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Late Famennian shark teeth from the Holy Cross Mts, Central Poland

ABSTRACT: Late Famennian shark teeth, mostly of the phoebodonts, have been found in the residues of conodont samples from the Holy Cross Mts, Central Poland. Two new species of the genus *Phoebodus*, viz. *Ph. gothicus* sp. n. and *Ph. limpidus* sp. n., have been established. Provisional stratigraphic ranges of the three most significant species: *Thrinacodus ferox* (TURNER), *Phoebodus australiensis* LONG and *Ph. gothicus* sp. n. have been correlated with international data.

INTRODUCTION

Numerous Devonian ichthyoliths, among them elasmobranch microremains, have appeared in the last few decades in the collections of Polish workers. Shark teeth from the Holy Cross Mts, Central Poland, were found during the studies on the Upper Devonian fish macrofossils or in the residues of dissolved conodont samples, but only few of the collected specimens have hitherto been described. KULCZYCKI (1957, Pl. 13, Figs 4—8) figured five Famennian teeth, which he assigned to the genera *Dittodus* and *Cladodus*. A single specimen of *Phoebodus* from the Givetian of Mt. Laskowa was figured by RACKI (1985, Pl. 6, Fig. 1a—1b: designated as a “cladodont tooth”).

About sixty shark teeth, mainly of phoebodont affiliation, coming from the Upper Famennian (above the marginifera condont Zone) of the western part of the Holy Cross Mts are reported in this article. Since these specimens are well dated by conodonts, it was possible to present provisional, incomplete stratigraphic ranges of the most significant species and to correlate them with the data from the other places in the world.

The major part of the material under study comes from the students guided by Professor M. SZULCZEWSKI, University of Warsaw: I. NASIŁOWSKI, M. Sc. (Ostrówka Quarry) and J. OLSZAK, M. Sc. (vicinities of Wzdół Rządowy), and from the samples kindly handed to the Author by Dr. S. SKOMPSKI (Todowa Grząba Hill) and Dr. G. RACKI (Zbrza). Further specimens have been selected

from the same samples, as the conodonts used in the papers of SZULCZEWSKI (1973; Dalnia Hill) and ŻAKOWA, SZULCZEWSKI & CHLEBOWSKI (1983; Mt. Jabłonna).

A few *Cladodus*-type teeth, one specimen of *Dittodus* and one of *Denaea*, in addition to almost fifty specimens of the Phoebodontidae (*Phoebodus* and *Thrinacodus*) occur in the studied material. The teeth are usually well preserved (except of broken tips of the cusps), and only those from Todowa Grząba have lost their ornament due to recrystallization.

All the investigated specimens are housed in the Institute of Geology, University of Warsaw (Instytut Geologii Podstawowej, Uniwersytet Warszawski — abbreviated as IGPW) in Warsaw.

STRATIGRAPHY

The Famennian in the Holy Cross region is developed in two basic facies. Rhythmic, lime-marly-clayey deposits with local nodular limestone intercalations prevail in northern, eastern and southern areas. Differently, the central

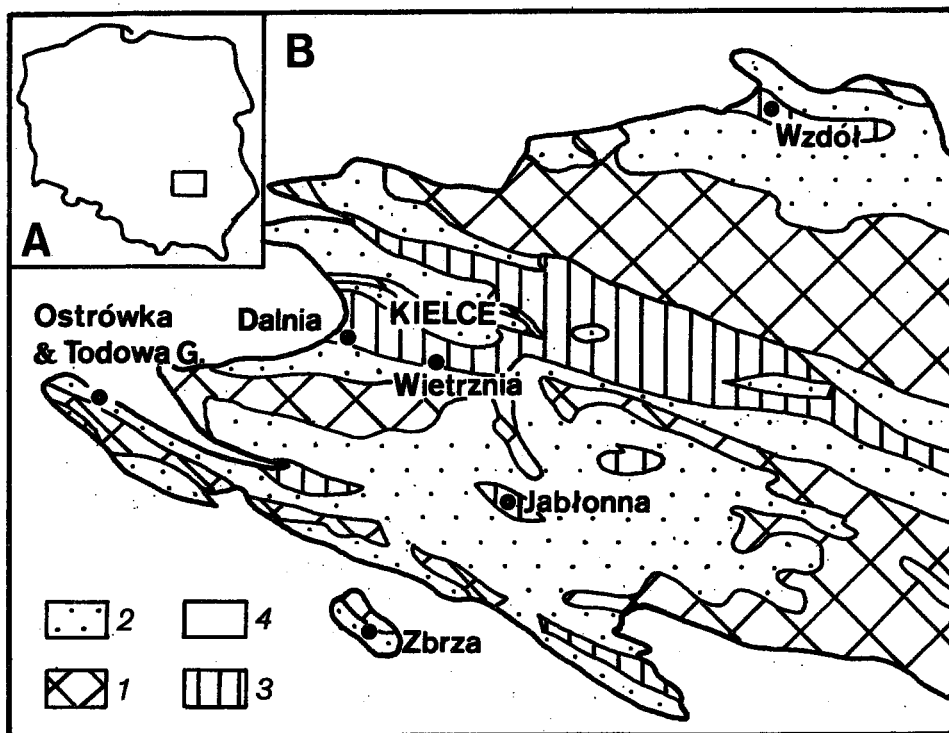


Fig. 1. General map of Poland (A) and geological sketch-map (B) of the western part of the Holy Cross Mts, showing location of collecting localities yielding the Upper Famennian shark teeth
1 — pre-Devonian Paleozoic, 2 — Lower and Middle Devonian, 3 — Upper Devonian and Lower Carboniferous, 4 — Permian-Mesozoic cover

area to the south and south-west of Kielce is characterized by a condensed pelagic limestone facies, often rich in fauna. Boundaries of these facies are, at least locally, sharp and seem to have their origin in the synsedimentary block-faulting (SZULCZEWSKI 1971, 1973, 1978, 1981). The most of the hereafter described localities (*see* Text-fig. 1) belong to the latter facies. Only the sections of Wzdół and Zbrza represent, respectively, northern and southern basinal regions.

