Marek NARKIEWICZ, Katarzyna NARKIEWICZ

Transgressive pulse in the Upper Frasnian of the Janczyce I section (Holy Cross Mts): sedimentology and conodont biofacies

The Upper Frasnian part of the Janczyce I borehole section displays sedimentological as well as biofacies evidence of a transgressive event. It corresponds to the lithological boundary between the nodular limestones unit and the laminated marly limestones unit. According to the conodont zonation it represents most probably the late part of the Late *rhenana* Zone. The transgressive pulse caused deepening of a sedimentary environment probably by ca. 50 m: from near the aerobic/dysaerobic zone boundary under photic and intermittent wave-influence, to anaerobic and aphotic zone below storm wavebase.

INTRODUCTION

Transgressive-regressive sequences reflect successive stages of formation and development of sedimentary basins, thus constituting important elements of a depositional basin-architecture (M. Narkiewicz, 1991 and the literature cited therein). In turn, most important methods of studying sea-level changes include analysis of vertical facies sequences (e. g. J. G. Johnson et al., 1985; J. Dadlez, R. Dadlez, 1986; M. Narkiewicz, 1987). In the present paper, independent sedimentological and biofacies evidence was used in order to document and interpret the transgressive episode recorded in the Upper Devonian part of the Janczyce I borehole section. The section is located in the eastern part of the Holy Cross Mts, southern Poland (Fig. 1). It forms an important stratigraphical reference in geological studies of the Devonian carbonates in the southern (Kielce) region of the Holy Cross area (M. Narkiewicz, I. Olkowicz-Paprocka, 1983).
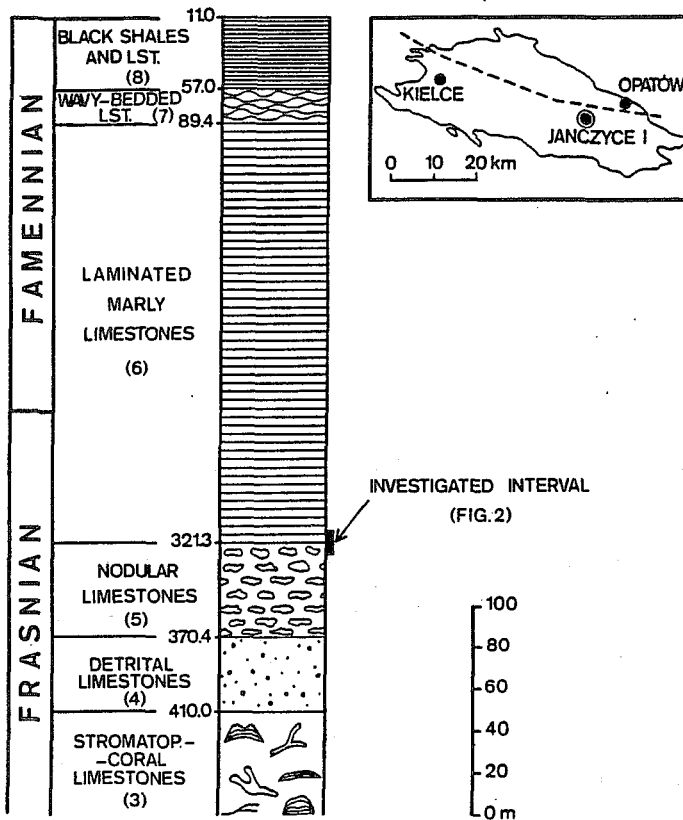
Fig. 1. Location of the Janczyce I borehole against the outline of the Paleozoic core of the Holy Cross Mts (map) and the location of the investigated part of the section within the framework of the Upper Devonian stratigraphy. Broken line on the map marks the course of the important Holy Cross Dislocation coinciding with the northern limit of the Kielce Region. Lithostratigraphy after M. Narkiewicz and I. Olkowicz-Paprocka (1983)

Lokalizacja profilu Janczyce I na tle zarysu trzonu paleozoicznego Gór Świętokrzyskich (mapka) oraz położenie badanej części profilu na tle podziału stratygraficznego górnego dewonu. Linią przerywaną zaznaczono na mapce przebieg dyslokacji świętokrzyskiej. Litostratygrafia według M. Narkiewicza i I. Olkowicz-Paprockiej (1983)

The Janczyce I borehole was fully cored, cores being stored in the core repository of the State Geological Institute in Iwiczna. For the purposes of the present study, we measured and sampled the interval of 11 m (Fig. 2) including the boundary between the nodular limestones (unit 5 according to the above cited authors) and the laminated marly limestones (unit 6). Investigations embraced 14 conodont samples (location on Fig. 2), 15 thin sections and 15 polished sections.

lems. The drawings were made by A. Chwesiuk, and the photographs of thin- and polished-sections were taken by J. Modrzejewska.

SEDIMENTOLOGY

Investigated section (Fig. 2) represents the uppermost part of the nodular lime-stones unit and atypical basal part of the laminated marly limestones unit. For the purposes of the present study we define the latter as the "Basal Member" (described below) overlain by a typical monotonous clayey-calcareous sequence.

N o d u l a r   l i m e s t o n e s. These are dark, almost black lime mudstones to grainstones, with variable clay admixture concentrated in a matrix between nodules, and as residual seams in otherwise homogeneous mudstones. The nodular structure displays irregular variability. In places nodules are "typical", i. e. globular and lense--shaped with their longer axes parallel to the bedding, and with diffuse lateral boun-daries. Such a structure may, however, grade to chaotically-oriented micritic fragments showing sharp outlines and more differentiated shapes and sizes (Pl. I, Figs 1, 2; cf. also M. Narkiewicz, I. Olkowicz-Paprocka, 1983, Tabl. VII, Figs 23, 25). The latter variety, comparable in many respects to intraformational conglomerates, is accompa-nied by redeposited and reworked skeletons of crinoids, stromatoporoids and corals, particularly in the lower part of the described unit.

The upper part of the nodular limestones contains moderately common brachio-pod and crinoid skeletons. Moreover, in thin sections we found remains of ostracods, tentaculitoids, tubular algae, gastropods, and, in the lower part of the unit, also calcispheres, foraminifers and an alga *Girvanella*. Bioturbation is common, expressed as well-defined cylindrical burrows, as a chaotic orientation of skeletal components, and in the form of pelletization of marly-micritic matrix (Pl. I, Fig. 3).

Pyrite is a common component, developed as millimeter-sized euhedral crystals (mostly in more clayey rocks), and in the form of microcrystalline impregnations. The latter occur within some burrows, but mostly within a micritic matrix. Here, they form spherical concentrations less than a millimeter to more than ten millimeters in diameter. Their outlines may be gradual or sharp. In the latter case, pyrite may concentrate in a rim or in a centre, and grain boundary may display traces of mechani-cal or organic abrasion (Pl. I, Fig. 3). Such grains may form protruding elements of above described redeposited nodules, and also they may have umbrella structures associated with them.

L a m i n a t e d   m a r l y   l i m e s t o n e s. These are monotonous dark-grey to black bituminous marly lime mudstones and marls. An average contents of a clay admixture is considerably higher than in the nodular limestones (I. Olkowicz-Pa-procka, M. Narkiewicz, 1986, Tab. 1).

