












**CZECH  
GEOLOGICAL  
SURVEY**

# Annual Report 2021











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## Long-Term Conceptual Development of Research Organizations for 2018–2022

-  Research on the structure and evolution of the Earth's crust
-  Research on the biodiversity and global changes in the past
-  Research on and use of natural resources
-  Research on geosphere–biosphere–atmosphere interactions
-  Research on geohazards
-  Research on and development of geochemical and mineralogical methods





## Director's introduction

In 2021, the Czech Geological Survey continued to adapt to the change in working conditions due to the COVID-19 pandemic. Working from home and online meetings have become a new normal, and many administrative agendas have been rapidly digitized. It represented a challenge that we were able to cope with and, in the end, the difficult conditions did not affect our performance significantly. We generated a positive net income of nearly CZK 9 million, which extended our continuous series of 14 years of profitable management. About 25% of the CGS income was contributed the Ministry of the Environment (MoE), and we obtained the remaining part from funds for the long-term development of research organizations, from research grants, projects, contracts and other activities (see page 82 for details).

In 2021, the Government Council for Research, Development and Innovation published a peer review evaluating selected outputs and a bibliometric analysis according to a FORD classification comparing production of research organizations in 2017, 2018, 2019 and 2020. In addition to copious publication activity which includes excellent research results, the CGS also produces significant applied research results. We confirmed our leading position among organizations established by the MoE and ranked 6<sup>th</sup> among all the evaluated research organizations in the Czech Republic. As the only institute of the MoE, the CGS belongs among the most important research institutes in the Czech Republic with the largest number of outputs in the first decile and quartile, ranking 5<sup>th</sup> in both categories. The published CGS outputs in their respective fields are significantly above the national and international median, which is also the result of our substantial international cooperation.

During the second half of the year, CGS experts under my leadership were part of a government team that negotiated an agreement between the Czech Republic and the Republic of Poland on cooperation to deal with impacts of brown coal mining in the Turów mine on the Czech territory (see page 16). Protracted negotiations took place almost every week from June to the end of September, with the CGS being in charge of aspects concerning groundwater. A compromise agreement was finally signed in February 2022 by the new Prime Minister of the Czech Republic, Petr Fiala, and the Prime Minister of Poland, Mateusz Morawiecki. It exemplified the role that the CGS played as an expert state institute, which provides support for the government's agenda at the highest level.

The above mentioned successful results demonstrate how the CGS fulfils its vision of serving as a pillar of the Czech state in providing geoscientific information for decision-making in matters of natural resources, hazards and sustainable development and strengthening our position of a leading geoscience research institute based on our high-quality expertise.

The ongoing climate change and global energy crisis are increasingly spurring on the quest for alternatives to conventional fossil fuels. The potential of geothermal energy has yet to be discovered and harnessed in the Czech Republic. Heat pumps using shallow geothermal energy are already relatively common, but the use of deeper sources beneath the Earth's surface is lagging behind. A consortium of research organizations, universities, companies and other partners led by the CGS is preparing a comprehensive SYNERGYS project, focusing on the use of geothermal energy in Litoměřice (Ústí nad Labem Region), to apply for the new Just Transformation Fund. It will include a combination of heat from depths of 2–3 km, arrays of shallower wells to depths of 100–500 m, photovoltaic panels and green hydrogen used primarily for central urban heating or, conversely, for cooling and storing heat underground during the summer season (see page 22). This ground-breaking and expensive project should be launched in 2023.

The CGS pays systematic attention and capacities to international cooperation and overseas activities (see page 44). A second phase of the international PanAfGeo project was prepared and approved during 2021. The project is funded by the European Commission and implemented by a consortium of 10 European surveys led by the French geological survey BRGM, which aims to educate and transfer knowledge to colleagues from African geological surveys. More than 1,000 specialists from nearly 50 African countries participated in these training courses during the first phase. The CGS has the honour to lead one of the core courses focused on teaching geological mapping. Our team's leadership and competence is greatly appreciated by our foreign partners.

The CGS is also part of a consortium of 50 partners coordinated by the association of European geological surveys EuroGeoSurveys, which prepared a project for the Horizon Europe research programme in 2021. The project aims to create a permanent network of national geological surveys, which will provide the latest scientific knowledge and expertise collected at the EU level for the needs of European citizens, institutes and companies. Thematically, the project focuses on geothermal energy, underground CO<sub>2</sub> storage, critical raw materials essential for decarbonization, groundwater, and on an integrated data and information platform. The project was approved by the European Commission in the spring of 2022 and will be launched this year.

In addition, our multi-year mapping projects in Ethiopia, which are funded by the Czech Development Agency, continue to be carried out successfully, and the one-year UNDP project evaluating the slope instability hazards in the Georgian Kazbek region was very productive.

From the bottom of my heart I wish to thank and express my deep appreciation to all my colleagues who participated in all the successful results we achieved last year. I want to mention not only individual specialists, technicians and administrative workers, but also those who dedicate their capacities to the management of departments and projects, i.e. those who lead others, take care of "their people" and help create the best working conditions for them. Because one of the main principles that guides us at the CGS is that our employees should be highly qualified, motivated, and also satisfied and proud of the institute in which they work and spend a significant part of their lives.

Zdeněk Venera

# Organizational Structure

Situation as of 31 December, 2021

Advisory bodies	Directorate		Advisory bodies
<p>Scientific Board Review Board Editorial Board CGS Map Approval Committee</p>	<p>Management Project Management Management and Administration of the Brno Branch</p>	<p><b>Zdeněk Venera</b> Director  Human Resources Section Internal Audit  zdenek.venera@geology.cz</p>	<p>Editorial Boards of the Bulletin of Geosciences and Geoscience Research Reports CGS Portal Board Library Board</p>
<p><b>Geochemical Division and Central Laboratories</b></p> <p><b>Jan Pašava</b> Head of Division &amp; Deputy Director for Research  jan.pasava@geology.cz</p>	<p><b>Economic Division</b></p> <p><b>Zdeněk Cilc</b> Head of Division &amp; Deputy Director for Economics  zdenek.cilc@geology.cz</p>	<p><b>Geological Division</b></p> <p><b>Petr Mixa</b> Head of Division &amp; Deputy Director for Geology  petr.mixa@geology.cz</p>	<p><b>Division of Information Systems</b></p> <p><b>Vít Štrupl</b> Head of Division &amp; Deputy Director for Informatics  vit.strupl@geology.cz</p>
<p><b>Environmental Geochemistry and Biogeochemistry</b></p> <p><b>Martin Novák</b> Head of Department  martin.novak@geology.cz</p>	<p><b>General Economics</b></p> <p><b>Jana Kuklová</b> Head of Department  jana.kuklova@geology.cz</p>	<p><b>Regional Geology of Crystalline Complexes</b></p> <p><b>Zita Bukovská</b> Head of Department  zita.bukovska@geology.cz</p>	<p><b>Informatics</b></p> <p><b>Richard Binko</b> Head of Department  richard.binko@geology.cz</p>
<p><b>Rock Geochemistry</b></p> <p><b>Anna Vymazalová</b> Head of Department  anna.vymazalova@geology.cz</p>	<p><b>Economics and Administration</b></p> <p><b>Mirko Vaněček</b> Head of Department  mirko.vanecek@geology.cz</p>	<p><b>Regional Geology of Sedimentary Formations</b></p> <p><b>Zuzana Tasáryová</b> Head of Department  zuzana.tasaryova@geology.cz</p>	<p><b>Geofond</b></p> <p><b>Milada Hrdlovicsová</b> Head of Department  milada.hrdlovicsova@geology.cz</p>
<p><b>Mineral Resources Research and Policy</b></p> <p><b>Petr Rambousek</b> Head of Department  petr.rambousek@geology.cz</p>		<p><b>Applied Geology</b></p> <p><b>Petr Kycl</b> Head of Department  petr.kycl@geology.cz</p>	<p><b>Mineral Raw Materials</b></p> <p><b>Jaromír Starý</b> Head of Department  jaromir.stary@geology.cz</p>
<p><b>Central Laboratory Prague</b></p> <p><b>Věra Zoulková</b> Head of Department  vera.zoulkova@geology.cz</p>		<p><b>Regional Geology of Moravia</b></p> <p><b>Jan Vít</b> Head of Department  jan.vit@geology.cz</p>	<p><b>Mining Impacts</b></p> <p><b>Jolana Šanderová</b> Head of Department  jolana.sanderova@geology.cz</p>
<p><b>Central Laboratory Brno</b></p> <p><b>Juraj Franců</b> Head of Department  juraj.francu@geology.cz</p>		<p><b>Litospheric Research</b></p> <p><b>Karel Schulmann</b> Head of Department  karel.schulmann@geology.cz</p>	<p><b>Geological Exploration</b></p> <p><b>Zdeňka Petáková</b> Head of Department  zdenka.petakova@geology.cz</p>
		<p><b>Jeseník Office</b></p> <p><b>Vratislav Pecina</b> Head of Section  vratislav.pecina@geology.cz</p>	<p><b>Information Services</b></p> <p><b>Hana Breiterová</b> Head of Department  hana.breiterova@geology.cz</p>
			<p><b>CGS Publishing House</b></p> <p><b>Patrik Fiferňa</b> Head of Department  patrik.fiferna@geology.cz</p>



# Management

## Czech Geological Survey

The Czech Geological Survey is a highly respected state organization that compiles, stores, interprets and provides objective expert geological information for the state administration, the private sector and the public. It is a state-funded body, the departmental research institute of the Ministry of the Environment responsible for functioning as the state geological survey in the Czech Republic. It is the only institution tasked with the systematic investigation of the geological structure of the entire Czech Republic.

The well-established reputation of the Czech Geological Survey is based on the optimum combination of services to society with top-ranking research in geological science, natural resources, geohazards and environmental protection.

As an internationally respected scientific institution, it responds to the requirements of society for sustainable development and plays a significant role in education and in the popularization of geology.

### Main fields of activity

- Geological research and mapping
- Rock environment and its protection
- Mineral resources and environmental impacts of mining
- Geohazards, prevention and mitigation of their impact
- Geoinformation management and delivery

### Mission

- Geological mapping and regional research within the territory of the Czech Republic
- Basic and applied research on geohazards, mineral resources, groundwater sources, rock environments and environmental protection
- Serves as the state geological survey in accordance with Act No. 62/1988 Coll. (on geological work)
- Gathering, compilation and interpretation of data on the geological structure, mineral resources and geohazards of the CR

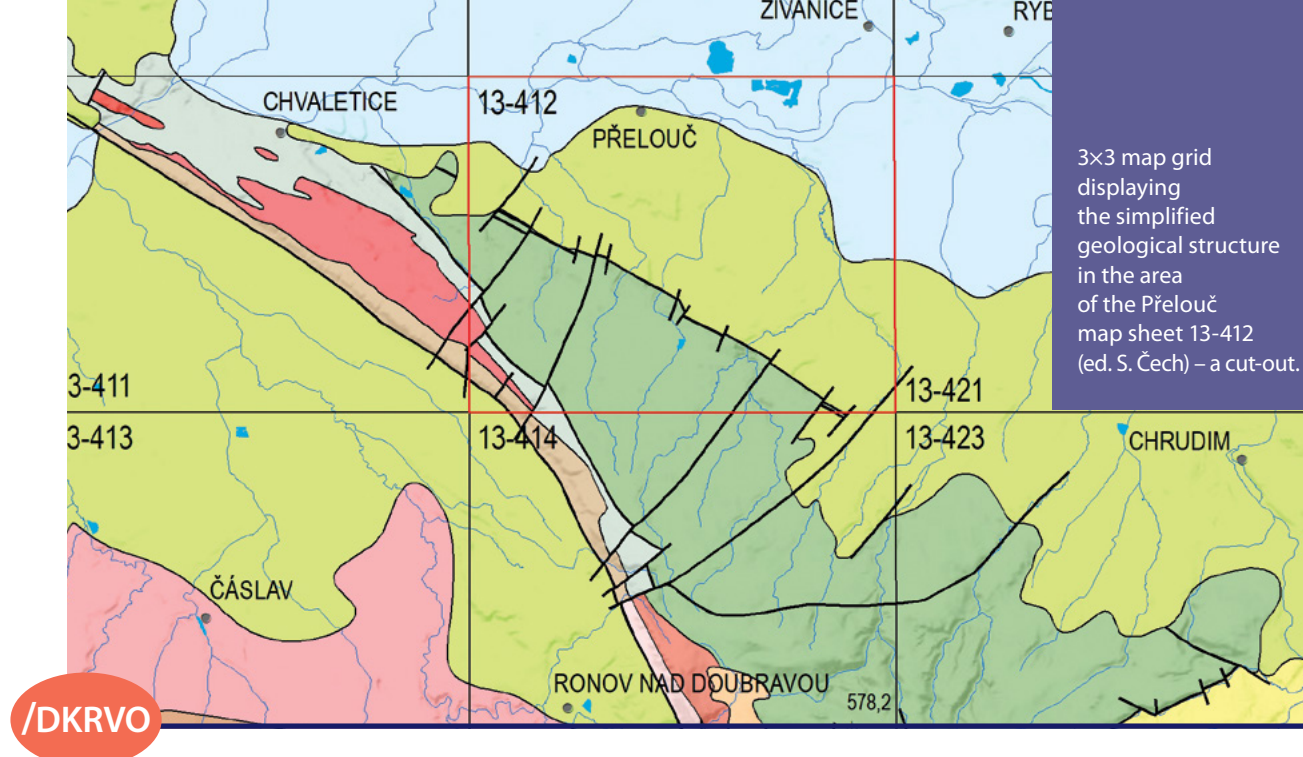
- Provision of geoscientific information and expert advice to support decision-making on issues of state and public interest
- International cooperation and foreign development aid
- Education in geosciences and environmental protection

### Vision

Through innovative research and use of the most up-to-date technology, the Czech Geological Survey will continue to provide the Czech State with the geoscientific information needed to make crucial policy decisions about energy, water and other critical resources, natural hazards and sustainable development, while working to maintain its position as a leading research institution in the field of Earth sciences.



In the middle: **Zdeněk Venera** – Director of the Czech Geological Survey.  
From the left: **Petr Mixa** – Deputy Director of the Czech Geological Survey and Deputy Director for Geology, **Zdeněk Cilc** – Deputy Director for Economics, **Vít Štrupl** – Deputy Director for the Division of Informatics, **Oldřich Krejčí** – Director of the Brno Branch, **Jan Pašava** – Deputy Director for Research and Head of the Geochemical Division and Central Laboratories.



# Geological and thematic maps



David Buriánek

Project leader for geological mapping of the Czech Republic 1:25,000

Geological maps provide comprehensive information on the geological structure of the Czech Republic. They are used for environmental protection, geohazard assessment, mineral exploration, and for land use planning.

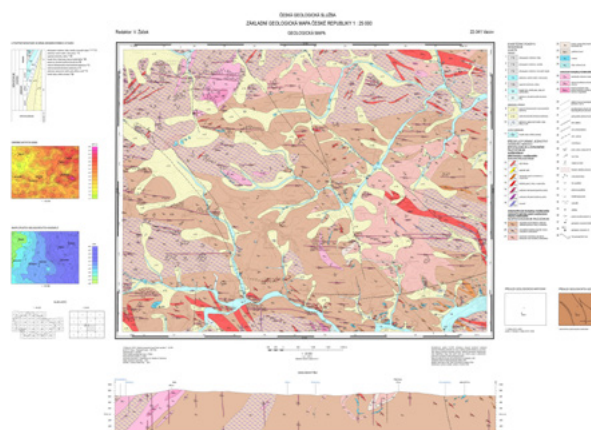
## Geological mapping

Geological mapping has been one of the main tasks of the state geological survey since its founding. Our goal lies in creating images of areas studied that reflect their geological structure and geological development by using the most modern analytical methods, including the study of the chemical composition of rocks and minerals or geochronological methods. However, geological maps are also compiled by assessing many other factors, the knowledge of which is necessary for environmental protection and which provides for increased awareness of geohazards. Newly acquired information on mineral resources, including their evaluation, has a direct economic benefit as well. Geological mapping includes not only the creation of geological and thematic maps at various scales but also the collection, processing and provision of

accompanying data files and samples. In recent decades, many geological and derived maps were compiled, focusing mainly on protected landscape areas and other places of public interest in the Czech Republic. In addition, the Czech Geological Survey has also been involved in long-term foreign projects mainly in the form of foreign development cooperation, in recent years particularly in Ethiopia.

## Geological maps at 1:25,000 scale

Currently, the research activities of the Czech Geological Survey focus primarily on mapping at a scale of 1:25,000.



▲ Geological map, Vacov map sheet 22-341 (ed. V. Žáček).



Map sheets and their explanatory notes are compiled on the basis of a unified legend, which facilitates easy connection to adjacent geological maps. Since 2003, completed geological maps have gradually been made available to the public on the geological map server [www.geology.cz](http://www.geology.cz).

The geological mapping project at a scale of 1:25,000 includes the creation of geological maps with a graphic legend, supplemented by graphic information outside the map frame. In addition to geological maps, the project also includes derived maps, such as a map of mineral deposits, bedrock maps, tectonic maps and others were compiled for specific areas. The explanatory notes to these maps contain information on the mapped areas with regard to geochemistry, geophysics, hydrogeology, engineering geology, structural geology, economic geology, pedology and environmental geology.

New geological maps are one of the main sources of information for the safeguarding and inventory of important geosites. The database of geological documentation points currently contains 115,718 entries, including 3,706 newly created geological documentation points during 2021.

At present, the regional geological mapping project at 1:25,000 scale includes work being carried out in the following six areas: the Železné hory National Geopark, the Novohradské hory Mts, the Pošumaví region, the Bohemian Paradise, Central Moravia and the former Brdy military district. In 2021, explanatory notes and associated maps at 1:25,000 scale were completed for the map sheets Vacov 22-341 and Přelouč 13-412. Explanatory notes to the Brno-jih and Veverská Bítýška map sheets at 1:25,000 scale were published at the end of 2020. A Map of Decorative Stones of the Liberec Region was completed as well.

### Contribution to land development and the ecosystem

The newly completed explanatory notes to the 1:25,000 geological maps include data gathered during field surveys as well as the results of laboratory analyses of soil, rocks and water. They provide state authorities and the professional community with information on groundwater protection zones, on the extent of slope instabilities and mineral resources. They also include selected areas deserving protection with regard to geology or landscape ecology.

### Follow-up research

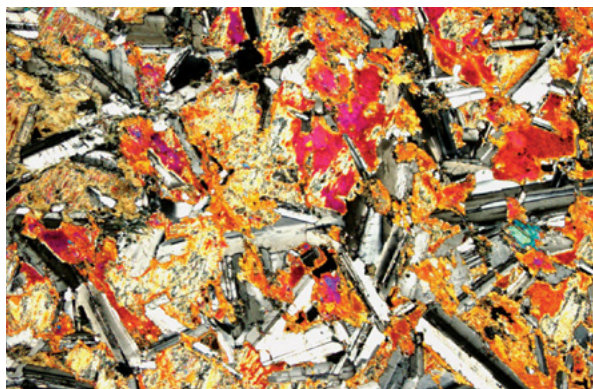
The data obtained from mapping activities contribute to a better understanding of the geological evolution of areas studied and aid in preparing many scientific publications. In 2021, several articles were published in professional journals. They involved micropaleontological, sedimentological,



▲ Profile documentation at the Předklášteří locality. Photo by D. Buriánek.



▲ View of the Chvaletice power plant tailings pond. Photo by D. Buriánek (Chvaletice map sheet 13-411).



▲ Photomicrograph of gabbro from the Brambory locality on the Chvaletice map sheet 13-411. Photo by D. Buriánek.

petrographic and geochemical research in the Předklášteří locality. The origin of phosphates in the Jesenec Limestone of the Konice-Mladeč Belt, belonging to the Drahaný Facies Domain of the Moravian-Silesian Paleozoic in Moravia, was interpreted. The migration of alkali metals in weathering profiles, which formed on migmatites in the Svatka Crystalline Unit and Moldanubicum, was addressed. The provenance of gold in the fluvial sediments of streams situated in the rocks of the Brunovistulicum northwest of Brno-Žebětín in South Moravia was dealt with as well.





Geophysical measurements on Luž Hill, the highest point of the Lužické hory Mts. Photo by V. Rappich.

## Regional geological research

Basic and applied research into the structure and evolution of the Earth's crust on a national and global scale is interconnected with geological mapping, remote sensing, and structural and sedimentological studies.

### Applied research in the Czech Republic

Contracted work dealing with the concept and future construction of a deep radioactive waste repository (HÚ RAO), which was carried out for the Radioactive Waste Repository Authority, addressed the interaction of storage overpacks with rocks in the Bukov Underground Research Facility (URF) during the "Bukov URF Interaction Experiments" project. At the same site, work performed during the "Study of Fracture Connectivity" project focused on creating a conceptual 3D geological model of the studied rock block and also on the connection and function of fracture networks. Work began on the "Bukov URF Pilot Corrosion Test" project, which will allow for a long-term test of materials in an environment simulating the conditions of the future repository. During the excavation of new areas for performing underground experiments, work was carried out on the "Geological and Geotechnical Characterization of the Rock Environment – URF II" project, which will describe the environment of the future laboratory



**Zita Bukovská**

Head of the Regional Geology of Crystalline Complexes Department

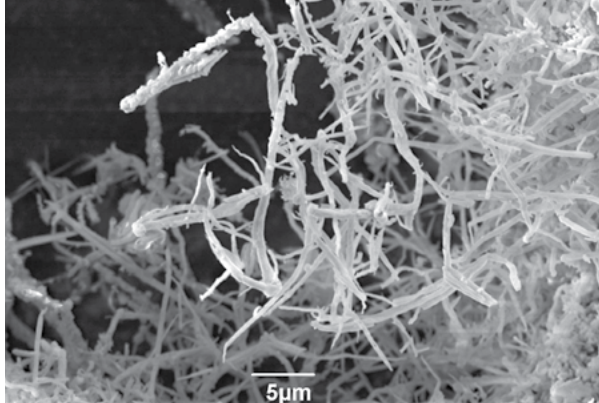


**Zuzana Tasáryová**

Head of the Regional Geology of Sedimentary Formations Department

and also prepare a system for classifying the rock mass of the repository. The "Preparation of Safety Analyses for Periodic Safety Assessment of Operated Radioactive Waste Repositories" project, which includes the preparation of 3D geological models of the wider surroundings of the existing Bratrství, Richard and Dukovany repositories, dealt with the safety of near-surface radioactive waste repositories. Results were published following previous research carried out at the Březový potok and Janoch candidate sites for the construction of deep radioactive waste repositories. The combined data were used to compile a new geological map and tectonic network of the area and its 3D model. The suitability, accuracy and scope of individual methods were discussed as well. This study presents a multidisciplinary research approach, which provides unique information necessary for understanding the subsurface geological and tectonic structure.

Climatic scenarios and relief evolution models for the upcoming two hundred thousand years, which serve as input for compiling radionuclide transport models at the model sites of



▲ The newly described mineral pertoldite, trigonal  $\text{GeO}_2$ , isostructural with quartz, was named in honour of Professor Zdeněk Pertold, a colleague and friend. Backscattered electron image by R. Škoda.

deep repositories, were completed during the Geotrans project. Reconnaissance geological mapping, emphasising the collection of brittle and ductile deformation data, was carried out for the “Groundwater in Crystalline Rocks” project in selected districts of the hydrogeological zone of the Vltava River Catchment and Kutná Hora region based on an evaluation of archived documents. Geophysical work and detailed geological mapping were performed in selected areas of the hydrogeological districts.

Within the frame of the TACR PERUN project, a geomorphological, structural and geological analysis was conducted to evaluate the spatial variability of hydraulic conductivity in model areas, which will define bodies and zones with more intensive groundwater circulation.

Last but not least, in 2021 newly acquired data were evaluated, a geological model was updated following up on drilling and geophysical activities, and documents on geological-hydrogeological issues were prepared for intergovernmental negotiations involving the expansion of the Turów mine.

Documents for survey work for future sections of the D3 motorway were completed for the Road and Motorway Directorate. Research on hazards posed by impacts of undermined areas includes the creation of a comprehensive 3D model of two selected localities affected by historical mining activities (Kaňk – mining of polymetallic ores, Mariánské Radčice – lignite mining). Selected previously created 3D models of potential deep repository sites or of the planned Sřešovice tunnel were presented in a 3D viewer on the CGS website.

### Applied research abroad

A development cooperation project compiling a geological and hydrogeological map at a scale of 1:1,000,000 for the entire territory of Ethiopia continued in 2021. The aim of the project is to collect, unify and provide current geoscientific information for potential users (state administration, local authorities, project implementers) for the purpose of setting priorities and planning with regard to natural resources and environmental protection. Furthermore, preparations began on the next phase of the international PANAFGEO 2 project,

aimed at improving the quality and technological progress of personnel in African geological surveys.

The GACR EXPRO project included the publication of a study describing the polyphase tectono-metamorphic evolution of the Altai accretionary wedge margin in western Mongolia. In terms of international cooperation, which dates back to the implementation of a development cooperation project in Costa Rica, a paper on a study of the provenance of detrital zircon in the Neogene San Carlos Basin was published.

### Applied research in the Czech Republic and abroad

The results of a field and microstructural deformation analysis, combined with U–Pb isotope dating of monazite and xenotime from an area of geological complexes at the northern margin of the Moldanubian Domain, led to a discussion and publication regarding the timing and kinematics of all phases of the Variscan orogenic cycle in the Bohemian Massif. A detailed mineralogical study of two phases of germanium,  $\text{GeS}_2$  and  $\text{GeO}_2$ , which formed by crystallization from hot gases on a burning heap of the Kateřina mine in the Trutnov region, was conducted. The research led to both phases being approved as new minerals: radvaniceite and pertoldite. Field research continued on the newly discovered diatreme near Jablonná near Chyšě in West Bohemia, which was discovered during a detailed survey of the potential HÚ RAO site Čertovka. An additional geophysical survey using ERT was conducted at the site, including the drilling of three shallow wells.

In 2021, a third map was issued in a series of thematic maps of rocks mined in the past and present for construction and decorative purposes in individual regions of the Czech Republic. The Map of Crushed and Decorative Stones of the Liberec Region displays localities with occurrences of rocks suitable for architectural or artistic use on a geological base map, supplemented by information on their petrographic classification and by descriptions of stone objects.

Basic research activities involving sedimentary geology and volcanology included published multidisciplinary studies conducted in the Czech Republic and abroad. The climate changes studied spanned the Paleozoic (Silurian global stratotypes in the Prague Basin), Mesozoic (Turonian greenhouse effect in the Bohemian Cretaceous Basin) and Tertiary (Miocene climatic fluctuations in the Most Basin).

International activities included research on Late Archaic granite in Canada, geoarchaeological research on a Late Bronze Age earthquake in Macedonia, and Czech-Polish cooperation also involved the compilation of paleogeographic maps and floristic studies in the Intra-Sudetic Basin.





Silurian sediments in the Broken River area (Queensland, Australia) record the largest collapse of the global carbon cycle in the last 500 million years.

/DKRVO

# Research on global changes and evolution of life in the geological past

Jiří Frýda and team

Coordinator of research  
on past global changes

The study of global changes and evolution of life in the geological past focuses mainly on global events (bioevents), which significantly affected the development of the entire biodiversity of the marine or terrestrial ecosystem. With the aid of paleontological, sedimentological and geochemical methods, the CGS research team analyses changes in selected abiotic characteristics of the paleoenvironment and parameters characterizing the evolution of paleodiversity in periods prior to, during and after global crises. Therefore, the analysis of paleodiversity development includes time-consuming taxonomic, paleoecological and paleobiogeographic research.

Research results in 2021 were published in the form of papers in scientific journals with impact factors (24 papers) and in peer-reviewed journals and presented at lectures and on posters at international conferences. The main research results were published in the following scientific journals: *Earth-Science Reviews*, *Scientific Reports*, *Nature Communications*, *Palaeogeography*, *Palaeoclimatology*, *Palaeoecology*, *Life*, *Earth and Planetary Science Letters*, *Chemical Geology*, *Sedimentology*, *Palaeobiodiversity and Palaeoenvironments*, *Bulletin of Geosciences*, *International Journal of Paleopathology*, *Fossil Record*, *Papers in Palaeontology*, *Historical Biology*, *Journal of Quaternary Science*, *Review of Palaeobotany and Palynology*, *Palaeontographica*, *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen* and *Sedimentary Geology*. Significant results were also presented as separate chapters in two scientific books (published by the Geological Society, London, and Springer). Several members of the “Global Changes” team participate in the research activities of two IUGS subcommittees, specifically the Subcommission on Devonian Stratigraphy and Subcommission on Silurian Stratigraphy (International Commission on Stratigraphy).



The “Marine Paleozoic” team provides full editing and technical support and publishes the international IF-indexed journal *Bulletin of Geosciences*. In 2021, the journal included 25 scientific papers comprising 511 pages (Volume 96, 2021). In 2021, the *Bulletin* received an impact factor of 1.6, ranking it in the second quartile among the world’s leading paleontological journals. Today, the *Bulletin of Geosciences* is one of the most prominent scientific journals published in

the Czech Republic thanks to the editorial board’s long-term efforts.

In addition, the members of the “Global Changes” team serve as “instructors” for Ph.D. students at Charles University and at the Czech University of Life Sciences, where they are engaged as guarantors of several fields and also give several lectures to master’s and postdoctoral students (“Evolution of Global Ecosystems”, “Geochemistry”, “Paleoecology” and partly “Zoology”).



▲ Carbonate mud mounds in Lower Devonian strata at Hamar Laghdad, located in the eastern part of the Moroccan Anti-Atlas, facilitate analyses of seawater and hydrothermal fluid interaction.



▲ *Scyphocrinites elegans* Zenker from the Silurian–Devonian boundary in the Moroccan Anti-Atlas.



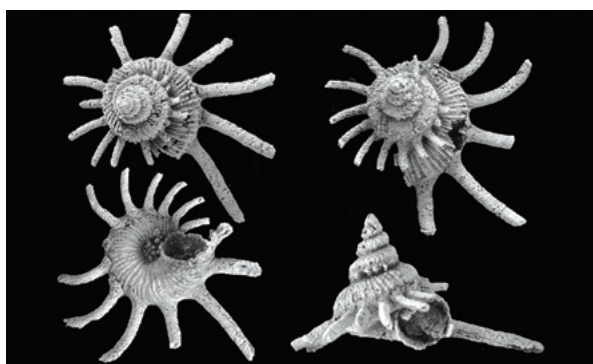
▲ Carboniferous crinoid columnalia from Oklahoma, USA.



▲ Disintegrated shells of gigantic Silurian cephalopods from Morocco.



▲ The oldest known nacre from the Carboniferous sediments of Oklahoma. Original marine aragonite facilitates the analysis of the isotopic composition of seawater.



▲ The Silurian gastropod *Spinicharybdis krizi* Rohr, Blodgett and Frýda, named in honor of Dr. Jiří Kříž, the most important post-war paleontologist and stratigrapher of the CGS.

# Mineral resources

The supply of mineral resources forms the basis for the economic and technological development of the Czech Republic. The task of the Department of Minerals Research and Raw Materials Policy of the Czech Geological Survey deals with the study of new resources of minerals, their future prospects and research into the laws governing their formation.

By participating in expert assessments and legislative activities, the department's staff contributes to the safeguarding and efficient use of minerals in the regions of the Czech Republic. In 2021, 11 full-time and four part-time researchers and one technician of the department focused on virtually all commodities, with the exception of crude oil and natural gas. Attention is mainly directed towards resources and indications of critical and strategic metals, industrial minerals and energy minerals (coal and uranium) and on the use of minerals, particularly construction minerals, in land use planning in the regions of the CR. Particular attention was also paid to the impacts that mining and processing of raw materials has on the environment and human health, primarily in areas of current lignite mining and in abandoned mining districts. Work activities also included legislative support for state authorities in preparing the raw materials policy of the CR, development of new methods for studying mineral deposits, and mining heritage research. Due to the past year's COVID-19 pandemic, work abroad was carried out to a limited extent, focusing primarily on environmental issues in developing countries and along the Czech-Saxon border. During economic geology projects, the staff cooperated with a number of top research institutes at the national as well as international level and participated in



**Petr Rambousek**

Head of the Department of Mineral  
Resources Research and Policy

the education of students and professionals. The research activities of economic geologists is part of the Long-Term Conceptual Development of Research Organizations for 2018–2022, and the assessment and expert activities carried out by economic geologists fulfil the mission of the state geological survey.

## Critical and strategic raw materials study

The "Rock Environment and Natural Resources - RENS" project continued in 2021. The project is co-funded by the state through the Technology Agency of the Czech Republic (TACR) under the Environment for Life Programme. The main goal of this very extensive project involves studying, monitoring and evaluating the status of the rock environment, natural resources, geohazards and geological information throughout the Czech Republic. Newly acquired knowledge will serve state authorities as well as professionals and the public.

The project is divided into four thematic fields of research – Minerals, Groundwater in the System of Karst Areas, Geohazards – Landslides and Geohazards, and Undermined Areas. In 2021, the Minerals research theme included a detailed selection of relevant critical and strategic minerals based on the current list of critical raw materials of the EU and on selected strategic raw materials of the Czech Republic. Subsequently, key archival material began to be collected for these important raw materials.

At the same time, field work commenced at selected sites: sampling and processing of representative mineral samples, geophysical work and thematic geological mapping. The obtained samples were chemically analysed and subjected to other specialized study according to the nature of mineralization, such as separation of mineral phases, their identification, morphological analysis using electron



microscopy combined with analysis of backscattered electrons and so forth. To aid the prospecting for hidden resources, remote geophysical methods began to be used under the subcontract "Application of Methods of Satellite-Borne Geophysical Analysis in the Central Part of the Krušné hory Mts".

The study and identification of strategic minerals in bodies of surface deposits included field reconnaissance and deposit sampling in the prospective areas of the South Bohemian and Plzeň regions.

A methodology standardizing procedures for identifying accumulations of strategic commodities and the conditions for using strategic minerals was compiled and will be submitted for certification in the near future.

Research into new technological processing methods for graphite raw material continued. A study of new methods for obtaining concentrates of strategic and rare raw materials (for instance, Au, In, W, Ge, REE, etc.), continued with technological research and development involving the verification of methods for processing samples of gold-bearing raw material. At the same time, a study for optimizing the Ge-coal combustion process was conducted. Current information and a newsletter of the project are available on the website <https://rens.geology.cz>.



▲ Collecting metallometric samples from test pits at the Utín locality during the RENS project. Photo by P. Rambousek 2021.

The year 2021 was the last year of the four-year project "Acquisition of Strategic Raw Material Deposits" (STRASUR), conducted under Government Resolution No. 713/2017 based on a horizontal cooperation agreement with the DIAMO state enterprise. The project focused on assessing the importance and perspectives of individual sites of strategic raw materials (SNNS) of the Czech Republic in four thematic pillars. The first of these was an inventory of strategic mineral deposits and resources. A total of 169 detailed inventory records were made and also stored with supplemented mining and technical parameters in the thematic information system IRIS managed by the DIAMO state enterprise.

These inventory records yielded seven selected localities that were recommended for further verification by geological survey and for possible deposit safeguarding. The second research pillar involved a revision of samples, based on which the contents of rare earth elements at the Mo-Nb-Zr sources at Hůrka near Čistá and also the In contents in samples from the Zlatý kopec and Krupka localities were examined. The third pillar included field research aided by satellite and ground-based geophysics at the Homolka locality with Nb(Ta)-Sn-Li mineralization, of a Sn-Li source in the Smrčiny massif and W (Bi, Te) at Vysoká near Havlíčkův Brod.

The fourth pillar involved technological research focused on more energy-efficient processing of Li raw materials and thorough utilization of waste after its treatment, on increasing the efficiency of processing graphite from South Bohemian deposits, and on the possibility of recovering scheelite concentrate via dry method. Additional technological research was linked to the above-mentioned resources (REE+Y concentrates from the Hůrka source, Nb-Ta concentrates from Homolka) that were verified in the field and with archived samples.

The TACR project project "Study of Be, Ge, Ga and In Contents in Tailings Ponds of Ash From Coal Combustion in the Czech Republic", funded under the BETA2 programme, was completed under the leadership of GET Ltd in cooperation with the University of Chemistry and Technology Prague (UCT Prague) aimed at a general assessment of the raw material potential of fly ash deposits of power plants. Promising sites were surveyed by drilling boreholes and evaluated chemically and technologically. The Tisová ash tailings pond was studied in detail. The output of the project produced a summary and technological report with inventories of sources and their detailed mapping.

The TACR project "Research on the Raw Material Potential of Strategic Minerals in Brines of the Bohemian Massif" was launched in cooperation with UCT Prague and led by GET Ltd. The project aims to provide a critical investigation focused on brines and mineralized water as a potential raw material for obtaining industrially usable strategic minerals, elements or salts, to evaluate the qualitative and quantitative parameters of the world's most important mined deposits, to parameterize processing capacities in Europe, to examine the occurrences of brines and mineralized water in the Czech Republic, to provide comparisons with global equivalents, and to competently define occurrences suitable for follow-up research. The most suitable locations for research wells are to be specified based on a study of selected sites, field reconnaissance and identified conflicts of interest.



A key goal of the project is to evaluate the possibility of using mineralized water in the Czech Republic as a potential source for obtaining industrially usable strategic minerals, elements or salts and to provide related research on environmentally friendly methods for their recovery.

