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PALYNOLOGY, PETROGRAPHIC COMPOSITION AND DEPOSITIONAL ENVIRONMENTS OF THE SELECTED WESTPHALIAN A COAL SEAMS FROM THE INTRASUDETIC BASIN (SW POLAND)

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ABSTRACT. Selected coal seams of the Żacler Formation (Westphalian A) were studied palynologically and petrographically. Three miospore-maceral associations were distinguished. In the high vitrinite coal of the 430 seam with changeable mineral matter content the arborescent lycopsid and mixed associations were recorded. Coal of both associations were accumulated in the planar rheotrophic mire. The arborescent lycopsids association represent its central part and coal of the mixed association were deposited in the marginal part. Rich in the inertinite coal of the 409 and 412/413 seams which contain low mineral matter amount represent the herbaceous and/or sub-arborescent lycopsids association, which is believed to correspond probably to the ombrotrophic domed mire.

KEY WORDS: macerals, microlithotypes, miospores, mire, Carboniferous, Lower Silesian Coal Basin

INTRODUCTION

This paper presents an approach to reconstruct the environments under which coal of the Intrasudetic Basin was formed. Palynological and coal petrographical data have been applied to achieve this aim. In this study term “mire” (“palaeomire”), according to Moore’s classification (1987) in the further consideration on coal seam studied depositional environment has been used.

On the basis of miospore data and all known connections between miospore taxa and the parent plants the palaeofloral assemblages may be reconstructed. Assignment of dispersed spores to their respective parent plant groups (e.g. lycopsids, ferns, calamites etc.) is based on compilations of Ravn (1986) and Górecka-Nowak (1995). Features of the environment may be interpreted because of known ecological preferences of particular plant groups (DiMichele & Phillips 1994).

Results of the facies analysis on the basis of the palynologic studies may be complemented by the results of coal petrography. Petrographic studies based on macroscopic (lithotype) or microscopic (microlithotype or maceral analyses) criteria. In this studies first of them were adopted from Nowak (1993), however second based on traditional maceral and microlithotype classification (Stach *et al*. 1982). Detailed description of the method applied here was presented by Nowak and Górecka-Nowak (1999).

RESULTS

The coal seams studied occur in the two areas of the Intrasudetic Basin (Fig. 1): north-western part – the Wałbrzych region, and south-eastern part – the Słupiec region. They belong to the Żacler Formation and represent Westphalian A in age (Górecka-Nowak 1995, 1996, 1997). All samples have been collected in the underground mines. From numerous coal seams from the first of these regions the seam 430 has been selected and sampled in the Victoria mine. The objects of the studies from the Słupiec region have been seams 409 and 412/413, sampled in the Słupiec field of the Nowa Ruda mine. Coals studied represent high volatile bituminous coal in rank, where R_o ranges from 0,91 to 1,09%.

Seam 430 – two profiles of this coal seam, including partings, have been studied. Thickness of the seam exceed 2 m. Profiles have been divided into petrographic intervals. Sample form each interval has been studied petrographically and palynologically.

Semibright coal is the main lithological type of this seam (Tab. 1). Content of vitrinite maceral group is high. Liptinite is represented mainly by microsporinite, sometimes by megasporinite. Inertinite was encountered in varying proportions. Variability of mineral matter is a characteristic feature for this seam. Clarite is the main type in the microlitotype composition (Nowak 1993, 1996, 1997a, b).

