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RESTORED LIMESTONE QUARRY AS AN ATTRACTIVE PLACE FOR EDUCATIONAL PURPOSES AND REFUGE OF BIODIVERSITY

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Abstract: The purpose of this article is to present the restoration method used in the closed limestone quarry Lipówka in Rudniki near Częstochowa (Poland). It focuses on natural and educational values of the site. The restoration has been possible thanks to the abundance of species that live at the Lipówka quarry, attracted by the diversity (of aquatic and terrestrial) habitats. Restoration activities include preparing: information panels for the educational trail, drafting educational and promotional materials and organising training sessions for teachers in the region. Educational and promotional materials comprise: leaflets advertising the educational nature trail, a guidebook to the trail, audio guides and lesson plans. The quarry has been adapted to host classes in sciences, biology, geography and geology for children and adolescents. Also fieldwork for students of bachelor and master programmes in natural sciences can be held there.

Key words: closed quarry, abandoned quarry, brownfields, restoration method, education, biodiversity.

Introduction

Closed quarries, considered as brownfields, are often referred to as degraded areas. However, contrary to the statement above the flora and fauna present there can be highly diverse. Often valuable animal and plant species are found in the brownfields. In addition, these may be rare species that cannot be encountered in the area surrounding the quarry, or they may even be endemic species [1, 3, 5, 9].

The species composition of developing plant communities is determined by the diversity of habitats and their characteristics, including the structure (texture) of the substrate. Diverse habitats and spontaneous succession in industrial areas may build a system richer than the man-made ones in rehabilitated quarries

[12, 24]. Thus, a closed quarry in which new habitats appeared, different than those in place prior to extracting the rock material, can become a refuge for fauna and flora living there. It often includes valuable species both in the country and in the region. Such places become areas of high biodiversity. Post-mining areas, with a varied morphological structure of the substrate and diverse wildlife habitats, are well-suited for educational purposes.

Restoration of abandoned mining areas may consist in creating geological and educational trails in their area or geoparks that serve both educational and touristic purposes [4, 6, 15, 18, 21, 25]. The closed Lipówka quarry in Rudniki near Częstochowa is an example of how a closed quarry can be used in various areas of education, and not limited to study of geology. The aim of this article is to present possibilities of using the quarry's natural values in education.

Characteristics of the quarry

Closed Lipówka limestone quarry (Fig. 1) belongs to CEMEX Poland and is located in Rudniki near Częstochowa (50°52.522`N 19°14.074`N Datum WGS 84). It covers an area of 550,000 square metres. Exploitation of limestone deposits for the needs of the lime industry ceased in 1989. During the quarry liquidation the infrastructure was dismantled and the land was partially rehabilitated through planting tree seedlings, mainly silver birch *Betula pendula*, Scots pine *Pinus sylvestris* and black locust *Robinia pseudoacacia*. Over 26 years that have passed since the reclamation, also spontaneous land colonization by plants and animals occurred. Local organisms could find niches suitable for them thanks to the presence of highly diverse habitats in the quarry (terrestrial habitats, wetlands, water). The varied topography and numerous anthropogenic transformations also contribute to high landscape value of the quarry [23]. Local slopes are characterized by varying degrees of inclination - from gentle slopes to almost vertical stone walls made of various types of limestone. These are more weathering-resistant limestone with clearly visible borders of components and marl limestone, prone to weathering.

Fig. 1. Bird's eye view of the Lipówka quarry in Rudniki (photo M. Braszczyński)

In the central part of the quarry there is a heap of unused, excavated limestone. It is gradually being overgrown by herbaceous plants, silver birch *Betula pendula* and common aspen *Populus tremula*. Also the bottom of the quarry has a varied structure. The three largest depressions hold permanent bodies of water, while shallow depressions periodically fill up with water. These tanks created conditions for development of aquatic and mud plants, and subsequently, settlement of invertebrates and vertebrate animals associated with wetlands. Seven species of amphibians were found in the excavation area [22]. All of them are protected species in Poland [20]. Among them there is the European fire-bellied toad *Bombina bombina* – protected under the Berne Convention [7] and listed in Annex II and IV to the Habitats

