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Latest Devonian conodonts from an olistolith in the northern part of the Góry Bardzkie, West Sudetes

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Abstract Latest Devonian conodonts have been recovered from siliceous rock at Bardo Śląskie, Góry Bardzkie (Mts), West Sudetes. The exposure in the Nysa Kłodzka river cut consists of several undisturbed intervals, separated by zones of fault breccia, interpreted as one large olistolith of Devonian rock embedded in a surrounding Lower Carboniferous graywacke. The siliceous rock shows signs of very low-grade contact metamorphism (300–360°C; conodont CAI = 5) attributed to the late Carboniferous granite intrusion. They represent intervals from Mid- to probably Late-*expansa* Zone, Mid-*expansa* to the Early-*praesulcata* Zones and undivided *praesulcata*-Zone, all suggesting the latest Famennian age for the siliceous host rocks, which appear the youngest Devonian sediments paleontologically documented to date in the allochthonous domain of the Góry Bardzkie. *Palmatolepis* and *Polygnathus* are the most frequent genera. The two genera are believed to indicate the deepest pelagic environment of the late Devonian sea. Both the biofacies and lithofacies of the investigated sediments strongly suggest their distal, deep-water basinal origin. The presence of the open-marine pelagic sediments in the uppermost Famennian seems to imply a continuous sedimentation rather, than a break at the Devonian–Carboniferous boundary in the Góry Bardzkie allochthonous domain.

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INTRODUCTION

The Góry Bardzkie (Mountains) form a separate structural unit within the West Sudetes of southwestern Poland (Fig.1). They are built up with Palaeozoic sediments which span the late Ordovician to early Carboniferous age and uniquely escaped any regional metamorphic overprint. Within these sediments autochthonous and allochthonous domains can be discerned (see Wajsprych, 1995). The lower Carboniferous flysch deposits, referred to as the Srebrna Góra Formation (Wajsprych, 1986, 1995), contain numerous olistoliths of metasediments with Silurian and Devonian fossils. Conodonts from one of these olistoliths, recently found in the northern part of the Góry Bardzkie, are the subject of the present paper.

The biostratigraphic position of the olistoliths of Palaeozoic rocks in the Góry Bardzkie Mts. has been documented by graptolites (Jaeger, 1959; Teller, 1960; Porębska, 1980; 1984) and conodonts (Haydukiewicz, 1974, 1979, 1980; Chorowska, 1980). A partial presence of the following ages of the Devonian has been proven: Lochkovian, Pragian, late Eifelian, early Givetian, late Frasnian, and middle Famennian. The youngest ages documented to date by conodonts have been the *postera* and Early *expansa Zones* (Haydukiewicz, 1979, 1990).

The purpose of this paper is to report on the occurrence of the Mid- and Late *expansa* and *praesulcata* conodont interval zones which date the latest Famennian age. The presence of these zones indicates that the allochthonous Devonian rocks in the Góry Bardzkie span a larger interval of time than previously documented.

DESCRIPTION OF THE CONODONT LOCALITY AT BARDO ŚLĄSKIE

The locality which yielded conodont fauna is found in the Nysa Klodzka river cut north of a bridge in the middle of the Bardo Śląskie town (Fig. 1). There, the 130 meter long exposure of siliceous rocks consists of several undisturbed intervals, called blocks. Each block is a few to over a dozen meters thick (Figs 2 and 3). The blocks are separated by zones of fault breccia and are built up with dark grey, pelitic, siliceous rock. Siliceous rock layers are usu-

