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Quality of coal and structure of seam 510 (Namurian B) in the Upper Silesian Coal Basin (Poland)

Kakovost premoga in zgradba plasti 510 (namurij B) v Zgornješlezijski premogovni kadunji (Poljska)

Krystian Probierz, Marek Marcisz*

Silesian University of Technology, Faculty of Mining and Geology, Institute of Applied Geology, 2 Akademicka Str., PL 44-100 Gliwice, Poland

*Corresponding author. E-mail: marek.marcisz@polsl.pl

Abstract

Coal seam 510 (Namurian B) is a starting point for limnic sedimentation in the USCB and occupies about ¾ of USCB's surface, which might reach up to 7 400 km^2. This coal seam occurs usually among the sandstones of Saddle Beds of the Upper Silesian Sandstone Series and is characterized by considerable thickness, from several meters in the west up to even 24 m in the eastern part of the coal basin. In the east, the coal seam 510 constitutes an equivalent of Saddle Beds (100 % of the thickness of a series is a coal seam) and in the western part, as a result of seam splitting and simultaneous increase of thickness, the coal-bearing capacity decreases to a value of a few percent. In the eastern part of the basin, power coals occur in the coal seam 510, whereas in the west the rank of coals from this seam increases and even coking coals tend to appear.

Key words: Upper Silesian Coal Basin, bituminous coal, coal seam 510, coal quality, quality parameters

Izvleček

Premogova plast 510 (namurij B), s katero se začenja jezerska sedimentacija v Zgornješlezijski premogovni kadunji (ZŠPK), je razširjena na okroglo ¾ površine te kadunje, kar ustreza površini blizu 7 400 km^2. Ta plast je razvita navadno v peščenjakih antiklinalne serije premoških plasti ZŠPK. Zanjo je značilna precejšnja debelina, od nekaj metrov na zahodu do celih 24 m v vzhodnem delu kadunje. Na vzhodu je premogova plast 510 ekvivalent antiklinalnih plasti (100 % debeline serije tvori premogova plast), medtem ko se na zahodu delež premoga zmanjša na vsega nekaj odstotkov zaradi cepitve premogove plasti in hkratnega zvečanja debeline. V vzhodnem delu je surovina v premogovi plasti 510 elektrarniške kakovosti, medtem ko proti zahodu kakovost narašča in doseže celo stopnjo, primerno za koksanje.

Ključne besede: Zgornješlezijska premogovna kadunja, črni premog, premogova plast 510, kakovost, parametri kakovosti

Introduction

The 510 seam is one of the key seams of the Upper Silesian Coal Basin, which is substantiated both by geological and mining factors. The seam fulfils all conditions of a key seam in a coal-bearing series while maintaining significant (although variable) thickness at a great area of the basin.

From the geological point of view, the 510 seam is a characteristic stratigraphic level constituting a starting point for the sedimentation of limnic deposits formed on the paralic deposits in the USCB. Stratigraphically, the seam represents the saddle beds of the Upper Silesian Sandstone Series of the Namurian B.

The mining factors distinguishing the 510 seam are related to the highest richness in coal (occurring in the seams of the Upper Silesian Sandstone Series, while the coal seams of the Saddle Beds – due to high coal bearing capacity – have constituted one of the most attractive deposit parts from the point of view of mining – although their thickness isn't very high as compared to other seams).

The most disctinctive quality of the 510 seam is its thickness, which reaches up to 24 m in the NE part of the USCB (the Jaworzno region), at a complete reduction of accompanying barren rocks. The 510 seam in this part of the basin thus represents all Saddle Beds (is their equivalent), which – in view of the number of seams and the thickness of barren rock between the seams – fully develops only in the western direction [1, 2].

The article presents the occurrence characteristics of the 510 seam within the Polish part of the Upper Silesian Coal Basin.

Geological characteristics of the Upper Silesian Coal Basin

The Upper Silesian Coal Basin (USCB) is one of the most significant Carboniferous basins of Europe. It is located in the area of occurrence of coal-bearing formations of the Carboniferous covering the north-western part of Europe, in the Variscan foredeep.

The area of the USCB ranges from 6 100 km^2 to 7 400 km^2. This discrepancy results from the difficulty to exactly determine the course of the southern boundary of the basin. The southern boundary of the USCB, which is in the shape of a triangle trough filled with coal bearing upper Carboniferous formations, is conventionally determined by the overthrust line of the Carpathian Mountains.

