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OPEN

Arch. Min. Sci., Vol. 61 (2016), No 3, p. 677–694

Electronic version (in color) of this paper is available: http://mining.archives.pl

DOI 10.1515/amsc-2016-0047

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STRUCTURALLY ALTERED HARD COAL IN THE AREAS OF TECTONIC DISTURBANCES – AN INITIAL ATTEMPT AT CLASSIFICATION

STRUKTURY ODMIENIONE WĘGLA KAMIENNEGO W STREFACH ZABURZEŃ TEKTONICZNYCH – WSTĘPNA PROPOZYCJA KLASYFIKACJI

As regards the exploitation of hard coal seams, the near-fault zones and faults themselves are considered to be particularly dangerous areas, which is due to a high probability of the occurrence of gasogeodynamic phenomena. Tectonic dislocations running across a seam have a destructive impact on coal. Degradation of the coal structure, particularly visible in the microscale, is reflected in the coal's strength or gas properties. Such "structurally altered" coal is characterized by the presence of numerous fracturings, crushed areas, or dislocations of some of its fragments, and sometimes even the total destruction of the original structure. The present paper provides a detailed analysis and description of near-fault coal obtained from selected seams of the Upper Silesian Coal Basin, completed due to the application of optical methods. Both the type and the degree of changes in the structure of such coal were identified. On this basis, the author attempted to systematize the nomenclature used in relation to selected Upper Silesian hard coal seams, which, in turn, resulted in a proposed classification of the "altered structures" of the near-fault coal.

Keywords: hard coal, faults, coal structures, cataclasis, mylonite

Podczas eksploatacji węgla kamiennego, za szczególnie niebezpieczne obszary, ze względu na możliwość wystąpienia zjawisk gazo-geodynamicznych, uważa się strefy przyuskokowe i same uskoki. Przebiegające przez pokład dyslokacje tektoniczne wpływają destrukcyjnie na węgiel. Degradacja struktury węgla dostrzegalna, szczególnie w skali mikro, ma odzwierciedlenie w jego cechach wytrzymałościowych czy też gazowych. Taki, „odmieniony strukturalnie" węgiel, charakteryzuje się występowaniem licznych spękań, skruszeń, czy przemieszczeń poszczególnych fragmentów, a niekiedy i całkowitym zniszczeniem pierwotnej struktury. W pracy, posługując się metodami optycznymi, dokonano szczegółowych obserwacji i opisu węgla przyuskokowego pobranego z wybranych pokładów Górnośląskiego Zagłębia Węglowego. Zidentyfikowano rodzaj i intensywność zmian w strukturze takiego węgla. Na tej podstawie podjęto próbę usystematyzowania stosowanego nazewnictwa w odniesieniu do wybranych górnośląskich pokładów węgla kamiennego, co w konsekwencji zaowocowało zaproponowaniem klasyfikacji „struktur odmienionych" tego przyuskokowego węgla.

Słowa kluczowe: węgiel kamienny, uskoki, struktury węgla, kataklaza, mylonit

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1. Introduction

Hard coal reveals various types of structural deformations, which can be either the result of the escalation of the coalification process or the consequence of the impact of tectonic disturbances on a seam. The effects of the influence of tectonic phenomena on coal can be the emergence of a dense network of fractures, crushing, or overgrinding – on such a scale that, in extreme cases, the original structure of coal will be totally altered, blurred (Shepherd et al., 1980; Cao et al., 2000). Some specific structural characteristics of hard coal from the so-called shear zone were of interest to – among other researchers – Rakowski et al. (1977); Bodziony & Lama (1996); Cao et al. (2000, 2001, 2003); Li et al. (2003); Jiang et al. (2004); Ju et al. (2005); Gentzis (2006); Liu et al. (2009); Ming et al. (2011). The description and nomenclature regarding the coal structures occurring in the areas of tectonic disturbances, provided by the above-mentioned authors, differ considerably. This is due to various research locations, different geological and structural conditions, and each author's individual approach to the investigated phenomenon.

Researchers associated with the Strata Mechanics Research Institute has been dealing with issues related to the safety of coal mining, especially the various aspects related to gas hazards (including Wierzbicki, 2013; Skoczylas, 2012; Skoczylas et al., 2014). Gas-geodynamic hazards are, in turn, closely related to the structural and petrographic characteristics of coal, in particular the one from fault zones (including Młynarczuk & Wierzbicki, 2009; Godyń, 2011, 2012, 2013).

The author of the present paper – inspired by this experience and aided by the data found in relevant sources – aimed to provide a classification of the altered hard coal structures from these Upper Silesian coal seams which are characterized by the presence of tectonic disturbances. The completion of this task was based on the results of studies of over 60 coal samples collected from near-fault zones in selected Upper Silesian seams. At the same time, the paper is an introduction into studies of this specific creations on a much wider scale. The plan for the future is to analyze the greatest possible number of near-fault hard coal samples, collected from various geological formations and uneven-aged seams of the Upper Silesian Coal Basin.

2. Structurally altered coal in works of various authors

The structural (in the present paper, a set of structural and textural characteristics of coal from near-fault zones is generally referred to as **„structure”**. However, these are – as a matter of fact – structural-textural characteristics (according to Ryka & Maliszewska, 1991). Structures encompass – among other things – the size of particular pieces of coal, their shape and the way they are interrelated. Textures are the arrangements of the crushed pieces of coal, directionality, positioning in space, etc.) characteristics of hard coal are influenced by numerous factors. Among others, these are: the age of the seam and the degree of its metamorphism (according to Gabzdyl, 1987, the term “does not correspond to the metamorphism of sedimentary rocks, and can be replaced with the term ‘coalification’”), location, weathering processes, and the extent of tectonic phenomena affecting the seam (such as the type and size of the fault). The faults occurring in seams have a significant impact on the degradation of the internal structure of coal. Such „structurally altered” coal is referred to as „tectonic breccia” (e.g. in Ćmiel, 2002, Ćmiel et al., 2006), „sheared coal” (Dutka&Wierzbicki, 2008), „mylonitized coal” (Jakubów et al., 2006; Bukowska & Gawryś, 2010), or „pressed coal material” (Patyńska & Kidybiński, 2008). Such broadly defined names are only to signal the occurrence of untypical, deformed coal fragments within a rock mass; they do not provide a detailed description of the structures created as a result of the impact of tectonic forces.

A lot of researchers have occupied themselves with both macro- and microscale analysis of these structures, as well as their description and a search for some methods that would prove effective in monitoring the frequency with which fractures and fissures appear in coal seams as a result of tectonic distortions. Among others, these were: Barker-Read (1980); MacDonald (1980); Goszcz&Kuś (1985); Dumpleton (1990), followed by Frodsham and Gayer (1998); Su X., et al. (2001).

