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Conodont biostratigraphy of shallow marine Givetian deposits from the Radom–Lublin area, SE Poland

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Detailed conodont data were obtained from 66 samples in 9 deep wells representative of three palaeogeographic regions of the Mid Devonian epicontinental basin of southeastern Poland: (1) the elevated part of the East European Platform representing the basin margin, (2) the Lublin Graben with a larger proportion of open marine systems, (3) the Radom Area characterized by more offshore, purely marine deposition and larger subsidence rates in the Radom Area. The 1344 specimens collected were assigned to 8 genera: *Icriodus*, *Polygnathus*, *Ancyrodella*, *Belodella*, *Mehlina*, *Neopanderodus*, *Pandorinellina* and *Skeletognathus*, and 38 taxa of species or subspecies rank. The vertical distribution of the conodont assemblages studied in particular sections is highly irregular and discontinuous with many barren intervals controlled by less suitable palaeocological conditions, mostly representing restricted and/or very shallow-water facies. We found only a single index species characteristic of deeper marine facies, as applied in the standard conodont zonation. Therefore the biostratigraphic interpretation also takes into account the total range of all taxa found in particular samples, established after a critical analysis of adequately published total ranges of these taxa. The stratigraphic ranges of the following taxa were modified: *Icriodus arkonensis arkonensis*, *I. a. walliserianus*, *I. eslaensis*, *I. platyobliquimarginatus*, *I. subterminus*, *I.* aff. *I. subterminus*, *Polygnathus ansatus*, *P. latifossatus*, *P. linguiformis linguiformis*, *P. timorensis* and *P. varcus*. As a result of the stratigraphic analysis of the conodont assemblages we distinguished five zones in the Givetian of the studied area, i.e. the *rhenanus/varcus*, *ansatus*, *hermanni*, *norrisi* (= lower part of Lower *falsiovalis* Zone) zones, and also two informal units, the *subterminus* and *insita* faunas. We documented the co-occurrence of *I. subterminus* and *P. latifossatus* which supports the earlier supposition of Rogers (1998) that the Lower *subterminus* Fauna may partly correspond to the Lower *hermanni* Zone.

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INTRODUCTION

The most commonly applied Devonian conodont zonation is the subdivision compiled by Clausen, Weddige and Ziegler (1993). Its standard character is also stressed by the fact that it has been involved in defining the stage boundaries. So far it is the most accurate biozonation of the Devonian, unrivalled by the zonations based on other fossil groups. However, certain aspects of this scheme, particularly its Givetian-lowermost Frasnian part, are problematic and require reconsideration. This refers to the Givetian–Frasnian boundary interval (see Racki and Wrzołek, 1989; Sandberg *et al*., 1989; Klapper and Johnson, 1990) and to the *varcus* Zone and its subdivisions (see Bultynck, 1987). Finally, the applicability of this zonation to restricted marine facies is unsatisfactory.

The epicontinental Middle Devonian of southeastern Poland exemplifies problems in the application of classical biostratigraphy, including the "standard" conodont zonation in particular. The alternation of continental, marginal marine and more open marine systems led to a highly discontinuous conodont succession. Index taxa are rarities, whereas forms typical of shallow-water and/or nearshore environments prevail (Narkiewicz and Narkiewicz, 1998). Therefore, in the present study we have attempted to apply alternative conodont subdivisions based on taxa not used in defining classical "standard" zones for the Givetian Stage. In particular, we have applied a fourfold subdivision for the lower-middle Givetian (Bultynck, 1987) instead of the *varcus* Zone subdivision as defined by Ziegler *et al.* (1976). We have also explored the applicability of biostratigraphic units rarely used for the European Givetian. These include the informal *subterminus* and *insita* faunas for the upper part of the Givetian (Klapper *et al.*, 1971; Rogers, 1998), and the *norrisi* Zone, the more open marine equivalent of the *insita* Fauna (Klapper and Johnson, 1990).

CONODONT ZONATION OF THE GIVETIAN

In the "standard" subdivision compiled by Clausen *et al.* (1993) the Givetian comprises five zones and three of these are subdivided (Table 1; see also Narkiewicz, 2006). The lower zonal boundaries are based on the first appearance of the nominal taxon, whereas the upper is based on the appearance of the successive taxon. This rule, however, does not apply to the *varcus* Zone for which the index species for the base of the Lower *varcus* Subzone is *Polygnathus timorensis*, and thus not the nominal *P. varcus*, which appears slightly higher (Ziegler *et al.*, 1976). The index taxa of the Givetian zones are typical of the deeper parts of marine basins, known, for example, from the eastern Rhenish Slate Mts., the Montagne Noire, the Tafilalt area (Anti-Atlas) and Nevada (Ziegler *et al.*, 1976; Ziegler and Klapper, 1982; Bultynck, 1987; Klapper and Johnson, 1990; Ziegler and Sandberg, 1990). They are either absent or much more rare in shallow-marine facies dominated by icriodids (see Bultynck, 1987; Bultynck *et al.*, 2000; Yolkin *et al.*, 2000).

Table 1

Chronostratigraphy and conodont zonation of the uppermost Eifelian, Givetian and the lowermost Frasnian (compiled by Narkiewicz, 2006)

SERIES	STAGES	SUBSTAGES (Bultynck, 2005)	CONODONT ZONATION: Klapper *et al.* (1971)		Ziegler (1971)	Ziegler and Sandberg (1990)	Marshall and House (2000)	Klapper and Johnson (1990)
U. DEV.	FRAS.		*A. rotundiloba*		*Po. asymmetricus* Lower	*Pa. transitans*	*Pa. transitans*	M.N.4
U. DEV.	FRAS.		*A. rotundiloba*		*Po. asymmetricus* Lower	*U. M. falsiovalis*	*A.rotundiloba*	M.N.2/3 M.N.1
MIDDLE DEVONIAN	GIVETIAN	UPPER	*Pandorinellina insita* Fauna		*Po. asymmetricus* Lowermost	Lower *M. falsiovalis*	*S. norrisi*	*S. norrisi*
MIDDLE DEVONIAN	GIVETIAN	UPPER	Rogers (1998)	Upper *subterminus* Fauna	Ziegler and Klapper (1982)	*K. disparilis*	Upper	
MIDDLE DEVONIAN	GIVETIAN	UPPER	Rogers (1998)	?	Ziegler and Klapper (1982)	*K. disparilis*	Lower	
MIDDLE DEVONIAN	GIVETIAN	UPPER	Rogers (1998)	Lower *subterminus* Fauna	Klapper and Johnson (1990)	*Sch. hermanni*	Upper	
MIDDLE DEVONIAN	GIVETIAN	UPPER	Rogers (1998)		Klapper and Johnson (1990)	*Sch. hermanni*	Lower	
MIDDLE DEVONIAN	GIVETIAN	MIDDLE	Bultynck (1987)	*latifossatus/ semialternans*	Ziegler *et al.* (1976)	*Po. varcus*	Upper	
MIDDLE DEVONIAN	GIVETIAN	MIDDLE	Bultynck (1987)	*ansatus*	Ziegler *et al.* (1976)	*Po. varcus*	Middle	
MIDDLE DEVONIAN	GIVETIAN	MIDDLE	Bultynck (1987)	*rhenanus/ varcus*	Ziegler *et al.* (1976)	*Po. varcus*	Lower	
MIDDLE DEVONIAN	GIVETIAN	LOWER	Bultynck (1987)	*timorensis*	Ziegler *et al.* (1976)	*Po. varcus*	Lower	
MIDDLE DEVONIAN	GIVETIAN	LOWER	Bultynck (1987)	*Po. hemiansatus*				
MIDDLE DEVONIAN	EIFEL.		*Po. ensensis*					
MIDDLE DEVONIAN	EIFEL.		*T. k. kockelianus*					

The standard conodont zonation is represented between the black bold lines; grey — the Middle Devonian part; light grey — alternative zonation for shallow-marine biofacies

The subdivision defined by Bultynck (1987) is accepted by several authors (Belka *et al.*, 1997, Bełka *et al.*, 1999; Bultynck and Walliser, 2000; Narkiewicz, 2006). It was introduced in order to more properly define the *varcus* Zone. The lower boundary of the *timorensis* Zone, equivalent to the lowermost part of the Lower *varcus* Subzone, is defined by the first appearance of *P. timorensis*. The *rhenanus/varcus* Zone, comprising the upper part of the Lower *varcus* Subzone, is defined by the first occurrence of either *P. rhenanus* or *P. varcus*. The *ansatus* Zone corresponds to the Middle *varcus* Subzone minus its uppermost part with *Ozarkodina semialternans* (Wirth, 1967). The *latifossatus/semialternans* Zone is defined by the first appearance of either *O. semialternans* or *P. latifossatus*. Bultynck (1987) introduced this zone because *O. semialternans* is widespread and common whereas *P. latifossatus* is rather rare and appears only slightly above the former species. The conodont faunas on which the above subdivision was based, including the index taxa cited, were described by Bultynck (1987) from the deeper marine facies of the Tafilalt area (Morocco).

In the upper Givetian of areas with a shallower neritic facies the conodont faunas are often dominated by representatives of the genus *Icriodus*. This observation led to establishment of alternative subdivisions based on the *subterminus* Fauna typical of shallow shelf areas. The lower boundary of the *subterminus* Fauna is defined by the first appearance of *Icriodus subterminus*, the upper one by the entrance of *Pandorinellina insita* (Bunker and Klapper, 1984). Witzke *et al.* (1988) subdivided the *subterminus* Fauna into a Lower and an Upper Fauna, with the boundary defined by the appearance of *Polygnathus angustidiscus* and *Mehlina gradata* co-occurring with *I. subterminus*. The Lower *subterminus* Fauna would represent a possible equivalent of the Lower *disparilis* Subzone, whereas the upper one could correspond to the Upper *disparilis* Subzone. However, Rogers (1998) suggested that the Lower *subterminus* Fauna may in fact represent not only the Lower *disparilis* Subzone but may also be "...an equivalent of part of the Lower *hermanni* Subzone, or of either part or all of the Upper *hermanni* Subzone...". According to Rogers (*op. cit*., p. 731) the base of the Upper *subterminus* Fauna is defined by the first occurrence of *P. angustidiscus*. In Nevada (Johnson *et al*., 1980) the entrance of *P. angustidiscus* is within the Lower *dengleri* Subzone which was later designated as the Upper *disparilis* Subzone (Johnson *et al*., 1985). The lower and upper boundaries of the Lower *subterminus* Fauna are poorly established due to the lack of detailed data on the first appearance of the index species and disparities between the first appearances of characteristic species, i.e. *M. gradata* and *P. angustidiscus*. In summary, the Lower *subterminus* Fauna cannot be younger than Lower *disparilis* Subzone, while the upper one cannot be older that the *disparilis* Zone.

Previous studies of the *subterminus* Fauna were carried out mostly in North America, in eastern and north-central Iowa (USA), Alberta, Manitoba and the southern part of the north-west Territories in Canada (Bunker and Klapper, 1984; Witzke *et al*., 1988; Rogers, 1998; Norris and Uyeno, 1998). In Europe equivalents of the fauna were recognized in the Boulonnais area of Northern France (Brice *et al*., 1979), and in south-central Poland in the Holy Cross Mts. and in the Kraków–Częstochowa area (Racki, 1992; Sobstel, 2003).

The *norrisi* Zone was proposed by Klapper and Johnson (1990) for the interval between the upper boundary of the *disparilis* Zone and the upper boundary of the Middle Devonian (within the lower part of the Lower *falsiovalis* Zone). Its lower boundary was defined by the first appearance of *Skeletognathus norrisi*, and the upper one by the entrance of the early form of *Ancyrodella rotundiloba sensu* Klapper, 1985. *S. norrisi* is a species distributed worldwide (see Feist and Klapper, 1985). In addition to North America and Africa, it has been found also in Asia (Bardashev and Ziegler, 1985; Hong-fei *et al*., 1985) and in Europe. In the latter, it was described from the eastern Rhenish Slate Mts. in Germany (Sandberg *et al*., 1989), Cornwall in England (Marshall and House, 2000), the Montagne Noire in France (Feist and Klapper, 1985), the Aragonian Pyrenees (Liao *et al*., 2001) as well as from in Poland (Racki, 1992; Racki and Bultynck, 1993; Racki and Turnau, 2000). It appears particularly useful for biostratigraphy as it occurs not only in pelagic environments characterized by a mesotaxid-polygnathid biofacies (Sandberg *et al*., 1989, p. 200, tab. 1) but also with shallow-marine facies characterized by the presence of *Pa. insita* (Uyeno, 1967; Klapper *et al*., 1971; Johnson *et al*., 1980, tab. 23, p. 98; Klapper and Johnson, 1980, p. 415; Norris *et al*., 1982, tab. 13).

The *insita* Fauna is defined as the fauna dominated by *Pa. insita* in strata below the first appearance of *Ancyrodella rotundiloba* (Bryant, 1921) and is representative of the shallow-water neritic facies development of the time interval discussed (see Klapper *et al*., 1971, p. 300). Having in mind a potential of correlation of sections from different facies zones, it is worth stressing that the appearance of *Pa. insita* is approximately synchronous with the earliest occurrence of *S. norrisi* (Klapper and Johnson, 1990). The palaeogeographic range of the *insita* Fauna generally corresponds to the regional distribution of the *subterminus* Fauna (Klapper *et al*., 1971; Norris and Uyeno, 1981, 1983; Witzke *et al*., 1988; Day, 1990). In Europe *Pa. insita* has been identified only in the Ardennes so far (Coen and Coen-Aubert, 1971; Bultynck, 1982).

