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PETROGRAPHIC COMPOSITION OF COAL AGAINST THE BACKGROUND OF PALEOTEMPERATURES IN SOŚNICA – KNURÓW FOLD OF NW-PART OF THE UPPER SILESIAN COAL BASIN (USCB)

PETROGRAFICKÉ SLOŽENÍ UHLÍ VE VZTAHU K PALEOTEMPERATURÁM VRÁSY SOŚNICA-KNURÓW V SEVEROZÁPADNÍ ČÁSTI HORNOSLEZSKÉ PÁNVE

Abstract

The paper presents characteristics of petrographic composition of coal from the NW part of the USCB and characteristics of paleotemperature, occurring in study area, evaluated on the basis of mean vitrinite reflectance. Correlation between petrographic and optical properties were conducted for individual geological structures of the study area i.e. the Sośnica – Knurów fold.

Abstrakt

Článek se zabývá charakteristikami petrografického složení uhlí ze SZ části hornoslezské pánve a paleotemperatur ve studované oblasti, vyhodnocenými na základě střední odraznosti vitrinitu. V jednotlivých geologických strukturách studovaného území, tj. vrásy Sośnica-Knurów, byla provedena korelace mezi petrografickými a optickými vlastnostmi.

Key words: NW part of Upper Silesian Coal Basin, petrographic composition of coal, vitrinite reflectance, paleotemperature.

Introduction

Properties of coals mainly depend on their petrographic composition and rank of coal. The petrographic composition of coals mainly depends on facial conditions and composition of organic matter in a paleoswamp. The coal rank is mostly influenced by temperature, indication of which is a vitrinite reflectance [3, 8, 9].

In this paper a petrographic composition of coals and vitrinite reflectance, as a reflection of paleotemperature were analised. These quantities were analysed against the background of sedimentation and diastrophism evolutions in selected geological structure of the NW part of The Upper Silesian Coal Basin i.e. the Sośnica-Knurów fold. Characterization of coal in the study area included determination of the petrographic composition, i.e. determination of each maceral group: vitrinite, liptinite, inertinite and mineral matter as well as average vitrinite reflectance. Average vitrinite reflectance is the most important petrographic parameter for determination of paleotemperatures' values.

The examined area is situated in the north – western part of The Upper Silesian Coal Basin and includes areas of „Knurów" and „Szczygłowice" coal mines. There is the area of Orlowa – Boguszowice overthrust in the western part of the studied field. Main and the most important structure of the examined area is a meridionally oriented the Sośnica - Knurów fold with the longitudinal axis dipped toward south. There are also numerous faults with small displacements. The faults are nearly parallely oriented (fig. 1).

