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Estimation of mining impact on surface in relation to rock mass type

Introduction

An analysis of the impact of mining with caving on the surface shows that a type of rock mass strata seems to be one of the critical factors affecting the process. In addition, also a sequence of weak and strong strata deposition above a coal seam is of crucial importance in this respect. If, for instance, a strong layer is deposited below a weak one, then there is a risk of a sudden and unexpected roof failure in major areas of the opening, whereas in the opposite case, frequent failures of roof strata are likely to occur. The influence of a rock type and a sequence of deposition, as well a depth of exploitation, on a specificity of terrain surface behavior has already been confirmed by such researchers as Sałustowicz (1957), Labasse (1961) or Ryncarz (1992).

Despite this, there are still not enough instances of systematic experimental studies attempting at a deeper exploration and explanation of the subject matter. One of the reason this situations is the complexity of the phenomena taking place in rock mass disturbed by mining.

In most theoretical considerations, homogeneous and isotropic rock mass is usually assumed (Knothe 1984; Białek et al. 2001). In natural conditions, rocks with coal deposits consist of strata complexes possessing particular physical and mechanical properties (Gharabraie et al. 2017; Hu et al. 2015; Majcherczyk et al. 2013; Suchowerska et al. 2016).

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Correlating the values of mining-induced surface deformation with the rock mass structure and the state of its disturbance is of crucial importance. Therefore, if other mining conditions are left unaffected, then those factors exert the key influence on a course and distribution of subsidence and rock mass deformation (Sasaoka 2015). A behavior a roof strata of the seams depends mainly on their lithology, divisibility and variability in their vertical profile, as well as on the state of rock mass disturbance (Mielimąka 2009).

A proper description of rock mass type and properties also seems rational for a proper determination of prediction parameters, especially in the case of a multi-seam coal mining, and/or the exploitation carried out at considerable depths.

A general outcome of the study discussed in this paper is the development of the methodology and model practices for determining the rock mass type and, as a result, for selecting the optimal values of parameters for predicting the values of surface subsidence in relation to particular geological and mining conditions.

1. General description of research sites

In order to determine the relations expressing the influence of rock mass type on the values of subsidence induced by the mining with caving, a broad analysis of coal-mine research was carried out (Kryzia 2017).

The paper presents three selected cases, in which the analyzed rock mass consisted of weak and fractured strata, as well as of the strata with strong and compact rocks. In the analyzed areas, mining exploitation was executed at varied depths and the overburden of loose rocks was also varied (Fig. 1).

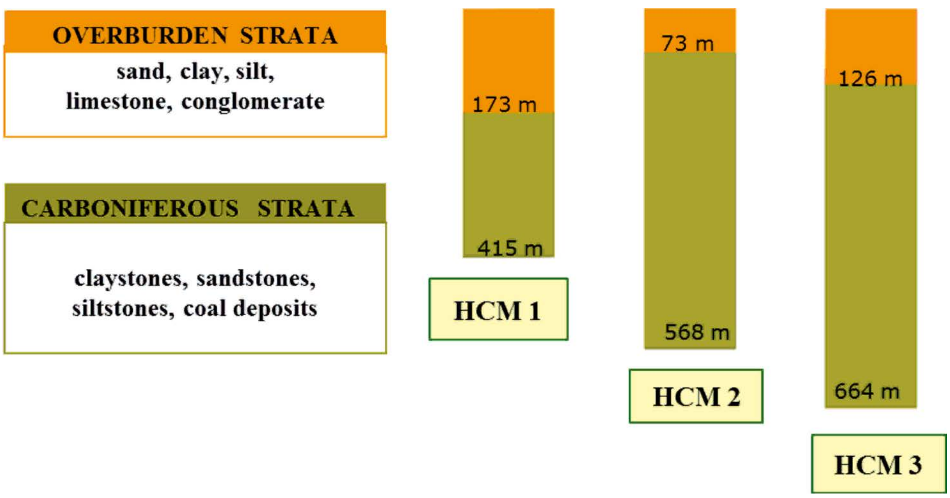

Fig. 1. Structure of overburden and Carboniferous strata in the research area

Rys. 1. Struktura warstw nadkładu i karbonu w rejonach badań

1.1. The case of Hard Coal Mine 1 (HCM 1)

The rock mass in the mining area of HCM 1 is characteristic due to the occurrence of strata with large thickness in all the stratigraphic layers. In the Tertiary strata there are thick layers of clay (22.60 m and 128.20 m). The thickness of the overburden constitutes more than 42% of the total thickness. In the Carboniferous strata there are thick layers of sandstone with the thickness of min. 17.20 m and max. 57.40 m (average 26 m), however the thickness of those layers constitutes 85% (205.80 m) of the total thickness of the Carboniferous strata (241.50 m). Hence, in the area of HCM 1 there is a strong (block) Carboniferous zone, in which only the analyzed seam was exploited and there is no disturbance caused by earlier mining. In the Tertiary layers there are clays, whereas in the Carboniferous strata there are thick strips of sandstones, which is schematically presented in Figure 2.

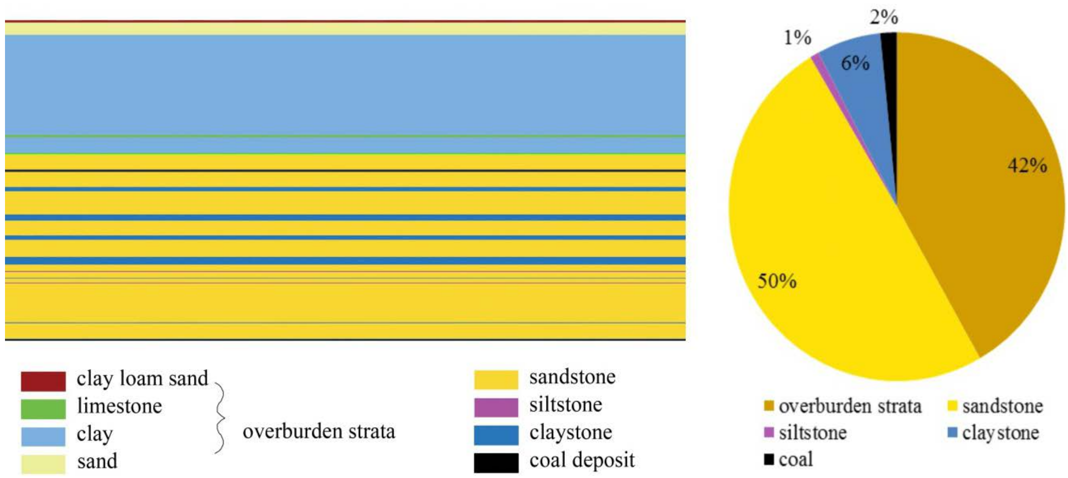

Fig. 2. Simplified structure of rock mass in the area of HCM 1

Rys. 2. Uproszczona budowa górotworu w rejonie KWK 1

In the analyzed area, the mining was executed in the seam 207 (Fig. 3) at the depth of 420–490 m below the surface. The liquidation of a post-mining void was a result of roof caving. In the period of measurements, the mining exploitation was executed in 7 longwalls.

