*), Jezioro Okrągłe IG-1 (940·1 m); approx. ×42.
Fig. 4. Paratype (Bp. XV/13*v*), Kętrzyn IG-1 (1595·5 m); approx. ×62.
Figs. 5-8. A range of pedicle valves of different size (Bp. XV/13*p*, *r*, *s*, *t*), Kętrzyn IG-1 (1595·5 m); Figs. 5, 7, 8 — approx. ×42, Fig. 8 — type specimen, Fig. 6 — approx. ×50.

Ephippelasma spinosum n. sp. 96
Kętrzyn IG-1 (1602·1 m), north-eastern Poland

Fig. 9. Scanning electron micrograph. Detail of surface concentric ornamentation; ×1300.

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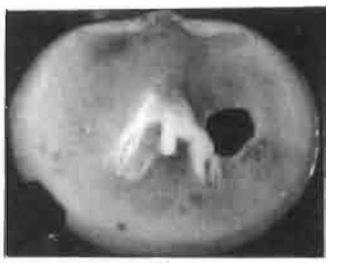

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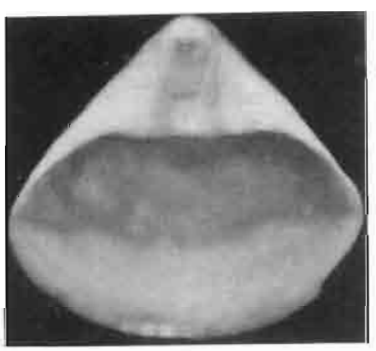

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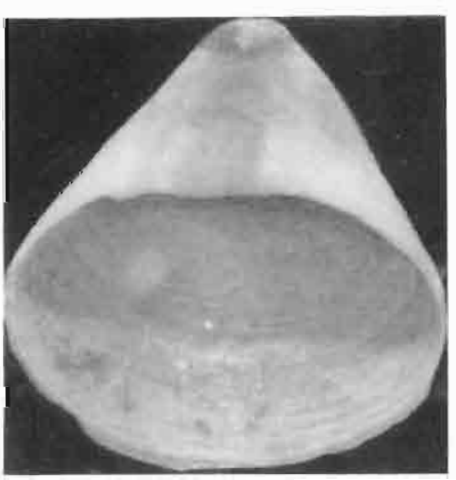

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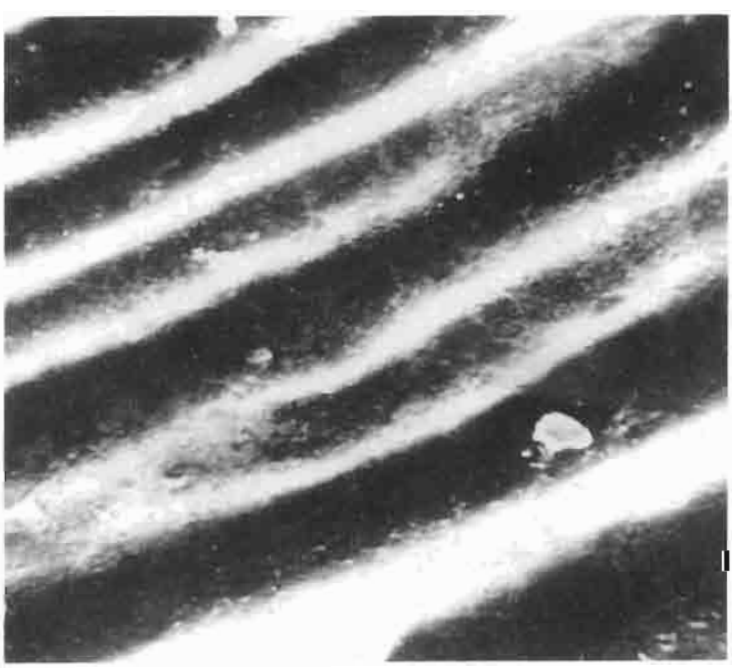

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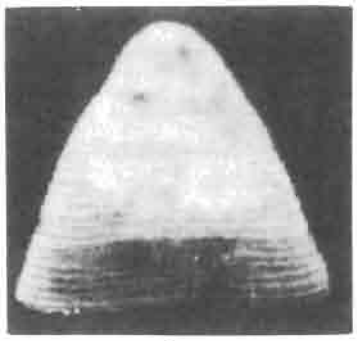
G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXV

Figs. 1-2. Two pedicle valves (Bp. XV/14*v*, *z*). Fig. 1 — in ventrical side and dorsal side views, approx. ×55; Fig. 3 — other specimens in dorsal side view; approx. ×30.

Figs. 3-4. Two brachial valves with preserved trace of vertical supporting plate (Bp. XV/14*t*, *y*); approx. ×55.

Figs. 5-8. Almost complete specimen in slightly different positions (posterior half of the pedicle valve damaged), showing the "hinge" line and position of the median septum on the brachial valve (Bp. XV/14*u*); Fig. 7 — approx. ×30, Figs. 5, 8 — approx. ×55, Fig. 6 — approx. ×80.



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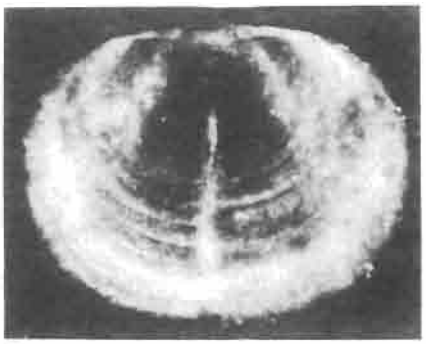

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1b

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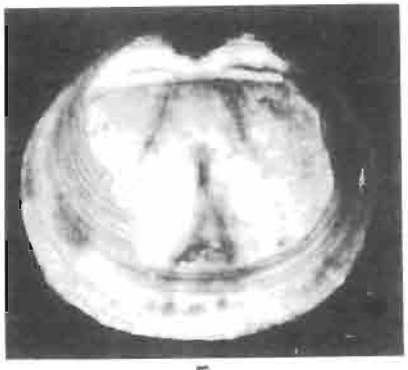

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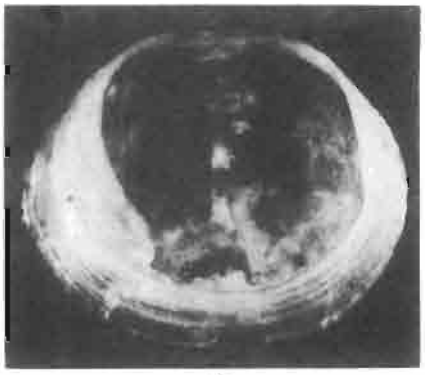

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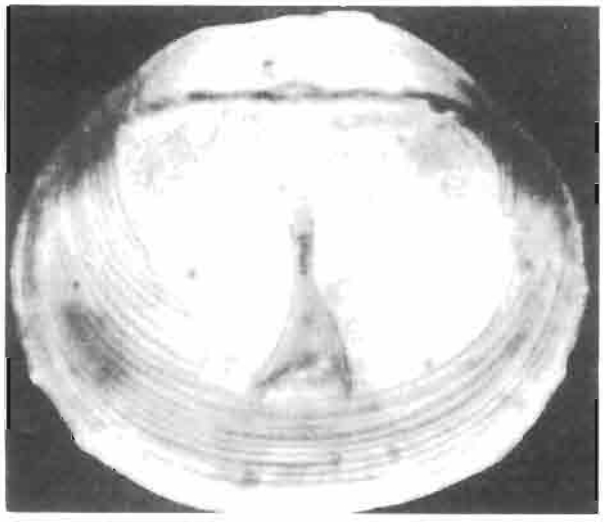