The USCB represents an orogenic basin type formed in the mountain foredeep of the Silesian and Moravian Variscides area while its sedimentation is characterized by gradual transformation from flysch to molassic coal-bearing formations.

The lithostratigraphic profile (and the geological structure) of the USCB, which has been so far explored by means of > 6 500 boreholes (5 800 in Poland and 700 in the Czech Republic), is comprised of substrata from Precambrian, Cambrian, Devonian, lower Carboniferous and the upper Carboniferous productive series to the overlay seams: Permian, Triassic, Jurassic, Miocene and Quaternary.

The coal-bearing productive formation is comprised of the upper Carboniferous formations indicating significant decrease of thickness in the direction from west to east and a characteristic bipartition in the stratigraphic profile. The lower part of the profile of the coal-bearing formations is characterized by the qualities of the paralic coal-bearing series, while the higher members of the profile include continental limnic deposits. The maximal thickness of the coal-bearing surface reaches up to 8 500 m in the areas of the greatest subsidence (Figure 1).

In the coal-bearing formations of the upper Carboniferous (the range of which has been presented in Figure 2), the following lithostratigraphic series may be differentiated (Figure 3): the Paralic Series (Namurian A), the Upper Silesian Sandstone Series (Namurian B and C), the Mudstone Series (Westphalian A and B) and the Cracow Sandstone Series (Westphalian C and D).

The overlay of the productive formation is constituted by the formations of the Permian, Triassic, Jurassic, Tertiary (Miocene) and Quaternary periods [2–11].

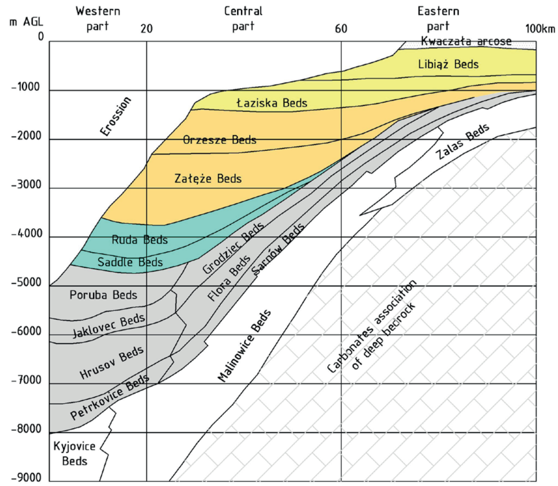


Figure 1: *Litostratigraphical series of upper and lower Carboniferous periods of the USCB* [2].

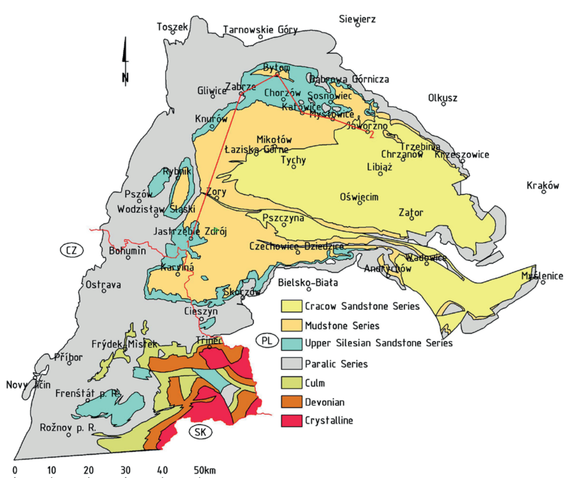


Figure 2: *Geological sketch of the USCB* [2].

Location of the 510 seam in the lithostratigrapic profile of the USCB

The formations of the *Upper Silesian Sandstone Series* (Figure 3) are a starting point for the profile of the sediments of the limnic series. In the lower part of the profile, it encompasses Saddle Beds numbered from 510 to 501. These sediments differ from the Paralic Series present lower in the lack of levels with sea fauna and the dominating part of coarse-clastic rocks (conglomerates, sandstones), among which coal seams – usually characterized by high thickness – occur. The seams, as it has it has been mentioned before, are also characterized by high coal bearing capacity. The highest thickness – 1 100 m – is exhibited in the Upper Silesian Sandstone Series in the west part of the basin. Subsequently, the series grows thinner to 480–860 m in the central part and continues to do so in the eastern direction where the seams meet and the series reaches only 300–400 m in thickness (Figure 1). At the NE and E boundary of the USCB, the Upper Silesian Sandstone Series fades and is represented only by the seam 510, 24 m in thickness [2].

