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CONTENTS OF PB AND ZN AND AFFINITY TO ORGANIC COAL FRACTION FROM FLYSCH ASSOCIATION (VISEAN) IN THE UPPER SILESIAN COAL BASIN (USCB)

Abstract

Shed coals from flysch association tend to be not very thick and contain a low ash content. The contents of Pb in coal and coal ash of these shed coals is higher, while Zn content is lower than the contents of Pb and Zn in the coals and coal ashes from paralic and limnic series of the USCB. A relationship between Pb and Zn and organic matter of coal was noted. Element sorption by organic matter had probably a significant impact in reaching present-day contents of ash, and Pb and Zn in coal.

Key words: Geochemical characteristics, Zn, Pb, coal.

Introduction

In the years 1975-1988, the Upper Silesian Branch of the Polish Geological Institute (PIG) made 24 drill holes in the USCB (Fig. 1) as part of the „Research project of deep-level productive carbon" developed and later on supervised by Kotas [10]. The project aimed at a detailed description of the USCB geological structure in the area with poorly documented occurrence of a paralic series floor. The samples were thoroughly analysed geologically and geochemically by the PIG, the Upper Silesian Branch, and the results were compiled in geological documentation for specific drill holes. The contents of trace elements were determined in ashes of coal beds (525oC) with the use of X-ray fluorescence spectrometry (Table 1). Petrographic or technological quality indices of the coal beds were not available to the author, but he had only the contents of Pb and Zn, and ash. This article concludes a stage of analysis of the results [such as 13, 15, 16] conducted together with Engineer Anna Różkowska from the PIG, the Upper Silesian Branch.

The aim of this work is to determine contents and affinity of Zn and Pb to organic and mineral matter of shed coals in the USCB flysch association because so far there have not been any geochemical characteristics of coal beds below the Štur sea level which would be established in this way. The Malinowice Beds representing the formations of this association were drilled in 9 boreholes (Fig. 2).

Results and their interpretation

Shed coals from 0.10 m to 0.30 m thick, best preserved, thin and with relatively stable lateral extension, were observed in the Zalaskie Beds in the area of Leńcze. The beds represent deposits of the marginal USCB formed during the sea regression and are considered to be pseudomolasse. On the other hand, the typical Malinowice Beds are a cryptoflysch formation deposited as a result of aqueous solid flows [8, 9, 11]. These formations contained two coal beds from 0.15 m to 0.30 m thick each, in the area of Poręba Wielka and Poręba Żegoty. According to Kotas [11], they both were formed from the middle Visean to the lowermost Namurian A. The absence of results for the Malinowice Beds in the area of Bestwina, Bielowicko, Czechowice, Dębowiec, Łąka and Rudzica, is due to an inadequate mass of coal samples for examination (Fig. 2).

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Average thickness of the investigated coal beds is several times lower as compared with average thickness of the coal beds in the USCB and with the most frequent thickness of the coal beds in the Bug Beds (0.40 m), Kumów Beds (0.37 m) and the Lublin Beds (0.67 m) in the Lublin Coal Basin (Table 1). The shed coals with the thickness of below 0.3 m, and thin coal seams from 0.3 m to 0.7 m thick (not included in the recoverable reserves of the USCB as per Polish standards) occur mainly in the paralic series directly overlying the flysch association and in the USCB limnic series [16]. In the limnic series of the USCB the most frequent coal beds have thickness of 0.7 m – 1.5 m, and also thickness of 0.3 m – 0.7 and 1.5 – 4.0.

The average ash content in the shed coals is similar to the average ash content in bituminous coals from Polish basins (Table 1). An interesting regularity was observed, namely the increase of the ash contents in the shed coals with the increase of thickness (r = 0.78; Table 2). The same trend was noted earlier for coals of the USCB limnic series [16]. However, in the limnic series the trend was reversed, i.e. together with the increase in the coal bed thickness its ash content decreased.

