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Palynostratigraphy of the Zechstein in the North Sudetic Trough

Four spore-pollen assemblages representing the *Lueckisporites virkkiae* palynological zone were distinguished within the evaporitic deposits of the Zechstein in the North Sudetic Trough. It was the first attempt to apply biostratigraphy in a series which has been distinguished so far only according to lithological criteria. All the assemblages are strongly dominated by xerophytic elements.

INTRODUCTION

The cyclothem subdivision of the Zechstein is of great use in central part of the Zechstein Basin whereas of limited importance in its marginal part, where coparatively quick changes of mineral facies occur. Such situation takes place in the North Sudetic Trough. There have not been sufficient evidences here for determination of the stratigraphical position of the sulphate-siliclastic complex occurring below the Platy Dolomite. T. M. Peryt and A. Kasprzyk (1992) gave the two possible interpretation that this complex may represent the top regressive part of the Upper Anhydrite or may be rather a facial parallel of the carbonate-evaporate complex of the PZ2 cycle. The correlation of the upper clastic sequence of the Zechstein in the southern part of North Sudetic Trough however remained controversial (A. Fijałkowska, T. M. Peryt, 1995). Therefore palynological studies of the Zechstein deposits from the North Sudetic Trough were carried out in 1992–1994. Their aim was definition of microfloral characteristics, distinction of spore-pollen assemblages and working out, for the first time, the palynostratigraphy of the Zechstein evaporitic deposits from the mentioned area.

First data about occurrence of Zechstein miospores in the North Sudetic Trough were presented by H. Kotańska (H. Kotańska, J. Krasoń, 1966) who described several miospore taxa from the first and third cyclothems.

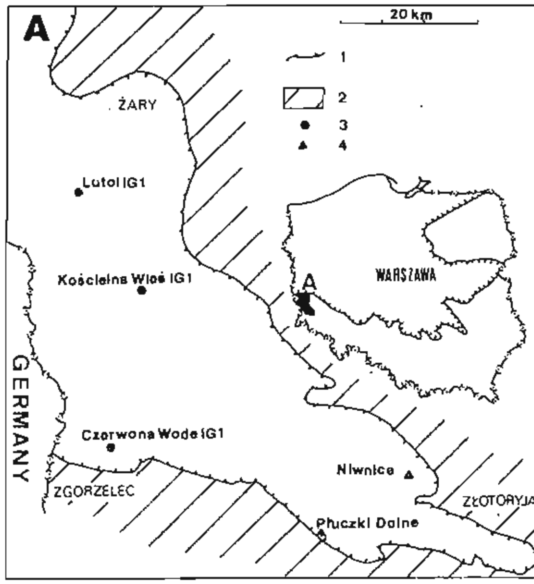

Fig. 1. Location of studied boreholes and outcrops in the North Sudetic Trough (after T. M. Peryt, A. Kasprzyk, 1992)

1 — present limit of Zechstein deposits; 2 — areas without the Zechstein deposits; 3 — boreholes; 4 — outcrops

Lokalizacja badanych otworów wiertniczych i odsłonięć na obszarze niecki północnosudeckiej (według T. M. Peryta, A. Kasprzyk, 1992)

1 — obecny zasięg utworów cechsztynu; 2 — obszary pozbawione utworów cechsztynu; 3 — otwory wiertnicze; 4 — odsłonięcia

METHODS AND MATERIALS

Palynological data for this study were gathered and complied from the Zechstein interval from 3 boreholes: Czerwona Woda IG 1 at depths of 672.8–681.2, 714.9–738.0 m (Fig. 1, Tab. 1), Kościelna Wieś IG 1 (780.2–794.6, 813.7–838.0, 871.5–883.0 m) (Tab. 2) and Lutol IG 1 (804.0–808.4 m) and two outcrops: in Niwnice from the "gypseous shale" member and in Płuczki Dolne from the gray mudstones overlying the Zechstein Limestone. In total, 70 samples were taken. The samples from the Lutol IG 1 borehole and Płuczki Dolne outcrop appeared barren.

Samples were selected mainly from the dark gray and gray mudstones as well dolomites making up interbeds within the anhydrites and also from the clayey anhydrites. The samples taken from the pure anhydrites were generally barren.

Maceration process was based on the HF method.

In total 64 species of miospores from 39 genera and a single algae were recognized (Anex 1, Tab. 3).

GEOLOGICAL CHARACTERISTICS OF THE STUDIED COMPLEXES

The most recent lithostratigraphic scheme of the studied deposits was presented by T. M. Peryt, A. Kasprzyk (1992) and A. Fijałkowska, T. M. Peryt (1995).

The Werra Cyclothem (PZ1) consists of a few lithological complexes of variable thickness. The lowermost is the Kupferschiefer (T1) overlain by the Zechstein Limestone (Ca1), whose thickness increases from 40 m in the southern part of the trough up to 90 m in the center. The Lower Anhydrite (A1d) is built of clayey anhydrites less than 20 m thick in the southern part and changes into pure anhydrite 8 m thick in the center. The horizon of anhydritic breccia (A1b) is observed in all the studied sections. The top of the first cyclothem is made of the Upper Anhydrite (A1g) 35–45 m thick.

The Stassfurt Cyclothem (PZ2) is composed of the "gypseous shale" about 20 m thick in the southern part of the trough and the Main Dolomite (Ca2; several metres thick) overlain by the Basal Anhydrite (A2) with a thickness of 10 m in the center.

The Leine Cyclothem (PZ3) consists of the Platy Dolomite (Ca3), whose thickness decreases from 8 m in the southern part of the trough to 2 m in the center, and the Main Anhydrite (A3) 30–40 m thick, which occurs in the central and northern parts. The uppermost part of the Zechstein is built of the Top Terrigenous Series (Pzt).

PALYNOSTRATIGRAPHY

Four spore-pollen assemblages (I–IV), representing the Upper Permian *Lueckisporites virkkiae* palynological zone, were distinguished in the Zechstein deposits.

ASSEMBLAGE I

Characteristics. This is a poor spectrum with respect to both the quality and quantity of differentiation of taxa. It is dominated by bisaccate pollens of *Lueckisporites virkkiae* Potonié et Klaus, represented mainly by the Aa, Ab specimens. *Lunatisporites noviaulensis* (Leschik) Scheuring and *Klausipollenites schaubergeri* (Potonié et Klaus) Jansonius occur frequently, whereas *Jugasporites, Limitisporites* and *Crustaesporites* forms are less abundant. Moncolpate pollen are represented in greater number by *Cycadopites coxii* Visscher. Spores are scare.

