RR GEO

RESEARCH REPORTS

2021

INSTITUTE OF GEOLOGY
CZECH ACADEMY OF SCIENCES

Cover photo: Sandstone landscape of Wadi Rum, Jordan.
Photo by M. Filippi.

PUBLISHED BY THE INSTITUTE
OF GEOLOGY OF THE CZECH
ACADEMY OF SCIENCES
2021

CONTENTS

1. DIRECTOR'S INTRODUCTION

Expectation is a remarkable human trait. To a higher or lesser degree, it is a part of life in each of us. It shapes our habits and actions and gives light to our journeys.

The year 2021 was full of expectations. The preceding year 2020 was connected with an enormous spread of COVID disease and, after the whole society has bcome affected, with epidemic-related restrictions and their direct and indirect consequences. So, the following year brought us to the mood of expectation. When shall this situation come to an end? What should we do to make our lifes better? How to be better?

One of the proverbs says that where there is no expectation, there is no disappointment. Such statement is completely truth but leaves a bitter aftertaste of pessimistic moods.

In the Czech Academy of Sciences, year 2021 was associated with presentations within a part of the IInd phase of evaluation. After the previous year's experience, these were organized as an online meeting. Such a way, unfortunately, deprived us of the possibility to meet experienced colleagues from abroad face to face. Moreover, we had no opportunity to show the Institute in person. On the other hand, this step concluded a complex piece of work which, besides the assessment and feedback, provided us with *materia* for future work with a lot of expectations. Related not only to the budget, but also to opportunities, wishes and new projects.

This text was prepared in 2022. So, retrospectively, I can say that some of our expectations were met in their full extent, such as the completion of a major reconstruction at the Department of Physical Properties of Rocks, while others were obscured by more general events, like the conflict in Ukraine and the extraordinary wave of inflation.

Imagination and expectations often give us hope and a wish to continue. So let's hope for better professional and personal lives of each of us, whatever that might mean to whoever.

TOMÁŠ PŘIKRYL
DIRECTOR

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
e-mail: 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.) by the change of 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.	Director of the Institute

doc. RNDr. Emil Jelínek, CSc. (Faculty of Science, Charles University)
prof. RNDr. Martin Mihaljevič, Ph.D. (Faculty of Science, Charles University)
Ing. Petr Pruner, DrSc.
RNDr. Tomáš Přikryl, Ph.D.
RNDr. Ladislav Slavík, CSc.
Mgr. Martin Svojtka, Ph.D.
Ing. Petr Uldrych (Ministry of the Environment of the Czech Republic, Prague)

Supervisory Board

prof. Jan Řídký, DrSc. (Inst Phys, Czech Acad Sci, Prague)	Chairman
RNDr. Radek Mikuláš, DSc.	Vice-Chairman

RNDr. Pavel Hejda, CSc. (Geophys Inst, Czech Acad Sci, Prague)
doc. RNDr. Václav Kachlík, CSc. (Faculty of Science, Charles University)
prof. RNDr. Stanislav Opluštil, Ph.D. (Faculty of Science, Charles University)

3B SCIENTIFIC DEPARTMENTS

The **Department of Analytical Methods** continued to provide scientific services to other institutional departments and non-institutional academic bodies. Diverse data were obtained by the instruments hosted by the Department. Scanning electron microscopy provided both imaging- and composition-related data. Quantitative chemical analyses were acquired by electron microanalyzer. Information on the phase composition of materials was determined based on X-ray diffraction analysis. Phase and structural information were extracted from vibrational molecular spectral methods.

Next to services provided to others, the own research activities of the Department's scientists continued. It focused, among other topics, on testing a combination of various analytical techniques for the combined spatial representation of the structural and chemical composition of the studied materials in relation to environmental or ore deposit applications. In particular, the distribution of uranium- and uranium-bearing mineral phases in sandstones was visualized using 2D and 3D projections and quantified by methods of automated mineralogy and computed microtomography in co-operation with CEITEC Brno, company TESCAN, Institute of Geological Sciences of Faculty of Science of Masaryk University in Brno, and Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague. This approach allows to observe hidden uranium-bearing domains and to obtain important data for understanding ore genesis and for uranium mining (P. Mikysek). Also, continuing from the past years was the chemical and structural study of enstatite meteorite minerals and their synthetic analogues. In 2021, the research, carried out in collaboration with the Czech Geological Survey in Prague within a project of the Grant Agency of Charles University, focused on the role of titanium contents on crystal structures of synthetic iron monosulfide and its structural derivatives (N. Mészárosová). Further, the study of tektites (in collaboration with scientists from the Czech Geological Survey and foreign universities)

evidenced zoning of the moldavite strewn field in potassium isotope compositions (R. Skála). Forensic applications of analytical methods involving electron-beam techniques (SEM-EDS, EPMA) and Raman spectroscopy were demonstrated by the study of garnets and iron meteorites (project of the Ministry of the Interior; N. Mészárosová, R. Skála).

In the 2021, research effort of the **Department of Environmental Geology and Geochemistry** was aimed at obtaining a broad body of knowledge in both areas. In the area of environmental geology, our new insight on sandstone weathering, supported by results of field measurements, ascertained that the compact state of the main rock mass is essential to slow down sandstone disintegration. Important work summarizing the results of long-time monitoring of mercury cycling in the forest ecosystem was published in the field of geochemistry, relating mercury runoff to current climate warming.

Further research was performed in the study area of hotspots in floodplains contaminated with toxic metals and precise determination of cadmium isotopic ratios.

Our research was funded by several projects of the Czech Science Foundation. Continued projects in 2021 include GAČR 19-06759S (Cadmium hyperaccumulation in macrofungi: from isotopes to proteins and bacterial communities, principal investigator J. Borovička) and GAČR 19-14082S (Stress- and hydraulic field-controlled weathering and erosion of granular rocks, co-investigator M. Filippi), GAČR 20-14292S (Overlooked mercury threat in ecosystems of the Czech Republic reacting on global change, principal investigator T. Navrátil) and GAČR 20-06728S (Enter of Cd, Hg, and U from the pollution hotspots in floodplains to food web, co-investigator T. Navrátil).

The long-term project focused on monitoring of fluxes and deposition within the Bohemian Switzerland National Park as well as the long-term monitoring project based on the Lesní potok experimental catchment in the Voděradské bučiny National Nature Reserve continued within the GEOMON network also in 2021.

Department members conducted teaching at Faculty of Science, Charles University, Prague, delivering courses titled "Heavy metals in the environment" and "Dating of environmental changes".

Team members of the Department were appraised by recognized awards several times. The most important one is that presented to K. Žák, titled "Za zásluhy o speleologii" (Merit Award for Speleology).

In the **Department of Geological Processes**, laboratory works and measurements related to newly introduced zircon dating were completed in 2021. They employed the isotope dilution method (also called U-Pb ID-TIMS) with the previously installed thermal ionization mass spectrometer (TIMS). Results of the laboratory measurements were sent to the international Earthtime working group (http://www.earthtimetestsite.com) with the aim of recognizing the high quality of our lab within the international geochronological community. Another analytical method launched in 2021 is the determination of silicon isotope composition in geological and environmental samples, in cooperation with the Centre National de La Recherche Scientifique (CNRS, Toulouse, France) and the Czech Geological Survey. The Department was extended by F. Karaoglan, a specialist in low-temperature fission-track dating aided with laser ablation ICP–MS. He comes from Cukurova University (Adana, Turkey) and will be staying for a two-years' project. The staff of the Department were engaged in 7 grant projects supported by the Czech Science Foundation (CSF) as principal investigators or co-investigators. These projects were focused on: chert and carbonate geochemistry (L. Ackerman), Sm-Nd composition of foraminiferal tests (L. Ackerman), the study of soils in archaeology (L. Lisá), processes of granite greisenization and albitization (K. Breiter), dating and geochemistry of Archaean granites (M. Svojtka), dating and petrology of the Uralides (M. Svojtka), and a junior project of the CSF aimed at processes of magma emplacement in collapsing orogens (F. Tomek). The geological correlation of intra-Alpine crustal units with the Bohemian Massif was the subject of a Mobility project (support from the Ministry of Education, Youth and Sports CR, M. Svojtka).

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, invertebrate and 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 knowledge of climate changes in the past and to the refinement of Geological Time Scale.

In 2021, activities were again largely affected by the global pandemic of coronavirus. Accordingly, many events were cancelled or postponed to next years. These include, among others, The 15th International Palynological Congress to be held in Prague not before 2024 (J. Bek – Chair of the Organizing Committee). In spite of all complications, many issues were successful and some events happened at least via on-line platforms. L. Slavík organized and conducted Annual Business meeting of the Subcommission on Devonian Stratigraphy (SDS/ICS of the IUGS), and two members of the Department held key notes at The Micropalaeontological Society Annual Conference (TMS 2021). L. Laibl participated in, and delivered an invited talk at, the IGCP 653 – IGCP 735 workshop in Lyon. Department members took part in several important results that were published in prestigious geological journals. For example, a special issue of the journal Review of Palaeobotany and Palynology is dedicated to the results of the international team of Czech and Chinese paleobotanists and palynologists in Inner Mongolia, China, and includes many co-authorships by Department members (J. Bek, J. Votočková Frojdová). Z. Roček published a large monograph on anuran genus Palaeobatrachus in Abhandlungen der Senckenberg Gesellschaft für Naturforschung and was honoured by a newly introduced and published genus *Rocekophryne*. Many results in the field of vertebrate and invertebrate paleontology and palynology were published in journals, e.g., Life, Cretaceous Research, Papers in Palaeontology and Geological Magazine. M. Aubrechtová accomplished her DAAD fellowship at the Museum

für Naturkunde Berlin and returned back to our Department. L. Vaňková defended her Doctoral Thesis at Faculty of Science, Charles University, Prague and accomplished her Ph.D. In 2021, three projects of the Czech Science Foundation started.

The **Department of Paleomagnetism** is mainly focused on research of magnetostratigraphy, magnetomineralogy, paleomagnetism and rock magnetism. Resulting studies provide valuable data for various geoscience disciplines.

