WebGIS Cadastre of Abandoned Mines in Autonomous Province of Vojvodina

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Summary: This paper presents the development of a WebGIS application aimed at providing safe and reliable data needed for recultivation of abandoned mines in national parks and other protected areas in Vojvodina in compliance with existing legal regulations. The geodatabase model for this application has been developed using UML and CASE tool Microsoft Visio featuring an interface with ArcGIS. The WebGIS application was developed using GeoServer, an open source tool in the Java programming language, with integrated PostgreSQL DB and the possibility of generating and publishing WMS, WFS and KML services. The WebGIS application is publicly available, based on an appropriate central database, which for the first time encompasses all available data on abandoned mines in Vojvodina, and as such may serve as a model for similar databases on the territory of the Republic of Serbia.

Keywords: WebGIS, Geodatabase, Abandoned mines, Mine reclamation.

1. INTRODUCTION

Project "Cadastre of abandoned mines on the territory of the Autonomous Province of Vojvodina and accompanying database" was realized by University of Belgrade, Faculty of Mining and Geology for Vojvodina Provincial Secretariat for Energy and Mineral Resources. The aim was to secure safe and reliable data needed for recultivation of all abandoned mines in national parks and other protected areas. Given that systematized and structured data on the number, geolocation, status, state and applied measures of remediation and recultivation of such abandoned facilities did not exist, the need arose for developing an appropriate inventory of these "black spots".

For all known abandoned mines on the territory of the AP Vojvodina their current state was registered, as a starting point for data storage, and for planning of resources for further remediation and recultivation. The geodatabase model of abandoned mines includes the name, geolocation, administrative affiliation, size, geological structure, history, status and condition of recultivation, implemented measures for remediation and recultivation with supporting multimedia records (photographs) for each abandoned mine on the territory of AP Vojvodina respectively.

The software solution provides for viewing, search, and classification of abandoned mines by priorities based on defined criteria. When creating the database, special attention was devoted to functions for reporting that enable the management of sustainable development, spatial planning and environmental security.

The next section presents the methodological approach to development of the geodatabase, and a description of logical structure and physical database implementation. Section 3 outlines the development environment and usage of the system components, including the handling of spatial and attribute data, searching, reporting, and various types of statistics.

2. METHODOLOGY

2.1 Experience in the world

The development of the database has been harmonized with the existing international and European trends and standards (ISO 19115 and ISO 19119) [1]. With the adoption of Directive 2007/2 / EC [2] by the European Parliament and the Council of Europe in European Union member countries, the infrastructure was established for spatial information records with the aim of improving environmental policy, that is policies and actions that have an impact on the environment (INSPIRE). Emphasis is placed on interoperability in terms of availability of data related to the environment. Interoperability within INSPIRE implies the possibility of combining spatial data and web services from various sources throughout the European Union in a consistent way without specific human or hardware requirements, relying on EN ISO 19115 and EN ISO 19119 [3].

The GeoMine (USA) geoportal supports the decision-making process in connection with activities related to surface mining of coal by improving access to data, timely dissemination of data and understanding of geospatial data on different scales and at different levels [4].

Abandoned Mine Land Inventory System (e-AMLIS) (USA) includes information on abandoned mines that are in need of remediation, and the mines which were recultivated, that is, where the remediation process was completed [5].

U.S. Geoscience Information Network, USGIN is the federal framework for the exchange of information using the free and open source technology that enables connection to similarly configured data exchange networks. This approach offers a long-term solution for the storage and exchange of data without commercial software. USGIN makes available, connects and opens the data related to the earth sciences [6].

The aim of the Upper Midwest Environmental Sciences Center - Ohio Valley Abandoned Mine Lands Study was to provide a central location for accessing and obtaining GIS spatial data needed for different aspects of the study of the terrain of abandoned mines and/or their remediation. These data include: basic data, hydrogeology, biology, geology and mining as well as specific information related to the terrain of abandoned mines [7].