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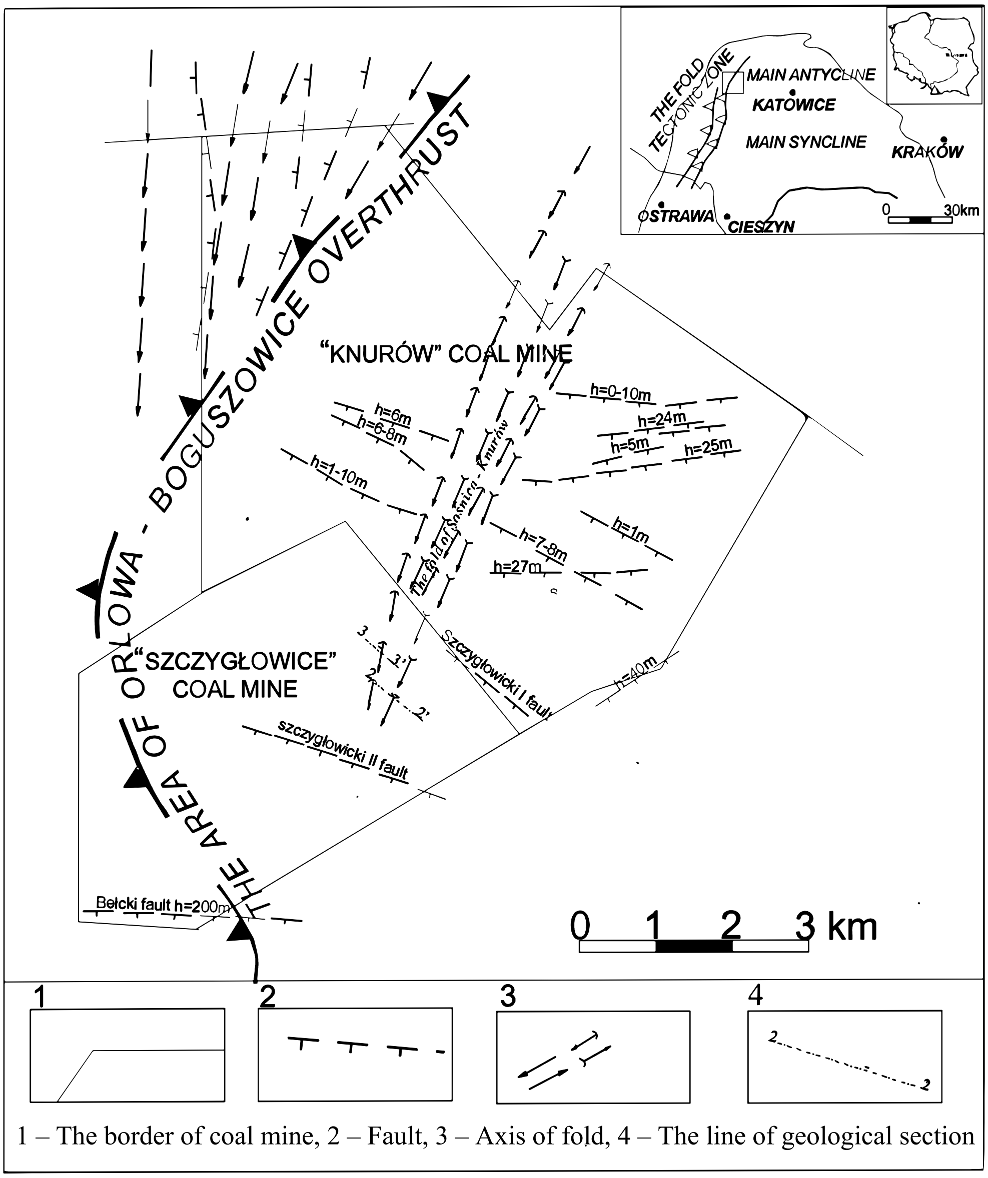

Fig. 1. Tectonic sketch of the study area

In lithostratygraphic profile of the study area the Quaternary and the Tertiary beds, which were the overburden of the Carboniferous coal – bearing, were distinguished. The Carboniferous in the analysed depth section (ie. to about 1000 m) of the study area is represented by limnic beds of mudstone series (załęskie beds - Westfalian A) and sandstone series (rudzkie beds - Namurian B).

Petrographic characterization of coals of the study area

The analysed part of the deposit includes coal seams from 357/1 to 415/2 (according to the Czech nomenclature doubrawskie and susskie beds) from the depth section from -106 to -600 m. u.s.l. All samples are situated in one geological structure, i.e. The Sośnica – Knurów fold. Vitrinite reflectance and petrographic composition of coals are qualified on the grounds of 126 samples of coal (tab. 1).

In the petrographic composition of coals from the analyzed coal seams an attention is drawn to the wide range of changes of participation vitrinite, from 60 to 79 % mmf, according to the authors' own research and from 49 to 91 % mmf according to the given data from the coal mine "Szczygłowice". The content of liptinite and inertinite are adequately 5 - 13 % mmf and 14 - 34 % mmf according to the research and 2 - 15 % mmf and 4 - 42 % mmf according to the given data from the coal mine "Szczygłowice". In the inertinite group dominates semifusinite (7 - 18 % mmf) while inertodetrinite (3 - 7 % mmf) and makrinite (1 - 6 % mmf) occur in smaller quantities. Remaining macerals of inertinite groups occur sporadically.

Tab.1. Optical properties and petrographic composition of coal from the seams of the study area.