The vertical dislocation obtained from the geodesic measurements in the points of the measurement line in the analyzed area is presented in Fig. 4.

In the total period of the four-year observation study, the maximal surface subsidence reached the value of approx. 2.0–2.10 m. The subsidence was significantly affected by the

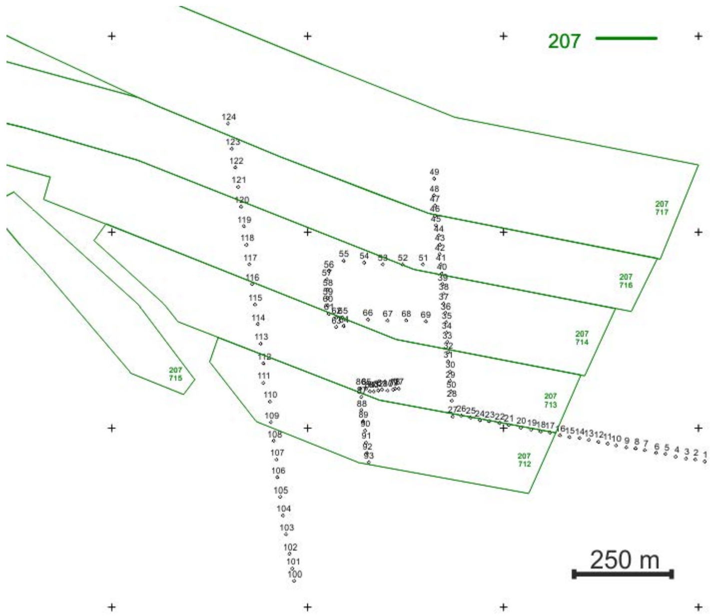

Fig. 3. The exploitation site in the analyzed area of HCM 1 in the period Jan.1987–Sept.1997, ith the positioning of the observation line

Rys. 3. Lokalizacja eksploatacji w analizowanym rejonie KWK 1 w okresie 01.1987–09.1997 z umiejscowieniem linii obserwacyjnej

longwalls 712 and 713 in the seam 207, which were exploited directly below the measurement lines.

1.2. The case of Hard Coal Mine 2 (HCM 2)

In the analyzed area of HCM 2 the Quaternary overburden is characteristic due to the occurrence of sands with the thickness of 70 m with a thin inclusion of clay. In the "orzeskie" layers, claystones and silty claystones constitute 68% of the total rock mass thickness. The layers have the thickness ranging from several to more than a dozen meters (average 9.4 m). The siltstone occurs only in three layers. In the area of HCM 2 there are more than a dozen layers of fine-grained sandstone with the thickness of several meters, which constitute 15% share for the depth of exploitation at 568 m. Due to the character of strata occurring in the rock mass, weak layers can be distinguished both in the overburden and the Carboniferous zone, which is presented in a simplified manner in Figure 5.

In the analyzed area of HCM 2, the exploitation was executed in two seams (No. 338/2 and No. 341) at the depths ranging between 540–570 m. The largest intensiveness of exploitation can be observed in the seam 338/2. The average thickness of exploited coal seam

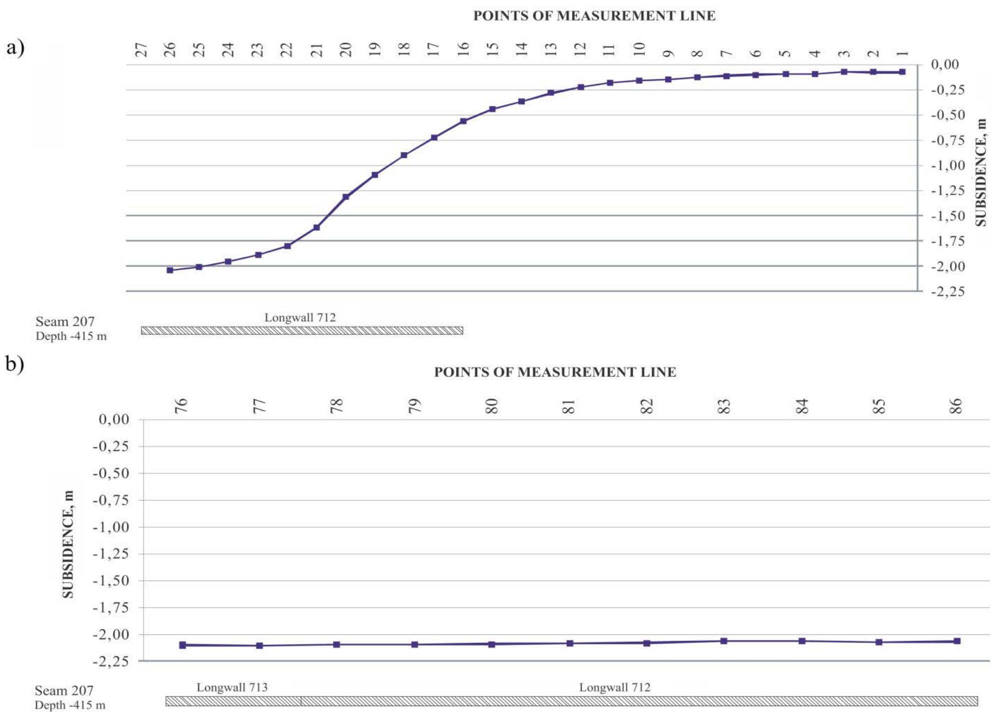

Fig. 4. The subsidence profile observed in the period March 1992–June 1996 in the area of HCM 1, along with the positioning of exploitation directly below the lines points 1–27; b) points 76–86

Rys. 4. Obniżenia punktów na liniach pomiarowych w obszarze KWK 1 w okresie 03.1992–06.1996 wraz z umiejscowieniem eksploatacji bezpośrednio pod liniami a) punkty 1–27, b) punkty 76–86

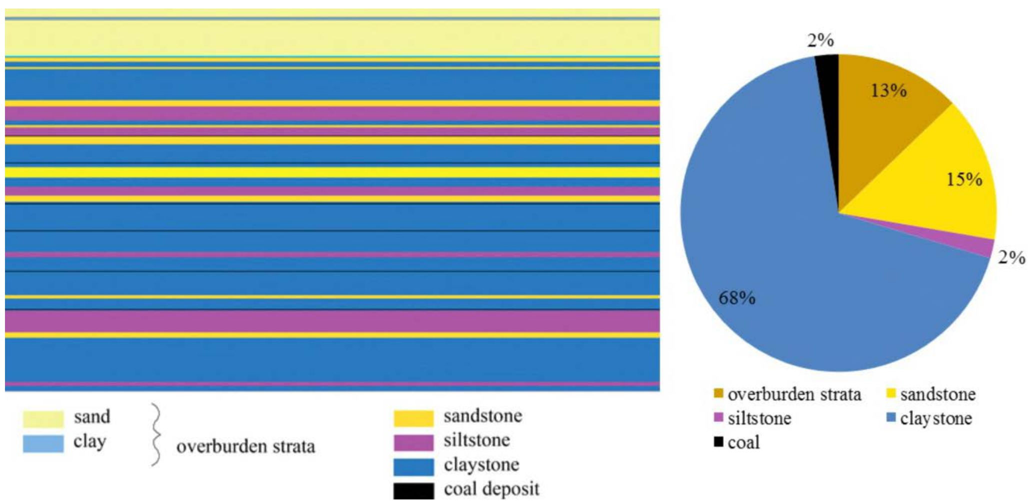

Fig. 5. Simplified rock mass structure in the area of HCM 2

Rys. 5. Uproszczona budowa górotworu w rejonie KWK 2 usually was approx. 2.0 m. Figure 6 presents the distribution and shape of particular longwalls with the positioning of the measurement line.

