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EVALUATION OF LANDSCAPE ELEMENT CHANGES BY MEANS OF GIS IN FORMER MINING DISTRICTS OF OSTRAVA-JIH, VÍTKOVICE, MORAVSKÁ AND SLEZSKÁ OSTRAVA, PŘÍVOZ, RADVANICE AND BARTOVICE

HODNOCENÍ ZMĚN KRAJINNÉHO CHARAKTERU POMOCÍ GIS V BÝVALÉ HORNICKÉ OBLASTI OSTRAVA-JIH, VÍTKOVICE, MORAVSKÁ A SLEZSKÁ OSTRAVA, PŘÍVOZ, RADVANICE A BARTOVICE

Abstract

The paper deals with the results of an analysis of landscape element changes, such as forests, water areas, agricultural areas, built-up areas, anthropogenic structures in the selected area. The applied method makes use of the possibilities of Geographical Information Systems, terrain observation, documentation and study of archives. The starting time period for which the landscape character analysis was carried out is the year of 1946 (military aerial photos) and the present time (last maps -1996). The research is localized in the selected area of the city of Ostrava, which has been affected by former mining of black coal. Ostrava, which is situated in the north-east of the Czech Republic, belongs among the worst affected European regions, with regard to landscape and environmental changes, and thus it is suitable for the above-mentioned research. The overall project was divided into nine model areas (1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 3c), while this paper evaluates a partial model area of 2c, which is defined by the aerial photos No. 655, 657 and 659 from 1946. Namely they are Ostrava-Jih, Vítkovice, Moravská and Slezská Ostrava, Přívoz, Radvanice and Bartovice. The mentioned methodology was applied in the interest area for the first time and thus the results are awaited by the expert public.

Abstrakt

Cílem studie, které výsledky jsou uvedeny v této publikaci, je analýza změn krajinných prvků jako jsou lesy, vodní plochy, zemědělské plochy, zastavěné plochy, antropogenní plochy ve vybrané oblasti. Metodika, která to umožňuje využívá možnosti geografických informačních systémů, terénního pozorování, dokumentace a archivního studia. Výchozími časovými úseky v kterých je prováděna analýza změn krajinného charakteru je rok 1946 (vojenské letecké snímky) a 1996 (poslední mapové podklady). Lokalizace výzkumu je vybrané oblasti města Ostravy, která byla ovlivněna bývalou hornickou činnosti těžbě černého uhlí. Ostrava, která se nachází v severovýchodní části České republiky patří k nejvíc postiženým regionům Evropy, co se týče změn krajiny a životního prostředí a proto je velmi vhodná na uvedený výzkum. Celý projekt byl rozdělen na devět modelových oblastí (1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 3c), přičemž publikace hodnotí dílčí modelovou oblast 2c, která je vymezena leteckými snímky č. 655, 657 a 659 z roku 1946. Jedna se o oblast Ostrava-Jih, Vítkovice, Moravská a Slezská Ostrava, Přívoz, Radvanice a Bartovice, uvedena metodika je zde poprvé uplatněna a proto jsou její výsledky velice očekávány odbornou veřejnosti.

Key words: environment, mining, landscape elements, aerial photos, GIS

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Introduction

The monitored area [1-15] is located in the cadastral district of the municipalities of Ostrava-Jih, Moravská Ostrava and Přívoz, Slezská Ostrava, Radvanice-Bartovice. The border of the monitored area is given by the meet of the topographic maps and aerial photographs. The topographic maps are in the scale of 1: 10 000 (map sheet No. 15-43-09, 15-43-10, 15-44-06, 15-43-14, 15-43-15, 15-44-11), issued in 1996, compiled as per 1995 by Czech Surveying Administration in Opava. The aerial photos (No.655, 657 and 659) showing the state as per 1946, were compiled by the Military Institute of Topography. The monitored area, i.e. 29.785 km^2, is represented in Figures 1 and 2. Among working districts (WD) extending in the monitored area there are: WD Vítkovice, WD Slezská Ostrava, WD Radvanice, WD Petřvald.

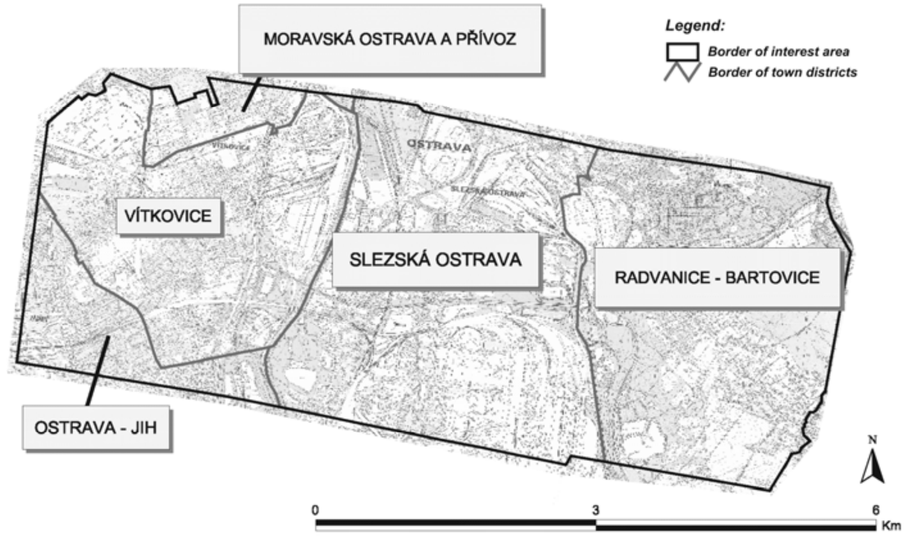

Figure 1: A map of the monitored area with marked boundaries of municipalities

Obr. 1: Mapa sledovaného území s vyznačenými hranicemi městských obvodů

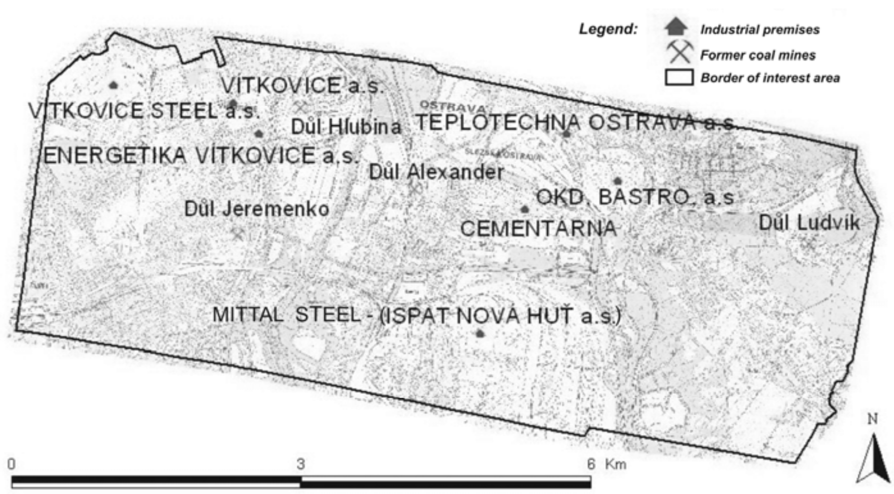

Figure 2: A map of the monitored area with marked industrial premises and mines

Obr. 2: Mapa sledovaného území s vyznačenými průmyslovými objekty a doly

Methods applied

For the work in GIS, basic topographic maps in the scale of 1:10 000 published in 1996 and aerial photographs from 1946 were used. Those materials were, post scanning, linked to the JTSK co-ordinate system by means of a geometric transformation in the TopoL program and finally they were vectorized in the ArcView program.