There have also been numerous and varying attempts to present divisions or classifications of coal structures subjected to the impact of tectonic phenomena (faults). In 1969, German authors (Jüntgen et al., 1969) proposed a uniform categorization of structurally altered coal. Their work became the foundation on which Czech researchers (Rakowski et al., 1977) based the conclusions formulated in a paper dealing with the changes in structures and textures in the hard coal seams from the Paskov and Stařić mining facilities (cf. Table 1). According to the Czechs, the process of destruction of coal structure can be divided into the following stages: solid coal with a small number of fractures, coal with an increased number of fractures, and coal with a dense network of fractures/tectonic microbreccia.

TABLE1

Types of structurally altered coal, based on the classification by Rakowski et al. (1977) and Jüntgen et al. (1969)

Microstructural coal types according to Rakowski et al. (1977)	**Description of fractures**	**Microstructural types of coal according to Jüntgen et al. (1969)**
A	Solid coals with a small number of fissures, usually positioned perpendicularly or askew in relation to stratification	1. Intact coals (Intakte Kohle)
„Transitive" types	A+B type combination	2. Weakly fractured coals (Schwach rissige Kohle)
B	Solid (massive) coals with an increased number of fissures (medium degree of tectonic disturbances)	3. Highly fractured coals (Stark rissige Kohle)
C	C_1 – diversified coals with a dense network of fractures C_2 – tectonic microbreccia (high degree of tectonic disturbances)	4. Mylonitized coals (Mylonitisierte Kohle) 5. Briquetted coals (Brikettkohle)

Cao et al. (2000, 2001, 2003), analyzing coal samples at high magnifications, provided the following categorization: normal coal, revealing no division into smaller pieces; cataclastic coal, which reveals division into irregular pieces with sharp edges – bits, usually larger than 1mm; granular coal, in which the edges of particular pieces are less sharp and the fragments themselves are smaller; finally, altered mylonitic coal, revealing the highest extent of destruction. Li et al. (2003), in turn, divide the coal structures into: undisturbed coal; cataclastic-angular coal; cataclastic-granular coal; foliated coal; and mylonitic coal.

Another description of the structures of „altered" coal was provided by Jiang et al. (2004). The authors divide the coal structures into two types: the cataclastic type and the mylonitic type. The cataclastic coal is formed gradually, together with an increase in stress. As a result, the coal material is slowly crushed. At first, primary cataclastic coal appears; then, cataclastic coal is formed. The next stage is porphyroclastic coal, and the final transition stage is granulitic coal. The subsequent phase of structural deformations is the creation of mylonitic coal. It is a long process in which the key role is played by stress and – to a lesser extent – temperature. The initial stage of the process is the emergence of squamaceous coal, then winkle coal appears, and the final stage is the creation of mylonitic coal.

Ju et al. (2005) and Ming et. al (2011) present a slightly different classification of tectonically deformed coal, which divides its structures into the following types: primary cataclastic structural coal; cataclastic structural coal, mortar structural coal, and schistose structure coal.

In 2009, Ju and Li provided an even more detailed categorization of altered coal structures, which encompasses structures created as a result of brittle, brittle-ductile, and ductile deformations. As a result of brittle deformations, the following structures are formed: cataclastic coal, mortar coal, granulitic coal, mealy coal, schistose coal, and thin-layer coal. The effect of brittle-ductile deformations is scale coal, and ductile deformations yield winkle coal, mylonitic coal, and ductilely structural coal.

Coal from near-fault zones reveals not only specific structural characteristics, but also peculiar optic qualities. Komorek et al. (1995), Komorek et al. (1998) and Pozzi (1996) observe that, in coal from near-fault zones in the Upper Silesian Coal Basins, the optical anisotropy of coal increases (this property is analyzed by measuring the reflexivity of vitrinite; the graphical representation of this is an indicatrix constructed on this basis). This is caused by the impact of tectonic stresses on the coal substance – and, more precisely, on the course of the coalification process. The above-mentioned authors are of the opinion that the analyzed coal should be referred to as „tectonite", i.e. deformed rock where tectonic forces caused reorientation of texture and optical axes.

The problem of structurally altered coal is of interest not only to scientists. It is also an important question as regards safety of hard coal exploitation in underground mining facilities all over the world. Changes in the coal structure have a negative impact on its strength properties. They also cause an increase in its gas capacity, which makes the risk of the occurrence of gasogeodynamic phenomena considerably bigger. Due to the importance of this phenomenon, some countries with working hard coal mines address the issue in their mining regulations. Along with such parameters as the rate of gas desorption, Protodyakonov's impact tests, or measurements of the seam pressure, the problem of the coal structure degradation is mentioned. In the mining regulations of such countries as Russia and China, particular attention is focused on the identification of this type of coal. Also, these regulations recommend that such structures should be described according to a classification system encompassing 5 structural types of coal (Instruction..., 1989; Guo et al.). In other countries with working hard coal mines – among which there is also Poland – relevant regulations suggest that increased attention is paid to coals from the areas of tectonic disturbances; however, the degree of these structural changes is not defined in a detailed manner.

3. Methodology

The research material used for the purpose of achieving the objectives outlined in this paper encompassed coal material from selected Upper Silesian coal seams with faults. In total, over sixty coal samples from near-fault zones were analyzed.

The collected material served as the basis for preparing specimens – polished sections, both granular and in the form of chunks. The instruments used during analyses were the AXIOPLAN polarization microscope by ZEISS and a computer-operated mechanical table XYZ. The image from the microscope was displayed on the monitor due to the application of a CCD camera. The magnification was 500X, which complies with the PN-ISO 7404-3: 2001 norm regarding petrographic analyses of hard coal. The polished sections were investigated in reflected light (white one), and the technique used was oil immersion. The result is a series of photographs which show coal with no visible structural changes, fractured coal, and highly deformed.