Table 1

Stratigraphic distribution of shark teeth in the Late Famennian of the Holy Cross Mts

Stages	F A M E N N I A N										TOURN.	
Conodont zones	triangularis- -marginifera	trach.		post.		expansa			praesulc.			
		L	U	L	U	L	M	U	L	M	U	
<i>Ph. australiensis</i>		P-A-12				F-11			D-F			
<i>Phoebodus gothicus</i>		F-14		F-13II, GR-Z			F-11, F-9					
<i>Ph. limpidus</i>	←				F-11							
<i>Phoebodus</i> sp.	←	P-13					F-10					
<i>Thrinacodus ferox</i>		F-14		TG-CP		F-11			TG-CP			
<i>Dittodus</i> sp.	←				F-11							
<i>Denaea</i> sp.	←				TG-CP							
" <i>Cladodus</i> " sp.	←	J-1		F-9, F-10, F-11, F-8								

Samples: F-8 to F-14 — Ostrówka; TG-CP — Todowa Grząba; D-F — Dálnia; P-13, P-A-12 — Wzdół; J-1 — Jabłonna; GR-Z — Zbrza

Solid line — possible position of not condensed samples; broken line — range of condensation; arrow — probable occurrence of the species in the Lower Famennian or Frasnian

Conodont zones: *trach.* — trachytera; *post.* — postera; *praesulc.* — praesulcata; L — Lower, M — Middle, U — Upper

OSTRÓWKA and TODOWA GRZĄBA

A section of the Ostrówka Quarry, close to the Todowa Grząba Hill in the Gałęzice region (see BELKA & SKOMPSKI 1988, Fig. 2) is the most interesting from biostratigraphic point of view. Amphiporoid limestones are covered here by a sequence of condensed limestones, the range of which has been determined by SZULCZEWSKI (1978) as lasting since the Upper marginifera to the undivided Siphonodella Zones (Upper Famennian — Lowermost Carboniferous). Shark teeth have been obtained from six successive samples (marked here with *F*) from the Upper trachytera to the Middle praesulcata Zone (Table 1).

Above the condensed limestone sequence there appear: a complex of shales with radiolarian chert intercalations (Zaręby Beds), and further on, at the Todowa Grząba Hill, the Carboniferous Limestone. A lense of breccia occurs at the base of the latter (BELKA & SKOMPSKI 1988, p. 444), and clasts of light-colored calcarenites, containing mixed Famennian — Tournaisian conodont fauna, are present in that breccia material. In one of such clasts (sample *TG-CP*), conodonts *Palmatolepis glabra lepta* and *Scaliognathus anchoralis* were found, which indicates that the minimum range of condensation is no shorter than from the Lower trachytera to the anchoralis Zone. Three specimens of *Thrinacodus ferox* and one of *Denaesa* sp. have been obtained from that sample.

DALNIA

The only positive sample from the Dalnia Hill (sample *D-F*) has been taken from the condensed limestone, infilling a neptunian dyke (SZULCZEWSKI 1973). The contained conodonts show condensation ranging at least from the Upper expansa to the crenulata Zone (SZULCZEWSKI 1973, Table 1, sample *f*).

JABŁONNA

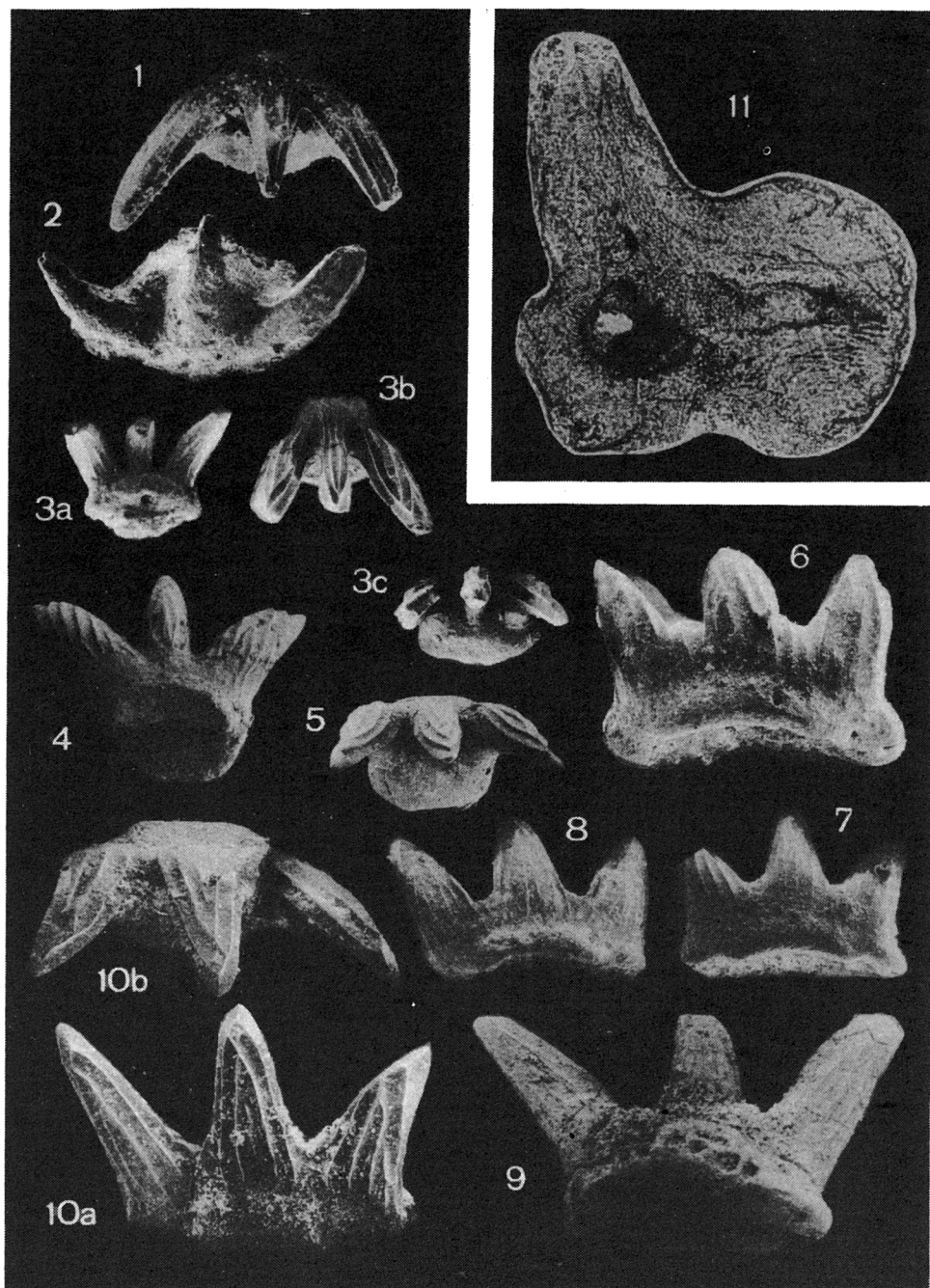
Sample *J-1* from the nodular limestones of the borehole Jabłonna *IG-1* (depth 63.9 m) have yielded a single cladodont tooth. The age of the sample can be estimated as the trachytera or the postera Zone (between the marginifera and the Lower styriacus Zone; see ŻAKOWA, SZULCZEWSKI & CHLEBOWSKI 1983).

WZDÓŁ

Shark teeth have been found in two samples, collected in the section near Wzdół Rządowy. Both samples (*P-13*, *P-A-12*) have been taken from the nodular limestones, of the Lower trachytera Zone.

