Occurrence of Faults in the Western Donbass at Mining Works

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Abstract

The article discusses the features of the formation, distribution and manifestations of fault structures in the Western Donbass for planning mining operations in disturbed areas.

As a result of the study and manifestation features of faults it was established that violations in Western Donbass mines are occurred in limited quantities by compressing tectonic stress of north-east direction with a shift of the wings and lifting pre-exploding zones in the vertical plane with the formation of sliding surfaces. Confirmation of faults formation nature is shown by the example while intersection of Fault Bogdanovskiy with vertical amplitude of 320 m by the mining operations of "Samarskaya" mine at Company "DTEK "Pavlogradygol".

According to the study of the propagation of faults, it was found that tectonic faults are not reservoirs for overflow water from the overlying aquifer, the major complicating factors are the collapse of the roof rocks and vertical convergence.

Keywords: violation, fault plane, nature of tectonic disturbances, propagation of faults

Introduction

Mines of DTEK "Pavlogradugol" company (Western-Donbass coal basin) are located in the central block of 30–40 km wide and elongated in a north-west direction for 90 km. This block represents the stage structure of three blocks: Medium, Pavlogradskiy graben and Samarskiy horst. Fault planes of this tectonic fissures fall in opposite directions at an angle of 55–70° (Alymov et al, 1963). It considered that these faults were formed during sedimentation (Bulakhovskiy, Central, Bogdanovskiy), and Pavlogradsko-Viazovskoi and Petopavlovkiy faults were formed during the inversion of vertical movements (Nagornyj Ju. and Nagornyj V., 1973).

Tectonic disturbances are divided into five groups (Alymov and Danilevskaja, 1963):

I – The largest faults of region with vertical amplitude of up to 2000 m;

II – Faults inside blocks with vertical displacement of 80–250 m;

III – Faults inside blocks with a vertical amplitude of up to 70–200 m;

IV – off shooting faults which are characterized by displacement amplitude of 20–30 m and have negligible depth.

V – micro-faults with an amplitude of up to 2–3 m and affect one or more seams.

The main feature of geological tectonics of the Western Donbass industrial region is the prevalence of tectonic fractures in the form of faults. Small-amplitude violations of IV and V groups are usually found within strata of small thickness and have a minor extent. Thus, it is observed that small-amplitude folded and disjunctive dislocations are the result of a single process, but it is impossible to set it on the geological data (Zabigajlo et al, 1994).

The manifestation of faults of IV and V groups in the Western Donbass was considered to establish the nature of its formation. The research of these manifestations is based on the principles of fixing major morphological signs of violations that need to be related to the nature of formation and of course do not depend on the production human activity. It is important to study the nature of faults formation in the region and features of their manifestation to predict mining operations in disturbed zones.

Materials and methods

The direction and value of faults wings movement can be determined by slide mirrors, which is the fault plane (Ushakov, 1979). Considering that, in accordance with the theory of Mohr, failure occurs under the action of shear stresses, sliding track can be some of the geometric parameters of the formation of normal stresses principal axes (Garber et al, 1979). In the condition of weak rock in the walls of mine workings, such as siltstones and mudstones in the Western Donbass, these displacement tracks in the form of lines and furrows are not fixed by the Geological Survey of mines because of their inability to establish them visually. This complicates the solution of the problem.

The presence of several differently oriented systems of faults creates uncertainty of their determination. The intersection of one fault by another should indicate a younger age of first one. On the geological maps of the Western Donbass multidirectional fissures are shown as contiguity (jamming) of smaller discontinuity to the

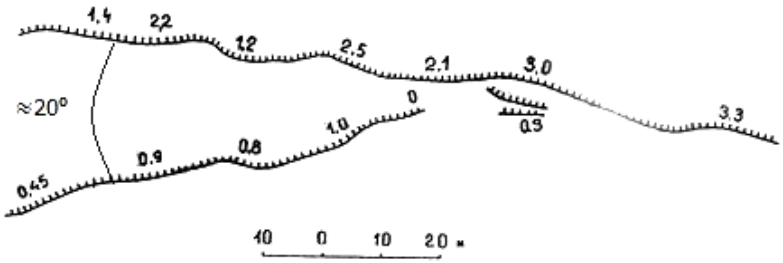

Fig. 1 "Jamming" of faults in the lava, mine "Dneprovskaya"

