Sborník vědeckých prací Vysoké školy báňské - Technické univerzity Ostrava
číslo 2, rok 2009, ročník IX, řada stavební
článek č. 29

Piotr STRZAŁKOWSKI[1], Roman ŚCIGAŁA[2]

DISCONTINUOUS DEFORMATIONS IN MINING AREAS - THE ANALYSIS OF OCCURRENCE CONDITIONS

NESPOJITÉ DEFOMACE V PODDOLOVANÝCH OBLASTECH - ANALÝZA PODMÍNEK VZNIKU

Abstract

The classification of discontinuous deformations and conditions of their arising due to underground mining in the Upper Silesian Basin has been presented in this paper. The exemplary deformations in the shape of ground steps and sink holes have been shown in this paper too. On the basis of analyses of local mining-geological conditions that influenced the behaviour of rock mass, conclusions have been drawn concerning conditions of these deformations arising.

Abstrakt

V příspěvku je představena klasifikace nespojitých deformací a podmínky pro jejich vznik v důsledku poddolování v Hornoslezské pánvi. Uvedeny jsou také příklady deformací ve tvaru stupňů a poklesových kotlin. Na základě analýz lokálních důlně-geologických podmínek, které ovlivňují vlastnosti horninového masivu, jsou stanoveny odpovídající podmínky pro vznik těchto deformací.

Introduction

Underground mining leads to many adverse changes to the natural environment as well as constructions in urbanised areas. The most obvious form of land surface transformations due to underground mining there are continuous deformations in the shape of subsidence troughs. Rarely one can find another form of deformations – discontinuous ones. They arise mainly in the form of sinks or ground steps and cracks. Sinks form generally as the effect of shallow extraction, but there are examples of their occurrence due to activation of old shallow abandoned workings by present extraction led at the greater depth. This type of deformations was often found in last 30 years of XX century. Nowadays in the Upper Silesian Basin one can observe the qualitative changes in deformations type – there are much more ground steps and cracks than sinks. This type of deformations is caused mainly by : occurrence of faults zone covered by

[1] Dr hab. inż. Piotr Strzałkowski, Prof. Pol. Śl., Silesian University of Technology Gliwice, Poland, email: piotrs@polsl.pl
[2] Dr inż. Roman Ściagała, Silesian University of Technology Gliwice, Poland, e-mail: sciagala@polsl.pl

thin overburden layers and leading of multiple extraction in several seams toward common border (for example border of protective pillar).

It is necessary to mention here that this type of discontinuous deformations is to be very dangerous one to buildings and objects of underground infrastructures. Another important thing to keep in mind is the fact that there are no methods of forecasting the probability of their occurrence.

Some examples of discontinuous deformations occurrence in Upper Silesian Basin have been presented below together with the analysis of causes of their formation.

The examples of ground steps occurence

Ground steps formed due to fault activation

The characteristics of deformation

Ground steps with height from 0.2m to 1.0m formed on the length of 200m across the street R. The characteristic feature of this deformation was that there were steps leading in two directions forming some kind of horst (fig.1). Deformation arose in the 2001 and was active to the 2006. The horizontal plan of its location on the background of one of extracted coal seam map is presented in fig.2.

