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GEOLOGICAL INFORMATION PORTAL OF SLOVAKIA

State Geological Institute of Dionýz Štúr, Bratislava

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Preface

Thanks to a dynamic development of the society, the requirements of individual sectors, IT development, climate change and its consequences as well as the fulfilment of tasks arising from the relevant Slovak legislation, directives and decisions of the European Commission larger and larger demands are addressed to current information relating to the environment and geology as such. The information obtained by geological research and exploration are effectively utilized only in terms of general and simple availability. In the European Union a natural geological standardized system for the provision of information through the Internet is a common practice. These services are in most cases entrusted to the competent geological surveys. In the Slovak Republic the State Geological Institute of Dionýz Štúr is in charge of the Geological Survey services.

The State Geological Institute of Dionýz Štúr (SGIDŠ) is a contributory organization, its founder is the Ministry of Environment of the Slovak Republic. The Institute ensures the performance of the state geological survey of the Slovak Republic in terms of § 36 sect. 1, lett. x) of the Act no. 569/2007 Coll. on Geological Works (Geological Act) as amended by further legislation and Statute of SGIDŠ.

Under the Act on Public Administration Information Systems (no. 275/2006 Coll.) with effect from 20/5/2006 and in terms of the Concept of Information System Development of the Ministry of Environment for the period 2008-2013 SGIDŠ is commissioned to create, operate and perform the tasks pertaining to the information system as part of the state information system, which is in line with the Strategy of Public Administration, the National Concept of Public Administration and in accordance with Act no. 3/2010 Coll on the National Spatial Data Infrastructures - NSDI, by adoption of which Slovakia has met legislative obligation to transform the INSPIRE Directive into national legislation.

The INSPIRE Directive came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2019. The INSPIRE Directive aims to create a European Union (EU) spatial data infrastructure. This will enable the sharing of environmental spatial information among public sector organisations and better facilitate public access to spatial information across Europe.

The State Geological Institute of D. Štúr is a research institute; among its main activities belong in particular:

- Provision of the state geological survey in the field of geological research and exploration of the territory of the Slovak Republic;
- Provision of the national monitoring of geological environmental factors;
- **Creation of an information system in geology;**
- **Registration, record keeping and making available the results of geological works carried out in the Slovak Republic;**
- **Performance of the Central Geological Library of the Slovak Republic**
- Issuance of geological maps and professional geological publications;
- Providing activities of reference geoanalytical laboratories of the MoE.

By execution of the above activities SGIDŠ provides important information needed for decision-making processes of state and local governments as well as professional and general public.

Creation of the information system in geology is at the same time one of the prime tasks of the Concept of Geological research and Exploration of the Territory of the Slovak Republic for the period of 2007 – 2011 (with outlook until 2015) approved by Government Resolution no. 1001 of November 28, 2007. The solution of the project Geological Information System (GeoIS, solved in the period 10/2005 – 12/2014) implemented intentions of the approved Concept and introduced new ways of collecting, storing and providing geological information in the agenda of MoE.

An important milestone for ensuring the fulfilment of these tasks was the year 2006 when in the context of organizational change the position of the Deputy Director for Informatics was established who supervised two separate departments - Geofond and Information Systems.

The Geofond is a guarantee for administration of registers, management of exploration territories, administration of attests on exclusive deposits, administration of exclusive deposits resources and balance of raw mineral resources, management of register of old mining works, collecting, administration and making available geological works results.

Department of Information Systems is holder of the projects "Geological Information System" (GeoIS), which started at the end of 2005 and their mission has been to develop a web application, providing access to spatial geological information, namely (maps), regional geological (structural, tectonic...), engineering geologi-

cal, hydrogeological, geochemical and geophysical data. In cooperation with the Geofond the GeoIS has participated in developing of digital archive of geological reports as well.

One of the main objectives of this change was organizational management of information system creation. This project presented and began to implement the process of system integration of all relevant sources into a coherent and technologically optimum form. In general, under the system integration we understand the model management and operation of complex information system in terms of heterogeneous IS/IT subsystems, products and services. The system integration shall secure the most advanced and continuous process deployment of standardized information technology in order to meet all the concepts and requirements of the system administrator, and its users as well.

The geological project solution consisted of creating an open information system on geology, geological data, including databases and access to information via the internet.

The partial objectives of the project were:

- Obligatory structures for particular types of geological data compiled on the basis of analysis of the current status and needs of all involved components.
- Development of system architecture, including setting up user hierarchy and system security.
- Creation and maintenance of databases.
- Development of client applications.
- To the greatest extent processed and made available reliable geological data.

In addition to the final report, all results incurred during solutions of approved annual projects were continuously published in Map Server and Digital Archive of SGIDŠ. After two years of data preparation, testing options, functionalities of developing solutions there was achieved the first serious breakthrough in the project solution.

On 1/4/2008 there were ceremonially put into operation two key applications, Digital Archive and Maps Server of SGIDŠ. Since that date, the results of geological tasks have been provided to users via the Map Server as separate applications. In the annual update Map Server over the years many applications have been made accessible. At the same time, works were being performed at Geofond, including ensuring continuous operation of these services.

In terms of the Slovak Geological Law No. 569/2007 the data from all geological results (geological reports) retrieved by geological research, exploration, etc. must be sent to Geofond (archive). Regarding the privately financed projects – the subject can restrict the data in report from being publicly used (max. for 10 years – then they become public) and may define conditions of confidentiality: when, how, by whom, with or without payment, how much.

In general, all geological data and services are free of charge and SGIDŠ can charge only a small service fee. All information about geological works (and results) are provided free of charge, they are funded from the public finances.

The project Geological Information System has involved as guarantors and the coordinators of the individual data fields many SGIDŠ workers. Let me list them in alphabetical order, and to thank them for their active cooperation.

Ing. Miroslav Antalík, Ing. Peter Bajtoš, PhD., Ing. Peter Baláž, PhD., RNDr. Dušan Bodiš, CSc., Ing. Martina Brodianska, Mgr. Gabriela Bystrická, RNDr. Róbert Cibula, RNDr. Klement Fordinál, PhD., RNDr. Milan Gargulák, CSc., RNDr. Augustín Gluch, RNDr. Ľubomír Hraško, CSc., RNDr. Ľubica Iglárová, RNDr. Patrik Konečný, PhD., RNDr. Jozef Kordík PhD., Andrea Kozmerová, Assoc. Prof. RNDr. J. Kráľ, CSc., Mgr. Dušan Kúšik, Ing. Kristína Lacenová, RNDr. Jaroslav Lexa CSc., RNDr. Pavel Liščák, CSc., RNDr. Peter Malík, CSc., Ing. Jozef Mižák, Mgr. Martin Ondrášik, M.Sc., Assoc. Prof. RNDr. Stanislav Rapant, DrSc., RNDr. Igor Slaninka PhD., RNDr. Peter Šefčík, PhD., Mgr. Jaromír Švasta PhD., Jozef Vlachovič and the staff of contributing organisations Esprit, spol. s r. o., Banská Štiavnica and YMS, a.s., Trnava.

Currently, the web environment of the Map Portal and Digital Archive including the applications themselves is available only in Slovak. In the scope of the project GeoIS 2 we are preparing a new version of map server, which will now also include the English language. Home version with general information and descriptions of applications in English will be available simultaneously with the issuance of the SGM 1/2015. For temporary assistance for English-speaking users to use applications and better readability the functionalities are listed at the end of this issue with Slovak/English translation of the terms used. The Digital Archive keeps articles and reports dominantly in Slovak and therefore does not envisage future translation of the application into English.

Štefan Káčer

ACRONYMS AND SYMBOLS

API	Application Programming Interface
CMS	Content Management System
CMS GF	Partial Monitoring System – Geological Factors
CSW	Catalog Service for the Web
EAs	Exploration Areas
EG	Engineering Geological
EU	European Union
GeoIS	Geological Information System
GIB-GES	Complex Geological Information Base for the Needs of Nature Protection and Landscape Management
GIS	Geographic Information System
GK	Gauss-Krüger
GPS	Global Positioning System
HTML	Hyper Text Markup Language
HTTP	Hyper Text Transfer Protocol
IAH	International Association of Hydrogeologist
ICA	IBM Content Analytics
ICC	IBM Content Collector
ICM	IBM Content Manager
ICN	IBM Content Navigator
ICT	Information Communication Technology
INSPIRE	Infrastructure for Spatial Information in Europe
IS	Information system
IT	Information technology
JBI	Java Business Integration
JMS	Java Message Service
JPEG	Joint Photographic Experts Group
JTSK	Krovak (East/North) Coordinate System (Czech/Slovak)
MD	Material Documentation
MoE	The Ministry of Environment
MVC	Model View Controller
NATURA	Nature Protection Areas
NSDI	National Spatial Data Infrastructures
OAI PMH	Open Archives Initiative Protocol Metadata Harvesting
OMW	Old Mining Works
OPIS	Operational Programme Information Society
REST	Representational State Transfer
RSS	Rich Site Summary
RVA	Radon Volume Activity
SAPAG	Sandberg-Pajštún Geopark

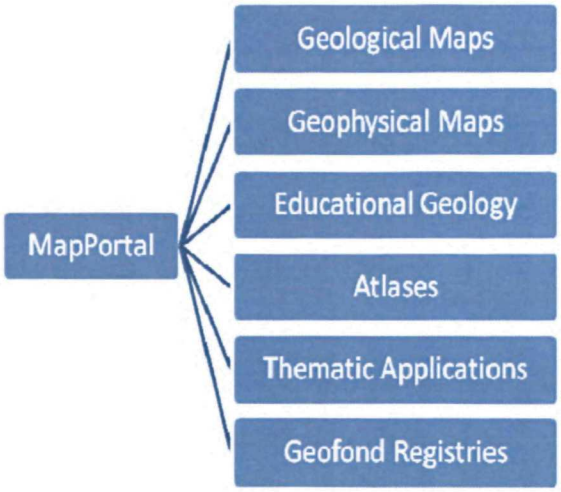
SGR	Spiš-Gemer Rudohorie Mts.
SIP	Session Initiation Protocol
SPA	Single Page Application
SCW	Catalogue Service Web
SGIDŠ	State Geological Institute of Dionýz Štúr
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SPA	Single Page Application
SQL	Structured Query Language
SR	Slovak Republic
TANAP	Tatra National Park
TIFF	Tagged Image File Format
VES	Vertical Electrical Sounding
VM	Virtual Machine
WebADF	Web Application Development Framework
WebGIS	Web Geological Information System
WS	Web Service
XML	eXtensible Markup Language

1. Map Portal as a Gateway to the Geological Information

In 2015 Map Portal has replaced the original version of the Map Server 2008. An extension has been achieved not only in terms of content, but also functional and technical design. It has become the only place which integrates all essential digital spatial information of SGIDŠ.

The SGIDŠ Map Portal is an information system, which consists of a large number of applications connected to each other via REST web services. Since 2008, it has undergone an extensive development. Of the original eight mapping applications it has been extended to 49 WebGIS applications that display data in the 459 datasets with 2,311 attribute data. All applications are classified into the following thematic groups.

The gradual development of new applications tailor-made to the needs of users has significantly expanded its functionality, including support for mobile devices. Logical arrangement of the Map Portal is in Fig. 1.1.



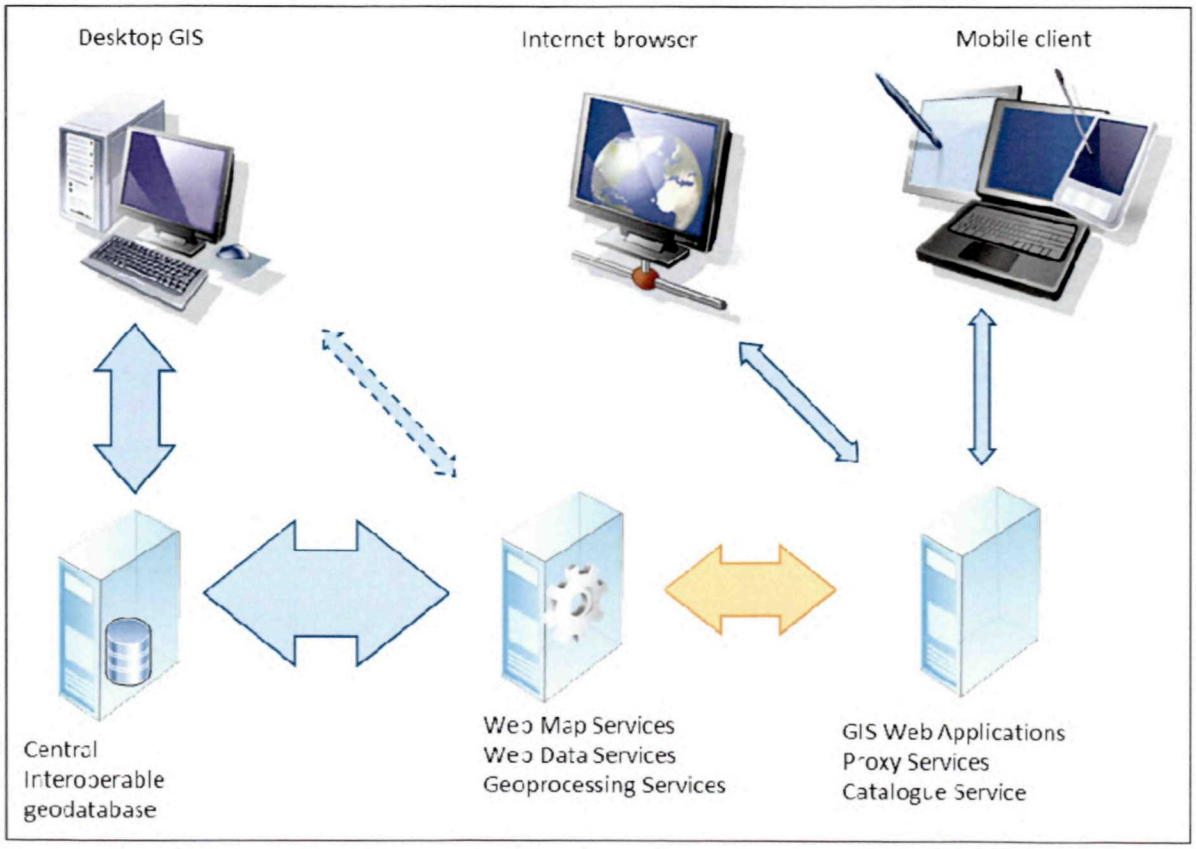


Fig. 1.1 Logical arrangement of Map Portal Information System (compiled by Cibula)

Due to the increase in the amount of data and applications we have gradually increased performance of hardware infrastructure by purchasing new servers. This has enabled to utilise their virtualisation. The technical solution of the existing infrastructure allows after completion of additional servers to create a failover cluster. In Fig. 1.2 virtualised (Hyper-V) infrastructure with existing server applications are displayed.

Fig. 1.2 Content of virtual servers (compiled by Cibula)

An integral part of the GeoIS-is meta-information system, which consists of two subsystems. The first subsystem is designed as a Single Page Application (SPA) with responsive design. It serves as a gateway to the Map Portal. It shows clearly individual WebGIS applications together with information on how to create various datasets, including their description with relevant layers and tables. Information on the data kept in the Map Portal to the level of individual attributes can be obtained using full text search.

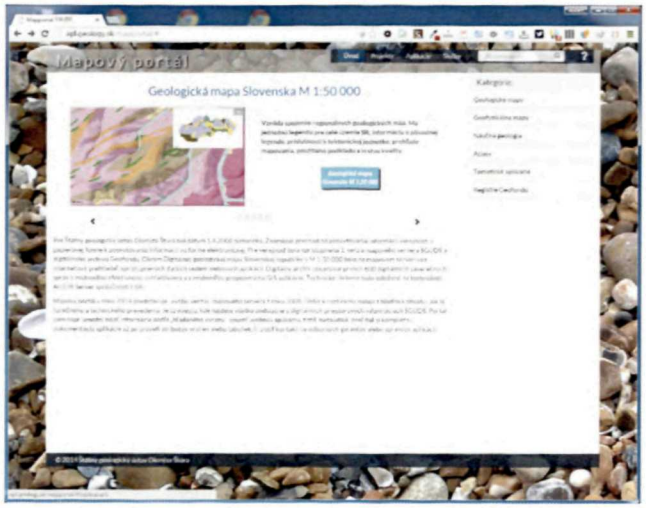


Fig. 1.3 Home screen information system „Map Portal"

Fig. 1.4 Overview of WebGIS applications

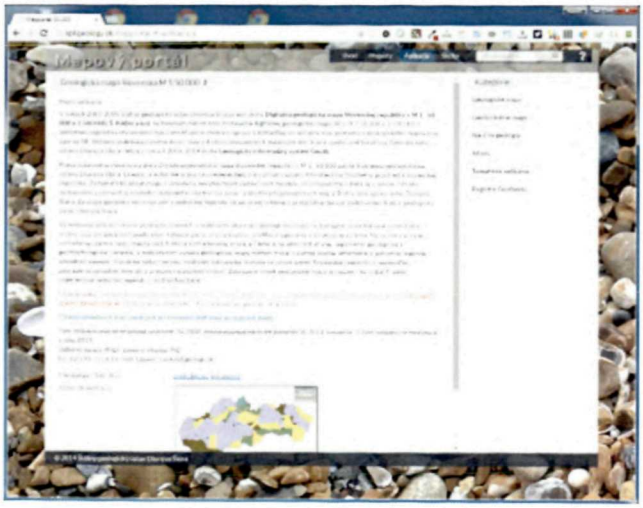


Fig. 1.5 Depth view of introductory information related to the Geological Map 1:50,000

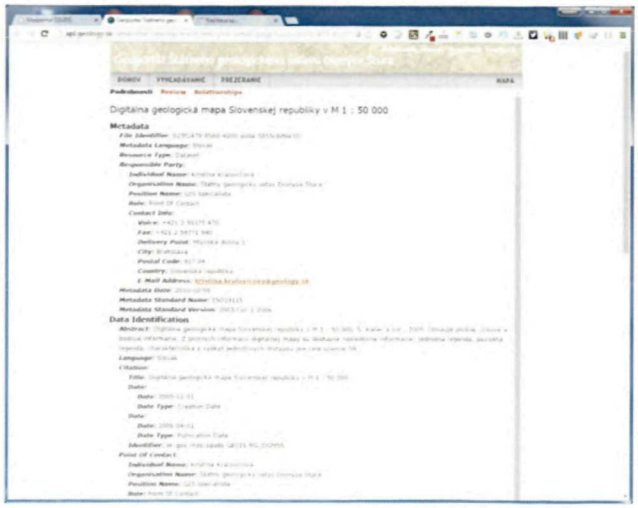


Fig. 1.6 INSPIRE descriptive meta-information

Figs. 1.3 to 1.5 show examples of functionalities of data visualization of the first subsystem of the meta-information system.

The second subsystem is created using open source Geportal by ESRI. The information are provided in accordance with legislative standards INSPIRE. This subsystem contains Catalogue Service (CSW), which allows data harvesting into the National Geoportal in accordance with the relevant legislative requirements.

In addition to comprehensive metadata a component of the SGIDŠ Map Portal are the actual map and web applications that are described in the following sections.

2. WEB Services and Applications of Map Portal

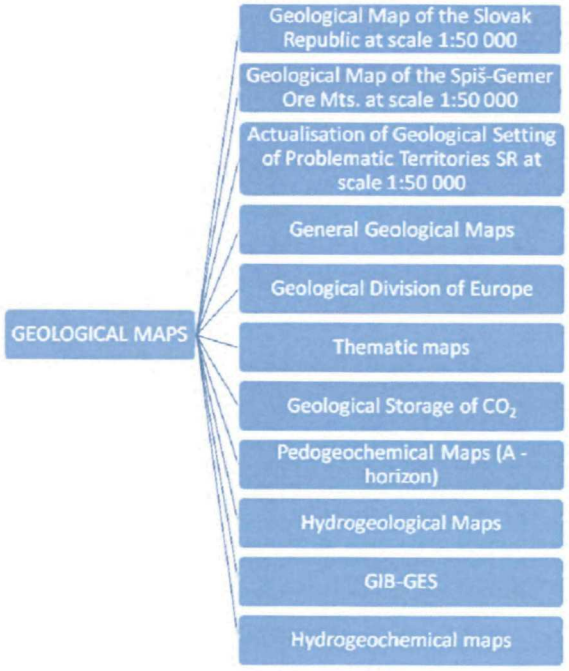
In this chapter there are detailed information on the content, source, author of the relevant data contained in each application. These texts are partly taken from the final report Geological Information System GeoIS (Káčer et al., 2014) and texts published on the SGIDŠ Map Portal – www.geology.sk.

2.1. GEOLOGICAL MAPS

Geological maps represent the content and expertly extensive works of monograph nature; they are intended to serve professional and the lay public. They are an essential underlying layer for further applications. The creation of a geological map of a region is a multi-year process, and coverage of the Slovak Republic territory by geological maps has taken several decades. This naturally led to the fact that some interpretations of the geological setting have advanced along with the change of the wider concepts of geological structures of the Western Carpathians. The new concepts have been supported also by updated research methodologies, which led to the more accurate insight in the age and tectonic affiliation of rock complexes. The process is ongoing and therefore new maps are still being compiled and innovated.

The geological map is a two-dimensional depiction of the territory geological setting, but experienced geologist knows to decipher from it even a third dimension, as well as in-depth details of the fourth dimension – a geologic timeline.

Since 2005, when Digital Geological Map of SR at scale 1:50,000 was presented to the public, the SGIDS has issued a number of new regional map works, and this Digital Map has been enriched on them. On the other hand, there are also newer map works at hand, that are based on a different concept, as the regional geological maps edition, and for those we have created a special display within the map server. Among them is the map of Spiš-Gemer Ore Mts. at scale 1:50,000. So, professionally oriented user may choose between different approaches to the compilation of a geological map.



2.1.1. Geological Map of the Slovak Republic at scale 1:50,000

Geological Map of the Slovak Republic at scale 1:50,000 [online since 2013]
Bratislava: State Geological Institute of Dionýz Štúr
Available on Internet: http://mapserver.geology.sk/gm50js

In the period of 2003-2005 the State Geological Institute of Dionýz Štúr solved the project *Digital Geological Map of the Slovak Republic at Scales 1:50,000 and 1:500,000, Káčer, et al., 2005.* Its goal was a compilation of digital geological map SR at scales 1:50,000 and 1:500,000 with opened unified legend which should enable to implement updates on actual state of the knowledge and geological mapping of the territory of Slovakia. The web-publication of both maps and other relevant map documents, issued by the State Geological Institute of Dionýz Štúr was implemented in the period of 2005-2014 under the umbrella of the project *Geological Information System GeoIS.*

In the web application in addition to areal, line and point information of the geological map the following separate layers are available: a list of the groundwork documents, categorization (quality layer), an overview of mapping and structural scheme. For a quick and precise retrieval of an area, or a site serves a function Search, which is divided into administrative, regional-geological

and geomorphological division. The areal information of the Digital Map include: unified legend, the original legend, characteristics and occurrence of individual lithotypes across the whole territory of Slovakia with an option of display of the original legend and transition to selected occurrence. The displayed section of a geological map can be printed, or unified legend can be generated with print option.

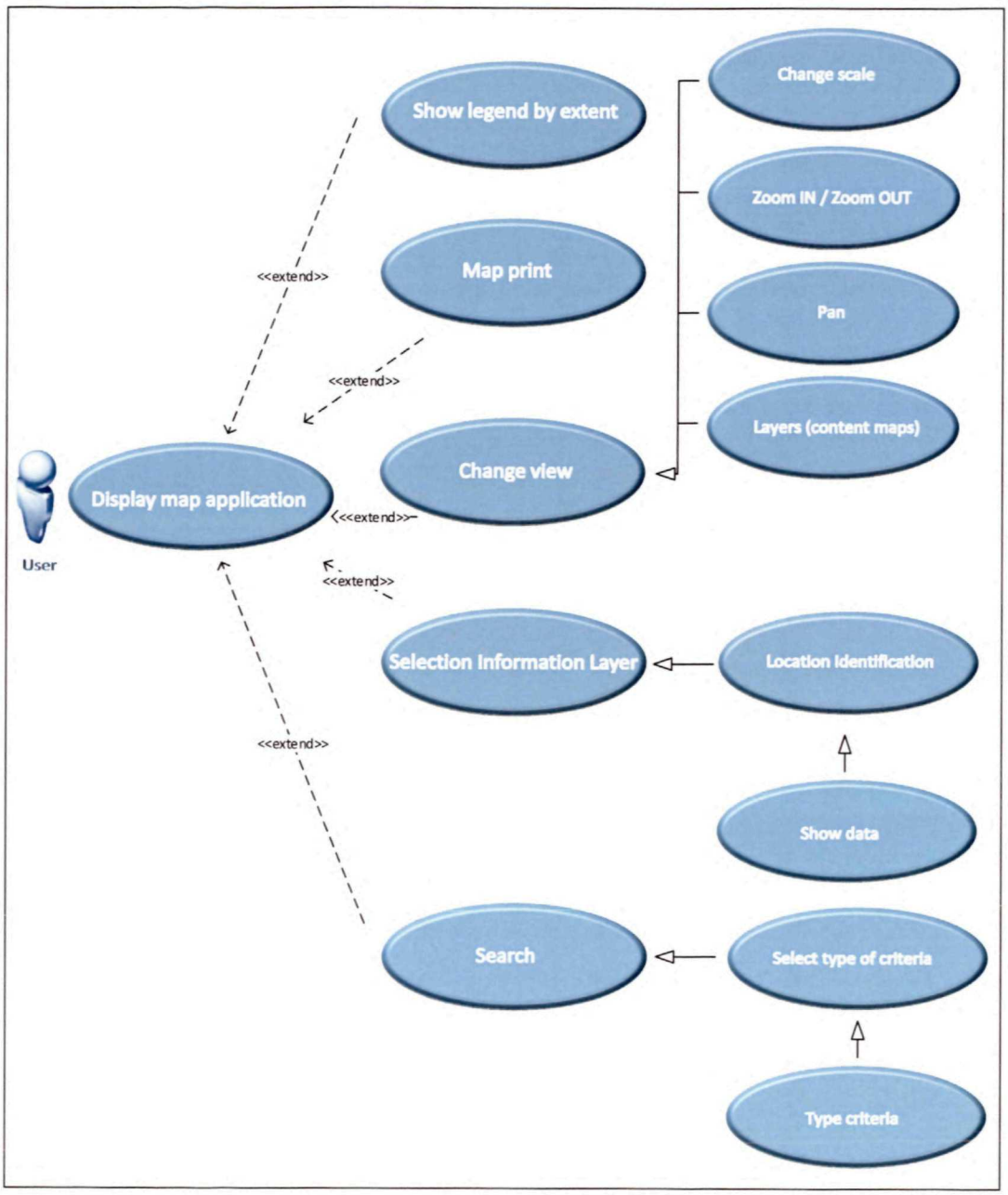


Fig. 2.1 Use Case diagram of Geological Map of the Slovak Republic at scale 1:50,000(compiled by Cibula)

Geological maps from different parts of the territory of Slovakia were digitized and are shown in Fig. 2.3. According to the types and quality of the base maps they were divided into six groups. A combination of several methodological steps had to be implemented to adjust these map documents groups of varying quality in order to create a seamless digital map:

- legend adjustment (legend transformation into a single open one);
- compilation of seamless geological map of 1:50,000 from existing documents;
- professional review and update of the geological map;
- adjustment of the geological map to the current digital topographic map;
- digitisation, editing and transformation of the geological map into co-ordinate and information layers;
- establishment of appropriate GIS;
- approval of the Digital Geological Map.

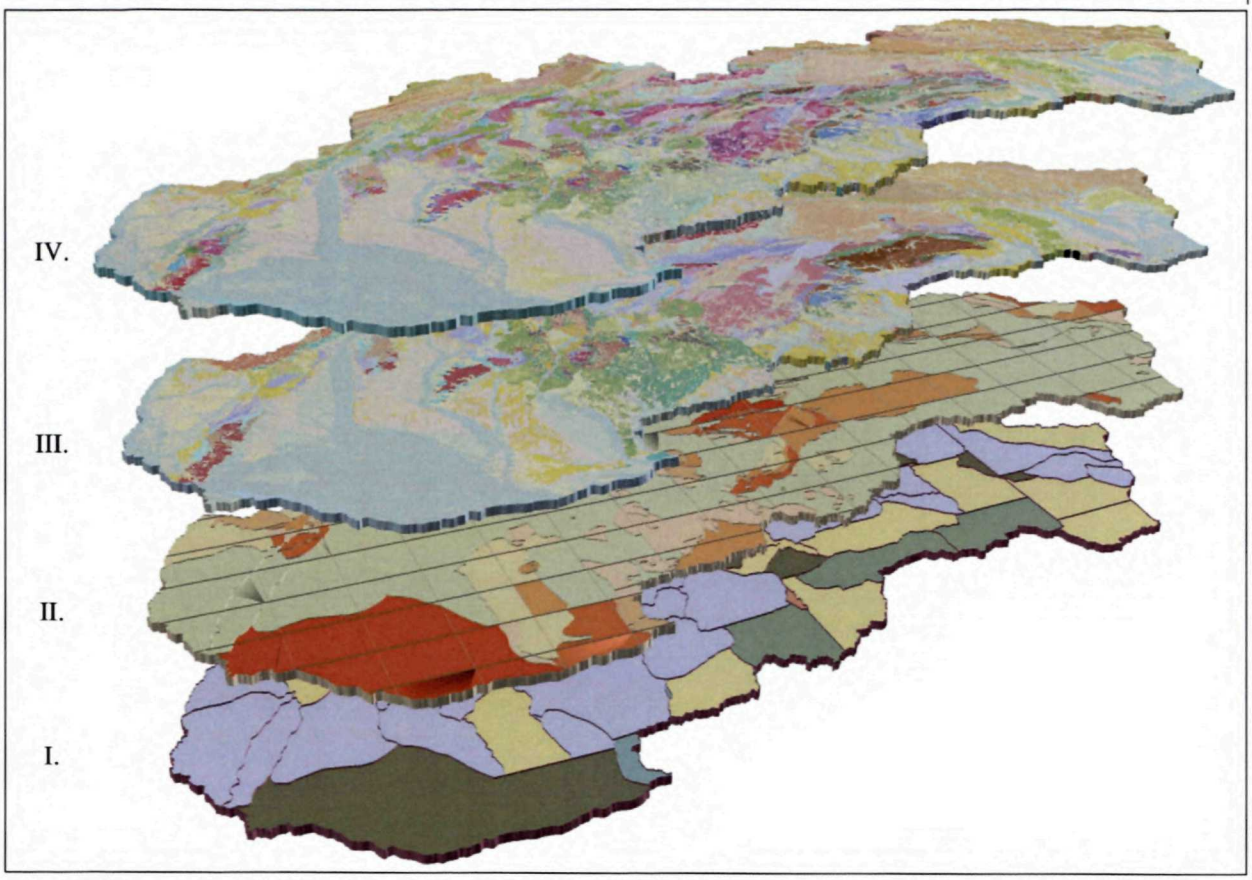


Fig. 2.2 Layers of the Geological Map of the Slovak Republic at scale 1:50,000 (compiled by Bystrická)
I. – Layout of used source documents, II. – Quality layer, III. – Structure scheme, IV. – Geological map

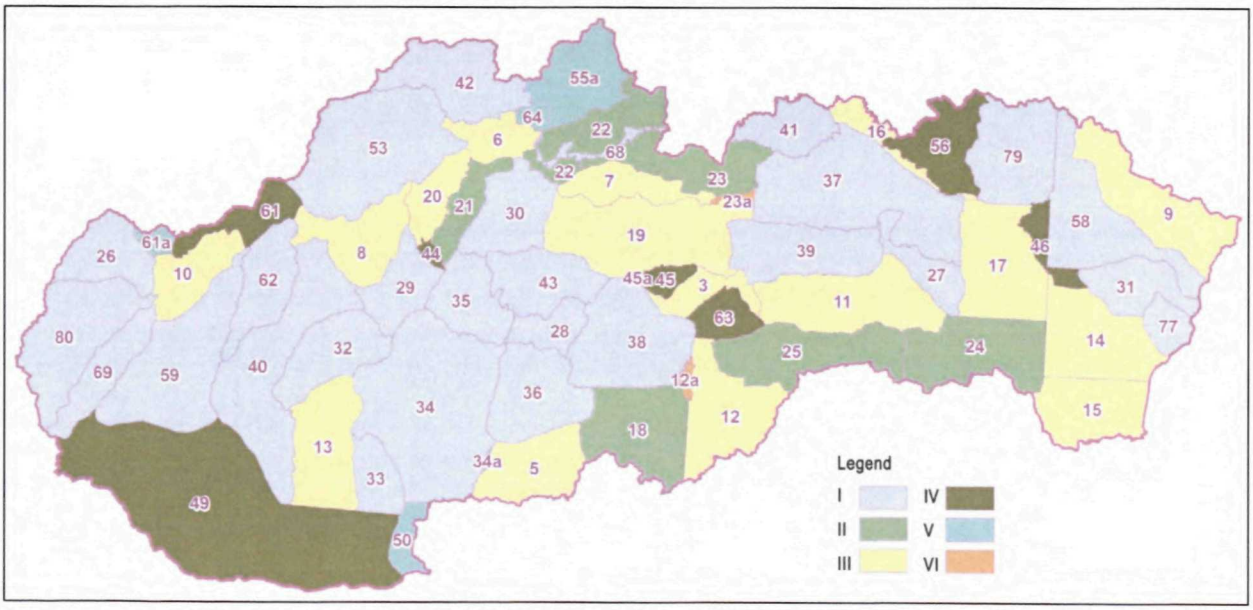


Fig. 2.3 Overview of geological groundwork documents used at compilation of the Digital Geological Map of the Slovak Republic at scale 1:50,000
I – Regional geological maps at scale 1:50,000 processed digitally on non-deformed topographic groundwork ; II – Regional geological maps at scale 1:50,000 processed by classical method on non-deformed topographic groundwork; III – Regional geological maps M 1:50,000 processed by classical method on deformed topographic groundwork; IV – Thematic geological maps at scale 1:50,000, peer reviewed; V – Geological maps at scale 1:50,000, updated; VI – Geological maps at scale 1:25,000, peer reviewed

Overview of geological groundwork documents used at compilation of the Digital Geological Map of the Slovak Republic at scale 1:50,000 is available at http://www.geology.sk/new/sites/default/liles/media/geois/ms_zozn_gp_en.pdf

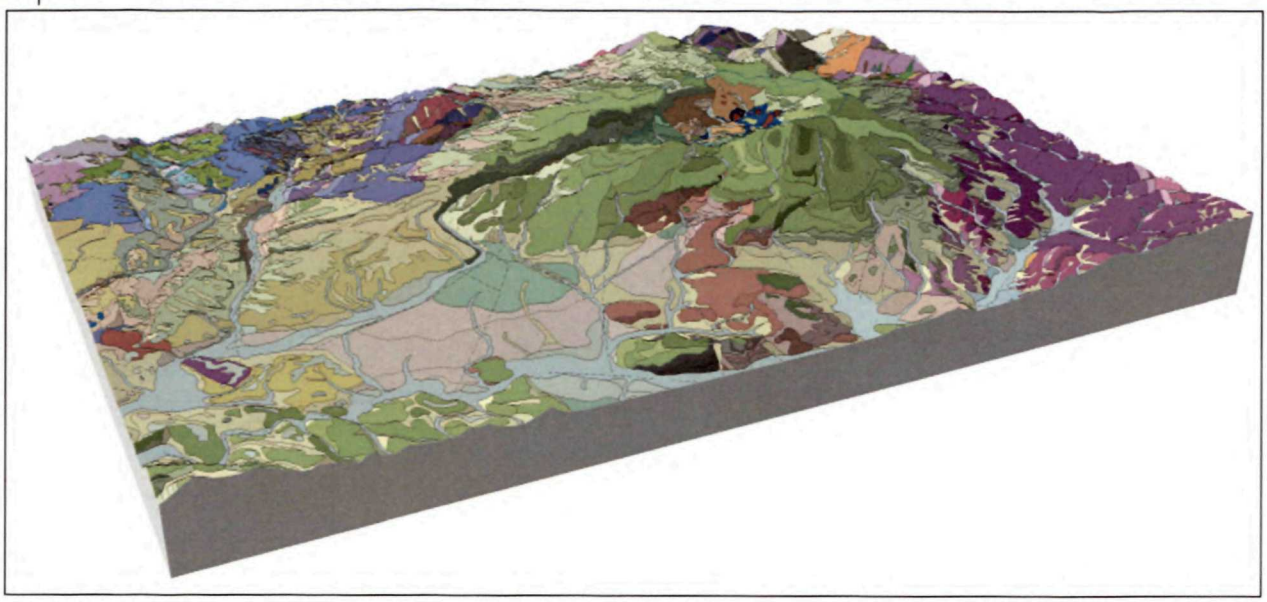


Fig. 2.4 3-D view of Poľana – Geological Map (compiled by Bystrická)

Fig. 2.5 3-D view of Poľana – Structural scheme (compiled by Bystrická)

2.1.2. Geological Map of the Spiš-Gemer Ore Mts. at scale 1:50,000

GRECULA, P. et al.: Geological Map of the Spiš-Gemer Ore Mts. (SGR) at a scale 1:50,000 [online since 2011]. Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/spisgemer

The Geological Map of the Spiš-Gemer Ore Mts. at a scale 1:50,000, being approved and subsequently published in 2009, was compiled by the team of the authors P. Grecula, J. Kobulský, Ľ. Gazdačko, Z. Németh, Ľ. Hraško, L. Novotný and J. Maglay. It is grounded on comprehensive geological-geophysical and geochemical surveys, geological mapping and additional correlations realized within the scope of the projects SGR – Geophysics (1978 – 1992), Atlas of Geological Maps of SGR (1993 – 2001) and Geological Map of SGR 1:50,000 (2005 – 2006). The map provides an interpretation of the geological setting, lithology and tectonics in the southern part of the Inner Western Carpathians.

The concept of the compilation of the Geological Map of SGR and its explanatory notes is based on partially different principles, than the unified legend for the whole territory of the SR in the frame of the project *Digital Geological Map of SR at a scale 1:50,000*. In this case, it depends only on the user, which version of the geological map will be used. We expect that the pro-fessional public will appreciate the web public accessing of the work and will contribute to solving the conceptual differences of this map visualization in comparison with the older version of the Geological Map of the Slovak Ore Mts. – Eastern Part, compiled by Bajaník et al. (1984), which has been incorporated in the Digital Geological Map of SR at a scale 1:50,000.

Fig. 2.6 Localisation of the Spiš-Gemer Ore Mts. region.

2.1.3. Actualisation of Geological Setting of Problematic Territories SR at scale 1:50,000

Available on Internet since 2014: *http://mapserver.geology.sk/akt50js*

In the period of 2006-2013 the State Geological Institute of Dionýz Štúr solved geological project *Actualisation of Geological Setting of Problematic Territories SR at scale 1:50,000* (Hraško et al., 2013).

The solution of the geological project included assessment of the geological groundwork documents appropriateness for the creation of the Digital Geological Map SR at scale 1:50 000, which is available on SGIDŠ map server. Single geological objects were assessed independently and the layer quality depicted particularly those objects with lower quality. In the next step started the solution of particular issues of the geological setting focused in the territories with lower quality of geological groundwork documents.

The problematic territories were solved in such a way, that in a selected territory either all geological objects were studied in a complex way, or the problematic objects were studied and the rest of geological bodies was taken over from the older documents. Major part of the results is included in the geological map. Part of the effort included reassessment of lithological, chronostratigraphical or tectonic characteristics of geological bodies.

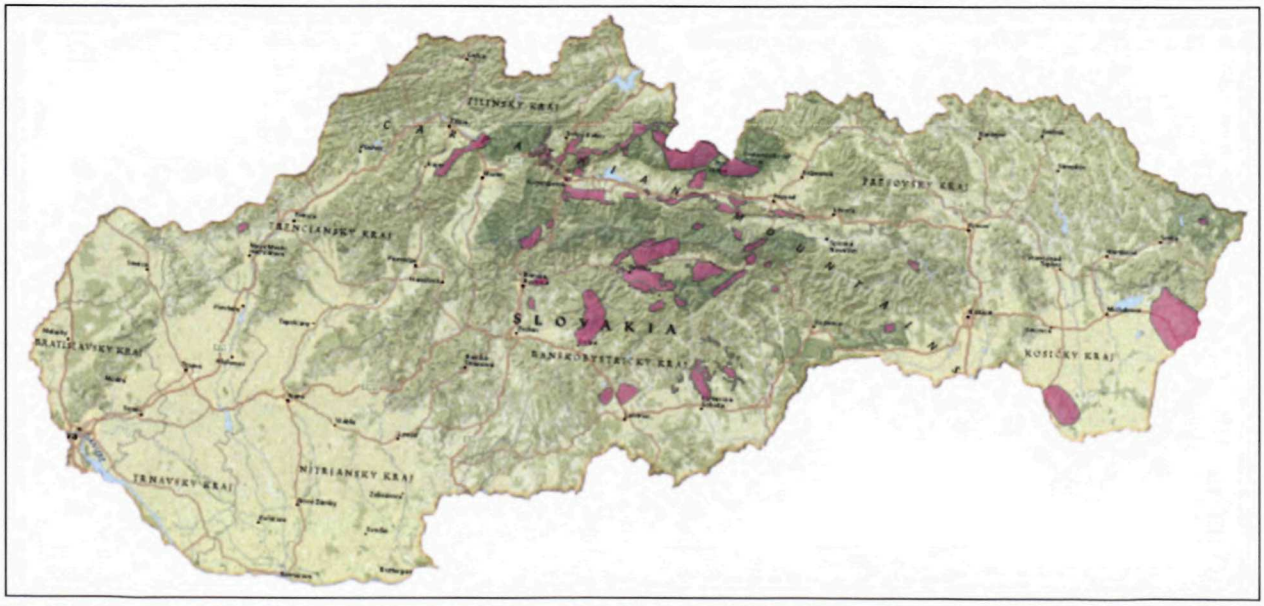


Fig. 2.7 Re-compiled and updated areas (in violet colour) in the scope of the project Actualisation of Geological Setting of Problematic Territories SR at scale 1:50,000

2.1.4. General Geological Maps

General Geological Maps [online since 2008]. Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/pgm

Application includes the following four separate geological maps of various scales:

a) Structural Scheme of the Western Carpathians and Adjacent Areas, Lexa et al., 2000, 1:2,000,000

b) Geological Map of the Slovak Republic, Vozár & Káčer et al., 1998, 1:1,000,000

c) Geological Map of the Western Carpathians and Adjacent Areas, Lexa et al., 2000, 1:500,000

d) General Geological Map of the Slovak Republic, Bezák, et al., 2008, 1:200,000

Application provides contiguous display of the geological setting of the Western Carpathians. By zoom change (depiction scale) the visualised is changed. The range of available information corresponds to a detail of individual legends to the printed above-maps, respectively.

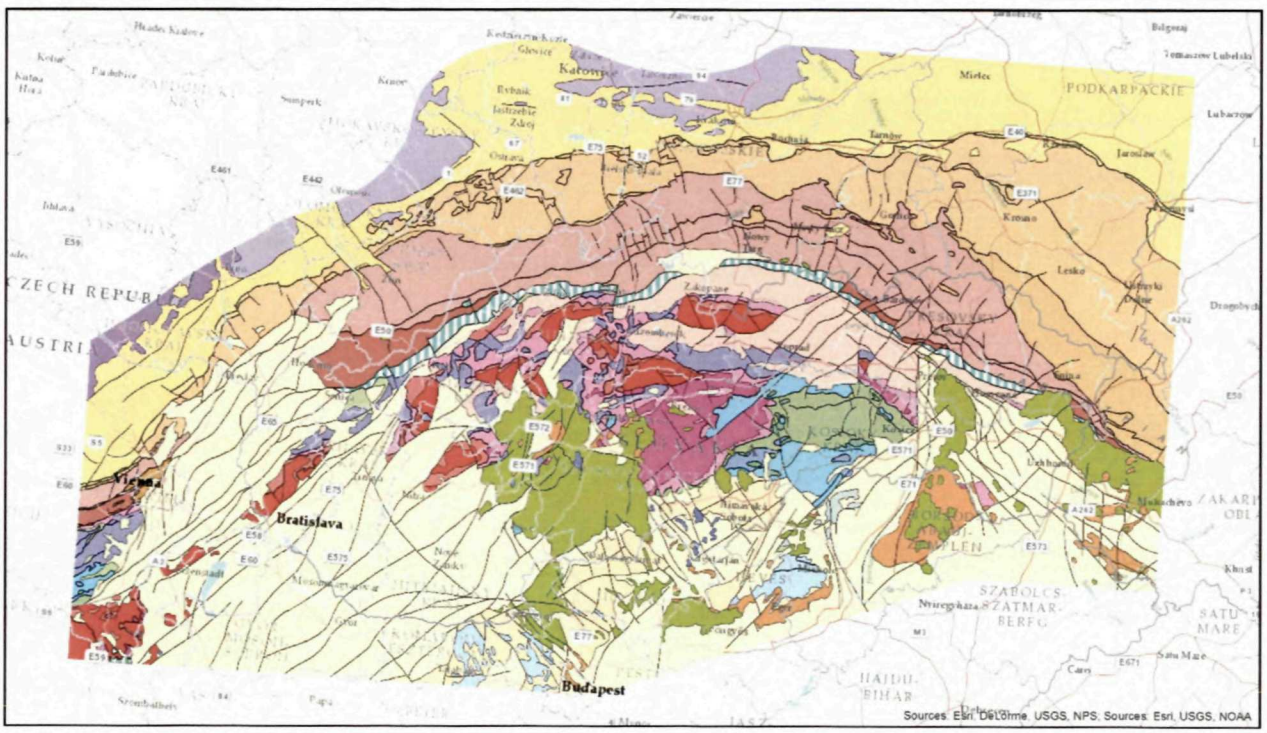


Fig. 2.8 Structural Scheme of the Western Carpathians and Adjacent Areas at scale 1:2,000,000, Lexa et al., 2000

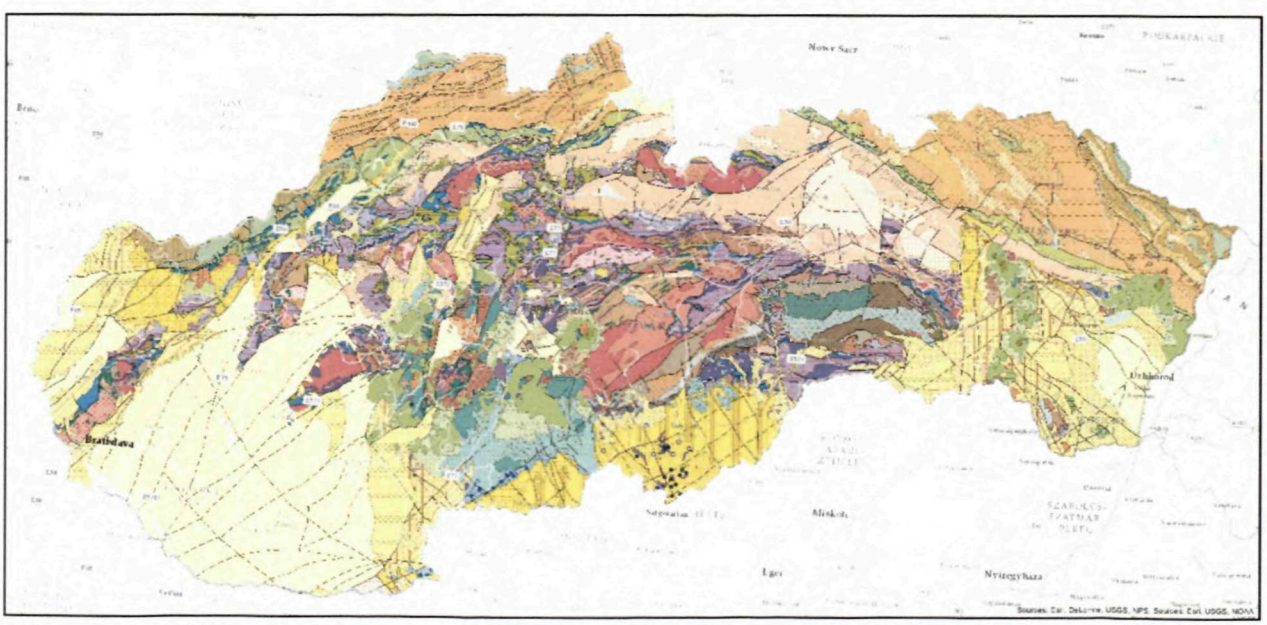


Fig. 2.9 Geological Map of the Slovak Republic at scale 1:1,000,000, Vozár & Káčer et al., 1998.