Palynologic studies provided well preserved miospore material consisting of 33 miospore genera (Tab. 2). They

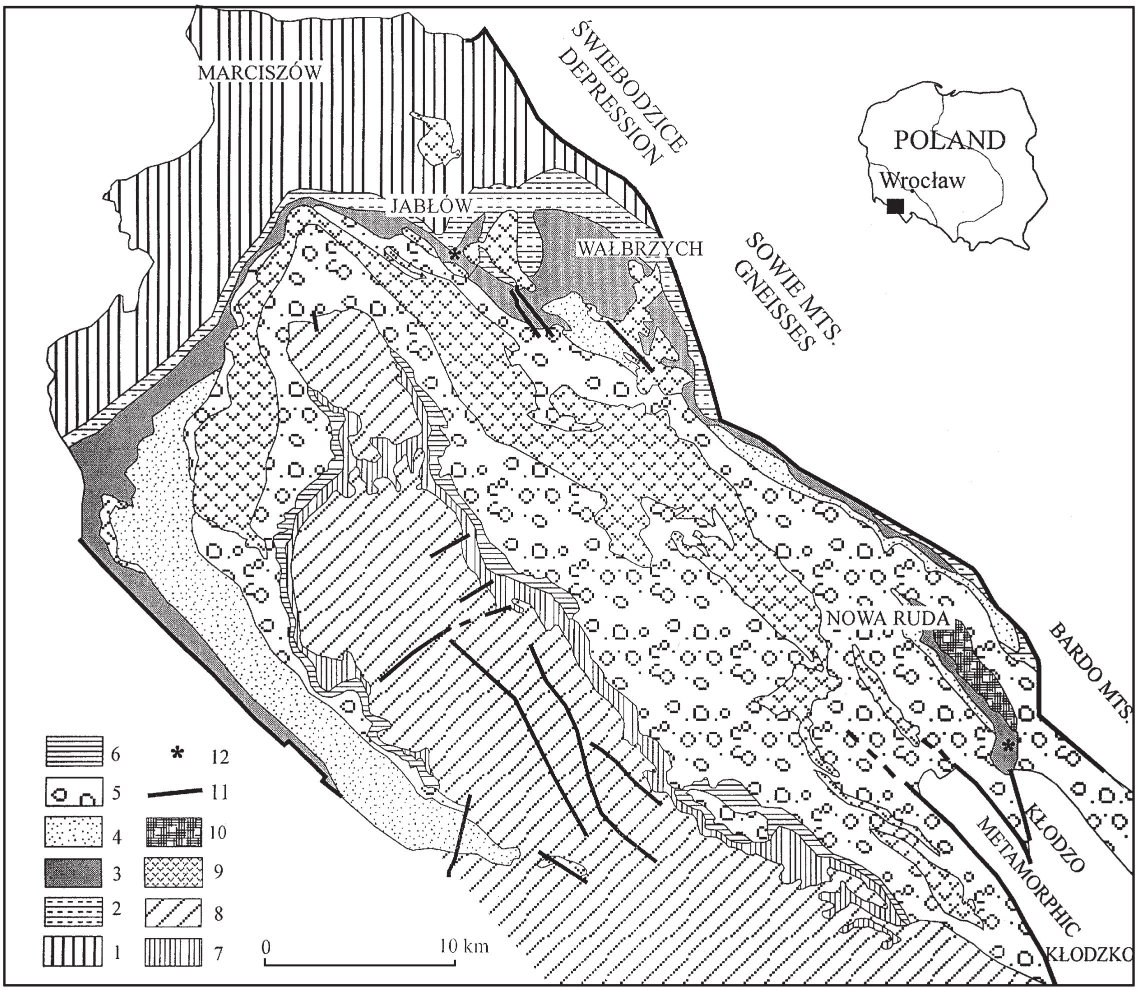

Fig. 1. Geologic map of the Intrasudetic Basin (from Teisseyre *et al*. 1957). 1 – Lower Carboniferous (Turnaisian and Visean deposits), 2–4 – Upper Carboniferous: 2 – Namurian, 3 – Westphalian, 4 – Stephanian, 5 – Lower Permian, 6 – Upper Permian, 7 – Triassic, 8 – Upper Cretaceous, 9 – Late Variscan volcanic rocks, 10 – gabbro of the Nowa Ruda Massif, 11 – fault, 12 – sampling site

represent five major Westphalian plant groups (lycopsids, calamites, ferns, seed ferns, cordaites) and occur in seam in varying proportions. Genus *Lycospora* is dominating in whole seam and represent large lycopsid trees as *Lepidodendron*, *Lepidophloios* and *Paralycopodites*. Important component of palynoflora from this seam is genus *Calamospora* produced by calamites. Its percentage exceeds 20% in certain intervals of the seam. Another important group of flora represented in the miospore assemblages were small ferns, producing *Granulatisporites*, *Leiotriletes* and other trilete, shaerotriangular genera.