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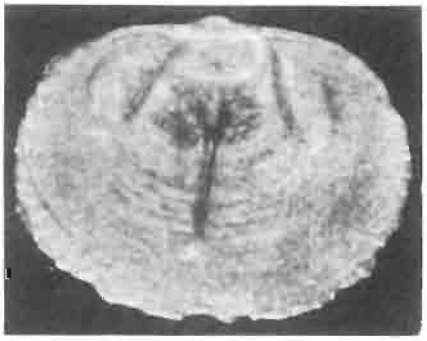

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXVI

Page

Ephippelasma spinosum n. sp. 99

Arenigian-Llanvirnian, Kętrzyn IG-1 (1602·1 m), north-eastern Poland

Scanning electron micrographs

Fig. 1. Median septum view showing the tubular spines, covering the under side of the surmounting plate; ×240.
Fig. 2. Apical view of the pedicle valve showing a pedicle foramen; ×625.
Fig. 3. Protegulum and adult valve junction of the pedicle valve; ×1200.
Fig. 4. External view of the pedicle valve; ×180.

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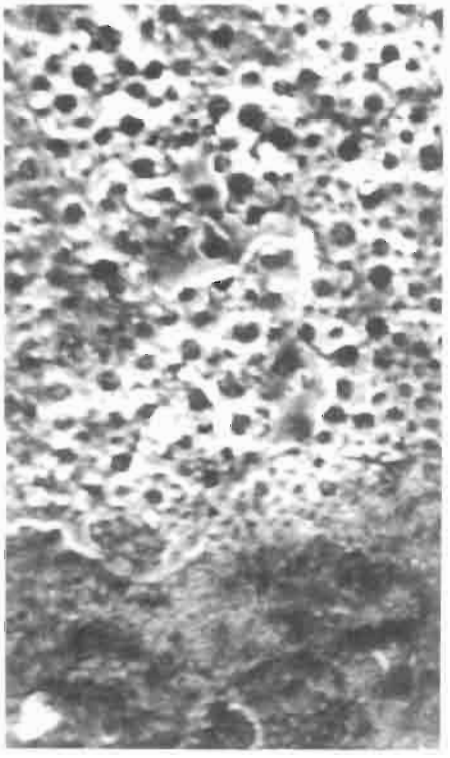

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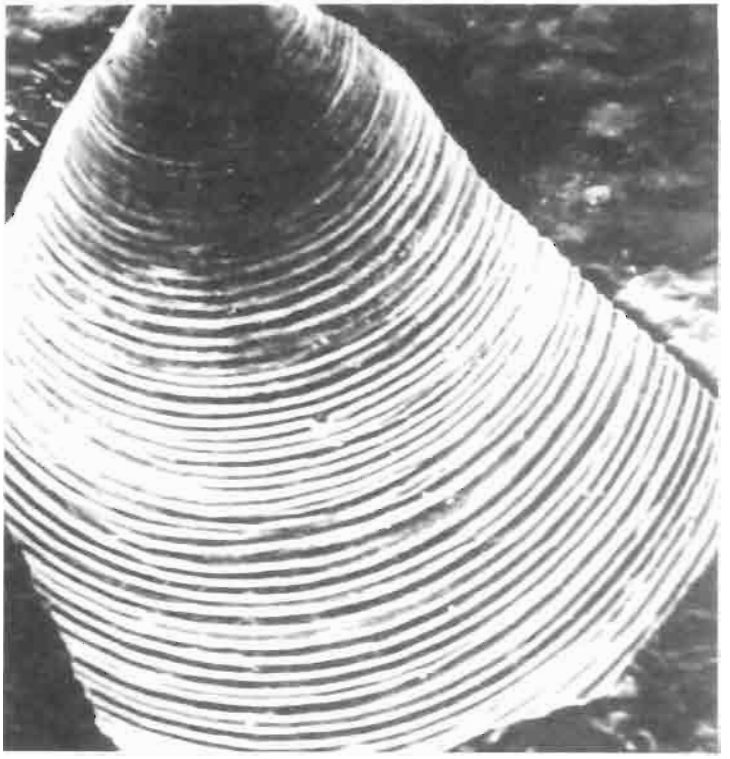

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXVII

Page

Orbithele bicornis n. sp. 101

Tremadocian chalcedonites, Wysoczki

Figs. 1-3. Three different pedicle valves (Bp. XV/1 *k, p, l*); Fig. 1 — type specimen, pedicle foramen and apical spinose processes preserved; Figs. 1, 2 — approx. ×28, Fig. 3 — external and internal view of pedicle valve approx. ×55.

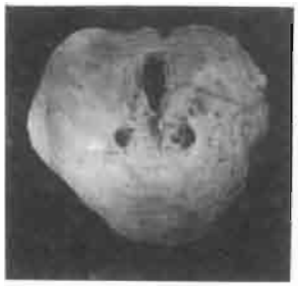
Siphonotreta acrotretomorpha GORJANSKY 105

Tremadocian chalcedonites, Wysoczki

Figs. 4-7. A range of pedicle valves in different size and in a varying state of preservation (Bp. XV/*l, i*1, *o, r, s*); Figs. 4, 5 — approx. ×40, Figs. 5—7 — approx. ×50.

Fig. 8. Brachial valve of young individual (Bp. XV/1 *x*); approx. ×40.

Figs. 9-10. Scanning electron micrographs. View of surface of a valve showing a fragmentary surface spines; Fig. 9 — ×600, Fig. 10 — ×2500.



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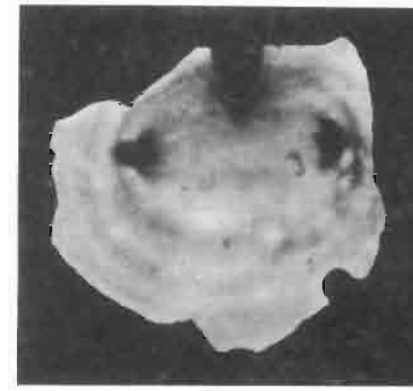

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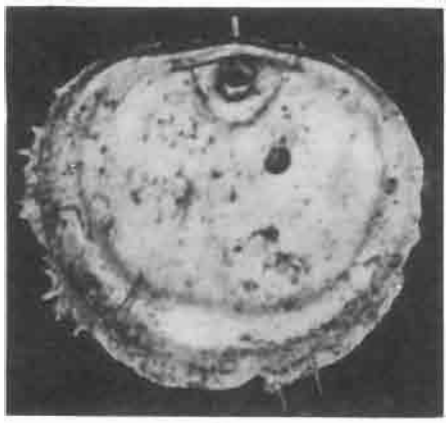

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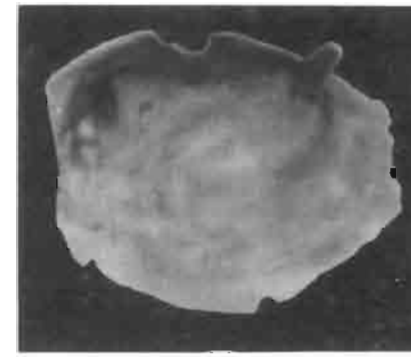

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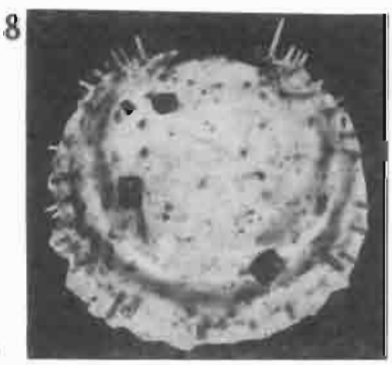