During the analysis of hard coal samples collected from fault zones, it turned out that the coal occurring in those areas was different – sometimes to a considerable extent – as far as its structural and textural features were concerned. The content of "structurally altered" coal was higher (even up to over a dozen percent of the total volume) as the distance to the fault diminished (Godyń, 2011, 2012, 2013). As a result of observations carried out with a microscope and concerning the material collected from the faults and adjacent areas, several different groups of structures were identified. The classification was based on the degree of damage revealed by the analyzed samples. It needs to be stated that the geological phenomena which resulted in the emergence of the identified structural types originated in the upper ares of the lithosphere (i.e. at the depth of up to 6 km), where rock dust and tectonic breccia are formed (according to Dadlez & Jaroszewski, 1994). The structural types of the analyzed caustobioliths, discussed below, represent the zone of near-fault tectonic microbreccia formation. The nomenclature used in this work is to describe, in a clear way, the structural types of the brecciafied near-fault coal. It should be added that the present paper does not discuss just the phenomena that led to the emergence of these specific, near-fault coal structures, but describes the characteristics of the „structurally altered" material, so that the process of its identification is facilitated. These are not cataclases and mylonites in the strict sense, but coal creations revealing some features resembling those of cataclasis or mylonite.

4. A review of the structures of near-fault coal from selected seams of the upper Silesian Coal Basin

4.1. Normal/unaltered coal with a natural network of fracturings

Macro- and microanalyses of hard coal from various locations and seams (e.g. Bodziony et al., 1990) demonstrated that even structurally unaltered coal always reveals more or less complex systems of fractures, fissures, and pores. Unaltered coal, in the light of studies performed with a microscope, is coal in which we do not observe a significant increase in the number of fractures, and whose already existing fractures are endogenic. There are two mechanisms behind the formation of fractures/fissures – the one that causes the formation of the original (diagenetic, endogenic) fractures during peat-formation and coalification processes, and the one that causes the formation of post-diagenetic (exogenic) fractures, related mostly to dislocation metamorphism (the impact of stress). Endo-microfractures are most common and most numerous in macerals belonging to the vitrinite group – collinite (mainly in telocollinite) (Yan-Bin & Dameng, 2009). The macerals of the vitrinite group are the most brittle ones. They are characterized by the presence of fractures and fissures (the so-called contraction fissures) perpendicular to each other, whose visibility increases with the degree of coalification. The fissures in question increase the brittleness of the vitrinite coal (Kruszewska & Dybova-Jachowicz, 1997; Manecki & Muszyński, 2008).

Endogenic fractures have several specific properties: they are isolated, usually linear; they cross at a right angle, intertwine, and may form an ordered, two-way network. Some examples of such systems of fractures are presented in Figure 1.

4.2. Fractured – exogenic coal (post-diagenetic coal)

The development of the network of fissures and pores in coal is also influenced by exogenic processes. The external forces, by exerting an impact on a coal seam, may lead to a significant increase in the number of fractures. Exogenic transformations encompass the impact of tectonic forces, changes in pressure, and compaction in various time periods. An increased share of such fractures may signal the proximity of a tectonic deformation. In contrast to endo-microfractures, exo-microfractures form an irregular network, composed of node-like flexures, sometimes dendrite- or mosaic-like one. As opposed to original fractures, tectonic ones are accidental, chaotic, and occur randomly, which increases the anisotropy of coal. Endo- and exo-microfractures differ also with respect to the frequency with which they occur. The latter are usually more numerous. Endo-microfractures are usually present in the macerals from the vitrinite group, and exo-microfractures appear also in the macerals of the liptinite group, and even of the inertinite group, although intertinite is quite resistant to crushing (Manecki & Muszyński, 2008). Quite often, endo- and exo-microfractures in the same body of coal overlap, which makes it more difficult to differrentiate between them. Figure 2 provides sample photographs of exo-microfractures.

4.3. Coal with cataclastic structures (cataclastic tectonic microbreccia)

Coal fractured as a result of the impact of post-diagenetic processes – due to increasing influence of shearing forces causing crushing – is comminuted more and more. Subsequently, it becomes coal with cataclastic structures.

The borderline between coal which is highly fractured due to the impact of exogenic processes and coal with **cataclastic** structures is hard to establish. As stress increases, seam stresses increase as well, which results in growing numbers of fractures and further crushing of pieces of coal. When fractures begin to form an irregular network which becomes denser, pieces revealing a cataclastic structure are formed. Such a structure has a range of specific properties. Moreover, as metamorphism becomes more advanced due to tectonic dislocations, the structure in question undergoes transformations of ever-increasing intensity, until it is almost completely blurred. The categorization of particular stages of cataclasis formation, together with their description, is provided below.

Pre-cataclasis is the first stage in the formation of cataclastic structures. This stage, involving the destruction of the coal structure, initiates a series of transformations occurring one after another. The coal with such properties reveals – under a microscope – a network of fractures

Fig. 1. Primary, or endogenic fractures. The coal samples were collected from the Zofiówka colliery, seam no. 406/1, and the Pniówek colliery, seam no. 403/3. Magnification 500×; reflected light, immersion

which is larger and more complex as compared to exo-microfractured coal. Here, there are no isolated, single fractures; just a more complex network which becomes visibly denser and denser. A characteristic feature of such pieces of coal is the fact that they give us an opportunity to discern (again, under a microscope) their original, undistorted structure. One can observe lamination, microlithotypes, visibly separated intermaceral links, and lack of dislocations, or

