



REVITALIZATION POSSIBILITIES OF THE POST-MINING AREA OF NATURAL AGGREGATE MINE IN THE WARYŚ VILLAGE

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Abstract

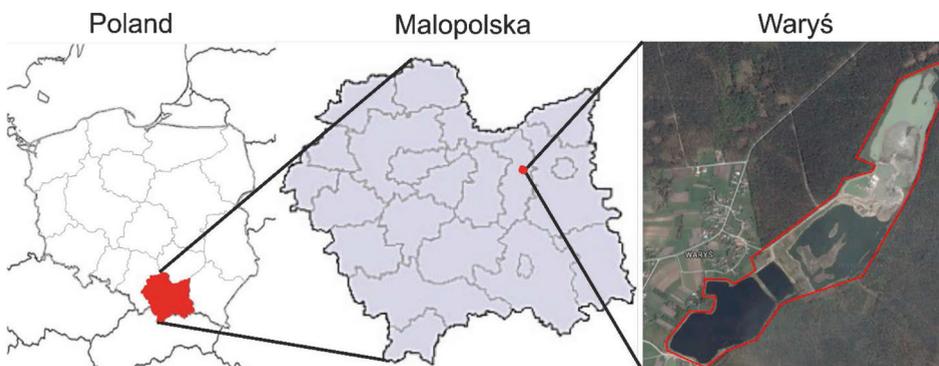
According to the social expectations, the natural aggregates post-mining area in Waryś should be revitalized towards the water function and serve as a recreational area. The paper identified the features which characterize the post-mining area of “Waryś” mine and its surroundings. On the basis of these features evaluation of opportunities for recreation and leisure functions was conducted. The conducted analysis indicates that although this feature seems to be attractive for many reasons, from the point of view of economic efficiency it is not justified, as the necessary revitalization works will require incurring high capital investment costs necessary for proper formation of the recreation and leisure space and its surroundings. At the same time the possible financial benefits probably will not balance the amount of costs incurred for the maintenance of the infrastructure and objects serving the recreation and leisure functions. However, the risk of failure of the revitalization may be decreased by diversifying the form of shaped space, because various revitalization modes and/or functions may efficiently coexist with each other, thereby forming a synergy effect.

Keywords: post-mining areas, tourism and recreation space, revitalization, mine natural aggregate, Waryś

INTRODUCTION

Modern society is becoming more and more tired by the lifestyle popularized in the mass media and dominated by constant striving to meet the needs of civilization. Leisure time, facilitating the recovery of psychophysical balance, is an essential element of this lifestyle. This results in increased interest in various forms of recreation and the search for new recreational and leisure space (Fagiewicz, 2010).

In recent years, an increased interest in using the opportunities offered by the surface mining pits, which can be used as sites for recreation and leisure, can be observed. This is supported by the regulatory requirements for the protection of the environment and the growing needs and expectations of the society towards the revitalization of brownfields.



Source: www.google.pl/maps/

Figure 1. Localization of post-mining area in Waryś

One of the regions rich in natural aggregate deposits is Tarnów subregion, located in the southern part of Poland, in which several dozen of sand and gravel quarries have operated. Some of these deposits have already been depleted or their exploitation will be completed in the near future. They will be subjected to the processes of reclamation and development both of which are more and more often called revitalization. In a significant proportion of cases, these pits will serve as recreation and leisure areas, which is dictated by high social expectations in this respect and the acceptance of the local authorities (Kryzia, Kryzia, 2016). One of them is the „Waryś” deposit with an area of about 40 hectares, exploited in the “Waryś” natural aggregate mine. The mine began operating in 2003 in the village of Waryś (Borzęcin municipality, Brzesko County, subregion of Tarnów, Małopolska Province (Fig.1)) and in the period of the peak mining production was ranked among the largest mines in Poland. Currently, this deposit

is becoming depleted; at the same time plans for revitalization of the post-mining areas are being prepared (www.kopalniawarys.pl).