Seams 409 and 412/413 – from each seam the channel sample, representing its whole profile has been studied. Coal seams 409 and 412/413 have the intermediate vitrinite content, high content of inertinite and constant liptinite percentage (Tab. 3). Liptinite occurs mainly as sporinite, where oval-shaped crassisporinite, being diagnostic maceral of the facies determination is observed. Typical feature of these coals is the low content of inorganic components. In microlithotype composition trimacerite predominates over other microlithotypes, with vitrite occuring in less amount (Nowak 1993, 1996, 1997a, b).

Palynological assemblage has been rich in specimens, but not diverse (Tab. 2). Main components of the monotonous miospore assemblages are *Densosporites* and related crassicingulate spores (e.g. *Cristatisporites*, *Radiizonates*, *Cingulizonates*). Palynologic data indicate that sub-arborescent plants *Sporangiostrobus* (= vegetative *Bodeodendron*) (Wagner 1989) were the main component of the palaeofloral assemblages from the time of these coals deposition. These plants composed above 80% of the palaeofloral association. Ferns (small and arborescent), arborescent lycopsids and sphenopsids occurred in minor abundance.

ENVIRONMENTAL INTERPRETATION

Three miospore-maceral associations have been established in the coal seams studied:

Table 1. Maceral composition of coal seam 430 of the Wałbrzych region

MACERALS (vol %)									
I	Th (m)	Lithotype**	Tc	De	V*	Sp	L*	I	Pi
Profile I									
A	0.8	semibright	23.2	22.4	13.2	7.2	0.8	25.0	2.0
B	0.1	semibright with fibrous coal	24.4	17.0	6.2	9.0	2.4	32.0	3.0
C	0.25	parting	–	–	–	–	–	–	–
	0.25	parting	–	–	–	–	–	–	–
E	0.25	semibright & bright	48.0	20.4	3.4	11.4	1.8	8.8	1.2
F	0.1	parting	–	–	–	–	–	–	–
G	0.6	semibright	36.0	29.4	2.2	10.6	1.0	18.0	1.2
Profile II									
A	0.3	semibright	38.4	25.8	1.4	13.4	0.8	16.4	0.2
B	0.1	banded bright	32.2	34	4.4	10.0	1.4	15.6	0.2
C	0.3	semibright	37.0	20.0	3.2	10.8	1.4	15.2	3.4
D	0.1	parting	–	–	–	–	–	–	–
E	0.1	banded coal	28.0	20.6	2.2	8.2	4.2	24.4	2.4
F	0.25	parting	–	–	–	–	–	–	–
G	0.1	banded coal	34.8	19.8	3.0	13.4	0.6	14.0	2.1
H	0.4	parting	–	–	–	–	–	–	–
O	0.25	undivaded group of lithotyp	25.4	22.6	9.0	11.0	1.2	17.6	2.2

I – interval
Tc – telocollinite
V* – rest of vitrinite macerals
Sp – sporinite
L* – rest of liptinite macerals
I – inertinite
MM – mineral matter
Th – thickness
** lithotype classification and nomenclature according to Nowak (1993)

1. arborescent lycopsids association;
2. mixed association;
3. herbaceous and/or sub-arborescent association.

Miospore assemblage of first of them is rather monotonous, prominently dominated by arborescent lycopsids. Percentage of *Lycospora* usually ranges 60–80%. Arborescent lycopsids association corresponds to the high vitrinite coals. High percentage of this maceral is caused by high content of telocollinite and desmocollinite. Coal of this association contains changeable amount of mineral matter – from low to high.

