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GEOLOGICAL ENVIRONMENT AS AN IMPORTANT ELEMENT OF THE RECLAMATION AND REVITALIZATION OF THE QUARRIES

1. Introduction

Poland has numerous documented deposits of various rock minerals differing in origin and stratigraphy. They are located primarily in the southern part of the country including the Sudety, the Karpaty, the Wyżyna Krakowsko-Częstochowska and Góry Świętokrzyskie. In the remaining part of Poland their concentration and diversity are much smaller (Fig. 1).



Fig. 1. Distribution of rock mineral deposits in Poland

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Technical and decorative properties of rocks determined their extraction and diverse economic use. Transformations of the environment, especially the landscape and biosphere, and to a lesser extent, hydro-and atmosphere, are associated with the extraction (Fig. 2). Usually, these changes are considered as negative.

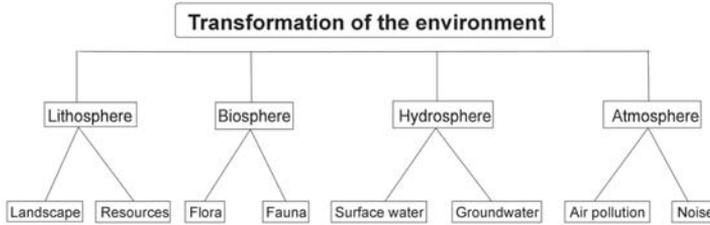


Fig. 2. Transformations of the environment caused by mining activities

Whereas, increasingly, it proves that mining activities also have a positive impact on the surrounding environment (Fig. 3).

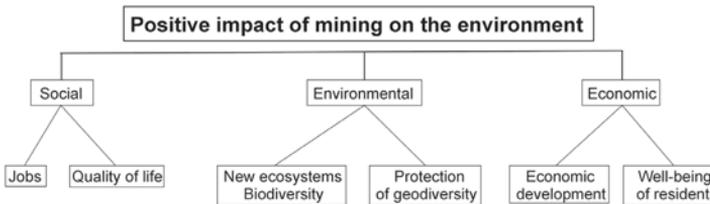


Fig. 3. Positive impact of mining on the environment

This mainly concerns the local community, which helps them gain new employment, thus increasing the quality of life. Mining activities in the region are also associated with direct economic benefits, which allow for the development and growth of the citizens prosperity. So far, the positive impact of mining on the environment has been ignored. Whereas, post-mining areas form new ecosystems, often of higher biodiversity, with many rare or protected species of plants. In addition, these areas are enriched the geological environment, which have scientific and educational values, unique in the region or country.

2. Geological environment and its values

The term geological environment, although often used, has no official definition. According to the definition proposed in the Encyclopedic Dictionary of Environmental Protection (1998) it is a subsurface of the earth's crust with all the atmo-, hydro-and biosphere factors which react with the crust and within it, along with internal subcrust geological processes altering the crust. In some publications [Small lexicon of mining 2005] authors introduce the concept of geological landscape which is defined as a form of the earth's surface relief and the natural and artificial rock

exposure which combine the cognitive (scientific) and visual values, documenting the construction of the earth's crust, geological processes that shaped it and which take place in it now and which present the occurrence and use of natural resources. Somewhat more broadly this concept is defined by Nieć et al. [2], stating that with the concept of geological landscape one should also include constructions and buildings made of local minerals, which illustrate their diverse use. The author is then able to define the concept of the geological environment proposes to connect and extend the above definitions. The geological environment is defined as *the natural and anthropogenic forms of the earth's surface relief, exposing parts of the geological structure along with all the geological processes shaping it (now and in the past) and with all mineral resources available for use, and also the preserved signs of mining activity and building works in the vicinity which indicate the scale of the use of minerals occurring in it.* The values and the attractiveness (scientific, environmental, cultural, historical, etc.) of the geological landscape should be protected by including them as important elements determining the direction of future direction of reclamation and revitalization of such post-mining areas.

Mining exploitation of mineral deposits results in forming of a quarry, inside which parts of the geological structure of the region with all the contemporary and historical effects of geological processes are exposed. These exposed fragments of geological structure may relate to tectonics (Fig. 4), lithology and sedimentation (Fig. 5), paleontology (Fig. 6), mineralogy (Fig. 7).