The result of vectorization is digitization of the mentioned materials; by means of lines (with line elements) and polygons (with areal elements) digital layers were created, gradually for each landscape element. 11 landscape elements were digitized, for each element 2 layers were created. First was on the maps, second on the aerial photographs. On the basis of such results it is possible to visually compare the quantitative representation of the individual landscape elements nowadays and in the year of 1946. Next, areas were calculated, or lengths of individual landscape elements in both time periods and the changes were compared.

Geographical information systems [12] was employed the following methods:

Geometrical transformations

Geometrical transformations (sometimes numerical transformations in contrast to analytical ones) ensure the attaching of the national coordinate system to the map, layers, or make it possible to coordinate the position of layers towards one reference layer. This procedure is designated as registration or georeferencing, or warping. Data layers in one area was unified (referred to one coordinate system) so that it may be possible to work with them.

In the step 1, points of known location are selected (control points, check points, identical points) and in the step 2 the layer was transformed. For raster transformation, affinitive and polynomial transformations are used most frequently.

a) *Registration by relative position*

   Registration by relative position was used for attaching aerial photos. In the course of this procedure, one data layer designated as secondary (slave) was registered with the reference layer (master).

   The first step was the selection of elements (small objects, points, intersection of lines) represented in both layers. These elements were control points in both the layers (always 1 point in the reference layer and the relevant point in the secondary layer). The higher the number of reference points and the more regular distribution of them over the whole area of the layer, the better is the result of transformation. On the basis of the control points, a transform function was calculated used then for the proper transformation of the entire secondary layer. As a result of this registration, positional errors are transferred from the reference layer to the secondary layers. This operation is also called rubber sheeting.

b) *Registration by absolute position*

   Registration by absolute position was used for attaching topographical, quaternary, engineering geological maps. In the course of this procedure, each layer is attached separately to the chosen coordinate system. The advantage of this procedure is the fact that the positional error from the reference layer is not transferred to other layers. Moreover, the accuracy of each layer may be evaluated independently. On the other hand, the disadvantage is that small positional errors in particular layers were independent, and thus objects boundaries when overlapping each other may not be accurate. These discrepancies may be removed by the procedure – conflation.

Evaluation of landscape elements changes

This chapter deals with an overall outline and analysis of landscape element changes, while the following subchapters deal with the individual changes. The graphic representation of landscape element area percentage of the total monitored area (29.785 km^2) in 1946 is shown in (Figure 3, Table 1) and the current proportion of areas is shown in Figure 4 and Table 1. The landscape element changes in both time periods were recorded applying Geographical Information Systems and completed with terrain observations and studies of archives. It is apparent that in the first time period (1946 – Figure 3) the largest proportion of the monitored area was taken up by fields and meadows. However, nowadays (Figure 4) the built-up area considerably exceeds other landscape elements.

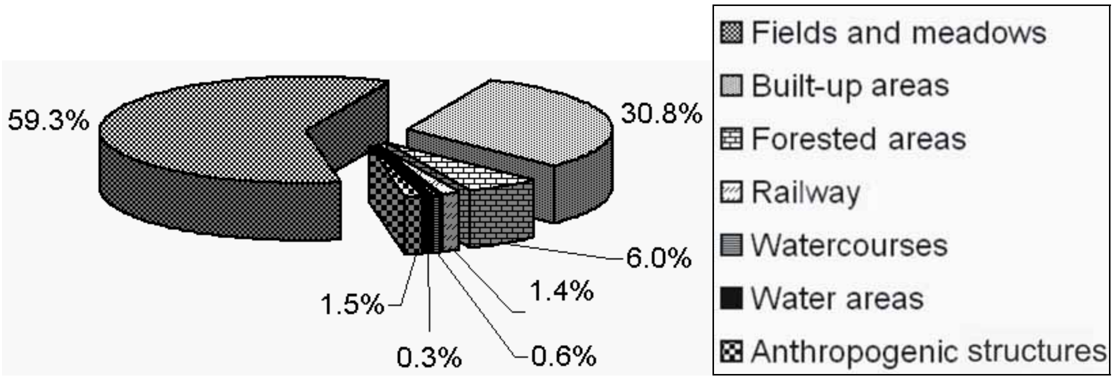

Figure 3: Chart – percentage representation of GIS layers in the monitored area in 1946

Obr. 3: Podíl GIS vrstev na celkové ploše sledovaného území v roce 1946

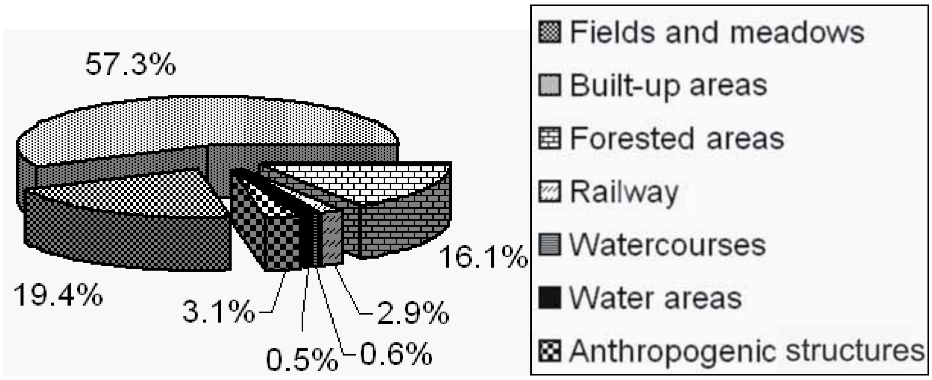

Figure 4: Chart - percentage representation of GIS layers in the monitored area at present

Obr. 4: Podíl GIS vtrstev na celkové ploše sledovaného území v současnosti

Table 1: Percentage representation of GIS layers in the monitored area

Tab. 1: Podíl GIS vrstev na celkové ploše sledovaného území

GIS layers	*1946*	*Present*	*Difference*	*Percentage representation (%)*	
	(km^2)	*(km^2)*	*(km^2)*	*1946*	*present*
Bulit-up areas	9,169	17,056	7,887	30,785	57,266
Forested areas	1,781	4,789	3,008	5,978	16,079
Fields and meadows	17,691	5,793	-11,898	59,396	19,450
Anthropog. structures	0,443	0,933	0,490	1,488	3,133
Water areas	0,099	0,153	0,054	0,333	0,514
Railway	0,420	0,882	0,462	1,410	2,961
Watercourses	0,182	0,178	-0,003	0,610	0,598

Changes in built-up area

In 1946 the built-up area took up approximately 9.169 km^2, which represented 30.785 % of total monitored area (29.785 km^2). Currently, it is roughly 17.056 km^2, which means 57.264 % of total monitored area. In the course of the monitored period there has been an increase in built-up area of 86.014 % (of 7.887

km²). The changes in built-up area are shown in Figure 5. What was digitalized as built-up area are industrial premises, residential houses including adjacent parts of roads outside the quarters.

