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CONODONT BIOSTRATIGRAPHY AND PALEOGEOGRAPHICAL RELATIONS OF THE ORDOVICIAN MÓJCZA LIMESTONE (HOLY CROSS MTS, POLAND)

Abstract. — The presence of Ordovician conodont zones from the Late Arenigian (Middle Kunda stage) to the Late Caradocian has been indicated in 8 m thick Mójcza Limestone (Holy Cross Mts, Poland). The conodont fauna of Mójcza is of the Baltic type and decidedly differs from the fauna known from Rzeszówek, situated about 300 km to the west in the Kaczawa Mts (Sudeten Mts). *Phragmodus polonicus* sp.n. from Mójcza and *Erraticodon balticus* gen. et sp.n. from a Baltic erratic boulder have been described.

INTRODUCTION

A sequence of the Ordovician organodetritic limestones, about 8 m in thickness, overlaying, in a sedimentary continuity, *Orthis* sandstones (pl. 12: 1, 2) is outcropped in a quarry on Skała hill at Mójcza. A very sandy organodetritic limestone, with a sparitic binder, chamosite oolites and rare grains of glauconite outcrops in the lower part. The content of quartz sand and glauconite decreases in the middle part of the sequence, where an increase in chamosite content is observed (cf. Tomczyk and Turnau-Morawska 1964). A decrease in detritus content and increase in the amount of clayey substances, with a simultaneous appearance of oncolites, takes place in the top. Thin (about 5 cm) layer of bentonite occurs in the middle part of limestone section (Ryka and Tomczyk 1959).

The conodonts from Mójcza limestones were studied by Spassov and Teller (1962), Bednarczyk (1966, 1972) and Bergström (1971). On the basis of the occurrence of *Prioniodus alatus*, Spassov and Teller found that the Mójcza limestones represented Llandeilo and/or Caradocian, while Bednarczyk (1971), taking into account the entire assemblage of conodonts, determined their age as Llanvirnian-Llandeilo. On the basis of a sample supplied by Spassov, Bergström (1971) maintained that the *Prioniodus variabilis* subzone of the Lower Caradocian occurred at Mójcza. Unfortunately, none of these authors gave the sampling place in the sequence and the number of samples, which precludes any detailed discussion. The samples from Mójcza were made use of in studies on the evolution of the Ordovician conodonts of the Baltic region (Dzik 1976).

ACKNOWLEDGEMENTS

The writer's profound gratitude is due to Dr. Viive Viira of the Geological Institute in Tallinn, Estonia for a discussion of the subject and making available conodont materials from Estonia, to Dr. Ladislav Marek of the Geologicky ustav ČSAV, Prague, Czechoslovakia for lending conodont samples from the Ordovician of Bohemia and to Dr. Jerzy Trammer of the University of Warsaw for a discussion and critical evaluation of the manuscript.

CONODONT BIOSTRATIGRAPHY OF THE MÓJCZA LIMESTONES

A scheme of the Middle Ordovician conodont zonation, presented by Bergström (1971), is accurately applicable to the Mójcza sequence. Slight modifications introduced to it consist only in giving up the differentiation of zones and subzones, in defining precisely the boundaries of some of them, in adding at the bottom the *E. pseudoplanus* Zone and in basing the division in the Llandeillan on the evolution of the genus *Amorphognathus*. The detailed evolution scheme of conodonts on which the considerations presented below are based and their paleontological descriptions were presented previously (Dzik 1976). A review of particular conodont zones, according to Bergström's (1971) modified pattern, with a commentary on the possibility of documenting them at Mójcza, are given below.

(1) *Amorphognathus variabilis* Zone

Erected by Sergeeva (1966) as a biozone. *Amorphognathus variabilis* occurs in fact for a considerably longer period than the duration of this zone in the traditional sense. Thus, the origin of *A. variabilis* should be considered as a base of the zone and the origin of *Eoplacognathus pseudoplanus* as its top. In Estonia, *A. variabilis* appears in the uppermost part of B IIIα (Lower Kunda stage) and, therefore, this is the boundary between the *Microzarkodina parva* and *A. variabilis* zones. *E. pseudoplanus* evolved from *E. zgierzensis* probably in the top of B IIIβ (Middle Kunda stage). The boundary between this two species is unclear. In the Mójcza limestone, *A. variabilis* occurs up to the *P. robustus* Zone and then gradually evolves into *A. kielcensis* (fig. 1*a*). *Eoplacognathus* probably occurs already in sample 14, but, unfortunately, none of the specimens has its lower branch preserved complete so that it is impossible to state for certain whether it is *E. zgierzensis* or the elements of *A. variabilis*, hardly distinguishable at such a state of preservation. The keislognathiform elements of *Prioniodus alatus* from samples 11, 28 and 14 display the length of the lateral branch corresponding to the degree of its reduction observed in the lower and middle parts of the Kunda stage. Likewise, *Polonodus clivosus* found in samples 11 and 14 is characteristic of the *A. variabilis* Zone. Location of samples in Mójcza profile see pl. 12: 2.

(2) *Eoplacognathus pseudoplanus* Zone

Erected by Viira (1974) as a biozone. The base of the zone probably lies in the upper part of B III β and is marked by the evolutionary transformation of *E. zgierzensis* into *E. pseudoplanus*, expressed in an elongation of the lower branch of the amorphognathiform element. The top of the zone is situated approximately in the middle part of the Aseri stage and is marked by the formation of a distinct asymmetry of ambalodiform elements characteristic of *E. suecicus*.

The occurrence of *Histiodella serrata* in sample 14 may be indicative of its belonging to the lower part of the *E. pseudoplanus* Zone. In Estonia, this species is characteristic of the lower part of B III γ and appears later than *P. clivosus*.

(3) *Eoplacognathus suecicus* Zone

According to Bergström (1971), the base of the *Pygodus serrus* Zone and, consequently, of the *E. suecicus* Subzone, coincides with the appearance of *P. serrus*, whereas this species has not been found so far in the lower part of the zone and, therefore, it would be more correct to base the definition of this boundary on the appearance of the species *E. suecicus* in the middle part of the Aseri stage. The top is marked by the formation of the species *Eoplacognathus foliaceus*.

Here may belong sample 15 in which the keislognathiform elements of *Prioniodus alatus* yet display the rudiments of lateral branches. This corresponds to the temporal subspecies *P. alatus medius* which occurs in the upper part of the Kunda stage and in the Aseri stage.

(4) *Eoplacognathus foliaceus* Zone

The base of this zone is marked by the appearance of *E. foliaceus* (with a characteristic right ambalodiform element with a short posterior branch) and the top by its evolutionary transformation into *E. lindstroemi reclinatus* (Bergström, 1971). No index species diagnostically characteristic of this zone was found at Mójcza.

(5) *Eoplacognathus reclinatus* Zone

The base of the zone is marked by the appearance of *E. lindstroemi reclinatus* (a T-shaped left and Y-shaped right ambalodiform element) and the top by its evolving into *E. lindstroemi robustus*. Conodonts from sample 10, displaying short lower branch of the ambalodiform element, may belong to the temporal subspecies, *E. lindstroemi reclinatus*, and probably represent a late evolutionary stage of *E. l. reclinatus*, close to *E. l. robustus*.

(6) *Eoplacognathus robustus* Zone

The base of the zone is marked by the appearance of *E. lindstroemi robustus* (its left ambalodiform element has slightly raised lateral branches and right one has a long lower branch) and the top by its evolving into *E. lindstroemi lindstroemi*. In the Mójcza limestone, *E. lindstroemi robustus* occurs in samples 17 and 27.

(7) *Eoplacognathus lindstroemi* Zone

The base of the zone is marked by the appearance of *E. lindstroemi lindstroemi* (both ambalodiform elements are Y-shaped). The top is marked by the formation of *Pygodus anserinus* (Bergström, 1971). At Mójcza, the *E. lindstroemi* Zone is represented in samples 9, 8 and 26.

(8) *Pygodus anserinus* Zone

The base of the zone is marked by the appearance of *Pygodus anserinus* (with four ribs on the amorphognathiform element) (Bergström 1971) and the top — by the appearance of *Amorphognathus inaequalis*. The designation of the upper boundary of the lower subzone of the *Pygodus anserinus* Zone *sensu* Bergström, which corresponds approximately to *P. anserinus* Zone as understood above, was based by Bergström (1971) on the appearance of the species *Prioniodus variabilis*. Primitive specimens of *P. variabilis* have amorphognathiform elements hardly distinguishable from those of *P. alatus* and their diagnostic shelf, formed by a widening of the basis, is strongly variable in the organogenesis. Evolutionary transformations in particular species of the genus *Amorphognathus* are considerably more distinguishable and hence, in my opinion, it would be more proper to base on them the diagnosis of the zone. As compared with the lower part of *P. anserinus* Zone *sensu* Bergström, the *P. anserinus* Zone adopted in the present paper is shorter. At Mójcza, the *P. anserinus* Zone is represented in sample 18.

(9) *Amorphognathus inaequalis* Zone

The base of the zone is marked by the origin of *A. inaequalis* (with a short anterodorsal branch of the amorphognathiform element and short main cusp of the oistodiform element) from *A. kielcensis*. The top coincides with evolving *A. inaequalis* into *A. tvaerenensis*.

In the Mójcza limestone this zone is represented in samples 7, 19, 6, 5, 20.