In the area of mining exploitation, a measurement line running in the direction North-South, perpendicular to the line of the mining face, was installed. In this line, the measurements of surface subsidence were carried out every half a year. The measurements provided key data for an analysis of subsidence in the period from April 1994 to March 2007. During the period of thirteen years of the measurements, the maximum surface subsidence reached the value of 3.41 m in the point No. 130 of the measurement line. The longwalls exploited directly below the measurement line, i.e. Nos. 001, 002, 005, 007, 009 in the seam 338/2, and the longwalls Dz-1–Dz-3 in the seam 34, exerted a significant influence on the observed subsidence (Fig. 7).

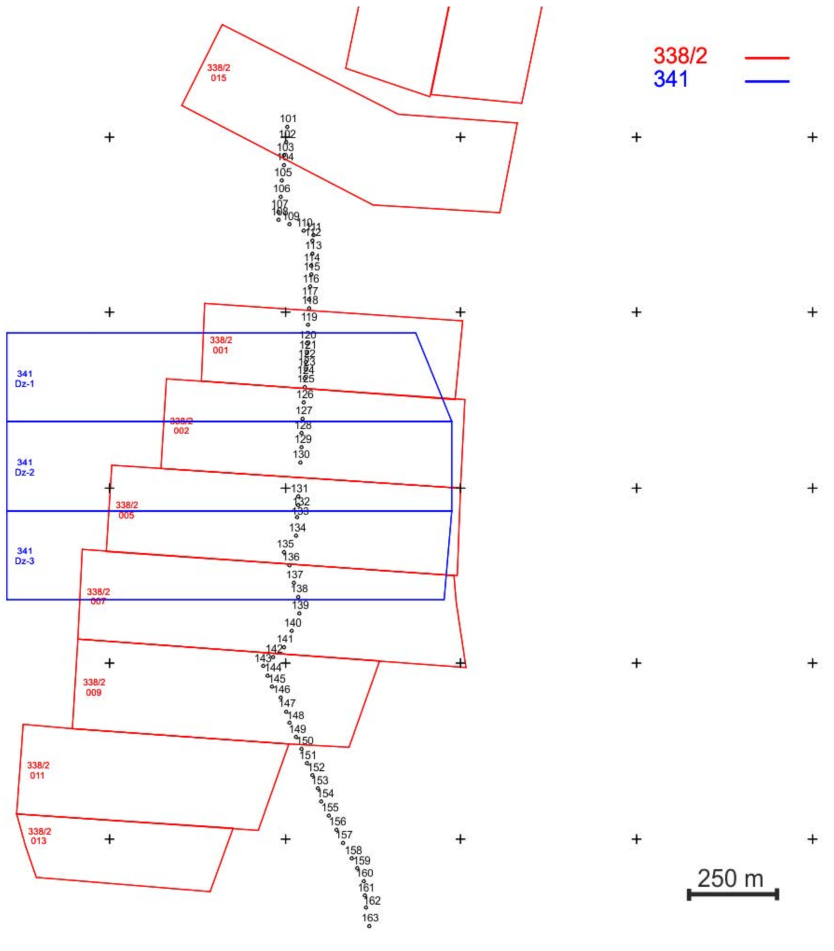

Fig. 6. The exploitation site in the analyzed area of HCM 2 in the period March 1994–March 2007, with the positioning of the observation line

Rys. 6. Lokalizacja eksploatacji w analizowanym rejonie KWK 2 w okresie 03.1994–03.2007 z umiejscowieniem linii obserwacyjnej

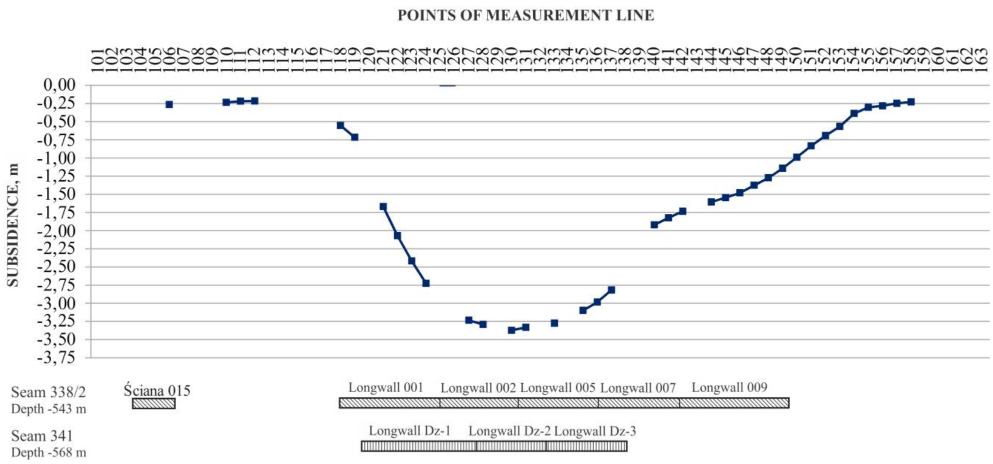

Fig. 7. The subsidence profile observed in the period April 1994–March 2007 in the area of HCM 2, with the positioning of the exploitation directly below the line

Rys. 7. Obniżenia punktów na linii pomiarowej w obszarze KWK 2 w okresie 04.1994–03.2007 wraz z umiejscowieniem eksploatacji bezpośrednio pod linią

1.3. The case of Hard Coal Mine 3 (HCM 3)

The overburden in the analyzed area of HCM 3 is characteristic due to the occurrence of thick layers of clay (39.30 m and 55.10 m) and sand (29.50 m). Its total thickness is approx. 126 m (19% of the total rock mass thickness). Below those layers there is almost a 330-meter packet of thin strata of fine-grained sandstones, silty claystones and coal ("rudzkie" layers). In this packet, also several layers of sandstone with large thicknesses (7.80–47.00 m) can be distinguished, with the total thickness of 173.35 m. In this section, a disturbance of the rock mass with a multi-seam mining can be observed. In the "siodłowe" layers, the thick strata of sandstone (10.90–41.40 m) occur among the thin strata of claystones, conglomerates and coal deposits. Due to a multi-seam mining, a phenomenon of old goaf activation is likely to occur in the rock mass. Following the analysis of the rock mass strata in HCM 3, it may be argued that in this case there are strong strata in the Carboniferous zone and weak strata in the overburden zone. A schematic model of the rock mass in the area of HCM 3 is presented in Figure 8.

