Kwartalnik Geologiczny, t. 27, nr 1, 1983 r., str. 41-58

UKD 552.574.1:551.735.2.022.4.004.14 mikrofacje: 622.142.1

IUGS UNESCO IGCP

Project 166

Krystyna KRUSZEWSKA

Microfacies types of coal seams in Upper Silesian Coal Basin

The microfacies character of Upper Silesian coal seams has been investigated on the ground of microlithotype analises. As a result following microfacies types of coal seams have been determined: I – basic type, the most common one, with coal composed predominantely of vitrite and trimacerite, both of them exceeding 15% amount; other microlithotype groups are in minority; II – vitrite type where only vitrite exceedes 15% and other microlithotype groups are in minority; III – clarite type, where apart of vitrite and trimacerite also clarite exceedes 15% of total amount; IV – durite-inertite type where apart of vitrite and trimacerite also either durite of inertite (or both) exceedes 15% of total amount; V – mixed type where apart of vitrite and trimacerite also clarite and either durite or inertite (or both) exceedes 15% of total amount; VI – carbominerite type where apart of vitrite and trimacerite as well as other microlithotype groups also carbominerite exceedes 15%.

The distribution of these types throughout the Upper Carboniferous succession in Upper Silesian Coal Basin, compared with macrofacial development of associated rocks, suggest following conclusions: 1 – there is uniformity in macro- and microfacies in Upper Silesian coal-bearing formation; 2 – the microfacies character of Upper Silesian coals can be used as an indicator of their genetic conditions; 3 – forest swamps were the main source for coal seam formation but during Westphalian A and B also calamitean reeds played probably also an important role; 4 – the microfacies characteristics of coal seams can be applied in practice for predicting their industrial application.

INTRODUCTION

The Carboniferous coal-bearing formation in Upper Silesian Coal Basin is subdivided into following lithostratigraphical series (Z. Dembowski, 1972*a*):
- Paralic Series (Namurian A);
- Upper Silesian Sandstone Series (Namurian B and C);
- Siltstone Series (Westphalian A and B);
- Cracow Sandstone Series (Westphalian C and D).

Each of these series can be determined by some general lithofacial features which distinguish them from other sedimentary successions. Petrographical investigations of samples gathered from most of mines and boreholes distributed throughout the basin and representing Upper Silesian coal seams from all lithostratigraphic series revealed that their petrographic composition show clear relationship to macrofacies features of the series.

The purpose of this paper is to clear up this relationship on the ground of microlithotype analysis of Upper Silesian coals. As a result, the microfacies systematics of Upper Silesian bituminous coals is presented along with a hypothesis of genetic conditions of Upper Silesian coal seams formation.

GENERAL REMARKS

Upper Silesian coals developed almost exclusively in humic facies. Sepropelic coals are rare and usually associated with humic coal seams as their top or base sediments. Microscopical analysis of some 3,000 samples of coal, collected from all stratigraphic units in most of Upper Silesian coalfields, revealed significant regularites. Upper Silesian humic coals are mostly composed of following groups of microlithotypes:

V i t r i t e, occurying as bands and lenses originated from stems and branches under conditions of high ground water level and restricted oxygen supply, collite, seldom telite, dominates in most of analysed coals. Only in the saddle group (Anticlinal Beds – Namurian B) coal seams are often dominated by the second abundant group – trimacerite.

I n e r t i t e, usually represented by lenses or, sometimes, bands of semifusite, fusite, sclerotite and inertodetrite, is less common in the majority of known coals seams. Fusite and semifusite present in Carboniferous coals are regarded as degradofusinite and degradosemifusinite rather than pyrofusite and are recognized as remains of temporarily dried peat surface which was exposed to the influence of oxygen from the atmosphere (M. Teichmüller, 1975). Also origin of macroite is connected with the process of superfacial oxygen. Inertodetrite is connected with subaquatic facies.

L i p t i t e has been recognized in some of analysed coals, usually as lenses of resinite, thick megaspores in lower rank coals or as sporangia, usually in amounts not exceeding 1%.

C l a r i t e is found in variable amounts in bands or, sometimes, lenses in most of analysed coals. The most common microlithotype of this group in Upper Silesian coals is sporoclarite, though beautiful examples of cuticuloclarite have been also found in several coals. Resinoclarite was often identified in thicker bands or lenses (50 μm) of telinite with cell lumens infilled by resinite. According to M. Teichmüller (1975) "...clarites suggest a formation under moist conditions and so the microlithotype is particularly common in seams of rapidly subsiding coal basins...". In coals affected by II-nd coalification jump clarite is converted into vitrite due to the process of vitrinitisation of exinite.

D u r i t e in most of analysed coals is usually represented by spore-rich durite related to subaquatic ooze deposits (M. Teichmüller, 1975). These durites normally consist of *Crassisporites* (*Densosporites* sp., *Anulatisporites* sp., *Cingulizonates* sp., *Crassispora* sp.) plus macrinite, macrinite and inertodetrinite which also indicate their subaquatic origin. Thick seams often particularly rich in durite develop in areas of slowly subsiding basement (M. Teichmüller, 1975).

V i t r i n e r t i t e in Upper Silesian coals of lower rank is found regularly in rather small amounts. This type of vitrinertite composed of finely dispersed micrinite in collinite or as tellinite with cell lumens impregnated by micrinite is according to M. Teichmüller (1975) attributable to frequent dessication of swamps. According to M. Shiboaka (1978), at least some part of micrinite in vitrinertite arises from porigellinite. Coals of higher rank which passed already II-nd coalification jump are enriched in vitrinertite due to transformation of trimacerite and loss of its exinite in the process of „vitrinization".

Trimacerite which besides of vitrite is the most common group of microlithotypes in Upper Silesian coals, is transitional between clarites and durites. The most common type of trimacerite in Upper Silesian seams is represented by exinite-rich duroclarite which most likely have been formed in subaquatic conditions. Clarodurite consisting of inertodetrite fragments may suggest periodic dessication of the surface. This type of trimacerite is often common in Anticlinal Beds (Namurian B, lower part of Upper Silesian Sandstone Group).

Carbominerite is commonly identified in Upper Silesian coals, especially in siltstone series (Załęże and Orzesze Beds), in the form of carbargilite. Carbopyrite is less abundant but also quite frequent. Carbankerite was found to occur in negligible amounts and carbosilicite is rare. Carbopoliminerite is normally identified as pyrite associated with clays in coal. Minerite mainly occurs as clay lamines or lenses more then 50 μm thick throughout the whole coal-bearing succession but in various amounts. Both carbominerite and rock are common in Ruda, Załęże and Orzesze Beds. Less frequently they were identified in Poruba, Łaziska and Libiąż Beds.

All above mentioned microlithotypes usually form characteristic assemblages. Quantitative microlithotype analysis shows that Upper Silesian coals can be classified into six different types. The subdivision is based on abundance of individual maceral groups in given coal sample. It is to be stressed that only those maceral groups were taken into account which were found in the amounts exceeding 15%.

According to these premises the following microfacies types were distinguished:

I. BASIC TYPE

Coals of this type are most common throughout the Upper Silesian succession. They are dominated by two most common microlithotype groups: vitrinite and trimacerite (other groups are in minority) and they can be considered as representative microfacies of Upper Silesian coal measures. Trimacerite passing II-nd coalification jump alters into vitrinertite. Vitrinertite in coals of lower rank in most cases occurs in minor amounts. It is to be stressed up that vitrinertite in Upper Silesian coals of lower rank consist of vitrinite associated with fine-grained micrinite which according to M. Teichmüller (1975) originate from bituminite during first coalification jump. M. Shiboaka (1978) attributes genesis of micrinite rather to porigelinite. It plays an important role in high-rank coals when replaces trimacerite after second coalification jump.

Microscopically, vitrite-trimacerite-rich coal is finely lamined and it consists of alternating thin bright and matt layers. In such coal seams clarain dominates. Generally, the coal seams were formed below water surface, under limnited oxygen supply. More or less regularly (due to changes of subsidence), the facial condition have changed and in a bit deeper water sediments precursory to trimacerite have formed. When this process progressed, arised conditions for prae-durite formation. In vitrite-trimacerite coal seams such conditions were rare, and therefore amount of durite in these coals doesn't exceed 15%. Coal contributed to a Upper Silesian basic type occurs in following varieties: 1 – vitrite-trimacerite, and 2 – vitrite-vitrinertite.