Saddle Beds are a special case of changes in the thickness of series and splitting of seams in the Upper Silesian Coal Basin (Figure 4). Their maximal thickness reaches 290 m. The key seam of the entire basin – the 510 seam (24 m in thickness) in an equivalent of the entire coal series in the eastern part of the basin (the Jaworzno region, Figure 2). This means that Saddle Beds are represented only by a single seam, while the coal bearing capacity of the Saddle Beds in that region amounts to 100 % [1, 2].

In the eastern part of the basin (the Jaworzno region, Figure 2), the Saddle Beds are characterized by variable thickness of series. Their total thickness is from a few meters to 35 m. Their form is a single 510 coal seam, in the roof of which a shoal of clay slate or sandstone is sometimes present. The thickness of the seam is from a few meters to around 24 m.

In the western direction of the basin, the thickness of the Saddle Beds increases and the 510 seam is split.

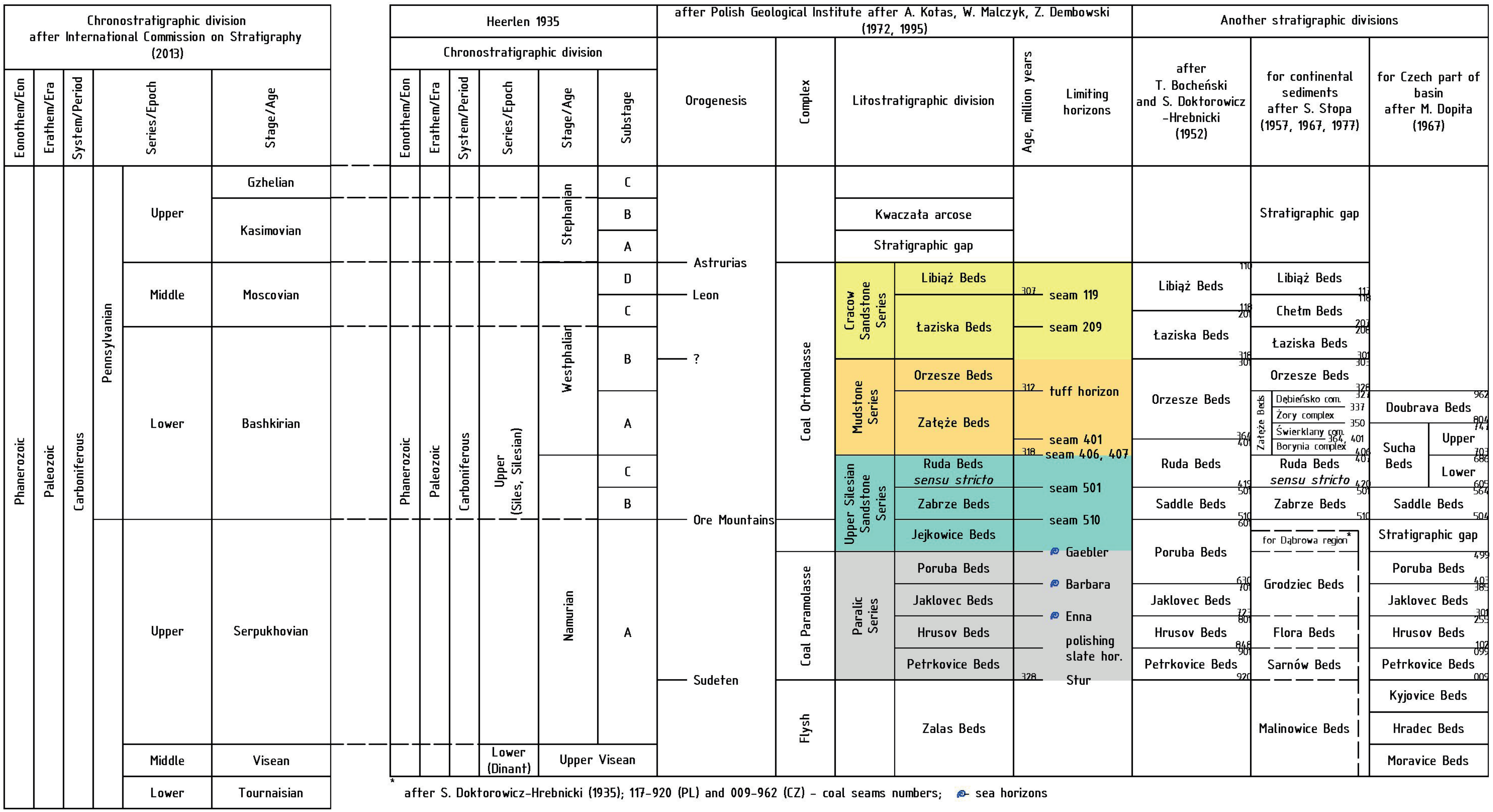
Initially, in the area of Mysłowice (Figure 2) into two thick 501 and 510 seams with a total thickness of ≈ 19.5 m, divided by a small interburden.