In the analyzed period of time, i.e. from February 1987 to September 2005, the mining exploitation was executed in 21 longwalls located in seven seams. The distribution and the shape of particular longwalls, alongside with the positioning of the observation line, is presented in Figure 9.

The highest exploitation intensiveness took place in the late 1980s, when as much as nine longwalls were mined out, with the thickness ranging between 1.4 and 3.3 m (average

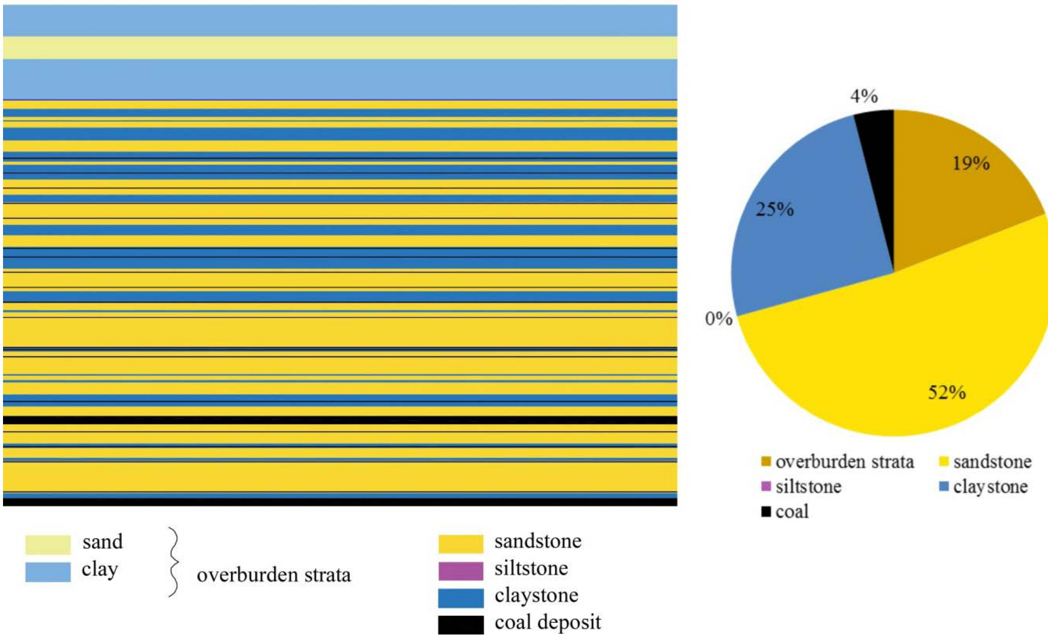

Fig. 8. Simplified rock mass structure in the area of HCM 3

Rys. 8. Uproszczona budowa górotworu w rejonie KWK 3

1.85 m), at the depth ranging from 383 m to 492 m, in the seams 501/1-2 and 502/1. In the last decade of the 20th century, 11 further longwalls were exploited in the seams 503/1-2, 504/2, 505/1wd and 510/1. The longwalls were located at the depths between 521 m and 683 m and their thickness ranged from 1.3 m to 3.6 m. In the period between the early 1999 to mid 2004 no mining was executed in the area. Later, only the longwall No. 25 with the thickness of 3.4 m was exploited in the seam 510/2wd at the depth of 670 m.

In the measurement line running in the direction North-South, the surface subsidence was measured in time intervals depending upon the intensiveness of the deformation process. The measurements allowed for an in-depth analysis of the subsidence from February 1987 to September 2005. During the eighteen years of monitoring, the surface subsidence in the area of the measurement line reached the value of 3.15 m in the point No. 22. The subsidence was significantly affected by the longwalls mined out directly below the measurement line, i.e. the longwall No. 39 in the seam 501/1-2, the longwalls Nos. 43 and 44 in the seam 502/1, and the longwalls Nos. 10 and 14 in the seam 505/1wd. A juxtaposition of the measured subsidence and the mining executed directly below the measurement line is presented in Figure 10.

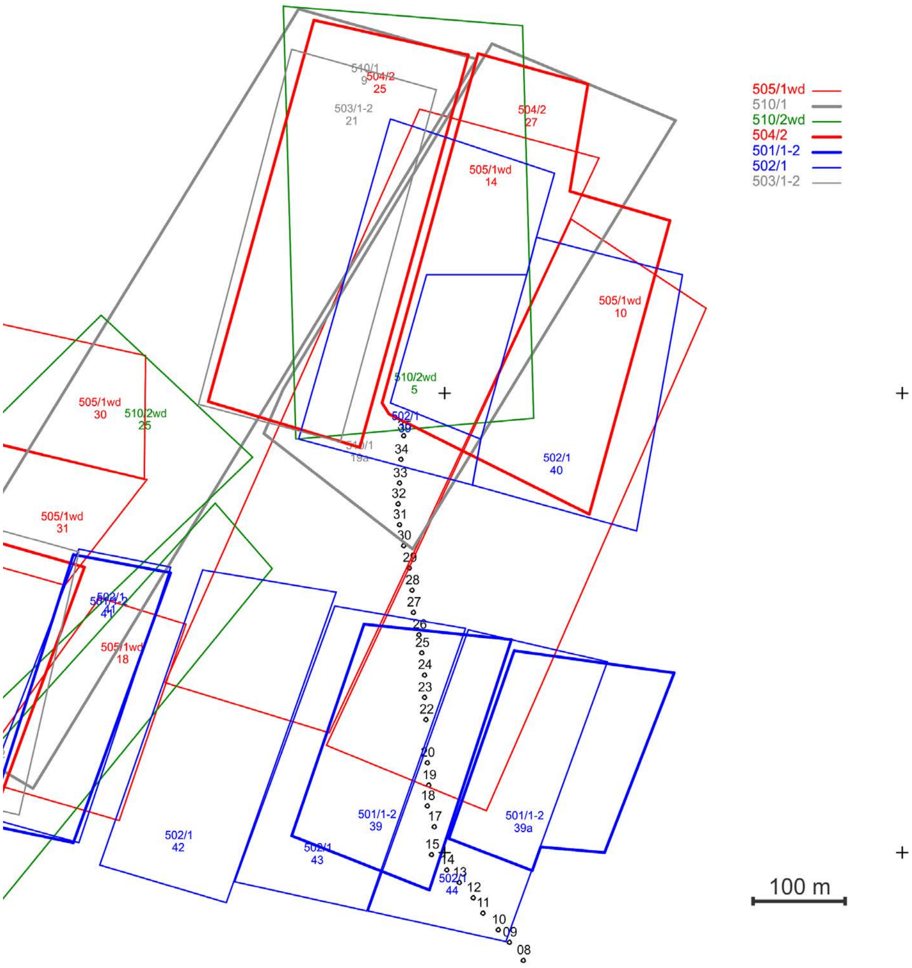

Fig. 9. The exploitation sites in the analyzed area of HCM 3 in the period Nov. 1985–Sept. 2005, with the positioning of the observation line

Rys. 9. Lokalizacja eksploatacji w analizowanym rejonie KWK 3 w okresie 11.1985–09.2005 z umiejscowieniem linii obserwacyjnej

2. Rock mass type assessment for subsidence predicting

Three models of rock mass can be distinguished for the analyzed research sites, i.e. weak, average and strong rock mass, which primarily depend on a type of strata and a degree of rock mass disturbance.

