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*Marian Marschalko**, *Lubomír Třeslín**, *Matej Fuka**

POSSIBLE IMPACT OF CURRENT AND FORMER MINING ACTIVITIES ON A RESEARCH LOCALITY IN THE OSTRAVA-KARVINÁ DISTRICT**

1. Introduction

The research locality of Orlová-Lazy is situated in the cadastral district of Orlová Town (Fig. 1) in the Karviná District, Moravskoslezský Region which is a scientifically interesting example of an area affected by active underground mining of black coal in the Karviná section of the Ostrava-Karviná District on the north-east of the Czech Republic.

According to the geomorphological classification of the Czech Republic (publication Higher Geomorphological Units of the CR) the interest area lies in the Alpine-Himalayan system, subsystem of Carpathians, province of Western Carpathians, subprovince of Outer Carpathian Depression, section of Northern Outer Carpathian Depression, complex of Ostrava Basin and the subcomplex of Orlovská Plateau. From the regionally geological point of view the locality belongs to the North-Moravian section of the Carpathian fore-deep, Ostrava glacigenous basin.

Signs of activity attributed to slope movement in the first stages showed in the locality. However later, activity showed on discontinuous deformations originating due to undermining at probable coactions of copying the geological predispositions of the so-called Orlovská fault (Fig. 2). Older slope deformations were stabilized by fly ash embankments. The locality is in the interference of two impacts of undermining, fading effects in the northern part with millimetre subsidence (Poruba working district, mine J. Fučík, plant Žofie (fading away impacts, mining was terminated in 1998) and in the southern part with subsidence values in tens of centimetres conditioned by still active mining in Lazy Mines (Karviná I — Lazy working district).

* Hornicko Geologická Fakulta, VŠB-Technická Univerzita Ostrava, Ostrava-Poruba

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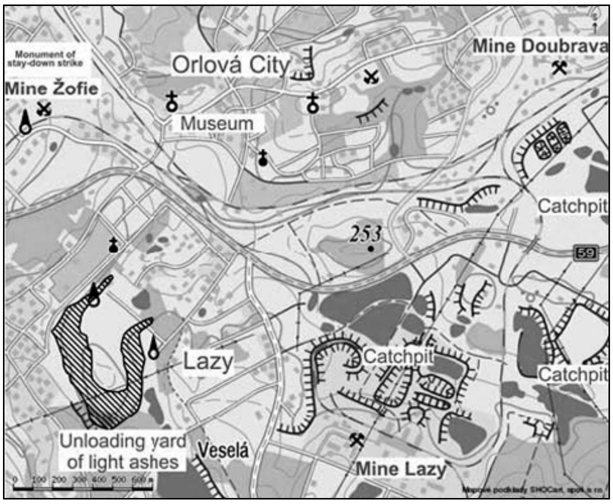

Fig. 1. Localization of the Orlová Lazy interest area

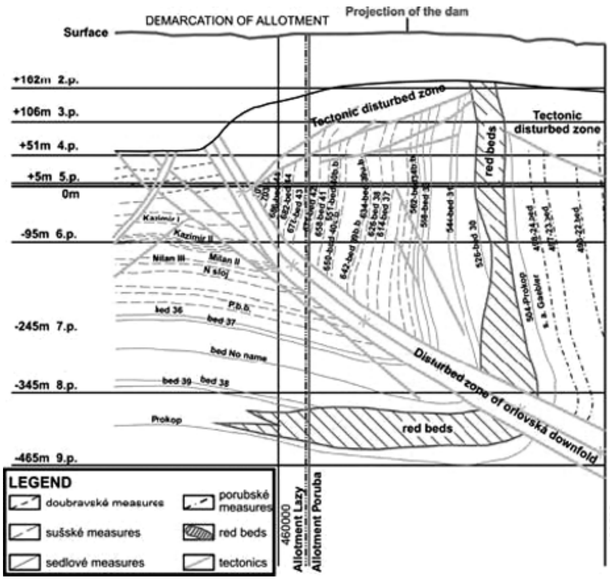

Fig. 2. Skeleton geological structure of the locality bedrock

The geological structure of the interest area (Fig. 3) as a whole is quite complex and varied. The Quaternary sedimentation (loess loam, glacigenous sediments — salic, elster) is genetically varied; in the individual sections of the interest area it considerably changes both in the horizontal and vertical direction as a result of uneven surface of the pre-Quaternary bedrock (claystone).