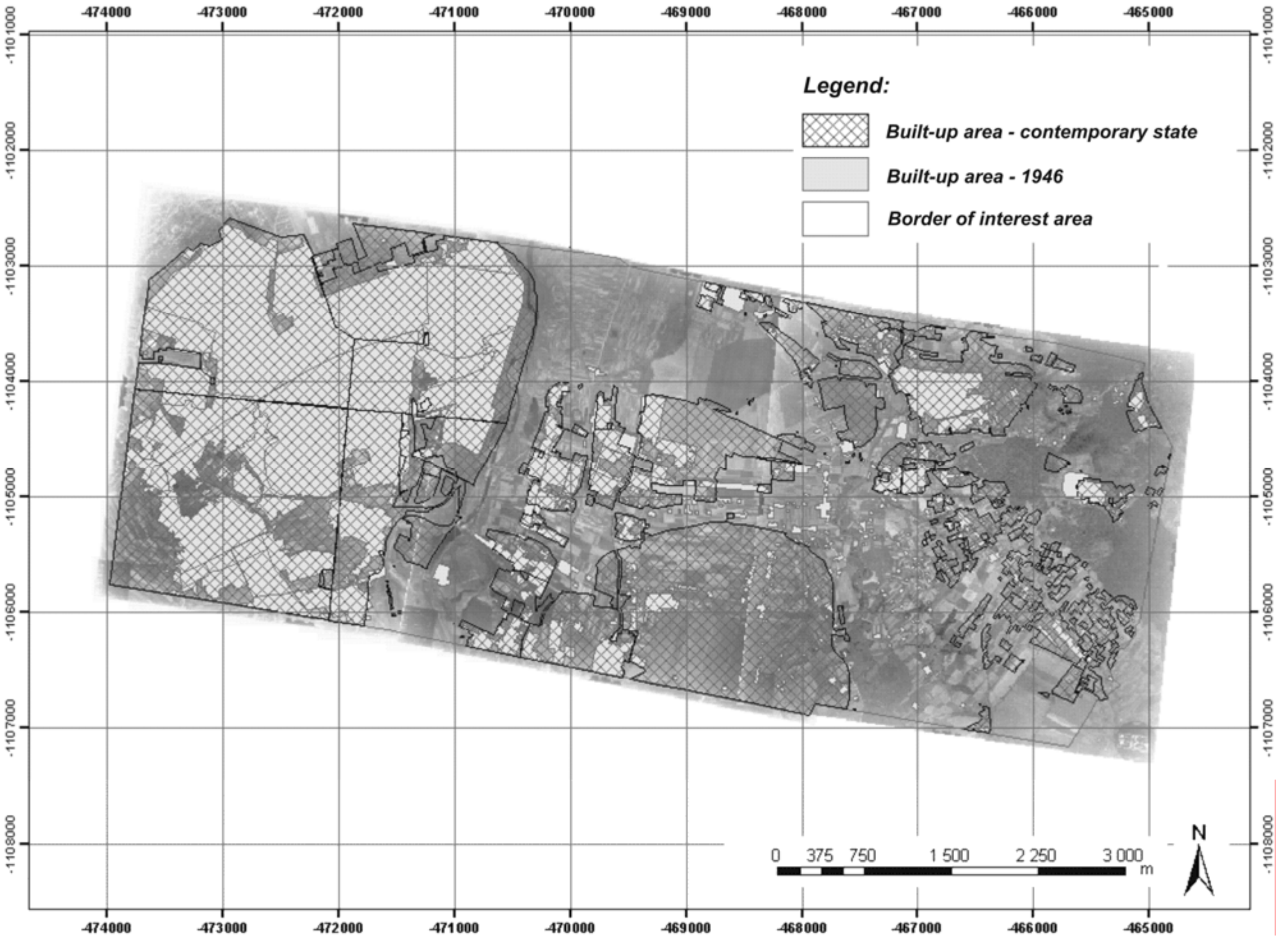

Figure 5: Changes in built-up area shown in the aerial photos from 1946

Obr. 5: Změny v zástavbě zobrazené na leteckých snímcích z 1946

An overview of the most important changes in built-up area

The most significant changes in the monitored area is construction of Nová huť premises in Ostrava-Kunčičky. The basis for the construction was the Southern plant of Vítkovice Ironworks, so-called "Südbau", which was built during the German occupation in 1942. It also comprised of an engineering plant and an unfinished tube mill. The construction was initiated in 1948. Gradually, blast furnaces, coke-oven batteries, foundry, steelworks, pit furnaces, part of power system, gas lines, railway and road networks were built and the tube mill was finished. Production was gradually started since 1952 when on 1 January 1952 the President Antonín Zápotocký started fire in a new blast furnace No. 1. In the course of the construction of Nová huť (New Mill), embankments of the total volume of 545,279 m³ were built. The embankments were mainly made up from waste rock from Jeremenko Mine. During the past years, there have been a lot of changes as for new technologies and production processes, which have increased the efficiency of the production process and decreased the environmental impact. For example, between 1967 and 1985 there was large modernization of open-hearth furnaces into tandem furnaces. After 1989 within privatization of Nová huť certain plants or operations were separated and independent trading companies were set up, e.g. pig iron production was transferred to a stock company of Vysoké pece Ostrava as of 1 January 1997. The current Mittal Steel (Figure 6) specializes in metallurgical production and partly in mechanical engineering.

Another notable change is the *removal of the scattered buildings* in the place of Nová huť in course of its construction and in its protection sanitary zone, which extends into the municipalities of Radvanice, Bartovice, Kunčice and Kunčičky. The houses were bought out and people moved out. There was large planting of ameliorating and protective species and greenery.

Next important change in the monitored area is *establishment of industrial premises* in the 1960s, for which the incentive was implementation of metallurgical production in Nová huť, its further continual completion and development of mining. One of the companies is an engineering-assembly company of OKD, Bastro, a.s., which was founded in 1952 in Ostrava-Radvanice. In 1993 it became a subsidiary of OKD, a.s. and an affiliate of Karbon invest, which is its sole proprietor. Nowadays, the company deals in complex deliveries, assembly and modernization of technological equipment for a range of industrial branches (metallurgy, engineering, power-engineering, etc.).

Teplotechna Ostrava a.s., which is a constructional-assembly company, has been active since 1951. The Ostrava plant, as one of the formerly national enterprise of Teplotechna, specialized in the construction of large metallurgical, engineering and power-engineering works and namely in the deliveries of refractory linings and furnace devices. In the area of high-rise buildings they have a lot of experience with construction of smokestacks (walled, ferroconcrete, steel) up to the height of 300m, including their maintenance and monitoring.