The concept of revitalization (Latin: re – back + vita = life, recovery) is defined in the government program for brownfields (Program... 2004) as activities involving the process of reclamation and the process of re-landscaping (including remediation, reconstruction and modernization of the existing land cover), allowing to utilize post-mining areas. Revitalization, in addition to a comprehensive use of land, of buildings and their surroundings should be associated with improved quality of people's life; this can be achieved by eliminating threats to the natural environment, creating new jobs, and preserving cultural heritage (Ostręga, Uberman, 2005). Thus, in order to effectively utilize post-mining areas, the revitalization process should be implemented in accordance with the principles of sustainable development, usually through the introduction of new functions of the mentioned areas (Kasztelewicz, Ptak, 2011; Dołzbłasz, Mucha, 2015).

However, brownfield revitalization in accordance with the principles of sustainable development is a major challenge, especially in rural industrial areas such as the former mine of Sao Domingos in Alentejo (Portugal), which have little chance of attracting private investments (Sardinha, et al., 2013). In the literature one may find numerous examples of areas where revitalization in accordance with the principle of sustainable development was a success, bringing interchangeable economic, environmental and social benefits. These include:

- Landschaftspark Duisburg-Nord w Duisburg-Meiderich (Germany), which serves as a multifunctional space of recreation with sports areas and playgrounds, arranged in an old steelworks (Keil, 2005);
- Schöneberger Südgelände Natur Park in Berlin (Germany) – ecological city park, built on the grounds of a former railway station (Kowarik, Langer, 2005);
- The Zollverein coal mine and coking plant industrial complex located in Essen (Germany) listed in the UNESCO World Heritage List (Ćopić et al., 2014);
- Family amusement park Pirkau in Hohenmölsen (Germany) (ReRegions, 2007);
- Bryn Bach Park in Tredegar (United Kingdom), which is a sports and recreation area, consisting of a lake surrounded by meadows and forests (Probert, 1986);
- Amusement park Cap ,Decouverte in Carmaux (France) built in a former lignite mine (ReRegions, 2007);
- The ROM-Redesign Roma Quarry in Sankt Margarethen (Austria) which is a theatrical space with a concert hall in the open air, located in a former granite quarry (Xiao, 2016);

- Dalhalla amphitheater built in a limestone open pit in Rättvik (Sweden) (Rubio, 2004);
- The Eden Project in St Austell (United Kingdom) whose main component is a botanical garden created in depleted kaolin pit (Blewitt, 2004);
- Brownstone Park in Portland (USA) – a recreation center offering a wide palette of sports built on the site of former quarries (McCandless, 2013);
- Ferropolis acting as an open air museum in a closed mine Golpa Nord in Gaefenhainichen (Germany) (Kasztelewicz, Kaczorowski, 2009),
- Hippodrome and autodrome located in a suburban recreation area „Velebudice” (Czech Republic) created at the site of the external dump of the J. Šverma mine (Kasztelewicz, Kaczorowski, 2009);

In addition, works are conducted within the project ReSOURCE aimed at revitalizing the mining areas in Central Europe: Mansfeld-Südharz, Zwickau-Lugau-Oelsnitz, Steirische Eisenstrasse/Styrian Iron Route, Zasavje, Sokolov–East, Salgotárján, Wałbrzych (Wirth, et al., 2012). These projects are large initiatives, in which economies of scale and synergistic effects are visible, often decisive for the success of the project.

Effects of the revitalization process can increase the attractiveness of the surroundings of open-pit mines as they enrich the landscape with new morphological forms, promote nature conservation by creating new habitats, support forest management and create recreation areas (Kasztelewicz, Zajączkowski, 2010). Given the fact that revitalization is conducted in the context of the function for which the reclaimed area will be used, the revitalization process is responsible for the final shape of the space subjected to the process.

There are different modes and functions of revitalization. The most important are discussed by Fagiewicz (2010), Ostreęga and Uberman (2010), and Paulo (2008). The choice of a revitalization mode is determined by certain characteristics of the post-mining area and its surroundings.