In 2021, a significant part of the effort was devoted to two Czech Science Foundation projects on stratigraphic boundaries in the Carpathians. In the final year of the Cretaceous/Paleogene boundary project, comprehensive studies of sections in the Czech Republic and Slovakia were finalized. Magnetic analyses provided a substantial contribution to magnetic signature across the Cretaceous/Paleogene boundary. Integration of magnetic records with palynology, biostratigraphy and sedimentological data provided valuable paleoenvironmental information for selected localities. The ongoing Jurassic/Cretaceous boundary project utilized a high-resolution magnetostratigraphic method on numerous profiles in Bohemia, Slovakia, Poland, Austria and Serbia. Project objectives are based on interdisciplinary cooperation with other Institute departments as well as Czech and foreign institutions. Magnetic results are thus supplemented with important parameters like mercury variations, analyses of calcareous nannofossils, ichnological and palynological studies, geochemical analyses, lithostratigraphic studies and other methods. An important part of research was also focused on geotectonic, stratigraphic and paleogeographical syntheses, including paleoenvironmental reconstructions of karst sediments in the Czech Republic, Slovakia and Slovenia. Robust chronology of flowstone profile in the Račiška pečina (Slovenia) was created based on magnetostratigraphy and isotopic oxygen stratigraphy and correlated with paleontological, U-series and radiocarbon results. Complex multi-proxy studies of karst and cave sediments were finalized in the Krkonoše National Park. The research was performed in close co-operation with other Institute departments and a number of Czech and foreign universities, research institutes, companies or NGO bodies. Furthermore, a study of methods for determining the paleointensity of a geomagnetic field preserved in geomaterials/archaeological furnaces was carried out. The intensity of the Earth's magnetic field shows considerable variability over the time. Using a suitable methodology, the intensity of the geomagnetic field in the past can be determined and this knowledge can be used in a wide range of interdisciplinary applications.

From the organizational perspective, reconstruction of a new pavilion located about 300 m from the current Paleomagnetic laboratory is scheduled be finished in June 2022. The new laboratory space for placing a new system for thermal demagnetization is going to be used immediately when the works are completed. The pavilion is planned to be shared with the Czech Metrology Institute which can contribute to an interesting collaboration in the future.

The **Department of Physical Properties of Rock** focuses on laboratory research linking the rock structure and its mechanical properties. There were 5 scientists and four technicians employed at the Department in year 2021. Newly employed was V. Vavrycuk. The laboratory building was under complete reconstruction, which is scheduled to be finished in early 2022. It significantly improved the working conditions, considering both the experimental and office work. It will reduce the operating costs of the Department as well.

Staff members of the Department were involved in a grant project supported by the Czech Science Foundation: Study of petrographic parameters and rock mechanical properties influencing technological-mechanical performance of selected rocks used for crushed stone (co-investigator: T. Lokajíček). Further, they were involved in an international project, contributing by the study of elastic anisotropy and properties of lithosphere materials using neutron diffraction and ultrasonic sounding and elastic anisotropy of layered rocks. Furthermore, we received a new three-year project to start in 2022: The role of rock anisotropy in hydraulic fracturing through acoustic emission (T. Lokajíček). Significant results achieved in 2021 include: determination of the causes of elastic anisotropy of Westerly granite, description of the role of mica minerals as carriers of gneiss anisotropy, introducing of ultrasonic methods for monitoring of the alkali-silica reaction, estimation of elastic anisotropy of Alpine rocks in the upper crust. 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.

FIG. 1 Clean chemistry laboratory. Photo by M. Svojtka.

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

Two laboratories are used for processing samples destined for (ultra)trace element and isotopic analyses (**Fig. 1**). 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 scales (precision of 0.1 mg) and a 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 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 scales (precision of 0.01 mg), a combined device for the preparation of ultraclean water (Elix 3 + IQ 7000 + Q-POD Element by Millipore), and a centrifuge.

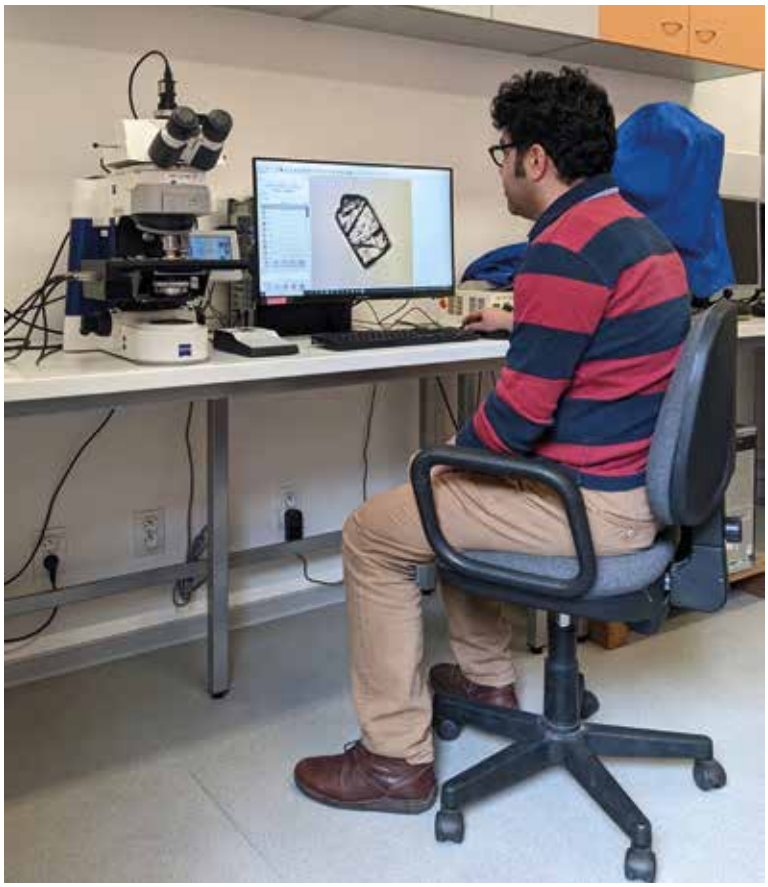

FIG. 2 Fission-track counting system. Photo by M. Svojtka.

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). The integral part of the laboratory is an APX 010 polishing machine (MTH), a binocular microscope (Nikon), and a flow box for the etching of the 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 Cillas 1190 laser particle size analyzer in the Geoarchaelogy Laboratory. Photo by M. Svojtka.

Geoarchaeology Laboratory
(Head: L. Lisá)

The geoarchaeological laboratory (**Fig. 3**) serves mainly for the processing of sedimentary samples 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 preparation before drying and impregnation in Pollylite resin. After impregnation, the samples are slowly treated in a fume-hood designed for the work with strong acids. There is an available dryer and vacuum chamber for sample impregnations. The grain-size analyses employ the Cillas 1190 laser particle-size analyser with the range of 0.004–2,500 micrometers, and sets of sieves for different types of grain-size analyses. A centrifuge serves as a device operating a part of the grain size sample processing .

FIG. 4 Grinding machines with diamond plated wheel Montasupal and custom-made grinding machines with wheels for loose abrasive powder. Photo by R. Skála.

Grinding and Polishing Shop
(Supervised by R. Skála)

Reliable quantitative local chemical analysis 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 to prepare polished sections or thin sections is available (cutting and grinding machines Buehler PetroThin and Struers Discoplan TS, grinding machines (**Fig. 4**) with diamond platen wheel Montasupal, custom-made grinding machines with wheels for loose abrasive powder, custom-made saw, polishing machines Struers Planopol-3, Kent Mark II (2 pcs), and MTH APX-010 with MTH KOMPAKT-1031).

FIG. 5 Laser ablation ICP-MS laboratory with Element2 magnetic sector field ICP-MS and Analyte/Excite excimer 193 nm laser ablation system. Photo by M. Svojtka.

ICP-MS Laboratory
(Heads: J. Ďurišová and 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·l-1 to sub pg·l-1 concentration range and (2) measuring of isotope ratios. A typical application of isotope ratio measurement is the 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 is Element2 ICP-MS coupled with an ANALYTE EXCITE excimer 193 nm laser ablation system (Cetac/Teledyne) for analyses of solid samples (sample holder is for thin sections – width 27 mm – or round resin block – diameter 25 mm) and with an Aridus II (Teledyne) desolvating nebulizer.

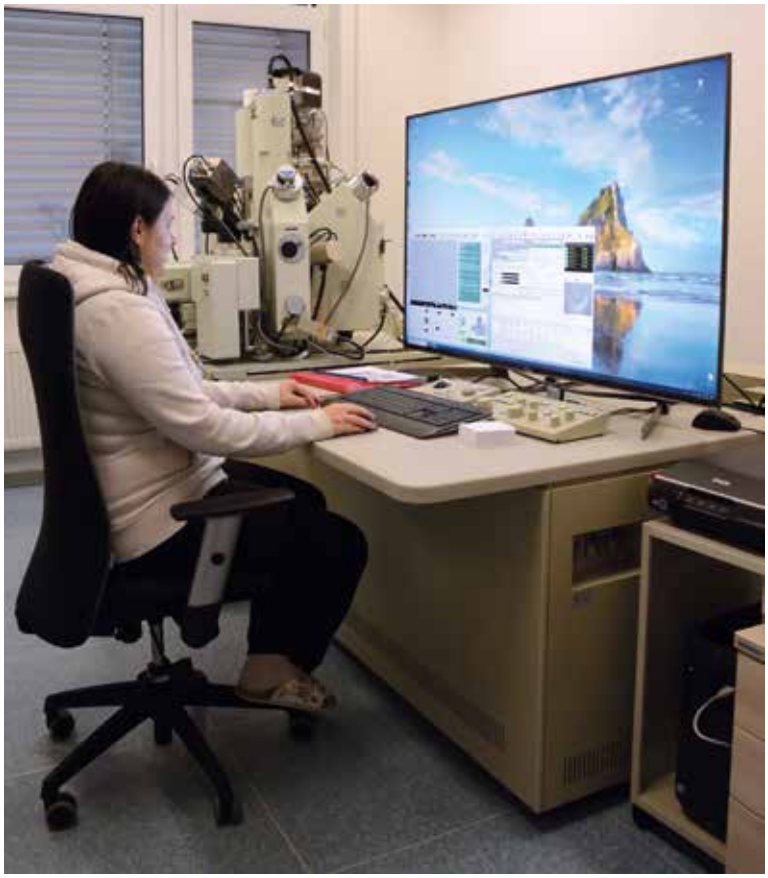

FIG. 6 Taking analysis with the electron probe microanalyzer JEOL JXA-8230. Photo by R. Skála.

