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CONODONTS FROM THE TREMADOCIAN CHALCEDONY BEDS, HOLY CROSS MOUNTAINS (POLAND)

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Conodonts extracted by means of hydrofluoric acid from the Upper Tremadocian chalcedony beds of the Holy Cross Mts. are described. Two multielemental simple-cone apparatuses are recognized: *Drepanoistodus deltifer pristinus* (Viira) and *Acodus?* sp. *Drepanoistodus deltifer* (= *Paltodus deltifer*) Zone is subdivided into *D. deltifer pristinus* and *D. deltifer deltifer* Subzones. Correlation of the subzones over northern Europe, and approximate intercontinental correlation, are established. Possible differences in internal structure are recognized between the Tremadocian cordylodids and simple cones.

K e y w o r d s : conodonts, stratigraphy, Ordovician, Tremadocian, Poland.

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INTRODUCTION

Tremadocian conodonts of the North Atlantic Province are known from a few localities in the Baltoscandian area (Pander 1856; Lindström 1955, 1971, Sergeeva 1966; Viira 1966, 1970, 1974; Van Wamel 1974; Mägi and Viira 1976). However, the Tremadocian sequence is nowhere at those localities complete and hence, the present knowledge of conodonts of this age is far from sufficient. The investigated conodont assemblage from the Holy Cross Mts. is also derived from merely a part of the Tremadocian and it includes mostly forms known to science. Nonetheless, it contributes to the reconstruction of two multielemental primitive simple-cone apparatuses and to refinement of the conodont biostratigraphy.

The chalcedony beds of the Holy Cross Mts. yielded perfectly preserved fossils already subjected to some paleontological studies. Kozłowski (1948) extracted from these beds the unique material for his monograph of non-graptoloid graptolites. Bednarczyk (1964) and Biernat (1973) described inarticulate brachiopods found in these beds, while Górka (1969) investigated the acritarch assemblage, and Starmach (1963) the algal one.

The chalcedony beds comprise also abundant and diverse sponge spicules, trilobite fragments, and various problematica. The perfect preservation state of the fossils is due to syngenetic embedding of the organic remains in siliceous gel (Kozłowski 1948; Turnau-Morawska 1958). This state of preservation however causes much difficulty in extraction of the fossils from the rock.

Conodonts were already noted in the chalcedony beds by Kozłowski (1948). The investigated conodont collection derives mostly from samples taken in the early fifties by him and Professor Adam Urbanek (Warsaw University) from a pit at Wysoczki by Bogoria; some conodonts have also been found in samples taken by myself from the exposures at Wilcza Góra by Szumsko and at Chojnów Dół by Zbilutka (fig. 1).

The investigated collection is housed at the Institute of Paleobiology of the Polish Academy of Sciences, Warsaw (abbreviated as ZPAL).

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Warm thanks are also due to Dr. Viive Viira, Institute of Geology of the Academy of Sciences of the Estonian SSR, Tallinn, for making available conodont collections and for helpful discussion.

Fig. 1. Generalized location map; *1* outcrops of the Holy Cross Mts. Paleozoic core, *2* location of the sections of the chalcedony beds sampled for conodonts.

SEM micrographs were taken at the Department of Geology and Mineralogy of the Ohio State University in Columbus and at the Institute of Experimental Biology of the Polish Academy of Sciences, Warsaw.

DESCRIPTION OF THE LOCALITIES AND THE MATERIAL

A detailed lithological description of the chalcedony beds of Wysoczki was given by Samsonowicz (1948), and that of the beds exposed at Chojnów Dół and Wilcza Góra by Bednarczyk (1966). The petrology of the rocks was studied by Turnau-Morawska (1958) and Chlebowski (1971). The chalcedony rocks actually make up intercalations and lenses within glauconitic fine-grained sandstones and siltstones. According to Samsonowicz (*op. cit.*), the 16 m thick set of Tremadocian deposits includes 46 chalcedony intercalations of 2.8 m total thickness. The thickness of chalcedony intercalations usually ranges between 3 and 7 cm but may reach up to 15 cm. They occur most commonly in the middle of the lithological set. The chalcedony is transparent bluish when fresh. It comprises sponge spicules and glauconite grains as a rule. The sandstones are fine-grained, weakly cemented, yellow to green in color. They occur in beds of 4 to 10 cm in thickness (exceptionally up to 20 cm). Some 10% of the rock is represented by evenly distributed fine glauconite grains. According to Turnau-Morawska (1958), the chalcedony beds accumulated in a shallow-water, open-marine environment having a considerable water circulation; the chalcedony matter derived mostly from inorganic subaerial degradation of silicates under conditions of inhibited erosion. Chlebowski (1971) recorded tuffogenic material in the investigated rocks and supposed that the siliceous matter contributing to the chalcedony is of volcanic origin.

There is no documentation of the position of the samples from Wysoczki in the stratigraphic section. Hence, all the material derived from those field samples are here regarded as a single sample. One may however suppose that the field samples were actually taken from some distinct layers, most probably from the middle part of the section where the chalcedony layers are thickest. Some 8 kg of the rock were dissolved in hydrofluoric acid, which yielded over 500 identifiable conodont specimens. The richest in conodonts were the samples with considerable proportions of detritic quartz and glauconite and relatively large amounts of sponge spicules and inarticulate brachiopods.

The samples from Wilcza Góra and Chojnów Dół were taken by myself from a few of the thickest chalcedony layers. Rock samples from both the localities, 0.5 in weight, were dissolved and yielded each a dozen or so specimens representative of a conodont assemblage identical with that recorded at Wysoczki.

Most specimens are very well preserved. The only damage they show is corrosion of their surface, which is due to the action of hydrofluoric acid.

CONODONT ASSEMBLAGE

The apparatuses *Drepanoistodus deltifer pristinus* (Viira) and *Acodus*? sp. described in the present paper are the most primitive ones among thus far known multielemental simple-cone apparatuses. They are representatives of the families Distacodontidae and Prioniodontidae, respectively, that gave rise to various later conodonts (see Lindström 1970; Sweet and Bergström 1972). The only other conodontophorid recorded in the investigated material is *Scolopodus peselephantis* Lindström, representing most probably a monoelemental apparatus. All these conodonts appear for the first time in the Upper Tremadocian and are primitive morphologically. One can hardly recognize their origin at the moment. Aside of the genus *Cordylodus*, very few conodontophorids older than Late Tremadocian have thus far been recorded in the North Atlantic Province. Viira (1970, 1974) was the first to describe some coniform elements already in the Pakerort Stage of Estonia. The form species *Oneotodus altus*, *Scandodus vitreus*, and *Acodus firmus* described by that author could actually be elements of a single apparatus the ancestor of *Drepanoistodus deltifer pristinus*. One can hardly trace phylogeny of the conodonts under discussion because there is a gap between the Lower and Upper Tremadocian conodonts in the North Atlantic province (table 1) and moreover, the Lower Tremadocian conodonts are rather poorly known. In the North American Midcontinent Province, conodonts related in morphology to the elements of *Drepanoistodus deltifer* occur already in the Upper Cambrian. Nonetheless, their phylogenetic relationship to *D. deltifer* remains uncertain.