The EU GeoERA project ([www.geoera.eu](http://www.geoera.eu)) was completed after an extension due to the pandemic situation in autumn 2021. The CGS was involved in two mineral projects. In the *Mintell4EU* subproject (<https://geoera.eu/projects/mintell4eu7>), the CGS was engaged in updating the European Minerals Yearbook and entering data into the EU database and information system of important EU mining expos. The data are gradually integrated into the joint EU information infrastructure EGDl (<https://www.europe-geology.eu/>), managed by EuroGeoSurveys. In the second sub-project *FRAME* (<http://www.frame.lneg.pt/>), the CGS collaborated on the compilation of a metallogenic map of critical raw materials in Europe, on studies of the critical battery raw materials and raw materials from critical countries (Nb, Ta), and on a study focused on indications of phosphate with elevated REE concentrations and on the exploitation of abandoned mines and their dumps and tailings ponds for critical raw materials. In addition to the updated EGDl database, the final reports on the topics addressed are available on the project website. The final presentation and meeting of project leaders took place via a hybrid conference on 28 September 2021 in Lisbon, Portugal.

### Additional mineral resources projects

In June 2021, in cooperation with GET Ltd and the University of Chemistry and Technology in Prague, the CGS commenced work on the TACR project “Research on Promising Mineral Fillers and Quartz Raw Materials in the Bohemian Massif, Their Treatment and Use for Modern Industrial Applications”. The project is based on the need to identify promising previously unmined sources of mineral fillers and quartz raw materials in the Czech Republic, to carry out field reconnaissance, to define the potential of verified prognostic resources, and to assess the technological possibilities of their industrial use. One important task also involves recommending the use of the studied resources to the private business sector.

The department’s employees also participated in other specialized research, such as a study of geochemical parameters of vein and fissure mineralizations in a selected rock block in the environment of the Bukov URF during the new projects Connectivity and Bukov 2.

Projects funded by the Ministry of the Environment (MoE) include a “Geological and Metallogenic Study of Selected Ore Deposits and Mineralizations of the Bohemian Massif”, “Demarcation of Prognostic Moldavite Resources (Category Q)

in the Cadastral Area of Dolní Svince in the South Bohemian Region”, and a “Revision of Prognostic Resources of Industrial Minerals and Ores, Category Q, in the South Bohemian Region”.

Economic geology experts were thoroughly involved in compiling and finalizing mineral maps and relevant explanatory notes for the internal project “Regional Geological Mapping of the Czech Republic at 1:25,000 Scale”. The Pohorská Ves (32-422), Vacov (22-341) and Horní Stropnice (33-133) maps were processed in this manner.

### Mining heritage research

Economic geology specialists collaborated on the publication “Proposed Description and Evaluation of Mine Workings”, which was based on observations and recommendations of a project completed in 2019.

Remnants of historical mining and processing of minerals were continuously documented during field surveys of other projects, predominantly carried out in historical mining districts.

### Environmental impact of mining

As part of the geological mapping project of the Czech Republic at 1:25,000 scale, environmentally significant elements – heavy metals in soils were monitored in the Železné hory Mts. In 2021, the As, Be, Cd, Co, Cr, Cu, Hg, Ni, Pb, V and Zn concentrations in soil cover were evaluated in the area covered by Vilémov map sheet 13-432.

Soil samples from surface and subsurface horizons were collected at sampling points, measured with a portable PXRF device, and samples thus selected were more accurately analyzed using other methods. Field and laboratory work involving the Chvaletice 13-411, Chrudim 13-423 and Ronov 13-414 map sheets continued to be carried out.

The cross-border project “recomine Saxony–Czechia” (EU) deals with the remediation of ecological impacts from the region’s past mining of ore and industrial minerals and with modern use and technological processing of mineral resources of the Krušné hory Mts. The project, which commenced in June 2021, aims to create a professional network of companies, research, academic, non-governmental and administrative institutions dealing with the remediation of old impacts and modern use of mineral resources in the Krušné hory Mts. The Wirtschaftsförderung Erzgebirge GmbH, Helmholtz-Zentrum Dresden-Rossendorf e.V., and the Czech Geological Survey collaborate on the project. It is a follow-up to a project implemented on the Saxon side (<https://www.recomine.net/de/>). Future challenges, focused already on specific topics, will rely on the created network of contacts.

Processes that occur during pyrolysis of coal and uranium heaps in the Žacléř region were experimentally studied in 2021, as part of sub-goal 3.1.2 DKRVO. It was discovered that the volatility of potentially hazardous elements changes significantly with the pyrolysis temperature. Mercury is already mobilized at a temperature < 500 °C, while other elements (In, Sb, Tl, Zn, As, Mo, Sn, Pb, Se and Cd) are released at a pyrolysis temperature of 700–900 °C.

The influence of uranium minerals on the physical and chemical properties of coal matter was studied on non-burning heaps in the Žacléř region.

Abroad, CGS mineral experts collaborated on studies of impacts of ore mining and processing in the mining districts of Namibia, Zambia and Botswana. Work activities in Namibia focused on studying the redistribution of mercury during bush fires near a smelter in Tsumeb. The study showed that many elements (including As and Hg) are redistributed during fires and that the total area contaminated with these elements increases significantly. A study in the Kabwe (Zambia) area, which was heavily affected by the emissions from a lead smelter, revealed that the contamination is associated only with the uppermost soil horizon (depth of 0–20 cm). Very high concentrations of Pb and Cd were also detected in dust particles collected in the vicinity of public roads. A study of environmental aspects at the abandoned Mn ore deposit of Kanye (Namibia) confirmed that the greatest hazard stems from redeposition of flotation waste, which contains high concentrations of As and V. Villages in the immediate vicinity of the abandoned mine are particularly affected by the redeposition of flotation waste left over from Mn ore mining.

### **Legislative support for the use of minerals and their significance for land use planning**

The TACR project “Elaboration of a Methodology for Regional Raw Materials Strategies” led by the CGS in cooperation with GET Ltd was completed in 2021. The project’s goal was to combine methodological procedures for preparing raw material strategies at the regional government level into a proposed method, which was tested in Central Bohemia, including the capital city of Prague, and in the Karlovy Vary Region. The methodology was handed over for certification to the Ministry of Industry and Trade (MIT) acting as project guarantor, and the studies were handed over to the regions and the capital city of Prague for use in their strategic planning.

At the end of the year, a commentary on the SEA process “Update of the Regional Raw Materials Policy of the Liberec Region (2020)” was completed, in which CGS mineral specialists were actively engaged, and the Regional Office

of the Liberec Region handed over the document to the MoE for approval.

A proposal for the “Update of the Regional Raw Materials Policy of the South Bohemian Region” study was completed. The potential critical shortage of primary aggregate resources for public construction projects continued to be analyzed for the MIT in 2021. A “Study of the Availability of Aggregates for Planned Motorway and Road Network Construction and Planned Railway Corridor Construction” was prepared in cooperation with the Mining Association, the Road Contractors Association and selected planning companies. A “Study Evaluating the Current Status and Perspectives of Construction Mineral Use in the Czech Republic with Emphasis on Crushed Stone and Sand and Gravel” was updated and completed, in cooperation with the Mine Planning and Consultancy Office, the Road Contractors Association of the Czech Republic and the Mining Association. The study evaluated the status and prospects for using deposits and resources of crushed stone and sand and gravel in the Czech Republic, the lifespan of existing realistically recoverable reserves of mined deposits, including those that will foreseeably be exhausted in 5 to 10 years.

### **Expert assessments**

While performing the tasks of the state geological survey, regional economic geology experts provide administrative authorities with expert assessments, studies and documents for administrative and strategic decision-making, the most important of which are the following:

- Assessment of the CGS regarding the Notification of the Intent No. MŽP506 “DP and POPD Cínovec – approval of mining lease and partial extraction of Li-Sn-W ore reserves via underground mining”.
- Update of selected data for the needs of the Regional Office of the Liberec Region and implementation of the Regional Raw Materials Policy of the Liberec Region concerning the use of building material deposits – particularly the lifespan of reserves at deposits in the Liberec Region and adjacent regions in the near future.
- Joint meeting regarding the proposal of change No. 12 of the Land Use Plan of the municipality of Kájov.
- Expert consultancy involving the preparation of the 5th complete update of the Land-Use Analysis Document of the South Bohemian Region.
- Assessment of documents for the land use proceedings regarding the construction project “Modernization and Full-Capacity Use of Vodňany – Nová Hospoda Road I/20, Layout 2+1”.
- Assessment for the public hearing regarding the Land-Use Plan of the municipality of Trnávka.



Preparation to flow rate measurement of the Hrádecký Stream with a StreamPro instrument, "Groundwater in Crystalline Rocks" project. Photo by J. Grundloch.

/DKRVO

# Groundwater research and evaluation



**Lenka Rukavičková**  
Hydrogeological  
research coordinator

Groundwater is an important component of the environment and, at the same time, an irreplaceable source of drinking water. Due to declining groundwater reserves in some areas of the Czech Republic and to the need for their protection, this field of research by the CGS is becoming increasingly important. The research focuses on evaluation of climate change and effect of long-term drought and mining activities on natural groundwater resources. Part of the research focuses on particularities of groundwater protection in karst areas, in places with mineral water occurrence, and in areas comprising crystalline rocks. The aspects of finding a suitable environment for siting various types of underground repositories are also addressed.

## Study of natural groundwater sources and their protection

Research in 2021, including the monitoring of the status of ground and surface water, continued in the border area of the Frýdlant Salient and Hrádek in the Liberec Region. Here, the deepening of the Polish Turów mine has a long-term effect on the hydrogeological conditions and groundwater sources in shallower as well as in deeper Tertiary aquifers. The research results were used, for instance, to bring an action before the court of the European Commission and for a bilateral agreement between the Czech Republic and Poland. The aim of the TACR project "Targeted Replenishment of Groundwater as a Tool to Reduce Drought Impacts in the Czech Republic" is to introduce changes in groundwater management. The changes involve shifting from a passive approach to water protection in the form of restricting its use to an active approach leading to an increase in groundwater reserves in the landscape. An interactive map layer is being compiled in order to aid the Ministry of the Environment in providing subsidy programmes and to provide the state administration with information on localities suitable for targeted replenishment. The "Groundwater in Crystalline Rocks" project continued in 2021. The aim of the project is to identify suitable areas for new groundwater sources in three hydrogeological zones





▲ Martínkov well drilled to a depth of 50 m during the “Groundwater in Crystalline Rocks” project. Photo by R. Hadacz.

consisting predominantly of metamorphic and igneous rocks. The primary objectives are identification of the areas most affected by hydrogeological drought, collection of data for determination of water retention in the landscape, as well as development of methods for evaluating groundwater reserves in this specific environment.

The PERUN project focuses on evaluating the status and temporal changes of natural groundwater sources, predicting their evolution, and studying the sensitivity of selected natural systems with regard to dry spells and climate change in the Czech Republic.



▲ Flow rate measurement of the Kyselá voda Stream near České Budějovice using the salt dilution method, PERUN project. Photo by J. Holeček.

The protection of natural curative sources of mineral water is also dealt with in a general way and in specific problematic localities (such as Lázně Skalka) as well.

The research topic “Groundwater in the System of Karst Areas” was dealt with during the “RENS: Rock Environment and Minerals” project. The research aims to determine the impacts of anthropogenic activity and climate change on hydrogeological structures in the karst areas systems and on their recharge zones. The research includes the Moravian Karst, Hranice Karst, Javoříčko and Mladeč Karst, and Chýnov Karst.

### Applied hydrogeology

Specialists in hydrogeology and hydrochemistry are engaged in several applied projects dealing with underground disposal of high-level waste.



▲ Sampling of groundwater in the Císařská Cave in the Moravian Karst, RENS project. Photo by R. Hadacz.



▲ Sampling of groundwater from a research borehole near the newly excavated underground research laboratory of the Radioactive Waste Repository Authority in the Rožná mine. Photo by L. Rukavičková.

Work activities in underground laboratories include the monitoring of changes in the regime and chemical composition of groundwater in the vicinity of on-site storage site mock-ups and hydrogeological documentation during the excavation of a new laboratory in the Rožná mine. An interdisciplinary collaborative effort also dealt with groundwater associated with geothermal energy and with CO<sub>2</sub> storage in underground spaces.

### International cooperation

Extensive international cooperation with hydrogeologists from European geological surveys continued under the GeoERA programme on the following projects: Pan-EU Groundwater Resources Map (compilation of a pan-European hydrogeological map), CHAKA (typology of karst areas in Europe), and GeoConnect<sup>3d</sup> (method for preparing and publishing geological information including geological models).



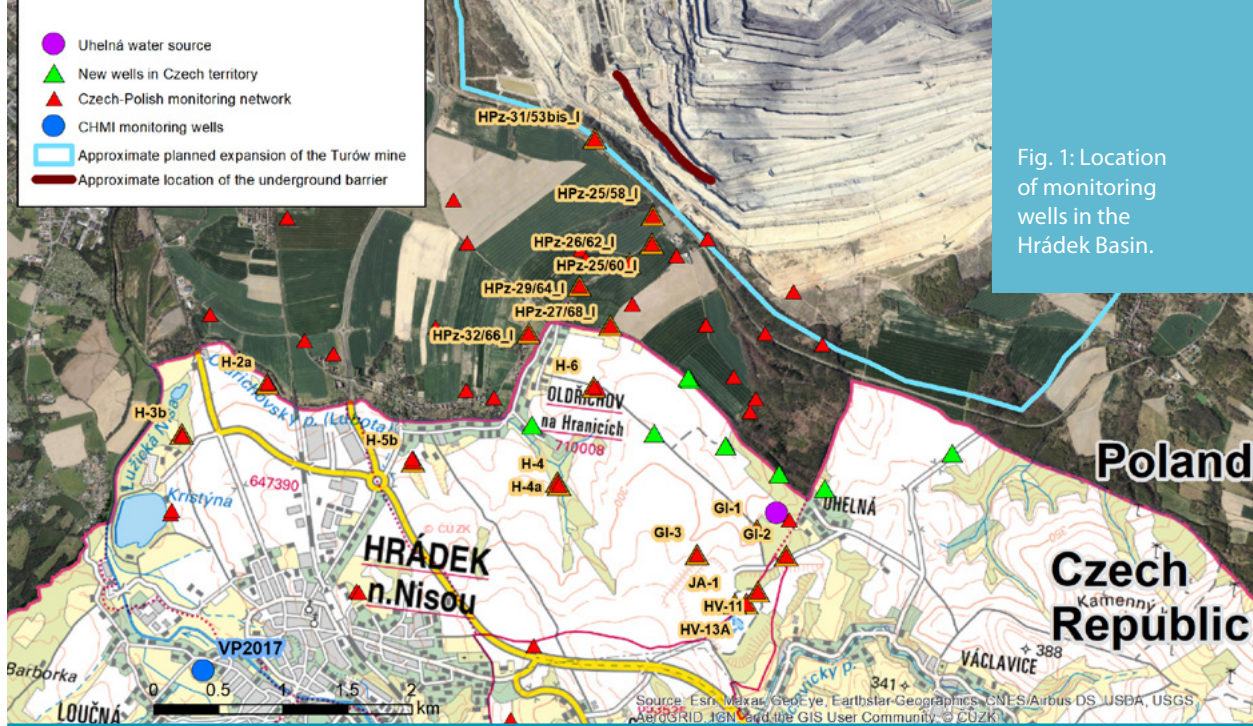


Fig. 1: Location of monitoring wells in the Hrádek Basin.

## Changes in groundwater levels in the vicinity of the Turów mine



Ondřej Nol  
Hydrogeology  
and hydraulics expert

In 2020 and 2021, the CGS added 18 monitoring wells to the groundwater monitoring network and also ensured that streamflow gauging stations were reconstructed on surface streams in Czech territory near the Turów mine. All data (newly acquired and historical) were evaluated in detail, and the conclusions were used to resolve a dispute between the Czech Republic and the Republic of Poland regarding the Turów mine's impact on the Czech border area.



Renáta Kadlecová  
Turów  
project manager



Zdeněk Venera  
Director of the Czech  
Geological Survey





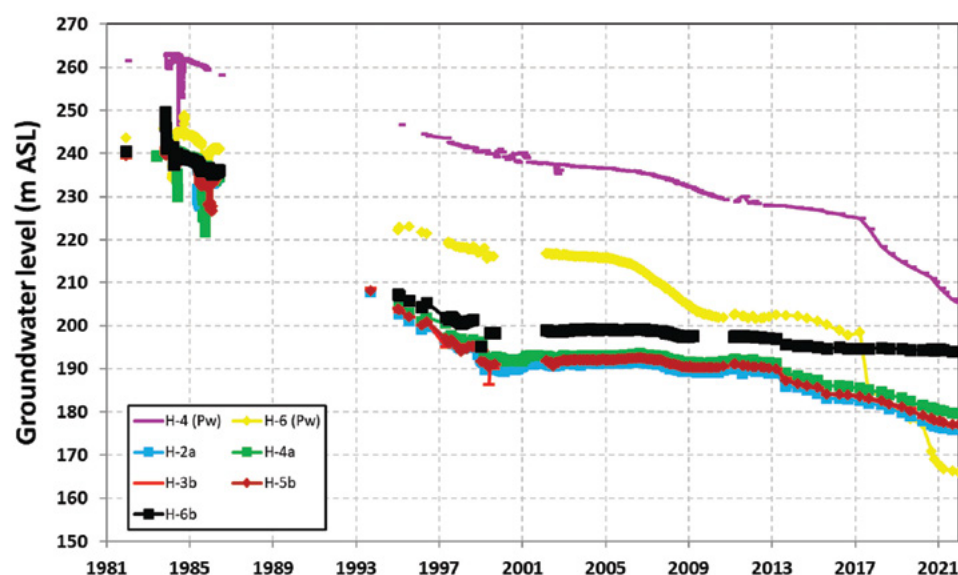
In Czech territory, the surroundings of the Turów mine include the Hrádek part of the Zittau Basin, which is filled with sediments and volcanic rocks of Tertiary age. The basin fill forms several aquifers at various depths and with different behaviour in groundwater levels. The Tertiary sediments are covered by Quaternary sediments, locally up to several tens of metres thick, which together with the uppermost Tertiary sediments form a groundwater aquifer used for water management. The groundwater of this aquifer has been used by the Uhelná water source since the 1960s (Fig. 1).

### Groundwater level decline in deeper aquifers

After the Poludřový fault, which was considered an impermeable barrier, was mined out in the Turów mine in the mid-1980s, groundwater levels in the Czech and Polish territories fell by roughly 50m in deeper Tertiary aquifers by 1999. The groundwater level decline had slowed down since 1999, and the groundwater level more or less stagnated or decreased only slightly until 2013 (Fig. 2). In 2013–2019, the groundwater level fell by another 10m (Fig. 2), despite reducing the pumping of water at the southern hydraulic barrier from a maximum of 90 l/s in 1991 to 15 l/s in 2014. Groundwater pumping at the southern hydraulic barrier prevented groundwater inflow into the Turów mine from the south after the Poludřový fault was mined out. In 2021, the Polish side stated that the pumping rate was very low at the hydraulic barrier and that groundwater was spontaneously seeping into the Turów mine at a rate of 2.4 m<sup>3</sup>/min (40 l/s) at the site of the mined-out Poludřový fault. A total decline of groundwater levels in deeper Tertiary aquifers of more than 70 metres was recorded (Fig. 2) as of January 2022. The groundwater level is currently at an all-time low (Fig. 2) in deeper Tertiary aquifers in Czech territory (except for the H-2a well).



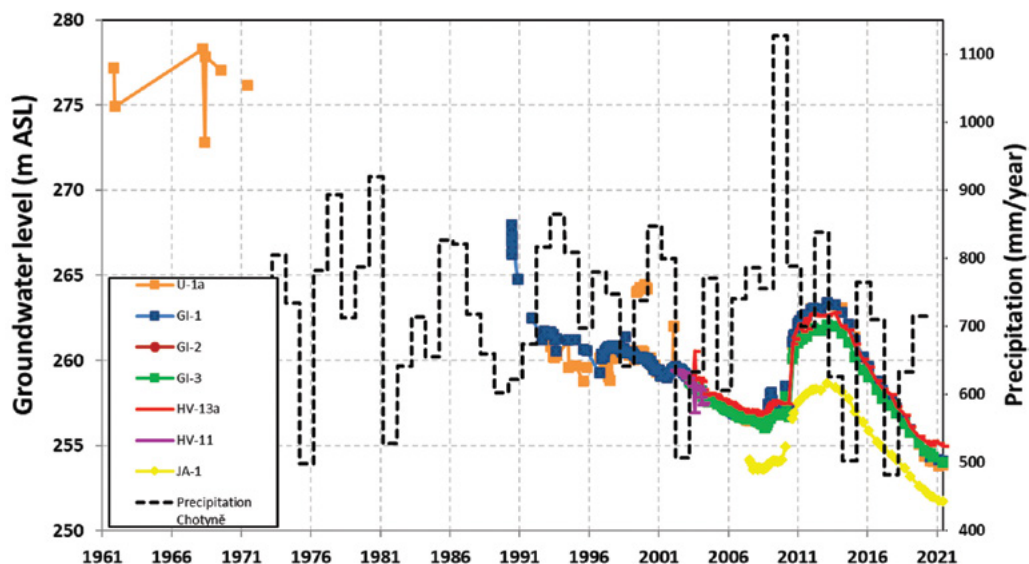
▲ Turów mine.



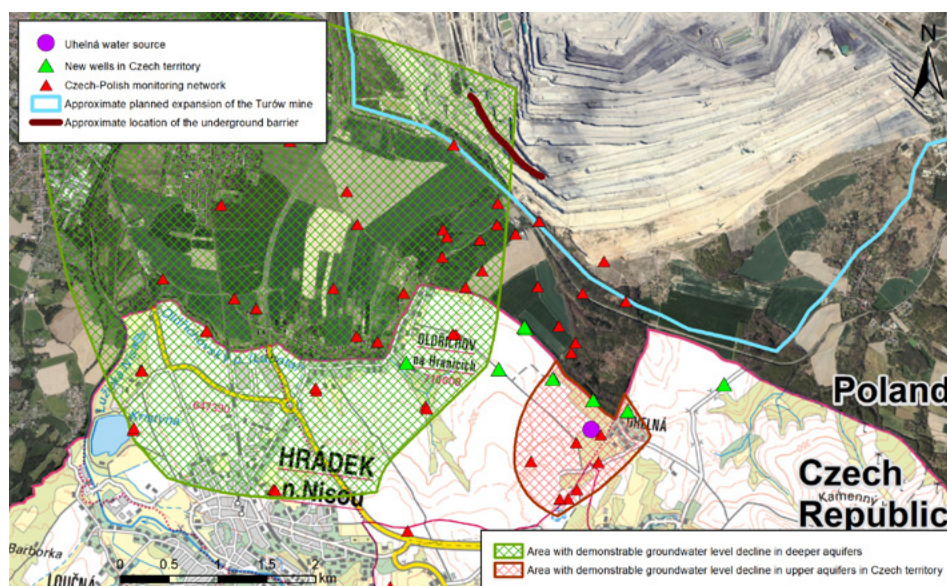
◀ Fig. 2: Changes in groundwater level in selected Czech wells in deeper aquifers.

## Changes in groundwater levels in the vicinity of the Turów mine

► Fig. 3: Changes in groundwater level in upper aquifers near the Uhelná withdrawal area.



► Fig. 4: Demarcation of areas with demonstrable groundwater level decline.



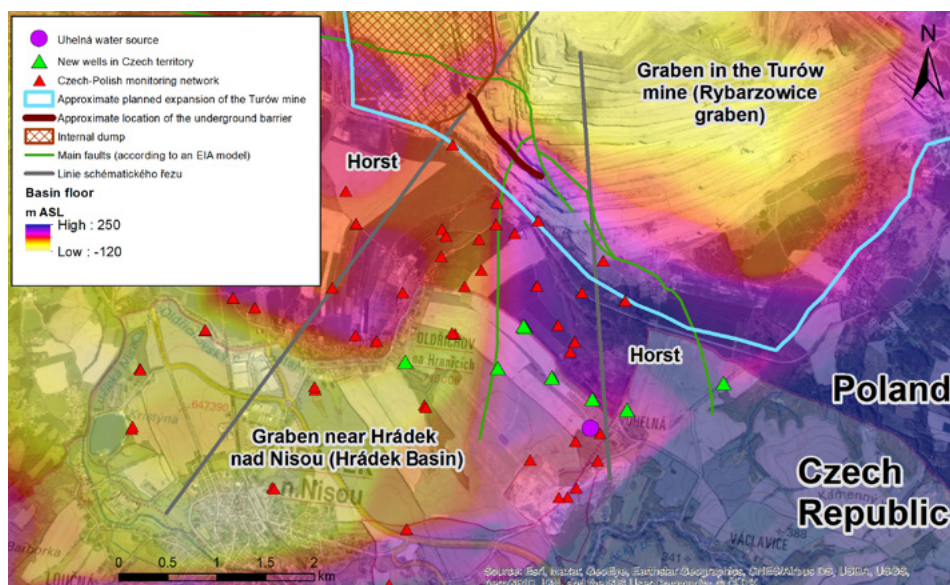
Groundwater level declines in deeper aquifers are documented in an area north and northeast of Hrádek nad Nisou, in Oldřichov na Hranicích, and between the southwestern edge of the Turów mine and the Czech-Polish border (Fig. 4). This area of the Czech Republic includes the deepest parts of the Zittau Basin. Such a sharp drop in the groundwater level was not detected eastward towards Uhelná because the base of the Zittau Basin rises here considerably (by up to 200 m). The surroundings of Uhelná and its northern stretch toward the Turów mine lie on a raised block (horst), which separates two graben – in the Czech Republic near Hrádek nad Nisou and Oldřichov na Hranicích with the highest groundwater level declines and in Poland in the Turów mine – the Rybarzowice graben (Fig. 5).

Deeper aquifers located on the horst itself are monitored by the Czech-Polish monitoring network in the Polish part in the Turów mine's forefield. However, the monitored decline of groundwater levels here is not as high as in the surroundings of Hrádek nad Nisou and in Oldřichov na Hranicích. Here, the groundwater levels are roughly 40–50 m higher than in Oldřichov.

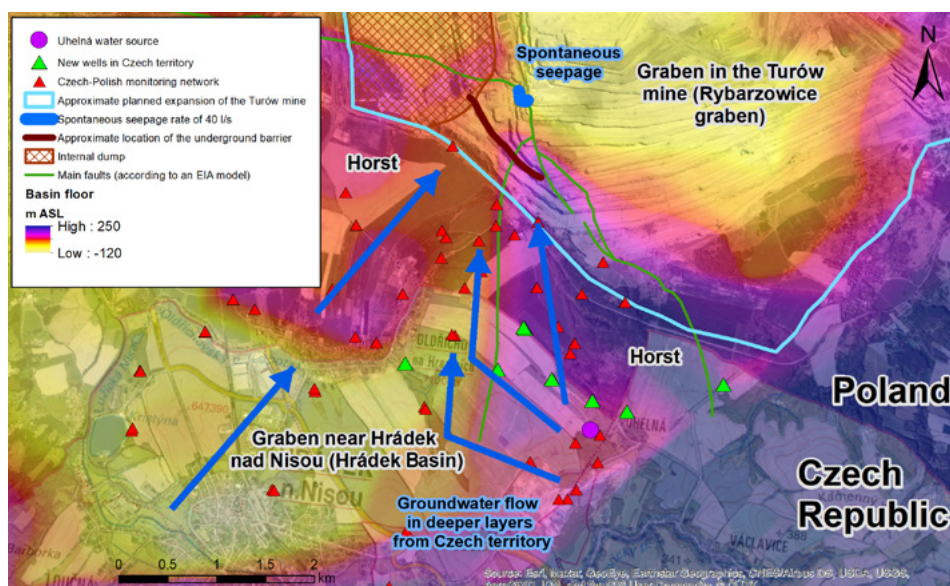
### Groundwater level decline in upper aquifers

In Czech territory, long-term monitoring of groundwater levels in upper aquifers is carried out only in the vicinity of the Uhelná water source (Fig. 3). At present, groundwater is withdrawn at a rate of about 7–8 l/s from the Uhelná water source at a depth of 75 m.





◀ Fig. 5: Base of the Zittau Basin with lines of schematic geological cross-sections.



◀ Fig. 6: Base of the Zittau Basin and possible directions of groundwater flow into the Turów mine.

In 1962–1972, when the Uhelná waterworks was already in operation, the groundwater table fluctuated at a maximum level and more or less stagnated at a depth of roughly 30–44m below ground level. The groundwater level near the waterworks was already lower than the usual depth of shallow domestic wells. Groundwater levels were not monitored in the upper aquifers in Czech territory during 1973–1992 (when, as mentioned above, the Poludřový fault was mined out in the mid-1980s and when groundwater levels simultaneously fell in deeper aquifers). Regular monitoring of groundwater levels, which commenced in 1993, showed that the groundwater levels in the vicinity of Uhelná were 13–15m lower than in 1962–1972. In 1993–2009, the groundwater level gradually fell by another 6–7m. After the floods in 2010, when even the mine was

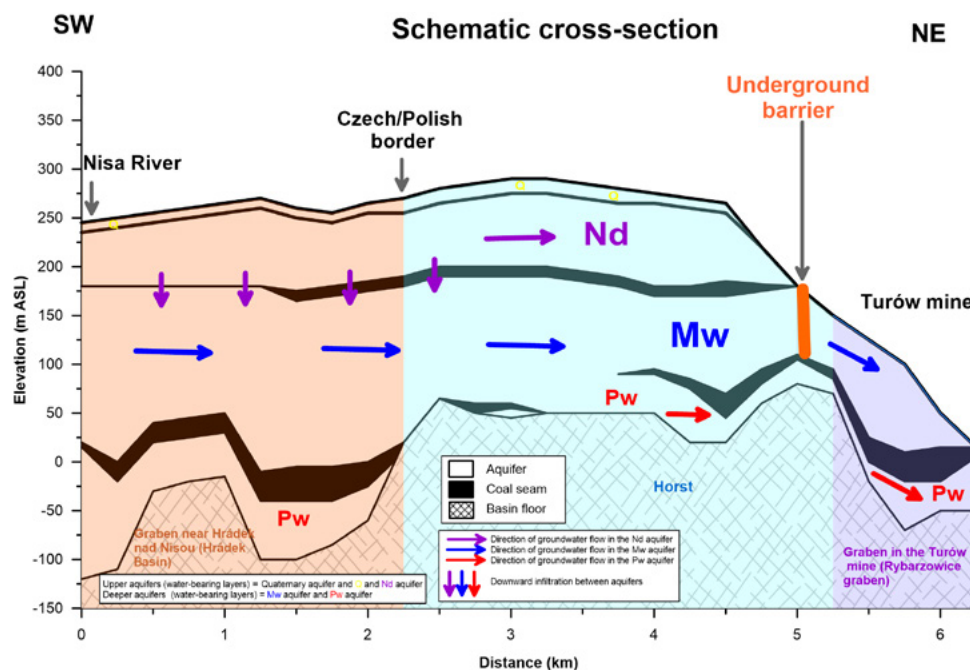
partially flooded, a sharp groundwater level rise lasted until 2014, when the groundwater level was even higher than in the first half of the 1990s.

Since 2015, which marked the onset of a period of hydrological drought, the groundwater level in upper aquifers has been declining steadily to the current historical minimum in January 2022. The groundwater level near the Uhelná waterworks currently fluctuates at 53–67m below ground level and has fallen by about 20m over the past 50 years.

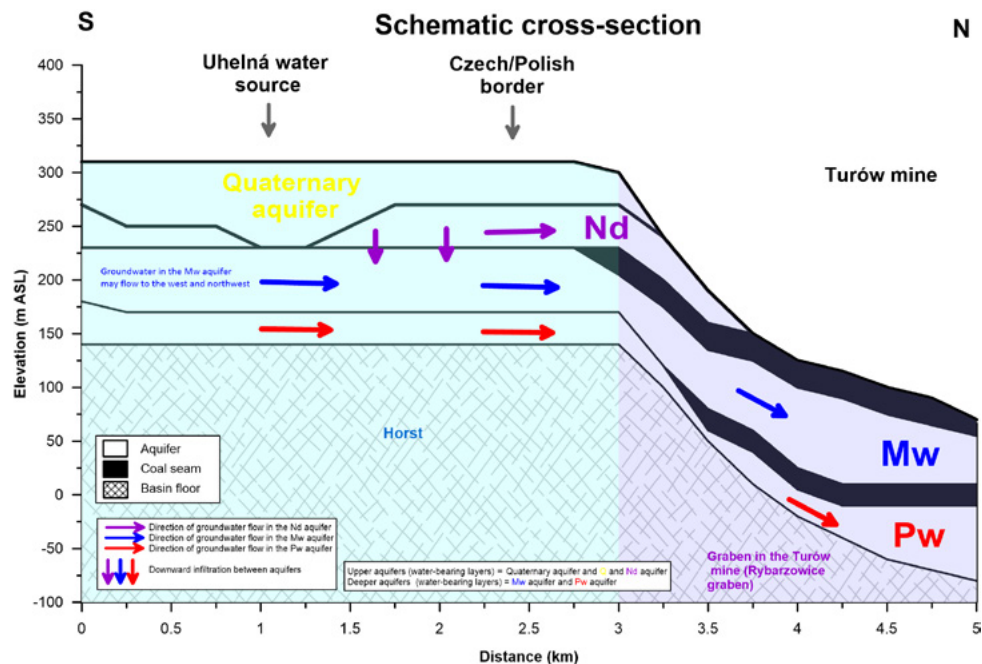
The groundwater level declines in upper aquifers have been recorded in the vicinity of the Uhelná water source. This is the only area in Czech territory where the groundwater level is being monitored over the long term in upper aquifers. New wells near Uhelná have been monitoring groundwater

## Changes in groundwater levels in the vicinity of the Turów mine

► Fig. 7: Schematic geological cross-section in the area of Hrádek nad Nisou.



► Fig. 8: Schematic geological cross-section in the Uhelná area.



levels since 2020. Here, the extent of the impact on the upper water-bearing layers may be greater, but it cannot be demonstrated because long-term groundwater level measurements are not available.

### Impacts on the groundwater status

The decline of groundwater levels in deeper aquifers is caused only by the activities of the Turów mine, with which the Polish side agrees. The groundwater level decline

probably affected the upper aquifers as well. However, in addition to the activities in the Turów mine, the magnitude of precipitation, the effect of drought, and the actual groundwater withdrawals at the Uhelná waterworks also contribute to the groundwater level fluctuations in upper aquifers.

The groundwater in the upper aquifers flows mainly toward the Turów mine and some of it flows to the Uhelná water source, where it is pumped. The groundwater flow paths





▲ Turów mine.



to the Turów mine are not entirely known. Groundwater may flow directly to the active mining sites of the Turów mine, but groundwater has not been pumped here thus far and neither has groundwater seepage directly in the mine been documented here. The second possibility is that the groundwater in deeper aquifers flows from the horst towards Oldřichov na Hranicích to areas with the highest groundwater level declines and subsequently to areas where the Poludňový fault was mined out and where groundwater spontaneously seeps into the Turów mine.

### Groundwater status and underground wall construction at the beginning of 2022

An underground impermeable barrier is being built roughly at the site where the Poludňový fault was mined out (Fig. 5). On a slope north of the mined-out Poludňový fault (Fig. 6), spontaneous groundwater seepage occurs in the Turów mine. The Turów mine is building the underground wall not only to prevent the flow of groundwater from Czech territory but primarily to minimize groundwater inflow into the mine, thereby enabling and facilitating the mining of coal. In 2021, 200 injection wells were drilled along the line of the underground impermeable barrier. According to current information from the Turów mine, a sealing compound was injected into all the wells and its effectiveness is currently being tested. Additional sealing

will take place depending on the results. June 2022 is the deadline and completion date for the underground impermeable barrier. Annual monitoring and evaluation will be conducted thereafter.

The groundwater levels in nearly all the Czech wells (monitoring upper and deeper aquifers in Czech territory) fluctuated at an all-time low as of January 2022. A positive effect of the underground barrier has not yet been observed. The last joint measurement took place at Polish wells in autumn 2021. The groundwater levels in the monitoring wells continued to decline in deeper wells. Another joint Czech-Polish measurement will take place at the Polish wells in April 2022.

If the underground impermeable barrier wall fulfills its function, groundwater levels will cease to decline or begin to rise in the deeper aquifers, which are closest to the underground barrier on its southern side (on the inlet side). A cessation of the decline or rise of groundwater levels should gradually be recorded in the Polish wells and subsequently in the Czech wells of the Czech-Polish monitoring network. If it is shown that the Turów mine is responsible for a further decline in groundwater levels, the Polish side will implement additional measures under a concluded agreement, such as the expansion or deepening and re-sealing of the underground barrier wall, so that maximum groundwater protection is ensured in the Czech Republic.

/DKRVO

## Geoenery research

The social importance of geoenery technologies has been growing in recent years, particularly with regard to the approved ambitious goal of achieving climate neutrality at the EU level by 2050. Research topics such as the use of geothermal energy as a renewable source, underground energy storage or geological storage of carbon dioxide aiming to reduce its atmospheric concentration and thus its contribution to the greenhouse effect are attracting widespread attention among professionals and the general public, and they are being integrated in national decarbonisation strategies. This also places new demands on research institutes that deal with these issues.

The CGS engaged intensively in these areas of geoenery research in 2021. Many national and international projects were carried out; a significant part of the research was conducted in close cooperation with other research institutes in the Czech Republic as well as abroad, and also in cooperation with private companies.

### Geothermal energy

The main activity in 2021 involved the preparation of the new national project SYNERGYS (Systems for Energy Synergy), which was selected as one of the strategic projects of the Ústí nad Labem Region under the Just Transition Fund. Its aim is to test the synergy of various technologies for the production and use of renewable energy sources (geothermal source, photovoltaics, green hydrogen production, and waste heat) in combination with the possibility of storing thermal energy in a geothermal energy storage facility for later use.