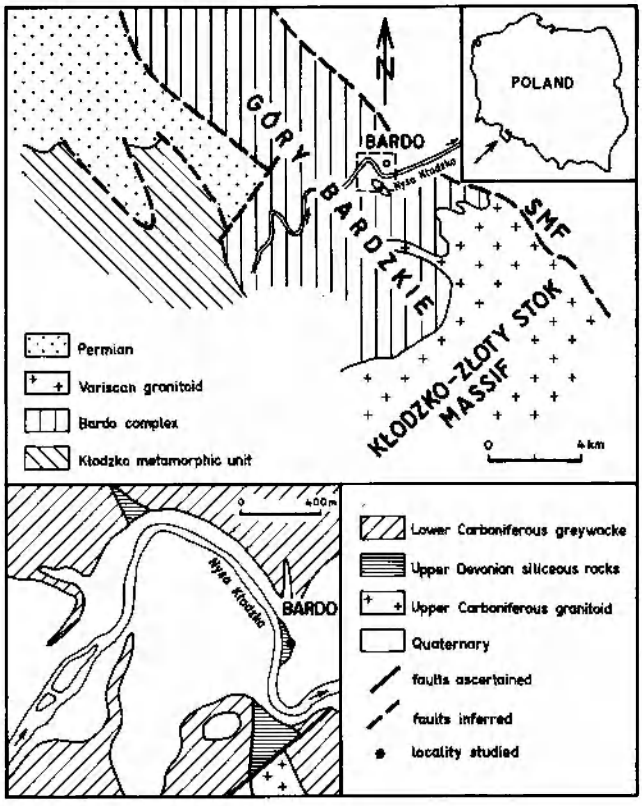

Fig. 1. Location map of the Góry Bardzkie within the West Sudetes with the Bardo area (dashed box) and sketch-map of the Bardo region (modified after Finckh, 1929). SMF Sudetic Marginal Fault

Fig. 2. Position of the conodont-bearing samples in the Block III at the Bardo Śląskie locality (numbers refer to samples as in Table 1). Scale bar is 0.5 m

ally about 0.2 m thick and dip 55–80° steeply towards the north. According to Haydukiewicz (1979), these rocks are a lithofacies of the Zdanów series which has been described by Oberc (1957) as the Mikołajów shale. Wajsprych (1986, 1995) considers these rocks to be allochthonous elements which belong to the Srebrna Góra Formation of the late Visean age.

There are also signs of low-grade contact metamorphism assigned to the Variscan intrusion of the Kłodzko–Złoty Stok granitoid (Oberc, 1957). These are marked by appearance of biotite as the only new mineral (Wierzchołowski, 1976).

The conodonts have been found in four blocks. Two of them from the middle part of the section (designated BIII, BIV on Pl. III, IV), yielded taxonomically identifiable material. Thickness of the layers which comprise block BIII and BIV is 4 m and 2 m, respectively. In addition to conodonts, the samples also yielded scarce radiolaria.

SAMPLING, RECOVERY AND PRESERVATION OF CONODONTS

A total of 155 samples from siliceous rocks have been collected throughout the Bardo Śląskie locality (Fig. 1). The samples were processed for conodont analysis by the standard micropaleontological technique using hydrofluoric acid (Haydukiewicz, 1979). A rough estimation of the relative conodont abundance can be made knowing that 1 kg of rock treated for 20 minutes in 20% HF yielded few to a few dozen specimens from the roughly 10% of the rock which had dissolved.

A total 600 specimens of conodonts were obtained. Most of them represented ramiform elements. Most specimens were damaged, corroded and had split edges. Some specimens were fractured and the fractures filled with quartz veins. Most of the damage is the result of preparation; the fractures, however, are caused by tectonic deformation. Best preserved are small forms less than 1 mm in size, while larger specimens are, as a rule, incomplete.

The colour of the conodonts has changed due to heat. Most of the specimens are black, except the juvenile ramiform elements are grey.

Specimens which are the subject of this report have been stored in the collection of the Institute of Geological Sciences of the Wrocław University under the sample collection # ING/H 106 - 124.