What is striking in the investigated conodont assemblage is the total absence of any representatives of the genus *Cordylodus*. In the Upper Tremadocian of Baltoscandia, the latter genus occurs indeed much less frequently than in the Lower Tremadocian (Sergeeva 1966; Viira 1970) but nevertheless, it is represented in all thus far described Upper Tremadocian conodont assemblages of this area. To explain the lack of cordylodids in the collection from the chalcedony beds, one may refer to either some unique ecological conditions in the Holy Cross basin unfavorable for these conodontophorids, or a total destruction of the originally present cordylodids by the treatment with hydrofluoric acid (see the next chapter).

The conodontophorids are associated with a few paraconodontids in the chalcedony beds of the Holy Cross Mts. The latter group is represented by two genera: *Westergaardodina* and *Prooneotodus*. Both these genera attained their acme in Late Cambrian time but they persisted up to the Ordovician. One may suppose that *Prooneotodus tenuis* (Müller) is to be assigned to the Chaetognatha instead of Conodonta, whereas *Prooneotodus* cf. *gallatini* (Müller) is homologous to the basal filling of the Conodontophorida (see the systematic descriptions).

POSSIBLE STRUCTURAL DIFFERENCES BETWEEN TREMADOCIAN CORDYLODIDS AND SIMPLE CONES

In the search for an explanation for the absence of cordylodids from the investigated conodont collection from the chalcedony beds, I treated with hydrofluoric acid some cordylodid and simple-cone specimens which, were, collected from the Varangu Member (Tremadocian), Estonia (see Viira 1970), and the *Ceratopyge* beds exposed at Stora Backor, southern Sweden (see Lindström 1955). The result was that all the cordylodid specimens underwent fragmentation followed by almost complete dissolution, while all but a few simple cones maintained their original form and underwent merely some corrosion. To find out the cause for this differential resistance, I analysed 4 cordylodid and 6 coniform elements from Stora Backor exposure using a scanning electron microscope equipped with Energy Dispersive Analyser [1]. The analysis demonstrated that all the cordylodid specimens contained very large amounts of titanium (7.3 to 18.0% in weight) and smaller but constant amounts of iron (1.0 to 1.3% in weight); while these elements were unrecognizeable in the simple cones (only a single one contained 1.3% of titanium, and another one 0.7% of iron). For comparative purposes, I analysed also by the same method cordylodid and coniform elements from the Middle Ordovician of North America (Pratt Ferry Formation, Alabama), and Southern Scotland. The latter conodonts did not show any difference in resistance to hydrofluoric acid; nor did they contain an significant amounts of iron or titanium. One may therefore claim that the contents of titanium and iron in the Baltoscandian Tremadocian cordylodid resulted from a diagenetic mineralization. The proneness of cordylodids to that mineralization may be due to their internal structure being different from that shown by simple cones. Cordylodids may actually show greater interlamellar spaces and/or finer-grained crystallites than do simple cones (cf. Pietzner *et al.* 1968). This peculiar internal structure and stronger diagenetic mineralization are probably responsible for the lower resistance of cordylodids to the action of hydrofluoric acid.

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[1] The analyser permits recognition of approximate mutual proportions of all chemical element with atomic number greater than that of the sodium.

STRATIGRAPHY

The chalcedony beds of the Holy Cross Mts are usually dated as Tremadocian on the bases of inarticulate brachiopod, graptolite, and acritarch assemblages (Samsonowicz 1948; Kozłowski 1948; Bednarczyk 1964, 1971; Górka 1969; Bednarczyk and Biernat 1978). However, Znosko and Chlebowski (1976) are of the opinion that these strata are of Early Arenigian age. The later authors claim that the graptolites recorded in the chalcedony beds have been redeposited from the *Dictyonema* Shale. The investigated conodonts are however very well preserved and do not show any evidence of redeposition. Furthermore, both the conodont and graptolite assemblages (Kozłowski 1948) differ widely from those reported thus far from the *Dictyonema* Shale.

It was already noted (Bednarczyk in Huddle 1974; Szaniawski 1976; Bednarczyk and Biernat 1978) that the conodonts of the chalcedony beds are indicative of the Upper Tremadocian. In fact, they are representative of the *Drepanoistodus deltifer* (= *Paltodus deltifer*) Zone equivalent to the *Ceratopyge* beds of Baltoscandia (Lindström 1971). The present study permits further refinement of their biostratigraphic dating.

The Tremadocian conodont faunas of Baltoscandia, especially those reported from Estonia (Viira 1970, 1974; Viira *et al.* 1974), and the investigated one from the chalcedony beds of the Holy Cross Mts, make actually a sufficient base for subdivision of the *D. deltifer* Zone into *D. deltifer pristinus* Subzone at the base and *D. deltifer deltifer* Subzone at the top

Table 2

Intercontinental correlation of the *Drepanoistodus deltifer* Zone

Northern Europe Lindström 1971 and this paper		Northern Iran Müller 1973	North American Midcontinent Ethington and Clark 1971	Siberia Abaimova 1975	Australia Queensland Druce and Jones 1971
Drepanoistodus deltifer Zone	*Drepanoistodus deltifer deltifer* Subzone		Fauna D (lower part)	Complex IV	*Chosonodina herfurthi* – *Acodus* Ass. Zone
	Drepanoistodus deltifer pristinus Subzone	*Assemblage* Zone 7	Fauna C	Complex III	*Cordylodus rotundatus* – *C. angulatus* Ass. Zone (upper part)

(table 1). The boundary between the subzones is marked by the appearance of *Paroistodus numarcuatus* (Lindström). The investigated conodont assemblage is typical of the lower subzone. It is most closely related to the assemblage recorded in the lower part of the Varangu Member, Estonia (Viira 1970; Mägi and Viira 1976). The clayey strata of the Varangu Member (A_{III}, *Drepanoistodus deltifer* Zone) overlie in northern Estonia the *Dictyonema* Shale assigned to the Pakerort (A_{II}), and are in turn overlain by the Latorpian (B_I) glauconitic sandstones (Männil 1958; Viira *et al.* 1970). Both the boundaries of the Varangu Member are marked by discontinuity surfaces. There is also a discontinuity surface within the member. The Varangu Member has been subdivided into two parts (Viira *et al.* 1970) after its lithological variation, discontinuity surfaces, and conodont fauna. The lower part of the member yields conodonts assigned in the present paper to the apparatus *Drepanoistodus deltifer pristinus* (which is representative of the lower subzone), while the assemblage yielded by the upper part of the member is dominated by the elements of *D. deltifer deltifer* and *Paroistodus numarcuatus* typical of the upper subzone.