II. VITRITE TYPE

The facies conditions related to high groundwater level and limited oxygen supply are favourite for gelification and, when maintained for long periods of time, coal seams may become enriched in single microlithotype group: vitrite. Coal seams of this microfacies type macroscopically consist of vitrain bands. This microfacies type has no varieties. Its range is shorter comparing to a basic type. Regularly is found in Załęże Beds of Siltstone Series (Westphalian A) and in the uppermost part of Ruda Beds (top of Upper Silesian Sandstone Series, Namurian C). It was also identified in single cases in the remaining parts of Ruda Beds. In Anticlinal Beds (Namurian B), Orzesze (Westphalian B), Łaziska Beds (Westphalian C) this type was identified in single samples. In Paralic Series (Namurian A) and top section of Cracow Sandstone Series (Libiąż Beds, Westphalian D), vitrite type have not yet been found.

III. CLARITE TYPE

This type is characteristic, because of abundant clarite ($\geq 15\%$) normally associated with vitrite or vitrite and trimacerite. Coals with predomination of clarite-trimacerite so far were not found in coal-bearing succession. The most common is sporoclarite with *Lycospora* sp. sp., but cuticuloclarite has also often been found. This type may be subdivided into following varieties: 1 – vitrite-clarite, and 2 – vitrite-clarite-trimacerite.

IV. DURITE-INERTITE TYPE

Several coal seams consist of microfacies type where apart of vitrite and trimacerite also inertite and durite occur in amounts exceeding 15%. This type is subdivided into:

IVa – inertite subtype,
IVb – durite subtype,
IVc – durite-inertite subtype.

All of them occur in the same facies sequences.

IVa. Inertite subtype is enriched in inertite (mainly degradofusite) which indicates longer dry periods during coal seam formation. Usually it is associated with vitrite and trimacerite or vitrinertite and occurs in thick coal seams in Upper Silesian Sandstone Series (Namurian B and C) and Cracow Sandstone Series (Westphalian C and D). Within this subtype following varieties have been recognized: 1 – inertite-trimacerite, 2 – vitrite-inertite-vitrinertite, 3 – vitrite-inertite-trimacerite, and 4 – inertite-vitrinertite.

IVb. Durite subtype in Upper Silesian coals, enriched mostly in crassidurite, is connected with more frequent and longer facies conditions favourable for accumulating subaquatic ooze deposits (P.A. Haquebard, 1964, D. Reideneuer et al., 1967; M. Teichmüller, 1950; A.H.V. Smith, 1964, 1968). This subtype is regularly distributed in Upper Silesian Sandstone Series, being common in Łaziska Beds (Cracow Sandstone Series). The following varieties have been distinguished within this subtype: 1 – vitrite-durite, 2 – durite-trimacerite, and 3 – vitrite-durite-vitrinertite.

IVc. Durite-inertite subtype is characterised by abundance of both inertite and durite which indicates longer and more frequent periods of dry seasons succeeded by seasons with higher water level, suitable for subaquatic ooze deposition. Both microlithotype groups are normally associated with vitrite, trimacerite, vitrinertite and consist of three or four abundant microlithotype groups. Following varieties were identified: 1 – vitrite-inertite-durite, 2 – vitrite-inertite-trimacerite, and 3 – inertite-durite-trimacerite.

V. MIXED TYPE

In rare cases, mainly within Upper Silesian Sandstone Series, coal is characterized by microlitbotype composition where both clarite and durite or inertite (or both) occur in significant amounts. Only 16 cases of such a type have been found and following varieties distinguished: 1 – vitrite-clarite-inertite, 2 – vitrite-clarite-durite-trimacerite, and 3 – vitrite-inertite-durite-clarite.

As stated above, this type and its variations are of marginal importance in Upper Silesian Basin. Their occurrence is limited to Upper Silesian Sandstone Series and the lowest part of Siltstone Series. Two samples of tbat type were identified in Cracow Sandstone Series coals. Most of coals of this type belong to thick coal seams. Facial conditions during their formation were probably for some reasons more differentiated tban normally.

VI. CARBOMINERITE TYPE

This type is characterized by abundant carbominerite, mostly carbargillite or minerite, occurring in laminae and lenses thicker than 50 μm and it is associated with Siltstone Series and Ruda Beds (upper part of Upper Silesian Sandstone Series). In coals of Paralic Series as well as lower part of Upper Silesian Sandstone Series (Anticlinal Beds) and Cracow Series this type is less frequent and usually connected with different type of carbominerite. The most common varieties of this type are connected with vitrite, clarite and basic (vitrite-trimacerite) types wbere carbominerite usually is represented by carbargillite. They occur regularly in Załęże Beds together with vitrite, clarite and basic types and following common varieties were distinguished: 1 – vitrite-clarite-carbominerite, 2 – vitrite-clarite-minerite, 3 – vitrite-clarite-carbominerite-minerite, 4 – vitrite-minerite, 5 – vitrite-carbominerite, 6 – vitrite-carbominerite-minerite, 7 – vitrite-trimacerite-carbominerite, 8 – vitrite-trimacerite-minerite, and 9 – vitrite-clarite-trimacerite-carbominerite. The latter one was distinguished in a single sample (coal seam no. 329/3). Varieties connected with inertite-durite type are significantly less common and were mainly identified in the part of Załęże Beds between coal seams 405 and 362. Following varieties were distinguished: vitrite-inertite-carbominerite, vitrite-inertite-minerite, and vitrite-inertite-trimacerite-carbominerite.

In single sample the variety: vitrite-clarite-durite-minerite was identified. As it was stressed above, carbominerite as well as minerite are mainly represented by clayish components. Quite commonly found is also pyrite (syngenetic as well as epigenetic) and in several coal seams more or less abundant carbonates were identified. Quartz is rare and usually insignificant mineral component of Upper Silesian coal seams. Carbopolyminerite normally consist of argillite plus pyrite integrally mixed up with organic matter. Clay mineral contaminations in Załęże Beds are obviously connected with aleuritic-pellitic macrofacies. Mineral contaminations in inertite-durite type of coal in both Sandstone Series are usually very low.

DISTRIBUTION OF MICROFACIES TYPES IN UPPER SILESIAN CARBONIFEROUS PROFILE

As it was stressed above, several lithostratigraphic units may be distinguished by their specific microfacial character in Upper Silesian coal-bearing strata.

Detailed distribution of types and their varieties is presented in Tables 1—4. Development of coal bearing organic-inorganic sediments in Upper Silesian Basin is characterized by lithostratigraphic complexes connected with specific seam petrographic features discussed below.

PARALIC SERIES – NAMURIAN A (TABLE 1)

The oldest coal bearing series has the local subdivision into Petřkovice, Hrušov, Jaklovec and Poruba Beds. First coal bearing sequence in Polish part of the basin are Hrušov Beds. By now they are exposed exclusively in Gliwice Mine. They reach a thickness of 1300 m and are divided into two megacyclothems of the coal bearing sedimentation (A. Kotas, W. Malczyk, 1972*a*).

The lower megacyclothem, 360—650 m thick, comprises coal-bearing sediments beginning with whetstone, considered either as quartz pellite or a sort of tuffite (J. Kuhl, 1955). It consist of several coal intercalations and nineteen of the more constant seams, numbered 848—829. The coal-bearing complex is clearly cyclical in pattern of beds and paralic in character (A. Kotas, W. Malczyk, 1972*a*) and its thickness ranges from 310 to 520 m. The sandstone content in the column of this series ranges from 37.1 to 58.6%. Thick interbeddings of claystone-siltstone rocks with syderite concretions predominate here. Marine fauna occurs in three intercalations in the middle part of the packet. Only two coal seams 816 and 819 were analysed from microfacial point of view. Both maceral and microlithotype analysis indicate clarite type but further investigations of coal seams from Hrušov Beds are necessary.

J a k l o v e c B e d s lay between two thick and widespread barren sediments with marine bands: Enna (VII) and Barbara (V). They are typical limnic sediments with frequent zones of fresh-water fauna. Their maximum thickness is about 380 m in average and contain aproximatelly 35 coal seams numbered from 723 to 701 (A. Kotas, W. Malczyk, 1972*a*). The sandstone content varies from 26—44% in Jejkowice Trough to 43% in Gliwice Mine. The stratigraphic equivalent of Jaklovec Beds in Dąbrowa Region and the eastern part of the basin is the uppermost part of Flora Beds and lower part of Grodziec Beds (A. Jachowicz, 1972). Their thickness reaches 200 m in the Maczki area and rises up to 450 m in the Jowisz Mine. Their basal part is framed by sandstone overlied by claystone-siltstone complex, including Barbara (V) marine horizon with very rich assemblage of fauna. Coal seams are rather thin (A. Kotas, W. Malczyk, 1972*a*). Microfacies character of 703, 707, 708, 721 coal seams from four mines is mainly of basic type. Seam 703 from Chwałowice Trough is characterized by clarite type (vitrite-clarite variety). Coal seam 707 from Rymer Mine is characterized by inertite-durite type IV (vitrite-trimacerite variety). Maceral analysis of these coals shows increase of inertinite content comparing to Hrušov Beds.