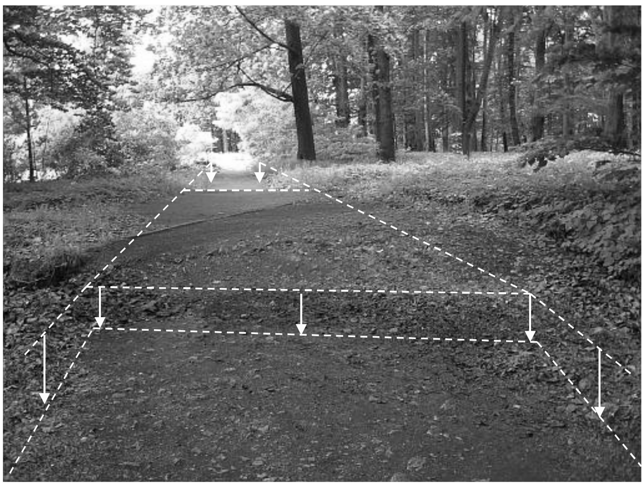

Fig.1 Ground steps caused by extraction close to “R” street

The characteristic of rock mass

In the area of ground steps, rock mass consists of overburden and Carboniferous layers. Overburden layers are: Quaternary and Triassic. Quaternary layers have thickness of 5-60m and they are built up of gravel, sand, clay and mud. Triassic layers are built of limestone as sandstone with thickness up to 100m Carboniferous is built of “rudzkie”, “siodłowe” and “porębskie” layers.

Tectonics

There is “Wschodni” fault outcrop formed directly under deformation zone. It has main direction from NW to SE with throw from 5 to 30m and angle of dip in the range of 65°-85°.

Underground extraction

Basic information concerning extraction led in the past close to the fault zone is presented in table 1. Locations of extraction edges with illustration of total height of extracted deposit are shown in fog.2. Analysing this map one can find that along both sides of fault zone, extraction was led in several coal seams to the same border. Maximum total extraction height was about 26m.

Table 1 Basic data concerning underground extraction led close to the fault zone

Coal seam	Height of extracted layer	Depth of extraction	Extraction period	Roof controlling
501	1.6m-3.2m	650m	1984-86 and 50's	caving and stowing
503	2.5m-3.0m	680m	50's	stowing
504	2.5m-3.2m	700m	50's i 60's	caving
506	1.6m	770m	1989-90	caving
507 w.g.	2.0m-3.5m	780m	1974-78 i 1986-88	caving
507 w.d.	2.1m-4.0m		1974-78	caving
509 w. g.	2.1m-2.7m	820m	1985-86 i 1992-93	caving
509 w. d.	2.7m-2.9m		1985-89 i 2000-02	caving
510 w. g.	1.7m-2.4m	840m	1969-77 i 2003-05	caving
510 w. d.	1.8m-2.0m		1969-77	caving

Analysing presented data one can state that the main cause of deformation occurrence in this case there was fault activation due to intensive extraction in several coal seams led close to the fault zone.

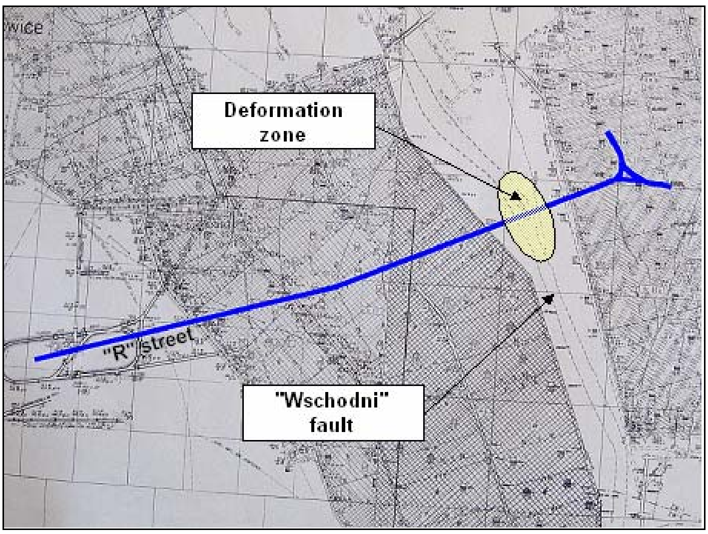

Fig. 2 The sketch of deformation zone on the background of mining map of coal seam 507