Basing on the conodonts collected in Öland island, Van Wamel (1974) subdivided the *Drepanoistodus deltifer* Zone into some conodont assemblage zones. He recognized the *Drepanoistodus acuminatus* assemblage zone below the mid-point of the *D. deltifer* Zone and defined it as follows: "A conodont assemblage zone defined by the occurrence of *Drepanoistodus acuminatus* before the first appearance of *Drepanoistodus numarcuatus* and *Paroistodus amoenus*" (p. 26). However, this must be a misapprehension because the same author stated later: "This conodont assemblage zone was based on two samples (3 and 4) of section 1" (p. 27), but there are no elements diagnostic of the apparatus *Drepanoistodus acuminatus* (that is oistodontiform and suberectiform elements) in the samples refered to (Van Wamel *op. cit.*, Chart II). Actually, the elements diagnostic of *D. acuminatus* appear but higher in the section, associated with elements of the apparatuses *D. numarcuatus* and *Paroistodus amoenus* (Van Wamel *op. cit.*, Chart II and IV). Furthermore, the elements of *D. acuminatus* (Pander) *sensu* Van Wamel do not differ significantly from those of *D. deltifer deltifer*; they co-occur with the latter and all are probably to be assigned to a single apparatus.

In turn, the conodonts described by Lindström (1955) from the *Ceratopyge* beds of Stora Backor exposure, southern Sweden, are representative of the *D. deltifer deltifer* Subzone only. There is a sedimentary discontinuity in that section between the *Dictyonema* Shale and *Ceratopyge* beds (Thorslund 1937). The corresponding stratigraphic gap comprises the upper part of the *Dictyonema* Shale and the lower part of or even the whole *D. deltifer pristinus* Subzone.

Judging from the conodont assemblages reported by Sergeeva (1966) from the Leningrad region, no conodonts have there been recorded in the stratigraphic interval between the Lower Tremadocian (*Cordylodus angulatus* Zone) and Lower Arenigian (*Drepanodus proteus* Zone).

INTERCONTINENTAL CORRELATIONS

Any intercontinental correlation of the Baltoscandian *Drepanoistodus deltifer* Zone is considerably hampered by a large biogeographic differentiation among conodont faunas of this age. An intercontinental time correlation can be approximated (table 2) based on the ranges of world-wide distributed cordylodids and the evolutionary development of some simple cones (mainly drepanodids). A conodont assemblage most closely related to that typical of the Baltoscandian *D. deltifer* Zone occurs in northern Iran (Müller 1973). Forms conspecific with, or very closely related to, those of the *D. deltifer* Zone are confined mostly to the assemblage zone 7 of Müller (*op. cit.*). These are: *Cordylodus angulatus*, *C. rotundatus*, *C. prion*, *Drepanodus subarcuatus*, *D. suberectus*, *D. tenuis*, *Oistodus inaequalis*, *O. lanceolatus*, *Prooneotodus tenuis*, and *Westergaardodina fossa*.[2] The assemblage resembles that of the *D. deltifer pristinus* Subzone, which agrees indeed with the opinion of Müller that his assemblage zone 7 is a little older than the conodonts collected from the *Ceratopyge* beds exposed at Stora Backor, Sweden.

A North American equivalent of the *D. deltifer* Zone is the Fauna C and most probably the lowermost part of the Fauna D of Ethington and Clark (1971). The Fauna C includes coniform elements related to those known from the Baltoscandia (*Oistodus*? *triangularis*, *Oistodus* sp., *Paltodus bassleri*, *Drepanodus suberectus*, *D. homocurvatus*, and *Acodus oneotensis*), associated with *Cordylodus angulatus*, *C. rotundatus*, and *C. prion*. However, the assemblage lacks any conodonts similar to the elements of *Paroistodus numarcuatus* typical of the *D. deltifer deltifer* Subzone. Such elements appear in North America only in the Fauna D of Ethington and Clark (*op. cit.*), including also some forms typical of the Lower Arenigian of the Baltoscandia (*Oistodus linguatus*, *O. forceps*, *Distacodus stola*; cf. Lindström 1976).

In the Siberian platform (Middle Lena region), conodonts related to those of the *D. deltifer* Zone occur most commonly in the conodont Complexes III and IV (Chunsk Beds) of Abaimova (1975). These are: *Drepanodus subarcuatus*, *D. suberectus*, *D. homocurvatus*, *Oistodus abundans*, *O. excelsus*, and *Scandodus sinuosus*. It is to be noted that *Oistodus excelsus*, which resembles most closely the oistodontiform element of *Paroistodus numarcuatus*, appears only in the Complex IV.

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[2] The original taxonomic identifications are retained in this chapter.

Table 1

Correlation of the North European Tremadocian conodont zonations

Baltic Stages	Southern Sweden (Stora Backor) Lindström 1955	Leningrad region Sergeeva 1966	Northern Estonia Viira, Kivimägi and Loog 1970	Baltic Shield Lindström 1971	Estonia Viira 1974	N. W. Öland Van Wamel 1974	Holy Cross Mts This paper	Northern Europe compiled zonation This paper	
CERATOPYGE BEDS (A III)	Zone I characterized by: *Acodus tetrahedron*, *Cordylodus angulatus*, *C. rotundatus*, *Oneotodus variabilis*.	?	?	*Paltodus deltifer* Zone	?	*Drepanodus arcuatus* Ass. Zone	?	*Drepanoistodus deltifer* Zone	*Drepanoistodus deltifer deltifer* Subzone
			Upper fauna of the Varangu Member		*Scandodus varanguensis* Zone	*Drepanoistodus numarcuatus*/ *Paroistodus amoenus* Ass. Zone			
			Lower fauna of the Varangu Member			~~*Drepanoistodus acuminatus* Ass. Zone~~	*Drepanoistodus deltifer pristinus* Subzone		*Drepanoistodus deltifer pristinus* Subzone
	?		?	?	?	?	?	?	
PAKERORTIAN (A II)	*Dictyonema* Shale no conodonts found / ?	*Cordylodus angulatus* Zone	Fauna of the Maardu Member	*Cordylodus angulatus* Zone	*Cordylodus angulatus* Zone	*Cordylodus rotundatus* Ass. Zone / *C. angulatus*/ *C. prion* Ass. Zone		*Cordylodus angulatus*, Zone	

Australian equivalents of the *D. deltifer* Zone are most probably the upper part of *Cordylodus angulatus* — *C. rotundatus* assemblage zone and the *Chosonodina herfurthi* — *Acodus* assemblage zone of Druce and Jones (1971). Apart from the cordylodids, the following forms can also be regarded as comparable to the Baltoscandian ones: *Oistodus inaequalis*, *O. lanceolatus*, *Drepanodus acutus*, *D. tenuis*, *D. subarcuatus*, *Oneotodus gracilis*, *O. erectus*, *O. variabilis*, and *Acodus oneotensis*. Druce and Jones (1971) assigned several Australian simple cones to species recorded for the first time in the Baltoscandia but in most cases conspecificity of the former with their Baltoscandian relatives may be questioned.

