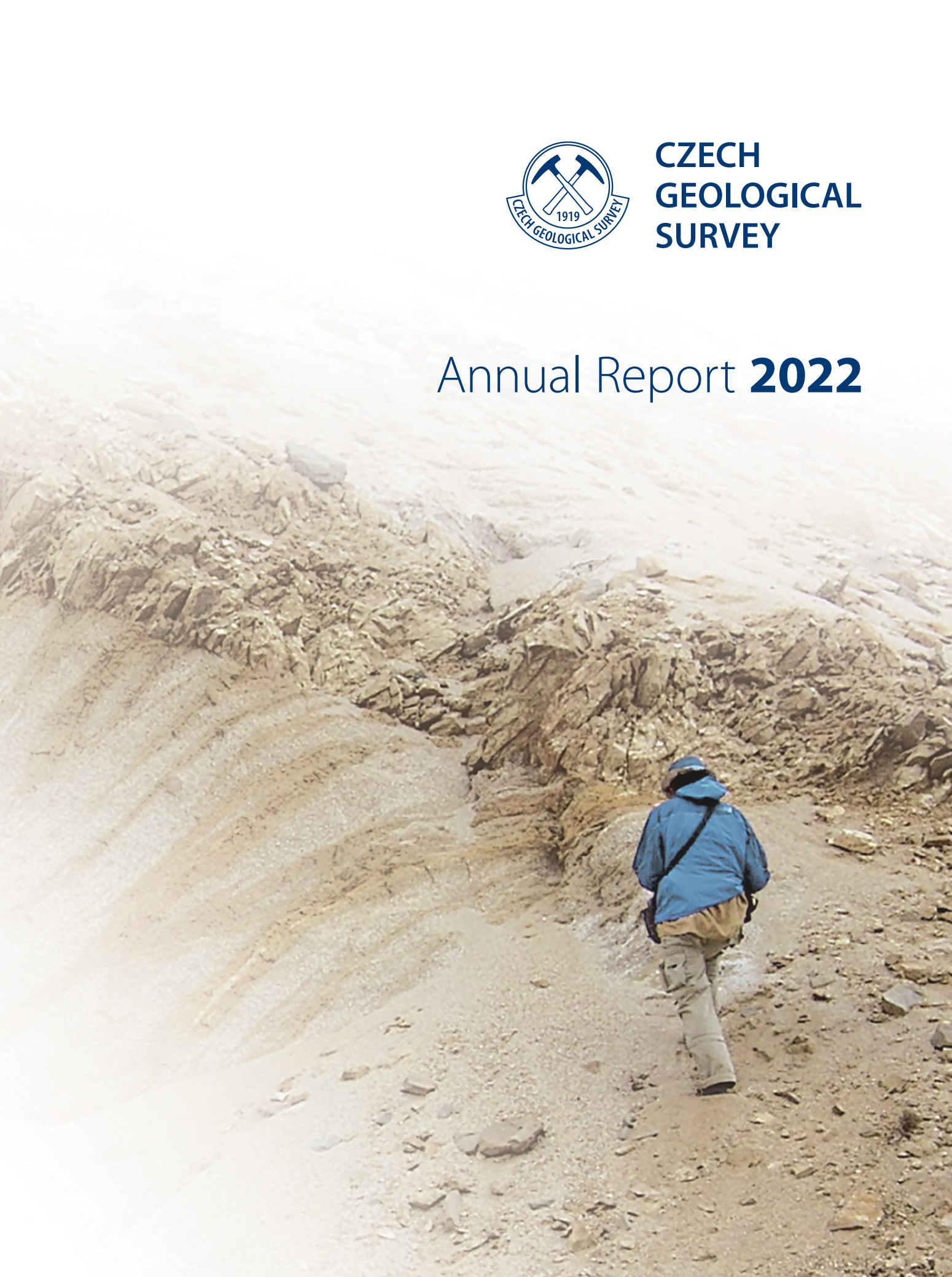




**CZECH
GEOLOGICAL
SURVEY**

Annual Report **2022**



Content

	Director's introduction	1
	Geological and thematic maps	4
	Regional geological research	6
	Lithospheric research	8
	Research on global changes and evolution of life in the geological past	10
	Mineral resources	12
	Groundwater research and evaluation	16
	Geoenergy research	18
	Geosphere–biosphere–atmosphere interactions	20
	Geohazard research	24
	Regional Geological Administration	26
	State geological survey agenda of the Information Systems Division	28
	Mine workings and mining waste	32
	Geological Information System	34
	Remote sensing	38
	International activities and cooperation	40
	Laboratories	46
	Library and Collections	50
	Geological documentation	52
	CGS Publishing House	54
	Selected publications issued	58
	Periodicals	60
	Selected posts on YouTube	62
	Caught your eye on Facebook	64
	Selected scientific papers	68
	Financial review for 2022	74
	Human resources	75
	Principal events in 2022	76
	Projects	83

Long-Term Conceptual Development of Research Organizations 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 2022, a life and economics in the Czech Geological Survey (CGS) were scarred by the despicable war of aggression triggered by the Russian Federation in Ukraine on the 24th February. CGS as an institute expresses its unequivocal support for and solidarity with Ukraine and its people.

An event of prime international importance in 2022 in which the CGS was principally engaged were negotiations with Poland regarding a negative environmental impact on groundwater in the Czech Republic caused by the Polish Turów lignite open-pit mine. The Czech-Polish intergovernmental negotiations commenced in June 2021, only after the Court of Justice of the European Union issued an interim measure, based on a Czech lawsuit, ordering Poland to halt mining operations immediately. CGS took part in negotiations led by high officers and lawyers from the Ministry of the Environment and the Ministry of Foreign Affairs, and addressed the mine's impact on hydrogeological conditions in the Czech territory. After a long series of negotiations, the representatives of both countries reached a consensus resulting in the Agreement between the Government of the Czech Republic and the Government of the Republic of Poland on Cooperation to Address the Mining Impacts of Poland's Turów Open-Pit Lignite Mine on the Territory of the Czech Republic. The agreement was signed in Prague on the 3rd February 2022 by the Prime Ministers Petr Fiala and Mateusz Morawiecki. Although I would personally prefer to see some specific points more favourable to our side in this agreement, concessions had to be made by both countries. Mr. Martin Smolek, Deputy Foreign Minister at that time, summed up the agreement in these words: "In my opinion, the agreement is an absolute victory and the maximum we could achieve with Poland at this moment." By performing our professional expertise in this case, CGS fulfilled its role in the state administration impeccably.

CGS has been for years engaged in research of sites considered for a deep geological repository of radioactive waste (p. 6). In 2022, another phase of our work was launched under the Horizontal Cooperation Agreement, concluded between CGS and the Radioactive Waste Repository Authority and effective till 2030. Further research and exploration work in the future will focus on four selected sites, which were approved by the Czech government. These sites include Březový potok, Janoch, Horka and Hrádek. The activities primarily comprise geological and hydrogeological mapping at scales of 1:25,000 and 1:10,000, structural and geomorphological analyses, processing of drill cores, construction of 3D geological models, data management and, inter alia, participation in the selection of the final and backup sites.

A request by the state-owned company ČEZ – a leading electric power company in Czechia – for an assessment of the geological characteristics of existing fossil-fuel power plants with regard to the possibility of installing small modular reactors in the future, so as to meet the criteria of national and international legislation for siting nuclear facilities.

This presents for us a new challenge and engagement in another strategic project of a nation-wide importance.

One of the most important ongoing research activities in CGS is the "Main mechanisms of peripheral continental growth during the supercontinental cycle" project (EXPRO of the Czech Science Foundation, see p. 9). The project is conducted in southwestern Mongolia by an international team led by Prof. K. Schulmann, and has already produced many excellent publications, which have attracted worldwide acclaim.

In terms of contributing to decarbonization, CGS is currently working on two key projects. The first is the CO₂-SPICER project, funded by the Norway Grants / Technology Agency of the Czech Republic, aimed at preparing a pilot CO₂ repository in a sedimentary complex in the Carpathian flysch of South Moravia (p. 18). The second project is the final preparation of the SYNERGYS project for a comprehensive use of geothermal energy for local heating in the town of Litoměřice. The project, worth € 50 million, was selected by the Ústí nad Labem Region for funding from the newly announced Operational Programme Just Transition from 2023 (p. 82).

On the international scene, CGS is a member of EuroGeoSurveys – consortium of European geological surveys, which succeeded in obtaining the unique "Geological Service for Europe (GSEU)" project funded by the Horizon Europe programme as a Coordinated and Support Action. It aims to create coordinated expert services focusing on carbon-free energy, critical mineral resources, groundwater, geohazards, and on the development of European data models that will be available to the European Commission, national governments and the European public (p. 40). The international PanAfGeo project, funded by the European Commission, continued with a second phase aimed at providing African geological surveys with the know-how of European geological surveys. The first three-year phase had excellent reviews and the training of African colleagues is now again in full swing after a break due to the COVID-19 pandemic. Under the leadership of Dr. V. Štědrá, CGS conducted an intensive geological field mapping course in Namibia, participated in a course in Morocco, and other training sessions are being prepared in Malawi, Eritrea and possibly in Tanzania.

As our need to find further financial resources for our operations continues to grow so do our project activities and reputation of our performance as the state geological survey. It requires to enhance continuously the institute's staff by recruiting young and high-qualified experts. At the same time, the CGS also benefits by employing a senior staff, which is willing to pass on its lifelong knowledge and experience to younger generations. I am proud of all our achievements, and my colleagues deserve my deepest appreciation and thanks for their commitment and undying enthusiasm, with which they carry out their work.


Zdeněk Venera

Organizational Structure

Situation as of 31 December, 2022

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

Management



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

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

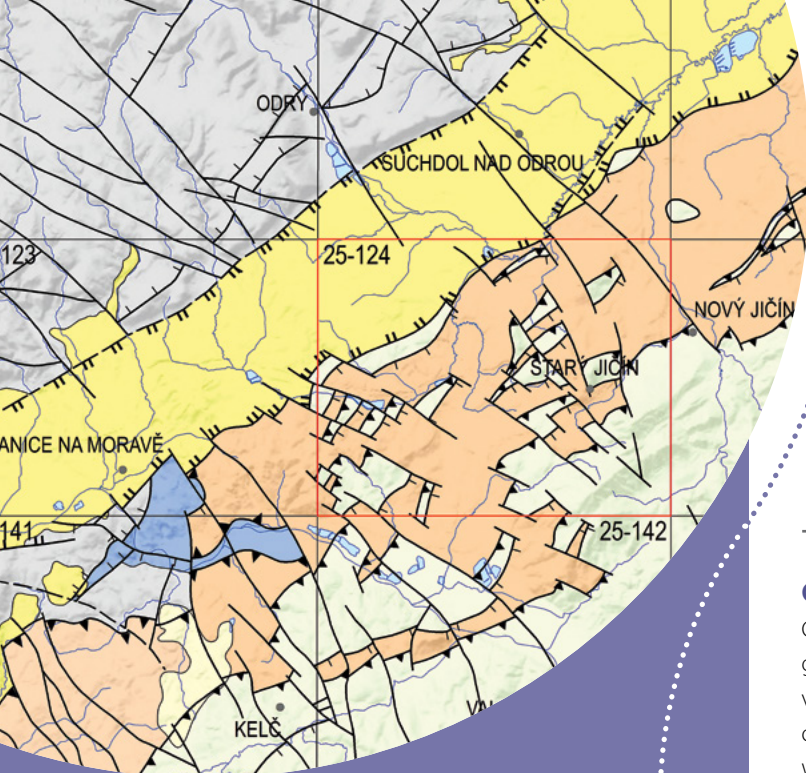
- Geological research and mapping
- Rock environment and its protection
- Mineral resources and environmental impacts of mining
- Geohazards, prevention and mitigation of their impact
- Geoinformation management and delivery

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.



► Figure 1. Overview of regional geological units next to the Starý Jičín map sheet (25-124) at 1:25,000 scale.



David Buriánek

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

Geological and thematic maps

/DKRVO

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 is one of the main tasks of the state geological survey. Our goal lies in obtaining a comprehensive view of the geological structure and geological evolution of the studied areas. Research includes field studies during which data is recorded via applications on mobile devices. This approach allows combining field observations with information obtained from previous studies. Geological mapping involves the creation of geological and thematic maps at various scales and collecting, processing and providing of accompanying data files and material samples. Field data are stored in a unified database, where they are subdivided thematically (geology, hydrogeology, pedology). Collected samples are studied in detail in the Czech Geological Survey laboratories, and in other laboratories worldwide. We mainly study the structure of rocks and their chemical, isotopic and mineral composition. In the case of selected samples, we determine the age of magmatic crystallization or metamorphism. A broad range of paleontological, chemical and mineralogical methods (micropaleontology, chemostratigraphy, heavy minerals) are used to interpret the sedimentary cover.

Geological maps

Currently, the research activities of the Czech Geological Survey focus primarily on mapping at a scale of 1:25,000 (Fig. 1). Numerous geological and derived maps, focusing mainly on protected landscape areas and other places of public interest in the Czech Republic, were compiled during the course of the mapping. 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.

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 maps of mineral deposits. Bedrock maps, tectonic maps and others were compiled for specific areas. The explanatory



► **Figure 2.** Photomicrograph of fine-grained calcareous sandstone with glauconite, Nemetice Formation, Vysoká, XPL. Photo by H. Gilíková (1:25,000 Starý Jičín map, 25-124).

notes to these maps contain information on the mapped areas with regard to petrography (Fig. 2), geophysics, hydrogeology (Fig. 3), engineering geology, structural geology, economic geology, geochemistry, pedology and environmental geology.

Geological mapping is one of the main sources of information for the safeguarding and inventory of important geosites. The database of geological documentation points currently contains 118,450 entries, including 3,530 geological documentation points newly created in 2022.

Presently, the regional geological mapping project at 1:25,000 scale includes work being carried out in six areas: the Železná hory National Geopark, the Novohradské hory Mts, the Pošumaví region, the Bohemian Paradise, Central Moravia and in the former military district of Brdy. In 2022, explanatory notes and associated maps at 1:25,000 scale were completed (bedrock map, Quaternary geology map, environmental geofactors map, economic geology map or hydrogeological map) for the map sheets Horní Stropnice 33-133, Pohorská Ves 32-422, Sobotka 03-344, Vacov 22-341 and Starý Jičín 25-124.

Two 1:25,000 scale maps with explanatory notes (Mokrá-Horákov and Šlapanice) were printed.

The Czech Geological Survey has been involved in long-term foreign projects mainly in the form of foreign development cooperation, in recent years particularly in Ethiopia (mapping at various scales, such as 1:100,000 and 1:50,000). During the “Ensuring sustainable land management in selected areas of Ethiopia based on geoscience mapping” project, two sets of maps at 1:100,000 scale and associated explanatory notes were compiled last year for the Gedeo and Sidama areas (geological, hydrogeological and soil maps – six maps in total).

Contribution to land development and the ecosystem

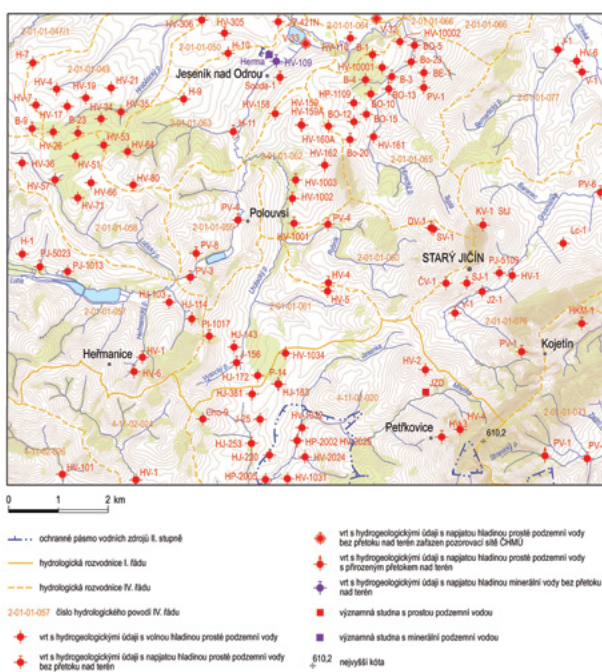
The newly completed explanatory notes to the 1:25,000 geological maps include data gathered during field surveys and also the results of laboratory analyses of soil, rocks and water. They provide state authorities and the professional community with information on groundwater protection zones, on the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

on mineral resources, including their evaluation, has a direct economic benefit as well.

Updated soil maps are being newly compiled (in 2022 for the map sheets Vyšší Brod 32-41 and Rožmberk 32-42) as part of the “Update of soil maps at 1:50,000 scale” project of the Geology Department of the Ministry of the Environment. Brief explanatory notes are always prepared for the map sheets, including a description of a given area's soils and of the processes that led to their formation. Until now, the maps mentioned were only available in analogue form. The project's aim is to produce new digitized versions based on the most up-to-date data. Pedological maps are gradually being made available for the online map server and as standard printed maps for the map archive.

Follow-up research

In 2022, four papers were published in expert journals with impact factors and focused on interpreting the origin of the Weinsberg granite and highly fractionated rocks in the Třebíč Pluton. Two additional papers dealt with germanium sulphides from burning heaps at the Radvanice locality near Trutnov. Three papers were published in a peer-reviewed science journal (Scopus). This involved a study of the chemical composition of amphibole in airborne dust from selected localities in the Brno region. Another study dealt with the mineralogy of titanite-rich nodules from the biotite granite of the Tábor Pluton in the Moldanubicum. The results of a study of a new occurrence of rocky-coast facies of the Kolín lithofacial development of the Bohemian Cretaceous Basin at Ronov nad Doubravou were published.



► **Figure 3.** Hydrological and water management phenomena on the Starý Jičín map sheet 25-124.



► The “bone bed” layer containing vertebrate bones (course marked by arrows) at the palaeontological site of Bradlecká Lhota (Ploužnice Horizon, Semily Formation). Photo by Zbyněk Šimůnek.



Zita Bukovská

Head of the Regional Geology
of Crystalline Formations Department



Zuzana Tasáryová

Head of the Regional Geology
of Sedimentary Formations Department

Regional geological research

/DKRVO

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, sedimentological and volcanological studies.

Applied research in the Czech Republic

Cooperation with and contracted work performed for the Radioactive Waste Repository Authority (SÚRAO) involve a number of ongoing projects that deal with the concept and future construction of a deep geological repository for high-level radioactive waste disposal and the characterization of the rock environment of potential sites for repository.

In 2022, the CGS collaborated in describing, parametrizing and modelling the rock environment with regard to subsequent modelling of transport and flow in a fractured rock environment. The work was carried out at the Bukov Underground Research Facility (URF). The behaviour of metal materials for the manufacture of disposal containers for radioactive waste is being verified during a pilot corrosion test. The CGS characterized the environment and created a 3D geological model, according to which locations for experimental and monitoring boreholes were selected, and their mutual connection and possible influence was studied. Another project generally defined the properties, events and processes related to the rock environment, which can negatively affect a deep repository during its construction and operation, also with regard to long-term safety lasting up to one million years. Monitoring of the temperature of the rock massif project included the documentation of monitoring sites, the creation of 3D photogrammetry models and a description of sites for temperature probe installation and for subsequent heat flow interpretation. During the construction of a new section of the URF, the rock environment continued to be characterized from a petrological, mineralogical, geochemical and structural geology perspective. Inflows into laboratory galleries and tunnels associated with brittle structures and a visualization of sections of the future laboratory were dealt with in the form of

photogrammetry and 3D geological models. In relation to the environment description, a classification system is being prepared for the future construction of a deep geological repository.

Three geological models of the wider surroundings of the operating low- and intermediate-level radioactive waste repositories of Bratrství near Jáchymov, Richard near Litoměřice and Dukovany were completed in 2022 as well. The 3D geological models are used for periodic safety assessments. In cooperation with the Elektrárna Dukovany II a. s. company, a 3D geological model of a planned construction site of a new nuclear source west of an existing power station was created. This non-public model is used for follow-up engineering geology and geotechnical work and analyses.

Research on hazards from undermining involved the creation of a set of 3D models of the Mariánské Radčice locality, including a landscape model in addition to a geological model. Similar models were also constructed for the historical Kaňk site for polymetallic ore mining.

Preliminary work was performed as part of the horizontal cooperation between SÚRAO and the CGS involving geological work at potential deep geological repository sites. Work projects were drawn up, which will focus on describing the rock environment of the sites and on selecting the most suitable site in the future.

Geological and geomorphological analyses were conducted for the Groundwater in Crystalline Rocks project in selected districts of the Vltava and Kutná Hora catchments to define hydrogeological structures with groundwater accumulations and localities suitable for strengthening water resources by converting surface runoff to subsurface runoff.

The TACR PERUN project, aimed at predicting climate change and the impact of drought in the Czech Republic, included a comprehensive geological analysis to assess the spatial variability of hydraulic conductivity in pilot areas in the Bohemian Cretaceous Basin and South Bohemian basins. Attention was paid to classification of groundwater level fluctuations in an extensive dataset provided by monitoring wells and to explanation of the possible causes from a geology perspective. The issue of the impact of mining in the Turów mine on a groundwater level in the Czech border area was addressed in a series of Polish–Czech meetings in 2022, which applied the results of extensive hydrogeological and geological works over the past years. CGS employees took part in several inspections of the Turów mine.

Applied research abroad

Another phase of the PanAfGeo-2 Africa – EU Partnership project took place involving support for geoscience and technologies. The course continued for a third year in Namibia in cooperation with the Geological Survey of Namibia. A total of 25 geologists from 13 African countries were trained during

the course, and field training was conducted near the town of Karibib in central Namibia with the participation of Czech, Namibian and Portuguese lecturers.

Sets of geoscience maps of the Sidama Region, Gedee zone, and land-use and landscape plans for selected local governments were published in 2022 during foreign development cooperation projects in Ethiopia. A national geological and hydrogeological map of Ethiopia is being compiled as well.

Applied research in the Czech Republic and abroad

Geological mapping in 2022 continued in the Pošumaví region, Novohradské hory Mts, Bohemian Paradise and Brdy. The work focused on the Sušice 22-314, Pohoří na Šumavě 33-311, Kamenec 33-313, Sobotka 03-344, Jičín 03-433 and Bohutín 22-122 map sheets, which were the last to be completed. The preparation of a monography on the Šumava National Park included field revisions and photo documentation of selected geosites.

A project dealing with the record of supercontinent cycles in the Central European Variscan basement included a study of the age of clastic zircons from units of the Brunovistulian unit and their Hf isotopic composition. The study results showed that the region belonged to the Baltic or Amazonian craton in the Lower Neoproterozoic and that it was part of the active continental margin of Gondwana or Baltica in the Upper Neoproterozoic. The research results also disprove the existence of the Rheic suture in the Bohemian Massif and were published in the *Precambrian Research* journal.

Articles describing two recently approved germanium minerals, radvaniceite (GeS_2) and pertoldite (trigonal GeO_2), were published in the *Minerals* and *Journal of Geosciences* journals. Basic sedimentological and volcanological research in 2022 included published multidisciplinary studies conducted in the Czech Republic and abroad. Other international successes included the proposal of an auxiliary stratotype for the Turonian/Coniacian boundary in Střeleč, which was approved by the International Commission on Stratigraphy.

Furthermore, a scientific borehole was drilled during the ICDP (International Continental Scientific Drilling Program) project in the newly described Pleistocene Bažina maar. Study of the drill core helps to understand the growth process of pyroclastic cones inside maar craters. Geochemical and isotopic study of zeolitized wood helped reveal the conditions under which trunks were buried in trachybasalt lahars.

Several paleontological sites in the Krkonoše Piedmont were reviewed in 2022 as well. Collecting fossils at most of the sites is only possible with great difficulty. Only the Bradlecká Lhota site (in the Semily Formation) appears promising in terms of flora finds and scattered small vertebrate remains (fish scales, small bones, teeth) in the thin "bone bed" layer of the Ploužnice Horizon.



► *Collecting samples for subsequent analysis, Dariv District, Mongolia. Photo by P. Hanžl.*



Karel Schulmann

Head of the Centre
for Lithospheric Research

Lithospheric research

/DKRVO

The Centre for Lithospheric Research has been studying the processes in the continental crust for ten years. Using modern geological, geophysical and computer methods, it focuses on describing and understanding the evolution of collisional and accretionary orogens, the formation of continental crust and its interaction with the mantle.

The centre was founded in 2012 and has, since then, been focusing mainly on the study of events that occur at convergent lithospheric plate boundaries, during continental crust formation and continental growth. This research involves field geology combined with modern structural geology, quantitative metamorphic petrology, igneous petrology, geochemistry, geochronology, geophysics, and analogue and computer modelling.

The resulting conceptual models integrate the following sources of information:

- Temporal evolution of pressure-temperature conditions of geological terranes compiled on the basis of petrographic observations combined with thermodynamic modelling and monazite and zircon U-Pb geochronology methods.
- Deformation and metamorphic evolution of rocks reconstructed on the basis of microscopic observations and microstructural analysis.
- The environment, in which rocks were formed, using chemical and isotopic composition of minerals and rocks.
- Deep crust structure depicted by geophysical methods such as gravity, seismic and magnetic surveys.
- Dynamics of orogenic processes simulated by computer and analogue models.

In terms of regions, the research focuses mainly on the European Variscides, including the Bohemian Massif, the Vosges, the Massif Central, the Pyrenees and the Moroccan Meseta; on the Central Asian Orogenic Belt in Mongolia, China and Russia; and on Africa, including Madagascar and northern Africa.

One EXPRO project of the Czech Science Foundation and three internal projects of the CGS were carried out in 2022.

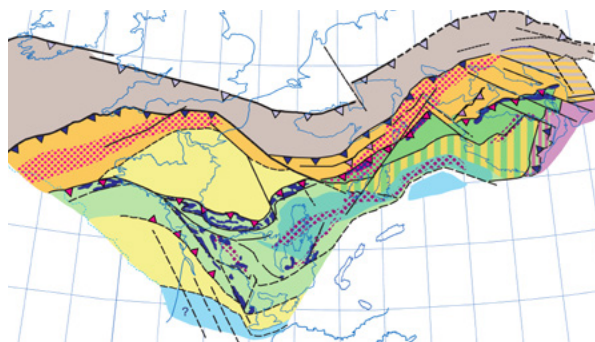
The most significant work on the structure of the Variscan orogen in Europe was published in the *Earth-Science Reviews* journal. This paper provides a complete review of geophysical and geological data from the Variscan part of the European continent, allowing definition of the architecture of the Variscan mountain range and definition of the Variscan orogenic crust. Based on a seismic data, three continental crust types

are defined – cratonic, transitional and Variscan orogenic crust. The Variscan crust is the result of three processes: collisional stages when the crust was thrust onto the Gondwana continent and subsequent lithospheric extensions associated with large-scale magmatism. Another important result are extensive isotopic and geochronological data from the metabasites of the Mariánské Lázně Complex, published in the *Geoscience Frontiers* journal. The paper provides new insight into the subduction of a (Cambrian) volcanic arc during the Devonian and into the age of the oceanic crust. According to these results, this crust represents a fragment of the Mirovoi Ocean and cannot be considered to be a part of the Rheic oceanic crust. The work of Collett *et al.* in the *Precambrian Research* journal further provides a ground-breaking view on the subduction of the Mirovoi Ocean prior to the formation of younger interior oceans.

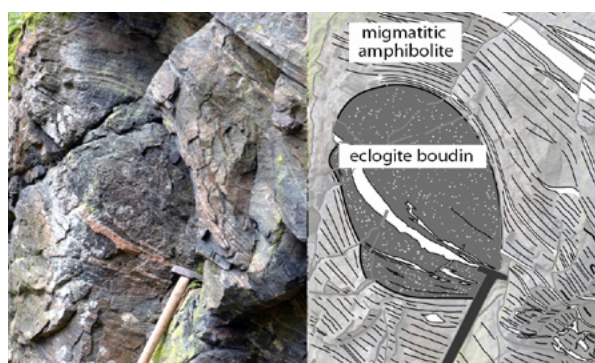
In addition, our research team conducted intensive studies on the eclogites of the European Variscan Belt, specifically in the Bohemian Massif and French Massif Central. The age of the protolith as well as of the eclogites and high-pressure metamorphism was determined.

After an imposed two-year break, an expedition to Mongolia was undertaken during the EXPRO project “Main mechanisms of peripheral continental growth during the supercontinental cycle” (funded by the Czech Science Foundation, 2019–2023). The expedition was divided into two groups, which focused on two significantly different areas of southwestern Mongolia. The results of the EXPRO project were published in ten international publications, the most significant of which is a paper in the *National Science Review* journal, which has the highest impact factor among periodicals of natural science. This ground-breaking paper summarizes the results from five years of paleomagnetic, structural and geochronological research and provides a new insight on the accretion and deformation of units of the Paleo-Asian Ocean to the Siberian Platform. Other important outputs are two articles in the *Tectonics* journal, which describe the formation and deformation of the Altai accretionary system in Mongolia and North China as part of the cyclic retreat and advance of the Pacific Plate during the Paleozoic. These articles indicate a two fold extension and shortening of the accretionary wedge from the Silurian to Permian.

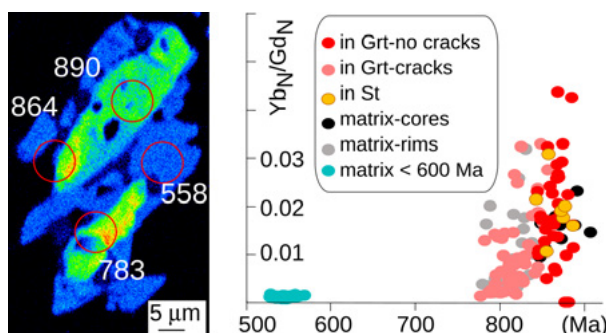
The centre cooperates with a number of institutes in the Czech Republic, primarily with the staff of the Faculty of Science of Charles University and the Institute of Geophysics of the Czech Academy of Sciences as well as with an extensive network of foreign universities and scientific institutions in Europe, Asia, America, Australia and Africa, particularly with the universities of Strasbourg, Kiel, Montpellier, Nice and Rennes, ETH Zurich, Imperial College London, the universities of Santa Barbara, Johannesburg, Monash and Hong Kong, and with the



► A new tectonic map of the European Variscides (Schulmann *et al.*).



► Photograph and sketch of an eclogite boudin in migmatitic amphibolite, Mariánské Lázně Complex (Collett *et al.*). Photo by V. Peřstý.



► U-Pb analysis of monazite directly in thin sections enables the dating of various stages of metamorphism. The images shows the dating results for gneiss from the Baidrag area, Mongolia (Štípská *et al.*).

institutes of the Chinese Academy of Sciences in Guangzhou and Beijing.

The centre's staff co-organized three symposiums of the EGU in Vienna and trained five Ph.D. students at the CGS.



► A carbonized trunk buried by a local phreatomagmatic eruption – Oligocene, Rokle near Kadaň.

Jiří Frýda

Coordinator of research
on global changes in the past

Stanislava Vodrážková

Coordinator of research
on global changes in the past

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

/DKRVO

The main goal of our research involves the reconstruction of fossil marine and terrestrial ecosystems, their evolution over time, and the study of their individual components and mutual relationships. We focus primarily on global events (bioevents) that significantly influenced the evolution of overall biodiversity.

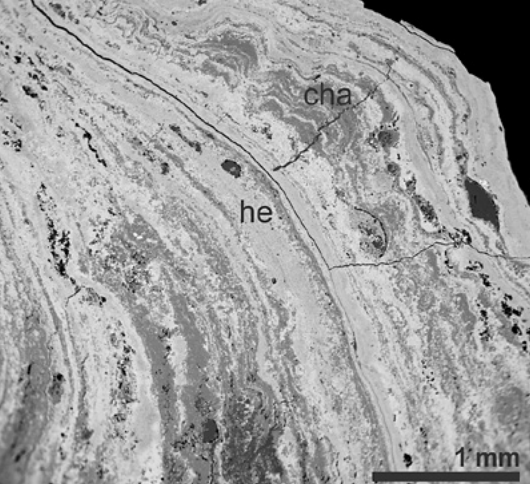
We employ paleontological, paleobiological, sedimentological and geochemical methods to characterize abiotic and biotic parameters of the environment in periods prior to, during and after global crises. Thanks to a wide range of proxy indicators we can, for instance, obtain information regarding the chemistry and temperature of ancient oceans, the CO₂ content in the atmosphere, the characteristics and chemistry of sediments, changes in sea level, and so forth. The study of biotic components of fossilized ecosystems, in turn, aids in understanding the evolutionary and ecological processes that created and maintained biodiversity on Earth and also how environmental changes shaped the speciation, migration and extinction of organisms. Understanding the mechanisms of ancient environmental and climatic changes and studying the reactions of organisms to these changes, including subsequent ecological regeneration, is important for comprehending current climate change and predicting future changes.