The natural layer sequence was disrupted by extraction of sand and brick loam, and follow-up utilization of the area as a disposal site (embankments).

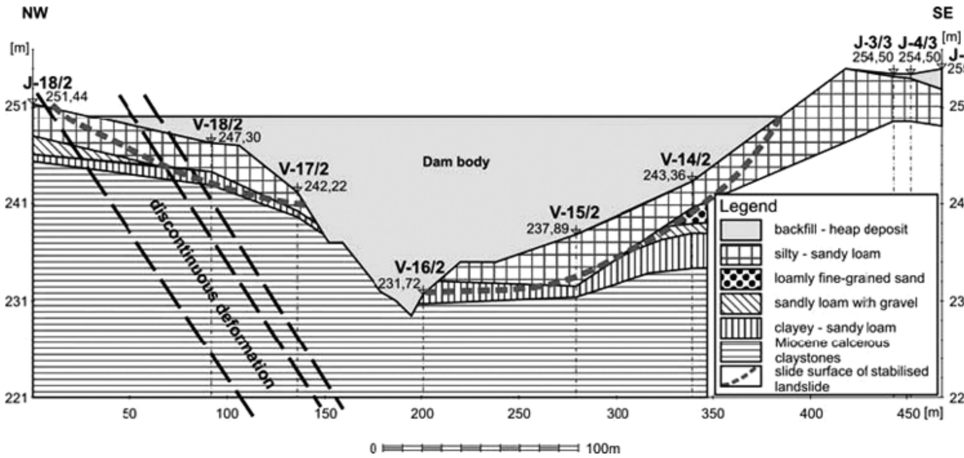

Fig. 3. Geological section in the interest locality Orlová-Lazy

2. Geofactor of undermining

An important geofactor arising due to negative impacts of anthropogenic interference is undermining with subsidence of the ground surface. Mining activities during excavating mineral resources under the ground brings the above mentioned undermining which applies to the areas within the reach of underground mining of mineral resources. In the studied area mining of black coal falling in the Ostrava-Karviná District took place there in the past.

According to ČSN 73 0039 Standard (Design of premises on undermined areas), apart from engineering-geological survey and other common documentation, an analysis of mining conditions (mining assessment) must be added to the application for zoning and planning decision and for building permission subject to the provisions for undermined areas. It deals with an analysis of safety conditions for the premises built on an undermined area, which rate the character, parameters and possibly time course of the terrain transformation due to the impact of underground mining.

According to the size of undermining impact, observed manifestation and intensity of expected deformations in the studied area or its parts, there are the following groups:

I) area with potential occurrence of compound faults and extraordinary large deformations,

II) impact of undermining will always affect constructions above foundations; as a rule, the premises therefore need complete protection from undermining with possible rectification from delevelling,

III) it can be estimated that after small constructional measures also flexible constructions can be designed there. Stress from undermining is usually over 10% of standard material strength,

IV) stress on the constructions above the foundations is below 10% of standard material strength,
V) stress from undermining is very low, lower than 30% of stress from other effects.

In group I there are also areas where there are potential discontinuous terrain deformations (compound faults).

In terms of the impact of undermining on the constructions there are the following rules:

- building sites of group V are suitable for all types of structures,
- building sites of groups III and IV are conditionally suitable, namely according to the solidity and size of the load-bearing structure and the arrangement of the building; construction protection from the impacts of undermining is still financially acceptable,
- building sites of groups I and II are unsuitable; placement of constructions on such areas must be justified if they are simple premises with sufficient endurance and minimal sensitivity.

In general, the most suitable are such areas where on the surface there is a continuous layer of soils which absorbs the undermining impacts better than solid rocks. Unsuitable are such areas where the foundation soils are solid rocks and semirocks (also in the groups III and IV) (Pašek J., Matula M., 1995).

Due to undermining there are changes in tension and physical-mechanical properties of the foundation soils. Especially in the tension zones at the edges of subsidence troughs there is a decrease in the number of grains contacts, the soils eases, there is a drop in shear strength and a rise in compressibility (Čurda *et. al*., 1992).

3. The impact of undermining in the studied locality

In wider surroundings of the researched locality the development of the subsidence trough, which is characteristic for undermined areas, is apparent from ground subsidence maps in four chronological time intervals (provided by OKD a.s. company). They are supplemented by summarizing and forecast periods. The intervals are chosen approximately evenly from 1983 (beginning of levelling) to 2005; the summarizing interval includes subsidence from 1983 to 2002, which is followed by an interval showing forecast till the year 2010 (since 2003).

