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RECLAMATION AND REVITALISATION OF LANDS AFTER MINING ACTIVITIES. POLISH ACHIEVEMENTS AND PROBLEMS

1. Introduction

Minerals are essential for the economic and civilization development of societies and their acquisition is indissolubly linked with the history of mankind. Mining activity has not only a positive but also a negative side, bringing the consequences for the environment. The effects of mining activities may be permanent (loss of mineral resources, transformation of the landscape) or transient (noise, dust, change of water conditions), which disappear after the cessation of the extraction.

Since ancient times mining has tried to minimize and repair the damages during the extraction of minerals, of course, if this was possible at that time. Proof of these activities is constituted by the records of the oldest Polish documents (the edict of Casimir the Great from the fourteenth century, the edict of Stefan Batory from the sixteenth century to abolish the regalia), as well as concrete projects, although from later years (19th century), but until today showing the need and opportunities for reclamation and the use of post mining facilities (Bednarski Park in Kraków). These were, however, sporadic cases. More attention was given to the need to correct the effects of the activity, not only mining, but also after a period of industrial and so-called intense industrialization, and especially after World War II.

However, the issue of the reclamation and revitalisation of post-mining areas took on specific dynamic after 1989 — during the transformation of the Polish economic–social system. A large number of closed mines, and even entire mining districts, significant costs, as well as the long period of the liquidation of the mines, caused a need for the preparation of theoretical bases for the design, the preparation of formal and legal procedures, decision

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making and project execution organization, and above all to determine mine closure funding resources along with the reclamation and revitalisation of areas after mining activity.

The previous experience and major achievements of the Polish mining industry in both theoretical and design areas as well as in the field of mine closure projects including the reclamation and revitalisation of post-mining areas are the subject and content of the article.

2. Reclamation, redevelopment and revitalisation — the current legal status

The repair of the effects of mining activities in the environment was, until recently, confined mostly to restoring, at least in part, the previous state — before the exploitation. In practice, the areas after exploitation were left for natural succession or reclamation works were undertaken in the modes of agriculture or forestry use. Such actions were sanctioned by the laws and regulations then in force.

The Mining Law, revised in 1960, introduced legislation requiring companies to eliminate mining facilities and reclaim mining areas, in the event of the termination of the activity. Resolution No. 301 of the Council of Ministers dated 6 September 1966 on the reclamation and redevelopment of land transformed in connection with the exploration and exploitation of minerals was another piece of legislation, however only relating to the mining industry [12].

The above-mentioned resolution differentiated the stages in the recovery activities of the post-mining areas, namely reclamation and redevelopment. These stages were upheld by the Act of 26 October 1971 on the Protection of Agricultural and Forest Lands and Land Reclamation [13] however, the obligation of the reclamation and redevelopment was extended to all the devastated and degraded lands. This situation has not changed in the subsequent versions of the provisions of the Act, i.e. from 1982 and 1995 (presently in force).

In the Act on the Protection of Agricultural and Forest Lands [15] the term “reclamation” and “redevelopment” have also been defined. In accordance with Article 4 of the Act the reclamation of land is understood as *creation or restoration of utility or natural value for degraded or devastated land through proper formation of the landscape, enhancements of physical and chemical properties, regulation of water conditions, and restoration of soil, reinforcement of scarps and reconstruction or construction of indispensable routes and redevelopment is understood as agricultural, forestry or other use of reclaimed land.*

From these definitions it follows that the remedial work has been mainly targeted with the needs of agriculture and forestry reclamation (reconstruction), but also include the possibility of extending the concept of reclamation onto other possible use of the transformed areas. Also, the Act of February 4, 1994, Geological and Mining Law [14], by introducing the obligation requiring reclamation and redevelopment of land after mining activities, refers to the provisions of the Act on the Protection of Agricultural and Forest Lands, Article 80. 2: *For the reclamation and redevelopment of land (...), the provisions on the Protection of Agricultural and Forest Lands shall suitably apply (...),* which maintained a preference for the agricultural and forest modes of the reclamation.