ZBRZA

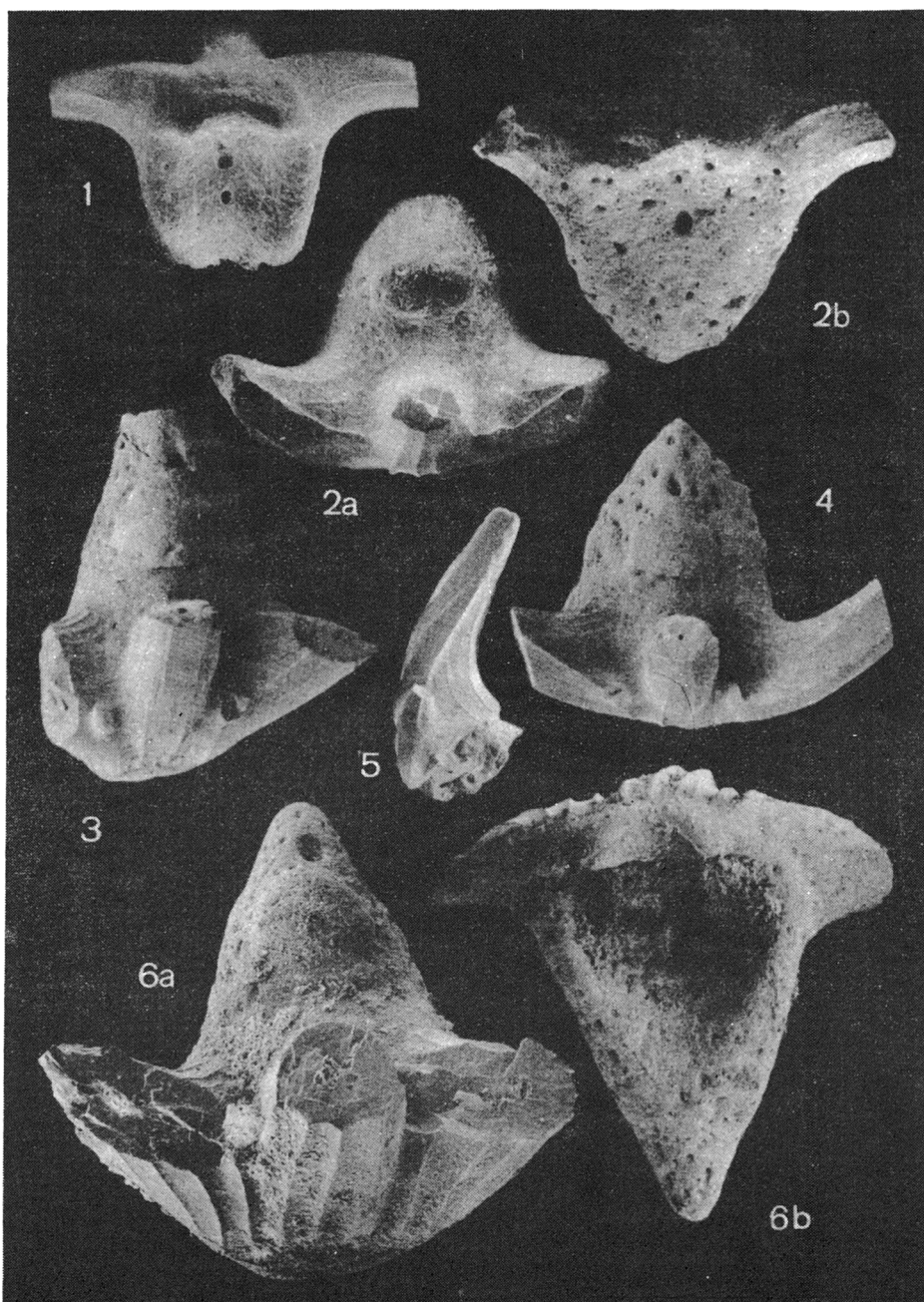
Sample *GR-Z* from Zbrza comes from the pelagic limestone of the Lower expansa age with some admixtures from the Upper trachytera and the postera Zone (KUCIA 1987).



1-2 — *Phoebodius* sp.: 1 — IGPUW/Ps/1/38, 2 — IGPUW/Ps/1/37; occlusal views

Phoebodius australiensis LONG: 3 — IGPUW/Ps/1/16, lingual (3a), labial (3b) and occlusal (3c) view; 4 — IGPUW/Ps/1/17, labial/basal view; 5 — IGPUW/Ps/1/15, occlusal view; 6 — IGPUW/Ps/1/36, labial view; 7 — IGPUW/Ps/1/26, labial view; 8 — IGPUW/Ps/1/27, labial view; 9 — IGPUW/Ps/1/28, lingual view; 10 — IGPUW/Ps/1/25, occlusal (10a) and labial (10b) view; 11 — IGPUW/Ps/1/14, vertical section through the median cusp and the base, to show longitudinal and transversal basal canals

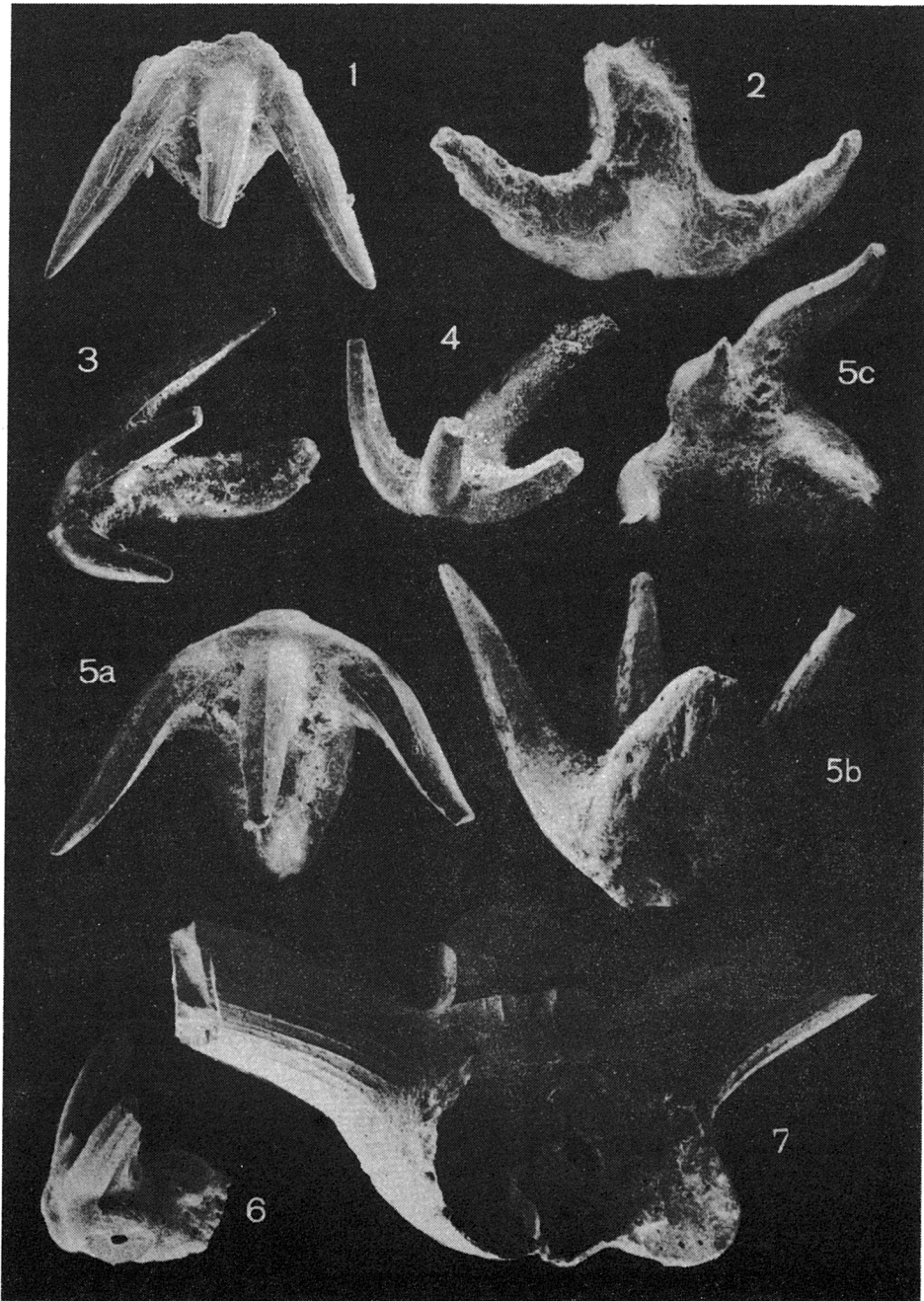
1 × 30; 2, 3, 5-8 × 40; 4, 9, 10 × 60; 11 × 120