In the mixed association arborescent lycopsids, producing miospore genus *Lycospora,* were still the dominant group of the palaeofloral assemblage, but their percentage does not exceed 40%. Whole plant community was more diverse, with relatively high frequency of calamites and small ferns. Characteristic feature of coals belonging to this association is high percentage of vitrinite with predominance of telocollinite over desmocollinite as well as enrichment in mineral matter.

Both associations have been recognised in the 430 coal seam. First of them has occurred in coal of the basal part of the seam (samples A and B, profile I; sample A, profile II), but sometime appears in its middle part (sample G, profile II). Similar miospore assemblages have been recorded in some barren partings. However the mixed association has occurred in remaining levels of the 430 coal seam (Fig. 2).

Coal of the arborescent lycopsids association may be compared with the “*Lycospora* phase” (Smith 1962, 1968) and were formed in a forest swamp, in habitat with long periods of standing water (Teichmüller 1962, Strehlau 1990). Flooded environment was favoured by tree lycopsids due to their specialised growth and reproductive strategies (DiMichele & Phillips 1994). It is an important defining parameter of the mire, which then

Table 2. Miospore taxa distribution in samples from studied coal seams

Taxa	SEAM 430/I							SEAM 430/II							SEAM 409	SEAM 412/413
	A	B	C	D	E	F	G	A	B	C	E	F	G	O		
Leoitriletes spp.			6				1			3	5					
Punctatisporites spp.	3		4	5	3	12	13	6		8	11	12	5	8	7	4
Calamospora spp.		5	28	3	18	25	17	7	24	39	29	27	2	15		3
Granulatisporites spp.	2	6	9	6	10		1	1	6	1	1	6	3	5	2	
Cyclogranisporites spp.	3		5	6	13	5	12	1	3		4	5	5	7	1	
Converrucosisporites spp.	2								1		1			1		
Verrucosisporites spp.	3	3		2	6		11		5		12			3	1	3
Lophotriletes spp.	7	1	11		11	4	7		1		3	3		6		
Procoronaspora spp.	1															
Apiculatisporis spp.		3	7		5		6	5	2	7	6	5		8	5	
Anaplanisporites spp.	2						6		1				6			
Granasporites spp.		4	2			6	5		7	1		3		1		
Acanthotriletes spp.		2					3			1				1		
Raistrickia spp.	3	3	7	5	4	17	4		3			13	1	7		6
Convolutispora spp.		2		1			3						2	1		
Waltzispora spp.						1										
Dictyotriletes spp.	2						3									
Camptotriletes spp.	5			4	12	4	12	3			2	4	3			
Ahrensisporites spp.	4		13	9	3	7	1			5		1	9	13		
Triquitrites spp.			9	1	1	5	4	5	11	7		3	1	5	3	
Reticulatisporites spp.						1	5									
Savitrisporites spp.	9	7	14	5	15	8	32	3	35	26	21	12	4	9	9	5
Kuhlensisporites spp.	4				1		4	1	10	5	1	1		11		
Crassispora spp.			2			1		4		3	2	2	2		1	
Densosporites spp.	2	4	1				2	1		3	5			1	151	160
Cingulizonates spp.	1	2													4	2
Cristatisporites spp.			1												3	
Lycospora spp.	136	142	78	150	90	90	32	156	80	70	87	90	154	75	6	6
Radiizonates spp.															3	1
Cirratriradites spp.	1						1	1								3
Laevigatosporites spp.						6	6		4	11		7	1	7		2
Punctatosporites spp.	8	12	3	5	5	3	10	6	7	7	2	3	2	6	4	
Florinites spp.	2	4			3	4				3	3	1	1			
TOTAL number of specimens in sample	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200

was of rheotrophic type (Moore 1987) or may be called planar mire (Cecil *et al*. 1985). Changeable, sometimes high, percentages of inorganic matter may suggest an influences of river floods. That kind of mire could be developed in the neighbourhood of the river. These areas may have been the flood plains (Nowak 1996, 1997a, b, Nowak & Górecka-Nowak 1999). Stronger activity of rivers or short periods of river floods is especially marked as clastic partings.

