INFORMATION SYSTEM FOR REGENERATION OF LANDSCAPE AFFECTED BY MINING

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ABSTRACT

As a result of mining and quarrying is the exploitation of the landscape (e.g., mine depression or heaps as results of underground mining, or change in landscape due to opencast mining). Restoration of affected landscape is necessary in accordance with current legislation so as to allow its continued use. There are a number of procedures, methods and solutions for reclamation. The aim of our work was to design the information system which would provide basis for planning and decision making about process and methods of reclamation. Our approach to the revitalization of the landscape affected by mining activities is based on the restoration of its function throughout the area, together with the renewal of the diversity of landscape structure. The starting point is to restore the permanent sustainability area. Based on the analysis of the necessary information the information system described in this paper has been designed and developed. Part of the solution is the creation of models proposed alternative strategies for landscape reclamation and future usage. Landscape modelling problems were mainly solved by using a geographic information system technology. The information system, developed models and analysing the results led to construction the digital models of landscape restoration and its subsequent presentation in 3D including the creation of a virtual scene.

Keywords: brownfield, COBRAMAN, GIS, information system, reclamation, restoration of the landscape, virtual reality

INTRODUCTION

Renewal of functional use of the countryside affected by minerals mining makes an integral part of the area preparation before the exploitation start, but it is necessary mainly in the course of the mining process and after its termination. In connection with the minimization of costs of damage suffered in the area concerned, the main aim of the strategy of landscape restoration after mining activities is the permanent sustainability of countryside, complex solution of restoration in consideration of maintenance of functional use and simultaneously biotic variability in cultural post-mining countryside, with successful co-existence of all the countryside elements - productive and non-productive ones. The basic starting point is the whole-area solution of functions and relations restoration in the countryside areas. The requirement of the whole-area solution of mining countryside restoration is based on the countryside zoning depending on past and future functional use.

We have been engaged in redevelopment of landscape affected by mining for a long time, especially in relation to the possibilities of using projection methods of the future condition of the area. In order to use information technology in the landscape redevelopment process, we are developing a database system that uses a maximum extent of landscape data characteristics, including relevant metadata to allow selective access to the data. The final application of the database and visualization must allow displaying the development of the area over time, as well as generation of visualizations that provide access to the potential of both natural and urbanized environments at any given point in the past, present, and, alternatively, the future. The visualization methods we engage in developing must enable the comparison of various forms of different degrees of intervention into the environment, including the alternatives free of any intervention whatsoever. Our solutions of information systems and visualizations also include the assessment of variants from the economic and environmental points of view (including ecology). An inherent part of the solution is the assessment of area externalities, not only the negative ones, yet with an accent to the positive ones (both economic and environmental).

THE PROCEDURE OF CREATING THE SYSTEM

The system, in our concept, means the application of information technology used to store, manage, analyse and present spatial data, information and related descriptive data.

The basic components of this technology are as follows:

- Data (spatial and descriptive);
- Metadata (acquisition: form, source, validity; temporal anchoring);
- Programme tools (for data entry, storage, analysis and presentation);
- Technical equipment (computers, peripheral equipment, communication equipment).

The procedure of designing the system can be summarized as follows:

- Identifying the requirements for the system functions;
- Analysing the process of landscape reclamation;
- Alternatives of invasion into the landscape;
- Determining the system output;
- Analysing the entry data and determining the methods of acquiring the data;
- Finding the programme tool, the needs of its modification;
- Suggesting the data structure of the system and the way of using the data;
- The system implementation;
- Verifying the functions.

The outcome is a verified procedure of creating the systems for variant complex evaluation of the interventions to the landscape and the management of the use or the smoothing of interventions, the functional landscape restoration and its sustainable and effective rehabilitation because it is not effective and not yet possible to create a protected nature reserve from this world.

Before the beginning with mining or with different invasive procedure (generally intervention to the landscape) it is necessary to have an idea about what the landscape can be or will be used for after the intervention ends. This means to have a complex knowledge of the default status of the landscape (or previous statuses) based on the files of the discrete (descriptive) quantities or their – on the basis of empirically derived analysis – likely reconstructions that respect the time dimension, which allow us to assess the dynamics of development unlike still commonly used statistic procedures.