Phoebodus gothicus sp. n.

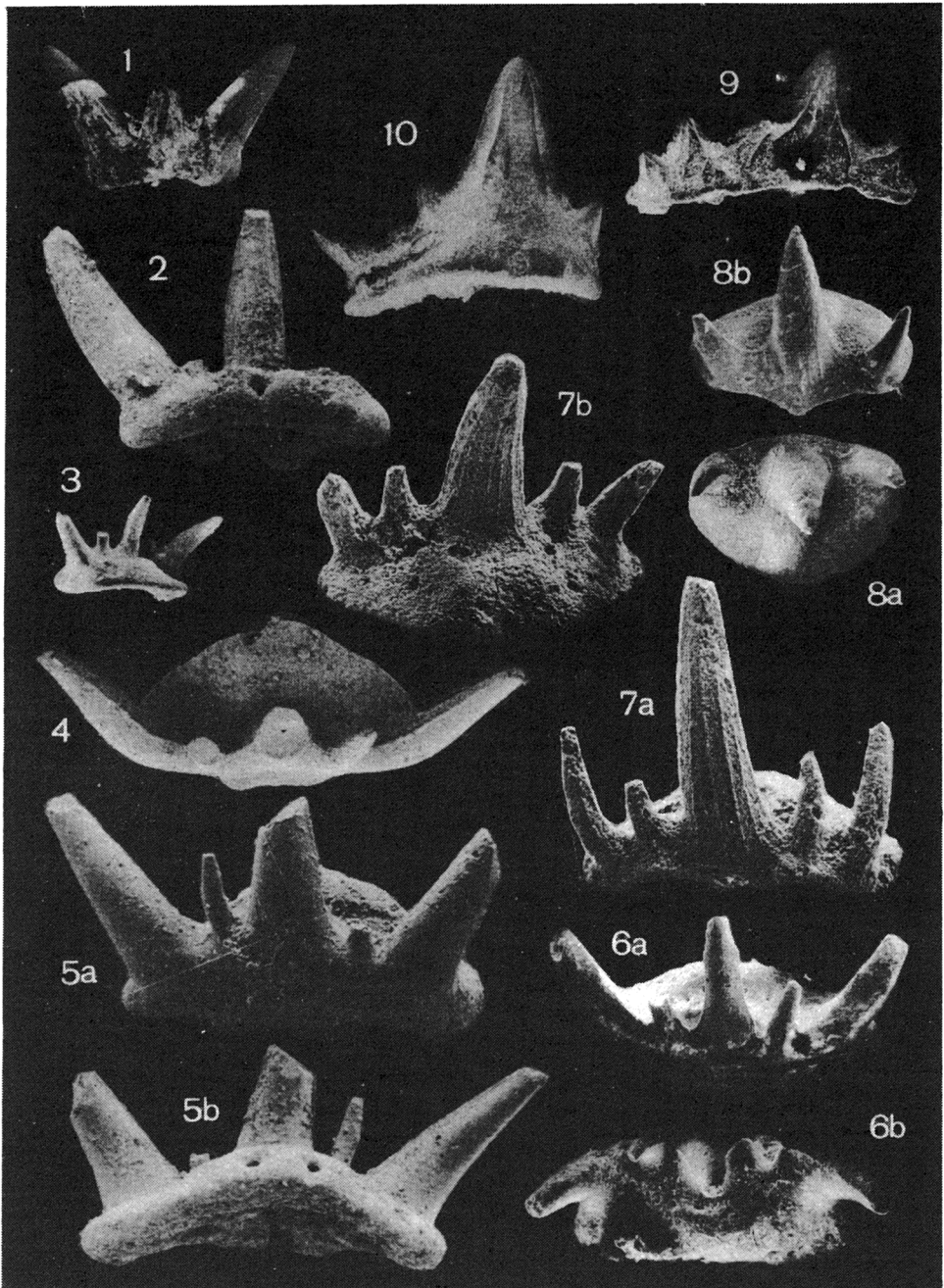
1 — IGPUW/Ps/1/3, basal view; 2 — IGPUW/Ps/1/4, occlusal (2a) and basal (2b) view; 3 — IGPUW/Ps/1/8, tooth with long base, lingual end broken, occlusal view; 4 — IGPUW/Ps/1/5, occlusal view; 5 — IGPUW/Ps/1/10, two isolated cusps, lateral view; 6 — IGPUW/Ps/1/1, **holotype**, occlusal (6a) and basal (6b) view

1 × 15; 2–6 × 30



Phoebodus gothicus sp. n.: 1 — IGPUW/Ps/1/46, occlusal view; 5 — IGPUW/Ps/1/6, occlusal (5a), basal (5b) and oblique lingual (5c) view; 6 — IGPUW/Ps/1/9, with broken lateral cusp showing pulp canal; 7 — same tooth as Pl. 2, Fig. 1 (magnified), to show main and additional basal canals
Thrinacodus ferox (TURNER): 2 — IGPUW/Ps/1/51, occlusal view; 3 — IGPUW/Ps/1/47, oblique lingual view; 4 — IGPUW/Ps/1/48, occlusal view

All × 30



1 — *Dittodus* sp.: IGPUW/Ps/1/62, labial view
Phoebodus limpidae sp. n.: 2 — IGPUW/Ps/1/41, lingual view, right main cusp and additional cusps broken; 3 — IGPUW/Ps/1/42, oblique lingual view; 4 — IGPUW/Ps/1/40, occlusal view; 5 — IGPUW/Ps/1/39, holotype, lingual (5a) and labial (5b) view; 6 — IGPUW/Ps/1/63, labial (6a) and occlusal (6b) view
Denaea sp.: 7 — IGPUW/Ps/1/55, labial (7a) and lingual (7b) view
 "Cladodus" sp.: 8 — IGPUW/Ps/1/57, occlusal (8a) and labial (8b) view; 9 — IGPUW/Ps/1/59; 10 — IGPUW/Ps/1/56