Characteristic for the described deposits is the co-occurrence of purely micritic laminae and layers, with darker, more clayey intercalations. Bedding varies in the section from even to flaser and wavy (M. Narkiewicz, I. Olkowicz-Paprocka, 1983, Tabl. VII, Fig. 24). There occur also stronger intraformational deformations in the form of folds, sedimentary boudinage, intra-bed micro-faults etc. On the other hand,
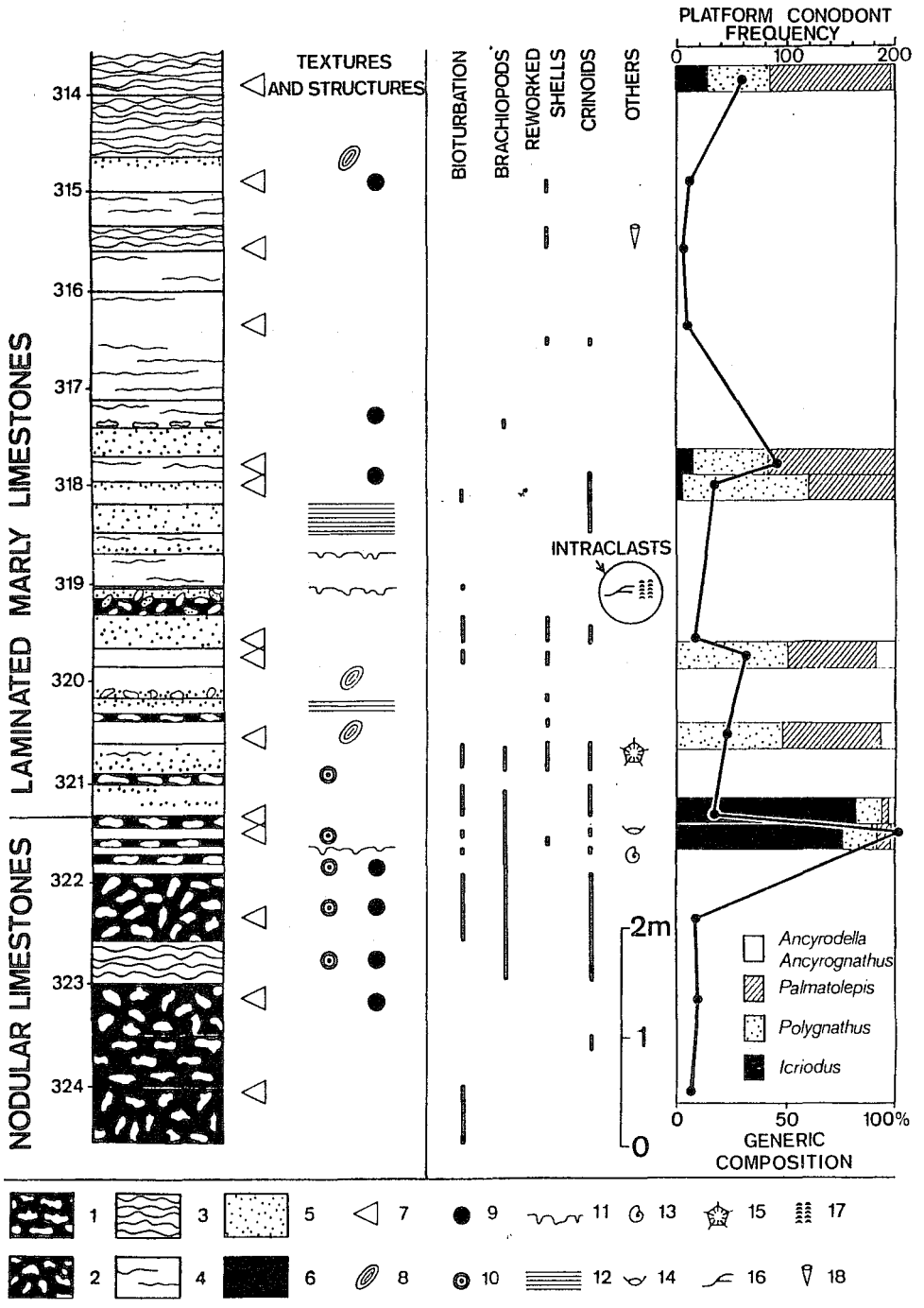
the above structures are never accompanied by detrital layers, intraformational conglomerates and other evidence of redeposition. Typical nodular structure occurs subordinately, more common are calcareous lenses or concretions embedded in a marly matrix. Lamination — ranging from even and parallel to wavy and irregular — consists of an alternation of millimeter-thick micritic and clay-rich laminae. The latter are enriched also in organic matter and/or in fine skeletal material (H. Matyja, M. Narkiewicz, 1992, Pl. 5, Figs 1, 3).

In general, organic skeletons are much less important quantitatively than in the nodular limestones. Tentaculitoid skeletons may be common in a lower part of the unit, and cephalopods occur in several beds in the Famennian portion. Other rare constituents are brachiopods, radiolaria, foraminifers, and entomozoid ostracods. Bioturbation is remarkably less ubiquitous than in the nodular limestones while pyrite is as common.

B a s a l   M e m b e r . This is a lithological complex occurring at the base of the above described unit (depth 314.7–321.3 m) and in several aspects transitional to the underlying nodular limestones. Its characteristic feature consists in interlayering of grey-beige, regularly bedded calcilutites 10 to 40 cm thick, with calcarenite beds being 5 to 30 cm thick. Clay admixture is generally insignificant, and intercalations of black marly shale and nodular limestone occur subordinately.

Calcilutite beds consist, in variable proportions, of lime mud and grains, ranging from lime mudstones to packstones. Common features are wavy clayey seams and pyritization in the form of above described concentrations and grains. Generally strong infaunal activity is evidenced by a chaotic arrangement of skeletal fragments, well-defined disruptions of detrital/muddy laminae, as well as by variously oriented cylidrical burrows, 2 to 5 mm in width, filled partly or entirely with a micritic or detrital sediment. Among typical organic components are crinoid fragments, brachiopods, cephalopods, tentaculitoids, and, less common, small gastropods, foraminifers, ostracods, calcispheres, small sparry tubes (algae ?) and fine indeterminable skeletal detritus.

Fig. 2. Lithology, sedimentological characteristics, organic constituents and conodont biofacies at the boundary between the nodular limestones and the marly laminated limestones in the Janczyce I section
1 — typical nodular structure; 2 — redeposited nodules and/or other intraclasts in a marly-micritix matrix; 3 — wavy-bedded lime mudstones; 4 — mudstones to wackestones with a few residual clayey seams; 5 — calcarenites (packstones to grainstones); 6 — marls; 7 — conodont samples; 8 — oncoids; 9 — homogeneously pyritized grains; 10 — grains/oncoids with a concentric pyritization; 11 — erosional surfaces; 12 — even lamination; organic skeletons: 13 — cephalopods, 14 — ostracods, 15 — massive *Rugosa*, 16 — branching stromatoporoids, 17 — *Renalcis*, 18 — tentaculitoids
Litologia, charakterystyka sedymentologiczna, występowanie fauny i biofacje konodontowe na pograniczu wapieni gruzłowych i laminowanych wapieni marglistych w profilu Janczyce I
1 — typowa struktura gruzłowa; 2 — redeponowane gruzły i/lub inne intraklasty w mikrytowo-marglistym tle skalnym; 3 — wapienie mikrytowe o falistym warstwowaniu; 4 — wapienie mikrytowe do mikrytowo-ziarnowych z pojedynczymi ilastymi smugami rezydualnymi; 5 — kalkarenity (wapienie ziarnowo-mikrytowe do ziarnowych); 6 — margle; 7 — próbki konodontowe; 8 — onkoidy; 9 — ziarna z jednorodną pirytyzacją; 10 — ziarna/onkoidy z koncentryczną pirytyzacją; 11 — powierzchnie erozyjne; 12 — laminacja płaska; szkielety organiczne: 13 — głowonogów, 14 — małżoraczków, 15 — korali *Rugosa* masywnych, 16 — stromatoporoidów gałązkowych, 17 — *Renalcis*, 18 — tentakulitoidów

The described deposits contain several oncoid-rich horizons (Pl. II, Fig. 2). The oncoids are mostly globular to discoidal in shape, ranging to 1 cm in diameter, and displaying poorly developed concentric structure (Spongiostromata according to T. M. Peryt, 1981). Different oncoid varieties, ascribed here to Porostromata, display a distinct skeletal structure. It is expressed in the form of alternating submillimeter--thick sparitic/micritic lamellae, irregularly enveloping micritic sediment fragments or skeletal particles (Pl. III, Figs 1, 2). Grain shapes may be globular to irregular, elongated and grape-like in a case of compound forms. Concentric layers envelope few primary pores and skeletal elements, and some laminae are selectively replaced by finely-crystalline dispersed pyrite.

The detrital intercalations range from homogeneous to evenly and parallel laminated, to normally or reversely graded (Fig. 2). In a few cases they rest on clearly erosional surfaces. Single bed of intraformational conglomerate reveals calcilutite and calcarenite clasts, the latter containing *Amphipora* and *Renalcis* skeletons (Pl. II, Fig. 1). In addition to grainstones also packstones were found (intrabiomicrites to sparites) with sorting and rounding of detrital particles being medium or poor. At least some intraclasts have an algal origin. Among bioclasts, macroscopically discernible are most commonly brachiopod and crinoid fragments, and, in a single case, also massive corals. Moreover, thin-sections reveal algal fragments (*Solenoporaceae, Girvanella, Renalcis*, kamaenids), stromatoporoids, including branching forms, gastropods, calcispheres, ostracods, foraminifers, and a few bryozoans and tentaculitoids (Pl. II, Fig. 3; Pl. III, Fig. 3).