STUDY AREA

In the Mid Devonian the study area formed a part of the epicontinental marine basin at the southern margin of the Old Red Continent (Laurussia) in a tropical climatic belt (Narkiewicz *et al*., 1998*b*). Earlier sedimentological studies (Narkiewicz *et al*., 1998*a*; Narkiewicz, 2002) documented that the area in question comprised three distinct palaeogeographic domains: the elevated part of the Precambrian East European Platform (EEP) in the east, the Lublin Graben (central part) and the Radom–Kraśnik High, named also the Radom Area, in the west (Fig. 1). Strictly speaking, the Lublin Graben was established as a separate depocenter in the mid-Frasnian. Therefore during the Mid Devonian it was still characterized by low subsidence rates and similar depositional development to that of the elevated EEP. Both areas are characterized mainly by marginal-marine or even partly continental siliciclastic facies interlayered with shallow-water platform carbonates and evaporites and, subordinately, subtidal marly deposits. Thickness ranges from *ca*. 100 metres in more proximal parts to 200 metres eastwards while it is reduced towards the north-west.

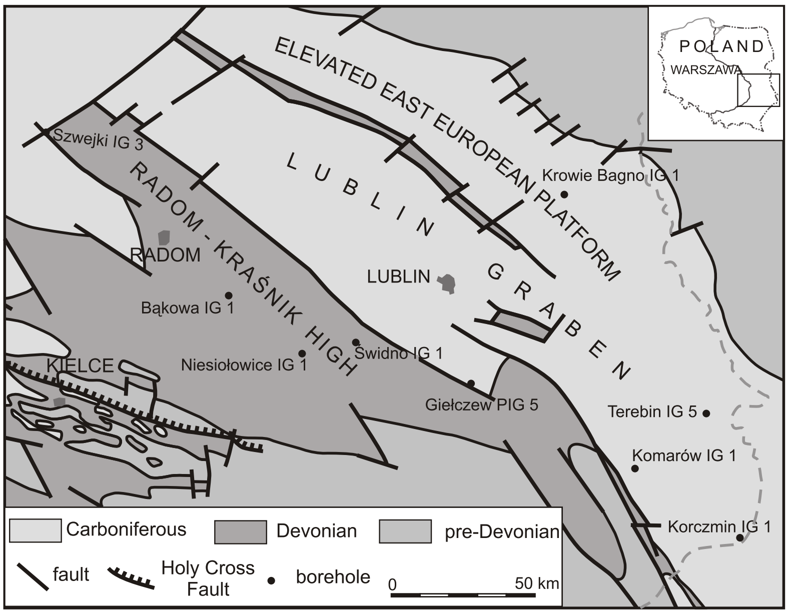


Fig. 1. Location of the areas and well-sections investigated on a simplified geological sub-Permian map (after Pożaryski and Dembowski, 1983); the inset map of Poland shows the location of the region investigated

The Lublin Graben area displays thicker and more open-marine facies relative to the elevated EEP.

The Radom Area was undergoing subsidence, with stratal thickness in the range of 1000 metres. The predominant lithotypes are marly carbonates and silty clays with a pelagic fauna or carbonate levels with abundant brachiopods or corals and stromatoporoids. These facies are usually regarded as deeper shelf systems although the term "deeper" is obviously relative as the water depths probably only rarely exceeded few tens of metres.

CONODONT DATA

Conodont material was obtained from 66 core samples from 9 deep wells (Fig. 1): Szwejki IG 3, Bąkowa IG 1, Niesiołowice IG 1, Świdno IG 1 (Radom Area), Giełczew PIG 5, Komarów IG 1, Korczmin IG 1, Terebin IG 5 (Lublin Graben) and Krowie Bagno IG 1 (elevated EEP). The specimens studied belong mainly to two genera: *Icriodus* and *Polygnathus*, with a smaller proportion of *Ancyrodella*, *Belodella*, *Mehlina*, *Neopanderodus*, *Pandorinellina* and *Skeletognathus* (Fig. 2). A total number of 38 taxa of species and subspecies rank has been identified, including 9 taxa found in Poland for the first time: *Icriodus arkonensis arkonensis*, *I. arkonensis walliserianus*, *I. excavatus*, *I. lilliputensis, I. platyobliquimarginatus*, *I.* aff. *I. subterminus*, *Pandorinellina insita*, *Polygnathus klugi* and *P. rhenanus*. The occurrence and number of elements in particular samples are given in tables 2–10. Figure 3 contains full names of species and subspecies (and their authors) which were applied for biostratigraphic purposes and which will be discussed below.

It should be stressed that the generic spectrum of the conodont assemblages studied (Fig. 2) is independent evidence, in addition to lithofacies data, of the shallow-marine Mid Devonian environments prevailing in the Radom–Lublin area studied. In addition to generic percentages the authors analysed the ecological preferences of particular taxa most commonly occurring in the material investigated, including *P. ansatus*, *P. ling. linguiformis*, *I. subterminus*, *I. brevis* and *I. symmetricus*. It may be concluded that the Middle Devonian conodont assemblages investigated generally were associated with the neritic zone, comprising a shallow to slightly deeper shelf of moderate energy, below the fair-weather wave-base. Applying the criteria proposed by Sandberg *et al*. (1989), four biofacies were distinguished: polygnathid, polygnathid-icriodid, icriodid-polygnathid and icriodid.

The middle Givetian is dominated by polygnathid-icriodid and icriodid-polygnathid biofacies. Polygnathid biofacies occurs sporadically and is characterized by impoverished *Polygnathus* faunas in most cases. By the end of the mid Givetian a shallowing of the sea is inferred from the appearance of the icriodid biofacies. In the upper Givetian the icriodid-polygnathid and icriodid biofacies prevail. The uppermost Givetian displays considerable variability: from the polygnathid biofacies in the Lublin Graben, to the polygnathid-icriodid in the Radom Area, to icriodid in the elevated EEP. The two first-named biofacies are dominated by narrow-platform representatives of *Polygnathus* displaying a wide range of distribution over shelf areas — from shallow-water neritic to deeper, pelagic environments (Schumacher, 1976; Klapper and Lane, 1985; Vandelaer *et al*., 1989; Belka and Wendt, 1992). However, considerable contribution of the *subterminus* group with insignificant numbers of the more pelagic *I. symmetricus* (less than 5 specimens per sample) and a lack of typical pelagic forms such as *Klapperina* or *Mesotaxis* argues against deeper pelagic environments of the shelf slope.

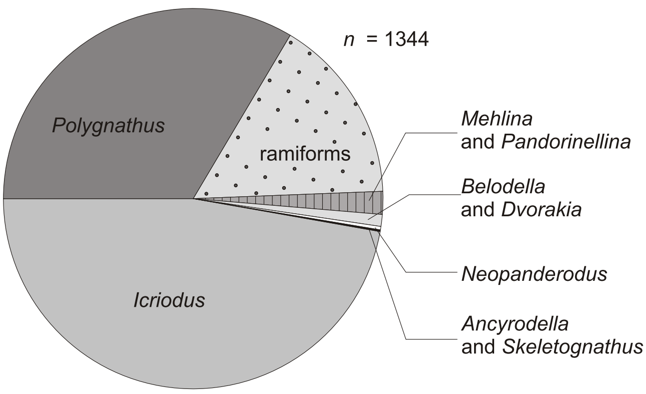


Fig. 2. Generic composition of the Givetian conodont assemblages from the Radom–Lublin area

n — number of specimens

CRITICAL ANALYSIS OF RANGES OF SELECTED CONODONT TAXA

The biostratigraphic analysis was conducted based on index taxa or taxa characteristic of alternative zonations. When the latter were lacking, it was based on comparison of total stratigraphic ranges of all taxa identified in a sample. Therefore it was important to analyse and verify the stratigraphic ranges as thoroughly as possible. This analysis was based mainly on published data from the following papers: Ziegler (1975), Ziegler *et al*. (1976), Weddige (1977), Klapper and Johnson (1980, 1990), Bardashev and Ziegler (1985), Hong-fei *et al*. (1985), Garcia-Lopez (1987), Bultynck (1987, 2003), Mawson and Talent (1989), Ziegler and Sandberg (1990), Bardashev (1992), Klapper (1997), Belka *et al*. (1997), Rogers (1998), Bełka *et al*. (1999), Sparling (1999), Ziegler *et al*. (2000), Ovnatanova and Kononova (2001), Aboussalam and Becker (2001), Garcia-Lopez *et al*. (2002), Aboussalam (2003) and Gouwy and Bultynck (2003). As a result of the above analysis we selected 33 key taxa of stratigraphic importance for the area studied, out of which the total ranges of eleven taxa were modified (Fig. 3). Ranges of the following 6 taxa were amended based solely on the literature data: *Icriodus arkonensis arkonensis*, *Polygnathus ansatus*, *P. latifossatus*, *P. ling. linguiformis*, *P. timorensis* and *P. varcus*. In the case of 5 taxa data collected during the present

T a b l e 2

Conodont distribution in the Giełczew PIG 5 well-section

Conodont Zones	*hem.-a.?*		*ansatus*									*s*F.	Lower *falsiovalis*		
													*i*F.		
Sample depth [metres]	2099.2	2095.8	2017.9	2017.6	2017.5	*2016.0–2015.8	2010.7	2010.6	*2006.2–2006.1	2003.0	2002.5	1970.2	1969.7	*1969.5–1969.2	1967.1
Pandorinellina cf. *P. insita*													2		
Polygnathus pollocki															3
Polygnathus webbi													1		
Polygnathus dubius															3
Polygnathus klugi															4
Polygnathus alatus													1		
Mehlina gradata													1	4	
Mehlina cf. *M. gradata*														2	
Icriodus cf. *I. symmetricus*															5
Icriodus subterminus												2	1	1	2
Icriodus aff. *I. subterminus*												2	1		
Icriodus cf. *I. subterminus*															
Icriodus aff. *I. lilliputensis*															1
Icriodus excavatus										1					
Icriodus cf. *I. excavatus*								1							
Icriodus difficilis										5	11				
Polygnathus ansatus			7	12	4	4		1							
Polygnathus denisbriceae															2
Polygnathus cf. *P. denisbriceae*					1										
Polygnathus xylus															
Polygnathus timorensis				1			2	1							
Polygnathus pseudofoliatus				1	1										
Polygnathus ling. linguiformis			1	7	2	1									
Polygnathus ling. subsp. indet.							1	2							
Icriodus latecarinatus			2	3	2	2					2				
Icriodus brevis				1			1				1				
Icriodus eslaensis							1				1				
Icriodus lilliputensis				3						1	5				
Icriodus arkonensis walliserianus			1		1										
Icriodus arkonensis arkonensis										2					
Icriodus aff. *I. platyobliquimarginatus*			1	1											
Icriodus platyobliquimarginatus				1											
Icriodus lindensis	1														
Belodella devonica			1	2		1									
Dvorakia chattertoni			1	2											
Neopanderodus sp. indet.						1									
Icriodus sp. indet.		1	8	7	6	3	6	2	3	13	24	4	3	1	7
Polygnathus sp. indet.			6	17	2	15	8	3							44
Coniform elements			1			1				1	2				
Ramiform elements			4	6	4	3	2	3					1	5	7
Total number of specimens	1	1	33	64	23	31	21	13	3	23	46	8	11	13	78

hem. — *hemiansatus*, *a*. — *ansatus*, *s*F. — *subterminus* Fauna, *i*F. — *insita* Fauna, * — sampled by AMOCO

Table 3

Conodont distribution in the Korczmin IG 1 well-section

Conodont zones	*ansatus*					*a*-U*h*.
Sample depth [metres]	*2492.3	2492.0	2489.0	2488.6	2485.0	*2483.0
Polygnathus ansatus	1	7	3		3	
Polygnathus cf. *P. ansatus*	2					
Icriodus cf. *I. difficilis*				1		
Icriodus latecarinatus			2			
Polygnathus cf. *P. varcus*						1
Polygnathus denisbriceae		1			1	
Polygnathus timorensis			1			
Icriodus brevis					1	
Icriodus cf. *I. brevis*	1					
Icriodus eslaensis					5	
Icriodus aff. *I. arkonensis walliserianus*	3					
Icriodus arkonensis walliserianus		3			1	
Polygnathus linguiformis linguiformis	1	5	4	12	2	
Polygnathus linguiformis subsp. indet.	3	3	2		2	
Polygnathus parawebbi				1		
Belodella devonica						1
Icriodus sp. indet.		4	3	1	2	
Polygnathus sp. indet.		2		5	2	
Coniform elements		3				
Ramiform elements	2	1	2	2	8	
Total number of specimens	13	29	17	22	27	2

a — *ansatus*, U*h*. — Upper *hermanni*, * — sampled by AMOCO

study were applied: *I. arkonensis walliserianus*, *I. eslaensis*, *I. platyobliquimarginatus*, *I. subterminus*, *I.* aff. *I. subterminus*. When correcting the total stratigraphic ranges of taxa we based our conclusions only on papers giving photographs of particular forms, thus making the original taxonomic identifications reliable.

Icriodus arkonensis arkonensis. The earliest occurrence of the subspecies was documented photographically from the Upper *hermanni* Subzone by Garcia-Lopez (1987, pl. 9, fig. 1–6). However, after detailed inspection of the illustrations in the cited paper it appeared that the specimens from figures 1–4 (*op. cit.*) should be correctly assigned to *Icriodus difficilis* (compare Ziegler *et al.*, 1976, pl. 1, fig. 17), whereas those from figures 5 and 6 (*op. cit.*) may be assigned to *Icriodus expansus*→*Icriodus arkonensis sensu* Sparling, 1995. The Lower *hermanni* Subzone suggested by Bardashev and Ziegler (1985, p. 69, fig. 3) and Bardashev (1992, p. 52, fig. 14) as the last occurrence of *I. a. arkonensis* also should not be taken into account in view of a lack of photographic documentation. The last illustrated occurrence was confirmed from the Middle *varcus* Zone (= *ansatus* Zone in the present paper) by Sparling (1995, p. 898, pl. 3, fig. 5). Consequently, the *ansatus* Zone is here accepted as the upper stratigraphic range of the subspecies (Fig. 3).