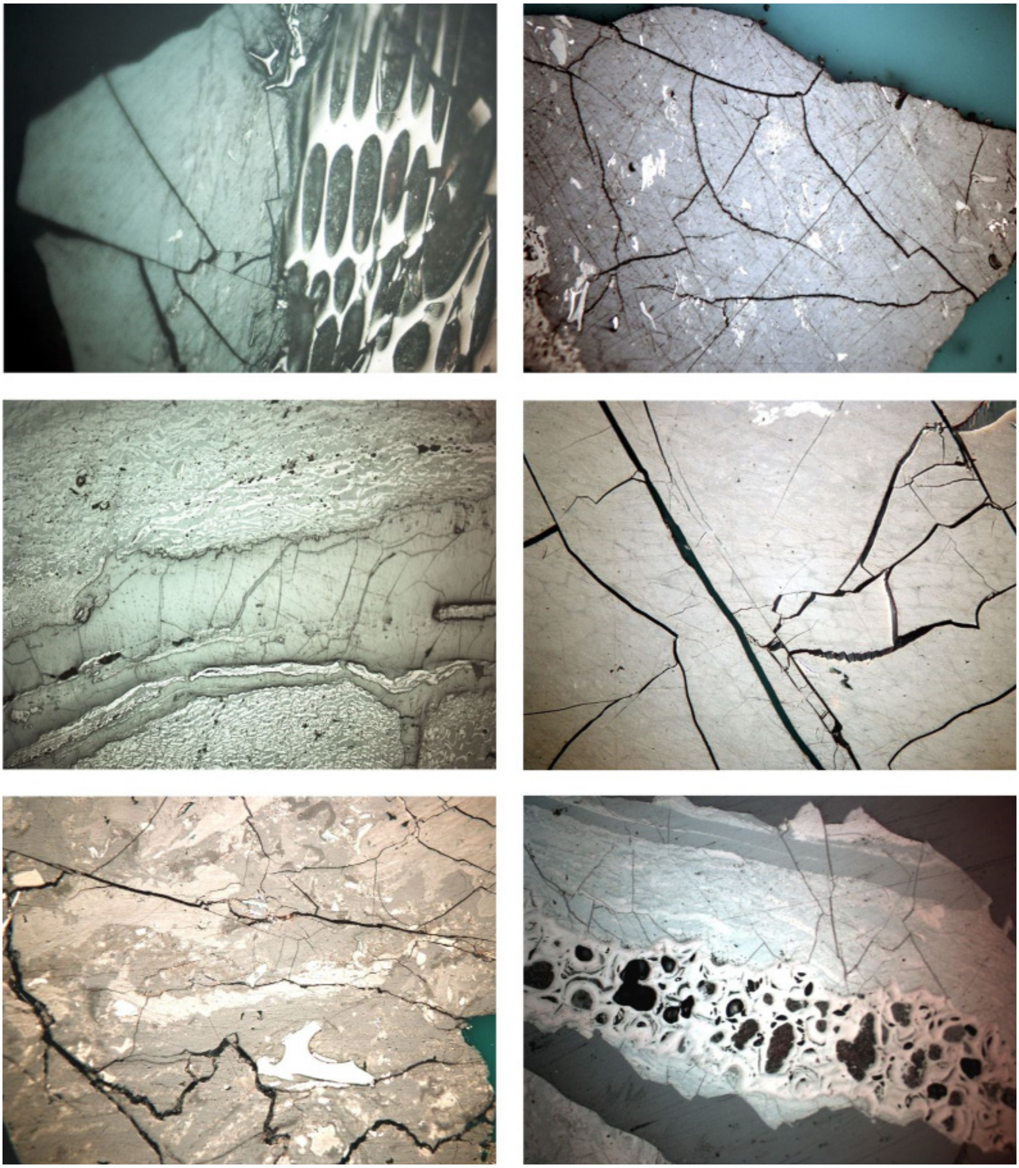

Fig. 2. Secondary, or exogenic fractures. The coal samples were collected from the Zofiówka colliery, seam no. 406/1, and the Pniówek colliery, seam no. 403/3. Magnification 500×; reflected light, immersion

very minor dislocations, of particular coal fragments in relation to each other. Examples of such pre-cataclastic structures are presented in Figure 3.

Meso-cataclasis. Another stage of structural changes of coal altered due to the impact of the forces connected with fault creation is the emergence of meso-cataclasis. The forces affect-

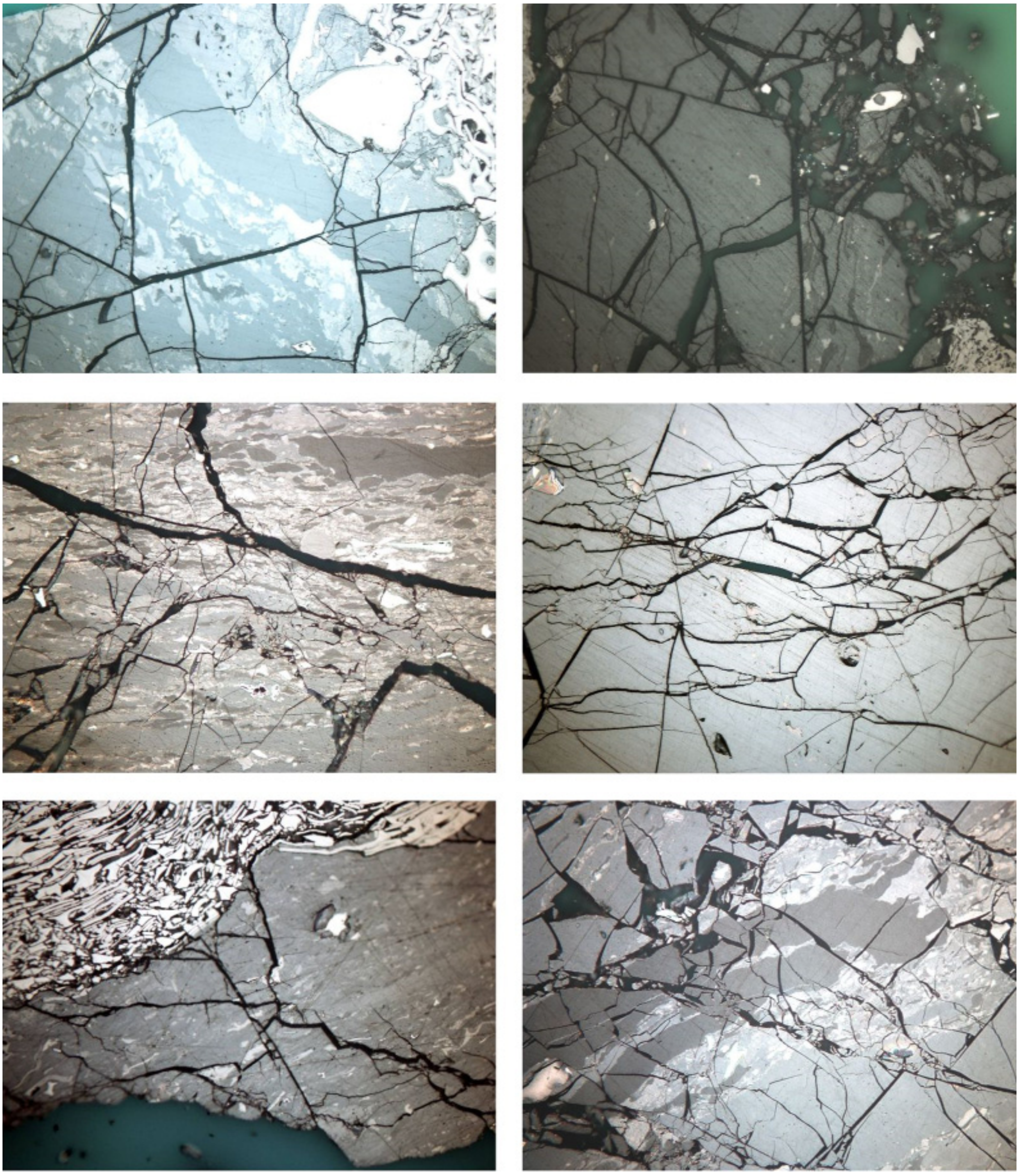

Fig. 3. Coal with cataclastic structures – pre-cataclasis. The coal samples were collected from the Zofiówka colliery, seam no. 406/1 and 412łg+łd, and the Pniówek colliery, seam no. 403/3. Magnification 500×, reflected light, immersion

ing a coal seam result in the creation of a dense network of fractures. Calculating these fractures is extremely difficult due to the fact that they overlap, which sometimes makes it impossible to analyze the observed image. Coal with meso-cataclastic structures usually reveals its primary structures (at least partially saved); also, it is generally possible to identify particular maceral groups. Meso-cataclasis additionally reveals minor dislocations of newly created pieces of crushed coal. Most often, the shape of such bits is irregular, and their edges sharp. Examples of meso-cataclastic structures are presented in Figure 4.