2.1.5. Geological Division of Europe

LEXA, J.: Geological Division of Europe [online since 2008]. Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/gm20000

Geological Division of Europe, Lexa, 2002, at scale 1:20,000,000, Landscape Atlas of the Slovak Republic

The structural scheme of Europe represents the situation of Slovakia (the Carpathians and the Pannonian Basin) in the context of the geological building of the whole continent. It combines the basic tectonic elements with some elements of the geological building (by dissection of the sedimentary cover) of the platforms by age. Slovakia is situated in the northern branch of the Alpid belt with orogenic development in the Mesozoic and Tertiaryeras. This belt has developed on the ruins of the Caledonian or Variscan orogenic belt in the southern part of the European continent. Part of these older orogens are included into the Alpine zone and represent part of its geological structure.

Fig. 2.10 Geological Division of Europe at scale 1:20,000,000, Lexa, 2002

2.1.6. Thematic maps

Thematic maps [online]. Bratislava: State Geological Institute of Dionýz Štúr, 2014
Available on Internet: http://mapserver.geology.sk/tmapy

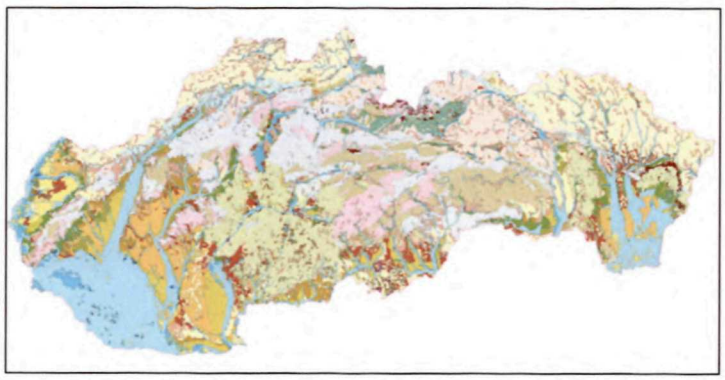
The application contains a set of 21 general maps with brief annotations at scales 1:500,000, or 1:1,000,000 with an option of autonomous visualization of a map and access to information, corresponding to printed versions of respective maps. List of thematic maps:

1. **Quaternary Deposits** (Maglay and Pristaš et al., 2002), 1:1,000,000

Compared to earlier periods of geologic history of the Earth the Quaternary is the youngest and the shortest period of time (2.4 mil. years), which continues to these days. Current knowledge about the spatial distribution of basic genetic types of Quaternary sediments in Slovakia comes from the latest results of the regional geological mapping.

2. General Geological Map of Quaternary of the Slovak Republic (Maglay et al., 2011), 1 : 200,000

This is the first-ever map of this scale, which shows the spatial distribution of a wide range of genetic types of deposits of the youngest period of the geological history of the Earth – Quaternary. Its content is targeted synthesis of knowledge acquired through long-term geological mapping and Quaternary research in Slovakia. It enables the basic orientation in the geological structure of the Quaternary deposits and provides essential image for synthetic scientific studies and in the field of applied geology and soil science. In addition to a qualitative evaluation of the surface of individual genetic types of Quaternary deposits it includes also courses of the Quaternary faults and point features showing small-scale archaeological and paleontological sites.



3. Quaternary Geological Map of Slovakia – Quaternary Genetical (Deposits) Types (Maglay et al., 2009), 1 : 500 000

The map shows the spatial distribution and areal extent of all basic genetic types as well as some selected transitional" facies of Quaternary sedimentary and volcanic rocks of Slovakia. It provides primary picture of their development and their patterns of distribution and deposition. Part of the map is a lithostratigraphic scheme of the Quaternary of Slovakia.

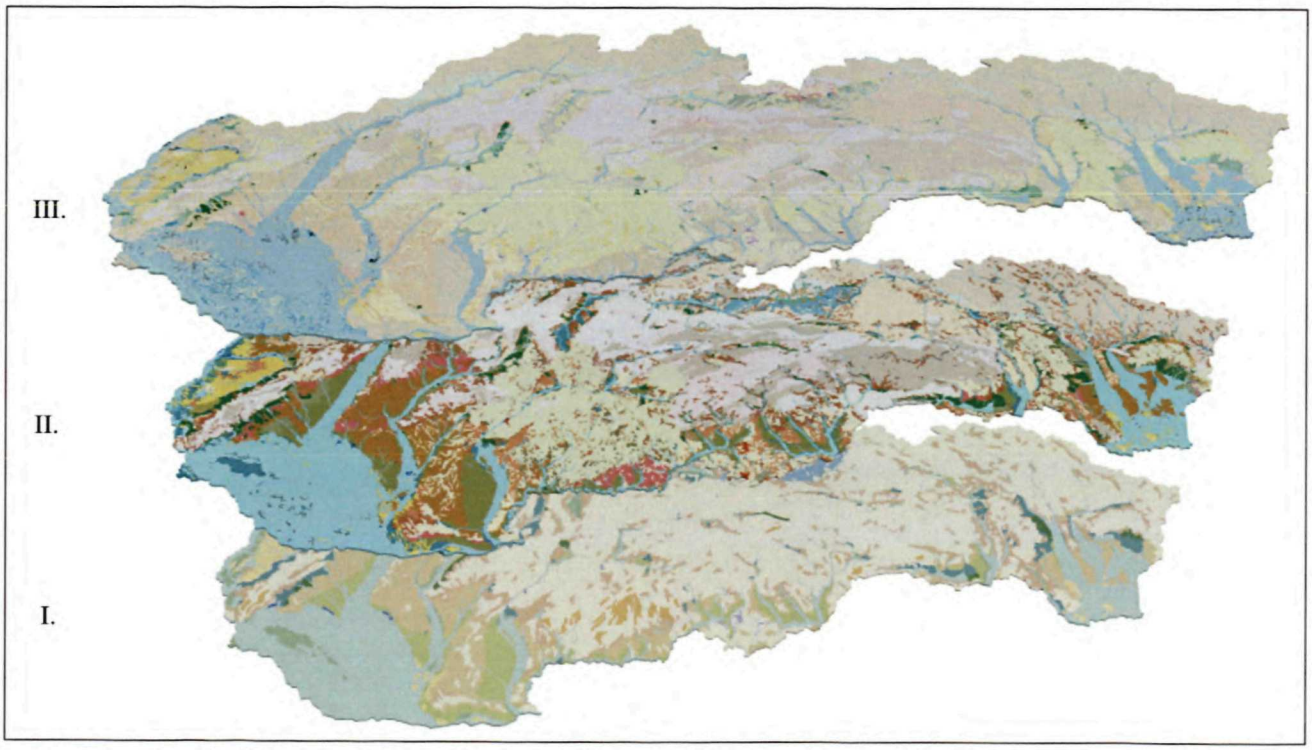
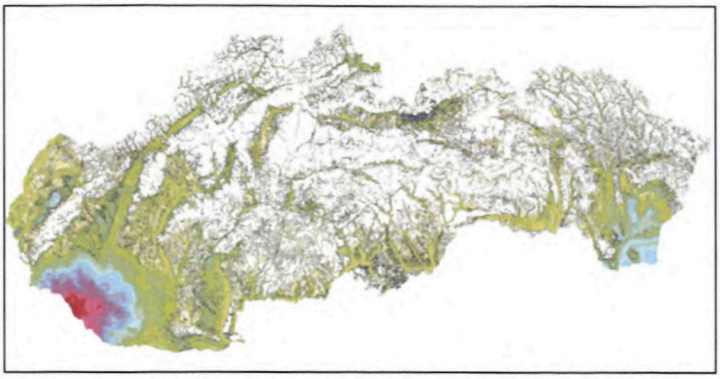


Fig. 2.11 Quaternary Geological Maps of Slovakia. (compiled by Bystrická)
I. – Quaternary Deposits at scale 1:1,000,000, Maglay et al., 2002; II. – Quaternary Geological Map of Slovakia – Quaternary Genetical (Deposits) Types at scale 1:500,000, Maglay et al., 2009; III. – General Geological Map of Quaternary of the Slovak Republic at scale 1:200,000, Maglay et al., 2009.

4. Quaternary Geological Map of Slovakia – Quarternary Cover Thickness (Maglay et al., 2009), 1:500,000



For the first time in the given scale and range the conceptual and qualitative evaluation of the thickness of the Quaternary deposits of the Western Carpathians and the Pannonian Basin in Slovakia is elaborated. Correlated to individual genetic types shown in the map of genetic types of Quaternary deposits the map shows the thickness of the resulting sequence of Quaternary cycle of the geodynamic evolution of Slovakia. Its main contents are isolines of thickness of the Quaternary deposits shown in the appropriate depth intervals, distinguished by colour. The depth intervals are staggered so that it reflects truthfully the territory neotectonic conditions and vertical movement trends of various structural-tectonic blocks shown in the attached sketch.

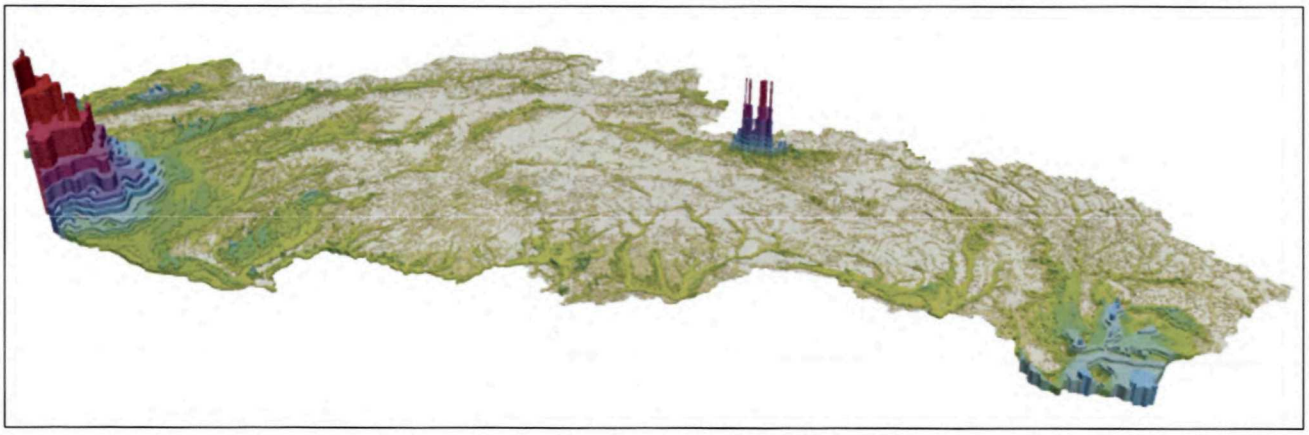
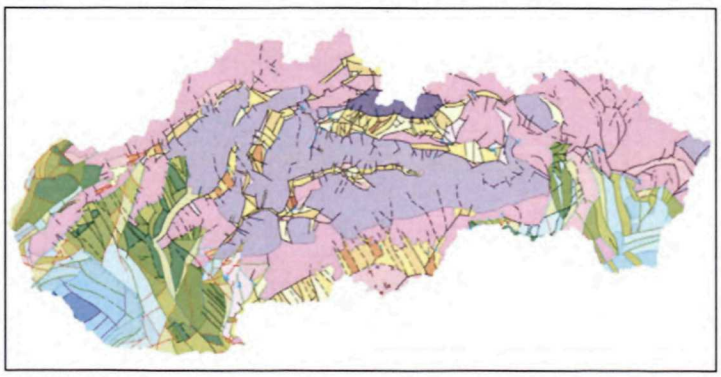


Fig. 2.12 3-D view of Quaternary Geological Map of Slovakia – Quaternary Cover Thickness at scale 1:500,000, Maglay et al., 2009 (compiled by Bystrická)

5. Neotectonic Map of Slovakia (Maglay et al., 1999), 1:500,000



For the first time the map of this scale presents quality evaluation of the last cycle of the youngest tectonic activity of the Western Carpathians and the Pannonian Basin in Slovakia. It shows the resulting sequence of tectonic activity of the geodynamic evolution cycle. It records relative dynamics of vertical movements of the individual block structures; their current status and the resulting movement trends of likely prognosis for the subsequent development of tectonic activity in geological periods to come.

Due to the fact that, compared to older formations the Quaternary period is extremely short and, moreover, in Slovakia it is represented exclusively by continental facies, the situation on the map is not limited to the Quaternary period, but involves movements in the time diapason extended to last 3.5 million years which takes into account the dynamics of the Late Pliocene period. Another reason for extending the period of tectonic evolution seems in practice often difficult to unbundle the Late Pliocene sediments from Early Pleistocene as a result of gradual transition in the sedimentation subsidence areas, or the corresponding continuous tectonic evolution at the interface of Pliocene-Quaternary.

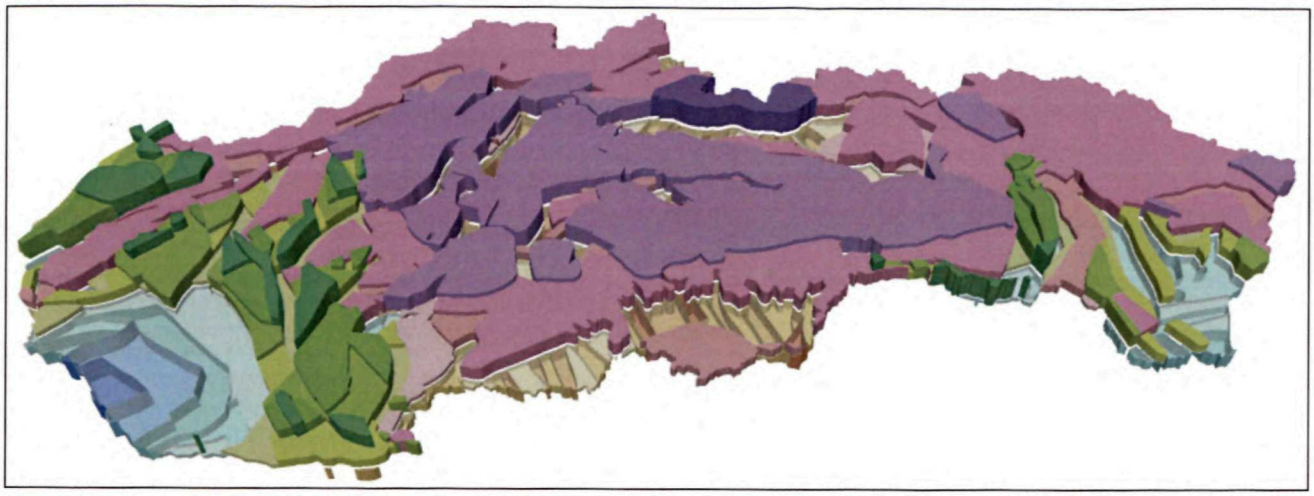
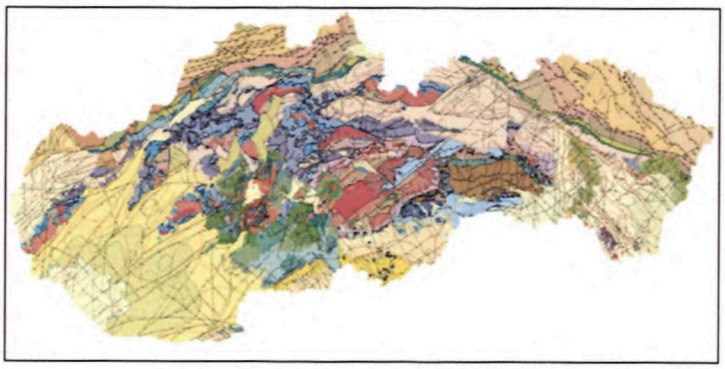


Fig. 2.13 3-D view of Neotectonic Map of Slovakia at scale 1:500,000, Maglay et al., 1999 (compiled by Bystrická)

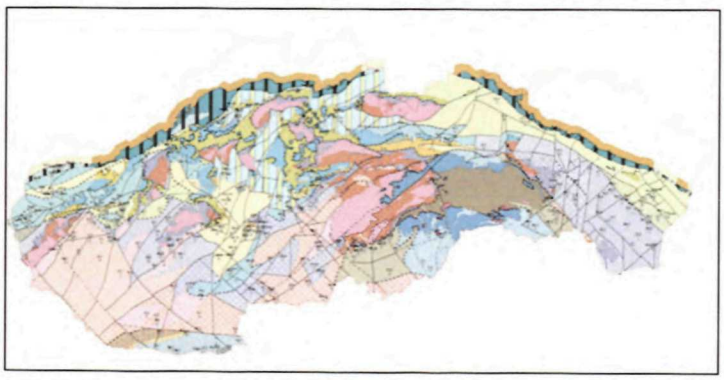
6. Tectonic Map of Slovakia (Bezák et al., 2004), 1:500,000



The bulk of the Western Carpathians mountain system is situated in the Slovak Republic. These mountains have been subjected to a complex tectonic evolution. On the tectonic map of the Slovak Republic the team of authors expresses their current view of the tectonic setting of the Western Carpathians. The principle of the division of tectonic map and its legend are the stages of tectonic evolution of the Western Carpathians.

The Tectonic Map of Slovakia 1:500,000 is mainly based on last geological groundwork documents at scale 1:500,000 (Biely et al., 1996; Lexa et al, 2000) as well as data from regional geological maps 1:50,000. The last tectonic maps of these scales were Tectonic Map of Czechoslovakia 1:500,000 (Maheľ et al., 1984) and Tectonic Map of Czechoslovakia 1:1,000,000 (Biely et al., 1968).

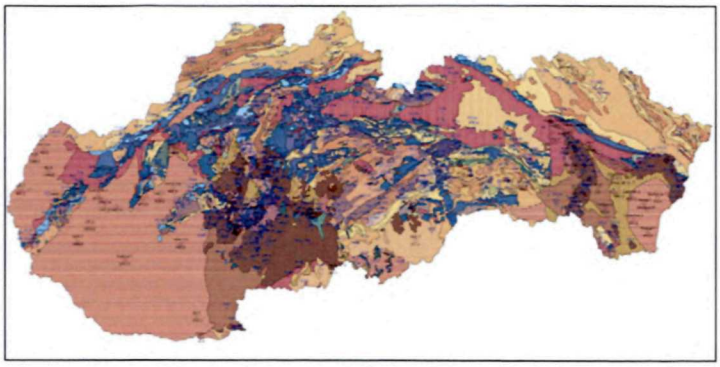
7. Tectonic Map of Tertiary Basement of the Inner Western Carpathians (Fusán et al., 1987), 1:500,000



Tectonic Map of the Tertiary Basement of the Inner Western Carpathians at scale 1:500,000 shows pattern of basic tectonic units of pre-Late Cretaceous age, when nappe structure had been formed. The map depicts the extension of the tectonic units on the surface and interprete their continuation below post-nappe sedimentary and volcanogenic formations of Cenozoic (Paleogene, Neogene and Quaternary) age. Interpretation of the structure is based on geophysical data and drilling with reached pre-Tertiary basement or on drillings which are interpretive important, but did not reach bedrock. There is displayed pattern of faults, overthrusts and nappe lines identified and projected from the surface structures or identified at a depth by geophysical measurements and wells. The Tertiary basement of the Inner Western Carpathians is interpreted till Pieniny Klippen Belt that separates the Inner and Outer Western Carpathians (in terms of division by Biely). In the external (flysch) zone, the thickness of nappes made of sedimentary rocks mainly of Tertiary age is so large that even currently on the territory of Slovakia none of the boreholes reached bedrock of flysch nappes. Geophysical measurements allow only indirect interpretation of tectonic structure and rock filling of the Tertiary basement of the Outer Western Carpathians, so the map does not interpret the Outer Zone.

Interpretation of covered Tertiary basement in the depressions and basins is a prerequisite of exploration for new mineral resources and geothermal energy in deep geological structures.

8. Map of Lithogeochemical Types of Slovakia (Lexa and Marsina et al., 1995), 1:1,000,000.



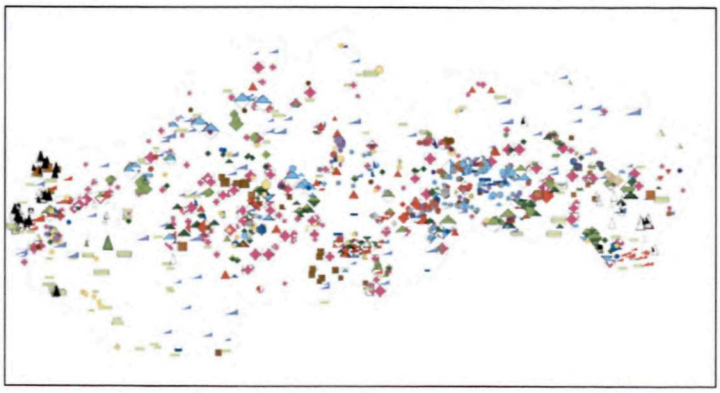
Geochemical Atlas of the Slovak Republic, Part III: Rocks, GS SR, 1999

Map of Lithogeochemical Types of Slovakia displays geochemically defined lithotypes/lithofacies, in the form of simple lithotypes or a set of lithotypes which, because of their mutual alternation can not be separated. The contours of the individual lithotypes are derived from the geological map of Slovakia 1:500,000 (Biely et al., 1992), or the geological map of Slovakia 1:1,000,000 (Vozár and Káčer et al., 1998).

9. Metallogenetic Map of Slovakia (Lexa et al., 2004), 1:500,000

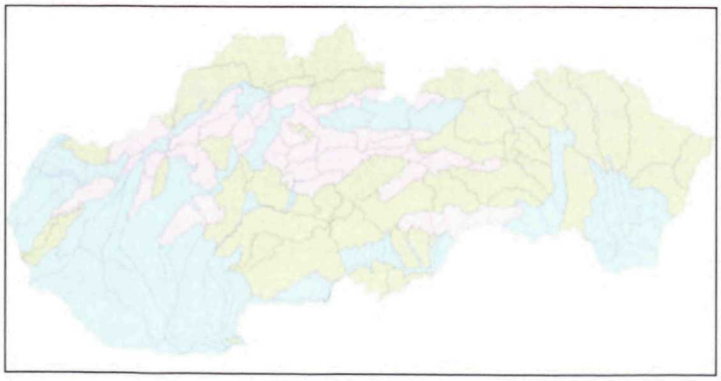
The basis of metallogenic map is a simplified geological map of the Slovak Republic at scale 1:500,000 (Biely et al., 1996) modified for the purposes of the geological map of the Western Carpathians (Lexa et al., 2000). The Metallogenetic Map shows all deposits and occurrences of ore minerals, including numerous mineralogical occurrences. The size of a mark indicates whether the object is large- or medium-sized deposit, small deposit, mineralogical occurrence or raw mineral occurrence. Unlike the deposit maps, the assignment in terms of a size is based on the size of the object prior to extraction.

10. Mineral Resources of Slovakia (Zuberec et al., 2004), 1:500,000



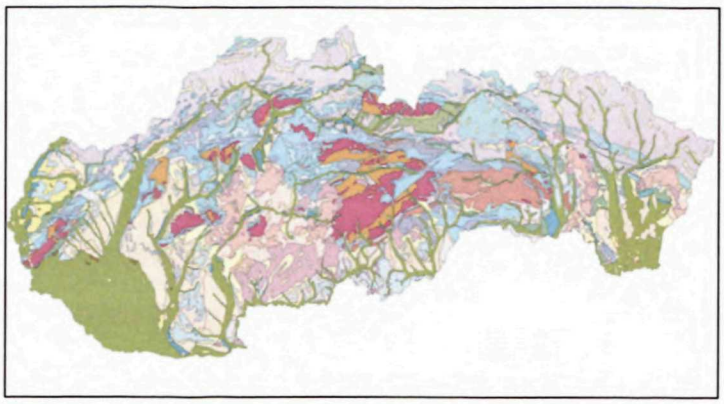
The map displays the information on distribution and reserves of deposits and significant occurrences of mineral resources in Slovakia. The latest findings were drawn from the results of the geological projects Metallogenic Evaluation of Slovak Territory and Comprehensive Evaluation of Mineral Resources SR. The set of maps is directly related to the latest monograph Raw Minerals of SR. In this way both documets offer comprehensive information and an overview of the raw material base of Slovakia, referring to the new trends in the use of resource potential.

11. Principal Hydrogeological Regions (Malík and Švasta, Atlas of Landscape SR, 2002), 1:500,000



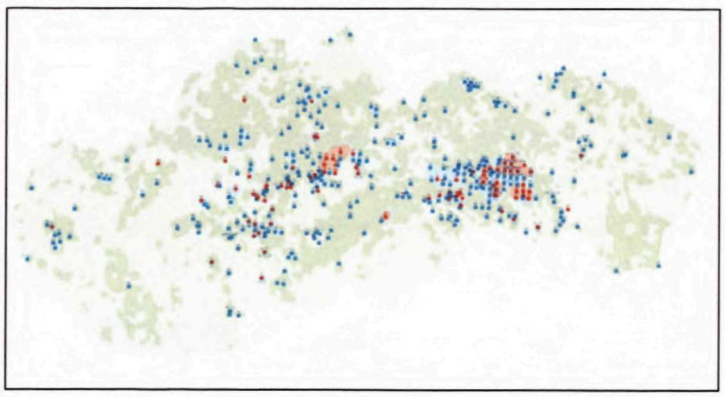
Hydrogeologic regions depicted on this map, respond to the hydrogeological zonation of the Slovak Republic (Šuba et al., 1984). The zones are distinguished in various colours coded according to the type of determining permeability of the rock environment in these territorial units into 3 categories: dominating intergranular, karst-fissure or fissure permeability. Number of hydrogeological region shown on the map, corresponds to the number of hydrogeological zone as it is registered and water-balanced by the Slovak Hydrometeorological Institute.

12. Engineering Geological Zoning Map (Hrašna and Klukanová, Atlas of Landscape SR, 2002), 1:500,000



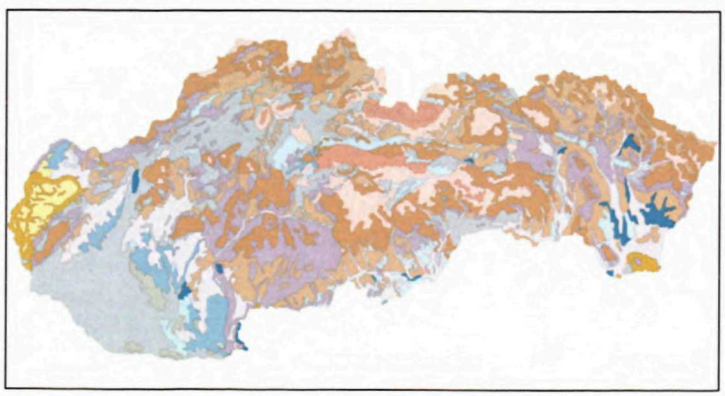
Engineering geological zones are allocated based on the genesis and lithological nature of the rock environment. Displayed are zones of Quaternary and pre-Quaternary rocks. In the event of two Quaternary lithological complexes above the other, with a smaller thickness of the surface complex as 5 m combined zones are displayed, while in their name and symbol both complexes are expressed. The schematic map of earmarked engineering geological regions corresponds to fundamental geological and tectonic units of the Western Carpathians, sub-regions are earmarked in part by the same principles as regions, in part by the characteristics of the specific lithological rock environment. Territorial units of engineering geological zoning at given scale of detail allow to determine the suitability of the ground in terms of different ways of land-use.

13. Soil Contamination (Čurlík and Ševčík, Atlas of Landscape SR, 2002), 1:500,000



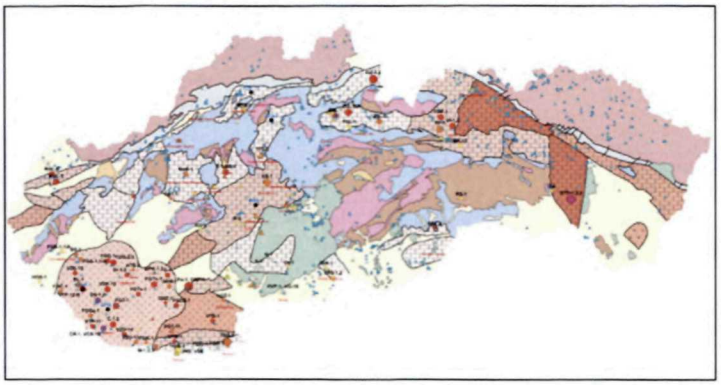
Inorganic soil contamination is expressed by overlapping of excessive values of risk elements. This includes nutrients, if their content in the soil is exceeded (e.g. Zn, Cu and others). The map was compiled from mono-element geochemical maps constructed by geostatistical methods based on database of 5,189 chemical analyzes of forest and agricultural soil. The sampling density in soils within geochemical mapping was one sample per 10 km^2, on average. The map displays point and areal (diffuse) contamination of soils according to applicable limits. By the contents of contamination the areas with relatively clean soils and areas where the above background concentrations of elements in soils occur, are distinguished. Extending over-limit content of hazardous elements in soils refers to geochemical, but mainly anthropogenic sources of contamination, especially in areas of old mining, mineral processing and metallurgical plants (Central Slovakia and Spiš-Gemer region). At the same time it indicates the transfer of contaminating elements in the alluvial areas of rivers and streams.

14. Soil Susceptibility to Acidification (Čurlík, Atlas of Landscape SR, 2002), 1:1,000,000



Ability of soils to resist acidification depends on the content of carbonates, humus, clay minerals and salts. At least prone to acidification are carbonate and alkaline soils, which does not create significant changes in pH (carbonate buffering system). This includes soils that belong to different soil units (carbonate chernozems, fluvisols, mollic fluvisols, rendzinas, saline marshes and solonchaks). On the opposite side are highly washed-out (leached) soils of mountain areas in which no appreciable change in the pH occur because of the extreme acidity (aluminum buffering system). Among them, four classes of soil are allocated according to different susceptibility to acidification, depending on the buffer capacity, controlled by clay, humus, and alkaline ions content. Very sensitive (vulnerable to acidification) are light sandy soils low in humus and clay, where the slightly acidic to neutral pH is maintained by liming and fertilizing.

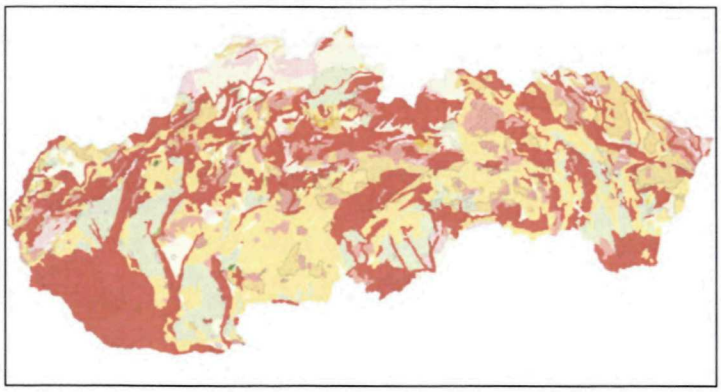
15. Geothermal and Mineral Water Sources (Fendek et al., Atlas of Landscape SR, 2002), 1:500,000



Based on the extent of potential collectors of geothermal energy and geothermal field activity in Slovakia there were demarcated 26 prospective areas, or structures suitable for exploitation and use of energy. They involve mainly Tertiary basins, or intermountain depressions distributed dominantly in the inner zone of the Western Carpathians. Their total area is 34 % of Slovakia. Geothermal energy in Slovakia is mainly represented by geothermal waters, which are bound to Triassic dolomites and limestones of the Innertectonic units, less to the Neogene sands, sandstones and conglomerates or the Neogene andesites and their pyroclastics. These rocks as geothermal water collectors are present at depths of 200 – 5,000 m and they host geothermal water at 20 – 240 °C. The total geothermal potential of geothermal waters in Slovakia is 5,538 MWt, of which 4 985 MWt falls on the reserves and 553 MWt on resources. So far there have been verified by wells about 1,200 $l \cdot s^{-1}$ of geothermal waters whose heat output is approximately 270 MWt.

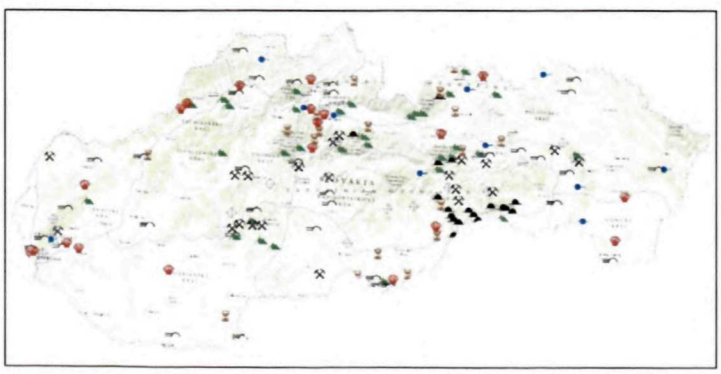
On the territory of Slovakia, there are over 1,600 mineral water sources that are bound to all geological and tectonic units of the Western Carpathians. Often their minimum yield does not exceed one hundredth to one thousandth $l \cdot s^{-1}$. When talking about a maximum yields of mineral waters they can be dozens $l \cdot s^{-1}$, but mostly up to 50 $l \cdot s^{-1}$. Minimum temperature of mineral waters begins at the average annual air temperature for the site and the maximum temperatures rarely exceed 70 °C.

16. Suitability of Territory for Waste Deposition (Klukanová and Iglárová, Atlas of Landscape SR, 2002), 1:500,000



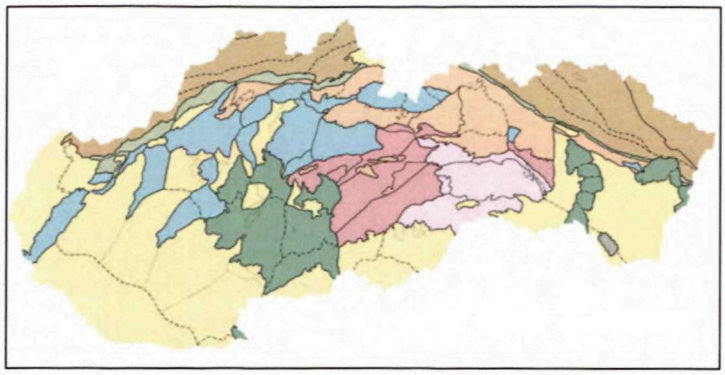
The map is based on the maps of territory suitability for waste disposal at a scale 1:50,000, which were compiled for each district by the SGIDŠ. Based on the evaluation of the decisive factors for the waste disposal, the map delineates the appropriate, conditionally appropriate and inappropriate areas. The following factors were evaluated: protected water area, groundwater resources, protected natural areas, protected forests, mineral deposits, structural layout of the ground with respect to the degree of threat to groundwater, geodynamic phenomena and hydrogeological characteristics.

17. Important Geological Sites (Liščák et al., Atlas of Landscape SR, 2002), 1:1,000,000



The map displays 174 geological attractions of Slovakia. Some sites are protected under the Act no. 287/1994 Coll. on Nature and Landscape Protection under the highest – 5th level of protection as national natural monuments, natural monuments, national wildlife or nature reserves, some are declared by the Convention on the Protection of the World Cultural and Natural Heritage. Most of the stratigraphic and paleontological sites are not protected by law, but from a scientific and academic point of view they represent extremely valuable geological objects that should be preserved for future generations as geological heritage. The sites are divided into nine categories by nature.

18. Regional Geological Division of Slovakia (Vass et al., 1988), 1:500,000

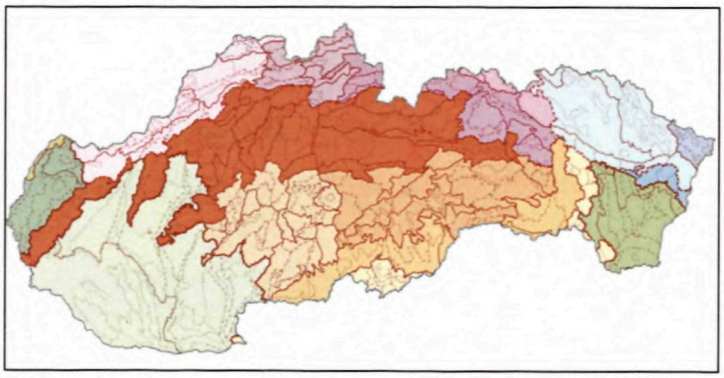


At the end of the 70s there was a need for regional geological classification of the Czechoslovak Western Carpathians. It resulted from emerging databases related to deepening regional geological research programmes and compilation of geological maps of regions at 1:50,000. In the scope of their preparation in general terms there have been followed the principles of regional-geological division of the Bohemian Massif.

The Map of Regional Geological Division of the Western Carpathians and the northern spurs of the Pannonian Basin distinguishes three levels of units, from the largest to the smallest units. In some areas there were earmarked also the fourth order units usually representing pre-Tertiary basement complexes surrounded by younger rocks.

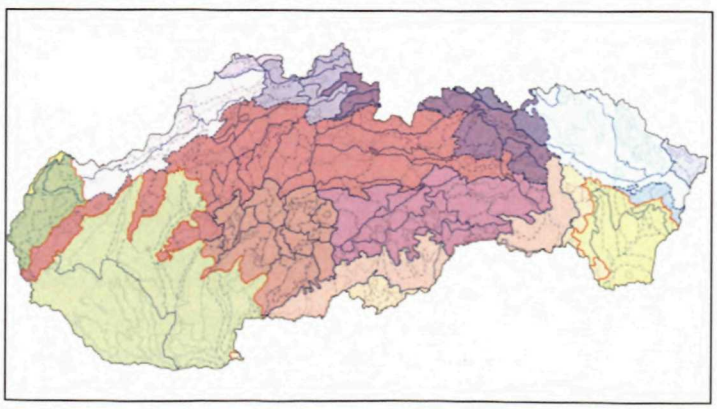
The regional-geological units are compared with those ones of regional-geomorphological classification (Mazúr and Lukniš, 1978; 1980 and Czudek et al., 1972). On most sites they are similar, but in some areas, for example, in the depressions and basins or the units of the Inner-Carpathian Paleogene they differ.

19. Geomorphological Division of Slovakia (Kočický and Ivanič, 2011), 1:50,000



In the period of 2007 – 2011 SGIDŠ addressed in cooperation with Company Esprit Banská Štiavnica geological project "Complex Geological Information Base for the Needs of Nature Protection and Landscape Management (GIB-GES)". One of the results is also general map of geomorphological division of Slovakia, which was created during the revision of the borders of geomorphological units of the Maps of Geomorphological Division of SR at scale 1:500,000 (Mazúr and Lukniš, 1986). The map respected the former hierarchical structure of units. The boundaries of these units were adjusted based on digital elevation model with a resolution of 20x20m and morphometric characteristics derived therefrom, digital geological map 1:50,000, digital map of abiocomplexes, digital map of river network, maps of the horizontal and vertical dissection and satellite images, in order to be conform with the geomorphological, geological and tectonic conditions in the area expressed on an appropriate scale. Thus bounded units were then evaluated and characterized by geostatistical summary indicators – minimum and maximum altitude, altitudinal range, average height, density of river network, the average slope of a geomorphological unit and total dissection of relief of a geomorphological unit. All features are part of digital spatial database.

20. Geomorphological Division of Slovakia (Mazúr and Lukniš, 1986), 1:500,000



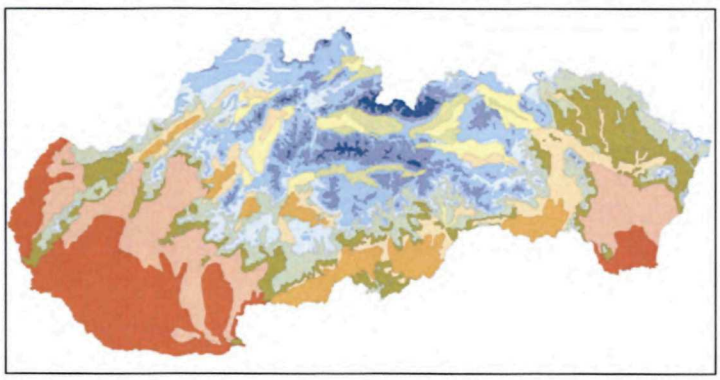
Analog maps of geomorphological division of Slovakia by Mazúr and Lukniš, 1986 belong among the outstanding works of prominent Slovak geograpers.

The authors made a synthesis of the orographic division by Hromádka (1956), map of relief types (Mazúr and Činčura, 1975), geological maps at 1:200,000, map of morphostructures of the Western Carpathians and particularly of own knowledge of their field work. The classification of their geomorphological division underwent certain development, and the digital map is processed according to updated edition of 1986 (Mazúr and Lukniš, 1986).

The territory of Slovakia is hierarchically divided into 8 levels – system, subsystem, province, subprovince, area, unit and subunit parts – in total into 499 individual geomorphological units.

Slovakia belongs to Alpine-Himalayan System, the territory is divided into two subsystems – the Carpathians and the Pannonian Basin, which in the next level are divided into Western and Eastern Carpathians, Western Pannonian and Eastern Pannonian Basins.

21. Climatic-Geographic Types (Kočický and Ivanič, 2011), 1:50,000



In the period of 2007 – 2011 SGIDŠ addressed in cooperation with Esprit Banská Štiavnica geological project "Comprehensive Geological Information Base for the Needs of Nature Conservation and Landscape Management (GIB-GES)". In the scope of the project climate and climate-geographic classification was processed.

The climate in Slovakia is significantly differentiated. Its character depends on the intensity of solar radiation, atmospheric circulation, altitude and distance from the sea. These are the most important climate-forming factors that impact the temperature, precipitation and cloudiness. The territory of Slovakia lies in the transitional arrea, the Central European type within the temperate climatic zone with regular changes of the seasons and the prevailing westerly circulation. In the western and northwestern parts the predominant influence has the Atlantic Ocean, to the south and east the area is influenced by the Mediterranean climate and continental climate of Eurasia. Important climatogenetic factor is also a large geomorphic dissection of the territory of Slovakia and banded arrangement of mountain ranges with barrier effect of the mountains. Maritimity level of climate reaches 50 % in the western part, while the degree of continentality rises towards the east at 55 %. The result are extreme winters in the Eastern Slovakia, longer and drier summers with longer sunshine as the Western parts (Špánik, Šiška et al., 2004).

The climate of Slovakia is divided into three basic climato-geographic types:

- lowland climate with mild temperature inversion, dry to moderately dry;
- basin climate with large temperature inversion, slightly dry to moist;
- climate with small inversion of temperature, wet to very wet.

2.1.7. Geological Storage of CO_2

Geological Storage of CO_2 [online since 2011]. Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/ccs

By the adoption of Act no. 258/2011 Coll. on the Permanent Storage of Carbon Dioxide in Geological Environment and further amendments to certain laws (hereinafter the "Act") there was transposed into Slovak law Directive of the European Parliament and Council Directive 2009/31/EC of April, 23, 2009, on the Geological Storage of Carbon Dioxide and on change and amendment of the Council Directive 85/337/EEC, European Parliament and Council Directive 2000/60/ES, 2001/80/ES, 2004/35/ES, 2006/12/ES and Regulation (EC) No. 1013/2006. This Directive is part of a larger global effort to minimize the negative impacts of climate change. It obligates the Member States to adopt such laws and measures that are necessary to comply with this Directive within a period of two years from its entry into force.

The Law specifies the conditions for issuing a storage permit, authorization of application to store, control, update and cancellation of storage permits. The criteria and procedure for storing and monitoring of repositories are specified, along with criteria for associated surface and injection facilities and storage complex. When detecting leakage of carbon dioxide, or if significant irregularities within the storage complex are identified, the Law defines remedies and additional corrective measures. A procedure is set for the closure of repositories. Conditions for transferring responsibility to the competent authority after repository closure are defined.

Application provides a clear picture of areas where it is possible, or impossible to perform a deposit geological exploration for oil and flammable natural gas and the definition of natural rock structures and underground spaces for the purposes of permanent storage of carbon dioxide in the geological environment. This solves the Legislative Act no. 569/2007 Coll. on Geological Works.

