RR GEO

RESEARCH REPORTS

2023

INSTITUTE OF GEOLOGY
CZECH ACADEMY
OF SCIENCES

Cover photo: A section in volcanic rocks at the easternmost point of Madeira,
Pedra Furada, Sao Lourenco, Portugal. Photo by Michal Filippi.

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1. DIRECTOR'S INTRODUCTION

The largest portion of time in the active lives of all people is occupied by work. I am convinced that most of us try to perform our jobs at our best not only to meet the expectations of the others but also to fulfil our ambitions. Some extend their job engagements to their homes, working in their spare time. This is often due to the fact that they find their work joyful and take it as their hobby. And I am also aware of the fact that this attitude is exceptional and – in a certain aspect – privileged.

Nevertheless, every job must be set in a broader context and must be giving sense as a whole. The common goal can be outlined by a strategic plan, or may pose an intersection of a historical concept and changes that have taken place on the way. Some of these changes tend to prove effective over time while others less so.

In 2023, research activities of the Department of Physical Properties of Rocks were terminated at the Institute of Geology. This team had functioned over 15 years at the Institute, having achieved a number of interesting results. With respect to the fact that the centre of such research activities was lying in a different Institute within the Academy of Sciences, this crucial step was made in line with the conceptual management plan of the Institute. I am fully confident that this decision unequivocally strengthens the position of the Institute of Geology in the institutional system of the Czech Academy of Sciences.

Several projects supported by the Czech Science Foundation were completed in year 2023, and the success rates in new competitions of grant agencies are lower than would be desired. In spite of this, we are not pessimistic about the anticipated development of the Institute. We do trust in our ability to come up with attractive and economically feasible research projects. We do trust that the upcoming all-academic evaluation will reflect our real achievements. Although the society-wide perception of reality, including the international situation, can be designated as far from ideal, we should also acknowledge the nicer things around us. These include, among others, our possibility to find pleasure in our work.

IN AUGUST 2024,
TOMÁŠ PŘIKRYL
DIRECTOR OF
THE INSTITUTE
OF GEOLOGY

2. GENERAL INFORMATION

Up-to-date information on the Institute is available on the Internet:
http://www.gli.cas.cz.

Institute of Geology of the Czech Academy of Sciences, v. v. i.
Rozvojová 269
165 00 Praha 6 – Lysolaje
Czech Republic
+420-233 087 208 (Secretary)
+420-233 087 206 (Director)
+420-220 922 392
inst@gli.cas.cz

Institute of Geology of the Czech Academy of Sciences, v. v. i.
Department of Paleomagnetism
U Geofyzikálního ústavu 769
252 43 Průhonice
Czech Republic
+420-272 690 115
inst@gli.cas.cz

Institute of Geology of the Czech Academy of Sciences, v. v. i.
Department of Physical Properties of Rocks
Puškinovo náměstí 9
160 00 Praha 6 – Dejvice
Czech Republic
+420-224 313 520
inst@gli.cas.cz

The Institute of Geology is a public research institute organized within the Czech Academy of Sciences. It concentrates on scientific study of the structure, composition and history of the Earth's lithosphere and the evolution of its biosphere. Although the Institute does not have the opportunity to cover all geological disciplines (in the widest possible sense) or regionally balanced geological studies, its activities span a relatively broad range of problems in geology, geochemistry, paleontology, paleomagnetism and rock mechanics. The Institute takes part in the understanding of general rules governing evolutionary processes of the lithosphere and biosphere at regional as well as global scales; for this purpose, the Institute mostly employs acquisition and interpretation of relevant facts coming from the territory of the Czech Republic.

The Institute of Geology of the Czech Academy of Sciences is a broad-scope scientific institute performing geological, paleontological, petrological, mineralogical and other disciplines, lately accentuating environmental geology and geochemistry. Major research areas covered by the Institute include: petrology and geochemistry of igneous and metamorphic rocks; lithostratigraphy of crystalline complexes; volcanology and volcanostratigraphy; structural geology and tectonics; paleogeography; terrane identification; taxonomy and phylogeny of fossil organisms; paleobiogeography of Variscan Europe; paleoecology (incl. population dynamics, bioevents); paleoclimatology as evidenced by fossil organisms and communities; biostratigraphy and high-resolution stratigraphy; basin analysis and sequence stratigraphy; exogenous geochemistry; exogenous geology, geomorphology; Quaternary geology and landscape evolution; karstology and paleokarstology; paleomagnetism, magnetostratigraphy and petromagnetism, and physical parameters of rocks.

As concerns the history of the Institute, its predecessor, Geological Institute of the Czechoslovak Academy of Sciences (ČSAV), was founded on July 1, 1960. Nevertheless, its structure had developed in the period of 1953 to 1961. During this period, several independent laboratories were constituted: Laboratory of Paleontology, Laboratory of Engineering Geology, Laboratory of Pedology and Laboratory of Geochemistry; Collegium for Geology and Geography of the ČSAV represented the cover organization since 1957. On July 1, 1960, also the Institute of Geochemistry and Raw Materials of the ČSAV was established. This Institute covered technical and organization affairs of adjoined geological workplaces until their unification within the Geological Institute of the ČSAV in July 1960.

On August 1, 1964 the Institute of Geochemistry and Raw Materials of the ČSAV was integrated within the Geological Institute. On July 1, 1969 the Institute of Experimental Mineralogy and Geochemistry of the ČSAV was founded; a successor of the Institute of Geochemistry and Raw Materials was newly established. A part of the staff of the Geological Institute joined the new institute. On January 1, 1979 the Institute of Experimental Mineralogy and Geochemistry was integrated within the Geological Institute.

On March 1, 1979, the Geological Institute merged with the Mining Institute of the ČSAV under the Institute of Geology and Geotechnics of the ČSAV, and finally split from the latter on March 1, 1990 again.

On January 1, 1993, the Academy of Sciences of the Czech Republic was established by a transformation from the ČSAV, and the Geological Institute became a part of the Academy. The Institute belongs to the 1st Department of Mathematics, Physics and Earth Sciences and to the 3rd Section of Earth Sciences. On January 1, 2007 the Institute became a public research institute (v. v. i.) based on a change in legislation on research and development.

The economic and scientific concept of the Institute of Geology of the Czech Academy of Sciences and the evaluation of its results lie within the responsibility of the Executive Board and the Supervisory Board, which include both internal and external members. Plans of Institutional Financing are evaluated by a special Committee at the Czech Academy of Sciences. Besides research, staff members of the Institute are involved in lecturing at universities and in the graduate/postgraduate education system. Special attention is also given to the spread of the most important scientific results in the public media.

3. ORGANIZATION UNITS

3A MANAGEMENT, EXECUTIVE BOARD, SUPERVISORY BOARD

Management

RNDr. Tomáš Přikryl, Ph.D.	Director of the Institute
Mgr. Michal Filippi, Ph.D.	1st Deputy Director

Executive Board

prof. RNDr. Pavel Bosák, DrSc.	*Chairman*
Mgr. Michal Filippi, Ph.D.	*Vice-Chairman*
doc. RNDr. Jiří Kvaček, DSc. (National Museum, Prague)	
RNDr. Tomáš Přikryl, Ph.D.	
RNDr. Roman Skála, Ph.D.	
RNDr. Ladislav Slavík, CSc.	
Mgr. Martin Svojtka, Ph.D.	
Ing. Petr Uldrych (Ministry of the Environment of the Czech Republic, Prague)	
prof. RNDr. Jiří Žák, Ph.D. (Faculty of Science, Charles University, Prague)	

Supervisory Board

prof. Jan Řídký, DrSc. (Inst Phys, Czech Acad Sci, Prague)	Chairman
Mgr. Jiří Adamovič, CSc.	Vice-Chairman
RNDr. Pavel Hejda, CSc. (Inst Geophys, Czech Acad Sci, Prague)	
doc. RNDr. Václav Kachlík, CSc. (Faculty of Science, Charles University, Prague)	
prof. RNDr. Stanislav Opluštil, Ph.D. (Faculty of Science, Charles University, Prague)	

3B SCIENTIFIC DEPARTMENTS

The **Department of Analytical Methods** provides scientific services for other institutional and non-institutional academic bodies as well as commercial entities. These include imaging and compositional data obtained using scanning electron microscopy as well as quantitative chemical analyses taken with an electron microanalyzer, information on the phase composition of materials based on X-ray diffraction analysis, and finally phase and structural information extracted from vibrational molecular spectral methods. The topics covered, for example, the chemistry of Rb-mica, zircons, monazites, optical fibers doped with REE, mafic minerals in ultramafic rocks, sulfides and Ge oxides in sublimation products from mine tailings, and historical pigments. In addition, the Department's own research continued. This was aimed, among others, at the study of the chemical composition of Muong Nong-type moldavites and their mineral inclusions or the characterization of moldavite hydration products, and the chemical and structural study of minerals of enstatite meteorites and their synthetic analogues.

Further, cooperation with the J. Heyrovský Institute of Physical Chemistry – Centre for Innovation in the Field of Nanomaterials and Nanotechnologies was deepened. Within this cooperation, the Department was analytically involved in the characterization of new photocatalytic nanomaterials used for the removal of pollutants from water and air. Furthermore, analytical services of the NanoEnviCz research infrastructure, whose main coordinator is the J Herovsky Inst Phys Chem, were used. This collaboration allowed to obtain valuable data on the porosity and surface properties of uranium-bearing sandstones, which are studied at the Department.

In connection with the study of uranium ores, cooperation with the DIAMO state enterprise was newly established. This will allow to expand research into the origin of U mineralization at deposits in the northern Bohemian Cretaceous Basin in the coming years.

The **Department of Environmental Geology and Geochemistry** is a specialized department dealing with geology and geochemistry of the recent period with special emphasis on environmental issues.

The research carried out in 2023 in the field of environmental geology continued with the weathering of sandstone formations. Factors influencing the evolution

of sandstone sea caves were studied in detail. Attention was further focused on the behaviour of sandstone formations affected by forest fires.

In the area of environmental geochemistry, we have studied the distribution of toxic metals in biomass components as a function of geological factors, such as their concentration in the topsoil or atmosphere. We observed the extraordinary ability of the fruiting bodies of the fungus Telephora penicillata to accumulate arsenic or cadmium, and addressed the environmental and biological significance of this ability. In response to the growing interest in the socially important topic of wildfires in the landscape, we prepared a comprehensive project with colleagues from other institutes of the Czech Acad Sci on the impact of wildfire on soil, hydrology and the balance of ecologically important elements in the context of the vegetation present. This project was accepted and financially supported by TAČR (Technology Agency of the Czech Republic). We followed up on previous successful projects with the Administration of Natural Curative Resources and Colonnades (SPLZAK, Karlovy Vary), where we conducted detailed research on the chemistry of the Vřídlo (Sprudel) spring and the Vřídlo sinters under the Strategy AV21 programme.

Monitoring activities were continued in the Lesní potok catchment in the Voděradské bučiny National Nature Reserve within the GEOMON network area and in the territory of the Bohemian Switzerland NP as a part of the long-term joint project of the Inst Geol and the Bohemian Switzerland NP.

The staff of the department participated in lectures at Faculty of Science of Charles University, where lectures on "Heavy metals in the environment", "Dating of environmental changes" and "Geomycology" were given. A project on the use of coniferous tree rings as a geochemical archive was found attractive by a M.Sc. student at Faculty of Science of Charles University who decided to devote her thesis to this topic.

Considerable attention was given to the spread of the knowledge gained among the public and to general education. Staff members of the Department shared the achieved results with the public, which can be demonstrated by a number of public lectures.

The **Department of Geological Processes** utilized a combined approach using a range of methods in petrography, mineralogy, geochemistry and geochronology. In 2023, we initiated several new methodical procedures significant for a further development of the labs. First, the method of separation and subsequent isotopic determination of uranium using the TIMS mass spectrometer was tested. The results indicated a great potential for the δ238U determination and possible further research in this direction. Secondly, separation of individual mineral fractions in the economically important group of rocks – carbonatites – was tested. Purity of the fractions obtained by a successful separation was approved by Raman and infrared spectroscopy. Staff of the Department was involved in five grant projects supported by the Czech Science Foundation at the positions of principal investigators or co-investigators. These projects were aimed at geoarchaeological research of a medieval fortified settlement (L. Lisá), silicite and carbonate rock geochemistry (L. Ackerman), isotopic composition of neodymium in foraminiferal tests (L. Ackerman), stable isotope geochemistry of redox-sensitive elements of continental red beds (L. Ackerman) and the age of detrital zircon grains as a tool for the interpretation of terrane provenance (M. Svojtka). Besides the results in basic research (e.g., journals Earth and Science Reviews, Geoscience Frontiers, Gondwana Research), the staff members also contributed to results of societal relevance within the Strategy AV21 programme. The activity Water for Life continued a project focused on concentrations of indicative elements in fish otoliths significant for a better management of Czech water reservoirs (M. Svojtka). The activity Dynamic Planet Earth studied the effects of forest fires on sandstone bedrock (J. Adamovič), compositional and structural controls of rockfall in sandstones (J. Adamovič) and also allowed to supplement the existing web-based rockfall database (J. Adamovič). Innovative methods in the study of geological processes and environmental monitoring were tested within the same activity (T. Hrstka).

The **Department of Paleobiology and Paleoecology** is involved in paleontological and paleoenvironmental interpretations, concentrating on four major areas: Paleozoic stratigraphy and paleoenvironment, Paleozoic to Cenozoic palynology, vertebrate paleontology and Cretaceous research – that can be further subdivided into various sub-topics. The studies of the department contribute to the understanding of the evolution and extinctions of fossil communities, to our knowledge of climate changes in the past and to the refinement of the Geological Time Scale.

Members of the Department of Paleobiology and Paleoecology actively participated in the organization of international events in 2023. L. Slavík and P. Štorch organized annual business meetings as chairs of the international stratigraphic subcommissions (SDS and ISSS/ICS of the IUGS). The Mobility Project Plus called „Cenozoic fossil fishes from Taiwan and the Czech Republic – the once thrived ichthyofaunas“ (principal investigator T. Přikryl) together with Biodiversity Research Centre of the Academia Sinica continued during 2023. In autumn 2023, PhD student Ms. Jiayi Yin from University of Wuhan joined the Department and a new stratigraphic project focused on global correlation of the Silurian–Devonian boundary started. Members of the Department contributed to several important results that were published in prestigious journals. These include publications in Frontiers in Ecology and Evolution, Historical Biology, Integrative Zoology and Newsletters on Stratigraphy. Particular achievements have been made in global stratigraphy – submission of proposals for three new global stratotypes GSSP in the Silurian. These include the published proposal for the subdivision of the Přídolí Series, and global standards for the lower boundary of the Aeronian and Telychian stages (Llandovery Series) – just recently approved by the International Commission on Stratigraphy. L. Laibl received a special award from the Živa journal for the public promotion of biological sciences. M. Chroust was awarded a prestigious Polonez Bis grant and joined the Institute of Paleobiology of the Polish Academy of Sciences in Warsaw in mid-2023. At the beginning of 2023, KEYENCE digital 3D microscope was acquired, and T. Weiner became the head of the Department's optical laboratory. In 2023, 6 projects of the Czech Science Foundation continued.

The **Department of Paleomagnetism** is mainly focused on the research of magnetostratigraphy, magnetomineralogy, paleomagnetism and rock magnetism. The resulting studies provide data on magnetic field recorded in rocks or archeological materials, and contribute with valuable information to other geoscience disciplines.

Research in 2023 was focused on a completion of a Czech Science Foundation project, comprising innovative methods to study the boundary interval between the Jurassic and Cretaceous (J/K) using high-resolution magnetostratigraphy in combination with rock-magnetic analyses on sections in Czechia, Slovakia, Poland, Austria, France and Serbia. The objectives were achieved due to an interdisciplinary cooperation with other departments of the Inst Geol, Czech Acad Sci, and other Czech and foreign partners. The results were supplemented by litho- and biostratigraphy, analyses of calcareous nannofossils, stable isotopes, and ichnological and palynological studies. Results from this project are utilized by the international Berriasian Working Group of the International Commission on Stratigraphy focusing on a definition of the J/K boundary in the Upper Tithonian. Other topics included archeomagnetic research and paleoenvironmental reconstruction of rocks from the end of the Cretaceous to the base of the Eocene found in the Žilina 1 borehole in Slovakia. Magnetic research methods, correlated with other geochemical and micropaleontological methods, enabled to record a series of major paleo-events, including the Upper Cretaceous extinction and the Danian hyperthermal event. Initially, magnetic record on the Úpohlavy section (Czechia) was studied and will be combined with other methods to better understand Late Cretaceous paleoenvironmental changes. Research was also focused on geotectonic, stratigraphic, paleoenvironmental, paleogeographic and paleomagnetic syntheses of karst sediments from Czechia, Slovakia and Slovenia. The results provided important information about the geotectonic and geomorphological evolution of the studied areas. The Brunhes/Matuyama boundary transition was characterized and dated in Račiška pečina Cave (Classical Karst, SW Slovenia). The first evidence of the sulfuric acid speleogenesis in Slovakia was proved in the Plavecký Karst (Malé Karpaty Mts.). The Department is also involved in the European Space Agency project "Advanced compression noise reduction for hyperspectral imagers data", dealing with the development of on-board algorithms to remove noise and compress hyperspectral images taken by space probes in order to reduce the volume of transmitted data. Moreover, Strategy AV21 projects "Loess as a Quaternary thermometer" and "Study of samples at the site of lightning strikes" were run. The research team also works on the first paleomagnetic record from the Holocene lake sediments in Polish Tatra Mts. to investigate regional non-dipole field variations in the geomagnetic field in the Central European region. Magnetostratigraphy of coal-bearing sediments of the Most Basin (Miocene, Czechia) was studied from a rock-magnetic perspective, including the effects of sulfur diagenesis.