Housing development has extended especially due to an increased migration of inhabitants in the 1960s. This development is very varied, e.g. linear development is typical of the municipality of Ostrava Radvanice-Bartovice.

Another change concerns the *extension and transformation of Vítkovice Ironworks* in Ostrava-Vítkovice. For example, an engineering plant of heavy machinery was erected in Ruská Road and steelworks were rebuilt because of an increased production capacity. Areally, those changes are not that significant. What is more interesting about Víkovice Ironworks is the Lower Quarter (Figure 7) where pig iron and coke production was concentrated. The final stop to the production of agglomerate, coke and pig iron in Víkovice Ironworks occurred in the form of last tapping of blast furnace No.1 on 27 September 1998. Hlubina Mine makes part of the complex. Because of extraordinary memorial value of the whole complex of Hlubina, coking plant and Víkovice Ironwork's blast furnaces, the individual premises and their technological equipment have been declared National Monuments and their immediate surroundings and visual corridors have become a protection zone. In addition, this area has been suggested by the Czech Republic for an entry into UNESCO's World Cultural and Natural Heritage List.

Figure 6 (left): Eastern part of Mittal Steel premise; Figure 7 (right): Eastern part of Vítkovice-Lower Quarter

Obr. 6 (vlevo): Východní část podniku Mittal Steel; Obr. 7 (vpravo): Východní část Vítkovice-Dolní oblast

Mines in the interest area and their characteristics

Hlubina Mine (Figure 8) was established in 1852 by S. M. Rothschild. On 16 November 1931 it merged with Šalamoun Mine, which became its auxiliary plant in 1938 and in 1939 it became independent again. On 1 January 1958 Hlubina Mine merged with Jeremenko Mine and became its Plant I. Hlubina Mine operated between 1852 and 1996. Coal was mined between 1863 and 1991. Its area was 382 ha, it had 12 working floors and 3 pits. The extraction and discharge air shafts were filled up between 1995 and 1996 [8].

Jeremenko Mine (Figure 9) was set up in 1891 by the company of Spojené vítkovické kamenouhelné doly. On 1 January 1958 it merged with Hlubina Mine as Plant 2. As of 1 January 1979 the lower part of Alexander Mine working district was joined to it. The mine existed between 1981 and 1996. Coal was extracted from 1896 to 1992. Its area was 290 ha, it had 8 working floors and 3 pits. The discharge air shaft No.2 was filled up in 1996. In the premises two water shafts stay in operation as a part of OKD pumping system for pumping and control of underground water in the attenuated Ostrava part of Ostrava-Karviná District (OKR) [8].

Figure 8 (left): Hlubina Mine shaft frame; Figure 9 (right): Jeremenko Mine shaft frame

Obr. 8 (vlevo): Těžební věž dolu Hlubina; Obr. 9 (vpravo):Těžební věž dolu Jeremenko

Alexander Mine (Figure 10) was established in 1896 in the place of current Ostrava-Kunčičky. As of 1 August 1926 it merged with Zárubek Mine by means of underground transfer of coal mining and then it acted as an auxiliary mine. In 1976 the lower part of the mine, approximately 1000 m deep, was delimited to Jeremenko Mine. The mine operated from 1896 to 1994 and spread on 247 ha. Coal was mined between 1898 and 1926. There were 10 working floors and 2 pits. Both pits were filled up between 1993 and 1994 [8].

Figure 10: Alexander Mine shaft frame

Obr. 10: Těžební věž dolu Alexander

Ludvík Mine was founded in 1898 by Ostravská báňská společnost. Its mine field makes part of PDP in terms of geology. As of 1 April 1961 it merged with Julius Fučík Mine and became its Plant 3. Eventually, on 1 January 1989 the independent Plant 3-Ludvík was organizationally stopped. The mine was active from 1914 to 1992. Its area was 748 ha, it had 6 working floors, 1 supplementary floor and 3 pits. Coal mining was finished in 1992, i.e. the first mine in PDP, closed down within a state-directed phase out of mining in OKR. Having filled up the pits between 1995 and 1996, the majority of premises were knocked down due to undermining damage and the terrain was reclaimed.

Changes in anthropogenic structures

In 1946 anthropogenic structures took up 0.443 km^2, i.e. they represented 1.488 % of total monitored area (29.785 km^2). Currently, it is 0.933 km^2, which means 3.134 % of the monitored area. In the course of the monitored period there has been an increase of 110.607 %. Changes in anthropogenic structures are displayed in

Figure 11. During digitalization, the landscape element layer of anthropogenic structures also included sedimentation basins, dumps, spoil banks and flood banks.

There are two types of dumps - slag and waste rock. *Slag dumps* are formed following metallurgical activities. They have a specific character, which lies in a variety of material of steel and blast-furnace slag and the so-called cold bank, thus different technologies of land-reclamation techniques and level of difficulty of turning them green. Slag is substrate that does not weather. Not even banking permits spread of all forms of vegetation. Slag can be used as building material or in background embankments.

Waste rock dumps arise due to mining activities. They are formed by rock material from mine-field development and preparation or after coal processing. In the Ostrava part of OKR it is carboniferous waste rock, made up almost entirely by sandstone and claystone, extracted in the main roof and seat rock of coal seams. Sandstone is much harder and it remains many years with no apparent influence of weathering processes. Claystone weathers faster, fragments, retains humidity in the land waste and thus forms suitable conditions for rooting and development of vegetation. It is greenery started by controlled biological reclamation or rooted due to self-seeding (birch, elm, maple, etc.). In terms of composition, carboniferous waste rock is rich in minerals, which is favourable for rooting of vegetation. On the other hand, its disadvantage is its lower content of nitrogen and organic substances.