Polygnathus ansatus. The last occurrence of the species, represented by merely a single specimen, was reported from an interval comprising the *hermanni* Zone to the lowermost part of the *disparilis* Zone (Bardashev, 1992, fig. 27, pl. 5). Nevertheless, the presence of *Schmidtognathus hermanni* Ziegler, 1966, together with *P. ansatus* (see Bardashev, 1992, fig. 3, p. 35) constrains the upper stratigraphic range of the species to the upper part of the Upper *hermanni* Subzone. Extending the range into the lower part of the *disparilis* Zone appears unsubstantiated.

Polygnathus latifossatus. The literature data on the last occurrence of the species are ambiguous and partly questionable. According to the compilation of Klapper and Johnson (1980, tab. 12) *P. latifossatus* probably made its last appearance in the Lowermost *asymmetricus* Zone (= *falsiovalis* Zone) in the Rhenish Slate Mts. (Germany) and in Morocco. However, the relevant samples from Germany with the last occurrences of *P. latifossatus* are dated to the *hermanni* Zone (no. 19a and probably no. 20 from the Koppen section and no. 13 from the Giebringhausen section — Ziegler *et al.*, 1976). The age of the younger sample no. 16 from Giebringhausen, with a possible *P. latifossatus* occurrence, was given by Ziegler and Klapper (1982) as the lower part of the Lower *disparilis* Subzone. However, according to the cited authors the presence of the species in the sample is questionable and thus cannot be assumed with confidence. In Morocco, the last photographically documented occurrence of *P. latifossatus* is from the Bou Tchafrine section, sample BT 35, dated as the middle part of the Upper *hermanni* Subzone (see Bultynck and Hollard, 1980, pl. IX, figs. 11, 12). The presence of the species stratigraphically higher is uncertain as in the sample BT 37 the specimens were identified as *P.* aff. *P. latifossatus* by Bultynck and Hollard (1980).

Uncertainty is also connected with the latest occurrence of the discussed species in Middle and Southern Tien-Shan and the Pamirs (Bardashev, 1992). The relevant sample no. 23-B-4, located 36 meters above the base of the Akbasai Fm., is assigned to the *falsiovalis* Zone by the cited author. In addition to *P. latifossatus* representatives of *Sch. wittekindti* Ziegler, 1966 and *P. webbi* were found. The stratigraphic range of *P. webbi* is not compatible with the ranges of the other two species (compare Klapper and Johnson, 1990; Ziegler and Sandberg, 1990) which may suggest incorrect taxonomic determination. The cited author himself marks the last occurrence of *P. latifossatus* in the lower part of the *disparilis* Zone and not in the *falsiovalis* Zone (Bardashev, 1992, fig. 14). However, the only figured specimen from the *disparilis* Zone (*op. cit.*, pl. 9, figs. 17 and 27) is more similar to *O. semialternans*. One good specimen of *P. latifossatus* (*op. cit.*, pl. 5, fig. 31) is from sample 12-3-103 of the Kalagach Fm. co-occurring with *Sch. hermanni* and assigned to the *hermanni* Zone (*op. cit.*, p. 40, fig. 4).

In summary, it is here assumed that the last well documented occurrence of *P. latifossatus* is from the middle part of the Upper *hermanni* Zone (see above — Bultynck and Hollard, 1980). The same age may be assigned to the non-illustrated representatives of the species from the Rhenish Slate Mts.

Table 4

Conodont distribution in the Terebin IG 5 well-section

Conodont zones	*rh/v.-ansatus*			*ansatus*		*a.*- ?*s*F.		*s*F*?*	sF? -L*r*.
Sample depth [metres]	1608.6	1606.8	1605.3	1577.2	1576.6	1574.7	1574.6	1551.2	1432.8
Mehlina gradata									1
Polygnathus angustidiscus									2
Icriodus subterminus								1	
Polygnathus alatus								1	
Polygnathus cf. *P. ansatus*				2					
Polygnathus xylus					1			5	
Icriodus difficilis					1				
Icriodus cf. *I. difficilis*					1				
Icriodus latecarinatus			1			1			
Icriodus cf. *I. latecarinatus*	1						1		
Icriodus platyobliquimarginatus					1				
Icriodus cf. *I. lindensis*		1							
Icriodus arkonensis walliserianus				1					
Polygnathus linguiformis linguiformis				1		4			
Polygnathus linguiformis subsp. indet.							2		
Polygnathus parawebbi			6						
Belodella triangularis						2	1		
Dvorakia chattertoni		1							
Neopanderodus sp. indet						1			
Icriodus sp. indet.			3	1	3	1	2		
Polygnathus sp. indet.			1	2	3	2		1	1
Coniform elements				3		1			
Ramiform elements	3		6	2	3	4	1		16
Total number of specimens	4	2	17	12	13	16	7	8	20

rh/v. — *rhenanus/varcus*, *a*. — *ansatus*, *s*F. — *subterminus* Fauna, L*r*. — Lower *rhenana*

(Ziegler *et al*., 1976) in the Bicken (sample 821) and Koppen (samples 19–20?) sections.

Polygnathus linguiformis linguiformis. The youngest *in situ* stratigraphic occurrences of *P. ling*. *linguiformis* are assigned to the Upper *hermanni* Zone (Ebert, 1993; Weary and Harris, 1994; Aboussalam, 2003). Several authors noted the subspecies from the undivided *hermanni* Zone (Clausen *et al*., 1979; Bardashev *et al*., 1985; Johnson *et al*., 1985; Kullman and Ziegler, 1970). However, only Aboussalam (2003, pl. 17, figs. 3–5) and probably Bardashev (1992, pl. 3, fig. 25) documented the presence of *P. ling*. *linguiformis* in this zone. The latter author, in plate captions, assigned the specimen from the Abkasai Fm. to the *hermanni* Zone (sample 2-I-27; Bardashev, 1992, p. 66) but at the same time he did not include *P. ling*. *linguiformis* in the taxa listed for that sample (Bardashev, 1992, p. 35, tab. 3).

Dating of the last occurrence of *P. ling*. *linguiformis* as the lowermost part of the undivided *disparilis* Zone by Lazreq (1990, 1999) seems unfounded. All the representatives of the subspecies illustrated in the cited papers were obtained from the *varcus* Zone of the same section. Photographic documentation related to the *disparilis* and *hermanni* zones is lacking.

In a few localities the species has been found in younger beds corresponding to the uppermost Givetian to Lower-Middle Frasnian interval. This is the case for Martenberg in Germany (Sandberg *et al*., 1989; Aboussalam, 2003), Nevada and Idaho (Sandberg *et al*., 1989), Indiana (Orr and Klapper, 1968; Klapper and Johnson, 1980; Sandberg *et al*., 1994), western New York (Huddle, 1981), west Virginia, Maryland and Pennsylvania (Weary and Harris, 1994) and Manitoba in Canada (Norris *et al*., 1982). However, from the lithostratigraphic information given in these papers it can be concluded that the samples may include reworked conodont specimens. For this reason we do not use these uppermost Givetian and Lower–Middle Frasnian occurrences of *P. ling*. *linguiformis* in our biostratigraphic interpretations.

A single specimen of *P. ling*. *linguiformis* was found by Ovnatanova and Kononova (2001, p. 43) in the Rzhaksa 1 section of the central EEP area, in strata assigned to the Pashiya – Lower Timan horizons. These horizons are correlated with the

Table 5

Conodont distribution in the Bąkowa IG 1 well- section

Conodont zones	*rh/v.*		*ansatus*		*a.- her.*		*her.*	*her. - norrisi*			*nor.*	*nor.-tran.*	
Sample depth [metres]	2252.3	2248.1	2116.0	2040.1	1874.1	1866.7	1858.8	1818.0	1555.9	1535.7	1493.4	1449.6	1439.4
Ancyrodella pristina													1
Skeletognathus norrisi											1		
Polygnathus webbi											2		
Polygnathus aff. *P. pollocki*											6		
Polygnathus klugi											3		
Polygnathus cf. *P. klugi*											1		
Polygnathus dubius											5		
Polygnathus denisbriceae											4		
Icriodus aff. *I. symmetricus*											3		
Icriodus subterminus											7		
Icriodus aff. *I. subterminus*							3				5		
Icriodus expansus											4		
Polygnathus alatus			1						2		1		
Icriodus difficilis										1	1		
Icriodus cf. *I. difficilis*			1								2		
Icriodus latecarinatus							1	1					
Icriodus excavatus					1								
Icriodus brevis			2								2		
Icriodus eslaensis		2	1								1		
Icriodus lilliputensis			1	1									
Icriodus cf. *I. arkonensis*			1										
Polygnathus ansatus			4										
Polygnathus timorensis							1						
Polygnathus rhenanus		2											
Polygnathus cf. *P. rhenanus*	1												
Polygnathus ling. linguiformis		9	4										
Polygnathus cf. *P. ling. ling.*		6											
Neopanderodus sp. indet.		1											
Icriodus sp. indet.		1	5	2		2		3			38		
Polygnathus sp. indet.		1	5	1		2			1		68	1	
Coniform elements											3		1
Ramiform elements	2	1	2		1	4			1	2	12		6
Total number of specimens	3	23	27	4	2	8	5	4	4	3	169	1	8

rh/v. — rhenanus/varcus, a. — ansatus, her. — hermanni, nor. — norrisi, tran. — transitans

hermanni-cristatus, disparilis and *binodosa* zones (*op. cit*., p. 6, tab. 3). However, conodonts found in that interval (*op. cit*., p. 8) do not allow a reliable assignment to any of these conodont zones. Klapper and Johnson (1980, tab. 13) and Kleinebrinker (1992) noted the presence of *P. ling. linguiformis* in the lower Frasnian, in the Lower *asymmetricus* Zone, corresponding to the upper part of the *falsiovalis* Zone and the *transitans* Zone. The first authors based their stratigraphic ranges on data from the Ardennes and Rhenish Slate Mts. The occurrence in the Ardennes, in the Sourd d'Ave section (Klapper and Johnson, 1980, p. 446, tab. 13) is problematic. Its presence in sample 3 of the Sourd d' Ave section (Bultynck, 1974, fig. 3), dated to the Lower *falsiovalis* Zone, is probably caused by admixture during the processing of the sample. The latter supposition is supported by CAI observations and by resampling of the same interval with negative results (Bultynck, 1982, fig. 5, samples 19a, b, tab. 2).

In the Rhenish Slate Mts. Klapper and Johnson (1980, p. 446) mentioned three localities with *P. ling. linguiformis* occurring in the Lower *asymmetricus* Zone: the Koppen section, the Padberg Limestone and the Martenberg section (see above). In the Koppen section (Ziegler *et al*., 1976, tab. 13) the subspecies was not listed for samples 23 and 24, contrary to suggestions by Klapper and Johnson (1980). Its last occurrence was noticed in sample 18a assigned to the *hermanni* Zone. In turn, the Padberg Limestone was ascribed by Bischoff and Ziegler (1957, p. 34 and tab. 3, p. 133) to the *dubia-rotundiloba* Subzone (upper Givetian–lower Frasnian boundary). However, incomplete data, such as lack of photographic documentation, missing information on the taxonomic composition of

Table 6

Conodont distribution in the Komarów IG 1 well-section

Conodont zones	*rh/v.*	*ansatus* - L.*s*F.				L.*s*F.
Sample depth [metres]	2377.5	2376.0	2375.6	2370.6	2368.7	2353.5
Icriodus subterminus						4
Icriodus aff. *I. subterminus*						1
Polygnathus latifossatus						2
Polygnathus ansatus		4	4	3	1	
Icriodus difficilis			6	2		1
Icriodus brevis				6		
Icriodus eslaensis			2	2		
Polygnathus linguiformis linguiformis	3		4			
Polygnathus linguiformis subsp. indet.	1	1	1			
Polygnathus rhenanus	2					
Icriodus lindensis	2					
Icriodus aff. *I. arkonensis walliserianus*		1				
Icriodus sp. indet.		1	7	16	3	5
Polygnathus sp. indet.	1	4	7	12	2	1
Coniform elemens		1	4			
Ramiform elements	1	2	6	4	1	
Total number of specimens	10	14	41	45	7	14

rh/v. — *rhenanus/varcus*, L.*s*F. — Lower *subterminus* Fauna

Table 7

Conodont distribution in the Świdno IG 1 well-section

Conodont zones	*rh/v. - a.*		*her.*	U.*her.*-L*f.*	
Sample depth [metres]	1299.1	1241.2	1238.2	1237.1	1218.8
Polygnathus alatus					4
Icriodus aff. *I. subterminus*			1		1
Icriodus brevis					3
Icriodus difficilis			2	1	2
Icriodus eslaensis					2
Icriodus expansus				2	
Icriodus latecarinatus	1		13	14	
Polygnathus denisbriceae			1		
Polygnathus timorensis		1			
Polygnathus ling. linguiformis		2	2		
Icriodus eslaensis	1				
Icriodus platyobliquimarginatus		2			
Icriodus arkonensis walliserianus	9	2			
Icriodus arkonensis arkonensis	2				
Icriodus sp. indet.	2	6	9	17	12
Polygnathus sp. indet.		1		3	
Coniform elements		2	1		
Ramiform elements		2	2	2	3
Total number of specimens	15	18	31	39	27

rh/v. — *rhenanus/varcus*, *a.* — *ansatus*, U. — Upper, *her.* — *hermanni*, L*f.* — Lower *falsiovalis*

samples and frequency of particular taxa, preclude more exact location of *P. ling. linguiformis* specimens within the fairly wide interval of the *dubia-rotundiloba* Subzone.