When processing the project documentation of the reclamation plan for a concrete area, it is advisable to create a digital model of the terrain and to create a virtual model for using the area and, consequently, the visualization. Modelling enables to create several options of virtual solutions. The virtual solutions can reveal possible problems and discrepancies before the final solution of the project. This helps to avoid unexpected financial costs incurred by the delay of completing the reclamation.

DESIGNING THE SYSTEM

Based on our research in the area of collecting and processing the data and information relevant in the process of landscape reclamation and in the assessment of externalities, we present the following steps of our own solution:

- Secure the programme (this is dependent on various methodological alternatives of a concrete region and a country);
- Design the data structure;
- Examples of practical solution;
- Creating the model of the landscape.

The solutions of substantial points are presented further in this paper.

DATA STRUCTURE

The system includes a number of activities that involve designing and modelling the affected landscape while using the information about particular components of the landscape, geology, hydrology, ecology and the environment. Considering the large amount of observed variables and their mutual relation, it is necessary to carry out a proper information preparation in order to achieve a good function of the system [1], [2]. The task is to select a suitable robust data model. The data model ensures the basic requirements for high-quality and effective data management needed and mainly used to carry out the landscape reclamation and also covers both basic components of data description, ie the attribute and graphic component. The designed data model is designed with storing the graphical data outside the database system. The links ID of geographical objects to the records in the database are the linking element.

The main target of this model is to select the relevant groups of data, to limit the duplicity of data acquirement and to ensure a logical consistency of the data by uniting the data sources and their aspects of quality, namely the position accuracy and up-to-date state. Consequently, the optimization of the data structures is added, and that from the point of view of the data storage and, mainly, processing. Individual levels enable to link the object attributes based on the ID objects and to cooperate in the common part of the database. Another interaction is enabled by linking particular thematically oriented parts of the database by a unifying system of identifiers. This enables passing on the information of particular levels in the groups of one project.

The groups, levels and attributes are designed after the analysis of methods and procedures of closing a mine and the following landscape reclamation. The structure is defined by the documentation necessary for closing the mine; by the information for identifying the properties of the removed materials during the mining; the information necessary for particular stages of reclamation; by the prescribed documentation and the model of the final state. A significant part of the data is mainly the assessment of the external parts, both negative and positive, which is not regular. The following groups, levels and attributes have been designed:

- The scheme of the allotment area and the protected deposit area;
- The access for transport, electricity, heat, water, steam, telecommunications;
- Official territorial permission and related legislation;
- Regional connections – power station, heat station, distribution;
- The details of the deposit – geological situation, tectonic structure, coal reserves, the quality of the coal;
- The documentation describing the drops in the landscape, the estimate of future development and the prediction of the final state;
- Basic safety conditions – the bent of the slopes in the waste banks, safety measures taken against infusions, fires and flooding the subsidence basins, etc.;
- The description of surface structures – the operation facilities, additional operation, social services and others;
- Technical and economic properties of the mine according to the valid legislation: mining capacity, coal quality, etc.;
- The documentation of the investment construction according to the type of construction, technological complexes and induced investment;
- Workforce, economic indicators;
- Geological and hydrological details (before, during and at the end of mining process);
- Ecological indicators and details, including biological information (abiotic and biotic factors: historical data, current state, migration routes, the permeability of the environment for genetic information, etc.);
- The values of the externalities from ecological functions (negative and positive);
- The models of solving the minimize of negative externalities from ecological functions;
- The models of the landscape of the areas of interest according to the topographic information;
- The models of the landscape ordered according to the time
- The models of the reclamation projects implemented before;
- The models of characteristic elements of the landscape and the components of the geological landscape;
- The models of the course of real or planned subsidence processes;
- The models of the hydrological situation;
- The models of the anthropogenic terrain shapes (e.g. quarry walls; residual pits, mine dumps, waste piles, downward basin, sedimentation tanks, etc.);
- The models of ecological links between particular landscape elements;
- The models of buildings, communications, etc.;

- The models of the final versions of the terrain during and after the reclamation works (in time lines).