Porphyro-cataclasis. Near-fault coal may also reveal some structures whose characteristic feature is the presence of two generations of bits of coal. It is possible to discern large (50-200 mm)

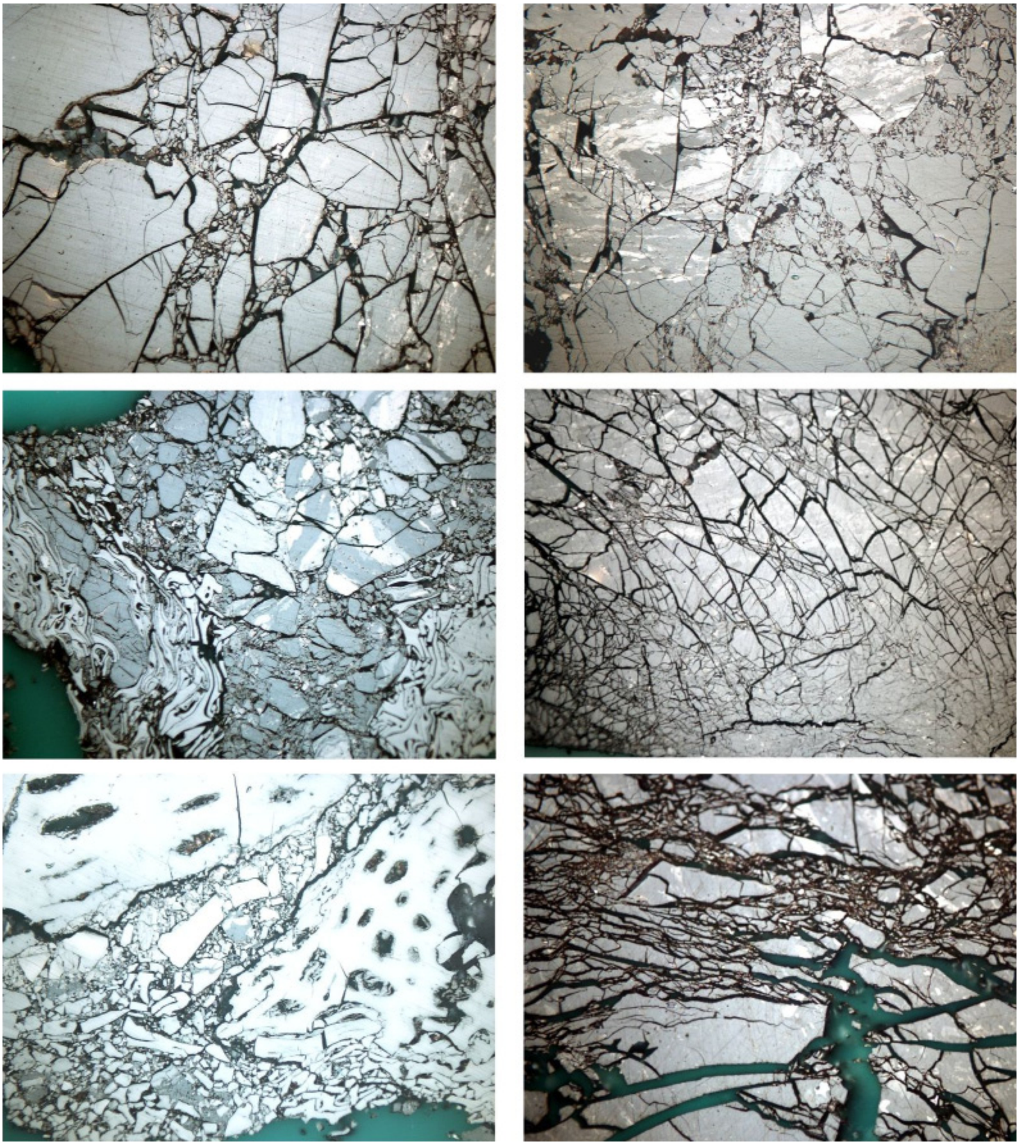

Fig. 4. Coal with cataclastic structures – meso-cataclasis. The coal samples were collected from the Zofiówka colliery, seam no. 406/1, the Pniówek colliery, seam no. 403/3, and the Brzeszcze colliery, seam no. 352 "Zachód". Magnification 500×, reflected light, immersion

pieces which can be fractured (porphyroclasts). They are surrounded by fine, highly comminuted cataclastic material, whose components are dislocated in relation to each other. The primary coal structures can be seen only in larger bits, and in fine fragments of highly comminuted coal they are completely invisible, blurred. The size of the latter fragments usually does not exceed 50 mm (most often, it falls within the range of 10-20 mm). Examples of such structures are presented in Figure 5.