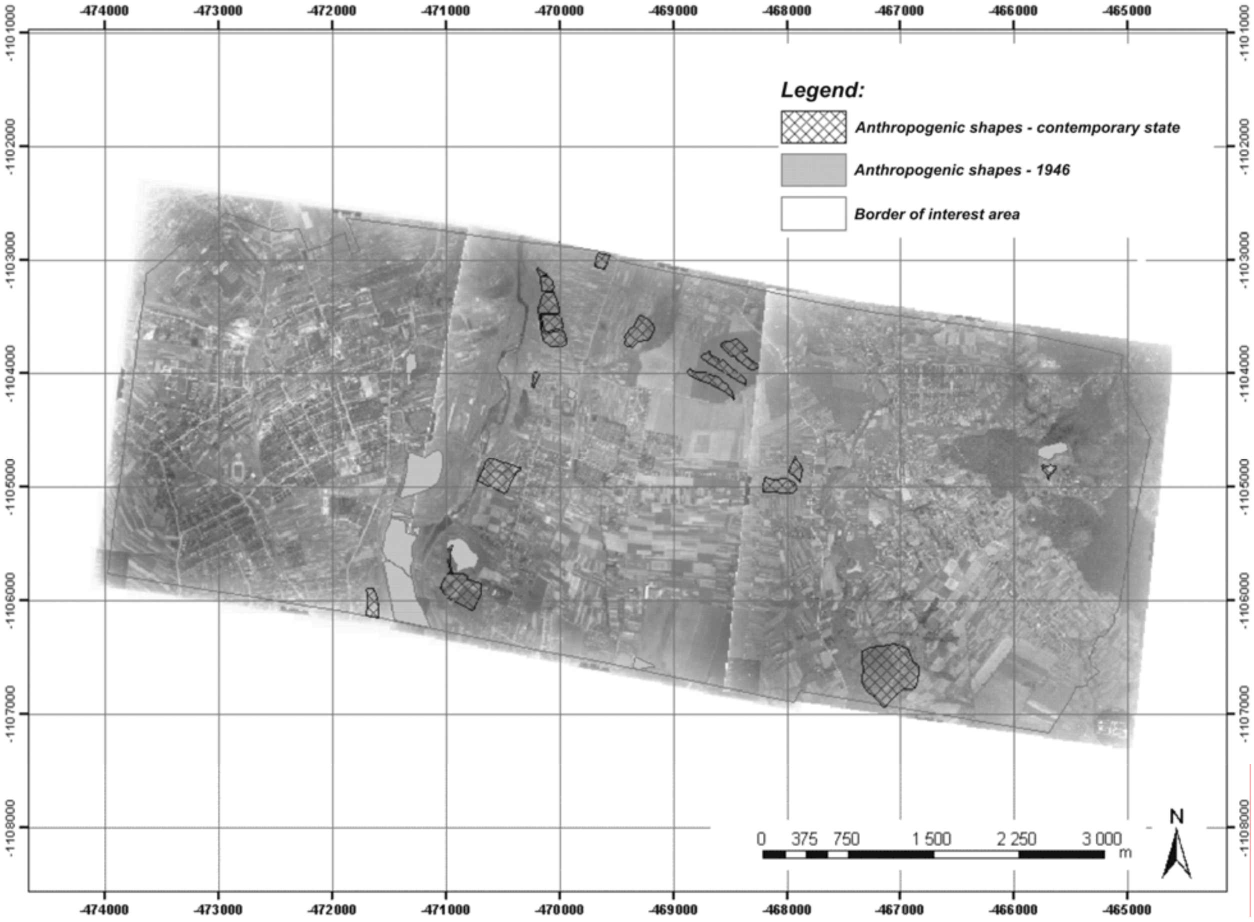

Figure 11: Changes in anthropogenic structures displayed in the aerial photos from 1946

Obr. 11: Změny antropogenních tvarů zobrazené na leteckých snímcích z 1946

An overview of significant changes in anthropogenic structures

South-west of Zárubek Mine, a *Zárubek Central Dump* was started. The dump material is made up by carboniferous waste rock, rock from mine-field development and preparation from several mines, e.g. Zárubek Mine and Hlubina Mine. Nowadays, its predominant part is afforested and incorporated into the landscape.

The *Jeremenko Mine Dump* was transformed into a sports complex, about 300 m eastwards of Jeremenko Mine, behind Místecká Road.

A dump at Ludvík Mine in Ostrava-Radvanice has been afforested.

An incorporated dump of Jeremenko Mine and Vítkovice Ironworks was established in Ostrava-Hrabůvka. As of 31 July 1996 special conditions for dumping were terminated in this technically unsecured disposal site. This included the method of disposal site terrain creeping by selected waste of "O" category (others), phased completion of technical and biological reclamation. These days, it is possible to observe successful forestry reclamation on the slopes along Místecká Road.

North of Nová huť, in the area between Šenovská and Lihovarská Streets and the tramline from Hranečník to Nová huť, *a Lihovarská Dump* was established. The dump was rail-connected to the eastern head of the Northern Station of Nová huť and it was finished in summer of 1958. The first pilot tipping onto the dump took place on 9 August 1958. The dump was formed by hot blast-furnace slag, cold bank and its northern part was made up by a large disposal site of steel slag, which is supposed to be reused in future metallurgical operations. Currently, gradual forestry reclamation is under way (Figure 12).

Sedimentation basins of Rudná I and Bartovice were started by Nová huť. The *sedimentation basin of Rudná* lies north of Nová huť premises, behind Rudná Road. The sedimentation basin was constructed by means of an embankment dam from slag, along the whole sedimentation basin. Chiefly, blast-furnace slurry is dumped there. In the east, it is partly drawn and about half is covered in thin vegetation from self-seeding tree species. As per 2000, the amount of slurry was estimated at 450,000 tonnes, with an average Fe-content of 50 % at average bulk density of blast-furnace slurry of 2 300 $kg \cdot m^{-3}$ and humidity of 35 %. The *Bartovice sedimentation basin* is located east of Nová huť premises in the cadastral district of Ostrava-Bartovice (Figure 13). Partly, it makes use of terrain roughness as well as embankment dams. This sedimentation basin is divided into several segments, out of which in three northern ones there are fly ashes, in the most western part there is blast-furnace slurry and in two eastern segments under the slope there is steel slurry. In 2002 in the sedimentation basin, there were about 404,000 tonnes of dry blast-furnace slurries, 547,000 tonnes of steel slurry solids with an average Fe-content of 60% and 635,000 tonnes of fly ash solids [13].

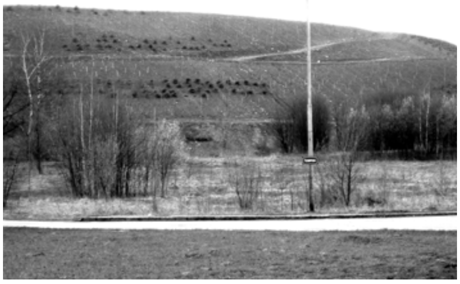

Figure 12 (left): Lihovarská Dump -western part

Figure 13 (right): Bartovice sedimentation basin located east of Nová Huť premises

Obr. 12 (vlevo): Lihovarská halda - západní část

Obr. 13 (vpravo): Odkaliště Bartovice umístěno na východ od areálu Nové Hutě

A so-called *Fly ash disposal site* was set up east of Vítkovice Ironworks, behind the Ostravice river (Figure 14). At present, the fly ash is gradually drawn and liquidated. It was initiated due to vanadium pollution, an increased content of cyanide, manganese, sulphates and nitrites, after an environmental audit in Vítkovice a.s. in 1999. According to 2002 Annual Report of Energetika Vítkovice a.s., 249, 670 tonnes of fly ashes had been drawn by the end 2002.

Figure 14: Fly ash disposal site of Energetika Vítkovice a.s

Obr. 14: Úložiště popílku Energetiky Vítkovice a.s

Several sedimentation basins were created on the right bank of the Ostravice river, about 500 m north of Rudná Road. Those sedimentation basins have all been drawn to date. Figure 15 shows one of the sedimentation basins.

ČOV Lučina water treatment sediment disposal site was founded east of Nová huť, near the Lučina river (See Figure16).