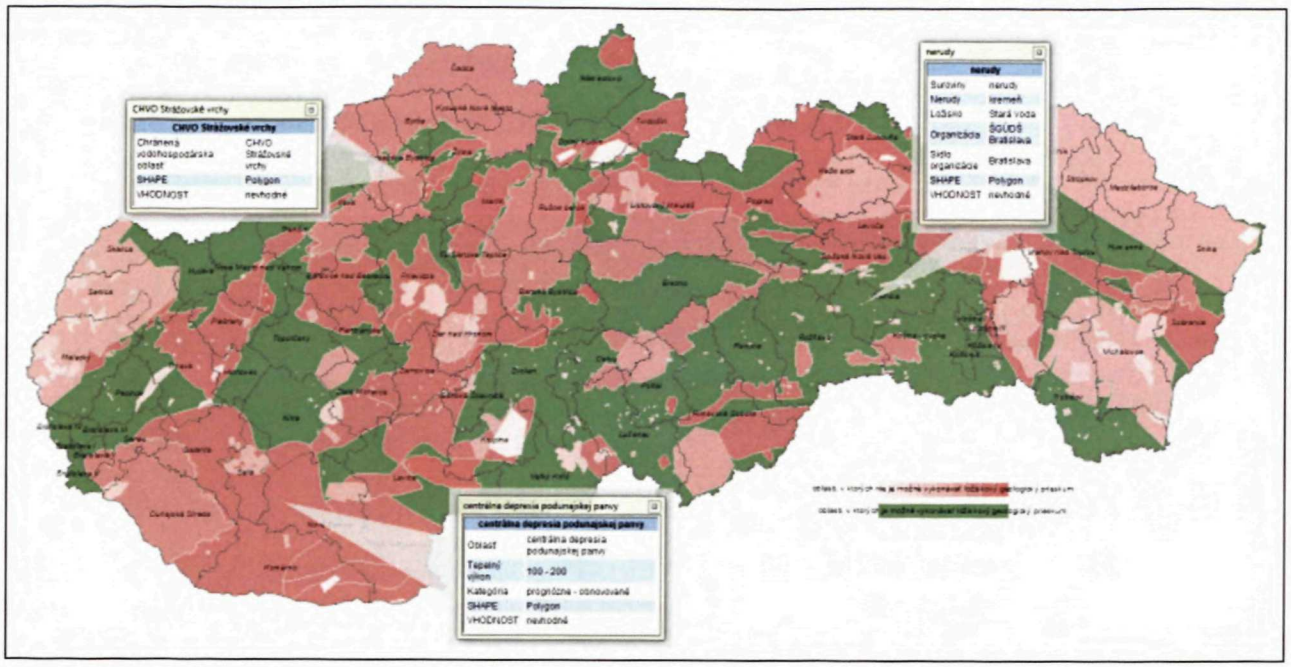


Fig. 2.14 Geological Storage of CO_2 – example of a map application (compiled by Bystrická)

2.1.8. Pedogeochemical Maps (A - horizon)

ŠEFČÍK, P.: Pedogeochemical Maps (A - horizon) [online since 2012].
Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: *http://mapserver.geology.sk/pedo*

The pedogeochemical maps compilation was based on the results of the environmental-geochemical mapping of soils of Slovakia. The maps show and present trace elements distribution (As, Ba, Be, Bi, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Sn, V and Zn) and the variability of soil properties (pH/H_2O, humus content, carbonate content, soil granularity) in surface humus-rich soil horizons -throughout the Slovakia. Pedogeochemical data were retrieved in the scope of the solutions of the research projects, implemented in a way of unified mapping, sampling and analysing of soils:

a) *Geochemical Atlas of Soils of Slovakia* (Čurlík and Šefčík, 1999);

b) Set of maps of geological factors of environment at scale 1:50,000 in selected regions of Slovakia;

c) other environmental-geochemical projects and tasks.

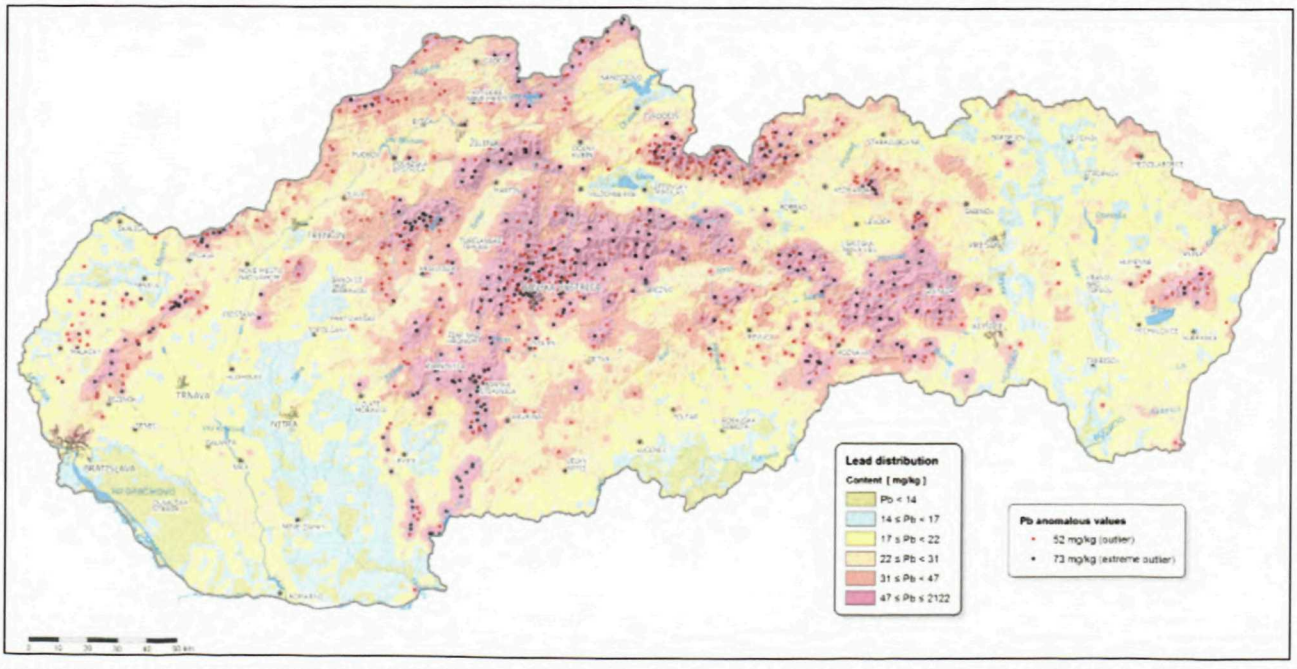


Fig. 2.15 Pedogeochemical Map of Lead distribution – Pb anomalous values – Pb raster – Content [mg . kg^{-1}] (compiled by Bystrická)

2.1.9. Hydrogeological Maps

Hydrogeological Maps [online since 2008]. Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/hydrogeol

The first set of basic hydrogeological maps at 1:200,000 was compiled in the years 1971-1978 in manuscript form, however, these maps were issued in the period from 1983 to 1991. Their compilation represented the first comprehensive programme of hydrogeological maps issuance with unified methodology (IAH/ UNESCO), which in this scale seamlessly covers the whole territory of Slovakia and is still the most detailed display of complex hydrogeological conditions of our territory. These maps were digitized and processed in a geographic information system in the years 1995 – 1998 for the purposes of the project 12-02-9/129 *Hydrogeological Research of Ground Water with Advanced Methodologies for Preparing Quantitative and Qualitative Assessment of Groundwater Protection in the Mountains of the Western Carpathians* in order to minimize groundwater inefficient and often environmentally inappropriate use.

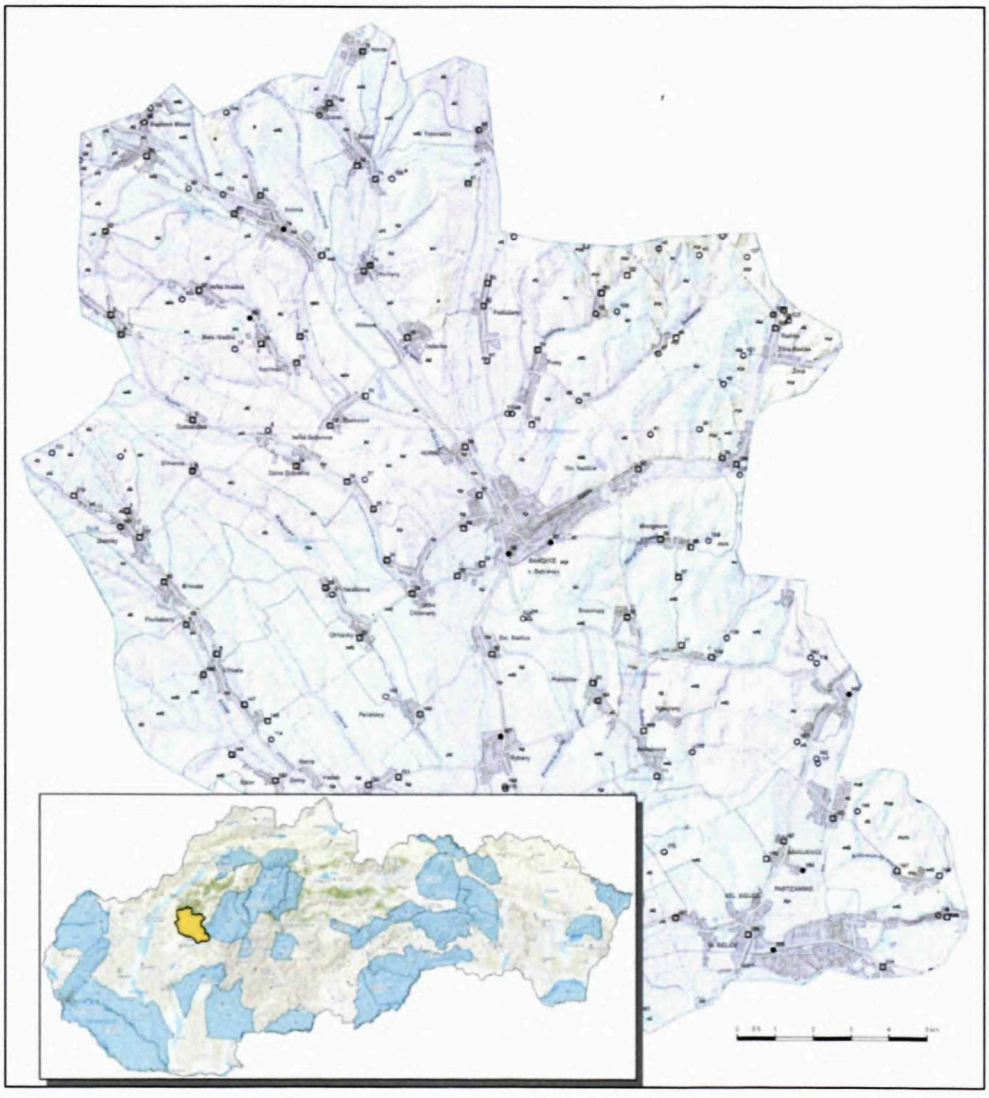


Fig. 2.16 Available Hydrogeological Maps (in blue), Hydrogeological Map of the Bánovská kotlina Basin (in yellow) (compiled by Bystrická)

In the period from 2006 to 2008 in the scope of an international project of 16 EU countries and the European Commission called *eWater „Multilingual Cross-Border Access to Ground Water Databases"* (within the projects *eContentplus*; Ballofet et al., 2008 Tchistiakov et al., 2008) on these maps a common legend was used. The legend is in agreement with the requirements of UNESCO/IAH and in the broad extent links the different approaches to cartographic processing of hydrogeological conditions of each country. The presented hydrogeological map at a scale of 1:200,000 reflects the unified legend and is presented jointly in English and Slovak.

The advent of hydrogeological works associated with drawing up hydrogeological maps at 1:50,000 dates back to the eighties of the 20th Century. The methodical process which generates double-sheet maps – hydrogeological and hydrogeochemical – for the same region was adopted in 1994 and confirmed by the relevant Directives of the Ministry of Environment in 2004. The hydrogeological maps prepared in accordance with this methodology at the scale of 1:50,000 show the hydraulic parameters of assessed area – transmissivity (flow capacity), while at the same time they describe the basic features of geological setting, affecting the movement of groundwater in the area.

There are also illustrated the locations of significant springs and hydrogeological wells in a given territory – point data necessary for further hydrogeological, environmental and water management assessment.

2.1.10. GIB-GES

GIB-GES [online since 2013]. Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/gibges

The State Geological Institute of Dionýz Štúr solved in the period of 2007 – 2011 geological project *Comprehensive Geological Information Base for the Needs of Nature Conservation and Landscape Management (GIB-GES)*. The aim of the project was to create a multifunctional geological and hydrogeological documentation of primary landscape structure for optimum conservation and rational management of the landscape (landscape-planning) throughout Slovakia. The fulfilment of this objective is GIS-based reclassification of morphological parameters and abiocomplexes in form of a digital database, creation of a uniformly assessed regional characteristics of morphological and geological diversity and processing of data on groundwater table level and direction of groundwater flow.

The application contains a map of groundwater table level below the surface, map of groundwater flow directions and database of engineering geological and hydrogeological wells.

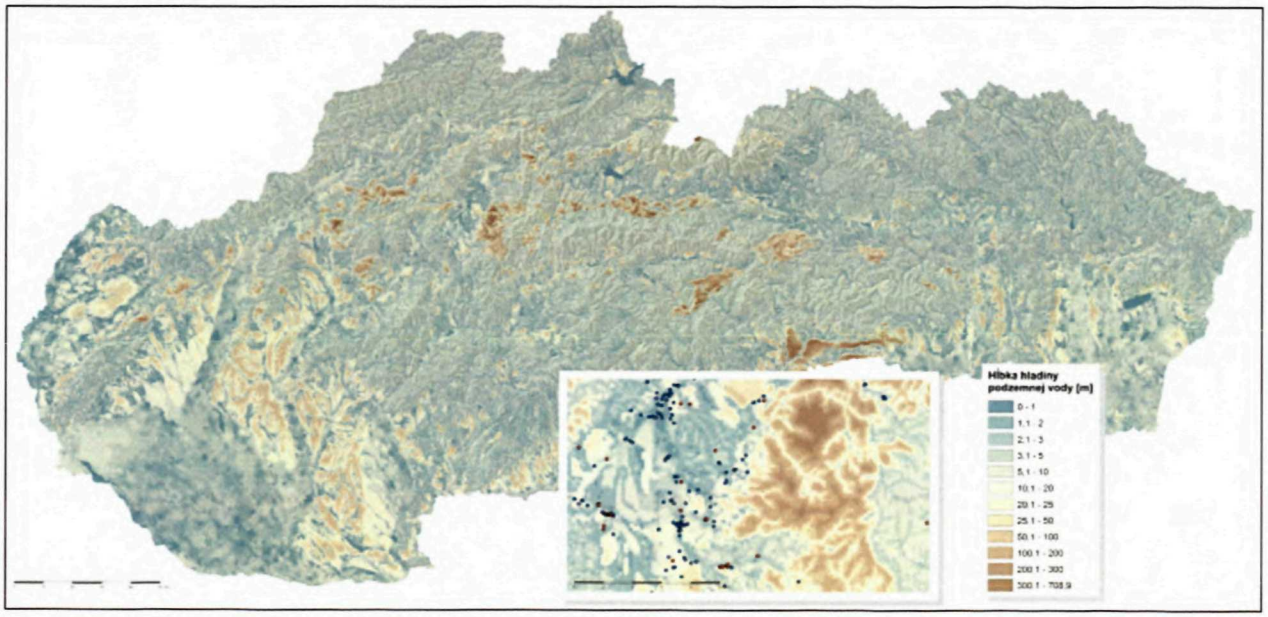


Fig. 2.17 Groundwater table levels below surface [m] (compiled by Bystrická)

2.1.11 Hydrogeochemical Maps

Hydrogeochemical Maps [online since 2008]. Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/hydrochem

This application contains regions covered by hydrogeochemical maps at a scale 1:50,000. The primary purpose of the hydrogeochemical map is to display the most important qualitative and geochemical characteristics of the groundwater of the first water-bearing aquifer, eventually further major water-bearing aquifers. The following areal criteria are presented: Qualitative – quality class is expressed by colour fill, Geochemical – geochemical groundwater groups are expressed by pattern fill, and Water management – outlined by the contours of the same treatment class. The point labels present groundwater sampling points, along with chemical composition, geochemical and qualitative assessment.

The methodological procedure for these maps compilation was based on the Directive of the Ministry of Environment SR dated October 26, 2004, No.8/2004-7 on the compilation of basic hydrogeological maps, as well as Directive of the Ministry of Environment SR dated October 26, 2004, No.9/2004-7 on the compilation of basic hydrogeochemical maps, as well as the Directive of the Ministry of Environment SR No. 2/2000 on the principles of processing and submission of the project results in the Geographic Information System.

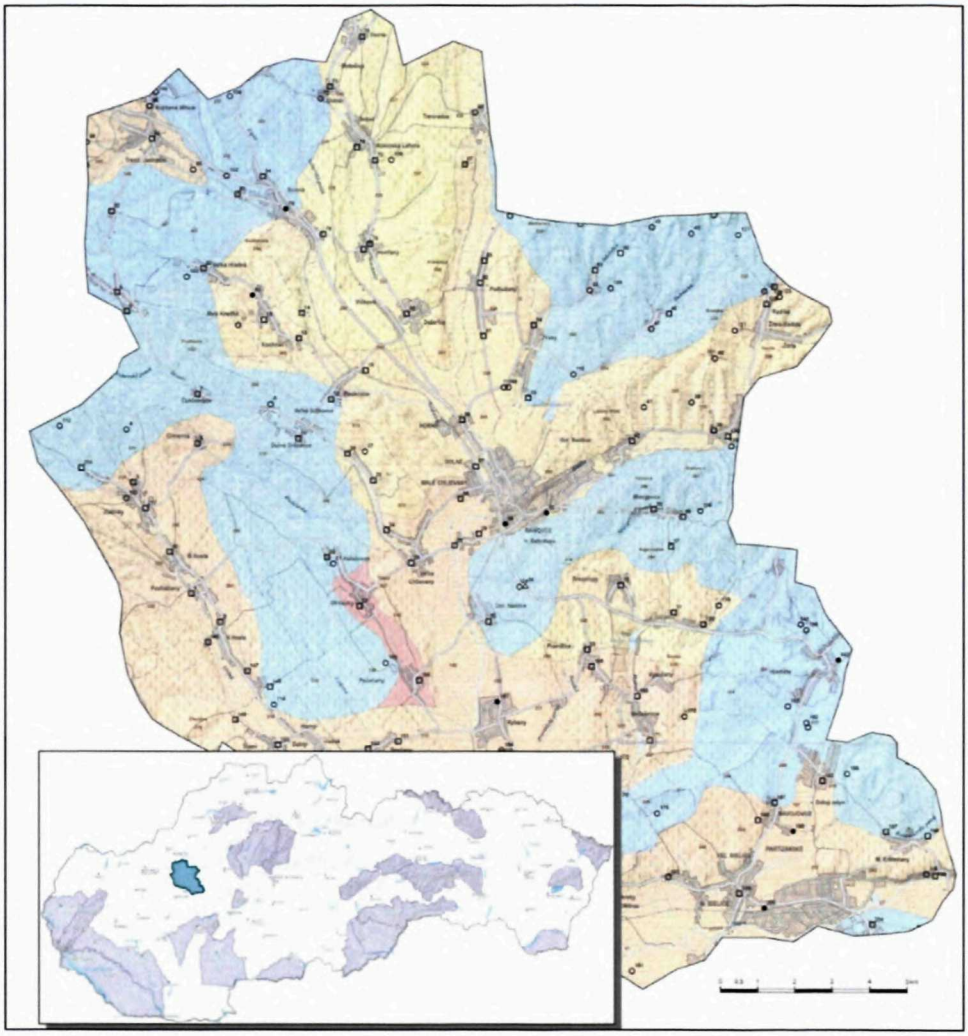
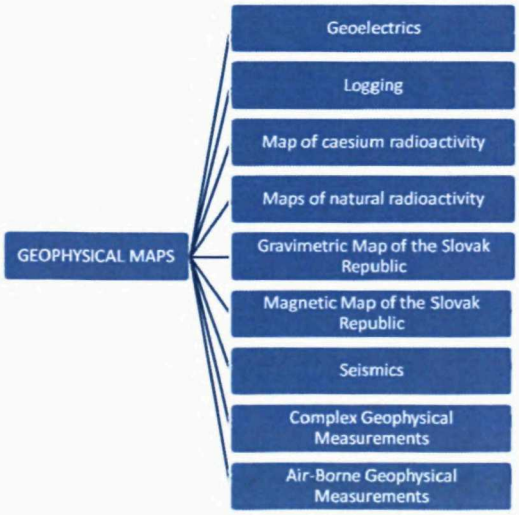


Fig. 2.18 Available Hydrogeochemical Maps (in violet), Hydrogeochemical Map of the Bánovská kotlina Basin (in blue) (compiled by Bystrická)

2.2 GEOPHYSICAL MAPS



Applied geophysics studies a variety of physical (both natural and artificial) fields of the Earth from the air, at the surface, at water surface and in underground; these fields are important in addressing regional and detailed geological practice tasks.

The results of measurements and outputs find their application practically in all areas and stages of the solutions of the survey. Their main task and objectives are to define the units with approximately the same physical characteristics.

The geophysical methods enable us to identify electric, (electro) magnetic, mechanical, gravimetric, radiometric, and various other properties of the rock environment.

Rationally designed complex of geophysical methods allows for quick, cheap, and effective assessment of the area of interest.

2.2.1. Geoelectrics

GLUCH, A. et al.: Geoelectrics [online since 2009]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/geoelektika

Methods of geoelectrical survey examine stationary electric field of the Earth and the entire area of non-stationary electromagnetic fields, i.e. geological environment reaction on these fields. The output is a classification of the rocks based on their electrical resistivity, mapping the areas with anomalous induction effects occurrences, localization of areas of accumulation of electric charge in the rocks, etc.

Given the number of sources of electromagnetic fields and their manifestations various parameters can be recorded. Ultimately, this resulted in a significant number of geoelectric methods (probably most numerous of all geophysical methods).

One of the most common methods is geoelectric vertical electrical sounding (VES). It is used to detect downward changes in resistivity of the ground. The measurements are usually carried out along profiles, the length of the spacing of the electrodes is chosen according to the desired depth range. The method is convenient for screening of (sub)horizontal interfaces of geological layers.

On the map portal there is available object-oriented information system with a set of relevant information, data and documents from selected VES measurements from the whole territory of Slovakia.

A total of 18,167 individual VES measurements is reassessed, processed and made available in the application. From a part of measurements information necessary for interpretation or reinterpretation of the geological structure of an area of interest are archived – particularly the thickness and lithology of Quaternary and partly Neogene sediments.

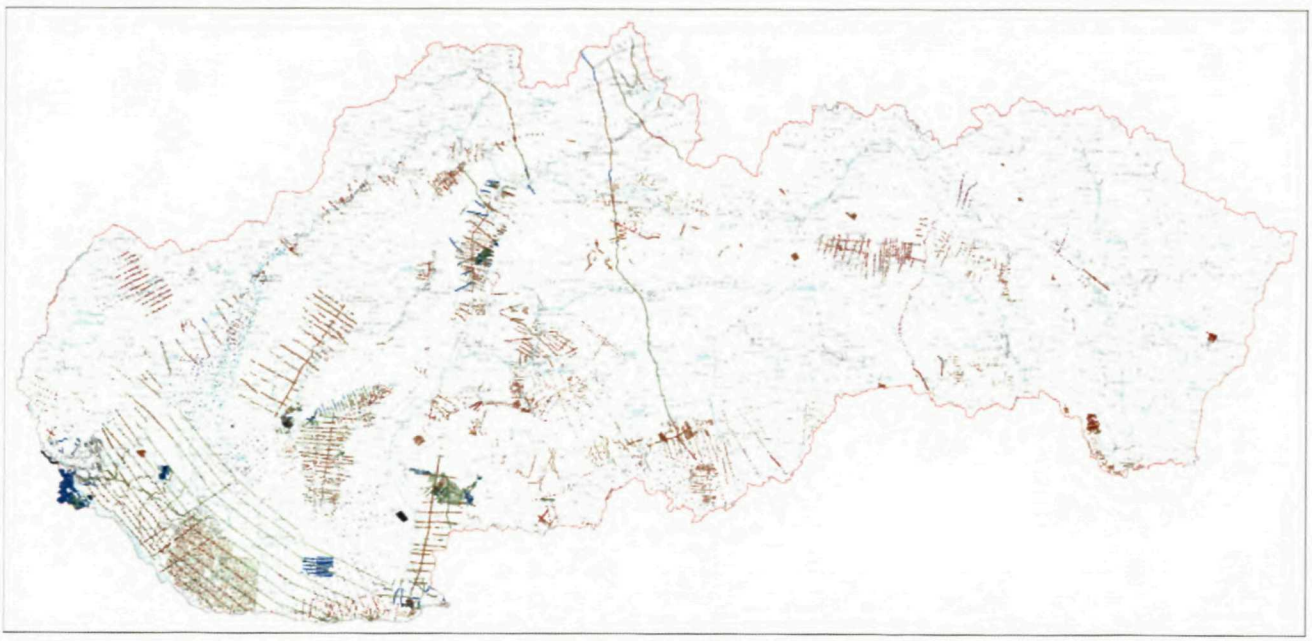


Fig. 2.19 Map of VES profiles from the geophysical database, Gluch et al., 2013

2.2.2. Logging

GLUCH, A. et al.: Logging [online since 2009]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/karotaz

Geophysical measurements in the borehole (logging) represent a comprehensive set of geophysical methods, the results of which provide information on the physical properties of rocks along the axis of the well – e.g. the degree of porosity and pores fills in the rock (water, oil, gas), electrical resistance, density, technical condition and the course of the axis of the borehole, the physical properties of the fluid filling the borehole, hydromechanic conditions in the well.

On the GeoIS website the results of logging of the former Czechoslovak Uranium Exploration k. p. Liberec, Plant IX., Spišská Nová Ves, obtained from the first half of the 50s of the last century are now made available.

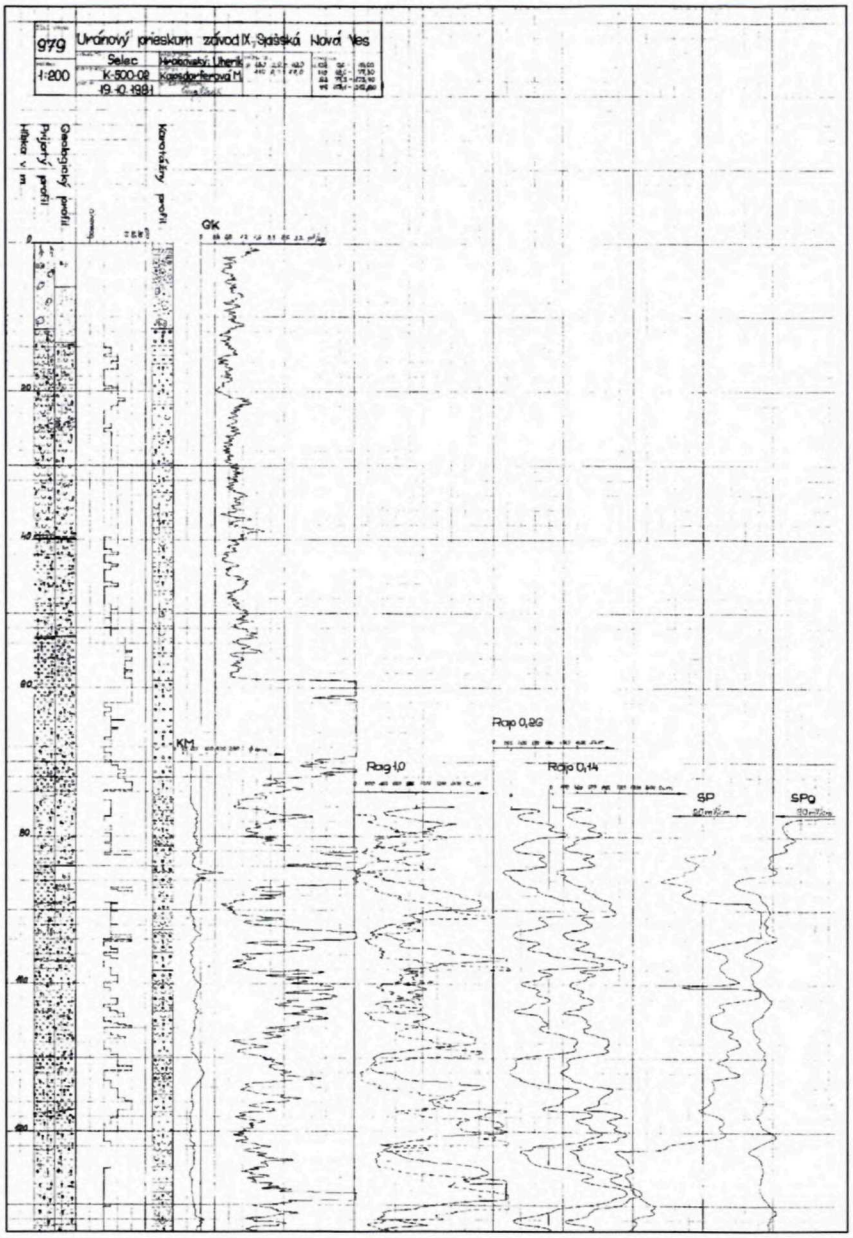


Fig. 2.20 Record of sounding in the well 979 – geophysical-geological interpretation of rocks along the well axis

Complex of geophysical methods:

GK (gama logging) – the results of measurements of natural radioactivity in the well [pA/kg]

KM (cavernometry) – determination of the borehole diameter [ϕ; mm]

Rag 1,0 – geoelectric measuring with gradient probe of 1.0 m [ohmm]

Rap 0,26; Rap 0,14 – geoelectric measuring with potential probe with a length of 0.26, respectively [ohmm]

SP, SPg – natural potentials and their gradient [mV/cm]

2.2.3. Map of Caesium Radioactivity

GLUCH, A. et al.: Map of Caesium Radioactivity [online since 2009]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/cezium

A set of spatial maps of ^{137}Cs activity documenting the state of the pollution of the territory of Slovakia by this radioisotope relative to the reference date of 01.01.2005. There were used all the results of the ^{137}Cs activity across the whole territory of the Slovak Republic for the years 1990 to 2003.

Distribution of values of surface activity of ^{137}Cs in Slovakia is significantly differentiated. The lowest activities are concentrated in the east, in the central part of southern Slovakia and in the west in the catchment areas of Váh and Nitra. The lowest levels of surface activity of ^{137}Cs (below 500 Bq/m^2) are in areas of the Eastern Slovakia Lowland, Košice Basin and Slanské vrchy Mts.

Increased activity of ^{137}Cs (over 3,000 Bq/m^2) were observed in about 40 km wide zone of approximately NE-SW direction, covering the area of High and Low Tatras, Štiavnické vrchy Mts., Pohronský Inovec Mts., the Danube Lowland in a wide area between Galanta and Dunajská Streda. In the zone near Banská Štiavnica (18,077 Bq/m^2), Nový Tekov (28,684 Bq/m^2) and Košúty (23,054 Bq/m^2) there were also the highest surface activities of ^{137}Cs in the territory of Slovakia.

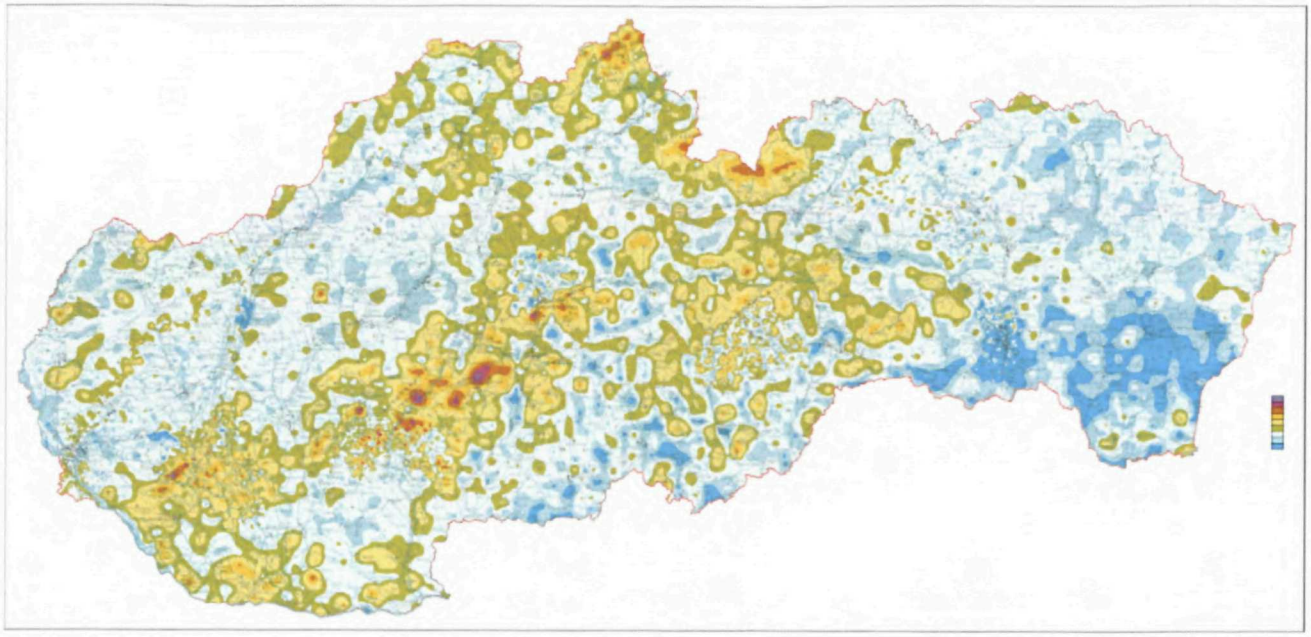


Fig. 2.21 Map of areal activity activity ^{137}Cs, Gluch et al., 2005

2.2.4. Maps of Natural Radioactivity

GLUCH, A. et al.: Maps of Natural Radioactivity [online since 2009]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/radio

A set of general maps of natural radioactivity of the Slovak Republic (rock, underground and surface water, radon risk) at scale 1:500,000, or 1,200,000, was processed for the purposes of the Map Portal, based on the results of field measurements and laboratory determinations collected in geophysical data bank since the beginning of the 90s of the last century.

The output maps were constructed on the basis of: *General Geological Map of the Slovak Republic 1:200,000,* Bezák et al., 2008, or *Hydrogeological Zoning of Slovakia,* Šuba et al., 1984 with extended use of the geological analogy.

There were taken into account also other additional resources (structural-geological, hydrogeological, engineering geological and radiometric data and archival documents, etc.). The maps are made up of all relevant data archived funded from the state budget since 1990.

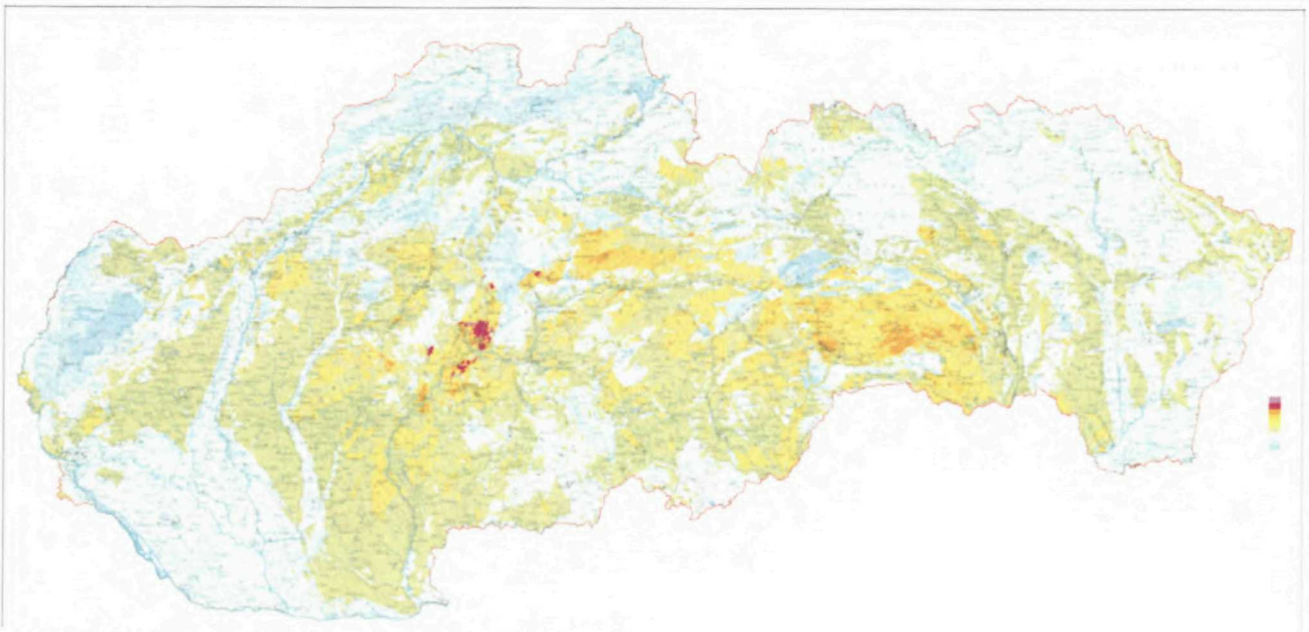


Fig. 2.22 Maps of total natural radioactivity, Gluch et al., 2011

2.2.5. Gravimetric Map of the Slovak Republic

GLUCH, A. et al.: Gravimetric Map of the Slovak Republic [online since 2009].
Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/gravimetria

Gravimetry is a field of applied geophysics, engaged in measuring and evaluating gravitational acceleration of the gravitational field of the Earth. The measured values are used for determining inhomogeneities in the Earth's crust – e.g. the search of underground cavities, issues of petroleum geophysics, hydrogeology, environmental and economic geology, but also in solving many other problems where structure under study produces an anomality with different density.

On the map portal are publicly accessible results of the geological project which reviewed data from nearly 212,500 points of gravimetric measurements of the entire SR and then processed in the presented gravimetric maps.

In the scope of the solution of the project there were comprehensively processed and unified all gravimetric measurements of regional character at scale 1:25,000. There was compiled database of regional gravimetric measurements based on geophysical information system, elaborated the united map of complete Bouguer anomalies (UBA) and purpose-derived gravity map of Slovakia at scales of 1:500,000 and 1:200,000. For selected areas of SR there were compiled UBA maps and purpose derived gravity maps and density models were constructed along selected regional gravimetric profiles across the territory of the Western Carpathians.

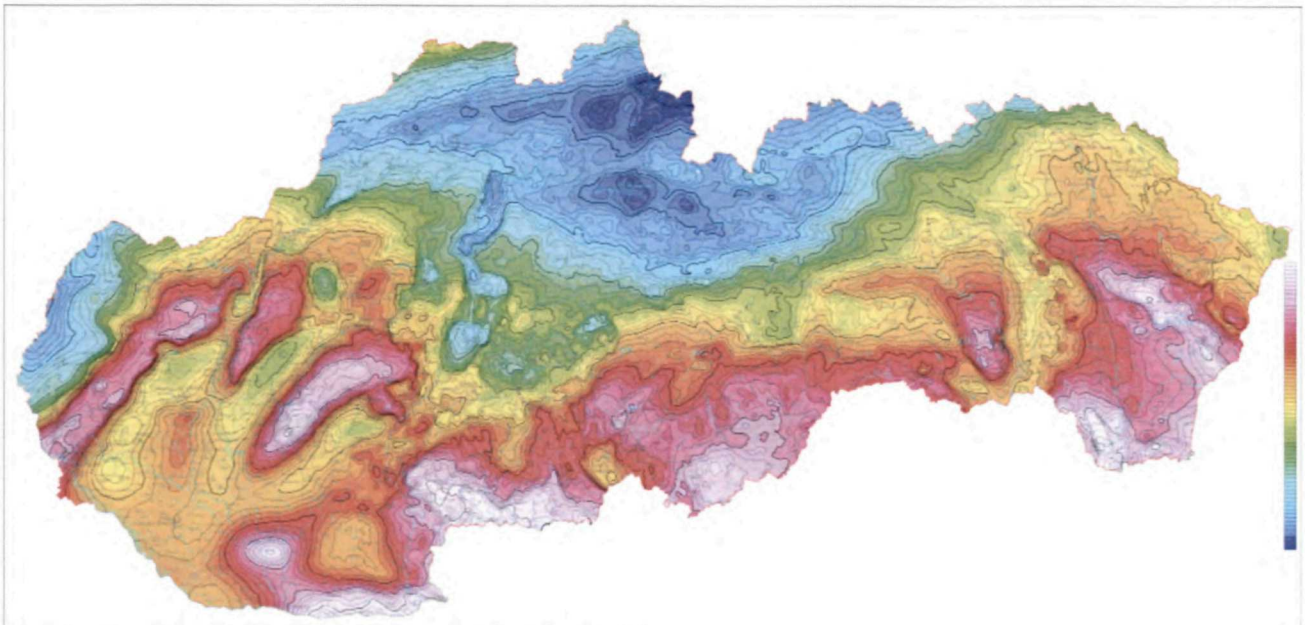


Fig. 2.23 Map of complete Bouguer anomalies, Grand et al., 2011

2.2.6. Magnetic Map of the Slovak Republic

GLUCH, A. et al.: Magnetic Map of the Slovak Republic [online since 2009].
Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/magnet

The magnetometry is a field of applied geophysics, investigating the Earth's magnetic field and the possibility of its use for a variety of practical purposes: to address various engineering, environmental and geological tasks (e.g. search for iron ore deposits), but also in the archaeological and pyrotechnic survey.

On the Map Portal there are made available the results, data and documents, which were acquired till 2008 when working on the elaboration of a magnetic map of Slovakia. Aeromagnetic measurements were utilized to which there were attached the results of ground-based measurements of the vertical component of total vector of magnetic induction of the Earth's magnetic field (Z) obtained in early 60-ies in the area of the Danube and the Eastern Slovakian Lowland and in the western part of the Outer Flysch Zone of the Western Carpathians.

Additional geomagnetic measurements were carried out between 2005 and 2008. The value of total induction of the magnetic field of the Earth (T) were adjusted to the International Reference Normal Field (IGRF 1995).

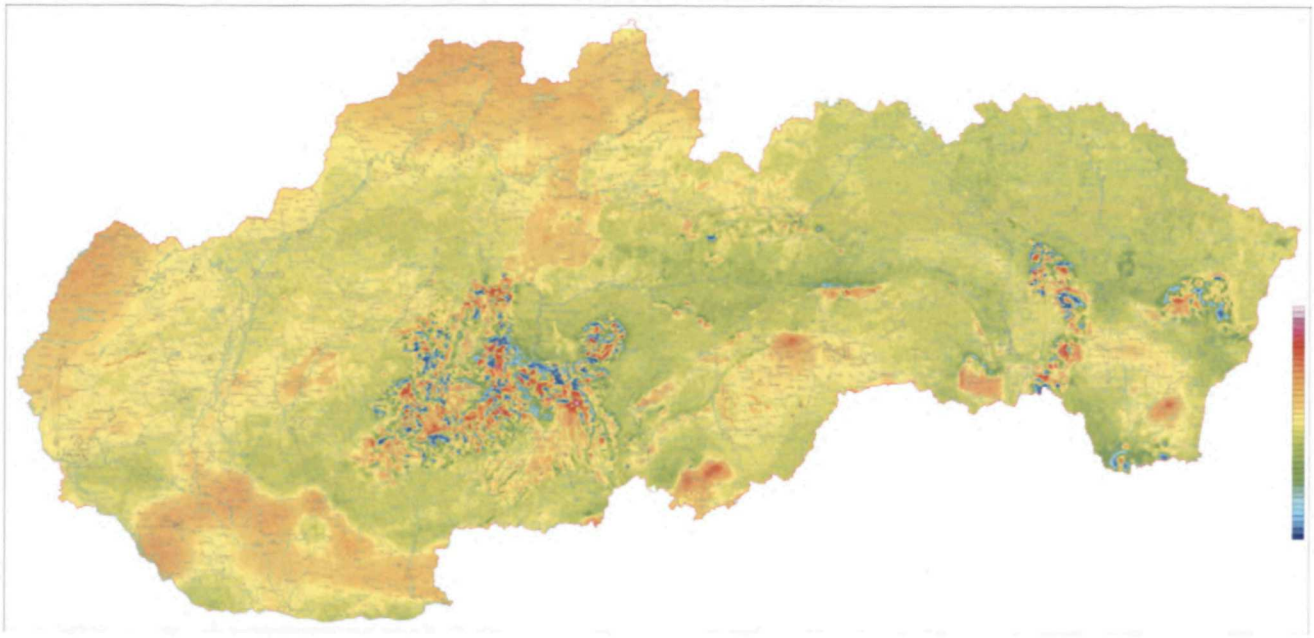


Fig. 2.24 Magnetic map, Kubeš & Gluch, 2009

2.2.7. Seismics

GLUCH, A. et al.: Seismics [online since 2009]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: *http://mapserver.geology.sk/seizmika*

Seismic survey is a set of methods, methodologies and interpretative processes by which we define structure of the Earth's crust. These methods are based on the examination of the artificially generated elastic waves propagating through Earth's body in all directions, and recorded on the Earth's surface along a seismic profile.

By measuring the arrival time of seismic waves to the surface and study the nature of their movement in geological structures it is possible to determine the depth, shape and nature of the interface on which a registered seismic wave was created.

We distinguish two main groups of methods: reflective seismics and refraction seismic.

In addressing the diverse geological, ecological and other issues of exploratory practice both of the methods are used, either alone or they complement each other.

Currently, the map portal provides public access to basic meta-information on individual seismic objects (profiles or areas).

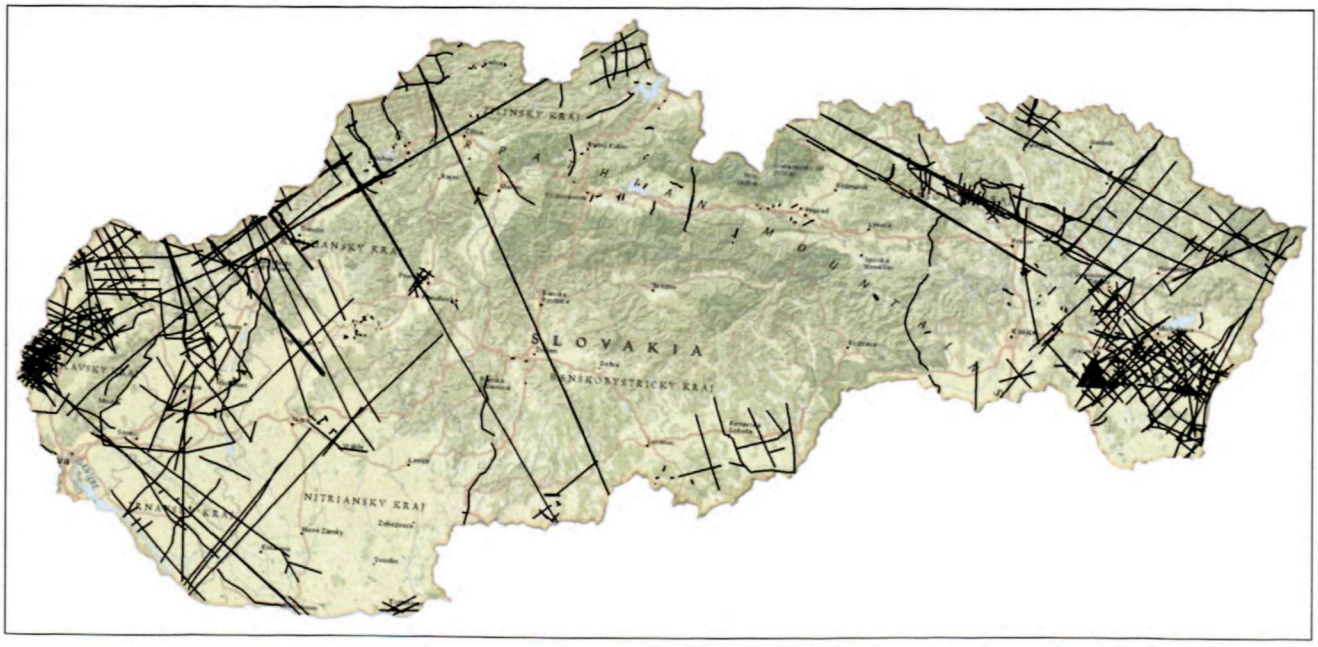


Fig. 2.25 Map of seismic profiles

2.2.8. Complex Geophysical Measurements

GLUCH, A. et al.: Complex Geophysical Measurements [online since 2009].
Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/gfmerania

Geophysical works are used in all fields and stages of geological research – geological, geotechnical, ecological. In all these sectors, their main aim is to define quasi homogeneous units with identical physical characteristics along selected profiles, but also within the survey areas, or in 3-D (processing of longitudinal and transverse profiles) and to locate the boundaries among these units. Using additional data and information (field and laboratory tests and analyzes, the results of logging) and based on defined geophysical properties the identified units can be quantitatively evaluated, appreciated and geologically interpreted.