P o r u b a B e d s and their equivalent in north-eastern part of the basin — Upper Grodziec Beds, are distributed in: Jejkowice and Chwałowice Trough, Gliwice area, Dąbrowa area, Main Anticline area and the eastern part of the Upper Silesian Coal Basin. In Jastrzębie, Cieszyn and Main Trough areas Poruba Beds

Table 1

The distribution of microfacies varieties in coal seams from Paralic Series

Seam number	Type varieties																																	
	V	*V Ct*	*V Ct Tr*	*V Ct Cm (m)*	*V Ct Tr Cm (m)*	*V Cm (m)*	*V Tr*	*V Vt*	*V Tr Vt*	*Vt Tr*	*V Tr Cm (m)*	*V Vt Cm (m)*	*V It*	*Dt Vt Tr*	*V Tr Dt*	*Dt Tr*	*Dt It Tr*	*V It Tr Dt*	*V It Tr*	*V Vt It*	*V It Vt Tr*	*V It Dt Vt*	*V It Dt*	*V Dt*	*V It Cm (m)*	*V It Tr Cm (m)*	*V Ct Dt Tr*	*V Ct Dt Cm (m)*	*V Ct Dt*	*(m)*	*It Tr*	*It Vt*	*Vt It Ct Dt*	*Vt Ct Tr*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
601						∧																			+									
610		×	×	∧																														
613																									+									
615		×	×																															
616																																		
620				∧			Δ																							O				|
621					∧																													
625		×				∧	Δ				▲																							
626							Δ																											
628			×				Δ																											
628/2			×																															
630/1			×				Δ																											
630/2							Δ																											
703		×					Δ																											
707							Δ																											
707/708							Δ																											
721																																		
816			×																															
819																																		

V – vitrite (witryt), *It* – inertite (inertyt), *Ct* – clarite (klaryt), *Vt* – vitrinertite (witrynertyt), *Dt* – durite (duryt), *Tr* – trimacerite (trimaceryt), *Cm* – carbominerite (karbomineryt), *m* – minerite (mineryt), Δ – varieties of basic type – I (odmiany typu podstawowego – I), × – varieties of types: vitrite – II and clarite – III (odmiany typów: witrytowego – II i klarytowego – III), ● – varieties of inertite-durite type (odmiany typu inertytowo-durytowego), V – mixed type (typ mieszany), ∧ – carbominerite type – clarite-vitrite connected variety (typ karbominerytowy – odmiana witrytowa), ▲ – carbominerite type – vitrite-trimacerite connected variety (typ karbominerytowy – odmiana witrytowo-trimacerytowa), + – carbominerite type – inertite (durite) – clarite connected variety (typ karbominerytowy – odmiana witrytowo-klarytowo-inertytowa), O – carbomineryte type – minerite variety (typ karbominerytowy – odmiana minerytowa), | – others (inne)

Table 2

The distribution of microfacies varieties in coal seams from Upper Silesian Sandstone Series

Seam number	Type varieties																																	
	V	*V Ct*	*V Ct Tr*	*V Ct Cm (m)*	*V Ct Tr Cm (m)*	*V Cm (m)*	*V Tr*	*V Vt*	*V Tr Vt*	*Vt Tr*	*V Tr Cm (m)*	*V Vt Cm (m)*	*V It*	*Dt Vt Tr*	*V Tr Dt*	*Dt Tr*	*Dt It Tr*	*V It Tr Dt*	*V It Tr*	*V Vt It*	*V It Vt Tr*	*V It Dt Vt*	*V It Dt*	*V Dt*	*V It Cm (m)*	*V It Tr Cm (m)*	*V Ct Dt Tr*	*V Ct Dt Cm (m)*	*V Ct Dt*	*(m)*	*It Tr*	*It Vt*	*Vt It Ct Dt*	*Vt Ct Tr*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
407	×		×				Δ																											
407/1						∧														●	●													
407/2	×		×			∧	Δ								●	●		●																
407/3						∧	Δ		Δ																									
407/4	×						Δ		Δ										●															
408	×			∧		∧	Δ																											
408/1			×				Δ																											
408/2						∧	Δ																											
409			×	∧							▲					●														O				
409/1			×			∧	Δ		Δ																									
409/2	×		×																							V								
409/2–3						∧																												
409/3			×																															
409/4		×	×				Δ																					|						
410			×	∧			Δ	Δ	Δ		▲								●	●										O				
411			×						Δ																									
411/3									Δ																									
412						∧	Δ																											
413			×			∧																												
414	×						Δ				▲																							
414/1				∧			Δ				▲								●															
414/2							Δ												●															
414/4							Δ																											
415/1–2							Δ																											
416						∧								●					●	●	●													
416/1							Δ												●	●											●			
416/2				∧				Δ					●																	O				
416/1–2																																		
417																																|		
418	×					∧	Δ		Δ		▲		●							●									V					
418/1						∧																												
418/2																			●															
419						∧	Δ		Δ				●																V					
419/1																				●														
420							Δ	Δ	Δ																									
501	×						Δ	Δ	Δ					●	●	●		●		●														
501a														●																				
502											▲									●														
503			×																		●													
504			×				Δ	Δ	Δ				●		●			●	●	●	●						V				●			
505						∧														●	●													
505/1							Δ												●	●														
506			×				Δ	Δ							●												V							
507															●	●		●	●								V					●		
509							Δ								●																			
509/510							Δ								●			●																
510		×	×			∧	Δ	Δ	Δ				●	●	●	●		●	●			●										●		
510/1																				●														
510/2																			●	●														

Explanations as given in Table 1

Table 4

The distribution of microfacies varieties in coal seams from Cracow Sandstone Series

Seam number	Type varieties																																	
	V	*V Ct*	*V Ct Tr*	*V Ct Cm (m)*	*V Ct Tr Cm (m)*	*V Cm (m)*	*V Tr*	*V Vt*	*V Tr Vt*	*Vt Tr*	*V Tr Cm (m)*	*V Vt Cm (m)*	*V It*	*Dt Vt Tr*	*V Tr Dt*	*Dt Tr*	*Dt It Tr*	*V It Tr Dt*	*V It Tr*	*V Vt It*	*V It Vt Tr*	*V It Dt Vt*	*V It Dt*	*V Dt*	*V It Cm (m)*	*V It Tr Cm (m)*	*V Ct Dt Tr*	*V Ct Dt Cm (m)*	*V Ct Dt*	*(m)*	*It Tr*	*It Vt*	*Vt It Ct Dt*	*Vt Ct Tr*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
116															●												|	|						
116/1														●											+									
116/2															●																			
117		×	×																															
118			×																															
119/1																																		
119/2							Δ																											
203/1			×				Δ																											
205/1							Δ								●																			
205/2			×				Δ																											
205/3																																		
205/4			×																															
206							Δ																											
207		×	×	∧			Δ		Δ													●												
207/3							Δ																											
207/4							Δ																											
207/6			×																															
208		×		∧																														
208/1		×																																
208/2															●																			
209							Δ							●															|					
211			×				Δ																											
212			×				Δ																											
214			×	∧			Δ				▲																							
215							Δ				▲			●					●															
216				∧																														
301			×				Δ											●	●															
302							Δ		Δ						●																			