(10) *Prioniodus variabilis* Zone

The base of the zone is marked by the appearance of *Amorphognathus tvaerenensis* (the main cusp of the oistodiform element strongly incurved posteriorly) and the top by the evolving of *P. variabilis* into *P. gerdae* (Bergström 1971). At Mójcza probably in sample 4/5 (the poor state of preservation of index conodonts precludes their reliable determination).

(11) *Prioniodus gerdae* Zone

The base of the zone is marked by the appearance of *P. gerdae* (denticles on the lateral shelf of the amorphognathiform element) (Bergström 1971), and the top by the appearance of *P. alobatus.*

In the Mójcza limestone, there occur no species diagnostically characteristic of *P. gerdae* Zone, but samples 22, 24, 25 and 21 contain *Rhodesgnathus elegans polonicus* which probably evolved from *P. gerdae.* It differs from the *P. gerdae* in the development of a shelf on the lateral part of the ambalodiform element and in the lack of branched elements of the apparatus. These samples ought not, therefore, to be older than *P. gerdae* Zone and, since *P. alobatus* appears later (in sample 22), samples 21, 24 and 25 probably represent *P. gerdae* Zone.

(12) *Prioniodus alobatus* Zone

The base of the zone is marked by the appearance of *P. alobatus* (Bergström 1971), the top is provisionally determined at Mójcza by the appearance of *Hamarodus europaeus.* The boundaries are inaccurate and require a more precise determination.

Most likely, *Prioniodus alobatus* evolved from *P. variabilis.* A smooth passage from the latter to the former probably took place at Mójcza. Unfortunately, the fragmentation and a poor state of preservation of the material preclude the documentation of this hypothesis and the determination of a moment at which *P. alobatus* was formed. In the Baltic region, *P. variabilis* is followed in the evolutionary continuity by *P. gerdae* (Bergström 1971). *P. gerdae* and *P. alobatus* were probably allopatric species and the appearance of the latter in the Baltic region is not tantamount to its evolutionary formation, but the displacement of *P. gerdae.*

Bergström (1971) places the *P. alobatus* Subzone within the *P. tvaerenensis* Zone and adopts the formation of *Amorphognathus superbus* as its end, whereas the evolutionary transformation of *A. tvaerenensis* (an incurved main cusp of the oistodiform element) into *A. superbus* (a straight main cusp of this same element) took place in the initial stage of the occurrence of *P. alobatus.* As a matter of fact, Bergström's diagnosis is not in conformity with the diagram he presents. However, basing the upper boundary of the zone on the appearance of *H. europaeus* is unsatisfactory, since its appearance on the western border of the East European Platform probably resulted from its migration, rather and not evolutionary transformation.

At Mójcza, sample 22 may be referred to be *P. alobatus* Zone.

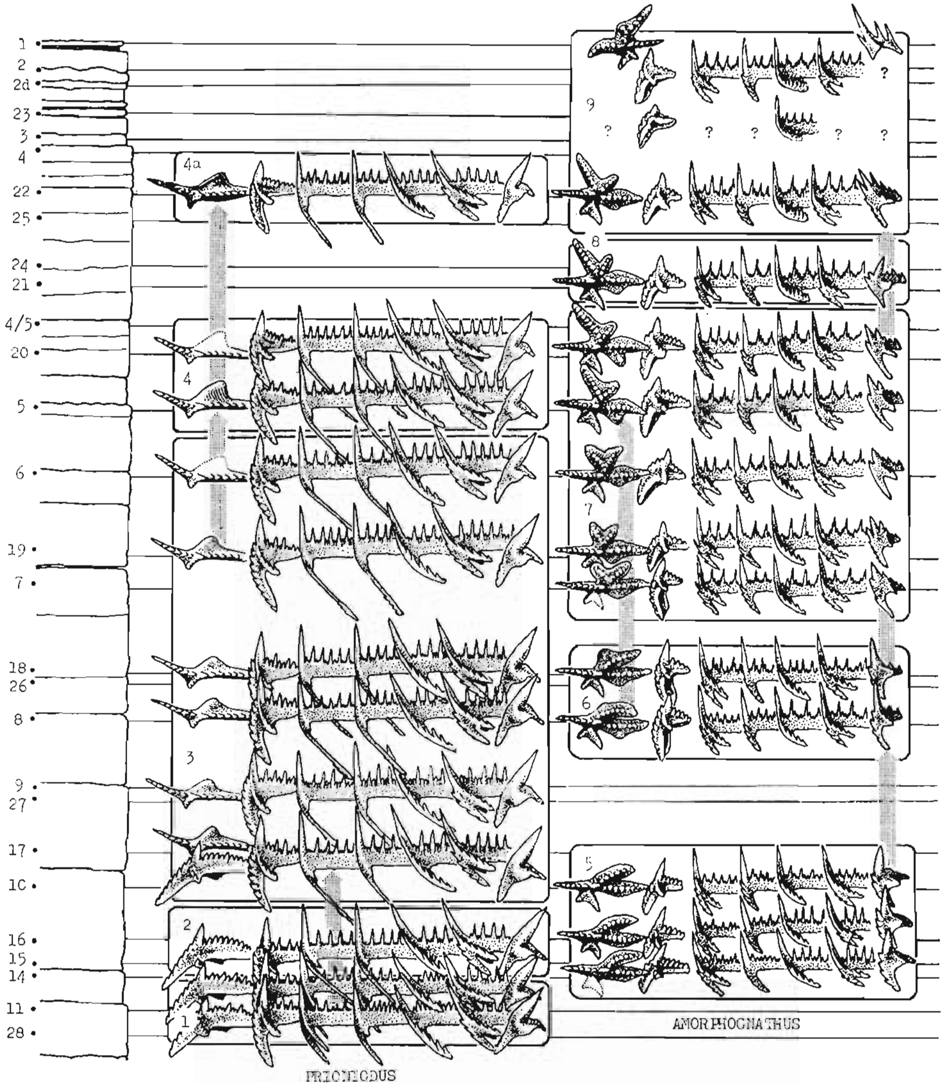
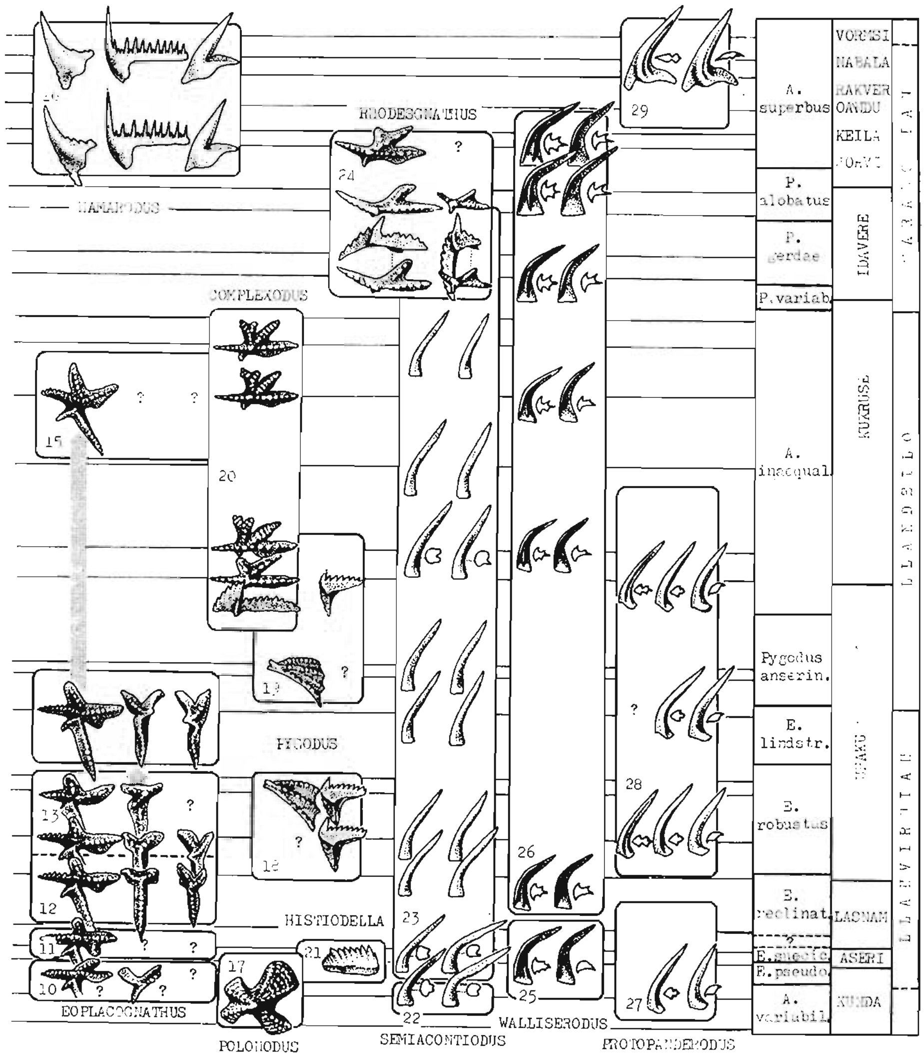


Fig. 1. A sequence of stratigraphically important species of the Conodontophorida in the Mójcza limestones. Numbers on the left designate sample numeration. Arrows indicate diagnostically important evolutionary transformations.

