The Geology in Digital Age

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Meetings of the Association of European Geological Societies (MAEGS) have a long tradition, since the first one in Reading - England, 1975, up to the latest one in Cluj Napoca – Romania 2009. The MAEGS-17 continues this practice with a demonstration of the latest research results and achievements in geological sciences.

Increasing of quantitative methods in the geology as well as magnitude of information in general, led to immense use of computers in the geoscience. This was highly useful in solving different problems varying from geological mapping, petroleum geology, reservoir and basin modeling, data acquisition, environmental geology, as well as modelling of geological processes of various kinds. Moreover, a new fields of research arosed, such as GIS aplications, geodatabase design, Applied Geomathematics and Geostatistics, 2D and 3D models, 3D visualization and simulation.

However, vast use of computers is followed with inevitable problems: Various incompatible information, dissimilar hardware or software systems, diverse segments of geoinformation spectrum, Redundancy, etc. In accordance with this there is constant need for collaboration through exchange of information and experiences, research results, etc. Thus Core subject "Geology in Digital Age" was proposed.

Editors

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Digital Mapping for Collection and Visualization of Geoscientific Data

Luca Ghiraldi[1], Simon Martin[2] , Luigi Perotti[3], Enrico Giordano[3] & Marco Giardino[3]

Abstract. During the last years we have witnessed a revolution in the information technology applied to Earth Sciences, in particular in the fields of geological and geomorphological landscape's studies. The most innovative aspect concerns the integration of data coming from different sources. The paper presents the methodology used and developed by Torino Natural Sciences Museum (Italy), Department of Earth Sciences of Torino University (Italy) and the Institute of Geography of Lausanne University (Switzerland), which allow to collecting, storing and displaying geoscientific data. With regard to the terrain data collection, a palm PC equipped with GPS and GIS software specifically customized has been used. In order to organize and make available information, data have been stored into a relational database and published on Internet. The visualisation of geospatial data is through a customized interface of GoogleMaps which allows dynamism and interactivity to the users.

Key words: GPS, Mobile-GIS, Database, Internet Mapping, Google Maps.

Introduction

Maps are used to show locations and to display geographic relationships between geometric entities. Furthermore they are used for navigation, exploration, illustration and communication in the public and private sectors. During the last years, mapping production has been widely benefited by the information revolution. Better database software allows the management of vast amounts of information, advanced visualization techniques allows to create increasingly sophisticated representations of our environment. This set of tools and methodologies have introduced radical changes in the field of geological and geomorphological landscape's studies. The most innovative aspect concerns the integration and the use of data coming from different sources, but the real progress is the opportunity of integrating traditional terrain data with the digital ones, in order to obtain interpretations and representations more and more real. The results can flow into a unique environment, allowing the integration and the production of geo-thematic maps that reflect the integrated analysis of data. The most important recent developments have been in navigation and remote sensing. The Global Positioning System (GPS) has revolutionized field data collection in several areas including geological and geomorphological surveying. Similar advances are occurring in the areas of geographic data dissemination. Government agencies at all levels are embracing this technology to provide access to vast amounts of spatial and textual information to the public cheaply and quickly. The Internet is likely to replace printed maps and digital media as the most important means of data distribution.

On the basis of assumptions cited above the Torino's Natural Science Museum and the Department of Earth Sciences of Torino University, started a project whose aim is to develop tools able to collecting and popularizing geological and geomorphological information of different sectors of Piemonte region (NW Italy).

Collection and visualisation of data

Classical methods for field data collection on geological and geomorphological features are based on the use of relatively simple tools and many types of

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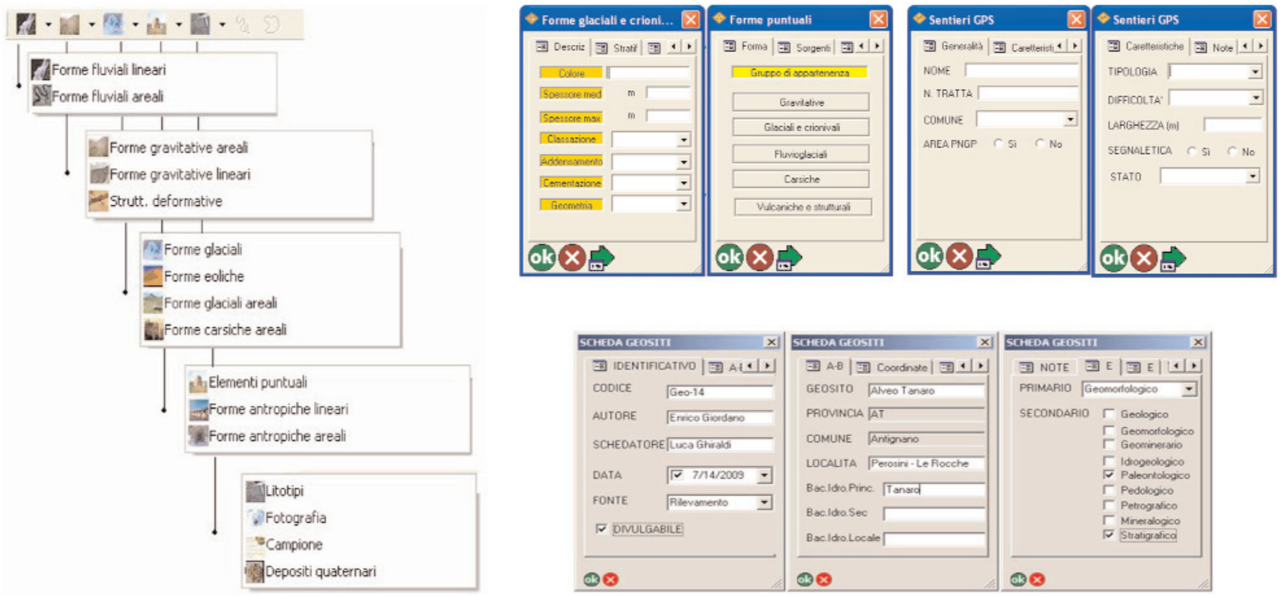

Fig. 1. Customized extensions for mobile-GIS software. On the left the toolbar with predifined layers in shapefile format; on the right-top: the cards to describe geomorphological features and to classify the track. On the right-bottom the cards to describe geological heritage.

maps. So far, data collected on the field had to be interpreted, summarised and redrawn (GIARDINO *et al*., 2010). In order to improve and speed up this kind of process, a palm PC equipped with GIS software and GPS (Ground Position System) has been used. This allows to bring on the terrain any type of georeferenced raster or vector files. The GPS equipment offers the opportunity to get in the real time the "exact" position on the map, without having to use paper maps and allowing a precise and immediate survey. The GIS software includes extensions purposely set-up in Visual Basic. They add several capabilities that enables the digital representation of the features observed during field activities. Depending on the operational needs, different toolbars have been created, allowing to select predefined layers in shapefile format. Each of them have an external database containing fields to be valued with data (Fig. 1).

Once edited, the surveyed features are classified with alphanumeric data in order to perform a complete description. In order to disseminate and popularize information, all data collected on the ground or coming from others sources have been transferred into a relational database accessible from Internet, which allows to get results using a simple query interface.

The Internet is also suitable for presenting and distributing geographic information. The simplest option is to present static map images integrated into Web pages just like any other graphic or photographs. Such Web sites can give users access to useful information, however, they do not allow the user to manipulate the data and to produce custom maps for specific geographic areas.

Among the applications freely available for viewing geospatial data there are the so called "virtual globes", such as NASA WorldWind, Google Earth, Microsoft Virtual Earth and others. These softwares are able to integrate satellite imagery, aerial photography, and digital maps and present a three-dimensional interactive representation of data on a global scale.

GoogleMaps option was chosen for the following reasons:

- Typical features of a Web-GIS;
- Wide dissemination and handiness of use;
- Basic cartography always available and up to date;
- Ability to display three-dimensional view (Google Earth Plugin);
- Customizable interface using GoogleAPI, HTML and javascript;
- Power to manage data through connection to a relational database or through the use of XML or KML file.

The application developed is structured according to the scheme shown in Figure 2.

The interface (Fig. 3) consists of a window reserved for the map with navigation tools, selection of the background map., while the right column is dedicated to the exploration of data. The originality of this application lies in its almost total dynamism. Most part of specific information have been stored into the database in order to avoid redundancy information and facilitates new inset and the update. In this way the application is not a single map but an infinite number of possible maps. The basic functions - intuitive navigation, zoom, fast display and labelling, create an efficient and enjoyable framework for consulta-

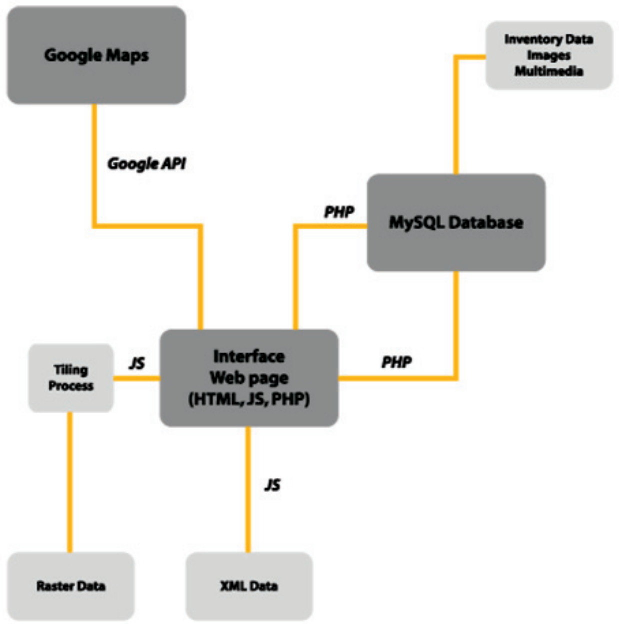

Fig. 2. The structure of the application developed using GoogleMaps interface. Data can be stored into a Database or added using KML or XML files.

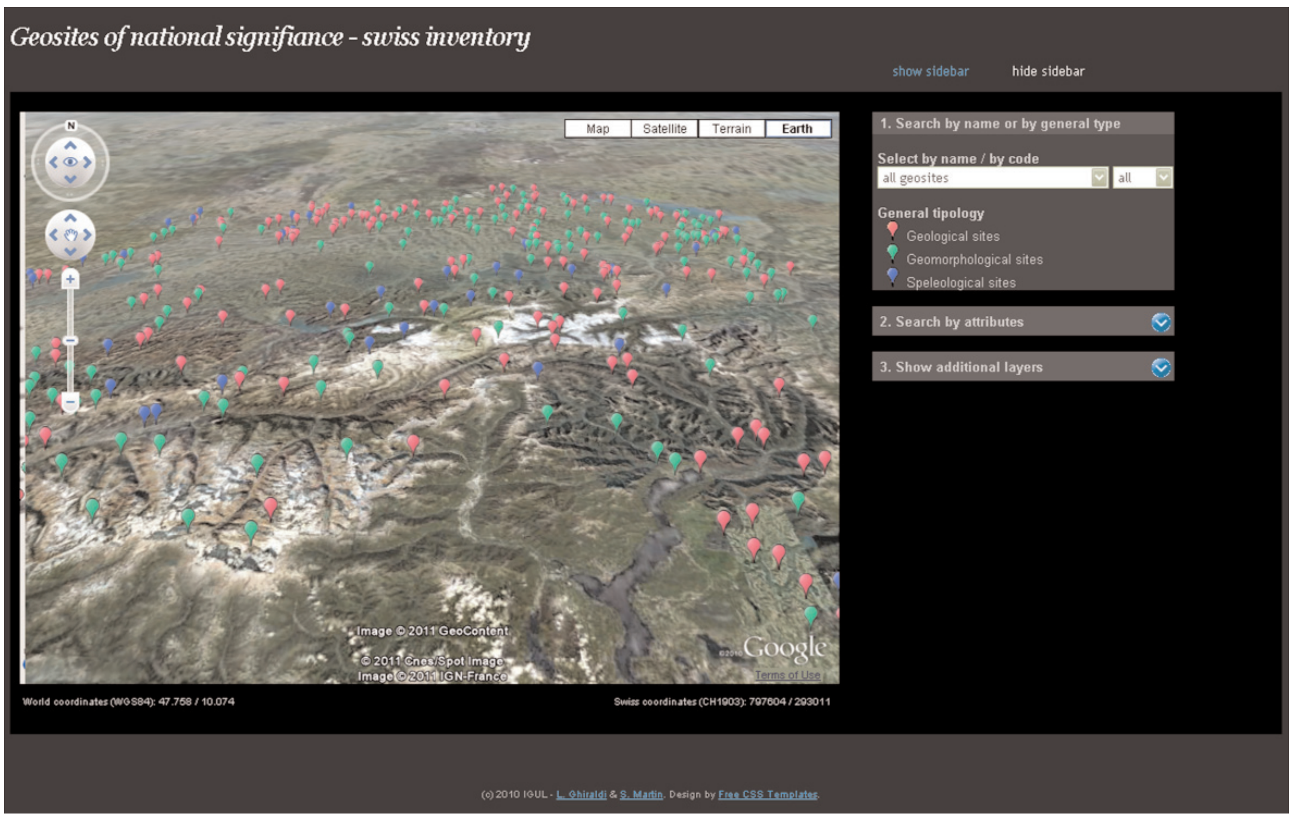

Fig. 3. The application based on GoogleMaps. On the right the panels 1 & 2 allows to query the data stored into the database. The panel number 3 allows to add on the main window layers stored in KML or XML files. Navigation tools on the top of the main window allows to switch the way of visualisation.

tion. These features plus the ability to interact with data, the power to link different kinds of documents and to displays many layers of spatial information, allows retrieving and accessing more information. The digital representation of the real world, allows not only to transmit static information, but to create an application that can provide a teaching tool, even among people not involved in the Earth sciences disciplines, able to create awareness for the protection and preservation of natural landscape.

Conclusions

The direct production of thematic maps and the immediate recording of the most part of data seem to be the most promising aspects of the proposed methodology, which can be used for different needs such as: geological and geomorphological mapping, geosites inventory, trails classification and by different people such as: researchers, technical staff opereting in natural park or in others territorial institutions. In order to disseminate information to a wide audience, virtual globe systems such as GoogleMaps, are recognized as an important trend in geoscience research and applications. These systems also enable researchers to conveniently collaborate and share their research projects and results. The tools and the methodology presented in this paper, were tested in several projects concerning different sectors of the

Piemonte region (NW Italy): Middle Tanaro Valley in Cuneo province (GHIRALDI *et al*., 2009, 2010) Susa and Sangonetto Valleys in Torino province (GIARDINO *et al.,* 2004, 2010), Sesia Valley in Vercelli province.

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Geomatic Techniques Contributing to Understanding Geo-Morpho-Structural Assessment of Veny Valley (Courmayeur, Ao)

MARCO GIARDINO[1,2], LUIGI PEROTTI[1,2], MARCO BACENETTI[1] & PAOLO ZAMPARUTTI[1]

Abstract. The present work is orientated at the comprehension of the geomorphologic processes of periglacial environment past and on going of Veny valley (Courmayeur, Ao) and their interation with the morpho-structural setting through geomatic techniques. Previously studied sectors within the project area with large quantities of data were integrated and compared by detailed research within sectors of scarce pre-existing field data.

First, the field data were collected using pocket-PC and integrated GPS whit mobile GIS in order to create an ESRI-GIS based geodatabase. Considering that the area was setting in an alpine context, stereoscopic models from the '97 and '03 flights with a 4 m precision were build to map geomorphological features in unaccessible area. Contemporaneously, to support these data, LiDAR '08 images were processed to include hillshade, slope, and aspect maps.

Data interpretation yieled to obtain three geotematics layer: a) geomorphologic, within mapped landforms b)morpho-structural, concerning the structural evolution c) debris cover of Miage glacier, for the multitemporal analysis.

The remote sensing technologies, applied in this project, showed to be more affordable than the usual field-based approaches, in the prespective perspective of a safe analysis of stability conditions in mountainous areas.

Key words: pocket-PC & mobile GIS, geodatabase, LiDAR, morpho-structural setting.

Introduction

Study area

The study area is located in the Italian side of the Mont Blanc Massif (NW-Alps), close to the border of France and Suisse (Fig. 1). The massif has its highest elevation at 4808 m.s.l., and many of its fractured granite faces, peaks and crests stand well above 3000 m.

From the geological point of view the study area includes two main domains: Helvetic-Ultrahelvetic (mostly granites and clay-carbonatic schist) and Penninic Domain (Quartzite, dolomite, limestone breccias and schist; PERELLO *et al.*, 1999).

The Mont Blanc massif displays a cross-range asymmetry. The northwest side has relatively gentle slopes and has the largest glaciers. The southeast flank is very steep, with small glaciers bounded by high, subvertical rock-walls. This asymmetry explains the more prominent altitudinal distribution of the glacial, periglacial, and forest belts on the northwest side of the massif than on the southeast side, e.g. DELINE (1998).

Materials and methods

Pocket-PC and mobile GIS

Simplicity, precision and rapidity of field survey techniques are some key-features of the pocket PC equipped whit dedicated Mobile GIS software and code GPS receiver. Mobile GIS fundamentally changes the way information are collected, used in the field and shared with the rest of an organization.

For faster and more suitable procedures of field mapping activities, we used the "SRG2" application: an ArcPad (mobile GIS) extension including a toolbar

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with several functions for a useful mapping and classification of geological/geomorphologic features.

Geomatic techniques (LiDAR, Digital stereo ortophotos, Coltop 3d)

Airborne LiDAR data providesnew opportunities to overcome some of the problems associated with traditional, field-based, geomorphologic mapping, such as restrictions on access and constraints of time or cost. The combination of airborne LiDAR data and GIS technologies facilitates the rapid production of geomorphologic maps. Classification of LiDAR data according to elevation in a GIS enables the user to identify and to delineate geomorphologic features similarly to field mapping; however it is necessary to use a range of classification intervals in order to map the various types of feature that occur within a single reach.

Stereographic digital models were obtained from the scanned aerial photograms and then elaborated. Stereo models obtained from different photograms were useful to make considerations about the evolution of the area. The stereo-pairs allowed to observe the stereographic digital models through Stereo Analyst (GIS extension) and view them in 2.5D ArcScene.

Coltop3D is a software developed by Quanterra (University of Lausanne); the GeoSitLab (University of Torino) is part of the BetaTesters. The software Coltop-3D computes the orientation of each cell of the DEM. The result is a coloured shaded relief map combining both terrain slope angle and slope aspect (direction of slope) in a unique representation. DEM LiDAR images were imported into Coltop 3D to analyse the main joint sets of the valley.

GIS: geodatabase and draws geomorphic features

Modern GIS allow complex data management and easy loading structures e.g. Arctur & Zeiler (2004) to store details derived from field activities and remote sensing investigations. Their differences essentially consist in the scale of analysis, which has repercussions on the geodatabase structure and on the total number and type of available fields and records, e.g. Giardino *et al*., (in press).

A problem to drawing the geologic data concern a few geomorphic features: alluvial fans, debris-flows, debris cones and avalanche cones whose dimensions and orientations change significantly into space. The introduction of Representation in the package ArcGIS/ArcInfo Desktop 9.2, thanks to the wide range of complex symbolism and representation tools associated with them also independent of the geometric primitives of the feature in question, has given the cue for the correct and comprehensive resolution of the symbolization of the polygons geomorphologic environment directly in ArcGIS without switching to graphics platforms, e.g. Zazzari *et al*. (2009).

Discussion

Local geo-morpho-structural analysis

In the Val Veny two main geomorphologic features dominate the landscape: debris-covered glaciers (Miage and Brenva) and steep rock slopes on the left side. The Miage Glacier is fed by 4 tributary glaciers, flowing from the peak of Mont Blanc through a narrow valley surrounded by steep rock slopes. The glacial tongues of these glaciers built great moraines on the outlet of the valley. These apparatus blocked the valley stream (Dora di Veny) and created two lakes, now filled by fluvio-glacial deposits, forming the Zerotta plain and the Combal plain.

Several stages of glacial advance and retreat are registered along Val Veny, most of the preserved landforms had been built after the LGM. Neogenic climate fluctuations strongly modify the geomorphology of the valley. Glacial variation during the Holocene interglacial is an important key for interpreting the palaeoclimatic conditions, although the transfer function between climate signals and glacier oscillations remains poorly understood, e.g. Orombelli & Deline (2002). Study of the sediments of moraines dammed lakes (i.e. Combal) suggests that the main moraines of the Miage and Brenva glacier have built since 5.0 kyr BP, e.g. Deline & Orombelli (2005)

Other geomorphologic features suggesting past glacial condition are: small glacial deposits and terraces on one side of the Miage valley slopes. Moreover two tributary suspended glacial valleys (actually free of ice), have been mapped at elevation of about 2650 m a.s.l..

Four sectors whit different morpho-tecnonic behaviour have been recognized in Val Veny:

1. the upper part of Val Veny (Lex-Blanche valley), characterized by cryogenic processes and rock-glaciers, mainly affecting carbonate-type rocks;
2. the middle-lower right side of Val Veny, where: evaporitic rocks outcrops, slopes are affected by DSGSD and incisions show debris flow deposits;
3. the lower left side of Val Veny: the granitic bedrock is affected by four major joint set; Markland tests on N70°/60° open fractures underlines the aptitude to toppling and wedge sliding; at the base of this sector, polygenic cones (Breuillat, Fréney, Combalet) are fed mainly by rock falls and avalanches.
4. the Miage glacier basin: the major tributary of Val Veny, crossing the Mont Blanc Massif for 7 km length, with a N/NW trend. Back analysis by

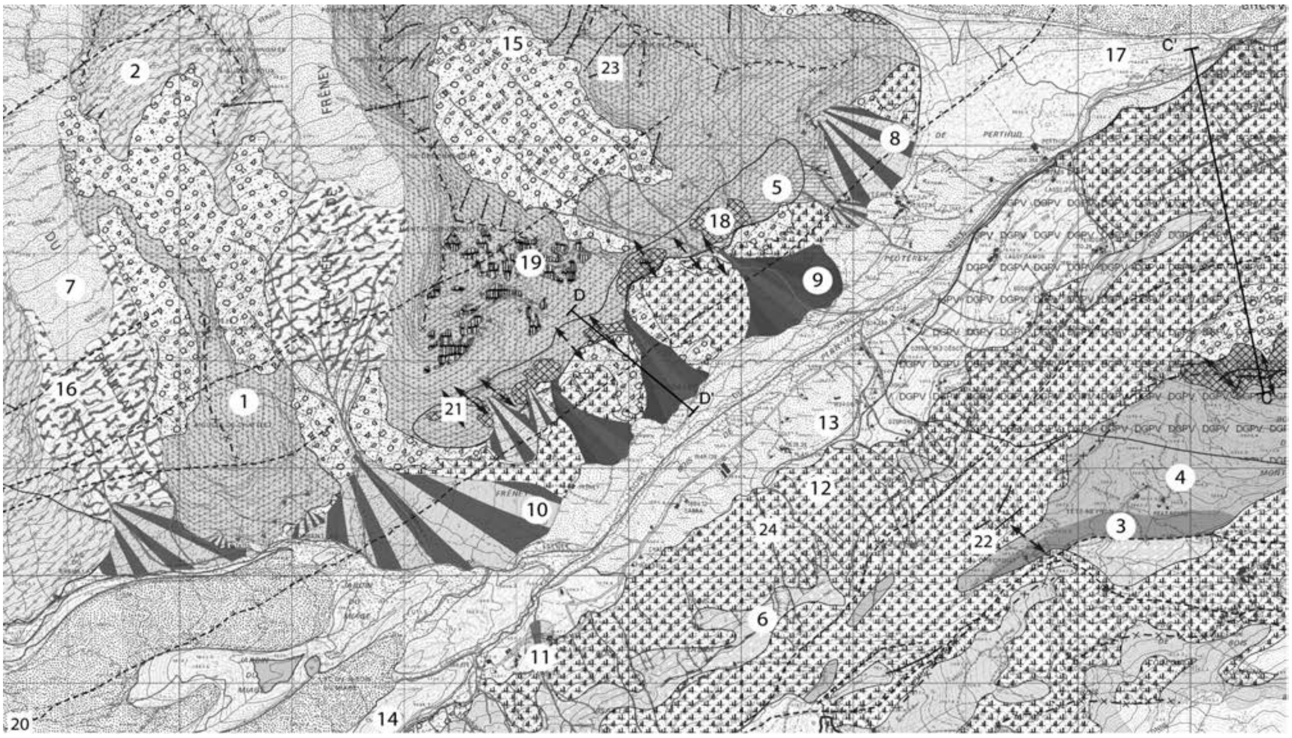

Fig. 1. Extract of Morpho-Neo-Tectonic map of the dynamics of the area. Legend: (1) Granitc rocks; (2) Paragneiss; (3) Sedimentary cover of Mt Chetif; (4) Porphyry; (5) Limestone; (6) Calcareous arenite; (7) (8) Glacier; (9) Mixed cones; (10) Alluvial fans; (11) Debris-flows; (12) Debris and slope-deposits stable,; (13) Recent and current bottom valley fluvial deposits; (14) Glacial deposit; (15) Talus; (16) rocce esarate dai ghiacciai (17) Recent glacial deposit; (18) Fractured rocks; (19) Areas of potential gravitational instabilities; (20) Mojor rocks discontinuities; (21) Open fractures; (22) Trench; (23) Structural features; (24) Deepened incisions.

Coltop 3D individuated unstable sectors on the left slope of Miage valley; here all the joint sets intersect each other and the Markland tests show the aptitude of wedge sliding.

These information have been summarized into a Morpho-Neo-Tectonic map of the dynamics of the area (1:15.000 in scale, fig. 1)

Conclusion

The integration of the data and their geomorphologic interpretation have demonstrated how powerful could be the application of these innovative methodologies. The usual field-based approach could be upgraded using remote sensing technologies as they proved to be affordable for the safe analysis of mountainous areas. A GIS system was set up to store and to manage data, each layer being used to interpret the landforms. The most important elements have been used as keys for interpreting the relationships between landforms and bedrocks, glaciers evolution and landslides.

Integration of all collected data inside the GIS allowed to understand the complete morpho-structural setting of the Val Veny area.

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Plotgooglemaps – A Simple Solution for Geological Survey Web Mapping

MILAN KILIBARDA[1], ZORAN RADIĆ[1] & BRANISLAV BAJAT[1]

Abstract. Google Maps represent set of cartographic data in combination with satellite imageries and/or aerophotogrammetric images. Nowadays, Google Maps Application Programming Interface (API) based on Asynchronous JavaScript and XML (AJAX) technology as standard Web service, facilitate users with publication of interactive web maps, thus opening new possibilities in relation to the classical analogue maps. The objective of this work is to provide solution for easy creation of the interactive web map, with base map supplied by Google, where all map elements and additional functionalities should be handled by just one line of code. The solution for the automatic creation of complete web map based on the Google Maps API (the HTML file with Cascading Style Sheets (CSS) styling and Java Script functionality) is the package *plotGoogleMaps* developed in **R** programming language.

The feasibility of usage developed package was demonstrated for mapping geotechnical survey data. The case study area covers great part of New Belgrade municipality – banks of Sava and Danube rivers. Over sixty project reports treating detailed geotechnical research for main civil design projects of numerous constructions in period from year 1970 to year 2007 were collected end mapped via package *plotGoogleMaps.*

Key words: Web cartography, Goole Maps API, PlotGoogleMaps, geological survey.

Introduction

The development of internet technology has significantly influenced the development of cartography and maps visuelisation techniques, enforcing web cartography as a primary cartographic medium, today. The development of web cartographic tools has brought significant possibilities for mass cartographic communication.

Google Maps represent set of cartographic data (spatial and attribute data) in combination with satellite imageries and/or aerophotogrammetric images. Google Earth/Maps is a ground braking software in at least five categories: availability of application, high quality background maps, a single coordinate system, web-based data sharing, popular interface and availability of API services (HENGL, 2009). Google Maps and Google Earth project derived from Google Maps project, significantly changed web cartography approaches (XIAOJUN *et al*., 2008; GIBIN *et al*., 2008).

In June 2005, Google is officially presented Google Maps API which provided combination of user's data with Google's spatial data. Presently, Google Maps has launched a new concept of the map content and interactivity. This concept is based on the AJAX (ASLESON and SCHUTTA, 2005) which implies new way of client/server communication with possibility of adding additional information on the map; the speed and commodity of map manipulation were significantly improved. Furthermore, Google provided free access to the programming code in the form of APIs. The API contains set of predefined routines, classes and functionalities which are available for use by programmers in form of coding in some of scripting programming languages like JavaScript, php or some other.

This cartographic content could be implemented in any web page without any technical requirements. Google Maps API application based on AJAX technology as standard Web service; facilitates users with publication interactive web maps, thus opening new possibilities in relation to the classical analogue maps.

The objective of this work is to provide solution for the easy creation of the interactive web map, with

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base map supplied by Google, where all map elements and additional functionalities should be handled by just one line of code. The solution for the automatic creation of complete web map based on the Google Maps API (the HTML file with CSS styling and Java Script functionality) is the package *plotGoogleMaps* developed in **R** programming language.

The plotGoogleMaps software package

The **R** language is free and open source software under the terms of the GNU General Public License designated for statistical computation and graphics that is similar to the **S** language (BECKER & CHAMBERS, 1984). The main difference is the license, the **R** is free and open source software, and very popular in academic circles at the time. The syntax of the language is similar to **C** programming language. However, it is a fully functional interpreter that permits the creation of functions and calculations within an environment that is defined by a command line window or graphical user interface (GRUNSKY, 2002). The **R** is organized as collection of packages.

The R packaging system has been one of the key factors of the overall success of the R project (R DEVELOPMENT CORE TEAM, 2008). The R contains the base system which allows statistical computation, linear algebra computation, graphics creation and similar. A package is a related set of functions, help files, and data files that have been bundled together. Packages in R are similar to modules in Perl, libraries in C/C++, and classes in Java. The specific packages are not necessary to be installed if it is not a part of the user computing and analyzing interests.

The set of developed packages are especially interesting for the geoscientists. R developers have written the R package *sp* to extend R with classes and methods for spatial data (PEBESMA & BIVAND, 2005). Classes specify a structure and define how spatial data are organised and stored. Methods are instances of functions specialised for a particular data class (BIVAND *et al*., 2008). Another important package used in this research is *rgdal* package. This package uses functions of the Geospatial Data Abstraction Library to read and write GIS data with options to handling coordinate referent system (CRS). There is an option to define CRS or CRS, which might be obtained directly from the data, and an option to perform transformations among different CRSs by using PROJ4 library (http://trac.osgeo.org/proj/) implemented in *rgdal* package.

The *plotGoogleMaps* package (KILIBARDA, 2010) could provide new interactive plot device of the geographic data for web browsers. It also provides a complete map in HTML, whereby HTML becomes the medium for cartographic communication. The package *plotGoogleMaps* uses *sp* object to produce HTML file that contains Google Maps API web interface. It represents the platform for creating inexpensive and effective web maps with high quality of base maps provided by Google. The issues like control of web map interactivity, base map, map elements like scale bars, pan or zoom control could be easily defined as simple function arguments which are implemented in the package. The visualization of additional data could be set in the same way; the package user could set colors, line width, transparency, ect. Attribute data for every single feature is converted in JavaScript InfoWindow object; its activation is available by clicking on the related feature on the map. The combination of different layers in the web map is a possible solution obtained by using *plotGoogleMaps* package.

Case study

Diversely alluvial deposits have been impounded in upper Quaternary, during the younger phase of creating Sava and Danube river valleys. Through the Holocene the deposits of salty-sandy clay – with symbol Q_2ap_1g (CL/CI) have been formed. This clayey complex has been investigated at the New Belgrade (N=44°48', E=20°24') municipality area (territory about eight square kilometers) in the zones which are marked as alluvial sediments in the fundamental geological map of Belgrade.

After analysis the values of geomechanical properties, the statistical elaboration of all parameters (grain size, effective particle size, weight density of water, dry weight density, bulk density, water content, plasticity limits, porosity, void ratio, saturated density, content of organic matter, carbonate content, permeability value, shear strength parameters, compressibility of soil, penetration resistance) has be done (based on 150 to 300 samples). The part of foregoing prospecting of alluvial clays is presented in (RADIĆ, 2007).

Silty-sandy clay covers almost the whole investigated surface and subsurface areas of New Belgrade (where the recent terrain heights are between 75 and 78 m) with average thickness between 2.5 to 5.0 m and with some instance up to 7.0 m. The lower part of the layer has thickness – complex level from 64.0 m to 70.0 m. The upper parts of the complex are silty clay and clay with rich unequal organic materials, hydrokside Fe, Mn and $CaCO_3$, which are unevenly located. Usually, the sediments are covered with artificial sand or clay embankments. The grain-size-distribution is presented by using *plotGoogleMaps* in Figure 1 as pie chart form for every specimen.

Massive texture and granular in structure with intergranular porosity and dark yellow-brown in color. In some locality zone due to the increase in the per-centage of organic material, clay has lance shape

Fig. 1. Google Map based on satellite imagery, with grain size diagrams.

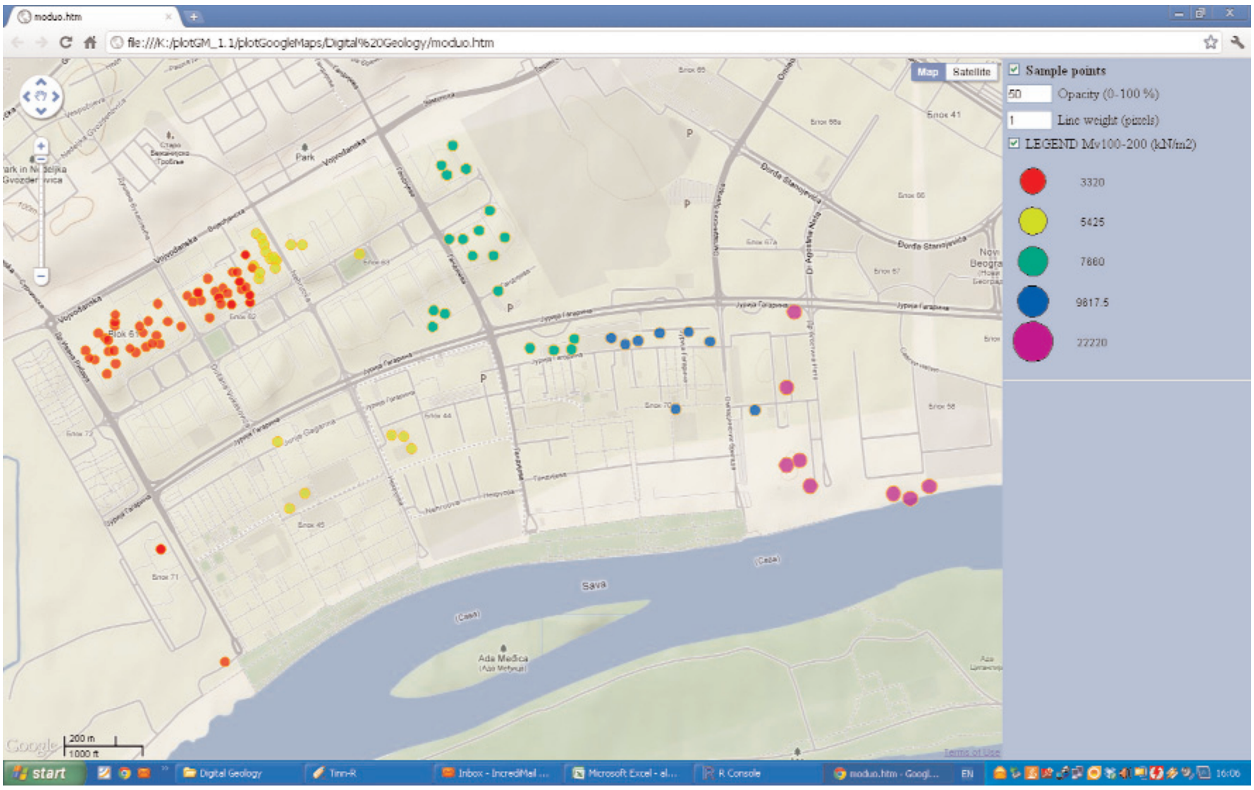

Fig. 2. Google Map based on street maps ,with buble plots indicating Mv inetensity.

and transformed into peats dark grey to grey-black in colour. Present are very soft clay, with high compressi-bility, small cohesion and low to medium plasticity (CL/CI according to USCS), unconsolidated with reduced resistances and deformability characteristics.

The soil has been classified from soft to firm consistency, permanently saturated with low to very low coefficient of permeability (**Kf**) between ≈ 10–5 – 10–7 cm/s. The introspection to **Mv(100–200)** (compressibility of soil in the edometer with vertical axial loadings from 100 to 200 kPa) values is feasible throug the bubble map presentation (Fig. 2) where the bubble size and colour indicates the intensity of these values.

This kind of presentation of the results has multiple advantages over the conventional use of the existing geotechnical documentation at various stages of planning and construction design. Instead of scrolling extensive existing text documents expert's job comes down to the unified visually presented results of conducted measurements. Based on the visual presentation of quantitative and qualitative data, it is easier to make evaluation of the general characteristics of the terrain for planning, designing and constructing purposes.

It is also easy to evaluate the number of necessary surveys and proper selection of samples for further geological exploration of an area. Moreover, new data collected from field and laboratory tests can be easily added to existing measurements and thus easy to update.

Conclusions

The *plotGoogleMaps* presents simple solution for all specialists that are involved in field measurements, whereby sampling locations could be mapped on the Google Maps. It provides good insight on accomplished field work, indicating further steps to obtain comprehensive sampling pattern. That is especially important for spatial data or observations which are in spatial correlation with other environmental factors. Satellite images or basic street maps used as cartographic base of Google Maps are good foundation for designing environmental variables sampling scheme.

Rendering new capabilities of data visualization, it also facilities a new approach in communication between the experts in the internet environment.

Acknowledgements

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17th Meeting of the Association of European Geological Societes	Proceedings	13–16	BELGRADE, 14–18 September 2011

OneGeology – a Project that Changed the Way Geological Maps are Accessed Globally

MARKO KOMAC[1], IAN JACKSON[2], FRANCOIS ROBIDA[3] & JOHN BROOME[4]

Abstract. OneGeology is a worldwide initiative of Geological Survey Organisations (GSO) that emerged in 2006 and has since developed into the most extensive geological project ever. Its simple aim is to make accessible digital global geological map data at small scale (~1:1 million), served by the participating countries. Currently there are more than 130 organisations from 117 countries participating and sharing more than 230 digital geological datasets from around the globe.

Key words: digital geological map, geology, global initiative, geological standards, GeoSciML, geological data portal.

Introduction

OneGeology is a GSO initiative that was launched in the UN International Year of Planet Earth 2008. Its aim was to make public and Internet-accessible the best available geological map data worldwide, initially at a scale of about 1:1 million, to better address the needs of society. Its basic goal is to create dynamic digital geological map data of the world, and it is the geological surveys of the world who are working together to achieve this. Currently there are 117 countries participating, of which 50 (and 6 states/provinces) are also sharing their data (Fig. 1).

Rationale

Modern society is desperately short of natural resources and too often suffer from the devastating impact of natural hazards. Many economies are based on exploiting natural resources and geology lies at the heart of most of today's most pressing environmental issues. Knowing the rocks beneath our feet, understanding their genesis, and to comprehend the deep processes inside the Earth is crucial if not essential to the modern society. Public interest in the environment and in particular climate change, solving the problem of excess CO_2, or future sources of energy, is growing. When considering these issues one understands the importance of geology and the importance of its proper use for the benefit of mankind and the environment we live in. One also appreciates that these challenges do not respect political borders and we need to work together on a global scale to address them.

But what do GSOs do, how can they contribute best to tackle these issues? Geological Surveys and geoscientists around the world have a responsibility to 1) make accessible the best geological map data they possess, 2) work towards consistent standards for data access – schematic and semantic interoperability, and 3) enhance and increase the use and usability of their (geological) data. These basic principles lead to a logical follow-up, the primary objectives of the OneGeology initiative: 1) to make existing geological map data accessible in whatever digital format is available in each country, 2) to transfer know-how to those who need it, adopting an approach that recognises that different nations have differing abilities to participate, and 3) to stimulate a rapid increase in interoperability, achieved through the development and use of the web mark-up language, GeoSciML.

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Fig. 1. OneGeology world coverage (status, July 2011). Light grey – participating countries; Dark grey – countries sharing their data.

Approach or Why and How?

The methods of achieving the goals were in place. The technology (geological mapping, GIS, emerging digital standards, software and hardware, internet capability, long distance knowledge and know-how transfer potential), skills (two decades of intensive development of GIS in geology) and culture (openness and a will to share the knowledge and data) of the majority of the organisations who are involved are now mature enough and in place. An opportunity of the UN International Year of Planet Earth 2008 was taken to get every nation (through its geological survey) to make a commitment to deliver their part of the global geological jigsaw puzzle and to made a practical contribution to doing something global and making a difference in helping to understand our global environment to solve global environmental problems at a global scale. One of the biggest challenges was (and still is) to overcome the variable quality and consistency of digital geological map data. OneGeology aims by bringing it all together and making it easily accessible to help make progress with the issues of availability and consistency.

The OneGeology concept is a completely modern paradigm: it is organised as a distributed model – a dynamic set of geological map data served mostly on a national basis by individual GSO and other bodies (e.g. the polar and marine surveys and research bodies) to a web portal and as such are and will be frequently updated and improved by them and reflect the most up to date data they possess. To achieve its goals the project team consists of experts that possess state of the art skills in geoscience data modelling and information management with worldwide expertise and experience in lithological and stratigraphical classification. The project is closely interlinked with the IUGS Commission for the Management and Application of Geoscience Information (CGI) and in particular its work on a global data model and interchange standard – GeoSciML. Also the Intellectual Property Rights and Data Use issue is being addressed as it is an important aspect of sharing the data.

The overriding principle is that the data should be available for use. and each participant is stimulated to freely share as much data as possible. OneGeology thus benefits many users (different (intra)governmental bodies, agencies and initiatives (EU, UNESCO, EEA, GIN, GEO/GEOSS...), NGO (Geoparks, Young Earth Scientists...), web map service providers and commercial companies , and other users (children – via OneGeology4Kids,.).

The project is a truly multinational and multilateral venture and involves many different stakeholders working together, the global GSO network, International Year of Planet Earth (IYPE), Commission for the Geological Map of the World (CGMW), Commission for the Management and Application of Geoscience Information (CGI), Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP), EuroGeoSurveys, Geoscience Information Consortium (GIC), Geoscience Information in Africa (GIRAF), Group on Earth Observations (GEO), International Lithosphere Program, International Union of Geological Sciences (IUGS), International Steering Committee for Global Mapping (ISCGM), and UNESCO.

Organisational structure

OneGeology is managed by a Steering Group composed of senior representatives from GSOs from seven continents. Observers from the major global geoscience organisations also attend Steering Group meetings. A Secretariat supported by an Operational Management Group coordinates OneGeology on a day to day basis and a Technical Working Group oversees the computing and informatics issues.

Tools and state-of-the-art

As the project's aim is to deliver dynamic digital geological map data for the world. The data is available from a portal via the Internet using the latest computing technology, and exploits GeoSciML. Such an approach allows different types of data and formats to be made available and these are accessible by anyone using the web. There is no requirement for prior technical knowledge to be able to take part in the initiative as methodology and a series of 'user cookbooks' guide participants through the process (from creating digital scans of paper maps if digital GIS data is not available, to 'serving' it on the web via the Portal) have been developed. Data licensing and ownership is also addressed carefully as this an important issue. Map data served to the Internet as part of OneGeology remain in the ownership of the originating GSO or organisation, and ideally are available at no cost.

The primary tool that enables data sharing is GeoSciML (GeoScience Markup Language), a GML (Geography Markup Language) application language for the field of geoscience. It is an XML schema for data exchange over the Internet that incorporates the ability to represent geography (geometries e.g. polygons, lines and points using the OGC's GML specification) as part of the features that are being exchanged. The range of features being offered for exchange are defined by the domain or subject area of geoscience or the geological sciences. GeoSciML accommodates the short-term goal of representing geoscience information associated with geological maps and observations, as well as being extensible in the long-term to other geoscience data. It draws from many geoscience data model efforts, and from these establishes a common suite of feature types based on geological criteria (units, structures, fossils) or artefacts of geological investigations (specimens, sections, measurements). Supporting objects are also considered (timescale, lexicons, etc), so that they can be used as classifiers for the primary objects. GeoSciML is based on W3C, OGC and ultimately ISO international standards for data exchange over the Internet. This language is designed in a format that can be used in a wide variety of desktop programs such as ArcMap, Gaia from Carbontools, and NASA World Wind. GeoSciML is being designed under the umbrella of the IUGS Commission on the Management and Application of Geoscience Information (CGI) and its CGI CGI Interoperability Working Group.

The data shared through OneGeology is available via the OneGeology Portal (http://portal.OneGeology.org), a modern yet simple to use application that enables users to have quick and reliable access to geological data stored at GSO servers worldwide (data is 'served' directly from the provider organisation, or if the GSO is unable to do so, a buddy system is in place to provide the technology necessary to serve the data to the web). The portal can be accessed using a variety of widely available internet browsers. Basic map data in the OneGeology Portal is delivered via WMS (Web Map Service), and a more sophisticated map data and information via WFS (Web Feature Service).This also enables export of the data into other data formats, used in today's GIS community (Gaia (v3.4), ESRI ArcGIS ArcMap (v9.3.1), NASA World Wind (v1.4), Dapple, Google Earth).

Conclusions and the way forward

OneGeology has made impressive progress since its inception in 2006 but to assure its sustainability the initiative is moving to organise itself in a form of independent legal entity. Accelerating the interoperability of geological data will continue to be one of the main goals to pursue in the coming years. The design, build and deployment of information technologies that enable and advance geoscience information management, analysis and delivery will require systems that are interoperable following international agreed standards that are relevant to the geosciences (this is particularly pertinent in Europe where the INSPIRE Directive will mandate all EU nations to comply with such standards). Also widening of participating countries (and involving more geoscientists) continues to be a major challenge and participation of every country remains a goal. As technology progresses and user expectations increase there are numerous challenges arising almost on a daily basis, OneGeology (and geosciences community) is striving to address the most important and to keep the pace with other spatial sciences. However, it is also true that geoscience through OneGeology occasionally leads and steers the wheel of future development in spatial data access. And at the end of the day, better and more frequent usage of the geological (or geological based) data by the decision-makers, expert public, and even wider public is the ultimate goal and OneGeology is the perfect way to achieve it.

Acknowledgements

The authors would like to thank to all the geoscientists, information experts, managers, communications people around the world, without whom OneGeology would still be an idea.

17th Meeting of the Association of European Geological Societes | Abstracts | 17–18 | BELGRADE, 14–18 September 2011

One Geology, One Europe, Many Players: Aspects of Digital Geoscience Information in the 21st Century

KRISTINE ASCH[1]

Digital Information, its management, application and technology poses numerous challenges to the Geoscientists in each county, as the development of new techniques has increased rapidly in the last 10 years. In addition Europe is "growing together" and interoperable information, better: harmonized information across political boundaries becomes more and more important for not only the EC administration, but for industry, consultants, universities and national governmental organizations. Also world-wide cooperation and standards need to be considered, as Europe is not an Island. Furthermore, the geology beneath our feet did remain the same as 200 years ago (mainly), but the scientific and technical methods of its localization, subdivision and determination have changed enormously.

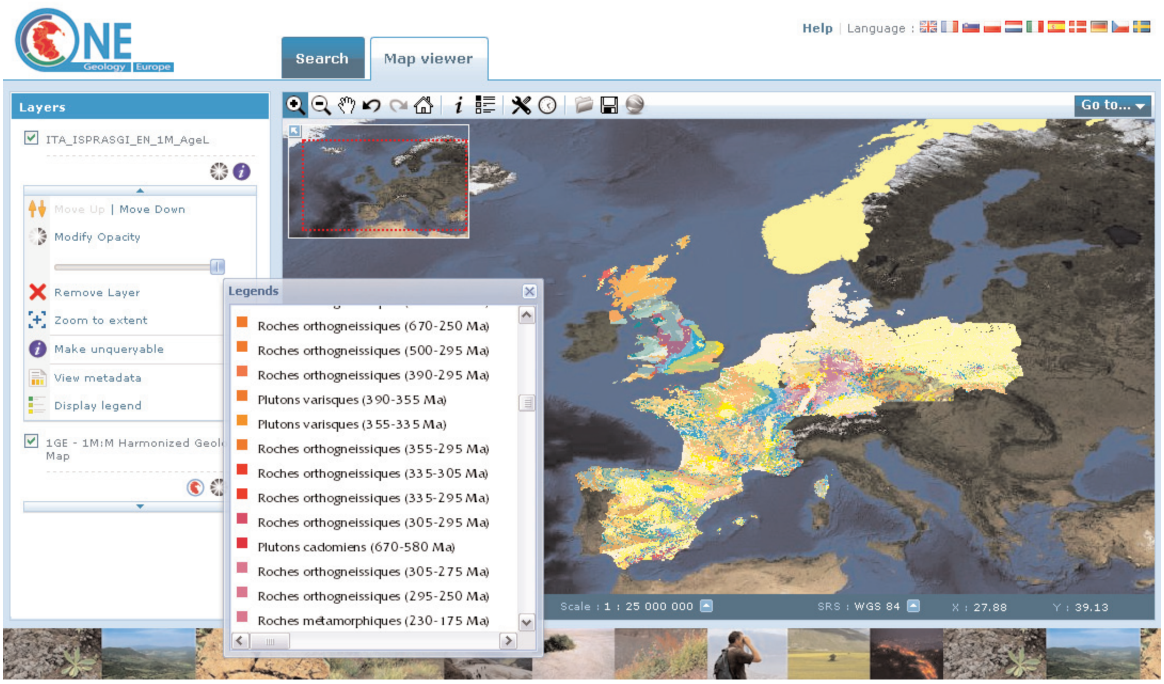

Fig. 1. The Portal of OneGeology-Europe.

The OneGeology-Europe (1G-E) project is an example of how to cope with these challenges (not only) the European Geoscience community is facing. 1 G-E was a two year project funded by the EC which has made geological spatial data held by the Geological Surveys of Europe more easily discoverable, accessible and shareable. The project has accelerated the development and deployment of an international interchange standard for geology, GeoSciML which includes common Europe accepted scientific and geological data specifications including a vocabulary/dictionary. It has also progressed the harmonisation of spatial geological data across data Europe.

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These are enabling the sharing of data both within and outside of the geological community, within Europe - and globally. An interoperable geology spatial dataset at a 1:1 million scale has been made available for more than 20 European nations on a state-of-the-art web map portal. OneGeology-Europe has addressed the legal aspects of data access and the outcome is a single harmonised licence agreed by all data providers allowing free access for all. A multilingual discovery metadata portal has been developed to facilitate access to the data in the portal and much more data residing in geological surveys. Arguably Europe is now leading the world in the development of a multinational geoscience spatial data infrastructure (SDI) and the project is making substantial contribution to the implementation of INSPIRE.

OneGeology-Europe is a practical, nevertheless science-based working foundation which provides the European continent with a better geological base for geoscience projects than any other continent.

The presentation will describe the challenges European Geoscience community is facing and show the achievements of the 1G-E project and how it is providing information which allows both scientists and the wider user base to exploit the richness of the data which exist in the geological institutions across Europe.

17th Meeting of the Association of European Geological Societes	Abstracts	19–19	Belgrade, 14–18 September 2011

First Maps on Internet

Danka Blagojevic[1]

Having in mind the fact that all published sheets BGM (Basic Geologic Map) scale 1:100000 are scanned but not georeferenced, the manuscripts of these sheets in scale 1:25000 exists only in analog form (in the form of prints on paper), as well as accompanying Interpreter for BGM which is also in the form of printed text, made the transformation to a new way to record accurately in digital form.

It is set up a reference system identical to the reference coordinate system by which the territory of Serbia is divided into sheets BGM 1:100000 and sheets on scale 1:25000 (Greenwich division). The reference system is required to eliminate distortions „iron“ publication print on paper, and for their accurate and precise georeferencing and mutual fitting.

Methodology consists of the following: In the framework of the existing fund documentation the preparation and systematization of collected material was made. After that scanning all the available sections BGM 1:100000 and 1:25000 was done, and cropping all out framework content for fitting with adjoining sheet and georeferencing has been done.

Georeferencing is a semi-automatic computerized process by which the rotating and translational and slanted shifts picture elements (pixels) allowing a correction of external geometric distortions of raster objects.

The aim of georeferencing was introducing previously collected and scanned maps in National coordinate system (Gauss-Krueger 3°, datum Hermannskogel, Bessel).

On this occasion a software package ArcGis editor, Georeferncing module and sub module Rectify was used.

In Arc Gis personal base is designed with mesh of polygon entities that consist the border of each section 1:25000. Georeferencing procedure is tantamount to manually find the common points (pixels) on a scanned sheet section and the previously mentioned network, whereby points on nongeoreferencing background (scanned sheet) automatically get value of those same points with the reference section of the network.

But then there is a correction only for external geometrical deformations, which means that the exact coordinates will have only reference points, while the other points in the system have inaccurate coordinates.

This phenomenon is corrected in the process of rectification, which is inseparable from the process georeferencing and that the correct internal geometric distortions.

Type of transformation that is used on this occasion for the rectification is "Nearest Neighbor". This model is geometrically simple algorithm that assigns each pixel value (X, Y) the nearest pixel in the system.

Referencing were used only for points, since the maps are being used to reference without coordinates division. There is the possibility of drawing the grid on each section, before scanning, with the translation start of the network, but it is technically a very time-consuming work, which have requested additional time and participants in work.

The main result achieved in this project was that the all maps BGM and Interpreters, which, until now have been exclusively printed on paper (and therefore subject to wear and destruction) have become permanently usable for any future project of geological research, which brings real economic savings.The other advantage lies in the fact that map was done this way can be directly loaded into GeolISS.

At the end, as all the cards are introduced in the National reference coordinate system, they can be used in many other production and research fields: Energy and mining, geology through the basics researches, concession documentation, planning, research bearing minerals, spatial planning and infrastructure; environmental protection, water management. etc.

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Mapping of the Quaternary Deposits of the Eastern Part of the Pannonian Basin (Romanian Section) Based on the Interpretation of the Leveling and on the Paleogeographical Reconstructions

MIRCEA ȚICLEANU[1], ADRINA ION[1], RADU NICOLESCU[1] & GHEUCA ION[1]

Attempts of interpretation and cartographic recovery of the morphological details of the eastern rim of the Pannonian Depression (including those contained in the satellite images), finally we have conducted to the morphological analysis based on the classic topographic maps. These attempts aimed mainly to identify the former Quaternary shores of the Pannonian Lake, under the perspective of some Romanian geographers that accept the successive regression of these shorelines during the Pleistocene. This analysis proved to be optimal using the topographic maps with 1:25,000 scale. Through them was possible the achievement of some pale geographic sketches which may correspond to the Lower Holocene and to the some final moments of the Pleistocene. The special value of these maps was due to the period in which they were made: before the great draining campaigns started after 1960 in the Pannonian area. Therefore contain many hydrographical details which disappeared from the latest maps. The paleogeographical reconstructions were based mainly on the marshy areas which reflects the presence in the past of some lakes. These are in turn the relict lakes of larger lacustrine areas. These reconstructions were kept in view the possible ancient shorelines, sometimes very well marked morphological, but particularly were concerned the shore suspected to be placed at +150, +100 and +85 m elevation. Of these the shoreline approximated at about +100 m elevation could reflect the maintaining till the end of the Pleistocene of a lacustrine area to the south-east part of the Pannonian Depression (already non-endoreic), lacustrine area that we called in previous studies "Relict Pannonian Lake". It would be the direct successor of the lake imagined in the same area by the Serbian geologists (KRSTIĆ *et al.*, 2006) about 250 ky ago. At about +85 m elevation might place the shoreline of the last lacustrine area of the Pannonian Basin. This could characterize from paleogeographical point of view the Lower Holocene and should precede the configuration of the actual hydrographical network of the Pannonian Depression. An older shore, at about +150 m elevation, could be earlier when Heinrich event 4 (~40,000 years ago). This shore seems to be well defined morphologically in the area of the Mecsek Massif (Hungary) and also could explain the atypical mega-site from Cornesti, north of Timisoara. Here some walls could reflect the development of the settlement in relation to the shoreline at about +150 m elevation and another series of walls could correspond to the evolution of this settlement in connection with a new and provisional shoreline at about +125 m elevation. Otherwise all these paleogeographical images can be confronted successfully with the absolute age of the archaeological sites of entire Pannonian area and on the other side can provide a very good base for the possible correlations with the paleogeographical data present in some fundamental myths of the mankind. Finally we remark that the complete interpretation of the Romanian sector will require the need of the new paleogeographical images for the entire Pannonian Depression, at the same level of detail.

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Using ArcGIS for Landslide "Umka" 3D Visualization

UROŠ ĐURIĆ[1], BILJANA ABOLMASOV[1], RADMILA PAVLOVIĆ[1] & BRANISLAV TRIVIĆ[1]

Abstract. The recent developments in earth sciences software are mostly related to the extension allowing graphical representations of volumes and geological bodies. In this paper, we present a tool for 3D visualization of landslide body using only ArcGIS© software and its 3rd party extensions. The model was built using existing geological surveys, DEMs, borehole logs and site investigation data. The case study chosen to illustrate the method is the Umka landslide (Belgrade, Serbia), an area with relatively simple geology, but with deep seated landslide and with block-translational sliding mechanism.

Key words: landslide, 3D modeling, visualization, ArcGIS, DEM.

Introduction

Over the past two decades a series of new 3D modeling technologies identified as GIS system software have been developed to subsurface characterization, modeling and visualization needs (BONHAM-CARTER, 1994; BURROUGH & MCDONNELL, 1998). Rapid development of computer hardware and software, data base design concepts and expanded information transfer across Internet encourage geoscientist for easer using sophisticated 3D modeling and decision-support system technologies. TURNER (2006) discussed about challenges and trends for geological modeling and visualization. HACK *et al*. (2006) illustrated a number of three and more dimensional modeling examples in geo-engineering. CULSHAW *et al*. (2006) explained a needs for provisioning of digital spatial data for engineering geologist with examples of using those data for 3D modeling and creating fence diagram of Swansea/Port Talbot area. A modern approach to geological surveying and its relevance in the urban environment with examples of the 3D geology of London and the Thames Gateway was presented by FORD *et al*. (2008).

In this paper we presented possibilities of using ArcGIS© for 3D visualization of landslide. A 3D perspective creates a realistic simulation of a project, environment, or critical situation to help a variety of clients plan and prepare for and proactively mitigate potential issues. For modeling and visualization of landslide, we have used 3D Analyst© module and its extension ArcScene©. Module provides advanced visualization, analysis, and surface generation tools. Using this module, we can view large sets of data in three dimensions from multiple viewpoints, query a surface, and create a realistic perspective image that drapes raster and vector data over a surface. ArcScene© allows earth scientists to create both traditional and unconventional three-dimensional displays from real-world data. Figures created from elevation and depth values are commonly used to reveal the earth's surface and expose its interior. Alternatively, other measures can represent a third dimension of earth-scientific data. For Case Study, we selected landslide "Umka", most famous, biggest and deepest landslide in Belgrade. Object was to generate Digital elevation models (DEM) of landslide surface, geological units and slip surface, then their visualization as geological block diagram with cross sections, inside ArcGIS software.

Materials and methods

Case study

Large active landslide "Umka" is formed in Neogene marly clay sediments and takes up surface of 1.8 km^2 (Fig. 1, left). Pannonian sediments, silty - clayey massive soft rocks, have dominant role in geologic composition of terrain. Those sediments are: grey marls

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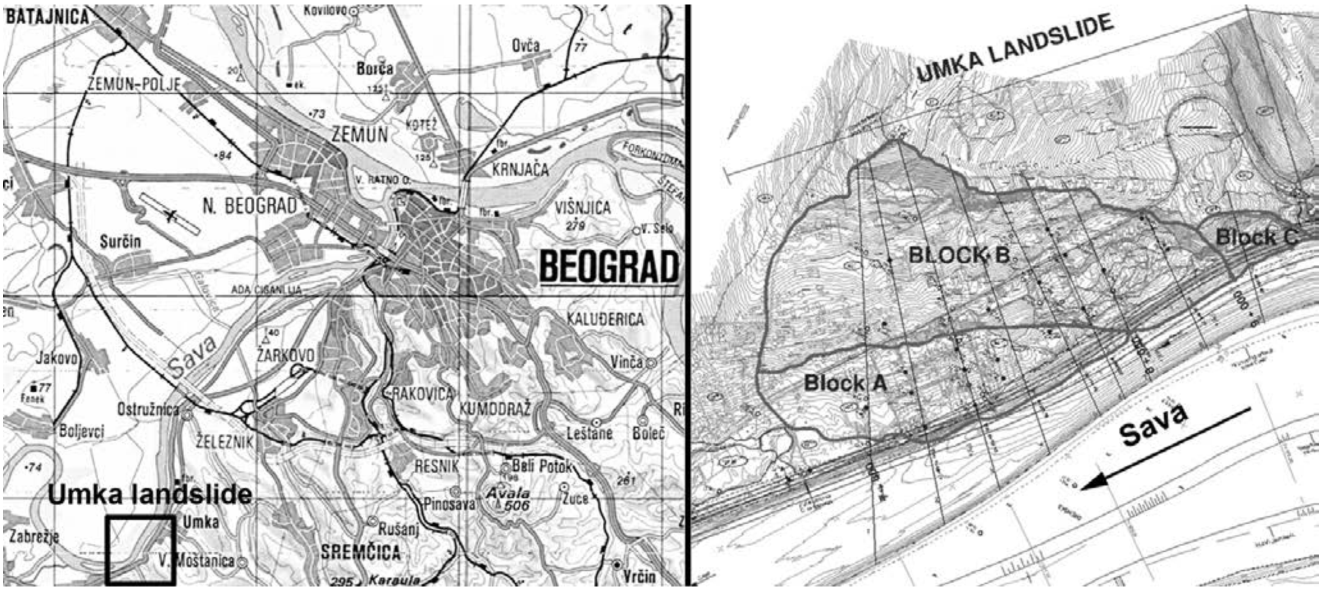

Fig. 1. Position of landslide Umka within Belgrade area (left), Singleouted blocks inside landslide body (right) (The Highway Institute d.o.o., Belgrade, 2005).

($M_3{}^2L$) more than 200 m thick and their upper part formed of weathered marly clays ($M_3{}^2GL$) 10–25 m thick. Colluvial deposits (ko) emerged from the gravitational motion of rock masses down the slopes. Material set in motion in the course of time changed its: primary structure, water-borne, and physical mechanical properties. As a rule, colluvium thickness is predisposed by border between more plastic weathered marly clays and hard grey marls, where is obviously deepest sliding surface. Physical mechanical properties of the colluvium vary in a wide range due to the complexity of its composition and susceptibility to external impacts.

This landslide is fan-shaped, with the length along the slope of 900 m, toe width of 1450 m, area of 180 hectares, average depth of 14 m, 7000000 m^3 volume and average terrain gradient of 9°. Upstream landslide part is surrounding the steep frontal scar with the height from 5 to 25 m, whereas downstream landslide part doesn't have a pronounced leap.

The last observations have been made on installed 29 inclinometers, 20 piezometers and 2 exploratory shafts during 2004–2005 yr. According to morphology and sliding mechanism, three blocks have been singled out: A, B, & C (Fig. 1, right).

The length of blocks along the river is 850, 350 and 250 m. During 2005–2006 yr., due to extensive displacements, majority of inclinometers were discontinued. The deepest displacements were recorded in block A - 26 m (Fig. 2), while in blocks B&C landslide depth was 5 to 15 m. Displacements as a rule have translational pattern along slightly inclined parting planes. Displacement speed is increasing during the diminution of Sava river level (GROUP OF AUTHORS, 2005).

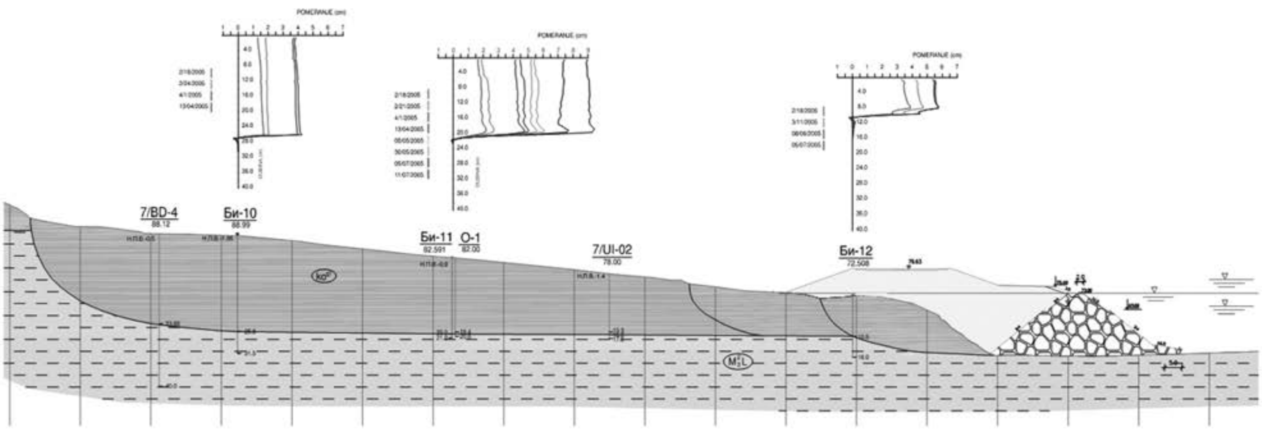

Fig. 2. „Umka“ landslide cross-section, block A (The Highway Institute d.o.o., Belgrade, 2005).

Performing of block diagram and cross sections was completely done inside ArcGIS software. For any 3D landslide interpretation, essential data is derived from borehole logs. In first place, it is crucial to analyze borehole and interpret borehole log. In this paper, we have analyzed data from 28 borehole logs. Used data was obtained from The Highway Institute d.o.o., Belgrade.

Preparing data for modeling landslide

A continuous geological surface can be generated from the formation picks of each landslide borehole using interpolation techniques. A variety of interpolation techniques is available, including using expert's experience: Hand Contouring, Triangular Irregular Network (TIN), Inverse Distance Weighted averaging (IDW), Spline, Trend/Polynomial, Natural Neighbors, Hydrological Correct Interpolation and Kriging.

First, we created table with borehole coordinate and numbers, and then we added surface elevation slip surface elevation, and marl surface elevation fields. Surface elevation and marl elevation was obtained from borehole logs and slip surface elevation was calculated as borehole surface elevation minus depth to slip surface. ESRI point shapefile was created by obtained and calculated data. Example of attribute fields (with first two boreholes) in that shapefile is shown on table 1.

Table 1. Example of attribute fields in borehole point shape file.

FID	Shape	Borh_Id	Surf_elev	Slip_Surf_el	Marl_Surf
0	Point	Bi-24	72,66	68,21	63,11
1	Point	Bi-27	70,2	67,19	63,14

Then, using ArcGIS IDW interpolation tool, we created three DEMs, one for surface (z field was surf_elev), one for slip surface (z field was slip_surf_elev) and one for marl surface (z field Marl_Surf). Surface DEM was cropped by extent of research area and slip surface DEM was cropped by polygon shape that was created by landslide border, which was obtained by previous research (Djurić, 2011).

Creating landslide block diagram

We may say that Geologists have a "passion" for illustratively dissecting the land to create block diagrams. These drawings show a perspective, cutaway view of surface and subsurface geologic features. Using ArcScene, it is possible to generate very creative landslide block diagrams. Essential data for creating block diagrams are DEMs and landslide border polygon shapefile as described by Kennely (2003).

After we loaded all surface DEMs to ArcScene project, the properties for each data layer in an ArcScene project was set to create geologic block diagrams or the other types of three-dimensional data displays discussed in this article. In the Layer Properties dialog box, the Base Heights and Extrusion tabs were used to specify the display of three-dimensional data for all surfaces.

Creating cross sections

After the geological surfaces are generated, cross-sections can be made in any direction. This involves extracting the picks for each surface along the cross-section line. This was done by using ArcMap and 3rd party extension XTools©.

Steps for creating each surface picks was defined by Mei (2008):

- Loading surface layer in ArcMap
- Drawing line in preferred cross section direction using Drawing tool
- Converting graphic line to line feature using XTools Feature Conversions | Convert Graphics to Shapes
- Converting line shape feature to points, using XTools Point to Feature Conversions | Convert Features to Points (with Equidistant points set to 1000)
- Converting feature points to 3D using ArcGIS Convert | Features to 3D, and creating cross_points_surface.shp as output file.
- Adding X, Y and Z values cross_points_surface.shp from surface DEM, using XTools Table Operations | Add X, Y, Z Coordinates tool.
- Repeating steps 5&6 for slip surface and marl surface DEMs
- Joining all surface generated cross_points_X.shp files in one shape file named cross_points_all_picks.shp

Next step was loading cross_points_all_picks.shp into ArcScene, and copying that layer three times inside ArcScene (for each surface). Inside Layer Properties dialog box, the Base Heights and Extrusion tabs were used to specify the display of three-dimensional data for cross section. Process was repeated for second cross section that was normally positioned compared to first cross section.

For creating a 3D display of a geological solid, it was necessary to construct its top and bottom surfaces and the side boundary surface. The top and bottom surfaces of the solid was created by clipping the top and bottom geological surfaces using the extent of the solid; the side boundary surface was created and displayed in the same way as a cross-sections.

Figures 3 shows generated landslide block diagram with surfaces and Figure 4 shows generated landslide cross-sections in form of block diagram, using methods mentioned in this paper.

N represent an attribute. 2D systems represent the world as a collection of data layers, and all conventional GIS, including ArcGIS, use this data model as its base. 2,5D data usually comes in X, Y & Z format, where X & Y are spatial coordinates and Z is sampled attribute representing relative height/elevation (e.g.

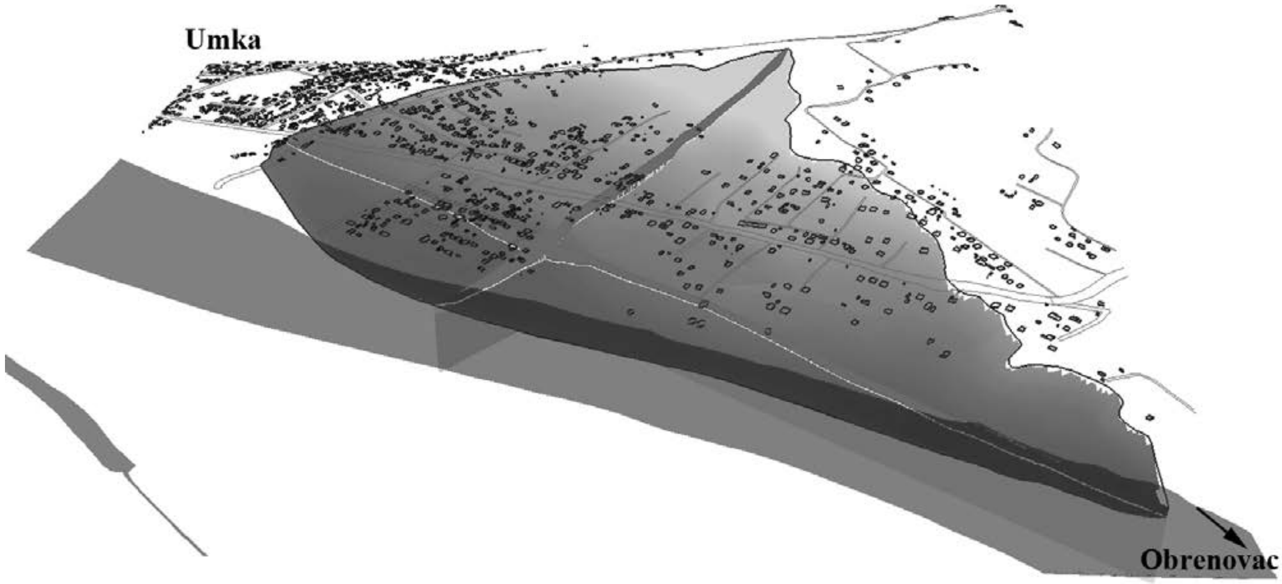

Fig. 3. „Umka"Landslide block diagram with generated surfaces.

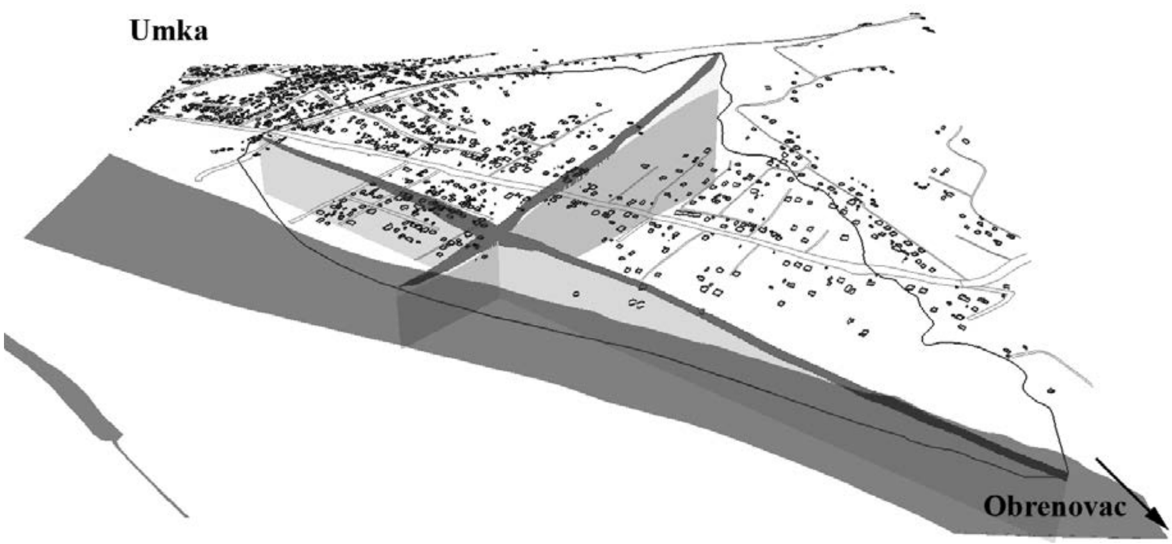

Fig. 4. "Umka"Landslide cross-sections in form of block diagram.

Results and discussion

Strictly speaking, using GIS terminology, the 3D visualization demonstrated in this paper actually represents 2.5D visualization, not a true 3D presentation. In GIS models, 2D data usually comes in X, Y & N form, where X and Y represent spatial coordinates and

DEM). DEM is actually matrix of elevations that are considered as 2.5D data. However, they are usually plotted as a DEM surface to be visualized in a 3D perspective drawing. Most important thing in geological modeling is that is not always necessary for surface to be an elevation, it could be: lithological facies, porosity, permeability or some other geological parameter that could be plotted as surface. 3D data usually is represented with X, Y, Z & N, where X, Y & Z are spatial coordinates and N are is an attribute.

3D heterogeneity within a geological unit can be presented only in a true 3D presentation using 3D data. In a 2.5D representation, it is impossible to represent different attributes at two different elevations at the same 2D point (which is a true 3D presentation) and maintain a 2D data model. As a result, the three dimensional heterogeneity within a geological unit cannot be modeled and displayed in ArcGIS. This limits the full use of borehole log data that contain geological attributes measured with x, y and z coordinates MEI (2008).

Conclusion

The figures accompanying this article are just a few examples of how geologist data can be displayed in conditionally 3D with ArcScene. As demonstrated by the surface and subsurface landslide examples, z-values can be derived from elevation values. Alternatively, the z-coordinate can be derived from any measured value. These values can vary continuously and create a surface over which additional data may be draped or can be discrete and cause abrupt changes in z-values at boundaries. The flexibility of assigning z-values from various sources makes ArcScene a powerful tool for anyone who needs to show the quantitative variations in 2,5D data.

Main advantages in this approach of landslide modeling are:

- Analyzing terrain data to determine what can be seen from different observation points,
- Modeling subsurface features such as wells, groundwater, slip surfaces, networks and facilities that could be affected by landslide
- Determining optimum facility placement or resource location for geological investigations,
- Sharing 3D views, animations, and analyses with stakeholders and decision makers,
- Geologist can examine subsurface structures and calculate volumes

3D geological models are also used to complete valuable calculations for use in geotechnics. Many times, geotechnics engineers are unable to calculate precise volume of landslide body, which is very important for 3D slope stability analysis, and therefore it is important to have software that can calculate these variables. With surface layers performed by methods mentioned in this paper, it is easy to calculate exact volume of landslide, converting surface and slip surface to TINs and then using Tin difference tool inside ArcGIS© for precise volume calculation.

Acknowledgments

The authors wish to acknowledge to Mr BRANKO JELISAVAC, MSc. Geol., The Highway Institute, d.o.o, Belgrade, for providing us materials, papers and projects necessary for making landslide model described in this paper. The research was supported by the Ministry of Science and Technology of the Republic of Serbia Project TR 36009.

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GIS Supported Bauxite Deposit Geological Data as a Tool For Mining Operations Design

Aleksandar Milutinović[1], Aleksandar Ganić[1], Meri Ganić[1] & Igor Miljanović[1]

Abstract. Terrain geological prospecting and data acquisition on mineral-raw material deposits are common activities enabling the definition of the spatial position and geometrisation of the mineral-raw material deposit. This information is serving as a ground for planning and design of mining operations, aiming for the exploitation of the mineral-raw material. New standards in observations of geological data calls for creation of a GIS, in order for complex interpretation, visualisation, cartographic production, geocommunication and other deposit-related activities to be raised to the next level in comparison to the classic approach.

The paper presents a GIS proposal for the geological data of the "Podbraćan" bauxite deposit near Milići. GIS support to the results of geological exploration, analysis and geometrisation of the "Podbraćan" deposit would have a great importance for further research during the exploitation, ensure the foundation for mining projects, and enable higher recovery of the mineral-raw material.

Key words: mineral-raw material, geological data, GIS, mining operations.

Exploration and description of bauxite deposit

"Podbraćan" deposit, covering the area of over 523,000sqm is so far the largest known bauxite deposit in this bauxite-bearing region. By its structure it is red bauxite grade one deposit. The "Podbraćan" deposit was explored with 209 exploratory geological drillholes, with overall length at 21,200m and mining activities conducted at the mine exploitation field. The drillholes were drilled in a square shaped network 50×100 m. A total of 55 drillholes were drilled through red bauxites, with overall length of 917.9m.

Beside the exploration drillhole data, other data from the "Podbraćan" Open pit Mine were used in order for an accurate definition of the ore body contour. The contour of the bauxite ore body was defined on the basis of longitudinal and transversal profiles, constructed along the profile lines alongside drillholes. In the process, an extrapolation was utilized up to the half of the allowed distance between the exploration operations for a certain reserve category.

The ore body is predominantly covered by neogene sediments, reaching locally up to 300 m in depth, but only partially breaking out to the surface. Before the neogene sediments were settled, the deposit was uncovered in the northern region of the ore body. The region is largely eroded, so today it is only the erosion residue. The ore body is irregularly shaped, layered, and mildly waved to south and southeast, under the inclination of 20°. Ore body thickness varies from only few decimeters up to 37 m, with medium thickness at 13.44 m. Central deposit area is the thickest (data from the geologic documentation of the SC „Boksit" Milići bauxite Mine, Republic of Srpska).

Deposit mining

The bauxite deposit "Podbraćan" is mined by opencast mining for a longer tima. According to the Main Mining Project of the Open pit Mine "Podbraćan", increase of pit depth up to K=+410 m is planned. Developing the Open Pit Mine of "Podbraćan" deposit according to this Project will result in excavation of bauxite ore reserves in the middle and north area up to the K=+410 m, while more than million tons of ore reserves will remain above this level in the southern area of the deposit. The analysis made in the Case Study on the possibility of widening the Open

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Pit Mine area, determined that opencast mining of this area of the deposit is not justifiable in economic sense. Following the above, bauxite ore reserves in the southern area of the "Podbraćan" deposit above the K=+420 m will be mined by underground mining, which is the first phase of the underground operations. In the second phase, deeper area of the deposit will be mined up to the elevation of K=+ 338m.

Regarding the future underground mining operations, and having in mind the geological complexity of the deposit (tectonic disturbances), spatial disposition and deposit geometry, it is justifiable to employ GIS for the purpose of processing, analysis, visualization and interpretation of the geological data for this area of the deposit, required for underground mining projects, MCCOY (2004).

Justification of geological data GIS formation

Creating the GIS demands investing in certain material and human resources hence its utilization must be justified for certain activities, no matter if the topic is mining, geology or some other scientific or technical discipline. Justification of creation of GIS on the "Podbraćan" deposit lies in:

– Need for provision of high quality bauxite from the remaining areas of the deposit, predisposed for the underground mining;
– Development of the technical and technological solutions for further mining;
– Ensuring bauxite production continuity, according to the development program of SC "Bauxite";
– Adjusting the opencast mining used so far to the underground mining;
– Flexible and contemporary technical and technological solution for further bauxite ore mining, with as few losses as possible;
– Economically justified bauxite production in real time, according to the reserves determined, way of mining and market ore price.

GIS creation

The proposal to create GIS of the "Podbraćan" deposit is based on ArcGIS software, with implemented data of the geological exploration, exploratory drillholes, geological plans and maps, exploitation field plan and the Open Pit Mine plan as alphanumeric and graphical databases, MILUTINOVIĆ (2007). Based on the geological databases, the visualisation of the deposit that fit in a spatial and geometry sense into the present condition of the Mine's exploitation area, STRES (2001).

The existing alphanumeric data of the geological exploration performed so far were presented in tables classified according to the topic, containing relevant data on geological exploratory drillholes, bauxite contour, lithological composition, overlying bed and the shelf of the deposit, geological profiles, SiO_2 contents and tectonics. The tables were created in Microsoft Excel, and later integrated into the Microsoft Access, system relational database management for the purpose of their implementation into ArcGIS, and after that into the ArcCatalog module, VIENNEAU *et al.* (2004), with two databases of alphanumeric data (Personal Geodatabase) created, entitled "BAUXITE" and "Geological drillholes" (Figures 1 and 2).

The existing graphical data were presented as plans, maps and geological profiles, developed in AutoCAD. Direct import of graphical supplements into the Arc Catalog module and graphical databases was accomplished due to compatibility of ArcGIS and CAD applications (Figures 1 and 3).

Data in the alphanumeric and graphical data database within Arc Catalog can be searched according to the given criteria, PERENCSIK *et al.* (2004), exported into another database, geocode, etc. Figure 2 shows the table with geological drillhole data, while Figure 3 shows the geotectonics map of the spatial disposition of bauxite deposit with alumina concentrations, as well as one of the geological profiles.

After creating and reviewing the database in ArcCatalog module, the next phase in developing geological data GIS is to create database in ArcMap module, where the alphanumeric data are connected with graphical entities, queries created, data updated, geocoding completed, data conversion, printing, etc. These activities of ArcMap are just a portion of possibilities, featured by a large number of tools in the ArcToolbox command menu.

Data are imported from ArcCatalog into the ArcMap module. ArcCatalog contains the datafiles sorted by titles given during the database creation in ArcCatalog. Figure 4 shows the alphanumeric data file in ArcMap, and the mining-geological plan containing infrastructure objects located at the exploitation field of the Mine, Open pit Mine benches, previous underground mining operations, isolines of the bauxite deposit, geological drillholes, etc.

By appropriate ArcMap commands (Join, Join Data), a selection of the alphanumeric table and the graphical entity to be merged is made. In GIS systems with relational database structure, it is necessary to connect attribute with spatial databases in manual data input. This is accomplished by common identificators. During the data input, certain identifier is added to the graphical entity. By selecting the graphical view (Select Features), selection of table attributes is made automatically and vice versa. In this manner, GIS user is conducting search easier and spending less time to accustom oneself, i.e. visualise the connection established between the alphanumeric and graphical data, despite huge amount of data (without the need for removing certain layers).

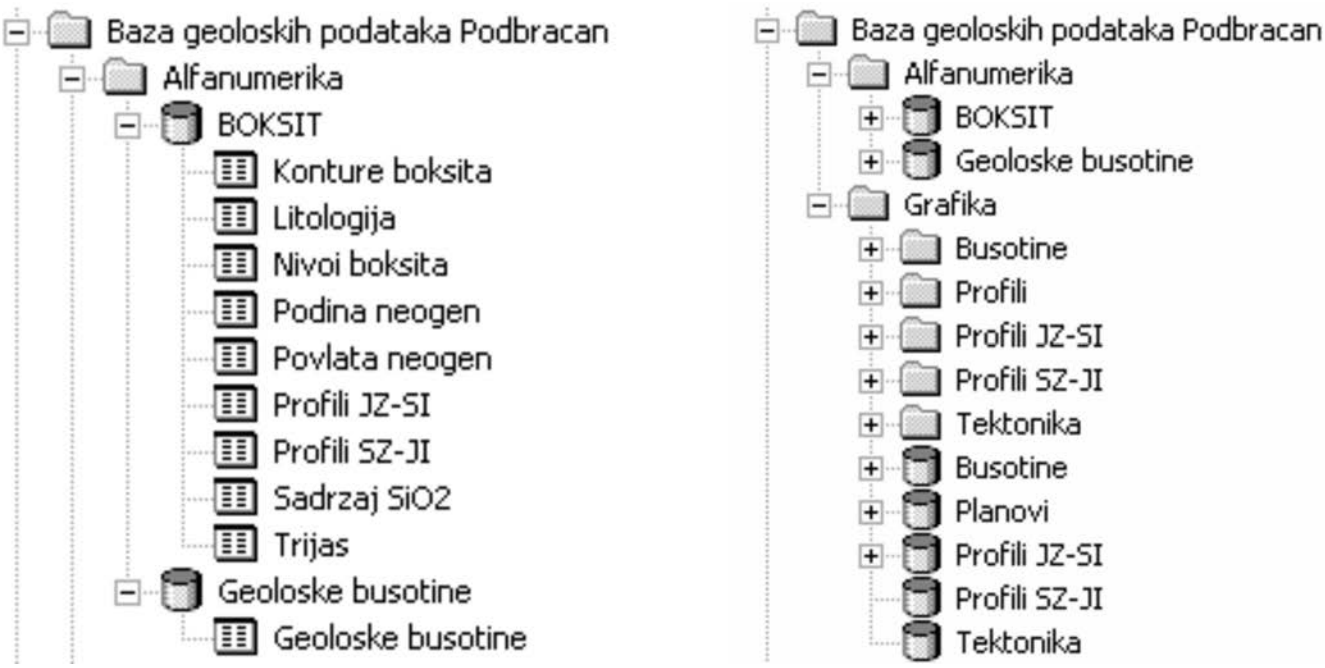

Fig. 1. Creating the alphanumeric and graphical database in Arc Catalog.

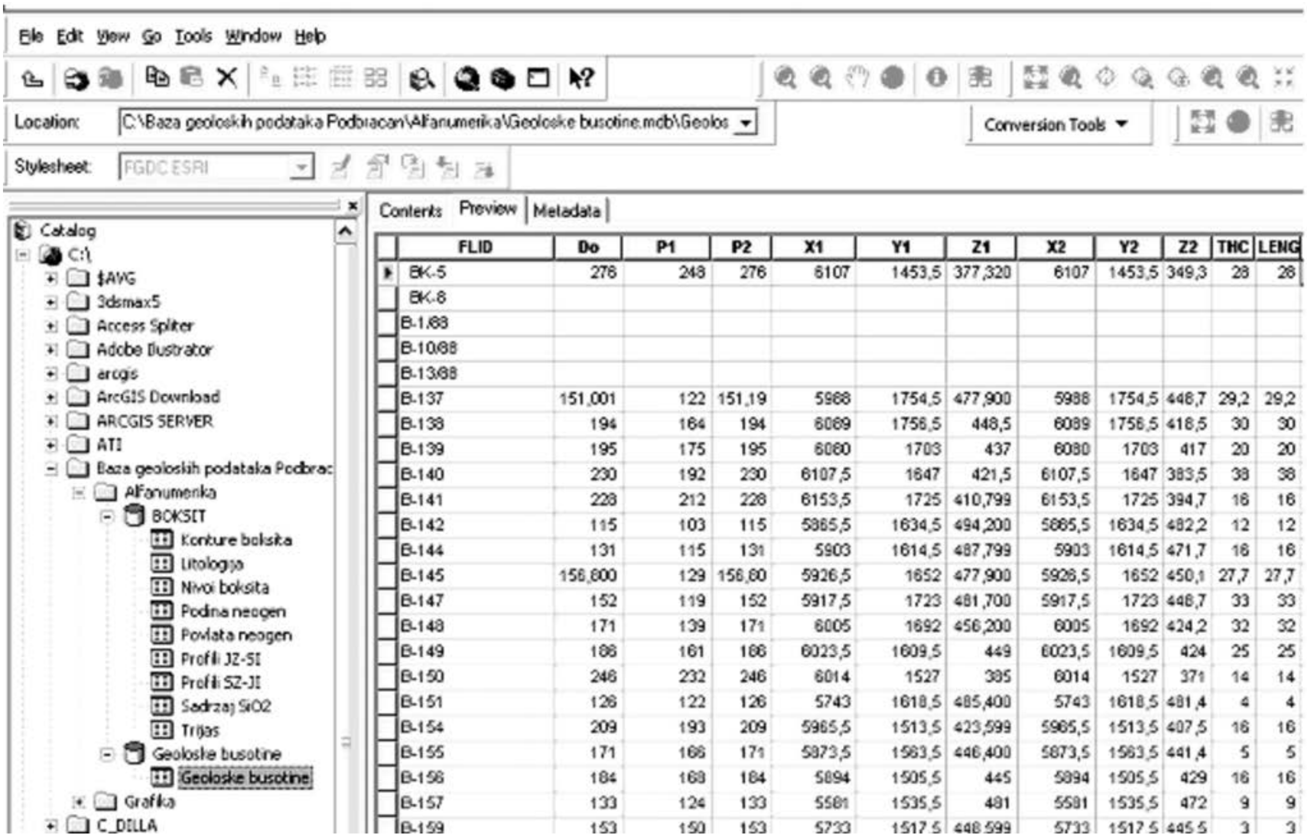

Fig. 2. A review of alphanumeric database.

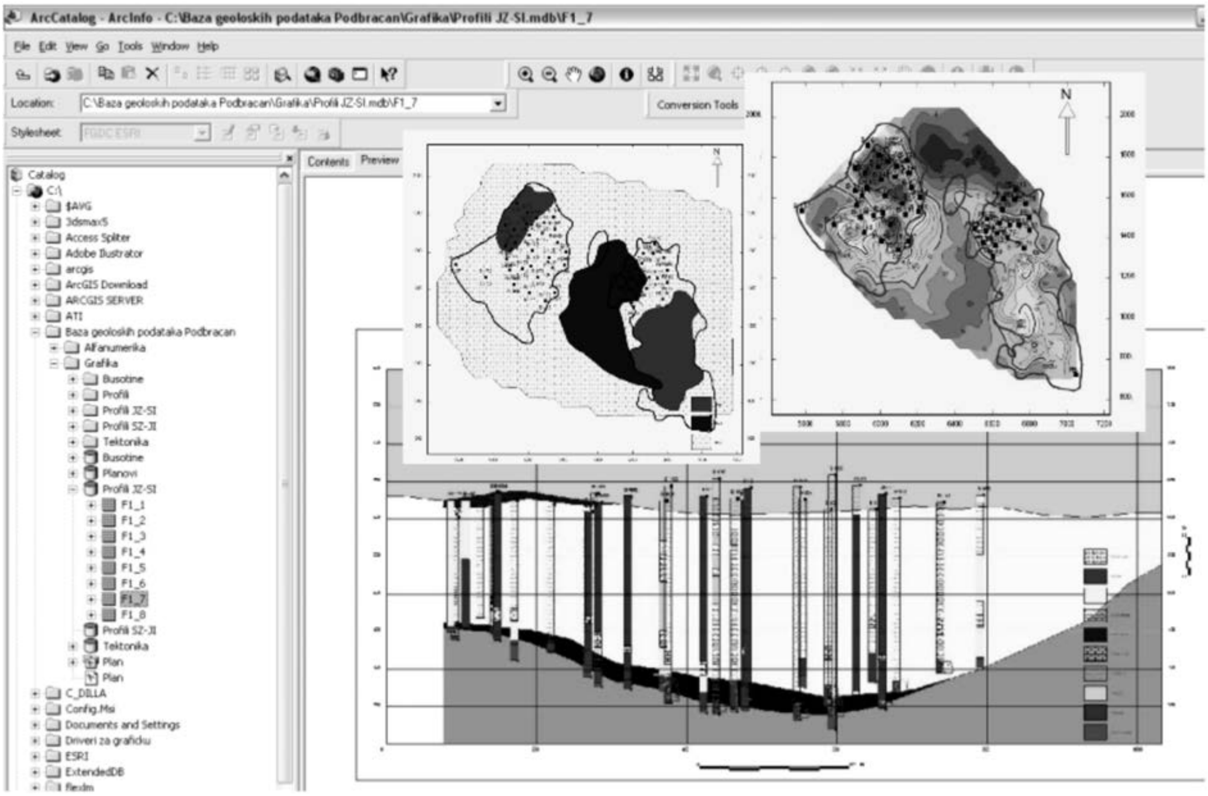

Fig. 3. A review of graphical database supplement.

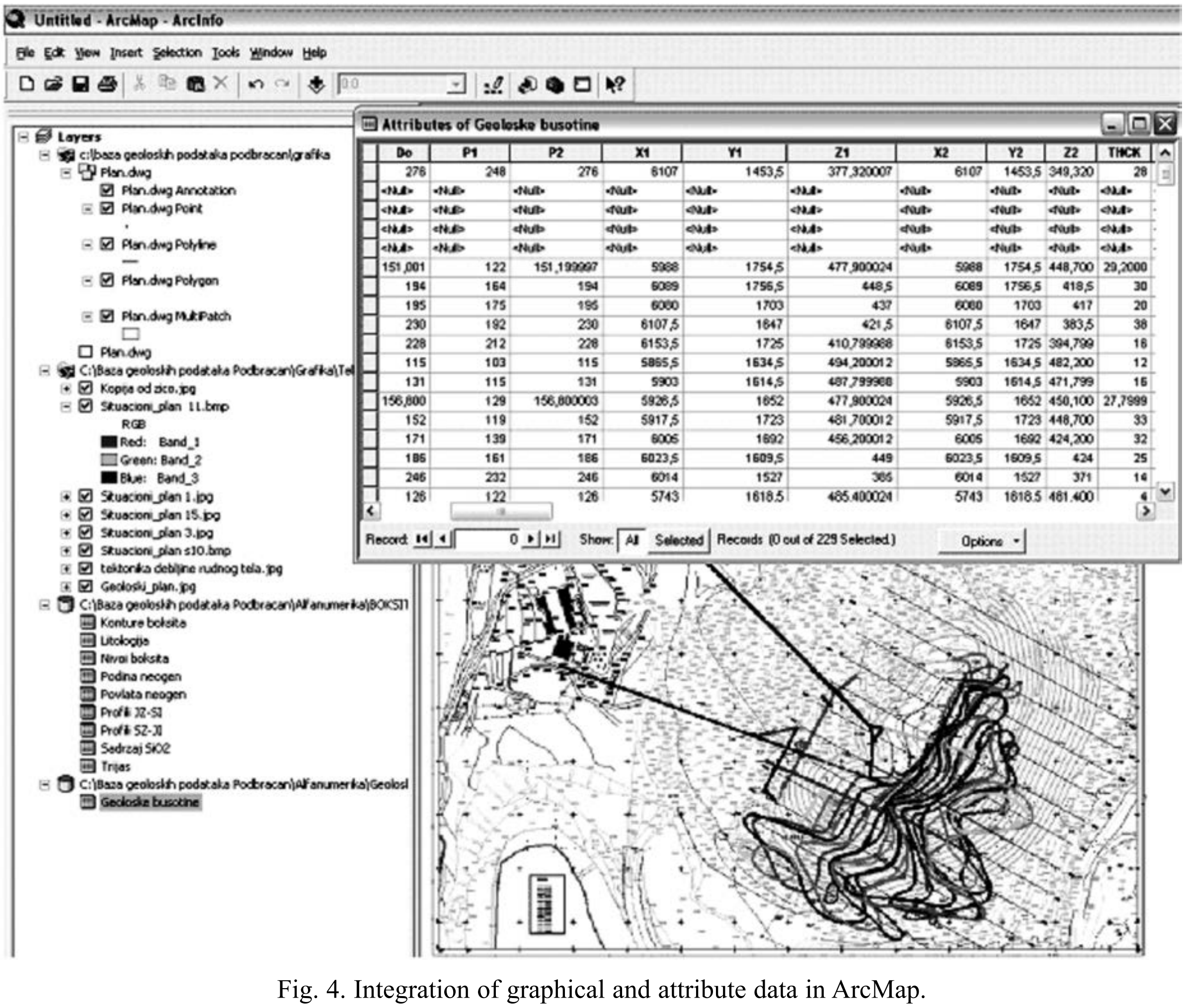

Fig. 4. Integration of graphical and attribute data in ArcMap.

Based on the spatial geological data on the deposit, it is necessary to develop a 3D model of the ore body (Figure 5a), with the aim of spatial visualization, PRICE (1999). In model development, georeferencing should be performed (Figure 5b), in order to achieve spatial fit with the other, previously georeferenced spatial entities (exploitation field of the Mine, Open Pit Mine, geological drillholes, etc.).

data. More often, during the query creation, it is necessary to employ creativity with the aim of easier and simpler access to the database search, together with fulfilling certain procedural principles and in anticipation of a certain answer.

The system proposed should be open for the input of new data, originated from the future drillholes in underground mining rooms. This will call for certain

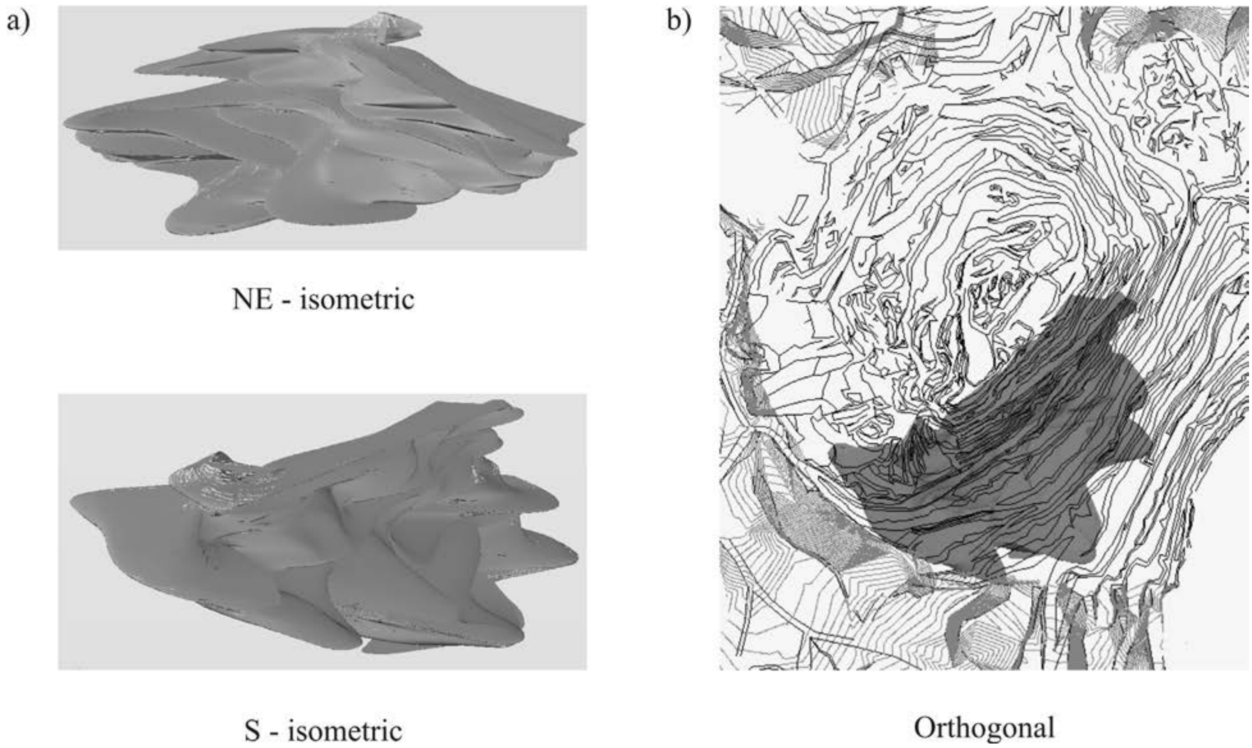

Fig. 5. a) 3D model of bauxite deposit; b) Georeferenced 3D deposit model.

The last phase in creating the geological data GIS are the activities in the ArcScene module where the alphanumeric data from the already created database are inserted, together with the spatial drawings, i.e. 3D models (Figure 6). Similar to ArcMap, it is necessary to perform coding and linking the graphical and attribute spatial data. Upon completing this task, the virtual presentation of the deposit, ensures for a more quality interpretation of the deposit and the area surrounding the deposit by using a line of ArcScene movement tools (Navigate, Pan, Fly, etc.), with the aim of high quality analysis and making correct design decisions concerning mining.

With the aim of achieving frequent system utilization, obtaining updated data, and fast and easy database search, it is not sufficient or rational to review only the geological data. Software tools like those of ArcGIS enable the possibility for making all types of queries, conditions and criteria in searching the database, i.e. setting the demands for obtaining certain

adjustments, both alphanumerical and graphical with respects to the deposit, its geometry, spatial position, quantification, tectonic disturbances, hydrogeological occurrences, etc.

Conclusion

The proposed approach in geological data GIS development, methodology defined and operational phases in creation and in particular its contents points out the justification in creating and utilizing the geological data GIS for the purposes of Mining projects. From the practical viewpoint, GIS application is expected to improve the effects of geological and mining design services, thus improving the quality and effects of production, and resulting in more economical mining. Therefore, geological data GIS is suitable for utilization in mines from several viewpoints:

– Increasing the quality of the geological and

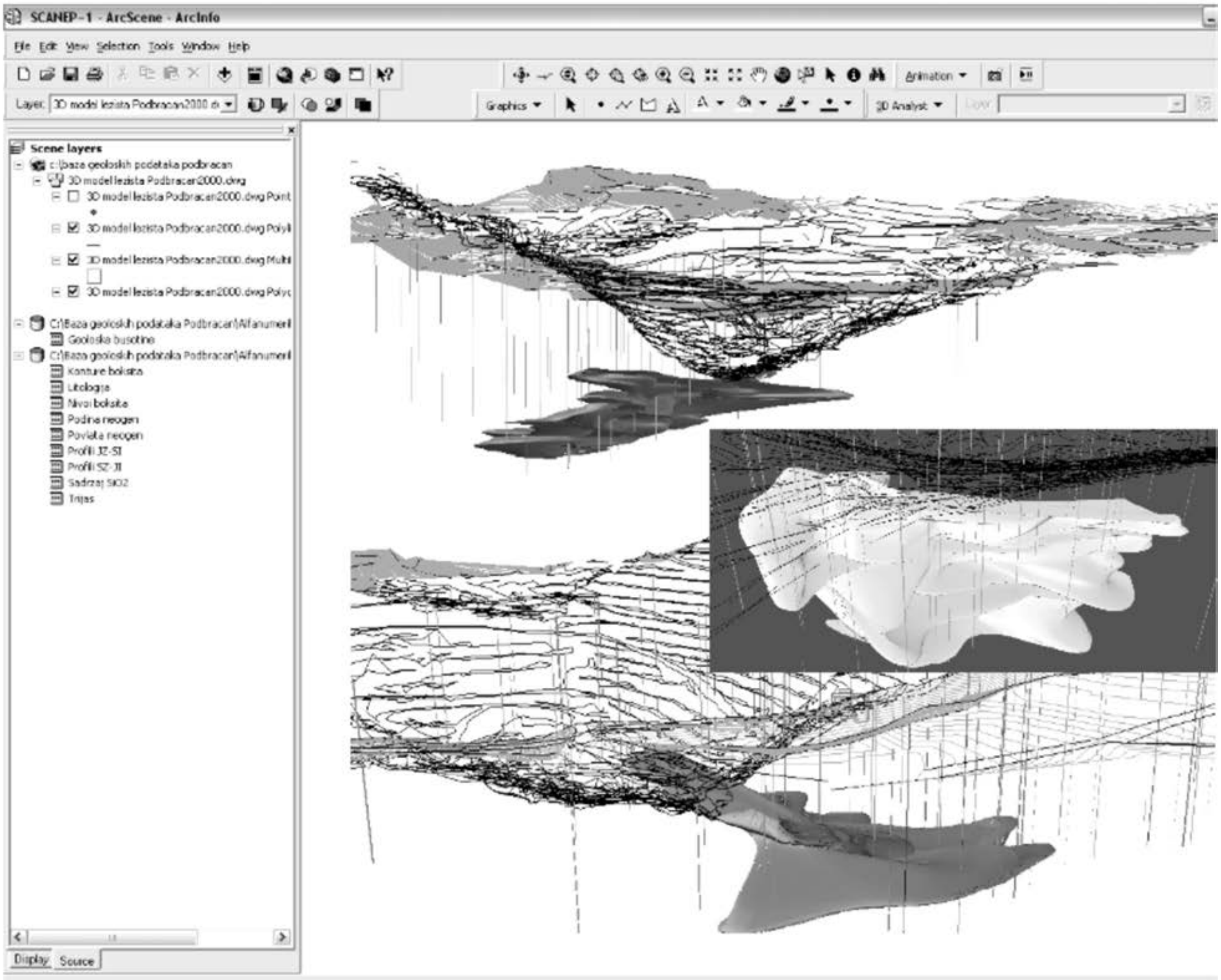

Fig. 6. 3D models of deposit and bauxite Open Pit Mine in ArcScene.

economy assessment, and directing the activities towards the ore body determination;

- Within the bauxite deposit and the Open Pit Mine "Podbraćan", there is a need for complex processes solution (slope stability, ore body tectonics) having in mind future mining of bauxite;
- It is necessary to update the existing geological documentation by new data, and make additional observations, due to new engineering geology conditions and in order to ensure the highest possible recovery degree of the reserves proved;
- GIS supported acquisition of geological data holds much importance for further exploration;
- Suggested way of GIS creation and its potential realisation, upon proven justification, has perspective and the potentiality of utilisation even on other localities and exploitation fields of bauxite but also of other mineral raw materials as well.

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Using of GIS Technology for Digitalization of Neotectonic Map of Albania

Gafur Muka[1], Adem Hyseni[1], Ibrahim Milushi[2], Majlinda Cenameri[1] & Ernilda Faruku[1]

Abstract. Production of digital products through GIS technology currently constitutes a serious commitment of specialists from many fields. In this context, the Albanian geologists, who possess a very large amount of geo-data, materialized in analogous geological maps, see the necessity to apply GIS technology for the digitalization of available data and the inclusion of new ones as well.Through this commitment they realize not only increase the efficiency of their work in documenting of the geological phenomena but also discovering the complex addictive of phenomena.

Neotectonic map of Albania is a very important basis for recognition of geological phenomena related to the types of rocks, their ages, fault zones, tectonic zoning, etc. Its construction is the product of geological studies, which requires several years, like all other cartographic products, time after time updating and using from all users involved in the study of the phenomena mentioned.

The realization of digitalization of neotectonic map through GIS technology provides for all stakeholders new opportunities for advancing research in this area and thorough review of geological properties of Albania.

In addition, it is also a contribution to geology as a whole because it creates the possibility of constructing, administering, processing and presenting data at regional level (the Balkans) and beyond.

Key words: GIS, neotectonic, digitalization, analogous, geological maps.

Introduction

The aim of this paper is the digitization of existing databases of neotectonic map of Albania (scale 1:200000), (Aliaj *et al.*, 1995) processing, analysis and presentation (visualization) of them. The realization of this goal is done using GIS technology. Specifically is used ArcGIS Info 9.2 software.

For both classification of rocks and their age structure were built data base "feature class" using configuration "polygon" for their positioning shape.

For the faults is used the "Polyline" type. After the building of the model with these data, is passed in their processing and analysis. In this case are defined the topological properties and are calculated the geometric elements: surface area and length. Visualization of data for clarification of the models created was made by techniques outlined in the GIS (Bolstad, 2007; Hennermann, 2006; Liebig & Mummentthey, 2008).

Methodology

Basis for the creation of digital neotectonic map have served the analogue product at scale 1:200000 (Aliaj *et al.*, 1995).