Geophysical methods are used to determine electric, (electro)magnetic, mechanical, gravity, radiometric and various other properties of the ground. The choice of efficient and rational complex of geophysical measurements greatly depends on the purpose or the focus of the survey itself.

2.2.9. Air-Borne Geophysical Measurements

GLUCH, A. et al.: Air-Borne Geophysical Measurements [online since 2013].
Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/letectvo

In air-borne (aero) geophysical measurements of natural or artificially induced fields, the most often used methods are: aeromagnetometry (monitoring of magnetic properties of rocks and minerals), aeroradiometry (detection of gamma-radiation of the rock environment), aerogravimetry (measuring of gravitational acceleration of the gravitational field of the Earth) and different variants of air-borne electrical and electromagnetic methods.

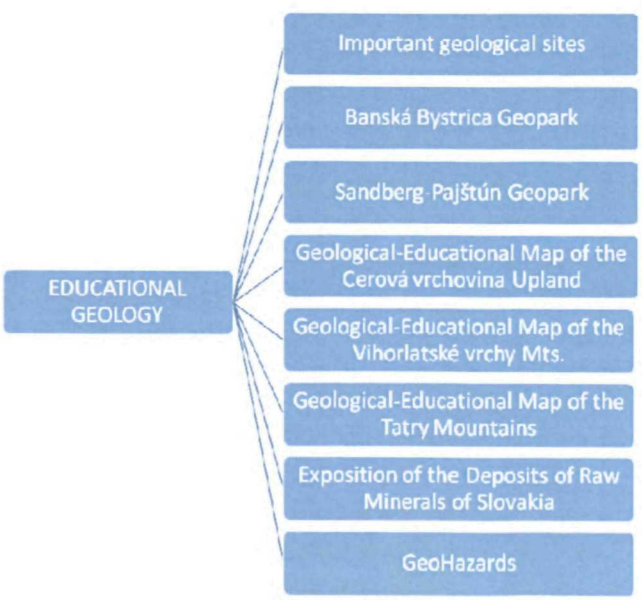
Aerial measurements are carried out along profiles in the network in the required scale of exploration works. The advantage is the speed of air-borne geophysics and in many methods also considerable measurements precision.

On the Map Portal the archived data of the results of air-borne geophysical measurements will be successively presented in full extent.

2.3. EDUCATIONAL GEOLOGY

Currently, the knowledge and experience of geologists significantly assist in the protection of the environment. The contribution of the geologic community is influencing awareness of human society (and in particular of the younger generation) by way of preparation and issuing the whole spectrum of geological publications (books, maps, etc.) about nature, about its past, present and future. Within this broad spectrum of publications appropriately fits also the edition of Educational Geological Maps. The purpose of these maps is to bring a wide range of new knowledge about the geological setting, natural formations, tourist attractions, living and inanimate nature of individual regions of Slovakia and about the mutual relations between these components of the environment. The experience of several countries allows to assume that geological maps are a great asset:

– for the development of tourism and geotourism;
– for the general development of the knowledge of the residents about the geological setting of the region;
– for popular-scientific, promotional and awareness-raising goals;
– as teaching aids for primary and secondary schools in visual teaching of science subjects in nature, in the preparation and implementation of school excursions and excursions into the countryside.



2.3.1. Important Geological Sites

LIŠČÁK, P. et al.: Important Geological Sites [online since 2012]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/g_vglg

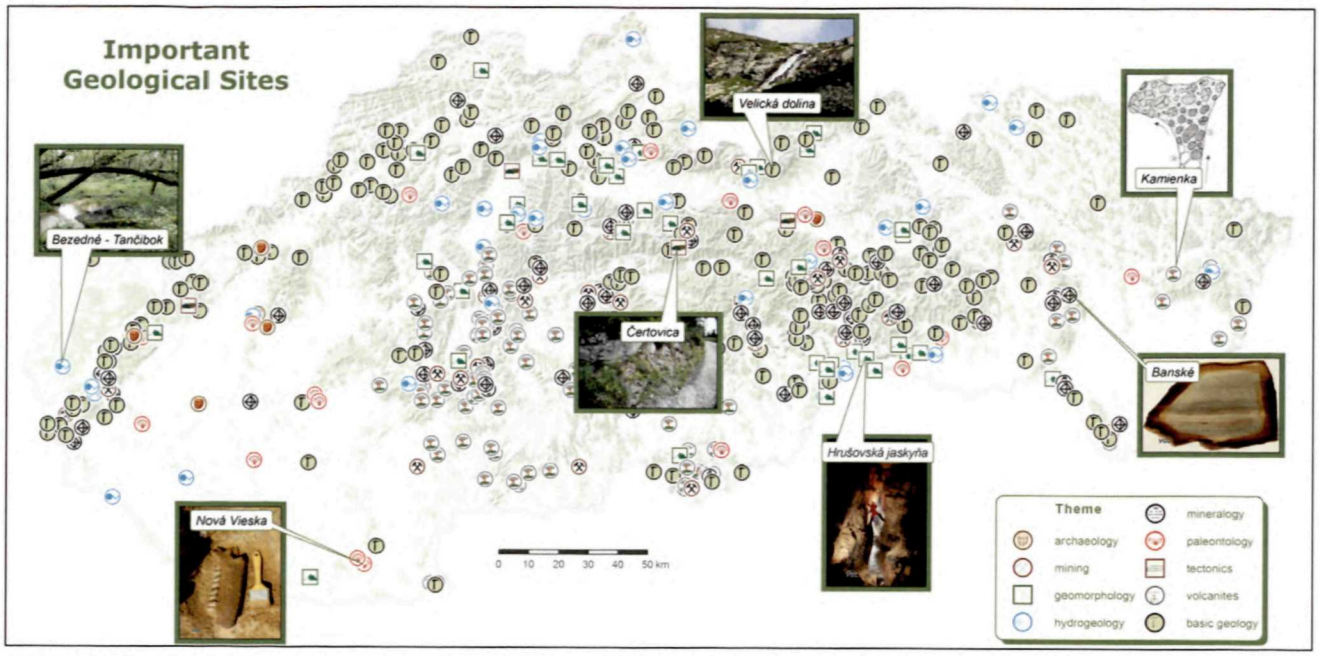
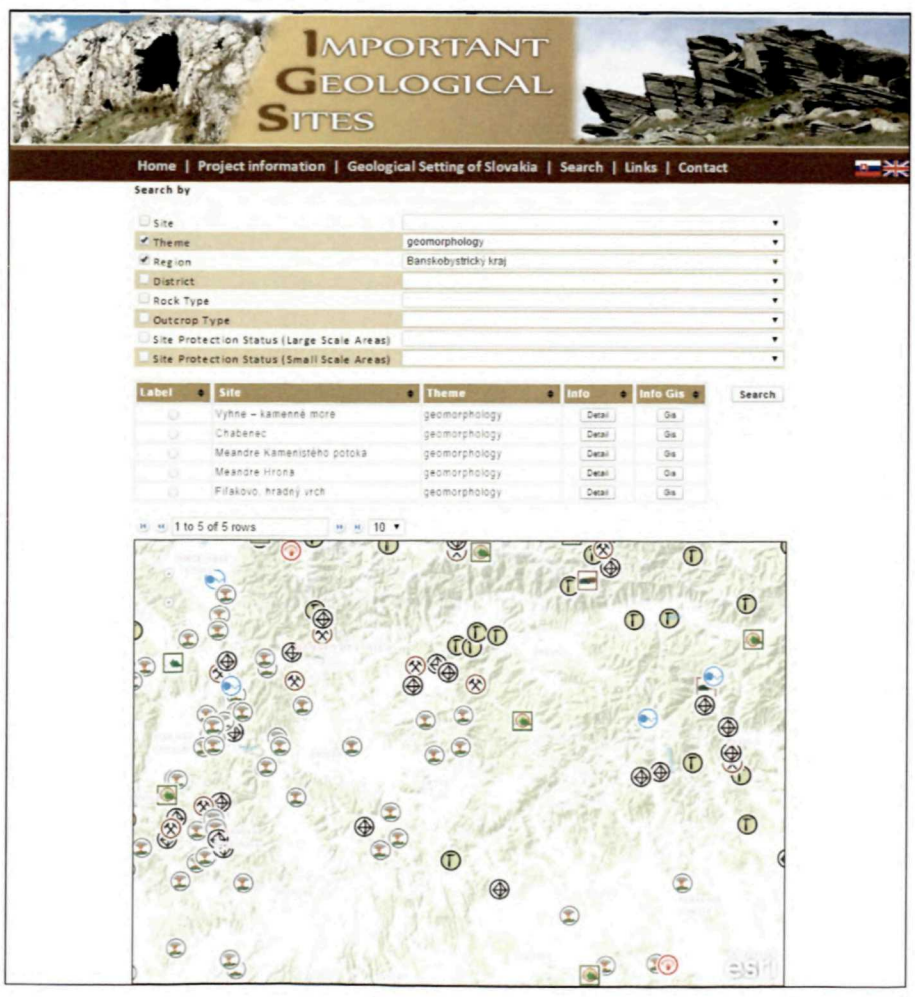


Fig. 2.26 Map of important geological sites (compiled by Bystrická)



The information on the important geological sites in Slovakia are stored in their database. Some sites are protected under Law. 543/2002 Coll. of 25 June 2002 on the Protection of Nature and Landscape by the highest – 5th or the 4th degree of protection as National Natural Monuments, Natural Monuments, Nature Reserves and National Nature Reserves, some of which are declared by the Convention on the Protection of World Cultural and Natural Heritage.

Each record contains geological description of the site in detail, degree and the reason for its protection, location within the tourist map and within the geological map at scale 1:50,000 (Map Server SGIDŠ), references.

Information on geosites are accessible either through map server application, or through database using selection criteria.

Fig. 2.27 Map of Important Geological Sites – web application

2.3.2. Banská Bystrica Geopark

FERENC, Š. et al.: Banská Bystrica Geopark [online since 2013]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/bbgparkg

On the basis of the principles adopted by UNESCO a geopark is a territory containing phenomena of a special geological importance, of certain peculiarities, or beauty; they are presented depending on the region, geologic development, formation and processes that shaped them.

The project of the *Banská Bystrica Geopark* was completed in 2010. The information about the sites is collected in the Banská Bystrica Geopark database. The database contains records on the sites, which are protected in terms of the Act No. 543/2002 Coll. on Nature and Landscape Protection. The information on the site is divided into the General information, Graphic documentation, geological characteristics, protection of the territory, description of the site, references and processing of the record.

The attractiveness of the territory proposed for Banská Bystrica Geopark establishment is primarily supported by variegated geological setting, manifested in quite dissected morphology. This region is also interesting from the point of view of ore mining in the past (historic mining monuments – the smelters, shafts, galleries, knocking towers), from the ethnographic point of view (preserved original architecture, Špania Dolina Lace), from the perspective of the tourism and the landscape (numerous hiking and educational trails) and last but not least also by the fauna and flora of the surroundings of Banská Bystrica.

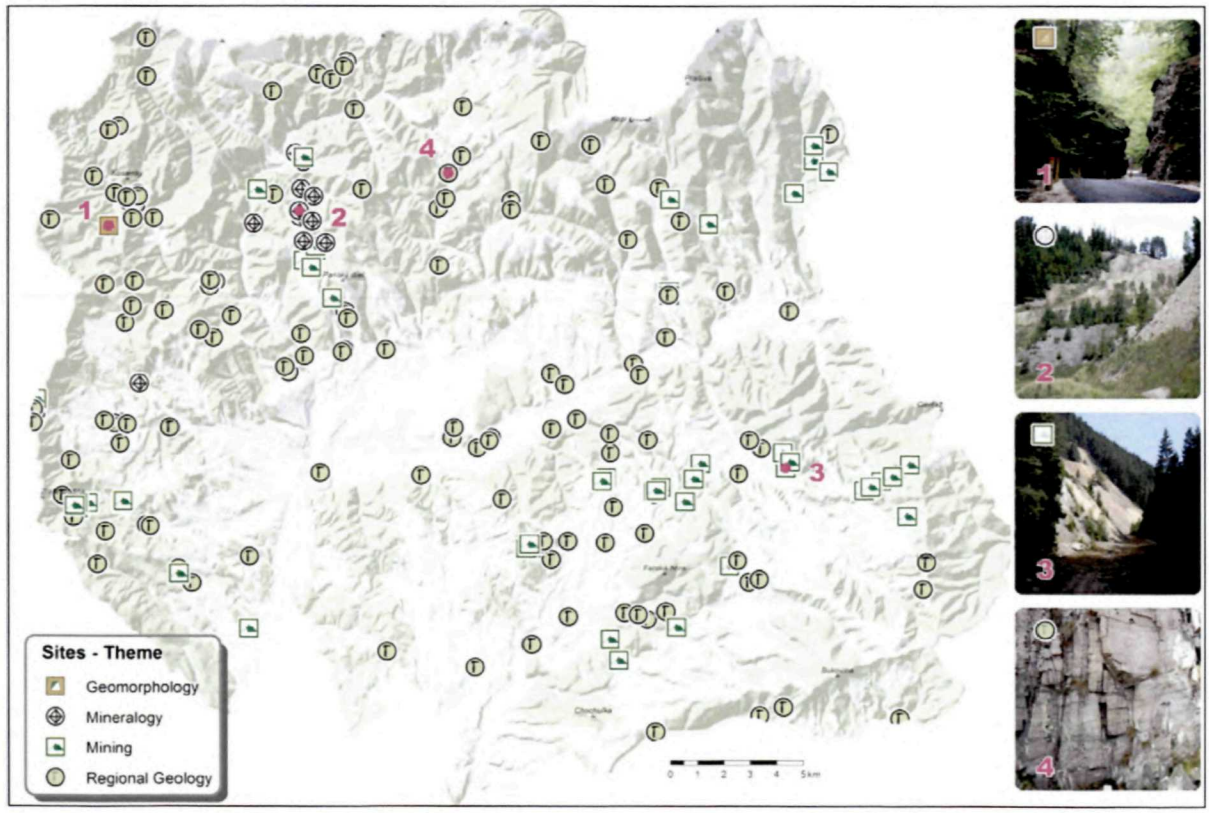


Fig. 2.28 Map of Banská Bystrica Geopark (compiled by Bystrická)

2.3.3. Sandberg-Pajštún Geopark

MADARÁS, J. et al.: Sandberg-Pajštún Geopark [online since 2014]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/sapag

Geological and Tourist Map of the Sandberg-Pajštún Geopark (Editor: J. Madarás) at a scale of 1:25,000, published in 2014, in addition to interpreting geological structure provides information on the natural beauties of the region, tourist attractions and major mineralogical occurrences.

The territory of the Sandberg-Pajštún Geopark extends within the wider environment of the Capital of Slovakia – Bratislava, tourist well-known and popular. This area is characterized by diverse geological structure across a relatively small area, which results in various forms of morphology. Part of its territory is Protected

Landscape Area (PLA) Little Carpathians and partially PLA Záhorie and PLA Danube Floodplains. The Geopark is located in the Bratislava region and its three districts: Bratislava IV, Malacky and Pezinok.

List of information panels:

1) SAPAG – introductory infopanel
2) Abrasion Cave, Slovinec Cliff
3) Geology of Devínska Kobyla, Sandberg
4) Wait's quarry and historic quarries on Devínska Kobyla
5) Devín Castle Hill
6) Quaternary geology of the rivers Morava and Danube
7) Marianka – Shale Gallery
8) Pajštún Castle Hill
9) Borinka - Pod Zámčiskom - mining of manganese ores
10) Borinka Karst: Limbach exsurgence (estavella)

Fig. 2.29 Sandberg-Pajštún Geopark, map and information panels (compiled by Bystrická)

2.3.4. Geological-Educational Map of the Cerová vrchovina Upland

ELEČKO, M. et al.: Geological-Educational Map of the Cerová vrchovina Upland [online since 2013]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/cervrch

The Geological-Educational Map of the Cerová vrchovina Upland at scale 1:50,000 was released in 2001 as a pilot map of a new edition of the geological educational maps of Slovakia. The Map interprets the geological setting and provides the information about tourist attractions of the territory of the region.The Cerová vrchovina Up-

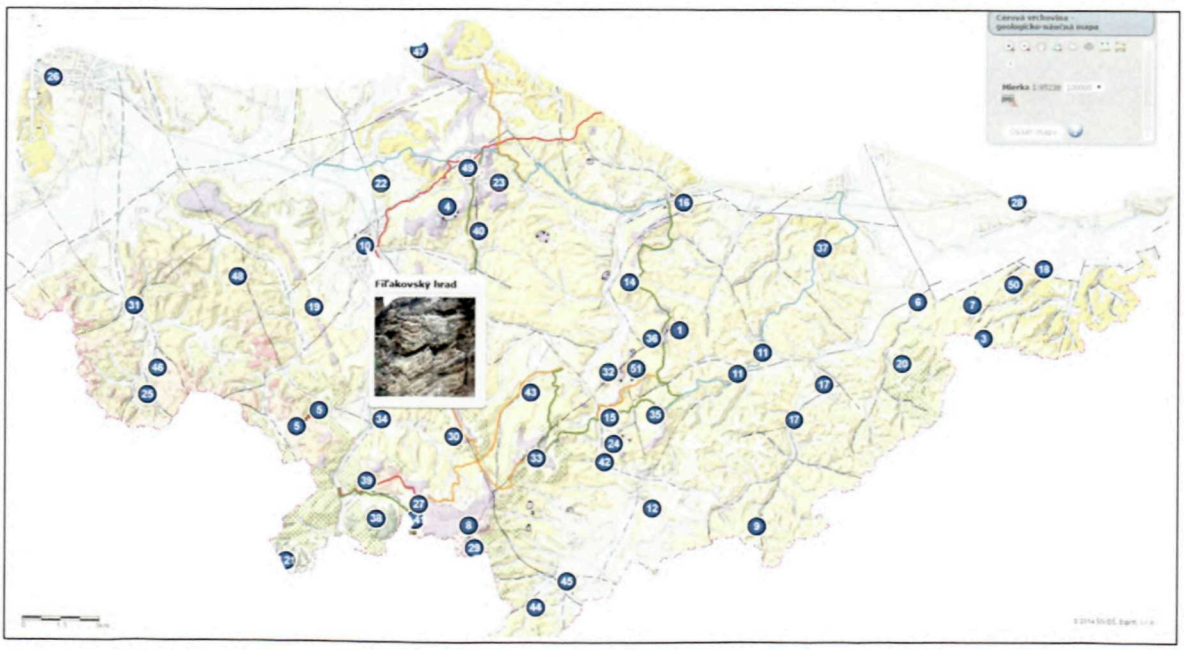


Fig. 2.30 Geological-Educational Map of the Cerová vrchovina Upland (compiled by Bystrická)

land of volcanic origin is situated in the Southern Slovakia. It is spread over the territory of Banská Bystrica Region in two of its districts: Lučenec and Rimavská Sobota. It has an elongated shape from the West to the East. On its territory the Protected Landscape Area Cerová vrchovina is situated (proclaimed in 1989) with numerous National Nature Reserves. Very valuable is the National Natural Reserve Šomoška(declared already in 1954). It is a rare example of the disintegration of basalt on the Castle Hill into columns and penta- and hexagonal prisms – Stone Waterfall, which belongs to the European curiosities. Among the attractive protected Natural Monuments we may include Pohanský hrad (Pagan Castle) and Hajnáčka – the ruins of a gothic castle of the 14th century on a rocky hill of volcanic origin.

2.3.5. Geological-Educational Map of the Vihorlatské vrchy Mts.

ŽEC, B. et al.: Geological-Educational Map of the Vihorlatské vrchy Mts. [online since 2013]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/vihorlat_g

Geological-Educational Map of the Vihorlatské vrchy Mts. at a scale of 1:50,000 was issued in 2001. In addition to the interpretation of geological structure of the region the map gives information about the natural beauties of the region, tourist attractions and major mineralogical occurrences. The Vihorlatské vrchy Mts. represent our easternmost volcanic mountains. The Vihorlat Landscape Protected Area, as well as a lot of nature protected areas and reserves, nature reserves and natural monuments, are located within their territory. They stretch over the Košice and Prešov regions and four districts: Michalovce, Sobrance, Snina and Humenné.

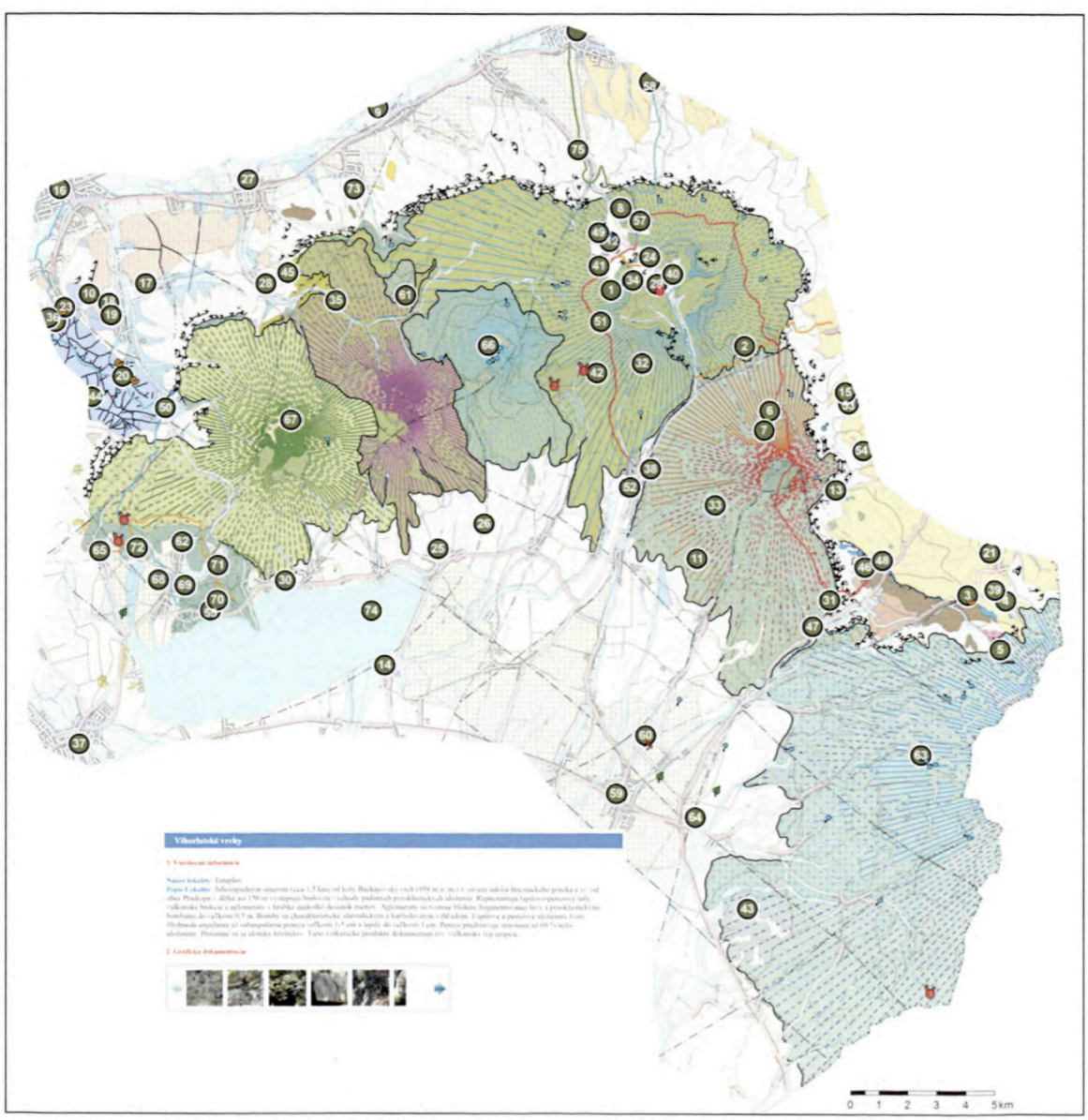


Fig. 2.31 Geological-Educational Map of the Vihorlatské vrchy Mts. (compiled by Bystrická)

2.3.6. Geological-Educational Map of the Tatry Mountains

BEZÁK, V. et al.: Geological-Educational Map of the Tatry Mountains [online since 2013]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/vtatry

Geological-Educational Map of the Tatry Mts. (authors of the Slovak part: Bezák et al.; authors of the Polish part: Piotrowska et al.) at a scale of 1:50,000 was issued in 2011. In addition to the interpretation of geological structure of the region the map gives information on tourist attractions, as well.

Tatry Mountains are the northernmost and highest mountain range in the entire Carpathian mountain range system. They are so unique, because, although they are the smallest high mountains by area in the world, their area encompasses so many natural beauties and peculiarities, as elsewhere, many times at much higher elevated and inaccessible areas. Many of you are certainly interested in the answer to the questions of how and when this mountain range and its morphology were formed, which are the most outstanding natural objects. The territory of the High Tatras Mts. hosts the oldest Slovak national park – Tatra National Park TANAP (declared in 1949). It has an area of 73,800 hectares and is located on the territory of Žilina and Prešov regions involving four districts: Poprad, Liptovský Mikuláš, Tvrdošín and Kežmarok. To the North it borders with the Polish Tatra National Park (Tatrzański Park Narodowy), forming the bilateral cross-border protected area. On the territory of TANAP there is also a Site of Community (European) Importance and Special Protection Area for Birds. The aim of the NATURA 2000 network is to maintain or improve the favourable conservation status of rare and endangered species of plants, animals and natural biotope types.

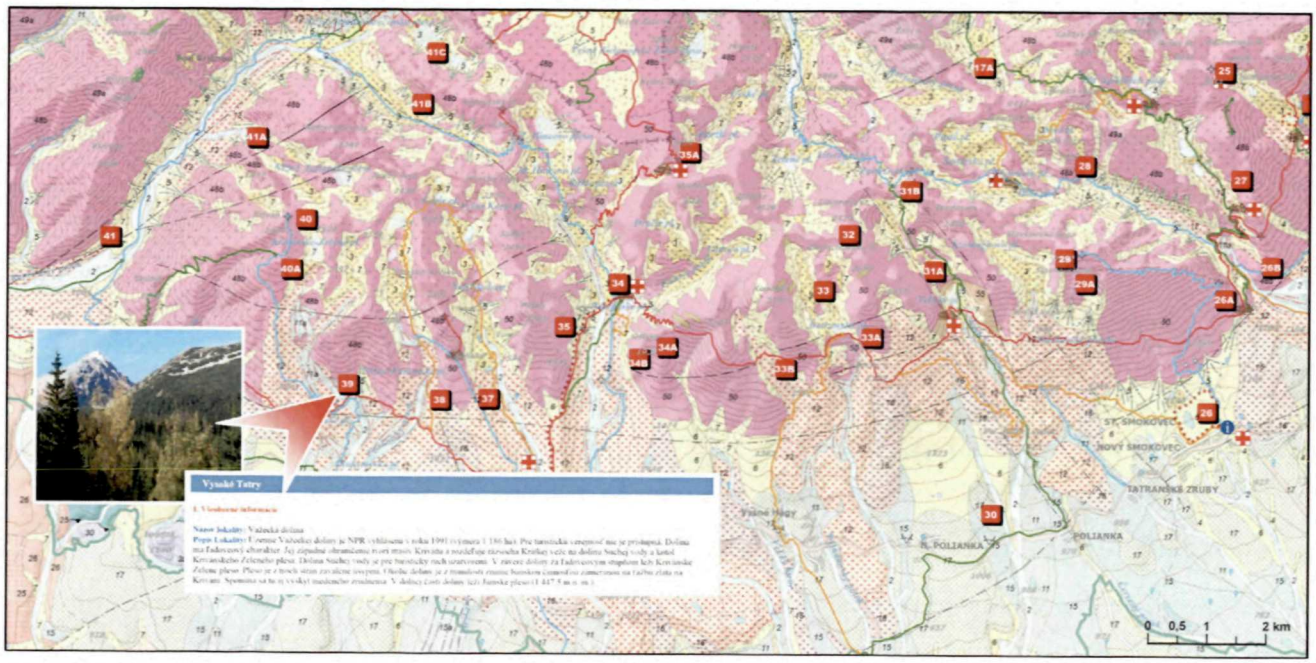


Fig. 2.32 Geological-Educational Map of the Tatry Mountains (compiled by Bystrická)

2.3.7. Exposition of the Deposits of Raw Minerals of Slovakia

GARGULÁK, M. et al.: Raw Mineral Deposits [online since 2014]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/gpark

The mineral wealth of the Austro-Hungarian Empire and long mining history of Slovakia is directly reflected not only by the fact that raw materials are extracted, but also collected, systematically studied and exhibited. Mining and quarrying with mining methods, machinery, equipment and associated technological structures, undoubtedly form part of the technical heritage. Taking care of raw minerals is a key role of museums; however research institutes in this field have also an irreplaceable role.

In SGIDŠ in 2005 there started to be collected representative samples of minerals from all over Slovakia in such a way, that they should represent in the collection all kinds (types) of minerals that were mined in our territory. The exposition was placed in the open air – in the premises of the Institute.

Each exhibit is marked by a single metal sheet which states:
- kind of raw mineral;
- its utilisation;
- name of the deposit;
- mining organisation.

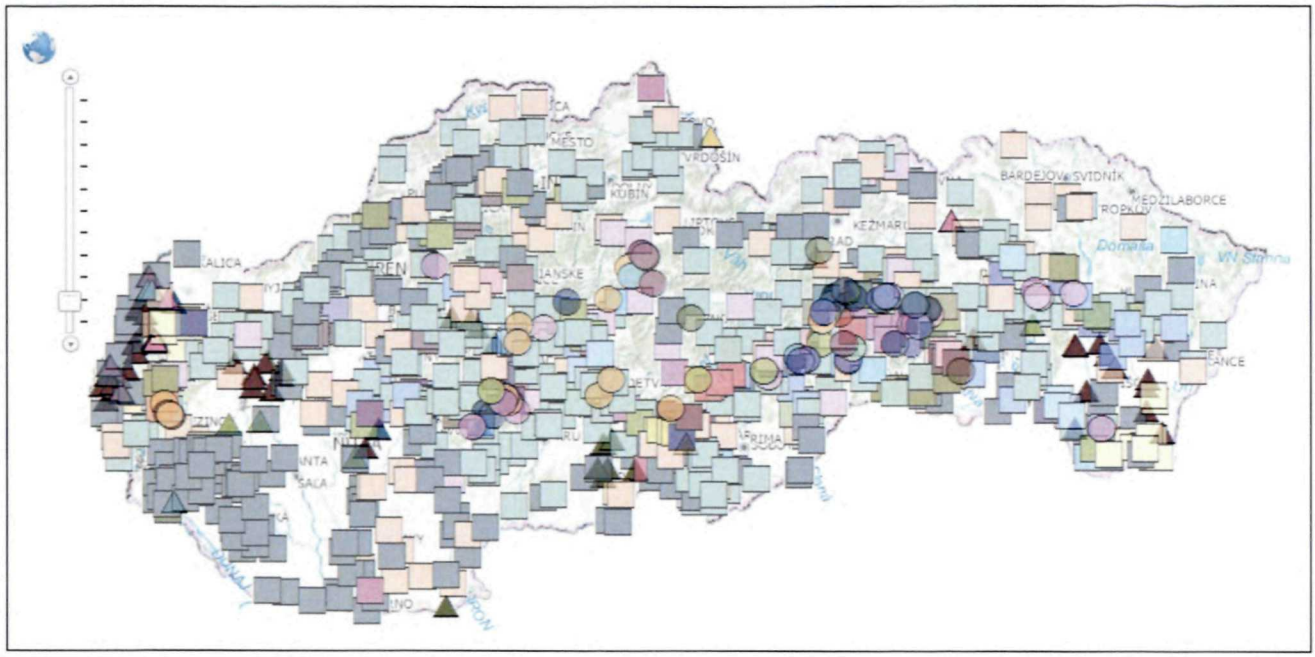


Fig. 2.33 Web application of Raw Mineral Deposits in Slovakia

2.3.8. GeoHazards

LIŠČÁK, P. et al.: GeoHazards [online since 2014]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/geoportal

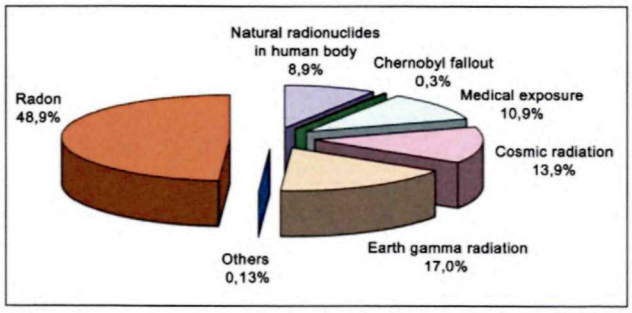


Fig. 2.34 Radon risk in the environment

Natural hazards in Slovakia almost annually require casualties and damage in the hundreds of millions of euro. SGIDŠ being in charge of the Geological Survey of Slovakia is vitally interested in gradual reduction of the vulnerability of the population and areas at risk of natural hazards. Based on cross-sectional cooperation with all sectors of society the SGIDŠ seeks to provide information, services and knowledge of the geological hazards in Slovakia.

In Slovakia we register several geological hazards:
- Landslides and other slope failures;
- Erosion;
- Earthquakes;
- Neotectonic movements;
- Karst processes;
- Volume changes of rocks;
- Territory undermining;
- Natural radon risk.

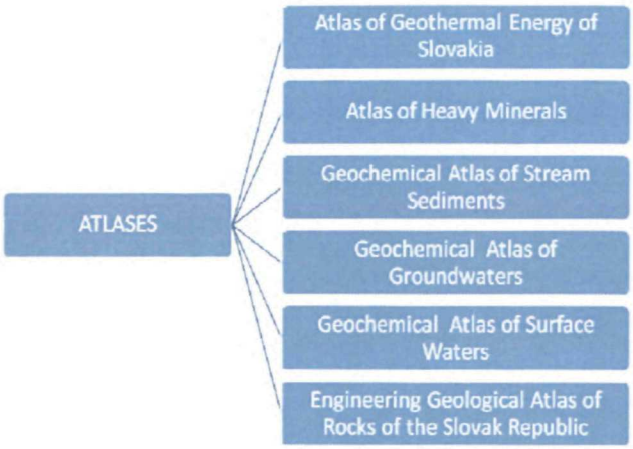
2.4. ATLASES

Set of digitally processed atlases.

1. *Atlas of Geothermal Energy of Slovakia* – digitally processed Atlas of 1995, which offers an overview of geothermal activity across the area of SR and in more detailed scales geothermal activity of defined areas is shown.

2. *Atlas of Heavy Minerals* – the results of the geological project *Panned Concentrates Survey Reinterpretation in Slovakia* – overview distribution map of 36 kinds of selected minerals.

3. *Geochemical Atlas of Stream Sediments* – Geochemical Atlas of the Slovak Republic, Part VI. – map display of the distribution of chemical elements in stream sediments – distribution of 35 elements depicted in the form of model mono-element maps (grids).



4. *Geochemical Atlas of Groundwaters* – Geochemical Atlas of the Slovak Republic, Part I. – map display of the distribution of chemical elements in groundwaters 1996) – course of distributions of the concentrations of individual elements and components in the national context.

5. *Geochemical Atlas of Surface Waters* – Geochemical Atlas of the Slovak Republic, Part VII. – 29 maps show the distribution of chemical elements and compounds determined in surface water through mono-element maps at a scale 1:1 million.

6. *Engineering Geological Atlas of Rocks of Slovakia* – basic attributes and characteristics of the 146 quarry sites in Slovakia.

2.4.1. Atlas of Geothermal Energy of Slovakia

FRANKO, O. et al.: Atlas of Geothermal Energy of Slovakia [online since 2010]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/atlasge

The Atlas of Geothermal Energy of Slovakia summarizes data obtained during more than two decades of investigations. These investigations were based on geologic, hydrogeologic and geothermic information accumulated before 1970.

Slovak territory is essentially illustrated on maps of two different scales. A 1:1,000,000 map shows generally the geothermal activity in the whole territory. Maps at scale 1:200,000 and more detailed ones depict geothermal activity in determined areas. The combination of level maps, maps of pre-Tertiary basement and heat-flow density maps gives the overall spatial distribution of geothermal activity in the territory concerned.

The maps are processed in two ways. Geothermal activity throughout the territory represents a set of 15 maps which are processed in vector form, as well as maps of the four identified areas, namely:

- Vienna Basin,
- Central Depresion of Danube Basin,
- Liptovská kotlina Basin,
- Topoľčany Embayment and Bánovská kotlina Basin.

The point, line and polygon information are available in separate layers. These maps are also supplemented by a map in pdf format with legend and scale. Other identified areas are available only in pdf format.

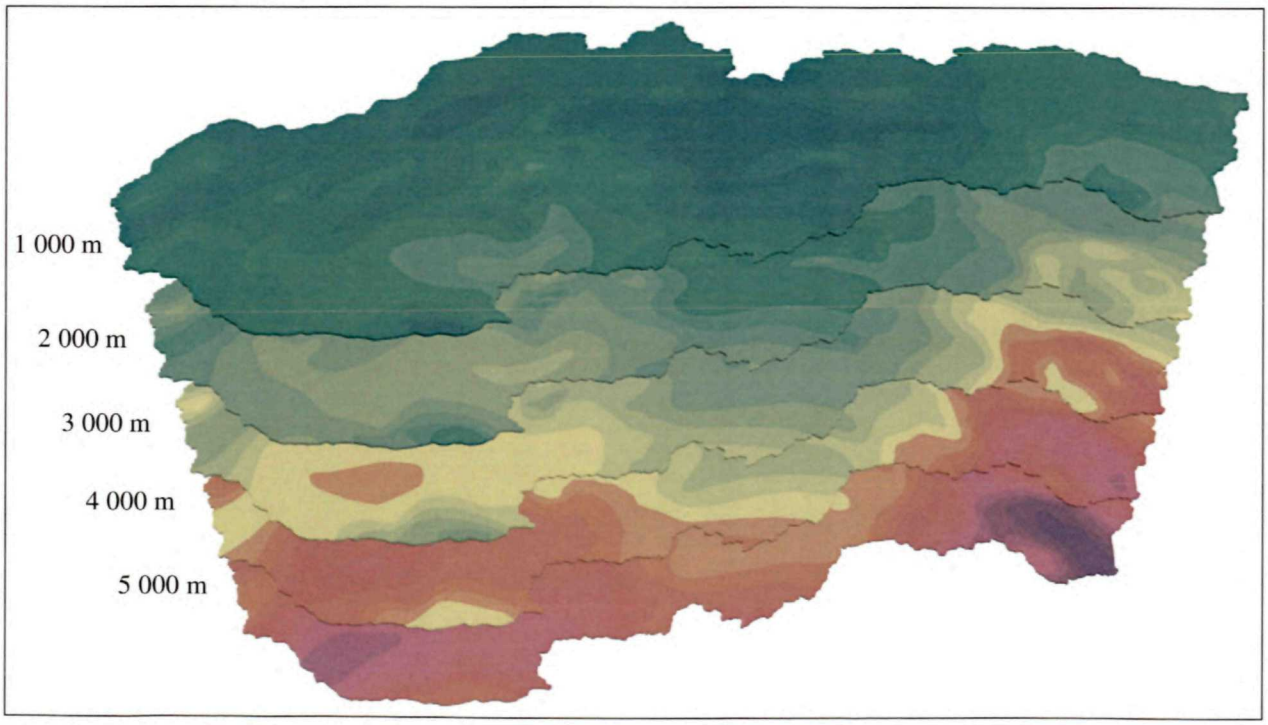


Fig. 2.35 Atlas of Geothermal Energy of Slovakia – Geothermal map of Slovakia in different levels below surface (compiled by Bystrická)

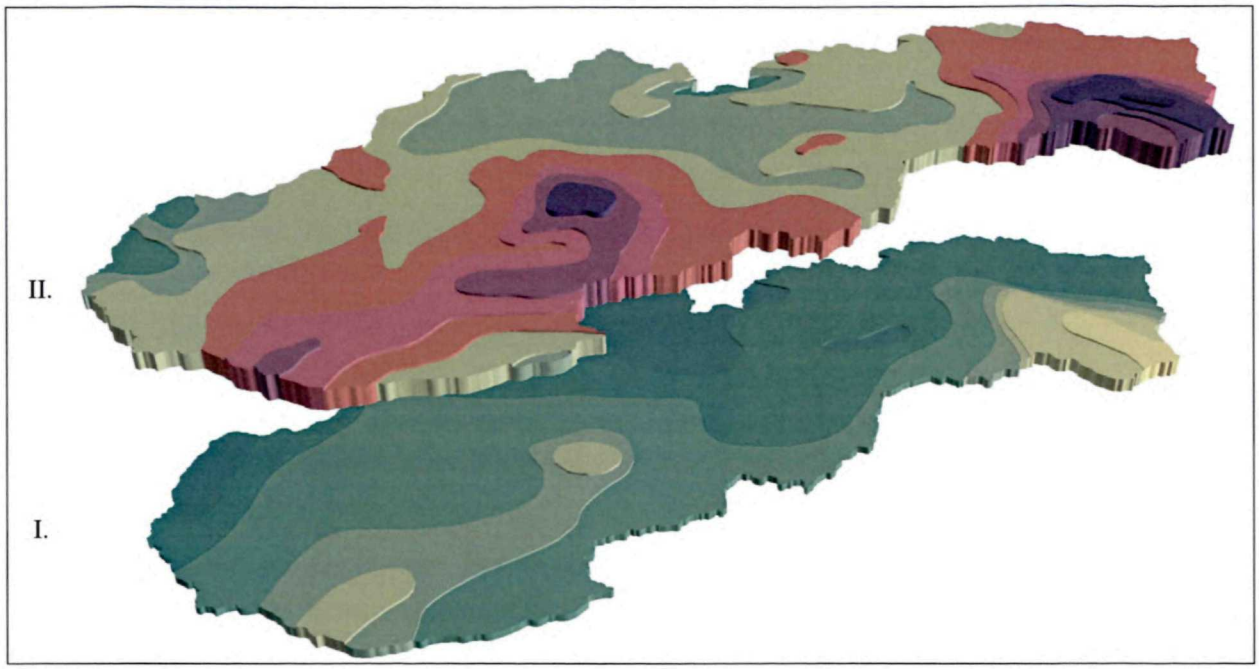


Fig. 2.36 Atlas of Geothermal Energy of Slovakia. I. – Map of heat flow density on Moho-discontinuity, II. – Map of surface heat flow density (compiled by Bystrická)

2.4.2. Atlas of Heavy Minerals

BAČO, P. et al.: Atlas of Heavy Minerals [online since 2010]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/atlastm

The main objective of the project *Panned Concentrates Survey Reinterpretation in Slovakia* was to assess the available sample material of specific regional projects in an uniform manner. On this basis, the database has been compiled for more than 50,000 samples and more than 60 variables for each sample. Thus, the resulting database provided input for creation of distribution and interpretation maps of selected species of minerals. For the first time we have at hand a complex assessment of the territory with geological, metallogenic and environmental aspects.

The Atlas of Heavy Minerals (2004) contains graphic and text annexes. The graphic annexes are maps at a scale of 1:800,000, namely: Map of regional projects dealing with panned concentrates prospecting, Map of sampling locations and Distribution maps showing the distribution of 36 kinds of minerals. They are processed in vector format. The text annexes are available in PDF format.

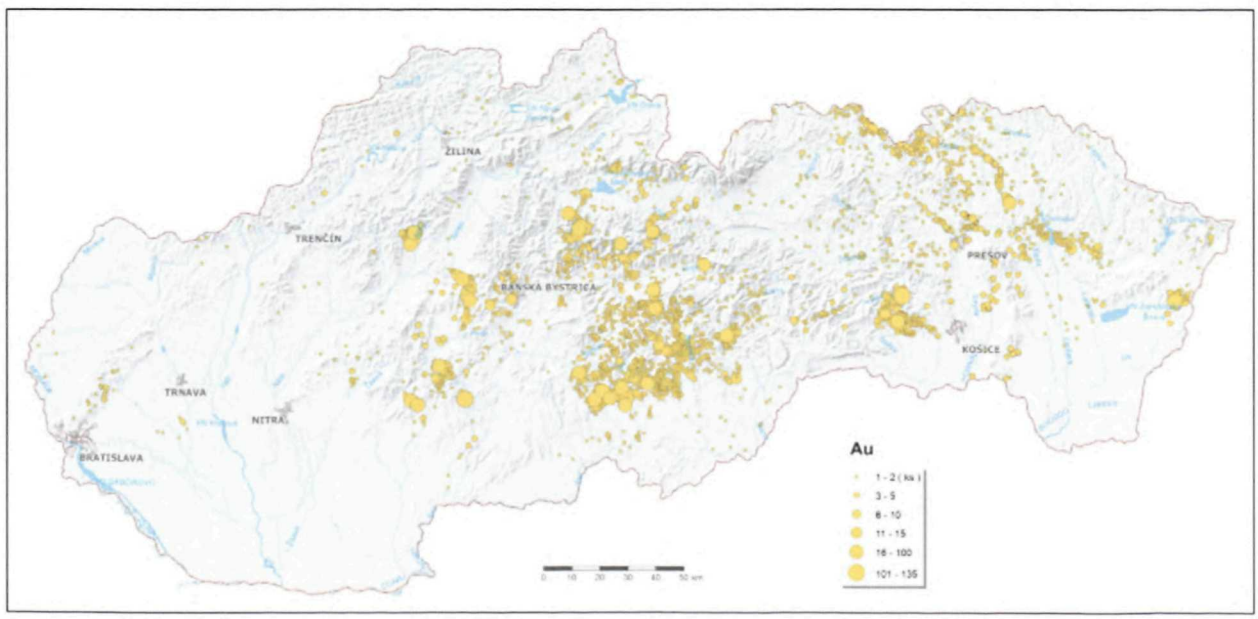


Fig. 2.37 Atlas of Heavy Minerals – Gold samples – Diamagnetic fraction (compiled by Bystrická)

2.4.3. Geochemical Atlas of Stream Sediments

BODIŠ, D. – RAPANT, S. et al.: Geochemical Atlas of Stream Sediments [online since 2011]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/atlasrs

From an environmental point of view the studied geological material – fine sediment of active streams (brooks and rivers) is the most important medium in Slovakia, mainly owing to Slovakia's dense stream pattern and relatively rugged topography. The stream-sediment sampling density represents 1 sample per 2 km^2. A total of 25,000 samples were collected and analysed. 24,432 samples were eventually processed and used in the compilation of the geochemical maps. The samples were collected in a fairly limited space of time between 1991 and 1995.