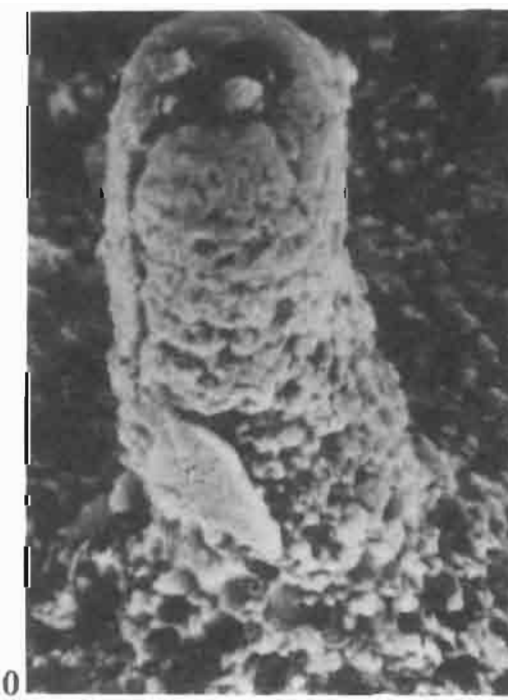

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXVIII

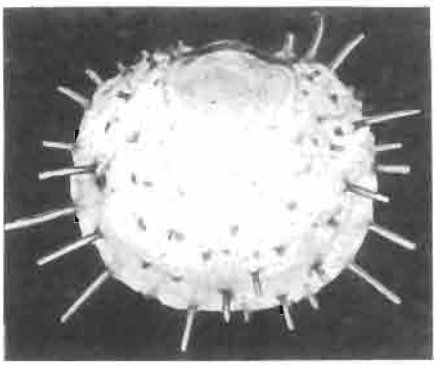
Page

Siphonotreta acrotretomorpha GORJANSKY 105
Tremadocian chalcedonites, Wysoczki

Figs. 1-4. Four brachial valves in different individual age (Bp. XV/2*o*, *p*, *r*, *s*). Figs. 1, 2 — approx. ×62, Figs. 3, 4 — approx. ×42.

Figs. 5-6. Two pedicle valves (Bp. XV/2*t*, *u*); in different individual age; Fig. 5 — approx. ×50, Fig. 6 — approx. ×80.

Fig. 7. Scanning electron micrograph. Apical part of a pedicle valve; ×600.



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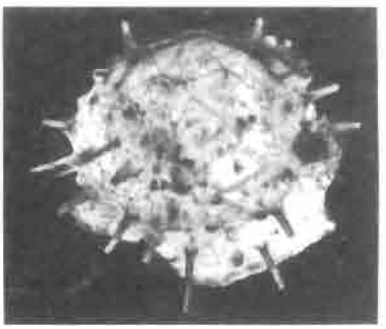

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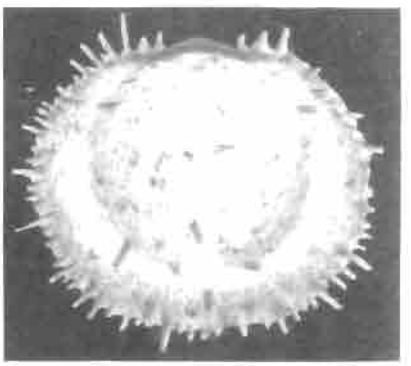

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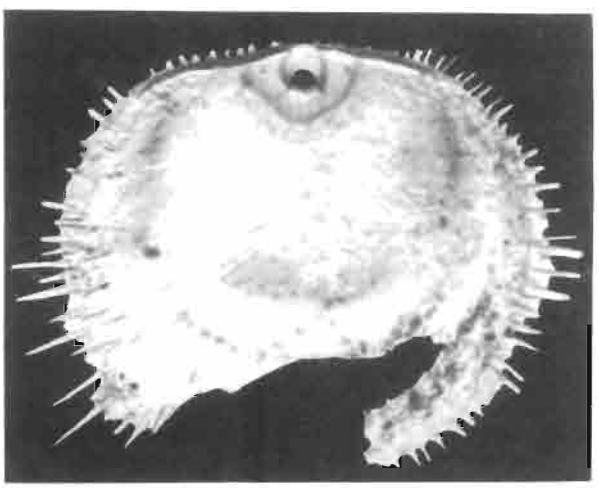

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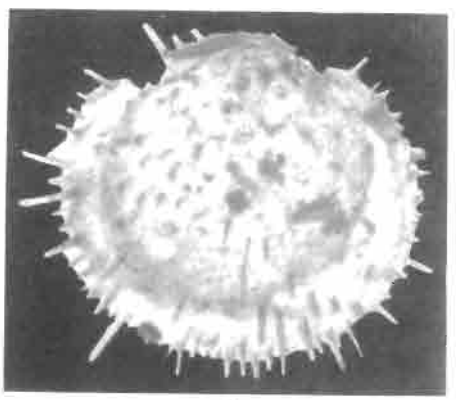

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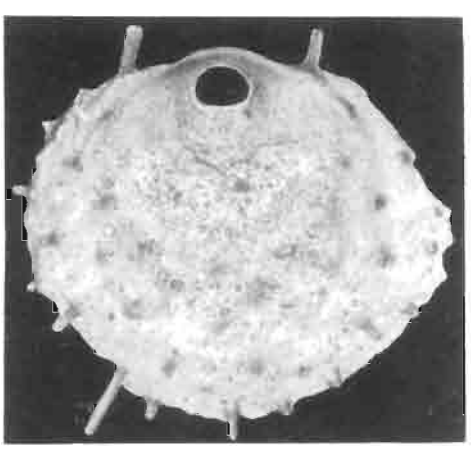

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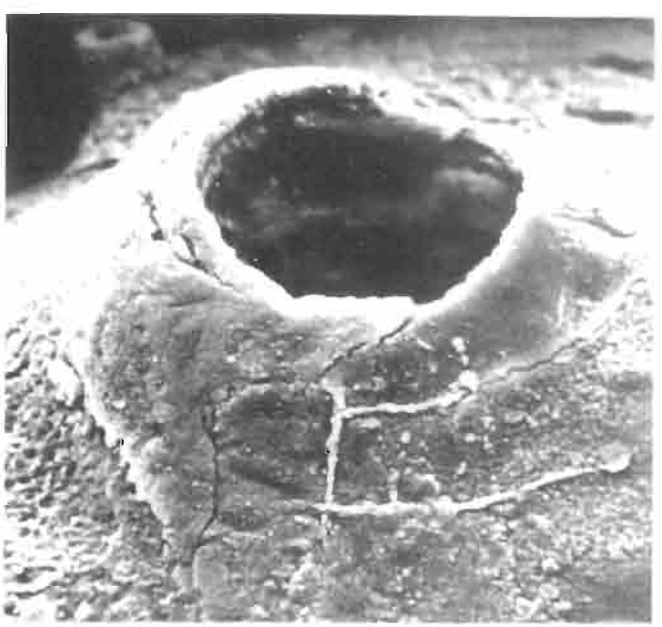

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXIX

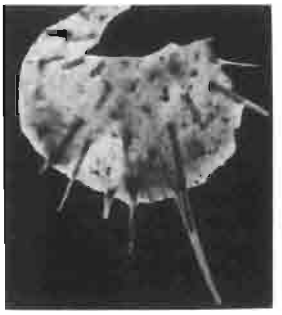
Page

Siphonotreta acrotretomorpha GORJANSKY 105
Tremadocian chalcedonites, Wysoczki

Fig. 1. A fragmentary brachial valve with surface spines preserving a different length (Bp. XV/2*x*), approx. ×27.