In the region of Katowice (Figure 2), the Saddle Beds reach 37–50 m in thickness and incorporate 2 or 3 coal seams characterized by large thickness (501 seams with thicknesses between 3.5 m and 4.0 m and 510 seams with a thickness of 10 m are considered economic).

Two thick seams are also present in the region of Chorzów (Figure 2), with thicknesses of 9.0 m and 2.3 m.

In the region of Zabrze (Figure 2), as many as seven seams have been identified: 501 (thickness of 1.1–1.7 m), 502 (1.2–1.8 m), 503 (1.7–3.2 m), 504 (8.5–12.0 m), 507 (2.6–3.6 m), 509 (3.0–4.6 m) and 510 with a

Figure 3: *Stratigraphic division of the Upper Silesian Coal Basin* [2, 5, 11].



* after S. Doktorowicz-Hrebnicki (1935); 117–920 (PL) and 009–962 (CZ) – coal seams numbers; sea horizons

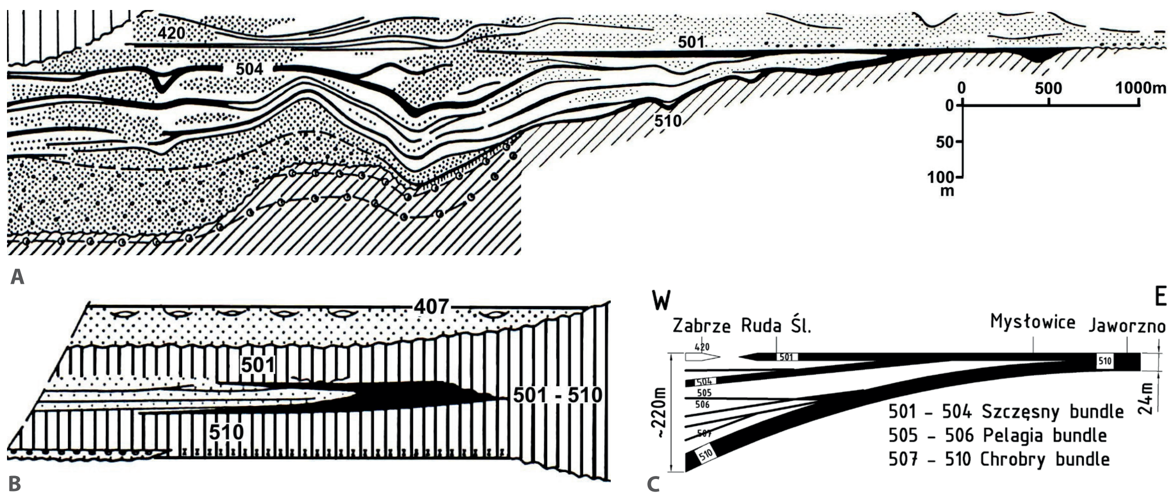


Figure 4: *Schematic drawing of the distribution of saddle beds in the USCB, as provided by different authors [2, 6, 10, 12, 13], simplified and altered.*

thickness of 3.8–5.1 m. In total, the Saddle Beds reach up to 32.0 m in thickness. The seams 504 and 510 are assumed to be the key seams characterized by the most stable form.