Geo-referencing of this map was done using digital border of Albania as reference, in the appropriate coordinate system (Datum: Pulkovo 42, the network: Gauss-Krueger projection (Aliaj *et al.*, 1995; Muka & Korini, 2010) Registration of the data was originally done by creating of the data base "feature class" (Bolstad, 2007; Hennermann, 2006) which was named "Neotectonics". In this database, where to the field "shape" the objects are defined as "polygon" was digitized in ArcInfo, with the activated topology, the geometric elements of mapping: the boundaries of rock lithologies. Qualitative attributes "classification" and "age" were registered in relevant fields. Following were created two new fields with quantitative attributes respectively "perimeter" and "surface" (Fig. 1). In

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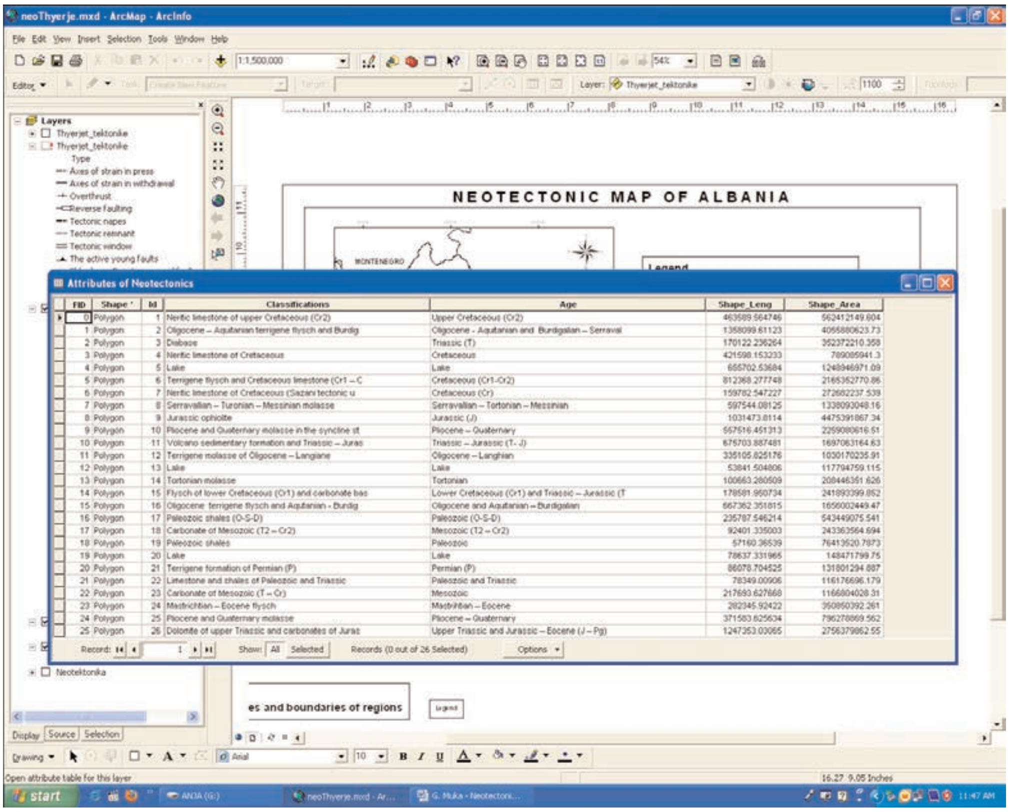

Fig. 1. Feature class: “Neotectonics”.

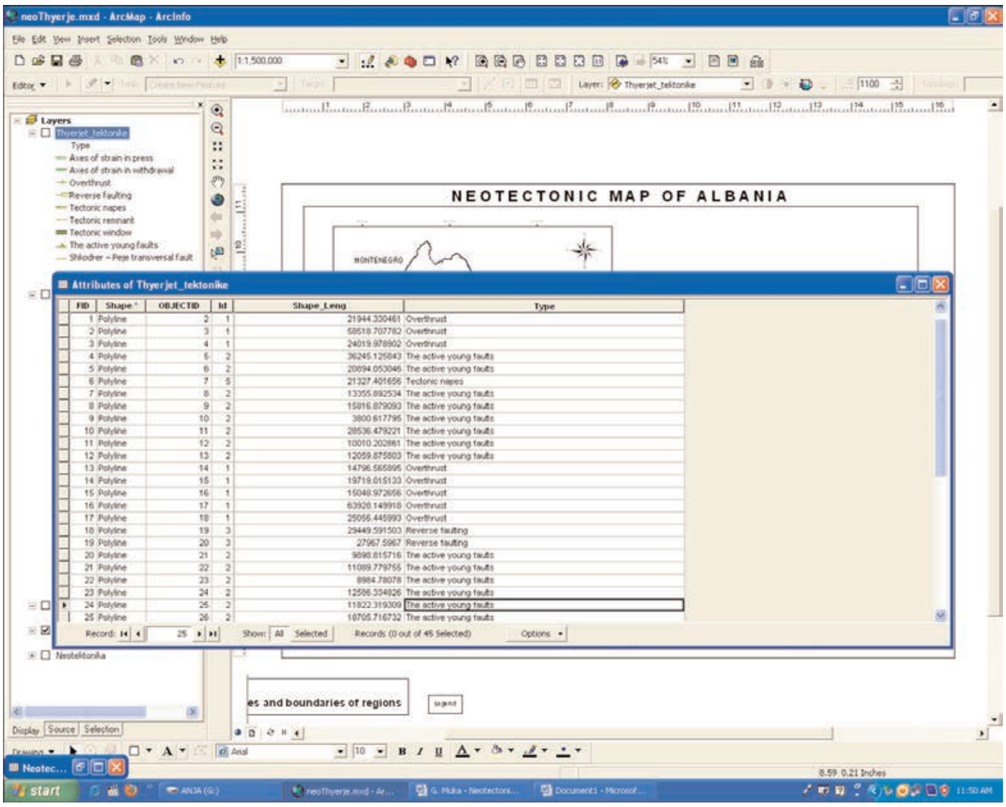

Fig. 2. Feature class: “Faults”.

Fig. 3. Lithological map.

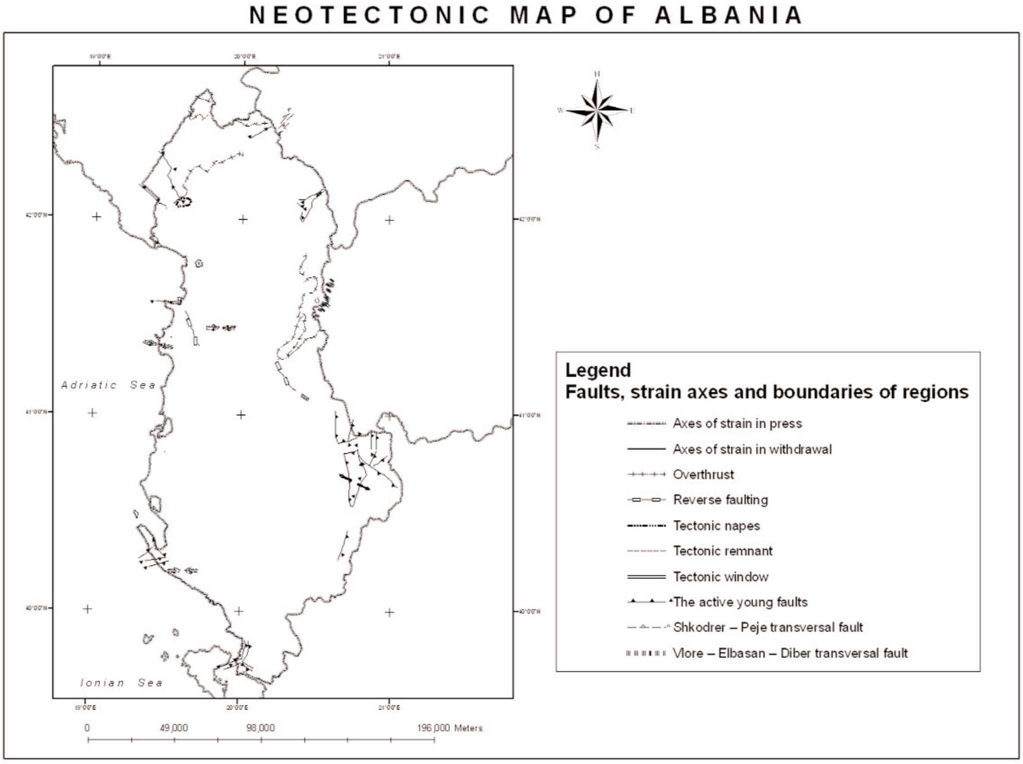

Fig. 4. Map of the tectonic elements (faults, axial strains, zonal boundaries).

the same way is created data base “feature class” named “faults” (Fig. 2) where the field type “shape” is “polyline” and attributes of fields are labeled “type” (fault type) and length of the elements “ length shape”. Even in this case the digitization is done by activating the topology in ArcInfo. Visualization of data is done

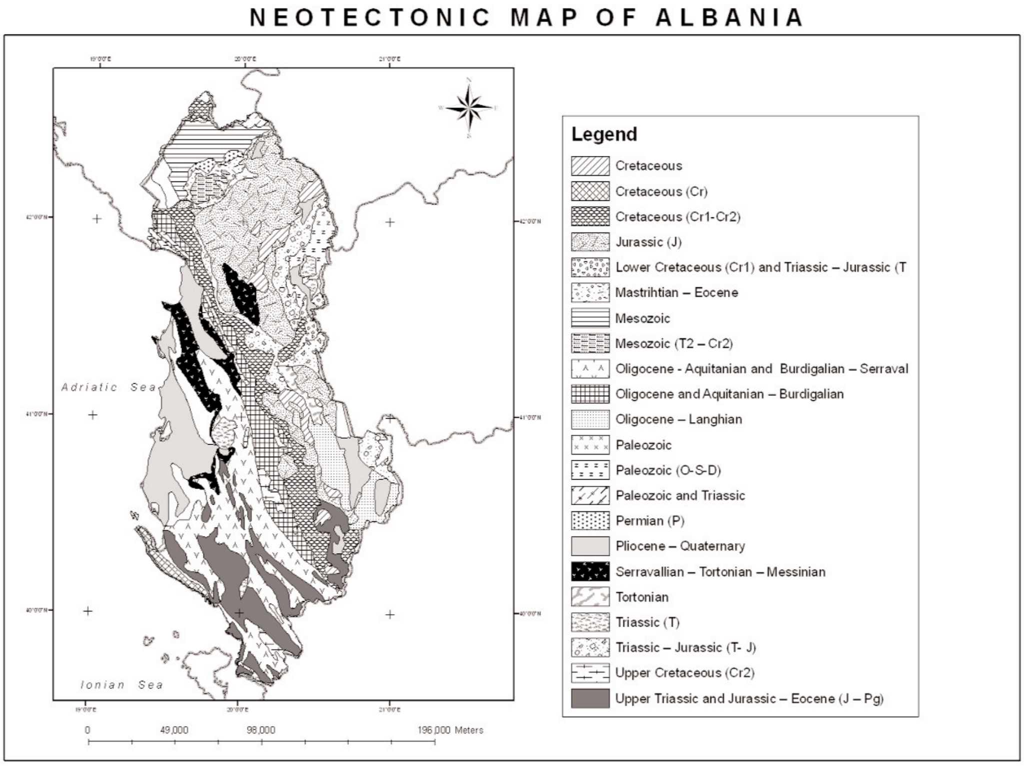

Fig. 5. Map of the age of rocks (visualization).

automatically based on the database. Symbols are chosen to be same as those used in the current analog product (ALIAJ, 1995) which is similar to that of the international classification (MAWER, 2002).
The presented products are:

1. Map which shows lithology (Fig. 3);
2. Map of the tectonic elements (faults, axial strains, zonal boundaries), (Fig. 4)
3. Map of the age of rocks (visualization) (Fig. 5)

These products should be seen as basic products which are obtained by the digitizing of the neotectonic map of Albania. By editing the fields for other attributes in the tables of data base can be realized the presentation according to creator and user requirements.

Conclusions

1. Using of GIS technology to visualize the data of the neotectonic map of Albania enables modeling, management, analysis and presentation of data according to requirements of users by facilitating them in the themes of the desired concentration.

Specifically in this paper are covered:

i. Map based on classification according to lithological composition
ii. Map of faults, axes of strains and boundaries of the neotectonic regions
iii. Map based on the age of rock formations

2. Digitized product increases the level access to users and provides them the possibility of a critical review on the quality of the product.

3. Availability "on line" of the product increases the interoperability and thus contributes to the ongoing review of geological phenomena (neotectonic) in the region and beyond.

4. The product allows the inclusion of new data (update) and analysis, processing and comprehensive presentation of the phenomena with the smallest cost and higher effectiveness.

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17th Meeting of the Association of European Geological Societes	Proceedings	37–41	BELGRADE, 14–18 September 2011

Geological Mapping Using Landsat-7 Satellite Image, Compared With GIS Data. Case Study From Lake Volvi Basin, Central Macedonia, Greece

DIMITRIOS OIKONOMIDIS[1] & KONSTANDINA MAKROVASILI[1]

Abstract. Geological mapping is one of the fundamental acts that a geologist should perform in order to proceed to higher levels of a research. This includes basically, mapping of lithological units and tectonic lines (faults). Satellite images give geologists a unique opportunity to observe the complex interaction of large-scale geological structures that make up Earth's landscape. Furthermore, digital satellite data can be manipulated and enhanced in order to accentuate the surface expressions of certain geological features. In most of the cases, this is usually done in "ideal" test sites, with absence of vegetation, soil cover, etc. In this paper, various digital image processing techniques were applied on Landsat-7/ETM+ satellite image, in order to produce the most appropriate images for geological mapping, in typical inland Mediterranean terrain. The basin area around Volvi lake was chosen as case study. Boundaries of photo-lithological units and photo-lineaments are drawn on the above satellite image. The results are compared with digitized geological maps of 1/50.000 scale and are evaluated.

Key words: Lithology, lineaments, remote sensing, GIS, Lake Volvi.

Introduction

Different digital image processing techniques have been proposed by geoscientists for lithological and tectonical mapping. Usually, the test areas are remote territories (deserts most of the times) with little geological knowledge about them, but having the great advantage of large-scale surface exposure of rock types. In this paper, we studied an area that was mapped by geologists on the field, the past decades, but having small degree of surface exposure of rocks, since vegetation covers a considerable part of the area. We preferred to study this areas with Landsat-7/ETM+ satellite image, since it combines the good spectral information (many bands) with the satisfactory for geological mapping, spatial resolution (15 m).

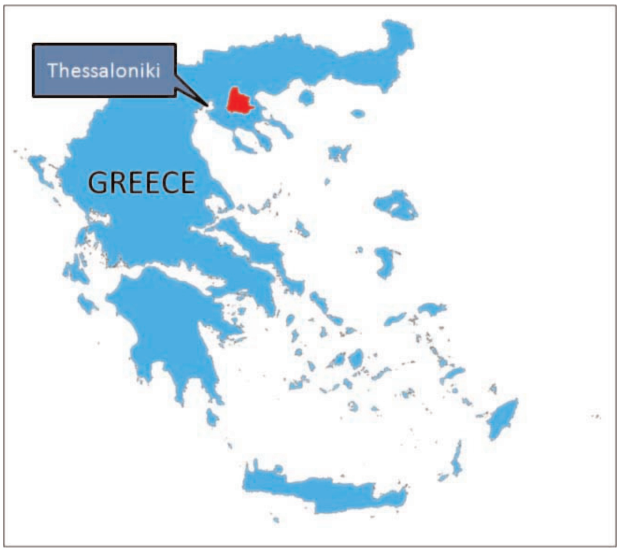

Fig. 1. Location of the study area.

Location and physical background of the study area

The study areas that has been selected, is the basin of Lake Volvi, in Macedonia area, Northern Greece (Fig. 1): The basin of Lake Volvi covers an area of 954.2 km^2 and the heights range from 11 m to 1129 m.

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Concerning its lithology, it consists of recent deposits, clays, amphibolites, limestones and marbles, gabbros, gneisses, granites, rhyolites, schists, phyllites quartzites and ultra-mafic rocks. (geological maps of Institute of Geological and Mineral Exploration/IGME).

The area belongs to the Mediterranean Climate Type, Csa (BALAFOUTIS, 1977), that is, it is characterized by hot and dry summers and mild and wet winters. Also, a big part in the study area, is covered by agricultural land and natural vegetation (broad-leaved forests and sclerophyllus vegetation).

Materials-Methodology

The following data and software were used:

- Geological maps covering the study area. Sheets: Zangliverion, Vasilika, Thermi, Stavros, Sochos, Arnaea and Poliyiros, 1/50,000 scale, source: Institute of Geology and Mineral Exploration/IGME.
- Landsat-7/ETM+ satellite image, covering the study area (http://image2000.jrc.ec.europa.eu)
- Image processing software: ENVI 4.7.
- GIS software: ArcGIS 9.3.

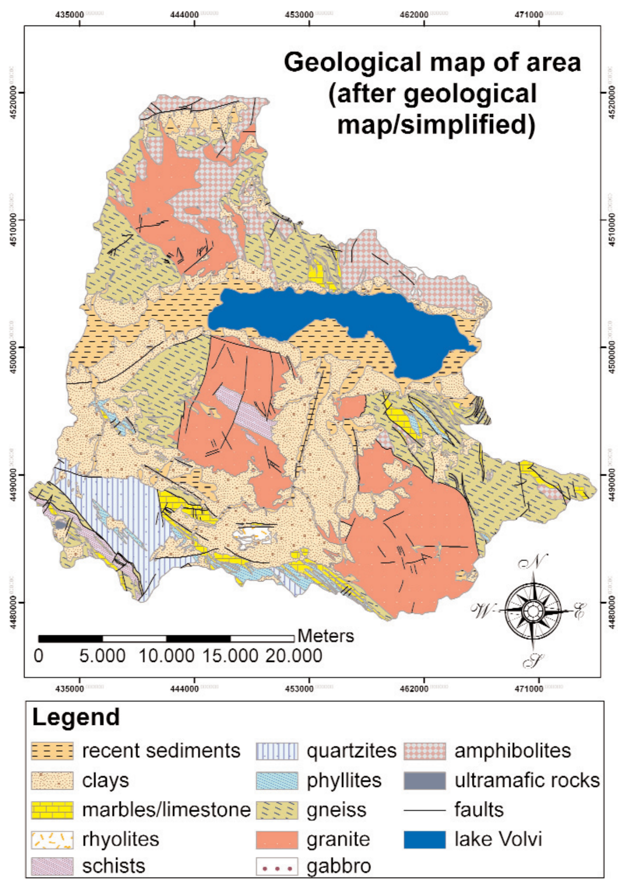

Fig. 2. Geological map (lithology and faults) of the study area, derived from geological maps of IGME (simplified by the authors).

Lithological units and faults were digitized from the maps of IGME. After that, the geological map (simplified lithology and faults) and the rose diagramme were constructed (Figs. 2, 3). Then, certain digital image processing was applied to the satellite images, so that lithological units and photo-lineaments could be extracted. Lithological map and lineaments' map were also produced. Finally, rose-diagrammes were constructed for comparing tectonic data from geological maps and lineaments derived from satellite image.

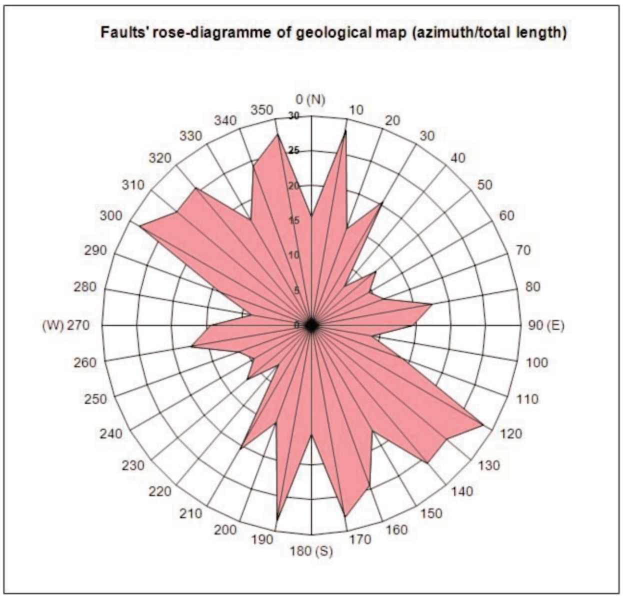

Fig. 3. Faults' rose-diagramme (azimuth/total length per class) of the study area. Source: geological maps of IGME.

Landsat-7/ETM+ image processing

Basics

Landsat-7 ETM+ image contains both multispectral and panchromatic bands with different spatial resolutions (30 m and 15 m). For this reason, an image sharpening methodology (else called merging or fusion) had to be applied, so that all the bands would have the same pixel size and could be processed easier. There are numerous methodologies for this, such as Principal Components Analysis/PCA sharpening, IHS (or HSV) sharpening and Color Normalized (Brovey) sharpening. Among them, the PCA sharpening was chosen because by this technique we can have all 6 multispectral bands (except the thermal one) sharpened at once and not only 3 at a time.

In the PCA sharpening, a principal components transformation is performed on the multispectral data. The PC band 1 is replaced with the high-resolution band (PAN in our case), which is scaled to match the PC band 1, so that no distortion on the spectral information occurs. Then, an inverse transform is performed. The multispectral data is automatically resampled to the high resolution pixel, using a nearest neighbour, bilinear or cubic convolution technique (ENVI User's Guide, 2005).

Landsat-7/ETM+ image processing/lithological mapping

The second step was to produce a Normalized Difference Vegetation Index/NDVI image which has the form NIR-R/NIR+R. In the case of a ETM+ image, the formula becomes 4–3/4+3. This was necessary to be done to extract areas with dense vegetation (bright pixels).

Several image processing techniques, from past-published papers, including HSV and PCA transformation, band ratios, filtering and simple False Colour Composites/FCCs were applied on the Landsat image for extracting lithological boundaries, but the results were not satisfactory.

The best results occurred when a 5/3,4/2,3/1:RGB band ratio FCC image was produced (Amri *et al*., 2010). Furthermore, an equalization radiometric enhancement was applied on the above image. As a result, an image occurred which proved to be more

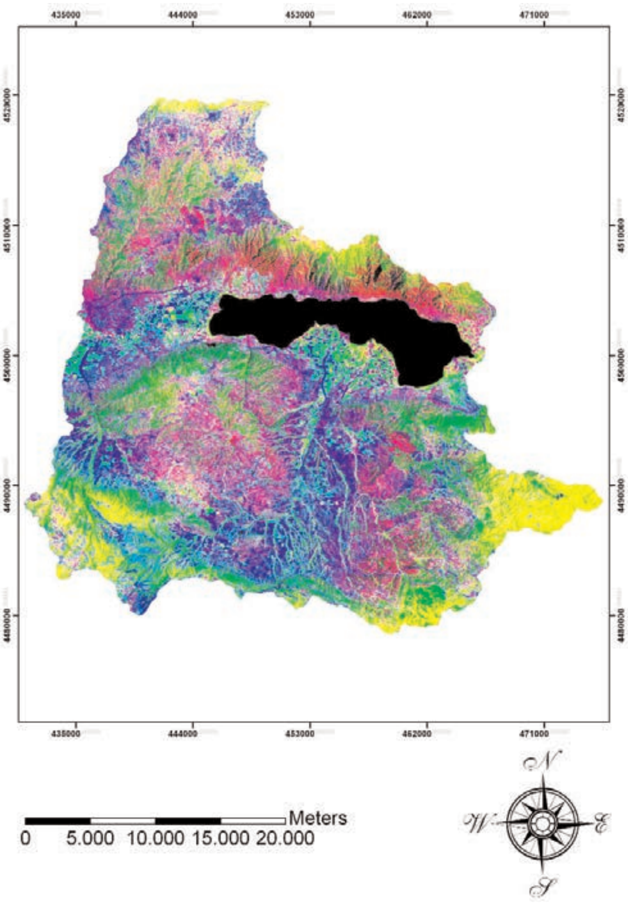

Fig. 4. 5/3,4/2,3/1: RGB Landsat image, for lithological mapping.

suitable for lithological mapping, compared to others, for our study area (Fig. 4). A digitization of lithological boundaries on this image, produced the map of Figure 5.

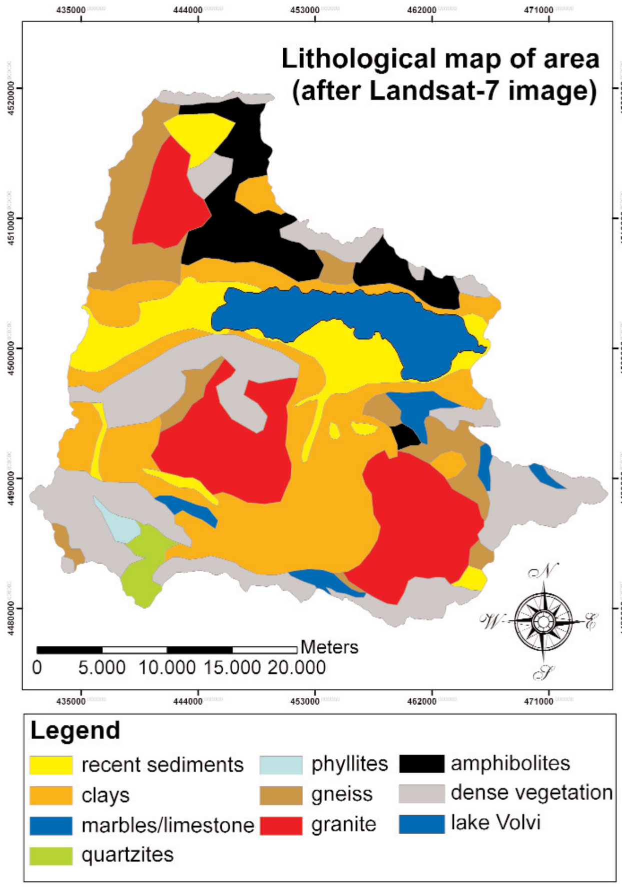

Fig. 5. Lithological map derived from the Landsat-7 image of Figure 4.

Landsat-7/ETM+ image processing/lineaments' mapping

Concerning lineaments, the most suitable methodology applied on the Landsat image, proved to be the 5/3,5/1,7/3:RGB FCC image (Raharimahefa & Kusky, 2009). An equalization enhancement was applied on the above image for improvement. After the digitization of lineaments on this image, the image-map of Figure 6 was created. The rose-diagramme of the lineaments drawn, is shown on Figure 7.

Comparison of the derived data and results

Considering that the geological map of IGME is the "correct" source, we come to the following results:

1) The recent sediments around Lake Volvi were mapped with high accuracy.

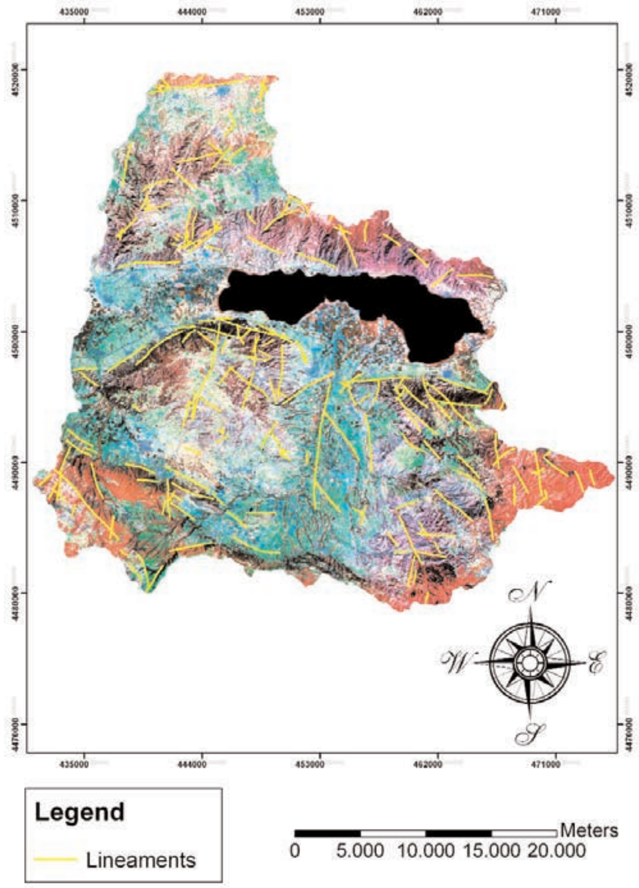

Fig. 6. Lineaments delineated form 5/3,5/1,7/3:RGB Landsat images.

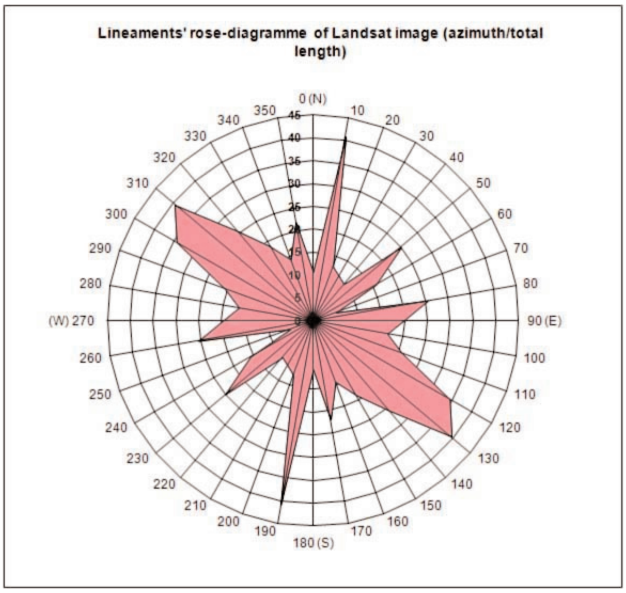

Fig. 7. Lineaments' rose-diagramme (azimuth/total length per class), as derived from Landsat image.

2) Clays were mapped with high accuracy.

3) Marbles and limestones were mapped with moderate accuracy, that is, in some cases they coincide in both the satellite image and the geological map of IGME while in some other, they were mapped in areas were according to the geological map of IGME, there are not present, and vice versa.
4) Quartzites were mapped partly, because of the dense vegetation.
5) Phyllites were mapped partly, because of the dense vegetation.
6) Gneisses were mapped satisfactory, excluding the areas of dense vegetation.
7) Granite was mapped with satisfactory accuracy.
8) Amphibolites were mapped with high accuracy.
9) Rhyolites, schists, gabbro and ultramafic rocks, could not be mapped either because they occupy small areas or because they are located into areas of dense vegetation.

From GIS measurements we found out that the total length of faults of the geological map (323.11 km) is smaller than that of the lineaments delineated from the satellite images (368 km).

From the study of the rose diagrammes, we see that the major strikes (directions) of the mapped lineaments is the same with those of the faults, that is N–W and NW–SE. The minor groups of lineaments on the satellite images that have similar strikes with minor groups of the faults on the geological map, that is NE–SW.

Summarizing, concerning discrimination of lithological units, Landsat-7/ETM+ satellite image proved satisfactory, with the exception of densely-vegetated areas or lithological units that cover relatively small areas.

In the detection of tectonic lines, major similarities were found between the satellite lineaments and the faults of the geological map, concerning strike (direction). The total length of the (photo)lineaments is higher than that of the faults from the geological map and this is caused by the fact that not all lineaments are tectonic lines and a thorough field investigation is the next step. Nevertheless, judging from experience on earlier projects, a significant number of the mapped lineaments will prove that they correspond to faults, meaning that the geological maps need a revision in that field.

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17th Meeting of the Association of European Geological Societes	Proceedings	43–46	BELGRADE, 14–18 September 2011

Vulnerability Assessment – a Prerequisite for Groundwater Protection to Contamination (use of GIS Technology)

FLORA PROGNI[1], ARJAN BEQIRAJ[1] & MAJLINDA CENAMERI[1]

Abstract. Groundwater quality has been recently deteriorating particularly in the basin of Tirana which represents the most contaminated one due to the intensive urbanization and industrialization of this region. Groundwater vulnerability assessment was done by using a DRASTIC model combined with a Geographic Information System (Arc Gis 9.2 INFO). The aim of this study is to assess the vulnerability of groundwater to contamination for the basin of Tirana–Fushe Kuqe which represents the most important alluvial aquifer of Albania because of high dynamic reserves and high demographic density in this region. As a result of the vulnerability assessment, 17 % of the Erzeni basin was classified as being very highly vulnerable, 8 % highly vulnerable, 40 % moderately vulnerable, 20 % low vulnerability and, finally, around 15 % of the basin has very low vulnerability.

Key words: Vulnerability, Drastic Index, GIS-based evaluation, alluvial aquifer, groundwater.

Introduction

Groundwater, that represents a major source of water for domestic, industrial and agricultural uses in Albania, is recently suffering a deterioration of its quality especially in the regions with extensive demographic and industrial development, due to excessive groundwater withdrawal and introduction of different contaminants from the surface. Over the past 30 years, groundwater vulnerability maps have been developed in many countries as a basis for developing land use strategies that take into consideration aspects of protection of groundwater from pollution (FRITCH *et al*., 2000; NAQA *et al.,* 2006). The final goal of vulnerability maps is the subdivision of the area into several hydrogeological units with different levels of vulnerability. The aim of this study is to assess the vulnerability of groundwater to contamination for the basin Tirana–Fushe Kuqe which extends from Tirana city in the southeast to river Mati in the northwest (Fig. 1, a). Groundwater vulnerability assessment was done by using a DRASTIC model (ALLER *et al.*, 1987) combined with a Geographic Information System (Arc Gis 9.2 INFO). This model is based on seven parameters (D-Depth to water, R-Net Recharge, A-Aqufier Media, S-Soil Media, T-Topography, I-Impact of vadose zone, C-Hydraulic conductivity) to be determined as input for computing the DRASTIC index number, which reflects the pollution potential for the aquifer (ALLER *et al.*, 1987). The Tirana–Fushe Kuqe Basin, which is one of the most important alluvial groundwater basins in Albania (EFTIMI *et al*., 1989), consists mainly of Quaternary alluvial gravels that are 5–70.0 m thick. The main recharge of the aquifer occurs from the south-eastern and eastern sides of the area and groundwater flows to the north-western and western parts of the basin where the groundwater is under pressure due to the impermeable clay cover layer.

Materials and Methods

For the assessment groundwater vulnerability to contamination of the Tirana–Fushe Kuqe basin the DRASTIC (ALLER *et al.*, 1987) model and a geographic information system (ArcGIS) (NAPOLITANO, 1995) were used to produce the vulnerability map. This involved: (i) data (hydrogeological, geological and pedological) collection, (ii) scanning of toposheets and digitizing (raster to vector) source data, (iii) creating the attribute table, (iiii) analyzing the DRASTIC factors for evaluation of Drastic Index, (iiiii) rating these areas as to their vulnerability to con-

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tamination and deriving a Graduated Map. After the toposheets were scanned and converted from TIF to vector format, an attribute table was created in Excel containing X, Y coordinates of the hydrogeological well and values of Drastic Index. The data of attribute table were imported from Excel to Arc Gis 9.2 INFO where the Drastic Index (vulnerability map) was created in Arc Gis 9.2 INFO by using Spatial Analyses. Aquifer vulnerability methods require validation (sensitivity analysis) to reduce subjectivity in the selection of rating ranges and to increase reliability (RAMOS-LEAL & RODRÍGUEZ-CASTILLO, 2003). The first step of the analysis was to compute the vulnerability values using six maps instead of seven (*i.e.*, removing one map). For each sub-area, vulnerability index was calculated using combinations of 6 of the 7 parameters (GOGU & DASSARGUES, 2000) and the output values were re-scaled by a factor 7/6. For comparing the new index with the initial one LODWIK *et al.* (1990) defined the sensitivity parameter $Si = (Vi/N) - (Vxi/n)$ to removing one parameter, where Si is the sensibility, Vi is the vulnerability index for the ith cell, N is the total number of parameters used in obtaining the vulnerability for each of the cells, VXi represents the vulnerability index of the ith cell excluding the Xi parameter, and n is the number of parameters used in the sensitivity analysis. A variation index (Vxi) can be computed from the following expression (GOGU & DESSARGUES, 2000): $VI = (Vi-Vxi)/Vi$. Each parameter contributes with an effective weight (WXi) (NAPOLITANO & FABBRI, 1996) to the final vulnerability index, which can be calculated for each sub-area as: $Wxi = [(Xri * Xwi)*100]/V$ where Xri and Xwi are, respectively, the rating values and the weights for the parameter X assigned in the subarea i, and Vi is the vulnerability index for the subarea i. The most sensitive parameter to contamination is the depth to water and impact on the vadose zone, followed by net recharge, hydraulic conductivity and aquifer media.

Results and discussion

Different models can be applied to mapping of groundwater vulnerability, but the most commonly used model in assessing groundwater vulnerability in porous aquifers seems to be the DRASTIC model (ALLER *et al.*, 1987). The DRASTIC acronym stands for the seven hydrogeological parameters: Depth to water, net Recharge, Aquifer media, Soil media, Topography (slope), Impact on the vadose zone media, and hydraulic Conductivity of the aquifer. The DRASTIC model has four assumptions (ALLER *et al.*, 1987): 1) the contaminant is present on the ground surface; 2) the contaminant is flushed into the groundwater by precipitation; 3) the contaminant has the mobility of water; 4) the area being evaluated by DRASTIC is 0.4 km^2 or larger. For the determination of the DRASTIC index number (pollution potential) each factor rating was multiplied by its weight and the resulting values were added together:

DRASTIC Index = DrDw + RrRw + ArAw + SrSw + TrTw + IrIw + CrCw (*)

where r = rating for area being evaluated (1–10), and w = importance weight for the factor (1–5). Importance weights are found in a generic DRASTIC table that lists weights for factors having greater applicability (ALLER *et al.*, 1987) while factor ratings are derived from data on each factor. Finally, the Drastic Index values are calculated by using the above (*) equation. Higher sum values, i.e. higher DRASTIC index, represent a greater potential for pollution or a greater vulnerability of the aquifer to contamination. The DRASTIC index was further divided into five categories: very low, low, moderate, high, and very high. The sites with high and very high categories are more vulnerable to contamination.

The Arc Gis 9.2 INFO was used to compile the geospatial data and to generate the final vulnerability maps of the Tirana–Fushe Kuqe basin. The grid layer for depth to water (D factor) was generated by computer subtraction of water-level elevation data sets from land surface elevation. The water-level elevation data sets were obtained from the groundwater well records. The depth to water table ranges from 2.0 m to 50.0 m from the surface. The factor score for depth to water ranges from 5 to 45. The grid layer for net recharge (R factor) was computed using the long-term water balance for the Tirana–Fushe Kuqe basin. The factor score map for net recharge ranges from 4 to 32. The grid layer for aquifer media, which is mainly composed of gravel with subordinate sand, was extracted from the geological map, scale of 1:10000. The factor score for aquifer media ranges from 15 to 27. The grid layer of soil media was extracted from the pedological map, scale of 1:10000. Soil shows a wide compositional range along the extension of Tirana–Fushe Kuqe basin. The factor score for soil media ranges from 0 to 10. The grid layer for the topography of the basin was generated from a DEM. Most of the slopes in this study were in the range of 2 to 8 %. The topography factor ranges from 18 to 20. The grid layer for the impact on the vadose zone depends on soil permeability and depth to water table. The rating of impact on the vadose zone, composed of sand, silt and clay, varies from 10 to 35. The hydraulic conductivity of the aquifer was obtained from pumping test analysis of the groundwater wells. The score factor for hydraulic conductivity ranges from 18 to 30.

The DRASTIC index map (Fig. 1, b) was prepared to determine the vulnerability to groundwater contamination (*i.e.*, pollution potential). This map shows that the vulnerability of the Tirana–Fushe Kuqe alluvial aquifer to contamination ranges from very low (DI=75–100) to very high (DI=175–200). The most vulnerable areas of the aquifer to groundwater con-

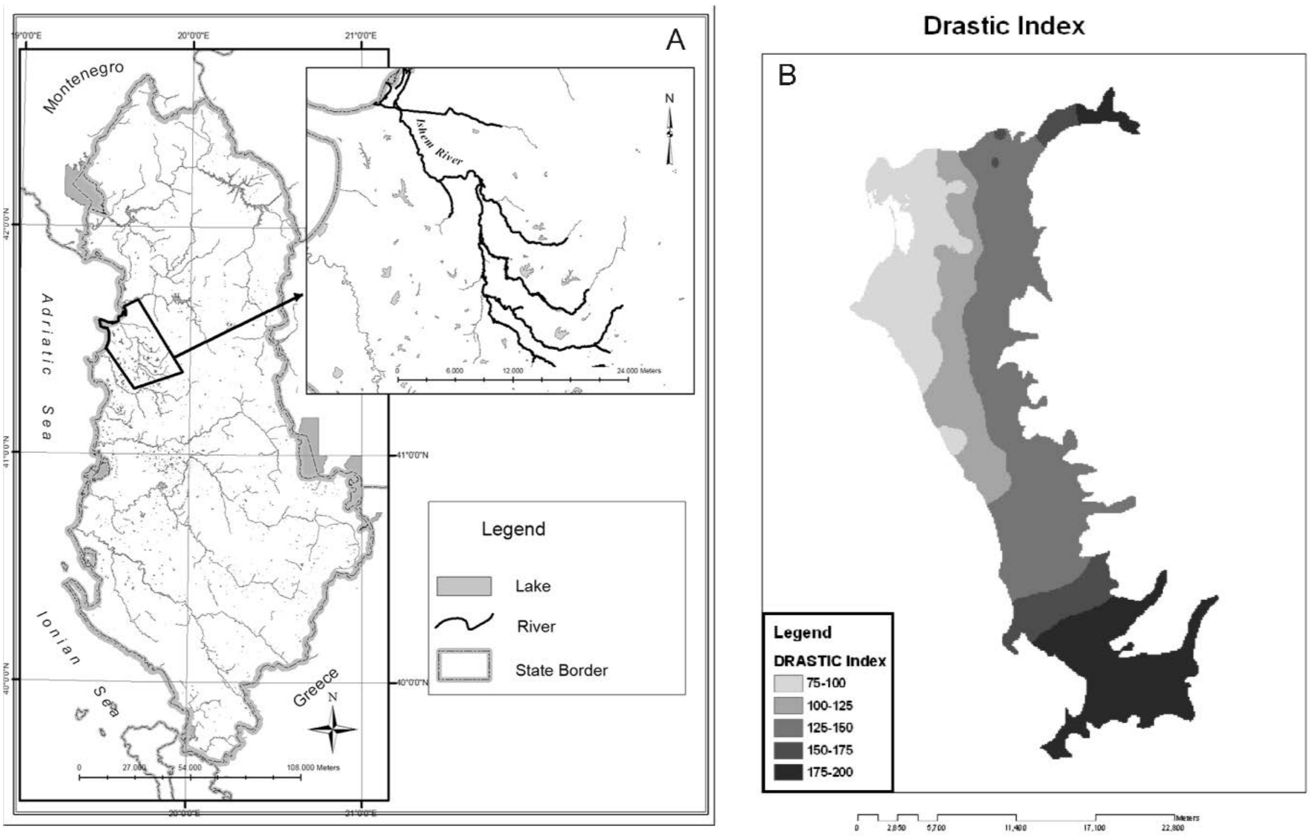

Fig. 1. A) Hydrographic map of Tirana–Fushe Kuqe basin; B) Vulnerability map.

tamination are located in the southeast and east areas of the basin where the soil cover and/or vadose zone are absent or very thin, whereas along the northwestern and western sectors of the basin, where a thick (20–50 m) vadose zone with a well developed soil cover are present, the lowest vulnerable areas of the aquifer to groundwater contamination are located. Even the very high vulnerable area represents less than 20 % of the basin, it has a strong impact on aquifer vulnerability because it represents the recharge area of the basin. After entering the aquifer in this area the contaminant can be distributed in other parts downward the aquifer flow. The above configuration of the vulnerability to groundwater contamination fit very well with the data of the qualitative monitoring which detected different levels of ammonium ions, nitrites, nitrates, phosphates, etc, in the groundwater of the southeastern sectors of the aquifer.

Conclusions

Groundwater of Tirana–Fushe Kuqe basin is recently suffering a serious risk of deterioration of its quality due to extensive demographic and industrial development of the region. The integral use of the Drastic model combined with a Geographic Information System (Arc Gis 9.2 INFO) made possible the construction of the vulnerability map which showed that the groundwater vulnerability to contamination ranges from very low (DI=75–100) to very high (DI=175–200). The most vulnerable areas of the aquifer are located in the southeast and east areas, whereas the western sectors of the basin belong to the lowest vulnerable areas of the aquifer groundwater to contamination.

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17th Meeting of the Association of European Geological Societes	Abstracts	47–48	BELGRADE, 14–18 September 2011

The Earth Beneath Our Feet: Start of the International GIS and Map of Quaternary Geology of Europe

KRISTINE ASCH[1]

The Quaternary is an essential part of geology: it is the uppermost layer of the geological subsurface and thus is in strong demand: it provides Sand and Gravel deposits, groundwater resources, building ground for houses, streets, landfills, plants and many more. Geological maps have always provided for their users basic knowledge about the distribution of natural resources such as ore, water, oil or building stones. They may, albeit indirectly, warn about the danger of natural hazards or supply information about suitable sites for land-fill, house-building or tourism. They thus provide the basis for environmental planning and protection and support public-policy decision-making. Geological maps are the basis for understanding the earth and its processes. They record, store, visualize and disseminate the geologist's knowledge, the results of their investigation of the rocks and unconsolidated deposits of the Earth's surface and their interpretation.

Already in 1932 at the 2nd Congress of the International Union for Quaternary Research (**INQUA**) held in St. Petersburg the idea was discussed to represent the main features of the European Quaternary for the whole of Europe. Since then, in cooperation with INQUA and with numerous geological surveys and universities in Europe the BGR compiled the 1 : 2,5 Million International Quaternary Map of Europe (IQUAME). This traditional paper map was published in 15 map sheets, the last of which was finished in 1995 (sheet "Bern").

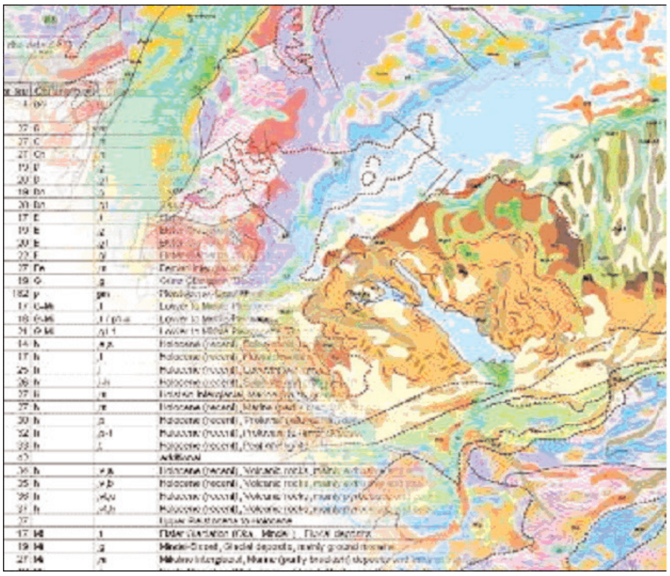

Fig. 1. Start Building the GIS of the Quaternary geology of Europe.

However, with the advent of Information Technology (IT), some factors that constrained our predecessors 50 -15 years ago no longer exist. Modern computing systems (databases, Geoinformation systems, the Internet)

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allow us to store, retrieve, combine and present far more information and knowledge about an area than we could ever display on a 2-dimensional piece of paper. Thus, the availability of a modern, up-to date inventory of the uppermost layers of the underground is important and a GIS map and database provides the ideal means.

In 2009 BGR started to rework and digitize the IQUAME paper map in order to build a Quaternary Geological Information system (GIS) of Europe where Quaternary information can be retrieved, combined and used without any political boundary problems across the entire Europe. The Quaternary information is planned to be made compatible with the already existing GIS of the 1: 5 Million International (pre-Quaternary) Geological Map of Europe and Adjacent Areas (Asch, 2005) so that the information of both layers can be combined, selected and cross-referenced. At the 2011 INQUA congress in Bern the project was introduced for the first time to international experts in order to seek international cooperation and scientific advise.

At the MAEGS 17 Meeting in Belgrade the plans for building the GIS and map will be introduced to the MAGES community and cooperation and scientific advise seeked of especially the South Eastern European Community geological community.

17th Meeting of the Association of European Geological Societes	Abstracts	49–49	BELGRADE, 14–18 September 2011

Computerization of Data Related to the Age of Albanian Ophiolites by Applying GIS Technology

ARIANA BEJLERI[1] & MENSI PRELA[1]

The aim of this study is to computerize the data provided by radiolarian assemblages in Albania. The data for the Radiolarian Assemblages in Albania are in the hard copy format and not easily to be used. A relational geodatabase is developed to computerize this abundant information by applying MS Access and GIS techniques. This geodatabase is particular because except digital attributes (number, text etc.) displays and raster attributes (lithostratigraphical columnof section, photo of the species etc.).

The age of Albanian Ophiolites has been determined by the age of siliceous sections, lying above them. The data for the Radiolarian Assemblages in Albania are taken from the chert sections which belong to the siliceous sedimentary cover of the ophiolite of the Mirdita zone and to the carbonate successions deposited on the continental margin of the ophiolites. In the Mirdita zone (Albania) the ophiolites crop out in two parallel and continuos belts (western and eastern ophiolitic belts) that differ for their geochemical and petrological characteristics.

Many tables are designed which contain all the data needed (age, author, position, sample, species, section, succession etc.) These tables are related with one to many relationship.

Four different searches are design such as: Synchronization Search, Simple Search, Search by Age and Search all the data. The Synchronization search is designed to search simple data by entering data in a synchronize way, The Simple Search is designed to search data by simply choosing a data from a combo box. Search by Age find data that has exactly a given age or are included in given interval time. Search all data is designed to search every properties about one type of data.

There are designed several digital and thematic maps, where the data are returned in spatial data. We mark the points that show the geographical position of sections on these maps. Different thematic maps generate different kind of information. For example: if we mark points of section on geological map we received geological data, except the other data of section. By clicking in a section name in the map we find all information about that section. (Section Properties, Sample Properties and Species Properties). This geodatabase built in GIS environment allow to perform a lot of queries, to quickly identify sections that are in a certain Geological and Geographical Position. Each section has many properties such as name, localization, lithostratigraphical column, section picture, bottom age, top age. In each of sections, are taken several samples Every sample has its properties such as name, position, bottom age, top age and the section name where it is taken. In each sample are found many species. Their properties are: name, author, first occurrence, last occurrence, picture, section and sample name where this species are found. A print preview form accompanied every search and that data can be printed.

This geodatabase will be used by geologists to better understand the problems regarding the age of the beginning of siliceous sedimentation of Albanian Ophiolites.

Key words: computer, ophiolites, radiolarians, age, geodatabase, GIS, section, sample, species.

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Pangeo – Enabling Access to Geological Information in Support of GMES

REN CAPES[1] & MARKO KOMAC[2]

PanGeo is a Collaborative project (02/2011 – 01/2014) with the objective of **enabling free and open access to geohazard information in support of GMES.** This will be achieved by providing an INSPIRE-compliant, free, online geohazard information service for 52 of the largest towns in Europe covering approximately 13 % of the population.

The geohazard information will be served in a standard format by the 27 EU national Geological Surveys via a modified version of the 'shared access' infrastructure as devised for the DG ISM project *One-Geology Europe*. The information to be served (a new *ground stability data-layer* and interpretation) will be made by each Survey. Products will be compiled from integrations of:

- Satellite Persistent Scatterer InSAR processing, providing measurements of terrain-motion.
- Geological and geohazard information and expertise held by national Geological Surveys.
- The polygonal landcover and landuse data contained within the GMES Land Theme's *Urban Atlas*.

PanGeo web-portal will integrate the ground stability layer with the Urban Atlas to highlight landcover polygons influenced. User input to design is facilitated by the 27 national Geological Surveys contracted into the project and a core group of Local Authority representatives. Sustainability of PanGeo will be achieved by attracting other Urban Atlas towns to procure the PanGeo service for their towns. The service that will already be provided in their country will form the basis of the required promotional activity.

The key users of PanGeo are anticipated as:

- Local Authority planners and regulators who are concerned with managing development risk,
- National geological surveys and geoscience institutes who collect and disseminate geohazard data for public benefit,
- Policy-makers concerned with assessing and comparing European geological risk, much as the Urban Atlas data is used to compare the landcover/use status of European towns.
- The public.

The provision of an open-access, standardised information service on geohazards will enable policy-makers, regulators, and the public to:

- Systematically assess geohazards in each of the 52 towns involved.
- Gain understanding of the geohazards themselves.
- Know who to talk to for more information.
- Statistically analyse and cross-compare geohazard phenomena across EU countries.
- Gain a better understanding of the socio-economic costs involved.
- Make more informed decisions, e.g. on civil defence, planning controls.
- Have confidence that the information provided is robust and reliable.

The PanGeo team comprises 13 'core' partners, as well as all 27 EU national geological surveys: Core Team partners are: Fugro NPA Ltd (UK – Project Coordinator), British Geological Survey (UK), Landmark Information Group (UK), TNO (N), SIRS (F), Institute of Geomatics (E), BRGM (F), EuroGeoSurveys (B), AB Consulting Ltd (UK), European Federation of Geologists (B), Tele-Rilevamento Europa (I), Altamira Information (E), Gamma Remote Sensing (S).

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Digital Register of Karst Caves

Vojkan Gajović[1,2], Jelena Ćalić[1,3] & Mihajlo Mandić[1,4]

Presently, Serbia does not have a register of karst caves which would be integrated on a national level. Various sets of speleological data are situated within a number of segmented registers of speleological clubs and societies, as well as in several institutions.

During the last three decades, the majority of clubs and institutions have used a registry sheet (form) developed in the early 1980s for the purpose of the project Speleological map of Serbia 1:100.000. Starting from the year 2010 and the development of the digital register of caves within the Student Speleologic and Alpinistic Club (ASAK) from Belgrade, the former registry sheet has been modified and upgraded according to new scientific advances in karstology and modernization of exploration techniques and survey instruments. The analogue version of the register is presently being transferred to the digital format.

The digital register of karst caves is based on a Geographic Information System (GIS) and a Relational DataBase Management System (RDBMS), as background for storing data. Data gathered in exploration are entered into GIS directly, and stored into a data model which resides in RDBMS, so that later users can perform search of data, selection, analysis and presentation. Users can enter the data directly into GIS software, or into Microsoft Access customized forms appropriate for users who are not familiar with GIS software. Register is available on two levels: (a) desktop level, and (b) as an interactive map, visible through particular web-mapping applications.

Key words: karst, caves, register, database, GIS.

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17th Meeting of the Association of European Geological Societes	Abstracts	52–52	BELGRADE, 14–18 September 2011

Using GIS to Estimate Selo Landslide Volume, SW Slovenia

TOMISLAV POPIT[1] & TIMOTEJ VERBOVŠEK[2]

The investigated Selo landslide is located in a Vipava Valley (SW Slovenia). It represents a Pleistocene large fan-shaped sedimentary body that differs significantly from other slope deposits with its exceptional size and the transport mechanism. It covers an area of 9.92 km^2 and stretches from the hillslope of the bordering Čaven Mountain to the central part of the valley. The Selo landslide consists of two facies units: the lower, mud supported unit present only locally, and the overlying gravelly unit. The lower unit is mud supported and is composed of pebbles, cobbles and several m^3 blocks of limestone and sandstone, embedded in muddy matrix. The upper unit is clast supported and consists predominantly of limestone gravel with subordinate amount of limestone cobbles and blocks. Fan-shaped form of landslide is typical for large catastrophic event by a debris flow with high energy and relatively high velocity of transport. The sedimentary accumulation reaches maximum 50 m thickness with an average of 10 to 15 m.

The volume of the Selo landslide was estimated from measurements in six cross-sections. In each cross-section, several points have been chosen determing the base and top surface of a landslide body before subsequent erosion. Additional points were placed along the edge of the landslide. From these, the base and top surfaces were interpolated with TIN network and the Cut/Fill method was used in ArcGIS to determine the landslide volume. This is estimated to approximately 172 mio m^3. It is believed to be Slovenia's largest landslide, and possibly the largest Pleistocene landslide of its type in Europe. The current work is focused on the recognition of a complex internal structure of the landslide with emphasis on the determination of the geometry of lower, mud supported unit, and the overlying gravelly unit.

Key words: debris flow deposit, sedimentary body, ArcGIS, mud supported, clast supported.

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Developing of the Geologic Terminology for the Geologic Database of Serbia

BRANISLAV BLAGOJEVIĆ[1]

Abstract. Geologic terminology and vocabularies are being developed/constructed for use in the geologic information system of Serbia (GeolISS). The goal is to provide geologic data to geologist and non-geologist (publicity), using consistent descriptive terminology. These terms and definitions are used to classify observable or inferred geologic facts and to assign values for properties in descriptions.

Over the years of working on terminology, a substantial opus of inputs was introduced into GeolISS, which should facilitate the work of geologists when presenting the results of observations and its interpretations. However, the everyday geological practice will certainly require more terms, especially when it comes to describing the specific geological formations such as the ophiolitic mélange, a phenomena characteristic for the particular terrains etc. Therefore, it is necessary to continuously amplify the existing terminology with the new terms and concepts.

Key words: Terminology, Geologic Information System, vocabulary structure, hierarchy, communications.

Introduction

The Development of geological terminology and nomenclature for the geologic database of Serbia started with the physical implementation of the geological information system of Serbia (GeolISS). The main development objective is to provide a standard and logically consistent terminology for description, interpretation and classification of geologic materials, units, geologic structure, mineral deposits, hydrogeologic and geotechnical properties of rocks through GeolISS. The development of the terminology involved the experts from different geological disciplines, the geologic-map producers and the geologic-data users.

The approach to the development of geologic terminology

The initial ideas about the development and role of terminology in the geologic information system revolved around a variety of views; from the opinion that lists of geology terms for each domain should be made or favouring the idea of simply taking the terms from *Geologic Terminology and Nomenclature* edited by PETKOVIĆ (1975), through to the belief that taking the terms from *Glossary of Geology* (BATES & JACKSON, eds., 1995) would be the best course of action. Finally, these ideas have resulted in a partial analysis of *Geologic Terminology and Nomenclature* edition (PETKOVIĆ, 1975), analysis of terms used in traditional geologic maps (field logs, accompanying pamphlets and map legends), and an analysis of the available terminology made for purposes of geological information systems (USGS, CGS, BGS, IUGS).

The results of these analyses showed that the Geologic Terminology and Nomenclature (PETKOVIĆ, 1975) is undoubtedly the most comprehensive local geologic-lexicographic edition, but rich in synonyms and different, often contradictory, meanings, homonyms with the same meaning, idioms, archaisms insufficiently known or unknown etymology, imprecise determinations of terms, etc. Terminology used in traditional geologic maps is very rich, but the descriptions of the observation locations are sometimes too 'baroque' or too short and cryptic, pamphlets contain very general outlook, without reference to specific data.

When it comes to the terminology developed for the geological information systems, the American Science-Language Standard for digital geologic-map database (*in* SOLLER, D.R., ED. 2004) is the most comprehensive and in many ways represents a terminolog-

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ical system (DE KAIZER *et al.*, 2000). It focuses not only on the classification of geologic materials, but also in a very precisely defined terms to describe the material properties, including its genesis.

The terminology of the Canadian Geological Survey, originally developed independently of the other (STRUIK & DAVENPORT, 2002), contains strict petrologic classification of rock materials.

Rocks Classification of British Geological Survey (GILLESPIE & STYLES, 1999; ROBERTSON, 1999; HALLSWORTH & KNOX, 1999; MCMILLAN & POWELL, 1999) is an excellent material from petrologic and practical aspects of the view, since it contains almost all the criteria for the rocks determination and multi-hierarchic classification (Genesis, composition, structure and texture).

IUGS publications related to the classification of Igneous rocks (LE MAITRE *et al.,* 2002), Stratigraphic Guide (SALVADOR, 1994), as well as Chrono-stratigraphic divisions (GRADSTEIN *et al.,* 2004), have been widely accepted by the national geological community and academic institutions. As such, they provide good resources of terms and guidelines for the development of geologic terminology.

The above-mentioned publications made it clear that:

– the terminology, in the geologic information system, cannot consist of a list of geologic terms only, but that every term or concept must be clearly and unequivocally determined, namely, defined and that only then it can have a communications role;
– analytical requirements of comparison, correlation, grouping and searching geologic similarities and differences, details and unique features of rock material, geological units and structures call for assigning the central role to terminology in the information system;
– older, inherited terminology must be included in the GeolISS vocabulary, because that is the only way for the original concepts from the historical geologic documents to be entered into the digital database, to track their evolution, i.e. possible changes of meaning over time;
– the progressive nature of the observation process (from reconnaissance to detailed) requires a hierarchical language structure—that is, language that begins at a generalized level and develops into progressively more specific categories that communicate more refined information about an geologic material (SOLLER, D.R., ED., 2004).

Vocabulary Structure

In order for the vocabulary to be able to meet all previously derived requirements and be functional within GeolISS, the UML model with a special structure was developed (Fig. 1).

The class *Rečnik (Vocabulary)* in the model is a lexicographic superclass whose instances are inherited. *Geološki Rečnik (Geologic Vocabulary)* has been implemented as an abstract class, since the class *Koncept (Concept)*, above all, allows entering general geologic concepts and terms common to all geologic disciplines and centralizes individual classifications (petrologic, mineralogic, stratigraphic, chronostratigraphic). The term "concept" itself (lat. conceptus – notion) naming the central class has been used in its original meaning to refer to an abstract or a general idea of an assumed or concrete instance (ANGELES, 1981).

The hierarchical structure of the vocabulary (Fig. 1) is made possible through involution i.e. recursive relation modelling the relation hypernym–hyponym in such a way that any (hyponymous) term in the vocabulary hierarchy can appear only once and have just one hypernym. Moreover, every term can have an equivalent in one or more foreign languages via the *MultijezičkiLeksan (MultilanguageLex)* class. The relations between different terms (e.g. derived from, having broader meaning than, lexical variant, etc.) can be recorded in the class *Relacije Termina (Term Relationship)*. Written source/s from which concepts or terms were taken, together with their meaning are entered into the class *Bibliografija (Bibliography)* and the author who added the new vocabulary entry is registered through the *Metapodatak (Metadata)* class.

Guidelines for further development of geological terminology

The geological terminology used in the information systems actually represents the terminology applied in the everyday practical and theoretical geological discourse. The only difference is that the terminology of information system is involved in the pre-defined semantic framework and that, apart from its descriptive and communicational role, there is an analytical function. In this sense, the 'development' of terminology for GeolISS has time necessity character, as well as the revisal character over the domestic geological lexicography in the context of the recent methodological and analytical techniques.

The fundamental principles which should be applied in further work on the new inputs are:

– Avoiding the repetition of the terms that already exist in the dictionary just because someone thinks that they have a different meaning within the context of a specific geological discipline;
– A fundamental difficulty could be the use of terms, even of some basic geological terms, in different meaning, the frequent use of particular feature to nominate the material and the lexical variations (i.e. slate, pelite, siltstones, cracks, crevices, etc.);

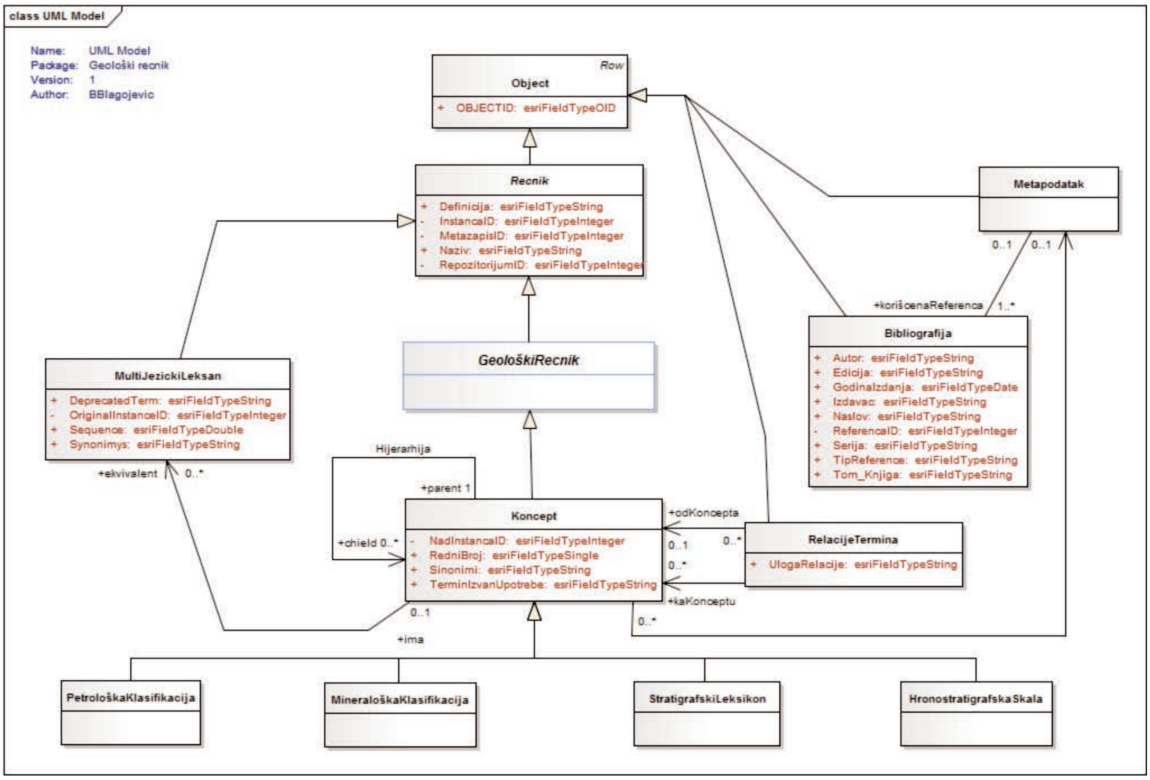

Fig. 1. UML model of the structure of the GeolISS vocabulary (ESRI profile).

– Avoiding designating / defining the concept by the other concept;
– Before making entry of the new inputs several domestic and foreign sources should be reviewed and the meaning of the term should be carefully analyzed, as well as the context of its communicational/scientific use;
– Legacy terminology should archive and organize verbatim, without attempting to translate such term(s) into modern science language;

Conclusion

The development and use of the standardized terminology in digital databases is in many respects a novel field that is bound to evolve over time, as more experience is gained in that area. The significant steps and progress that have been made in Serbia in the domain of geology, understandably, suffer from all the shortcomings that accompany such a project. The absence of unified, unequivocal and universally accepted classifications that can satisfy all the needs of geology as a science must certainly be emphasized. Thus, the expansion of the range of terms included in GeolISS will continue to be a fundamentally and operationally important task, aimed primarily at a clearer determination of the geologic content and improving the quality of geologic data. Immediate and end users of the information system can undoubtedly be instrumental in achieving that goal, above all, geologists, but also all other experts focusing on the geoscience-related research.

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Digital Data and Their Storage in Albanian Geological Survey

Lavdie Moisiu[1], Albert Avxhi[1] & Edlira Plaku[1]

Abastract. AGS possesses an important amount of geological information stored in form of reports and studies, created during a 60-year activity. This hard copy information is being increased with the digital one received from the Department of digital data elaboration, operational since 2001. Both types of information need to be stored, maintained and managed for simpler searching, living it as an inheritance for future generations. Furthermore, the increased demand from foreign and local investors poses the need for a better organization of archival data, to response in real time to each request for geological information.

Key words: Digital data, archival data, database, geological maps.

Introduction

Established since 1951, AGS has in its archive the products of 60 years of work. All this activity is synthesized in the form of reports, projects, reserves estimates, survey charts, maps etc, and is collected and stored in this archive. Documents stored in the archive reach up to 10,000 titles.

The digitizing sector, has started its activity since in 2001, and continues to produce digital data. The digital products created by this department have formed a new dimension of the archive – the digital one.

As result the duties of this department have been enlarged focusing databases creation for different purposes in the geological field.

Meanwhile, the number of digital files has increased significantly, posing several questions. Which file formats suit best our data types? Which are the best devices for data storage? What is the cost of creating digital data? Who will have access privileges? Which is the best way for a longevity data storage? In order to discuss these problems, a round table with participation of geologist, informatics experts, archivist, record creators was held. At the end of the meeting, a roadmap with instructions for storing digital data was predefined.

Sources of data and methodology

The Geo-information Department receives the main inputs from central archive of AGS, cartographic department as well. Its structure incorporates three sections.

1. The digitizing sector, since the beginning of its existence, has elaborated and realized many important products such as the Geological Map, Metalogenic Map, Geological Hazard Map, Hydro-geological Map all of scale of 1:200,000. Geological maps of 1:50,000 scale cover 79 % of territory, meanwhile for the maps of 1:25,000 the coverage is the following: geological– 84 %, hydro-geological – 68 %, geological-engineering – 61 % and the Natural Resources Map covers 57 % of Albanian territory. All the maps have been elaborated by using AutoCAD and are saved in *.*dwg* format.

The sketch of the thematic map production process is given in the sketch below:

At the end of data processing, thematic maps come out as a final product. The final version of maps is stored as a *.*dwg* file or exported in a *.*pdf* format. Since this sector is located in another building, different from the one where the server is, all digital outputs are in first place stored in a PC that plays the role of server. One copy, using portable devices, is brought afterwards to the General Directorate to be saved into the server.

2. The second source where digital data come from is the sector of data elaboration (database sector). This sector actually is developing the following three databases.

1) Mineral resources database.
The purpose of this database is to be linked with the map of Mineral Resources of Albania, which is already finished and is ready for publications.

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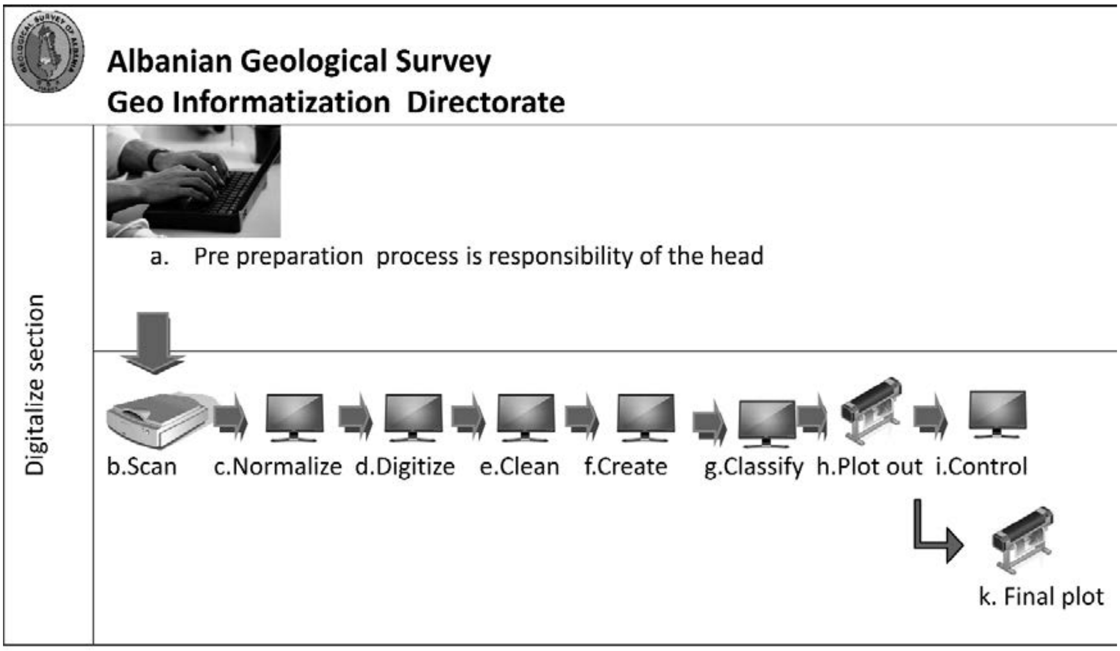

Fig. 1. The sketch of map production.

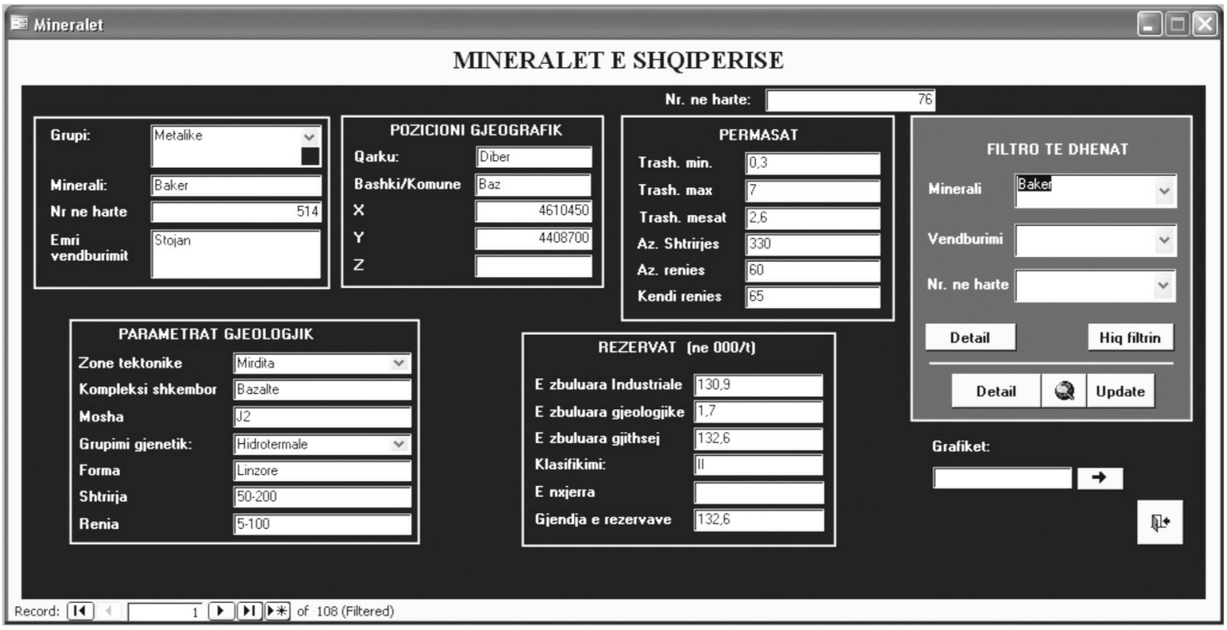

Fig. 2. Interface view of mineral resources database.

The programming of the mentioned database is carried out by the AGS's staff. The main fields are grouped into 6 parts ranked as follows:

a. Mineral number, mineral mine;
b. Geographic information (state, city/town, system coordination, measurements of ore body);
c. Geological information (geological structure, geological parameters as age, geneses, shape etc);
d. Scale of mineral deposit (scale, volume, thickness of layer, depth, azimuth etc);
e. Estimated reserves (mining survey, geological survey, deposit volume, extracted volume, remaining volume)
f. Others

Each type of mineral has its own interface.

2) Borehole database

This database aims to collect and store, all data taken during 1970-1990 period from geological expeditions, in situ. These data are very useful and requested for 3D modeling.

The database is organized into 6 parts as follows: Collar (nr of drilling, profile, XYZ, depth etc); Geo-

Fig. 3. View from Central Archive.

logy (hole size/drill size); Survey (azimuth, inclination, depth of layers); m recovery; chemical analysis.

3) Metadata database. This database concerns mainly archive metadata. The archive constitutes the third source for digital elaboration.

The AGS Archive keeps a 60 years activity, from reports to maps, surveys, graphs and so on reaching about 10,000 titles. After the 90s, the open market increased the demand of geological information from local and foreign investors, for investment purposes on mining sector. Searching manually all this huge amount of information ended up with the impossibility of answering in real time to consumer requests. This was the main reason from which emerged the need to structure the information in a digital format, in such a way that could describe, explain, localize, retrieve and manage data as much as fast and simple possible. Organized information is filtered quickly and delivered in time facilitating also the work of Archive employees. The database is built in MS-Access 2000 and handles more than 9,000 records. The process of building the digital archive passed through four stages. It started with scanning (A4 to A0 format, depending on paper size), cleaning up of scanned files, their conversion in *pf* file (smaller than other file formats), digital books creation based on the originals and finishes with linking them in the metadata program.

Fig. 4. View interface of metadata.

The storage of digital data

The scheme applied at AGS to store digital data is simple. AGS has in total four places for digital data storage.

1. Central Archive computer.
2. In 2 computers of Digitizing Sector
3. A copy of above data is kept in the main server of General Directorate. Backup of all data is stored in tapes. (Look at the schema).

searching of digital files. Digital archive maintenance and its protection remain one of main priorities of Geo-Information Directorate. One of the challenges ahead is the conversion of all dwg files into shp file format. Linking graphical data with numerical ones would complete the framework of geological information AGS has. On the other side, integrating in GIS of maps of all thematic would have its positive impact because it would increase the possibilities of keeping data up to date, facilitating their management and also

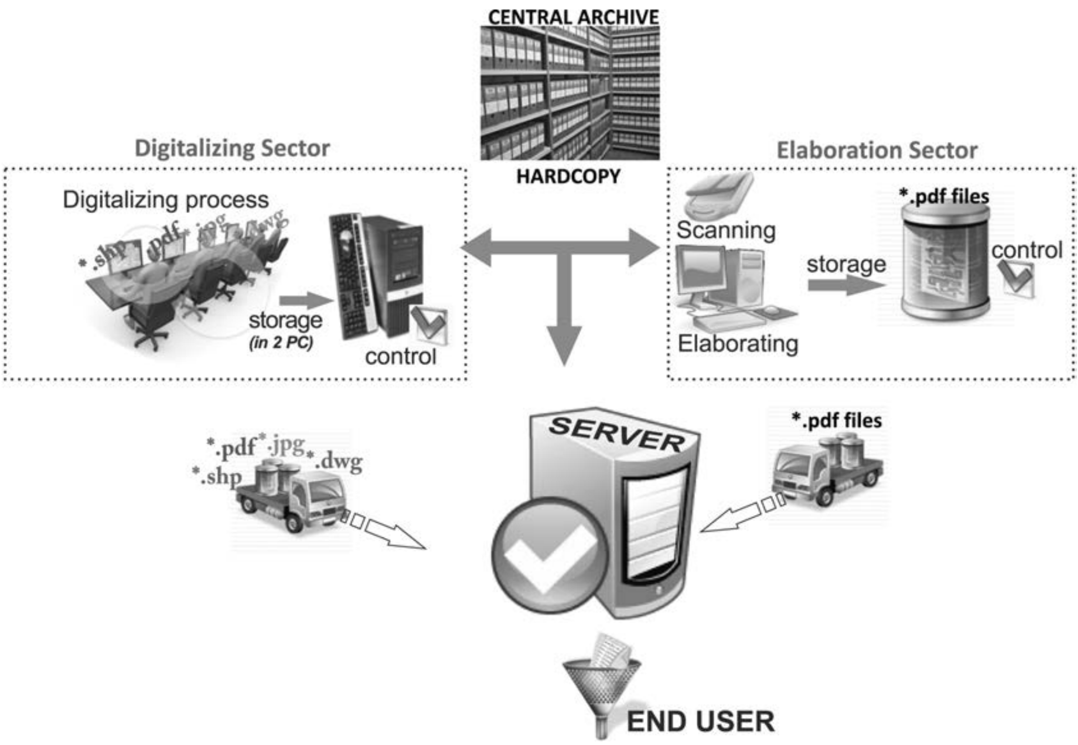

Fig. 5. Storage schema of digital data.

Experience has shown that trying to store digital information in CDs or DVDs is unsuccessful because of:

- Limited capacity of CD/DVD
- High risk of their mechanical deterioration (break, scratch etc)
- Big files have to be fragmented increasing the possibility of corruption or damage of digital information
- With time can be damaged due to exposure to atmospheric agents.
- Hardware and software of CD/DVD writing or reading might change in the future creating issues in accessing them.

Conclusions and recommendations

The amount of digital data is increasing and big volumes are created daily. Organizing them into folders following a predefined schema would help fast their filtering according to the requirements of the non-scientific community. In the same time storing the digital archive in a central server facilitates the backup process and keep data more secure.

Also tapes, even they suit better our needs, have their limitations. The best solution would be installing a storage system. Until this system in put in place, is relying in server hard disk drives.

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17th Meeting of the Association of European Geological Societes	Proceedings	61–65	BELGRADE, 14–18 September 2011

Development of the Serbian Geological Resources Portal

RANKA STANKOVIĆ[1], JELENA PRODANOVIĆ[1], OLIVERA KITANOVIĆ[1] & VELIZAR NIKOLIĆ[2]

Abstract. The Geological information system of Serbia (GeolISS) represents a repository for digital archiving, query, retrieving, analysis and visualization of geological data. The development and implementation of GeolISS is managed by a team from the Faculty of Mining and Geology at the University of Belgrade (FMG). Following the development of a geodatabase in ArcSDE and an ArcMap extension for data management, a web component was added to GeolISS. This web component is constantly being developed. The development of the portal of geological resources combines the elements of a geoportal and classical web applications. The portal (http://geoliss.ekoplan.gov.rs) features geological maps as well a web GIS maps, different multimedia content, and it also offers the possibility of online database search. This paper presents technologies and tools used to develop the portal for geological resources of Serbia, which were created as part of a project funded by the Ministry of Environment, Mining and Spatial Planning (MEMSP). The cartographic part of the portal was developed using: ArcGIS Server, HTML Image Mapper and Google Maps API.

Key words: geoportal, web mapping, web GIS, geodatabase, GIS portal, geology.

Introduction

The Geological information system of Serbia (GeolISS) represents a repository for digital archiving, query, retrieving, analysis and visualization of geological data. The development and implementation of GeolISS is managed by a team from the Faculty of Mining and Geology at the University of Belgrade (FMG) and funded by the Ministry of the Environment, Mining and Spatial Planning (MEMSP). The main goal of the implementation of GeolISS is the integration of existing geologic archives, data from published maps on different scales, newly acquired field data, intranet and internet publishing (BLAGOJEVIĆ *et al.*, 2008). GeolISS was implemented in ArcGIS 9.3.1 technology as a collection of .Net classes, as an extension of ArcGIS.

It is now commonplace to see maps or other geologic information integrated seamlessly into websites. This is why a web component was added to GeolISS. This web component is constantly being developed. While systematizing data from different geological research funded by the MEMSP before entering them into the geological database, we realised that certain data, which by their content and structure did not correspond to the initial geological database design, could still be interesting to the expert public. Because of this, the development of the portal for geological resources combined the elements of a geo-portal with classical web applications, presenting the information from diverse sources in a unified way. This paper presents technologies and tools used to develop the portal available at http://geoliss.ekoplan.gov.rs. A geo-portal is a type of web portal used to find and access geographic information (geospatial information) and associated geographic services via the Internet.

MEMSP, as the geologic information provider for Serbia, is using the geo-portal to publish geologic information, while information consumers, professional or lay, use geo-portals to search and access the information they need. Thus geo-portals have an increasingly important role in the sharing of geologic information and can help avoid duplicated efforts, inconsistencies, delays, confusion, and a waste of resources.

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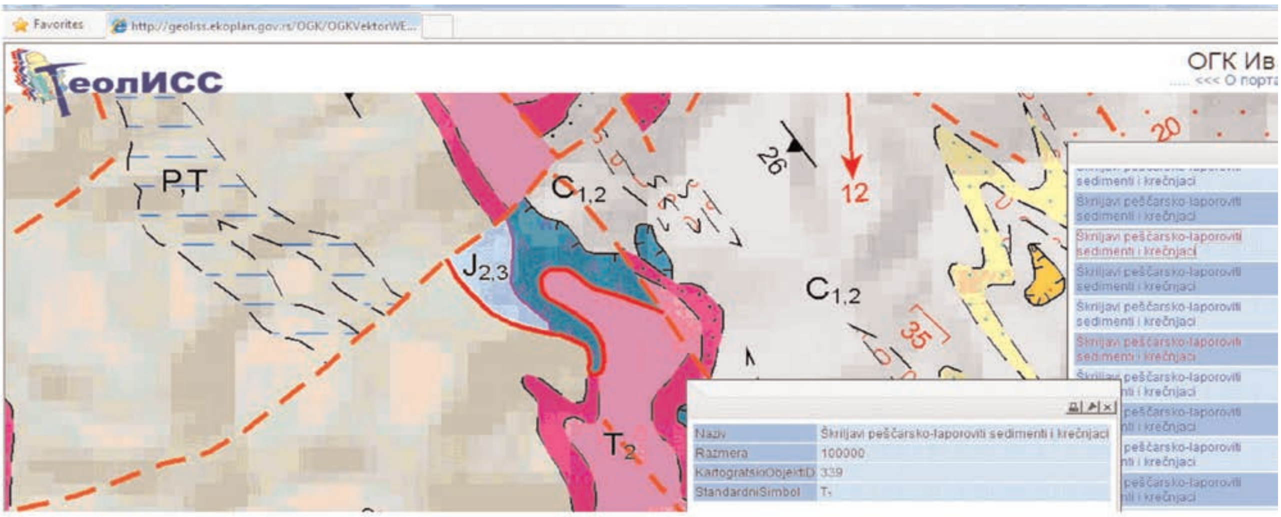

Fig. 1. One detail of General geological vector map of Serbia 1:100.000.

Development of Serbian geological portal follows the guidelines given by OneGeology[3], an international initiative of the geological surveys of the world and the INSPIRE[4] directive that aims to create a European Union (EU) spatial data infrastructure. Geological information needed for good governance at all levels should be readily and transparently available.

The web portal for geological resources of Serbia was created with the aid of modern web and GIS technologies. The largest part was realized with the use of the PHP (Hypertext Preprocessor) script language on server side and the XHTML (eXtensible HyperText Markup Language) language on the client side. In addition to this, the part of the web portal pertaining to geological terminology and nomenclature (GeolissTerm) was developed using ASP.NET web application framework (STANKOVIĆ *et al*., 2011). In order to develop the cartographic part of the portal we used: ArcGIS Server, HTML Image Mapper[5] and Google Maps API[6]. During the development of the portal, the emphasis was placed on the use of modern technologies. Thus, the result was a comprehensive solution, visually and technologically in compliance with modern concepts in the creation of web applications, offering the user a simple and intuitive interface with cross browser support. Conceptually, the contents of the portal can be divided into the part dedicated to the cartographic presentation of spatial data, the multimedia part, and the active pages for database search.

Web GIS

For several projects online GIS maps were created with the ArcGIS extension: HTML ImageMapper NG2, allowing full control over cartographic quality and functionality. This approach was implemented for small to medium sized GIS Projects, whose geo data have little need for updating. Initial resources for web publishing were ArcMap documents, connected to geodatabases and georeferenced rasters. With flexible parameters and user friendly interface, the HTML ImageMapper NG2 allows easy presentation of geo data, both as vector and raster datasets.

The georeferenced raster datasets, can be seen in the following maps: General geological map (raster) of Serbia 1:100.000, available at http://geoliss.ekoplan.gov.rs/OGK/RasterSrbija, Geological Map Of The Carpatho-Balkanides Between Mehadia, Oravita, Niš And Sofia 1:300000, available at http://geoliss.rgf.rs/KarpatoBalkanidi and Groundwater vulnerability map of Serbia, http://geoliss.ekoplan.gov.rs/hidro/KartaUgrPodVodWeb. Several ArcMap documents based on vector data sets are published: Map of geological curiosities in Serbia, available at http://geoliss.ekoplan.gov.rs/geoZanimljivosti/web, National park Djerdap, set of hydro-geological maps and related description, available at http://geoliss.ekoplan.gov.rs/?page=djerdap and General geological map (vector) of Serbia 1:100.000, with 9 sheets, available at

[3] OneGeology, 2007. International initiative of the geological surveys of the world http://www.onegeology.org

[4] European Parliament and Council, 2007. Infrastructure for Spatial Information in the European Community (INSPIRE), http://inspire.jrc.ec.europa.eu/index.cfm

[5] ALTA4 Geoinformatik AG. 2008. HTML ImageMapper NG2, www.alta4.com

[6] Google Maps API Family, http://code.google.com/apis/maps/index.html

http://geoliss.ekoplan.gov.rs/OGK/OGKVektorWEB. Figure 1 presents one detail of the vector map for sheet Ivanjica.[7]

Several maps were prepared with ArcGIS Server 9.3.1 and web services were published, compliant with the Open Geospatial Consortium's (OGC) Web Map Service (WMS) specification. The next step consisted of building web applications with GIS capabilities using the .NET Web Application Developer Framework (.NET Web ADF) an ASP .Net AJAX (asynchronous JavaScript), with both server-side and client-side controls and libraries. With the use of the above-mentioned technologies, the following was published: Map of the Tara National park available at http://geoliss.ekoplan.gov.rs/Tara (Fig. 2) and the Map of exploration and exploitation permits in Serbia (STANKOVIĆ *et al.*, 2010), available at http://geoliss.ekoplan.gov.rs/geoliep. GeolIEP is a subsystem of GeoISS which deals with keeping track of exploration and exploitation permits and works in the mineral resources field, and 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.[8]

Google Maps API Web Services are also used for the presentation of GeolIEP resources. Namely, the initial KML file is produced from GeolIEP resources, and is subsequently published using Google Earth web service at http://geoliss.rgf.rs/gmap/GE_GeolIEP.htm and Google Maps web service at http://geoliss.rgf.rs/ /gmap/GM_GeolIEP.htm .

The Geological atlas of Serbia 1:2.000.000, published both in Serbian and English, encompasses a number of maps and accompanying legends (DIMITRIJEVIĆ, 1996). The web edition of the Atlas, available at http://geoliss.rgf.rs/index.php?page=atlas, was created with the use of Adobe flash plug-in Zoomify, which enables zooming in real-time, without loss of image quality.

Multimedia part of the web portal

The part of the web portal pertaining to geoheritage and geodiversity of North-Western Serbia represents the Adriatic geotectonic unit through different cycles of geological history, in the time span between 390 and 65 million years. This part of the portal was

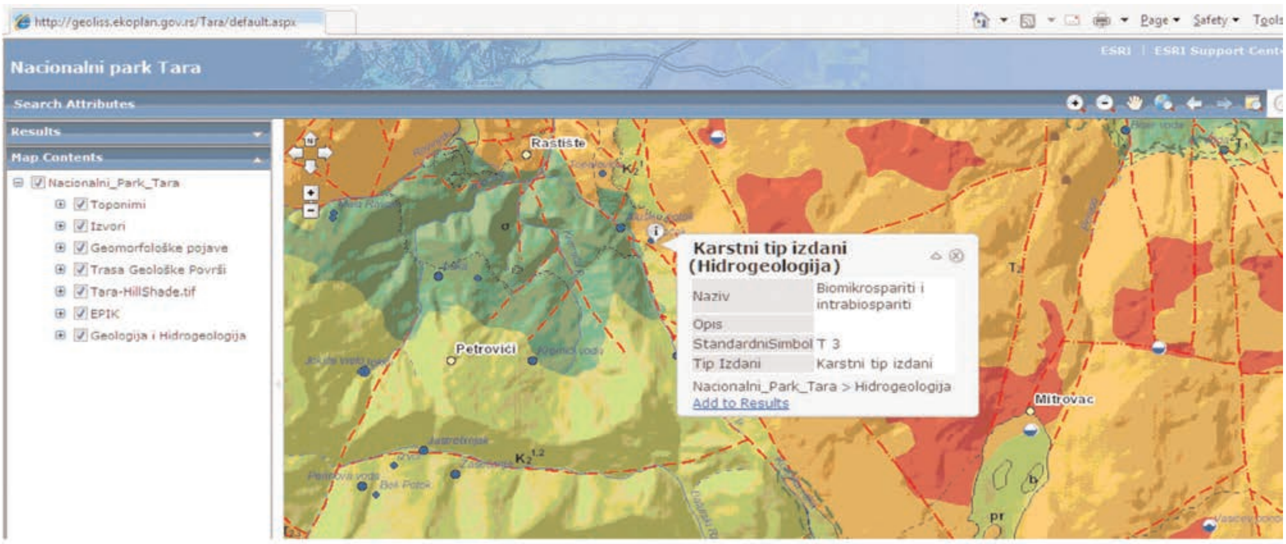

Fig. 2. Map of the Tara National park.

[7] Several projects financed by MEMSP. *Geologic Institute od Serbia*: Geo-referencing of scanned pages, cropping and linking into the national coordinate system of the Basic geological map 1:100.000, 2009, BLAGOJEVIĆ D. *Geozavod Nemetali:* Map of geological curiosities in Serbia 2004-2005, JOVANOVIĆ, J. *FMG:* Study on the hydro-geological research carried out in order to create the geological and hydro-geological information system of the National park Djerdap, DRAGIŠIĆ, Monitoring groundwater resources of Serbia: Drafting the map of the vulnerability of underground water resources of Serbia, 2007-2011. (together with the Institute for water management "Jaroslav Cerni"), STEVANOVIĆ, Z. 2009., Translation of the published cartographic content and the content of the legend for the Basic geological map (OGK) into the format of the Geological information system of Serbia (GeolISS) 2008-2009, JEMCOV, I. & TRIVIĆ, B. 2009.

[8] The project funded by the Provincial secretariat for energy and mineral resources: "Creation of the subsystem for the Autonomous province of Vojvodina within the framework of the geological information system of Serbia – GeolISS", 2009, TRIVIC, B. The project of hydro-geological research with the aim of creating a geological and hydro-geological information system of the Tara National park, 2008-2011, funded by the Ministry, carried out by FMG, DRAGISIC.

developed with the use of PHP script language, jQuery library for text animation and generation of detailed overview of objects, as well as external Adobe flash plug-ins, FlashPageFlip and Zoomify.

Database search

In addition to multimedia contents, the web portal includes several complex forms for searching catalogues: projects, archive documentation and bibliography, documentation of the funds and research-exploitation permits for water and solid mineral resources[10]. The above-mentioned searches were derived from the basic model which is based on multiple entry of key words, phrases, different criteria and finally, the most important part – a ranking of search results.

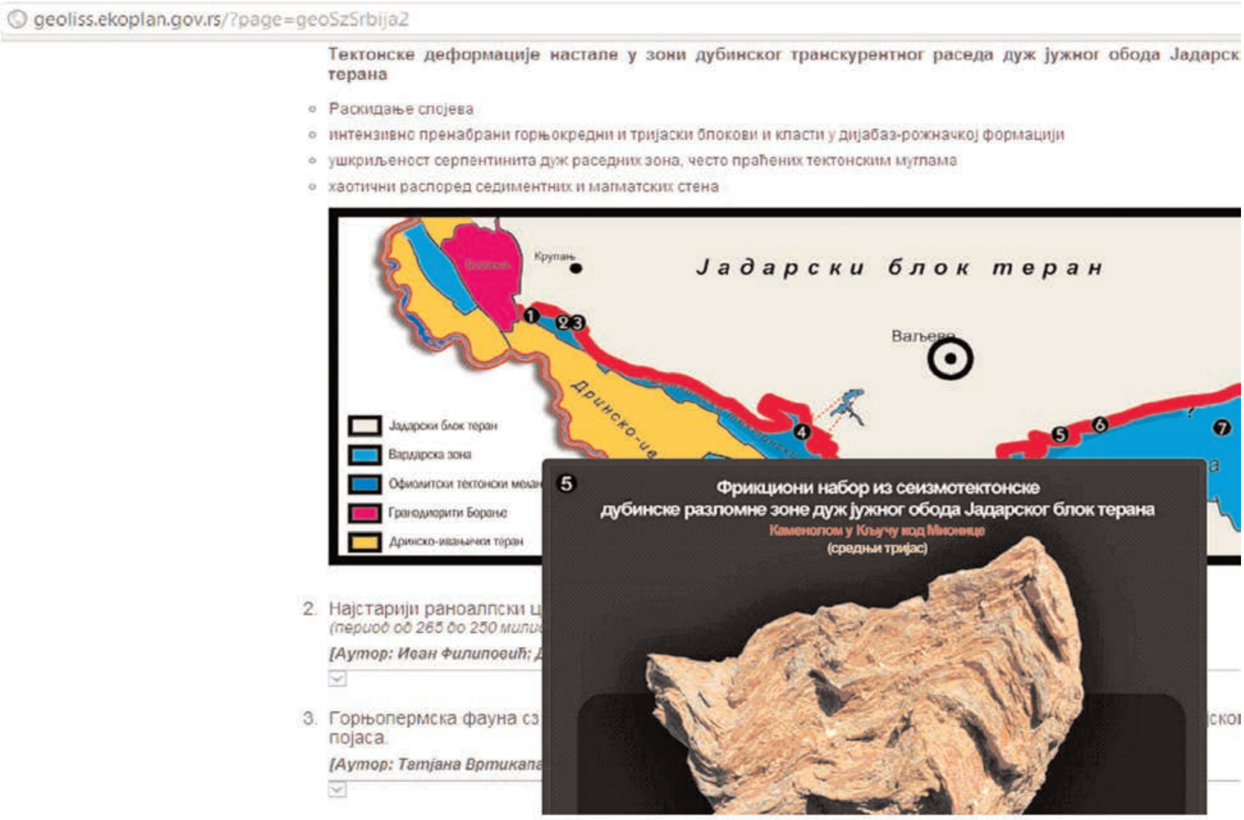

Fig. 3. Details from the webpage on geoheritage and geodiversity of North-Western Serbia.

The multimedia part of the portal is organized in several subsections: subsection consisting of the gallery of photographs, presentations, and video clips and the subsection reserved for the presentation of jewelry mineral resources of Serbia[9].

Photo gallery of geological resources of Serbia was created with the use of PHP script language with the addition of Query library for handling photographs on the client webpage. Video clip gallery was realized using the VideoLightBox library. Video clips are uploaded to the server in .flv (Flash video) format. After importing these libraries, the engine of this plug-in adds the thumbnail of the first frame of the video clip with the link to the .swf player, which plays the clip in a modal panel, adding navigation controls, as well.

The search system includes advanced methods for ranking search results, based on weight factors associated with specific fields in the function of search criteria. Since the data on available search fields, as well as the weight factors for each field, are located in the database, a simple change of these values provides for dynamical adding of criteria, as well as fine-tuning of

[9] The project was funded by MEMSP, Geologic Institute of Serbia: Geo-heritage and geo-diversity of North-Western Serbia 2007-2011, FILIPOVIĆ, I. & JOVANOVIĆ, D. 2011. FMG: Synthesis of geological research of jewelry mineral resources of Serbia with the evaluation of potential 2010-2012, MILADINOVIĆ, Z.

[10] Projects funded by MEMSP. *FMG*: Geological bibliography of the Republic of Serbia

the ranking of search results, based of the number of appearances of a key word or phrase, and the sum of weigh factors of the search field. Namely, a number of entities and their attributes within the database correspond to each search criterion, and each entity/attribute has certain weight factors which determine the relevance of the appearance of a resource within the set of results.

Entering different search criteria is provided for by JavaScript functions, while the search engine was developed with the use of PHP script language and AJAX. By using HTML and CSS for markup, JavaScript for the access to DOM elements, XML (Extensible Markup Language) or JSON (JavaScript Object Notation), data is downloaded from the server and the final results are formated. Query processing on the server side expands the query by creating a matrix of keywords and field types which are searched for on one side, and a list of attributes and weight factors on the other. The query is subsequently transformed into SQL (Structured Query Language) format. Expanded in this way, the query is used to search resources on the basis of entered key words and phrases, within the subset of attributes in the database which fit the chosen search criteria. Ranking of results is performed by adding weight factors and the number of key word/phrase appearances. For example, if the search criterion "mineral resource" is chosen – first a list of entities and attributes which are being searched for the given criterion is read from the database. In this case two entities are searched, the table of documents and their descriptions. The textual field type is searched, and the list includes the title of the paper which includes the entered word, signature of the discipline, abstract of the paper, key words and paper description, with weight factors 4, 2, 3, 1, respectively. If the keyword "gold" is entered, the method on the server sums up the number of appearances of the word "gold" in the abovementioned fields in relation to the given factor. Ranking of the results is carried out in descending order according to the field containing the total sum of factors. The search method described here can be seen at: http://geoliss.ekoplan.gov.rs/index.php?page=fodib.

Geological terminology and nomenclature (GeolissTerm), available at http://geoliss.ekoplan.gov.rs/term, was developed with the use of ASP.NET technology, in combination with jQuery and AJAX. Since the dictionary has a hierarchical structure, terms are displayed in the form of a three to help the user grasp the data and to improve their visibility. When a specific node is chosen, the definition, synonyms and references related to the select dictionary entry are displayed, as well as terms of hyponym and hypernym concepts. The dictionary can also be searched with the use of key words. After entering a string of characters (word or part of a word), the user is offered a list of dictionary entries where the given string of characters appears, and by choosing from the list, the user can get a detailed view of the entry.

Concluding remarks

In this paper, we tried to give a brief presentation of the content of the GeolISS portal, designed to present the data from geological research funded by the MEMPS, as well as the technology used for its realization. Current activities in the development of GeolISS components, as well as the activities related to the portal, are focused on the migration to the ArcGIS 10 platform, the implementation and intensive use of web services and web applications which consume them. Further steps encompass the creation of a lexicon of mapped units, and integration of the dictionary and cartographic representation of spatial objects in which they appear. Further publication of results of both recent, as well as older projects is planned in the upcoming period, as well as the translation of these results into GeolISS format. We also plan to enable the export of data sets from GeolISS to GeoSciML format (http://www.geosciml.org), like BRGM French Geological Survey, CSIRO Exploration and Mining, Australian Government Geoscience portal and other national geological institutions and organizations.

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ESRI: GIS and mapping software, http://www.esri.com, ESRI Developer network http://edn.esri.com

17th Meeting of the Association of European Geological Societes	Abstracts	66–66	BELGRADE, 14–18 September 2011

Geologic Information System of Serbia

BRANISLAV BLAGOJEVIĆ[1], BRANISLAV TRIVIĆ[2], RANKA STANKOVIĆ[2], OLIVERA KITANOVIĆ[2] & NENAD BANJAC[2]

Geologic information system of Serbia (GeolISS) represents repository for digital archiving, query, retrieving, analysis and geologic data visualization. The GeolISS is implemented through ESRI ArcGIS technology, and is designed to operate as a personal geodatabase (MS Jet 4.0 Engine) and SDE enterprise geodatabase in MS SQL Server. The objective of GeolISS implementation is integration of existing geologic archives, data from published maps at different scales, newly acquired field data, as well as Web publishing of geologic information.

Physical implementation of GeolISS has been guided with conceptual and logical model in those specified the basic kinds of geologic entities of interest and how they are described.

The attempt has been influenced by NADM-C1 implementation from USGS and CGS, by GeoSciML interchange scheme from CGI, IUGS (www.seegrid.csiro.au), by different geologic models of European geologic surveys (BGS, BRGM, CGZ, etc.), and various models proposed as part of the International Organization for Standardization Geographic Information/Geomatics project (ISO TC211, http://www.isotc211.org). The design was also significantly influenced by the Ontology Web Language (OWL).

Logical framework of GeolISS implementation is based on five elements: Concept, Observation, Description, Spatial entity – Features and Metadata, mutually linked with relationships.

Concept represent the core of GeolISS that is implemented as compilation of geologic vocabularies such as petrologic and mineralogic classification, geologic time scale, stratigraphic lexicon etc. The terms in the vocabularies are used to classify observations/interpretations, or to specify attribute values.

Observations implement field data, records and measurements i.e. the basis for classified features, interpretations and models. Any observed property can be expressed as a text, number, picture and geometry (location).

Spatial entities are treated as observation localities and mapped/interpreted geologic entities (occurrences). In the ESRI geodatabase they are implemented as a *Feature Classes,* geometrically adjusted to points, lines and polygons. Each of them is linked to one or more description objects that specify property values.

Description is implemented as an instance of observation and interpretation. Any instance is collection of properties with assigned values (e.g. attributes) that characterize some geologic occurrence.

Metadata implemented in the GeolISS allows the recording of data source, links to the bibliographical references and persons involved and responsible for data acquisition. Metadata also include essential information's about project, for which the data are to be collected.

For data entry in GeolISS database designed special ArcGIS extension was designed and implemented in MS Visual Studio and ArcObject.NET API to support data entry in both; personal and enterprise geodatabase.

Key words: Geologic information system, Conceptual model, Logical model, Implementation, Geodatabase.

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17th Meeting of the Association of European Geological Societes	Proceedings	67–71	Belgrade, 14–18 September 2011

Sedimentation and Basin Modeling as an Innovative Trend of Regional Geological Projects of LLC "Gazpromneft Science and Technology Center"

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Abstract. The ultimate goal of the regional studies is a further growth of the hydrocarbon resource base required for the execution of the Company's Strategy to increase hydrocarbon production. The main purposes of the regional studies include geological history reconstruction, petroleum system analysis and resource estimate of onshore and offshore basins with different geological structure and state of knowledge. Sedimentation and Basin modeling approach has been implemented in the Company's Science and Technology Center with use of Beicip Franlab software tools.

Sedimentation modeling (Dionisos software) based on regional geology, tectonics and stratigraphy data is an innovative method that significantly refines the traditional facies mapping and analysis. Simulation of depositional systems helps to predict the reservoir and source rocks distribution in a sedimentary basin. Sedimentation modeling is basically performed for both frontier and mature regions. The scale of the model can vary in the range of tens to hundreds of kilometers.

Modeling of hydrocarbon systems is performed in Temis Suite software. It helps to understand the petroleum systems evolution: hydrocarbon generation time constraints, most favorable migration paths and drainage areas, accumulation volumes, phase and location. The analysis allows to complete qualitative and quantitative resource estimate of the basin and to make licensing recommendations.

Regional projects involving the basin analysis and 3D modeling techniques were performed for the Black Sea shelf, Eastern Siberia, Caspian and Kara Sea shelves. As the results, resource estimates of the basins were made and licensing recommendations regarding the most promising blocks were given. These results, in particular, suggest that the geologic conditions in the South Kara Basin are favorable for further discoveries of giant gas fields.

Key words: Sedimentation, basin, modeling, shelf, Kara, sea, licensing, resources.

Introduction

Regional scientific studies are of huge practical use since it is a pre-requisite for further growth of the resource base and the implementation of the Company's hydrocarbon production growth plans. Regional studies are often aimed at underexplored, difficult-to-access areas. One of the Gazpromneft's strategic focuses today is the development of the Arctic Shelf /1/. Initial total recoverable resources in the area amount to over 80 Btoe, with more than 80 % accounted for gas.

Until recently, the investigation of major regions was the exclusive privilege of governmental institutions, whereas Research and Development (R&D) divisions within Russian oil-and-gas companies normally performed research limited to their license areas. However, in the last few years, the production companies experienced a significant increase in in-house R&D, including regional studies. According to the Deloitte independent consulting agency, to date, scientific and R&D centers of Russian oil-and-gas companies perform up to 80 % of all the R&D and design documentation work/2/, including 13 % by the governmental institutes. The underlying reason why "Gazprom neft" wants to perform in-house regional studies is the need for an independent view on the geology, thus, resources and phases in the offshore / onshore areas.

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Little regulation is applied to regional projects and this makes them different from standard geological design documents, such as oil resource estimations, prospecting and exploration projects, etc., which are governed by detailed procedures. This sphere is of the most creative nature and requires personal scientific interest along with a high qualification of the staff involved. The outcome of regional studies is not easy to assess from the objective point of view because there is no uniform solution for the problems to be resolved. When modeling an underexplored area, we assume lots of uncertainties that more or less influence the results. This leads to multiple solutions of a problem. The criteria, which can be applied to sense check the adequacy of the region's model built, is zero discrepancy between the subsurface processes that occurred and the most probable evolution scenario. The ultimate and practical output resulting from this work is the independent assessment of HC resources and subsequent selection of areas as potential license areas and focus. Therefore, such work serves as basis for new trends and new regions in the Company's business.

Gazpromneft Science and Technology Center has formed a regional project algorithm (Fig. 1) based on the use of sedimentation and basin modeling. The key objective of such studies is to trace back the evolution of subsurface continental and marine regions with various geology and state of exploration. First, a cartographic database is built up together with making the grid of the region under study.

To further resolve the problem of prospecting, the specialist of the Company's Science and Technology Center consistently use the software by the French Beicip Franlab for sedimentation modeling (Dionisos) and basin modeling (Temis). Those tools help to define the subsurface processes that occurred in time and to trace the basin history. Due to the uncertainties that arise when modeling underexplored areas, the specialists have to calibrate the results by comparing the calculated data with the actual data. When there is no well control in the region, modeling is done given the current assumptions and uncertainties with multiple solutions. The result of such studies depends on testing the models to pick up the most probable case.

Seismic data interpretation.

One of the most important basic geophysical tools for regional oil and gas studies is 2D seismic. Gazpromneft Science and Technology Center evaluates the quality of seismic acquisition data and then, if needed, involves contractors to process or reprocess seismic data using state-of-the-art technologies and software. Then, the specialists of Gazpromneft Science and Technology Center perform further interpretation of 2D seismic data. Seismic horizons are interpreted observing phase, amplitude and frequency variations jointly with regional and structural geologists. Seismic data are often complemented with data obtained by other geophysical methods, for instance, electric, gravity, magnetic exploration, as well as log data. Seismic section interpretation results are then used for structural mapping of individual horizons and seismic isopach mapping. The deliverable for seismic data interpretation combined with other geological and geophysical (G&G) information is the regional seismo-geological 3D model.

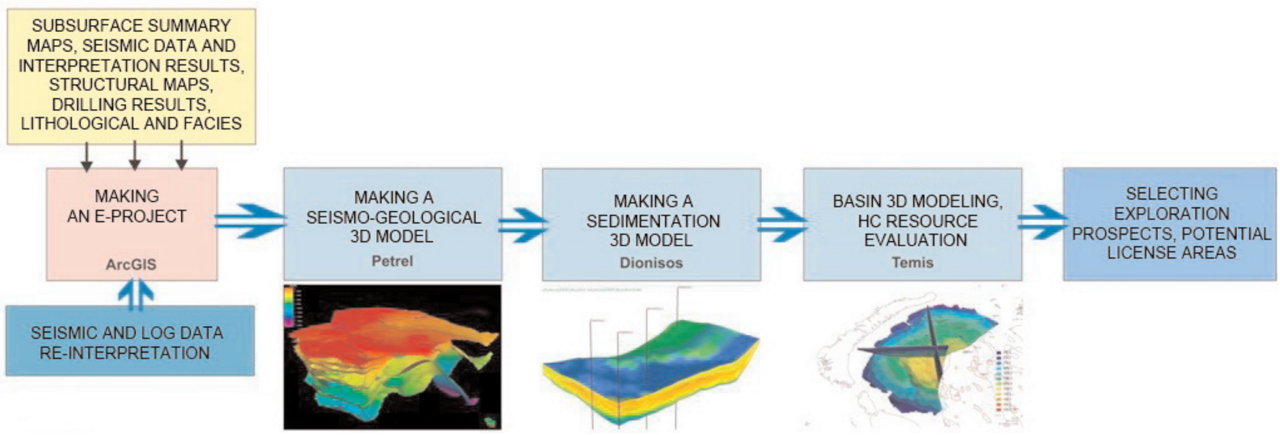

Fig. 1. Regional Project Sequence.