In the first interval 1983 to 1990 a subsidence trough had already developed in the surroundings of the observed locality, with maximum subsidence of 200 cm in the right section (See Fig. 4). In the site of the dam with discontinuous deformations the closest is isocatabase 10 cm; considerable density of isocatabases gives evidence of the subsidence trough slope gradient of about 1:400, which increases in the right part of the figure to approximately 1:120. In the following period 1983–1995 a distinct rise in subsidence is apparent, especially in the right part of Figure 4.

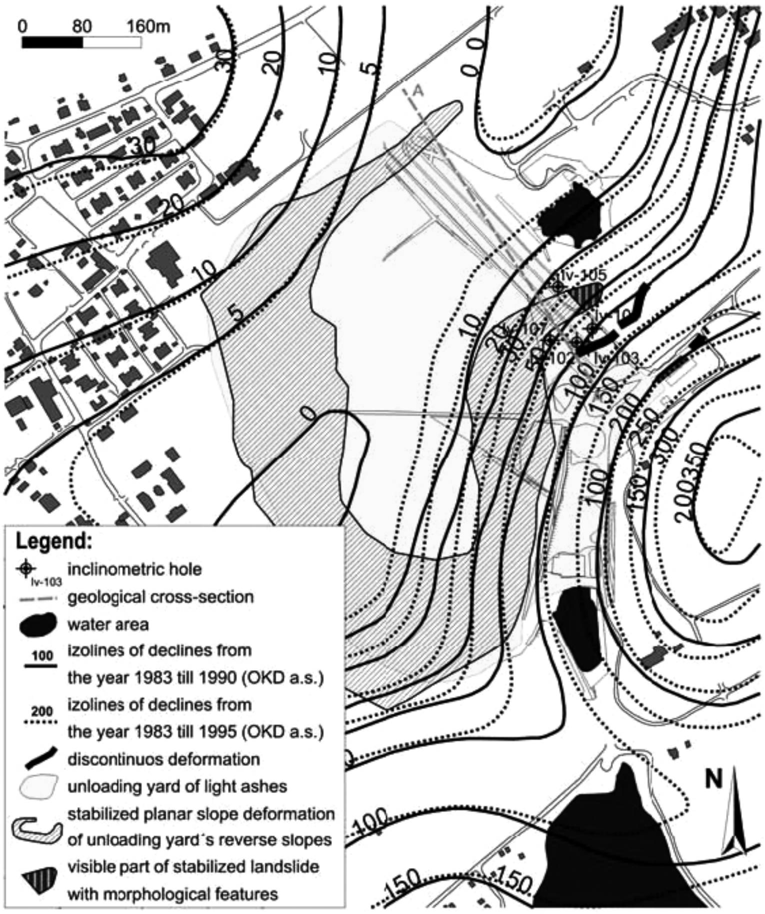

Fig. 4. Subsidence caused by undermining between 1983–1990 and between 1983–1995 in the locality of Orlová Lazy

In the third interval 1983–2000 subsidence is quite similar in the observed area (about 75 cm) as well as the subsidence trough slope gradient approaches 1:100. A significant increase of roughly 50 cm can be observed in this period again in the right part of Figure 5, south-eastwards from the observed locality. Maximum subsidence trough slope gradient corresponding to the maximum gradient of the previous period (about 1:80) may be seen in the identical area. Within wider surroundings of the observed area, there is an identical trend with the subsidence trough also till 2005.

Around the earth dam there is no change in the subsidence or the subsidence trough slope gradient compared with the previous period; the highest increase in subsidence (of 50 cm) and gradient (to 1:60) can again be registered in the right part of the position (Fig. 5).