7 × 30; 1, 3, 6, 8—10 × 40; 2 × 60; 4, 5 × 80

SYSTEMATIC ACCOUNT

Class **Chondrichthyes**Family **Phoebodontidae** WILLIAMS, 1985

REMARKS: Systematic position of this family is still unclear, since the skeletal remains of phoebodonts show characters of the sharks belonging (according to ZANGERL 1981) to two different orders: Euselachii (including the superfamily Ctenacanthoidea; see WILLIAMS 1985) and Xenacanthida (family Xenacanthidae; see ZIDEK 1973, MADER 1986). MAISEY (1984) regards xenacanthids only as a specialized group of ctenacanthiform sharks. In such a case, all the three families: Ctenacanthidae, Phoebodontidae and Xenacanthidae should be placed in the same order and are expected to be morphologically close to one another. Another possibility is that the Phoebodontidae do not constitute a monophyletic group.

Genus *Phoebodus* ST. JOHN & WORTHEN, 1875

Type species: *Phoebodus sophiae* ST. JOHN & WORTHEN, 1875

Phoebodus australiensis LONG, 1990

(Pl. 1, Figs 3—11)

1973. "*Cladodus*" sp. indet.: W. GROSS, p. 136, Pl. 34, Fig. 3.

1985. *Phoebodus politus* NEWBERRY; S.-T. WANG & S. TURNER, p. 225, Pl. 3, Fig. 2a-b.

1990. *Phoebodus australiensis* sp. nov.; J. A. LONG, pp. 59—61, Figs 2A-M, 3J-O, 4A-E.

MATERIAL and OCCURRENCE: Eleven specimens from Ostrówka: IGPUW/Ps/1/14—24, sample *F-11*, the Upper expansa or the Lower praesulcata Zone. Ten specimens from Dalmia: IGPUW/Ps/1/25—34, sample *D-F*, Uppermost Famennian — Lower Tournaisian (mixed conodont fauna). One specimen from Wzdót: IGPUW/Ps/1/36, sample *P-A-12*, the Lower trachytera Zone.

REMARKS: The studied material consists of three-cuspid teeth corresponding to LONG's (1990) diagnosis of *Phoebodus australiensis*, with respect to size, overall appearance and ornamentation. It also displays similar variability, considered by LONG (1990) as intraspecific. Two extreme morphotypes can be distinguished in the Holy Cross Mts material, as follows:

Morphotype 1: The labial face of distinctly recurved cusps is covered with a characteristic lanceolate ornament (Pl. 1, Figs 3—5); lingual part of the base is thick and squarish (Pl. 1, Figs 3a, 11); a round nutritive foramen occurs on its lingual wall (Pl. 1, Fig. 3a; see also GROSS 1973, Pl. 34, Fig. 3). The holotype of the species, figured by LONG (1990, Fig. 2A-B, 4A-B), belongs to this morphotype.

Morphotype 2: The cusps are weakly inclined linguad or straight; ornament of their labial face consists of ribs which can anastomose at various heights or run separately towards the tips; the sculpture, though sometimes close to that of Morphotype 1, is more irregular (Pl. 1, Figs 6—8, 10a). The base is narrow and arcuate.

Between these two extremes there are many transitional specimens. Particularly, this can be seen in the sample from Dalmia, where the forms with irregularly ornamented cusps may have thicker and broader bases (Pl. 1, Fig. 9). In the sample *F-11* from Ostrówka the specimens with regular, lanceolate sculpture possess sometimes weaker developed bases.

LONG (1990) assigned all the specimens figured by TURNER (1982, 6A, 6B) [as *Phoebodus* cf. *P. politus*] and by WANG & TURNER (1985, Pl. 2, Fig. 1 and Pl. 3, Fig. 2) [as *Ph. politus*] to *Ph. australiensis*. Probably only the last of these specimens (WANG & TURNER 1985, Pl. 3, Fig. 2) belongs to *Ph. australiensis*, Morphotype 1. The others (WANG & TURNER, 1985, Pl. 2, Fig. 1, and TURNER, 1982, Fig. 6A, 6B) may be only tentatively referred to *Ph. australiensis*, Morphotype 2 (see remarks to *Ph. gothicus*).

The specimen figured by GROSS (1973, Pl. 34, Fig. 3) as "*Cladodus*" sp. indet. belongs almost undoubtedly to *Ph. australiensis*. The position of the cusps, a fragment of ornamentation of the right cusp, the shape of the base and a distinct nutritive foramen on its lingual wall are very similar

to those observed in the specimens from Ostrówka (Pl. 1, Fig. 3a) and in the specimens illustrated by LONG (1990, Figs 2C, 3K). GROSS (1973, p. 136) has noted resemblance of his specimen to *Phoebodus*, but nevertheless he decided to place it among "Cladoselachier-Zähne".

Phoebodus gothicus sp. n.
(Pl. 2, Figs 1—6 and Pl. 3, Figs 1, 5—7)

1973. *Phoebodus politus* NEWBERRY; W. GROSS, pp. 132—133, Text-fig. 29C-G, 30A, 31A, and Pl. 34, Figs 12—22.
1988. *Phoebodus politus* NEWBERRY; C. DERVYCKE, Pl. 1, Figs 5—6.

HOLOTYPE: The specimen IGPUW/Ps/1/1, figured in Pl. 2, Fig. 6a-6b.

TYPE LOCALITY: Ostrówka Quarry close to the Todowa Grząba Hill, Gałężice region, south-western part of the Holy Cross Mts. Central Poland.

TYPE HORIZON: Undetermined position within the Lower postera to the Lower expansa Zone, sample F-13 II.

DERIVATION OF THE NAME: Latin *gothicus* = gothic, from the ogival outline of the base.

DIMENSIONS: Length of the base (labio-lingually) --- 2.2 mm; width of the base in the crown region --- 1.2 mm.

MATERIAL and OCCURRENCE: Eight specimens from Ostrówka: IGPUW/Ps/1/1 (holotype) and IGPUW/Ps/1/2 from sample F-13 II, undetermined position within the Lower postera to the Lower expansa Zone; IGPUW/Ps/1/46, sample F-9, the Upper expansa or the Lower praesulcata Zone; IGPUW/Ps/1/3—5, sample F-11, the Upper expansa or the Lower praesulcata Zone; IGPUW/Ps/1/6—7, sample F-14, the Upper trachytera Zone. Five specimens from Zbrza: IGPUW/Ps/1/8—12 from sample GR-Z, the Upper trachytera - Lower expansa Zone.