The international project MUSE (Managing Urban Shallow Geothermal Energy), co-funded by the Horizon 2020 programme within the GeoERA action was completed at the end of 2021. The project addressed the use of shallow geothermal energy in densely populated areas. The project pilot area in the Czech Republic was the territory of the capital city of Prague. A number of results have been produced, including methodologies and recommendations for resolving

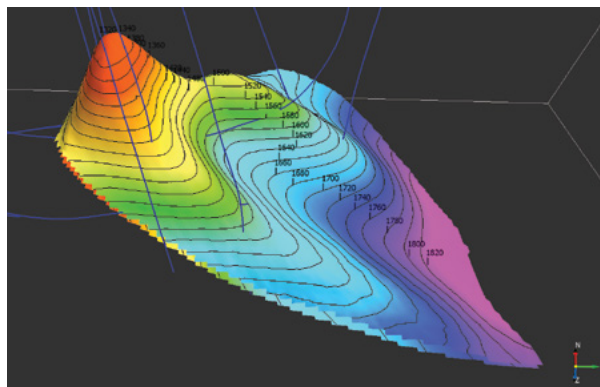
Measuring the CO<sub>2</sub> concentration in soil gas at the Zar-3 site during the CO<sub>2</sub>-SPICER project.



Vít Hladík

Geoenery  
research coordinator





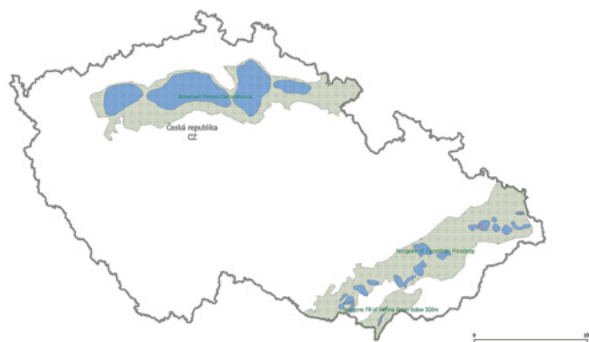
▲ 3D view of the surface of the reservoir rocks (Jurassic Vranovice carbonates) at the Zar-3 field, view from the south.

conflicts of interest arising from geothermal energy use. These documents will subsequently be used in current and future projects dealing with the use of shallow geothermal energy. The TACR project (THETA Programme) “Analysis of the Geothermal Potential of the Czech Republic” entered an advanced stage. In 2021, the collected geothermal measurement results were evaluated and source data were prepared for compiling updated map of the geothermal potential on the territory of the Czech Republic at depths of 400–5,000 m. These new maps will set a new standard for evaluating the geothermal potential of the Czech Republic and contribute to the development of this renewable energy source.

The result of the European project HotLime (Horizon 2020 – GeoERA), completed in autumn 2021, is a joint Czech-Austrian cross-border 3D model of Jurassic sediments of South Moravia and Lower Austria with temperature distribution at the surface and base of these sediments. The model was included in a European study on deep-seated geothermal resources in carbonate rocks.

### Geological storage of carbon dioxide

The primary research activity with regard to geological storage of CO<sub>2</sub> involved the Czech-Norwegian CO<sub>2</sub>-SPICER project (CO<sub>2</sub> Storage Pilot in a Carbonate Reservoir), funded by Norway Grants through the TACR KAPPA Programme. Its main objective is to prepare the selected Zar-3 hydrocarbon field in Southeast Moravia for conversion into a pilot carbon dioxide storage site. The initial phase of the project focused mainly on collecting, consolidating, verifying and harmonizing input data, constructing a 3D geological model of the storage complex, evaluating geochemical and geomechanical properties of rocks and fluids in the storage reservoir and its surroundings, specifying the main risks associated with the storage site operation, and examining the usability of various monitoring methods for long-term monitoring of the stored CO<sub>2</sub>.



▲ Map of the Czech Republic depicting areas and structures potentially suitable for underground hydrogen storage, evaluated in the HyStorIES project.

### Underground energy storage

In 2021, the CGS joined the new European project HyStorIES (Horizon 2020 programme), which focuses on evaluating the possibilities for geological storage of hydrogen in depleted hydrocarbon fields and aquifers in 22 European countries. For the purposes of the project, several potentially suitable areas and structures in the Bohemian Permo-Carboniferous basins, in the Neogene of the Carpathian Foredeep, and in the Neogene of the Vienna Basin were evaluated.

Geological storage of hydrogen is also the research theme of the internal CGS project “Possibilities for Underground Hydrogen Storage in the Geological Settings of South Moravia”. Its goal is to evaluate the geological conditions in the area of the southeastern slopes of the Bohemian Massif and the Vienna Basin in terms of their suitability for hydrogen storage. The initial phase in 2021 focused on gathering and examining subsurface exploration data and geological information on hydrocarbon fields in the area of interest.

### Use of subsurface voids created by mining

The TACR project (THETA Programme) “Controlled and Assisted Microbial Methanogenesis in Situ” (2018–2022) continued in 2021. Analyses of coal, water and gases were conducted in the closing coal mines of the Karviná region and in the SD Bílina, Tušimice and Vršany lignite mines. Detailed chemical analyses of gases and microbiological genome (DNA) analyses were performed.

### Subsurface management

The international multidisciplinary project GeoConnect<sup>3d</sup> (Cross-border, cross-thematic multiscale framework for combining geological models and data for resource appraisal and policy support), co-funded by the Horizon 2020 programme (GeoERA action), was completed in 2021 with the participation of the CGS. It focused on the use of geological modelling for resource management and utilization of underground structures (subsurface management).



Surface runoff (Černý Stream) from the Filc peatland in Lysina, characterized by an extremely high concentration of dissolved organic carbon. Photo by K. Pérez Rivera.

/DKRVO

# Geosphere– biosphere– atmosphere interactions



**Martin Novák**

Head of the Environmental Geochemistry and Biogeochemistry Department

Environmental studies belong to core research activities of the Czech Geological Survey. Projects results are highly recognized by the international scientific community and the general public. Research on geosphere–biosphere–atmosphere interactions includes interdisciplinary studies using biogeochemistry, isotope geochemistry, hydrology, biology and ecosystem modelling.

Results published in 2021 involve three fundamental areas: i) long-term monitoring of biogeochemical and hydrological cycles in the GEOMON network of small forest catchments, ii) studies in the most polluted areas of the

Czech Republic (Ostrava, mountain peaks and areas impacted by traffic and mining), iii) studies on the impact of climate change and the mechanism of harmful substance release from soil into water or possibly into the food chain. Such extensive research cannot be carried out solely by the CGS and requires significant cooperation with the following research organizations in the Czech Republic: University of South Bohemia in České Budějovice, Global Change Research Institute of the Czech Academy of Sciences (CAS), Biology Centre České Budějovice (CAS), University of Life Sciences (CZU) – Faculty of Environmental Sciences, Faculty of Mathematics and Physics and Faculty of Science of Charles University, and the Czech Hydrometeorological Institute (CHMI). International collaboration with the Norwegian Institute for Water Research, University of New Hampshire and Pennsylvania State University (USA), Dresden Technical University and University of Bayreuth (Germany), Swedish Environmental Research Institute, French University of Lorraine, Metz and CEREGE, Aix-en-Provence (France), University of Bristol (UK), University of Saskatchewan (Canada), and Sun Yat-Sen University (China) is of equal importance.





▲ Winter sampling lysimeters at U Dvou louček, Orlické hory Mts. Photo by P. Pacheroová.

### i) Small catchments

Intensive agricultural and industrial production increases the amount of nutrients in global ecosystems, which leads to changes in biodiversity and to qualitative changes in soil and water (eutrophication). One of the most effective elements causing eutrophication is nitrogen (N). At the same time, its excessive amount in the environment can stimulate plant growth, thus partially increasing the capacity of terrestrial ecosystems to sequester carbon (C) from anthropogenic CO<sub>2</sub> emissions. The extent of nitrogen retention in forests was quantified using stable N (<sup>15</sup>N/<sup>14</sup>N) isotopes and long-term measurement fluxes of nitrogen (N) in catchments. The amount of nitrogen that is returned to the atmosphere in the form of N<sub>2</sub>O and N<sub>2</sub> through denitrification was determined more accurately. The rate of global denitrification in forest ecosystems is estimated at 8.9 Tg per year. This amount is equivalent to 39% of annual nitrogen deposition.

Large-scale dieback of monoculture forests in recent years is urgently raising the question as to what extent the current forest management model is capable of coping with risks associated with climate change. Forest production is purposefully tuned to the conditions of the past century and is currently reaching its limits, particularly in areas where evapotranspiration approaches the amount of precipitation. These areas are situated mostly at altitudes of 450–600 m ASL. In connection with climate change, the most striking phenomenon is the continuous rise of average annual air temperature. At intermediate altitudes (450–800 m ASL), where most of the GEOMON forest catchments are located, the years 2014–2018 were more than 2 °C warmer than the long-term average in 1961–1990 (5.4 °C). Average precipitation in 2014–2018 was fifteen percent lower compared to 25 years before, when the monitoring of the catchments began. The result of lower annual



▲ Regular monthly monitoring of precipitation and soil water at Načetín, Krušné hory Mts. Photo by J. Čuřík.

rainfall combined with higher temperatures is a significant decrease in surface water runoff (45 percent lower than the average for the same period 25 years before).

Analysis of yield trends at selected springs of the Šumava Mts indicates a long-term decline. During the course of the year, the highest decline occurs in the spring months of April and May. This corresponds to changes in the precipitation and temperature regime. Although the annual rainfall decrease is not statistically significant, a considerable decrease occurs during April and November, simultaneously with a substantial temperature rise in April and summer months. Predictions of future development anticipate extreme runoff conditions, when more floods but also dry spells may be expected.



▲ Winter collector of atmospheric precipitation and litterfall trap for plant organs – Načetín, Krušné hory Mts. Photo by J. Čuřík.



▲ Sampling of peat moss – Blatenská slať bog, Šumava Mts. Photo by E. Přechová.

Monitoring of  $\delta^{26}\text{Mg}$  values in precipitation, runoff and soil water at the Na Zeleném locality allowed for quantification of Mg sources in runoff. The presence of  $\delta^{26}\text{Mg}$  increases in the following order: precipitation in open areas, throughfall, runoff and soil water, which reflects contributions of Mg released from three main reservoirs – rocks, soil and vegetation.

Data on concentrations of toxic lead in precipitation and runoff are processed for all forest catchments, and annual balances and their development over time are calculated from 1996 until the present. The input of lead ranged between 430–4,953  $\mu\text{g}/\text{m}^2/\text{year}$  and output between 55–3,043  $\text{g}/\text{m}^2/\text{year}$ . The highest amount of water-soluble and bioavailable lead occurs in the uppermost layer (45 and 48%) and roughly 20% in deeper layers.

The current and future generation of runoff from the Lysina forest catchment was successfully simulated in collaboration with Chinese modellers using two American models (BROOK and PIHM). Until the end of this century, the projected climate change will negatively affect the amount and timing of surface runoff.

## ii) Areas of high pollutant deposition

Emission and deposition levels are monitored in the Ostrava area in cooperation with CHMI. The influence of local emission sources is assessed based on the isotopic composition of nitrogen and sulphur.  $\text{SO}_2$  emissions come from industrial

sources in the Ostrava region and transboundary transport from the Polish part of Silesia.  $\text{NO}_x$  emissions are generated mainly by intensive transport, along with coal combustion. The sources of carbon in dust particles were determined at eight sites in the Ostrava region, including their subsequent accumulation in soil.

A detailed study of the soil composition along the pollution gradient east of base ore processing plants in the Polish part of the Upper Silesian Basin, along the elevational gradient of the slopes of Lysá hora Mountain in the Moravian-Silesian Beskydy Mts, and in anthropogenically stressed urban areas



▲ Filtration of water in the Pluhův bor catchment for analysis of cations and trace elements. Photo by P. Krám.



▲ Preparation of a peat moss sample for an incubation experiment. Photo by I. Jačková.





▲ Sharp-crested measuring weir in the Pluhův bor catchment (the brown water in the flow measurement vessel is due to a high concentration of organic carbon). Photo by P. Krám.

of Ostrava helped to identify the sources of atmospheric deposition of toxic elements and their transfer into soil and plants. Concentrations and isotope ratios of lead and strontium were determined at three additional sites (Olomouc, Hradec, Brno) and used for source apportionment. Emissions from the Bílina Open Pit were evaluated using carbon isotopes in a study specifying the balance of coal emissions. Antimony deposition in vertical and horizontal winter precipitation was monitored at nine sites in the Czech Republic (border mountains with elevations of roughly 1000 m). The extent of atmospheric antimony deposition under these climatic and geographic conditions ranges between low and heavy pollution at an average value of  $1.3 \cdot 10^{-4} \text{ g} \cdot \text{m}^{-2} \cdot \text{yr}^{-1}$ . The average Sb concentration in winter precipitation was  $0.62 \text{ mg} \cdot \text{l}^{-1}$ . This concentration represents the sum of the concentrations of soluble and insoluble antimony in snow (i.e., in vertical precipitation) and soluble and insoluble antimony in rime (i.e., in horizontal precipitation). An evaluation of the trajectories of air mass transport revealed that the main emission areas are the Silesian region in Poland and the Ostrava region in the Czech Republic. The main mechanism for removal of antimony from the atmosphere at these elevations is soluble antimony in snow.

### iii) Study of the mechanism of pollutant release

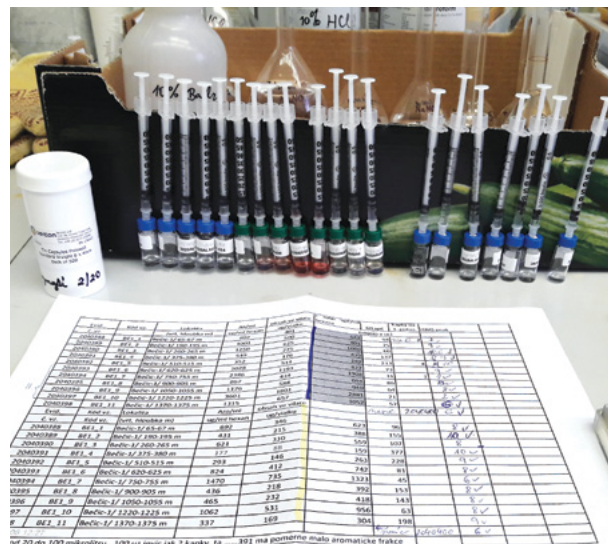
The mechanism of arsenic release from agricultural soils was monitored in soil from the Polabí region. Arsenic, bound in adsorption complexes with iron and organic carbon, is released into surface water due to the thermal decomposition of these complexes. Antimony from vehicle emissions



◀ Sampling of snow – elevational gradients on Lysá hora Mountain, Beskydy Mts. Photo by O. Šebek.

captured in the upper layers of soil is also released into plants due to the decomposition of the adsorption complex. The decomposition dynamics of organic matter in soil was monitored during a comprehensive experiment in the Krušné hory Mts. Here, the soil chemistry was modified by artificially adding sulphur and nitrogen in order to achieve different levels of acidity of soil with varying tree cover. The experiment with various types of litterfall demonstrated that the ability of microorganisms to decompose organic matter was reduced as soil acidity increased. By contrast, increased nitrogen availability had virtually no effect on litterfall decomposition.

Because individual rock-forming minerals represented in weathered soil differ in terms of abundance, content of elements of interest and susceptibility to weathering, laboratory experiments of sequential leaching of minerals were performed to determine the dissolution rates. These experiments combined with a study of the isotopic composition of Ca and Mg will help determine what role chemical dissolution in incongruently weathered rocks actually plays in runoff generation.



▲ Preparation of samples for measurement of aliphatic and aromatic hydrocarbons on a DELTA instrument. Photo by L. Burešová.



View of pylon V423/883 with a highlighted active accumulation zone of landslide 24-34-09/4a from 2010. Photo by O. Krejčí.

/DKRVO

## Geohazard research

The main scope of work involved the development of the geodatabases “Inventory of Slope Instabilities of the Czech Republic” and “Radon Index Maps of the Bedrock 1:50,000”. In the case of the Inventory of Slope Instabilities, a new “Documentation and Systematizing Method for Recording Slope Deformations for the Purpose of Unifying and Modernizing an Integrated Publicly Accessible Information Portal” was completed and submitted for review.



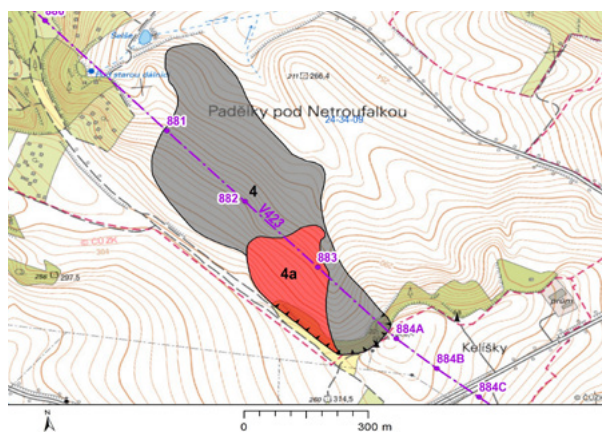
**Oldřich Krejčí**  
Geohazard research  
coordinator



**Ivan Barnet**  
Head of the Geochemical  
Hazards Department

The new methodology is based on the original and thus far used documentation method, which was an output of the project “Compilation of an Interactive Map of Slope Stability Hazards and Rock Falls in the Czech Republic” from 2011. This methodology, although still in use, is no longer adequate due to the development of new methods. The new methodology integrates new trends regarding geographic information systems (data preparation, DMR 5G – LiDAR) and is based on published classifications of slope movements. The uniformly developed methodology with new components focuses particularly on the following goals:

- well-arranged presentation of the informative value of published information (metadata),
- presentation of primary and mainly interpreted data to professionals, the public and public authorities,
- update of attribute tables for geodatabase maps and records and addition of newly monitored types and properties of slope instabilities, including an updated field inventory form,
- long-term active and targeted updates of data related to slope instabilities, editing and refinement of data,
- links to national systems and connection to pan-European systems (INSPIRE, global information and data infrastructures).



▲ Pylon V423/883 is located in the active landslide area 24-34-09/4a and its exposure to the landslide is inspected annually by CGS staff.





▲ Reactivation of an old landslide during a construction pit excavation at the Leitnerova and Kopečná street intersection in the built-up part of the city centre of Brno. Photo by O. Krejčí.



▲ Drilling of an engineering geology borehole with a depth of up to 30 m on the sidewalk on Anenská Street in Brno to determine the depth of the landslide's rupture surface. Photo by O. Krejčí.



▲ Main scarp of an old landslide in a construction pit at the Leitnerova and Kopečná street intersection in Brno. Photo by O. Krejčí.



▲ Czech Geological Survey employees making a log of the engineering geology borehole on Anenská Street in Brno. Photo by O. Krejčí.

Engineering geology research was also carried out in co-operation with operators of transport and transmission line structures (Road and Motorway Directorate of the Czech Republic, Railway Administration, ČEPS a.s. – Czech Transmission System Operator). Employees of the Czech Geological Survey were thus engaged in dealing with specific practical problems involving the construction of motorways, high-speed railway lines and tunnels as well as inspections of endangered high-voltage pylons. Many practical recommendations were issued regarding key existing and future structures.

Published outputs focused on engineering geological models of large planned structures and on a landslide analysis in Peru. Map outputs concentrated on photogrammetric models of landslide areas, obtained by unmanned aerial vehicles and by evaluating the level of hazard posed by slope movements in the southern part of the Chřiby Mts in the Carpathian Flysch Belt. The research outputs were also used by citizens, cities, municipalities and the State Environmental Fund to evalu-

ate applications for grants from European funds from the Operational Programme Environment in accordance with valid programme documents.

Radon risk from the bedrock is one of the serious geohazards that directly influences the population's exposure to radiation. The significance of dealing with radon occurrence in the bedrock lies, among other things, in the fact that it is followed-up by interdisciplinary monitoring of radon concentrations in potable water and building materials. The project results contributed to a detailed assessment of natural radioactivity, which is classified among geohazards.

International cooperation activities in 2021 were restricted due to anti-virus measures. It was only possible to hold the 15<sup>th</sup> International Workshop on the Geological Aspects of Radon Risk Mapping, which was postponed in 2020. Participation in foreign congresses and conferences in 2021 was limited to web meetings. Foreign work activities were conducted to a limited extent only in Ethiopia and Georgia.



Černolice Rocks.  
Photo by  
K. Motyčková  
and J. Šír.

## Regional Geological Administration



Jan Čurda

Head of the Regional Geological Administration

The activities of regional geologists and experts on economic geology and hydrogeology, including assessment activities, are carried out in the entire territory of the Czech Republic as required by Act No. 62/1988 Coll., on geological work, as amended.

The activities are conducted regionally. This implies a subdivision of the country's territory into variously defined regions for which a relevant regional geologist or specialist bears responsibility. Relevant internal methodological guidelines define the core areas of activity of the regional geologists and specialists (basic research, practical and organizational activities, documentation, assessments and other activities) to ensure that the expert activities are performed in an operational, high-quality and methodologically uniform manner. The most frequently performed tasks of regional geologists and specialists include expert assessments, which primarily involve geohazards, conflicts of interest, land-use planning, environmental impacts of structures and technology, zoning and construction management, mitigation of old ecological burdens, mining-related problems and nature conservation planning, and which are based on written requests by public authorities. This systematic acquisition, collection, conservation and, in

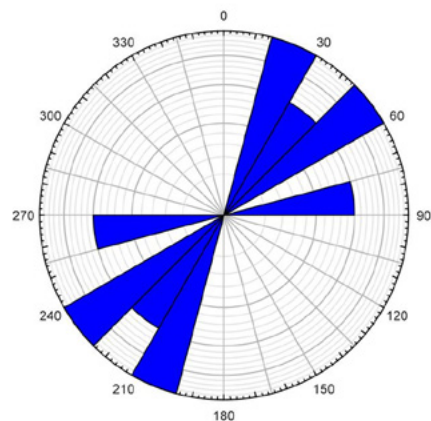
particular, processing and ensuing provision of data on the geologic setting of the national territory, on the protection and use of natural resources and groundwater, and on geohazards, subsequently serve as a basis for political, economic, judicial and ecological decision-making, for instance, in land-use planning, environmental protection, remediation of old ecological burdens and slope instabilities, landscape and natural resource protection, and for principles underpinning the ecological stability of areas and so forth.

In 2021, the entire external as well as internal filing agenda of the Regional Geological Administration of the CGS was run completely on-line via the Regional Geological Administration's agenda application on the CGS internet portal. The agenda management system is constantly being fine-tuned and upgraded so that it continues to accommodate the requests made to the Regional Geological Administration, which seeks to manage the ever-increasing demand for high-quality assessment services. The Regional Geological Administration's digitized agenda, running on software stabilized in recent years, proved to be a fundamental advantage, enabling it to run smoothly during government-imposed restrictions and home office work. In 2021, a map application continued to be improved allowing for easy topographic and regional geological integration of relevant cadastral districts. During the "Access to the Expert Research Outputs of CGS Regional Geologists, CGS Regional Economic Geology Specialists, CGS Regional Hydrogeology Specialists and CGS Engineering Geology Specialists" project, funded additionally in recent years by the MoE, the Regional Geological Administration continued

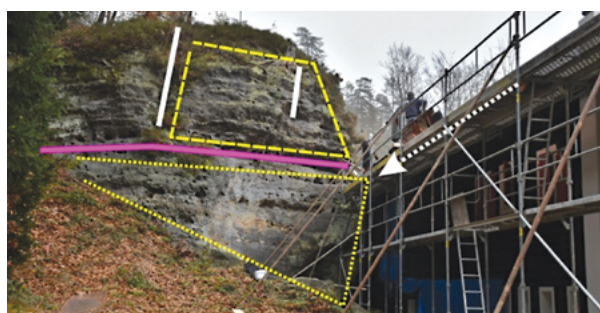




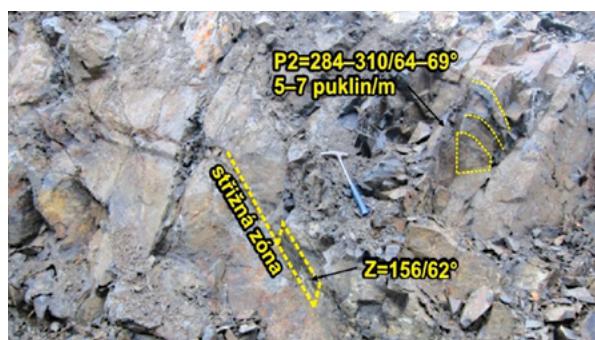
▲ Polygons (black lines) with occurring geodynamic phenomena were demarcated by geomorphological analysis of a 5<sup>th</sup> generation digital terrain model (© ČÚZK). On the left, an erosional depression is evident with slopes affected by assumed slope movements (pylon R19), on the right, an area of a compound slope instability with a frontal shape (pylon R17).



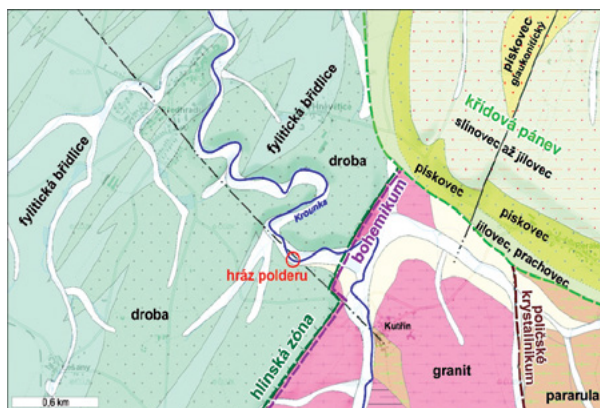
▲ P2 joint system.



▲ View to the northeast. The pink line indicates a layered surface and the dotted white line the surface of a ledge. The white lines highlight discontinuous joints with a NE-SW direction. The dashed yellow polygon highlights the upper part of the massif and the dotted yellow line the base of the outcrop connected firmly with the ground (massif).

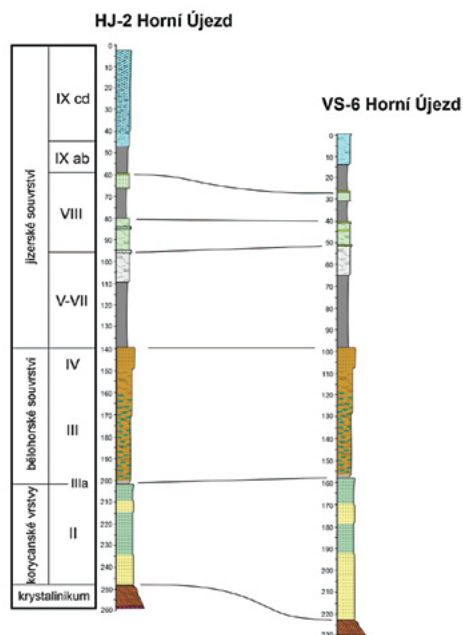


▲ P2 joint system dipping WNW to NW at an angle of 64–69°. The strike of the P2 joint system is roughly NE-SW. The joints frequency is 5–7 joints/m. A local shear surface dipping SSE at an angle of 62° occurs in the middle. This shear structure corresponds to the regime of the older Z1 fault system.

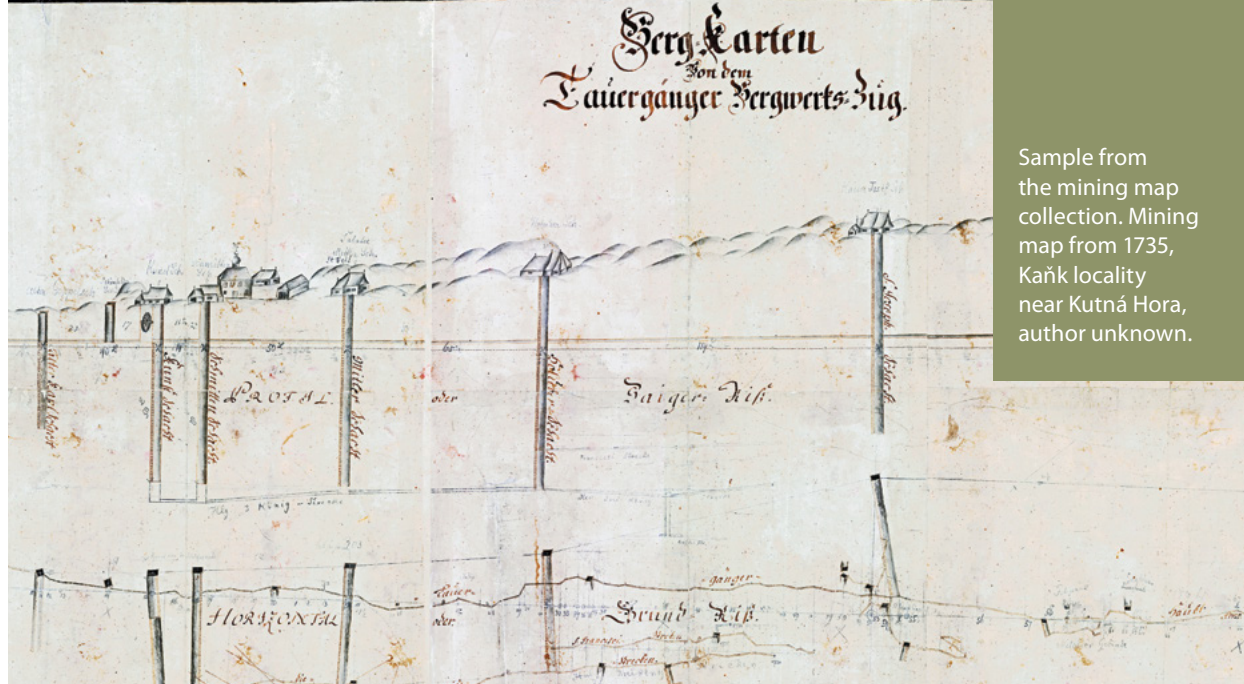


▲ Geological setting near the Kutřín detention basin.

to prepare all backfiles of its agenda for on-line access, dating back to 2003, via an interactive map of assessments, which provides interested parties with an overview of roughly 13 thousand outputs stored in the database as well as of nearly eleven hundred activities administered by the Regional Geological Administration in 2021 on a regional level for any relevant cadastral area.



▲ Lithological and lithostratigraphic section of boreholes HJ-2 and VS-6.



Sample from the mining map collection. Mining map from 1735, Kaňk locality near Kutná Hora, author unknown.

## State geological survey agenda of the Information Systems Division



**Jaromír Starý**

Head of the Mineral Information System Department



**Zdeňka Petáková**

Head of the Geological Exploration Department



**Milada Hrdlovicsová**

Head of the Geofond Department



**Jolana Šanderová**

Head of the Mining Impacts Department

The Information Systems Division performs the tasks of the state geological survey set forth in current laws and in the organization's foundation charter. These mainly include relevant provisions of the Geological Act (Act No. 62/1988 Coll., on geological work), the Mining Act (Act No. 44/1988 Coll., on the protection and use of mineral resources), the Mining Waste Act (Act No. 157/2009 Coll., on mining waste management) and the Building Code (Act No. 183/2006 Coll.).

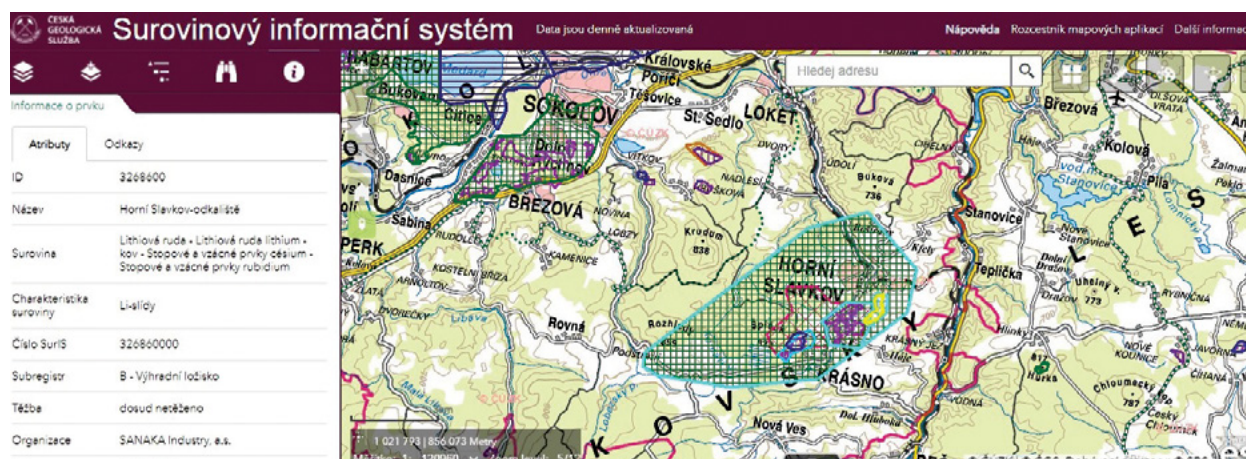
### Inventory of geological projects

Organizations carrying out geological projects in the Czech Republic submit pertinent documents to the Czech Geological Survey, which inventories them according to § 7 of the act on geological work and according to relevant decrees. The CGS was tasked by the Ministry of the Environment with the inventory's management. Geological projects of 253 organizations and 5,376 registration forms involving geological activities were recorded in 2021.

### Mineral resources

The Mineral Information System (SurlS) collects and provides all available data on the mineral potential of the Czech Republic in coherent form. It is based on the database of





▲ Display from the publicly available *SurIS* map application.

mineral deposits of the Czech Republic, with which other sub-databases are linked, such as companies, mining leases, protected deposit areas, preliminary mining lease approvals, exploration areas, approval of reserves, and spatial features. *SurIS* includes economic databases as well. A map application on the Czech Geological Survey's website (<https://mapy.geology.cz/suris/>) provides access to basic *SurIS* data.

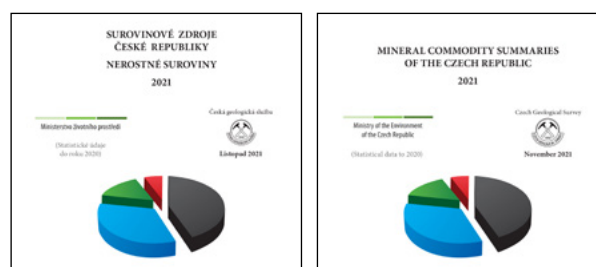
As of 31 December 2021, *SurIS* included 10,135 objects, of which 1,517 were registered reserved deposits, 809 registered non-reserved deposits, 813 unregistered resources, 257 approved prognostic resources, 1,065 other prognostic resources, 1,428 negative exploration results, non-prospective areas and mineral occurrences, 4,222 abandoned and exhausted deposits, and 24 geological structures serving as gas storage facilities, underground repositories and as industrially usable sources of thermal energy from the Earth's crust. A total of 49 new objects were added and 2,680 objects updated in 2021.

According to § 8 of the Mining Act, the CGS is tasked with the safeguarding and inventory of reserved deposits. As of 31 December 2021, it recorded 359 reserved deposits that are safeguarded by the establishment of 339 protected deposit areas.

The following monographs were compiled based on *SurIS* data:

- "Review of Reserved Mineral Deposit Reserves of the Czech Republic as of 1 January 2021" based on the departmental statistical report Geo (MoE) V 3-01: Part I: Ores, Trace Elements, Part II: Mineral Fuels, Part III: Reserved Deposits of Industrial Minerals.
- "Inventory of Mineral Deposit Reserves of the Czech Republic as of 1 January 2021", containing deposits of non-reserved minerals (construction minerals).

The yearbook "Mineral Commodity Summaries of the Czech Republic – Mineral Resources 2021 (Statistical Data 2020)", published in Czech and English versions, containing data on



▲ Czech and English title pages of the *Mineral Commodity Summaries of the Czech Republic*.

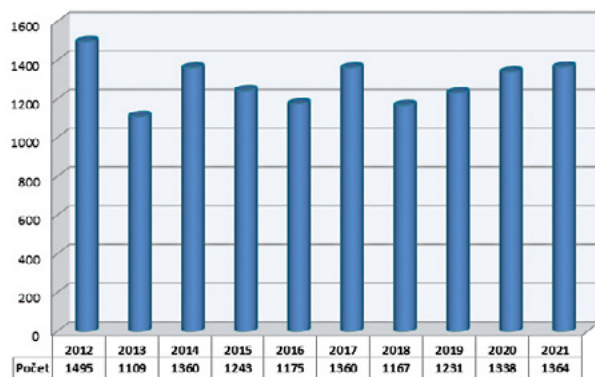
minerals from a global perspective, information on resources, reserves and domestic mineral production, and on mineral prices and foreign trade in the Czech Republic. The yearbook will be available on the CGS website (<http://www.geology.cz/extranet/publikace/online/surovinove-zdroje>).

- "Changes in Reserves of Reserved Mineral Deposits in 2011–2020" is a non-public review prepared for the Ministry of Industry and Trade, the Ministry of the Environment, and the State Mining Administration. It is also used by the CGS to prepare background material for the national raw materials policy.
- "Summary of Mineral Reserves in Mining Leases and Other Exploited Deposits of Non-Reserved Minerals as of 1 January 2021", a non-public review compiled with data from the Hor – MPO records on mining technology, provided to the Ministry of the Environment, the Ministry of Industry and Trade, the Czech Mining Authority and to other authorized organizations.

### Expert assessment of land use planning documents

The Information Systems Division provides comprehensive assessments of land development and land-use plans with regard to areas with specific geological structures by virtue

## State geological survey agenda of the Information Systems Division



▲ Number of processed expert assessments of land use planning documents in 2012–2021.