This study identified the features of the post-mining area of the “Waryś” mine and its surroundings. On the basis of these features, evaluation of the suitability of the post-mining area of natural aggregates mine in Waryś for recreation and leisure purposes was conducted. This function is indicated by the local government and residents of Waryś as highly desirable.

FEATURES DETERMINING THE SELECTION OF THE MODE AND FUNCTION OF REVITALIZATION

Selecting the mode and function of revitalization requires careful description of those features of the area and its surroundings that influence this choice.

Moreover, it requires setting specific criteria and indicating the method for choosing the mode and function (Ostręga, Uberman, 2010).

An analysis of the described factors allows determining the criteria which may introduce certain restrictions, preferences, admissibility or discretion when choosing the revitalization method. This analysis provides the basis for determining the optimal mode of revitalization. The term “revitalization mode” should be understood as the target use of the land that requires corrective actions. In the literature, there are many classifications of revitalization modes (Ostręga, Uberman, 2010). The division proposed by Malewski (1998) appears to be the most useful for the needs of quarrying. It includes the following modes: natural, recreation and tourism, agricultural, forestry, water, and industrial. Within these modes, detailed modes, the so-called functions of the revitalized area, can be specified.

The choice of the revitalization mode depends on a number of features that characterize the area (and its surroundings) in need of revitalization in terms of spatial and socio-economic development. Among the most characteristic factors the following parameters can be specified: internal, environmental (natural), formal and legal, social, spatial, economic, hydrological, infrastructural, and agrarian (Bobrek, Paulo, 2005; Kwiatkowska-Malina, Wyszomierska, 2014; Ostręga, Uberman, 2005, 2010).

The above-mentioned features characterizing the post-mining area of the “Waryś” deposit are described below.

The internal conditions of the deposit

The open-pit was created as a result of exploitation of the „Waryś” deposit is an area of approximately 65.8 hectares and is filled with water (60.0 hectares). This is the result of a shallow water table, located at the average depth of 1.3 meters. The average thickness of the deposit is 6.5 meters while the average thickness of the overburden is 1.5 meters. Mining of the aggregates (quaternary gravels and sands) was conducted below the water table. The pit lake now has a varied coastline. Islands, peninsulas and dikes may be found. Overburden and mining waste dumps are virtually not present.

Natural conditions

The created pit lake is located within the Radłów-Wierzchosławice Protected Landscape Area and is a permanent water reservoir without runoff, located on the left terrace of the Kisielina river, at a distance of about 2 km from the river. In the immediate vicinity of the pit there are woodlands, meadows, pastures, and wastelands. Forests and woodlots are extremely valuable part of the landscape, while act as refugia for many plant and animal species. These are mainly pine forests, which grow on poor sandy soils. These forests are abundant

in mushrooms and fruits of undergrowth. Their immediate proximity to the excavation increases its attractiveness.



Source: Own work

Figure 2. A view of post-mining area of mine natural aggregate in Warys

Legal conditions

The revitalization mode must comply with the provisions of the local spatial development plan. According to the existing documents, the post-mining area of the „Warys” mine should be reclaimed towards agricultural and water use. Municipal authorities in Borzęcin passed a resolution to change the local spatial development plan for Borzęcin municipality in order to include part of the Warys village within its administrative boundaries. These changes will affect the revitalization mode of the post-mining area and its function. Thus, the local government affects the shape of the post-mining areas through adapting them to recreational and leisure purposes (Naworyta, 2013b).

The factor that may significantly reduce the chances for implementation of the revitalization process of the „Warys” mine’s post-mining areas are unregulated ownership issues and the associated difficulties in finding common ground between the owners.

Social conditions

The revitalization processes should take into account the potential beneficiaries of the managed objects, or the social factor. This term is not understood as social expectations, but above all the as the adjustment of the object and its features to the needs of the local community and visitors (Naworyta, 2013b; Ostręga, Uberman, 2005).