Laboratory of Electron Microanalysis
(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 detector of secondary electrons at low vacuum (LVSTD). Chemical analyses and fast elemental mapping (incl. large area mapping, see **Fig. 6**) are possible through an energy-dispersive (ED) X-ray spectrometer Oxford Ultim Max 65.

Electron probe microanalyzer (EPMA) JEOL JXA-8230 is used mainly for non-destructive quantitative analysis of solid-state materials on the micrometer scale. The instrument is equipped with five wave-dispersive crystal spectrometers hosting 14 analytical crystals in total. The instrument allows analyses for elements from B to U. To image the studied samples, the 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.

FIG. 8 Laboratory of Optical Microscopy. Photo by M. Filippi.

FIG. 9 2G 755 4K Superconducting Rock Magnetometer. Photo by J. Petráček.

Laboratory of Liquid and Solid Samples Analysis
(Supervised by J. Rohovec)

This lab is a general-purpose laboratory (**Fig. 7**) for preparation, workup, decomposition and various analyses of liquid and solid samples of environmental, geochemical and geological interest. It is equipped with the analyser of C, H, N, S in organic matrices VarioMacro CUBE Elementar (2020), the high-pressure microwave digestion oven Preekem (long-term testing loan from HPST s. r. o.), DTA/DSC (2018), Ultrasonic horn Bandelin Sono plus (2016), gas chromatography system for methylmercury separation DANI (2015), ICP-EOS spectrometer Agilent 5100 (2014), HPLC system (KNAUER 2010), anion analysis in aqueous samples using ion-exchanging column and conductivity detector (2013), Anton Paar High Pressure Asher (2012), Mettler-Toledo (2011), analytical balances, TOC-VCPH Shimadzu (2011), total Carbon Analyser, MARS (2009), microwave digestion unit – with 8 fully equipped PTFE digestion vessels, MILESTONE mls 1200 mega (2009), microwave digestion unit – with 6 fully equipped PTFE digestion vessels, CINTRA 303 (2009), UV-VIS Spectrometer, BALANCE 2000G (1999), analytical scales, B-2A Epi/FL (1996), filtration blocks, SARTORIUS Basic analytical (1992) analytical scales. Provided with this equipment, members of the team are able to perform all basic analyses without the need of outsourcing.

Laboratory of Optical Microscopy
(Supervised by M. Filippi)

OLYMPUS SZX 16 Optical binocular microscope with the CANON digital photocamera and specialized QuickPHOTO Micro software and a Deep Focus module is used for the documentation of samples, separation of sub-samples for other methods and, of course, for imaging of samples and details for publications. 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 documentation, image preparation and image analysis. The microscope is equipped also with a fluorescent source of different wavelengths (**Fig. 8**).

Laboratory of Paleomagnetism
(Supervised by L. Kouklíková)

The laboratory is equipped with the following state-of-the-art instruments for paleomagnetic research and measurement: 2G 755 4K Superconducting Rock Magnetometer – a highly sensitive and accurate instrument for remanent magnetization and alternating field (AF) demagnetization measurements (**Fig. 9**); sensitive AGICO JR5A and JR-6A Spinner Magnetometers; MAGNETIC MEASUREMENTS MMTD80 Thermal Demagnetizer – a standard instrument for thermal demagnetization; MAGNETIC MEASUREMENTS MMPM10 Pulse Magnetizer for creating isothermal remanent magnetization up to 9T; AGICO MFK1-FA highly sensitive kappabridge for measuring anisotropy of magnetic susceptibility as well as susceptibility in variable magnetic fields, frequencies and temperatures; AGICO LDA-5 and PAM-1 Specimen Unit for anhysteretic magnetization and AF demagnetization up to 200 mT; MAVACS – Magnetic Vacuum Control System – a unique, highly accurate system for creating and maintaining variation-free magnetic vacuum for thermal demagnetization of rock samples. Moreover, the laboratory is equipped with other instruments for laboratory and field measurements and sample collection.

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 (**Fig. 10**) has two main research purposes: (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, pressure intensifier (MTS 286) of hydraulic pump (EMDC 400-250, GL Test Systems) is used. A 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 anisotropy of P and S wave velocity in detail on a spherical samples in 132 independent directions.

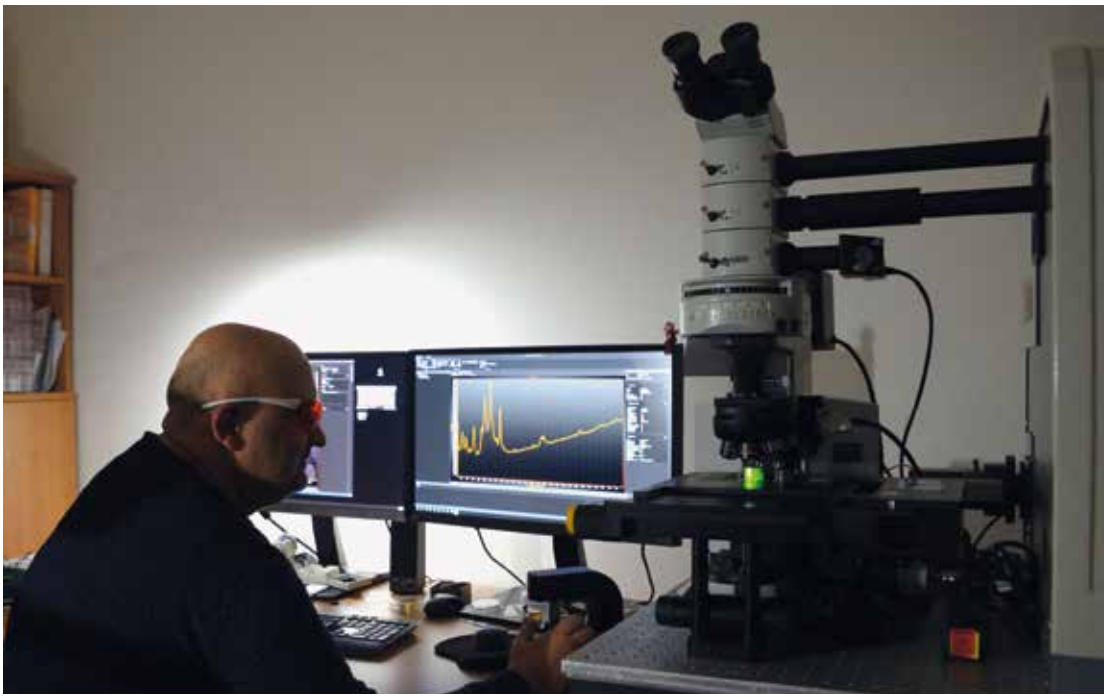

FIG. 11 Acquisition of a Raman spectrum with the microspectrometer Spectroscopy & Imaging Monovista CRS+. Photo by D. Kořínková.

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

Raman dispersive micro-spectrometer S&I MonoVista CRS+ (**Fig. 11**) 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. Microscope is designed for sample observation in either reflected or transmitted light. Objective lenses with following magnifications are installed: 4×, 10×, 50×, 50× LWD and 100×. Samples are placed on computer controlled motorized stage. Spatial resolution with 100× objective is 1 µm laterally and 2 µm axially. System allows collection of spectra within the range of 60–9,300 cm^{-1} with 488 nm and 532 nm excitation lasers and 60–3,500 cm^{-1} with 785 nm excitation laser. A Fourier-transform infra-red 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 KBr window. In transmission arrangement, the spectrometer covers the wavenumber range of 7,800–350 cm^{-1}. In the ATR mode, the wavenumbers covered are 4,000–100 cm^{-1} depending on used beam-splitter.

FIG. 12 A new disk mill Pullverisette 13 (Fritsch) was acquired in the Mineral Separation Lab. Photo by M. Svojtka.

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

The laboratory (**Fig. 12**) is used for separation of 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 zircon, apatite, garnets, biotite, pyroxenes, and also sulfides (e.g., pyrites, chalcopyrites). In addition, clay minerals are separated using 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), and Wilfey floating table. Necessary additional equipment includes ultrasonic sieve cleaner I-17 (Fritsch), vibratory Sieve – Shaker analysis 3 (Fritsch), and a ring agate mill (Siebtechnik) for samples sensitive to contamination. Frantz® magnetic barrier laboratory separator – model LB-1 (SG Frantz) is used for the separation of the magnetic fraction.

FIG. 13 Placing the corundum calibration standard to the sample holder of the X-ray powder diffractometer Bruker D-8 Discover. Photo by R. Skála.

Laboratory of X-ray Powder Diffraction
(Supervised by R. Skála)

X-ray powder diffractometer Bruker D8 DISCOVER (**Fig. 13**) 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.). Diffractometer is of the θ-2θ design and allows studying materials in both reflection and transmission (either foil or capillary) geometry. 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., Kα1,2 radiation is used) and beam limited with a collimator and a 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
(Supervised by T. Navrátil)

This unique laboratory is focused on 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, a speciation oven for RA-915 M Lumex analyser: upgrade (2019), two zone cylinder furnaces Clasic (2018). Total mercury and methylmercury analyser of BrooksRand system MERX (2017), RA-915M Lumex mercury analyser: real time direct detection of mercury vapor analysis in air and gases. (2016), Shimadzu DOC/TOC analyser: 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 processing room with hoods and levigation sinks.

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

Sedimentary Laboratory
(Supervised by A. Žigová)

The laboratory (**Fig. 16**) is equipped with an apparatus for sample preparation and pH measurements: planetary mill FRITSCH (1986), analytical balance SETRA EL–2000S (1999), ultrasonic cleaner TESLA (1985), laboratory dryer WST 5010 (1991), muffle furnance LMH (2011), pH-meter pH 330 / SET-2 (2000).

FIG. 17 Triton Plus mass spectrometer (TIMS laboratory). Photo by M. Svojtka.