Fig. 2. Pedicle valve almost complete, pedicle foramen well marked (Bp. XV/2*z*): approx. ×50.

Figs. 3-5. Scanning electron micrographs. Fig. 3 — a fragment of pedicle valve surface with spines, ×670; Fig. 4 — general appaerance of a spine, ×2600, Fig. 5 — general view of partly preserved pedicle valve, ×130.



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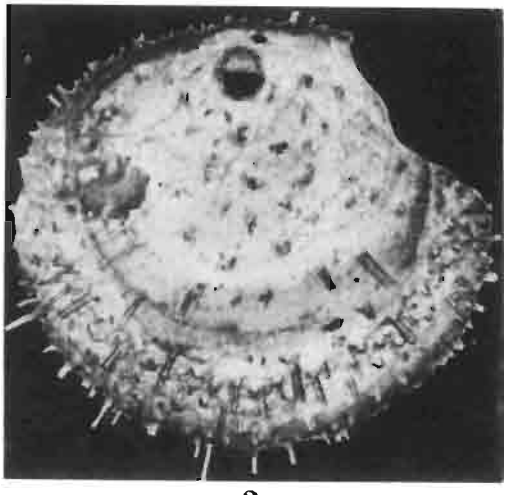

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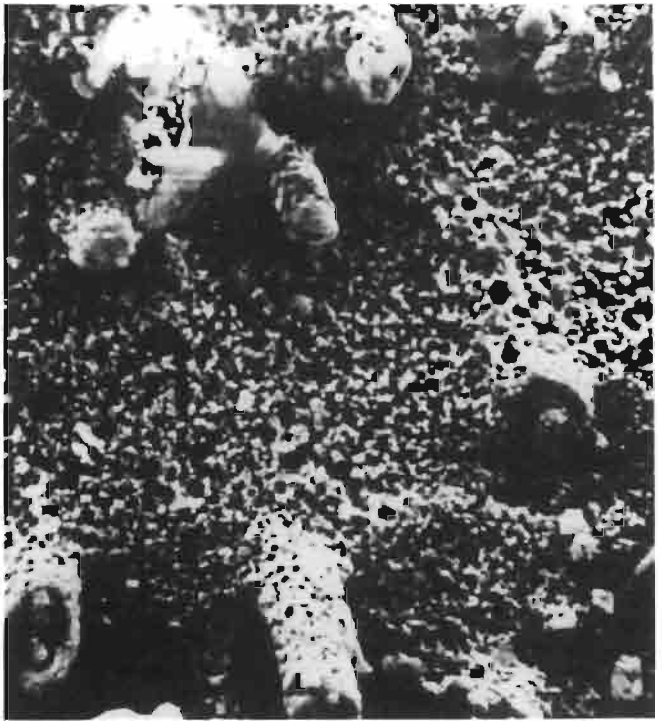

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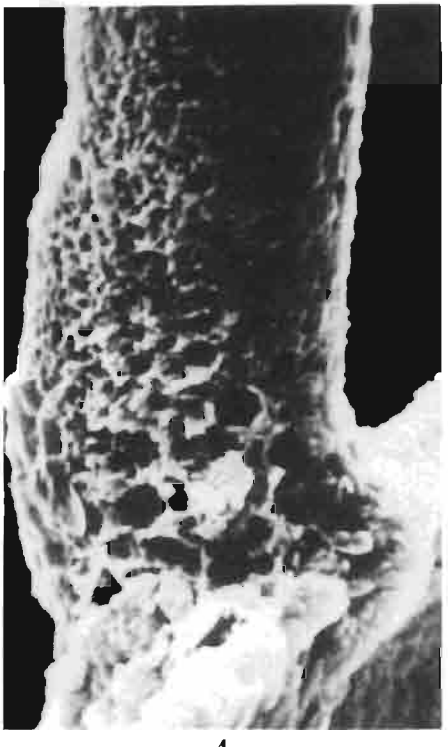

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PLATE XXX

Page

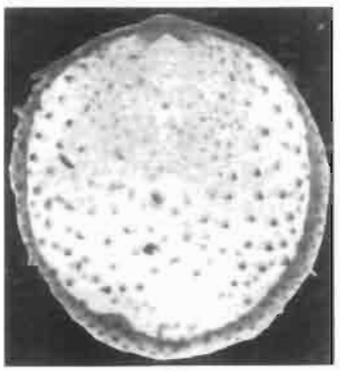
Siphonotreta cf. *verrucosa* (EICHWALD) 107
Tremadocian chalcedonites, Wysoczki

Figs. 1, 2. External view of two brachial valves (Bp. XV/8*h*, *g*); approx. ×30.
Figs. 3-5. External view of three pedicle valves in different state of preservation (Bp. XV/8*k*, *l*), Figs. 3, 5 — approx. ×40, Fig. 4 — approx. ×30.

Siphonotreta acrotretomorpha GORJANSKY 105
Tremadocian chalcedonites, Wysoczki

Scanning electron micrographs

Fig. 6. View of posterior margin of the pedicle valve, showing preserved spines; ×600.
Figs. 7, 8. Marginal elongate processes; ×1300.



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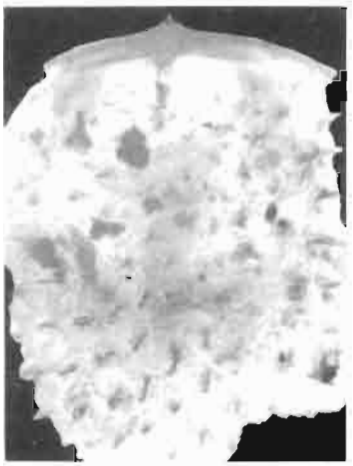

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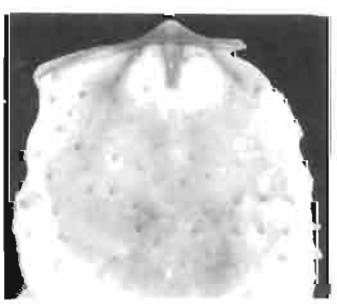

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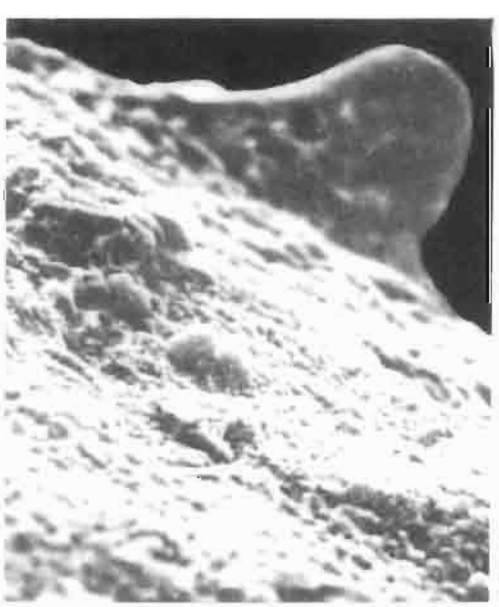