Occurrence. The Czerwona Woda IG 1 borehole at a depth of 729.1–731.5 m.

Comparisons and correlations. The assemblage can be most probably correlated to the *Lueckisporites virkkiae* Ab spectrum distinguished in the Lower Anhydrite (A1d) deposits in the Holy Cross Mts. area (A. Fijałkowska, 1991, 1992). A similar assemblage was described by S. Dybova-Jachowicz and D. Laszko (1978) from the Lower Zechstein deposits of the Nida Trough.

Table 1

Palynomorph occurrence in the Zechstein of the Czerwona Woda IG 1 borehole

LITHOSTRATIGRAPHY (after T.M. Peryt, A. Kasprzyk, 1992, slightly modified)	ZECHSTEIN		
	PZ1		? PZ2
	A1d	A1g ?	A2
	729.1-731.5	714.9-721.4	674.3-681.2
1	2	3	4
Calamospora pedata			+
Calamospora cf. *tener*			+
Calamospora sp.		++	+
Laevigatisporites sp.		*	*
Apiculatisporites sp.		+ +	++
Verrucosisporites sp.		*	
Lycospora permica		+	
Lycospora sp.			++
Laevigatosporites sp.		*	+*
SPORITES INDET.		v *x	xx+
Perisaccus granulatus		+ +	*
Cordaitina donetziana		+	
Cordaitina uralensis			++
Nuskoisporites dulhuntyi		+	+v
Nuskoisporites klausi		+ +	++
Nuskoisporites sp.		+	+
Trizonaesporites grandis		+	+
Crucisaccites sp.			+
MONOSACCITES INDET.		+ +	+*
Protohaploxypinus latissmius		+ +	
Protohaploxypinus samoilovichii		* +*	+*
Protohaploxypinus sp.		+ v*	*v
Strotersporites richteri		+	+
Strotersporites wilsoni		+	*
Strotersporites sp.			*
Striatoabietites balmei		+	*
Lueckisporites virkkiae NAa, Ab	*	x xx	xxx
Lueckisporites virkkiae NAc		* *	*v
Lueckisporites virkkiae NBa, Bb		* *v	vx
Lueckisporites virkkiae NC		+	++
Lueckisporites virkkiae ND			+
Lueckisporites virkkiae NE		+	+*
Lueckisporites virkkiae f. with a "dark body"		+	+++
Lunatisporites alatus			+
Lunatisporites albertae			+
Lunatisporites gracilis		+ *+	**+
Lunatisporites labdacus			+++
Lunatisporites microsaccatus			+
Lunatisporites multiplex			++
Lunatisporites noviaulensis	+	x xx	xxv
Lunatisporites ortisei			+
Lunatisporites transversundatus		+	+
Lunatisporites sp.	*	v vv	xx*
Protosacculina sp.			+
Vittatina costabilis		+	++
Vittatina hiltonensis			+

Tab. 1 continued

1	2	3	4
Vittatina simplex			++
Vittatina subsaccata		• ++	+
Vittatina vittifera		+	+
Vittatina sp.		+	•
Aumancisporites striatus			•
Hamiapollenites cf. *bifurcatus*		+	
Hamiapollenites sp.		+ •	++
STRIATITES INDET.		•+	+v
Klausipollenites decipiens		vv	vv•
Klausipollenites minimus		•	•v
Klausipollenites schaubergeri	•	• x•	xx•
Klausipollenites staplinii			•
Klausipollenites vestitus			+
Klausipollenites f. Y			+
Klausipollenites sp.	+	v xx	xx•
Falcisporites zapfei	+	v vx	•xx
Falcisporites sp.		•	•
Vesicaspora sp.			++
Paravesicaspora sp.			+•
Platysaccus niger		+	+
Platysaccus papilionis			•+
Platysaccus sp.		+	••
Illinites elegans			+
Illinites unicus		+ v	•v+
Illinites sp.			v+
Vitreisporites koenigswaldii			+
Vitreisporites sp.		• +	+•
Jugasporites delasaucei		•	•v
Jugasporites latus			++
Jugasporites lueckoides			•+
Jugasporites paradelasaucei		+ vv	xv
Jugasporites cf. *parvus*		•	++
Jugasporites purus		+	
Jugasporites schaubergeroides			+
Jugasporites NB			+•
Jugasporites sp.	+	+ vv	vx
Triadispora crassa		+ •	v•
Triadispora plicata			++
Triadispora visscheri		•	+•+
Triadispora sp.		+	•v
Limitisporites moersensis	+	+ •v	v•
Limitisporites rectus		• •v	••
Limitisporites parvus			+
Limitisporites sp.		+	+++
Gardenasporites heisseli		+	•
Gardenasporites moroderi		+ •	v•
Gardenasporites oberrauchi		+ +	+•
Gardenasporites sp.		• v•	•v+
Chordasporites sp.		+ +	•v
DISACCITES INDET.	v	x xx	xxx
Crustaesporites globosus		+	
Crustaesporites sp.			•+
?*Pakhapites* sp.			•
Gnetacaepollenites sp.			+
Cycadopites coxii	+	• vv	vv•

Tab. 1 continued

1	2	3	4
Cycadopites cf. *follicularis*		*	+
Cycadopites hartii			+*
Cycadopites sp.	+	* *v	vv*
SPORE-POLLEN ASSEMBLAGES	I	II	III

Frequency of palinomorphs occurrence: + — 1–4 specimens, * — 5–10 specimens, v — 1–10%, x — more than 10%

ASSEMBLAGE II

Characteristics. The assemblage is strongly dominated by pollen grains (92.5% of the spectrum); among them the most abundant are conifer bisaccate forms, which belong to *Lueckisporites virkkiae* Potonié et Klaus species (23.5% of the spectrum). It is represented mainly by the Aa and Ab norms whereas Ba, Bb norms are less frequent and C, E, as well the form with a "dark body", seldom occur. Striatite pollen grains belonging to *Lunatisporites* (10.0% of the spectrum) as well *Protohaploxypinus* genera are comparatively abundant. The representatives of *Vittatina, Hamiapollenites* and *Strotersporites* are less frequent. The vesicate pollen of *Klausipollenites* as well *Jugasporites* (*J. delasaucei* (Potonié et Klaus) Leschik, *J. paradelasaucei* Klaus, *J. latus* (Leschik) Foster) are common. *Limitisporites* specimens occur seldom.