Coal Mine	Coal seam	R_0 [%]		S^d	Petrographic Composition			Mineral matter [%]
					Vitrinite [%] mmf	Liptinite [%] mmf	inertinite [%] mmf	
SZCZYGŁOWICE COAL MINE	357/1(9)	min.	0,78	0,03	78	4	6	2
		max.	0,91	0,05	90	11	13	38
	364(27)	min.	0,82	0,02	53	3	4	1
		max.	0,90	0,05	91	15	32	24
	401/1(22)	min.	0,81	0,03	63	2	6	0
		max.	0,93	0,05	91	9	27	26
	403/1(8)	min.	0,82	0,03	57	6	12	1
		max.	0,89	0,04	82	13	32	26
	405/1(8)	min.	0,90	0,04	55	4	20	2
		max.	0,95	0,05	76	8	40	18
	405/3(8)	min.	0,85	0,03	60	5	20	1
		max.	0,91	0,04	74	11	30	16
	407/1(7)	min.	0,86	0,03	66	5	12	3
		max.	0,91	0,05	81	11	26	7
	407/3(7)	min.	0,85	0,03	61	5	5	2
		max.	0,89	0,04	87	10	32	9
	408/1(13)	min.	0,86	0,03	52	5	12	1
		max.	0,99	0,05	79	14	40	60
	415/2(11)	min.	0,90	0,04	49	3	13	1
		max.	1,00	0,05	82	9	42	19
KNURÓW COAL MINE	405/1(3)	min.	0,92	0,04	66	6	14	1
		max.	0,96	0,06	79	7	28	2
	408/3 - 413/1 (3)	min.	0,940	0,05	61	5	24	3
		max.	1,020	0,06	71	6	34	4

Vitrinite reflectance changes within the range from 0,82 to 1,02 % at s = 0,04 - 0,06 according to own research and from 0,78 to 1,00 % at s = 0,04 - 0,06 according to given data from the coal mine Szczygłowice. These coals can be rate among orthobituminous coals of average coalification (C).

Location of samples in one geological structure and lack of faults, which dislocate coal seams, influenced an increase of coefficient of correlation between the depth and the vitrinite reflectance. Along with the growth of depth grows the value of the vitrinite reflectance and the coefficient of correlation equals to r = -0,72 (fig. 2).