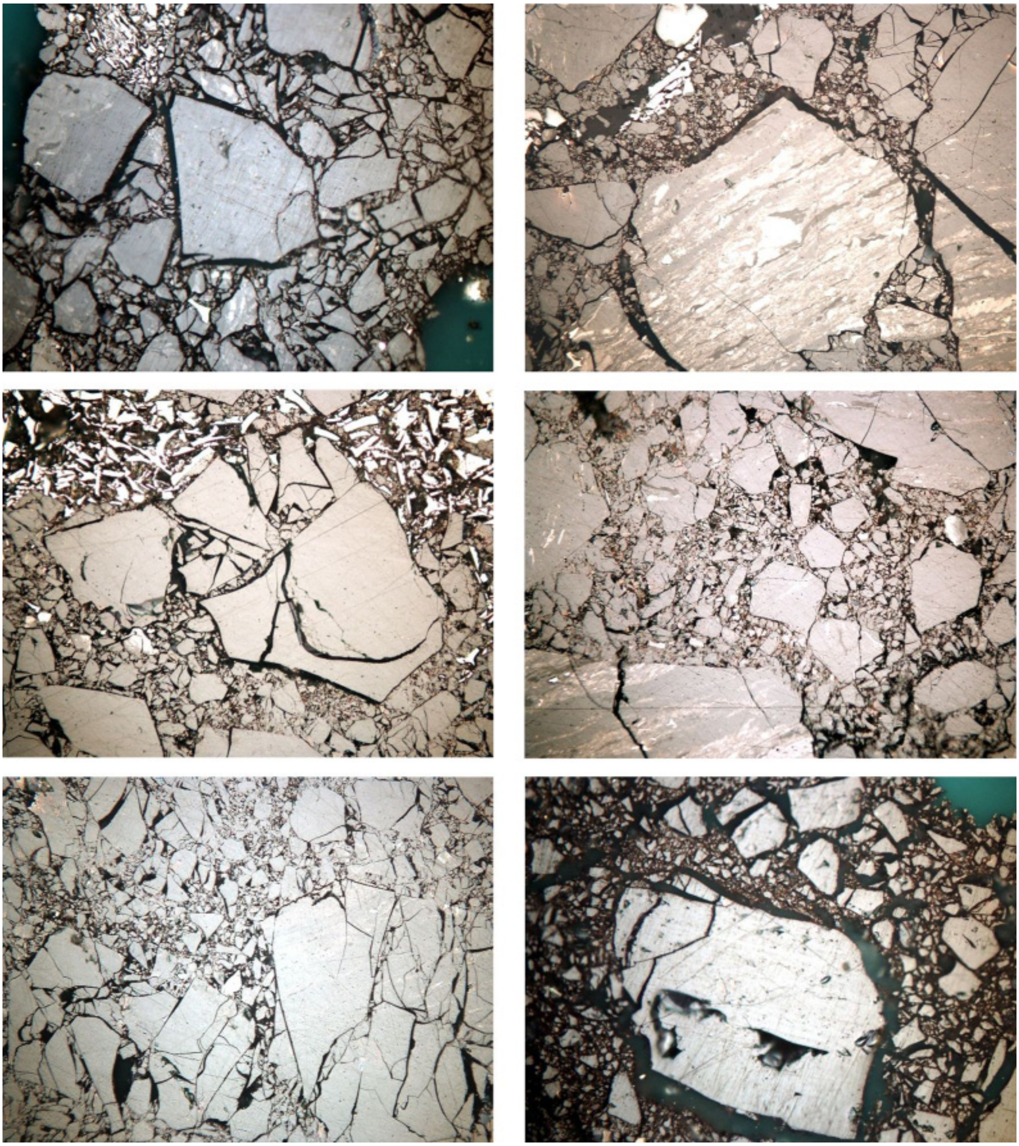

Fig. 5. Coal with cataclastic structures – porphyro-cataclasis. The near-fault coal samples were collected from the Zofiówka colliery, seam no. 406/1, the Pniówek colliery, seam no. 403/3, and the Brzeszcze colliery, seam no. 352 "Zachód". Magnification 500X, reflected light, immersion

Cataclasis proper. The final stage of cataclastic transformations is cataclasis proper. This type of coal deformation is characterized by the total destruction of its original structure. Cataclasis proper reveals a very dense network of fractures, in which single pieces are dislocated in relation to the original structure and each other. Due to the high extent of material comminution, it is generally not possible to fully identify particular maceral groups. Highly comminuted coal

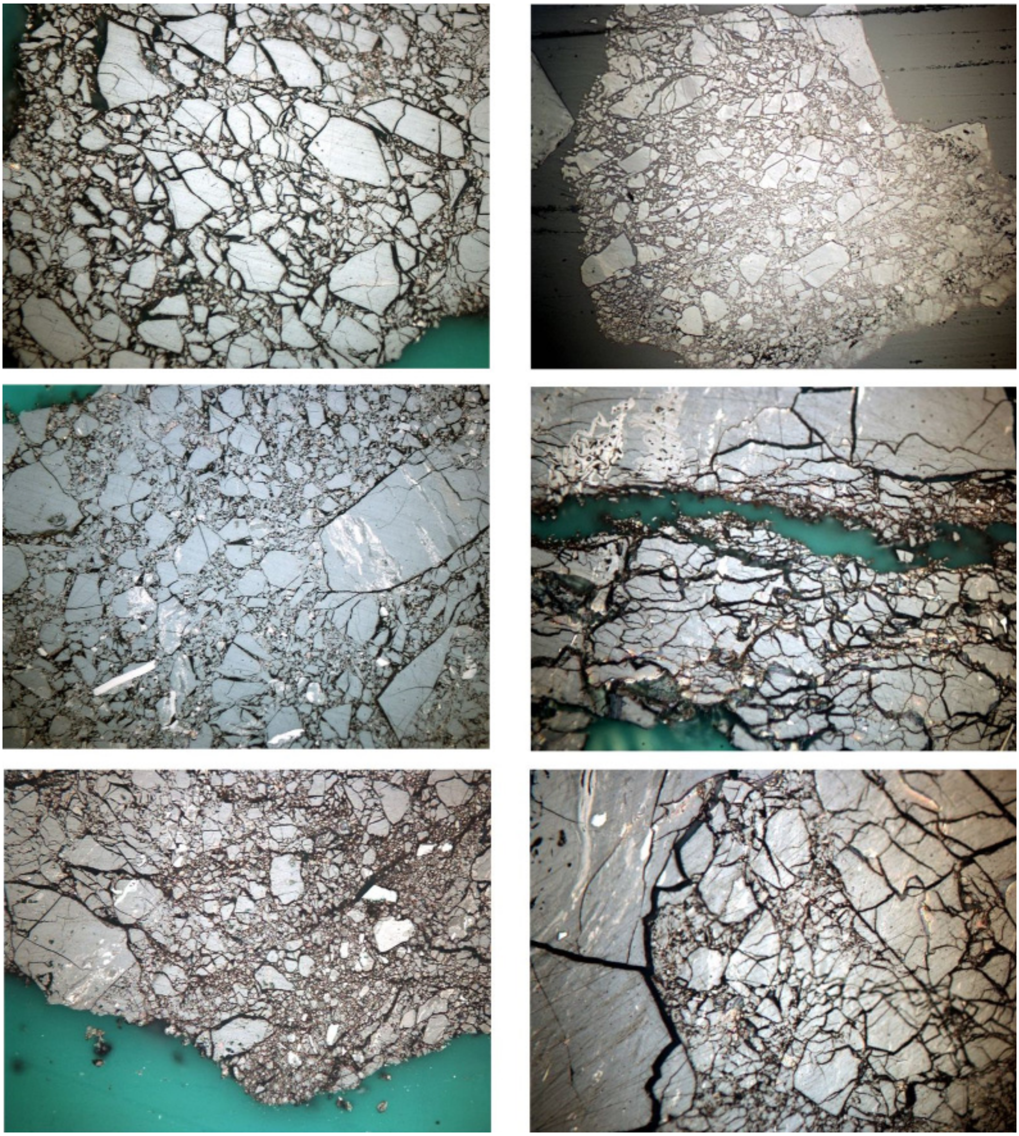

Fig. 6. Coal with cataclastic structures – cataclasis proper. The coal samples were collected from the Zofiówka colliery, seam no. 406/1, and the Pniówek colliery, seam no. 403/3. Magnification 500×, reflected light, immersion

pieces lose their sharp edges; instead, they are considerably rounded. Examples of such structures are presented in Figure 6.