Spatial data in the aforementioned study on terrain of abandoned mines as well as data concerning the remediation of this terrain were generally available. However databases of geographic information systems were often incoherent and/or incomplete for targeted use. A central repository for regional GIS spatial data was necessary in order to facilitate the preparation of a study as well as efficient locating of personnel and resources during the remediation of sites and abandoned mines themselves.

2.1 Serbian practice

The Serbian Law on Mining and Geological Research of 2011 states that "The Ministry shall keep a special register of documents on abandoned mines and mining facilities, as well as the records of remediated and recultivated mines and mining facilities." In the mining waste fields cadastre data are entered on the limits of the mining waste field, on the carrier of exploration and/or exploitation or economic entity that produces mining waste, on the economic entity which is the operator of mining waste, on the characterization and categorization of mining waste landfills within the mining waste field, as well as other data related to the management of mining waste. In the cadastre of abandoned mines and mining facilities data on the position and status of those mines and mine facilities are entered, as well as data on implemented measures for remediation and recultivation [8].

One of the requirements in developing the new system was to integrate it with the existing GIS application GeoIIEP for management of exploration and exploitation permits and works in the mineral resources field. GeoIIEP represents a basis for archiving and efficient handling of vector, raster and related thematic alphanumeric content in one place, as well as efficient management and usage of mineral resources. The use of GeoIIEP results in cost reduction in data storage and archiving and accessibility of data to a wider circle of users. The system is implemented within the ESRI ArcGIS technology framework as an ArcMap .Net extension that supports distributed user access to manipulation of spatial and alphanumeric data, issuing of permits, visualization of spatial data, generating of a cadastre of exploratory and exploited areas, data export, as well as web search and visualization [9].

2.3 Geodatabase model

The geodatabase model was developed using UML (Unified Modeling Language) and CASE (Computer-Aided Software Engineering) tool Microsoft Visio, which has a developed integration feature with ArcGIS. Figure 1 shows part of the logical data model with basic classes of the registry of abandoned facilities, which inherit abstract ESRI classes Feature and Object. The central place is the *abandoned_facility_registry* class, which maps the data on a degraded area, and defines the titleholder by the relation to the class *company*. Like other attribute classes, it inherits the abstract class *generic_attributes* and receives attributes of the primary key, relations to the metadata, comment, and record author classes.

The class *company* comprises contact details of all titleholders in the database, while the class *terrain_record* models notes taken during field visits. The class *multimedia* is intended for photos and video records collected during field visits. The spatial polygonal class *abandoned_facility* describes the geometric parameters of the degraded area: contour, surface, average bench heights, the overall depth of the pit, volume, as well as general data collected during the field visit related to recultivation, water level (whether the mine is above, below, or above and below water level), as well as the site, for example, a pit, a landfill, workshop or plant. Figure 1 shows part of the conceptual data model.
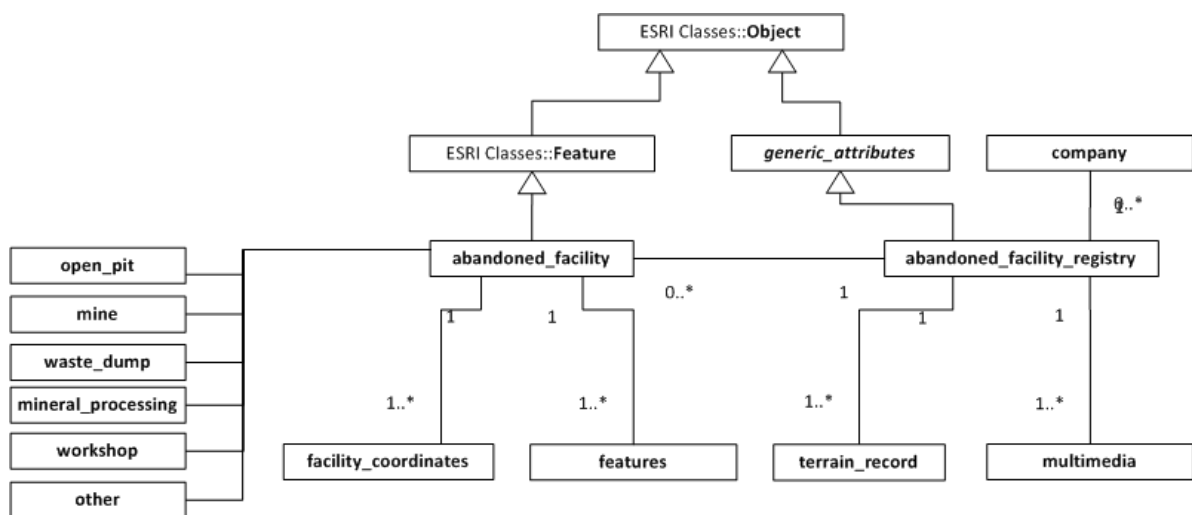
Figure 1 *Characteristic part of the conceptual model*