BIOSTRATIGRAPHY

Biostratigraphic analysis was based solely on platform elements. Ranges of particular taxa were compared within the framework of the most recent Upper Devonian zonation scheme embracing 32 zones and including recently revised Frasnian zones (C. A. Sandberg et al., 1988, 1989; W. Ziegler, C. A. Sandberg, 1990). In the cited papers, names and definitions of the Frasnian zones were based exclusively on an evolution of the genus *Palmatolepis*, using ranges of nominal species for delimitation of particular zones.

We processed 15 conodont samples of averge weight ca. 0.5 kg. Only one sample appeared barren, remaining samples revealed frequency between 6 and 207 specimens (Tab. 1). Total number of platform specimens is 626; they were assigned to 22 taxa of species and subspecies rank. Plate IV (Figs 1–11) illustrates stratigraphically important forms. Up to date most of these forms were not illustrated in the Polish literature.

Precise age determination of the three lowermost samples (324.2 to 322.3 m) is difficult. *Polygnathus webbi* Miller et Youngquist displays wide stratigraphical range. In turn, *Icriodus* cf. *I. alternatus* sensu Sandberg et Dreesen, 1984 ranges from the Late *hassi* Zone to the Late *rhenana* Zone in the sections studied by W. Ziegler, C. A. Sandberg (1990, Tabs 2, 7). Also *Palmatolepis hassi* Müller et Müller and *Ancyrodella nodosa* Ulrich et Bassler were introduced in the Early Frasnian: *P. hassi* Müller et Müller ranges from the nominal zone to an early part of the *linguiformis* Zone, and *A.*

nodosa Ulrich et Bassler from the Late *hassi* to *linguiformis* Zone (W. Ziegler, C. A. Sandberg, 1990, Tabs 1–4, 7).

Rich microfaunal assemblage was found in the sample from depth 321.4–321.5 m. Here, *Icriodus alternatus helmsi* Sandberg et Dreesen defines the lower limit of the age interval at the late part of the Late *rhenana* Zone. The upper limit is indicated by the termination of *Ancyrognathus triangularis* Youngquist in early part of the *linguiformis* Zone. Age of the upper sample (321.3–321.4 m) was determined basing on the co-occurrence of *Icriodus alternatus helmsi* Sandberg et Dreesen with *Ancyrodella lobata* Branson et Mehl. In the sections studied by W. Ziegler, C. A. Sandberg (1990) the latter species disappears in an early part of the *linguiformis* Zone.

Other conodonts with narrow stratigraphical ranges were found in the sample from depth 319.6–319.7 m. These are forms *Palmatolepis rotunda* Ziegler et Sandberg and *P. subrecta* Miller et Youngquist which restrict the possible age interval to the Late *rhenana — linguiformis* zones. The occurrence of *A. nodosa* Ulrich et Bassler may point that the sample is not later than an early part of the *linguiformis* Zone. Age of the following sample (319.5–319.6 m) is determined by the presence of *P. hassi* Müller et Müller and *P. rhenana nasuta* Müller which disappear in the *linguiformis* Zone. Numerous conodonts were also found in the sample from depth 317.7–317.9 m. Earlier age limit is defined by the presence of *P. subrecta* Miller et Youngquist (Late *rhenana* Zone) while the later one — by the termination of *Ancyrodella nodosa* Ulrich et Bassler and *Polygnathus pacificus* Savage et Fuani (early part of the *linguiformis* Zone).

The age of the uppermost of the investigated samples (313.7–313.9 m) covers the time-span from the late part of the Late *rhenana* Zone (presence of *Icriodus alternatus helmsi* Sandberg et Dreesen) to the *linguiformis* Zone. The latter age is indicated by the presence of *Polygnathus pacificus* Savage et Fuani disappearing before the end of *linguiformis* Zone, in sections studied by W. Ziegler, C. A. Sandberg (1990).

In summary of the biostratigraphic considerations, the lower part of the section represented by the lowest three samples is not later than the Late *rhenana* Zone. In turn, almost entire studied depth interval (321.5–313.7 m) represents the narrow age interval not exceeding the Late *rhenana* to *linguiformis* zones. There are certain premises allowing a further narrowing of that age interval to merely the late part of the Late *rhenana* Zone. Lower age limit is determined by the presence of the above mentioned *Icriodus alternatus helmsi* Sandberg et Dreesen. Upper limit is more difficult to determine as forms disappearing at the *rhenana/linguiformis* boundary are missing in the investigated material. Some of the well-known forms, i. e. *Ancyrognathus triangularis* Youngquist, and, particularly, *Ancyrodella lobata* Branson et Mehl and *A. nodosa* Ulrich et Bassler, were reported in the literature as ranging to an earlier part of the *linguiformis* Zone at most. In turn, G. Klapper, H. R. Lane (1985) report on the occurrence of *Polygnathus aequalis* Klapper et Lane, *P. alatus* Huddle and *P. evidens* Klapper et Lane in the deposits not younger then the Lower–Upper *gigas* (= *rhenana*) zones. Other premise suggesting the lack of the *linguiformis* Zone in the investigated section is the absence of taxa appearing in the critical zone, including the nominal species in particular. *Palmotolepis linguiformis* Müller was found much higher above the studied interval in the Janczyce I section (H. Matyja, M. Narkiewicz, in press). In general, however, this species is rare and composes only up to 2% of the total coeval

Occurrence and frequency of conodonts in the studied interval of the Janczyce I section

Species	Late *hassi* Zone – Late *rhenana* Zone			Late *rhenana* Zone – ?*linguiformis* Zone										
	depth in m													
	324.0–324.2	323.1–323.25	322.3–322.5	321.4–321.5	321.3–321.4	3205–320.6	319.6–319.7	319.5–319.6	318.0–318.15	317.7–317.9	316.3–316.4	315.6	314.8–314.9	313.7–313.9
Polygnathus webbi Miller et Youngquist	2			6		1	1	2	3	3	3	1	3	6
Polygnathus brevis Miller et Youngquist						1				1				
Polygnathus alatus Huddle								1	1					
Polygnathus decorosus Stauffer				2		4	10		8	3			1	
Polygnathus pacificus Savage et Fuani										1			1	1
Polygnathus aequalis Klapper et Lane						6	11		6				2	
Polygnathus evidens Klapper et Lane								1		7				
Polygnathus sp. A				1										1
Polygnathus sp. B										1				
Polygnathus sp. C							1							
Polygnathus sp. D				1										
Polygnathus juven.	1	6	3	19		3	8		1	14	2			6
Polygnathus sp. indet.		1	3	1	4	6	4		4	1	1	1	1	2
Ancyrodella lobata Branson et Mehl					1									
Ancyrodella buckeyensis Stauffer													1	
Ancyrodella curvata (Branson et Mehl)											1			1
Ancyrodella nodosa Ulrich et Bassler		1		2			6	1		1				
Ancyrodella sp. indet. Youngquist						2								
Ancyrognathus triangularis Youngquist				2		1								
Palmatolepis hassi Müller et Müller		1		5		2	8	2		12			2	3
Palmatolepis gigas paragigas Ziegler et Sandberg				2			1							
Palmatolepis rhenana nasuta Müller							1	1						1
Palmatolepis rotunda Ziegler et Sandberg							2							

	Palmatolepis subrecta Miller et Youngquist	Palmatolepis sp. A	Palmatolepis sp. B	Palmatolepis sp. C	Palmatolepis juven.	Palmatolepis sp. indet.	Icriodus subterminus Youngquist	Icriodus symmetricus Branson et Mehl	Icriodus cf. Icriodus alternatus (sensu Sandberg et Dreesen, 1984)	Icriodus alternatus alternatus Branson et Mehl	Icriodus alternatus helmsi Sandberg et Dreesen	Icriodus juven.	Icriodus sp. indet.
	3	1					1	12	11	1	2	3	1	2
										1			1	
								2	1	1			1	
									3					
	2							24	15	4			1	2
								14		1				
								8		1				
	2	1					2	8						
							9	9						
					1					18		1	2	6
			4		4	1	1			148	7			
					7		2	1			2			
			4	2			3							
			2		5				1					

Palmatolepis population, being interpreted as a deeper-water species (C. A. Sandberg et al., 1988, p. 280). Thus, one cannot exclude an influence of paleoecological factors on the distribution of the described species in the studied section.

The above characterized depth interval 321.5 to 313.7 m comprises the top of the nodular limestones unit together with the facies transition analysed in detail in the present paper (= Basal Member). One may thus assume that the above transition represents most probably the narrow age-interval of a late part of the *rhenana* Zone.