The upper stratigraphic range of the subspecies in Bergisches Land given by Kleinebrinker (1992, p. 57, tab. 12) also raises serious reservations. The taxonomic composition of the relevant samples 12*, 42+, 41+ and 37+ as well as their superposition in the section (p. 11, fig. 3 and tab. 15, p. 69) indicate that we are dealing with stratigraphically mixed conodont assemblages. The age of sample no. 37+ established as the Lower *disparilis* Zone based on *P. latifossatus* cannot be younger than the age of the lower sample 12* which contains *Palmatolepis transitans* Müller, 1956 and which is indicative of the Frasnian *transitans* Zone.

In summary, all the well-documented representatives of *P. ling. linguiformis* presented made their last appearance in the *hermanni* Zone (Aboussalam, 2003). The presence of the subspecies in the *disparilis* Zone and the Lower *falsiovalis* Zone should be regarded as problematic.

Polygnathus timorensis. This species appears at the base of the *timorensis* Zone but it is also very common in the *ansatus* Zone (e.g., Ziegler *et al*., 1976; Weddige, 1984; Bardashev and Ziegler, 1985; Bultynck, 1987; Mawson and Talent, 1989; Uyeno, 1991; Kleinebrinken, 1992; Lazreq, 1999; Aboussalam, 2003). In younger zones the frequency decreases. Its presence in the Upper *varcus* Subzone (= *latifossatus/semialternans* Zone in the present paper) was noted by Ziegler *et al*. (1976), Schönlaub (1985), Johnson *et al*. (1985), Bardashev and Ziegler (1985), Hong-fei *et al*. (1985) and Mawson and Talent (1989).

The last appearance of *P. timorensis* was noted in the *hermanni* Zone by Bardashev (1992) and Lane *et al*. (1979, fig. 8, pl. 2). The latter paper includes a well-documented occurrence whereas the former illustrates only juvenile and/or problematic specimens which lack important diagnostic features (Bardashev, 1992, pl. 5, figs. 24, 28). Lane *et al*. (1979, p. 215) found *P. timorensis* in their sample no. 1844, dated to the *hermanni* Zone based on two illustrated taxa: *P. limitaris* Ziegler and Klapper, 1976 and *P. linguiformis weddigei* Clausen, Leuteritz and Ziegler, 1979 (= *P. ling. linguiformis* morphotype δ of Ziegler *et al*., 1976). *P. limitaris* appears first in the Lower *hermanni* Subzone (Klapper and Johnson, 1980; Bardashev, 1992; Aboussalam, 2003), whereas the last appearance of *P. ling. weddigei* is in the Upper *hermanni* Subzone. It can be thus concluded that the upper stratigraphic range of *P. timorensis* is within the undivided *hermanni* Zone.

Polygnathus varcus. The upper stratigraphic range of the species is well documented in the *hermanni* Zone by Ziegler *et al*. (1976) and Bultynck and Hollard (1980). Due to the absence of photographic documentation we did not take into account the data published by Lazreq (1999, p. 19, fig. 9 — Bou-Alzaz section) and Clausen *et al*. (1979). Furthermore,

Table 8

Conodont distribution in the Niesiołowice IG 1 well-section

Conodont zones	*rh/v. - ansatus*			?	L.*s*F.	U.*s*F.
Sample depth [metres]	1512.1	1510.0	1481.3	1397.6	1358.5	1337.8
Polygnathus pollocki						1
Polygnathus angustidiscus						1
Icriodus subterminus					1	1
Icriodus aff. *I. subterminus*					1	1
Icriodus cf. *I. subterminus*						
Icriodus difficilis						1
Polygnathus alatus					1	
Polygnathus cf. *P. timorensis*			1			
Polygnathus linguiformis subsp. indet.			5	1		
Icriodus eslaensis				2		
Icriodus brevis			4			
Icriodus latecarinatus			3			
Icriodus lindensis	1	2	19			
Icriodus arkonensis walliserianus	1	1				
Icriodus cf. *I. arkonensis*	1					
Polygnathus varcus	1					
Icriodus sp. indet.	3	2	16			
Polygnathus sp. indet.			4		2	1
Ramiform elements			1		2	5
Total number of specimens	7	5	53	3	7	11

Sample 1397.6 m probably represents the interval from the *rhenanus/varcus* Zone to the Lower *subterminus* Fauna; *rh/v.* — *rhenanus/varcus*, L. — Lower, U. — Upper, *s*F. — *subterminus* Fauna

Table 9

Conodont distribution in the Krowie Bagno IG 1 well-section

Conodont zones	L.*s*F.	U.*s*F.	*ins*F.
Sample depth [metres]	1333.0	1332.6	1332.2
Pandorinellina insita			5
Pandorinellina sp. indet.			1
Mehlina gradata		7	
Mehlina sp. indet.		2	
Icriodus subterminus	6	7	6
Icriodus aff. *I. subterminus*	9	4	7
Icriodus cf. *I. subterminus*	7	16	9
Icriodus excavatus			1
Icriodus aff. *I. lilliputensis*	4	3	
Polygnathus denisbriceae	3		
Polygnathus xylus		10	
Icriodus sp. indet.			
Polygnathus sp. indet.	3	8	
Ramiform elements	1	5	16
Total number of specimens	33	62	45

L. — Lower; U. — Upper; *s*F. — *subterminus* Fauna; *ins*F. — *insita* Fauna

Table 10

Conodont distribution in the Szwejki IG 1, IG 3 well-section

Conodont zones	*ansatus-h.*		L*h*.- U.*s*F?	U.*s*F?
Sample depth [metres]	4546.4	4542.0	4343.8	4343.0
Icriodus subterminus				1
Icriodus aff. *I. subterminus*			1	
Mehlina sp.				1
Polygnathus ovatinodosus limitaris			1	
Polygnathus ansatus	1			
Polygnathus timorensis		1		
Icriodus cf. *I. difficilis*	1			
Icriodus sp. indet.	1	1		
Polygnathus sp. indet.			1	2
Coniform elements				
Ramiform elements	2		3	1
Total number of specimens	5	2	6	5

L. — Lower, *h*. — *hermanni*, U.*s*F — Upper *subterminus* Fauna

the present authors do not accept the middle part of the Frasnian as the last appearance of *P. varcus*, as proposed by Aboussalam (2003, p. 190). The cited author included the data published by Bultynck (1986) in spite of the fact that the specific name was given with quotation-marks thus expressing uncertainty as to the proper taxonomic determination. When comparing the lectotype (Klapper *et al*., 1970, p. 658, figs. 3, 4) with the specimen illustrated by Bultynck (1986, pl. 1, fig. 3) it can be noted that the latter distinctly differs from the typical forms and therefore should be identified as *P.* aff. *P. varcus*. In conclusion, the last certain occurrence of *P. varcus* is known from the Upper *hermanni* Subzone (*cf.* Klapper and Johnson, 1980).

Icriodus arkonensis walliserianus. According to Weddige (1977, 1988) the stratigraphic range of the subspecies was limited to the *ensensis* Zone. Included herein into *I. a. walliserianus* are specimens identified as *I. arkonensis* by Mawson and Talent (1989, pl. 1, figs. 1, 2) and Qiang (1992, pl. 1, figs. 11–15). As the above forms co-occur with the taxa indicative of the *rhenanus/varcus* Zone, the range of *I. a. walliserianus* is here extended to this zone. In the Radom–Lublin area *I. a. walliserianus* (Fig. 4P) was found together with *P. ansatus* (Fig. 4C) in the following wells: Giełczew PIG 5 (Table 2, depths 2017.9 m and 2017.5 m), Korczmin IG 1 (Table 3, depth 2492.0 m; Fig. 4V and W; pl. I, fig. 4 in Narkiewicz and Narkiewicz, 1998) and Terebin IG 5 (Table 4, depth 1577.2 m). The above data extend the upper range of the species into the *ansatus* Zone. In the Giełczew PIG 5 well the co-occurrence of *P. ansatus* (Fig. 4G) with *I. lilliputensis* (Fig. 4Z and AA) in the sample from depth

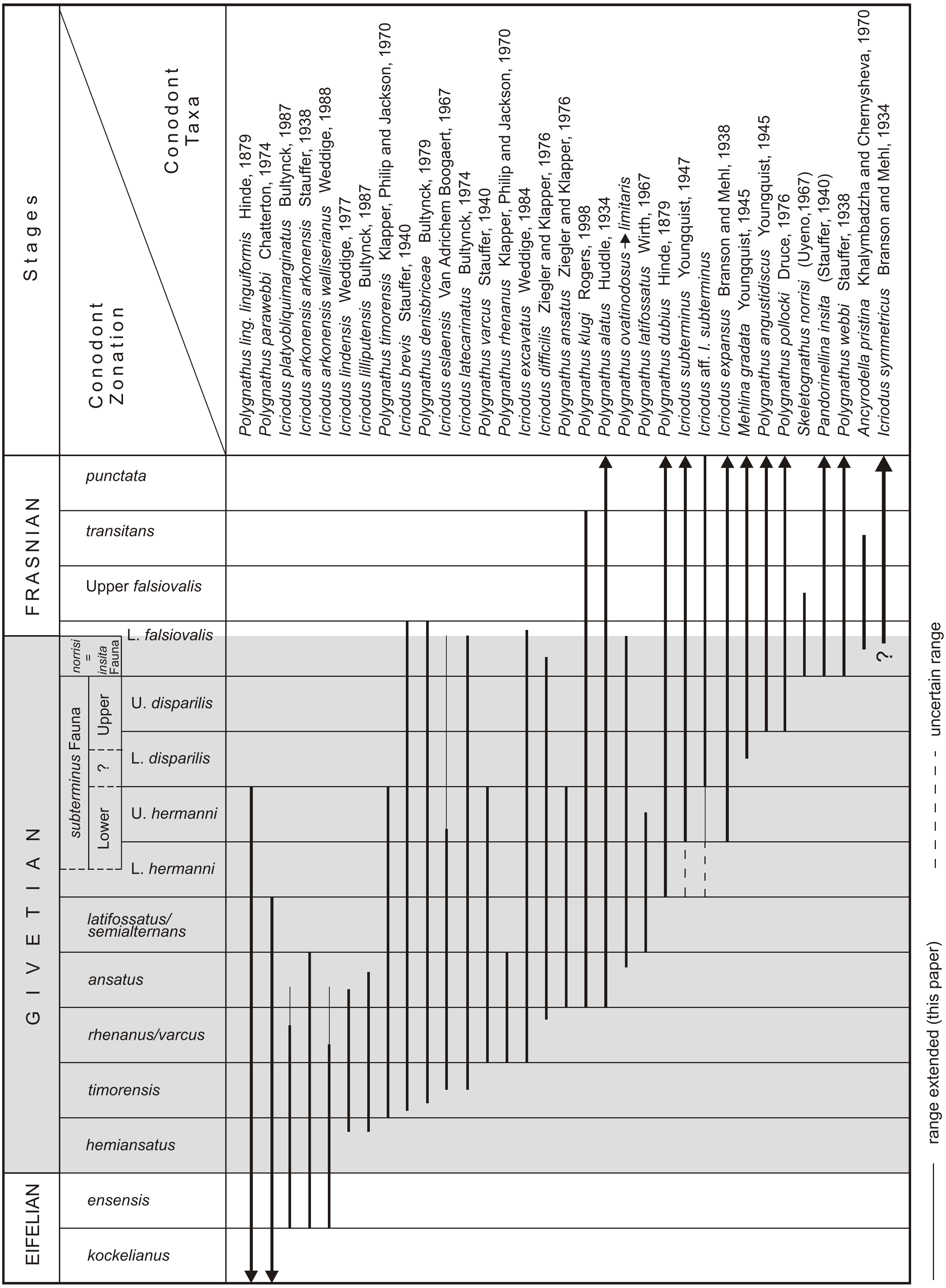


Fig. 3. Stratigraphic ranges of selected conodont taxa according to Weddige (1977), Klapper and Johnson (1980, 1990), Bultynck (1987, 2003), Ziegler and Sandberg (1990), Klapper (1997), Rogers (1998), Sparling (1999), Ziegler *et al.* (2000), Ovnatanova and Kononova (2001), Aboussalam (2003); with the modifications introduced by the present authors

→

Fig. 4. Conodont elements from the *ansatus* Zone

A–E, **G**, **K** — *Polygnathus ansatus* Ziegler and Klapper, 1976: A — Bąkowa IG 1, 2116.0 m, × 65; B — Korczmin IG 1, 2492.3 m, × 55; C — Giełczew PIG 5, 2017.9 m, × 55; D — Korczmin IG 1, 2849.0 m, × 50; G — 2017.6 m, × 60; K — 2017.6 m, × 65; E — Komarów IG 1, 2376.0 m, × 55; **F** — *Polygnathus* cf. *P. ansatus* Ziegler and Klapper, 1976, Terebin IG 5, 1577.2 m, × 40; the inner and the outer geniculation points are opposite, the outward bowing of the outer anterior through margin is well developed, the one on the inner side cannot be seen due to sediment particles; where it can be seen, the ornamentation of the platform is nodose; **H**, **I**, **T** — *Icriodus platyobliquimarginatus* Bultynck, 1987: H, I — upper and lateral views, Giełczew PIG 5, 2017.6 m, × 65: T — Terebin IG 5, 1576.6 m, × 65; **J** — *Dvorakia chattertoni* Klapper and Barrick, 1983, Giełczew PIG 5, 2017.6 m, × 55; **L** — *Polygnathus pseudofoliatus* Wittekindt, 1965, Giełczew PIG 5, 2017.6 m, × 60; **M** — *Icriodus arkonensis arkonensis* Stauffer, 1938, Giełczew PIG 5, 2003.0 m, × 40; **N**, **O**, **X** — *Icriodus brevis* Stauffer, 1940: N, O — upper and lateral views, Bąkowa IG 1, 2116.0 m, × 40; X — oblique-lateral view, Giełczew PIG 5, 2002.5 m, × 50; **P**, **V**, **W** — *Icriodus arkonensis walliserianus* Weddige, 1988; P — Giełczew PIG 5, 2017.9 m, × 50; V–W — upper and lateral views, Korczmin IG 1, 2492.0 m, × 50; **Q**, **R** — *Icriodus eslaensis* Van Adrichem Boogaert, 1967: Q, R — upper and lateral views, Korczmin IG 1, 2485.0 m, × 65; **S** — *Icriodus difficilis* Ziegler and Klapper, 1976, Giełczew PIG 5, 2002.5 m, × 40, **U** — *Icriodus latecarinatus* Bultynck, 1974, Korczmin IG 1, 2489.0 m, × 65; **Y**, **Z**, **AA**, **BB**, **CC**, **DD** — *Icriodus lilliputensis* Bultynck, 1987: Y — Bąkowa IG 1, 2040.1 m, × 70; Z–AA — upper and lateral views, Giełczew PIG 5, 2017.6 m, × 45, BB–CC — upper and lateral views, 2003.0 m, × 35; DD — 2002.5 m, × 40

2017.6 m constrains the upper age limit to the lower part of the *ansatus* Zone (*cf.* Fig. 3).

