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FORMER MINING AREA IN TERMS OF SUBSIDENCE CAUSED BY UNDERMINING AND SLOPE MOVEMENTS IN THE LOCALITIES OF SLEZSKÁ OSTRAVA, VÍTKOVICE AND RADVANICE**

1. Introduction

The subject of the study is two important geofactors limiting the utilization of landscape in terms of landscape planning, i.e. undermining and slope movements. The interest area is situated in Ostrava and is determined by a map sheet in 1:10 000 scale (map sheet number 15-43-10) and this area has been affected by hard coal mining [6, 7, 15, 16]. Therefore, for such areas and similar territories surface subsidence caused by undermining is a significant land use planning factor. The second, also very important geofactor is slope deformation. Slope movements make the land use more complicated. In case of land use planning for the construction needs there is a better quality engineering-geological survey and subsequent, more complicated and more financially demanding foundation engineering taking into account the character of stability conditions of the given slope deformations [3, 9].

The mentioned geofactors have been registered in the interest area by means of geographic information systems and overlapped with the layers of the current and former built-up area [8].

The area of interest represents part of cadastral territory of Ostrava city. According to a regional geology, the area of interest belongs to Ostrava Glacial Basin, that is a part of front Carpathian fore-deep of Outer Western Carpathians.

Quaternary sediments represent Holocene fluvial deposits of lower and upper alluvium plane and anthropogenic deposits such as backfills and dumps. Quaternary deposits represent glaci-fluvial, fluvial, deluvial deposits, loess loam, and Tertiary eluvia [1].

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Quaternary aquiferous systems are created a pores, incoherent sands, gravel-sands. The water is an atmospheric origin. It keeps oxidized environs within the area of intensive circulation with the earth ground [2].

Neogene sediments are underlying of Quaternary deposits. They contain pelite sediments especially. Pelite represents greenly grey to grey calcareous clays with the variable carbonate content.

Pre-Variscian crystalline basement called brunovistulikum is underlying of Neogene. Brunovistulikum contains migmatites and migmatitic paragneiss. Upper components are Moravian Karst Devonian deposits, and Lower Carboniferous Culm. Upper Carboniferous sediments begin with basal coarse grained sandstone, subsequently siltstone with rooty aleuropelite, coal seam, and, finally aleuropelite or pelite with the limnic, brackish or sea fauna [1].

Based on the engineering-geological map [13] the interest zone is characteristic for the zone of polygenetic loess sediments (Lp); zone of alluviums lowland streams (Fn); spoil banks, stock piles and dumps zone (An); zone of settling basins and waste dumps (Ao); deluvial sediments zone (D); predominantly cohensionless glaciofluvial and glacial sediments zone (Gf); deluvial-fluvial sediments zone (Du); zone of Pleistocene river terraces (Ft); undiscriminated flysch sediments zone (Sf) and predominantly cohesive drift zone (Gm). Each zone is described with age and the character of soils, subzones and orientation classification of soils into classes based on the grain-size distribution, according to Standard 73 1001, and into workability of rocks based on the characteristic properties and difficulty in disintegration, which is dealt with in ČSN 73 3050 Standard (Earthwork) [11, 13].

2. Evaluation of subsidence caused by undermining and slope movements in the area of Slezská Ostrava, Vítkovice and Radvanice

An important geofactor arising due to negative impacts of anthropogenic interference is *undermining* with subsidence of the ground subsoil surface. Underground Mining activities during excavating mineral resources produces above mentioned undermining.

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 planning decision and for building permission subject to the provisions for undermined areas [4, 14]. It deals with an analysis of safety conditions for the premises buildings an undermined area, which rate the character, parameters and possibly time course of the terrain transformation due to the impact of underground mining [5].

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:

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

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

In group I there are also areas where 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.

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) [12].

In the studied area it is possible to come across the manifestation of undermining in the form of subsidence troughs that are for example found in the bottomlands of the Ostravice River. In those localities even during smaller subsidence waterlogging of the surface occurred and saturated drainless troughs were formed. The subsided areas were followingly filled with various waste, embankments and dumps or they were further land reclaimed [14].