The imposition of the obligation for the reclamation and redevelopment post-mining areas on the mining entrepreneur in the provisions of law [14], led to many misunderstandings and conflicts due to the lack of an unambiguous determination of the project scope and boundaries between them, especially when it comes to opencast excavations. In order to avoid misunderstandings and not charge mining companies with the sometimes very high costs of redevelopment of the reclaimed areas, the new Geological and Mining Law (of 9 June 2011) left only the obligation of reclaiming the area, excluding the redevelopment and use of land and buildings from these obligations [16].

The term “revitalisation” does not occur in the above-mentioned provisions of law or in any other provision of a legislative nature. This term is defined in the strategic documents and operational programmes as a basis to apply for funding revitalisation projects from EU funds. It should be added that one definition of revitalisation does not function, but a lot of different definition function in these documents. According to the Małopolska Regional Operational Programme revitalisation (Latin: *re – return + vita – life = revival*) is *a comprehensive, coordinated, multi-year process of spatial, technical, social and economic changes initiated mainly by the local government in order to lead the region out of crisis by giving a new functional quality and create conditions for its development on the basis of specific endogenous determinants* [17].

A common feature of all definitions of revitalisation is to join the technical and environmental measures with economic and social activities into one process, which, in turn, will bring the socio-economic recovery to the area affected by the crisis. Only projects that meet these criteria, and therefore complex projects, have a chance of obtaining funding.

The revitalisation activity has become current in recent years, especially in urban areas, where large plants, or industrial units along with infrastructure are being closed due to outdated technology and the lack of the demand for the current production. In mining, this problem particularly affects the mining districts (e.g. the Wałbrzych, Upper Silesia and Tarnobrzeg districts), in which industrial plants along with the entire infrastructure, industrial and residential areas operated near the mines.

Next to the technical (removal of the excavation) and environmental (removal of the effects in the environment) activities the social problems of industrial agglomerations are the most difficult to solve. Thus the use of labour force and infrastructure facilities after the mines closed down is the main objective of the revitalisation process.

There is currently a need in the mining industry to pursue all three forms of repairing the effects of mine closure, such as the implementation of reclamation, redevelopment and revitalisation.

3. Types of facilities and their structure

A large variety of mine types (underground, opencast, boreholes), various forms of spatial-organisational (individual mines, mining and processing conglomerates, mining and industrial districts), the difference in the effects of exploitation on the environment, including the transformation of the site (excavations, overburden dumps, subsidence troughs) and,

above all, the new requirements and the needs of society greatly expanded the list of ways to repair and re-use the land after mining activities.

If the main modes of the reclamation until recently have been agricultural and forestry, which was determined by large areas of land exploitation by open pit method and surface overburden dumps and landfills, the aim at present is to vest the post-mining areas, often with extensive industrial infrastructure and housing estates, new use-values, adequate to the conditions and social needs. They are the often multi-function, and the selection of optimal solutions requires not only the execution of studies and an interdisciplinary project, but also to have the proper tools for ensuring the objectivity and rationality of solutions, and finally possessing large financial resources.

The selection of the manner of repairing the effects must first and foremost take the type and the specificity of the site and subject into consideration. As previously noted, there are many differences between them depending on the particular mining industry. Even such basic, mining facilities as excavations are radically different in their different methods of operation — underground, opencast or borehole. However, the methodology of designing reclamation projects needed to classify and systematize the industrial and territorial types and structures, which was the subject of works carried out in the Department of Opencast Mining of the AGH University of Science and Technology.

The basic unit subject to liquidation in the mining industry is the mine. In the case of the concentrations of several mines and related facilities in one vicinity, the post-mining area (district) is the subject of the liquidation and repair works. If the post-mining units with a similar profile and similar characteristics are located at certain distances, they may be related to the future functions of the so-called thematic trail.

In each mine certain elementary facilities stand out, namely:

- excavations,
- overburden dumps and landfills,
- industrial infrastructure,
- industrial areas.

Excavations are facilities specific to a particular method of exploitation and are the most varied. Other facilities in the each of the exploitation methods are similar in form and function and may vary in size. Units or architecture and landscape interior complexes are also differentiated in the individual facilities (Fig. 1).