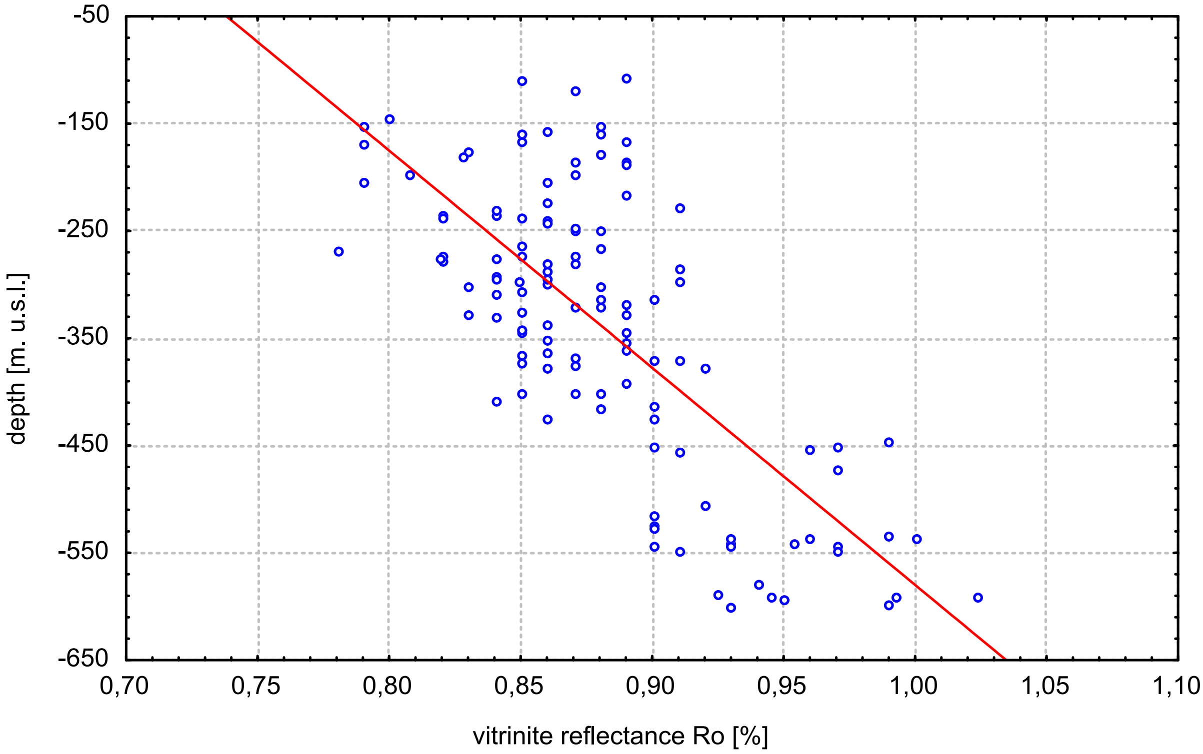

Fig. 2. Relationship between vitrinite reflectance and coal seam depth in the study area

Average gradient of vitrinite reflectance estimated on the basis of the correlational equalization amounts to 0,026 % R_o on the depth of 100 m. Resemblance in isolinies of vitrinite reflectance's course and location of coal seams is also observed. Distribution of the vitrinite reflectance isolines is approximately parallel to the arrangements of coal seams in geological sections, which are perpendicular to the longitudinal axis of the Sośnica – Knurów fold. One should add, that the course of the vitrinite reflectance isolines on geological section 3-3' (fig. 1, 3) is determined in older stratigraphic section of profile than one determined in geological section 2-2'.

From the stratigraphic point of view the fragment of the stratigraphic profile, presented on geological section 2-2' is younger but at present it can be found deeper due to dipping of the longitudinal axis of fold toward south. On the basis of analysis of conformity of coal rank isolines' course (vitrinite reflectance) and location of coal seams we can assume that the coalification process had synorogenic or pre- and postorogenic character in this region.

Low correlation between the vitrinite reflectance and the content of vitrinite, liptinite and inertinite is observed. The correlation coefficient amounts to -0,29, -0,21 and 0,39 respectively (fig. 4). Therefore the content of macerals of vitrinite group and liptinite group insignificantly decreases with the increase of the vitrinite reflectance. The content of macerals of inertinite group insignificantly increases with the increase of the vitrinite reflectance.