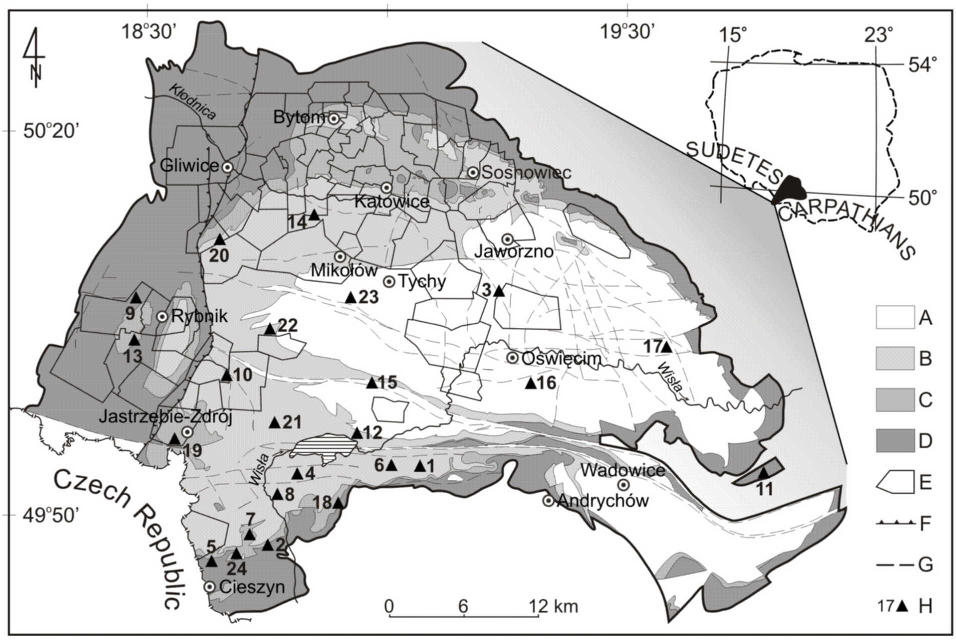

Fig. 1 Sampling locations of coal in the USCB: A - Cracov Sandstone Series, B - Mudstone Series, C - Upper Silesian Sandstone Series, D - Paralic Series, E - coal mine boundaries, F - thrusts, G - fault, H - symbols of drill holes: 1 - Bestwina, 2 - Bielowicko, 3 - Chełmek, 4 - Chybie, 5 - Cieszyn, 6 - Czechowice, 7 - Dębowiec, 8 - Drogomyśl, 9 - Jejkowice, 10 - Krzyżowice, 11 - Lencze, 12 - Łąka, 13 - Niedobczyce, 14 - Paniowy, 15 - Piasek, 16 - Poręba Wielka, 17 - Poręba Żegoty, 18 - Rudzica, 19 - Ruptawa, 20 - Szczygłowice, 21 - Studzionka, 22 - Woszczyce, 23 - Wyry, 24 – Zamarski