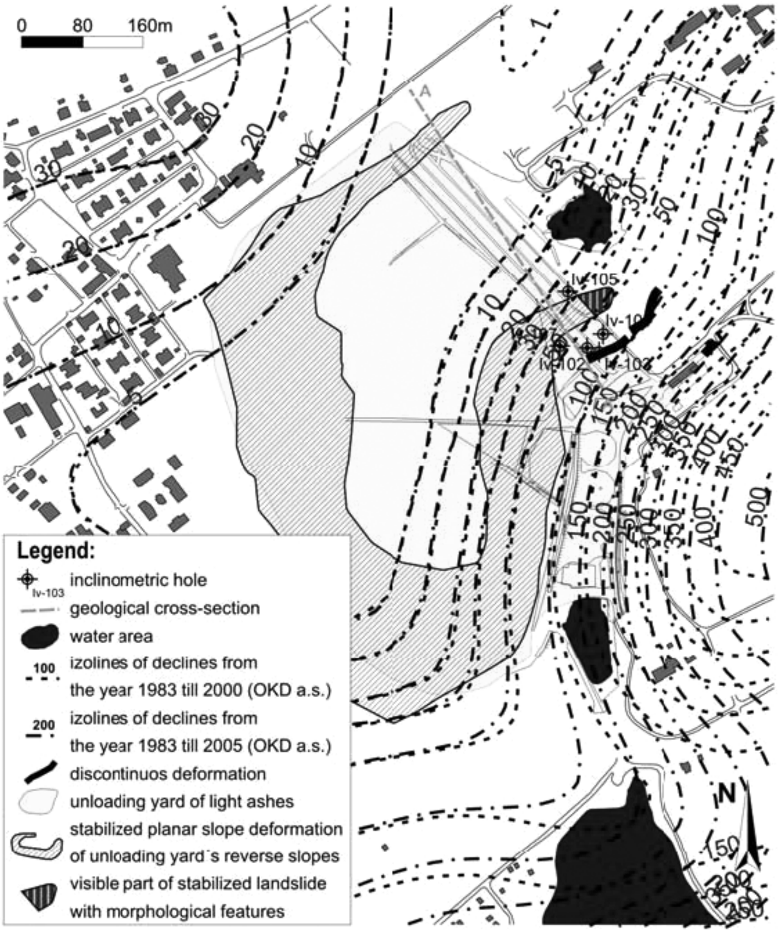

Fig. 5. Subsidence caused by undermining between 1983–2000 and between 1983–2005 in the locality Lazy

The last state of affairs (Fig. 6) represents a summary of subsidence between 1983 and 2002, forecast of subsidence increase and distribution of building site groups (as of ČSN 73 0039 Standard) between 2003 and 2010. The building site groups are characterized in the previous chapter. A subsidence value of about 435 cm may be estimated in the observed area adding the subsidence represented by the real isocatabase (subsidence till 2002) and forecast one (2003–2010).

The same reference method may deduce the subsidence trough slope gradient in the place of the dam as 1:40. In terms of forecast building site group distribution, the observed area will in all probability be in group I, i.e. the most extensive negative impact on the ground surface due to undermining.

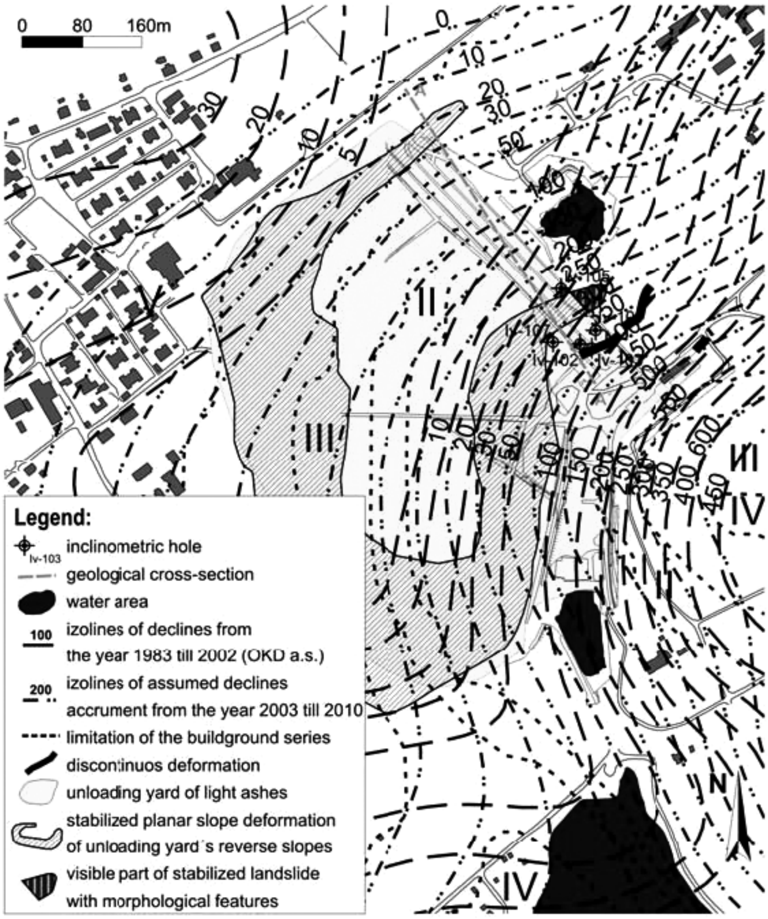

Fig. 6. Subsidence caused by undermining between 1983–2002 and subsidence increase forecast between 2003–2010 in the locality Lazy