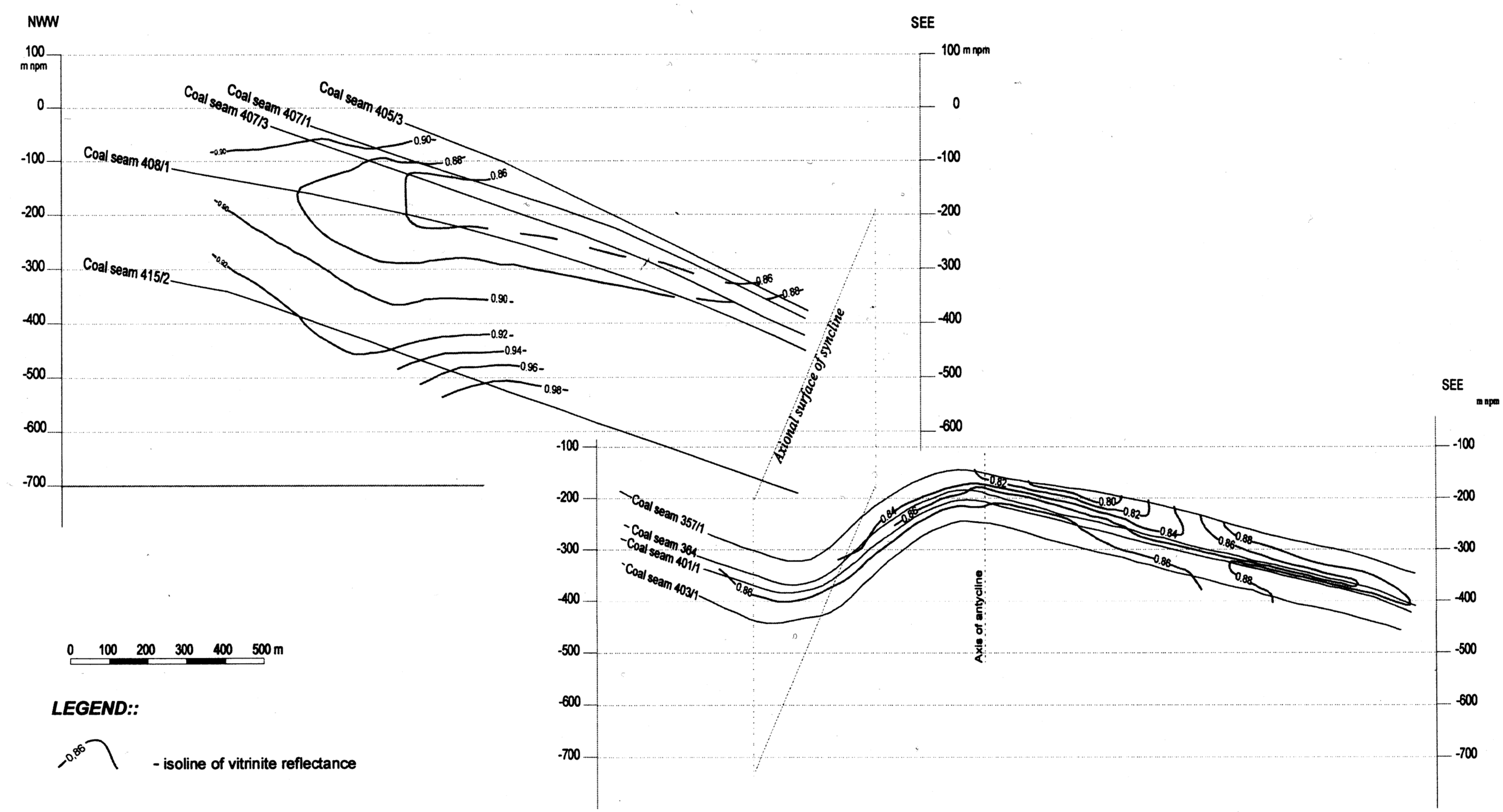

Fig. 3. Distribution of vitrinite reflectance on the geological section through the sośnica – knurów fold

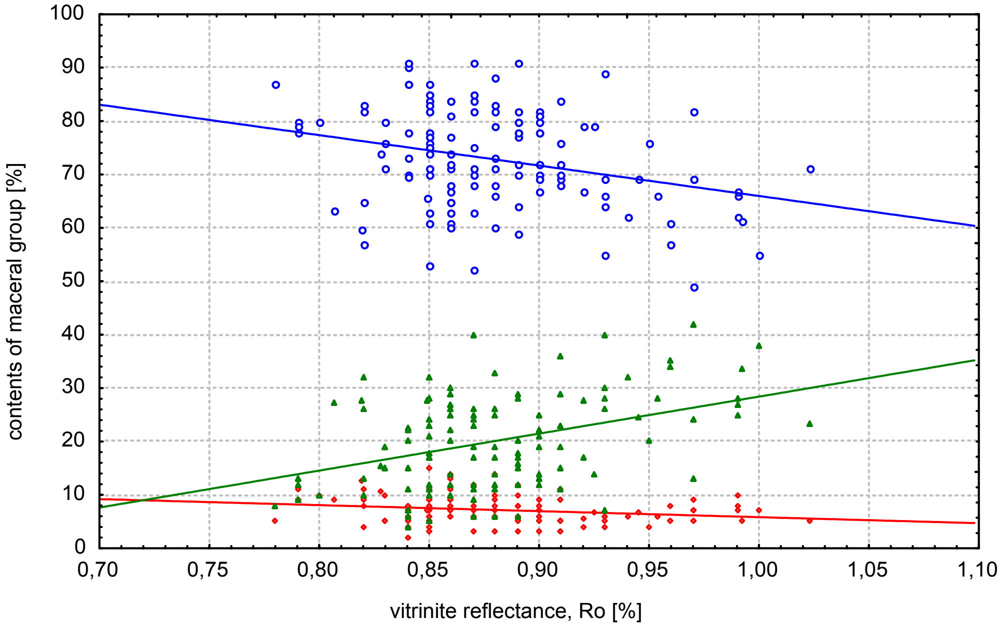

Fig. 4. Relationship between vitrinite reflectance and content of maceral groups in coal of the study area

The analysis of the content of macerals of each group showed that the increase of the macerals of the vitrinite group occurs at the cost of the decrease of content of macerals of inertinite group (fig. 5).