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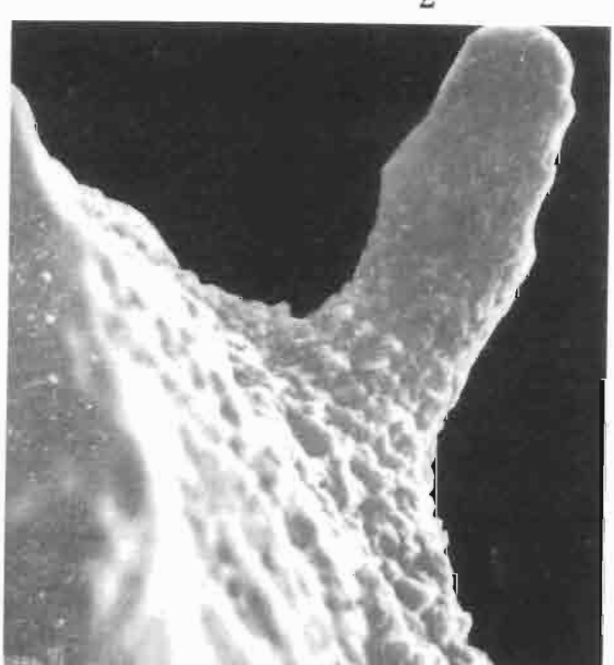

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXXI

Page

Alichovia analogica n. sp. 109
Tremadocian chalcedonites, Wysoczki

Figs. 1-4. View of surface spines, approx. ×60.
Figs. 5, 6. Two incomplete brachial valves with scattered surface spines, one spine bifurcating (Fig. 6), (Bp. XV/2, 5); approx. ×60.

Siphonotreta acrotretomorpha GORJANSKY 105
Tremadocian chalcedonites, Wysoczki

Fig. 7. Scanning electron micrograph. View of the surface spinose protuberance; ×1250.

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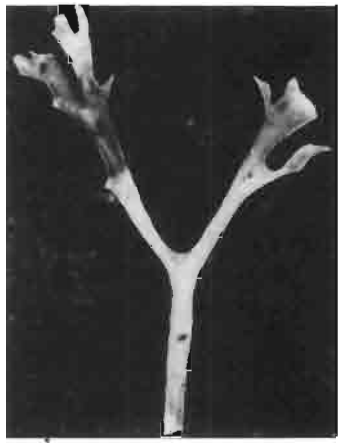

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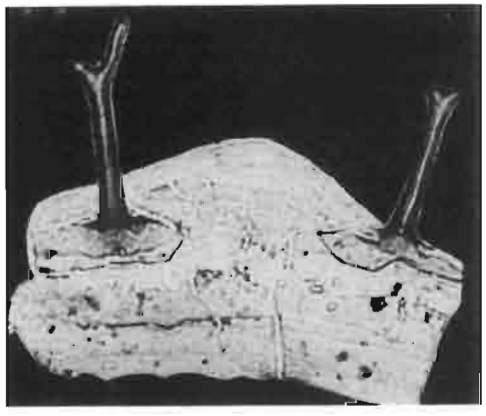

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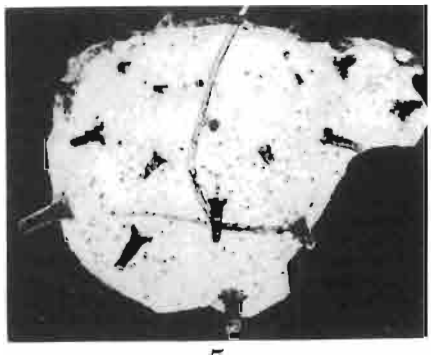

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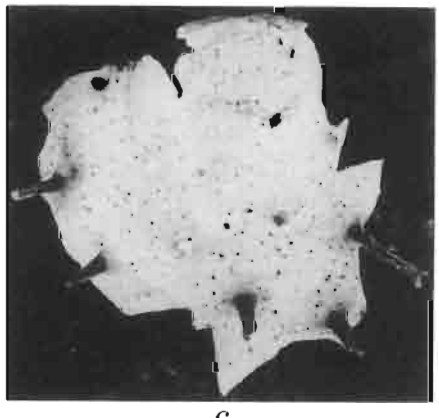

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXXII

Page

Alichovia analogica n. sp. 109
Tremadocian chalcedonites, Wysoczki

Figs. 1-4. Scanning electron micrographs. View of surface branched spines preserved in fragments; Fig. 1 — ×2600, Fig. 2 — ×2300, Fig. 3 — ×1250, Fig. 4 — ×2300.

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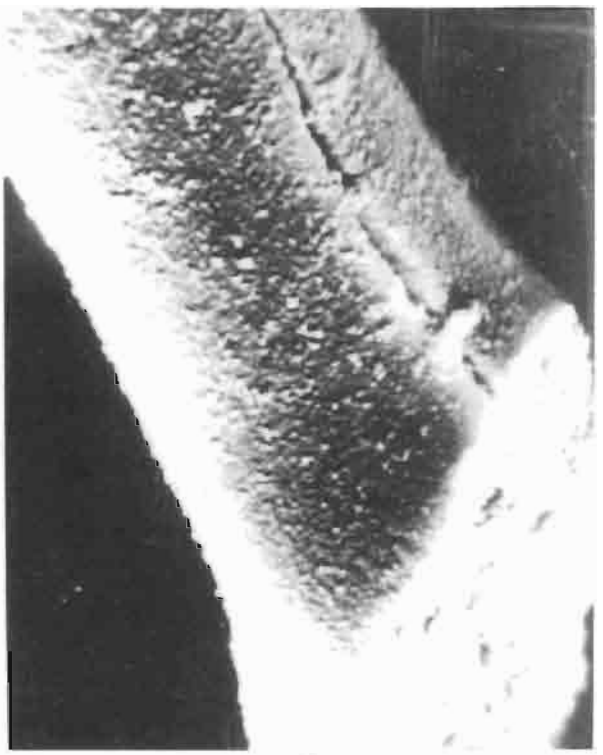

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXXIII

Page

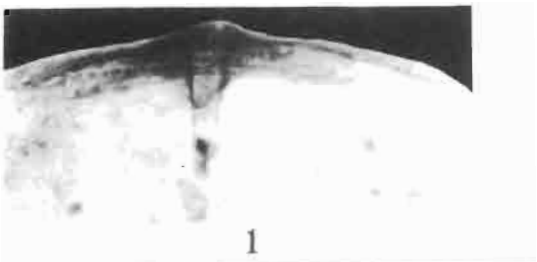
Helmersenia cf. *ladogensis* (JEREMEJEV) 110

Tremadocian chalcedonites, Wysoczki

Figs. 1-5. Five pedicle valves in different state of preservation. Figs. 2, 4, 5 — exterior view; Figs. 1, 2 — interior view (Bp. XV/2*r*, *s*, *t*, *u*, *v*); Figs. 1, 2 — approx. ×55, Fig. 3 — ×40, Figs. 4, 5 — approx. ×27.

Fig. 6. Internal view of a fragmentary branchial valve (Bp. XV/2*y*); approx. ×40.

Fig. 7. Scanning electron micrograph. General view of the brachial valve surface; ×150.