Fossil marine ecosystems

In 2022, the scientific team studying Paleozoic marine ecosystems published, for instance, a study confirming the



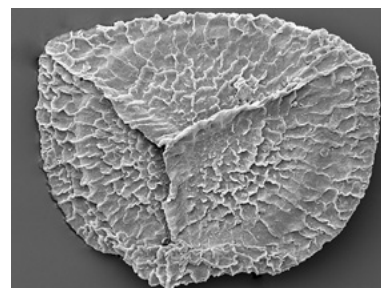
► Devonian and Ordovician limestone outcrops in the Antelope Valley, central Nevada.



► Sample of a so-called oncoide, formed by alternating hematite (he) and chamosite (cha) laminae. Precipitation of these minerals was induced by microbial communities that were concentrated around the hydrothermal vents.



► Spruce pollen (*Picea*), Quaternary.



► Megaspore *Triangulatisporites tertius* from herbaceous lycophyta of the genus *Selaginella*, Radčice near Plzeň, Carboniferous.

hypothesis of a causal relationship between the Silurian global changes and the parameters of the Earth's orbit around the Sun. Furthermore, a model was constructed showing the course of an anoxic event and its relationship to extinction and the most significant collapse of the global carbon cycle during the past 500 million years. The scientists also analysed changes in the global uranium cycle in the Silurian based on a study of U isotopes and tested a model depicting the course of an anoxic event from the Ludfordian glaciation. A study was also published dealing with the rare occurrence of ferruginous lenses from relatively deep-water facies of the Lower Devonian of the Prague Basin. The alternation of Fe^{3+} and Fe^{2+} mineral phases in precipitates was interpreted as resulting from a microbial Fe redox cycle.

Paleontological and paleobiological research included, for example, a study of a unique type of healed injury in a Middle Ordovician nekto-benthic trilobite, with a large cephalopod or a thus far unknown predatory arthropod identified as being the predator. A publication on the Tafilalt Biota provided a truly unique insight into the trophic structures and evolution of Upper Ordovician ecosystems, specifically thanks to exceptionally preserved "soft-bodied" fossils and the ecological composition of the fauna. An extensive and very important monograph, providing a comprehensive overview of the nannofossils of the Bohemian Cretaceous Basin and the Outer Western Carpathians in the territory of the Czech Republic, was published as well.

A total of 11 scientific papers were published in journals with impact factors by the experts studying fossil marine ecosystems, of which three were printed in prestigious journals listed in the Nature Index. One scientific book and four separate chapters in scientific books were released as well.

Fossil terrestrial ecosystems

Research activities focused mainly on the Carboniferous and Quaternary periods as well as on palynomorphs from the

Wenlock (Silurian), specifically from a period when significant changes in the composition of flora occurred – a study was published confirming the importance of volcanic islands for the evolution of early terrestrial plants. The enigmatic Carboniferous gymnosperms of the genus *Lesleya*, which are of stratigraphic and paleoecological significance in the Carboniferous, were studied as well. Another study of material from the Czech–Polish border showed that oases also occurred in the Lower Permian along lakeshores and allowed for growth of hydrophilous plants, not normally found in Permian sediments.

A total of six papers were published in journals with impact factors by the experts on terrestrial ecosystems.

Other activities

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 2022, the journal included 22 scientific papers comprising 535 pages (*Bulletin of Geosciences*, Volume 97, 2022). The *Bulletin's* impact factor in 2022 was 1.4. 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 tutors for Ph.D. students at Charles University and at the Czech University of Life Sciences, where they are engaged as guarantors for several fields and also give numerous lectures to master's and postdoctoral students ("Evolution of Global Ecosystems", "Geochemistry", "Paleoecology" and partly "Zoology").



► The Krásno-Vysoký kámen feldspar deposit, where leucocratic albite to albite-topaz granite is mined. It is one of the Czech Republic's most important Na-feldspar deposits, which produces raw material for the ceramics and glass industry and for other use as well. Photo by J. Starý.



Michal Poňavič

Head of the Department of Mineral Resources Research and Policy

Mineral resources

/DKRVO

The supply of mineral resources forms the basis for the economic and technological development of the Czech Republic. The task of the Department of Mineral Resources Research and Policy of the Czech Geological Survey deals with the study of new mineral resources and their future prospects.

In 2022, the economic geologists of the Czech Geological Survey were involved in a number of national and international projects dealing with the study of the mineral resource base of the Czech Republic. The research was focused not only on deposits and resources of critical raw materials but also on construction and energy minerals. An essential part of the work activities also included legislative support for state authorities, specifically in preparing the Czech Republic's raw materials policy on a regional level as well as in dealing with mineral extraction issues involving land-use planning.

Particular attention was also paid to studying the impacts that mining and processing of raw materials has on the environment and human health, to the development of new research methods concerning mineral deposits, and to mining heritage research. During economic geology projects, the CGS employees were also engaged in educating students and professionals.

Critical raw materials study

Work on the extensive research project "SS02030023: Rock Environment and Minerals (RENS)" continued. During the project's economic geology phase, indications of critical raw



► Collecting a large-volume heavy mineral sample, during a study of heavy mineral associations. Photo by M. Poňavič.

materials were investigated in the areas of Nové Město pod Smrkem, Šluknov, Havlíčkův Brod and near historical Au districts in the Moldanubicum. Using methods of satellite geophysical analysis, a prospective area with occurring polymetallic skarns was defined in the central part of the Krušné hory Mts (Přísečnice). Research into mineral processing technology continued with the testing of the technological processing of graphite raw material from South Bohemia and Moravia as well as with technological research and development of new methods for processing samples of gold-bearing raw material from the Kašperské Hory. Research into the technological extraction of Ge from lignite continued as well.

During 2022, all goals planned for the given period were completed. A specialized map with scientific content (N_{map}) "Map of the Czech Republic with locations of deposits, potentially prospective and other resources of critical raw materials (CRMs) of the EU as of 1 January 2022" was compiled. In addition, the consortium partner of the project (the GET Ltd company) prepared a comprehensive research report "Identification of accumulations of strategic commodities and conditions for using strategic minerals" and, above all, a proprietary methodology was compiled and certified.

The priority project "Acquisition of Strategic Raw Material Deposits", conducted under Government Resolution No. 866/2021, was continued this year as well. In addition to other research activities, field research was also evaluated. The occurrences of albite granite in the Central Moldanubian Plutonic Complex appear to be most promising. The occurrences were mapped in detail, geochemically and petrologically evaluated, and an indicative technological study was conducted on the raw material. The geological-technological findings obtained thus far show that the granite may be an important source of Na-feldspars with the accompanying mineral resources of Nb (Ta) and Sn concentrates, including the possibility of obtaining Li-muscovite concentrates (with Li concentrations of roughly 30% compared to the mica concentrate from the Cínovec deposit) and topaz concentrates.

Projects undertaken in 2022 included joint activities of the CGS and GET Ltd (funded by the BETA TACR programmes), which focused on research on the raw material potential of strategic minerals in brines of the Bohemian Massif (TITSMPO026) and also on research on promising mineral fillers and quartz raw materials in the Bohemian Massif (TITSMPO031).

New research began on the European Union's HORIZON projects. The SEMACRET project, focusing on orthomagmatic deposits containing critical raw materials, was launched in June. One of four studied European reference sites is the Staré Ransko ore district. At this site, the CGS will coordinate new modern field and laboratory research (litho-geochemical modelling, new airborne geophysics, soil geochemistry, 3D modelling, etc.).

Since 2022, the CGS has been engaged as a project partner in the international Brine-RIS project, led by the Wrocław University of Science and Technology on the EIT platform. The project focuses on resources of Li and other critical elements in mineralized waters, which may also serve a geothermal energy source.

Other projects

The geological projects "Demarcation of Prognostic Moldavite Resources (Category Q) in the Cadastral Area of Kvítkovice in the South Bohemian Region" and "Revision of Prognostic Resources of Industrial Minerals and Ores, Category Q, in the South Bohemian Region" were carried out for the Geology Department of the Ministry of the Environment.



► A prognostic resource of Habří moldavite, remnants of illegal moldavite mining. Photo by T. Vorel.

The EuroGeoSurveys association's GSEU-CSA project, which is a follow-up to a preceding GeoERA project, was launched as well. The project deals with the metallogenesis of critical raw materials along with the entry of information into the European geodatabase EGD. During these activities, the CGS will also participate in the construction of a centre for evaluating and compiling a methodology for assessing mineral resources in the 3D-UN UNFC system.

As part of a short-term contract with the French Geological Survey (BRGM), the department's staff prepared a research study on potentially more economically significant deposits and occurrences of wollastonite in the Czech Republic. Particular attention was paid to the regions of West Bohemia and North Moravia. Important localities were subsequently discussed in more detail with a potential multinational industrial partner, for whom the BRGM prepared a pan-European study on wollastonite.

Environmental impact of mining

The international EU project "recomine Saxony-Czechia" continued to be carried out with the aim of creating



► Participants of the international conference of the “recomine Saxony–Czechia” project, Cínovec, 7–8 October 2022.
Photo by Š. Mrázová.

a partnership between Saxon and Czech institutes dealing with resources, the environment and civic involvement in ore mining in the border region of the Krušné hory Mts. Four international conferences took place in 2022.

The cross-border transport of contaminants from the Polish part of the Upper Silesian Basin to the Czech Republic continued to be monitored. Sampling in Poland and the Czech Republic focused on air pollution originating from the mining and processing of Pb ore in the Olkusz area.

The environmental impact of slag dumps in the Luanshya smelter site was studied in Zambia. The results showed that soluble copper salts form and are leached into underlying soils as the slag weathers.

Increased legislative support for comprehensive use of minerals

The project “TITSMPO909: Elaboration of a Methodology for Regional Raw Materials Strategies” was completed in 2022. The

project’s goal was research into unified and methodological procedures for preparing regional government strategies, testing of a proposed methodology for preparing raw material strategies, development of standards for periodic updates and subsequent final certification of a methodology for preparing regional raw material strategies. Specifically, these are model raw materials policies for the Central Bohemian and Karlovy Vary regions.

The “Study of the Availability of Aggregates for Planned Motorway and Road Network Construction and Planned Railway Corridor Construction” was completed for the Ministry of Industry and Trade by the Czech Geological Survey along with the Mining Association and Road Contractors Association. This is a thorough expert review regarding the supply of essential building materials for planned state-funded construction projects. The study aims to compare actual available reserves and required products in currently active operations with convenient transport distances for transport line construction projects.

► Field excursion to the modern recycling facility of the KVD, s.r.o., company in Dolní Beřkovice during the TACR project “TITSMPO909, Elaboration of a Methodology for Regional Raw Materials Strategies”.
Photo by J. Godány.





► The Koněprusy deposit. High-quality Koněprusy limestone is mined here and further processed in Čertovy schody lime works. Photo by J. Starý.

Evaluations of the raw material strategies for the Central Bohemian, Karlovy Vary and South Bohemian regions commenced at the same time, focusing specifically on environmental impacts (SEA process).

The CGS was also engaged in preparing the Information System of the Regional Raw Materials Policy for the Liberec Region.

Mining heritage research

Together with the Příbram Mining Museum, economic geologists were engaged in preparing the 16th International ERBE Symposium on mining heritage.

A conservation study of finds from the treatment and metallurgical processing of ore in a flood area beneath the Schweidrich ore district near Kunratice in the Šluknov area was evaluated.

Assessment activities

Regional economic geology experts are appointed to perform tasks of the state geological survey and represent the Czech Geological Survey at expert meetings in designated regions. In coordination with regional geologists, they provide assessment activities and services and communicate with public authorities. The expert assessments of the CGS involving mineral resources usually include, for instance, requests for approval of exploration permits, requests for approval or extension of mining leases, issues regarding the siting of buildings in Protected Deposit Areas (CHLÚ), and evaluations of mining plans included in environmental impact assessments pursuant to Act No. 100/2001 Coll., as amended. They also deal with various requests from state and local authorities as well as courts, the police and state organizations. The most significant assessments include the following:

- Expert assessment of the significance of a proposal to resume mining at the reserved crushed stone / syenite deposit of Kosov near Jihlava (B 3029600) with an emphasis on its nationwide importance for the production of aggregate for track ballast under reference No. ČGS-441/22/124_SOG-441/0127/2022 dated 18 March 2022.
- Alternative solution regarding a partial removal of the thus far inventoried potentially economic blocked reserves of the unexploited reserved lignite deposit of Proboštov-Jaroslav (B 3078400) and the unexploited reserved lignite deposit of Modlany-hlubina (B 3118400) in the cadastral area of Soběduhy from the inventory of reserves under reference No. ČGS-441/22/316_SOG-441/0317/2022 dated 2 May 2022.
- Expert assessment No. ČGS-441/22/380*SOG-441/0382/2022 justifying the economic use of kaolin reserves at the reserved kaolin and bentonite deposit of Krásný Dvůr – Podbořany (B3111200) in the Podbořany mining lease (for State Administration Department IV Ústí nad Labem to assess the necessary appropriation of agricultural land).
- CGS expert assessment No. ČGS-441/22/543*SOG-441/0543/2022 for a requested approval of the Nesměň I and Nesměň II exploration permits, with regard to the economic potential of REE and Y in the Koroseky sand and gravel (for State Administration Department II České Budějovice).
- CGS expert assessment No. ČGS-441/22/1027*SOG-441/1005/2022 regarding a construction waste dump in the protected deposit area of Křenov (No. 14120000) (for the Police of the Czech Republic).



► *Spring of ferruginous waters from Carboniferous formation at Lísek near Beroun. Photo by J. Holeček.*



Lenka Rukavičková
Hydrogeological
research coordinator

Groundwater research and evaluation

/DKRVO

Groundwater is an important component of the environment and an irreplaceable source of drinking water. Due to declining groundwater reserves and due to the need for their protection, this field of CGS research is becoming increasingly important. The research focuses on evaluating the impact of climate change, long-lasting drought and mining activities on natural groundwater sources, as well as on specific conditions of their protection in karst areas, in places with mineral water occurrence and crystalline rocks areas. The aspects of finding a suitable environment for situating underground repositories were also addressed.

Study of natural groundwater sources and their protection

Research in 2022, including the monitoring of the status of groundwater 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 deeper Tertiary aquifers. A cooperation agreement was concluded between the governments of the Czech Republic and Poland in order to deal with the impacts of open-pit lignite mining in Turów on the condition of groundwater and surface water. The agreement assigns the CGS, including the representatives of the Ministry of the Environment (MoE), to regularly examine the effectiveness of implemented measures aimed at eliminating the negative impacts of activities in the Turów mine (underground wall).

The aim of the TACR project "Targeted Replenishment of Groundwater as a Tool to Reduce Drought Impact 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 was created in 2022 in order to aid the MoE in providing subsidy programmes and to furnish the state administration with information on sites suitable for targeted replenishment.

The "Groundwater in Crystalline Rocks" project continued in 2022. The aim of the project is to identify suitable areas for new groundwater sources in three hydrogeological areas built predominantly by metamorphic and igneous rocks, to define those areas most affected by hydrogeological drought, to obtain data for assessing water retention in the landscape, and to develop a method for the evaluation of groundwater reserves in this specific environment.

The PERUN project focuses on evaluating the status and development of natural groundwater sources, predicting their development, and studying the sensitivity of selected natural



► Measuring the Rokytná River's flow rate with a velocimeter, PERUN project. Photo by R. Hadacz.



► Water pressure tests in the Bukov II Underground Research Facility in the Rožná mine. Photo by J. Holeček.

systems with regard to dry periods and climate change in the Czech Republic. An analysis of groundwater level fluctuation in the Czech Republic in combination with baseflow was completed in 2022.

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 theme "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 conditions in areas with karst systems and on their recharge zones. Thematic hydrogeological maps defining the extent of the recharge zones of karst structures were processed in 2022 for the Moravian, Mladeč-Javoříčko, Hranice and Chýnov karsts.

Applied hydrogeology

Specialists in hydrogeology and hydrochemistry are engaged in several applied projects dealing with underground disposal of high-level waste. 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 underground laboratory in the Rožná mine. An interdisciplinary collaborative effort also dealt with groundwater associated with geothermal energy and with underground CO₂ storage.



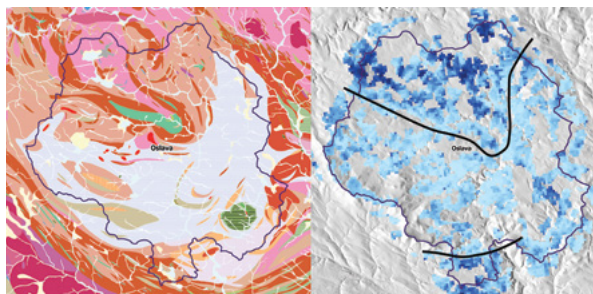
► Measurement of the Oslava River's flow rate with a velocimeter. Photo by R. Hadacz.



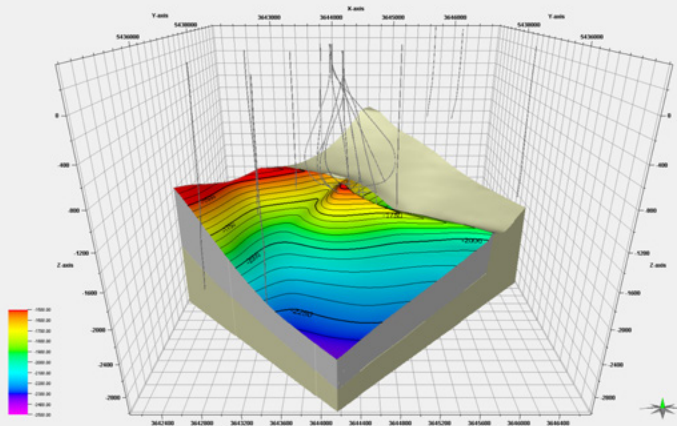
► Water sampling in the Punkva Cave. Photo by R. Hadacz.



► CGS specialist measuring water flow.



► Relative surface humidity for 2016–2021 detected in the Oslava River basin based on Sentinel-2 satellite data and its potential spatial correlation with lithology, the "Groundwater in Crystalline Rocks" project.



► 3D model of the Zar-3 pilot CO₂ storage with boreholes and the surface of the underlying carbon.



Juraj Franců

Geoenergy
research coordinator

Geoenergy research

/DKRVO

The social importance of geoenergy 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.

Research on the sequestration of carbon dioxide in the rock environment focused on preparing the Zar-3 pilot storage complex during the CO₂-SPICER project (Norway Grants/TACR). The partners are NORCE (Norwegian Research Centre), MND a.s., the Technical University of Ostrava and the Institute of Geophysics of the Czech Academy of Sciences. 3D geological models of the deposit area were created (Fig. 1) based on drilling and seismic data.

The model is limited by the underlying crystalline surface and consists of a body of Carboniferous greywackes and siltstones of the Myslejovice Formation, a dolomite collector of the Vranovice Formation of the Middle and Upper Jurassic, and cover rocks including marlstones of the Mikulov Formation of the Upper Jurassic, claystones and siltstones of the Nesvačilka Formation of the Eocene, and the mantle of the Ždánice Unit of the Carpathian Flysch Zone.

Each of the bodies of the static model has its own petrophysical and geochemical properties. The distribution of permeability is key in the subsequent dynamic modelling, which simulates the movement of fluids in the collector, especially water and supercritical carbon dioxide when it is deposited in the depleted reservoir.

The results of thin section petrography, mineralogy and rock geochemistry were used to characterize the aquifer and cap rocks. Three facies types were distinguished in the dolomites of the main aquifer (Fig. 2).

Atmogeochimical "baseline" monitoring continued, prior to the start of CO₂ storage in the depleted crude oil and natural gas deposit. Permanent stations were used to monitor the composition of soil air from June 2021 to October 2022 (Fig. 3). The results show periodic fluctuations of the CO₂ concentration in the soil depending on climate temperature and respiration of soil flora.

All the results are interpreted in order to assess the feasibility of CO₂ storage in the given structure and to gain experience in risk assessment and in monitoring the impacts on environmental quality at the given site.

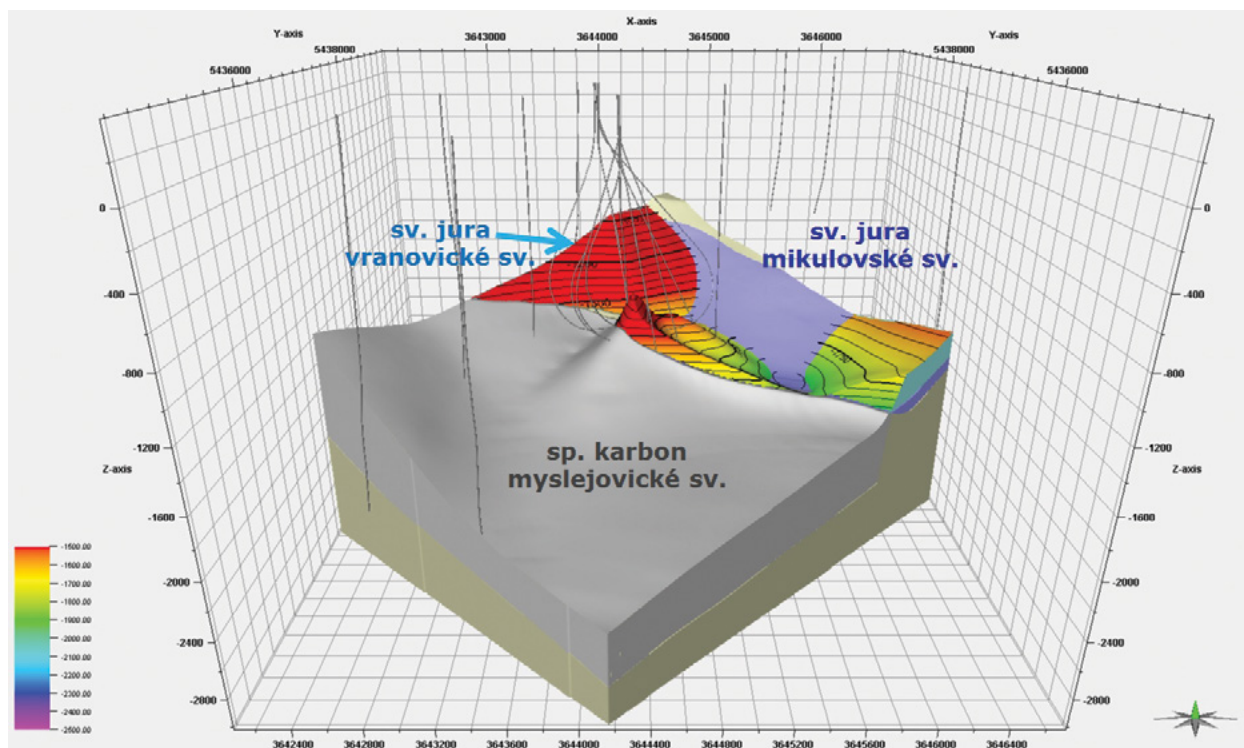


Figure 1. 3D model of the Zar-3 pilot storage complex.

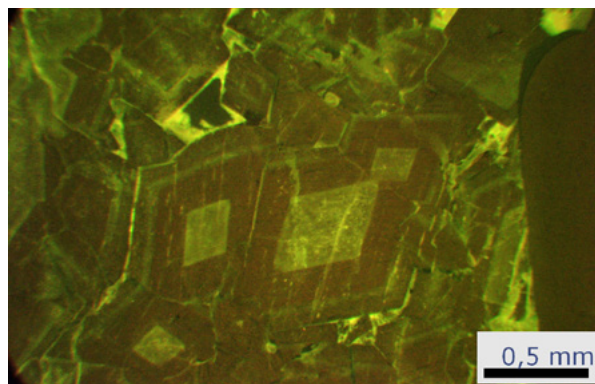
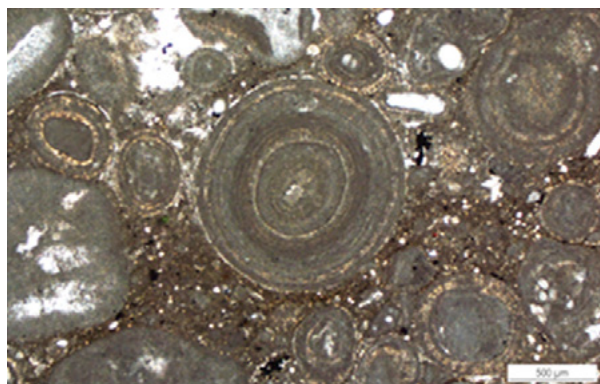


Figure 2. Two characteristic types of aquifer rocks: ooid limestone (left) and dolomite (right).

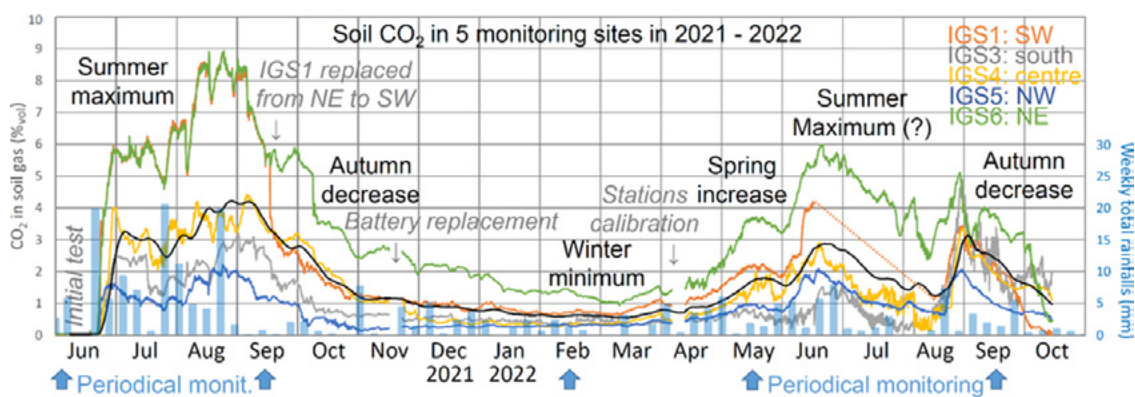


Figure 3. Changes in the CO₂ concentration in soil above the Zar-3 deposit in 2021 and 2022. Measured by five permanently placed soil probes.



► Lichen sampling during the DiESCALiDi project.
Photo by P. Krám.



Martin Novák

Head of the Environmental Geochemistry
and Biogeochemistry Department

Geosphere– biosphere– atmosphere interaction

/DKRVO

Interdisciplinary study of processes linking the geosphere, biosphere and atmosphere uses insights from biogeochemistry, hydrology, biology, isotope geochemistry, sedimentology and ecosystem modelling and is the basis for studying the status of the environment and its changes.

Monitoring of aquatic and terrestrial ecosystems

Chemistry of surface water from the GEOMON catchments in the Slavkov Forest was used in a pan-European study, which demonstrated that the long-term trend of increasing dissolved organic carbon in water (causing browning of surface water) occurs due to decreasing concentrations of inorganic ions, originating from atmospheric deposition. Significant reduction of emissions of acidifying compounds and dust fallout over the past 30 years caused significant decreases in the amounts of dissolved substances in precipitation and consequent decreases in ionic strength of rain water. This led to concomitant decreases of these compounds and elements in soils, from which more humic acids and fulvic acids began to be released into soil solutions and surface water. This represents a reversion to conditions that prevailed in surface waters prior to the period of very high air pollution in the 20th century. The study was published in *Science Advances* (IF = 13.4).

As part of the Norway Grants project “The Fate and Future of Carbon in Forests”, a collaborative effort with the Norwegian Institute for Water Research (NIVA) continued to develop the new MOBIUS modelling platform, which chains together models involving hydrology, biogeochemistry and vegetation modelling for forest catchments. This platform is being successfully tested on long-term deposition, soil chemistry, and runoff data from the GEOMON network of small catchments. During the spring, CGS employees collected soil samples in Norwegian catchments for further chemical analyses at the CGS Central Laboratories in Barrandov.



► Soil sampling in Norway. Photo by P. Pacherová.



► Katherine Pérez Rivera working with stream probes.
Photo by P. Krám.

Within the DivLand project, an online interface allowing users to visualize and download annual deposition rates of sulphur and nitrogen on the Czech Republic's territory since 1950 was developed. A map of exceeded critical loads for nitrogen for all habitats defined in the Czech Republic was made available. These data can be used for analyses of ecological relationships of landscape units. Maps are available at: <https://centrumdivland.users.earthengine.app/view/depozice>.

High-frequency monitoring of chemical composition of runoff water and of substance metabolism of selected streams in the Slavkov Forest was carried out in cooperation with doctoral student Katherine Pérez Rivera from Virginia Tech, Blacksburg, USA, and was funded by the Fulbright Foundation. The investigated streams were characterized by an extremely wide range of pH values, ranging from ultra-acidic bog water to alkaline water flowing from ultramafic rocks

Biogeochemical processes in the landscape

Lichen biodiversity and its dependence on rock outcrop chemistry, tree canopy shading and atmospheric deposition is being investigated in collaboration with three Italian universities led by Sergio Favero Longo from the University of Turin as part of the DiESCALiDi project. The fieldwork focused on serpentinite and granite outcrops in the Slavkov Forest.

Surface waters flowing from serpentinite areas usually contain nickel and chromium concentrations that greatly exceed recommended hygiene standards. The EcoCroNicks and GeoChemTox projects of two French universities, led by David Vignati from the University of Lorraine in Metz, focus on the bioavailability of these toxic metals to aquatic organisms in the Pluhův Bor catchment in the Slavkov Forest. The first experiments in 2022 showed that Ni and Cr had little effect on selected green algae, apparently because the predominant form of the metals is in the colloidal fraction, not in truly dissolved form or in complexes with dissolved organic carbon. However, these preliminary results only involve low flow conditions. High flow conditions have yet to be studied. Results of this research will be included in dissertations presented at universities in Metz and Paris.



► Analysis of chromium forms at Pluhův Bor. Photo by P. Krám.

Assessment of the causes of the Bohemian Switzerland National Park forest fire

Prof. Jakub Hruška led a group of scientists from various institutes tasked by the Ministry of the Environment to evaluate the reasons for the origin and spread of a fire in the Bohemian Switzerland National Park in the summer of 2022. Climate-meteorological analysis of the fire situation showed a long-term increase of fire susceptibility across the entire territory of Central Europe. Forest fires affected roughly 860 thousand hectares of forests in Europe in 2022. The drought index (SPI-6) showed that the drought in the Bohemian Switzerland which occurred in August 2022 was the most severe in the past 60 years. Extremely low soil moisture in clearings helped spread the fire and was documented by measurements taken directly from the area.

Model analyses show that the fire in the Bohemian Switzerland National Park could not have been prevented easily under the given conditions. The primary cause of the rapid and initially uncontrollable spread of the fire involved high wind speed, very low humidity of woody debris and forest soil, as well as high air temperatures during the first three days of the fire. A key simulation result is for the case where dryland areas arising from bark beetle infestation are cleared of all timber and the area was replaced by a grass-shrub and grassland vegetation type. The fire in the clearings would have burned significantly faster and with greater intensity. It is unclear if it would have been possible to bring such a fire under control at all, raising the probability of spread over a larger area than it actually had.

It is evident that the clearings were surprisingly strongly affected by the fire, despite being cleared of standing and fallen tree trunks, as well as logging residue such as branches. The fire was also able to overwhelm all forest types. Even in areas most



► *Bracken in the Bohemian Switzerland National Park.*
Photo by J. Hruška.

severely affected by the fire, a significant part of the ecosystem always remained untouched; the soil seed bank was probably preserved in these places. In the short term, rapid growth of herbs and grasses, such as birch, aspen, pussy willow and Scots pine may be expected in forest areas. Allowing natural regeneration as the main process of recovery in the forest impacted by the fire is justified from a scientific perspective and in accordance with the national park's fundamental mission. A paleoecological analysis shows that fires have occurred regularly throughout the area since the end of the last ice age. Fire events are more frequent in forests dominated by coniferous tree species (pine and spruce stands), the fewest fires occurred when deciduous forests (beech trees) dominated.