The data structure has been designed for a particular situation requiring the solution of a concrete problem. It can be complemented by adding other levels or elements as it will be necessary in further steps when solving another problem or when the reclamation project is changed.

MODELLING AND VISUALIZATION OF THE LANDSCAPE RECLAMATION

One of the crucial aspects of mineral material mining is that from the immediate beginning of extraction, we need to consider the consequences of the process, as well as the inevitable impact on the landscape. For that reason, it is necessary to engage in planning future landscape redevelopment as soon as the extraction work commences. We can refer to the requirements for using the refurbished landscape in order to modify, even during mining, the projected development of the landscape after the extraction has been completed. This is relevant not only to the goal of re-establishing the functionality of the landscape, but also in shifting the values towards positive externalities.

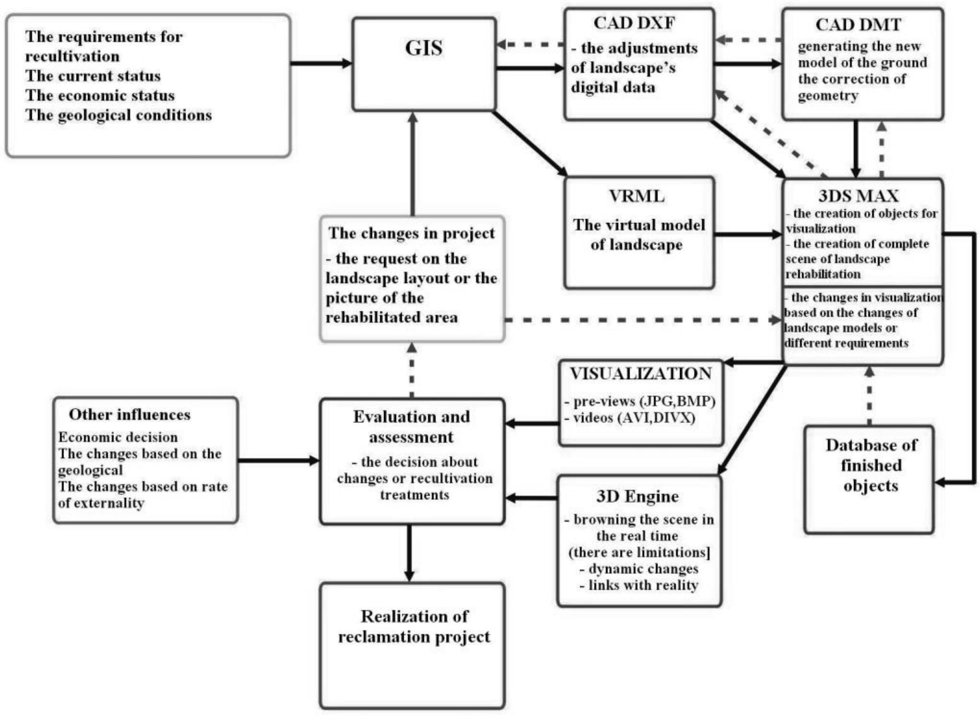

Fig. 1 Block diagram of system

As we wish to obtain a concise picture what the countryside might look like after the reclamation process, we are developing models and subsequent visualization of the projected future appearance of the landscape. However, planning the reclamation process is a matter of many years during which changes in the final design occur. In order to prevent repeated modelling and adapting the terrain objects to the landscape after every change of the area, we are trying to create the least complicated updates of the existing scenes. The system the block diagram of which is shown in Figure 1 allows this type of solution.

Our visualizations, or virtual reality, use the environment of 3ds MAX which generates the final landscape model; this software is also used for drawing the individual objects which are subsequently inserted into the model. The output is a realistic 3D model which is suitable for viewing, making movie clips of walk-throughs or flybys, or, in the final result, for converting into Virtual Reality worlds. As described above, the generated procedures and environment allow modifications of the model including the direct link to the data model.