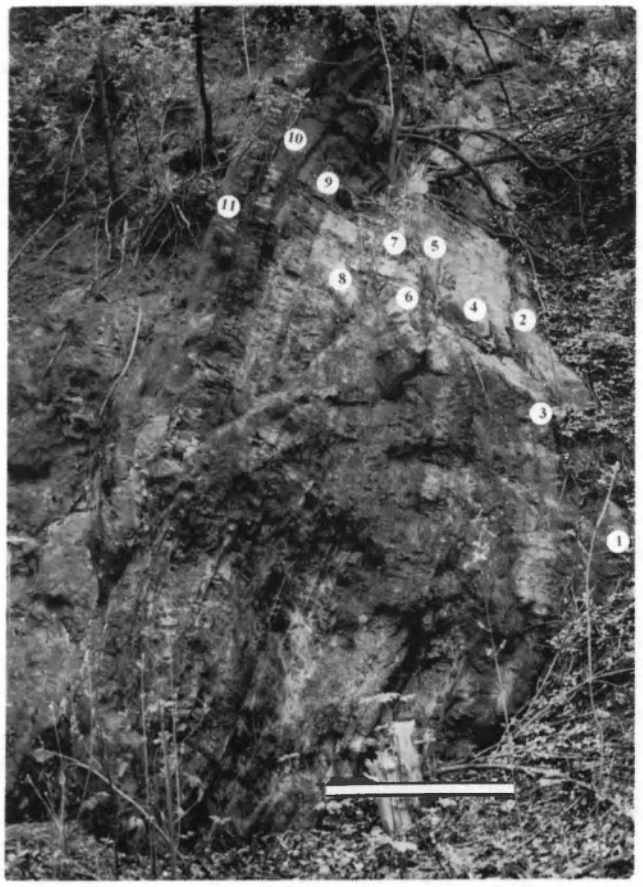

Fig. 3. Position of the conodont-bearing samples in the Block IV at the Bardo Śląskie locality (numbers refer to samples as in Table 2). Scale bar is 0.5 m

BIOSTRATIGRAPHY

The platform elements of the conodonts, which constitute about 43 per cent of specimens, have been utilized in the analysis of the samples.

In this paper has been accepted and utilized the standard Late Devonian conodont zonation revised by Ziegler and Sandberg (1984, 1990). According to these authors "a standard Late Devonian conodont zone has a timespan, the start of which is defined by the first occurrence of a diagnostic species or subspecies and the end of which is defined by the first occurrence of another diagnostic species or subspecies, which preferably is the phyletically next younger taxon". Conodonts of each zone are represented by a distinctive association of conodont elements, which includes the diagnostic taxon defining its beginning. If the diagnostic taxon is absent, a zone can be recognized by the remaining conodont species, and zonal limits can be roughly defined by overlaps in ranges of taxa within successive faunas.

An application of original zone definitions was not possible in the siliceous rocks in the Bardo locality, only several intervals which are equivalents of 3–5zones have been recognised.

BLOCK III

Samples BIII/5 and BIII/9 yielded biostratigraphically significant specimens (Figs 2, 4 and 5, Tab. 1). Sample BIII/5 indicates an interval from the Middle *expansa* Zone to the lower part of the Early *praesulcata* Zone. This interval corresponds to the stratigraphic range of the *Polygnathus znepolensis* (Ziegler & Sandberg, 1984). Sample BIII/9 probably represents the Mid-to-Late *expansa* Zone interval. The lower boundary of this interval is defined by *Polygnathus znepolensis* and the upper by *Palmatolepis perlobata* cf. *schindewolfi*. This taxon reaches up to the Late *expansa* Zone (Ziegler & Sandberg, 1984; Ji & Ziegler, 1993).

BLOCK IV

Table 1

Distribution and relative abundance of conodonts from the siliceous rocks of block BIII

Conodonts	Samples					
	1	5	6	8	9	12
Palmatolepis gracilis gracilis	1				4	
Palmatolepis gracilis sigmoidalis				4	2	
Palmatolepis gracilis subsp. indet.	5	4	3			2
Palmatolepis perlobata schindewolfi				1	1cf	
Palmatolepis sp. indet.	1	1	1	2		
Polygnathus znepolensis		10			2	
Polygnathus sp. indet.	3	5				
Pseudopolygnathus micropunctatus					1	
Pseudopolygnathus sp. indet.					1	
Spathognathodus stabilis		1		2		
Ramiform elements	10	17	13	20	23	14

Taxa identified in samples BIV/2, BIV/3 and BIV/7 are listed in Table 2 (Figs 3–5). Sample BIV/2 indicates an interval from the Early *postera* to Mid-Late *expansa* Zones. This interval covers the maximum stratigraphic range of the *Palmatolepis perlobata postera* (Ziegler & Sandberg 1984; Ji & Ziegler 1993). A narrower interval, namely from the Middle *expansa* Zone to the Early *praesulcata* Zone, has been marked by the *Polygnathus znepolensis* found in the sample BIV/3.