It is expected that the development of tourism in the Borzęcin municipality may result in raising the level of economic and social life of its inhabitants. Revitalization projects should, however, be planned at a level that allows their implementation and which is adapted to the social and economic structure (Kwiatkowska-Malina, Wyszomierska, 2014; Gilewska, Otremba, 2015). This condition is not quite met in the case of Waryś village. The rate of social and economic development is overestimated. Recreational and leisure function of the pit lake is not justified by actual social demand. Waryś is located at a considerable distance from a large urban area; therefore, due to the lack of adequate social potential, a high demand for this type of service or a large number of potential users shall not be expected. In addition, in a short distance from the Waryś village, there are other mine pits, which are revitalized or their revitalization is aimed towards adapting them to recreational and leisure purposes. As a result, on high competition can be expected. Therefore, uncritical implementation of social expectations, not taking into account the insufficient demographic potential can lead to the failure of the project, especially in economic and reputational terms (Naworyta, 2013b).

Spatial requirements

The area around the excavation is flat, with no hills. In the immediate vicinity of the pit lake (at a distance of several dozen meters) there are residential and farm buildings belonging to the inhabitants of Waryś. More than half of the perimeter of lake is bordered by forest. The area, which can be used for the construction of infrastructure for recreation and leisure, is significantly reduced because there are few meadows, fields and wastelands in the immediate vicinity of the excavation. At present the village has no accommodation or restaurants. Farm tourism and accommodation in the Waryś village and in Borzęcin municipality are non-existent. Waryś village is located several kilometers from the nearest national road. There is, however, a railway station, in the near village of Biadoliny.

Economic conditions

A common shortcoming when choosing the method of reclamation is neglecting the costs of facility maintenance after its development. This applies

mainly to the recreational and leisure areas desired by the local community. It is believed that a water reservoir with recreational functions will lead to the flourishing of tourism, which will improve the economic situation of the municipality. Meanwhile, the maintenance of the facility after the reclamation also involves costs, for which the local government or an entrepreneur that owns these areas are often unprepared. Such objects rarely generate enough money to ensure their maintenance in good condition (Naworyta, 2013a, 2013b). The municipality plans to raise money for the implementation of the revitalization process from the European funds. Municipal authorities have not provided detailed assumptions of the business plan for the funding of the project during its entire lifecycle. The high operating costs and low social potential of projects related to recreation and leisure raise concerns about the economic viability of such a solution.

Hydrological conditions

Hydrogeological conditions largely determine the state of the excavation and thus the mode of revitalization. In the case of the pit filled with water as is the case in Waryś, it seems obvious to conduct the revitalization with the aim of developing water infrastructure. However, the function of the water reservoir depends on its nature and water resources (Ostręga, Uberman, 2010).

At the moment, the water purity class in the pit lake in Waryś is unknown. Some of the features of the lake meet the requirements set for recreational and leisure reservoirs: mainly the low amplitude of the water-table fluctuations (below 0.5 m) and the area exceeding 5 hectares. On the other hand, the lake is deeper than 3 meters and does not allow isolating a shallow area for beginning swimmers (under 1.5 meters). While the shallowing of the reservoir is possible, it is not economically justified. In addition, it is necessary to conduct profiling (for future beaches) of the slopes facing south and making them available for sunbathing, including covering with a layer of sand or gravel.

At the same time, the lake formed during the exploitation of the „Waryś” deposit located below the water does not meet the traditional requirements for fish ponds. Permanent waterlogging of the pits prevents draining of water, cleaning, and drying the bottom in order to conduct sanitary treatment, which is of great importance in fish farming. The optimum depth of a fish pond is 1.5-2 m, for some species up to 2.5 m (Bobrek, Paulo, 2005). The discussed pit lake is deeper.

Infrastructural conditions

Waryś village does not have a sewage system. Waste water is usually collected in household tanks, the so-called septic tanks. It happens that people dump waste water directly into drainage ditches. The lake with recreational and leisure functions requires maintaining water quality in the reservoir which would in

turn require installing sewage system in the residential areas within 2 km from the reservoir and reducing fertilization of adjacent lands. It is also important to build catering and accommodation facilities, internal roads and parking lots to minimize the risk of contamination of water in the lake. There is medium voltage energy line in a short distance from the lake. The village is equipped with a water supply line and a low-pressure gas line powered with high-methane natural gas.

