



# The proposal for recultivation of post-mining areas of limestone deposits Żychcice II – Saturn in Wojkowice

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## Abstract

*Recultivation understood as the process of restoring economic value and utility of natural sites of post-mining areas should be regarded not only as a legal obligation for entrepreneurs but primarily as an opportunity for cities and municipalities. The properly selected direction of land recultivation should be converted to an asset for the further revitalization process and it could contribute to a significant increase in the attractiveness of those areas.*

*The following study is a proposal for the most efficient land-use of post-mining areas of „Żychcice II – Saturn” mine. The presented method is a compromise between the expectations of the local population and real demands. In the process of creating the concept, authors took under the consideration a number of factors, which determine the best land-use – especially economic, nature and social factors.*

*This implementation idea allows Wojkowice to optimize usage of that lands for improving their potential as a city and increase its attractiveness for inhabitants as well as tourists. Revitalization of post-mining areas would be a big challenge for municipalities, but also it could be a chance to increase the natural and usable values of these terrains.*

*Keywords: recultivation, open-pit, limestone, post-mining areas*

## Introduction

Recultivation of post-mining areas, because of its universality, is a topic, which is taken relatively often by mining specialists as well as by environmental engineering experts. (Gliniak et al., 2015; Hamanaka et al., 2016; Hudeček et al., 2014; Konečná et al., 2014, Naworyta et al., 2013).

This elaboration was prepared for the purpose of selecting the appropriate way of recultivation of the limestone open-pit „Żychcice II – Saturn“ located in Wojkowice.

One of the most important aspects of choosing correct direction of recultivation, is to focus on the real needs and possibilities for further use of those terrains. The forest-way direction, proposed by the authors, is in their opinion, the most optimal solution, That implementation is not only perfectly matched with the city development plan, but also contributing to meeting sustainable development goals and city planning assumptions for the following years. The selected recultivation option, in the perspective of further revitalization

process, should not only contribute to the continuous increase of natural values but also to the useful and recreational values of the city. With the mutual cooperation of entities involved in the extensive development of the post-mining areas, there is a high possibility to make these terrains an indispensable added value for the whole Wojkowice municipality.

## General information

Post-mining terrains of the “Żychcice II-Saturn” limestone are located in the county of Będzin, in the north-western part of the Wojkowicko-Rogoźnicki Hill. The vast majority of the deposit is located within the administrative boundaries of the town of Wojkowice. The “Żychcice II – Saturn” limestone mine had been working till 1991 as sole supplier for the “Saturn” cement factory which was located in Wojkowice (Przemsza-Zieliński, 2002; Dod. nr 3 do dok. geol. złoża „Żychcice II“ i „Saturn“, 2010; Inwentaryzacja i waloaryzacja przyr. terenów położonych w granicach administracyjnych gminy Wojkowice, 2014).



Fig. 1. Situational-elevation map with marked boundaries of the mine “Żychcice II – Saturn”, Appendix 3 to the geological documentation of Triassic limestone deposits “Żychcice II” and “Saturn” in category B, AGOS-GEMES Sp. From o.o., Katowice 2010  
 Rys 1. mapa sytuacyjno-wysokościowa z naniesionymi granicami kopalni „Żychcice II – Saturn”, Dodatek nr 3 do dokumentacji geologicznej złoża wapieni triasowych „Żychcice II” i „Saturn” w kat. B, AGOS-GEMES Sp. z o.o., Katowice 2010 r.

This cement factory was built in 1929 and had been one of the most modern facilities in the world at those times. This contributed not only to the rapid development of Wojkowice as a city but also to significant economic development for the whole region. Exploitation of the limestone had begun on 01 January 1962 and lasted until 31 December 1991 (Dod. nr 3 do dok. geol. złoża „Żychcice II” i „Saturn”, 2010).

These dates are reflected in the production of cement and lime raw materials in 1960–1990, where the values were respectively: 1960 – 16 million tons, 1970 – 38 million tons, 1980 – 57 million tons, 1990 – 48 million tons.