Thermal Ionization Mass Spectrometry (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: (a) elemental abundance determination with the isotope dilution method; (b) precise isotopic ratio analysis; (c) isotopic fractionation measurement. TIMS is routinely used for the analysis of Sr, Rb, Nd, Sm, Pb, U, Os, and Cd in the geological (e.g., basalt, granite, chert, carbonate), paleontological (foraminifers), archaeological (e.g., bones, enamels) as well as in environmental samples (e.g., mushrooms, leaves). TIMS is supplied with five 10^{13} 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 the filament degassing and a PCR box Airstream for sample loading.

3D LIBRARY

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 or mineralogy. The fund includes approximately 8,800 books, 480 journals and 300 maps. Some of the latest additions in 2021 are, for example, *Catalogue of Plant Fossils Described in Works by Kaspar M. Sternberg* by J. Kvaček, J. Dašková and M. Libertín, *Půda a život civilizací* by V. Cílek and others, and *Karst, Caves and People* by N. Zupan Hajna.

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 Academy of Sciences specifically for this purpose.

4. AWARDS AND FELLOWSHIPS

Cílek V., Mikuláš R., Hladil J., Štorch P.
The award in the category of Non-fiction literature for the book "The landscapes of Joachim Barrande / Krajem Joachima Barranda" presented by the Club of Non-fiction Literature, Book-Fair "The World of Books/Svět knihy", Prague.

Krmíček L.
Dean's award for the competition "TOP 10 publications in impacted journals", Faculty of Civil Engineering, Brno University of Technology, Brno.

Tomek F.
Dean's award for early career researchers and teachers, Faculty of Science, Charles University, Prague.

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

Weinerová H.
Dean's award for the best students in the Doctoral programme, Faculty of Science, Masaryk University, Brno.

Žák K.
Medal of Merit in Speleology, awarded by the Czech Speleological Society in recognition of publication activity in speleology.

Žigová A.
Bronze medal for an exceptional contribution to the development of science and research in the field of agriculture. Czech Academy of Agricultural Sciences, Prague.

5. DEGREES OBTAINED

Ph.D.

Vaňková L.
Lower Cretaceous belemnites (including J/K boundary interval) in the NW Tethys, biostratigraphy, palaeobiogeography and palaeoecology (Institute of Geology and Paleontology, Faculty of Science, Charles University, Prague; supervised by M. Košťák)

6. PROJECTS

6A FOREIGN GRANTS, JOINT PROJECTS AND INTERNATIONAL PROGRAMMES

FINISHED PROJECTS

***Innovation Fund of the Museum für Naturkunde Berlin*: Lituitid cephalopods from the Ordovician erratics of the Orthoceratite Limestone (Dieter Korn, Museum für Naturkunde, Berlin, Germany; *M. Aubrechtová*; 2021)**

Cephalopods of the order Lituitida are among the most characteristic elements of Ordovician fossil assemblages, especially those of Northern Europe and China. The lituitids were recognized as early as in the 18th century and most taxa were described in the 19th century. Since then, however, not many studies dealt with the lituitids comprehensively due to the difficulties with species identification and delimitation. Another issue is the commonly incomplete preservation of lituitid conchs, which concerns also the type specimens of many species. The result is insufficient knowledge on lituitid morphology, ontogeny. Consequently, diversity changes over time and phylogenetic relationships are also unclear.

However, over the past several years, the application of modern methods and approaches on Ordovician cephalopods helped to address some of the long-standing questions including those that concern lituitids. The above project represented one of the steps in these efforts. It was aimed at updating and clarifying the classification and stratigraphic occurrence of members of the Lituitida. To resolve the difficulties with taxa definition, ontogenetic changes in coiling parameters, ornament and overall conch morphology were evaluated. At the end, several ambiguous taxa were re-described, and neotypes for two historical species, *Lituites lituus* and *L. perfectus* (**Fig. 18**), were proposed; additionally, eleven species were newly described. The study was performed using cephalopod collections of the Museum für Naturkunde Berlin, which include many type specimens and previously published originals. The studied material originated from the Darriwilian (Middle Ordovician) erratics in Pleistocene glacio-fluvial sediments in Germany, Poland and the Kaliningrad Region of Russia. Some lituitid specimens in the collection also came from *in situ* limestones across Baltoscandia, and one additional, exceptionally complete specimen from the Datianba Formation (Middle or Late Ordovician) of the Songtao County (Guizhou, South China) was added to the study, as well.

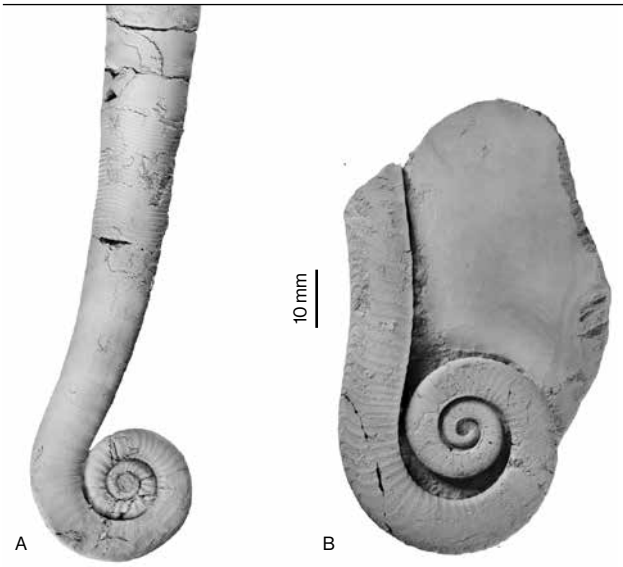

FIG. 18 Details of the coiled and backcoiled conch parts in proposed neotypes for two lituitid species. A – *Lituites lituus*, MB.C.30527, from Oderberg, Bralitz (Brandenburg, Germany); B – *L. perfectus*, MB.C.30544, from Lansen near Malchin (Mecklenburg-Vorpommern, Germany). Photo by M. Aubrechtová and L. Voß (MfN), modified by D. Korn (MfN).

ONGOING PROJECTS

***Bilateral Mobility Project No. SAZU-19-01*: Cave sediments: multi-proxy for interpretation of karst processes (N. Zupan Hajna, A. Mihevc, A. Švara, B. Otoničar, Karst Research Institute ZRC SAZU, Postojna, Slovenia; *P. Pruner, Š. Kdýr, P. Bosák*; 2019–2022)**

Systematic research of cave sediments in Slovenia was mostly located in the Classical Karst (NW part of Dinarides) and in the Slovenian Southern Alps. Protected in caves, sediments are generally well-preserved and represent an exceptionally good, multi-proxy record of past surface environmental conditions. We applied a number of different methods and approaches. Systematic acquisition of paleomagnetic data within individual segments of the studied sediment sections was carried out with special focus on relict and unroofed caves. In intervals with polarity change, the frequency of sampling was so dense that almost continuous

records of rock magnetic and paleomagnetic parameters were obtained. The construction of high-resolution magnetostratigraphic profile supported correlations among profiles which were, where possible, calibrated by relative, numerical and correlated dating methods. Age sequences were compiled from spatially and temporally highly discontinuous sediment records covering different ages within the Cenozoic era. Nevertheless, more or less continuous Pliocene to Pleistocene deposition was characteristic for a large number of studied sections, yielding robust chronology. Calibrated data contributed to the interpretation of speleogenesis, depositional mechanisms in caves, and indirectly also to the age of karst evolution and the succession of tectonic phases and climate changes. The research indicated that most sediments in relict and unroofed caves are up to >5 Myr old (**Fig. 19**), which contrasts with the traditional concept of Pleistocene age of cave sediments. The speleogenesis itself cannot be much older with the respect to geotectonic models of Adria Plate rotations in the past ca 6 Myr. The main results can be summarized as follows: (1) cave sediments have proven to be an important source of information on depositional style in caves which indirectly reflected the evolution of the surrounding landscape, especially Cenozoic evolution of catchment areas, climatic changes with flood events and/or changes of tectonic regimes; (2) speleogenesis and cave infilling processes in Slovenia started well below the Tertiary/Quaternary boundary; (3) ~5 Myr old sediments are now present in relict caves closer to the surface or in already unroofed caves exposed to the surface by denudation; (4) the Pliocene/Quaternary boundary was detected in some sediment sections; (5) the Pliocene/Pleistocene sedimentation was not interrupted in many sediment sequences; clearly, there occurred no principal change during the last 2.6 Myr, and (6) cessation of allogenic sedimentation in the caves was mostly controlled by tectonics and related changes in hydrological regime(s) with detachment of cave passages/systems from active water flows due to a drop of the piezometric level.

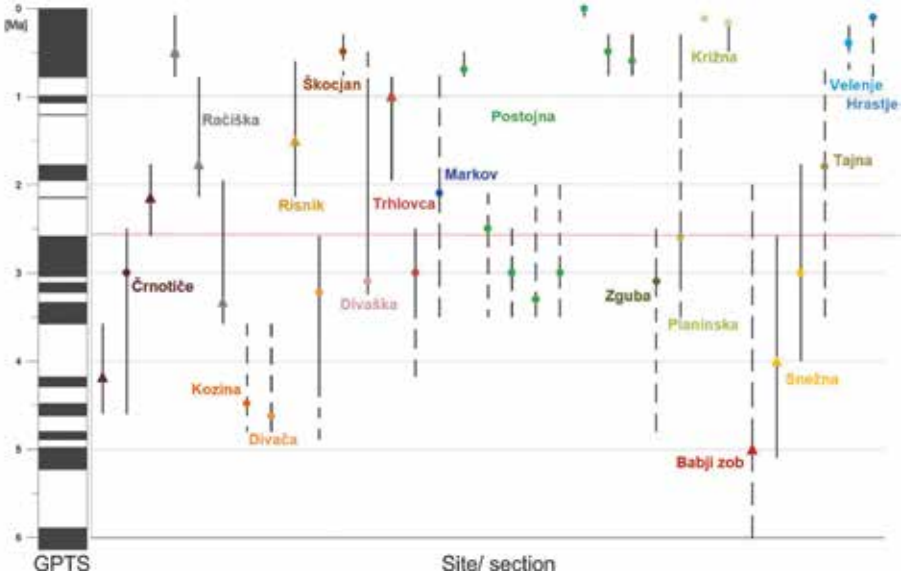

FIG. 19 Age of sediments from selected Slovenian karst sites with respect to Global Paleomagnetic Timescales (GPTS; left column), calibrated by other dating methods. Data points represent the most possible ages of sediments: triangles represent dated speleothem sections, and circles belong to allogenic sediments. Full bars represent the most possible ages of dated sediment sections; dashed bars represent possible age intervals for sections with less data. Profile name colors refer to the respective sites. Red dotted line represents Pliocene/Quaternary boundary. Chart by N. Zupan Hajna 2020, modified.