The locality Orlová Lazy was also assessed in terms of changes in ground deformation parameters. For such purposes a point was selected on the ground surface (with regard to large surface area of undermining in proportion to the small area of the discontinuous deformation the discussed deformation parameters within this deformation do not change) with which changes in ground deformation parameters were observed based on extrapolated values in the time periods mentioned above, namely inclination, horizontal proportional deformation in the direction and perpendicularly to the subsidence trough slope gradient direction, curve radius and subsidence.

This fact is also confirmed by the definition of the individual parameters. The terrain inclination can be specified as the proportion of subsidence differences of two points in a subsidence trough to their mutual distance. The horizontal proportional deformation represents a proportional lengthwise change of a subsidence trough part in the horizontal direction. The terrain curve radius is given by the radius of an osculating circle of terrain surface curvature in the given point and vertical section trough the subsidence trough. The terrain subsidence characterizes the vertical component of spatial movement of a point in the subsidence trough.

Despite the parameters being related to the point, they express spatial evaluation of a wider area, which may be characterized by an approximately identical subsidence value and gradient as well as subsidence trough slope position. Figure 7 represents a chart of development values of the ground deformation parameters that are subject to ČSN 73 0039 Standard used to assess the so-called building site groups. According to this criterion, the locality fell into the 5th group in 2005.

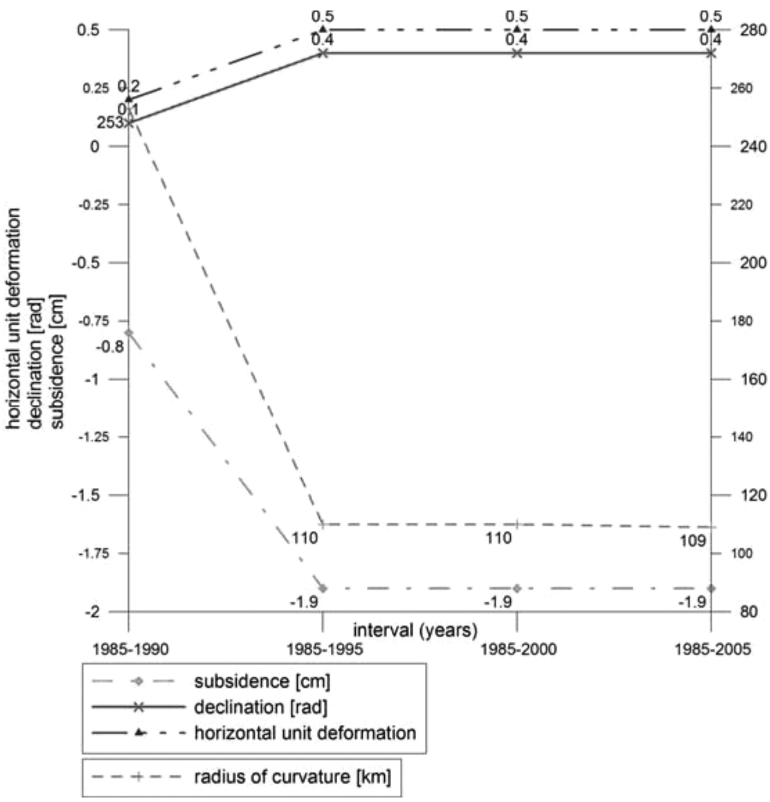

Fig. 7. Changes in ground deformation parameters in the locality Lazy during a selected time period

The development of the ground subsidence marked in the chart by a dot-and-dash green curve may be generally specified by very low values, while since 1995 the vertical component of the spatial movement has stayed unchanged at 1.9 cm. The ground inclination may be expressed by the proportion of the subsidence difference of two points to their mutual distance; it increased similarly to subsidence only between 1990 and 1995, i.e. from 0.2 radian (11.46°) to the value of radian (28.69°), which has not changed since 2005. The development of horizontal proportional deformation imitates the development of inclination; it differs only in values lower lower by 0.1 radian (5.73°). The rise in the proportional longitudinal change of one subsidence trough section may be again observed only during the period of 1990 to 1995; positive values express ground surface elongation. The curve radius values changed considerably during the monitored period also between 1990 and 1995, namely from 253 km to the value of 110 km. Based on these positive values the centre of osculating circle of curvature may be localized below the ground surface and the curvature may be characterized as convex.