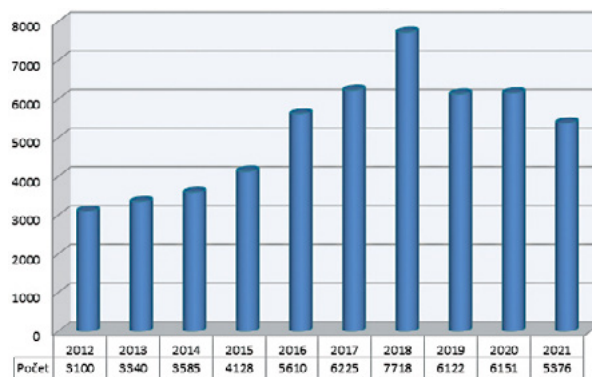
of § 13 of the Geological Act and § 18 and § 19 of the Mining Act. This involves cases of undermined areas and reserved deposits, which the CGS is authorized to safeguard and record. In 2021, 1,364 requests for assessments concerning mineral deposit safeguarding and 135 assessments of undermined areas were handled. The assessments were carried out in close cooperation with the assessment activities of the CGS Regional Geological Administration.

### Provision of territorial data for land-use analysis documents

The CGS provides selected data in accordance with § 27 of the Building Act. A digital data delivery module for land-use analysis documents allows users to download relevant data from their areas free of charge based on specifically generated login data. According to the Standard for Monitored Phenomena, this involved protected deposit areas, protected areas for special interventions into the Earth's crust, and mineral deposits – reserved deposits, presumed deposits of reserved minerals, undermined areas, landslide areas and other geohazard areas, and mining impacts. Data are also provided free of charge to the Ministry of the Environment, the Ministry of Regional Development and the State Land Office. In 2021, 35 municipalities with extended scope and seven regions downloaded data on reserved deposits (1,654 objects), prognostic resources (167 objects), protected deposit areas and protected areas for special interventions into the Earth's crust (861 objects), reported mine workings (2,551 objects), undermined areas (4,100 objects) and landslides (12,565 objects). One requested download made by the State Land Office included data on 1,164 protected deposit areas.

### Borehole surveys and hydrogeological database

The Czech Geological Survey maintains and manages the geologically documented objects database, including hydrogeological and geophysical data. The database mainly



▲ Inventory of geological projects – number of Registration Forms in 2012–2021.

contains information on geological, exploratory and other boreholes/wells drilled in the Czech Republic. Information is provided as individual outputs or via the “Borehole Logs” and “Geologically Documented Objects” web applications. Borehole surveys include the following datasets maintained by the CGS: the Geologically Documented Objects Database (GDO), the Borehole, Shaft and Well Record Database (GEO), the Hydrogeological Database (HYD), the Drill Logging Database (KAR), the Material Documentation Database, and the Technical Parameters of Well Drilling Database (TECH).

The **GDO Database** contains basic information on geological exploration work and, as of 31 December 2021, contained 712,220 objects, mainly boreholes. The database includes data on 117,191 economic geology, 117,987 hydrogeological, 442,156 engineering geology, 987 structural and 22,520 mapping-related objects. Specialized databases are linked to the GDO.

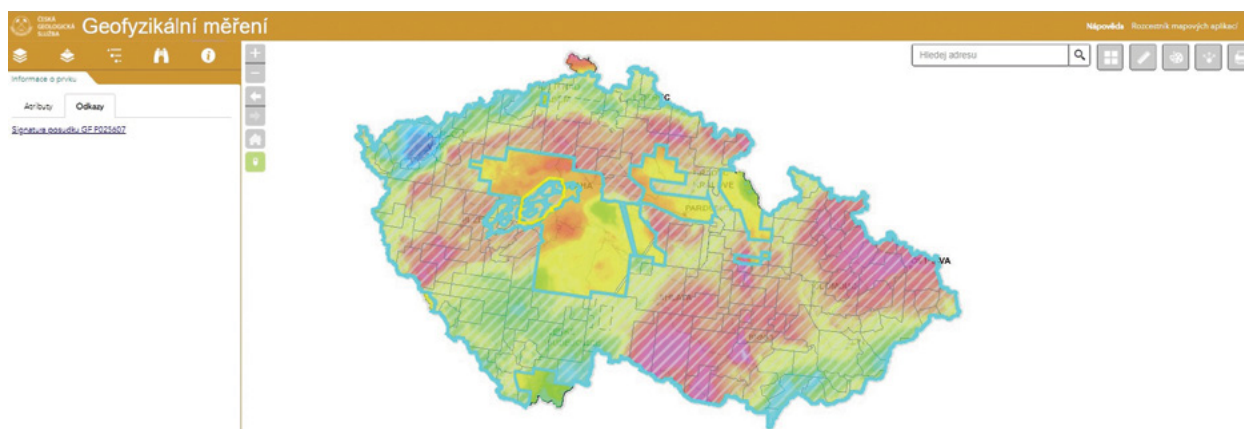
The **GEO database** was established in 1976 and is the most extensive and longest-running CGS database. It contains detailed data on objects with a geological description of rocks encountered as well as a link to evaluations – primary final reports. From new reports received by the CGS Archive, 4,524 objects were selected for filing and further processing in 2021. The database contained 622,977 objects with geological profiles as of 31 December 2021.

In 2021, 1,623 objects were entered into the **HYD database**. As of 31 December 2021, it contained data on 109,853 objects. The data is provided through the “Borehole Surveys” and “Geologically Documented Objects” applications.

The **Technical Parameters of Well Drilling Database (TECH)** is linked to the HYD database and contains information on well construction and casing parameters for nearly 3,500 wells.

The **Groundwater Data and Information Dataset** collects data on groundwater reserve estimation polygons and data on regional hydrogeological resource evaluation





▲ Display from the publicly available Geophysical Measurements map application.

polygons. In 2021, 66 polygons from 25 assessments made in 2017–2021 were prepared for addition to the database. Usable groundwater reserves were not determined in the assessments processed. Objects are being added gradually. As of 31 December 2021, the database contained 918 objects (polygons), of which 653 came from regional hydrogeological surveys, 164 from the resource reports collection, and 65 polygons from theses. Usable groundwater reserves were determined in 15 assessments for category A, in 62 assessments for category B, in 82 assessments for category C1, and in 85 assessments for category C2, and uncategorized usable groundwater reserves were determined in 51 assessments (58 polygons).

The **Drill Logging Database (KAR)** contains digitized drill-logging data from 5,799 boreholes and directional log data from 3,010 hydrogeological objects.

### Geophysical surveys

Through the online “Geophysical Measurements” map application ([https://mapy.geology.cz/geofyzikalni\\_mereni/](https://mapy.geology.cz/geofyzikalni_mereni/)), the public is provided with key expert information subdivided into topics (web map services) involving Geophysical Surveys (with “Regional Surveys” and “Local Surveys” layers), Gravimetry (with “Overview of Gravimetric Map Scales”, “Gravity Campaigns” and “Complete Bouguer Anomaly Map” layers), Seismics (with “Seismic Reflection Profiles” and “Well Shoots” layers) and Vertical Electrical Sounding. Selected geophysical data are also available via WMS and as pre-prepared files for download via ATOM feed. More detailed information is available on the CGS website at: <http://www.geology.cz/extranet/vav/zemska-kura/geofyzika>.

The CGS updated, consolidated and made its geophysical databases available during projects of the CZECHGEO/EPOS consortium for geophysical field observations (information is available on the [www.czechgeo.cz](http://www.czechgeo.cz) website, created and operated by the CGS).

### Mining impacts

Information on activities associated with mine workings, undermined areas and mining waste is given in the chapter “Mine workings and mining waste”.

### Geological documentation

Information on the activities of the geological reports archive, map archive, archive services and on borehole core material documentation is provided in the chapter “Geological documentation”.

### Mining History Department of the Czech Geological Survey in Kutná Hora

The department in Kutná Hora is located in the city’s historical centre. It holds more than 17,000 copies of mining maps from various map collections. Their data are entered into the Information System and made publicly available through the “Mining Maps” application. The office’s science library has undergone a fundamental change in recent years and has been a full-fledged part of the CGS science library since 2018. A part of the ID codes for the Resource Reports Collection (FZ) from the CGS Archive is stored at the Kutná Hora office. Roughly 65% of the stored FZ reports were digitized in 2012–2021.

A reconstruction of the ground floor of the CGS’s Kutná Hora office commenced in 2021 and should be completed in 2022. The reconstruction involves the original archive of the Resource Reports Collection and an area formerly used as an apartment. Its purpose is to transform the building’s entire ground floor into a new Resource Reports Collection archive, equipped with a modern basic archive system. The new archive spaces should accommodate the original part of the archive and eventually also its remaining part, which will be transferred here from Prague where it is currently stored. Part of the new office space will also be designed for archiving mining maps.



Section of mining map RD/532 (J. Capeta, 1738, historical map archive, CGS – Kutná Hora). Location of mine workings in the southern part of Rudolfof, Český Budějovice district.

# Mine workings and mining waste



Vít Štrupl

Head of the Information Systems Division and Deputy Director

The tasks of the state geological survey performed by the Czech Geological Survey include also the maintenance of the Mine Working Impacts Inventory according to the Mining Act.

## Mine Working Impacts Inventory

On the Earth's surface, mine workings usually form areas of collapsed or subsided soil, or occur simply as open adits and shafts. The Mining Act imposes obligations on reporting, recording and dealing with such phenomena if they are encountered. All old mine workings, whose original operator or a legal successor does not exist or is unknown, and all abandoned exploratory mine workings, whose legal successor is the Czech state, are recorded by the CGS. Subsequently, these sites are investigated, documented and observed.

The "Mining Impact Report" web application ([https://app.geology.cz/dud\\_ozn/](https://app.geology.cz/dud_ozn/)), accessible through the CGS website, is available online for reporting and recording all newly detected cases of mining impacts. The application allows anyone to report the mining impact, including attachment of photo documentation. Expert staff of CGS subsequently conduct initial on-site investigations and regular inspections of safeguarding measures taken at all mines, which were

funded by the Ministry of Environment (MoE). The field investigations are based on a long-established method that includes the location and description of detected features including up-to-date photo documentation. Data are constantly added to the inventory and provided to the MoE. In 2021, CGS employees inspected 1,386 mine working sites and documented their impacts. Their activities are largely based on information contained in unpublished reports on geological project results, stored in the CGS Archive (Geofond), in publications, map collections and in other databases of the CGS Information System. These are mainly the **abandoned mine lands** database containing records on areas with deep underground mines (data on 5,666 sites as of 31 December 2021), the **mine workings** database with a comprehensive inventory of underground mines (data on 29,265 sites and more than 26,000 digital charts as of 31 December 2021), and the database of **mining maps** (data on nearly 18,000 maps and related scans as of 31 December 2021).

The Mine Working Impacts Inventory comprises files containing all relevant documents for each reported case. Data are stored in the mine working impacts database of the CGS Information System. As of 31 December 2021, the Mine Working Impacts Inventory contained a total of 2,982 reported mine working impacts. Information on the status and location of reported mining impacts are also





▲ Collapse of an old shaft in the garden of residential home in Rudolfov, České Budějovice district. View from W. Documented in the Mine Working Impacts Inventory.

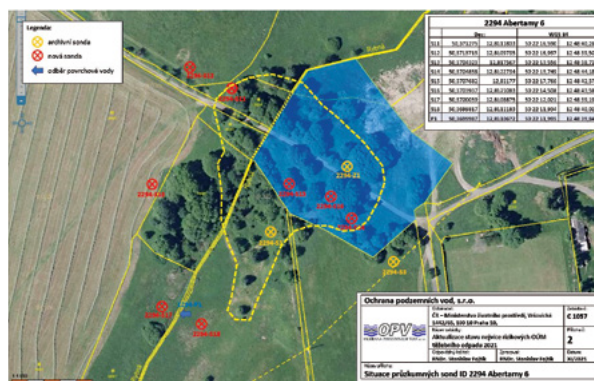
displayed by the “Mining Impacts” ([https://mapy.geology.cz/dulni\\_dila\\_poddolovani/](https://mapy.geology.cz/dulni_dila_poddolovani/)) and “Reported Mining Impacts” ([https://mapy.geology.cz/oznamena\\_dulni\\_dila/](https://mapy.geology.cz/oznamena_dulni_dila/)) map applications, which are permanently accessible to the public on the CGS website.

### Inventory of Mining Waste Facilities

Another state geological survey task performed by the Czech Geological Survey involves the maintenance of the Inventory



▲ Collapsed pit in the Turkaňk zone in a wooded part of Kaňk Hill northeast of Kutná Hora.



▲ Satellite image of the Abertamy 6 waste facility with the locations of probe holes in the body of spoil heap.

of Hazardous Waste Facilities according to the Mining Waste Management Act (§17 of Act No. 157/2009 Coll.).

Mining and mineral exploration left numerous remnants in the landscape in the form of spoil heaps, tailings ponds, dumps and abandoned placers. In some cases, they have become significant land-forming features with unique flora and fauna. They may also represent secondary sources of minerals or even pose a serious threat to the environment and human health. In particular, tailings left over from ore mining and dressing contain a wide spectrum of toxic elements which, when released by weathering, contaminate the surrounding soil and groundwater or surface water. Some old mine working sites are also prone to landslide or subsidence hazards.

The Mining Waste Management Act that came into force in 2009 included a comprehensive inventory of mining waste disposal sites in the Czech Republic. The Czech Geological Survey created the Inventory of Mining Waste Facilities, which was included in the CGS Information System. It is constantly updated and contained 7,104 sites as of 31 December 2021. Detailed data on the mining waste sites, including their location, are publicly available via the “Inventory of Mining Waste Facilities” map application on the CGS website.

### Inventory of Hazardous Waste Facilities

The Inventory of Mining Waste Facilities also includes sites that have been classified as hazardous waste facilities. Above-threshold values for pollutants were detected at these sites and, in combination with other factors, they exceed hazard index (HI) 1. Each year, six of the potentially most problematic sites are inspected and investigated. The Inventory of Hazardous Waste Facilities was launched on 1 May 2012 as a separate web application in Czech and English versions. It includes 24 facilities as of 31 December 2021. One site, previously listed in this category, has gradually been remediated.



# Geological Information System



Richard Binko

Head of the Department of Informatics

The Czech Geological Survey gathers, processes and provides data on the rock environment of the Czech Republic. Development of a geological information system is essential both for an efficient and effective handling and providing of environmental information to state authorities and the public, and also for the research and other expert activities of the CGS. The concept of the system is compatible with Czech and EU legislation on information access and security. Use of international standards safeguards the interoperability of data sources and their integration into the national and European spatial data infrastructures.

## Geological Information System (GeoS)

The core of the Geological Information System (GeoS), designed by the Czech Geological Survey to be compatible with national and international standards, is the Central Data Store (CDS), which is being consolidated and made accessible over the long term. The CDS stores spatial data (maps, geological cross sections, inventories of hazardous waste facilities, slope instabilities and other items) as well as descriptive data (code lists, results of analyses, the digital Geofond archive, mapping documentation, etc.). The GeoS contains a wide variety of thematic subsystems: geological maps – National Geological Map Database (NGMD); mineral resources – Mineral Information System (SurlS); mining waste – inventory of mining waste facilities; mining impacts – abandoned mine lands and mine workings; a subsystem for geologically documented objects (boreholes, test pits, etc.); geohazards (an inventory of slope instabilities and complex radon information); hydrogeology; geophysics; soil and others.

The database and application environment of the CGS Metadata Information System (MIS; [micka.geology.cz](http://micka.geology.cz)) were upgraded considerably in 2021. The MIS allows for orientation in CGS datasets, services, applications, websites, AR, and 3D models and scenes. It is fully compatible with the current national metadata profile as well as with the INSPIRE Implementing



Rules and serves as a source of up-to-date information for national ([geoportal.gov.cz](http://geoportal.gov.cz)) and international geoportals ([inspire-geoportal.ec.europa.eu](http://inspire-geoportal.ec.europa.eu); [europe-geology.eu](http://europe-geology.eu)). In 2021, 410 public metadata records on CGS data sources were managed in the MIS. For the CGS Information Portal, the MIS is used to automatically generate thematic lists of web map services WMS (<http://www.geology.cz/extranet-eng/maps/online/wms>), services based on Esri ArcGIS for Server technology (<http://www.geology.cz/extranet-eng/maps/online/esri>), public web applications (<http://applications.geology.cz>, <http://maps.geology.cz>), and a thematically structured interactive overview of CGS databases (<http://www.geology.cz/extranet-eng/science/information-systems/data-management/databases-cgs>), which presents the content of the CDS in a schematic way.

### Interoperability of geodata

As required by the INSPIRE Directive of the European Commission and the Council (Act 123/1998 Coll. in Czech legislation), the CGS provides up-to-date metadata for data sources covered by INSPIRE themes on geology, soil, mineral resources, energy sources and geohazards and is working on making relevant data sources accessible in a harmonized form, as defined by the directive. In 2021, work continued on harmonizing data for the themes Soil, Natural Risk Zones, and Mineral Resources.

The CGS is actively involved in the implementation of the INSPIRE directive in the Czech Republic mainly by participating in the technical working groups of KOVIN. In 2021, work also began on a publication plan for opening up of data managed by the CGS and on defining the most possible open licenses for their further use. A specific licensing model for each dataset will be described in the metadata in the MIS. The opening up of data is scheduled for 2022.

In terms of data management, a new internal data directive was prepared for implementation in 2022.

### Development of the technology and content of data sources

In 2021, a multi-year migration of scanned reports of the CGS Archive was completed, during which the thus far used DJV format was replaced with the commonly used JPG. The migration included the development of a new database and a browser application linked to the existing search application <http://www.geology.cz/app/asgi>.

A central database for authenticating users and their access rights to applications was also introduced during the course of the year. An application access administration application was created for editing the database.

Continued development of the NGMD (National Geological Map Database) in 2021 mainly involved a revision of the data structure for geological maps at a scale of 1:25,000, including the addition of older maps to the CDS data structure and the development of a unified legend for the regions of the Bohemian Paradise-Liberec-Krkonoše Mts, Lugicum, Křivoklát-Brdy Mts, Brno agglomeration and Moravia. This work will continue in 2022 so that all geological maps (bedrock and Quaternary maps) can be accessed in applications and by the public (<https://mapy.geology.cz/geocr25/>). Map symbols and English and Czech descriptions were revised for geoscientific maps at all scales as well.

### Use of the Geographic Information System (GIS)

The GIS continued to be used as a tool for processing, utilizing and providing spatial data throughout the CGS. The Enterprise License Agreement with Esri enabled the CGS staff to routinely use GIS methods for spatial data analysis, 3D modelling or digital cartography for research projects in the Czech Republic without significant limitations on the number of licenses. In 2021, this involved geological mapping at 1:25,000 scale, contracts for the Radioactive Waste Repository Authority (preparation of data for 3D models of potential RAW repositories), DIAMO (deposits and resources of strategic minerals), and the "Targeted Replenishment of Groundwater as a Tool to Reduce Drought Impacts in the Czech Republic" project. A central data warehouse was prepared for the "Water in Crystalline Rocks" project, thereby enabling the construction of schemes (hydrogeological, geomorphological, etc.) and seven thematic hydrogeological maps at a scale of 1:100,000 (hydrogeological zones 6320, 6531, 6550). Work continued on the RENS projects (Geohazards, and Water in Karst).

The innovative cloud GIS approach was used in the CO2-SPICER project. For the purpose of operational sharing of spatial data with colleagues outside the CGS, a portal was launched in the ArcGIS Online environment, allowing logged-in users to view created map compositions of the project's datasets directly in a web browser or to create and export their own maps and schemes. The portal allows all spatial layers to be downloaded in a wide variety of formats for further local use.

GIS methods were also used in foreign cooperation projects, such as Turów (materials for negotiations regarding the Turów mine's mining impact on the Czech territory) and also in projects in Ethiopia (compilation of two extensive geological maps at 1:100,000 scale of Sidama and Gedeo). Tools in Python scripts continued to be developed for ArcGIS Pro, such as a tool for creating lenticular and funnel-shaped

## Geological Information System

bodies and a tool for raster interpolation from drilling data (both used to prepare data for 3D geological modelling in the MOVE software).

A methodology for the preprint processing of maps was developed during the course of the year and will be verified in 2022.

### Providing access to geoscience data and information

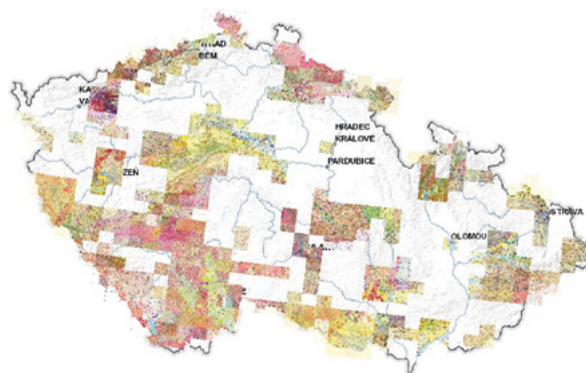
Access to additional datasets and maps on the CGS Map Server via map applications continued to be provided in 2021. Scans of individual manuscript geological maps at 1:25,000 scale along with their legends were added to the GEOČR25 map application. Now the application displays all scans of geological maps in the S-JTSK 25 map series and also a complete reference information for these maps.

The hydrogeological map of the Kutná Hora Crystalline Complex hydrogeological zone, compiled within the “Groundwater in the Crystalline Rocks” project, was added to the application Hydrogeological Map 1:50,000 – regions. A unified presentation legend was developed for an easier inclusion of additional regions.

An output of the “Geological Conditions in the Spa Springs Protection Zones” project of the Geology Department of the MoE is a single-purpose application displaying the “Protection Zones of Natural Curative Sources” archive layer, which defines areas with occurrences of water sources usable for curative purposes. The application will serve as a source of data for future adjustment of the protection zone boundaries.

An internal map application “Radiometric Anomalies and Research from ČSÚP Data”, developed in 2021, provides access to radioecological data from roughly fifty years of work of the former Czechoslovak Uranium Industry (ČSÚP) company. Maps and attribute tables contain descriptions of radioactive objects with radiometric measurements and investigation activities. Anomalous areas of radioecological hazards are defined according to the data. Another dataset presents the radiometric survey of the ČSÚP divided in four categories according to the level of detail of the measurements. The last composition includes 1:500,000 scale vectorized ČSÚP maps displaying regional units of interest, a structural map, and a U-mineralization map.

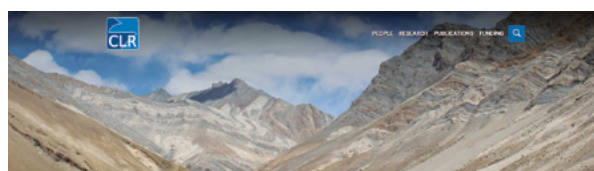
Five 3D models were published during 2021 on the website on 3D geological modelling by the Czech Geological Survey (<http://www.geology.cz/extranet-eng/science/earths-crust/3d>): a conceptual 3D geological model for the Střešovice railway tunnel, a conceptual 3D geological model of the Rožná uranium deposit, a structural geological 3D model for the Erzgebirge railway tunnel, a 3D model



▲ Overview of scans of geological maps in the S-JTSK map series at 1:25,000 scale, which are available in the GEOČR25 application (<https://mapy.geology.cz/geocr25/>).

of the paleo-valley of the Svatka riverbed, and updated 3D structural geological models of the potential deep radioactive waste repositories at Hrádek and ETE-Jih. A central store with a defined uniform structure was set up for archiving of the 3D models.

The preparation phase for developing a new generation of map applications involved a questionnaire survey among users in 2021, which addressed the strengths and weaknesses of current applications and requests for missing features. Over 1,000 respondents took part in the survey, and a document listing their requirements for a new map application version was created upon evaluating their answers. Short intuitive video tutorials were also created to assist in using the features of existing map applications. The main activity concerning web presentations of the CGS involved its cooperation in developing the so-called Star Portal, a publishing system for website administration within the Ministry of the Environment. A test transfer of two smaller CGS-operated websites (the website of the Centre for Lithospheric Research – <https://clr.geology.cz> and the website of the International Geoscience Information Consortium – <https://www.g-i-c.org/>) to this system was performed in 2021. At the same time, a CGS working group

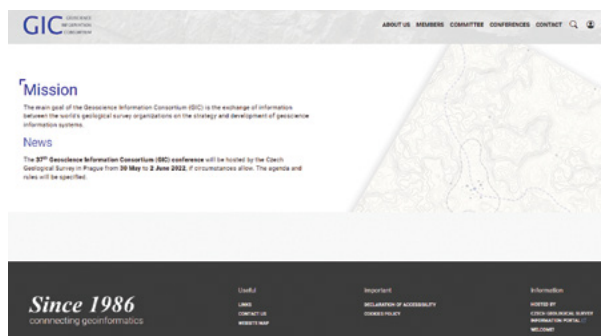


### Centre for Lithospheric Research Czech Geological Survey

Welcome to the Centre for Lithospheric Research website.  
The Centre for Lithospheric Research was formed in 2012 at the Czech Geological Survey based on an initiative of the Czech government, which encouraged outstanding Czech researchers living abroad to create excellent research groups of international level in the Czech Republic. The research at the Centre for Lithospheric Research was originally centred around the project: "The role of Palaeozoic sedimentary and orogenic systems on the formation and growth of continental crust: aiming to develop new models of continental growth and mechanisms of formation of Palaeozoic orogenic belts". In 2013 the Centre acquired a National Foundation excellence project (GEOCR): "Regional mechanisms of peripheral extensional growth during supercontinent cycle" which allows to continue the high quality research. The research is carried out together with our closest partners: Institute of Petrology and Structural Geology of Charles University and the Geophysical Institute of Academy of Sciences, the Czech Republic.  
The group integrates geoscientists coming from a variety of different research fields including geodynamics, tectonics, metamorphism, petrology, tectonic geochronology, geochronology and geophysics with active research on five continents. The main focus of our group is to develop a new research taking geodynamics of Pacific type sedimentary and tectonic orogenic systems. The main processes involved are the east-west flow of orogenic belt crust in these orogens, tectonic behavior of the lithosphere and mechanisms of continental growth.

▲ Website of the Centre for Lithospheric Research – <https://clr.geology.cz>.





▲ Website of the Geoscience Information Consortium – <https://www.g-i-c.org/>.

was set up to prepare a new CGS website in the Star Portal. The work resulted in a proposal of the structure, navigation and features of the new website.

The websites of the RENS (<https://rens.geology.cz>) and CO2-SPICER (<https://co2-spicer.geology.cz>) projects were also launched during the course of the year.

## International cooperation

In spite of the continuing difficult pandemic situation in 2021, the representatives of the CGS Informatics Division managed to work in international teams. They continued to manage the existing metadata catalogues of the European “Minerals4EU” and “ProSUM” projects. In 2021, the CGS kept on developing the EGDl metadata catalogue (<https://egdi.geology.cz/>), which served as the basis for the implementation and successful completion of the “GeoInformation Platform” (GIP-P) project of the GeoERA programme (<https://geoera.eu/projects/>). A new catalogue editing environment was developed during the project, and in 2021 also instructional

videos and a FAQ document for creating metadata for results of other GeoERA projects (see <https://czechgeologicalsurvey.github.io/MICKA-Docs/>). By the end of 2021, 4,140 metadata records on data sources from 33 European countries and 27 European projects were managed in the EGDl catalogue. A total of more than 50 European geological organizations contribute metadata to the catalogue. Prior to the end of the GIP-P project, the metadata content of the results of all GeoERA projects was thoroughly reviewed, particularly with regard to compliance with the FAIR principles (findability, accessibility, interoperability, reusability of data sources).

Dana Čápková continued as chairwoman of the Spatial Information Expert Group (SIEG), the expert advisory body of EuroGeoSurveys (EGS), whose priority in 2021 was the preparation of documents for the project under the programme Coordination and Support Action – A Geological Service for Europe (CSA – GSEU), which should commence in mid-2022.

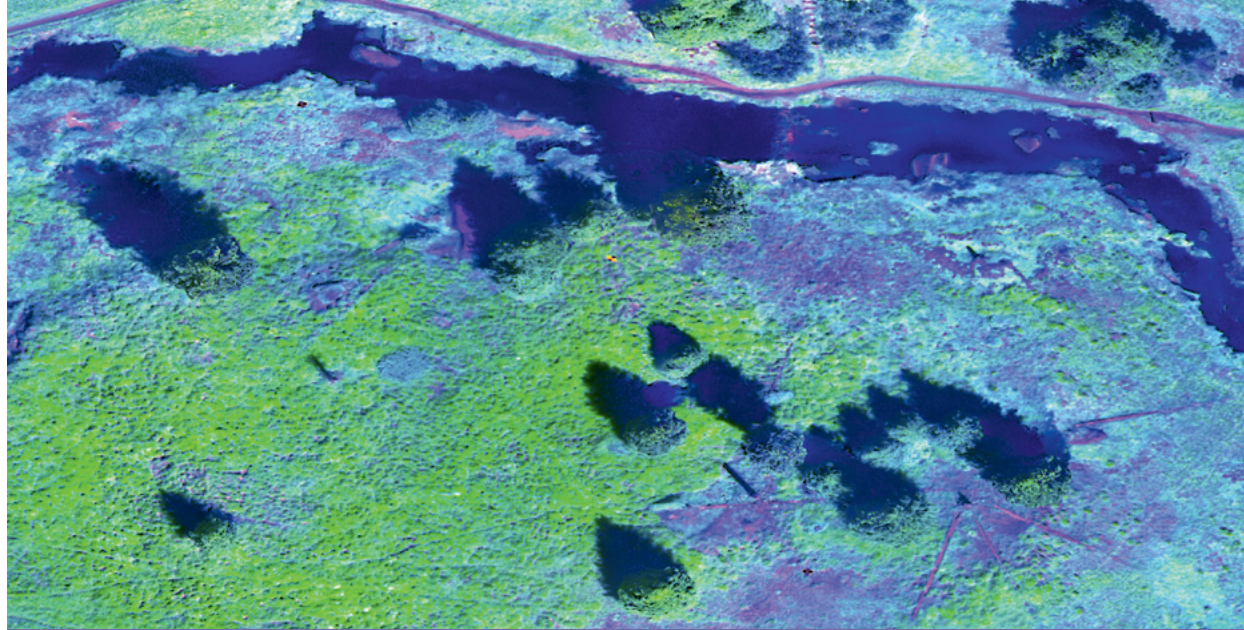
Dana Čápková also continued to chair the EPOS Thematic Core Service Geological Information and Modelling consortium. On behalf of EGS, the EGDl provides services for access to information on geology, mineral deposits, borehole surveys, and to the 3D geological models index layer. The EPOS platform is still under development, and the services provided are being tested.

Dana Čápková is also a member of the steering committee of the Geoscience Information Consortium (GIC). Due to the pandemic situation, the annual GIC conference in 2021 was again held as a web meeting.

Another phase of the EMODnet project, in which the CGS cooperates in creating and managing metadata in the EGDl catalogue, was successfully completed in 2021.



▲ The GIC conference in 2021 was held as a web meeting.



# Remote sensing



**Veronika Strnadová**

Head of the Remote Sensing Centre

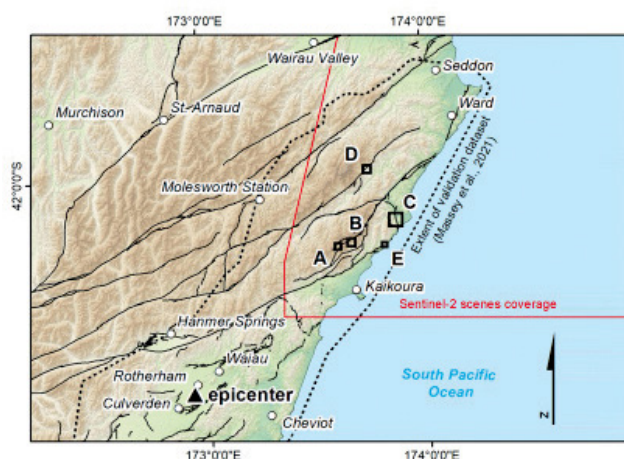
Thanks to new space programmes and fast developing technologies, remote sensing is nowadays the most widespread method of acquiring spatial data on the Earth's surface and objects. Rapid development of new applications allows for systematic monitoring of the Earth and linking of various geoscientific disciplines.

## Activities of the Remote Sensing Centre

The Remote Sensing Centre (RSC) focuses over the long-term on employing quantitative image spectroscopy methods by using optical and thermal hyperspectral (HS) image data. The RSC's team employs quantitative spectroscopic methods as a modern tool to monitor all environmental constituents (rocks, vegetation and water) and to study their interactions. Models were constructed during national and international long-term research projects with the aid of RS image data to determine the surface pH gradient in exposed substrates and the contamination of surface mine waters. A model was also constructed to assess the overall health of forest stands that thus far do not exhibit any visible signs of damage. Generally stated, the above-mentioned image spectroscopy applications have great potential for environmental monitoring because they enable, for instance, the identification of acid substrates and their relation to Acid Mine Drainage (AMD) or to the quality of surrounding surface water and vegetation.

The RSC's team currently focuses primarily on designing new approaches and algorithms for quantitative analysis and classification of RS image data. Conceptually, these activities target the following areas of development: I. an environmental application (soil degradation, assessment of mining impacts), II. an application of non-destructive remote sensing methods for evaluating the potential of strategic mineral deposits (e.g., REE), III. creation of new algorithms/models combining optical and thermal HS data, IV. creation of models using new-generation satellite data (e.g., Sentinel-1-3 and EnMAP). In addition to HS technologies, the RSC was engaged in other fields of remote sensing. New methods and tools developed at the RSC for hydrogeology mainly include automatic classification of morphometric features and their rapid geomorphological interpretation and a method allowing for updates of tectonic and hydrogeological elements based on ALOS PAL-SAR satellite radar data. The centre is also developing its own tools for "cloud" processing of large amounts of satellite data (extensive areas and long-time series), which enable detection of soil moisture in the Google Earth Engine environment. With regard to geohazards, radar interferometry methods (SBAS-DInSAR or PSI) are being newly used for the detection of vertical terrain movements and deformations. Radar interferometry was employed, for instance, to identify landslide movement along the D8 motorway in the České středohoří Mts or to evaluate the land stability near the Polish Turów mine. The centre also developed its own SW tools for automated detection and evaluation of post-seismic phenomena, which were tested and validated on the example of the





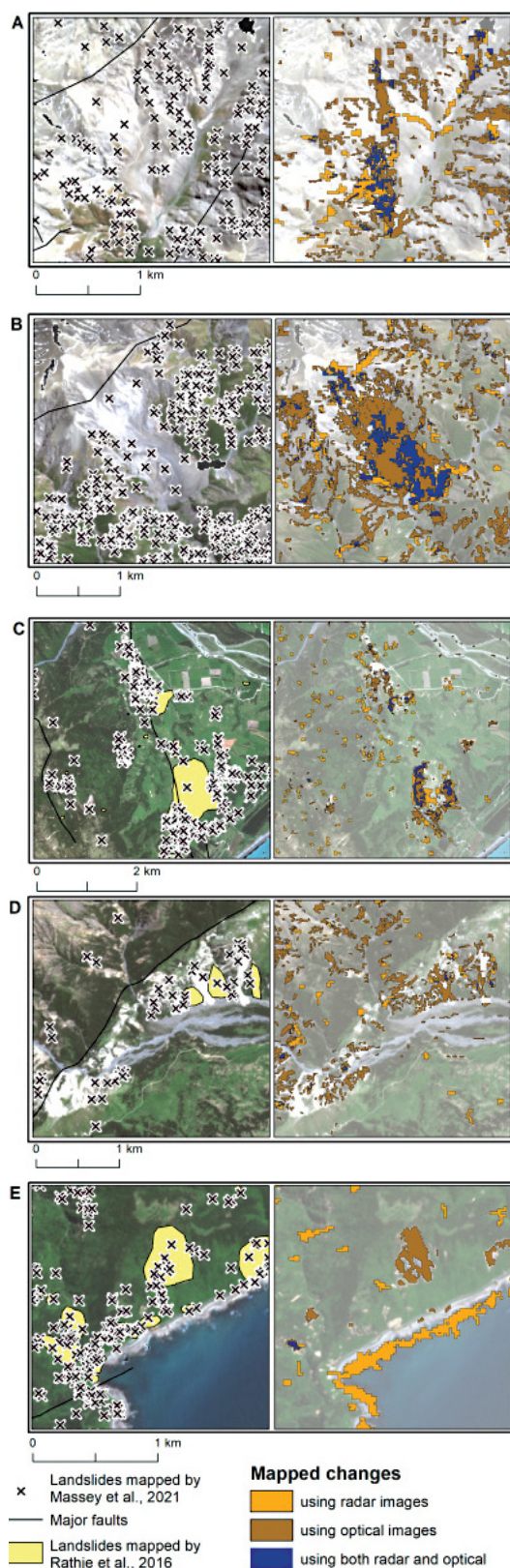
2016 New Zealand earthquake. The results were published in the prestigious international journal *Remote Sensing of Environment*. Due to their ability to respond to changes in surface parameters, radar data are also used to detect landslides and mudslides after heavy precipitation or earthquakes.

The RSC has successfully implemented unmanned systems, which gather optical and thermal image data. The centre is equipped with two drones, a Flydeo Y6 hexacopter and a DJI Phantom 4 quadcopter, which may be mounted with the following sensors: a hyperspectral Resonon Pika L, a multispectral Parrot Sequoia, a multispectral MAPIR Survey2 NDVI, a thermal FLIR Duo R and a thermal Workswell WIRIS 2nd gen 640. The RSC is also equipped with a Spectral Evolution laboratory spectroradiometer, which makes it possible to supplement image data with high-quality in-situ measurements of samples. Unmanned imaging allows for independent scanning of study localities on a local scale with high resolution, which supplements existing airborne or satellite data, while enabling operational data acquisition for new scientific topics and projects. In 2021, the RSC's team focused on systematic scanning of sites where landslide movement is expected to continue.

The centre constantly publishes its results, which involve the above-mentioned research areas, in IF-indexed, international peer-reviewed science journals or as other applied research outputs intended for state organizations (Radioactive Waste Repository Authority, Ministry of the Environment).