Icriodus eslaensis. Based on previously published literature the last occurrence of the species is from the lowermost part of the Upper *hermanni* Subzone (Garcia-Lopez, 1987, p. 31, fig. 8, pl. 8, fig. 13; Garcia-Lopez and Sanz-Lopez, 2002, p. 175, fig. 5). In the Bąkowa IG 1 well (Table 5), *I. eslaensis* (Fig. 5H and I) co-occurs in the sample from depth 1493.4 m, with i.a. *Skeletognathus norrisi* (Fig. 5V) and *I. difficilis* (Fig. 5M). Both species constrain the age of the conodont assemblage to the *norrisi* Zone (Klapper and Johnson, 1990; Bultynck, 2003). Therefore, the upper stratigraphic range of *I. eslaensis* should be extended to the above-mentioned zone (Fig. 3).

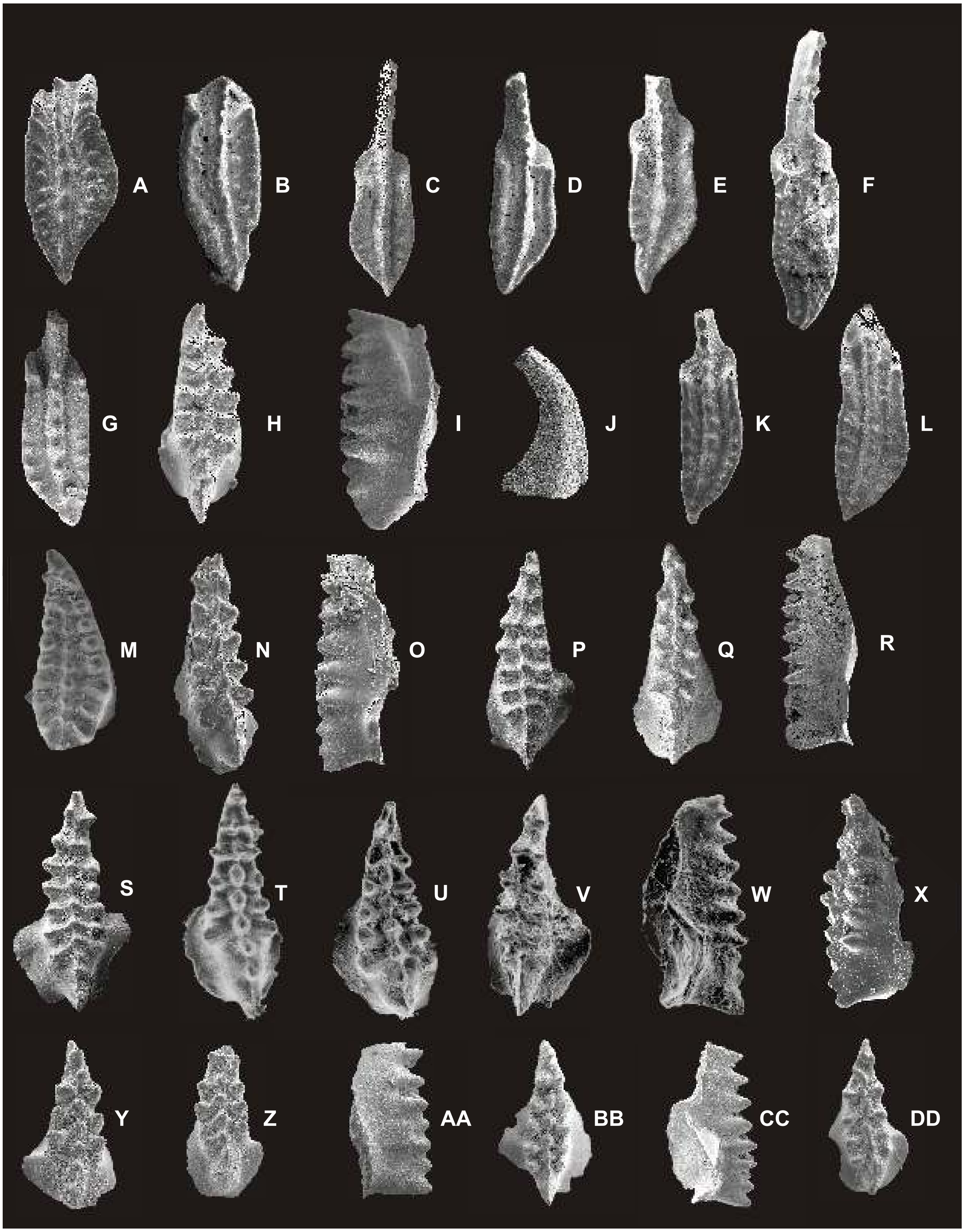
Icriodus platyobliquimarginatus. The upper range of the species has been originally established in the *rhenanus/varcus* Zone (Coen *et al*., 1974; Bultynck, 1987, 2003). In the Radom–Lublin area in the Giełczew PIG 5 well (Table 2, 2017.6 m) *I. platyobliquimarginatus* (Fig. 4H and I) co-occurs with *P. ansatus* (Fig. 4G and K) and *I. lilliputensis* (Fig. 4Z and AA) which extends the range of the species into the lower part of the *ansatus* Zone (*cf.* Fig. 3).

Icriodus subterminus. Comparison of the stratigraphic distribution of the species reveals a distinct regional variability (Bultynck, 2003). In Europe and Northern Africa it first appears in the Lower *falsiovalis* Subzone, whereas it is clearly earlier in North America. The earliest appearance was noted from Member D of the Dawson Bay Fm. in Manitoba, Canada (Norris *et al*., 1982), dated as the Middle *varcus* Subzone (*ansatus* Zone). The biostratigraphic position of the member was later modified and it was moved up to the undivided *hermanni* Zone or the lower part of the *subterminus* Fauna (Day *et al*., 1996, fig. 2). Occurrence of *I. subterminus* in the Lower *disparilis* Subzone was reported by Witzke *et al.* (1988), Day (1990), Norris and Uyeno (1998) and Rogers (1998). The last-named author did not exclude the presence of the species also in older strata, possibly equivalent to part of the Lower and/or Upper *hermanni* Subzone. In the present paper the *hermanni* Zone is assumed to be the oldest zone with the first appearance of *I. subterminus*, its presence in the Lower *hermanni* Subzone being regarded as uncertain (*cf.* Fig. 3).

Icriodus* aff. *I. subterminus. The first occurrence of this form was noted in the Argillaceous Limestones Unit (B) of the Point Wilkins Mb., Souris River Fm. from Manitoba in Canada (Norris *et al*., 1982). These strata, originally assigned to the upper part of the Lower and to the Upper *disparilis* Subzone (Braun *et al*., 1988) are presently regarded as an age equivalent of the Upper *subterminus* Fauna (Day *et al*., 1996). In the present study, in the Bąkowa IG 1 well (Table 5, depth 1858.8 m), *Icriodus* aff. *I. subterminus* (Fig. 6K) was found together with *P. timorensis* (Fig. 6F). Therefore, the *hermanni* Zone in which *P. timorensis* makes its last appearance (see above) should be accepted as the first appearance of *Icriodus* aff. *I. subterminus*. As it was impossible to ascertain in which of the two subzones of the *hermanni* Zone *P. timorensis* disappears, the first appearance of *Icriodus* aff. *I. subterminus* is somewhere in the *hermanni* Zone. However, having in mind the above-mentioned data from Canada, the Lower *hermanni* Subzone is here regarded as uncertain in this respect (*cf.* Fig. 3).

BIOSTRATIGRAPHY: POSSIBILITES OF DISTINGUISHING CONODONT UNITS

Polygnathus ansatus is the only taxon of the "standard" zonation found in the material studied. We also collected five index taxa (*P. rhenanus*, *P. varcus*, *Icriodus subterminus*, *Skeletognathus norrisi* and *Pandorinellina insita*) and two characteristic species (*P. angustidiscus* and *M. gradata*) applied in the alternative zonations. The age of particular samples in the 9 wells studied (Tables 2–10) was established by comparing total stratigraphic ranges of all the forms present, not only the index and characteristic taxa. These data were then extrapolated and interpolated in particular well-sections taking into account the stratigraphic succession of samples. As a result, seven biostratigraphic units were distinguished in the Givetian. The alternative zonation comprises, in ascending order, *rhenanus/varcus*, *ansatus* and *norrisi* zones, and *subterminus* and *insita* faunas, whereas the "standard" units include the *hermanni* and Lower *falsiovalis* zones.



Correlation of the sections investigated including a synthetic presentation of biostratigraphic data is shown in Figures 7 and 8. It should be stressed, however, that the stage boundaries are shown tentatively due to the highly discontinuous and irregular distribution of biostratigraphic data. The latter is caused by the irregular vertical succession of conodont faunas controlled by fluctuating suitable and adverse palaeoenvironments. Forms for identified biostratigrafic units are illustrated in Figures 4–6, 9, 10.

Figure 7 shows correlation and sample horizons of the well-sections from the Lublin Graben Area (Giełczew PIG 5, Komarów IG 1, Korczmin IG 1 and Terebin IG 5), and the elevated EEP (Krowie Bagno IG 1). The tentative correlation is based on tracing the Lower–Middle Devonian boundary

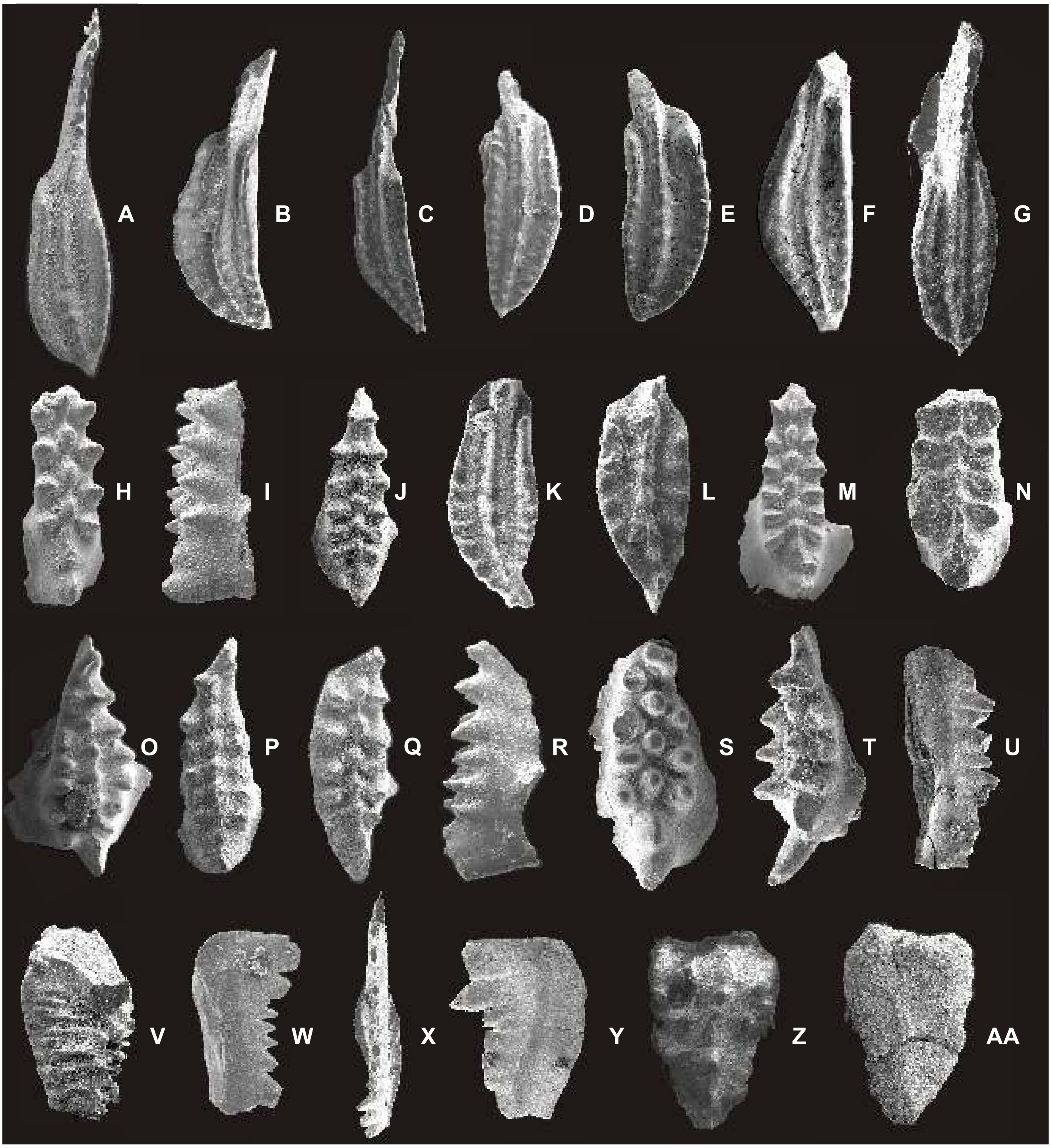


Fig. 5. Conodont elements from the *norrisi* Zone, *insita* Fauna and/or Lower *falsiovalis* Zone