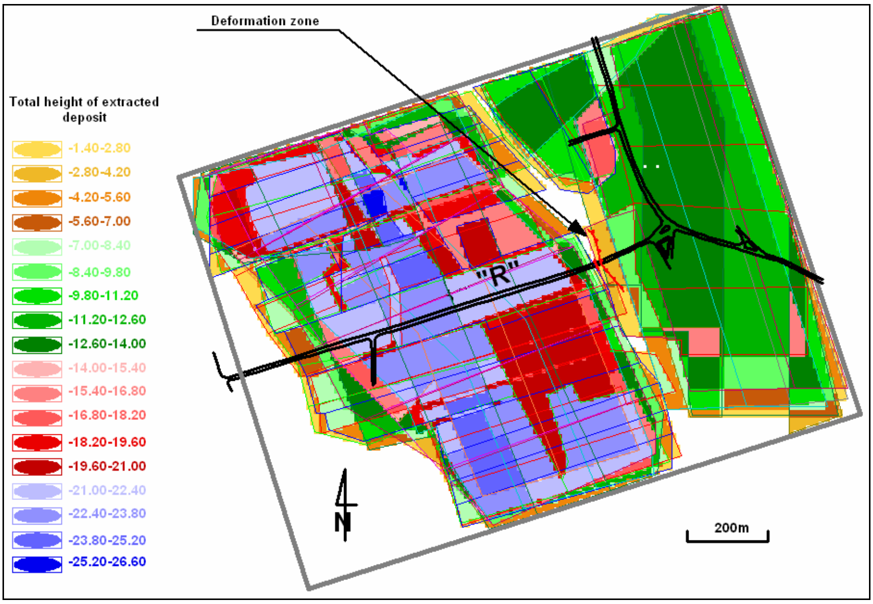

Fig. 3 The sketch of exploitation edges with total height of extracted deposit

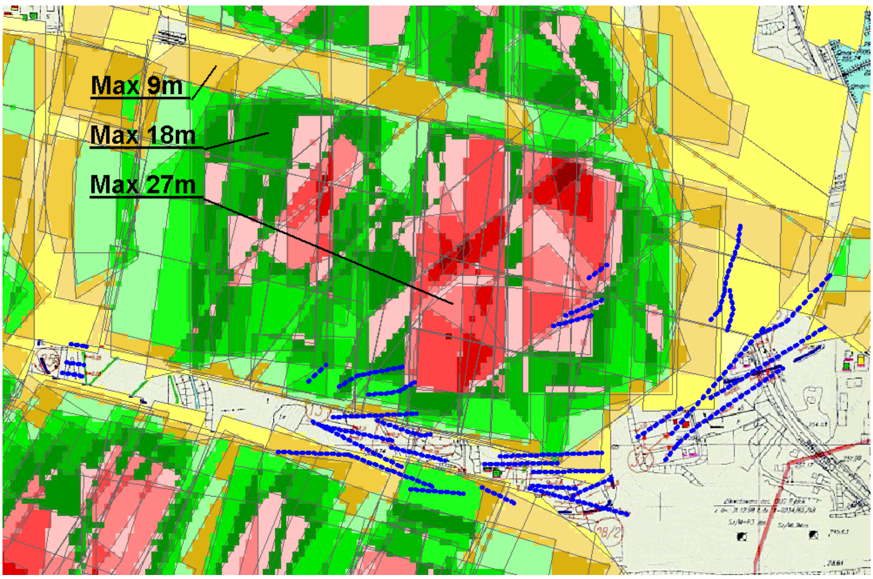

Fig. 4 The map of total height of extracted deposit in the area of ground steps

Ground steps formed due to multiple extraction led to the same border

Deformation characteristic

In the area of interest, ground steps occur from the year 1968. Steps height changes from 0.1m to 1.0m. They formed in large numbers around the edges of multiple extraction edges – fig.4.

The characteristic of rock mass

Rock mass consists of overburden and Carboniferous layers. Overburden layers are : Quaternary and Tertiary. Quaternary layers have thickness of 0-70m and they are built up of gravel, sand, clay and sandy clays with some dusty sediment. Tertiary layers are built of gray-green clays and mudstones, as well as dusty sediments. The total thickness of tertiary layers is variable – from 45 up to 575m. Carboniferous is built of “rudzkie” (thickness 350-500m), “siodłowe”(thickness 250m) and “porębskie” layers (thickness 700-830m).