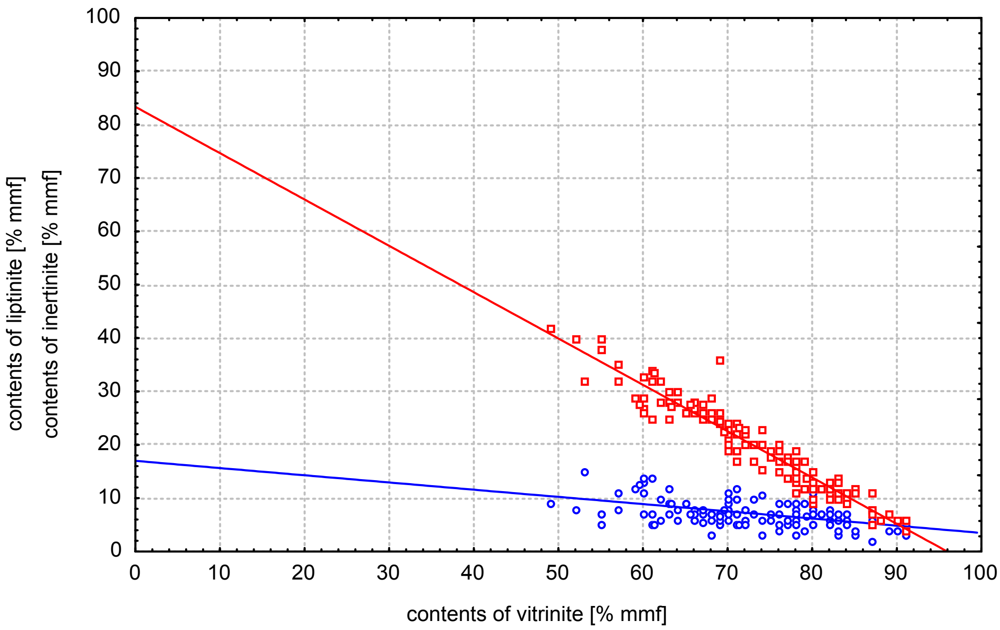

Fig. 5. Relationship between content of vitrinite and content of liptinite and inertinite in coal of the study area

Paleotemperatures

Paleotemperatures in the examined profile section of Carboniferous complex was determined on the basis of the vitrinite reflectance and effective heating time [7], which was estimated with the use of the analysis of evolution of sedimentary – diastrophic conditionses [4, 6]. For this purpose the Bostick's nomogram [2] and the Barker and Pawlewicz's method were applied [1]. The results are shown in Tab. 2.

Tab.2. Values of paleotemperatures and gradients in research depth-level of the study area

Depth, m [sea l.]		**R_o [%]**	**Gradient R_o [$\%R_o \cdot 100\ m^{-1}$]**	**T_{max} [^OC] ***				**Paleogradient*** [$^OC \cdot 100\ m^{-1}$]**
				after Bostick`s			**after Barker & Pawlewicz`s**	
				EHT [10^6 years] **				
				20	**61**	**66**		
Min.	-106	0,78	0,026	125	110	108	122	2,4
Max.	-600	1,02		147	132	130	156	3,7

* – From the given range of temperature lower value was assigned for lower value of vitrinite reflectance (R_o) and refers to upper part of the examined profile section. Respectively, higher value of temperature was assigned for higher value of vitrinite reflectance and refers to lower part of the examined profile section

** – EHT –effective heating time

*** – Lower value of paleogradient was calculated for the paleotemperatures' values obtained from the Bostick's nomogram for EHT=20 million years. Higher value was calculated according to the values of the paleotemperatures obtained with the aid of the Barker and Pawlewicz's method.