Due to undermining there are changes in tension and physical-mechanical properties of subsoils. Especially in the tension zones at the edges of subsidence troughs there is a decrease in the number of grains contacts the soils eases and shear strength and decrease compressibility.

Subsidence caused by undermining was monitored in the interest area in two time intervals. It was discovered that in the studied period the whole interest area was affected by ground subsidence. The values and the course varied with time, namely in connection with the termination of mining. There was a gradual decrease in the subsidence effects close to the present [10].

In the time of the first time interval (from 1961 to 1999) more serious effects of undermining were identified, manifested by values with maximum 300 cm (Fig. 1).

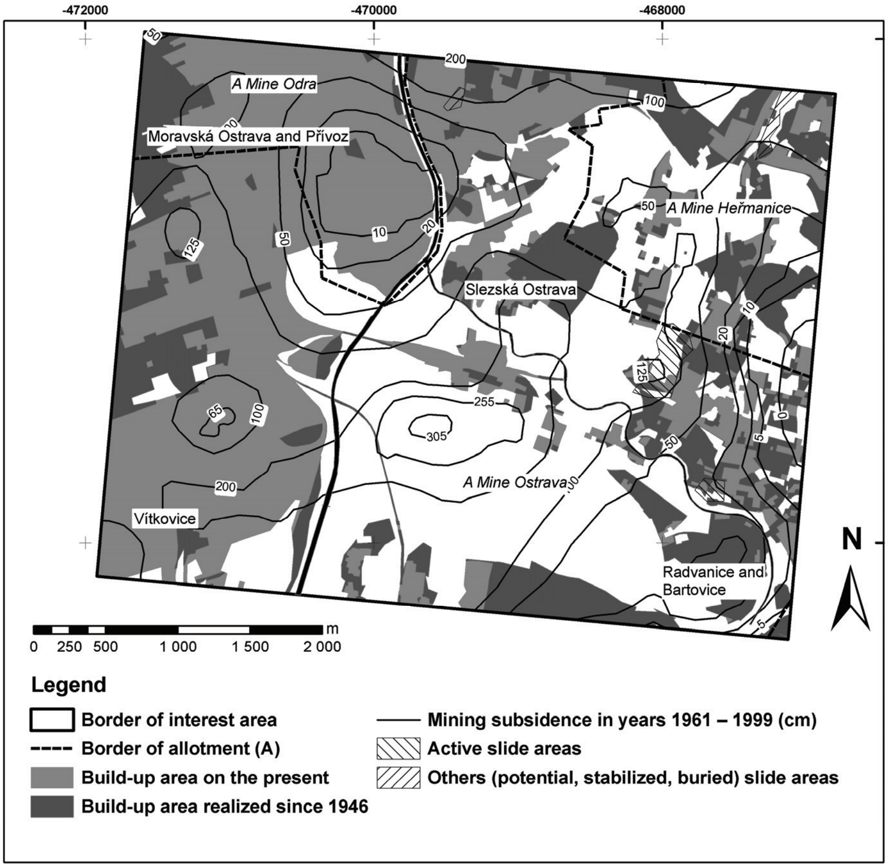

Fig. 1. Mining subsidence between 1961 and 1999 with marked changes in the built-up area

These were observed in the area between the Lučina and Ostravice Rivers. From the point of view of the affected area, localities were classified according to the following subsidence: 0–10 cm (1.26 km^2 — 6.9% of the area), 10–50 cm (4.16 km^2 — 22.7% of the area), 50–100 cm (5.48 km^2 — 30% of the area), 100–200 cm (5.72 km^2 — 31.3% of the area), 200–300 cm (1.62 km^2 — 8.8% of the area) and 300 cm and more (0.04 km^2 — 0.2% of the area). The landscape element which is affected the most from the point of view of people is the built-up area. It was found out that in the given period the whole built-up area was affected by subsidence (subsidence below 10 cm — 0.9 km^2 — 8.3% of the built-up area; 10 to 50 — 2.47 km^2 — 22.8% of the area; 50 to maximum values — 7.48 km^2 — 68.9% of the area) [10].