Rys. 1 Uskoki w lawie, kopalnia Dneprovskaya

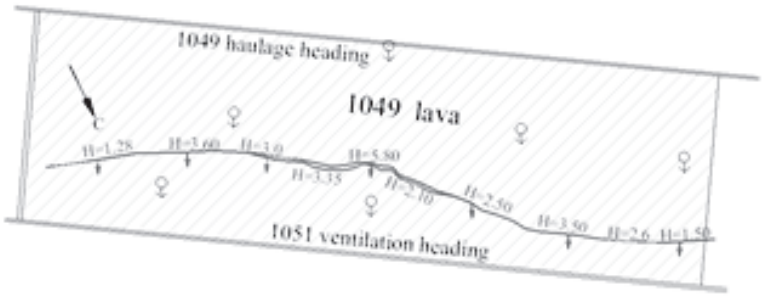

Fig. 2 Extract of mine plan, the mine "Dneprovskaya", Company “DTEK “Pavlogradygol”

Rys. 2 Plan wydobycia w kopalni Dneprovskaya, firma DTEK Pavlogradygol

larger one. Smaller discontinuities are called "apophyse" (Paffengol'c, 1973). It was found that in the place of jamming of one violation to another the amplitude of smaller one is zero at transition of faults by the mechanized complexes in Western Donbass (Fig. 1) (Kolokolov O.V., Khalymendyk, 1995). Disturbed areas represent the combination of individual fault planes located sub parallel to each other or elongated in chain.

There were cases when contouring of the excavation field did not give information about the presence of faults (Fig. 2). These facts confirm elements of the phase formation of faults by the theory of M.V.Gzovsky in closed volumes (Gzovskij, 1975).

On rose-diagrams analysis of shear zones of faults in "Pavlogradskaya" mine established that chips are oriented at an angle of 15–20° to the zone of the main displacement and authors carried them to the Riedel chipping (D'jachenko N.A., Privalov, 2006).

In the transition of tectonic violations by the mechanized complexes staggering of faults are found (Fig. 3) (Kolokolov O.V., Khalymendyk, 1995), which generally corresponds to the shape of the stepped arrangement of faults in horizontal shifts with a simple chips (Reuther, 2012).

While in service of the field it was recorded 28 cases of disturbed crossing zones mine workings of the main directions of the vertical amplitude from 4 m to 109 m. Forecasting these manifestations of faults required to systematize the results of mining operations at the intersection of disturbed zones in the conditions of the Western Donbass. Manifestation of factors has been established in analysis of the cases of intersection of large amplitude discharges in the Western Donbass. They include:

– geomechanical, as roof rocks collapse and increased convergence;

– water seepage from the fault plane of tectonic disturbances;

– gas emission.

According to descriptions of faults venues all disturbed areas have broken breed with a lot of "sliding mirrors". The width of the disturbed zone is characterized by a plurality of fault planes, and it reaches a width of up to 25 m.

In the conditions of modern production and intensification of mining operations there is a need to increase the mine fields of several mines. In order to extending the service life of the enterprise, namely mine "Samarskaia" of Mine Management "Ternovskoe" at "DTEK" Pavlogradugol" Company, it was decided to construct the opening crosscuts at C_{10} coal seam through the zone of discontinuous tectonic disturbances. These violations are the Alefirovsky discharge of the vertical amplitude of up to 15 m and Bogdanovsky discharge

Fig. 3 Staggered faults

Rys. 3 Ciągnące się uskoki

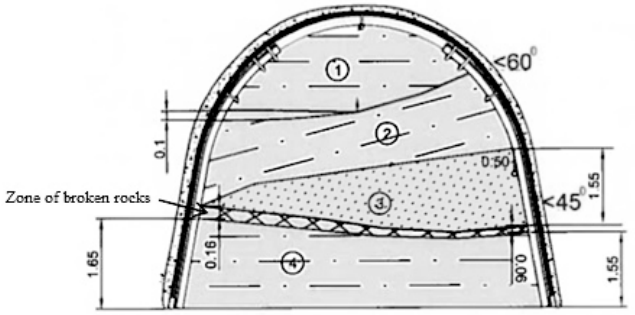

Fig. 4 Sketching of haulage crosscut face on the seam C10.
(1 - siltstone horizontally layered with thin interbedded of fine sandstone; 2 - siltstone gray with oblique unidirectional interbedding of sand and clay materials; 3 - Sandstone light gray, fine-grained, moist, contact is clear, strong; 4 - siltstone gray with fine interbedding of sand and clay material).