Reflector maps made from the seismo-geological model are the input data for sedimentation modeling, along with structural and stratigraphic analysis results. **Sedimentation modeling** is done in the Dionisos software package and is the innovation method that complements, detalizes and can be used instead of traditional paleogeographic and litho-facies mapping. Sedimentation modeling involving regional geology, tectonics, and stratigraphy data enables a well-substantiated prediction of reservoir and source rock distribution in the sedimentary basin. The simulation principles for terrigeneous sedimentation systems consist in mathematical formulation of different size clastic material transportation from the source of supply into the basin. In the case of carbonate and mixed systems, accumulation and dissolution (erosion) rates of biogenic and chemogenic deposits functionally depend on such depositional environment as the depth of the basin, type of the water drive, rock type, environmental features of reef-building organisms, etc. The modeling accounts for such parameters as basin warping rate, paleotopography, sea level fluctuations, climate, etc. Then such a model allows to assess the most probable distribution of clastic rock types, their facies and thicknesses and study the influence of depositional processes on the petroleum potential of the basin. Sedimentation modeling can be performed for both underexplored and mature regions, and the model scale can vary in a wide range from tens to hundreds kilometers.

Basin modeling

Further 1D, 2D, and 3D modeling of HC basin systems in the Temis software package makes it possible to understand HC generation, migration and accumulation evolution processes, which ultimately leads to identifying reservoirs and traps with expected HC potential and resource characterization.

First regional projects at Gazpromneft Science and Technology Center to include basin modeling technology were performed as far back as in 2009 for the Black Sea Shelf and Predpatom Basin in the Eastern Siberia/3/. Modeling was done in 2D, which helped to analyze the behavior of HC systems, identify critical factors for the generation and evolution of such systems, trace back the time and scale of the HC generation process, identify the most favorable HC migration paths and predict key accumulation zones.

This year, the Caspian and Kara Sea Basin regional work has seen completion. To analyze HC systems within those basins, we used 3D basin modeling and evaluated the petroleum potential in the regions both on the qualitative and quantitative level. HC system models for the South and North Kara Basins were built based on sedimentation models, which helped to carry out the studies at an absolutely new level. The sedimentation modeling results, along with G&G and geochemical data for the offset inland areas, became the basis of the approved G&G and geochemical model, in other words, that enabled to predict the lithological composition but also forecast the distribution of source rock in the Kara Sea offshore area, since, in general, clay and carbonate clay facies and the basin depth control the organic content and geochemical properties.

3D modeling, as distinguished from 2D, helps to identify the most favorable HC migration paths and give a quantitative evaluation of HC accumulations. In the course of the work, we performed the basin resource estimation and recommended the most promising areas for licensing. The modeling results proved in the South Kara Basin there exist all the conditions to discover giant oil and gas fields. In addition, several uncertainties were established as related to insufficient information of the prospective North Kara Basin. One of the key risks for this basin is the distribution of regional top seals and the phase. Seismic data re-interpretation that included the known regional tectonics in the Paleozoic (Baikal, Caledoniam and Hercynian tectonic genesis) caused a considerably new vision on the North Kara Sedimentary Basin. The known bitumen shows at the rimming archipelagoes of the Severnaya n Novaya Zemlya are traditionally viewed as the sign of oil and gas in the subsurface, whereas in some scenarios they can be relicts of pre-existent pools. Younger pools in the sedimentary basin can predominantly be gas ones. However, it is worth highlighting that the current state of subsurface knowledge does not allow for exact conclusions, which is why further comprehensive regional study is a critical issue.

Hydrocarbon resource evaluation is performed as part of the regional studies based on sedimentation and basin modeling. Modern software products make it possible to fully analyze the conditions influencing the generation of the source rock, reservoirs, top seals, and predict cases of oil and gas generation, migration, accumulation and preservation. Specifically, such programs give a basically new vision on geology and the resource potential of this rich but hard-to-access and underexplored area (with insufficient drilling and seismic coverage), which is the Russian Arctic. As the available technique enables a higher degree of confidence in evaluating localized resources, prospecting for the licensing purpose is done at a high quality level.

Prior to the work, we analyze and assess the reliability of resource evaluations by other authors and perform the HC density distribution within the basin. The most famous and representative are the evaluations of the region's resource potential performed by the Russian Geological Research and Development Oil Institute (VNIGNI), Trofimuk Oil and Gas G&G Institute (INGG SB RAS), US Geological Survey (USGS). In addition, there are other original evaluations based on personal opinions of individual specialists. Such opinions are also taken into account and critically analyzed. When Gazpromneft Science and Technology Center performs the HC resource evaluation based on basin modeling, the results are necessarily compared with the previous ones. Oil and gas accumulation zones can be identified as part of prospecting (Fig. 2).

Conclusion

The truth is that in the Arctic, exploration is oriented to finding major fields since only reservoirs with

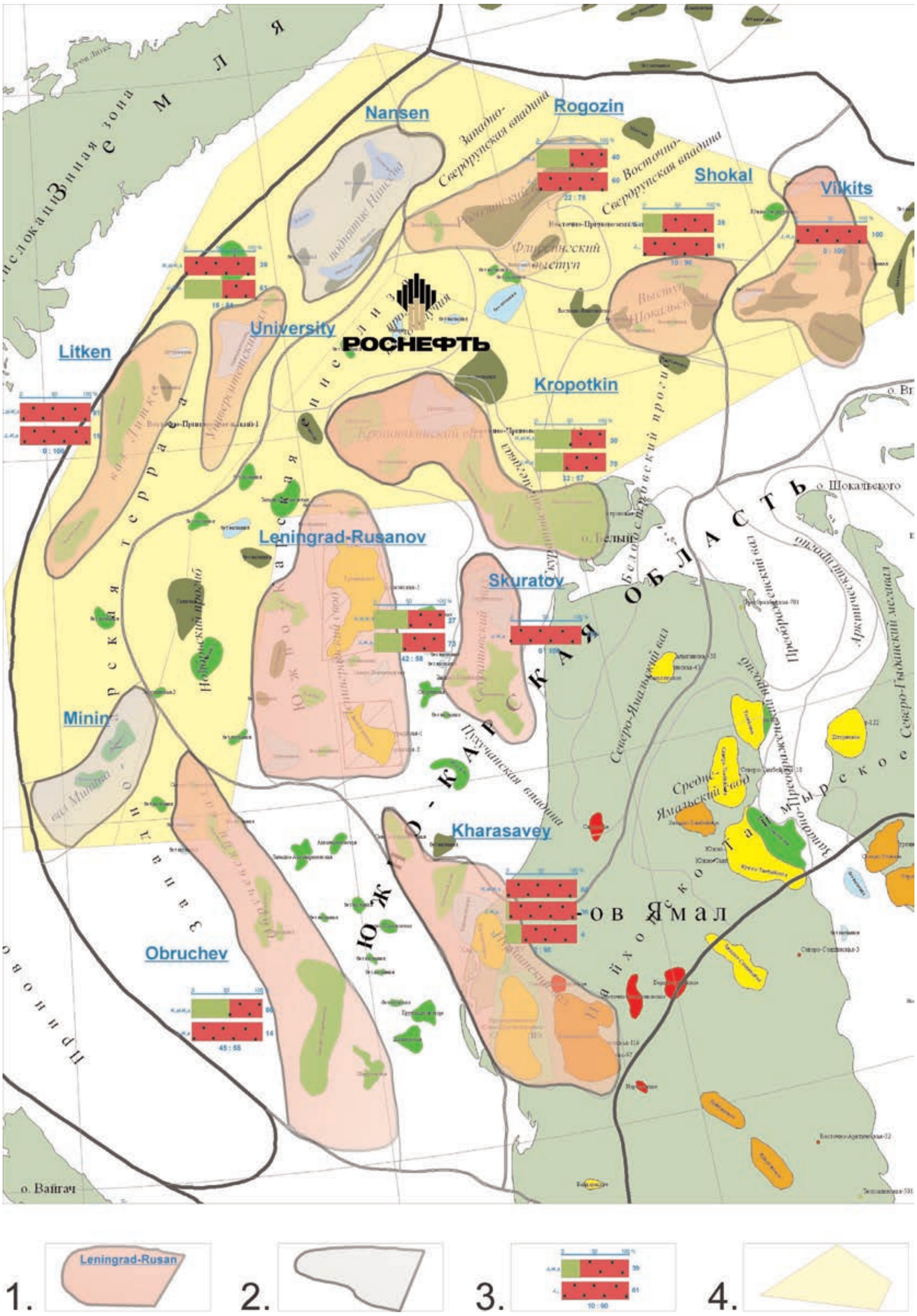

Fig. 2. Oil-and-gas Accumulation Zones, South-Kara Region. Legend: 1. Oil-an-gas accumulation zones: established presence of oil and gas, zones are potential prospects based on basin modeling; 2. Oil-an-gas accumulation zones: no-prospect zones based on basin modeling; 3. in the column: on the left – age of the units, on the right – initial total in place HC resources per each unit in % of the total for the zone, in the center – percentage of liquid and gaseous HC in the resources of each unit (solid color fill – oil and condensate resources, pattern fill – gas resources). At the foot of the column there is a ratio of liquid and gaseous HC in the cross-section as a whole; 4. Rosneft license areas.

large resources can be economic. Offshore project require high financial investment at the initial stage of development, so the error in subsurface predictions should be as low as possible. Subsurface risk assessment is performed for that purpose, as related to reservoir properties, top seals, traps, fluid generation and migration from the source rock. Thorough selection of the targets is critical for managerial and investment decision-making.

Prospecting is the end result of regional studies. Their size and outline account for the areal and geometry variation of the prospects through exploration. However, it is important to determine the optimal dimensions of the area since the Operator will have payment obligations and they will depend on the acreage.

Thus, regional studies for Russian companies are of huge importance in the practical terms. This work is based on sophisticated software systems to include both sedimentation and basin modeling. Gazpromneft Science and Technology Center developed and generally applies the regional technique, which enables qualitative petroleum potential evaluation of underexplored onshore and offshore areas. The results of the studies serve as basis for outlining and recommending the prospects for further licensing, which when developed will extend the resource base and increase the Company's capitalization.

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17th Meeting of the Association of European Geological Societes	Proceedings	73–75	Belgrade, 14–18 September 2011

Involvement in Development Hard to Recover Reservoirs Based on Killed Wells

Vladislav Bakhurskiy[1], Marat Azamatov[1] & Aleksey Artamonov[1]

Abstract. In our days working with oil fields at last stage of development it is important to give attention to inactive wells that is wells which are in conservation or flooded wells. In this article it is considered activities to movement inactive wells to production wells in order to involve into development unworked reserves not produced reservoir BS12 of Muravlenkovskoe oil field.

Key words: development, killed wells, hard to recover reservoirs.

Introduction

Muravlenkovskoe oil field is situated in Purovskiy region, Tumen region near to Sutorminskoe and Krainee oil fields, north from Noyabrsk-city. The general objects of development are BS101, BS102, BS11, BS12 reservoirs. Now days it is about 1300 exploitation wells on Muravlenkovskoe oil field, and only no more 290 wells are produced and about 200 wells are injection wells. Other wells are inactive wells. Most of wells are produced at incumbent, not open up BS12 reservoir (Fig. 1). Productivity of reservoir is proved by exploratory well 247R: oil rate is 6,8 m^3/day, bottom hole pressure is 183 atm. Initial oil in place is 1,328 million ton., recoverable reserves 0,221 million ton.

History of development

Development of BS12 reservoir based on wells 1206, 2194, 2410. It is produced about 4498 ton. of oil since 1992 to 2001 years.

For the purpose of increase oil production every production well is fractured.

Well 2194, well pad 49, was perforated in 1992 year (initial parameters: fluid rate 6 m^3/day, oil rate 5 m^3/day, water cut 18%). In 1997 year it was fractured (5 ton. of proppant in stratum) and was started with parameters: fluid rate 31 m^3/day, oil rate 1,5 m^3/day, water cut 95 %. At the moment of fracturing it was produced about 1184 ton. of oil. After fracturing it worked 10 days and was stopped due to high water cut level.

Fracturing of well 1206, well pad 66, was also unsuccessful. After injection into stratum 14 ton. of proppant well was started with parameters: fluid rate 40 m^3/day, oil rate 1 m^3/day, water cut 97 %. In the same month well was stopped as profitless well.

In 1997 year well 2410, well pad 54, after fracturing and injection into well 5 ton. of proppant was started with parameters: fluid rate 51 m^3/day, oil rate 16 m^3/day, water cut 69 %. By produced 1865 ton. of oil before frac, it was additionally recovered 1430 ton. It stopped in 2001 year due to small oil rate: fluid rate 13 m^3/day, oil rate 1 m^3/day, water cut 92 %. One of reason of high level of water cut of wells are its margin location relative to arch of reservoir and as result possible bounder of oil-water contact (Fig. 2).

Deepening of well 937 to bs12 reservoir

Well 937, well pad 49, was changed as optimal candidate to “return” to produced reservoir BS12 (Fig. 3). Well was exploited since 1989 year on base reservoir BS11. In 2006 year it was moved to conservation well stock due to high level of water cut. Since 2007 to 2010 years it is injection well on base reservoir BS11. For “returning” well to developing of underseam BS12 it was isolated reservoir BS11 and after that it

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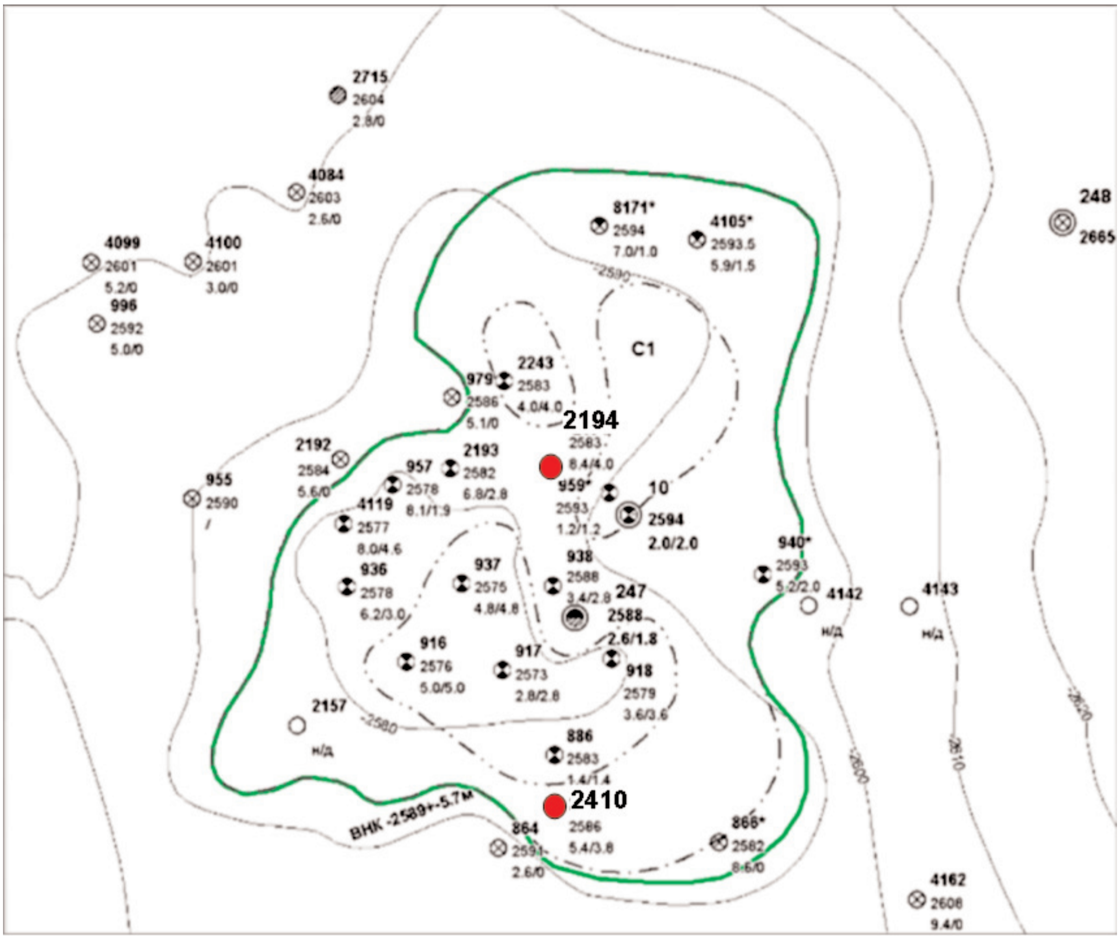

Fig. 1. Segment of structural map of BS12 reservoir of Muravlenkovskoe oil field.

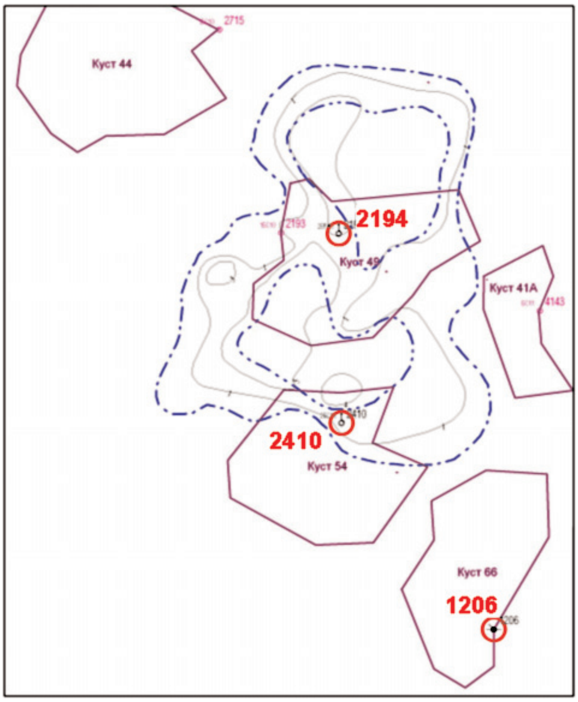

Fig. 2. Drilling out map of BS12 reservoir of Muravlenkovskoe oil field.

was drilled 34 meters cement shoe in order to deepening to BS12 (initial drilled depth – 2865 m, bottom of casing – 2831m, current depth of well – 2792m).

The feature of activities is that drilling was operated not drilling rig and without using drilling equipment, but using workover gang. Such procedure decrease economical costs of repair. For drilling 34 m of cement shoe by ring cutter it is taken about 49 hours.

In June of 2011 year well was fractured and it was injected about 37 ton. of proppant. Well started with parameters: fluid rate 55 m^3/day, oil rate 14 m^3/day, water cut 70 %. It is considered that level of water cut is decreased and as result oil rate is increased. It is predicted that well will produced about 11700 ton. of oil by its unprofitability (that is water cut 98%).

Conclusions

Deepening of well to underseam reservoir BS12 is seems successful as technical feature and as geological feature providing profitable oil rate from well.

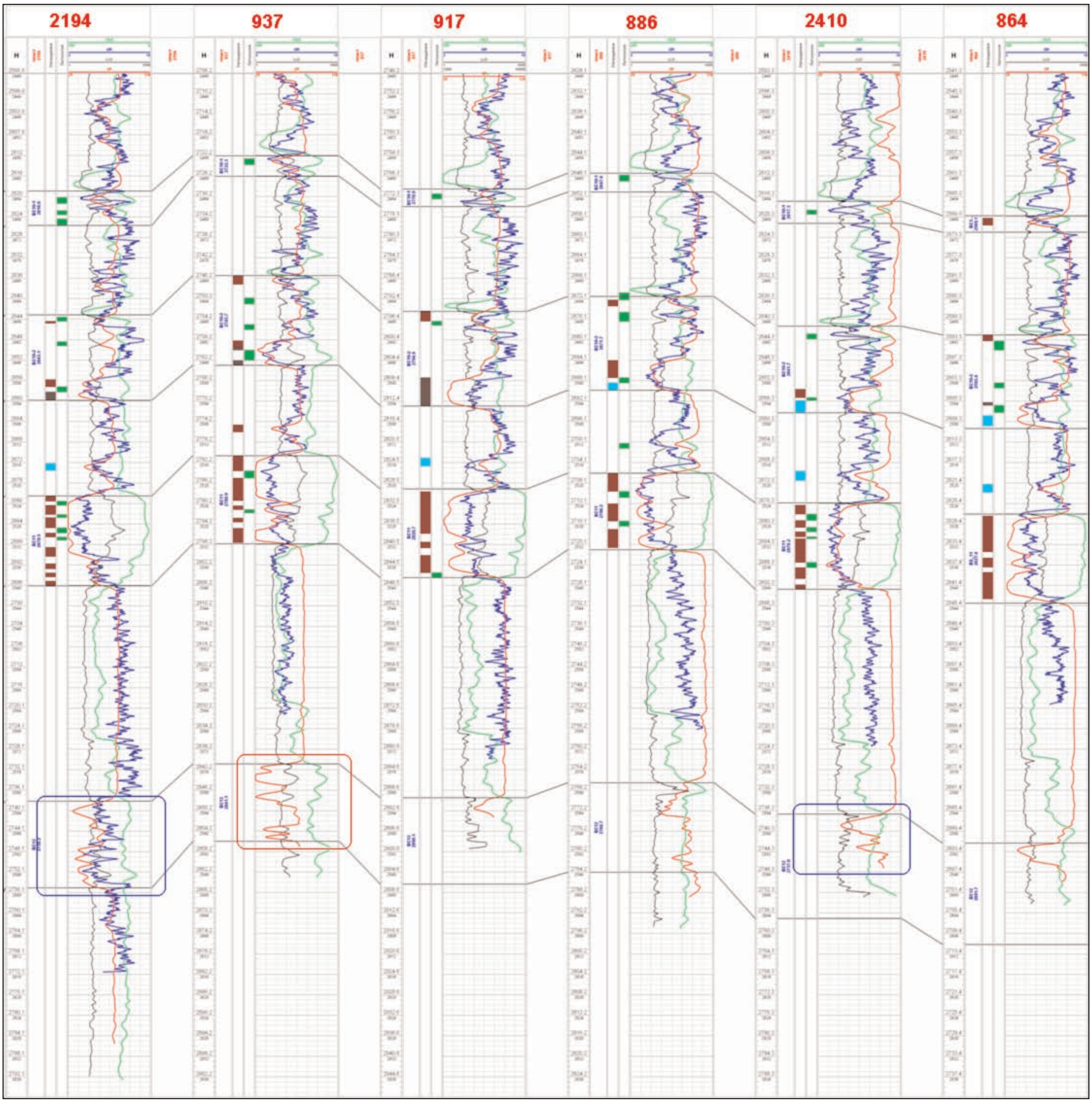

Fig. 3. Geological cross-section, wells 2194-937-917-886-2410-864.

Large number of inactive wells drilled to base reservoir BS12 is allowed to suppose activities for effective development of reserves of reservoir BS12 of Muravlenkovskoe oil field.

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Oil-and-Gas Content Prospects of the Kuznetsk Bending (the South of Western Siberia, Russia)

JAROSLAV GUTAK[1]

Abstract. The main oil and gas content of the section the Kuznetsk coal basin (Kuzbass) belongs to the second half of the Carboniferous (Mississippian) and the Permian stage. The coal layers of Kuzbass are enriched with methane and can be regarded as a gas source. Prospective resources of gas in coals of the basin up to the depth of 1,8 km according to experts are about 13 trillion m^3. Extraction of methane from coal layers of Kuzbass has already begun (Taldinsky deposit) and in the long term it can cover all region requirements for these resources. Considerable resources of free methane are supposed to be detected under the Salair allochton. The second potential sources of hydrocarbons in the Kuznetsk bending are undercarbonic deposits (the Middle and the Upper Devonian, the Lower Carboniferous). The positive estimation of hydrocarbonic resources of the Kuznetsk bending rests upon a number of direct signs: In the Middle Devonian section there are petroparent rocks (bituminous shale of Dmitrievsko–Pereboiskaya suite) and deposit of lithobiolith coal in pool of the Barzas river (Barzasskaya rogozhka, barzassit) which relates to the bottom part of the Middle Devonian section and are represented by two layers of industrial capacity. Barsassit resources in Barzassky area, up to the depth of 600 m, by official estimation total 64 million tons.

Key words: Devonian, Carboniferous, Permian, coal, oil, gas, Kuznetsk, Siberia.

Kuznetsk bending (widely known under the name the Kuznetsk coal basin, Kuzbass) as geological structure, had began its formation in the Middle Devonian (the beginning the Eifelian Age). It is the largest sedimentation pool within the southeast frame of the Western-Siberian plate (with the flat area of 26700 square km).

Last stages of sedimentation referred to the Permian System. During that significantly long time interval (nearly 110 million years) thicknesses of sedimentary rocks of high capacity mainly terrigenous (conglomerate, sandstone, aleurolite, argillite) were formed within the bend. In the bottom part of section there are limestone (bedded and biohermal). Coal layers are known all around the section. The first of them were fixed at section basis and dated as the Eifelian Age of the Middle Devonian. The main oil and gas content of the section attributes to the second half of the Carboniferous (the Mississippian) and the Permian. In total section contains about 420 carboniferous layers with general capacity of more than 400 m. The considered resources of coal to 1800 m depth exceed 600 billion t, including coals of coking sorts. By its coal resources Kuzbass takes the third place in Russia. Today Kuzbass enterprises extract more than 50% of all the Russian coal and 80% – of coking sorts of coal (KONTOROVICH & CHURASHOV, 2008).

This feature of the region has negatively affected its oil gas content study, though prospects of finding hydrocarbon deposits here are considerably great. Potential oil content of the Kuznetsk bend was noted by I. M. Gubkin – the outstanding Russian researcher of hydrocarbons in 1932, and as far as his two predictions for oil presence in the Volga region and Western Siberia have come true why not his third prediction to come true.

Geologically Kuznetsk bend has dissymmetric structure with natural increase in capacity of sedimentation layers from the east on the west, from structures of the Kuznetsk Ala Tau to folded systems of Salair and Tom'-Kolyvan (capacity of the Devonian, the Carboniferous and the Permian deposits here totals up to 10 km). Intensity of folded and explosive deformations is increasing in the same direction. According to geological and geophysical supervision of structure Tom'-Kolyvanskaya zone and Salair are pulled over

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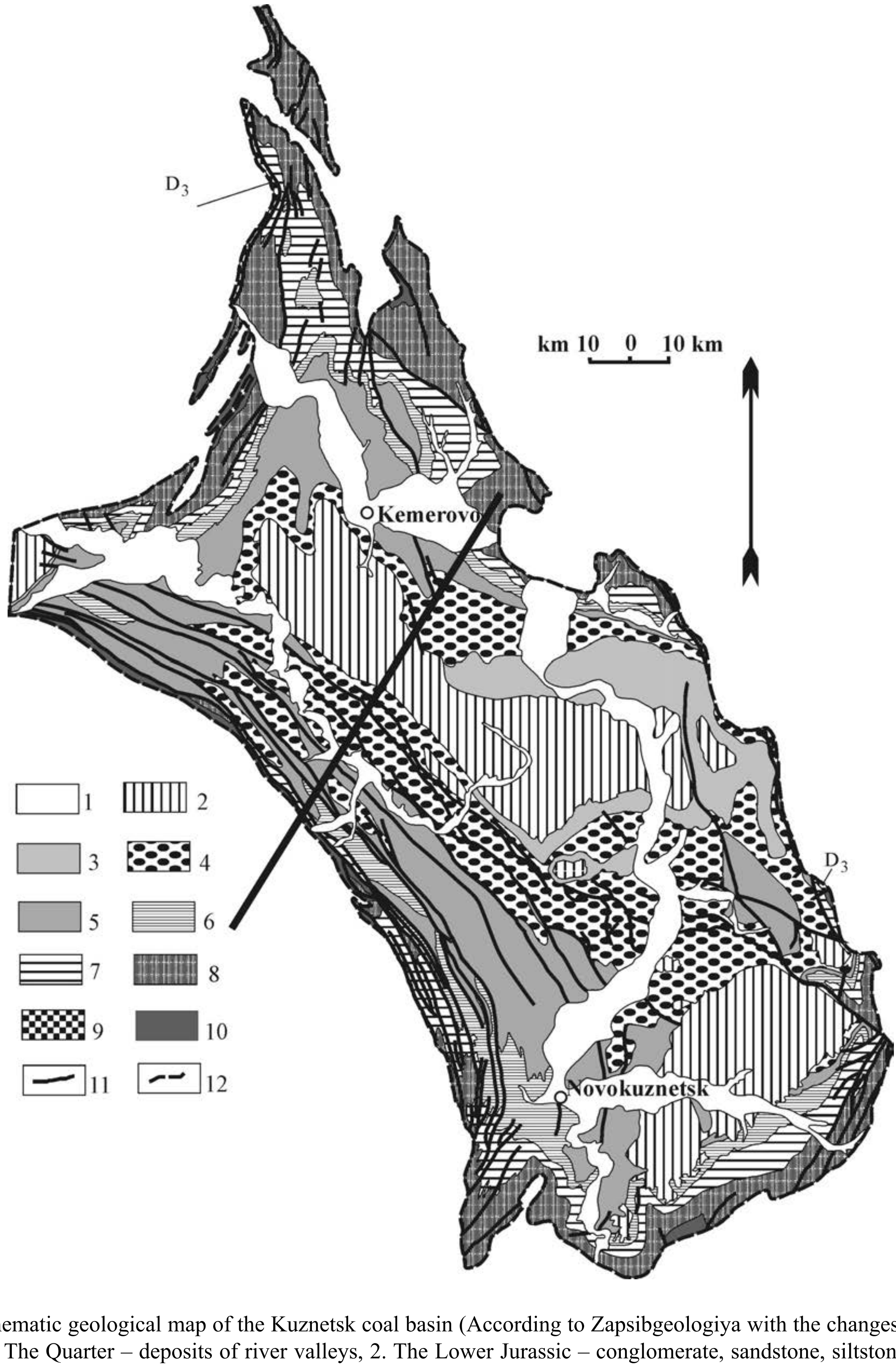

Fig. 1. Schematic geological map of the Kuznetsk coal basin (According to Zapsibgeologiya with the changes made by the author). 1. The Quarter – deposits of river valleys, 2. The Lower Jurassic – conglomerate, sandstone, siltstone, brown and black coals, 3. The Lower Triassic – sandstones, siltstones, tuffs, basalts, 4. The Upper Permian, Erunakovskaya Formation – sandstones, siltstones, coals, 5. The Upper Permian, Ilinskaya Formation – sandstones, siltstones, mudstones, coals, 6. Lower–Middle Permian, Kuznetsk Formation – sandstones, siltstones, marls, 7. The Lower Permian, Verhnebalahonskaya Formation – siltstones, conglomerates, coals; 8. The Carboniferous, Pennsylvanian, Nizhnebalahonskaya, Kaezovsky Formation – siltstones, conglomerates, coals, 9. Carboniferous, Mississippian, Mozzhuhinskaya and Evseevskaya Formation – limestone, sandstone, mudstone, marl, dolomite, 10. The Upper Devonian – conglomerates, sandstones and limestones, marl, 11. Faults, 12. Boundary of the Kuznetsk coal basin.

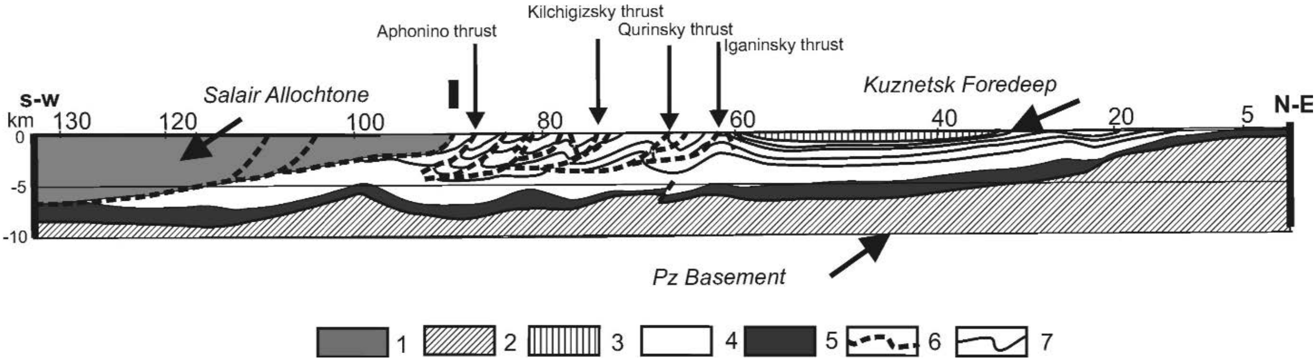

Fig. 2. Schematic section of the Kuznetsk basin based on seismic profile 05. 1. Salairsky allochthone, 2. The foundation of the Kuznetsk basin, 3–5. The structures of the Kuznetsk basin (3. Mesozoic, 4. Coal-bearing sediments of the Late Carboniferous and the Permian, 5. Deposits of the Middle Devonian – the Early Carboniferous), 6. Faults; 7. Structural lines of coal-bearing deposits.

carboniferous deposits of Kuzbass. The joint with Tom'-Kolyvan passes on Tomsky overthrust (proved amplitude exceeds 15 km), the border with Salair is traced along the Tyrganskye overthrusts zone (prospective amplitude according to seismicity reaches hundreds kilometers). In a sense the Kuznetsk bending reminds marginal foothill deflections (the Prekarpatsky for example).

Salairsky range according to these interpretations is considered to be a large terrane, pulled over the structures of the Kuznetsk bending during the Mesozoic time. Footwall of this allochtoon is regarded as gas deposits prospective. The coal layers of Kuzbass enriched with methane can be regarded as a gas source. Prospective resources of gas in coals of the basin up to the depth of 1,8 km according to experts are about 13 trillion m^3 (Kontorovich & Churashov, 2008). Extraction of methane from coal layers of Kuzbass has already begun (the Taldinsky deposit) and in the long term it can cover all region requirements for this raw material. Considerable resources of free methane are supposed to be detected under the Salair allochtoon.

The second potential source of hydrocarbons in the Kuznetsk bending is undercarbonic deposits (the Middle and the Upper Devonian, the Lower Carboniferous). They are composed of multicolored terrigenous-carboniferous rocks complex of considerable capacity. Mainly there are sea shelf deposits containing wedge-shaped deposits of continental genesis. Coarse-grained terrigenous deposits, especially wedge-shaped, possess high free porosity and can be regarded as potential collectors. In some cases carbonate rocks posses good collective properties, specially reef facies (reeves of the Kuznetsk bending are localized in the top part of the section in the Frasnian layer of the Upper Devonian). Powerful packs of clay rocks containing in the section will act as magnificent lithologic screens.

The positive estimation of hydrocarbonic resources of the Kuznetsk bending rests upon a number of direct signs:

– in the Middle Devonian section there are petroparent rocks (bituminous shale of Dmitrievsko–Perebojskaya suite). They emerge on a surface in pool of the river of Barzas near village Dmitrievka where they form the Dmitrievskoye deposit of burning shale. Capacity of bituminous rocks unit is 35–40 m. According to its resources capacity this deposit is regarded as an average – up to 755 million tons). Hydrocarbons make 8–12 % of rocks body. They are presented by an oily liquid of yellowish-brown colour with a typical oil smell, containing: C (78 %), H (10 %), O (1 %). Humidity of burning shale counts to1, 5–2,5 %, ash content 63–73 %, devolatilization 9–25 % (Cherepovski, 2003).

– in pool of the river of Barzas near the settlement with the same name the deposit of lithobiolith coal (Barzasskaya rogozhka, barzassit) is known. The deposit relates to the bottom part of the Middle Devonian section and represented by two layers of industrial capacity. Barsassit resources in Barzassky area up to the depth of 600 m (by official estimation) totals to 64 million tons (Fedorin *et al.*, 2003). Distinctive feature of this deposit is high content of hydrocarbons in coals, so that they may be petrogenerating. Elements structure of coals by high hydrogen (to 8,6 %) and carbon (to 86 %) content. Tar extraction from the ordinary coal is 14,7 %. Institute of combustible minerals in 1984 constituted high (95 %) degree of transformation of coal organic mass with the consumption of hydrogen of 1,7–2,3 % for the organic mass of paste, extraction of liquid products of 91,7–93,7 % and low (4,6–5,1 %) gas generation. In liquid products prevails the fraction with boiling temperature above 300° C. Low phenol resin with the subsequent processing in liquid fuel and organic binding material for asphalt concrete may be produced from Barsassky coal (Cherepovski, 2003).

– sedimentary deposits of the Kuznetsk bending are broken by intrusions (sills) basalts of the Trappean formation of the Early Triassic. In some cases basalt almonds are composed by bitumen and crude oil that specifies the break of real oil pools by intrusions.

Despite the obvious signs of oil-bearing of region, there were no significant attempts of its detection. Only reconnaissance parametrical drilling of several well around the Nevsky clint in the middle of last century and the project of drilling of a basic deep parametrical well under Salair overthrust in the nineties of last century may be recollected. The first attempt was interrupted by opening of the big oil in Western Siberia, and the second has not been fulfilled because of political and economic crisis burst out in country.

It is unlikely that such works will be renewed now. That would require mandatory state financing and the developed long-term program of parametrical and search drilling (with well depths to five-six thousand meters). Required is advance areal geophysical investigation (seismic profiling). During all the history of investigations in Kuzbass only one profile was driven in the end of last century, but that works have not been finished.

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Application of Jet Drilling Technology for Incremental Recovery of Hard to Recover Reserves

KONSTANTIN GRIGORYEV[1], VITALY KORYABKIN[1] & PAVEL KOLBA[1]

Abstract. The jet drilling technology came in Russia in 2002. Since its first applying in Russia the jet drilling technology is considered as one of the reliable technologies for fluid recovery in fractured formations. However, this technology is not widely adopted in terrigenous formations which the main part of oil fields in Western Siberia is referred to. Since the jet drilling technology does not have specific physical limitations, it could be employed to formations of any lithology. Nevertheless, the question about its applicability in conditions of Western Siberia is still open. It is caused by lack of information about technology testing on terrigenous fields.

The purpose of the presented work is to estimate possibilities of applying the jet drilling technology to recover remaining reserves of the 1BP11 formation in Vyngajahinskoe field. The 1BP11 formation is characterized by premature shut-in of wells caused by significant value of well production water cut. Widely used incremental recovery methods – hydraulic fracturing and sidetracking – have failed because of the complex geology aspects.

In the presented work authors show the perspectives of application of the jet drilling technology for incremental recovery of hard to recover oil reserves from the 1BP11 formation in the Vyngajahinskoe field.

Key words: Jet Drilling, Incremental Recovery, Oil Reserves, Western Siberia.

Description of Field Conditions and Production History

The 1BP11 formation in Vyngajahinskoe field is a terrigenous oil saturated formation which contains the main part of reserves of the field. The formation is characterized by premature shut-in of wells, low current recovery factor and high remaining reserves. The critical parameters of the formation are presented on the Figure 1.

Core examinations display significant changes in permeability from bottom of the formation to top. This anisotropy in permeability is equal to one thousand percents according to core laboratory analysis (see Figure 2). Also permeability anisotropy could be indicated by change in SP and GR curves behaviour on a typical cross-section that is shown on the Figure 3. Both curves predict reduction of permeability from the top of the formation to the bottom.

A good quality of conventional and production logs in wells (both producers and injectors) proves that the top of the formation is characterized by higher perme-

Vyngajahinskoe field, formation 1BP11	
STOIIP, 10^3 tones	178 843
Recoverable oil, 10^3 tones	74 452
Average net pay thickness, m	8.3
Initial reservoir pressure, bar	227
Bubble point pressure, bar	123
Oil viscosity @res.cond., cP	0.78
Oil volume factor, scm/rcm	1.205
Gas oil ratio, scm/scm	72.4
Oil density @st.cond., tones/scm	0.832
Cumulative oil production, 10^3 tones	27 211
Current recoverable oil, 10^3 tones	47 241
Target Recovery Factor	0.417
Current Recovery Factor	0.152

Fig. 1. Core analysis of the 1BP11 formation.

[1] LLC "Gazpromneft Science & Technology Centre"

Well #	Core interval	Position in reservoir	ϕ, %	k, mD
411	2350-2350.65	bottom	18	1
538	2720-2730	bottom	16.8	0.5
443	2345-2346	bottom	18.5	0.8
583	2355.5-2369.7	top	20.2	27
	2370-2371	bottom	18.7	1.3
558	2384-2388	top	21	45
	2389-2391	bottom	15	1
623	2390-2401	bottom	16.2	1.5
626	2372-2380	top	20	13.5
630	2386.2-2386.7	bottom	19	0.8

Fig. 2. The critical parameters of the 1BP11 formation.

ability in comparison with the bottom one. The part of structural map with generalized production logs is presented on the Figure 4. Thus, it may be concluded that mentioned above permeability anisotropy can be a reason for water breakthrough from injectors to producers through the most permeable top of formation.

The production history is shown on the Figure 5 where rapid water encroachment can be observed. This fact confirms the statement that the top of formation is flushed with injected water while reserves of the bottom part of formation are not involved into development. As it is presented on the Figure 6, the 1BP11 formation was previously exposed to incremental recovery methods – hydraulic fracturing and sidetracking. These methods are ineffective for 1BP11 formation because of the complex geology aspects such as permeability anisotropy, presence of water bearing formation in close proximity to the oil saturated one, thin shale barriers (it is possible to see it on the typical cross-section on the Figure 3) and high cost of drilling in case of sidetracking. That is why it is necessary to search new technologies for incremental recovery of hard-to-recover reserves appropriate to the 1BP11 formation conditions.

Jet Drilling Technology

The jet drilling technology includes two main stages. The first is drilling a hole in the casing liner or production string. The second – lowering the jet assembly down to the well bottom into the created hole and jetting high-pressure fluid through the hose and jet-nozzle (see Figure 7). The penetration of the tool into the formation is contributed to the water-jet energy and the jet-nozzle effect. There are four basic mechanisms of penetration: surface erosion, hydraulic fracturing, proelastic tensile failure and cavitation. This procedure is repeated 4–10 times according to the number of projected channels. When the channels created the well could be acidized.

The principle scheme of jet-nozzle is shown on Figure 8.

Candidate well for jet drilling should meet the following requirements: good cementing quality (absence of leakage), formation thickness at least 2 m, maximum MD of well should not exceed 3200 m, 10-meter sump below milled point, well inclination less than 30°, casing thickness less than 10 mm, formation temperature should not exceed 120° C.

Sector Simulation Model and Economics

The sector simulation model was built to the examined part of the field (Figure 4) characterized by low current recovery factor and high remaining reserves. The modeled region is 2800×2600 meters, average formation gross thickness is 9.2 m. The sector model dimensions are 56×52×50 cells; average dx, dy, dz of cells are 50, 50, 0.3 m respectively. The pore volume of border cells was increased to simulate the border conditions. Well perforation intervals were reviewed to match the production log results. All fracturing data was also involved in the model.

The permeability distribution in the model was the crucial point because it is the permeability (its vertical distribution) that causes the remaining reserves at the bottom and the flushed zone at the top of the formation. Relations between porosity and permeability obtained from the core data were used to calculate continuous permeability on well-log basis. To simplify history matching analysis resulted permeability was adjusted to the well-test data. The results of well-testing show the integral permeability of approximately 25 mD. The Figure 9 presents the basics of well-test permeability adjustment to the same from logs (well-test on vertical wells is under assumption, so the influence of vertical permeability is negligible). The function that fits both logs and value of integrated permeability from well-tests was derived and applied to distribute permeability in the sector model.

After history matching the model was ready to well treatment simulation. The jet drilled channels were modeled by horizontal well segments with 5 cm in diameter and 100 m length. So as to increase simulation calculations accuracy, the local grid refinement was applied to the near wellbore area, Figure 10. Cells penetrated by channels have dimensions of 12.5×2.0×0.11 m, where the highest value is the cell length along a channel; the smallest one is its high. The challenge with local refinement was solved by modeling seven separated LGRs, associated with amalgam method (ECLIPSE software was used for simulation). Four of them (called North, South, West and East for convenience) were related to channels modeling. One more LGR was built to model the connections of four radial channels in the central cell. The rest two LGR (below and above channels level) were made to simulate the

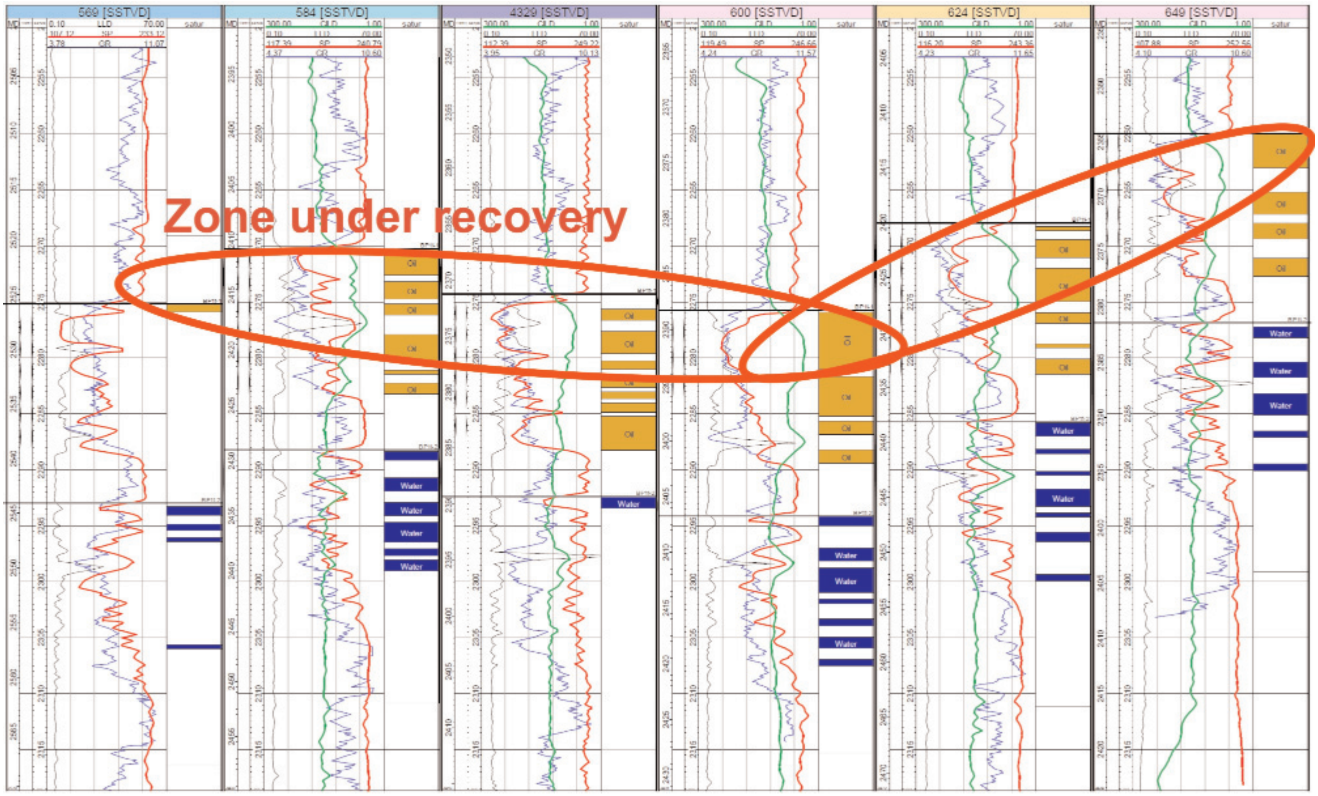

Fig. 3. Typical well cross-section.

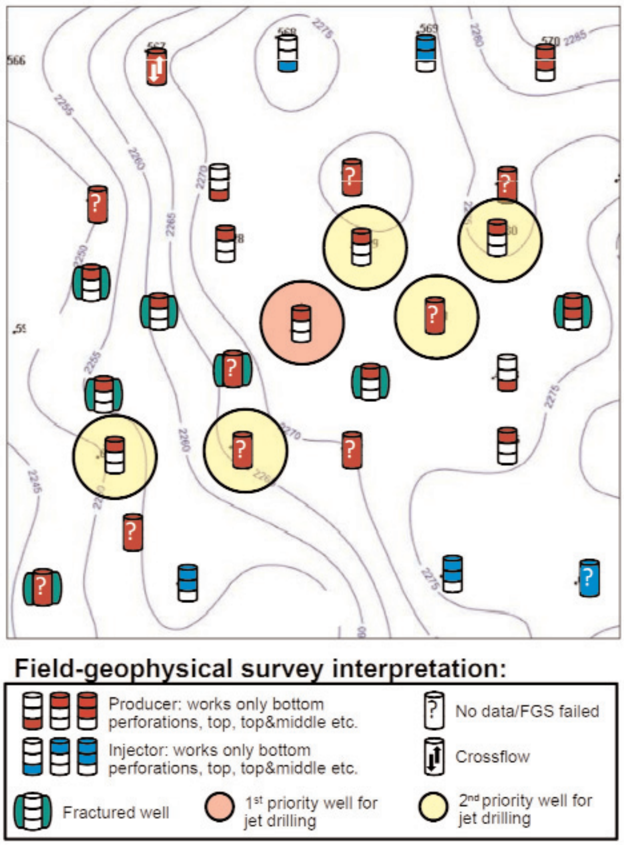

Fig. 4. Production log interpretation map.

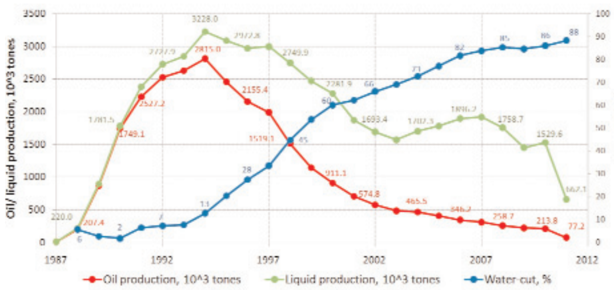

Fig. 5. Field development history.

near wellbore zone with perforation just before well treatment because initially the entire formation thickness was perforated. Polymer treatments for near injectors were modeled (by shutting the top perforations on injectors) to avoid water breakthrough into the treated producer through the top of the formation.

Since the forecast was completed the economic calculations were processed, see Figure 11. The values of oil and liquid production rates after well treatment are 25 tones/day and 30 scm/day respectively. The cumulative oil production after five years is about 14,000 tones, and the water-cut at the end of forecast period is 99.7 %. The main water breakthrough is expected in two years after treatment.

Principal economic indices of a project are following: CAPEX=161,000$, NPV=963,000$, PI=4.5.

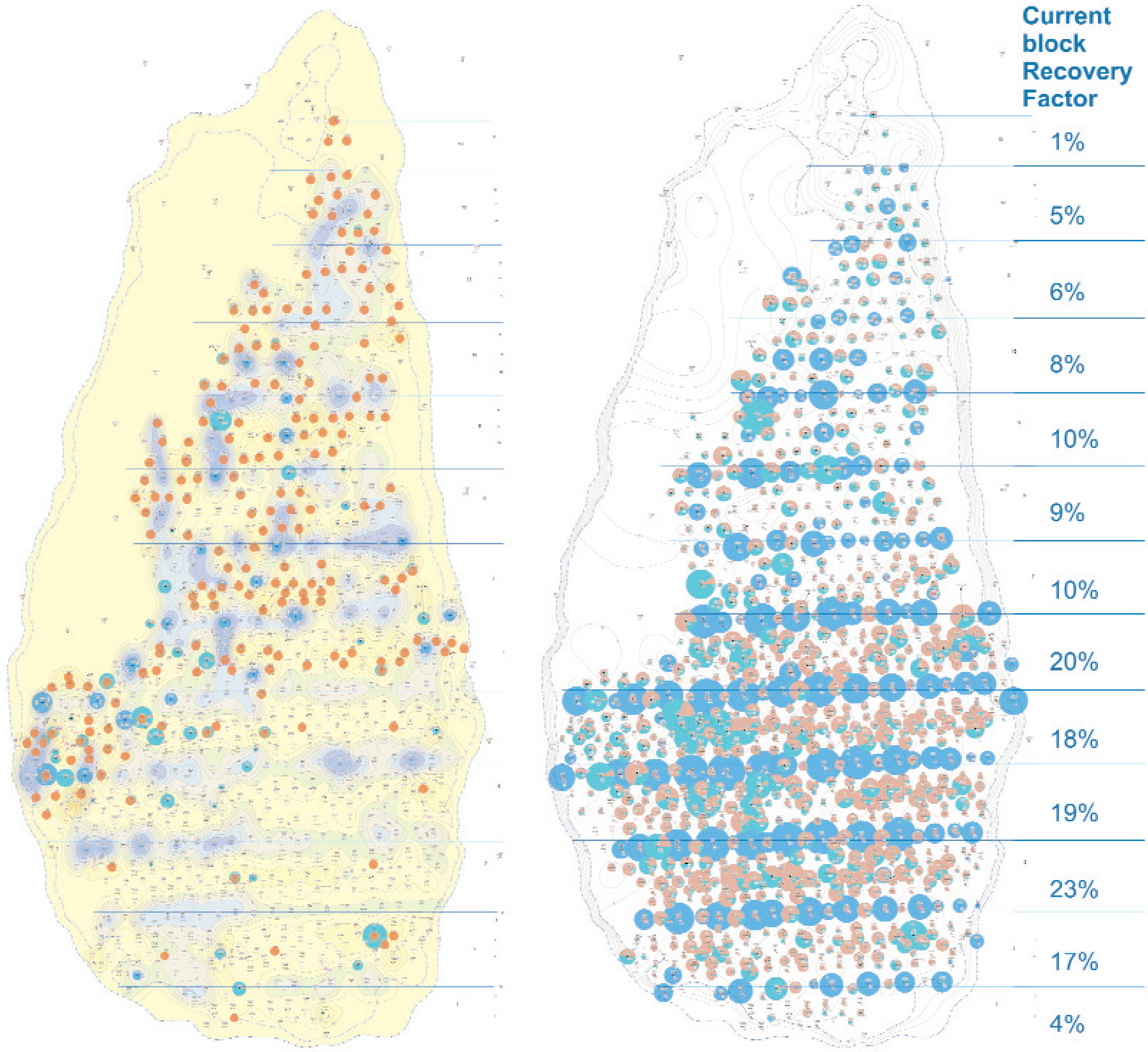

Fig. 6. Fractured wells and current prod/inj map on pressure map (left) and Cumulative prod/inj map and CRF on net pay thickness map (right).

Payback period is only 2.5 month, the maximum of cumulative discounted cash flow is reached after two years after treatment with a value of 934,000$.

Uncertainties and Recommendations

By the reason that the jet drilling technology is relatively new technology for enhanced oil recovery, there are some technological uncertainties. Further technology improvement and equipment upgrading are required for uncertainties reduction. At present time following uncertainties of the jet drilling technology should be noted:

- uncertainties in attitude position of channels created in process of jetting action. Currently there are no tools that allow determination of channel deviation in process of jetting action or after it. There are also no tools for positioning the jetting tool while jetting is in process. This is a trouble spot of technology and further improvement in technology is required to overcome it.
- channel mudding in process of jetting action. Immediate acid treatment after jetting action completion is required to reduce this unfavourable factor. Thus, correct selection of acid composition could also be crucial point of successful application of the jet drilling technology at specific conditions.
- hole sloughing in case of significant value of mechanical impurities in produced fluid. At present time there are no specific casings to decrease this undesirable effect occurrence probability.

Conclusion

In the presented work authors show the perspectives of application of the jet drilling technology for

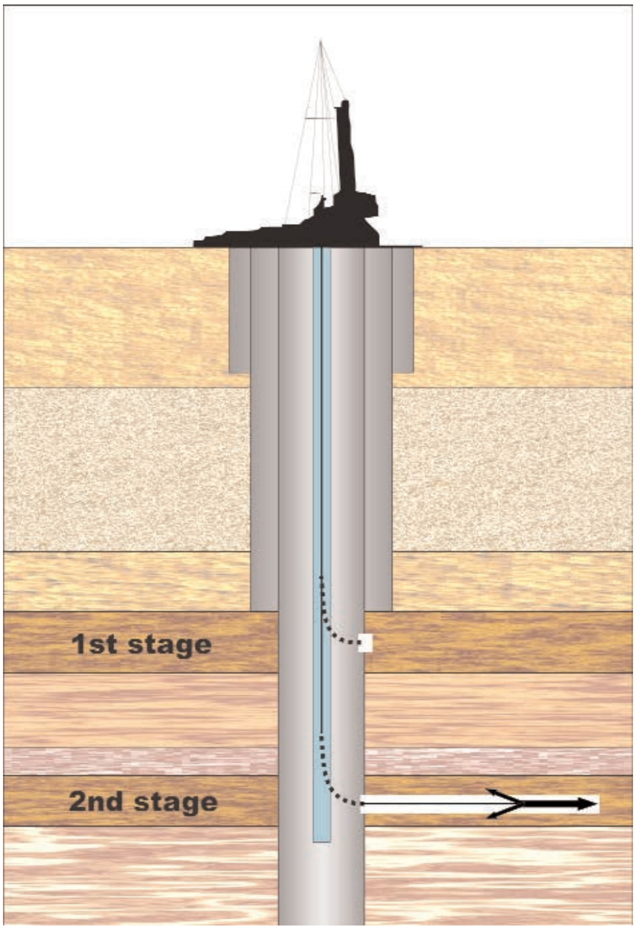

Fig. 7. Two stage jet drilling scheme.

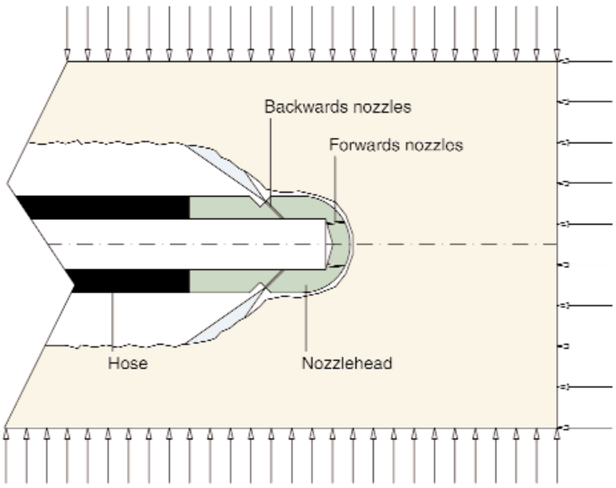

Fig. 8. Scheme of the jet-nozzle (after SPE 68504).

incremental recovery of hard to recover reserves from the bottom part of 1BP11 oil formation in the Vyngajahinskoe field. According to 5-year forecast the additional cumulative oil comes up to 14,000 scm. The jet drilling technology utilization is cost-effective and more profitable than well fracturing and side-

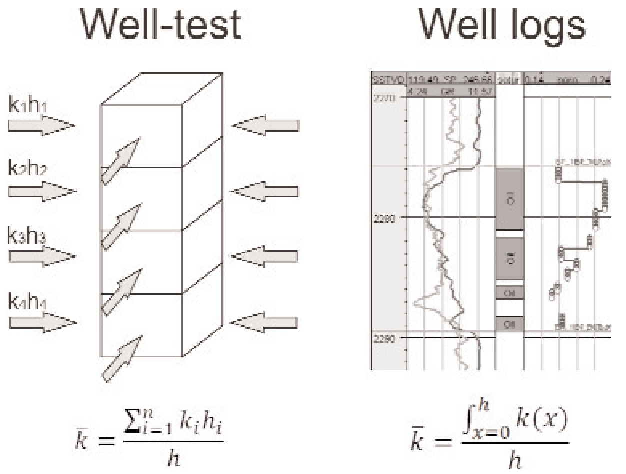

Fig. 9. Average permeability from well test data and from well logs

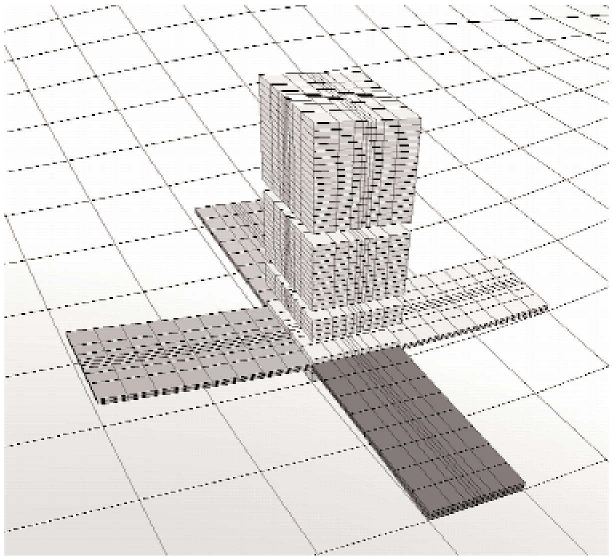

Fig. 10. Local grid refinement.

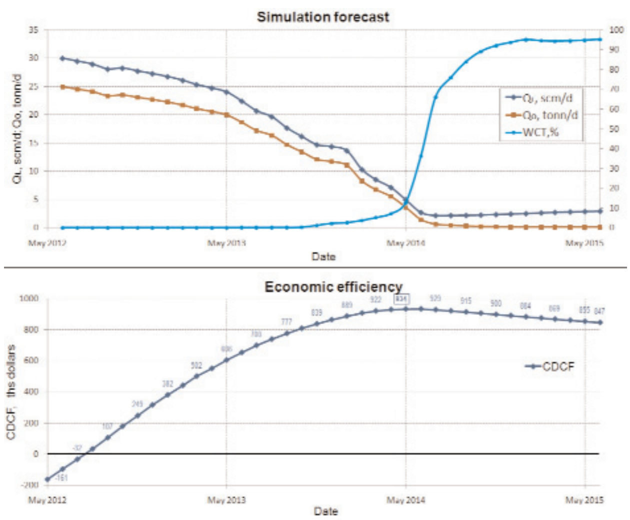

Fig. 11. Production forecast after well treatment.

tracking. The best results can be achieved by simultaneous application of the jet drilling technology for producers and polymer treatments for neighbor injectors. The results of this work will be applied in pilot project in 2012.

Acknowledgments

We would like to express our gratitude to associates from Muravlenko branch of JSC «Gazpromneft-Noyabrskneftegaz» for interest and help in our investigations.

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Prospective Oil and Gas Traps in the South Caspian Offshore Sector

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Dmitriy Zolotarev[1], Irina Istomina[1] & Nataliya Bogomolova[1]

Abstract. The South Caspian Basin is one of the oldest gas and oil producing regions in the world with summary hydrocarbon potential of 8–8.5 bln TEF. The basin is located in the rift depression of the Alpine-Gimalay orogenic foldbelt. The geological structure of the depression is featured by a 25 km thick sedimentary cover that occurs on a thin sub-oceanic crust of 10–18 km.

Due to the rapid Late Pliocene–Early Quarternary downlift the accumulation of thick terrigenous deltaic formation took place in the basin. This formation contains good quality reservoirs accounting for the bulk of hydrocarbon reserves in the South Caspian region. During the basin downlift gravity and geodynamic activities took place at the depression edges. Split by listric faults formations slumped into the depression. The great horizontal stress formed the abnormal pressure fluid zones with shale diapirs and mud volcanoes.

The majority of oil and gas fields in the South Caspian Basin Province are situated on it perimeter. They controlled by brachyanticline folds of gravity genesis and have been drilled to date. The further exploration prospects are associated with the offshore. There are new several types of the offshore perspective traps:

– Structural overlap traps of tectonic blocks on the basin edges;
– Stratigraphic traps of Lower Pliocene paleodeltaic systems (alluvial fans and clinoformes);
– Combined Quarternary traps formed by mud chambers.

Key words: South Caspian Basin, offshore, mud chambers, paleodeltaic systems, tectonic blocks, perspective traps.

The South Caspian Basin is one of the oldest gas and oil producing regions in the world (Fig. 1). Well production in the coastal areas of the Azerbaijan and Turkmenistan dates back to the middle of 19 century – Glumov *et al*. (2004). Due to technological progress exploration drilling has been underway offshore in the Caspian Sea since the 20-s of the previous century.

There are 165 hydrocarbon fields in the South Caspian Basin with total recoverable reserves currently standing at over 7 bln TEF (Fig. 1) – Glumov *et al*. (2004). The bulk of reserves are located in Azerbaijan. The majority onshore fields are in the late development stage. Reserves depletion is above 70 %. The total hydrocarbon potential of the basin is estimated at 8–8.5 bln TEF– Glumov *et al*. (2004). The bulk of exploration prospects in the South Caspian is tied to the offshore portion of the basin.

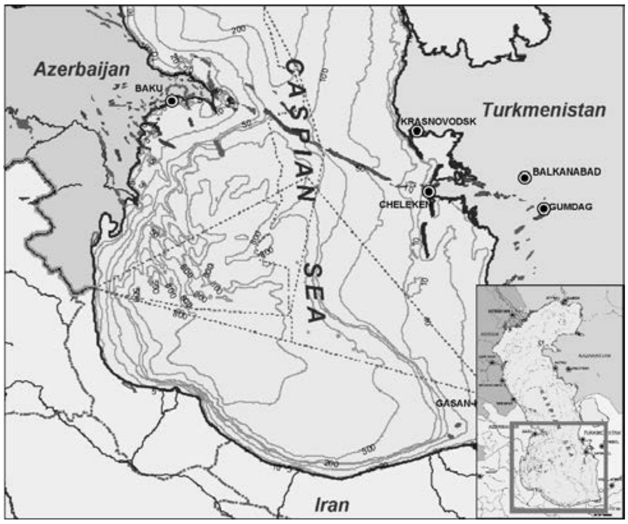

Fig. 1. South Caspian Basin review map.

Tectonically, the South Caspian Basin is confined to the rift depression of Alpine-Gimalay orogenic

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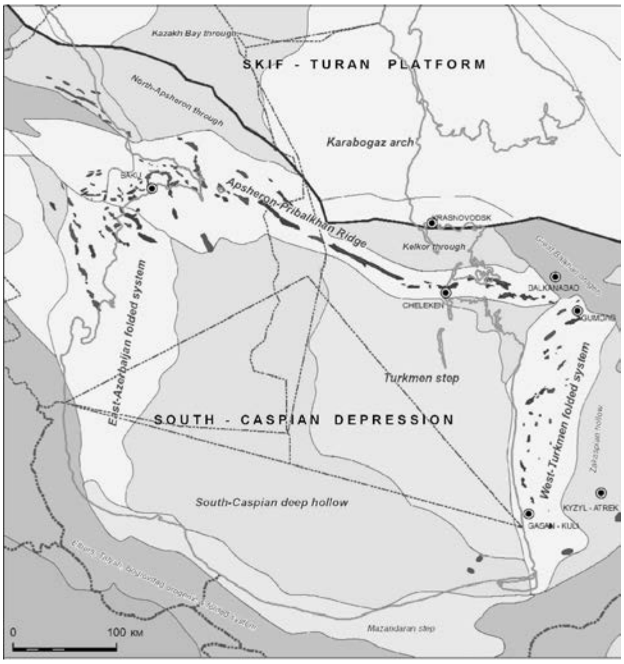

Fig. 2. South Caspian tectonic map.

foldbelt – OBUKHOV (1997) (Fig. 2). This depression is an active expansion zone where the new crust is forming. The geological structure of the depression is featured by a 25 km thick sedimentary cover that occurs on a thin sub-oceanic crust of 10–18 km (Fig. 3).

deltaic formation took place in the basin – OBUKHOV (1997). This formation contains good quality reservoirs with the main hydrocarbon reserves of the South Caspian region. During the Basin downlift the gravity and geodynamic activities took place at the depression edges. Splited by listric faults formations slumped into the depression– OBUKHOV (1997). The great horizontal stress has formed the abnormal pressure fluid zones with shale diapirs and mud volcanoes. The different forms of mud volcanoes are widely spread on the shore and offshore of the South Caspian region. Their roots are placed in the Oligocene-Miocene shale formation probably.

The South Caspian petroleum system has a very narrow stratigraphical range. The main quantities of hydrocarbon reserves are located in the terrigenous Pliocene formation. Interlacing beds of sandstones, siltstones and shales have fluviodeltaic origin and named as "Productive - Red Beds Series" – GLUMOV *et al*. (2004).

The majority of oil and gas fields in the South Caspian Basin are situated on it perimeter. They controlled by structural and stratigraphical traps within the limits of East Azerbaijan and West Turkmenistan folded systems and Apsheron–Pribalkhan threshold (Figs. 1, 2). The main structural shapes that control multilayer oil and gas reservoirs are brachyanticline folds of gravity genesis. Those folds are not tectonic structures and have been formed due to gravity slumping of sediment formations on the South Caspian de-

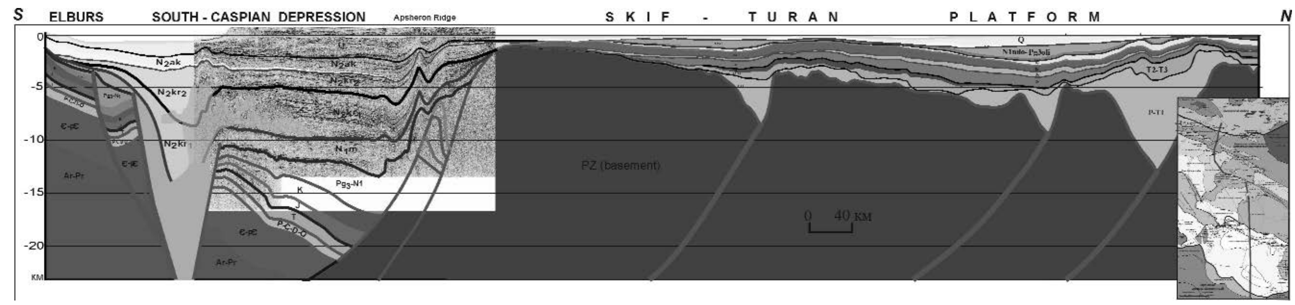

Fig. 3. Submeridional geology section.

The deepest wells in the offshore portion of the basin have been drilled to the depth of 8 km. They encountered the portion of the sedimentary section constituting the Pliocene–Quaternary terrigenous formation. According to the seismic and gravitational exploration data a deeper basin structure can only be assumed. Presuming that the South Caspian Basin is a rift did not form structurally as a depression until the Oligocene (Fig. 3). There was an aggregate zone of two platforms: Scif-Turan in the north and ancient Iran in the south.

Due to the rapid Late Pliocene–Early Quaternary downlift the accumulation of thick terrigenous fluvio-

pression edges – OBUKHOV (1997). The folds distinctive feature is asymmetric shape with the sharpest angle toward the water area. The Apsheron–Pribalkhan threshold structures are complicated by numerous tectonic faults, mud volcanoes and shale diapirs. The fold is up to 3.5 km high and up to 70 km long. The tectonically broken and decompactioned zones that complicated fold crests are the hydrocarbon migration channels from Oligocene–Miocene source rocks.

The further exploration prospects are associated with the Neogene–Quaternary terrigenous formation on the offshore. There are new several types of the offshore perspective traps:

– Structural overlap traps of tectonic blocks on the Basin edges;
– Stratigraphic traps of Lower Pliocene paleodeltaic systems (alluvial fans and clinoformes);
– Combined Quarternary traps formed by mud chambers.

Due to the seismic data the South Caspian depression east edge have stepped imbedding by high amplitude fault system toward the water area (Fig. 4).

which the prospective Miocene formation (6.5–7 km) lies can present a challenge to the exploration process. But the present-day technologies have the capability to reach this depth.

The process of South Caspian depression creation had the irregular character. Periods of the active downlifting was replaced by periods of the relative tectonic inactivity. The position of shore line was changed constantly. During this time the different types of paleogeographic environments (continental, marine, shelf and deep water) were changing. Large amounts of terrigenous sediments were transferred by paleorivers into the Basin from the north, west and east (Fig. 5) – Volozh *et al*. (2002).

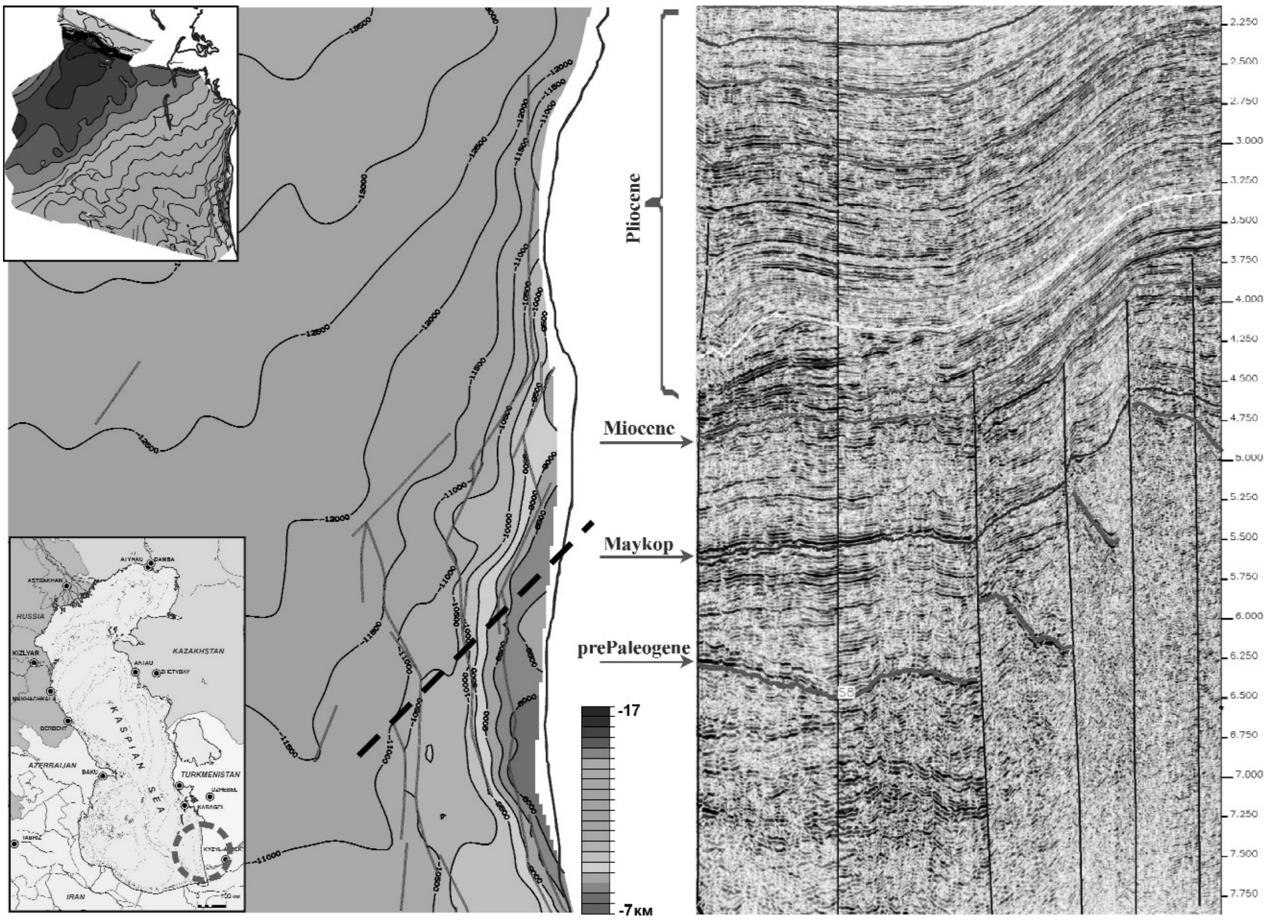

Fig. 4. Structural overlap traps of tectonic blocks.

The faults have the most amplitude displacement on the pre-Paleogene level. These tectonic blocks accompanied by anticline ridges in the Miocene and Lower Pliocene formations. Ridges extend from north to south and are between 3 and 10 km wide and are up to 100 km long. They can provide containment for oil and gas accumulations and are referred to as 'Miocene ridges'. The nearby source rocks and the presence of faults as hydrocarbon migration channels increase the prospective potential of that area.

There is an additional confirmation of oil and gas presence possibility. On the Akpatlaukh field that is situated in 8 km to the east there was drilled a well. The oil flow of 200 tons per day was received during the testing of Miocene formation. The great depth at

The dominance of fluviodeltaic environments during the non-compensated basin downlift caused the clinoforme structure of Pliocene–Quarternary formation.

A number of different age clinoformes can be marked clearly on the seismic lines. The clinoformes have some special signs – increasing of thickness between reflectors and amplitude anomalies (Fig. 6). The same structures control the basic hydrocarbon reservoirs in the West Siberia Basin Province.

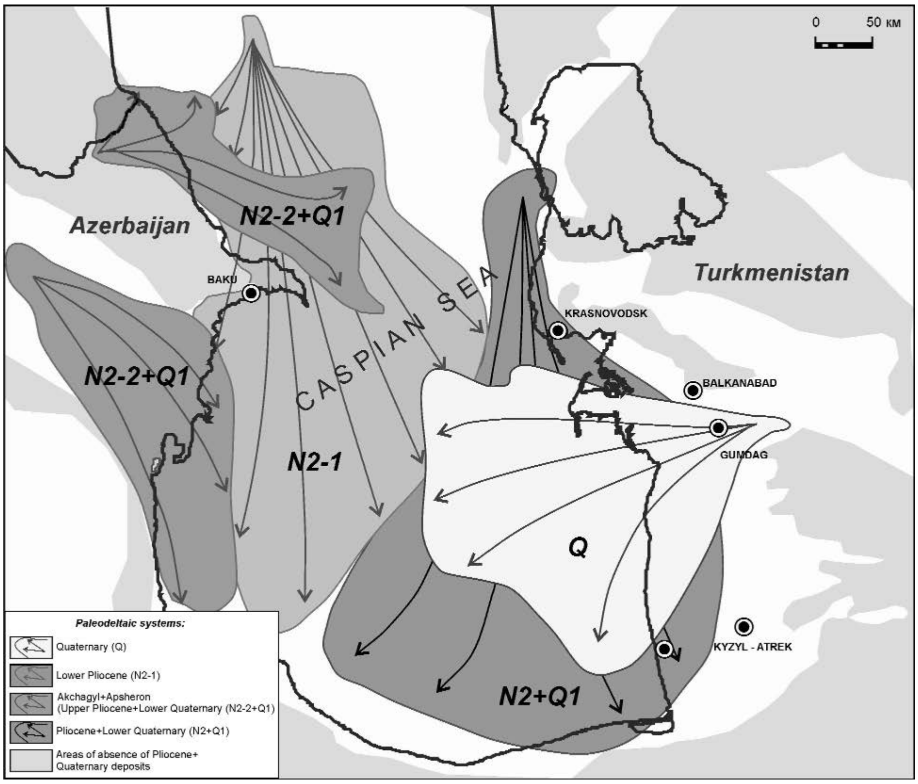

Fig. 5. Distribution of Pliocene–Quaternary paleodeltaic systems – Volozh *et al*. (2002).

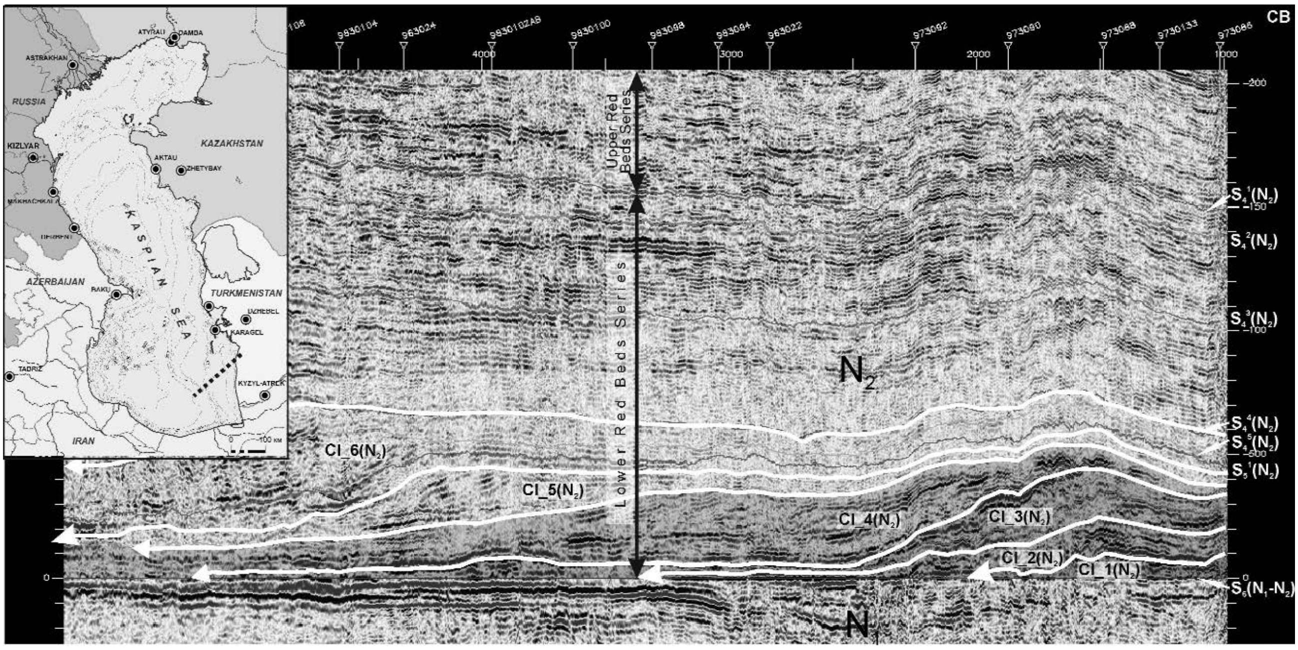

Fig. 6. Lower Pliocene clinoformes.

The chimneys and mud chambers can be marked as anomalies on regularly recorded seismic lines (Fig. 7).

They are filled by a mixture of noncompacted sediments, mud and gas. Those structures measure between 20×20 and 20×60 km. They occur on the depth of 1.5–2 km and located in the deep water portion of the South Caspian Sea at depths of 500–700 m.

At present the South Caspian Basin is a tectonically active region. The intensive processes of transformation and redistribution of sediments are ongoing – GULIEV *et al*. (1998).

The active fluid dynamics, convection and phase transitions cause the intensive phase and mechanics instability of sediments and fluids in the Basin, and, as

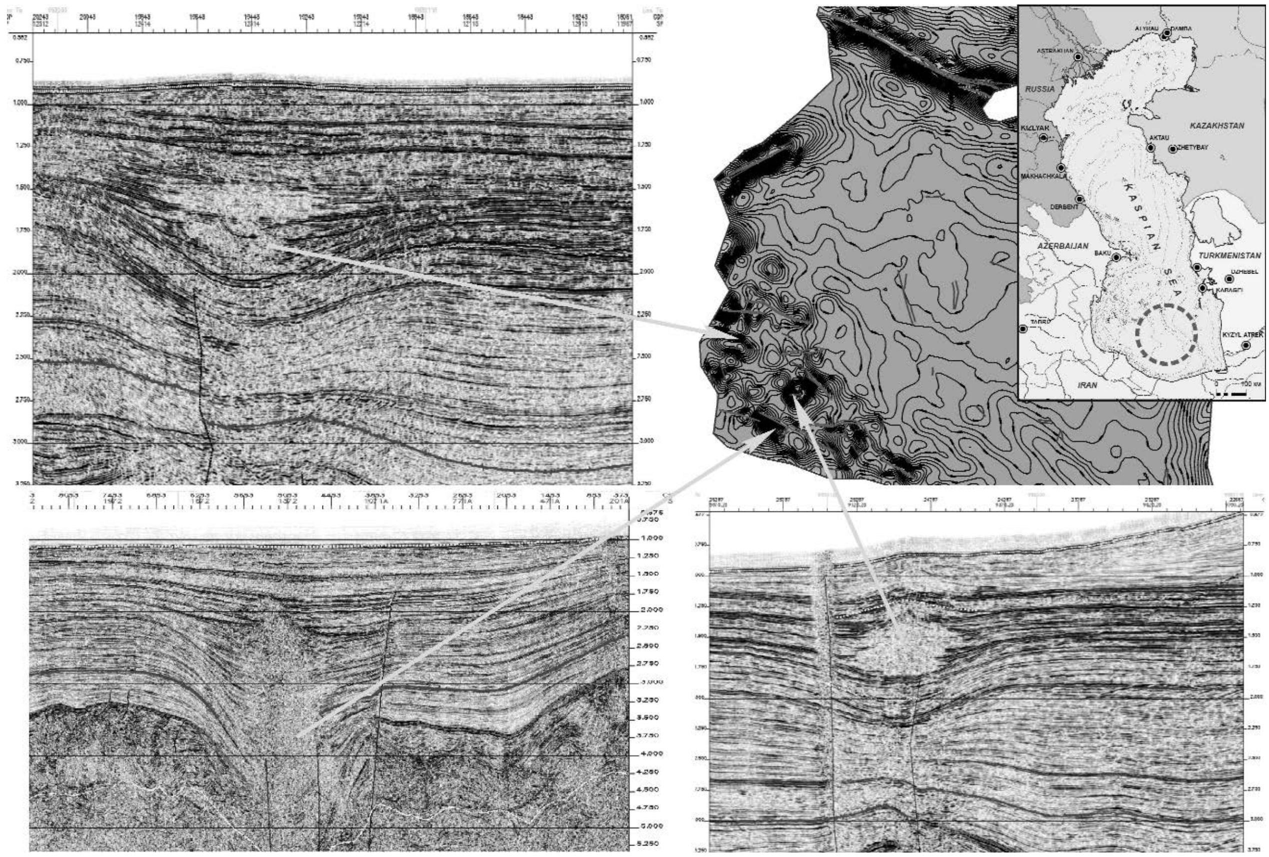

Fig. 7. Quaternary mud chambers.

a consequence, the intensive dynamics processes – movements of sediments and fluids mixtures by tectonically broken zones, mud volcanoes eruptions – GULIEV *et al*. (1998).

These structures during the intrusion in to the superposed formations damage the normal sediments bedding and can give rise to lithologic accumulations in the associated terrigenous formations. Fig. 8 has shown the examples of the hydrocarbon fields from the Thrinidad Basin (A) and Azerbaijan (Peschany field) (B) – GULIEV *et al*. (2009). Total recoverable reserves of the same multilayer (till 12–15 reservoirs) fields reached to 50–60 million TEF.

At present the pool of large anticline structures that controls the existing fields in the South Caspian Basin is depleted. Further exploration effort should be oriented to the less conventional prospects such as nonanticline and combined traps. Those targets can be identified following the dedicated analysis of seismic data.

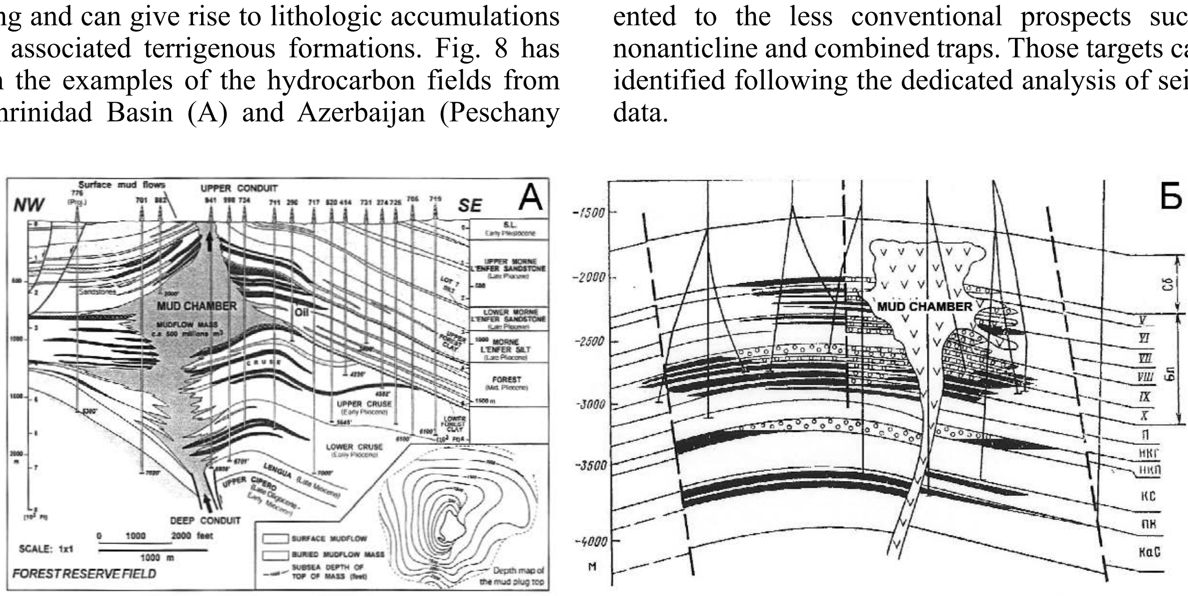

Fig. 8. Examples of fields associated with mud chambers.

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Tectonic Setting and Hydrocarbon Potential of the Albanides Fold-and-Thrust Belts

ENGJELL PRENJASI[1], ALTIN KARRIQI[1], SHAQIR NAZAJ[1] & KLEMENT GJONI[2]

Abstract. Syntheses on tectonic setting and hydrocarbon potential of the Albanides thrust belts have started with regional geological mapping, seismic and gravimetric surveys as very necessary works to understand structural models, tectonic events, location of possible hydrocarbon and ore prospects, as well as to orient design and carry out more detailed exploratory works. Subsequently, numerous integrated geological-geophysical data have brought about making out several structural-facial or tectonic zones overthrusted westward onto each other and entirely onto the Apulia Foreland. In other words Albanides, as northern continuation of the Hellenides have napping tectonic character, which opposes some concepts as "Carbonate Ring", "Mirdita Ocean", etc used in several studies that tackle the ophiolitic rocks place of formation and their present tectonic relationships with neighbouring sedimentary rocks. Meanwhile the Intermountain basins of Korça and Burreli cover transgressively some parts of the Mirdita ophiolitic and the Volcano sedimentary mélange nappes. Also the Periadriatic foredeep covers transgressively some parts of the Ionian-Kruja nappe and mostly the Apulia foreland.

Key words: Tectonic, hydrocarbon potential, Albanides, thrust belts.

Introduction

From the hydrocarbon potential point of view, the most prolific units have resulted the Periadriatic foredeep, Ionian-Kruja nappe and the Apulia foreland carbonates. These units comprise several types of hydrocarbon accumulation traps discovered and many depicted prospects in the targets of the Cretaceous––Paleogene limestone and the Neogene sandstone. But, the depicted prospects need further attention to prepare for their final check and evaluation by drilling. In other wards it is required a constant search to review the exploration philosophy and improve its technology, as the most promising and effective way to discover new hydrocarbon reserves.

Tectonic Setting and Hydrocarbon Potential of the Albanides Thrust Belts

Numerous geological and geophysical gained data and integrated syntheses depict the Albanides thrust belts as a segment of the whole Alpine chain located between Dinarides in the north and Hellenides in the south (MILJUSH, 1973; JACOBSHAGEN *et al.,* 1987; FRASHERI *et al.*, 2003). The Dinarides, Albanides and Hellenides are folded and overthrusted westward in form of tectonic nappes owing to the collision between the African plate and the Euro-Asiatic one (RICOU, 1986, Fig. 1). Thus the Albanides thrust belts represent partly the Apulia Foreland, some orogenic tectonic nappes, Periadriatic foredeep and two intermountain or Piggy back depressions (Fig. 2).

A. The Apulia Foreland has a restricted outcrop along the south western edge of Albanides Onshore (Fig. 2), while at depth its is detected in few onshore seismic lines (Fig. 7), as well as throughout the Albania offshore of Adriatic (Figs. 3, 5), and Ionian sea (TUSHE *et al.*, 1994; PRENJASI *et al.,* 1994). Outcropped sections and the drilled wells ones confirm that the Apulia foreland comprises a thick platform carbonate of the Upper Triassic to Oligocene age (ZAPPATERRA, 1990, ISGP 1985), followed upward by transgressive premolasse and molasse sequences (Fig. 5). Meanwhile, evaporitic deposits of considerable thickness aged Upper Triassic to Lower Cretaceous

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lies under the base of the carbonate section of the Apulia foreland and the Ionian–Kruja tectonic nappe. The e vaporitic deposits have emerged upward desecting younger carbonate and terrigenous deposits of up to the Plio-Quaternary excluded (Fig. 3) owing to diapirism phenomenon. Subsequently, presence of some monoclines dissected by oblique or longitudinal faults, as well as some carbonate mounts somewhere eroded and buried characterize tectonic features of the Apulia foreland.

B. Albanides Orogeny comprises several tectonic nappes formerly called tectonic zones (ISGP 1985, BAKIA *et al.*, 1987). Thus based on lithological content, their age, folding and tectonic features in the Albanides thrust belt are made out some 8 tectonic nappes, which have their analogues in Dinarides and Hellenides (ZAPPATERRA E., 1990).

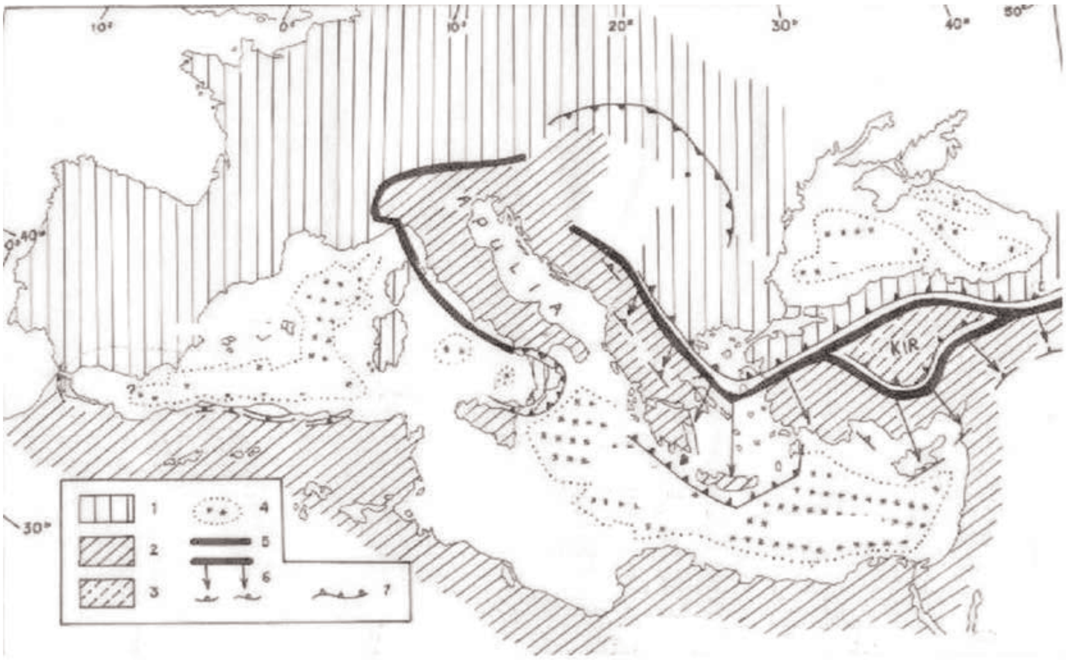

Fig. 1. Location of the Albanides thrust belts in the framework of the African plate subduction under the Euro–Asiatic one (RECOU *et al.*, 1986) 1. Euro–Asiatic continent; 2. African continent; 3. Kishir block; 4. Present oceanic basins; 5. Boundaries of Mesozoic oceans; 6. Boundaries of Mesozoic oceans and the main ophiolitic napes; 7. Troughs of present and past subduction.

The tectonic nappes of the Albanides orogeny (Figs. 2, 3) like Hellenides (Fig. 4) overthrust onto each other westward and onto the Sazani/Paxos zone (Pre-Apulia foreland) to begin from the Ionian–Kruja nappe, which is the youngest in age. Meanwhile going north eastward across the Albanides outcrop nappes of the Krasta, Marly flysch, Volcanic sedimentary-mélange, Albanian Alps, Gashi, Mirdita and Korabi.

1. Ionian–Kruja–Gavrovo nappe comprises of the Ionian zone and the Kruja one, which represent respectively the northern continuation of the Ionian and Gavrovo Western Hellenic nappes (JACOBSHAGEN *et al.*, 1986). Considering the stratigraphic and geological mapping data gained in Albanides, the Ionian zone and the Kruja one represent two different zones (PRENJASI, 1981; BAKIA *et al.*, 1983, ISGP 1985) with gradual lithological and structural transition to each other. In other words there is no overthrust of the Kruja (Gavrovo) zone onto the Ionian one (PRENJASI, 1979, 1981, 2001). Subsequently, form the tectonic point of view both zones in question represent one nappe overthrusted onto the Sazani/Paxos zone (Pre-Apulia foreland), (Figs. 2, 3, 4).

2. Krasta nappe is analogue to the Pindos zone in Hellenides and Budva one in Dinarides (ISGP 1985). The Krasta nappe consists of three rocky sequences; the "Early flysch" of Albian–Cenomanian, limestone of the Turonian–Campanian and "Young flysch" of Maastrichtian–Paleocen–Eocene. Particular feature of the limestone sequence of the Krasta nappe is their anticline folding associated with longitudinal and cross faults which vanish into "Young flysch" (PRENJASI, 1982, 1983, etc). On the other hand outcrops of the "Young flysch" anticline folds as tectonic window under the older nappes witness the napping feature of Albanides (Figs. 2, 3). The Krasta nappe is considered as sub zone of the Krasta–Cukali tectonic zone (ISGP 1985). But the Cukali unit consists of Triassic–Cretaceous carbonate rocks, some Middle Triassic effusive rocks and little radiolarites in the upper part of the Upper Jurassic. In other words, the

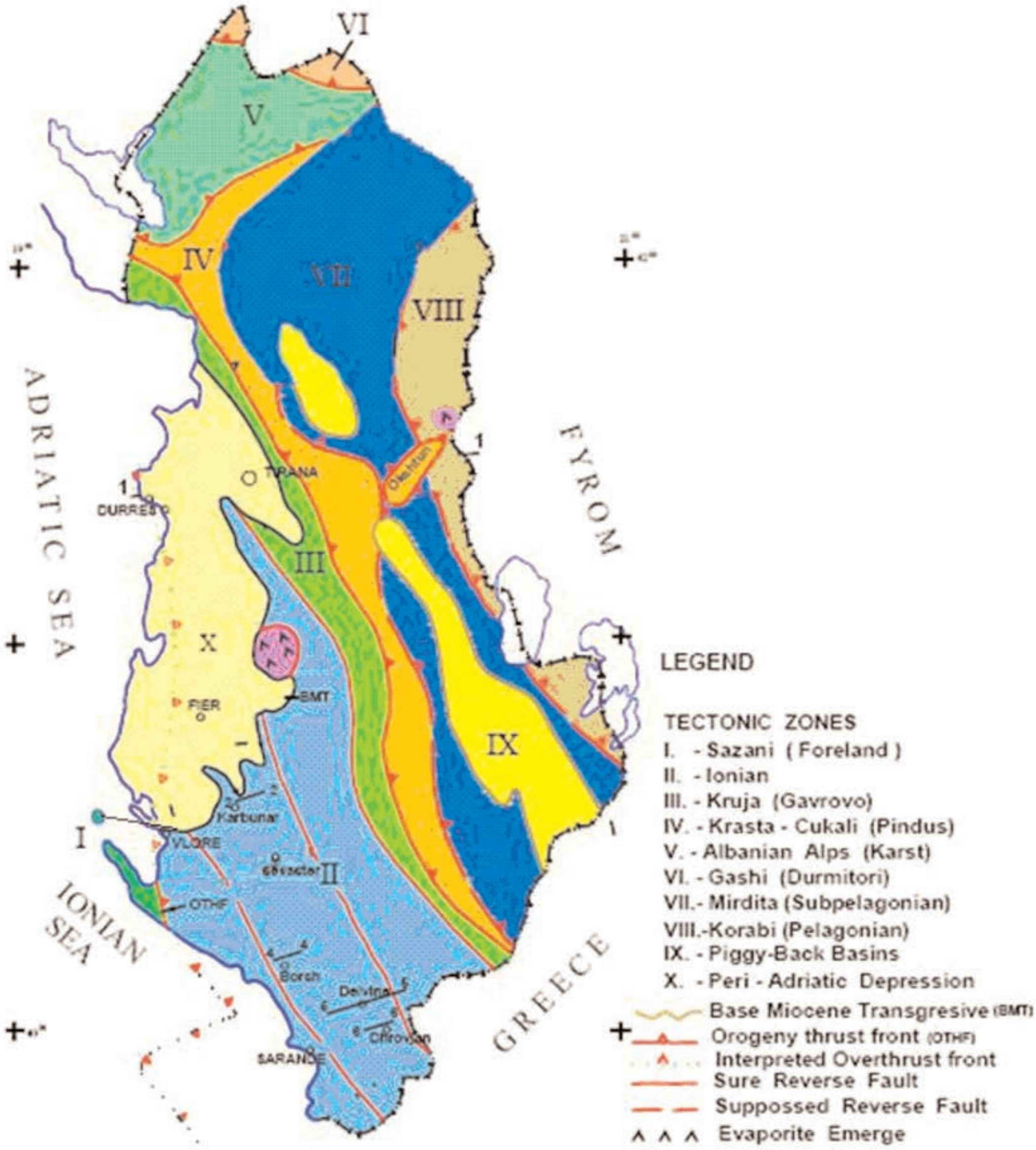

Fig. 2. Tectonic sketch of Albanides fold-and-thrust belt.

rocky formations of the Cukali unit are quite different to the Krasta nappe and what's more they overthrust the "Young flysch". Subsequently, the Cukali unit must not be a sub-zone of the Krasta nappe as interpreted so far (ISGP 1983, 1985).

3. Marly flysch nappe has some restricted outcrops at southeast of Elbasan, north of Guri Topit, (Prenjasi, 1983), beyond the western side of the "Young flysch" of the Okshtuni tectonic window (Fig. 3), etc.

The Albanides marly flysch consists mainly of medium to thick bedded marls, sandy limestone and sandstone of Titonian–Valnginian, which overthrust the Krasta nappe and may be analogue to the rocky outcrop of the Olympos tectonic window in Hellenides (Fig. 4).

4. Volcano sedimentary-mélange nappe locates everywhere underthrusted the ophiolitic rocks and overthrusts the Marly flysch nappe or the Krasta nape (Fig. 3). It may be analogue to carbonate sequence of Pelagonian nappes (Fig. 4), which comprises two successive lithological packages. The lower package consists of some diabases, shale, cherts and thin to medium bedded pelagic limestone, which frequently pinch out into cherts and marls along their extension. Meanwhile going upward a mélange mixture of sandstone, gravels, shale and olisthostrome of neritic carbonates of very various sizes dominate the section of the upper package.

The age of the Volcano sedimentary-mélange nappe ranges from Upper Triassic to Upper Jurassic–Lower Cretaceous (Prenjasi, 1982, 1983). Also, as lithological content and age interval of the Volcano sedimentary-mélange nappe are similar to the Cukali unit, the later may be its integral part or a separate similar nappe.

A particular feature of the Volcano sedimentary-mélange nappe is absence of present folds and faults

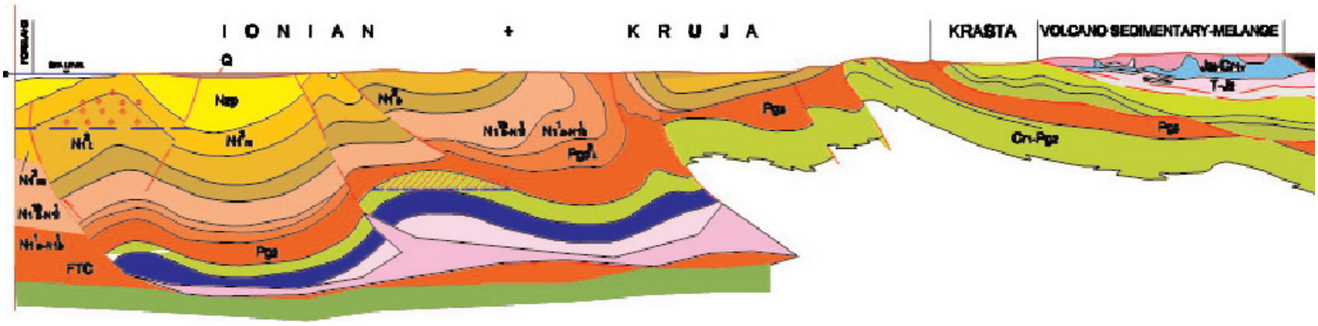

Fig. 3. Geological-geophysical profile 1-1: Thrusting of the Albanides tectonic nappes onto each other and the whole Orogeny onto the Foreland. Q Quaternary, N2p Pliocene, N13m Mesinian, N13t Tortonian, N12s Serravallian, N11bb- N111 Burdigalian–Langhian, N11a- N11ba Aquitanian–Burdigalian, Pg33k Upper Oligocene, zone Globorotalia Kugler, Pg3 – Lower + Middle + Upper Oligocene, Cr1-Pg2 Cretaceous–Eocene, Upper cCr2m-Pg2 Maastrichtian–Eocene ("Young Flisch"), Cr2c-c Coniacian–Campanian, Cr1a-Cr2t – Aptian–Turonian ("Early Flysch"), J3t-Cr1v Tithonian–Valanginian (Marly Flysch), J3t-Cr1b Tithonian–Berriasian (Mlange), T-J2 – Triassic–Middle Jurassic (Volcano sedimentary suite), P-J Permian–Triassic (Ophyolitic rocks), T3e - Upper Triassic evaporitic rocks, T3d Upper Triassic dolomitic rocks, FTC Foreland (Apulia and Pre-Apulia / Sazani zones) Top carbonates, Orogeny – Albanides thrust belt nappes, Supposed gas and oil-water contact.

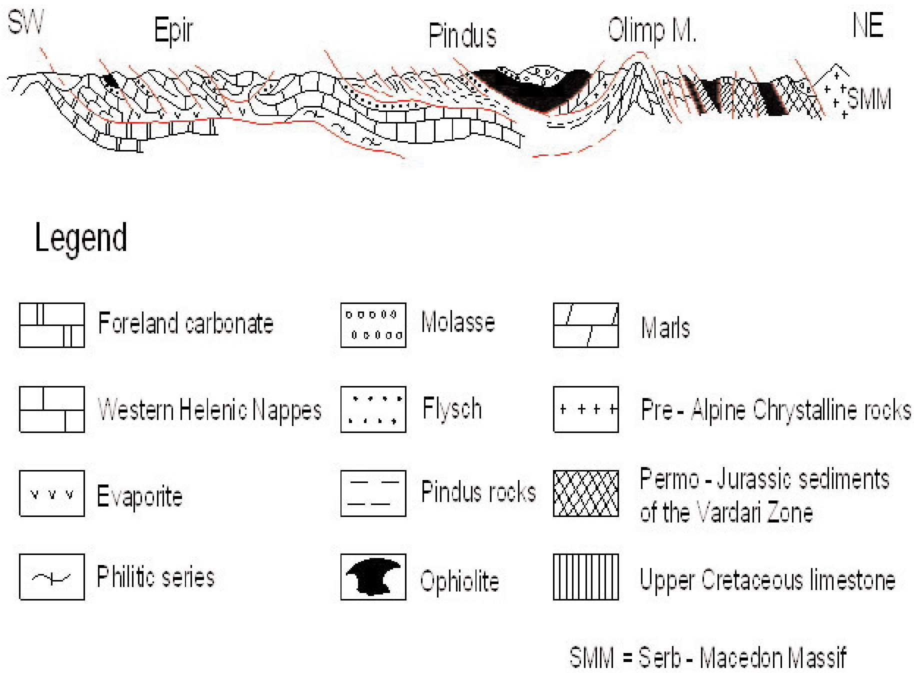

Fig. 4. Schematic profile across Hellenides tectonic nappes (JACOBSHAGEN, 1986)

(PRENJASI, 1982, 1983, etc), whereas drawings of such phenomena on the geological map of Albania (ISGP 1983) ignoring the data of many detailed geological mapping are just humankind wrong doings.

5. Albanian Alps nappe is considered as analogue to Parnas zone in Hellenides and High Karts one in Dinarides (ISGP 1983, 1985). It consists of terrigenous rocks of Permian and carbonates of Triassic which outcrop in form of a big monocline overthrusted onto the Cukali unit.

6. Gashi nappe locates in the very north of Albanides (Fig. 2) and continues into Dormitory zone in Dinarides (MILJUSH 1973). It consists of basic and intermediate rocks, as well as some terrigenous, carbonate and metamorphic rocks of Permian and Triassic age overthrusted onto the Albanian Alps nappe and the Cukali unit.