Fig. 4. Tectonic phenomena



Fig. 5. Components of sedimentation and lithology



Fig. 6. Ammonite shell



Fig. 7. Calcite brush

Very often, especially in complexes of carbonate rocks, during the time of their exploitation unveiling of caves and caverns with interesting dripstone forms may occur (Fig.8).



Fig. 8. Stalactite and stalagmite formations in the cave

Mining activities after its completion also results in abandoning of the technical infrastructure, which can be given us evidence of how the technology of exploration and processing evolved (Fig. 9).



Fig. 9. Technical infrastructure

Important elements of the geological environment are also religious and industrial architecture facilities or residential buildings located in the vicinity of the quarries and made of rock materials, which were the subject of the quarries operation (Fig. 10). They provide evidence of the economic possibilities of the use of the exploited rock and its technical and decorative (aesthetic) values.

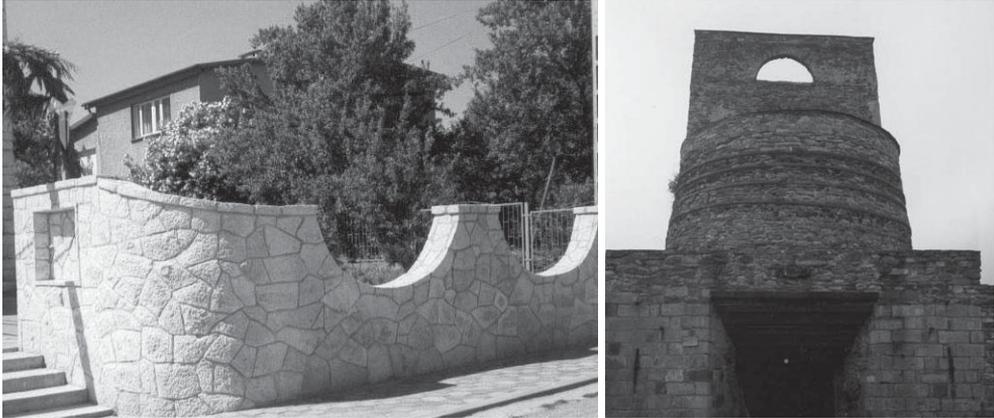


Fig. 10. Rock minerals and their economic use

Presented elements of the geological environment, exposed by the operation within the quarry's walls, along with the technical infrastructure and architectural facilities in the quarries vicinity can be characterized by high values and attractiveness. These values may be of an aesthetic character, harmoniously integrate with the surroundings. Most of the times, however, they are a combination of the cognitive values (scientific, educational) or they need protection because of the uniqueness or specificity.

3. Criteria for selecting the direction of reclamation and revitalization of the quarries

Reclamation is a concept quite widely used, but depending on the use it is defined differently. Among farmers, rehabilitation is a set of engineering and agronomic activities and biogeochemical processes that shape both the new and desirable biocoenotic structure of the soil [3]. Whereas, in case of the liquidation of mining activities the impact this term has means *all actions and works transforming post-mining areas and dump sites to the state which enables their efficient use for economic, industrial and other purposes* [4]. A similar definition is also used in Western publications countries. The concept of revitalization was originally used in medicine to describe a return to health, and later in technology applied to modernization. In recent years, as a result of wider interest in post-industrial, post-military areas and pieces of land left after large farms, this term is used primarily as *a process of reclamation and redevelopment of the site, including the reconstruction and modernization of the existing cover, which will restore the state in which the area performs its utility functions* [5]. As defined in the Dictionary of the Ministry of Regional Development (2010), revitalization are *comprehensive, integrated local programs lasting for several years, initiated by local government for the implementation of the technical, economic and social activities — with the principles: territorial cohesion and environmental protection — in diverse areas such as: degraded districts or post-industrial and post-military areas.*

In the mining industry the term ‘reclamation and redevelopment’ land left after the exploitation of minerals have ceased. Reclamation includes the technical processes (land leveling, protection of the excavation slopes, etc.) and biological (afforestation and restoration of agricultural use). Whereas, redevelopment is a set of activities, which grant new utility functions to post-mining areas. Therefore, the term redevelopment can be replaced by the term regeneration, although they differ both in the scope of works as well as in natural and anthropogenic measures. For this type of action maybe a more appropriate term would be regeneration, that is the renewal of the devastated landscape to enhance its functional, cultural value e.g. for recreational, leisure etc. purposes [7].