CONODONT BIOFACIES

Introductory remarks. First attempts of a paleoecological interpretation of conodont occurrences date back to the early seventies (G. Seddon, 1970; G. Seddon, W. C. Sweet, 1971; E. C. Druce, 1973). The second of the cited papers introduced the notion of a conodont biofacies to the geological literature. G. Seddon, W. C. Sweet (1971) considered the Late Devonian *Icriodus* and *Palmatolepis* biofacies as being shallow- and deeper-water, respectively. In turn, E. C. Druce (1973) interpreted the three described biofacies in terms of both paleobathymetry and proximity to a nearshore zone.

C. A. Sandberg (1976) defined a conodont biofacies as a conodont assemblage including one or two genera that constitute at least 65% of the total population. Subsequently, C. A. Sandberg et al. (1988), adopted a higher treshold value of 75%. C. A. Sandberg (1976) described five biofacies (I–V) from the Late Famennian deposits of the U.S.A., and he ascribed these biofacies to the five palaeogeographic zones — from deep,

pelagic to shallow, nearshore. Since the cited paper had been published, a total number of the Late Devonian biofacies increased to about a dozen. Following biofacies had been reported from the Frasnian: palmatolepid (I), palmatolepid-polygnathid (II), polygnathid-ancyrodellid (XI — C. A. Sandberg, R. Dreesen, 1984), polygnathid (X — C. A. Sandberg, F. G. Poole, 1977; G. Klapper, H. R. Lane, 1985), polygnathid-icriodid (III), polygnathid-pelekysgnathid (IV — C. A. Sandberg, R. Dreesen, 1984; C. A. Sandberg et al., 1988, p. 273). Moreover, in more recent publications several authors propose that paleoecology of conodonts should be investigated on a species level rather than on a generic one (G. Klapper, H. R. Lane, 1985; W. C. Sweet, 1988; Z. Bełka, J. Wendt, 1992). This approach is substantiated by growing amount of data on different, facies-controlled distribution of particular species belonging to the same genera.

Conodont biofacies concept is being applied in a correlation of coeval microfaunal assemblages associated with different lithofacies (e. g. G. Seddon, 1970; C. A. Sandberg, R. Dreesen, 1984), in an interpretation of overall paleogeographic realms (C. A. Sandberg, F. G. Poole, 1977; H. Matyja, 1987), and in a detection, interpretation and correlation of transgressive-regressive cycles (e. g. C. A. Sandberg et al., 1988; M. Szulczewski, 1989; G. Racki, 1990; H. Matyja, M. Narkiewicz, in press).

Investigated material. From the total number of 14 studied conodont samples we selected only those with a frequency of platform elements exceeding 30 (7 samples, 538 specimens).

We were able to establish the presence of two biofacies among the investigated samples: icriodid and palmatolepid-polygnathid (Fig. 2). The former occurs in two samples from depths 321.4–321.5 and 321.3–321.4 m. In both the cases the genus *Icriodus* distinctly predominates (76 and 82%, respectively), with much lower *Polygnathus* percentage (15 and 12%), and subordinate *Palmatolepis* (7 and 3%). *Ancyrodella* and *Ancyrognathus* (total 2 and 3% in respective samples) are quantitatively insignificant, similarly as in remaining samples.

Palmatolepid-polygnathid biofacies occurs in five of the studied samples. Percentages of *Palmatolepis* and *Polygnathus* forms, respectively, are as follows: 45 and 48% (320.5–320.6 m), 38 and 53% (319.6–319.7 m), 37 and 60% (318.0–318.15 m) 58 and 33% (317.7–317.9 m), and 56 and 28% (313.7–313.9 m). Both the genera distinctly predominate, while the *Icriodus* percentage varies from zero in the two lowermost samples to 8 and 14% in the two uppermost ones.

Vertical biofacies succession (Fig. 2) demonstrates that there exist distinct transition from the icriodid biofacies characterizing the topmost part of the nodular limestones to the palmatolepid-polygnathid biofacies in the basal part of the laminated marly limestones. Generic composition of poor samples (not included into the quantitative considerations) generally confirms above pattern. However, such samples may show irregular variability in mutual proportions of dominant genera. Composition of a few samples from the lower part of the nodular limestones (H. Matyja, unpublished data) suggests the occurrence of the polygnathid-icriodid biofacies, with a subordinate presence of *Palmatolepis*. In turn, data from the laminated marly limestones point to a continuity of the palmatolepid-polygnathid biofacies.

It appears from the presented data that the investigated lithostratigraphic boundary (Figs 1, 2) coincides with a turning point in a biofacies sequence: replacement of *Icriodus* — dominated assemblages by the palmatolepid-polygnathid biofacies. Moreover, within the latter biofacies one may discern a characteristic bipartition of the section. In its lower part, down to the depth of about 318 m, genus *Polygnathus* predominates over *Palmatolepis*, while higher up the proportion reverses.

I n t e r p r e t a t i o n. Interpretation of the described biofacies using the current concepts of the Late Devonian conodont paleoecology (G. Seddon, W. C. Sweet, 1971; E. C. Druce, 1973; C. A. Sandberg, 1976; C. A. Sandberg et al., 1988) leads to a conclusion that the investigated succession represents a transition from shallower, more nearshore environments to deeper, more open-marine ones. G. Seddon (1970), and G. Seddon, W. C. Sweet (1971) regarded *Icriodus* as an indicator of a shallow--water deposition. E. C. Druce (1973) assumed that the *Icriodus* biofacies is typical for water depths not exceeding 50 m, while the *Palmatolepis* biofacies characterizes deeper waters. Among the Frasnian representatives of the genus *Icriodus* there is an exceptional species — *I. symmetricus* Branson et Mehl — which, according to E. C. Druce (1975), is more characteristic for the deeper-water biofacies III (cf. also G. Klapper, H. R. Lane, 1985). Our investigations confirm this interpretation as most of (few) determinable specimens of *I. symmetricus* Branson et Mehl have been found in the palmatolepid-polygnathid biofacies (compare Fig. 2 with Tab. 1).

In the model by G. Seddon, W. C. Sweet (1971) the *Palmatolepis* biofacies is restricted to deeper basinal areas away from a reef facies. Similar occurrence ("inter--reef facies") is interpreted by E. C. Druce (1973). In turn, C. A. Sandberg (1976) relates the palmatolepid-polygnathid biofacies to "shallow to moderately deep water on the continental shelf". According to C. A. Sandberg, R. Dreesen (1984) this biofacies belongs to the most seaward ones and represents middle or upper part of a continental slope.

Several authors envisage a paleoecological control on the distribution of particular species of the genus *Polygnathus* during the Frasnian. According to G. Klapper, H. R. Lane (1985) *Polygnathus decorosus* Stauffer "...is numerically dominant in some collections of the *Palmatolepis* biofacies, whereas other *Polygnathus* species with narrow platform ... have not as yet been found in a presumed position farther offshore (i. e., in the *Palmatolepis* biofacies)...". Z. Belka, J. Wendt (1992) suppose that "...*P. decorosus* Stauffer must have favoured a more nearshore setting, but it certainly did not live at very shallow depth...". In the Janczyce I section *Polygnathus decorosus* Stauffer was found mostly within the depth interval between 320.5 and 317.7 m (Tab. 1) which coincides with the Basal Member.

When applying above interpretations to the studied section one may conclude that the succession of the conodont biofacies indicates that the nodular limestones represent relatively shallow-water sedimentation near the edge of a reef-complex or a carbonate platform. In contrast, the laminated marly limestones were deposited in deeper environment, more distal relative to carbonate shoals. Deepening of the depositional environment started rapidly (sharp biofacies boundary) and then continued in a more gradual way (progressive change of *Palmatolepis* to *Polygnathus* ratio).

INTERPRETATION OF SEDIMENTARY DEVELOPMENT

Sedimentological observations reveal the existence of distinct vertical gradients at the boundary interval between the nodular limestones and marly laminated limestones. These gradients may be interpreted in terms of changes in: (1) environmental energy, (2) oxygen availability, and (3) presence versus absence of light.