Explanations as given in Table 1

The distribution of microfacies varieties in coal seams from Siltstone Series

Seam number	Type varieties																																	
	V	V Ct	V Ct Tr	V Ct Cm (m)	V Ct Tr Cm (m)	V Cm (m)	V Tr	V Vt	V Tr Vt	Vt Tr	V Tr Cm (m)	V Vt Cm (m)	V It	Dt Vt Tr	V Tr Dt	Dt Tr	Dt It Tr	V It Tr Dt	V It Tr	V Vt It	V It Vt Tr	V It Dt Vt	V It Dt	V Dt	V It Cm (m)	V It Tr Cm (m)	V Ct Dt Tr	V Ct Dt Cm (m)	V Ct Dt	(m)	It Tr	It Vt	Vt It Dt	Vt Ct Tr
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
303	×						Δ																											
304			×																															
304/2		×																																
305						∧	Δ				▲																							
305/2			×																															
312	×					∧	Δ																											
313			×																															
314				∧																														
318							Δ																											
320/2						∧													●															
324			×				Δ																											
325			×								▲																							
326/2			×																															
326/4							Δ																											
327			×				Δ																											
327/5			×																															
328	×		×								▲																							
328/1																																		
328/3	×					∧								●																				
329/2			×																															
329/3					∧																													
329/4				∧																														
330							Δ																											
330/1		×				∧																												
330/2		×	×			∧																												
330/3			×			∧																												
331/1	×		×																															
331/2				∧																														
332/1		×																																
332/2		×	×										●																					
333			×			∧																												
333/1	×																																	
333/2	×																																	
333/3	×	×					Δ																											
334																																		
334/1	×		×	∧		∧																												
334/2							Δ				▲																							
335/1	×	×	×			∧																												
335/2	×																																	
336							Δ				▲		●																					
336/1		×	×				Δ																											
336/2	×	×	×																															
336/3	×																																	
336/4	×					∧																												
338/1	×					∧	Δ																											
338/2	×						Δ																											
338/3		×	×	∧																														
339			×																															
340/1		×																																
340/2		×				∧	Δ																											
341							Δ																											
342/1	×		×			∧	Δ				▲																							
342/2							Δ																											
343											▲																							
344/1	×						Δ				▲																							
344/2	×		×				Δ																											
344/3		×	×			∧	Δ																											
344/4		×	×			∧	Δ																											
345		×	×			∧					▲																							
345/1−2							Δ																											
346																			●															
346/1		×				∧	Δ																											
346/2		×		∧		∧	Δ																											
346/3							Δ						●																					
346/4	×		×				Δ																											
347							Δ																											
348/1			×				Δ																											
348/2	×	×				∧	Δ																											
349						∧	Δ																											
349 B																																		
349/1	×			∧			Δ																											
349/2	×	×				∧	Δ				▲																							
349/3	×	×	×				Δ																											
349/4							Δ																											
349/5	×						Δ												●															
350/1	×	×	×			∧	Δ																											
351	×		×				Δ																											
351/1		×	×				Δ																											
351/2	×	×	×				Δ																											
351/3	×	×	×				Δ																											
352		×					Δ						●																					
352/1	×	×					Δ		Δ										●															
352/2	×			∧			Δ																											
353		×	×			∧	Δ		Δ																									
353/1							Δ																											
354			×			∧	Δ																											
354/1						∧	Δ																											
354/2	×						Δ				▲																							
355	×					∧	Δ																											
355/1		×				∧	Δ																											
355/2							Δ																											
356		×	×			∧	Δ																											
356/1	×						Δ																											
356/2	×					∧	Δ				▲																							
357			×	∧		∧	Δ				▲																							
357/1	×		×			∧	Δ																											
357/2	×		×				Δ							●																				
358							Δ				▲								●															
358/1	×	×	×			∧	Δ																											
358/2	×	×	×				Δ							●							●													
358/3	×		×				Δ				▲																							
359	×					∧	Δ																											
359/1							Δ																											
359/2						∧	Δ	Δ			▲																							
359/2−3	×	×	×				Δ				▲		●																					
360	×					∧	Δ		Δ																									
360/1	×		×			∧	Δ																											
360/2						∧	Δ																											
360/3			×			∧																												
361	×	×	×			∧	Δ	Δ			▲																							
362			×			∧	Δ																			I								
362/1	×					∧	Δ				▲								●															
362/2			×			∧	Δ				▲																							
362/3																																		
362/4																																		
363	×					∧	Δ												●		●													
363/2	×					∧	Δ						●																					
364		×				∧	Δ								●																			
364/1							Δ																											
364/2		×	×				Δ																											
367								Δ																										
369/3																																		
401						∧	Δ	Δ	Δ										●															
401/1	×	×	×			∧	Δ		Δ						●											I								
401/2		×	×			∧	Δ				▲																							
401/3																																		
402		×	×			∧	Δ				▲								●															
402/1	×					∧	Δ	Δ								●																		
402/2	×		×				Δ												●											○				
402/3			×																															
403	×			∧		∧	Δ																											
403/1	×	×	×				Δ				▲																							
403/2	×		×			∧	Δ				▲		●																					
403/3							Δ				▲																							
403/4							Δ				▲																							
404			×				Δ										●																	
404/1	×		×				Δ				▲		●						●						+									
404/2	×		×			∧	Δ	Δ			▲	▲							●						+									
404/3	×	×				∧	Δ				▲		●						●															
404/4		×	×				Δ				▲														+	I								
404/5						∧	Δ																											
404/9							Δ																											
405						∧	Δ	Δ						●					●															
405/1	×		×			∧	Δ	Δ	Δ				●		●				●		●		●		+									
405/2	×		×				Δ								●	●			●		●					I								
405/3							Δ	Δ										●																
405/4							Δ																											
405/5							Δ																											
406		×					Δ				▲																							
406/1	×		×			∧	Δ		Δ		▲						●		●		●													
406/2						∧	Δ				▲								●		●													
406/3							Δ																											
406/3−4							Δ																											

Explanations as given in Table 1

are strongly reduced. They constitute the uppermost lithostratigraphic member of the Paralic Series. Their maximum thickness is 1100 m. The main marine bands are known under names: Barbara (V), Gabriela (IVb), Koks (IVa), Henryk (III), Konrad (II), Eleonora and the uppermost Gaebler (in bands Ia, Ib, Ic and Id). Aproximately 80 coal seams were identified within this sequence. The more important of them are numbered 630 to 601. The top part of Paruba Beds is eroded. Lithologically this series consist of thick sandstone bands alternating with silt-stone-claystone sediments (A. Kotas, W. Malczyk, 1972*a*).

Coal seams from most of areas mentioned above have been examinated, namely: 601, 610, 613, 615, 620, 621, 625, 926, 628/2, 630/1 and 630/2. Coal seams of the lower sequence of Poruba Beds (630 – 620) are characterized by following microfacies types: basic type and clarite type, carbominerite type mostly connected with clarite and basic types was also recognized. Following varieties were fixed up:

– clarite type: vitrite-clarite, vitrite-clarite-trimacerite;

– basis type: vitrite-trimacerite;

– carbominerite type: clarite connected variety, vitrite-trimacerite connected variety.

Coal seams which occur in upper part of Poruba Beds (616 – 601) are characterized by clarite type and carbominerite type. The latter one is different than in coals in lower part and is represented by clarite connected variety and mixed clarite-durite connected variety. The latter, rare variety characterize seams 601 and 613 (Table 1). Average results of maceral analysis of Poruba coal seams show increasing vitrinite and decreasing inertinite content comparing to Jaklovec Beds.

Microlithotype analysis from coals seams of paralic series show that generally they developed in clarite and vitrite-trimacerite microfacies, with mineral ingredients occurring in some of samples. This type of microfacies indicates domination of high water level conditions and mostly short dry periods. These conditions were favourable for forest swamps and reeds development.

UPPER SILESIAN SANDSTONE SERIES – NAMURIAN B AND C (TABLE 2)

This series consists of two stratygraphic members: Anticlinal Beds and Ruda Beds.

A n t i c l i n a l B e d s (Namurian B) consist mostly of thick coal seams accompanied by intercalations of dark grey siltstone and claystones. The sandstones are generally medium- and coarse-grained, containing quartz, fragments of quartzite, lydite also plagioclases and kalifeldspars. Muscovite is abundant whereas biotite and chlorite is rather rare (A. Kotas, W. Malczyk, 1972*b*).

The fine-grained rocks are represented almost exclusively by siltstone which consists of quartz-hydromica-kaolinite pelitic mass, frequently chlorite and additions of carbonates (A. Kotas, W. Malczyk, 1972*b*). It is well known fact that Anticlinal Beds differ significantly from older sediments of Paralic Series. This difference occurs also in microfacies character of thick coal seams 501 to 510. Basic (vitrite-trimacerite) type is rather regularly represented (Table 2), but vitrite type was identified only in 501 seam and clarite type occurs irregularly, mainly as vitrite-clarite-trimacerite variety. The typical microfacies type here is inertite-durite type which occurs in several frequently recognized variations: vitrite-durite-trimacerite, vitrite-inertite-durite, vitrite-inertite-durite-trimacerite, durite-trimacerite, vitrite-inertite, vitrite-inertite-trimacerite, vitrite-inertite-durite-trimacerite, vitrite-inertite-vitrinertite, and vitrite-inertite-vitrinertite-trimacerite.

Characteristic features of this microfacies are: abundance of inertite and durite, domination of clarodurite in trimacerite, 3 and more microlithotypes abundant in the coal seam, few cases of mineral matter contamination, the presence of rare mixed type.

Maceral analysis of these coals shows the highest inertinite content and lowest vitrinite content within the whole coal-bearing succession.

