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THE IMPACTS OF UNDERGROUND MINING AS A POSSIBLE FACTOR AFFECTING THE DOUBRAVA OPLÍŽÍ SLOPE MOVEMENT ACTIVITY

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Abstract: The locality of Doubrava Oplíží is one of the landslides within an extensive slope front situated between the municipalities of Doubrava and Dětmarovice in the Moravian-Silesian Region and at the same time, in the allotment of Karviná Mine, ČSA Plant. The slope deformation stability was assessed in terms of the impacts of underground mining making use of isocatabase maps, terrain deformation parameter values determining the group of building sites subject to ČSN 73 0039, movements measured by zone extensometry and rainfall totals. The assessment of rainfall totals as well as a generally significant factor influencing the mobility of landslides did not identify any reaction in the measured movements of the slope deformation. The maps of subsidence caused by underground mining revealed a concordant declination of the slope deformation with the subsidence basin slope inclination that shall further increase according to the prospective maps till 2010. Thus, it is the case of the least favourable impact of the subsidence basin on the slope deformation when its inclination is being enhanced. Similar conclusions may also be drawn from the development of terrain deformation parameter values. Whereas in 2005 the slope deformation was in the 4th group of building sites, in 2010 its upper part will have been in the 3rd and the lower part in the 2nd group of building sites. In all probability, this fact shall similarly reduce the degree of landslide stability, which will jeopardize a road and parallel underground services running along the lower side.

1. INTRODUCTION

The locality of interest of Doubrava Oplíží is a partial slope deformation on an extensive slope front situated between the municipalities of Doubrava and Dětmarovice in the Moravian-Silesian Region. The slope is morphologically predisposed to the existence of a terrain degree on the left bank of the Karvinský Stream, which in terms of the geomorphological zoning of the relief of the Czech Republic, forms the border between the Orlová Plateau and the Ostrava Bottomland [5].

Within the study of archive materials [1]–[12] no direct exploratory work was identified to be carried out in the locality. The implemented terrain survey discovered the limits of the slope deformation, i.e. the scar edge, approximate side borders and the area of deposition, including morphological elements in the landslide body and those are marked in the site plan of the locality. In order to identify the engineering-geological conditions, geological cross-sections implemented within the archive exploratory work in the close proximity of the interest locality were used. Generalization of the cross-sections specified the probable geological structure of the locality and a hypothetic geological cross-section was made. The failure surfaces were localized on the basis of geophysical measurement using the method of resistance tomography on to cross-sections conducted approximately through the centre of the slope deformation. To verify this, implementation of direct exploratory work will be vital in the future.

About two thirds of the slope front, in which the locality of interest is situated, are affected (from the south-east) by underground mining of coal carried out by the company of OKD, a.s. in the allotment of Karviná Mine, ČSA Plant. In this plant, the average extraction depth rages around 852 m below the surface, while the deepest working faces reach as low as 970 m, which at the mean ground altitude of 280 m represents the absolute depth of 1250 m. Driving of preparatory workings is done by a ripping machine making use of jumbos joined with loaders. Own extraction by outbye longwall caving is carried out in coalfaces making use of mechanized advancing supports and power loaders.

The beginning of mining in the area dates back to the year of 1780. In 1836, the individual shallow shafts merged into one mining company owned by Count J.E. Larisch-Mönnich and Baron Richard Mattencloit. In 1856, the current ČSA Mine was established (Mine of Czechoslovak Army) merging the existing shafts into one company. The more modern history of industrial mining at ČSA Mine dates back to 1951 when a state company "Velkodůl Čs. Armády" was founded and an extensive reconstruction took place.

2. POSSIBLE IMPACTS OF UNDERGROUND MINING ON THE DOUBRAVA OPLÍŽÍ SLOPE DEFORMATION

The development of the subsidence basin in the area of the Doubrava Oplíží deformation may be analyzed based on the terrain subsidence maps in four subsequent intervals, provided by the company of OKD, a.s., which were vectorized for the needs of overlay analyses. The intervals are selected approximately evenly from the beginning of levelling back in 1983 to 2005, while before 1995 (the first two intervals) no subsidence was registered in the vicinity of the slope deformations and thus these are not represented in separate figures in the paper. The fifth interval represents subsidence totals between 1983 and 2002 and the sixth one is a prognosis of subsidence for the period between 2003 and 2010.