The cause of the fire was reportedly human activity, probably related to violations of the visitor regulations. As part of fire prevention, it is essential to focus the capacity of the guard staff to work in the field in the coming years. In particular, attention should be paid to the fire risks associated with excessive tourism in some locations.

Use of isotopes in biogeochemistry and environmental research

Using nitrogen isotope analysis ($\delta^{15}\text{N}$) in tree rings, we reconstructed the effects of air pollution on nitrogen cycling in forest ecosystems over the last 150 years. Nitrogen emitted

by human activities is continuously deposited in forest soils, making soils more fertile.

The accumulation of anthropogenic nitrogen in forests is proportional to the availability of other biogenic elements, especially phosphorus. The nitrogen isotopes in tree rings thus become an important natural archive, recording the impact of human activity on forests. The study was published in the *Environmental Pollution* journal (IF = 9.99). Furthermore, we focused on the long-term trends of stable carbon isotopes ratios (^{13}C and ^{12}C) in the annual rings of selected tree species to understand the relationship between photosynthesis and water loss (transpiration). Increasing atmospheric CO_2 concentration leads to an increase in tree water-use efficiency (WUE). This trend has been weakening over the past two decades and is directly proportional to the amount of available calcium in forest stands. Calcium has long been known to be an important regulator of the soil pore water conductivity, and our research highlighted that calcium availability can affect the water cycle at the ecosystem level, significantly affecting future forest productivity in high atmospheric CO_2 environments.

Mushroom uptake may represent an important source of isotopic variation in biogeochemical cycling of nutrients such as Mg, Zn and Cu, and toxic elements such as Cd. We studied elemental and Mg-Cu-Zn-Cd isotopic compositions of mushrooms from three small headwater catchments (LYS, NAZ and PLB) underlain by contrasting bedrock (leucogranite, amphibolite, and serpentinite, respectively) both on the substrate-to mushroom interface and within the mushroom's fruiting body. P, Ag, K, Zn, S, Cd, and Rb were the main elements in which the mushrooms were significantly enriched relative to the substrate soil. Isotopes of Mg, Cu, Zn and Cd fractionated during both uptake from the substrate soils and within the mushrooms fruiting bodies. Isotope fractionations were induced by different processes and occurred to various extents for different elements. In the case of Cu, fractionation was induced by redox reactions: reduction reactions led to negative fractionation, and re-oxidation reactions led to positive fractionation. Fractionation of Mg, Zn and Cd can be due to preferential incorporation of heavier or lighter isotopes mobilized from the substrate material by the mushroom's released organic acids. Overall, within-mushroom isotope fractionation was more subtle than that observed for vascular plants from elsewhere.

Lignite coal mine emissions

As a part of the assessment of greenhouse gas emissions from opencast lignite mines, the chemical and isotopic composition of gases from three mines in the North Bohemian Lignite Basin were measured. We measured CH_4 and CO_2 emissions in the area of the Bílina, ČSA and Libouš mines. Coal samples were also collected directly from a mined seam. We monitored the amount

of released CH_4 and CO_2 , the dependence of the amount and isotopic composition of the gases through time and on the particle size during the gradual disruption of the coal structure during coal processing. By analysing the isotopic composition of ^{13}C and ^2H , the origin of the gas can be determined. A distinction can then be made between primary gas, produced during carbonification, and secondary gas, produced by subsequent transformation inside the deposit. The ^{13}C values of methane and carbon dioxide released in the Bílina mine and in some of the samples from the Libouš mine were consistent with their biogenic origin. In the samples from the CSA mine and in a part of the samples from Libouš, it was possible to identify CO_2 of subsurface origin and CH_4 from carbonification.

Adsorption capacity, which is determined by the size and quality of pores, is very important for estimating the amount of gases emitted. Samples with a higher adsorption capacity have a significant proportion of pores with a diameter of less than 2.5 nm. Coal crushing at all the investigated sites releases mostly carbon dioxide; methane desorption is minimal. Atmospheric CH_4 emissions decrease sharply with distance from the seam increases, while CO_2 emissions are significantly higher.

Fugitive emissions in the Ostrava region

In cooperation with the Czech Hydrometeorological Institute, we investigated the sources of airborne dust emissions in Ostrava and its surroundings. Samples of atmospheric aerosol PM_{10} were collected by automatic sampling equipment at three locations in Ostrava, Studénka and Věřňovice. Soil samples were collected at the same sites to determine long-term deposition. The distribution of pollution sources along the dominant airflow trajectories (SW–NE or NE–SW) was calculated based on the ^{13}C mass balance and differences in the concentration of organic carbon and ^{13}C PM_{10} in each area. Topsoil analyses revealed the long-term deposition of the same emission sources. Monitoring of the stable isotope ^{13}C in organic carbon and in the elemental carbon fraction can be used to distinguish local sources of PM_{10} pollution in relatively small urban areas that have discrete sources of pollution.

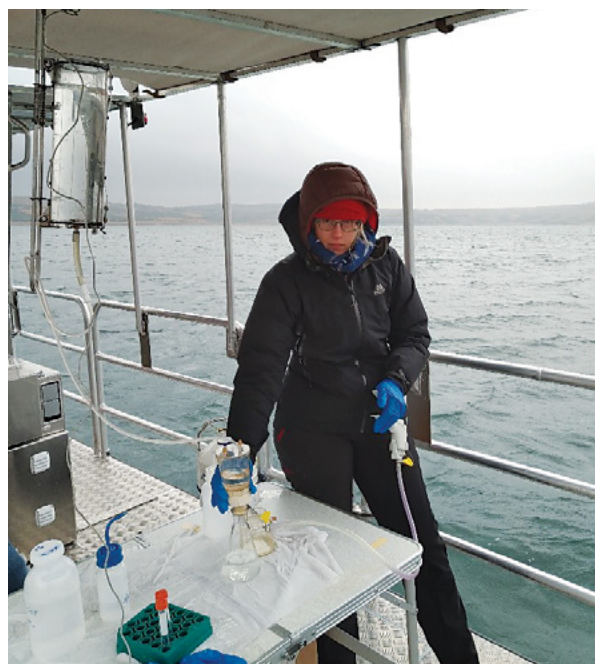


► The ČSA Bílina mine. Photo by J. Čuřík.

Areas of high pollutant deposition

In collaboration with the Biology Centre of the Czech Academy of Sciences (BC-CAS), we developed a pilot method for removing harmful levels of arsenic from water sources. This process, referred to as bioelectrochemical removal of arsenite As(III) , involves propagating precipitation of synthetic iron mineral precipitates, which react with arsenic to form solid particles that can be removed by sedimentation or filtration. This method is particularly effective in anoxic water sources, cost-effective and environmentally friendly, because it does not require the use of chemicals nor does it produce toxic by-products. Groundwater associated with a post-mining system (Medard Lake), which is characterized by high iron and sulfate concentrations, was studied in order to understand the effects on microorganisms and on their mineral products in an aquatic ecosystem.

The effect of organic matter in sediments on the stability of iron oxide minerals was analysed in a related study. The findings of this collaborative research have implications for understanding the geochemical behaviour of iron in sedimentary environments. It is useful for predicting and managing the impacts of human activity on iron oxide dynamics in sedimentary systems.



► Sampling at Lake Medard. Photo by D. Petrash.

Organic pollutants in cave sediments

A large set of cave sediment samples from the Moravian Karst was analysed for the contents of petroleum substances, polycyclic aromatic hydrocarbons and polychlorinated biphenyls. This monitors the degree of contamination of the cave environment and of adjacent groundwater sources.



► Slope deformation 24-44-18/3 with a Moravia gas pipeline in Jestřabice. Photo by O. Krejčí.



Oldřich Krejčí
Geohazard research
coordinator



Ivan Barnet
Head of the Geochemical
Hazards Department

Geohazard research

/DKRVO

With regard to national priority needs, research activities in 2022 focused on providing expert documents based on applied research results for the safeguarding and use of the rock environment, soil, groundwater and mineral resources by minimizing impacts of relevant anthropogenic factors in the landscape. The activities also contributed to the development of equipment and technologies for identifying, monitoring, predicting, preventing and reducing the risk of natural disasters and for monitoring their impacts in order to ensure a safe society.

The research tasks of Czech Geological Survey involved the following topics:

- Mapping, documenting and investigating geohazards including their classification on a regional and local scale, mitigating negative anthropogenic impacts on the quality of environmental components (post-mining impacts, contamination of the rock environment and potential health risks).
- Development of the geological survey's portal and access to geohazard data for professionals and the general public.
- Influence of erosion from agricultural activity on destructive landslides in the environment of the Carpathian Flysch Belt and Carpathian Foredeep.
- Landscape changes due to undermining and landslide susceptibility in the area of the South Moravian Lignite Basin.
- Geohazard research by the CGS also focuses on engineering geology studies. Engineering geological zones are defined based on similarity or homogeneity of those properties that are important primarily for engineering geology and geotechnics.
- Specialized landslide susceptibility maps continued to be compiled for individual geomorphological-geological units and selected urban agglomerations. These activities are



► Documenting a rock fall at the Žebračka sinkhole in Heřmanovice with a CGS drone. Photo by J. Nečas.



► *Monitoring of slope deformations from 1997 with a CGS drone. Slope deformation 25-32-05/82 Vsetín – House of Prayer. Photo by J. Nečas.*

carried out annually along with the implementation of the INSPIRE directive at the CGS.

- Research outputs are used by cities, municipalities and the State Environmental Fund of the Czech Republic to evaluate applications for grants from European funds from the Operational Programme Environment 2021–2027 in accordance with valid programme documents. Data were also used by the General Directorate of the Fire and Rescue Service according to the Crisis Management Scenario. CGS employees participated in mapping the damage and hazards caused by the fire in the Bohemian Switzerland.
- Radon risk from the geological bedrock is one of the most serious geohazards that directly influences the population's exposure to radiation. The significance of dealing with radon occurrence in the geological 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.

Activities in 2022 took place mainly at road and motorway construction sites of the Road and Motorway Directorate of the Czech Republic. In contractual cooperation with ČEPS plc., the entire network of extra-high voltage pylons in the Czech Republic is continuously analysed and monitored for slope instability hazards.

Research activities also included innovations in methods of monitoring sloping terrain and an innovated methodology to determine conditions for issuing warnings and designing warning systems at pilot sites. Geophysical instruments and drones of the CGS were also used during these activities, whereby CGS employees participated in the monitoring of some sections of the D8 motorway and its slip roads in the Děčín area as well as the ongoing D3 motorway construction. 3D GeoCIM models (Perštýn locality in Liberec), 3D photogrammetric models, digital terrain models and orthophotomosaics from in-house unmanned aerial imaging were developed.

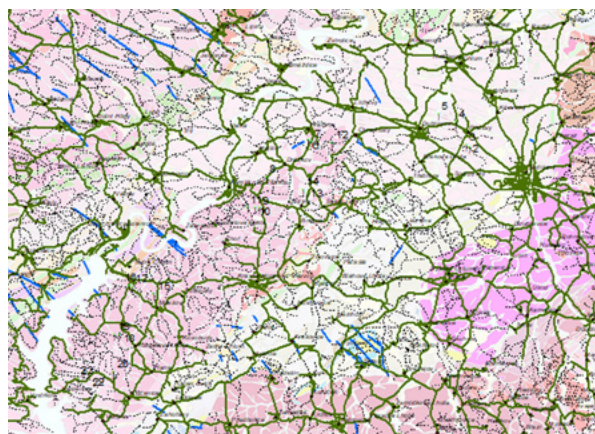
An investigation was conducted in the Moravian Karst on how ferrous slag transported by underground streams from former ironworks influences the abrasion of the rock environment and its contamination. Together with local experts, Czech scientists from the CGS and the Institute of Rock Structure and Mechanics of the Czech Academy of Sciences studied an extensive rock slide in the Cuzco Department in Peru. This 4.5-kilometre-long

Cuyo Chico landslide threatens an identically named village with constant movement that has damaged houses, a school, irrigation canals and roads in the past few years.

The joint XVI Hydrogeological Congress and IV Engineering Geology Congress was held on 6–9 September 2022 in Ústí nad Labem at the Jan Evangelista Purkyně University. The main organizers were the Czech Association of Hydrogeologists and the Czech Association of Engineering Geologists. The patrons of the congresses were the Czech Geological Survey Director, Zdeněk Venera, and the T.G. Masaryk Water Research Institute Director, Tomáš Urban. Nearly 350 experts took part in the traditional prominent scientific and social meeting of experts in hydrogeology, engineering geology and other applied geological disciplines.

Radon risk from the geological bedrock

In 2022, as part of the National Radon Action Plan, radon concentrations and equivalent dose rates were measured at selected contacts of mafic rocks and their dyke equivalents in an area between Sedlčany and Týn nad Vltavou. Measurements at 23 sites focused mainly on bodies of syenite porphyry and porphyrite situated in an environment of amphibole-biotite granodiorites of the Vltava and Těchnice type. It was discovered that the syenite porphyries and porphyrites are characterized by high to extremely high concentrations of Rn, exceeding values of 240 kBq.m⁻³ in some areas. Dyke rocks occurring in the Vltava-type granodiorites are characterized by more frequent values above 100 kBq.m⁻³ than in the Těchnice-type granodiorites. This difference is also reflected in the distribution of the equivalent dose rates, whereby maximum values exceeding 0.3 μSv.h⁻¹ are associated with points with high Rn concentrations. The values determined validates the inclusion of syenite porphyries and porphyrites in the high radon index category. The work carried out in 2022 was funded by the Geology Department of the Ministry of the Environment under project 383900.



► *The locations of the syenite porphyry and porphyrite areas measured are depicted with green symbols on a 1:50,000 scale geological map (source: CGS map server).*



► Detail of a marlstone massif of the Jizera Formation affected by rockfall beneath the Church of St. John of Nepomuk in Chmelík.



Jan Čurda

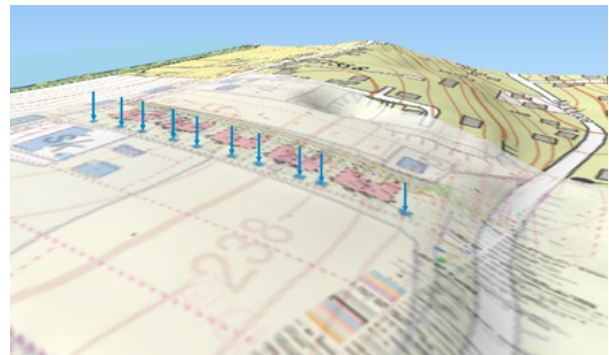
Head of the Regional Geological Administration

Regional Geological Administration

The activities of regional geologists and experts in economic geology, hydrogeology and engineering geology, 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.

Therefore, it is preferable to conduct activities 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 written expert assessments, which are based on written requests by public authorities, and which primarily involve geohazards, conflicts of interest, land-use planning, impacts of structures and technology on the rock environment, zoning and construction management, mitigation of old ecological burdens, nature conservation planning and so forth. 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 serves as a basis for political, economic, judicial and ecological decision-making, for instance, in land-use



► Spatial view towards the northwest of seepage pits situated in a line along the fall line (pointed out by small blue arrows) at the landslide site Záblatí u Bohumína on a 5th generation digital relief model, overlaid with a 1:10,000 scale map (© ČÚŽK).



► A general view of the detached rock pillar in the northern vicinity of an existing main scarp in the Větrušická rokle National Nature Reserve. A continuous vertical fracture is highlighted by yellow arrows.

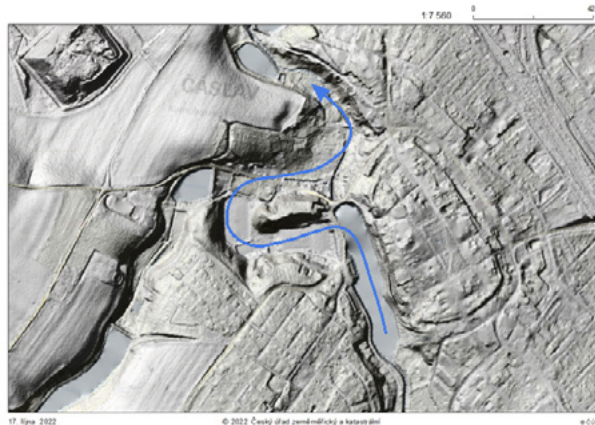
planning, environmental protection, remediation of old ecological burdens and slope deformations, landscape and natural resource protection, and for principles underpinning the ecological stability of areas and so forth.

In 2022, the administration's twenty-fifth anniversary, the entire external as well as internal filing agenda of the Regional Geological Administration of the CGS was run exclusively on-line (for the seventh year in a row) via the Regional Geological Administration's agenda application on the CGS internet portal. The agenda management system was constantly 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 and enabled it to run smoothly at the beginning of 2022 during imposed restrictions, when home office work was preferred.

In 2022, a map application continued to be improved allowing for easy topographic and regional geological integration of

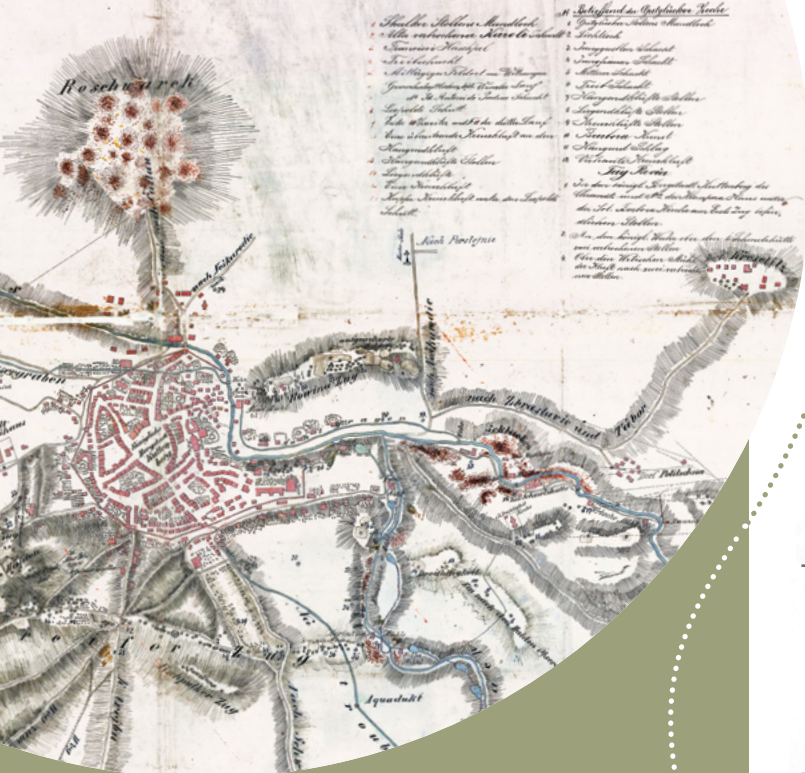


► A white polygon depicts the general slope of a rockfall area in the Větrušická rokle National Nature Reserve on a 5th generation digital relief model (© ČÚZK). Blue areas mark parts of the terrain with slopes of 50–90°, representing other potential rockfall occurrences.



► The likely original course of the Čáslavka Stream, altered by the construction of a medieval fortification, moat and dam of the Podměstský Pond.

relevant cadastral districts, and conceptual work commenced to prepare detailed locations of activities according to parcel numbers. 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 to prepare all backfiles of its agenda, dating back to 2003, for on-line access. This was done via an interactive map of assessments, which provides interested parties with an overview of roughly 13,500 outputs stored in the database as well as of nearly 1,024 activities administered by the Regional Geological Administration in 2022 on a regional level for any relevant cadastral area. More than a third of the activities dealt with assessments focused on hydrogeological issues. The second most frequent outputs involved assessments of land-use plans, followed by 65 outputs dealing with slope deformations.



► Kutná Hora ore district, map from 1796.



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

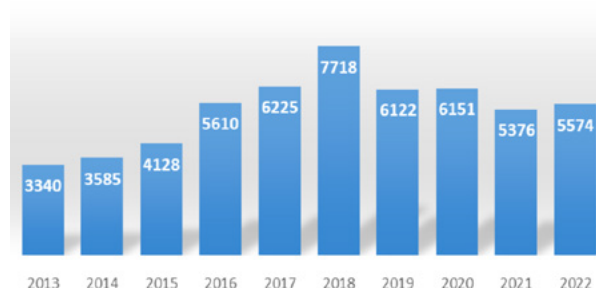
Head of the Mining
Impacts Department

State geological survey agenda of the Information Systems Division

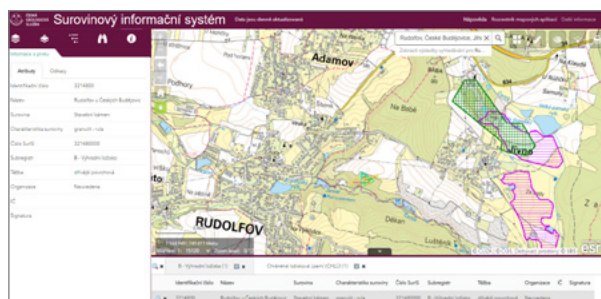
The Information Systems Division performs the tasks of the state geological survey set forth in current laws and in the organization's foundation charter. These mainly include relevant provisions of the Geological Act (Act No. 62/1988 Coll., on geological work), the Mining Act (Act No. 44/1988 Coll., 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 inventorizes 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 250 organizations and 5,574 registration forms concerning geological activities were recorded in 2022.



► Inventory of geological projects – number of registration forms in 2013–2022.



► Display from the publicly available SurlS map application.

Mineral resources

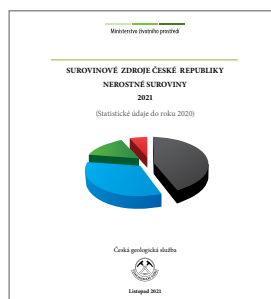
The Mineral Information System (SurlS) collects and provides all available data on the mineral potential of the Czech Republic in coherent form. It is based on the database of mineral deposits of the Czech Republic, with which other sub-databases are linked, such as companies, mining leases, protected deposit areas, preliminary mining lease approvals, exploration areas, approval of reserves, and spatial features. SurlS includes economic databases as well. A map application on the Czech Geological Survey's website (<https://mapy.geology.cz/suris/>) provides access to basic SurlS data.

As of 31 December 2022, SurlS included 10,158 objects, of which 1,520 were registered reserved deposits, 835 registered non-reserved deposits, 811 unregistered resources, 256 approved prognostic resources, 1,064 other prognostic resources, 1,433 negative exploration results, non-prospective areas and mineral occurrences, 4,235 abandoned and exhausted deposits, and 24 geological structures serving as gas storage facilities or underground repositories. A total of 23 new objects were added and 2,840 objects updated in 2022.

According to § 8 of the Mining Act, the CGS is tasked with the safeguarding and inventory of reserved deposits. As of 31 December 2022, it recorded 357 reserved deposits, of which 337 are covered by protected deposit areas.

The following monographs were compiled based on SurlS data:

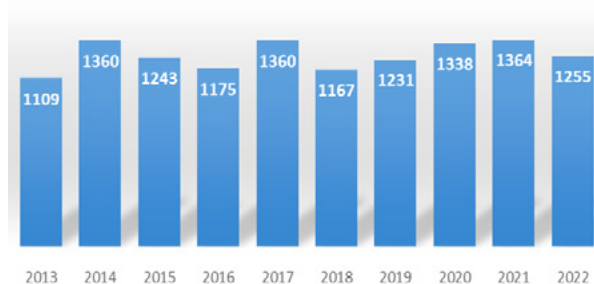
- "Balance of Reserved Mineral Deposit Reserves of the Czech Republic as of 1 January 2022" based on the departmental statistical report Geo (MoE) V 3-01: Part I: Ores, Trace Elements, Part II: Mineral Fuels, Part III: Reserved Deposits of Industrial Minerals.
- "Inventory of Mineral Deposit Reserves of the Czech Republic as of 1 January 2022", containing deposits of non-reserved minerals (construction minerals).
- The yearbook "Mineral Commodity Summaries of the Czech Republic (Statistical Data 2021)", published in Czech and English versions, containing data on 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



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

website (<http://www.geology.cz/extranet/publikace/online/surovinove-zdroje>).

- "Movement and Changes in Reserves of Reserved Mineral Deposits in 2012–2021" 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 2022", a non-public review compiled with data from the Hor – MPO records on mining technology, is provided to the Ministry of the Environment, the Ministry of Industry and Trade, the Czech Mining Authority and to other authorized organizations.



► Number of processed expert assessments of land-use planning documents in 2013–2022.

Expert assessment of land-use planning documents

The Information Systems Division provides comprehensive assessments of land development and land-use plans concerning areas with specific geological structures by virtue 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 2022, 1,255 requests for assessments concerning mineral deposit safeguarding and 108 assessments of undermined areas were handled. The work was 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 involves 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 2022, 33 municipalities with extended scope, 12 regions and the State Land Office downloaded data on reserved deposits (2,414 objects), prognosticated resources (346 objects), protected deposit areas and protected areas for special interventions into the Earth's crust (1,313 objects), reported mine workings (2,797 objects), undermined areas (5,235 objects) and landslides from the original Geofond database and from CGS mapping activities (38,086 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 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 2022, contained 715,644 objects, mainly boreholes. The database includes data on 117,445 economic geology, 119,003 hydrogeological, 444,346 engineering geology, 988 structural and 22,520 mapping-related objects. Specialized databases are linked to the GDO database.

The **GEO database** was established in 1976 and is the most extensive and longest-running CGS database. It contains detailed data on objects with geological descriptions of rocks encountered as well as a link to evaluations – primary

final reports. From new reports received by the CGS Archive, 3,424 objects were selected for filing and further processing in 2022. The database contained 624,167 objects with geological profiles as of 31 December 2022.

In 2022, 1,956 objects were entered into the **HYD database**. As of 31 December 2022, it contained data on 111,809 objects. The data are 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.

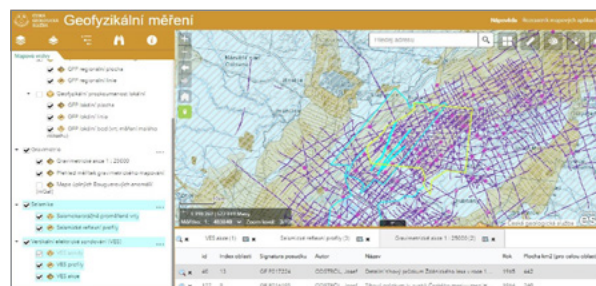
The **Groundwater Data and Information Dataset** collects data on groundwater reserve estimation polygons and data on regional hydrogeological resource evaluation polygons. In 2022, 46 polygons from 14 assessments were prepared for entry into the database. Usable groundwater reserves were not determined in the processed assessments. The database contained 964 objects (polygons) as of 31 December 2022.

The **Drill Logging Database (KAR)** contains digitized drill-logging data from 5,799 boreholes and directional log data from 3,011 hydrogeological objects.

Geophysical surveys

Through the online "Geophysical Measurements" map application (https://mapy.geology.cz/geofyzikalni_mereni/) of the CGS, 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 the projects of the CZECHGEO/EPOS consortium for geophysical field observations (information



► Display from the publicly available Geophysical Measurements map application.



► Sample from the mining map collection: ID Code RD/482 Všekary (Plzeň – south), J.R. Fischer, 1810. Remains of old workings at the Pb-Zn vein near the Church of St. Barbara. Groups of spoil heaps are depicted and their orientation recorded as well. Coloured map with ground plan and front elevation measuring 325 × 100 cm.

is available on the 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 provided 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 CGS office in Kutná Hora is located in the city's historical centre. Among other things, 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 set of ID codes for the Resource Reports Collection (FZ) from the CGS Archive is stored at the Kutná Hora office. Roughly 69% of the stored FZ reports were digitized in 2012–2022. The office also issues statements concerning mining history upon request and is involved in other contract work and projects of the CGS.

The ground floor of the CGS's Kutná Hora office was reconstructed in 2021–2022. The reconstruction involved the original archive of the Resource Reports Collection as well as an area formerly used as an apartment and transformed the building's entire ground floor into a new Resource Reports

Collection archive, equipped with a modern basic archive system. The new archive spaces again accommodate the original part of the Resource Reports Collection archive (147 linear metres) and subsequently the first batch of the Resource Reports Collection, amounting to 71 linear metres, was transferred here from Prague, where it was stored thus far at the office in Kostelní St. The remaining part of the Resource Reports Collection should be gradually relocated from Prague to Kutná Hora in the coming years. The new archive area also includes a section designed for archiving mining maps, which will provide adequate space for archiving temporarily stored maps.



► New archive of the CGS office in Kutná Hora.



► *Flooded initial part of the adit near Nové Oldřůvky, Opava District. Documented in the Mine Working Impacts Inventory.*



Vít Štrupl

Head of the Information
Systems Division and Deputy Director

Mine workings and mining waste

The tasks of the state geological survey performed by the Czech Geological Survey include 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 occur as areas of collapsed and subsided ground or simply as open adits and shafts. The Mining Act imposes obligations on reporting, recording and dealing with such phenomena if they are encountered. Mine workings, whose original operator or a legal successor does not exist or is unknown and abandoned exploratory mine workings, whose legal successor is the Czech state, are recorded by the CGS. Subsequently, these sites are investigated, documented and observed.

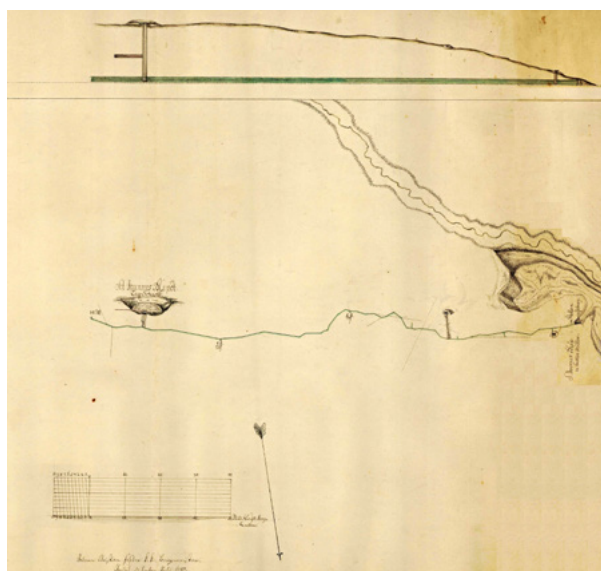
The "Mining Impact Report" web application (https://app.geology.cz/dud_ozn/), accessible through the CGS website, is available online for reporting and recording all newly detected cases of mining impacts. The application allows anyone to report mining impacts, including attachment of photo documentation. Expert staff of ČGS subsequently conduct initial on-site investigations and regular inspections of safeguarding measures taken at all mines, which were funded by the 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 2022, CGS employees inspected 1,857 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 underground mines (data on 5,671 sites as of 31 December 2022), the mine workings database with a comprehensive inventory of underground mines (data on 29,384 sites and more than 26,000 digital charts as of 31 December 2022), and the database of mining maps (data on nearly 18,000 maps and related scans as of 31 December 2022).

The Mining Impacts Inventory comprises files containing relevant documents for each reported case. Data are stored in the mining impacts database of the CGS Information System.



► A rock outcrop above a stream with a safeguarded shaft entrance, driven into the St. John of Nepomuk Adit in the settlement of Hamry near Hybráléc, Jihlava District. Documented in the Mine Working Impacts Inventory.



► Section of mining map RD/603 (Fischer, 18th century, CGS – Kutná Hora map archive). Elevation and ground plan of the St. John of Nepomuk Adit near Hybráléc, Jihlava District.

As of 31 December 2022, the Mining Impacts Inventory contained a total of 3,030 reported mine working impacts. Information on the status and location of reported mining impacts are also displayed by the “Mining Impacts” (https://mapy.geology.cz/dulni_dila_poddolovani/) and “Reported Mining Impacts” (https://mapy.geology.cz/oznamena_dulni_dila/) map applications, which are permanently accessible to the public on the CGS website.