Ruda Beds (Namurian C) are the upper member of Upper Silesian Sandstone Series. Similarly to Anticlinal Beds sandstone predominate interspersed with claystone-siltstone intercalation and thick coal seams reaching as much as 6–8 m. Towards the top the lithological profile of Ruda Beds gradually changes its sandy character and in its uppermost part begins to display more claystone character. This change begins earlier in some areas (Bytom Trough, Ruda Syncline and the north-western part of the basin – A. Kotas, W. Malczyk, 1972*b*). From petrographic point of view sandstones differ slightly in composition from the sandstones of Anticlinal Beds. Generally they contain less feldspars and grain – rise variety is greater. Ruda Beds contain several coal seams numbered from 412 to 407. From microfacies point of view coal seams of Ruda Beds are similar to those of Anticlinal Beds, but there are also some differences, for instance:

– vitrite type appears more frequently especially in upper part of beds (from seam 408 and above) though regularity of its occurrence is still not very high;

– clarite type totally absent in lower part of the sequence becames frequent from 413 seam up to the top seam 407;

– carbominerite type occurs rather regularly within the whole section;

– abundance inertite-durite type decreases towards the top of beds and becomes irregular.

Maceral analysis shows that average inertinite content decreases comparing to anticlinal seams in which the vitrinite content is generally higher (K. Kruszewska, K. Olszewska, 1978; K. Kruszewska et al., 1977, 1983).

SILTSTONE SERIES – WESTPHALIAN A AND B (TABLE 3)

Siltstone Series consist of two members: Załęże Beds (coal seams numbered from 406 to 328) which corresponds to Westphalian A in international stratigraphic subdivision and Orzesze Beds (Westphalian B) with coal seams numbered from 327 to 303. They occur in following areas of Upper Silesian Coal Basin: Central Trough area, Chwałowice Trough, Western Region, Cieszyn Region, Main Anticline area and Dąbrowa Region.

Lithologically the Siltstone Series as a whole is characterized by monotonous and fairly uniform facies development. It consists of clastic, phytogenic and carbonate sediments (syderitic concrections). Tonstein horizons are also known here. The most characteristic features of the series include predominance of aleuritic-pellitic sediments over coarse-clastic ones and the presence of large number of coal cyclothems. There is a distinct increase of coarse-clastic rocks in the upper part of the series – mostly above the group of seams 322–320, and in the Jaworzno Region even lower with the result that clay and sandstone rocks occur in equal proportions (J. Porzycki, 1972). The siltstones usually account for from 32 to 38% of the total thickness of the series.

The claystone mostly accounts for from 45 to 56% of the total thickness of the series (J. Porzycki, 1972). The coarse-clastic sediments represented exclusively by sandstones account for from 16 to 26% of the total thickness of the series. They occur throughout the entire succession mostly as rather thin bands of fine- and medium-grained sandstones. Coarse-grained sandstones are in minority (J. Porzycki, 1972).

Coal seams and claystones on the average account for from 5 to 6% of the total thickness of the series and their frequency is the greatest throughout the whole Upper Silesian Carboniferous succession. Nevertheless, single coal seams are rather thin usually and irregular in horizonted extension. Their microfacies character is recognized very well mainly due to long-term works carried on by Central Mining Institute in Katowice (K. Kruszewska et al., 1977, 1983).

Załęże Beds (Westphalian A). This is the best recognized lithostratigraphic unit throughout the whole Carboniferous succession. Some 134 coal seams (from 406 to 328) from 22 mines and boreholes have been investigated. Generalized microfacial coal characteristics of these seams are as follows: regularity of basic (vitrite-trimacerite) type occurrence; frequency of vitrite type; frequency of varieties: vitrite-clarite and vitrite-clarite-trimacerite of clarite type; frequency of carbominerite type connected with vitrite, clarite and basic types. Its frequency and variability is less intense than in Ruda Beds but still significant within coal seam group 406/3-404 (Table 3). Varieties: vitrite-inertite, vitrite-inertite-vitrinerite, vitrite-durite-trimacerite, vitrite-inertite-durite-trimacerite, vitrite-durite-trimacerite, vitrite-inertite-durite-vitrinertite, inertite-durite-trimacerite and vitrite-inertite-vitrinertite-trimacerite were identified during microlithotype analysis as well as varieties of carbominerite type connected with inertite-durite type.

The sequence between coal seams 403/2 and 357/2 is characterized by further regression in frequency and variability of inertite-durite subtype (Table 3). Vitrite-inertite, vitrite-durite-trimacerite and one example of vitrite-inertite-vitrinertite-trimacerite varieties have been identified. Above seam 357/2 only seven coal seams in few points are of inertite-durite type. Coal seams: 352/2 and 346/4, 336 and 332/1 are represented by vitrite-inertite variety in single analysed samples.

Three coal seams: 352/1, 349/5 and 346 are in single points characterized by vitrite-inertite-trimacerite variety. Above seam 332/1 up to the top of Załęże Beds examples of inertite-durite type were so far not identified. Maceral analysis shows reduction in average inertinite content.

Orzesze Beds (Westphalian B) are the continuation of microfacies character of Załęże Beds though some differences have to be taken into account. The main features of these beds are as follows: domination of basic (vitrite-trimacerite) and clarite types; regression of vitrite type very characteristic for Załęże Beds – only in two coal seams: 312 and 303 this type was identified; less frequent mineral contamination i.e. less frequent carbominerite type; inertite-durite type is almost totally lacking and only one sample from seam 324 was characterized by vitrite-inertite-trimacerite variety. Maceral analysis show that Orzesze coal seams consist in average of more vitrinite and of least inertinite in Upper Silesian coal bearing succession.

CRACOW SANDSTONE SERIES – WESTPHALIAN C AND D (TABLE 4)

The last series of coal-bearing strata in Upper Silesian Coal Basin is subdivided into two members: lower Łaziska Beds (Westphalian C) and the uppermost Libiąż Beds (Westphalian D). The lithological development of the Cracow Sandstone Series is fairly uniform but, nevertheless it can be divided into following two parts. Łaziska Beds, forming a lower part and comprising the sequence of beds from the base of the series, which develop as a complex of coarse clastic sediments with bands of siltstone-claystone layers usually adjusted to thick coal seams. Libiąż Beds constitutes the upper part of Cracow Sandstone Series comprising of the sequence of beds from the base of the siltstone band that underlines seam 119, to the top of the coal-bearing sediments (Z. Dembowski, 1972*b*).

Łaziska Beds from microfacies point of view differ strongly from Orzesze Beds. Their characteristic features are as follows: the complete lack of vitrite type; infrequent vitrite-clarite variety of clarite type; more or less regularly identified vitrite-clarite-trimacerite variety of clarite type; very regular (with few exceptions) occurrence of basic type; the comeback of inertite-durite type with following varieties: vitrite-inertite, vitrite-inertite-trimacerite, vitrite-inertite-durite-trimacerite, durite-vitrinertite-trimacerite, vitrite-durite-trimacerite, vitrite-inertite--durite-vitrinertite; the comeback (in few samples) of mixed type.

Łaziska Beds resemble in some way microfacies character of upper part of Ruda Beds (Table 2), but some differences have to be stressed. The main difference between coal seams of those two beds is lack of vitrite type in Łaziska Beds. However, occurrence and frequency of inertite-durite type varieties and presence of rare mixed type as well as frequency of basic type are similar to coals from Ruda Beds. Also average results of maceral analysis reveal similar frequency of vitrinite and inertinite content in Łaziska and Ruda Beds.

Libiąż Beds (Westphalian D). The uppermost sequence of Upper Silesian coal-bearing succession is known only from Libiąż area and coal seam samples taken from Janina Mine Group of seams numbered from 119/2 to 116 have been analyzed. Their microfacies character is very peculiar and different from that of other stratigraphic units. The most interesting feature of coal seams belonging to Libiąż Beds is regression of basic type which occurs exclusively in the basic seam 119/2. Seams 117 and 118 are of clarite type, whereas uppermost group of analyzed seams 116/2, 116/1 and 116 is characterized by durite subtype as well as mixed and carbominerite types. Maceral analysis of Libiąż seams reveal lower share of less inertinite and more vitrinite than Łaziska seams. It is to be stressed up that presented data on Libiąż Beds are rather incomplete and further investigations of these coal seams are recquired.