Figure 15 (left): A sedimentation basin on the Ostravice right bank about 500 m north of Rudná Road

Figure 16 (right): Water treatment sediments from ČOV Lučina

Obr. 15 (vlevo): Odkaliště na pravém břehu řeky Ostravice asi 500 m severně od silnice Rudné

Obr.16 (vpravo): Úložiště čistírenských kalů ČOV Lučina

Changes in forest percentage

In 1946 the forest area was 1.78 km^2. The forest percentage coefficient k_L equalled 5.98 %, with regard to total monitored area (29.78 km^2). Currently, the forest area takes up 4.79 km^2 and the forest percentage coefficient k_L is 16.079 %. Since 1946 there has been an increase of 168.95 %. Changes in forest percentage are shown in Figure 17. The calculation formula for forest percentage coefficient is $k_L = (P_L / P_U)x100$ (%), while P_L is the area of forests and P_U is the total area of the monitored locality.

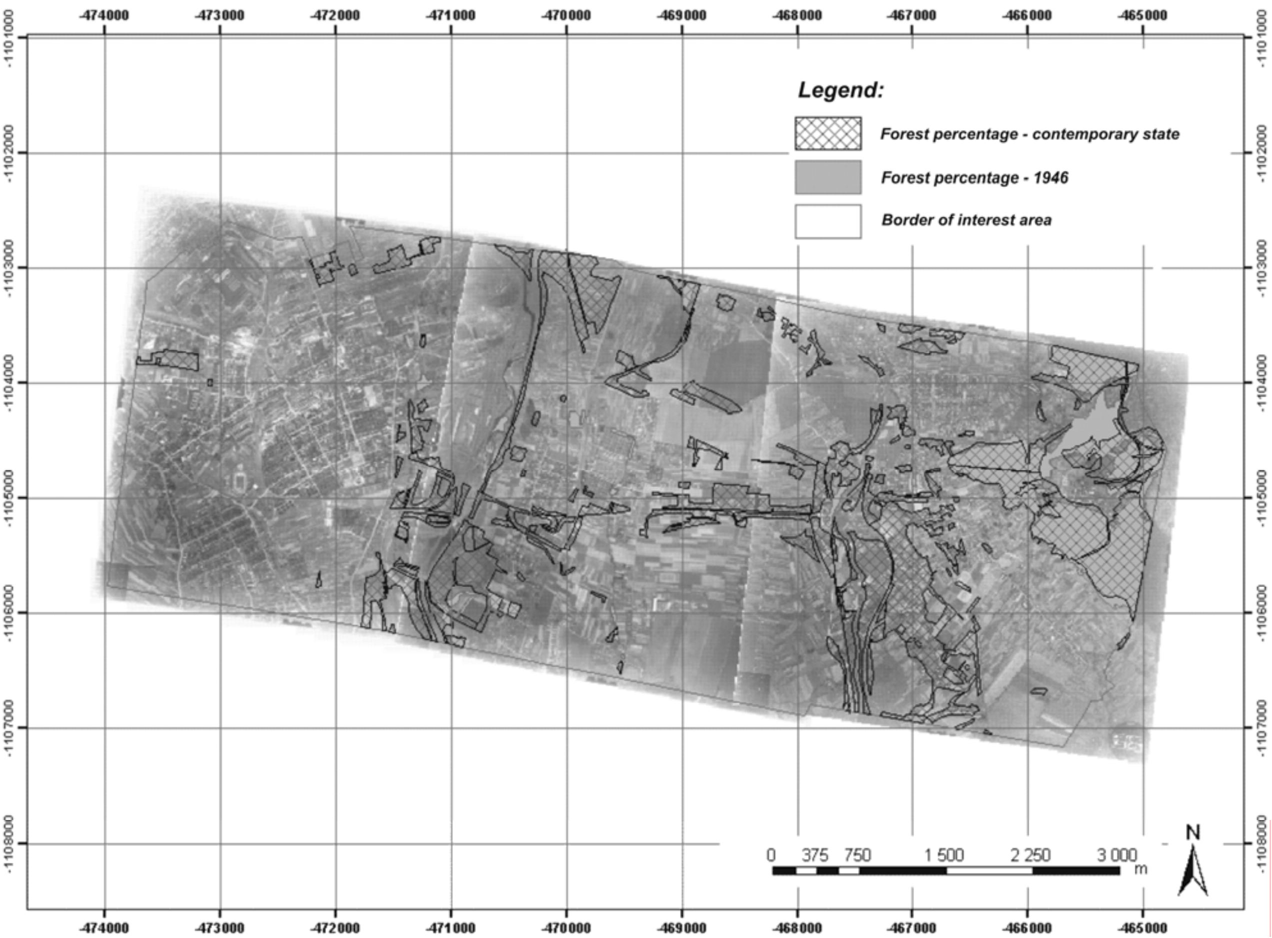

Figure 17: Changes in forest percentage shown in the aerial photos from 1946

Obr. 17: Změny lesnatosti zobrazené na leteckých snímcích z 1946

The most significant changes in forest areas are the larger afforested parts of Zárubek Central Dump within forest reclamation (Figure 18), planting trees on the slopes of the incorporated dump of Vítkovice Ironworks and Jeremenko Mine in Ostrava-Hrabůvka, plantation of forest stand within the protection sanitary zone of Nová huť and planting tree vegetation on the banks of the Ostravice and Lučina rivers.

Figure 18: Afforested parts of Zárubek Central Dump along Frýdecká Road

Obr. 18: Zalesněná část centrálního odvalu Zárubek podél silnice Frýdecká

Changes in areas – fields and meadows

In 1946 the area of fields and meadows had 17.691 km^2, which was 59.396 % of total monitored area (29.785 km^2). At present, it takes up 5.793 km^2, which represents 19.450 % of total interest area. In the course of the monitored period, there has been a fall of 67.255 % (-11.898 km^2).

In the course of the monitored fifty years, the most dominant changes in the areas of fields and meadows have been brought about by construction of Nová huť, establishment of Lihovarská Dump by Nová huť, formation of Zárubek Central Dump due to piling of waste rock from mining activities, expansion of road and railway networks, increase in area occupation assigned for residential development due to increased migration of inhabitants, and increased forest stand.

Changes in water areas

In 1946 water areas took up 0.099 km^2, which was 0.333 % of total monitored area (29.785 km^2). At present, it is 0.153 km^2, which means 0.514 % of total monitored area. Since 1946 there has been a rise of 54.519 %.

The most important changes in water areas have been mainly caused by formation of water areas in Nová huť premises, foundation of two ponds in Bučina Forest in Ostrava-Radvanice, out of which one is filled from a pond which existed back in 1946 (they are used for fishing – Figure 19), formation of water areas filling depressed areas, e.g. under the eastern slope of Zárubek Central Dump (Figure 20).