A Lower Tremadocian conodont fauna typical of the North American Midcontinent Province, and a Lower Arenigian one typical of the North Atlantic Province are known from the western Newfoundland (Fåhraeus and Nowlan 1978). No Upper Tremadocian conodonts are known there. Fåhraeus and Nowlan (*op. cit.*) consider the lower part of Bed 8 of the Cow Head Group, Newfoundland, as time equivalent to the *Drepanoistodus deltifer* Zone of Baltoscandia but the conodont fauna they recorded (*Cordylodus proavus*, *Proconodontus muelleri muelleri*, *P. primitivus*, *P. tricarinatus*, and *Hertzina* spp.) corresponds actually to the North American Fauna A (*sensu* Ethington and Clark 1971) and there is no doubt that it is older than that of the Baltoscandian *D. deltifer* Zone. The upper part of the Bed 8 of the Cow Head Group contains a conodont assemblage, including *Drepanodus arcuatus*, *Drepanoistodus forceps*, *Scolopodus bassleri*, *S. filosus*, and *S. gracilis*, which represent already the Lower Arenigian. One may thus conclude that there is a gap in either stratigraphic sequence or conodont fauna succession corresponding to at least the Upper Tremadocian.

SYSTEMATIC DESCRIPTIONS

Genus *Acodus* Pander, 1856.

Type species: *Acodus erectus* Pander, 1856.

Remarks. — The concept of this genus in multielement sense is not completely clear. Bergström and Sweet (1966) reconstructed an apparatus of *Acodus mutatus* (Branson and Mehl) composed of acodontiform and acontiodontiform element. Lindström (1971) presented reconstruction of *Gothodus costulatus* Lindström consisting of prioniodontiform (acodontiform), gothodontiform, tetraprioniodontiform, trichondodelliform and oistodontiform elements. Bergström (1968) and Sweet and Bergström (1972) stated that form species (*Gothodus costulatus* is indistinguishable from belodontiform elements of *Prioniodus elegans* and included form genus *Gothodus* into the synonymy of multielement *Prioniodus*. McTavish (1973) reconstructed some skeletal apparatuses consisting of prioniodontiform (acodontiform), oistodontiform, and transition series of ramiform (including acontiodontiform) elements and assigned them to *Acodus*. Lindström (1977) accepted McTavish's concept of the genus, revised its diagnosis and put *Acontiodus* and *Gothodus* (in multielement sense of Lindström 1971) into its synonymy. The author reconstructed also the apparatus of *Acodus erectus* Pander, the acodontiform element of which is identified with the type species of the genus. Unfortunately, there is no clear published evidence of this reconstruction. Moreover, specimens identified by Viira (1974) and Lindström (1977) with form species *Acodus erectus* are incomplete (Viira 1974: fig. 17; pl. 2: 25) and differ from the holotype by a base more weakly differentiated from the cusp and by a better developed and sharper costa. We can not be sure if these specimens are really conspecific with the holotype. In this situation it would be safer to apply to this apparatus the generic name *Acontiodus* because it is much more likely that its acontiodontiform element is conspecific with the type species of that genus, *Acontiodus latus* Pander.

Löfgren (1978: 43) assigned tentatively to *Acodus* "non-prioniodont species *A. mutatus* (Branson and Mehl)". She confirmed the correctness of the first reconstruction of its apparatus (Bergström and Sweet 1966) as consisting of two elements only.

I have brought elements of *Acodus*? sp. into one taxon mainly on the basis of homologisation with apparatuses reconstructed by McTavish (1973) and Lindström (1977). I realize that this reconstruction is not supported by sufficient evidence as yet but I decided to present it because the apparatus is the most primitive of that type and if its composition can be confirmed it will contribute to our understanding of the phylogeny of these forms. *Acodus*? sp. probably could be better assigned to *Acontiodus* Pander but we have put it tentatively into *Acodus* to indicate its homology with prioniodont apparatuses assigned until now to this genus.

Acodus? sp.

(pl. 15)

Material. — 7 specimens of acodontiform element, 13 oistodontiform, 2 acontiodontiform, 1 tetraprioniodontiform and 2 ramiform?.

Remarks. — *Acodus*? sp. is probably an ancestor of *Acodus erectus* in the multielement sense of Lindström (1977). Its prioniodontiform (acodontiform) element is close to the form species *Acodus tetrahedron* Lindström but differs from it by stronger lateral compression of the base and location of the lateral costa closer to the anterior edge. The acodontiform elements of the apparatus of *A. erectus* has a lateral costa placed along the midline of the unit (Viira 1974: fig. 17; pl. 2: 25). The acontiodontiform element, at the present state of knowledge can not be distinguished well from that of *A. erectus* (form species *Acontiodus latus*). It probably differs from it slightly in cross section of the base because of less pronounced posterior keel. From one of the specimens illustrated by Viira (1974: fig. 28) it differs also by less curved cusp. The oistodontiform element differs from corresponding elements of more advanced species (*A. erectus*, *A. deltatus*) by a less conspicuous tongue-like posterior projection of the base. The remaining two elements of *Acodus*? sp. have no counterparts in the apparatus of *A. erectus* but it is possible that they are not yet discovered because they are very rare. The tetraprioniodontiform (ramiform) element recalls that of *A. deltatus deltatus* (form species *Distacodus rhombicus*). The remaining element (ramiform?, pl. 15: 2, 3) is symmetrical and possibly belongs to the transition series of the acontiodontiform element. Similar conodonts were described by Viira (1974: 123; fig. 159; pl. 1: 25) from the Upper Tremadocian of Estonia (Varangu Member) as *Scandodus*? sp.n. B.

All elements of *Acodus*? sp. are much smaller than those of *A. erectus* and *A. deltatus*.

Genus *Drepanoistodus* Lindström, 1971

Type species: *Oistodus forceps* Lindström, 1955.

Remarks. — The concept of the genus is controversial. In 1966 Bergström and Sweet recognized the Middle Ordovician simple cone apparatus *Drepanodus* (= *Drepanoistodus*) *suberectus* (Branson and Mehl) to be composed of drepanodontiform, suberectiform and oistodontiform elements. On the basis of Lower Ordovician material Lindström established the multielement genus *Drepanoistodus*, the species of which according to this author contain only drepanodontiform and oistodontiform elements. In 1974 Van Wamel presented a more complete reconstruction of the Lower Ordovician apparatus of *Drepanoistodus* with drepanodontiform, oistodontiform, suberectiform, acodontiform and scandodontiform elements and put into synonymy the genus *Paltodus* Pander in the multielement sense of Lindström (1971). However, Lindström (1977) points out that species of these two genera differ significantly in morphology and evolution and presented a revised diagnosis of *Paltodus* in which its apparatus is taken to be composed of acodontiform, drepanodontiform and oistodontiform elements only. Löfgren (1978) distinguishes only three essential elements of *Drepanoistodus* (homocurvatiform, suberctiform and oistodontiform) but includes in the synonymy of *D. forceps* the complete set of elements recognized by Van Wamel (*op. cit.*). In my collection, as well as in the collections of Viira (1970, 1974) all elements assigned by Van Wamel (1974) to *D. inaequalis* (= *Paltodus deltifer* of Lindström, 1971, 1977) co-occur. Moreover, I can state that drepanodontiform, acodontiform and two types of scandodontiform elements form a transition series. This seems to support the more complete apparatus reconstruction of Van Wamel (1974).