DISCUSSION

The analysis of microfacies character of coal seams throughout the Upper Silesian Carboniferous coal-bearing succession makes it possible to draw some remarks. The two microlithotype groups: vitrite and trimacerite are basic components of Upper Silesian coals and can be considered as indices of facies conditions of phytogenic sedimentation of most coal seams in Upper Silesian Coal Basin. Vitrite is believed to form in forest-swamps facies with a high groundwater level. The origin of trimacerite is more complicated. Most of Upper Silesian coals show characteristic predomination of spore-rich duroclarite, which according to M. Teichmüller (1975) probably formed under the water, similarly as exinite-rich clarites. As show Tables 1—4, most of analyzed coal seams are characterized by more than one microfacies type. The reconstructed microfacies development of coal seams throughout the whole coal-bearing succession was probably as follows: the sedimentary environment at the oldest Hrušov and Jaklovec coal seams is still poorly known because of insufficient analyzed material. Few analyzed samples of Jaklovec coal seams represent types: clarite, basic and inertite subtype, which indicate variety of conditions during coal formation. The only one case of higher inertite content among all analysed paralic coal seams was fixed up in one of samples from the seam 707 (Table 1).

Coal seams from Poruba Beds are fairly well known. They developed in two microfacies types: basic and clarite, which indicates that they formed mostly in forest swamps and reeds. A subaquatic deposition favourable for clarite and duroclarite formation have been frequent during that period. General microfacies character of paralic coal seams indicates high water level, intensive subsidence and short dry seasons. Microfacies character of Sandstone Group with significant predominance of inertite and durite thick layers and clarodurite predominant in trimacerite as well as irregular occurrence of clarite type and total lack of vitrite type, indicates different facies conditions comparing to those during Paralic Series formation.

Slow subsidence, long periods of peat surface drainage favourable for degradofusite and degradosemifusite formation as well as for swamp fires „producing" pyrofusite and pyrosemifusite, were separated by high water intervals when in subaquatic conditions crassidurite have been formed. Very likely, at least part of inertodetrinice groundmass of this durite is due to desintegration and hypautochtonic sedimentation of contemporary fusites and semifusites. Vitrite formation though still noticable has taken place the least once during formation of the Upper Silesian coal-bearing profile. Such microfacies conditions for coal seams formation were accompanied by specific clastic sedimentation characterized by origin of alluvial rocks in river channels (A. Kotas, W. Malczyk, 1972*b*).

Both macro- and microfacies character of Ruda Beds overlying Anticlinal Beds are in a way different from the latter ones. The Ruda Beds arised from a different sedimentation rhythm that began with intensification of erosion and that covered an area greater than that of the Anticlinal Beds (A. Kotas, W. Malczyk, 1972*b*). Also different sandstone composition and the distribution of the thickness of the series differs widely. Upper Silesian Sandstone Series as a whole constitutes a full megacyclothem with sediments marking the period of orogenic movements of the Erzgebirge phase and the associated reconstruction of the area where the coal-bearing molasse sediments were deposited from a foredeep to an ineramontane depression (A. Kotas, W. Malczyk, 1972*a*).

Ruda Beds constitute upper part of this megacyclothem and microfacies character of their seams is gradually altering from similar to that of anticlinal seams to resembling already siltstone series seams. Similarly to anticlinal seams they are still regularly rich in inertite, but durite becomes less frequent (Table 2), basic type occurs regularly, and trimacerite is already composed mainly of duroclarite. First irregular occurrences of vitrite type have been noticed along with and more or less regular presence of this type starts from seam numbered 408.

Clarite type in vitrite-clarite-trimacerite variety occurs more or less regularly from the middle part of Ruda Beds (the level of seam 413). Also within Ruda seams mineral contamination occurs, on contrary to very „clean" anticlinal coal seams. It is to be stressed up that most of Anticlinal and Ruda seams often alters horizontally from one microfacial type to the other. The famous 510 coal ((Reden, Pochammer) for instance, represents types: clarite, carbominerite, basic (vitrite-trimacerite), durite and inertite subtypes and altogether 14 varieties (Table 2). Coal seam 504 represents also four microfacies types: clarite, basic (trimacerite), inertite and durite subtypes and mixed type, altogether 12 varieties. Ruda seams gradually become less differentiated, but still are distinctly variable.

Above presented microfacies characteristic of Upper Silesian Sandstone Series coal seams indicates that they generally formed under conditions of slow subsidence with long high water periods conditions favourable for subaquatic predurite sedimentation separated by dry periods favourable for fusite, semifusite formation. In Ruda Beds conditions for subaquatic crasidurite sedimentation were gradually regressing whereas dry periods are traceable up to the top of the series. Sub-

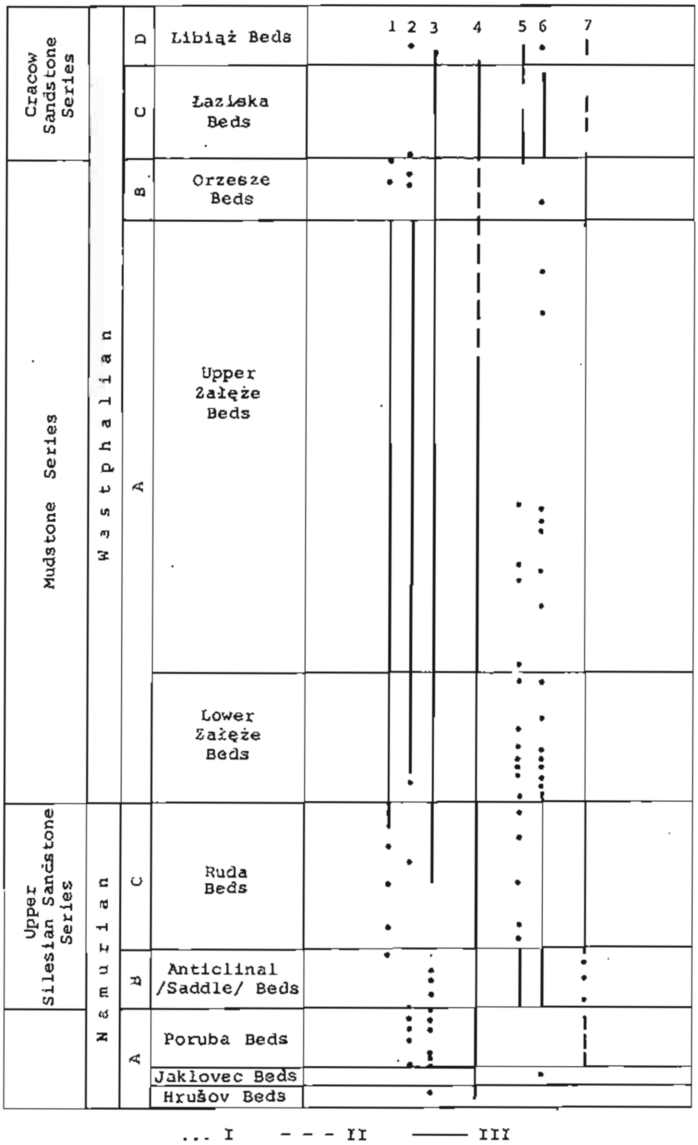

Fig. 1. The range of microfacies types and their more important varieties in Upper Silesian Coal Bearing Succession

Zasięg występowania typów mikrofacjalnych i ich ważniejszych odmian w osadach węglonośnych Górnego Śląska

1 – vitrite type; 2 – clarite type; vitrite-clarite variety; 3 – clarite type; vitrite-clarite-trimacerite variety; 4 – basic type; vitrite-trimacerite variety; 5 – inertite-durite type; durite subtype; 6 – inertite-durite type; inertite subtype; 7 – carbominerite type as a whole; distribution of individual types of microfacies in coal seams: I – single occurrences, II – discontinuous, III – continuous

1 – typ witrytowy; 2 – typ klarytowy; odmiana witrytowo-klarytowa; 3 – typ klarytowy; odmiana witrytowo-klarytowo-trimacerytowa; 4 – typ podstawowy; odmiana witrytowo-trimacerytowa; 5 – typ inertytowo-durytowy; podtyp durytowy; 6 – typ inertytowo-durytowy; podtyp inertytowy; 7 – typ karbominerytowy; występowanie poszczególnych typów mikrofacjalnych w warstwach: I – pojedyncze, II – nieciągłe, III – ciągłe

aquatic crassidurite-forming conditions were in the uppermost part of the series replaced by conditions favourable for development of calamitean reeds which provided sporite-rich clarite formation.

In the uppermost part of the series begins regular development of vitrite type which reflects the start of forest swamps domination with ground water level high enough to form thicker vitrite bands and layers. The process of forest swamps and reeds development combined with subaquatic duroclarite-type deposition is displayed throughout the whole Załęże Beds sequence. Domination of vitrite, clarite and basic type (the latter becomes less regular in the upper part of beds), and constant regression of inertite-durite type as well as significant frequency of carbominerite type provide the complex of characteristic features for Załęże Beds. Moisture, high groundwater level, shorter and infrequent dry periods, provided conditions for large development of forest swamps accompanied by reeds.