Tectonics

In this area no important fault zones have been found.

Underground extraction

In the considered area extraction has been led from the 1965 in 17 coal seams. Because of large number of data no additional information will be presented here. In the fig.4 extraction edges are sketched together with the map of total height of extracted deposit.

Analysing presented data one can state that there is a significant correlation between location of ground steps and the multiple edges of extracted fields especially in the zone of narrow pillar left for underground workings protection.

The example of sing holes

Deformation characteristic

The sinks occurred in the area of dispersed development, between two railway lines, south-east of Czarna Przemsza river. There were identified 9 sinks – their location is shown in fig.5:

- two sinks no 1 i 2 with diameter 2.5 i 1.4m and depth 1.5m i 3.5m, occurred in the cultivable area in the reciprocal distance 15m.
- sink no 3 with diameter 1.5m and depth 0.3m occurred close to the railway embankment base.
- sink no 4 of elliptical shape with diameters : 3.5m x 2.0m and depth 1.5m occurred in the vicinity of local road.
- sink no 5 with diameter 3.0m and depth 2.0m occurred in apartment house corner . It was liquidated by sand filling. Several years later, in the year 2000, it occurred again (sink no 7 – fig.7) and was liquidated by injection of multicomponent mixture composed with use fly ashes, directly to underground cavern. Due to the deformation, building construction was partially damaged.
- sink no 6. with diameter 1.2m and depth 2.5m occurred close to the railway line. It was liquidated by filling with waste rock hardened with cement wash. Additionally, underground cavern was filled by injection of 1407 tons of fly ashes through 8 boreholes.
- sinks no 8 and 9 with diameters 2.0 m and 3.0 m and depth : 0.5m and 1.0m. They occurred in the year 2000 in the area of waste land.

The characteristic of rock mass

Rock mass consists of overburden Quaternary and Carboniferous layers. Quaternary layers have thickness of 0-10m and they are built up of sands, sandy clays with some sandstones. Carboniferous is built of "orzeskie" layers, where one can find coal seams from group "300", sandstones and mudstones.

Tectonics

In this area no important fault zones have been found.

Underground extraction

In the considered area, in XIX century Luiza Coal Mine led mining extraction. Deposit opening was done by rise galleries from the land surface in the vicinity of Czarna Przemsza river, close to the coal seam outcrop. Another opening was done by driving small shafts. Mine model one can define as coal model with large number of preparatory headings. Extraction was led with system of shortwalls with caving, from the outcrop of coal seam (fig.5). Basic mining data is presented in the table 1.

Table 2 Basic mining data from "Luiza" Mine

Extraction period	Mining height [m]	Mining depth [m]	Overburden height [m]
1810 – 1820	2.5	5	5
1854 – 1855	2.5	17	10
1848 – 1865	2.5	35	10

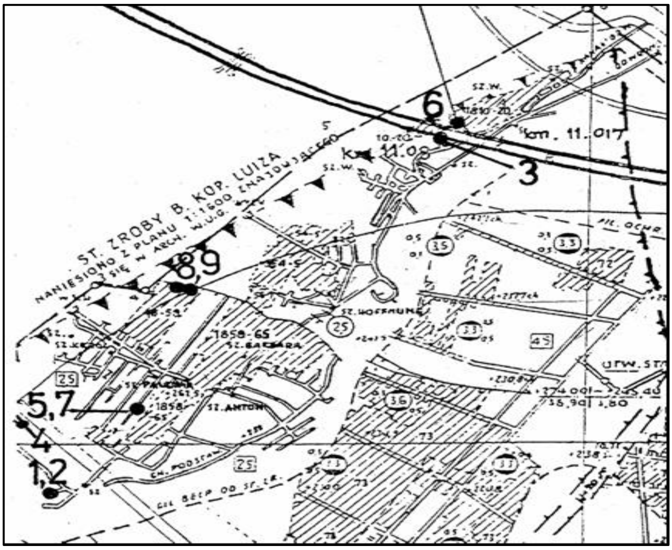

Fig. 5 The fragment of coal seam 304/2 map. Not to scale.