Inventory of Mining Waste Sites

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

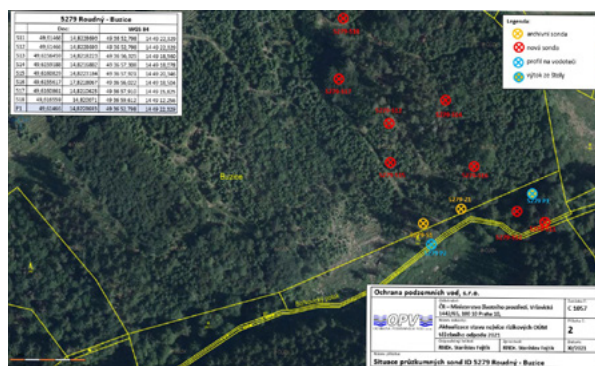
of Hazardous Waste Facilities according to the Mining Waste Management Act.

Mining and mineral exploration left numerous remnants in the landscape in the form of spoil heaps, tailings ponds, dumps and abandoned placers. They have become significant land-forming features with unique flora and fauna or may represent usable secondary sources of minerals. However in some cases, they 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.

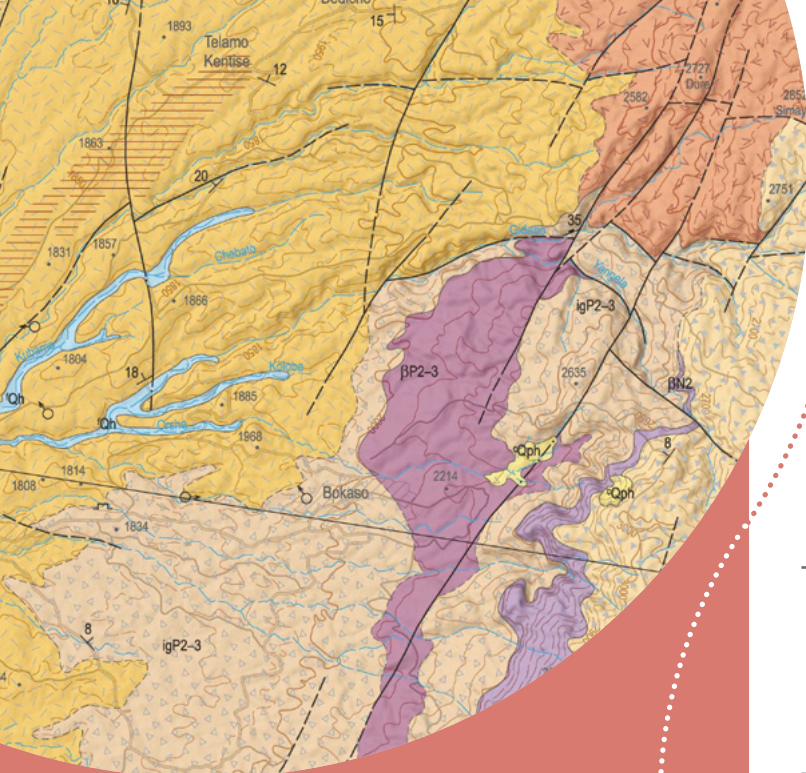
The Mining Waste Management Act that came into force in 2009 included a comprehensive inventory of mining waste disposal sites in the Czech Republic. The Czech Geological Survey created the Inventory of Mining Waste Facilities, which was included in the CGS Information System. It is constantly updated and contained 7,104 sites as of 31 December 2022. Detailed data on the 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, the Ministry of the Environment inspects and investigates six of the potentially most problematic sites. 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 2022. One site, previously listed in this category, has already been remediated and no longer poses a threat to the surrounding environment.



► Satellite image of the Roudný – Buzice waste facility (Benešov District) with the locations of probe holes drilled during a site review.



► A section from a geological map of the Sidama Region of Ethiopia, completely digitized in the Geographic Information System.



Richard Binko
Head
of the Informatics Department



Lucie Kondrová
Head
of the Central Data Store

Geological Information System

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 for providing information to state authorities, the public and also for the research and other scientific activities of the CGS. The system's concept 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 infrastructure.

The core of the Geological Information System (GeolS), 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 documents, etc.). The GeolS 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); geophysics (seismic profiles, VES, magnetics, gravimetry, petrophysics, well logging, etc); hydrogeology; soil and others.

In 2022, the CGS Metadata Information System (MIS; micka.geology.cz), which allows for orientation in CGS datasets, services, applications, websites, AR, and 3D models and scenes, was mainly upgraded (to version 7) with regard to applications. The MIS is fully compatible with the current national metadata profile, with the INSPIRE Implementing Rules and new "Open Data" as well. It serves as a source of up-to-date information for national (geoportal.gov.cz, data.gov.cz) and international geoportals (inspire-geoportal.ec.europa.eu, europe-geology.eu, data.europa.eu). In 2022, 422 public metadata records on CGS data sources were documented and managed in the MIS. For the CGS Information Portal, the MIS is used to automatically generate thematic lists of web map services WMS (wms.geology.cz), services based on Esri ArcGIS for Server technology (www.geology.cz/extranet/mapy/mapy-online/esri),

public web applications (aplikace.geology.cz, mapy.geology.cz), and a thematically structured interactive overview of CGS databases (www.geology.cz/geodata), which presents the schematic content of the CDS.

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 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 2022, work continued on harmonizing data for the themes Geology (Geophysics) and Areas Threatened by Natural Hazards. 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.

Development of data sources

In 2022, extensive work commenced on the GDO database, involving its consolidation and, simultaneously, the development of application software for operating the database. The database of the mining waste facilities inventory was consolidated as well. A consolidated version of the significant geosites database was created, serving as a source for public (presentation) applications. Application software for the consolidated database will be developed in 2023. For this reason, regular recovery of data from the currently running original database to its consolidated form was ensured.

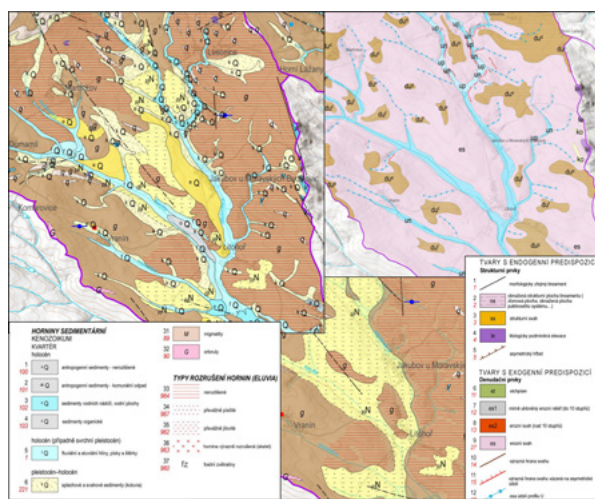
Continued development of the NGMD (National Geological Map Database) in 2022 mainly involved a revision of the data structure for geological maps at a scale of 1:25,000, whereby older maps for the areas of the Saxothuringicum, Doupovské hory Mts, Central Bohemia and Železné hory Mts were added to the CDS data structure. Legends were prepared and will be linked with the maps after revision, and all geological maps (bedrock and Quaternary maps) will be accessible in applications and also to the public (<https://mapy.geology.cz/geocr25/>) in 2023. In addition to geological maps, a new data structure was developed for maps of minerals as well. A new nationwide legend was prepared, which will be supplemented with symbols that are necessary for presentation in web applications. Map symbols and English and Czech descriptions were revised for all geoscience map scales as well.

A new directive of the CGS Director, which defines and describes the handling of data obtained from CGS activities, went into effect on 1 December 2022. The directive includes an explanation of terms used, definitions of individual roles (rights and obligations), and methods of handling data (acquisition, management and provision of data).

A scenario for replacing part of the infrastructure, which provides access to spatial data on the Internet, was prepared and specifically involves database servers, a map server and a map portal. The new infrastructure will be developed as a new installation, to which the existing data will then be transferred. This upgrade method will provide a new, stable and functional environment with data free of residues from previous installations. Nothing will change for users of map services and applications, and addresses will remain the same. The scenario implementation is planned for 2023.

Use of the Geographic Information System (GIS)

The GIS continued to be used as a tool for processing, utilizing and providing spatial data. 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 2022, 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 Impact in the Czech Republic" project. A central data warehouse continued to be developed for the "Groundwater in Crystalline Rocks" project (primarily involving the creation and approval of legends for geological and geomorphological maps – see Fig. 1), thereby enabling the construction of schemes (hydrogeological, geomorphological, etc.) and also of the first geological and geomorphological maps at a scale of 1:100,000 (for hydrogeological zones 6320, 6531, 6550). Work continued on the "RENS – Geohazards" and "RENS – Water in Karst" projects. A set of thematic maps was created using ArcGIS Pro software.



► Figure 1. Display of a geological and geomorphological map, constructed during the "Groundwater in Crystalline Rocks" project.

The main map of the “Geology, U-Pb dating and 3D visualisation of the late-orogenic Klenov Pluton (Pelhřimov Core Complex, Bohemian Massif)” paper, which was under review by the *Journal of Maps* at the annual report’s deadline, was prepared in the GIS environment.

Horizontal Cooperation of the Radioactive Waste Repository Authority (SÚRAO) and CGS commenced, whereby the GIS was used to prepare maps for requests to establish an exploration area for special interventions into the Earth’s crust for the Joint Area of Interest of the horizontal cooperation and also to prepare schematics for project documents. An important project document of the horizontal cooperation is the Data Management Plan, which was prepared by the Informatics Department’s employees, who deal with data acquisition, storage and transfer, a key CGS activity.

GIS methods were also used in foreign cooperation projects, such as Turów (materials for negotiations regarding the Turów mine’s mining impact on Czech territory) and also in foreign projects in Ethiopia (completion of two extensive geological maps at 1:100,000 scale of Sidama and Gedeo and ongoing compilation of a map of Gamo).

Tools in Python scripts continued to be developed for ArcGIS Pro, such as a tool for raster interpolation from drilling data, used to prepare data for 3D geological modelling in MOVE software. A user tool was also prepared to extract part of the 5G DMR (Digital Terrain Model) for project purposes.

During the course of the year, a method for prepress preparation of maps was updated with a description of new methods in the Adobe Illustrator environment, which were mainly used to prepare oversized maps for the project in Ethiopia.

Providing access to geoscience data and information

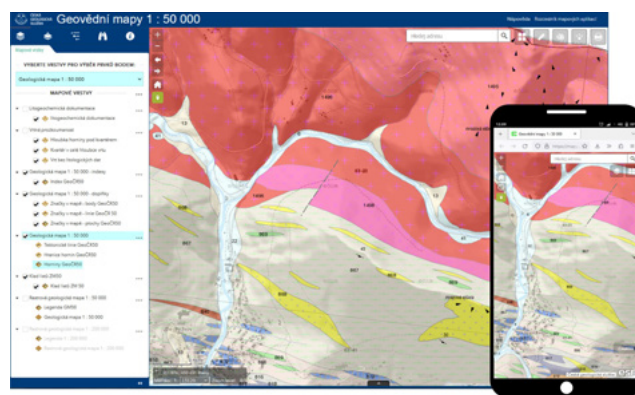
Access to additional datasets and maps on the CGS Map Server via map applications continued to be provided in 2022. The main output of the “TK02010092 – Analysis of the geothermal energy potential at medium and great depths in the Czech Republic based on available data” project is the Geothermal Potential of the Czech Republic map application (https://mapy.geology.cz/geotermalni_potential/), which clearly depicts the geothermal potential and restrictive conditions in the territory of the Czech Republic. The geothermal potential is shown by map layers of temperature distribution at different depths, by a map of the distribution of the Earth’s surface heat flow, and by a map of the thermal conductivity of rocks. The application also contains thematic layers of restrictive conditions and conflicts of interest. These are restrictions on the use of geothermal energy, due to natural hazards, technical restrictions on the construction of geothermal installations, and legal restrictions.

In 2022, the development of the internal map application “Radiometric Anomalies and Research from ČSÚP (Czechoslovak Uranium Industry) Data” was completed and its content was supplemented with additional map layers: Radon Index for Radioactive Objects, Overview Map of Radioecological Impact in Regional Units of the Czech Republic and Radioecological Risk of Regional Units. They represent a complete set of data and maps compiled by the ČSÚP along with other previously published layers.

Based on user comments from a questionnaire survey conducted in 2021, access to scanned legends of raster maps available in the Geological Map 1:50,000, Hydrogeological Map 1:50,000, Soil Map 1:50,000 and Geological Map 1:25,000 applications was improved significantly. Users are provided with high-resolution legends, with which they can work in a new intuitive browser.

The development environment for map applications was updated with the ArcGIS Web AppBuilder 2.24 version. In 2022, all applications from the CGS map guidepost (<http://mapy.geology.cz>) were transferred to this version. The new application versions take less time to load applications into the browser and optimizes the display of attached photo documentation. However, the mobile mode for applications is the main benefit of the update. Each application can now be run in a browser as well as on a mobile device, where maps are loaded in a simplified mode, which by contrast with the desktop version contains only tools for changing the topographic background, a list of map layers and an address search (see Fig. 2). But compared with the desktop version, location tracking and zoom control can be turned on.

Two additional models were published during 2022 on the website on 3D geological modelling by the CGS (<http://www.geology.cz/3d>) – a GeoCIM model of the Perštýn locality, a selected area in the urban area of Liberec, and an updated 3D structural geology model of the potential underground RAW repository site of Březový potok. In 2022, the CGS joined an initiative for providing open data. A publication plan for open CGS data was prepared and



► Figure 2. Display of the desktop and mobile modes of CGS map applications.

the first two open datasets (mine workings, abandoned mine lands) were published in the NKOD (National Open Data Catalogue), which are now accessible to the professional and lay public. Other open databases will be provided in this manner in 2023. Vít Štrupl, CGS Deputy Director for Information Systems, was appointed coordinator of the open CGS data.

The main activity concerning the web presentations of the CGS involved the technical development of a new CGS public website as part of the StaR Portal (a publishing system for website management within the Ministry of the Environment). This was carried out in cooperation with a contractor throughout the year, whereby additional requirements will be finalized at the beginning of 2023. The new site is expected to be launched in mid-2023.

A new website of the Czech Stratigraphic Commission (<https://stratigraphy.geology.cz>), managed by the Czech Geological Survey, was launched at the beginning of the year. This website was also developed as part of the StaR Portal.

International cooperation

In 2022, the representatives of the CGS Informatics Division worked again fully in international teams. The most important milestone of 2022 was the launch of the five-year A Geological Service for Europe (GSEU) project under the Coordination and Support Action programme (<https://eurogeosurveys.org/research/gseu/>), which commenced on 1 September 2022. The CGS is engaged significantly in most of the work packages, particularly WP7 dedicated to the development of the European Geological Data Infrastructure (EGDI). In 2022, the CGS continued to maintain a metadata catalogue (<https://egdi.geology.cz/>), which will serve as an integral part of the EGDI and GSEU. By the end of 2022, more than 4,200 metadata records on data sources from 20 European countries, 34 European organizations and 28 European projects (for instance, from the ongoing EMODnet project) were managed in the EGDI catalogue.

In 2022, Dana Čápková continued as chairwoman of the Spatial Information Expert Group (SIEG), the expert advisory body of EuroGeoSurveys. Two plenary sessions, one as a webmeeting and one in a hybrid format, were held. The sixth meeting of geoinformaticians from Central European geological surveys (CE-GIC) also took place in a hybrid format in Bratislava, Slovakia (see Fig. 3).

Dana Čápková is also a member of the steering committee of the Geoscience Information Consortium (GIC). The CGS organized the Geoscience Information Consortium conference, which was held from 30 May to 2 June 2022 at Berchtold Castle. The conference was attended by 67 participants from 26 countries, of which 22 attended in person and 45 participated via video conference. Intensive personal debates, focused on exchanging information and knowledge involving mainly the introduction of

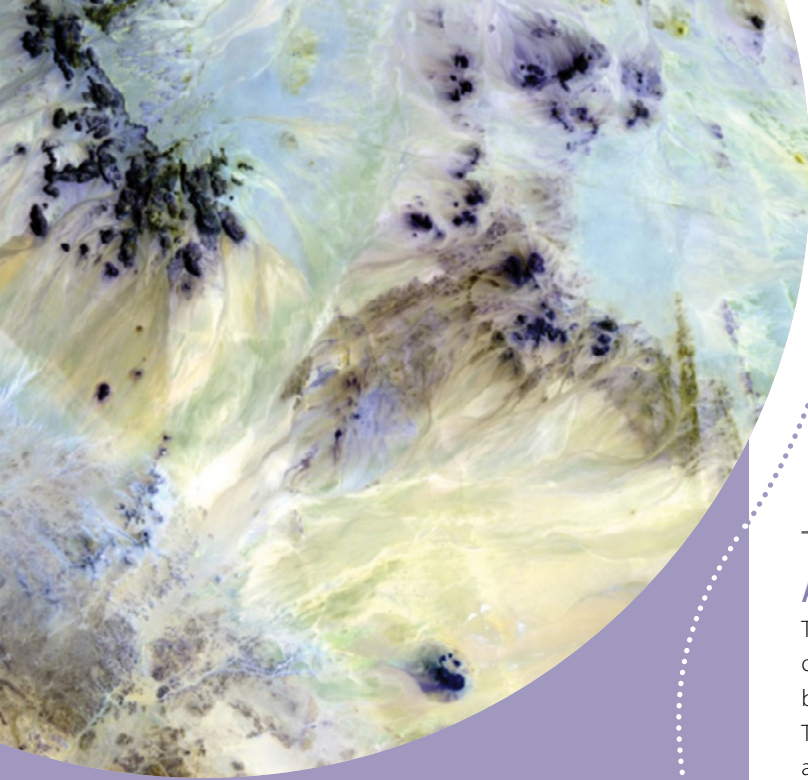


► Figure 3. Participants of the CE-GIC 2022 working meeting held in Bratislava.

new technologies and procedures, were very beneficial. The most important part of the programme involved the presentation and discussion regarding National Reports, and subsequent sessions were devoted to topics such as From 3D to Digital Twins, Data/Knowledge Infrastructures, Linked Data, Machine Learning, AI, Standardization, FAIR Principles, and Data Workflow Lifecycle. During 2022, Lucie Kondrová completed a three-month internship at the Danish Geological Survey, which was thematically focused on developing a database for storing 3D models and their metadata description, the outputs of which will be analysed in terms of feasibility and usability in the CGS environment after the CGS infrastructure is upgraded. The internship was as part of a MEYS (Ministry of Education, Youth and Sports) project facilitating the mobility of CGS researchers. In 2022, the “Innovation of Geological Information Systems in Bosnia and Herzegovina” project was developed with the financial support of the Czech Development Agency (CDA). The preparation phase included joint meetings held with colleagues from the Geological Survey of the Federation of Bosnia and Herzegovina and the Geological Survey of the Republic of Srpska in Prague and Sarajevo (see Fig. 4). The project was approved by the CDA and is expected to commence in early 2023.



► Figure 4. Joint meeting with colleagues from Bosnia and Herzegovina in Sarajevo.



► *Carbonatite complexes in northern Namibia: satellite data from the PRISMA hyperspectral satellite, acquired by the Italian Space Agency (ASI).*



Veronika Strnadová

Head of the Remote
Sensing Centre

Remote sensing

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 its physical and chemical properties. The parameters of the data acquired by sensors located on various platforms are constantly being improved. The data are already commonly provided free of charge (for instance, by NASA's Landsat and ESA's Copernicus programmes) and thus accessible for a wide range of research. The so-called "cloud calculations" along with SW tools are also provided free of charge, thereby enabling fast analysis of large volumes of data.

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. In sum, 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. environmental use (assessment of mining impacts), II. use of non-destructive remote sensing methods and new machine learning algorithms for evaluating the potential of strategic mineral deposits (for example, REE), III. creation of new algorithms/models combining optical and thermal hyperspectral data, IV. creation of models using new-generation satellite data (for example, Sentinel-1, 2 and 3 PRISMA and EnMAP hyperspectral satellite data).

In addition to HS technologies, the RSC is 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 PALSAR 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.

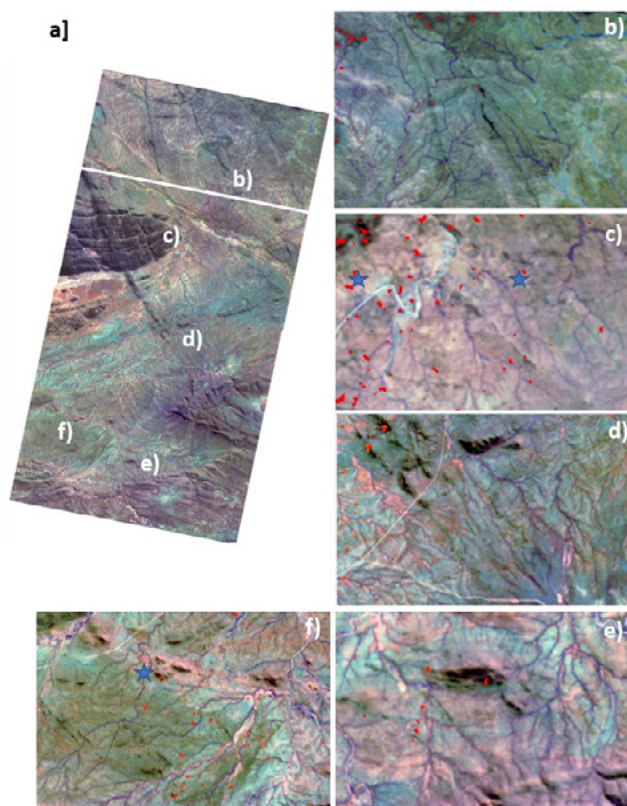
With regard to geohazards, radar interferometry methods (SBAS-DInSAR or PSI) are being newly used for the detection of vertical terrain movements and deformations. Radar interferometry was employed, for instance, to identify landslide movement along the D8 motorway in the České středohoří Mts and to 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. Unmanned imaging allows for independent scanning of studied 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 2022, the RSC's team focused on systematic scanning of sites where landslide movement is expected to continue. Detected thermal gradients made it possible to expose newly occurring fractures and movement in areas of existing landslides.

The RSC constantly publishes its results, which involve the above-mentioned research areas, in international peer-reviewed science journals with impact factors or as other applied research outputs intended for state authorities (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 (GFZ)
- Tel Aviv University
- NASA – Goddard Space Flight Center
- EuroGeoSurveys: Earth Observation and Geohazards Expert Group (EOEG)



► Northern Namibia: evaluation of potential REE enrichment using PRISMA satellite hyperspectral data: red polygons show the highest potential.



► Eisenerz-Erzberg (Austria): carbonate iron ore mine.
Photo by Jaromír Starý.

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 Czech Geological Survey is an active member of EuroGeo-Surveys (EGS) – a non-profit organization representing European national and regional geological surveys. Through joint research and activities of EGS expert groups, CGS specialists participate in providing European institutes, regulatory authorities, industries and the public with expert consultancy, harmonized geological maps and data infrastructure.



The Geological Surveys of Europe

Launch of the Geological Service for Europe project

The “Geological Service for Europe” project, whose preparation was coordinated by EuroGeoSurveys, commenced in September 2022. The project consortium includes 48 partner organizations from 36 European countries (mainly national and regional geological surveys and associated partners). The project will run for five years and is largely funded by the European Commission through the Horizon Europe programme.

The goal of the project is to establish a “Geological Service for Europe” as an entry point to a permanent collaborative network of European geological surveys and to provide European institutions, enterprises and citizens with up-to-date 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, CO₂ 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 an infrastructure linked to the existing EGD (European Geological Data Infrastructure), which will provide access to data and information services developed during the project and elsewhere.

PanAfGeo project: geological mapping courses in Namibia and Morocco

The international project “PanAfGeo-2: Africa-EU Partnership – Support to Geological Sciences and Technology”,





► A PanAfGeo-WPA work group during structural geology training, Tsaobis, Namibia, 2022. Photo by V. Štědrá.

which is co-funded by the European Union, aims to enhance the quality and technological progress of employees of African geological surveys. This project is aimed at conducting 40 training courses and ten workshops involving seven geoscience fields. The Czech Geological Survey is tasked with coordinating a programme focused on practical geological field mapping and work with satellite data as a part of the WPA work package. In 2022, the CGS conducted one monthly course in English in Windhoek, Namibia, and organized a monthly course in French in Tinghir, Morocco. Both of the courses, organized in cooperation with the local state geological survey, included an introductory and interpretive study part, and a demanding methodological and mapping part in the field. A total of 49 geologists from 29 African countries were trained.

UNESCO International Geoscience Programme (IGCP)



The IGCP programme, which was founded at the initiative of Czechoslovak geologists, aims to facilitate geological cooperation across countries. In 2022, 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 2022, together with foreign partners, the Czech Geological Survey was engaged in many projects.

CO₂-SPICER – CO₂ Storage Pilot in a Carbonate Reservoir



The main goal of the Czech-Norwegian CO₂-SPICER project is to prepare a pilot CO₂ storage facility at a depleted crude oil and natural gas field, located in Southeast Moravia. The process involves capturing CO₂ emitted by large industrial plants and subsequently storing it in liquid form in rocks deep beneath the Earth's surface in boreholes. The objective is an attempt to limit the growing amount of CO₂ in the atmosphere and to mitigate the associated climate change. If the objective proves successful, it will be the first CO₂ 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 the TACR (Technology Agency of the Czech Republic) under the KAPPA Programme.

The Fate and Future of Carbon in Forests (CatchCaN)

In cooperation with the Biology Centre of the Czech Academy of Sciences, IVL Swedish Environmental Research Institute Ltd. and the Norwegian Institute for Water Research, we are developing modelling software for predicting the amount of carbon and nutrients in forest ecosystems. The project was funded by Norway Grants and the TACR (KAPPA).

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).



► Krásno (Czech Republic): quarry of albite granite for feldspar raw material. Photo by Jaromír Starý.

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 Wirtschafts-förderung 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 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 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.

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

The project deals with microbial facies associated with some of the most dramatic Phanerozoic events, specifically the Kellwasser (Upper Devonian) and Hangenberg (Devonian–Carboniferous) events, and also two Middle Devonian events, the Basal Choteč and Kačák events. The project is being carried out in cooperation with Axel Munnecke, Alexander-Universität Erlangen-Nürnberg, GeoZentrum Nordbayern, Erlangen, Germany, and was funded by the Czech Science Foundation.

The CGS is involved in exploration projects and extraction of critical raw materials key to modern industry

Sustainable exploration for orthomagmatic (critical) raw materials in the EU: Charting the road to the green energy transition

The goal of the project is to promote the responsible sourcing of critical raw materials (CRM) in the EU and to diversify their supply from third countries. Critical raw materials are fundamental to EU industry and strategic sectors, particularly with regard to the green energy transition. Important critical raw materials such as nickel, cobalt, copper, titanium and platinum occur

in orthomagmatic mineral systems. The project is designed to develop socially and ecologically sustainable means of exploring for orthomagmatic CRMs. The collaboration of Finnish, Portuguese, Polish and Czech geoscience and social institutes will provide a mineral systems approach, define areas with high exploration potential, and promote social awareness of the importance of responsible exploration and mining. Project website: <https://cordis.europa.eu/project/id/101057741>

The project was funded by the EU Framework Programme for Research and Innovation Horizon Europe.

BrineRIS – Brines of RIS countries as a source of CRM and energy supply

The project aims at building the capacities of RIS countries (countries taking part in the Regional Innovation Programme under the funding model of the European Institute of Innovation and Technology) in carbon-neutral recovery of critical raw materials (CRM) from geothermal brines. To reduce Europe's dependence on imported metals for battery production, BrineRIS will identify promising brine deposits in Europe and test new raw material recovery technologies. By creating an interactive platform and investment case study, BrineRIS will attract investors to RIS regions participating in the project.

Project website: <https://brineris.geo3bcn.csic.es/>

The project is funded by the European Institute of Innovation and Technology.



► Sampling of mineral water within the frame of the BrineRIS project – Luna spring, Louny.

The Czech Geological Survey successfully implements foreign development cooperation projects

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

The project was completed by the end of 2022 in cooperation with the geological surveys of Bosnia and Herzegovina and Serbia and with the support of the Czech Development Agency. It aimed at preparing clearly defined conditions for these geological surveys to cooperate in research on renewable energy sources. The project was funded by the Czech Development Agency and will be followed up by a cooperation project between the two geological surveys, which will commence in 2023.

Ensuring sustainable land management in selected areas of Ethiopia based on geoscience mapping

The project focuses primarily 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.

Compilation of a national geological and hydrogeological map at a scale of 1:1,000,000 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, 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 developed to be freely available to anyone interested in using geoscience data. The project was funded by the Czech Development Agency.

Membership in international organizations

AAPG	American Association of Petroleum Geologists	J. Franců
AGU	American Geophysical Union	A. Andronikov, I. Andronikova, J. Hruška
CAAG	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
CBGA	Carpathian-Balkan Geological Association	M. Bubík, national delegate
Central European Initiative	Association of the Central European geological surveys of the Czech Republic, Slovakia, Austria, Hungary, Croatia, Poland and Slovenia	Z. Venera
CEP – ATS	Committee for Environmental Protection – Antarctic Treaty System	Z. Venera, D. Nývlt
CETEG	Central European Tectonics Group	Z. Venera, P. Mixa
CO2GeoNet	European Network of Excellence for Geological Storage of CO ₂	V. Hladík
EAG	European Association of Geochemistry	A. Andronikov
EAGE	European Association of Geoscientists and Engineers	V. Hladík
EGS (EuroGeoSurveys)	Association of European Geological Surveys	Z. Venera, Board of Directors
EGS Geoenergy Expert Group	EGS Geoenergy Expert Group	V. Hladík
EGS Earth Observation and Geohazards Expert Group	EGS Earth Observation and Geohazards Expert Group	V. Strnadová
EGS Geochemistry Expert Group	EGS Geochemistry Expert Group	M. Poňavič
EGS Mineral Resources Expert Group	EGS Mineral Resources Expert Group	P. Rambousek, V. Wertich
EGS Spatial Information Expert Group	EGS Spatial Information Expert Group	D. Čápková, chairwoman (since 2019), L. Kondrová
EGS Urban Geology Expert Group	EGS Urban Geology Expert Group	J. Jelének
EGS Geological Mapping & Modelling Expert Group	EGS Geological Mapping and Modelling Expert Group	Z. Bukovská
EGS Water Resources Expert Group	EGS Water Resources Expert Group	E. Kryštofová
ENERG	European Network for Research in Geo-Energy	V. Hladík
EPOS TCS GDM	EPOS Thematic Core Service, Geological Information and Modelling	D. Čápková, co-chair

GEO – GEO4MIN	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)
GIC	Geoscience Information Consortium, representing the managers of informatics of 35 geological surveys around the world	D. Čápková, steering committee member
GIC CE	A consortium representing 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
IAGOD	International Association on the Genesis of Ore Deposits	B. Kříbek, J. Pašava, international committee member
ICDP-SAG	International Continental Scientific Drilling Program – Science Advisory Group (evaluation of submitted projects)	J. Kotková
ICL	International Consortium on Landslides	P. Kyčl
IMA	International Mineralogical Association	F. Laufek, Commission for Ore Mineralogy
INQUA	International Union for Quaternary Research	D. Nývlt
International Organisation of Palaeobotany	International Organisation of Palaeobotany	Z. Šimůnek
ICS – ISOS	International Commission on Stratigraphy – International Subcommission on Ordovician Stratigraphy	P. Budil, member correspondent
ICS – SCCS	International Commission on Stratigraphy – I.U.G.S. International Subcommission on Carboniferous Stratigraphy	Z. Šimůnek
ICS – SDS	International Commission on Stratigraphy – International Subcommission on Devonian Stratigraphy	P. Budil, member correspondent
ProGEO	European Association for the Conservation of Geological Heritage	P. Budil, chairman of the Czech national group
SEG	Society of Economic Geologists	J. Pašava, international committee member
SGA	Society for Geology Applied to Mineral Deposits – a scientific society representing 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
SGS	Slovak Geological Society	P. Budil, honorary member
SRG	The Society of Resource Geology (Japan)	J. Pašava



► RETSCH Planetary Ball Mill PM 100.