1. In contrast to the laminated marly limestones, the nodular limestones display the influence of increased water turbulence. Redeposition is responsible for the presence of allochthonous benthic skeletons found in the lower part of the unit, while exhumation and reworking of early cemented nodules points to *in situ* turbulence without much transportation (cf. M. Narkiewicz, 1978). Similar resedimented nodules were recently described by J. Bednarczyk (1990) from the Devonian Dębnik Limestone in the Cracow area (southern Poland). In the present example, the influence of intermittently lowered (storm ?) wavebase seems the most probable factor. In recent marine environments storm wavebase occurs at depths between 20 and 200 m (T. J. M. Schopf, 1980). A larger-scale sediment transport, e. g. in the form of debris flows, seems less probable in the described example, as it implies much larger contrast between redeposited and autochthonous sediments. On the other hand, gravity flows appear a probable transport mechanism in a case of the detrital beds in the Basal Member. The development of these beds suggests various types of flow: from turbidity currents in a case of normally graded beds, to debris flow (single bed of the intraformational conglomerate) to grain flow (resulting in a reversed grading).

2. According to the model of oxygen-deficient sedimentary basins, laminated marly limestones represent the anaerobic zone, generally below 150 m (C. W. Byers, 1977). On the other hand, the nodular deposits and the Basal Member were deposited near the transition between the aerobic and dysaerobic zones at the approximate depth on the order of 50 m (*op. cit.*). This is evidenced by a common bioturbated structure accompanied by a skeletal assemblage poor in both specimens and taxa.

3. Both skeletal algal remains and oncolitic horizons document the presence of a photic zone during deposition of the nodular limestones and the Basal Member. According to T. J. M. Schopf (1980) in recent marine environments this zone reaches down to ca. 100 m. The lack of the above evidence in the upper lithostratigraphic unit testifies against the presence of a photic environment during its deposition. Additional to the water depth, also suspended clay particles may have contributed in an overall decrease of a light penetration.

Presented biofacies and sedimentological evidence confirms the consistent pattern of deepening of the depositional environment. The initial water-depths were representative of the aerobic/dysaerobic zone boundary under the photic conditions and with intermittent wave influence. After the deepening they increased to the anaerobic and aphotic zone below a storm wavebase. According to the biofacies and "energy" criteria the major deepening pulse corresponds to the vertical facies change between the nodular limestones and the Basal Member. In turn, the evidence related to a degree of oxygenation and light penetration suggests that an abrupt deepening is recorded by the base of the typically developed laminated limestones. Basing on reported average

or "typical" water-depths of the discussed bathymetric zones we may estimate the amplitude of the sea-level change at 50–100 m.

There are no direct counterparts of the described facies among recent sedimentary environments. Review of ancient examples reveals that the closest analogies exist between the described section and the Late Devonian clayey-carbonate sequence of epicontinental deposits in Alberta (Canada) described in detail by F. A. Stoakes (1980). The nodular limestones analogous to the Holy Cross ones were ascribed by the cited author to the upper slope of the carbonate platform in aerobic conditions, at depths 35 to 55 m. The Canadian laminated limestones and calcareous-shaly deposits (*op. cit.*, Fig. 21) share many similarities with the laminated marly limestones described above. In the cited example they were ascribed to toe-of-slope and shelf--basin environments in a dysaerobic zone at depths below 90 m. In turn, a transitional setting in the middle slope between the both above named facies is occupied in Canada by the bioturbated calcareous shales with intercalations of calcareous turbidites. The latter contain numerous skeletons of shallow-water benthic organisms redeposited from the carbonate platform. These deposits are a counterpart of the Basal Member in the Janczyce I section while the whole analysed sequence repeats, according to the Walther's Law, a lateral facies transitions from shallowest at the bottom to deepest at the top.

F. A. Stoakes (1980) investigated several transgressive-regressive sequences developed in the above described facies. Basing on a detailed thickness data of particular cycles he was able to determine quantitatively depositional depths of particular facies, as well as the slope of a carbonate platform (4–7 m/km). Obviously, one should be careful with direct applying those values in the Polish example. On the other hand, however, the above outlined paleobathymetric interpretation is generally consistent with the results of F. A. Stoakes (*op. cit.*). Using these results we may estimate the amplitude of deepening in the Holy Cross Mts at 35 to 55 m, values being close to the minimum limit of the above interpreted range between 50 and 100 m. With all the above argument in mind, it seems most probable that the amplitude of the interpreted sea-level rise was on the order of 50 m.

Previous investigations did not supply any evidence of a transgressive pulse in the Late *rhenana* Zone neither in the Holy Cross Mts nor in other regions of the Late Devonian shelf of southern Poland (M. Narkiewicz, 1987, 1988). The eustatic curve shows a regressive event within this time interval (J. G. Johnson, C. A. Sandberg, 1988). Therefore, the described transgressive pulse may be a purely local phenomenon related e. g. to the rapidly increased rate of subsidence in the analysed part of the basin.

REFERENCES

BEDNARCZYK J. (1990) — Geneza struktur gruzłowych w wapieniach dębnickich (żywet/fran) w świetle badań sedymentologicznych i analizy zawartości izotopów stałych węgla i tlenu. Prz. Geol., **38**, p. 206–209, nr 4.

BEŁKA Z., WENDT J. (1992) — Conodont biofacies patterns in the Kellwasser Facies (upper Frasnian/lower Famennian) of the eastern Anti-Atlas, Morocco. Palaeogeography, Palaeoclimatology, Palaeoecology, **91**, p. 143–173, no. 1/2.

BYERS C. W. (1977) — Biofacies patterns in euxinic basins: a general model. Soc. Econ. Paleont. Miner., Spec. Publ., **25**, p. 5–17.

DADLEZ J., DADLEZ R. (1986) — Transgresja późnodewońska w profilu Unisławia. Kwart. Geol., **30**, p. 445–472, nr 3/4.

DRUCE E. C. (1973) — Upper Paleozoic and Triassic conodont distribution and the recognition of biofacies. Geol. Soc. Amer., Spec. Paper., **141**, p. 191–237.

DRUCE E. C. (1975) — Conodont biostratigraphy of the Upper Devonian reef complexes of the Canning Basin, Western Australia. Commonwealth of Australia, Dept. of Nat. Develoment, Bureau of Mineral Resources, Geol. Geophys. Bull., **158**.

JOHNSON J. G., KLAPPER G., SANDBERG C. A. (1985) — Devonian eustatic fluctuations in Euramerica. Geol. Soc. Amer. Bull., **96**, p. 567–587, nr 5.

JOHNSON J. G., SANDBERG C. A. (1988) — Devonian eustatic events in the Western United States and their biostratigraphic responses. Can. Soc. Petrol. Geol. Mem., **14**, p. 171–178, part 3.

KLAPPER G., LANE H. R. (1985) — Upper Devonian (Frasnian) conodonts of *Polygnathus* biofacies, N. W. T., Canada. Jour. Paleont., **59**, p. 904–951, nr 4.

MATYJA H. (1987) — Conodont biofacies in the Famennian Stage of Pomerania, northwestern Poland. In: Conodonts: Investigative techniques and applications (ed. R. L. Austin), p. 363–381. Ellis Horwood, Ltd. Chichester.

MATYJA H., NARKIEWICZ M. (in press) — Conodont biofacies succession near the Frasnian/Famennian boundary: Some Polish examples. Cour. Forsch.-Inst. Senckenberg.

NARKIEWICZ M. (1978) — Geneza struktury gruzłowej w górnodewońskich wapieniach okolic Olkusza i Zawiercia. Kwart. Geol., **22**, p. 693–708, nr 4.

NARKIEWICZ M. (1987) — Zdarzenia na późnodewońskim szelfie południowej Polski i ich znaczenie stratygraficzne. Kwart. Geol., **31**, p. 581–597, nr 4.

NARKIEWICZ M. (1988) — Turning points in sedimentary development in the Late Devonian in southern Poland. Can. Soc. Petrol. Geol. Mem., **14**, p. 619–635, part. 2.

NARKIEWICZ M. (1991) — Analiza basenów sedymentacyjnych jako strategia badawcza. Kwart. Geol., **35**, p. 189–206, nr 2.

NARKIEWICZ M., OLKOWICZ-PAPROCKA I. (1983) — Stratygrafia dewońskich utworów węglanowych wschodniej części Gór Świętokrzyskich. Kwart. Geol., **27**, p. 225–256, nr 2.

OLKOWICZ-PAPROCKA I., NARKIEWICZ M. (1986) — Dewon węglanowy wschodniej części synklinorium kielecko-łagowskiego i jego znaczenie surowcowe. Biul. Inst. Geol., **351**, p. 5–44.

PERYT T. M. (1981) — Phanerozoic oncoids — an overview. Facies, **4**, p. 197–214.