The **Department of Physical Properties of Rocks** focuses on laboratory research linking the rock structure and its mechanical properties. In 2023, it employed 5 scientists (2 full-time, 3 part-time) and four technicians (3 full-time, 1 part-time). At the end of 2022, it was decided that the building and the laboratory itself, including all the equipment, would be transferred from the Inst Geol, Czech Acad Sci to Inst Rock Struct Mechan, Czech Acad Sci, Prague. From the beginning of 2024, the laboratory is a part of the Department of Engineering Geology at the Inst Rock Struct Mechan, Czech Acad Sci, Prague.

Staff members of the Department were involved in two grant projects supported by the Czech Science Foundation: (i) The role of rock anisotropy in hydraulic fracturing through acoustic emission (investigator: T. Lokajíček); (ii) Study of petrographic parameters and rock mechanical properties influencing technological-mechanical performance of selected rocks used for crushed stone (co-investigator: T. Lokajíček). Significant results achieved in 2023 include: (i) estimation of bi-modularity of fracturing in sandstone and (ii) evaluation of the impact of grain size heterogeneity in the fracturing process of granites. The mentioned research was carried out in cooperation with international and Czech research institutions. The results were published in highly cited geophysical and geotechnical journals. Most of the published data in these papers were produced by the laboratory of the Department. Besides scientific papers, the department produced several unpublished reports which contain experimentally estimated mechanical properties of rocks mainly for the purpose of planning engineering projects by private companies.

3C LABORATORIES

FIG. 1 Analytical sample preparation in a laminar box in the clean chemistry lab. Photo by M. Svojtka.

Clean Chemistry Laboratory
(Head: V. Renčiuková, supervised by L. Ackerman)

Two rooms (**Fig. 1**) for processing the samples destined for (ultra)trace element and isotopic analyses. Both are supplied with HEPA-filtered air. One lab (class-100000 filtered air) is used for sample decomposition and labware cleaning. It contains a plastic custom-made fume-hood and working table for the work with strong acids (e.g., HF, and HCl), two Teflon distillation apparatuses for the preparation of ultraclean acids (Savillex), analytical weight (precision of 0.1 mg) and device for preparation of clean water (Millipore Elix 3). The other lab (class-10000 filtered air) is used for clean chemistry (e.g., ion-exchange chromatography and extraction of selected elements) and for the final preparation of the samples for mass spectrometry (ICP-MS, TIMS). It contains two custom-made laminar flow workspaces (class-100 filtered air), a Teflon-coated hotplate (Savillex), analytical weight (precision of 0.01 mg), a combined device for preparation of ultraclean water (Elix 3 + IQ 7000 + Q-POD Element by Millipore), and centrifuge.

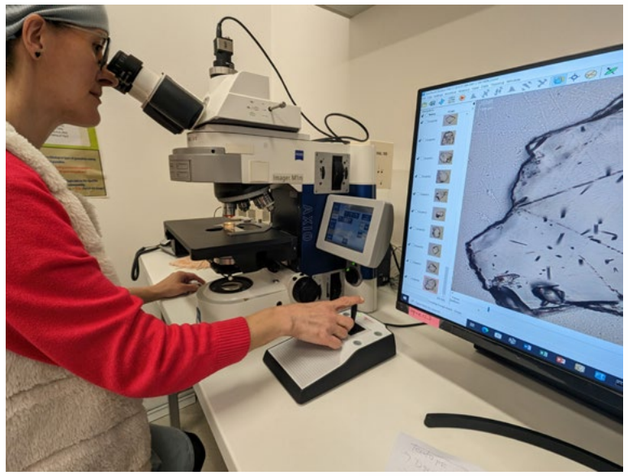

FIG. 2 Counting grains using Automated Zeiss microscope counting system in the fission-track lab. Photo by M. Svojtka.

Fission-track Laboratory
(Head: D. Kořínková)

The laboratory (**Fig. 2**) provides low-temperature dating and thermal-history modeling of rocks using apatite fission-track (AFT) data (spontaneous densities, relative U concentration, confined track lengths, and annealing kinetic parameters). The analytical system for fission-track analysis includes an IMAGER M1m microscope (Zeiss) with a computer-controlled microscope stage (Autoscan) running on the software Fission Track Studio (with TrackWorks and FastTracks modules). An integral part of the laboratory is an APX 010 polishing machine (MTH), a binocular microscope (Nikon), and a flow box for etching of samples. Relative uranium concentrations are measured with laser ablation ICP-MS mass spectrometer housed at the department and are finally used for T/t modeling and AFT age determination.

FIG. 3 Maintenance of the the Cillas 1190 laser particle size analyzer in the Geoarchaelogy lab. Photo by M. Svojtka.

Geoarchaeology Laboratory
(Head: L. Lisá)

The geoarchaeological laboratory (**Fig. 3**) serves mainly for the processing of sedimentary samples such as, for example, basic sample descriptions, micromorphological sample preparations, pH measurements, and particle size analyses. One of the most important methods in geoarchaeology is the study of micromorphological samples. The lab serves for sample resampling before drying and impregnation in Pollylite resin. After impregnation, the samples are slowly cured in fume-hood designed for the work with strong acids. There is an available dryer and a vacuum chamber for sample impregnations. Grain size analyses are processes in Cillas 1190 laser particle size analyzer with the range of 0.004–2500 micrometers, and sets of sieves for different types of grain size analyses. A centrifuge is also used for grain-size sample processing.

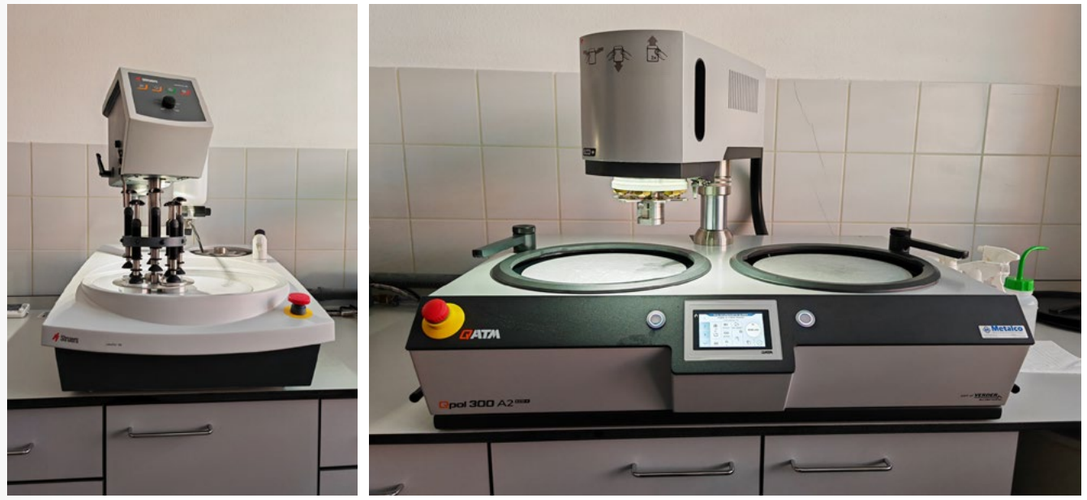

FIG. 4 Grinding and polishing machines Struers LaboPol-30 (left) and QATM Qpol 300 A2-ECO+ (right) purchased in 2023. Photo by R. Skála.

Grinding and Polishing Shop
(Head: J. Jabůrková, supervised by R. Skála)

Reliable quantitative local chemical analyses and/or acquisition of element distribution maps using EPMA/SEM require planar polished conductive surfaces. Such prerequisites are fulfilled when bulky solid samples are sectioned and polished. For that purpose, a suite of cutting, grinding, lapping, and polishing machines is available to prepare polished sections or thin sections (cutting and grinding machines Buehler PetroThin and Struers Discoplan TS, grinding machine with diamond platen wheel Montasupal, custom-made grinding machines with wheels for loose abrasive powder, custom-made saw and a polishing machine Struers Planopol-3). In 2023, the polishing shop was completely refurbished and two new polishing machines were acquired. Struers LaboPol-30 is a grinding and polishing machine for 300 mm diameter discs suitable for grinding, lapping, and polishing. It is equipped with a semi-automatic specimen mover LaboForce-Mi for thin sections and mineralogical specimens. A programmable double-wheel grinding and polishing machine for working wheels of 300 mm diameter QATM Qpol 300 A2-ECO+ allows saving up to 200 preparation methods that can be fine-tuned for specific materials (**Fig. 4**).

FIG. 5 Maintenance of high-resolution Element 2 magnetic sector field ICP-MS (left) connected with an Analyte/Excite excimer 193 nm laser ablation system (right) in the ICP-MS lab. Photo by M. Svojtka.

ICP-MS Laboratory
(Head: J. Ďurišová & Š. Matoušková, supervised by M. Svojtka)

The laboratory (**Fig. 5**) is equipped with the ELEMENT2 (ThermoFisher Scientific) high-resolution magnetic sector field ICP-MS (inductively coupled plasma–mass spectrometer), purchased in 2009. The instrument is equipped with a high mass resolution to access spectrally interfered isotopes and is used for: (1) multi-element trace analysis across the periodic table covering an $mg \cdot l^{-1}$ to sub $pg \cdot l^{-1}$ concentration range and (2) measuring of isotope ratios. A typical application of isotope ratios measuring is an analysis of solutions (bulk sample solution analysis). In solid samples (in-situ isotopic analysis), we routinely provided U-Pb dating of zircons, monazites, or other minerals or trace element analysis of silicates and sulfides. For these purposes, Element2 ICP-MS is coupled with an ANALYTE EXCITE excimer 193 nm laser ablation system (Cetac/Teledyne) for analysing solid samples (sampler holder is for thin sections 27 mm in width or round resin blocks 25 mm in diameter) and with an Aridus II (Teledyne) desolvating nebulizer.

FIG. 6 Quantitative chemical analysis by an electron microprobe JEOL. Photo by R. Skála.

Laboratory of Electron Microanalysis
(Head: N. Mészárosová, supervised by R. Skála)

Scanning electron microscope (SEM) TESCAN VEGA3XMU allows observation and analysis of not only carbon-coated or gold-sputtered materials but also of uncoated specimens including biological materials. It is equipped with detectors of secondary (SE) and back-scatted electrons (BSE) as well as a detector of secondary electrons at low vacuum (LVSTD). Chemical analyses and fast elemental mapping are possible through an energy-dispersive (ED) X-ray spectrometer Oxford Ultim Max 65.

Electron probe microanalyzer (EPMA) JEOL JXA-8230 (**Fig. 6**) is used mainly for non-destructive quantitative analysis of solid-state materials on the micrometer scale. The instrument is equipped with five wavelength-dispersive crystal spectrometers hosting 14 analytical crystals in total. The instrument allows analysis for elements from B to U. To image the studied samples, BSE, SE, and panchromatic CL detectors are used. For fast compositional screening, the EPMA is equipped with an ED X-ray spectrometer.

The laboratory also possesses necessary instruments to carbon-coat or gold-sputter the specimens including VEB Hochvakuum Dresden B 30.2, Carl Zeiss Jena HBA 1, and Quorum Q150T ES.

FIG. 7 Laboratory of Liquid and Solid Samples Analysis. Liquid samples workup. Photo by P. Lisý.

Laboratory of Liquid and Solid Samples Analysis
(Head: Jan Rohovec)

A general-purpose laboratory for the preparation, workup, decomposition and various analyses of liquid and solid samples of environmental, geochemical and geological interest (**Fig. 7**). It is equipped with HP microwave digestion oven Preekem (2022), ball mill Vario 500 (Retch), analyzer of C, H, N, S – VarioMacro CUBE Elementar (2020), DTA /DSC TA Instruments model STD650 (2018), Ultrasonic horn Sono plus Bandelin (2016), gas chromatograph for MeHg DANI (2015), ICP-EOS spectrometer Agilent 5100 (2014), HPLC system (KNAUER 2010), anion analyzer with ion-exchanging column and conductivity detector (2013), analytical balances Mettler-Toledo (2011), total Carbon Analyser TOC-VCPH Shimadzu (2011), UV-VIS Spectrometer CINTRA 303 (2009), analytical balances BALANCE 2000G (1999) and SARTORIUS Basic (1992). Provided with this equipment, we are able to perform all basic analyses without the need of outsourcing.

FIG. 8 3D microscope Keyence VHX-7000. Photo by M. Filippi.

Laboratory of Optical Microscopy
(Head: T. Weiner)

OLYMPUS SZX 16 Optical binocular microscope with the CANON digital photocamera and specialized QuickPHOTO Micro software and a Deep Focus module are used for the documentation of samples, separation of sub-samples for other methods and, of course, for imaging of samples and details for publication. OLYMPUS BX50 Optical polarizing microscope with the DP 70 digital camera and specialized QuickPHOTO software and a Deep Focus module is used for a detailed study of thin (for transmitted light) and polished (for reflected light) sections. Software enables the documentation, image preparation and image analysis. The microscope is equipped also with a fluorescent source of different wavelengths. A new 3D microscope Keyence VHX-7000 was purchased at the end of 2022 (**Fig. 8**). The Keyence VHX-7000 is an excellent instrument for 3D analysis of various geological objects, however, the study of thin sections in polarized light is also possible.

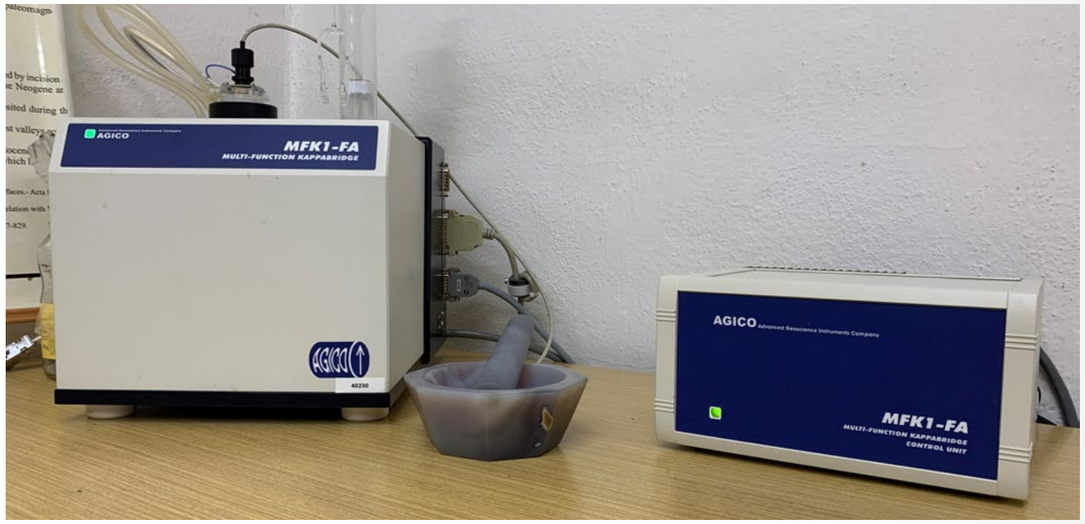

FIG. 9 AGICO MFK1-FA highly sensitive kappabridge for measuring anisotropy of magnetic susceptibility and susceptibility in variable magnetic fields, frequencies and temperatures. Photo by L. Kouklíková.

Laboratory of Paleomagnetism
(Supervised by L. Kouklíková)

The laboratory is focused on processing rock samples to obtain precise paleomagnetic and rock-magnetic analyses and is equipped with the following scientific instruments: 2G 755 4K Superconducting Rock Magnetometer – a highly sensitive instrument for remanent magnetization and alternating field (AF) demagnetization measurements, AGICO JR5A and JR-6A Spinner Magnetometers; Magnetic Measurements MMTD80 Thermal Demagnetizer – a standard instrument for thermal demagnetization; Magnetic Measurements MMPM10 Pulse Magnetizer for isothermal remanent magnetization up to 9T; AGICO MFK1-FA highly sensitive kappabridge for measuring anisotropy of magnetic susceptibility and susceptibility in variable magnetic fields, frequencies and temperatures (**Fig. 9**); AGICO LDA-5 and PAM-1 Specimen Unit for anhysteretic magnetization and AF demagnetization; MAVACS – Magnetic Vacuum Control System – a unique, highly accurate system for creating and maintaining variation-free magnetic vacuum for thermal demagnetization of rock samples. A new Magnetic Vacuum Control System was built in the Průhonice premises. The laboratory is equipped with other instruments for laboratory and field measurements.

FIG. 10 Hydrostatic pressure vessel for measurement of detail, P and S wave, velocity anisotropy. Photo by V. Filler.