Tereza Grabmüllerová

Head
of the Central Laboratory Prague



Juraj Franců

Head
of the Central Laboratory Brno



František Laufek

Head of the Department
of Rock Geochemistry



Irena Sedláčková

Head
of the Sample Preparation Laboratory

Laboratories

/DKRVO

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 conducts chemical analyses for internal projects of the CGS as well as for projects funded from other national and international sources. 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 and surface water. Compliance with the quality system is regularly monitored by CAI employees.

Homogenization

Rock samples are prepared for chemical analysis by being handled, crushed, quartered and pulverized to analytical fineness.

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 during scientific CGS programmes that monitor the status of selected river basins in the Czech Republic.

Basic water analysis involves the determination of Li, Na, K, NH_4^+ , Mg, Ca, Mn, Zn, Fe, Al, SiO_2 , pH, F, Cl, NO_3^- , HCO_3^- , SO_4^{2-} , conductivity, alkalinity, pH and total phosphorus.

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. Additional selected elements can also be determined by ICP-MS in acidified samples. The laboratory has a Teledyne Tekmar Torch analyzer for determining organic carbon and total nitrogen in water.

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 SiO_2 , TiO_2 , Fe_2O_3 , FeO, Al_2O_3 , SrO, BaO, Li_2O , MnO, CaO, MgO, Na_2O , K_2O , P_2O_5 , moisture, bound water, CO_2 , C_{tot} , S_{tot} , F, and loss on drying or ignition. All these components are included in silicate analysis. The laboratory offers four methods of silicate analysis – complete, simplified, technical and modified silicate analyses, which differ in the number of analyzed components and in the total sum of all components. Individual determinations included in the silicate analysis may be requested separately.

For soil analysis, total acidity and exchangeable Al can be determined from leachate in BaCl_2 by titration. The pH in aqueous leachate and in KCl leachate are determined as well. The P_2O_5 concentration can be determined spectrophotometrically in Mehlich III leachate. 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 can also be determined with an X-ray spectrometer from the Rigaku company using the XRF-WDX method without the need for sample decomposition. Elements (As, Ba, Bi, Ce, Co, Cr, Cu, Ga, La, Mo, Nb, Nd, Ni, Pb, Rb, Sc, Sn, Sr, Th, Ti, U, V, W, Y, Zn, Zr) are determined from pressed pellets.

The limit of detection of this analysis falls within the ppm range. 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 CO_2 and Eltra CS-580 analyzers, state-of-the-art water deionization equipment, modern automatic titrators and a Radiometer pX-meter.

Central Laboratory Brno

The accredited Central Laboratory in Brno focuses on organic and gas geochemistry as well as on microscopic porosity in transmitted and fluorescent light.

Analysis of rocks and bitumen

The Central Laboratory in Brno performs analyses of organic and mineral carbon in rocks. The gas chromatography-mass spectrometry method is used to analyze saturated and aromatic molecular fossils – biomarkers. This method is employed in the ongoing Norway Grants/TACR CO₂-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 of Jurassic petroleum into overlying layers. The facies types of limestones and their dolomitization types are characterized using reflected and fluorescent light microscopy. All methods are interpreted with reference to 3D models of geological bodies and to the thermal history of the monitored model basin.

Ecology

Persistent organic pollutants (POPs) are monitored in soils, airborne dust, and recently also in recycled asphalt stored in the landscape during road and highway renewal. 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. Special studies examine polycyclic aromatic hydrocarbons (PAH) as indicators of large-scale fires in terrestrial vegetation.

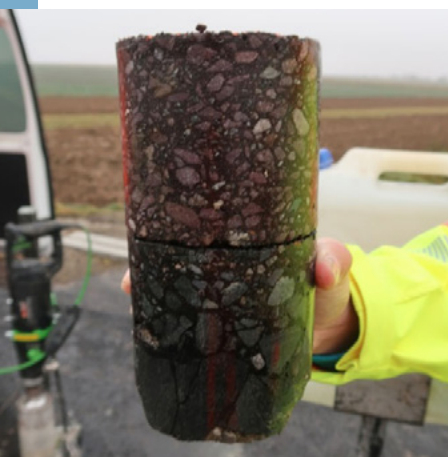
Gases

For field measurements of gases, the laboratory's staff uses Ecoprobe 5 and Draeger portable instruments. As part of an ongoing TACR project, hundreds of surface measurements are being evaluated in the form of isopach maps of a natural source of carbon dioxide at a future CO_2 storage facility site. Accredited detailed chromatographic quantitative analysis determines 22 compounds including hydrogen, helium, argon and sulfane.



Laboratories

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. As part of the TACR project, these analyses are used to evaluate microbial activity in coal mines at a depth of one kilometre or above plugged wells of crude oil deposits. These analyses are now linked with microbiological analyses of the consortia of archaea and bacteria.



► A sample of road surface asphalt collected with the COLAS CZ, a.s. company for an accredited analysis of polycyclic aromatic hydrocarbons (PAHs): the upper layer consists of modern high-quality bitumen while the lower, older layer of the penetration macadam contains tars and harmful PAHs, which represent an ecohazard.

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 also engaged in university education and other activities involving the teaching and training of students.

Isotope Geochemistry and Geochronology Laboratory

The laboratory focuses on the analysis of traditional radiogenic isotopic systems (Sr, Nd, Os), drawing on decades' worth of knowledge accumulated by the CGS, and of modern non-traditional stable isotope systems (Li, Mg, Fe, Cr, Cu, Zn, etc.). 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 allows for microsampling of geological material requiring a chemical separation of elements prior to isotope analysis, with a wide range of applications, such as for studying the temporal evolution recorded in mineral growth zoning.

The majority of samples are prepared using ion selective chromatography methods in a specialized laboratory with controlled sterility (USL). In addition to methodological

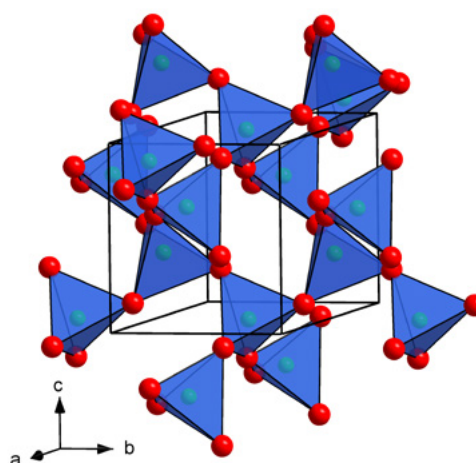
development, the laboratory's research focuses mainly on the origin of igneous rocks of the Bohemian Massif. The laboratory staff also utilizes isotope systems in several geological and interdisciplinary research projects.

The laser ablation laboratory is equipped with an Analyte Excite 193 nm laser ablation system (Photon Machines) 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 determining trace element concentrations in different matrices.

Laser ablation in conjunction with a Neptune multi-collector ICP-MS (Thermo Fisher Scientific) is used to determine the Hf isotopic ratio in zircons in situ.

X-ray Diffraction Laboratory

The X-ray Diffraction Laboratory is equipped with Bruker D8 Advance and Philips X'Pert X-ray powder diffractometers. The laboratory performs mineralogical analyses of a wide range of geological materials – rocks, minerals, mineral concentrates, clays and soils, and also synthetic materials including construction materials, waste products, energy products, sludge, precipitates from mines, and so forth. The laboratory's activities also deal with solution and refinement of the crystal structures of minerals and synthetic substances. An integral part of the research conducted in the laboratory also involves the mineralogical-geochemical study of clay minerals and their interactions in the environment.



► The new mineral pertoldite, trigonal GeO_2 crystal structure refined in the X-ray Diffraction Laboratory. Tetrahedra $[\text{GeO}_4]$ are shown.

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 the 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 size) in minerals from diverse geological environments.

Experimental Mineralogy 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. With the aid of paleontological, sedimentological and geochemical methods, the laboratory's scientific team analyses changes in selected abiotic characteristics of the paleoenvironment and parameters characterizing the evolution of paleodiversity in the periods prior to, during and after global crises. The analysis of paleodiversity evolution also involves taxonomic, paleoecological and paleobiogeographic research.

Separation Laboratory and Grinding Facility

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 2022, the grinding facility processed 2,000 samples, most often preparing polished thin sections and also covered thin sections and polished sections.

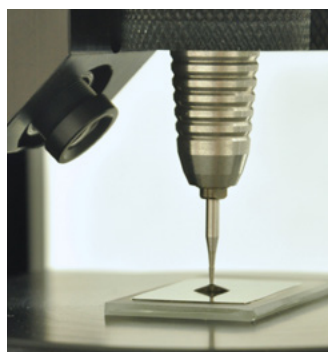
Sample Preparation Laboratory

The Sample Preparation Laboratory is part of the Regional Geology of Moravia Department. It prepares rocks and sediments for paleontological and mineralogical study, geochemical analysis and geochronological dating. It mainly meets the needs of the parent department's staff and, as required, of the geology division's other departments. 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.

The laboratory's equipment is being constantly upgraded and expanded. In 2022, the laboratory acquired a RETSCH Planetary Ball Mill PM 100 and a BRIO BCD-4 pre-crusher, and the crushing facility's ventilation system was upgraded. The laboratory now grinds samples to an analytical fineness. Due to demand, the range of methods was expanded to include separation of conodont fauna, but only to a limited extent depending on circumstances.

In 2022, the laboratory processed a total of 760 samples, and thus participated in the solution of sixteen projects. The largest number of samples was processed for the Czech Development Agency's project ET-2019-019-RO-43040 ("Ensuring sustainable land management in selected areas of Ethiopia based on geoscience mapping", 42%). Another large portion of samples was processed for the "RENS – Rock Environment and Minerals" project ("Groundwater in the Karst System" sub-project, 29%) or for the Inventory of Slope Instabilities (8%). The remaining volume of laboratory work involved regional geological mapping, other internal projects of the CGS, and external contracts.

In the past year, contracting parties most often requested sample preparation for geochemical study (268 samples, 35%), separation of microfossils (175 samples, 23%), and soil grinding (138 samples, 18%). A total of 12 samples were processed for geochronological dating in 2022.



► Detail of microsampling of a thin section using a Micromill. Drilling is performed in a drop of deionized water. Photo by J. Hora.



► Engraving depicting rocks.



Hana Breiterová
Head of the Information Services
Department and Geological Library



Petr Budil
Head of the Collections and Material
Documentation Department

Library and Collections

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 institutions but also by students, private researchers and other interested members of the public. All researchers may use the study rooms in Kláro, 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 recognized full-text databases (Science Direct, SpringerLink, Wiley 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

Translation

*Das Im Königreich Böhmen und dessen Königrätzer
Creys gelegene verwunderwürdige Adersbachische Stein-Gebirge,
In einer kurtzen Beschreibung deselben und einem Kupfer-Blatte.*

The Adršpach Rocks

**located in the Kingdom of Bohemia and its Hradec Králové Region,
briefly described on a copperplate engraving.**

*Allen Liebhabern der Begebenheiten in der Natur,
Ingleichen allen Reisenden zur Nachricht, und Vergnügen
aus Licht gestellet von*

Information to all nature lovers as well as travelers provided by

*Gottfried Langhanß,
Schol. Svidn. Evangel Prorectore.*

Gottfried Langhans
Vice-rector of the evangelical school in Svidnice

*Breßlau,
In Johann Jacob Korn's Buchhandlung,
1739*

Vratislav
**In the Johann Jacob Korn's bookstore
1739**



► Publication about Adršpach from 1739: title, title page translation.

a member. Of all the libraries administered by the MoE, the CGS Library provides the widest range of online information sources.

The CzechElib project at the CGS Library (2018–2022)



In 2018–2022, the CGS was provided with electronic information resources (EIR) through the CzechElib consortium. The goal was to create better conditions for member institutes to access EIR, to enhance research, development and education, and at the same time to join other developed countries that successfully operate similar national licensing centres. Specifically, the CGS project secured access to EIR, provided nearly trouble-free operation for the project's entire duration and, last but not least, easier administration. Statistics of annual access to specific information resources for the CGS staff are shown in the table.

	2018	2019	2020	2021	2022	Total
SpringerLink		4,755	5,186	4,221	3,905	18,067
Wiley Interscience	1,246	5,074	4,467	4,564	5,700	21,051
Science Direct	24,609	18,122	20,036	15,962	17,578	96,307
GeoScienceWorld	258	2,709	1,700	2,835	2,906	10,408
Scopus		4,682	4,005	3,588	3,322	15,597
Web of Science		8,430	8,515	9,945	3,964	30,854

Collections

The Collections and Material Documentation Department stores and provides access to fossils, mineral and rock samples, thin sections and other geology-related items collected by the geological survey's researchers and also access to the findings made by other organizations as well as by private collectors. The most valuable samples from a science perspective are located in geological and paleontological collections. These museum-quality collections are stored, made accessible and recorded by the department in the CES national inventory by virtue of Act No. 122/2000 Coll., as amended, and Decree 275/2000 Coll. The management of these samples 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 2022

The most significant additions to the collections in 2022 included samples of exceptionally well-preserved Ordovician echinoderms obtained by M. Nohejlová during fieldwork in

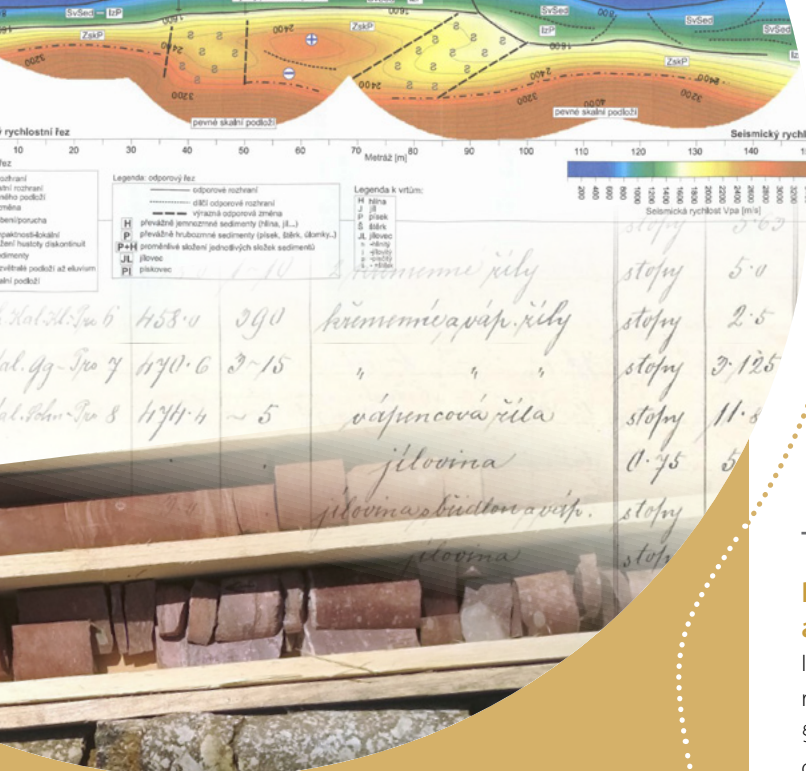
Morocco, Ordovician trilobite material, non-trilobite arthropods and echinoderms collected by O. Zicha, Silurian graptolites processed by P. Štorch, Silurian and Devonian molluscs from the collections of Š. Manda, and valuable samples of exceptionally preserved echinoderm, trilobite, mollusc and ichnofossil material from an excavation on Blýskava Hill near Loděnice, which was processed for publication. Note-worthy additions to the geological-mineralogical sub-collection include valuable foreign material handed over by B. Mlčoch or the star quartz samples from the Chyňava locality described by Žák *et al.* (2019). In 2022, the Collections and Samples Department also continued to process the vast collection of Assoc. Prof. Josef Sekyra from his research in Antarctica, deserts, and the world's high mountains.

To some extent, the COVID-19 epidemic and the ongoing financial crisis had a negative effect on visits to the collections in 2022 – with a few exceptions, foreign researchers did not visit due to travel restrictions and project budget cuts. Thus, the collections provided even more online services (photographs of items, latex casts, consultations, and so forth).

The maintenance of the CGS collections in 2022, which include roughly 300,000 items in total, included very intensive publishing activities performed by the collection department's staff members in addition to their work as regional geological experts. In 2022, the collection department's staff was again engaged in teaching at the Faculty of Science of Charles University. The study room of the collections facility and the stored collections were again used 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).



► Freshwater gastropod *Melanopsis boettgeri* Klika, 1891 from the Lower Oligocene of the Valeč locality at the south-eastern margin of the Doupovské hory Mts. It belongs to material that was discovered during mapping work conducted between the 1950s and 1980s and is now stored in a sample collection in Lužná near Rakovník. The material is included in a comprehensive study on the gastropod faunas of the volcanic regions of the Bohemian Massif.



Milada Hrdlovicová

Head of the Geofond
Division

Receive of geological documents and geological project results

In 2022, 5,518 reports and assessments of geological project results were handed over to the CGS Archive pursuant to § 12 of Act No. 62/1988 Coll., by geological project owners or by organizations that carry out the projects.

Archive collections

The archive collections permanently hold and provide access to over 280,000 archive records of unpublished geoscience documents. In 2022, a part of the Resource Reports Collection was transferred from Prague to a new depository that was opened at the CGS office in Kutná Hora.

The collection is also being restored and revitalized over the long term with the aid of available duplicates.

Archive services

A large community of professionals uses the archive services of the main study room located at Kostelní 26, in Prague 7. In 2022, the study room operated free of pandemic restrictions and was visited by approximately a thousand researchers.



Geofond Archive: a part of the archive additions in 2022.

Geological documentation

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

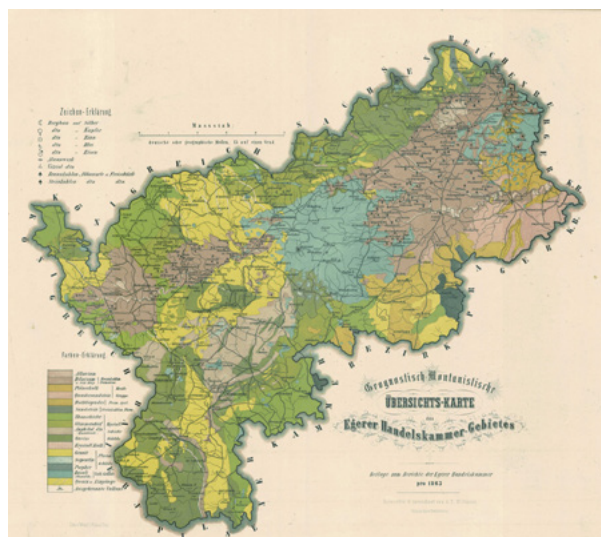
There is increased interest in the use of remote services, which offer researchers the possibility of receiving scans of selected pages of archive documents online. The archive employees handled 432 of such requests. Other orders were handled as standard data service requests.

ASGI archive database

All documents submitted to the archive are continuously processed as search records with brief content annotations and with the use of indexing terms from a science thesaurus. This processing method enables a subsequent parametric search of all archived documents in the “ASGI” archive application at <http://www.geology.cz/app/asgi>.

Map archive

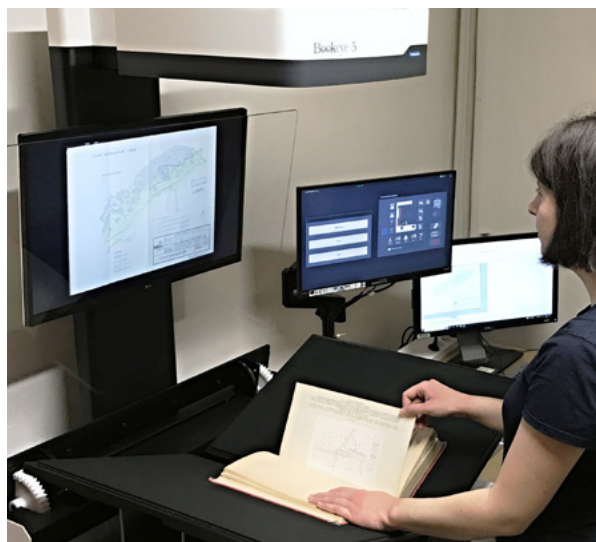
A separate collection of the map archive collects CGS map outputs and also contains other geoscience maps from the Czech Republic as well as from foreign countries, including historical maps. In 2022, 650 maps were added to the collection, often including accompanying texts and explanatory notes. Most of the collections are also available in digital form and can be found online in the map archive applications at <http://www.geology.cz/extranet/mapy/archiv>.



► Map archive: historical map. Hickmann, A.L.; 1863; *Geognostisch-Montanistische Übersichts-Karte des Egerer Handelskammer-Gebietes* (Synoptic geological-mining map of the Cheb Chamber of Commerce area).

Digitization

More than 50,000 digital archive documents, containing over 4.3 million image files, are now available. In 2022, roughly 170 scientists used the paid online “Browser” that is linked to the “ASGI” application. In addition to external orders, mainly



► A1 Bookeye 5 V1A Book Scanner: In 2022, the digitization department began using a new scanner for bound documents.

the documents required for CGS research projects were digitized as well as older or damaged reports to ensure their permanent preservation.

Borehole core material documentation

Based on requests, the staff of the Borehole Core Material Documentation Department provide access to a constantly growing set of more than 36 thousand metres of continuous drill cores or rock samples from structural and other important wells in the Czech Republic. Over 15,500 sample containers with 2,773 objects are accessible in special storage systems in the Kamenná, Stratov and Lužná repositories. Among other things, a unique drill core from the HJ-2 Horní Újezd – Krásnoves borehole, documenting the Bohemian Cretaceous (spanning the Cenomanian – Middle Turonian) down to its underlying layers, was archived in the CGS Lužná Repository in 2022.



► Borehole core material documentation: sampling of drill cores from the Staré Ransko area (CGS Stratov Repository).



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.



Patrik Fiferina

Head of the CGS
Publishing House

Books and maps

Each year, the Czech Geological Survey publishes scientific material 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 35 titles in 2022.



► On 21 April 2022, the Czech Geological Survey held a joint launch of the books *Byla-nebyla potopa světa?* ("Was the Earth Flooded – or Not?") by Jiří Jiránek and *Čeští geologové ve Střední Americe* ("Czech Geologists in Central America") by Petr Hradecký et al. The patrons of the books were Prof. Ing. Jaroslav Klokočník, DrSc., and Mgr. Milan Jakobec, who also brought the books to life with the sounds of his guitar and singing.

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 150 posts were published on the Facebook page World of Geology and five 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. 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 published regularly on the Czech Geological Survey's website. A new publishing house activity also includes the release of the *Svět geologie* ("The World of Geology") magazine. The quarterly brings the most significant events and information involving the activities of the Czech Geological Survey as well as interesting geoscience facts. *Svět geologie* is free to download on the CGS website and is intended for all those interested in the latest news in geology. It is mainly available electronically but also published in printed form.



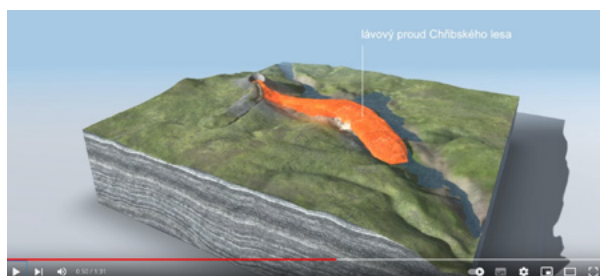
► The *Svět geologie* ("The World of Geology") magazine is a new quarterly that brings the most significant events and information involving the activities of the Czech Geological Survey as well as interesting geoscience facts. *Svět geologie* is free to download on the CGS website.



► The regional round of the Geology Olympiad for the capital city of Prague was held on 4 April 2022 at the Czech Geological Survey. The contestants not only passed a theoretical test and identified geological samples, but interesting talks by CGS specialists or a virtual reality presentation on Paleozoic marine life was prepared for them as well. We congratulate all the participants, who made it all the way to the regional round, and of course the winners as well! The winners are listed in an attached file.



► The CGS was engaged in organizing the Open House Prague 2022 festival, which took place during the week beginning on 16 May. During the festival's eighth year, 101 buildings were made accessible for free throughout the capital city. A rich accompanying programme was prepared for visitors. More than a thousand guests visited the CGS on Saturday and Sunday. The richly decorated Chapel of St. Raphael, where an exhibition of photographs was held documenting the interesting history of the building, the original Klar Institute for the Blind, aroused the greatest interest.



► The animated geological origin of Velký Roudný was the most popular animation of the past year. It depicts how this volcanic cinder cone towering over the Slezská Harta Reservoir was formed. Velký Roudný still has a well-preserved and morphologically visible asymmetric crater, which opens southeastward. It is also the Czech Republic's best preserved volcano.

Six new animations on the origin of geosites, geological processes and project presentations

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 2022, six new animations on the origin of geosites or rocks were published on the YouTube channel – for example, Velký Roudný, Ztracený rybník or Bažina. Animations also help to depict the principles of implemented projects, as in the case of the SYNERGYS project in the animation *Development of Geothermal Energy – Energy Synergy Systems*. The *Groundwater Contamination due to Transport Accidents* animation shows how the rock environment influences the spread of contamination, whereby potential human-induced contamination poses a significant risk and threat to water sources in karst areas.



► The Czech Geological Survey was one of the Prague 21 district's partners who organized Earth Day on April 22. The rich programme for nearly 600 visitors included various information booths. The Czech Geological Survey presented its contribution to society and prepared a workshop focused on the production of jewellery from semi-precious stones. Other organizations familiarized visitors, for instance, with ecological beekeeping, the life of birds of prey and animals kept in zoos, ecological gardening or the life cycles and needs of forest culture. The programme included a lecture on dragonflies by Dan Bárta along with an exhibition of their photographs.



► The Czech Geological Survey invited young and old visitors to the Geology Day. On Friday, 24 June, and Saturday, 25 June, the courtyard at the CGS headquarters was filled with inquisitive guests who were able to gain an understanding of geological disciplines at individual booths and try out some practical activities. The Geology Day with the Czech Geological Survey attracted nearly 800 visitors!

Publishing and project activities

During 2022, the publishing house was engaged in the projects "CO₂-SPICER – CO₂ Storage Pilot in a Carbonate Reservoir" and "RENS – Rock Environment and Minerals". The main task of the publishing house's staff is to provide project publicity and promotional activities.



► An exhibition of photographs by Jan Novotný from the Czech Geological Survey entitled *Kavkaz, Andy a Himálaj objektivem geologických expedic* ("The Caucasus, Andes and Himalayas through the Lens of Geological Expeditions") was on view from May to September at the CGS Geological Bookstore.



► An exhibition of photographs by Vladimír Žáček from the Czech Geological Survey entitled *Z historie kladenských uhlen* ("From the History of Kladno's Coal Mines") was on display from September to the end of the year at the CGS Geological Bookstore. The images documented the now abandoned mines in Kladno and were taken in 1994–95.



► The Cotopaxi Expedition to the highest active volcano in the world took place in 1972 and included the world's first descent made to the bottom of this Ecuadorian volcano's crater by the expedition's members. The diverse goals of the Czechoslovak-Polish expedition, which were very exotic judged by the standards at that time, involved natural science, volcanology as well as ethnography. In 2018, the Czech Geological Survey published the book *Až na dno... Cotopaxi!* (*All the Way Down ... Cotopaxi!*) by Gabriela Zoubková and Miroslav Krůta, which colourfully depicts the expedition. On the occasion of the 50th anniversary of the Cotopaxi Expedition, a ceremonial meeting of the expedition members was held on 24 November at the Czech Geological Survey. The members recounted memories of the journey and geological mapping in Ecuador and subsequent volcanological research in Central America supported by the CGS at the event that was entitled *Proniknout do expedice Cotopaxi – dobýt nejvyšší vulkán světa* ("Joining the Cotopaxi Expedition – Conquering the World's Highest Volcano"). The guests were able to view an exhibition of photos from the expedition, which was launched by the Ambassador of the Republic of Poland to the Czech Republic, Mateusz Gniazdowski. The event was organized by Archiwum Nauki PAN i PAU (Archive of Sciences of the Polish Academy of Sciences and the Polish Academy of Arts and Sciences), Instytut Historii PAN (Institute of History of the Polish Academy of Sciences), and by the Masaryk Institute and Archives of the Czech Academy of Sciences in cooperation with the Czech Geological Survey.



Selected publications issued by the CGS

Books



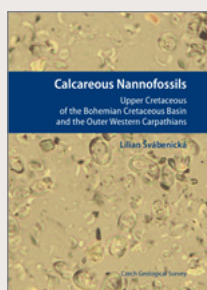
Stone Sculptures Adorning Twentieth-Century Buildings in Prague

Václav Rybařík



Across the Czech Republic with a Geologist

Zdeněk Kukal



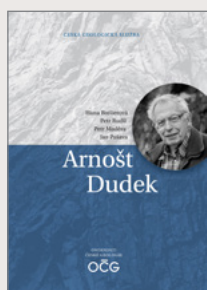
Calcareous Nannofossils. Upper Cretaceous of the Bohemian Cretaceous Basin and the Outer Western Carpathians

Liliana Švábenická



Personalities of Czech Geology: Zdeněk Kukal

Zdeněk Kukal Jr., Hana Breiterová, Petr Maděra *et al.*



Personalities of Czech Geology: Arnošt Dudek

Hana Breiterová, Petr Budil, Petr Maděra, Jan Pašava



Personalities of Czech Geology: Vladimír Prouza

Miroslav Coubal, Eva Riedlová, Jan Kolda

Calendar 2023



RENS – Calendar Dynamics in Geology

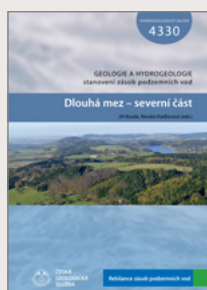


Review of Groundwater Resources

In 2010–2016, the Czech Geological Survey conducted 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.

The geological and hydrogeological conditions of evaluated hydrogeological zones were updated for 25% of the Czech Republic using modern and conventional methods including geophysical measurements, borehole surveys, determination of residence time in rocks, chemical analyses of groundwater and surface water, hydrological measurements, and so forth. The boundaries of the evaluated zones were also revised based on the research, including proposals for their possible modification.

In 2022, the Geology and Hydrogeology – Determination of Groundwater Resources edition included another publication of detailed evaluations of individual hydrogeological zones, which are planned until 2023.



Dlouhá mez – Northern Part (HG Zone 4330)

Jiří Burda,
Renata Kadlecová (Eds)



Cretaceous of the Roudnice Area (HG Zone 4530)

Iva Kůrková, Jiří Burda (Eds)



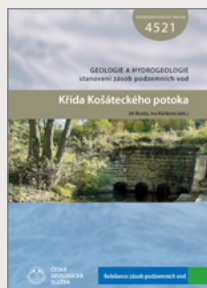
Cretaceous of the Velké Opatovice Area (HG Zone 4280)

Jiří Burda, Jiří Grundloch (Eds)



Coniacian of the Jizera River (HG Zone 4420)

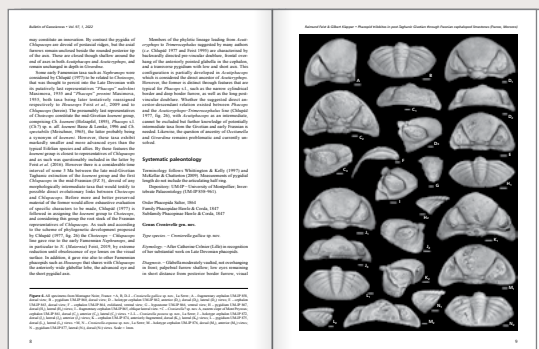
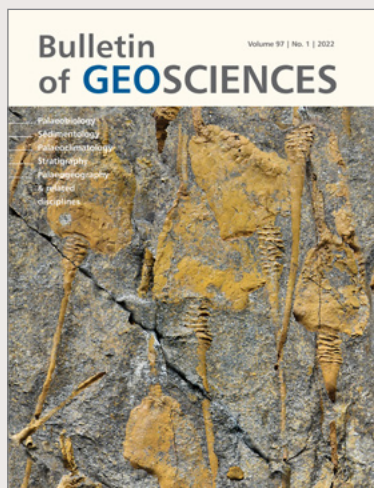
Iva Kůrková, Jiří Burda *et al.*



Cretaceous of the Košátecký Stream (HG Zone 4521)

Jiří Burda, Iva Kůrková *et al.*

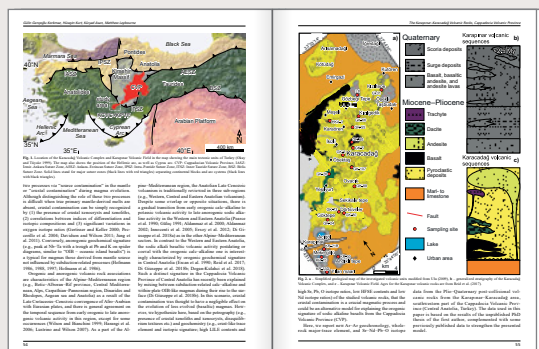
Periodicals



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.