In the area of Gliwice (Figure 2), the thickness of the Saddle Beds which has formed as a result of the splitting of the 510 seam reaches ≈ 220 m and the following groups may be distinguished:

— *Szczęsny* – seams from 501 (with a thickness of ≈ 5 m) to 504,
— *Pelagia* with 505–506 seams in the form of lenses,
— *Chrobry,* that is the 507–510 seams.

The total thickness of the seams in these groups reaches 28 m, while the thickness of the 510 seam exceeds 6.3 m.

In the area of Bytom (Figure 2), the thickness of the Saddle Beds (including the 501, 503, 504, 506, 507, 509 and 510 seams) reaches 80–150 m.

In the south-western part of the basin (Jastrzębie region), the thickness of the Saddle Beds reaches 240–290 m [2].

Coal quality in the 510 seam

The seam encompassing such a great area includes coal characterized by high variability of quality understood as values of quality parameters (Figure 5).

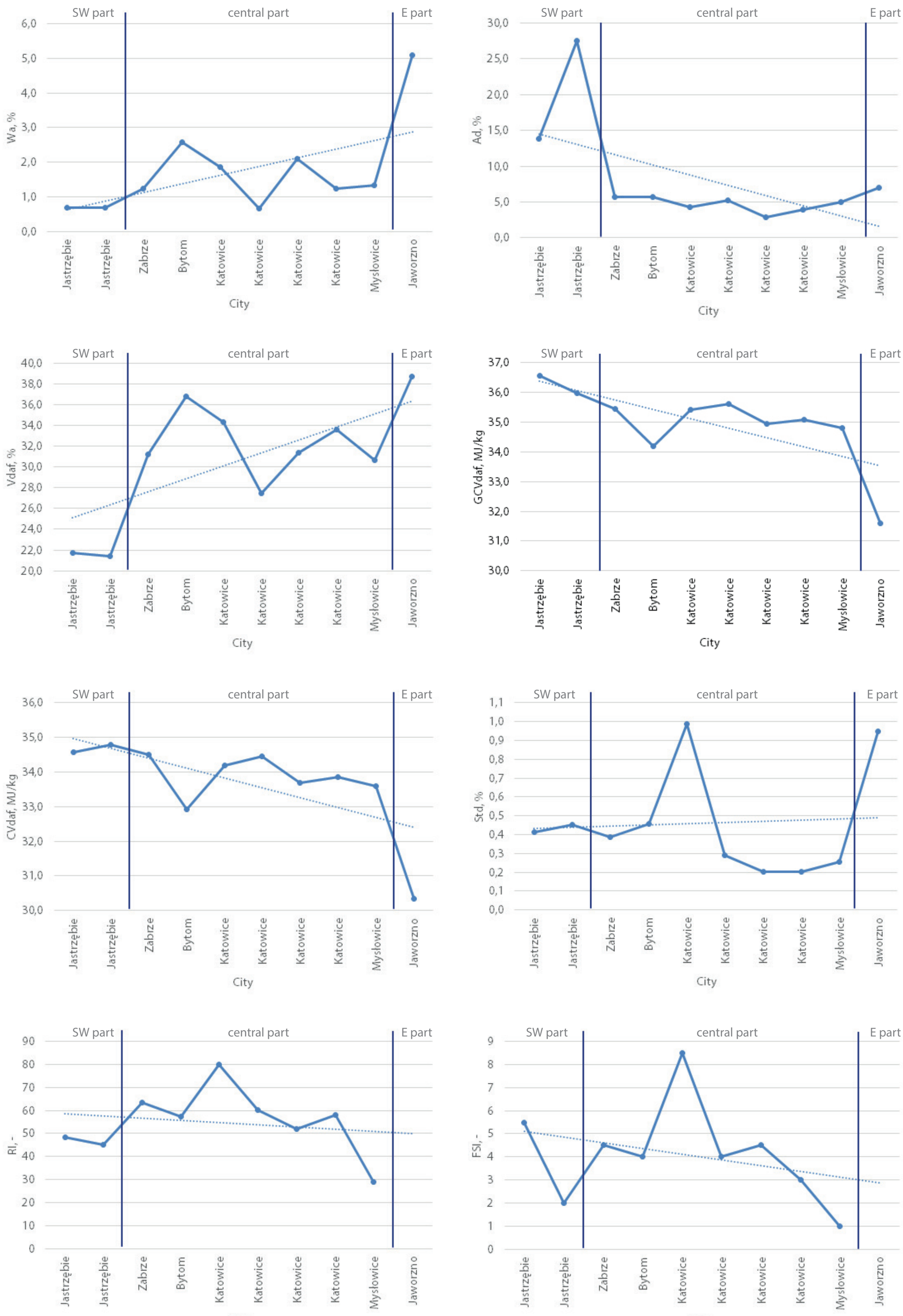
The W^a moisture content changes in steps and ranges from 0.7 % to 2.6 % (with one exception of 5.1 %) and by averaging the changes, a weak falling tendency in the southern direction may be noted. This may speak for the occurrence of a weak and slightly irregular Schürmann's rule manifestation – the regular decrease of moisture with the depth of the seam presence.