Cataclasis proper marks the end of the process of structural destructions based on the crushing of coal material.

4.4. Coal with mylonitic/mylonitized structure (mylonitic tectonic microbreccia)

In the fault zones, the processes of coal crushing may, in certain places, reach their maximum. In such a situation, the total grinding of coal pieces and the directing of the coal pulp occur. Within the creations with totally blurred original structure and within newly created directional structures, coals with mylonitic structure may be formed. The formation of mylonitic structures depends on the value of stress and, to a lesser extent, on temperature.

The analysis of the samples collected from Upper Silesian hard coal seams revealed that the share of fractured and cataclastic coal was greater than the share of mylonite. Nonetheless, mylonite is also present in the investigated samples, and its properties differ from the properties of coal with cataclastic structures. In mylonite – just like in cataclastic coal – one can observe distortions of various degree of advancement.

Pre-mylonite. During the initial stage of coal, pre-mylonite is formed. Properties of cataclasis – i.e. pieces of crushed and well-rounded coal, dislocated in relation to each other – can be seen. However, the material is strongly pressed and densely packed. Some borderlines between the pieces of coal become blurred, and a solid, almost uniform mass is created, in which one can sometimes observe (particularly when applying high microscope magnification) micro-folds, at times made more conspicuous by the presence of a mineral substance. Examples of pre-mylonite from the Upper Silesian Coal Basin are presented in Figure 7.

Mylonite proper. The occurrence of such type of structures is less frequent as regards the types of coal deformation resulting from the fault impact. Such coal shows the highest degree of transformations. The microscope image of mylonite proper reveals an almost uniform coal mass. It is virtually impossible to discern single bits and pieces of coal material. Instead, a new, uniform, often directional structure is formed. With mylonites, it is generally not possible to identify particular groups of macerals. One can only observe crushed bits of macerals of the inertinite group, which – due to their high reflexivity – contrast with the solid and uniform mass of the investigated coal sample. Additionally, such coal can reveal secondary fractures, which obscures its original structure even more. Such structures are the rarest ones as far as the Upper Silesian coal seams are concerned, and the most difficult to interprete. Sample photographs of mylonite proper are presented in Figure 8.

5. Summary

The author subjected to analysis over sixty samples of coal from the fault zones of the seams of the Upper Silesian Coal Basin. This material was formed in the zone of near-fault tectonic microbreccia formation.

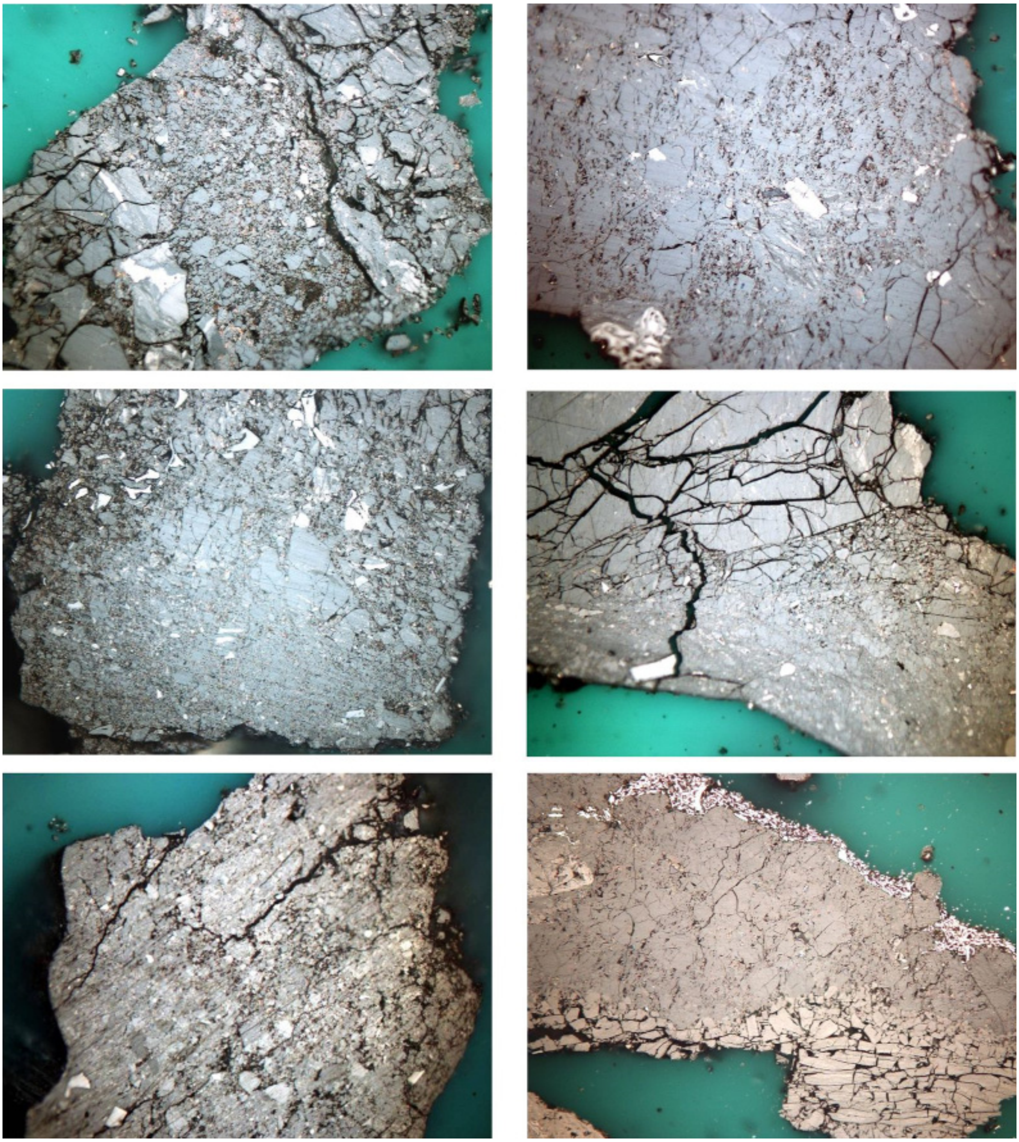

Fig. 7. Coal with mylonitic structures – pre-mylonite. The coal samples were collected from the Zofiówka colliery, seam no. 406/1, and the Pniówek colliery, seam no. 403/3. Magnification 500×, reflected light, immersion