The monosaccate pollen grains, represented mainly by *Nuskoisporites dulhuntyi* Potonié et Klaus make 3.2% of the spectrum. Moncolpate pollen of *Cycadopites* are more frequent (8.1% of the spectrum). The share of spores, belonging to *Calamospora* and *Laevigatosporites* makes 7.5% of the spectrum.

Occurrence. The Czerwona Woda IG 1 borehole at a depth of 714.9–721.4 m.

Comparisons and correlations. This spectrum can be correlated to the *L. virkkiae* Ab and *Strotersporites* sp. div. assemblage distinguished within the Terrigenous Series (T1r) and Upper Anhydrite (A1g) in the Holy Cross Mts. area (A. Fijałkowska, 1991, 1992). A similar assemblage was recognized in the Nida Trough (A. Fijałkowska, 1991). A similarity to the EZ1 assemblage described from the Lower Magnesian Limestone in England (J. Pattison *et al.*, 1973) can be suggested.

ASSEMBLAGE III

Characteristics. The assemblage is dominated by pollen grains (95.3% of the spectrum) among which the *Lueckisporites virkkiae* Potonié et Klaus forms are the most abundant (22.4%). *Lunatisporites* specimens (*L. noviaulensis* (Leschik) Scheuring, *L. multiplex* (Visscher) Scheuring, *L. labdacus* (Klaus) Fijałkowska, *L. microsaccatus* (Jansonius) Fijałkowska) make 14.4% of the spectrum. Pollen of *Klausipollenites* (*K. schaubergeri* (Potonié et Klaus) Jansonius, *K. decipiens* Jansonius, *K. minimus* Góczán) occur in similar quantity (16.5% of the spectrum). The specimens of *Jugasporites* make 8.0% of the spectrum. Besides the dominant form of *J. delasaucei* (Potonié et Klaus) Leschik such taxa as *J. lueckoides* Klaus and *J. schaubergeroides* Klaus appear here. The comparatively high amount of *Gardenasporites* specimens (3.0% of the spectrum) is the characteristic feature for this assemblage.

The share of monosaccate pollen is almost the same as in assemblage II. Moncolpate pollen makes 6.5% of the spectrum. Spores belonging mainly to *Verrucosisporites, Calamospora* and *Laevigatosporites* genera are less frequent.

Occurrence. The Czerwona Woda IG 1 borehole at a depth of 678.7–681.2 m, Kościelna Wieś IG 1 borehole (820.5, 829.8–830.8 m) and probably in the Niwnice outcrop.

Comparisons and correlations. A similar spectrum was described in the Basal Anhydrite (A2) from the Opoczno PIG 2 borehole (A. Fijałkowska, 1993). It shows greater similarity to the *L. virkkiae* Ac Subzone distinguished in the PZ3 deposits than to the *L. virkkiae* Ab Subzone, recognized within the PZ1 cyclothem. Some taxa characteristic for the Upper Zechstein, for example, *Jugasporites lueckoides* Klaus and *Vittatina hiltonensis* Chaloner et Clarke, appear here. This assemblage can be also correlated to the spectrum described by H. Grebe (1957) and H. Grebe, H. J. Schweitzer (1962) from the Stassfurt Cyclothem in Germany.

ASSEMBLAGE IV

Characteristics. The assemblage is dominated by pollen grains (98.0% of the spectrum) among which the *Lueckisporites virkkiae* Potonié et Klaus specimens are the most frequent. The Ac norm is comparatively abundant here. Striatite pollen are common. The representatives of *Lunatisporites* make 15.2% of the spectrum and *Striatoabietites* forms as well *Strotersporites* are more frequent than in older assemblages. The share of *Klausipollenites* is high (17.0% of the spectrum). The representatives of *Gardenasporites* (*G. heisseli* Klaus, *G. moroderi* Klaus, *G. oberrauchi* Klaus) make 4.0% of the spectrum.

Monosaccate pollen are scare whereas moncolpate comparatively abundant (7.9% of the spectrum).

Occurrence. The Kościelna Wieś IG 1 borehole at a depth of 785.4–786.4 m.

Comparisons and correlations. This spectrum can be correlated to the *L. virkkiae* Ac assemblage of the *L. virkkiae* Ac Subzone distinguished in the Main Anhydrite (A3) and at the base of the Top Terrigenous Series (Pzt) in the Holy Cross Mts. area (A. Fijałkowska, 1991, 1992).

PALAEOCLIMATIC ASPECTS

A combination of the H. Visscher, C. J. van der Zwan (1981) and G. Jerenič, B. Jelen (1991) models, based on the statistical analyses of xerophytic and hygrophytic elements in microfloral assemblages, were used for palaeoclimatic reconstructions (Fig. 2). The ten groups of palynomorphs (A–J) containing elements characteristic for a dry climate (G–J)

Table 2

Palynomorph occurrence in the Zechstein of the Kościelna Wieś IG 1 borehole

LITHOSTRATIGRAPHY (after T.M. Peryt, A. Kasprzyk, 1992)	ZECHSTEIN			
	PZ2			PZ3
	820.5 829.8-830.8			785.4-786.4
1	2			3
Calamospora sp.				+
Apiculatisporites sp.				+
Lycospora permica				*
Lycospora sp.				*
SPORITES INDET.	+	+		v
Perisaccus granulatus				+
Endosporites hexarecticulatus				*
Nuskoisporites klausi				+
Trizonaesporites grandis				+
MONOSACCITES INDET.			+	*
Protohaploxypinus latissmius				+
Protohaploxypinus samoilovichii				*
Lueckisporites virkkiae NAa, Ab	+	+		x
Lueckisporites virkkiae NAc				*
Lueckisporites virkkiae NBa, Bb				*
Lueckisporites virkkiae NBc				+
Lueckisporites virkkiae NC				+
Lueckisporites virkkiae NE				+
Lueckisporites virkkiae f. with a "dark body"				+
Lunatisporites alatus				+
Lunatisporites gracilis				+
Lunatisporites labdacus				*
Lunatisporites multiplex				+
Lunatisporites noviaulensis	+		+	x
Lunatisporites sp.	+	+		x
Vittatina subsaccata				*
Vittatina vittifera				*
Vittatina sp.	+			v
Hamiapollenites sp.				+
Klausipollenites minimus				v
Klausipollenites schaubergeri	+	+	+	x
Klausipollenites staplinii				*
Klausipollenites sp.	+	+	+	x
Falcisporites zapfei				v
Falcisporites sp.				*
Vesicaspora sp.				*
Platysaccus sp.				+
Illinites unicus				*
Illinites sp.			+	+
Vitreisporites sp.				*
Jugasporites delasaucei				v
Jugasporites latus				+
Jugasporites lueckoides				+
Jugasporites paradelasaucei				v
Jugasporites cf. *parvus*				*
Jugasporites purus				+
Jugasporites NB				v
Jugasporites sp.	+	+		*