The arrangement and systematization of the post-mining lands and facilities make research studies and projects aimed at selecting the most favourable modes of reclamation and revitalisation, which make up the starting point for methodological problem solved in the design processes much easier.

4. Methodology of reclamation and revitalisation designing

The mines closure and the reclamation and revalorisation of facilities and areas is a complex process that requires the careful preparation of the design and documentation for the project and its completion:

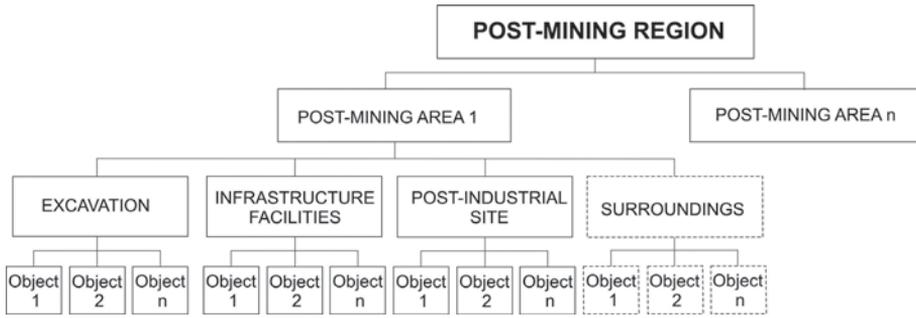


Fig. 1. The spatial structure for the post-mining region [4]

- inventory and characterisation of facilities,
- determining the modes of reclamation and revitalisation,
- determining the implementation schedule,
- preparing a cost estimate,
- elaborating guidelines for the implementation of repair and maintenance processes of the facilities resulting from revitalisation.

The basic step is a detailed inventory of the facilities with an assessment of their condition, suitability and any formal and legal restrictions on their use. Performing this task serves to develop a classification and systematic of the areas and facilities. The inventory should include a detailed description of the factors that determine the possibility of using the facility. The most common factors for the post-mining sites and facilities are as follows: cultural, economical, environmental, formally-legal, hydro-geological, technical, social and spatial [4]. The analysis of factors is one of the most important steps in the revitalisation process. It allows for a detailed description of not only the area and facilities that require remedial action, but also the environment, and subsequently establish criteria, which prefer, or do not allow specific functions to be carried out.

5. Reclamation (revitalisation) mode

The Polish law does not define the term “reclamation mode”. Despite this, the term “determine mode of reclamation” for example agricultural, forest, water, etc. is used in administrative decisions regarding reclamation. It should be mentioned that in practice, more than one mode can and should be set for a compound facility, which results from the different individual elements of the reclaimed unit. The reclamation and redevelopment of lands for the following functions are most commonly recommended for the post-mining areas: Forest, Agricultural, Water (natural, recreation, economic, fishing ponds), Recreational (sports, tourist, leisure), Cultural (contemplative, artistic), Educational, Natural (different forms of protection, natural succession), Housing and Economic.

When determining the mode of the reclamation and redevelopment of the mines in the post-mining district, the following should be considered:

- stages (for certain facilities),
 - target reclamation immediately,
 - a temporary reclamation, for example, in the first phase of filling the excavation with waste, and target reclamation in the second phase;
- collision-free — one cannot accept mutually exclusive functions, for example a contemplative one for a part of the mining site and an entertainment facility for the neighbouring mining site;
- incorporation into their surroundings — incorporation into their closer and further surroundings with reference to the values of the environment to enrich the function;
- social needs and acceptance as well as market conditions.

The manner of determining compliance reclamation modes for areas where multi-functional redevelopment is planned is presented in Figure 2.