Drepanoistodus deltifer (Lindström, 1971)

Remarks. — Generic and specific designation of this species is controversial. Lindström (1971, 1977) assigned it to *Paltodus* Pander. Van Wamel (1974) considers *Paltodus* emend. Lindström 1971 (not *Paltodus* Pander) as a synonym of *Drepanoistodus*. In my opinion, the generic name *Paltodus* can not be applied to the apparatus in question because the type species of that genus, *P. subaequalis* Pander (form species) differs greatly from all elements of this apparatus. *P. subaequalis* possesses a well defined costa on the both lateral sides and a sharply delimited groove on the anterior side. These features were clearly described and well illustrated by Pander (1856: 24; pl. A: 4*a*; pl. 1: 24). If we shall regard one margin of the anterior groove as a keel and the other as a costa we still have an unit significantly different from all elements of *D. deltifer* which bears a costa on one lateral side only. Therefore, I prefer to use the generic name *Drepanoistodus* for this form. However, this does not mean that in my opinion all multielement species assigned until now to *Paltodus* have to be transferred to *Drepanoistodus*. *D. deltifer* is most primitive of the all known apparatuses of the two genera and most probably gave rise to both of them.

Vam Wamel (1974) is of the opinion that *D. deltifer* is conspecific with form species *Oistodus inaequalis* Pander. However, oistodontiform elements of *D. deltifer* differ slightly from *O. inaequalis* by a less reclined cusp, a more weakly developed carina, and a different course of the aboral margin. Moreover, none of the other conodonts described by Pander (1856) is similar to elements of *D. deltifer*. I assume that this apparatus was not represented in Pander's collection. This is consistent with the statement of Viira (1975; table 1) that Pander did not describe Upper Tremadocian conodonts at all.

Drepanoistodus deltifer pristinus (Viira, 1970)
(pl. 16, 17 and 18: 2, 7—11, 13)

1970. *Acodus firmus* Viira: 225, fig. 2, pl. 1: 9.
1970. *Drepanodus bisymmetricus* Viira: 226, figs 3, 4, pl. 1: 1—5.
1970. *Drepanodus pristinus* Viira: 227, figs 5, 6, pl. 1: 7, 8.
1970. *Drepanodus* aff. *subarcuatus* Furnish; Viira: pl. 1: 18, 19.
1970. *Scandodus varanguensis* Viira: 230, figs 8, 9, pl. 1: 11, 12.

Revised diagnosis. — Multielement apparatus composed of oistodontiform, suberctiform, and transition series of drepanodontiform, acodontiform and two types of scandodontiform elements. Oistodontiform element with slightly reclined or nearly erect cusp. Suberectiform element bears two very short lateral costae on the base. Acodontiform element with short and weakly developed costa.

Material. — Drepanodontiform elements 182, acodontiform elements 58, scandodontiform elements of type I 32, scandodontiform elements of type II 44, suberctiform elements 45, oistodontiform elements 129 specimens (of the latter, 7 are of the varanguensiform kind).

Remarks. — *Drepanoistodus deltifer* (Lindström) can be subdivided into two subspecies: *D. deltifer deltifer* (Lindström) with the type material from the *Ceratopyge* Limestone at Stora Backor, Sweden (Lindström 1955) and *D. deltifer pristinus* (Viira) with the type material from the Varangu Member at Varangu, Estonia (Viira 1970). The two subspecies differ both in morphology of elements and in their stratigraphic range. The more primitive *D. deltifer pristinus* has less diversified elements with less strongly developed characteristic features. The oistodontiform element of this subspecies has less reclined cusp and usually narrower shorter base. In some of the specimens a base is comparatively wide but cusp erect, and short (pl. 16: 7, 9). Such forms have been decribed by Viira (1970) as form species *Scandodus varanguensis*. The suberectiform element of *D. deltifer deltifer* is known as the form species *Distacodus peracutus* Lindström (Lindström 1955: 555, pl. 3: 1, 2, not text-fig. 5d) which co-occur with other elements of this apparatus in all collections of this age from the Baltoscandian area. The corresponding element of *D. deltifer pristinus* (form species *Drepanodus pristinus*) differs from it by having shorter lateral costae which are developed only on the base. The drepanodontiform element of the more primitive subspecies posseses narrower base, which is often weakly differentiated from the cusp. The base is variable in cross section. In the drepanodontiform element sensu stricte, it is strongly flattened laterally (pl. 17: 13). In transitional forms to the acodontiform element, it is much wider, semioval, and truncated from the antero-inner lateral side (pl. 17: 5). Acodontiform element differs from that of *D. deltifer deltifer* by shorter and weaker developed costa. Scandodontiform elements of *D. deltifer* were known until now only from the description of Van Wamel (1974: 66, pl. 2. 11, 12), and the difference between those in the two subspecies can not yet be well defined. Our forms seem to be less differentiated and more similar to drepanodontiform element. They differ from it by being more asymmetrical and having a different outline of the basal margin. One type of them (pl. 18: 2—7, 11, 13) has a rounded outline which is only slightly flattened from one lateral side and undulated from the other. The second type (pl. 17: 1, 8, 9) has the base laterally flattened with an incision at the antero-basal corner on the inner side.

Comments to the synonymy list. — All species cited in the list of synonyms were described by Viira also in 1974. Form species *Scandodus varanguensis* and *Drepanodus bisymmetricus* represent extreme forms in the variation series of oistodontiform and suberectiform elements. Remaining oistodontiform elements of *D. deltifer* from Estonia were assigned by Viira (1974) to the form species *Oistodus inaequalis*. The specimen illustrated by her (pl. 16: 13) belongs to the subspecies *D. deltifer deltifer* but having had the opporunity to study her collection I can state that elements with narrow base and less reclined cusp which are characteristic for *D. deltifer pristinus* predominate in the lower part of the Varangu Member. Elements of *D. inaequalis* (= *D. deltifer*) described by Van Wamel (1974: 65, pl. 2: 7—13) belong rather to *D. deltifer deltifer* although some of them (oistodontiform and acodontiform) are very close to *D. deltifer pristinus*. Elements assigned by Van Wamel (1974: 62, pl. 2: 1—6) to *Drepanoistodus acuminatus* are in my opinion indistinguishable from *D. deltifer deltifer* (see also p. 107).

From the Tremadocian of Iran, Müller (1973) described several conodonts (*Drepanodus subarcuatus* Furnish; *D. suberectus* (Branson and Mehl); *D. tenuis* Moskalenko, pl. 6: 2—6, not pl. 6: 1; *Ulrichodina* sp., *Oistodus inaequalis* Pander, pl. 8: 6, not pl. 8: 7) which are close to *D. deltifer pristinus* but probably should be separated into another subspecies.

Occurrence. — Upper Tremadocian of Baltoscandian area and Holy Cross Mts (central Poland).

Genus *Prooneotodus* Müller and Nogami, 1971

Type species: *Prooneotodus gallatini* (Müller, 1959).

Prooneotodus tenuis (Müller, 1959)

(pl. 18: 5, 6)

Material. — 3 specimens.

Remarks. — The specimens at hand do not differ significantly from some specimens of the type material (Müller 1959: pl. 13: 11).