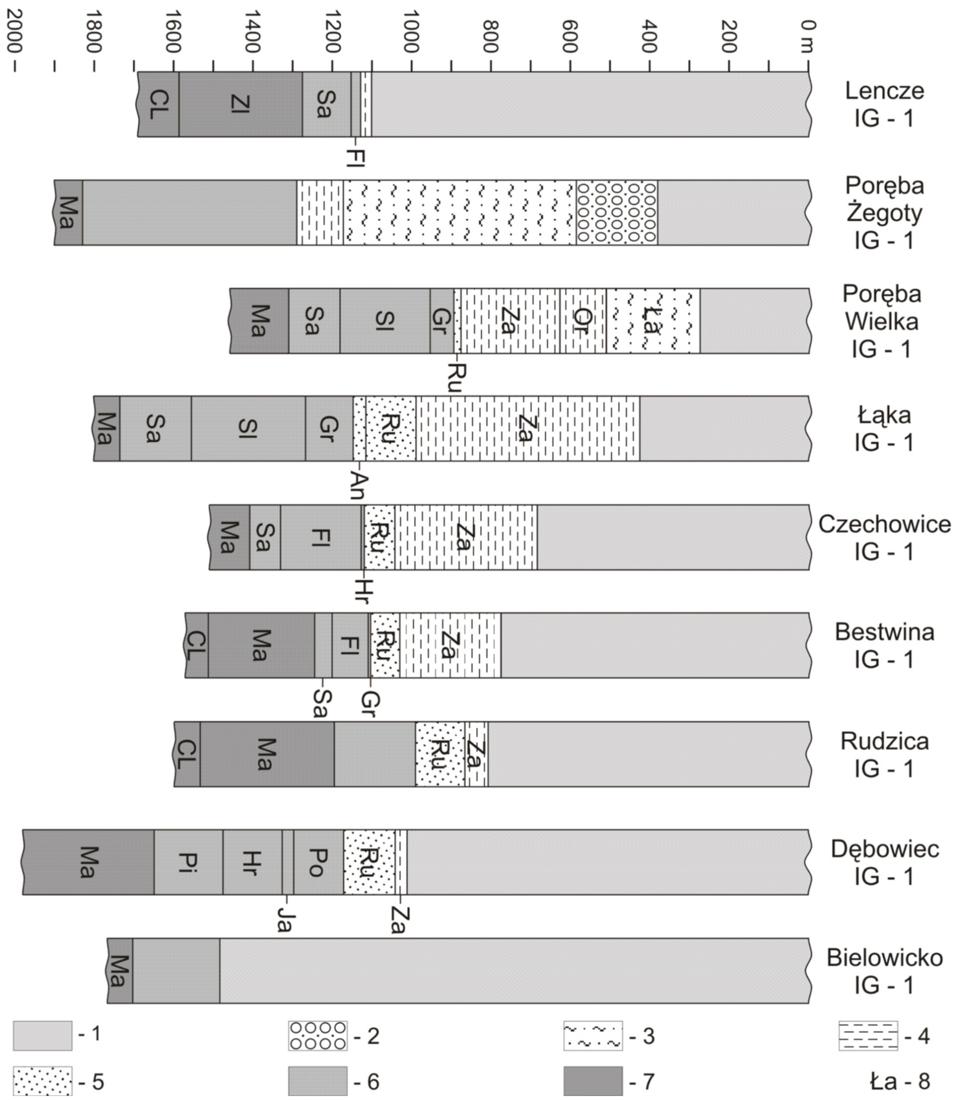

Fig. 2 Generalized litostratigraphic sequence of Carboniferous formations exposed in the boreholes to the floor of the flysch association 1 - Tertiary + Mesosoic, 2 - Kwaczała Arcose, 3 - Cracow Sandstone Series, 4 - Mudstone Series, 5 - Upper Silesian Sandstone Series, 6 - Paralic Series, 7 - Flysh Association, 8 - Carbonate Association, 9 - Symbols of the formations (beds): Ła - Łaziska, Or - Orzesze, Za - Załęże, Ru - Ruda, An - Anticlinal, Po/Gr - Poręba = Upper Grodziec, Ja/Gr - Jaklovec = Lower Grodziec, Hr/Fl - Hrušov = Flora, Pt/Sa - Petřkovice = Sarnow, Ma/Zl - Malinowice = Zalas, CL - Coal Limestone

Characteristic of coal seams in flysch association in the USCB

Tab. 1 LCB – Lublin Coal Basin, LSCB – Lower Silesian Coal Basin, A – calculated by the author based on works by Pendias [18], Winogradov [26] and Bossowski [2], B – calculated by the author based on works by Pendias [17] and Winogradov [26].
Citation of results from: 1 – Bossowski [2], 2 - Cebulak [4], 3 – Jureczka and Kotas [8], 4 – Mielecki and Krzyżanowska [12], 5 - Parzentny et al. [16], 6 – Porzycki and Zdanowski [19], 7 - Ptak and Różkowska [20].

Element		Range	Geometric mean	Standard deviation	Other bituminous coals in Poland
Thickness of coal seams (m)		0.05 - 0.3	0.17	0.09	USCB: 1.01[5] LCB: 0.40[6]; 0.37[6]; 0.67[6] LSCB:
Ash_{525} (%)		5.68 - 24.3	13.57	5.66	USCB: 13.00[3]; 13.79[4] LCB: 13.69[2]; 14.82[6] LSCB: 14.00[1]
Pb (ppm)	in ash	18.5 - 53.4	206.71	13.65	USCB: 180.5[2]; 132[7] LCB: 133.6[2] LSCB: 394[A], 700[B]
Zn (ppm)	in ash	24.4 - 53.5	247.06	10.82	USCB: 403.5[2]; 328[7] LCB: 250.6[2] LSCB: 408[A], 896[B]
Pb (ppm)	in coal	85 - 470	28.08	133.65	USCB: 25[5]; 18[7]; LCB: 17.7[2] LSCB: 55.2[A]; 98.0[B]
Zn (ppm)	in coal	150 - 760	33.55	212.95	USCB: 46[5]; 45[7] LCB: 32.6[2] LSCB: 51.7[A]; 125.4[B]

The average lead content in the shed coals and coal ash is higher than its content in coal ashes and the coals from the USCB and LCB, while it is lower than in the coals and coal ashes of the LSCB (Table 1). What is more, the zinc content in shed coals and their ashes is lower than its content in the coals and coal ashes from the USCB and LSCB, while it is comparable with the zinc content in the coals and coal ashes from the LCB. The contents of Pb and Zn in the shed coals are similar (Pb) or lower (Zn) as compared from the contents of these elements in the paralic series coals of the USCB (Pb = 24 ppm, Zn = 52 ppm) determined by Ptak and Różkowska [20]. This trend supports the regularity described earlier. It has been noted that mainly the contents of Pb and Zn in the USCB coals decreases beginning from formations of the Cracow Sandstone Series towards the floor of the paralic series [14, 20].