Laboratory of Physical Properties of Rocks
(Supervised by M. Petružálek)

The laboratory has two main research directions: (i) study of mutual relations between spatial arrangement of structural elements of rocks (minerals, cracks) and directional dependence (anisotropy) of their physical properties (elasticity, magnetic susceptibility), (ii) detailed research of brittle failure process of rocks studied through acoustic emission monitoring and ultrasonic sounding. The laboratory equipment consists of servo-hydraulic loading frame (MTS 815), with a possible implementation of the triaxial cell Ergotech (100 MPa, 200 °C, 16 channel AE monitoring) or hydraulic fracturing unit Strozatech (biaxial loading, 15 cm cube, 18 channel AE monitoring). To generate and control the loading pressure, a pressure intensifier (MTS 286) of a hydraulic pump (EMDC 400–250, GL Test Systems) are used. Permeameter (Quizix Q5000) is used to measure the permeability or to control pore pressure. The Vallen AMSY 6 serves for AE monitoring and ultrasonic sounding. The self-designed pressure vessel (up to 400 MPa) is used to measure detail anisotropy of P and S wave velocities on spherical samples in 132 independent directions (**Fig. 10**).

FIG. 11 Selecting a measurement spot on a Raman micro-spectrometer. Photo by D. Kořínková.

Laboratory of Raman and Infrared Spectroscopy
(Supervised by R. Skála)

Raman dispersive micro-spectrometer S & I MonoVista CRS+ is based on Olympus BX-51 WI upright microscope, Princeton Instruments SpectraPro SP2750 spectrometer and a CCD detector ANDOR iDus 416. Excitation lasers have wavelengths of 488 nm, 532 nm and 785 nm. The microscope is designed for sample observation in either reflected or transmitted light. Objective lenses with the following magnifications are installed: 4×, 10×, 50×, 50× LWD, 100× and 100× LWD. The samples are placed on a computer-controlled motorized stage. Spatial resolution with a 100× objective is 1 µm laterally and 2 µm axially. The system allows the collection of spectra within the range of 60–9300 cm^{-1} with 488 nm and 532 nm excitation lasers and 60–3500 cm^{-1} with 785 nm excitation laser (**Fig. 11**).

A Fourier-transform infrared spectrometer (FTIR) Thermo Scientific Nicolet iS-50 with built-in mid- and far-IR capable diamond attenuated total reflectance (ATR) accessory is equipped with a ceramic infra-red radiation source and a DLaTGS detector with a KBr window. In transmission arrangement, the spectrometer covers the wavenumber range of 7800–350 cm^{-1}. In the ATR mode, the wavenumbers covered are 4000–100 cm^{-1} depending on the used beam-splitter.

FIG. 12 Dust-tight jaw crusher BB50 Retsch in the separation lab. Photo by M. Svojtka.

Laboratory of Rock Processing and Mineral Separation
(Head: L. Mrázková)

This laboratory is used to separate minerals and paleontological objects from rock materials before subsequent processing in other laboratories (clean chemistry, fission-track laboratory, ICP-MS, and TIMS). The most common minerals that are processed include zircons, apatites, garnets, biotites, pyroxenes, and also sulfides (e.g., pyrite, chalcopyrite). In addition, clay minerals are separated by the sedimentation method for their next determination. For the needs of paleontologists, objects such as conodonts (or others) are separated. The following equipment is routinely used: Anti-Pollution System – JET CLEAN DF (Coral), jaw crusher Pulverize 1 (Fritsch), and disk mill Pullverisette 13 (Fritsch), dust-tight jaw Crusher BB 50 (Retsch; **Fig. 12**), and Wilfley floating table. The necessary additional equipment includes ultrasonic sieve cleaner I-17 (Fritsch), vibratory Sieve - Shaker analysis 3 (Fritsch), and ring agate mill (Siebtechnik) for samples sensitive to contamination. For the separation of magnetic fraction, we employ the Frantz® magnetic barrier laboratory separator – model LB-1 (SG Frantz).

FIG. 13 Inserting a sample holder into an X-ray powder diffractometer Bruker D-8 DISCOVER. Photo by R. Skála.

Laboratory of X-ray Powder Diffraction
(Head: P. Mikysek, supervised by R. Skála)

X-ray powder diffractometer Bruker D8 DISCOVER is a multipurpose powder X-ray diffraction instrument with a variable measuring radius designed to study powder samples or solid polycrystalline blocks (polished/thin sections, rock chips etc.). The diffractometer is of the θ-2θ design and allows studying materials in both reflection and transmission (either foil or capillary) geometry (**Fig. 13**). Optional focusing primary asymmetric monochromator of Johansson type produces spectrally pure Kα1 radiation. Diffracted radiation is collected with a position-sensitive 1D silicon strip detector LynxEye. In the microdiffraction setup used for bulk samples, the primary monochromator is replaced by polycapillary optics (i.e., $K\alpha_{1,2}$ radiation is used) and the beam is limited with a collimator, and the sample is placed on a special motorized xyz-stage.

FIG. 14 A pair of cold vapor atomic absorption spectrometers AMA-254 by Altec, Prague with autosamplers and power backup station. Photo by T. Navrátil.

Mercury Analysis Laboratory
(Head: T. Navrátil)

This unique laboratory is designed for ultra-trace analyses of mercury (Hg) in all types of environmentally relevant samples. The laboratory is equipped with a set of two mercury analysers AMA 254 (**Fig. 14**) with autosampler for solid and liqud samples (2019, 2008) working on CV AAS principle, Speciation oven for RA-915 M Lumex analyzer: upgrade (2019), two zone cylinder furnace Clasic (2018). Total mercury and methylmercury analyzer of BrooksRand system MERX (2017), RA-915M Lumex mercury analyzer: real time direct detection of mercury vapor analysis in air and gases (2016), Shimadzu DOC/TOC analyzer: Dissolved organic carbon content, total organic carbon content, inorganic carbon in aqueous samples (2010), PSA Millennium Merlin: ultra-low mercury analysis in liquid samples on CV-AFS principle. Extension of this analytical procedure with a single-purpose HPLC enables mercury species separation and analysis (2009).

FIG. 15 Micropaleontological laboratory. Photo by P. Lisý.

Micropaleontological Laboratory
(Supervised by P. Lisý & L. Slavík)

The laboratory of micropaleontology (**Fig. 15**) disposes of a room for sample preparation with standard equipment and chemicals and a laboratory for sample processing with hoods and levigation sinks.

FIG. 16 Sedimentary Laboratory. Photo by P. Lisý.

Sedimentary Laboratory
(Head: A. Žigová)

The laboratory (**Fig. 16**) is equipped with an apparatus for sediments and soil sample preparation and study: Analytical balance SETRA EL–2000S (1999), WST 5010 (1991), laboratory dryer, FRITSCH (1986), planetary mill, pH-meter pH 330 / SET (2000), TESLA (1985), ultrasonic cleaner.

FIG. 17 Maintenance of the Triton Plus mass spectrometer in the TIMS lab. Photo by M. Svojtka.

TIMS Laboratory
(Head: J. Rejšek, supervised by L. Ackerman)

The laboratory is equipped with TRITON Plus (ThermoFisher Scientific, **Fig. 17**), a thermal ionization mass spectrometer (TIMS) whose applications are divided into three purposes: (i) Elemental abundance determination with the isotope dilution method; (ii) Precise isotopic ratio analysis; (iii) Isotopic fractionation measurement. The TIMS is routinely used for the analysis of Sr, Rb, Nd, Sm, Pb, U, Os, and Cd in geological materials (e.g. basalts, carbonatites), paleontological samples (foraminifera), archaeological samples (e.g. bones, enamels) as well as in environmental samples (e.g. mushrooms, leaves). The TIMS is supplied with five 1013 Ω technology amplifiers along with a 3.3 pA current calibration board, the central dual-channel detector (SEM/Faraday cup), oxygen bleeding valve, and RPQ device. The filament bakeout device is placed in the TIMS laboratory for filament degassing and PCR box Airstream for sample loading.

3D INFORMATION CENTRE AND LIBRARY

Information Centre and Library
Bc. Jana Popelková – head librarian
Bc. Sabina Janíčková – librarian

The Institute Library is a public library with a specialized library fund. Its main purpose is to collect, process, store and provide scientific information contained in the library fund. It provides its readers with literature focused on Earth sciences, especially from the fields of geology, paleontology, petrology and mineralogy. The fund includes approximately 9,000 books, 480 journals and 300 maps. Some of the latest additions in 2023 are, for example, Nerostné bohatství Krupky, Cínovce a Moldavy (Mineral wealth of the Krupka, Cínovec and Moldava region), Krkonošský kras, Kudy plyne Vltava: co je řeka, jak vzniká, jak se proměňuje a kam spěje?, or Příroda Berouna mezi Českým krasem a Křivoklátskem. Many additions are represented by staff work, i.e., publications created by the Institute staff.

Another significant task of the Library is to collect, process, store and spread information on publications and other information outputs of the Institute's basic research. These records are stored in the ASEP database, which is designed for the Czech Acad Sci specifically for this purpose.

4. AWARDS AND FELLOWSHIPS

FIG. 18 Lukáš Krmíček with the Signum Excellentiae medal. Photo by S. Krmíčková.

FIG. 19 Lukáš Laibl recieving a Special Award of the Živa magazine. Photo by J. Landergott.

Krmíček L.
Signum Excellentiae Silver Medal for excellent results in research, teaching and science-promotion activities, Faculty of Civil Engineering, Brno University of Technology, Brno (**Fig. 18**).

Křížová Š.
Czechoslovak Microscopic Society award for the best PhD thesis with a significant contribution of microscopic techniques for the year 2022 (Chemical and physical properties of impact glasses), awarded at the annual "Microscopy 2023" conference, Olomouc.

Laibl, L.
Special Award of the Živa magazine for a popular science article series, Prague (**Fig. 19**).

Tomek F.
Radim Kettner award for the best junior paper of the Institute of Geology and Paleontology, Faculty of Science, Charles University, Prague.

5. DEGREES OBTAINED

Ph.D.:

Krmíčková S.
Origin and pre-Variscan evolution of the Brunovistulian microcontinent (Faculty of Science, Masaryk University, Brno; supervised by L. Krmíček).

6. PROJECTS

6A FOREIGN GRANTS, JOINT PROJECTS AND INTERNATIONAL PROGRAMMES

FIG. 20 Spodmol v Selski Lozi – a nearly unroofed side passage of the Loza Unroofed Cave with traces of excavations in front of the cave entrance where paleomagnetic sampling was carried out (see also Fig. 21; Astrid Švara as a scale). Photo by N. Zupan Hajna.

FINISHED PROJECTS

***Bilateral co-operation between Czech Geological Survey, Prague and Geologische Bundesanstalt Wien, Austria:* Palynology of Gosau Group sediments in Salzkammergut, in particular on maps 3211 – West Wolfgangsee, 3211-Ost Bad Ischl and 3206-West Gmunden (H. Lobitzer, Geologische Bundesanstalt, Wien, Austria; L. Švábenická, Czech Geological Survey, Prague, Czech Republic; *M. Svobodová*; 2023)**

Paleoenvironmental and especially biostratigraphic conditions were interpreted based on the study of calcareous nannoplankton and palynology in the area of the Zwieselalm Plateau (Nierenthaler Schichten) in Upper Austria. Newly collected samples confirmed the previous results of the Lower Maastrichtian age of the studied samples. A gradual deepening of the palaeoenvironment was confirmed. Grey marly sediments provide stratigraphically important angiosperm pollen of the Normapolles Group as well as dinoflagellate cysts.

The elevated number of nannofossil species documents deeper marine conditions far from the mainland.

Broinsonia parca constricta and *Reinhardtites levis* confirm the UC16-UC18 zone interval, Lower Maastrichtian. The occurrence of *Lithraphidites praequadratus-quadratus*, rare *L. quadratus* and *Corollithion completum* in the overlying brick-red rocks indicate UC20a^{TP} zone, lower Upper Maastrichtian.

***Bilateral Mobility Plus Project No. AS-22-01 between Czech Academy of Sciences and Academia Sinica, Taipei, Taiwan*: Cenozoic fossil fishes from Taiwan and the Czech Republic – the once thrived ichthyofaunas (Ch.-H. Lin, D. Mediodia, Biodiversity Research Center, Academia Sinica; *T. Přikryl, L. Vaňková*; 2022–2023)**

Fossil fish remains are an essential document of fish evolution preserved in sedimentary archives and often represent the only preserved macro-biota in Cenozoic marine deposits. The fish fossils thus serve as an available indicator of the paleoenvironment and evidence of the morphological evolutionary history of the respective group. Fish fossils of Taiwan (West Pacific) and the Czech Republic (Central Paratethys) ranging from the Paleogene and Neogene were examined on the base of the hypothesized geographical shift of the fish diversity from Europe (including Mediterranean) to the modern Indo-Pacific. Attention was paid to undescribed fishes from the Mio-Pliocene of Taiwan and two relatively common Oligocene and Oligo-Miocene fish taxa of the Central Paratethys (*"Glossanodon" musceli* and *"Serranus" budensis*). Furthermore, as a directly linked topic, attention was paid to skeletal anatomy of Recent representatives from family Argentinidae and several acropomatiformes available in the region.

The project reached several published outputs, and presentations of results during international conferences. The published outputs may be briefly summarized:

FIG. 21 An excavated section in front of the Spodmol v Selski Lozi Cave, April 2016. Probably the oldest cave sediments in the Classical Karst at the bottom of the pit (reddish brown to yellow) are covered by young greyish loamy screes. Photo by A. Mihevc.

(i) Four specimens from the Mio-Pliocene deposits of the Kueichulin Fm. (Tachi, northern Taiwan) were determined as a members of family Stereolepididae – the specimens thus present oldest known evidence of the family and second evidence of this group worldwide (the group was previously recorded in the fossil record in the Pleistocene of Japan only). Preliminary results with classification to order Acropomatiformes were presented during several conferences and the final results were published in *Rivista Italiana di Paleontologia e Stratigrafia*. (ii) Study of the morphology and molecular data *Synagrops japonicus* as a part of the doctoral project of D. Mediodia revealed new species of the genus *Synagrops* from Dongsha Island (Taiwan). The new species was described based on number of specimens collected in the South China Sea and manuscript submitted for publication in the journal *Zoological Studies*. The publication represents result of wider studies focused to anatomy, evolution and diversity of acropomatiform fishes.

Unpublished results are represented as follow: (i) *Oliganodon budensis* (synonym *"Serranus" budensis*) from the Euro-Asian Oligocene was studied based on several specimens from the Czech Republic, Poland and Romania. The obtained results suggest that the species should probably be classified within order Acropomatiformes. Unfortunately, more detail research is needed to express this affinity. (ii) Study of argentiniform fish *"Glossanodon" musceli* is based on numerous specimens from the Czech Republic, Poland and Romania and uses a new visualization method *via* Keyence microscope. Detail anatomical study and comparison with fossil and contemporary argentiniforms revealed general similarity with genus *Glossanodon*, but contrary to that, studied fossils present unusual condition of the caudal skeleton preventing classification not only to that genus, but also to proper family. Whole situation remind condition known in genus *Surlykus* from Eocene of Danmark. Although the study is in relatively advanced stages, for the moment we are not able adequately answer key questions. That will be possible after personal observation of the type series of this taxon housed in Romania.

Aside of these results, the comparative collection was created through purchases and donations. The collection serves as a handful morphological tool for comparative and determinative purposes. For the moment, the collection listed more than 300 specimens of teleosts (with several representatives of cartilaginous fishes too). Special result is represented by personal connections and plans for future cooperation with colleagues from related areas.

***Bilateral Mobility Plus Project No. SAZU-22-08:* Deeper insight into the deposition of cave sediments (N. Zupan Hajna, A. Švara, B. Otoničar, Karst Research Institute ZRC SAZU, Postojna, Slovenia; *P. Pruner*, *Š. Kdýr*, *P. Bosák*; 2022–2023)**

We continued our work in open themes, completinmg some of them, and at several new sites. More broadly applied new methods and their combinations were introduced (numerical U-Pb and cosmogenic isotope dating, correlated-age OIS method). Complex aspects of karstogenesis in areas with ongoing active tectonics were studied with special focus on dating the processes using cave and karst sediments (both clastic and chemical). The application of multi-method and multi-approach analysis of cave deposits, in several cases employing method combinations used for the first time elsewhere, indicated that the oldest speleogenetic phase which can be studied both in relict and unroofed caves took place in a relatively narrow time period in all Slovenian karst provinces before their tectonic uplift to different present altitudinal positions – caves and cave systems developed in less differentiated and lower altitudes than the present ones. Recently unroofed caves started to be fossilized already in the Miocene at ~6–7 Myr. The reason was in the change of the geotectonic regime responsible for the Messinian crisis. Moreover, a single cave in the uplifted thrust front indicates the deposition of cave fills during the ~24–9 Myr interval and opens the insight to the presently non-existing – denuded – Miocene karst landscapes of the past Dinaric Lake System. The actual research resulted in some regionally- and generally valid results:

(i) The the Matuyama/Brunhes boundary in the Račiška Pečina Cave was detected in a transition zone, 6 mm thick, by high-resolution paleomagnetic analysis calibrated by the OIS (related to the M/B boundary age of 0.781 ka). A quick transition in mid-Marine Isotope Stage (MIS) 19 was identified at 777.9–777.2 ka with the midpoint at 777.7 ka. The transition is marked by a dramatic change in stable isotope compositions, trace element concentrations, and flowstone fabrics that point to changes in surface temperatures and precipitations. Two distinct maxima in the trace element concentrations at the beginning and the end of the M/B transition indicate two distinct periods of higher precipitation with increased input of clays into the cave. In addition, the stable isotope compositions indicate a significant cooling and high precipitation during the period of M/B reversal, within the generally warm MIS 19.