The data model, its individual layers of digital terrain models, vector data and the proposed interface enable a connection between information and visualization systems, [3]. In order to update the scene, the proposed interface transfers all required from the layers of the information system. This interface also realizes reverse transfer of the new generation of layers and the updated layers into information systems. During the exploration of the project, methods and procedures for generation of 3D models of objects and landscape have been designed to generate most realistic scenes of reclaimed landscapes with an accent on updating the scene. Automated scene updating scripts and methods for modifying the digital terrain model have been prepared to implement the required changes into the project. Examples of projects and the virtual models are shown in Figures 2 and 3.

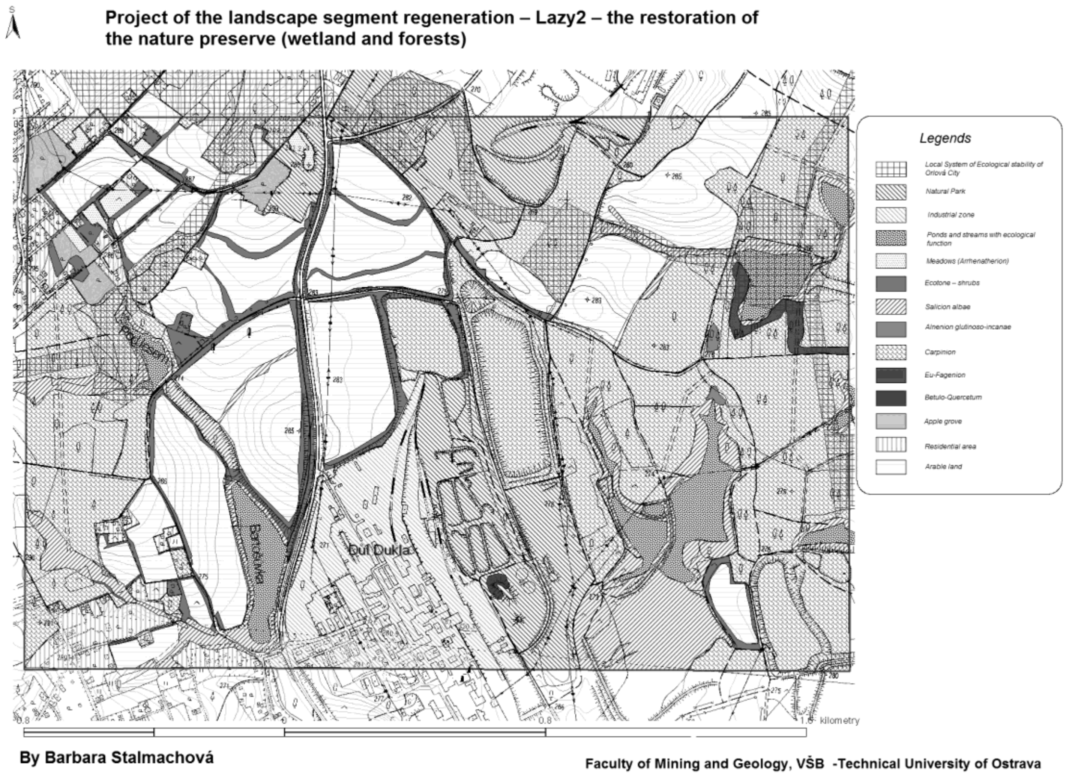

Fig. 2 Project of the landscape segment regeneration – coal mine LAZY, the map output from GIS

3D modelling and application of Virtual Reality to landscape affected by extraction of mineral materials seems to be an asset. 3D models are capable of providing quick projection of the appearance of the future landscape; the virtual reality technology allows the user to “take a walk” through such landscape. Using 3D models and virtual reality applications represents a tool for deciding about the most feasible variant of the reclamation project; at the same time, users are able to have a major influence of the value of externalities so as to react to the ecological cost of the damage to the area and landscape.

Within the scope of projects [4] and other successive work, we have created a virtual scene of a reclaimed area in the VRML environment and in the engines of 3DState and ORGE.