In the study area values of paleotemperatures, estimated on the grounds of the Bostick's nomogram, varies depending on assumed EHT within the range of temperatures from 108 – 130°C to 125 – 147°C. The difference between the maximal and minimal values amounts to 22 °C. Taking into consideration distribution of paleotemperatures' values in analyzed interval of depth, i.e. from –106 to –600 m above sea level, a paleothermic gradient equal to $2{,}4^oC \cdot 100\ m^{-1}$ was received.

Values within the range of 122 - 156°C were obtained applying the Barker and Pawlewicz's method during estimation of paleotemperatures. It should be noticed that this range is a little bit broader then the range received with the use of the Bostick's nomogram for EHT=20 million years. The paleothermic gradient, determined on the basis of paleotemperatures from the Barker and Pawlewicz's method amounts to about $3{,}7^oC \cdot 100\ m^{-1}$.

References

[1] Barker C.E., Pawlewicz M.J., 1986: The correlation of vitrinite reflectance with maximum temperature in humic organic matter. *In: Buntebarth G., Stegena L. (eds.): Paleogeothermics, Lecture Notes in Earth Sciences, 5, Springer, Berlin, s. 79-93.*

[2] Bostick N.H., 1979: Microscopic measurements on the level of catagenesis of solid organic matter in sedimentary rock to aid exploration for petroleum and determine former burial temperatures – a review. – *Soc. Econ. Paleont. Miner. Spec. Publ. 26, s. 17-43.*

[3] Gabzdyl W., 1988: Geologia węgla. *Skrypt nr 1472/2 Pol. Śl. (Silesian Technical University), Gliwice.*

[4] Lewandowska M., 2001: Warunki występowania wód podziemnych, na tle ziemskiego strumienia ciepła, w kopalniach północno zachodniej części GZW. – *Arch. Pol. Śl. Gliwice, Praca doktorska (Silesian Technical University, PhD. Thesis).*

[5] Probierz K., 1989: Wpływ metamorfizmu termalnego na stopień uwęglenia i skład petrograficzny pokładów węgla w obszarze Jastrzębia (GZW). – *Zeszyty Naukowe Pol. Śl., nr 179, Gliwice.*

[6] Probierz K., Lewandowska M., 2000: Próba odtworzenia warunków paleotermicznych NW-części GZW. – *Zeszyty Naukowe Pol. Śl., nr 246, Gliwice.*

[7] Probierz K., Lewandowska M., 2001: Terrestrial heat flow and paleotemperatures of rock massif in the NW-part of the Upper Silesian Coal Basin. *Documenta Geonica 2001, Geonics 2001, Ostrava, 15-17.05, s. 129 – 135.*

[8] Stach E., Makowsky M.-Th., Teichmüller M. Taylor G.H., Chandra D., Teichmüller R., 1982: Stach's Textbook of Coal Petrology, Gebrüder Borntraeger, Berlin-Stuttgart.

[9] Taylor G. H., Teichmüller M., Davis A., Diessel C.F.K., Littke R., Robert P, 1998: Organic Petrology. Gebrüder Borntraeger, Berlin-Stuttgart.

Resumé

Předmětem studie byly černouhelné ortotypy z vrásy Sośnica-Knurów. Výsledky výzkumu naznačují určitý vztah mezi petrografickým složení uhelných typů a paleotemperaturou v horninovém masívu. Byla pozorována korelace mezi střední odrazností vitrinitu a hloubkou, indikovaná gradientem změn hodnot 0,026 % $R_o \cdot 100\ m^{-1}$. V závislosti na použité metodě se stanovené hodnoty gradientu paleotemperatury pohybují v rozmezí 2,4 – 3,7°C·100 m^{-1}. Analýzy distribuce odraznosti vitrinitu ve vztahu k uložení sloje naznačují buď synorogenní nebo pre- a postorogenní charakter prouhelnění. Byl zjištěn růst obsahu inertinitu se stoupající odrazností vitrinitu. Tento jev již byl popsán u uhlí sedlových vrstev (Namurian A). Jeho příčina může spočívat ve specifickém petrografickém složení těchto vrstev stejně tak jako ve vlivu tepelné metamorfózy uhlí. Ve druhém případě by to znamenalo, že část inertinitu by mohla mít sekundární charakter, protože se netvořila v paleorašeliništi, ale v uhelné sloji během vlivu zvyšující se teploty (paleotemperatury).

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