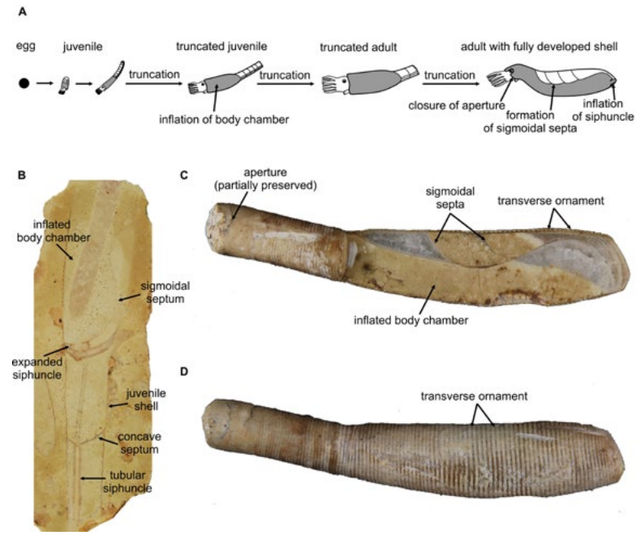

FIG. 22 A: A scheme of ontogeny of ascoceratid cephalopods (redrawn and adapted after Furnish & Glenister 1964); B: A truncated subadult shell with an attached juvenile shell and an inflated body chamber with a sigmoidal septum and an inflated siphuncle (specimen Mo 58679 from Othem, Wenlock Series, Silurian); C–D: A fully developed adult shell (specimen Mo 58659 from Klints in Othem, Wenlock Series, Silurian), C: A polished section showing internal structures, D: External view showing a transverse surface ornament. Both specimens from the paleozoological collection of the Swedish Museum of Natural History, Stockholm. Photos by M. Aubrechtová.

(ii) The Loza Cave System (Slavinski ravnik) developed in contact karst with allogenic inputs from the Postojna Basin in a tectonically active region. Three cave levels with allogenic sediments and speleothems developed under significant stages of tectonic uplift/tilting in phreatic, epiphreatic and vadose zones, the uppermost being unroofed (4.3 km long). Speleogenesis in this system started before the last major tectonic changes triggered by the CCW rotation and compression of the Adria Microplate at the end of the Miocene (7–6 Myr). The Loza Unroofed Cave and Spodmol v Selski Lozi holds the oldest cave sediments in the Classical Karst including unusual gravel transported from sources situated far in the north (**Figs. 20, 21**).

***SYNTHESYS+*: Ascoceratid cephalopods from the Silurian of the Island of Gotland, Sweden (*M. Aubrechtová;* 2022)**

Members of the order Ascoceratida Kuhn, 1949 are rare and morphologically peculiar Early Paleozoic cephalopods. Like all ectocochleate cephalopods, ascoceratids had external calcareous shells that protected the soft-body of the animal and acted as a powerful buoyancy regulation device. The ascoceratids are, however, unique among other cephalopods in that their shells underwent drastic morphological changes during the ontogeny (**Fig. 22**). These changes involved periodic truncation of the curved, conical juvenile shell and the gradual development of an inflated shell of the mature growth stage; there, the phragmocone chambers were separated by sigmoidal, lacunose septa and located above the body chamber. Such a major change in shell form and internal structure led to a *syn-vivo* transition in the orientation of the animal in the water column and improved hydrodynamic and hydrostatic properties of the shell. Thus, the ascoceratid shell represents a unique attempt in the evolution of the Cephalopoda towards more efficient shell morphologies. However, finds of ascoceratid cephalopods are scarce and the known specimens are mostly incomplete. As a result, some fundamental questions regarding the paleobiology, paleoecology and phylogenetic relationships of the group remain unresolved.

Ascoceratids are mostly restricted to the Middle Ordovician–late Silurian (~470–419 Myr) warm-water limestones of North America and Europe. The Silurian representatives are known from only two regions: the Prague Basin (central Bohemia) and the Swedish island of Gotland, from both of which they have been collected in astonishingly high numbers. The SYNTHESYS+ grant project was used to support a study of the latter material, collected by G. Lindström in the 19th century and by later collectors, and now deposited in the Swedish Museum of Natural History in Stockholm. The Swedish collection is essential because it contains specimens representing taxa that do not occur outside Gotland. In addition, some specimens have juvenile shells (including embryonic shells) still attached to the morphologically modified mature shells. Such a preservation is extremely rare and is only known in specimens from Gotland. Therefore, the project aimed at revising the individual taxa, investigating their variability and diversity, refining the stratigraphic distribution and establishing paleogeographic relationships with previously studied ascoceratids from the Prague Basin. The combination of data from both regions will allow the evaluation of the entire order of Ascoceratida thus contributing to the understanding of the function, ecology and phylogeny of a poorly known group of Paleozoic cephalopods.

***UNESCO IGCP project No. 679*: Cretaceous Earth Dynamics and Climate in Asia (G. Li, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, China; T. Hasegawa, Department of Earth Sciences, Faculty of Science, Kanazawa University, Kakuma, Japan; D. K. Cheong, Department of Geology, College of Natural Sciences, Kangwon National University, Republic of Korea; V. Prasad, Birbal Sahni Institute of Palaeobotany, India; *P. Pruner, T. Elbra, Š. Kdýr, R. Mikuláš, J. Adamovič, A. Svobodová, P. Schnabl;* 2019–2023)**

Cretaceous geological records, rapid climate and environmental changes, as well as the nature of linkages between these parameters were studied in marine and terrestrial facies (i) to improve the understanding of characteristics of environmental changes and global warming, including influence of human response to contemporary global warming trends, and (ii) to promote geoscience communication among the Asian countries as well as some countries outside Asia. Furthermore, our research group was mainly focused on paleomagnetism and rock-magnetism of the Berrias section in France and the Dedina section in Serbia contributing to Europe–Asia correlations.

ONGOING PROJECTS

***Bilateral cooperation between Inst Geol, Czech Acad Sci and Institute of Geological Sciences of the Polish Academy of Sciences in Warsaw (signed agreement)*: Uranium series dating of carbonates using ICP-MS measurement (H. Hercman, M. Gąsiorowski, I. Sekudewicz, P. Sierpień, Institute of Geological Sciences, PAN, Warsaw, Poland; Š. Matoušková; since 2016)**

The cooperation consists of field work, sampling, sample selection, chemical preparation of samples, measurement and data evaluation of carbonate samples, mostly speleothems, but also bones. The first step (sample preparation, chemical separation of U and Th, and age calculation) is made by Inst Geol. Sci, Polish Acad Sci staff, whereas the isotopic ratio measurement by ICP-MS and raw data preparation are performed at Inst Geol, Czech Acad Sci, Prague. The numerical radiometric method permits the dating of samples from thousands of years up to 500/600 kyr. Thanks to this cooperation, 100 to 150 samples per year can be dated with high precision.

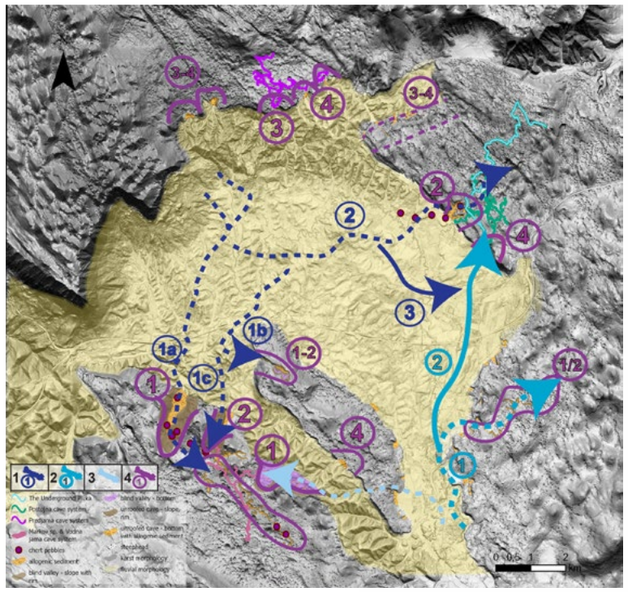

FIG. 23 A conceptual model of the morphogenesis of the Postojna Basin and its contact karst. 1) The Nanoščica and "paleo-Nanoščica" (dashed curve) rivers. 2) The Pivka and "paleo-Pivka" (dashed curve) rivers; 3) The Sušica River; 4) Estimated formation phases of main geomorphological features. Numbers 1 to 4 mark an event succession from the oldest to the youngest (a to c) with possible variants. DEM-LiDAR data: Geodetic department ARSO. Cartography: A. Švara, Karst Research Institute ZRC SAZU. From the Ph.D. Thesis of A. Švara (2023) with permission.

***Bilateral co-operation between Inst Geol, Czech Acad Sci and Karst Research Institute, Scientific Research Centre, Slovenian Academy of Sciences and Arts (signed agreement)*: Paleomagnetism and magnetostratigraphy of Cenozoic cave sediments in Slovenia (A. Švara, N. Zupan Hajna, A. Mihevc, Karst Research Institute ZRC SAZU, Postojna, Slovenia; *P. Pruner, P. Bosák, Š. Kdýr*; in co-operation with MOBILITY No. SAZU-22-08; since 1997)**

Morphogenesis of karst periphery is studied in the Postojna Basin. The Slavinski ravnik represents an outstanding contact karst area in the SW part of the Postojna Basin. It reflects a long history of ponor activity, evidenced by the morphogenesis and speleogenesis of blind valleys of Biščevci, Sajevško polje and Ivačevci, and the Loza Cave System (LCS). The LCS is developed in 3 levels, 30–40 m apart, that followed two phases of tectonic uplift with a successive formation of drainage routes. Speleothems were dated by the radiometric U-Th method. Clastic cave sediments were calibrated by paleomagnetism and magnetostratigraphy. The former ponor of the Nanoščica River *via* the Biščevci blind Valley, the Učičnik site, the Unroofed cave Loza, and the Spodmol v Selski Lozi (viz **Fig. 20**) represent the oldest speleogentical stage responsible for the evolution of the upper cave level with preserved allogenic sediments from the Gilbert Chron, at least. Clastic deposits revealed clockwise rotations which date the cave fill to Upper Miocene times (i.e., >6 Myr), representing the oldest known cave deposits in unroofed caves in Slovenia (viz **Fig. 21**). U-Th dates from speleothems in the upper cave level range from 210 ka to ≤1.2 Myr and document vadose conditions under preserved cave ceiling at that time, before its denudation and collapse. The middle cave level represents the lower passage of the Šimčev spodmol Cave, where sediments were deposited in the epiphreatic zone at least in the Gauss Chron (i.e., 2.61–3.596 Myr) and reveal extremely high 35–38° counterclockwise rotations. Deposition time of allogenic sediments of the lower cave level (i.e., Markov spodmol and Vodna jama) were correlated with the Brunhes and Matuyama Chrons (i.e., <0.773–2.61 Myr). At present, the Rakuliščica Stream occasionally sinks in the Markov spodmol, while epiphreatic floods are common in the Vodna jama. The regional compressional-tectonic regime has significantly influenced the changes in the drainage of the Postojna Basin during the last 7 Myr, with different uplift phases documented by the drops in karst water tables. The water-table drop in the contact karst areas of the Postojna Basin was followed by at least 2–3 successive speleogenetic phases observed in the Predjama, Postojna, and LCS (**Fig. 23**). Uplift phases differ in time and space in different karst corrosional plains surrounding the Postojna Basin. The major uplift was reflected by a change in the course of the Nanoščica River from the Slavinski ravnik to the Postojna Karst from S to N, which presumably occurred between ca 3.6 and >1.77 Myr and represented the last important general change in the drainage pattern of the Postojna Basin.

***Bilateral co-operation between Inst Geol, Czech Acad Sci and State Nature Conservancy of the Slovak Republic – Slovak Caves Administration, Liptovský Mikuláš (signed agreement)*: Paleomagnetism and magnetostratigraphy of Cenozoic cave sediments and speleogenesis of selected caves in Slovakia (P. Bella, State Nature Conservancy of the Slovak – Republic Slovak Caves Administration, Liptovský Mikuláš and Catholic University in Ružomberok, Slovakia; H. Hercman, M. Gąsiorowski, M. Błaszczyk, Institute of Geological Sciences, Polish Academy of Sciences, Warsaw, Poland; J. Szczygieł, Institute of Earth Sciences, University of Silesia, Sosnowiec, Poland; M. Gradziński, Institute of Geological Sciences, Jagiellonian University, Cracow, Poland; *P. Bosák, P. Pruner, Š. Matoušková*; since 1997)**

A delayed valley incision due to karst capture was identified in the Demänová Valley (Nízke Tatry Mts., Slovakia). Numerical ages of speleothems (over100 U-Th analyses) and magnetostratigraphy results (**Fig. 24**) from an active cave system were applied to determine the mid Pleistocene history of the entrenchment of the valley. The deceleration magnitude of the valley incision due to karst drainage through the Demänová Cave System was determined by referencing the vertical position of fluvial active and inactive cave passages to the valley bottom. The well-developed karst system captures a significant volume of surface water and reduces surface erosion. This, in turn, causes a delay in the incision of the valley drained by the caves in comparison to the downstream positions (below the resurgences), where fluvial erosion dominates. Karst drainage has reduced the erosional efficiency in the inflow part of the Demänová Valley due to a hydraulic gradient between the inputs and outputs of allogenic waters, mostly during the mid and late Pleistocene. The cave level that contains the active underground segment of the Demänovka River, previously dated to ~350 ka, definitely existed prior to 600 ka. The period from ~600 to ~395 ka was characterized by relatively stable conditions with a continuous deposition of flowstones, regardless of the climate episodes, including several glacial/interglacial cycles. This period was followed by a rapid and short-lasting incision by up to 4 m.

***International Geoscience Programme (IGCP) of UNESCO & IUGS, Project Code IGCP No. 735*: Rocks and the Rise of Ordovician Life (Rocks n' ROL). Global change theme (International Leader: Bertrand Lefebvre, University of Lyon, France; Czech representatives: O. Fatka, Faculty of Science, Charles University, Prague; other Czech workers: *R. Mikuláš*; P. Budil, Czech Geological Survey, Prague; 2021–2026).**

Preservation of digestive structures in trilobites is generally rare. Despite this, a new fieldwork and collection study also found exceptionally well-preserved specimens of adult, fully articulated trilobites of the genus *Dalmanitina*. These were collected from Upper Ordovician strata in the Barrandian area. The described specimens represent the first well-documented example of digestive structures in the subfamily of Dalmanitininae. All studied specimens are preserved as internal forms and show a narrow band-like structure that runs sagittally or subsagittally below the axial lobe of the trilobite carapace. These band-like structures differ significantly from the scavenger burrows, which, like the vast majority of tubular ichnofossils, have a constant diameter. The new finds are interpreted as the remains of digestive tubes. A slightly expanded anterior part of the digestive system is preserved in the head shield of six specimens and is interpreted as a remnant of the anterior mid-gut. Quantitative chemical analyses show that in the genus *Dalmanitina* the digestive system is preserved as a dark mass containing partially digested food particles.

***International Geoscience Programme (IGCP) of UNESCO & IUGS, Project Code IGCP-No 751*: Four Continents Connected through Playful Geoeducation (International Leading Team: M. Pásková, University of Hradec Králové; *R. Mikuláš*; J. Mwankunda, Tanzania; M.A.R. Núñez, Nicaragua, A.C. Cabana, Peru; J. Ganub, Philippines; 2022–2027).**

Geoparks are based on the initiative of local residents and are not included in legal nature protection. They focus on the voluntary protection, presentation and interpretation of the geological past and natural values, at the same time they educate the public about them and participate in improving the quality of life of the locals not only by caring for the environment, but also by responsible development of the local economy. Geoparks thus promote geosciences, for example through tourism or traditional activities of the region. The most important geoparks are connected by the Global Geopark Network (GGN), in which 147 locations from 41 countries are represented. UNESCO Global Geoparks are areas comparable in size to national parks. The basic unifying element of geoparks is their transnational geological significance. This is presented to visitors together with the concept of nature protection and the involvement of local communities in deciding the future of the area. In 2023, the proponent and co-proponents of the IGCP 751 Project organized a number of domestic programs related to the above topics and one international meeting in the Czech Republic (Hradec Králové and Příbram, September 22 to October 2, 2023). For detailed information see https://www.4geon.org/events.

FIG. 24 A drilled core from a hanging speleothem baldachin above the active Demänovka Stream at Rázcestie (Demänová Cave System, Slovakia) segmented for paleomagnetic analysis. Photo by J. Petráček.

FIG. 25 Pre-sampling Berriasian/Tithonian sedimentary rock sequence in the Freshwater Bay (England). Photo by J. Petráček.