The A^d ash content in the area of power coals varies in the range between 2.8 % and 7.0 %, exhibiting a mean value of 5.3 %. Significantly higher values, however, have been noted in the area of coking coals.

The V^{daf} volatile matter content is characterized by a regular decrease in the western and southern directions – from 38.7 % to 21.7 %. This may be the evidence of the manifestation of Hilt's law – a regular decrease of V^{daf} along the depth of the seam presence.

The GCV^{daf} gross calorific value exhibits a weak growing tendency from 34.8 MJ/kg to 36.6 MJ/kg (departure from this regular tendency is observed only in the regions of Jaworzno and Bytom). The CV^{daf} calorific value changes similarly, which is a direct result of the relation between the two parameters (calculation of the values of both these parameters).

Surprisingly, the S_t^d total sulphur content also exhibits directionality of changes. A weak growing tendency is observed in the direction from the east to the west and south,



SW part
central part
E part
Wa, %
Ad, %
Vdaf, %
GCVdaf, MJ/kg
CVdaf, MJ/kg
Std, %
RI, -
FSI, -
Jastrzębie
Jastrzębie
Zabrze
Bytom
Katowice
Katowice
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Mysłowice
Jaworzno
City

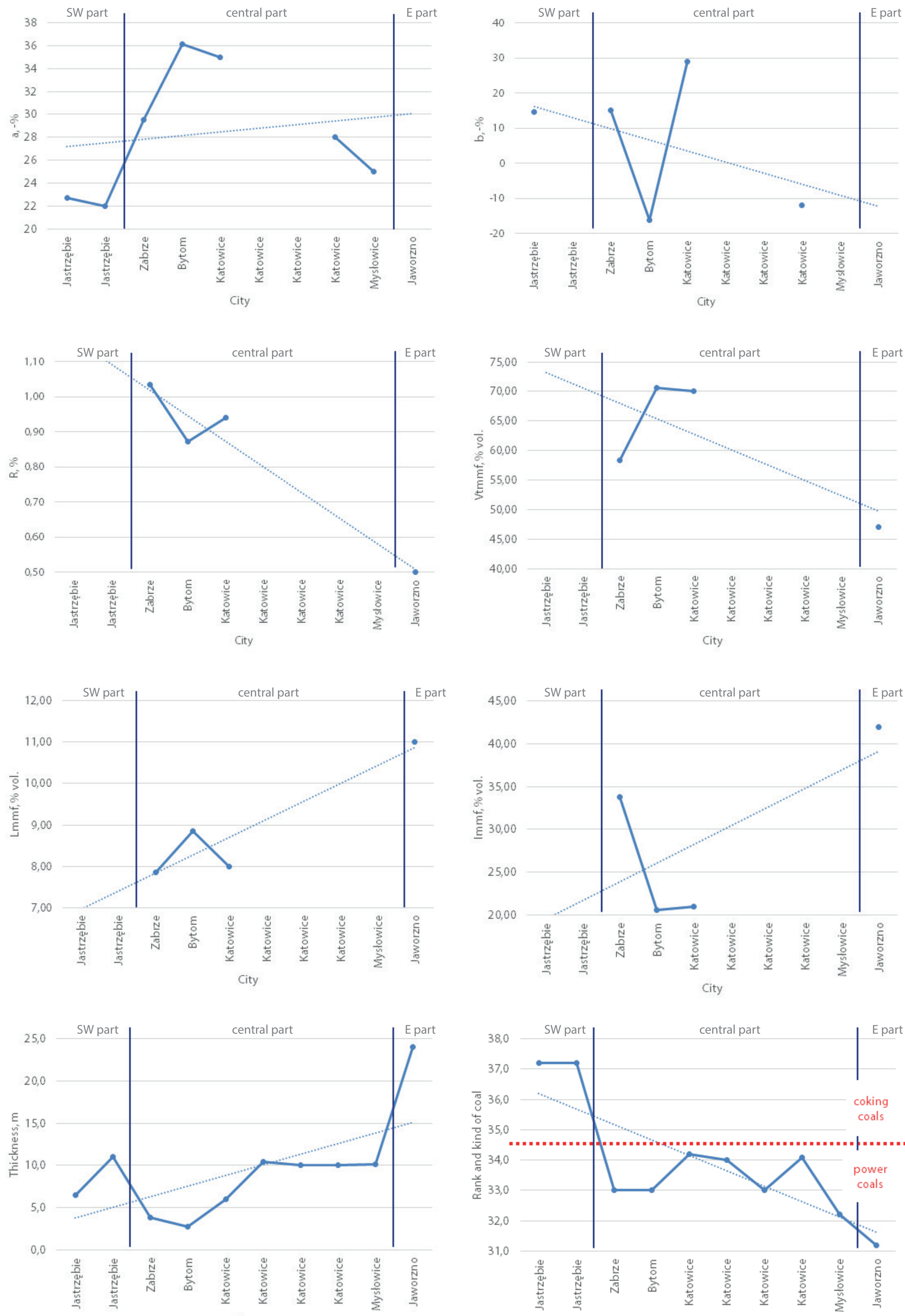

Figure 5: *Changes in the quality parameter values of the coal from the 510 seam.*

from 0.2 % to 0.5 % (the high value of this parameter in the region of Jaworzno and Katowice constitutes an exception).

Coking indicators, caking capacity in line with the Roga Index and the *FSI* free swelling index exhibit a similar character of changes. The *RI* values initially increase from 29 to 80 and subsequently decrease to 45 and 49. The *FSI* values, however, increase from 1 to 8 ½, and subsequently decrease to 2 and 5.

In case of dilatometric indicators relating to contraction, a growing tendency in the area of power coals from the east to the west may be observed – from 25 % to 36 %. In the area of coking coals, the values of this parameter are lower – in the range of 22–23 %.

The *R* reflectance values in the area of power coals increase from the east towards the west from 0.50 % to 1.04 %.