The subsidence in the interval of 1983 to 2000 and that in the interval of 1983 to 2005 (figure 1) represent the third and fourth intervals of the monitored period. In the third interval, the landslide is located in the place sunken by about 10 to 20 cm, while its lower part drops more (20 cm) but the upper falls less (10 cm). It is apparent that the subsidence basin slope inclination corresponds to the gradient of the landslide slope, and thus the slope deformation inclination increases as a result of mining. In the following interval of 1983–2005, there is a similar direction of the subsidence basin slope inclination in the place of the slope deformation; the subsidence in the slope's upper part is 30 cm and about 65 cm in the lower part of the slope.

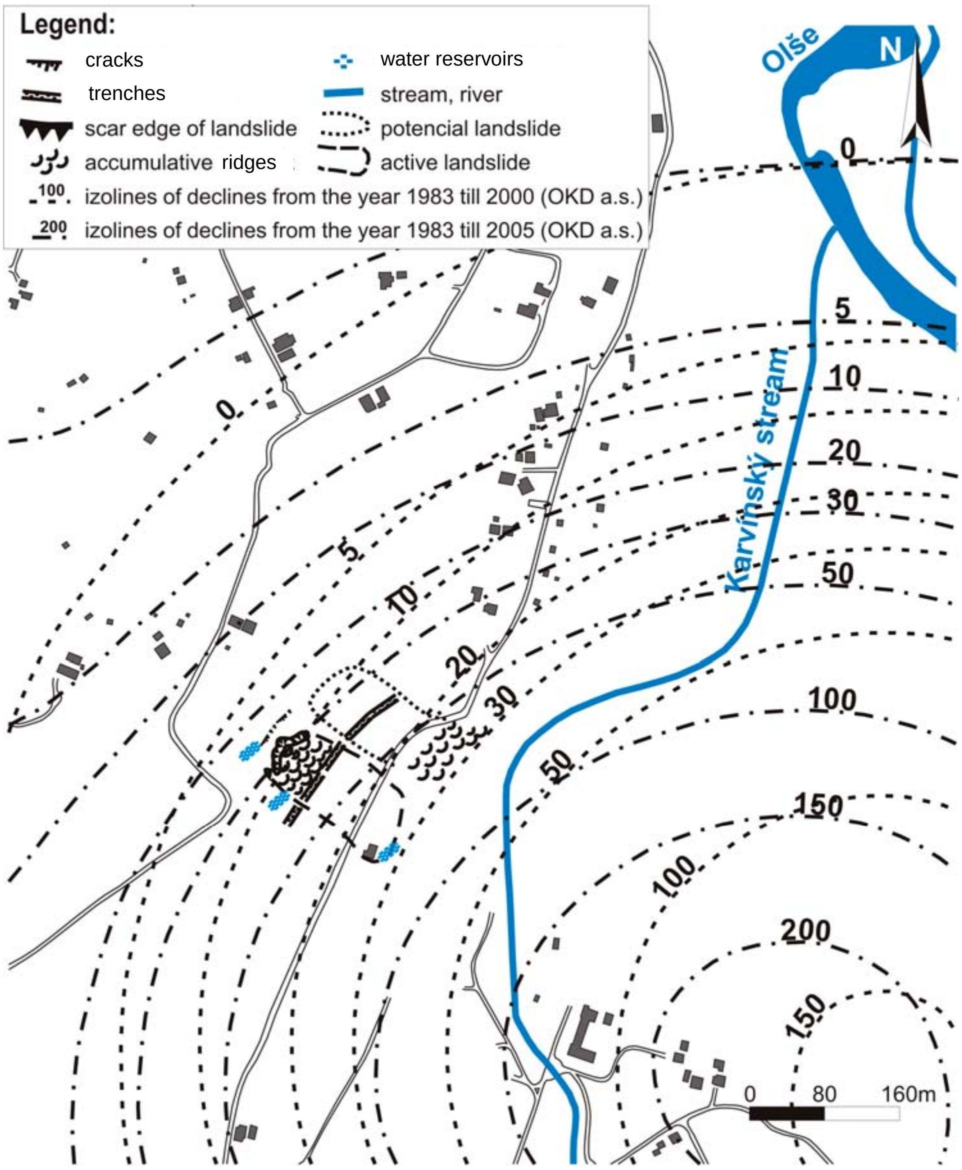

Fig. 1. Declines in centimetres caused by mining in the periods of 1983–2000 and 1983–2005 with marked positions of slope deformations