Rys. 4 Schemat czoła drogi przewozowej w pokładzie C10:
(1 – skały iłowe ułożone poziomo wraz z drobnymi wpryśnięciami piaskowca; 2 - szary iłowiec z wielokierunkowo uformowanym materiałem piasku i gliny; 3 – jasnoszary iłowiec, drobno uziarniony, o dużej wilgotności, linia kontaktu jest wyraźna, silna; 4 – szary iłowiec z drobno wpryśniętymi piaskami i glinami).

with maximum vertical amplitude is 340 m. It was necessary to take into account the nature of foundation and features of the spread of tectonic disturbances in the region to cross this zone.

Geological studies in the zone of influence of Bogdanovskiy discharge have been carried out in 1977. As a result of the analysis and systematization of the materials it was determined that in the territory of Western Donbass there were recorded 346 points of intersection zones of tectonic disturbances by wells. Bogdanovskiy fault has been opened by 51 times, and it was 356 cases of opening zones of tectonic disturbances by mine workings of coal mines (Instructions, 1986).

Fault “Bogdanovskiy” was crossed for the first time by mine workings. Within the field of mine "Samarskaya" the Fault “Bogdanovskiy” was opened by wells 9 at a depth of 127–430 m. The stretch of Bogdanovskiy fault is northwest, which coincides with the strike of strata of Lower carboxylic rocks. The azimuth of fault plate stretch is 340°. The angle of fault plane incidence is 45–60°. The amplitude of the displacement is from 35 to 320 m. The width of the damaged zone near the violation reaches 85 m. On the field of mine "Zapadno-Donbasskaya" it was opened by 23 wells at a depth of 120–640 m and at length of 11 km. The stretch of Bogdanovskiy fault is northwest with small deviations, the inclination of fault plane is northeast at an angle of 40–55°. The amplitude of the vertical displacement of rocks on fault within the mine field varies from 185 to 340 m. The thickness of broken rock zone is up to 20 m.

According to (Instructions, 1986), during mining operations in disturbed areas, it is necessary to observe the measures to prevent the emergence of negative factors. Thus, for conducting the haulage crosscut on the seam C_{10} the following activities have been proposed:

– Drilling of leading wells to the prediction of water inflow in mine workings taking into account the hydrological and geological conditions of their construction;

– Tamping the out-support space and anchoring with polymer chemistries in order to strengthen marginal rock mass;

– The use of frame and anchoring support, installation of a number of steel-and-polymer anchors.

Two wells were drilled, one was inclined at an angle of 45° to the horizontal, and the second one was hori-

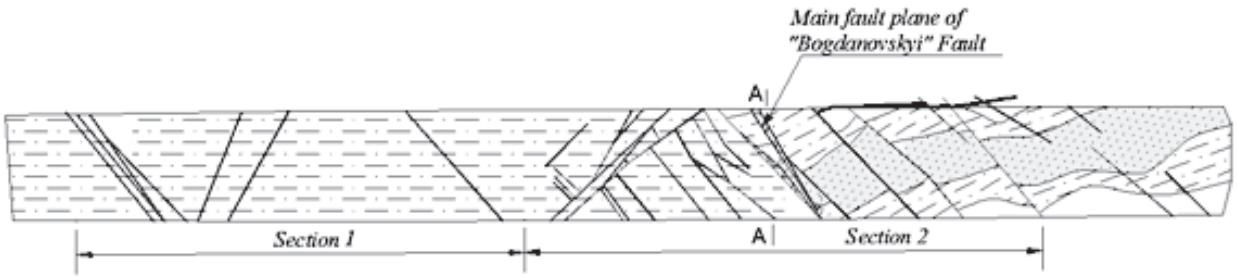

Fig. 5 Vertical section for haulage crosscut at the seam C_{10} of "Samarskaya" mine