***Bilateral co-operation between Institute of Geology of the Czech Academy of Sciences, v. v. i., and Karst Research Institute, Scientific Research Centre, Slovenian Academy of Sciences and Arts*: Paleomagnetism and magnetostratigraphy of Cenozic cave sediments in Slovenia: Updates on Račiška pečina sedimentary sequence studies (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-19-01; since 1997)**

FIG. 20 The sedimentary section in the Račiška pečina. Photo by N. Zupan Hajna.

The Račiška pečina (RP) sediment sequence is characterized by the deposition of speleothem layers alternating with lutitic material from the surface above the cave and separated by abundant hiatuses after the cave became detached from its hydrological function (**Fig. 20**). Rare mammal fauna and gastropods were present in several horizons of clastic sediments. The obtained magnetostratigraphic profile was calibrated by paleontological data and by numerical dating in detail. The lower part, according to fauna determined in the middle part above, was dated from ~3.4 Ma at the bottom up to 2.595 Ma at its top (Neogene/Quaternary transition). In the middle part, a boundary between N- and R-polarized magnetozones within the basal bed with fauna can be identified with the base of C2n Olduvai subchron (1.925 Ma). The sequence above represents the whole Olduvai subchron and terminates at 1.78 Ma. The upper part of the section starts shortly below the Matuyama/Brunhes boundary (in an R-polarized magnetozone) and terminates shortly above a charcoal lamina dated by radiocarbon method to ~3 ka. Large mammal bones collected in clays in upper profile segment support the assignment of studied specimens to large cave bears (*Ursus ex gr. spelaeus*), bearing no characteristics diagnostic features of brown bears. All small mammal items obtained from the upper part of the section seem to belong to *Clethrionomys glareolus* or to a closely related form of extinct species dated from Late Early Pleistocene (Q2) up to the Recent. One fragment can be tentatively attributed to the genus *Pliomys*, in which major radiation appeared during the earliest Pleistocene (MN17–Q1). Gastropods, their fragments and imprints, were found in 3 samples of red clays.

FIG. 21 The slope of the Mních Horst above the low terrace of the Váh River with entrances to the 3D maze of the Liskovská jaskyňa Cave. Triassic Gutenstein limestones are truncated by a higher Váh River terrace. Slope modified by quarrying. Photo by P. Bosák.

We suspect that they belong to the genus *Zospeum* sp., subterranean gastropods living in caves (mostly in the Dinaric Karst), where some species are endemic; we believe that they represent the first fossil find of this subterranean species. Three dark layers (soot) within flowstone layers were dated to ~11, ~9, and ~3 ka (radiocarbon). A detailed chronology of the RP section based on magnetostratigraphy and isotopic oxygen stratigraphy was interpreted and correlated with paleontological, U-series, and radiocarbon results. Principal climatic changes during the growth of the section appeared at about 2.6–2.5 Ma (around the Neogene/Quaternary boundary). Prior to this datum, climates were controlled by regional Mediterranean Sea factors, and after that by global Atlantic Ocean factors. The RP sedimentary section is an important source of paleoclimate information for the last ~3 Myr with Pliocene/Quaternary and Matuyama/Brunhes transitions.

***Bilateral co-operation between Institute of Geology of the Czech Academy of Sciences, v. v. i., and State Nature Conservancy of the Slovak Republic – Slovak Caves Administration, Liptovský Mikuláš*: Paleomagnetism and magnetostratigraphy of Cenozic cave sediments and speleogenesis of selected caves in Slovakia: Liskovská jaskyňa Cave (P. Bella, Slovak Caves Administration, Liptovský Mikuláš and Catholic University in Ružomberok, Slovakia; J. Littva, Slovak Caves Administration, Liptovský Mikuláš; *P. Bosák, P. Pruner, P. Mikysek*; since 1997)**

Liskovská jaskyňa Cave, an important archaeological site, represents the most distinctive example of 3D maze caves in Slovakia. It is located in a Mesozoic basement horst (Mních Horst) of the Hronic Unit, uplifted above the unconformably overlying Paleogene basin fill in the westernmost part of the Liptovská kotlina Basin near the city of Ružomberok (**Fig. 21**). The unusually high density of cave passages (about 4.5 km long passages occur within the area of approximately 0.12 km^2) points to an atypical cave speleogenesis and complex internal horst tectonics. The horst is limited by ENE–SWS-striking faults and internally dissected by NW–SE- to N–S-striking faults, which influenced also the directions of cave passages. Preliminary structural analysis shows that they were formed in a transtensional tectonic regime with a NE–SW-oriented tensional component and perpendicular compression. Barite crystals were identified in a cavern situated on a N–S fault.

Previously, it was proposed that the cave was formed by an underground arm of the Váh River. Fluvial gravels, uncovered by archaeological excavations, occur only near cave entrance, but not in cave interior which is dominated by fine-grained infiltration fills. Nevertheless, three horizontal cave segments were correlated with the terrace system of the Váh River. Very limited occurrence of solutional speleogens linked with active subterranean streams (only in the entrance part) contrasts with speleogens typical for slow-flowing to stagnant water (cave interior). In phreatic regime, waters ascended along faults from bathy- and deep phreatic zones. The occurrence of small barite crystals allows to speculate on deep thermal origin of original waters (hypogenic speleogenesis), a typical feature along faults limiting and dissecting the Liptovská kotlina and active to the present. Therefore, a multi-stage model can be proposed for the evolution of the cave: older ascending phreatic speleogenesis (partly hypogene) was followed by substantially younger epiphreatic re-shaping by diffuse infiltration water of groundwater from river sediments and/or floodwater penetration under pressure into the rock massif linked with the incision of the Váh River. Its action is distinct only in the present near-entrance part of the Liskovská jaskyňa.

***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 researchers: *R. Mikuláš*; P. Budil, Czech Geological Survey, Prague; 2021–2026).**

Deciphering the complex interactions between climate change, biodiversity and ecosystem structuration is a major societal issue for future generations. In the Czech Republic, the Lower Paleozoic sediments of the Barrandian area are globally renowned as a classical example of well-preserved skeletal marine fauna, including abundant remains of trilobites. Several tens of morphologically anomalous exoskeletons of trilobites were collected and documented from Cambrian to Devonian clastic sediments and carbonates. One of them, an exceptionally preserved articulated and partly enrolled exoskeleton of the Ordovician nektobenthic trilobite *Parabarrandia bohemica* (NOVÁK, 1884) exhibits a prominent paleopathological anomaly in its pygidium. This anomaly is interpreted as a healed traumatic injury and attributed to a failed predatory attack. The subsequently healed injury is classified as the ichnogenus *Oichnus* BROMLEY, 1981. The structure on the pygidium is strongly reminiscent of injuries caused by octopods, and a large cephalopod is proposed as a potential durophagous predator responsible for the injury.

***Project of Joint Institute for Nuclear Research, Dubna, Russia, No. 04-4-1142-2021/2025*: Investigations of functional materials and nanosystems using neutron scattering (T. Ivankina, I. Zel, R. Vasin, Joint Institute for Nuclear Research, Frank Laboratory of Neutron Physics, Dubna, Russia; *T. Lokajíček, M. Petružálek, A. Aminzadeh, T. Svitek*)**

Subproject 1: Evaluation of structural, elastic and magnetic anisotropy of continental rocks from neutron diffraction, neutron tomography, magnetic and ultrasonic measurements. In this work, we show the contribution of imaging methods such as X-ray and neutron tomography (**Fig. 22**) in the study of rock structure that exhibits anisotropic character through lineation and foliation fabrics. Spherical samples of two different samples of biotitic gneiss were tested. An application of scanning method to 3D data of mica spatial distribution allowed us to reveal the presence, orientation and strength of foliation and lineation fabrics. We also performed grain shape analysis using the approximation of the individual elements of segmented mica phase by equivalent (Legendre's) ellipsoids. As a result, we determined the shape preferred orientations of mica grains and calculated the corresponding shape orientation distribution functions. The comparison of structural properties obtained from tomography studies with experimentally determined P wave and magnetic anisotropy demonstrated their mutual correlation. The effective elastic and magnetic properties were calculated based on the shape orientation distribution functions determined from tomography data.

Subproject 2: Structure and texture transformations of rocks during metamorphic processes of the Earth's crust: study by neutron diffraction, structural geology and ultrasonic sounding. In our study, we show elastic anisotropies of the range of typical lithologies within deformed upper crustal rocks in the Alps. We sampled rocks in the Adula Nappe of the central Alps, typical for upper crust in collisional orogens. The two major rock types found are orthogneisses and paragneisses; however, small lenses of metabasites and marbles also occur. Crystallographic preferred orientations (CPOs) and volume fractions of minerals in the samples were measured using time-of-flight neutron diffraction. These data were used to determine average elastic anisotropy of a typical upper crustal rock within the Alps. Average mineral volume percentages within the gneiss samples were used for the calculation. In addition, ultrasonic measurements of elastic anisotropies of the samples at increasing pressures were performed. These measurements, together with the microcrack pattern determined from thin sections of the samples, were used to model the closure of microcracks in an average sample with increasing depth. At ≈740 MPa, the microcracks are assumed to be closed, yielding average elastic anisotropies of 4 % for the average gneiss. This value is an approximation, which can be helpful for seismic models of the lithospheric or asthenospheric scale.