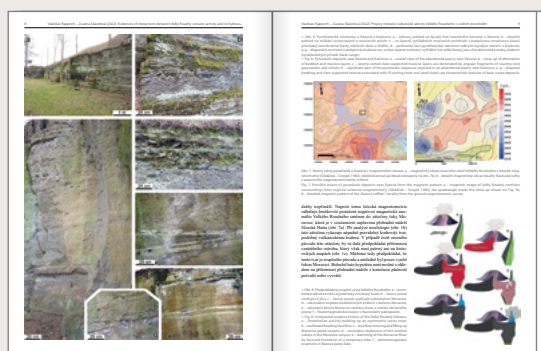
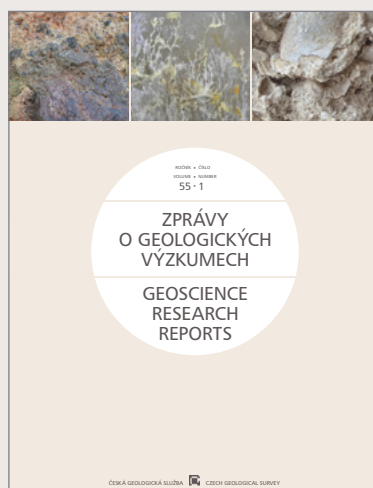
ISSN 1802-8225 (online), 1214-1119 (print)



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

(65th 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)

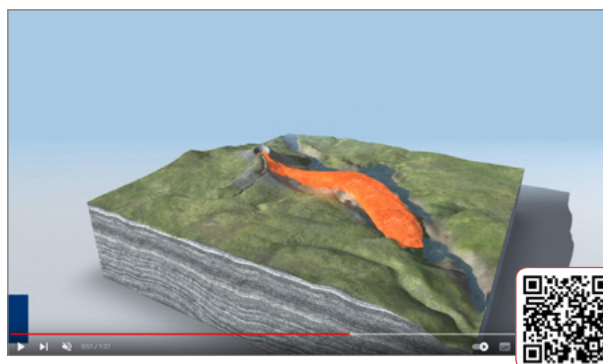


Svět geologie ("The World of Geology"), CGS Newsletter

The Czech Geological Survey produces, stores and provides impartial expert geological information to the state administration, private sector and public. It regularly informs of news involving the organization's activities on its website

and the CGS Annual Report. The *Svět geologie* quarterly also brings the most significant events and information involving the institute's activities as well as interesting geoscience facts. The magazine is free to download on the CGS website and intended primarily for electronic distribution.

Selected posts on YouTube YouTube^{CZ}



Velký Roudný – geological evolution

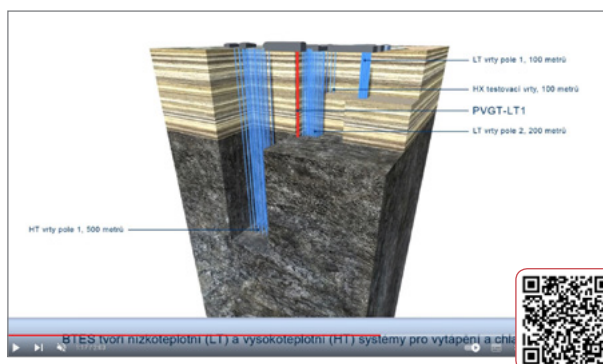
Although the highest concentration of remnants of volcanic activity in the Czech Republic is in the foothills of the Krušné hory Mts, the best-preserved volcano is located elsewhere - in the Nízký Jeseník Mts. It is Velký Roudný, one of the youngest volcanoes in the Czech Republic. Its cinder cone towers above the Slezská Harta Reservoir. Velký Roudný still has a well-preserved and morphologically visible asymmetric crater, which opens southeastward. Two lava flows gradually gushed out from the crater: first the Černý les lava flow followed by the Chřibský

les lava. The second-mentioned stream of lava flowed into the original canyon of the Moravice River, thereby damming it temporarily. Rootless eruptions occurred as water, trapped in the gravel beneath the hot lava flow, flashed to steam and exploded through the lava flow.



Groundwater contamination due to transport accidents

The animation shows how the rock environment influences the spread of contamination. Potential anthropogenic contamination represents a significant risk and threat to water sources in karst areas. Leaving aside local contamination (unauthorized landfills, leaks from factories and households), it mainly involves road tanker and rail tank car accidents. The transported contaminating fluids escape and spread rapidly in karst areas due to their “karstic permeability”.



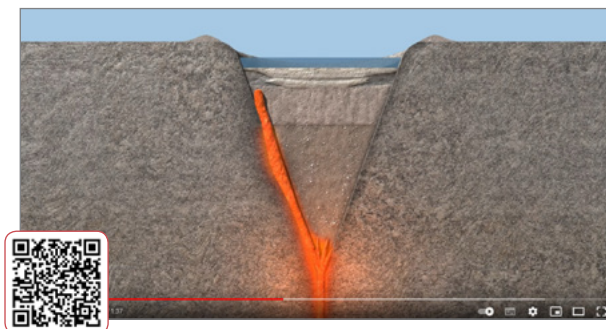
Geothermal Energy Development – SYNERGYS Project – Energy Synergy Systems

The animation presents the new strategic project SYNERGYS, which focuses on implementing new technologies for capturing the Earth's heat and storing energy in the rock environment. It briefly introduces an existing infrastructure, built on the site of the former barracks in Litoměřice, where the deepest geothermal exploration well with a depth of 2.1 km is located, which since 2019 serves as a seismic

monitoring well with a probe positioned 1.5 km beneath the surface. The animation also presents the SYNERGYS project itself and its key components: deep EGS wells and shallow BTES wells, used for energy storage and its reuse. The depths of the boreholes are drawn to scale and are also connected to a view of the entire barracks site, existing buildings and their use for the installation of energy sources (photovoltaics, hydrogen production, and so forth). The images show the presumed locations of individual borehole fields and their approximate extent, and the accompanying comments indicate the potential output of individual energy sources. The animation will be gradually fine-tuned as the project preparation progresses and as the final designs of individual technological units are completed. The project will be implemented in 2023–2027 and funded by the Operational Programme Just Transition – Ústí nad Labem Region.

Ztracený rybník and Bažina – geological evolution animation

Once in a while, a new volcano may be discovered in the Czech Republic even at the beginning of the 21st century. This is especially true of maars, which are explosion craters that do not create distinctive topographic features. A pair of such maars were recently discovered in West Bohemia near the village of Polná. While the activity in the case of the first crater, known as Ztracený rybník, ended with an explosion that created a maar crater, the second maar continued to be active. In the second crater, known as Bažina, additional portions of rising magma gradually formed three small pyroclastic cones stacked on top of one another. This volcanologically very interesting evolution of the small volcano was revealed due to a comprehensive geophysical exploration of the site and, particularly, due to two research wells drilled within the scope of the international ICDP programme.



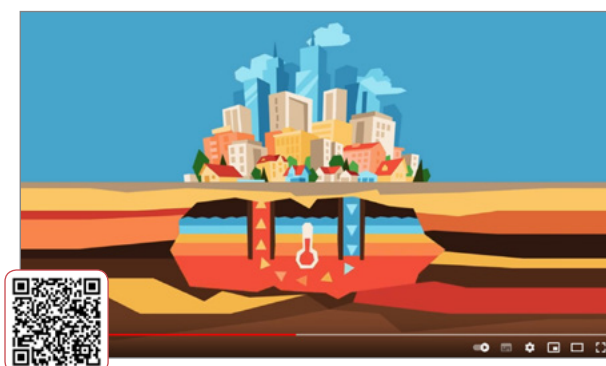
The National Parks of Costa Rica and their potential of becoming a UNESCO Global Geopark

The goal of the National Parks of Costa Rica project and their potential of becoming a UNESCO Global Geopark is to provide expert documents for the historically first UNESCO Geopark in Costa Rica, which is of great interest to the partner organization DGM (Dirección de Geología y Minas del MINAE – Ministerio de Ambiente y Energía). The project will follow the geological projects conducted in 1997–2019 in Central America, in Costa Rica as well as in Nicaragua and El Salvador. Focus will be placed on the national parks in Costa Rica, where protection measures include inanimate nature and where active volcanoes as well as non-volcanic areas occur. Based on obtained data, one national park will be recommended as a candidate for the UNESCO Global Geoparks network.



Urban geology

Urban geology aids urban planning, when land-use conflicts and hazards associated with unlicensed subsurface interventions may arise. Cooperation between geologists, urban planners, city officials and the public is beneficial for sustainable urban development, supports the readiness of cities for future challenges and, as a result, improves the living conditions of citizens. The video was co-produced by the Czech and Norwegian geological surveys during project 1379562019 funded by Norway Grants.



Caught your eye on Facebook



#geotipnavylet



January Bílá voda Stream

The Bílá voda Stream, which emerges in the central part of the Drahanská vrchovina Highland, disappears underground in a semi-blind valley near Holštejn in the north of the Moravian Karst, just a few hundred metres from the boundary of the Lower Carboniferous Protivanov Greywacke and the Middle to Upper Devonian Vilémov Limestone. The wide valley is dominated by a rock wall with the remains of a castle and the Lidomorna Cave,

which served as a prison during the castle's existence. The stream disappears into the Nová Rasovna Cave, which is spanned by a road bridge and which was used for the disposal of dead and sick animals. When this subsidence does not suffice during floods, the water fills the valley up to its end. Here, it disappears into the Stará Rasovna Sinkhole beneath a prominent rock face, following a cleavage in the limestone. The water that disappears into the limestone near Holštejn joins the Sloupský Stream underground and, like the Punkva River, flows through the unique Amatérská Cave system to the Punkva Cave, where it again emerges at the surface.



#geozajimavosti #geotipnavylet



February Nýznerov Waterfall

The waterfalls of Stříbrný Stream are located on the eastern slope of the Rychlebské hory Mts, about 5.5 km southwest of Žulová. The best known and most visited Nýznerov Waterfall created a roughly 100-metre-long rock gap just above the confluence with Bučinský Stream, through which it drops in a series of water cascades and waterfalls with a total height of about 14 metres. A staircase dating from the end of the 19th century provides access to the upper part of the gorge with

a spectacular waterfall plunging into a distinctive plunge basin. A few hundred metres upstream of the Bučinský Stream lies the lesser-known Bučinský Waterfall, whose highest cascade measures about 3.5 metres. The waterfalls formed on a metagabbro dyke several tens to hundreds of metres thick, which lies in the easily weathered schist and gneiss of the Staré Město Belt. Even though gabbro is a very resistant rock, the strength of geological processes is indicated by its intense slaty cleavage and folding along the dyke's edges. This can be clearly observed on the rocky outcrop beneath the bridge near the waterfalls.



#geotipnavylet



March Špičák u Střezivojic

Špičák u Střezivojic is a 16-metre-long and 13-metre-high rock formation. It is composed of Cretaceous coarse-grained quartz sandstone of the Jizera Formation of Turonian age. The rock tower is reinforced with reddish-brown to black-grey iron incrustations in the form of "rock roses", small ledges, box-like structures, bizarre circular formations and shrivelled wrinkles. It is one of the most beautiful formations of its kind in the Kokořínsko region.



April

Kámen a štětec ("Rock and Paintbrush")

Kámen a štětec ("Rock and Paintbrush") is a film about wandering through the countryside with painter Adam Kašpar, who is fascinated by rocks and geology. The Czech Geological Survey was also engaged in producing the film (not only) about the geology of the Jeseníky Mts.



#geoaktuality



May

Skalka u Velimi

Skalka u Velimi (Němečkův Quarry) was declared a natural monument in 1987. It is safeguarded because of its unusually rich occurrence of exceptionally preserved Mesozoic marine fauna. It is a former open pit quarry for amphibolite, which is currently partially flooded and partially used for storing and crushing granite. Coastal Cretaceous conglomerates, calcareous sandstones and bioclastic limestones occur in the pockets of underlying migmatites and paragneisses of the Kutná Hora Crystalline Complex. It is an exceptionally rich Cretaceous fossil site with isolated well-preserved marine animals – bivalves, bryozoa, brachiopods and others.



#geotipnavylet



June

Velká and Malá Buková hills

Velká and Malá Buková are two inconspicuous hills located between Ralsko and Mimoň off the beaten path in the former military area of Ralsko. They are worth visiting for this reason alone. As in the case of the surrounding landmarks Bezděz and Ralsko hills, these peaks also owe their origin to volcanic activity during the Neogene, when basalt magma penetrated the sedimentary rocks of the Bohemian Cretaceous Basin at the end of its journey from the Earth's mantle to the surface. Faintly distinct, nearly horizontal columns on an alkaline basalt rock just beneath the summit of Malá Buková Hill indicate that it is probably a short dyke. Far more attractive is the rock, which is slowly splitting off from the bedrock on the steep north-western slope above a path leading around the hill and which consists of alternating calcareous, clayey and quartz sandstones of the Jizera Formation of the Bohemian Cretaceous Basin. At first glance, the volcanic breccias with a chimney of massive lava that was partially excavated by small old quarries at the top of Velká Buková Hill are not very interesting, but they indicate that it is a volcanic conduit for magma. The peak is dominated by a massive Scots elm. Russian inscriptions on the surrounding trees remind us that Ukraine is not so far away. But the views of Ralsko Hill, Břehyňský Pond and Lake Mácha, Bezděz Hill or the Krkonoše Mts with spring remnants of snow make up for this unpleasant reminder.



#geotipnavylet



#geotipnavylet



July

Váté písky near Bzenec

Did you know that... an exposed strip of aeolian sand stretches along the railway line from Rohatka to the Bzenec–Přívoz railway station? It is 5.5 km long and sixty metres wide! A little further on, the air-borne sands are exposed in a former military training area. The strip of sand and training area are narrow. They are lined on both sides by a sparse pine forest, which was planted

here in regular rows to prevent the wind-blown sands from being driven further in the landscape. Nevertheless, a unique wilderness evolved here due to the fact that sand was deposited on the bottom of the Vienna Basin during the Upper Tertiary Period and also in the terraces of the Morava River during the Postglacial Epoch. Fine quartz sands were lifted and removed from the already dry sediments by prevailing winds, thereby forming low, flat dunes that are overgrown with grasses, bushes and trees, which tolerated the local acidic soil. The local sands are primarily fine grains of quartz, which have accumulated here to a thickness of up to thirty metres. This is an extraordinary geological phenomenon given the conditions in the Czech Republic. (Author: Assoc. Prof. Václav Ziegler)



#geozajimavosti #geotipnavylet



August

Paleorhyolite near Bohdánkov

In the past, paleorhyolite was mined as road aggregate in several quarries located northward and eastward of the small village of Bohdánkov, near Hodkovice nad Mohelkou. It was previously referred to as quartz porphyry and is of Permo-Carboniferous age. In addition to roads, it was used in construction and, for example, to build the Hodkovice train station building. Much younger lacustrine sediments (Peruc Member) of the Bohemian Cretaceous Basin were uncovered during quarrying in one of the former quarries. Rich Cenomanian flora of the subtropical climate, which prevailed in our latitude at that time, was discovered there.



#geoprojekty #geozajimavosti



September

Petroglyphs at the Khavtsgait site

One of the many occurrences of petroglyphs scattered throughout Central Asia is located at the northern margin of the Gurvan Saikhan mountain range, which dominates the South Gobi plains. The Khavtsgait site has the (dis)advantage of being on one of Mongolia's tourist routes. Therefore it is relatively easy

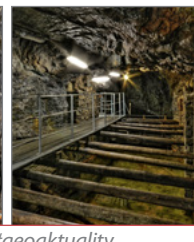
to get to, but on the other hand, the engravings suffer at the hands of contemporary imitators without an iota of talent and patience. In addition, you may likely not be alone to enjoy the local art of the Bronze Age. The area was already inhabited in the Stone Age thanks to springs, which are still used as irrigation for small agricultural production. The images are made by pecking away at the desert varnish on the fractured surfaces of massive Lower Paleozoic greywackes, which only rarely contain layers of fine-grained conglomerates. Hundreds of petroglyphs, mainly depicting wildlife, were created in 8000–3000 BC. The remarkable time span is indicated by the degree of preservation and style of the images.

The images show that the Gobi fauna has not changed much over thousands of years, just as its inhabitants' fascination with hunting and masculinity. But what exactly led prehistoric artists to climb high into the mountains and spend hours and days here pecking away at rocks will probably remain a mystery forever.



October Prokop Adit

Prokop Adit or Royal Hereditary Adit Prokop, sometimes also known as the Brokárna after the local mine and smelter, is located in the town of Stříbro in the Tachov District of the Plzeň Region. Mining activity in this locality was terminated in 1966.



#geoaktuality



November Babí lom Hill

Babí lom Hill is a rocky north-south oriented ridge located between Lelekovice and Svinošice, north of Brno. It is composed of Lower Devonian quartz conglomerates, which crop out in a steeply deposited tectonic slice separating two different zones of the Brno Massif. The ridge with an observation tower at its southern end is an attractive destination at any time and in any weather. Perhaps the most attractive period is in autumn, when mist fills the Brno Basin and highlights the landscape relief at the boundary of the Bohemian Massif and Carpathian Foredeep. In



#geotipnavylet

In the northwest, the dome-shaped Sýkoř Hill dominates the eastern part of the Bohemian-Moravian Highlands. The plateau of the Drahanská vrchovina Highland rises in the northeast and the pilgrimage church in Vranov appears in the east. Eye-catching columns of steam rise above the cooling towers of the Dukovany power plant to the southwest, and the most striking feature to the southeast is the karst plateau of Hády, reminiscent of a mesa. To its right one can make out the highest peaks of the White Carpathians. However, the most attractive view is from Brno to the Pavlovské vrchy Hills, roughly 50 km away. And under optimal conditions, once or twice a year, even the easternmost spur of the Alps appears behind the water tower in Kohoutovice.



December Ammonites in Hrubý Rohozec

Ammonites occur in a profile beneath Hrubý Rohozec Castle. Calcareous sandstones of the Jizera Formation of the Bohemian Cretaceous Basin are exposed throughout the beautiful canyon of the Jizera River from Malá Skála to the weir in Turnov. However, from Dolánky u Turnova to the Kotler garden in Turnov, entire rock walls of these sandstones rise along the Jizera River's right bank, part of which were selected as a stratotype of the Jizera Formation near Dolánky itself. Further on, this formation is also very well-developed, with all



#geotipnavylet #geoviteze

the stratotype attributes, best of all beneath Hrubý Rohozec Castle and in the Kotler garden in Turnov. The profile beneath Hrubý Rohozec Castle is located in a railway cut leading from Turnov to Malá Skála. The profile consists of a high wall, which is located right next to the railway line and in which Middle Turonian layers (Jizera Formation of the Bohemian Cretaceous Basin) crop out. It is an exceptionally well-preserved section of this formation, in which grey fine-grained calcareous sandstones to siltstones with irregular lenses of hard clayey-sandy limestones are exposed – everything belonging to the Middle Turonian of the Bohemian Cretaceous Basin, Jizera Formation. It is also a rich Middle Turonian fauna site. The ammonites *Lewesiceras peramplum*, *Scaphites geinitzi*, the nautiloids *Eutrophoceras sublaevigatus*, *Deltocymatoceras rugatus*, the sea urchins *Cardiaster anachytis*, *Micraster michelini*, *Hemiaster plebeius*, crayfish of the genus *Protocallianassa*, snails of the genera *Turritella*, *Leptomaria* as well as brachiopods, serpulidae, bryozoa, sponges and more were discovered here in addition to numerous bivalves. Large ammonite shells up to a metre in diameter, which can be viewed at the Museum of the Bohemian Paradise in Turnov and at the National Museum in Prague, and the stratigraphically significant bivalve *Inoceramus (Inoceramus) lamarcki* were found at the site as well.

(Author: Assoc. Prof. V. Ziegler)

Selected scientific papers

- ACKERMAN, L. – ŽÁK, J. – KACHLÍK, V. – SVOJTKA, M. – TOMEK, F. – SANTOLÍK, V. – SLÁMA, J. – TRUBAČ, J. – STRNAD, L. – VACEK, F. (2022): The diversity of sources of late Archean granites reflects a transition from plume-dominated to plate tectonics in the Superior Province, Canada. *Precambrian Research*, **370**.
- ACKERMAN, L. – ŽÁK, J. – ŽÁK, K. – PAŠAVA, J. – KACHLÍK, V. – HORA, J. – VESELOVSKÝ, F. – HAJNÁ, J. (2022): Carbon, oxygen, and strontium isotopic fingerprint in Neoproterozoic to early Cambrian limestones in an active margin setting: A record of local environment or global changes? *Precambrian Research*, **370**.
- ALTUNKAYNAK, S. – ALDANMAZ, E. – NÝVLT, D. (2022): Effects of mantle hybridization by interaction with slab derived melts in the genesis of alkaline lavas across the back-arc region of South Shetland subduction system. *Journal of Petrology*, **63**(11).
- ANDRONIKOV, A. V. – ANDRONIKOVA, I. E. – POUR, O. (2022): Major and trace-element chemistry of Cr-spinel in upper mantle xenoliths from East Antarctica. *Minerals*, **12**(6).
- ANDRONIKOV, A. V. – ANDRONIKOVA, I. E. – SEBEK, O. (2022): First data on isotope and trace element compositions of a *Xerocomus subtomentosus* mushroom sample from western Czech Republic. *Environmental Science and Pollution Research*, **29**(6), pp. 9369–9374.
- ARSLAN, M. – TEMIZEL, İ. – ACKERMAN, L. – YÜCEL, C. – YAZAR, E. A. (2022): Highly siderophile element and Os isotope systematics of the Cenozoic volcanic rocks from the Eastern Pontides, NE Turkey: Constraints on the origin and evolution of subcontinental mantle-derived magmas. *Lithos*, **410–411**.
- BATTISTI, M. A. – BITENCOURT, M. D. F. – SCHMITT, R. D. S. – NARDI, L. V. S. – MARTIL, M. M. D. – DE TONI, G. B. – PIMENTEL, M. M. – ARMSTRONG, R. – KONO-PÁSEK, J. (2022): Reconstruction of a volcano-sedimentary environment shared by the Porongos and Várzea do Capivarita complexes at 790 Ma, Dom Feliciano Belt, southern Brazil. *Precambrian Research*, **378**.
- BEK, J. – OPLUŠTIL, S. – DRÁBKOVÁ, J. (2022): Palynology of Late Pennsylvanian – Asselian strata of the Krkonoše-Piedmont Basin, Czech Republic. *International Journal of Coal Geology*, **263**.
- BEK, J. – ŠTORCH, P. – TONAROVÁ, P. – LIBERTÍN, M. (2022): Early Silurian (mid-Sheinwoodian) palynomorphs from the Loděnice-Špičatý vrch, Prague Basin, Czech Republic. *Bulletin of Geosciences*, **97**(3), pp. 385–396.
- BUBÍK, M. – ELBRA, T. – FRANČŮ, J. – KDÝR, Š. – SCHNABL, P. – ŠVÁBENICKÁ, L. (2022): Post-Cretaceous-Paleogene slumping in the Subsilesian Unit of the Outer Western Carpathians: Biostratigraphic, sedimentary and magnetic records from the Bystřice section. *Geologica Carpathica*, **73**(6), pp. 561–577.
- BURIÁNEK, D. – IVANOV, M. – JANDERKOVÁ, J. – PATZEL, M. (2022): Importance of accessory minerals for the vertical distribution of uranium and thorium in soil profiles: A case study of durbachite from the Třebíč Pluton (Czech Republic). *Catena*, **213**.
- BURIÁNEK, D. – SOEJONO, I. – SCHULMANN, K. – JANOUŠEK, V. – HANŽL, P. – ČÁP, P. – BOLD, U. – SVOJTKA, M. – COLLETT, S. – ŽÁČEK, V. (2022): Subduction-controlled temporal and spatial variations in early Palaeozoic sedimentary and volcanic record of the Mongol-Altai Domain. *Journal of Asian Earth Sciences*, **230**.
- BURSÁK, D. – DANIELISOVÁ, A. – MAGNA, T. – PAJDLA, P. – MÍKOVÁ, J. – RODOVSKÁ, Z. – STRNAD, L. – TRUBAČ, J. (2022): Archaeometric perspective on the emergence of brass north of the Alps around the turn of the Era. *Scientific Reports*, **12**(1).
- BUZEK, F. – ČEJKOVÁ, B. – JAČKOVÁ, I. – GERŠLOVÁ, E. – MACH, K. – LHOTKA, M. – ČUŘÍK, J. – VESELOVSKÝ, F. (2022): Secondary processes on coal deposits change the emission of greenhouse gases. *International Journal of Coal Geology*, **262**.
- COLLETT, S. – MAZUR, S. – SCHULMANN, K. – SOEJONO, I. (2022): Significance of a late Neoproterozoic – Early Cambrian southern Baltica active margin in late-stage Rodinian and early Gondwanan reconstructions. *Precambrian Research*, **383**.
- COLLETT, S. – SCHULMANN, K. – DEILLER, P. – ŠTÍPSKÁ, P. – PEŘESTÝ, V. – ULRICH, M. – JIANG, Y. – DE HOÏM DE MARIEN, L. – MÍKOVÁ, J. (2022): Reconstruction of the mid-Devonian HP-HT metamorphic event in the Bohemian Massif (European Variscan belt). *Geoscience Frontiers*, **13**(3).
- DECRÉE, S. – PAŠAVA, J. – BAELE, J. – MERCADIER, J. – RÖSEL, D. – FRIMMEL, H. (2022): In-situ trace element and Sr isotope signature of apatite: A new key to unravelling the genesis of polymetallic mineralisation in black shales of the Early Cambrian Niutitang Formation, Southern China. *Ore Geology Reviews*, **150**.
- ELLIS, B. S. – NEUKAMPF, J. – BACHMANN, O. – HARRIS, C. – FORNI, F. – MAGNA, T. – LAURENT, O. – ULMER, P. (2022): Biotite as a recorder of an exsolved Li-rich volatile phase in upper-crustal silicic magma reservoirs. *Geology*, **50**(4), pp. 481–485.
- EMBUI, V. F. – SUH, C. E. – LEHMANN, B. – ACKERMAN, L. (2022): Molybdenum isotopic composition of molybde-

- nite and the fertility potential of the Ekomédion U–Mo prospect, SW Cameroon. *Journal of Geosciences (Czech Republic)*, **67**(4), pp. 317–330.
- ERBAN KOCHERGINA, Y. V. – ERBAN, V. – HORA, J. M. (2022): Sample preparation and chromatographic separation for Sr, Nd, and Pb isotope analysis in geological, environmental, and archaeological samples. *Journal of Geosciences (Czech Republic)*, **67**(3), pp. 259–271.
 - ETTLER, V. – HLADÍKOVÁ, K. – MIHALJEVIČ, M. – DRAHOTA, P. – CULKA, A. – JEDLICKÁ, R. – KRÍBEK, B. – VÁNEK, A. – PENÍŽEK, V. – SRACEK, O. – BAGAI, Z. (2022): Contaminant binding and bioaccessibility in the dust from the Ni-Cu mining/smeltering district of Selebi-Phikwe (Botswana). *GeoHealth*, **6**(11).
 - ETTLER, V. – MIHALJEVIČ, M. – DRAHOTA, P. – KRÍBEK, B. – NYAMBE, I. – VÁNEK, A. – PENÍŽEK, V. – SRACEK, O. – NATHEROVÁ, V. (2022): Cobalt-bearing copper slags from Luanshya (Zambian Copperbelt): Mineralogy, geochemistry, and potential recovery of critical metals. *Journal of Geochemical Exploration*, **237**.
 - ETTLER, V. – MIHALJEVIČ, M. – STRNAD, L. – KRÍBEK, B. – HRSTKA, T. – KAMONA, F. – MAPANI, B. (2022): Gallium and germanium extraction and potential recovery from metallurgical slags. *Journal of Cleaner Production*, **379**.
 - FAIMON, J. – BALDÍK, V. – BURIÁNEK, D. – REZ, J. – ŠTELCL, J. – VŠIANSKÝ, D. – SEDLÁČEK, J. – DOSTALÍK, M. – NEČAS, J. – NOVOTNÝ, R. – HADACZ, R. – KRYŠTOFOVÁ, E. – NOVOTNÁ, J. – MÜLLER, P. – KRUMLOVÁ, H. – ČÁP, P. – FAKTOROVÁ, K. – MALÍK, J. – ROHÁČ, J. – KYCL, P. – JANDERKOVÁ, J. (2022): Historical ferrous slag induces modern environmental problems in the Moravian Karst (Czech Republic). *Science of the Total Environment*, **847**.
 - FAIMON, J. – BALDÍK, V. – KRYŠTOFOVÁ, E. – ŠTELCL, J. – REZ, J. (2022): Calcite raft formation in abandoned technical adit (Moravian Karst). *Applied Geochemistry*, **141**.
 - FATKA, O. – BUDIL, P. (2022): Contribution of August Heinrich Ernst Beyrich to the knowledge of Ordovician trilobites in the Czech Republic. *PalZ*, **96**(4), pp. 669–687.
 - FATKA, O. – BUDIL, P. – MIKULÁŠ, R. (2022): Healed injury in a nekto-benthic trilobite: “Octopus-like” predatory style in Middle Ordovician? *Geologia Croatica*, **75**(2), pp. 189–198.
 - FILIPPI, M. – ZANONI, D. – REBAY, G. – RODA, M. – REGORDA, A. – LARDEAUX, J. – SPALLA, M. I. (2022): Quantification of Alpine metamorphism in the Edolo Diabase, Central Southern Alps. *Geosciences (Switzerland)*, **12**(8).
 - FILIPPI, M. – ZHANG, Y. – MOTYČKA, Z. – ROWSELL, P. – HAVLÍČEK, D. – ZHANG, J. (2022): Identification and potential of newly emerging geoheritage karst areas south of Hanzhong, Central China. *Geoheritage*, **14**(4).
 - FÜGER, A. – KUESSNER, M. – ROLLION-BARD, C. – LEIS, A. – MAGNA, T. – DIETZEL, M. – MAVROMATIS, V. (2022): Effect of growth rate and pH on Li isotope fractionation during its incorporation in calcite. *Geochimica et Cosmochimica Acta*, **323**, pp. 276–290.
 - GERŠLOVÁ, E. – MEDVECKÁ, L. – JIRMAN, P. – NEHYBA, S. – OPLETAL, V. (2022): Source rock potential of the Miocene sedimentary rocks in the Carpathian Foredeep of the Czech Republic. *Geological Quarterly*, **66**(1).
 - HILL, G. J. – WANNAMAKER, P. E. – MARIS, V. – STODT, J. A. – KORDY, M. – UNSWORTH, M. J. – BEDROSIAN, P. A. – WALLIN, E. L. – UHLMANN, D. F. – OGAWA, Y. – KYLE, P. (2022): Trans-crustal structural control of CO₂-rich extensional magmatic systems revealed at Mount Erebus Antarctica. *Nature Communications*, **13**(1).
 - HOLUŠA, J. – NÝVLT, D. – WORONKO, B. – MATĚJKA, M. – STUHLÍK, R. (2022): Environmental factors controlling the Last Glacial multi-phase development of the Moravian Sahara dune field, Lower Moravian Basin, Central Europe. *Geomorphology*, **413**.
 - HROUDA, F. – FRANĚK, J. – GILDER, S. – CHADIMA, M. – JEŽEK, J. – MRÁZOVÁ, Š. – POŇAVIČ, M. – RACEK, M. (2022): Lattice preferred orientation of graphite determined by the anisotropy of out-of-phase magnetic susceptibility. *Journal of Structural Geology*, **154**.
 - HŮNOVÁ, I. – NOVÁK, M. – KURFÜRST, P. – ŠKÁCHOVÁ, H. – ŠTĚPÁNOVÁ, M. – PŘECHOVÁ, E. – KOMÁREK, A. – ČUŘÍK, J. – VESELOVSKÝ, F. – BOHDÁLKOVÁ, L. (2022): Contribution of rime to atmospheric sulphur deposition in Central Europe: A combined empirical and modelling approach. *Atmospheric Environment*, **270**.
 - JAKUBOVÁ, P. – KOTKOVÁ, J. – WIRTH, R. – ŠKODA, R. – HAIFLER, J. (2022): Morphology and Raman spectral parameters of Bohemian microdiamonds: implications to elastic geothermobarometry. *Journal of Geosciences (Czech Republic)*, **67**(3), pp. 239–257.
 - JANOUŠEK, V. – ERBAN KOCHERGINA, Y. V. – ANDRONIKOV, A. V. – KUSBACH, V. K. (2022): Decoupling of Mg from Sr–Nd isotopic compositions in Variscan subduction-related plutonic rocks from the Bohemian Massif: implications for mantle enrichment processes and genesis of orogenic ultrapotassic magmatic rocks. *International Journal of Earth Sciences*, **111**(5), pp. 1491–1518.
 - JIANG, Y. – ŠTÍPSKÁ, P. – SCHULMANN, K. – AGUILAR, C. – WANG, S. – ANCZKIEWICZ, R. – ZHANG, J. – LI, P. – CHOPIN, F. (2022): Barrovian and Buchan metamorphic series in the Chinese Altai: P–T–t–D evolution and tectonic implications. *Journal of Metamorphic Geology*, **40**(4), pp. 823–857.