Agricultural conditions

In the immediate vicinity of the post-mining excavation there are sandy soils of class 5 and 6 which require fertilization in order to produce satisfactory yields.

SELECTING THE MODE AND FUNCTIONS OF THE REVITALIZATION AS OPTIMIZATION PROBLEM

The above-mentioned conditions are the basis for defining the constraints to be taken into account at the stage of selecting the mode and function of revitalization. However, in the market economy, making decisions on implementation of investment projects, including revitalization projects, requires economic efficiency assessment.

Selecting the mode and function of revitalization should be based on the optimization of the economic criterion. One solution may be to select more than one mode or function of revitalization. If more than one method of revitalization could be implemented, the area of optimal solutions would increase considerably.

The problem of choosing the revitalization mode has been the subject of many theoretical works (Malewski, 1998; Ostręga, 2004; Uberman, Ostręga, 2012). The methods aimed at solving the problem of optimal choice of the revitalization mode, were based on expert assessment of the factors characterizing the feasible revitalization modes. These include methods by Cymerman (1988), Malewski (1998), and Ostręga (2004).

DIVERSIFICATION OF THE MODE AND FUNCTION OF REVITALIZATION

The recent literature of the subject suggests that the conversion of the natural aggregates post-mining areas into recreation and leisure areas is increasingly popular. However, in most cases these activities are not successful ventures. The risk of revitalization's failure can be reduced by diversifying forms of the shaped space.

Revitalization of a post-mining area does not need to be conducted in only one direction and with only one function in mind. The combination of several

modes and/or functions leads, to a greater or lesser extent, to the emergence of synergistic effects. Different modes and/or functions of revitalization may coexist effectively, especially in the case of large mining areas. Moreover, the selection of the single mode and/or function of revitalization around the entire mining area is often impossible due to the large diversity of local conditions (Bobrek, Paulo, 2005; Naworyta, 2013a, 2013b).

All modes or functions of revitalization conducted in a post-mining area should be interrelated, which affects the shape and functioning of the revitalized area through the resulting synergies, allowing obtaining multiplied benefits. The strength of the synergy effect depends on the ability to interconnect different modes and functions of revitalization and the type and level of their interrelations. Therefore, when it is possible to combine a number of functions, it is worth to focus on variety when planning the revitalization process (Naworyta, 2013a). For example, next to the recreational use of post-mining pits, part of the transformed land can be used as a shelter for plants and animals. Post-mining areas, especially those located near the flooded workings, can be used for holiday housing. Simultaneously, thematic paths of various kinds may be created along with hiking, cycling, and horse riding paths, sport fields, tennis courts, fields for team games and playgrounds. The proximity of forests and meadows (occupying considerable space) may be made more attractive by building horse stables, a riding school, and a hotel for horses. Other solutions include construction of platforms for launching light boats, construction of floating platforms for the purposes of recreation, fishing, canoeing, for mooring light boats and pedal boats.

SUMMARY

The process of revitalization shapes the space of post-mining areas. Before choosing the revitalization and future function of the revitalized area it is important to conduct an analysis of the area undergoing revitalization in terms of a number of factors. Diversification of modes and functions of the post-mining area revitalization is highly desirable because it leads to the emergence of positive synergies and reduces the risk of the revitalization process at all levels.

According to the social expectations, the natural aggregates post-mining area in Waryś should be revitalized with the aim of developing water infrastructure and serve as a recreation area. An analysis of factors characterizing this post-mining area and its surroundings indicates that this mode of revitalization is justified; however, the recreational and leisure function is not. This feature seems to be attractive for many reasons, but not from the point of view of economic efficiency, as the necessary revitalization will require incurring high capital investment necessary for proper formation of the recreation and leisure space and its surroundings. At the same time, the possible financial benefits probably would

not balance the amount of costs incurred for the maintenance of the infrastructure and objects for recreation and leisure purposes. Thus, the formation of the recreation and leisure space in the context of the revitalization of the post-mining area must be treated as a commercial venture investment governed by the laws of the free market.