Directive of the European Union [8]. Two species of reptiles protected in Poland were observed in the quarry, i.e. sand lizard *Lacerta agilis* and grass snake *Natrix natrix*. In total 33 species of invertebrates considered rare or protected in Poland were observed there. Butterflies constituted the largest group among them with as many as 26 species. A particularly interesting representative of butterflies is the large copper *Lycaena dispar*, which is listed in Annex II and IV of the Habitats Directive of the European Union [8]. The area of the quarry makes a good environment for numerous animals, therefore it is frequently visited by many species of birds. Water reservoirs give shelter to several species of fish, and in the Szeptun cave one can spot bats [22]. The western part of the quarry has no surface water bodies. On the gentle northern slope grassy shrub communities have developed. This part of the quarry is mostly characterised by the scattered bushes of dog rose *Rosa canina* and hawthorn *Crataegus* sp., which give this area a look of thermophilic thickets. Other slopes and plateaus are covered by herbaceous vegetation or trees and shrubs, some of which appeared here spontaneously, and some in the process of reclamation plantings. In the quarry there are 33 taxons of lichen belonging to 10 families [22. Water macroscopic algae are represented by two species of characeae: *Chara globularis* and *Chara vulgaris*. Varied habitats in the quarry allow for existence of 308 taxons of vascular plants belonging to 201 genera and 67 families [23]. Of these, 6 species of vascular plants are partially protected and 1 species is strictly protected [19]. Macroinvertebrates of 20 orders and 44 families were found in the quarry surface water bodies.

Three zones of natural value were established in the quarry (Fig. 2) according to their varied habitats, occurrence of rare and protected species and landscape assets [23]. The first zone with the highest value covers areas in the north-eastern part of the quarry. These are wetland areas with adjacent land areas.