The limits put on the development of building and heavy industry, but also the changes in the structure of using mineral resources in the early nineties caused continuous downward trend in cement and lime production sector. The exploitation of rock raw materials has been increasing once again dynamically since 2002. (Kasztelewicz, 2010). Although statistics could suggest that analyzed mine had been closed due to economic reasons at the macroeconomic level, the reasons for abandoning of the exploitation were purely internal. „Żychcice” field closure was directly connected with using of its resources practically in its entirety. The minor quantity of mineral was deposited only in slopes, in the immediate vicinity of the protective pillar and in the bottom layers of the deposit. „Saturn” field, due to a few stock resources (1863.7 thousand tons) was not exploited at all. This decision had been also contributed to the obesity of the fault a protective pillar in geomorphological structure on this terrain, which disrupts the deposit and holds almost 3500 thousand tons of core resources inside (Dod. nr 2 do dok. geol. złoża „Żychcice II” i „Saturn”, 1990).

Due to the all above-mentioned reasons, resumption of the exploitation is technically and economically unjustified (Dod. nr 2 do dok. geol. złoża „Żychcice II” i „Saturn”, 1990; Chybiesz, 2009).

## Technical specifications

### Location

The majority of the deposits of limestone “Żychcice II – Saturn” is located in the north-western city limits of Wojkowice in the Będziński District. Other areas include south-western part of the city Rogoznik in the commune Bobrowniki (map). The total area of the open pit is approximately 25 ha. This area is marked in Fig. 1 by thicker dotted line.

From the south side, the deposits border with Municipal Stadium and City Park. In the immediate surroundings, from the southwest side it is a prison, and approx. 1.5 km in the same direction was located several years ago an old cement factory “Saturn”, which was the main receiver of output from exploited limestone. The geological layer is located on acclivity where land elevations are ranged from about 295 m above sea level in the southern area to about 330 m above sea level in the north-eastern part of the deposit.

### Geological deposits

The exact location of the deposit is shown in Fig. 1., which is a part of the map attached to the geological documentation of the analyzed area.

Referring to the Physico-geographical regionalization of Poland, based on Jerzy Kondracki, “Żychcice II” and “Saturn” is located in mesoregion – Garb Tarnogórski.

The geological structure of the deposit was acquired from the regular operational works which have been followed up over the walls of the quarry with a length



Fig. 2. Fragment of a geological map of Poland, with marked boundaries of the deposit “Żychcice II- Saturn”, Appendix 3 to the geological documentation of Triassic limestone deposits “Żychcice II” and “Saturn” in category B, AGOS-GEMES Sp. From o.o., Katowice 2010  
 Rys. 2. Fragment mapy geologicznej Polski, z naniesionymi granicami złoża „Żychcice II- Saturn“, Dodatek nr 3 do dokumentacji geologicznej złoża wapieni triasowych „Żychcice II” i „Saturn” w kat. B, AGOS-GEMES Sp. z o.o., Katowice 2010 r.

of approx. 800 m, and also by recognizing works which contain elaboration of the 40 boreholes.

The geological structure of the deposit consists mainly Triassic and Quaternary compositions which are overburden Carboniferous series such as coal, clay stones, and sandstones. Triassic series are built from materials such as sandstones, clays, ret, shell limestone (data is provided, inter alia, from the geological map of Poland, which fragment is in Figure 2).

As a result of these analyses, the resources of the “Żychcice” (to the elevation of 270 m above sea level) have been classified to the category A, and the following parts of the deposit to the category B. “Saturn” deposit is included at its all to the category B. After those classifications both deposits were merged and after that process the successfully function under one name: the Triassic limestone deposit “Żychcice II – Saturn” and under common category B.

The post-mining area has strongly diversified geological structure. Fault zones, occurring in both the northern and the southern part of the deposit, are the cause of variable composition of thickness for minerals. Exploitation of “Żychcice” took place on two operating levels:

- Level I to the 290 m above sea level limit and over a wall height of about 20 m,
- Level II to the 275 m above sea level limit and a wall height of about 15 m.

In “Saturn” engineers anticipated one operating level setted at the 290 m limit and a maximum height of 24 m over a wall, but the field was never exploited.