The *Palmatolepis gracilis gracilis*, *P. gracilis sigmoidalis* and *Protognathodus collinsoni* identified in the sample BIV/7 suggest the *praesulcata Zone*. The presence of *Protognathodus collinsoni* suggests that the assemblage cannot be older than the *praesulcata* Zone because the occurrence of this form has been reported slightly above the lower boundary of this zone (Ziegler & Sandberg, 1984). On the

Table 2

Distribution and relative abundance of conodonts from the siliceous rocks of block BIV

Conodonts	Samples										
	1	2	3	4	5	6	7	8	9	10	11
Palmatolepis gracilis gracilis		12		2	8		37		2	3	1
Palmatolepis gracilis sigmoidalis		5	6	9	2		27	2	4	2	3
Palmatolepis gracilis subsp. indet.		8	4			5				8	2
Palmatolepis perlobata postera		1									
Palmatolepis ex. gr. perlobata		1	2								
Polygnathus znepolensis			3								
Polygnathus communis communis					3		15			11	
Protognathodus collinsoni							1				
Pseudopolygnathus dentilineatus							1				
Pseudopolygnathus sp. indet.		1									
Spathognathodus stabilis		2			2	4	8		1	7	1
Platform fragments	1	1	10	2			9	1			
Ramiform elements	8	18	35	17	13	7	86	7	6	25	8

other hand, the predominance of *Palmatolepis gracilis gracilis* and *P. gracilis sigmoidalis* as well as a lack of early Tournaisian *sulcata* Zone specimens precludes the possibility that BIV/7 is of Carboniferous age. It is worth noting that the above mentioned subspecies were recorded within the *sulcata* Zone (cf. Ji, 1987; Gagiev & Kononova, 1990; Nemirovskaya *et al.*, 1992; Kürschner *et al.*, 1992) but only in single specimens. Lack of index species in the sample BIV/7 hampers the possibility of further subdivision of this zone.

Aforementioned stratigraphic ranges of the identified interval zones imply that the middle and the upper layers of the block III (samples from BIII/5 to 9) span the Mid-to-Late *expansa* Zone. The lowermost layers of the block III are probably of the same age or slightly older but this is rather hypothetical because of sparse recovery and poor preservation of the specimens. For the same reason, the lower and the upper part of the block IV can not be precisely dated. Its lower layers might be considered younger than Late *expansa* Zone (sample BIV/2). The middle part of the block (samples BIV/3-6) represents Mid-*expansa* to Early *praesulcata* zones, and the upper part of the block (samples BIV/7-11) indicates undivided *praesulcata* Zone.

COLOUR OF THE SPECIMENS AND THE PALEOTEMPERATURE

The estimation of the organic maturity of sediments based on the colour alteration of microfossils has been performed routinely in many sedimentary basins (Epstein *et al.*, 1977; Aldridge, 1986; Belka, 1982, 1990, 1993; Bender & Königshof 1994; Burnet *et al.*, 1994; Jones, 1992). The Colour Alteration Index (Rejebian *et al.*, 1987) has been utilized in order to establish paleotemperature and organic maturity of the conodont specimens from the siliceous rocks in question.

The conodonts from the described locality are intensely black in colour except for the juvenile ramiform specimens which are grey. Using the scale of Rejebian *et al.* (1987) the CAI value is 5 which suggests a temperature between 300 to 480°. Considering the high content of silica in the analyzed samples, which probably have had a negative impact on the degree of alteration, it can be assumed that the conodonts from the locality in question turned black below 300°C (4.5 CAI corresponds to 230–340°C; cf. Jones, 1992, Fig.1). According to Rejebian *et al.* (1987) the minimal temperature in which the platform elements of the conodonts change from black to grey is 360°C (Rejebian *et al.*, 1987, Fig. 2B) and this has not been observed in the samples in question (only thin ramiform elements have grey coloration). Therefore, it seems reasonable to assume temperatures between 300°C and 360°C for the analyzed samples.

The so called Graniec–Bardo apophysis of the Klodzko–Zloty Stok granitoid (tonalite) intrusion crops-out at a distance of about 600 m from the conodont-bearing siliceous rocks in question. In pelitic sediments altered within a thermal aureole only biotite appears 600 up to 2200 m from the intrusion suggesting temperatures from 400 to 515°C (Wierzcholowski, 1976). It is worth noting that the CAI values for siliceous rocks are usually about one half unit lower than for non-siliceous rocks (Belka, 1993).