RACKI G. (1990) — Frasnian/Famennian event in the Holy Cross Mts., central Poland: stratigraphic and ecologic aspects. Lecture Notes in Earth Sci., **30**, p. 169–181.

SANDBERG C. A. (1976) — Conodont biofacies of Late Devonian *Polygnathus styriacus* Zone in Western United States. Geol. Ass. Can., Spec Paper, **15**, p. 171–186.

SANDBERG C. A., DREESEN R. (1984) — Late Devonian icriodontid biofacies models and alternate shallow-water condont zonation. Geol. Soc. Amer., Spec. Paper, **196**, p. 143–178.

SANDBERG C. A., POOLE F. G. (1977) — Conodont biostratigraphy and depositional complexes of Upper Devonian cratonic-platform and continental-shelf rocks in the Western United States. California Univ. Riverside, Campus Mus. Contr., **4**, p. 144–182.

SANDBERG C. A., ZIEGLER W., BULTYNCK P. (1989) — New standard conodont zones and early *Ancyrodella* phylogeny across Middle–Upper Devonian boundary. Cour. Forsch.-Inst. Senckenberg, **110**, p. 195–230.

SANDBERG C. A., ZIEGLER W., BUTLER J. L. (1988) — Late Frasnian mass extinction: conodont event stratigraphy, global changes, and possible causes. Cour. Forsch.-Inst. Senckenberg, 102, p. 263–307.

SCHOPF T. J. M. (1980) — Paleoceanography. Harvard University Press. Cambridge, Mass.

SEDDON G. (1970) — Frasnian conodonts from the Sadler Ridge-Bugle Gap area, Canning Basin, Western Australia. Jour. Geol. Soc. Austral., 16, p. 723–753, part 2.

SEDDON G., SWEET W. C. (1971) — An ecologic model for conodonts. Jour. Paleont., 45, p. 869–880, nr 5.

STOAKES F. A. (1980) — Nature and control of shale basin fill and its effect on reef growth and termination: Upper Devonian Duvernay and Ireton Formations of Alberta, Canada. Bull. Can. Petrol. Geol., 28, p. 345–410, nr 3.

SWEET W. C. (1988) — The Conodonta: morphology, taxonomy, paleoecology, and evolutionary history of a long-extinct animal phylum. Oxford Monogr. Geol. Geoph., 10. Clarendon Press. Oxford.

SZULCZEWSKI M. (1989) — Światowe i regionalne zdarzenia w zapisie stratygraficznym pogranicza franu i famenu Gór Świętokrzyskich. Prz. Geol., 37, p. 551–557, nr 11.

ZIEGLER W., SANDBERG C. A. (1990) — The Late Devonian standard conodont zonation. Cour. Forsch.-Inst. Senckenberg, 121, p. 1–115.

Marek NARKIEWICZ, Katarzyna NARKIEWICZ

PULS TRANSGRESYWNY W GÓRNYM FRANIE PROFILU JANCZYCE I (GÓRY ŚWIĘTOKRZYSKIE): ZAPIS SEDYMENTOLOGICZNY I BIOFACJE KONODONTOWE

Streszczenie

Analiza pionowych sekwencji facjalnych stanowi jedną z podstawowych metod wykrywania, badania i korelacji wahań poziomu morza, zarejestrowanych w osadowych cyklach transgresywno-regresywnych. Przedmiotem tego rodzaju analizy był fragment profilu górnego dewonu w otworze wiertniczym Janczyce I, we wschodniej części Gór Świętokrzyskich. Badaniami sedymentologicznymi i mikrofaunistycznymi objęto pogranicze dwóch jednostek litostratygraficznych: wapieni gruzłowych i laminowanych wapieni marglistych (podział według M. Narkiewicza, I. Olkowicz-Paprockiej, 1983).

Wapienie gruzłowe wykazują oznaki redepozycji części wcześniej scementowanych gruzłów, przy silnej bioturbacji i domieszce szkieletów, m. in. ramienionogów, liliowców, glonów, ślimaków i otwornic. Wyżej leżące utwory charakteryzują się natomiast większą domieszką ilastą, niklym stopniem bioturbacji i znacznie mniejszym udziałem szkieletów organicznych, głównie tentakulitoidów (fran), głowonogów i radiolarii (famen). U podstawy tej jednostki występuje „ogniwo spągowe" o miąższości około 5 m, złożone z przeławiceń regularnie warstwowanych kalcylutytów z kalkarenitami. Te ostatnie zawierają m. in. fragmenty glonów, ramienionogów, liliowców, stromatoporoidów, ślimaków, nielicznych korali i mszywiołów. Z kolei w kalcylutytach stwierdzono poziomy wzbogacone w onkoidy.

Badania konodontów pozwalają na pewne zaliczenie analizowanych utworów do dwóch najwyższych poziomów franu — górnego *rhenana* i *linguiformis*, a z dużym prawdopodobieństwem — do wyższej części starszego z wymienionych poziomów. Strop wapieni gruzłowych charakteryzuje się stosunkowo płytkowodną biofacją ikriodidową, natomiast wyższe jednostki — biofacją palmatolepidowo-polygnatidową, interpretowaną w literaturze jako bardziej dystalna i głębokowodna. Pionowa zmienność zespołów konodontowych sugeruje, że pogłębienie się środowiska sedymentacji początkowo dokonało się raptownie (kontrast obu biofacji), a następnie przebiegało stopniowo. To ostatnie zjawisko odzwierciedlone jest w zmianie proporcji przedstawicieli rodzajów *Palmatolepis* i *Polygnathus* w ogniwie spągowym.

Badania sedymentologiczne potwierdzają obecność późnofrańskiego, geologicznie raptownego pulsu transgresji. Wskazują na to: (1) ogólne zmniejszenie turbulencji odzwierciedlonej w stopniu redepozycji

osadów, (2) pionowe przejście od facji aerobowej-dysaerobowej z fauną bentoniczną i bioturbacją do anaerobowej, bez śladów infauny, (3) przejście do utworów strefy afotycznej, pozbawionej glonów bentonicznych.

Badane utwory wykazują znaczne podobieństwo do frańskich facji kanadyjskiej prowincji Alberta (F. A. Stoakes, 1980). Przez analogię do modelu podanego przez cytowanego autora, świętokrzyskie wapienie gruzłowe można przypisać górnej części stoku platformy węglanowej, natomiast laminowane wapienie margliste reprezentowałyby podnóże stoku i basen szelfowy. Ogniwo spągowe ma wykształcenie zbliżone do kanadyjskiej facji środkowego stoku platformy, położonego między wymienionymi środowiskami depozycji. Zgadzałoby się to, na mocy prawa Walthera, z pośrednią pozycją tych utworów w sekwencji transgresywnej. Amplituda względnego podniesienia się poziomu morza, oszacowana na podstawie cytowanego modelu, wynosi około 50 m.

PLATE I

Fig. 1. Nodular limestone with densely packed nodules in the central part of the photo and redeposited poorly-sorted nodules above and below. Lower part shows the cross-sections of burrows. Polished section, depth 349.6 m (all specimens and samples are from the Janczyce I borehole)

Wapień gruzłowy o ciasno upakowanych gruzłach w części środkowej zdjęcia, a wyraźnie redeponowanych, źle wysortowanych w górnej i dolnej. Dół — widoczne przekroje nor. Naszlif, głęb. 349,6 m (wszystkie okazy i próbki pochodzą z otworu wiertniczego Janczyce I)

Fig. 2. Detrital appearance of a nodular limestone. Polished section, depth 322.5 m

Detrytyczny pokrój wapienia gruzłowego. Naszlif, głęb. 322,5 m

Fig. 3. Skeletal wackestone showing strong bioturbation manifested as a chaotic arrangement of grains. Tubular burrows are completely filled with micrite (e. g. to the right of the upper dark grain) or with geopetal sediment and sparry cement. Dark pyritized grains show traces of mechanical abrasion and organic boring. Thin section, depth 332.4 m