DIAGNOSIS: The tooth crown composed of three, almost equal in size, slightly sigmoidal main cusps, covered with more or less distinct ribs; between the main cusps minute additional cusps may occur; the base strongly advanced linguad forms a narrow semi-ellipse or a pointed arch; a prominent, rounded or slightly oval articular boss (a "button") occurs on the upper side of the base.

COMPARATIVE DESCRIPTION: The studied material almost totally coincides with the GROSS' (1973) illustration and detailed descriptions of the specimens from the Upper Devonian of Iowa, assigned by him to *Phoebodus politus* NEWBERRY, 1889.

Both in the investigated collection and that of GROSS (1973) there can be distinguished specimens possessing additional, minute cusps between the main cusps (Pl. 2, Figs 3—5, Pl. 3, Fig. 6; comp. GROSS 1973, Pl. 34, Figs 13a, 15a-b, 16, 18a-b) and the others not having them (Pl. 2, Fig. 6a, Pl. 3, Figs 5a, 7; comp. GROSS 1973, Pl. 34, Figs 12a-b, 14a-b, and 17). Among the specimens from Ostrówka there is also a form, which possesses only one additional cusp (Pl. 2, Fig. 2a).

The crown of the tooth bears a shiny, enameloid substance, which does not continue on the base surface. The latter is perforated by two major canal openings, one at the foot of the "button" on the lingual side (Pl. 2, Figs 3, 4, 6a) and another in the center of a depression on the underside (Pl. 2, Figs 1, 2b, 6b and Pl. 3, Fig. 5b), as well as by numerous minute, irregularly placed nutritive foramina. The both big openings are connected by a wide basal canal (Pl. 3, Fig. 7; GROSS 1973, Text-fig. 29C), associated with many smaller ones.

A short arcuate swell (Pl. 2, Figs 1, 2b, 6b), characteristic also of other species of *Phoebodus*, occurs on the underside in the crown region.

REMARKS: The species *Phoebodus gothicus* sp. n. differs from *Ph. politus* NEWBERRY, 1889, by the shape of the base. The original of NEWBERRY (1889, Pl. 27, Figs 27—28) has a wide, almost circular base, forming a narrow parapet on the labial and lateral sides of the crown, while the width of the base in *Ph. gothicus* never exceeds the size of the crown base, even in broader specimens of GROSS' collection. Furthermore, the "button" on the upper side of the base is strongly elongate and bilobed in *Ph. politus*, while in *Ph. gothicus* the "button" may be oval (see GROSS 1973, Pl. 34, Figs 12a, 14a, 15a, 16), but it never tends to divide.

Basing only on the outline of the crown it is not easy to distinguish *Phoebodus gothicus* from *Ph. politus*. It seems, that the angle between the lateral cusps should, in most cases, be larger in *Ph. gothicus* (in many specimens it exceeds 90°) but this is no obligatory rule: immature specimens (Pl. 3, Fig. 5a—5c) have the cups diverging at much smaller angle.

The characters of two specimens figured by DERYCKE (1988, Pl. 1, Figs 5—6) as *Phoebodus politus* NEWBERRY correspond exactly to the diagnosis of *Ph. gothicus* sp. n. Both of the specimens have sigmoidal, striate cusps and pointed lingual ends of the bases.

WANG & TURNER (1985) illustrated two specimens from China as *Phoebodus politus* NEWBERRY. Due to the lack of a substantial part of the base, the first of these specimens (WANG & TURNER, 1985, Pl. 2, Fig. 1a-b) cannot be safely assigned to any of the above discussed species. A sign of a parapet on the left side of the specimen figured by WANG & TURNER (1985, Pl. 2, Fig. 1a) and small inclination of the cusps could indicate that it belongs rather to *Ph. politus*, or to *Ph. australiensis* LONG. The second specimen (WANG & TURNER 1985, Pl. 3, Fig. 2a-b) belongs undoubtedly to *Ph. australiensis*.

The specimens identified by TURNER (1982, Fig. 6A-6B) as *Phoebodus* cf. *P. politus* NEWBERRY, with prominent "buttons" but short and squarish bases and only slightly recurved cusps, may belong to *Ph. australiensis* Morphotype 2 (see the description of *Ph. australiensis*) or to some Lower Famennian, relative but not yet described species. The Myrtlevale Beds, in which those specimens occur, were placed by PICKETT (1981; *vide* TURNER 1982) in the lower part of the Famennian. Similar forms occur in the Lower Famennian crepida — rhomboidea Zones of Mt. Miedzianka in the western part of the Holy Cross Mts.

Phoebodus limpidus sp. n.
(Pl. 4, Figs 2—6)

?1979. *Phoebodus* sp.; V. J. GUPTA & P. JANVIER, pp. 163—164, Pl. 1, Figs 2, 3, 5.

?1985. *Phoebodus* sp.; S.-T. WANG & S. TURNER, p. 225, Pl. 2, Fig. 3a-b.

HOLOTYPE: The specimen IGPUW/Ps/1/39, figured in Pl. 4, Fig. 5a—5b.

TYPE LOCALITY: Ostrówka Quarry close to the Todowa Grząba Hill, Gałęzice region, south-western part of the Holy Cross Mts.

TYPE HORIZON: Upper expansa or Lower praesulcata Zones, sample F-9.

DERIVATION OF THE NAME: Latin *limpidus* = clean, from the almost smooth and shiny surface of the tooth.

DIMENSIONS: Width of the base (along the crown) — 0.6 mm; length of the base (labio-lingually) — 0.3 mm; distance between the tips of the lateral cusps — 0.8 mm.

MATERIAL and OCCURRENCE: Six specimens from Ostrówka: IGPUW/Ps/39 (holotype), sample F-9, the Upper expansa or the Lower praesulcata Zone; IGPUW/Ps/1/40—44, sample F-11, the Upper expansa or the Lower praesulcata Zone. Probably also a single specimen from the Wietrznia Quarry: IGPUW/Ps/1/63, the Uppermost Frasnian pelagic limestones.

DIAGNOSIS: Three main and two smaller, intermediate cusps in the crown, slightly inclined linguad, smooth or covered with fine striae; the intermediate cusps very thin and long, reaching almost half the length of the main cusps, which are relatively slender; labial and lingual faces of the cusps may be separated by a low, but distinct blade; the base thin, subelliptical or slightly triangular, with one or two nutritive foramina on its lingual rim.

REMARKS: Construction of the base is a common feature with *Phoebodus* sp. from China described by WANG & TURNER (1985, Pl. 2, Fig. 3a-b); in both cases the upper surface is gently convex, the underside is concave, and a narrow, short ridge delimits the latter in the crown region (in some of the specimens from Ostrówka the ridge may be bipartite; see Pl. 4, Fig. 2), and canal openings are placed on the lingual rim. Some differences appear, however, in the crown: while in the Holy Cross specimens lateral cusps form an almost right angle, the corresponding angle in the specimen from China is no more than 45°. Moreover, intermediate cusps in the latter form are much stronger.