#### Scientific cooperation:

- Faculty of Science, Charles University
- CzechGlobe, Academy of Sciences of the Czech Republic
- Deutsches GeoForschungsZentrum
- Tel Aviv University
- NASA – Goddard Space Flight Center
- EuroGeoSurveys: Earth Observation and Geohazards Expert Group (EOEG)



▲ Automatic detection, evaluation and validation of post-seismic phenomena on the example of the 2016 New Zealand earthquake.



Documentation of slaty Devonian limestone, Gobi-Alai, southern Mongolia. Photo by P. Hanžl.

## International activities and cooperation

International projects are an integral part of the activities of the Czech Geological Survey. Multifaceted international cooperation is very important and beneficial. That is why the CGS participates in many projects as a participating or leading member of international consortia and cooperates with other European geological surveys and other institutes and foreign partners on projects involving research, innovation and development. The CGS is an active member of many international organizations.

### Cooperation with European geological surveys



The Geological Surveys of Europe

The Czech Geological Survey is an active member of EuroGeoSurveys (EGS), an association of European geological surveys. This non-profit organization, representing 38 national geological surveys and several regional geological surveys, provides European institutions with expert pan-European consultancy and information, such as assistance in

problem solving, policy making, regulations and programme preparation. CGS experts are members of many of EGS expert groups. The EGS activities in 2021 focused mainly on preparing a proposal for the coordination and support action “Geological Service for Europe” under the Horizon Europe programme and also on finalizing projects under the GeoERA programme (Establishing the European Geological Surveys Research Area to Deliver a Geological Service for Europe).

### Geological Service for Europe

The proposal of this project, submitted for the call of the Horizon Europe programme by a consortium of 49 partners, aims to create a “Geological Service for Europe” as an entry point to a permanent cooperation network of European geological surveys and to provide European institutions, businesses and citizens with up-to-date and high-quality information, aggregated at the EU level. The specific goals of the project include, among other things, the development of several pan-European harmonized data and information services focused on primary raw materials and specifically on critical raw materials, as well as geothermal energy sources, CO<sub>2</sub> and energy storage, groundwater dynamics and quality, coastal zone issues, a methodology for collecting basic geological information, and development of 3D models and visualizations. An important part of the project also involves the development of infrastructure linked to the existing EGDI (European Geological Data Infrastructure), which will provide access to data and information services developed as part of the project and externally.



GeoERA projects contribute to optimal use and management of subsurface resources



In 2021, the CGS along with partners from EGS continued, among other things, to work on the “Establishing the European Geological Surveys Research Area to Deliver a Geological Service for Europe (GeoERA)” research programme, which is partly funded by the European Commission through the Horizon 2020 Framework Programme for Science and Research (ERA-NET Cofund). The CGS was actively engaged in nine of fifteen GeoERA projects in four thematic areas. All these projects, dealt with since 2018, were successfully completed at the end of 2021.

### Geoenergy

- **Managing Urban Shallow Geothermal Energy (MUSE)**

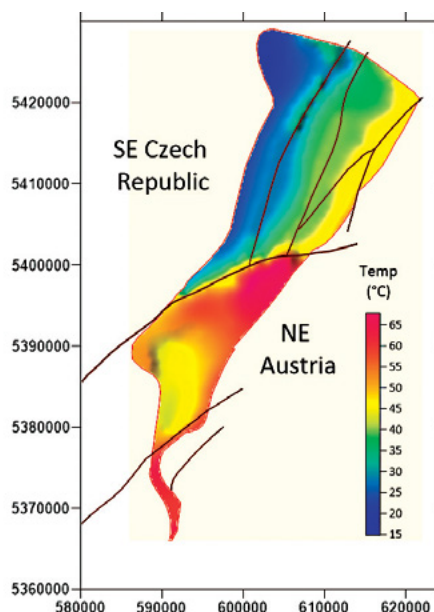
This international partnership included 16 partners from European geological surveys. The project addressed the use of shallow geothermal energy in densely populated areas. The project’s pilot area in the Czech Republic was the territory of the capital city of Prague. The benefits of the project yielded many methodologies and recommendations for resolving conflicts of interest arising from geothermal energy use. These documents will subsequently be used in current and future projects dealing with the use of shallow geothermal energy (for instance, the “Analysis of the Geothermal Potential of the Czech Republic” project).

- **Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks – Cross-domain Implications and Impacts (HotLime)**

The project addressed the geothermal potential in carbonate aquifers in Europe. International cooperation resulted in improved awareness of methods for calculating the energy potential from collected geological data. The Czech and Austrian geological surveys cooperated on the compilation of a cross-border structural map of the surface and base of Jurassic carbonate rocks and associated temperatures.

- **3D geomodeling for Europe (3DGEO-EU)**

The project was coordinated by the German Bundesanstalt für Geowissenschaften und Rohstoffe in cooperation with ten other geological surveys from the federal states of Germany and also from Denmark, the Netherlands, Poland, Spain, Ukraine and the Czech Republic. During this project, thanks to the cooperation



▲ Joint cross-border Czech-Austrian map of the Jurassic surface with displayed temperatures (Pereszlényi, Franců and Porpacz 2021). The border runs north of the distinctive fault in the centre of the image.

with other geological surveys, the Czech Geological Survey succeeded in developing algorithms for semi-quantitative determination of the uncertainty of 3D geological models created by the CGS.

- **Cross-border, cross-thematic multiscale framework for combining geological models and data for resource appraisal and policy support (GeoConnect<sup>3d</sup>)**

The project focused on using geological modelling to assist in decision-making on the use of subsurface structures. A new methodological approach to preparing and sharing geological information, which was developed and tested, will make this information more understandable and usable for all those involved in these decisions.

### Groundwater

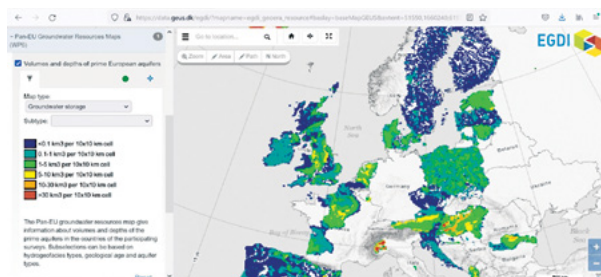
- **Hydrogeological processes and geological settings over Europe controlling dissolved geogenic and anthropogenic elements in groundwater of relevance to human health and the status of dependent ecosystems (HOVER)**

Work on individual work packages was completed and a geoportal was created for the presentation of results (<https://geoera.eu/projects/hover8/hover-map-viewer/>). The final report “Database for concentrations of dissolved elements and associated parameters and harmonized terminology to define thermal and mineral water (Database and associated technical report)” was prepared as part of WP3, in which the CGS was engaged.

## International activities and cooperation

- **Resources of groundwater, harmonized at cross-border and pan-European scale (RESOURCE)**

The project aimed to harmonize data and access to data on water resources. The output is a map of hydrogeological conditions and natural water resources in European countries that participated in the project. The CHAKA work package, which is a part of the project, dealt with the typology of karst areas in Europe. Existing outputs are published online at <https://geoera.eu/projects/resource9>.



▲ RESOURCE map application.

## Mineral resources

- **Mineral Intelligence for Europe (Mintell4EU)**

The project aimed to improve the EU's awareness of mineral resources. The project followed up on several previous projects, such as Minerals4EU, ProSUM, ORAMA, whose task was to build a mineral resources database, and also on a project involving the publicly available electronic European Minerals Yearbook delivered via Minerals4EU. Mintell4EU consolidated existing data sources, increased



▲ Abandoned Lousal pyrite mine in Portugal, where an educational exhibit on pyrite mining and the subsequent challenging remediation of the acidified area was created (one of the typical GeoERA Mintell4EU sites as an example of an educational mining museum). Photo by P. Rambousek.

the coverage of individual European countries, increased the quality of data provided and supplemented them with production and survey data, and significantly improved data harmonization and automated data collection. Now, the database also contains data on mineral deposits in the UNFC classification, and several case studies on the use of this classification were conducted during the project. An overview was compiled of nearly 500 historical mines as tourist destinations and will also be published as a formal printed publication. The project outputs are important for the EU's political and regulatory bodies, and for geoscientists and the general public as well. The resulting unified map is available at [https://data.geus.dk/egdi/?mapname=egdi\\_geoera\\_mintell4eu#baslay=baseMapGEUS&extent=-327100,759230,8832080,5706150](https://data.geus.dk/egdi/?mapname=egdi_geoera_mintell4eu#baslay=baseMapGEUS&extent=-327100,759230,8832080,5706150).

- **Forecasting and Assessing Europe's Strategic Raw Materials Needs (FRAME)**

A collection of information on Czech Republic's resources and their metallogenesis was completed during the FRAME project (<http://www.frame.lneg.pt/>). A paper (Al-Bassam et al. 2021) on new discoveries of phosphate nodules in the Czech Republic was published. As part of WP5, addressing potential EU resources of "battery raw materials", a final report summarized the characteristics of resources and indications of graphite, lithium and cobalt in the Czech Republic and EU. The CGS team also participated in the tasks of WP7, which identified abandoned historical mines with CRM potential. Potential resources in the Příbram and Kutná Hora ore districts were described in more detail. The project's results were evaluated at a project meeting in Lisbon, Portugal (<https://www.frame.lneg.pt/#News/Events>).

## Information platform

- **GeoERA Information Platform Project (GIP-P)**

The project aimed to provide information support for 14 other GeoERA research projects, all of which generated a large number of pan-European and cross-border datasets. The existing European Geological Data Infrastructure (EGDI) was chosen as the technical platform for GIP-P. This platform was developed significantly during the GIP-P. The functionality of the web-GIS, metadata system, central database, harvesting systems, 3D geological database and its visualization was enhanced. A project dictionary based on Linked Data technology, document storage and related search system, a general search system connected to all EGDI parts, applications for entering new data, and an e-learning module with user manuals and so forth were developed. The data content of the EGDI platform was expanded to include



the results of all 14 GeoERA projects. This ensures that the results of the entire GeoERA programme are, after its termination, permanently stored and provided in a standardized form.

The PanAfGeo project continued with a second phase



The international project “PanAfGeo-2: Pan-African Support to Geological Sciences and Technology Africa-EU Partnership” follows up on a successful three-year first phase, during which over 1,150 geologists were trained in seven thematic areas in various practical fields essential for autonomous management of natural resources. The second phase of the three-year project, approved in 2021, aims to enhance the quality and technological progress of employees of African geological surveys. The project was launched in October during a ceremonial international online conference under the auspices of the European Commission’s DG-INTPA with broad participation of European and African representatives. The Czech Geological Survey is tasked with coordinating a programme focused on practical geological field mapping and work with satellite data. The WP-A work package continues with the preparation of two geological field mapping courses in Namibia and in cooperation with the BRGM in Morocco. Unlike the first phase, the CGS can also invite interested parties from Portuguese-speaking African countries to its programme due to the participation of specialists from the Portuguese Geological Survey LNEG.



▲ Czech and Ethiopian training personnel jointly preparing materials for field mapping training near Axum and Adwa. Photo by V. Štědrá.

## The UNESCO International Geoscience Program (IGCP) was founded in 1972 at the initiative of Czechoslovak geologists



The IGCP programme aims to facilitate geological cooperation across national borders and cultural zones throughout the world. In 2021, the Czech Republic actively participated in the following IGCP projects:

- IGCP 637 (Heritage Stone Designation)
- IGCP 652 (Reading Geologic Time in Paleozoic Sedimentary Rocks)
- IGCP 653 (The Onset of the Great Ordovician Biodiversification Event)
- IGCP 668 (Equatorial Gondwanan History and Early Palaeozoic Evolutionary Dynamics)
- IGCP 679 (Cretaceous Earth Dynamics and Climate in Asia)
- IGCP 682 (Mine Tailing Revalorization)

## Other international cooperation projects

In 2021, in cooperation with foreign partners, the Czech Geological Survey was engaged in many projects.

### CO<sub>2</sub>-SPICER – CO<sub>2</sub> Storage Pilot In a CarbonatE Reservoir



The main goal of the Czech-Norwegian CO<sub>2</sub>-SPICER project is to prepare a pilot CO<sub>2</sub> storage facility at a depleted crude oil and natural gas field located in Southeast Moravia. In addition to dynamic modelling and computer simulation of CO<sub>2</sub> injection, the CO<sub>2</sub>-SPICER project will employ a number of new approaches and methods, such as the latest monitoring techniques or an evaluation of the possibility of combining CO<sub>2</sub> storage with bacterial methanogenesis. If the project proves successful, it will be the first CO<sub>2</sub> storage pilot project in Central and Eastern Europe.

Project website: <https://co2-spicer.geology.cz/cs>.

The project is being carried out in cooperation with Czech and Norwegian partners and is funded by Norway Grants and by the TACR under the KAPPA Programme.

### The fate and future of carbon in forests (CatchCaN)

The project aims to develop modelling software for predicting the amount of carbon and nutrients in forest ecosystems and to use a model for long-term monitoring of

## International activities and cooperation

forest catchments in the Czech Republic, Norway and Sweden. The project partners in addition to the Biology Center of the CAS are the IVL Swedish Environmental Research Institute Ltd. and the Norwegian Institute for Water Research.

### **COST Geothermal DHC**

The project strengthens international cooperation in the use of geothermal energy in district heating and cooling grids. Geothermal-DHC is a research network for the inclusion of geothermal technologies in decarbonized heating and cooling grids. Project website: <https://www.geothermal-dhc.eu/>.

The project was funded by the EU Framework Programme for Research and Innovation Horizon 2020, COST programme.

### **Hystories – HYdrogen STORAge In European Subsurface**



The project is being carried out by an international consortium involving 17 European countries, including the Czech Republic. It focuses on research into hydrogen storage in porous rocks, including existing crude oil and natural gas deposits and deep saline aquifers.

Project website: <https://hystories.eu/>.

The project is funded by the EU Framework Programme for Research and Innovation Horizon 2020 / Fuel Cells and Hydrogen Joint Undertaking (FCH JU).

### **recomine SN–CZ**

The project aims to create a contact network and strengthen cooperation between Czech and Saxon companies, administrative, research and academic institutes, and non-governmental organizations dealing with remediation of environmental impacts from past mining of ores and industrial minerals in the region and with new ways of utilizing mineral resources of the Krušné hory Mts and their technological processing. Future challenges, focusing on specific topics, will rely on the created network of contacts. The project's lead partner is the Wirtschaftsförderung Erzgebirge GmbH, and the other project partners are the Helmholtz Institut Freiberg (HIF) and the Czech Geological Survey. The project was approved for funding from the European Regional Development Fund (Cooperation Programme Czech Republic – Free State of Saxony) in 2021.

### **e-shape – Next-generation satellite data and creation of innovative applications**

The three-year international project, launched in 2019, aims to increase the use of next-generation satellite data (Copernicus Programme) and to develop innovative

applications that will contribute to the goals of sustainable development (Sustainable Development Goals, SDGs). The Czech Geological Survey's expert group on remote sensing is involved in the project and contributes to pilot area 6.3 – Assessing Geohazard Vulnerability of Cities & Critical Infrastructures. Its primary scope deals with presenting and promoting the new possibilities that the Copernicus programme brings to the monitoring of geohazards with emphasis on the urban environment, its development and infrastructure. It is funded by the EU Framework Programme for Research and Innovation Horizon 2020.

### **Building partnership and knowledge base towards sustainable use of underground in cities**

The initiative focuses on the transfer of knowledge in facilitating access to and use of 2D/3D geological data by municipalities and on promoting urban geology to reduce the environmental impacts of subsurface use and to develop new technologies. The project aims to establish cooperation between partners and to share knowledge of urban geology, geomatics and 3D modelling. The initiative's partners are the Geological Survey of Norway and Masaryk University Brno. The project was funded by Norway Grants – a bilateral fund, and by the Programme Environment, Ecosystems and Climate Change.

### **Searching for biological fingerprints and grain alteration patterns in Devonian and Carboniferous microbial facies – examples from the Bohemian Massif**

In 2021, an international research team focused on precipitates composed of hematite, chamosite and Fe carbonate (Lower Devonian age, Pragian stage). By analyzing rare earth elements, trace elements (via LA-ICP-MS method) and stable isotopes ( $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ ), and by studying microstructural characteristics (via BSE method), the precipitates were interpreted as being microbial, forming due to hydrothermal fluids penetrating into the marine environment. The project is being carried out in cooperation with Axel Munnecke, Alexander-Universität Erlangen-Nürnberg, GeoZentrum Nordbayern, Erlangen, Germany, and was funded by the Grant Agency of the Czech Republic.

### **Palaeogeographic maps of Permian continental basins of Central Europe**

The project, which is in its final phase, focuses on unifying and updating stratigraphic schemes of the Permian in the Intra-Sudetic Basin based on discovered traces and fossils and on their comparative analysis. Geochronological, paleoecological and paleoenvironmental studies were conducted. The project is being carried out in cooperation with the Państwowy Instytut Geologiczny – Państwowy



Instytut Badawczy and was funded by the National Science Centre of Poland (Narodowe Centrum Nauki) under the Harmonia Programme.

### **International mobility of researchers of the Czech Geological Survey**

The international activities of the CGS also include a project involving research stays at foreign worksites for CGS staff members. The project aims to improve and enhance the knowledge of employees and also to establish scientific cooperation across countries. Project participants get a unique opportunity to work with devices and applications that are not available in the Czech Republic. During the research stays, they have an opportunity to meet leading experts in their field and then to pass on the experience gained in this manner to other CGS employees. The international mobility project was funded by the European Union's Operational Programme RDE.

### **Preparation of project documents in cooperation with the geological surveys FBiH and RS**

In cooperation with the geological surveys of Bosnia and Herzegovina and Serbia and with the support of the Czech Development Agency, a project has been underway since October 2021, the aim of which is to prepare clearly defined conditions for these geological surveys to cooperate in research on renewable energy sources.

The Czech Geological Survey is successfully implementing two foreign development cooperation projects in Ethiopia

### **Ensuring sustainable land management in selected areas of Ethiopia on the basis of geoscientific mapping**

The main focus of the project is on eliminating the degradation of agricultural land and its restoration as well as on enhancing natural diversity according to the sustainable development goals of the UN. The fulfillment of these goals is based on the acquisition of comprehensive information in order to compile a set of geoscience maps and detailed

land-use/landscape plans in key areas of southern Ethiopia (in the Sidama Region, Gedeo and Gamo zone in the SNNPR). These outputs will allow for analysis of adverse geological phenomena (such as volcanic eruptions and seismic tremors, landslides and rock slides, formation of earth fissures, etc.) and also contribute to efficient and careful use of natural resources (groundwater, soil and minerals). The project was funded by the Czech Development Agency.

### **Geological and hydrogeological map compilation on a 1:1,000 000 scale for the entire territory of Ethiopia**

The project focuses primarily on compiling a national geological and hydrogeological map of Ethiopia at a scale of 1:1,000,000. These map outputs will help address the acute increased demand for drinking water supply and for other practical purposes in various industries and for developing the national infrastructure and sustainable agriculture. In addition, the professional capacity of experts and government officials in the practical use of geoscience information will be enhanced. Furthermore, an interactive online map system will be created to be freely available to anyone interested in using geoscience data. Activities in 2021 focused on creating a new topographic base for processing map outputs, on reinterpreting geophysical and remote sensing data, on creating a new geological legend, and on a regional geological division of the territory and stratigraphy. The project was funded by the Czech Development Agency.

### **Study of geological phenomena in foreign localities**

International cooperation projects of the CGS also include the study of geological phenomena in foreign localities, which is carried out by CGS experts. Fieldwork abroad in 2021 was often hampered by the COVID-19 pandemic. Projects in 2021:

### **Did the West-Gondwana orogens form through inversion of long-lived rift domains?**

The project was successfully completed in 2021. Funded by the Grant Agency of the Czech Republic.



▲ Before going out into the field. Geological camp on the border of Gobi-Altai and Trans-Altai Gobi, southern Mongolia. Photo by P. Hanžl.

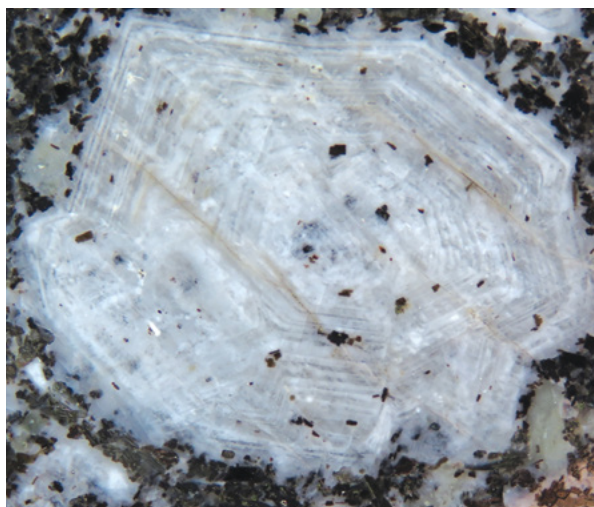
## International activities and cooperation

### Principal mechanisms of peripheral continental growth during the supercontinent cycle

The EXPRO project included work activities carried out mainly in the eastern part of the Central Asian Orogenic Belt (CAOB), specifically in the Dunhuang Block of North China, in the Mongolian and Chinese Altai, and in the Zabaykal region of Siberia. The work yielded a new model of the amalgamation of the microcontinents of Gondwana with the Siberian block during the formation of the Mongolian Orocline. This process was simulated with the aid of analogue modelling. Geophysical studies also made it possible to characterize the internal deformation of the southern branch of the CAOB associated with oroclinal bending. Petrological and geochronological studies provided new data on Paleozoic tectonic overstepping and allow for better understanding of the dynamics of the Paleopacific ocean's subduction. The results of the work were published in seven scientific publications with the highest impact factor.

### Granulite-migmatite domes – insights to Devonian and Carboniferous evolution in the Variscan belt

Work results were published in five scientific publications with the highest impact factor. In the Owl Mts Massif, the tectonic setting and paleogeographic position of sedimentary paleo-basins and the age of their metamorphism indicate a relationship with the Galicia-Trás-os-Montes Massif in Spain and the Münchberg Massif in Germany, which together probably formed a unified terrane at the northern margin of Gondwana during the Cambrian and Ordovician and were then subducted together during the Devonian. In the Eger Crystalline Complex, based on the dating and chemistry of rare monazite elements in relation to the temperature-pressure path of rocks, high-pressure metamorphism was dated at 354 Ma and decompression at 338–340 Ma, which indicates that the process of subduction



▲ Potassium feldspar phenocrysts in durbachite, Vosges Mts. Photo by V. Janoušek.

to exhumation lasted roughly 15 Ma. The modelling of the relamination process of subducting continental plates and a comparison of temperature-pressure paths of rocks from the central and eastern parts of the Bohemian Massif indicate a horizontal transport of continental rocks through the mantle and their diapiric exhumation through the upper plate. The project was funded by the Grant Agency of the Czech Republic.

### Petrogenesis of (ultra-)potassic magmas in the European Variscides – implications for the development of collisional orogens and crustal growth models

During the GACR 18-24378S project, three papers were published in 2021 in a special double issue (402–403) of the *Lithos* magazine devoted to selected contributions from the Hutton Symposium on the Origin of Granites and Related Rocks (Nanjing, China, 2019). The first two (Moyen et al., Jacob et al.) deal with the dichotomy of models for the petrogenesis of granitoid rocks, presuming the anatexis of various crustal protoliths or the fractionation of mantle magmas. The papers show that both models can usually be applied together, but in different geodynamic environments to different degrees; it also underlines the important role of hybridization at various scales (from individual mineral grains to magmatic provinces). The third paper summarizes the results of a comprehensive geochemical study of Mg- and K-rich igneous rocks from the French Vosges Mts (Hora et al.), which sampled various domains of a heterogeneous lithospheric mantle, metasomatically overprinted by the Variscan subduction of the oceanic and, locally, of the continental crust. The project was funded by the Grant Agency of the Czech Republic.



▲ Hohneck, Vosges Mts.



### **Origin and metamorphic evolution of allochthonous units in the eastern French Massif Central**

(Funded by the Ministry of the Environment from the Programme of Long-Term Conceptual Development of Research Organizations)

### **Variscan evolution of the MECS micro-plate exemplified by the Maures Tanneron massif (SE France): A link between the European and North-African Variscan belt?**

(Funded by the Ministry of the Environment from the Programme of Long-Term Conceptual Development of Research Organizations)

### **Petrogenesis, structures and emplacement of post-collision Weinsberg granitoids (Moldanubian Batholith)**

(Funded by the Ministry of the Environment from the Programme of Long-Term Conceptual Development of Research Organizations)

### **Genesis of post-orogenic granites of the Aaj Bogd massif in the Trans-Altai Zone in southwestern Mongolia**

This publication project summarizes the geological position and genesis of little-known post-orogenic granites with alkaline affinity from the margin of the Trans-Altai Zone in southwestern Mongolia. It is based on data previously obtained during the GACR projects "Crustal growth and



▲ Mongolia, Altai Mts.

construction of continental crust as exemplified by the Central Asian Orogenic Belt" (researcher K. Schulmann, 2012–2015) and "Contrasting mechanisms of formation of the Pangea supercontinent: new insights into the formation of the continental crust" (researchers K. Schulmann and O. Lexa, 2016–2018). The aim of the project includes the organization of existing petrological and geochemical data, recalculation and cleansing of geochronological data from LA-ICP-MS, genetic interpretation, regional correlations and a description of the geotectonic evolution of the post-orogenic intrusions in the above-mentioned region. The project was funded by the Ministry of the Environment from the Programme of Long-Term Conceptual Development of Research Organizations.



▲ Mongolia, Altai Mts.

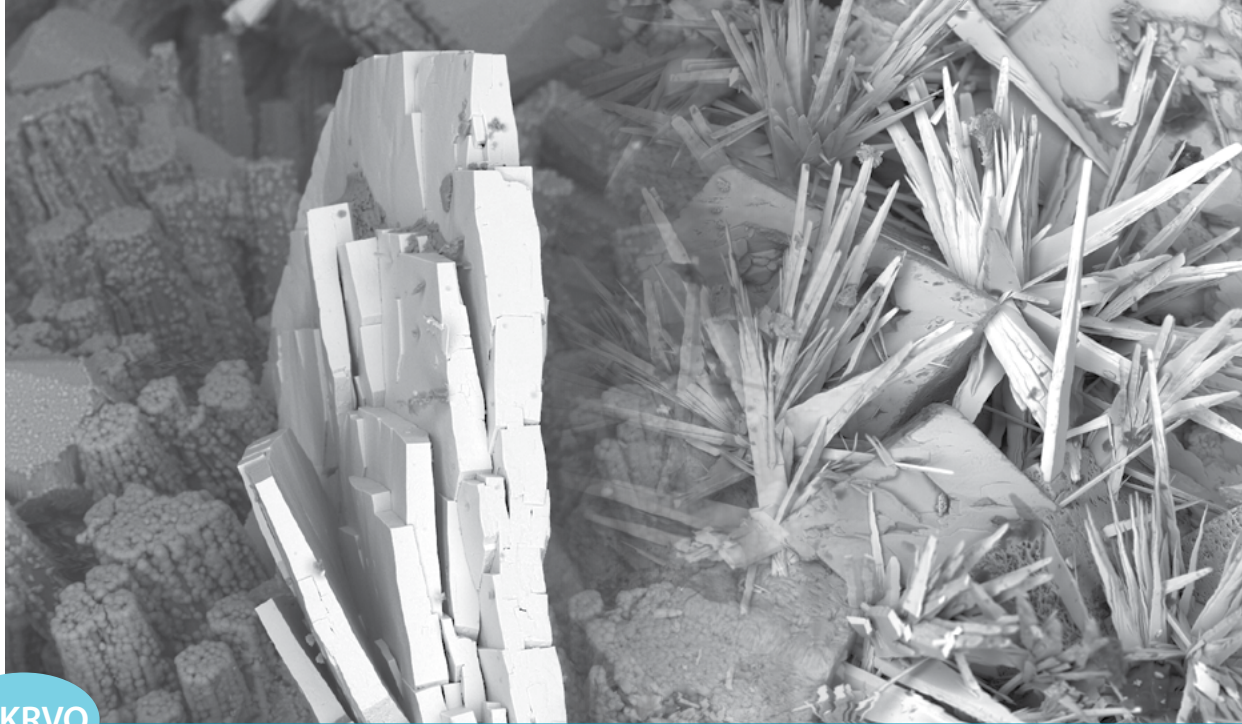
## International activities and cooperation

### Membership in international organizations

<b>AAPG</b>	American Association of Petroleum Geologists	J. Franců
<b>AGU</b>	American Geophysical Union	A. Andronikov, I. Andronikova, J. Hruška
<b>CAAG</b>	Czech Association of Geophysicists, a member of the Council of Scientific Societies of the Czech Republic (CSS), a member of the Union of Geological Associations (UGA), and an associated society of the European Association of Geoscientists and Engineers (EAGE)	D. Čápková, CAAG board member
<b>CBGA</b>	Carpathian-Balkan Geological Association	M. Bubík, national delegate
<b>Central European Initiative</b>	Association of the Central European geological surveys of the Czech Republic, Slovakia, Austria, Hungary, Croatia, Poland and Slovenia	Z. Venera
<b>CEP – ATS</b>	Committee for Environmental Protection – Antarctic Treaty	Z. Venera, D. Nývlt
<b>CETEG</b>	Central European Tectonics Group	Z. Venera, P. Mixa
<b>CO2GeoNet</b>	European Network of Excellence for Geological Storage of CO <sub>2</sub>	V. Hladík
<b>EAG</b>	European Association of Geochemistry	A. Andronikov
<b>EAGE</b>	European Association of Geoscientists and Engineers	V. Hladík
<b>EGS (EuroGeoSurveys)</b>	Association of European Geological Surveys	Z. Venera, Board of Directors
<b>EGS Earth Observation and Geohazards Expert Group</b>	EGS Earth Observation and Geohazards Expert Group	V. Strnadová
<b>EGS Geochemistry Expert Group</b>	EGS Geochemistry Expert Group	M. Poňavič
<b>EGS Geoenergy Expert Group</b>	EGS Geoenergy Expert Group	V. Hladík
<b>EGS Geological Mapping and Modelling Expert Group</b>	EGS Geological Mapping and Modelling Expert Group	Z. Bukovská
<b>EGS Mineral Resources Expert Group</b>	EGS Mineral Resources Expert Group	P. Rambousek, V. Wertich
<b>EGS Spatial Information Expert Group</b>	EGS Spatial Information Expert Group	D. Čápková, chairwoman (since 2019), L. Kondrová
<b>EGS Urban Geology Expert Group</b>	EGS Urban Geology Expert Group	J. Jelének
<b>EGS Water Resources Expert Group</b>	EGS Water Resources Expert Group	E. Kryštofová
<b>ENeRG</b>	European Network for Research in Geo-Energy	V. Hladík



<b>EPOS TCS GDM</b>	EPOS Thematic Core Service, Geological Information and Modelling	D. Čápková, co-chair
<b>GEO – GEO4MIN</b>	Group on Earth Observation, Community Activity GEO4MIN on Earth Observation Data for Managing Mineral and Non-Renewable Energy Resources	V. Strnadová, co-chair (since 2018)
<b>GIC</b>	Geoscience Information Consortium, gathering the managers of informatics of 32 geological surveys around the world	D. Čápková, steering committee member
<b>GIC CE</b>	A consortium gathering the managers of informatics from the Central European geological surveys of the Czech Republic, Slovakia, Austria, Hungary, Croatia, Poland and Slovenia	D. Čápková, L. Kondrová, O. Petyniak
<b>IAGOD</b>	International Association on the Genesis of Ore Deposits	B. Kříbek, J. Pašava, international committee member
<b>ICDP-SAG</b>	International Continental Scientific Drilling Program – Science Advisory Group (evaluation of submitted projects)	J. Kotková
<b>ICL</b>	International Consortium on Landslides	P. Kycl
<b>ICS – ISOS</b>	International Commission on Stratigraphy – International Subcommission on Ordovician Stratigraphy	P. Budil, member correspondent
<b>ICS – SCCS</b>	International Commission on Stratigraphy – I.U.G.S. International Subcommission on Carboniferous Stratigraphy	Z. Šimůnek
<b>ICS – SDS</b>	International Commission on Stratigraphy – International Subcommission on Devonian Stratigraphy	P. Budil, member correspondent
<b>IMA</b>	International Mineralogical Association	F. Laufek, Commission for Ore Mineralogy
<b>INQUA</b>	International Union for Quaternary Research	D. Nývlt
<b>International Organisation of Palaeobotany</b>	International Organisation of Palaeobotany	Z. Šimůnek
<b>ProGEO</b>	The European Association for the Conservation of the Geological Heritage	P. Budil, chairman of the Czech national group
<b>SEG</b>	Society of Economic Geologists	J. Pašava, international committee member
<b>SGA</b>	Society for Geology Applied to Mineral Deposits – a scientific society gathering over 1,300 experts on geology and mineral deposits from over 80 countries around the world; the SGA publishes the prestigious <i>Mineralium Deposita</i> journal	J. Pašava, executive secretary, A. Vymazalová, vice-president for student affairs, B. Kříbek, I. Kněsl, M. Tuhý
<b>SGS</b>	Slovak Geological Society	P. Budil, honorary member
<b>SRG</b>	The Society of Resource Geology (Japan)	J. Pašava



/DKRVO

## Laboratories



**Věra Zoulková**  
Head of the Central  
Laboratory Prague



**Juraj Franců**  
Head of the Central  
Laboratory Brno



**Anna Vymazalová**  
Head of the Department  
of Rock Geochemistry



**Irena Sedláčková**  
Head of the Sample  
Preparation Laboratory

The laboratories play an irreplaceable role in fulfilling the theoretical and practical goals of geoscience research at a national and international level. Rapid modernization of instruments emphasizes exact approaches for the description of natural systems, as well as the quantification of substance flow. It is important to not only employ proven methods for studying the components of the rock and natural environment and for scientific interpretation of research results but also to actively introduce new analytical procedures.

### Central Laboratory Prague

The Central Laboratory plays a significant role in the basic and applied research of the Czech Geological Survey by performing the tasks of DKRVO (Long-term Conceptual Development of Research Organizations 2018–2022) and of the state geological survey. It performs chemical analyses for internal projects of the CGS as well as for projects funded from other national and international sources (GACR, TACR, MoE, MIT, MoA, EU and others). Since 1993, the Central Laboratory has been accredited by the Czech Accreditation Institute (CAI) according to the ČSN EN ISO 17025 standard. The results of accredited outputs are valid in all countries of the European Union. A developed quality system is described in the Quality Manual, the Confirmation Procedures for Instruments and in the laboratory's Metrological Rules. The accreditation pertains to inorganic analyses of geological



materials, surface water and leachates. Compliance with the quality system is regularly checked by CAI employees.

### Water analyses

Complete analyses of various types of surface water and precipitation are carried out in the Central Laboratory. Analytical methods have been tested over the long-term by CGS experts in programmes that monitor the status of selected river basins in the Czech Republic. Samples are handled according to pre-approved procedures, specified in the Quality Manual or Notes on Analytical Methods. Comprehensive water analysis involves the determination of Li, Na, K,  $\text{NH}_4$ , Mg, Ca, Mn, Zn, Fe, Al,  $\text{SiO}_2$ , pH, F, Cl,  $\text{NO}_3$ ,  $\text{HCO}_3$ ,  $\text{SO}_4$  and conductivity. Trace elements that are determined in concentrations of  $\mu\text{g/l}$  include Al, As, Be, Cd, Co, Cr, Cu, Mo, Ni, Pb, V and Hg.

For water analyses, the laboratory is equipped with the following instruments: a Radelkis pH meter, a pXmeter, a conductometer, an AMA 254 mercury analyzer, a Perkin-Elmer Hitachi 200 absorption photometer, a Knauer Azura ion chromatography detector with conductivity detection, Perkin Elmer AAnalyst 100 and Perkin-Elmer PinAAcle 500 flame AA spectrometers, a Perkin Elmer AAnalyst 700 AA spectrometer with electrothermal atomization, and an Agilent Technologies 7900 series inductively coupled plasma mass spectrometer.

### Analysis of solid samples

The laboratory offers of solid sample analyses that determine  $\text{SiO}_2$ ,  $\text{TiO}_2$ ,  $\text{Fe}_2\text{O}_3$ , FeO,  $\text{Al}_2\text{O}_3$ , SrO, BaO, Li<sub>2</sub>O, MnO, CaO, MgO,  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ ,  $\text{P}_2\text{O}_5$ , moisture, bound water,  $\text{CO}_2$ ,  $C_{\text{tot}}$ ,  $S_{\text{tot}}$ , F, and loss on ignition. All these components are included in silicate analysis. The laboratory offers four methods of silicate analysis – a complete, simplified, technical and modified silicate analyses, which differ in the number of analyzed components and in the total sum of all components.

For soil analysis, bulk acidity and exchangeable Al are determined from leachate in  $\text{BaCl}_2$ . The pH in aqueous leachate and in KCl leachate and  $\text{P}_2\text{O}_5$  concentration in Mehlich III leachate are determined as well. Individual elements can be determined in leachates by FAAS. The laboratory also takes requests for specialized decomposition and trace element analyses, performed on FAAS or ICP-MS instruments.

Rare earth elements are measured by ICP-MS as well. Trace elements are also determined by X-ray spectrometry without decomposition of the sample from the tablet. In addition, the Central Laboratory performs inorganic analyses of special materials, such as wood, peat, needles, leaves, and so forth. For solid sample analyses, the Central Laboratory

uses Perkin-Elmer AAnalyst 200 and Perkin-Elmer PinAAcle 500 flame AA spectrometers, an Agilent Technologies 7900 series inductively coupled plasma mass spectrometer, an AMA 254 mercury analyzer, Eltra CS-500  $\text{CO}_2$  and Eltra CS-580 analyzers, state-of-the-art water deionization equipment, a Rigaku BE 67000104 X-ray spectrometer, modern automatic titrators, and a Radiometer pX-meter.