Figure 19 (left): A pond in Bučina forest in Ostrava-Radvanicem

Figure 20 (right): Northern part of water area under Zárubek Central Dump

Obr.19 (vlevo): Rybník v lese Bučina v Ostravě-Radvanicích

Obr. 20 (vpravo): Severní část vodní plochy pod Centrálním odvalem Zárubek

The impact of undermining

Due to mining activities there are subsided areas. The subsided areas differ in dependence on geological bearing conditions and tectonics, and they are proportional to the area of mined coal seams and their thicknesses [7]. In the Ostrava part of OKR there is lower subsidence than in the Karviná part of OKR, as the coal seams are of smaller thickness and the position of such seams is much deeper underground. The subsided areas were utilized as sedimentation basins, e.g. for flotation tailings, coal slurries, fly ashes or they can be filled up, evened out and land-reclaimed.

Two maps of depression isolines were used as the source for the evaluation of the impact of undermining on the terrain surface in the monitored area. The first map is from the period of 1961 – 1999 (obr.21) and the second map source is from the time period of 1961 – 1989.

The monitored area extends into the working districts of WD Vítkovice, WD Slezská Ostrava, WD Radvanice, WD Petřvald. The most prominent subsidences in the monitored area related to the period of 1961-1989, approximately 4.5 m, occurred in Ostrava-Radvanice in the surroundings of Ludvík Mine. A larger part of this locality is covered by the forests of Bučina and Bartovický les. With regard to 1999, there was an increase in the subsidence up to 5.6 m. Other significant subsided areas related to the period of 1961-1989, from 1 to 3 m, are in the area between and in the vicinity of Zárubek Mine, Hlubina Mine and Alexandr Mine. For example, there was a 3-metre subsidence in the complex of Zárubek Central Dump. With regard to 1999, no values show any significant change in that locality. On the contrary, a locality which has not been affected by any subsidence is Mittal Steel premises.

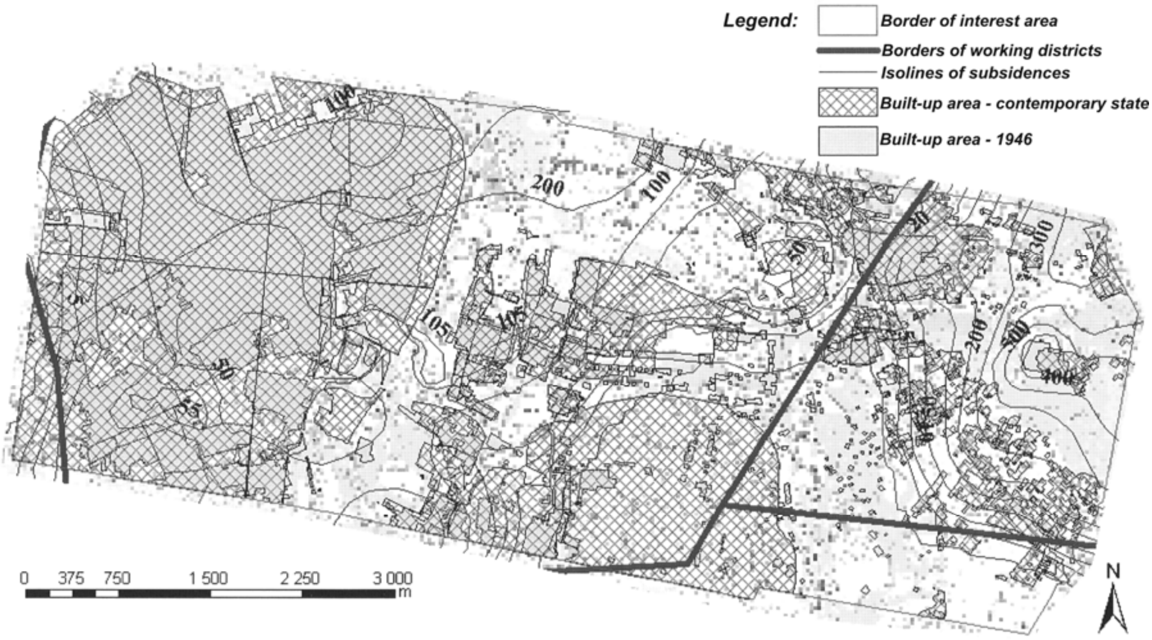

Figure 21a: A map of the interest area with marked subsidence isolines (1961-1999), working district boundaries and changes in built-up area.

Obr. 21a: Mapa zájmového území s vyznačením izolinii poklesů (1961-1999), hranic dobývacích prostor a změn zástavby.

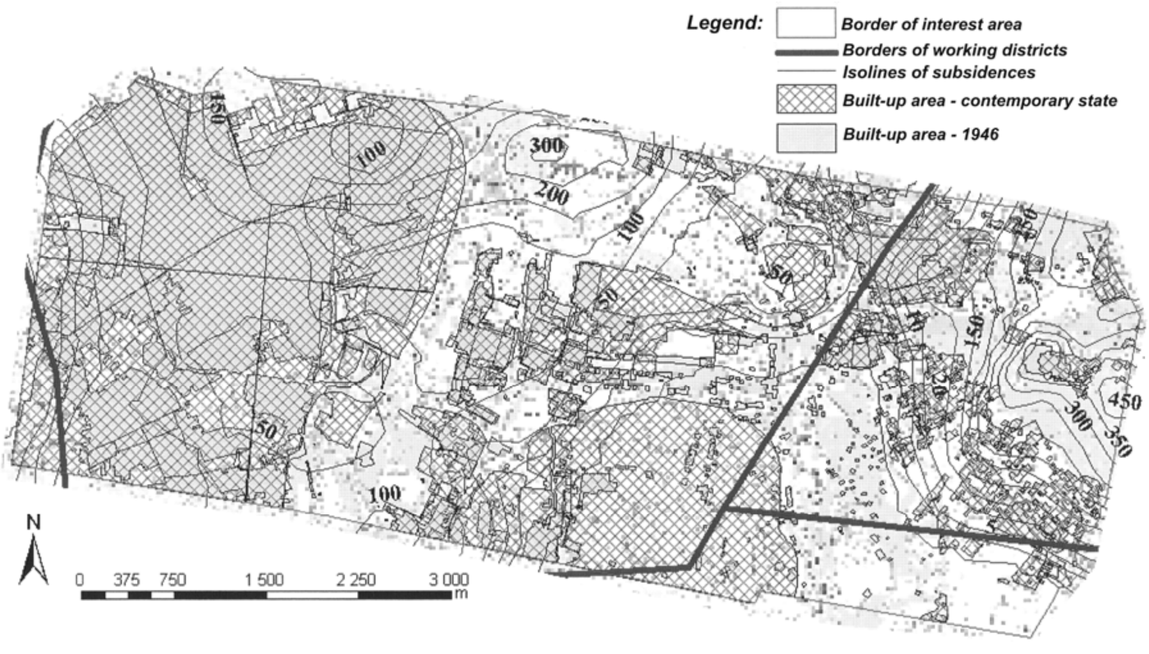

Figure 21b: A map of the interest area with marked subsidence isolines (1961-1989), working district boundaries and changes in built-up area.