Tab. 2 continued

1	2	3
Triadispora crassa	+	•
Triadispora visscheri		+
Triadispora sp.	+	+
Limitisporites moersensis		x
Limitisporites rectus	+	v
Limitisporites parvus		+
Limitisporites sp.	+	•
Gardenasporites heisseli		+
Gardenasporites leonardii		+
Gardenasporites moroderi		▪
Gardenasporites oberrauchi		+
Gardenasporites sp.		•
Chordasporites sp.		•
DISACCITES INDET.	+ ▪ •	x
Gnetacaepollenites steevesi		+
Cycadopites sp.	• +	•
Sphaeripollenites sp.		v
SPORE-POLLEN ASSEMBLAGES	III	IV

For explanations see Tab. 1

as well for a humid one (A–C) and mixed forms (D–F) were distinguished here. The frequency of these elements in the three analyzed spectra is almost the same. Strong domination of the xerophytic forms is observed in all assemblages (70.2% in assemblage II, 77.9% in III and 70.2% in IV). Striatite pollen of conifers (G group) are the most abundant among the xerophytic elements. Vesicate conifer pollen (J group) are less frequent.

The hygrophytic forms make 15.6% of assemblage II, 11.2% of III and 9.9% of IV. They consist mainly of ferns and lycopod spores (A and B groups) as well as cycadales pollen (C group) which make 8.1% of assemblage II, 6.5% of III and 7.9% of IV.

The strong domination of the xerophytic elements indicates a dry, warm climate during the deposition of the studied sediments. This is also confirmed by lithology of the evaporitic series (T. M. Peryt, A. Kasprzyk, 1992).

CONCLUSIONS

Four spore-pollen assemblages were distinguished within the Zechstein evaporitic deposits of the North Sudetic Trough. They can be correlated to spectra recognized in the Holy Cross Mts.: *Lueckisporites virkkiae* Ab from the Lower Anhydrite (A1d), *L. virkkiae* Ab and *Strotersporites* sp. div. from the Terrigenous Series (T1r) and Upper Anhydrite (A1g), to the spectrum described from the Basal Anhydrite (A2) as well as the *L. virkkiae* Ac assemblage from the Main Anhydrite (A3) and base of the Top Terrigenous Series (Pzt).

The stratigraphic interpretation of results, obtained from palynological study, confirms the earlier suggestions of T. M. Peryt and A. Kasprzyk (1992) who included the sulphate-siliclastic complex occurring below the Platy Dolomite, to the Stassfurt Cyclothem (PZ2).

Table 3

Stratigraphic distribution of palynomorphs in the Zechstein of North Sudetic Trough

LITHOSTRATIGRAPHY (after T.M. Peryt, A. Kasprzyk, 1992, modified)	Zechstein							
	PZ1			PZ2		PZ3		Pzt
	Ca1	A1d	A1g	Ca2	A2	Ca3	A3	
1	2	3	4	5	6	7	8	9
Calamospora pedata					–			
Calamospora cf. *tener*					–			
Calamospora sp.			–		–		+	
Laevigatisporites sp.			–				–	
Apiculatisporites sp.			–		–		–	
Verrucosisporites sp.		–	–					
Lycospora permica			–				–	
Lycospora sp.			–	–	–		–	
Laevigatosporites sp.			–	–	–			
Perisaccus granulatus					–		–	
Cordaitina donetziana			–					
Cordaitina uralensis					–			
Endosporites hexarecticulatus							–	
Nuskoisporites dulhuntyi			–		–			
Nuskoisporites klausi			–		–		–	
Nuskoisporites sp.			–		–			
Trizonaesporites grandis			–		–		–	
Crucisaccites sp.					–			
Protohaploxypinus latissmius			–				–	
Protohaploxypinus samoilovichii			v		+		+	
Protohaploxypinus sp.			+		–			
Strotersporites richteri			–		–			
Strotersporites wilsoni					+			
Strotersporites sp.					–			
Striatoabietites balmei			–		–			
Lueckisporites virkkiae NAa, Ab		+	v	–	v		v	
Lueckisporites virkkiae NAc			+		+		+	
Lueckisporites virkkiae NBa, Bb			+		v		+	
Lueckisporites virkiae NBc			–		–		+	
Lueckisporites virkkiae NC			–		–		–	
Lueckisporites virkkiae ND					–			
Lueckisporites virkkiae NE			–		–		–	
Lueckisporites virkkiae f. with a "dark body"			–		–		–	
Lunatisporites alatus					–		–	
Lunatisporites albertae					–			
Lunatisporites gracilis			–		+		–	
Lunatisporites labdacus					–		+	
Lunatisporites microsaccatus					–			
Lunatisporites multiplex					–			
Lunatisporites noviaulensis		–	v		v	–	+	
Lunatisporites ortisei					–			
Lunatisporites transversundatus			–		–			
Lunatisporites sp.		+	–	–	v		+	
Protosacculina sp.					–			
Vittatina costabilis			–		–			
Vittatina hiltonensis					–			
Vittatina simplex					–			
Vittatina subsaccata			–		–		+	
Vittatina vittifera			–		–		–	
Vittatina sp.			–	–	+		+	
Aumancisporites striatus			–		–			