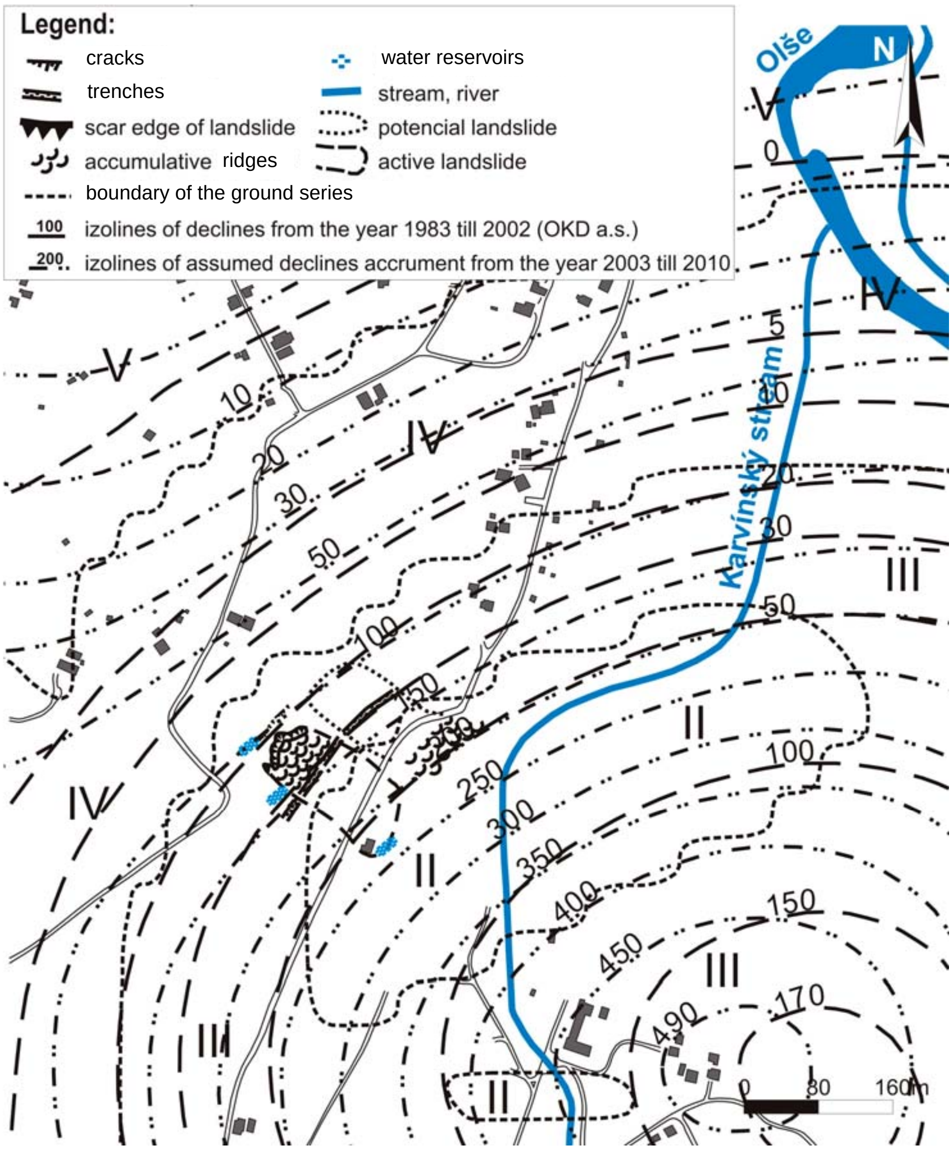

Fig. 2. Declines in centimetres caused by mining in the periods of 1983–2002 and the forecast increase by 2010 with marked positions of slope deformations

The declines caused by mining between 1983 to 2002 range approximately in mean values of the previous two intervals. The prognosis for the period of 2003–2010 implies a similar direction of the subsidence basin slope inclination; the size of the expected subsidence in the upper part of the slope fluctuates around 100 cm, in the lower one it is 230 cm (figure 2). Subject to ČSN 73 0039 it is possible to determine a group of building sites to which the landslide may belong to by 2010 according to the prognosis. As apparent from figure 2, the upper part of the slope deformation lies in the third group and the lower one in the second group of building sites, which represents a considerable negative effect of mining on the ground surface as well as structures situated there.