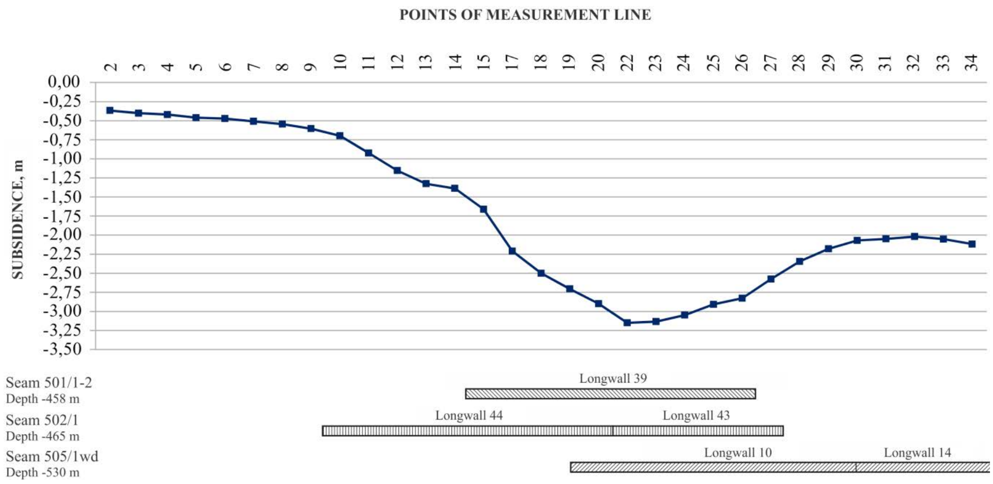

Fig. 10. The subsidence profile observed in the period Feb. 1987–Sept.2005 in the area of HCM 3, along with the positioning of the exploitation directly below the line

Rys. 10. Obniżenia punktów na linii pomiarowej w obszarze KWK 3 w okresie 02.1987–09.2005 wraz z umiejscowieniem eksploatacji bezpośrednio pod linią

In order to describe the rock mass properly and precisely, it is absolutely necessary to apply a suitable classification. A selection of such rock mass ratings worked out by researchers in late 20th century is presented in Table 1.

Nowadays practically there are no properly standardized or commonly recognized checklists of criteria for a selection of parameters for a theory of mining influence prediction depending upon a type of rock mass. Meanwhile, more and more common practice of multi-seam mining at still increasing depths of exploitation calls for an urgent determination of a methodology of parameter selection for surface subsidence prediction.

On the basis the areas analyzed in the study, the determination of mining-induced factors describing the rock mass and affecting its behavior was proposed.

Depending on a lithology of coal seams roof strata, the overburden and Carboniferous layers are distinguished. What is meant by the overburden layers is a complex of soil and rock layers deposited from the surface down to the Carboniferous strata.

Depending on a thickness of the overburden zone, a little, an average and a large overburden impact is distinguished. The little overburden impact is assumed for the situations when the thickness of the Quaternary and the Tertiary fails to reach 20% of the depth of an exploited seam. The average overburden impact is assumed for the thickness of overburden ranging between 20–40%, whereas the large overburden impact is assumed for the thickness of overburden reaching almost half of the exploitation depth. Depending on a character of rocks constituting the overburden, a weak and a strong overburden zone is distinguished. The weak overburden zone is characteristic for the layers of loose sands and clays deposited

Table 1. Selected proposals for rock mass classifications applied in surface deformation assessment in relation to rock types

Tabela 1. Wybrane klasyfikacje górotworu do oceny deformacji powierzchni w zależności od rodzaju skał

Selected proposals for rock mass rating			
Szpetkowski (1969)	Kowalczyk (1972)	Popiołek (1976)	Kowalski (1985)
◆ very strong and compact Carboniferous rocks created mostly by hard sandstones ◆ Carboniferous rocks with an equal share of sandstones and shales ◆ Carboniferous rocks with prevailing shales ◆ weak and brittle Carboniferous rocks (sandstones with clay binder) ◆ rock mass made of Tertiary and Quaternary layers (loams, mudstones)	◆ magmatic and metamorphic rocks, thick layers of very strong compact sandstones, strong and compact limestone, dolomites and anhydrites ◆ strong sandstone layers of average thickness, deposited interchangeably with strong shales with a total thickness of sandstones not less than a total thickness of shales ◆ thin layers of very weak sandstones, shale sandstones, shales, claystones, loams and compacted clays ◆ very plastic rocks, such as soft shales, clays, loams or crumbled thin insertions of siltstones	◆ compact rock mass (dominating sandstones) ◆ fairly compact rock mass (prevailing sandstones) ◆ average rock mass (approx. 50% of shales and 50% of sandstones) ◆ poor compact rock mass (more shales than sandstones, not large loose overburden) ◆ loose rock mass (prevailing loose overburden) ◆ very loose rock mass (100% of loose overburden)	◆ compact rock mass (strong): little overburden of Tertiary and Quaternary strata ($Hn < 0.2$ H), Triassic strata, or more sandstone layers than shales in Carboniferous rock mass ◆ poor and average compact rock mass (weak): thick overburden of Tertiary and Quaternary strata ($Hn \geq 0.2$ H), or more rocks made of shales or claystones than sandstones in Carboniferous rock mass ◆ Hn – thickness of overburden ◆ H – depth of exploitation

interchangeably, whereas the strong overburden zone consists of such strong compact rocks as limestones and dolomites, deposited in various configurations.

A complex of rocks between the overburden layer and the deepest exploited seam was denominated as the Carboniferous strata zone. Depending on a lithological structure of rock mass, characterized predominantly by means of a rock type, a thickness of particular layers and a mutual configuration of layers, the following categories were distinguished (Fig. 11):

- strong Carboniferous strata – the strata occurring in this zone are characteristic for their large thickness, large strength and the fact that they are deposited above a given coal seam in large blocks; the group embraces sandstones and siltstones;
- weak Carboniferous strata – the strata occurring in this zone are characteristic for their little compaction and cohesion (they easily become subject to fracture, loosening, failure and dislocation); the group embraces claystones and coal shales;
- average Carboniferous strata – the strata occurring in this zone are characteristic for their vast variety as there are both layers classified as strong and weak Carboniferous strata; average rock mass (approx. 50% of shales and 50% of sandstones).

In a multi-seam exploitation, some disturbed zones may be distinguished and their range above the excavated mining fields broadens depending on the exploitation of a particular volume of the seam and the type of strata above the exploited seam. In relation to an intensiveness of this process, weakly, moderately and strongly disturbed rock mass can be distinguished in the zone of Carboniferous strata.