3. SYSTEM IMPLEMENTATION

3.1 Development environment

The relational database management system used was PostgreSQL with the PostGIS extension to support spatial data. GeoServer was used for generating and publishing WMS (Web Map Service) and WFS (Web Feature Service), KML (Keyhole Markup Language) and everything else needed to create a web GIS application. GeoServer is an open source tool designed in Java which enables users to serve spatial data. Its primary role is to serve as connection in an open spatial data infrastructure (SDI). Using the open

standards of the OGC, GeoServer allows significant functionalities for viewing and sharing of geographic objects and maps, as well as interoperability with a large number of commercial and free geoinformation systems and cartographic applications.

OGC (Open Geospatial Consortium) is the main international and industrial organization for standardization in the field of geospatial data. Web Map Service (WMS) is an OGC standard and at the same time the most popular and most widely used OGC Web service which specifies the communication between unrelated programs when sending or receiving pre-generated map imagery to users who have issued a request. Simply put, the WMS is a service by which the client can send a request to view a map from a server. This cartographic web service produces maps of georeferenced data by drawing them in the standard format for images (PNG, GIF, JPEG,...) and publishes them via the Web [10]. Web Feature Service (WFS) enables communication at the level of the class itself and can be used for editing spatial data over the Web [11].

Cartographic web services are also available as Keyhole Markup Language (KML), which means that any application that reads KML, such as ArcGIS Explorer, ArcGlobe, and Google Earth, can read and interpret these services [12].

3.2 WebGIS

The development of the software solution is compliant with recommendations related to spatial data infrastructure (SDI), as a data infrastructure implementing a framework of geographic data, metadata, users and tools that are interactively connected in order to use spatial data in an efficient and flexible way [13]