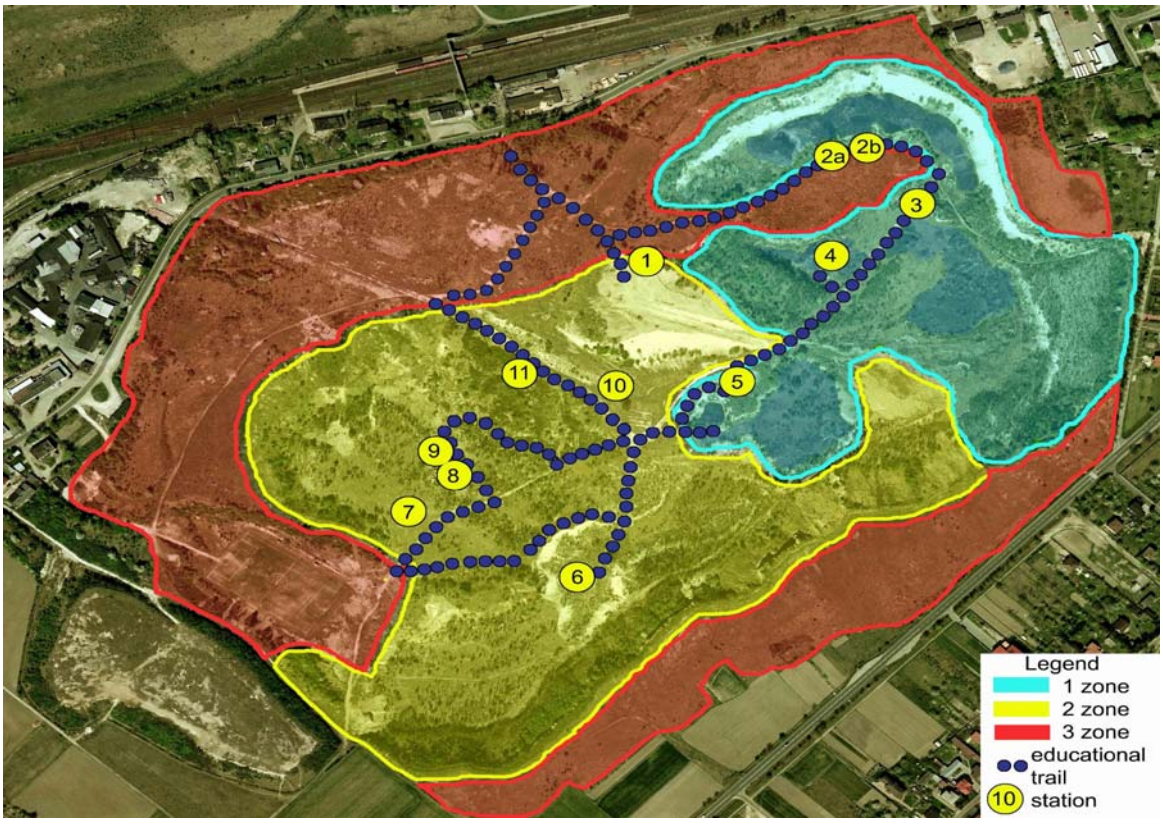

Fig. 2. Zones of natural value and the course of educational trail in the Lipówka quarry in Rudniki (Google Earth changed)

The protected Marsh Helleborine *Epipactis palustris* grows at two sites there. The first zone also includes a rock wall with the largest water reservoir and the reclaimed south-eastern slope with the site of partially protected Royal Helleborine *Epipactis atrorubens*. The zone of highest natural value includes also a heap in the middle part of the quarry. The heap's slopes have a unique structure in the form of deep rills caused by water erosion. This is an example of how an interesting morphology was created as a result of an interplay between human industrial activities and natural processes.

The second zone is of lower value, because it has less varied habitats. It includes land areas with sites of partially protected species: silver thistle *Carlina acaulis* and Royal Helleborine *Epipactis atrorubens*. There are also species mentioned in the regional Red list [16]: willowleaf yellowhead *Inula salicina* and limestone oak fern *Gymnocarpium robertianum*. Within this zone there is a slope of marl limestone with a relatively large number of fossils. In this zone, on the south wall of the quarry, there is the entrance to the Emerald Cave (Szeptun Cave) with a karst lake.

The remaining part of the quarry was classified as the third zone, i.e. the least valuable from the wildlife point of view. This area is mainly covered by grassland, dominated by bushgrass *Calamagrostis epigeios*.

Preparing the quarry to serve as an educational facility

Preparing the area for educational purposes involved a number of activities. The first stage of work consisted in taking inventory of the species present in the quarry's area. During the stock-taking sites of special natural value have been designated (the so-called natural value zones). They were selected on the basis of the number of habitat types and the occurrence of rare or protected species in Poland. Results of this work are summarized in the previous section of this article. They provided a basis for implementation of the next stage of preparations, namely tracing of the educational trail. The educational trail runs through 11 of the most interesting sites (in terms of animate and inanimate nature), located in various zones of natural value (Fig. 2). The sites received the following names: Good View, Rock Lake, Birch-site, Toad Lake, Surprise Lake, Szeptun Rock, Old Perch, The Silica Valley, Lichens - Small Pioneers, Natural Pharmacy and Sunny Slope. The educational trail is a loop approximately 2 km long, with an average walking time of 1.5 hours. With proper planning the route can be modified (shortened) and thus adapted to individual tasks.

Each site is marked with a large and colourful educational panel. Colour pictures, brief descriptions of natural phenomena and species, as well as many trivia illustrate the abundance of quarry wildlife. Two panels describe the history of quarrying in Lipówka and limestone mining in the currently operating quarry Latosówka located several miles away. Subsequently a guide was prepared "Lipówka - a quarry restored to the nature" [22] to facilitate educational activities in the quarry. It is an extension of the content presented on illustrated panels on the educational trail. It is addressed to a wide audience, including teachers and students, and can be used as an aid in the fieldwork. Educational institutions received the guides free of charge.

At the next stage of preparing the quarry site for educational use an audio-guide was recorded. Mp3 audio files can be downloaded free of charge from the quarry owner's website: CEMEX Poland or accessed via the QR codes, on the educational panels. They contain links to recordings that supplement the content of the guide and educational panels, e.g. [14]. In order to make information about the quarry wildlife accessible to the widest possible group of people, both the one-page leaflet and the entire guide [22] were made available as a free download from the CEMEX's website.

The final stage of adapting the quarry for educational purposes involved trainings for teachers from nearby municipalities. They were held in the form of fieldwork and labs with the aim to extend the teachers' knowledge of the natural environment of the quarry.

Quarry's educational potential

Environmental and ecological education is very important at all levels of formal education [11, 13, 17]. Educational activities are a part of teaching process at various stages of education of children and adolescents across the curriculum. Teaching sciences in schools can and should be accompanied with fieldwork, where contact with nature and direct observation support effective teaching. Fieldwork always evokes positive emotions

among students, which is desirable in teaching, as they provide a base for successful learning.

