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Rehabilitation of Post-Mining Areas in the Bohumin City Area (Czech Republic). Case Study

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INTRODUCTION

Mining activity in the Upper Silesia region is slowly coming to an end. An important aspect is to note that once mines were not only a guaranteed workplace for the population, but also a good prospect for the future, especially in view of the constantly progressing economic development. Demand for the raw material continued to grow, as coal was considered to be one of the most full-value fuel sources. Permanent demand development for the raw material was related to the multiplication of hard coal mining, and thus to the expansion of underground mining. Over the years, the conditions of raw material extraction became increasingly difficult and dangerous. Despite new, constantly developing technologies and machines designed to improve the quality and safety of underground mining, they did not eliminate such threats as: deformation of the surrounding land, residential areas or roads. Due to the risk of huge damage, but also due to the prospect of loss of extraction profitability in a given area, mining plants are being liquidated and closed down. The mines have always occupied a large area of land, thus leaving these areas undeveloped brings enormous costs to the owner of this land, which include securing these sites. Most often the authorities of the municipalities where they are located become the owners of these areas. Therefore, the rehabilitation of post-mining areas has become an appropriate idea (Białecka & Biały, 2014; Białecka, 2014; Uberman & Uberman, 2010).

The condition for developing a proper concept of land development in the revitalization process is its natural, geological-mining and socio-environmental recognition. The land can only be assessed by specialized staff who will skillfully combine the above mentioned revitalization aspects.

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On the example of the city of Bohumin, examples of good practices in the management of post-mining areas degraded by many years of mining industry were presented.

ŚLĄSK WITHIN THE BORDERS OF TWO COUNTRIES – HISTORICAL BACKGROUND

Silesia – a historical land located in Central Europe, in Poland, Czech Republic and Germany. From the 15th to the 16th century, the division into Lower Silesia and Upper Silesia has been distinguished. Silesia is located in the basin of the Upper and Central Odra River and the initial course of the Vistula River, historical capital of the whole Silesia area is Wrocław (Fig. 1, 2).

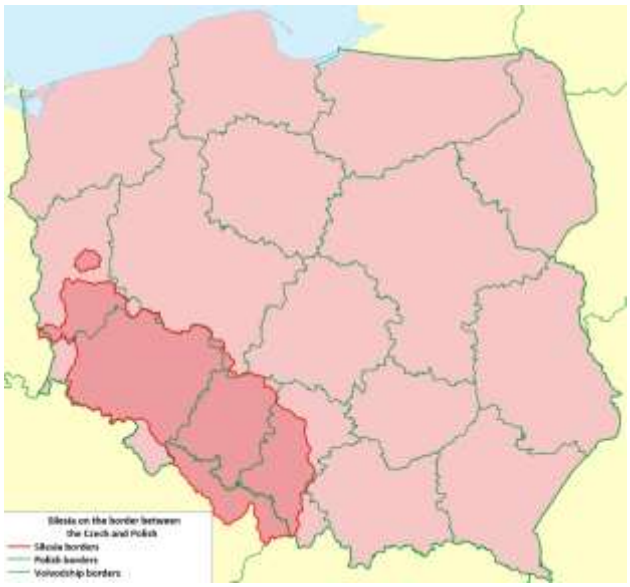

Fig. 1 Location of Silesia within the borders of Poland and the Czech Republic
Source: https://pl.wikipedia.org/wiki/Śląsk#/media/Plik:Śląsk.png