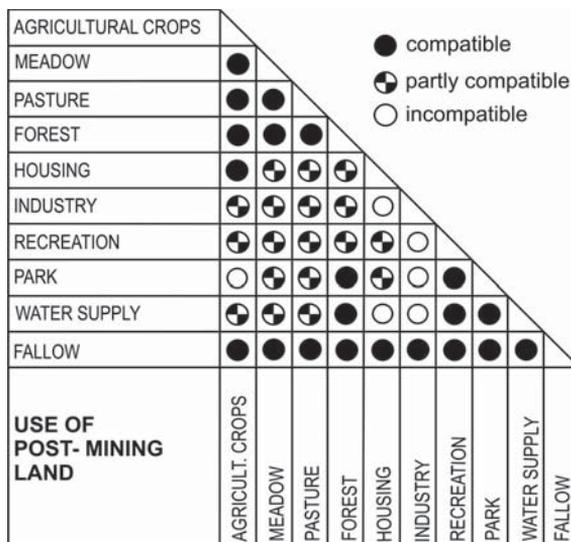


Fig. 2. Matrix of land-use compatibility [2, 7]

The redevelopment phase is no longer the obligation of the mining entrepreneur, and hence it is necessary to find funding sources that expect a return on the investment. The investments should previously obtain public approval.

6. Methods of selecting reclamation and revitalisation modes

In the case of the feasibility implementation of alternative functions, the optimal one should be selected. Several methods to select the mode of reclamation have been developed in Poland. The methods based on assessment of a geological suitability of soil for agricultural and forestry reclamation include the Skawina and Trafas, Żuławski and Krzaklewski methods [11].

The expert methods make up a large group of methods, based primarily on the evaluation of scoring conditions for their suitability for different modes of use of devastated or degraded areas [11]. One of them is the J. Malewski method, taking the entrepreneur and local authorities “interests” (preferences) into account is a variation of the method [3]. Since the reclamation, specifically the revitalisation projects tend to be very costly, multi-criteria methods with a preference of CBA methods (Cost-Benefits Analysis) are useful for the selection of optimal solutions.

In the assessment of reclamation and revitalisation projects alongside measurable criteria (e.g. currency) non-parametric criteria (e.g. aesthetics, quality) are also considered. In such cases, the method of Analytic Hierarchy Process (AHP) is very useful for the selection of optimal solutions. This is one of heuristic methods developed by American mathematician Thomas L. Saaty, based on mathematics and psychology elements. It helps optimal selections to be made in the case of multi-criteria decision problems, thanks to their positioning in a multi-level hierarchical structure. It is important that the AHP enables the simultaneous use of measurable and immeasurable factors. If the compared elements are not measurable the linguistic approach based on the fuzzy set theory, which allows imprecise terms to be described, can be applied [4, 10].

The AHP method was firstly used in the field of revitalisation to select the optimum regeneration concept of the Krzemionki Podgórskie area, after the mining and industrial activities in Kraków [4]. Six unused quarries after limestone and marl exploitation as well as the former German concentration camp “Płaszów” located between them with small quarries and crowbars are located in the region of Krzemionki. So far, only two quarries have been regenerated: School of Twardowski quarry turned for the Bednarski city park, as well as the marl quarry turned for the “Bonarka” Inanimate Nature Reserve. The characteristics of the region in terms of the factors listed in chapter 4, including the consideration of the industrial heritage, the natural succession of wildlife, both valuable and degraded facilities in the vicinity of quarries, and particularly World War II martyrdom caused, that the decision on how to regenerate the individual quarries and the entire region as a whole, required advanced methods. This was the reason that the AHP method was applied.

7. Sources of financing and organisational forms

According to the Geological and Mining Law [16] from 1 January 2012 repair works which are the obligation of the mining entrepreneur have been limited to reclamation (Article 129), and also not to redevelopment as constituted by the provisions from the Act of 1994 [14]. The primary source of financing these projects is a fund for the closure of a mining plant. By 2012, this fund was created in the following manner [9]:

- for mining companies using the underground or borehole systems for the excavation of liquid and gas minerals, and plants conducting the non-reservoir storage of substances or wastes in the rock mass, including underground mining excavations, no less than the equivalent of 3% of the depreciation allowances for the fixed assets of the mining plant,

- for companies using the underground or borehole systems, for minerals other than liquid and gas — no less than equivalent of 5% of the depreciation allowances for the fixed assets of the mining plant,
 - for mineral extraction by open pit mining — the equivalent of 10% of the royalty.
- According to a new Geological and Mining Law the deductions will be [16]:
- for mineral excavation using the underground or borehole systems — no less than the 3% of the depreciation allowances for the fixed assets of the mining plant,
 - for mineral extraction by open pit mining — no less than equivalent of 10% of the royalty.