Thermal alteration of the conodont-bearing siliceous

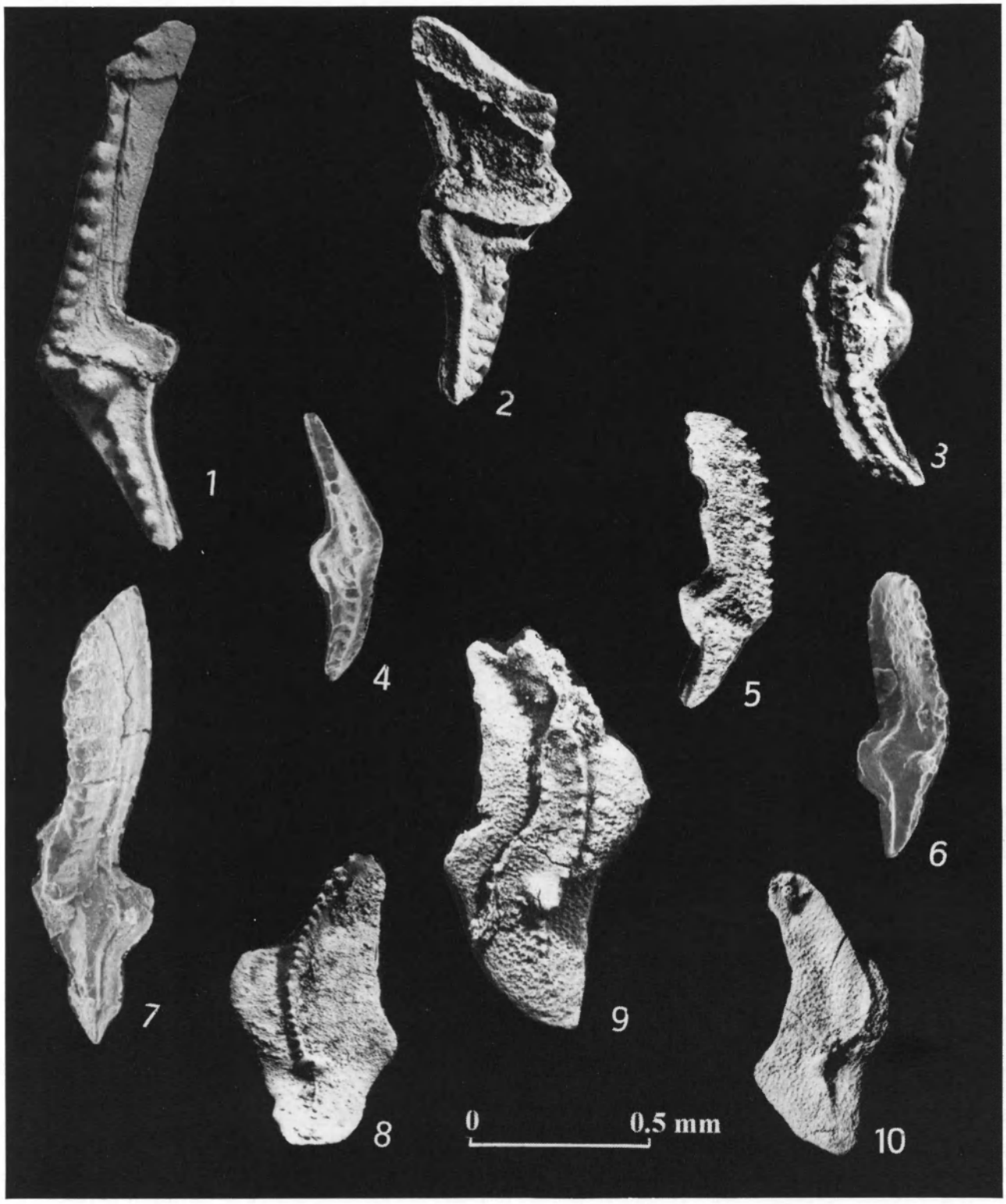

Fig. 4. Conodonts retrieved at the Bardo Śląskie locality. Genus *Palmatolepis*.
Palmatolepis gracilis gracilis Branson & Mehl, 1934: 1 – specimen with the free blade broken longitudinally, upper view, sample BIII/9; 2 – specimen cut by quartz vein, lateral view, sample BIII/9; 3 – nearly complete specimen, upper view, sample BIV/7; 4 – incomplete specimen, upper view, sample BIV/7; 7 – specimen interpreted as a form transitional to *Palmatolepis gracilis sigmoidalis*, the free blade is fissured, oblique upper view, sample BIV/7. *Palmatolepis gracilis sigmoidalis* Ziegler, 1962: 5 – oblique upper view, sample BIV/4; 6 – oblique upper view, sample BIV/7. *Palmatolepis perlobata schindewolfi* Müller, 1956: 8 – specimen with strongly upward bent posterior part of the platform, upper view, sample BIII/8. *Palmatolepis perlobata* cf. *schindewolfi* Muller, 1956: 9 – incomplete specimen with strongly corroded platform, upper view, sample BIII/9. *Palmatolepis perlobata postera* Ziegler, 1960: 10 – juvenile specimen showing narrow inner parapet paralleling the platform.