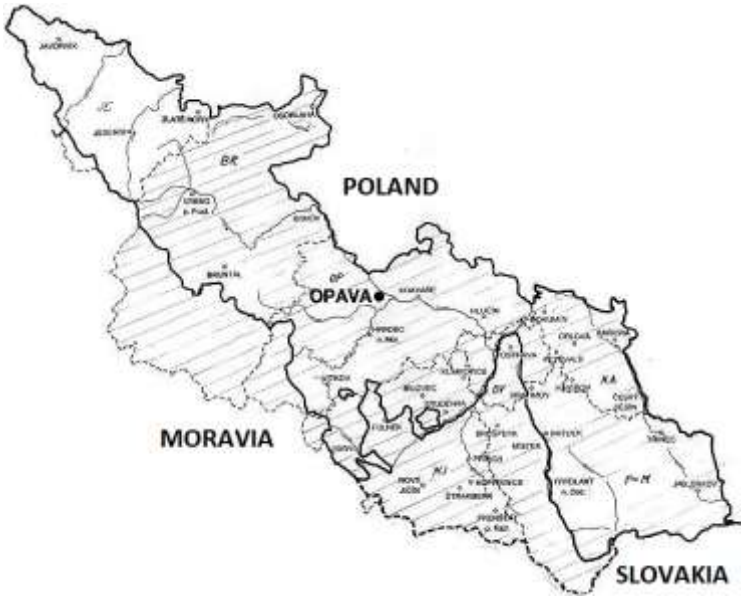

Fig. 2 Czech Silesia
Source: https://podroze.onet.pl/gdzie-na-weekend/czeski-slask-slask-morawski-javornik-karlova-studanka-jesionik-zlate-hory-opawa/s0vbsvf

Geographically, Upper Silesia covers the eastern and southern part of Silesia, located in the basin of the first section of Vistula and Upper Odra River – hence the name and its Latin and German equivalents: Silesia Superior, Oberschlesien.

MINING EXPLOITATION IN THE OSTRAVA-KARVINÁ HARD COAL DISTRICT

The Ostrava-Karviná district is considered to be the largest hard coal mining area in the Czech Republic. Exploitation of deposits in this area has a 200-year tradition (Fig. 3).

Fig. 3 View of the Ostrava-Karviná hard coal district
Source: http://www.okd.cz/cs/tezime-uhli/ostravsko-karvinska-uhelna-panev

The size of geological coal reserves determined by the Czech Geological Institute (Geofond) was estimated at 1519 million tonnes of hard coal, of which 181 million tonnes are classified as balance sheet (Mineral 2016; Euracoal 2018). Prospective resources have been estimated at 6,000 million tonnes of hard coal, with a maximum depth of 1600 tonnes. The minimum thickness of deposits for hard coal varies from 0.6 m (Mineral 2016). According to the state's energy policy, coal will remain the country's main source of energy in the future, despite the increased use of nuclear energy and natural gas. The government expects coal to account for 30.5% of the energy produced in 2030 (Surovinove 2017).

The largest hard coal deposits are located in the Upper Silesian Coal Basin (GZW), a basin with an area of 6500 km^2 is among the largest in Europe. Most of it is located in Poland, and about one sixth (1200 km^2) is located in the Czech Republic. The Czech part is called the Ostrava-Karviná hard coal district, coal is extracted from deep mines (Mineral 2016).

The only Czech hard coal producer is OKD, once known as Ostrava-Karviná doly. So far, 60 percent of the output has been thermal coal, while coking coal accounts for the remaining 40 percent.

The OKD mining group – the only Czech hard coal producer, will lead to the closure of the last mines.
In 2017, the Paskov Mine was closed, while the dates of the subsequent closures will depend on economic indicators. According to the original plan, the Lazy and Darkov Mines were planned to be closed in 2018.
OKD conducts mining in deep mines in the southern part of the Upper Silesian Coal Basin – in the Ostrava-Karviná region. The coal is used as fuel or raw material in the coking and chemical industries, among others (www.msregion.cz/pl, 2015).
The mining company Ostrava-Karviná Mines (OKD) completed the extraction of hard coal from the Łazy Mine in Orłowa, Zaolzie on 28 November 2019. It was then that the miners from the mines took out the last cart with the excavated material.
The Company will continue mining in the four remaining mines: Darkov, CzSA. (formerly the “Czechoslovak Army”), as well as CzSM-North and CzSM-South (formerly “Czechoslovak Youth Union”). OKD plans to reduce mining operations in these mines as well, but the timetable for their decommissioning is not yet known.
According to the plan adopted a few years ago, the mines belonging to it are to be gradually decommissioned and the last mine is to be closed in 2024.
Analysing statistical data, it is estimated that hard coal reserves will last for 200-300 years. By carrying out a comparative analysis of hard coal resources with other raw materials used in the industry, where oil (resources are 40 to 50 years old) or uranium (resources for 100 years), it can be concluded that it is a raw material that will still be used.
From the perspective of research development and technological possibilities, the methods of converting hard coal into another ecological fuel in gaseous or liquid state are known (www.msregion.cz/pl, 2015).