The WebGIS application of the Cadastre of abandoned mines of Vojvodina is publicly available at http://kanakov.vojvodina.gov.rs. Figure 2 depicts the home page where the central part of the screen shows a map which can have one of the following Google Maps as underlying: Physical, Streets, Hybrid or Satellite, depending on user choice. Over the base map two layers are displayed: polygons singled with remote sensing method and polygons resulting from the analysis of exploitation authorizations, requests for recultivation and field visits.
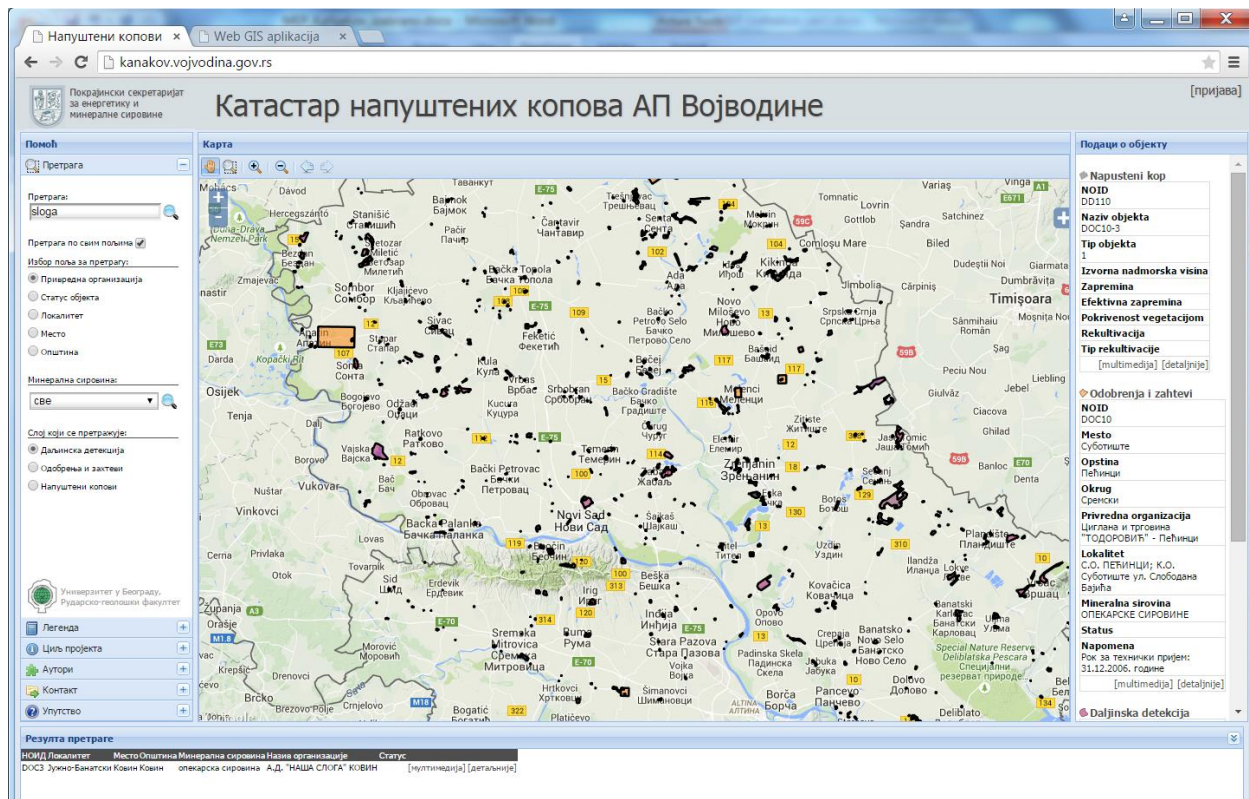

Figure 2 *Main page of the Cadastre of abandoned mines of Vojvodina*

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The left side of the screen consists of several tabs: help, search, legend, objective and scope, as well as the project authors. The lower part of the screen displays a table with search results, while the right part displays data for the selected polygon, that is, the abandoned mining facility. The panel for search provides for locating abandoned mines that match the user query. Users can search by titleholder name, mineral resource, type and status of the object, etc. The lower part of the screen displays a list of abandoned pits that match the query, and the user has the option to view each of them in more detail: to zoom or read the record stored in the database.

In the upper right corner there is a link for registration of users authorized to work with data. Administrators have the possibility to manage all the data, while editors have the option of editing data related to pits and commercial organizations, but not data related to user accounts and data dictionary.

3.3 Web application for textual (attribute) data

Authorized users can use the protected part of the application on the following pages: Users, Industrial organizations, Registries, Abandoned facilities, Directories, Statistics, Reports. Handling of all datasets takes place in a similar way: the first page features a tabular representation of the data set with the possibility of search, that is, filtering according to given criteria. The level of access to data and the possibilities for editing depend on privileges that are assigned to a particular user.