Geochemical Atlas of Stream Sediments (1999) contains graphic and text annexes. Graphic annexes form maps at a scale 1:1,000,000 with 35 elements whose distribution is shown in the form of model mono-element maps (grid): aluminium, arsenic, boron, barium, beryllium, bismuth, calcium, cadmium, cerium, cobalt, chromium, copper, iron, gallium, mercury, potassium, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorus, lead, rubidium, antimony, selenium, tin, strontium, titanium, vanadium, yttrium, zinc and zirconium. A point map was compiled only tungsten, the only analysed element whose contents were below the detection limit of the analytical method used in more than 50% of the samples. Text attachments are available in PDF format.

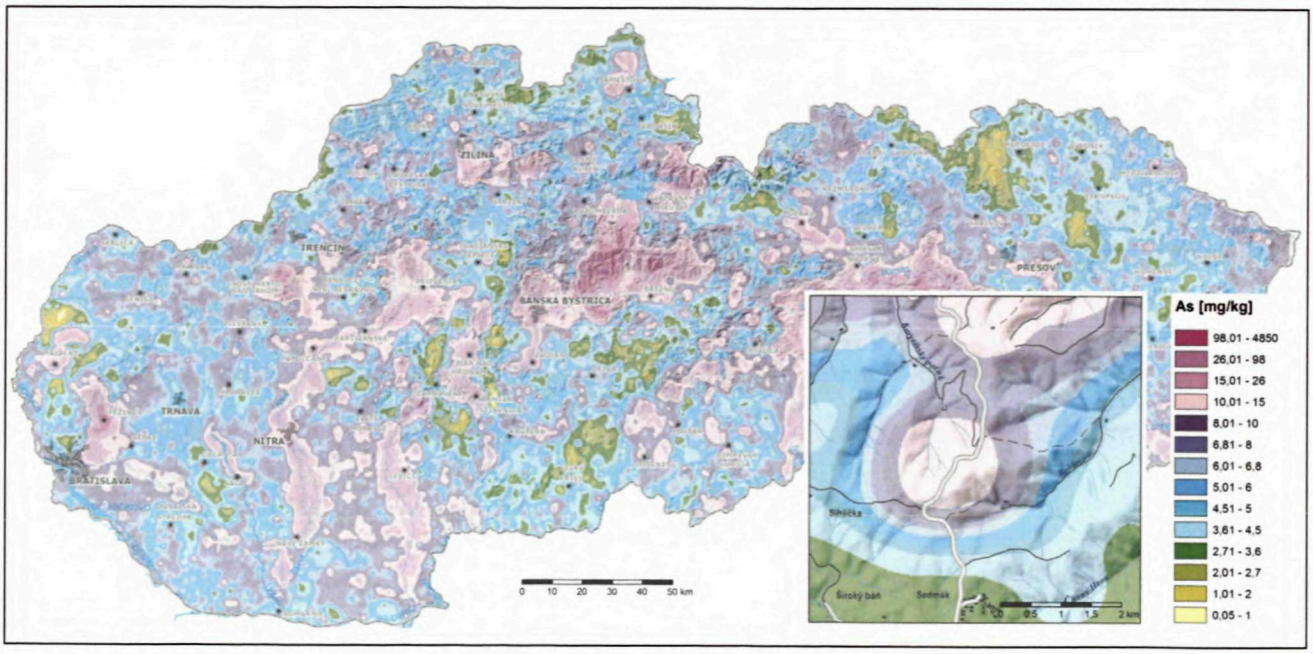


Fig. 2.38 Geochemical Atlas of Stream Sediments – Distribution of arsenic (As) contents [mg . kg^{-1}] (compiled by Bystrická)

2.4.4. Geochemical Atlas of Groundwaters

RAPANT, S. – VRANA, K. – BODIŠ, D. et al.: Geochemical Atlas of Groundwaters [online since 2011]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/atlaspv

Based on sampling of groundwater of the first aquifer (springs, wells, drillholes), the hydrogeochemical mapping of the Slovak territory was aimed at illustrating the regional distribution of those elements, components and parameters, which are the most important from environmental and water-management points of view. The graphic and interpretative part illustrates groundwater chemistry of the first aquifer in the Slovak territory at the time of sampling (1991–1994). However, the results of the regional hydrogeochemical mapping are valid more generally as they respect basic hydrogeologic variability of the Slovak territory and assess the role of primary and secondary factors in the formation of groundwater chemistry in a regional scale. Hydrogeochemical data obtained (16,359 groundwater samples) will be used in both national and regional scales to compare changes in groundwater quality in the years ahead.

Geochemical Atlas of Groundwaters (1996) contains graphic and text annexes. The graphic annexes are maps at a scale of 1:1,000,000.

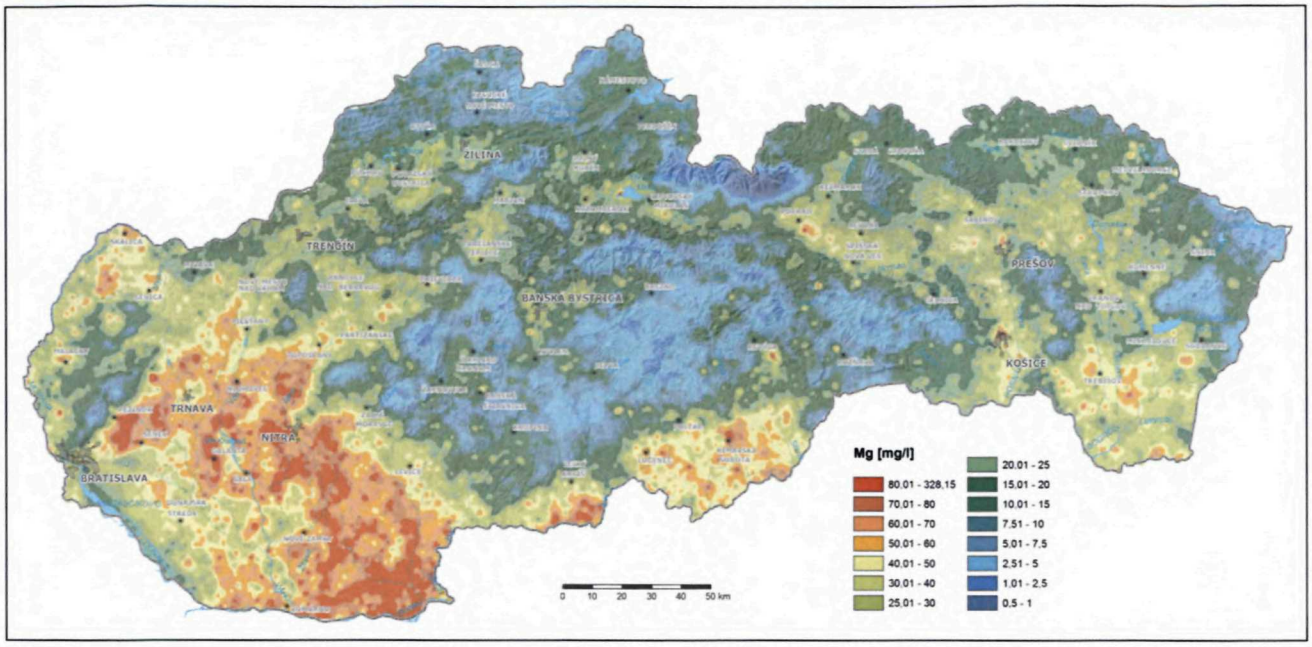


Fig. 2.39 Geochemical Atlas of Groundwaters – Distribution of magnesium contents (Mg) [mg . l^{-1}] (compiled by Bystrická)

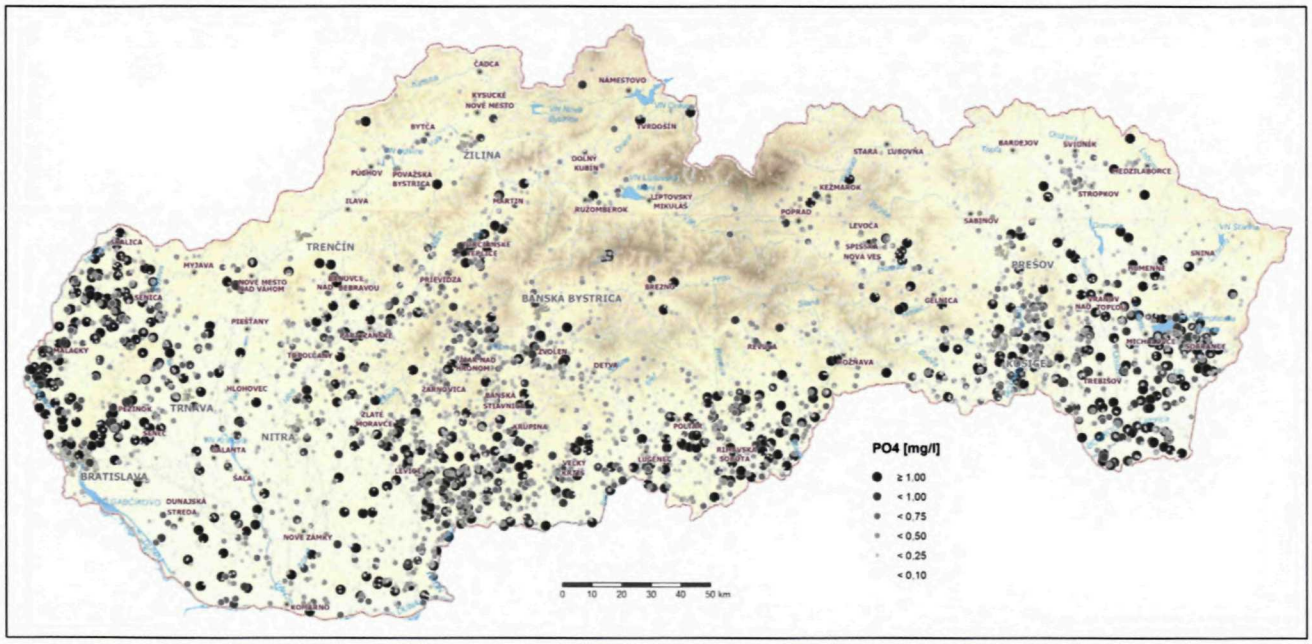


Fig. 2.40 Geochemical Atlas of Groundwaters – Distribution of phosphate contents (PO_4) [mg . l^{-1}] (point depiction) (compiled by Bystrická)

Distribution of monitored elements and components is displayed by two types of maps (due to the number of representative samples) – point and areal (diffuse). The condition for preparation of diffuse maps was the number of analyses with less than 50% of the values smaller than the determination limit. Colour scale of diffuse maps was created using the percentiles and is selected according to the "traffic light principle", from the lowest concentrations of blue up to the highest ones highlighted in red colour. In this way the distribution maps of the contents of aggressive CO_2, barium, potassium, nitrates, fluoridy, aluminium unfiltered, pH values, magnesium, bicarbonates, chemical oxygen demand, chlorides, lithium, copper, total dissolved solids, silica, sulphates, sodium, strontium, water hardness, calcium, zinc and iron, are compiled.

The point maps are compiled in the case the criteria of the surface model have not been met. They display the indicated concentration of elements/compounds at a site of sampling. Size of circle in the point map shows the corresponding concentration interval of elements/compounds. The distribution maps display contents of ammonium, antimony, arsenic, phosphates, aluminium, chromium, cadmium, manganese, lead, mercury and selenium.

Text attachments to individual maps are available in PDF format.

2.4.5. Geochemical Atlas of Surface Waters

BODIŠ, D. et al.: Geochemical Atlas of Surface Waters [online since 2015].
Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/atlaspov

In the period of 2008 – 2014 the State Geological Institute of Dionýz Štúr solved the project *Geochemical Atlas of SR VII. Part – Surface Waters*. This is the last part of the Geochemical Atlas of Slovakia dedicated to the result of hydrogeochemical mapping of surface water. The main focus of this part of the Geochemical Atlas was to clarify the interpretation and distribution of elements/compounds in the maps at 1:1,000,000.

The basis for compiling the Atlas were chemical analyses of surface water from own sampling, samples of the national monitoring network for surface waters and chemical analyses results obtained from other works. A requirement for inclusion a sample into database was complete chemical analysis of the main components, analytical error could not exceed 5 % of the value and sites of sampling must have their coordinates. The final number of samples in the database reached 10,960 chemical analyses. The statistical density of the territory of Slovakia coverage is roughly 1 sample/5km^2. Distribution of samples depends on the density of the river network.

Distribution of monitored elements and components is displayed by two types of maps (due to the number of representative samples) – point and areal (diffuse). The condition for preparation of diffuse maps was the number of analyses with less than 30% of the values smaller than the determination limit. The second condition was the surface evenness across the whole territory of Slovakia. Colour scale of diffuse maps was created using the percentiles and is selected according to the "traffic light principle", from the lowest concentrations of blue up to the highest ones highlighted in red colour. In this way the distribution maps of the contents of ammonium, potassium, nitrates, fluorides, phosphates, aluminum, magnesium, bicarbonates, chemical consumption of oxygen, chloride, manganese, total mineralization, pH, sulphate, sodium, hardness, calcium, conductivity, zinc and iron, are compiled.

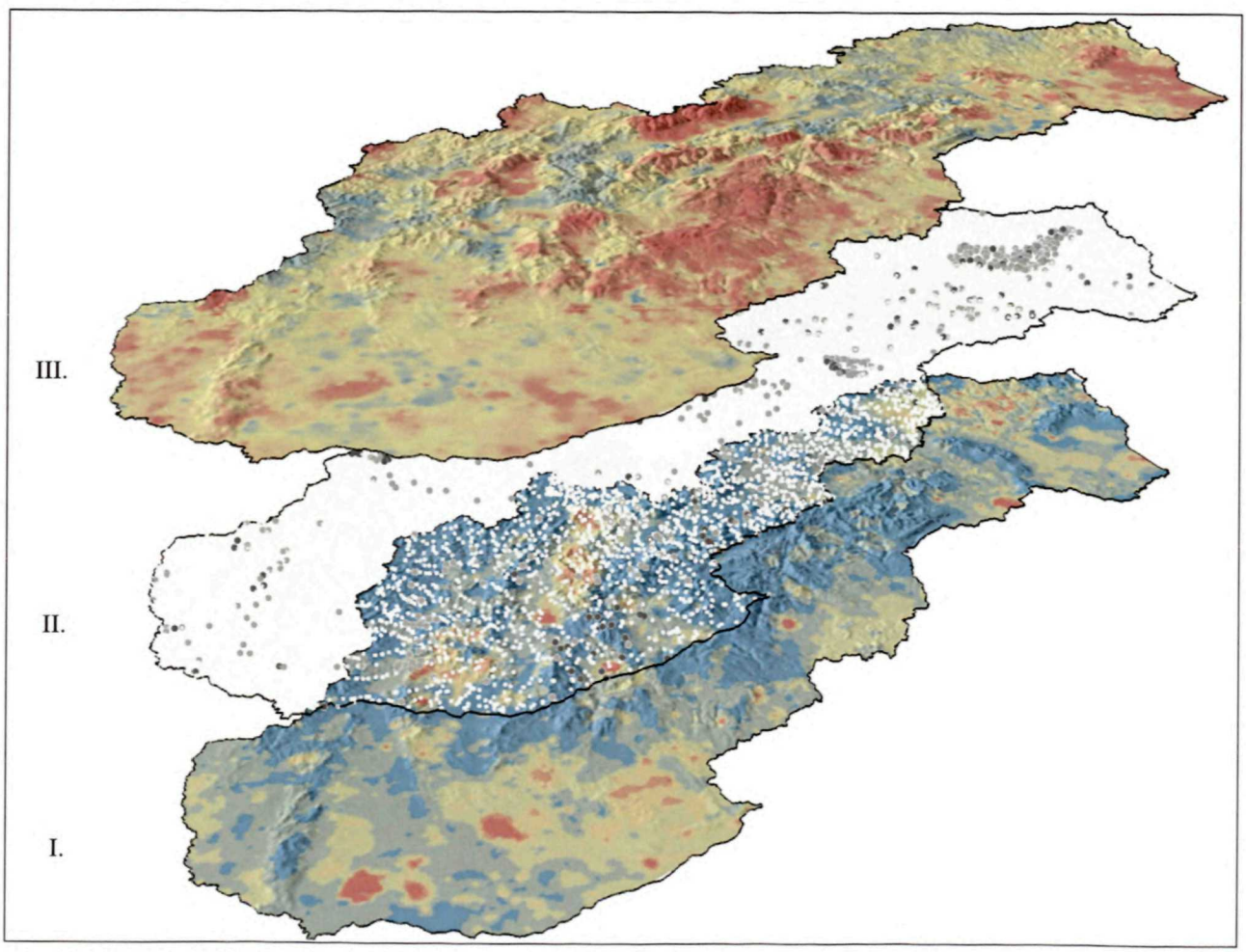


Fig. 2.41 Geochemical Atlas of Surface Waters (compiled by Bystrická)
I. – Areal map of fluorides distribution courses [mg . l^{-1}] (frequency) (grid), II. – Point map of lead (Pb) distribution courses [mg . l^{-1}] (frequency), III. – Areal map of pH distribution courses (frequency) (grid)

The point maps are compiled in the case the criteria of the surface model have not been met. They display the indicated concentration of elements/compounds at a site of sampling. Size of circle in the point map shows the corresponding concentration interval of elements/compounds. The distribution maps display contents of arsenic, barium, cadmium, chromium, copper, mercury, lithium, dissolved oxygen, lead, antimony, selenium, silicon and strontium.

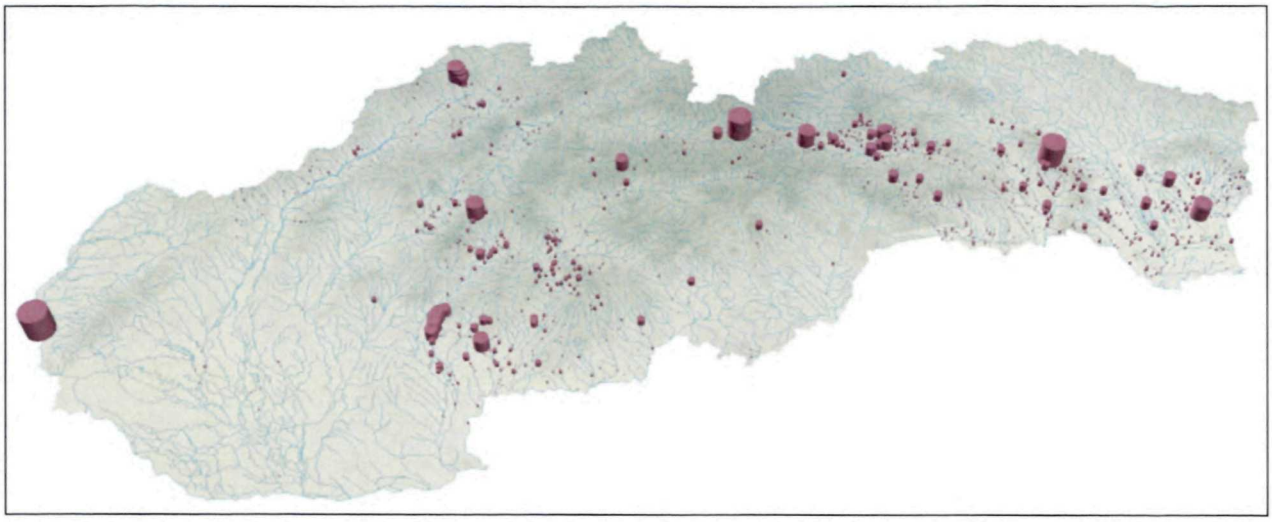


Fig. 2.42 Geochemical Atlas of Surface Waters – distribution courses of aluminum (Al) [mg.l^{-1}] (frequency) expressed by column graphs (compiled by Bystrická)

2.4.6. Engineering Geological Atlas of Rocks of the Slovak Republic

HOLZER, R. et al.: Engineering Geological Atlas of Rocks of the Slovak Republic [online since 2012]. Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/igatlasg

In the "Engineering Geological Atlas of Rocks of the Slovak Republic" (EG Atlas, Holzer et al., 2008)) basic attributes and characteristics decisive for the behaviour of the rock environment are presented in the unified form. The EG Atlas contains extensive information concerning the state and properties of solid and semi-solid rocks which have been created and systematically collected across the entire area of Slovakia during the long-term investigation of the rock environment at more than 250 sites since 60-ties of the previous century. Such comprehensive information from finally processed 146 sites is applicable especially to solve diverse engineering geo-

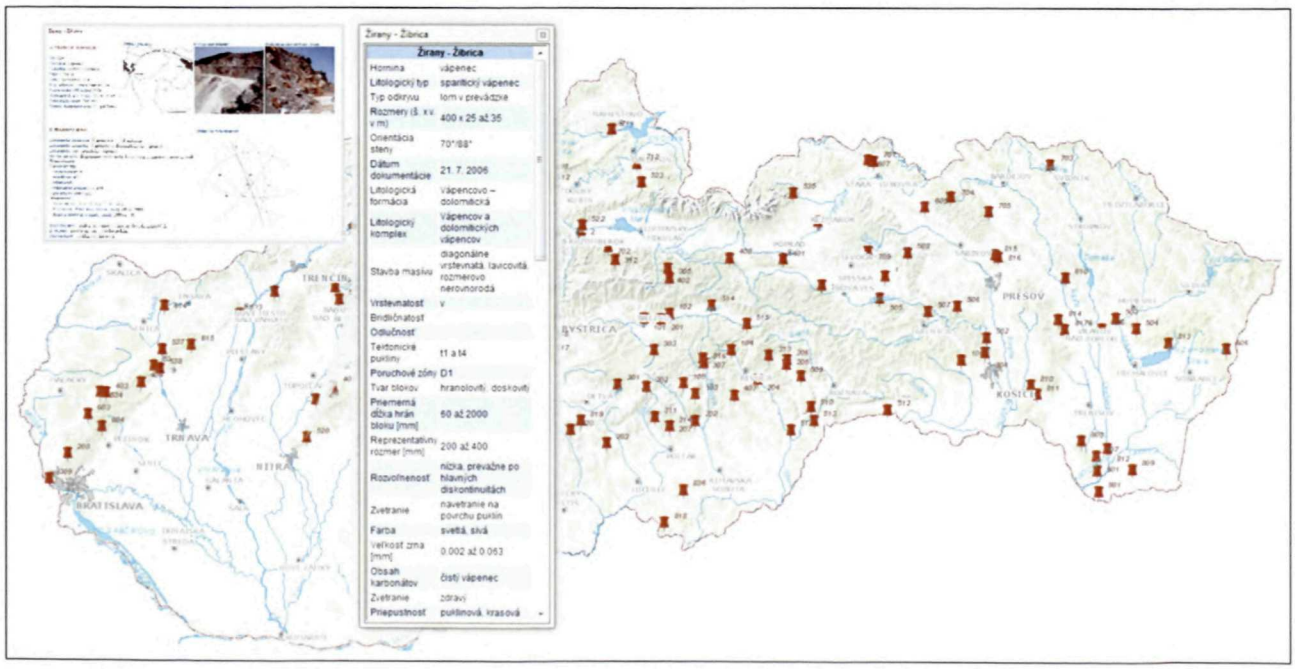


Fig. 2.43 Engineering Geological Atlas of Rocks of the Slovak Republic – composition from map application (compiled by Bystrická)

logical, geotechnical, mining and other tasks. Additionally, experts in other fields who deal with the rock environment from a specific perspective can obtain from the EG Atlas a lot of valuable information.

Creation of the relational database illustrates important progress in information processing of data characterizing state and properties of solid and semi-solid rocks. The clear advantage of the database is the possibility of almost unlimited repeatable calculations and assessments with new data and the flexible modifications of the structure and data within the database.

Besides all these information collected and elaborated in the EG Atlas, the end-users can also find other purposes to which the data can be applied. In respect of it, the EG Atlas presents a rich source of currently applicable data and creates a reliable basis for further development of investigation in this field.

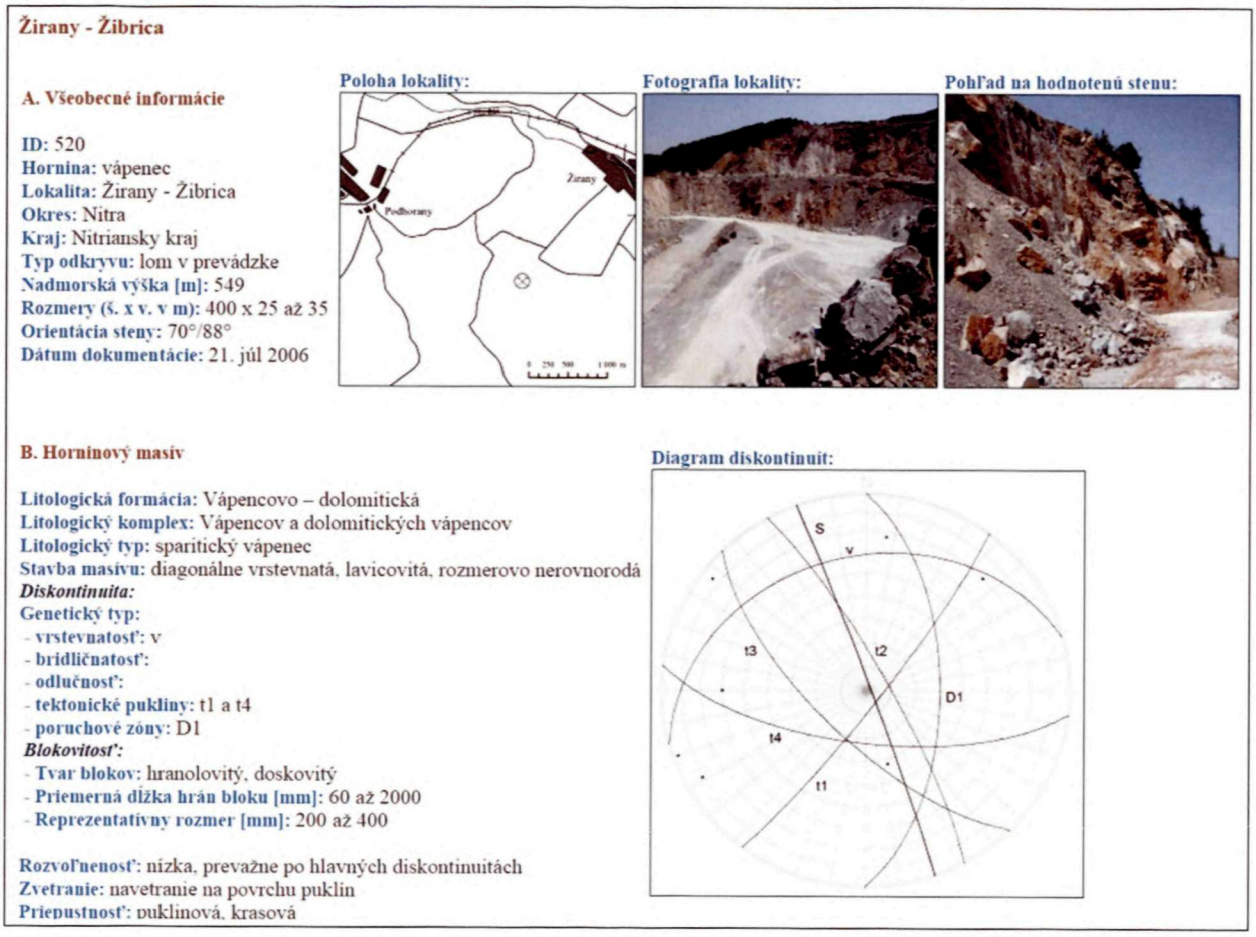


Fig. 2.44 Engineering Geological Atlas of Rocks of the Slovak Republic – composition from map application

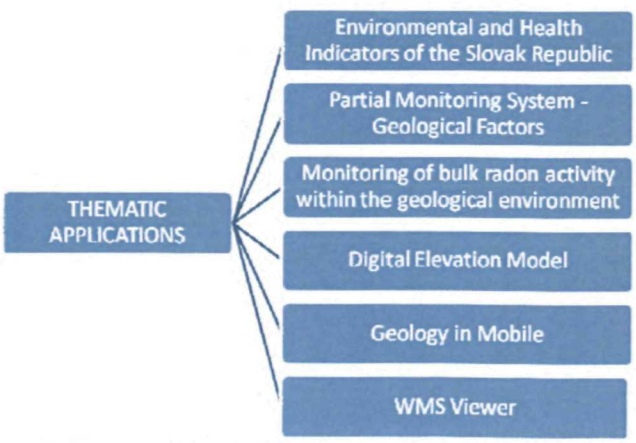
2.5. THEMATIC APPLICATIONS

1. Environmental and Health indicators – detailed information on the contents of chemical elements (a pollution status) in the geological environment (environmental indicators) and on indicators of the health status of the population (health indicators).

2. Partial Monitoring System – Geological Factors (CMS GF) – monitoring focused mainly on the so-called geological hazards, i.e. adverse natural or anthropogenic geological processes that threaten the natural environment, and ultimately humans.

3. Monitoring of Radon Volume Activity in Geological Environment – graph display of measured data of radon concentrations in rock environment and groundwater in the annual cycle of monitoring.

4. The Digital Elevation Model – raster digital model of relief of Slovakia with spatial resolution 20x20 meters.



5. Geology in Mobile – mobile application is used to obtain basic information about the geological setting of

of Slovak Republic, landfills, slope deformations and important geological sites.

6. WMS viewer – viewer map services WMS. Applicable to tag, view, and print a tailor-made map composition.

2.5.1. Environmental and Health Indicators of the Slovak Republic

RAPANT, S. et al.: Environmental and Health Indicators of the Slovak Republic [online since 2014]. Bratislava: State Geological Institute of Dionýz Štúr. Available on Internet: http://mapserver.geology.sk/indikatory

Application of environmental and health indicators evolved by processing the results of two geological projects.

a) *Environmental and Health Indicators of the Slovak Republic (Rapant et al., 2010a)*

The SGIDŠ project solved in collaboration with the organisation ENVIRONMENT a. s., Nitra in the period of 2006 – 2009. It provides for the Slovak Republic detailed information on the contents of chemical elements (a pollution status) in the geological environment (environmental indicators) and on indicators of the health status of the population (health indicators). Data are presented in the form of mean values for each municipality in Slovakia. Environmental indicators have been processed also fir higher administrative units – districts and regions.

b) *The Assessment of the Potential Impact of Geological Environment on the Health Condition of the Population of the Banská Štiavnica Area (Rapant et al., 2010b)*

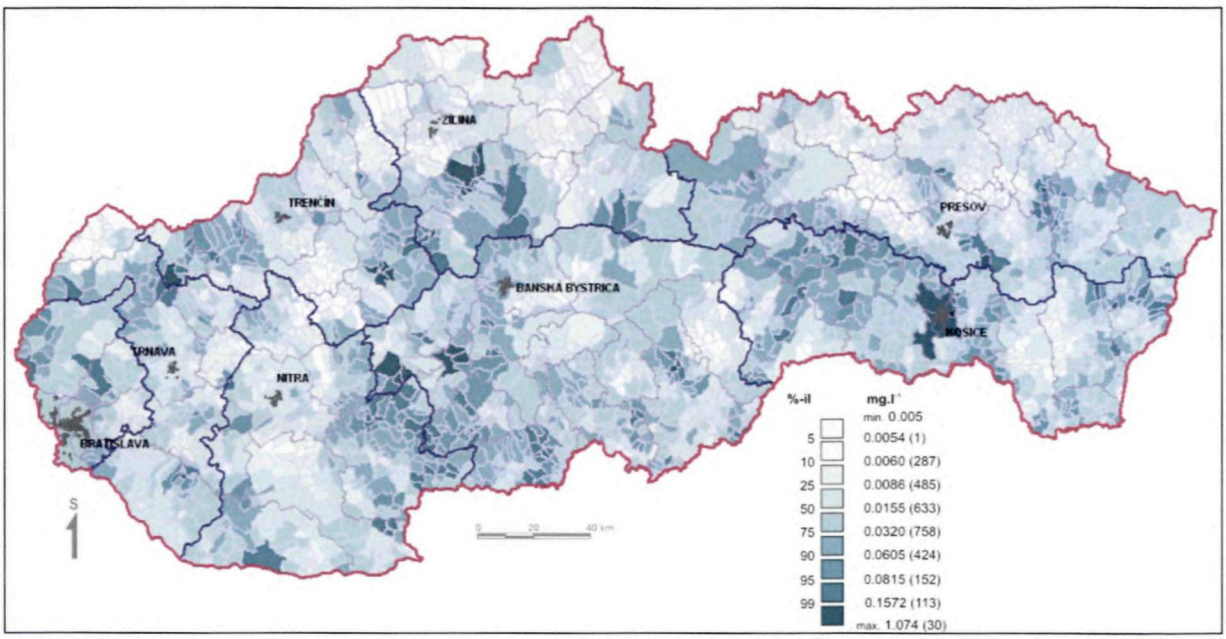


Fig. 2.45 Distribution of aluminum in the groundwaters of the Slovak Republic – composition from map application

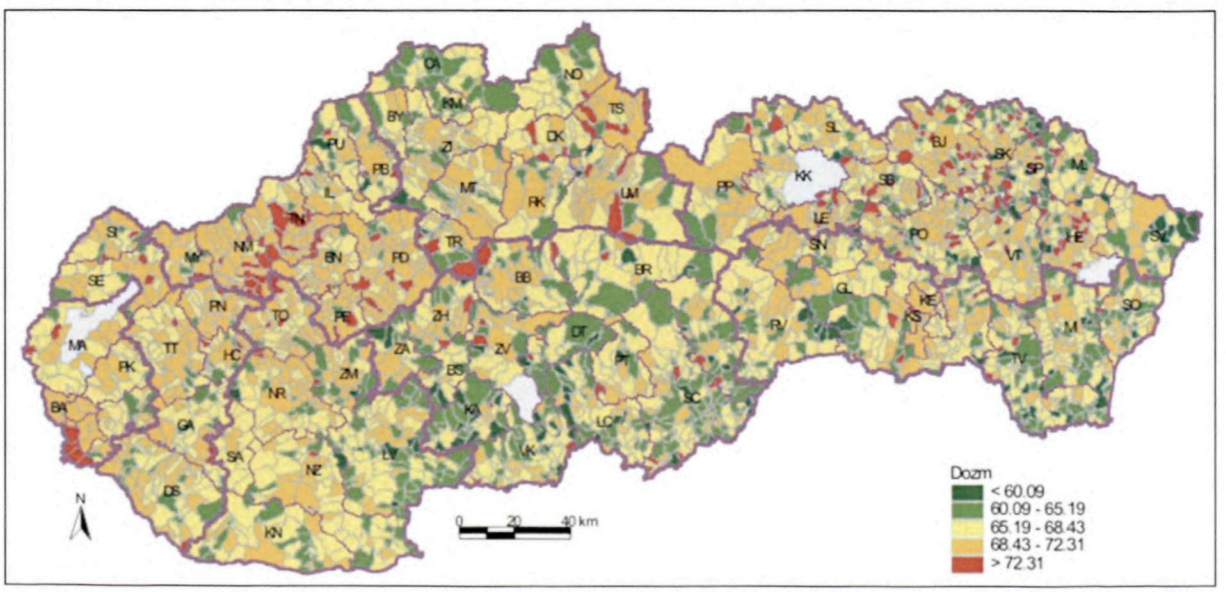


Fig. 2.46 Indicator no. 1 – Life expectancy of males (DOZM) in the municipalities of Slovakia in the period of 1994 – 2003 (Indicator for Slovakia is 67.44 years)

The SGIDŠ project solved in the period of 2006 – 2010 in cooperation with the organisation ENVIRONMENT a. s., Nitra (mainly health indicators) and the Slovak Medical University in Bratislava (mainly ^{222}Rn measuring in residential premises). The project provides for the Banská Štiavnica area detailed information on the contents of chemical elements (environmental indicators) in the geological environment (in particular groundwater and soil), which are processed into indicatives for each municipality of the region.

2.5.2. Partial Monitoring System – Geological Factors

LIŠČÁK, P. et al.: Partial Monitoring System – Geological Factors [online since 2013].
Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: *http://mapserver.geology.sk/monitoring*

System of monitoring along with information system are important tools to ensure the quality of the environment. At the same time they provide the basis for decision-making on the current and future activities in the field of the environment. The environmental monitoring is a systematic, time/space defined observation of the characteristics of the environment compounds (usually in points, forming a monitoring network), with a certain degree of power to represent the area under study, and in summary, a larger territorial unit. The monitoring provides objective knowledge of the characteristics of the environment and their changes in the area under study.

Partial Monitoring System – Geological Factors is a component of the *Monitoring System of the Environment of the Slovak Republic*. The focus is mainly in the so-called geological hazards, i.e. harmful natural or anthropogenic geological processes that threaten the natural environment and, ultimately, humans. We have experienced the more and more adverse effects of natural forces in recent years, the number of incidents, disasters that have posed a negative impact on the lives and health of people or their property; in particular, recurring floods and landslides. The results of the monitoring provide information to adopt appropriate and timely measures to prevent the incidents.

The monitoring of the geological environmental factors of the Slovak Republic is seen as multi-component, integrated and open system. Separate objects of monitoring are divided into the following subsystems:

01 Landslides and other slope failures
02 Tectonic and seismic activity of the territory
03 Anthropogenic sediments of the environmental burdens nature
04 Impact of mining upon the environment
05 Monitoring of the radon bulk activity within the geological environment
06 Stability of rock masses below historic objects
07 Monitoring of fluvial sediments
08 Volume unstable soils

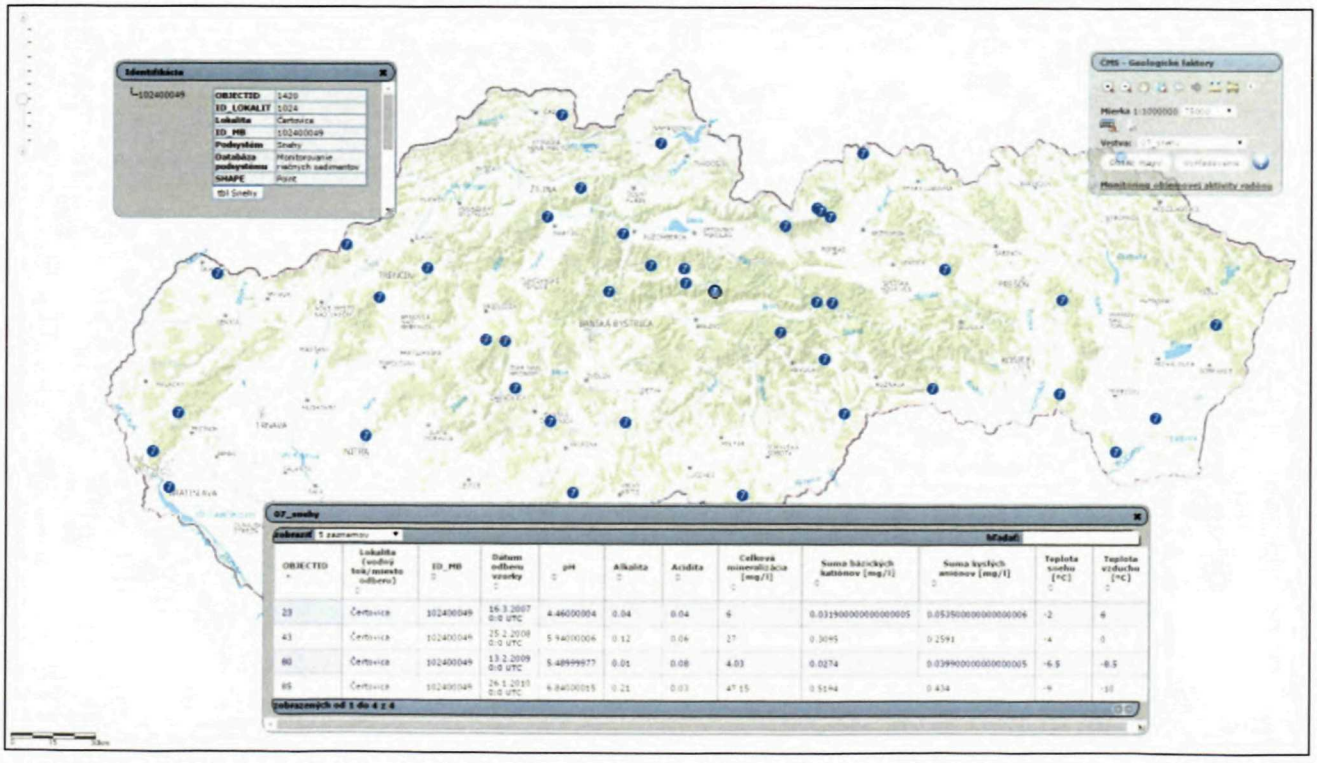


Fig. 2.47 Monitoring of stream sediments/chemical composition of solid precipitations – composition from map application (compiled by Bystrická)

2.5.3. Monitoring of Bulk Radon Activity within the Geological Environment

GLUCH, A. et al.: Monitoring of Bulk Radon Activity within the Geological Environment [online since 2013]. Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/radon

Radiation burden of the population is among the major factors in a wide range of areas with more or less significant negative impact upon humans. Over the long-term the attention and concern of the public are aimed rather to artificial sources of radiation (nuclear energy, nuclear weapons, etc.), while the most significant exposure (besides the nuclear accidents) cause natural background radiation sources. Acquiring relevant information on radioactivity from natural sources as well as on our territory is therefore necessary.

The main source of natural radon is a geological environment and it is therefore the aim of the monitoring to document and comprehensively assess the short-term (seasonal), but also the long-term (in the order of units up to tens of years) variations of the concentrations of radon in the rock environment and groundwater. The monitoring of radon volume activity (RVA) in the geological environment on the territory of Slovakia is carried out in 3 thematic areas:

a) radon contained in soils at reference areas; b) radon contained in soils along tectonics; c) radon in waters.

The application displays the evaluation of measured data in the annual cycles of monitoring using graphs, which are appropriate for each monitored site; they are also displayed on the map. The emphasis is placed on the presentation of the results of observation of the annual cycle in individual months. The reason is the diversity of climatic conditions that affect the evaluation of the RVA in the geological environment.

The application also allows searching for information using SQL selection and selection according to the spatial division (administrative, regional geological and geomorphologic).

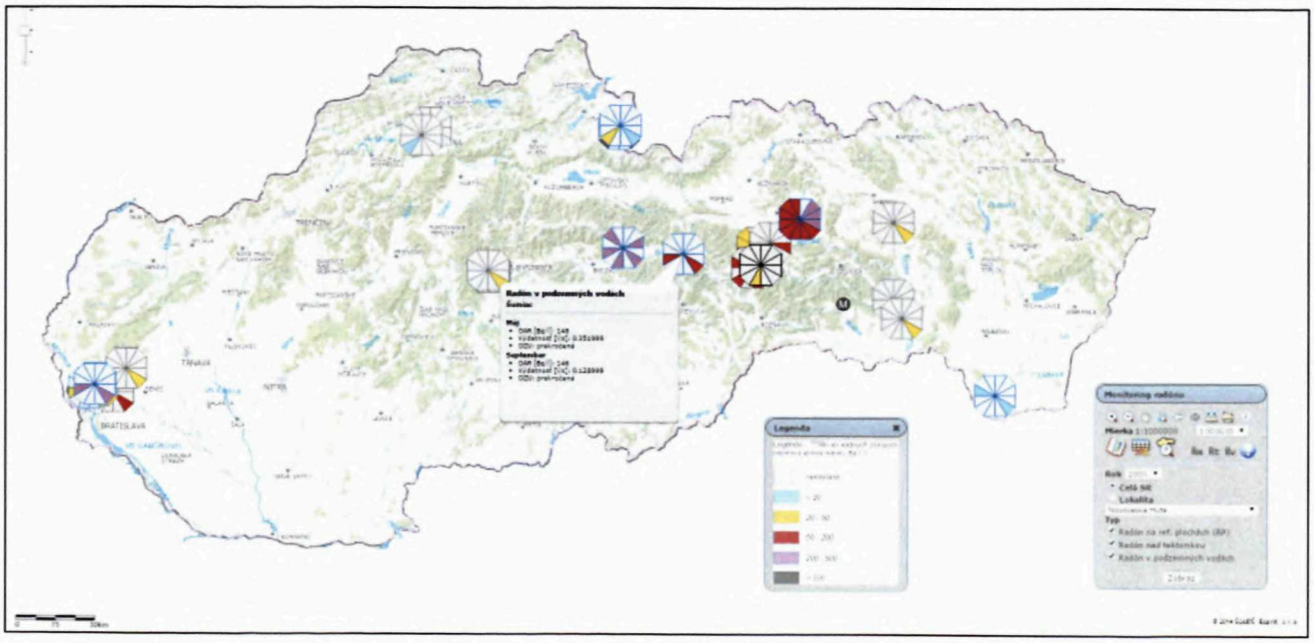


Fig. 2.48 Monitoring of bulk radon activity within groundwaters – composition from map application (compiled by Bystrická)

2.5.4. Digital Elevation Model

Digital Elevation Model [online since 2009]. Bratislava: State Geological Institute of Dionýz Štúr.
Available on Internet: http://mapserver.geology.sk/dmr

The raster digital model of the georelief of Slovakia with the spatial resolution 20x20m was constructed using the digital elevation data – contour lines and altitude points from the Basic Topographic Map at a scale 1:10,000. Other elements entering into calculation were the valley lines expressed by the detail river network, water areas and in the area of the Tatry Mts. also the mountain ridges and crest lines. This data set was supplemented by further elevation data in the form of points and contour lines for the purpose of clarification of the field of altitudes in the raster model. The spatial extent of the model covers the entire territory of the Slovak Republic continuously in a seamless way. The spatial reference system is a mathematical model of the coordinate system S-JTSK.