7. Mirdita nappe consists of ophiolitic rocks overthrusted onto the Volcano sedimentary-mélange nappe or younger ones of Marly flysch and Krasta. The ophiolites comprise the ultrabasic massifs, gabbros, granites and volcanic rocks, which have a total thickness of 2 to 14 km (FRASHERI *et al*., 2003), while their age interval is reported Late Triassic–Middle Jurassic (SPAHO *et al*., 2000)

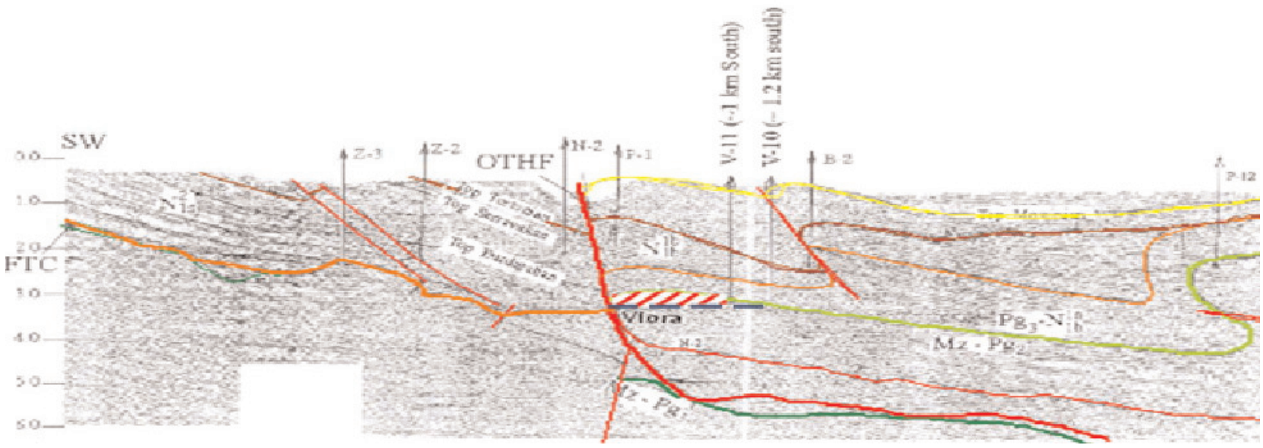

Fig. 5: Geological-geophysical profile 3-3: The Vlora prospect located at the edge of the Ionian–Kruja tectonic nappe of the Albanides Orogeny overthrusted onto the Pre-Apulia / Sazani Foreland. BPT Base of Pliocene transgression, BMT Base of Messinian transgression, OTC Orogeny top carbonates, OTHF Orogeny thrust front, FTC - Foreland top carbonates, Mz - Pg2 Carbonate sequence of Mesozoic–Eocene in the Ionian–Kruja nappe, Mz-Pg33 Carbonate sequence of Mesozoic–Oligocene in Pre-Apulia (Sazani) Foreland, Pg3_N11ba Oligocene to lower Burdigalian, N11bb Upper Burdigalian, N11l Langhian, N12s Serravallian, N13t Tortonian, N13m Messinian, P-1 Drilled well, Supposed oil-water contact.

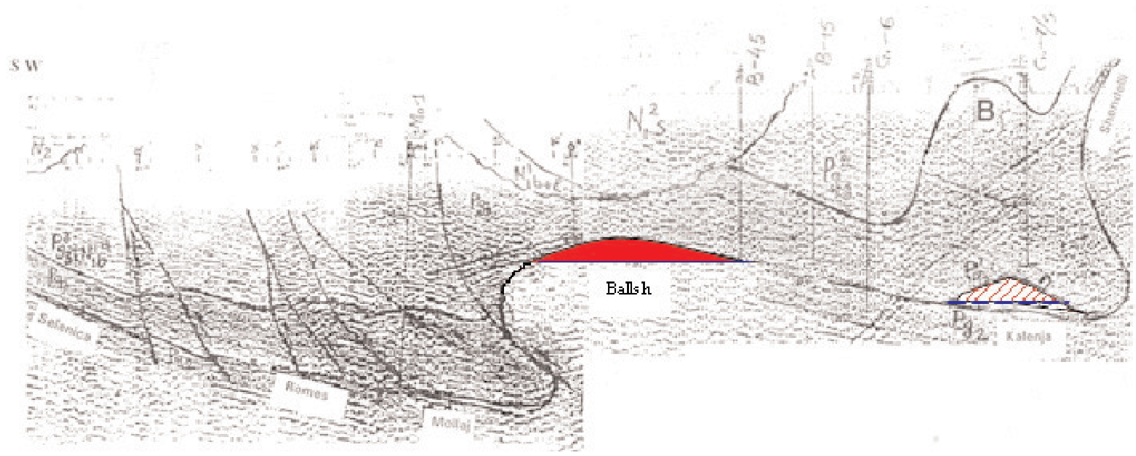

Fig. 6. Geoseismic profile 2-2: The anticline of the Ballsh oil field (A) and the small anticline of the Kalenja prospect (B). Cr-Pg2 Cretaceous–Eocene limestone target, Pg31-3 Oligocene flysch, N11b Burdigalian, N11l Langhian, N12s Serravallian, N2 Pliocene, B-45 Drilled well, Proved oil-water contact, Supposed oil-water contact.

8. Korabi nappe consists of sedimentary, volcanic and metamorphic rocks of Silurian to Permian age intersected by evaporitic diapire of Triassic. It is analogue to the Pelagonian zone of Hellenides and Golia zone of Dinarides (Jacobshagen, 1986; Miljush, 1973, ISGP 1983, 1985).

The Korabi nappe overthrusts onto the Mirdita and Volcano sedimentary-mélange ones, while the outcrops of the "Young flysch" and the Triassic evaporates must represent tectonic windows of the Krasta and Ionian–Kruja nappes.

C. Intermountain or Piggy back Basins of Burreli and Korça comprise some transsgresive sequences of basal conglomerates of the Lower Cretaceous, carbonates of the Upper Cretaceous and terrigenous deposits of the Oligocene to Pliocene, which lay transgressively on the Mirdita ophiolithes and Volcano sedimentary-mélange nappes (Figs. 2, 3, 4)

D. Periadriatic Foredeep consists of Miocene to Plio-Quaternary molasses, which cover transgressively most of the Apulia–Sazani–Paxos foreland and partly the Ionian–Kruja–Gavrovo orogeny nappe (Figs. 2, 3). Thus the Periadriatic foredeep deposits erect the upper tectonic stage which increases its thickness northwestward up to 6000 m (Frasheri *et al.*, 2003)

Hydrocarbon Potential of Albanides

Confirmed hydrocarbon bearing targets of the Albanides are the limestone of the Cretaceous–Paleogne of the Apulia foreland and the Ionian–Kruja tectonic

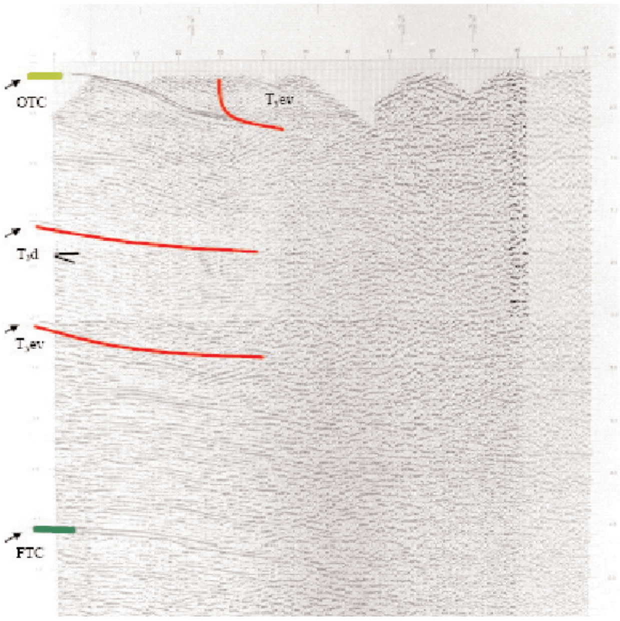

Fig. 7. The cross seismic time section, which offer obvious information on the geological setting of the area westward to the thrust front of the Mali Gjere anticline. Thus, OTC is Orogeny top carbonates and FTC is the Foreland top carbonates below evaporitic sequence T3ev of the Albanides thrust belts. But there is a total black out on the eastern part of this section, where locates the Delvina field, due to improper methodology of 2D seismic, while shooting on the eroded carbonate section of Mesozoic.

nappe, as well as the sandstone bodies of the Tortonian and Messinian molasses deposits of the Periadriatic foredeep (Figs. 2, 3). Meanwhile, dry gas accumulations discovered in the Serravallian, Tortonian, Messinian and Pliocene deposits of this foredeep.

Geological setting of the Apulia foreland and the Ionian–Kruja tectonic nappe comprises the lower and upper tectonic stages (DALIPI, 1985; PRENJASI, 1992). The Lower Tectonic stage consists of the Mesozoic––Eocene carbonates, as well as the Oligocene flysch deposits sequences up to the Lower Burdigalian included. While the Upper tectonic stage consists of the Serravallian, Tortonian, Messinian and Pliocene deposits.

Considering the structural features and relationship between reservoir rocks and the seal ones within the Apulia foreland, Ionian–Kruja tectonic nappe and the Periadriatic foredeep there are made out the following types of hydrocarbon accumulation traps.

1. Massive eroded and or buried traps**,** located in the Apulia carbonate structures of the Cretaceous–Oligocene reservoir sealed by the Burdigalian marls or clay packages of the Miocene and Pliocene transgressive deposits (TUSHE *et al*., 1994).

2. Massive anticline traps located in the Ionian zone carbonate structures, which comprise the Cretaceous–Eocene reservoir sealed by the Lower Oligocene flysch. This type of trap is proved in the cases of known fields of the Cakrani, Gorrishti (PLAKU *et al*.,

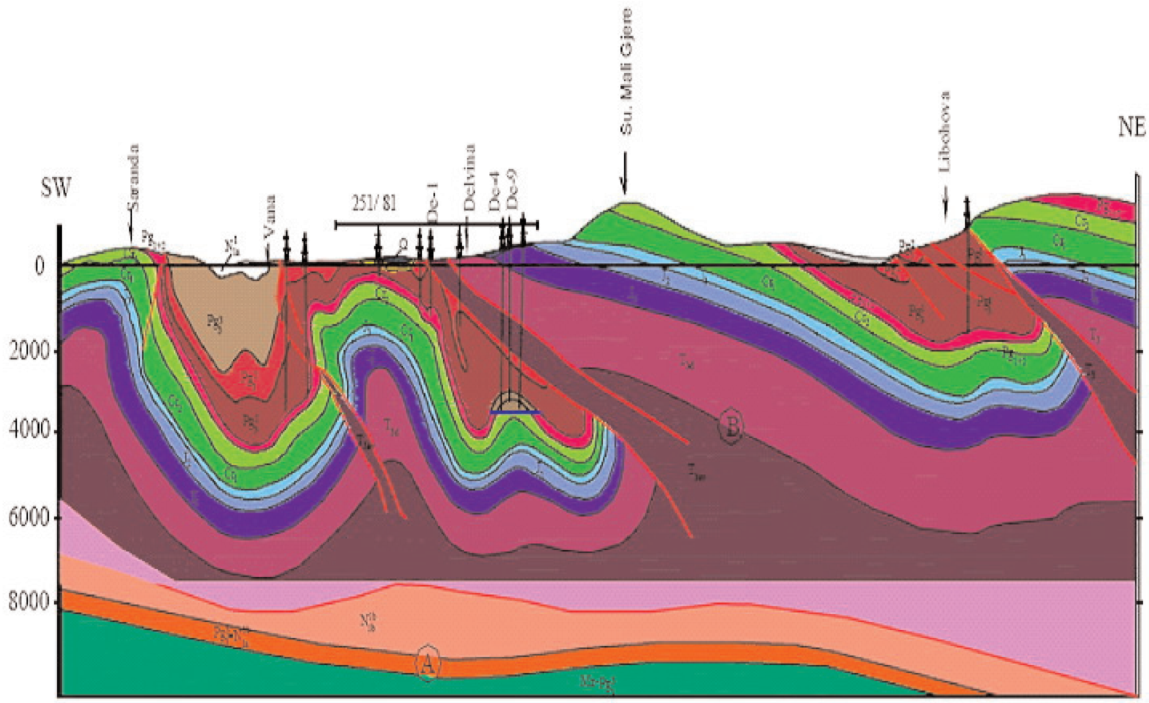

Fig. 8. Cross geoseismic profile 5-5 of the Delvina gas condensate field below the thrusted anticline of Mali Gjere and seismic detection of the Apulia Foreland (A), below the Albanides thrust belts (B). (PRENJASI *et al*., 1994). Q.- Quaternary, N11b. Burdigalian, N11a. Aquitanian, Pg31, 2, 3. Lower, Middle, Upper Oligocene, Pg1+Pg2. Paleocene + Eocene, Cr1, 2. Lower, Upper Cretaceous, J1, 2, 3. Lower, Middle, Upper Jurassic, T3d & T3e Upper Triassic (dolomite & evaporitic deposits), Proved gas condensate-water contact.

1962) and in depicted prospects of Paperri, Sasaj, etc (PRENJASI 1992). Some structures of the massive traps are masked by overthrust of big eroded anticlines associated with evaporitic diapirism through their thrust plane, as in the cases of the Delvina gas condensate field (Figs. 7, 8, PRENJASI, 1994, 1980). While, some other anticline structures are masked by transgressive sequences of premolasses deposits of the Burdigalian to Tortonian age as in the cases of known fields of Ballsh (Fig. 6) and depicted prospects of Peza (Fig. 3), or the transgressive cover may be the molasses deposits of the Messinian to Pliocene as in the case of the Vlora prospect (Fig. 5).

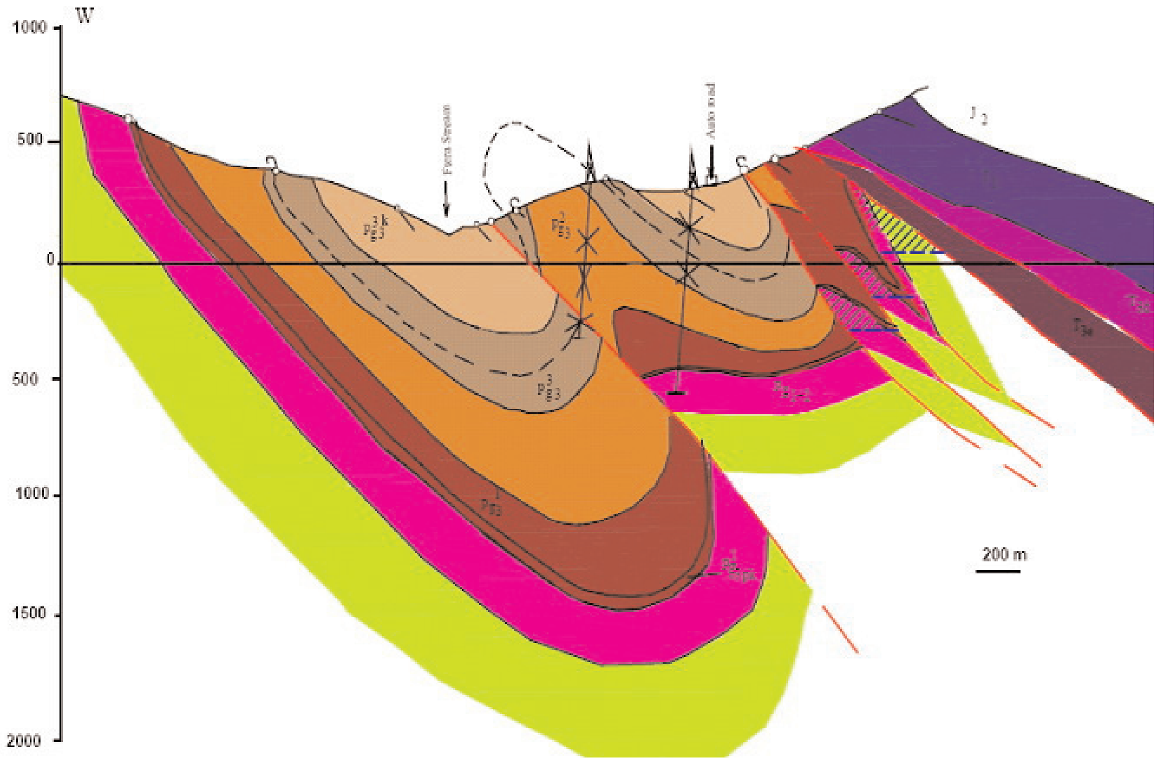

Fig. 9. Geological profile 4-4 of probable duplex tectonic screen traps of the Borshi prospect located on the eastern part of this figure. Meanwhile a relatively small Oligocene flysch fold reflected merely as a terrace at the Cretaceous–Eocene carbonates locates on the very center part of this figure. Pg31,2,3 Lower, Middle, Upper Oligocene, Pg1+2 Paleocene + Eocene, Cr2 Upper Cretaceous, J1, 2, 3 Lower, Middle, Upper Jurassic, T3d & T3e Upper Triassic (dolomite & evaporitic deposits), Supposed oil-water contact.

3. Tectonic screen traps conditioned by cross faults cutting of foraminifera limestone of the Lower Oligocene flysch as in the Drashovica oil field (MURATAJ, 1964). Also, tectonic entrapments have taken place owing to dissection of the Eocene limestone by development of a duplex pattern fault and screened them against the Lower Oligocene flysch deposits as it is proved in the Karbunara oil field (TUSHE *et al*., 1982; GJOKA *et al*., 1985) and interpreted in the eastern part of the Borshi profile (Fig. 9), while the evaporitic screen entrapment may have taken place in the Dhrovjani prospect, which locates along the eastern flank of the Dhrovjan–Humelice syncline desected by evaporitic diapire of the eroded anticline of Mali Gjere (Fig. 10).

4. Hydrodynamic traps in the Cretaceous–Eocene limestone reservoir sealed with the Lower Oligocene flysch and conditioned by the underground water movement, as in the Fitore prospect (PRENJASI, 1992).

The molasses sequence of the Messinian and Pliocene of the Periadriatic foredeep consists of several oil and gas or gas-bearing sandstone suites, as in the oil fields of the Patos–Marineza (GJOKA *et al*., 1985) and Kuçova, gas fields of the Divjak, Frakull, depicted gas discovery of Durres (Fig. 3) and gas prospects of Seman (TUSHE *et al*., 1994), etc. Thus the followings are the main types of traps of oil and gas accumulation in the sandstone bodies of the molasses sequence of the Upper tectonic stage.

5. Anticline traps in the sandstone beds of the Tortonian–Messinian, as in case of the Divjaka and Povelça gas fields (DALIPI *et al*., 1977) and the Durres gas discovery (Fig. 3), etc.

6. Litho-stratigraphic traps of the sandstone beds of the Messinian, as in case of the Patos–Marinza oil

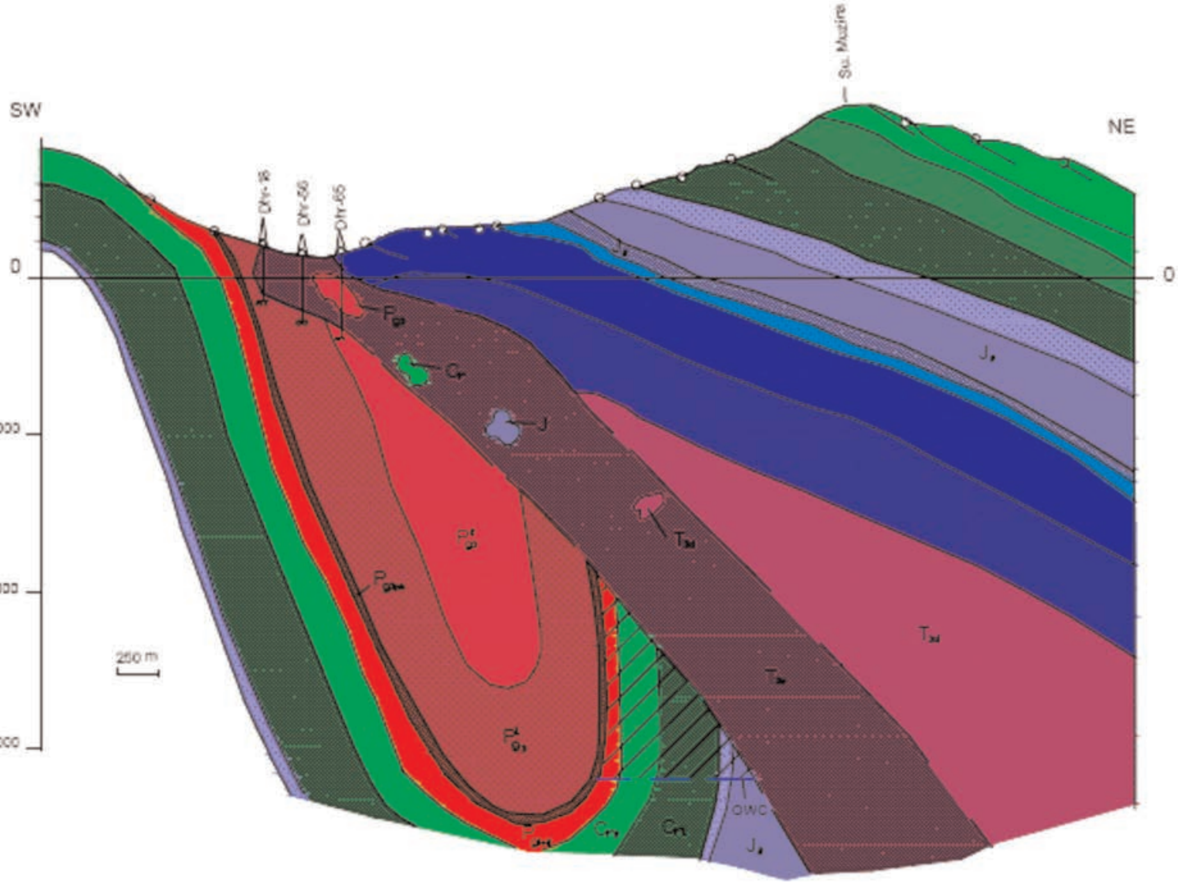

Fig. 10. Geologic profile 6-6 of the tectonic screen trap of the Dhrovjani prospect. Pg31, 2, 3. Lower, Middle, Upper Oligocene, Pg1+Pg2. Paleocene + Eocene, Cr1, 2. Lower, Upper Cretaceous, J1, 2, 3. Lower, Middle, Upper Jurassic, T3d & T3e Upper Triassic (dolomite & evaporitic deposits), Supposed oil-water contact.

field (GJOKA *et al*., 1985) and Sasaj Bay prospect (PRENJASI *et al*., 1994), etc.

7. Lithologic traps in the sandstone beds of the Messinian, as in case of the Kuçova oil field (SHEHU *et al*., 1966, etc).

8. Tectonic screen traps of the sandstone beds of the Messinian, conditioned by evaporitic diapirism of the Upper Triassic and the Oligocene flysch, as in the case of the Pekisht-Murriz oil discovery (MURATAJ *et al* 1962; GJENERALI *et al* 1964).

Conclusions

1. Geological survey must be in the leading role of carrying out regional geology, as well as natural resources exploratory works in the fold and thrust belt regions. Also, geophysical surveys oriented and supervised geologically, have provided enormous available information on geological setting and natural recourses potential of the Albanides. Thus geological and geophysical surveys, as well as many drilled wells results have enabled making up the geological and tectonic maps of the Albnides and discovering many natural recourse fields as oil, gas, drinking water, chromium, cooper, Iron-Nickel, coal, etc.

2. Several structural-facial zones or tectonic nappes overthrusted westward onto each other and entirely onto the Apulia Foreland make up tectonic setting of Albanides fold-and-thrust belts.

The Ionian–Kruja nappe comprises the Ionian trough structural facial zone and the Kruja (Gavrovo) ridge one, which have obvious gradual and lithological and structural transition to each other. This is the youngest tectonic nappe of the Albanides orogeny overthrusted onto the Apulia and Pre-Apulia / Sazani Foreland.

The Krasta nappe consists of different rocks from those of the Cukali Unit, which similar too much more with the Volcano sedimentary-mélange nappe. Subsequently tectonic nomination of the Cukali unit position needs further detailed accurate investigation into stratigraphic, structural and tectonic field and laboratory data.

The ophiolitic rocks represent a separate tectonic nappe overthrusted onto the Volcano sedimentary-mélange or younger nappes. In other words there is no room for concepts of the so-called "Mirdita Ocean" and its "Carbonate Ring".

3. Cretaceous and Paleogene limestone, as well as Miocene and Pliocene sandstone rocks are two main confirmed targets for hydrocarbon exploration in the Apulia foreland, Ionian–Kruja nappe and Periadriatic Foredeep.

4. Recent failures of the Albanian and foreign companies in hydrocarbon exploration does not mean poor perspective. But it means that further hydrocarbon exploration needs desperately applying hi-tech and low cost geological and seismic surveys, which can become a real access to new hydrocarbon reserves. In other words, presently hydrocarbon exploration means harder work, because we are exploring for new fields deeper and in more complicated geological setting traps. Subsequently, experimental works for picking up right acquisition and processing parameters, as well as providing obvious geological guide and link of seismic lines with known lithological markers from the field acquisition to the final interpretation of the all integrated geological-geophysical data remains a permanent must.

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Regional Study of Pannonian Basin

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Abstract. Despite a long period of geological study of the Pannonian Basin and its environment, this unique space continues to attract great attention of geologists. One of the most important motives for more intense research are certainly the petroleum explorations. Due to the increasingly complex demands of research, the need for cooperation between geologists of the Pannonian Basin region has shown up, so the company JSC «Gazprom Neft» and Petroleum Industry of Serbia proposed regional research project of the Pannonian basin and adjacent areas. The project would encompass the period 2012–2015 and would take place through several stages - from the creation of geological database for the entire region of the Pannonian Basin up to the regional model development phase of the Pannonian Basin and its neighborhood, with a choice of the most promising areas for the development of petroleum geological research.

Key words: Pannonian Basin, project, regional model, tectonics, oil and gas, cooperation.

Introduction

Pannonian Basin, as a back-arc type of basin, is an integral part of the Alpine orogenic belt. It is surrounded by the Carpathians on the North and East, the Eastern and Southern Alps in the West and Dinarides at the South. These mountain ranges were formed during the closure of Tethys Ocean due to collision of European and African plates, and the Cretaceous–Miocene continental collision of the European plate with several smaller continental fragments. Today, the Pannonian basin is a complex subbasen system of Neogene age, among which the most important are Bekes, Mako, Zala, Sava, Drava, Vienna, Transylvanian, Danubian basin and others.

Basement of Neogene complex of the Pannonian Basin consists of several microplates with developed Paleozoic and Mesozoic formations: Alcapa in the North, Tisza–Dacia in the center and the East and the Adriatic at the South. Today's microplates boundaries and their fragments are the major zones of geotectonic events in this area. Particular importance has Middle Hungarian lineament, transcurent fault at the border of Alcapa and Tisza–Dacia microplates.

Pannonian basin area is approximately 260.000 km^2, with a maximum width of about 600 km and a length of about 500 km. Basin is situated on the territory of Hungary, Romania, Serbia, Croatia, Slovenia, Bosnia and Herzegovina, Slovakia, Czech Republic, Austria, Ukraine and Moldova.

The area of the Pannonian Basin has a long history of petroleum explorations. The first oil discovery occurred in the area of present-day Croatia at 1856, while the first commercial gas field was discovered at 1917. Until today, in this area, about 500 oil and gas fields was discovered, and petroleum explorations were mostly focused on the Neogene Pannonian Basin complex, while the knowledge of the geodynamic evolution of pre-Tertiary structural systems, which are also important objects of research, remains insufficient. This, as well as complex structural-tectonic relations within Neogene complexes, represent a motive for the proposal of systematic and regional study of the Pannonian Basin and its immediate surroundings.

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Need for a Regional Geological Model of the Structure, Development and Oil and Gas Potential of Pannonian Basin

In the structure of the Pannonian Basin can be differ pre-Neogene basement of the basins and Neogene sediments. Pre-Neogene basement of the basin is built from different Proterozoic–Paleozoic and Mesozoic rocks. Proterozoic–Paleozoic is represented by metamorphites and magmatites. These tectonized and intensively cracked igneous and metamorphic rocks are important reservoir rocks in many subbasins (Hungary, Romania, Croatia, Serbia).

Mesozoic is represented by the different formations of Triassic, Jurassic and Cretaceous age. In the Triassic largest distribution have carbonate platform sediments, including proven petroleum source rocks, as well as significant reservoir rocks. The oldest known source rocks in the region of the Pannonian Basin belong to Triassic formations (Vienna basin, field Nagylengyel in Hungary, etc.). Jurassic is represented by the deep and shallow-sea sediments, ophiolites and ophiolitic melange rocks. In the central part of the Pannonian Basin, finegrained pelagic sediments of the Lower and Middle Jurassic has been identified as source rocks, and in the area of the Vienna basin complex of Upper Jurassic sediments has a great source rock potential. In the development of the Lower Cretaceous were designated different formations of clastic basin sediments and shallow marine reef limestones. Upper Cretaceous is characterized by the development of flysch formations, volcanogenic-sedimentary formations and shallow marine and bathyal carbonate-clastic sediments. It is significant that much of the Cretaceous carbonate and clastic sediments are potential source rocks, while the shallow Upper Cretaceous limestones are known as the reservoir rocks in Hungary, Austria, Croatia, Romania, Serbia etc.

Paleogene is represented by various marine (flysch, clastic-carbonate) and the continental sediments. The petroleum potential has been proven for Upper Eocene–Lower Oligocene marine formations and Upper Oligocene freshwater formations.

However, the main objects of research in of the Pannonian Basin are Neogene sediments. They are represented with a variety of Miocene and Pliocene formations, including differ continental molasse sediments, marine, brackish, caspibrakish, freshwater lacustrine, fluvial and swamp sediments, and there are also different volcanoclastites. Rocks of Miocene age are considered as the most important source of oil and gas in most parts of the Pannonian Basin. These are the clay-marly Middle to Upper Miocene sediments, while a negligible amount of production of oil, gas and biogenic gas belongs to Pliocene.

Such a complex geological structure of Paleozoic, Mesozoic and Cenozoic of Pannonian Basin and adjacent regions, necessarily requires consideration of a comprehensive regional petroleum potential of the individual sedimentary basins. Understanding of the regularities of oil and gas fields can be obtained only through scientific analysis and compilation of a series of general maps of Pannonian Basin, taking into account the geological and geophysical data of geological services in the region (Croatia, Hungary, Slovakia, Czech Republic, Romania, Austria, Slovenia, Bosnia and Herzegovina, Serbia, Moldova and Ukraine)

Proposals for Regional Studies

Despite the long study period, oil and gas resources of the Pannonian Basin have not been studied to the limit. At 2008 JSC "Gazprom Neft" at the example of the Serbian part of the basin was faced with a situation of non-uniform area of study and the lack of a regional model for the whole zone of oil accumulation. Thus, exist the relatively well-studied Banat graben and poorly studied area to the west. Virtually there are no information on the results of exploratory drilling in the neighboring countries and there is a lack of regional seismic profiles through the basin.

JSC "Gazprom Neft" in recent years in the Scientific and Technical Center organized a regional study of perspective territories at the level of integrated oil and gas basins. This enables to get the most accurate and comprehensive information about the geological history of the generation and accumulation of hydrocarbons within the regional petroleum systems. We have conducted complex tectonic and lithological studies, including work on basin modeling of petroleum systems in the Eastern Black Sea, Caspian, Timan–Pechora and Kara basins.

Work continues on the Arctic, the northern part of West Siberian and East Siberian regions. Thus, the analysis is performed on basins of any degree of knowledge, and always these studies provide new and interesting results and indicate areas for further exploration.

In this context, JSC "Gazprom Neft" offers European geological community and the oil companies operating in the Carpathian-Balkan region, focus, knowledge and experience to create a regional geological model of the structure, development and oil and gas potential of Pannonian Basin. To combine this into one accumulated geological and geophysical material and, especially, the regional seismic studies, because only they can be used to obtain the most accurate information about the structure of the basin.

JSC "Gazprom Neft" is ready to act as coordinator and take over part of the financial cost of this work.Our offer is directed not only to geologists of countries on whose territory lies the Pannonian Basin. Cenozoic sedimentary basins of the Outer Carpathians, the Balkans and the Adriatic certainly evolved in similar conditions, which is evidenced by their obvi-

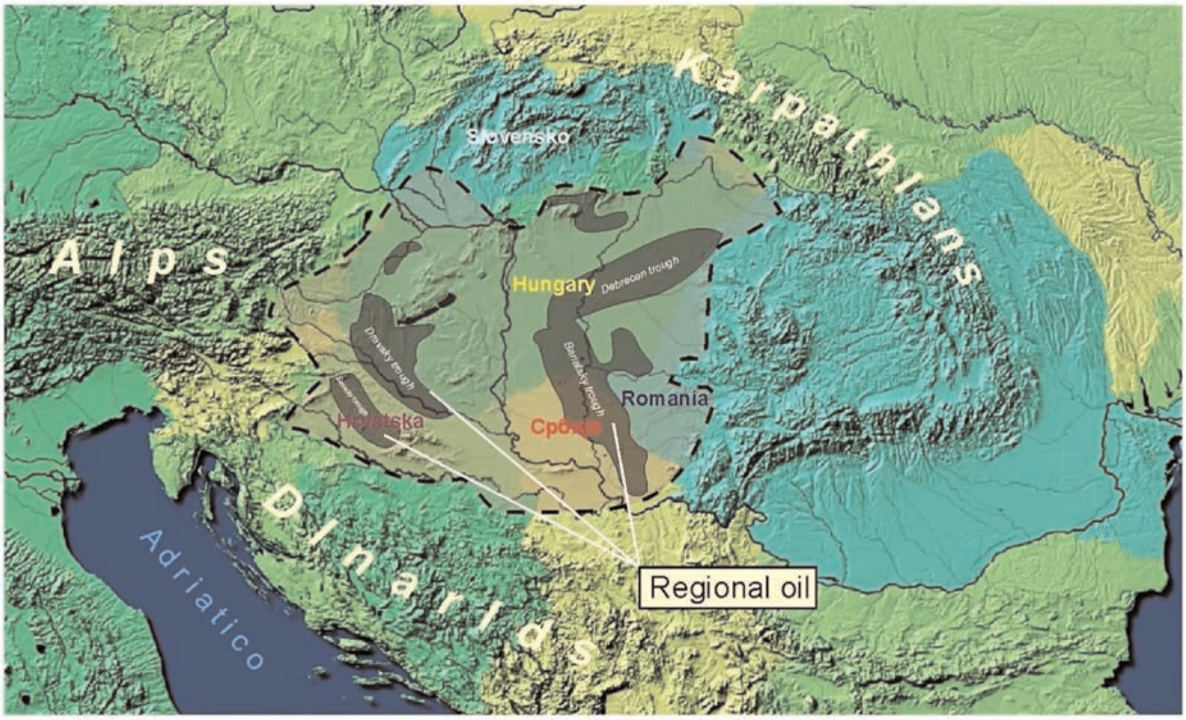

Fig. 1. Overview of the Pannonian Basin.

ous similarity in restriction of tectonic sedimentary formations.

Conclusions

Thus, in the Pannonian Basin and the entire Carpathian-Balkan region in Scientific and Technological Center of the Petroleum Industry of Serbia, with the participation of the Scientific Technical Center of JSC “Gazprom Neft”, plan to carry out a comprehensive research project on the Pannonian Basin basin modeling.

The project will perform the following activities:

1. Creation of geological and geophysical database for the Pannonian Basin and adjacent areas;
2. Compilation of regional seismic and geological sections and correlations of sections, description of petroleum systems;
3. Compilation of a series of maps of scale 1:200.000–1:500.000 at reflective (and productive) horizons;
4. Carrying out basin modeling and selection of the most promising areas for oil and gas.

The main goal - to provide new knowledge and new geological information for issue recommendations on the formulation of exploration including a Paleozoic–Mesozoic formations.

Implementation period – 2012–2015.

Our company is open to suggestions and requests.

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Environments and Age of Oil-Source Beds in the South of Siberian Craton

ARKADII STANEVICH[1]

Abstract. Oil deposits in the south of the Siberian platform were formed and redistributed in some stages. The primary volume of hydrocarbons was collected as a result of vital activity ability of the deep-water chemolithotrophic bacteria south of platform, in backarc basin of the Sayan–Baikal folded area by the end of Neoproterozoic. Formation of oil and its north migration in Vendian-Cambrian sediments occured as a result of collision events on the Siberian craton margin from the end Vendian up to Silurian.

Key words: Late Proterozoic, Siberian craton (platform), depositional environment, geodynamic reconstruction, microfossils, algae, bacteria.

Introduction

The Siberian platform is bounded from the south by the Sayan-Baikal folded area (SBFA, Fig. 1). Rich deposits of oil and gas in sediments of Vendian–Cambrian age are known northern of SBFA. These sediments cannot be source of oil because of their composition and small thickness. There exist the point of view about migration of oil from the south, from SBFA territory. This assumption could not be accepted for a long time in a view of the conventional opinion about ancient, Mezo-Neoproterozoic or even Early Proterozoic (FEDOROVSKII, 1985) age of formations of Bodaibo zone. Results of geochemical and microphytological researches (NEMEROV & STANEVICH, 2001; STANEVICH *et al.*, 2006, 2007), and also chemostratigraphic and isotope data (POKROVSKII *et al.*, 2006; MEFFRE *et al.*, 2008; KUZNETSOV *et al.*, 2011, in press) allow to present geodynamic evolution of the south of Siberian craton in second half of the Neoproterozoic, conditions of maturation of hydrocarbonic raw material and its primary migration.

Age and environment of sediments of the SBFA

Sections of the Baikal and Patom zones are the most studied and there were selected levels of regional horizons. Regional horizons have been allocated in 80–90 years in southern zones as a result of works of many geologists (STANEVICH *et al.*, 2006, 2007) (Fig. 2). The age of all retinues of regional horizons was estimated in an interval of the Mezo-Neoproterozoic or more than 1 billion years. New isotope and chemostratigraphic data from sediments of the Baikal, Patom, Bodaibo zones have been received in the recent years (POKROVSKII *et al.*, 2006; MEFFRE *et al.*, 2008; KUZNETSOV *et al.*, 2011, in press). They have shown, that the most part of all sections has an age interval 600–540 million years (Fig. 2).

All sections SBFA (Figs. 1, 2) reflect three basic stages in development of region: Medvezhevka–Ballaganakh, Dalnetaiga–Zhuya and Yudoma (NEMEROV & STANEVICH, 2001; etc.). Sedimentation was defined by conditions of the riftogenic sea of Siberian craton passive margin in Medvezhevka–Ballaganakh stage (STANEVICH *et al.*, 2006). The basin was filled with basalts, volcanic and terrigenous coarse material in the beginning of a stage. Two powerful transgressive cycles are allocated above. These environments are well correlated with processes of disintegration of supercontinent Rodinii during 780–680 million years (LI *et al.*, 1999; GLADKOCHUB *et al.*, 2005; etc.).

The period 600–570 million years (Dalnetaiga horizon, Figs. 1, 2) is defined by the beginning of convergent events, initiation and evolution of an island arc and backarc basin. It is suggested that deposition of

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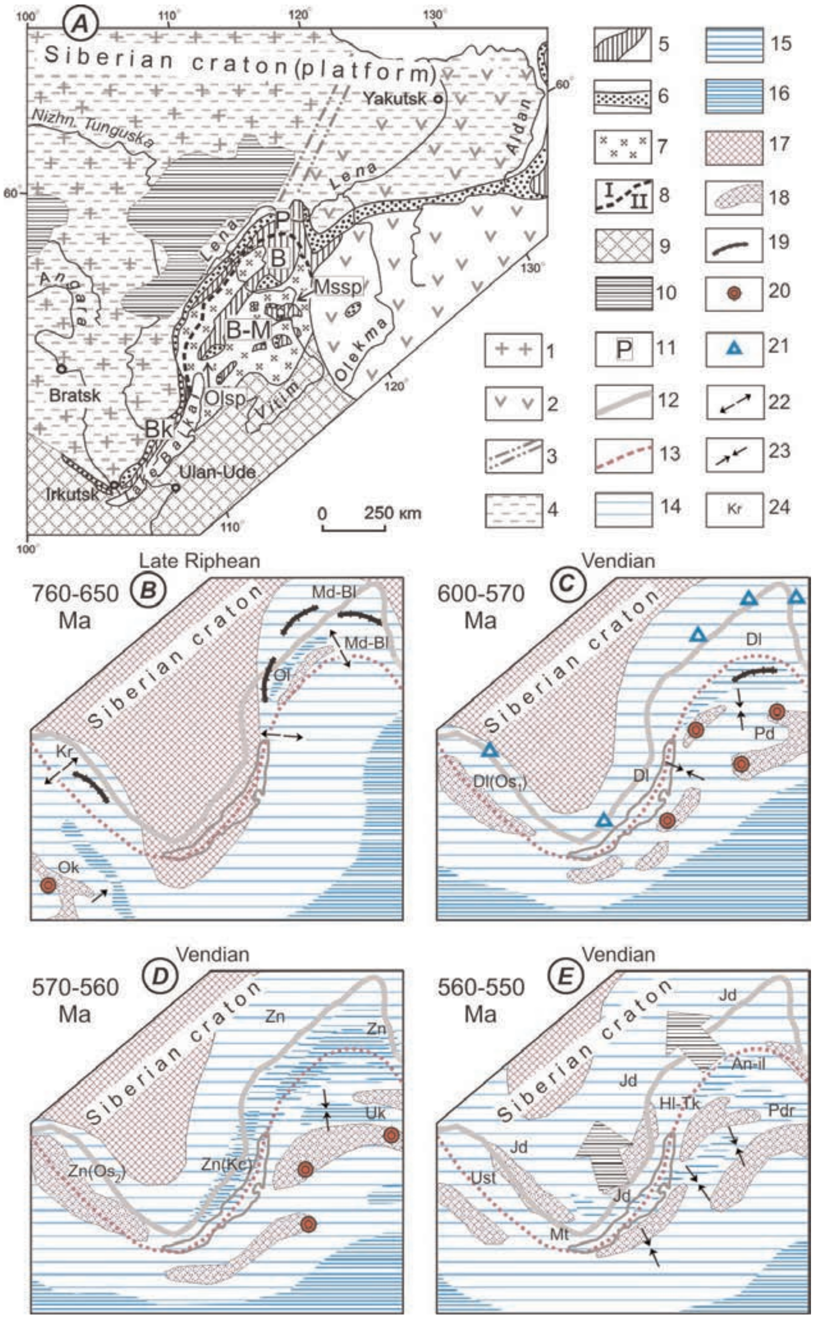

Fig. 1. The geological scheme and tectono - paleogeographic cuts of evolution of a southern fragment Siberian craton (platforms) in Neoproterozoic. 1–4. Siberian craton: 1. Angara block, 2. Aldan block, 3. joint zone of Angara and Aldan blocks, 4. nonsegmented rocks of sedimentary cover of the Siberian platform; 5. sedimentary and sedimentary-volcanic rocks of Neoproterozoic; 6. deposit of Vendian–Lower Cambrian; 7. nonsegmented formations of the Sayan–Baikal folded area (SBFA); 8. border external (I) and internal (II) belts of the SBFA; 9. Transbaikalian folded area. 10. perspective areas of an oil recovery (A) and ways of migration of hydrocarbons to deposit of Siberian platform (E); 11. structurally-formation zones of the SBFA: B – Bodaibo, Bk – Baikal, B–M – Baikal–Muya (spaces: Olsp–Olokit, Mssp–Muya), P – Patom; 12. border of Siberian platform and Sayan–Baikal folded region; 13. morden border of Siberian craton; 14–16. assumed area of sea space: 14. shallow part of basins and shelfs; 15. depressions of the closed and semiclosed basins; 16. probable fondowater area; 17. assumed area of the craton land; 18. assumed area of the island land; 19. riftogenic zones with basic magmatism; 20. area of aerial bimodal volcanism; 21.glacial area; 22. probable divergent movements; 23. probable convergence movements; 24. stratigraphic units (formations): An-il – Anangra-Iligir; Dl – Dalnetaiga; Dl(Os_1) – Dalnetaiga (Oselok); Hl-Tk – Kholodnaya-Tukolami; Jd – Judoma; Kr – Karagas; Md-Bl – Medvezhevka-Ballaganakh; Mt – Moty; Ok – Oka; Ol – Olokit; Pd – Padra, Pdr – Padrokan; Srh – Sarkhoi; Uk – Ust'kelyana; Ust – Ust'tagul; Zn – Zhuya; Zn(Kc) – Zhuya (Kachergat); Zn(Os_2) – Zhuya (Oselok).

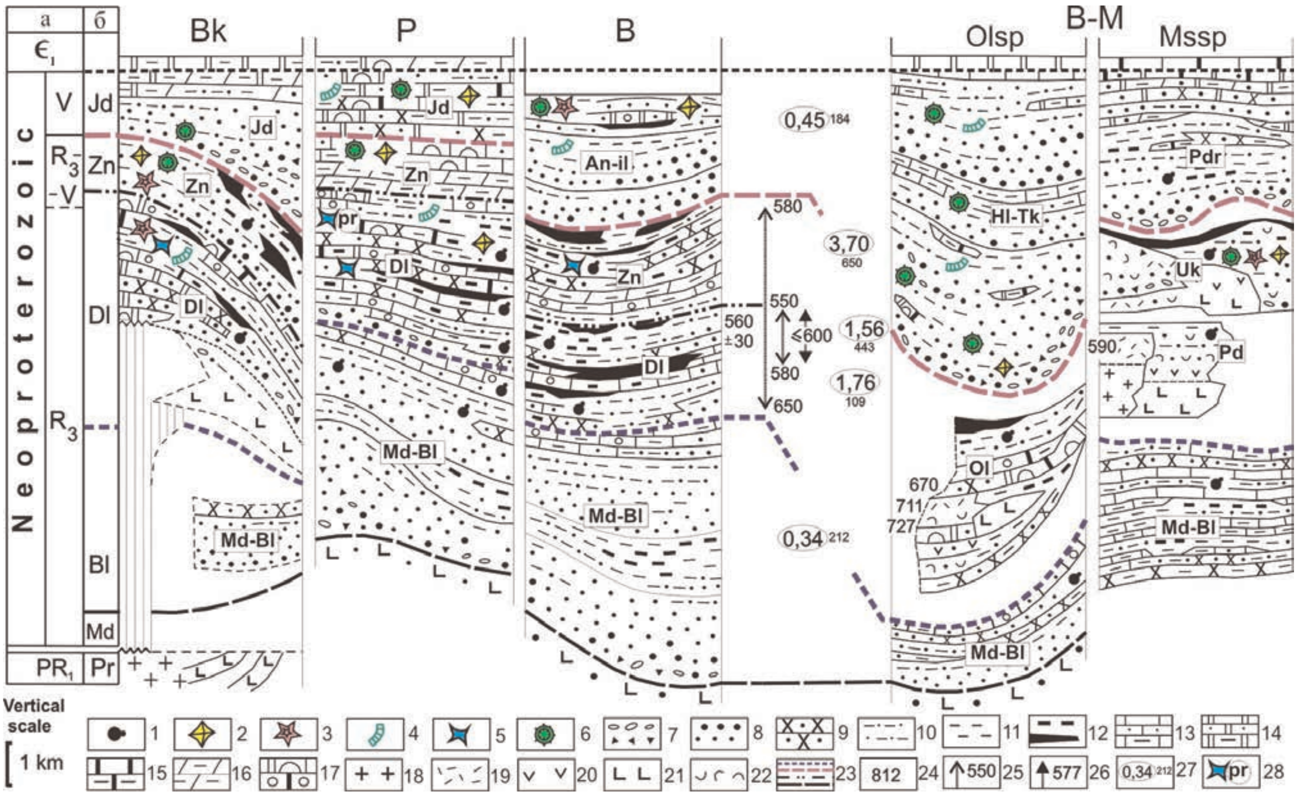

Fig. 2. The scheme of correlation of the Late Precambrian formations of the Sayan-Baikal folded area (SBFA). Occurence and ecobiological interpretation of microfossils. a – general chronostratigraphic scale; b – regional horizons (series) of SBFA: Md – Medvezhevka; Bl – Ballaganakh; Dl – Dalnetaiga; Zn – Zhuya; Jd – Judoma. Pr – Primorskii granites complex. 1–6. the eco-biological microfossil assemblages (explanation see at the end); 7. conglomerates and conglo-breccia; 8. polymictic, arkosic-graywacke gritstones and sandstones; 9. quartz sandstones; 10. aleurolites; 11. argillites, aleurite-argillites; 12. carbon-bearing argillites and aleurite-argillites, mark of carbon-bearing sediments; 13. limestone, arenaceous limestone, intercalation of limestone and aleurite-argillites; 14. dolomites, arenaceous dolomites, intercalation of dolomites and aleurite-argillites; 15. limestone-dolomite sediments, aleurite-argillitic limestone-dolomitic sediments; 16. marl; 17. limestone-dolomite sediments with stromatolithes and oncolites; 18. granites, plagiogranites; 19. felsic igneous rocks; 20. medium igneous rocks; 21. basic igneous rocks; 22. tuffs and tuffites; 23. border of regional horizons; 24–27. isotope age data, in millions years: 24. 670±65 (Rb–Sr isochrona); 711±6, 727±18, 590±5 (U-Pb on zircons); 560±30 (Pb–Pb on limestone); 25. interval of approbation and conclusion about age interval under the relation of $^{87}Sr/^{86}Sr$ in limestones: 650–580, 580–550; 26. interval of approbation and conclusion about age clastic zircons (U–Pb); 27. average contents of C_{org} (%) in aleurolites and argillites of regional horizons in zones Bk, P and B, and quantity of samples.

Ecobiological microfossil assemblages (number of legend - 1–6): 1. anaerobic, sulphate-producing and others (?) bacteria, variable-depth marine benthos; 2. aerobic sulphur bacteria, shallow-marine benthos; 3. dinoflagellates or aerobic prosthecobacteria, facultative marine plankton; 4. cyanobacterial communities, mainly littoral; 5. acanthomorphic and other eukaryotic algae, mainly plankton (28 – Pertatataka acritarch association of the Ediacaran); 6. green algae, facultative marine plankton.

Legend of structurally-formation zones and spaces see Fig. 1.

basal layers of horizon and their analogues occured 600–590 million years ago, and glacial events of this time are correlated with global glaciation Marino (Vorob'eva *et al.*, 2008). Island-arc andesite and basalt are significant for the Baikal–Muya zone. Their influence is established in sediments of the Bodaibo and Patom zones. The period 570–560 million years (Zhuya horizon) is characterized by formation of foreland basin, which later (about 560 million years) was replaced by system of piedmont troughs of orogenic stage (Yudoma horizon) (Nemerov & Stanevich, 2001; Stanevich *et al.*, 2006, 2007).

Biotic component

At hundreds sites of all zones of the SBFA are studied numerous microfossils (Stanevich *et al.*, 2006;

etc.). Sedimentological reconstruction and actuapaleontological comparison have allowed to plan ecological and biological belonging of a part of the organowall microfossils. The forms of green, brown algae, dinoflagellates and variable-depth bacterial communities are selected. The formation of new characters at microfossils, carried to green, occured on the Dalnetaiga and Zhuya horizons boundary, during change of a sedimentation conditions. Forms of chemolithotrophic (sulfatereductionic, ferruterous and others, the size 1–15 microns) bacteria form congestions, layers and often are rock-forming (up to 25 % from the area of microsections).

Conditions of origin and migration of hydrocarbons

Stage of the transition from backarc basin to foreland basin (on the Dalnetaiga and Zhuya horizons boundary) is the most important for the beginning accumulation of carbonaceous sediments. This transition is characterized by increase of deposits biomass that well is fixed by increase of the importances biophile elements, by increase of the taxonomic variety organic remains and sharp increase of values C_{org} (Fig. 2). The greatest mass of microfossils, which is found in deep-water shelf, side and troughs of the basin (Baikal and Bodaibo zones), pertains to chemolithotrophic bacteria. As it is expected, these bacteria are released the acumulation of metal in hydrothermal field of the foreland basin (NEMEROV *et al.*, 2010). They formed a huge biomass in stagnatory conditions of basin depressions. Carbonaceous deposits have been overlied by thick terrigenous deposit at the Yudoma time. Clastic material in Baikal, Bodaibo and Baikal–Muya zones was transported from the southern upland which have been raised at Early-Yudoma orogeny. Pressure of southern plates upon edge of the Siberian craton, probably, has caused the beginning of redistribution of hydrocarbons on the north (Fig. 1). Later, Yudoma thicknesses have been overlied by carbonate-terrigenous deposits of the Cambrian and Ordovician. This period of burial metamorphism of the Neoproterozoic rocks, most likely, is possible to consider as time of the basic formation of oil. But, the most intensive tectonic events have occured in the Ordovician. This time is characterized by a collision of plates complex with southern edge of the Siberian craton (FEDOROVSKII *et al.*, 1995). Fold-thrust processes and dislocation metamorphism, down to high-rank metamorphism, are dated for this time. Probably, during a collision and after it (Ordovician, Silurian) the hydrocarbonic raw material was wrung out on sandy collectors on the north and concentrated in diagenetic transformed sandstones and carbonates of the Vendian–Cambrian.

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Review of Energy Resources Shale Gas in Europe

Sunjay Sunjay[1]

Abstract. With a view to energy security of the world ,unconventional energy resources - coalbed methane (CBM) , Methane GasHydrate,shale gas, basin centred gas, tight gas,oil shale and heavy oil- exploration and exploitation is pertinent task before geoscientist. Shale gas is natural gas from shale formations which acts as both the source and the reservoir for the natural gas. Each Shale gas reservoir has unique characteristics. Shale has low matrix permeability, so gas production in commercial quantities requires fractures to provide permeability. For a given matrix permeability and pressure, gas production are determined by the number and complexity of fractures created, their effective conductivity, and the ability to effectively reduce the pressure throughout the fracture network to initiate gas production. Understanding the relationship between fracture complexity, fracture conductivity, matrix permeability, and gas recovery is a fundamental challenge of shale-gas development. Shale gas reservoirs almost always have two different storage volumes(dual porosity) for hydrocarbons, the rock matrix and the natural fractures. Because of the plastic nature of shale formations, these natural fractures are generally closed due to the pressure of the overburden rock. Consequently, their very low, matrix permeability, usually on the order of hundreds of nanoDarcies (nD), makes unstimulated, conventional production impossible. Almost every well in a shale gas reservoir must be hydraulically stimulated (fractured) to achieve economical production. These hydraulic fracture treatments are believed to reactivate and reconnect the natural fracture matrix .

Key words: Unconventional Reservoir, 3D-Seismic, Anisotropic processing, Hydrofracturing.

Introduction

Shales and silts are the most abundant sedimentary rocks in the earth's crust. In petroleum geology, organic shales are source rocks as well as seal rocks that trap oil and gas. In reservoir engineering, shales are flow barriers. In drilling, the bit often encounters greater shale volumes than reservoir sands. In seismic exploration, shales interfacing with other rocks often form good seismic reflectors. As a result, seismic and petrophysical properties of shales and the relationships among these properties are important for both exploration and reservoir management. Another key difference between conventional gas reservoirs and shale gas reservoirs is adsorbed gas. Adsorbed gas is gas molecules that are attached to the surface of the rock grains. The nature of the solid sorbent, temperature, and the rate of gas diffusion all affect the adsorption. Presently, the only method for accurately determining the adsorbed gas in a formation is through core sampling and analysis. Understanding the effects of adsorption on production data analysis increase the effectiveness of reservoir management in these challenging environments. They contain natural gas in both the pore spaces of the reservoir rock and on the surface of the rock grains themselves that is referred to as adsorbed gas. This is a complicated problem in that desorption time, desorption pressure, and volume of the adsorbed gas all play a role in how this gas affects the production of the total system. Adsorption can allow for significantly larger quantities of gas to be produced. Shale gas reservoirs present a unique problem for production data analysis. The effects of the adsorbed gas are not clearly understood except that it tends to increase production and ultimate recovery. The phenomena of gas storage and flow in shale gas sediments are a combination of different controlling processes.

Theory

Gas flows through a network of pores with different diameters ranging from nanometres (nm = 10^{-9} m)

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to micrometres (μm = 10^{-6} m). In shale gas systems, nanopores play two important roles. Petrophysical imaging employs first,second & third generation wavelet to delve deep into complex shale gas reservoir. Nanoscale gas flow in Shale gas sediments has scope to cope with research on dry nanotechnology (smartfluid/nanofluid). Anisotropy in sediments may develop during deposition or post deposition. In clastic sediments, anisotropy can arise both during and after deposition. In carbonates, anisotropy is controlled mostly by fractures and diagenetic processes, and so tends to arise after deposition. For anisotropy to develop during deposition of clastics, there needs to be an ordering of sediments-in essence, some degree of homogeneity, or uniformity from point to point. If a rock were heterogeneous in the five fundamental properties of its grains- composition, size, shape, orientation and packing- anisotropy cannot develop because there would be no directionality intrinsic to the material. Anisotropy at the bedding scale that arises during deposition therefore may have two causes. One is a periodic layering, usually attributed to changes in sediment type, typically producing beds of varying material or grain size. Another results from the ordering of grains induced by the directionality of the transporting medium. Anisotropy is therefore governed not only by variation in the type of material but also by variation in its arrangement and grain size.

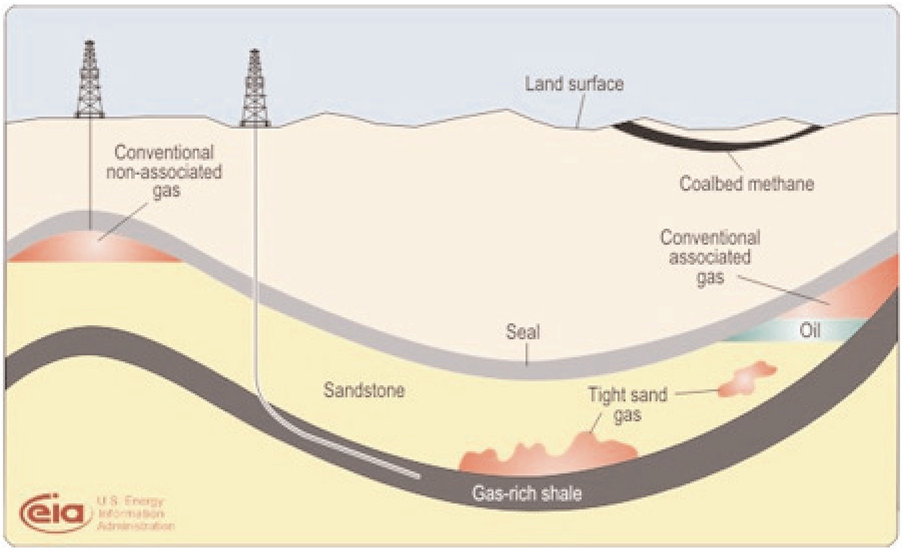

Fig. 1. Occurrence of Shale Gas.

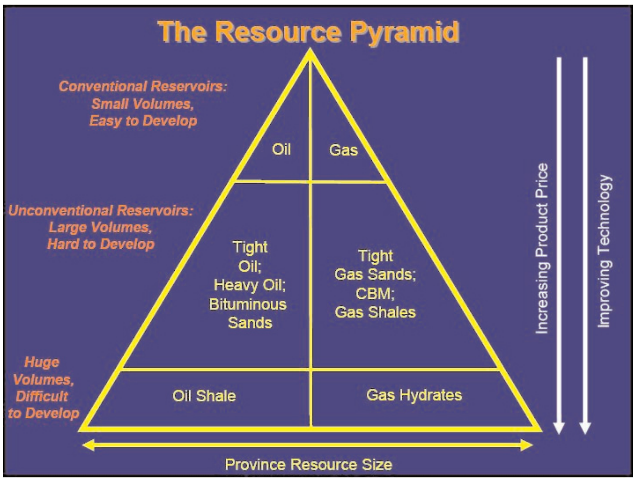

Fig. 2. The resource triangle unconventional resources.

Nonlinear Seismic Imaging: In a nonlinear elastic system, the principle of superposition does not hold and the frequency mixing, harmonic generation, and spectral broadening takes place. These changes that add new frequencies to the frequency spectrum provide us with a means of measuring the elastic nonlinearity parameter of the reservoir rocks. This elastic nonlinearity parameter is unique, and can be effectively used as a seismic attribute to map the rock properties of the reservoirs for improving the results of the exploration and exploitation efforts. The sensitivity of the nonlinear response to the porosity, fracturing, and pore fluids of the reservoir rocks is relatively larger than the linear measurements being used today. Industry needs to take advantage of this additional seismic attribute to reduce the ambiguity of the seismic-based geologic interpretation.Nonlinear seismic imaging enables the end-user to retain the conventional linear seismic images and provides additional nonlinear seismic images that identify the porous and fractured reservoir rocks. In areas where the current seismic fails to map the stratigraphic or fractured hydrocarbon traps, nonlinear seismic technology can provide the useful reservoir information.

Azimuthal Anisotropic Seismic Signal Processing

Shale – inherent heterogeneity and anisotropy: 3D seismic is becoming successful because of the ability to identify fracutre and fault trends. This is why 3D is now being used aggressively and successfully. Unconventional reservoirs require some form of stimulation to obtain commercial production. Shale gas reservoirs require fracture stimulation to unlock gas from extremely low-permeability formations. As fracture stimulation is an important aspect of well completions, production companies need to know basic information about fractures. Three types of information extracted from seismic are useful in optimizing drilling locations: fracture characterization, geomechanical properties, and principle stress measurements (vertical maximum and minimum horizontal stresses). Anisotropic effects are observed on 3D seismic data as changes in amplitude and travel time with azimuth. In multicomponent data shear wave splitting can be observed. When geophysics met geomechanics: Imaging of geomechanical properties and processes using elastic waves. The focus is primarily on geophysical imaging using elastic waves, whose propagation is controlled by a material's elastic properties and density. The former can be thought of as the summation of contributions over a range of length scales: grains, discontinuities (including cemented or uncemented grain contacts), inter- or intra-granular cracks, fractures and layers, which can all be anisotropic or can produce an anisotropic aggregate material. Geophysicist derives a host of geomechanical properties from migrated CDP gathers, including Young's Modulus, Poisson's Ratio, and shear modulus, by first inverting the data for P- and S-wave velocities and density. With this information, fracture dimensions can be predicted and wells drilled in the most brittle rock.

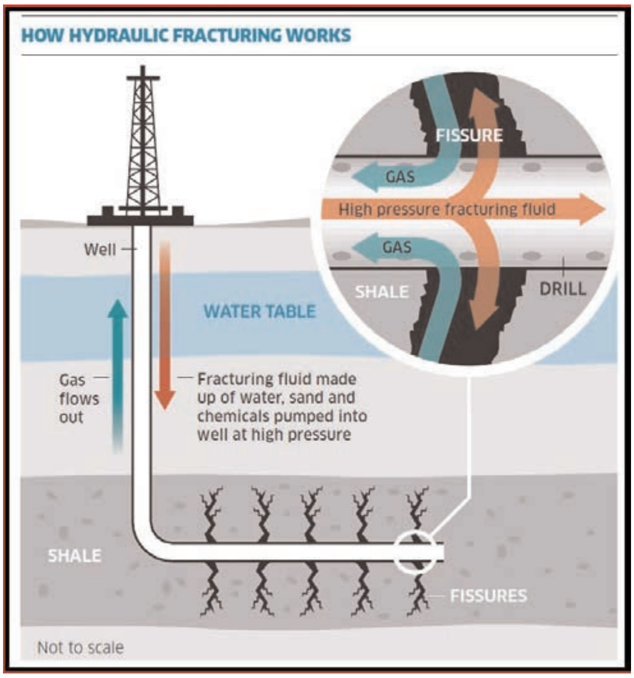

Fig. 3. Hydraulic fracturing shale gas.

Hydraulic fracturing, often called fracking, fracing or hydrofracking, is the process of initiating and subsequently propagating a fracture in a rock layer, employing the pressure of a fluid as the source of energy. The fracturing, known as a frack job (or frac job) is done from a wellbore drilled into reservoir rock formations, in order to increase the extraction rates and ultimate recovery of oil and natural gas. Hydraulic fracture complexity is the key to unlocking the potential of shale plays. Microseismic monitoring suggests that complex fracture network can be developed in some shale plays. Microseismic monitoring is a proven technology and has been widely used to monitor and evaluate the effectiveness of hydraulic fracture treatments in various formations, including shale. Theoretically, in shale plays, a complex fracture should produce better compared to bi-wing planer fractures as a result of increased fracture surface area. The value of the microseismic data is that it provides operators with 3D visualization of where the hydraulic fracture process is impacting the rock in the reservoir. When real-time monitoring is used, the microseismic information can be used to prevent fracture growth out of zone. Micro-seismic hydraulic fracture monitoring is another of these new technologies. One of the principal costs in extracting natural gas is the hydraulic fracture process. The rock must undergo extensive fracturing to create the permeability required to allow gas to flow into the wellbore. "Micro-seismic methodologies arguably offer industry the best method to determine the efficiency of the fracture stimulation process, as it applies to making contact with the gas resource locked in the rock.

Shale gas potential in Europe

The shales are deposited in three basins – The Baltic in the north, the Lublin in the south, and the Podlasie in the east. The organically rich shales in these three basins appear to have favorable characteristics for shale gas exploration. Baltic Basin- The Baltic Basin covers an area of approximately 102,000 square miles area in Poland, Lithuania, Russia, Latvia, Sweden and the Baltic Sea. Its southwestern border is formed by the Trans-European Fault Zone. Paleozoic sediments compose 75 % of the basin fill, with the Silurian strata most prevalent. The southwest margin of the Baltic Basin received very thick sediments of marine deposits as the basin subsided during the late Ordovician–Silurian collision of the Avalonia and Baltica tectonic plates. Anoxic conditions in the deep marine environment of the early Silurian allowed for the deposition of thick layers of organic rich shale, which were subsequently buried to depths sufficient to thermally mature the shales into the wet to dry gas window. Lublin Basin –The Lublin Basin contains very similar Silurian depositional strata to the Baltic Basin, though regional tectonic events and rifting during the Devonian created a different maturity and depth profile than observed for Silurian Shale in the Baltic Basin. The primary shale gas target in the Lublin Basin is the Lower Silurian Wenlock Formation.

Podlasie Basin-The Podlasie Basin (Podlasie Depression) is an isolated section of the Lower Paleozoic sedimentary basin, east of the Baltic and Lublin basins. Eastern Europe-However, several basins contain promising shale gas targets, such as the northern Baltic Basin in Lithuania, the southeastern extent of the Lublin Basin into Ukraine and the Dnieper–Donets Basin in Ukraine. Additional potentially prospective basins include the Pannonian–Transylvanian Basin in Hungary and Romania, and the Carpathian-Balknian in Southern Romania and Bulgaria. The Baltic Basin (Baltic Syneclise) is a large marginal synclinal basin located in the southwestern part of the East European Craton and a major structure of the three Baltic States. The shale gas target in the Baltic Basin

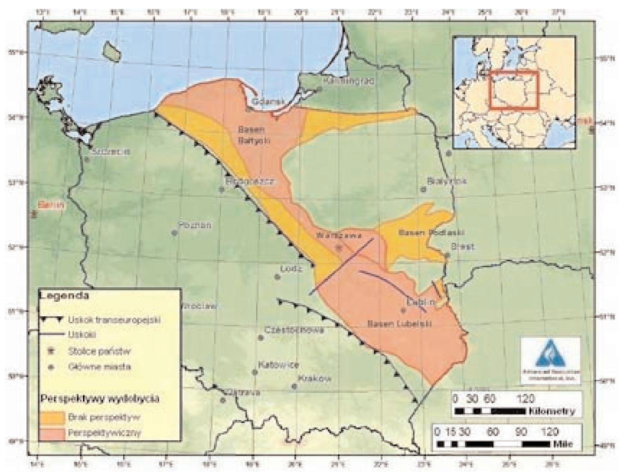

Fig. 4. Shale gas potential in Baltic Europe.

is the lower Silurian marine shale package, which, though less mature than in Poland, has favorable characteristics for shale gas development. Dnieper–Donets Basin– The Dnieper–Donets (Dniepr–Donets) Basin forms a NW–SE trend through central Ukraine and into Russia. It is part of the larger Pripyat–Dniepr–Donets intercratonic rift basin, which trends further NW into Belarus. The basin is flanked by the regional highs: the Ukrainian Shield (to the south) and the Voronezh Massif (to the North). Carboniferous (Rudov Bed). The prospective area of the Dneiper–Donets Basin is most limited by its great depth. The Dnieper–Donets Basin is under investigation for unconventional gas potential. At present, shallower CBM deposits in the eastern area of the basin are the primary exploration targets.Ukranian Lublin Basin-The Ukrainian Lublin Basin is the southern extension of the Lower Paleozoic sedimentary basin deposited along the western slope of the Baltica paleocontinent. Pannonian–Transylvanian Basin. Shale gas exploration in the Pannonian–Translyvanian Basin is still in a very speculative phase. Carpathian-Balkanian Basin– The Carpathian-Balkanian Basin is a geologically complex basin composed of a series of mountain nappes, foredeeps and plains in Southern Romania and Bulgaria.

Shale gas potential in Western Europe: Paris Basin– The Paris Basin contains two organically rich shale source rocks: the Toarcian "Schistes Carton" black shale formation and the Permian-Carboniferous shales. The lower thermal maturity "Schistes Carton" shales are the source rock for most of the oil produced in the Paris Basin. Permian-Carboniferous shales referred to in this report encompass a series of horizons ranging from the Pennsylvanian (Carboniferous) to late Permian. Southeast Basin- The basin is bounded on the east and south by the Alpine thrust belt and on the west by the Massif Central, an uplifted section of

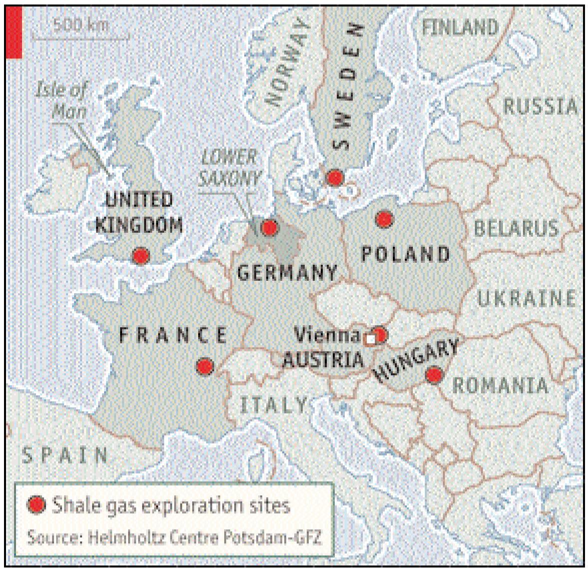

Fig. 5. Shale gas potential in Western Europe.

the Paleozoic basement. Upper Jurassic "Terres Niores". The "Terres Noires" black shales are marine shales deposited throughout the Southeast Basin. North Sea–German Basin– A number of smaller, localized basins, such as the German Lower Saxony, Musterland and the West Netherlands basins exist as grabens within the more regional North Sea–German Basin. Several formations in the North Sea–German Basin show potential for shale gas development. The three best identified formations are the marine Lower Jurassic "Posidonia"Shale, the deltaic Lower Cretaceous "Wealden" Shale and the marine Carboniferous Namurian Shale in the northwest of Germany and parts of the Netherlands. Lower Jurassic (Liassic) Posidonia Shale. The Lower Jurassic shale sequence referred to in the report as the Posidonia Shale actually contains three shale bearing members: The Posidonia Formation, the Aalburg Formation and the Sleen Formation. Cretaceous Wealden Shale. The Wealden Shale is a known source rock in the Lower Saxony

Graben of the North Sea–German Basin. Like the Posidonia Shale, it is immature with respect for gas generation throughout most of its area, but is prospective in its deeper core areas. Carboniferious Namurian Shale. The Namurian sequence in the Netherlands contains two prospective formations, the Epen and Geverik, which are collectively termed the Namurian Shales.

U.K. Southern Petroleum System– The U.K. Southern Petroleum System contains the Mesozoic Weald and Wessex basins and ranges from the Variscan Front south to the English Channel. The most prospective source rock for shale gas development in the Southern Petroleum System is a group of Liassic interbedded shallow marine shales and clays, known as the Liassic Clays, Vienna Basin– The Vienna Basin is a Tertiary pull-apart basin located in northwest Austria and extending northward into the Czech Republic.

Conclusions

GASH is the first European interdisciplinary shale gas research initiative (http://www.gas-shales.org).

According to geologists, there are more than 688 shales worldwide in 142 basins. Shale Gas exploitation is no longer an uneconomic venture with availability of improved technology as the demand and preference for this clean form of hydrocarbon have made Shale Gas, an energy in demand. The reserve accretion, production & development of shale gas from one basin to another around the world are rapidly increasing. Real-time monitoring of micro-seismic events allows operators to immediately optimize the hydraulic stimulation process by modifying the fracture stage design while pumping into the formation. The operator used the real-time data to experiment with how different perforation patterns impacted fracture propagation. The firm also used the data to make real-time changes in the fracture program. At one point, the data showed an absence of growing micro-seismic activity geometry, alerting the operator to stop pumping proppant and flush the well with water to avoid a potentially costly sanding-off of the fractures. Recording micro-seismic events to monitor rock fracturing in 3D space and time during the stimulation process allows operators to confirm the rock volume and formation geometry being stimulated. As a result, operators can optimize future well placement and completion designs, for cost-effective drainage of unconventional reservoirs. Europe has great potential of shale gas.

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Microbiological Enhanced Oil Recovery Methods and their Applicability for West Siberia Reservoirs

MARIA ZAYTSEVA[1]

Abstract. The attempt represents an approach to the enhanced oil recovery for watered mature production fields, using advanced biotechnologies on the example of the "Muravlenkovskneft" affiliate's field of OJSC "Gazpromneft-NNG". It proves their technological and economic advantage over the traditional physico-chemical enhanced oil recovery methods used in the affiliate's fields.

Key words: Oil recovery methods, microorganisms, microbial activity, Russia.

Introduction

In our country for about half a century a negative downward trend of designed oil recovery is being observed: in comparison to the 50's it has reduced twice (Fig. 1). The longstanding reduction in the designed oil recovery coefficient, according to expert opinion, is connected with the fact that adequate modern methods of increased oil production are not used for development of reserves. Since 1965 oilmen have left about 14 billion tones of potentially developable reserves under the ground; as much as has been produced in history of oil industry in Russia. In the USA, for instance, intensity of the new enhanced oil recovery techniques (EORT) application is growing year by year, while it is lowering in Russia (Fig. 2), KOSTINA *et al*. (2005).

At the present stage, the EOR problem can be solved by the microbiological formation impact. Such technologies are based on diverse activity of formation microflora: synthesis of surfactants– intermediate oxidation products of hydrocarbons; gas escape– carbon dioxide and methane, reducing oil viscosity and increasing the formation pressure; synthesis of low-molecular acids dissolving formation rock and increasing its porosity, and etc.

Similar enhanced oil recovery methods meet more recognition all over the world as high-performance, with their low investment requirements, and safe for the environment. Implementation of the MEORM worldwide shows that oil production exceeds background indexes per various deposits from 10 to 30 % (GATAULLIN *et al.*, 2009).

MEOR mechanisms

Traditional chemicals such as dissolvents and surfactants are used for the oil mobility improvement and contribute to its recoverability. However, these chemicals are "passive" materials, as they can be delivered to the required location only mechanically. When water-flooding, chemicals transfer to the field by means of a pumped water stream, generally getting only to areas where oil has already been displaced by the water, or they are spent since before they get into the place where they are required most of all.

It is known already for decades that tailor-made natural microorganisms are capable of metabolizing hydrocarbons, producing organic dissolvents such as spirits and aldehydes, surface action fatty acids, as well as several other biochemicals known for their capability of the oil mobility improvement (Table 1). Consequently, it is rather reasonable to suggest that if such living movable organisms are inserted in the fields, they will be able to move to the final resting place of remaining oil - and operate oil which has been considered to be immobile and unrecoverable. This process will be efficient as microorganisms permanently produce the required biochemicals in area where it is required most of all, - that is in the porous formation zones (BOKSERMAN *et al*., 2010).

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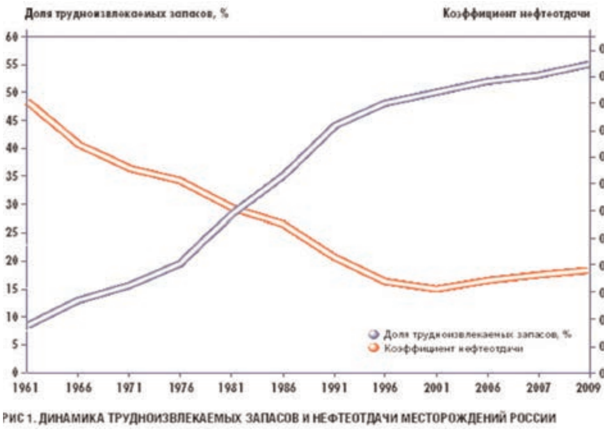

Fig. 1. The dynamics of hard-to-recover reserves and oil recovery in the Russian fields.

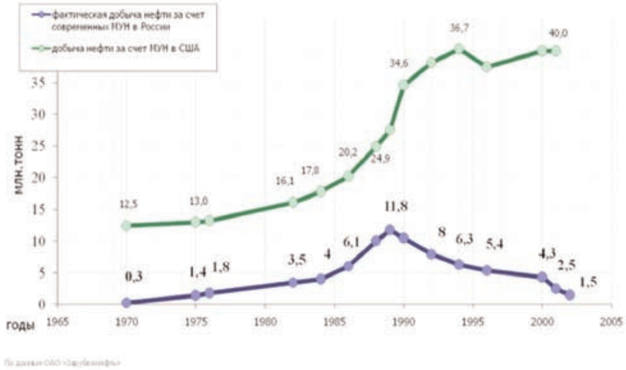

Fig. 2. Oil production due to the EORT in the USA and Russia.

Table 1. Enhanced oil recovery mechanisms due to the MEORM.

Microbial product	Enhanced oil recovery mechanism	Effect
Gas (H_2, N_2, CH_4, Co_2)	Oil viscosity reduction Oil mobility improvement Oil displacement	Oil recovery increase due to gas Pressure increase down the hole
Acids	Porosity, penetration increase CO_2 obtained in the course of a chemical reaction between acid and carbon, reduces oil viscosity	Oil recovery increase
Dissolvents (spirits, ketones and etc.)	Oil viscosity reduction Purification from the ARSD (asphalt, resin and paraffin deposits) Boundary tension reduction	Emulsion production
Bio-surfactants	Boundary tension reduction Wettability alteration	Surfactants generation Improvement of the water-flooding nature
Biopolymers	Plugging of high porous interlayers and flushed zones	Selective plugging

MEOR types

All microbiolgical formation stimulation methods can be divided into two main groups. The first contains technologies, which use the microbial productions – metabolites obtained above ground (at the industrial units-fermenters). These methods are on the verge of chemical ones. Improvement of oil-sweeping properties of pumped water in this case is due to such compounds as bio-surfactants, biopolymers, emulgators. However, this method is expensive and environmentally unsafe.

The second group provides development of microbiological processes in order to obtain metabolites directly in the formation. In this case oil-displacing agents are generated in the result of microbiological activity directly in formation due to additional insertion of microorganisms and nutrient substances in the formation - molasses, whey and other food- and chemical-industry wastes. In its turn, the second group may be divided into subgroups depending on the biocoenosis type – tabular or inserted from the surface.

The first group contains biotechnologies, in which natural formation microflora is activated by the nutrient substance supply from the surface; and the second – biotechnologies, in which microorganism cultures with nutrient substances are inserted in the formation. As a result of their life activity, microorganisms form a wide range of compounds influencing fluids, formation rock and oil-displacing processes.

The following components are used in the microbiological process: bacteria recovering hydrocarbons (hydrocarbon oxidizing bacteria), inorganic nutrient substances and biocatalysts (the latter is a now-how). Bacteria, most effective in the hydrocarbon metabolizing, have been extracted for application in this process (Table 2.). Tests conducted in laboratories confirm that mixed bacterial culture is safe for processing and does not constitute a threat for plants, animals and human. Granulated inorganic nutrient substances, which contain nitrogen, kalium, phosphorous and microelements, act as vitamins and minerals for the bacteria. Biocatalyst is a liquid enzymatic agent. It is a know-how which improves the microbiological activity, increases bacterial tolerance to high salt content, as well as maximizes their capability of oxygen usage, BOKSERMAN *et al.* (2006).

Table 2. Bacteria used in the MEORM.

Microbial agent	Microbes	Product
Gas	Clostridium	Methane, hydrogen
Acids	Clostridium Enterobacter Mixed acidogens	Propionic acid Oil acid
Dissolvents	Clostridium, Zymomonas and Klebsiella	Acetone Butanol Propane-2-diol
Bio-surfactants	Acinetobacter Bacillus sp Pseudomonas Rhodococcus sp., etc.	Emulsan and alasan Surfactin, rhamnolipid, lichenysin Rhamnolipid, glycolipids Viscosin and trehaloselipids

Range of application of biotechnologies is wide:

1. Projects for single wells: MEORM is applied in single wells in order to stimulate and increase oil production: bio-solution is compounded and pumped down through an annular space; then liquid volume (oil or water usually produced at the same field) sufficient for movement of the whole biological solution to the formation through the perforation zone. Afterwards, the well is closed for the required period (usually, from 24 hours to 7 days), whereat it is taken off into a production mode. This procedure is repeated once pre three-six months, which allows microorganisms moving deeper into the field, so they can contact with generous amount of oil.
2. Water-flooding improvement with the microbiological method. The MEORM is used during water-flooding for the efficiency improvement and oil production increase when treatment of the whole field. Biological materials are constantly or periodically added to the water tank in the formation pressure maintenance shop. Afterwards, they get into the formation with water through the existing water-flooding system without change of work speed and pressure parameters. The existing water injection system equipment requires insignificant modifications (or does not require), so that the water-flooding procedure is not suspended. The present MEORM application scheme is the most popular all over the world and in Russia, in particular in connection with its technological simplicity and efficiency
3. Selective plugging. Bacteria injection follows injection of nutrient substances for the biopolymer production and generation of bacteria, which can plug the high porous collector layers. So the conformance control is happening.
4. Well treatment with the purpose of ARPD, paraffin removal. Several degassed oil samples from the pilot areas, on which microbiological treatment has been performed, show reduction in the paraffin silica resin content by 20–40 %. As well as in some cases reduction in SRB (sulphate reducing bacteria) is registered, desulphurization and denitrification are happening; this reduces the risk of equipment damage because of metal corrosion.

It is to be noted that the MEORM technology is efficient for a wide range of field characteristics.

MEORM advantages

The most important is that there are no drawbacks to the microbiological technology application for the well stimulation in case when the MEORM is correctly applied. This method is the most cost-effective; it also has the most extended period of activity, wherefore microbiological "factories" are inserted directly in the field. Fresh nutrient substances recover native flora, completing it with foreign microorganisms; it helps increasing the results and performance. Besides, MEORM has the following advantages:

1. Inserted bacteria are cheap, easily accessible, and their price does not depend on oil price.
2. MEORM is cost-effective for the mature production fields with high water-cut ratio.
3. It does not require expensive deficient chemical reagents, special equipment; it is not a labour-intensive technology.

4. It easily integrates with the existing water-flooding technology.
5. Ecologically clean technology.
6. After destruction of the microorganisms, biological components in their cells become nutrient substances for the ecosystem; thus there is no microbiological contamination. On the contrary – application of the MEORM technology will allow reducing environmental contamination due to refusal of toxic chemicals.
7. Microbiological activity effect inside the formation is increasing as a result of their growth; while effect from other EORMs is fading in the course of time and distance.
8. Integrated effect on the formation when the formation microflora activation.
9. Moreover, quality of the produced oil is increasing:

- Light alkanes increase < C 20.
- Reduction in middle alkanes C 20 – C 40.
- Destruction of high-molecular heavy hydrocar bons.
- Cracking of structural aromatic rings.
- Cracking of structural phenolic rings.
- Transformation of sulphurous organic compounds.
- Reduction in content of metal microelements.
- Crude oil emulsification.

MEORM drawbacks

1. No mathematic models.
2. Technology is not perfectly studied.
3. Sparsity of specialists in this field.
4. Impossible to predict results.

Technology used in Russia and the know-how

The formation microflora activation technology, created by the employees of Institute of Microbiology, Russian Academy of Science, Belyaev and Ivanov with participation of petroleum experts from Tatarstan, is easy to apply and cost effective. This method is principally new and has no parallel in the world practice. It is based on activation of the natural formation microflora life activity, generating during field development by means of water-flooding with surface waters. Object-oriented regulation of microbial activity allows obtaining effective oil-displacing agents, surfactants and biopolymers directly in the formation pores. Generating products contribute to oil mobility improvement. They form an oil bank and migrate across the formation with water, causing oil displacement from the enclosing rocks. Principle of this method consists in cyclic injection of aerated mineral salt solutions into oil collectors. Microbial activity (both aerobic and anaerobic) as a result of injection is rising sharply in the injection well bottom-hole area. It is found that microbiological processes are the two-staged. The first step includes activation of aerobic processes: oxidation of oil organic compounds leading to formation of such oil-displacing reagents, as organic acids, spirits, surfactants, polysaccharides and carbonic acids. At the second stage, water is injected in order to deliver the generated products to other– anaerobic bacteria. The anaerobic bacteria convert oil oxidation products to methane and carbonic acid. Methane acts as gas and reduces oil viscosity, at the same time increasing local formation pressure. Carbonic acid also reduces oil viscosity. However, it also dissolves carbonate formation rocks. Therefore, oil-displacing properties of the formation are significantly improving (Fig. 3).

As against the well-known method with molasses involved as a part on nutrient medium, this method does not require huge capital investments as it eliminates expenses for the microorganism cultivation in special ferments, and for special equipment for the substrate injection into formation. As this method fits in the secondary oil production system with water-flooding involved, expenses for drilling of new wells are also excluded (BOKSERMAN *et al.,* 2006).

This method gains maximal effect on highly watered layers, and allows obtaining additionally more than 6 % of oil from its residual content in the formation. This index of additional oil recovery is high enough and can be compared to the foreign ones.

When pilot test of this method at the Bondjunskoe oil-field in Tatarstan, about 47 K tonnes of oil have been additionally obtained from one section during 5 years after the test start; this amounted to appr. 30 % of the total oil production in this area over the specified period. Tests at other oil-fields (Romashkinskoe in Tatarstan, Sergeevskoe in Bashkortostan, Lokbatanskoe in Azerbaidzhan) allowed obtaining additionally from 29 to 35 % of oil from its total production on the tested areas of these oil-fields.

In recent years, pilot experiments are being started at the west-siberian oil-fields. Over the first test stage at the Bystrinskoe and Solkinskoe oil-fields 10.5 and 5.8 K tonnes of oil have been produced correspondingly. At present, scientists from the Institute of Microbiology are performing a contract in China. At the Dagan oil-field as a result of biotechnologies application water-cut has reduced and oil content in the production liquid has increased; this allowed obtaining additionally more than 14 K tonnes of oil within 3.5 years of tests.

Experiment at the Vyngapurovskoe oil-field in 1893

It is not widely known that these technologies have already been tested in Western Siberia, at that some-

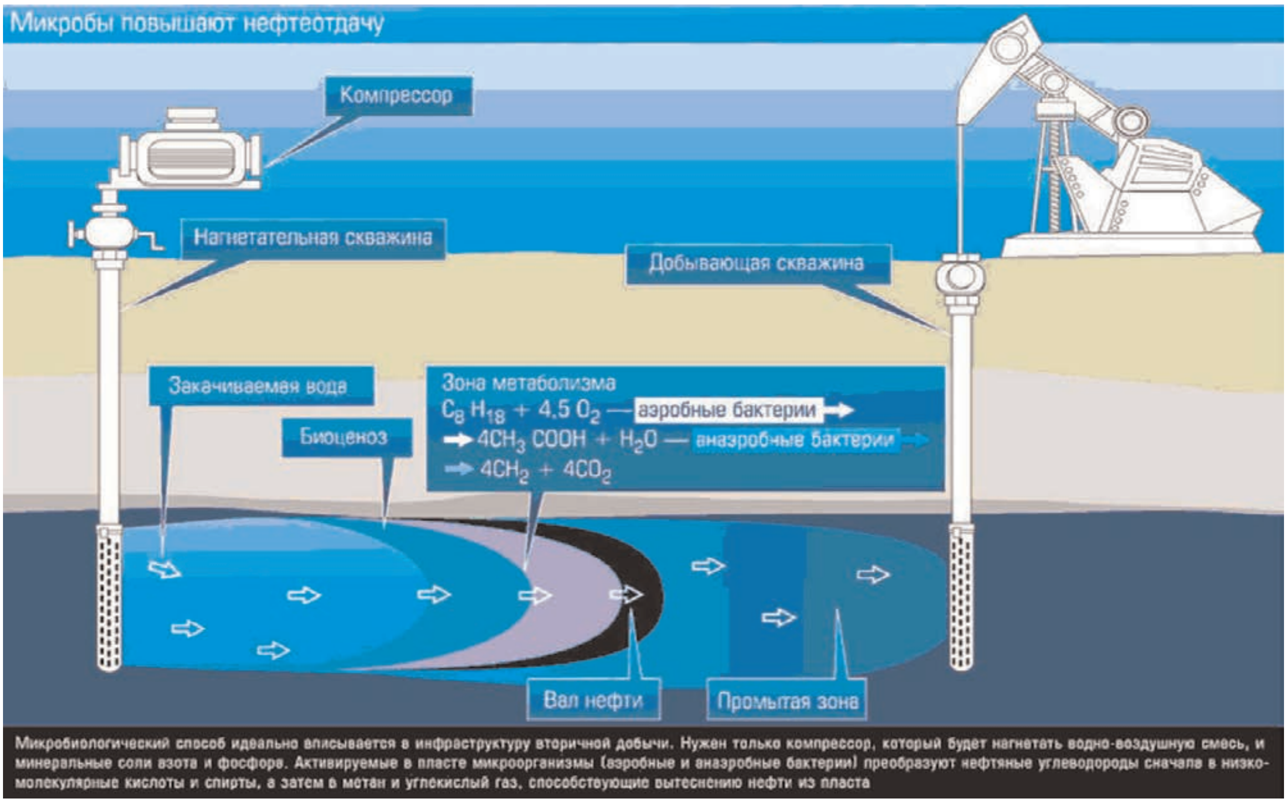

Fig. 3. Enhanced oil recovery mechanisms due to MEORM, developed by the scientists of Institute of Microbiology, Russian Academy of Science, named after Vinogradskiy.

what successfully. A pilot area, consisting of one injection well and three production wells, has been chosen at the Vyngapurovskoe field (Fig. 4).

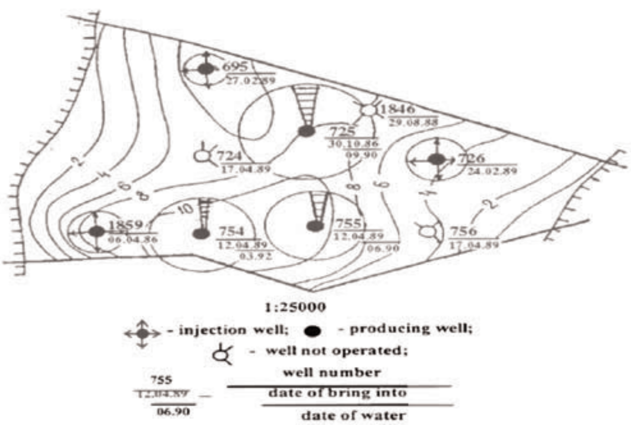

Fig. 4. Pilot area for the microbiological treatment at the Vyngapurovskoe oil-field.

Nutrient substances containing nitrogen and phosphorous sources with concentration of 0.5–1.5 and 1–1.5 g/l correspondingly, as well as food-industry wastes (milk whey, lactic bacteria), concentration of which has been selected according to the laboratory tests, have been pumped in the injection well 726. It has been a two-cycle injection with month interval. Production wells have operated in the usual course. Water-cut of products from the production wells as of start of treatment amounted to 98–99 %. Pilot area has been under the supervision for 3 years, and prfoduction data has been compared with forecasts without the MEORM involved. Due to generation of microbes waste products in the formation, oil production gain in the 725 well was doubled, 754- increased by 30 %, 755- by 2 %. Microbiological water-flooding allowed obtaining additional oil production gain of 2268.6 tonnes, reducing water-cut of products from the production wells by 3 % (33 902 m^3). Herewith, no capital expenditures.

Therefore, experiment at the Vyngapurovskoe oilfield has shown efficiency of biotechnologies for the enhanced oil recovery in Western Siberia.

Pilot project of the “Muravlenkovskneft”

Section at the Sugmutskoe field has been chosen as one of the pilot areas, formation 2BS9, which is similar to the Vyngapuroskoe area by physical and chemical properties (Figs. 5, 6). Thus, results of the microbiological treatment can be approximately indicated.

The selected area consists of one injection well 1206 and three hydrodinamically connected produc-

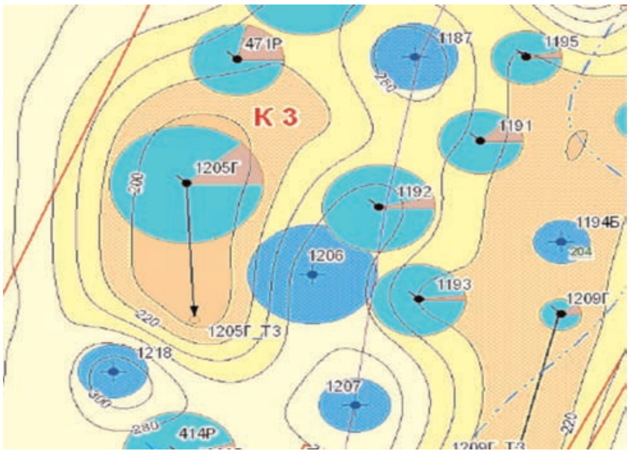

Fig. 5. Fragment of the BS_9^2 formation development map.

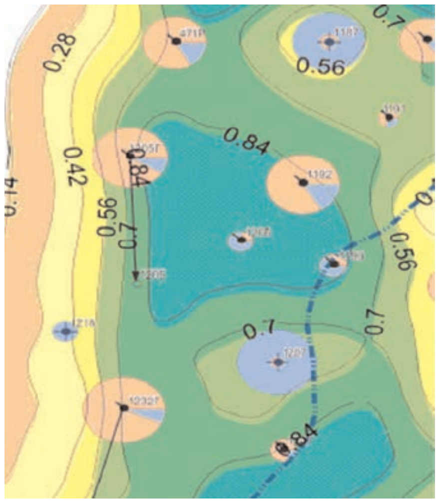

Fig. 6. Distribution of the residual oil reserves near the well of group No. 3.

tion wells 1205G, 1192, 1193; it is also defined by the following parameters:

- Oil production? 76,3 t/day
- Injection– 814 m^3/day
- Current water content 93 %
- Mineralization of injected water 25,8 g/l
- Initial formation temperature 88° C
- Core permeability 50 mD.

At the present pilot area, preliminarily (and afterwards, based on the laboratory test results of the injected water and produced fluid) injection of the aerated nitrogen salt and phosphorous solutions is recommended (diammonium phosphate, hydrogen dioxide (oxygen source), nitrates (ammonia and other nitrate), with additional microbial material involved (hydrocarbon oxidizing bacteria cultivated in the laboratory).

Project economics

Forecast of the microbiological treatment results within the selected area of the Sugmutskoe oil-field is as follows (Table 3, Figs. 7, 8):

On the assumption of sensitivity analysis it can be seen that Operating expenditures are low, which does not influence the total income practically.

Conclusions

1. The proposed MEORM-process actuates oil resources, which otherwise would remain immobile and unrecoverable.
2. The MEORM-process overcomes natural and chemical barriers existing in oil-fields and usually preventing the growth of microorganisms.
3. The MEORM is safe for oil-fields and the environment. It does not constitute a threat for plants, animals and human.
4. Application of the MEORM significantly simplifies solution of wide spread manufacturing problems, connected with deposition of paraffins, ARP and equipment corrosion.
5. Application of the MEOR-process is technologically and economically feasible, both at the initial phase of well production activity and at the late stage of development with the high water-cut ratio, where traditional chemical methods have no effect.
6. The MEORM-process is easy to apply; usually minimal modification of the available production equipment is required (if any required).
7. In neither case, oil production decline is observed after application of biotechnologies.
8. This process can be successfully applied for the greater part of oil-fields.
9. It gives immediate results. The ROI index can amount to 6:1, payback time ~ 1-3 months.
10. It is an accessible technology: prime cost~ 300 RUR/tonne, when chemical EORM >1500 RUR/tone; while the technology can be more efficient than many other chemical EORMs.
11. Additional oil production amounts to 30 %.

Therefore, microbiological EORMs are cheaper, ecologically safer, and probably more efficient than many traditional physicochemical enhanced oil recovery methods applied at the "Muravlenkovskneft" affiliate's fields. Currently, preparation for microbiological treatment is being performed as the PDP (Pilot Development Planning) in the selected areas. It is planned to perform treatment of 11 injection wells of the Sugmutskoe, Kraynee and Sutormisnkoe fields.

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Table 3. Project economics.

CAPEX	N/A. Injection is performed by means of an CA aggregate
Work price per 1 injection well (incl. Reagents and laboratory tests, exclusive of taxes)	~ 380 M RUR
Duration of work	3 months (at least 2 injections per well)
Durability of gains	2-3 years
Additional oil production over 2 years	3,23 K tonnes
Water content reduction in products	By 3-5%
Prime cost of 1 extra tonne of oil produced	~ 300 RUR/tonne (while conformance control for the Sugmut > 1000 RUR/tonne)
NPV	**11,5 MM RUR**
Payback time	1 month

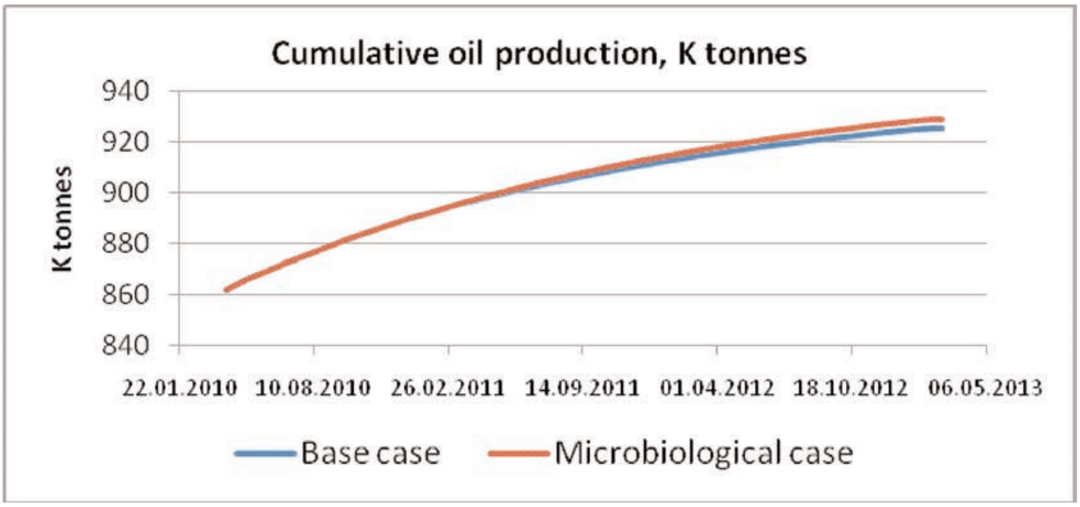

Fig. 7. Cumulative oil production forecast per the selected pilot area.

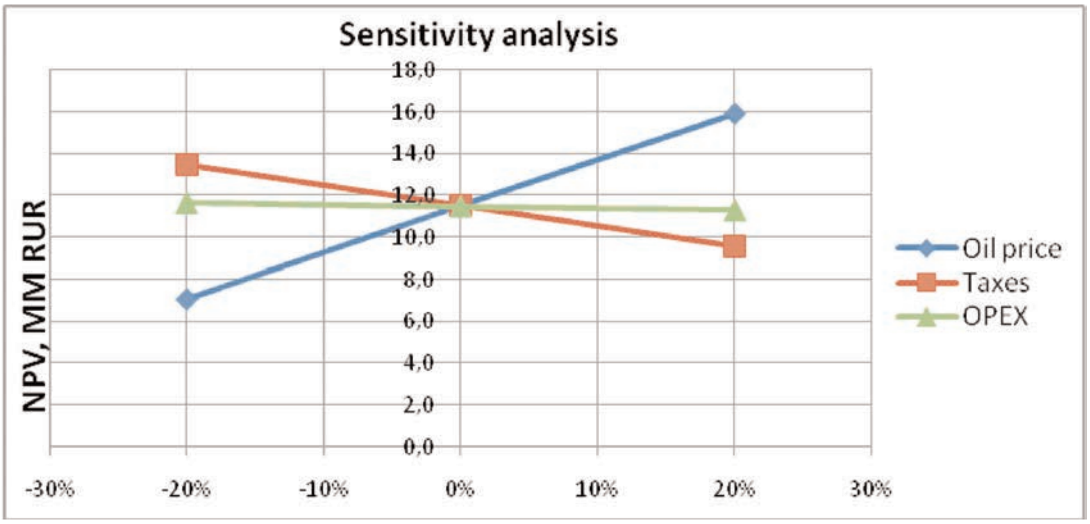

Fig. 8. Analysis of project NPV sensitivity to economic factors.

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17th Meeting of the Association of European Geological Societes	Abstracts	125–125	Belgrade, 14–18 September 2011

The Results of AVO Analysis on the Reservoir "Torda Shallow"

Snežana Antić[1]

The existence of amplitude anomalies on the reservoir "Torda shallow" was confirmed when had done AVO analysis on 3D seismic data of Melenci survey to check the geological model of that area.

3D seismic data processing of the Melenci survey was carried out in NIS a.d. Science and Technical Center, the Department of Geophysics. Processing was done on computers IBM - cluster system in an operating system Red Hat Enterprise Edition v3 update 8 with the application software used Focus 5.4, GeoDepth and Probe, Paradigm Geophysical Company Ltd. 3D seismic data were processed to be preserved relative amplitude ratio.

Amplitude versus offset (AVO) analysis is relatively new seismic technique used very successfully to predict hydrocarbon (especially gas) and lithologies for oil exploration and reservoir characterization.

Using the AVO technique seismic amplitudes and their variation as a function of offset are analyzed. This information is then used to predict lithology and fluid content.

The basic concept behind the AVO technique is the analysis of the reflection process. We take advantage of the fact that the measured amplitude is related to the strength of the reflection (reflection coefficient), and that the reflection coefficient depends on three parameters:

1. Change in *P*-wave velocity across the interface.
2. Change in *S*-wave velocity across the interface.
3. Change in density across the interface.

The amplitude for each sample was analyzed and distinguish two AVO attributes: intercept and slope that best approximates the points obtained in the coordinate system of the amplitude - the angle of incidence. These two attributes give us a basic description of the AVO behavior.

Computing and analysis AVO attributes has done in program Probe, Paradigm Geophysical Company Ltd.

Crossplot analysis tools is an integral part of the program Probe. Essence of crossplot analysis is that after the selection of appropriate attributes get the opportunity to detect known or assumed reservoir.

The characteristic anomaly was realized and confirmed across multiple attributes and we can determine the reservoir and all similar phenomena in the area.

AVO analysis of seismic amplitudes showed that all relevant AVO attributes point to existing reservoir "Torda shallow". The gas reservoir of "Torda shallow" ranges from time 1272 ms to 1291 ms, which coincides with the anomalous zones obtained on the analysis crossplots AVO attributes.

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17th Meeting of the Association of European Geological Societes	Abstracts	126–127	BELGRADE, 14–18 September 2011

Geological and Seismic Data from the Border Zone Between Tisza Mega-Unit and Vardar Zone in South Backa (Northern Serbia)

IVAN DULIĆ[1], TASKA VASILJEVIĆ[1] & MILAN RAŠKOVIĆ[1]

In the Neogene basement of South Backa is located granite-metamorphic complex of Tisza and Mesozoic formations of Vardar Zone (Eastern Vardar Ophiolites - SCHMID *et al.*, 2008) with the Cretaceous-Paleogene cover. Granite-metamorphic complex of Tisza, by numerous authors, is part of the Tisza Composite Terrane, under which were separated three geodynamic units::

– BIHOR (Mecsek, Villany, Lower Codru, Urmat),
– BIHARIA (Upper Codru, Biharia, Baia de Aries),
– VARDAR – MURES.

Thrusting of Paleozoic metamorphic complex over the Mesozoic formations was determined in exploration wells in Hungary. Based on the model of tectonic interpretation of the Carpathian region (CSONTOS & VÖRÖS, 2004), under the Biharia and Kodru polymetamorphic complex, there are Mesozoic sedimentary formations of Mecsek and Vilany zones and sediment complex of "Urmat" formation.

For consideration of the tectonic relationship of the Tisza Composite Terrane and the Vardar Zone, are particularly important data from the Tud-1 borehole in South Backa, in which, under the metamorphic complex of Tisza (determined thickness of metamorphic complex 760m), are drilled Middle Triassic limestones and Jurassic ophiolitic complex (diabases, peridotites, serpentinites, amphibolites, greenschists). There is no doubt that with this borehole are determined Cretaceous–Paleogene horizontal movements and thrusting on the large distance, and, the Vardar Zone subduction under the Palaeozoic metamorphic complex of Tisza. This tectonic contact is well visible on seismic profiles at the part of Southern Backa.

Above the Tisza granite-metamorphic complex and Vardar Zone were developed Neogene–Quaternary sediments, whose development and structural-tectonic built up were defined by the processes of space reduction and Neogene compression geodynamic events.

Due to intense space narrowing, in a very close situated wells in South Backa were developed various formations and facies of freshwater and marine Neogene, and within them are often discordant and transgressive relationships. In particular, the regional unconformity are clearly recognized on the border of Lower and Middle Miocene, Lower and Upper Badenian, Badenian and Sarmatian, during the Middle and Upper Sarmatian and during Upper Pannonian–Lower Pontian.

Late Neogene-Quaternary tectonics formed a large number of structures, whose layout, orientation and depth indicate the main directions of compression, the arrangement of smaller blocks, their mutual relations, rotation, and intensity of the space narrowing. The main tectonic style of these depressions and structures is defined by deep reverse faults with a fall towards the southwest and west. This style is nicely recognizable on the structures „Srbobran" and „Sirig", which are formed during the younger Miocene and Pliocene. Some faults of this type were reactivated during Pleistocene and on the seismic sections can be clearly observed that they are still active. North and Northeast from these structures, by the "strike slip" faults in the Pliocene and Pleistocene, Srbobran depression was deformed and was formed flower structure „Turia". During these geodynamic events was formed the "strike-slip extensional duplex" with positive flower structure of a East–West orientation. By the 3D seismic interpretation it was concluded that this are the youngest tectonic movements in the relevant area and that they are very active during the Holocene.

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Key words: South Backa, Tisza Composite Terrane, Vardar Zone, subduction, reverse fault, strike slip fault.

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17th Meeting of the Association of European Geological Societes	Abstracts	128–129	BELGRADE, 14–18 September 2011

Geological Composition of Reservoir Rocks of Petroleum Deposit "Pz+Sm" Kikinda-Varoš (Vojvodina, Serbia)

RADMILO JOVANOVIĆ[1]

Petroleum deposit „Pz+Sm" Kikinda-Varoš is located below the town of Kikinda, North Banat, Vojvodina, Serbia. In geographic sense North Banat belongs to southeastern part of Pannonian Basin, which is according to geotectonic zoning located east of the Alps, north and north-east of the Dina-rides, and south and south–east of the Carpathian and Balkanides. Deposit is located in the positive underground morphostructure, in its apical part at depth of 2000 m. The deposit is situated in the oil-gas province of North Banat, and includes three large oil and gas fields: Mokrin, Kikinda and Kiki-nda-Varoš, and several smaller oil and gas fields. Size of the structure, where is deposit „Pz+Sm" Kikinda-Varoš, is about 10 km^2.

Petroleum of deposit „Pz+Sm" Kikinda-Varoš is located in the secondary porosity of Proterozoic–Paleozoic granitoids and metamorphites and in the primary pore space and secondary porositu (of tectonic origin) of Sarmatian carbonate-clastic sediments.

Reservoir rocks of plutonic-metamorphic origin (Formation of granitoids of Kikinda-Varoš) are primarily built of plutonic rocks of granitic and granodioritic composition, rarely found in fresh co-ndition. They are partially schisty, tectonized, dynamometamorphozed to cataclasis and partially migmatized. The main lithotypes are biotitic granites, granodiorites, tonalites, gneiss-granites and cata-clased granitoids. In them are common enclaves of muscovitic, biotite-muscovitic and chlorit-musco-vite-biotitic schists and rare occurrences of schisty peridotitic rocks. As an example of schist, one albite-muscovite-chlorite schist.

All these lithotypes are exposed as a unique rock mass in sense of reservoir properties. Their reservoir characteristics (as a basic criteria for determination of reservoir rocks) are not connected to mineral and chemical composition, than for the level of alteration, cataclasis and tectonization of entire rock mass.

In majority of acidic plutonic rocks granular texture is destroyed by cataclasis. Because of directional pressure and movement, rock is disintegrated into bigger pieces, encircled with pulverized (myloniti-zed) parent rock material. Cataclasis happened at great depth in the Earth's crust, where existed conditions (increased P, T) for recrystallization of mylonitic „paste". It was metamorphosed into fine-granular mosaic aggregate of mainly quartz and also plagioclase (probably albite), zoisite and few epi-dote. Calcite component for formation of zoisite originates from primarily plagioclase from granodiorite which is usually oligoclase-andesine. Larger pieces of crystals, i.e. porphyroclasts or lenticular crystal aggregates are parallelly oriented.