The observed correlation coefficient ($r = -0.74$) indicates an empirical relationship in which the contents of Pb and Zn in the investigated shed coals increase with their thickness decrease (Table 2). The relationship results probably from the mechanism of enriching coal seams in trace elements and ash-forming substances in contact with other sedimentary rocks noted by Yudovich and Ketris [27] and supported by other authors [1, 5, 21]. Inclusions in sedimentary rocks of the transformed and untransformed organic matter together with aggregates of clay minerals frequently separating them are intensively sorbed by trace elements. In the area of contact of

Correlation relationships between Pb and Zn contents in the investigaed coals

Tab. 2 A - Correlation coefficient for confidence interval 95% is r = ±0.35.

Correlation coefficient[A]		Thickness	Ash content	Pb	Zn	Pb	Zn
				in ash		in coal	
Thickness		1.00	0.78	-0.25	0.00	-0.74	-0.74
Ash content		0.78	1.00	-0.15	0.27	-0.72	-0.72
Pb	in ash	-0.25	-0.15	1.00	-0.44	0.74	-0.30
Zn		0.00	0.27	-0.44	1.00	-0.26	0.42
Pb	in coal	-0.74	-0.72	0.74	-0.26	1.00	0.38
Zn		-0.74	-0.72	-0.30	0.42	0.38	1.00

the coal bed (shed coal or seam) with the surrounding rocks, we usually observe a coal layer of several millimetres enriched in elements. The difference of the element contents between the surface of the coal bed and its median portion leads to Pb and Zn diffusion into the bed. Consequently, the roof and floor portions of the coal seams become enriched in some elements, which was supported in the results of USCB coal examination [4, 7, 14, 25]. Following the processes, thin coal layers (shed coals) may become enriched across their whole thickness.

Usually, the increase of ash content appears during the the enrichment of coal beds with trace elements [4, 7, 14, 25]. In the investigated coal beds this relationship was not noted but quite an opposite phenomenon was observed. With the increase of Pb and Zn contents, their ash contents decreases (r = -0.72; Table 2), which indicates the relationship of the elements with organic matter. Zn and Pb probably concentrated in the matter with higher sorption rate of the compounds by organic matter than by clay minerals, and with lower infiltration rate of the peat layer, and then coal, with solutions and suspensions rich with Zn and Pb. Otherwise, the investigated coal seams would have contained higher contents of ash-forming substances. The relationship between Pb and Zn with organic matter of bituminous coals from different international basins were already studied many a time [e.g. 3, 6, 28]. The relationship is the stronger, the more similar or lower is the contents of Pb and Zn in the coals to their average contents in international coals (Pb = 25 ppm, Zn = 50 ppm; Valković, 1983) and similar to lithosphere clarkes (i.e. Pb = 12.5 ppm, Zn = 70 ppm; Taylor, 1964). Poor positive correlation between the content of Pb and Zn in the coal (r = 0.38) and, at the same time, poor positive correlation between the contents of Pb and Zn in coal ash (r = 0.38), and poor negative correlation between Pb and Zn contents in coal ash (r = -0.44) were observed. The relationship supports the earlier assumption that these elements co-occur in organic matter of the investigated shed coals.

Conclusions

The shed coals drilled in the area of Leńcze, Poręba Wielka and Poręba Żegoty are thin (0.17) and have a low ash content (13.57%). The shed coals are marked by a higher Pb content and lower or similar content of Zn in the coal and coal ash as compared with coals and ashes from the productive series of the USCB and LCB.

Together with the decrease in thickness of the shed coals, their ash contents decreases with the simultaneous increase of Pb and Zn contents. These dependencies indicate the relationships between Pb and Zn with organic matter of coal as well as a greater role of sorption of the elements by organic matter than by clay minerals in reaching the present-day contents of ash and Pb and Zn in the coal from the flysch association.

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