Fig. 5. Conodonts retrieved at the Bardo Śląskie locality. Genera *Polygnathus, Protognathodus, Pseudopolygnathus*. *Polygnathus znepolensis* Spasov, 1965: 1 – upper view, sample BIV/3; 2 – oblique upper view, sample BIII/5; 3 – specimen damaged after identification, upper view, sample BIII/9. *Polygnathus communis communis* Branson & Mehl, 1934: 4 – incomplete specimen, upper view, sample BIV/7; 5 – incomplete specimen, lower view, sample BIV/7; 6 – juvenile form, oblique upper view, sample BIV/7. *Protognathodus collinsoni* Ziegler, 1969: 7 – form transitional to *Protognathodus kockeli*, upper view, sample BIV/7. *Pseudopolygnathus dentilineatus* Branson, 1934: 8 – specimen with corroded platform, oblique upper view, sample BIV/7. *Pseudopolygnathus micropunctatus* Bischoff & Ziegler, 1956: 9 – oblique upper view, sample BIII/9.

rock took place in late Carboniferous time. The K-Ar volumetric method applied by Depciuch (1972) gave 298 Ma as an average age of the Kłodzko-Złoty Stok intrusion. A hypotethical duration of the thermal alteration process has been estimated at 500 000 years (Wierzchołowski, 1976).

DISCUSSION AND CONCLUSIONS

The Mid-to-Late *expansa* and an undivided *praesulcata* conodont interval zones which have been documented in this paper from the Bardo Śląskie locality suggest the latest Famennian age for the siliceous rock in question. It is therefore reasonable to assume the presence of the entire Upper Devonian in the Góry Bardzkie area and a continuous sedimentation throughout the Devonian/Carboniferous boundary in the basin.

It appeared impossible to establish the exact conodont frequency relations in a given sample, nevertheless it was clear that significant differences in the number of elements between samples did exist. In almost all analyzed samples which contained the platform elements (with the exception of BIII/5) the *Palmatolepis* genera predominates over the *Polygnathus*, the second most frequent appeared to be *Spathognathodus stabilis* (identified in most samples of the BIV block).

The *Palmatolepis* and *Polygnathus* predominate in the deepest pelagic sedimentary environment of the late-Devonian sea. According to the existing biofacial models (Sandberg, 1976; Sandberg & Ziegler, 1979; Sandberg & Dreesen, 1984; Ziegler & Sandberg, 1984; Sandberg *et al.*, 1988) these genera dominate the palamtolepid or the palmatolepid-bispatoid (I), and the palmatolepid-polygnatid biofacies (II). The presence of the deep marine biofacies as well as the pelagic lithological character of the siliceous rocks from the Bardo Śląskie locality strongly suggest the presence of similar facies of early Carboniferous age in this part of the basin.

In the southern part of the Góry Bardzkie, in the Gologowy section, the facies is different. There, the late Famennian is represented by limestone which belongs to the Mid-to-Late *expansa* Zone. Above, there are argillaceous sediments of Tournaisan age (Late *duplicata* to *sandbergi* Zones). A hiatus which apparently occurs between the Famennian and Tournaisian spans the Late *expansa* and Early *duplicata* Zones. The cause of this break is not clear, but it is not impossible that the break is of a tectonic nature (Haydukiewicz, 1981). A similar situation has been reported from the NW part of the Góry Bardzkie (Wapnica section) where the upper Devonian limestone is overlain by the lower Carboniferous sediments (Schiendewolf, 1937; Lewowicki, 1959; Weyer, 1965; Freyer, 1968) with a break representing almost the entire *praesulcata* interval up to the *duplicata* Zone (Oberc & Chorowska, 1980).

The siliceous rock from the Bardo Śląskie section represents the *praesulcata* interval which is missing in the aforementioned Gologowy and Wapnica sections. It should be stressed, however, that an almost continuous succession of the Upper Devonian to Lower Carboniferous in the Góry Bardzkie has been documented paleontologically only from allochthonous domain. The siliceous rock in question has been thermally (300–360°C) altered by the Kłodzko–Zloty Stok granitoid intrusion during the late Carboniferous.

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