### Activities in 2021

The main scope of activities in 2021 involved work for internal and grant projects of the CGS staff as well as support for state geological survey tasks.

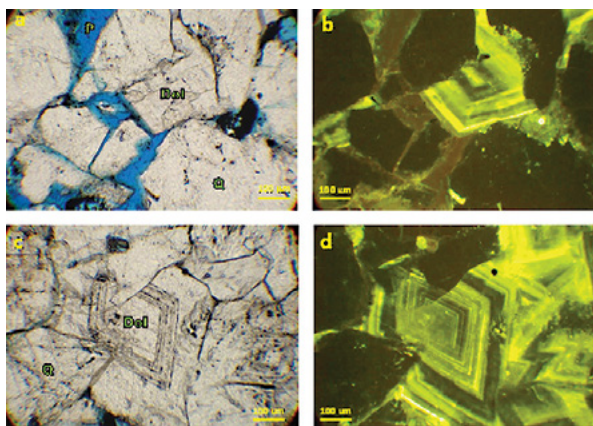
Measurement results are evaluated by the unified integrated processing system for analytical data and their network-oriented database management – Personal III, which meets the requirements of geologists for delivery of analysis results in electronic form, which facilitates the transfer of data to a central database and their link to geological data, related to a given sample. Electronic data processing also meets the requirements stemming from the accreditation for statistical processing of control analyses at individual laboratories.

### Central Laboratory Brno

The accredited Central Laboratory in Brno focuses on organic and gas geochemistry, and recently also on microscopic porosity.

### Analysis of rocks and crude oil

For a more detailed characterization of the depositional environment and the biological origin of organic substances, the Central Laboratory of Brno analyzes molecular fossils – biomarkers. This method is used in the new CO<sub>2</sub>-SPICER project to distinguish the facies types of carbonate and siliciclastic sediments of the Paleozoic, Jurassic and Paleogene, as well as to determine the rate of migration



▲ Photomicrograph of a thin section in transmitted (a, c) and fluorescent light (b, d): Nikolčice Formation, Middle Jurassic.

## Laboratories

of Jurassic oil into overlying formations. The facies types of limestones and their dolomitization types are characterized using reflected and fluorescent light microscopy. All methods are interpreted with reference to the thermal history of the monitored model basin.

### Ecology

The laboratory monitors persistent organic pollutants (POPs) in soil and airborne dust. Detailed analysis of their composition indicates whether they come from natural sources or pollution. The total concentration of polycyclic aromatic hydrocarbons or their mutual ratios are used to compile environmental load maps. Recently, the laboratory has been studying polycyclic aromatic hydrocarbons (PAH) as indicators of large-scale fires in terrestrial vegetation.

### Gases

For field measurements of gases, the laboratory's staff uses Ecoprobe 5 and Draeger portable instruments. Accredited detailed chromatographic quantitative analysis determines 20 compounds including helium and argon. These measurements along with the analysis of the isotopic composition of carbon in methane and in higher hydrocarbons help determine the origin of gases, for instance, from collieries, and microbial activity at depths of several kilometres or in areas above plugged wells of crude oil deposits. These analyses are now linked with the microbiological analysis of methanogenic archaea-bacteria. As part of an ongoing TACR project, hundreds of surface measurements are evaluated in the form of isopach maps of the natural source of carbon dioxide at a future CO<sub>2</sub> storage facility site.

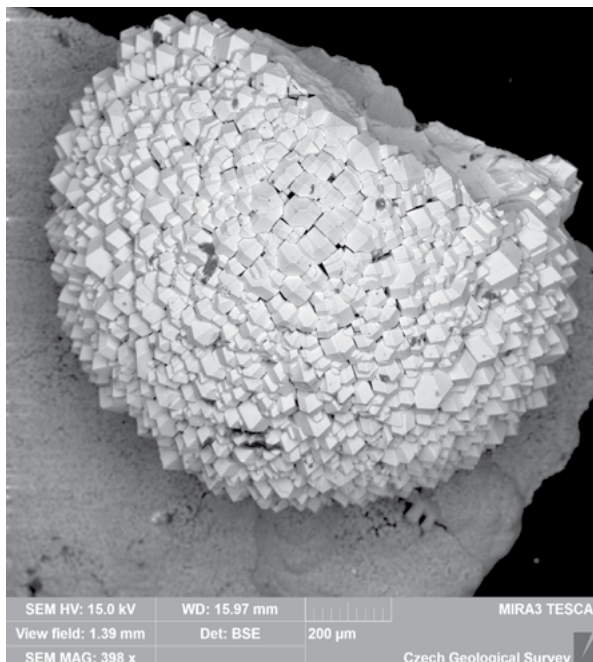
### Specialized Laboratories

The Specialized Laboratories provide expert services, primary data and aid with their interpretation. They are actively involved in a number of national, international and multidisciplinary projects. Their findings are published in reputable journals and presented internationally. Many staff members of the laboratories are prominent experts in their fields and are also engaged in university education and in other activities involving the teaching and training of students.

#### Isotope Geochemistry and Geochronology Laboratory

The laboratory focuses on the analysis of traditional isotopic systems (Rb → Sr, Sm → Nd, Re → Os), following up on decades worth of knowledge gathered by the CGS. A high-quality Triton Plus thermal ionization mass spectrometer (Thermo Fisher Scientific, Germany) was purchased in 2017.

In 2020, a new section of the laboratory with Micromill (ESI) equipment and microbalances (Mettler Toledo) was put into operation. This will allow for sampling of geological material requiring a chemical separation of elements prior to isotope analysis, with a wide range of applications, such as for the study of the temporal evolution recorded in mineral growth zoning.



▲ Backscattered electron image of harmotome, Kluček near Heřmaničky. Photo by O. Pour.



▲ Backscattered electron image of linarite, Zlatý kopec. Photo by O. Pour.



The majority of samples are prepared using ion selective chromatography in a specialized pressurized ultra-trace laboratory with controlled sterility (USL). In addition to methodological development, the laboratory's research focuses mainly on the origin of igneous rocks of the Bohemian Massif. The laboratory staff is also involved in the application of isotope systems in several geological and interdisciplinary research projects.

The laser ablation laboratory is equipped with a HelEx two-volume ablation cell in conjunction with an Agilent 7900x ICP-MS quadrupole inductively coupled plasma mass spectrometer (Agilent Technologies Inc., Santa Clara, USA), allowing for in situ measurement of trace elements and isotope ratios of a wide range of petrogenetically significant elements in many natural and synthetic materials. The laboratory employs methods for geochronology using U-Th-Pb isotopes in zircon and for the determination of trace element concentrations in different matrices.

### **X-ray Diffraction Laboratory**

The staff members of the X-ray Diffraction Laboratory, which is equipped with powder diffractometers (Bruker D8 Advance and Philips X'Pert), perform mineralogical analyses of a wide range of geological materials – rocks, minerals, clays and soil. They specifically analyze various crystalline synthetic materials, waste products, fly ash, sludge, precipitates from mines, construction materials and others.

### **Electron Microscopy and Microanalysis Laboratory**

With the use of a Tescan Mira3 GMU FEG-SEM high resolution electron microscope, the laboratory can characterize studied materials based on morphology and chemical composition, and capture 3D images of objects as well. The microscope is equipped with the EDS, WDS and EBSD (Oxford Instruments) analysis systems and AzTec 3.3 acquisition software, enabling characterization of materials with respect to chemical composition and crystallographic orientation on a microscale.

### **Fluid Inclusion Laboratory**

The Fluid Inclusion Laboratory is equipped with an Olympus BX53M polarizing microscope with a fluorescent light source and a LINKAM THMSG thermometric instrument. The instrument is used to study the temperatures of inclusions (from -180 up to +600 °C) and the composition of aqueous and gaseous fluids in inclusions (up to 5 mm) in minerals from diverse geological environments.

### **Experimental Mineralogical Laboratory**

Research focuses primarily on the synthesis of chalcogenides, on phases of Pt metals, and on the study of phase relationships.

### **Laboratory of Micropaleontology, Ecostratigraphy and Paleobiology**

The laboratory studies the influence of global changes in the paleoenvironment on marine and terrestrial communities. An integral part of the work performed by the rock geochemistry department involves mineral separation and production of microscopic preparations for further research. The separation laboratory at Barrandov combines several methods to achieve the purest possible mineral concentrates. The process includes the crushing and grinding of rocks to less than 0.75 mm, initial wet separation on a gravity concentration table, heavy mineral separation, separation in heavy liquids and final magnetic separation. Zircon is most often separated, and there is also increased interest in the separation of garnet, monazite, apatite and mica. In 2021, the grinding facility processed 2,000 samples, the most common being polished thin sections, and also covered thin sections and polished sections.

### **Sample Preparation Laboratory**

The Sample Preparation Laboratory is part of the Regional Geology of Moravia Department, located in the Brno office. It prepares rocks and sediments for paleontological and mineralogical research, geochemical analysis and geochronological dating.

It mostly meets the needs of the parent department's staff and, as required, those of the entire geology division. The basic methods of sample processing include crushing, wet and dry sieving, pebble analysis, granulometry, flotation, gravity separation (shaking table, heavy liquid), magnetic and electromagnetic separation using a Cook electromagnetic separator and, if need be, manual separation.

In 2021, the laboratory processed 630 samples and thus participated in the solution a total of eighteen projects. The largest number of samples was processed for the TACR project ("Leading-edge instrumental methods in high resolution global Jurassic-Cretaceous boundary correlations", 27%). Another large portion of samples was processed for the "Groundwater in the Karst System" project (25%), or for the Inventory of Slope Instabilities (10%). The remaining volume of laboratory work involved regional geological mapping and other internal projects of the CGS, projects of the Ministry of the Environment, or external contracts.

In the past year, contracting parties most often requested the separation of microfossils (302 samples, 45%), sample preparation for geochemical study (230 samples, 34%), or the separation of heavy minerals (90 samples, 13%). A total of 7 samples were processed for geochronological dating in 2020.



# Library and Collections



**Hana Breiterová**  
Head of the Information Services  
Department and Geological Library

Already the first CGS director, Cyril Purkyně, emphasized the significance of a science library for the proper functioning of the state geological survey. Today's library and collections are part of the Information Services Department, which includes a record management department since 2017. The vast selection offered by the library and collections are used not only by experts from the Czech Geological Survey or other scientific institutes but also by students, private researchers, and other interested members of the public. All researchers may use the study rooms in Klárov, Prague, and at the Brno office, where study material from the library and collections are provided. Mining literature can be studied at the Kutná Hora office.

## CGS Library

Access to the largest collection of geoscience literature in the Czech Republic is provided by the Czech Geological Survey Library, which since 2013 also includes a specialized archive from the former library of the Ministry of the Environment (MoE). It is the only library in the Czech Republic that also offers literature on waste management. Nine proprietary and two article databases may be accessed by all registered readers using the library catalogue. Internationally recog-

nized full-text databases (Science Direct, SpringerLink, Willey Interscience, Blackwell, GeoscienceWorld) and bibliographic databases (Web of Knowledge, Scopus, Georef and Geobase) are accessible through the CzechELib consortium, of which the CGS Library is a member. Of all the libraries administered by the MoE, the CGS Library provides the widest range of online information sources.

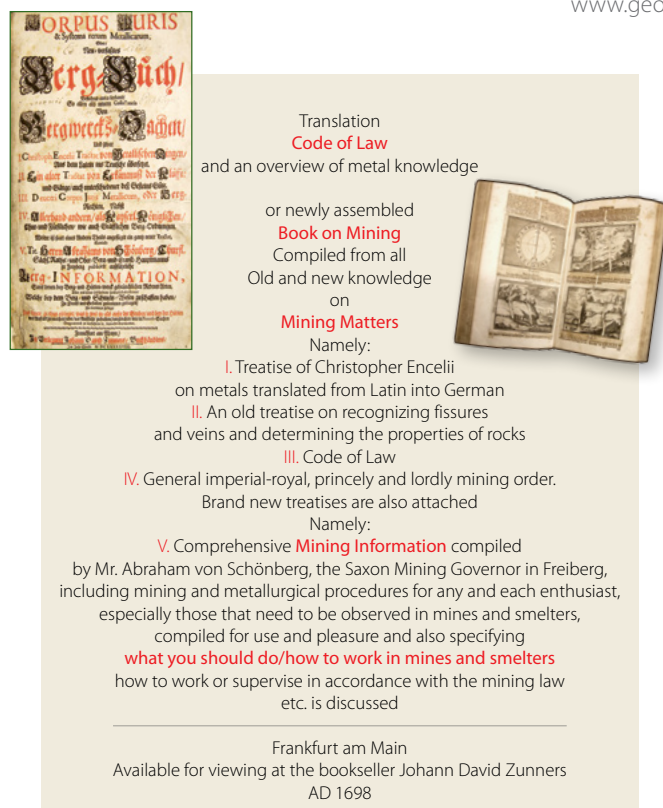
## CGS Library in 2021

Due to the epidemic situation in 2021, the CGS Library continued to function as in 2020. Most of the work associated with cataloguing was again done remotely. This included the maintenance of the system and dictionaries, entry of GEOL and ENVI articles into databases, and examining reports made to the National Library. Services were mainly provided based exclusively on orders, without the possibility of on-site study at the study rooms due to closures and restrictions. Despite that fact, the library staff managed to process nearly 3,200 loans at the study room in Prague, and 528 loans in Brno.

## Collections

The Department of Geological Collections stores and provides access to fossils, mineral and rock samples, thin sections and other geology-related items collected by the researchers of the Czech Geological Survey and access to the findings made by other organizations as well as by private collectors. The most valuable samples from a science perspective are housed in geological, mineralogical, and paleontological collections. These museum-character collections are stored, made accessible and recorded by the department in the CES national register by virtue of Act No. 122/2000 Coll., as amended, and Decree 275/2000 Coll. The management





▲ *Corpus Iuris* (1660): title, title page translation, selected photo from the book (IC 1094).

of these items is subject to strict conditions defined by the above-mentioned and subsequent legal regulations. The documented samples – geological and paleontological samples from geological mapping and thin sections – are stored by the CGS in accordance with Act No. 62/1988 Coll., as amended by Act No. 66/2001 Coll.

### Collections in 2021

In 2021, the most significant additions to the collections included the purchase of the second part of the F. Ficner collection (unique material from Čelechovice na Hané and from the Moravian Tertiary), the purchase of the J. Kočerhan collection, which again represents unique material from the Moravian Devonian, from the Stínava locality. Also worth mentioning is the trilobite *Paleolenus* with the remains of a digestive system obtained by O. Fatka or the original and type phytopaleontological material related to the publications of Z. Šimůnek. In addition, significant material was acquired for the geological collection – samples from the estate of the eminent geologist F. Markovič (geological, mineralogical, and paleontological samples) were transferred to the depositories in Lužná u Rakovníka and will be processed in the coming years.

Since 2014, the collections and material documentation department has also been processing the vast collection

of J. Sekyra from his research in Antarctica, deserts, and the world's high mountains. The drill cores in Lužná have been managed by the CGS – Geofond borehole material documentation department since 2017. The onset of the COVID-19 epidemic restricted visits to the collections – the study room had to be closed several times and, with a few exceptions, foreign researchers again did not visit due to travel restrictions in 2021. Therefore, there was increased interest online for the services provided by the collections department, such as consultancy, production of photographs of archived material, or mailing of latex casts to foreign researchers based on their requests.

The maintenance of the CGS collections in 2021, which include roughly 300,000 items, involved very intensive publishing activities performed by the collection department's staff members as well as their work on grant project 18-14575S and on internal tasks of the CGS (including a paleontological rescue mission at the Špička quarry in Radotín) in addition to their work as regional geological experts. In 2021, the collection department's staff was again engaged in teaching at the Faculty of Science, Charles University. The study room of the collections facility and the stored collections were again used (albeit for a short period when permitted by epidemic measures) for teaching purposes (such as the ichnofossil study course led by Dr. R. Mikuláš from the Institute of Geology of the Czech Academy of Sciences).



▲ Pygidium of the trilobite *Odontochile cf. hiberna* Šnajdr, 1985, Řeporyje Limestone (Pragian), Špička quarry in Radotín. Whitened with ammonium chloride, the scale corresponds to one centimetre. Photo by M. Nohejlová 2021.



Map collection of the CGS Archive: *Spezial-Karte vom Riesengebirge* ("Special Map of the Krkonoše Mts"); author: Chrétien, J.-C.; year: 1850, publisher: Justus Perthes, Gotha.

## Geological documentation



Milada Hrdlovicsová  
Head of the Geofond Division

The Geofond Division fulfils the tasks of the state geological survey by functioning as a public archive, documentation and study centre and also by collecting, storing, processing and providing access to written geological documentation and material samples.

### Archive collections

According to § 12 of Act No. 62/1988 Coll., 5,733 reports and assessments of geological project results were handed over to the CGS Archive in 2021 by geological project owners or by organizations that carry out the work. Currently, the archive collections permanently hold and provide access to over 275,000 archive records of unpublished geoscience documents.

### Archive services

A large community of professionals use the archive services of the main study room located at Kostelní 26, in Prague 7. In 2021, the study room operated on a modified basis due to the current epidemic situation. Access to on-site loans was maintained but limited to pre-scheduled visits to adhere to the daily number of researchers allowed. At the same time, the variety of online services on offer was operationally expanded and many researchers took advantage of obtaining documents remotely via scans sent according to their requests.

### ASGI archive database

Documentation submitted to the archive is continuously processed in the form of annotation records with a brief description of document content and with the use of indexing terms from a science thesaurus. This processing method allows for subsequent parametric search of all archived documents in the "ASGI" archive application at <http://www.geology.cz/app/asgi>.





▲ Preparation of archive documents for digitization: prior to scanning, all documents undergo a technical annotation, which mainly includes a detailed verification of completeness and division into logical units according to content.



▲ Borehole core material documentation: Borehole DO-574 in original sample containers.

## Map archive

A separate collection of the map archive gathers CGS map outputs from and also contains other geoscience maps from the Czech Republic as well as from foreign countries, including historical maps. In 2021, about 800 maps were added to the collection, often including accompanying texts and explanatory notes. Most of the collections are also available online in digital form and can be found in the map archive applications at <http://www.geology.cz/extranet/mapy/archiv>.

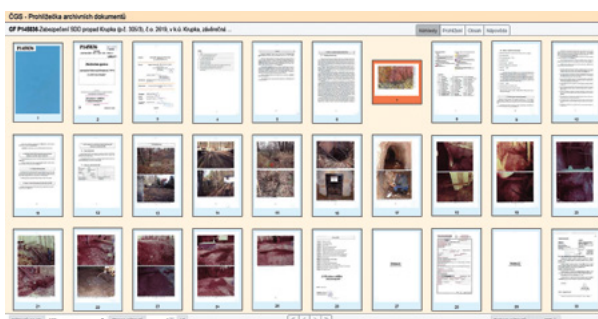
## Digitization

Digitization enables fast and remote access to the archive collection. A new service launched for the public in 2021 is the "Archive Document Viewer", linked directly to the ASGI application to search for archived reports. Currently, more than 49,000 digital archive reports, containing over four million image files in JPG format, are already available online. In addition, digitization of archived documents may be requested as a paid service.

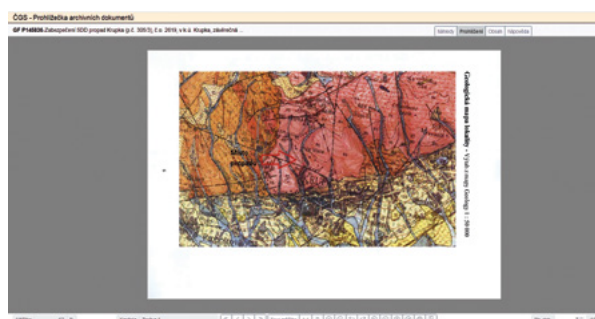
Digitization work in 2021 focused mainly on completing external orders, which increased significantly due to the corona crisis. Digitization also played a role in providing archived documents for research projects conducted by the CGS, particularly those involving economic and engineering geology.

## Borehole core material documentation

Based on requests, the Geofond Division provides access to a constantly growing set of more than 35,000 m of continuous drill cores or rock samples from structural and other important wells in the Czech Republic. Over 15,200 sample containers with 2,700 objects (primarily drill cores) are stored in a special system in the Kamenná, Stratov and Lužná repositories. Among other things, a unique drill core from boreholes DO-574 and DO-583 (in the surroundings of Droužkovice near Chomutov – Doly Nástup Tušimice), drilled beneath a coal seam in a seismically detected canyon in the crystalline complex (at a depth of 102.0–227.3 m and 137.0–229.0 m), was stored in the CGS Lužná repository in 2021.



▲ Digitized Document Viewer: Preview mode with an overview of all scanned pages of a given document. Detailed view of individual pages in the "View" mode.





# CGS Publishing House



**Patrik Fiferka**

Head of the CGS  
Publishing House

The Publishing House of the Czech Geological Survey is the largest publisher of geological literature in the Czech Republic. It also publishes multimedia content promoting the activities of the Czech Geological Survey and geology as a field of study. Each year, it releases expert publications dedicated to various Earth sciences, geological and thematic maps at various scales, and popular science and education literature, including those using modern technologies such as augmented reality.

The Publishing House presents the research results of Czech Geological Survey specialists to the public through geoscience exhibits, fairs, conferences, educational activities, the CGS information portal, social networks and other modern technologies.

## Books and maps

Each year, the Czech Geological Survey publishes expert publications devoted to individual geosciences, periodicals, monographs, geological and thematic maps of various scales as well as popular science titles, including those that use modern technologies such as augmented reality. The publishing, project and commercial activities included the release of 30 titles in 2021.

## Promoting CGS activities and popularization of geology

In addition to maps and publications, the Czech Geological Survey also conducts promotional activities. It systematically acquaints the public with the research results of CGS specialists and promotes the popularization of geoscience in various forms, manages the World of Geology on Facebook (<https://www.facebook.com/svetgeologie>) and Geology TV on YouTube (<https://www.youtube.com/user/Geologycz>). During the course of the year, nearly 200 posts were published on the Facebook page World of Geology and six films and animations on the YouTube channel. The animations on the origin of geosites arouse the greatest interest. The popularity of CGS programmes on YouTube is also confirmed by the number of new subscribers for the published content, amounting to nearly three thousand, and also by a significant percentage increase in views of individual videos.







▲ The Czech Geological Survey (CGS) and the Museum of the Nový Jičín District prepared the exhibition “Antarctica – Evidence of Life from the Eternally Frozen Continent”, which was devoted to the results of CGS field research in Antarctica, where Czech geologists experienced unprecedented success in making discoveries of global significance, some of which the exhibition documented, such as the discovery of a fossilized *Plesiosaurus*, a marine reptile, and giant ammonites. The exhibition was on view at the Šipka Museum in Štramberk from June to September.

Promotion of the institute's activities was also bolstered by an increase in the number of reports published on various information servers, which drew on the current events regularly published on the Czech Geological Survey's website, the number of which doubled compared to the previous year.

### Twelve new animations on the origin of geosites, rocks and minerals

Multimedia content promoting the activities of the Czech Geological Survey and geology as a field of study is a permanent feature of the Publishing House's production. This includes, for instance, mobile applications, animations depicting the formation of selected geological features and also animations with augmented reality. In 2021, six new animations on the origin of geosites or rocks and minerals were published on the YouTube channel – for example, Altenberg-Teplice Caldera, Fossilized Seabed in Deblav or Formation of Moldavites and Microdiamonds.

### Publishing and project activities

During 2021, the Publishing House was engaged in the projects CO<sub>2</sub>-SPICER – CO<sub>2</sub> Storage Pilot in a Carbonate Reservoir,



▲ The process of moldavite formation was the most popular animation of the past year. Moldavite, a term derived from the Vltava (Moldau) River, formed roughly 14.8 million years ago, after the fall of an extraterrestrial object about 1 km in diameter in the area of today's town of Nördlingen in southeastern Germany. Today, the crater that formed has a diameter of about 26 km. Research was funded by the Grant Agency of the Czech Republic. Although the animation was not published until the end of the year, it was seen by nearly 3,000 viewers in just a few weeks.

RENS – Rock Environment and Minerals, and GECON – Geology Cooperation Network. The main task of the Publishing House's staff is to provide project publicity and promotional activities. The GECON – Geology Cooperation Network project, which was conducted in cooperation with Polish partners, concluded successfully with an April conference entitled *Landscape of Mutual Cooperation*.



▲ For the “Tracing the Footsteps of Life” nature trail in the Železné hory National Geopark, CGS created an identically named application with augmented reality and an animation of the formation of the Na Deblavě rock.



▲ The Czech Geological Survey was engaged in organizing the Open House Prague 2021 festival, which took place on 2–8 August 2021. Visitors were given a guided tour of the entrance foyer, courtyard and chapel of St. Raphael. They were also able to view an exhibition of photographs documenting the history of the original Klárov Institute for the Blind and its premises. The fact that nearly 700 guests came in a single day indicates that there was enormous interest in visiting the headquarters of the Czech Geological Survey.

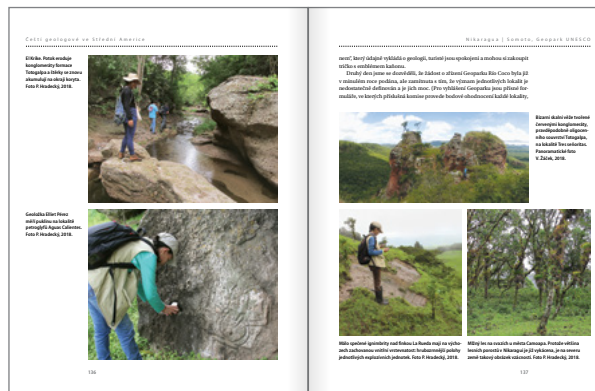


▲ The *Landscape of Mutual Cooperation* was the motto of the final conference of the Czech-Polish project GECON, which took place online on 8 April 2021. The aim of the project was to create and develop a geological cooperation network – an informal platform of institutes sharing a common interest in the study, protection and popularization of the geological wealth in the Czech-Polish border area.

# Selected publications issued

## Czech Geologists in Central America Nicaragua / El Salvador / Costa Rica

Petr Hradecký (Ed.)



The book gives an account of the activities of Czech geologists in Nicaragua, El Salvador and Costa Rica by popularizing their studies that document and predict natural hazards based on the geological structure of the terrain. In addition to basic information, particularly on the lithology and tectonics of volcanic rocks, the book describes the daily life of geologists in their places of work, and their collaboration with local experts and representatives of institutes and state authorities. It also

includes descriptions of natural sites which are inaccessible to foreigners but which required the presence of geologists. The project was implemented under the Development Cooperation Programme of the Czech Republic, administered by the Ministry of the Environment and organized and conducted by experts from the Czech Geological Survey.

## Calendar 2022 – Central America Through the Eyes of Czech Geologists

Petr Hradecký (Ed.)



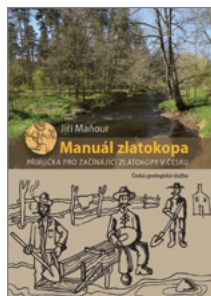
Through a series of selected photographs, the calendar looks back on the activities of experts from the Czech Geological Survey in Central America. In a vivid and engaging way, it shows the environment in which they worked, including its natural splendor and attractions as well as demanding living conditions.



## Books

### Gold Prospecting Manual, a Guide for Beginning Gold Prospectors in the Czech Republic

Jiří Maňour



### Was the Earth flooded – or not?

Jiří Jiránek



### Gold in the Nový Knín Area: History and the Present

Veronika Štědrá, Pavel Lhotský (Eds)



### Concept for Describing and Evaluating Historical Mine Workings

Josef Večeřa et al.



### Geology of the Outer Western Carpathians and Southeastern Margin of the West European Platform in the Czech Republic

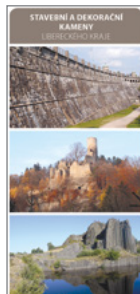
Zdeněk Stráňák et al.



## Map

### Building and Decorative Stones of the Liberec Region

Barbora Dudíková, Markéta Vajskebrová,  
Vladislav Rapprich, Jakub Šrek, Josef Klomínský,  
Marcela Stárková



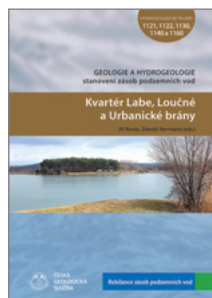
## Review of Groundwater Resources

In 2010–2016, the Czech Geological Survey carried out the “Review of Groundwater Resources” project, which covered approximately one quarter of the Czech Republic. During the course of the project, natural and usable groundwater sources were determined, including the conditions for their use by authorized state administration bodies. Using modern and conventional methods including geophysical measurements, borehole surveys, determination of residence time in rocks, chemical analyses of ground and surface water, hydrological measurements, and so forth, the geological and hydrogeological conditions of evaluated hydrogeological zones were updated for 25% of the Czech Republic. The boundaries of the evaluated zones were also revised based on the research, including proposals for their possible modification. In 2021, the Geology and Hydrogeology – Determination of Groundwater Resources edition included another publication of detailed evaluations of individual hydrogeological zones, scheduled until 2023.

### Review of Groundwater Resources

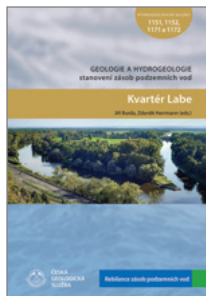
#### Quaternary of the Labe River, Loučná River and Urbanice Gate (HG Zone 1121, 1122, 1130, 1140, 1160)

Jiří Burda, Zdeněk Herrmann (Eds)



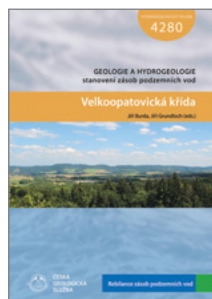
#### Quaternary of the Labe River (HG Zone 1151, 1152, 1171, 1172)

Jiří Burda, Zdeněk Herrmann (Eds)



#### Cretaceous of the Velké Opatovice Area (HG Zone 4280)

Jiří Burda, Jiří Grundloch (Eds)



#### Cretaceous of the Chrudim Area (HG Zone 4310)

Jiří Burda, Jiří Grundloch (Eds)





## Dlouhá Mez – Southern Part (HG Zone 4320)

Jiří Burda, Renáta Kadlecová (Eds)



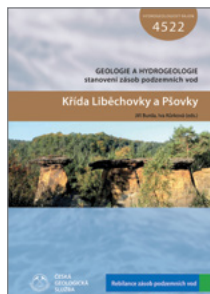
## Dlouhá Mez – Northern Part (HG Zone 4330)

Jiří Burda, Renáta Kadlecová (Eds)



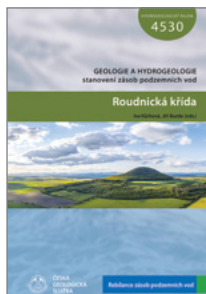
## Cretaceous of the Liběchovka and Pšovka Streams (HG Zone 4522)

Jiří Burda, Iva Kůrková (Eds)



## Cretaceous of the Roudnice Area (HG Zone 4530)

Iva Kůrková, Jiří Burda (Eds)

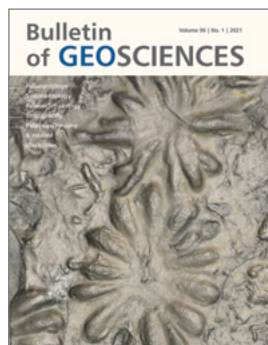


## Cretaceous of the Lower Kamenice River and Křinice Stream (HG Zone 4660)

Jiří Burda et al.



# Periodicals



The *Bulletin of Geosciences* is the most important scientific journal published by the Czech Geological Survey. Its predecessor *Věstník Státního geologického ústavu Československé republiky* was founded at the request of the scientists of the State Geological Institute of the Czechoslovak Republic and the first volume was issued in 1925. Since then, thousands of scientific papers have been published and it now constitutes an archive of the most important scientific research on the geology of the Bohemian Massif. In 2006, a new editorial board set the focus of the journal on paleoenvironmental research and on the evolution of life on Earth. In 2007, the *Bulletin of Geosciences* was included with other international scientific journals in the most prestigious scientific databases. In 2010, based on its high-quality scientific content, the journal received an impact factor from the prestigious American company Thomson Reuters.

Thanks to the long-term efforts of the current editorial board, the *Bulletin of Geosciences* is one of the top 10 most important scientific journals published in the Czech Republic. ISSN 1802-8225 (online), 1214-1119 (print)



The Czech Geological Survey is a co-publisher of the *Journal of Geosciences* (<http://www.jgeosci.org>), released by the Czech Geological Society with the grant support of the Council of Scientific Societies of the Czech Republic and the Czech Literary Fund Foundation. Being a periodical with a long tradition (65<sup>th</sup> volume), it follows its predecessors *Časopis pro mineralogii a geologii* ("Journal of Mineralogy and Geology") and *Journal of the Czech Geological Society*. Since 2006, it has been focusing on process-oriented studies dealing mainly with mineralogy, structural geology, petrology, and with the geochemistry of igneous and metamorphic rocks.

In addition to regular volumes, special monothematic issues are also published.

The *Journal of Geosciences* maintains a high standard and is indexed in a number of database services, including the prestigious Web of Science, Scopus and GeoRef. Thanks to this fact, the journal received an impact factor from the Thomson Reuters company in 2011. ISSN 1803-1943 (online), 1802-6222 (print)



The *Geoscience Research Reports*, a compilation of reports, has been published as a periodical in printed form by the Czech Geological Survey since 1952. In recent years, free access has been provided to the full texts of published papers in electronic form as well. The reports have been available since 1991. The *Geoscience Research Reports* acquaint the general public with current knowledge from a wide range of geological fields. Readers are provided with the research findings of academia, state institutions and private companies, involving regional geology, stratigraphy, Quaternary research, engineering geology, paleontology, mineralogy, petrology, geochemistry, hydrogeology, minerals, geophysics, geoinformatics and research abroad. The published papers have a high professional standard and are peer-reviewed. The multicolour publication with English summaries is included in the List of Reviewed Non-Impact Periodicals approved by the Czech government's Research, Development and Innovation Council. The CSAB (Content Selection and Advisory Board) has recommended the inclusion of this title in Scopus, for whose content Elsevier B.V. is responsible.

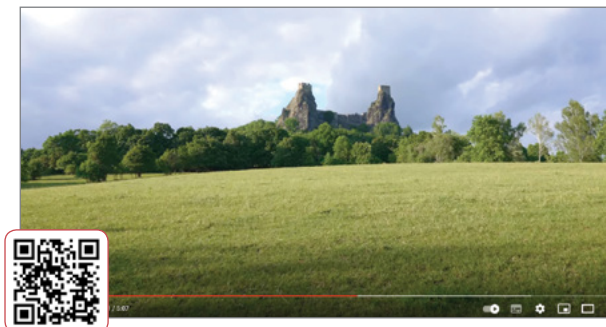
ISSN 2336-5757 (online), 0514-8057 (print)



# Selected posts on YouTube YouTube<sup>CZ</sup>

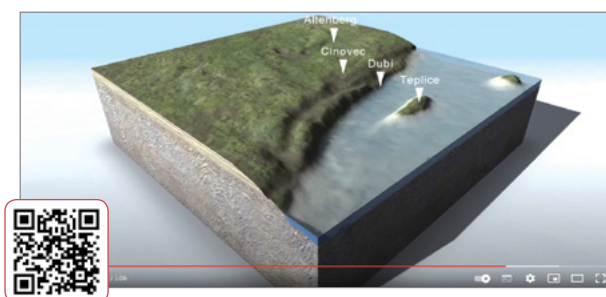
## Trip to the Bohemian Paradise

This video clip presents the Bohemian Paradise UNESCO Geopark as a landscape with an exceptional concentration of geological and geomorphological phenomena as well as paleontological and mineralogical sites, which provide insights into the geological history of the Earth. They also demonstrate the role that natural conditions play in the economic and cultural development of society over the millennia. Three geologically different areas converge in the geopark, which is why the local diversity of living and inanimate nature is so unique. The video also presents the Bohemian Paradise as a picturesque landscape with historical and cultural monuments. The unique sites that can be viewed in the clip include, for instance, the Hrubá Skála “Rock Town” (castellated rocks), the Rieger Trail in the canyon of the Jizera River, Trosky, Kozákov Hill, Klokočské Rocks or Vranov Ridge, and also historical monuments such as the Kost, Valdštejn or Hrubá Skála castles. In December 2021, the video clip presented the geopark at the 1<sup>st</sup> international film festival of UNESCO Global Geoparks in Korea. The video was shot by the CGS during project 389100 – Revalidation of the Bohemian Paradise UNESCO Global Geopark, co-funded by the MoE. The video was created by director and producer David Rauch, and the chief cinematographer is Martin Štěpánek.



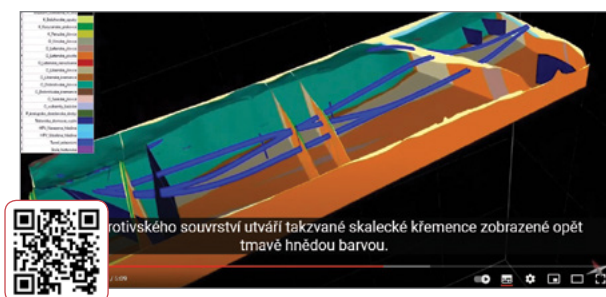
## Altenberg-Teplice Caldera – geological evolution

The Teplice thermal springs were already used at a time when the territory was inhabited by Celtic tribes. Teplice was a spa town of European importance until 1879, when a thermal-water inrush occurred at the Döllinger mine. But why did thermal springs form specifically in the Teplice area? Deep-reaching faults intersect a local volcano, which although being extinct for more than 300 million years is the largest in the Czech Republic. A massive crater, filled with Th-rich rocks, heats the water to nearly 20 °C. The water heats up even more as it continues to flow underground. For the proper functioning of the entire system, it is important that the area between Teplice and the Krušné hory Mts was covered with impermeable clayey rocks, which force the water to circulate at great depth and prevent it from mixing with colder water.