#### ***The current state of the excavation***

Excavation void is currently characterized as an absorptive and endorheic area. To a maximum depth

of operation (275 m above sea level), there was no groundwater. Stopping water between loam-clay structure may occur only in the deepest parts of the open pit, after intensive rainfall.

The area of the former mine has a very poor vegetation level, which forms do not represent any natural value. The area is now overgrown with self-seeders shrubs and trees barren. It also does not provide any economic value. In the north-eastern part of the deposit are located farmlands and clusters of trees and shrubs.

In the closest range of the post-mining areas, there are no objects which have been taken under special nature protection. Rivers and lakes occur in the proximal and distal surroundings, do not represent any danger for deposit. There is also no risk caused by gas and geothermal sources.

#### **The proposal for recultivation of the “Żychcice II – Saturn” open-pit**

Recultivation of post-mining areas is not only the duty for the entrepreneur to restore the value and utility of natural sites, but it should be also a good “foundation” for further development of those terrains. These processes should be planned in a deliberate in a correct way to do not create unnecessary costs during the subsequent revitalization processes. That is why it is so important in this case, to make a full cooperation of entities responsible for the different stages-reaching in the revitalization process.

All the activities to which the entrepreneur is obliged by functioning law includes only chemical, biological, and technical phase, that are designed to prepare all the facilities for the further development. The entrepreneur is not however obliged for the upgrading locations in special facilities for improving aesthetics,

tourism, social, or economic. A land development is a challenge for the legal successors of reclaimed areas albeit that phase is not legally required in opposition to recultivation projects.

The main three factors which should be followed in a process of the selecting acceptable and optimal recultivation way are:

- The economic factor,
- The environmental factor,
- The social factor.

The cost factor (economic) dedicated for choosing correct recultivation way could be divided into four basic demands:

- striving to minimize the cost of all activities during recultivation process,
- striving for self-sufficiency of the recultivated areas and minimizing the cost of its maintenance as well,
- striving to obtain not only the income from the activities started up on recultivated areas but also striving to regular and measurable profit for the municipality,
- full knowledge in internal features of recultivated areas and awareness of generating additional costs by altering them.

Natural conditions (such as geological, geomechanical, water conditions) are internal considerations, it is the reason why they put the biggest impact when it comes to choosing the direction of recultivation.

Social factor partially determines the success of the project, because well matched venture for the terms and demand of local society ensures usability and realization return on invest criteria. However, it should be always considered to remember to keep the right balance between the expectations of the community and the real demand, occurring in the processed area.

The criterion, which in many cases determines the direction of land recultivation is an internal set of conditions. A good example of such relation might be Lignite Mine Turów, whose excavation plunge during the years of use was and still is drained. If the drainage system is turned off, it will immediately fill the pit with water, even without the need to supply water from the outside sources. That aspect makes the direction of recultivating it into water reservoir the only practicable solution. In opposition to that case, limestone mine "Żychcice II – Saturn" is an endorheic and absorbent area. To a maximum depth of operation (275 m above sea level), there was no groundwater. For these and other reasons stated below, the authors concluded that the most advantageous direction for the recultivation process is converting that post-industrial area into a forest.

Valuable documents, which assist authors in the se-

lection of recultivation way, were: Local Development Plan for the Wojkowice and Eco-physiographic study for the municipality Wojkowice. The mentioned documents show directly that terrains which were taken under considerations are not designed to perform functions other than nature ones and their further development should aim towards nature usage and recreation.

Żychcice excavation has been already partly developed as a landfill for mining waste and wooded.

Chosen direction for the recultivation process goes well with the internal conditions of excavation, but also with the demand for forest areas. Wojkowice Municipality is characterized by a low forest cover at around 30 ha, which represents 2,5% of the whole area. In addition, all the forests in the municipality have been artificially planted or are the result of secondary succession. Eco-physiographic study for the municipality Wojkowice shows that local forests do not have a spatial continuity. This type of fragmentation of forest areas leads to a reduction of biodiversity, which has been confirmed by many of the world's researchers. Therefore, the authors propose to connect future forest with the border of Park Wojkowice. Proposed tree species are *Pinus sylvestris* and *Betula pendula*. These trees are capable of growing in soilless terrains characterized by a high pH at neutral or slightly alkaline level. These species possess pioneering and phytoremediation properties and are called "forensic afforestation".