Coal of the mixed association may be considered as formed in rheotrophic conditions, too. The edaphic conditions did not favoured the dominance and proliferation of any one plant group, but rather resulted in the heterogeneous distribution of plant types (Eble & Grady 1993,

Table 3. Petrographic composition of coal seams 412/413 and 409 in the Słupiec region

Seam	Macerals (vol. %)					
	Cl	V*	Sp	L*	I	MM
412/413	29.4	5.0	12.6	3.2	45.8	4.0
409	55.0	3.4	14.8	0.6	22.6	2.8

Cl – collinite
V* – rest of vitrinite macerals
Sp – sporinite
L* – rest of liptinite macerals
I – inertinite
MM – mineral matter

Strehlau 1990). It has been developed in the rather marginal part of the extensive mire on the flood plain (Nowak & Górecka-Nowak 1999).

Herbaceous and/or sub-arborescent association has been recognised in coal seams 409 and 412/413 from the Słupiec region (Fig. 2). Palynological and petrographical characteristics of this association is given above. This association corresponds to coal representing "*Densospo-rites* phase" (Smith 1962, 1968). Picture of the vegetation reflected in the miospore data is very monotonous. Palynologic data display that herbaceous and/or sub-arborescent lycopsids were the main components of the palaeofloral assemblages from the time of these coal deposition and all the remaining plant groups were rare. Low percentage of the mineral matter in these inertinite-rich coals, as well as their palynologic characteristics indicate that coals of this association probably developed in the conditions of ombrogenous mire called by Cecil *et al*. (1985) domed peat forming environment.

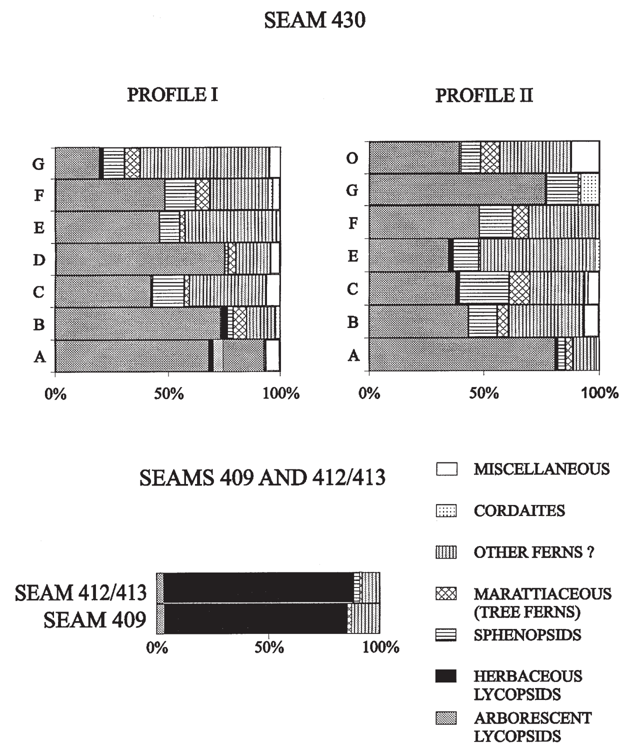

Fig. 2. Composition of the palaeofloral assemblages of coal seams studied

CONCLUSIONS

The coals studied of the Westphalian A of the Żacler Formation in the Intrasudetic Basin display changeable petrographic and palynologic composition. In general coal of the 430 seam from NW part of the basin represents rheotrophic mire connected with river plains subenvironment. Variation of the palynological assemblages composition as well as differentiation in maceral composition indicate that they have developed in the extensive planar mire, either in its central or marginal part. However coal of seams 409 and 412/413 from SE part of the basin has originated in different palaeoecological conditions. They probably represent domed ombrotrophic mire.

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