THE CONCEPT OF REHABILITATION AND DEVELOPMENT OF POST-MINING AREAS

Coal mining in the Ostrava-Karviná district has been carried out for about 200 years, hence one of the effects of mining is the creation of large amounts of waste, currently deposited in landfills (heaps) in the Ostrava area. These landfills are subject to rehabilitation and, if possible, to the recovery of combustible materials or management in the process of aggregate production. An example is the management of waste from the Heřmanice landfill (Korolev 2018).
Rehabilitation – is based on restoring both ecological and usable values to the natural environment, and thus to land degraded by industrial activities, including mining, agricultural, municipal and domestic exploitation and by the elements of nature (Biały & Mroczkowska, 2015; Siuta et al., 2012).
Analysing the definition of rehabilitation, referring to PN-G-07800 from 2002, the following phases can be further identified (Uberman & Uberman, 2010):

- preparatory,

- basic (technical),
- detailed (biological).

Since the rehabilitation relates to a post-mining area, it is necessary to define exactly what is covered by this term. Post-mining area, also called excavation site, is the area of final excavation, external and internal heaps, storage yards, workshop and warehouse service areas, technological roads and other areas related to shut-down mining activities (Glapa & Korzeniowski, 2005).

With particular reference to mining operations, it is known that these activities have had a strong, even degrading, impact on the natural environment for years. Therefore, looking at the transformed and deformed landscape of agricultural, residential or road areas, there is a need to make appropriate decisions related to the remedial actions of a given area and the analysis of costs related to the implementation of rehabilitation projects and settlement of compensation to the injured (Siuta et al., 2012).

Taking into account the decommissioning of mines, it should be taken into account that the scope of necessary works is extensive, and additionally includes not only (as it may seem) the physical decommissioning of facilities, but also applies to unnecessary equipment and machinery. The whole process also involves rehabilitation and management of post-mining excavations, dumping grounds, landfills and other post-mining areas (Uberman & Uberman, 2010).

Rehabilitation process of post-mining areas resulting from decommissioning of a specific mine consists of several significant stages (Białecka & Biały, 2014):

- rehabilitation of land on which heaps are located,
- decommissioning of mine excavations,
- rehabilitation of tailings ponds.

The rehabilitation of post-mining land and its future development is carried out according to the guidelines of previously approved technical documentation. The entire rehabilitation process must be carried out in accordance with certain legal regulations. The legal basis for proper performance of rehabilitation activities are the provisions of the Act on protection of agricultural and forest land, applying the provisions of Article 109(1) point 5 of the Geological and Mining Law, which refers to the fact that in the area of construction and liquidation of a mine (including both rehabilitation and land use), all supervision and control is exercised by specially trained mining supervisory authorities (Uberman & Uberman, 2010).

An important aspect in the cycle of rehabilitation activities in post-mining areas are tasks related to the whole process of transformation which are conditioned by the binding regulations, mainly the Act of 13 April 2007 on the prevention and repair of environmental damage (Journal of Laws of 2007 No. 75, item 493) (Białecka & Biały, 2014).

A substantial detail of the project implementation of a new, future-oriented design of selected mining area is the identification and characterization

of factors reflecting a given area of former mining exploitation. According to A. Ostręga (2004), the following factors can be distinguished:

- economic,
- formal and legal,
- technical (geological-engineering),
- hydrogeological and hydrological,
- cultural,
- spatial,
- social,
- environmental.

The presented and characterized factors are to become a kind of guidance regarding possible methods of rehabilitation and management of the selected post-mining area (Ostręga 2004).

CASE STUDY – VRBICE, BOHUMIN CITY DISTRICT

Bohumin is a town situated on the territory of the Czech Republic, were the Olza River flows into the Odra River, bordering on Poland. Bohumin is located in the northern part of the Moravian-Silesian Region in the area of Cieszyn Silesia in the Czech Republic, which is part of Upper Silesia (Figure 4).

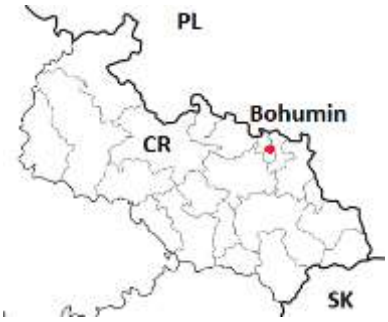

Fig. 4 Bohumin within the borders of the Czech Republic on the map of Moravian-Silesian region

Source: https://pl.wikipedia.org/wiki/Bogumin; 2019

Bohumin was a city of strategic ideal location, i.e. for centuries it has been situated at the crossroads of important trade routes. An important aspect is the fact that today's city has become a link between the Old Bohumín area and the industrial centre of New Bohumín, established in the 19th century around the railway station and several nearby municipalities (www.mesto-bohumin.cz/pl, 2015).