P. tenuis is widely distributed and its fused clusters of several virtually identical elements are also rather commonly preserved. Landing (1977) reconstructed the complete apparatus of the species and expressed the opinion that it "... served in a grasping function" (p. 1072). I agree with this interpretation because the apparatus shows a striking similarity to the grasping organ of the Recent Chaetognatha. The similarity in morphology of particular elements as well as in construction of the whole apparatus is so great that a possibility of phylogenetic relation of *P. tenuis* to the Chaetognatha should be taken in consideration. Landing (*op. cit.*) questions the generic assignment of *P. tenuis* on the base of its supposed structural distinctness. However, one can thus far hardly say whether there is indeed any considerable difference in structure between *P. tenuis* and the type species of the genus, *P. gallatini*.

Occurrence. — The species shows world-wide distribution. It is known from the Middle Cambrian to Upper Tremadocian. Its Upper Tremadocian occurrence has already been reported from Iran (Müller 1973).

Prooneotodus cf. *gallatini* (Müller, 1959)
(pl. 18: 1)

Material. — 3 specimens.

Remarks. — Specimens of this species differ from all others in the collection by a dark-brown colour and rough surface. They are similar to some specimens of the type material of *P. gallatini* (Müller 1959: pl. 13: 9, 18) but differ from them by the base less differentiated from the cusp and a slightly different mode of curvature of the whole specimen.

It is possible that the species represents the basal cone of another conodont. A similar opinion was expressed by Ethington (*in*: Miller 1969: 435) with reference to the holotype of *P. gallatini*. However, one may also suppose that the species in question is homologous to the basal cone of other conodonts but has been never associated with any element proper.

Genus *Scolopodus* Pander, 1856

Type species: *Scolopodus sublaevis* Pander, 1856.

Remarks. — The status of this problematic genus was recently discussed by Löfgren (1978) and by Fåhraeus and Nowlan (1978).

Scolopodus peselephantis Lindström, 1955
(pl. 18: 3, 4)

Material. — 6 specimens.

Remarks. — Our specimens fit well with the description of the species based on the material from Upper Tremadocian and lowermost Arenigian of Sweden (Lindström 1955: 595, pl. 2: 19, 20; fig. 3Q) except that no striation can be traced on them. The striation could have been damaged during processing of the samples in hydrofluoric acid. On the other hand, Viira (1974: 124, fig. 62) stated that some Tremadocian representatives of the species can be completely devoid of the striation.

The species is currently treated very broadly (Hamar 1964, Fåhraeus 1966, Viira 1974, Van Wamel 1974) and this results in its wide stratigraphic range. In my opinion, the scope of the species should be constricted. Forms close to the holotype occur only in Upper Tremadocian and Lower Arenigian.

So far only one type of elements of this species is known. Most probably its apparatus was monoelemental.

Occurrence. — Lower Ordovician of the Baltoscandian area.

Genus *Westergaardodina* Müller, 1959.

Type species: *Westergaardodina bicuspidata* Müller, 1959.

Westergaardodina cf. *fossa* Müller, 1963
(pl. 18: 12)

Material. — 1 specimen.

Remarks. — The specimen is poorly preserved. It seems to be most closely related to *W. fossa* but the most characteristic feature of this species, a median furrow at the lower side, is not so well developed (or preserved) as in the type material. Side cavities are also hardly discernible. *W. fossa* is known from the uppermost Cambrian and Tremadocian of Iran.

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HUBERT SZANIAWSKI

KONODONTY Z WARSTW CHALCEDONOWYCH TREMADOKU GÓR ŚWIĘTOKRZYSKICH

Streszczenie

Warstwy chalcedonowe tremadoku Gór Świętokrzyskich są źródłem doskonale zachowanych skamieniałości będących już przedmiotem kilku opracowań paleontologicznych. W niniejszej pracy opisano konodonty wypreparowane przy pomocy kwasu fluorowodorowego z chalcedonitów pobranych z przekopu w Wysoczkach koło Bogorii, a w mniejszym stopniu także z odsłonięć w Wilczej Górze koło Szumska i w wąwozie Chojnów Dół koło Zbilutki (fig. 1). Zebrana kolekcja liczy ponad 500 nadających się do oznaczenia okazów. W występującym tu zespole wyróżniono dwa gatunki wieloelementowe: *Drepanoistodus deltifer pristinus* (Viira) i *Acodus*? sp. oraz cztery gatunki monoelementowe: *Scolopodus peselephantis* Lindström, *Prooneotodus tenuis* (Müller), *P. cf. gallatinii* (Müller) i *Westergaardodina* cf. *fossa* Müller. Opisane po raz pierwszy aparaty *Drepanoistodus deltifer pristinus i Acodus*? sp. są najprymitywniejszymi z dotychczas poznanych wieloelementowych aparatów konodontów stożkowych.

Opisany zespół reprezentuje poziom konodontowy *Drepanoistodus deltifer* obejmujący warstwy ceratopygowe regionu bałtyckiego. Poziom ten w oparciu o dotychczas opisane konodonty oraz zespół opisany w niniejszej pracy podzielono na dwa podpoziomy: dolny — *D. deltifer pristinus* i górny — *D. Deltifer deltifer*. Granicę tych podpoziomów wyznacza pojawienie się *Paroistodus numarcuatus* (Lindström). Zespół konodontów z warstw chalcedonowych reprezentuje podpoziom dolny i jest najbardziej zbliżony do zespołu poznanego z dolnej części serii Varangu w północnej Estonii (Viira 1970, Viira *et al.* 1970, Mägi i Viira 1976). Przeprowadzono korelację wyróżnionych podpoziomów w regionie bałtyckim (tablica 1) oraz przybliżoną ich korelację międzykontynentalną (tablica 2).

Brak w opisanym zespole konodontów z rodzaju *Cordylodus* nie dowodzi ich braku w osadzie. Stwierdzono, że są one mniej odporne na działanie kwasu fluorowodorowego niż konodonty stożkowe, mogły więc ulec całkowitemu zniszczeniu podczas maceracji.

Praca została wykonana w ramach problemu międzyresortowego MR II/3, finansowanego przez Polską Akademię Nauk.

EXPLANATION OF THE PLATES 15—18

All the specimens derived from the chalcedony beds of Wysoczki, Holy Cross Mts

Plate 15

Acodus? sp.

1, 5. Acontiodontiform (ramiform) elements; *1* postero-basal view of ZPAL C.XI/1, *5* posterior view of ZPAL C.XI/2.

2, 3. Ramiform? elements; *2* posterior view of ZPAL C.XI/3, *3* oblique lateral view of ZPAL C.XI/4.

4a, b. Tetraprioniodontiform element; *4a* broken specimen in posterior view, ZPAL C.XI/5, *4b* posterior part of the same specimen in oblique lateral view.

6—8. Acodontiform (prioniodontiform) elements; *6* inner side of ZPAL C.XI/6, *7* posterior view of ZPAL C.XI/7, *8* outer side of ZPAL C.XI/8.

9—11. Oistodontiform elements from inner side, ZPAL C. XI/13, 14, 15.

1, 2, 4a, 5—11×133; 3×120; 4b×90

Plate 16

Drepanoistodus deltifer pristinus (Viira)

1—4, 8. Suberectiform elements; *1*, *2* inner side of ZPAL C. XI/342, 343, *3* basal view of ZPAL C.XI/344, *4* outer side of ZPAL C. XI/345, 8 inner side of the basal part of ZPAL C.XI/346.