FINISHED PROJECTS

No. *GA20-06134S*: Paleoecology of early angiosperms during mid-Cretaceous, case study of material from Iberian Peninsula and central Europe (J. Kvaček, National Museum, Prague; *J. Dašková*; 2020–2023)

Within the project, we documented, discussed, and interpreted Cretaceous fossil plants from the Bohemian Massif and Iberian Peninsula. New conifers and angiosperms from the studied areas were described. By comparing the floras from Portugal, Spain, and Czechia, we arrived at the commonly accepted interpretation that the arborescent stature helped angiosperms to penetrate gradually to the main plant assemblages in mid Cretaceous. Angiosperms switched their strategies from the ruderal (disturbed) strategy in the Early Cretaceous to the competitive strategy in the Late Cretaceous. This conclusion is the major message of the manuscript that was submitted to the Palaeogeography, Palaeoclimatology, Palaeoecology journal.

No. *GA20-10035S*: Leading edge instrumental methods in high resolution global Jurassic-Cretaceous boundary correlations (*P. Pruner, P. Schnabl, T. Elbra, P. Bosák, T. Navrátil, L. Chadimová, R. Mikuláš, M. Svobodová, M. Roll, A. Svobodová, Š. Kdýr, L. Koukliková*; M. Košťák, M. Mazuch, *L. Vaňková*, Faculty of Science, Charles University, Prague; P. Skupien, P. Doupovcová, Institute of Geological Engineering, Faculty of Mining and Geology, VŠB-Technical University Ostrava; M. Bubík, L. Švábenická, Czech Geological Survey, Prague; 2020–2023)

A multi-disciplinary approach was used to integrate geochemical, biostratigraphic and magnetic data (e.g. magnetostratigraphy) in order to acquire and evaluate new evidences for the global definition of the Jurassic-Cretaceous (J/K) boundary in marine environment (**Fig. 25**). Classic key-sections, such as Kurovice (Czechia), were supplemented by new sections from Silesian Unit (Czechia and Poland), Rettenbacher (Austria), and Golubac-Dedina (Serbia). The newly established data was combined with previous knowledge to (i) verify stratigraphic (e.g. magnetozone) boundaries, and (ii) produce new bio-, magneto- and chemostratigraphy for the sections. The obtained data contributed to the work of former Berriasian Working Group (BWG), which effort culminated in proposal of a GSSP. Integrated stratigraphy, based on stable isotopes in relation to bio- and magnetostratigraphy, enabled global correlation of the J/K boundary interval. New results and published data, including lectures at conferences, continue to significantly contribute to the detailed inclusion of Tithonian-Berriasian (J/K) boundary formations and the dating of the J/K boundary in the GSSP by new BWG, which was appointed in 2021 by the Cretaceous Subcommission of the International Commission on Stratigraphy. The 2023 activities of our group (Inst Geol, Czech Acad Sci /GLI/) were focused on the finalizing all analyses of samples taken during previous years [e.g. magnetic measurements of Golubac-Dedina section], comparing them with results by other methods [calcareous nannofossils and foraminifera – Czech Geol Surv /CGS/ team; calpionellids – D. Reháková; non-calcareous dinoflagellates – VŠB-Techn Univ Ostrava /VŠB-TU/ team; and geochemical data from the bulk rock and macrofossils (e.g. $^{87}Sr/^{86}Sr$ and $\delta^{13}C$, $\delta^{18}O$ isotope data) – Inst Geol Paleontol, Charles Univ / IGP-ChU/ team; Hg – GLI team], and compilation of all the data into publications in international peer-reviewed journals. The results were summarized in several joint papers submitted to the Cretaceous Research: e.g. Karpentná and Ropice sections, Rettenbacher, and Dedina. Furthermore, the Kurovice ichnological, magnetic and stable isotope paper was published in the Ichnos (online). The paper on Berrias type area was written in collaboration with W. Wimbledon (Cretaceous Research).

No. *GA20-14292S*: Mercury – overlooked threat in the Czech ecosystems responding to global change (*T. Navrátil*; F. Oulehle, Czech Geological Survey, Prague; 2020–2023)

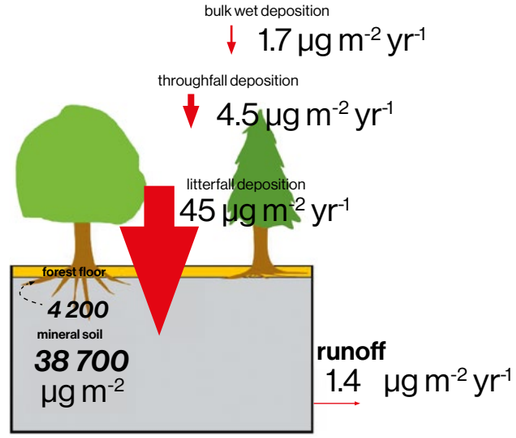

FIG. 26 A conceptual diagram of the mercury cycling in the central European forest ecosystems based on data from 14 GEOMON catchments within the Czech Republic.

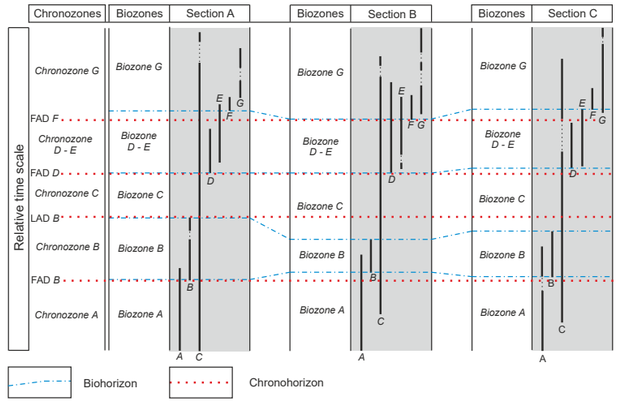

FIG. 27 Biostratigraphic and chronostratigraphic utility of the graptolite fossil record. Biostratigraphic subdivision with interval biozones named after biozonal index species (*A, B, C, D, E, G*), defined by bounding biohorizons, and characterized by an assemblage of other typical taxa. Base of the biozone is commonly defined by the stratigraphically lowest occurrence of the biozonal index species, the top by the lowest occurrence of the biozonal index of the next biozone. Biozone *C* exemplifies the so-called "interzone" or "interregnum" named after some abundant species ranging well beyond the stratigraphical limits of the biozone, the base of which is defined by the stratigraphically highest occurrence of species B and its top by the lowest occurrence of species *D* – biozonal index of the next biozone. Biozone *D–E* is named after two species of similar stratigraphical range. The lowest occurrences of species *D* in the respective sections define its base whereas the top is defined by the lower bounding biohorizon of the stratigraphically higher biozone *G*. The latter biozone is named after abundant species *G*, but its base may be defined by the lowest occurrence of the prominent, short-ranging species *F*. A biohorizon is not a time surface as the lowest and the highest occurrences of graptolite species differ in time among respective local sections due to both collection failure, preservation constraints, and different environment and living conditions. The first appearance datum (FAD) of a species is a time surface or a chronohorizon defined by the lowest documented occurrence of the species in each and every local section in its geographical range. Such a time surface, most precisely identified by means of a computer-assisted constrained optimization exercise, is an important tool in chronostratigraphic correlation and construction of the time-calibrated chronology of Earth history.

The project assessed the total Hg concentration in specific soil horizons and its distribution. The forest O horizon was enriched in Hg due to litterfall deposition, but the largest soil Hg pool was found in the mineral soil because of its greater thickness and specific weight. Site-specific properties such as soil carbon storage and soil sulfur concentrations were identified as determining factors for the extent and mode of Hg accumulation.

The wet Hg deposition levels at all GEOMON catchments were generally low, with a mean bulk precipitation Hg deposition of 1.7·µg·m^{-2}·yr^{-1} across the 14 catchments. As there is a lack of data on wet Hg deposition in Europe, we also included a site near a Hg emission source – chlor-alkali plant in Neratovice, where the deposition was elevated at 3.6·µg·m^{-2}·yr^{-1}.

The foliage assimilates atmospheric Hg and it represents the main pathway of Hg deposition to the forest ecosystems, therefore we quantified Hg litterfall deposition at GEOMON catchments, averaging 44.5·µg·m^{-2}·yr^{-1}. Thus, litterfall represents the major input path of Hg into forest ecosystems. Previous estimates of European litterfall Hg deposition from global modeling studies were much lower, ranging from 16–20 µg m^{-2} yr^{-1}. Thus, the data from this project will allow for a more precise estimation of the continental litterfall Hg deposition rate.

To quantify Hg accumulation in small forest catchments, it was also necessary to observe the runoff through the surface water. The calculated average stream output from the 14 GEOMON catchments was small, at 1.4·µg·m^{-2}·yr^{-1}, and positively correlated with the DOC runoff.

The project results summary compares the balance between Hg input and output fluxes at the GEOMON sites and partly in contaminated areas (**Fig. 26**). The main project output is an understanding of the relationship between current atmospheric Hg and wet depositions, litterfall, and organic soil horizons. Forest soil serves as the primary storage site for deposited Hg. Given the anticipated decrease in soil organic material stability resulting from temperature increases associated with climate change, it is crucial to monitor the accumulation of Hg in forest soils.

No. *GA20-23363S*: Biostratigraphy and faunal dynamics of the Silurian pelagic biota of the Prague Basin in the context of major environmental changes and perturbations. (*P. Štorch, L. Slavík, Z. Strossová*; Š. Manda, Czech Geological Survey, Prague; 2020–2023)

This project encompassed a comprehensive study on Silurian graptolite biostratigraphy and faunal dynamics in the Prague Basin, based on range charts of 386 graptolite species. Through bed by bed sampling of 46 sections, supplemented by published graptolite records from an additional 42 localities, we achieved the recognition, definition, and description of 46 graptolite biozones and 7 subzones. The durations of these biozones, ranging between 0.1 and 1.74 Myr, were inferred from correlation with the GTS 2020 age model and the global standard graptolite biozonation. The range charts supplied data for analysis of regional graptolite faunal dynamics, traced through species richness per biozone, mean standing diversity, time-normalized Van Valen's metrics, and FADs/LADs score per biozone (**Fig. 27**).

In a subsequent study, we analyzed the pivotal role of planktic graptolites as primary fossils for biostratigraphical subdivision and correlation of Ordovician, Silurian, and Lower Devonian offshore marine successions worldwide. The rapid evolution and dispersal, morphological

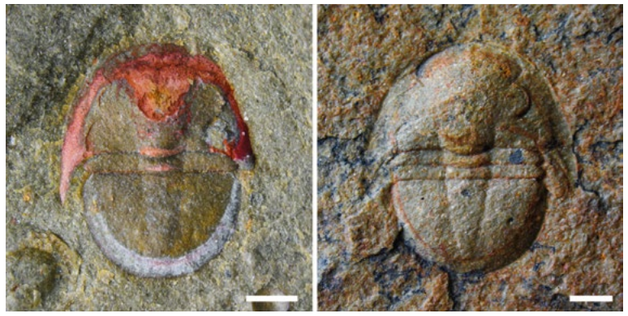

FIG. 28 Early developmental stages of trilobite *Platypeltoides* were likely nourished by large yolks. Scale bar = 1 mm. Author: L. Laibl.

diversity and complexity of graptolite rhabdosomes, the high numerical abundance of preserved specimens, and the wide geographical distribution of species, have made graptolites the optimal biozone fossils. Although the maximum utility of graptolite biostratigraphy and correlation is linked to the widespread facies of graptolitic black shales, less-detailed subdivision and correlation may be applied in relatively shallow-marine, well-oxygenated settings. Indeed, graptolites facilitate correlations between disparate biofacies. Graptolite biostratigraphy based on assemblage biozones has been refined by the use of various types of interval biozones, defined by their characteristic assemblages, bounding biohorizons, and typical index taxa. Further enhancement of stratigraphical resolution and correlation is achieved by integrating graptolite data with the conodont and chitinozoan record and implementing quantitative biostratigraphy.

Another output focused on chronostratigraphic division of the Přídolí Series into Jarovian and Radotinian stages. Correlation markers applicable in the division were discussed based on data from relevant sections in the Prague Synform. Graptolite *Wolynograptus bouceki* has been suggested as the primary marker for definining the base of the upper Radotinian stage, with conodont *Delotaxis detorta* entering close to the base of the *bouceki* Biozone. The Hvížďalka section has been proposed as a potential GSSP.

Last but not least, the International Commission on Stratigraphy selected the black shale succession of the Želkovice Formation exposed near Hlásná Třebaň as the new Global Stratotype Section and Point (GSSP) for the lower Silurian Aeronian Stage. This decision resulted from the extensive study, description, and formal proposal submitted by the international research team led by Petr Štorch. The new international stratotype was ratified by the IUGS on January 20, 2024.

No. *GA21-10799S*: Environmental control on the rise and fall of the earliest land plant assemblages of Silurian volcanic islands of the Prague Basin (Czech Republic) (*J. Bek*; J. Pšenička, West Bohemian Museum, Pilsen; J. Frýda, Czech University of Life Sciences, Prague; Jiří Kvaček, National Museum, Prague; 2021–2023)

Main output of the project was discovery of new localities with Silurian plants and palynomorphs and taxonomical research of plant specimens from Silurian of the Prague Basin. Samples yielded specimens of cooksonioid plants and palynomorphs including trilete spores, cryptospores, chitinozoans, acritarchs including prasinophytes, leiospherids, scolecodonts and algae together with graptolites. Among taxonomic results one of the most important is the occurrence of the oldest monolete spores in the global scope from the Loděnice-Špičatý vrch locality, i.e. locality with the oldest vascular land plant *Cooksonia barrandei* occurs. Another significant output is common feature of the cryptospore and trilete spore records is that their number is surprisingly globally lowest in the tropical climatic belt and much higher in the temperate and especially in the cool latitudes. Results are based on the study of thirty-seven Silurian and Early Devonian plant genera with sixty-four species. In general, based on the dispersed spore record, we can estimate that the plant assemblages of the tropical belt were dominated by rhyniophytes; trimerophytes probably prevailed over rhyniophytes in the temperate belt, and rhyniophytes again dominated within the cool belt. Dynamics of Silurian plants as response to climate changes outlines the paths that the research of the oldest land flora. Our analysis of spore diversity evolution clearly indicates a very distinct exponential evolutionary acceleration of trilete spore producers starting in the lower Wenlock and defined the first event for early land plants. After three distinct middle to late Silurian glaciations and increase of diversity are correlated with the rise of the global temperature after the glaciations. Homerian glaciation affected decine of diversity of cryptospores and trilete spores. This indicates different sensitivity of eophytidae vs. trilete spores.

No. *GA21-26542S:* Influence of postgenetic alterations of granites on their resistance to weathering processes in cultural heritage structures (R. Přikryl, Faculty of Science, Charles University, Prague; *T. Lokajíček, M. Petružálek, A. Aminzadeh*; Z. Weishauptova, D. Řimnáčová, Inst Rock Struct Mechan, Czech Acad Sci, Prague; 2021–2023)

Postgenetic alteration processes (e.g., hydrothermal alteration) accompanied with brittle damage and secondary mineral fillings are common in granites used in construction. These alterations are manifested by discrete phenomena in rock-forming minerals and rock microfabric (e.g., alteration of more basic cores of plagioclases, recrystallization of quartz aggregates and formation of discrete microcracks filled with clay minerals). The question of the influence of these discrete mineralogical and microstructural changes on mechanical properties and on behavior during weathering processes has been neglected in previous studies. This might be influenced by the fact that above mentioned discrete changes in original rock magmatic fabric have negligible impact on examined strength characteristics but can significantly influence stress-strain behavior which is still scarcely examined on materials from cultural heritage structures. Similarly, influence of type of mineral filling on deformational characteristics and on durability has not been studied, yet.

No. *GJ20-23550Y*: Exploring developmental aspects in fossil arthropods during Cambrian explosion and Ordovician biodiversification (*L. Laibl*; 2020–2023)

The project was extended for six months due to the COVID-19 pandemic. In 2023, the research was finalized and published as four main papers. In the first paper, we showed that stratigraphically (and evolutionarily) earliest trilobites have had a direct development with larvae living on the sea floor. Indirect development with planktic larvae evolved independently in several trilobite groups during the latest Cambrian and earliest Ordovician. This invasion into the pelagic realm was likely related to the increasing diversity of the phytoplankton. The second paper describes several large trilobite babies from the Fezouata Shale (Morocco) that were likely nourished by large yolk (**Fig. 28**). Such type of development is often present in today's high-latitude invertebrates and some trilobites were likely similarly adapted to the high-latitude environment of the Fezouata Shale. In the third paper, we described superbly preserved larvae of Ordovician arthropods. The investigation of these larvae by synchrotron microtomography revealed that their appendages were of similar morphologies as in their adult stages. Such similarities suggest an absence of ontogenetic niche differentiation in these early arthropods. This was likely the ancestral condition present in the last common ancestor of Arthropoda. Finally, the fourth paper shows that the development of extant and extinct horseshoe crabs was rather conservative when compared to the development of other Paleozoic chelicerates. In total, the project resulted in the publication of nine papers in impacted journals over three and half years.