With the changed rules and the correct mine closure cost estimate, the needed funds will be collected after the mine's functioning. However, when there is a need to close the mine earlier (e.g. due to the loss of profitability) the collected funds will be inadequate. It will be necessary to apply for funds from other sources such as:

- funds for environmental protection, such as the Regional or National Fund for Environmental Protection and Water Management,
- Funds for agricultural land protection,
- European Union funds.

Each of these funds has some restrictions on the scope or the type and level of funding, but using them can support the reclamation works. It should be noted that until 2001, the system of collecting funds for the mine closure did not function in Polish mining industry. The huge needs arising from the closure of many unprofitable mines and even basins after 1989 were covered by the state budget.

At present, after the amendment of the Geological and Mining Law [16], the provisions of which require only carrying out reclamation from an entrepreneur, an urgent need has arisen to solve the manner of implementing the next stage i.e. the redevelopment (revitalisation). First and foremost, this refers to the preparation of conditions and the preference for this type of investment, taking the principles of the market economy into account.

The first experiences with the organisation of financing such investments are the "Solvay" Soda Plant transformed into the "Zakopianka" Shopping Centre in Kraków and Katowice-Kleofas Coal Mine turned into the Silesia City Centre in Katowice.

8. Chosen examples of revitalisation of post-mining areas

Although according to the statistics the most often carried out reclamation and redevelopment modes are agriculture and forestry, one can find a lot of other interesting and above all socially desirable ways of using post-mining areas, among the completed revitalisation projects. Overburden dumps at the mines, which are located far from the mountain areas are a great opportunity for adaptation into winter sports facilities. The water reservoirs in inactive excavations provide a wide spectrum of possibilities to adapt them to new functions, from natural, through fishing, to the advanced recreational and sports functions. The infrastructures of underground and borehole mines are gladly converted to museum and facilities of a cultural nature.

Some examples of the revitalisation of all the mining sectors, which have been implemented or are in progress will be presented.

8.1. Underground mining

In Poland, the most common way to regeneration both the underground excavations and a surface infrastructure are museums and tourist routes, accompanied by cultural features, wellness and others. An example is the **Archaeological and Natural Museum and Reserve “Krzemionki Opatowskie”** created from the prehistoric complex of flint mines. The mines were exploited during the Neolithic and Early Bronze Age, and were discovered in 1922. After the relevant work historical flint mines were open for tourists. The underground complex was recognized as a historical monument in 1994.

Excellent examples of using the fascination of the underground world are making the **“Wieliczka” and “Bochnia” Salt Mines** accessible for tourists. The underground excavations illustrate the different stages in the development of mining technology, and additionally provide wellness, cultural and recreational sports functions. The Wieliczka Salt Mine is included in the UNESCO World Cultural and Natural Heritage List.

In 2006 an **Industrial Monuments Route of the Silesian Province** was created. This is a tourist route, connecting 36 facilities related to the industrial heritage of Silesia, including old mines and mining settlements. The most popular is the historic **“Guido” Coal Mine** in Zabrze (Fig. 3), which offers not only sightseeing, but also many cultural attractions. An integral part of the Route is the International Centre for Documentation and Research for the Industrial Heritage Tourism, established in 2008.



Fig. 3. Historical coal mine “GUIDO” in Zabrze.
Source: <http://www.zabytkitechniki.pl>

The former Katowice-Kleofas Coal Mine was redeveloped for the economic functions (commercial, recreational). The construction of the Silesia City Centre — commercial-entertainment centre was completed in 2005. Apart from the technical procedures preparing the

land for the construction of new facilities, several historic buildings of an old mine were subject to preservation and restoration, including the George [Jerzy] Shaft engine house, which was adapted into a chapel (Fig. 4).



Fig. 4. Former engine house of the George [Jerzy] Shaft transformed into chapel — view from the Shaft.