Szkieletowy wapień mikrytowo-ziarnowy z silną bioturbacją w postaci chaotycznego ułożenia ziarn. Walcowate nory wypełnione mikrytem (np. na prawo od górnego ciemnego ziarna) lub osadem geopetalnym i cementem sparytowym. Ciemne spirytyzowane ziarna wykazują ślady abrazji i drążeń organicznych. Szlif, głęb. 332,4 m
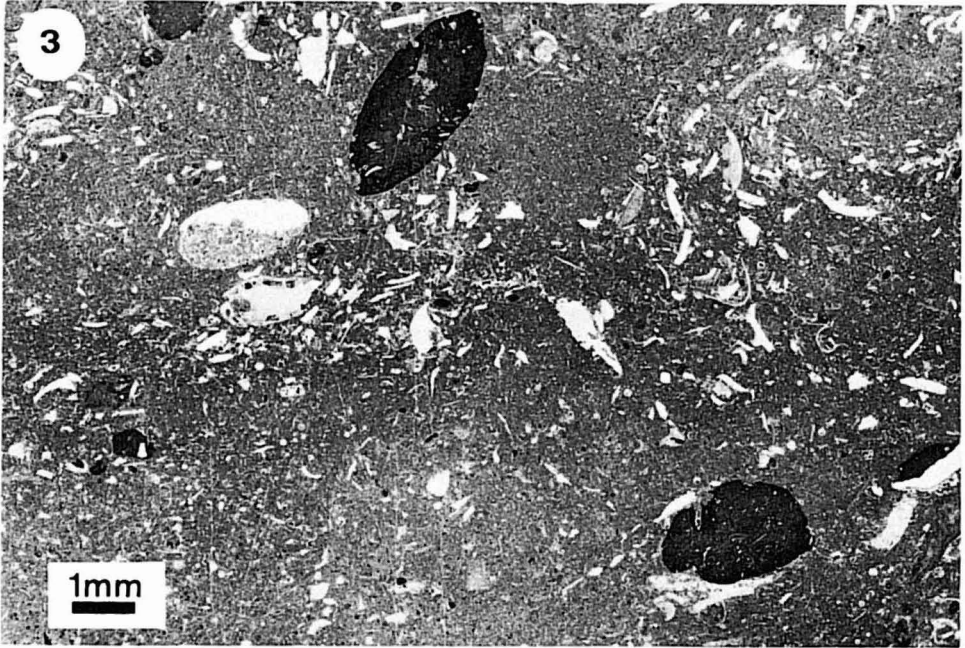
Marek NARKIEWICZ, Katarzyna NARKIEWICZ — Transgressive pulse in the Upper Frasnian of the Janczyce I section (Holy Cross Mts): sedimentology and biofacies

PLATE II

Fig. 1. Intraformational conglomerate with intraclasts built of *Renalcis* and *Amphipora* biomicrites. Polished section, depth 319.2 m

Wkładka zlepieńca śródformacyjnego z intraklastami zbudowanymi z biomikrytów renalcisowych i ampfiporowych. Naszlif, głęb. 319,2 m

Fig. 2. Oncoid-rich horizon. Polished section, depth 320.4 m

Poziom onkoidowy. Naszlif, głęb. 320,4 m

Fig. 3. Packstone intercalation with strongly abraded fragments of branching stromatoporoids embedded in a biointramicritic matrix. Thin section, depth 319.0 m

Wkładka wapienia ziarnowo-mikrytowego z silnie zabradowanymi fragmentami gałązkowych stromatoporoidów w obrębie tła biointramikrytowego. Szlif, głęb. 319,0 m
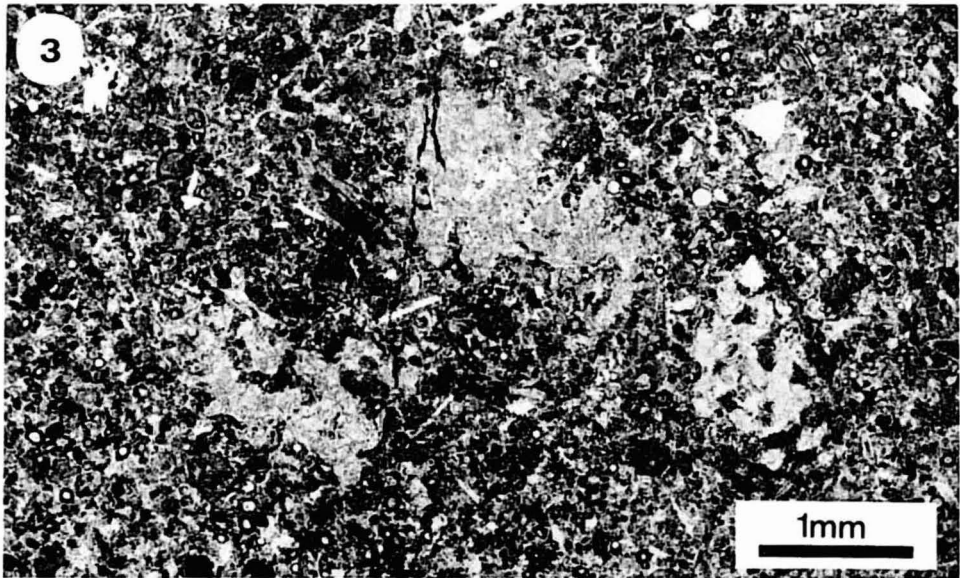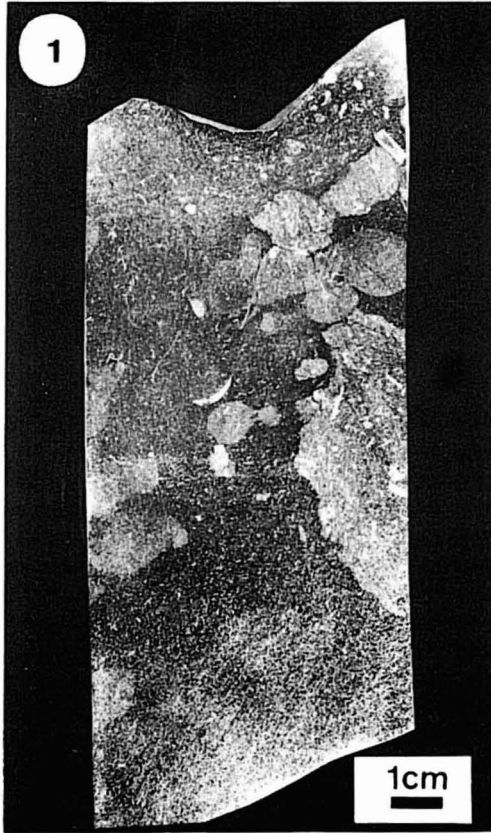
PLATE II

Marek NARKIEWICZ, Katarzyna NARKIEWICZ — Transgressive pulse in the Upper Frasnian of the Janczyce I section (Holy Cross Mts): sedimentology and biofacies
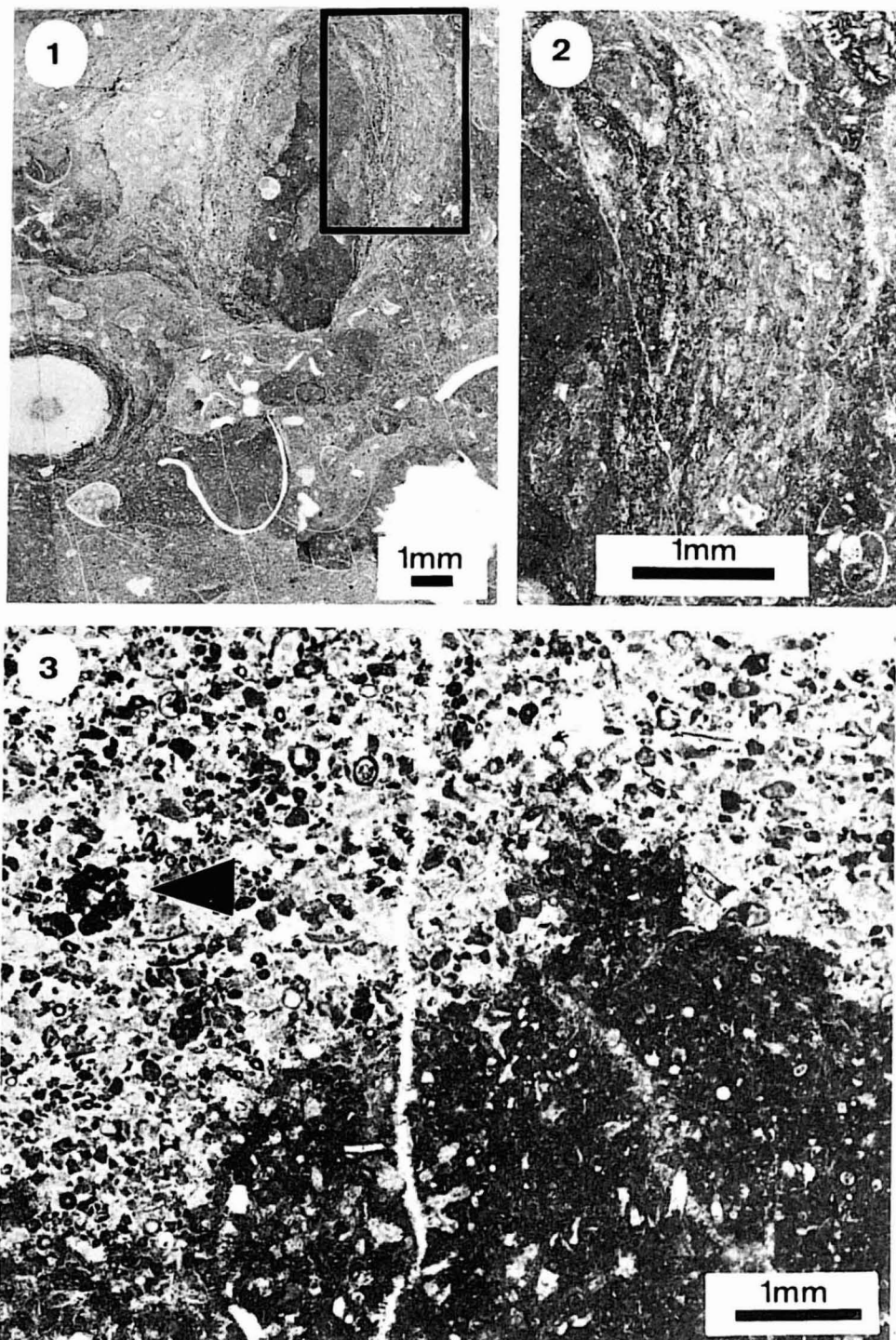
PLATE III