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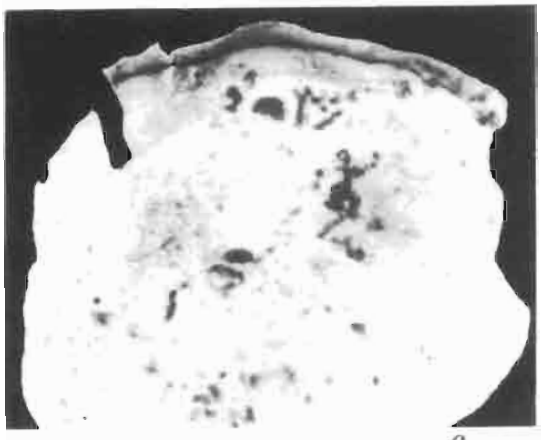

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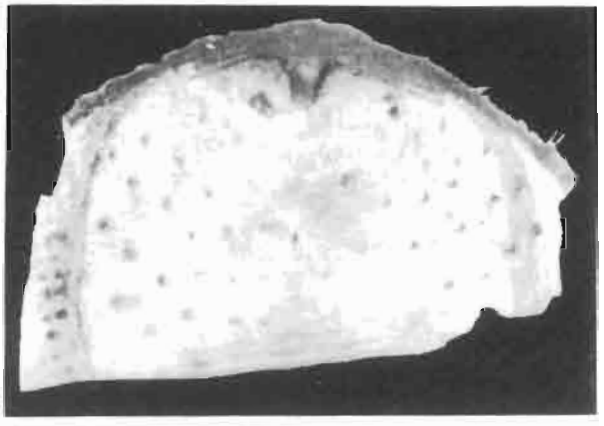

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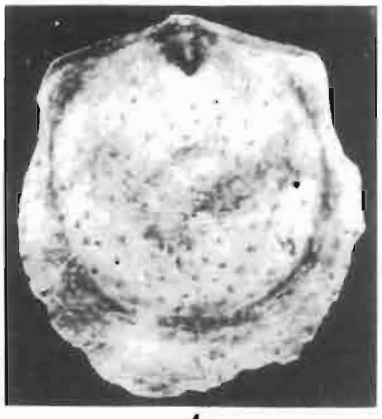

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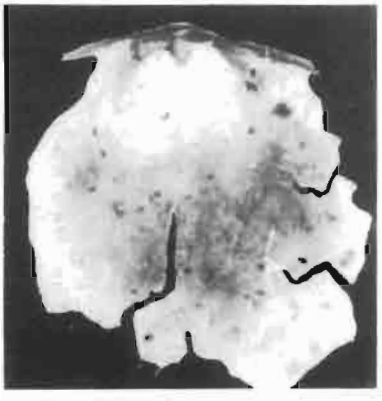

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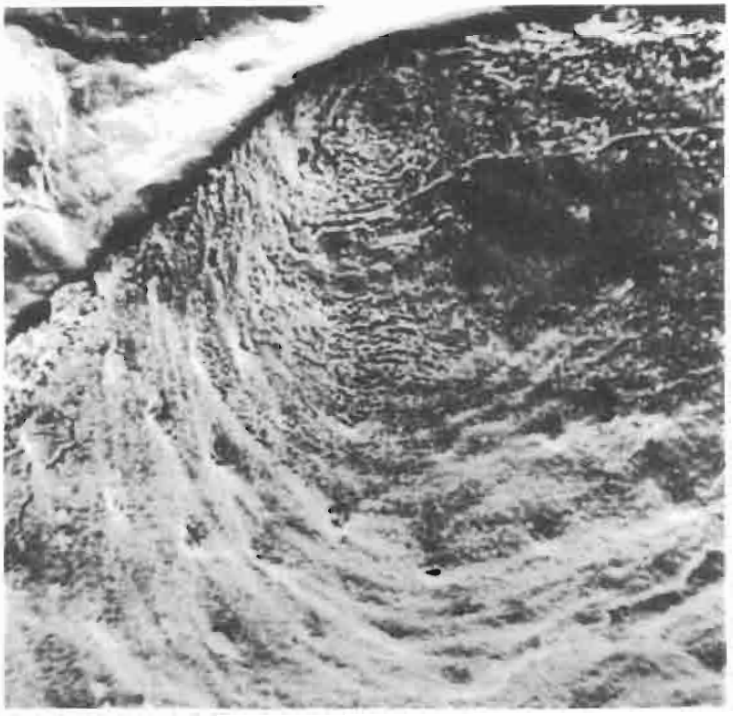

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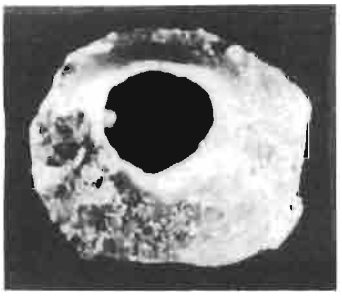
G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXXIV

Page

Eoconulus cryptomyus GORJANSKY 112
Volkhov horizon, Suhkrumägi, Estonia

Figs. 1-3. Three different brachial valves in apical view. Fig. 3*a* — in side view (Bp. XV/5*s*, *t*, *u*); approx. ×50.
Figs. 4-5. Scanning electron micrographs. Fig. 4 — apical view ×240; Fig. 5 — surface ornamentation view, ×1300.



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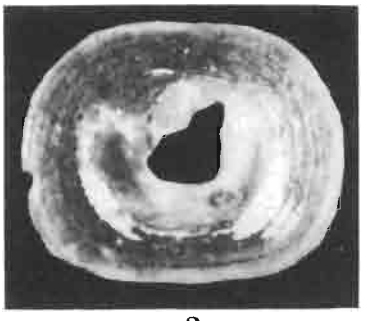

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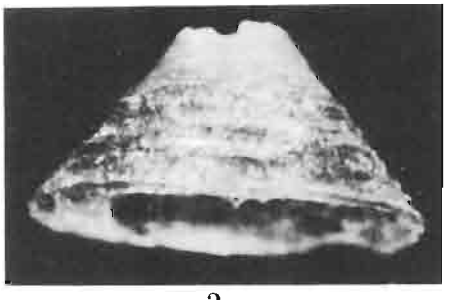

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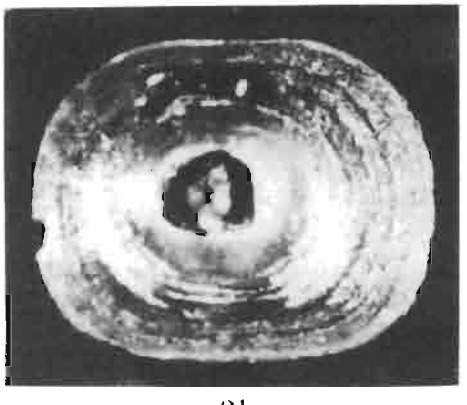

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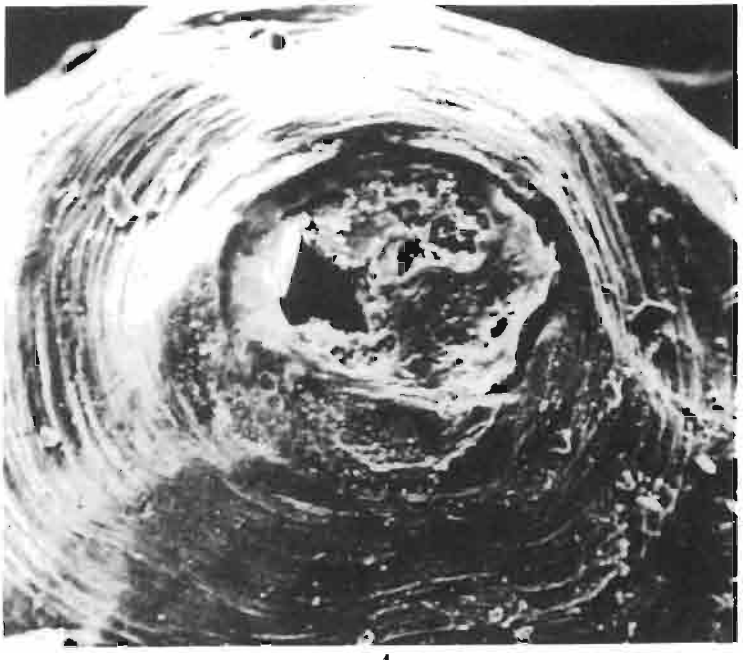

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXXV

Page

Eoconulus cryptomyus GORJANSKY 112
Volkhov horizon, Suhkrumägi, Estonia

Scanning electron micrographs

Fig. 1. Left side of the brachial valve; ×240.
Fig. 2. Protegulum and adult valve junction; ×600.
Fig. 3. View of the posterior half of the brachial valve; ×1300.
Fig. 4. Surface ornament on the anterior half of the brachial valve; ×400.