Tab. 3 continued

1	2	3	4	5	6	7	8	9
Hamiapollenites cf. *bifurcatus*			–					
Hamiapollenites sp.			–	–	–		–	
Klausipollenites decipiens			–		–			
Klausipollenites minimus			–		–		+	
Klausipollenites schaubergeri		+	v	–	v	–	v	
Klausipollenites staplinii					–		–	
Klausipollenites vestitus					–			
Klausipollenites f. Y					–			
Klausipollenites sp.		–	+	–	+	–	+	
Falcisporites zapfei		–	+		+		–	
Falcisporites sp.			–		–		+	
Vesicaspora sp.					–			
Paravesicaspora sp.					–			
Platysaccus niger			–		–			
Platysaccus papilionis					–			
Platysaccus sp.			–		+		–	
Illinites elegans					–			
Illinites unicus			–		–		–	
Illinites sp.					–	–	–	
Vitreisporites koenigswaldii					–			
Vitreisporites sp.			–		+		+	
Jugasporites delasaucei			+		+		v	
Jugasporites latus					–		–	
Jugasporites lueckoides					–		–	
Jugasporites paradelasaucei			–		+		+	
Jugasporites cf. *parvus*			–		–		+	
Jugasporites purus		–					–	
Jugasporites schaubergeroides					–			
Jugasporites NB					–		–	
Jugasporites sp.		–	v	–	v		+	
Triadispora crassa			–		+	–	+	
Triadispora plicata					–			
Triadispora visscheri			–		+		–	
Triadispora sp.			–	–	+		–	
Limitisporites moersensis			+		+		+	
Limitisporites rectus			+	–	+		+	
Limitisporites parvus					–		–	
Limitisporites sp.				–	–		–	
Gardenasporites heisseli			–		–		–	
Gardenasporites leonardii							–	
Gardenasporites moroderi			–		+		+	
Gardenasporites oberrauchi			–		–		–	
Gardenasporites sp.			+		+		+	
Chordasporites sp.			–		–		–	
Crustaesporites globosus		–						
Crustaesporites sp.					–			
?*Pakhapites* sp.					–			
Gnetacaepollenites steevesi							–	
Gnetacaepollenites sp.					–			
Cycadopites coxii		–	v	–	+	+	+	
Cycadopites cf. *follicularis*					–			
Cycadopites hartii					–			
Cycadopites sp.		–	+	–	+		+	
Sphaeripollenites sp.							+	
SPORE-POLLEN ASSEMBLAGES		I	II		III		IV	

Frequency of palynomorph occurrence: – — singly, + — rare, v — common

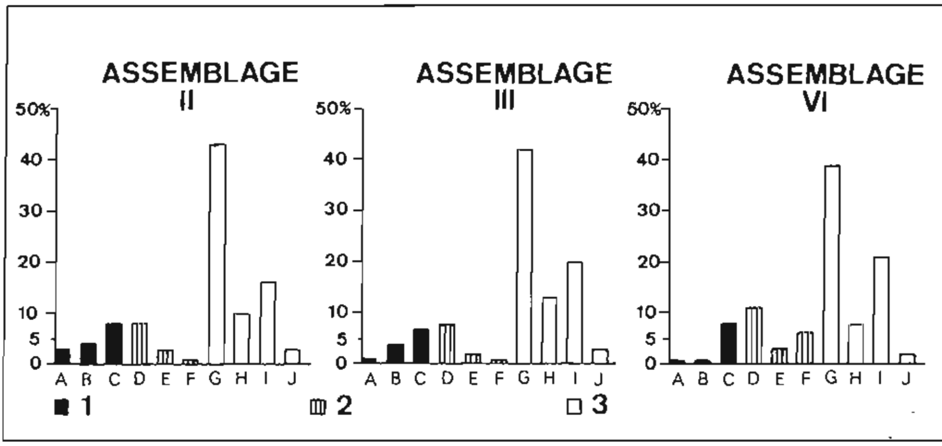

Fig. 2. Palaeoclimatical model

1 — hygrophytic elements; 2 — mixed elements; 3 — xerophytic elements; palynomorph groups: A — trilete, acavate, laevigate and apiculate spores, B — trilete, cingulate and zonate spores, C — monosulcate pollen, D — bisaccate monolete pollen, E — bisaccate, trilete pollen, F — bisaccate alete pollen, G — taenie, bisaccate pollen, H — *Triadispora* group, I — vesicate pollen, J — monosaccate pollen

Model paleoklimatyczny

1 — elementy higrofilne; 2 — elementy mieszane; 3 — elementy kserofilne; grupy palinomorf: A — gładkie spory ze znakiem trilet, B — spory ze znakiem trilet z pierścieniem lub zoną, C — pyłki *monosulcate*, D — pyłki dwuworkowe ze znakiem monolet, E — pyłki dwuworkowe ze znakiem trilet, F — pyłki dwuworkowe bez znaku, G — pyłki dwuworkowe prążkowane, H — grupa *Triadispora*, I — pyłki *vesicate*, J — pyłki jednoworkowe

The more detail considerations concerning this correlation are presented by T. M. Peryt (A. Fijałkowska, T. M. Peryt, 1995). The determination of position of this complex is of a great importance for reconstruction of the Stassfurt Cyclothem development. At the end of deposition of the Upper Anhydrite (A1g) in the northern part of the North Sudetic Trough (Kościelna Wieś IG 1 borehole), a sulphate shelf was subaerial exposed, which then was submerged during transgression of the Main Dolomite (Ca3), whereas, in the southern part of the trough (Czerwona Woda IG 1 borehole), the sulphate-clastic sedimentation of sebha provenance took place (A. Fijałkowska, T. M. Peryt, 1995).

All the microfloral assemblages are strongly dominated by xerophytic forms (mainly conifer pollen), which indicates a dry, warm climate during the deposition of the Zechstein evaporitic series.

Anex 1

LIST OF DETERMINED TAXA

Anteturma SPORITES Potonié, 1893

Turma **Triletes** (Reinch) Potonié et Kremp. emend. Dybova et Jachowicz, 1957

Subturma **Azonotriletes** Luber, 1935
Infraturma **Laevigati** (Bennie et Kidston) Potonié, 1956
Genus *Calamospora* Schopf, Wilson et Bentall, 1944

Calamospora pedata Kosanke, 1950
Calamospora cf. *tener* (Leschik) de Jersey, 1964 (Pl. I, Fig. 1)
Calamospora sp.

Genus *Laevigatisporites* Dybova et Jachowicz, 1957

Laevigatisporites sp. (Pl. I, Fig. 2)

Infraturma **Apiculati** (Bennie et Kidston) Potonié, 1958
Genus *Apiculatisporites* (Ibrahim) Potonié et Kremp, 1956

Apiculatisporites sp.

Infraturma **Verrucati** Dybova et Jachowicz, 1957
Genus *Verrucosisporites* (Ibrahim) Potonié et Kremp, 1956

Verrucosisporites sp.