- JOUHARI, M. – CHOPIN, F. – EL HOUICHA, M. – GHIEUNE, J. – SCHULMANN, K. – MÍKOVÁ, J. – CORSINI, M. (2022): U–Pb detrital zircon geochronology and source provenance in the Moroccan Meseta (Variscan belt): A perspective from the Rehamna massif. *Journal of African Earth Sciences*, **194**.
- KOFFI, A.Y. – THÉBAUD, N. – KOUAMELAN, A. N. – BARATOUX, L. – BRUGUIER, O. – VANDERHAEGHE, O. – PITRA, P. – KEMP, A. I. S. – EVANS, N. J. (2022): Archean to Paleoproterozoic crustal evolution in the Sassandra-Cavally domain (Côte d'Ivoire, West Africa): Insights from Hf and U–Pb zircon analyses. *Precambrian Research*, **382**.
- KONG, L. – JIANG, Y. – SCHULMANN, K. – ZHANG, J. – EINBERG, R. F. – SUN, M. – WANG, S. – SHU, T. – NING, J. (2022): Petrostructural and geochronological constraints on Devonian extension-shortening cycle in the Chinese Altai: Implications for retreating-advancing subduction. *Tectonics*, **41**(9).
- KŘÍBEK, B. – KNĚSL, I. – DOBEŠ, P. – VESELOVSKÝ, F. – POŘÁDEK, P. – ŠKODA, R. – ČOPJAKOVÁ, R. – LEICHMANN, J. – KOŠEK, F. (2022): The origin of synchysite-(Ce) and sources of rare earth elements in the Rožná uranium deposit, Czech Republic. *Minerals*, **12**(6).
- KRÝZA, O. – ZÁVADA, P. – SHU, T. – SEMERÁD, J. (2022): Modes and geometry of crustal-scale detachment folding in hot orogens – Insights from physical modeling. *Frontiers in Earth Science*, **10**.
- KUBEŠ, M. – LEICHMANN, J. – BURIÁNEK, D. – HOLÁ, M. – NAVRÁTIL, P. – SCAILLET, S. – O'SULLIVAN, P. (2022): Highly evolved miaskitic syenites deciphering the origin and nature of enriched mantle source of ultrapotassic magmatism in the Variscan orogenic root (Bohemian Massif, Moldanubian Zone). *Lithos*, **432–433**.
- KUBEŠ, M. – LEICHMANN, J. – KOTKOVÁ, J. – ČOPJAKOVÁ, R. – HOLÁ, M. – SLÁMA, J. (2022): Diversity of origin and geodynamic evolution of the mantle beneath the Variscan Orogen indicating rapid exhumation within subduction-related mélange (Moldanubian Zone, Bohemian Massif). *Lithos*, **422–423**.
- LEHMANN, B., – PAŠAVA, J. – ŠEBEK, O. – ANDRONIKOV, A. – FREI, R. – XU, L. – MAO, J. (2022): Early Cambrian highly metalliferous black shale in South China: Cu and Zn isotopes and a short review of other non-traditional stable isotopes. *Mineralium Deposita*, **57**(7), pp. 1167–1187.
- LI, R. – AO, S. – XIAO, W. – SCHULMANN, K. – MAO, Q. – SONG, D. – TAN, Z. – WANG, H. – BHANDARI, S. (2022): Tectonic juxtaposition of two independent Paleoproterozoic arcs by Cenozoic duplexing in the Arun Tectonic Window of the Eastern Nepalese Himalaya. *Frontiers in Earth Science*, **10**.
- MACHEK, M. – SOEJONO, I. – SLÁMA, J. – ŽÁČKOVÁ, E. (2022): Timing and kinematics of the Variscan orogenic cycle at the Moldanubian periphery of the central Bohemian Massif. *Journal of the Geological Society*, **179**(3).
- MAHMMUD, R. – SRACEK, O. – MUSTAFA, O. – ČEJKOVÁ, B. – JAČKOVÁ, I. – VONDROVICOVÁ, L. (2022): Groundwater geochemistry evolution and geogenic contaminants in the Sulaimani-Warmawa Sub-basin, Sulaimani, Kurdistan Region, Iraq. *Environmental Monitoring and Assessment*, **194**(5).
- MAJZLAN, J. – KIEFER, S. – LILOVA, K. – SUBRAMANI, T. – NAVROTSKY, A. – TUHÝ, M. – VYMAZALOVÁ, A. – CHAREEV, D. A. – DACHS, E. – BENISEK, A. (2022): Calorimetric study of skutterudite (CoAs_{2.92}) and heazlewoodite (Ni₃S₂). *American Mineralogist*, **107**(12), pp. 2219–2225.
- MANZOTTI, P. – SCHIAVI, F. – NOSENZO, F. – PITRA, P. – BALLÈVRE, M. (2022): A journey towards the forbidden zone: a new, cold, UHP unit in the Dora-Maira Massif (Western Alps). *Contributions to Mineralogy and Petrology*, **177**(6).
- MATÝSEK, D. – SKUPIEN, P. – BUBÍK, M. – JIRÁSEK, J. – ŠKODA, R. (2022): Multi-stage alteration history of volcanic clasts containing buddigtonite from Upper Cretaceous strata of the Subsilesian Unit, Czech part of the Outer Flysch Carpathians. *Mineralogy and Petrology*, **116**(6), pp. 429–441.
- NEUKAMPF, J. – LAURENT, O. – TOLLAN, P. – BOUVIER, A. – MAGNA, T. – ULMER, P. – FRANCE, L. – ELLIS, B. S. – BACHMANN, O. (2022): Degassing from magma reservoir to eruption in silicic systems: The Li elemental and isotopic record from rhyolitic melt inclusions and host quartz in a Yellowstone rhyolite. *Geochimica et Cosmochimica Acta*, **326**, pp. 56–76.
- NOVAK, M. – ANDRONIKOV, A. V. – SEBEK, O. – KOTKOVA, J. – ERBAN KOCHERGINA, Y. V. – STEPANOVA, M. – STRNAD, L. – KRAM, P. – ARKAS, J. – VESELOVSKÝ, F. – EDRA, V. – CURIK, J. – CHRASTNY, V. – PRECHOVA, E. – HOUSKOVA, M. (2022): Chromium isotope systematics in three mantle-derived domains of Central European Variscides: Relationship between $\delta^{53}\text{Cr}$ values and progressive weathering of serpentinized ultramafic rocks. *Chemical Geology*, **604**.
- OKRUGIN, V. M. – VYMAZALOVÁ, A. – KOZLOV, V. V. – LAUFEK, F. – STANLEY, C. J. – SHKILEV, I. A. (2022): Svetlanaite, SnSe, a new mineral from the Ozerovskoe deposit, Kamchatka peninsula, Russia. *Mineralogical Magazine*, **86**(2), pp. 234–242.
- OPLUŠTIL, S. – ŠIMŮNEK, Z. – MENCL, V. (2022): Macroflora of the Krkonoše-Piedmont Basin (Pennsylvanian–early Permian); Bohemian Massif, Czech Republic. *Review of Palaeobotany and Palynology*, **303**.

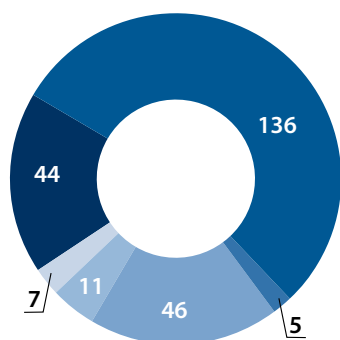
- OSAFO, N. O. – JAN, J. – VALERO, A. – PORCAL, P. – PETRASH, D. A. – BOROVEC, J. (2022): Organic matter character as a critical factor determining the fate and stability of its association with iron in sediments. *Journal of Soils and Sediments*, **22**(6), pp. 1865–1875.
- OULEHLE, F. – ŠTĚPÁNEK, P. – TRNKA, M. – URBAN, O. – HRUŠKA, J. (2022): Changes in forest nitrogen cycling across deposition gradient revealed by $\delta^{15}\text{N}$ in tree rings. *Environmental Pollution*, **304**.
- PERCIVAL, J. J. – KONOPÁSEK, J. – ANCZKIEWICZ, R. – GANERØD, M. – SLÁMA, J. – DE CAMPOS, R. S. – BITEN-COURT, M. D. F. (2022): Tectono-metamorphic evolution of the northern Dom Feliciano Belt Foreland, Santa Catarina, Brazil: implications for models of subduction-driven orogenesis. *Tectonics*, **41**(2).
- PETRASH, D. A. – STEENBERGEN, I. M. – VALERO, A. – MEADOR, T. B. – PACES, T. – THOMAZO, C. (2022): Aqueous system-level processes and prokaryote assemblages in the ferruginous and sulfate-rich bottom waters of a post-mining lake. *Biogeosciences*, **19**(6), pp. 1723–1751.
- PLINT, A. G. – ULIČNÝ, D. – ČECH, S. – WALASZCZYK, I. – GRÖCKE, D. R. – LAURIN, J. – HANK, J. A. – JARVIS, I. (2022): Trans-Atlantic correlation of Late Cretaceous high-frequency sea-level cycles. *Earth and Planetary Science Letters*, **578**.
- POLECHOVÁ, M. (2022): The bivalve fauna from the Letná Formation (Upper Ordovician) of Bohemia: Significance for palaeobiogeography, palaeoecology and diversification of bivalves. *Geobios*, **70**, pp. 55–73.
- RIFL, M. – VACEK, F. – HOLCOVÁ, K. (2022): Microboring variability in bioclasts from a carbonate platform and a mixed carbonate ramp: Paleoenvironmental implications (Upper Triassic, Slovenia). *Marine Micropaleontology*, **170**.
- SANITÀ, E. – DI ROSA, M. – LARDEAUX, J. M. – MARRONI, M. – PANDOLFI, L. (2022): Metamorphic peak estimates of the Marguareis Unit (Briançonnais Domain): New constraints for the tectonic evolution of the south-western Alps. *Terra Nova*, **34**(4), pp. 305–313.
- SANITÀ, E. – DI ROSA, M. – LARDEAUX, J. – MARRONI, M. – PANDOLFI, L. (2022): The Moglio-Testico Unit (Ligurian Alps, Italy) as subducted metamorphic oceanic fragment: Stratigraphic, structural and metamorphic constraints. *Minerals*, **12**(11).
- SANITÀ, E. – LARDEAUX, J. – MARRONI, M. – PANDOLFI, L. (2022): Kinematics of the Helminthoid Flysch-Marguareis Unit tectonic coupling: consequences for the tectonic evolution of Western Ligurian Alps. *Comptes Rendus – Geoscience*, **354**, pp. 141–157.
- SCHÖPFER, K. – NÁDASKAY, R. – MARTÍNEK, K. (2022): Evaluation of climatic and tectonic imprints in fluvial successions of an Early Permian depositional system (Asselian Vrchlabí Formation, Krkonoše Piedmont Basin, Czech Republic). *Journal of Sedimentary Research*, **92**(3), pp. 275–303.
- SCHULMANN, K. – EDEL, J. – MARTÍNEZ CATALÁN, J. R. – MAZUR, S. – GUY, A. – LARDEAUX, J. – AYARZA, P. – PALOMERAS, I. (2022): Tectonic evolution and global crustal architecture of the European Variscan belt constrained by geophysical data. *Earth-Science Reviews*, **234**.
- SEJKORA, J. – ŽÁČEK, V. – ŠKODA, R. – LAUFEK, F. – DOLNÍČEK, Z. (2022): Radvaniceite, GeS_2 , a new germanium sulphide, from the Kateřina Mine, Radvanice near Trutnov, Czech Republic. *Minerals*, **12**(2).
- ŠIMŮNEK, Z. – CLEAL, C. J. (2022): The last lavezineopterid – The systematic and floristic relationships of *Laveineopteris nervosa* (Medullosales) from the Stephanian of the Czech Republic. *Review of Palaeobotany and Palynology*, **304**.
- ŠIMŮNEK, Z. – PLOCH, I. (2022): New flora from the Permian of the Intracrustal Basin, Polan. *Geologia Croatica*, **75**(2), pp. 199–209.
- SKÁCELOVÁ, Z. – MLČOCH, B. – ČECH, S. (2022): Geological interpretation of a seismic reflection profile in the eastpart of the Bohemian Cretaceous Basin. *Journal of Geosciences (Czech Republic)*, **67**(1), pp. 1–17.
- SOEJONO, I. – SCHULMANN, K. – SLÁMA, J. – HRDLIČKOVÁ, K. – HANŽL, P. – KONOPÁSEK, J. – COLLETT, S. – MÍKOVÁ, J. (2022): Pre-collisional crustal evolution of the European Variscan periphery: Constraints from detrital zircon U–Pb ages and Hf isotopic record in the Precambrian metasedimentary basement of the Brunovistulian Domain. *Precambrian Research*, **372**.
- SOLDNER, J. – YUAN, C. – SCHULMANN, K. – JIANG, Y. – ŠTÍPSKÁ, P. – ZHANG, Y. – HUANG, Z. – WANG, X. (2022): Early Paleozoic Cascadia-type active-margin evolution of the Dunhuang block (NW China): Geochemical and geochronological constraints. *Bulletin of the Geological Society of America*, **134**(9–10), pp. 2503–2530.
- SPROSON, A. D. – POGGE VON STRANDMANN, P. A. E. – SELBY, D. – JAROCHOWSKA, E. – FRÝDA, J. – HLADIL, J. – LOYDELL, D. K. – SLAVÍK, L. – ALNER, M. – MAIER, G. – MUNNECKE, A. – LENTON, T. M. (2022): Osmium and lithium isotope evidence for weathering feedbacks linked to orbitally paced organic carbon burial and Silurian glaciations. *Earth and Planetary Science Letters*, **577**.
- SUKHBAATAR, T. – LEXA, O. – SCHULMANN, K. – GUILAR, C. – ŠTÍPSKÁ, P. – WONG, J. – JIANG, Y. – MÍKOVÁ, J. – ZHAO, D. (2022): Paleozoic geodynamics and architecture of the Southern Part of the Mongolian Altai Zone. *Tectonics*, **41**(8).

- TOLSTYKH, N. D. – TUHÝ, M. – VYMAZALOVÁ, A. – LAUFEK, F. – PLÁŠIL, J. – KOŠEK, F. (2022): Gachingite, $\text{Au}(\text{Te}_{1-x}\text{Se}_x)$; $0.2 \approx x \leq 0.5$, a new mineral from Maletoyvayam deposit, Kamchatka peninsula, Russia. *Mineralogical Magazine*, **86**(2), pp. 205–213.
- TOMEK, F. – OPLUŠTIL, S. – SVOJTKA, M. – ŠPILLAR, V. – RAPPRICH, V. – MÍKOVÁ, J. (2022): Altenberg–Teplice Caldera sourced Westphalian fall tuffs in the central and western Bohemian Carboniferous basins (eastern Variscan belt). *International Geology Review*, **64**(4), pp. 441–468.
- TONKACHEEV, D. – VIKENTYEV, I. – VYMAZALOVA, A. – MERKULOVA, M. – TRIGUB, A. – KOVALCHUK, E. – MAKEYEV, A. – OSADCHII, V. (2022): The chemical state of Hg in synthetic crystals of zinc and mercury sulfides studied by XAFS spectroscopy. *Journal of Solid State Chemistry*, **305**.
- TREML, V. – TUMAJER, J. – JANDOVÁ, K. – OULEHLE, F. – RYDVAL, M. – ČADA, V. – TREYDTE, K. – MAŠEK, J. – VONDROVICOVÁ, L. – LHOTÁKOVÁ, Z. – SVOBODA, M. (2022): Increasing water-use efficiency mediates effects of atmospheric carbon, sulfur, and nitrogen on growth variability of central European conifers. *Science of the Total Environment*, **838**.
- TVRDÝ, J. – PLÁŠIL, J. – VRTIŠKA, L. – SEJKORA, J. – ŠKODA, R. – DOLNÍČEK, Z. – PETR, M. – VESELOVSKÝ, F. (2022): Ferroberaunite, $\text{Fe}^{2+}\text{Fe}^{3+}(\text{PO}_4)_4(\text{OH})_5 \cdot 6\text{H}_2\text{O}$, a mixed-valence iron member of the beraunite series, from the Gravel Hill mine, Perranzabuloe, Cornwall, England. *Mineralogical Magazine*, **86**(3), pp. 363–372.
- VALERO, A. – JAN, J. – PETRASH, D. A. (2022): Anaerobic dissolved As(III) removal from metal-polluted waters by cathode-stabilized Fe(III)-oxyhydroxides. *Environmental Science: Water Research and Technology*, **9**(2), pp. 454–466.
- VAN ROY, P. – RAK, S. – BUDIL, P. – FATKA, O. (2022): Redescription of the cheloniellid euarthropod *Triopus draboviensis* from the Upper Ordovician of Bohemia, with comments on the affinities of *Parioscorpio venator*. *Geological Magazine*, **159**(9), pp. 1471–1489.
- VAN WYK DE VRIES, B. – KARATSON, D. – GOUARD, C. – KAROLY, N. – RAPPRICH, V. – AYDAR, E. (2022): Inverted volcanic relief: Its importance in illustrating geological change and its geoheritage potential. *International Journal of Geoheritage and Parks*, **10**(1), pp. 47–83.
- VILHELM, J. – FISCHER, T. – ALEXA, M. – VALENTA, J. (2022): Non-linear stacking of signals using generalized average of complex numbers. *Measurement: Journal of the International Measurement Confederation*, **202**.
- VLČEK, T. – KOVÁČOVÁ, M. – ŠARINOVÁ, K. – RYBÁR, S. – HUDÁČKOVÁ, N. – RUMAN, A. – JAMRICH, M. – FRANČŮ, J. (2022): Multiproxy constraints on Central Paratethys Sea and Lake Pannon paleoclimate and paleoenvironment transitions during the Middle-Late Miocene (Danube Basin, Slovakia). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **600**.
- VODRÁŽKOVÁ, S. – KUMPAN, T. – VODRÁŽKA, R. – FRÝDA, J. – ČOPJAKOVÁ, R. – KOUBOVÁ, M. – MUNNECKE, A. – KALVODA, J. – HOLÁ, M. (2022): Ferruginous coated grains of microbial origin from the Lower Devonian (Pragian) of the Prague Basin (Czech Republic) – Petrological and geochemical perspective. *Edimentary Geology*, **438**.
- VRTIŠKA, L. – TVRDÝ, J. – PLÁŠIL, J. – SEJKORA, J. – ŠKODA, R. – CHUKANOV, N. V. – MASSANEK, A. – FILIP, J. – DOLNÍČEK, Z. – VESELOVSKÝ, F. (2022): Redefinition of beraunite, $\text{Fe}^{3+}_6(\text{PO}_4)_4\text{O}(\text{OH})_4 \cdot 6\text{H}_2\text{O}$, and discreditation of the name eleonorite: a re-investigation of type material from the Hrbek Mine (Czech Republic). *European Journal of Mineralogy*, **34**(2), pp. 223–238.
- VYMAZALOVÁ, A. – WELCH, M. D. – LAUFEK, F. – KOZLOV, V. V. – STANLEY, C. J. – PLÁŠIL, J. (2022): Sluzhenikinite, $\text{Pd}_{15}(\text{Sb}_{7-x}\text{Sn}_x)$; $3 \leq x \leq 4$, a new platinum group mineral (PGM) from the Oktyabrsk deposit, the Norilsk deposits, Russia. *Mineralogical Magazine*, **86**(4), pp. 577–585.
- WALASZCZYK, I. – ČECH, S. – CRAMPTON, J. S. – DUBICKA, Z. – IFRIM, C. – JARVIS, I. – KENNEDY, W. J. – LEES, J. A. – LODOWSKI, D. – PEARCE, M. – PERYT, D. – SAGEMAN, B. B. – SCHIÖLER, P. – TODES, J. – ULIČNÝ, D. – VOIGT, S. – WIESE, F. – LINNERT, C. – PÜTTMANN, T. – TOSHIMITSU, S. (2022): The Global Boundary Stratotype Section and Point (GSSP) for the base of the Coniacian Stage (Salzgitter-Salder, Germany) and its auxiliary sections (Ślupia Nadbrzeżna, central Poland; Střeleč, Czech Republic; and El Rosario, NE Mexico). *Episodes*, **45**(2), pp. 181–220.
- WERTICH, V. – KUBEŠ, M. – LEICHMANN, J. – HOLÁ, M. – HAIFLER, J. – MOZOLA, J. – HRŠELOVÁ, P. – JAROŠ, M. (2022): Trace element signatures of uraninite controlled by fluid-rock interactions: A case study from the Eastern Moldanubicum (Bohemian Massif). *Journal of Geochemical Exploration*, **243**.
- XIAO, W. – ŞENGÖR, A. M. C. – SELTMANN, R. – SCHULMANN, K. – LIN, S. – DILEK, Y. (2022): Altaids and accretionary orogenesis: preface. *International Journal of Earth Sciences*, **111**(8), pp. 2445–2448.
- ŽÁČEK, V. – ŠKODA, R. – LAUFEK, F. – SEJKORA, J. – HAIFLER, J. (2022): Pertoldite, trigonal GeO_2 , the germanium analogue of α -quartz: a new mineral from Radvanice, Czech Republic. *Journal of Geosciences (Czech Republic)*, **67**(3), pp. 229–237.

- ZAJÍCOVÁ, K. – CHUMAN, T. (2022): O and A soil horizons' boundaries detection using GPR under variable soil moisture conditions. *Geoderma*, **422**.
- ZHANG, F. – FRÝDA, J. – FAKHRAEE, M. – LIN, Y. – WEI, G. – CAO, M. – LI, N. – ZHOU, J. – FRÝDOVÁ, B. – WEI, H. – SHEN, S. (2022): Marine anoxia as a trigger for the largest Phanerozoic positive carbon isotope excursion:

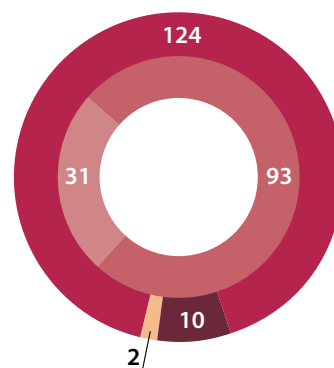
Evidence from carbonate barium isotope record. *Earth and Planetary Science Letters*, **584**.

- ZUO, J. – WEBB, A. A. G. – CHIN, E. J. – ACKERMAN, L. – HARVEY, J. – HAPROFF, P. J. – MÜLLER, T. – WANG, Q. – HICKMAN, A. H. – SORGER, D. – RAMÍREZ-SALAZAR, A. (2022): Earth's earliest Phaneritic ultramafic rocks: mantle slices or crustal cumulates? *Geochemistry, Geophysics, Geosystems*, **23**(12).



CGS publishing activities in 2022

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

Financial review for 2022

In 2022, the total expenditures and total income of the Czech Geological Survey amounted to CZK 460,059,000 and CZK 461,573,000, respectively.

Total expenditures of the organization

Total expenditures (CZK)	460,059,254
Material and power consumption	16,166,697
Services	78,490,083
Total personnel cost	289,357,758
Depreciation of tangible and intangible assets	24,428,493
Other expenses	51,616,223,

Total income of the organization

Total income (CZK)	461,573,558
Sales and other own-source revenue	72,365,019
Allocation for activities of the organization	97,316,000
Institutional funding for development of research organizations	117,698,745
Funds for projects and commissioned services	161,826,523
Income from transfers	12,367,271



Zdeněk Cilc

Deputy Director for Economics
and Head of the Economic Division

In 2022, the CGS reached a positive financial balance of CZK 1,514,000, of which CZK +1,125,000 represented primary activities and CZK +389,000 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 72,365,000, of which the largest portion of revenues came from the sale of accounting entry 602 services (mainly contracts) in the amount of CZK 26,810,000, and additional revenue from accounting entry 649 activities (mainly overhead costs from projects and contracts) in the amount of CZK 36,923,000, and from drawing on accounting entry 648 funds (remuneration fund and property reproduction fund) in the amount of CZK 4,499,000. The year-on-year difference in profit (– CZK 7,473,000) was due, among other things, to a postponement of funding for the “Groundwater in Crystalline Rocks” project (starting in 2023 from the Operational Programme Environment), to a reduction in contracted work for the Diamo state enterprise, and due to an increase in labour costs (rates) in 2022.

The organization's total revenue, 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 364,258,000 and account for 79% of the total revenue.

The overall financial balance ensured sufficient revenue to cover the expenditures of the Czech Geological Survey and its continuing development. Total personnel cost in the amount of CZK 289,358,000 increased by CZK 17,298,000 year-on-year (of which CZK 6,046,000 was due to an increase in rates as of 1 September 2022), and investments in 2022 included the necessary purchase of upgraded equipment by the Czech Geological Survey amounting to a total of CZK 28,490,000.

With its results in science and research in 2022, 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 117,699,000. In 2022, the Czech Geological Survey successfully carried out international projects (such as Horizon 2020, Norwegian projects, projects of the EU's European Commission, and so forth) and foreign development projects as well.

The financial results from 2022 as well as from previous years form a solid basis for the organization's continuing existence and development for carrying out the state geological survey's tasks, science and research projects, and for providing services to various state authorities, local governments and the public.



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 language, legal and economic courses and seminars, 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 confirmed 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 PhD study programmes.

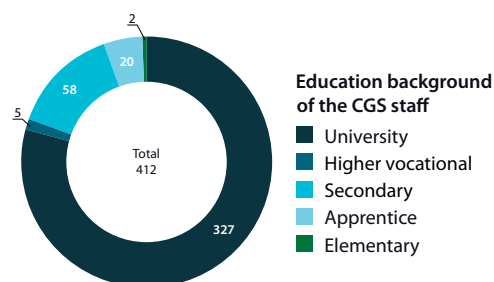
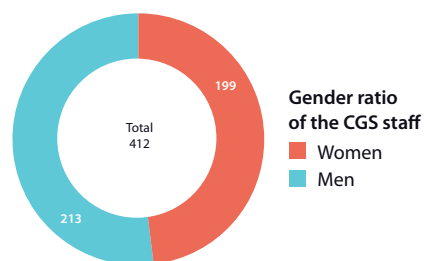
In 2022, the CGS commissioned an external team of experts to prepare an equal opportunity audit, which addressed a wide range of topics related to equal opportunity and gender equality in the workplace – for example, work team diversity, career growth, negative workplace behaviour including sexual harassment, development and training, remuneration and evaluation, or reconciling work and personal life.

A Gender Equality Plan (GEP) for 2022–2025 was prepared based on the audit and is intended to develop a high-quality personnel policy with regard to education, science and research as well as employee care.

In this way, the CGS strives to create an open, tolerant and respectful environment that excludes any form of discrimination, whether based on gender or other differences. These are binding values at the national, European and international level, which the Czech Geological Survey acknowledges.

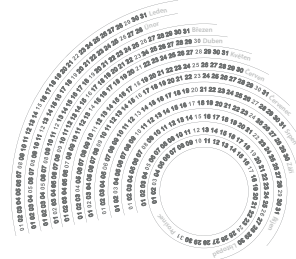
Human resources

In 2022, the Czech Geological Survey had 412 employees, including those on maternity and parental leave. The full-time equivalent amounted to 351.21, numbering 199 women and 213 men.



Principal events in 2022

(listed by date of publication on the CGS website)



Czech geologists participated in a study of ancient brass artifacts

26 January 2022

Together with the staff of the Institute of Archeology (IAP) of the Czech Academy of Sciences, the Czech Geological Survey specialists Tomáš Magna, Jitka Míková and Zuzana Rodovská participated in a study of ancient brass artefacts discovered in the Czech Republic. According to Daniel Bursák from the IAP, it was possible to link the objects to ore deposits in the Western Mediterranean region or in France's Massif Central, thereby also providing proof of contact between the Roman Empire and the Germanic tribes that inhabited the territory of the Czech Republic. The Czech geologists were engaged in leading a team that conducted a chemical analysis of the discovered objects. The study's results were

published in the *Scientific Reports* journal. A link to the article with detailed information, published on ČT 24, is attached below.

Author: Klára Froňková



Brass discovered in Czech territory is of Roman origin, providing proof of an interconnected ancient world – article on ČT 24 (online).



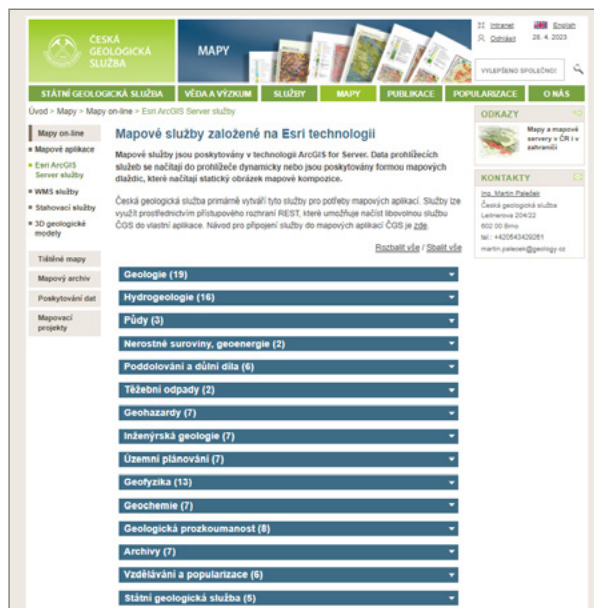
Quarry Inventories (1932–1962) published as a map service

8 February 2022

Based on a contract with the Jan Evangelista Purkyně University in Ústí nad Labem, the Czech Geological Survey published the "Quarry Inventories (1932–1962)" map application. They are digitized map entries depicting the locations of construction mineral mining sites (quarries, sand pits, loam pits) from accompanying maps to these publications. The digitized maps were an output of the bachelor's thesis by Peterková, M.T. (2015): Digitization of Quarry Inventories of the Czechoslovak Republic/Czechoslovak Socialist Republic. Bachelor's thesis, Faculty of the Environment, Jan Evangelista Purkyně University, 56 pages, supervisor: Ing. R. Pokorný.

The data provide an overview of the location of sites and their basic characteristics at the time of their inventory. As far as the accuracy of the digitized 1:75,000 scale map scans is concerned, they can still be used today as a valuable archive source for geological mapping, environmental analysis or historical socioeconomic links. The CGS plans to supplement the published data with additional information. You can find the application in the CGS map services directory at: <http://www.geology.cz/extranet/mapy/mapy-online/esri> Or you can add it to any CGS map application or GIS software from the following address: https://mapy.geology.cz/arcgis/rest/services/Dulni_Dila/soupis_y_lomu/MapServer Metadata record link: <https://micka.geology.cz/record/basic/61f14c2a-bb2c-4a35-ae9a-21920a010852>

Author: Otmar Petyniak



Map services based on Esri technology



Report on the status of geological CO₂ storage in Europe

7 March 2022



The CO2GeoNet Association, of which the Czech Geological Survey is also a member, organized a webinar on 21 February 2022 to present a report on the status of geological storage of CO₂ in Europe. The report contains the latest information on the current knowledge regarding storage potential and the status of research, pilot and demonstration projects, legislation, and general conditions for CCS technology development in 32 European countries. The main advantage of the report is the fact that it relies on information provided directly by the association's individual member institutes and other allied organizations based directly in individual countries. The entire report contains more than 300 pages, two-thirds of which include an appendix with a detailed description of the situation in individual countries. A video recording of the webinar is available on the CO2GeoNet website.