The second time interval, i.e. from 1990 to 1999, shows (Fig. 2) that the subsidence affected only a small part of the area (32.8%, out of which 44.4% is built up) with local maximums up to 20 cm, which is situated north-west off the interest area, in the district of Moravská Ostrava and Přívoz. During this period subsidence from 0 to 5 cm affected

23.8% of the area (4.3 km^2), subsidence from 5 to 10 cm — 4.6% (0.8 km^2), subsidence from 10 to 20 cm — 3.3% (0.6 km^2) and subsidence from 20 to 30 cm affected 1.2% of the area (0.2 km^2). Even more significant is the relation to the built-up area, subsidence 0–5 cm affected 29.3% of the built-up area (3.2 km^2), subsidence 5÷10 cm — 7.5% (0.8 km^2), subsidence from 10 to 20 cm — 5.5% (0.6 km^2) and subsidence from 20 to 30 cm — 2.1% (0.2 km^2).

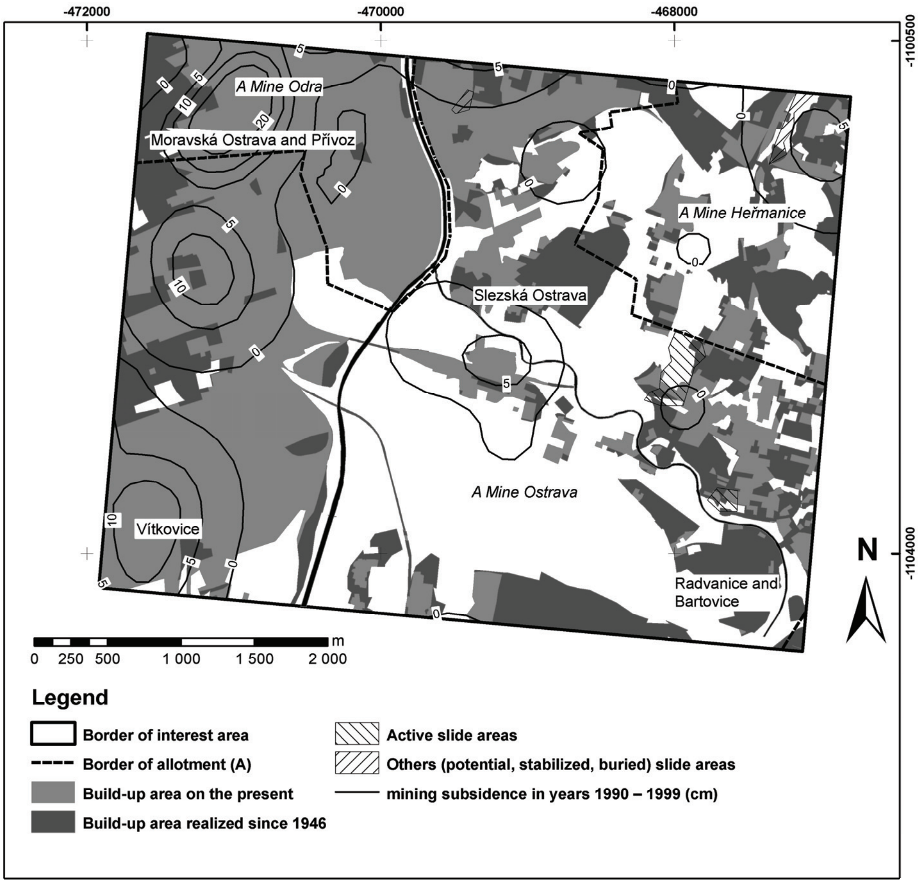

Fig. 2. Mining subsidence between 1990 and 1999 with marked changes in the built-up area

Another geofactor from engineering-geological conditions that significantly influences foundation engineering and landscape planning is slope stability, especially in relation to the existing of *slope deformations*. Slope deformations are the results of slope rock movement processes, where rock material goes down the slopes due to gravity, with the exception of such movements during which material is carried off by transportation media (water, snow, wind) in a conventionally set ratio larger than 50%.