## 3D geological model of the Střešovice tunnel

The Czech Geological Survey created a 3D geological model for the planning of alternative routes for a new interconnection of the Prague-Dejvice and Prague-Veleslavin railway stations (J. Franěk et al. 2020) – referred to as the Střešovice railway tunnel. The model depicts folded Lower Paleozoic sediments of the northwestern limb of the Prague Synform, covered with platform sediments of the Bohemian Cretaceous Basin and unconsolidated Quaternary deposits. The model aims to provide a unified visualization of the geology and faults beneath the surface of this densely built-up area in relation to the proposed railway tunnel options.





### **Principle of patent PV 2018-357 for processing graphite raw material**

The Czech Geological Survey was granted patent PV 2018-357, in force as of 31 December 2020, for processing graphite raw material. The principle of the patent consists of using ultrasound for processing graphite raw material after first being separated by flotation. Described in very simple terms, the principle of patent PV 2018-357 is based on proven use of ultrasound in the processing of graphite raw material after first being

separated by flotation. Graphite raw material is usually processed by crushing and grinding to a required grain size, but this process often breaks down the platy graphite crystals, referred to as flakes. When ultrasound is used, the planar surface of the graphite flakes is separated from mica, with which graphite forms a natural composite. Therefore, this processing method enhances the efficiency and effectiveness of the flotation separation of graphite, increasing the graphite concentration in the flotation concentrate, with fewer flotation cycles. This method was developed mainly for graphite raw material that is difficult to beneficiate (when the graphite concentrate still contained a large amount of inorganic admixtures even after several cycles of flotation separation). Thanks to this process, some graphite deposits, considered non-prospective due to difficult raw material beneficiation, can once again become economically promising. The team of Czech Geological Survey specialists, engaged in developing the patent, consisted of František Ptíčen, Michal Poňavič, Bohdan Kříbek and František Veselovský.



### **Fossilized "traces" in Deblou**

A European rarity is located in Deblou, near Chrudim. It is a fossilized seabed of Paleogene age, specifically Ordovician age. Thousands of holes left over from corridors and tunnels of marine organisms, probably worms, provide compelling evidence that this is a seabed. The hardened, fractured and sloping bed is again brought to life, not only in this animation but also thanks to the activities of the Železná hora National Geopark, which provide access and visitor infrastructure.



### **Moldavites – formation process**

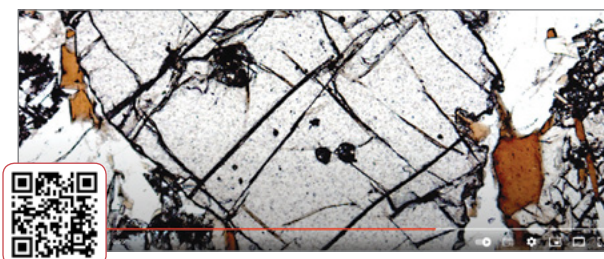
The Czech Geological Survey created an animation that shows how moldavite, which is one of the four occurring tektite types known throughout the world, was formed. Moldavites, a name derived from the Vltava (Moldau) River, were formed roughly 14.8 million years ago after the fall of an extraterrestrial object about 1 kilometre in diameter in

the area of today's town of Nördlingen in southeastern Germany. The projectile landed in a swampy to lacustrine area and ejected a massive amount of remelted surface materials, which formed a fan of strewn fragments of moldavite melt that landed in several areas of today's Czech Republic, Germany, Austria and Poland, at distances ranging between 200 and 500 kilometres from the impact centre. Today, the crater has a diameter of about 26 kilometres, where even American astronauts preparing for the Apollo 14 and 17 missions learned to identify impact materials. The typical moldavite sculptation was produced by selective weathering of chemically heterogeneous glass and along microscopic cracks, caused by stress in the moldavite glass after its rapid cooling upon impact. Research was funded by the Grant Agency of the Czech Republic.



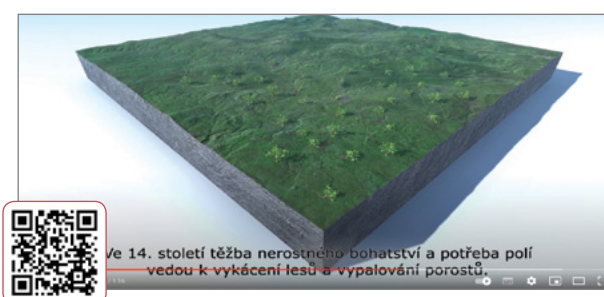
## ▶ Formation of microdiamonds

Jana Kotková from the CGS lead the research team that discovered microdiamonds reaching 5–30 micrometres in size, enclosed mainly in garnet in rocks referred to as granulites in Northwest Bohemia. These microdiamonds were formed during plate subduction to a minimum depth of 140 km. What is striking is that the occurrence of perfect octahedral diamonds is a worldwide rarity because irregular grains and polycrystalline aggregates of diamond dominate elsewhere. The research showed that the peak pressure and temperature conditions of diamond-bearing rock formation cluster along water activity-related phase transitions. Diamonds are formed from water-rich fluids at low temperatures and from melts in the presence of water at higher temperatures, and octahedra are formed only at extreme temperatures exceeding 1,100 °C from melts formed by the decomposition of hydrated phases. The effect of temperature on diamond morphology also explains the predominance of octahedra in the case of much larger diamonds from kimberlites, which are formed at higher temperatures. In April 2021, Jana Kotková published a paper on the discovery of microdiamonds in the prestigious journal *Scientific Reports* (see QR code).



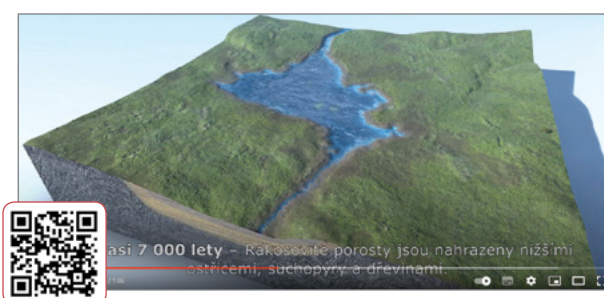
## ▶ The Žďárské vrchy Hills – geological genesis

Their geological development can be described as a sort of abstract fairy tale about origin of rocks. The shape of the local landscape was actually completed relatively short time ago – during the glacial and interglacial periods and in the course of the last centuries. At first, frost, water, wind and ice formed prolonged mountain ridges that disintegrate to more or less known rocks. Consequently, the deep valleys have been formed. Man become the last former of the landscape. He cut down the forest cover in several phases and made use of local natural wealth.



## ▶ Velké Dářko Pond – geological genesis

The Velké Dářko Pond, frequently visited by tourists, is the biggest water reservoir by far; at the same time, it is a source of the Sázava River, and last but not least, it is a remarkable natural oasis. The pond surroundings are bordered by wetlands with occurrence of protected plant and animal species. A part of these wetlands can be walked through using a nature trail.

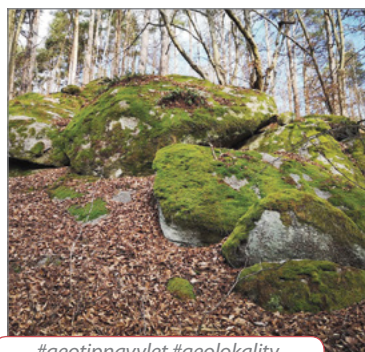


## ▶ Devět skal Hill ("Nine Rocks") – geological evolution

The highest peak of the Žďárské vrchy Hills was originally an elongated rocky ridge, which gradually disintegrated during glacial and interglacial periods into its current shape of nine separate rock blocks. Gneiss rocks indicate the enormous force of erosion exerted over time.



# Caught your eye on Facebook



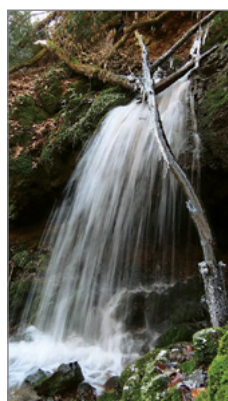
#geotipnavylet #geolokalita



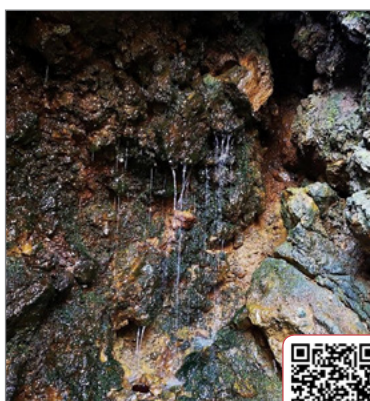
## January Libochovka Valley

A marvellous profile of the varied lithology of the Strážek Moldanubicum is exposed along several kilometres in the Libochovka Valley between Rojetín and Kutiny. East of Rojetín lies a body of eclogite with small serpentinite lenses along the margins and rare occurrences of the critically endangered Ladder Spleenwort fern. The oval rock blocks with conspicuous feldspar phenocrysts occurring further along the Libochovka Valley belong to the durbachites of

the Drahonín Pluton. Towering high above the valley, the Sochorská Rock consisting of migmatite offers a beautiful view of the Kutina railway viaduct. Here, a small memorial plaque commemorates a tragic railway accident in December 1970.



#geozajimavosti



## February Maršov Waterfalls

The Maršov Waterfalls have again reappeared thanks to the rainy year of 2020 and recent thaw. They formed in a narrow ravine on several rocky steps comprising resistant silicites, which lie directly beneath the Dřínová overthrust. Along this important structure, the Moravicum was thrust onto the Brunovistulicum and its Devonian cover during the Variscan orogeny. One of the typical sites, where this structure was described, is located near Šmelcovna in the Bílý Stream valley not far from the waterfalls.



#geotipnavylet #geolokalita



## March Hodonínka Valley

The right slope of the Hodonínka Valley near Štěpánov nad Svratkou is dominated by the Vysoká Rock consisting of Bíteš augen orthogneiss, which alternate here with layers of amphibole-biotite gneiss. Due to the different competence and position near the tectonic contact of the Moravicum with the overlying Svratka Crystalline Complex, the rocks were deformed into attractive recumbent folds of various scales. Duplexes (or also structural horses), which attest to the thrust system of the Moravicum, are also clearly visible from a view parallel to the axis of the folds. From the top of the roughly 50-metre-high rock tower, a cast iron cross from the nearby Štěpánov foundry keeps an eye on all this as well as the souls of dead climbers and those who ended their lives here voluntarily.





April

## New book: Concept for Describing and Evaluating Historical Mine Workings

The Czech Geological Survey published a special issue of a book by Dr. Josef Večeřa and co-authors, which is dedicated to describing and interpreting historical mine workings. In addition to the publication's introduction, devoted to the description method and terms for mine workings, the book contains the all-important appendix No. 3, which comprises an exceptionally well-founded, detailed and also well-arranged glossary of mining terminology. The book summarizes the knowledge that the author acquired, throughout his geological career, in archives and literature as well as in the field. On behalf of the geological community, we wish to congratulate Dr. Večeřa and his team on an exceptionally successful book, which will surely become a valuable guide for all mining heritage and geology enthusiasts, experts and public alike, who are interested in studying, documenting and protecting the monuments of the Czech Republic's rich mining history.



May

## Bohemian-Moravian Highlands

The glades of the Bohemian-Moravian Highlands, which occur here in forests affected by a bark beetle calamity, offer new views of well-known and forgotten rock outcrops. The surroundings of Lomnice near Tišnov are dominated by rocks consisting of Bíteš augen orthogneiss. It is a Cadomian granite heavily reworked during the Variscan orogeny. The rock disintegrates easily along metamorphic foliation planes. Large solid stone slabs beneath the rocky outcrops served as excellent building blocks. When wandering through the spring landscape, you can also usually find them on stone bridges over larger or smaller streams.

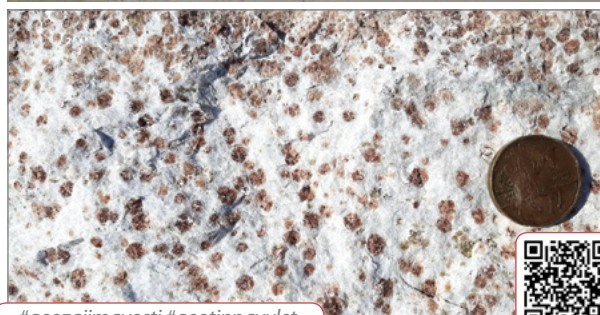


June

## Skryje Pond

The picturesque ravine of the Zbiroh Stream was formed mainly in volcanic rocks – dark grey fine-grained dacites and tuffs of the Upper Cambrian Křivoklát-Rokycany zone. The shape of rock walls and the formation of steps was influenced by the columnar jointing of the volcanic rocks. Silty and clayey shales of the Middle Cambrian Jince Formation with numerous fossils, primarily trilobites and brachiopods, crop out locally onto the surface.





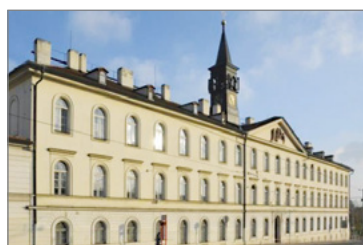
#geozajimavosti #geotipnavylet



July

## Quarry on the outskirts of Bludov

A small, occasionally mined quarry on the northern outskirts of Bludov near Šumperk has attracted mineralogists and geologists since the second half of the 19<sup>th</sup> century, when the local native R. Kašpar referred to a strikingly spotted rock as bludovite. It is a local name for calcium-silicate rock (erlan), which is characterized by structural variability and varying mineral composition. Typical bludovite is a white rock with a matrix of wollastonite and protruding brownish-red garnet grains. Vesuvianite is less common. With increasing amounts of diopside, plagioclase and quartz, it passes into erlan. These rocks were formed due to the Šumperk pluton's thermal effect on the calcareous and silicate layers in the metasediments of the Branná Group at the southern end of the Kepník Dome of the Silesicum.



#geoaktuality



August

## Open House Prague

The Czech Geological Survey was engaged in organizing the Open House Prague festival, which took place from 2 to 8 August. The purpose of the festival is to allow visitors to view buildings and places usually closed to the public and to experience the unique and diverse architecture of Prague's buildings, thereby arousing people's interest in the city and public space. The CGS, which was one of the new attractions of this year's festival, offered guests a tour of the entrance foyer, courtyard and chapel of St. Raphael, where there was also a photography exhibiton documenting the history of the building, originally the Klárov Institute for the Blind.



#geozajimavosti



September

## Gobi

In the south-eastern Gobi Altai, the Upper Devonian flysch sediments contain tabular limestone bodies up to several hundred metres thick, in which thicker light grey, pure and less competent layers with silicified multi-coloured layers alternate. These are considerably more competent (more solid), and this difference in rheology is an ideal environment for the formation of folds, as soon as deformation of rocks occurs. Their beauty stands out mainly due to the colour contrasts in the early evening sun and due to selective weathering as well.





## October Vinařice Hill

A Tertiary body of volcanic origin was formed in several phases during the Oligocene to Lower Miocene. Alternating layers of basalt and volcanic ejecta can easily be observed in several quarries, where high-quality basalt, referred to as olivine nephelinite, was mined. The Cretaceous Peruc-Korycany Formation and Bílá hora marlstones crop out on the slopes. A deposit of interesting secondary minerals.



#geotipnavylet



## November Christina Adit

The portal of the Christina Adit is located high above Lake Hallstatt in the Northern Limestone Alps. It is the gateway to the oldest active salt mine in the world. The mine is exposing a salt diapir, which was formed from continental lagoon sediments of the Upper Permian to Lower Triassic and which penetrated the overlying shallow- to deep-water limestone of Middle Triassic age.

The mine's galleries were driven in breccia, the matrix of which consists of dark clay, in which variably large fragments of massive or banded halite and anhydrite with larger blocks of preserved isoclinal folds float. The formation of breccia began during the evolution of the salt diapir and ended with tectonic processes during the overthrusting by Alpine nappes. The diapir's vertical extent can be fully grasped by imagining the extent of mine workings, which are located at elevations of 514–1,267 m ASL. Today, salt is extracted via boreholes, through which water is injected into the salt horizons, thereby gradually dissolving them. The resulting brine is pumped through a pipeline into the valley for further processing. The ongoing mining and the preservative effect of salt are a godsend for archaeologists. The onset of mining in Hallstatt dates back to the Neolithic Period based on a discovery of a miner's antler pickaxe. Organized mining began in the Bronze Age roughly 2,500 years ago and is well documented by radiocarbon dating of a wooden ladder from ancient open cuts. One prehistoric culture was even named after the rich archaeological finds dating back to 800–400 BC, which proves that not only in fairy tales is salt more precious than gold. Another remarkable story involves the mummy of a miner, who died roughly 350 BC and was unearthed in 1734, thereby posing a problem regarding his burial because he had not been baptized.



#geotipnavylet #geozajimavosti



## December Bačov Nature Monument

The Bačov Nature Monument is an important paleontological site for fossils of Permian stegocephalia located in the Boskovice Graben in an abandoned quarry near a road leading from Sudický dvůr towards Víska (near Bačov). It is a significant locality for fossils of Paleozoic amphibians (such as the genus *Discosauriscus*) discovered in the Permo-Carboniferous shales of the Boskovice Graben. At the same time, it is also a very important site with occurrences of interesting herb species. The nature monument was established in 1998 in an area of three hectares. The rocks that occur in this area are over 280 million years old and belong to the period known as the Permian.



#geotipnavylet #geozajimavosti

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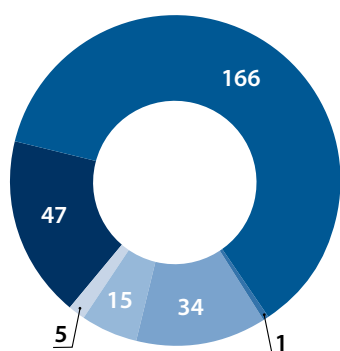


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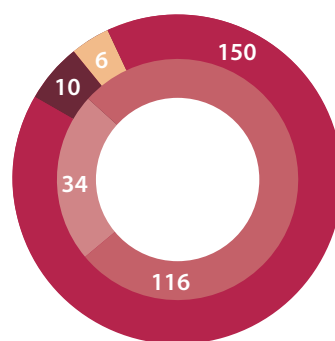


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#### CGS publishing activities in 2021

- Papers in journals
- Papers in peer-reviewed compilations
- Papers in non-peer-reviewed compilations
- Scientific book
- Book chapter
- Maps



#### Number of papers in journals

- Papers in peer-reviewed scientific journals with impact factors
- Papers in peer-reviewed scientific journals without impact factors
- Papers in non-peer-reviewed scientific journals
- Papers in popular science and education periodicals and newspapers



# Financial review for 2021



**Zdeněk Cilc**

Deputy Director for Economics  
and Head of the Economic Division

In 2021, the total expenditures and total income of the Czech Geological Survey amounted to CZK 413,386,000 and CZK 422,349,000, respectively.

In 2021, the CGS reached a positive financial balance of CZK 8,962,000, of which CZK + 8,731,000 represented primary activities and CZK + 231,000 secondary activities.

The positive financial balance was achieved mainly due to income from the sale of services and other service-related activities amounting to a total of CZK 59,891,000. A more detailed breakdown of main expenditures and income is provided in the attached diagrams.

Total income, including subsidies for carrying out projects and tasks involving the long-term development concept for research organizations obtained apart from contributions provided by the organization's founder, represent a total of CZK 326,021,000 and account for more than 75% of the total income. The overall financial balance ensured sufficient revenue to cover the expenditures of the Czech Geological Survey and its continuing development. Total personnel cost increased by CZK 19,001,000 year-on-year, and investments in 2021 included the necessary purchase of upgraded equipment by the Czech Geological Survey amounting to a total of CZK 21,886,000.

With its results in science and research in 2021, the Czech Geological Survey maintained its leading ranking in the science and research evaluation system in the Czech Republic, thus securing the necessary funding for the development of the research organization amounting to a total of CZK 114,345,000. The Czech Geological Survey carried out international projects (such as Horizon 2020, Norwegian projects, projects of the EU's European Commission, etc.) and foreign development projects with that same distinction and professionalism as well.

The financial results from 2021 and previous years form a solid basis for the organization's continuing existence and development for carrying out the state geological survey's projects, science and research projects, and for providing services to various state authorities, local governments and the public.

## Total expenditures of the organization

Total expenditures (CZK)	413,386,179 Kč
Material and power consumption	22,067,578 Kč
Services	59,547,341 Kč
Total personnel cost	272,064,875 Kč
Depreciation of tangible and intangible assets	20,183,812 Kč
Other expenses	39,522,573 Kč

## Total income of the organization

Total income (CZK)	422,349,019 Kč
Sales and other own-source revenue	59,890,836 Kč
Allocation for activities of the organization	96,328,000 Kč
Institutional funding for development of research organizations	109,344,931 Kč
Funds for projects and commissioned services	145,142,225 Kč
Income from transfers	11,643,027 Kč





## Human resources

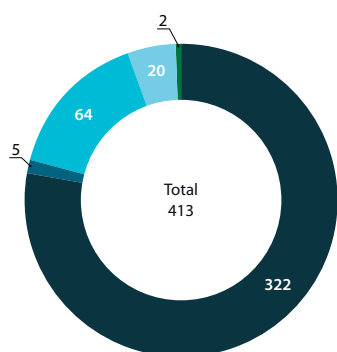
In 2021, the Czech Geological Survey had 413 employees, including those on maternity and parental leave. The full-time equivalent amounted to 354.30. The number of women was 199 and the number of men 214.



**Helena Žemličková**  
Head of the Human Resources Department

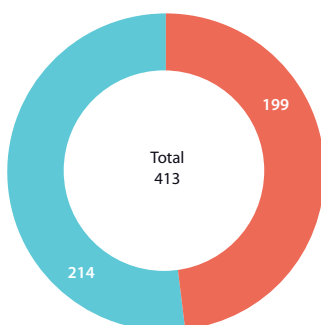
The indicators given above not only underline the high level of competitiveness in the labour market, but they also emphasize the organization's economic growth and prestige among research institutes in the Czech Republic. The Czech Geological Survey actively supports the professional development of its employees and takes an interest in enhancing their qualifications. It provides training for its employees through a wide range of courses and seminars, such as language, legal and economic courses, expert training, specialized seminars and so forth.

The CGS observes the principles of equal employment opportunity for all age groups, women and men alike, covering a wide range of employment conditions. This is reflected by the fact that employees returning from maternity or parental leave are offered the opportunity of working part-time as in the case of working seniors and staff members involved in university or Ph.D. study programmes.



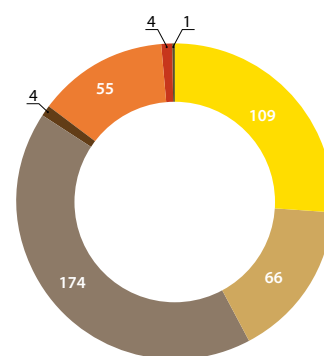
**Education background of the CGS staff**

- University
- Higher vocational
- Secondary
- Apprentice
- Elementary



**Gender ratio of the CGS staff**

- Women
- Men



**Place of work**

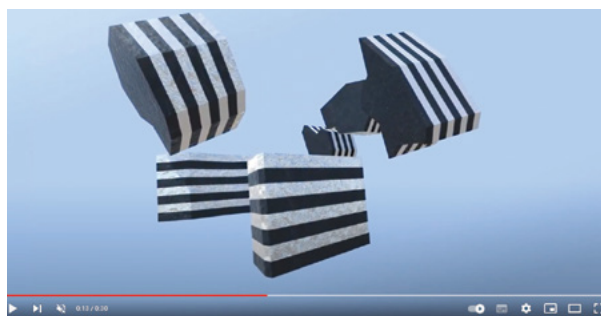
- Prague – Barrandov
- Brno
- Prague – Klárov
- Jeseník
- Prague – Kostelní
- Kutná Hora
- Lužná

# Principal events in 2021

Sorted according to the date of publication on the Czech Geological Survey website

## The Czech Geological Survey obtained a patent for processing graphite raw material 5 January 2021

The CGS was granted patent PV 2018-357, in force as of 31 December 2020, for processing graphite raw material. The principle of the patent consists of using ultrasound in the processing of graphite raw material after first being separated by flotation. Graphite raw material is usually crushed and ground to a required grain size, thereby often breaking the platy graphite crystals, referred to as flakes. By contrast, the use of ultrasound allows for the planar surface of graphite flakes to be separated from mica and other clay minerals, with which graphite forms a natural composite. Therefore, this method significantly enhances the effectiveness of flotation separation of graphite, thereby increasing the graphite concentration in the flotation concentrate and its quality, with fewer flotation cycles. The process was developed primarily for graphite raw material that is difficult to beneficiate, where the graphite concentrate contained a large amount of inorganic admixtures even after several cycles of flotation separation. Thanks to this process, some graphite deposits, considered non-prospective



due to difficult raw material beneficiation, can once again become economically promising. The attached animation provides a simplified illustration of the patent's principle. The team of CGS specialists, engaged in developing the patent, consisted of František Pticeň, Michal Poňavič, Bohdan Kříbek and František Veselovský.



Principle of patent PV 2018-357 for processing graphite raw material – animation

## Zdeněk Venera on the conclusions of an analysis of the impact of activities at the Polish Turów mine for Aktuálně.cz 2 February 2021

The Director of the Czech Geological Survey, Zdeněk Venera, gave an interview to the news server Aktuálně.cz. The article has a peculiar title "Satellites detect that something is occurring near Hrádek. The landscape is subsiding as water disappears into Poland". Zdeněk Venera clearly summarizes the methods and conclusions of long-term research, which the Czech Geological Survey conducted near the mine in Czech territory and which served as a basis for preparing an expert hydrogeological assessment for the Ministry of the Environment.

Author: Klára Froňková



Satellites detect that something is occurring near Hrádek.  
The landscape is subsiding as water disappears into Poland



## Czech-Norwegian conference on CO<sub>2</sub> capture and storage held online 9 March 2021



On 5 March 2021, the Czech Geological Survey organized the *Czech-Norwegian Cooperation on CCS* conference focused on CO<sub>2</sub> capture and storage. The conference was held online due to government regulations in response to the coronavirus epidemic. Guests were welcomed by the Ambassador of the Kingdom of Norway to the Czech Republic, Robert Kvile, by the Director of the Czech Geological Survey, Zdeněk Venera, and by the Director of InoCure, Matej Buzgo. More than 70 participants were given presentations on CO<sub>2</sub> capture and storage technologies in the Czech Republic, on methods for their implementation, and also an insight into the broader context of the development of these technologies throughout Europe.

The conference also launched the CO<sub>2</sub>-SPICER and METAMORPH projects, which focus on research into and development of CO<sub>2</sub> capture and storage technologies and which are funded by Norway Grants and the Technology Agency of the Czech Republic under the KAPPA Programme. The Czech Geological Survey is the coordinator of the CO<sub>2</sub>-SPICER project.

*Author: Klára Froňková*

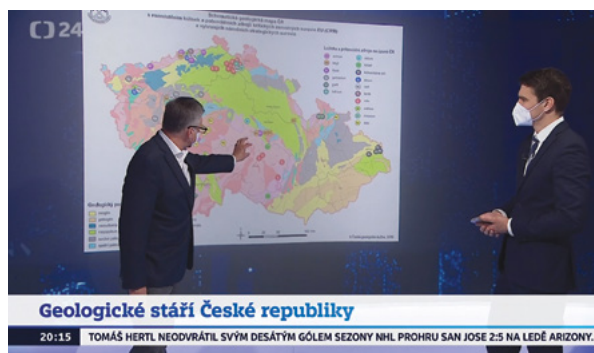


## Zdeněk Venera on Czech Television's "Hyde Park Civilizace" programme 29 March 2021

The Director of the Czech Geological Survey, Zdeněk Venera, was the main guest on Czech Television's "Hyde Park Civilizace" programme. He offered a comprehensive perspective on the institute's core activities and on the scientific mission of geology. Particular attention was also paid to contemporary society's current issues, in which geology plays a key role – such as minerals and their extraction, water reserves, nuclear waste storage, CO<sub>2</sub> capture and storage, and landslides.

The programme is available via QR code at the attached link.

*Author: Klára Froňková*



Zdeněk Venera on the  
"Hyde Park Civilizace"  
programme on ČT24

## 3D geological model for planning the Střešovice railway tunnel for interactive online viewing

3 April 2021

A new 3D geological model for planning alternative routes for a new interconnection of the Prague-Dejvice and Prague-Veleslavín railway stations (J. Franěk et al. 2020) was added to the map overview on the 3D geological models web page. You can view the model online in your web browser (Firefox, Edge, etc.) in a 3D scene viewer via ArcGIS Online.

The model depicts folded Lower Paleozoic sediments of the northwestern limb of the Prague Synform, covered with platform sediments of the Bohemian Cretaceous Basin and unconsolidated Quaternary deposits. The model aims to provide

a unified visualization of the geology and faults beneath the surface of this densely built-up area in relation to the proposed railway tunnel options.

In the 3D viewer, try your hand at creating, for example, your own geological cross-sections of the model in the right toolbar using the “Analyze” tool and “Separate Objects” tab.

*Authors: Jan Franěk, Martin Paleček, Lucie Kondrová*



[Online visualization of the 3D geological model of Střešovice in Prague 6](#)

## Vít Baldík from the Czech Geological Survey discovered a cave near Lažánky

24 May 2021

On 15 May 2021, Vít Baldík, a regional geologist from the Czech Geological Survey and member of the Czech Speleological Society, discovered the entrance to an unknown cave during an inspection of a water main trench near the village of Lažánky. The entrance lies two metres below ground level and the cave resembles a meandering phreatic tube with small narrow chimneys leading towards the surface with locally developed eccentric sinter forms. The passage bends several times and ends with an impenetrable narrowing roughly 10 metres from the entrance.

The discovery of even such a short cave passage is of great importance in this area, because very few caves have been described in the Lažánky Valley thus far. The fact that the passage leads beneath the Harbechy Plateau and that there is a draft at the end, indicating a possible continuation, is very positive information. This cave may provide clues for gaining further knowledge about the Harbechy Plateau, which CGS specialists have been studying for a long time with surface geophysical methods but also with

geological surveys of the caves themselves.

The existence of thus far unknown caves is indicated by numerous sinkholes on the Harbechy Plateau. The third largest area of the Moravian Karst is located at a depth of 85 metres in the Harbechy Cave beneath one of the sinkholes. Recently, another large hall was discovered in the Ševčík Sinkhole near the village of Vilémovice.

*Author: Martin Dostálík*



[News coverage of the cave's discovery \(NCA CR – Administration of the Moravian Karst Protected Landscape Area, FB\)](#)



## Zdeněk Venera gave an interview to Czech Radio about the impacts of mining in the Turów mine

7 June 2021

The Director of the Czech Geological Survey, Zdeněk Venera, was the main guest of Czech Radio's "Zaostřeno" programme, where he spoke about the impacts of mining in the Turów lignite mine. The topic entitled "Closing the Turów mine and power plant would be an economic disaster for us, says Polish unionist Tyszkiewicz" involved a preliminary injunction of the Court of Justice of the European Union banning mining in the Polish Turów mine due to negative impacts on the area's hydrogeological conditions.

The Czech Geological Survey conducted long-term research near the mine. In a follow-up hydrogeological assessment, it justified the Czech Republic's concerns regarding a possible negative impact of the Polish Turów mine's expansion and deepening on the groundwater status in the Czech Republic.

In the interview, Zdeněk Venera shed light on the geological conditions in the affected area and particularly on why water is now flowing away from Czech territory. He also explained the basic function of the subsurface sealing barrier that the Polish side intends to construct to prevent groundwater flow.

The interview is available online via QR code at the attached link (from 10:20).



Closing the Turów mine and power plant would be an economic disaster for us, says Polish unionist Tyszkiewicz

Author: Klára Froňková

## Bulletin of Geosciences – the most successful Czech geoscience journal

2 July 2021

It has been 15 years since the Bulletin began to focus on palaeoenvironmental research and the evolution of life on Earth. During those 15 years, around 1,000 scientists from 43 countries have published their scientific research results in the Bulletin. Since 2007, the Bulletin has published 535 scientific papers, which have been cited more than 6,000 times in journals included in the Web of Science database. In 2020, the Bulletin was cited 757 times in one of the scientific journals of the Web of Science database, which averaged to twice per day in 2020. Thanks to the editorial board's systematic efforts, the *Bulletin of Geosciences* is the most important geoscience journal published in the Czech Republic and one of the leading international paleontological journals (ranked in the second quartile according to the Journal Citation Reports). The new impact factor of the *Bulletin of Geosciences* for 2020, announced this week, is the second highest in the Bulletin's history (its three-year impact factor is 1.60 and five-year impact factor 1.76).

This undoubted success would not have been possible without the long-term efforts of the Bulletin's editorial board and its technical support. I particularly wish to thank Dr. Zuzana Tasáryová, Dr. Štěpán Manda and Mgr. Oleg Man for their daily efforts and also the international editorial board members and authors of publications. Thanks are also due to the Czech Geological Survey and the Museum of West Bohemia in Plzeň for their financial support of the Bulletin. In conclusion, I also congratulate the affiliated *Journal of Geosciences* on receiving an excellent impact factor as well.

Author: Jiří Frýda



### The Czech Republic hosted the 35<sup>th</sup> International Meeting of Sedimentology

20 July 2021

The Czech Geological Survey was engaged in organizing the 35<sup>th</sup> International Meeting of Sedimentology. The event, supported by the International Association of Sedimentologists, was held online on 21–25 June 2021 due to measures related to the COVID-19 pandemic. The abundance of lectures was complemented by a section with virtual exhibition stands, in which the Czech Geological Survey also participated, having been assigned a special “silver partner” status. The Czech Geological Survey was represented by specialists Juraj Franců, Lukáš Jurenka and Petr Jirman who prepared a presentation entitled *Diagenesis and dolomitization of Jurassic carbonate rocks in the SE Bohemian Massif*, by Karel Martínek, Kryštof Verner and Martin Svojtka with their paper *Evolution of the Krkonoše Piedmont Basin (Czech Republic) in the Pennsylvanian – Caenozoic: extension to basin inversion*, and last but not least Stanislava Vodrážková, Radek Vodrážka, Jiří Frýda and Magdalena Koubová in cooperation with colleagues from other organizations contributed with their presentation *Ferruginous coated grains in the Lower Devonian Řeporyje Limestone (Prague Basin, Czech Republic)*. A thematic poster entitled *Early Permian fluvial-lacustrine system interaction in the Krkonoše Mountains Piedmont Basin, NE Czech Republic* was prepared by Roland Nádaskay, Karel Martínek and Kateřina Schöpfer, and another poster entitled *Late Paleozoic – Mesozoic tectonosedimentary evolution of the northern Bohemian Massif: state-of-the-art* was produced by a team consisting of Roland Nádaskay, Jiří Žák, Karel Martínek, Bedřich Mlčoch, Kateřina Schöpfer, Jiří Sláma, Martin Svojtka, Tamara Sidorinová, Radim Jedlička and Jaroslav Valečka.

Author: Klára Froňková

### Open House Prague: The Czech Geological Survey welcomed close to 700 visitors in a single day

13 August 2021

The Czech Geological Survey was engaged in organizing the Open House Prague 2021 festival, which took place on 2–8 August 2021. Visitors were given a guided tour of the entrance foyer, courtyard and chapel of St. Raphael. They were also able to view an exhibition of photographs documenting the history of the original Klárov Institute for the Blind and its premises. The fact that nearly 700 guests came in a single day indicates that there was enormous interest in visiting the headquarters of the Czech Geological Survey.

Author: Klára Froňková





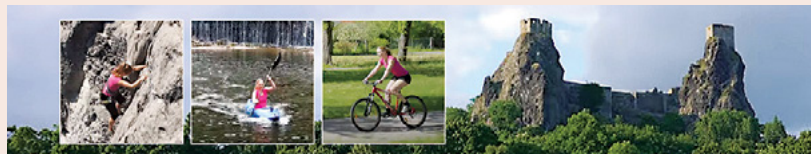
## The Czech Geological Survey presents the competing video “Trip to the Bohemian Paradise”

14 September 2021

The Czech Geological Survey shot the video “Trip to the Bohemian Paradise” for the Bohemian Paradise UNESCO Global Geopark. The video clip presents the geopark as a landscape with an exceptional concentration of geological and geomorphological phenomena as well as paleontological and mineralogical sites, which provide insights into the geological history of the Earth. They also demonstrate the significant role that natural conditions play in the economic and cultural development of society over the millennia. Three geologically different areas converge in the geopark, which is why the local diversity of living and inanimate nature is so unique. The video also presents the Bohemian Paradise as a picturesque landscape with historical and cultural monuments. The unique sites that can be viewed in the clip include, for instance, the Hrubá Skála “Rock Town” (castellated rocks), the Rieger Trail in the canyon of the Jizera River, Trosky, Kozákov Hill, Klokočské Rocks or Vranov Ridge, and also historical monuments such as the Kost, Valdštejn or Hrubá Skála castles.

In December 2021, the English dubbed video presented the Bohemian Paradise UNESCO Geopark at the 1<sup>st</sup> international film festival of UNESCO Global Geoparks in Korea and was co-funded by the Ministry of the Environment’s project 389100 – Revalidation of the Bohemian Paradise UNESCO Global Geopark. The video was created by director and producer David Rauch, and the chief cinematographer is Martin Štěpánek.

*Author: Klára Froňková*



[Trip to the Bohemian  
Paradise – video clip](#)

## Hospodářské noviny write about CGS foreign development cooperation in Ethiopia

5 October 2021

The foreign development cooperation projects of the Czech Geological Survey are an important area of activity, aimed at eradicating poverty, supporting economic and social development, and environmental protection in developing countries. The domain of CGS experts is geological mapping, mineral exploration, geohazard assessment or evaluation of the negative environmental and human health impacts of mining, including awareness of safe water sources.