According to the analysis of the absolute age, plutonites are Caledonian, and metamorphic enclaves are Variscan age. Enclaves of metamorphites, predominantly of green-schist facies, are most probably connected to late Variscan and the early phases of Alpine orogeny.

Contact of reservoir rock of sedimentary origin (Formation of organogeno-terrigenous limestones of Kikinda-Varoš) to the base isdiscordant and tectonic. Pannonian fine-grained sediments of cover lie concordantly, against to Sarmatian reservoir rocks. Maybe they lie unconformably, because in wider region of the Pannonian basin is proved Post-Sarmatian emersion. That conclusion confirms their discordantly relation when lie directly on reservoir rocks of plutonic-metamorphic origin in areas where Sarmatian beds were eroded. According to the intensive geodynamic movements, locally and tectonicaly is possible the contact of these two petroleum-geological units.

Reservoir rocks of sedimentary origin are composed of carbonate and clastic sedimentary rocks. Such a complex lithological structure is result of complex syndepositional, syndiagenetic and postdiagenetic tectonic

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processes. This highly dynamic tectonic activity caused the successive change of various sedimentary cycles, manifested by the change of carbonate precipitates with teriggenous influx of siliciclastics. Synchronously with sedimentary cycles happened and the erosional cycles. These processes were manifested by erosion of carbonate precipitates of carbonate platforms and patch reefs and their redeposition in the form of organogeno-detritic limestone, often syndepositionally with terrigenous influx. This sedimentary-erosional cyclicity was not rhythmic and typical features of rhythmic sedimentation in form of identical sequences were not recognizable.

Findings of fossils in reservoir rocks of sedimentary origin may indicate age of the unit, but they are not reliable and final. The presence of elphidiums, nubecularids and miliolids indicates Lower Sarmatian age. The presence of anomalinoides as indicator of Upper Badenian age is not enough for con-firmation of Badenian age of these sediments. Regarding on the fact that majority of limestones are detritic in origin, and most of fossil flora and fauna appear as fossil detritus, ordinarly is supposed that these fossil remnants are mostly redeposited.

Key words: Geological composition, reservoir rocks, petroleum deposit, Formation of granitoids of Kikinda-Varoš, Formation of organogeno-terrigenous limestones of Kikinda-Varoš, Vojvodina, Serbia.

Applied Geomathematics and Geostatistics

17th Meeting of the Association of European Geological Societes	Proceedings	131–134	BELGRADE, 14–18 September 2011

Monitoring Chestnut Ink Disease Using Satellite Imagery and Field Surveys

LUCA D'ERAMO[1], DARIO ADAMO[2], GIARDINO MARCO[1], LUIGI PEROTTI[1] & GENTILE GIORDANO[2]

Abstract. Chestnut ink disease, caused by *Phitophtora cambivora*, is one of the most dangerous and deadly pathologies afflicting chestnut trees. During the last decade, an outbreak of this phytopathology was recognized in southern Piedmont. To estimate the *Phitophtora*'s spread in the territories of Comunità Montana delle Alpi del Mare (South Piedmont – Italy), an approach combining the use of satellite data and field works has been adopted. After some field surveys to acquire sample areas within ill and healthy plants, the data collected have been plotted on a IKONOS image. Following to a preliminary classification of vegetated areas using the Normalized Difference Vegetation Index (NDVI), and monitored the healthy status of plants observing the spectral signatures, three different algorithms (minimum-distance, parallelepiped and maximum likelihood) have been tested to identify the infected zones. Subsequent to several tries, the maximum likelihood classification has produced the better results. The overall accuracy of method has been confirmed by 92.3 % of properly classified plants, using confusion matrices. This research shown the usefulness of high resolution satellite imagery for this kind of studies, but at the same time, the high acquisition cost of these satellite imagery may limit its applicability.

Key-words: IKONOS, NDVI, Supervised Classification, *Phitophtora cambivora*, *Castanea sativa*.

Introduction

Chestnut ink disease, caused by *Phitophtora cambivora*, is one of most dangerous and deadly pathology affecting chestnut trees. Since the end of past century, Europe was affected by this phytopathology significantly (VANNINI & VETTRAINO, 2001). During the last decades, an outbreak of this disease was recognized even in southern Piedmont. This pathology causes considerable economic losses and prevents the development of new chestnut groves (*Castanea sativa*). The main characteristics of this disease are: reduced leaf size with an opaque yellow colour, a rarefied foliage at canopy tree, flame shaped dark necroses on collar tree, and black exudates on soil surrounding the infected trees (VANNINI & VETTRAINO, 2001).

In the last years, several applications have successfully used data acquired by sensor aboard of airplanes to monitor this disease (AMBROSINI *et al.*, 1997; MARTINS *et al.*, 2007; VANNINI *et al.*, 2005), which are showing the potential of remotely sensed techniques even for this kind of researches. In this study, instead of aerial-photograph acquisitions, we used a high resolution satellite image and field works, as explained in the followings section.

Materials and methods

To monitor the *Phitophtora*'s spread inside the area of Comunità Montana delle Alpi del Mare (CMAM), we used the municipality of Robilante (Cuneo province) as test site. After a first survey to identify some sample areas within ill and healthy plants, a subsquent field work was done to acquire plant positions using a total station and a double frequency GPS. The global accuracy of data acquired has been estimated around 5 cm; an acceptable error considering the geometric resolution of satellite image used. Subsequently, the points collected have been reprojected on a IKONOS image. Launched in 2000, IKONOS is the first satel-

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lite acquiring high resolution imagery for commercial purposes. It is composed by one panchromatic band and 4 spectral channels (Red, Green, Blue, Near Infrared (NIR)), with a geometric resolution of 1 m and 4 m at nadir, respectively. Before any quantitative analysis, we applied on image a radiometric calibration, i.e. the conversion from digital number to reflectance, and an atmospheric correction (dark subtraction).

The photosynthetic activity of plants is highlighted within the Red and NIR bands, using the Normalized Difference Vegetation Index (NDVI). This band ratio is expressed as:

$$NDVI = (NIR - Red) / (NIR + Red) \quad (1)$$

We applied (1) to extract the vegetated areas from image, and subsequently monitor the healthy status of plants observing the spectral signatures. In particular, the chestnut groves were extracted from NDVI mask created, using ancillary information coming from the chestnut geodatabase realized by CMAM. The collected field samples were divided in two groups. Using one of these samples, we tested the efficiency of three different supervised classifications i.e., minimum-distance, parallelepiped, and maximum likelihood, in order to evaluate the best method able to highlight the spread of disease. During the first attempt, the sample used has been estimated too less representative and meaningful. Thus, more chestnut areas were extrapolated from geodatabase, and introduced into classification process. On this incremented sample, we applied again the three supervised classifications. Finally, to reduce the classic 'salt and pepper' effect coming from classification process, we applied a clump, i.e. a grouping operation, in order to obtain a more suitable image for visual interpretation.

Discussion

We used confusion matrices to validate the methodology adopted and the classification results (Table 1). The results obtained on two sites are presented (Figure 1A and 1B), before (site 1) and after (site 2) the increase of sample. In the first site we acquired the positions of 8 healthy trees, 12 ill trees and 2 grass zones, while in the second area: 24 healthy trees and 2 grass zones. In table 1 we have included the grass areas into the category called 'other', due to the occasionally presence of other elements (e.g., houses, roads,…) inside the sample sites.

Tab. 1. Confusion matrices showing the results obtained on two sample sites, before (site 1) and after (site 2) the sample increase, applying: minimum-distance, parallelepiped, and maximum likelihood algorithm.

	SITE 1					SITE 2				
PARALLELEPIPED		Ill trees	Healthy tress	Other	Total		Ill trees	Healthy tress	Other	Total
	Ill trees	12	0	0	12	Ill trees	0	0	0	0
	Healthy tress	8	0	0	8	Healthy tress	24	0	0	24
	Other	2	0	0	2	Other	2	0	0	2
	Total	22	0	0	22	Total	26	0	0	26
				Global accuracy	54.4 %				Global accuracy	0 %
MINIMUM-DISTANCE		Ill trees	Healthy tress	Other	Total		Ill trees	Healthy tress	Other	Total
	Ill trees	1	11	0	12	Ill trees	0	0	0	0
	Healthy tress	0	8	0	8	Healthy tress	10	14	0	24
	Other	2	0	0	2	Other	0	0	2	2
	Total	3	19	0	22	Total	10	14	2	26
				Global accuracy	40.9 %				Global accuracy	61.5 %
MAXIMUM LIKELIHOOD		Ill trees	Healthy tress	Other	Total		Ill trees	Healthy tress	Other	Total
	Ill trees	10	2	0	12	Ill trees	0	0	0	0
	Healthy tress	6	2	0	8	Healthy tress	2	22	0	24
	Other	1	0	1	2	Other	0	0	2	2
	Total	17	4	1	22	Total	2	22	2	26
				Global accuracy	59.1 %				Global accuracy	92.3 %

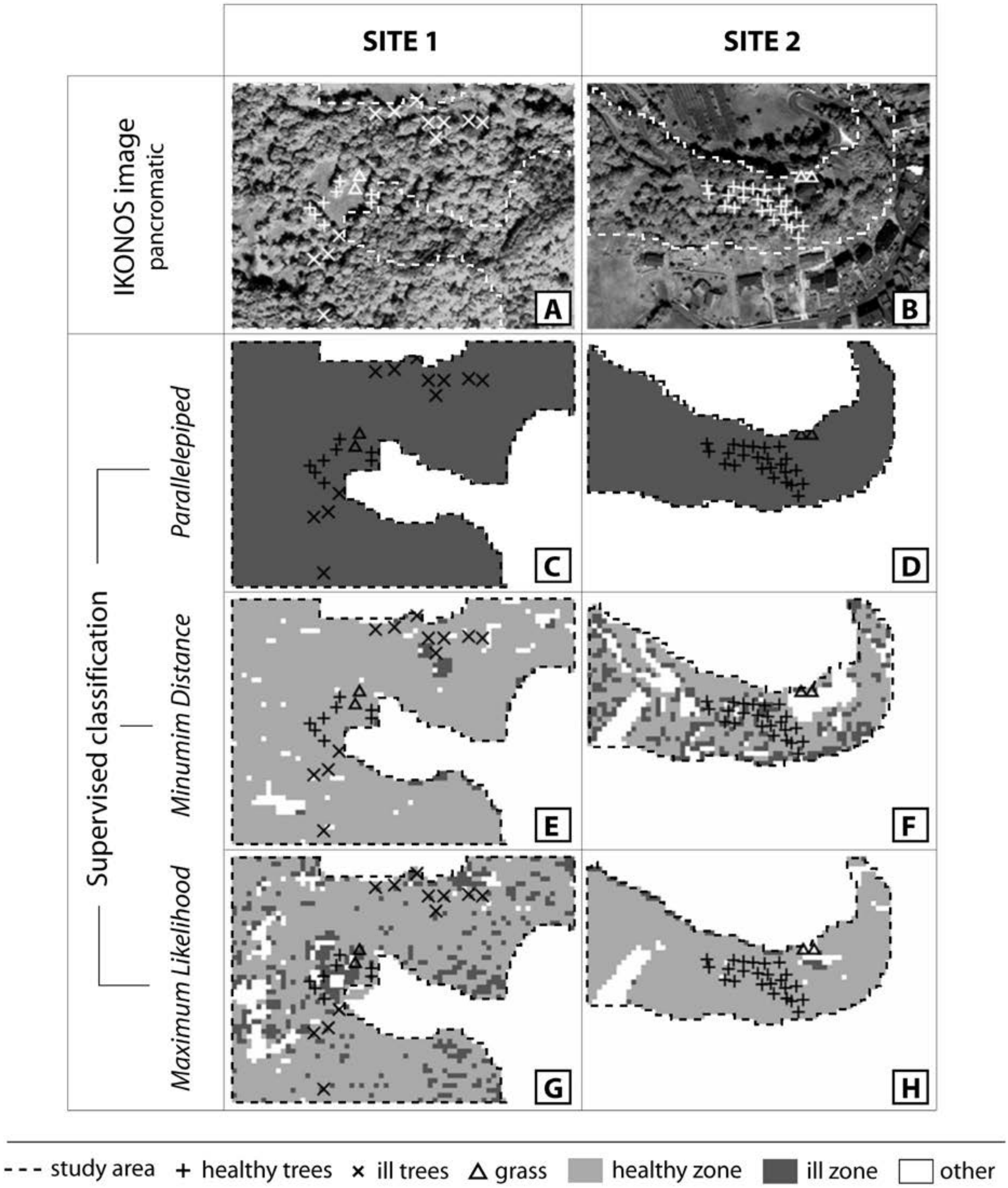

Fig. 1. Results obtained on two sites (A–B), before (site 1) and after (site 2) the sample increase, using three supervised classifications (minimum-distance: C–D, parallelepiped: E–F, and maximum likelihood: G–H).

It is possible observe how the parallelepiped algorithm overestimate the area affected by *Phitophtora* in both cases (Figure 1C and 1D). The minimum-distance algorithm has properly classify all healthy trees in the first site, and more than the half of second sample (Figure 1E and 1F); but in any case, the results are not statistically meaningful. Using the maximum likelihood classification we got to be the better results in both sites, obtaining the 92.3 % of properly classified elements, after the increase of sample (Figure 1G and 1H).

Conclusion

This paper illustrates as the methodology proposed can be helpful to monitor the spreading of chestnut ink disease. The high geometrical resolution of IKONOS images permits to control the healthy status of each plant over time, if a multitemporal monitoring is carried out. The main disadvantages are correlated to high acquisition costs of IKONOS imagery, and long time needed to acquire an adequate sample suitable for classification. In the future, it is planned to apply a topographical correction to IKONOS data, to reduce classification errors caused by different lighting conditions, and test the capabilities of other satellites/sensors (e.g., SPOT, ASTER), which may represent the right compromise between geometric resolution and acquisition cost.

Acknowledgments

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17th Meeting of the Association of European Geological Societes	Proceedings	135–138	BELGRADE, 14–18 September 2011

Applying Terrestrial Laserscanning Technology on Rock Slope – A Case Study

BILJANA ABOLMASOV[1], VLADIMIR ŠUŠIĆ[1] & SNEŽANA ZEČEVIĆ[1]

Abstract. The technology of LIDAR (Light Detection and Ranging) system creates automated remote collection of accurate, high resolution topographic data and represents step forward that will increase speed, precision, cost effectiveness and overall quality of geotechnical investigations. The example refers to the rock slope on the location of "Letnja Pozornica", Belgrade, in the area of protected natural-geological heritage. The process of scanning was performed with different resolution on the three series of scans. The first scan was carried out with resolution 5 cm/30 m, the second on 1 cm/30 m and the third one with resolution 0.5 cm/15 m. The data of scanning can be exported to computer-aided design applications for additional modelling such as AutoCad, or as a Digital Terrain Model in GIS. This paper presents features and benefits of introducing new technology in order to provide quality topographic data for detailed rock slope stability investigations.

Key words: geotechnical, remote sensing, rock slope stability, topographic data, laser scanning data.

Introduction

The detailed three-dimensional characterization of site topography is critical to many geotechnical studies of slope stability. Whether it's a matter of landslides, rock falls or anyother failures, understanding how these changes progress over time depends directly on detailed collection of high quality topographic data. A new terrestrial laser system used exploits advancements in technology to collect an unprecedented amount of data in a very short time. For rapidly changing natural slopes or cuts, such as landslides and rock falls, sites can now be efficiently surveyed repeatedly over a period of months, days or even hours. The high resolution of LIDAR data, in combination with the ability to obtain multiple datasets over a short period of time, allows researchers to better understand the mechanics of these natural phenomena and to calibrate models for predicting future change.

LIDAR (Light Detection and Ranging) is an optical remote sensing system that measures properties of scattered light to find a range and/or other information of a distant target. The prevalent method to determine distance to an object surface is to use laser pulses. The range to an object is determined by measuring the time delay between transmission of a pulse and detection of the reflected signal. The spatial information data are stored as received or can be transformed to be stored as a group of *x*, *y* and *z* coordinates. The data of spatial information can be exported to computer-aided design applications for additional modelling, such as AutoCAD®, or as 3D Digital Terrain Modelin GIS.

Generally, there are two possibilities for LIDAR mapping technology related to geotechnical engineering and slope stability problems – measurements made from airborne LIDAR (from airplanes or helicopters) or ground-based (mobile or based on site) terrestrial LIDAR. The application of airborne LIDAR for slope stability assessment discussed in CHEN *et al.* (2006), GLENN *et al.* (2006) and LAN *et al.* (2010). Terrestrial LIDAR measurements have been used for several slope and rock cuts stability assessments as discussed in ABLELLAN *et al.* (2010), ABOLMASOV *et al.* (2010), ARMESTO *et al.* (2009), BALDO *et al.* (2009), DUNNING *et al.* (2009), LATO *et al.* (2009a, 2009b), STURZENEGGER & STEAD (2009) and STURZENEGGER *et al.* (2011).

In this paper we present the first experience and results of scanning by 3D Terrestrial Laser Scanner on rock slope in Serbia. The „Letnja Pozornica" rock slopecase study presented illustrates the effect of

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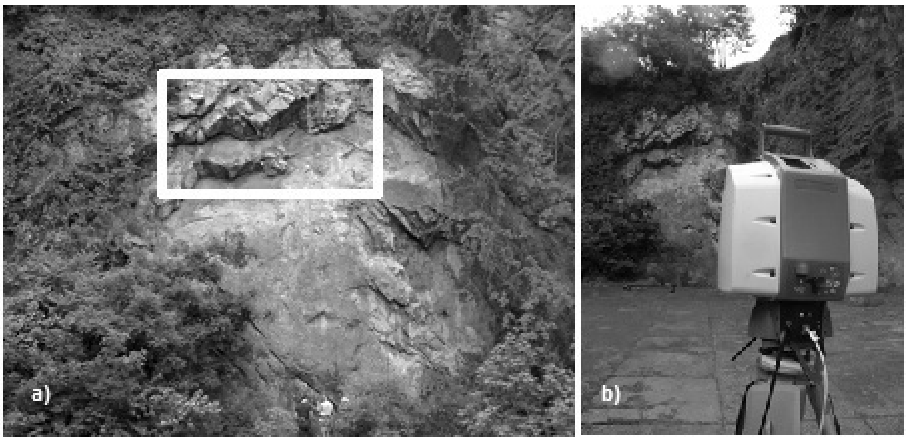

Fig. 1. Photo of "Letnja Pozornica" rock slope: a) part with marked detail (white box) and b) Leica Scan Station 2 on the site.

topographic surface characterization by Terrestrial LIDAR and possible application in geotechnical investigations of slope stability.

Measurement method and site location

A case study of scanning by 3D TLS was performed by Leica Scan Station 2 (Figs. 1a, b). Technical features of the device are available at www.leica-geosystems.com. The specific feature of terrestrial laser scanning technology is that it automatically registers "point cloud" on the basis of the given scanning resolution instead of standard surveying measurements of the points which requires procedures of visioning and repetitions. The model of scanner used also has a camera which adds the value of registered electromagnetic radiation in the visible part of spectre to each scanned point, i.e. pixel RGB (red, green, blue) value. After scanning, the filtration of point cloud is performed by appropriatealgorithms to remove murmurs in the sample of collected data. The last phase is modelling of 3D Digital Terrain Model on the basis of assembly of points by suitable software tools.

The example refers to the slope on the location of "Letnja Pozornica" in Belgrade in the area of protected natural-geological heritage. The space at the location was used as natural theatre scene during the nineties, but nowadays it is totally deserted. The small rock and block falls as well as ravelling and flaking at the location are obvious, and due to the abandonment, the protection is totally non-functional. The protective nets are unfixed, torn and in the case of rock falling of volume larger than 1 m^3 they do not have any protective function. Terrain was formed of flysch of the upper Cretaceous with a lot of fossil residues, and due to that fact, the whole location is protected as natural-geological heritage. Both slopesare nearly 20 m high, with orientation 10/75 and 90/75, andinaccessible for direct measurement of joint parameters (Figs. 1a, b).

The process of scanning was performed with different resolution on 3 series of scans. The first scan was carried out with resolution 5 cm/30 m (Figs. 2 and 4), the second on 1 cm/30 m (Fig. 3) and the third one with resolution 0.5 cm/15 m (Fig. 5). The "point cloud" obtained by scanning with 5 cm resolution of zoomed slope detail is presented on the Figure 2, and shows the same zoomed slope detail with 1 cm resolution where in the both cases the RGB value was added to each point (presented in grey scale).

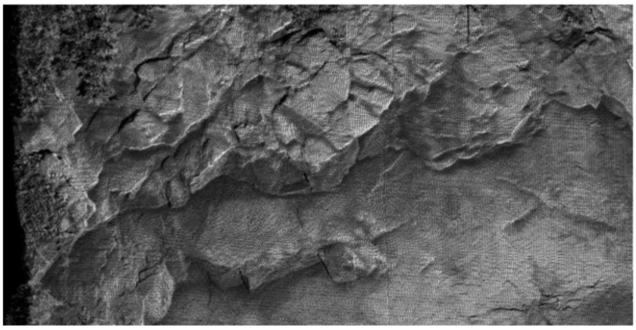

Fig. 2. Point cloud (grey scale) with resolution on 5 cm/30 m.

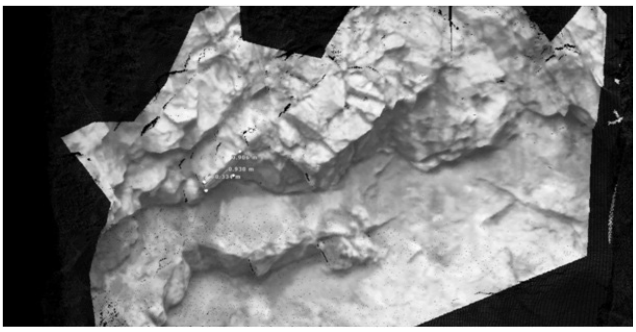

Fig. 3. Point cloud (grey scale) with resolution on 1 cm/30 m.

Results and discussion

The basic idea of 3D terrestrial laser survey on location was to detect possibilities of application of new technology of rock slope surveying, i.e. its application in the future geotechnical investigations of

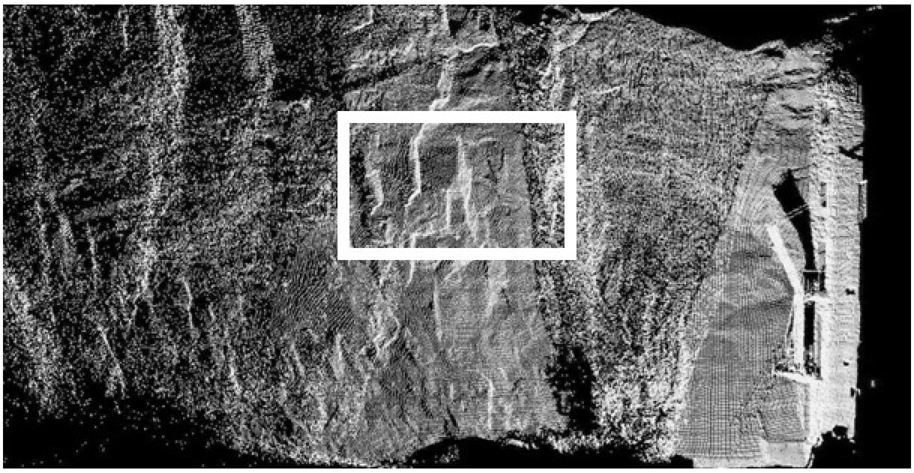

Fig. 4. Point cloud (grey scale) with resolution on 5 cm/30 m and old torn protective net (white arrow), ivy and trees.

slope stability.Taking into consideration the height and grade of the slope, the problem of mapping of inaccessible parts of slope was present, i.e. the issue of possible errors during presentation of joints line by conventionally surveyed slopes. The first performed scan with resolution of 5 cm provided "point cloud" with satisfactory precision referring the precision of data for the requirements of detailed mapping of slopes. We would like to mention that the scanning for the slope 20 m high and 40 m long lasted 10 minutes with previous geo-referencing which lasted 20 minutes. No additional referencing was required for any further scanning. However, better visualization and possibility to perform further detailed mapping of joints was achieved by further scanning with resolution of 1cm, i.e. 0.5 cm of slope detail (Figs. 3 and 5). Both figures present slope details which are inaccessible for direct measurement of jointing features (Figs. 1 and 4). In addition to details of surveyed data and visualization of real state at the location, the details of torn protective net are also presented in the left and right corner on the Figure 4. Beside the point cloud presented at Figures 2, 3 and 5 obtained by scanning

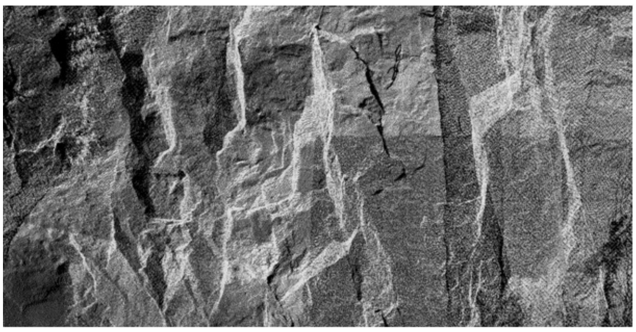

Fig. 5. Point cloud (gray scale) of slope detail with resolution on 0.5 cm/15 m

in different resolutions, the data in AutoCAD® was obtained as an outcome, which satisfied the need for preparation of vertical sections of terrain, where each point in the section was referenced in the state coordinates system.

After scanning of rock slope atthe site, the advantages of obtained topographic data with 3D terrestrial LIDAR and DTM modelling showed numerous additional possibilities in addition to the application of the topographic data as the background for performance of remedial measures. The filtration of point cloud is performed as next step by appropriatealgorithms to remove murmurs (vegetation and torn protective net) in the sample of collected data for slope from Figure 4. The last phase is modelling of Digital Terrain Model on the basis of assembly of points by suitable software tools (Fig. 6).

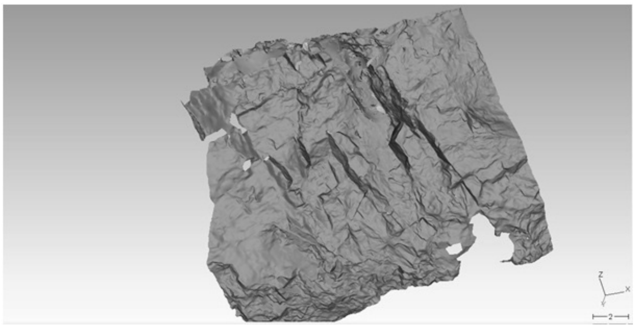

Fig. 6. Rotation of 3D DTM of slope (rock slope 90/75) after cleaning (grey scale)

Conclusion

The results of performed investigations, i.e. scanning of terrain indicated the numerous possibilities of applied technologies, which can be briefly summarized in the following advantages. The speed of measurement and automatic processing of data provide topographic data in very short period with the precision which can be adapted to each concrete case, but in any case is more precise than any conventional method of surveying. The possibility of export to numerous user programs which are used for the presentation of design documentation, enables application of data in geotechnical practice. The advantages of remote sensing approach enables the obtaining of data of higher precision in the case of inaccessible slopes (very high slopes or vertical ones), where the data on joints (roughness, length etc.), can be obtained only by observing. Preparation of Digital Terrain Model enables additional modelling(like block size and shape), which can help designer to understand the problems of instability on rock slopes.Series of laser scanning can also provide exact volumes and precise location of fallen material in the rock slopes where the rock falls, ravelling and flaking are dominant. Efficient use of terrestrial LIDAR surveys allows steep slopes to be monitored on a monthly or even daily basis, as needed. The economic advantage of this method is indisputable due to the quality of data obtained in a short period and the possibility of work in all conditions.

3D terrestrial laser scanning of terrain on "Letnja Pozornica" location was performed for the first time in Serbia, with the aim of determination of possibility of its application in the detailed geotechnical investigations of slope instability. Additional investigations which would connect data of scanning and engineering geological mapping of joint sets with adequate software for various numerical modelling are impending.

Acknowledgements

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Horizontal Edges Detection of Magnetic Anomaly Sources Based on Aeromagnetic Data

Snežana Ignjatović[1] & Milenko Burazer[2]

Abstract. During geological survey in the eastern Serbia, north part of Timok Magmatic Complex (TMC), Geotech Ltd. carried out geophysical measurements for company Dundee Plemeniti metali d.o.o (now Avala resources d.o.o). This paper explains procedure of aeromagnetic data processing in order to detect horizontal edges of magnetic anomaly sources. In this case following techniques are used: pre-processing, calculation of anomaly values of total magnetic intensity field, reduction to the pole, upward continuation and tilt derivative. Tilt derivative zero contours can facilitate interpretation of potential field maps.

Key words: aeromagnetic measurement, data processing, detection of horizontal edges, reduction to the pole, upward continuation, tilt derivative.

Introduction

In the period March 24th to June 18th 2006 Geotech Airborne Ltd. (Geotech) carried out aeromagnetic survey in the eastern Serbia, north part of Timok Magmatic Complex (TMC), for company Dundee Plemeniti metali d.o.o (Fig. 1). The magnetic sensor utilized for the survey was Geometrics optically pumped cesium vapor magnetic field sensor, mounted at a height of 15 m below the helicopter. The sensitivity of the magnetic sensor is 0.02 nT at a sampling interval of 0.1 s. Helicopter is maintained 90 m above ground. The distance between flight spacing was mixture of 50 m and 100 m. Data processing is done using the software package Geosoft Oasis montaj.

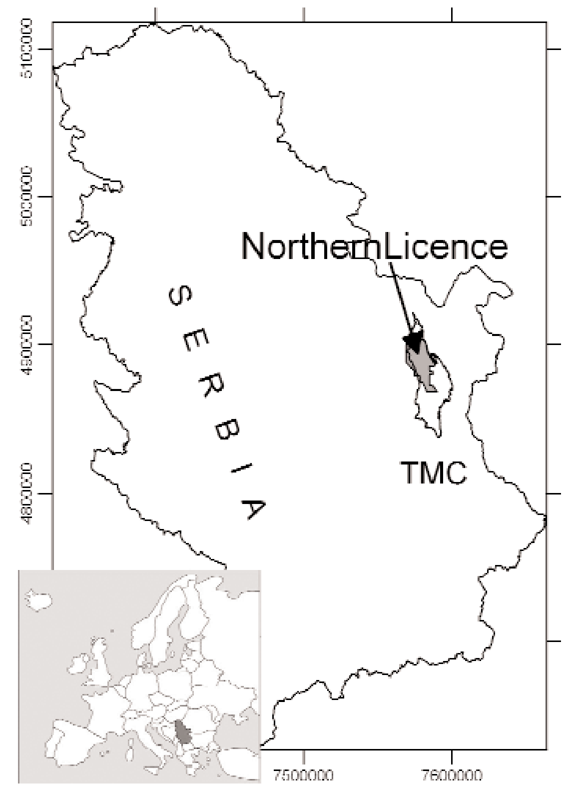

Fig. 1. Location map. Aeromagnetic survey-Northern License, Timok Magmatic Complex (TMC)

Aeromagnetic data processing

The pre-processing of the aeromagnetic data involved the correction for diurnal variations by using the digitally recorded ground base station magnetic values. Tie line levelling was carried out by adjusting intersection points along the traverse lines. After that microlevelling procedure was applied. Microlevelling adjustments are necessary because quite minor data errors become clearly visible when grids of data are

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displayed as enhanced images, LUYENDYK (1997). This technique is designed to remove persistent low-amplitude components of flight line noise remaining after tie line levelling. Measured total magnetic intensity data (TMI) corrected by means of diurnal variations, tie line levelling and microlevelling.

Total magnetic intensity (TMI) data are acquired from aeromagnetic measurements. Normal field values are calculated by means of model IGRF (International Geomagnetic Reference Field) for date 1.3.2006 including topography. Inclination value (I) is 61° and declination value (D) is 4°. Anomaly values of total magnetic intensity field are calculated like difference between measured values of magnetic field and calculated values of normal field. The magnetic anomaly data interpolated in grid 50×50 m. Magnetic field anomaly map show in Figure 2.

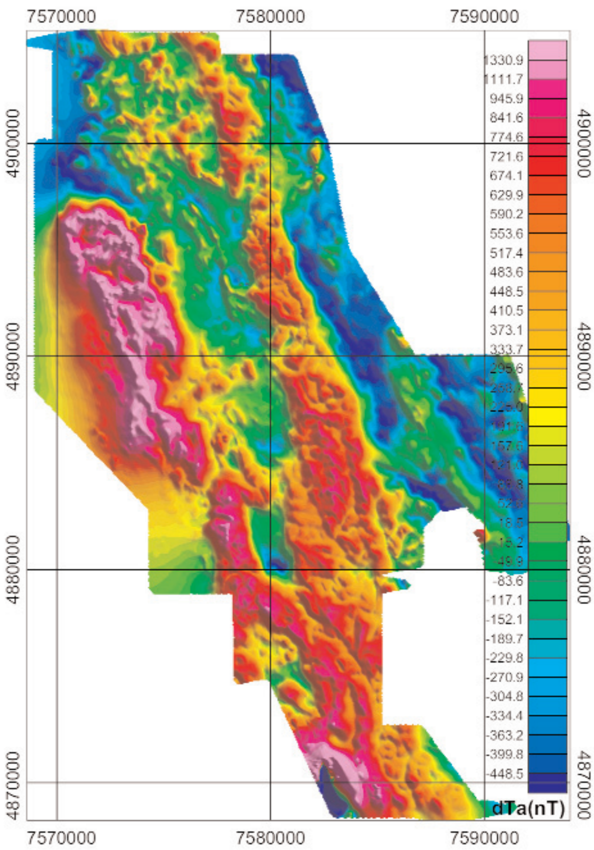

Fig. 2. Map of magnetic field anomaly (dTa)

In Figure 3 proposed steps of processing procedure are shown.

Because of dipolar nature of the magnetic field the first step in data processing is the reduction to the pole (RTP). Reduction to the pole assumes all rock magnetization to be vertically induced and remanence-free. This RTP transformation makes the shape of magnetic anomalies more closely related to the spatial location of the source structure and makes the magnetic

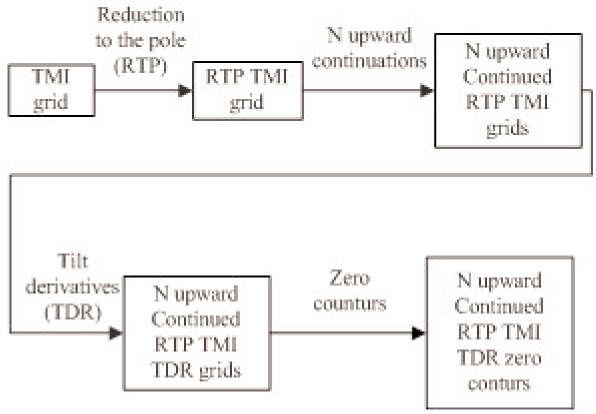

Fig. 3. Flowchart of the processing procedure, after LAHTI & KARINEN, 2010

anomaly easier to interpret, as anomaly maxima will be located centrally over the body, SALEM *et al.* (2007). The aeromagnetic data was reduced to the pole using the magnetic inclination and declination which corresponds to magnetic filed at the time of the aeromagnetic measurements (Fig. 4).

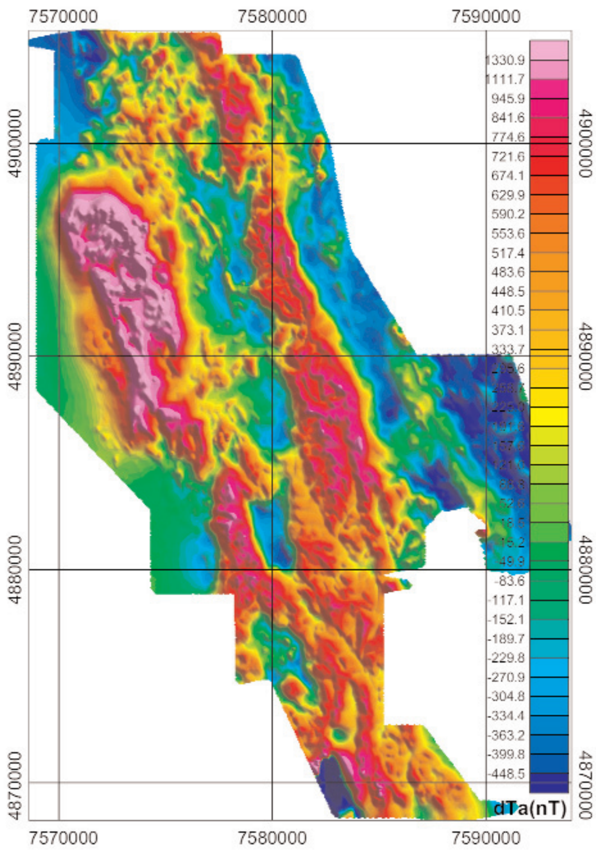

Fig. 4. Map of magnetic field anomaly reduced to the pole (RTP).

Upward continuation transforms the magnetic field measured on one surface to the field that would be measured on another surface father from all sources. In this way upward continuation help us to diminish the effect of short-wavelength information. It is known that upward continuation tends to accentuate anomalies caused by deep sources at the expense of anomalies caused by shallow sources.

Derivatives of potential field data can help define and estimate the physical properties of the source structure causing the anomaly. The tilt derivative (TDR) is highly suitable. The TDR is a normalized derivative based on the ratio of the first vertical derivative (VDR) and total horizontal derivative (THDR) of the RTP field,

$$TDR = \tan^{-1}\left[\frac{VDR}{THDR}\right],$$

where

$$VDR = \frac{\partial M}{\partial z}, \quad THDR = \frac{\partial M}{\partial h} = \sqrt{\left(\frac{\partial M}{\partial x}\right)^2 + \left(\frac{\partial M}{\partial y}\right)^2},$$

and $\partial M/\partial x$、$\partial M/\partial y$、$\partial M/\partial z$ are the derivatives of the magnetic field M in the x, y and z directions.

The tilt derivative uses the absolute value of the total horizontal derivative. Due to the nature of the arctan trigonometric function, all amplitudes are restricted to values between $+\pi/2$ and $-\pi/2$ (+90° and –90°) regardless of the amplitude of VDR or THDR, GETECH (2007). Figure 5 shows magnetic field anomaly with RTP and TDR. The tilt derivatives vary markedly with inclination. For inclinations of 0 and 90°, the zero crossing is close to the edges of the model structures.

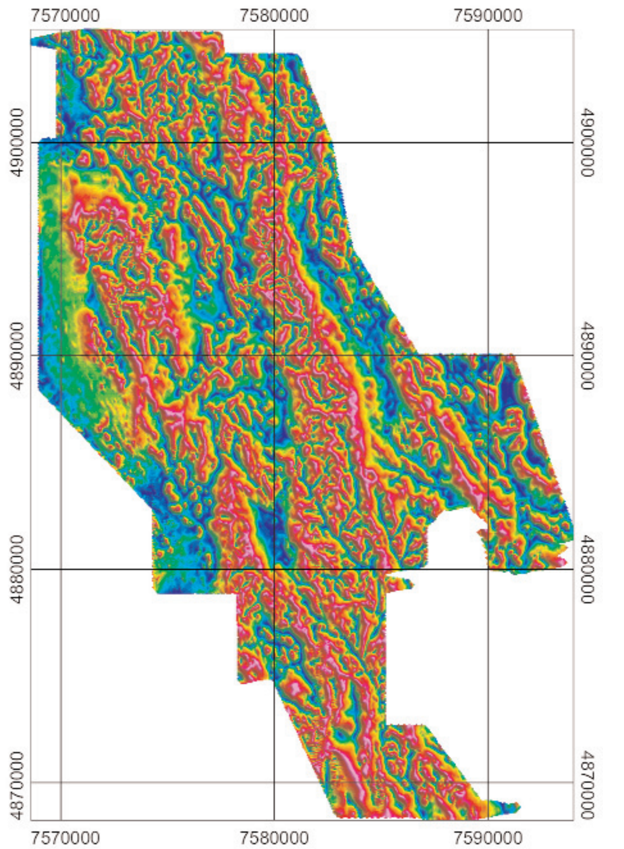

Fig. 5. Map of tilt derivative (TDR) of magnetic field anomaly reduced to pole (RTP).

Filed example

In this section we present technique to extract geometrical information of anomaly sources from magnetic map. This information can be acquired by examining the TDR zero contours with varying upward continuation levels. We present field examples to demonstrate the technique.

The area of our interest was eastern Serbia, north part of Timok Magmatic Complex. In our case processing of aeromagnetic data the zero contours of the TDR grids were calculated using five continuation levels (100 m, 200 m, 300 m, 400 m and 500 m). The zero contour level of the tilt derivative marks the location of the horizontal edges of the magnetic source.

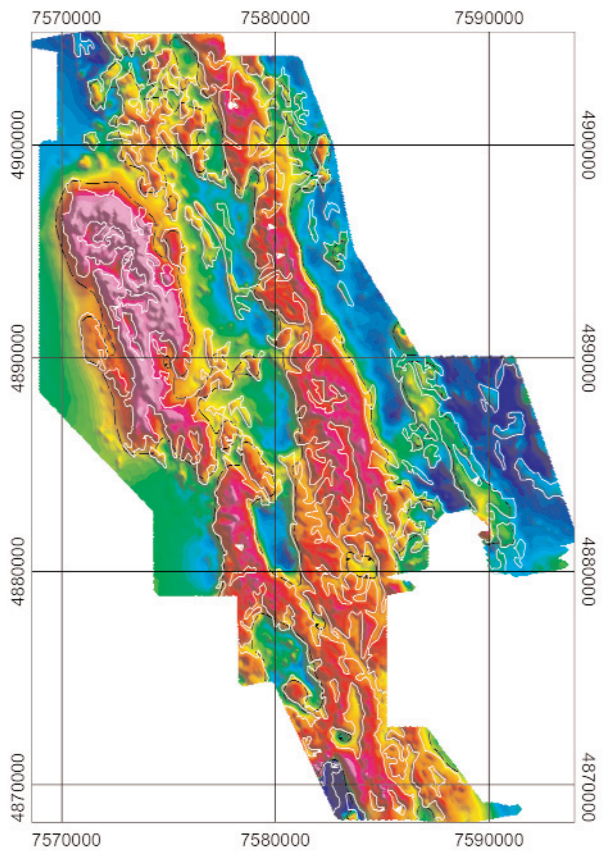

Fig. 6. Map of magnetic field anomaly reduced to pole and TDR zero contours: a) flight level (white contours) b) upward continuation level of 500 m (black dashed contours).

In the figure 6 shows airborne magnetic map, containing RTP-corrected, processed TDR zero contours for the flight level and upward continuation level of 500 m. TDR zero contours for the flight level are marked with white lines and upward continuation level of 500 m is marked with black dashed lines.

Conclusion

In this paper, we have shown procedure of aeromagnetic data processing by means of certain software package. We demonstrated steps to detect horizontal edges of various scale magnetic anomaly sources. The basic point of our procedure of data processing was a tilt derivative and the zero contour level of the tilt derivative.

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Geological Features and 3D Model of the Field “E”, Kolubara Coal Basin

MARIJA VELIČKOVIĆ[1] & DRAGANA ŽIVOTIĆ[1]

Abstract. This article presents a preparation of 3D model of the coal field “E” (Kolubara lignite basin) using the GDM computer software. Preparation of 3D model was performed using a surface based modelling approach. The topology of key horizons has been modelled using the “Kriging for linear variogram without drift” in regular networks. For this purpose we used all known data points (x, y, z) representing drill-hole intersections (formations) of logged geological boundaries (within defined deposit boundaries).

Key words: 3D modelling, GDM software, Kolubara basin, Filed E, Lignite.

Introduction

3D modeling is the process of developing a mathematical representation of any three-dimensional surface of ore bodies with specialized software. It is the applied science of creating computerized representations of portions of the ore bodies and structures, based on geophysical and geological observations, made on and below the Earth surface. 3D model is the numerical equivalent of a three-dimensional ore bodies complemented by a description of physical quantities which integrates structural geology, sedimentology, stratigraphy, paleoclimatology, diagenesis…. In 2 dimensions a geologic formation or units or bodies is represented by a polygon, which can be bounded by faults, unconformities or by its lateral extent, or outcrop. In geological models a geological unit is bounded by 3-dimensional triangulated or gridded surfaces. Geometric objects are represented with parameteric curves and surfaces or discrete models (MATHERON, 1976; RIVOIRARD, 1994) such as polygonal meshes.

Economic and Mining geologists use modelling to determine the geometry and position of mineral deposits in the subsurface of the earth. They then determine the concentration and volumes of the minerals or ores investigated. Economic constraints are applied to the model determining the value of mineralization. Plans for mineral extraction are made determined by the ability of the mining company to make an economic extraction of the defined ore.

In this study we have formed 3D modell of the coal field „E” and calculated reserves and basic quality parameters within defined boundaries for both coal seams (Upper and Main).

Geological setting

Coal field “E” is located in the southeastern part of the Kolubara coal basin (Fig. 1) and covers the area of about 9 km^2. The Kolubara coal basin, located some 60 km SSW of Belgrade, covers the area of almost 600 km^2, extending E–W up to 55 km, and S–N up to 15 km.

The area of Kolubara basin is formed of Paleozoic, Mesozoic, Tertiary, and Quaternary rocks. Both the border and the basement of this basin consists of Devonian and Carboniferous schist, gneiss, slate and sandstone, Mesozoic carbonate and marly sediments, Tertiary dacite-andesite rocks and pyroclastics, lacustrine, brackish and marine clastic sediments. Neogene of the Kolubara basin consists of the following lithostratigraphic units (KEZOVIĆ, 2003; Fig. 2):

1. Lower Miocene, made of fresh water marlstone, tuffite, and claystone;

2. Badenian, consisting of marine sand and loosely bounded conglomerate and freshwater sand, clay, and gravel;

3. Badenian-Sarmatian, made of sand, clay and gravel;

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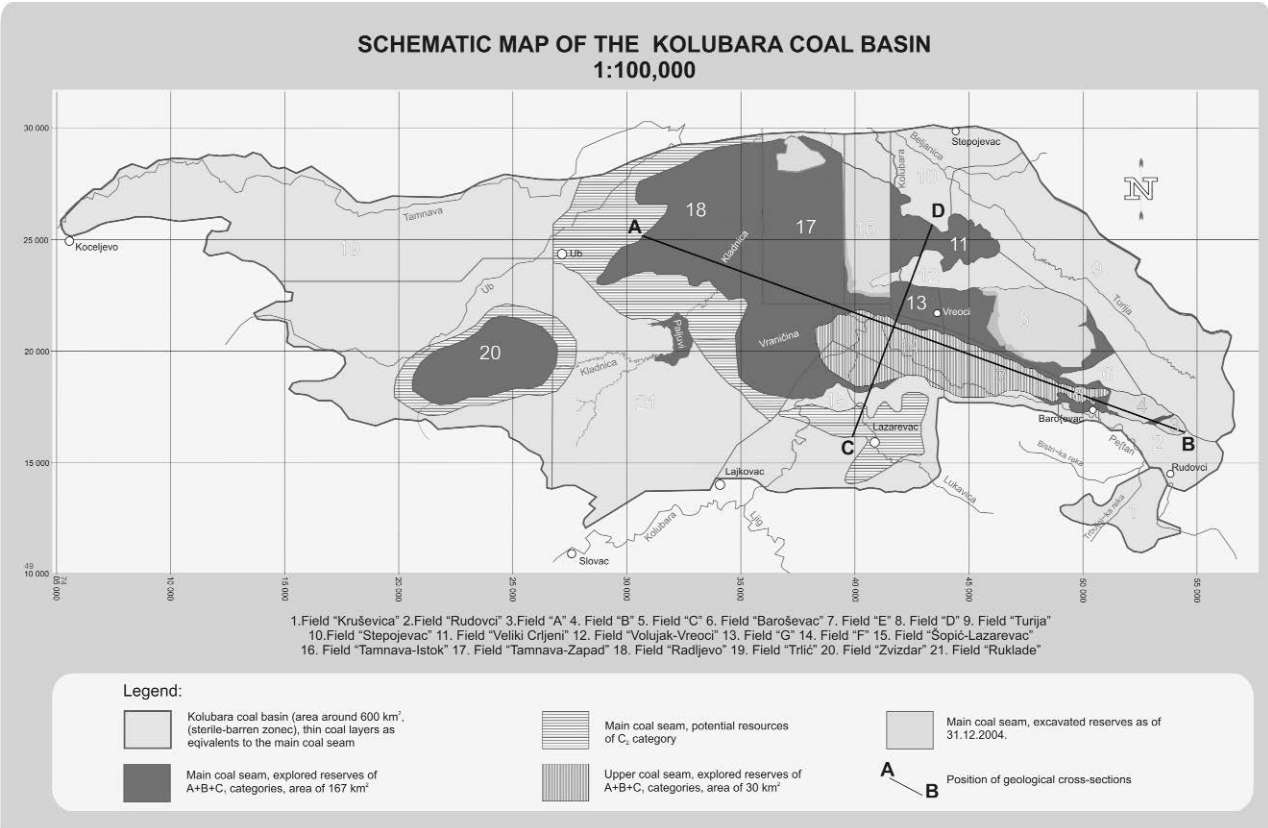

Fig. 1. Position of different coal fields within Kolubara basin (compiled after different authors).

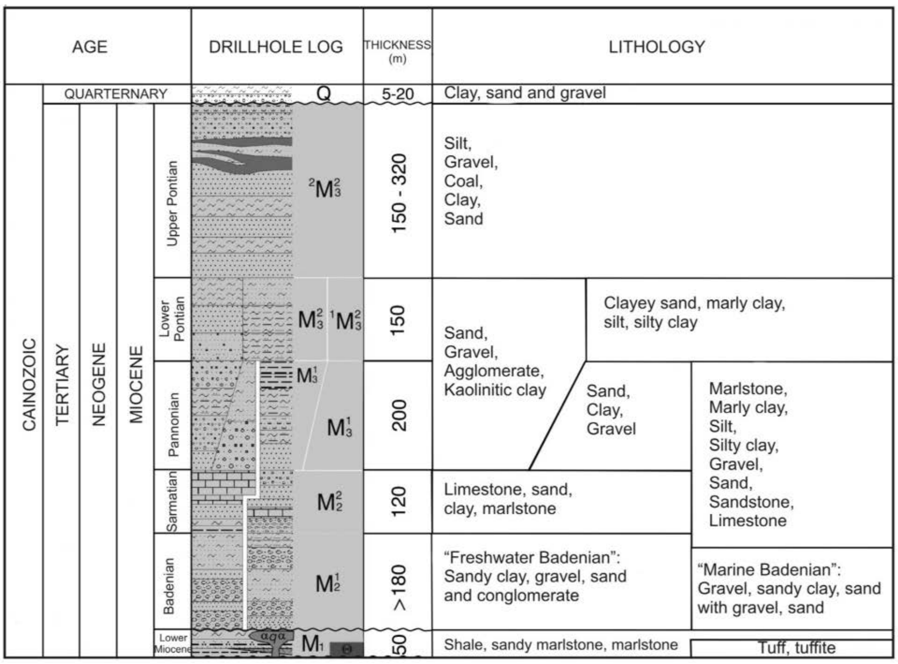

Fig. 2. Lithostratigraphic units of the Kolubara Neogene sediments (compiled after different authors).

4. Sarmatian, made of brackish clayey-marly and sandy sediments and limestone;

5. Pannonian, contains caspi-brackish sand, sandy clay, marly clay, silt, rarely gravel, and marlstone;

6. Pontian, consists of clastic sediments, with three coal seams: seam III or Lower coal seam, seam II or Main coal seam, and seam I or Upper coal seam, having typical thickness of 7 m, 25 m, and 11 m, respectively (NIKOLIĆ & DIMITRIJEVIĆ, 1990). The total thickness of the Pontian series is 250–320 m;

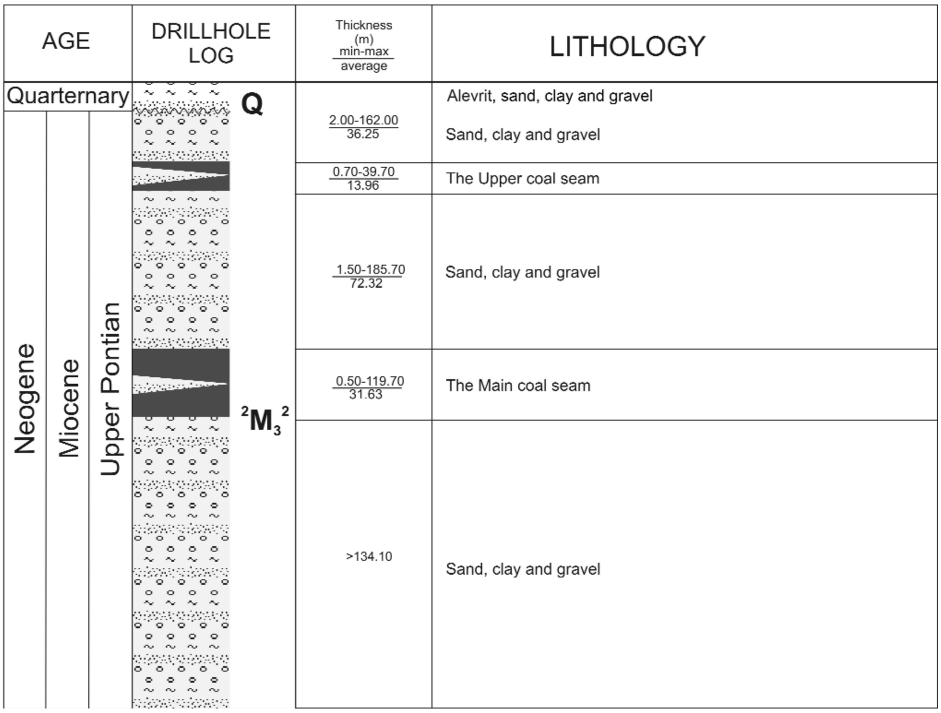

Fig. 3. Litostratigraphic colum of Field “E“ (Veličković, 2010).

7. Quaternary, made of fluvial gravel, sand, clay and sandy-clayey sediments.

Coal field “E” consists of Neogene and Quaternary sediments (Fig. 3). The underliying sediments of the Main coal seam are made of sand and clay. Maximum thickness of footwall sediments, determined by exploration is 134.10 m. The Main coal seam extends almost continuously throughout the deposits area, except in the southern part where it wedges out. Seam thickness varies from 0.50 m to 119.70 m. Sediments between the Main and Upper coal seams consists of clay, sand and gravel, where thickness varies from 1.50 to 185.70 m.

The Upper coal seam has minimum thickness 0.70 m, and the maximum one is 39.70 m. Within the coal seam the presence of intercalations and lenses of dark gray coal-clay with varying thickness was noted.

The overlaying sediments of the Upper coal seam are made of Upper Pontian and Quaternary sediments: sandy clay, gray-yellow sands and gravels, with thickness from 2.00 m to 162.00 m.

The most important faults of the Kolubara basin are (Đoković *et al.*, 1988): Radljevo fault (WSW–NNE direction), separating the central from the southern parts of the basin; Peštan fault (E–W) in the southern and SE part of the basin; Ćelije fault (E–W) in the southern part of the basin; Obrenovac fault (E–W) in the northern part of the basin; Barič–Šljivovica fault (N–S) in the eastern part of the basin; Vrelo fault (N–S) in the central part of the basin; Dubrava fault (N–S) in the western part of the basin, and Dren fault (SW–NE) in the north-west part of the basin.

Tectonic features of Neogene sediments are relatively uniform in the major part of the basin; coal seams dip at low angles to the northern and central parts of the basin. Only along the southern border of the SE part of the basin, coal seams are characterized by a synform, due to intense post-sedimentary faulting, causing occasional coal erosion in the SE part of the basin, as well. The basic structural characteristic of coal field “E” is an asymmetric trench-syncline in the central part of the deposit, whose longer axis has the general direction of NW–SE.

Average huminite reflectance of the coal from the Kolubara basin is 0,30 % (Ercegovac, 1998), thus placing the coal in soft brown coal (lignite) stage of coalification.

Results and discussion

To resolve the complexity of the coal field “E” and visualise the stratigraphy hosting the coal seams, we have used a surface based modeling approach. The topology of key horizons has been modeled using optimised regular networks that connect all known data points (x, y, z) representing drill-hole intersections within defined geological boundaries. The horizons were fitted to these well markers (drill-hole intersections), which were imposed as control points constraints. Border constraints were also implemented, to straighten and smooth each horizon’s outline, and to model existing and interpreted relationships between horizons.

GDM implements properties for different object (e.g. different proprieties can be assigned to a vertex of a triangulated surface). Properties were interpolated using the “Kriging for linear variogram without drift” with grid dimensions 31.25×31.25 m.

Fig. 4 illustrates an example of interpolation of topography, floor of the Quaternary sediments, and roof and floor of the Upper and Main coal seam on the cross-section.

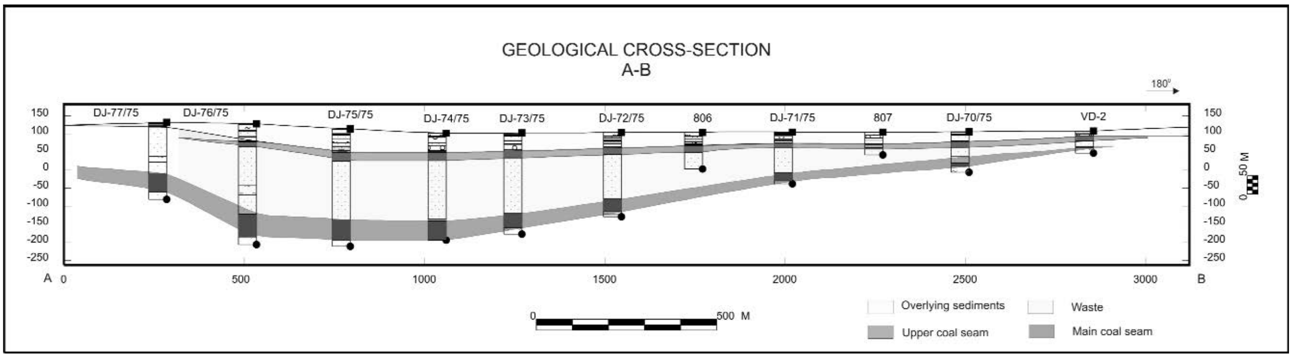

Fig. 4. Cross-section of the Coal Field "E" (VELIČKOVIĆ, 2010).

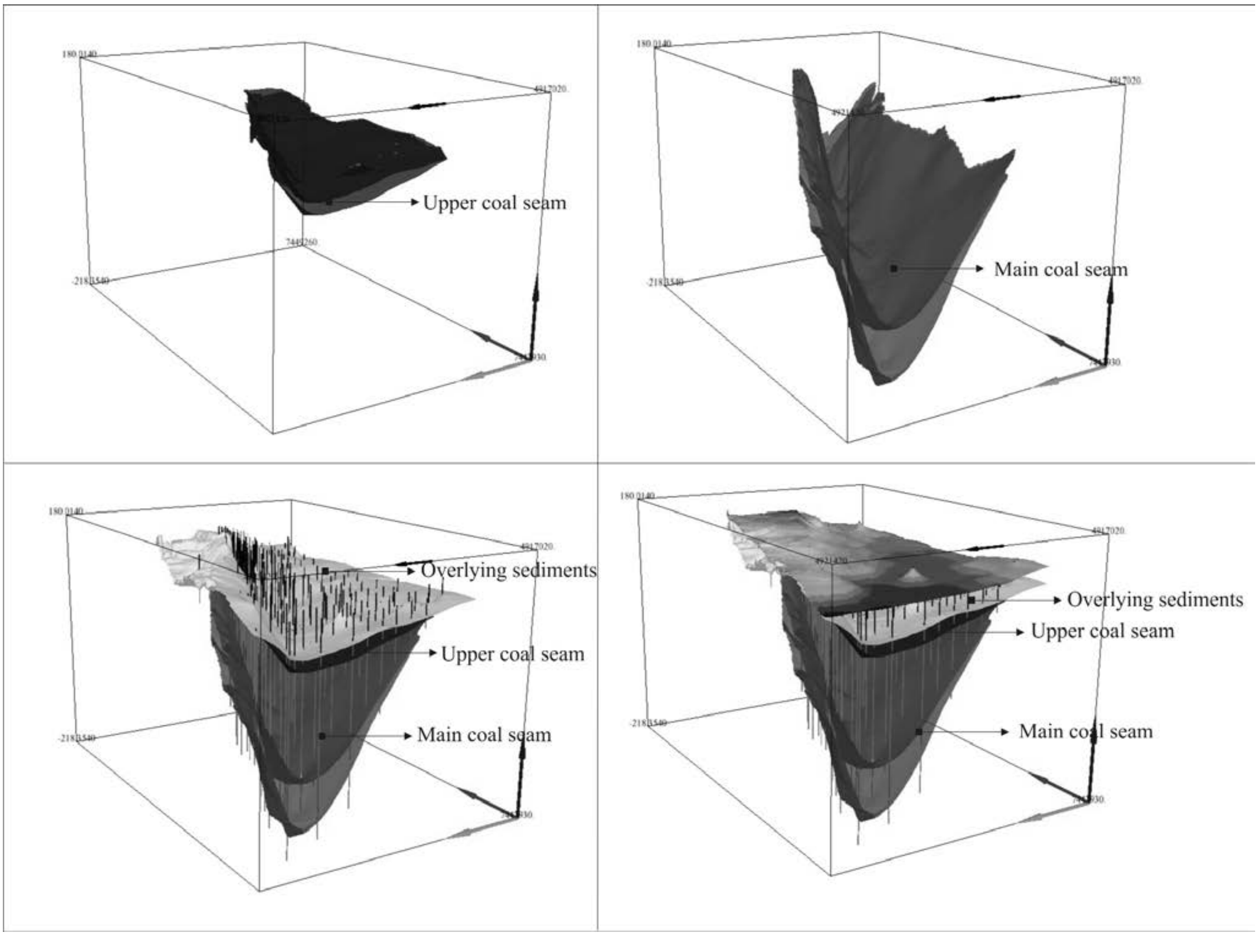

Fig. 5. 3D model of Field "E" (VELIČKOVIĆ, 2010).

ash content as receive basis and Net calorific value) on the same grid, thus making it possible to perform calculations between the surfaces. In calculation of coal thickness and surface of floor and roof of coal seams

Final model is a product of merging the surface models (floor of the Quaternary sediments, and roof and floor of the Upper and Main coal seam), thicknes of coal and quality parameteres (total moisture content, we used certain program functions to correct this anomaly in the model (a negative value for the thickness, and also to forbid the surface floor formation's to pass above the roof of formation in some parts).

Table 1. Comparative analysis of coal reserves in the “E” coal field

Coal seam	**RESERVE (t)**		**DIFFERENCE**	
	The miniblock method	**Study on coal reserves (BABIC, 2005)**	**Absolute (t)**	**Relative (%)**
Upper	127,937,514	126,289,094	1,648,420	1.29
Main	288,023,019	300,043,280	-12,020,261	-4.17
TOTAL:	**415,960,533**	**426,332,122**	**-10,371,589**	**-2.49**

When the final model was performed, 3D visualisation with key surfaces (topography, roof and floor of the Upper coal seam and roof and floor of the Main coal seam) and boreholes was created (Fig. 5).

Coal reserves for Upper and Main coal seam have been calculated for each block, where block volume was multiplied with relative density of coal (1.14 t/m^3 for Upper coal seam and 1.16 t/m^3 for the Main coal seam). The calculated geological coal reserves for Upper coal seam amounted to 127,937,514 t and the Main coal seam 288,023,019 t. Comparative analysis of reserves calculated using the miniblocks method with geological blocks method (Table 1) shown in the Report on the reserves of coal in Field ”E” (BABIĆ, 2005) showed that the calculation is done with great accuracy. The total relative difference in relation to the basic method is –2.49 % and 1.29 % for Upper coal seam and –4.17 % for the Main coal seam.

Conclusions

Coal field “E” is located in the southeastern part of the Kolubara lignite basin, located some 60 km SSW of Belgrade. The area of Kolubara basin is formed of Paleozoic, Mesozoic, Tertiary, and Quaternary rocks. The Upper Miocene (Pontian) field “E” consists of sandy and clayey sediments with two coal seams. Thickness of the lower, Main coal seam, varies between 0.50 m and 119.70 m, and for the youngest, the Upper coal seam, between 0.70 m and 39.70 m. Sediments between these two seams consists of clay, sand and gravel, where thickness varies from 1.50 to 185.70 m.

Preparation of 3D model of the coal field “E” was done by GDM software with a surface based modeling approach. The topology of key horizons (topography, floor of the Quaternary sediment, floor and roof of the Main and Upper coal seam) has been modeled using the “Kriging for linear variogram without drift” in regular networks. For this purpose we used all known data points (x, y, z) representing drill-hole intersections (formations) within a defined boundaries. Comparative analysis of calculated reserves with reserves calculated in the Geological Report (BABIĆ, 2005), showed a high level of accuracy.

Acknowledgements

The authors are grateful to the anonymous reviewers for their constructive comments and the Ministry of Education and Science of the Republic of Serbia (Project No. 176007) for financial support.

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17th Meeting of the Association of European Geological Societes	Proceedings	149–153	BELGRADE, 14–18 September 2011

Geological Characteristics and 3D Model of the Brick Clay Deposit ''Majdan III" near Kanjiža

MLADEN ZDRAVKOVIĆ[1] & VLADIMIR SIMIĆ[2]

Abstract. Geological characteristics and 3D model of the "Majdan III" brick clay deposit in Kanjiža are presented. Preparation of 3D model was performed using a surface based modelling approach and GDM computer software. The topology of key horizons (topology, roof of the Loess complex and the Yellow clay and roof and floor of the Blue clay) has been modelled using the "Kriging for linear variogram without drift" in regular networks. For this purpose we used all known data points (x, y, z) representing drill-hole intersections within defined deposit boundaries. Discussion revealed that there are no major differences between applied methods of classical reserves calculation and GDM software, but we can say that geology and clay grade is more precise when GDM software is used.

Key words: 3D modelling, GDM software, Majdan III, Brick clay deposit.

Introduction

3D modeling is the process of developing a mathematical representation of any three-dimensional surface of ore bodies with specialized software. It is the numerical equivalent of a three-dimensional ore bodies complemented by a description of physical quantities. In 2 dimensions a geologic formation or units or bodies are represented by a polygon, which can be bounded by faults, unconformities or by its lateral extent, or outcrop. In geological models a geological unit is bounded by 3-dimensional triangulated or gridded surfaces. Objects are represented with parametric curves and surfaces or discrete models (MATHERON, 1976; RIVOIRARD, 1994) such as polygonal meshes.

Economic geologists use modelling to determine the geometry and position of mineral deposits in the subsurface of the earth. Also, they then determine the concentration and volumes of the minerals or ores investigated. Economic constraints are applied to the model determining the value of mineralization.

In this study we have formed 3D model of the "Majdan III" brick clay deposite, and calculated reserves and basic quality parameters within defined boundaries for the Loess complex and Yellow and Blue clay.

Geological setting

The deposit of brick clay "Majdan III" is located a few kilometers eastern of Subotica in northern part of the Republic of Serbia, near the border with Hungary (Fig. 1). The wider area of the deposit (and the whole area of northern Bačka and Banat) is made of Quaternary sediments, which lie over the Upper Palludin series of the Pannonian Basin. Geomorphologically, the area of the deposit is very simple and uniform. In the area of several dozen square kilometers elevation of terrain ranges from 70 to 90 m, and elevation differences are usually within the range of ten meters.

Hydrogeological features of the deposit are rather simple. This is a sequence of uniform geological and lithological composition to the depth of drilling, around 20 m. The only lithological member which has the characteristics of hydrogeological collector is clayed blue sand.

The deposit is sub horizontal, stratified, in which brick clay was formed in three horizons. The surface boundary of the deposit has the form of irregular polygon elongated in the direction of NNW–SSE.

Previous geological exploration was performed during 1989, 1992, 2000, 2002, and 2007, and consisted of core drilling exploration and sampling.

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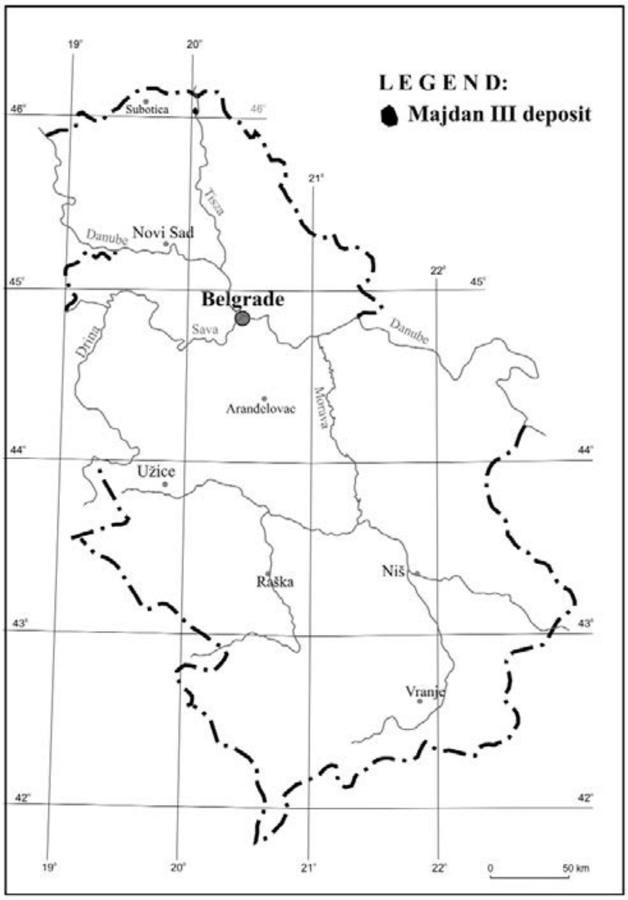

Fig. 1. Position of "Majdan III" deposit.

Method of parallel vertical exploration sections using the shallow (up to 20 m) vertical boreholes was applied as the best method of exploration for sub horizontal stratified deposits, located near the surface.

After analysis of previously conducted exploration, the following lithological series were distinguished within the deposit, which have specific technological properties and were used for deposit modeling (Fig. 2):

- Soil;
- Lîess complex (humified lîess, loess-like clay and yellow sandy clay);
- Yellow and yellow-blue clay, hereinafter referred to as yellow clay
- Blue fat clay with peat and a slightly sandy clay in the deeper parts of the deposit, hereinafter referred to as blue clay;
- Blue clayey sand (waste).

Soil and blue clayey sand are not the resources for structural ceramics (roof tiles), and therefore are shown in the model as separate formations, and lîess complex, yellow clay and blue clay are grouped in a special formation.

Geological characteristics of certain types of brick clay materials have affected their technological properties, as confirmed by extensive laboratory and industrial-scale tests.

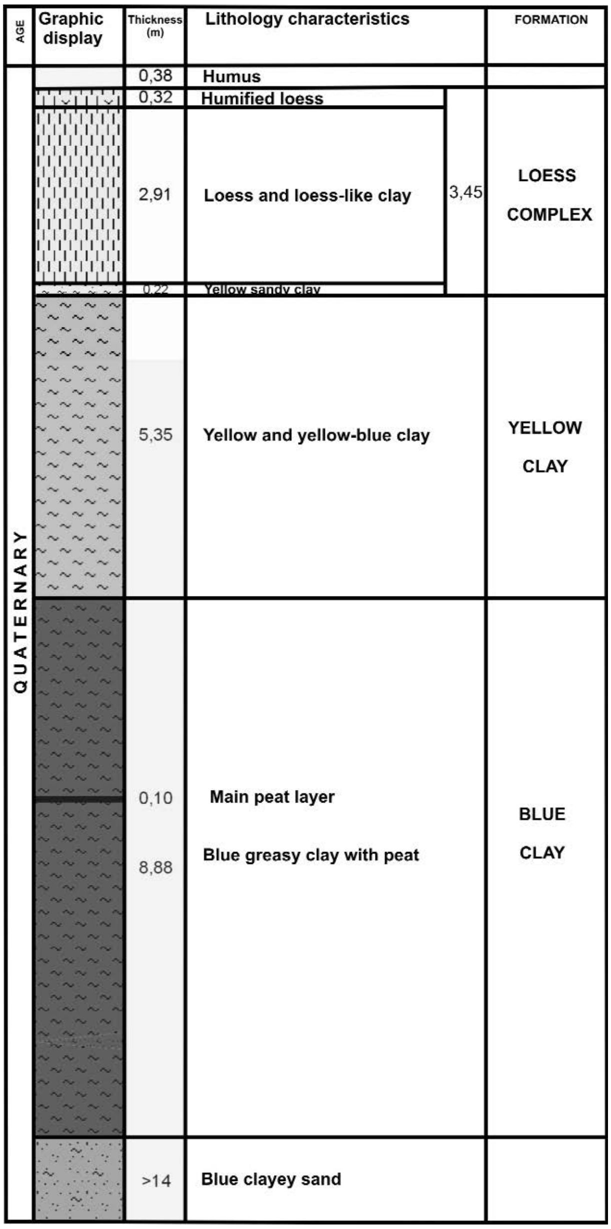

Fig. 2. Litostratigraphic colum of the "Majdan III" deposit (SIMIĆ, 2003).

Loess complex is characterized by high carbonate content (Fig. 3a) and sandy component. Carbonates occur as loess concretions, fossil remnants but mostly as finely dispersed in the loess mass. Content of clayey component is small, resulting in low plasticity of brick clay materials. In some horizons the presence of numerous shell remnants was detected.

Organic matter occurs in the form of roots and small veinlets. Loess complex is a distinct lithologic unit, transported by winds to the depositional environments.

Yellow clay is characterized by a significantly lower content of carbonate (Fig. 3b) and sandy component in relation to loess complex, while the content

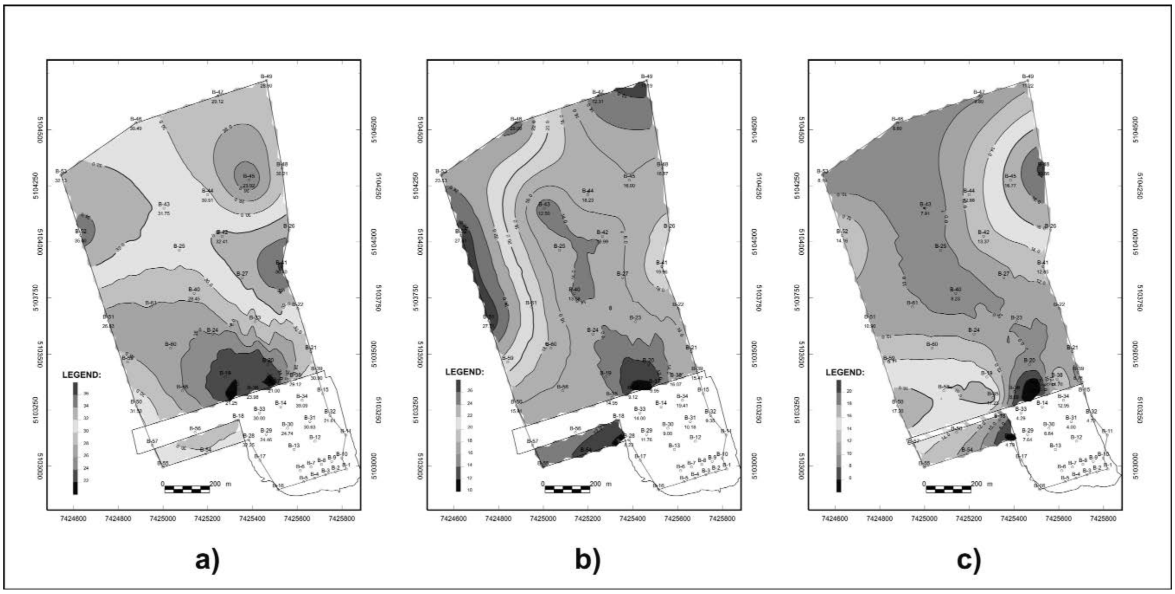

Fig. 3. Carbonate content of a) Loess complex, (%), b) Yellow clay, (%), c) Blue clay, (%).

of clay particles is considerably higher. Most of the coarse fraction of yellow clay consists of concretions and shell fragments. Organic matter content is very low in these clays.

Blue greasy clays are characterized by the lowest carbonate content (Fig. 3c) and sandy component of all lithologic series of brick clay, and simultaneously, are the richest in clay component. Content of concretions are carbonate is generally lower than in the yellow clay.

Content of shells is very low, while the share of organic matter is much more compared to the other lithologic series. The blue clays have one widespread layer of peat, and one or two layers with local development.

The ''Majdan III'' deposit belongs to the sedimentary deposits. It was created as a result of the mechanical process of differentiation of materials during transport and deposition in the wider coastal area of the Tisa river plain (SIMIĆ, 2002).

Results and discussion

3D modeling of the ''Majdan III'' deposit near Kanjiža was performed with GDM 6 geological software, in order to determine the geological characteristics, quality and reserves calculation of brick clay. To resolve the complexity of the ''Majdan III'' deposit and visualise the topology of key horizons, we have used a surface based modelling approach. The topology of key horizons has been modelled using optimised regular networks that connect all known data points (x, y, z) representing drill-hole intersections within defined geological boundaries. GDM implements properties for different object (e.g. different proprieties can be assigned to a vertex of a triangulated surface). Properties were interpolated using the "Kriging for linear variogram without drift" with grid dimensions 25×25 m.

Final model is a product of merging the surface models (topography, roof of the Lîess complex, and the Yellow clay and roof and floor of the Blue clay), thickness of key horizons and quality parameters (remaining on the sieve, reaction to carbonates and linear shrinkage on drying) on the same grid, thus making it possible to perform calculations between the surfaces. In calculation of the key horisons thickness and surface of roof and floor, we used certain program functions to correct this anomaly in the model (a negative value for the thickness, and also to forbid the surface floor formation's to pass above the roof of formation in some parts).

Fig. 4 illustrates an example of interpolation of topography, roof of the Lîess complex, and the Yellow clay and roof and floor of the Blue clay on the cross-section.

When the final model was performed, 3D visualisation with surfaces of key horisonts and boreholes was created (Fig. 5).

Brick clay reserves for all formations have been calculated for each block, where block volume was multiplied with relative density of brick clay (2.00 t/m^3 for the Loess complex and Yellow clay, and 1.95 t/m^3 for the Blue clay). The calculated geological brick clay reserves in GDM software package amounted to 40.324.202 t.

Comparative analysis of reserves (Table 1) calculated using the miniblocks method with parallel cross-section method shown in the Report on the reserves of brick clay deposit "Majdan III" (ŽIVOTIĆ, 2007) showed that the calculation is done with great accuracy. The difference of the total reserves using those two

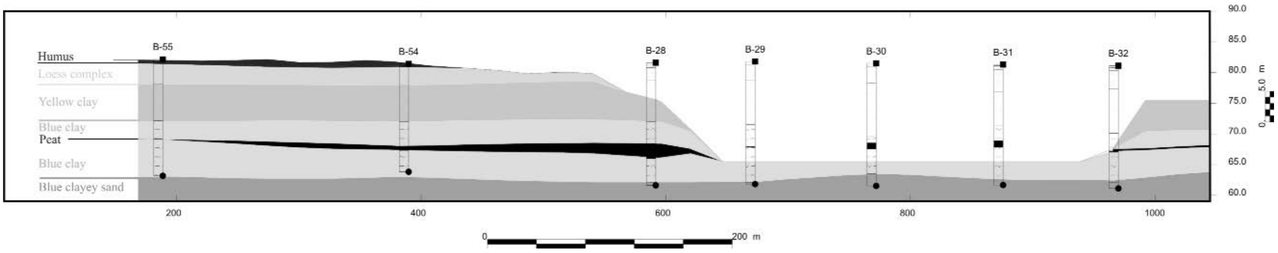

Fig. 4. Cross-section of the "Majdan III" deposit.

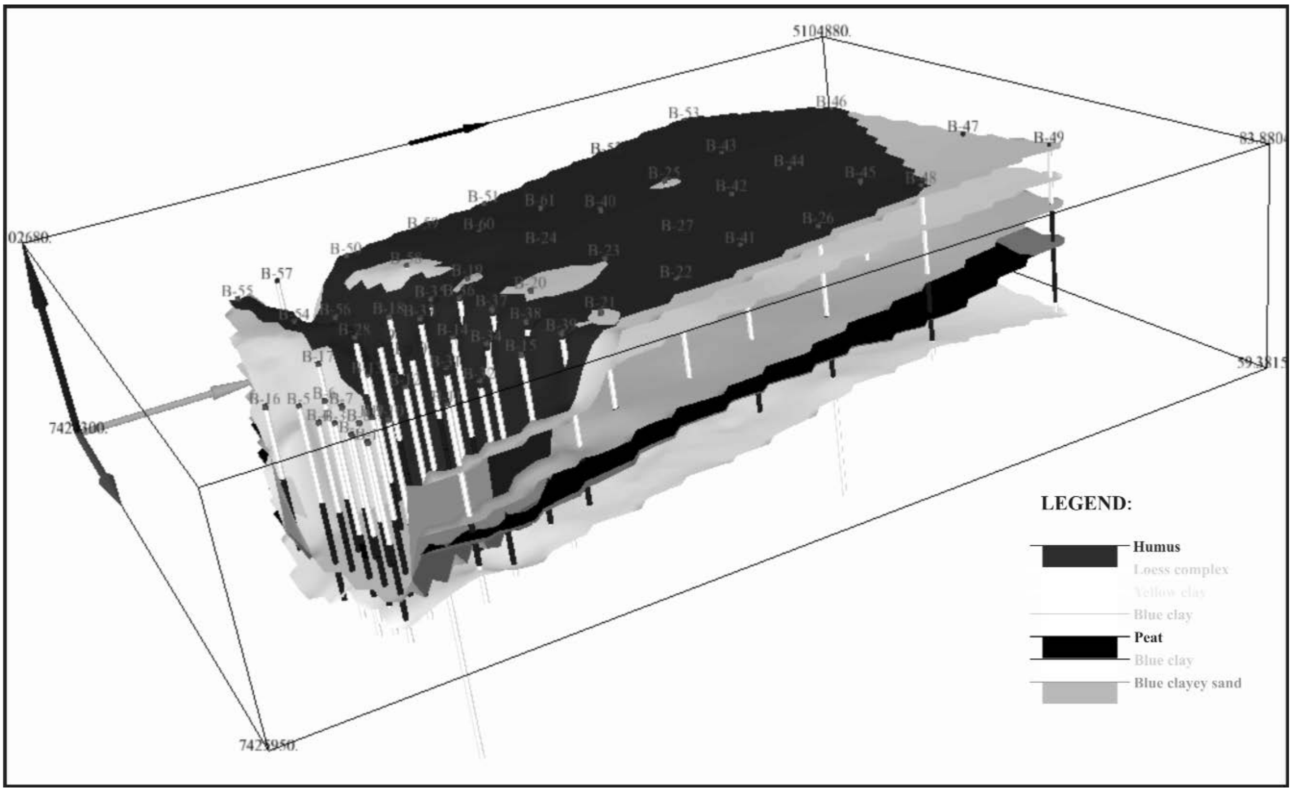

Fig. 5. 3D model of the "Majdan III" deposit.

Table 1. Comparative analysis of brick clay reserves of the Majdan III deposit.

GEOLOGICAL RESERVES (t)	Loess complex	Yellow clay	Blue clay	TOTAL
Study on brick clay reserves (ŽIVOTIC, 2007)	7.939.410	9.677.736	22.707.056	40.324.202
The miniblocks method	8.001.697	9.662.125	22.487.709	40.151.531
Absolute difference	-62.287	15.611	219.347	172.671
Relative difference (%)	**-0,78**	**0,16**	**0,97**	**0,43**

methods is 172671 t, and the relative difference is 0.43 %.

Conclusions

"Majdan III" brick clay deposit near Kanjiža (Northern Serbia) consists of three technological and geological types of clay, from top to bottom: loess complex, yellow clay and blue clay. Each of those lithological tupes has specific ceramic properties, which is the reason for selective exploitation of mineral commodity. That was also the reason why "Majdan III" deposit was selected to test the GDM software package and to present that it is very usefull for 3D modelling and all other applications. A surface based modelling approach was used to form the 3D model. The topology of key horizons has been modelled using optimised regular networks that connect all known data points (x, y, z) representing drill-hole intersections within defined geological boundaries. Obtained results were more precise compared to classic 2D modeling approach.

Acknowledgements

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17th Meeting of the Association of European Geological Societes	Abstracts	154–154	BELGRADE, 14–18 September 2011

Application of GPR and 3D Modeling as the Support for Protection of Objects of Importance and Arheaeological Research

MILENA CUKAVAC[1], GORAN KLEMČIĆ[2] & ČASLAV LAZOVIĆ[3]

Georadar research methods becomes more and more used in everyday practice of surveyors, archaeologists, builders as well as other scientific and professional fields, where the definition of underground facilities are not only the idea of discovering mineral deposits. This paper presents a georadar method in detection of objects and structures that are underground. The results of these studies are support to the protection of objects of importance and support in archaeological research.

GPR systems work by sending a tiny pulse of energy into a material via an antenna. An integrated computer records the strength and time required for the return of any reflected signals. Subsurface variations will create reflections that are picked up by the system and stored on digital media. These reflections are produced by a variety of material such as geological structure differences and man-made objects like pipes and wire.

Gradac Monastery in the Raska is one example of successful cooperation between a team of archaeologists, geophysicists and surveyors leaning on georadar method in use to define underground objects. This project plan defines the foundation walls and spread of historic buildings and potential burial places in the interior courtyard of the monastery, cadastral topographic plans, and installation of underground lines, three-dimensional model of the monastery and the content below the surface. The paper provides an analysis of the flow and content of post-processing of three-dimensional block model consisting of radargrams collected in high resolution on a investigative probes located in the narthex of the monastery. The measurements were carried out Georadar Swedish company MALA RAMAC model.

Surface radar data were acquired using a 500 MHz Geophysical Survey Systems, Inc. shielded antenna. Data were acquired along multiple parallel survey lines. The spacing between survey lines was 0.25 m, and lines extended 6.3 m. Each trace consisted of 152 samples collected for 150 ns with a continuous measurement along the route profile. Variant field frequency filters and gains were applied, based on daily field conditions, in order to facilitate real-time data visualization and quality control. Postprocesing was performed at the German software company REFLEXW SENDMEIER GEO.

Subsequent to data collection in the field, the processing sequence applied to surface radar data was accomplished in two steps: signal-to-noise ratio improvement, and the application of utilities and the selection of translucence settings for 3D display. Signal processing consisted of the removal of field gain settings, the application of a band-pass frequency filter (15 to 600 MHz) and the re-application of a linear gain to improve the contrast of target-scattered energy in later time. Using constructed color mapping effectively emphasized volume features of interest.

Key word: georadar, postprocessing, archaeological research, 3D modeling.

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17th Meeting of the Association of European Geological Societes	Abstracts	155–155	Belgrade, 14–18 September 2011

Influence of Orography on TRMM Acquisition (3b42 Product)

Luca D'Eramo[1] & Luigi Perotti[1]

Since its launch in 1997, Tropical Rainfall Measuring Mission (TRMM) has become one of most used satellites to study worldwide distribution of rains. Originally planned to investigate the tropical rainfall, the TRMM, after 2000, started covering from 50 degree to –50 degree of latitude, and from –180 degree to 180 degree of longitude. To study the precipitation regime over the North–West of Italy (Piedmont and Aosta Valley), we compared four years (2004–2007) of TRMM acquisitions (3B42 V6 product), with the dense rain gauge network fitting the two regions (383 gauge stations). The selected test site is close to Northern edge of TRMM acquisition, and is characterized by a very complex topography. In fact, the highest mountains of Western Europe are located within this area. To monitor the quality of TRMM product, we performed three different analyses: daily, monthly and seasonally. The correlation coefficients (CC) obtained show better results over the plain zones (average of 0.60 CC), and a gradually worst correlation in areas with a progressively more complex topography, especially over the Alps chain (average of 0.35 CC). During the seasonal peaks of precipitations, we noticed a general tendency to underestimate the total rain amounts, and an opposite behaviour during the driest periods. To highlight the relationship between the CC and the topography, we have normalized the surface inside each pixel, using the ASTER digital elevation model (DEM) data, obtaining thus, a "pixel roughness index" (PRI). Comparing each CC value with the respective PRI value, it has been possible observe how the TRMM acquisition is influenced by the morphology of area being investigated. As other studies carried out over area with complex topography, our work confirms the not so good performance of 3B42 product.

Key words: precipitations, rain gauges, Western Alps, pixel roughness index, remote sensing.

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17th Meeting of the Association of European Geological Societes	Abstracts	157–158	BELGRADE, 14–18 September 2011

Neogene Geodynamics in the Light of 3-D Visualization – an Example Along the Sava River (Belgrade)

MERI GANIĆ[1], SLOBODAN KNEŽEVIĆ[2], LJUPKO RUNDIĆ[3], ALEKSANDAR MILUTINOVIĆ[4] & ALEKSANDAR GANIĆ[5]

47 boreholes located in Belgrade costal area along the Sava and the Danube Rivers, where interesting data were obtained on deep position and thickness of certain stratigraphic members of Neogene and Quaternary are included in this research. Such relations have initiated the need to study the nature and character of kinematic movements.

Construction of the model of movements was made by using AutoCAD Land Desktop v2009 Software, where the following graphic operations were made: database creation based on the total number of boreholes, spatial positioning and interpolations of overlaying and underlaying part of stratigraphic units. After, the thickness map and the palaeostructural maps were made, the interpretation of neotectonic activity was carried out and block diagrams for individual stratigraphic segments were created.

Main tectonic feature of this terrain is large blocks separation that was initiated and developed during the different phases of the Neogene and Quarternary (syn-rift and post-rift phases of the evolution of Pannonian basin and Peri-Pannonian realm). Near the Sava-Danube confluence a large amplitude of vertical movement was noticed (up to 85 m displacement of the Upper Cretaceous, flysch deposits in the PdUS-13 and PdUS-8 boreholes). Such relations point to the horst like structure, KNEŽEVIĆ & GANIĆ (2005), and similar relations may be observed within B-1 and UPD-1 boreholes, RUNDIĆ *et al.* (2011). Upstream, in the area of Ada Ciganlija, it was established that there are vertical displacement of the blocks up to 45 meters (Cukarica bank of the River Sava compared with the block at the peak of Ada Ciganlija). Simultaneously, on the other riverside of Sava in Novi Beograd, there is a block, which is separated from the mentioned one at the peak of Ada Ciganlija. The whole amount of vertical displacement along the fault was not definitely established but it is certainly larger than 50 m.

During the Sarmatian, the large island of Avala that is existed as the great land area between coastal part of the Sava River and south margin of the Kosmaj Mt. was broken by faults. Due to the differential blocks movements, the northeast part of the island has sunk, which resulted in marine ingression of the Central Paratethys Sea (Badenian and Sarmatian) into existing areas of Čukarica and Ada Ciganlija. At the same time, in the area close to the Sava – Danube confluence, the absence of Sarmatian sediments were observed on certain places, probably because of the pronounced recession process, STEVANOVIĆ (1977).

During the Pannonian, due to an uplift of the Eastern Carpathians, the Paratethys Sea was replaced by the Lake Pannon. Subsidence was dominant and as well as the process of basinal filling.

Younger neotectonic movements (Upper Pliocene – Pleistocene) have resulted in significant changes in the basinal paleogeography. Along the large dislocation zones, the low land of the Pannonian domain was separated from the area of the Balkan Peninsula. This has predisposed the development of ancient valley of the Sava River, where, together with multiphase sinking of the bottom, polycyclic river sediments, known from the older literature as “Makiš beds” or “Beds with *Corbicula fluminalis*” were formed during the Pleistocene Period.

Key words: Neogene, geodynamics, boreholes, 3-D model, Belgrade City area.

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17th Meeting of the Association of European Geological Societes	Abstracts	159–159	Belgrade, 14–18 September 2011

I2GPS – A new Approach to 3D Surface Displacement Monitoring

Marko Komac[1], Blaž Milanič[1], Pooja Mahapatra[2], Ramon Hanssen[2], Hans van der Marel[2], Alan Fromberg[3] & Rachel Holley[4]

Persistent Scatterer Interferometry (PSI) is capable of millimetric measurements of ground deformation phenomena occurring at radar signal reflectors (persistent scatterers / PS) that are phase coherent over a period of time. However, there are also limitations to PSI; significant phase decorrelation can occur between subsequent SAR acquisitions in vegetated and low-density PS areas. Here artificial amplitude- and phase-stable radar scatterers may have to be introduced. I2GPS is a Galileo project (02/2010 – 09/2011) that aims to develop a novel device consisting of a Compact Active Transponder (CAT) with an integrated Global Positioning System (GPS) antenna, to ensure millimetric co-registration and a coherent cross-reference. Advantages are: 1) all advantages of CATs; 2) absolute calibration for PSI data; 3) high sampling rate of GPS means that abrupt ground motion in three dimensions can be detected; 4) vertical components of the local velocity field can be derived from single-track InSAR line-of-sight displacements. Two field trials were set to test the approach: a ‘laboratory trial’ in Delft (NL) to validate the capabilities of the technology, and a potential landslide site in Potoška planina (SLO, still ongoing) to evaluate the applicability for operational monitoring of natural hazards. Preliminary results from the Delft trial show that PSI and levelling are mostly in agreement, within error bounds. Further analysis will be performed to investigate whether CATs are phase-stable enough to be used in place of corner reflectors as artificial PS for measuring slow deformation, including outlier removal schemes and additional sources of information such as GPS and levelling. Preliminary results from the Slovenian trial highlight some of the key considerations for operational deployments in the field. Ground motion measurements also allow an assessment of landslide hazard at the site, and demonstrate the synergies between InSAR and GPS measurements for landslide applications.

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17th Meeting of the Association of European Geological Societes	Abstracts	160–161	BELGRADE, 14–18 September 2011

Geological Settings of Soko Banja Coal Basin and 3D Modell of OP-4 Field

DRAGOSLAV MARSENIĆ[1], DRAGANA ŽIVOTIĆ[1] & DRAGAN JOKOVIĆ[2]

The intermontane Soko Banja coal basin is located 250 km south-east from Belgrade, and covers about 250 km^2. The Soko Banja basin is a north-south elongated tectonic depression with a maximum length of 29 km and width of 16 km. The basin is filled by up to 1500 m thick limnic sediments, which accumulated during the time interval from the lower Palaeogene to the upper Miocene age. The total production during the period 1965–2000 was about 5 Mt of low-rank coal. Coal resources and reserves are estimated at 200 Mt.

Serbian low-rank coals represent the country's major energy source and have relatively large geological resources and reserves (99.6 % of total reserves and resources). Previous investigations of Serbian low-rank coals were focused mostly on the chemical properties.

The basement of the Soko Banja basin is comprised of Proterozoic schist, Devonian schist and sandstone, Carboniferous schist and mudstone with a thin coal bed, Permian sandstone, Triassic sandy limestone, Upper Jurassic dolomite and limestone, and Upper Cretaceous limestone.

The Tertiary sediments, hosting the low-rank coal seams, consist of conglomerate, sandstone, marlstone, and clay. The total thickness of the Lower Palaeogene is estimated at 500 m and of the Neogene sediments at 950 m. Four series of sediments are recognized within the coal-bearing strata.

1. *The Lower Palaeogene Series* (Palaeocene–Eocene) was formed in a narrow graben (5K8 km) in the NE part of the basin. This series commences, after unconformity over Upper Cretaceous limestone, with transgressive reddish quartz, conglomerate and thick-bedded sandstone, which are overlain by bituminous-bedded limestone, yellow and olive-green bedded fine-grained sandstone with volcaniclastics and laminated oil shale. The age of the Lower Palaeogene series was determined by the *Archeolithothamnium lugeoni* PFENDER, which was found in the bituminous limestone.
2. *The Čitluk Series* (probably Lower Miocene) overlies transgressively both Lower Palaeogene and older formations. The Čitluk Series consists in the bottom parts of conglomerate, grey thick-bedded sandstone with clay lenses and grey laminated marlstone with lenses of marly and carbonaceous clay. The overlying coal-bearing horizon consists of grey marly clay, the Main coal seam, and bedded yellow marlstone and sandstone with a high concentration of methane. The uppermost part of the Čitluk Series consists of yellow and grey marlstone, grey bedded sandstone, the upper coal seam (0.5–3 m thick) and grey marly clay. Only the older, main, coal seam has been in exploitation since 1928. The maximum thickness of the main coal seam is approximately 43 m with the average being 23 m. The coal seam dips northwards at an angle of 20–45°. The sediments of the Čitluk Series were deposited in a limnic environment during the Lower Miocene.
3. *The Vrmdža Series* (Lower Miocene?) is also transgressive and consists the following sediments: grey to red conglomerate and gravel, red loose bedded sandstone, laminated grey marlstone with lenses of sandstone and clay, bentonite, tuff, marly clay and sandy marlstone with a thin uneconomical low-rank coal layer.
4. *The Upper Series* (Upper Miocene), transgressively overlying the Vrmdža Series, consists of clastic sediments, red, grey to green sand and gravel, occasionally with clayey cement.

The most important Soko Banja, Vrmdža, and Rtanj–Krstatac faults strike E–W, WNW–ESE, NW–SE, respectively. There are also minor faults running N–S, which, together with the previously mentioned, control both the general contour and the shape of the basin.

At the contact of limestone and clayey-marly sediments there are several springs and wells in the Tertiary complex. The main collector of the underground water is limestone in the paleorelief of the basin. The total water

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input into the underground mine is from 2090 m^3 to 9540 m^3 per month.

Coal is exploited from the depth of around 400 m, and is overlain by loose and poorly consolidated sediments. The pressure is huge, often causing breaking of steel support.

3D modelling of the Soko coal deposit represents three-dimensional view of the exploited coal layer of the Čitluk Series. Primary object of the 3D modeling is high quality image of the coal layer as well as the roof and floor sediments. For preparing 3D model we have used the academic version of GDM Geological Software (Geological Database Management).

Apart from geological modelling of mineral deposits, GDM is also used for designing tunnels, dams, ground storage sites, urban planing, soil pollution assessments, managing resources such as water, etc.

When creating 3D model, 90 boreholes drilled within the deposit were used. Each drillhole is defined by lithology and quality parametres. Large number of faults in the deposit caused blocky structure so the reserves were calculated within the blocks. Position of faults was digitalised form the tectonic map of the deposit.

Based on geological drilling data, position of faults, and data from the underground mining works, a database was formed and used for 3D modeling (Fig. 1). 3D model includes thickness of each package of overburden

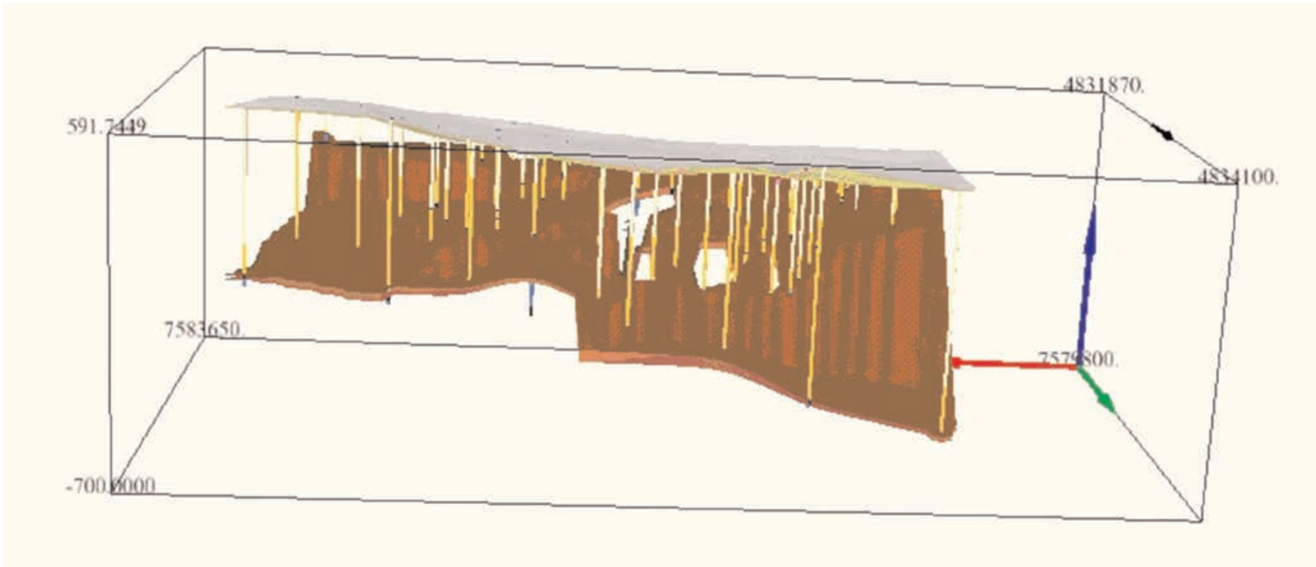

Fig. 1. 3D Modell of the Čitluk deposite (Sokobanja basin).

sediments, coal seam, contact with underlying sediments and relevant coal quality parametres. Coal reserves with respective quality were calculated for each block, and total reserves for the whole deposit were calculated as sum of all blocks.

Key words: Soko Banja basin; Lower Miocene, 3D modelling, GDM, main coal seam.

17th Meeting of the Association of European Geological Societes	Abstracts	162–162	BELGRADE, 14–18 September 2011

Acoustic Impedance Model and Porosity Prediction From 3D Seismic Data

ALEKSANDAR RISTOVIĆ[1] & JELENA ŽIVKOV[2]

Abstract. Porosity prediction from 3D seismic survey is a pioneering venture in our country. The method was successfully used abroad, and shows a lot of good results in the detection zones with suitable porosity, in areas where we have 3D seismic survey, without borehole data. The work also includes the process of preparing well log acoustic and density measurements and their correlation with the 3D seismic surveys. After determining the time-depth dependence (correlation via synthetic seismic) we create the initial acoustic impedance model based only on well logs of density and acoustic . Based on the initial model, the basic 3D seismic data and existing logs, created a detailed model of acoustic impedance in the whole area covered by 3D seismic survey using seismic inversion.

Acoustic impedance model in the continuation of the procedure is used to create the final model of porosity along the cube 3D seismic survey. As input data used are detailed model of acoustic impedance, the basic 3D seismic survey and porosity logs are interpreted in the levels of known oil and gas deposits in the area covered by seismic surveys. Then created a multi-attribute analysis of input data and created lists of correlative seismic attributes that are used for the final stage of porosity distribution across the entire 3D seismic cube.

Key words: 3D seismic survey, acoustic impedance, porosity model, seismic attributes.

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17th Meeting of the Association of European Geological Societes	Abstracts	163–163	Belgrade, 14–18 September 2011

Basic Principles of Development and Using the Digital Block Model in Designing by the Gemcom and Whittle Softwares on the Example of the "Veliki Krivelj" Copper Mine in Bor

Zoran Vaduvesković[1], Miodrag Banješević[2],
Nenad Vušović[2] & Daniel Kržanović[1]

Based on lithological, chemical and other laboratory analyses on the samples from exploratory drill holes and underground exploration drifts at the site of Veliki Krivelj (porphyry Cu deposit) a database was formed in the ACCESS. The arranged data from the database in the software Gemcom, which is the basic program, used for development the block model by the geostatistical method – kriging. After validation of the block model, which has several attributes: lithology, density, elements such as Cu, Au, Ag, etc., the block model was exported to the Whittle (software for strategic planning and economic optimization), where, based on the economic parameters, the optimum contour of open pit per the Lerch Grosmman algorithm was determined. By importing into Gemcom of such defined contour, further procedure of open pit designing stated with an intermediate step in Gemcom – by development the pit list which defines the order of excavation in stages – push backs. Pit list as an additional attribute of the block model, re-exported to Whittle where the annual excavation dynamics (long-term planning) was defined by the analysis procedure. The dynamics obtained by described method from Whittle, is a guideline for detailed long-term planning of dynamics of works in the software Gemcom (Cut Evaluation). Block model affected the area with (local) geographic coordinates: X: from 88100–91010; Y: from 85700–88700. Block model has: 200 rows, 194 columns and 47 benches (E+590 – E –100). Origin block model with mini blocks 15 × 15 × 15 is: X=89750; Y=85500; Z=605; Rot. 45°.

Key words: block model, data base, kriging, origin, block model attribute, pit list.

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Modelling of Geological Processes

17th Meeting of the Association of European Geological Societes	Proceedings	165–168	BELGRADE, 14–18 September 2011

Stick-slip Frictional Instability as a Model for Earthquakes

SRDJAN KOSTIĆ[1] & NEBOJSA VASOVIĆ[2]

Abstract. Earthquakes have long been recognized as a fracture phenomenon. The classical view of earthquake mechanism is based on Reid's elastic rebound theory, which emphasizes the significance of a sudden stress release in strained rocks. However, BRACE & BYERLEE (1966) pointed out that the rock friction might have the key influence on earthquake occurence. This opinion has been confirmed for some in situ conditions, especially in shallow parts of the Earth's crust. The proposed, so-called, stick-slip motion, coupled with Dieterich-Ruina rate and state variable friction law, has later been observed in many laboratory experiments, and accompanied frictional fluctuations arose as the main factor in earthquake nucleation. In this work, some experimental results are presented, together with the plausible concequences for seismic motion. In conclusion, propositions for future research were mentioned, with the accent on the dynamical stability of this system and a possibility for chaotic dynamics to occur.

Key words: stick-slip motion, Burridge-Knopoff model, stress, Dieterich-Ruina friction law, frictional stability.

Introduction

Earthquakes, as catastrophical phenomena, have always been in the center of many scientific investigations. Concidering their huge impact on the environment and material goods, researchers have been trying to reveal the nature of their origin, so as to be able to predict the seismic motion. For a long time, Reid's elastic rebound theory (1910) has been recognized as a possible explanation for the nucleation of earthquakes. However, it was soon realised that the earthquakes seldom occur by the sudden appearance and propagation of a new fault. Instead, they occur by a sudden slippage along a pre-existing fault. Therefore, earthquakes are a frictional, rather than fracture, phenomen, with brittle fracture playing a secondary role in the lengthening of faults and fricional wear. This distinction was firstly pointed out by BRACE & BYERLEE (1966), who claimed that earthquakes must be the result of a stick-slip frictional instability. Thus, the earthquake is the 'slip' and the 'stick' is the interseismic behavior. Subsequently, a complete constitutive law for rock friction – Dieterich-Ruina law (1979, 1983) – has been developed based on laboratory studies. The properites traditionally thought to control the seismic motion – strength, britleness and ductility – are subsumed within the concept of frictional stability regimes.

Stick-slip as a mechanism for earthquakes

Some laboratory experiments suggest a way of meeting certain criticism of the Reid's theory for earthquakes with a focal depth of less than 25 km. When two surfaces of rock slide over one another, the motion is usually jerky rather than smooth. In order to examine this behavior, a sample of granite was placed under confining pressure and then loaded on the ends in compression (Fig. 1). The stress was increased until a fault formed, with a large stress drop accompanied by a small amount of slip on the fault. After that, the stress was reapplied. In a second experiment, the sample contained an artificial fracture. The force-displacement curve resembled that of the originally unfaulted rock. The observed jerky sliding motion is called stick-slip, which appears to be common in rocks under laboratory conditions (porphyry – JAEGER, 1959;

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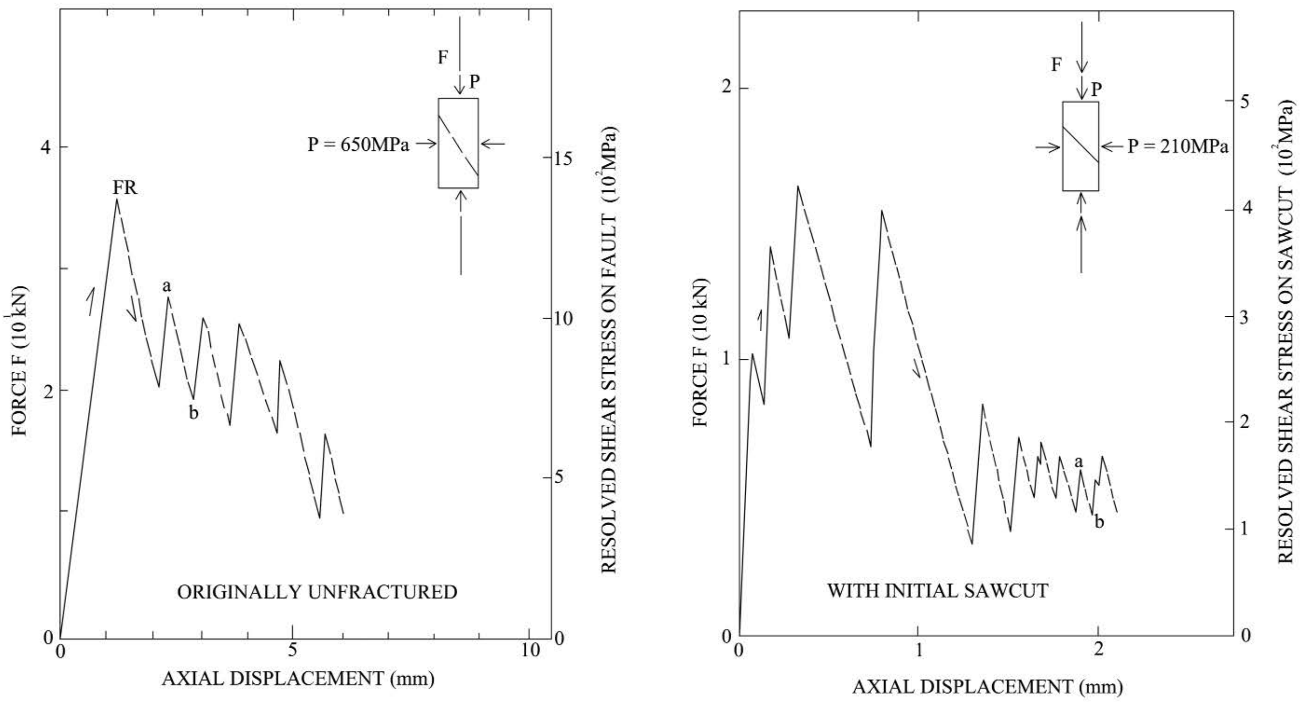

Fig. 1. Left: Force-displacement curve for the axial direction in a cylindrical sample of Westerly granite. Right: The sample contained a sawcut with finely ground surfaces as shown schematically by a heavy line.

dunite, quartzite – GRIGGS *et al.*, 1960). BRACE & BYERLEE (1966) suggested that it can be regarded as a possible source of earthquakes. An earthquake might represent one of the small stress drops associated with faulting or sliding, which could explain why this stress drop is small relative to the strength of most rocks. Also, stick-slip provides a mechanism for sudden energy release in rocks which are already fractured, BRACE & BYERLEE (1966). However, GRIGGS *et al.* (1960) found no jerky sliding with granite or dunite at 500 MPa and 500° C. It is quite possible that high temperature and slow strain rate suppress stick-slip in rocks, which limits this phenomenon to very shallow crustal depths. On the other hand, it is conceivable that behavior of rocks in laboratory conditions is dependent on the characteristics of the loading system. The significance of these experiments is in the emphasis on stability, not strength, in explaining the mechanism of earthquakes.