The application enables to display these morphometric characteristics:

a) slope;
b) aspect;
c) horizontal curvature of the relief in the contours direction;
d) normal curvature of the relief in the direction of gradient curves;
e) specific contributing area [m^2/m].

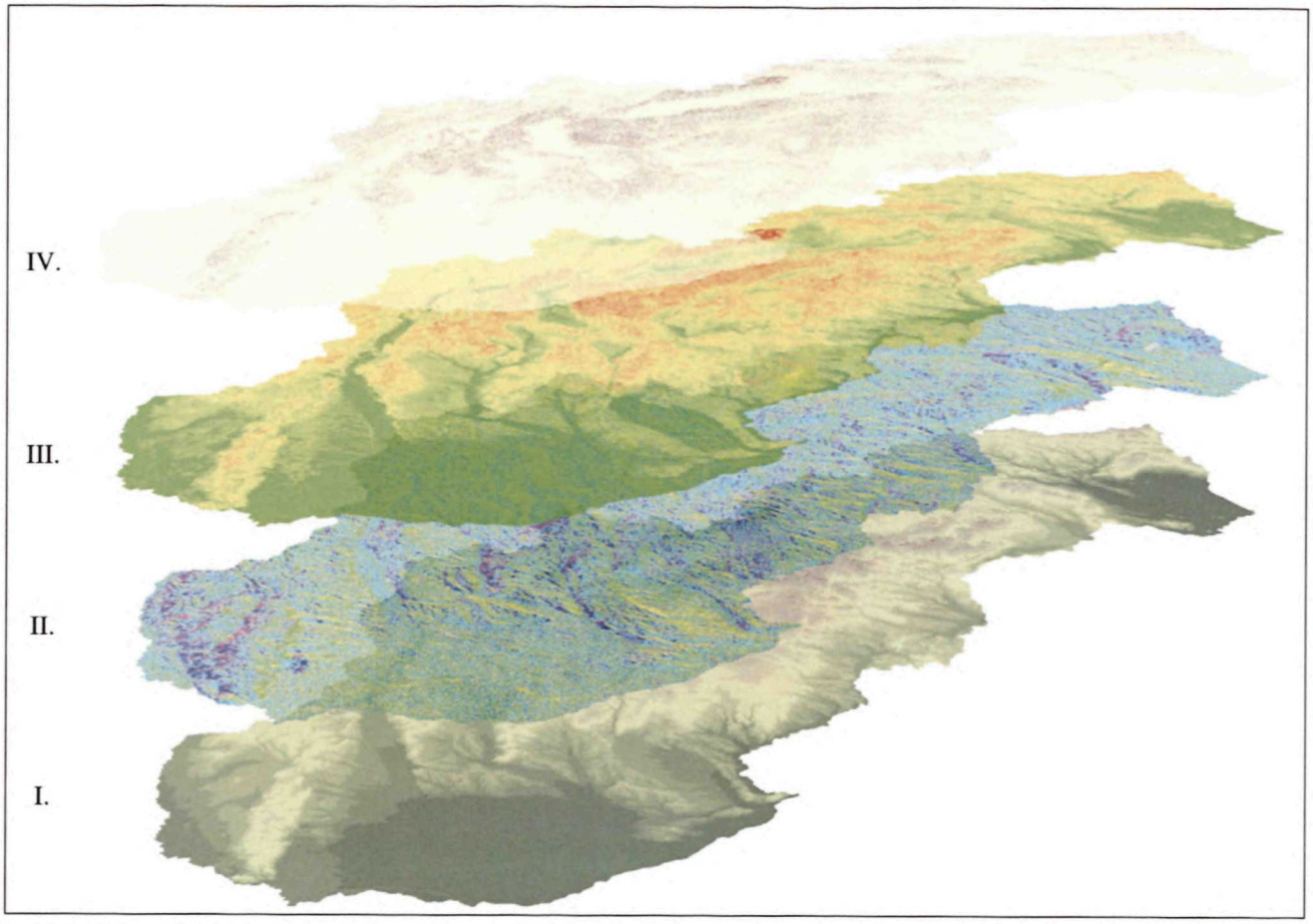
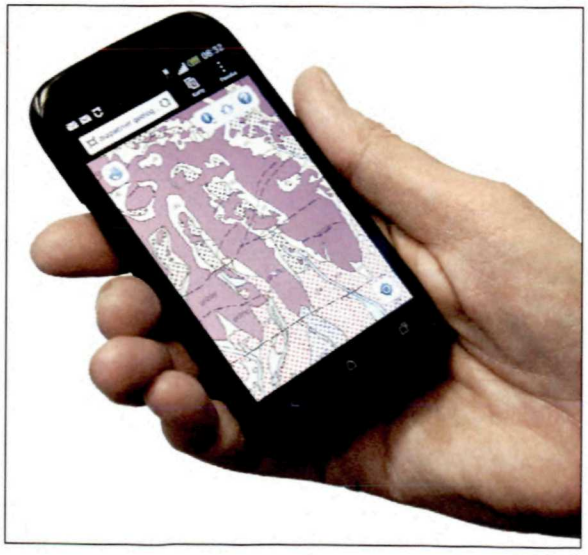


Fig. 2.49 Morphometric characteristics
I. – Elevation, II. – Aspect, III. – Slope angle, IV. – Horizontal curvature of the relief in the contours direction (compiled by Bystrická)

2.5.5. Geology in Mobile

Available on Internet since 2014: http://mapserver.geology.sk/gismobil



Application of Geology in Mobile is optimized for use by mobile devices equipped with Android OS, Windows Mobile or iOS. The Internet connection is necessary. The application is not necessary to download and install; it runs directly through user`s browser.

The application allows user to obtain basic information on the geological setting as displayed in the Digital Geological Map of the Slovak Republic 1:50,000, information on the waste disposals, slope failures and significant geological sites. Information is available either directly from the area in which a user is located (using GPS module), or from anywhere across the territory of the Slovak Republic.

Fig. 2.50 Mobile application – Geology in Mobile

2.5.6. WMS Viewer

Available on Internet since 2014: *http://apl.geology.sk/wms*

This application is designed to tag, view, and print a user-selected map composition. A map composition can contain any layer not only from the default Map Server of SGIDŠ but also other source accessible through REST interface and files in SHAPE format in compressed ZIP form. At layers we can define the order and transparency, to generate a print file title.

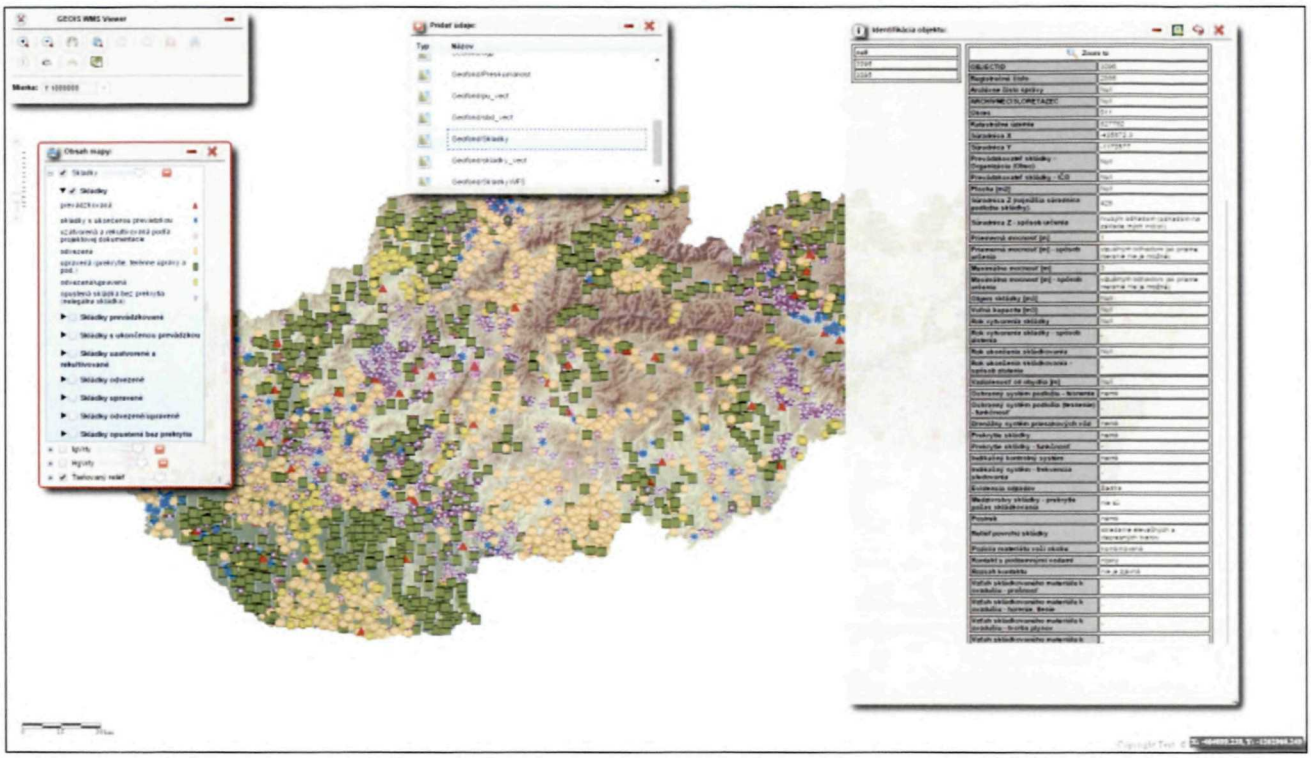
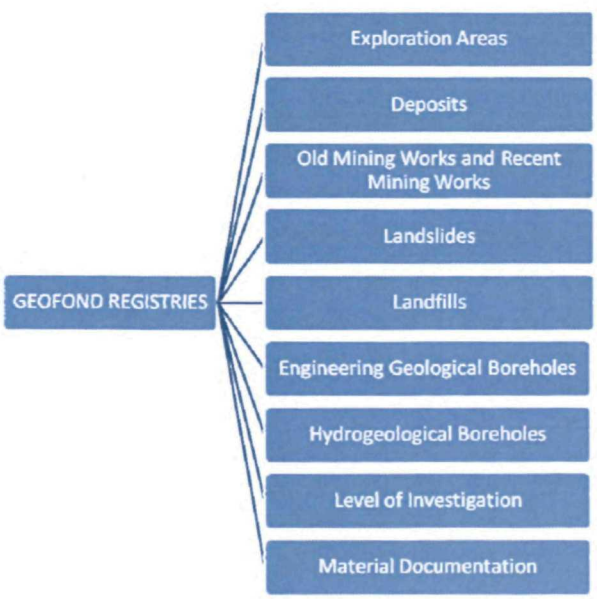


Fig. 2.51 WMS Viewer – composition from map application (compiled by Bystrická)

2.6. GEOFOND REGISTRIES



Geofond registries represent a complex of spatial information about the geological exploration of the SR territory, which are processed and kept on the basis of Act No. 569/2007 Coll., on Geological Works (Geological Act) and Act No. 44/1988 on the protection and Utilisation of Mineral Resources (the Mining Act), as amended by further regulations. Historically they originated at different times, and not continuously.

1. The Exploration Areas – the registry in which they are set identified areas in which the licensed organizations search for reserved minerals.

2. The Deposits – the registry represents the currently active and verified deposits of minerals (reserved deposits and non-reserved minerals deposits).

3. The Old Mining Works – registry that maps the manifestations of historical mining.

4. The Landslides – the registry keeps slope deformations documented (lanslides).

5. The Landfills – registry of waste dumps keeps all the registered waste dumps.

6. Engineering Geological boreholes – the registry of engineering geological wells.

7. Hydrogeological boreholes – the registry of hydrogeological and geothermal wells.

The applications of the registries are used, inter alia, when expressing the expert opinions to investments and to the physical planning documents of the municipalities (ÚPN O) and territorial plans of the large territorial units (ÚPN VÚC) on the basis of Act No 50/1976 50/1976 on Land-Use Planning and Building Order (Building Act), as amended by further regulations.

8. Level of Investigation – includes Deposits, Geological Map and Geophysical Investigation.

9. Material Documentation – includes the drilling recovery of geological explorations and surveys across our territory. It is available in warehouses in Bratislava-Trnávka, in Kráľová pri Senci and in Betliar.

2.6.1. Exploration Areas

Available on Internet since 2009: http://mapserver.geology.sk/pu

The Register keeps records of the proposed Exploration Areas (Eas), determined EAs, EAs blocked and cancelled. All these categories are part of the submitted applications. To each object a simple attribute table is assigned with the following information on EA: the name by the claimer, the type of mineral, business name of the EA holder and its address, number of decisions on the claim, the date of the decision, the date of the claim being in force, the date of the claim being blocked, extension. To the table all the written agenda is attached (determination, changes, and cancellation of EA) in a PDF. file (Acrobat Reader). Part of the application is a SQL database search by various search criteria selected as well as other interesting tools usable in particular by EA claimers. The application is also used in expressing the statements to the capital investments and to the physical planning (Master Plans of municipalities) and higher territorial units under Law. No. 50/1976 on Land-Use Planning and Building Order (Building Act) as amended by further regulations.

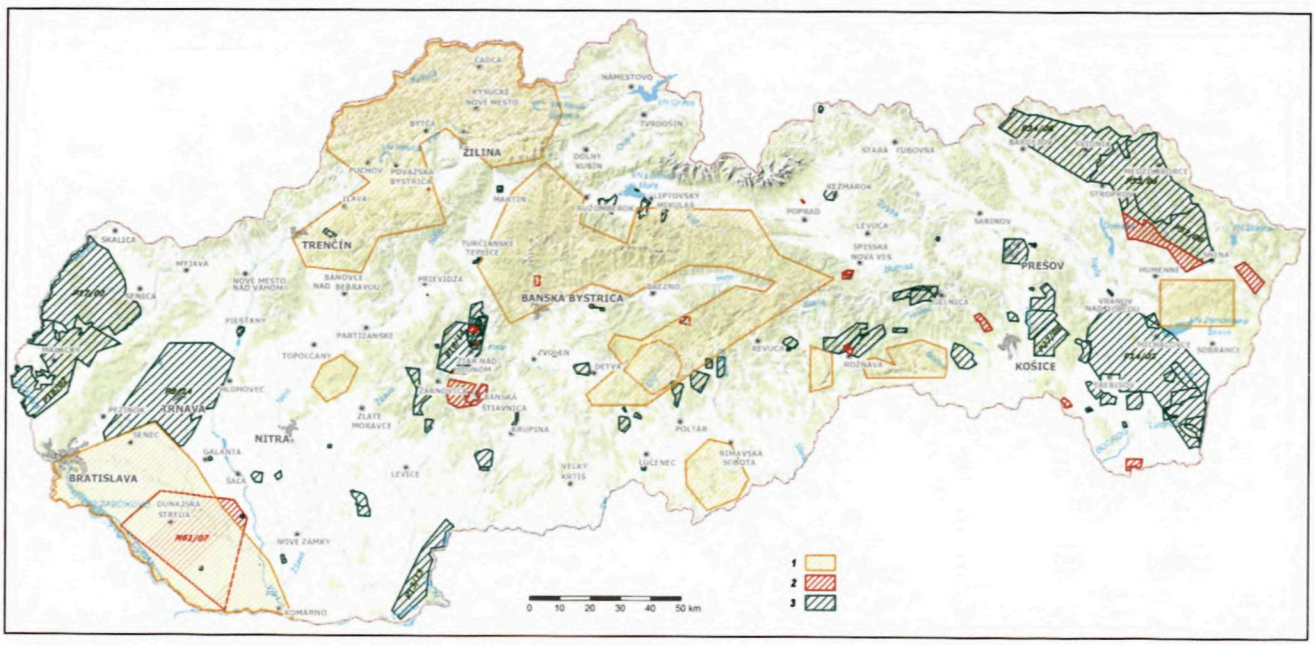


Fig. 2.52 Exploration Areas (compiled by Bystrická).
Explanations: 1 – areas blocked for exploration for oil and natural gas, 2 – proposed exploration areas, 3 – defined exploration areas

2.6.2. Deposits

Available on Internet since 2009: http://mapserver.geology.sk/loziska

The first digital edition of Reserved Deposits across the SR was established in 2002 in the scope of the project "Relationship Between the Rock Environment and Protection of Nature and Landscape", whose main objective was to create layers of mining areas and protected deposit areas and determine their overlap with protected areas of nature conservation and landscape. Accounting for a "live" system (deposits are being generated and diminished, their boundaries and managements are being changed, along with the other factors) it is necessary to ensure regular updating of these data. This is secured based upon the decisions on changes in mining areas and protected deposit areas boundaries and reserves depreciations, which are covered by individual Mining District Authorities, as well as upon the statistical statements GEO 3-01.

The statements are regularly delivered to mining companies by the beginning of each year. Filled-in statements provide the groundwork for the Balance of the Reserves of Reserved Deposits SR. In 2006 to the system a layer of non-reserved mineral deposits was added.

The application is also used for statements to the capital investments and to the Master Plans of municipalities and Higher Territorial Units under Law No. 50/1976 on Land-Use Planning and Building Order (Building Act) as amended by further regulations.

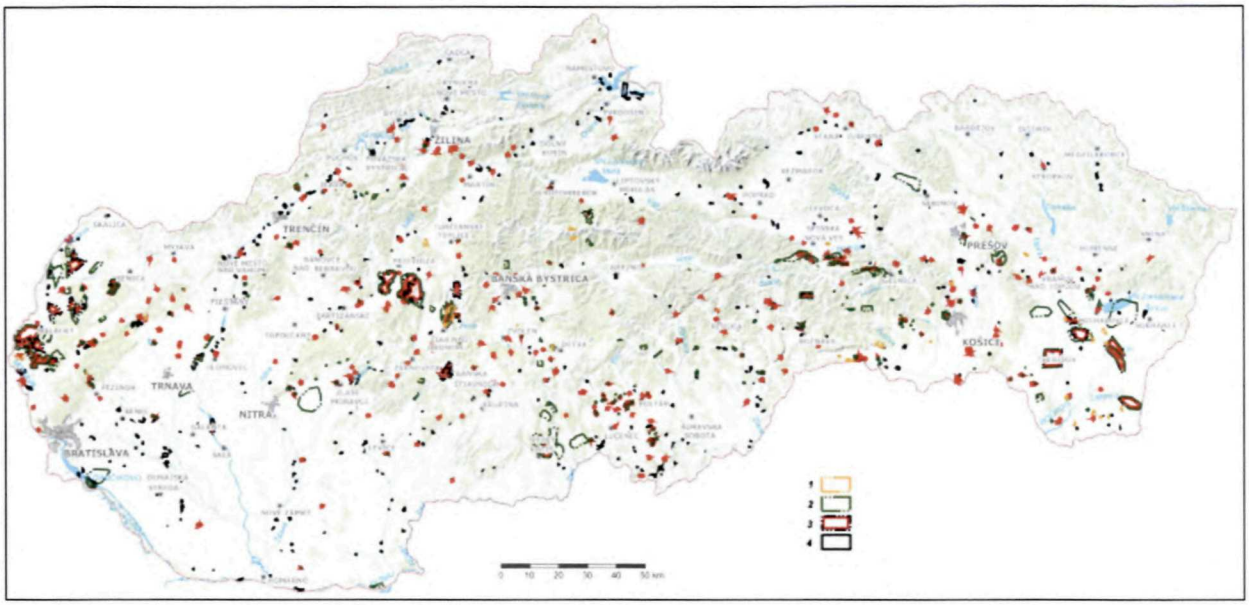


Fig. 2.53 Deposits (compiled by Bystrická).
Explanations: 1 – reserved deposits, 2 – exclusive deposits of protected deposit areas, 3 – exclusive deposits with mining claims, 4 – deposits of non-reserved raw minerals

2.6.3. Old Mining Works and Recent Mining Works

Available on Internet since 2009: http://mapserver.geology.sk/sbd

The first digital version of OMWs across the SR was founded in 1996 as a result of the project "*Slovakia – Proposal for Remediation of Old Mining Works – Inventory, Reconnaissance Survey, as of 31/12/1996*"; the main objective was the assessment and inventory of all occurrences of OMWs across the territory of the SR outside the determined MCs, the evaluation of their impact on the environment and proposal for their remediation, if required by their current status and manifestations on the surface.

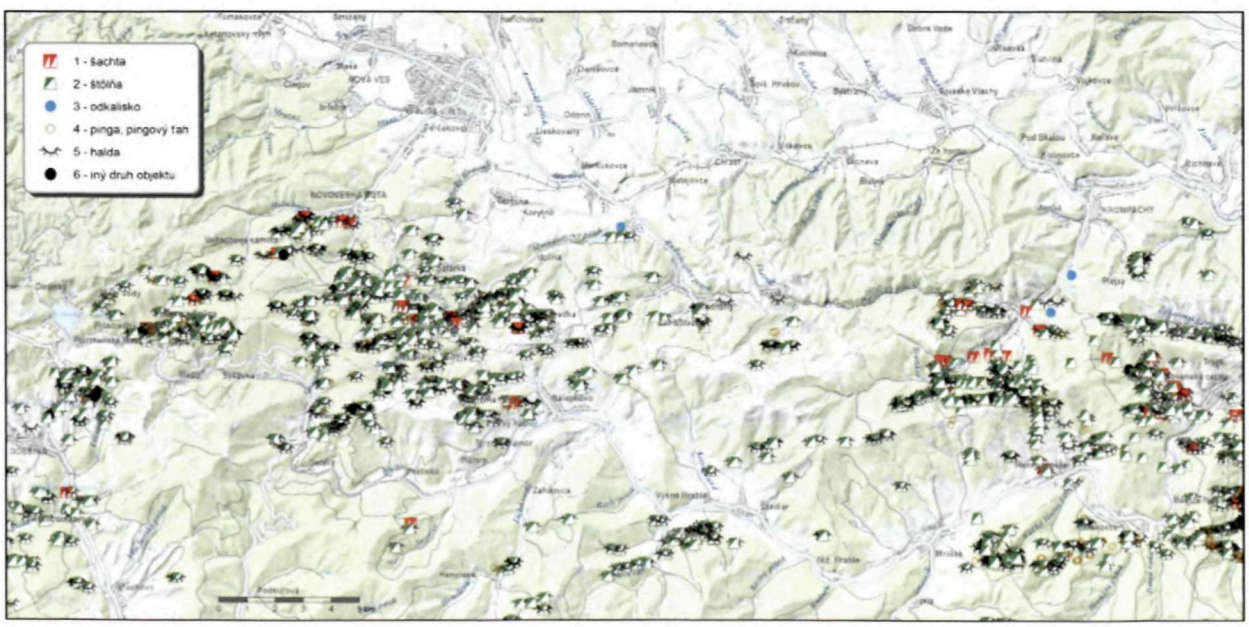


Fig. 2.54 Old Mining Works and Recent Mining (compiled by Bystrická).
Explanations: 1 – shaft, 2 – gallery, 3 – tailing pond, 4 – pinga, 5 – dump, 6 – objects of other kind

The present application is mapping the historic manifestations of mining in Slovakia outside the mining claims (for illustrative purposes they are included in the application as an individual layer). For the applications there were developed labels for different types of OMWs based on mining geodesy regulations.

The application allows a simple database SQL search by various search criteria selected. The application is also used for statements to the capital investments and to the Master Plans of Municipalities and Higher Territorial Units under Law No. 50/1976 on Land-Use Planning and Building Order (Building Act) as amended by further regulations.

2.6.4. Landslides

Available on Internet since 2010: http://mapserver.geology.sk/zosuvy

The register keeps evidence of documented slope deformations in Slovakia. The register distinguishes the small-size and the large-size landslides.

As a groundwork of digital layers serve the data from the project *of Atlas of Slope Stability Maps SR at scale 1:50,000* (Šimeková et al.), which was completed in 2006 (the orderer of the geological works was the Ministry of Environment) and the Geofond register of landslides.

To each slope failure an attribute table with information about the landslide is assigned to: the identification number in the register of landslides, geomorphological unit, engineering geological area, source of information, type of slope deformation, degree of activity, geological formation, geological setting, hydrogeological conditions, size, slope, endangered objects, the cause, remediation, etc.

The application enables to search database by various selected search criteria such as degree of activity (active, potential and stabilized landslides). The register provides information on the status of the territory related to the period of its inventory, and therefore its continuous update is essential.

Besides the other purposes, the application will also be used in statements to capital investments and the Local Municipalities Plan and Higher Territorial Units under Law. 50/1976 on Land-Use Planning and the Building Order (Building Act) as amended.

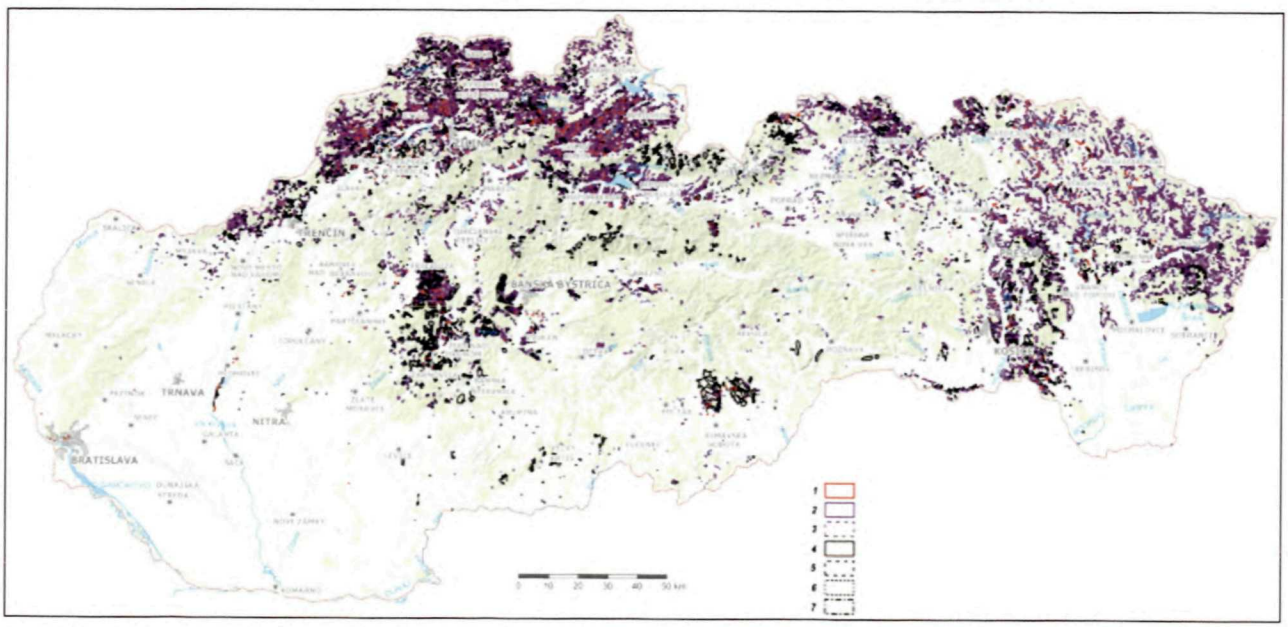


Fig. 2.55 Slope Deformations (compiled by Bystrická).
Explanations: Activity degree: 1 – active, 2 – potential, 3 – with potential and active threats, 4 –stabilized, 5 – with stabilized and active forms, 6 – with stabilized and potential forms, 7 – with stabilized, potential and active forms

2.6.5. Landfills

Available on Internet since 2010: http://mapserver.geology.sk/skladky

The landfills register keeps the information on all registered landfills in the Slovak Republic. The register has been intensively developed since 1992, in the scope of the project of the Slovak Geological Bureau "*Maps of Territory Suitability for Waste Disposals*" at scale 1:50,000, covering the whole territory of Slovakia. Within this project, the inventory of landfill sites across all districts was completed at scale 1:10,000.

Registered landfills are characterized by the following attributes: topographic situation, relation to the biosphere, geological data, hydrogeological parameters and composition of the waste. The registry keeps the data on

a site operator, proposal for further use of landfill, landfill status, regional importance and method of operation. All these items are part of the presented application, which allows database SQL search by a variety of search criteria selected.

Individual data are regularly updated (e.g. extension of the landfill surface, changes in its volume, setting up a monitoring system, landfill closure, etc.). The update takes place annually on the basis of reports by workers of Environmental Municipal Administration.

Besides the other purposes, the applications will also be used in statements to capital investments and the Local Municipalities Plan and Higher Territorial Units under Law. 50/1976 on Land-Use Planning and the Building Order (Building Act) as amended.

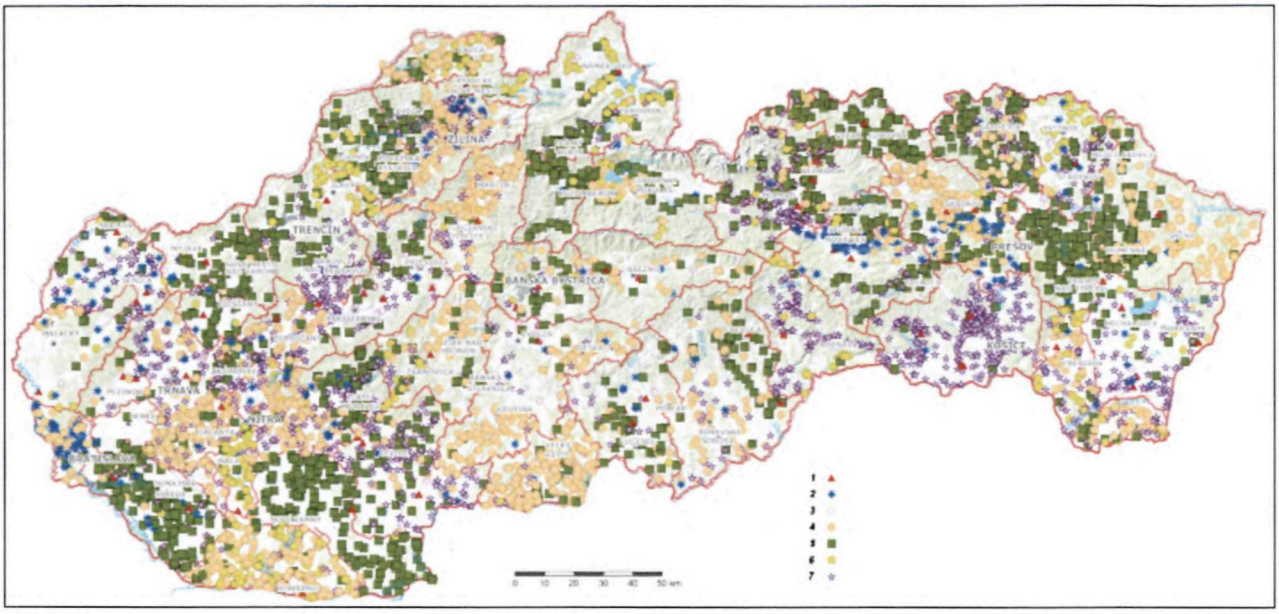


Fig. 2.56 Landfills (compiled by Bystrická).
Explanations: Landfill status: 1 – operated, 2 – closed, 3 – closed and recultivated according to project documentation, 4 – liquidated, 5 – modified (top-sealed, with earthworks etc.), 6 – liquidated/modified, 7 – abandoned landfilled without top sealing (illegal landfill)

2.6.6. Engineering Geological Boreholes

Available on Internet since 2013: http://mapserver.geology.sk/igvrty

The application is based on wells database registry. It allows rapid orientating in the surveys conducted in a territory of interest and refers directly to the report in the Geofond archive. For better orientation the topographic documents are used, as well as scanned maps of the register at the scale of 1:25,000 (1:10,000). The database contains identification data (borehole label in the report, number of the report in the Geofond archive, borehole purpose, its depth, map sheet 1:25,000 or 1:10,000, designation in the map sheets). Given the large number of wells described in the Geofond reports not all the wells are processed in the database, however, they are supplemented continuously. The application contains also drillings for mapping, deposit, structural and other purposes.

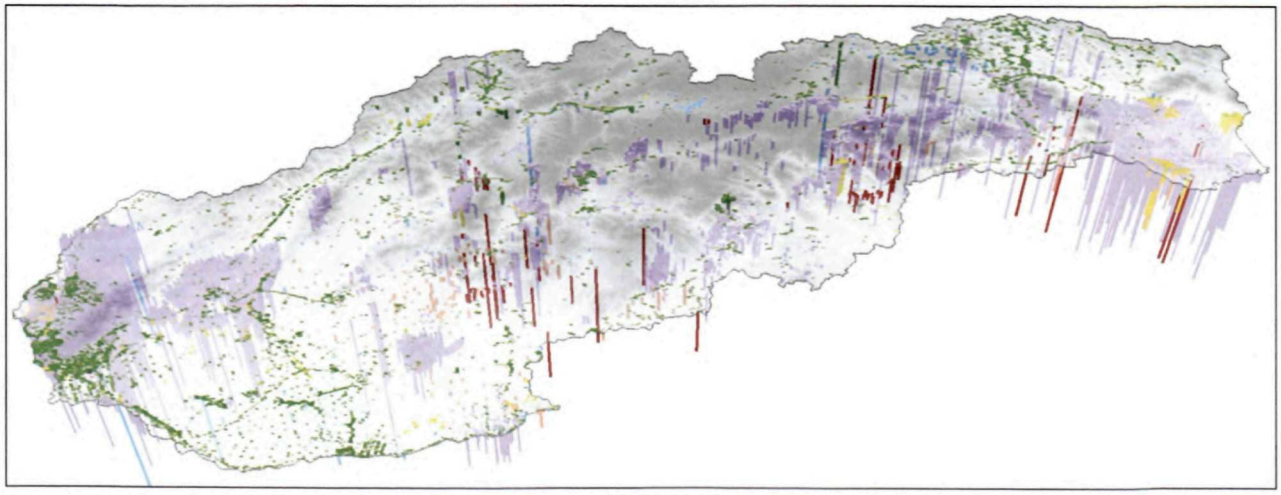


Fig. 2.57 3-D view of Engineering Geological Boreholes (compiled by Bystrická)

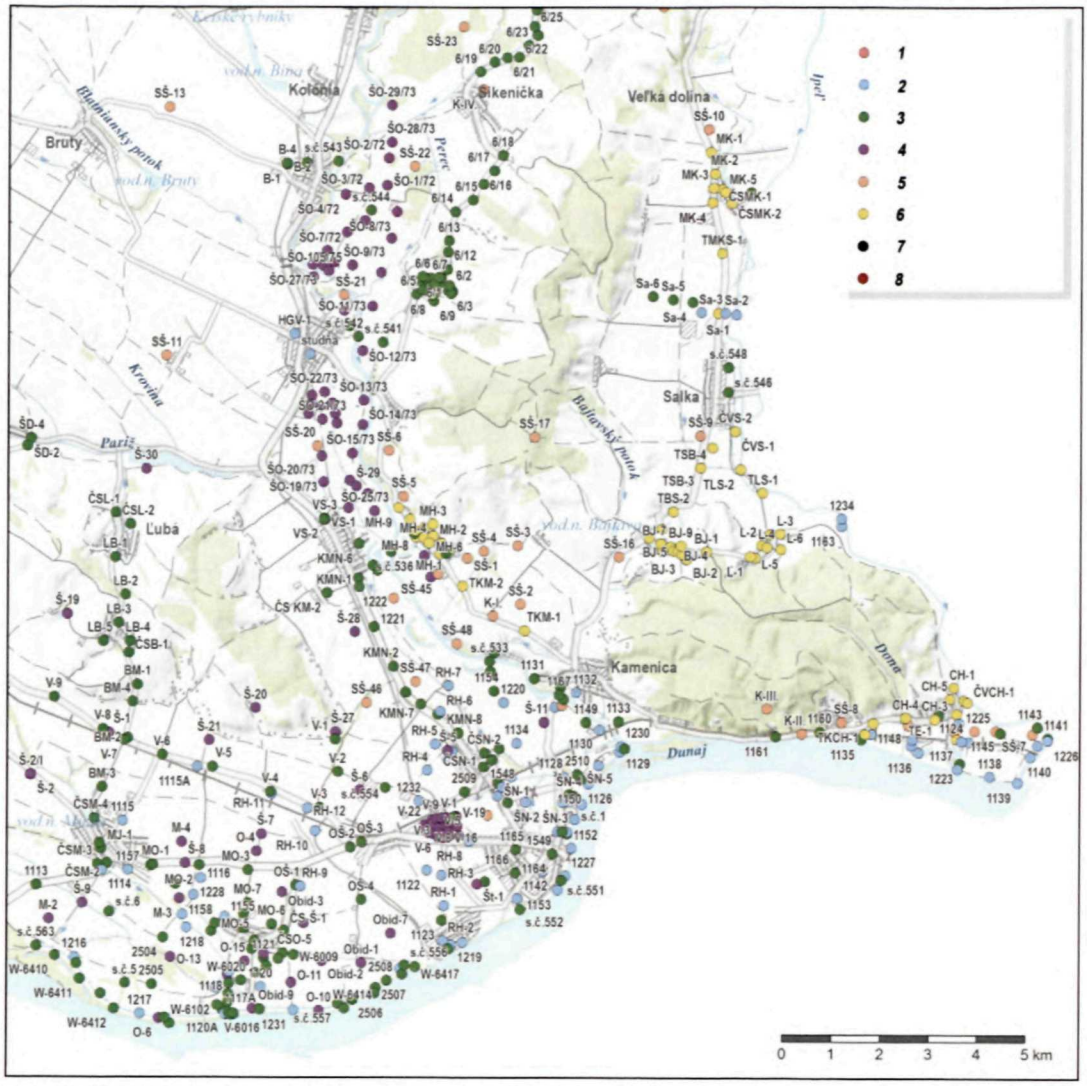


Fig. 2.58 Engineering Geological Boreholes (compiled by Bystrická).
Explanations: Well purpose – group: 1 – without purpose-setting, 2 – hydrogeological, 3 – engineering geological, 4 – deposit, 5 – mapping, 6 – multipurpose, 7 – special purpose, 8 – structural

2.6.7. Hydrogeological Boreholes

Available on Internet since 2013: http://mapserver.geology.sk/hgvrty

The main register of hydrogeological and geothermal wells was created as a separate registry in 1962 by filtering from the borehole coverage registry, which included the processing of all wells of the final reports addressing geological problems of Slovakia, because of the increase in the amount of information on wells.

The register of hydrogeological and geothermal wells includes also those ones drilled for the purposes of local supply of potable water, search for mineral and table waters resources, structural wells of hydrologic research and exploration, hydrogeothermal boreholes of regional character intended for purposes of new geothermal energy wells, the purpose-made drillings of the monitoring network of the Slovak Hydrometeorological Institute and others.

The hydrogeological wells are detailed processed in the inventory forms and displayed graphically in maps 1:25,000. The hydrogeological wells coordinates are either taken from the final reports, or subtracted from the coordinates of geodetic surveys. Each borehole is identified by a label that symbolizes the purpose of the borehole. The number of processed hydrogeological wells is about 25,000 and is still growing.

Part of the registry is pilot information on hydrogeological studies, assessments, research, theses in the form of annotation records. The hydrogeological registry is attended by about 450 users per year.

In 1994, a proposal was developed to store the basic factual data of the main hydrogeological drillings register into the hydrogeological database. The proposal has been drafted so that the database provides fully sufficient information as a basis for the processing of geological projects.

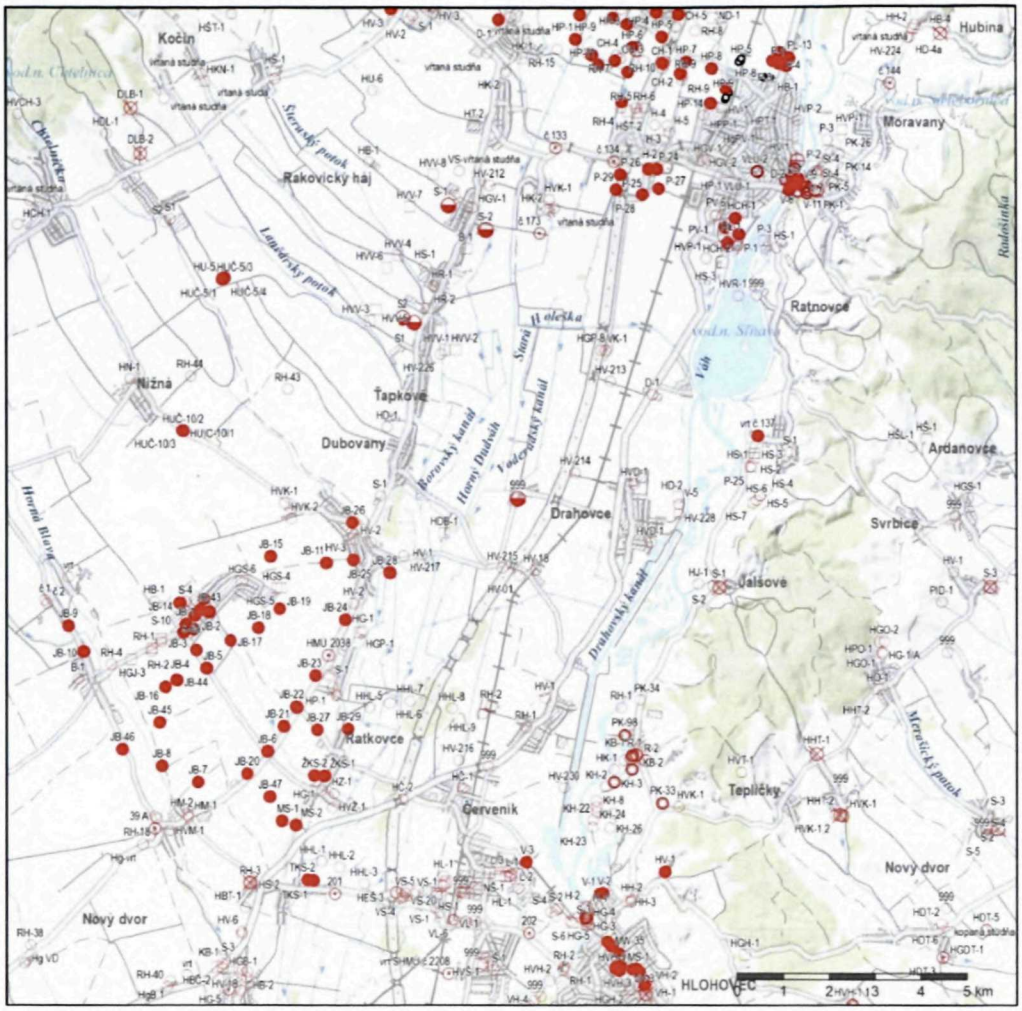


Fig. 2.59 Hydrogeological Boreholes

2.6.8. Level of Investigation

Available on Internet since 2014: *http://mapserver.geology.sk/preskumanost*

Deposits Investigation - register represents the surveys on energy (e.g. oil, gas, coal), ore and non-ore raw minerals from the whole territory of the Slovak Republic, retrieved from the reports contained in the Geofond archive.

The database includes all the deposit surveys on the different types of raw minerals that have been completed by the final report. They are featured in the map as point, line and surface layers, however, they are not visualized in the application map due to numerous overlaying objects. In the database basic identification data on deposit survey are used, e.g. type of raw material, calculated inventory category, or prognostic resources, Survey name and the most important item in the database is a number(s) of the report(s) from which the survey data were retrieved.

Geological Map Investigation – register represents the geologically mapped regions (maps) of geological reports contained in the Geofond archive.

The database included Subregister of general geological exploration and Subregister dedicated to geological exploration (covering engineering geological, hydrogeological, deposit-geological, soil, geological environmental factors, geochemical maps...).

The application is based on the registry database. It enables to find quickly archived report number, with respective geological map. The displayed area in the application expresses a factual area of the map (mapped area).

The database contains identification data (subregister type, the number of report in the Geofond archive, date by which the report was processed in the register, map type and purpose, map scale, the map author, year of issuance, map sheet – 1:200,000, JTSK or GK).

Geophysical Investigation – register represents the regions covered by geophysical works (in the form of areas and profiles) and loggings contained in geological reports in Geofond archive.

The database includes Subregister of geophysical investigation of areas and profiles (providing information on 2D mapping and profiling) and Subregister of geophysical exploration drilling (logging) – (covering wells where logging was performed).

The application is based on the registry database. It enables to find quickly archived report number, with respective geophysical maps, profiles and boreholes.

The database contains identification data (respective number of report in the Geofond archive, date by which the report was processed in the register, profile label, method and group of methods, map sheet – 1:200,000, JTSK or GK). The Logging database contains identification data (respective number of report in the Geofond archive, date by which the report was processed in the register, borehole label and type, drilling depth, site, coordinates X, Y, Z, eventual logging curve, the accuracy of measurement, network density, logging depth range, logging curve scale, method and group of methods, map sheet – 1:50,000 or 1:10,000, JTSK).

Fig. 2.60 Level of Investigation – composition from map application (compiled by Bystrická)

2.6.9. Material Documentation

Available on Internet since 2009: http://mapserver.geology.sk/hdokgis

The Material Documentation (MD) of drilling recovery conducted on the territory of Slovakia is situated in the MD stores in Bratislava–Trnávka, in Kráľová pri Senci and Betliar. These spaces are storing MD of over 7,000 wells, which is approximately 230 km of drill recovery.

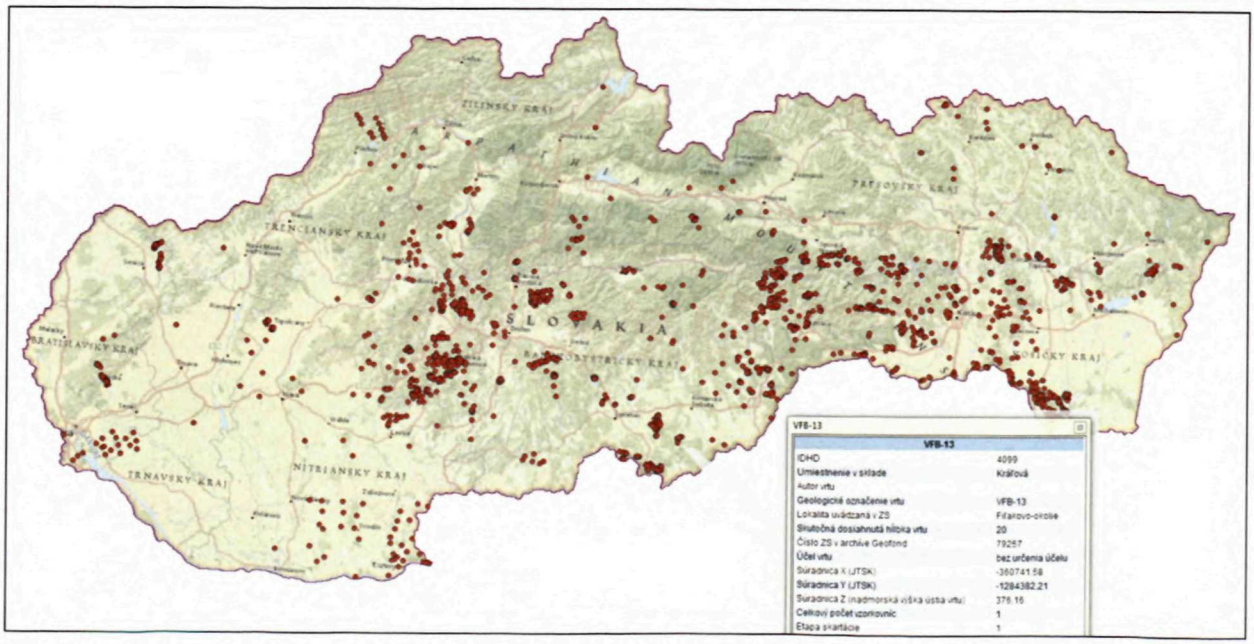


Fig. 2.61 Material Documentation – composition from map application (compiled by Bystrická)

Fig 2.62 Storage room of material documentation

The first digital version of the MD register was established in 2000; at that time some structural boreholes were processed. Gradually, further drillings have been processed and stored in the database – deposits, mapping.