Obr. 21b: Mapa zájmového území s vyznačením izolinii poklesů (1961-1989), hranic dobývacích prostor a změn zástavby.

Conclusion

In terms of surface, the most prominent change has been in “forest” landscape element, where there has been a rise of 169 %. This is partly due to afforestation of a number of dumps, which were created in the monitored area either following mining or metallurgical activities. Another significant aerial increase has been in the landscape element of “anthropogenic structures”, i.e. of 110 %. This has been caused by starting dumps, sedimentation basins, building flood banks, etc. Built-up area has grown by 86 % as a consequence of construction of industrial premises, e.g. Nová huť, and residential development. Next, the landscape element of “water area” has expanded by 54 %. These were also ponds in Ostrava-Radvanice used for fishing that assisted such an increase. In contrast, in the landscape element of fields and meadows, there has been an aerial fall of 67 %, i.e. at the expense of built-up area, anthropogenic structures and increased forest percentage.

The objective of the study was to expand on the knowledge of landscape element changes in prominent mining areas that represent, in terms of interference with the environment, one of the worst affected types of landscape. What was analysed are changes of landscape elements such as forests, water areas, agricultural areas, built-up areas, anthropogenic areas by means of GIS in two time series (aerial photos from 1946 and current topographical maps). The research was completed by terrain observation and documentation. The above-mentioned transformations were brought about by former mining of black coal. The mentioned methodology was applied in the interest area for the first time.

In addition, in the GIS layer of “water courses” there has been a decline of 1.7 %, due to straightening of water courses, both with the Ostravice and the Lučina rivers. This straightening of courses has also been demonstrated in the length of river courses, which has dropped by 7 %. Railway lines have grown by 110 %. This has been mainly due to construction of Ostrava-Vítkovice Railway Station, which makes part of Nová huť s siding network. An important rise in length of 92 % has been monitored in the GIS layer of “railway network”, which has been brought about by construction of Polanka traction bond, Nová huť company siding network and their joining to Czech Railways network.

The largest subsidence in the monitored area with regard to the period of 1961-1989, about 4.5 m, occurred in Ostrava-Radvanice in the proximity of Ludvík Mine. A predominant share of this locality is covered by the forests of Bučina and Bartovický les. Having applied the values to the year of 1999, there was a rise up to 5 m. Other significant subsidence in the course of 1961-1989, from 1 to 3 m, took place in the area between and in the vicinity of Zárubek Mine, Hlubina Mine and Alexandr Mine. For example, there was a 3-metre subsidence in the complex of Zárubek Central Dump. With regard to 1999, no values show any significant change in that locality. On the contrary, a locality which has not been affected by any subsidence is Mittal Steel premises. Despite the locality being situated in the area affected by mining activities and subsided areas have been observed there, development continued. The most significant changes in built-up area in localities with subsidence occurred in the north-east part of Ostrava-Vítkovice and in Ostrava-Radvanice, where subsidence ranged between 1 and 2 m. Subsidence of such sizes did not represent any considerable threat to the development in such affected locality.

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Resumé

Sledované území se nachází na území katastru městských obvodů Ostrava-Jih, Moravská Ostrava a Přívoz, Slezská Ostrava, Radvanice-Bartovice. Sledované území uvedené v předloženém článku je jedno z devíti studovaných na VŠB-Tu Ostava a jeho hranice je definovaná průnikem uvedených topografických map a leteckých snímků. Topografické mapy jsou v měřítku 1: 10 000 (mapový list č. 15-43-09, 15-43-10, 15-44-06, 15-43-14, 15-43-15, 15-44-11), vydané v roce 1996, zpracované ke stavu v roce 1995 Českým úřadem zeměměřičským v Opavě. Letecké snímky (č.655, 657 a 659), zobrazující stav k roku 1946, byly zpracované Vojenským topografickým ústavem. Sledované území, o rozloze 29,785 km^2, je zobrazeno na obrázcích č.1 a 2. K dobývacím prostorům (DP) zasahující do sledovaného prostoru patří: DP Vítkovice, DP Slezská Ostrava, DP Radvanice, DP Petřvald.

Studie v této publikaci měla za cíl rozšíření poznání o změnách krajinných prvků v hornicky exponovaných oblastech, které představují z hlediska zásahů do životního prostředí jeden z nejpostiženějších typů krajiny. Analyzovány zde byly změny krajinných prvků jako lesy, vodní plochy, zemědělské plochy, zastavěné plochy, antropogenní plochy pomocí GISu ve dvou časových řadách (letecké snímky z roku 1946 a současné topografické mapy). Výzkum byl doplněn terénním pozorováním a dokumentací. Vliv na výše uvedené změny měla dnes už bývalá těžba černého uhlí. Uvedená metodika v zájmovém území byla poprvé uplatněna.

Plošně došlo k největší změně u krajinného prvku „lesy“, kde nastal nárůst o 169 %. Část tohoto nárůstu je přičítána především zalesnění řady hald, vzniklých na sledovaném území ať už hornickou nebo hutní činností. K dalšímu výraznému plošnému nárůstu došlo u krajinného prvku „antropogenní tvary“, a to o 110 %. Příčinou nárůstu bylo zakládání hald, odkališť, vybudování protipovodňových ochranných hrází ap. Významný plošný nárůst o 86 % nastal u krajinného prvku „zástavba“, jako důsledek výstavby průmyslových objektů např. Nové hutě a obytné zástavby. Dále se zvětšil zábor plochy o 54 % u krajinného prvku „vodní plochy“. Částečně se na tomto nárůstu podílely založené rybníky v Ostravě-Radvanicích, využívané k sportovnímu i rekreačnímu rybaření. Naopak u krajinného prvku pole a louky došlo k plošnému snížení o 67 %, a to na úkor zástavby, antropogenních tvarů a zvýšené lesnatosti.

K největším poklesům na sledovaném území vztažených k období 1961-1989, asi 4,5 m, došlo v Ostravě-Radvanicích v okolí Dolu Ludvík. Větší část tohoto území tvoří les Bučina a Bartovický les. Z hodnot poklesů vztažených k roku 1999 došlo k nárůstu poklesu na 5 m. Další významnější poklesy vztažené k období 1961-1989, od 1 do 3 m, byly na území mezi Dolem Zárubek, Dolem Hlubina a Dolem Alexandr a v jejich blízkém okolí. Z toho k 3 m poklesu došlo v areálu Centrálního odvalu Zárubek. Z hodnot poklesů vztažených k roku 1999 nedošlo k žádné výraznější změně poklesu v této oblasti. Naopak k území nezasaženému poklesy patří např. areál Mittal Steel ap. I přesto, že se území nachází na území ovlivněné hornickou činností a jsou zde zaznamenány poklesy, pokračovalo se s výstavbou na tomto území. K největším změnám zástavby na území s poklesy došlo v severovýchodní části Ostravy-Vítkovice a v Ostravě-Radvanicích, kde se poklesy pohybovaly od 1 m do 2 m. Velikost poklesů o těchto hodnotách nepředstavoval významnější ohrožení zástavby na takto ovlivněném území.

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