3. TERRAIN DEFORMATION PARAMETERS

On the surface of the Doubrava Oplíží slope deformation, a point was selected (with regard to the large spatial extent of mining related to a small extent of the slope deformation the solved terrain deformation parameters do not change within the landslide) where changes in terrain deformation parameters were observed based on the extrapolated values in the above mentioned four time intervals. These are declination, horizontal unit deformation in the direction and upright to the direction of subsidence basin slope inclination, radius of curvature and subsidence. Note that despite the parameters belonging to a point, they express spatial evaluation, which arises from their definitions.

The declination of the terrain may be specified as the proportion of the difference of two decline points in the subsidence basin to their mutual distance, the horizontal unit deformation represents the proportional change in length of a subsidence basin section in the horizontal direction. The radius of terrain curvature is given by the radius of an oscillatory circle of the ground surface curvature at the given point and vertical section trough the subsidence basin. The terrain subsidence characterizes the vertical component of the spatial movement of a point in the subsidence basin. As follows from figure 3, since 1995 all the values have gradually deteriorated, in the case of all the terrain deformation parameters that are determined for the classification of the given area into the building site groups according to ČSN 73 0039, which is manifested by a gradual transition of the point in question from group V to group IV. However, both the groups constitute no significant problems as for the stability of the area and the engineering structures situated there. However, this cannot be said about the impact on the stability of slope movements as it must be stressed that even relatively minute changes in the vertical direction may cause changes in the horizontal pressures which may have a very potential effect.

The chart of the course of the individual terrain deformation parameters on the Doubrava Oplíží slope deformation implies the beginning of influence between 1995 and 2000. In that period, an increase in declination may be observed, i.e. the proportion of two decline point difference in the subsidence basin to their mutual distance, while a more significant rise to the value of $2.7.10^{-3}$ rad is manifested in the following period till 2005. The horizontal unit deformation in the direction of the subsidence basin slope inclination ranges in the positive values, reaching the maximum of 1.2 at the end of the monitored period. The relative change in length of a subsidence basin section in the horizontal direction (horizontal unit deformation) upright to the direction of the subsidence basin slope inclination fell within negative values of 0.2 to 0.5. The terrain declines representing the vertical component of the spatial movement of the points in the subsidence basin grew from zero to about 43 cm between 1995 and 2005. Before 1995, the radius of terrain curvature ranged in infinity, which means that no oscillatory circle of terrain curvature existed in the vertical section. The following decreasing positive values evidence an increase in the terrain curvature with the oscillatory circle centre below the ground surface (convex curvature).