1 — *Prioniodus alatus parvidentatus* (Sergeeva), 2 — *P. a. medius* Dzik, 3 — *P. a. alatus* Hadding, 4 — *P. variabilis* Bergström, 4a — *P. sp.* (cf. *P. alobatus* Bergström), 5 — *Amorphognathus variabilis* Segeeva, 6 — *A. kielcensis* Dzik, 7 — *A. inaequalis* Rhodes, 8 — *A. tvaerensis* Bergström, 9 — *A. superbus* (Rhodes), 10 — *Eoplacognathus* (?) sp., 11 — *E. cf. suecicus* Bergström, 12 — *E. lindstroemi* cf. *reclinatus* Hamar, 13 — *E. l. ro-*



bustus Bergström, 14 — *E. l. lindstroemi* (Hamar), 15 — *E. elongatus* (Bergström), 16 — *Hamarodus europaeus* (Serpagli), 17 — *Polonodus clivosus* (Viira), 18 — *Pygodus serrus* (Hadding), 19 — *P. anserinus* Lamont and Lindström, 20 — *Complexodus pugionifer* (Drygant), 21 — *Histiodella serrata* Harris, 22 — *Semiacontiodus cornuformis* (Sergeeva), 23 — *S. longicostatus* (Drygant), 24 — *Rhodesgnathus elegans polonicus* Dzik, 25 — *Walliserodus costatus* Dzik, 26 — *W. nakholmensis* (Fahraeus), 27 — *Protopanderodus rectus* (Lindström), 28 — *P. varicostatus* (Sweet and Bergström), 29 — *P. insculptus* (Branson and Mehl).

(13) *Amorphognathus superbus* Zone

The base of the zone is based provisionally on the appearance of *Hamarodus europaeus*, the top corresponds to the evolutionary transformation of *A. superbus* into *A. ordovicicus*. In Estonia, *Hamarodus europaeus* occurs in Vormsi and Nabala stages (Viira 1974), and has a similar range in the entire Baltic region (Bergström 1971).

At Mójcza, samples 4, 3, 23, 2d, 2 and 1 belong to the *A. superbus* Zone. Sample 2 revealed a single amorphognathiform element probably belonging to *A. superbus*. The concurrence of *Protopanderodus insculptus* may, however, indicate that samples 23, 2d, 2 and 1 belong to the *A. ordovicicus* Zone. A single oistodiform (neoprioniodiform?) element from sample 1 may belong to both *A. ordovicicus* and *A. superbus*, or to some unknown representative of the Ozarkodinina.

As follows from the above considerations, the beginning of the calcareous sedimentation falls at Mójcza in the lower part of the Baltic Kunda stage, that is, at the presumable boundary between the Arenigian and the Llanvirnian. The absence of index conodont species of few zones (a relative rarity of conodonts of the genus *Eoplacognathus*, as compared with those of the Baltic region, makes the stratigraphic correlation difficult), is not a sufficient basis for suggesting the existence of stratigraphic gaps within this sequence. The final stage of calcareous sedimentation at Mójcza probably falls in the upper part of the *Amorphognathus superbus* Zone, that is, in the Uppermost Caradocian, although the occurrence of some part of Ashgillian sediments is not unlikely. A continuous sedimentation of detritic Mójcza limestones throughout the Llanvirnian, Llandeillian and Caradocian, precludes the occurrence, during that period (at least in the Kielce region), of repeated orogenic movements, suggested by Tomczyk (1964) and confirms Bednarczyk's (1971) interpretation. The bentonite layer (between samples 7 and 19) is of Llandeillian age and cannot be correlated satisfactorily with any of the many bentonite layers in the Ordovician of Bornholm (Bergström and Nilsson 1974).

FAUNAL RELATIONSHIPS OF THE ORDOVICIAN OF MÓJCZA

Except for *Complexodus pugionifer* (Drygant), *Rhodesgnathus elegans polonicus* Dzik and *Phragmodus polonicus* sp.n., all species of conodonts, found in the Mójcza sequence, also occur in the Baltic region. The first of these exceptions occurs in Volhynia (Drygant 1974), the second is rather related to American forms, althought it is also known from Wales (Bergström 1971) and probably occurs in Thuringia (? = *Sagittodontina bifurcata* Knüpfer, 1967), while the third is evolutionally transitional between the Baltic species *Microzarkodina ozarkodella* and the American *Phragmodus inflexus*. As far as it can be judged from figures in Knüpfer's (1967)

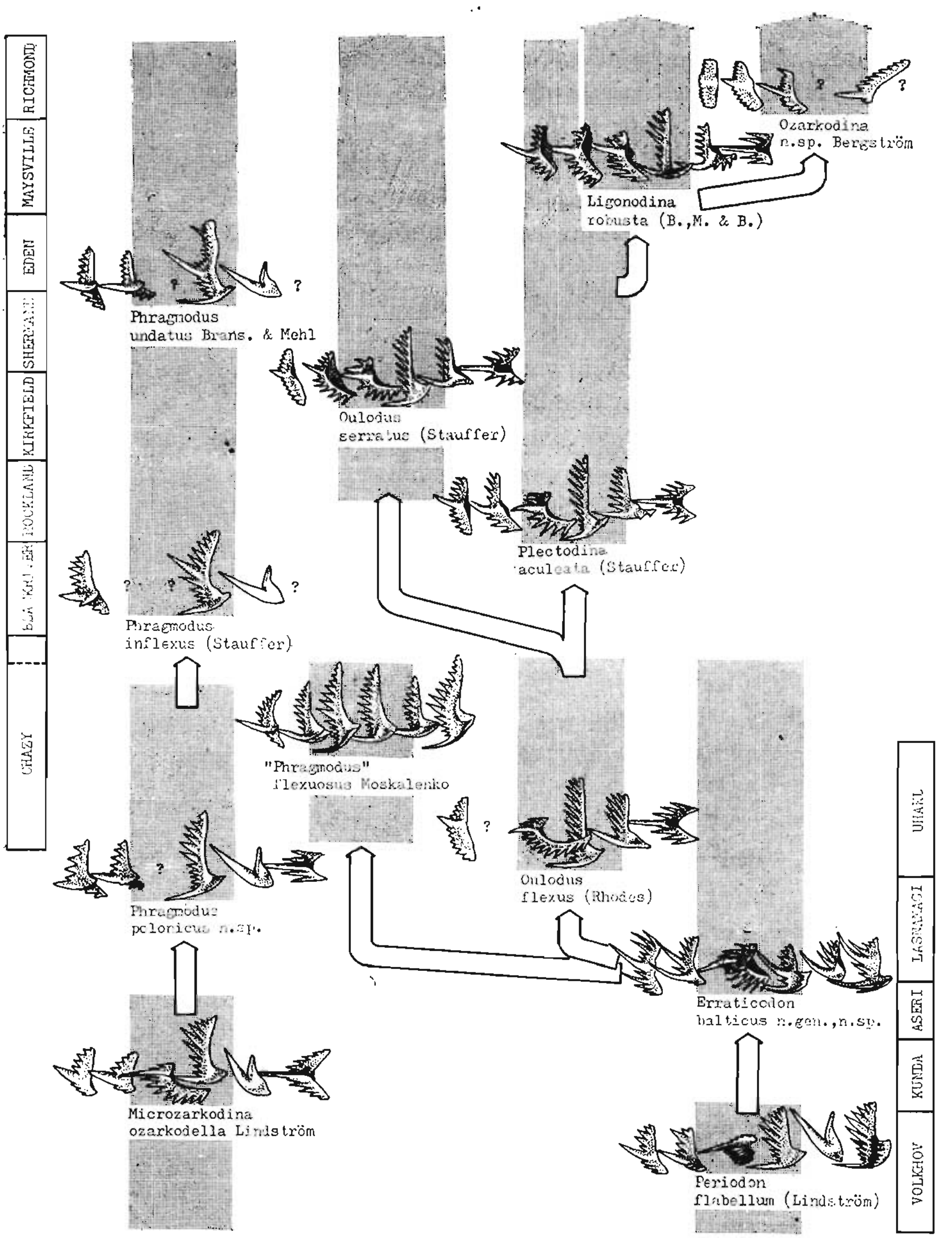


Fig. 2. Relationships between the Ordovician Ozarkonidina of the Baltic region, Siberia and the North American Midcontinent. Elements of the apparatus illustrated in the following order: spathognathodiform, ozarkodiniform, plectospathodiform, hindeodelliform, neoprioniodiform and trichonodelliform. The data of Sweet and Bergström (1972, 1976), Moskalenko (1972) and Sweet and Schönlaub (1974) have been made use of.

work, all species from Oberen Erzhorizontes of Thuringia are common with those of the Upper Caradocian of Mójcza. On the other hand, the geographically nearest fauna of Rzeszówek (fig. 4) in the Kaczawa Mts. (Baranowski and Urbanek 1972) displays considerable differences. As indicated by its conodonts, the Rzeszówek sequence to a considerable extent corresponds in age to the Mójcza limestones. Some species of the family Plectodinidae, which does not occur in Mójcza and makes up only an accessory element in the Baltic region, is here a predominant element. The very primitive *Erraticodon balticus* gen. et sp.n. (fig. 6), and only Baltic species of this family, very rarely occurs in the *E. foliaceus* Zone of Sweden (Fåhraeus 1966), in the *E. robustus* Zone of Estonia (Viira 1974) and the erratic boulders of northern Poland (pl. 15: 1—3, 5, 6). The family Prioniodinidae is extensively distributed in North America, beginning with the Upper Llandeillian (Glenwood Formation, Webers 1966; Sweet and Bergström 1976). It is also represented in the Lower Llandeillian of Brittany (Lindström, Racheboeuf and Henry 1974) and Wales (Bergström 1971).