5—7, 9—13. Oistodontiform elements; *5*, *6* inner side of ZPAL C.XI/387, 388, 7, *9* inner side of specimens with extremely short and erect cusp, varanguensiform type, ZPAL C. XI/389, 390, *10* outer side of ZPAL C.XI/391, *11—13* inner side of ZPAL C.XI/392, 393, 394.

1, 4, 5, 7, 9—13×100; 2, 3, 6, 8×133

Plate 17

Drepanoistodus deltifer pristinus (Viira)

1, 8, 9. Scandodontiform elements of type II, inner side of ZPAL C.XI/298, 299, 300.

2, 4, 11—15. Drepanodontiform elements; *2* outer side of a juvenile form, ZPAL C.XI/25, *4* inner side of a juvenile form, ZPAL C.XI/26, *11—12* inner side of ZPAL C.XI/27, 28, *13* basal view of ZPAL C.XI/29 (inner side to the left), *14*, *15* outer side of ZPAL C.XI/30, 31.

3. Oistodontiform element in basal view, ZPAL C.XI/395 (inner side to the left).

5—7, 10. Acodontiform element; *5* oblique outer side view of ZPAL C.XI/208, *6* posterior view of ZPAL C.XI/209 (inner side to the right), 7 oblique inner side view of ZPAL C. XI/210, *10* oblique inner side view of ZPAL C.XI/211.

all figures ×100

Plate 18

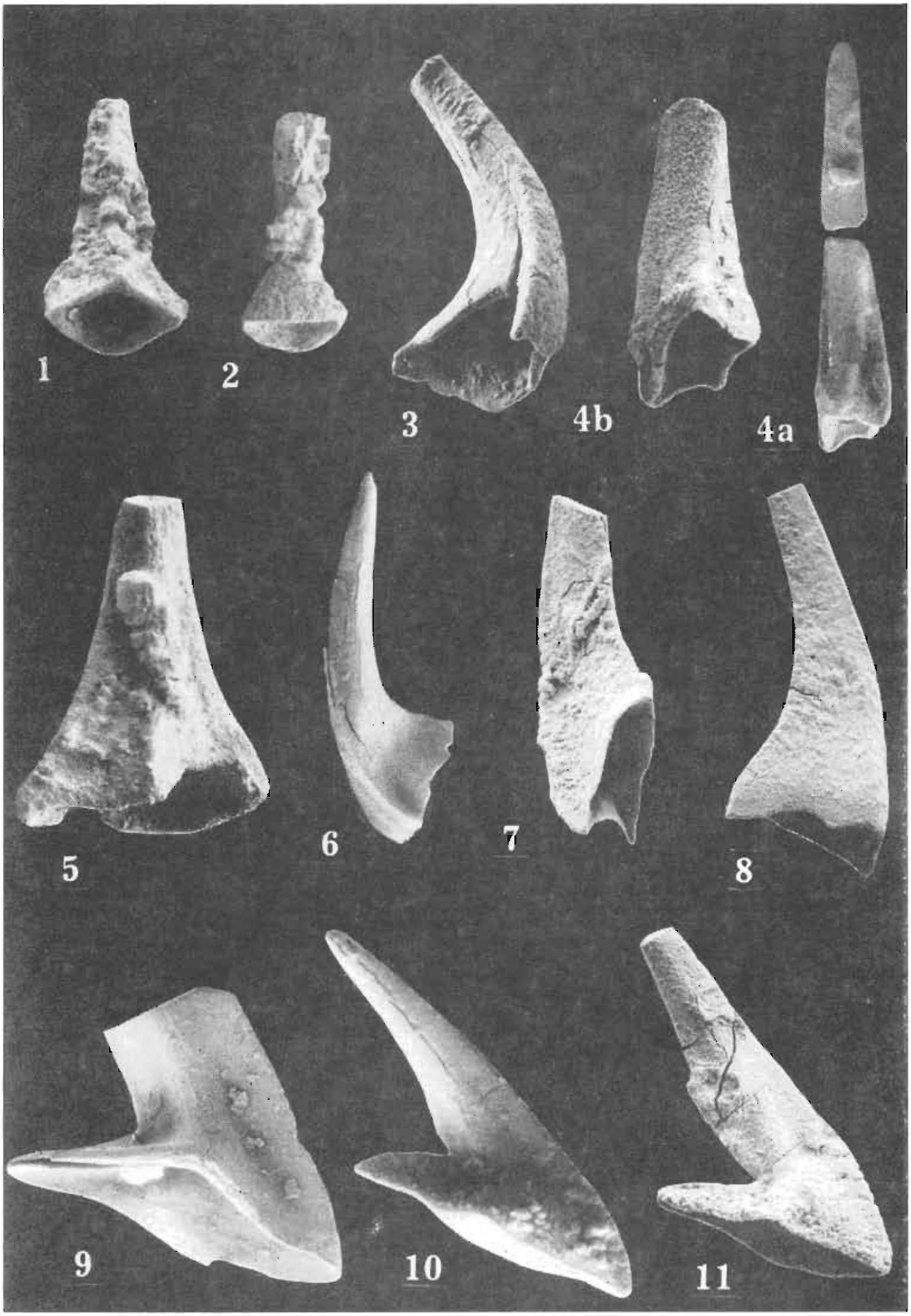
1. *Prooneotodus* cf. *gallatini* (Müller), ZPAL C.XI/519, ×100.

2, 7—11, 13. *Drepanoistodus deltifer pristinus* (Viira), scandodontiform elements of type I; *2* antero-lateral view of ZPAL C.XI/266, ×100, *7a* outer side of ZPAL C.XI/267, ×133, *7b* fragment of the surface of the same specimen ×3000, *8* inner side of ZPAL C.XI/268, ×66, *9* posterior view of ZPAL C.XI/269, ×133, *10* inner side of ZPAL C.XI/270, *11* anterior view of ZPAL C.XI/271, ×133, *13* oblique lateral view of ZPAL C.XI/272, ×133.

3, 4. *Scolopodus peselephantis* Lindström; *3* posterior view of ZPAL C.XI/522, *4* lateral view of ZPAL C.XI/523, both ×133.

5, 6. *Prooneotodus tenuis* (Müller) ZPAL C.XI/516, both ×150.