It is important to note that the city of New Bohumin owed its existence to the construction of the "C.K. Privileged Railway of the Northern Emperor Ferdinand", which at the time connected Vienna with Cracow. The further development of railway transport made Bohumin a priority transportation hub. In a short time, public buildings such as the Catholic Church, the Evangelical-Augsburg Church, the Town Hall and the Notre Dame Sisters' Monastery were built in the surrounding municipalities and at the station. In addition, in the second half of the 19th century Bohumin became a prosperous industrial centre in comparison

with other cities of the Ostrava-Karviná district. A mineral oil factory, a pipe rolling mill, brickyards and mines were established in this area, among others.
After many field changes, the city of Bohumin currently consists of seven districts: New Bohumin, Old Bohumin, Skrzeczoń, Zabłocie, Pudłów, Wierzbica (Vrbice), Szonychel (Jakubczyk, 2011).
The map (Fig. 5) indicates the area belonging to the city of Bohumin, where the mine once operated. The area of former mining exploitation was shown in Figure 5 – area 2. Currently, the Vrbice Technical Museum is located in this area. However, it can be noted that there are still two separate parts of the mining area. One of them – marked with an oval (Area 1, Figure 5) – has been selected as the main area for rehabilitation operations. The second part (Area 2) is the area designated for future rehabilitation (Podsiadło, 2015).
The presented post-mining area, where the Museum currently functions, still has a ventilation shaft, which was built in 1911 by the North Railway of Emperor Ferdinand.

Fig. 5 Post-mining area in Vrbice district of Bohumin city
Source: (Podsiadło, 2015)

It is one of the most isolated shafts in the Ostrava-Karviná hard coal district. The shaft is considered a cultural monument in the Czech Republic and is under state protection. The shaft aspires to be included on the UNESCO World Cultural Heritage List. In view of the current use of shaft, the OKD company (DPB Paskov) operates a degasification station for the discharge of mining gases from the underground (www.okd.cz/pl, 2015).
A proposal to develop the area marked as Area 1 in Figure 5 is indicated in the engineering design (Podsiadlo, 2015). The idea is to establish a “VRBICE Business and Conference Centre” in Area 1. Such an original idea of the project, from the perspective of architectural activities, is to refer to the climate in which the previously mentioned Vrbice shaft was preserved, combined with modern design. The resulting initiative seems to be very promising for the future, among others, due to the fact that nowadays, the beginning young entrepreneurs – the so-called start-ups – are more often looking for space for rent, where they will

be able to develop their business together with a team of co-workers. In addition, the location of the area on which the Conference Centre is to be built is located near the highway. As far as the location of the future centre is concerned, the location is very favorable in terms of communication. In the newly created centre, there is going to be a space for creating guest rooms with sanitary and catering facilities. In addition, there will be an area reserved for a wellness centre and a swimming pool, which will be used by both guests and private persons. An area full of greenery and flowers is to be created around the centre, which will be used as an opportunity to relax and rest.
Thanks to this type of land development project, the area will not remain useless, but will additionally bring profits, which will make the rehabilitation process profitable.

ALTERNATIVE SOLUTION TO THE DEVELOPMENT OF A SELECTED DISTRICT OF THE BOHUMIN CITY – ADDED VALUE

Taking into account the location and size of the ground area of this post-mining site in Bohumin in the Vrbice district (marked as Area 1 in Figure 5), it can be used for the construction of “RC-BV Logistics Centre”. Then, in this area, a gas station and many storage halls would be built for rent, e.g. by clothing, footwear and automotive companies.
It is necessary to make sure that the spatial development plan allows for the construction of logistic centre in chosen location and that the investment will comply with all legal regulations in order to create the project.
The advantage of building a logistics centre is the possibility of quick assortment delivery to the warehouse, considering the distance between centre and expressway and the highway. In addition, the location of logistics centre becomes a strong point – it will not be located in the very “heart” of the city (Fig. 6).

Fig. 6. Development plan for a post-mining area in Vrbice district for a logistics centre
Source: (Palka & Biały, 2015)

This is due to the fact that it is not necessary to wait in a car jam for the possibility of entering or leaving the city in order to reach the intended destination quickly. Apart from warehouses, the logistics centre will also have an administration building where services will be located to supervise settlements and corrective actions in terms of organization and management. There will be designated parking spaces on the centre's premises, designed mainly for the customers and the staff employed there.