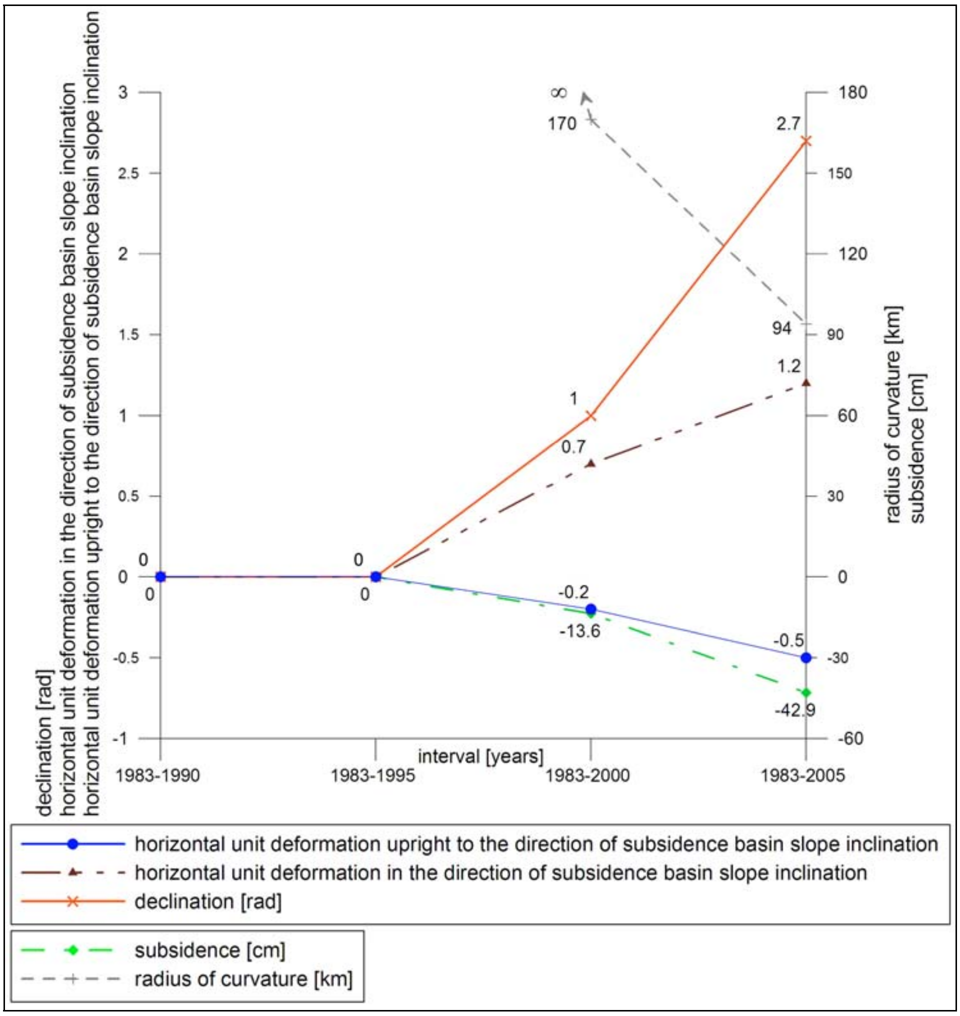

Fig. 3. Chart of terrain deformation parameter changes on the Doubrava Oplíží slope deformation during the monitored time periods

4. MEASURING SLOPE MOVEMENT

The movement of the slope deformation in Doubrava Oplíží was monitored through regular measurement of the distance of point pairs placed in such a way that one point was always situated on the stable bedrock and the second one in the landslide body. This measurement was implemented using the method of zone extensometry, while in the locality there are no engineering-geological drills provided for measuring the precise inclinometry in order to identify movements on the failure surfaces. In the course of the monitored period, relatively small movements in the order of the first centimetres were observed, with the exception of the maximum rise from 23.9 to 151.4 mm measured between March and May 2007 on a pair of points C–C´ (figure 4). Rainfall totals from two closest rainfall gauging stations were assessed as an important factor affecting the activity of slope deformations. The Station in Karviná–Staré město was closed in March 2008 and the other one is not close enough, therefore, later on only rainfall totals from the Station in Dolní Lutyně–Nerad are given in the chart.

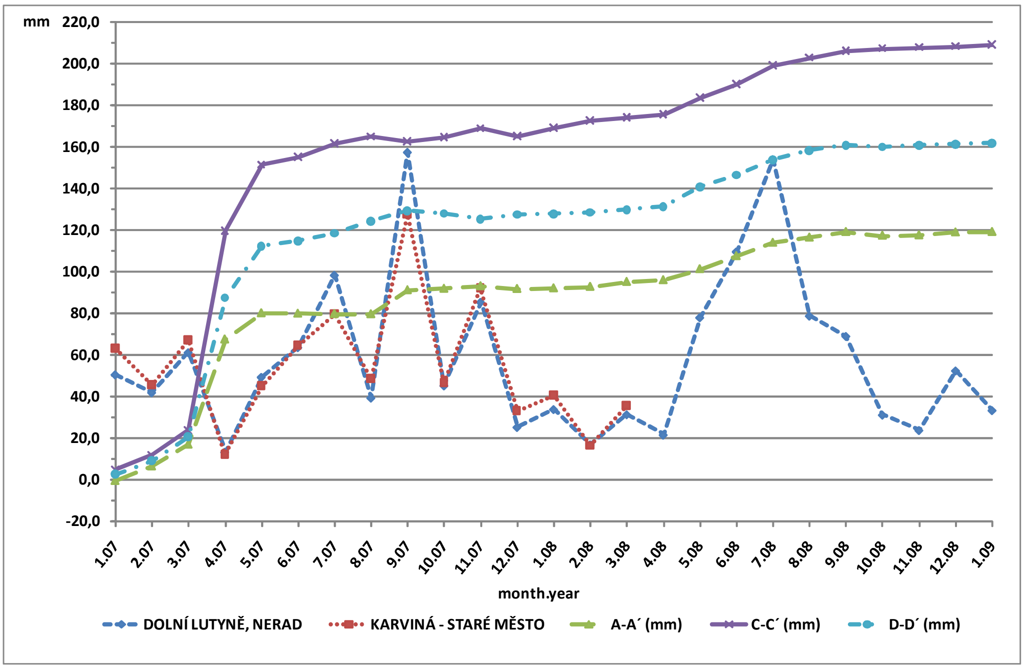

Fig. 4. Chart of measured landslide movements and monthly precipitation from two nearest rainfall gauging stations to the Doubrava Oplíží slope deformation for the monitored period

The maximum rainfall totals (about 130, or 160 mm) in both the stations were registered in September 2007, which however did not indicate change in the monitored movement size (figure 4). Based on the facts identified, the observed movements thus cannot be attributed to rainfall. The probable cause appears to be the impacts of mining that, with regard to the identically oriented thalweg of the sliding slope as well as the subsidence slope, increase the inclination of the slope deformation. The negative values of the order of millimetres may be a consequence of volume changes of the rock environment caused by fluctuation of groundwater level or its state in the near-surface zone.