REFERENCES

- Blewitt, J. (2004). *The Eden Project—Making a Connection*. *Museum and Society* 2(3), p. 175–89.
- Bobrek, K., Paulo, A. (2005). *Problemy zagospodarowania wyrobisk po eksploatacji kruszywa naturalnego na przykładzie złóż w dolinie Soły między Kętami a Bielanami*. *Geologia*, 31 (2), p. 153–165.
- Ćopić, S., Đorđević, J., Lukić, T., Stojanović, V., Đukićin, S., Besermenji, S., Tumarić, A. (2014). Transformation of Industrial Heritage – an Example of Tourism Industry Development in the Ruhr Area (Germany). *Geographica Pannonica*, 18 (2), p. 43-50.
- Cymerman, R. (1988). *Rekultywacja gruntów zdewastowanych*. Skrypty Akademii Rolniczo-Technicznej w Olsztynie. Olsztyn: Wydawnictwo ART.
- Dołzbłasz, S., Mucha, P. (2015). *Wykorzystanie terenów pogórnich na przykładzie Walbrzycha*. *Studia Miejskie*, 17, p. 105–118.
- Fagiewicz, K. (2010). *Kształtowanie przestrzeni turystyczno-wypoczynkowej na obszarach pogórnich (na przykładzie adamowskiego zagłębia węgla brunatnego). Krajobrazy rekreacyjne – kształtowanie, wykorzystanie, transformacja*. *Problemy Ekologii Krajobrazu*, XXVII, p. 147–155.
- Gilewska, M., Otremba, K. (2015). *Rekultywacja i rewitalizacja gruntów pogórnich na przykładzie gminy Kleczew*. *Zeszyty Naukowe Uniwersytetu Zielonogórskiego. Inżynieria Środowiska*, 159 (39), s. 15–21.
- ReRegions – *Handbook of best practice for reclamation and utilisation of brown coal mining areas in Europe. Environmental dimension*, 2007.
- Kasztelewicz, Z., Kaczorowski, J. (2009). *Rekultywacja i rewitalizacja kopalń węgla brunatnego na przykładzie Kopalni Belchatów*. VI Międzynarodowy Kongres Górnictwo Węgla Brunatnego. Kwartalnik AGH, s. Górnictwo i Geoinżynieria, z. 2, Kraków.
- Kasztelewicz, Z., Zajączkowski, M. (2010). *Wpływ działalności górnictwa węgla brunatnego na otoczenie*. *Polityka Energetyczna*, 13 (2), p. 227–243.
- Kasztelewicz, Z., Ptak, M. (2011). *Rekultywacja terenów pogórnich w kopalniach surowców skalnych*. Wrocław: Oficyna Wydawnicza Politechniki Wrocławskiej.
- Keil, A. (2005). *Use and perception of post-industrial urban landscapes in the Ruhr*. Kowarik I. (red.), Körner S. (red.), *Wild Urban Woodlands*, Springer-Verlag, Berlin–Heidelberg, p. 117-130.

Kopalnia Kruszywa Naturalnego Waryś. Sk Invest Green Sp. z o.o. Pobrane z: www.kopalniawarys.pl (10.09.2016)

Kowarik, I., Langer, A. (2005). *Natur-Park Sudgelande: Linking conservation and recreation in an abandoned railyards in Berlin*. Kowarik I. (red.), Körner S. (red.), Wild Urban Woodlands, Springer-Verlag, Berlin–Heidelberg, p. 117-130.