A — *Polygnathus alatus* Huddle, 1934; Bąkowa IG 1, 1493.4 m, × 50; **B**, **E** — *Polygnathus webbi* Stauffer, 1938: B — Giełczew PIG 5, 1969.7 m, × 55; E — Bąkowa IG 1, 1493.4 m, × 50; **C**, **F** — *Polygnathus denisbriceae* Bultynck, 1979: C — Bąkowa IG 1, 1493.4 m, × 50; F — Giełczew PIG 5, 1967.1 m, × 55; **D** — *Polygnathus dubius* Hinde, 1879, Bąkowa IG 1, 1493.4 m, × 50; **G**, **K**, **L** — *Polygnathus klugi* Rogers, 1998: G, K — Giełczew PIG 5, 1967.1 m, × 70 and × 65; L — Bąkowa IG 1, 1493.4 m, × 75; **H**, **I** — *Icriodus eslaensis* Van Adrichem Boogaert, 1967: H, I — upper and lateral views, Bąkowa IG 1, 1493.4 m, × 80; **J** — *Icriodus expansus* Branson and Mehl, 1938; Bąkowa IG 1, 1493.4 m, × 40; **M** — *Icriodus difficilis* Ziegler and Klapper, 1976; Bąkowa IG 1, 1493.4 m, × 40; **N** — *Icriodus* cf. *I. symmetricus* Branson and Mehl, 1934; Giełczew PIG 5, gł. 1967.1 m, × 70; **O** — *Icriodus excavatus* Weddige, 1984; Krowie Bagno IG 1, 1332.2 m, × 45; **P** — *Icriodus* aff. *I. symmetricus* Branson and Mehl, 1934; Bąkowa IG 1, 1493.4 m, × 55; the specimen differs from the nominal species in having a shorter and more massive spindle, by the irregular arrangement of the denticles on the anterior part of the spindle and by the markedly inwards deflection of its anteriormost part; **Q**, **R**, **S**, **T** — *Icriodus subterminus* Youngquist, 1947; Q, R — upper and lateral view, Giełczew PIG 5, 1967.1 m, × 65; S — 1969.7 m, × 100; T — Krowie Bagno IG 1, 1332.2 m, × 90; **U** — *Mehlina gradata* Youngquist, 1945; lateral view, Giełczew PIG 5, 1969.7 m, × 48; **V** — *Skeletognathus norrisi* (Uyeno, 1967); Pb element, Bąkowa IG 1, 1493.4 m, × 55; **W**, **X** — *Pandorinellina insita* (Stauffer, 1940); Krowie Bagno IG 1, 1332.2 m: W — lateral view, medium-sized form, × 70; X — upper view, adult form × 70; Y — *Pandorinellina* cf. *P. insita* (Stauffer, 1940); lower view, Giełczew PIG 5, 1969,7 m, × 55; **Z**, **AA** — *Ancyrodella pristina* Khalymbadzha and Chernysheva, 1970: Z, AA — upper and lower views, Bąkowa IG 1, 1439.4 m, × 50; diagnostic features include the small number of nodes between the carina and platform margin, and the large basal pit on the lower surface

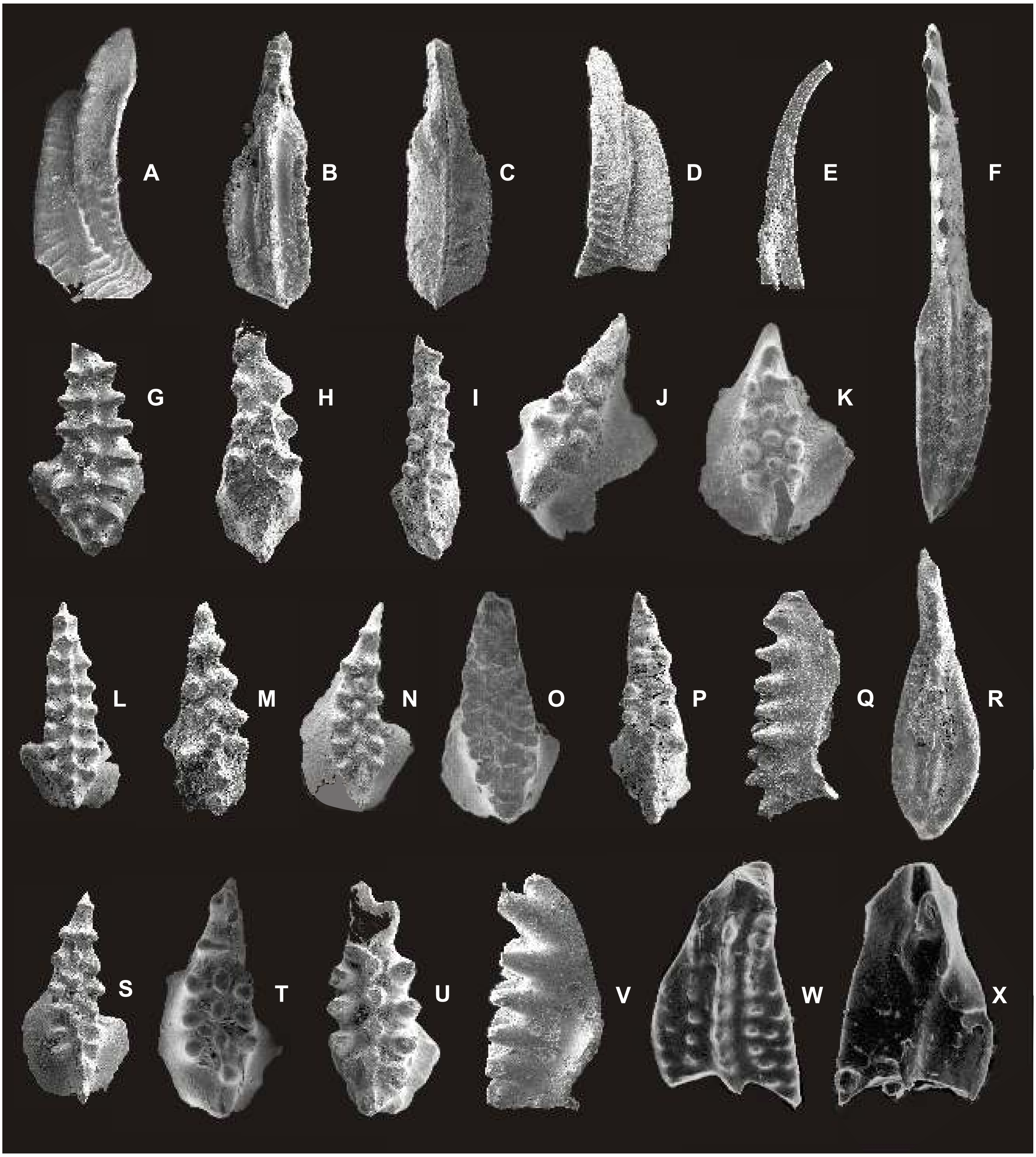


Fig. 6. Conodont elements from the interval of *ansatus–hermanni* zones

A, **D** — *Polygnathus linguiformis linguiformis* Hinde, 1879: A — Świdno IG 1, 1238.2 m, × 80; D — Terebin IG 5, 1574.7 m, × 75; **B**, **C** — *Polygnathus* cf. *P. varcus* Stauffer, 1940; upper (re-illustration K. Narkiewicz and M. Narkiewicz, pl. I, fig. 15) and lower views, Korczmin IG 1, 2483.0 m, × 70; **E** — *Neopanderodus* sp.; Terebin IG 5, 1574.7 m, × 55; **F** — *Polygnathus timorensis* Klapper, Philip and Jackson, 1970; Bąkowa IG 1, 1858.8 m, × 80; **G**, **M** — *Icriodus latecarinatus* Bultynck, 1974: G — Terebin IG 5, 1574.7 m, × 45; M — Bąkowa IG 1, 1818.0 m, × 60; **H**, **K**, **T**, **U**, **V** — *Icriodus* aff. *I. subterminus*: H, T — Świdno IG 1,1238.2 m, × 80 and 1218.8 m, × 60; K — Bąkowa IG 1, 1858.8 m, × 75; U, V — upper and lateral views, Szwejki IG 3, 4343.8 m, × 55; **I** — *Icriodus eslaensis* Van Adrichem Boogaert, 1967; Komarów IG 1, 2370.6 m, × 55; **J** — *Icriodus excavatus* Weddige, 1984; Bąkowa IG 1, 1874.1 m, × 70; **L**, **N**, **S** — *Icriodus difficilis* Ziegler and Klapper, 1976: L — Świdno IG 1, 1238.2 m, × 30; N — Bąkowa IG 1, 1535.7 m, × 50; S — Świdno IG 1, 1218.8 m, × 45; O — *Icriodus expansus* Branson and Mehl, 1938; Świdno IG 1, 1237.1 m, × 40; **P**, **Q** — *Icriodus brevis* Stauffer, 1940; P–Q — upper and lateral views, Świdno IG 1, 1218.8 m, × 60; **R** — *Polygnathus alatus* Huddle, 1934; Świdno IG 1, 1218.8 m, × 65; **W**, **X** — *Polygnathus ovatinodosus* Ziegler and Klapper, 1976 → *limitaris* Ziegler and Klapper, 1976, upper and lower views, Szwejki IG 3, 4343.8 m, × 80 (re-illustration Malec *et al*., pl. I, figs. 12, 13)

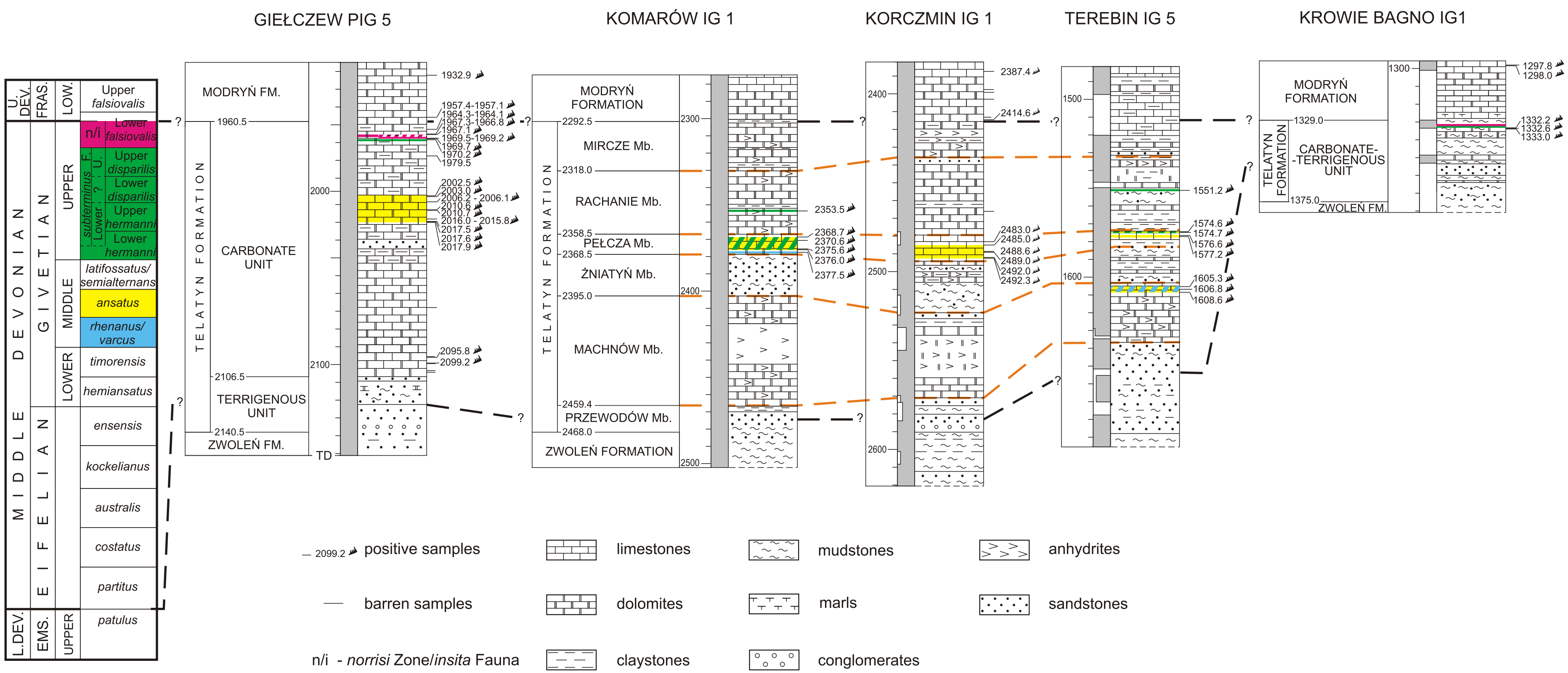


Fig. 7. Succession of the conodont zones and faunas recognized in the well-sections against the lithostratigraphic correlation of the Middle Devonian units in the Lublin Graben and the Elevated East European Platform area; only the coloured biostratigraphic units were recognized