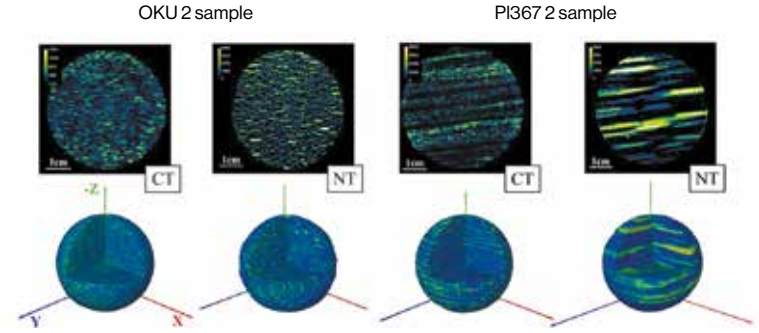

FIG. 22 Spatial distribution of the mica mineral phase in the studied gneiss samples (OKU2 and PI367) obtained from the X-ray (CT) and neutron (NT) tomography methods: upper row – selected slices taken from reconstructed 3D models; lower row – 3D models of sample spheres of 50 mm in diameter. Color maps reflect the variations in the attenuation coefficient, yellow-green colors correspond to the mica phase. Compiled by M. Petružálek.

***Sepkoski Grant*: The origin of the genus *Testudo* (*M. Chroust*; 2021–2022)**

The aim of the project is the taxonomic description of the oldest terrestrial tortoise of the genus *Testudo* (n. sp.) from Ahníkov (early Miocene, Czech Republic) and to create a new data matrix and clarify the phylogenetic position of the Czech material within the genus *Testudo*. In September 2021, the author visited the Institut Català de Paleontologia Miquel Crusafont and studied Spanish material. However, after a detailed prospection and comparison, the Czech material does not preserve the most important diagnostic characters, which makes the taxonomic description impossible. Even the data matrix cannot be created. Nevertheless, tortoise material from Ahníkov will be included in the study of fossil tortoises from Mokrá Quarry and other fossil sites. It will extend our knowledge of fossil tortoises from the Czech Republic.

***UNESCO IGCP project No. 679*: Cretaceous Earth Dynamics and Climate in Asia (G. Li, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China; T. Hasegawa, Department of Earth Sciences, Faculty of Science, Kanazawa University, Kakuma, Japan; D. K. Cheong, Department of Geology, College of Natural Sciences, Kang-won National University, Kangwondoo, Korea; V. Prasad, Birbal Sahni Institute of Palaeobotany, Lucknow, India; *P. Schnabl, A. Svobodová, P. Pruner, J. Adamovič, T. Elbra, Š. Kdýr*; 2019–2022)**

Cretaceous was the warmest period in the Phanerozoic Eon. Compared to the present, it comprised more elevated atmospheric CO2 levels and considerably higher global sea level. The project addresses three main topics: (1) Cretaceous geological records of sea and terrestrial facies in Asia; (2) climate and environment, and (3) the nature of linkages between major geological events and rapid climate and environmental changes with the aim to understand biodiversity evolution under greenhouse climate conditions. The information about Cretaceous 'Greenhouse' oceanic and terrestrial climate, environmental conditions, and their evolution, will lead to an in-depth knowledge of the existing characteristics of rapid climate and environmental changes and global warming. These results can also provide scientific evidence for human response to contemporary global warming trends. The project will play a significant role in promoting geoscience communication among Asian countries, including some countries outside Asia.

6B CZECH SCIENCE FOUNDATION

FINISHED PROJECTS

***No. GA19-07516S*: Cretaceous-Paleogene boundary in Carpathians - multidisciplinary search for local variations in global cataclysm event (*T. Elbra, Š. Kdýr, T. Kohout, P. Pruner, P. Schnabl, R. Skála*; M. Bubík, Czech Geological Survey, Brno; P. Skupien, VSB – Technical University of Ostrava, Ostrava; 2019–2021)**

The paleomagnetic team concentrated on finalizing the comprehensive studies of Bukovec section (Czech Republic). The Bukovec section (Silesian Unit) consists of isolated outcrops of the Upper Maastrichtian–Lower Paleocene strata and contains valuable information on Cretaceous–Paleogene (K–Pg) boundary events in the sub-CCD (below the calcite compensation depth) carbonate-free sediments of the deep-sea basin. During the summer field campaign (**Fig. 23**), two new outcrops were cleaned and sampled for detailed magnetic studies and geochemistry (Hg, etc.). In addition to Bukovec, the team also worked on finalizing the analyses of the Uzgruň section (Magura Unit) which combines four turbidite (sub-CCD) subsections in individual tectonic slices. Magnetic signature across the K–Pg was revealed for both sections. A combination of rock magnetic results with scanning electron microscope analyses provided information about magnetic mineralogy. Despite the presence of pyrite which considerably influenced some of the obtained results, variations in magnetite contents were revealed to convey the magnetic signal. A strong effect of remagnetization was observed at both localities. Potentially elevated Hg deposition was identified in several stratigraphic intervals (Maastrichtian–Danian) in the Uzgruň section.

Furthermore, magnetic data from the Kršteňany borehole (Slovakia) were published. This multifacies section (from terrestrial sediments through shallow-marine to pelagic sediments) offers a high-quality reference succession for unravelling the Paleogene events in the Tethyan realm. Established magnetostratigraphy (from C20n to C29r) helped to localize the K–Pg transition interval.

Magnetic analyses provided valuable contribution to the magnetic signature across the K–Pg in the Carpathians of central Europe. Integration of our magnetic data with sedimentological data, palynology and biostratigraphy (Czech Geological Survey, Prague and the VŠB-Technical University teams) provided paleoenvironmental information for the studied localities.

FIG. 23 Sampling activities at the Bukovec section. Photo by T. Elbra.

ONGOING PROJECTS

***No. GA18-05935S*: From past to present: fossil vs. recent marine shelled organisms as a substrate for colonization and bioerosion (K. Holcová, Faculty of Science, Charles University, Prague; Z. Heřmanová, National Museum, Prague; M. Vohník, Inst Botany, Czech Acad Sci, Prague; *R. Mikuláš, L. Slavík*; M. Mergl, University of West Bohemia in Pilsen; 2018–2023)**

Tube-dwelling polychaetes, which are adapted to live sticking in soft ground, starting from the Permian, represent widespread but overlooked and understudied substrates for bioerosion. The serpulids can be considered small macrofauna. However, due to the small diameter of serpulid tubes, borings in them are perceived rather as micropaleontological objects, with a size on the order of 0.01–0.9 mm in diameter. Extensive and methodologically broad research (vacuum castings studied by SEM; computed tomography) for borings in these specific substrates was performed on material from the Cenomanian of Le Mans area (France) and Cenomanian and Turonian of the Bohemian Cretaceous Basin (Czechia). It shows that the bioerosive traces can be included in the existing ichnogenera *Rogerella*, *Trypanites*, *Entobia*, *Maeandropolydora*, and *Iramena*. Somewhat surprising is the frequency and disparity of dwelling borings. Several clues, especially in the more abundant ichnogenera *Rogerella*, *Trypanites*, and *Entobia*, support the hypothesis that the tracemakers of these borings adapted to the necessary miniature proportions and lived to adulthood.

***No. GA19-02606S*: Oppidum as an urban landscape: multidisciplinary approach to the study of space organization "intra muros" (P. Goláňová, Faculty of Arts, Masaryk University in Brno; *L. Lisá*; 2019–2022)**

In 2021, no further archaeological fieldwork took place within the project in Bibracte oppidum – with the exception of geophysical survey, which covered the areas necessary for the interpretation of some of the oppidum areas at Bibracte, and collection of some reference samples related to the pedogenesis at the site. Activities were focused mainly on completing analyses and preparing publications. A part of the activities related to the interpretation of the pedochemical analyses was focused on the discussion with specialists on magnetic proxies of soils which can be influenced by metallurgical activities. It is possible to track the human influence on the soil substrate based on changes in soil geochemistry. The high soil substrate redeposition due to the construction of anthropogenic terraces during the Celtic as well as Medieval times changed the structure of the oppida soil cover extremely. Such a high human impact is reprinted in recent landscape till today.

***No. GA19-05198S*: Greisenization and albitization – geological processes potentially concentrating some critical raw materials for modern technologies (*K. Breiter, J. Ďurišová, Z. Korbelová*; M. Novák, Faculty of Science, Masaryk University in Brno; 2019–2022)**

Our work in 2021 was focused on the evaluation of materials collected in Portugal in 2019. Planned study of other typical localities outside the Czech Republic was partly replaced by study of similar domestic material.

The strongly peraluminous P, F, Li-rich granitic system at Argemela, central-eastern Portugal, is an ideal object for the study of relations between the chemical composition of granitic rocks, rock-forming minerals, rock and mineral textures, and the

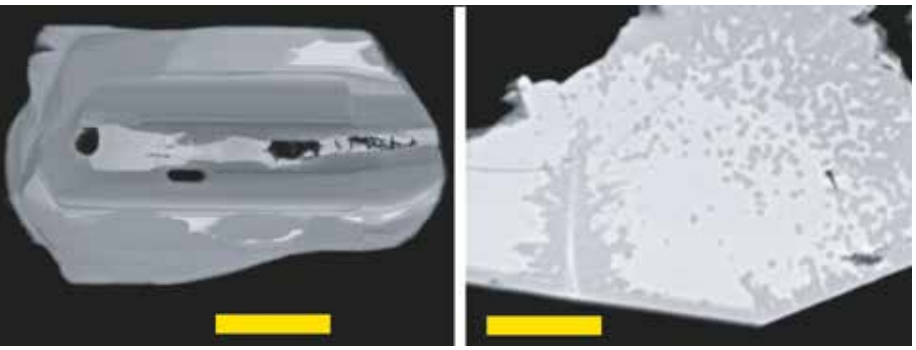

FIG. 24 Tantalum-niobium minerals from Argemela: a zoned crystal of columbite (left) and an irregular grain of plumbomicrolite (right). Images in back-scattered electrons, scale bars 10 μm. Photo by Z. Korbelová.

associated Sn, Ta and W mineralization. Taken into account all collected data, namely the bulk-rock and mineral composition and rock textures, the origin of the Argemela granitic system can be modeled in several steps including magma fractionation, reactions of early crystals with residual melt, separation of orthomagmatic fluid enriched in Sn and Ta, crystallization of ore minerals (**Fig. 24**), and contamination of granites with late fluid from neighboring slates.