Stick-slip motion in rocks occurs repetitively – the stress drop (instability) is followed by a period of no motion during which the stress is recharged, followed by another instability. In such systems essentially all sliding occurs during the instabilities (regular stick-slip). The conditions for an instability are illustrated in Figure 2, where a simple frictional slider is considered, coupled by a spring with stiffness K to a moving loader plate, BURRIDGE & KNOPOFF (1967). The spring stiffness may represent the elastic properties of the medium surrounding a fault. Suppose that the frictional resistive force F of the slider has a maximum followed by a decrease with continued slip. During the latter stage the spring unloads following a line of slope K. If a tangent point B is reached, F will decrease faster with u (displacement) than K, and an instability will occur because there will be a force imbalance that will produce an acceleration of the slider. The condition for instability $|dF/du| > K$ is therefore both a property of the friction of the slider and the elastic properties of the environment that is loading it.

The frictional behavior in which strength falls with slip is known as slip weakening, which does not intrisically provide a mechanism for the frictional strength to regain its prior level and hence will not lead to regular stick slip. Such a ''healing'' mechanism was first shown by RABINOWICZ (1951, 1958), in that if two surfaces are held in stationary contact under load for a time t, then μ_s increases approximately as $log t$. He also made the crucial observation that there was a critical slip distance D_c in order for friction to change from one value to another. Rabinowicz also found velocity weakening in systems that exhibitted regular stick slip, i.e. at steady state sliding velocity V, μ_d decreases with $log V$, SCHOLZ (2002).

Analogy with earthquakes

The stick-slip motion that is in best agreement with experimental data is observed in a system coupled with Dieterich-Ruina's friction law, which was empirically determined by DIETERICH (1979) and RUINA

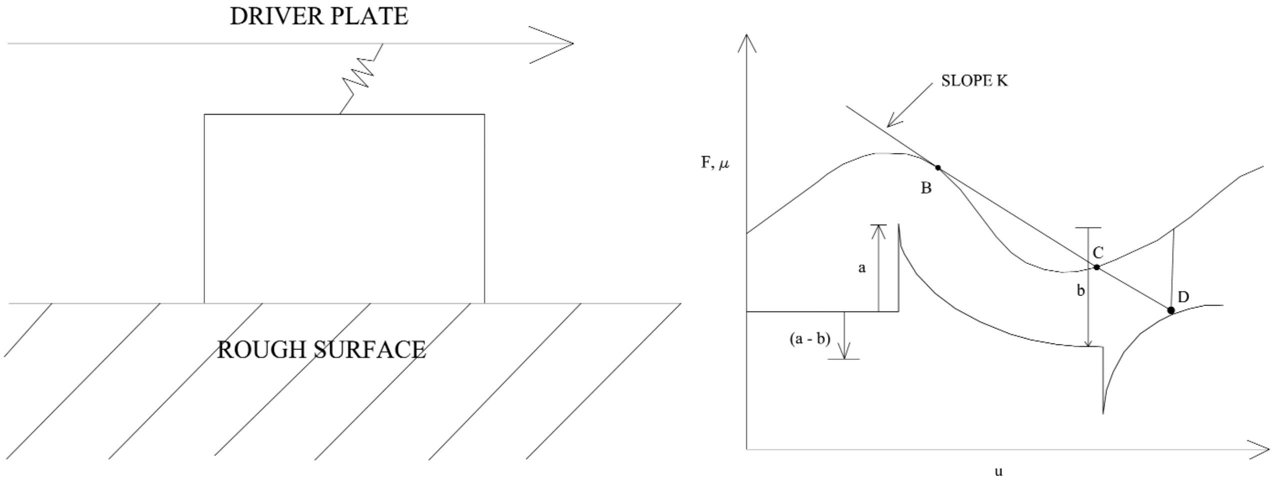

Fig. 2. Schematic diagram illustrating the origin of frictional instability: a) a Burridge-Knopoff model; b) a force-displacement diagram showing a hypothetical case in which the frictional resistance force falls with displacement at a rate faster that the system can respond.

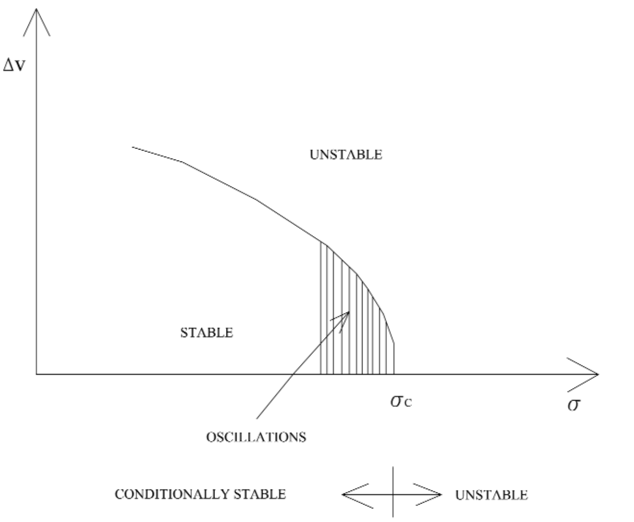

Fig. 3. The stability diagram of the Burridge-Knopoff model, showing the velocity jump necessary to destabilize the system as a function of the applied normal stress.

(1983). This law states that friction depends both on instantaneous sliding velocity V and a time-dependent state variable θ: $\mu(V,\theta)=\mu_0+a\ln(V/V_0)+b\ln(V_0\theta/D_c)$ in which the state variable θ evolves according to: $d\theta/dt=1-(\theta V/L)$. In the static case, $\theta = t$, so DIETERICH (1979) suggested that θ can be interpreted as the the average elapsed time since the contacts, existing at a given time, were first formed. The critical slip distance D_c is then the sliding distance, at a constant velocity V, through which an amount of contacts is destroyed and replaced by an uncorrelated set, so that $\theta = D_c/V$. The friction parameters a and b are always positive quantities of the order 10^{-2}. Apparently, the earthquakes originate from frictional instability, which depends on the combined parameter (a–b) and D_c. The frictional stability regimes are described in Figure 3. Considering a simple spring–slider model with fixed stiffness k, the bifurcation occurs at a critical value of effective normal stress, given by: $\sigma_c=kD_c/(a-b)$. If $\sigma>\sigma_c$, sliding is unstable under quasistatic loading. In the conditionally stable regime, $\sigma<\sigma_c$, sliding is stable under quasistatic loading but can become unstable under dynamic loading if subjected to a velocity jump exceeding ΔV. In a narrow region at the bifurcation, sliding occurs by a self-sustaining oscillatory motion. Earthquakes can nucleate only in those regions of a fault that lie within the unstable regime.

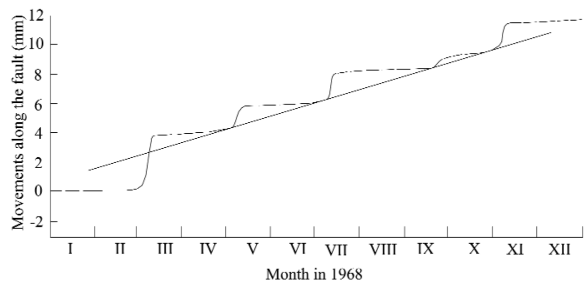

Fig. 4. Oscillatory motion (creep episode) of the creeping section of the San Andreas fault in central California. The straight line is for the reference (SCHOLZ, 2002)

The confirmation of this stability regimes is found on the San Andreas fault. There is an evidence of 'creep episodes' along faults, that represent aseismic slip, which appears to be the same as the oscillatory behavior observed at the stability boundary (Fig. 4).

The most likely mechanism for the anomalous behavior of this section of the fault is the presence of unusually high pore pressures in the fault zone, SCHOLZ (1998).

Conclusion

The presented Burridge-Knopoff model, coupled with Dieterich-Ruina friction law, gives qualitatively satisfying analogy with seismic motion. It seems that the stress drop during an earthquake, which appears as a result of a slipping along the fault, could be explained by frictional instability of the stick-slip phenomenon. The stability of this motion is dependent of critical distance, *Dc*,and material properties *(a–b)*. This idea is partially empirically proven, using the field data of the motion observed along San Andreas fault. Some furher research could be done on mathematical description of this motion, in order to examine the dynamical stability of the system. The existence of bifurcations could imply a route to chaos, which could have significant implications for earthquakes.

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17th Meeting of the Association of European Geological Societes	Proceedings	169–174	BELGRADE, 14–18 September 2011

Development of the Conceptual Model of the Zagreb Aquifer System

ZORAN NAKIĆ[1], KRISTIJAN POSAVEC[1],
JELENA PARLOV[1] & ANDREA BAČANI[1]

Abstract. The conceptual model of the Zagreb aquifer system is developed in order to arrive at a sufficient understanding of its characteristics, to allow decisions to be made and the risks associated with pressures on the groundwater quality and quantity and to describe the relation between groundwater quality, the geogenic conditions and anthropogenic impacts in an understandable way. In order to build conceptual model(s) of the aquifer system, physical and geochemical processes are integrated, with special attention given to the description of the initial and boundary conditions.

Key words: conceptual model, Zagreb aquifer system, boundary conditions, hydrogeochemical processes, background values.

Introduction

Developments of industry and fast growth of the City of Zagreb have considerably affected quality of groundwater in this aquifer system. Increasingly progressive groundwater pollution in the heterogeneous aquifer system underlying the City of Zagreb has been observed for the last twenty-five years. The most significant pollution sources are leaky sewerage, the city landfill, agriculture, illegal waste depositories, illegal gravel pits, and also industrial facilities. High concentrations of pollutants like nitrates, atrazine, heavy metals and chlorinated hydrocarbons in groundwater confirm the impacts of pollution sources on groundwater quality.

The general transport modelling approach consists of achieving a better understanding of the transport regime of heavy metals and quantifying the dominant controlling processes both in unsaturated and saturated zone. For that purpose (hydrogeological) conceptual model is developed in order to arrive at a sufficient understanding of the relationships between the principal characteristics of the Zagreb aquifer system and to allow decisions to be made and the risks associated with pressures on groundwater quality and quantity to be evaluated to a satisfactory level of accuracy.

Site description

The Zagreb aquifer system is located in the NW part of the Republic of Croatia, in the urban area of the Croatian capital, along the Sava River (Fig. 1).

Numerous well fields are accommodated within this aquifer system, which are crucial for the water supply of the City of Zagreb and its greater region.

The aquifer is unconfined and connected to the Sava River. It covers area of approximately 350 km^2. Groundwater is used for the water supply of approximately one million citizens of the City of Zagreb, and it is mainly acquired by pumping on the 6 major well-fields. Zagreb aquifer system is the only and therefore exceptionally important source of potable water for the Croatian capital. The average seasonal resources are estimated to be at the size of the $10^5 \times 10^6$ m^3/year. Average annual temperature and precipitation in this area are 11.7 degrees Celsius and 920 mm, respectively. Thus, this area represents aquifers in temperate climate. The aquifer system is built of two Quaternary aquifers (Fig. 2 and 3), deposited during the Middle and Upper Pleistocene (lacustrine-marshy deposits) and Holocene (alluvial deposits).

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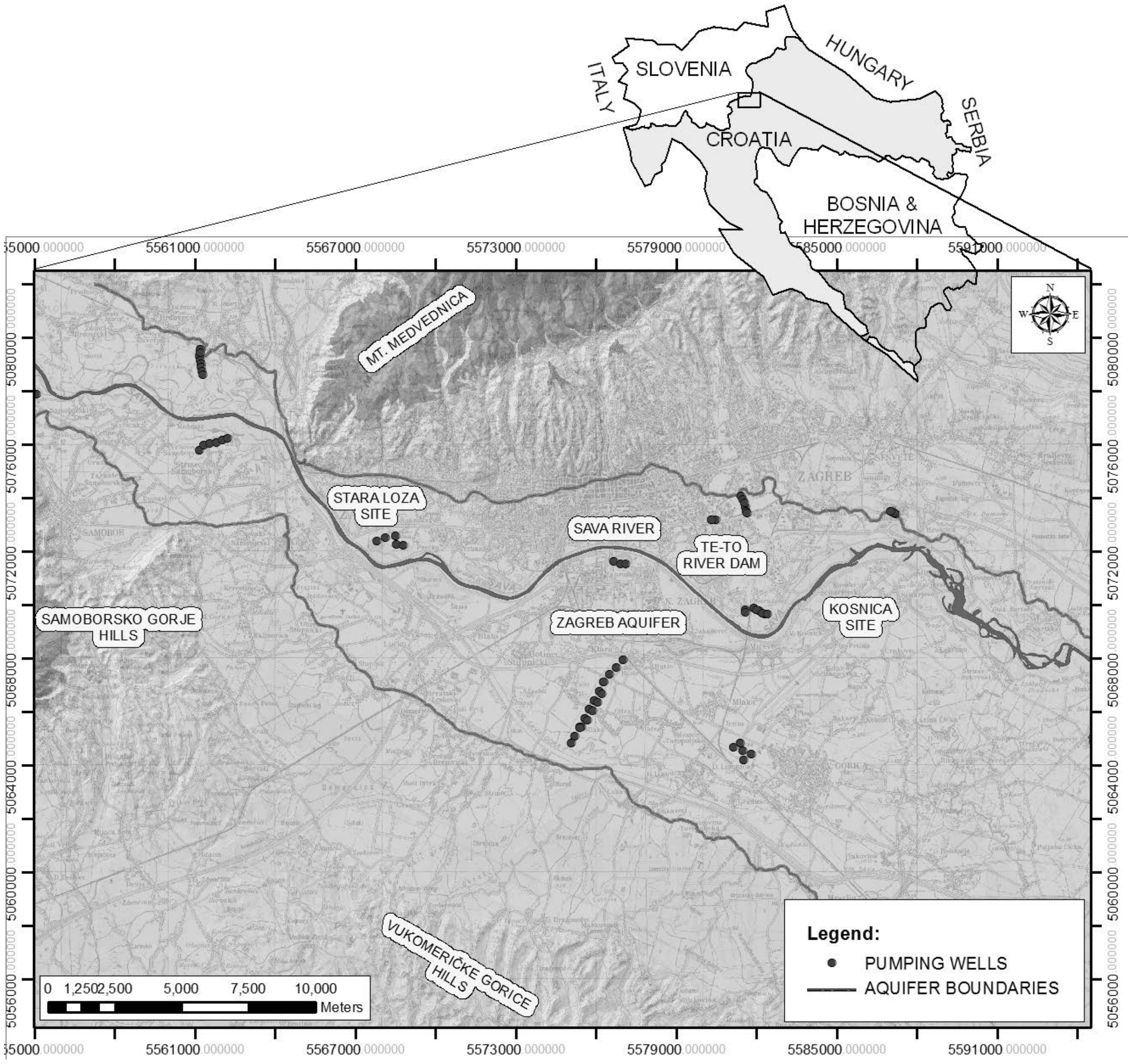

Fig. 1. Zagreb aquifer site map

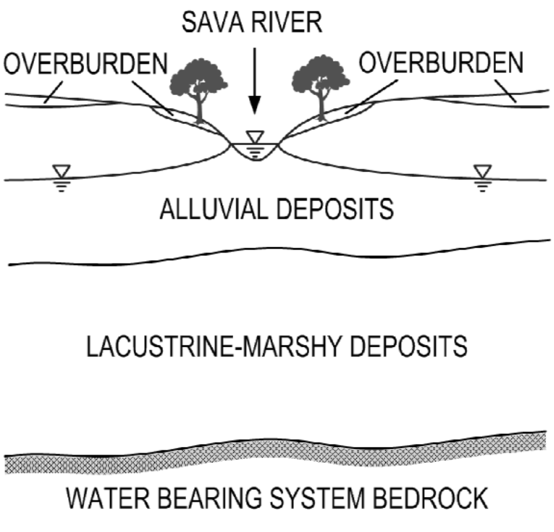

Fig. 2. Schematic hydrogeological cross-section of the Zagreb aquifer system

Considering hydrogeological aspects, the Quaternary deposits are divided into three basic units: aquifer system overburden built of clay and silt; shallow Holocene aquifer built of medium-grain gravel mixed with sands; and deeper aquifers from Middle and Upper Pleistocene, with frequent lateral and vertical alterations of gravel, sand and clay.

The Sava River, which is the largest river in Croatia with extremely asymmetric catchment's area and 75% of the catchment situated on the right bank of the river, divides the Zagreb aquifer system into two parts. The river, which is the main source of groundwater recharge within aquifer system, is in direct hydraulic connection with the shallow aquifer, which has extremely high values of hydraulic conductivity (up to 3000 m/day).

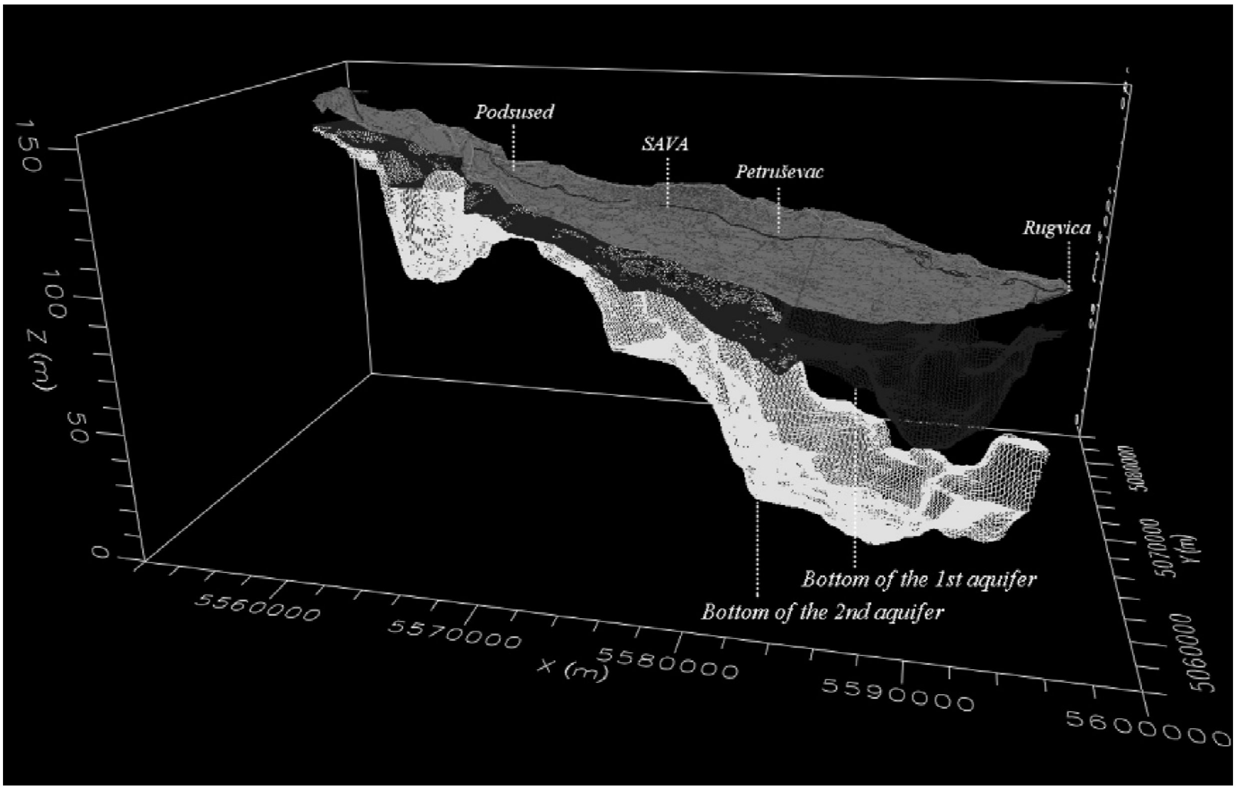

Fig. 3. 3D hydrogeological model of the Zagreb aquifer system

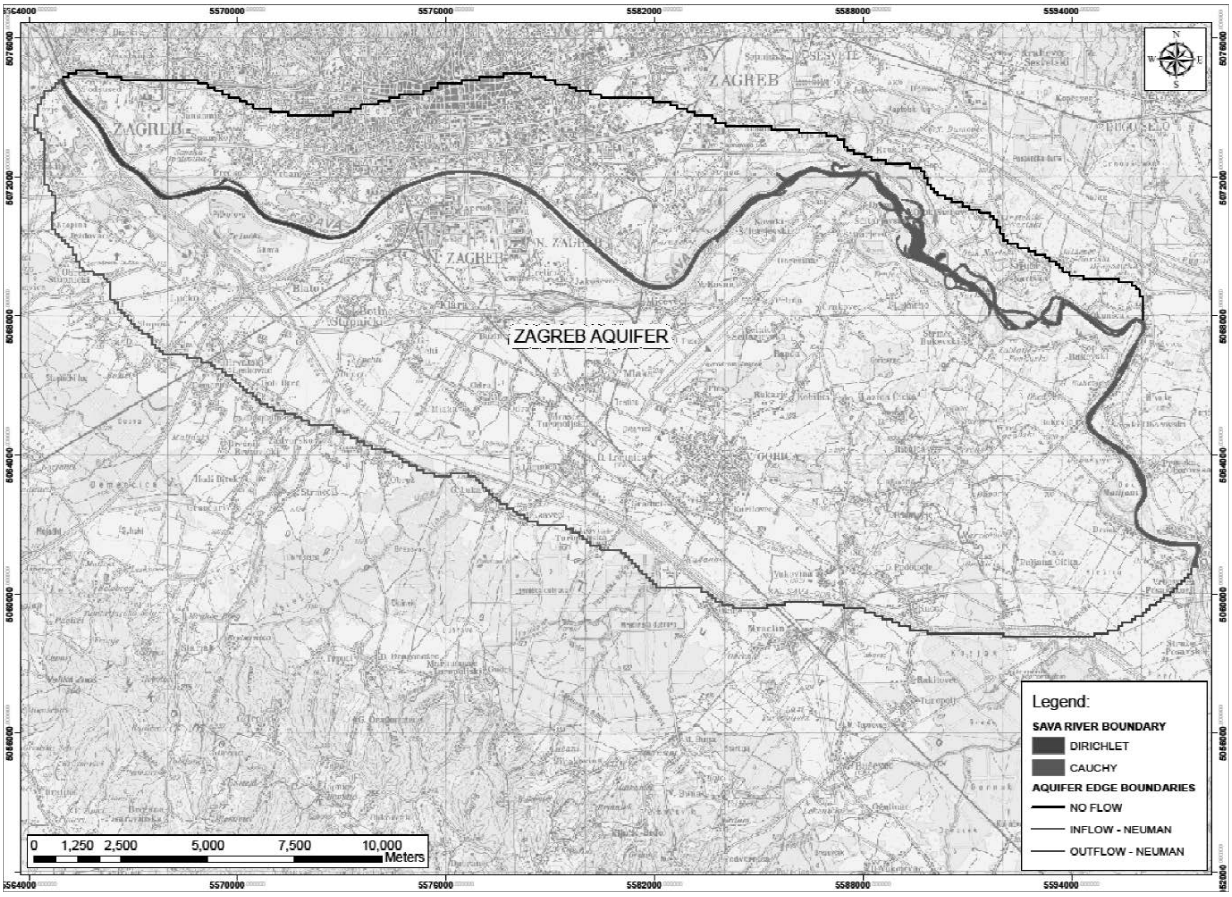

Fig. 4. Boundary conditions

Conceptual model setup

Hydrogeological boundaries

Zagreb aquifer is an unconfined aquifer with no flow boundary on the north, inflow boundary on the west and south and outflow boundary on the east. General ground water flow directions are from west to east, south east. Determination of inflow/outflow/no flow boundaries was based on analysis of head contour maps for high, medium and low ground water levels (POSAVEC, 2006). The results showed that there is no significant inflow or outflow through northern aquifer boundary. The reason can be found in mainly impermeable deposits of the Mt. Medvednica which causes dominantly surface flow. Surface flow is mainly regulated and ends in the Sava River. Western part of the aquifer boundary is defined as inflow and eastern as an outflow boundary. Characterization of the southern boundary is rather difficult due to lack of data and observation wells. Based on head contour map analysis and water balance analysis it can be assumed that some inflow through southern boundary do exist but with rather different fluxes across the region. Head contour maps analysis also showed that during high Sava River water levels the river infiltrates ground water on all parts of the flow while during medium and low water levels the river drains ground water on some parts of the flow.

Aquifer edge boundaries can be described using Neuman boundary condition in terms of hydraulically impermeable boundary on the north, inflow boundary on the west and south while eastern boundary can be described as the outflow boundary (Fig. 4).

Boundaries within the aquifer are represented with the Sava River, which can be simulated using Dirichlet boundary condition in the western part of the aquifer and as Cauchy boundary condition in the central and eastern part of the aquifer.

Recharge

The Sava River represents the main source of water for the Zagreb aquifer system. Although recharge also occurs through precipitation, the changes in the Sava river water levels dominantly influence the changes in the groundwater levels across the whole aquifer. Quantity of ground water is diminishing continuously (Fig. 5) due to negative trends of ground water levels.

The main reasons for the lowering of groundwater levels are: (1) extensive riverbed erosion due to upstream Sava river regulation in Republic of Slovenia; (2) embankment of the Sava river which stopped occasional flooding of the area and potential infiltration to groundwater; (3) excessive pumping at the municipal and industrial well fields; and (4) prolonged drought periods. Ground water levels have already reached the minimum levels (top elevations of the well screens) on some well fields, causing water scarcity during droughts.

Geochemical processes in the Zagreb aquifer system

The numerous research results on the human impact on the groundwater quality indicate that the Zagreb area accommodates an extremely high number of diverse pollution sources causing degradation of the groundwater quality and causing a particular threat for its use in the future (BAČANI *et al.*, 2002; NAKIĆ *et al.*, 2007a; VLAHOVIĆ *et al.*, 2009). In order to be sure that pollution is taking place, knowledge is required of the natural spatial and temporal characteristics and trends of the chemical substances. Under natural conditions, groundwater quality is determined by the sum of soil-modified atmospheric inputs plus water-rock interaction taking place at the soil-bedrock interface and from longer-term reactions taking place along flow paths in the saturated zone (EDMUNDS & SHAND, 2008). Although human activity in Zagreb area lead to groundwater compositions which occasionally exceed drinking water standards, it was found that groundwater quality limits have been also breached for elements as Mn, Fe or As by entirely natural processes, the result of geochemical conditions existing in part of the aquifer system (NAKIĆ & HORVAT, 2002; VLAHOVIĆ *et al.*, 2009).

In order to set the initial conditions in the coupled transport model, the background values for heavy metals have to be calculated. In the Zagreb area the geochemical background range of inorganic substances was calculated on several occasions (table 1) using model-based objective statistical methods (NAKIĆ *et al.*, 2007b; NAKIĆ *et al.*, 2008; NAKIĆ *et al.*, 2010), primarily to make a distinction between geogenic and anthropogenic influences in groundwater quality. Model-based objective statistical methods are based on quantitative approach for the partitioning background data in the conceptual geochemical model framework, which recognizes that a background population has a characteristic probability density function that results from the summation of processes that have produced the background substrate. However, it was pointless to attempt to determine presettlement background values, because natural concentrations in Zagreb area have been affected by human activities for a long time. An option, used in Zagreb area, is to define an *ambient background values* under slightly altered conditions, when elevated levels of element concentrations in soil or water result from long term human impact, such as agriculture, industry and urbanization and are no longer natural (REIMANN & GARETT, 2005).

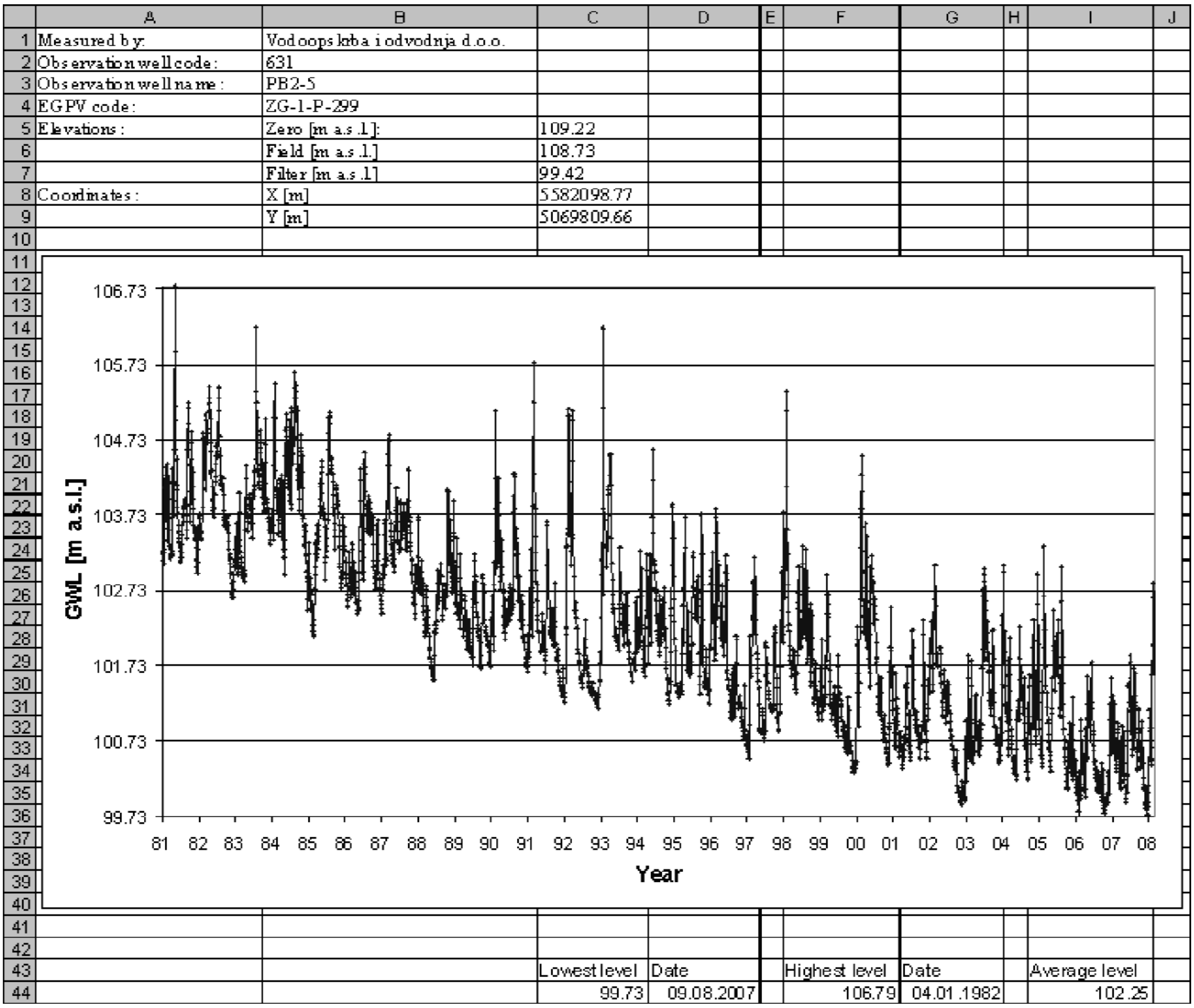

Fig. 5. Negative trend of ground water levels

Overall, the ranges of background values for the selected chemical parameters reflects local geological and geochemical condition in the aquifer system as well as slight impact of anthropogenic sources, e.g. agricultural activities or atmospheric inputs due to emissions from the burning of fossil fuels. Variable background ranges of iron and manganese is due to rapidly changing concentrations of these elements across redox boundaries in the Zagreb aquifer system. As a consequence, its concentrations may vary over four to five orders of magnitude across the shallow and deeper aquifers.

It is possible to differentiate between groundwater chemical composition of the shallow Holocene alluvial aquifer and deeper Middle/Upper Pleistocene aquifers. NAKIĆ *et al.* (2004) have shown that shallow Holocene aquifer and deeper Pleistocene aquifers have different macrochemical composition and source of replenishment. Besides, significant differences in groundwater macrochemical composition have also been encountered within shallow Holocene alluvial aquifer. On the basis of the pattern of the distribution of the saturation indices (SI) of the carbonate mineral phases within the shallow aquifer (NAKIĆ, 2003) and the results of the grouping of the groundwater chemical samples by applying multivariate statistical method, *hierarchical tree clustering* (NAKIĆ *et al.*, 2004), it was found that very similar macrochemical composition of the groundwater exist in the area along the Sava River, which support the evidence of the intensive impacts of changes in the river water levels on the groundwater tables within the belt by the river. Changes in macro chemical composition on a greater distance from the river confirms weakening of the river impact on the aquifer replenishment and domination of lasting seasonal replenishment conditions. Similar findings have been outlined by Vlahović *et al.* (2009), which compared the chemical composition of the Sava River with the groundwater chemical composition from the shallow and deep aquifers in the western part of the Zagreb aquifer system. They have concluded that the direct mixing of water from the

Table 1 Background values and threshold values of chemical parameters in groundwater of the Zagreb aquifer system.

Chemical Parameters	Background values	Threshold limits	Method of calculation	Source
Nitrate (mgN/l)	0.0–4.80	4.8	iterative 2- σ technique	NAKIĆ *et al.* 2007
	0.0–5.9	5.9	calculated distribution function	
	0.0–7.60	7.6	calculated distribution function	NAKIĆ *et al.* 2010
Dissolved oxygen (mg/l O_2)	1.4–8.4	1.4	iterative 2-σ technique	NAKIĆ *et al.* 2008
Sulphate (mg/l So_4)	14.2–47.6	47.6	iterative 2-σ technique	NAKIĆ *et al.* 2008
	19.6–52.9	52.9		NAKIĆ *et al.* 2010
Chloride (mg/l Cl)	1.7–35.3	35.3	iterative 2-σ technique	NAKIĆ *et al.* 2008
	2.9–27.8	27.8	calculated distribution function	NAKIĆ *et al.* 2010
Iron (μg/l Fe)	0.0–11.4	11.4	iterative 2-σ technique	NAKIĆ *et al.* 2008
	0.0–30.0	30.0		NAKIĆ *et al.* 2010
Manganese (μg/l Fe)	0.0–0.5	0.5	iterative 2-σ technique	NAKIĆ *et al.* 2008
	0.0–10.9	10.9		NAKIĆ *et al.* 2010

Sava River and groundwater is occurring in the near vicinity of the Sava River and it weakens further away, while the differences in hydrogeochemical characteristics grow.

Conclusion

In order to define causes and the consequences of the groundwater quality deterioration in the heterogeneous aquifer system underlying the City of Zagreb, a modelling approach has been set with the aim to achieve better understanding of transport regime of heavy metals in heterogeneous alluvial aquifers and possibly to reconstruct the evolution of an existing plume(s) (using heavy metals as indicators of contamination) from its origin to the present state. For that purpose, conceptual model is developed that encompasses complex combinations of qualitative and quantitative descriptions of the hydrogeological and hydrogeochemical processes and the impacts.

Acknowledgments

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Application of Satellite Gravity and Geomagnetic Data

Dragana Petrović[1] & Ana Mladenović[2]

Abstract. Satellite missions that will be discussed in this paper, since its launch, aimed at improving the global gravity and geomagnetic models of the Earth. This method of data collection has many advantages as: remote access, obtaining satisfactory density of continuously collected data. Missions CHAMP (Challenging The Mini-Satellite Payload) and GRACE (Gravity Recovery and Climate Experiment) primarily aimed to complementing the science involved in studying the composition of Earth. New measurements provide new insights in the study of Earth as a single system. However, this is not the only application data that is available from these. It is possible to get quality map and values for geological investigations on the local and regional level. In this paper it is considered how to use this kind of data for determine tectonic fabric in the local or regional level.

Key words: satellite missions, CHAMP, GRACE, gravity, geomagnetic, model, tectonic.

Introduction

CHAMP mission provides continuous monitoring of satellite, measurements, satellite observation of the magnetic and gravity field with high precision and spatial separation, Hećimović (2005). The data provides a consistent obtaining a space-time magnetic and gravitational models of the Earth. CHAMP mission data will allow the separation of individual signals. The highest expectation from mission is gravitational separation of signals that are caused by changes in the conditions of the masses.CHAMP mission aims at modeling the main, lithosphere, and external magnetic field, Holme (2003), and collected data on variable geomagnetic field, as a result of: processes in the Earth's core and in mantle, magnetization of rocks and sediments in the crust, the flow of electrons in the ionosphere and magnetosphere (external field), Kumar (2003).

GRACE is a continuation of CHAMP mission. GRACE is used to model the gravitational field, GPS measurements and measurement accelerometers, and high quality of measuring the distance between the two GRACE satellites, Adam (2002). Objective of the research is statics and dynamics of geosystem in combination of GRACE data with other terrestrial and satellite data. GRACE satellites are used as sensors that path deform in accordance with the gravity field anomalies, Bandeen *et al*. (2002). GRACE mission enables the development of several branches of Earth Sciences. In this way geophysicists get information on schedules and dense, physical and mechanical properties of the Earth's interior and crust.

Methods, results and discussion

In this section it is shown how to use geomagnetic and gravity data from satellite measurements for different type of modeling.

Global models of the Earth

In July 2003, the GRACE team released a more accurate (by a factor higher than 10×) gravity map of the entire world (Fig. 1). The free-air anomaly is built from measuring subtle changes in the shape of the satellite orbit around the Earth. We then applyed a free-air correction, for correcting the small change in satellite elevation about a mean orbit value (reference level). Since this is in space, there is no mass between elevation and the reference level: therefore was no need for Bouguer correction. The scale is in mgal.

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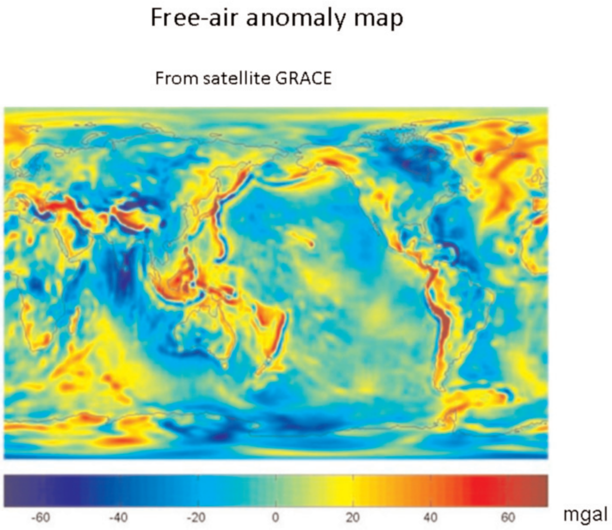

Fig. 1. Free air gravity anomaly map, GRACE mission.

This incorporates the ability now to show variations at the cm level. Gravity Highs are in red; Lows in blue.

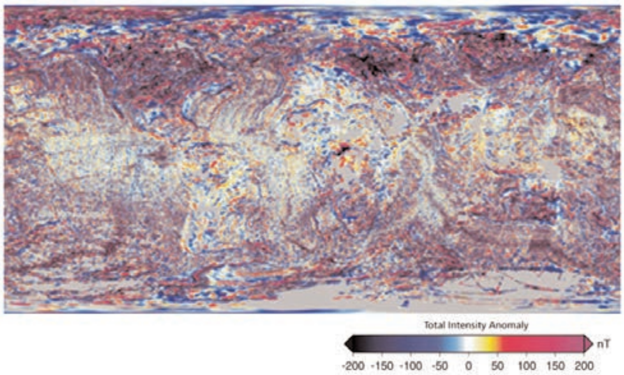

Fig. 2. EMAG2, global magnetic field anomaly map from satellite, airborne and marine magnetic data (GFZ).

Global magnetic field anomaly map from satellite, airborne and marine magnetic data EMAG2 are shown on Fig. 2. Magnetic Anomaly Grid of the Earth is composed of data obtained from satellite measurements, ship and air. Across continents and the Arctic were used existing grids, while the original data from the ship and air systematically analyzed in relation to other data, whenever they were available. Satellite magnetic measurements provide a magnetic field with wavelengths above 330 km.

NGDC-720 model (Fig. 3) is composed of satellite, marine, terrestrial and aeromagnetic research. Aeromagnetic and marine magnetic data have been combined into a common grid, EMAG2. Then the ellipsoidal harmonic coefficients of magnetic potential was calculated on the basis of least square error.

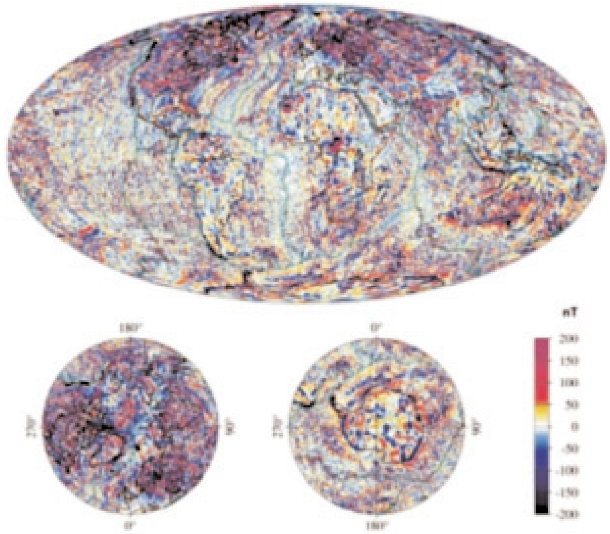

Fig. 3. The vertical component of the continental Earth's surface magnetic field is given by NGDC-720 model.

Regional and local tectonic model

Analyses in local level

Analysis of geological data consisted of analysis of Landsat7 satellite images, analysis of gravimetric and geomagnetic satellite and terrestrial data and interpretation of tectonic fabric. This phase was carried out using visual methods of Remote Sensing, whereby the entire attention towards defining the position of regional structures for a given area of research. For the analysis of regional structures, Landsat 7 satellite imagery were used. The imagery was passed through all stages of preprocessing and enhancement. Also, a transformation of DN values in the relative values of temperature was obtained. This data was also used to determine tectonic fabric of this area (Fig. 4). As a data base for determining the gravity characteristics of the terrain, gravity base from the Department of Geophysics on the Faculty of Mining and Geology in Belgrade and gravity CHAMP mission data, was used. On the basis of terrestrial measurement data on 2064 points, map of Bouguer anomalies was made. To eliminate the influence of shallow subsurface bodies, a filtering by Haning filter by step 2 was made. By analysis of the geological setting and by using a method of Parasnis, a calculation of the average density of rocks on the investigated area, was made (it was 2400 kg/m^3). Also, a second derivate of the gravity acceleration in the vertical direction, i.e. vertical gradient, was calculated. Data from this map was used to correlate with data obtained by analysis of satellite imagery and CHAMP and GRACE missions data .

Geomagnetic data base was used from the Department of Geophysics on the Faculty of Mining and Geology in Belgrade. On the basis of terrestrial measurements data on 582 points, a map of vertical compo-

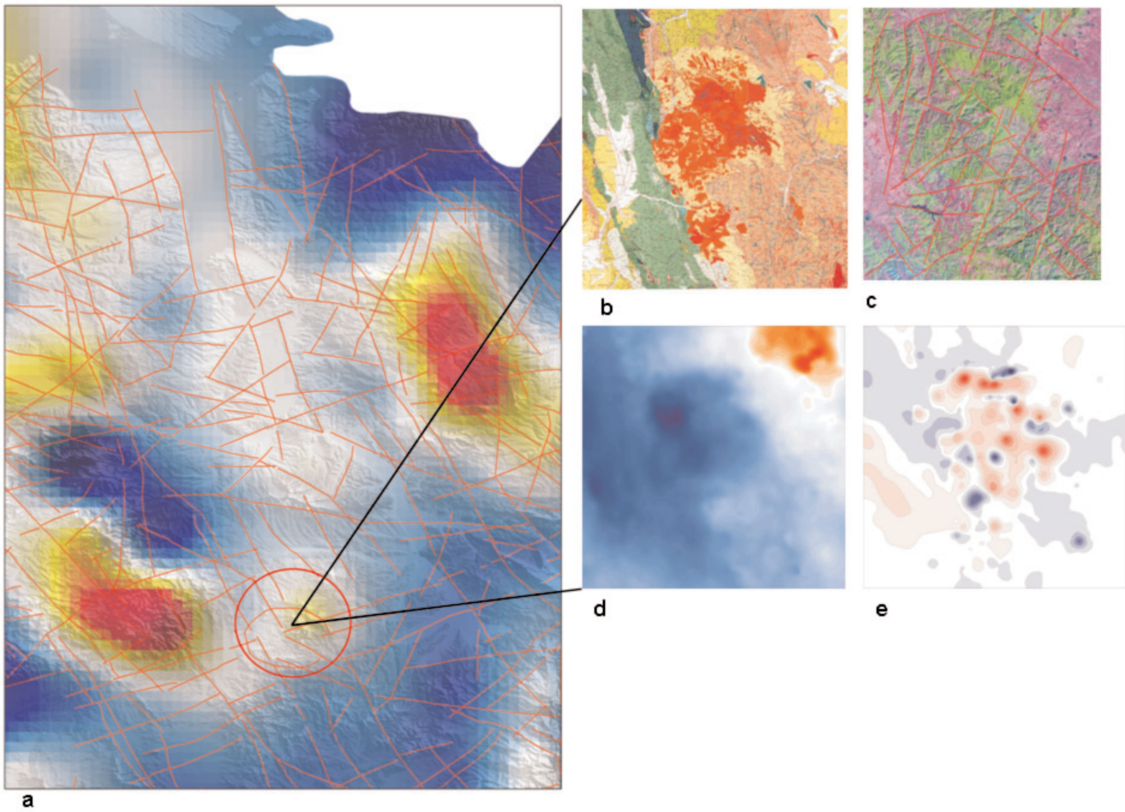

Fig. 4. a) EMAG2 and interpretation of rupture, b) Geological map of the investigated area (General Geological Map of Yugoslavia), c) Map of ruptures, obtained by analyzing of satellite imagery and map of vertical gradients of gravity acceleration, shown on Landsat 7 imagery, combination of bands 741, d): Bouguer anomalies map of the investigated area (negative values are blue, positive values are red), e) Map of anomalies of vertical component of the Earth magnetic field (negative values are blue, positive values are red).

nent of geomagnetic field was established. Data, obtained from geomagnetic measurements, terrestrial and satellite, were filtered by using a method of extension field up, with the step two, in order to eliminate the influence of shallow subsurface bodies.

Two big groups of ruptures have been determined (Fig. 4). Also, several other groups of ruptures have been determined. They have local extension, and mostly are subparalel to the main ruptures.

First, older, rupture group extends to WSW–ENE direction, while second, younger, group of ruptures extends by NW–SE direction. Ruptures of the older group are modified along ruptures that belong to the younger group. Also, Tertiary basin, which is situated in the eastern part of the investigated area, has been created by movements along the ruptures of the younger group.

Analyses in regional level

Analysis of geological data consisted of analysis of Landsat7 satellite image, analysis of gravimetric and geomagnetic satellite data and interpretation of regional tectonic fabric. This phase was carried out using visual methods of Remote Sensing and analysis of gravimetric and geomagnetic satellite data. The imagery was passed through all stages of preprocessing and enhancement. The data were used from International Gravimetric Bureau site (http://bgi.omp.obs-mip.fr). Analyzing all maps (Figs. 5, 6) it was found that the main structures extends to NW–SI (Fig. 7).

Extends of this ruptures is consistent with direction the Vardar zone and Carpatho-Balcanides in this region, in part of Balkan peninsula (Serbia, F.Y.R of Macedonia and Greece).

Conclusion

New satellite measurements in combination with field measurements and aerial data may provide improved models of the Earth as a global system. At the regional and local level, with the terrestrial data, can provide an excellent basis for geophysical and geological modeling of terrain.

For the determination of tectonic fabric it is possible to use satellite, terrestrial and aerial data.

Since terrestrial data are not always available, data obtained by satellite measurements may complement the missing part in order to analyze terrain. For regional analysis of tectonic fabric or other geological analysis it is possible to use data from CHAMP and GRACE satellites.

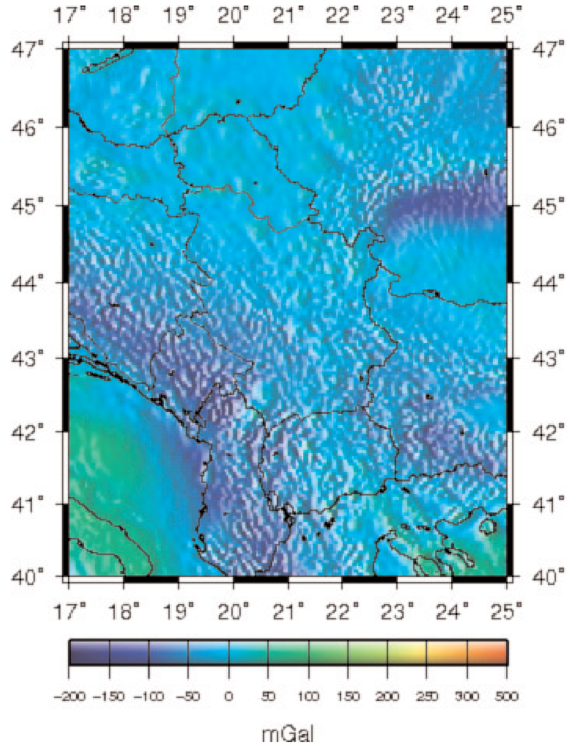

Fig. 5. Map of Bouguer anomaly, EGM08.

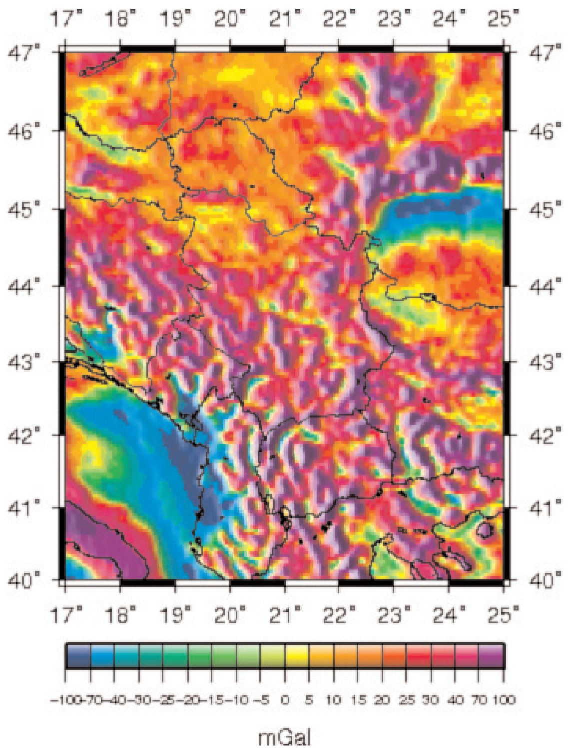

Fig. 6. Free airanomaly mapEGM08.

If the subject of research is the Earth as a global system, then, the best data that can be used, precisely are the satellite obtained data, because the mission CHAMP and GRACE provide satellite measurements in combination with terrestrial or marine data and wherever its possible and available.

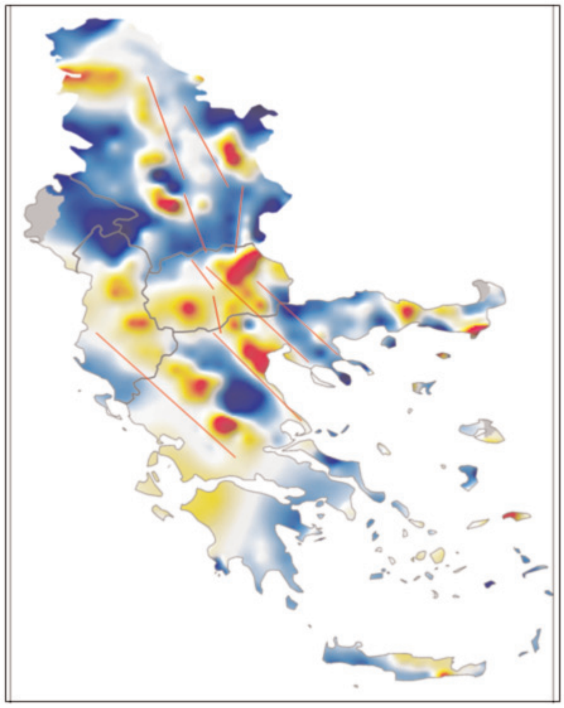

Fig. 7. EMAG2 model, study area and interpretation of regional rupture.

In case that the subject of research are geological investigation in smaller area, as in this paper, the satellite data must be combined with terrestrial measurements, only because the data density is still not sufficient. It is expected in the future increasing data density.

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Geoelectrical Signature of Hydrocarbon Contamination in Serbia

Milenko Burazer[1], Stanislav Dedovec[2],
Đorđe Komnenov[2] & Milana Bera [3]

Abstract. Petroleum contamination of the subsurface from accidental oil spills or leaking underground storage tanks remains a significant environmental problem.

The detection of petroleum hydrocarbon contaminants such as light non-aqueous phase liquid (LNAPL) in the subsurface using geophysical methods, particularly electrical resistivity methods has been the subject of considerable interest in recent years. Their detection is based principally upon the electrical properties of the hydrocarbons.

During 2010, direct current resistivity data were collected at the location of RNS (Oil Refinery Novi Sad) and "Obrenovac centar" fuel station site, Serbia. The objective of this study was to evaluate the possibilities of resistivity imaging techniques in detecting and locating anomalies of hydrocarbon contamination.

Resistivity measurements were carried out utilizing the Wenner array configurations. In order to achieve good vertical and lateral resistivity distributions for the investigated site electrode spacing was 1 m. The interpretations obtained from 2D-modelling of the field data show a highly conductive region in areas with LNAPL contamination. This explanation was supported by the presence of free hydrocarbon phase floated on the surface of water filling the drilled boreholes and geochemical analysis of core sample collected on these two investigation site.

Key words: enviromental pollution, LNAPL contamination, electrical resistivity imaging, soil sample chemical analysis.

Introduction

Subsurface contamination by LNAPLs is a worldwide problem and remains one of the most widespread and prevalent sources of groundwater contamination. In the United States, more sites are contaminated by petroleum hydrocarbons than any other type of contaminant Eweis *et al.* (1998).

In Serbia as in many other countries, LNAPL contamination of soils near oil refinery or gas station remains a major problem of environmental concern.

During the Balkan Wars and NATO bombing a lot of the large – capacity of oil tanks were directly hit and inflamed. During the hostilities app. 74000 tons of crude oil and petroleum products escaped in the RNS. From this amount app. 90 % burned away and remaining 10 % infiltrated in the collecting driange channels or in the soil enviroment (cca 2700 m^3).

The task of delineating and quantifying the amount of LNAPL present in soils and water was significant challenges to engineers and scientists involved in soil and water cleanup and remediation. Hydrocarbons are partitioned into various phases (vapour, residual, free and dissolved) in the subsurface. These phases have different spatial and temporal natures. The different properties of these phases make the characterization more difficult and compmplex the problem of soil and water remediation (after Atekwana *et al.,* 2002).

Numerous studies have been published on the broad topic of electrical resistivity investigation in soil contamination detection. However, in this paper we focus primarily on LNAPL contamination. We examine the geoelectrical signatures of LNAPL historical (long therm) contamination resulting from microbial processes and are example of case studies that illustrate and capture the physical changes in the contaminated environment.

To overcome the LNAPL plume characterization problem, engineers usually analyse soils and water samples collected in boreholes and piezometers. Based on these analyses, they extend the results to estimate the plume extent on the whole site. One major limit of

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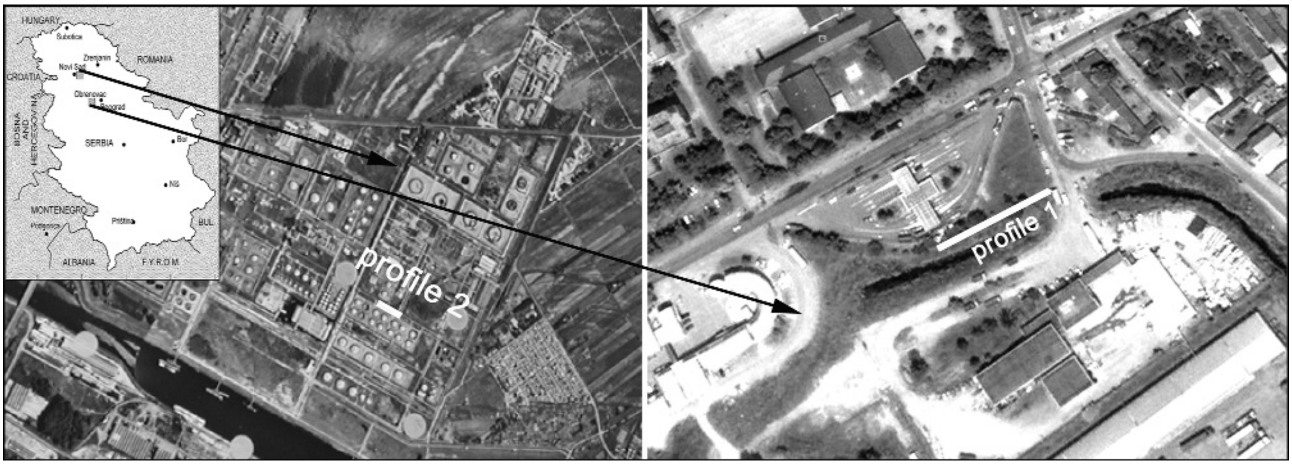

Fig. 1. Site location map. Oil Refinery Novi Sad (RNS) left, and Gas station ″Obrenovac grad″ right.

this invasive technique lies in the high costs of drilling operations, sampling and analyses. This often leads to limit the number of investigations. The plume extent is therefore often poorly delineated. Geophysical techniques hold great promise as inexpensive and minimally-invasive sensors of subsurface LNAPL contamination. As such, geophysical techniques including electromagnetic induction, ground penetrating radar (GPR), electrical resistivity, Self-Potential (spontaneous potential) and induced polarization have been applied to the hydrocarbon-impacted zones detection in the subsurface (e.g., ATEKWANA *et al.*, 2000, 2002; KEMNA *et al.*, 2002; SAUCK, 2000; SAUCK *et al.*, 1998).

The theoretical basis for the use of geoelectrical methods for the detection of LNAPL contaminants in the subsurface is dependent on the contrasting electrical properties of the LNAPL versus the pore and ground water displaced by the LNAPL.

Recent hydrocarbon contamination results in high resistivity anomalies, while mature oil contamination produces low resistivity anomalies SAUCK (1998). Several months after the spill has occurred, oil contamination creates low resistivity zone ATEKWANA *et al.* (2001), SAUCK (2000). The formation process of a hydrocarbon contaminated is linked to chemical reactions and variations in physical characteristics of the affected medium. According to SAUCK (1998), the low resistivity anomaly is due to an increase of Total Dissolved Solids (TDS) in the acid enviroment created by the bacterial action in the vadose zone or below the groundwater table (GWT). This zone is produced by a high TDS leachate which is aperiodically flushed down from the volume of intimately mixed hydrocarbon, water, oxygen and soil where microbial activity is a maximum. This leachate is a result of acidification of the heterogeneous free/residual product levels by organic and carbonic acids and is produced by the leaching and etching of the native mineral grains and grain coatings.

Background and Geological Setting

The Novi Sad Refinery is located on the left bank of Danube River, close to the artificial canal Danube–Tisa–Danube. The terrain is made of alluvial sediments, mostly sand and gravel, deposited in zone of Danube meanders on relatively flat area with low slopes. These fluvial deposits are partly covered with organic rich formations with residual of dissolved calcium carbonate. The natural terrain on top of which the facilities of Novi Sad refinery were constructed was backfilled with sand to the elevation of 77.2 to 78.2 m above sea level (thickness of sand from 1–3 m).

These sediments overlie the basic sandy aquifer. Thickness of the less permeable layer is between 0.5 and 2.5 m, but locally where the thickness reaches 4–6 m.

The site specific geology can be derived from the many drillings performed on the site provided the following representative stratigraphy is as follows:

- 0 to 1.1 m: sand, fine to medium grained, grey, dry;
- 1.1 to 2.3 m: silty sludge, dark brown, bound;
- 2.3 to 4.2 m: gray-brown sandy silt with clay fractions, bound, wet;
- 4.2 to 5.0 m: fine grain to silty sands, grey, weakly bound;
- 5.0 to 25.0 m: different middle to fine grain quartz sands, with small-grained gravel.

As regards to the hydrogeology characteristics of the area, a permanent free aquifer is present in the sandy layers. The water level regime is directly related to the regime of the Danube and changes depending on Danube's water level. At the morphologically lower parts of the alluvial plain the groundwater emerges to the surface and floods the plain. The total thickness of the aquifer is 25 meters on average, the upper layers (average thickness from 5–15 m) are mostly made of sand, while the lower part is consist of gravelly deposits (5–10 m thick).

The groundwater flow direction is influenced by the regime of Danube River. In the refinery, the prevalent flow direction is from North to South. The mean velocity of the groundwater flow is unknown, although the expected permeability in this lithological context is medium to high. Groundwater level in the Refinery area is usually between 1–2.5 meters below ground level, in backfilled sand.

The gas station "Obrenovac grad" is located on left bank of artificial canal Stara Tamnava. The terrain is made of alluvial sediments, mostly clay with sand (from the surface to the 1.4 m) and with small-grained sandy gravel above the unpermeable clay layer.

The water level regime is directly related to the seasonal changes. The depth of the aquifer is 2.5 meters on average.

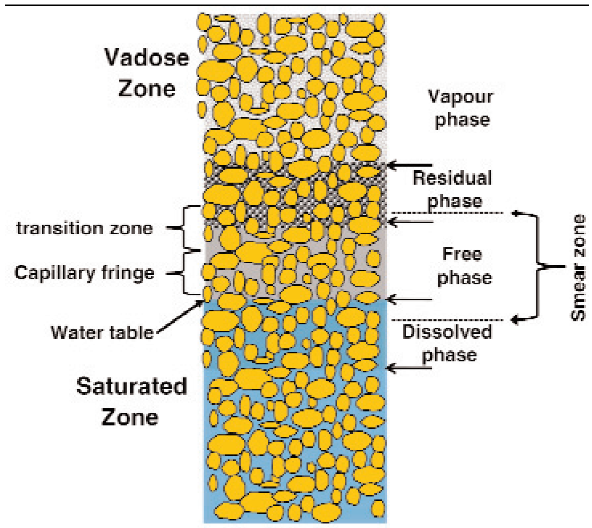

Fig. 2. Typical distribution of soil moisture and LNAPL in the subsurface after (after ATEKWANA, E.A. & ATEKWANA, A.E., 2009).

A conceptual model for the geoelectrical response of LNAPL plumes

Until recently, it has commonly been assumed that hydrocarbon-impacted sediments can be effectively imaged only by their higher resistivities compared to "background" due to the partial replacement of conductive soil and pore water by highly resistive petroleum compounds (e.g., MAZA´C *et al.*, 1990; DERYCK *et al.*, 1993). This premise is correct as long as the hydrocarbon is fresh, or has not been physically, chemically, or biologically altered.

There is ample evidence in the geochemical and microbiological literature to suggest physical and chemical alteration of hydrocarbons in contaminated sediments by indigenous microorganisms (e.g., COZZARELLI *et al.*, 1990). Because of the partitioning of hydrocarbons into different phases (free, dissolved, and residual) in the subsurface and the time-dependent biological transformation of hydrocarbons, the chemical and physical properties of hydrocarbon-contaminated sediments are expected to vary with time and in space at contaminated sites.

The near subsurface is generally described as a porous medium and divided into a water saturated zone below the water table and a vadose zone above the water table (Fig. 2). The interface between the saturated and vadose zones contains the capillary fringe and transition zones. The capillary fringe is a tension saturation zone above the water table and can vary in thickness (being greater for finer grained material).

The physical and chemical properties of the aquifer and physical and chemical properties of the saturating fluids (water, contaminant, or air) control the geophysical signatures.

During and shortly (weeks to several years) after a spill, the LNAPL partially displaces air and water in the formation. Due to its lower density than water, LNAPL will float on water and will partially displace water and air in the capillary fringe and transition zone. The free phase can also extend laterally for several tens to hundreds of metres.

The vapor phase consists of the volatile fractions of the hydrocarbon and is typically found in the upper parts of the vadose zone above the residual and free phase hydrocarbon zones (Fig. 3).

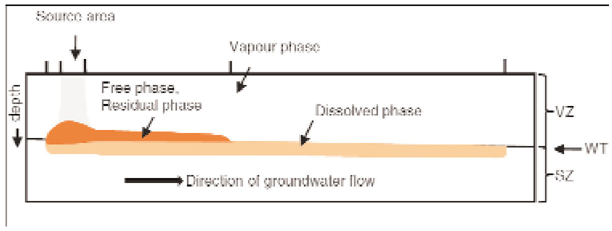

Fig. 3. Schematic vertical cross-sectional profile, of a LNAPL spill (ATEKWANA, A.E. & ATEKWANA, A.E., 2008). Legend: VZ-vadose zone, SZ-saturated zone, WT-water table.

The dissolved phase occurs in the saturated zone. The concentration of the LNAPL in the aqueous phase is determined by the solubility of the different fractions which are typically low.

With time and seasonal recharge, the residual and free phase LNAPL zones move up and down in the aquifer with fluctuations in the water table. Free LNAPL is trapped in the residual zone and the upper portion of the saturated zone causing a distinct smear zone SAUCK (2000).

The LNAPL contaminated subsurface is a dynamic and complex bio-physicochemical environment and its geophysical response will depend on factors such

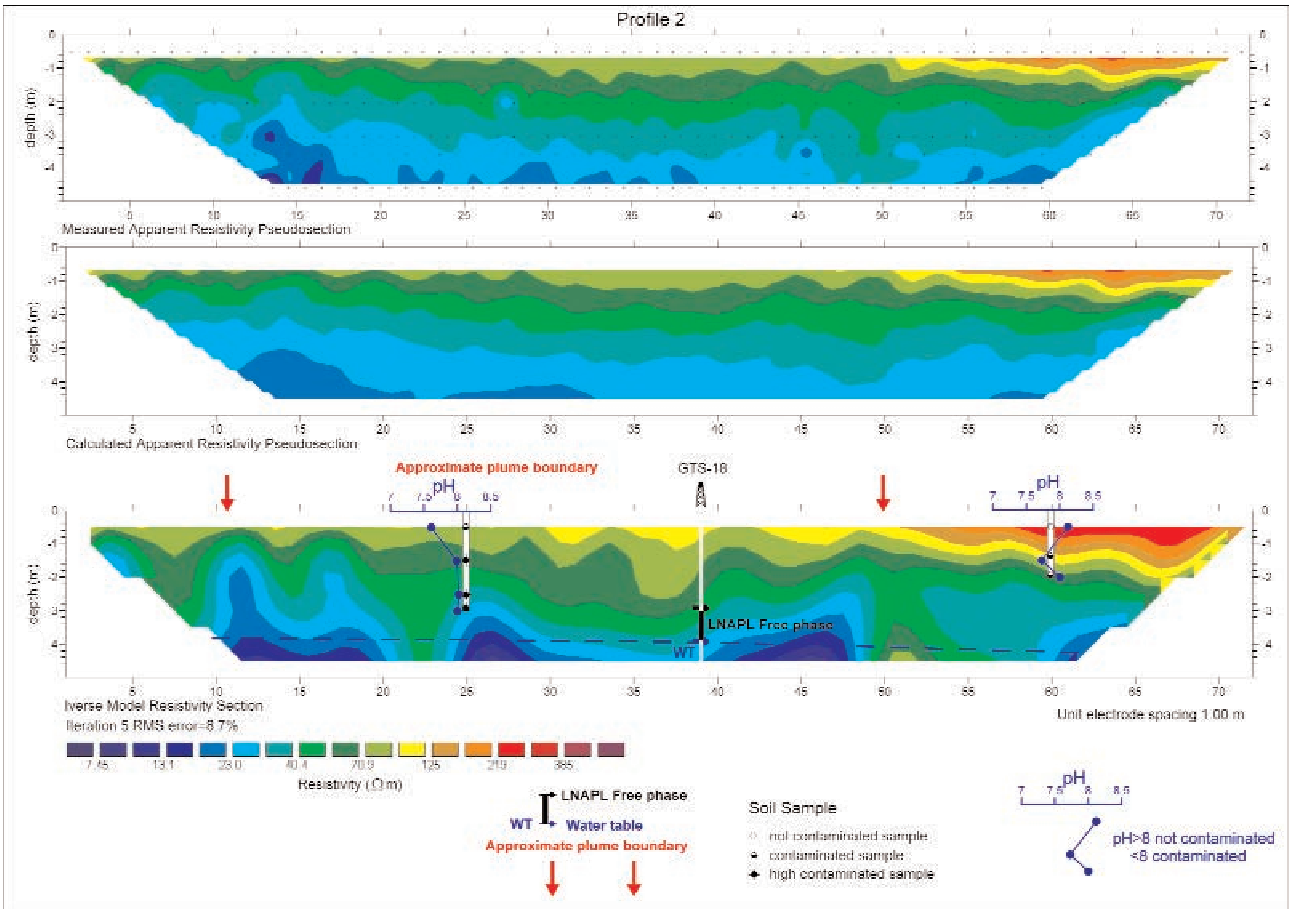

Fig. 4. Inverted Wenner resistivity profiles 2 along the contaminant plume.

as: the type of the LNAPL (crude oil, jet fuel, diesel fuel), LNAPL release history (e.g., continuous release or single release), the distribution of the LNAPL relative to air in the vadose zone or water in the saturated zone, hydrologic processes (e.g., advective transport, seasonal recharge), the saturation history of the contaminated media, biological processes, etc.

Geoelectrical data and Measures on Soil Samples interpretation

During this year of investigation our group studied 2 different sites of oil contamination in Serbia The Refinery Novi Sad (RNS) and pipeline accident at ″Obrenovac grad″ gas station (Fig. 1). Geophysical field experiments were conducted on the two sites to assess the efficiency of these nondestructive techniques to map hydrocarbon impacted areas, to recover the geometry and to detect oil plume extent. In order to construct a 2D model of the subsurface, resistivity surveys were carried out in RNS and on Obrenovac centar gas station.

These sites are different in contamination age and scale, depth of groundwater level (GWL), environment, surface conditions and the cause of contamination.

Figure 4 shows an electrical resistivity profile obtained in RNS (see Fig. 1 - for profile 2 location). The survey consisted of a Wenner resistivity array at 1 m electrode spacing using abgraded ABEM resistivity system with 32 electrodes.

An equivalent electrical resistivity profile obtained in Obrenovac (see Fig. 1 - for profile 1 location) is shown on Fig. 5.

A two-dimensional interpretation using software RES2DINV LOKE & BARKER (1996) was applied to several geoelectrical profiles. Two of them are depicted on Fig. 4 and Fig. 5. One from RNS, and one from Obrenovac centar gas station.

Geochemical (and undergoing microbial) investigation of LNAPL contamination at this site are compared with electrical resistivity imaging. Sediment samples at RNS were collected form both uncontaminated and contaminated location. Samples were obtained using Eijkelkamp rig and stored in the laboratory refrigerator until measurements were made.

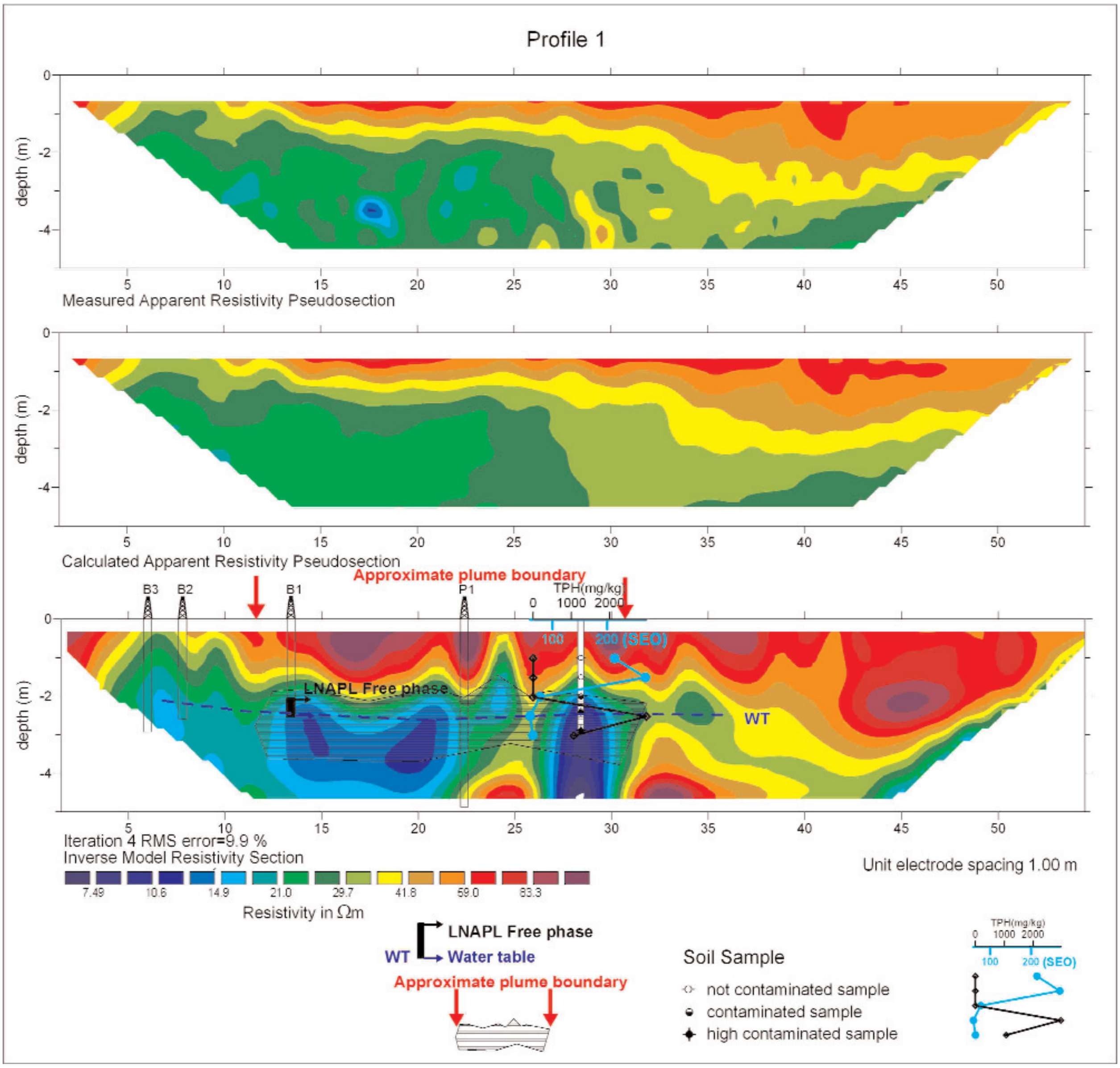

Fig. 5. Inverted Wenner resistivity profile 1 along the contaminant plume.

Ferous iron (Fe^{2+}) was analysed as well as Mg^{2+}, pH, Ca, TPH (Total Petroleum Hydrocarbon), and electrical resistivity.

Increasing level of Iron in the contamination plume is explained by anaerobic biodegradation – Fe (III) reduction: $60H^{+}+30Fe(OH)_3+C_6H_6=6CO_2+30Fe_2{}^{+}+78H_2O$

Figure 6 shows geochemical data collected from multi-level core samples across and beyond the LNAPL contamination plume. The high concentrations of Fe^{2+} a redox species is evidence of biodegradation of LNAPL in the plume. Major ion chemistry suggests that enhanced mineral weathering is occurring within the contaminated aquifer with elevated values of Ca^{2+} and groundwater specific conductance. During biodegradation, the pore fluid chemistry is changed by the degradation of the LNAPL (decrease in LNAPL concentration), decrease in the concentration (e.g., NO_3^{-}, SO_4^{2-}), the production of redox species (e.g., Fe^{2+} and Mn^{2+}), and production of metabolic byproducts such as organic acids (pH significantly decrease), biosurfactants, and biogenic gases (e.g., CO_2, H_2, CH_4, H_2S).

The profiles from both location show anomalously low electrical resistivity across the plume.

The profile 2-RNS clearly shows a low resistivity anomaly at horizontal location 10–50 m (Fig. 4). The low resistivity anomaly is mostly prominent in the saturated zone, but extends from the surface into the vadose zone.

The profile 1-Obrenovac clearly shows a low resistivity anomaly at horizontal location 12–31 m (Fig. 5). The low resistivity anomaly is mostly prominent in

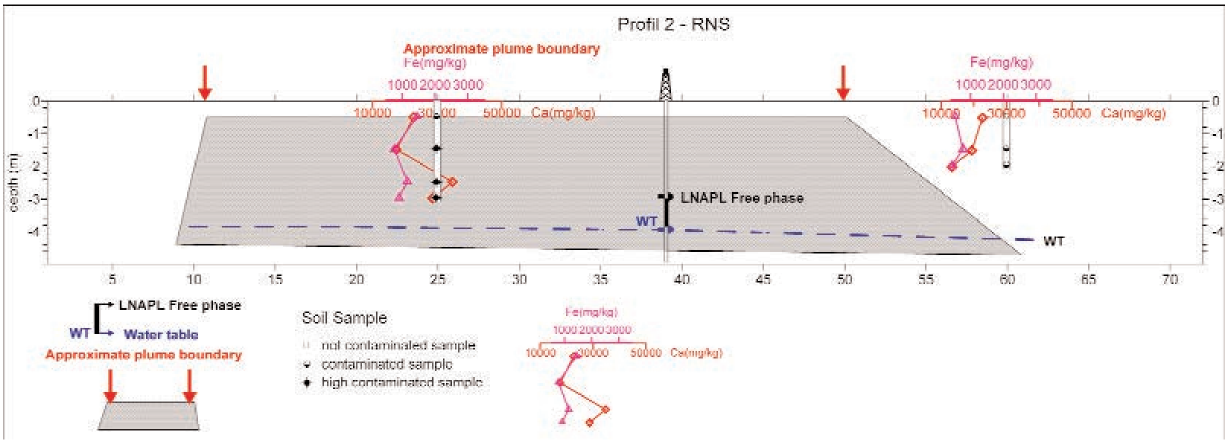

Fig. 6. Depth variations of selected chemical parameters at two sites along electrical profile 2 – RNS.

the saturated zone, but not extends to the surface into the vadose zone.

In both cases geoelectrical methods give valuable information for planning and optimizing geochemical probing. Electrical-resistivity surveys can give more detailed maps of contamination zones than geochemical sampling.

Our experience with contaminated sites characterization in Serbia shows that low resistivity anomalies caused by hydrocarbon contamination is possible to localize with the help of Electrical resistivity Imaging (ERI) and 2D data interpretation. Such contamination gives low resistivity anomaly as a result of petroleum biodegradation at shallow depth in the earth.

Conclusions

Petroleum hydrocarbons remain one of the most prevalent groups of soil contaminants. Consequently, a variety of geophysical techniques have been used and recently published to detect their presence and distribution in the subsurface.

The study pointed out the usefulness of electrical tomography in the characterization of underground leakage of hydrocarbons. Petroleum hydrocarbons naturally exhibit electrically resistive properties; however, this geophysical study, as well as many previous studies published before, has revealed electrically conductive characteristics of aged petroleum plumes.

Experimental results, obtained from a joint geochemical and geophysical investigation approach, indicated that subsoil which has been saturated with hydrocarbon for a long period exhibits an increased conductivity. It suggests that electrical tomography could be useful for monitoring the effects of induced biodegradation (bioremediation) through the repetition of the survey at different times. The strong conductivity anomaly, attributed to the hydrocarbon pollution zone, has been explained by increasing the organic activity and modification of the cation exchange capacity of the soil matrix.

We believe that the use of geophysical techniques (specifically geoelectrical) at hydrocarbon contaminated sites will become increasingly important not only in providing characterization of the subsurface geology and contaminant distribution, but also in understanding the impacts of biogeochemical processes on the electrical properties of the sediments. Therefore, understanding the relationship between the geoelectrical properties of hydrocarbon-impacted sediments and ongoing physical and biogeochemical processes is a key to the successful application of geoelectrical methods as proxies of these processes.

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Geochemical Map of Eastern Serbia in 1:1000000 and Application in Defining the Ecological Status of Selected Areas

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Abstract. A regional geochemical mapping of Serbia has been done, according to conception of making geochemical atlas of Western Europe. Research were conducted in the areas of eastern, western, southern and central Serbia, including the areas of Gnjilane, Pristina, Kosovska Mitrovica, and on the north areas of Vrsac–Bela Crkva and Pancevo.

Using geochemical prospection, the samples of different environments of the geosphere („Overbank“ sediments, stream sediments and A-horizons) were systematically collected by zones whose area is from 60 to 600 km^2, and the average density of sampling is a sample for 400 km^2, including an area of 60000 km^2. During geochemical prospection, on each location, in coastal profile lithogeochemical mapping and sampling of lithologic members was performed in which the geochemical information from larger drainage area was preserved. The sampling net is adjusted to the hydrographic characteristics of the terrain. The methodology of work is aligned with the criteria that working group for regional Geochemical mapping proposed on the meeting Western European geochemical associations (WEGS). In collected samples content of 38 elements was determined using appropriate analytical methods and international standards. Of particular imortance are results of radionuclides analyses ^{238}U, ^{232}Th, ^{40}K, especially in depleted uranium contaminated areas. This paper presents the results of research in Eastern Serbia in the period of postindustrial development of the region, and importance of the coastal profile in defining the status preindustrial region. A method of mathematical statistics was used for data processing, and program BRGM-GDM 5 for making maps.

By defining the ecological status of the region of Eastern Serbia, the basis for monitoring anthropogenic impacts on the environment was formed.

Key words: Depositional environment, stream sediments, overbank sediments, A-horizon, ecological status, Eastern Serbia.

Introduction

The increasing industrialization of the European countries has caused disruption of natural balance and pollution of the biosphere, which is manifested by increasing number of diseases in humans. To assess the level of pollution, samples were collected in depositional sediments of preindustrial and postindustrial period, according to the methodology proposed by working group for regional geochemical mapping WEGS a (Copenhagen, 1988).

Regional geochemical studies, applied in Western Europe has a partial character, because the sampling methods vary. The applied analytical methods are not standardized, and the detection limits of individual elements are not in accordance with the norms for making geological maps. Often the recommended standards are not used, and samples were analyzed on different instruments with limited technical detection limits. These problems are almost identical in the countries of Western Europe.

The methodology for mapping of geochemical atlas

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of the Republic of Serbia is harmonized with proposed guidelines for mapping of geochemical atlas of Western Europe. The proposed "overbank"-sediment (material deposited in the alluvial plain) in the development of geochemical maps of the Republic of Serbia has proved to be justified for several reasons:

- Represents a large drainage area, allowing the collection of a small number of samples,
- Obtaining the geochemical information of catchment area,
- Represents the catchment area upstream of the sampling place,
- Shows the natural changes and anthropogenic impacts,
- Relatively small for sampling and preparation,
- Valid for all countries of Western Europe.

In the screening phase of geochemical prospection, samples were collected with an area of about 60,000 km^2. Previous results confirm the validity of the methodology WEGS's, where are identified areas of anthropogenic impact on the environment.

Materials and Methods

In the screening phase of regional geochemical prospection, samples were collected from stream sediments, "Overbank" sediments and A - horizons according to the methodology WEGS. At each location three samples were taken:

- Surface, released from human interaction, which will be used in determination of natural geochemical changes (about 5 kg),
- Subsurface materials, because of determination of the human impact on the environment (5–15 kg),
- Stream sediments, because of correlation with other geochemical data (about 5 kg).

For determination of elements concentrations from different geochemical areas, following analytical methods were applied:

- For metals AAS (atomic absorption spectrophotometry) Ag, Au, Bi, Cd, Co, Cr, Cu, Mo, Na, Ni, K, Pb, Sb, Sn, V, Zn,
- For metals AES (atomic emisional spectrophotometry) Cs, Li, Rb,
- For metal and nonmetal ICP –AES (ICP- atomic emisional spectrophotometry) B,Ba, Be, P, S.

Samples were prepared by open digestion:

- *aqua regia* for: Ag, Au, Bi, Cd, Co, Cu, Mo, Ni, Pb, Sb, V, Zn,
- modified *aqua regia* for P, S,
- decomposition with: HF, HNO_3, $HClO_4$ za B, Ba, Be, Cr, Cs, Li, Rb, Sr.

International geochemical standards Granite G-1 and Diabase W-1 were used in the analytical procedure, as well as validation of the same samples in other laboratories. In the samples of anomalous concentrations of certain elements, other methods were applied, such as: mineralogical, sedimentological, spectrochemical and others. In the collected samples with low concentration if U (< 50 ppm), concentration were determined for total uranium U, ^{232}Th and ^{40}K. The measurements were performed using a sintilation detector 4'', firm „BIKRON", with crystal NaJ with multiplicative analyzer (MCA; 4096 cannal) type „ORTEC" – 7500. The analysis was based on measurement of radiation of high energy (0–3 MeV) and for calibration of spectrum and calculation of concentration of natural radionuclides were used in standard uranium and thorium ores "New Brunswick" Laboratory (USAEC).

NBL. No. 103 0,005 % U

NBL. No. 107 0,10 % Th

As a standard of potassium, potassium chloride was used (RA).

Research results

Based on the results of sedimentological analysis of collected sediment deposits of alluvial plains (FOLK, 1954) are determined as: sandy alevrite, alevritic sands, sands, gravel-alevrite and muddy sands. Development of some sediments in the coastal profile depends on the position of water flows and sedimentation time. In mountainous areas of overbank sediments are less developed with large grain factions opposed to the lowlands flows where fractions are more developed and fine grain.

Variations in chemical composition, as a result of natural or anthropogenic influences are very indicative, which are manifested in different concentrations of certain elements in A - horizon, overbank sediment and stream sediment. In Table 1 are listed elements concentrations in the geochemical profile of the catchment area of the river Timok.

Lithologic members and geochemical sampling places of the different areas (Fig. 1) are shown on the coastal profile of the river Timok. Geochemical information of the catchment area has been preserved in the coastal profile of the river Crni Timok river with tributaries: Borska reka, Kriveljska reka, Brestovačka reka, Zlotska reka, Radovanska reka; and area of Beli Timok with tributaries: Svrljiški Timok, Trgoviški Timok, Višnjevačka reka, Manojlička reka, Aldina reka, Debeštička reka, Janjska reka, and river Ravno Bučje.

The highest concentration of Cu, Zn, Cd, As and Au are found in ancient sediments and OB sediments built of coarse sandstone, ocher - yellow collored, which is loose and laminar (depth from 1.2 m). Results of chemical analyses of coastal profiles correspond to petrological built river basin district, nonferrous metal ore deposits and industrial facilities (Bor, Majdanpek etc.). Within metalogenetic area of Eastern Serbia, there are significant deposits of Au,

Table 1. Elements concentration (ppm) in the coastal profile of the river Timok.

RIVER TIMOK	Pb	Cu	Zn	Cd	Ni	Cr	V	As	Au
A horizon	30	356	43	1,7	19	160	85	12	0.14
OB sediment	31	106	14	1.3	20	190	145	100	0.16
OB sediment	52	189	7	1.3	29	60	100	45	0.20
OB sediment	32	181	21	2.1	15	130	200	150	0.16
OB sediment	63	2110	105	2.6	54	170	150	160	0.26
Strim sediment–S	48	2555	128	3.0	25	130	145	25	0.08

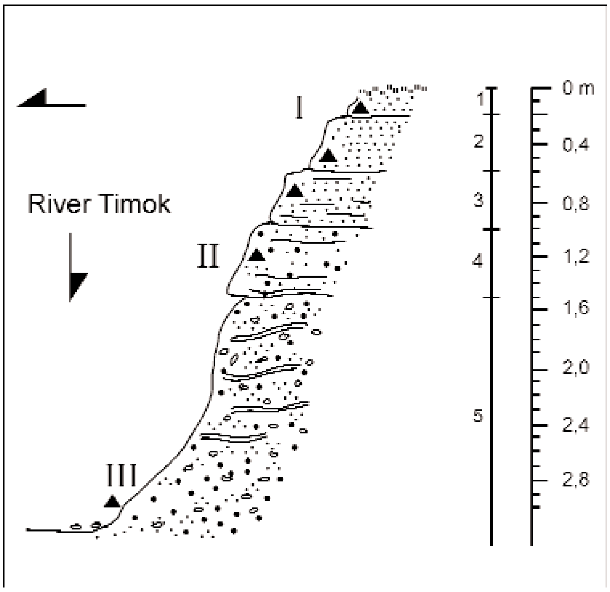

Fig. 1. Coastal profile of the Timok river. Legend: 1. Humus; 2. Sand, fine grain, multi – layered, yellow-gray color; 3. Sandstone, weakly bound, brown-gray to ocher-yellow, laminated contain organic matter and traces of plants, on surface crystallized yellow-greenish matter; 4. coarse grained sandstone, ocher-yellow, with Fe, incoherent, wavy laminated; 5. Iron conglomerate, wavy stratified, brown color from Fe, scattered bluish skim, I. A – horizon, II. Overbank sediment, III. Activate stream sediment, (black triangle) place of the sample.

Cu, less deposit of U, Fe, W and non-metallic minerals. The most important mineral resources of the Cu and Au, which are associated with volcanic intrusive complex calcoalcanic lava and structures of continental rift occurred in tectonic areas subduction of oceanic crust (JANKOVIĆ *et al*., 2003).

Systematization of geochemical information from the coastal profile is consistent with the characteristics of metalogenetic eastern Serbia, and of particular importance for development of pollution studies in the area of industrial buildings. Based on the results of geochemical prospection (Table 1) difference in chemical composition of different geochemical environments are clearly seen: A - horizons, overbank and stream sediments, as a result of natural or anthropogenic influences. Previous results confirm that the overbank sediment is very favorable and representative, because they show relationship between geochemistry of the overbank sediment and secure established area of the stream sediment for geochemical mapping. Special attention was dedicated to studying the causes of overbank sediment geochemical composition, local or regional character, which is important for the development of geochemical and geoecological maps.

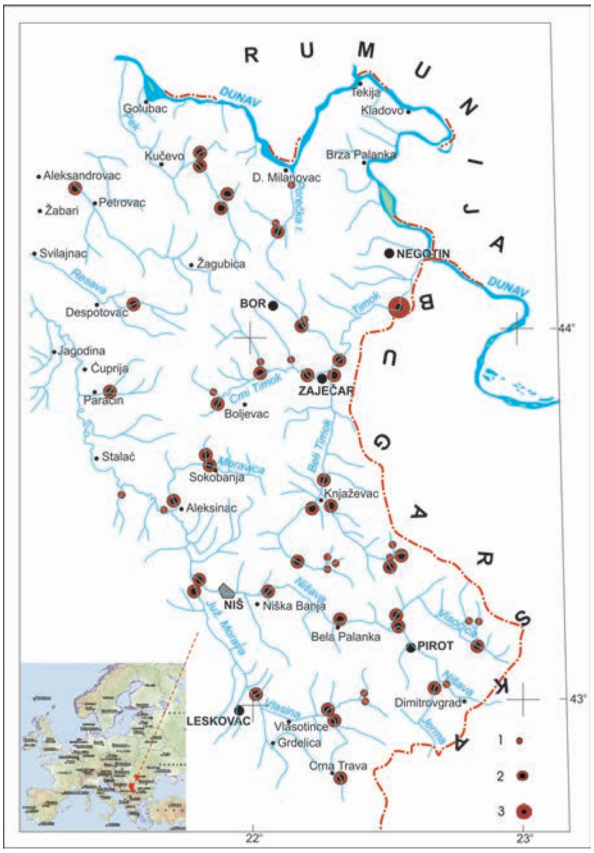

Fig. 2. Map of sampled locations. Legend: 1. Complement of the sampling net; 2. Sampling net with results on Fig. 3 and Fig. 4; 3. Profile of river Timok.

From geochemical map 1:1000000, Eastern Serbia was selected and that is shown in the scale 1:2000000. The results of chemical analyses of stream sediments from 33 locations were used for data processing (Fig. 2). Elements distributions from base rock are shown for each element separately: Cr (Fig. 3) i Ni (Fig. 4).

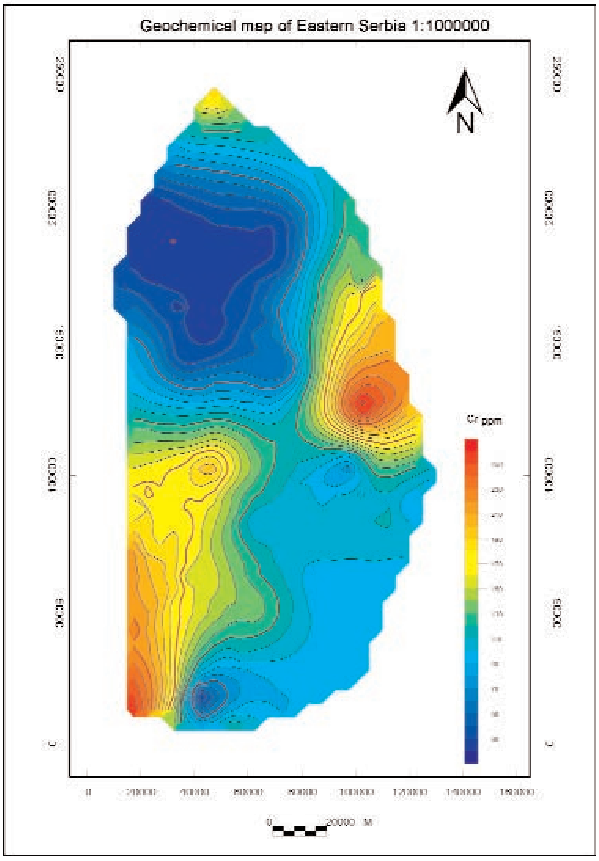

Fig. 3. Isolines of Cr content.

For examination of regularity of chemical elements distribution, in Eastern Serbia were determined the basic parameters of the statistical characteristics. The succession of individual phases of the research mentioned parameters are important elements of relationships in the correlation of geochemical data A-horizon, overbank sediment and stream sediment.

Treating the population of content elements in ancient sediments of Eastern Serbia has shown over the interval classes. Although network sampling is incomplete, reveals an increased concentration of Cr and Ni in the north-eastern and south-eastern part of Serbia. Increased concentrations of Cr follows the concentrations of Ni, which is consistent with the geological and structural characteristics of the land. The results of the distribution of chemical elements in different areas geosphere the methodology of the working group for the geochemical mapping (Working Group on Regional Geochemical Mapping), within the Western European Geological Association (Western European Geological Serveys - WEGS) are versatile applicable and necessary in the study:

- studying the Earth's crust and metalogenetic provinces,
- studying of contamination and surface tolerance,
- studying of geopathogenic zones and anthropological influence on the environment,

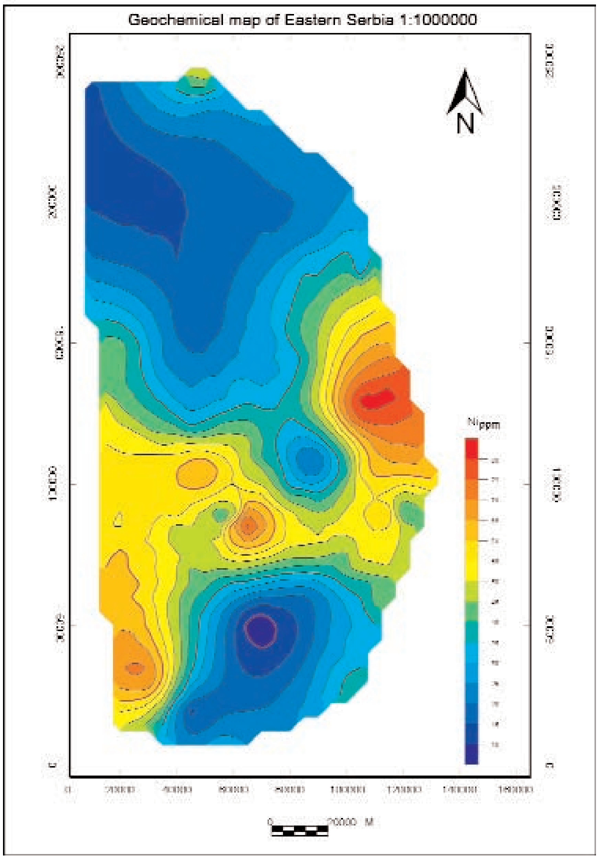

Fig. 4. Isolines of Ni content.

- in geomedicine, agriculture, forestry, water and land use
- sediment transport.

The data are of particular importance for the mapping of Western Europe and the global geochemical map.

Conclusion

Development of regional geochemical maps 1:1000000 according to the criteria WEGS gives a basis for future multidisciplinary research in the field of environmental protection, mineral resources, geomedicine, agriculture, forestry, soil quality, etc.

Applied methodology WEGS in developing of geochemical map is justified for several reasons, especially in terms of the formation of geochemical database as a basis for further research.

The research results presented in Figures isoline 2 and 3, reflecting the contemporary state of the active stream sediments and form the basis for further study research. Different concentrations of certain elements in the geochemical profile; A - horizons, overbank and active stream sediments, define the state of preindustrial and post-industrial period. During the preparation of geochemical maps of the locations of particular importance in areas where the ecological balance is disturbed during the bombing with depleted uranium, or other environmental accidents.

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1977 Jovac Landslide – a New Overlook on Environmental Effects and Material Loss

DRAGUTIN JEVREMOVIĆ[1] & SRĐAN KOSTIĆ[1]

Abstract. Landslide Jovac, activated near Vladičin Han, about 320 km southerly from Belgrade is shown in this paper, as a case study for the landslide risk. It is 3 km long, 1 km wide, while the sliding surface is about 50m deep. Period of intense movement lasted for over a month, with the total horizontal movement over 500m. This catastrophic landslide was caused by favorable geological conditions and intense damping, due to high precipitation and underground water. The damage caused by the sliding process is estimated at US$ 16 million (about 1230000000 dinars) – damage in agriculture production is about 63,32 % of the overall damage; for municipial infrastructure – 7,88 %; for roads – 14,44 %, and for travel and temporary settlement of the endagered community – 14,36 % of the overall. Property was mainly destroyed in 13 households in Ostrvica and 59 households in Jovac, while 59 households in Jovac, 6 households in Ostrvica, 11 households in Belanovce and 7 households in Kunovo were directly threatened by the new movements. The idea of this work is to show the caused damage in 1977 in detail, due to report of local authorities, as an example of landslide risk in Serbia, considering the fact that there is a direct material damage evaluation only for this catastrophic landslide. Moreover, landslide is still partially active durign the heavy precipitation, so this evaluation could be significant for local community.

Key words: megalandslide, precipitation, landslide-dammed lake, ground deformations, material loss.

Introduction

It is assumed that about 20 % of the area of Republic of Serbia is endangered by unstable slopes (JEVREMOVIĆ, 1995). They are mainly activated at the egde of Tertiary basins, in weathering crust of flysch sediments and Paleosoic shists, diabase-chert and andesite-tuff formation. Jovac landslide is considered as an example of MEGA landslides (rapid, giant landslides, or sturzstroms) in Serbia. In other words, it represents a catastrophic landslide, which cut the flow of river and creates a temporary water accumulation. There are many other examples of such landslides in Serbia – Berkovac, Zavoj and Milikici (SUNARIĆ, 2001; SUNARIĆ *et al*., 2008). In most cases, the causes of these landslides are heavy precipitation, earthquakes, human activity, or a combination of these (WIECZOREK, 1996). These processes are most effective in causing landslides when they occur in areas of rugged, landslide-susceptible topography and rocks that are susceptible to failure (SCHUSTER *et al*., 2002), like in the case of Jovac landslide. Apparently, this landslide was induced by heavy precipitation on about 10° inclined slope, when the sliding surface was formed in Upper-Eocene flysh sediments (especially marls and clays). Concerning the geological risk, large-volume slope movements in mountainous areas are a persistent threat to human activity, causing loss of lives as well as significant damage to urban infrastructure, forest, and agricultural development (HSU, 1975). These movements typically occur suddenly, with dramatic style of activity: after millennia of slow deformation, a mountainside can shift several kilometres within minutes. SCHUSTER *et al*. (2002) have recently showed that these catastrophic landslides could cause significant material loss. Also, significant environmental effects could be induced by MEGA landslides, especially ground cracks of various orientation and dimensions (PARRY & CAMPBELL, 2007; SARKAN & KANUNGO, 2010) and lanslide-dammed lakes (CRUDEN *et al*., 1993; DUMAN, 2009). The goal of this paper is to show material loss and ground deformations as a consequence of Jovac landslide, for several reasons. Firstly, the detailed report of material

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Fig. 1. Geographic position of the research field (schematic).

loss exists only for this catastrophic event in Serbia, due to investigation of local authorities in Vladicin Han. Hence, Jovac landslide would be treated as a case study for landslide risk in southern part of Serbia. Secondly, some parts of the landslide are still moving during the heavy precipitation, according to small ground cracks and fissures in Jovac and nearby villages. This is understandable, concerning the fact that no stabilisation methods were taken on this landslide. Thirdly, according to the Seismological map of Serbia (1987), the expected intensity of earthquakes is 8° (MSK-64 scale) for the recurrence period of 100 years (VUKASINOVIĆ, 1987) So, since the last great earthquake in the wider zone of endangered area happened in 1968 (6° MSK-64, epicentral area of Leskovac), there is a significant possibility that this landslide could be triggered during the next great earthquake. Moreover, in the case of these MEGA landslides, it is common to apply some new methodology and publish new data, in order to prevent possible catastrophic consequences, which is shown in many studies (SEMENZA & GHIROTTI, 2000; SADREKARIMI & OLSON, 2007; ALONSO & PINYOL, 2010). The applied methodology consisted of: 1) determination of link between activation of landslide and amount of precipitation, using data for period 1949–2009; Statistical year books (2011); 2) re-evaluation of engineering geological data, using new geotechnical data from the investigation of wider area, and data obtained by engineering-geological mapping; JEVREMOVIĆ *et al.* (2010); 3) assumption of material loss, on the basis of report of local communities. REPORT (1977).

Engineering-geological properties of landslide

Landslide ''Jovac'' is situated in the northern part of tertiary Vranje basin, in the zone of Neogene volcanic activity (Fig. 1). The oldest rocks that built this area are represented by Upper-Eocene flysh sediments (marls, clays, siltstones and sandstones), which are revealed in the southwestern part of the field. These sediments are well layered and in later phases tectonically disturbed and folded.

During the Middle-Miocene period, sedimentary-pyroclastic facia of clays, sands, gravel, volcanic ash, tuff and volcanic agglomerates was formed, in discordance to older sediments. Hard volcanic activity in Pliocene formed dacites, with significant amount of pyroclastic material, tuffs and agglomerates. The results of engineering-geological mapping are shown in Figure 2.

Engineering-geological properties of these rocks are determined according to the geotechnical investigations that were taken in the vicinity of the area

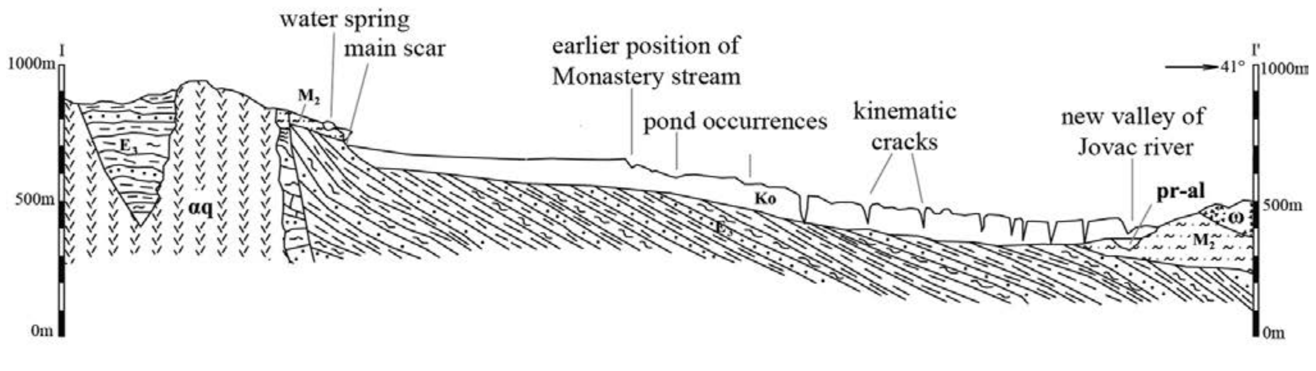

Fig. 2. Engineering geological cross section of the Jovac landslide. Legend: **Ko** – colluvial sediments, **pr-al** – prolluvial-alluvial sediments of Jovac river; $\mathbf{M_2}$ – Middle-miocene sediments; $\mathbf{E_3}$ – Upper-Eocene flysh sediments **ω** – pyroclastic material (tuffs, agglomerats); **αq** – dacites.

endangered by sliding. Dacites are mainly consisted of SiO_2 (64,75 %) and Al_20_3 (12,32 %), which give them significant uniaxial strength (246 MPa). Middle-Miocene sediments are relatively incoherent rocks, localy well layered, tectonically disturbed, and intensively weathered in the superficial parts. Weathered Upper-Eocene clays and marls usually have average plasticity index (PI) in range 30–40, which, according to Casagrande plasticity diagram, represent highly plastic clays (CH). As for the parameters of shear strength, weathered marls and clays have cohesion (c) in range 12–80 KPa, and angle of internal friction (φ) –15–20°. In another words, these Upper-Eocene flysh sediments, with thick weathering crust, combined with heavy rainfalls, represented favourable geological environment for landslide triggering (JEVREMOVIC, 2010). Apparently, in the period from November 1976 until February 1977 the measured rainfalls were the third highest in the interval of 60 years (1950–2009). (Fig. 3). (STATISTICAL YEAR BOOKS, 2011)

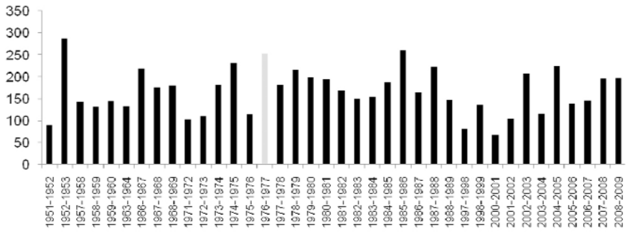

Fig. 3. The total amount of precipitation in mm/m² for november, december and january for the investigated field in the period 1950–2009 (period of 1976–1977 is colored in gray).

The effect of landslide on the environment

The impact of the landslide on the environment could be classified in two ways: a. ground deformations; b. landslide-dammed lake. Numerous cracks were formed in the field, some of which were 2 m wide, and 10 m deep. For example, the main scar was about 50 m deep, with a number of minor scars. Even today, slow movements of some parts of landslide cause the occurence of small ground cracks and fissures, 30–50 cm long and 5–10 cm wide (Fig. 4). Cracks are mainly oriented parallel to main scar. The cracks seem to be active and still widening, which clearly indicates the landslide activity. Beside these cracks, another type of ground deformations is represented by sag ponds or closed depressions on landslide, which are about 150 m long, about 50 wide and 1–3 m deep. These depressions today serve as lakes, widely known as "Jovac lakes" (Fig. 4). The other type of environmental effect is certainly a landslide-dammed lake. Apparently, the enormous mass of landslide cut

Fig. 4. Depression on landslide as one of the "Jovac lakes".

the flow of Jovac river, when the lake was formed, about 1,5 km long, 200 m wide and about 10 m deep. The natural dam was about 15–20 m high. This potrential accumulation had a volume of about 400000 m^3. (Fig. 5). (PETROVIĆ, 1981)

Fig. 5. Great lake in Jovac formed by the landslide.