On the basis of a geological and mining survey, a scheme was created, which allows to recognize and describe roof strata and to examine rock mass zones in the analyzed areas. The above-mentioned factors describing the rock mass, i.e. the volume and type of overburden, the thickness and type of particular Carboniferous rock layers, the number of layers

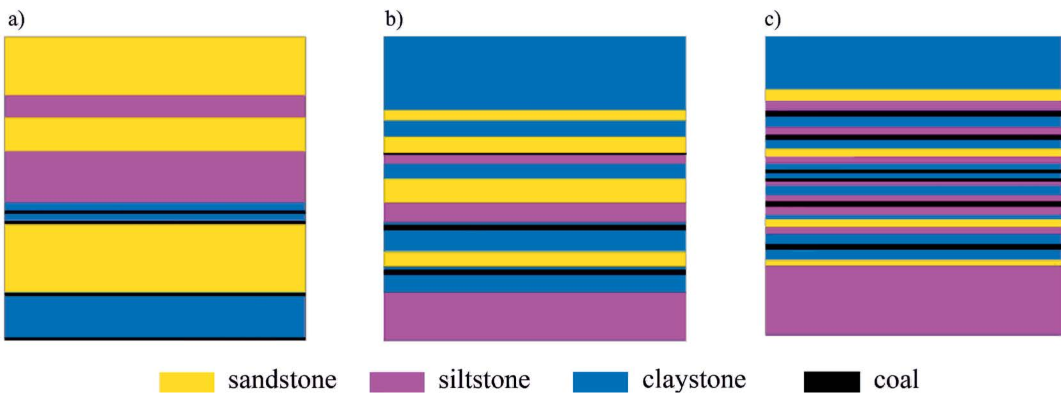

Fig. 11. Rock mass models
a) strong, b) average, c) weak

Rys. 11. Modele górotworu
a) mocny, b) średni, c) słaby

and the way of their distribution in the rock mass, the changes in rock mass structure affected by coal mining, as well as the depth of exploitation, were presented in a graphic form (Fig. 12).

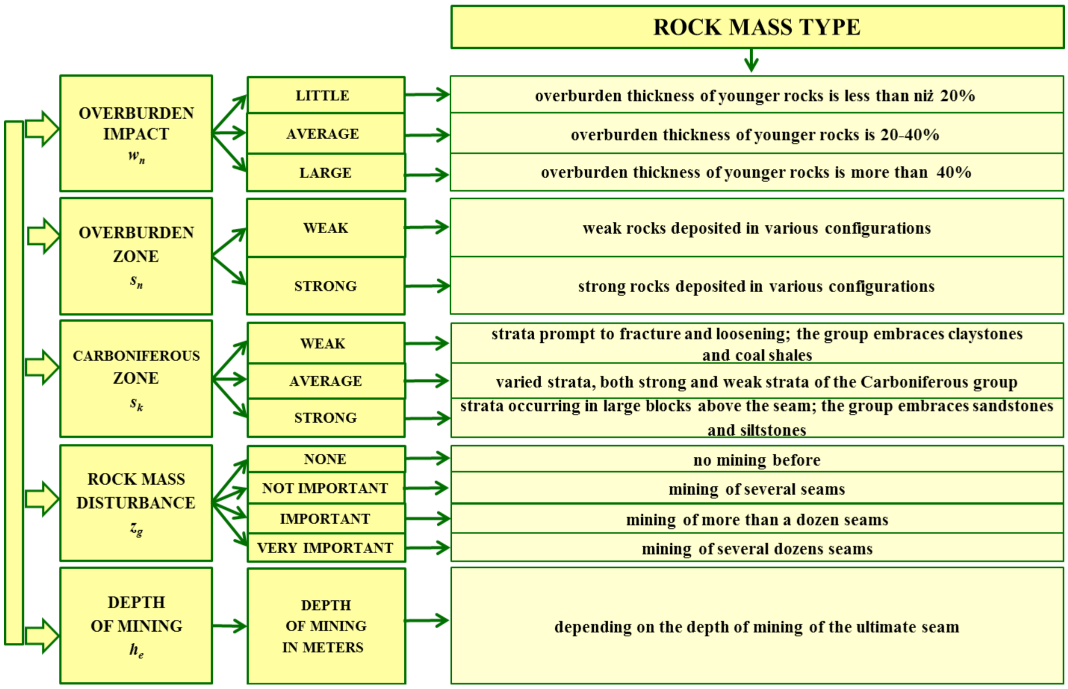

Fig. 12. Factors describing rock mass

Rys. 12. Czynniki charakteryzujące górotwór

Therefore, in the examination of the analyzed types of rock mass such parameters as the overburden impact, the overburden zone, the Carboniferous zone, the rock mass disturbance and the depth of mining should be taken under consideration. On the base rock mass type, the linear regression model was build for prediction values of parameters *a* and tgβ for predicting the values of surface subsidence (Kryzia 2017). Using the proposed examination and the data obtained from the measurement lines, the value of exploitation coefficient *a* and the tgβ parameter were fitted for the three analyzed areas of hard coal mines.

2.1. The area of HCM 1

Basing on the fitting of the measured subsidence of the measurement line points, the parameter values for Knothe theory were determined. Figure 13 presents the map of surface

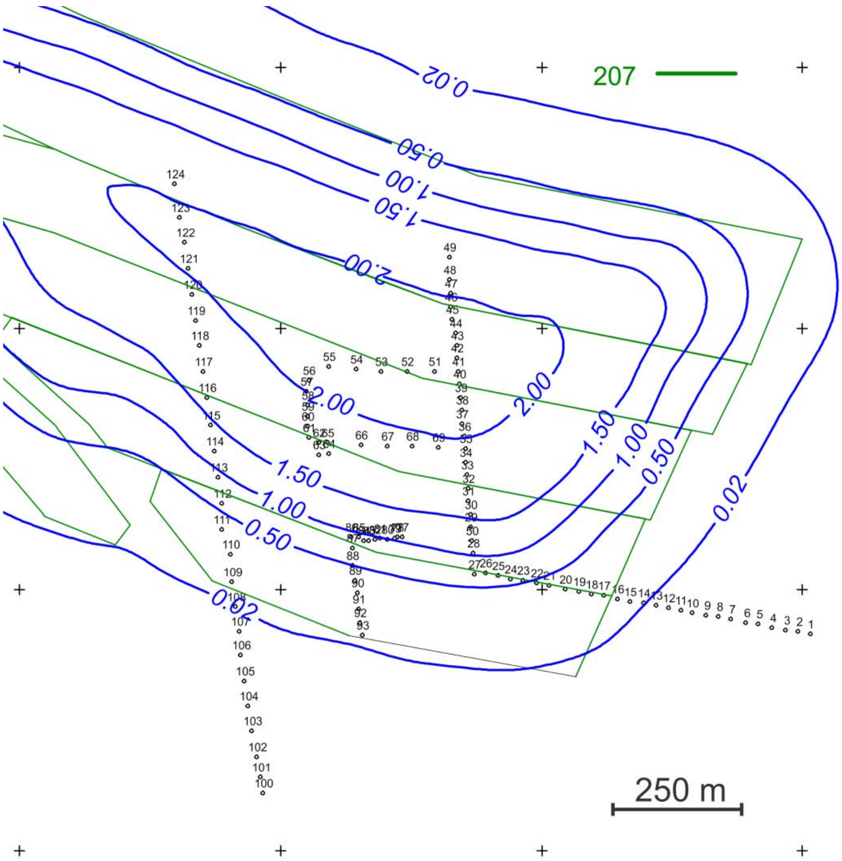

Fig. 13. The subsidence in the area of HCM 1 in the period March 1992–June 1996, with the positioning of the exploitation longwalls and the observation lines

Rys. 13. Obniżenia w rejonie KWK 1 w okresie 03.1992–06.1996 z umiejscowieniem ścian eksploatacyjnych i linii obserwacyjnych

subsidence in the area of HCM 1, prepared with the use of the determined parameters of the prediction.