The Panasqueira world-class lode-type tungsten deposit is located in central Portugal. Until now, relatively small attention has been paid to the internal structure of the completely hidden Panasqueira granite pluton including a cupola-like greisen body. Our study partly filled this gap: all preserved material from exploration boreholes and accessible granite/greisen outcrops in the mine were investigated using textural studies and bulk-rock and rock-forming and accessory minerals chemical analyses. New data show that the hidden granite body is more complicated than previously thought, forming a steep stock with thin steep and thick flat apophyses. The deposit originated in three principal stages: (1) two-phase intrusion (biotite granite, leucogranite) of fractionated rare-metal granite melt, formation of the cupola and apophysses; (2) supply of fluid from the deeper part of the granite body into the cupola, greisenization; (3) opening of flat structures, migration of fluid outside the cupola, formation of a system of ore veins.

The relation between late magmatic enrichment of albite in F-rich granites and postmagmatic hydrothermal albitization/K-feldspathization is a topic of long-term discussion starting already in ca 1960. Near Krásno, western Bohemia, a feldspar-rich suite of rocks is well exposed in an open pit and feldspar deposit of "Vysoký kámen". This provides, together with several boreholes up to 200 m deep, a good opportunity to study the relations between primary magmatic and metasomatized facies of granitoids. During year 2021, we checked all old borehole cores stored in the Czech Geological Survey and documented outcrops in the quarry, completed a part of bulk chemical analyses of typical rock facies, completed laser-ablation analyses of quartz and mica, and started microprobe study of accessory minerals. Bulk chemical survey of borehole Kž-22 proved that extreme feldspar enrichment of some domains is caused especially by K-enrichment (from 3–4 to 6.5–7.5 wt% K_2O), while Na-enrichment is only moderate (from 3.5–4.5 to 4.5–5.5 wt% Na_2O).

***No. GA19-06759S*: Cadmium hyperaccumulation in macrofungi: from isotopes to proteins and bacterial communities (*J. Borovička*; P. Kotrba, University of Chemistry and Technology in Prague; 2019–2022)**

The project combines mycological, biogeochemical, biochemical, molecular biology, and current microbiological/metagenomics approaches to investigate Cd accumulation in macrofungi (mushrooms). We particularly focus on the investigation of (i) Cd isotopic fractionation in mushrooms; (ii) Cd accumulation, sequestration and chemical speciation in fungal tissues, and (iii) bacterial communities associated with Cd-hyperaccumulating macrofungi.

Fruit-bodies of six *Thelephora* species (*Fungi*, *Basidiomycota*, *Thelephoraceae*) were analyzed for their trace element concentrations. In *Thelephora penicillata*, extremely high concentrations of Cd and As were found, followed by highly elevated concentrations of Cu and Zn (**Fig. 25**). The highest accumulation ability was found for Cd with a mean concentration of 1.17 ± 0.37 g·kg^{-1} (dry mass) in fruit-bodies collected from 20 unpolluted sites; the mean As concentration was 0.878 ± 0.242 g·kg^{-1}. Furthermore, a striking accumulation of Se (923 ± 28 mg·kg^{-1}) was found in one sample of *T. vialis* and elevated concentrations of

FIG. 25 *Thelephora palmata* does not contain high levels of Cd, which is hyperaccumulated in *T. penicillata*, but contains high concentrations of S (19.6 ± 5.9 g·kg^{-1} in dry weight). *Thelephora palmata* is characteristic for its unique smell of "rotten cabbage" and a similar odor is also known in the mushrooms *Gymnopus hariolorum* and *G. perforans*. In *Gymnopus*, S-containing lentinic acid and diastereomer epilentinic acid were detected, which are considered precursors of the sensory-active compounds. Both the high concentration of S and the characteristic smell suggest that these or similar compounds may also be present in *T. palmata*. Photo by J. Borovička.

S were detected in *T. palmata* (19.6 ± 5.9 g·kg^{-1}). The analyzed *Thelephora* species were sequenced and, based on the Maximum Likelihood phylogenetic analysis (ITS rDNA molecular marker) of the genus, possible other *Thelephora* (hyper)accumulators were predicted on the basis of their phylogenetic relationship with the discovered *Thelephora* (hyper)accumulators.

Regarding the metal transport in *Agaricus crocodilinus*, two metal transporters from CDF and one from ZIP protein family were identified, namely AcCDF1, AcCDF2, and AcZIP1 respectively. Full coding sequence of Zn-related AcCDF1 was acquired, thus allowing us to assess its phylogenetic position, spatial structure and characterize its transport properties in metal-sensitive yeast mutants. To explore the localization of AcCDF1 in yeasts by fluorescent microscopy, the protein was tagged by GFP. Fruit-bodies of A. *crocodilinus* from natural habitats were analyzed for Cd isotopic composition and preliminary analyses were performed on underlying substrates. To identify putative mycophosphatin and putative metallothioneins in A. *crocodilinus*, with expected function in detoxification of Cd, double strand cDNA expression library was constructed. Over 60,000 unique bacterial colonies harboring plasmids with DNA of different lengths were obtained from the initial transformation.

***No. GA19-06728S*: How precisely can we reconstruct Carboniferous tropical forests? Examples from the Czech Republic and China (S. Opluštil, Faculty of Science, Charles University, Prague; *J. Bek, J. Votočková Frojdová*; J. Pšenička, West Bohemian Museum in Pilsen; M. Libertín, National Museum in Prague; 2019–2022)**

The most important result of the project was a special volume of international journal Review of Palaeobotany and Palynology dedicated to the collaboration of Czech and Chinese paleobotanists and palynologists with the title: Wuda Tuff Flora: A Permian peat-forming T0 fossil plant assemblage from Wuda Coalfield, Inner Mongolia, published this year, where two authors from the Inst Geol, Czech Acad Sci contributed in the form of nine papers. The whole volume represents a combination of taxonomic studies of peat-forming vegetation including several new species of Permian ferns, sphenophylls, calamites, lycophytes and pteridosperms with paleoecological interpretations. Another contributions was a huge summary of palynological data from the Czech part of the Intra-Sudetic Basin including occurrences of 80 miospore and pollen genera during a 21 million years long interval of Pennsylvanian age. An important result concerns quantitative determination of relationships of coal-forming plants and their spores that can be very helpful for the reconstruction of tropical forests and their ecological conditions. Rare plant-insect interactions from Chinese Permian coal seams were described.

***No. GA19-08066S*: Late Archean granites: markers of modern-style plate tectonics? (J. Žák, V. Kachlík, J. Ježek, J. Hajná, F. Tomek, J. Trubač, K. Verner, F. Vacek, Faculty of Science, Charles University, Prague; *M. Svojtka, L. Ackerman, J. Sláma, J. Rejšek, J. Ďurišová, P. M. Le*; 2019–2022)**

In 2021, the fieldwork (**Fig. 26**) could not be conducted as planned in the original project proposal due to covid-19 travel restrictions, but a shortened (3 weeks) field campaign was made possible in September as

FIG. 26 Field sampling for the anisotropy of magnetic susceptibility (AMS) analysis. The studied rocks are porphyritic monzonites of the Radisson Pluton and the drilling of the samples is carried out by L. Ackerman and F. Tomek. Photo by M. Svojtka.

Canada was opened to incoming travels on 7th September. During this field campaign, our work was focused especially on a detailed sampling of a crustal-scale traverse along the N–S-striking James Bay Road, ca 500 km long. The fieldwork included detailed outcrop documentation, drilling for rock-magnetic studies, over 50 localities were sampled in total, and taking samples for geochemical and geochronological analyses of plutonic rocks and dikes and their metasedimentary host (a total of 17 localities sampled). Particular attention was also given to the metasedimentary Opinaca unit, which may provide a wealth of information on Late Archean geodynamics, as it has been interpreted in rather contrasting ways in recent works (accretionary wedge or a basin above a mantle plume), we took additional samples from this unit to complement our previous data set from 2019. Finally, we published a study about the diversity of sources of Late Archean granites. These rocks are ca 2.8–2.7 Ga plutons intruding different lithotectonic units of the north-eastern part of the Superior Province that demonstrate a complex nature and evolution of magma sources concerning a changing tectonic setting. Four distinct plutonic suites were newly identified: (1) sodic tonalite–diorite (TD) with a composition resembling low-pressure TTG-like melts, (2) sodic tonalite–granodiorite–diorite (TGD) with medium/high-pressure TTG-like signatures, (3) Mg–K-rich monzogranite to monzodiorite (sanukitoids; MMD), and (4) K-rich granodiorite–granite–monzogranite (GGM). These suites are interpreted as recording a temporal evolution from plume-assisted melting of lower mafic continental crust through melting of a subducted oceanic slab at different depths to large-scale re-melting of the previously formed and amalgamated crustal units.

***No. GA19-08614S*: Biogeochemistry of mercury isotopes in anthropogenically affected areas (*M. Vaňková*; J. Trubač, Faculty of Science, Charles University, Prague; 2019–2022)**

Research results included mercury (Hg) isotope systematics in soils polluted by mining and smelting of non-ferrous metal ores. Soil profiles in the vicinity of a copper smelter (Tsumeb, Namibia) were studied to trace major pollution sources and possible changes in Hg isotopic signature due to soil processes caused by post-depositional isotopic fractionation in the soil.

Smelting and mining wastes represent a potential source of Hg in surrounding soils. Soil mercury concentrations varied from 0.1 to 4.4 mg.kg-1 with the highest values in the A horizons. Isotopic signature of all soil samples from two studied soil profiles displayed negative δ202 ranging from -1.28 ‰ to -0.68 ‰. The lowest values were detected in upper soil horizons, and significant MIF were not observed in the soils.

Our theory that the contamination is mainly caused by the deposition of dust particles was confirmed by the enrichment of soils in lighter Hg isotopes; however, the smelting-related wastes need to be studied in more detail. The data from this research will be a part of the dissertation thesis of a PhD student.