Turma **Triletes-Zonales** (Bennie et Kidston) Potonié, 1956
Subturma **Zonotriletes** (Waltz) Potonié et Kremp, 1954
Infraturma **Cingulati** Potonié et Kremp, 1954
Genus *Lycospora* Schopf, Wilson et Bentall, 1944

Lycospora permica (Inosova) Fijałkowska, 1991 (Pl. I, Fig. 3)
Lycospora sp.

Turma **Monoletes** Ibrahim, 1933
Subturma **Azonomonoletes** Luber, 1935
Infraturma **Laevigatomonoletes** Dybova et Jachowicz, 1957
Genus *Laevigatosporites* Ibrahim, 1933

Laevigatosporites sp. (Pl. I, Fig. 4)

Anteturma POLLENITES Potonié, 1931
Turma **Saccites** Erdtman, 1947
Subturma **Monosaccites** (Chitaley) Potonié et Kremp, 1954
Infraturma **Monpolsacciti** (Hart) Dibner, 1970
Genus *Perisaccus* (Naumova) Potonié emend. Klaus, 1963

Perisaccus granulatus Klaus, 1963 (Pl. I, Fig. 5)

Genus *Endosporites* Wilson et Coe, 1940

Endosporites hexarecticulatus Klaus, 1963

Genus *Potonieisporites* Bharadwaj, 1954

Potonieisporites cf. *catagraphus* (Andreyeva) Hart, 1965 (Pl. I, Fig. 6)

Infraturma **Dipolsacciti** (Hart) Dibner, 1970
Genus *Cordaitina* (Samoilovich) Hart, 1963

Cordaitina donetziana Inosova, 1976
Cordaitina uralensis (Luber) Dibner, 1970

Genus *Nuskoisporites* Potonié et Klaus, 1954

Nuskoisporites dulhuntyi Potonié et Klaus, 1954 (Pl. I, Fig. 7)
Nuskoisporites klausi Grebe, 1957 (Pl. I, Fig. 9)
Nuskoisporites sp.

Genus *Trizonaesporites* (Leschik) Klaus, 1963

Trizonaesporites grandis Leschik, 1956

Genus *Crucisaccites* Lele et Maithy, 1964

Crucisaccites sp.

Subturma **Disaccites** Cookson, 1947
Infraturma **Striatiti** Pant, 1954
Genus *Protohaploxypinus* (Samoilovich) Hart emend. Morbey, 1975

Protohaploxypinus latissimus (Luber et Waltz) Samoilovich, 1953
Protohaploxypinus samoilovichii (Jansonius) Hart, 1964
Protohaploxypinus sp.

Genus *Strotersporites* (Wilson) Klaus, 1963

Strotersporites richteri (Klaus) Wilson, 1962
Strotersporites wilsoni Klaus, 1963
Strotersporites sp.

Genus *Striatoabietites* (Sedova) Hart, 1964

Striatoabietites balmei Klaus, 1964
Striatopodocarpites cf. *bricki* Sedova, 1956 (Pl. I, Fig. 8)
Striatoabietites multistriatus (Balme et Hennelly) Hart, 1964 (Pl. I, Fig. 10)

Genus *Lueckisporites* (Potonié et Klaus) Jansonius, 1962

Lueckisporites virkkiae Potonié et Klaus, 1954, NAa (after H. Visscher, 1971) (Pl. I, Figs. 13, Ab; 14, Ac; 12, Ba, Bb; 17, Bc, C, D, E, form with a "dark body" A. Fijałkowska, 1991; Fig. 18)

Genus *Lunatisporites* (Leschik) Scheuring, 1970

Lunatisporites alatus (Klaus) Fijałkowska, 1991
Lunatisporites albertae (Balme) Fijałkowska, 1993
Lunatisporites gracilis (Jansonius) Fijałkowska, 1991
Lunatisporites labdacus (Klaus) Fijałkowska, 1991 (Pl. I, Fig. 21)
Lunatisporites microsaccatus (Jansonius) Fijałkowska, 1991
Lunatisporites multiplex (Visscher) Scheuring, 1970
Lunatisporites noviaulensis (Leschik) Scheuring, 1970 (Pl. I, Fig. 11)
Lunatisporites ortisei (Klaus) Góczán, 1987
Lunatisporites transversundatus (Jansonius) Fijałkowska, 1991 (Pl.I, Fig.15)
Lunatisporites sp.

Genus *Protosacculina* (Maljavkina) Jansonius, 1962

Protosacculina sp.

Genus *Vittatina* (Luber) Wilson, 1962

Vittatina costabilis Wilson, 1962
Vittatina hiltonensis Chaloner et Clarke, 1962
Vittatina cf. *saccata* (Hart) Jansonius, 1962 (Pl. I, Fig. 22)
Vittatina simplex Jansonius, 1962
Vittatina subsaccata Samoilovich, 1953
Vittatina vittifera (Luber et Waltz) Samoilovich, 1953
Vittatina sp.

Genus *Aumancisporites* (Alpern) Jansonius, 1962

Aumancisporites striatus (Alpern) Jansonius, 1962

Genus *Hamiapollenites* Wilson ex Jansonius, 1962

Hamiapollenites cf. *bifurcatus* Jansonius, 1962
Hamiapollenites sp.

Infraturma Disacciatrileti Leschik, 1956
Genus *Klausipollenites* Jansonius, 1962

Klausipollenites decipiens Jansonius, 1962
Klausipollenites minimus Góczán, 1987
Klausipollenites schaubergeri (Potonié et Klaus) Jansonius, 1962 (Pl. I, Fig. 23)
Klausipollenites staplinii Jansonius, 1962
Klausipollenites vestitus Jansonius, 1962
Klausipollenites f. Y Jansonius, 1962
Klausipollenites sp.

Genus *Falcisporites* (Leschik) Klaus, 1963

Falcisporites zapfei (Potonié et Klaus) Leschik, 1955 (Pl. I, Fig. 19)
Falcisporites sp.

Genus *Vesicaspora* Schemel, 1951

Vesicaspora sp.

Genus *Paravesicaspora* Klaus, 1963

Paravesicaspora splendens Klaus, 1963 (Pl. I, Fig. 20)
Paravesicaspora sp.

Genus *Platysaccus* (Naumova) Potonié et Klaus, 1954

Platysaccus niger Mädler, 1964
Platysaccus papilionis Potonié et Klaus, 1954
Platysaccus sp.