Rys. 5 Przekrój pionowy czoła drogi przewozowej w pokładzie C10 kopalni Samarskaya

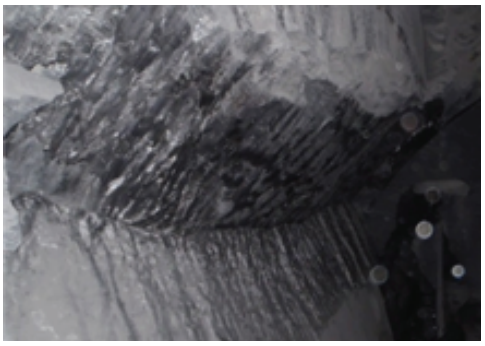

Fig. 6 "Glide Mirrors", sub perpendicular cracks

Rys. 6 „Lustra", poprzeczne pęknięcia

zontal. After re-drilling of sandstone by the down hole there was observed the water inflow of 0.3–0.4 m^3/h, which gradually decreased to 0.2 m^3/h and stabilized until the end of drilling. Water seepage in a horizontal well was not fixed.

It was revealed the presence of fault planes network with sliding mirrors As a result, the daily monitoring of the intersection zone of fault "Bogdanovskiy" by haulage crosscut. To main fault plane it can be attributed the fault plane with the presence of wet broken rocks which have rounded fragments between two planes. It variable thickness is up to 0.3 m (Fig. 4).

The intensity of occurrence of fault planes increases in lying wing as it approaches the main fault plane (Fig. 5).

Fault planes with perpendicular positioning to each other were met before the main fault plane (section 2, Fig. 5). Undulating vertical sliding furrows can be seen in some fault planes (Fig. 6).

To set the amplitude of each fault plane separately is impossible, because the mine working was constructed out in homogeneous rocks of lying wing of fault. Sub parallel fault planes were met in the hanging wing. The total width of the intensively broken zone in the horizontal plane was 25 m (Fig. 2).

Water seepage at the intersection of the broken zone was not recorded. The hanging wing there was wet sandstone. The most effect on the intensity of water seepage has the main roof rocks, which are represented by sandstones fed by the overlying aquifers.

In gently dipping seams in Western Donbass coal region is convenient to use graphical representation of propagation of fault plane crossing lines with the seam in the form of rose-diagrams. 8 seams were examined in nine mines. Total amount of examined crossing lines is 304, the maximum amplitude is 20 m. Distribution of crossing lines of fault planes with the seam is characterized by two dominant directions (Fig. 7) with an angle between them about 60°. One of the directions coincides with the direction of tectonic disturbances of the second group. All this confirms the generality of causes of their formation.

Taking the Anderson model of horizontal shift formation in pure chips (Reuther, 2006) it can be explained a lot of morphological manifestations of faults (Fig. 8). Under compressive tectonic forces Tn the chip is formed at an angle of 30° from the direction of the tectonic stress. Along the line I-I points 1 and 1 'will have to take a new position 2 and 2', that is, the array should be reduced in this direction with the formation of rupture. When shifting rocks along the line I-I parallel to the stress Tn, the array should be expanded. When shifting perpendicular to the stress Tn the array should shrink. As deformation of array occurs in closed

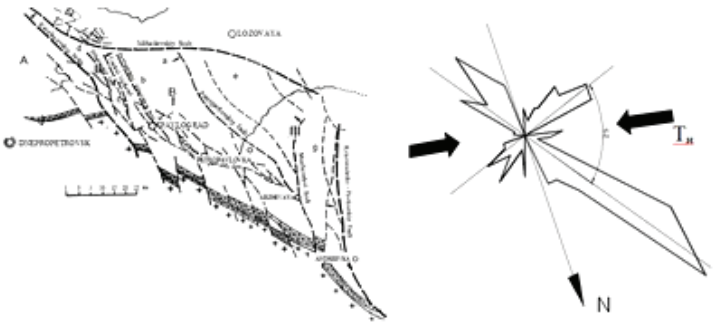

Fig.7 The scheme of distribution of discontinuous tectonic disturbances in the Western Donbass