As follows from the above considerations, the Middle Ordovician conodont fauna, typical of Siberia and North American Midcontinent, evolved from Baltic forms (fig. 2).*Phragmodus polonicus* from Mójcza is a transitional stage of transformation of the Baltic genus *Microzarkodina* into the Siberian-Midamerican *Phragmodus. Oulodus flexus* from the Llandeilo Limestone of England connects the Baltic genera *Periodon* and *Erraticodon* gen.n. with the Midamerican genus *Oulodus.* A similar position is probably occupied by the plectodinid species from Rzeszówek (cf. also Lindström 1976).

On the other hand, *Histiodella serrata* Harris, marked by a very extensive geographical distribution and narrow stratigraphic range, is an American immigrant. It has repeatedly been recorded in Poland (Dzik 1976), Estonia (Viira 1974), Sweden (Lindström 1969), New Foundland (Fåhraeus 1974) and North America (Landing 1976) in beds whose age corresponds to that of the upper part of the Baltic Kunda stage. At the same time, it is closely related with other, Central American, species of the genus *Histiodella* (Sweet, Ethington and Barnes 1971).

THE PALEOGEOGRAPHICAL SITUATION OF THE ORDOVICIAN OF MÓJCZA

It is of interest to compare the Mójcza sequence with that of the Brzeziny borehole, situated about a dozen kilometers away and which has been dated on the base of graptolites (Tomczyk and Turnau-Morawska 1964). Advances in correlating graptolite and conodont schemes of the Ordovician zonation (Bergström 1971, 1973) allow one for a fairly accurate

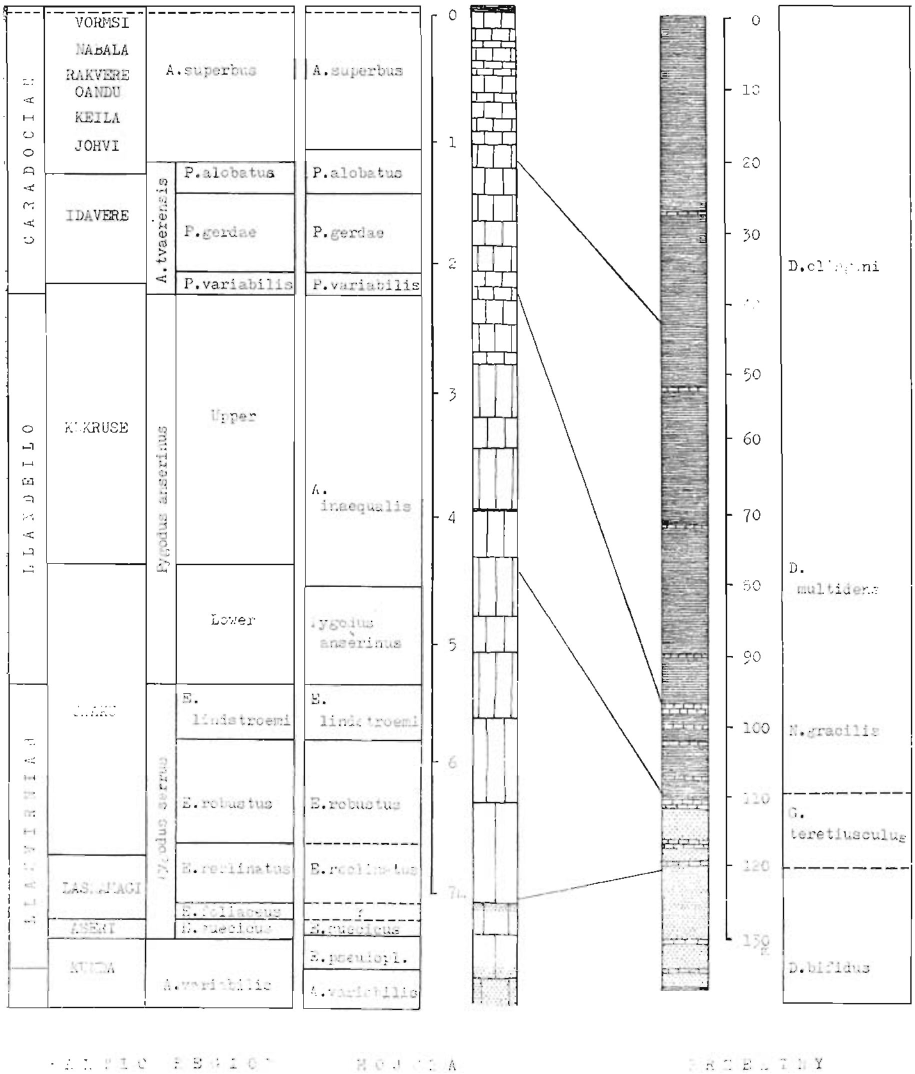


Fig. 3. A correlation of the stratigraphic division of the Baltic Ordovician (Bergström 1971); boreholes at Brzeziny (Tomczyk and Turnau-Morawska 1964) and Mójcza section. A correlation of the conodont and graptolite stratigraphy — according to Bergström (1973).

comparison of the thicknesses of particular stratigraphic units (fig. 3). The entire Ordovician sequence of Mójcza limestones about 8 m in thickness corresponds in age to 130 m of shales and sandstones occurring at Brzeziny. Since in the last-named locality, graptolite shales are a predominant deposit, these are undoubtedly deep-sea sediments. The nearest paleontologically documented Ordovician locality, situated to the west, is known from Rzeszówek in the Kaczawa Mts. (Baranowski and Urbanek

1972). These are metamorphic shales with siderites, that is, deep-sea sediments like those at Brzeziny. Except for the Kaczawa Mts, no Ordovician outcrops have been recorded in the Sudeten Mts. However, as follows from their tectonic history (Oberc 1966), in the Ordovician they constituted a consolidated block and the boundary of the area of deep-sea sediments ran probably not far to the south-west of Rzeszówek. This is in conformity with the views which have been expressed hitherto on the Ordovician paleogeography of Central Poland (Bednarczyk 1971). In this region, an area of the graptolitic facies forms a band stretching from the south-east to the north-west and joining, in the axial part of the Caledonian geosyncline, an area of the graptolitic facies of Northern Europe (Bednarczyk 1968; Modliński 1973). The Ordovician localities of Mójcza and Rzeszówek, situated on the opposite sides of this band, radically differ faunally (Lindström 1976). An abut 300 km broad band of the sedmientation of deep-sea deposits (fig. 4), probably geosynclinal in character (Znosko 1974), is an only barrier separating the typically Baltic fauna of Mójcza (*Amorphognathus* fauna; Lindström 1976) from the *Phragmodus* fauna (Lind-

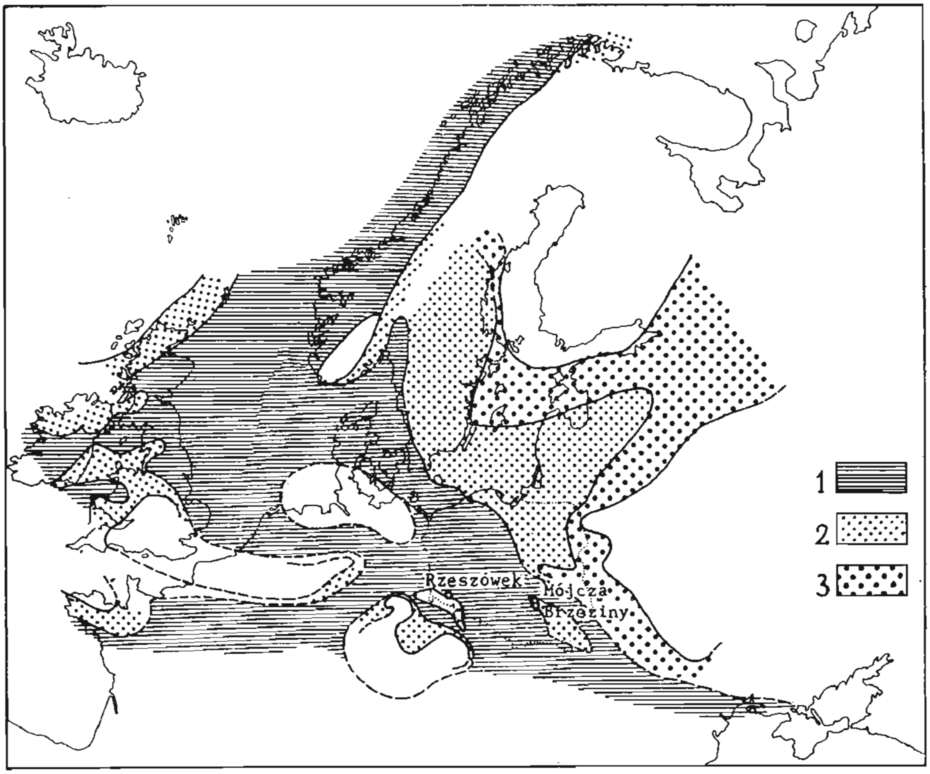


Fig. 4. The distribution of facies in Central Europe in the late Lower Ordovician on the basis of data from Havliček and Snajdr (1955), Oberc (1966), Männil (1966), Störmer (1967), Bednarczyk (1968), Burmann (1973), Ljutkevitch et al (1973), Modliński (1974), Ziegler (1974), Kvale (1975), Williams (1976) and others. *1* graptolite shales and flysch, *2*, *3* deep and shallow sublittoral facies.

ström 1976) of Rzeszówek which displays relationships with the American and Siberian faunas. To such pelagic [1] organisms as the Conodontophorida, the present distance between this localities could not in itself be a barrier separating and, consequently, precluding the blending of faunas. Lindström (1976), as well as Fåhraeus (1976), Havliček (1976) and Dean (1976) offer the effects of the continental drift as an explanation of faunal differences between the Balto-scanic Province (including the Holy Cross Mts) and the Sudeten Mts and Bohemia. A decrease in faunal differences between Bohemia and the Sudeten Mts during the Ordovician, Silurian and Devonian is interpreted as an effect of a gradual approach of Moldanubicum and Sudetian Block to the East-European Platform. Studying conodonts of the Ordovician of Bohemia would be of vast importance to the verification of such a view. Unfortunately, the facies development of the Ordovician in the Bohemian Basin was not favorable to the preservation of conodonts. They have been known so far only from the Arenigian tuffites outcropped in the environs of the village Mýto (Svatoštepánsky rybník) near Beroun, Bohemia. This fauna, consisting of the cosmopolitan *Prioniodus* aff. *transistans* (McTavish), *Drepanoistodus suberectus forceps* (Lindström), *Drepanodus arcuatus* Pander and *Scalpellodus* cf. *laevis* Dzik is indicative of the Upper Hunneberg stage (the upper part of *Paroistodus proteus* Zone), but does not give any information on zoogeographical relationships.