In order to identify the size and direction of movement caused by the discontinuous deformation we used the method of precise inclinometry. This measuring was done regularly on a number of holes, one of which (Iv-1) was selected to assess the size of movements as it was suitably located towards the discontinuous deformation. Measuring of the hole shaft inclination (precise inclinometry) is carried out in two mutually perpendicular planes A+A–, B+B–, while the direction A+ is selected in a way it best corresponded with the estimated movement vector. The representation of the results is done in two ways, namely as a difference of accumulated horizontal components (vertical view), out of which it is possible to read the size of movements in the individual planes and depth intervals. The second method is representation in the horizontal projection, which permits clear identification of the direction of movements on expected discontinuous deformation. Based on both representations it is possible to determine exact depth of the discontinuous deformation in the place of an engineering-geological hole and infer its probable course in a wider area.

The difference of accumulated horizontal components in the direction A+ on the first assessed hole Iv-1A reaches maximum shift values around 24 mm (end of 2008) in the depth interval 10.5÷12 m (Fig. 8). In the direction of plane B the biggest shift of about — 13 mm may be observed during the equivalent period and same depth interval. The direction of the shifts is well apparent from the horizontal projection and may be matched approximately north-westwards (Fig. 9). Occasional irregularity in the shift increase, i.e. the fact that for example the shift value taken in November 2008 is higher than the value taken in September may be caused by current continuous deformation of the ground or fluctuation of the ground water level.

To evaluate the causes of terrain surface unstabilitys it is suitable to place one well outside the discontinuous deformations or slope deformation body, especially in the localities where there can be potential impact of undermining on these phenomenons. Therefore, the inclinometric well Iv-3 was chosen. It is apparent from Figures 10 and 11 that the well tilts. However, it is not affected by the movement and thus it unambiguously documents the impact of undermining in the locality, which is also evidenced by the above mentioned isocatabase map.

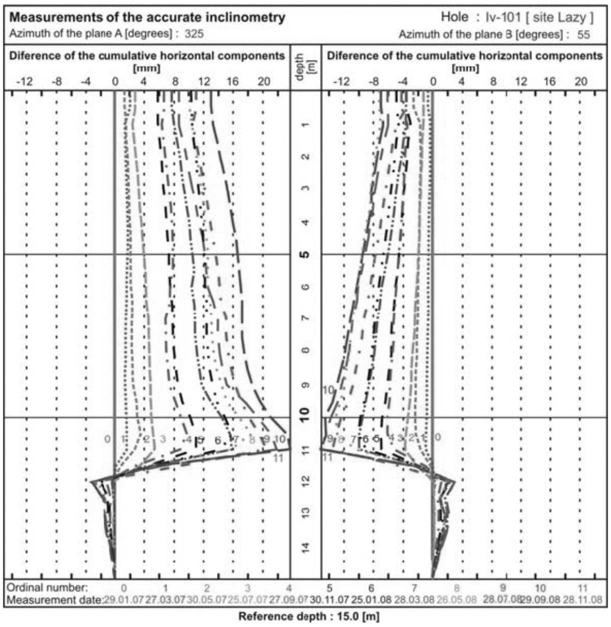

Fig. 8. Measuring of precise inclinometry in the hole Iv-101 in the locality Orlová Lazy — vertical view

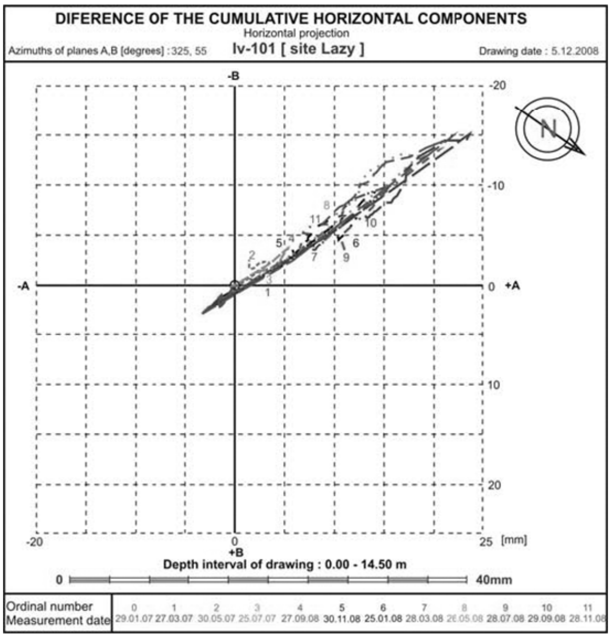

Fig. 9. Measuring of precise inclinometry in the hole Iv-101 in the locality Orlová Lazy — horizontal view