The regression of dry inertinite-forming conditions reached their optimum in the uppermost part of Załęże Beds (above seam 336) and especially in Orzesze Beds. Within these beds microfacies domination of vitrite-clarite-trimacerite variety of clarite type (Table 3) indicates a balance between forest swamps and calamitean facies.

Altogether the microfacies history of Siltstone Series coal seams indicates continously growing subsidence, prolongation of wet seasons, high groundwater level and subaquatic conditions favourable for clarite-duroclarite formation. The last distinct change in microfacies character of coal seams in Upper Silesian coal bearing succession took place within Cracow Sandstone Series (Tables 4, Fig. 1). Similarly to older Orzesze Beds vitrite-clarite-trimacerite variety of clarite type occurs regularly but comeback of basic and inertite-durite types is the main feature of this series. Carbominerite type is again in regression. Microfacies conditions of Łaziska Beds in the lower part of the series resemble those of the upper part of Ruda Beds but inertite subtype occurs less regularly and carbominerite type is less frequent than in the latter ones. Also total lack of vitrite type is typical for this beds. Finally, the top beds of Upper Silesian succession consist of a coal seam group where basic type have been identified so far in only one, lowest seam, vitrite type is absent and microfacies characteristic is limited to clarite type, durite subtype, one example of mixed type and two cases of carbominerite type. In addition microfloral and macrofloral characteristic of these beds differs widely from oldest carboniferous sediments (A. Jachowicz, 1972). Further investigations should prove whether presented microfacies characteristic reflect different facies conditions during formation of those seams.

PRACTICAL ASPECTS OF MICROFACIES INVESTIGATIONS

Apart of facies-genetic questions connected with microfacies development of coal seams, some practical advantages can be also taken into account. As stressed above, results of microlithotype coal seam analysis in a given point, provides information about maceral distribution and complexity within coal sample which is essential for further coal utilisation. Maceral analysis informs about maceral or maceral group proportions in analysed sample but from technological point of view it is also important to know the way macerals composed microlithotypes or microlithotype groups. In presented paper defined microfacies types and varieties of coal seam provide following informations:

I. B a s i c t y p e. Shows that vitrite and trimacerite or vitrinertite are in majority and at least a part of exinite is integrated with vitrinite. Inertite together with durite constitute less then 30% of the whole analysed coal samples and carbominerite and minerite are also in minority. Such coal can be considered as a good raw material for all kinds of utilization.

II. Vitrite type. Predomination of the only one microlithotype group – vitrite means that each of other microlithotype groups occurs in amount minor to 15%. This type of coal is particulary precious for carbonization and liquifaction processes.

III. Clarite type. This type shows that coal is overdominated by vitrite and clarite. Trimacerite can be in some cases the 3rd abundant component of this type. The most important variety for coal liquifaction is that composed of vitrite-clarite, but also vitrite-clarite-trimacerite is positive for this purpose.

IV. Inertite-durite type. This type informs, that apart of reactive vitrite and semireactive trimacerite (the usual components of most of varieties within this type) inertite of durite or both microlithotype groups take an important part in microfacies coal composition exceeding 15–30% of total sample organic-inorganic mass. This type indicates possible troubles with given coal during its carbonization or liquifaction as well as gasification and in some cases even combustion. Especially unwelcomed are coals characterized by inertite subtype as coarse fusite-semifusite layers and lenses are known as the most inert organic constituents. It is necessary to add that trimacerite in those coals is usually overdominated by clarodurite.

V. Mixed type. Cases of this type are very rare and therefore not taken into account.

VI. Carbominerite type. Its practical importance is not clear, depending on such factors as character of mineral matter, its syn- or epigenetic origin and the mode of use of a given coal. Syngenetic carbargillite or carbopyrite, very difficult for mechanic separation, are definitely negative from carbonization point of view, but under special conditions they can be even welcomed in batch autoclave liquifaction tests. The last remark concerning microfacies analysis is of workshop importance. To make results as short and clear as possible in routine laboratory work one can use microlithotype symbols instead of full names: vitrite – *V*, inertite – *I*, clarite – *Ct*, durite – *D*, vitrinertite – *Vt*, trimacerite – *Tr*, carbominerite – *Cm*.

The information about proportions between main microlithotype groups in given type variety is fixed by order of their recording. For example: coal of clarite type, vitrite-clarite-trimacerite variety where the most abundant is vitrite, next clarite and the least (but still more than 15%) trimacerite will be recorded as follows – *Tr–Ct–V* – this characteristic is easy to understand and can be used for storing microfacies data in computerized Bank of Information.

CONCLUSIONS

As a summary following conclusions are to be pointed out:

1. There was uniformity in macro- and microfacies conditions during sedimentation Upper Silesian coal-bearing formation. Sandstone series are generally connected with development of inertite-durite type, whereas vitrite and clarite types are characteristic for siltstone aleuritic-pelitic series. This regularity suggest autochtoneous origin of Upper Silesian coal seams.

2. Vitrite and clarite types can be used as indicators of rapid subsidence,

moisture, high groundwater level suitable for development of forest swamps with lepidophytes and pteridospermes forming vitrite, as well as calamitean reeds providing clarite and duroclarite microfacies.

3. Inertite-durite type indicates slow sinking of basement and frequent periods of forest swamps drainage in time of sedimentation of Upper Silesian Sandstone Series formation.

4. Forest swamps were the main source for coal seams formation, but during Westphalian A and B period, characterized by siltstone series sedimentation, calamitean reeds played probably also an important role in formation of phytogenic deposits of coal seams. All stratigraphic members have their typical microfacies character which allows to distinguish them within the whole succession and can be helpfull in lithostratigraphic differentiation of Upper Carboniferous sediments in Upper Silesia.

5. Microfacies coal seams characteristics by type can be applied in practice for selecting their industrial utilization.

Translated by the Author

Główny Instytut Górnictwa
Katowice, Pl. Gwarków 1
Received: 29 I 1982

REFERENCES

DEMBOWSKI Z. (1972*a*) – Ogólne dane o Górnośląskim Zagłębiu Węglowym. W: Karbon Górnośląskiego Zagłębia Węglowego. Pr. Inst. Geol., **61**, p. 9–22.

DEMBOWSKI Z. (1972*b*) – Krakowska seria piaskowcowa Górnośląskiego Zagłębia Węglowego. W: Karbon Górnośląskiego Zagłębia Węglowego. Pr. Inst. Geol., **61**, p. 509–537.

HAQUEBARD P.A. (1964) – Die Ablagerungabedinungen des Flözes Harbour in Sydney Kohlenbediet von Neuschottland (Canada). Fortschr. Geol. Reinld. n. Westf., **12**, p. 331–356.

JACHOWICZ A. (1972) – Charakterystyka mikroflorystyczna i stratygrafia karbonu produktywnego Górnośląskiego Zagłębia Węglowego. W: Karbon Górnośląskiego Zagłębia Węglowego. Pr. Inst. Geol., **61**, p. 185–277.

KOTAS A., MALCZYK W. (1972*a*) – Seria paraliczna piętra namuru dolnego Górnośląskiego Zagłębia Węglowego. W: Karbon Górnośląskiego Zagłębia Węglowego. Pr. Inst. Geol., **61**, p. 329–425.

KOTAS A., MALCZYK W. (1972*b*) – Górnośląska seria piaskowcowa piętra namuru górnego Górnośląskiego Zagłębia Węglowego. W: Karbon Górnośląskiego Zagłębia Węglowego. Pr. Inst. Geol., **61**, p. 427–466.

KRUSZEWSKA K.; ŁONAK I., OPATOWIECKA L. (1983) – The comparison between microfacies character Westphalian A and B coals from Upper Silesian and Lublin Coal Basins. Kwart. Geol., **27**, nr 2.

KRUSZEWSKA K., SAPIŃSKA M., MAGNES C. (1977) – Osady karbonu niecki chwałowickiej w świetle analizy litologicznej oraz badań palinologicznych i petrograficznych węgli. Pr. Nauk. UŚ, nr 169, Geologia, **1**, p. 47–86.

KRUSZEWSKA K., OLSZEWSKA K. (1978) – Monografia petrograficzna Zagłębia Górnośląskiego. Arch. Główn. Inst. Górn. Katowice.

KUHL J. (1955) – Petrograficzna klasyfikacja skał towarzyszących pokładom węgla w Zagłębiu Górnego Śląska. Pr. Główn. Inst. Górn. Ser. A, Kom. nr 171.