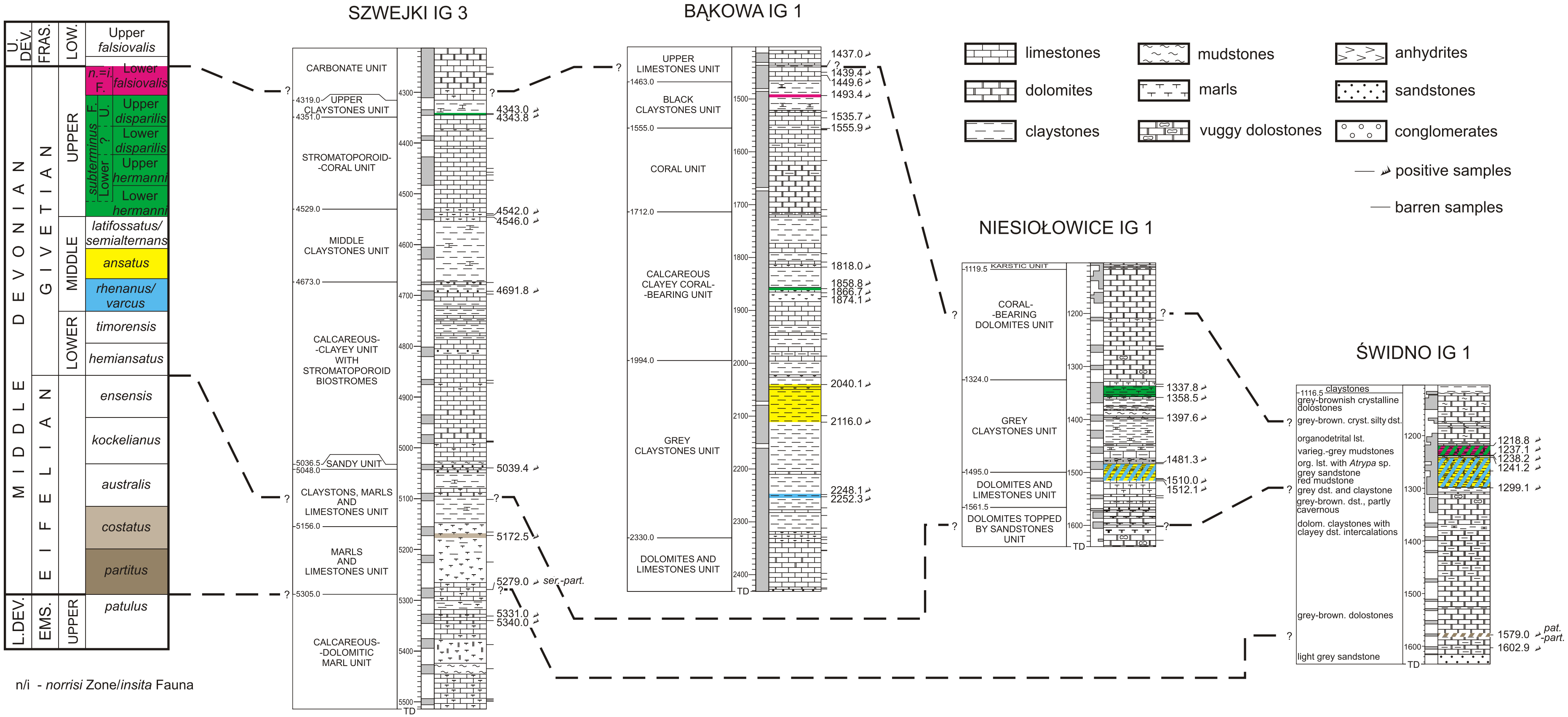


Fig. 8. Succession of the conodont zones and faunas recognized in the well-sections against the lithostratigraphic correlation of the Middle Devonian units in the Radom Area; only the coloured biostratigraphic units were recognized

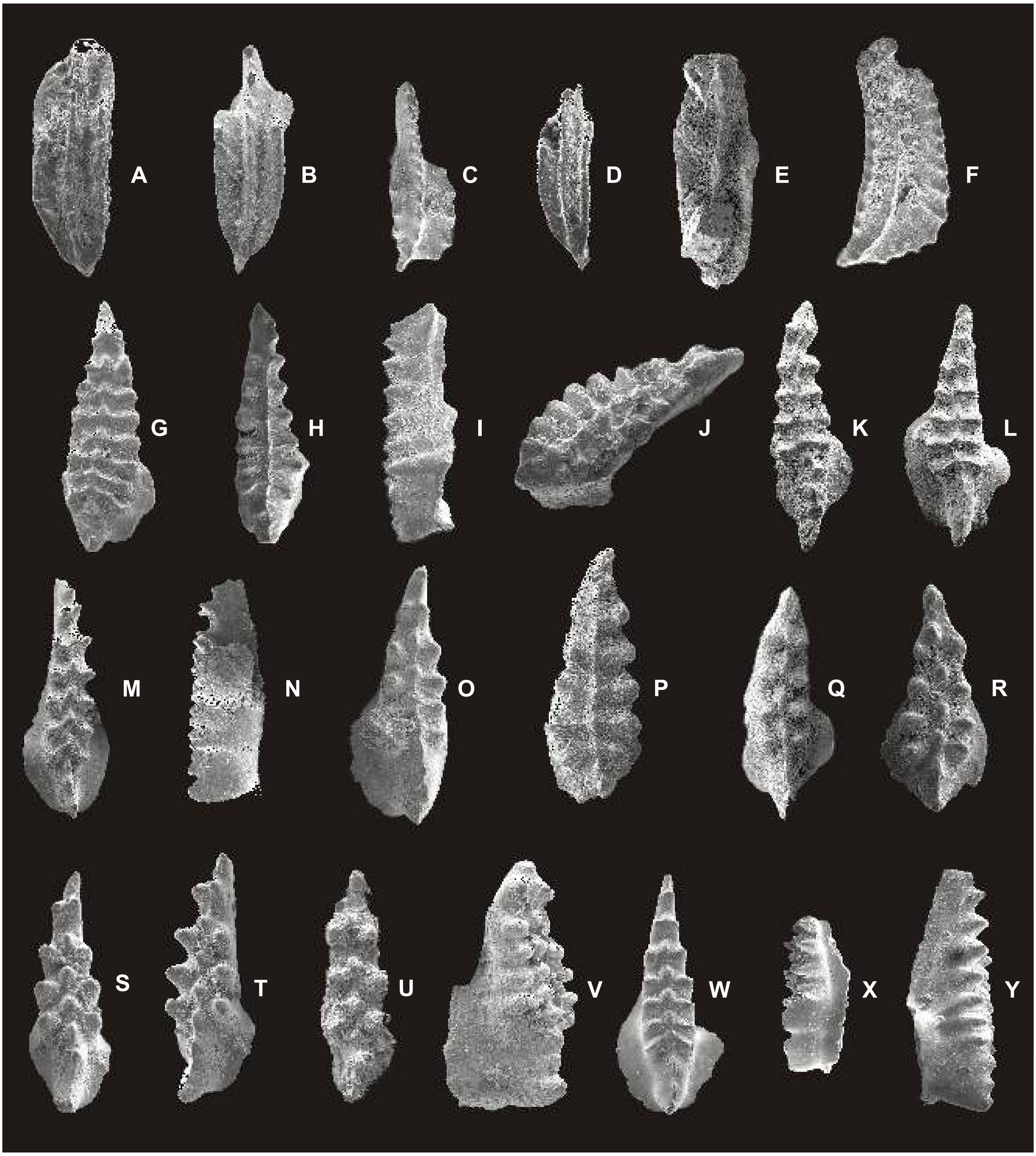


Fig. 9. Conodont elements from the *rhenanus/varcus–ansatus* zones

A — *Polygnathus timorensis* Klapper, Philip and Jackson, 1970, Świdno IG 1, 1241.2 m, × 50; although the blade is missing the specimen is assigned to the nominal species because of the narrow elongated platform and because the geniculation points are not opposite; **B**, **E** — *Polygnathus rhenanus* Klapper, Philip and Jackson, 1970: B — Bąkowa IG 1, 2248.1 m, × 95, E — Komarów IG 1, 2377.5 m, × 105, although the blade is missing the two specimens are assigned to the nominal species because of the short, markedly asymmetric platform and because the geniculation points are opposite; **C**, **F** — *Polygnathus parawebbi* Chatterton, 1974, Terebin IG 5, 1605.3 m: C — juvenile form, × 55, F — adult form, × 40; **D** — *Polygnathus varcus* Stauffer, 1940, Niesiołowice IG 1, 1512.1 m, × 80; **G**, **H**, **I**, **P** — *Icriodus arkonensis walliserianus* Weddige, 1988: G — Świdno IG 1, 1299.1 m, × 56; H, I — upper and lateral views, 1241.2 m, × 40; P — Niesiołowice IG 1, 1510.0 m, × 60; **J** — *Icriodus arkonensis arkonensis* Stauffer, 1938, Świdno IG 1, 1299.1 m, × 55; **K**, **L** — *Icriodus platyobliquimarginatus* Bultynck, 1987: K, L — Świdno IG 1, 1241.2 m, × 50, × 40; **M**, **N**, **Q**, **S**, **T**, **U**, **W**–**Y**— *Icriodus lindensis* Weddige, 1977: M, N — upper and lateral views, Niesiołowice IG 1, 1510.0 m, × 65; S, T, X — upper and oblique- lateral views, Niesiołowice IG 1,1481.3 m, × 80; W, Y — upper and lateral views, × 55; Q — Komarów IG 1, 2377.5 m, × 70; U — Giełczew PIG 5, 2099.2 m, medium-sized form, × 80; **O**, **R** — *Icriodus latecarinatus* Bultynck, 1974: O — Niesiołowice IG 1, 1481.3 m, × 65; R — Terebin IG 5, 1605.3 m, × 70; **V** — *Icriodus eslaensis* Van Adrichem Boogaert, 1967, Świdno IG 1, 1299.1 m, × 70