The shifts registered by inclinometric holes must be correlated with precipitation depth in the relevant time periods. Based on the correlation it is possible to deduce and assess whether and to which extent the precipitation depth size affected the measured movement values. Figure 12 shows precipitation depths taken in two rain gauging stations situated closest to the interest locality. The highest value was taken in September 2007, which should be primarily correlated with movements on the discontinuous deformation. If the impact of maximum precipitation depth in the given time period is not provable, it is low probable that lower rainfall in other months had any significant impact on the identified movements.

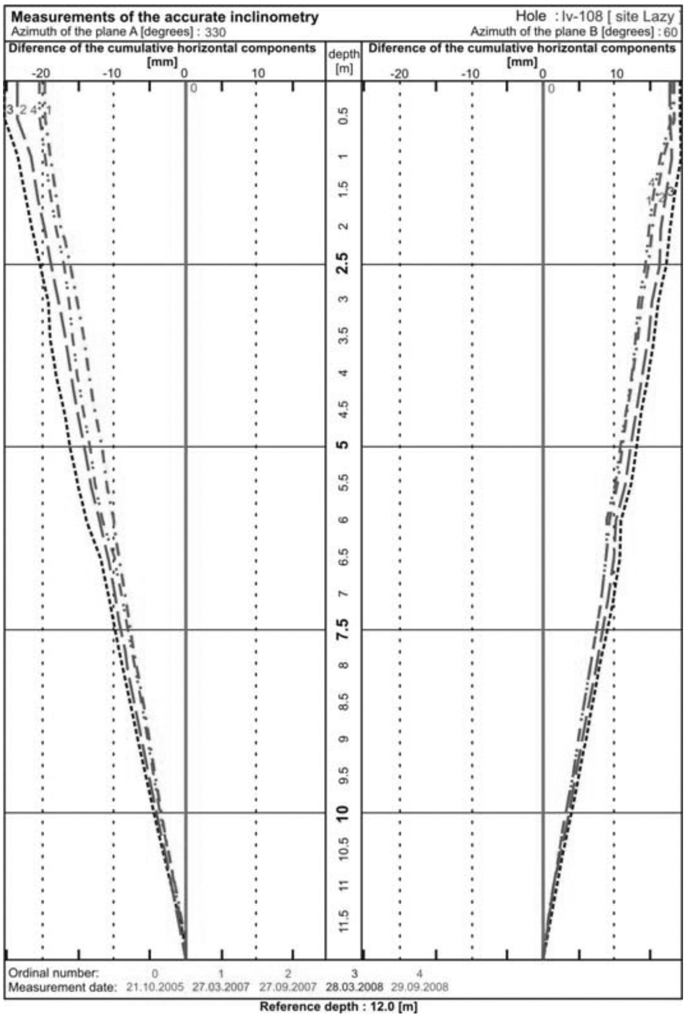

Fig. 10. Measuring of precise inclinometry in the hole Iv-103 in the locality Lazy — vertical view