PORZYCKI J. (1972) – Seria mułowcowa piętra westfalu dolnego Górnośląskiego Zagłębia Węglowego. W: Karbon Górnośląskiego Zagłębia Węglowego. Pr. Inst. Geol., **61**, p. 467–508.
REIDENEUER D., WILLIAMS E.G., DUTCHER R.R. (1967) – The relationship between paleotopography and sulfur distribution in some coals of western Pennsylvania. Econ. Geol., **62**.
SHIBOAKA M. (1978) – Micrinite and exudinite in some Australian coals and their relation to the generation of petroleum. Fuel, **57**, p. 73–77, nr 2.
SMITH A.H.V. (1964) – Zur Petrologie und Palynologie der Köhlen-flöze des Karbons und ihre Begleitschichten. Fortschr. Geol. Reinld. n. Westf., **12**, p. 285–302.
SMITH A.H.V. (1968) – Seam profiles and seam characters. W: Coal and coal bearing strata (ed. D.G. Murchison, T.S. Westoll), p. 31–40. Oliver and Boyd. Edinburgh.
TEICHMÜLLER M. (1950) – Zum petrographischen und werdegang der Weichbraunkohle (mit Berucksichtigung genetischer Fragen der Steinköhlepetrographie. Geol. Jb., **64**, p. 429–488.
TEICHMÜLLER M. (1975) – Origin of the petrographic constituents of coal. W: Stach Texbook of Coal Petrology, p. 176–238. Stuttgart.

Krystyna KRUSZEWSKA

TYPY MIKROFACJALNE POKŁADÓW WĘGLA W GÓRNOŚLĄSKIM ZAGŁĘBIU WĘGLOWYM

Streszczenie

W pracy omówiono mikrofacjalny charakter górnośląskich węgli kamiennych *in situ* w oparciu o wydzielone następujące typy mikrofacjalne:

I. Typ podstawowy (witrytowo-trimacerytowy), w którym witryt i trimaceryt lub witrynertyt w każdym przypadku przekraczają 15% udziału w analizowanej próbce węgla. Zawartość każdego z pozostałych grup mikrolitotypów wynosi 0–14%.

II. Typ witrytowy, w którym jedyną dominującą grupą mikrolitotypów przekraczającą 15% udziału w próbce jest witryt. Pozostałe grupy mikrolitotypów występują w ilościach 0–14%.

III. Typ klarytowy, w którym obok podwyższonej (15%) zawartości grup mikrolitotypów witrytu i trimacerytu lub witrynertytu stwierdza się występowanie klarytu w ilości przekraczającej 15% udziału w danej próbce węgla. Żadna z pozostałych grup mikrolitotypów nie przekracza 15%.

IV. Typ inertytowo-durytowy, w którym obok witrytu i trimacerytu lub witrynertytu pojawiają się w ilościach 15% inertyt i duryt. Wydzielono tu trzy podtypy:

– inertytowy, w którym z dwu grup mikrolitotypów inertyt przekracza 15% zawartości, a duryt występuje podrzędnie;
– durytowy o podwyższonej (15%) zawartości durytu, a inertyt występuje w ilości 0–14%;
– inertytowo-durytowy, w którym zarówno inertyt, jak i duryt przekraczają 15% udziału w próbce.

V. Typ mieszany, w którym obok witrytu i trimacerytu lub witrynertytu występują równolegle podwyższone ilości klarytu oraz durytu lub inertytu (15%).

VI. Typ karbominerytowy – każdy rodzaj typu mikrofacjalnego, w którym stwierdza się podwyższoną zawartość karbominerytu lub skały płonnej w ilości powyżej 15%. W zależności od występowania innych mikrolitotypów wyróżnia się następujące podtypy:

– karbominerytowo-trimacerytowy,
– karbominerytowo-witrytowy,
– karbominerytowo-klarytowy,

– karbominerytowo-inertytowo-durytowy.

W obrębie typów wyróżniono ich odmiany w zależności od udziału poszczególnych mikrolitotypów. Analiza rozmieszczenia typów mikrofacjalnych i ich odmian prowadzi do następujących wniosków:

1. Istnieje powiązanie w makro- i mikrofacjalnym rozwoju osadów karbonu górnośląskiego. Ogólnie rzecz biorąc, serie piaskowcowe są związane z występowaniem typu inertytowo-durytowego, podczas gdy serie paraliczna i mułowcowa charakteryzują się typami witrytowym i klarytowym. Zgodność ta sugeruje autochtoniczną genezę węgli górnośląskich.

2. Występowanie typów witrytowego i klarytowego sugeruje znaczną subsydencję, warunki wilgotne i podwyższony poziom lustra wody w czasie tworzenia się pokładów węgla.

3. Typ inertytowo-durytowy sugeruje wolne osiadanie dna i częste okresy wysuszania torfowiska, w czasie których zachodziły procesy utleniania masy torfowej.

4. Lasy bagienne były podstawowym czynnikiem węglotwórczym w górnośląskim karbonie węglonośnym, nie mniej w okresie powstawania serii mułowcowej prawdopodobnie większą rolę odgrywały również oczerety kalamitowe dostarczające materiału do tworzenia się klarytów sporowych.

5. Poszczególne warstwy stratygraficzne serii węglonośnej charakteryzują się specyficznymi dla siebie zespołami typów mikrofacjalnych pozwalających na wyróżnienie ich w profilu warstw.

6. Typy mikrofacjalne mogą być wykorzystane jako cenne wskazówki przy ocenie perspektyw wykorzystania węgli *in situ*.

Крыстына КРУШЕВСКА

МИКРОФАЦИАЛЬНЫЕ ТИПЫ УГОЛЬНЫХ ПЛАСТОВ В ВЕРХНЕСИЛЕЗСКОМ УГОЛЬНОМ БАССЕЙНЕ

Резюме

В статье рассмотрен никрофациальный состав верхнесилезских каменных углей *in situ* на основе следующих микрофациальных типов:

I. Основной тип (витритово-тримацеритовый) где витрит и тримацерит или витринертит во всех случаях превышают 15% состава анализируемой пробы угля. Содержание каждой из остальных групп микролитотипов составляет 0—14%.

II. Витритовый тип, где единственной преобладающей группой микролитотипов, превышающей 15% состава пробы, является витрит. Остальные группы микролитотнпов составляют 0—14%.

III. Кларитовый тип, в котором наряду с повышенным (15%) содержанием групп микролитотипов витрита и тримацерита или витринертита, отмечается содержание кларита, превышающее 15% состава данной пробы угля. Все остальные группы микролитотипов не превышают 15%.

IV. Инертитово-дуритовый тип, в которон наряду с витритом и тримацеритом или витринертитом появляются инертит и дурит в количестве 15%. Здесь выделено три подгруппы:

— инертитовая, в которой из двух групп микролитотипов инертит составляет более 15%, а дурит имеет второстепенное значение,

— дуритовая, с повышенным (15%) содержанием дурита и 0—14% содержанием инертита,

— инертитово-дуритовая, в которой как инертит, так и дурит составляют более 15% содержания пробы.

V. Смешанный тип, в котором наряду с витритом и тримацеритом или витринертитом содержится повышенное количество кларита и дурита или инертита (15%).

VI. Карбоминеритовый тип — каждый вид микрофациального типа, в котором отмечено повышенное содержание карбоминерита или пустой породы (более 15%). В зависимости от содержания других микролитотипов выделяются следующие подтипы:

— карбоминеритово-тримацеритовый,
— карбоминеритово-витритовый,
— карбоминеритово-кларитовый,
— карбоминеритово-инертитово-дуритовый.

Внутри типов выделены их разновидности в зависимости от содержания отдельных микролитотипов. Анализ размещения микрофациальных типов и их разновидностей позволяет сделать следующие выводы:

1. Существует связь между макро- и микрофациальным развитием пород верхнесилезского карбона. В общих чертах песчанистые серии отличаются инертитово-дуритовым типом, тогда как для паралической и алевролитовой серий характерны витритовый и кларитовый тип. Это соответствие предопределяет автохтонное происхождение верхнесилезских углей.

2. Витритовый и кларитовый тип говорит о значительном опускании дна бассейна, о влажной среде и повышенном зеркале вод во время образования угольной толщи.

3. Инертитово-дуритовый тип предопределяет медленное оседание дна и частые периоды высыхания торфяника, во время которых происходило окисление торфа.

4. Болотистые леса являлись основным материалом для образования угля в верхнесилезском угленосном карбоне, тем не менее во время образования алевролитовой серии, вероятно, большую роль сыграли также каламитовые очереты, доставившие материал для образования споровых кларитов.

5. Отдельные стратиграфические пласты угленосной серии отличаются характерными для них ассоциациями микрофациальных типов, позволяющих выделять их в разрезе.

6. Микрофациальные типы могут быть использованы в качестве ценных указателей при оценке перспектив использования углей *in situ*.