The value of the exploitation coefficient, obtained from matching the values of the measured subsidence with the predicted values, is 10% less than the one usually assumed ($a = 0.8$) and it amounts to $a = 0.721$. Since there is no rock mass disturbance, the value seems adequate in relation to the existing mining and geological situation. The value of tgβ parameter obtained from matching the real trough to the predicted trough is 1.488. Such a low value may be caused by such factors as the depth of exploitation, lack of rock mass disturbance and strong (block) strata occurring in the Carboniferous area.

In order to evaluate the accuracy of calculations, the coefficient of correlation between the calculated subsidence and the subsidence measured in the measurement line was determined. In the analyzed case of HCM 1, the correlation coefficient is 0.97. The determined standard deviation is 173 mm, whereas the value of the variability index M_w is 7.8. Hence, there is a strong relationship between the measured and the predicted subsidence.

3.2. The area of HCM 2

The values of the final subsidence in the points of the measurement line were used for obtaining the values of prediction parameters for the area of HCM 2, i.e. the coefficient of exploitation a and the theory parameter of tgβ. The values of those parameters were later utilized in preparing the map of surface subsidence in the area of HCM 2 (Fig. 14).

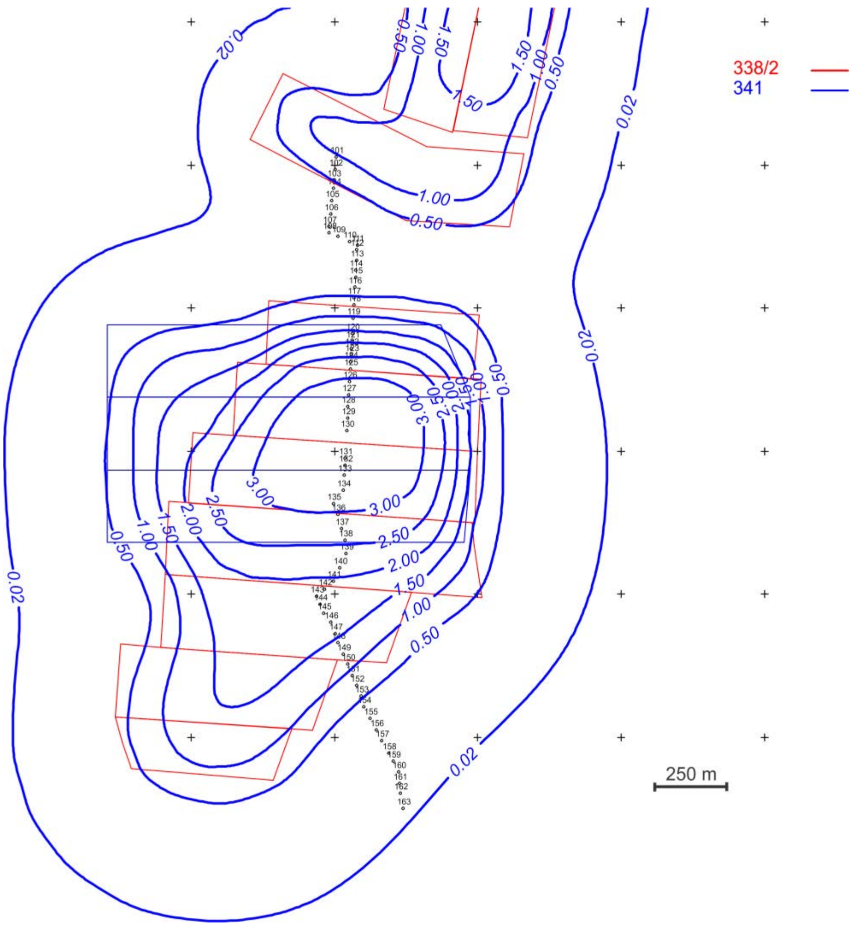

Fig. 14. The subsidence in the area of HCM 2 in the period April 1994–March 2007, with the positioning of the exploitation longwalls and the observation lines

Rys. 14. Obniżenia w rejonie KWK 2 w okresie 04.1994–03.2007 z umiejscowieniem ścian eksploatacyjnych i linii obserwacyjnych

The value of the coefficient of exploitation *a* for the area of HCM 2 amounts to 0.90, which means it is 11% higher than the standard value assumed in the prognostic calculations (a = 0.8). Mining and geological analyses suggest that it is the rock mass disturbance that is the major cause for such a value of the exploitation coefficient. The value of the theory parameter of tgβ obtained from matching the measurement results with the prediction is tgβ = 2.304. The analysis suggests that the layers of clay and claystone, occurring in the overburden and Carboniferous strata respectively, exert a major impact on the 15% increase of the parameter in relation to its typical value (tgβ = 2.0).

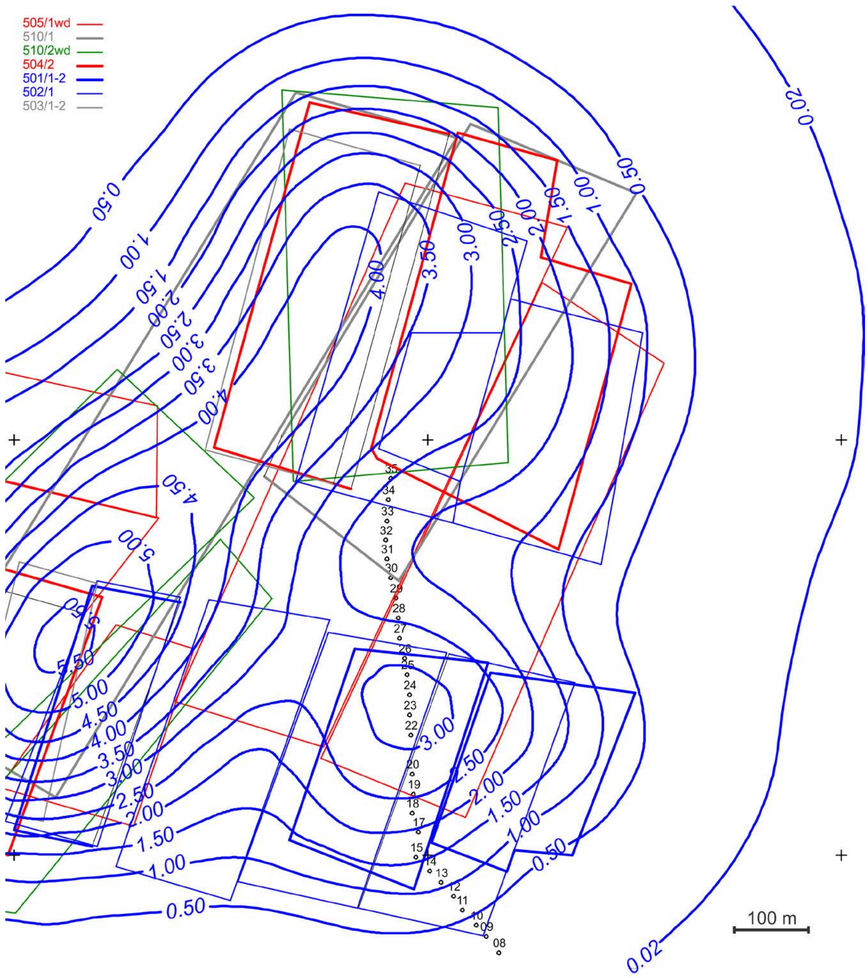

Fig. 15. The subsidence in the area of HCM 3 in the period Feb. 1987–Sept. 2005 with the positioning of the exploitation longwalls and the observation lines