Infraturma **Disaccitrileti** Leschik, 1956
Genus *Illinites* (Kosanke) Potonié et Kremp, 1954

Illinites elegans Kosanke, 1950
Illinites unicus Kosanke, 1950
Illinites sp.

Genus *Vitreisporites* (Leschik) Jansonius, 1962

Vitreisporites koenigswaldii Jansonius, 1962
Vitreisporites sp. (Pl. I, Fig. 26)

Genus *Jugasporites* (Leschik) Foster emend. Tiwari et Singh, 1984

Jugasporites delasaucei (Potonié et Klaus) Leschik, 1956
Jugasporites latus (Leschik) Foster, 1983 (Pl. I, Fig. 16)
Jugasporites lueckoides Klaus, 1963
Jugasporites paradelasaucei Klaus, 1963 (Pl. I. Fig. 29)
Jugasporites parvus (Klaus) Foster, 1983
Jugasporites cf. *parvus* (Klaus) Foster, 1983
Jugasporites purus (Leschik) Tiwari et Singh, 1984 (Pl. I. Fig. 25)
Jugasporites schaubergeroides Klaus, 1963
Jugasporites NB (after H. Visscher, 1971)
Jugasporites sp.

Genus *Triadispora* (Klaus) Scheuring emend. Brugman, 1979

Triadispora crassa Klaus, 1964
Triadispora plicata Klaus, 1964
Triadispora visscheri (Visscher) Fijałkowska, 1991 (Pl. I. Fig. 28)

Triadispora sp.

Infraturma **Disaccimonoleti** Klaus, 1963
Genus *Limitisporites* (Leschik) Klaus, 1963

Limitisporites moersensis (Grebe) Klaus, 1963
Limitisporites parvus Klaus, 1963
Limitisporites rectus Leschik, 1956 (Pl. I, Fig. 24)
Limitisporites sp.

Genus *Gardenasporites* Klaus, 1963

Gardenasporites heisseli Klaus, 1963
Gardenasporites leonardii Klaus, 1963
Gardenasporites moroderi Klaus, 1963
Gardenasporites oberrauchi Klaus, 1963
Gardenasporites sp.

Genus *Chordasporites* Klaus, 1963

Chordasporites sp.

Subturma **Polysaccites** Cookson, 1947
Infraturma **Polysacciti** Cookson, 1947
Genus *Crustaesporites* Leschik, 1956

Crustaesporites globosus Leschik, 1956

Turma **Plicates** Naumova, 1937
Subturma **Praecolpates** Potonié et Kremp, 1954
Infraturma **Praecolpati** Potonié et Kremp, 1954
Genus *Pakhapites* Hart, 1965

Pakhapites sp.

Subturma **Polyplicates** Erdtman, 1952
Infraturma **Polyplicati** Erdtman, 1952
Genus *Gnetacaepollenites* (Thiergart) Jansonius, 1962

Gnetacaepollenites steevesi Jansonius, 1962

Subturma **Moncolpates** (Wodehouse) Iversen-Troels et Smith, 1950
Infraturma **Inorti** (Naumova) Potonié, 1958
Genus *Cycadopites* (Wodehouse) Wilson et Webster, 1946

Cycadopites coxii Visscher, 1966 (Pl. I, Fig. 27)
Cycadopites follicularis Wilson et Webster, 1946
Cycadopites hartii Jansonius, 1962
Cycadopites sp.

Turma **Aletes** Ibrahim, 1933
Subturma **Azonaletes** (Luber) Potonié et Kremp, 1954
Infraturma **Psilonapiti** Erdtman, 1947
Genus *Sphaeripollenites* (Couper) Jansonius, 1962

Sphaeripollenites sp.

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Anna FIJAŁKOWSKA

PALINOSTRATYGRAFIA OSADÓW CECHSZTYNU W NIECCE PÓŁNOCNOSUDECKIEJ

Streszczenie

Badaniami palinologicznymi objęto serie ewaporatowe cechsztynu z niecki północnosudeckiej. Wyróżniono cztery zespoły mikroflorystyczne, które skorelowano ze spektrami znanymi z Gór Świętokrzyskich. Zespół I wykazuje duże podobieństwo do spektrum *Lueckisporites virkkiae* Ab wyróżnianego w osadach dolnego anhydrytu (A1d), zespół II — do *L. virkkiae* Ab i *Strotersporites* sp. div. z osadów serii terygenicznej T1r i anhydrytu górnego (A1g), zespół III — do spektrum stwierdzonego w anhydrycie podstawowym (A2) na terenie dalszego obrzeżenia Gór Świętokrzyskich oraz zespół IV — do spektrum *L. virkkiae* Ac wyróżnianego w anhydrycie głównym (A3) i spągu stropowej serii terygenicznej (Pzt).

Stratygraficzna interpretacja wyników badań palinologicznych potwierdziła wcześniejszą sugestię T. M. Peryta i A. Kasprzyk (1992), którzy zaliczyli siarczanowo-siliciklastyczny kompleks, leżący poniżej dolomitu płytowego, do cyklu PZ2. Określenie stratygraficznej pozycji tego kompleksu ma duże znaczenie dla rekonstrukcji rozwoju cyklu PZ2.