Currently the database contains information on the MD of more than 5,000 wells. The database contains identification data (name, report, depth, coordinates ...), geological profile (core recovery text description, scanned geological profile) as well as information about their storage (warehouse, location, number of core boxes stored). The database offers also an option of search a text string in the geological description of drill core.

Accounting for the huge amount of stored material, not all wells located in warehouses SGIDŠ were processed completely (incomplete or missing information); the database and applications are continuously replenished. Currently, the application contains about 30% of wells which are stored in MD warehouses of SGIDŠ.

2.7. OTHER APPLICATIONS

2.7.1 Slovak-English Dictionary

Available on Internet since 2014: http://mapserver.geology.sk/slovnik

Since the book's publication many disciplines, such as structural geology, stratigraphy, hydrogeology, hydraulics, the science of geothermal energy, engineering geology, geotechnical engineering, environmental geology and geoinformatics, but also the geological and mining legislation, we reported the entry of new technical terms. That`s why we decided to make web-based online version of the dictionary, which now includes new expressions and allows free access to this work.

The authors present an on-line version of the *English – Slovak Geological Dictionary with a Register of Slovak Headwords (Molák – Liščák et al., 2002)*, to help Slovak geologists and all those involved in the geoscientific disciplines in translation, interpreting or in their practice. The application offers the dictionary updated on new terms; this way this is an open-file project that would be periodically enhanced to cover wider spectrum of terms and disciplines and to include modern technical terms as they appear in the Earth Science and the related industry.

Slovak Geol. Mag., 15, 1 (2015), 7 – 80

3. Digital Archive as Part of the Cultural Heritage of Slovakia

3.1. Archive of Geofond and Central Geological Library, initial state

Within the organizational scheme of the SGIDŠ the Geofond Department is a modern archival working unit in the field of geology. The Geofond's archive collections are a unique fond of the results of geological works from the Slovak Republic territory which have been stored there from the beginning of the 50's (the first one was published in 1873). The Internet contains bibliographic information on the final reports. Currently, the Fund archive preserves and makes accessible more than 91 000 final reports, representing about:

- 1,400 linear meters of text documents, text and map annexes mostly in A4 – A3 formats, which is about 7 million pages;
- 14 linear meters attachments maps of varying scales and sizes up to A0 format, which is about 24,000 map sheets.

Each year, the archive is increasing on 700 to 800 new reports.

In the past the registration system had registered metadata only and not the reports themselves. Data were stored in a proprietary format and therefore they were not accessible to other applications. The system was not integrated with other SGIDŠ systems.

In order to comply to-date requirements, the Geofond Information System has been integrated into the project GeoIS through which there have been published individual datasets (graphical data – linear, point, polygon), table and raster data in the form of services and Internet applications.

By the Decision of the Ministry of Environment in 1993 the **Central Geological Library** of the Slovak Republic was established as a separate organisational unit. The Central Geological Library SR according to Act no. 183/2000 Coll. on the Libraries, as amended by further legislation, is a specialized scientific library focused on geological sciences and related scientific disciplines.

The Central Geological Library mission is to provide free access to information, first of all to scientific researchers, SGIDŠ employees, environmental sector, as well as pedagogical and scientific-pedagogical staff and students, institutions and the whole scientific community, as well as the Slovak citizens. For the SGIDŠ researchers it also provides some specific borrowing (national and international interlibrary borrowing service), research and other targeted services. The Library fulfils its tasks by providing library and information services from its own library collections and providing access to external information sources.

Many historic and rare books, but also complete volumes of many specialized geological journals, various atlases and catalogues that the Library keeps in its collection, are often demanded by the readers not only from Slovakia but also from abroad. The Library collection includes monographs, conference proceedings, bound volumes of periodicals (about 70,000 volumes), periodicals – (550 periodical titles and over 43,000 individual non-bound titles), maps, atlases, explanatory notes, reprints and databases on CD ROM (GEOREF, GEOBASE, EMBASE).

3.2. GeoIS, Digital Archive and Its Objectives

One of the objectives of the project GeoIS was to create a SGIDŠ Digital Archive. For this purpose the system was elaborated, which has resulted in:

- a stable and consistent evidence, which is accessible via the Intranet and the Internet – registering the reports – metadata, scanned files, the full-text index;
- connection to GIS and other systems in SGIDŠ;
- effective search;
- processing of all available metadata;
- full text search in texts of final reports;
- more complex search terms;
- making researches;
- monitoring of visits;
- practical print of catalogue cards;
- consolidation of the nomenclatures used;
- versioning of reports.

3.3. Implementation of System and Project Solution

After implementing the system analysis and design, we procured the system in 2006, which was based on several program components.

In technical terms, the system was based on IBM DB2 Content Manager, Oracle database and IBM WebSphere Process Server. Above this solution it was built independent superstructure allowing the implementation of additional functionalities, termed as WebCM.

In the scope of the project solution the system configuration took place, along with adjustment of the application to the SGIDŠ needs and import of existing data. There were created code lists during the import and their

Fig. 3.1 Architecture of the system

consolidation was carried out. Data repair was realized along with metadata import of 79,000 final reports.

Works defined in the project were completed and on April 1, 2008, the Digital Archive was open to the public. Since the delivery of the system the Archive personnel works exclusively in this new environment. Their work is related mainly to the increments and their inclusion in the relevant fund, to re-processing of bibliographic data, ongoing digitization of the final reports text, their processing, storing and making available in the system.

At the end of the project GeoIS there were digitally processed all the bibliographic data of the final reports fund, there were scanned and made available over the 6,000 final reports (without graphic attachments) with all functionalities described above.

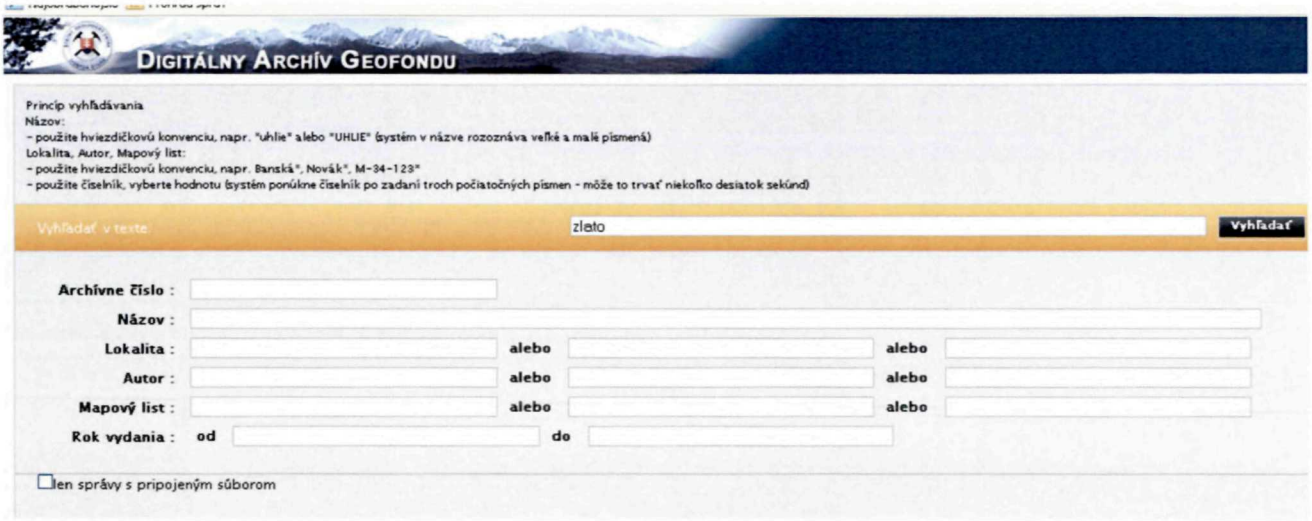


Fig. 3. 2 Digital Archive of 2008

3.4. Operational Programme Information Society OPIS

In the Call for applications for grants for the implementation of demand-driven projects under Priority Axis 2 OPIS the project **"Improvement and Completion of Digitization of Cultural, Scientific and Intellectual Heritage and Providing Access to Digital Content of Geofond and the Central Geological Library of the Slovak Republic"** was approved in 2013. During the period until the end of June 2015 we received the grant assistance in order to build a complete digitization working unit (scanning line, disk arrays, servers, relevant computer equipment, development of complete software) for processing and archiving of cultural, scientific and intellectual heritage and providing access to the digital content of Geofond and Central Geological Library of the Slovak Republic in the Internet environment. The project is co-financed by the European Union from the European Regional Development Fund with the support of the Ministry of Finance, Ministry of Culture and the Government Office of the Slovak Republic.

The main objective of the project is the digitization of text documents and graphic attachments in order to preserve them for future generations and making available without the need for physical handling of originals.

Through the main objective of the project it contributes to the improvement of the system of acquisition, processing, protection and utilization of knowledge and digital content of repository institutions, modernization and completion of the infrastructure of repository institutions at the national level.

Implementation of specific objectives of the project will improve the system of acquisition, processing, protection and utilization of knowledge and digital content of the SGIDŠ as repository institution. Through the modernization and completion of the infrastructure digital content storage of SGIDŠ funds has been secured. The digitized content will be continuously made accessible via the created applications to interested parties throughout Slovakia and abroad under the equal conditions. The documents in digital form will allow reducing the need for physical handling of originals, thereby minimizing the risk of damage, accelerate the borrowing term and will allow to work with the same documents to multiple users at the same time.

To meet the above requirements the following items were completed in the project:

Scanning workplace was established in the SGIDŠ premises, equipped with three productive scanners for digitizing documentation of various formats;

Network and application server created infrastructure for storage and processing;

Implemented automated software tool for managing and editing workflow processing of digitized documenttation;

Created automated services for the import of digitized data in an environment of the Digital Archive WebCM;

Implemented enhanced functionality for the Digital Archive WebCM;

Developed and made available integration services for providing data to third parties (departmental and interdepartmental institutions);

Implemented tools for converting digitized content into a SIP format and established procedures for the transfer of SIP packages to the central data warehouse operated by the University Library in Bratislava.

To achieve the goals a sequence of the following works was necessary:

a) Migration and upgrade of current solution

The solution operated in SGIDŠ since 2008 has not been already supported and it was necessary to upgrade it to the current version of V8.5.1 ECM technology with the implementation of superstructure modules on the IBM Websphere 8.5.5 and Oracle database platform v11.2.0.3.

b) Definition of process solution

Robustness and complexity of the deployment of a new version of the Digital Archive is the best presentable in the scheme in the Fig. 3.6.

c) Solution architecture

After working out the analysis of the previous status there was defined under the new requirements a new object structure and to the existing attributes of the final report we added 10 new attributes. There were elaborated Deployment Model and Application Architecture, which are shown schematically in the following figures.

d) Description and functionality of the modules of the Application Architecture

Active Directory (AD):

Tool for managing user accounts. Together with ICM tools it ensures that users registered in AD are assigned to the appropriate group with relevant privileges in the ICM.

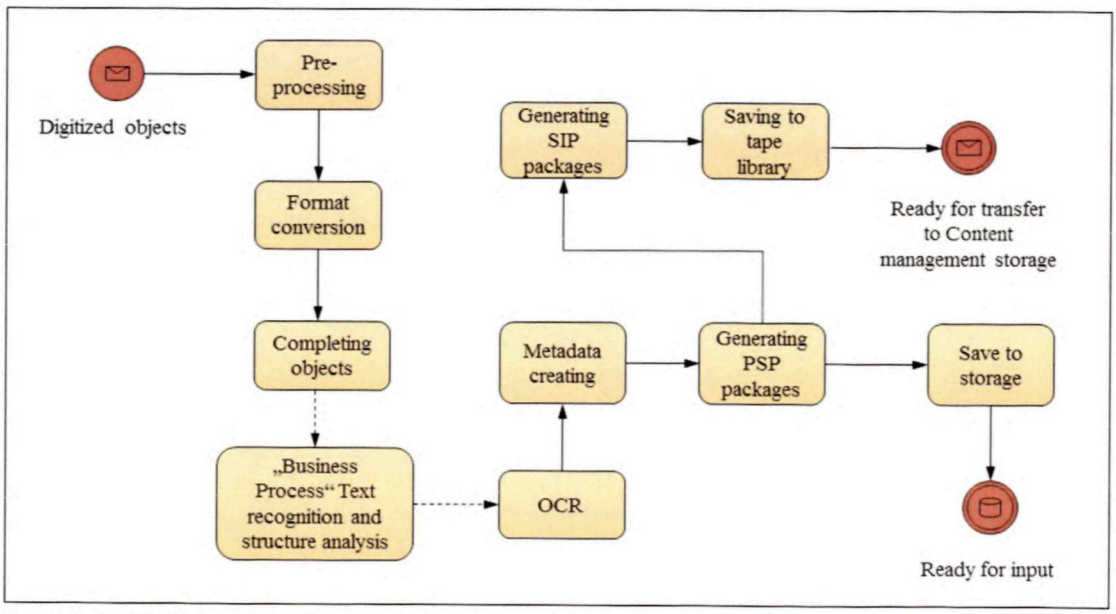


Fig. 3.3 Workflow

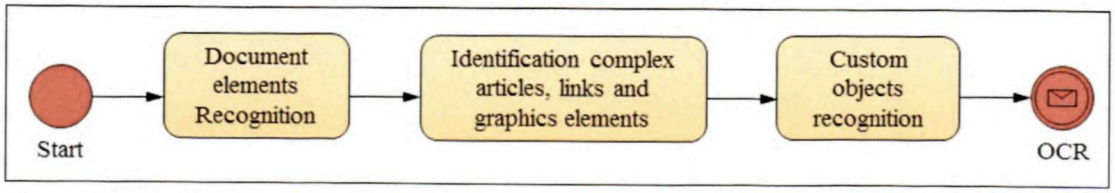


Fig. 3.4 Recognition of layout and analysis of text

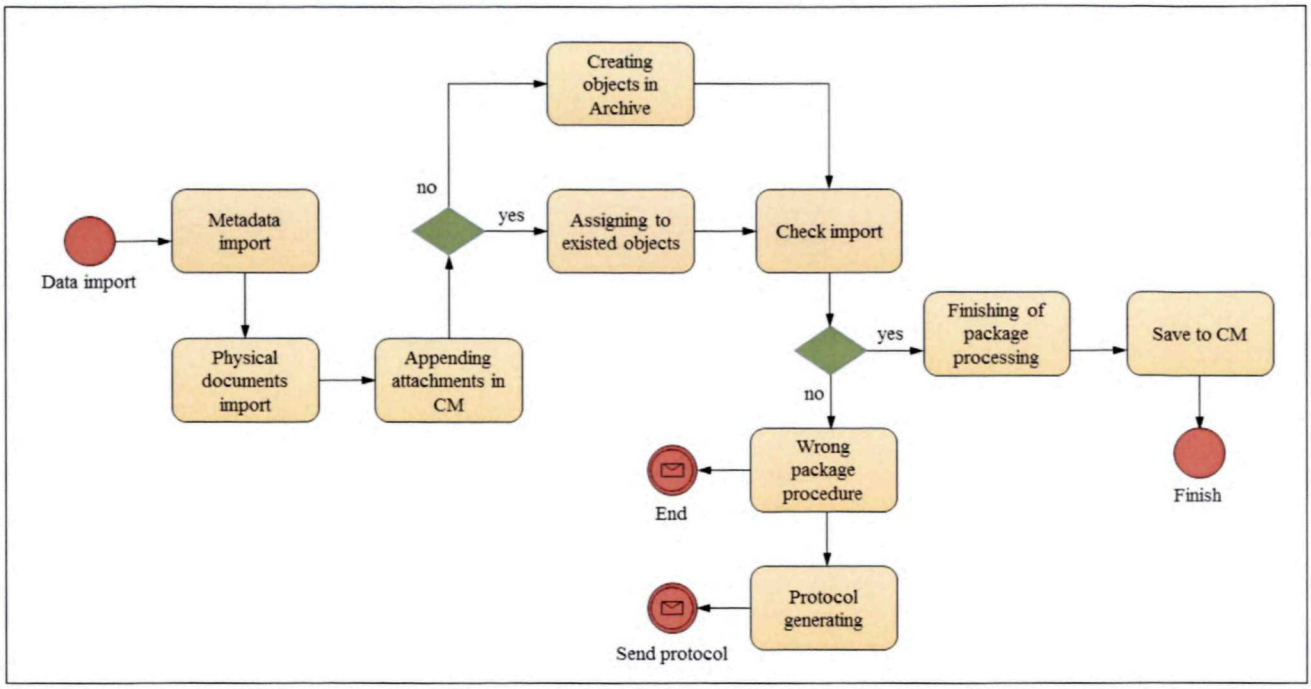


Fig. 3.5 Importing Process

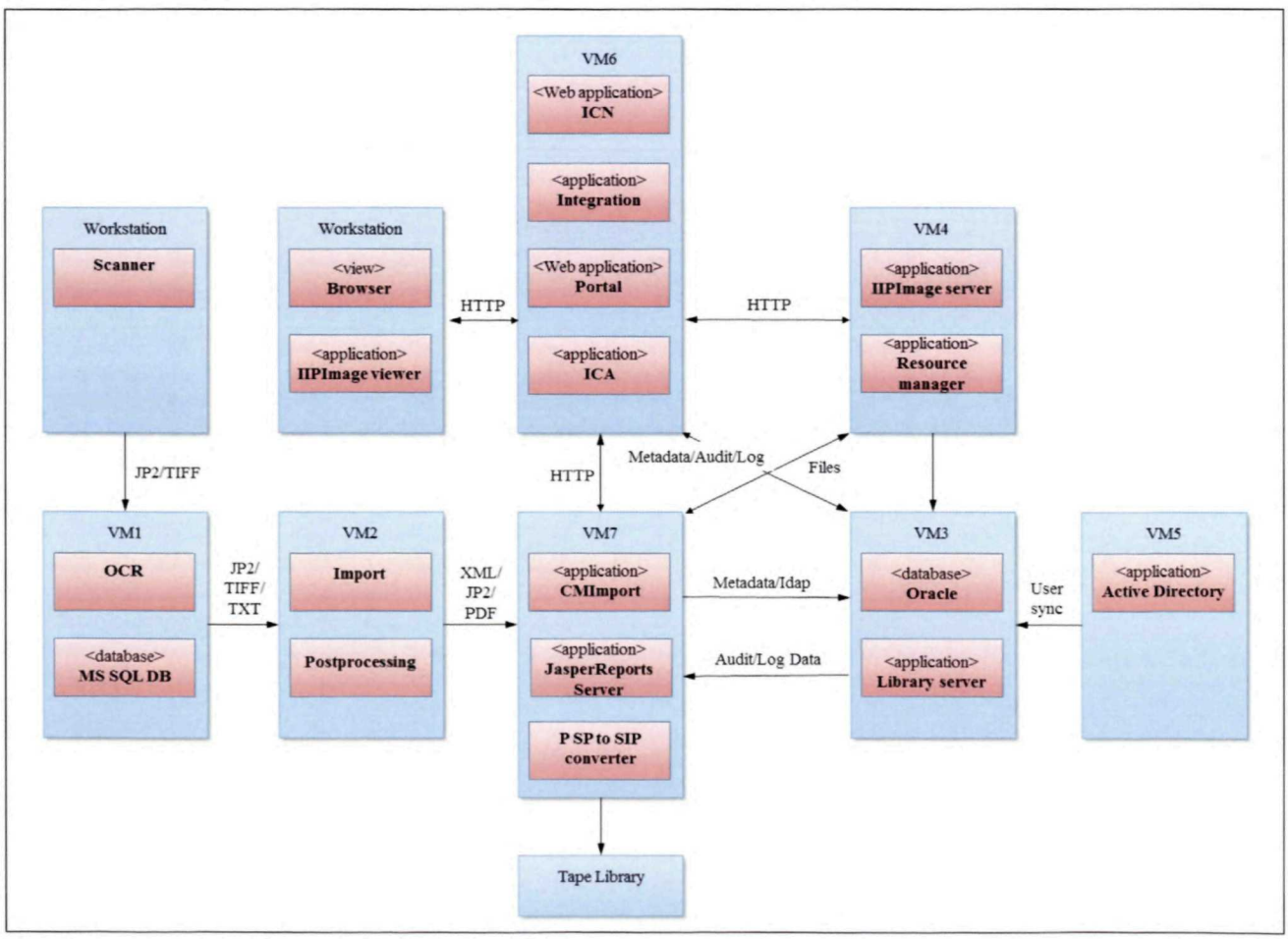


Fig. 3.6 Deployment Model

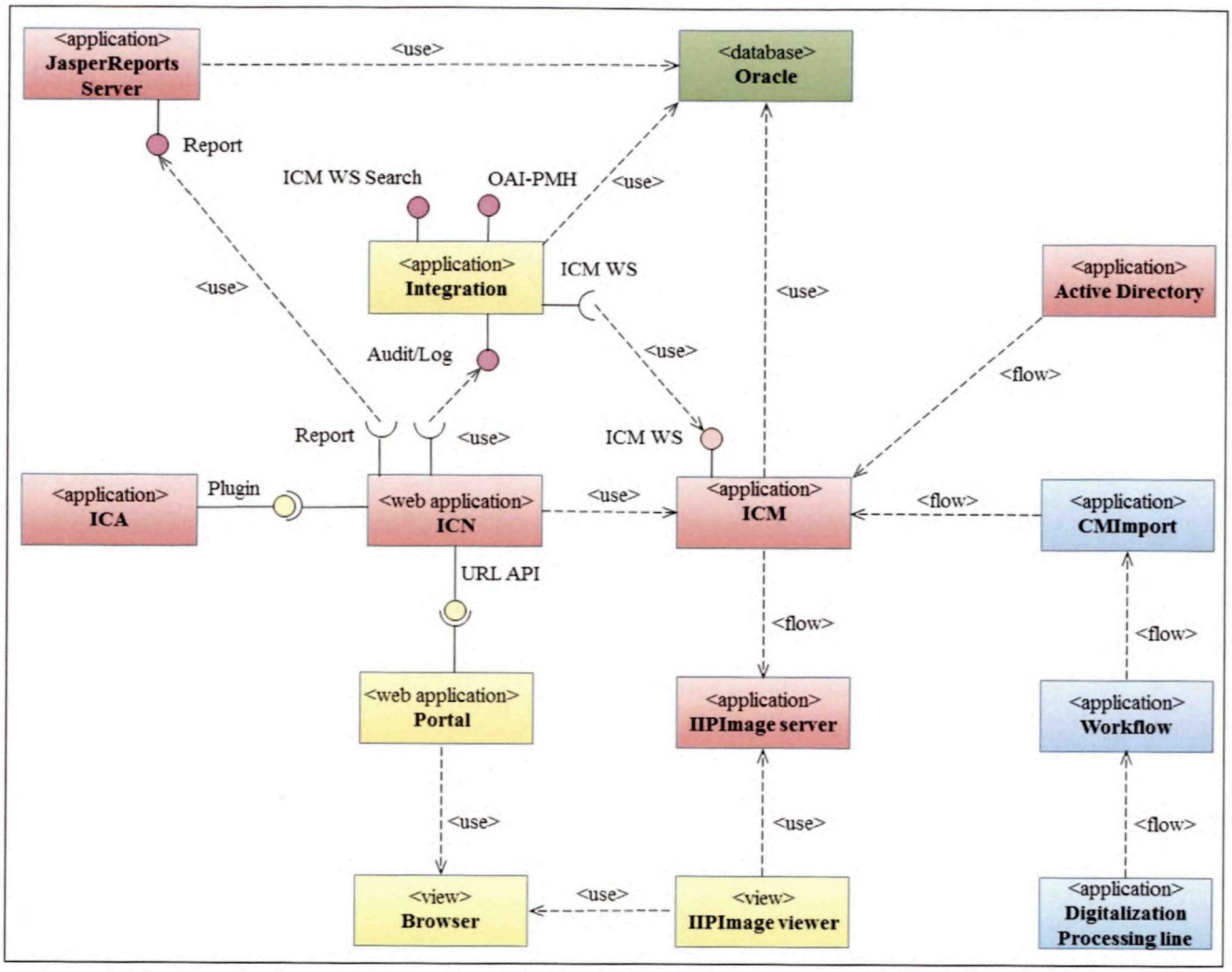


Fig. 3.7 Application Architecture

IBM Content Analysis (ICA):

Analytical tool for analysing the archive content. It has a separate server part, which manages the indexes needed for searching and analysis. Primarily, this component is incorporated into the architecture in order to support faceted search, but its full-text search function, marking of occurrence of searched keywords is utilized, as well.

IBM Content Collector (ICC):

The tool for importing structured data to ICM. As data source serves the Workflow component. It provides metadata in XML format and the attachments in PDF format (written documents) and JPEG2000.

IBM Content Manager (ICM):

IBM Web Content Manager is designed to allow users to create, manage and publish content, while maintaining control over it.

IBM Content Navigator (ICN):

ICN represents a graphic user interface of the entire solution. It is a web application used via Internet Browser.

Its basic functionality is extended on Customer Enhancements:

- Display and printout of the categorization tickets;
- Display and print of searches;
- Desktop access to the public, serves only to archives view and downloading attachments (borrowings);
- Audit and Log, all user activities in the system are monitored by central plugin, that stores all collected information on the activities for the purpose of further processing of reports.

IIPImage server:

Server for large attachments browsing support. It is closely integrated with the attachments repository ICMand through the browser built into the ICN it provides quick access to the annexes. The main function is to display attachments without copying the entire file to the client station.

Integration Component:

Integration component has the task of linking solutions with third-party external applications as well as services inside the application. Generally, the role of this component is to accept data from any source and based

on defined rules, to transform these data and transport them to certain destination.

In the current WebCM solution there are implemented SOAP integration services (ICM WS Search) to search in the archive. The user can get a particular item based on ID, a set of items retrieved by entering the search criteria on the basis of attributes (metadata) or full-text criterion. The services also allow attachments download.

- The service receives the request to search a report according to archive number;
- The service receives the request to retrieve the list of reports from the values of search attributes;
- The service receives a request for full-text search of reports;
- The service returns a complete bibliographic record of reports according to archive number;
- The service returns the PDF document of the report according to archived number;
- The service returns a list of retrieved reports according to the values of searched attributes.

To access the ICM archive there are used standard Web services ICM and transformation of their interface provides integration component. For existing systems using the services nothing has changed at present.

Part of the integration module is support for Web Harvesting. The embedded standalone module serves as a data provider for the provision of metadata (DublinCore) from the repository by another system. For implementation open source tools are used.

Another part of the integration component is the reception and distribution of audit and protocol information about the application usage. The interface provides the possibility to collect data in predefined formats as well as services for the publication of data for reports creating.

JasperReports Server (Component for reports creating):

For the reports creation there is used a standard component JasperReports. At the application level it is used to generate and print reports based on the contents of the archive (catalogue tickets, researches) as well as statistics on the use of the archive (monitoring of the number of registrations and borrowings).

Portal:

The Portal serves as a central component for user access. Primarily it provides the access to the web ICN interface and it also provides access to statistics regarding use of the archive.

Workflow:

The outputs of the scanning line are processed by Workflow component. The Workflow task for the purpose of content management is to generate data to be imported into the ICM. The data consist of metadata, which are written in XML format and attachments in JPEG2000 (text documents), and TIFF (large graphical attachments).

e) Integration Interfaces

The current WebCM solution offers SOAP integration services to search in the archive. The user can get a particular item based on ID, a set of items retrieved by entering the search criterion on the basis of attributes (metadata) or full-text criterion. The services allow also attachments download.

- The service receives the request to search a report by archive number;
- The service receives the request to retrieve the list of reports by the values of searched attributes;
- The service receives a request for full-text search of reports;
- The service returns a complete bibliographic record of a report according to archive number;
- The service returns a PDF document of a report according to archive number;
- The service returns a list of retrieved reports according to the values of searched attributes.

Part of the integration module is support for Web Harvesting. It was implemented by a separate module, which serves as a data provider for the provision of metadata (DublinCore) from another repository system. Currently it provides metadata for sectoral Information System on Environmental Burdens.

f) Project implementation flow

Within the project we have digitized by the end of June 2015 more than 40,000 objects. The reports from the Geofond Archive contain information derived from scientific research activities that are important for further understanding and development of the examined area. They are gathering information on reserves of exclusive mineral deposits, the amount of groundwater, including mineral water, calculation of underground rock structures and land space, information about significant environmental pollution and other results of geological works. SGIDŠ has in its collections reports published since 1950, which have a high historical and scientific value. By comparing data from the reports there is generated database necessary for monitoring the quality of the environment and its development. The findings of the final reports often form the basis for research and development and education in the field of geology and environment.

Another group of digitized objects consists of historic books and complete volumes of specialized geological journals, various atlases and catalogues issued by SGIDŠ. They are component of book collections of the Central Geological Library and are often requested by the readers not only from Slovakia but also from abroad.

During 2014, we procured scanning devices with operating software, disk array, server and hardware equipment from which the key ones are: large format scanner

WideTek 36DS Duplex for double-sided documents in width 915 mm (Fig. 3.8), high-duplex scanner XINO for unbound documents with scan speeds up to 200 sheets of A3+ format per minute (Fig. 3.9) and book scanner Bookeye 4 for bound documents, books and other attachments of up to A1 formats (Fig. 3.10).

Fig. 3.8 Scanner WideTek

Fig. 3.9 Scanner XINO

- Image processing in original formats, their optimization, lossless compression, optimized imaging and conversion into the required formats;

Fig. 3.10 Scanner Bookeye 4

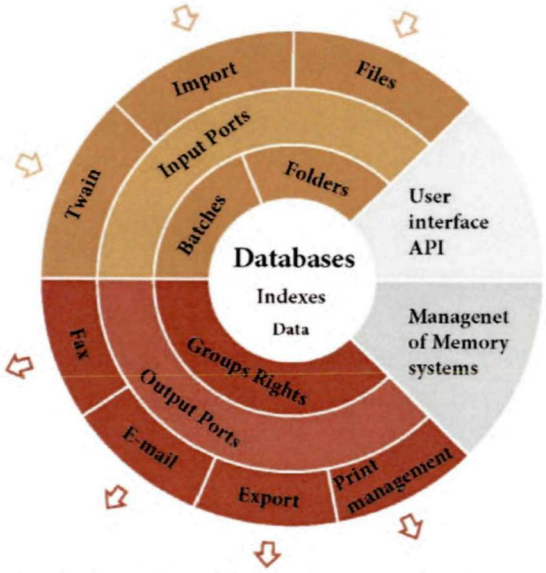


Fig. 3.11 Modular architecture of the system Sirius

The delivery included also workflow Sirius, programme complete solution for working with documents and data. It is a modular system designed for creating complex applications, in our case for the digitization and management of documents, system for archiving, processing and storage of text and images, optical character recognition and forms processing. The whole system is built on two- and three-level client/server architecture atop SQL database.

The Sirius system carries out automatically the following processes:

- Conversion of all kinds of documents in electronic form, in cooperation with supplied scanners;
- Workflow batch processing of high volumes of documents;
- OCR, a powerful recognition typescript including diacritics and transfer into electronic form;
- Document indexing, connection of descriptive data necessary for further search;
- Import from other applications and systems;
- Export of the processed content for web applications;
- Automatic generation of metadata by defining standards;
- Efficient document storage, backup and archiving them with the maximum restraint of the existence of duplicate files;
- Cooperation with third parties with the possibility of linking database records.

After months of work associated with the deployment of all components and their debugging, testing and

training of internal staff, we started in late summer 2014 with the very process of systematic digitization and processing of selected objects. The essence of this stage of work were the activities such as identification of objects, corre-sponding metadata creation, digitization plan, transfer of objects, preparing for the digital conversion, completeness check, physical digitization on the scanner, re-binder's processing, the return of objects into repositoriesand subsequent digital processing of the content. The process of digitization is shown schematically in Fig. 3.12. At planned and at the same time obligatory number of processed objects we have processed from September 2014 until the end of June 2015 around 40,000 objects. Some of them contained only text parts, but most of them also contained a number of large graphical attachments. The time required to complete processing from receipt of the object from the archives to digital processing and preparation for publishing accounts for about 3 minutes on one object (often more than 100 pages of text + annexes).

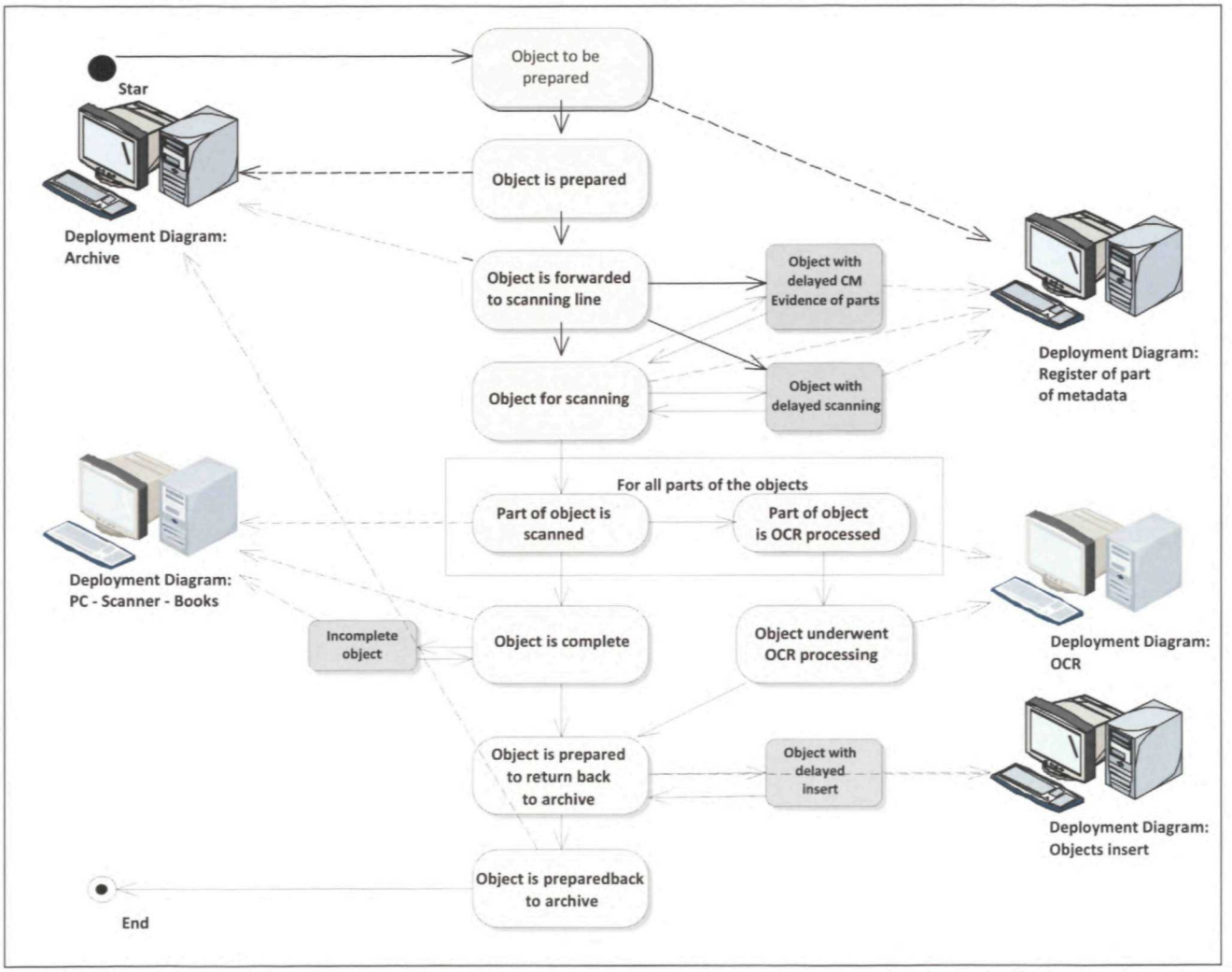


Fig. 3.12 Digitization process

Fig. 3.13 Scanning on large format scanner Widetek Scan

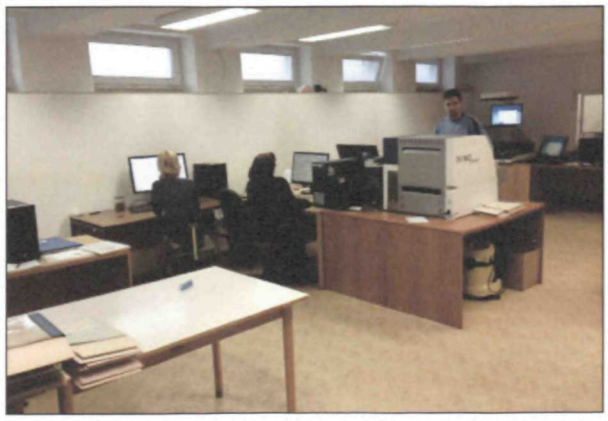


Fig. 3.14 Scanning on the scanner XINO, at the background the library scanner Bookeye 4

Fig. 3.15 Geofond store-space with final reports

Fig. 3.16 Study room of the Central Geological Library

3.5. New Digital Archive, making objects available on the Internet

To store all the required documents and their entanglement to existing metadata records it was necessary to ensure automated processing, storage, disclosure and networking of data. It was designed the architecture and technological solution, implementation of links between the scanning line and WebCM, rebuilding of the overall architecture solution and upgrade of existing WebCM superstructure taking into account the projected volumes of data. We subsequently processed framework for handling bulky graphic and text files and implemented web interface integration for sectoral and other Information Systems. After this stage of object digitizing we have started to make available the complete contents of the final reports from the fund.

- The basic functionality of the Digital Archive services from the perspective of the user is registered in the following brief workflow:
- The service receives the request to search a report according to archive number;
- The service receives the request to retrieve the list of reports according to the values of search attributes;
- The service receives a request for full-text and faceted search of reports;

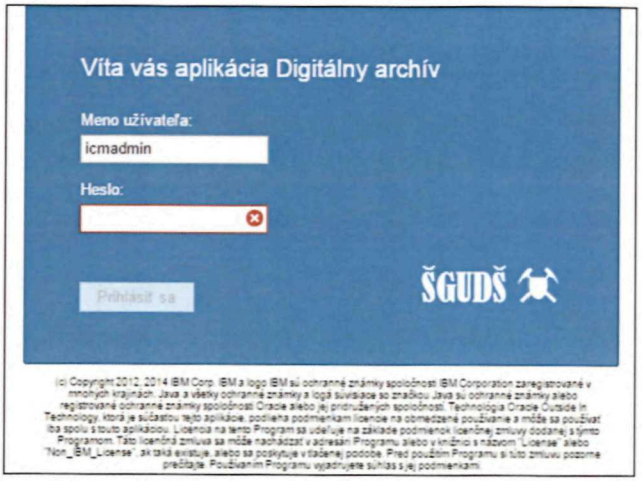


Fig. 3.17 Application Entry to the Digital Archive

- The service returns a complete bibliographic record of a report according to archive number;
- The service returns the PDF document of a report according to archived number;
- The service returns a list of retrieved reports according to the values of searched attributes.

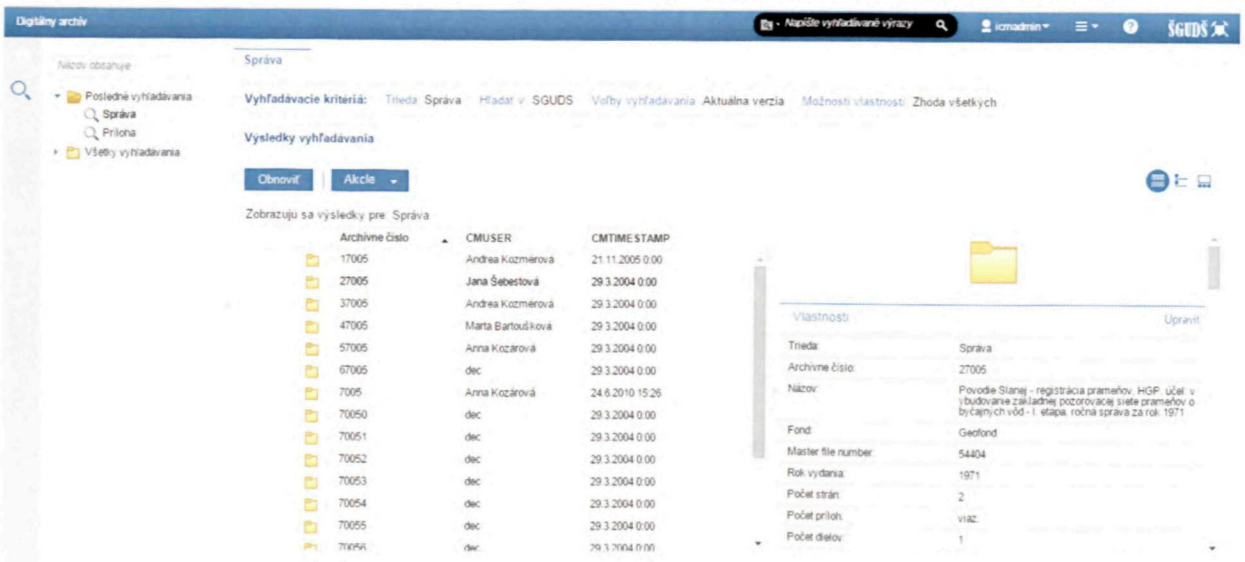


Fig. 3.18 Search criteria and the result of a search

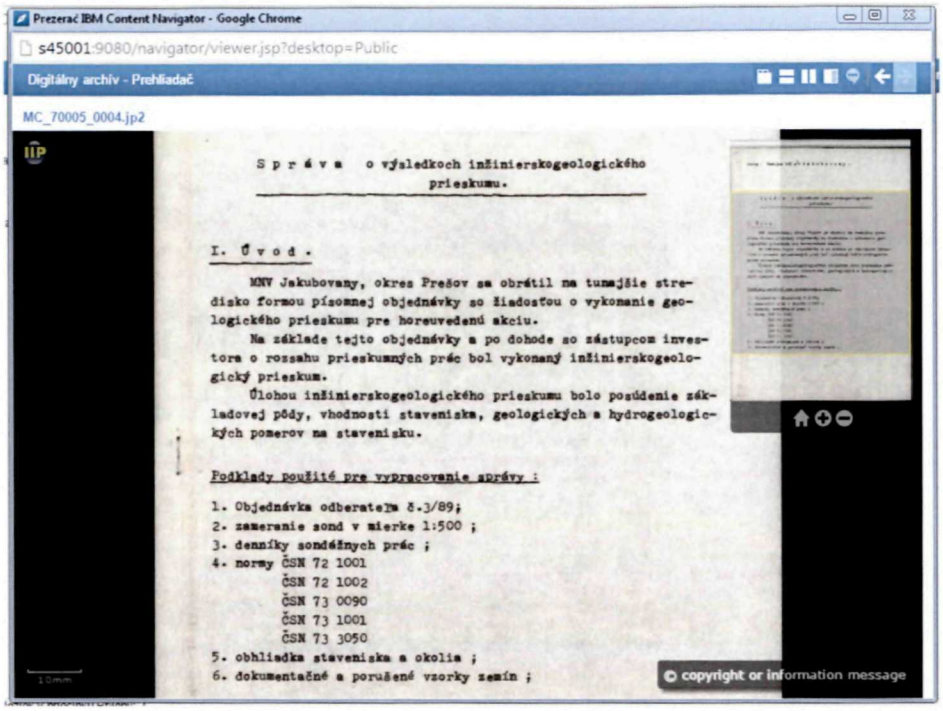


Fig. 3.19 Display of a retrieved report

Implementation of the current version of the Digital Archive enables new services:

- Browsing of the extensive map attachments;
- Option of attaching large volume annexes (above 30 MB);
- Development of a tool for batch processing of files;
- Installation of an integrated document viewer;
- Extending the existing full-text search on faceted viewing;
- Optimize documents printing;
- Processing of statistical tool to evaluate workload and accessing the system;
- Optimization for basic web browsers;
- Processing of web interfaces, support of open communication towards national aggregator of Slovakiana and Europeana Systems
- The implementation of portal solution for Intranet and Internet environments by providing authorization and authentication with graduated access rights to the public and specialized (professional) public.

4. Infrastructure of the Geological Information System

The Geological Information System in terms of its content and the technical aspects represents a result of activities carried out under the umbrella of the Digital Geological Map of the Slovak Republic at 1: 50 000 and 1:500,000 (Káčer et al., 2005) and Geological Information System GeoIS (Káčer et al., 2014). One of the aims of these projects was the design and implementation of technical solution for publishing spatial and non-spatial geological information on the Internet. Before the project GeoIS implementation this option was not available, because there was very little experience with the publishing of the results of geographic information systems on the Internet in Slovakia. The years 2008 and 2015 are the milestones in the building up of the geological IS.

Fig. 4.1 and 4.2 Ceremonial launching of the SGIDŠ Map Server, April 1, 2008

4.1. State of the Geological Information System in 2008

The result of the GeoIS project development in 2008 was the emergence of the following two systems with a single technical infrastructure linked via service-oriented architecture (SOA) using Web Services (WS): Map Server and Geofond Archive.