On the contrary, *Phoebodus* sp. of GUPTA & JANVIER (1979, Pl. 1, Fig. 2, 3, 5) [probably not from Himalaya, as the authors maintained, but from the New York State; Dr. P. JANVIER. *pers. comm.*] possesses the crown very similar to that of *Ph. limpidus* from Ostrówka, but the base of the former is probably thicker (detailed comparison cannot be done here because of strong abrasion of the teeth figured in that paper).

In a sample from the Wietrznia Quarry a specimen, possessing sculpture, shape and setting of the cusps identical with the holotype of *Ph. limpidus* was found, but the base of the former is more elongate laterally (Pl. 4, Fig. 6a-b). This difference is considered minor, so the form should be included into the newly established species.

Phoebodus sp.
(Pl. 1, Figs 1—2)

MATERIAL and OCCURRENCE: One specimen from Ostrówka: IGPUW/Ps/1/38, sample F-10, the Upper expansa or the Lower praesulcata Zone. One specimen from Wzdół: IGPUW/Ps/1/37, sample P-13, the Lower trachytera Zone.

DESCRIPTION: The crown consists of three long cusps, their labial face being covered with subparallel ribs; lingual face almost smooth. The base is thin, oval or gently triangular, with a shallow depression on the underside.

REMARKS: The studied forms are similar in the overall appearance to *Ph. australiensis*, in particular to Morphotype 2, but they differ clearly from the latter by the length of the cusps and by the lack of ornament on their lingual face.

Genus *Thrinacodus* ST. JOHN & WORTHEN, 1875
Type species: *Thrinacodus nanus* ST. JOHN & WORTHEN, 1875
Thrinacodus ferox (TURNER, 1982)
(Pl. 3, Figs 2—4)

1982. *Harpago ferox*, gen. et sp. nov.; S. TURNER, pp. 118—123, Figs 2—4.

1983. *Harpagodens ferox* (TURNER); S. TURNER, p. 38.

1985. *Harpagodens ferox* (TURNER); S.-T. WANG & S. TURNER, p. 266—227, Pl. 2, Figs 11—12.

1988. *Harpagodens ferox?*; C. DERVYCKE, Pl. 1, Figs 1—2.

1990. *Thrinacodus ferox* (TURNER); J. A. LONG, Fig. 51-M.

MATERIAL and OCCURRENCE: Four specimens from Ostrówka: IGPUW/Ps/1/47, sample F-14, the Upper trachytera Zone; IGPUW/Ps/1/48—50, sample F-11, the Upper expansa or the Lower praesulcata Zone. Three specimens from Todowa Grząba: IGPUW/Ps/1/51-53, sample TG-CP, Upper Famennian — Tournaisian (mixed conodont fauna).

REMARKS: The specimens are typical, small and almost symmetric. Big, asymmetric forms, such as figured by TURNER (1982, *eg.* Fig. 2 A-C) are absent. All the specimens have their cusps covered with enameloid. Canal openings have been observed in the half-length of the bases of some forms (Pl. 3, Fig. 4).

The genus *Thrinacodus* has been included here to the family Phoebodontidae because of its significant morphologic resemblances to *Phoebodus gothicus* sp. n.: far linguad expanded base and similar shape and ornament of the cusps (*comp.* Pl. 2, Fig. 3 or Pl. 3, Fig. 5; and GROSS 1973, Pl. 34, Fig. 17).

Order *Xenacanthida* GLIKMAN, 1964
Family *Xenacanthidae* FRITSCH, 1889

Dittodus sp.
(Pl. 4, Fig. 1)

MATERIAL and OCCURRENCE: One specimen from Ostrówka: IGPUW/Ps/1/62, sample F-11, the Upper expansa or the Lower praesulcata Zone.

REMARKS: The specimen from Ostrówka resembles to some extent *Phoebodus australiensis* LONG, since it possesses three triangular cusps in the crown. But its median cusp is much shorter and thinner than the lateral ones, which is a characteristic feature of the *Dittodus*-type teeth. This might be, however, only the result of intraspecific variability due to the position of the tooth within the jaw apparatus, as noted by HUSSAKOF & BRYANT (1918). In that case, *Dittodus* sp. would be conspecific with *Ph. australiensis*.

Order **Symmoriida** ZANGERL, 1981

Family **Symmoriidae** DEAN, 1909

Denaea sp.

(Pl. 4, Figs 7a—7b)

1987. *Denaea* sp.: H. MADER & H.-P. SCHULTZE. pp. 337—338, Fig. 6d-e.

MATERIAL and OCCURRENCE: One specimen from Todowa Grząba: IGPUW/Ps/1/55, sample TG-CP, the Upper Famennian — Tournaisian (mixed conodont fauna).

REMARKS: The crown has five cusps, the median one being much bigger (2—3 times) than those of the lateral pairs. The outer pair is higher than the intermediate one. Both sides of the cusps are striate. These features, and the outline of the base correspond exactly with the form illustrated by MADER & SCHULTZE (1987) as *Denaea* sp. There is, however, a sign of a double articular boss on the upper side of the base of the specimen from Todowa Grząba, which may suggest, according to Dr. S. TURNER (*pers. comm.*) a stethacanthid origin of the tooth.

Order indeterminate
Family indeterminate
“*Cladodus*” sp. div.
(Pl. 4, Figs 8—10)

In the samples, collected in the Ostrówka Quarry and at Mt. Jablonna, several teeth were found which can provisionally be assigned to this artificial genus. Each of the specimens possesses a prominent median cusp and one or more pairs of lateral cusps.

The specimen IGPUW/Ps/1/56 (Pl. 4, Fig. 10) is characterized by a very thick median cusp and a considerable angle between the lateral cusps; the tooth comes from Ostrówka, sample F-8, the Upper expansa or the Lower praesulcata Zone.

The specimen IGPUW/Ps/1/57 from Jablonna, sample J-1, the trachytera or the postera Zone, has only three, gently ornamented cusps on an oval base (Pl. 4, Fig. 8a-b). The specimen IGPUW/Ps/1/58, found in the sample F-10 from Ostrówka, the Upper expansa or the Lower praesulcata Zone, is similar to the former.

The specimens IGPUW/Ps/1/59-61 from Ostrówka are asymmetric with relatively short median cusp and a narrow base. IGPUW/Ps/1/59 (Pl. 4, Fig. 9) and Ps/1/60 come from sample F-8, the Upper expansa to the Middle praesulcata Zone; IGPUW/Ps/1/61 comes from sample F-9, the Upper expansa or the Lower praesulcata Zone.