Rys. 15. Obniżenia w rejonie KWK 3 w okresie 02.1987–09.2005 z umiejscowieniem ścian eksploatacyjnych i linii obserwacyjnej

The coefficient of correlation between the measured subsidence and the predicted subsidence in the measurement line in HMC2 was 0.99. The standard deviation in this case is 98 mm, whereas the value of the variability index M_w is 2.9. Hence, there is a very strong relationship between the measured and the predicted subsidence.

3.3. The area of HCM 3

On the basis of matching the measured values of subsidence, the values of the parameters of the exploitation coefficient *a* and the theory parameter of tgβ for the area of HCM 3 were determined, as well as the map of surface subsidence was prepared (Fig. 15).

The increased value of the parameter a = 0.903 was mostly affected by the rock mass disturbance caused by mining in seven seams. The value of the mining influence dispersion parameter in the area of HCM 3 exceeded the typical value of 2.0 by 12% and amounted to tgβ = 2.248. Such a situation may be caused by the activation of the rock mass with earlier multi-seam mining. The occurrence of weak overburden strata also may influence the increase of the value of tgβ.

The coefficient of correlation between the calculated subsidence and the measured subsidence in the measurement line for HCM 3 was 0.96, the standard deviation was 253.9 mm, whereas the value of the variability index M_w amounted to 4.5.

In order to summarize the entire analysis of the relationships between the assumed type of rock mass and surface subsidence, the obtained theory parameters of *a* and tgβ, as well as the factors describing rock mass, were systematically structured and presented in Table 2.

Table 2. The obtained values of theory parameters *a* and tgβ and factors of the assumed rock mass classification

Tabela 2. Uzyskane wartości parametrów teorii *a* i tgβ oraz czynniki przyjętej klasyfikacji górotworu

Factor / Area	Exploitation coefficient a	Rock mass parameter tgβ	Overburden influence w_n	Overburden zone s_n	Carboniferous zone s_k	Rock mass disturbance z_g	Depth of mining h_e, m	Rock mass type
HCM 1	0.721	1.488	large	weak	strong	none	414.80	strong
HCM 2	0.900	2.304	large	weak	strong	important	568.00	weak
HCM 3	0.903	2.248	large	weak	strong	very important	664.50	average

Conclusions

The study discussed in this paper seems to confirm the hypothesis that the influence of mining on the surface largely depends on the type of rock mass. The mechanism of caving is based on the consecutive failure of strata or strata complexes deposited higher and higher, triggered mostly by the unit weight of the overlying strata. However, it should be pointed out here that each layer possesses its own highly distinctive mechanical properties.

As the study of geological, geodesic and mining character of the analyzed areas indicates, surface deformation is largely varied and manifests itself in the form of individual strata or strata complex separation and their dislocation to a particular space, which affects the subsidence registered in the surface.

Such observations allowed for working out particular models of the rock mass, in which strong, average and weak rock mass was assumed. Matching the areas to a particular type of rock mass finds its reflection in the measured values of surface subsidence, whereas in the aspect of predicted subsidence – in the values of parameters of the theory of surface subsidence prediction. For the sake of the surface subsidence prediction, such parameters of the theory as the angle of the main influences range and the exploitation coefficient were utilized, whose values depend on a type of rock mass.

The study proves that for the better quality the subsidence predicting, the type of rock mass may be described by five factors such as: the influence of overburden strata, the influence of Carboniferous layers, the disturbance of rock mass and the depth of exploitation.

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ESTIMATION OF MINING IMPACT ON SURFACE IN RELATION TO ROCK MASS TYPE

Abstract

An analysis of the impact of mining with caving on the surface shows that a type of rock mass strata seems to be one of the critical factors affecting the process. Correlating the values of mining-induced surface deformation with the rock mass structure and the state of its disturbance is of crucial importance. Therefore, if other mining conditions are left unaffected, then those factors exert the key influence on a course and distribution of subsidence and rock mass deformation. A proper description of rock mass type and properties also seems rational for a proper determination of prediction parameters, especially in the case of a multi-seam coal mining, and/or the exploitation carried out at considerable depths. A general outcome of the study discussed in this paper is the development of the methodology and model practices for determining the rock mass type and, as a result, for selecting the optimal values of parameters for predicting the values of surface subsidence in relation to particular geological and mining conditions. The study proves that the type of rock mass may be described by such factors as the influence of overburden strata, the influence of Carboniferous layers, the disturbance of rock mass and the depth of exploitation.

Keywords: coal mining with caving, surface deformations, subsidence, rock mass type

OCENA WPŁYWU EKSPLOATACJI GÓRNICZEJ NA POWIERZCHNIĘ TERENU W ZALEŻNOŚCI OD RODZAJU GÓROTWORU

Streszczenie

Rozpatrując zagadnienie wpływu zawałowej eksploatacji górniczej na powierzchnię terenu, można stwierdzić, że jednym z ważnych czynników wpływających na powyższy proces jest rodzaj warstw skalnych budujących górotwór. Uzależnienie wartości deformacji powierzchni terenu spowodowanych eksploatacją górniczą od budowy górotworu i stanu jego zruszenia ma zasadnicze znaczenie, bowiem przy innych niezmienionych warunkach górniczych, właśnie te czynniki mają największy wpływ na przebieg i rozkład obniżeń oraz deformacje górotworu. Określenie rodzaju górotworu wydaje się również zasadne do określenia parametrów prognozy, szczególnie gdy eksploatacja jest wielopokładowa, a ponadto prowadzona na dużych głębokościach. W artykule przedstawiono schemat postępowania konieczny dla określenia rodzaju górotworu, a w konsekwencji doboru wartości parametrów prognozy umożliwiających predykcję wartości obniżeń powierzchni terenu w zależności od warunków geologiczno-górniczych. Z wykonanej analizy wynika, że rodzaj górotworu może być charakteryzowany przez takie czynniki jak wpływ warstw nadkładu, wpływ warstw karbonu, zruszenie górotworu oraz głębokość eksploatacji.

Słowa kluczowe: eksploatacja zawałowa, deformacje powierzchni, obniżenia powierzchni terenu, rodzaj górotworu