Analysing map presented in fig.5, one can find that majority of sink holes (except sinks 8, 9) occurred directly above old dog headings from XIX century. It can be assumed that after coal extraction from shortwalls, fall of roof was triggered, so majority of voids were filled by caving. On the other hand it is possible that timber lining installed in dog heading was not recovered after extraction and caused occurrence of not filled voids. Slow destruction of this timber lining through over 100 years might be the cause of its stability problems, so as a result of voids self-filling, sink holes occurred at the land surface.

Fig. 6 Sink holes 8 and 9, occurred in the Głowackiego street.

Fig.7 Filling in the underground cavern in the area of sinks 7

Concluding remarks

Summing up presented material one can draw following remarks:

1. Linear discontinuous deformations are very important aspect of negative influence of underground exploitation on the land surface, especially in urbanised areas - they often lead to serious damage to constructions. They arise mainly as the effect of :
   - ❑ fault activation,
   - ❑ multiple extraction led to the same border.

In the light of presented examples one should remember about effective ways of decreasing the danger of their occurrence. It means that the underground workings should not be conducted in a way that allows vertically overlapping of the extraction edges in a few beds, especially in the vicinity of faults.

2. Formation of sink holes is connected with other factors. Nowadays in the Upper Silesian Basin they mainly occur as the effect of old shallow workings activation due to influences of present extraction led at higher depth. It is necessary to point that problem arises due to activation of old excavation workings as well as dog headings and shallow shafts, that were not filled after their closing.

References

[1] CHUDEK, M. & OLASZOWSKI, W. Określenie rodzaju i wielkości deformacji nieciągłych. *Ochrona Terenów Górniczych*, 1976, nr. 38.

[2] CHUDEK, M. *Geomechanika z podstawami ochrony środowiska górniczego i powierzchni terenu.* Wydawnictwo Politechniki Śląskiej. Gliwice 2002.

[3] CHUDEK, M., JANUSZ, W. & ZYCH, J. Studium dotyczące stanu rozpoznania tworzenia się i prognozowania deformacji nieciągłych pod wpływem podziemnej eksploatacji złóż. *Zeszyty Naukowe Politechniki Śląskiej*. Seria Górnictwo z. 141. Gliwice, 1988.

[4] KNOTHE, S. *Prognozowanie wpływów eksploatacji górniczej. Wydawnictwo „Śląsk”*. Katowice 1984.

[5] Praca zbiorowa pod red. J. KWIATKA *Ochrona obiektów budowlanych na terenach górniczych.* Wydawnictwo Głównego Instytutu Górnictwa. Katowice 1997.

[6] STRZAŁKOWSKI, P. Wpływ płytkiej eksploatacji górniczej na zagrożenie powierzchni terenu deformacjami nieciągłymi. *Zeszyty Naukowe Politechniki Śląskiej*. Seria Górnictwo, z. 246. Gliwice, 2000.

[7] ŚCIGAŁA, R., Oprogramowanie dla celów tworzenia graficznego obrazu deformacji powierzchni terenu. In Konferencja Naukowa (2003): Górnictwo zrównoważonego rozwoju 2003. *Zeszyty Naukowe Politechniki Śląskiej*. Seria Górnictwo, z.258.Gliwice, 2003.

[8] SEDLAK, V. Deformation Vector Theory Development in the Specific Conditions of Mining Subsidence. *Transactions of the VSB. Civil Engineering Series*, 2/2004 (13. Regionalni konference : Rozvoj seismologie, inzenyrske geofyziky a geotechniky).

Oponentní posudek vypracoval:

Ing. Karel Hortvík, Ph.D., Ústav geoniky AVČR, v.v.i., Ostrava