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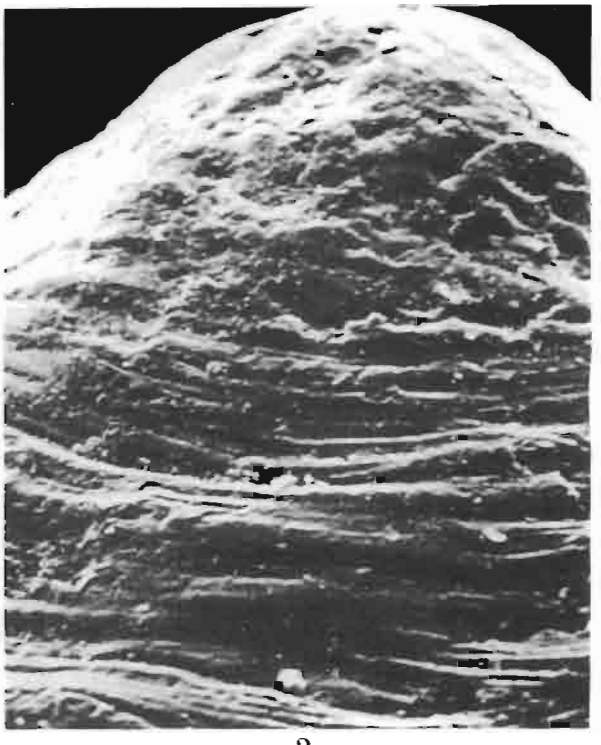

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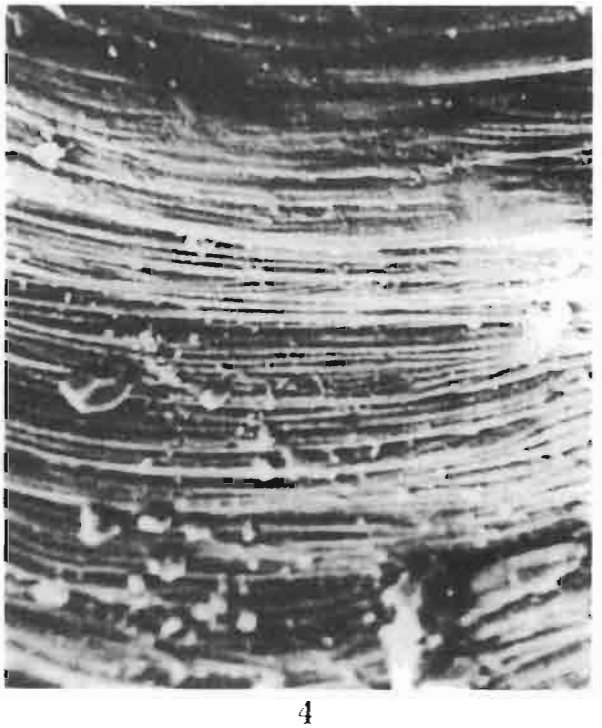

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXXVI

Page

Eoconulus semiregularis n. sp. 112

Erratic boulder No. O. 247, Jarosławiec, Baltic coast

Figs. 1-5. Apical view of five different valves (Bp. XV/6*s, t, u, v, z*); Fig. 1 — type specimen, Figs. 1-3 — approx. ×25; Figs. 4, 5 — approx. ×42.

Figs. 6-8. Side view of three valves (Bp. XV/6*y, s, w*); approx. ×25.

Eoconulus cryptomyus GORJANSKY 112

Volkhov horizon, Suhkrumägi, Estonia

Scanning electron micrographs

Fig. 9. View of the left part of the valve; ×600.

Fig. 10. Fragment of the anterior part of the valve; ×1125.

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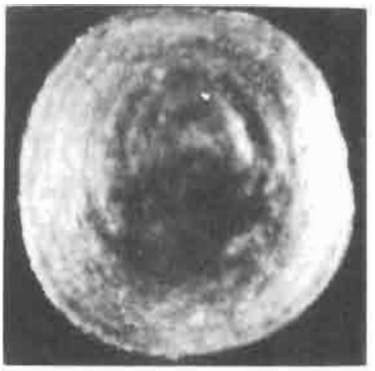

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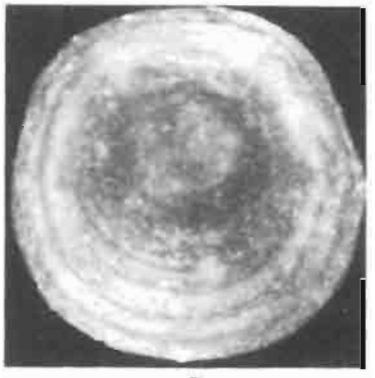

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXXVII

Page

Curticia minuta BELL 30

Upper Cambrian, Pilgrin Formation, Middle Belt Mountain, Montana, USA

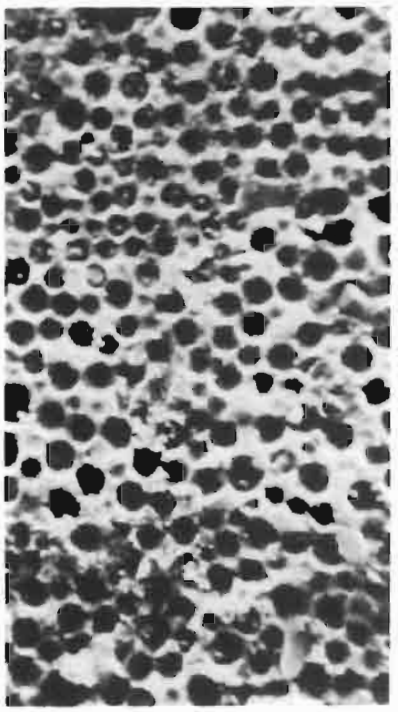
Fig. 1. A fragment of pitted ornamentation on median part of protegulum of the brachial valve; ×2500.
Fig. 2. General view of posterior third of the brachial valve, ×250.
Fig. 3. View of the surface ornament in adult shell; ×2500.

Rhysotreta corrugata COOPER 35

Middle Ordovician, Pratt Ferry Formation, Pratt Ferry Alabama, USA

Fig. 4. View of junction of protegulum and adult shell, ×130.