The project for construction of the logistics centre should take into account all the undesirable effects, including their valuation in order to check the investment profitability (Table 1 and 2).

Table 1. Examples of adverse effects and risks of building a logistics centre

Expected adverse effects	Risk
• destruction of the part of green areas due to the entry of heavy equipment into the area • deterioration of the access road to the rest of city with a deformation of the asphalt surface • increased truck and commercial vehicle traffic • noise	• delayed implementation of the investment • delays in signing warehouse lease agreements with other companies • loss of companies to settle in the logistics centre • overrun of the investment budget • lack of interest in the services provided by companies that populate the logistics centre

Table 2. Example of valuation of several adverse effects

Name of budget deviation	Starting calculation [in thousands PLN]	Post-work calculation [in thousands PLN]	Deviation
Concrete	295	525	-230
Cause of error	Incorrect calculation at the initial determination of a pre-dimension		
Remedies for the future	Accurate execution of future investment calculation stages		
Purchase of bathroom tiles on office premises and payment for labour	180	240	-60
Cause of error	Arrangement of decorative tiles in office space toilets according to the interior design plan was not taken into account		
Remedies for the future	Precise calculation of the interior design, taking into account all the details in the plan		
Construction site heating – equipment	0	500	-500
Cause of error	The whole period of the investment implementation, related to the construction of the logistics centre, scheduled for the autumn-winter period, but there is no weather clause included in the contract		
Remedies for the future	Analysis of the technology of work performed, taking into account weather conditions depending on a given season of the year		
TOTAL:	**475**	**1265**	**-790**

The design and construction of a logistics centre is related to the enormous costs of achieving the goal set – the cost may amount to PLN 50-70 million. However, it is possible to obtain funding for the investment from the European Union funds as well as through a credit agreement with a part of the own contribution.
A project developed in this way that is rich in valuable information may actually be implemented on the selected area (Area 1, Fig. 6), if the investor receives permission to develop the area.

CONCLUSIONS

There are many economic phenomena that cause environmental transformations in the Upper Silesian Coal Basin, while the largest and most diverse and visible changes are caused by mining activities (Babka O., Harta A, 2012).
The research and analysis of various rehabilitation solutions adopted as an example of the Bohumín post-mining area shows that the possibility of giving the area new utility values is even recommended. Nevertheless, each of the ideas of area' transformation should be considered thoroughly and all opportunities and threats related to the project implementation should be determined. It is necessary to take into account all the legal and economic issues stipulated among others in the environmental protection laws. When developing a plan for the implementation of new utility and restoration of the excavated land, the main focus should be on the elimination of environmental damage and risks. Such activities pose a great challenge from the perspective of maintaining safety, precision of their performance and inclusion in the project and its implementation of all levels of public administration. It is important to remember that in order for the post-mining area to be developed in a given way, professional rehabilitation activities must be undertaken in order for the area to take over new functions. Rehabilitation operations covering a given post-mining area usually involve removing any imperfections and remnants of already completed industrial activities and restoring to some extent the land's properties.
The study presents an example of one of many post-mining areas. An important aspect is the fact that post-industrial areas should be transformed in order to develop them again. Benefits will arise both for the inhabitants of nearby towns and for the town itself, where the post-mining area has been rehabilitated due to the possibility of its re-growth.

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Abstract.
Rehabilitation of post-industrial areas involves many areas. The area after hard coal mines, requires many specific actions and funds in order to eliminate any remnants of the former infrastructure that is located in this area. The area of Upper Silesia, which includes areas on both the Polish and Czech borders, belongs to the area where the process of underground hard coal mining is being extinguished. As a result of the completion of mining works, the mine areas and adjacent sites begin to undergo transformations. Thus, the landscape of this area changes, various types of land, residential buildings and roads are destroyed. The activities related to restoring the utility value to degraded areas should be carried out consistently, primarily from their inhabitants' perspective. The rehabilitation of post-mining area and its proper management can bring great benefits to the city and its inhabitants in the future. The publication presents a proposal for land development solutions for the former hard coal mine in Bohumin, Vrbice district in the Czech Republic.

Keywords: Bohumin, mine, post-mining areas, rehabilitation, land development