The forest-based direction of recultivation also fits with the objectives of sustainable development and peeled directions set for Wojkowice recognized directly in the Local Development Plan such as:

- recovery the environmental balance,
- protection of open areas, environmentally relevant,
- increasing the forest cover in the city,
- determination of urban greenery system and recreational areas,
- adaptation of brownfields to new features.

It is advisable to set a natural development way in hand to hand with recreation and leisure facilities. For that kind of space the demand is constantly growing. Well-developed flora attracts very fast diverse fauna, which further increases the value of recultivated terrains. However, it is not advisable to leave the area itself. It is necessary therefore to take a number of actions that are aimed at maximum improvement of habitat conditions of both plants and animals. The scope of such works should be always consulted with experts in that particular field.

Recultivation of the south-eastern part of the open pit (about 15,5 ha) was entrusted to an external company, and by 2006 was realized at approx. 30% (addition to the dock).

## Summary

The mine site “Żychcice II – Saturn” due to its properties would be never exploited in the future. For this reason, it would be necessary to recultivate those areas. After careful analysis of historical material and current documentation, which have been taken under the consideration, the optimal direction of recultivation for these particular terrains, in opinion of the authors, would be the forest-way. It came out not only from the internal conditions of the terrain but also from the appropriate fit into the city sustainable development plans as well as to the objectives and needs of the municipality. In addition, the suggestions for recultivated area provides the afforestation which would border directly with Park Wojkowice, what could give significantly increase the forest index of the municipality, but also will cause a recession in the fragmentation of forest areas.

That undertaking could substantially increase the biodiversity of fauna and flora on the processed terrains.

The choice is also determined by the fact that the site of the former mine has been already partly filled with waste and slightly wooded. Thanks to that, all recultivation activities should remain homogeneous and coherent.

An important aspect of the recultivation is also the cooperation between entities which are responsible for it, with account being taken, that all works on those areas should be executed with the thought, that future processes would change those terrains into sport and recreation ventures. That philosophy would allow for optimal usage of the potential and should undoubtedly contribute to increasing the attractiveness of the city and municipality.

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*Propozycja rekultywacji terenów przemysłowych złoża wapieni triasowych  
„Żychcice II – Saturn“ w Wojkowicach*

*Rekultywacja jako proces przywrócenia wartości użytkowych i przyrodniczych terenom poeksploatacyjnym powinna być traktowana nie tylko jako prawny obowiązek przedsiębiorcy, ale przede wszystkim jako szansa dla miasta i gminy, na których to terenach była prowadzona eksploatacja. Prawidłowo dobrany kierunek rekultywacji terenu poeksploatacyjnego, z uwzględnieniem dalszego procesu rewitalizacyjnego, może przyczynić się do znacznego wzrostu atrakcyjności obszarów występowania.*

*W artykule przedstawiono najbardziej optymalny, według autorów, kierunek rekultywacji terenów poeksploatacyjnych byłej kopalni wapienia „Żychcice II – Saturn“.*

*Przedstawiony sposób wykorzystania terenów poeksploatacyjnych jest, w mniemaniu autorów, kompromisem pomiędzy oczekiwaniami miejscowej ludności, a realnym zapotrzebowaniem na dane rozwiązanie. Proces ten powinien być poprowadzony w sposób, który pozwoli na pełniejsze wykorzystanie potencjału miasta Wojkowice oraz wzrost jego atrakcyjności, zarówno z perspektywy mieszkańców jak i turystów. Rewitalizacja terenów pogórniczych byłej kopalni wapienia będzie dla miasta dużym wyzwaniem, ale jednocześnie szansą na podniesienie wartości użytkowych oraz przyrodniczych danego terenu.*

*Słowa kluczowe: rekultywacja, górnictwo odkrywkowe, wapień, tereny poeksploatacyjne*