The article entitled “How a Group of Czech Geologists in Africa Helps Defend Europe from Migration”, published in Monday’s edition of *Hospodářské noviny*, discusses the fact that this mission also has far-reaching social and political consequences. It describes the excellent work performed by Czech geologists in Ethiopia and depicts how the Czech Geological Survey’s specialists support the professional development of local geologists and, primarily, how they improve the lives of local people.

*Author: Klára Froňková*

HOSPODÁŘSKÉ NOVINY



[“How a Group of Czech Geologists in  
Africa Helps Defend Europe from Migration” – online article](#)

### Cooperation during the recomine Saxony–Czechia project is developing successfully

18 November 2021

The Czech Geological Survey is engaged in conducting the recomine Saxony–Czechia project, during which the first public seminar on mine water pollution by dissolved heavy metals took place in September. As the press release of the Ministry of Trade and Industry demonstrates, the cooperation between the two countries is developing very successfully and another follow-up meeting took place. It included a discussion on methods of exploring for and processing critical minerals for a transition to renewable energy sources and mobility.

Author: Klára Froňková

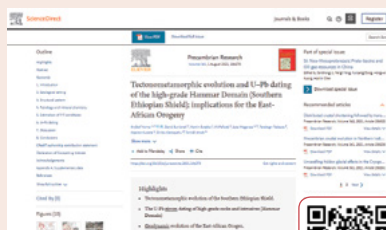


### Czech geologists published the results of scientific work in Ethiopia

22 November 2021

Together with colleagues from the GSE (Geological Survey of Ethiopia) and from a department of Addis Ababa University, the Czech Geological Survey specialists Kryštof Verner, Jan Valenta and Karel Martínek published the results of joint scientific work, which involves the foreign development cooperation projects of the CGS in Ethiopia. Papers devoted to the specifics of Ethiopian geology were published in renowned international journals. The online links to the publications are attached below.

Author: Klára Froňková



Kryštof Verner et al.:  
Tectonometamorphic  
evolution and U–Pb dating  
of the high-grade Hammar Domain...



Jan Valenta et al.:  
Ground fissures within  
the Main Ethiopian Rift:  
Tectonic, lithological and piping  
controls



Karel Martínek et al.:  
Main Ethiopian Rift  
landslides formed in contrasting  
geological settings and climatic  
conditions



### The Director of the Czech Geological Survey was elected to the board of the Institute of Geophysics of the Czech Academy of Sciences

8 December 2021



GEOFYZIKÁLNÍ ÚSTAV  
AKADEMIE VĚD ČESKÉ REPUBLIKY, v. v. i.

The academic staff of the Institute of Geophysics of the Czech Academy of Sciences elected the Director of the Czech Geological Survey, Zdeněk Venera, to the institute's board for the term of office spanning 2022–2027.

Author: Jana Kubová

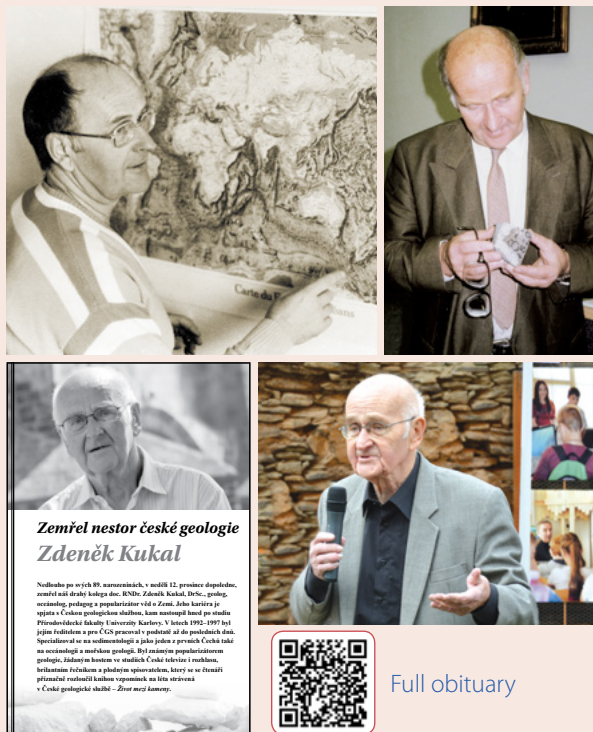


## Zdeněk Kukal, the doyen of Czech geology, passed away

### 14 December 2021

Our dear colleague Assoc. Prof. RNDr. Zdeněk Kukal, DrSc., geologist, oceanographer, teacher and populariser of Earth science passed away shortly after his 89<sup>th</sup> birthday on the morning of Sunday, 12 December. His career is linked with the Czech Geological Survey, which he joined immediately after graduating from the Faculty of Science at Charles University. In 1992–1997, he served as its director and worked for the CGS virtually until his last few days. He specialized in sedimentology and also, as one of the first Czechs, in oceanology and marine geology. He was a well-known populariser of geology, a sought-after guest on Czech Television and Czech Radio, a brilliant speaker and prolific writer, who in characteristic manner bade his readers farewell with the memoirs of his years spent with the Czech Geological Survey – *Život mezi kameny* ("Life Among Rocks").

Author: Petr Maděra



[Full obituary](#)

## Agreement concluded on horizontal cooperation of SÚRAO – CGS

### 28 December 2021



An agreement on horizontal cooperation between the Radioactive Waste Repository Authority (SÚRAO) and the Czech Geological Survey was signed by the directors of the institutes, JUDr. J. Prachař and Mgr. Z. Venera, Ph.D., on Tuesday, 21 December 2021. This extraordinary

type of contract regulates the assignment of scientific work by the SÚRAO involving research and investigation at four prospective sites for the construction of a radioactive waste repository. The contract is valid in 2021–2030. The expert activities correspond to those listed in the CGS Foundation Charter and mainly include geological and hydrogeological mapping at scales of 1:25,000 and 1:10,000, as well as structural, morphostructural and geomorphological analyses, descriptions, scanning and analysis of drill cores, the creation, validation and updating of structural geology and DFN models, data management, supervision of projects carried out by contractors for the SÚRAO, and involvement in the final evaluation of geological projects, in the assessment of the long-term safety of sites, and in the selection of final and backup sites.

The contract preparation lasted for much of 2021 and mainly involved L. Vondrovic and J. Urík from the SÚRAO, and P. Mixa and Z. Bukovská from the CGS. The work was performed under the audit supervision of the Deloitte ČR and NSG Morison companies.

The agreement on the long-term cooperation between the CGS and SÚRAO is significant not only because of the role that the CGS plays in the search process for a radioactive waste repository but also in terms of revenue and maximizing CGS employee capacity. Mainly however, it provides a basis for the long-term development of methodologies, capacities and equipment involving the above-mentioned scientific activities.

Author: Zdeněk Venera

# Projects implemented in 2021

## Czech Science Foundation

<ul style="list-style-type: none"> <li>19-07516S: Cretaceous–Paleogene boundary in the Carpathians – multidisciplinary search for local variations in a global cataclysm event (main project partner: Institute of Geology, Czech Academy of Sciences)</li> </ul>	M. Bubík
<ul style="list-style-type: none"> <li>20-10035S: Leading-edge instrumental methods in high resolution global Jurassic–Cretaceous boundary correlations</li> </ul>	M. Bubík
<ul style="list-style-type: none"> <li>18-14575S: Fossil assemblages of the Libeň and Letná formations (Upper Ordovician) – keys to understanding the Fezouata and Tafilalt biotas of Morocco (main project partner: Faculty of Science, Charles University)</li> </ul>	P. Budil
<ul style="list-style-type: none"> <li>19-04682S: Bioaccessibility and environmental interaction of antimony near busy traffic nodes (main project partner: University of Chemistry and Technology Prague)</li> </ul>	F. Bůžek
<ul style="list-style-type: none"> <li>19-17435S: Palaeoclimatologic significance of Palaeozoic red pelagic carbonates: time specific facies or products of microbial activity? (main project partner: Palacký University Olomouc)</li> </ul>	J. Frýda
<ul style="list-style-type: none"> <li>18-17295S: Climatic and air pollution effects on forest productivity</li> </ul>	J. Hruška
<ul style="list-style-type: none"> <li>1824378S: Petrogenesis of (ultra-)potassic magmas in the European Variscides – implications for the development of collisional orogens and crustal growth models</li> </ul>	V. Janoušek
<ul style="list-style-type: none"> <li>18-24281S: Did the West-Gondwana orogens form through inversion of long-lived rift domains?</li> </ul>	J. Konopásek
<ul style="list-style-type: none"> <li>18-27454S: Element transfer in a deep subduction environment: constraints from ultrahigh-pressure metamorphic terranes</li> </ul>	J. Kotková
<ul style="list-style-type: none"> <li>19-29124X: Evolution and post-emplacement history of carbonatites: implications for the mobility and concentration of critical metals (main project partner: BIC Brno spol. s r. o.)</li> </ul>	T. Magna
<ul style="list-style-type: none"> <li>20-23363S: Biostratigraphy and faunal dynamics of the Silurian pelagic biota of the Prague Basin in the context of major environmental changes and perturbations</li> </ul>	Š. Manda
<ul style="list-style-type: none"> <li>21-27420S: Controls of Mg, Ca and Sr isotope signals in catchment runoff: A multiple-site approach</li> </ul>	M. Novák
<ul style="list-style-type: none"> <li>20-19471S: GeoMicLink: Microbial imprint in catchment-scale nutrient retention</li> </ul>	F. Oulehle
<ul style="list-style-type: none"> <li>20-14292S: Mercury – an overlooked threat in Czech ecosystems responding to global change (main project partner: Institute of Geology, Czech Academy of Sciences)</li> </ul>	F. Oulehle
<ul style="list-style-type: none"> <li>20-13644S: Cherts and carbonates as geochemical proxies of paleoenvironmental conditions and Ocean Plate Stratigraphy (main project partner: Institute of Geology, Czech Academy of Sciences)</li> </ul>	J. Pašava
<ul style="list-style-type: none"> <li>GA21-30043S: Petrogenesis and emplacement of deep-marine alkaline basaltoids: a case of Early Cretaceous magmatism in the northern Tethys region (main project partner: VSB – Technical University of Ostrava)</li> </ul>	V. Rappich
<ul style="list-style-type: none"> <li>19-27682X: Principal mechanisms of peripheral continental growth during the supercontinental cycle</li> </ul>	K. Schulmann
<ul style="list-style-type: none"> <li>17-05743S: New spectral insight into biogeochemistry of small forested catchments (main project partner: Global Change Research Institute, Czech Academy of Sciences)</li> </ul>	V. Strnadová
<ul style="list-style-type: none"> <li>17-22207S: The role of inherited continental margin architecture on early Variscan convergence (main project partner: Faculty of Science, Charles University)</li> </ul>	P. Štípská

• 19-250355: Granulite–migmatite domes – insights to Devonian and Carboniferous evolution in the Variscan belt	P. Štípská
• 20-20785J: Searching for biological fingerprints and grain alteration patterns in Devonian and Carboniferous microbial facies – examples from the Bohemian Massif	S. Vodrážková

## Technology Agency of the Czech Republic

• TK01030054: Controlled biological methane production in situ (main project partner: EPS biotechnology s. r. o.)	J. Franců
• TITSMPO816: The research contents of Be, Ge, Ga and In in tailings ponds of ash in CR (main project partner: GET s. r. o.)	J. Godány
• TITSMPO909: Elaboration of a methodology for regional raw materials strategies	J. Godány
• TITSMPO031: Research on promising mineral fillers and quartz raw materials in the Bohemian Massif, their treatment and use for progressive industrial applications (main project partner: GET s. r. o.)	J. Godány
• TITSMPO026: Research on the raw material potential of strategic minerals in brines of the Bohemian Massif (main project partner: GET s. r. o.)	J. Godány
• 2019TK02010092: Analysis of the geothermal energy potential at medium and great depths in the Czech Republic on the basis of available data	J. Holeček, M. Klož
• TK02030120: Impact of geosphere evolution on radionuclide transport from a deep radioactive waste repository to the biosphere (main project partner: Technical University of Liberec)	T. Hroch
• SS01010208: Targeted replenishment of groundwater as a tool to reduce drought impacts in the Czech Republic (main project partner: T. G. Masaryk Water Research Institute)	R. Kadlecová
• TK01030031: Engineered barrier 200 °C (main project partner: Czech Technical University in Prague)	F. Laufek
• SS02030040: Prediction, evaluation and research for understanding national sensitivity and impacts of drought and climate change for Czechia (main project partner: Czech Hydrometeorological Institute)	O. Nöl
• SS02030031: Air quality research, assessment and monitoring integrated system (main project partner: Czech Hydrometeorological Institute)	M. Novák
• SS02030018: Center for Landscape and Biodiversity (main project partner: Silva Tarouca Research Institute for Landscape and Ornamental Gardening)	F. Oulehle
• SS02030023: Rock environment and natural resources	M. Poňavič

## Internal projects funded by the MoE (Ministry of the Environment) under the Long-Term Conceptual Development of Research Organizations

• Determination of the isotopic composition of Si using MC-ICP-MS at the Czech Geological Survey	L. Ackerman
• Trace elements and non-traditional stable isotopes in edible mushrooms from three small catchments underlain by different bedrock	A. Andronikov
• Preparation and use of LA-ICP-MS for study of trace elements in sulphides of various samples	I. Andronikova
• Geochemical cycle of cadmium in the long-term monitored catchments of GEOMON and its changes in the past two decades	L. Bohdálková



## Projects implemented in 2021

• Wetlands and their importance in the landscape	E. Břízová
• Special studies, research methodology, doctoral studies and theses	E. Břízová, A. Václavíková
• Continuous inventory of CGS samples in Brno	M. Bubík
• Impact of global change on Phanerozoic communities: Evolution of selected Cambrian to Devonian groups of invertebrates; study of selected Cenozoic fauna (Gastropoda, Amniota) – paleontological revision of CGS collections	P. Budil
• Mentoring	Z. Bukovská
• Subsurface geoinformation models (GeoCIM)	Z. Bukovská
• Editing of the journal <i>Geological Research in Moravia and Silesia</i>	D. Buriánek
• Regional geological mapping of the Czech Republic at 1:25,000 scale	D. Buriánek, J. Pertoldová
• Integrated terrane boundary analysis of the allochthonous complexes of the Bohemian Massif	S. Collet
• Geology of the Bohemian Cretaceous Basin	S. Čech
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Železné hory Mts	S. Čech
• Assessment services of regional geologists	J. Čurda
• The geodynamic significance of ultrabasic-basic rock association in orogens (example of the Bohemian Massif)	P. Deiller
• Decorative and building stones of the Czech Republic – editing of the on-line database and use of stone for ornamental and construction purposes	B. Dudíková
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Novohradské hory Mts	B. Dudíková
• Analysis of subsidence near the Turów mine based on satellite radar data	K. Fárová
• Editing and preparation of the electronic version of the <i>Bulletin of Geosciences</i>	J. Frýda
• Editing and printing of the <i>Bulletin of Geosciences</i>	J. Frýda
• Research on biodiversity and global change in the past	J. Frýda
• Evaluating the current status and prospects for the use of construction minerals in the Czech Republic with emphasis on dimension stone, and sand and gravel	J. Godány
• Petrogenesis, structures and emplacement of post-collision Weinsberg granitoids (Moldanubian Batholith)	T. Hájek
• Work in the steering committee of the international research network ENeRG	V. Hladík
• Development of methods for isotopic analysis of samples obtained by micromilling	J. Hora
• Geological survey of a unique archaeological site in the Podřipsko region	J. Hošek
• Origin of the post-orogenic granites of the AJ Bogd massif in the Trans-Altai Zone in southwestern Mongolia	K. Hrdličková

<ul style="list-style-type: none"> <li>• Soil maps 1:50,000 – lay-out of digital maps produced by the NCA CR according to the requirements for CGS map outputs, supplemented with explanatory notes to maps and printing for the archive</li> </ul>	J. Janderková
<ul style="list-style-type: none"> <li>• Preparations for developing a new online popularization portal of the CGS</li> </ul>	J. Jelének
<ul style="list-style-type: none"> <li>• Development of 3D geological models and related CGS databases</li> </ul>	L. Kondrová
<ul style="list-style-type: none"> <li>• Record of mantle metasomatism in ultrabasic Moldanubian rocks</li> </ul>	J. Kotková
<ul style="list-style-type: none"> <li>• Testing the use of drones and virtual reality for research purposes</li> </ul>	L. Koucká
<ul style="list-style-type: none"> <li>• Biogeochemistry and ecotoxicology of aquatic and terrestrial systems of the Slavkov Forest Critical Zone Observatory</li> </ul>	P. Krám
<ul style="list-style-type: none"> <li>• Inventory of Slope Instabilities</li> </ul>	O. Krejčí
<ul style="list-style-type: none"> <li>• Ag, Cu, Hg and Te substitutions in palladseite <math>\text{Pd}_{17}\text{Se}_{15}</math>: an experimental mineralogical study</li> </ul>	F. Laufek
<ul style="list-style-type: none"> <li>• Sedimentological and petrological study of the Malinovská skála Sandstone and Pústevní Sandstone (Godula Formation) in the Beskydy Mts</li> </ul>	L. Maceček
<ul style="list-style-type: none"> <li>• Publication of geological research results obtained during mapping projects in the Main Ethiopian Rift in 2015–2020</li> </ul>	K. Martínek
<ul style="list-style-type: none"> <li>• 3D reconstruction and presentation of selected fossil material from CGS collections</li> </ul>	M. Nohejlová
<ul style="list-style-type: none"> <li>• Analysis methods for organic pollutants</li> </ul>	D. Ocásková
<ul style="list-style-type: none"> <li>• Deposition of toxic antimony in the border mountains of the Czech Republic</li> </ul>	T. Pačes
<ul style="list-style-type: none"> <li>• Interpretation and publication of significant results from site evaluation projects for the location of a deep radioactive waste repository</li> </ul>	J. Pertoldová
<ul style="list-style-type: none"> <li>• Possibilities of building an underground hydrogen storage facility in the geological conditions of South Moravia</li> </ul>	R. Prochác
<ul style="list-style-type: none"> <li>• Transboundary transport of pollutants from the Polish part of the Upper Silesian Basin to the Czech Republic</li> </ul>	E. Přechová
<ul style="list-style-type: none"> <li>• Formation and evolution of asymmetrical depressions and lacustrine environments in the Bohemian Paradise in the context of late-glacial and Holocene climate change</li> </ul>	T. Radoměřský
<ul style="list-style-type: none"> <li>• Mineralization of biogenic material in a volcanic environment – case study of wood fossilization in alkaline basaltic volcanism of the Ohře Rift</li> </ul>	V. Rapprich
<ul style="list-style-type: none"> <li>• Volcanic systems VI</li> </ul>	V. Rapprich
<ul style="list-style-type: none"> <li>• Administration, maintenance and development of the PMČR50 geo-database related to the compilation of new soil maps and their safekeeping, printing and presentation</li> </ul>	J. Sedláček
<ul style="list-style-type: none"> <li>• Editing of the <i>Geoscience Research Reports</i> journal</li> </ul>	T. Sidorinová
<ul style="list-style-type: none"> <li>• Record of supercontinent cycles in the basement of the Central European Variscides: relationship between primary Proterozoic configuration and collisional evolution</li> </ul>	I. Soejono
<ul style="list-style-type: none"> <li>• Monograph of the Krkonoše Piedmont Basin and digitization of a 1:75,000 map</li> </ul>	M. Stárková
<ul style="list-style-type: none"> <li>• Phytopaleontological and sedimentological study of the Permo-Carboniferous basins of the Bohemian Massif</li> </ul>	Z. Šimůnek

## Projects implemented in 2021

• Expert support for the National Geoparks Network of the Czech Republic II	V. Štědrá
• Nitrogen cycle in mountain peatlands – summary of isotope data	M. Štěpánová
• Executing tasks of the state geological survey apart from approved projects – Geofond Division	V. Štrupl
• Nannofossils of the Tethyan and Boreal development of the Upper Cretaceous in the Czech Republic	L. Švábenická
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Bohemian Paradise II	L. Švábenická
• Silurian stratotypes of the Prague Basin	Z. Tasáryová
• Geological conditions in the discharge area of a hydrogeological structure of natural curative sources in the vicinity of Skalka near Prostějov	P. Tomanová Petrová
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Central Moravia	P. Tomanová Petrová
• Inventory, protection and popularization of geosites of the Czech Republic	M. Vajskebrová
• Selected Mesozoic and Cenozoic taphocenoses II: stratigraphy, palaeoecology, taxonomy and palaeobiogeography	R. Vodrážka
• Geology of the Křivoklátsko Protected Landscape Area	T. Vorel
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Brdy Mts	T. Vorel
• Addition of 1:25,000 scale manuscript geological maps to the map application of the Czech Geological Survey	V. Žáček
• Geology of the Šumava National Park and Protected Landscape Area	V. Žáček
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Pošumaví region	V. Žáček
• Printing of geological and applied maps	V. Žáček

## Ministry of the Environment of the Czech Republic

• Moravian Karst Protected Landscape Area – Spreading of slag contamination through the cave system of the Rudice Sinkhole – Býčí skála Cave and Josefov Valley: study of mechanical and geochemical impacts on calcite speleothems and the area's ecology (Geology Department of the MoE)	V. Baldík
• RANAP, 2020, Influence of anthropogenic inhomogeneities on the distribution of Rn and H values in the rock environment and update of the radon index map at <a href="http://www.geology.cz">www.geology.cz</a> (Geology Department of the MoE)	I. Barnet
• Geological and metallogenic study of selected ore deposits and mineralizations of the Bohemian Massif (Geology Department of the MoE)	P. Bohdálék
• Advisory and expert services provided for the Geology Department of the MoE (including landslides for the Operational Programme Environment, updates of maps, assessments and opinions), NP321 (gas leakage measurement), etc. (Geology Department of the MoE)	J. Čurda
• CGS archives – retransfer of documented samples from old boreholes to the standard storage system of the CGS Geofond Division (Geology Department of the MoE)	A. Donát
• Revalidation of the Bohemian Paradise UNESCO Global Geopark – activities of the Czech Geological Survey (Geology Department of the MoE)	P. Fíferna



<ul style="list-style-type: none"> <li>Database of plugged boreholes and boreholes with potential gas leakage in the North JVSČM section (Geology Department of the MoE)</li> </ul>	J. Franců
<ul style="list-style-type: none"> <li>Monitoring of hydrogeological boreholes in 2017–2020 (related to the Review of Groundwater Resources of the Czech Republic from the Operational Programme Environment 2007), including a general evaluation for 2017–2020 – continuation (Geology Department of the MoE)</li> </ul>	J. Grundloch
<ul style="list-style-type: none"> <li>Revision of mapped undermined areas and mine workings based on new acquisitions of digital map documents as a basis for investigating mining impacts and for consolidating data on abandoned exploratory mine workings, 2020 (Geology Department of the MoE)</li> </ul>	A. Horáková
<ul style="list-style-type: none"> <li>Operational geological documentation of linear infrastructure, 2021 (Geology Department of the MoE)</li> </ul>	J. Hošek
<ul style="list-style-type: none"> <li>Hydrogeological conditions near the Račice rowing venue and the influence of sand and gravel mining on the hydrogeological and hydrological parameters of the rock environment in its vicinity (Geology Department of the MoE)</li> </ul>	P. Hrazdára
<ul style="list-style-type: none"> <li>Restoration of selected parts of the geological documentation collection maintained by the CGS Geofond archives, 2021 phase (Geology Department of the MoE)</li> </ul>	M. Hrdlovicsová
<ul style="list-style-type: none"> <li>Management of a network monitoring the status of ecosystems with regard to air pollution (Air Protection Department of the MoE)</li> </ul>	J. Hruška
<ul style="list-style-type: none"> <li>Digitization of collections of the Geophysical Archive at the Geofond office in Brno (Geology Department of the MoE)</li> </ul>	E. Hudečková
<ul style="list-style-type: none"> <li>Update of soil maps at 1:50,000 scale (Geology Department of the MoE)</li> </ul>	J. Janderková
<ul style="list-style-type: none"> <li>Turów (Water Protection Department of the MoE)</li> </ul>	R. Kadlecová
<ul style="list-style-type: none"> <li>Geological Conditions in Spa Source Protection Zones – pre-project phase (Geology Department of the MoE)</li> </ul>	E. Kryštofová
<ul style="list-style-type: none"> <li>RANAP (radon) – Radiometric anomalies and research from ČSÚP data (Geology Department of the MoE)</li> </ul>	R. Kujal
<ul style="list-style-type: none"> <li>Mineral deposit information system (LIS), 2021, completion of MoE document scanning (Geology Department of the MoE)</li> </ul>	J. Mojžíš
<ul style="list-style-type: none"> <li>Groundwater in Crystalline Rocks (Geology Department of the MoE)</li> </ul>	J. Novotná
<ul style="list-style-type: none"> <li>Transfer of borehole logs from the archived reports of the FZ and P collections into the GDO and GEO systems, 2021 phase (Geology Department of the MoE)</li> </ul>	Z. Petáková
<ul style="list-style-type: none"> <li>Determination of prognostic resources of moldavite (category Q) at sites in South Bohemian basins – 2021 (Geology Department of the MoE)</li> </ul>	T. Peterková
<ul style="list-style-type: none"> <li>Review of prognostic resources of industrial minerals and ores, category Q, in the South Bohemian Region (Geology Department of the MoE)</li> </ul>	M. Poňavič
<ul style="list-style-type: none"> <li>Mineral Commodity Summaries of the Czech Republic and Changes in Reserves of Reserved Mineral Deposits (Geology Department of the MoE)</li> </ul>	J. Starý
<ul style="list-style-type: none"> <li>Subsidence detection using PSI: a study for the Turów open pit mine and its wide surroundings (MoE)</li> </ul>	V. Strnadová
<ul style="list-style-type: none"> <li>Processing and evaluating map documents stored in the national archives of the Czech Republic as a basis for investigating mining impacts (display modifications, filters) (Geology Department of the MoE)</li> </ul>	J. Šanderová
<ul style="list-style-type: none"> <li>Processing and evaluating final reports from the FZ collection at the Kutná Hora office as a basis for investigating mining impacts (Geology Department of the MoE)</li> </ul>	J. Šanderová
<ul style="list-style-type: none"> <li>Review of mitigated mining impacts and secured abandoned exploratory mine workings according to Czech Mining Authority Regulation No. 52/1997 Coll., on requirements for ensuring safety and occupational health and operational safety during the decommissioning of major mine workings, 2020–21 (Geology Department of the MoE)</li> </ul>	P. Šír

## Projects implemented in 2021

• First-hand investigation of reported mining impacts and abandoned mine waste sites (Geology Department of the MoE)	V. Štrupl
• Geological map of the Brdy Protected Landscape Area – summary map of geodynamic phenomena at 1:50,000 scale, final phase (Geology Department of the MoE)	T. Vorel

## Other ministries and local authorities

• QK1810186: Improving soil structure stability and infiltration through agricultural practices, cooperation with the Crop Research Institute (Ministry of Agriculture – “Země” Programme)	M. Koubová
• FV30153: Development of an inventory and monitoring system for geotechnical risk management, cooperation with Czech Technical University, DATASYS, STRIX Chomutov a.s. (MoE – Trio Programme)	P. Kycl
• RINGEN Geoenery Centre – preparation of the strategic SYNERGYS project (Assistance Vouchers of the Ústí nad Labem Region), cooperation with the RINGEN Research Infrastructure, the Institute of Geophysics of the CAS and the Chamber of Renewable Energy Sources	A. Tým

## Projects of the EC Framework Programme Horizon 2020

• GeoERA Information Platform Project (GIP-P); project of the international GeoERA consortium	D. Čápková
• HotLime – Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks – Cross-domain Implications and Impacts; project of the international GeoERA consortium	J. Franců
• 3DGEO-EU 3D geomodeling for Europe; project of the international GeoERA consortium	J. Franěk
• Mineral Intelligence for Europe; project of the international GeoERA consortium	Z. Gabriel
• Hydrogeological processes and geological settings over Europe controlling dissolved geogenic and anthropogenic elements in groundwater of relevance to human health and the status of dependent ecosystems	J. Grundloch
• COST Geothermal DHC: New geothermal sources for carbon-free heating grids	V. Hladík
• GeoConnect <sup>3</sup> d: Cross-border, cross-thematic multiscale framework for combining geological models and data for resource appraisal and policy support	V. Hladík
• Hystories – HYdrogen STORAge In European Subsurface	V. Hladík
• MUSE – Managing Urban Shallow geothermal Energy	J. Holeček
• Resources of groundwater, harmonized at cross-border and pan-European scale; project of the international GeoERA consortium	E. Kryštofová
• International Network of Raw Materials Training Centres (INTERMIN)	D. Mašek
• 820852 – Forecasting and Assessing Europe’s Strategic Raw Materials Needs; project of the international GeoERA consortium	P. Rambousek
• e-shape – Next-generation satellite data and creation of innovative applications	V. Strnadová

## Other EC and EU programmes

<ul style="list-style-type: none"> <li>CZ.02.1.01/0.0/0.0/16_013/0001800: Distributed system of observational and field measurements of geophysical fields, CzechGeo/EPOS-Sci (Operational Programme Research, Development and Education – OPRDE)</li> </ul>	D. Čápková
<ul style="list-style-type: none"> <li>CZ.11.4.120/0.0/0.0/16_026/0001087: GECON – Geology Cooperation Network (INTERREG: Czech Republic – Poland)</li> </ul>	P. Fífera
<ul style="list-style-type: none"> <li>101005416361: recomine SN–CZ (Cooperation Programme Czech Republic – Free State of Saxony)</li> </ul>	Š. Mrázová
<ul style="list-style-type: none"> <li>PanAfGeo: Geoscientific Knowledge and Skills in African Geological Surveys (European Commission, DG DEVCO)</li> </ul>	V. Štědrá
<ul style="list-style-type: none"> <li>PanAfGeo-2: Africa-EU Partnership – Support to Geological Sciences and Technologies (European Commission, DG DEVCO)</li> </ul>	V. Štědrá
<ul style="list-style-type: none"> <li>CZ.02.2.69/0.0/0.0/18_053/0017379: International mobility of CGS researchers (OPRDE)</li> </ul>	A. Velímková

## Czech Development Agency – foreign development cooperation

<ul style="list-style-type: none"> <li>Preparation of project documents in cooperation with the geological surveys FBiH and RS</li> </ul>	D. Čápková
<ul style="list-style-type: none"> <li>ET-2020-077-RO-31140: Compilation of a national geological and hydrogeological map at a scale of 1:1,000,000 for the entire territory of Ethiopia</li> </ul>	K. Verner
<ul style="list-style-type: none"> <li>ET-2019-019-RO-43040: Ensuring sustainable land management in selected areas of Ethiopia based on geoscience mapping</li> </ul>	K. Verner

## Other international projects

<ul style="list-style-type: none"> <li>TO01000112: CO<sub>2</sub>-SPICER – CO<sub>2</sub> Storage Pilot in a Carbonate Reservoir (EEA and Norway Grants)</li> </ul>	V. Hladík
<ul style="list-style-type: none"> <li>Building partnership and knowledge base towards sustainable use of the underground in cities (Norway Grants – Bilateral Fund under the Environment, Ecosystems and Climate Change Programme)</li> </ul>	J. Jelének
<ul style="list-style-type: none"> <li>2017/26/M/ST10/00646: Paleogeographic maps of Permian continental basins of Central Europe (PL – National Science Centre, Harmony Programme)</li> </ul>	Z. Šimůnek



# Information Portal

## ▼ Web

Czech Geological Survey website > [www.geology.cz/extranet-eng/](http://www.geology.cz/extranet-eng/)

State Geological Survey > [www.geology.cz/extranet-eng/sgs](http://www.geology.cz/extranet-eng/sgs)

Science and Research > [www.geology.cz/extranet-eng/science](http://www.geology.cz/extranet-eng/science)

Services > [www.geology.cz/extranet-eng/services](http://www.geology.cz/extranet-eng/services)

Maps > [www.geology.cz/extranet-eng/maps](http://www.geology.cz/extranet-eng/maps)

Publishing activity > [www.geology.cz/extranet-eng/publications](http://www.geology.cz/extranet-eng/publications)

Promotion > [www.geology.cz/extranet-eng/geology-for-all](http://www.geology.cz/extranet-eng/geology-for-all)

About us > [www.geology.cz/extranet-eng/about-us](http://www.geology.cz/extranet-eng/about-us)

## ▼ Thematic portals

Slope Instabilities > [www.geology.cz/svahovenestability](http://www.geology.cz/svahovenestability)

World of Geology – portal dedicated to the geosphere > [www.svet-geologie.cz](http://www.svet-geologie.cz)

CO<sub>2</sub> Capture and Storage (CCS) > [www.geology.cz/ccs](http://www.geology.cz/ccs)

## ▼ Journals

Bulletin of Geosciences > [www.geology.cz/bulletin](http://www.geology.cz/bulletin)

Journal of Geological Sciences > [www.geology.cz/sbornik](http://www.geology.cz/sbornik)

Special Papers > [www.geology.cz/spec-papers](http://www.geology.cz/spec-papers)

Geoscience Research Reports > [www.geology.cz/zpravy/en](http://www.geology.cz/zpravy/en)

## ▼ Web applications

Guidepost to applications > <http://applications.geology.cz>

Photoarchive > [fotoarchiv.geology.cz](http://fotoarchiv.geology.cz)

Map Server > [maps.geology.cz](http://maps.geology.cz)

Geological Encyclopedia > [www.geology.cz/encyklopedie](http://www.geology.cz/encyklopedie)

Dictionary of Geology E-C and C-E > <http://www.geology.cz/aplikace/encyklopedie/gsllov.pl?l=e>

Virtual Museum > <http://muzeum.geology.cz/?l=e>

Geological Localities > [lokalita.geology.cz/d.pl?item=1&l=e](http://lokalita.geology.cz/d.pl?item=1&l=e)

Interesting Geosites > <https://mapy.geology.cz/geosites>

Decorative Stones > [dekoracni-kameny.geology.cz/index\\_eng.pl](http://dekoracni-kameny.geology.cz/index_eng.pl)

Applications for the execution of the state geological survey > <http://www.geology.cz/extranet-eng/services/web-applications/sgs-apps>

Mineral Information System (SuriS) > <https://mapy.geology.cz/suris>

## ▼ Other web presentations

E-shop > [obchod.geology.cz](http://obchod.geology.cz)

The CGS channel on YouTube > [www.youtube.com/geologycz](http://www.youtube.com/geologycz)

Geology Olympiad > [www.geologicka-olympiada.cz](http://www.geologicka-olympiada.cz)

Facebook – World of Geology > [www.facebook.com/svetgeologie](http://www.facebook.com/svetgeologie)



# Principal Offices of the Czech Geological Survey



**Klárov Headquarters**

Klárov 3, 118 21 Praha 1,  
Phone: 257 089 411, Fax: 257 531 376

Directorate | Regional and Applied  
Geology | Library | Archive Collections |  
GIS and DB | Publishing House |  
Bookstore | Reprographic Centre



**Barrandov Laboratories**

Geologická 6, 152 00 Praha 5,  
Phone: 251 085 111, Fax: 251 818 748

Central Laboratory  
(inorganic geochemistry) |  
Geochemistry | Special Laboratories



**Kostelní Office**

Kostelní 26, 170 06 Praha 7,  
Phone: 234 742 111, Fax: 234 742 290

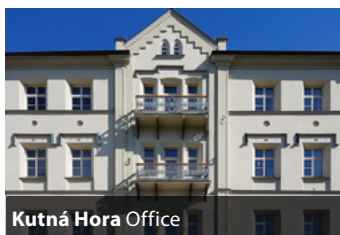
Geofond | Study Room | Video Archive |  
Document Archive (part.) | Specialized  
Offices



**Brno Branch**

Leitnerova 22, 658 69 Brno,  
Phone: 543 429 200, Fax: 543 212 370

Regional and Applied Geology, Geophysics |  
Geochemistry | Testing Laboratory  
(organic geochemistry) | Library and Archive |  
Bookshop | GIS and DB



**Kutná Hora Office**

Dačického náměstí 11, 284 01  
Kutná Hora, Phone/Fax: 327 512 220

Geofond – Mining Impacts Department



**Jeseník Office**

Erbenova 348, 790 01 Jeseník,  
Phone/Fax: 584 412 081

Regional Office | Archive of Geological  
Samples | Bookshop



**Electron Microprobe and Microanalysis  
Laboratory, Faculty of Science, MU Brno**

Kotlářská 2, 611 37 Brno,  
Phone: 541 129 496, Fax: 541 211 214

Electron Microprobe and Microanalysis  
Laboratory



**Jílové Regional Museum and Centre  
for Documentation of Gold Deposits**

Masarykovo nám. 16, 254 80  
Jílové u Prahy, Phone: 241 950 455

Archive of Geological Samples  
and Written Documentation



**Lužná Archive of Material  
Documentation**

270 51 Lužná u Rakovníka, čp. 432,  
Phone/Fax: 313 537 849

Archive of Geological Samples | Collections |  
Publications and Maps



**Stratov Archive of Material  
Documentation**

289 22 Stratov, čp. 184,  
Phone: 234 742 205

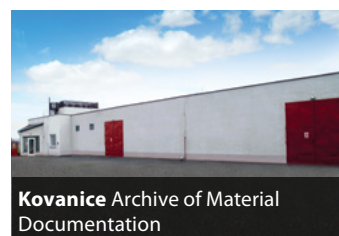
Archive of Geological Samples  
and Written Documentation



**Kamenná Archive of Material  
Documentation**

Kamenná 42, 262 31 Milín,  
Phone: 234 742 205

Archive of Geological Samples



**Kovanice Archive of Material  
Documentation**

288 02 Kovanice, čp. 184,  
Phone: 234 742 205

Archive of Written Documentation

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