The effect of landslide on material goods

The landslide Jovac in 1977 caused damage in the wider zone of Jovac village, which had the approximate value of US$ 16 million. The evaluation was done according to the report of Vladicin Han community (REPORT, 1977) In the original report, the assumed prices were given in Yugoslavian dinars (official currency in that time). In this paper, the prices are given in dollars, according to exchange rate of National Bank of Yugoslavia in 1977 (FASCICLES, 1985). The directly endangered communities were Jovac, Ostrvica and Belanovce, in which the caused damage could be classified in the following way:

– damaged households – the property of 13 households in Ostrvica and 59 household in Jovac was totally destroyed, while 59 households in Jovac, 6 households in Ostrvica, 11 households in Belanovce and 7 households in Kunovo were directly threatened by the movements;

- destroyed agricultural fields – agricultural fields and forests were totally destroyed in Jovac, Ostrvica and Belanovce, which is in total about 14.22 km^2, or 54,80 % of total cost (8768053.5 $);
- damaged agricultural objects, tools and machines – landslide also destroyed 141 agricultural accessory objects – 2,53 % of total cost (404673 $); the agricultural tools and machines were also destroyed, which is about 0,22 % of total cost (35588.6 $);
- damaged natural compost, livestock food and wheat – significant amount of compost (about 603 kg) and livestock food (about 400 kg) was destroyed. About 0,8 km^2 of area was under wheat, so the semen was entirly destroyed, and the owners of the fields had to be paid because of the expences for the plough (0,09 % of total cost, 13875 $) (Fig. 6);

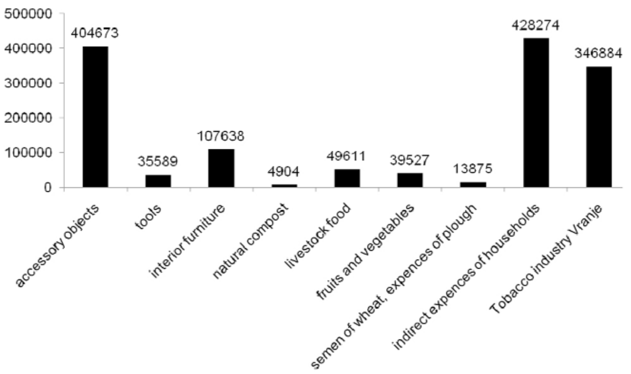

Fig. 6. The amount of damage in households, given in $.

- destroyed and damaged houses – 91 houses with 120 apartments and 72 households with 254 inhabitants were destroyed in Jovac and Ostrvica village, which was approximately 4,85 % of total cost (776733 $). Futhermore, 83 houses, with 97 apartments and 293 inhabitants, were directly threatened by the movements;
- destroyed and damaged roads – all the local roads in Jovac, Ostrvica and Belanovce were destroyed, while the roads Jovac–Kijevac and Stubla–Jovac–Belanovce were partially destroyed, which was about 9,1 % of total cost (1456642 $) (Fig. 7);
- expences of local comunity – transportation and temporary settlement of endangered inhabitants, by vehicles of public companies (”Delishes”, ”Plantaza”, ”Erosion”, ”8. september”, Tobbaco Industry „Vranje”, ”Paper factory” Vladicin Han) and private owners. Evacuated people were settled in Stubla and surrounding villages, with the necessary food supplies.

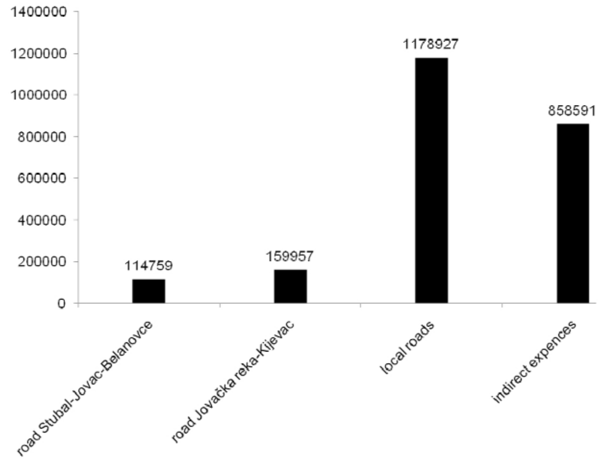

Fig. 7. The amount of damage of local roads, given in $.

Conclusion

This paper shows in detail the impact of Jovac MEGA landlside (sturzstrom) on material goods and environment. The investigation was based on previous and new engineering-geological data, combined with data about precipitation and loss. It could be considered as a case study for landslide risk in southern Serbia, which could be beneficial for local community, since in the past decade there were many examples of catastrophic flooding in wider area: Surdulica (2010, 2011) and Jablanica region (2005, 2007, 2009, 2010). Probably the most sever one was the flood in Trgoviste, in southern Serbia, during the May 2010, when several landslides activated, while the enormous debris flow destroyed approximatelly 200 houses. These facts implies the need for stabilization of existing landslides, especially mega landslides, like Jovac, in order to prevent future material loss and human victims. Hence, further geotechnical investigation should be done, including determination of mechanical properties of soil units that built wider zone of endangered area. Special attention should be made to installation of inclinometers and other instruments for contiuous monitoring of sliding. Only in that way could the presented scenario be avoided.

Acknoledgemets

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17th Meeting of the Association of European Geological Societes	Proceedings	199–202	Belgrade, 14–18 September 2011

Potentiality of the Mali Krivelj Ore Field Near Bor

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Goran Pačkovski[1] & Vladan Marinković[1]

Abstract. The ore field,"Mali Krivelj–Cerovo" is a complex of hydrothermally altered rocks that has a perspective for finding primarily the copper mineralization (ore). Investigations in this region – ore field began in early years of last century and with longer or shorter breakings last almost for a century. Investigations included many locations with variable intensity.

The entire ore region was declared as particularly interesting area regarding to the possibilities of finding the mineralization and the systematic investigation of this area started and lasts even today.

As the result of investigation, a number of different genetic and technological types of copper ore was found.

Key words: geological investigation, geological characteristics, deposit, ore field, hydrothermally altered rocks, copper mineralization.

Introduction and Characteristics of the Ore Field

The ore field Mali Krivelj–Cerovo is located 10 miles northwest of Bor, which is associated with an asphalt road from the village of Mali Krivelj. It stretches from Coka Curuli and Kriveljski Kamen in the south, going through the village of Mali Krivelj (the central part of ore field) to Balaconje in the north. The central part of ore field occupies a hydrothermally altered zone Mali Krivelj–Cerovo about 10 km in length and width of 1–2 km.

This ore field is located in the east end of TMC, what has a substantial influence on the geological structure and metalogenetic characteristics of this area, because in this part of TMC the volcanism of the first petrochemical phase is mostly developed in which the occurrences of deposits are common. Investigated area is made of: Lower Cretaceous sediments; upper Cretaceous rocks of volcanic-sedimentary series; intrusive rocks and hydrothermally altered and mineralized rocks and alluvial deposits.

The tectonic structure of the ore field Mali Krivelj–Cerovo is certainly the result of tectonic movements in the entire eastern edge of TMC. This zone can be considered as an extension of the Bor zone, where the Bor fault near Tilva Njalte spreads in the three faults, out of which two are particularly striking. The ore field Mali Krivelj–Cerovo presents a complex hydrothermally altered rocks to find promising primary mineralization (copper ore).

Geological Investigations

Geological activities in all stages of process are very diverse and permanently present and it is difficult to enumerate all of them, and only the most important will be given:

– Systematic geological mapping of the ore region Mali Krivelj-Cerovo (as the whole TMC) started in 1956 in scale 1:50,000;
– Within development of the Basic geological map scale, 1:25,000, the fields were affected of the whole TMC and its surroundings. This map perceived the place and importance of TMC as well as the metalogenetic units within the Carpatho-Balkan arc;
– During 1956, 1957 and 1958, mapping the entire area of TMC (including mining region Mali Krivelj–Cerovo) was completed, where the zones of hydrothermally altered rocks were separated. This map was gave the basis for planning the geological explorations. Special significance of

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this map is the first time recognition the whole structure of TMC, the tectonic relations and development of volcanism in it, metal genetic characteristics, types of mineralization and their arrangement, and other important geological data for exploration the deposit of mineral raw materials.

– Based on the previous works, the structural-tectonic maps were done, scale 1:10,000, as well as the synthetic structural-tectonic map, 1:50,000.
– Mineralogical-petrological investigations were intense and regularly followed the geological explorations as well as prospecting drilling and underground mine works.

Geochemical Testing

According to the scale of realization, or according to the network of taking samples (or the number of samples per km^2) in TMC, and also in the ore field of Mali Krivelj–Cerovo the geochemical prospecting was: *regional* – represents the beginning of use the geochemical methods and realization (in the 60-ies) in the preparation of geological map, *elementary* – (semi detailed) for the most part was performed in parallel with gravimetric - geomagnetic investigations per network 200×100 m and *detailed* - performed within the separated areas based on the basic geochemical prospection. Network of sampling was different (from 100×40 m to 50×20 m) and depended on the type of mineralization, which is expected.

Spectrochemical analysis of collected samples resulted into secondary halos of the main elements of Cu, as well as supporting elements Mo, Pb, Zn and Ag.

Geophysical Testing

The first geophysical testing in TMC was carried out immediately before the World War II using in the SP in already known the Bor ore field, performed by the foreign companies for French.

Geoelectrical investigations in the field Mali Krivelj–Cerovo are performed for many years. The first tests were carried out in 1949 by Professor O. Meisser using the SEP method and geomagnetic method, and they were carried out on Čoka Čuruli.

Systematic geoelectrical investigations of the hydrothermally zone started in 1965 using the method of induced polarization and electrical resistance. The tests were performed per network 100×40 m. In areas of stronger polarizations, the network was reduced to 50×20 m. Geoelectrical tests were performed in to period 1966–1970, using the method of induced polarization and resistivity (with prior removal of deficiencies of testing method) per network 100×40 m. Gravimetric-geomagnetic testing, in the early 70's. Upon completion the regional testing, a semi-detailed testing was initiated per network 200×100 m and 100×100 m, which covered all hydrothermally altered zones. Detailed gravimetric-geomagnetic testing were carried out within the anomalous zones of the previous phase, they were performed per network of 50×50 m to 25×25 m.

In addition to the above mentioned methods and ways of investigation within the geological explorations (in the latest period), the following methods are applied: aerial photography in color infrared technique; thermal-Scanning aerial; morph structure tests; testing of gas-liquid inclusions in the ore substance for the purpose of determining the temperature of creation; isotope testing of sulfur etc.

Exploratory Drilling and Underground Mine Exploration Works

Until the Second World War (the fifties of this century), the underground exploratory works prevailed, and exploratory drilling was used only for routing of works. These two periods of investigations are significantly different in the type of mineralization that was explored. Until the liberation, only high-grade (massive-sulfide and wired) Cu mineralization was explored, while low-grade (porphyritic) Cu mineralization was explored in the post-war period. The basic reasons for this way of conducting the exploratory activities were:

– In the first fifty years of this century, the technique for exploratory drilling was very primitive. It was often drilled manually operated, and the percentage of extracted core was very low and and drill holes were exclusively used for routing the underground explorations.
– It is also certain that the type of mineralization, shape of the ore body and its position in the area have a significant impact on the manner and methods of investigation. Only the porphy ritic copper deposits, in contrast to the massive sulfide deposits or vein, can be in today's conditions and the technical regulations in force, investigated to the level needed for the feasibility study and structure of ore reserves needed for design and opening by exploratory drilling.

Important Deposits

The most important deposits and occurrences of copper mineralization in the Bor metalogenetic zone were formed in volcanites and volcanoclastites predominantly of andesite composition. All important deposits are related to the zones of occurrence the deep fractures that probably reach the deep parts of continental crust that is upper parts of the magmatic

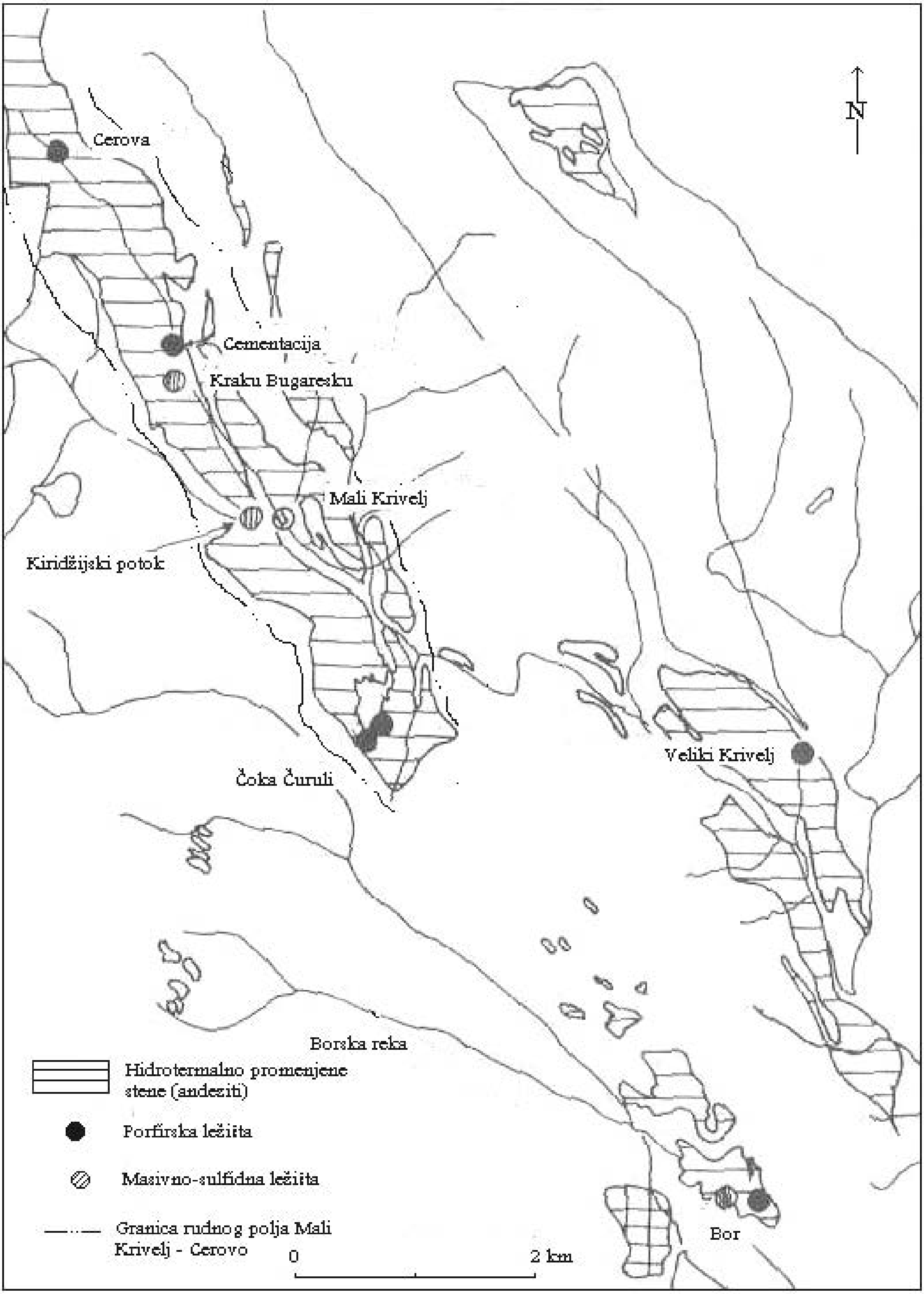

Fig. 1. Location of the ore field Mali Krivelj–Cerovo.

hearth. Gold occurs as the most important accompanying component in the deposits and occurrences of copper mineralization occurs.

According to the mineral parageneses, morphostructural characteristics and conditions of formation, the following presence was established in this ore field:

– porphyritic mineralization in the zones: Coka Curuli, Mali Krivelj, Cerovo-primary-Drenova;

– mineralization of secondary sulphide enrichment in the zone: Cementacija complex - system of ore bodies 1, 2, 3 and 4;

– massive sulphide mineralizations in the zone: Kraku Bugaresku - North and Kiridžijski stream;

– vein mineralization in the zone Kraku Bugaresku;

– ore breccias – mechanically re-deposited sediments in the zone of Kiridžijski stream and

– scarn mineralization (mainly small ore bodies, located next to the porphyric mineralization).

Due to this reason, during 2003'/2004', in the ore field Mali Krivelj–Cerovo, a geological exploration was carried out on deposit - copper ore body Kiridžijski stream, to define the direction of strike and fall of mineralized tectonic/fault zone as well as finding the massive-sulphide copper ore with gold.

Conclusions and Economic Justification

The aim of geological investigations in the ore field Mali Krivelj-Cerovo is the increase of mineral raw materials of various genetic and technological types of copper and gold of RTB Bor, which would create the conditions for the continuity of mining and processing of copper ore in Serbia (for the future).

In addition, the geological research should verify the results of previous geological investigations carried out on this site, as well as accurately determine the genetic, paragenetic, and other characteristics of the existing deposits, i.e. mineralized zones.

As it was mentioned earlier, due to the difficult economic situation in which it is, as the whole industry in the global and national levels, so the whole system of RTB Bor, the level of planned investigations is reduced to minimum. However, in order to find a way out of crisis (global nature), it is necessary to conduct further investments (the highest achievable level) to further investigations of these areas of proven potential.

Current economic indicators from the global stock market and the market price of copper itself indicate the full justification (in the final - cost) of investments in further investigations (to the exploitation) of this and further very prospective area.

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Unsaturated Zone of Zagreb Aquifer

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Abstract. Unsaturated zone of unconfined Zagreb aquifer system has never been investigated in detail. For the purpose of water flow and solute transport modelling, unsaturated zone profile and pedological burrow at location Kosnica were excavated. Sediments and soil are described in detail, boundary conditions are determined, main hydrogeological processes selected and field measurement of different parameters important for model calibration started.

Key words: unsaturated zone, geochemical processes, modelling, field data acquisition, Zagreb, Croatia.

Introduction

Groundwater quality of unconfined aquifer systems depends strongly on land use and unsaturated zone characteristics which influence water flow and solute transport. An understanding of how metals can migrate through the vadose zone is necessary for environmental professionals to predict the impact that contamination may have on human health and the environment. Subject of this study is unsaturated zone of Zagreb aquifer where high concentrations of several toxic metals in soils and sediments are found. The goal of the study is assessment of impact of land use on groundwater quality, by modelling water flow and solute transport at Kosnica site.

Case study description

Area of investigation is situated in northwest Croatia (Fig. 1). The broader area (Fig. 1) consists of a large alluvial plain bordered in the north and northwest by a mountain range, Mt Žumberak and Mt Medvednica. The region is characterized by large variability in lithology, pedological features and land use.

The mesorelief of the investigated area abounds in numerous meanders of the Sava River, inundated fluvial cones and numerous bowl-shaped depressions. From the geomorphologic aspect, there are two marked features, one being the raised sealed terrace of the Sava and Holocene terrace. The climate of Zagreb is classified as a moderately continental climate (Cfwbx in Köppen climate classification system).

Geology of the Zagreb aquifer area is represented mainly by Quaternary sediments. Lower Pleistocene deposits are predominantly composed of clayey silts / silty clays with sporadic lenses and interbeds of gravelly-sands, up to thickness of few decimeters (VELIĆ & DURN, 1993). While the lower and middle part of Middle Pleistocene unit is predominantly composed of sands, the upper part comprises silt and clay sized material (VELIĆ & DURN, 1993; VELIĆ & SAFTIĆ, 1996). The Upper Pleistocene unit is characterized by frequent lateral changes of gravels, sands, silts and clays. The Holocene is composed gravels and sands in which limestone cobbles prevail.

The thickness of unsaturated zone in Zagreb area varies from 8 meters in NW part to 2 meters in SE part (Fig. 2). The upper part of this zone is composed mainly of silty to sandy material, while the lower part consists of gravels. In some parts this material was intersected with clay layers. Predominantly three pedologic units developed on theese sediments: Fluvisols, Stagnic Podzoluvisols (Pseudogley) and Eutric Cambisols (SOLLITTO *et al.*, 2010).

Numerous studies of lateral and vertical metal distribution in soils have been made in the area of Zagreb and Zagreb County (NAMJESNIK, 1994; MIKO *et al.*, 2001; ROMIĆ, 2002; ROMIĆ & ROMIĆ, 2003; ROMIĆ *et al.*, 2004, 2005; SOLLITTO *et al.*, 2010). These studies show elevated concentration of metals in topsoils, as well as increase of cadmium, iron, manganese, and

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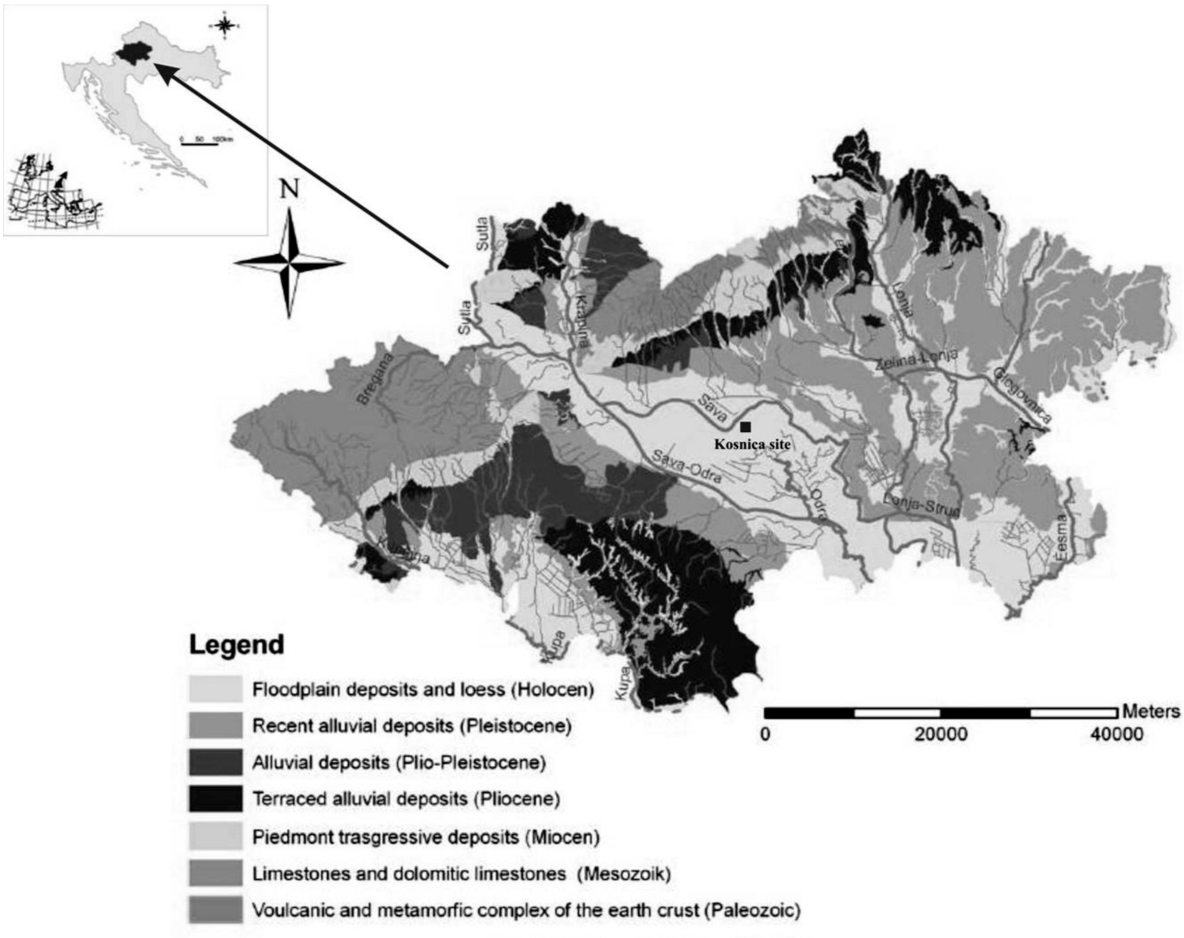

Fig. 1. Simplified geological and geomorphological map of Zagreb area according to SOLLITTO *et al*. (2010).

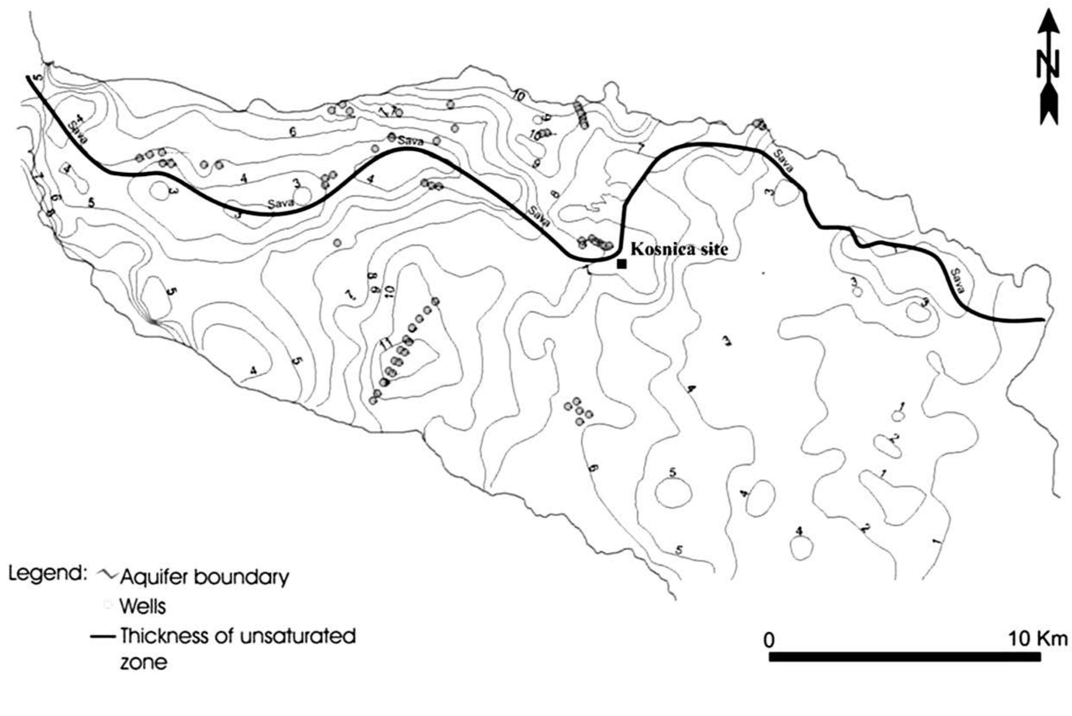

Fig. 2. Isopach map of unsaturated zone.

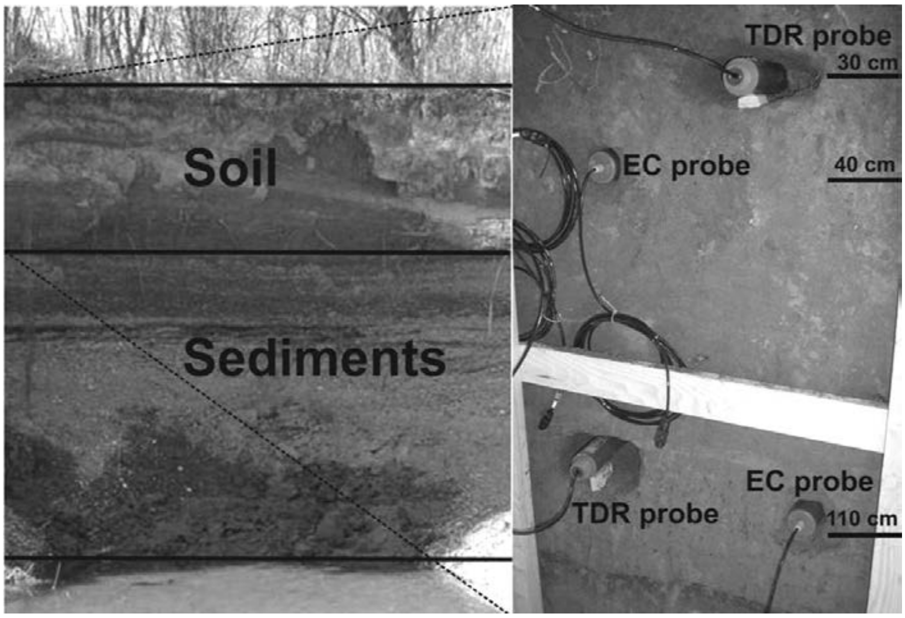

Fig. 3. Investigated pedological burrow with equipment for data acquisition.

nickel with depth. ROMIĆ & ROMIĆ (2003) emphasized that the distribution of trace elements in soils of investigated area is primarily controlled by: (a) geology, (b) industrial impact (traffic, heating plants, chemical industry and airports) and (c) external factors (some trace elements are brought by the Sava River, which has been exposed to intensive pollution by mining, industries and towns in its upper course). A portion of trace metals is introduced by wind, blown from the industrial region of north Italy (ANTONIĆ & LEGOVIĆ, 1999).

Flow and transport modeling in unsaturated zone

Location of investigated profile (Fig. 3) is located in second zone of sanitary protection of the water abstraction site Kosnica, about eight hundred meters from Sava river (Fig. 2). Detailed characterization (chemical, mineralogical and sedimentological) of sediments and soils is still in progress. Lower part of profile consists of gravels with sand component, while upper part is dominated by gravels with silty to sandy material. Stagnosols (Pseudogley) is developed of the top of unsaturated zone profile. The profile is consists of following soil horizons: O-A horizon; AC-C horizon; 2C/Cl horizon; 3Cl horizon and 4Cl/Cr horizon.

Modeling water flow and solute transport will be performed using Hydrus 1D software (ŠIMŮNEK *et al.*, 1998). Advection, dispersion and sorption are main processes which will be modeled. Boundary conditions for water flow model are atmospheric conditions (upper) and free drainage (lower), while for solute transport are flux (upper) and zero concentrations gradient (lower). Monitoring of parameters such are water content, electrical conductivity, pressure heads and concentrations of metals in percolating water) is necessary for calibration of models. Thitherto, pedological burrow (Fig. 3) two meters in depth was made, instruments installed and measurement started. Transport model will be used for particle tracking metals (cadmium, lead and zinc). Contaminated water will be spill on the top of the pedological burrow. The solutions will be prepared from $Pb(NO_3)_2$, ZnO and CdO. Leachate collection will be analyzed using AAS for detection of selected metals. Historical climate data has been obtained from the surrounding meteorological stations.

Conclusion

For the purpose of water flow and solute transport modelling of unsaturated zone above unconfined Zagreb aquifer, profile and pedological burrow at location Kosnica were excavated. Sediments and soil are described in detail, boundary conditions are determined, main processes selected and field measurement of different parameters important for model calibration started. The goal of this investigation is assessment of impact of land use on groundwater quality. The results of this study can contribute to better understanding how metals migrate through the unsaturated zone and affect sanitary protection zones of Zagreb aquifer.

Acknowledgments

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17th Meeting of the Association of European Geological Societes	Abstracts	207–207	BELGRADE, 14–18 September 2011

The Rudnik Mt. Volcanic and Metallogenetic Complex: an Example of Pb–Zn Tertiary Deposit in the Central Balkan Peninsula

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The Rudnik Pb–Zn deposit belongs to the Serbo-Macedonian metallogenetic belt. This belt is characterized mostly by Pb–Zn, Sb hydrothermal deposits formed by the Tertiary calc-alkaline volcano-plutonic activity. This general view was a strong oversimplification based mostly on a general view about the existing spatial and temporal relationship between volcanism and ore deposit formation. Hovewer, neither volcanic successions nor mineralization was known in detail. This study presents new K/Ar and petrological data about the Rudnik Mt. volcanic complex (central Serbia). The Rudnik volcanic rocks emplaced within a heterogeneous Upper Cretaceous flysch series containing olistolith limestone blocks. The presence of these olistoliths was crucial for the formation of a rather complex polymetallic (Pb–Zn–Cu–W) mineralization. K/Ar data and volcanological studies revealed the presence of two magmatic phases that occurred ≥30 Ma and ≥20 Ma. The first phase appears to be unrelated to the present mineralization and is represented by extrusions and subvolcanic intrusions of dacite/andesite rocks. The second phase is of rhyodacitic/quartzlatitic character and it resulted after a complex explosive-extrusive activity including plinian/sub-plinian explosive events followed by effusions and shallow intrusions. The extrusive products predominate consisting of high aspect ratio lava flows and domes as well as dikes that are situated in the central ore field. Unwelded and welded pyroclastic flow deposits are preserved only in the surroundings of the orefield as relicts of thick infills of paleodepressions. The volcanic rocks of these two phases are geochemically similar having a calc-alkaline affinity and LILE- and LREE-enriched patterns on primitive mantle- and chondrite-normalized spider diagrams. However, younger quartzlatite/rhyodacite rocks are richer in K_2O, Rb and Ba and poorer in Sr than Oligocene dacite/andesite volcanics. A special petrographic type of the Lower Miocene volcanic rocks is leucominette which also form transitions to quartzlatite/rhyodacite. This is an evidence that mixing between an ultrapotassic lamprophyre/lamproite magma and an acid calc-alkaline magma has played important role in petrogenesis of quartzlatite/rhyodacite and possibly in the formation of ore deposit as well. A petrogenetic model for the Mt. Rudnik volcanic complex involves the following stages: a) relatively barren dacite/andesite volcanism in Oligocene, b) formation of large magmatic chambers in Lower Miocene, c) injection of hot lamprophyric melts into stratified magmatic chambers, d) plinnian eruptions followed by effusions, e) crystallization of shallow intrusive facies and formation of hydrothermal systems, and f) precipitation of ore and formation of hydraulic breccia.

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17th Meeting of the Association of European Geological Societes	Abstracts	208–208	Belgrade, 14–18 September 2011

Digital Inventory of Geo Sites in Albania

Lavdie Moisiu[1], Albert Avxhi[1] & Afat serjani[2]

Key words: geo-sites, digital inventory, tourism.

Introduction

Geo heritage is a new area compared with traditional activities carried on by AGS. Many interesting geological and geo-morphological phenomena, of national and international value are encountered in Albania. Most of them are declared as protected areas (Council of Ministers Decision No. 676, 20.12.2002).

But even if identified, described and included in the studies, these geo-sites have remained so far unknown to the non-geologists groups. AGS in collaboration with ProGEO Albania has undertaken several projects to identify the Albanian geo-sites as part of the natural heritage that include the first inventory of Albanian geo-sites as well as the Albanian map of geo-sites (Serjani & Neziraj, 2000). All studies stored in the Central Archive of AGS are in hardcopy format. In order to ensure a well organized structure for all geo-sites known so far, fast and flexible update in real time and also to upload data into the official AGS' website, a digital inventory became necessary. Other factors that promote the digital inventory creation are: to be in line with UNESCO directives given in Barcelona congress, October 2008, to recognize and treat geo-diversity with the same importance as bio-diversity; to support the development of tourism providing useful information regarding geo-sites, supporting local authorities to know better the geology of region, to review and complete the CMD no. 676, 20.12.2002, including geo-sites and geo-parks as part of protected areas.

As benefits deriving by using a digital inventory we underline: interchange of information, know-how at international, national and regional level, compatibility with international standards. In combination with GIS system, are increased the possibilities in monitoring and managing of natural resources. An MS-Access database has been built, keeping the inventory of all geo-sites classified by their genesis, into 9 major groups. Each geo-site has its own inventory index, which is unique. Based on this index, geo-sites are related to data on geographical (x, y, z coordinates) and administrative location (region, district); geological (position and description); categorization (regional, national, international); status (protected or not); usefulness (didactic, scientific, tourism etc); safety; area (ha); infrastructure; road maps/photos. Database and graphical part are linked by using ArcGis 9.2 version.

Users can query any geo-monument and retrieve all related data, or search all geo-sites of a region to receive the required information.

Conclusions and recommendations

Albania has very interesting geological phenomena; most of them constitute geological sites. Geo-conservation policies still have to be developed and implemented in our country. Digital inventory and storage of Geo-sites network in GIS will help policymakers for a better management and protection of unique natural values. On the other side, it will help in increasing the public awareness, understanding rocks, minerals and landscapes. It will help many international institutions such as ProGEO and European Geopark Net, regional and local bodies, NGO-s, non-geologist groups to create a better view on geological sites distribution, to know their geographical position and surface.

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17th Meeting of the Association of European Geological Societes	Abstracts	209–209	BELGRADE, 14–18 September 2011

Natural Radioactivity of Granitic Plutons of Northern Greece

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The geology of northern Greece is characterized by numerous granitic plutons of various composition and age which could be potentially used as building materials. One hundred and one samples from every major occurrence of granitic rocks (as a market term) of northern Greece have been measured for their natural radioactivity in order to assess their radiological impact, in case they are used as building materials. More specifically, the specific activities of ^{40}K, ^{226}Ra and ^{232}Th in Bq kg^{-1} were measured by using gamma-ray spectroscopy. The investigated samples represent the plutons of the Rhodope massif (Xanthi, Papikion Mt, Kavala, Vrondou, Elatia-Skaloti-Paranesti, Panorama, Granitis and Philippi), the Serbomacedonian massif (Arnea, Flamouri, Ierissos, Stratoni, Mt Athos and Mouries), the Circum Rhodope zone (Maronia, Samothraki, Sithonia, Treis Vrisses–Chalasmata–Kassiterra and Leptokarya–Kirki), the Axios zone (Monopigadon and Fanos) and the Pelagonian zone (Varnountas, Kastoria, Mt Voras, Kastania and Deskati), including all major rock types found in those occurrences. As expected, the specific activities of ^{40}K, ^{226}Ra and ^{232}Th of the investigated samples exceed the average level of these radionuclides in soil and other kinds of building materials. However, this is typical for granitic rocks, because they contain U- and Th- rich minerals in higher amounts than other building materials and soil. In order to assess the health risk of using the above samples as building materials, the following indices proposed by the E.C. (European Commission) and UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) were calculated: absorbed gamma dose rate (D_a), annual effective dose (H_E), activity index (AI) and gamma-ray index (I_γ). The calculation of the above indices is based on the standard room model, proposed by UNSCEAR which implies a room with dimensions of 3×3×3 m, having infinitely thin walls, without doors or windows and being fully constructed of granite. Twenty three of the investigated samples exceed the acceptable limit for the absorbed gamma dose rate which is 160 nGy h^{-1}. As far as the annual effective dose (H_E) is concerned, nine samples exceed the limit of 1 mSv y^{-1}. The activity index (AI) of the samples is below or equal to the limit of 1, except for seventeen samples. Finally, no sample exhibits gamma-ray index (I_γ) higher than 6 which means that the use of all the samples investigated could be recommended. However, one sample from Maronia, one from Granitis and one from Fanos exhibit gamma-ray index above or equal to 2, which means that the use of these samples is recommended in local level, in exceptional cases. The average values of the above indices of the investigated samples is below world average, in the case of all indices. Moreover, the indices of the samples of this study are lower or equal to those of the imported granitic rocks in Greece. Therefore, at least from radiological point of view and for the investigated rocks, the granites from northern Greece can be used as building materials.

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17th Meeting of the Association of European Geological Societes	Abstracts	210–211	BELGRADE, 14–18 September 2011

Ir Anomaly in the Fish Clay and the Proportion of Extraterrestrial Component

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The lowermost Danian Fish Clay Member of the Rødvig Formation near the village of Højerup (hereafter referred as the Fish Clay) at Stevns Klint (eastern Denmark, Fig. 1) is a classic marine Cretaceous–Paleogene boundary section. ALVAREZ *et al*. (1980) have first reported anomalously high Ir concentrations in the Fish Clay and other prominent boundary clays. They explained this enhanced Ir proposing an impact of extraterrestrial bolide occurring at the KPB. It has been suggested that the impactor was a carbonaceous chondrite-type body.

The lithology of the Fish Clay characterizes four distinctive layers within this boundary section: black-to-dark marl with a basal red layer, brown-to-grey marl and at the top a light-grey marl. The red layer is underlain with (latest) Maastrichtian bryozoan-rich limestone; the top marl is overlain by (early) Danian Cerithium limestone, Fig. 2.

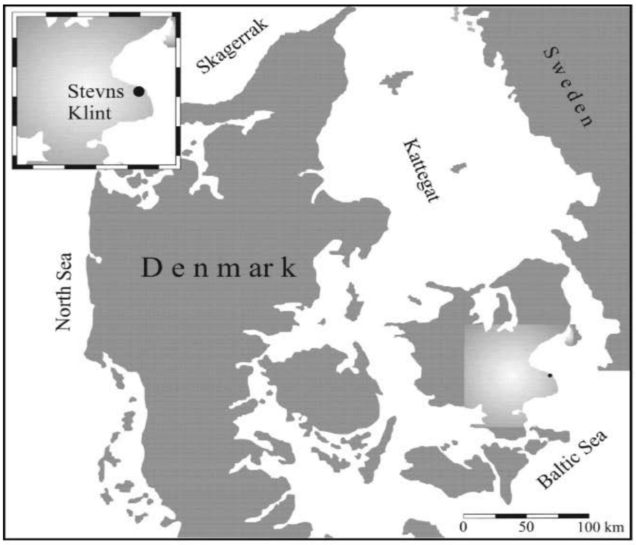

Fig. 1 Geographic location of Stevns Klint in Denmark.

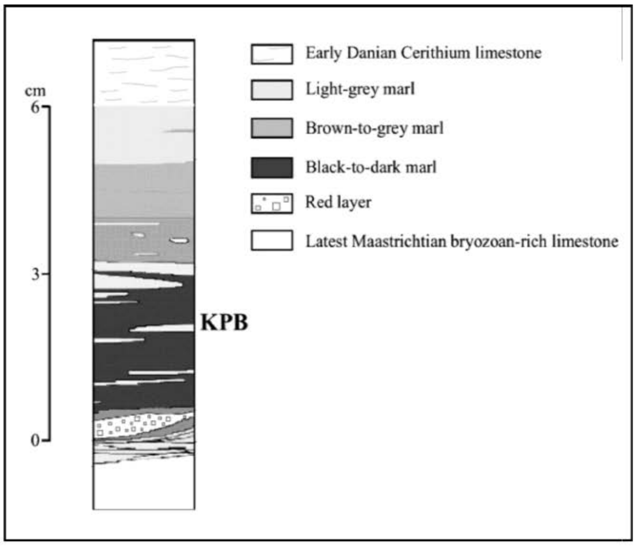

Fig. 2 Expanded lithological log of the Fish Clay at Højerup.

The carbonate-free fraction of the black-to-dark marl of the Fish Clay shows a considerable enrichment of Ir compared with marine sedimentary rocks. The most reliable measure of an Ir anomaly in the boundary clay is the integrated Ir fluence. This fluence for the carbonate-free black-to-dark marl (assumed a density of 2 g cm^{-2}) is estimated at about 500 ng cm^{-2} after integration in the interval from 0.5 cm to 3.0 cm. (For comparison, an estimate of the Ir fluency for the global impact deposit for the Cretaceous–Paleogene boundary about 40–55 ng cm^{-2}) 2004). This value corresponds approximately to 600 mg cm^{-2} to 1250 mg cm^{-2} carbonaceous chondrite, based respectively on 406.0 ppb to 849.4 ppb Ir in the carbonaceous chondrites. These estimates correspond to about 12–25 % carbonaceous chondrite in the decarbonated black-to-dark marl; for the average Ir content of 465 ppb in CI chondrite contribution is about 22 %. Such a significant proportion of CC is,

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however, not supported with any mineralogical evidence. Indeed, if initially the precursor material of black-to-dark marl contained a high percentage of the impact-derived ejecta fallout then diagenetic alteration would have left a residue with high concentrations of the impact-derived markers. To our knowledge, black-to-dark marl contains no altered meteoritic fragments and only about 0–6 shocked quartz grains per gram.

We conclude that the above estimated contributions of carbonaceous chondrite to the black-to-dark marl are most likely too high due to the significant Ir influx from the nearby marine or continental site to the Fish Clay.

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17th Meeting of the Association of European Geological Societes	Abstracts	212–212	BELGRADE, 14–18 September 2011

Microspherules of the Red Layer at the Cretaceous-Paleogene Boundary (Højerup, Denmark)

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We carried out scanning electron microscopy/analytical electron microscopy observations of the basal red layer of the Cretaceous–Paleogene boundary clay at Højerup. This layer contains the Fe-oxides (500–600 μm), pure Fe (200–350 μm), Fe-trace Ni (150–250 μm), Fe- rich silicate (150–250 μm), and pure Ag (50–100 μm) microspherules enclosed within a smectite matrix. It is suggested that these microspherules are globally distributed impact-derived particles which were probably reworked/redeposited at or near the Cretaceous–Paleogene boundary.

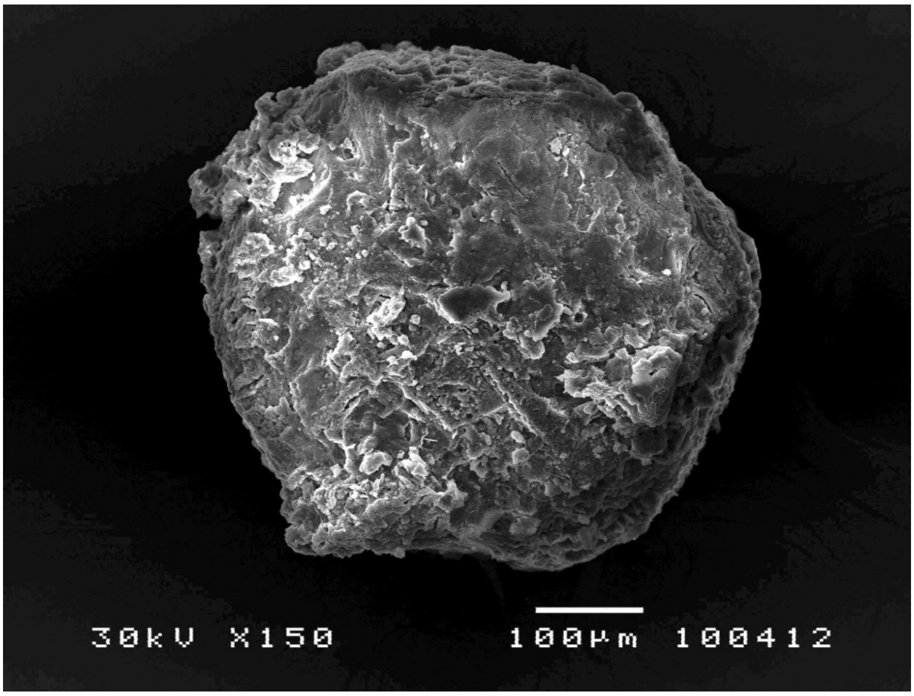

Fig. 1. Microspherule of pure Fe from the red layer of the Fish Clay.

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17th Meeting of the Association of European Geological Societes	Abstracts	213–213	BELGRADE, 14–18 September 2011

Relationship Between Geology and Earthquake Sensitive Planning at the Disaster Damages Reduction

SULE TUDES[1]

Earthquake which is the oldest natural hazards faced by humanity isthe part of a natural processthe formation and movement of the world.The main purpose of the modern city planning is to build, safe and sustainable habitat to communities and to create durable cities the natural hazard processes.

Primarily risks must be defined at the process of protection of the cities in earthquake. In the case of risk reduction, risks arising from city ground, settlement system and structures must be known in urban scale earthquake movement must be investigated on elements of an urba Common data sets c and suitable for use in inter-disciplinary.

Earthquake risk varies to sphere of influence of earthquakes and geological location, dispersion and density of settlements. Geological factors and urban parameters lead effects of earthquake and increase or decrease earthquake damage planning process, geological thresholdsshould be good analysis and earth science datashould have the primary effect in all kinds of spatial planning decisions. Citiesshow different behaviorswith the effect oflocal geological conditions, macro form,construction conditions, and settlement system earthquake. In this study, the relationship between earthquakes and planning will be build and be mentione physical planning principlesto reduce earthquake losses. Besides, it will be focused on the importance of earthquake and geology analysis of geologic thresholdcarried out before planning. It will be presented natural and artificial environment analysis needs to be done in the of earthquake-resistant cities. Urban risk analysis will be evaluated based on geohazardscaused by the earthquake.

If the ground of urban settlement is weak and if construction and population density are considerable, the possible loss of life and propertyincrease. Accordingly, urban risk is proportional to these parameters.In this context, the effects on urban settlements of earthquakesshould be analyzedin a systematic order. In these analyses, it must be investigated properties of earthquake, how the movements of earth affects local soil conditions, how the geological conditions are reflected to the spatial planning and relationship between the soil-structure interaction.In this context, effects of earthquake motion will be assessed the reflection of urban earthquake behavior in the spatial planning.

Key words: earthquake, geology, urban planning, urban risk.

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The Effect of Coriolis-Force on the River Course

ZOLTÁN UNGER[1] & ISTVÁN NÉMETH[1]

It is common knowledge that the moving objects change their trajectory in a rotating system due to the inertia thereof and therein. This phenomenon had been named after the French mathematician, Coriolis, who had described this force in the year 1835. In 1851 Foucault used this phenomenon in order to prove the rotation of the Earth by a pendulum hung up in the Pantheon in Paris. His genial idea conceived that during that movement, the oscillation plane of the pendulum will change and this event can be attributed to the rotation of the Earth. The second successful attempt for this experiment was performed in Hungary, in the year 1880 in Savaria – Szombathely by Adolf KUNCZ and his disciples (the Gothar brothers) by a pendulum hung up in the dome of the Roman-Catholic cathedral.

It has been commonly approved albeit that the rotation of the Earth has relevant impact upon geological processes as well. This phenomenon can be traced by watching the course of the river flows. For instance in Hungary one can witness either in field inspections or by interpreting the remote sensing images that our two major rivers flowing from North to South, the Tisza and the Danube, project west-bound channel migration.

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17th Meeting of the Association of European Geological Societes	Proceedings	215–217	Belgrade, 14–18 September 2011

W-Mo Skarn From the Mraconia Valley, Romania

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Abstract. The skarn from the Mraconia was formed at the contact between crystalline limestone of the Neamtu Series and a porphyritic granodiorite. The main metallic minerals in the Mraconia Valley are scheelite and molybdenite. The skarn mainly consists of garnet (andradite), ferro-actinolite, magnetite, epidote, apatite, vesuvianite and wollastonite. Four stages of mineralization overprint the primary skarn: (a) a high temperature stage, consists of the deposition of scheelite as impregnations in the mass of andraditic skarn and a simultaneous deposition of the classical ”quartz-molybdenum” ore along the cracks in granodiorite mass; (b) the hydrothermal stage which overprinted the first event, conducing to the deposition of pyrite, chalcopyrite and calcite along the cracks and leading to the impregnation of the skarn mass by pyrite and chalcopyrite; (c) the second hydrothermal stage conduced to the deposition of massive mineralization of chalcopyrite, pyrite, sphalerite and galena, while scarce pyrrhotite and tertahedrite mineralization formed veins and lenses in the skarn mass; (d) a low temperature hydrothermal stage yielded the depositions of bornite and covellite on chalcopyrite and hematite (specularite) on magnetite. The endoskarns are characterized by the presence of sulfides of Mo, Pb, Cu, Zn and the exoskarns are much richer in scheelite.

Key words: exoskarn, endoskarn, scheelite, molybdenite, Mraconia, Romania.

Introduction

The research area overlaps with the hydrographic basin of the Mraconia Valley. It is bounded by the the Poiana Mraconia and Lugojistea at north, the Satului Valley at east, the Ponicova Valley at south, and the Cracul Radului–Cracul Urzicea at west. The skarn was described for the first time by the Streckeisan (1934) within the Catramat Series with a depth gradient of catazonal to mesozonal. This series represents the debris of an old unit of Upper Carboniferous age.

In this study, we present our results of the petrological investigations and give the mineralization sequences related to the skarn formation.

Geology of the skarn area

The crystalline schist of the Poiana Mraconia Series (Codarcea *et al*., 1934) suffered a progressive metamorphism to the amphibolite with almandine facies and the kyanite-almandine-muscovite sub-facies. It associates with the meta-pelite paragenesis including kyanite, green hornblende, andesine and almandine. The primary metamorphism was followed to the regressive metamorphism by the Assyntic orogeny and Varisc cycles (Bercia & Bercia, 1975). The amphibolite paragneiss and the micas paragneiss (with biotite and garnet) associated with the quartz-feldspar gneiss were affected by the arteritic migmatization.

The studied skarn was formed along the contact between crystalline limestone of the Neamtu Series and a porphyritic granodiorite of probably Triassic age (Vlad *et al*., 1984). The magmatic rocks belong to the two generations of intrusions corresponding to the acid magmatic phase, followed by the dykes including kersantite and spessartite, respectively. The granitoids of the Mraconia valley are holocrystalline and hipidiomorphes, and their structure and texture are inetergranulare.

Skarn mineralogy

The W-Mo skarns, result of metasomatism of the adjacent formations due to magmatism from the Poiana

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Mraconia, have been found in the upper basin profile of the Ponicova, Mraconia and Soblanului Valleys. There are two types of skarns: exoskarns were formed on the limestone and hornfels calcic, and endoskarns came from the transformation of igneous rocks.

The endoskarns have a complex mineralogy; the pyroxenes are transformed into ferro-actinolite, clinozoisite, magnetite and quartz. Into this contact zone, important quartz vein occurs containing sulfides: pyrite, chalcopyrite, sphalerite, and galena and in some cases, the important molybdenite-quartz mineralization (Fig. 1 left).

Fig. 1. Molybdenite-bearing skarn with mineralization.

The exoskarns were developed on limestones and hornfels. The exoskarns of limestone are composed of garnet (andradite), clinopyroxene and some of wollastonite. Scheelite is mainly present in veins and associates with calcite (Fig. 1). The exoskarns on limestone contain pyrite late. The exoskarns on hornfels show a significant occurrence of sulfides, chloritization of biotite and the presence of magnetite.

Skarn Geochemistry

The endoskarns can be distinguished by their higher contents of Al, Na, K, Fe, Mg, Mn, Cu, Pb and Mo, while, the exoskarns are characterized by their high content of W. Thus, we have noticed a duality related to substratum (limestone, hornfels, granitoids) through which the metasomatic fluids.

Fig. 2. Scheelite skarn with quartz mineralized in the right.

The skarns in the systems ACF and $CaO–SiO_2–MgO$ (Figs. 2, 3 and 4) show clearly the difference between endoskarns and exoskarns, and the influence of the crystallization of garnet and pyroxene on the evolution of fluids between the igneous rocks and limestones. Some exoskarns show the presence of

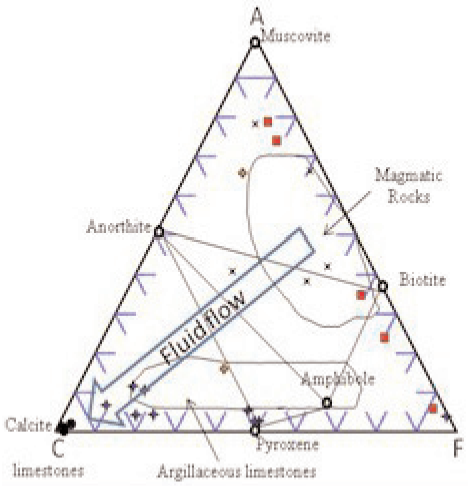

Fig. 3. Distribution of chemical composition of exoskarns and endoskarn in Ternary diagram A–C–F A ($Al_2O_3+Na_2O+K_2O$) – C (CaO) – F ($Mgo+Fe_2O_3+MnO$). The circled areas represent the magmatic rocks of the region and argillaceous limestones.

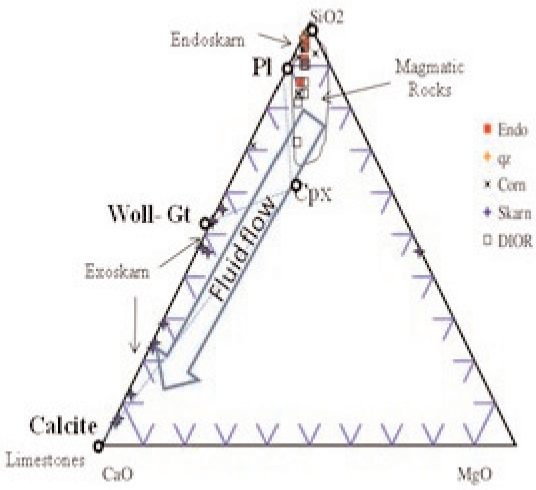

Fig. 4. Distribution of chemical composition of exoskarns and endoskarns in Ternary diagram $CaO–SiO_2–MgO$. The circled areas represent the magmatic rocks of the region and limestones.

wollastonite in this equilibrium. Finally endoskarns are characterized by the presence of sulfides of Mo, Pb, Cu, Zn; the other hand, the exoskarns are much richer in scheelite (Fig. 5).

The Garnet is contemporary with sulfide phase affecting the pyroxene. There has been a syn-crystallization of andradite and sulfides, and silicification associated with sulfides (pyrite, pyrrhotite). The assemblage andradite-quartz-sulfide results from the transformation of pyroxene in the presence of sulfide phase. If the fugacity of sulfur increases during the transformation, the pyrrhotite is unstable and only pyrite is present.

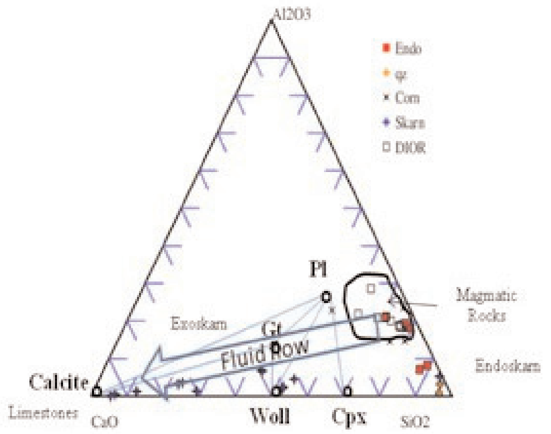

Fig. 5. Distribution of chemical composition of exoskarns and endoskarn in Ternary diagram SiO_2–Al_2O_3–CaO. The circled areas represent the magmatic rocks of the region and limestones.

Conclusions

The skarn from the Mraconia was devoled at the contact between crystalline limestone of the Neamtu Series and a porphyritic granodiorite probably Triassic or Upper Cretaceous age. The main metallic minerals from Mraconia Valley are scheelite molybdenite. The skarn is richer in garnet (andradite), ferro-actinolite, magnetite, epidote, apatite, vesuvianite and wollastonite. Four stages of mineralization overprinted the primary skarn:

1 - a high temperature stage, consists of the depositions of scheelite as impregnations in the andraditic skarn and a parallel deposition of the quartz-molybdeniteore along the cracks of granodiorite;

2 - the hydrothermal stage which overprinted the first event, conducing to deposition of pyrite, chalcopyrite and calcite on the cracks and of impregnations of pyrite and chalcopyrite in the skarn;

3 - the second hydrothermal stage conduced to the massive deposits of the chalcopyrite, pyrite, sphalerite, galena, pyrrhotite and tertahedrite, which forms veins and lenses in the skarn;

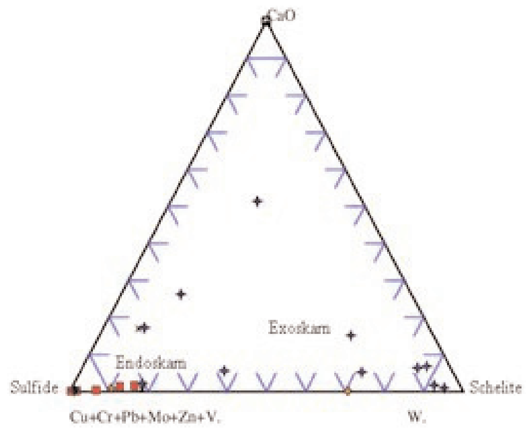

Fig. 6. Distribution of skarn and endoskarn in Ternary diagram W–CaO–(Cu+Mo+Cr+Zn+V).

4 - a low temperature hydrothermal stage yielded the formations of bornite and covellite on chalcopyrite but also of hematite (specularite) on magnetite.

The endoskarns and exoskarns on hornfels are characterized by the presence of sulfides of Mo, Pb, Cu, Zn and the exoskarns on limestones are much richer in scheelite.

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17th Meeting of the Association of European Geological Societes	Proceedings	219–221	BELGRADE, 14–18 September 2011

Laumontite-Type Zeolites in Plagiogranitic Rocks from Albanian Ophiolites

ENKELEIDA GOGA BEQIRAJ[1], FABRICE MULLER[2] & J.C. TOURAY[2]

Abstract. This paper presents the EMPA data on zeolites in plagiogranitic rocks from Tuci–Kimza region, Northern Albania. Plagiogranites, that represent the uppermost part of the plutonic section of the Albanian ophiolites, are intensively altered. They crop out in the north–eastern sectors of the Albanian ophiolitic complex and have intrusive contacts with volcanic and gabbroic rocks. A zeolite, that is typically secondary mineral, has filled thin veins and/or small vesicles of the rock. XRD, EMPA, DTA and optical observation revealed that zeolites belong to Laumontite–Leonhardite series.

Key words: Laumontite-Leonahardite, EMPA, Zeolite, Kimza, Plagiogranite.

Introduction

It is well known that zeolites are framework silicates consisting of interlocking tetrahedrons of SiO_4 and AlO_4. In order to be a zeolite the ratio (Si+Al)/O must be equally 1/2. Their alumo-silicate structure is negatively charged and attracts positive cations that reside within it. Unlike most other tectosilicates, zeolites have large vacant spaces or cages in their structure that allow enough space for large cations such as sodium, potassium, barium and calcium and even relatively large molecules and cation groups such as water, ammonia, carbonate ions and nitrate ions. Therefore, zeolites are known as able to act as ion exchangers of high ion exchange capacity (SOULAYMANA *et al*., 2004).

Zeolites have many useful purposes. They can perform ion exchange, filtering, odor removal, chemical sieve and gas absorption task. For example, the prospective use of chabazite to treat low level aqueous waste has been described (ROBINSON *et al*., 1993). Zeolites in Albanian ophiolites are related with intermediate volcanic rocks and with plagiogranites. The zeolites from later are scarcely studied (KATI, 1967). This study, aims to further advance their mineralogical-chemical characterization based on the new analytical data.

Geological setting and sampling

Seven samples were collected from plagiogranitic rocks of Kimza-Tuci region (Fig. 1). Quartz diorites and plagiogranites constitute the upper part of the plutonic sequence of the Albanian ophiolites and they are often accompanied by sheeted dyke complex. They consist of plagiogranite, quartz diorite, while lateral sectors of the above magmatic bodies are represented by microdiorite. Based on the geochemical data these rocks belong to tonalite – trondhjemite type showing a clear magmatic affinity with those from suprasubduction zone, being similar with sheeted dyke complex and basalt-andesite volcanic rocks (BEBIEN, *et al*., 1995; SHALLO, 1995). The uranium – lead radiometric dating method performed in apatite from Shemeria plagiogranite massif showed an absolute age of 166±22 Ma, whereas $^{40}Ar/^{39}Ar$ gave the absolute age of 163.8±1.8 Ma.

Methods of study

Zeolites enriched samples were obtained by purification processes based on greater friability and lower density (DE' GENNARO & FRANCO, 1979; DE' GENNARO & LANGELLA, 1996). Samples were characterized by

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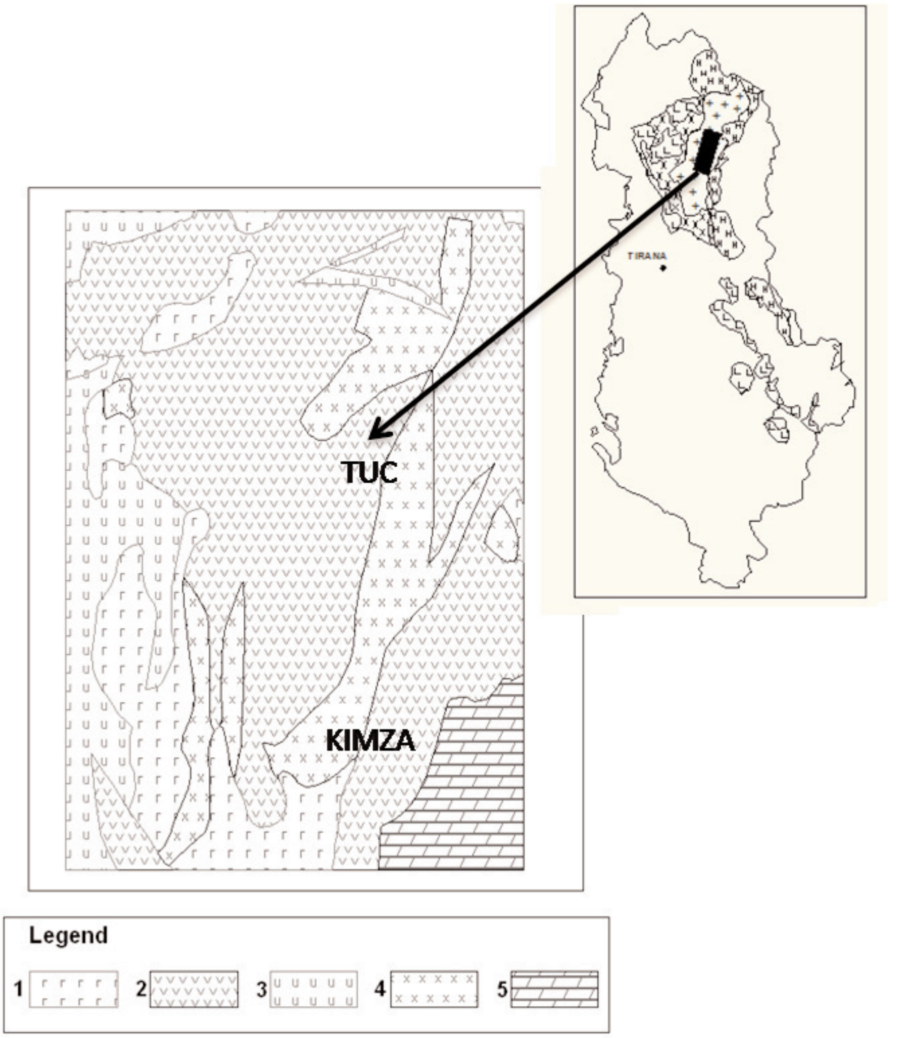

Fig. 1. Geological map of Kimza-Tuci region. Legend: 1. Gabbro, 2. Basalt – andesite, 3. Ultramafic rocks, 4. Plagiogranite, 5. Lower Cretaceous limestone.

thin X-fluoresence, thin section petrography, electron microprobe analysis (EMPA), X-ray diffraction (XRD), thermoanalytical methods (TG/DTG).

Mineralogy of bulk and separated material was examined by X-ray diffraction using transmission geometry. The patterns were recorded in a 5° to 120°, 2θ interval using a curved detector INEL, CPS 120 and a Co anticathode ($\lambda_{CoK\alpha1}$ = 0,70926 Å). The powder samples were placed in capillary tubes (0.5 mm). Chemical analyses of zeolites and associated minerals were performed using CAMECA (CAMEBAX type) electron microprobe under the following operating conditions: accelerating voltage of 20 kV, sample current of 10 nA and a beam diameter 7 to 10 μm. Microscopic observation was done using Leitz Wetzlar microscope.

Here we are focused in EMPA data which allows precise point analysis (REED, 2005) and thus a correct characterization of minerals. This is important since many minerals show a wide variability in size and composition and are not easy to be accurately determined with other methods. For example, feldspars, amphiboles or micas can incorporate many elements, which might be distinctive of certain rock types and their genetic development. Apart from the methodological advantages, one of the strengths of the electron microprobe is the effective combination of back-scattered electron images (BSEI) and quantitative analyses (IONESCU *et al*., 2010.)

Results and discussion

The zeolitization represents one of the most common secondary processes that have involved the plagiogranitic rocks, thus generating the so-called mineralized zone (KATI, 1965). Macroscopically, the zeolitized plagiogranites are white to pink coloured and they are often friable. Zeolites occur as small and thin veins and/or vesicles within the above mentioned rocks and, in some cases are cutting the sulphide mineralized dykes. The thickness of the zeolite veins ranges from a few mm up to 2–3cm.

Based on XRD, EMPA, DTA and optical observation the mineralogical composition of plagiogranite mainly consists of plagioclase and quartz (55–60 %), followed by zeolite (30–35 %) of laumontite-leonhardite series and subordinated amphibole and chlorite (10 %) (Fig. 2).

As from EMPA analytical data, the chemical composition of laumontite is normally near to its stoichiometric formula. The content (as a.p.f.u.) of the principal constituents ranges within the following intervals: 14.90–16.20, 7.91–8.49 and 2.8–3.8 for Si, Al and Ca, respectively. All the analysis show the presence of a Ca highly rich laumontite as it could be expected from the strong calc-alkaline affinity of the host rocks (plagiogranite).

Conclusions

The plagiogranitic rocks from Kimza–Tuci region, northern Albania, are intensively altered and contain veins and vesicles of zeolite. Their mineralogical composition consists of plagioclase and quartz (55–60

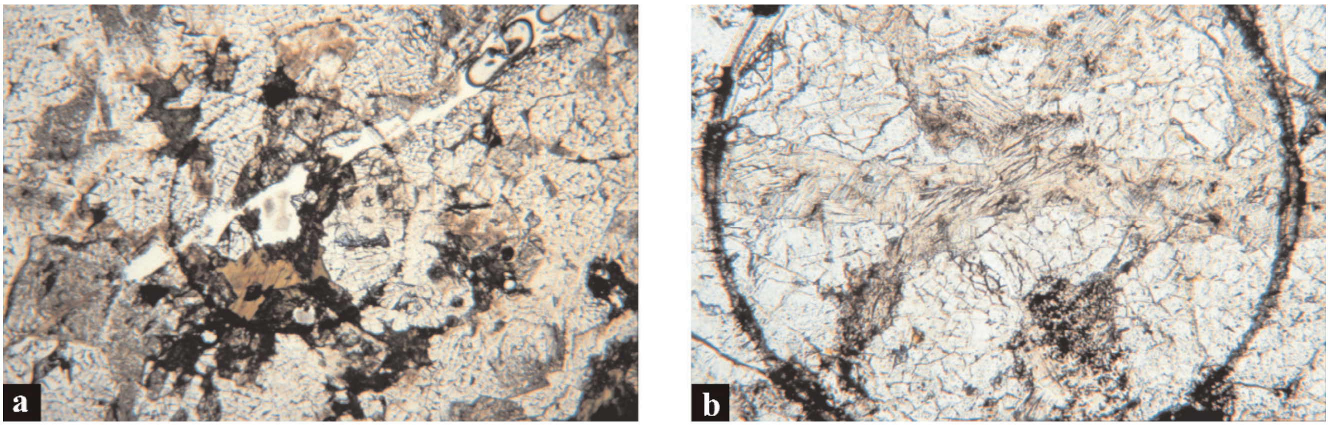

Fig. 2. Microphotos from plagiogranites, showing the zeolitization process; a. Zeolite-free plagiogranite; b. Zeolite-bearing plagiogranite.

%), followed by zeolite (30–35 %) and subordinated amphibole and chlorite (10 %). The zeolite belongs to laumontite-leonhardite series where the Ca highly rich laumontite dominates as it could be expected from the strong calc-alkaline affinity of the host rocks (plagiogranite).

Acknowledgments

We appreciate the help of Dr. Tonin Deda who accompanied us during the sampling.

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17th Meeting of the Association of European Geological Societes	Proceedings	223–228	Belgrade, 14–18 September 2011

Estimation of the Stability of a Marly Slope, After Raining. The Case of Kapsali Area, in Kithira Island

Basile Christaras[1], M. Argyriadis[2] & Eugenia Moraiti[3]

Abstract. In April 2004, the southern part of Kithira Island, in the uphill area of the touristic Kapsali Golf, consisting of marl and overlain by limestone, was affected by a large scale landslide, divided in two parts. This landslide destroyed the road Kapsali–Kalamos.

Our investigation was performed using a combination of lab tests data of cohesion (c) and angle of friction (φ) of the material and back analysis technique of the slope, taken the conditions at failure time.

The slope presents a limited stability which decreases during heavy raining. As it was derived from the analysis, the activation of sliding is related to the silty clayey (CL-ML) character of the material, in relation to the rain conditions and the low porosity of the material which does not permit the easy drainage of the slope.

The occurrence of new slides, in the area, could be real in the future if no protective schedule would be established.

Key words: Stability analysis, slope, landslide, Kapsali area, Kitihira Island, Greece.

The concept of the investigation

The concept of this investigation is related to the use of the back analysis technique for providing a realistic slope stability analysis. In this framework, the derived data, of possible c and φ values, were used for investigating other, neighbor, site of the marly, fine grained, formation.

Location

The investigation area is located at the southern part of Kithira Island, at the uphill area of Kapsali Golf, along the road which connects Kapsali village with Kalamos Village, capital of the island. The landslides were occurred in marls overlain by limestones.

The geological formations at landslide area

The area, which is located at the uphill area of the village, mainly consists of marls with occasional thin sandstone intercalations. The marl is partly weathered, consisting of silty clay (with occasional low percentages of sand), of low plasticity. The stratification of the formation presents a dip-direction of 280/35 (Fig. 2). The upper part of the area consists of calcareous conglomerates (called: plateau"), which are tectonically divided in big blocs, limited by vertical big joints, of E–W and NW–SE directions (Fig. 3). Two faults, of NW direction, limit the northern part of the area. The above measured tectonic data coincide to the general tectonic activity system of the island (Danamos, 1992). Kithira Island is a high seismicity area, as result of the western Greek arc's seismotectonic activity which gave, from 1750 to 1937, earthquakes of M=6.0–7.2 (Papazachos & Papazachou, 2002).

Slope stability analysis

As already referred, the slope consists of marls overlain by calcareous conglomerates. The landslides occurred in the marl. The marl is generally weathered

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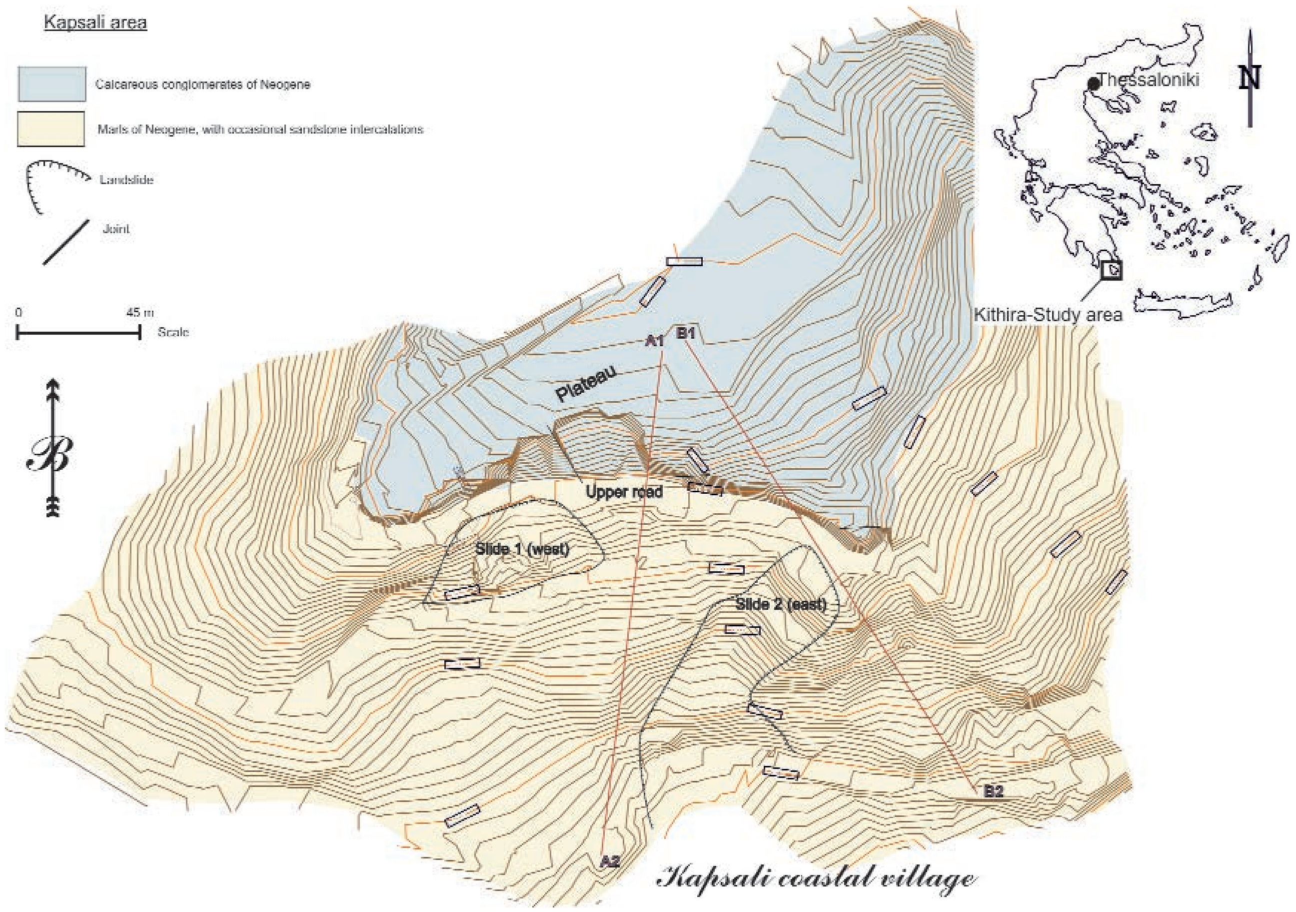

Fig. 1. Geological sketch with the location of the landslides and the studied cross sections (A_1–A_2 & B_1–B_2)

Fig. 2. Marl of Neogene

Fig. 3. Calcareous conglomerate of Neogene

given, in many cases, the impression of a soil. Under dry conditions, the material is hard and cohesive but under humid conditions, looses rapidly its cohesion. The water penetration is low, approximately 10^{-6} taken into account its grain size distribution ($k=100\times d_{10}^2=100\times 0.001^2=0.0001$ mm/sec $=10^{-6}$ cm/sec). The landslide is totally located in the marl and affects the road to Kapsali Village (Figs. 4). In Fig. 5, the toe of the western sliding (slide 2) is presented.

According to our lab-tests, the material is characterized as silty clay (CL-ML) of low plasticity, having the follow parameters: a) clay: 14,31%, b) silt: 74.56%, c) sand: 11.13%, d) LL: 11, e) PL: 5, f) PI: 6, g) φ =23.2° and h) c=0.227kg/cm^2.

Fig. 4. The crest of the eastern sliding "Slide 2"

Fig. 5. The toe of the western sliding "Slide 1"

The slope stability analysis was performed using both BISHOP (1955) and MORGENSTERN & PRICE (1965) methods, which gave similar results. For this reason, in the present paper, only the method of MORGENSTERN & PRICE (1965) was used.

According to our lab test results, the slope, in dry, presents sliding circles of limited stability, with values FS_{min}=1,05–1,3. These coefficients decrease under 1 (slide west: FS_1= 0.993 & slide east: FS_{2up}= 0.958 and FS_{2low}=0.996) in intensive raining conditions, which were considered as realistic for the time of failure.

In our investigation, we considered the marl as homogeneous, even if there are occasional thin sandstone intercalations, accepting c and φ values which correspond to the failure moment.

According to the calculations using lab test c & φ values combined with back analysis data, we estimated, for marl, c=4 kN/m^2 and φ =18°. Furthermore, it was estimated a moisture of 15% which gives an apparent weight of 23 kN/m^3.

Using the data used, at the slides 1 and 2, a new slope stability analysis was performed along to the axes A_1–A_2 and B_1–B_2 (Fig. 1).

Slide 1 (western)

The crest of the landslide is located at a height of 71 m (Fig. 1, 6) while the toe is located at a height of 62 m (Figs. 1, 5, 6). The sliding is circular with W–SW direction. This rotational movement created a failure of 2.5 m high and a horizontal opening of 0.5–1.5 m. For estimating the cohesion (c) and the internal friction (φ) of the marl and performing the slope stability

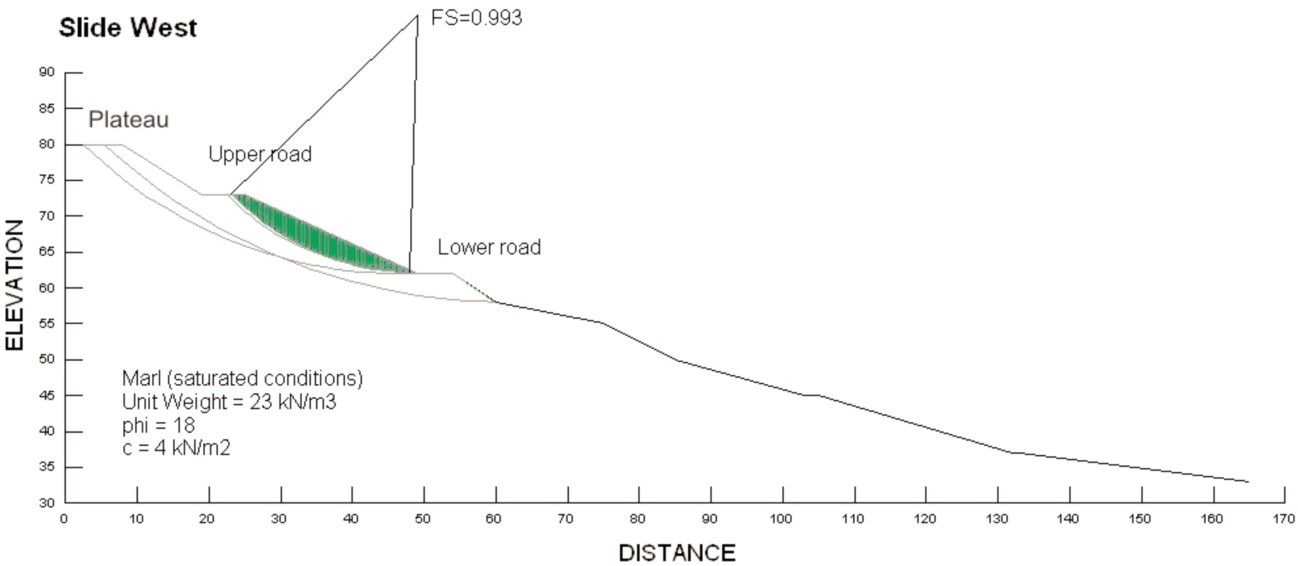

Fig. 6. Slope stability analysis of "Slide 1" using back analysis technique

analysis, we used the back analysis technique, for saturated conditions, which are similar to the raining conditions of the sliding time. So, we arrived to the following data: c=4 kN/m^2 and φ =18°, for the given landslide geometry and safety factor SF=0.993.

The above used values were also verified in the Eastern Slide. It is interesting to mention that several possible sliding circles are given in Fig. 6 but this which is used refers to the slide occurred, living possible the occurrence of a bigger sliding if the slope is not protected.

Slide 2 (Eastern)

This slide occurs two sliding parts. The crest of the upper sub-sliding is located at a height of 70 m (Fig. 1, 4, 7) while its toe daylights at a height of 64m (Figs. 1, 7). The crest of the lower sub-sliding is located at a height of 55 m while the toe daylights at a height of 44 m, not far from the houses (Fig. 1, 8). The sliding covers an area of about 3000 m^2 with a width of 45 m. The sliding was activated toward S–SW direction. The vertical slip, at the crest of the sliding was 5 m.

For similar reasons as for slide 1, we arrived to the following data: c=4 kN/m^2 and φ =18° and safety factor SF=0.958, for the upper sub-slide and SF=0.996 for the lower sub-slide.

Slope stability analysis along A1–A2 and B1–B2 axes

The results of above slope stability tests were used for analyzing the slope stability along the neighbor cross-sections A_1–A_2 (Figs. 1, 9) and B_1–B_2 (Figs. 1, 10).

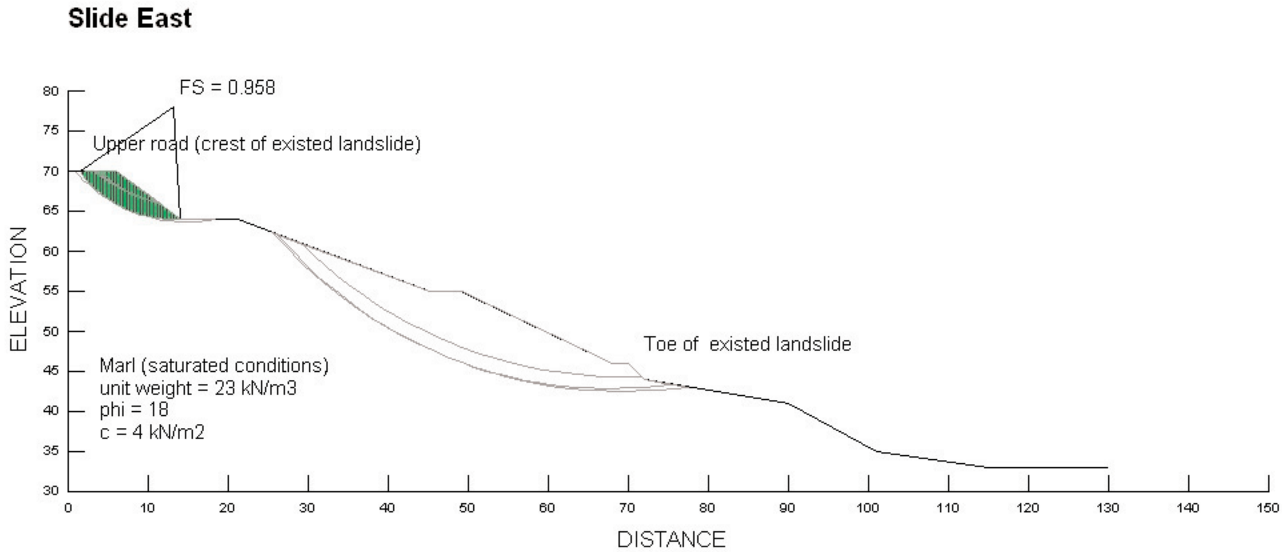

Fig. 7. Slope stability analysis at the upper part of the eastern slide (slide 2), using back analysis technique

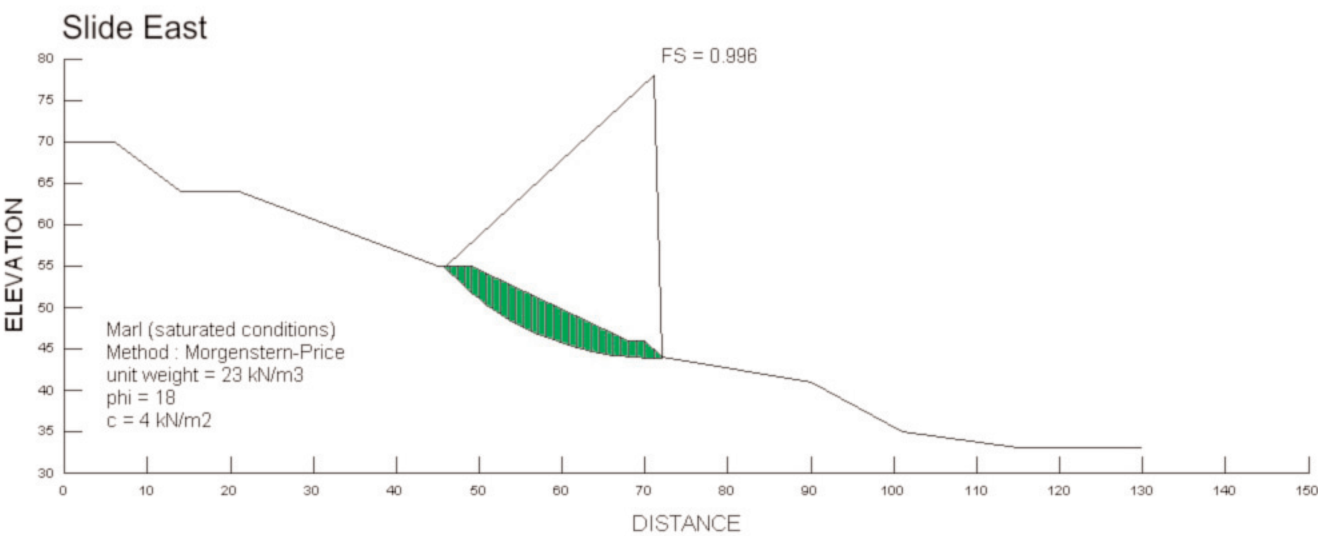

Fig. 8. Slope stability analysis at the lower part of the eastern slide (slide 2), using back analysis technique

According to our elaboration, the sliding circles give safety factors A_1–A_2: SF=0.926 (Fig. 9) and B_1–B_2: SF=0.66 (Fig. 10).

• The slope presents a limited stability which decreases during heavy raining. As it was derived, the landslides were activated by the heavy rain in relation to the low porosity of the silty-clayey (CL-ML) identity of the material which did not permit the easy drainage of the slope.

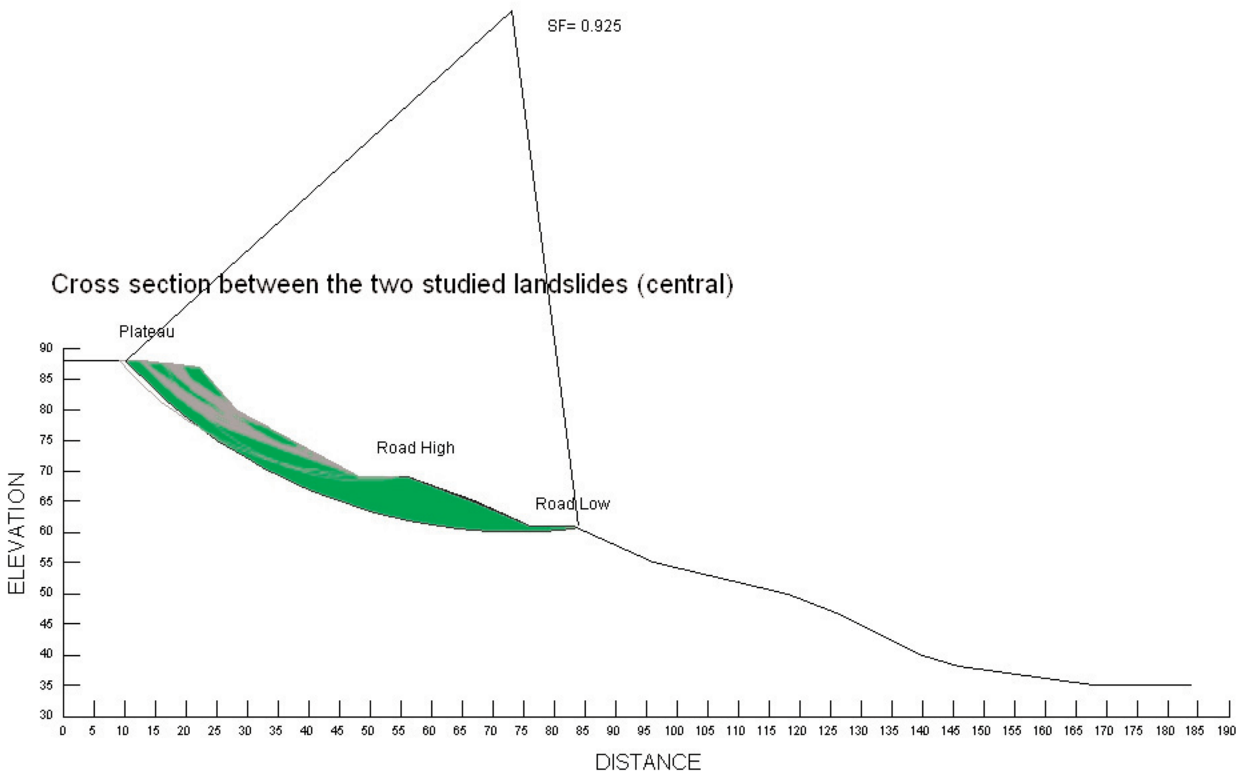

Fig. 9. Slope stability analysis along the axis: A1–A2, using back analysis data

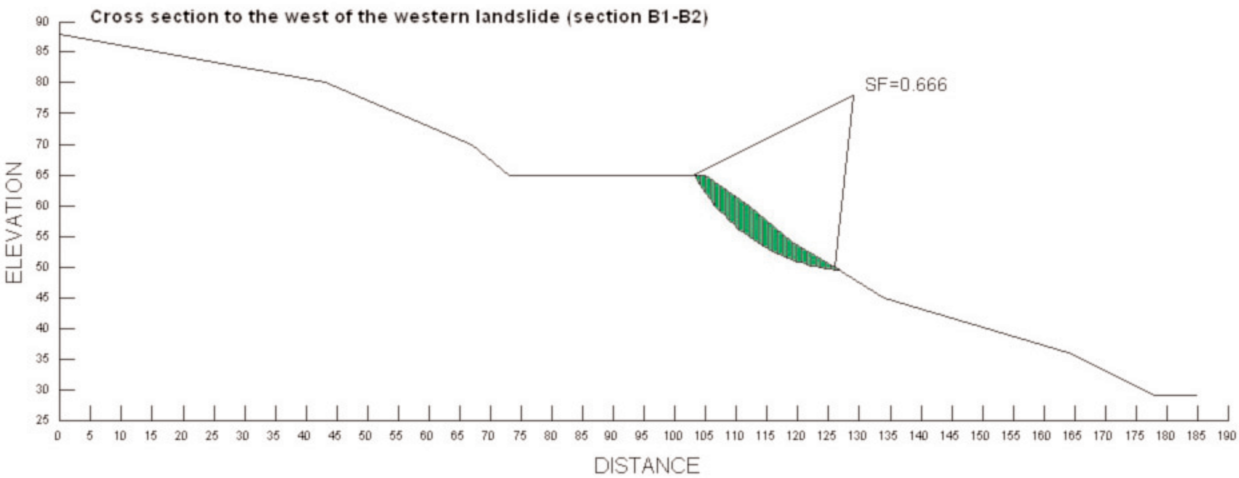

Fig. 10. Slope stability analysis along the axis: B1–B2, using back analysis data

Conclusion

According to our investigation, we conclude that:

• The combination of the calculations using lab test data with the back analysis technique takes in mind the conditions of the failure time.

• As we saw, in the case A_1–A_2 and B_1–B_2, the occurrence of new slides, in the area, can be real if no protective studies and measures are taken.

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Geotouristic Objects Revealed by Geotechnical Activities

DRAGUTIN JEVREMOVIĆ[1] & SRĐAN KOSTIĆ[1]

Abstract. In the past few years, geotourism slowly becomes one of the fast growing branches of tourism development in the world. The focus on the earth and its geological features, is essential to the planning, development and management of geotourism. Concerning the fact that important engineering objects, like dams, tunnels or quarries, include investigations to a great depth (100 m and more), there is a strong link between these works and geotourism development. Apparently, many interesting geological features are burried deep underground, and they could be easily revealed by tehnogenic activity. In this paper, some of those examples are mentioned, like Dinosuars Ridge in Denver or Road cut near Alabama. Besides these objects in the USA, there are numerous examples in Serbia - mammoth fossiles in coal mine ”Drmno” and clay mine in Kikinda, Han-Bulog limestones in ”Klisura” quarry, limestones with Ammonites near cement factory in Kosjeric, or fine Upper-Cretaceous cross-section with gastropods in ”Mašin majdan” quarry in Topcider. All these geo-objects imply a need for a cooperation between geotourism and engineering geology.

Key words: geotourism, geo-objects, excavation, fossils, geological formation, economic development, engineering geology.

Introduction

Over the past six decades, tourism has experienced continued expansion, becoming one of the fastest growing economic sectors in the world. As it can be seen in Figure 1a, in spite of occasionalshocks, international tourist arrivals have shown significant growth. In 2010, according to the World Tourism Organization, travel for leisure, recreation and holidays, which includes geotourism, accounted for over half of all international tourist arrivals (Fig. 1b).

This increased interest in geotourism is also confirmed by many studies: BUCKLEY (2003), RÖHLING & SCHMIDT-THOME (2004), HOSE (2008) and DOWLING (2011). Apparently, in the past few decades, there has been a substantial growth in geotourism, as tourists have demanded access to interesting geological features in as non-destructive fashion as possible - landforms, rock outcrops, rock types, and ”proceses”, such as volcanism, erosion, glaciation etc. DIMITRIJEVIĆ (1998), NOURI (2008). There are numerous beautiful geological sites all over the world, which are considered as a natural heritage (Grand Canyon in USA, waterfalls of Niagara and Victoria, Pamukkale in Turkey, geysers and volcanic necks of Yellowstone in USA, Great Barrier Reef in Australia, atoll Aldabra on Seyshells, Ngorongoro Crater in Tanzania, Los Glacares in Argentina, etc). However, many potential geotouristc objects are hidden deep in ground, covered with thick layers of different rock masses, or tectonically disturbed and displaced. Concerning this, engineering geological investigation and excavation for many engineering objects, like dams, tunnels and quarries, often reveal these rock masses, which could be mutually benefitial, both for local community development and for geology as a science.

Excavated Geotouristic Objects in the World

Probably the most famous geo-site excavated by engnineering works is a Dinosaur Ridge area in Denver (Colorado, USA), one of the world’s most popular dinosaur fossil localities. When Alameda Parkway was being constructed in 1937 to provide access to Red Rocks Park, workers discovered hundreds of dinosaur footprints, including mostly *Iguanodon* - like footprints, perhaps from *Eolambia*. Carnivorous theropod tracks are also present. CARSLON & NOE

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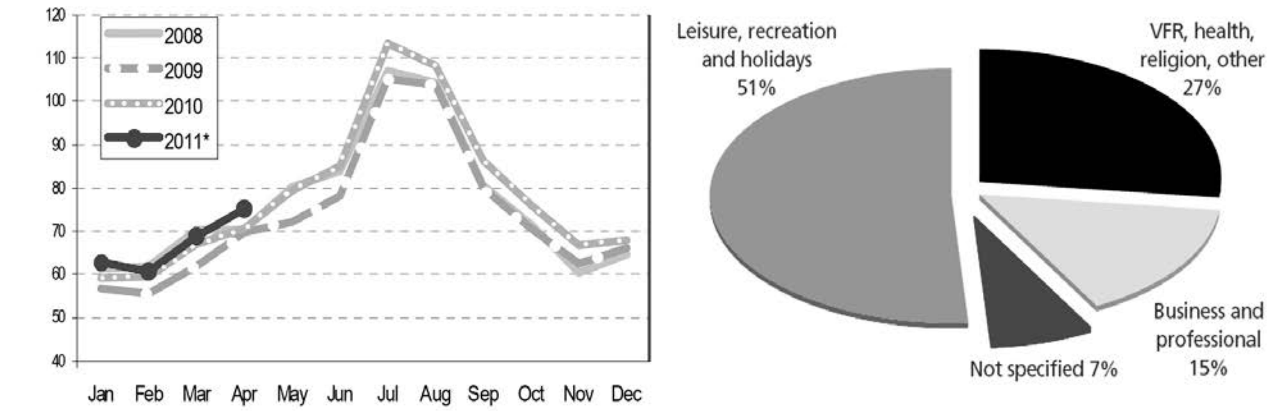

Fig. 1. a. International tourist arrivals in the world, monthly evolution; b. Inbound tourism by purpose of visit, 2010. (WTO, 2011).

(2006). Geological formation of the wider area is also interesting. The rocks on the west side of Dinosaur Ridge are part of the widespread Morrison Formation of Jurassic age, composed dominantly of siltstones, mudstones and claystones. East side of Dinosaur Ridge is a part of the Cretaceous Dakota Formation, which consists of two units, the Lytle Formation and the overlying South Platte Formation. Both formations are dominantly sandstone units, but both do have significant claystone and siltstone intervals (AMUEDO & IVEY, 1978).

Another example of excavated geo-object is the rock cut on the Red Mountain Expressway near Birmingham (Alabama, USA). During its construction, more than 1,5 milion m^3 of rock was excavated, forming a cut 555 m long, 63 m deep, 45 m wide at the bottom, and 141 m wide at the top. An unusually interesting geological section was exposed. Rocks vary from the limestones of Middle Ordovician age through Silurian formaton of shales, cherts, limestones and sandstones. Realising the huge geopotential of this cross-section, the cut was developed by constructing a series of steps and platforms, with access to viewing platforms at several levels LEGGET (1973).

Excavated Geotouristic Objects in Serbia

There are numerous geological features in Serbia which are revealed by engineering works. Firstly, mammoth skeleton, about 1,5 million years old, was found in 2009, in the coal mine ”Drmno” near Kostolac, in the 27 m deep gravel layer. It is almost completely preserved, except for small fractures of scull and tusk. Reconstruction has shown that mammoth was about 4,5 m high, 6m long, and weighted about 10 t. It belongs to species *Mammuthus meridionalis*.

This mammoth is a direct ancestor of mammoth ”Kika”, found in clay mine of the „Toza Markoviæ” factory, near Kikinda, in 1996. which belongs to species *Mammuthus trogontherii*. The remains of ‘‘Kika’’ could be seen in Natural Museum in Kikinda.

Furthermore, interesting geological profile of the Upper Cretaceous sediments was revealed during the works for the purpose of cement marls exploration, in the valley of Skrapez river, near Kosjeric. The basis of sediments is built up by Paleozoic schists, which are covered by gray and pink conglomerate-breccia limestones, with rare fossils of Rudists. In the upper part of the formation, there are pink and gray-yellow layered cement marls (PAŠIĆ, 1957)

The most famous example of Han-Bulog limestones are found in the ”Klisura” quarry, in village Trnava (Sirogojno, Zlatibor). The formation is built up by gray and red limestones rich in microfauna and Ammonites. These limestones have very favourable mechanical properties, with uniaxial strength of 117 MPa, and resistence to abrade of 18,9 $cm^3/50\ cm^2$.

Also, nice cross-section of Upper Cretaceous sediments with lots of Gastropod fossils is revealed by rock excavation in a quarry ”Mašin majdan” on Topcider, Belgrade. Would we have this geo-object today without rock excavation? Certainly not, but we would not have it neither if the excavation did not stop. This is a good example of a geo-object that was revealed by engineering activity, but also ”survived” due to abandonment of quarry. But, only few of these objects could be seen today. Many of them were ruined by the further excavation.

Geo-Conservation of Revealed Objects

Geo-objects, revealed by engineering activity should be protected and marked in a proper way, so as to provide a full touristic function. They should be bounded by a special fence, and, if necessary, other means of protection could be included (if, for exmaple, object is sensitive to the influence of precipitation). The main geological data (cross-section with characteristic details, fossils sketch, etc), as well as data about the geo-object itself (registration year, object category) should be presented on a special board in front of it. Also, a special touristic guide should be prepared for every object. Furthermore, a special map of geotouristic objects in Serbia should be made, where objcets would be classified according to their category and rank. The map should have an appropriate guide, which would complete the touristic function of excavated objects. Only in this way, the potential of these interesting locations would be fully used.

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17th Meeting of the Association of European Geological Societes	Proceedings	233–235	Belgrade, 14–18 September 2011

Geoscience in the Digital Age: a Perspective From "Down Under"

Ian Lambert[1,2] & Lesley Wyborn[1]

Abstract. New developments in web technologies, data transfer standards, computing power and open source processing algorithms are making geological and geospatial data and information much more accessible online and applicable for purposes beyond those they were originally collected for.

Geoscientists are progressively taking advantage of these advances to realise opportunities to apply their experience and skills in multidisciplinary systems approaches. These opportunities are arising because authoritative advice is being sought increasingly by governments as a basis for making decisions and developing evidence-based policies to address the many challenges we face in meeting the needs of societies while sustaining Earth systems.

This presentation will succinctly illustrate effective applications of integrated systems approaches to major issues for Australia, such as mineral and energy resources for the future, mapping and managing groundwaters and soils, land use decisions and mitigation and management of natural hazards.

Attention will also be drawn to the wide range of sessions on geology in the digital age which will be a feature of the 34th International Geological Congress (www.34igc.org), to be held in Australia in August 2012.

Key words: geoscience information, multidisciplinary systems approaches, authoritative advice

Introduction

Geoscientists are playing progressively more significant roles in multidisciplinary systems approaches to underpin "sustainable development". Faced with increasing scrutiny of their policies and decisions by a better educated and informed public, enlightened governments appreciate that such approaches can provide the evidence base they need to underpin important decisions and policies.

Ongoing advances in geological and geospatial information management and availability – a number of them benefitting from European leadership under the OneGeology initiative – as well as in the computing power to analyse and model these data, are rendering these approaches progressively more effective.

This presentation will discuss some Australian examples of geoscience contributions to evidenced-based decisions and policies. It will note that the influence of the geosciences depends on strategic approaches – the work of the national geological and geospatial organisation, Geoscience Australia, has focused on gvernment priorities and national challenges, and a collaborative approach has been adopted to geoscience information and national computing infrastructure.

It will also draw attention to the scientific program for the 34th International Geological Congress. While this large and prestigious meeting will cover the whole spectrum of the geosciences, it will feature a wide range of sessions on the influential roles the geosciences can play in the rapidly evolving digital age.

Recent advances

Over the last 50 years, Australian geoscientists in academia, in government geological surveys and in industry have amassed substantial volumes of digital geoscience data. Significant amounts of these data are now potentially available either via the internet or at a nominal cost of transfer. There is estimated to be up to 3 PB of publically funded geoscience data sets in Australia, and the majority of this is held by Gescience Australia (GA). This volume is growing exponentially as improvements in the capability of

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instruments have resulted in data being gathered at a greater rate and at higher resolution. However, the resolution and size of digital geoscience data sets have reached the point where the subsequent analysis of this data is exceeding the computational infrastructure of most organisations.

This has created a situation where geoscience organisations are not capable of utilising available digital data to its fullest resolution. In summary most organisations (research, government and industry) have the following problems:

1. Capability to store and dynamically access geoscience data sets internally;
2. Capability to process these data sets to their highest resolution;
3. Inability to provide them online to partners, clients and stakeholders, both nationally and internationally;
4. Inability to integrate digital geoscience data sets with data sets from other areas such as marine, water, climate, etc..

To address this issue of inability to fully utilise available geoscience data there is a move to more distributed systems which can allow seamless access to data that is coupled to online software and compute resources in the 'cloud'. Cloud computing is a delivery model for IT services based on the Internet. Users no longer need knowledge of, expertise in, or control over the technology infrastructure "in the cloud": such services are virtualised and mostly available on demand. They can remotely log on, do the required processing online and then download the result: where "in the cloud" the actual data, high performance computers and software are geographically located is irrelevant.

Such a distributed system is highly dependent on the adoption of international standards for the exchange and transfers of digital geoscience data, and internationally the initiatives of the International Union of Geological Sciences, in particular the Commission for the Management and Application of Geoscience Information and OneGeology.

A brief, high level overview will be given of recent advances in spatial data infrastructure and geoinformatics initiatives, dissemination and exploitation of geoscience data, 3D & 4-D modelling and visualisation. The increasing availability of open source software and cloud computing is opening up new avenues of geoscience research to much wide audiences.

Addressing major challenges

Clearly, time will limit the consideration that can be given to examples of the importance of geoscience data and geoscientists in addressing major challenges. The intention is to provide a general indication of some recent and potential applications in Australia.

Mineral and energy resources for the future

The demand for mineral and energy resources will not abate in the foreseeable future. However, the rate of discovery of new resources to replace those that have been produced is decreasing as exploration has to focus on targets with no obvious surface expression. Exploration under cover needs to be guided by integration of geophysical data with geological observations. Governments have been funding acquisition of regional scale data for this and other applications. A succinct outline will be given of how geophysical techniques can now be used as the basis of sophisticated models of subsurface materials and processes, which can guide exploration.

Natural disasters

Given rapid increases in populations and infrastructure, the economic and social losses caused by tsunamis, earthquakes, volcanic eruptions, fires and floods worldwide have increased dramatically in the last century. We will outline approaches to developing better tools for more effective risk management and improving our ability to monitor natural hazard phenomena. Capabilities have improved dramatically over the last two decades, due to timely access to data from the proliferation of observation platforms including real-time seismographic, geodetic and sea level networks as well as space- and air-borne remote sensing systems.

Groundwaters and soils

Enhanced knowledge of the quantities and qualities of groundwaters is vital in many parts of the world where water resources are under pressure. In cases where other observational data are limited, geophysical data can provide useful information. In particular airborne electromagnetic surveys, which distinguish materials of different conductivities, can provide information on the distributions of saline and fresh groundwaters. Interpretations should be confirmed by targeted drilling at key locations.

Radiometric (gamma ray) surveys map the distribution of natural radioactivity in materials to depths of about half a metre. These can be used for mapping soils, regolith and outcrops, and for understanding landscape processes.

Resolving land use issues

As populations and economies grow, there is inevitably increasing competition for access to land for a range of purposes. In particular, there is increasing acceptance that significant areas need to be protected. However, reality demands that there needs to be a balance between conservation and development and that multiple and sequential land use options need to considered. It will be outlined how integration of geoscience layers with environmental and social values can be used to facilitate land use decisions.