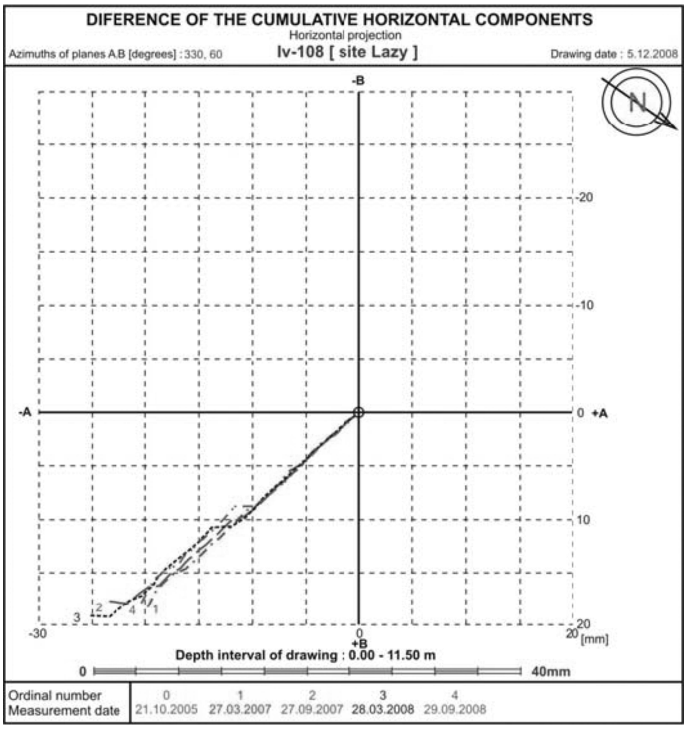

Fig. 11. Measuring of precise inclinometry in the hole Iv-103 in the locality Lazy — horizontal view

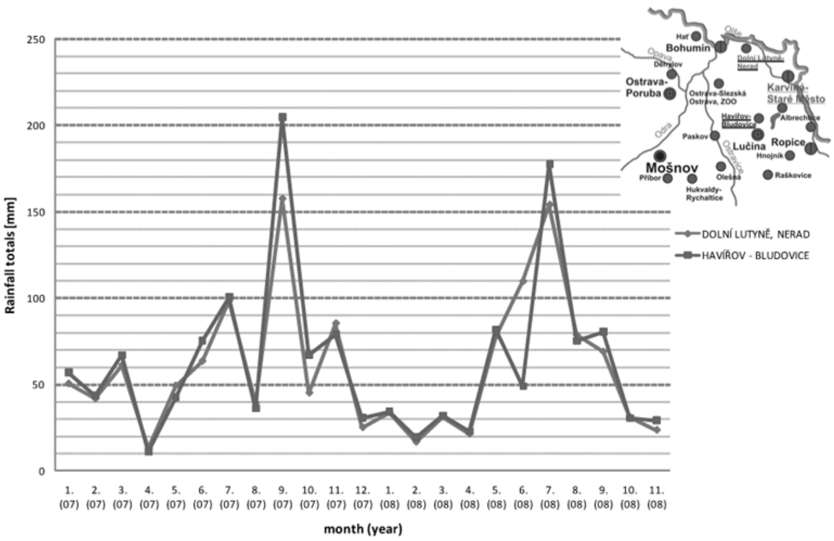

Fig. 12. Chart of monthly precipitation depths from two rain gauging stations situated closest to the locality Orlová Lazy for the period from January 2007 to January 2008

The impact of maximum precipitation depth on the measuring taken in hole Iv-1A is not evident and it is disputable in case of measuring in the hole Iv-3 as the cause of the mentioned changed orientation of the first movement between measuring 26 (June 2007) and 27 (September 2007) cannot be proved. The course of shift curves after measuring is already comparable and thus no extraordinary influence of rainfall may be assumed.

4. Conclusion

The subject of the research described in the paper was authentication of the impact of undermining on the stability of the interest locality Orlová Lazy, which showed the circumstantial evidence of slope instability first attributed to slope movement. However, later the existence of discontinuous deformations was proved.

According to the identified ground deformation parameters, the locality is situated on the edge of a subsidence trough with a convex course accompanied by dilatation. The position of the discontinuous deformations was probably affected by tectonic predisposition of the so-called Orlovská fault and vertical strata. This is all substantiated by earlier deposit survey for black coal mining, the results of which were recorded in the first stage of the archive study.

It was combination of inclinometric measuring correlated with isocatabase maps in different time sections retrospectively as well as on forecast ground deformation parameters, which proved optimal for the identification of the influence of underground mining on the identified discontinuous deformation. The obtained information shows clear time continuity of mining impacts. Based on the comparison of maximum movements from inclinometric measuring and precipitation depths taken in the closest rain gauging stations of ČHMÚ there is an apparent time incongruity in both phenomena. Therefore, it can be stated that the movement activity on the discontinuous deformations may be attributed, in all probability, to the only dominant, proved geofactors of undermining impact which was active in the studied period.

Undermining caused by underground mining of black coal in the Karviná part of the Ostrava–Karviná District clearly affects the changes in the engineering-geological conditions, while apart from the above identified facts it also influences the changes in the state of stress in slopes, structure and physical-mechanical properties of the rock material, regime of ground water level changes, etc. The identification of undermining impact should become an automatic part of each engineering-geological survey or research in all localities in which there is a potential influence of mining activities based on their geographical position. This can be easily identified comparing the position of the locality expanding the working districts stated in the geopool or mining offices.

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