Kryzia, K., Kryzia, D. (2016). *Oczekiwania społeczne w zakresie rewitalizacji terenu pogórniczego kopalni kruszywa naturalnego „Waryś”*. Odnawialne źródła energii i gospodarka odpadami oraz ochrona i gospodarowanie zasobami przyrody – wybrane problemy w Polsce. Tarnów: Wydawnictwa Państwowej Wyższej Szkoły Zawodowej, p. 51–59.

Kwiatkowska-Malina, J., Wyszomierska, M. (2014). *Zagospodarowanie obszarów po eksploatacji kruszyw naturalnych na przykładzie złoża Sitno w gminie Rzewnie*. Infrastruktura i Ekologia Terenów Wiejskich, II (3), p. 705–717.

McCandless, C., (2013). *No Longer Just a Hole in the Ground: the Adaptive Re-Use of Resource Depleted Quarries*. www.mit.edu/people/spirn/Public/Ulises-11-308/Quarrying.pdf. (10.04.2017)

Malewski, J. (1998). *Górnictwo i gospodarka zasobami ziemi*. Górnictwo Odkrywkowe, (2–3), p. 169–178.

Naworyta, W. (2013a). *Aktualne problemy oraz trendy w rekultywacji terenów poeksploatacyjnych w górnictwie skalnym*. Górnictwo Odkrywkowe, (5-6), p. 203–210.

Naworyta, W. (2013b). *Jeszcze raz krytycznie o kierunkach rekultywacji i ich wyborze*. Prace Naukowe Instytutu Górnictwa Politechniki Wrocławskiej. Studia i Materiały, (43), p. 141–155.

Ostręga, A. (2004). *Sposoby zagospodarowania wyrobisk i terenów po eksploatacji złóż surowców węglanowych na przykładzie Krzemionek Podgórskich w Krakowie*. Rozprawa doktorska. Biblioteka Główna AGH w Krakowie.

Ostręga, A., Uberman, R., (2005). *Formalno-prawne problemy rewitalizacji terenów przemysłowych w tym pogórnicznych*. Górnictwo i Geoinżynieria, 29 (4), p. 115–127.

Ostręga, A., Uberman, R. (2010). *Kierunki rekultywacji i zagospodarowania – sposób wyboru, klasyfikacja i przykłady*. Materiały IX Krajowego Zjazdu Górnictwa Odkrywkowego. Górnictwo i Geoinżynieria, 34 (4), p. 445–461.

Paulo, A. (2008). *Przyrodnicze ograniczenia wyboru kierunku zagospodarowania terenów pogórnicznych*. Gospodarka Surowcami Mineralnymi, 24 (2/3), p. 9–40.

Probert, G. (1986). *New life for wasteland*. Landscape Design, (159), p. 54-55.

Program Rządowy dla Terenów Poprzemysłowych przyjęty przez Radę Ministrów w dniu 27 kwietnia 2004 r. Ministerstwo Środowiska, Warszawa.

Rubio, R.F., (2004). *Sustainable mining. Environmental assets*. Jarvis, A.P. (red.), Dudgeon, B.A. (red.), Younger, P. L. (red.), Mine water 2004 – Proceedings International Mine Water Association Symposium 2, p. 251-271.

Sardinha, I.D., Craveiro, D., Milheiras, S. (2013). *A sustainability framework for redevelopment of rural brownfields: Stakeholder participation at SÃO DOMINGOS mine, Portugal*. Journal of Cleaner Production, 57, p. 200-208.

Uberman, R., Ostreęa, A. (2012). *Rekultywacja i rewitalizacja terenów po działalności górniczej. Polskie osiągnięcia i problemy*. Materiały I Polsko-Niemieckiego Forum Rekultywacji i Rewitalizacji Obszarów Pogórnicych, Wisła-Jawornik, 8–9 marca 2012.

Wirth, P., Cernic-Mali, B., Fischer, W. (eds.), (2012). *Post-Mining Regions in Central Europe – Problems, Potentials, Possibilities*. Munich, Germany.

Xiao, Y., (2016). *MaterialScape: the transformation and revitalization of an abandoned limestone quarry into an educational and recreational public park*. Ball State University Muncie, USA.

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