Figure 3 shows a typical panel for managing the registry of abandoned mining facilities. The user can filter the data, and then proceed to the inspection of selected data in more detail, as well as related data, including their editing and deletion. Detailed data on the registry of abandoned facilities consist of a name, place, municipality, district and site address. Object type is selected from the list of provided terms: open pit, underground mine, processing, waste deposit, maintenance workshop, other facility. Data on cadastral parcel or parcels and the titleholder are entered if this information is available from the cadastre. If the titleholder does not exist or is not known, "no titleholder" is entered. Further the year of the start and termination of work are entered. The status can be: active, abandoned, unknown, temporary suspension of the works, permanent suspension of the works. If a permit for exploitation exists, the provincial and republican cadastral numbers (list numbers) are recorded.

3.4 Reporting and data analysis

Within the reporting system it is possible to obtain a report of all data on an abandoned mine: register, titleholder, objects, coordinates, properties, evaluation, as well as the register of abandoned mines by municipalities, with the most important supporting information, the possibility of linking with the previous report, the report on abandoned mines, with evaluations and evaluation criteria. Report on ranked abandoned mines with evaluations and a list of business partners with and without registered abandoned facilities, but with mandatory status, are also available. The user can select to print a single record of an abandoned facility or records about all abandoned mining facilities in the municipality, district or national park.

Statistical reports provide an overview of the use of the application on the basis of log data (logons) and data entry, as well as the number of visits of the site using Google analytics. Statistics of mining facilities and results of remote sensing by property type, by district, municipality, by mineral resource or method of registration and the like are also available.

A system for reporting problems in system operation and review of frequently asked questions is also implemented at http://bugzilla.rgf.bg.ac.rs/.

Figure 3 *Panel for managing the registry of abandoned mining facilities*

4. CONCLUSION

In this paper we presented the results of the strategic project „Cadastre of abandoned mines on the territory of the autonomous province of Vojvodina and accompanying database" realized by University of Belgrade, Faculty of Mining and Geology, for the Provincial Secretariat for Energy and Mineral Resources of Vojvodina, and pointed out the usefulness, practical value and advantage of using WebGIS applications for accomplishing this task. The main reason for the realization of this project stemmed from the necessity of ensuring secure and reliable systematized data necessary for recultivation of all abandoned mines in Vojvodina, including national parks and other protected areas, in accordance with the existing legislation. The geodatabase model of abandoned mines included administrative and spatial data as well status and condition of recultivation, implemented measures for remediation and recultivation with supporting multimedia records for each abandoned mine on the territory of AP Vojvodina respectively. The geodatabase model was developed using UML and CASE tool Microsoft Visio, which has a developed integration with ArcGIS. The relational data base management system is PostgreSQL with the PostGIS expansion to support spatial data. GeoServer was used for generating and publishing WMS and WFS, KML and everything else needed to create a web GIS application. WebGIS application Cadastre abandoned mines in Vojvodina is publicly available. A simple search panel enables retrieval of abandoned mines, and a systematized database is available that for the first time brought together all the available data on abandoned mines in the territory of Vojvodina, and as such can serve as a model for similar bases on the territory of the Republic of Serbia.

The project activities preformed within the development of the Cadastre of abandoned mines in Vojvodina and the accompanying WebGIS application were complex and multidisciplinary, involving a team of experts form the geological, mining, economic, ecologic, informatics, mathematics and other domains. Special attention was given to securing a high level and quality of project work, both regarding the quality of content, namely data and information, but also regarding the quality of structural relations among data, as well as quality of user interface featuring easy and simple search and display od structured data. The application aspects are multiple, and relate not only to the relevant sectors of mining and geology, but also to economic, urban planning, spatial planning, agriculture, hydrology, ecology, safety and other sectors. Such a broad application base points to the main directions of further development and upgrading of the database and WebGIS application developed within the project. The aim is to secure their full and active application within mineral resource management, ecology management, but also management within official bodies, responsible for legislative legal, control and monitoring activities in realization of the mineral strategy, mineral policy and the concept of sustainable development in the mineral industry of Serbia.

Acknowledgements

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