Author: Vít Hladík



[Link to the report](#)



The “Geological Service for Europe” project was successfully evaluated by the European Commission

28 April 2022



The “Geological Service for Europe” project proposal, submitted during last year’s call of the Horizon Europe programme, successfully passed the European Commission’s evaluation process and initiated the grant preparation agreement phase. The project preparation is coordinated by EuroGeoSurveys, the association of European geological surveys, and the Czech Geological Survey will participate in the project as one of the consortium’s 50 partners. The project aims to create a permanent network of collaborating national geological surveys, which will provide European citizens, institutions and enterprises with the latest scientific knowledge and expertise aggregated at the EU level. The objectives of the project include the development of several pan-European harmonized data and information services focused on primary raw materials, specifically on critical raw materials for energy storage and production, geothermal energy sources and subsurface storage capacities for sustainable energy carriers and CO₂ sequestration, groundwater dynamics and quality, and basic geological information. Furthermore, it aims to develop an infrastructure linked to the existing EGDI (European Geological Data Infrastructure), which will provide access to data and information services developed during the project and elsewhere, and also to strengthen the network of national and regional geological surveys for the purpose of providing geological knowledge and services on a pan-European level and of ensuring the network’s sustainability even after the project’s termination.

Author: Ivana Svojková



Results of Czech Geological Survey's first inspection of the Polish Turów mine

30 May 2022

The Czech Geological Survey (CGS) conducted its first inspection at the Turów mine (PGE GiEK) in Poland, based on an agreement between the Czech Republic and Poland to address the mining impacts of this lignite mine near the Czech border.

The inspection took place on 17 May 2022, and CGS specialists focused on the mine's southern wall. As a result of higher rainfall totals just prior to collecting measurements, the detected streamflow rates must be considered indicative for the time being because of the mixing of precipitation, surface water and groundwater. The southeastern forefield of the Turów mine, where a fourth monitoring well began to be drilled into the crystalline bedrock on the Polish side, was also inspected. Roughly the first three metres were drilled. The PGE GiEK announced that the borehole will take three weeks to drill. The well will then be equipped with sensors to monitor the groundwater level.

Poland is still testing the functionality of the underground barrier and carrying out additional injection and sealing work. The deadline for completing the barrier was 30 June 2022, when its annual trial testing will commence. The Czech Geological Survey is now analysing data that the Polish side submitted to the Ministry of the Environment (MoE).

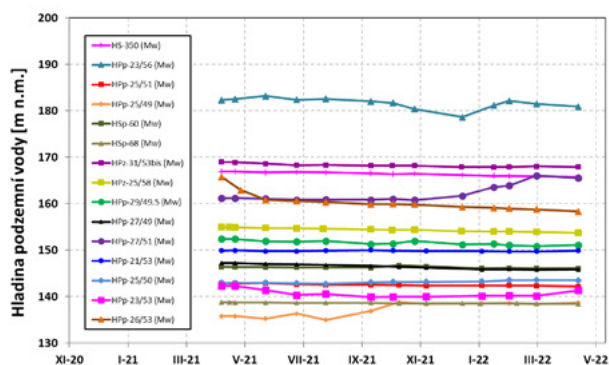
In early May, in accordance with the concluded agreement, the Polish Geological Institute provided the MoE with data from monitoring wells in the Turów mine area for the period spanning April 2021 and March 2022. The groundwater levels in the monitoring wells were stagnant or declining, with the exception of one well, in which the groundwater level rose by nearly 5 metres during the monitored period.

The PGE GiEK company informed the MoE about the current status of the underground wall. Due to identified deviations during the testing of the wall's effectiveness, the boreholes forming the wall in the area of the western Białopole fault will be spaced closer together and drilled further into the crystalline bedrock in order to seal the wall. All the above-mentioned work should be completed by the date set for 30 June 2022. Annual monitoring of groundwater levels and evaluation of the underground wall's effectiveness will commence on this date.

Detailed information on the changes in measured groundwater levels

With regard to recorded groundwater levels since 2015, the groundwater level decline clearly slowed and nearly ceased in 2022 in the middle aquifer Mw. Between April 2021 and March 2022, groundwater levels dropped more significantly west of the western Białopole fault (roughly the middle part of the underground wall) in the HPP-26/53 and HS-350 wells (a decline of 2–7 m). On the other hand, the HPP-27/51 well, located on the inlet side of the underground wall in the direction of the groundwater flow, showed that the groundwater level rose sharply by nearly five metres between April 2021 and March 2022.

Groundwater levels continue to drop at the western edge of the underground wall – in the HPP-29/49.5 well with a groundwater level decline of 1.59 m. The groundwater level is also rising beneath the underground wall, where an unexpected groundwater level rise of 2.63 m was recorded in the HPP-25/49 well. The vast majority of other wells show a groundwater level decline of up to one metre (see the attached graph).



Authors: Renáta Kadlecová, Ondřej Nol, Zdeněk Venera



The Geology Day with the Czech Geological Survey attracted nearly 800 visitors

27 June 2022

The Czech Geological Survey invited young and old visitors to the Geology Day. On Friday, 24 June, and Saturday, 25 June, the courtyard at the CGS headquarters was filled with inquisitive guests who were able to gain an understanding of geological disciplines at individual booths and try out some practical activities. For instance, they found out how to find and process geological samples, which they then examined under a microscope. Visitors were drawn to the 3D geological models and fleet of drones and did not hesitate to try their hand at flying them. Some were not even afraid to operate a drilling rig for exploratory wells. As usual, the panning for gold aroused the greatest interest among children, especially when they could take the gold particles that they found home. The production of jewellery from minerals and rocks attracted all age groups.

Visitors were interested in geothermal energy and its use or in viewing a Devonian reef as well as a virtual reality simulation of animals in the Devonian sea. They were able to see how water behaves in a landscape with varying bedrock, and they studied the texture of rocks on microphotographs as well. They tried working with a thermal camera and creating a geological map. In addition to these delicate activities, there was also great interest in one typical geological work activity – the breaking of rocks with a geological hammer! Many were rewarded by finding a hidden fossil.

Author: Klára Froňková



Geological Expedition Mongolia 2022

31 July 2022

After a two-year COVID break, a geological expedition to Mongolia was organized again in July 2022. Led by Prof. K. Schulmann and Assoc. Prof. O. Lexa, experts from the CGS, Charles University and the Geological Institute of the Mongolian Academy of Sciences, and students of the Mongolian University of Science and Technology worked on geological profiles several hundred kilometres long between the volcanic rocks of the Trans-Altai Gobi in the south and the sediments of the Mongol-Okhotsk Ocean in the north. As in previous years, the geological phenomena were enhanced by the breath-taking Mongolian landscape and unexpected meetings with local shepherds. The expedition culminated in a working lunch with the doyen of Mongolian geology, Prof. O. Gerel, and the Director of the MAS Geological Institute, Ms Odgerel. The research in Mongolia is the main pillar of the GACR EXPRO 19-27682X project "Main mechanisms of peripheral continental growth during the supercontinental cycle".

Author: Pavel Hanžl





Czech Geological Survey representatives in Indonesia discussed the cooperation possibilities regarding raw materials

12 August 2022

The Raw Materials Policy Department of the Ministry of Industry and Trade (MIT), in cooperation with the MFACR's (Ministry of Foreign Affairs of the Czech Republic) Embassy of the Czech Republic in Jakarta, organized the 2022 Czech-Indonesian Business Forum held on 18–22 July. The mission led by the department's director, Pavel Kavina, took place as part of the economic diplomacy project "Presentation of the potential of Czech companies involving mineral production and processing in Indonesia".

The Czech Geological Survey and representatives of Czech companies and other associations participated in the meeting as well. The Czech Geological Survey is a potential partner primarily for the Indonesian Geological Agency in Bandung. Cooperation was discussed with regard to development of information systems and GIS, geothermal energy use, capture and storage of carbon dioxide, mineral exploration, and mapping and inventory of strategic mineral reserves. The potential of Czech technologies for extraction and processing of minerals as well as the negotiation achievements are summarized in a press release by the Ministry of Industry and Trade and in an article on the website of the Ministry of Foreign Affairs.

Author: Klára Froňková



MIT press release from the departmental mission to Indonesia involving the mineral and mining industry.



► Vít Štrupl led the negotiations in Indonesia on behalf of the Czech Geological Survey.



Hydrogeological and Engineering Geology Congress in Ústí nad Labem

19 September 2022

The joint XVI Hydrogeological Congress and IV Engineering Geology Congress was held on 6–9 September 2022. The main organizers were the Czech Association of Hydrogeologists and the Czech Association of Engineering Geologists. The patrons of the congresses were the Director of the Czech Geological Survey, Mgr. Zdeněk Venera, Ph.D., and the Director of the T.G. Masaryk Water Research Institute, Ing. Tomáš Urban. Nearly 350 experts took part in the traditional prominent scientific and social meeting of specialists in hydrogeology, engineering geology and other applied geological disciplines.

The goal of this year's largest meeting was to evaluate developments in applied geology over the past years and to discuss its future direction. The congress programme also included a presentation of awards for lifelong contribution to both fields of study. In

engineering geology, it is the Academician Quido Záruba Award, which Anna Abramčuková and Jitka Dvořáková received this year,

and in hydrogeology, the Professor Ota Hyníe Award was given to Zbyněk Hrkál, Vojtěch Kněžek, František Pastuszek, Josef Slavík and Daniel Smutek.

The CGS had relatively many members present in the audience and among lecturers at the congress. A total of six contributions and two posters were presented in the hydrogeology session, six contributions and three posters in the engineering geology session, and another contribution in a joint session.

The congress ended with day-long field trips. The engineering geology excursion took place at the Stadice landslide, which was planned 54 years ago during the International Geological Congress held in August 1968 in the Czech Republic and which was cancelled due to the Russian occupation of the country.

Another session of the congress, which already ranks among the most successful in terms of the number of participants, is planned for 2026.

Authors: Petr Kycl, Josef Datel





The Czech Geological Survey joined the 60th anniversary celebrations of the founding of the IUGS

10 October 2022

The Czech Geological Survey was invited to join the 60th anniversary celebrations of the founding of the IUGS (International Union of Geological Sciences, the world's largest geoscience organization) by participating in a webinar called The Roots of a Geological Union for the Future of the Earth. The event was organized by the international organization INHIGEO (International Commission on the History of Geological Sciences) on 8 October. At the organizers' request, a lecture was given on the 23rd International Geological Congress, held in Czechoslovakia in 1968. Czech geologists are familiar with the congress, which was interrupted by the invasion of Warsaw Pact troops led by the then Soviet Union. However, the foreign geological community is no longer aware of these circumstances, so perhaps it was beneficial to think of them again nowadays. The library of the Czech Geological Survey has all printed materials pertaining to the congress, including excursion guides, and more than half of the materials have already been scanned. The publication entitled *Zmařený kongres* ("Derailed Congress"), which includes brief information on the congress and the memories of the participants, is for sale at the CGS Geological Bookstore.

Author: Zdeňka Petáková



[Link to the presentation](#)



The Cotopaxi Expedition members recollected the success of the expedition

30 November 2022

The Cotopaxi Expedition to the highest active volcano in the world took place in 1972 and included the world's first descent made the bottom of this Ecuadorian volcano's crater by the expedition members. The diverse goals of the Czechoslovak-Polish expedition, which were very exotic judged by the standards at that time, involved natural science, volcanology as well as ethnography. In 2018, the Czech Geological Survey published the book *Až na dno... Cotopaxi!* ("All the Way Down ... Cotopaxi!") by Gabriela Zoubková and Miroslav Krůta, which colourfully depicts the expedition.

On the occasion of the 50th anniversary of the Cotopaxi Expedition, a ceremonial meeting of the expedition members was held on 24 November at the Czech Geological Survey. The members recounted memories of the journey and geological mapping in Ecuador and subsequent volcanological research in Central America supported by the CGS at the event that was entitled *Proniknout do expedice Cotopaxi – dobýt nejvyšší vulkán světa* ("Joining the Cotopaxi Expedition – Conquering the World's Highest Volcano").



The guests were able to view an exhibition of photos from the expedition, which was launched by the Ambassador of the Republic of Poland to the Czech Republic, Mateusz Gniazdowski. The event was organized by Archiwum Nauki PAN i PAU (Archive of Sciences of the Polish Academy of Sciences and the Polish Academy of Arts and Sciences), Instytut Historii PAN (Institute of History of the Polish Academy of Sciences), and by the Masaryk Institute and Archives of the Czech Academy of Sciences in cooperation with the Czech Geological Survey.

Author: Klára Froňková



The Czech Geological Survey presented the SYNERGYS project to the residents of Litoměřice

2 December 2022

The representatives of the city of Litoměřice organized a public discussion about the SYNERGYS project on Monday, 28 November, at which councilors and experts in renewable energy sources presented the main activities, benefits and challenges of the project and answered questions posed by guests from the general public. The project's strategic partner is the city of Litoměřice, which issued a press release about the event (see attached link).

In his presentation, the Director of the Czech Geological Survey, Zdeněk Venera, explained the principles of using geothermal energy and technology, which will constitute a complex test site and which can be used for heating and electricity production at the community level.

The forthcoming strategic SYNERGYS project, which is owned by the Czech Geological Survey, aims to provide conditions for the development and application of new clean energy sources and will be implemented at the site of the former barracks of Jiří z Poděbrad ("George of Poděbrady") in Litoměřice.

Author: Klára Froňková



[Press release on the website of the Municipal Authority in Litoměřice](#)



Projects implemented in 2022

Czech Science Foundation	CGS project manager
20-10035S: Leading-edge instrumental methods in high resolution global Jurassic-Cretaceous boundary correlations	M. Bubík
19-04682S: Bioaccessibility and environmental interaction of antimony near busy traffic nodes	F. Bůžek
19-17435S: Palaeoclimatologic significance of Paleozoic red pelagic carbonates: time specific facies or products of microbial activity	J. Frýda
22-34175S: Interpreting geochemical data in igneous geochemistry: using the R language to develop new, and to integrate existing, free and open-source software	V. Janoušek
22-33820S: Multiphase solid inclusions in orogenic peridotites as tracers of metasomatization in collisional orogens	J. Kotková
19-29124X: Evolution and post-emplacement history of carbonatites: Implications for the mobility and concentration of critical metals	T. Magna
20-23363S: Biostratigraphy and faunal dynamics of the Silurian pelagic biota of the Prague Basin in the context of major environmental changes and perturbations	Š. Manda
21-27420S: Controls of Mg, Ca and Sr isotope signals in catchment runoff: A multiple-site approach	M. Novák
20-19471S: GeoMicLink: Microbial imprint in catchment-scale nutrient retention	F. Oulehle
20-14292S: Mercury – an overlooked threat in Czech ecosystems responding to global change	F. Oulehle
20-13644S: Cherts and carbonates as geochemical proxies of paleoenvironmental conditions and Ocean Plate Stratigraphy	J. Pašava
GA21-30043S: Petrogenesis and emplacement of deep-marine alkaline basaltoids: A case of Early Cretaceous magmatism in the northern Tethys region	V. Rapprich
19-27682X: Main mechanisms of peripheral continental growth during the supercontinental cycle	K. Schulmann
22-11661K: Towards integrated stratigraphy of the Late Paleozoic in eastern equatorial Pangea	Z. Šimůnek
20-20785J: Search for biological fingerprints and grain alteration patterns in Devonian and Carboniferous microbial facies – examples from the Bohemian Massif	S. Vodrážková
22-26485S: Synthetic platinum-group minerals and their applications	A. Vymazalová

Projects implemented in 2022

Technology Agency of the Czech Republic

CGS project manager

TK01030054: Controlled and enhanced microbial methane production in situ	J. Franců
TK01030031: Engineered barrier 200C	F. Laufek
TK02030120: Impact of geosphere evolution on radionuclide transport from a deep radioactive waste repository to the biosphere	T. Hroch
2019TK02010092: Analysis of the geothermal energy potential at medium and great depths in the Czech Republic	J. Holeček
SS01010208: Targeted replenishment of groundwater as a tool to reduce drought impact in the Czech Republic	R. Kadlecová
SS02030023: Rock Environment and Natural Resources	M. Poňavič
SS02030018: Center for Landscape and Biodiversity	F. Oulehle
SS02030031: Integrated system for air quality research, assessment and monitoring	M. Novák
SS02030040: Prediction, evaluation and research for understanding national sensitivity and impacts of drought and climate change in Czechia	O. Nol
TITSMPO031: Research on promising mineral fillers and quartz raw materials in the Bohemian Massif, their treatment and use for progressive industrial applications	J. Godány
TITSMPO026: Research on the raw material potential of strategic minerals in brines of the Bohemian Massif	J. Godány

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

CGS project manager

Wetlands and their importance in the landscape	E. Břízová
Geology of the Křivoklátsko Protected Landscape Area	T. Vorel
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
Geochemical cycle of cadmium in the long-term monitored catchments of GEOMON and its changes in the past two decades	L. Bohdálková

• Biogeochemistry and ecotoxicology of aquatic and terrestrial systems of the Slavkov Forest Critical Zone Observatory	P. Krám
• Formation and evolution of asymmetrical depressions and lacustrine environments in the Bohemian Paradise in the context of late-glacial and Holocene climate change	T. Radoměřský
• Monograph of the Krkonoše Piedmont Basin and digitization of a 1:75,000 map	M. Stárková
• Subsurface geoinformation models (GeoCIM)	Z. Bukovská
• Development of methods for isotopic analysis of samples obtained by micromilling, 2020–2021	J. Hora
• Work in the steering committee of the international research network ENeRG	V. Hladík
• 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	J. Janderková
• Testing of drones and virtual reality for research purposes	L. Koucká
• Geological survey of a unique archaeological site in the Podřipsko region	J. Hošek
• Interpretation and publication of significant results from site evaluation projects for the location of a deep radioactive waste repository	J. Pertoldová
• Volcanic systems VI	V. Rapprich
• Record of supercontinent cycles in the basement of the Central European Variscides: Relationship between primary Proterozoic configuration and collisional evolution	I. Soejono
• Selected Mesozoic and Cenozoic taphocenoses III: Stratigraphy, palaeoecology, taxonomy and palaeobiogeography	R. Vodrážka
• Phytopaleontological and sedimentological study of the Permo-Carboniferous basins of the Bohemian Massif	Z. Šimůnek
• Silurian stratotypes of the Prague Basin	Z. Tasáryová
• Possibilities of building an underground hydrogen storage facility in the geological conditions of South Moravia	R. Prochác
• Trace elements and non-traditional stable isotopes in edible mushrooms from three small catchments underlain by different bedrock	A. Andronikov
• Geology of the Šumava National Park and Protected Landscape Area	V. Žáček

Projects implemented in 2022



Research on biodiversity and global change in the past	J. Frýda
Deposition of toxic antimony in the border mountains of the Czech Republic	T. Pačes
Analysis of subsidence near the Turów mine based on satellite radar data	K. Fárová
Analysis methods for organic pollutants	D. Ocásková
Determination of the isotopic composition of Si using MC-ICP-MS at the Czech Geological Survey	L. Ackerman
Mentoring	Z. Bukovská
3D reconstruction and presentation of selected fossil material from CGS collections	M. Nohejlová
Mineralization of biogenic material in a volcanic environment – II	J. Mysliveček
Thematic geological map of the Jizera Meadow in the Jizerské hory Mts	J. Klomínský
Reconstructing pre-orogenic architecture of the Variscan suture zones of the Bohemian Massif	S. Collett
Correlation of basement domains in covered parts of the Bohemian Massif and their metamorphic record	V. Peřestý
Geochemistry and geochronology of an early-Variscan magmatic suite in the leptyno-amphibolite complex of the Haut-Allier (French Massif Central)	L. Dehoym
The relaminant in the Bohemian Massif: What is the protolith age?	P. Štípská
Origin and evolution of high-grade metamorphic metasedimentary complexes in the central part of the Bohemian Massif	E. Žáčková
Animate and inanimate nature of the city of Beroun – publication plan support and personal research	J. Holeček
Correlation between concentrations of trace elements in precipitation and soil in the polluted area of Ostrava and the Polish part of Upper Silesia	T. Pačes
FLOW2020: New tools for geohazard risk assessment in high mountain regions	L. Koucká
Application of the LA-ICP-MS methodology to study trace elements in oxide minerals using multiple reference materials for calibration	I. Andronikova
Preparation of an expert conference on sustainable development in karst areas: KARST, CAVES AND PEOPLE	V. Baldík
Preparation of a new version of the virtual museum of the Czech Geological Survey	P. Budil

• Diamond graphitization in nature and experiment	J. Kotková
• Inventory of Slope Instabilities	O. Krejčí
• Regional geological mapping of the Czech Republic at 1:25,000 scale	D. Buriánek
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Železné hory Mts	S. Čech
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Novohradské hory Mts	B. Dudíková Schulmannová
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Pošumaví region	V. Žáček
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Bohemian Paradise II	L. Švábenická
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Brdy Mts	T. Vorel
• Regional geological mapping of the Czech Republic at 1:25,000 scale, Central Moravia	P. Tomanová Petrová
• Development of 3D geological models and related CGS databases	L. Kondrová
• Expert support for the National Geoparks Network of the Czech Republic II	V. Štědrá
• Geology of the Bohemian Cretaceous Basin	S. Čech
• Decorative and building stones of the Czech Republic – editing of the on-line database and use of stone for ornamental and construction purposes (ongoing)	B. Dudíková Schulmannová
• Study assistance for CGS employees	A. Václavíková
• Editing of the <i>Geoscience Research Reports</i> journal	T. Sidorinová
• Printing of geological and applied maps	V. Žáček
• Editing of the journal <i>Geological Research in Moravia and Silesia</i>	D. Buriánek
• 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
• Inventory, protection and popularization of geosites of the Czech Republic, CGS, ongoing	M. Vajskebrová
• Administration, maintenance and development of the PMČR50 geo-database related to the compilation of new soil maps and their safekeeping, printing and presentation, CGS, ongoing	J. Sedláček (Brno)
• Assessment services of regional geologists	J. Čurda

Projects implemented in 2022



Executing tasks of the state geological survey apart from approved projects	P. Mixa
Executing tasks of the state geological survey apart from approved projects – Geofond Division, ongoing	V. Štrupl
Activities of the coordinators of Long-Term Conceptual Development of Research Organizations/CGS	J. Pašava
Activities of the CGS Project-Review Board	P. Mixa

Projects funded by the MoE for tasks of the state geological survey

CGS project manager

RANAP, 2020, Contact of the Cretaceous and Permo-Carboniferous, web map update	I. Barnet
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.	J. Čurda
CGS repositories – retransfer of documented samples from old boreholes to the standard storage system of the CGS Geofond Division – 2022 phase	A. Donát
Wells with potential gas leakage in the Czech Republic, 2022	J. Franců
Monitoring of hydrogeological boreholes in 2021–2024 (Rebalance sustainability)	J. Grundloch
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, 2022	A. Horáková
Restoration of selected parts of the geological documentation collection maintained by the CGS Geofond archives, 2022 phase	M. Hrdlovicsová
Digitization of collections of the geophysical archive at the Geofond office in Brno, 2022 phase	E. Hudečková
Update of soil maps at 1:50,000 scale	J. Janderková
Geological conditions in Spa Source Protection Zones – pre-project phase	E. Kryštofová
RANAP (radon) – Radiometric anomalies and research from ČSÚP data, 2022, update and map application	R. Kujal
Post-fire activities of CGS geologists in the Bohemian Switzerland National Park	J. Malík

Revision of prognosticated resources of industrial minerals and ores, category Q, in Central Bohemia	Š. Mrázová
Groundwater in Crystalline Rocks	J. Novotná
Transfer of borehole logs from the archived reports of the FZ and P collections into the GDO and GEO systems, feldspar, bentonite, 2022 phase	Z. Petáková
Determination of prognostic resources of moldavite (category Q) at sites in South Bohemian basins – 2022	T. Peterková
Mineral Commodity Summaries of the Czech Republic and Changes in Reserves of Reserved Mineral Deposits	J. Starý
Processing and evaluating final reports from the Resource Reports Collection at the Kutná Hora office as a basis for investigating mining impacts, 2022	J. Šanderová
Processing and evaluating map documents stored in the national archives of the Czech Republic as a basis for investigating mining impacts – 2022 phase	J. Šanderová
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, 2022	P. Šír

Projects for the MoE and other ministries

CGS project manager

Preparation of project documents in cooperation with the geological surveys FBiH and RS	D. Čápková
Management of a network monitoring the status of ecosystems with regard to air pollution	J. Hruška
ICP Modelling and Mapping Conference 2023	J. Hruška
Turów 7/2016–2044	R. Kadlecová
Institutional support for the long-term conceptual development of the research organization based on an evaluation of its achieved results	J. Pašava
ET-2019-019-RO-43040: Ensuring sustainable land management in selected areas of Ethiopia based on geoscience mapping	K. Verner
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	K. Verner

Horizon Europe and Horizon 2020

CGS project manager

GSEU – A Geological Service for Europe	D. Čápková
A Geological Service for Europe – Geological framework for the European geological data & information system	D. Čápková
A Geological Service for Europe – European Geological Data Infrastructure, EGDl	D. Čápková
A Geological Service for Europe – Communication, Dissemination & Exploitation	D. Čápková
A Geological Service for Europe – Geological Surveys Network and Sustainable Services for Europe	D. Čápková
HotLime – Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks – Cross-domain Implications and Impacts	J. Franců
3DGEO-EU – 3D geomodelling for Europe	J. Franěk
Mineral Intelligence for Europe	Z. Gabriel
A Geological Service for Europe – Critical Raw Materials, the International Centre of Excellence and United Nations Framework Classification	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
GeoConnect³d: Cross-border, cross-thematic multiscale framework for combining geological models and data for resource appraisal and policy support	V. Hladík
COST Geothermal-DHC: New geothermal sources for carbon-free heating grids	V. Hladík
HyStorIES Hydrogen Storage In European Subsurface	V. Hladík
A Geological Service for Europe – Geothermal energy & underground storage inventory	V. Hladík
MUSE – Managing Urban Shallow geothermal Energy	J. Holeček
Resources of groundwater, harmonized at cross-border and pan-European scale	E. Kryštofová
A Geological Service for Europe – Appraisal, protection & sustainable use of Europe's groundwater resources	O. Nol
820852 – Forecasting and Assessing Europe's Strategic Raw Materials Needs	P. Rambousek
e-shape – Next-generation satellite data and creation of innovative applications	V. Strnadová

Multi-Miner: Multi-source and multi-scale earth observation and novel machine learning methods for mineral exploration and mine site monitoring	V. Strnadová
PUSH-IT: Piloting Underground Storage of Heat In geoThermal reservoirs	A. Tým
SEMCRET – Sustainable exploration for orthomagmatic (critical) raw materials in the EU: Charting the road to the green energy transition	V. Wertich

Other projects co-funded by foreign entities

CGS project manager

TO01000112: CO₂ Storage Pilot in a Carbonate Reservoir	V. Hladík
TO01000220: The fate and future of carbon in forests (CatchCaN)	J. Hruška
Building a partnership and knowledge base towards sustainable use of the underground in cities	J. Jelének
recomine Saxony–Czechia	Š. Mrázová
Groundwater in Crystalline Rocks	J. Novotná
BrineRIS – Brines of RIS countries as a source of CRM and energy supply	P. Rambousek
2017/26/M /ST10/00646: Paleogeographic maps of Permian continental basins of Central Europe	Z. Šimůnek
Ringen Geoenergy Centre	A. Tým
SYNERGYS – synergy energy systems – preparatory project	A. Tým
CZ.02.2.69/0.0/0.0/18_053/0017379: International mobility of CGS researchers	A. Velímková



Information Portal

Web

Czech Geological Survey website > www.geology.cz/extranet-eng/
 State Geological Survey > www.geology.cz/extranet-eng/sgs
 Science and Research > www.geology.cz/extranet-eng/science
 Services > www.geology.cz/extranet-eng/services
 Maps > www.geology.cz/extranet-eng/maps
 Publishing activity > www.geology.cz/extranet-eng/publications
 Promotion > www.geology.cz/extranet-eng/geology-for-all
 About us > www.geology.cz/extranet-eng/about-us

Thematic portals

Slope Instabilities > www.geology.cz/svahovenestability
 World of Geology – portal dedicated to the geosphere > www.svet-geologie.cz
 CO₂ Capture and Storage (CCS) > www.geology.cz/ccs

Journals

Bulletin of Geosciences > www.geology.cz/bulletin
 Journal of Geological Sciences > www.geology.cz/sbornik
 Special Papers > www.geology.cz/spec-papers
 Geoscience Research Reports > www.geology.cz/zpravy/en

Web applications

Guidepost to applications > <http://applications.geology.cz>
 Photoarchive > <https://fotoarchiv.geology.cz>
 Map Server > maps.geology.cz
 Geological Encyclopedia > 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 > locality.geology.cz/d.pl?item=1&l=e
 Interesting Geosites > <https://mapy.geology.cz/geosites>
 Decorative Stones > 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
 The CGS channel on YouTube > www.youtube.com/geologycz
 Geology Olympiad > www.geologicka-olympiada.cz
 Facebook – World of Geology > www.facebook.com/svetgeologie

Principal Offices of the Czech Geological Survey



Klárov Headquarters

Klárov 131/3,
118 00, Praha 1, Phone: 257 089 411

Directorate | Regional and Applied Geology |
Specialized Library | Collections | IT systems
and GIS | Publishing House | Bookstore |
Reprographic Centre



Barrandov Laboratories

Geologická 577/6, Hlubočepy,
152 00 Praha 5, Phone: 251 085 111

Central Laboratory (inorganic geochemistry) |
Rock and Environmental Geochemistry |
Special Laboratories



Kostelní Office

Kostelní 364/26, Holešovice,
170 00 Praha 7, Phone: 234 742 111

Geofond Archive | Study Room | Scanner |
Specialized offices for the performance
of the state geological survey



Brno Branch

Leitnerova 204/22, Staré Brno,
602 00 Brno, Phone: 543 429 200

Regional and Applied Geology, Geophysics |
Rock and Environmental Geochemistry | Testing
Laboratory (organic geochemistry) | Library
and Geophysical Archive | IT and GIS



Kutná Hora Office

Dačického náměstí 11/7,
Kutná Hora-Vnitřní Město,
284 01 Kutná Hora, Phone: 327 512 220

Mining History Department | Archive of
Mining Maps | Archive of Resource Reports
Collection | Specialized Library



Jeseník Office

Erbenova 348/1, Bukovice,
790 01 Jeseník, Phone: 584 412 081

Regional Office | Archive of Geological
Samples | Bookshop



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

Kotlářská 267/2, Veverí,
602 00 Brno, Phone: 541 129 496

Electron Microprobe and Microanalysis
Laboratory



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

Masarykovo nám. 16,
254 01 Jílové u Prahy, Phone: 234 742 205

Archive of Written Documentation and
Geological Samples of Au Deposits in CR



**Lužná Archive of Material
Documentation**

Čsl. armády 432, 270 51 Lužná u Rakovníka

Archive of Geological Samples | Collections |
Publications and Maps



**Stratov Archive of Material
Documentation**

289 22 Stratov 20 a 21

Archive of Written Documentation
and Geological Samples



**Kamenná Archive of Material
Documentation**

Kamenná 42, 262 31 Milín

Archive of Geological Samples



**Kovanice Archive of Material
Documentation**

288 02 Kovanice 184

Archive of Written Documentation

Czech Geological Survey Annual Report 2022

Published by the Czech Geological Survey, Prague 2023

Editor: Lea Smrčková

Executive editor: Šárka Sedláčková

Graphic design: Eva Šedinová

Photo on the cover: Ilja Kněsl

Printed by the CGS Reprographic Centre

03/9 446-408-23

ISBN 978-80-7673-089-2

© Česká geologická služba, 2023

www.geology.cz



9 788076 730892