As mentioned earlier, the thickness of the 510 seam decreases in the western direction. In the region of Jaworzno it is 24 m in thickness, and subsequently the thickness decreases to approximately 10 m and 8 m in the region of Katowice. The minimal thickness – that is 2.8 m – has been found in the region of Bytom. In the southern part of the USCB, in the area of coking coals, the thickness of the seam initially increases to 11 m and subsequently decreases to 6.5 m in the region of Jastrzębie.

Figure 5 schematically presents also the variation in the coal rank. It seems that these changes occur in steps with a growing tendency in the southern direction. In the eastern and central part of the USCB, power coals dominate, while in the SW part coking coals occur.

Conclusions

The 510 seam is one of the key seams of the Upper Silesian Coal Basin from the geological point of view.

Its most characteristic quality is its thickness, which reaches even 24 m in the NE part of the USCB (the Jaworzno region), representing the entire profile of the Saddle Beds, which, in terms of number of seams, develop fully only in the western direction.

A weak occurrence of the Schürmann law and a more distinct occurrence of the Hilt's law is observed. The ash content is considerably different in the region of occurrence of power coals (lower values) as compared to the region of coking coal occurrence (higher values). Also a slight yet regular increase of the calorific value, the gross calorific value and the total sulphur content is observed in the direction from the east to the west and south. As far as the coking properties are concerned, lower values are observed in the east and the west, while the highest values are characteristic to the centre of the USCB (the region of Katowice).

The thickness of the 510 seam decreases from 24 m in the east to 3.8 m and 2.8 m in the west and north. In the south, the thickness of the seam reaches the value of 6.5 m and 11.0 m.

A schematic draft of the changes in the coal rank allowed to indicate the fact that the changes occur in steps. In the eastern and central part of the USCB, power coals dominate, while in the SW part coking coals occur.

The article gives consideration only to mean values of the parameters regarding the whole deposit areas (occurring in the regions of particular cities), so that the ranges of the changes and the areas of occurrence of coals (in the view of coalification), are probably broader than presented in the work.

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