Geology in the digital age featured at 34th IGC

This meeting, which will attract thousands of delegates from over a hundred countries, will cover the whole spectrum of the geosciences. The major **Geoscience Information** theme, which is being coordinated by Bruce Simons, Simon Cox, June Hill and Lesley Wyborn (Australia), Robert Tomas (Europe) and Richard Hughes (UK), will cover:

- The status of the main spatial data infrastructure and regional geoinformatics initiatives and developments from Oceania, Africa, Asia, Europe and the Americas.
- Geoscience information management best practice and standards that enable seamless access to distributed digital data
- New methods for the delivery, dissemination and exploitation of geoscience data and information – including developments and plans from the OneGeology Global and OneGeology Europe initiatives
- Information technology challenges and solutions in the geosciences; data assimilation at petascale; high performance computing and cloud technologies in the geosciences;.
- 3D & 4-D modelling and model fusion, towards the development of predictive environmental modelling platforms
- Applications of geomathematical analysis and modelling in the field of resource exploration; application of geostatistical and geomathematical methodologies and tools to the interpretation of geochemical data, remotely sensed data, rock anisotropy and climate data
- The ability to integrate geoscience information with other earth systems domains such as water, marine and environment
- The creation of information and knowledge from geoscience data to address societal needs and create societal impacts and benefits and developments and best practice in the delivery of dynamic and static data and information.

Concluding remarks

The geosciences have vital underpinning roles to play in multidisciplinary systems approaches addressing many of the major challenges of the 21st century. Our capacity to provide key information and advice to guide decisions and policies is being facilitated by developments in web technologies, data transfer, computing power and open source processing capabilities.

Acknowlegments

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17th Meeting of the Association of European Geological Societes	Proceedings	237–240	BELGRADE, 14–18 September 2011

Mineralogical Characteristic of Smelting Slag in the Technogenic Deposit „Depo 1" (Bor, Serbia)

VESNA LJUBOJEV[1], JELENA PETROVIĆ[1] & SLADJANA KRSTIĆ[1]

Abstract. Technogenic copper deposit of smelting slag "Depo 1" (treated as deposit of technogenic mineral resources, considering the content of useful components in it and the possibilities of their evaluation) is one of the four slag dumps in the industrial circle TIR (Smelter and Refineries) in Bor. "Depo1" is the most important and biggest dump slag from the reverberatory furnace. The "Depo 1" slag was dumped until 1997. This paper is the result of TR33023 Project, funded by the Ministry of Science and Technological Development of the Republic of Serbia. The paper shown mineralogical (and structural) characteristics of smelting slag from "Depo 1" in Bor, in order to determine as better possible the properties of slag (in order to determine the extent necessary for fragmentation in the further exspermental investigations in the flotation).

Mineralogical determination (qualitative and quantitative mineralogical analysis) was conducted on representative sample S-1. Smelting slag from reverberatory furnaces characterized by heterogeny in terms of physical, mineralogical and chemical properties. This is due to the variety of ores, concentrates and fluxes used in the smelting process, and technologies that were applied. Based on the qualitative mineralogical analyses, the following mineral composition of slag was found out: solid dissolved sulphide (Cu–Fe), chalkosine, pyrite, copper, chalcopyrite, bornite, magnetite and tailings minerals (quartz, fayalite etc.). The structural characteristics of samples are important because of provisions necessary degree of fragmentation for further research in the flotation. They can be divided into: simple mesogen (14.09 %) and mesogen compound (15.84 %) minerals.

Key words: technogenic copper deposit, smelting slag, structural characteristics, oreminerals, waste rock minerals, simple mesogen, mesogen compound minerals.

Introduction

Within the industrial zone RTB in Bor, the border zone of the rock overburden dump occurred during surface excavation of the geogenetic copper deposits "Bor" (or some of the ore bodies of this deposit); there is a technogenic copper deposit of smelting slag "Depo 1". In the industrial zone of TIR (Smelter and Refineries) in Bor, there are four landfills of smelting slag. The most important and largest dump slag from reverberatory furnace (dumped until 1997) is "Depo 1". Depot is indicated by number 1, because it is treated as bearing technogenic mineral content of useful components and possibilities of their evaluation. Reverberatory slag is disposed northwest of "Depo 1", the "Depo 4". Tray "Depo 1" takes the form subhorizontal plateau, with slopes that are inclined toward the NW. Technogenic copper deposit "Depo 1" is of izometric form, whose long axis orientation is NW–SE and NE–SW short. Long axis dimension is about 700 m and less about 200 m. Average thickness of deposit is about 30 m (Fig. 1a), JOVANOVIĆ (2007). In the southeastern part bordering with the flotation tailings (in the old open pit ore body H), while the northwest border with "Depo 4" which since 1997 is deposited by the slag from the flame the smelting furnace. Northeastern border of the bearing surface mine tailings is made by the southwestern industrial plants TIR (Sulphuric acid, smelting facilities and power plants), industrial and road and rail infrastructure. Medium content of useful components and the balance reserves of copper bearing technogenic "Depo 1" certified reserves of the study, NIKOLIĆ (2005). After that, the access to this deposit exploitation, KRZANOVIĆ (2007).

The landfill was created by successive outpouring of red-hot molten slag, and in this respect similar to

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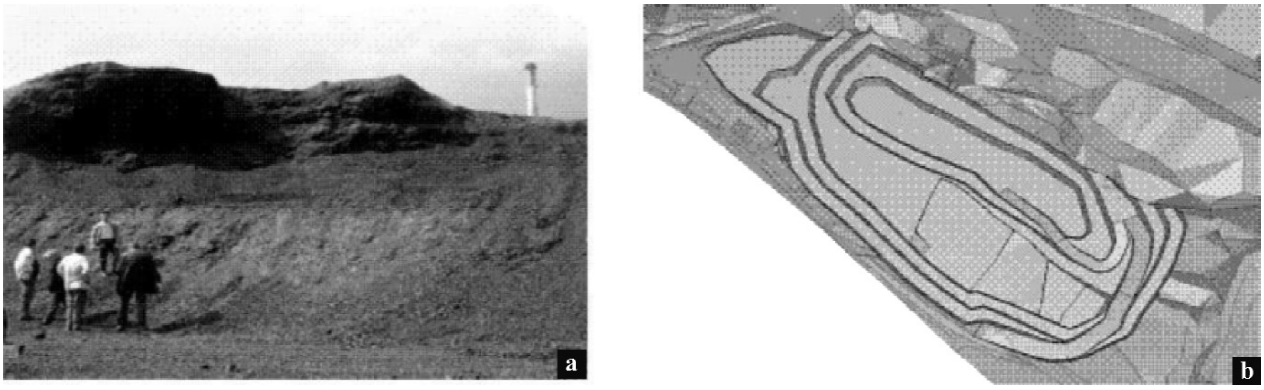

Fig. 1. a. Steep slopes of tehnogenic deposit “Depo 1”; b. Open pit “Depo 1” (3D).

the outbursts of lava. Geological characteristics of technogenic copper deposit “Depo 1” were conditioned, above all, the immediate backgrounds on which are deposited as landfill and method of formation. The immediate surfaces of the landfill are mostly also technogenic materials (rock overburden at the surface exploitation - “open pit waste”, etc.) Previously deposited in the bed of the Bor River, while only a small part just below the slag of the geogenetic formation (Bor conglomerates, volcanic clastic rocks and alluvium), KRZANOVIĆ (2009). The construction of open pit “Depo 1” was done on the basis of certified ore reserves categories B and C_1 using the software package for designing GemcoM 6.1.3 Pit Design in the module (Fig. 1.b). Bottom surface mine is 310 m. The highest floor is E 350, and is the largest

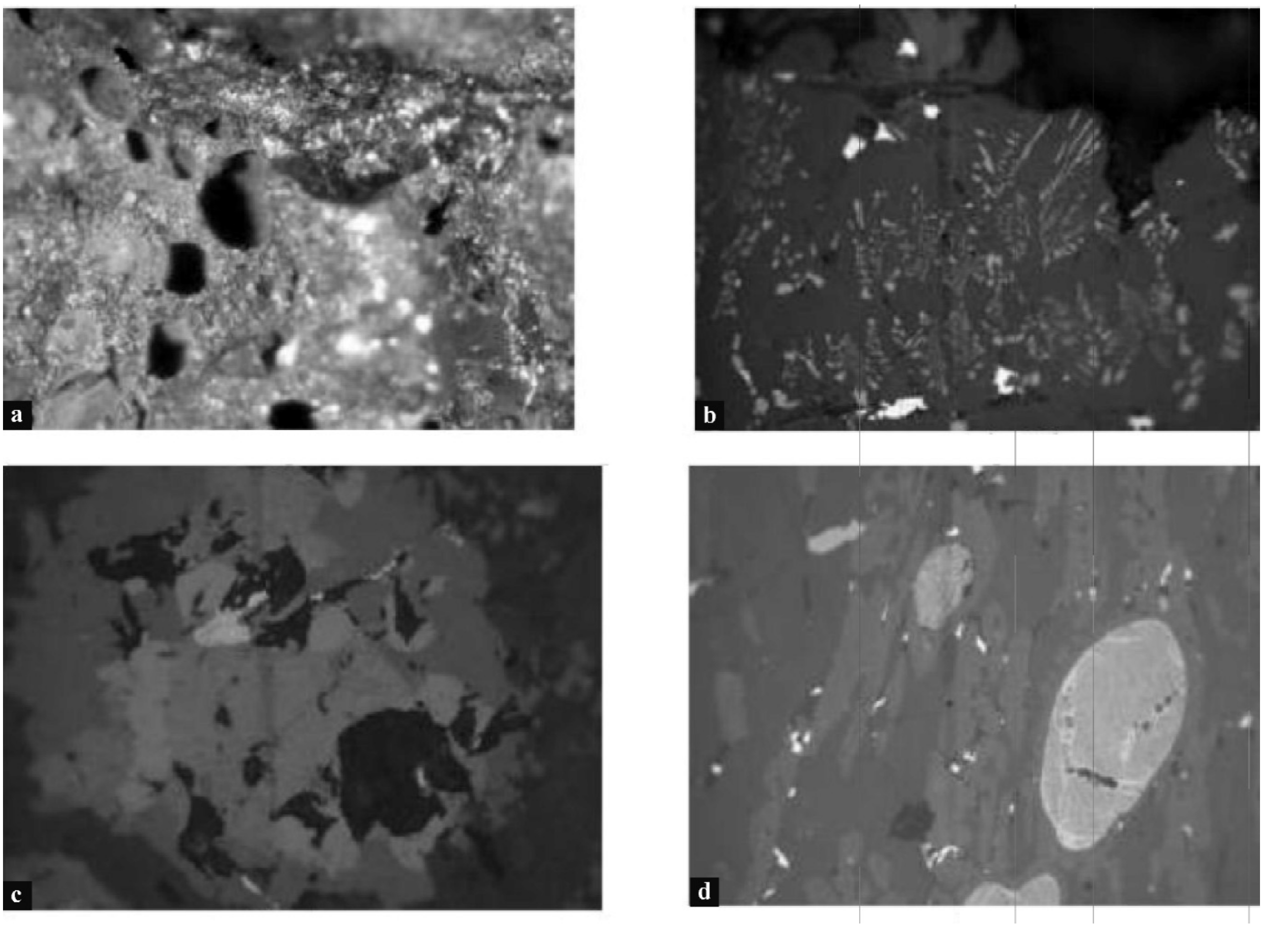

Fig. 2. a. Smelting slag sample 1, binokular, 50×; b. Photomicrography pyrite and dendrites ferrite, 50×II Nikol; c. Photomicrography mesogene chalcopyrite, pyrite and elemental copper matte with the allocations of copper, 50× II Nichol; d.Photomicrography copper matte in fayalite basis, 50× II Nichol.

Table 1. a. Quantitative mineralogical analysis of sample S-1; b. Structural set of sulphide minerals of sample S-1.

Name of mineral	%
Pyrite grown out with waste	10.16
Chalcopyrite grown out with waste	3.73
Chalcopyrite grown out with pyrite	1.53
Pyrite grown out with chalkosine	0.55
Chalcopyrite grown out with chalkosine	4.60
Chalkosine grown out with bornit e	3.16
Chalcopyrite grown out with (and inclusions of Cu)	0.01
Chalcopyrite grown out with pyrite . chalkosine and bornite	0.14
Chalkosine grown out with waste	0.89
Chalcopyrite grown out with waste and bornite	0.34
Chalcopyrite grown out with bornite and chalkosine	5.32
Native copper in copper matte	0.23
Waste	69.34
Total	100

a.

Structural set of sulphide minerals	
Mesogen	%
Simple mesogen	14.09
Complex mesogen	15.73
Total	29.84

b.

digging depth H = 50 m. Open pit depth is the height-type. Flotation recovery is (average) 50 % copper, 50 % gold and approximately 40 % silver. Metallurgical recovery of copper 94 %, gold 90 %, and silver 90 %, NIKOLIĆ (2006).

Materials and methods

The structural and mineralogical studies of smelting slag were done with a specified „Depo 1“ from which the representative samples were taken.Qualitative-quantitative mineralogical analysis was performed for mining products (S-1/1, S-1/2, S-1/3, S-1/4 and S-1/5). Determination slag samples was done by *Axsioskop 40 microscope*, with a device for photomicrography. Qualitative mineralogical analysis was performed with polarizing microscope (reflected light), which were used for identification the ore and waste rock minerals (determination of mineral composition and texture determination the structural characteristics of minerals). Quantitative mineralogical analysis was done using parallel profiles at distance of 1 mm. The distances between the examined fields and profiles were manually moved. Chemical analysis was performed on samples of isolated magnetic slag. It was carried out on the device *Niton XL-L3T-900*.

Discussion

All samples are dark gray color, steel shine, with local occurrences of irisating blue-green tint as the result of long standing slag in the air. On the surface of samples are visible spherical cavityies, which indicating the sample product-smelting slag. Qualitative mineralogical analysis showed the following mineral composition: fayalite and ferrite (Fig. 2b) which is the basis of slag in which pyrite, chalcopyrite, chalkosine, bornite, solid sulphide (copper mattes - Fig. 2.d) and native (metalliccopper) occur. Qualitative mineralogical analysis is shown in Table 1a.

Sulphide content in the sample mass is 29.84 %, where the sulphide mineral grains bound in a simple (about 14.09 %) and mesogene compound (about 15.75 %). Figure 3b shows the mesogene of pyrite and chalkosine. Structural set of sulphide minerals is given in Table 1b and in Fig. 4a.

It can be concluded from chemical analysis that the most common is iron 38.68 %. It indicates high mineral content of iron, which after thermal oxidation treatment in the smelter exceeds Fe_2O_3 and Fe_3O_4. Also, high iron content causes high magnetism of a sample. Copper is 0.382 %. The results are shown in Fig. 4b and 4c.

Conclusion

Technogenic deposit of smelting slag “Depo 1” in Bor was formed as a byproduct of one of the stages of pirometallurgical production of copper. Technogenic deposit of smelting slag “Depo 1” in Bor is characterized by a variety of textures. Megatexture of deposits in the meter to the observation area decametric pseudo-layers with characteristic cracks contractionary. Macrotexture in decimeter field observations, are very diverse (the observed patterns of porous, foam texture and crusty, breccia textures, solid texture, and other textures).

Based on previous data material is present in the deposit of copper “Depo 1” can be seen as unrelated to poor bonded, desintegrated material tehnogenic origin, viewed from the standpoint of its exploitation. According to the scale, the technogenic deposit “Depo

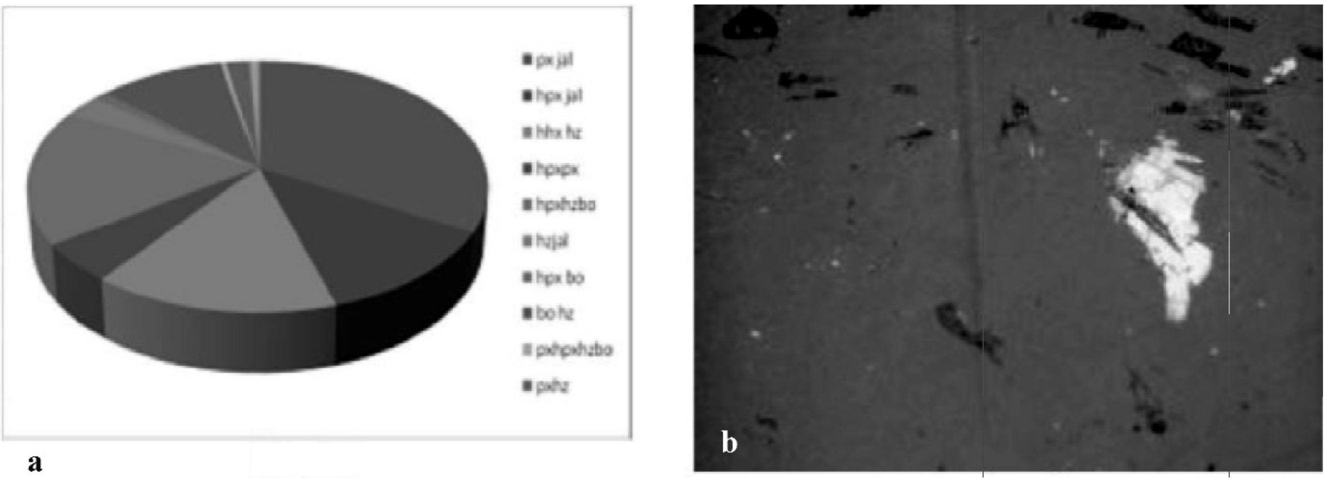

Fig. 3. a. Quantitative mineralogical analysisof sample S-1; b. Pyrite grown out withchalkosine.

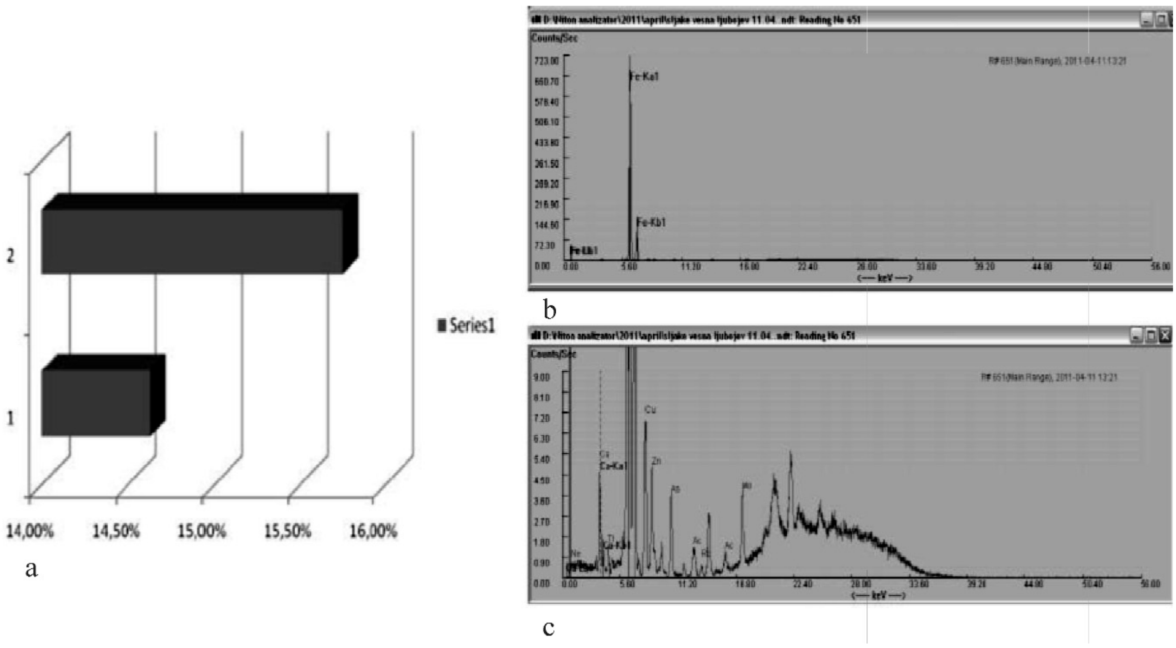

Fig. 4. a. Structural set of sulphide minerals of sample S-1; b. Chemical analysis ofsample S-1/1 (NITON XL-900-3t); c. Chemical analysis ofsample S-1/3 (NITON XL-900-3t).

1" belongs to the category of small copper deposits. Mineral composition of the slag consists of metallic and non-metallic minerals. Based on the qualitative mineralogical analysis showed the following mineral composition of slag is shown: solid dissolved sulphide (Cu–Fe), chalkosine, pyrite, copper, chalcopyrite, cuprite, bornite, magnetite and minerals tailings. Results chemical analysis on representative sample S-1: Fe 38.68 %; As 0.10 %; Zn 0.20 %, Cu 0.38 %; Si 10.87 %; Al 1.38 %; S 0.78 %; Mg <1.30 % and rest 43.74 %. Non-metallic minerals (tailings) are represented by the appearance of glass with different eutektic dendrites (fayalite etc.). Ore mineral is the most abundant sulphide phase "solid sulphide Cu–Fe melts". The structural characteristics of samples are important because of provisions the necessary degree of fragmentation for further research in the flotation. They can be divided into: simple mesogen (14.09 %) and mesogen compound (15.84 %) minerals.

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Hydrochemical Features of the Kavaja Groundwater Basin (Preadriatic Depression, Albania)

SUADA LUZATI[1], ARJAN BEQIRAJ[1], MAJLINDA CENAMERI[1] & JAUPAJ OLGERT[1]

Abstract. The basin of Kavaja is part of the Rrogozhina aquifer which is a multilayered aquifer consisting of Pliocene molassic formations and occurs under the typical artesian conditions. The groundwater shows variable geochemical composition due to different mineralogical composition where the HCO_3–Mg–Ca hydrochemical groundwater type dominates. The groundwater contains high content of iron that ranges from 0.2 % up to 2.5 % FeO. The general mineralization and general hardness of groundwater range from 500 to 800 mg/l and from 11 to 25° dH, respectively. In some cases, NH_4^+, SO_2, $Cl^–$, etc, are found in concentrations higher than the limits of drinking water. The groundwater geochemical composition evolves gradually from HCO_3 type in the recharge zone to Cl type in the discharge zone and its General Mineralization shows a gradual increase towards the depth of the aquifer. The lowest values of the General Mineralization and Hardness correspond to the highest values of the hydraulic conductivity in the central part of the groundwater basin.

Key words: Kavaja, groundwater, aquifer, hydrochemical composition.

Introduction

The basin of Kavaja is part of the Rrogozhina aquifer which spread out over the Albanian pre-Adriatic depression and extends from Shkodra in the north to Vlora in the south, over a surface of 2100 km^2 (EFTIMI, 1984). It is a multilayered aquifer consisting of intercalations between water-bearing Pliocene sandstone and conglomerate with impermeable clay layers. The basin of Kavaja forms a syncline (HYSENI, 1995), whose axial part consists of water-bearing Astian conglomerates and sandstone covered by Quaternary alluvial sediments, whereas the Piacensian clay formations construct the western and eastern flanks of the syncline (Fig. 1).

This aquifer occurs under typically artesian conditions because i) the water-bearing sandstones and conglomerates are intercalated with impermeable clays; ii) they construct syncline forms; iii) the recharge zones have higher quota then the discharge zones. The sandstones and conglomerates show very heterogeneous permeability due to their different lithological composition, variable particle size distribution, different extent of their compactness, type of the cement, depth of the water-bearing layer, etc. This has conditioned an extremely variable yield of the wells (EFTIMI, 1984). The main recharge source of the aquifer is represented by precipitations thanks to its vast (around 500 km^2) outcrop on the hilly terrains. Other recharge sources of the aquifer are the Quaternary alluvial aquifers on it, the rivers that intersect the aquifer transversally and the boundary aquifers. The groundwater drains in the form of springs in the surface, under the river gravel bed and mainly under the sea bottom. The wells drilled through the Rrogozhina aquifer represent a particular form of the groundwater drainage. The compactness grade of the Rrogozhina formations range from sand and gravel to sandstone and conglomerate, respectively, thus, conditioning the presence of both porous - and crack – type groundwater.

The geochemical composition of the Kavaja groundwater basin is variable, but they mostly belong to the HCO_3–Mg–Ca hydrochemical type. Such a chemical composition of groundwater is due to the mineralogical composition of the porous medium which mainly consists of magmatic and limestone materials. The general mineralization and general hardness of groundwater pumped from the Kavaja basin range from 500 to 800 mg/l and from 11 to 25° dH, respectively. In some cases, NH_4^+, SO_2, $Cl^–$, etc, are found

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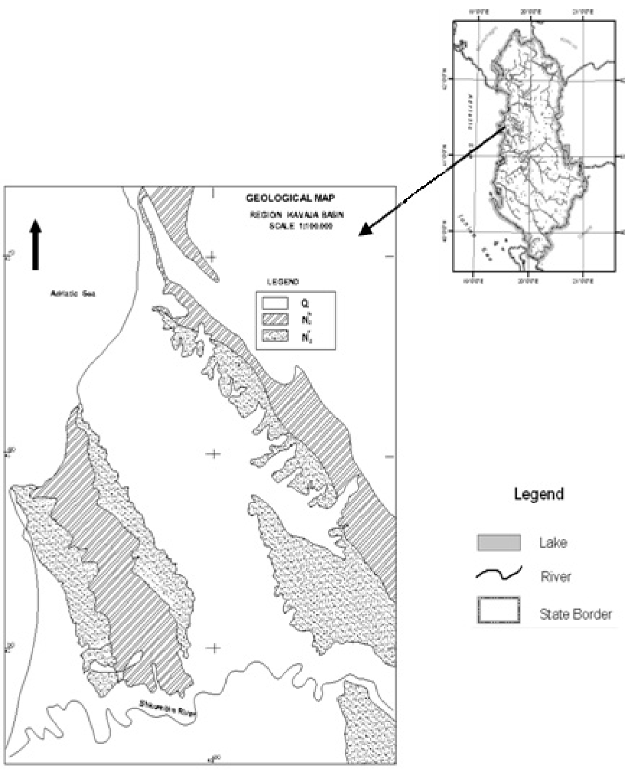

Fig. 1. Geological map of the Kavaja basin.

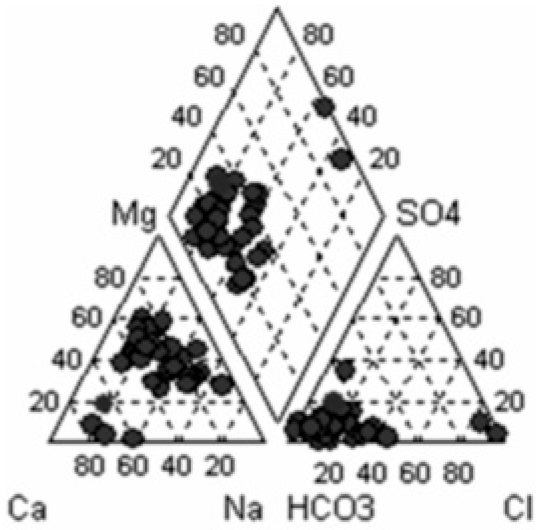

Fig. 2. Kavaja groundwater composition (Piper diagram).

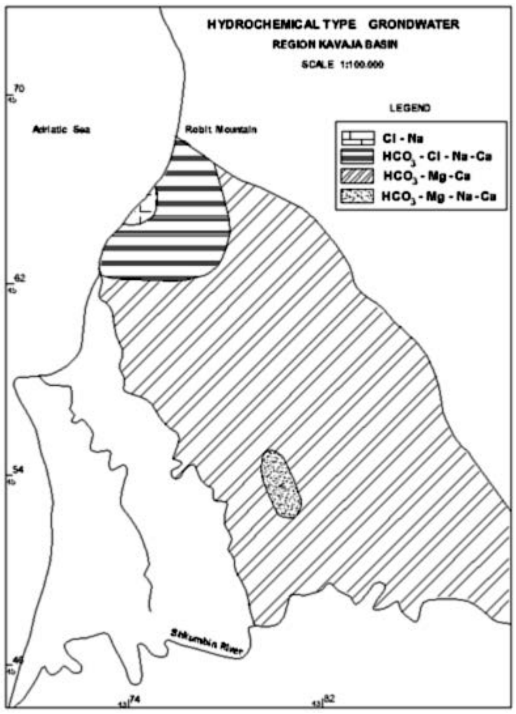

Fig. 3. Map of the groundwater hydrochemical types.

in concentrations higher then the limits of drinking water.

Hydrochemical composition of groundwater

The groundwater shows variable geochemical composition due to different mineralogical composition of its medium, vast extension of the aquifer, variable geological and hydrogeological features, relationships with boundary aquifers and seawater, relations of the tested groundwater with respect to recharge and discharge zone and possibly the depth of wells. However, the mainly magmatic – carbonate mineralogical composition of the water – bearing sandstones and conglomerates has determined a geochemical composition of groundwater consisting mostly of HCO_3–Mg–Ca hydrochemical groundwater type (Figs. 2, 3). Such a geochemical composition characterizes the groundwater of Rrogozhina aquifer as chemically immature groundwater (APELO *et al.*, 1996), which mainly plots near the centre of the Piper plot. Dissolution of minerals seems to be the major geochemical processes in the formation of the groundwater composition. Other less important hydrochemical types are mainly related with the Na enrichment in water through cation exchange processes between groundwater and clay formations that are more abundant over the plain extension of the aquifer. In general, the wells are drilled down to 250 m. The general mineralization and general hardness of groundwater pumped from the above drilled section range from 500 to 800 mg/l and from 11 to 25° dH, respectively. At the pHs commonly encountered in groundwater (pH = 7.0–8.5), HCO_3^- is the dominant carbonate species present. In general, up to the above drilled depth, all the hydrochemical parameters of the groundwater fit the Albanian and EU limits for the potable water. In some cases, NH_4^+, SO_2, Cl^-, etc, are found in concentrations higher than the limits of drinking water.

The geochemical composition of the Kavaja groundwater basin evolves gradually from HCO_3 type to Cl type, from southeastern (Shkumbini river) towards northwestern (Adriatic Sea) (BEQIRAJ *et al.*, 2007), that is from the recharge to discharge zone . On the other hand, the vertical evaluation of the groundwater geochemical composition towards the depth is expressed by means of the increase of the General Mineralization. In the diagram (not shown) of Total Mineralization (TM) versus well depth (H) was found that groundwater can maintain TM values less that 1.0 mg/l up to a depth that ranges from 400 to 500 m, according to the well position with respect to recharge and discharge zone. The mainly magmatic composition of sandstones and conglomerates is also responsible for the high content of iron in the groundwater of this aquifer (BEQIRAJ, 2008). Iron content is higher in sandstone related groundwater where the silt fraction is mainly composed by iron-bearing minerals such as magnetite, epidote, granate, sphene, amphibole and pyroxene. The General Mineralization and Hardness show a gradual decrease from both western and eastern flanks of the Kavaja depression towards its central part (Fig. 4a, b). The above evaluation of both General Mineralization and General Hardness of the Kavaja groundwater fits very well with the variation of the hydraulic conductivity values of the aquifer. Thus, the highest values of the General Mineralization and Hardness correspond to the lowest values of the hydraulic conductivity.

Conclusions

The groundwater basin of Kavaja is a multilayered aquifer that consists of intercalations between water-bearing Pliocene sandstone and conglomerate with impermeable clay layers of the Rrogozhina suite.

This aquifer occurs under typically artesian conditions because of its impermeable clay basement and semi-impermeable Quaternary cover and shows very heterogeneous permeability features.

The groundwater shows variable geochemical composition, but they mostly belong to the HCO_3^-Mg–Ca hydrochemical type because of the mainly magmatic – carbonate mineralogical composition of the water – bearing sandstones and conglomerates.

The mainly magmatic composition of sandstones and conglomerates is also responsible for the high content of iron in the groundwater of this aquifer which is higher in the sandstone.

The geochemical parameters evolve both horizontally and vertically, that is, from the recharge to discharge zones, and from the uppermost parts towards the depth of the aquifer.

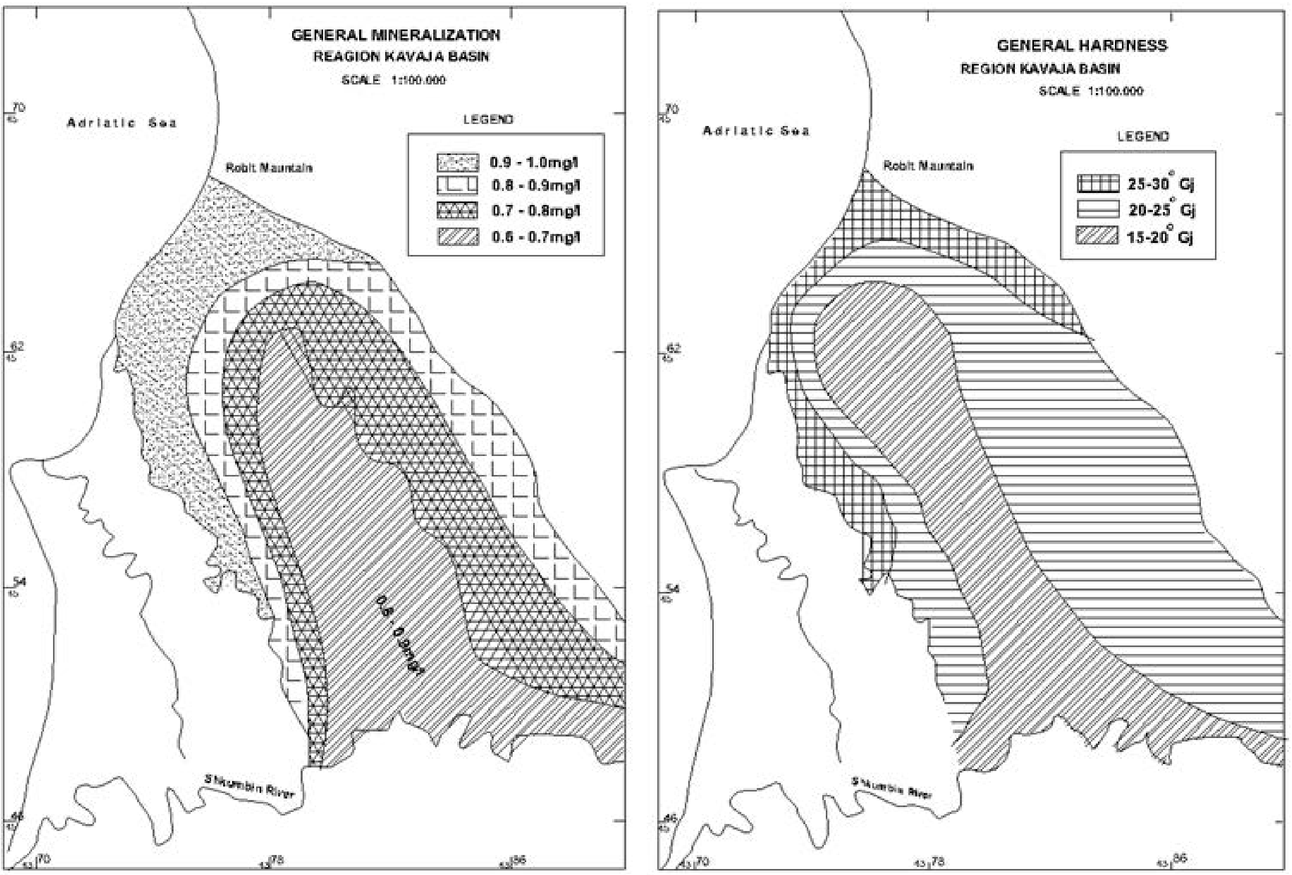

Fig. 4. A) Map of General Mineralization; B) Map of General Hardness.

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Devonian Deposits of the Tomsk Region (Russia): Biostratigraphy and Model of Development

SERGEI A. RODYGIN[1]

Abstract. The small amounts of oil, gas and bitumen are founded in Devonian sediments in the Tomsk region. Stratotype sections of Western Siberia's Devonian formations are well developed in Nyurolsk structurally-facial area and they are well studied here, although non-uniform distribution of boreholes and incomplete opening sections. The Devonian deposits in the Nyurolsk structurally-facial area are presented by terrigenous and carbonate sediments in two types of section, containing a rich complex of benthic and pelagic fossils. For a detailed biostratigraphic correlation of these sediments conodonts are of great importance and they were investigated in detail from Lohkovian up to Famennian stage. Thereby, their further studying will allow to improve model of paleogeographical development and to clarify the prospects of oil and gas.

Key words: Devonian, conodonts, biostratigraphy, Tomsk, Siberia.

In the Tomsk region the oil and gas produced rocks are Jurassic and Cretaceous. Nevertheless, the specialists consider also perspective on oil and gas deeper beds of the basement of the West Siberian plate including the Devonian sediments also. The small amounts of oil, gas and bitumen are found in them out. Many searching and prospecting boreholes in Western Siberia achieved the depth 2500–4000 m and more, disclosing the Paleozoic beds, including the Devonian. In Tomsk region the densest network of boreholes was drilled on a left bank of the river Ob'. The Devonian deposits are widespread here in many structurally-facial areas, but especially wide – in Nyurolsk structurally-facial area. In this area there are many stratotype sections of Western Siberia's Devonian formations. Devonian deposits are well studied here, though non-uniform distribution of boreholes and incomplete opening of some important fragments of Devonian section do not allow drawing a full picture of development of this area in Devonian (KRASNOV *et al*, 2009). The important result of researches was the acceptance in 1999 regional stratigraphic schemes of Paleozoic formations of the West Siberian plain, with participation of the author (KRASNOV *et al*, 1999).

In Nyurolsk structurally-facial area the Devonian deposits are presented by two types of sedimentation: the carbonate platforms and depressive zones dividing them with forming of carbonate banks (KRASNOV, 1999). In the beginning of Devonian the organogenic detritus deposits were here formed and replaced in the end of early Devonian by organogenesis reef limestone. Lohkovian–Early Emsian deposits are presented by Kyshtovskaya, Armichevskaya, Solonovskaya formations, Late Emsian deposits are presented by Nadezhdinskaya formation (SVIRIDOV *et al.,* 1999). Above these Gerasimovskaya formation (Middle Devonian) and Luginetskaya formation (Upper Devonian) are lying.

The carbonate-terrigenous (depressive) type of section is composed by following formations: Lesnaya, Mirnaya (Lower Devonian), Chusikskaya, Chaginskaya (Middle and Upper Devonian).

Devonian beds of Nyurolsk paleobasin were studied on boreholes of the several prospecting areas and contain a lot of fossils. There are tabulats, rugoses, stromatoporates, bryozoas, brachiopods, foraminifers, radiolarians, tentaculites, ostracodes, conodonts, etc. The author has studied conodonts together with L.M. AKSENOVA and V.F. ASTASHKINA and continues this work now.

The reef type of section. The conodont distribution on the section is non-uniform enough. In the Lohkovian and Pragian intervals of the section there are

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rare conodonts. In the Kyshtovskaya formation follows species are contained: *Ozarkodina remscheidensis remscheidensis* (ZIEGLER) – borehole Maloichskaya 21, interval 2898–2885 m, *Pandorinellina steinhornensis miae* BULTYNCK – borehole Zarechnaya 1, interval 3090–2888 m (ISAEV *et al.*, 1994). In the Armichevskaya formation *Pelekysgnathus serratus elongates* CARLS ET GANDL was found in the borehole West-Ostaninskaya 445, interval 2922,8–2916,2 m.

In the Solonovskaya formation with the stratotype in the borehole Solonovskaya 43 (interval 3150–2960 m), Emsian conodonts are established: *Polygnathus dehiscens* PHILIP ET JACKSON, *P. gronbergi* KLAPPER ET JOHNSON, *Pandorinellina exigua* (PHILIP). The Nadezhdinskaya formation (Upper Emsian) and the Gerasimovskaya Fm (Middle Devonian) contain rare conodonts. In the Upper Devonian's Luginetskaya Fm lying above it's the following conodont complex contains get from several boreholes: *Ancyrognathus triangularis* YOUNGQUIST, *Polygnathus asymmetricus ovalis* ZIEGLER ET KLAPPER, *Palmatolepis gigas* MILLER ET YOUNGQUIST, *Pa. triangularis* SANNEMANN, *Polygnathus znepolensis* SPASOV (KRASNOV, 1999).

In the depression or basin type of the section conodonts have non-uniform distribution too, though complexes are as a whole more representative. In Emsian Mirnaya Fm, with the stratotype in the borehole Kalinovaya 14 (interval 3252,0–3135,5 m), the following conodonts are found: *Pandorinellina exigua exigua* (PHILIP), *Polygnathus inversus* KLAPPER ET JOHNSON, *P. serotinus* TELFORD, *P. foliformis* SNIGIREVA. Between the Mirnaya Fm and Chusikskaya Fm, in the bottom of the Middle Devonian, the interruption is observed in an interval of conodont zones *patulus-australis*. Chusikskaya and Chaginskaya formations have the stratotype in the borehole Kalinovaya 13, int. 4434–2875 m (STEPANOV *et al*, 1985). The Lower Chusikskaya subformation containes the conodont complex *Tortodus kockelianus australis* (JACKSON) (L.M. AKSENOVA'S data), *Polygnathus varcus* STAUFFER, *Pol. xylus ensensis* ZIEGLER, KLAPPER, JOHNSON, *Icriodus obliquimarginatus* BISCHOFF ET ZIEGLER. In the limestone of the Upper Chusikskaya subformation *Klapperina disparilis* (ZIEGLER, KLAPPER, JOHNSON), *Polygnathus dubius* HINDE, *Icriodus symmetricus* BRANSON ET MEHL, *I. brevis* STAUFFER were found. They are characteristic for Givetian and Frasnian intervals of the section. The Chaginskaya Fm is characterized by conodonts in the borehole Selveykinskaya 1. There are *Palmatolepis glabra* ULRICH ET BASSLER, *Pa. glabra prima* ZIEGLER ET HUDDLE, *Pa. glabra lepta* ZIEGLER ET HUDDLE, *Pa. minuta minuta* BRANSON ET MEHL, *Pa. gracilis gracilis* BRANSON ET MEHL, etc. On the last our data (MAKARENKO *et al*, in press), the Chaginskaya Fm belongs to Famennian.

Thereby, the Devonian deposits in the Nyurolsk structurally-facial area are presented by terrigenous and carbonate in two types of section, containing a rich complex of benthic and pelagic fossils from Lohkovian up to Famennian inclusive. Their further studying will allow to improve their model of paleogeographical development and to clarify the prospects of oil and gas.

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Estimation of Exploitable Reserves in Multilayer Lignite Deposits by Applying Mining Software The Significant Impact of Geological Strata Correlation

CHRISTOS ROUMPOS[1], KATIA LIAKOURA[1] & TRYFON BARMPAS[1]

Abstract. The evaluation of the drill-holes exploratory data for the estimation of exploitable lignite reserves in multilayer lignite deposits is a very important problem of the lignite industry. The application of mining software needs thorough data organization and analysis, while an efficient geological input and interpretation is required in order to avoid errors in lignite reserves estimation.

The objective of this paper is to investigate the procedure for the formation of exploitable lignite blocks, to improve the algorithm for the evaluation of drill-holes layers and to propose a new approach to lignite reserves estimation.

From the proposed model, the significant impact of the geological strata correlation is proved, while better lignite reserves estimation results are derived.

Key words: lignite, multilayer, deposit, reserves, estimation, correlation, evaluation.

Introduction

Lignite exploitation in Greece is of primary interest because it is an abundant domestic energy resource that contributes more than 55 % in total electricity production. The majority of the lignite deposits have a multiple-layered structure.

For the exploitation of these deposits, the continuous surface mining method is applied.

The deposit structure in combination with the excavation equipment makes the procedure of lignite reserves estimation a very important problem that requires suitable approach. Lignite reserves play a crucial role in the viability of the lignite mining-power plant operation project (ROUMPOS *et al*., 2009; GALETAKIS & ROUMPOS, 2010). The spatial distribution of the geological lignite quality and the correlation to the data of the excavated lignite can contribute to a better prediction of run-of-mine data (KAVOURIDES *et al.,* 2000).

In this paper the procedure of the formation of exploitable blocks is investigated, an improved algorithm is proposed and a new approach of lignite reserves estimation method is described based also on the geological strata correlation.

Lignite deposit modelling and evaluation

The lignite bearing strata at Ptolemais basin belong to the upper Pliocene (ANASTOPOULOS & KOYKOYZAS, 1972).

At a typical drill-hole in the area we could distinguish groups of seams shown in Fig. 1.

Geological of the formation of lignite seams can enhance the process of lignite deposit modelling (LEONTIDIS *et al.,* 2001).

The results of the estimations of exploitable lignite reserves of multi layer deposits depend within wide limits on the algorithms for the determination of lignite and waste blocks in each drill-hole, on the algorithms for the calculation of the average lignite quality, on the accuracy of the data input, on the ore reserves estimation method and on the power stations specifications.

The evaluation of the mineable lignite reserves and quality is a process of compositing seams into blocks of exploitable lignite. The main criteria used for the formation of the exploitable lignite blocks are (KAVOURIDIS *et al.,* 2000) minimum thickness of lignite seam and waste layers that can be excavated by selec-

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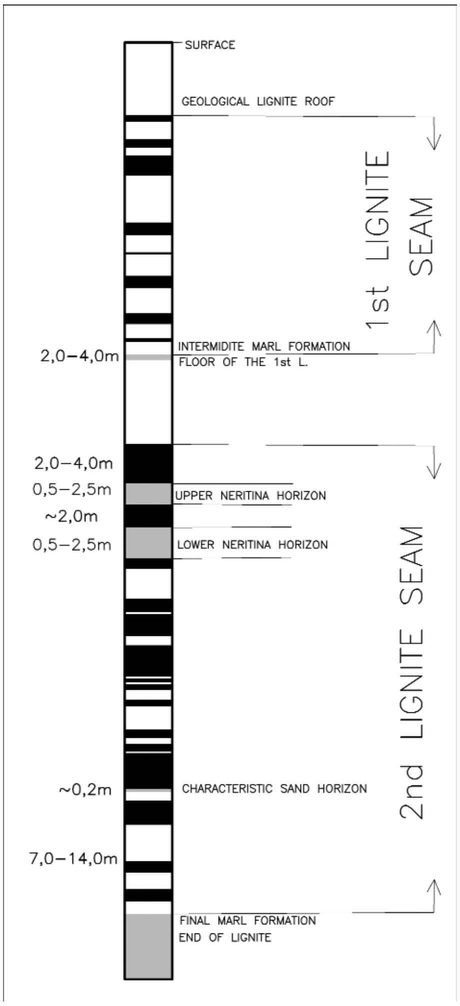

Fig. 1. Distinguished seams of a typical drill-hole.

tive mining, maximum ash content of the mined lignite, dilution and mining loss. The main steps of the evaluation process (described in KAVOURIDIS *et al.,* 2000) include initial raw seam coding, waste blocks formation, initial determination of selectively excavated waste blocks and evaluation of exploitable lignite blocks between waste blocks.

However, the lack of correlation of lignite layers reduces significantly the potential of the software for the accurate evaluation of the deposit.

In Fig. 2, a typical cross section in Kardia Mine is shown, constructed by the mining software from the original drill-holes data.

Geological strata correlation

Modern commercial mining software systems are not ideally adapted to that type of multilayered stratified lignite deposits. They are based on geology module which is designed to build a geologic model from exploration drill-holes.

Large deviations from the actual data, relating often with the lack of direct correlation of the lignite and waste strata, are often caused by extremely large the number of layers found in exploration drill-holes, by spatial variability that the quality characteristics of the lignite deposit present, by the existence of many faults with different dip directions and ages or by the differences in the original exploratory data among drill-holes.

In a first stage the correlation procedure is based on the characteristic layers and in a second stage the waste blocks with specific characteristics or the lignite layers rich in carbon minerals could be separated.

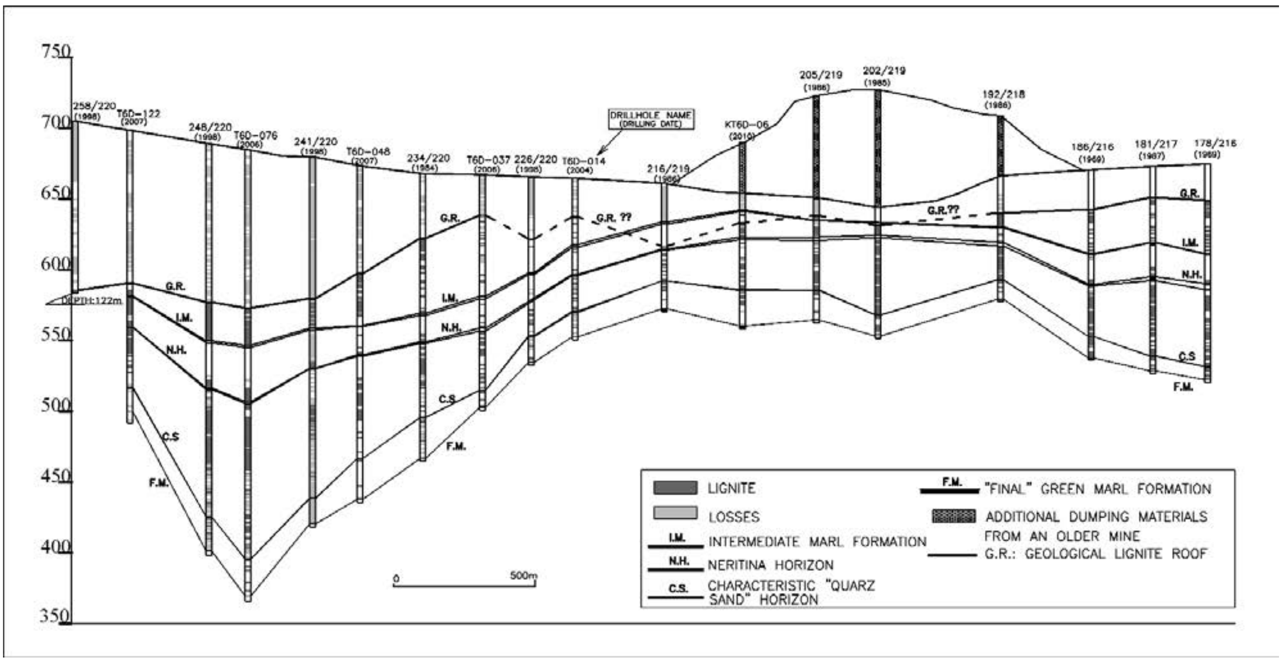

Fig. 2 Typical cross section in Kardia Mine with uncorrelated lignite layers.

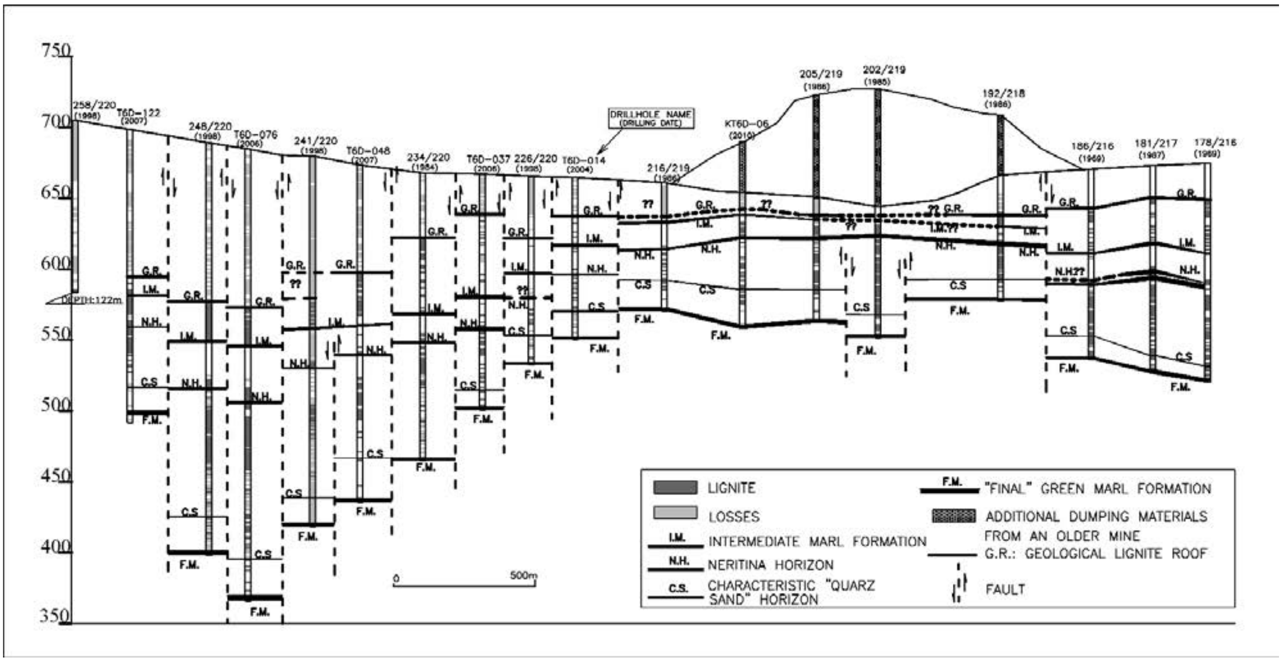

Fig. 3. Typical cross section (same with Fig. 3) in Kardia Mine with correlated lignite layers.

The typical cross section of Fig. 2 with correlated lignite layers is shown in Fir. 3.

The details of the correlation procedure are shown in Fig. 4, where a part of the typical cross section with correlated geological lignite layers is constructed.

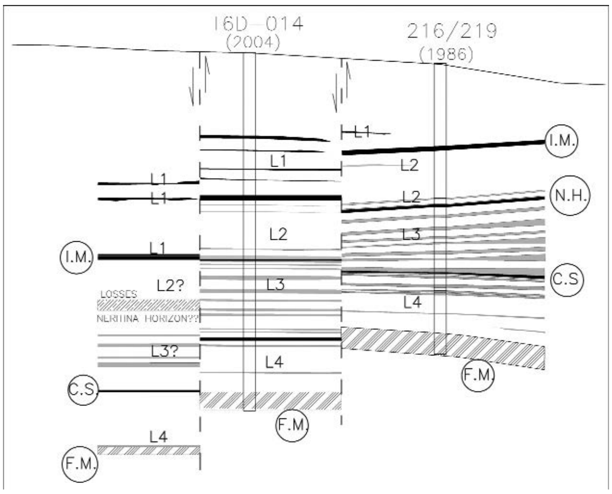

Fig. 4. Part of the typical cross section of Fig. 3 in Kardia Mine with correlated geological lignite layers.

As it is shown in Figure 4, a first separation of the layers can be done taking into account the discrete lignite seams (Li, i=1,..,4). Furthermore, taking into account the data of the structural (faulting systems) or other geological studies, we can confirm or reject the locations of the characteristic layers.

The same part of the typical cross section with correlated minable lignite layers is shown in Fig. 5.

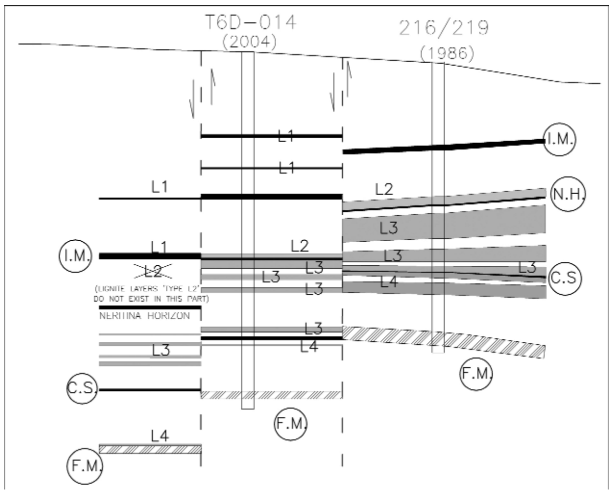

Fig. 5. Part of the typical cross section of Fig. 3 in Kardia Mine showing mineable lignite blocks.

Then, whatever mineral inventory estimation method is used [traditional (method of sections, triangular or polygonal, grid, inverse distance weighting or contouring) or geostatistical methods, combining also with fuzzy logic methods] the individual seams (Li) are not involved with each other and bench wise calculations are more accurate.

Improved algorithm and procedure

An improved algorithm should also take into acount the parameter of the lower calorific value of the lignite blocks.

The density also of layers is an important parameter which affects the conversion of volumes to tonnages and also takes part in the calculations formula of weighting quality of composite exploitable lignite blocks. In the improved algorithm the density of waste and lignite layers is calculated taking into account the properties of each layer.

The improved procedure that we propose (Fig. 6) aims at the solution of the above-mentioned exploratory drill-holes evaluation problems. This combines the use of modern mining software, after suitable adaptations in order to incorporate the improved evaluation algorithm.

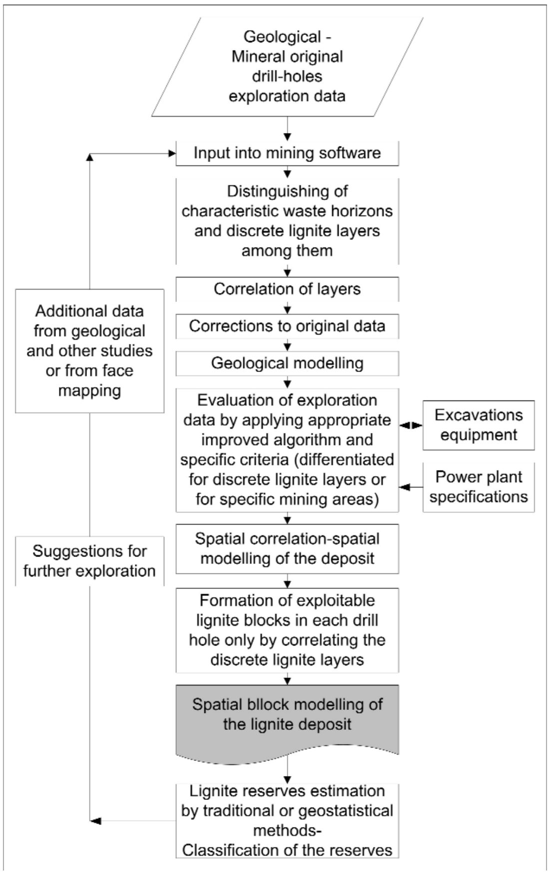

Fig. 6. Diagram of the improved algorithm and procedure of lignite reserves estimation.

Conclusion

With the improved algorithm of drill-holes exploratory data evaluation of multi-layered lignite deposits and the proposed procedure for lignite reserves estimation, more accurate reserves estimation is obtained with less deviations between actual data and data estimated by applying the adapted mining software.

The proposed procedure was based on the suitable correlation of the geological strata which resulted in a more reliable mineral deposit model.

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A View on the Copyright for Maps Resulting From Geological Explorations in Serbia

ACA UDICKI[1] & ZORAN NIKIĆ[2]

Abstract. The copyright for maps, which are original works of specialists in geological exploration, is not exactly regulated by law in Serbia. The Law on Copyright and Related Rights, Official Gazette of the Republic of Serbia (''SG RS'') No. 104/2009, Article 2, paragraph 2 reads: The following shall be deemed the works of authorship in particular: Point 8, cartographic works (geographical and topographical maps); Point 9, drawings, sketches, dummies and photographs. The Law on Copyright and Related Rights, chapter 7, defines: An original work, produced during the employment, determines the possession rights of the employer and the author, and the term of years. The Law on geological investigations (''SG RS'' No. 44/95 and 101/2005), defines geological projects, geological reports, geological supervision and geological inspection. In order to achieve these activities, and to create a new value, geologists should possess great knowledge, analytical mind, interpretative ability and creativity. Knowledge, analytical, interpretative and creative faculties are particularly important for implementation of provisions of the Act on Estimate and Classification of Mineral Resources and presentation of geological data (''SL SRY'' No. 12/98 and ''SG RS'' No. 101/2005). By applying provisions of this Act, and of several statutes on ore minerals (solid, petroleum and gas, water, and so forth) classification and categorization, a new value is created for the benefit of the community, the employer and the expert who participated in its creation. The authors suggest to introduce the copyrights for published geological maps and special rewards into legislation in Serbia. This would certainly contribute to personal affirmation and satisfaction, as well as will improve the financial situation of the geologists employed in different institutions and organizations dealing with geological exploration.

Key words: geological investigation, copyright, updating, geological map, intellectual possession.

Introduction

A major purpose of the act regulating the field of intellectual possession is to enhance the feeling of responsibility with the abiding employers (PETROVIĆ, 2000). Implementation of The Law on Copyright and The Patent Law would encourage creativity, search and use of original methods and approaches that best suit the given situation, which are neglected in the geological companies and often even restrained (PETROVIĆ, 2000). Intellectual possession refers to the products of mind that fall into two categories (COLLECTIVE AUTHORSHIP, 2009):

1. Industrial possession that includes patents (for inventions), small patents, techniques, seals, industrial designs; and

2. Copyright that includes writings (books, pamphlets, articles), industrial designs, cartographic works (geographical and topographical maps).

The intellectual, like any other possession right allows the author, the owner of a patent, small patent, seal or copyright to have some use of the work that he/she has created. These rights are specified in Article 27, Universal Declaration on Human Rights, which includes the right of authors to the protection of moral and material interests ensuing from the copyright.

A good system of the intellectual possession protection helps equilibrating the inventor's and the public interests. The copy and patent right award creativeness and encourage human efforts (COLLECTIVE AUTHORSHIP, 2009).

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Obstacles in developing creativity and inventiveness

Generally, obstacles common in developing creativity and inventiveness by companies in different sectors including those for geological exploration in Serbia are the following (PETROVIĆ, 2000):

– Criticism in advance, during the development of a new idea, is affecting the human need to invent new things;

– Fear of the failure is inhibiting people to try to be creative and inventive;

– Managerial climate does not encourage creativity and inventiveness, because managers prefer the employees to think the same as they do, and reward only the like-minded persons.

– Maintenance of the status quo, because creative ideas threaten the status quo, and those who disturb this situation are always criticized, never supported.

– Hierarchical idea filter, or the more hierarchical levels a developing idea is to pass, the greater chances for it to be destroyed or lost.

– Isolation of creativity and inventiveness; creativity and inventiveness in a company are initiated as the communication between the management and the employees, not to isolate those with different opinions. In the course of geological exploration, a geologist must be competent (UDICKI & ŠIJAKOVIĆ, 2010). The competence (term No. 3.1.6) means demonstrated ability to apply knowledge and skill (COLLECTIVE AUTHORSHIP, 2007).

A product of creative and inventive work, in order to be recognized as motivating for geologists in a company, is the reward. The reward is any kind of recompense that encourages and gives incentive to the geologists. Consequently, many geologists engaged in field works of the geological exploration companies feel underpaid. One way to raise the earning is the reward for saving money or for a new product that finds a market, based on creative and inventive work (UDICKI & ŠIJAKOVIĆ, 2010).

Importance and value of geological exploration

The importance of geological exploration is formulated in the Geological Exploration Act, Articles 5 and 8. Article 5 defines geological exploration as the activities of public interest for the Republic of Serbia. Article 8, states *inter alia* that geological investigations are performed for the purposes of land-use planning and for general town plans, to assess and evaluate the geological resources of a region, to establish the present and potential land uses. Article 25 defines that the reports on geological explorations are archive material for permanent safekeeping.

The value of geological exploration for the use and interest of the State of Serbia specified in Article 15 of the same Act is 5% of the value of the exploration completed in the given area. The recompense is the government revenue.

The fact is that the wealth and prosperity of a society, besides knowledge, depends largely on the available natural resources on its territory and on their control and use. The Act on Locating and Classifying Mineral Resources and Presenting Geological Exploration Data (''SL SRJ" Nos. 12/98, 13/98 and 101/2005) regulates these activities. Article 1 determines the manner of presenting geological exploration data and the obligation of writing a report. In addition to the estimate of the mineral reserves, the Article mentions geological maps, more specifically defined in Article 2, paragraph 3, and Article 12. Article 7, point 3 of the same Act defines that graphical documentation of the Report must include geographical map, geological maps and geological sections. Article 12 defines that geological maps shall contain textual explanation of the geological exploration data.

The statutory law on the criteria for assessment of potential mineral resources in an area (''SG RS" No. 51/96) in Articles 7, 8 and 9 specify stages of geological exploration, and geological maps, their scales and data presentation for each stage.

To be able to abide by the mentioned Act and Statutory Law, a geologist, author must possess knowledge, analytical mind, interpretative and creative faculties. The new value, created through the process of geological exploration, should be beneficial to the society, the employer and the specialist who helped creating the value.

The Concession Law (''SG RS" No. 55/2003) provides that concession may be granted also for exploitation of natural resources with compensation to the government administration at different levels. Article 5 specifies that concessions may be granted for exploration and exploitation of any kind of mineral resources.

Geological exploration products and copyright

An important product of the geological exploration process is the published geological map, which shows the exploration data, and additional geological sections, columns, sketches and plant, all defined in the legal and statutory acts regulating the geological exploration activities.

The Law on Copyright and Related Rights, Article 2, defines that entitled to this right are the authors of original writings (books, pamphlets, articles, translations and the like), cartographic products (geographical and topographical maps), plans, schemes, models and photographs. All the mentioned original works are integral parts of the geological final and other different reports. What is unclear is that the Act chapter on cartographic products omits the published geological maps, which are known to provide certain potential (in the domain of exploration and exploitation of mineral resources) and quality (in the domain of location and building different structures, geological hazard, risk, etc.). It is probably that geological maps are categorized under geographical ones, but this requires clear explanation and specification, considering their values and content.

The Law on Copyright and Related Rights, Chapter 7 Original work created during the employment, Article 98 states that if an author has created a work while executing his/her job for which he has been employed, the employer shall be entitled to use it for a period of five years from the day of its completion, and the author shall be entitled to a reward in proportion with the work utilization effect.

The Employer's five-year term of the original work utilization matches the term of the Final Report on mineral resources.

The question is why such reports are not recognized as original writings in the geological practice of the country, especially if admittedly they are the archive material in permanent custody. Were these reports recognized the original writings; the geologists who produced them would be entitled to some statutory defined reward.

The Income Tax Law (''SG RS" No. 24/2001), Article 52, recognizes writings (literary, scientific, technical, publicity and other works, studies, reviews, and so forth), cartographic representations, preliminary designs, sketches and drawings as liable to taxation. An organized society has mechanisms to provide some benefits for the society from the national budget. The Income Tax Law (''SG RS" Nos. 24/2001, 80/2002, 135/2004, 62/2006, 65/2006, 13/2006, 44/2009) recognizes all elements contained in the geological final and progress reports as original writings liable to taxation if the authors were rewarded. Such mechanism should be widely applied, on benefit of geologists, too.

Knowledge, improvement, innovation and learning in the standard SRPS ISO 9004:2009

The standard SRPS ISO 9004:2009, Management aimed at sustainable successful organization – approach through quality management (Collective authorship, 2009) introduces a new requirement, in Chapter 9 titled Improvement, Innovation and Learning. In the previous version of the standard SRPS ISO 9004:2001, innovation was mentioned only in few paragraphs.

The new version of the standard (SRPS ISO 9004:2009), Chapter 6.7 requires companies to establish and maintain the process with a management accomplished in knowledge, information and technology as the essential resources. The same standard, section 6.7.2 requires the top level executives to identify and protect the current know-how of the company.

In respect to the same standard provisions concerning knowledge and innovation, how is treated and protected knowledge of geologists, specialists, and their creative and inventive ideas, which remained unpublished in the form of articles or maps due to the current policy of the geological exploration companies?

Conclusion

This article hopefully will at least partly change the delusion that all what has been done during the service in a geological exploration company is contained in the respective job description and the agreement of service. This common and deep-rooted opinion and attitude, problematic from more than one aspect, is a great obstacle to the implementation of law that entitles geological specialists to assert their copyrights and thereby be more rewarded for their service.

Additionally to The Law on Copyright and Related Rights, Article 98, the delusion that creativity and inventiveness are part of the job description and service agreement is shattered by the presentation of the right of the employees defined in Section 14, Inventions made during the employment, The Patent Law (''SG SCG", Nos. 32/2004, 35/2004, 115/2006).

Implementation of legal provisions on copyright for published geological maps and on special rewards would certainly contribute to their personal affirmation and satisfaction, and improve the financial situation of the geologists who used their skill, knowledge, creativity and inventiveness and created new values during their service. Furthermore, geological specialists would be motivated to employ their utmost creative and inventive abilities.

A similar situation probably exists in many of European countries. Discussion on the issue and useful suggestion from this event may help to coordinate and synchronize the action.

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Jurassic Tectonostratigraphy of the Neotethyan Thrust Belt

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Abstract. After the formation of the Neotethyan thrust belt (preserved in the Hellenides/Albanides/Dinarides, the eastern Southern Alps, the Eastern Alps, the southern Western Carpathians, and in some blocks in the Pannonian realm) in Middle to early Late Jurassic times in a lower plate position due to the obduction of the accreted Neotethyan ophiolites (GAWLICK *et al.*, 2008; MISSONI & GAWLICK, 2011). Later, but still in Late Jurassic times, shallow-water carbonate platforms evolved on top of the rising nappe fronts, and still in a tectonic active geodynamic regime. We present the whole Jurassic evolution of this Neotethyan realm resp. Neotethyan thrust belt from the onset of ophiolite obduction with formation of a thrust belt in the lower plate position. This is documented by different trench-like basin fills in front of the advancing nappe stack and the onset, evolution and demise of shallow-water carbonate platforms on top of the nappe stack. The general evolution and palaeogeography of this history is exemplified by the Northern Calcareous Alps (Eastern Alps, Austria). Similar basins and platforms were formed also in the e.g., Western Carpathians, the Dinarides/Albanides/Hellenides, but still with more information needed (HAAS *et al.*, 2010). However, the different basins exemplified from the Northern Calcareous Alps can be correlated all over the region with more or less identical basin fills.

Tectonic shortening in the Neotethyan realm started in the late Early Jurassic. The onset of ophiolite obduction can be dated as Bajocian/Bathonian. Due to this event, a north-westward resp. westward propagating thrust belt with different deep-water trench-like basins in front of the nappes evolved on the lower plate. The first cluster of nappe fronts is formed by the accreted ophiolites forming the ophiolitic mélanges, the second cluster by the accreted distal shelf area of the lower plate (Hallstatt facies zone; Hallstatt Mélange) = former Middle Triassic to Early Jurassic passive continental margin facing the Neotethys Ocean to the southeast resp. east. These nappes were formed during Bajocian to Oxfordian times. In a later stage of thrust belt evolution also the more proximal shelf areas (Dachstein and Hauptdolomite facies belts) were incorporated in the nappe stack (Tauglboden and Rofan Mélange), mainly in early Late Oxfordian times. Thrusting decreased in Oxfordian times and the timespan latest Oxfordian to Early Tithonian is characterized by a period of relative tectonic quiescence, before around the Early/Late Tithonian boundary again tectonic movements started. From latest Oxfordian onwards the whole area is characterized by the uplift of the nappe fronts (rises) and the onset of independent carbonate platforms on top of them.

In the Northern Calcareous Alps, mainly the accreted Hallstatt facies zone and the Dachstein and Hauptdolomite nappes with its different mélanges are preserved, whereas the ophiolitic mélange is only preserved in small remnants. In contrast the ophiolite nappe stack with its ophiolitic mélange zones is well preserved in the Dinarides/Albanides/Hellenides; the Hallstatt Mélange occurs widespread and the Tauglboden and Rofan Mélanges are only preserved in small remnants.

The Kimmeridgian-Tithonian platform on top of the ophiolite nappe stack was eroded rather quickly after its formation (e.g., Kurbnesh Carbonate platform in the Albanides: SCHLAGINTWEIT *et al.*, 2008), whereas the other platforms are fairly well preserved – Plassen Carbonate Platform sensu lato and equivalents. On top of the accreted Hallstatt nappes the Lärchberg Carbonate platform as south-easternmost platform starts to establish in ?Late Oxfordian or Early Kimmeridgian times, in a central position the Plassen Carbonate Platform *sensu stricto* starts to form in Late Oxfordian times on top of the Trattberg Rise and in the north-westernmost position the Wolfgangsee Carbonate Platform starts it progradation in Early Kimmeridgian times from the top of the Brunnwinkl Rise. Between these platforms deep-water radiolaritic basins prevailed, e.g. the Sillenkopf Basin between

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the Lärchberg and the Plassen Carbonate Platforms, the younger part of the Tauglboden Basin between the Plassen and Wolfgangsee Carbonate Platforms and the Rofan Basin northwest of the Wolfgangsee Carbonate Platform (Details in GAWLICK *et al.*, 2009). The Sillenkopf and the younger Tauglboden Basin are interpreted as deep-water remnant basin between the two prograding carbonate platforms. Into the Sillenkopf Basin Late Jurassic shallow-water debris together with exotic clasts (e.g. from the ophiolite nappe stack) was transported through channels coming from the southeast, mobilized and redeposited since the latest Oxfordian or the Early Kimmeridgian. In contrast, sediment supply into the younger Tauglboden Basin during that time was very low; this basin was shielded by a topographic high in the south-east against carbonate shedding from the Plassen Carbonate Platform. In contrast, the Rofan Basin to the northwest carries a thick succession of resedimented shallow-water carbonates derived from the Wolfgangsee Carbonate Platform.

Deep-water carbonates in the basinal areas as well as shallow-water carbonates of the Plassen Carbonate Platform *sensu lato* (Kimmeridgian to Early Berriasian) formed on top of the rises resp. uplifted nappe fronts. This sedimentary cover sealed the Jurassic nappe stack but did not imply far-reaching tectonic quiescence. In the late Early Tithonian the Plassen Carbonate Platform *sensu stricto* degraded in an extensional collapse. This event produced high- and low-angle normal faults and probably also large scale strike-slip movements. The already deeply eroded ramp anticline of the former Trattberg Rise became sealed by the hemipelagic sediments of the Oberalm Formation and the Barmstein Limestone layers at the base and contained therein. In contrast, the south-eastern rim with the Kimmeridgian to Tithonian Lärchberg Carbonate Platform became uplifted around the Jurassic/Cretaceous boundary. Contemporaneously the Wolfgangsee Carbonate Platform in the northwest drowned. All these platforms provide complete sedimentary successions with slope, reef and lagoonal carbonates. In all facies zones high diverse fossil assemblages are well preserved showing also pronounced differences between different platforms.

A detailed description of the different formations of the radiolaritic basin fills and the complex platform-basin pattern is described in GAWLICK *et al.* (2009). Here the whole Jurassic evolution is reconstructed on base of the tectonostratigraphic concept.

The evolution of the different deep-water radiolarite basin formation and the Late Jurassic platforms and basins will be presented during a field trip (Northern Calcareous Alps, Salzkammergut region, Salzburg and Berchtesgaden Calcareous Alps) within the context of the 29th IAS Meeting of Sedimentology, which will take place in Schladming/Austria in Sept. 2009 (www.sedimentologists.org/ims-2012). This field trip will focus on the different deep-water radiolarite basins in front of the propagating nappe stack and the shallow-water carbonates of the three preserved platforms and their resediments: the Lärchberg, the Plassen, and the Wolfgangsee Carbonate Platform. This field trip should stimulate the ongoing work in the Dinarides/Albanides/Hellenides. Here in moment a similar detailed reconstruction is hampered by less dense information about the different sequences and analysis of the different mélanges. But first investigations show identical sedimentological features and basin evolution in both mountain chains, as demonstrated for the Albanides e.g., by GAWLICK *et al.* (2008) and SCHLAGINTWEIT *et al.* (2008), for the Dinarides e.g., by GAWLICK *et al.* (2009), HAAS *et al.* (2010), SUDAR *et al.* (2010), and for the Hellenides e.g., by KILIAS *et al.* (2010).

A detailed investigation of the different sedimentological successions and basin fills resp. mélanges in the Dinarides will result in a better understanding in the basin evolution processes and at least to a better reconstruction of the Jurassic mountain building processes in the Dinarides/Albanides/Hellenides. These will not only have great impact on the geological understanding of these mountain ranges; it will have also great impact on all topics related to applied topics, especially the hydrocarbon systems.

Key words: carbonate platforms, Northern Calcareous Alps, Neotethyan thrust belt, stratigraphy, facies.

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17th Meeting of the Association of European Geological Societes	Abstracts	258–258	BELGRADE, 14–18 September 2011

Determination of Basement Surface Configuration in North Western Desert of Egypt

GAMAL HASSAN SALEM[1]

The depth of the causative geological bodies is the most important parameters that can be determined from gravity and magnetic anomalies. Therefore, the basement surface configuration is one of the most important targets that can be determined from gravity and magnetic data in order to interpret adequately the structure geology of the area. Moreover, the depth to the top of the basement surface configuration can give the thickness variations of the sedimentary cover overlying the basement rocks. The study area is characterized by thick sedimentary section overlying the Pre-Cambrian basement complex ranging in age from Paleozoic to Quaternary with fault structures forming in some localities uplifts and basins as well as the depth to the basement surface configuration ranges between 3 to 6 km approximately.

Most papers which it was used modulus logarithm of gravity and magnetic anomaly spectra to determine the upper and lower of discontinuities surfaces, but without corrections for these depths. Therefore, our developed formulae for spectral analysis technique which it was suggested and applied from 1994 until now represent an accurate tool to determine the average depth values to buried bodies precisely.

Appling the present modified technique of spectral analysis to gravity anomalies of calculating the depth to the basement surface configuration is approximately 3.7 km. Comparing these results with the bore holes data of the nearest well in the study area called Um-barka Oil field which it was reached the basement rocks with depth 3.665 km. This is due to the obtained results agreed well with each others and with other geophysical techniques.

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Use of Geochemical Modeling in Provenancing Studies for Ancient Ceramics

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Since the first application in the early 1930's, a wide range of mineralogical-petrological methods were used for compositional, technological and provenancing studies of ancient ceramics. They approach the ceramics as an „artificial rock" and provide data on composition of the non-plastics, the clasts, which might be various minerals, rocks, fossils or older potshards.

For deeper insights in particular for provenancing studies, geochemical data can be used. Not only the major elements (SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, TiO_2, Na_2O, K_2O, P_2O_5) are important but also trace and Rare Earth elements. The geochemical data can be handled in a similar way as is done for the rocks, i.e. plotted in bivariate and ternary discriminating diagrams or/and REE and spider diagrams, respectively.

Our studies show that the selection of the variables and discriminating diagrams depends on the basic data, i.e. mineralogy and are specific for each ceramic. The overall chemistry can be normalized to the continental crust or average continental shale compositions.

Many ceramics are made of clays and non-plastic temper material forming a mixture of two sources. On the other hand, washing of clays separates out some non-plastics from the original raw composition giving rise to an artificial unmixing process. Geochemistry can be used to model these processes to a certain extent.

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Bronze Age Ceramic Slags in NW Romania

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In the Lăpuþ village (NW Romania), a Bronze Age (13th–12th c. B.C.) necropolis/cult area paved with waterworn pebbles was found to contain burial mounds, a multi-phased building. Numerous bronze objects, ceramic pots shards and slag pieces were exhumed. The shards often display signs of burning, *i.e.* cracked black surface, partial melting or a deformed shape. In order to infer their origin, 4 slag pieces were compared with 24 ceramic shards by OM, EMPA and ICP-MS chemistry.

The slags show a highly porous vitreous mass including partly melted quartz and feldspar, some zircon, ilmenite, Ti-oxides and spinels. The ceramic shards are mostly coarse grained and consist of a clayey matrix embedding quartz, feldspar and rock fragments, mostly quartzites. Some shards contain porous melted parts similar to the slags. The bulk chemistry of the slags points to a siliceous composition, with ~71–78 wt.% SiO_2, ~11–14 wt.% Al_2O_3, ~3–4 wt.% Fe_2O_3, ~2–4 wt.% K_2O, ~1 wt.% TiO_2. These chemical data are well comparable with the average chemistry obtained from the ceramic shards found at the same archaeological level.

The similarities in mineralogy, fabric and chemistry between the shards and the slags support the formation of the latter by overburning ceramic vessels during ritual offerings.

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17th Meeting of the Association of European Geological Societes	Abstracts	261–261	BELGRADE, 14–18 September 2011

Miocene Evolution of Snake Assemblages in Central Europe: Palaeoclimatic Implications

MARTIN IVANOV[1]

The first half of the Eggenburgian (Late Aquitanian to Early Burdigalian) was connected with rapid increase in MAT (mean annual temperature) from 18 °C to 20 °C. „Modern“ snake families of the Asiatic origin represented by Colubridae, Elapidae, and Viperidae did not penetrate into western Europe although continental connection in Rhine Graben was not interrupted by the 3-rd marine ingression (MARTINI, 1990). It seems possible that “modern” Asiatic immigrants of the MN 3 Zone persisted in central Europe as a result of the existence of complicated ecosystem of swamps, deltas and shallow or deep lakes which developed (KVAČEK *et al.*, 2004) at the beginning of the Miocene Climatic Optimum (MCO) in the area of the Most Basin. Merkur-North locality (MN 3a) is of particular importance. Natricinae snakes with *Natrix merkurensis* are dominant in this site, fossorial forms are represented by small elapids similar to the Recent genus *Calliophis*; viperid snakes of the genus *Vipera* (‘European vipers’, complex ‘*aspis*’) are very rare. It is evident that *Natrix merkurensis* was adapted to the semiaquatic environment. South German localities Schnaitheim 1 and Witershof-West (both MN 3b) represent somewhat different environment of karstic fillings. In Schnaitheim 1 *Vipera* ‘oriental vipers’ and *Bavarioboa* cf. *hermi* are dominant. Natricine snakes differ from *N. merkurensis*; In Wintershof-West small Boidae are dominant. It can be seen that most of Asiatic immigrants in Early Burdigalian (MN 3a) preferred semiaquatic conditions and did not compete boid (especially erycine) snakes which were adapted to the more arid biotopes. Although exchanges of „ancient“ snake fauna (i.e. *Falseryx*, *Bavarioboa*) between Germany and Western Europe might have persisted in MN 3a, new Asiatic immigrants with “modern” families preferred environments similar to those occurring in the Early Miocene of Most Basin. In a relatively short time span of about 500 ky a completely different fauna became widespread in all central Europe (at the beginning of the MN 4 Zone). However, the forthcoming changes are documented from Schnaitheim 1, where the earliest distinct occurrence of ‘Oriental vipers’ in central Europe is known. A significant marine ingression (NN 3-NN 4, ~ MN3b-MN 4) to the Rhine Graben prevented or strongly restricted faunal exchange between central and western Europe. Increasing temperature (MAT > 20° C) and humidity (MAP – mean annual precipitation = 617 ± 252 mm – 937 ± 255 mm for Mokrá-Western Quarry, Czech Republic, MN 4) caused that central Europe became unsuitable for the occurrences of erycine and probably also small non-erycine snakes as the dominant components of snake communities. Although substantial changes in the composition of the European snake fauna were evident in Late Eggenburgian and Ottnangian, ~ MN 4, the Middle Eggenburgian (Early Burdigalian), MN 3 Zone, played a key role in the development of the Miocene snake assemblages in central Europe. Changes in the composition of the snake fauna of Central Europe probably were not primarily caused by the selective pressure of penetrating Asian immigrants, but the unusual combination of climatic and palaeogeographic development was crucial. The first occurrence of distinctly thermophilous taxa (Miocene *Bavarioboa*, *Falseryx*) in MN 3a Zone indicate that the thermal optimum of the MCO has started earlier than previously thought. The LAD of pythonine snakes (*Python* sp.) in the Middle Miocene of Germany (Griesbeckerzell 1a+1b, MN 5-MN 6a; MAT = 18,6–20,8° C a CMT (cold month temperature) = 8,1–13,3° C; MAP = 750 ± 253 mm – 1025 ± 258 mm) document that thermal optimum persisted in central Europe up to 15–14.8 Ma. Subsequent rapid decrease in MAT was attended by decrease in humidity which is documented by the presence of erycine snakes (*Eryx* sp.) from several German Middle Miocene (MN 6) localities.

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17th Meeting of the Association of European Geological Societes	Abstracts	262–263	Belgrade, 14–18 September 2011

Actual Horizontal Movements in Dinarides and Pannonian Basin

Milan Mladenović[1]

Geodynamics of Central Europe and Asia Minor was shown in Mladenović (2010). In that paper, mostly based on reversed faults in the Moho-discontinuity, and on the appearance of new volcanic islands in the Mediterranean Sea from Gibraltar to the Gulf Genovese, the zone of strong horizontal movement under crust, which withdraw parts of the crust was discused. This zone is over 100 km wide and extends from the Atlantic through the Mediterranean to the Eastern Carpathians. It is limited with border lines named the Northern and Southern boundary lines. – In this paper these two lines are followed through Slovenia and Croatia.

Lake Balaton in Hungary has narrow and elongated shape because there was a great tectonic line in the past. Now, Balaton Lake is the most secure natural geodynamic landmark - in the north-east direction as well as in the opposite direction to Venice (through Slovenia). The largest Slovenian rivers flowing from the Alps, generally from north to south, and when they came to this direction (Balaton–Venice): rivers Sava, Drava and Mura suddenly turn toward the north-east, and after a small course to the north-east extend the natural flow to the south.

All that facts are not coincidental but are linked in geodynamic terms, means that the entire terrain south from the moving direction, moving very slightly towards the north-east and moves the rivers Sava, Drava, and Mura. Therefore, this general direction (Venice–Balaton) is taken for **Northern boundary line** that has the same direction through to the Eastern Carpathians (all these river flows and turns are clearly seen at all geographic and hydrographic maps) (Fig. 1).

Southern boundary line passes through Croatia at following route: Adriatic Sea – Island Rab – intersects northern Velebit – besides Zrinska Gora – besides river Ilona and Daruvar and intersects the river Drava (Fig. 1).

– In the domain of Zrinska Gora (Bania) Dinaric ophiolites and metamorphites are suddenly cease (Karamata, 1982) and, because there are cut off and dragged to Hungarian and Slovak mountains. This is where the Dinaric geomagnetic anomalies stop.

– Ilona River with its parallel confluent – runs for more than 50 km along the known zone of neotectonic parallel faults (Jamičić, 1995), and

– River Drava - changing the direction of its flow for about 20 degrees.

Earlier, it was observed on the map of Moho discontinuity that the Dinaric Moho Depression in its north-western end was rotated by 20 degrees to the north (Herak & Tomić, 1995). This indicates that the horizontal movement to the north–east was so strong - that not only rotate Dinarides, but also domains of the rivers Sava and Drava.

The **Southern boundary line** can be seen at the map of earthquake epicentres, where after Drava it intersects Danube river and according the epicentres has further direction to the state border with Romania and extends next to the border and the through Ukraine and ends under the Ukrainian Carpathians.

At the same map entire **Northern boundary line** can be seen, and it ends below the Slovak Carpathians.

From distribution an concentration of epicentres, many facts can be observed and explained. For the geodynamics are most important:

– It is clear where - the most active underthrusting (Continental Subduktion...), under the Dinarides is,

– It is clear why the northern Velebit is “cut off” and wrap around.

– The southern and northern boundary line can be seen,

– It is clear that between them is the largest chipping and the largest dragging to north-east.

Finally - I hope that this work will help modern researchers of this area – remindering of: Actuality is the key for past-understanding and future - prediction.

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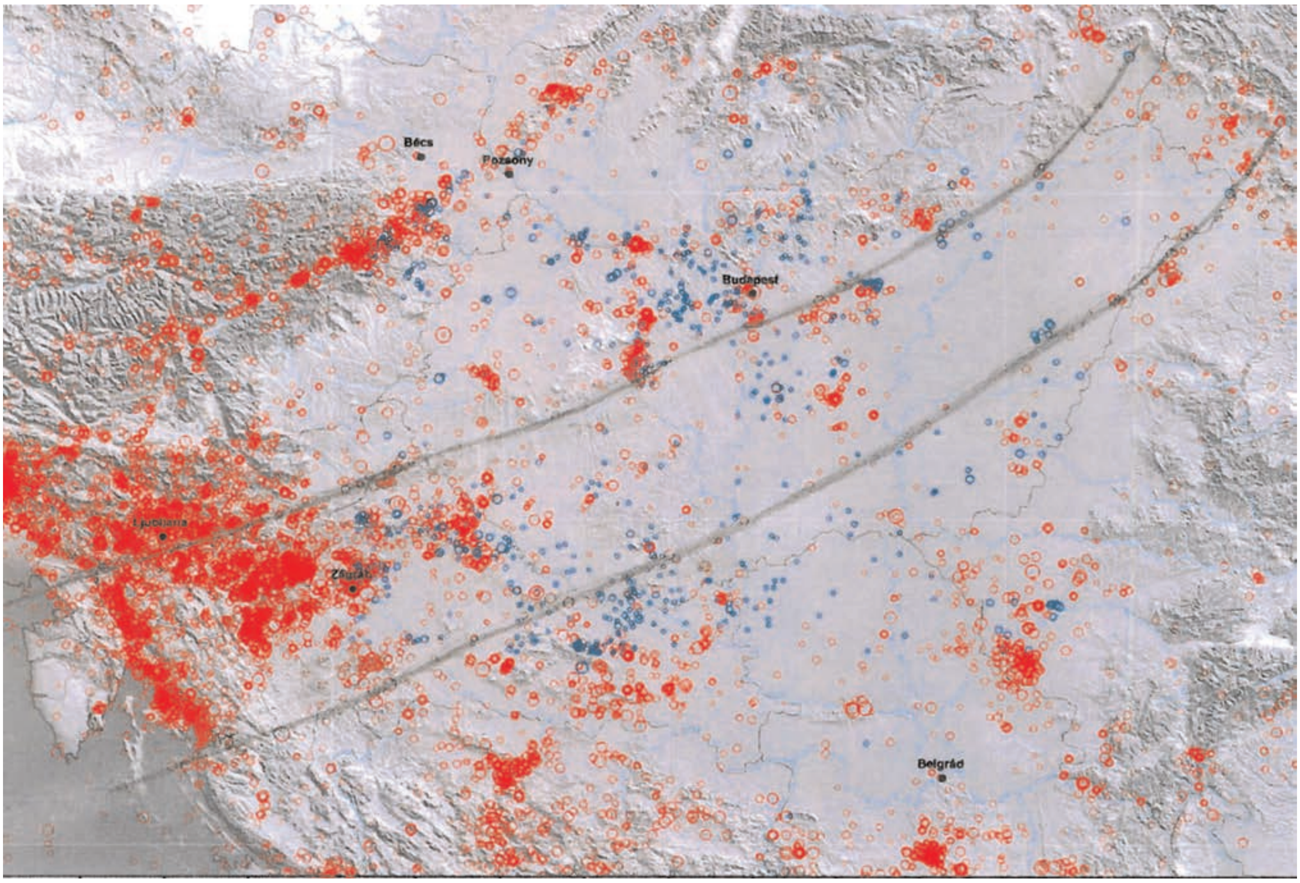

Fig. 1. Position of the Northern and Southern border lines.

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17th Meeting of the Association of European Geological Societes	Abstracts	264–264	BELGRADE, 14–18 September 2011

A new Concept for Albanide, Based on the Tectonic Style of Krasta-Cukali Zone

PETRAQ NAÇO[1], HASAN KULIÇI[1] & ENTON BEDINI[1]

Based on Albanian Geological Map, we can observe that Krasta–Cukali tectonical zone devides into three parts the sructural trunk of Albanides:

Northern Albanides, which are known as Albanian Alp zone; Eastern Albanides, where are included Korabi and Mirdita zones in Western Albanides, where are included Ionian and Kruja zones.

The Krasta–Cukali tectonical zone on the west is limited with visible tectonic contact to the Kruja zone, also on the east with Mirdita tectonical zone, while on the north, its tectonical relations with Albanian Alp zone, as it is accepted till now, are no clear.

Being so, a question is, what kind of the relations are characterized these tectonican units?

Along the Shkoder–Peja segment, there is a collosion between tectonic units, where Krasta–Cukali tectonical zone, is face to face to the Alp tectonical zone, leaving the place each other on extension, differently from the others on both sides, which continue without interupt the Albanide continuity. From these an idea is born; these tectonic – facial zones can be part of a huge paleotectonic unit. This idea is suported from the prezence of some unifying litofacial horizons as in subzones of the Krasta–Cukali zone, also in Alp zone and in Mirdita tectonik Crecatous unit.

Krasta–Cukali tectonical zone on its extension is divided on thee units: Krasta tectonical subzone, Spiten–Shelde tectonical subzone and Cukali tectonical subzone. These units, as they have common litofacial elements, have the element which diffentiate clearly these from each other.

Gramozi, Okshtuni and Peshkopia tectonical windows, constitute a next element of the Krasta– Cukali tectonical zone, inside eastern Albanides, what speaks for the allochtonism of those last.

Key words: Krasta–Cukali zone, Albanide, tectonic window, trunk.

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17th Meeting of the Association of European Geological Societes	Abstracts	265–265	Belgrade, 14–18 September 2011

Detached Part of the Central Parathetys in the Slovenj Gradec Basin, Northern Slovenia

Mirka Trajanova[1]

Miocene sedimentary rocks of the wider Slovenj Gradec area were not considered as a part of the Pannonian basin and Central Paratethys. The Pohorje and Kozjak mountains along with the Labot fault were representing boundary of the basins.

More recent investigations, comprising radiometric dating, paleomagnetism and structural parameters (Márton *et al*., 2006; Trajanova *et al*., 2008; Fodor *et al*., 2008), indicate that Miocene sediments of the wider Slovenj Gradec area were integral part of the Pannonian basin until mid-Middle Miocene. They were detached from the Pannonian basin by the left rotating eastern parts of the Austroalpine units (Pohorje and Kozjak) and tilting of Pohorje along the Labot fault. As deduced from the cooling history of Pohorje batholith, where the strongest tectonic activity took place at around 17 Ma and terminated in Badenian at around 15 Ma, this could be the time when the Slovenj Gradec part of the basin lost connection with the Pannonian basin.

Calcareous nannoplankton assemblages found in the borehole MD-1 (Ćorić, Trajanova & Lapanje, this issue) support marine environment of the deposition and correlate well with the findings in the Styrian and Mura-Zala basins (Jelen *et al*., 2008). After detachment, eastern part of the Slovenj Gradec basin underwent deepening and was syntectonically rapidly filling up by stream and alluvial fan sediments, as documented by the STG-1 borehole near Slovenj Gradec.

According to this model the westward continuation of the Central Paratethys can be followed via Mežica into Austria and could represent short transgression-regression cycle resulting in an opening of a marine passage to the Mediterranean Sea sensu Rögl (1998).

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17th Meeting of the Association of European Geological Societes	Abstracts	266–266	BELGRADE, 14–18 September 2011

3D Geological Model of Carpathian Orogenic Front Near Pilzno (SE Poland)

ANDRZEJ GLUSZYNSKI[1]

The model's main purpose is to predict the most probable and possibly the most detailed structural geometry of the contact zone between Carpathian orogen and Carpathian foredeep. 3D seismic data recently aquired by the Polskie Górnictwo Naftowe i Gazownictwo S.A. (*Polish Oil and Gas Company*) allow an accurate recognition and description of deep geological structure of the area to be made. 2D seismic data, together with those from boreholes and geological maps were also used while constructing this model.

The geological structure in the vicinities of Pilzno is tripartite. Its three components are major structural units: (1) the Miocene Carpathian foreland basin, overriden from the south by and partly deformed at the contact with (2) Cretaceous to Palaeogene flysch successions of the Outer Carpathian stack of thrust sheets and (3), Permo–Mesozoic strata underlying both (1) and (2), and representing the sedimentary cover of the post-Variscan platform.

It appears from the interpretation of the seismics that the folded and overthrust Miocene strata of the Zgłobice unit above the triangle zone's frontal backthrust were displaced toward the northeast along a oblique ramp in the west and were thrust upon a frontal ramp of E–W strike in the north. Fault-bend frontal anticlines developed above both the ramps. A SW-plunging syncline was also formed parallel to the oblique ramp in the west. Its SE limb overlies the triangle zone's frontal backthrust. Below the frontal backthrust tectonically thickened and folded Miocene evaporites occur.

The Mesozoic basement of the Carpathian foredeep in Pilzno area is dissected by SW-throwing normal faults together with accompanying subordinate lower-order events. The throws on those faults reach up to several tens of meters.

This is presented both in the form of three-dimensional visualisation and two-dimensional depth slice maps at any selected elevation level. The software packages used to build presented model were Kingdom (™SeismicMicro), Move (™Midland Valley) and Petrel (™Schlumberger).

Key words: 3D geological modelling, visualisation, 3D seismic, structural geometry, SE Poland, Petrel.

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17th Meeting of the Association of European Geological Societes	Proceedings	267–269	BELGRADE, 14–18 September 2011

The European Geologist Title – Why and How

IRIS VUKOVIĆ[1]

Abstract. Recent trends in globalisation require a different approach to the mobility of experts. As geology is a scientific and technical discipline that knows no borders, its professionals need to be mobile within the world of today. Sometimes it is difficult to overcome differences in formal and professional qualifications. Therefore, a new system of establishing the titles of „qualified persons" is an absolute necessity. The European Geologist Title is one of the milestones in such processes, as it is established as a proof of professional experience and good practice that is recognized throughout Europe and in some non-European countries, very important in the world of geological activities.

Key words: EurGeol Title, European Federation of Geologists, National Vetting Committee, Lifelong Learning, reciprocal agreements.

Introduction

Recent trends of globalisation are making the world smaller from a wide array of aspects. Geology is one of the disciplines that knows no political borders – there are many international infrastructure projects which could never see the light of the day without the geologists' active involvement, such as the Channel Tunnel or Rhinebrown Coal, thus the worldwide co-operation among the geologists is of the utmost importance. Also, ongoing developments within the international natural resource and finance sector increasingly require that technical reports, particularly those reporting on a company's mineral resource assets, must be signed off by a "qualified person" (CLIFFORD, 2002).

Even though it is not widely advertized as such, geology is ubiquitous in almost every aspect of ordinary life. Today, geologists' practice involves the health, safety and welfare of the public, the environment, and the economy and feasibility of engineered works. Every construction work needs engineering geological evaluation prior to commencemment of actual works. Many people speak of water as the „21st Century's Gold" and it is hydrogeologists who discover the water supplies and further on work on protection and sustainable usage of these. The raw materials which are neccessary for sustaining much aspects of the life we lead today, from energy (fossil fuels), to construction materials and base and precious metals, are discovered by geologists. Expertize in structural geology and tectonics is essential for locating sites for different establishments, including but not limited to the disposal of radioactive waste. In order to fulfill all those roles the geologists must strive to follow the highest possible standards in their work. Also, ongoing developments within the international natural resource and finance sector increasingly require that technical reports, particularly those reporting on a company's mineral resource assets, must be signed off by a "qualified person". All these circumstances lead to establishing the European-wide professional title for geologists – the European Geologist title.

European Federation of Geologists

The European Federation of Geologists ("EFG") is the federation of national geological associations from European countries. It was established in 1980, by representatives from Belgium, France, Italy, Portugal, Spain and the United Kingdom. The main objectives were, and still are:

– to represent the geological profession in Europe,
– to safeguard and promote the present and future interests of the geological profession in Europe,
– to promote best practice policies with regard to the responsible use of the Earth's natural resources,

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– to establish policies concerning environmental matters such as protection and sustainability.

Currently, the EFG has 20 Full Members: Belgium and Luxembourg, Croatia, Cyprus, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Italy, The Netherlands, Portugal, Russian Federation, Serbia, Slovakia, Spain, Sweden, Switzerland and the United Kingdom. There are also a number of Observer Members, while the United States is an Associate Member.

The members of the Federation represent the profession of geology throughout Europe to the public, as well as to the national governments, and to the European Union. The main goals of the activities are to promote the ubiquity and importance of geological information and advice for policy development regarding to the responsible use of the Earth's natural resources, avoiding environmental pollution, land-use planning and environmental protection. The EFG, in conjunction with its member associations and others, is to the forefront internationally in developing codes and guidelines (CLIFFORD, 2002).

As Europe is facing more and more challenges emerging from the continuously changing geopolitical framework of the European Union, the free movement of professionals within Europe, including geologists, is getting more and more important. Thus, great efforts within the EFG have been focused on mutual recognition of their academic and professional qualifications by the adoption of the title of European Geologist ("EurGeol").

A Quick Outline of the National Regulation

In Europe, the geological profession is regulated in only two countries - Italy and Spain. In the United Kingdom the title "Chartered Geologist" is regulated by The Geological Society of London, a learned society, and professional body, incorporated by royal charter.

In Italy, foreign academic qualifications do not have legal validity; so it is virtually impossible for qualified professional geologists from other countries to practice their profession in Italy. On the other hand, in Spain, there are two ways for a foreign citizen to legally practice their profession: to obtain recognition of their academic title by the Ministry of Education, Culture and Sports, while the other is governed by the terms of the free movement directive and operated by the Ministry of Science and Technology as the designated authority to authorise professional practice. The Ilustre Colegio Oficial de Geologos ("ICOG"), the Official Association of Spanish Geologists, is the legal body that registers all geologists practising in Spain. ICOG's statutes, which are recognized in Spanish Law, state that in order to practise geology in Spain, a graduate in geology must register in the association and that persons holding the EurGeol title are recognised by the ICOG as national geologists.

In the United Kingdom the regulated title "Chartered Geologist" is conferred by The Geological Society of London. Application for this title can be made at any time from a migrant. The application and appeal procedures are the same for UK national and non-national applicants.

Usually, in the countries where the profession is not regulated, it is the market forces that govern the situation.

Requirements and Procedure for the Award of the Title

In accordance with Directive 89/48/EEC (OJ L 9.24.1.1989, p. 16) and Directive 92/51/EEC (OJ L 209.24.7.1992, p. 25), the EFG has adopted a system of multi-lateral recognition between the affiliated national geological associations in 20 countries. All of these associations have agreed to accept each other's accredited degree courses, and have agreed a formula, which defines a professional geologist. This formula embraces education, training and experience. Holders of the title of European Geologists must comply with the EFG's Code of Professional Conduct and maintain their professional standards by participating in Lifelong Learning Programmes.

All professional geologists involved in any discipline can apply for the title, providing the applicant is a member of a National Association that is a Full or Associate member of the EFG, has relevant postgraduation experience in proffessional practice of geology – no less than eight years, including University studies, and satisfies the EFG requirements for award of the title.

The candidate should apply to the National Vetting Committee („NVC"), established by each National Association that is a Full Member of the EFG. The NVC should consist of no less than 3 members and they should all be European Geologists title holders, if applicable. Along with the application form, the candidate must submit the Professional Practice Report and any other documents confirming the facts stated in the Report and the Application form, as well as the statements of three Sponsors who are already the title holders.

The Licesed Body should administer and control the award of the Title of European geologist and maintain the title for the holders registered with the same Licensing Body. Some National Associations are licensed by the EFG Council to act as National Licensing Bodies for their countries. So far, only 4 countries have established National Licensing Bodies: The UK, Spain, Ireland and Switzerland. The goal of the EFG is that one day all the members act as National Licensing Bodies. However, during the process of bringing the title closer to all the active geologists in Europe, there is the International Licensing Body, responsible for the National Associations which do not have National Licensing Bodies established yet.

In order to guarantee wider international links the EFG has entered into reciprocity agreements with other professional geological associations including the American Institute of Professional Geologists ("AIPG") and the Canadian Council of Professional Geoscientists ("CCPG"). The title is also recognized by the Stock Exchanges in Toronto and Vancouver, Canada, London, UK, Dublin, Ireland, Johannesburg, South Africa and Lima, Peru (Jones *et al.*, 2008).

Lifelong Learning

An essential part of the strive for ensurement of high standards in the profession and practice of geology, the EFG requires all holders of the EurGeol title to maintain and develop their abilities as practitioners by a commitment to lifelong learning programmes of continued professional development. Lifelong learning is the process of continuous building of skills and knowledge throughout one's life. It may occur through different experiences, gained in different stages of life and situations. These experiences could generally be divided into formal and informal.

National associations can develop own life-long learning programmes within the context of the EFG policy. EFG recognizes that life-long learning programmes may include the following:

- On-the-job training where specific learning outcomes have been identified and planned
- Formal courses and conferences (passive or active involvement)
- Studying for a recognized award
- Different forms of distance learning
- Writing papers
- Holding lectures and presentations
- Managerial or organizational work within a scientific society or professional body
- Professional activities which support teaching or mentoring
- Private reading, including keeping abreast of' current publications
- Attending and organizing fieldtrips.

In order to maintain the European Geologist title, its holder needs to provide the evidence of CPD undertaken to the Licensed Body, responsible for his or her Title.

EurGeol Title Now and Future Perspectives

The EurGeol title is gaining more and more acceptance amongst geologists in all the members of the EFG. All the National Vetting Committees have been established and the first applications are processed. Hopefully the EFG will soon become the true European Federation of Geologists as more and more National Associations will join in order to enable its members to become the EurGeol Title holders.

Nevertheless it is important to keep in mind that the title does not have any legal status and confers no rights to work in any European country. On the other hand, the title holders will surely have wider opportunities and shorter time for processing their applications and in the future the title will surely be more and more recognized. All the national geological associations within the EFG have agreed that any professional holding the title will be automatically given the same rights and privileges as a national geologist, up to the legal and competency limits that each National Association might have. There are cases that the National Association is the office in charge of the recognition of foreign titles, and in this case, the recognition will be automatic. In those where its role is assisting a statutory registration authority, its recommendation will be favourable to the recognition, mentioning explicitly that the applicant bears the title of European Geologist.

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17th Meeting of the Association of European Geological Societes	Abstracts	270–270	BELGRADE, 14–18 September 2011

The EU Information System for Sustainable Supply of Europe with Energy and Mineral Resource

JASNA ŠINIGOJ[1] & STEPHAN GRUIJTERS[2]

The European Union currently imports more than 50 per cent of its hydrocarbons and minerals and this is growing each year. In view of the reduction in the world's hydrocarbon and mineral reserves, and the possible disruption of importation by uncontrollable political events, the rational use of these resources is becoming a central issue in EU economic policy.

The financial downturn in 2008 has affected global markets and, as a consequence, energy and mineral prices, in some cases leading to deprivation and social unrest. To enable sound economic and political decisions, as much information on energy and mineral supplies as possible is needed. At present this information is hard to find and, in some cases, unreliable or not even available. Three main factors are responsible for this: differences in information format, lack of information harmonisation between countries and organisations, and large discrepancies in how often information is updated.

In response to the need for quality information, the European Union, through the Information and Communication Technologies Policy Support Programme (ICT PSP), has funded a three year 2.5 million euro project to design and develop an information and policy support system for sustainable supply of energy and mineral resources in Europe – EuroGeoSource. The system will contain information from at least 10 European countries on geo-energy (oil, gas, coal, etc) and mineral resources (metal ore and non-metallic minerals, industrial minerals and construction materials such as gravel, sand, ornamental stone, etc.).

EuroGeoSource will provide users with actual, reliable and harmonised information on the European scale. Furthermore, it will bring together economical, administrative and geological information related to energy and mineral resources. The system, which takes the form of a web portal, will also provide users with functionality to search, locate, view and analyse pertinent geographical information.

The data that is going to be served at the EuroGeoSource web system will be compatible with INSPIRE. Therefore several experts on data management from EuroGeoSource are also members of the INSPIRE thematic working groups for 'geology and minerals' and 'energy'. Furthermore the project is registered as an SDIC and will act as a pilot for the development of minerals and energy data within INSPIRE. 11 Geological Surveys are present in the consortium and other surveys are encouraged to join the project as data providers to maximize the coverage of Europe.

EuroGeoSource is currently in its second year. During the first year contact was made with a wide group of potential end-users to ask them what they would expect from an information portal like EuroGeoSource. An inventory of the current situation in the participating countries regarding availability, accessibility and management of energy and mineral resources data was made. All this information was used to build a first draft version of the portal, which was met with enthusiastic reactions when demonstrated at the first EuroGeoSource public workshop in Budapest in March 2011.

Using the inventory of available data, a first draft of key economic attributes that will be served at the portal was made. These data include general information (e.g. location, start and end of production), economic information (e.g. in situ reserves and (UNFC-) classification) and geological information (e.g. host rock). The attributes are compared and synchronised with the first draft of the INSPIRE data specification for minerals and energy.

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Qualification Framework for Higher Education in Geology - the EuroAges Project

EVA HARTAI[1] & ISABEL FERNANDEZ FUENTES[1]

The EuroAges (European Accredited Geological Study Programmes) is a European pilot project in the context of the European Qualifications Framework (EQF), Lifelong Learning Programme.

The project was carried out during the period of January 2009 to January 2011. It aims at developing Europe-wide applicable quality standards and criteria for the assessment of higher education programs in geology in the context of the Bologna Process.

The project leader was ASIIN Consult GmbH, a German accreditation agency. Combining the common interests and individual strengths of ASIIN, The European Federation of Geologists, the Spanish Official Professional Association of Geologists, the Hungarian Geological Society and the Geology Section of the Swedish Association of Scientists, the EuroAges project has provided important reference documents as mapping the structure of geology study-programs across Europe and the existing qualification framework, including a set of learning outcomes which graduates of first and second cycle degree programmes are expected to achieve, and accreditation criteria & procedures.

The mapping of the existing qualifications for geology supported the increased transparency of earth sciences qualifications across Europe and therefore facilitates the improved academic and professional mobility across Europe. The document includes reports on 27 countries with information about the implementation of Bologna process, education in geology programs and structure, learning outcomes, professional pre-requisites, and accreditation systems.

The standards and criteria intend to provide means for reviewing the quality of higher education geology qualifications in the European higher education area, in a way that encourages the dissemination of good practice and a culture of continuous improvement of geology programmes. Given the great diversity of geology education across Europe, the attempt to create framework standards comprising all areas of the geology discipline appears ambitious. The EuroAges intends to provide an overarching reference point for the variety of geology programmes. In order to allow for possible inclusion of existing geology specialisations within European higher education institutions, the framework was formulated in rather general terms.

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THE GEOLOGY IN DIGITAL AGE

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