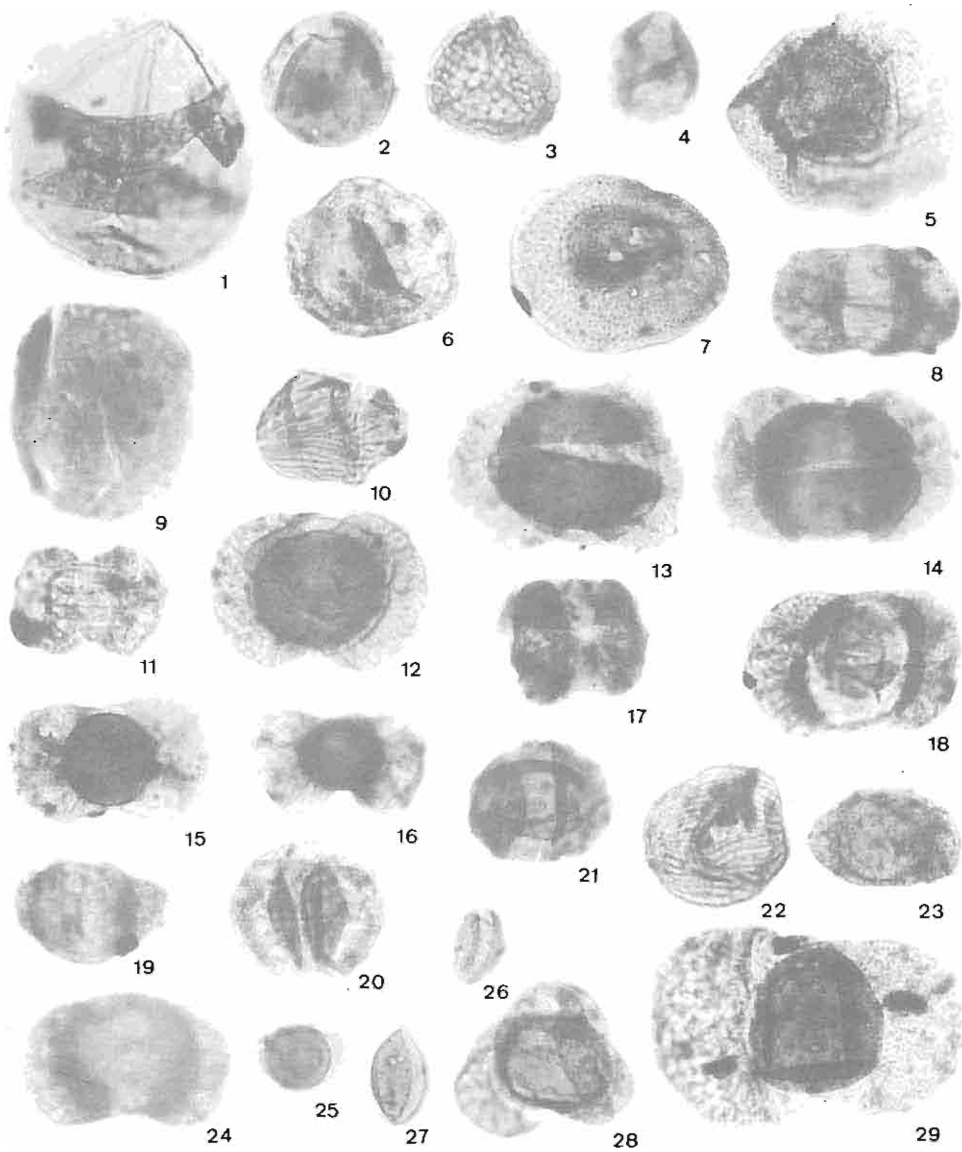
We wszystkich zespołach mikroflorystycznych wyraźnie dominują formy kserofilne — pyłki roślin iglastych, co wskazuje na suchy, ciepły klimat panujący w czasie sedymentacji serii siarczanowych.

PLATE I

Fig. 1. *Calamospora* cf. *tener* (Leschik) de Jersey
Fig. 2. *Laevigatisporites* sp.
Fig. 3. *Lycospora permica* (Inosova) Fijałkowska
Fig. 4. *Laevigatosporites* sp.
Fig. 5. *Perisaccus granulatus* Klaus
Fig. 6. *Potonieisporites* cf. *catagraphus* (Andreyeva) Hart
Fig. 7. *Nuskoisporites dulhuntyi* Potonié et Klaus
Fig. 8. *Striatopodocarpites* cf. *bricki* Sedova
Fig. 9. *Nuskoisporites klausi* Grebe
Fig. 10. *Striatoabietites multistriatus* (Balme et Hennelly) Hart
Fig. 11. *Lunatisporites noviaulensis* (Leschik) Scheuring
Fig. 12. *Lueckisporites virkkiae* Potonié et Klaus NAc
Fig. 13. *Lueckisporites virkkiae* Potonié et Klaus NAa
Fig. 14. *Lueckisporites virkkiae* Potonié et Klaus
Fig. 15. *Lunatisporites transversundatus* (Jansonius) Fijałkowska
Fig. 16. *Jugasporites latus* (Leschik) Foster
Fig. 17. *Lueckisporites virkkiae* Potonié et Klaus NBb
Fig. 18. *Lueckisporites virkkiae* Potonié et Klaus form with a "dark body"
Fig. 19. *Falcisporites zapfei* (Potonié et Klaus) Leschik
Fig. 20. *Paravesicaspora splendens* Klaus
Fig. 21. *Lunatisporites labdacus* (Klaus) Fijałkowska
Fig. 22. *Vittatina* cf. *saccata* (Hart) Jansonius
Fig. 23. *Klausipollenites schaubergeri* (Potonié et Klaus) Jansonius
Fig. 24. *Limitisporites rectus* Leschik
Fig. 25. *Jugasporites purus* (Leschik) Tiwari et Singh
Fig. 26. *Vitreisporites* sp.
Fig. 27. *Cycadopites coxii* Visscher
Fig. 28. *Triadispora visscheri* (Visscher) Fijałkowska
Fig. 29. *Jugasporites paradelasaucei* Klaus

Figs. 1, 3, 10, 25–27 — Czerwona Woda IG 1 borehole, depth 714.0–715.0 m, PZ1 (Werra Cyclothem) (A1g); Figs. 2, 4, 8, 11–21, 23, 24, 29 — Niwnice outcrop, ?PZ2 (?Stassfurt Cyclothem)(?A2); Figs. 7, 9 — Czerwona Woda IG 1 borehole, depth 674.3 m, ?PZ2 (?A2); Figs. 5, 6, 22, 28 — Kościelna Wieś IG 1 borehole, depth 785.4 m, PZ1 (A1d); magn. x 500

Fig. 1, 3, 10, 25–27 — otwór wiertniczy Czerwona Woda IG 1, głęb. 714,0–715,0 m, PZ1 (cyklotem werra) (A1g); fig. 2, 4, 8, 11–21, 23, 24, 29 — odsłonięcie Niwnice, ?PZ2 (cyklotem ?stassfurt)(?A2); fig. 7, 9 — otwór wiertniczy Czerwona Woda IG 1, głęb. 674,3 m, ?PZ2 (?A2); fig. 5, 6, 22, 28 — otwór wiertniczy Kościelna Wieś IG 1, głęb. 785,4 m, PZ1 (A1d); pow. 500 x



Anna FIJAŁKOWSKA — Palynostratigraphy of the Zechstein in the North Sudetic Trough