The presented elements of the geological environment can be a decisive factor in choosing the direction of the quarries revitalization. They should also be supplemented by:

- natural environmental values of both the interior and of the closest quarries surrounding;
- technical conditions for conducting the revitalization i.e. conditions which are difficult and demanding intensive earth works;
- the availability and location of the background region,
- social conditions and demand,
- the financial capacity of the region.

The ranking of the importance of various criteria and the potential of values and attractiveness of the natural and geological environmental elements should indicate the optimal direction for the revitalization of the quarry. This direction might be:

- cognitive (scientific) — exposed parts of the two environments may be subject to scientific research and education both of the geological region as well as of the changes induced in the region by mining activity and possibilities of exploited rock minerals use;
- protective — the elements of the geological and natural environment which are unique in the region or country and should be protected as i.e. monument or inanimate nature reserve;
- recreational and sports — properly exposed elements of the geological environment which only add to the increase of the revitalized quarry attractiveness;
- comprehensive — enables including all values and attractiveness for various reasons, elements of the geological environment along with the preserved technical infrastructure and elements of natural environment;
- economic — exposing in the quarry interior above all different types of mining equipment (differing in age), products of local rock minerals, etc.

4. Examples of quarries revitalization with use of the geological environment elements

In Poland there are many well-known revitalized quarries, in which the value of the geological environment have been exhibited. These are sites under legal protection because of geological and natural environmental values, or recreational and sports complexes. The first site of this kind, which used the values of the geological environment during the

revitalization, was created already at the turn of the 20th century in Cracow. It is the H. Bednarski's City Park, which was created in place of the Jurassic limestone quarries complex. Its walls with preserved fragments of the geological structure, are the boundaries of the formed Park, harmoniously integrated into green areas and alleys.

In the center of Kielce, in the 1970's, the Kadzielnia recreation and cultural complex was created in a former limestone quarry. Parts of the geological structure are of high scientific value (Karst phenomena) and were protected (Skalka Geologów), and in the remaining part of the quarry an amphitheater and alleys were integrated (Fig. 11).



Fig. 11. Skalka Geologów (Geologists Rock) and the amphitheater in the Kadzielnia quarry

There are also many quarries, in which because of their geological and natural environment value, inanimate nature reserves have been created. Actually, they have not undergone the processes of revitalization but only technical reclamation. It consisted mainly of exposing the fragments of geological structure with interesting processes or geological phenomena. They have a scientific and educational value as the sites are harmoniously inscribed into the local landscape (Fig. 12). Some of these quarries have architectural revitalization projects in progress in which the geological and environmental values are just one of the important



Fig. 12. Inanimate nature reserve "Bonarka" with elements of the geological structure

elements of their utility functions. Unfortunately, due to substantial funding these revitalizations have not been implemented. Such a situation may result in the irretrievable loss of the geological and environment values, because of very quick shrub and vegetation colonization as a result of natural succession.

5. Summary

The growing demand for rock materials in the coming years will also result in the increase of the acreage of land available after their exploitation has ceased. Keeping in mind, the potential of the geological and environmental value of post-mining areas (quarries), which can be used for reclamation and revitalization, cooperation between geologists, miners, landscape architects and local authorities are required. It is important to save the geological environment elements of the unique scientific, educational and aesthetic values, which should be considered when selecting the optimal direction of reclamation and revitalization. The selected course should meet the expectations of the local community, be economically viable and technically feasible. The effect of revitalization should have an impact on the attractiveness of the region, and further its dynamic socio-economic growth. It should be noted that not taking the geological and environmental value into account during the exploitation and subsequent reclamation and revitalization, leads to an irreversible loss of uniqueness and reduces regions attractiveness. This is not consistent with the principles of sustainable development, especially with the Rio Declaration, in which the need to protect geodiversity is highlighted, therefore it is important that the conservation of natural landscapes be taken seriously, otherwise they may disappear very quickly as a result of rapid human progress.

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