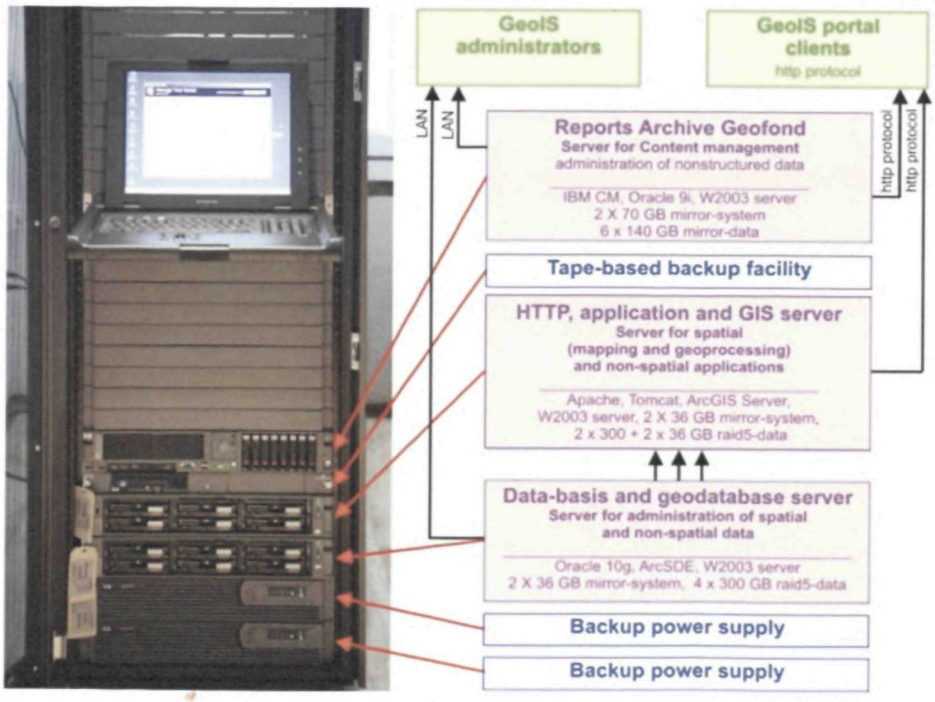


Fig. 4.3. Infrastructure of GeoIS in 2008

Technological solution of the Geological Information System allows connection of spatial information of the Map Portal with non-spatial information and documents of the Geofond Archive. This connection is realized by attribute data of spatial data (landfill, landslide, old mine works, etc.) – number of respective final report in the Geofond Archive.

4.1.1 Map Server

In 2008, the hardware infrastructure consisted of two servers:

- Database with Oracle 10g and application extension for spatial information ArcSDE 9.2 by ESRI.
- Application Server running with systems ArcGIS Server 9.2 and Apache Tomcat 6.

For the content management and creation of web services served ArcGIS Desktop 9.2. Logical infrastructure of the Map Server 2008 is shown in Fig. 4.3. During 2008, there were made accessible eight mapping applications on the Application Server (Figure 4.4) developed in Java programming language using WebADF libraries for Java.

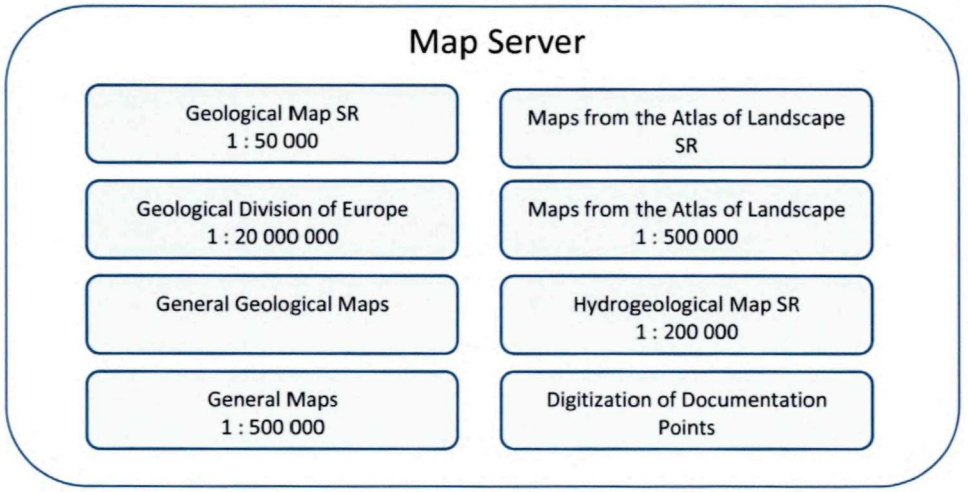


Fig. 4.4. Map Server applications in 2008

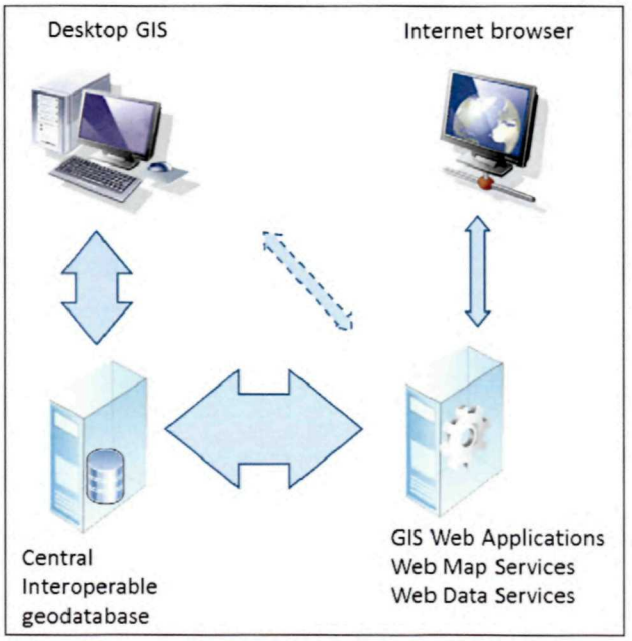


Fig. 4.5. Logic Infrastructure of the Map Server and Geodatabase (compiled by Cibula)

4.1.2 Geofond Archive

The information system had used single server with software based on software core IBM DB2 Content Manager, storage Oracle and IBM WebSphereProcess Server. Above this solution it was built WebCM independent extension, which was used to access the documents via the Intranet (Internet). Communication with IBM DB2 Content Manager and IBM Server WebSphereProcess ran through a standard open interface API. A schematic architecture of the system is shown in Fig 3.1.

4.2. State of the Geological Information System Creation in 2015

Since 2008, based on practical experience, important technological shift in creating applications of the Map Server and Geofond has been achieved. Significantly has changed functionality and technical infrastructure of GeoIS; its logical visualisation is shown in Fig. 4.6.

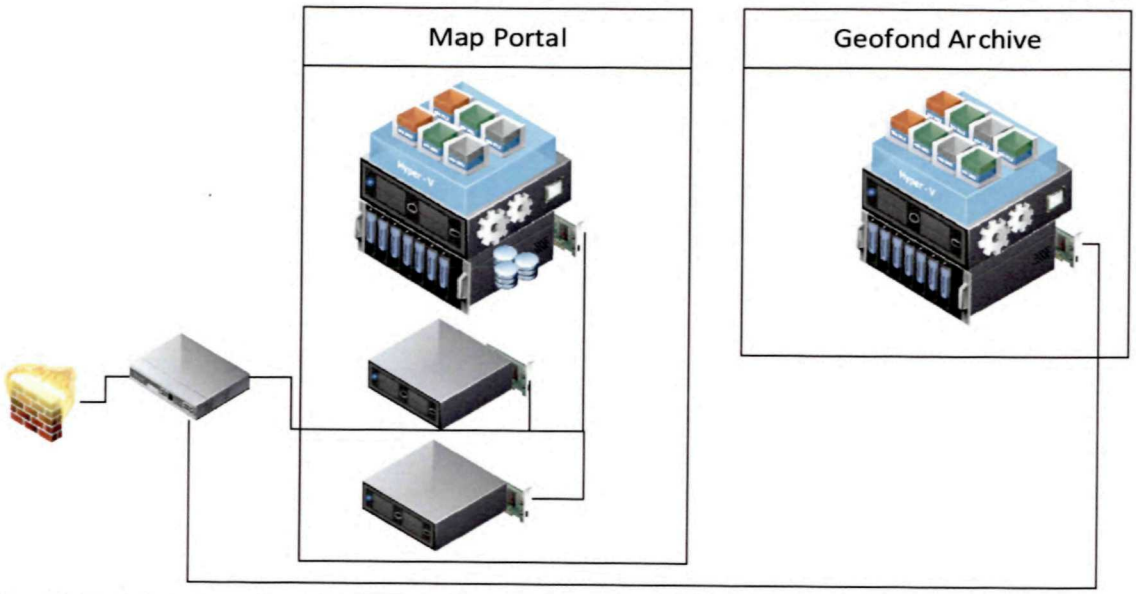


Fig. 4.6 Logical representation of the technical infrastructure (compiled by Cibula)

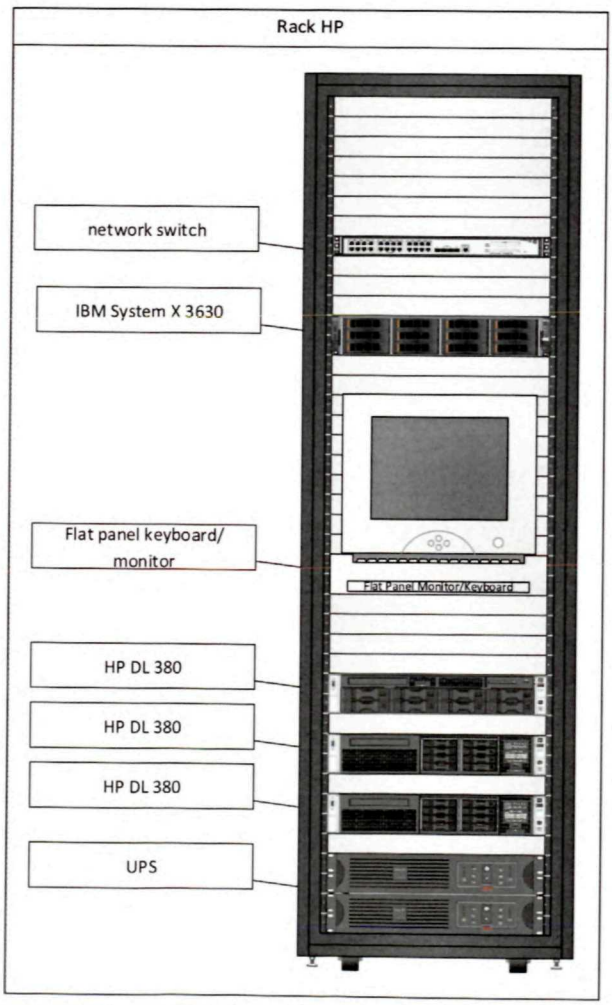


Fig. 4.7 Technical infrastructure of the Map Portal (compiled by Cibula)

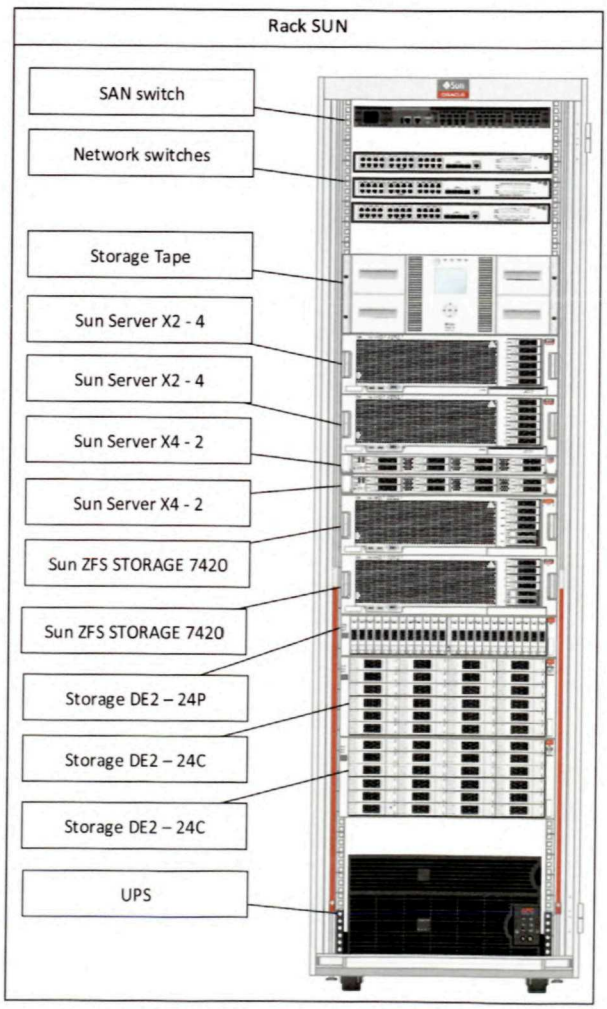


Fig. 4.8 Technical infrastructure of the Geofond Archive (compiled by Cibula)

4.2.1 Map Portal

Development of information and communication technology (ICT) has undergone large technological changes, the deployment of HTML 5, the development of REST services, the introduction of advanced mobile technologies and so on. Changes were also made in legislation linked to the management and provision of spatial information. ESRI ended WebADF libraries support, through which mapping applications had been developed. This resulted in the need to re-program all applications in JavaScript. At the same time expanded infrastructure with new servers and their virtualization was implemented; there are currently 49 new mapping applications and meta-information system on the above servers.

4.2.2 Geofond Archive

By obtaining the project funding from EU structural funds, we could proceed with the completion of a comprehensive Digital Archive with a lot of new functionalities. The resulting technical infrastructure is shown in Fig. 4.8 and is described in detail in Section 3 – The Digital Archive as Part of the Cultural Heritage of Slovakia.

5. Conclusion and Recommendations

The geological project Geological Information System GeoIS was solved in the period 2005 – 2014. Approval of the project for 10 years was unique from the start and pointed out its importance and great prospects. The individual works were carried out on the basis of approved annual projects. However, the annual project approval had its disadvantages in increased administrative burden, but on the other hand enabled optimal control, defining and following workflow or the completed geological projects, the results of which were then processed and have become part of GeoIS. It also enabled to quickly solve issues connected with the personal capacities of the organization. The range of issues that were addressed had not been solved at SGIDŠ ever before and thus the selected solution process proved to be optimal.

The solution of the geological project also required the acquisition of relevant hardware and software equipment from the launch of the task; this in a very long period has been proven as a highly effective solution. In the course of solutions we once received earmarked capital resources to buy a new server with accessories. All other funds needed to purchase computer equipment, new server software, including its support were covered from own resources of the organization. The current situation in terms of the operation of the system is sufficient, but not ideal. There is still missing HW equipment related to the system balancing, its speed, and not least its backup.

Addressing the digital archive as part of the project GeoIS also proved to be particularly appropriate. By change of registration, processing and disclosure of information from the archive in a manner supportive of binding standards, we could successfully compete for grant assistance from EU structural funds, which allow us to develop and make available information in its entirety.

The project has contributed mainly by the fact that we have made available digitally processed and unique and unrepeatable information of which a significant portion now should not be obtained and we should keep off their permanent loss. Final reports fund digitization has contributed to the protection of text objects, since paper original is protected. It also contributes to a more efficient and rapid acquisition of the necessary information, data and knowledge not only about the geological structure of Slovakia.

The target groups are the beneficiaries of government, local authorities, scientists, students of secondary schools and universities, experts and general public. The target groups are mainly legal and natural persons wishing to undertake strategic planning and preventive measures on the environment, renewable energy, to prepare and carry out construction work, underground work, earthworks, purchase and sale of land, estimates of insurance risk, and appreciation of real estate. Other target groups are employees of the Ministry of Environment, water management staff, designers, experts in the field of landscape design and urban planning, environmentalists, legal experts, publicists and journalists. The project allows using collections to users with disabilities and seniors from the comfort of their own home through online access, thus contributing to the promotion of the knowledge society. Outputs of the project through an online portal are not accessible only to users from Slovakia but also to all interested parties from abroad.

The project has contributed to the modernization and completion of SGIDŠ infrastructure. At the point of the completion of the geological project Geological Information System GeoIS we find ourselves in conditions which inevitably require maintenance, updating and completing the SGIDŠ Map Server, which is the basic output of the above task.

The aforementioned ideas and objectives described above shall be ensured by implementation of a new project "Geological Information System GeoIS – II". Through the solution of the new project SGIDŠ will fully meet and comply with the relevant legislation in addition to the Geological Act (Act no. 259/2007 Coll on Geological Works). This applies in particular to information on the environment and access to them, and the Law No.3/2010 Coll on the National Spatial Data Infrastructure.

The main topics of the project of GeoIS – II, which we will address the following four years, include:

- Technology management and update of the existing GeoIS;
- Creation of 3D applications with virtual exposition of raw mineral deposits;
- Data conversion with the transition to the new database server;
- Preparation of Information Geoportal;
- Creation of new applications for state administration;
- Creation of new map applications with responsive design allowing to run the applications on different devices and platforms;
- Implementation of the results of geological projects which shall contain partial IS outputs, or creation of databases;
- Upgrading of existing applications related to updating the data base;
- Extension of the digital archive on additional funds;
- Standardized services and applications, serving to share the national and departmental IS with the possibility of linking the international IS;
- Information Geoportal publishing data and services in accordance with European and national legislation – INSPIRE.

Among the fundamental functionalities that are currently absent, we include:

- Catalogue service;
- Download Services (ATOM);
- Transformation services;
- Harmonisation of data.

SGIDŠ as the only institution in Slovakia systematically generates a database of strategic information in the public interest on the state of the environment from the viewpoint of the geological structure of the area, geothermal energy, drinking water, mineral waters and healing springs, deposits of raw minerals, as well as data on the environmental burden, seismicity measurements, landslides and data from engineering geology. The above information are necessary for strategic planning and decision making of the state and local governments in planning and preventive measures of national interest in the field of environmental protection, particularly land use, exploitation and protection of drinking water sources, use of mineral resources, the prevention of environmental accidents. The Geofond registers are irreplaceable in planning constructions in the public interest with respect to environmental protection as well as making available data on the characteristics of the particular environmental issues for the citizens. Through digitization and access to these databases via the web portal Administration the citizens receive free of charge information on the area of interest.

In the scope of the solving of the projects of the Geological Information System and Operational Programme Information Society through digitizing objects of Geofond and the Central Geological Library and making these data available to the public in digital form the SGIDŠ significantly contributes to the preservation of scientific, intellectual and cultural heritage, natural science, especially in geological science and research. The specialized libraries and archives are in the process of information society irreplaceable, since these specialized institutions are a rich source of data suitable for study and research of the society. Due to the complex geological research and exploration of the country, the rich collections of the Central Geological Library of the Slovak Republic and Geofond, the SGIDŠ has been firmly positioned in the process of development of information society as a natural, reliable and well-established institution that plays a key role especially in the science, research, education and general culture.

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*Slovak/**English** Vocabulary*

1.	**Atribučný dopytovací nástroj**	*Attribute Query Tool*
2.	**Banskoštiavnická oblasť**	*Banská Štiavnica Area*
3.	**Bod**	*Point*
4.	**Celá SR**	*The Whole Territory of SR*
5.	**Databáza**	*Database*
	Databáza hmotnej dokumentácie	*Database of Material Documentation (Core Recovery)*
6.	**Editácia**	*Editing*
7.	**Formulár**	*Form*
8.	**Fulltext v geologickom profile**	*Fulltext in Geological Profile*
9.	**Grafická dokumentácia**	*Graphic Documentation*
10.	**Heslo**	*Password*
11.	**Hľadať (názov)**	*Search (Name)*
12.	**Hĺbka podzemnej vody**	*Groundwater Table Level Depth*
13.	**Hornina**	*Rock*
14	**Identifikácia**	*Identification*
	Identifikácia – click	*Identification – Click*
	Identifikácia objektu	*Object Identification*
15.	**Indikátor**	*Indicator*
	Environmentálne indikátory	*Environmental Indicators*
	Zdravotné indikátory	*Health Indicators*
	Environmentálne riziko	*Environmental Risk*
	Zdravotné riziko	*Health Risk*
16.	**Informácia o projekte**	*Project Information*
17.	**Kataster**	*Cadaster*
18.	**Kontakty**	*Contacts*
19.	**Kraj**	*Region*
20.	**Lokalita**	*Site*
	Lokalita obsahuje iba textové informácie	*The Site contains only text information*
21.	**Mapa**	*Map*
	z mapy	*From the Map*
22.	**Metaúdaje**	*Metadata*
23.	**Mierka**	*Scale*
24.	**Monitoring objemovej aktivity radónu**	*Monitoring of Bulk Radon Activity*
25.	**Nasledujúci výrez**	*Next Detail*
26.	**Návrh prieskumného územia**	*Proposal for Exploration Area*
27.	**Obec**	*Municipality*
	Obce	*Municipalities*
28.	**Obsah mapy**	*Map Content*
29.	**Ochorenia**	*Diseases*
30.	**Okres**	*District*
	Okresy	*Districts*
31.	**Podzemné vody**	*Groundwaters*
32.	**Polygón**	*Polygon*
33.	**Posun**	*Pan*
34.	**Potvrdiť**	*Confirm*
35.	**Pozícia**	*Position*
36.	**Pôdy**	*Soils*
37.	**Predchádzajúci výrez**	*Previous View*
38.	**Pridať údaje**	*To Add Data*
39.	**Preskúmanosť**	*Level of Investigation*
	Geofyzikálna preskúmanosť	*Geophysical Investigation*
	Mapová preskúmanosť	*Map Investigation*
	Ložisková preskúmanosť	*Deposit Investigation*
40.	**Priehľadnosť**	*Transparency*
41.	**Prihlásenie**	*Login*
42.	**Príručka**	*Manual*

43.	**Prvky**	*Elements*
44.	**Radón**	*Radon*
	Radón nad tektonikou	*Radon Above Tectonics*
	Radón na referenčných plochách	*Radon in Reference Areas*
	Radón v podzemných vodách	*Radon in Groundwaters*
45.	**Raster**	*Raster*
46.	**Rok**	*Year*
47.	**Ručné vkladanie bodov**	*Manual Insert of Points*
48.	**Skupina**	*Group*
49.	**Späť**	*Back*
50.	**SQL výber**	*SQL Search*
51.	**Súradnice, dĺžka, plocha**	*Coordinates, Length, Area*
52.	**Suroviny**	*Raw Materials*
	Energetické	*Energy*
	Nerudné	*Non-Metallic*
	Rudné	*Ore*
53.	**Téma**	*Theme*
54.	**Tlač**	*Print*
	Tlač mapy	*Map Print*
55.	**Topografický podklad**	*Topographic Groundwork*
56.	**Triedenie**	*Separation*
57.	**Typ**	*Type*
58.	**Účel**	*Purpose*
59.	**Úroveň**	*Level*
60.	**Úvod**	*Introduction*
61.	**Užívateľ**	*User*
62.	**Vlastnosť**	*Property*
63.	**Voľba vrstiev**	*Layer Selection*
64.	**Vrstva; Vrstvy**	*Layer; Layers*
65.	**Všeobecné informácie**	*General Information*
66.	**VÚC (Vyšší územný celok)**	*Selfgoverning Region*
67.	**Výber územia**	*Territory Selection*
68.	**Vyhľadávanie; Vyhľadaj**	*Search; Search*
	Vyhľadávanie podľa	*Search According*
	Vyhľadávanie podľa členenia	*Search According Division*
	Administratívne členenie	*Administrative Division*
	Geomorfologické členenie	*Geomorphologic Division*
	Regionálne geologické členenie	*Regional Geological Division*
69.	**Výmera**	*Acreage*
70.	**Vzdialenosť**	*Distance*
71.	**Záverečná správa**	*Final Report*
72.	**Zobraziť**	*Visualise*
	Zobraz	*Show*
	Zobraz všetko	*Show All*
	Zobrazená vrstva	*Depicted Layer*
73.	**Zoznam objektov**	*List of Objects*

References

Bačo P., Hvožďara P., Repčiak M., Kovaničová Ľ., Roch M., Šofranec M., Bóna J., Mihál' I., Cvengroš F., Majchrák A., Stašová H., Šoltýsová H., Doležalová E., Kyseľová M., Cvengrošová A., Nováková A., Konečný P., Siman P., Kollárová V., Potfaj M., Kočišová M. & Dzurenda Š., 2004: Outer Flysh Belt of Western Carpathians. Project No. 74 01 1007/20 98 (*Atlas of Maps of Heavy Minerals*). GEOMIN, Štátny geologický ústav Dionýza Štúra, Jihlava, Bratislava, 100 p. (In Slovak)

Ballofet E., Tchistiakov A, Jellema J., Hansen M., Fruijtier S., Exel M., Theelen J., Heirman A., Rodríguez J., Čápová D., Belicskas J., Pozingis A., Murnikova A., Arustiene J., Schubert G., Rotar-Szalkai A., Nagy P., Šinigoj J., Palumbo A., Malík P., Asman M., 2008: EWATER – The European Multilingual Ground Water Information System. Proc. XIIIth IWRA World Water Congress, France, Montpellier, Sept. 1 – Sept. 4, 2008.

Bezák V., Broska I., Ivanička J., Reichwalder P., Vozár J., Polák M., Havrila M., Mello J., Biely A., Plašienka D., Potfaj M., Konečný V., Lexa J., Kaličiak M., Žec B., Vass D., Elečko M., Janočko J., Pereszlényi M., Marko F., Maglay J. & Pristaš J., 2004: Tektonická mapa Slovenskej republiky 1 : 500 000 (*Tectonic Map of Slovakia*), Ministerstvo životného prostredia Slovenskej republiky, Štátny geologický ústav Dionýza Štúra, Bratislava. (In Slovak)

Bezák V., Maglay J., Polák M., Kohút M., Gross P., Piotrowska K., Iwanov A., Gazdzicka E., Rackowski W., Fleischer P., Hanzel V., Chovancová B., Koreň M., Kyselová Z., Madarás J., Pavlarčík S. & Reichwalder P., 2011: Geologicko-náučná mapa Tatier 1 : 50 000 (*Geological-Educational Map of the Tatry Mountains*), Ministerstvo životného prostredia, Štátny geologický ústav Dionýza Štúra, Bratislava

Bezák V., Elečko M., Fordinál K., Ivanička J., Kaličiak M., Konečný V., Kováčik (Ke) M., Maglay J., Mello J., Nagy A., Polák M., Potfaj M., Biely A., Bóna J., Broska I., Buček S., Filo I., Gazdačko Ľ., Grecula P., Gross P., Havrila M., Hók J., Hraško Ľ., Jacko S., Jacko S., Janočko J., Kobulský J., Kohút M., Kováčik M., Lexa J., Madarás J., Németh Z., Olšavský M., Plašienka D., Pristaš J., Rakús M., Salaj J., Siman P., Šimon L., Teťák F., Vass D., Vozár J., Vozárová A. & Žec B., 2008: Prehľadná geologická mapa Slovenskej republiky, 1 : 200 000 (*General Geological Map of the Slovak Republic*), Ministerstvo životného prostredia SR, Štátny geologický ústav Dionýza Štúra, Bratislava. (In Slovak)

Bodiš D., Rapant S., Khun M., Klukanová A., Lexa J., Mackových D., Marsina K., Pramuka S. & Vozár J., 1999: Geochemický atlas Slovenskej republiky. Časť VI: Riečne sedimenty 1 : 1 000 000 (*Geochemical Atlas of Stream Sediments*), Ministerstvo životného prostredia Slovenskej republiky, Geologická služba Slovenskej republiky, Bratislava, 145 p. (In Slovak)

Bodiš, D., et al., 2015: Geochemický atlas Slovenskej republiky. Časť VI: Povrchové vody 1 : 1 000 000, (*Geochemical Atlas of Surface Waters*), Ministerstvo životného prostredia Slovenskej republiky a Geologická služba Slovenskej republiky, Bratislava, 145 p.

Czudek T., et al. (1972): Geomorfologické členení ČSR (*Geomorphological Division of CSR*). Studia geographica, 23, 140 p. (In Czech)

Čurlík J., 2002: Náchylnosť pôd na acidifikáciu (*Soil Susceptibility to Acidification*), Atlas krajiny Slovenskej republiky, Bratislava, Ministerstvo životného prostredia Slovenskej republiky, p. 280.

Čurlík J. & Šefčík P., 2002: Kontaminácia pôd (*Soil Contamination*), Atlas krajiny Slovenskej republiky, Bratislava, Ministerstvo životného prostredia Slovenskej republiky, p. 278.

Elečko M., Vass D., Konečný V., Gaálová K. & Gaál Ľ., 2004: Geologicko-náučná mapa Cerovej vrchoviny 1 : 50 000 (*Geological-Educational Map of the Cerová vrchovina Upland*), pilotná mapa novej edície. Geologické práce, Správy, p. 73-76. (In Slovak)

Fendek M., Poráziková K., Štefanovičová D. & Supuková M., 2002: Zdroje geotermálnych a minerálnych vôd (Geothermal and Mineral Water Sources), Atlas krajiny Slovenskej republiky, Bratislava, Ministerstvo životného prostredia Slovenskej republiky, p. 214-215

Ferenc Š., Smolárik M., Olšavský M., Žuffa M., Antalík M., Lacenová K. & Šesták P., 2010: Banskobystrický geopark (*Banská Bystrica Geopark*), stav k 31.12.2010, regionálny geologický výskum. Záverečná správa. ŠGÚDŠ, Archív Geofondu, Bratislava, 79 p. (In Slovak)

Franko O., Remšík A., Fendek M., Fusán O., Král M., Bodiš D., Drozd V., Vika K., Elečko M., Gross P., Hrušecký I., Jančí J., Kaličiak M., Konečný V., Lexa J., Marcin D., Maťo J., Pereszlényi M., Pašeková P., Pôbiš J., Roháč J., Slávik M., Vass D. & Zvara I., 1995: Atlas geotermálnej energie Slovenska, (*Atlas of Geothermal Energy of Slovakia*) - Geologický ústav Dionýza Štúra , Bratislava, 267 p. (In Slovak)

Fusán O., Biely A., Ibrmajer J., Plančár J. & Rozložník L., 1987: Podložie terciéru vnútorných Západných Karpát (*Tectonic Map of Tertiary Basement of the Inner Western Carpathians*) - Geologický ústav Dionýza Štúra, Bratislava, 123 p. (In Slovak)

Grecula P., Kobulský J., Gazdačko Ľ., Németh Z., Hraško Ľ., Novotný L. & Maglay J., 2009: Geologická mapa Spišsko-gemerského Rudohoria 1 : 50 000 (*The Geological Map of the Spiš-Gemer Ore Mts.*), Regionálne geologické mapy Slovenska 1 : 50 000, Štátny geologický ústav Dionýza Štúra, Bratislava.

Holzer R., Laho M., Bednarik M., Wagner P., Magulová B. & Michalková J., 2008: Inžinierskogeologický atlas hornín Slovenska (*Engineering Geological Atlas of Rocks of the Slovak Republic*). Geológia a životné prostredie. Zborník vedeckých prác zo 6. slovenskej konferencie s medzinárodnou účasťou. Bratislava, 18. a 19.9. 2008. Bratislava: Štátny geologický ústav Dionýza Štúra, p. 53-57. (In Slovak)

Hraško Ľ., Bačo P., Bačová Z., Bezák V., Boorová D., Bóna J., Broska I., Buček S., Čech P., Demko R., Derco J., Elečko M., Ferenc Š., Filo I., Fordinál K., Gazdačko Ľ., Gluch A., Gross P., Harčová E., Havrila M., Ivanička J., Kobulský J., Kohút M., Kollárová V., Konečný P., Konečný V., Kováčik M., Kováčik M., Kováčiková M., Kráľ J., Kronome B., Kubeš P., Laurinc D., Madarás J., Maglay J., Nováčková M., Olšavský M., Potfaj M., Pristaš J., Pramuka S., Siráňová Z., Šimon L., Zlinska A., Žecová K., Antalík M., Vlachovič J., 2013: Aktualizácia geologickej stavby problémových území Slovenska v mierke 1: 50 000 (*Actualisation of Geological Setting of Problematic Territories SR*). Záverečná správa. Archív ŠGÚDŠ, 251 p. (In Slovak)

Hrašna M. & Klukanová A., 2002: Inžinierskogeologická rajonizácia, (*Engineering-Geological Zoning Map*), Atlas krajiny Slovenskej republiky, Bratislava, Ministerstvo životného prostredia Slovenskej republiky, p. 82.

Hromádka, J. (1956). Orografické třídění Československé repub-liky (*Orographic Division of the Czechoslovak Republic*). Sborník Československé společnosti zeměpisné, 61, p. 265 – 299. (In Czech)

Káčer Š., Antalík M., Lexa J., Zvara I., Fritzman R., Vlachovič J., Bystrická G., Brodnianska M., Potfaj M., Madarás J., Nagy A., Maglay J., Ivanička J., Gross P., Rakús M., Vozárová A., Buček S., Boorová D., Šimon L., Mello J., Polák M., Bezák V., Hók J., Teťák F., Konečný V., Kučera M.,

Žec B., Elečko M., Hraško Ľ., Kováčik M. & Pristaš J., 2005a: Digitálna geologická mapa Slovenskej republiky v M 1 : 50 000 a 1 : 500 000 (*Digital Geological Map of the Slovak Republic at Scales 1:50,000 and 1:500,000*). Záverečná správa geologickej úlohy, Manuskript. Štátny geologický ústav Dionýza Štúra, Bratislava, 42 p. (In Slovak)

Káčer Š et al.. 2005b: Digitálna geologická mapa SR v mierke 1:50 000, (*Digital Geological Map of the Slovak Republic*). Map Server of SGIDŠ. www.geology.sk. (In Slovak)

Káčer Š., Antalík M., Bodiš D., Cibula R., Gargulák M., Gluch A., Hraško Ľ., Liščák P., Malík P., Mižák J., Pauk J., Rapant S. & Slaninka I., 2014: Geologický informačný systém GeoIS (*Geological Information System*), Záverečná správa geologickej úlohy, Manuskript. Štátny geologický ústav Dionýza Štúra, Bratislava, 76 p. (In Slovak)

Klukanová &. A Iglárová Ľ., 2002: Vhodnosť územia na ukladanie odpadov (*Suitability of Territory for Waste Deposition*), Atlas krajiny Slovenskej republiky, Bratislava, Ministerstvo životného prostredia Slovenskej republiky, p. 309.

Kočický, D. & Ivanič, B., 2011: Geomorfologické členenie Slovenska (*Geomorphological Division of Slovakia*). Map Server of SGIDŠ. www.geology.sk. (In Slovak)

Kočický, D. & Ivanič, B., 2011: Klimatickogeografické typy (*Climatic-Geographic Types*). Map Server of SGIDŠ. www.geology.sk. (In Slovak)

Kúšik, D. & Lamoš, A., 2002: Vzťah horninového prostredia ku ochrane prírody a krajiny (*Relationship of the rock environment to nature and landscape protection*). Záverečná správa geologickej úlohy, Manuskript, archív ŠGÚDŠ Bratislava, 54 p. (In Slovak).

Lexa J., Bezák V., Elečko M., Eliáš M., Konečný V., Less G., Mandl G., Mello J., Pálenský P., Pelikán P., Polák M., Potfaj M., Radócz G., Rylko W., Schnabel G., Stráník Z., Vass D., Vozár J., Zelenka T., Biely A., Császár G., Čtyroký P., Kaličiak M., Kohút M., Kovács S., Mackiv B., Maglay J., Nemčok J., Nowotny A., Pentelényi L., Rakús M. & Vozárová A., 2000: Geological map of Western Carpathians and adjacent areas 1 : 500 000 - Ministry of the Environment of Slovak Republic, Geological Survey of Slovak Republic, Bratislava.

Lexa J., Bačo P., Bakoš F., Baláž P., Bezák V., Bystrická G., Cicmanová S., Ferenc Š., Gazdačko Ľ., Grecula P., Háber M., Helma J., Hojstričová V., Hraško Ľ., Hurai V., Huraiová M., Chovan M., Jeleň S., Kobulský J., Koděra P., Kohút M., Kollárová V., Konečný P., Konečný V., Kováčik M., Kráľ J., Kyselica M., Luptáková J., Marsina K., Mackových D., Maťo Ľ., Michalko J., Mikuš T., Moravanský D., Bahna B., Németh Z., Ozdín D., Petro Ľ., Pršek J., Radvanec M., Rojkovič I., Rojkovičová Ľ., Tréger M., Smirnov A., Smolka J., Šesták P., Žák K., Žáková E. & Žec B., 2005: Metalogenetické hodnotenie územia Slovenskej republiky, (*Metallogenetic Map of Slovakia*). Archív ŠGÚDŠ, Bratislava, 214 p. (In Slovak)

Lexa J., 2002: Geologické členenie Európy M 1:20 000 000 (*Geological Division of Europe*). Map Server of SGIDŠ. www.geology.sk. (In Slovak)

Lexa J., Marsina K., 1995: Mapa litogeochemických typov (*Map of Lithogeochemical Types of Slovakia*), Geochemický atlas SR. Časť III. Horniny 1 : 1 000 000, Ministerstvo životného prostredia SR, Geologická služba Slovenskej republiky, Bratislava, 135 p. (In Slovak)

Liščák P., Polák M., Pauditš P. & Baráth I. 2002: Významné geologické lokality, 1 : 1 000 000. No. 45. Important Geological Sites 1 : 1 000 000. Atlas krajiny Slovenskej republiky, Bratislava, Ministerstvo životného prostredia SR, p. 237.

Madarás J., Baráth I., Bystrická G., Gargulák M., Kohút M., Kováčik M., Liščák P., Maglay J., Malík P., Nagy A., Šoltés S., Vlačiky M., Zlinská A., Zlocha M., Ferenc Š., Gaži P., Plašienka D., Pivko D., Lehotský R. & Biskupič R., 2013: Sandbersko-pajštúnsky geopark (SAPAG), (*Sandberg-Pajštún Geopark*). Záverečná správa geologickej úlohy. Úloha č. 10 11. Manuskript. Bratislava, archív ŠGÚDŠ, 68 p. (In Slovak)

Maglay J., Halouzka R., Baňacký V., Pristaš J. & Janočko J., 1999: Neotektonická mapa Slovenska v mierke 1 : 500 000 (*Neotectonic Map of Slovakia*), Ministerstvo životného prostredia SR, Geologická služba SR, Bratislava. (In Slovak)

Maglay J., Pristaš J., Kučera M. & Ábelová M., 2009: Geologická mapa kvartéru Slovenska – hrúbka kvartérneho pokryvu 1 : 500 000, (*Quaternary Geological Map of Slovakia – Quaternary Cover Thickness*), Ministerstvo životného prostredia SR, Štátny geologický ústav Dionýza Štúra, Bratislava.

Maglay J., Pristaš J., Kučera M. & Ábelová M., 2009: Geologická mapa kvartéru Slovenska – genetické typy kvartérnych uložení 1 : 500 000 na základe vlastných prác s použitím regionálnych geologických máp Slovenska v mierke 1 : 50 000 a máp autorov: Žebera, K. (1968), Vaškovský, I. (1973), Kvitkovič, J. (1980), Maglay, J. a Pristaš, J. (2002) (*Quaternary Geological Map of Slovakia – Quaternary Genetical (Deposits) Types 1 : 500,000*), Ministerstvo životného prostredia SR, Štátny geologický ústav Dionýza Štúra, Bratislava.

Maglay J. & Pristaš J., 2002: Kvartérny pokryv v mierke 1 : 1 000 000, (*Quaternary Deposits*) Atlas krajiny Slovenskej republiky, Bratislava, Ministerstvo životného prostredia Slovenskej republiky, p. 84

Maglay J., Moravcová M., Vlačiky M., Šefčík P. & Pristaš J., 2011: Prehľadná geologická mapa kvartéru Slovenskej republiky 1 : 200 000 (*General Geological Map of Quaternary of the Slovak Republic*), Štátny geologický ústav Dionýza Štúra, Ministerstvo životného prostredia, Bratislava.

Malík P. & Švasta J., 2002: Hlavné hydrogeologické regióny, (*Principal Hydrogeological Regions*), Atlas krajiny Slovenskej republiky, Bratislava, Ministerstvo životného prostredia Slovenskej republiky, p. 104.

Malík P., Bahnová N., Ivanič B., Kočický D., Maretta M., Šilárová I., Švasta J.& Zvara I., 2011: Komplexná geologická informačná báza pre potreby ochrany prírody a manažmentu krajiny (GIB-GES) (*Comprehensive Geological Information Base for the Needs of Nature Conservation and Landscape Management*). Záverečná správa. Štátny geologický ústav Dionýza Štúra, Bratislava. Manuskript, ŠGÚDŠ Bratislava, 138 p. (In Slovak)

Mazúr E. & Činčura J., 1975: Planation surfaces in the Western Carpathians, Studia Geomorphologica Carpatho-Balcanica, 9, p. 27-36.

Mazúr E. & Lukniš M., 1978: Regionálne geomorfologické členenie Slovenskej republiky (*Geomorphological Division of Slovakia*). Geogr. Čas., 30, 2. (In Slovak)

Mazúr E., Lukniš M. 1986: Geomorfologické členenie SSR a ČSSR. Časť Slovensko (Geomorphological Division of SSR and CSSR. Part of Slovakia) In Atlas krajiny Slovenskej republiky 2002, Bratislava, Slovenská kartografia. (In Slovak)

Molák B. & Liščák P. a kol., 2002: Anglicko-slovenský geologický slovník so zoznamom slovenských názvov (*English-Slovak Geological Dictionary*). 518 p. Dionýz Štúr Publishers, Bratislava.

Rapant S., Letkovičová M., Cvečková V., Fajčíková K., Galbavý J. & Letkovič M., 2010a: Environmentálne a zdravotné indikátory Slovenskej republiky (*Environmental and Health Indicators of the Slovak Republic*). Štátny geologický ústav Dionýza Štúra, Bratislava, 2010, 245 p. (In Slovak)

Rapant S., Letkovičová M., Cvečková V., Fajčíková K., Galbavý J. & Letkovič M., 2010b: Zhodnotenie potenciálneho vplyvu geologického prostredia na zdravotný stav obyvateľstva banskoštiavnickej oblasti (*The Assessment of the Potential Impact of Geological Environment on the Health Condition of the Population of the Banská Štiavnica Area*), Štátny geologický ústav D. Štúra, Bratislava, 193 p. (In Slovak)

Rapant S., Vrana K., Bodiš D., Boboš V., Hanzel V., Kordík J., Repčoková Z., Slaninka I. & Zvara I., 1996: Geochemický Atlas Slovenska, Časť I. – Podzemné vody (*Geochemical Atlas of Groundwaters*), Ministerstvo životného prostredia, Geologická služba SR, Bratislava, 127 p. (In Slovak)

Repčiak, M., Záviš, V., Pristašová, Ľ., Caudt, Ľ., Hubač, P., Sandanus, M., Fodorová, V. & Hudáček., J., 1996: Slovensko - návrh sanácie starých banských diel - inventarizácia, vyhľadávací prieskum, stav k 31.12.1996 (*Slovakia – proposal for remediation of old mining works – inventory, exploration, state by 31/12/1996*). Záverečná správa geologickej úlohy, Manuskript. Bratislava, archív ŠGÚDŠ, 197 p. (In Slovak).

Struckmeier, W. F. & Margat, J., 1995: Hydrogeological maps. A guide and Standard Legend. International Contributions to Hydrogeology, 17, 1995, Heise, Hannover.

Šefčík P., Bystrická G. & Káčer Š., 2012: Pedogeochemické mapy (*Pedogeochemical Maps, A - horizon*), Map Server of SGIDŠ. www.geology.sk. (In Slovak)

Šimeková, J., Martinčeková, T., Abrahám, P., Gejdoš, T., Gre-nčíková, A., Grman, D., Hrašna, M., Jadroň, D., Záthurecký, A., Kotrčová, E., Liščák, P., Malgot, J., Masný, M., Mokrá, M., Petro, Ľ., Polaščinová, E., Solčiansky, R., Kopecký, M., Žabková, E., Wanieková, D., Baliak, F., Caudt, Ľ., Rusnák, M., Sluka, V., 2006: Atlas máp stability svahov SR v M 1:50 000, orientačný IGP (*Atlas of Slope Stability Maps SR at 1:50,000*). MŽP SR, INGEO-ighp, Katedra geotechniky SvF STU, SGIDŠ, GEOKONZULT, PriF UK. (In Slovak)

Švasta J. & Malík P., 2008: Digital hydrogeological map of Slovakia in 1:200 000 scale. Final Report of the eContentplus project eWater – Multilingual access to ground water databases, European Commission, Brussels

Špánik, F. & Šiška, B., 2004: Predpokladaná zmena klímy v 21. storočí a poľnohospodárstvo (*Agriculture and supposed cli-mate change impacts in 21st century*), Agrochémia. ISSN 1335-2415. Roč. 44, č. 1 (2004), p. 22-26.

Šuba J., Bujalka, P., Cibuľka, Ľ., Hanzel, V., Kullman, E., Porubský, A., Pospíšil, P., Škvarka, L., Šubová, A., Tkáčik, P. a Zakovič, M., 1984: Hydrogeologická rajonizácia Slovenska (*Hydrogeological Zoning of Slovakia*). SHMÚ Bratislava, 100 p.

Tchistiakov A., Schubert G., Arustiene J., Asfirane F., Asman M., Ballofet E., Belicskas J., Berka R., Bertrand F., Capova D., Centineo M., Daniels P., Dias E., Dumont B., Fruijtier S., Gargulák M., Hansen M., Hedlund F., Heger H., Heirman A., Heylen, C., Jellema J., Juračič P., Kollman W., Komac M., Krijn N., Lagarde P., Bravo J. L., Lukáčik E., Malík P., McCarthy P., Mizak J., Murniková A., Nagy P., Palumbo A., Prestor J., Rasmussen V., Rodríguez J., Rotar-Szalkai A., Severi P., Šinigoj J., Švasta J., Theelen J., Urban S. and Winckel. A. eWater – The European Distributed Hydrogeological Information System. In: Robert Marschallinger and Willi Wanker, eds. Computer-Anwendungen in Hydrologie, Hydrogeologie und Geologie. Beiträge zu COG-Fachtagung, Salzburg 2007. Heidelberg: Herbert Wichman Verlag, 2008, p. 47–50. ISBN 978-3-87907-449-5.

Vass D., 1988: Regionálne geologické členenie Slovenska (*Regional Geological Division of Slovakia*). Geologický ústav Dionýza Štúra, Bratislava. (In Slovak)

Vozár J., Káčer Š., Bezák V., Elečko M., Gross P., Konečný V., Lexa J., Mello J., Polák M., Potfaj M., Rakús M., Vass D. & Vozárová A. 1998: Geologická mapa Slovenskej republiky 1 : 1 000 000 na základe geologickej mapy Slovenska 1: 500 000 (*Geological Map of the Slovak Republic*), Ministerstvo životného prostredia SR, Geologická služba SR, Bratislava. (In Slovak)

Zuberec J., Tréger M., Lexa J. & Baláž P., 2005: Nerastné suroviny Slovenska, (*Mineral Resources of Slovakia*). Štátny geologický ústav Dionýza Štúra, Bratislava, 350 p. (In Slovak)

Žec B., Kaličiaková E., Žecová K., Stercz M., Rovňák L. & Palko L., 2005: Geologicko-náučná mapa Vihorlatských vrchov (*Geological-Educational Map of the Vihorlatské vrchy Mts.*), Mineralia Slovaca, p. 459-462.