ONGOING PROJECTS

No. *GA21-21829S*: Proposal for the GSSP of the Basal Emsian Boundary in the Prague Synform (*L. Slavík, J. Hladil, H. Weinerová, T. Weiner*; 2021–2024)

The present GSSP for the basal Emsian boundary is among the most problematic issues in the global Paleozoic stratigraphy recognized by the International Commission on Stratigraphy (ICS/IUGS). The former traditional Pragian Stage of the Lower Devonian that has been originally based on the Praha Formation in the Prague Synform was thus drastically reduced. The project aims at the search for alternative to the present GSSP. In 2023 the team focused on evaluation of all obtained paleobiological material and data from geochemistry, magnetic susceptibility (MS) and gamma-ray spectrometry (GRS). Data and samples from three selected stratigraphic sections with presence of the Bohemian Graptolite Event (BGE): Mramorka Quarry, Pod Barrandovem and Požáry-3 section were processed. Bulk carbonate $\delta^{18}O$ and $\delta^{13}C$ records, GRS measurements, MS measurements and data from INAA geochemical analyses across the BGE interval have been correlated with the new conodont biostratigraphic framework. The study resulted in proposal for the new GSSP for the basal Emsian boundary. The possible candidate section for the prospective basal GSSP redefinition – the Mramorka section near Chýnice, Prague Synform, Czech Republic is presented in the published paper. The *gracilis* Event that is close to the traditional boundary between the Pragian and Emsian stages was selected as the boundary criterion. The event is characterized by entry of conodont taxon *Latericriodus bilatericrescens gracilis* Bultynck, which is widespread in NW part of Gondwana. The lowermost entry of the taxon within the Prague Synform has been recorded in the proposed candidate section, 145 cm below the BGE interval. The Mramorka section is characterized by grey nodular calcisiltites largely influenced by ichnofabric. The BGE interval, however, consists mostly of darker grey, platy limestones interbedded with calcareous shales. The multiproxy studies in the Mramorka section show a marked change in geochemical proxies within and above the BGE. The values of Clay gamma-ray (CGR) and elements indicating terrigenous input show relatively higher values below the BGE interval and a gradual decrease above the BGE. The BGE interval is characterized by elevated paleoredox and paleoproductivity proxies. The MS is largely tied to the terrigenous input, but is also influenced by authigenic Fe minerals. Isotope ($\delta^{13}C$) values are markedly increased above the BGE. The strata below the BGE interval are considered to record the culminating transgression and strata above the BGE interval the highstand. The BGE interval itself records the maximum flooding. If present, the BGE interval, which is close above the *gracilis* Event, can be used as marker for approximation of the prospective GSSP boundary.

No. *GA22-00580S*: The role of rock anisotropy in hydraulic fracturing through acoustic emission (*T. Lokajíček, M. Petružálek, A. Aminzadeh, T. Svitek*; J. Šílený, P. Kolář, Z. Jechumtálová, Inst Geophys, Czech Acad Sci, Prague; 2022–2024)

Recently, a large variety of different aspects-features of the set-up of the hydraulic fracturing (HF) has been investigated. The texture anisotropy and/or crack anisotropy have a great influence over the effective mechanical properties of rocks and the way of their fracturing and failure. We believe that the influence of texture and/or crack anisotropy, as a characteristic property of most of the rocks, deserves to be studied in greater detail. The proposed project is a joint study concerning laboratory HF experiments and application of advanced seismological methods to registered acoustic emission. The HF will be performed on the rock analogue of anisotropic mica schist from research geothermal center at the Litoměřice site, Czech Republic. The stress conditions will be simulating the actual test site at the depth of 1 km. The advanced seismological methods will be implemented to anisotropic conditions and applied to detail analysis of registered acoustic emission. This research will lead to a better understanding of the role of the rock texture/crack anisotropy on the HF.

No. *GA 21-33751S*: The Late Pliocene lower vertebrates (fishes and frogs) from the konservat-lagerstätte Camp dels Ninots (north-eastern Spain) (*T. Přikryl*; 2021–2024)

The project evaluates from the systematic and paleoecological aspects lower vertebrates (fish and frogs) of the Camp dels Ninots (CdN) locality in the Catalonia. Unfortunately, difficult nomenclatoric history of some taxa, unclear systematic position of the earlier described relatives, together with high endemism of the Iberian Peninsula fish and persisted complications related to epidemiological restrictions and ongoing COVID-19 pandemic made numerous complications and affection of the schedule and caused delays in preparation of finalized results.

The Leuciscinae fish from CdN belongs to genus *Squalius*. The Barbinae specimens from CdN should be classified within genus *Luciobarbus*. Specimens of frogs from CdN excavations campaigns were documented graphically (10 articulated specimens) and interpreted taphonomically. Some 59 additional articulated fossil frog specimens from the Miocene locality of Libros (Teruel, Spain), crucial for correct interpretation of CdN frogs, have been studied and documented from different Spanish Natural History Museums. Ongoing results were presented within international conferences and manuscripts were prepared for publication.

No. *GA22-02149S*: Reconstruction of Medieval Castle Kitchen Operation in Relation to Waste Management on Rokštejn Castle Example (J. Mazáčková, Faculty of Arts, Masaryk University, Brno; *L. Lisá*; 2022–2024)

FIG. 29 Outcrop of Permo-Triassic sedimentary succession in the Colorado River valley near Moab, Utah, USA. Photo by L. Ackerman.

Castle kitchens represent specific features of fortified residences, along with their operation. The project focuses on interdisciplinary research of reconstructing such operation, based on facts from archaeological layers. Case study will be represented by the Rokštejn Castle which has been excavated since 1981, and which will allow observing of the evolution of the castle kitchens, not only in relation to time, but also to its dynamic remodellings of the castle with the changes in castle ownership. Archaeological features with artefactual/ecofactual material will be selected so that it is relatable to the workings of kitchens, or the waste management of the castle, that can contain evidence of dining culture. Expected results will be based on complex interpretation of archaeological, osteological, and geological data which will allow answering the question of the origin and composition of kitchen waste, be it osteological or ceramic components, and what economic models can be applied for castle kitchens.

No. *GA22-15405S*: Early diagenetic cycling of redox-sensitive geochemical proxies and palaeoclimatologic significance of continental red beds (O. Bábek, D. Šimíček, J. Kapusta, O. Šráček, T. Pluháček, Faculty of Science, Palacký University, Olomouc, Czech Republic; *L. Ackerman, H. Weinerová, J. Rejšek, J. Ďurišová, N. Mészárosová, V. Renčiuková*; 2022–2024)

Second year of the project was predominantly focused on collection and interpretation of analytical data obtained for Quaternary Pleistocene glacifluvial and glaciolacustrine sand deposits in the northern Bohemia (e.g., Grabštejn, Dubnice) and continental red beds in Lower Old Red Sandstone Formation (Pembrokeshire) in Wales, UK. Collectively, EDXRF, DRS, XRD, optical microscopy, SEM, in-situ geochemistry by EDAX-SEM and LA-ICP-MS studies were conducted and these were paralleled by the collection of Mo and Fe isotopic data, with three aforementioned methods performed at the Inst Geol, Czech Acad Sci. In terms of northern Bohemia localities, the results indicate that both syn-depositional and early diagenetic processes are responsible for the origin of color patterns in the Quaternary glaciofluvial sediments. The stable Mo–Fe isotopic fractionation is predominantly controlled by the breakdown of the primary Fe- and Mn- bearing silicates and the precipitation of the secondary Fe- and Mn-(oxy)hydroxides, such as goethite and birnessite. The textural patterns and geochemistry suggest that the color features were developed in time range of decades to several thousand years after the deposition along ancient subsurface redox gradients due to changes in groundwater flow associated with primary lithology, glaciotectonics, and seasonal changes in active layer of permafrost. At Old Red Sandstone, the data collected so far seems demonstrate that the red facies are enriched in very fine-grained opaque Fe oxyhydroxides, which are more-less evenly distributed in the mudstone matrix. In terms of Mo isotopic compositions, the $d^{98}Mo$ values range from -1.28 ‰ to 0.57 ‰, but most values (18 out of 22) are negative while the elemental distribution LA-ICP-MS maps show a distinct enrichment in redox-sensitive elements in certain phases.

Beside two above mentioned localities, fieldwork was also completed for the Permo-Carboniferous red bed succession of the Bohemian Massif where six sections (Žampach, Trutnov – St. Rokytník, Úpice, Havlovice, Vrchlabí, and Klášterská Lhota) have been described, gamma-ray logged, and sampled. Analytical works were completed including, bulk geochemistry (EDXRF + ICP-MS), diffuse reflectance spectroscopy (DRS), X-ray diffraction (XRD) analysis, thin section analysis by optical transmission / reflection microscopy, electron microscopy (SEM), in-situ geochemistry by EDAX-SEM and laser ablation ICP-MS with the results being currently processed and evaluated 2024.

Finally, another fieldwork focused on Permo-Triassic sedimentary red successions of the Colorado Plateau near Moab, SE Utah, USA were carried out in October, 2023 (**Fig. 29**). About 410 m of two stratigraphically overlapping sections were described in bed-by-bed manner, gamma-ray logged, and sampled.

No. *GA22-28249S*: Muong Nong-type-like moldavites in understanding the strewn field geometry and tektite origin (*R. Skála, N. Mészárosová, Š. Matoušková*; 2022–2024)

Fifty carefully selected individual samples collected at localities Besednice, Chlum nad Malší, Dolní Chrášťany, Dříteň, Jakule, Jankov, Krasejovka, Radomilice, Slavče u Trhových Svinů, Třebanice, Truskovice, and Veselí n. Lužnicí in the South Bohemian sub-strewn field were studied. From each sample, a polished thin section of ~400 µm thickness was prepared and observed under a binocular microscope in both parallel and convergent transmission illumination. Thin sections were further screened with back-scattered electrons in an SEM. Major element contents were determined with an EPMA and minor and trace elements were analyzed by an LA-ICP-MS.

Both macroscopic appearance and observations in an optical microscope make MN-type-like moldavites indistinguishable from many actual MNTs from the Australasian strewn field (**Fig. 30**). The size is comparable to the co-existing splash-forms, which is actually similar to occurrences in Indochina where MNTs are found mostly as relatively small fragments of possibly larger bodies. Both major and trace element contents are variable within as well as among individual measured MN-type-like moldavites. The distribution of elements is usually not normal as demonstrated by the difference between respective means and medians: when placed on a relative scale these differences vary from 2.5% for SiO_2 to 43% for CaO. Intra-sample variability expressed as relativized median absolute deviations vary in a similar way: the lowest value was attained for SiO_2 (0.7%), the highest for CaO (80.9%). Characteristic features not observed in other South Bohemian moldavites are overall extremely low CaO contents (sample median down to 0.26 wt.%) and high Na_2O concentrations (sample median up to 0.74 wt.%). Important are also elevated contents of volatile elements like Cu, Zn or Pb.

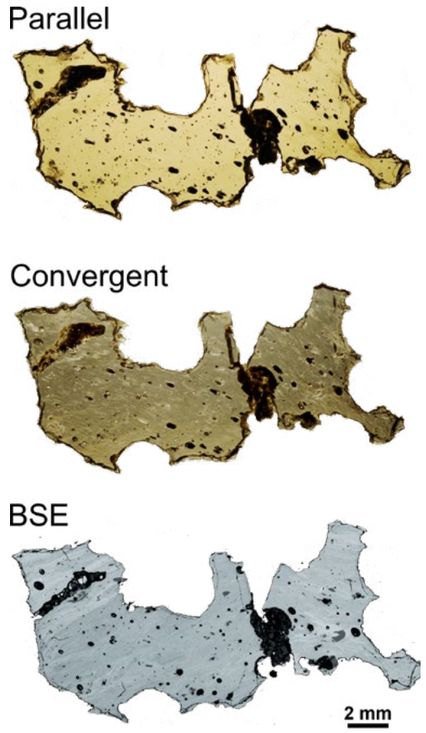

FIG. 30 Heterogeneous structure and "shimmery" appearance in the polished thin section of MNT moldavite imaged in parallel and convergent illumination and back-scattered electrons. Photo by R. Skála.

When documenting structure and chemical variability with an SEM, several new types of inclusions, in addition to already identified baddeleyite, monazite, and apatite, were observed: disintegrated quartz grains in lechatelierite, zircon, and chromite. A suite of crystalline inclusions occurring in type-locality Muon Nong tektites has been investigated in parallel with the inclusions from Bohemian samples for comparison. Two types of sulfide inclusions were observed: sulfide inclusions with a complex mineralogy including pentlandite and pyrrhotite as the main constituents, and inclusions formed mostly by pentlandite and chalcopyrite. Further, inclusions consisting of lechatelierite, quartz and coesite, and zircon with baddeleyite were identified, the latter being similar to those found in MN moldavites.

FIG. 31 Profile wall of the metamorphic basement present in the Emosson Lake (Swiss canton Valais) is a part of the Aiguilles Rouge massif and is represented by augen gneisses, considered by von Raumer (1987) possibly to represent Cambrian/Ordovician age. Photo by M. Svojtka.

No. *GA23-06708S*: Detrital zircon geochronology as a tool for interpreting terrane provenance (J. Žák, F. Vacek, F. Tomek, T. Tkáčiková, Faculty of Science, Charles University, Prague; *M. Svojtka, L. Ackerman, J. Sláma, J. Ďurišová, V. Renčiuková, F. Karaoglan, V. Santolík*; 2023–2025)

Three field and sampling campaigns in Lower Paleozoic and Nemmosoneoproterozoic terranes were focused in the first year of the grant project in several European areas. The field campaign in Bulgaria was focused on Lower Paleozoic low-grade metamorphic units from the Central Balkan Zone. It included the area of metasediments from Stakevtsi and Ribaritsa units, which are essential for understanding the distribution of detrital zircon ages spectra of the Central Balkan Zone. Considerable attention was given also to relations of the associated Ribaritsa and Klisura granite intrusions. Preliminary U–Pb age results using laser ablation ICP-MS technique yielded not only the Silurian and Devonian record but also a strong Neoproterozoic age component of Ediacaran and Cryogenian age. During the field campaign, many geochemical, geochronologic, and rock magnetic samples were taken together with structural data, the samples were successfully transported to the Czech Republic and are now being processed and analyzed. The second field campaign was focused on the pre-Variscan sequence of the Carnic Alps, which is exposed across the state border between northeast Italy and Austria. It includes Middle Ordovician to Lower Pennsylvanian rocks that, although affected by both Variscan and Alpine orogeny, preserve continuous and non-metamorphosed successions. Depositional settings vary from shallow water to open marine environments. Remarkable is the presence of the largest Devonian reefs of Europe, and related deposits from the back reef to the fore-reef and basin. The third field trip with a collection of main lithological types of Neoproterozoic and Lower Paleozoic succession was targeted at the profile of the Western Alps. In the Swiss Alps, this was the Aar-Gotthard Massif massive and the Innertkirchen Gneiss Complex (**Fig. 31**). Followed by the metasediments located in crystalline massifs Aiguilles Rouges and Belledonne in the southeast France and finally, metasediments of the Valsugana unit in the northern Italian Alps. All detrital zircon samples collected were analyzed on LA ICP-MS and are further processed.

No. *GF23-05142K*: The Late Cretaceous Flora of South Bohemia (J. Kvaček, National Museum, Prague; *J. Dašková*; 2023–2026)

The Late Cretaceous flora from the Klikov Formation of the South Bohemian Basins represents one of the best preserved Cretaceous floras in Europe. However, detailed palaeoecological and taxonomic comparisons with other Cretaceous floras are hampered by its currently only vaguely defined stratigraphic age, and the still fragmentary knowledge of the flora's taxonomic composition. Stratigraphy, plant diversity, and palaeoecology are therefore the major focus points of this project. The project started in mid-2023, and sampling began immediately. Plant mega-, meso-, and microfossils are gained from new outcrops along a highway construction site. This sampling will be followed by a comparison with earlier-described material, aiming at the description of new taxa, taxonomic revisions, and paleoecological interpretations.

6C GRANT AGENCIES OF UNIVERSITIES

FIG. 32 Forest in the Bohemian Switzerland National Park after the fire in 2022.

FINISHED PROJECTS

***START No. SCI/139*: Cuticles from the Lower Paleozoic of the Barrandian area (*Z. Strossová, M. Uhlířová*; V. Kovář, O. Fatka, Faculty of Science, Charles University, Prague; 2021–2023)**

Microfossil record reveals a large number of fragmented cuticles and many other structures, of which the origin remains unknown. The palynological maceration method allows the extraction of these micro- and mesofossils from rock samples to allow a more detailed study. One of the aims of this project was to connect the macrofossil record and microfossils obtained by the extraction of fossil remains of known taxa. The studied material comes from the Lower Palaeozoic localities of the Barrandian area. The samples were processed using the "low manipulation HF extraction" method or the cellulose film technique. Both methods involve the application of inorganic acids (hydrochloric and/or hydrofluoric). The residues were subsequently studied in transmitted light or with a scanning electron microscope. The isolated fragments were described and classified based on external morphological and, if preserved, internal anatomical features. The cuticles and tissues of selected groups of fossils including plants, phyllocarid crustaceans, tentaculites, and graptolites were described. A significant part was devoted to the study of the ultrastructure of the fossil genus *Pachytheca* Hooker.