BIOSTRATIGRAPHIC CORRELATION

Shark teeth of the family Phoebodontidae prove to be of the greatest biostratigraphic importance among the Late Famennian ichthyoliths from the Holy Cross Mts. They are highly differentiated, easy to distinguish and relatively best known as far as their morphology, histology, stratigraphic range

and geographic distribution are concerned. Among the recognized phoebodonts, three Famennian or Famennian-Tournaisian species, viz. *Thrinacodus ferox* (TURNER), *Phoebodus australiensis* LONG, and *Ph. gothicus* sp. n., are the most numerous and most widely represented. Their presence has been noted from Australia (TURNER 1982), through south China (WANG & TURNER 1985), Thailand (LONG 1990), the Harz Mts in Germany (GROSS 1973), Morocco (DERYCKE 1988) to the United States (GROSS 1973). The appearance of at least two of them in the same horizons and even in the same samples is also common: eg. samples *F-14* and *F-11* from Ostrówka, and samples *MCD 17* and *MCD 75* from Tafilalet in Morocco (see DERYCKE 1988). The precise stratigraphic ranges of any of these species have not actually been determined, but some delimitations can be presented (Table 2).

None of the well dated finds represent the age older than the marginifera Zones. The only exceptions are the questionable specimens of *Phoebodus* cf. *P. politus* (TURNER 1982, Fig. 6A, 6B) from the Myrtlevalle Beds (3 in Table 2). LONG (1990) referred them to *Ph. australiensis* (see remarks to *Ph. gothicus*). The Myrtlevalle Beds were dated (see TURNER 1982) as to *IIβ* (from the

Table 2

Correlation of stratigraphic ranges of *Thrinacodus ferox* (TURNER), *Phoebodus australiensis* LONG, and *Ph. gothicus* sp. n. in Australia (1—3), south China (4—5), Thailand (6), Harz Mts (7), Iowa (8), and the Holy Cross Mts: Ostrówka (9), Wzdół (10), Todowa Grząba (11), Dalnia (12), and Zbrza (13)

Stages	Conodont zones	<i>Thrinacodus ferox</i>	<i>Phoebodus australiensis</i>	<i>Phoebodus gothicus</i>
VISEAN				
TOURN.	anchoralis	1		
	sulcata - cuneiformis zones	4, 11		12
FAMENNIAN	praesulc.	? 5	5, 6, 9	8
	expansa	2, 6	6, 9	8, 9
	postera	9		13
	trachyt.	9	7, 10	
	marginif.		3?	
	rhomboidea - triangularis zones	?		
				?

Solid line — possible position of not condensed samples; dotted line — range of condensation; broken line — not precise dating
 Conodont zones: *marginif.* — marginifera; *trachyt.* — trachytera; *praesulc.* — praesulcata;
 L — Lower, M — Middle, U — Upper, Um — uppermost

rhomboidea to the base of the Upper marginifera Zone; all conodont interpretations of ammonoid zones *after* SZULCZEWSKI 1971).

Unfortunately, the stratigraphic position of the type series of *Thrinacodus ferox* from the Upper Bundock Creek Fm. (2 in Table 2), and the specimens of *Phoebodus gothicus* from the Maple Mill Shale (8 in Table 2), has not been defined precisely enough. The range of the former has been determined as "probably Famennian" (TURNER 1982), and of the latter — as late Upper Devonian (GROSS 1973).

Thus, the lowermost undoubtful appearance of *Th. ferox* is that in the sample *F-14* from Ostrówka, the Upper trachytera Zone. The upper limit bases on a single, broken specimen found in Australia, in the limestones close to the base of Bingleburra Fm. (1 in Table 2), dated as the Upper Tournaisian — Lowermost Visean (TURNER 1982). The occurrence of *Th. ferox* in the Carboniferous deposits have also been noted in China, Muhua section (4 in Table 2; sample *LMS-8*, Lower Tournaisian; see WANG & TURNER 1985).

The range of *Phoebodus australiensis* in Thailand (6 in Table 2) has been determined by LONG (1990) as *to V* or *to VI* (the Lower postera to the praesulcata Zone). A specimen of *Ph. australiensis* from the Harz Mts (7 in Table 2), figured by GROSS (1973, Pl. 34, Fig. 3) comes from *to III* (the Upper marginifera to the Upper trachytera Zone); this could be the lowest occurrence of the species.

Until now, *Ph. australiensis* has not been found in the Carboniferous. The sample from Dalnia (*D-F*) contains mixed conodont fauna, so it is not sure, whether the specimens present there come from the Devonian or the Carboniferous. The occurrence of *Ph. australiensis* in the uppermost zones of the Famennian (praesulcata) has been recorded both from China, Daihua Fm. (WANG & TURNER 1985, Pl. 3, Fig. 2*a-b*; 5 in Table 2) and in the Ostrówka Quarry (sample *F-11*).

As mentioned above, the GROSS' collection of *Ph. gothicus* has not been dated precisely, and thus the Holy Cross material is the only source of the range determination of this species. The lower range is defined by the age of sample *F-14* from Ostrówka (the Upper trachytera Zone), and the upper by the age of samples *F-11* and *F-9* (the Upper *expansa* or the Lower *praesulcata* Zone).

The above presented ranges of taxa are provisional, as they are based usually on poor material. Much more dispersed collections should be examined before applying Paleozoic shark teeth to the biostratigraphy. Their significance will be probably limited by their low frequency and relatively long ranges of particular species, at least in comparison with conodonts or ammonoids.

Acknowledgements

The Author is most grateful to Professor M. SZULCZEWSKI (Institute of Geology, University of Warsaw), who encouraged the Author's interest in the Paleozoic fishes, donated his material for investigation and critically revised the manuscript; to Dr. S. SKOMPSKI (the same institution) and Dr. G. RACKI (Laboratory of Paleontology and Stratigraphy, Silesian University) for supplying the

material and their assistance and useful discussions; to Ass.-Professor M. BORSUK-BIALYNICKA (Institute of Paleobiology, Polish Academy of Sciences), who helped in the work, read the manuscript and provided useful criticism and information; and to Dr. S. TURNER (Queensland Museum, Brisbane) for many important advices and revision of paleontological descriptions.

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M. GINTER

ZĘBY GÓRNOFAMEŃSKICH REKINÓW Z GÓR ŚWIĘTOKRZYSKICH

(Streszczenie)

W próbach konodontowych z odsłoneń górnego famenu w zachodniej części Gór Świętokrzyskich (patrz fig. 1) znaleziono około 60 zębów rekinów (patrz pl. 1—4), wśród nich przeważające ilościowo rodzaje *Phoebodus* i *Thrinacodus* z rodziny Phoebodontidae, pojedyncze okazy z rodzajów *Dittodus* i *Denaëa*, oraz kilka zębów zaliczanych do sztucznego rodzaju „*Cladodus*”.

Opisano nowe dwa gatunki: *Phoebodus gothicus* sp. n. oraz *Phoebodus limpidus* sp. n. Gatunek *Ph. gothicus* sp. n. obejmuje część okazów zaliczanych dotychczas do *Ph. politus* NEWBERRY (patrz m.in. GROSS 1973); gatunki te różnią się wyraźnie kształtem podstawy zęba.

Dokładne datowanie znalezionych okazów za pomocą konodontów (tab. 1) pozwoliło na precyzyjne ustalenie zasięgów stratygraficznych najszerzej rozpowszechnionych taksonów, tj. *Thrinacodus ferox* (TURNER), *Phoebodus australiensis* LONG oraz *Ph. gothicus* sp. n. (tab. 2).