In the studied interest area, localities affected by slope movements were marked in maps (see Figs. 1 and 2). There are four slope deformations of a slide character with a various activity.

The first one is a slide in the north of the interest area, in Čedičová Street in Slezská Ostrava, which is stabilized and according to the plan view of the deformation is frontal (width is considerably larger than the length).

The second slide is in Michálkovice. It is a potentional slide and according to the plan view of the deformation it is frontal.

The largest slide in the interest area is an active, frontal slide near the former Ján Maria Mine, which is mostly covered by forest, but dangerous the adjacent railroad.

The last slide is in Radvanice (Karvinská Street). It is active and according to the plan view of the deformation it is planar (the length is almost identical with the width).

The area endangered with slope deformations should be marked in all maps to do with landscape planning or engineering-geological conditions as, in terms of potential risks, they represent the most endangered localities. In the interest area, such affected localities cover 0,1 percent of the interest area and they are localized on the maps (Figs. 1 and 2).

3. Conclusion

One of the factors, which most changes the engineering-geological conditions, is mining activities, on the surface ground and underground. Underground mining that concerns the studied area forms a subsidence trough, within which uneven settlement, slope deformations and changes in hydrogeological conditions can occur. Since 1946 subsidence has affected up to 100% of the interest area (area that was closed by a polygon with subsidence over 5 cm.)

On the basis of both time intervals in relation to terminated mining activities in the Ostrava part of the Ostrava-Karviná District there is a clearly apparent decrease in the subsidence values, while in the future the values will be nearly zero. This is a positive trend, especially for foundation engineering and protection of the existing buildings. It is further apparent that the built-up area has surprisingly resisted a lot in such negatively affected environment, while the most unfavourable effects were on the edges of the subsidence troughs. The impact of undermining must be dealt with on an individual basis in relation to the above standard for structures on an undermined area, which rates 5 categories of posts according to horizontal deformations N (‰) ($mm.m^{-1}$), curve radius R (km) and delevelling D (‰) ($mm.m^{-1}$).

A very dangerous factor for foundation engineering and landscape planning is the existence of slope deformations. In the interest area, slope movements affected 4 localities (a slide in Čedičová Street in Slezská Ostrava, a slide in Michálkovice, a slide near the former Ján Maria Mine and a slide in Radvanice, Karvinská Street), which are localized in the created maps.

Due to reduction of suitable space for development, it is necessary (and many times there is no other option) to build in areas which were earlier referred to be as unsuitable. These areas can be sometimes preferred, for example thanks to a nice view, environment, etc. These days, it is possible to build on soils with low bearing capacity, high compressibility and also on areas endangered by mass deformations. In these cases, foundation requires appropriate steps even when it means increased cost of construction.

A good-quality geological survey is the basis. It defines all existing mass deformations in the area and establishes their types and current level of activity. Considering the fact that movements have a different character and can affect the structures to be built in different ways, there can be no intervention in the rock mass without perfect knowledge of the movements mechanism, causes and development history. The main goal when building on a landslide area is to secure the area stability. To achieve this, the course of sliding planes has to be determined first, which also represents the basic supporting material for calculation and evaluation of landslide area stability.

During spatial planning or rather in the initial stages of selecting and buying a building plot for the needs of create a new engineering object or just before beginning building site, it is necessary to evaluate the slope stability in the place, especially in relation to potentional existence of slope deformations. For such needs in the initial stage archive materials must be studied (a slide map register in particular). It happens that about the existing slides state administration staff do not know (building offices, landscape planning departments, etc.) and builders know about it even less.

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