6D INDUSTRIAL GRANTS AND PROJECTS

FINISHED PROJECTS

***Beijing University & Hong Kong University, China, Project No. 7004*: Highly siderophile element and Re-Os isotopic compositions of selected peridotites and mafic rocks from China (*L. Ackerman, V. Renčiuková, J. Ďurišová, J. Rejšek*)**

A joint project with Beijing University and Hong Kong University (Prof. Song, Dr. Chao) dealing with the nature of source parental rocks of Tethyan ophiolites in China.

***Bohemian Switzerland National Park Administration, Krásná Lípa, Project No. 7407*: Monitoring of Atmospheric Precipitation in the Bohemian Switzerland National Park (*T. Navrátil, I. Dobešová, J. Rohovec, Š. Matoušková*)**

In the hydrological year 2022, the average pH of both bulk and throughfall precipitations in the Bohemian Switzerland National Park decreased compared to the previous two hydrological years. The precipitation amount in 2022 was 944 mm, which is above the 10-year average of 884 mm. The dieback of virtually all the spruce trees near the sampling site of Kuní vrch Hill due to the bark beetle infestation was the main driver of changes in the chemistry of precipitation. The deposition of SO_4^{2-} and NO_3^- was at its lowest since monitoring had begun in 2002 due to a lack of canopy at the throughfall sampling site.

The bulk wet deposition of mercury remains low in the Bohemian Switzerland National Park, consistent with other European background sites. The database at the Kuní vrch sampling site contains 231 monthly records of the chemical composition of bulk and throughfall precipitations from April 2002 to June 2023.

The major forest wildfire that burned over 10 km² of forest in 2022 did not affect the chemical composition of precipitation at Kuní vrch Hill significantly. However, the long period of drought prior to the fire had a much greater effect on the chemical composition of precipitation (**Fig. 32**).

***Brno University of Technology, Faculty of Information Technology (as the Contractor of the European Space Agency "ESA"), Project No. 7804*: Advanced compression noise reduction for hyperspectral imagers data (*T. Kohout*)**

The project deals with the algorithm development for onboard denoising and compression of hyperspectral images obtained by spacecrafts in order to reduce volume of data transferred to the ground. The outcomes of the project will be applied to Earth observation and planetary exploration missions.

***Comenius University, Slovakia, Project No. 7004*: Sr-Nd-Pb isotopic compositions of mantle-derived xenoliths as well as volcanic and plutonic rocks from the Carpathians (*L. Ackerman, V. Renčiuková, J. Rejšek*)**

A joint project with Comenius University (Prof. Marián Putiš, Assoc. Prof. M. Huraiová) focused on the petrogenesis of mantle-derived xenoliths and volcanic and plutonic rocks from the Carpathians.

***Czech Geological Survey, Prague, Project No. 7004*: Highly siderophile element, Re-Os and Sr-Nd-Pb-Hf isotopic compositions of the Ransko massif (*L. Ackerman, V. Renčiuková, J. Ďurišová, J. Rejšek*)**

A joint project with the Czech Geological Survey (Dr. Vojtěch Wertich) focused on the petrogenesis of the Ransko massif, Czech Republic, and its Ni-Cu-PGE mineralization.

***Czech University of Life Sciences, Prague, Project No. 7004*: Cadmium isotopic composition of selected black shales and carbonates from the Prague Basin (*L. Ackerman, J. Rejšek*)**

A joint project with J. Frýda dealing with Cd isotopic compositions of black shales and carbonate rocks from the Prague Basin, Czech Republic.

***Faculty of Science, Charles University, Prague, Project No. 7004*: Strontium isotopic composition of Cretaceous belemnites (*L. Ackerman, J. Rejšek*)**

A joint project with M. Košťák, dealing with Sr isotopic compositions of belemnites from the Czech Republic.

***Faculty of Science, Charles University Prague, Project No. 7004*: Trace element compositions of the Miocene sedimentary rocks and selected foraminifera (*L. Ackerman, J. Rejšek*)**

A joint project with K. Holcová, dealing with the compositions of Miocene sediments from Turkey and Zanzibar.

***Inst Archaeol, Czech Acad Sci, Prague and Faculty of Philosophy, Charles University, Prague, Project No. 7004*: Re-Os isotopic compositions of artefacts, slags and ores (L. Ackerman, V. Renčiuková, J. Rejšek)**

A joint project with D. Bursák, dealing with Re-Os isotopic compositions of artefacts from selected burial grounds as well as slags and ores in the Czech Republic.

***Inst Archaeol, Czech Acad Sci, Prague and National Museum, Charles University and Muzeum Vysočiny, Czech Republic, Project No. 7004*: Strontium isotopic compositions of selected burial grounds (*L. Ackerman, V. Renčiuková, J. Rejšek*)**

A joint project dealing with Sr isotopic compositions of enamels, bones and artefacts from selected burial grounds in the Czech Republic.

***Institute of Geological Sciences, Polish Academy of Sciences, Krakow, Poland, Project No. 7042:* In-situ U-Th-Pb LA-ICPMS analyses of accessories (*J. Sláma*)**

A further development of a joint project with the Institute of Geological Sciences, Polish Academy of Sciences (B. Budzyn, M. Jaranowski, F. Tramm) focused on *in-situ* LA-ICP-MS analyses of accessory mineral phases routinely used in geochronology. The performed analyses in the ICP-MS lab of the Inst Geol were mostly used to define the absolute U-Th-Pb age of minerals and their trace element compositions with relation to possible fluid alteration. The long-term collaboration within the scope of this project led, over years, to the recognition of various processes that affect the U-Th-Pb system at different rates and under varying conditions specific for individual mineral phases. As an example, the xenotime U-Th-Pb system that was considered rather robust for geochronology is prone to migration of all the system elements depending on the PT conditions and composition of fluids. The competing effects are represented by the formation of discrete nano-inclusions rich in Th, U or Pb or segregation of U or Th into dislocation cores at the atomic scale. Such features usually remain unnoticed during routine analyses but may strongly affect the resulting age information.

There was a number of other *in-situ* U-Th-Pb and TE LA-ICP-MS analyses that were run in the ICP-MS lab of the Inst Geol within additional ca 27 smaller projects with partners from all over the world. For a future implementation into the *in-situ* dating techniques available in the ICP-MS lab, new reference materials of columbite (X36 and Coltan139) and rutile (R632) were acquired.

***Inst Rock Struct Mechan, Czech Acad Sci, Prague, No. 7172*: (U-Th)/He dating of zircons and apatites (*Š. Matoušková*)**

Thermochronological project with Inst Rock Struct Mechan, Czech Acad Sci, Prague focused on dating of geological samples from upper crust. The Inst Rock Struct Mechan, Czech Acad Sci provides the He measurement and sample preparation for the Inst Geol, Czech Acad Sci isotope analysis of U, Th and Sm.

***Municipal Museum of Ústí nad Labem and Jan Evangelista Purkyně University in Ústí nad Labem, Faculty of Arts, Project No. 7464*: Petrographic study for project Database of old quarries and mine workings in the territories of the Bohemian Switzerland National Park and the Elbe Sandstones Protected Area, Technological Agency of the Czech Republic ÉTA Programme, No. TL05000407 (*J. Adamovič*)**

A review of old sandstone quarries in the territory of the Bohemian Switzerland National Park and Elbe Sandstones PLA raised the need to identify sources of building stone for selected historical monuments in the Děčín and Litoměřice districts (**Fig. 33**). For this purpose, a standard set of methods of provenance analysis was used, including petrographic analysis, mineral phase analyses, scanning

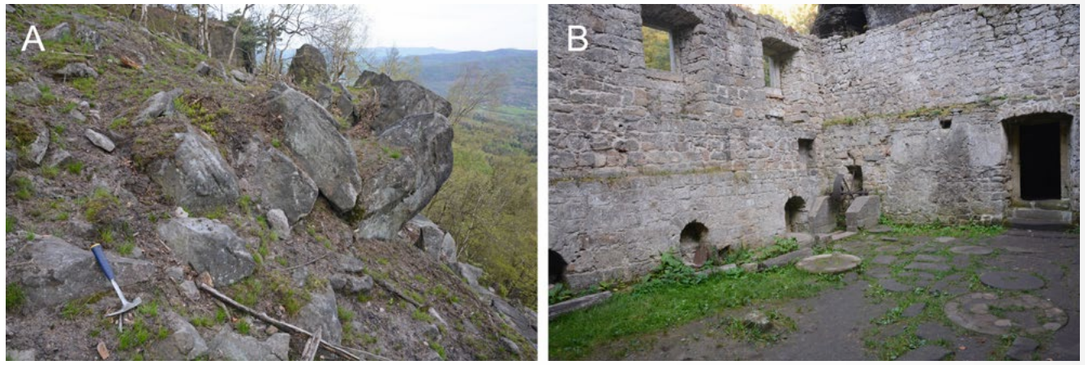

FIG. 33 A: The topmost bench in the Ruhr Quarry between Tisá and Sněžník, which was probably used as a source of quartz-cemented sandstone for millstone production, B: millstones kept on the floor of the Dolský Mill near Jetřichovice, corresponding to the rock from the Ruhr Quarry in their composition. Photos by J. Adamovič.

electron microscopy and microanalysis, and mercury porosimetry. The set of samples from quarries obtained in 2022 was extended by new samples at localities where the indicated sources did not fully match the archival data. All samples come from the Bílá hora and Jizera formations of the Bohemian Cretaceous Basin. The chapel and the tomb at Děčín-Podmokly, the Schönstein fort at Tisá and the lookout tower at Děčínský Sněžník Hill were proved to utilize local sources. The widest use was confirmed for stone from the Goldne Ranzen quarry area in the Bílá hora Formation south of Hřensko, which supplied material for the fortifications at Terezín. Another prominent quarry area, supplying quartz-cemented sandstone, lies in the topmost Bílá hora Formation between Tisá and Sněžník. It provided material for millstones kept at the Dolský Mill, but probably also for the church at Terezín. For most buildings and other historical objects, the source of sandstone material could be traced down to the level of quarry areas, and even to the level of individual quarries in some cases. In the conclusions, the study points to the need of an Open Access database of provenance-sensitive characteristics of sandstones with the practical aim to identify materials used in historical buildings. The use of authentic material in the reconstruction of objects of historical importance is one of the necessary preconditions for maintaining their authenticity, hence also their historical value. The completed study is an example of application of sandstone provenance analysis to issues of cultural heritage conservation and management and history of construction.

***Municipal Museum of Ústí nad Labem, Project No. 7464*: Petrographic study of volcanic rocks at Větrovec Hill, Bohemian Switzerland NP (*J. Adamovič*)**

Petrographic study complemented by XRD mineral phase analyses and EDS point analyses of mineral grains allowed to describe the textures and mineral compositions of volcanic rocks at Větrovec Hill (elev. 449.5). The rock from the main quarry can be described as rhoenite olivine basalt passing to rhoenite nepheline basanite.

***Saint Mary's University, Canada, Project No. 7004*: Sr-Nd isotopic compositions of selected volcanic and granitic rocks from Canada (*L. Ackerman, V. Renčiuková, J. Rejšek*)**

A joint project with Saint Mary's University (Prof. Dostal) dealing with the Sr-Nd isotopic composition of Cenozoic and Precambrian volcanic/plutonic rocks from Canada.

***University of Helsinki, Finland, Project No. 7004*: Strontium isotopic compositions of archeological and environmental samples from western Finland (*L. Ackerman, V. Renčiuková, J. Rejšek*)**

A joint project with University of Helsinki (L. Arppe, K. Mannermaa) dealing with Sr isotopic compositions of enamels and environmental samples (stream and lake water, fish meat etc.) from western Finland.

***University of South Carolina, USA, Project No. 7004*: Highly siderophile element and Re-Os isotopic compositions of mantle-derived rocks from Alaska (*L. Ackerman, V. Renčiuková, J. Ďurišová, J. Rejšek*)**

A joint project with University of South Carolina (M. Bizimis) focused on highly siderophile element systematics of mantle peridotites and pyroxenites from Alaska.

6E PROGGRAMMES OF STRATEGY AV21 OF THE CZECH ACADEMY OF SCIENCES

FIG. 34 Field documentation in the Dlouhý důl Valley in February 2023, five months after the devastating wildfire. Photo by J. Adamovič.

***Project No. 9221 within the Dynamic Planet Earth Programme*: Analytical techniques for the mining industry and environmental monitoring (*T. Hrstka*)**

In recent years, the DUST software has been progressively developed for similarity analysis of spectral data. The new release, DUST_2.4, launched in 2023, now enables faster and more accurate automated mineral identification and spectral clustering. Its applications in earth sciences facilitate the acquisition of statistically robust modal and textural data from samples of rocks, along with other natural and synthetic materials. Data derived from DUST_2.4 can be used to improve the scanning electron microscopy automated mineralogy analysis. This not only sheds new light on the processes of rock and ore deposit formation but also aids in understanding the impact of mineral processing and mining on the environment. The results of this project were presented at three international conferences.

***Project No. 9222_01 within the Dynamic Planet Earth Programme*: Mineralogical and other changes in sandstones induced by wildfires (*J. Adamovič, M. Filippi*)**

The present study made use of the biggest historical wildfire in the area of the Bohemian Switzerland National Park, northern Bohemia (**Fig. 34**). In August 2022, sandstone cliffs east and northeast of Hřensko were exposed to a severe fire over an area of 10.6 km^2 (i.e., 13 % of the National Park territory). The variety of sandstone types (from medium- to coarse-grained quartzose sandstones) and fire-exposure intensities provided a perfect source of data for the study of cliff-face degradation by fire, and of fire-related colour changes, mineral changes and porosity changes in the topmost rock layer. Observations and sampling concentrated to the Dlouhý důl Valley west of the Pravčická brána Arch. Spalling to a height of 4–8 above the cliff base was visible on up-wind sides of all outcrops, being accompanied by colour changes (reddening) of fallen rock layers. Maximum spalling intensities of 8 kg·m^{-2} were recorded on free-lying boulders. The colour change can be only partly attributed to the goethite→hematite transformation, and colour changes of glauconite and chlorite must be taken into account. Temperatures were only rarely found to be sufficient for a complete breakdown of kaolinite, which was commonly found in near-surface samples. While skeletal densities remain almost unchanged in fire-affected samples, total effective porosities were found to increase by 21–40 % in these samples relative to weakly affected samples deeper in the rock massif. These results will be compared from those in other areas in the National Park and in other sandstone areas to get a general picture.

***Project No. 9222_02 within the Dynamic Planet Earth Programme*: Causes of rockfall in sandstones of the Bohemian Cretaceous Basin (*J. Adamovič*; J. Blahůt, Inst Rock Struct Mechan, Czech Acad Sci, Prague)**

The recent (November 2021) rockfall at Krápníky site in the Teplické skály Cliffs, Broumov area, was studied in detail in collaboration with the Institute of Rock Structure and Mechanics Czech Acad Sci and the University of Wrocław. This collapse of a 10 m high pillar was given much attention because it occurred directly at a frequented tourist trail leading through the rock city. The fall was controlled by the original rock pillar morphology (a wider part standing upon a thin stem) in combination with vertical jointing and decoupling along bedding planes. The imminent trigger was probably a sudden drop of temperature on the days preceding the event, which resulted in frost expansion and a subsequent loss of internal stability of the sandstone body. Computer simulations revealed that the mechanism of failure was toppling, with the lowermost sandstone compartment acting as a pivot. This event can be compared with the October 2019 event on the NW edge of the same rock city, where fracturing and sliding along bedding planes also played a role. In 2023, rockfall research in the Teplické skály Cliffs was reported by the A magazín journal published by the Czech Acad Sci.

***Project No. 9222_03 within the Dynamic Planet Earth Programme*: On-line database of rockfalls in sandstones of the Czech Republic (*J. Adamovič*)**

The database https://rockfall.gli.cas.cz, established in 2016, proved useful in the landscape management performed by bodies of governmental nature protection (PLA and NP administrations) and self-administrative bodies. Registry of this phenomenon in sandstones of the Bohemian Cretaceous Basin is aided by a number of collaborators from these bodies and from wide public. As of December 31, 2023, the database holds 193 objects, most of which are new rockfall events registered within the last three decades. The most important rockfall events in 2023 were those in the southern part of the Kokořínsko PLA

FIG. 35 A rockfall in the Jizera Formation sandstones on the northern slope of Velký Beškovský kopec SE of Dubá. Almost 150 m^3 of rock were wasted during an event from early spring (April) 2023. Photo by J. Adamovič.

(Kokořínský důl, Velký Beškovský kopec; **Fig. 35**). Some of the recent rockfalls were completely remediated in 2023, e.g. the one between Velenice and Svitava east of *Česká* Lípa. Collaboration with the Municipal Museum of Ústí nad Labem reached the point that field documentation of rockfall events (e.g., Rabštejnské údolí near Česká Kamenice) could be incorporated in their project on rock stability in old quarries in the Děčín area. The representative set of rockfall events covering all major sandstone areas in the Czech Republic allows general conclusions on the lithological and structural controls of this phenomenon and on risk scaling of areas heavily visited by tourists.