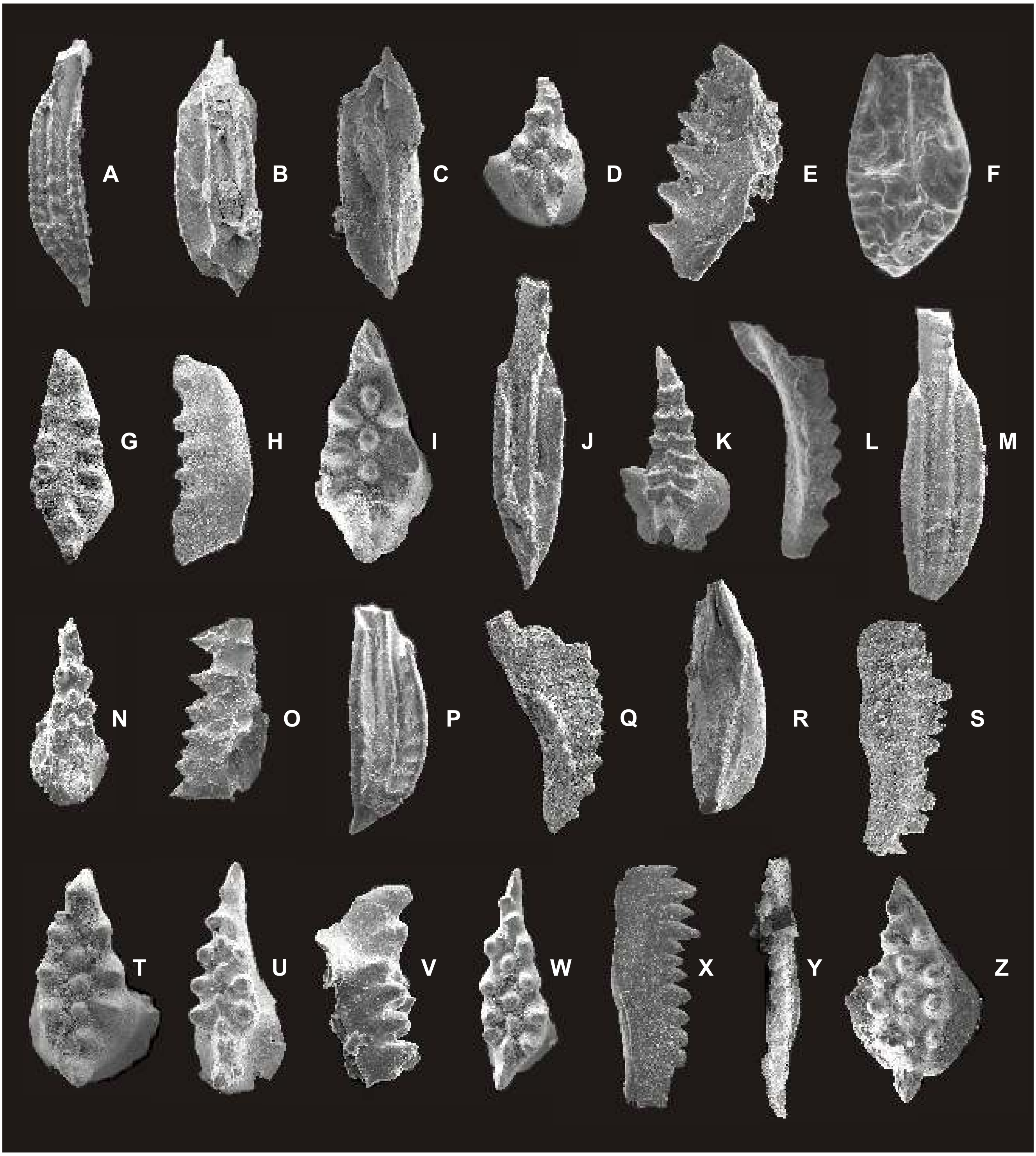


Fig. 10. Conodont elements from the *subterminus* Fauna interval

A — *Polygnathus denisbriceae* Bultynck, 1979, Krowie Bagno IG 1, 1333.0 m, × 55; **B**, **C** — *Polygnathus latifossatus* Wirth, 1967: B, C — upper and lower views, Komarów IG 1, 2353.5 m, × 90; **D** — *Icriodus* aff. *I. lilliputensis* Bultynck, 1987, Krowie Bagno IG 1, 1333.0 m, × 70; **E**, **G**, **H** — *Icriodus subterminus* Youngquist, 1947: E — Niesiołowice IG 1, 1358.5 m, × 80; G, H — upper and lateral views, 1337.8 m, × 50 ; **F**, **P**, **R** — *Polygnathus alatus* Huddle, 1934: F — Niesiołowice IG 1, 1358.5 m, × 80; P, R — upper and lower views, Terebin IG 5, 1551.2 m, × 80; **I**, **N**, **O**, **T**–**Z** — *Icriodus subterminus* Youngquist, 1947: I — Giełczew PIG 5, 1970.2 m, × 80; N, O — upper and lateral views, Terebin IG 5, 1551.2 m, × 70; T — Krowie Bagno IG 1, 1332.6 m, × 90; W — Krowie Bagno IG 1, 1333.0 m, × 70; U, V — upper and lateral views, Komarów IG 1, gł. 2353.5 m, × 80; Z — Szwejki IG 3, 4343.0 m, × 60 (re-illustration from Malec *et al*., 1996, pl. I, fig. 11); **J** — *Polygnathus pollocki* Druce, 1976, Niesiołowice IG 1, 1337.8 m, × 70; **K** — *Icriodus difficilis* Ziegler and Klapper, 1976; Niesiołowice IG 1, 1337.8 m, × 50; **L**, **Q** — *Polygnathus angustidiscus* Youngquist, 1945: L — Niesiołowice IG 1, 1337.8 m, × 80; Q — Terebin IG 5, 1432.8 m, × 70; **M** — *Polygnathus xylus* Stauffer, 1940, Krowie Bagno IG 1, 1332.6 m, × 80; **S**, **X**, **Y** — *Mehlina gradata* Youngquist, 1945: S — lateral view, Terebin IG 5, 1432.8 m, × 60; X, Y — lateral and upper views, Krowie Bagno IG 1, 1332.6 m, × 60 and × 50

(Turnau *et al*., 2005, fig. 2) and the Middle–Upper Devonian boundary (Miłaczewski, 1981; Pajchlowa and Miłaczewski, 2003). In the wells Komarów IG 1, Korczmin IG 1 and Terebin IG 5 the members of the Telatyn Fm. (Miłaczewski, 1981) were additionally correlated. These were not distinguished in the Giełczew PIG 5 (Miłaczewski, 1992), Krowie Bagno IG 1 (Miłaczewski pers. comm., 2005) wells, where only informal lithostratigraphic units were established.

The Szwejki IG 3, Bąkowa IG 1, Niesiołowice IG 1 and Świdno IG 1 wells were correlated separately (Fig. 8) due to the specific lithostratigraphic succession of the Radom Area. Tentative correlations of the lower and upper Middle Devonian boundaries and of the Eifelian–Givetian boundary were drawn based on unevenly distributed biostratigraphic data in the sections.

The *rhenanus/varcus* Zone was recognized in the Bąkowa IG 1 (Fig. 8 and Table 5, depth 2252.3–2248.1 m) and Komarów IG 1 (Fig. 7 and Table 6, depth 2377.5 m) wells basing on the occurrence of *P. rhenanus* (Figs. 9B and E, respectively) and taking into account the first appearance of *P. ansatus* in the upper parts of the sections.

The *ansatus* Zone was distinguished in four sections: Bąkowa IG 1, depth interval 2116.0–2040.1 m (Fig. 8 and Table 5), Giełczew PIG 5, 2017.9–2002.5 m (Fig. 7 and Table 2), Korczmin IG 1, 2492.3–2485.0 m (Fig. 7 and Table 3) and Terebin IG 5, 1577.2–1576.6 m (Fig. 7 and Table 4). The lower boundary was based on the first appearance of *P. ansatus* (Fig. 4A–B and F, respectively) at the base of the particular intervals. The upper boundary in Bąkowa IG 1 and Giełczew PIG 5 was based on the presence of *I. lilliputensis* (Fig. 4Y and DD, respectively) which has its last occurrence within the *ansatus* Zone (Fig. 3). In the Korczmin IG 1 well the boundary was based on the presence of *I. arkonensis walliserianus* at the depth 2485.0 m, whereas in the Terebin IG 5 well on the occurrence of *I. platyobliquimarginatus* (Fig. 4T) at 1576.6 m. These taxa disappear in the lower part of the *ansatus* Zone (Fig. 3).

It seems most probable that the *ansatus* Zone is also present in the Komarów IG 1 well, in the depth interval 2376.0–2368.7 m (Table 6), and in Terebin IG 5, depth 1574.7–1574.6 m (Table 4). In the first well the age of the respective interval corresponds to the total stratigraphic range of *P. ansatus*, i.e. it comprises the *ansatus* to Upper *hermanni* zones (Fig. 3). The sampled interval is within the Pełcza Mb. (see Fig. 7) in which the Taghanic Event (IIa transgression of Johnson *et al*., 1985) was recognized by Narkiewicz and Narkiewicz (1998) and assigned to the Middle *varcus* Zone (= *ansatus* Zone). The Taghanic Event starts within the *ansatus* Zone (Aboussalam, 2003). Therefore the same age is very likely in the case of the discussed interval 2376.0–2368.7 m.

Also in the Terebin IG 5 well the sampled deposits of the depth interval 1577.2–1574.6 m can be correlated with the Pełcza Mb. and are interpreted as corresponding to the Taghanic transgressive level (Narkiewicz and Narkiewicz, 1998, fig. 3). Lower conodont abundance and diversity compared with coeval assemblages from other wells may be explained by a more marginal location of the section in the sedimentary basin and therefore less suitable ecological conditions for the conodont fauna.

The *hermanni* Zone. It was identified in the Bąkowa IG 1 well at 1858.8 m (Fig. 8 and Table 5) and in the Świdno IG 1 well at 1238.2 m (Fig. 8 and Table 7) on the basis of the total stratigraphic ranges of taxa in these investigated assemblages. In Bąkowa IG 1 particularly important is the co-occurrence of *Icriodus* aff. *I. subterminus* (Fig. 6K) and *P. timorensis* (Fig. 6F), whereas in Świdno IG 1 *I.* aff. *I. subterminus* (Fig. 6H) and *P. ling. linguiformis* (Fig. 6A) are significant. The ranges of the above taxa constrain the age of the samples to the *hermanni* Zone (*cf.* Fig. 3).

The *subterminus* Fauna. The fauna was positively identified in four wells: Komarów IG 1, Krowie Bagno IG 1, Niesiołowice IG 1 and Giełczew PIG 5 (Fig. 8), whereas it likely occurs in two others, Szwejki IG 3 (Fig. 8) and Terebin IG 5 (Fig. 7). In the Krowie Bagno IG 1 and Niesiołowice IG 1 wells it was possible to subdivide the fauna into lower and upper parts.

The Lower *subterminus* Fauna was identified in the following wells and depths: Niesiołowice IG 1, 1358.5 m (Table 8), Krowie Bagno IG 1, 1333.0 m (Table 9) and Komarów IG 1, 2353.5 m (Table 6). In the first two wells the fauna was noted based on the nominal species, *I. subterminus* (Fig. 10E, W), together with the occurrence of the characteristic species, *P. angustidiscus* and *Mehlina gradate*, found together with the nominal species in the upper parts of the sections. In the Komarów IG 1 well the assignment is based on the co-occurrence of *I. subterminus* (Fig. 10U, V) with *P. latifossatus* (Fig. 10B, C) about 5 metres above the strata dated as probable *ansatus* Zone (see the discussion above).

The Upper *subterminus* Fauna was found in the Krowie Bagno IG 1 well, depth 1332.6 m (Fig. 7 and Table 9), Niesiołowice IG 1, 1337.8 m (Fig. 8 and Table 8), and probably Szwejki IG 3, 4343.0 m (Fig. 8 and Table 10). In the first two sections it was identified on the basis of co-occurrence of *I. subterminus* (Fig. 10T, G, H, respectively) with *P. angustidiscus* (Fig. 10L) for Niesiołowice IG 1, and with *M. gradata* (Fig. 10X, Y) for Krowie Bagno IG 1. An additional criterion is the vertical succession of the index and characteristic taxa in both wells.

In the Szwejki IG 3 well *I. subterminus* (Fig. 10Z) co-occurs with the specimen herein identified as *Mehlina* sp. but which is probably assignable to *M. gradata*. These elements were found 20 cm above the sample from the depth 4343.8 m, the age of which was determined as the Lower *hermanni*? to Lower *falsiovalis* zones based on the presence of *I.* aff. *I. subterminus* (Fig. 6U, V) and *P. ovatinodosus*→*limitaris* (Fig. 6W, X) (*cf.* Fig. 3). The taxonomic composition of the sample from 4343.0 m as well as the succession of assemblages in the interval 4546.4–4343.8 m suggest a probable presence of the Upper *subterminus* Fauna.

The undivided *subterminus* Fauna was found in the Giełczew PIG 5 well, depth 1970.2 m (Fig. 7 and Table 2) and probably in Terebin IG 5, 1551.2 m (Fig. 7 and Table 4). This is based on *I. subterminus* (Fig. 10I and N, O, respectively) identified in these samples, as well as on consideration of vertical successions of conodont assemblages in the sections. In the first well the *insita* Fauna was found at the depth 1969.7 m, 50 cm above the *subterminus* Fauna. In the Terebin IG 5 well the *subterminus* Fauna probably occurs at the depth 1551.2 m, which may be inferred from the appearance of *I. subterminus*. This level is located within the Rachanie Mb. which is consistent with the occurrence of the Lower *subterminus* Fauna in the Komarów IG 1 (see Fig. 7).

The *norrisi* Zone and its age equivalents were found in the Bąkowa IG 1, Krowie Bagno IG 1 and Giełczew PIG 5 wells. The *norrisi* Zone was identified only in the Bąkowa IG 1 well at the depth 1493.4 m (Fig. 8 and Table 5), based on the occurrence of a Pb element of *Skeletognathus norrisi* (Fig. 5V), and *I. difficilis* (Fig. 5M). The last appearance of the latter species is in the Givetian part of the Lower *falsiovalis* Zone (Fig. 3).

The *insita* Fauna was distinguished in the Giełczew PIG 5 well at the depth 1969.7 m (Fig. 7 and Table 2) and in Krowie Bagno IG 1, 1332.2 m (Fig. 7 and Table 9). In both wells the identification of the fauna is based on the presence of the nominal species *Pandorinellina insita* (Fig. 5Y, W–Z, respectively) as well as its superposition just above the *subterminus* Fauna both in Giełczew PIG 5 and Krowie Bagno IG 1 (Fig. 7).

The Lower *falsiovalis* Zone was determined only in the Giełczew PIG 5 well in the depth interval 1969.5–1967.1 m (Fig. 7 and Table 2) on the basis of the *insita* Fauna occurring in the lower part of the section and the presence of *P. denisbriceae* (Fig. 5F) at the top of the interval. The last representatives of this species occur in the Lower *falsiovalis* Zone (*cf*. Fig. 3).

CONCLUDING REMARKS

The biostratigraphic interpretation of the Givetian conodont faunas from sixty-six samples from nine deep wells in the Radom–Lublin area and their correlation required more than a routine application of a "standard" zonation. Only a few index taxa of formally defined Givetian conodont zones are present, *Polygnathus timorensis*, *P. rhenanus*, *P. varcus*, *P. ansatus* and *Skeletognathus norrisi*. Our interpretation also relies on the occurrence of two in formally defined conodont faunas, the *subterminus* Fauna and the *insita* Fauna, well known from upper Givetian shallow-water carbonate platform deposits in North America.

Furthermore our biostratigraphic interpretation also takes into account the total ranges of all conodont taxa occurring in particular samples. In this context we made a critical analysis of the adequately documented published ranges of these taxa. The total ranges of thirty-three taxa were checked from which eleven ranges have been amended. In this way it was possible to position the *hermanni* and Lower *falsiovalis* zones. This approach was necessary because the vertical succession of the conodont faunas in particular sections is highly irregular and discontinuous with many barren intervals controlled by less suitable palaeoecological conditions, mostly by restricted and/or very shallow-water facies.

Finally eight biostratigraphic units were recognized, i.e. the *rhenanus/varcus, ansatus*, *hermanni*, *norrisi* and Lower *falsiovalis* Zones, the Lower and Upper *subterminus* Fauna and the *insita* Fauna. The two lower Givetian conodont zones, the *hemiansatus* and *timorensis* zones, were not recognized due to the presence of terrigeneous sediments at this level.

It is stressed that the *subterminus* Fauna and its subdivisions are recognized outside North America for the first time and the present study indicates that the base of the *subterminus* Fauna corresponds to a level within the *hermanni* Zone.

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