12. *Westergaardodina* cf. *fossa* (Müller) ZPAL C.XI/518, ×200.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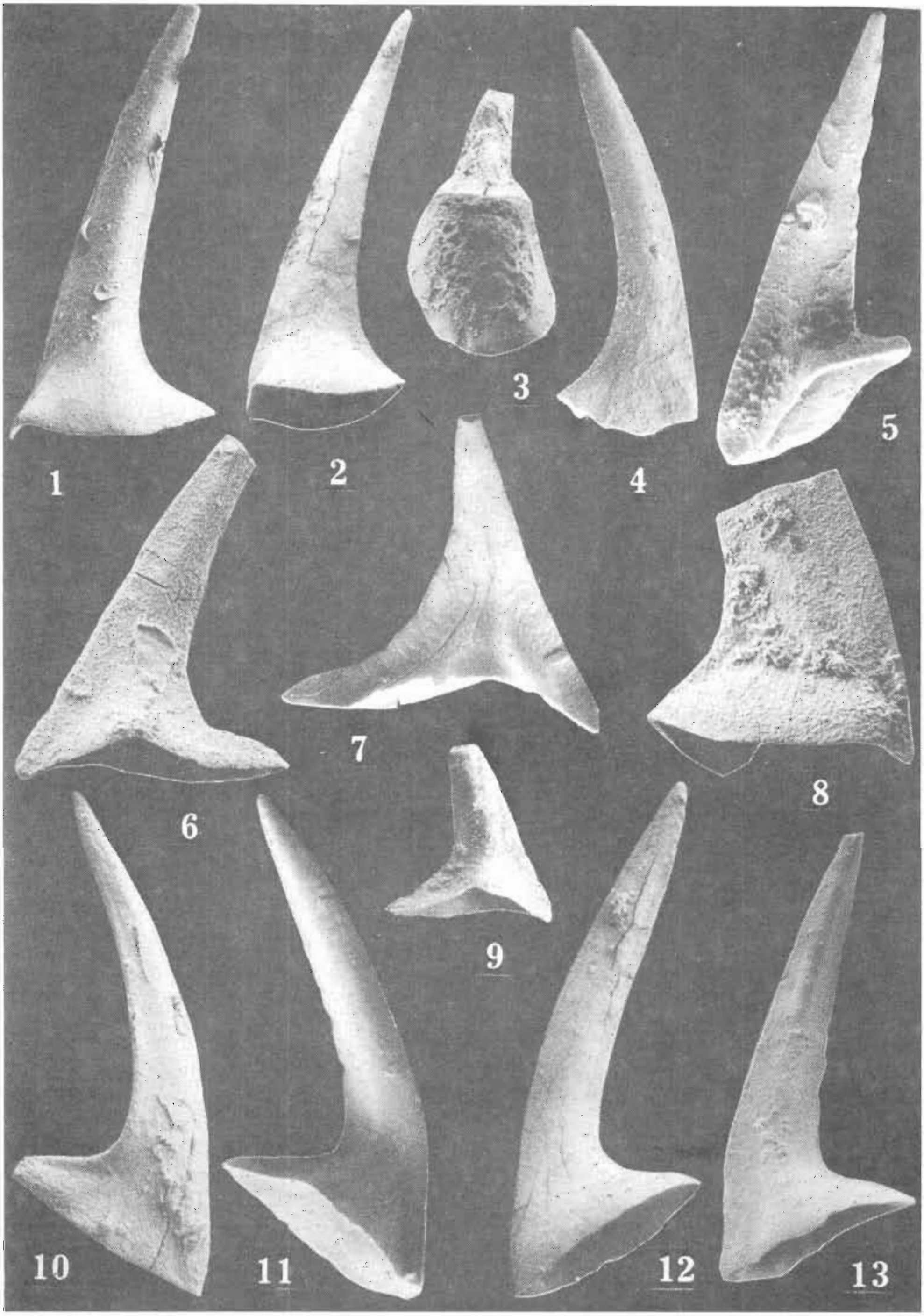

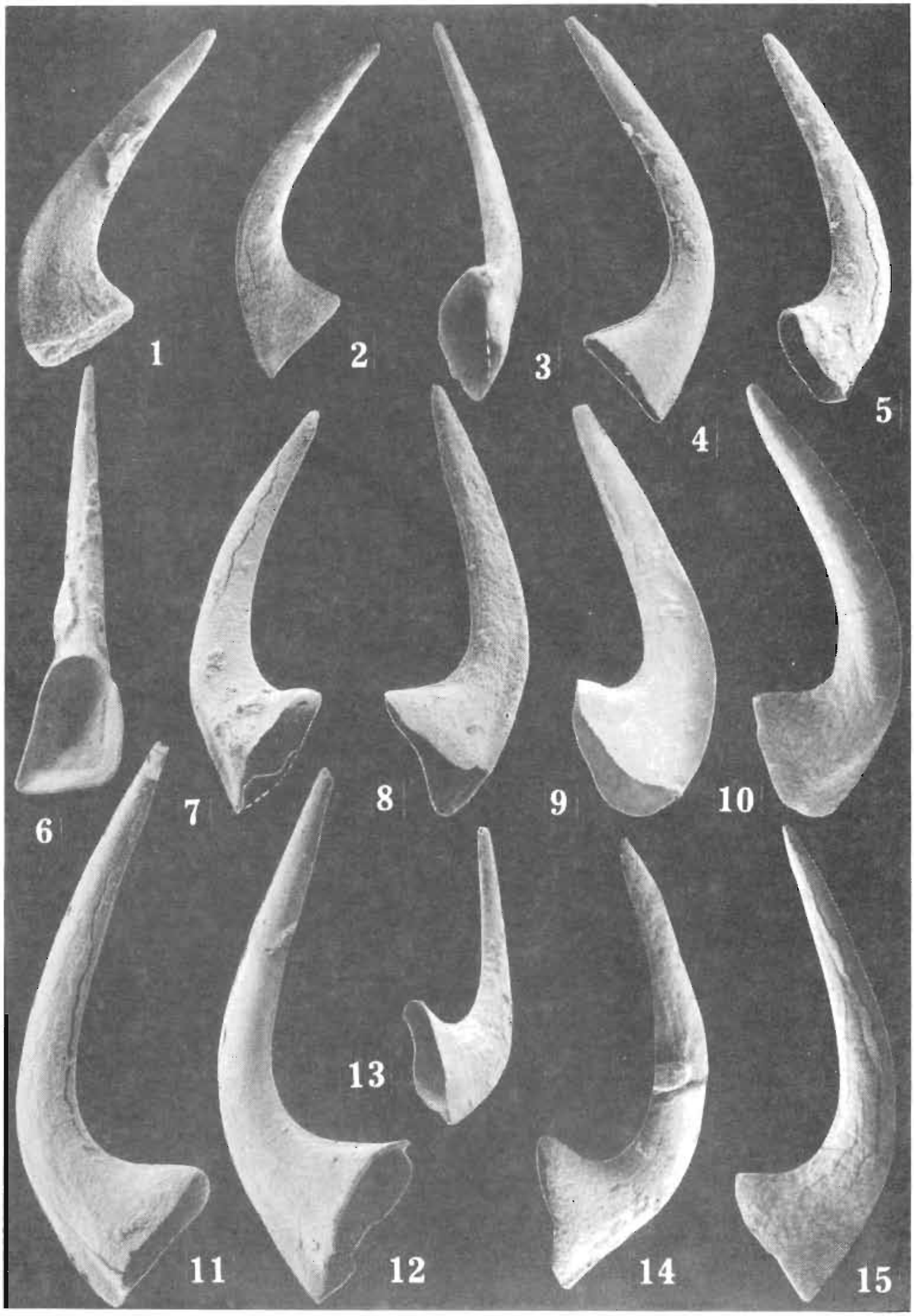
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