Photo: A. Ostreĝa, 2006

The most spectacular example of revitalisation in Poland is the creation of **the General George Ziętek Culture and Recreation Regional Park** on the areas highly transformed by mining and metallurgy activities. From 1952–1962 the area of 620 hectares was transformed into a recreational park with such attractions as a zoo, funfair, stadium, swimming pools, planetarium, heritage park, rose garden, cable car, exhibition pavilions forest reserves and green areas. The scale and complexity of the revitalisation project has not yet been repeated.

8.2. Borehole mining

In Poland, the borehole system is used for sulphur, oil, gas and mineral waters extraction. So far, there is no form of commemoration of native sulphur mining, using both the borehole and the open pit system. There is a chance that it will happen in the last in Poland and Europe and still active “Osiek” Sulphur Mine. Open-air museums were created on the former oil and gas mines. The largest and best known is **the Ignacy Łukasiewicz Museum of Oil and Gas Heritage Park** in Bóbrka. Since 2007, Kazimierz Dudka (“Magdalena” Oil Mine manager) has been building a **Museum of Oil Industry “The Magdalena”** in Gorlice in the Magdalena Mine site (Fig. 5).

It is worth noting that there are other facilities in Gorlice associated with the petroleum industry: oil refinery, drilling equipment factory, architecturally valuable administrative buildings and housing estates. The first in the world formally functioning oil mine (licence from 1852) functioned in Siary nearby Gorlice. There was also a distillery in Siary, in which



Fig. 5. Museum of Oil Industry “The Magdalena” in Gorlice.
Photo: A. Ostreǵa, 2011

I. Łukasiewicz completed the first non-pharmacy oil distillation, creating the foundation for the petrochemical industry (1856). Thus, it is possible to create a centre comprehensively illustrating the development of mining and processing of petroleum in Gorlice, which would be a valuable link in the Carpathian and the Galician Oil Trail. This would also show the role and importance in the development of Gorlice, not only in the national, but also the global oil industry.

8.3. Open pit mining

The oldest example of Polish revitalisation is the transformation of the exploited quarry in Podgórze (now part of Cracow) into a city park. It was conducted by a teacher Wojciech Bednarski between 1884–1886, without any legal and scientific basis. This is why this investment is considered to be the flagship. Another good example is the amphitheatre and the Inanimate Nature Reserve built in the former limestone quarry in Kielce (Fig. 6).



Fig. 6. Amphitheatre “Kadzielnia” and the Inanimate Nature Reserve in Kielce.
Photo: A. Młynarczyk, 2009

A successful reclamation and redevelopment project is the adaptation of an external overburden dump at the “Bełchatów” Lignite Mine for a ski run with the length of 760 m and other sports facilities as an alternative for the summer seasons with social infrastructure (Fig. 7). A wind farm was constructed on the plateau of the dump.



Fig. 7. The “Góra Kamieński” sport and recreational centre at the overburden dump in the Bełchatów Lignite Mine. Photo: A. Ostreża 2008

The multi-functional reclamation and redevelopment has been designed for the “Kujawy” Limestone Mine belonging to Lafarge Company and the “Obora” Filling Sand Mine belonging to KGHM Polish Copper. A sport and recreation function as well as a mouflon reserve, and a museum to commemorate mining activity have been proposed on the grounds of the “Kujawy” Mine. Due to the large surface of area of the mine (approximately 1,000 ha) three zones differentiated by the target redevelopment and use intensity were included in the concept of reclamation and redevelopment [6]. While the “Obora” Filling Sand Mine is planned to be transformed into a sports and recreation and spa treatment facility in the future, based on the natural resources of the copper mines (salt, geothermal water) [1].

9. Summary

Over the years the development of reclamation and redevelopment ideas has been observed. This is manifested not only by changes in the law requiring the reclamation and the collection of funds for its implementation, but also in the use of the assets of the post-mining areas (water-filled excavations, dumps). This entails the development of design methods for reclamation and redevelopment, including making various types of analysis that allows the concept, as well as the optimal choice to be outlined. A well-designed reclamation and redevelopment not only complies with environmental requirements, but also the expectations of society — is a compensation for necessity of tolerance of various nuisances at the operational stage of the mine. There is finally an opportunity for the social and economic development of municipalities and regions.

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