DESCRIPTIONS

Family **Periodontidae** Lindström, 1970
Genus *Phragmodus* Branson and Mehl, 1933
Phragmodus polonicus sp.n
(pl. 14: 1-5; fig. 5)

Holotype: ZPAL CVI/1-348, pl. 14: 1, ozarkodiniform element.

Type horizon and locality: Llanvirnian, *E. robustus* Zone, sample 27, Mójcza, near Kielce, Poland.

Diagnosis. — Spathognathodiform and ozarkodiniform (= dichognathodiform) elements with 3—4 denticles on the anterior margin.

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[1] According to Fåhraeus (1976*a*), "the majority of conodontophorids were benthic or nectobenthic in habit rather than pelagic." This supposition is based on statistically observable relation between the distribution of some species of the Conodontophorida and the development of facies (Fåhraeus and Barnes 1975; Barnes and Fåhraeus 1975), and, consequently, on the relation between the taxonomic diversity of conodonts and the development of epicontinental seas by the evolution of continents (Fåhraeus 1976*a*). The statistical character of this regularity indicates, however, in my opinion, that the distribution of conodonts is correlated with a paleogeographical situation rather than with the character of sediment. Therefore, it is in conformity with the distribution of population in relation to hydrographic and consequently trophic conditions observed in Recent pelagic organisms (e.g. Euphausiacea). The unusually extensive geographical distribution of the most conodontophorid species as relations between the facies and structure of conodont faunas is satisfactorily explained by the model of the pelagic Conodontophorida.

Material. — Twenty four specimens.

Description. — The apparatus of *Phragmodus polonicus* sp.n. is composed of spathognathodiform and ozarkodiniform (= dichognathiform) elements, with a strongly developed lateral branch, of hindeodelliform (= cordylodiform) elements, of neoprionidiform elements of the "*Oistodus*" type and, maybe also, of trichonodelliform elements with two cusps on lateral branches. The *P. polonicus* conodonts radically differ from all other concurring species, but, due to a very scarce material, the reconstruction of the composition of their apparatus may be considered as provisional only. It is clear, however, that there occurs a far-reaching similarity in the composition of apparatus of the species under study with that of the species of the genera *Microzarkodina* and *Phragmodus.* The relationship between *P. polonicus* and the temporarily preceding species *M. ozarkodella* is indicated by their far-reaching similarities in morphology, size and color of elements. Only a possible presence of the trichonodelliform element could differ *P. polonicus* from the best known species of the genus *Phragmodus*, that is, from *P. undatus* (fig. 2). Together with the denticulation of the anterior margin of the ozarkodiniform element, it may constitute a primitive character inherited from *M. ozarkodella. P. inflexus*, having only one denticle on the anterior margin of the ozarkodiniform element (fig. 2) is the closest in time and morphology to the ozarkodiniform element. The phylogenetic relationship between the genera *Phragmodus* and *Microzarkodina*, stipulated in the present paper, raises certain doubts concerning the correctness of the reconstruction of apparatus of several species of *Phragmodus*, presented by Sweet and Bergström (1972). Incomprehensible are the lack of the neoprioniodiform element of the "*Oistodus*" type and the inclusion of the element of the "*Cyrtoniodus*" type in the reconstruction of the apparatus of *P. inflexus.* A transformation of the element of the "*Oistodus*" type into the "*Cyrtoniodus*" element and then its reconstruction once again in *P. undatus* would be contradictory to the principle of the irreversibility of evolution. A similar simultaneous occurrence of the neoprioniodiform elements of the "*Oistodus*" and "*Cyrtoniodus*" types in *P. cognitus* is incomprehensible. The presence of the neoprioniodiform element of the "*Cyrtoniodus*" type, together with a trichonodelliform element having reduced lateral branches, precludes its descent from *P. polonicus* and its relationship with *P. undatus* (fig. 2).

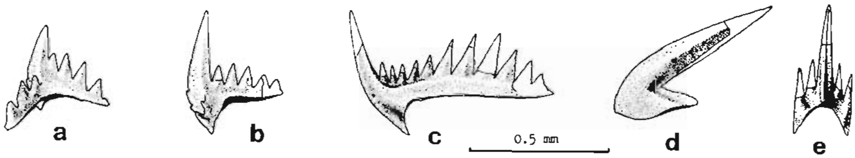

Fig. 5. The composition of the apparatus of *Phragmodus polonicus* sp.n.; *a* spathognathodiform element, *b* ozarkodiniform element, *c* hindeodelliform element, *d* neoprioniodiform element, *e* trichonodelliform element.

Distribution — Llanvirnian (*E. robustus* Zone) to Llandeilo (*A. inaequalis* Zone), Mójcza limestone, Holy Cross Mts (Table 1).

Family **Prioniodinidae** Bassler, 1925
Genus *Erraticodon* gen.n.

Type species: *Erraticodon balticus* sp.n.

Diagnosis: Three-branched trichonodelliform and plectospathodiform elements. Neoprioniodiform element with a denticulated posterior branch only ("*Cyrtoniodus*").

Table 1

Frequency of conodonts in samples from the Mójcza limestones

Sample		20	11	14	15	16	10	17	27	9	8	26	18	7	19	6	5	20	4/5	21	24	25	22	4	3	23	24	2	1
Histiodella serrata		-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oneotodus mitratus		-	-	-	-	-	-	1	-	-	-	-	1	1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Scalpellodus cavus		-	-	4	-	2	6	-	7	-	-	-	3	5	2	-	2	3	-	4	-	-	8	-	-	-	-	-	-
Panderodus gracilis		-	2	-	-	-	3	12	23	2	17	6	30	111	147	-	2	-	-	3	1	2	6	-	-	4	-	1	-
Panderodus mutatus		-	2	8	-	1	65	20	55	4	33	-	3	37	72	2	2	-	-	-	-	-	-	-	-	1	-	5	-
Panderodus similaris		-	-	-	-	-	-	-	-	-	-	-	-	-	33	2	6	17	-	40	25	188	14	16	115	6	168	294	23
Walliserodus costatus		-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Walliserodus nakholmensis		-	-	-	-	-	-	1	1	1	-	1	3	-	3	-	1	6	-	2	2	-	10	3	1	2	-	3	-
Strachanognathus parva		-	-	-	-	-	12	18	2	1	12	2	20	-	-	1	8	2	-	5	-	-	-	-	-	-	-	-	-
Scolopodus peselephantis		-	-	9	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drepanodus robustus		-	2	102	6	8	7	21	6	1	60	8	34	52	70	49	30	106	20	-	-	-	-	-	-	-	-	-	-
Semiacontiodus cornuformis		?	7	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semiacontiodus longicostatus		-	-	-	2	3	58	10	17	-	15	4	18	23	93	7	10	17	-	8	2	-	-	-	-	-	-	-	-
Protopanderodus sp.sp.		rectus					varicostatus																			insculptus			
	"a"	-	-	-	-	-	3	4	-	-	-	-	-	1	6	-	-	-	-	-	-	-	-	-	-	2	9	-	-
	"b"	-	15	112	6	7	84	10	2	-	20	5	17	1	28	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	"c"	-	2	17	3	2	15	6	1	-	3	2	7	-	1	-	-	-	-	-	-	-	-	-	-	-	14	3	-
Drepanoistodus suberectus	pri	5	5	36	9	-	55	37	17	1	57	5	10	14	16	-	1	-	-	6	2	-	1	1	-	-	-	-	-
	tri	1	1	3	2	1	6	5	2	1	10	2	2	2	3	-	1	-	-	1	1	-	-	-	-	-	-	-	-
	ois	-	1	14	2	2	20	12	8	-	25	2	3	5	14	-	1	-	-	2	2	1	1	1	-	-	-	-	-
Spinodus spinatus	pri	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	tri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	cor	-	-	-	1	-	2	1	1	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Prioniodus sp.sp.		a.parvidentatus			a.medius	alatus alatus											variabilis(?)						alobatus						
	amr+amb	-	52	51	27	82	62	33	69	-	33	13	28	27	138	4	0	9	1	?	-	?	?	-	1	-	-	-	-
	kei+lig	1	8	84	20	4	82	16	29	2	5	6	13	5	72	4	6	6	-	1	-		4	-	-	-	-	-	-
	tri	1	3	13	9	3	32	2	7	-	4	5	7	3	16	1	3	2	-	-	-	-	-	-	-	-	-	-	-
	tet	1	2	46	22	4	89	6	14	-	14	5	16	8	42	4	3	5	-	1	-	-	5	-	-	-	-	-	-
	ois	-	5	58	22	8	47	14	16	1	15	6	12	19	79	2	7	11	1	2	-	1	-	-	-	-	-	-	-
Rhodesognathus elegans	amr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	62	19	3	1	-	1	-	-	-	-
	amb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	96	20	10	?	-	?	-	-	-	-
Amorphognathus sp.sp.		variabilis								kielcensis				inaequalis						tvaeren.						superbus			
	amr	-	-	5	2	-	8	1	2	1	14	5	45	32	24	31	74	53	3	3	-	4	16	1	3	-	-	2	-
	amb	-	-	3	2	-	9	2	3	1	16	10	38	8	27	8	86	136	10	14	4	8	17	4	1	1	1	1	-
	kei	-	-	?	?	-	-	-	-	-	-	-	11	-	7	-	5	2	-	4	3	1	3	-	-	-	-	2	-
	lig	-	-	1	5	1	4	1	-	-	6	6	11	1	8	1	1	3	-	2	4	1	1	-	1	-	-	-	-
	tri	-	-	?	?	?	?	4	-	-	6	8	22	2	7	-	2	3	-	5	3	1	1	-	1	1	-	-	-
	tet	-	-	?	?	?	?	2	3	1	5	6	5	2	?	1	1	1	-	5	1	1	4	-	-	-	-	-	-
	ois	-	-	1	-	1	3	-	-	-	5	4	20	8	10	8	8	9	-	22	7	2	4	-	2	-	-	-	1
Eoplacognathus sp.sp.		pseudoplanus			sp.	robustus			lindstroemi								elongatus												
	amr	-	-	3	2	-	4	22	3	6	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
	amb	-	-	14	1	-	5	31	2	4	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Polonodus clivosus		-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pygodus sp.sp.		serrus											anserinus																
	amr	-	-	-	-	-	-	-	4	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	amb	-	-	-	-	-	-	2	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Complexodus pugionifer		-	-	-	-	-	-	-	-	-	-	1	-	23	126	-	6	23	1	-	-	-	-	-	-	-	-	-	-
Microzarkodina ozarkodella	ozr	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	neo(ois)	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phragmodus polonicus	ozr	-	-	-	-	-	-	-	6	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	tri	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	hin(cor)	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	neo(ois)	-	-	-	-	-	-	4	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Periodon aculeatus	ozr	-	-	-	-	-	-	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	plc	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	hin(cor)	-	-	-	-	-	-	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	neo(ois)	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hamarodus europaeus	ozr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	2	1	1
	hin(cor)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2	-	1	-
	neo(ois)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	6	1	12	-