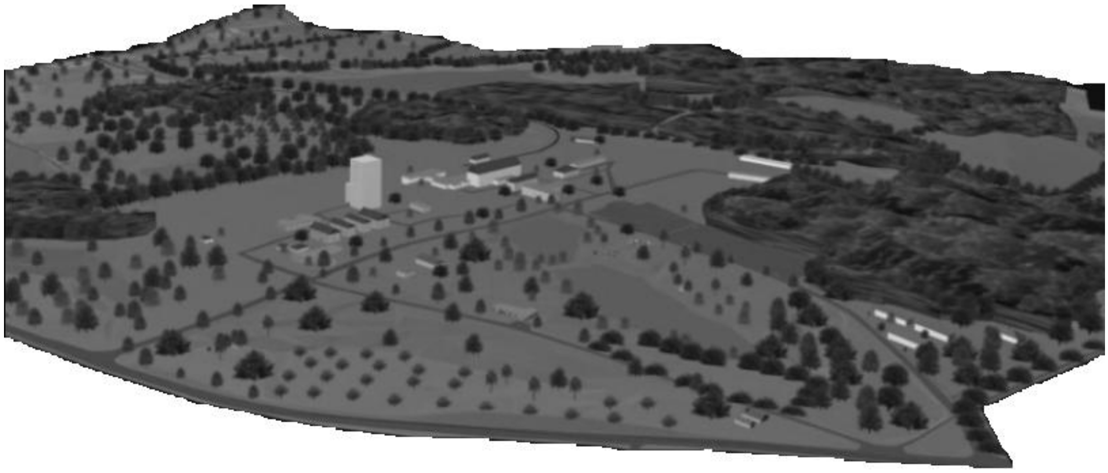

Fig. 3 Virtual model, visualization of the landscape segment regeneration LAZY

CONCLUSION

This paper briefly summarizes the results of the research and development in the area of application of the information systems and modelling the reclamation of a landscape exploited by mining.

The methods, procedures and solutions mentioned in this paper are a result of science and research grants and other projects carried out by our team.

a) Project GACR 105/94/1121 „The System for Modelling the Landscape after The Mining Process";
b) Project CEZ: J17/98:273500007 „The Problems of Minerals and Mining in 21st Century";
c) Project MŽP VaV/640/1/0 „The Initiation of Natural Ecosystems of Affected Overburden in the Process of Reclamation of the Karvina Region";
d) Project GACR 105/06/1242 "Sanitation and Reclamation of Downward Basins and Sedimentation Tanks in the Mining Area of Upper Silesia";
e) Project GACR 105/08/1242 "Research of Externalities Quantification by Biotopes of Cultural Landscape CR and Preparing of GIS data models";
f) **CENTRAL EUROPE project No 1CE014P4 "Manager Coordinating Brownfield Redevelopment Activities", COBRAMAN (2008-2011).**

The theoretical part of the paper applies generally for the area affected by the mining process. This solution has been chosen mainly in order to gather all the knowledge acquired by the teams of authors of the above mentioned projects dealing with the problems of landscape reclamation, and publish it within one paper in the way that would be useful not only for further related research but mainly for practical use in the area of landscape reclamation and sanitation and in the area of the externalities assessment. The data structure of the information security has been designed in a similar way.

In practice, the knowledge, procedures and methods have been so far applied mainly in the research and processing concrete areas model projects. In the future, however, it is assumed due to the interest from the side of organizations and experts, that the alleged procedures will be inseparable parts of dealing with the reclamation of landscape exploited by the mining process. The main advantage of these procedures and methods is the possibility of modifying projects according to the concrete needs and characteristics of the area. The procedures will be also used to assess and compensate positive and negative externalities. The advantage of the methodology and procedures is the possibility of fast adaptation to the changes that occur in the process of exploitation and struck-levelling, such as the needs of mining companies, new knowledge in the area of landscape management, new legislation and new views of the exploitation of the landscape or its parts. Another significant contribution is the possibility of virtual visualization of the reclamation measures in time series and horizons.

The paper brings results that point to the definite need to use the information systems and modelling in the area of landscape reclamation, the assessment and compensation of externalities together with the view of time dynamics of recent eco-systems. The research and development in the area of application of the information systems and modelling in the landscape reclamation is certainly not completed yet, especially with regards to the complexity of the system. This concerns mainly the problems with the authorization of individual processes, data communication and building up the knowledge and object databases.

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