***Project No. 9223 within the Water for Life Programme*: Water regime of the soil and watershed, precision water and mass balance of the mid-size watershed in the headwater area of the Bohemian Forest (M. Tesař, Inst Hydrodyn, Czech Acad Sci, Prague; F. Oulehle, Global Change Res Inst, Czech Acad Sci, Brno; *T. Navrátil*)**

Continued monitoring of mercury wet deposition in forest catchments in the Czech Republic has shown low levels of deposition, ranging from 1.1 to 2.5·µg·m^{-2}. In the Lesní potok catchment, which has been monitored since 2012, the bulk wet deposition of mercury decreased by more than 70 %. The annual concentrations of gaseous elementary mercury (GEM) at all monitored sites dropped within the range of 1.25 to 1.42·ng·m^{-3}. The Jezeří catchment was the only forest site with elevated GEM, originating from emissions from coal-burning power plants in the North Bohemian Coal Basin. In November 2023, T. Navrátil presented the project results at the Internal Seminar of the Czech Hydrometeorological Institute in the form of an invited plenary lecture.

***Project No. 9229 within the VP20 – Water for Life Programme*: The interconnection between research and water management practice (*M. Svojtka, J. Ďurišová*; J. Kubečka, Biol Centre, Czech Acad Sci, České Budějovice).**

In 2023, another set of otoliths for measurements on laser ablation ICP-MS technique was carried out at the Inst Geol workplace. In cooperation with the Biol Centre, Czech Acad Sci, České Budějovice, it has been shown that the micro elemental composition of pikeperch otoliths is a highly accurate tool to assess the natal origin of fishes, even in areas subjected to multiple stocking sources. When comparing the microelemental composition in the core and the rim of the otoliths, differences were recorded in the four significant elements, with the strongest differences being recorded in Mg/Ca where in all fish origin groups the values in the core were significantly higher than in the otolith rim. For Rb/Ca, significantly higher ratios were found in the rims in two fish sources (Lipno wild and Pelhřimov locality), whereas the Rb/Ca ratio was higher in the otolith core at Vodňany. The Sr/Ca ratio was significantly higher in otolith rims in two fish sources (Humpolec and Pelhřimov), while the K/Ca ratio was significantly higher in the otolith core at Vodňany. The classification model for fish of unknown origin was subsequently applied in a pool of samples from Lipno where the origin of pikeperch individuals was unknown. A total of 23 individuals had their microelemental compositions measured (Table 2) and the results were used to feed the machine-learning algorithm to classify the fish of unknown origin into one of the five known sources. The model classified 87 % (n = 20) of the fish as having been born in the Lipno Reservoir, whereas the remainder of 13 % (n = 3) fish have been born at Velké Rozběhlo (8.7 %, n = 2) and Pelhřimov (4.3 %, n = 1).

***Project No. 9231 within the Dynamic Planet Earth Programme, section Energy within the Earth*: Dynamics of the Vřídlo Spring water chemical composition (*J. Rohovec*)**

The project raises the question of the temporal variability of the chemical composition of dissolved and suspended mineral components present in the water of the world-famous Vřídlo Spring in Karlovy Vary. Suspended particles, trapped in the newly formed laminar layers of the spring carbonates provided information on the dynamics of the long-term evolution of the spring chemistry. The laminar structures of the sediments were studied by the LA-ICP-MS techniques. Long-term monitoring of the spring water composition and the effect of water composition on the chemistry of the sediments was conceptualized and launched.

***Project No. 9233 within the Dynamic Planet Earth Programme*: Paleontology helps to understand the evolution of the Earth's environment (*L. Laibl, M. Kočová Veselská*)**

In 2023, we undertook over 30 educational natural science programs and field trips for kindergartens, primary schools, and the public, including international primary schools. The courses were usually arranged as workshops (using inquiry-based learning) during which students learned about geological and paleontological concepts, such as plate tectonics, the evolution of life, erosion, changes in biodiversity, and climate changes. Lectures for students were conducted in cooperation with The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, v.v.i. and Trilopark. In cooperation with the Paleontological Section of the National Museum, one of us (MKV) delivered a lecture at the Stevns Klint site that captures the K-T extinction. In addition to that, a research paper (co-authored by LL), describing a unique fossil site in southern France, was submitted to the Nature Ecology and Evolution journal. The research reveals the history of polar ecosystems and confirms the migration hypothesis towards the Southern Hemisphere, where these species sought refuge from the high temperatures prevailing in the then-tropical zones. We have also started the preparation of an infographic about climate change in the geological history of the Earth in collaboration with the Facts on Climate Change (Fakta o klimatu) Institute.

***Project No. 9234 within the Dynamic Planet Earth Programme*: Extent and geometry of igneous/volcanic bodies (*F. Tomek, P. Vitouš*)**

Understanding the internal structure of extinct and eroded volcanoes is crucial for the study of active volcanic systems and the potential prediction of eruptions and associated hazards. The topic encompasses a comprehensive assessment of geological knowledge about three-dimensional architectures of volcanic and plutonic bodies from the perspective of structural geology, geophysics, and analog modeling of selected magmatic complexes in the Bohemian Massif. In the past year, a study on the origin and formation of Říp Hill of volcanic origin was completed, which is planned to be published in 2024. In close collaboration with the Inst Geophys of the Czech Acad Sci, equipment for monitoring surface deformations of magma chamber roofs, such as in caldera volcanoes, has been developed. Both the field and laboratory research will serve as a basis for shooting a series of short science-promotion films focusing on volcanic, plutonic, and tectonic processes. Preparations for these films, which will have a significant social and historical geoscience impact, were initiated and the shooting will continue throughout 2024.

***Project No. 9236 within the Changes of the Earth's Surface Programme*: Loess as a Quaternary thermometer (*Š. Kdýr, H. Ucar, T. Elbra, L. Kouklíková*)**

FIG. 36 Magnetic susceptibility measurement using a portable instrument to determine parameters of rocks possibly affected by lightning at the top of Bořeň Hill. Photo by H. Ucar.

The project responds to the current issue of climate change. Research on magneto-mineralogical changes in loess sediments presents climatic fluctuations in the recent geological history. Furthermore, the project helps to increase the understanding of these processes among the public by involving high school students. Research on the magnetic record of loess sections contributes to the knowledge of processes associated with Quaternary climate change that can be correlated with other sections worldwide.

***Project No. 9237 within the Above the Earth Programme*: Risk areas with frequent lightning strikes in the České středohoří Mountains (*H. Ucar, Š. Kdýr, T. Elbra, L. Kouklíková*)**

The effect of lightning on remanent magnetization of rocks has been subject to debate. In this project, we tried to identify consequences of this natural phenomenon in an area where frequent lightnings occur. Paleomagnetic samples were taken from Bořeň Hill, *České* středohoří Mts. (**Fig. 36**), to investigate the lightning remanent magnetization on volcanic rocks.

***Project No. 9238 within the Water for Life Programme*: Bioremediation of surface eutrophic waters (I. Bányiková, Inst Chem Proc Fund, Czech Acad Sci, Prague; P. Znachor, Biol Centre, Czech Acad Sci, České Budějovice; *J. Rohovec*)**

The project develops a new approach for the bioextraction of unwanted nutrients (e.g., environmentally risky phosphates) from surface waters based on the proliferation and growth of certain microscopic algae and cyanobacteria. These organisms have properties that can be advantageously used to extract dissolved nutrients from water into biomass. Total and intracellular phosphorus determination techniques and macro- and trace-element determination techniques using ICP-EOS and ICP-MS were applied to monitor the efficiency of the process involved and to quantify the mass flow in the course of bioextraction.

6F PROGRAMMES OF INSTITUTIONAL RESEARCH PLAN

Project No. 9331: Distribution of rare earth elements among rock-forming and accessory minerals in granites (***K. Breiter, J. Ďurišová, Z. Korbelová***; Fig. 37).

Project No. 9340: Traces of insect larvae, *Cochlichnus anguineus*, documenting the rate of sedimentation: Carboniferous, Westphalian, Lampertice Member of the Žacléř Formation. (***R. Mikuláš***; Fig. 38).

Project No. 9348: Revision of the Carboniferous fern species *Pecopteris pennaeformis* vs. *Senftenbergia pennaeformis* (***J. Votočková Frojdová***)

Project No. 9351: Magnetic records in the Úpohlavy and Snežnica carbonate successions: correlation with ichnofossils and stable isotopes (***T. Elbra, Š. Kdýr, P. Pruner, H. Ucar, L. Vaňková, R. Mikuláš***)

Project No. 9356: Ignimbrite volcanism of felsic calderas in the eastern part of the Axial zone, Catalan Pyrenees (***F. Tomek, P. Vitouš***)

Project No. 9371: Continuation of speleological-geological research in the Shaanxi Province, central China (***M. Filippi***)

Project No. 9392: The first paleomagnetic record from central European lake sediments of Holocene age (Tatra Mts., Poland) (***H. Ucar, Š. Kdýr, P. Pruner, T. Elbra, L. Kouklíková***)

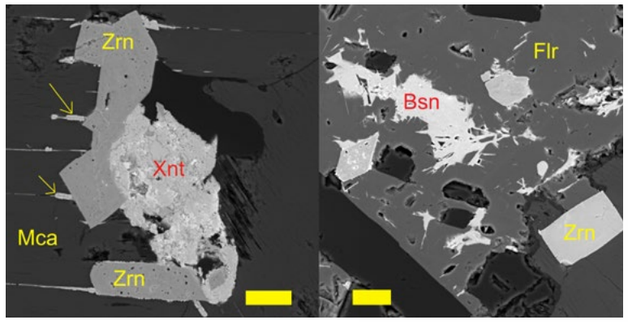

FIG. 37 Major mineral hosts of REE in the Cínovec zinnwaldite granite. Left: Zircon (Zrn) was stable during postmagmatic alteration, while xenotime (Xnt) was partially diluted and, after only a very short transport, precipitated to form thin veinlets along cleavage of enclosing mica (Mca) highlighted by small arrows. Right: Low-temperature CO2-bearing fluid liberated REE from their primary carrier fluorite (Flr) forming secondary bastnaesite (Bsn). Zircon (Zrn) is stable under these conditions. Scale bars 20 mμ.

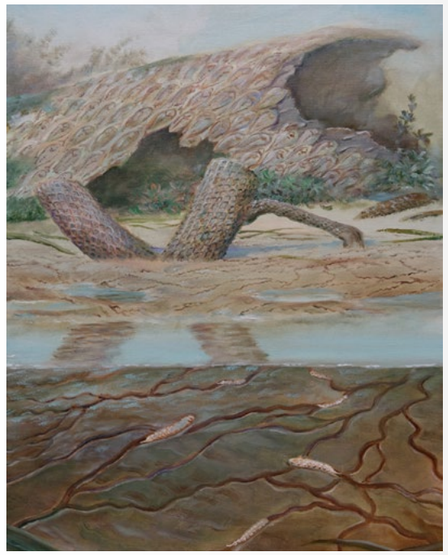

FIG. 38 Reconstruction of the environment of the origin of the *Cochlichnus anguineus* fossil trace at Žacléř. The tracemakers are unspecified insect larvae. Copyright: J. Svoboda, 2023.

7. PUBLICATION ACTIVITY

7A PAPERS

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8. SCIENCE PROMOTION

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Cílek V. Klima a potraviny. *Agrární komora ČR*. [Climate and food. *Agrarian Chamber of the Czech Republic*]. 14. 12. 2023, Kladruby. (In Czech)

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Cílek V. Uranová Příbram. Debata o knize. Knižní Veletrh, Praha [Uranium Příbram, a debate about published book, Book Fair, Prague]. 12. 5. 2023, *Praha*. (In Czech)

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Mikuláš, R.: Sandstone phenomenon of the Bohemian Paradise UNESCO Geopark. *Mini-conference of Taiwanese geoparks and the UNESCO Bohemian Paradise Global Geopark. Organizer: UNESCO Bohemian Paradise Global Geopark*. 30. 6. 2023, Hrubá Skála.

Navrátil T. Biogeochemický cyklus rtuti v životním prostředí. *Plenární zvaná přednáška na Interním semináři Úseku kvality ovzduší ČHMÚ a projektu ACTRIS CZ. Odbor kvality ovzduší Český hydrometeorologický ústav*. [Biogeochemical cycling of mercury in the environment. Speaker. *Plenary invited lecture at the Internal Seminar of the Air Quality Department of the Czech Hydrometeorological Institute and the ACTRIS CZ project. Department of Air Quality Czech Hydrometeorological Institute*]. 1. 11. 2023, Praha. (In Czech)

Rohovec J. Pyrit – minerál roku 2023. Přednáška pro veřejnosti o chemismu pyritu a jeho využití jako suroviny. *Proslovena k mineralogickému roku pyritu. PřF UK Praha.* [Pyrite – mineral of the year 2023. *Public lecture on pyrite chemistry and its use as a raw material. Speech for the mineralogical year of pyrite. Faculty of Science, Charles University Prague*]. 20. 10. 2023, Praha. (In Czech)

Rohovec J. Pyrit: vlastnosti a využití. *Gymnázium Prachatice*. [Pyrite: properties and uses. *Gymnasium Prachatice*] 2. 11. 2023, Prachatice. (In Czech)

Skála R. Neznámé známé vltavíny. *Knihovna Velké Přílepy*. [Unknown known moldavites. *Library Velké Přílepy*]. 7. 6. 2023, Velké Přílepy. (In Czech)

8D OTHER ACTIVITIES

Cílek V., Nikl P., Skála F. Umění a stav světa. *Komponovaný večer*. [Art and state of the world, an evening in the observatory]. 20. 4. 2023. Hvězdárna a planetárium Brno.

Filippi M., Kočová Veselská M, Vaňková L., Weinerová H., Weiner T., Roll M., Santolík V. Geologický ústav AV ČR. *Stánek na Veletrhu vědy: autoři a účinkující.* [Inst Geol, Czech Acad Sci. A stand at the Science and Technology Fair: authors and performers]. 8.–10. 6. 2023. Praha.

Matoušková Š. Dynamická planeta Země. *Stánek Programu AV21 na Veletrhu vědy a techniky: Spoluautor a spoluúčastník.* [Dynamic planet Earth, Programme AV21. A stand at the Science and Technology Fair: Co-author and performer]. 8.–10. 6. 2023. Praha.

Mikuláš R., Kočová Veselská M, Vaňková L., Weinerová H., Mrázková L., Lisá L., Roll M., Santolík V., Laibl L., Lisý P., Rohovec J. Geologický ústav AV ČR. *Týden Akademie věd ČR: autoři a účinkující.* [Inst Geol, Czech Acad Sci. Participation at The Week of the Czech Academy of Sciences: authors and performers]. 9.–10. 11. 2023. Praha.

9. PUBLICATIONS ISSUED

Dašková, J., Ed. Research Reports 2022. Czech Academy of Sciences, Institute of Geology, Prague. 2023, 1–52.

Geologica Carpathica
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10. ORGANIZATION OF CONFERENCES AND SCIENTIFIC MEETINGS

International meeting: ***2nd Annual Meeting 4GEON: Global geo-get-together. Hradec Králové and Příbram, September 22–October 2, 2023.*** *Organized by University of Hradec Králové,* Příbram-Orlov o.p.s. and Inst Geol, Czech Acad Sci.

Organizing committee: Pásková M., Zelenka J., ***Mikuláš R.,*** Zejda D., Gardoň jr. L., Staňková P., Gardoň L.

The IGCP project No. 751 interprets and disseminates for the needs of a demanding part of the public not only the knowledge of geological history and the development of life, but also of history, culture and typical crafts of the local population. The above organizational team, together with foreign colleagues, continuously translates geological facts and theories into appropriate messages for visitors to the UNESCO geopartks Ngorongoro Lengai (Tanzania), Bohol Island Geopark (Philippines), Rio Coco (Nicaragua) and Colca y Volcanes de Andagua (Peru). Barrandien National Geopark, an area with world-renowned palaeontology, is also involved. For more data see https://www.4geon.org/events. The 2nd Annual Meeting was focused on methods of interpretation in the five visited geoparks in the Czech Republic. For example, the Earth History collection of the Safari Zoo in Dvůr Králové, the monastery in Broumov, the tour of the Adršpach Rocks, the open-air museum in the Solvay quarries at Beroun were found to be good examples to follow.

11. FINANCIAL REPORT

In thousands of Czech Crowns (CZK)		**2023**
A.	**INCOMES**	
1.	From the annual budget of the Czech Acad Sci	52744
2.	From the Czech Science Foundation (accepted research projects)	9990
3.	From the internal research projects of the Czech Acad Sci	3181
4.	From other public sources	0
5.	Applied research	6234
6.	Investment (instruments)	4908
7.	Investment (constructions)	0
	TOTAL INCOMES	**77057**

B.	**EXPENSES**	
1.	Scientific staff (wages, insurances)	45604
2.	Research and scientific activities	14258
3.	Administration and technical staff (wages, insurances)	6124
4.	General expenses (service, maintenance of buildings, energies, transport, office supplies, miscellaneous, etc.)	5419
5.	Library	578
6.	Editorial activities	165
7.	Investment (instruments)	2798
8.	Investment (constructions)	2111
	TOTAL EXPENSES	**77057**

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