Species assigned: Type species and an undescribed species from the Krivoluksky horizon of Siberia.

Erraticodon balticus sp.n.

(pl. 15: 1—3, 5, 6; fig. 6)

1966. *Phragmodus?* sp.n.; Fåhraeus: pl. 3: 12a-b.
1966. "*Fibrous*" conodont; Fåhraeus: pl. 4: 6—8b.
1974. "*Chirognathus*" sp.; Viira: pl. 11: 15, 21, 22.

Holotype: ZPAL CVI/1—351, pl. 15: 4, trichonodelliform element.

Type horizon and locality: Erratic boulder E-231, Garcz near Kartuzy, Pomerania, Llanvirnian, *E. robustus* Zone.

Material. — Thirty-five specimens.

Diagnosis. — Lateral branches of the trichonodelliform element with one denticle, long medial branch and the plectospathodiform element with branches equal in length.

Description. — Apparatus composed of spathognathiform elements with long denticles (fig. 2, cf. Viira 1974: pl. 11: 22), an ozarkodiniform elements with short anterior denticles, a plectospathodiform element with several long denticles on each

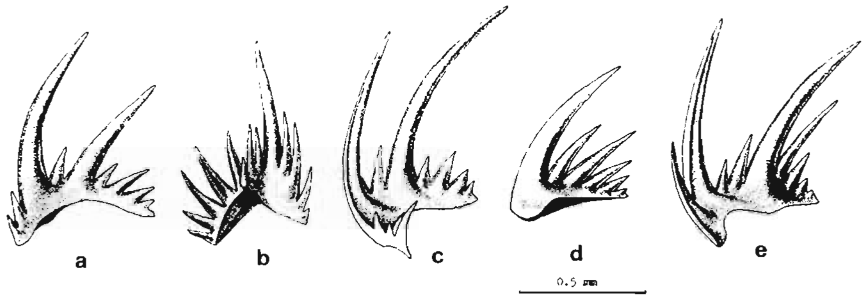

Fig. 6. The composition of the apparatus of *Erraticodon balticus* gen.n., sp.n., (schematized); *a* ozarkodiniform element, *b* plectospathodiform element, *c* hindeodelliform element, *d* neoprioniodiform element, *e* trichonodelliform element. The spathognathodiform element illustrated in Viira (1974, pl. 11: 22) and in present paper fig. 2.

branch, hindeodelliform elements with a short lateral branch and with some of denticles on the posterior branch robust, a neoprioniodiform element with a denticulate posterior branch and trichonodelliform elements with a long posterior and rudimentary lateral branches. Conodonts hyaline. Transverse section of denticles varying in the process of ontogeny. Young conodonts have flat denticles sword-shaped in transverse section and old ones with cusps round in transverse section and having sharp ribs on their margins.

The derivation of *Erraticodon* gen.n. from the genus *Periodon* is unequivocally indicated by the morphology of its trichonodelliform and plectospathodiform elements. *Erraticodon* gen.n, is probably an ancestor of all the rest of the Prioniodininae (fig. 2).

Distribution. — *Llanvirnian. E. foliaceus* Zone of Sweden, *E. robustus* Zone of Estonia and erratic boulders of Poland.

Corrigenda

In Dzik (1976) the following errors have been found:
p. 421, line 6 from the top, holotype of *Semiacontiodus carinatus* Dzik, 1976 should have the following collection number: ZPAL CVI/1-346, Pl. XVI, fig. 5.
p. 426, line 2 and 3 from the bottom should be: *p-s Semiacontiodus longicostatus* (Drygant): Mójcza limestone, sample A-19, 1—305, 306, 1—361, 362, Llandeillian.
p. 427, 1 line from the top should be: Fig. 14 *a-e Scalpellodus cavus* (Webers).

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JERZY DZIK

KONODONTOWA BIOSTRATYGRAFIA I SYTUACJA PALEOGEOGRAFICZNA ORDOWICKIEGO WAPIENIA Z MÓJCZY (GÓRY ŚWIĘTOKRZYSKIE, POLSKA)

Streszczenie

W ośmiu metrach miąższości ordowickich wapieni odsłoniętych w łomie na górze Skała w Mójczy koło Kielc stwierdzono występowanie poziomów konodontowych od pogranicza arenigu z lanwirnem (zona *A — morphognathus variabilis*, dolna część bałtyckiego piętra Kunda) do górnego karadoku (zona *Amorphognathus superbus*). Nie stwierdzono zauważalnych przerw w sedymentacji. Zarówno litologia wapienia jak i zespół fauny nie ulegały w trakcie sedymentacji nagłym zmianom. Umożliwiło to prześledzenie ewolucji stratygraficznie ważnych rodzajów Conodontophorida m.in. *Prioniodus, Amorphognathus* i *Eoplacognathus*. Szczególnie duże znaczenie stratygraficzne ma występowanie w obrębie całego profilu konodontów z rodzaju *Amorphognathus*, umożliwiające dokładne odtworzenie ewolucji poszczególnych elementów ich aparatu.

Cały zespół konodontów z Mójczy jest typu bałtyckiego i zdecydowanie różni się od odległego o około 300 km na zachód zespołu konodontów z Rzeszówka w Górach Kaczawskich (Baranowski and Urbanek 1973). Przedyskutowano możliwość wyjaśnienia tych różnic efektem dryftu kontynentalnego. Jedynie trzy gatunki konodontów z Mójczy nie były dotąd notowane z regionu bałtyckiego. Jeden z nich — *Complexodus pugionifer* (Drygant) — jest znany z Wołynia a drugi, typowo amerykański — *Rhodesgnathus elegans* (Rhodes) — notowany był również z Anglii; populacja z Mój-

czy wykazuje różnice upoważniające do wydzielenia odrębnego podgatunku. Najciekawszy z ewolucyjnego i zoogeograficznego punktu widzenia jest *Phragmodus polonicus* sp.n. morfologicznie i czasowo pośredni pomiędzy bałtyckim rodzajem *Microzarkodina* i grupą amerykańsko-syberyjskich gatunków z rodzaju *Phragmodus*. Podobnie jak występujący w regionie bałtyckim *Erraticodon balticus* gen. et sp.n. pośredni ewolucyjnie pomiędzy rodzajem *Periodon* i typowymi dla „Midcontinent" Ameryki Płn. i Syberii rodzajami *Oulodus* i *Plectodina*, wyjaśnie genezę środkowoordowickiej „*Phragmodus* fauna" (Lindström 1976).