Fig. 1. Porostromate oncoids in a biomicritic matrix. Oncoids are coated micritic intraclasts (top) and a crinoid plate (lower left). Black rectangle marks the area shown on Fig. 2. Thin section, depth 320.9 m

Onkoidy porostromatowe w tle biomikrytowym. Onkoidy rozwinięte są na intraklastach mikrytowych (góra) i członie liliowca (lewy dół). Fragment zaznaczony czarnym prostokątem powiększono na fig. 2. Szlif, głęb. 320,9 m

Fig. 2. Details of a skeletal structure of the oncoid shown on Fig. 1

Szczegóły szkieletowej struktury onkoida z fig. 1

Fig. 3. Contact between wackestone (biomicrite) and grainstone intercalation. Some of the grains are reworked *Renalcis* skeletons (arrow). Thin section, depth 319.1 m

Kontakt wapienia mikrytowo-ziarnowego — biomikrytu, z wkładką ziarnową. Wśród ziarn obecne fragmenty szkieletów glonów *Renalcis* (strzałka). Szlif, głęb. 319,1 m

Marek NARKIEWICZ, Katarzyna NARKIEWICZ — Transgressive pulse in the Upper Frasnian of the Janczyce I section (Holy Cross Mts): sedimentology and biofacies

PLATE IV

Fig. 1. *Palmatolepis subrecta* Miller et Youngquist
Depth (głęb.) 319.6–319.7 m; x 45
Fig. 2. *Palmatolepis rhenana nasuta* Müller
Depth (głęb.) 319.6–319.7; x 45
Fig. 3. *Palmatolepis gigas paragigas* Ziegler et Sandberg
Depth (głęb.) 321.4–321.5 m; x 50
Fig. 4. *Palmatolepis hassi* Müller et Müller
Depth (głęb.) 317.7–317.9 m; x 40
Fig. 5. *Polygnathus aequalis* Klapper et Lane
Depth (głęb.) 314.8–314.9 m; x 70
Fig. 6. *Palmatolepis rotunda* Ziegler et Sandberg
Specimen with a broken part of a free blade; depth (głęb.) 319.6–319.7 m; x 50
Fig. 7. *Polygnathus aequalis* Klapper et Lane
Depth (głęb.) 319.6–319.7 m; x 35
Fig. 8. *Icriodus alternatus helmsi* Sandberg et Dreesen
Depth (głęb.) 321.3–321.4 m; x 80
Fig. 9. *Icriodus alternatus alternatus* Branson et Mehl
Depth (głęb.) 321.4–321.5 m; x 95
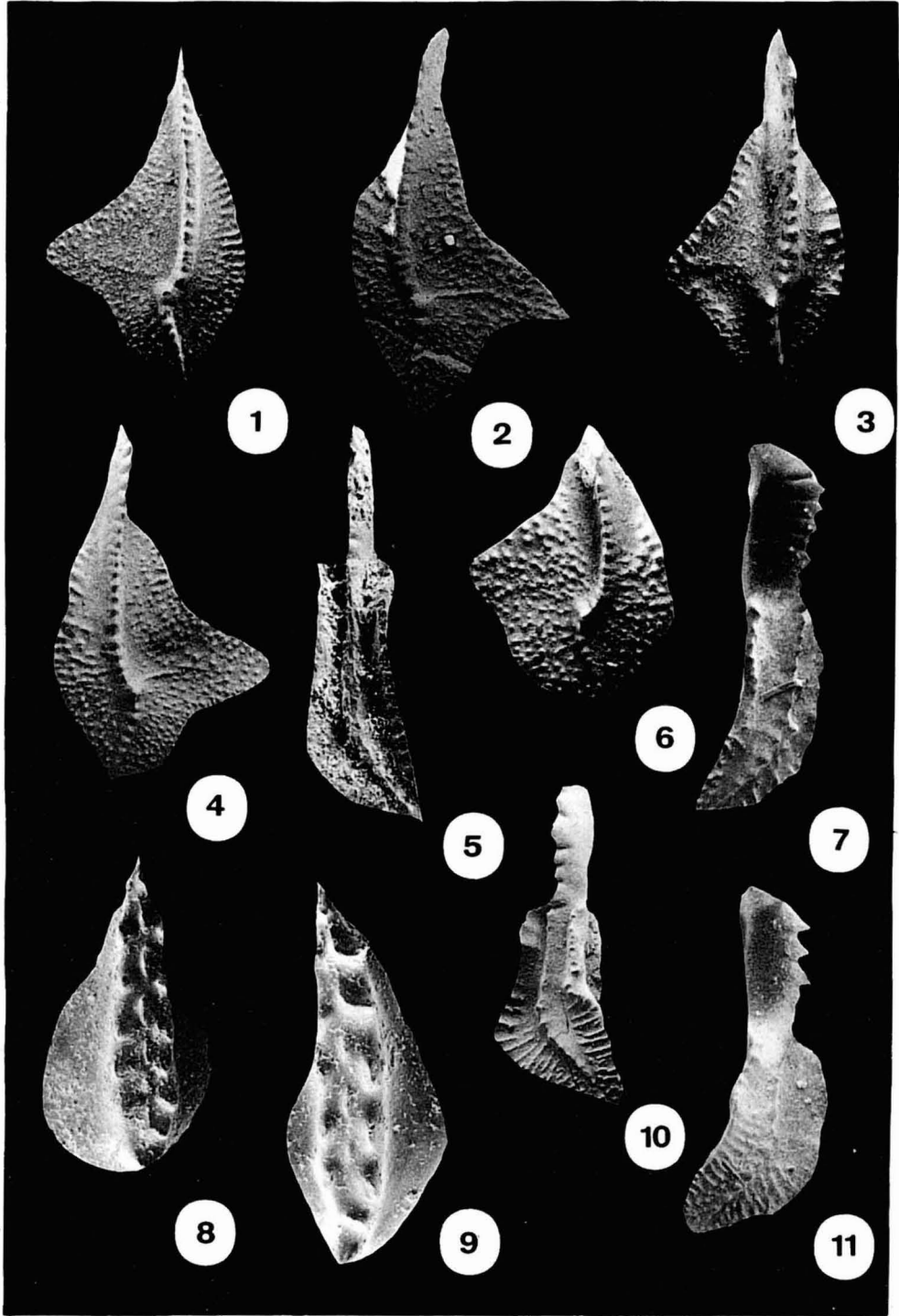Fig. 10. *Polygnathus evidens* Klapper et Lane
Depth (głęb.) 317.7–317.9 m; x 30
Fig. 11. *Polygnathus alatus* Huddle
Depth (głęb.) 321.3–321.4 m; x 35

Conodont fauna from the Janczyce I borehole
Konodonty z otworu wiertniczego Janczyce I

Marek NARKIEWICZ, Katarzyna NARKIEWICZ — Transgressive pulse in the Upper Frasnian of the Janczyce I section (Holy Cross Mts): sedimentology and biofacies