Rys. 7 Schemat rozkładu nieciągłych zakłóceń tektonicznych w Zachodnim Donbasie

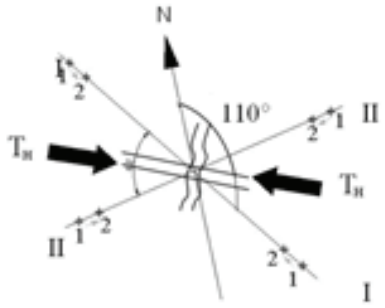

Fig. 8 Schematic of the formation of crossing lines of fault plane with the seam (≈ – compression of the rock mass; = – expansion of the rock mass)

Rys. 8 Schemat tworzenia się linii poprzecznych powierzchni uskoku w pokładzie (≈ – nacisk masy skalnej; = – ekspansja masy skalnej)

volume, points must be moved in horizontal and vertical directions. Taking into account the anisotropy of array and other geological factors such as heterogeneity the same displacements may occur along line II-II. The total angle between the lines I-I, II-II and Tn is approximately 60°, which corresponds to rose diagram (Fig. 7).

Results and discussion

A graphical representation of the spread of crossing lines of fault plane with the seam in the form of rose-diagram was used to reconstruct tectonic forces. Total, 8 layers in nine mines were reviewed. Distribution of crossing lines of fault planes with the seam characterized by two prevailing trends with the angle between about 60°. One direction coincides with the direction of tectonic disturbances propagation. These tectonic disturbances relate to the second group, which includes fault blocks with vertical amplitude up to 70–200 m. Common causes of formation of large and low amplitude faults in Western Donbass are confirmed by this fact.

As a result of the study and manifestation features of faults it was established that violations in Western Donbass mines are occurred in limited quantities by compressive tectonic stress of north-east direction with a shift of the wings and lifting pre-exploding zones in the vertical plane with the formation of sliding surfaces. Confirmation of faults formation nature is shown by the example while intersection of Fault Bogdanovskiy with vertical amplitude of 320 m by the mining operations of "Samarskaya" mine PAT “DTEK “Pavlogradygol”.

Conclusions

Tectonic faults in the Western Donbass coal basin were occurred in limited volumes of rock mass under the action of horizontal tectonic stresses. At the same time the long axes of most violations are oriented according to the model of formation of Anderson breaks. Based on the experience of crossing of disturbed areas with large amplitude by mine workings in the conditions of Western Donbas mines, it can be argued that the fault planes of disturbances are not reservoirs for water to flow from upper aquifer, such as “Buchakskiy” aquifer in the region. The main complicating factor during the crossing violations is the collapse of the roof rocks and vertical convergence.

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Występowanie uskoków w trakcie eksploatacji górniczej w Zachodnim Donbasie

W artykule przedstawiono chrakterystykę geologiczną, rozkład i występowanie struktur uskokowych w Zachodnim Donbasie służące do planowania operacji górniczych w zagrożonych kopalniach.

Wynikiem badania uskoków było ustalenie, że zakłócenia w kopalniach Zachodniego Donbasu występowały w ograniczonych ilościach, a spowodowane były napięciami tektonicznymi w kierunku północno-wschodnim oraz występowaniem stref przedwybuchowych w płaszczyźnie pionowej. Potwierdzenie przyczyn formowania się uskoków zostało pokazane na przykładzie przekroju uskoku Bogdanowskiego o pionowej amplitudzie 320 m, spowodowanego operacjami górniczymi kopalni Samarskaya należącej do firmy DTEK Pavlogradugol.

Na podstawie badań dotyczących prognozowania uskoków stwierdzono, że uskoki tektoniczne nie są zbiornikami dla wód, najbardziej skomplikowanymi czynnikami są skały opadające ze stropu oraz pionowa konwergencja.

Słowa klucze: zakłócenia tektoniczne, powierzchnia uskoku, natura zakłóceń tektonicznych, prognozowanie uskoków