Scanning electron micrographs



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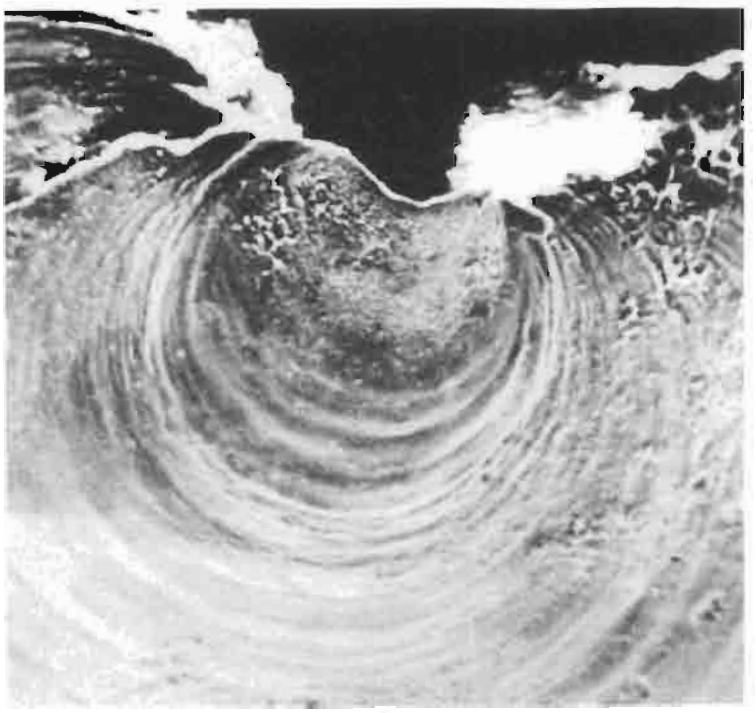

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G. BIERNAT: ORDOVICIAN INARTICULATE BRACHIOPODS

PLATE XXXVIII

Page

Apsotreta expansa PALMER 31

Upper Cambrian, Richy Formation, Llano Co., Texas, USA

Fig. 1. General view of the surface ornament; × 260.
Fig. 2. General view of the pedicle valve; × 70.
Fig. 3. View of junction protegulum and adult shell; × 1300.
Fig. 4. Protegulum of the pedicle valve with a pitted ornamentation; × 2600.

Scanning electron micrographs

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PLATE XXXIX

Page

Ceretreta hebes BELL 31

Upper Cambrian, Snowy Range Formation, Conaspis zone, Wyoming, USA

Fig. 1. General view of pedicle valve; × 65.
Fig. 3. Some detail of the surface ornamentation; × 260.

Rhysotreta corrugata COOPER 35

Middle Ordovician, Pratt Ferry Formation, Pratt Ferry, Alabama, USA

Fig. 2. General view of the adult shell showing surface ornamentation; × 260.

Prototreta sp. 35

Middle Cambrian Limestone, Horsehoe Hill, Montana, USA

Fig. 4. Protegular pits; × 2500.

Scanning electron micrographs

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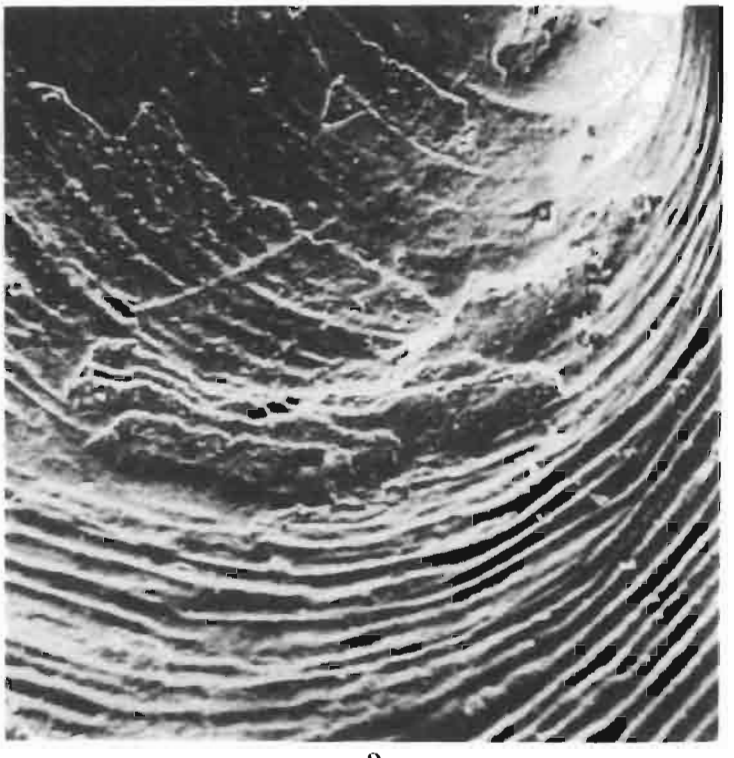

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PLATE XL

Figs. 1, 2. Surface ornamentation of the pedicle valve: details of discontinuous concentric ridges; ×1300.
Fig. 3. View of left side of the pedicle valve; ×140.
Fig. 4. Surface ornament on the anterior part of the valve; ×260.

Scanning electron micrographs

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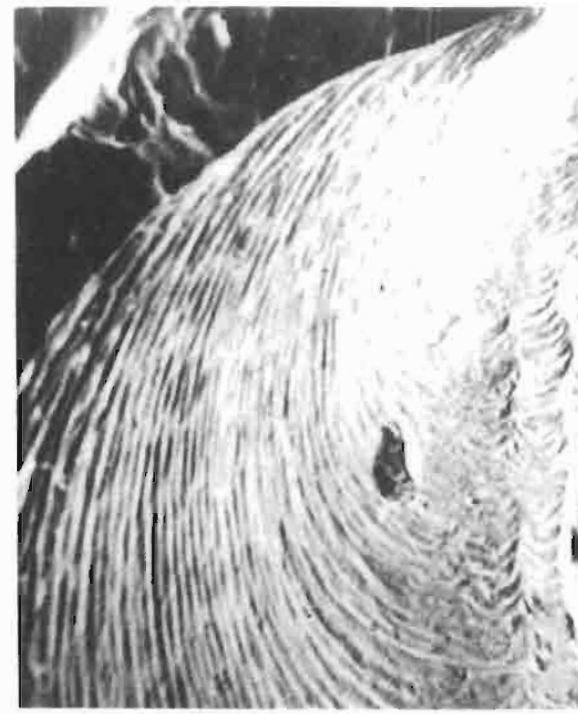

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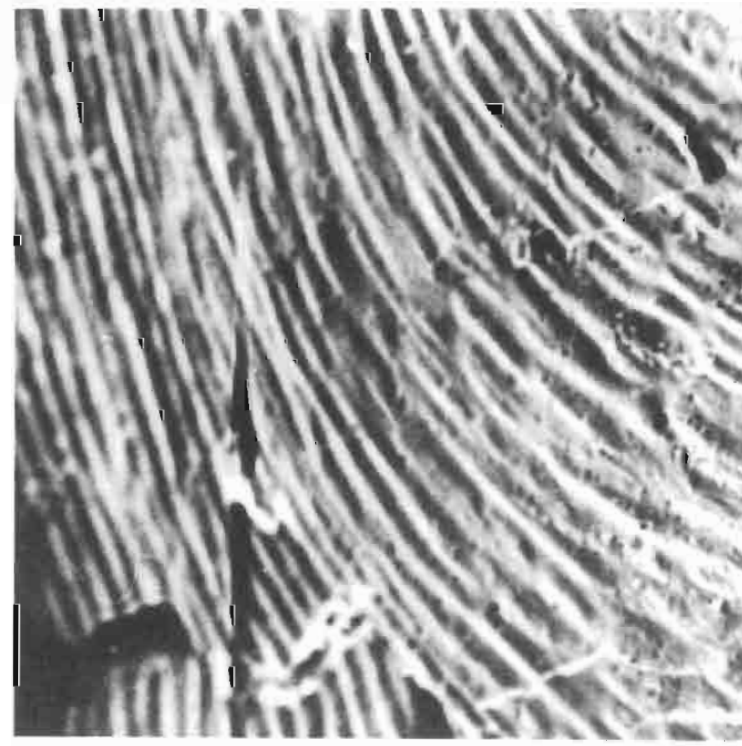

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