The project in the Lipówka quarry was carried out with a view to create an educational centre for local communities, in particular for school students (aged 6 - 18). The above-described series of preparatory actions yielded a site that can successfully serve broadly conceived educational purposes.

Educational activities at the Lipówka quarry can take various forms, such as lectures or experiment-based classes. These events can take place all year round at each and every site of the educational trail and can cover issues related to both animate and inanimate nature. The abundance of vascular plants, invertebrates and vertebrates allows using them as live models. Organisms dwelling there can exemplify differences in structure and adaptations to life in a variety of habitats. Large variety of plant species constitutes excellent teaching material to work on the systematic, morphological and anatomical characteristics of monocots and dicots. On that basis one can successfully present typical ecological topics (interdependence among species, structures and functioning of the ecosystem, biodiversity) and phenology-related matters. The only limit is the teacher's imagination. Natural potential of Lipówka also allows conducting activities beyond the core curriculum, such as extracurricular activities – for instance short-term (multi-day) and long term projects (several weeks and several months) [2].

The quarry area can also be used in courses for university students. Students of natural sciences at Jan Długosz University in Częstochowa visited it during fieldwork held by Environmental Protection and Biology faculties. In these classes students acquainted themselves with the methodology of field ecological research in making inventory and population count. Students were defining the area of occurrence of chosen protected species using the GPS method. Students also analyzed the diversity of individuals in the population and the share of generative shoots in the total number of individual shoots making up the population. The course is designed to demonstrate that great diversity of species occurring there is a result of highly varied habitats, and that the anthropogenic origin of this place plays a less important role in that respect. Students learn that properly rehabilitated excavations of rock materials may become biodiversity centres.

The Lipówka quarry, rehabilitated for education purposes, is also a great place for trainings for teachers of natural sciences (e.g. nature, ecology, biology, geography, geology). A series of trainings conducted by scientists of various specializations helped teachers to prepare lessons scenarios that can be carried out in the Lipówka quarry [10]. They cover issues included in the core curriculum and beyond, giving the possibility to develop a given subject at an advanced level. Binders with lesson scenarios were distributed free of charge among local schools.

The Lipówka quarry also serves as an educational and recreational facility for residents of the surrounding communities and CEMEX company employees. In the varied landscape of the quarry one can enjoy sports, outdoor games, cycling trips and integration meetings. For organized groups a short tour on the educational trial with a guide can be organised, who would not only present the quarry, but also answer questions from the audience.

There are plans to make a wider use of Lipówka's educational potential in 2015 and beyond through increased cooperation with teachers from the region. This will include also competitions for individuals and groups of participants. For instance teachers will be invited to a competition involving preparation of a field game scenario in the quarry. For students a contest for the best account of a trip to the Lipówka quarry will be organised. Everyone interested in photography will be able to take part in a photo contest. Its main theme will be the rich natural values of Lipówka.

Conclusions

The closed limestone quarry Lipówka in Rudniki, a post-industrial area, has been restored and is now used for educational purposes. Turning it into a useful space gave it a dramatically different role from its original industrial function. The key to success was the use of natural values of this site. Biodiversity in the quarry is a result of the diversity of habitats present there and rare species of plants and animals that appeared in the quarry without deliberate human intervention. It is a natural

development that occurs regardless of the rehabilitation carried out in the quarry.

Post-mining zones, often perceived as destroyed areas, can be made useful to population again. The priority in this regard is an appropriate metamorphosis and outline of new practical applications and possible forms of use. There are two key factors in the process: the actual state of such an area and its natural assets, and the ideas and commitment of the landowners. The ability to expose highlights of such an area can serve multiple purposes, including the most important one - education. Cooperation with the local community also plays a very important role, as it may translate into greater promotion of the site. In the case presented in this article further expansion of the palette of materials and ideas for the use of Lipówka quarry for educational purposes is expected through the already existing cooperation with teachers and schools in the region.

Adaptation of brownfield sites for educational purposes is one of many restoration solutions. Moreover, it does not entail high costs. The closed Lipówka quarry in Rudniki, near Częstochowa is an excellent example of such adaptation.

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