5. CONCLUSION

Making use of isocatabase maps a growing negative impact of underground mining on the stability of the Doubrava Oplíží slope deformation was found. The subsidence basin slope inclination direction is oriented almost or completely identically with the direction of the landslide inclination, and thus there is a rise in the slope deformation declination. With the on-going development of the subsidence basin, a more prominent difference between the subsidence in the landslide crest and toe may be assumed, which may bring about an acceleration of the sliding movement and a follow-up failure of the asphalt road and parallel underground facilities situated in the lower part of the slope deformation.

Based on the terrain deformation parameters the slope deformation could be characterized as the 4th group of the building sites in 2005. Making use of the identified direction of the advance of the subsidence basin and the expected subsidence development (figure 2) it is probable that before 2010 the upper part of the landslide may have been classified in the 2nd group (a site conditionally unsuitable for construction) and the lower one into the 3rd group of building sites (a site unsuitable for construction). Even if the road and close underground services were found only on a mining area without any sliding movements, subject to ČSN 73 0039 Design of structures on mining areas, their improvement would probably be necessary.

The context of rainfall and landslide movements appears to be complicated because during the monitored period no sudden increase in the movements was observed as a reaction to relatively extreme rainfall totals. The only probable reaction registered at the beginning of the monitored period (March to May 2007) was the more pronounced rise in the speed and size of movements due to the melting of snow.

Based on all the above, it may be stated that the Doubrava Oplíží slope deformation is an active landslide with prerequisite growing activity due to the expansion of the subsidence basin. The subsidence basin slope inclination is identical with the slope deformation inclination and thus there is an increase in the inclination, which reduces its degree of stability and jeopardizes the road and parallel underground services running in its lower part.

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REFERENCES

[1] BRADÁČ J., *Účinky poddolování a ochrana objektů, díl I. a II*, Ostrava, Dům techniky, 1999.
[2] ČERNÝ I., *Projevy dobývacích prací v karvinské části OKR*, Sborník konf. Hornická Ostrava, Hornická společnost, ČSVTS, Ostrava, 1987, 110–119.
[3] ČSN 73 0039 *Navrhování objektů na poddolovaném území*, Základní ustanovení, 1989.
[4] ČSN 73 1001 *Zakládání staveb*, Základová půda pod plošnými základy, Validity: 1.10.1988.
[5] DOPITA M. et al., *Geologie české části hornoslezské pánve*, Ministerstvo životního prostředí, Praha, 1997.
[6] HULLA J., ŠIMEK J., TURČEK P., *Mechanika zemín a zakladanie stavieb*, Alfa, Bratislava, 1991, p. 336.
[7] MALGOT J., BALIAK F., MAHR T., *Prognóza vplyvu ťažby uhlia v Handlovskom ložisku na prírodné prostredie*, Sborník Inženýrská geologie a energetická výstavba, ČSVTS Brno, 1985, 235–242.
[8] MARSCHALKO M., FUKA M., TŘESLÍN L., *Influence of Mining Activity on Selected Landslide in the Ostrava–Karviná Coalfield*, Acta Montanistica Slovaca, číslo 1, Ročník 13 (2008), Košice, 2008, 58–65.
[9] MARSCHALKO M., FUKA M., TŘESLÍN L., *Measurements by the Method of Precise Inclinometry on Locality Affected by Mining Activity*, Archives of mining science, Polish Academy of Sciences, Vol. 53, No. 3, 2008, 397–414.
[10] NEŠVARA J., *Geotechnické zvláštnosti poddolovaných území*, [in:] *Sborník – Vplyvy banskej činnosti na železničné stavby*, DT ČSVTS, Žilina, 1985.
[11] ZÁRUBA Q., MENCL V., *Sesuvy a zabezpečování svahů*, Praha, Academia, 1987, p. 338.
[12] ŽÍDKOVÁ S. et al., *Poklesy z předpokládaného dobývání v letech 1996–2010*, karvinská část OKD – MS IMGE, Ostrava, 1996.