ЕЖИ ДЗИК

КОНОДОНТОВАЯ БИОСТРАТИГРАФИЯ И ПАЛЕОГЕОГРАФИЧЕСКОЕ ПОЛОЖЕНИЕ ОРДОВИКСКОГО ИЗВЕСТНЯКА МУЙЧИ (СВЕНТОКРЖИСКИЕ ГОРЫ, ПОЛЬША)

Резюме

В восьми метрах толщи ордовикского известняка, открытой в карьере на горе Скала в Муйчи около Кельц, обнаружены конодонтовые зоны от границы аренига с ланвирнем (зона *Amorphognathus variabilis*: нижная часть кунгаского горизонта) до верхнего карадока (зона *Amorphognathus superbus*). Не были обнаружены заметные перерыви в седиментации. Как литология известняка, так и комплекс фауны не подвергались во время седиментации резкими изменениям. Это дало возможность проследить эволюцию стратиграфически важных родов Conodontophorida, а среди них *Prioniodus*, *Amorphognathus* и *Eoplacognathus*. Особенно большое стратиграфическое значение имеет выступление в границах всего профиля конодонтов рода *Amorphognathus*, что даёт возможность тщательно проследить эволюцию отдельных элементов их аппарата.

Целый комплекс конодонтов из Муйчи балтийского типа и чётко отличается от расположенного около 300 км на запад комплекса конодонтов Жешувка в Качавских Горах (Baranowski и Urbanek 1973). В статье обсуждена возможность объяснения этих разниц эффектом континентального дрейфа. Только три вида конодонтов из Муйчи не были до сего времени обнаружены в балтийском районе. Один из них — *Complexodus pugionifer* (Drygant) — известен в Волыни, другой, типично американский — *Rhodesgnathus elegans* (Rhodes) — был обнаружен в Англии: популяция из Муйци проявляет различия, которые позволяют выделить отдельный подвид. Самый интересный с эволюционной и зоогеографической точки зрения это — *Phragmodus polonicus* sp. n., морфологически и вре-

менно стоящей между балтиским родом *Microzarkodina* и группой американско-сибирских видов рода *Phragmodus*. Также как и встречающийся в районе Балтики *Erraticodon balticus* gen. et sp. n. эволюционно стоящей между родом *Periodon* и типичным для „Midcontinent" Северной Америки и Сибири родов *Oulodus* и *Plectodina*, он выявляет генезис среднеордовикской „*Phragmodus* fauna" (Lindström, 1976).

EXPLANATION OF THE PLATES

Plate 12

1. The Skała Hill at Mójcza viewed from Brzeziny. Situation of the outcrop of the Ordovician limestones indicated by arrow.
2. Sampling places in the outcrop on Skała Hill, as of 1974.

Plate 13

1, 2, 5. *Amorphognathus kielcensis* Dzik, 1976, Mójcza limestone, sample 26, *1* amorphognathiform element, ZPAL CVI/1—356, ×100; *2* ambalodiform element, ZPAL CVI/1—358, ×100; *5* oistodiform element, ZPAL CVI/1—357, ×100.

3. *Prioniodus* sp. (cf. *P. alobatus* Bergström), amorphognathiform element, Mójcza limestone, sample 22, ZPAL, CVI/1—360, ×100.

4, 7. *Rhodesgnathus elegans polonicus* Dzik, 1976, Mójcza limestone sample 22, *4* amorphognathiform element, ZPAL CVI/1—126, ×100; *7* ambalodiform element, ZPAL CVI/1—337, ×100.

6. *Complexodus pugionifer* (Drygant, 1974), Mójcza limestone, sample 21, amorphognathiform element, ZPAL CVI/1—335, ×100.

Plate 14

1—5. *Phragmodus polonicus* sp.n., Mójcza limestone, *1* ozarkodiniform element, sample 27, holotype ZPAL CVI/1—348, ×100;
2 spathognathodiform element, ZPAL CVI/1—346, sample 27, ×100;
3 trichonodelliform element, ZPAL CVI/1—347, sample 19; ×100;
4 hindeodelliform element, ZPAL CVI/1—349, sample 27, ×100;
5 neoprioniodiform element, ZPAL CVI/1—350, sample 27, ×100.

6, 7. *Histiodella serrata* Harris, 1962, Mójcza limestone, sample 14, *6* basal part of specimen ZPAL CVI/1—345, ×1000; *7* lateral view of the same specimen, ×250.

Plate 15

1—3, 5, 6. *Erraticodon balticus* gen. n., sp.n., erratic boulder E-231, *E. robustus* Zone, Garch near Kartuzy, Pomerania: *1* ozarkodiniform element, ZPAL CVI/1—352, ×100; *2* plectospathodiform element, ZPAL CVI/1—353, ×100; *3* hindeodelliform element, ZPAL CVI/1—354, *5* neoprioniodiform element, ZPAL CVI/1—355, ×100, *6* trichonodelliform element, holotype ZPAL CVI/1—351, ×100.

4. Plectospathodiform or neoprioniodiform element of unidentified conodontophorid (?*Amorphognathus ordovicicus*), ZPAL CVI/1—359, Mójcza limestone, sample 1, ×100.

7. *Walliserodus costatus* Dzik, 1976, Mójcza limestone, sample 14, specimen ZPAL CVI/1—342, ×140.