The structure of the investigated coal revealed – to a greater or lesser extent – the effects of the impact of tectonic deformations, i.e. faults running across the seams. On the basis of the information found in relevant scientific sources, it was concluded that structurally altered, near-fault coal is defined in various ways, and sometimes described only routinely. The analysis of coal samples and juxtaposition of the obtained results with the data found in the literature on

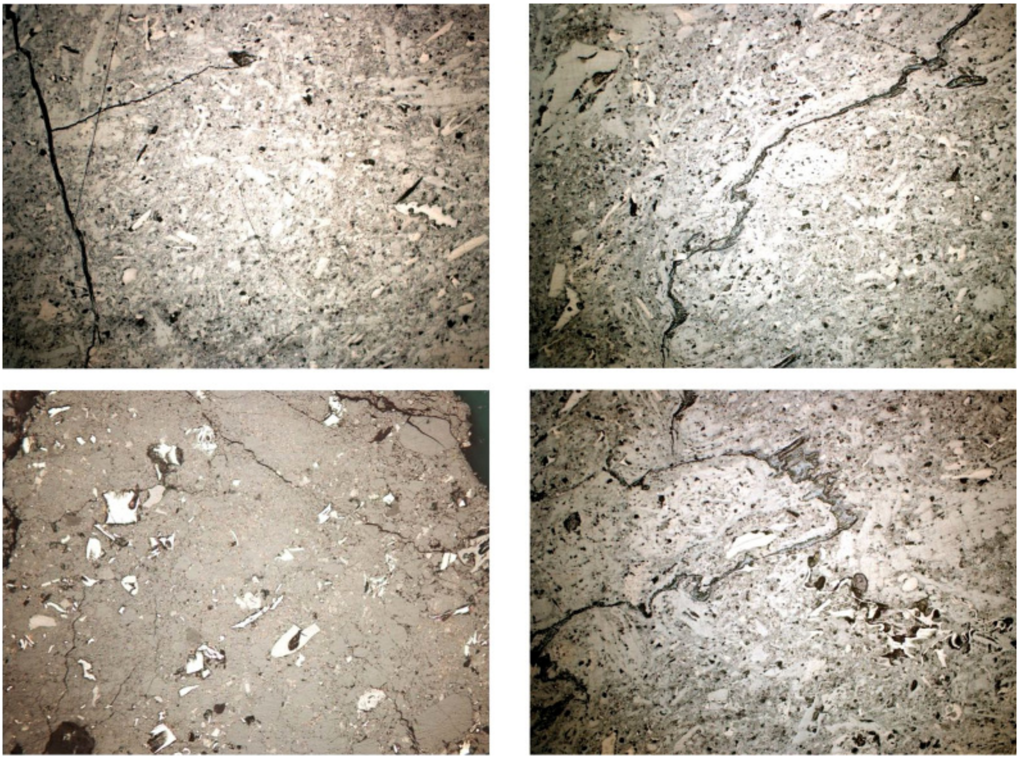

Fig. 8. Coal with mylonitic structures – mylonite proper. The coal samples were collected from the Zofiówka colliery, seam no. 406/1. Magnification 500×, reflected light, immersion

the subject resulted in a proposed systematization of the nomenclature regarding the hard coal from near-fault zones, in relation to selected Upper Silesian hard coal seams. On this basis, particular stages of the destruction of the near-fault coal structure were described, starting from fractured coal, through various stages of the formation of cataclastic structures, and ending with mylonite proper.

On the basis of sample analysis, the following coal types were identified:

- **structurally unaltered coal –** only the primary fractures, i.e. endo-microfractures, are visible;
- **structurally altered coal –** in these creations, the following stages of structural deformations occur:
  - **fractures (exo-microfractures**) – formed due to the impact of stress, resulting from tectonic dislocation,
  - **cataclastic structures –** created gradually, together with an increase in stress. As a result, the coal material undergoes the processes of gradual crushing. Depending on how advanced the processes are, first pre-cataclastic structures are formed, then meso-cataclases and porphyro-cataclases, until the coal structure becomes totally destroyed and cataclases proper appear,

– **mylonitic structures –**. It is a long process, in which the main factor is stress, but in which the coal material is also influenced by temperature. Depending on how advanced the processes are, first pre-mylonites are formed, and then mylonites proper.

On the basis of the obtained results, the following initial classification of coal altered structurally as a result of tectonic deformations is proposed by the author (cf. Table 2):

TABLE 2

The proposed classification of the structures of hard coal from the near-fault zones of selected Upper Silesian coal seams

Type of coal structure			Characteristic features
Structurally unaltered coal			Solid coal, lack of exogenic fractures, possible occurrence of endo-microfractures resulting from natural processes of coalification
Structurally altered coal – about the characteristic of tectonic microbreccia	**Fractured coal – exo-microfractures**		A network of irregular fractures of post-diagenetic origin
	Cataclastic structures	**Pre-cataclasis**	A dense network of irregular fractures, primary structures clearly visible
		Meso-cataclasis	A very dense network of irregular fractures, some pieces crushed and dislocated, primary structures partially blurred
		Porphyro-cataclasis	A high degree of fracturing, partial grinding of the coal material. Two populations are dominant (fine and large ones – pieces of 50-200mm). Primary structures visible only in large pieces (porphyroclasts)
		Cataclasis proper	Pieces of coal ground and dislocated in relation to each other. The primary structure totally blurred
	Mylonitic structures	**Pre-mylonite**	The transition stage between cataclasis and mylonite. (the properties of cataclasis proper and mylonite proper)
		Mylonite proper	Almost total absence of single coal pieces, formation of new, transformed structure, often with directional structure, microfolds, and secondary fractures

The present paper consitutes a prelude to further research, broader in scope. It is planned that the greatest possible number of near-fault hard coal samples, collected from various geological formations and uneven-aged seams of the Upper Silesian Coal Basin, will be analyzed. The results of the planned research should complement and perfect the proposed classification of hard coal structures from near-fault zones of the Upper Silesian Coal Basin.

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