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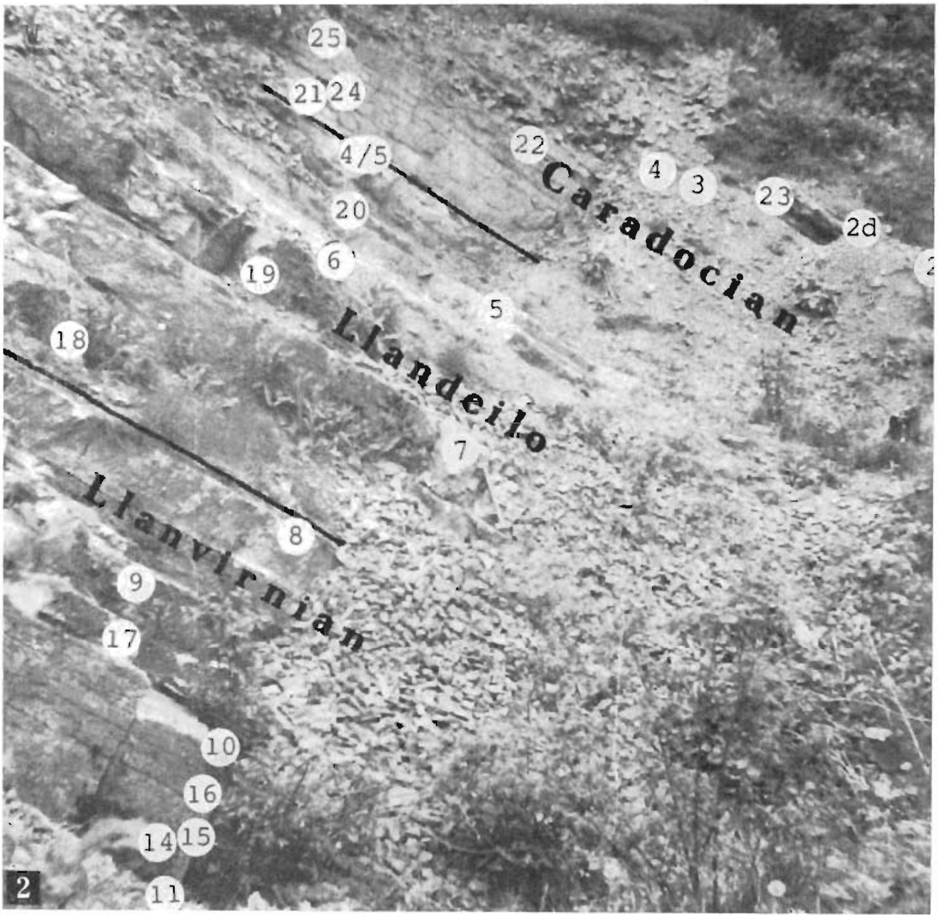
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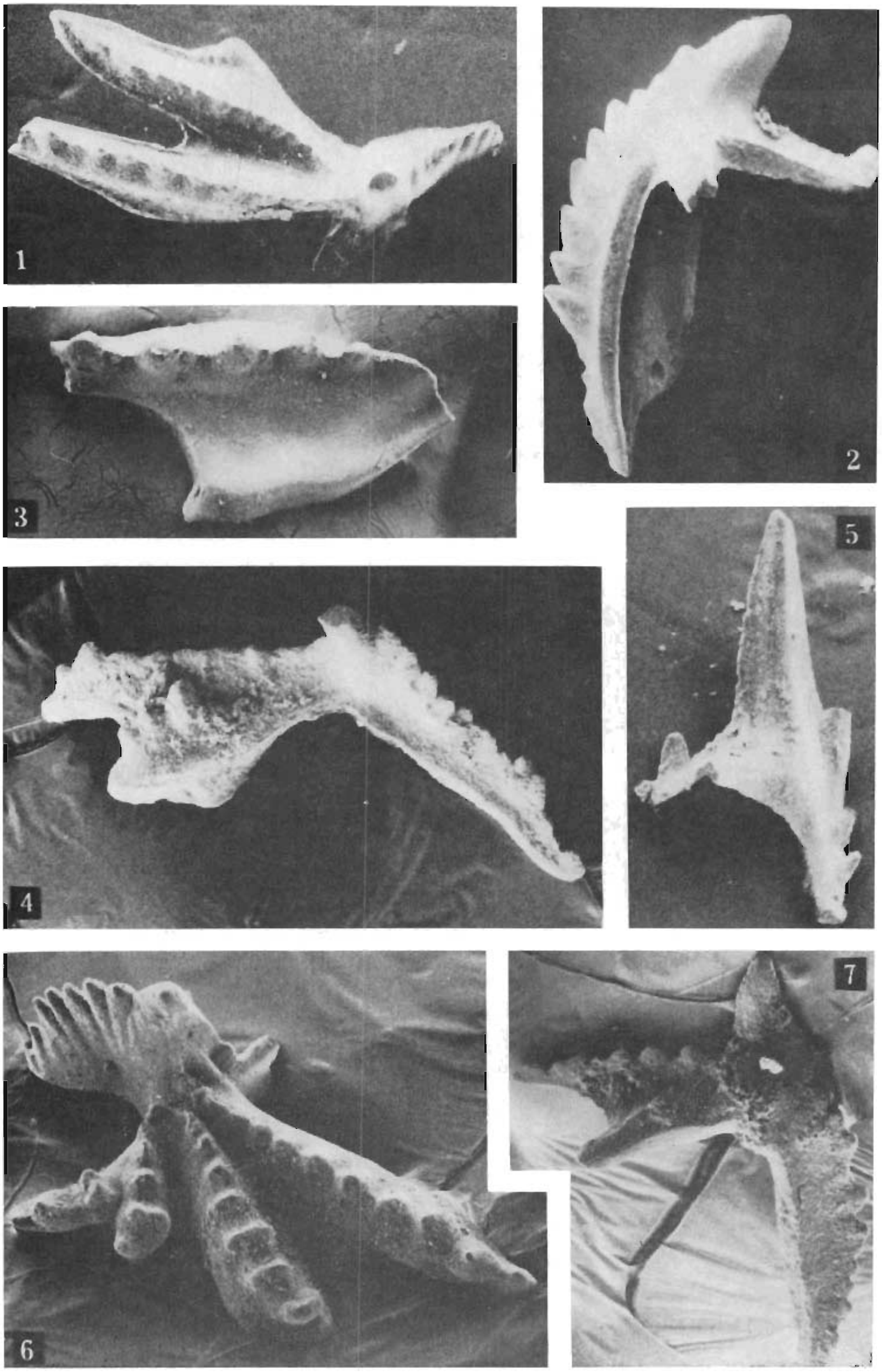
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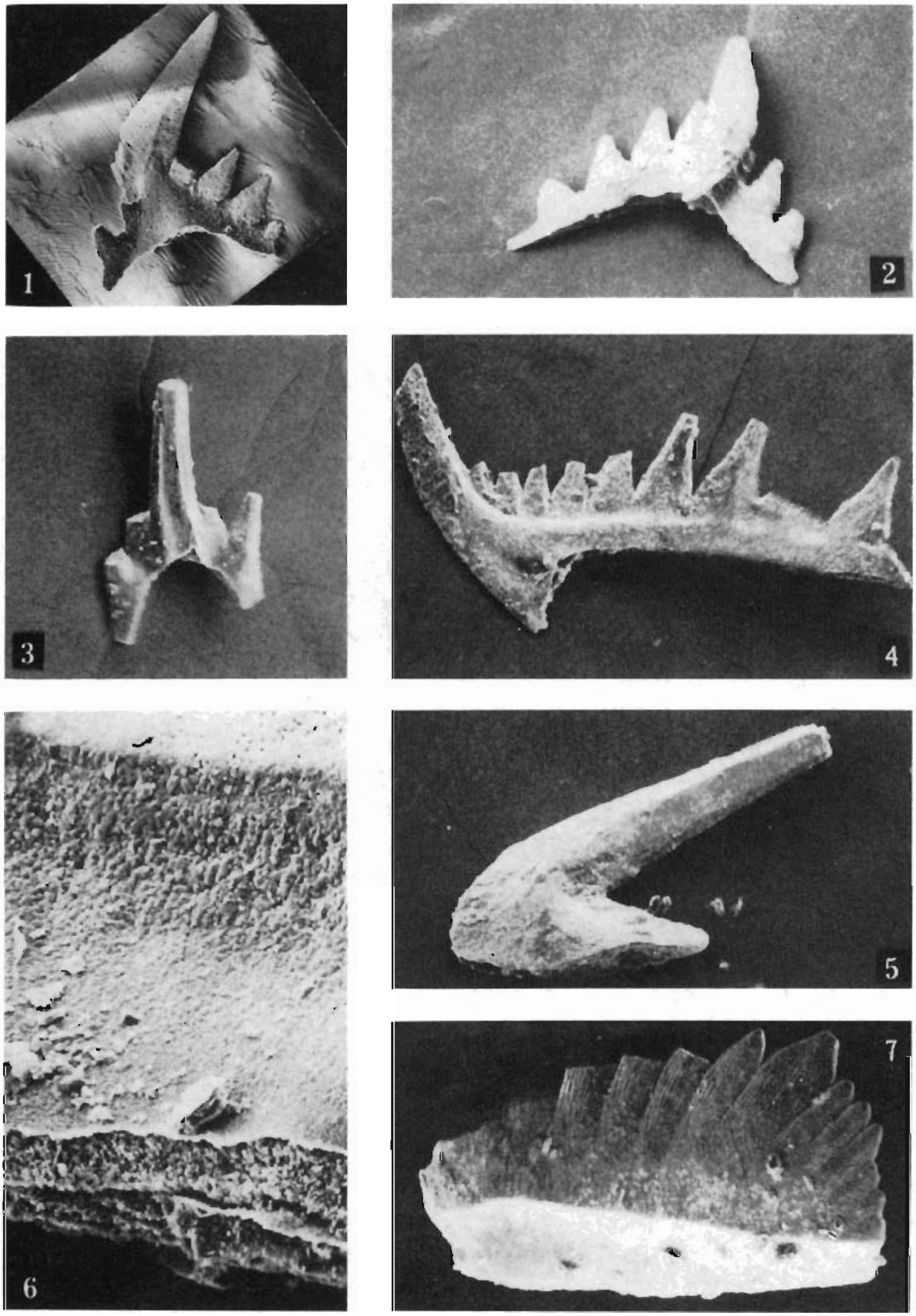
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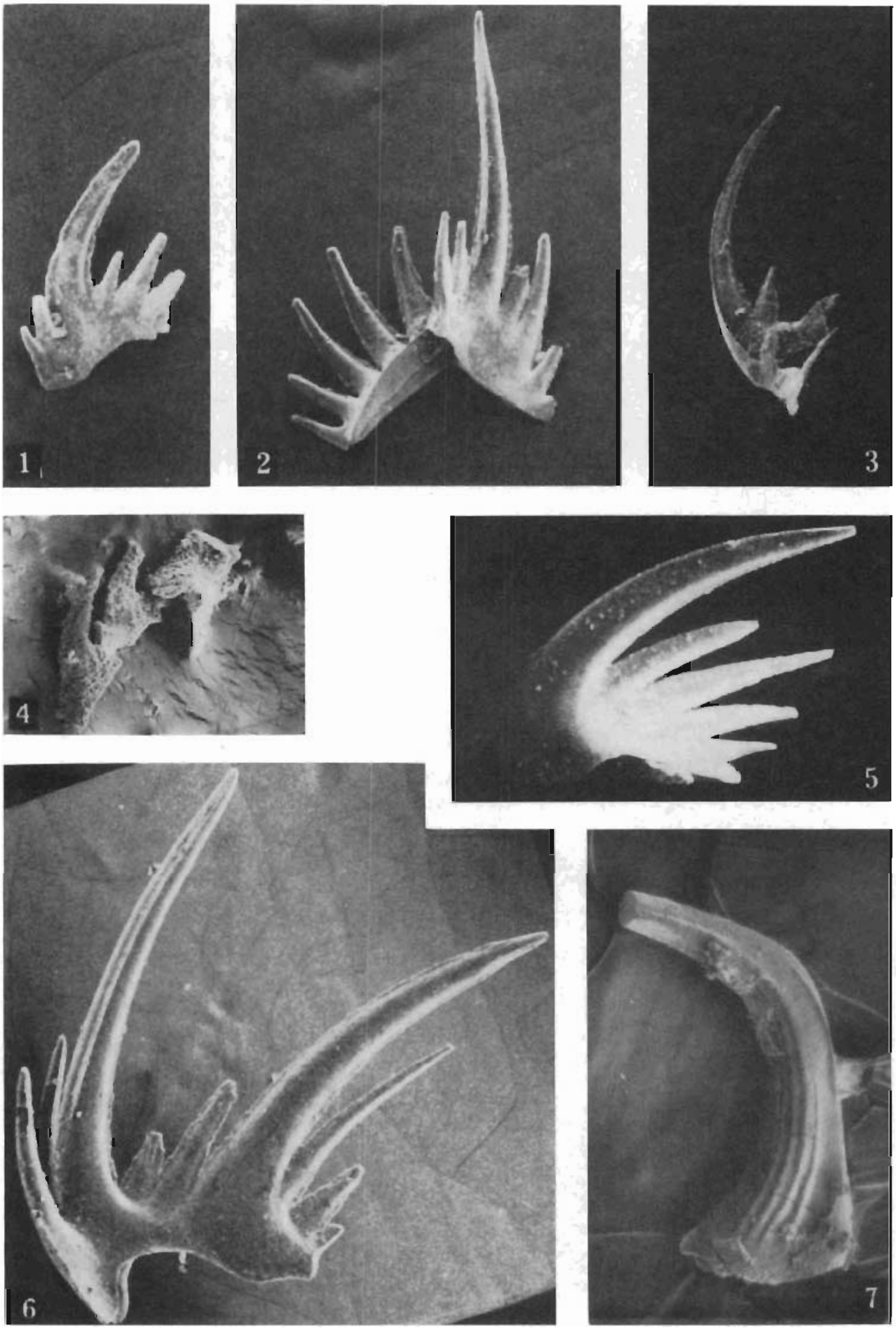
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