***No. GA19-14082S*: Stress- and hydraulic field-controlled weathering and erosion of granular rocks (J. Bruthans, Faculty of Science, Charles University, Prague; *M. Filippi*; J. Schweigstillová, Inst Rock Struct Mechan, Czech Acad Sci, Prague; 2019–2022)**

The project deals with the documentation and experimental testing of stress- and hydraulic field- controlled weathering and erosion of granular rocks. It is focused especially on sandstones, but also granites, tuffs and other granular rocks. The project combines several non-traditional approaches, which are based on sophisticated field measurements and laboratory weathering experiments. Data obtained via these two approaches are synthetized and thus new surprising interpretations may be presented. Introduction of a new type of sandstone outcrops recession is one of the most important results of the last year. The central aspect of this recession is a rapid disintegration of portions of the rock massif, which are no longer physically connected with the main rock mass, though still *in situ*. The surfaces of disconnection follow bedding planes and other planar elements and also subhorizontal fractures, and stress shadows on sub-vertical cliff faces. Weathered surfaces of this "disconnected portions" (**Fig. 27**) show reduced tensile strength and drilling resistance values, a faster capillary water absorption and a higher surface moisture compared to the much less weathered surfaces of the surrounding rock mass. Physical experiments demonstrated that a confinement by the surrounding rock mass may considerably delay the loosening of rock during weathering. The much faster disintegration rates of the disconnected portions

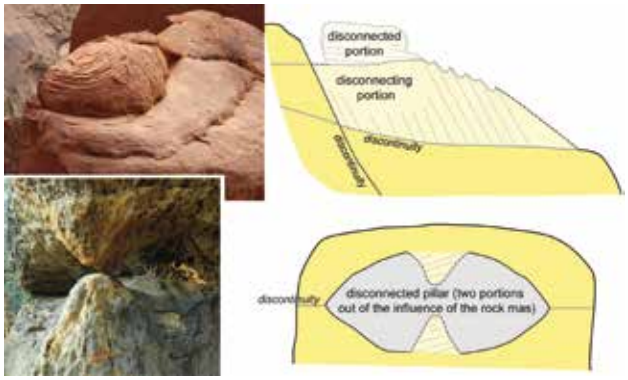

FIG. 27 Examples of two different detached portions on sandstone exposures. Photos and compilation by M. Filippi.

of rock compared to their surroundings are explained by the fact that they are not confined and have a larger surface area. The presence of disconnected portions is very common in dry climates where they are usually elongated parallel to horizontal surfaces. In humid temperate climates, however, they are less abundant, being elongated mostly vertically.

Drilled samples of rock containing salt subflorescences taken from previous field trips at many sites in the Czech Republic and abroad were analysed both by chemical analyses of rock leachates and XRD. Based on the data obtained, another paper was prepared, characterizing the spatial and depth distribution of salt concentration and mineralogy in tafoni.

***No. GA20-05872S*: The Langhian Mediterranean-Parathetys enigma: hydrography based on Nd isotopes proxy on foraminifera revealing changes in paleoceanography (K. Holcová, F. Scheiner, Faculty of Science, Charles University, Prague; *L. Ackerman, J. Rejšek, P. M. Le*; 2020–2022)**

In spite of further delay due to Covid-19 pandemic, we carried out extensive fieldwork at several locations to obtain representative foraminifera samples for the Langhian–Serravallian period. The expected area of the Mediterranean–Paratethys water-masses exchange was sampled at a transect from Tremiti Islands (ITA) – La Vedova section (ITA; **Fig. 28**) – Moria (ITA) section – Slovenia. The Eastern Mediterranean successions were sampled in Cyprus whereas those from the Western Mediterranean in southern Spain. Finally, the samples representative for Central Paratethys were acquired at the Hevlín Quarry. Additionally, we obtained samples from the core material from the Carpathian Foredeep in Poland in cooperation with Danuta Peryt (Institute of Paleobiology, Polish Academy of Sciences, Warsaw).

FIG. 28 The Langhian-Serravallian La Vedova section consisting of clay marls. Photo by L. Ackerman.

All collected samples were washed, wet-sieved and checked for the presence of foraminifera including the preservation state determination. The novel methodology of $^{143}Nd/^{144}Nd$ analysis of extremely small samples was successfully tested on standards as well as real samples and optimized. The single filament configuration using the NdO+ measurement proved to be more applicable benefiting from the higher ion yields. In total, 186 foraminiferal samples were analyzed for their $^{87}Sr/^{86}Sr$ compositions, of which 105 were measured with the required accuracy ($2s \leq 0.00001$). This large data set will allow to create the local $^{87}Sr/^{86}Sr$ curve for the Mediterranean–Paratethyanseawater across a broader Lower–Middle Miocene boundary interval. The dataset will be supplemented by values from the 2021 sampling campaign (we expect ~50 new values). In total, $^{143}Nd/^{144}Nd$ values were obtained for 43 samples. These values represent a basis for the paleoceanographic reconstruction of the Middle Miocene Mediterranean–Paratethys marine system and we expect that the dataset will be significantly expanded in 2022 by samples from the 2021 sampling campaign.

The importance of the study for the fulfilment of the project goals obtained during 2021: (1) evaluation of the reliability of geochemical proxies; (2) a multiproxy analysis across the Burdigalian/Langhian interval in the Paratethys: the synthesis and creation of paleoenvironmental models and paleoclimatic evolution using geochemical, paleontological and sedimentological proxies in the following Paratethyan basins: the Mt. Medvedica area (Croatia); the Eastern Paratethys–Crimea (Ukraine); (3) structure and hydrology of the Ivan Canyon in the Carpathian Foredeep (Moravia); (4) paleoenvironment of a riverine-influenced shelf (Hevlín, Carpathian Foredeep), and (5) paleoceanographic reconstruction of the Paratethys marine realm.

***No. GA20-06134S*: Paleoecology of early angiosperms during mid-Cretaceous, case study of material from Iberian Peninsula and central Europe (J. Kvaček, National Museum in Prague; *J. Dašková*; 2020–2022)**

The main objective of the project is to determine the paleoecophysiology and paleoecology of early angiosperms and place them in their paleoenvironmental context. The project focuses on paleofloristic and palynological studies of Aptian–Cenomanian floras of two areas in Europe with selected localities from each area. The project was significantly affected by the development of the pandemic. It was not possible to carry out the planned field surveys and sampling in Portugal and Spain. The fieldwork was carried out by the Portuguese colleague, who is involved in the processing of the previously undescribed material in the Czech Republic. It was under a collaboration with M. Mendes that a new species of conifer was described, as well as an angiosperm with pollen *in situ*. Palynological research on the Portuguese samples is still ongoing. Throughout the year, megaspores from two Czech Cenomanian localities were scanned using an electron microscope and preliminarily taxonomically evaluated: Pecínov (new collections), Březinka (collections of E. Knobloch, deposited in the National Museum; **Fig. 29**).

***No. GA20-06728S*: Enter of Cd, Hg, and U from the pollution hotspots in floodplains to food web (T. Matys Grygar, Inst Inorg Chem, Czech Acad Sci, Řež; *T. Navrátil*; F. Oulehle, Czech Geological Survey, Prague; 2020–2022)**

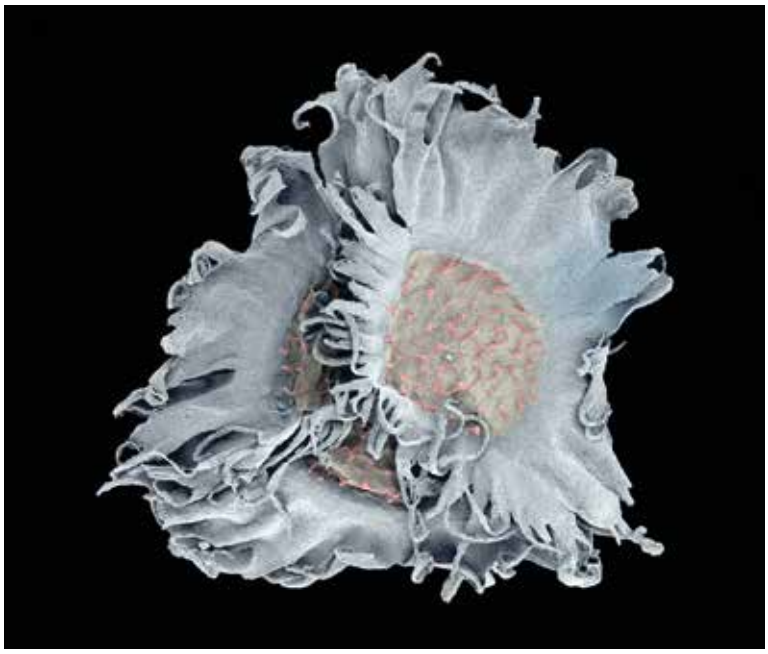

FIG. 29 Megaspore of aquatic plant from the Březinka locality. Photo by J. Dašková.

Research activities were primarily focused on the history and fate of mercury (Hg) released from the Chemical Factory in Marktredwitz City (Germany; CFM; **Fig. 30**). Tree ring archives of European Larch (*Larix decidua* Mill.) were used to reconstruct changes in air Hg levels near the CFM. Mercury concentrations in larch boles decreased from 80.6 $\mu g \cdot kg^{-1}$ at a distance of 0.34 km to 3.4 $\mu g \cdot kg^{-1}$ at a distance of

FIG. 30 Sampling of aquatic plants at Marktredwitz, Germany, near the former Chemical Factory. Photo by T. Nováková.

16 km. The temporal trend of atmospheric Hg emissions from the CFM reconstructed from the tree ring archives showed two main peaks. The first was in the 1920s, coinciding with the factory peak production of Hg-based fungicides, and the second peak in the 1970s, when the general usage and production of Hg chemicals and goods peaked Worldwide. We used the tree ring record to reconstruct past atmospheric Hg levels, and the precision of the tree ring model was checked against the results of air Hg measurements during the CFM remediation 30 years ago. According to the tree ring archives, the highest air Hg concentrations in the 1920s in Marktredwitz were >70 $ng \cdot m^{-3}$. Current air Hg levels of 1.18 $ng \cdot m^{-3}$, assessed in Marktredwitz, indicate the lowest air Hg in the past 150 years, underscoring the effective remediation of the CFM premises 30 years ago.

The monitoring of air Hg level at 1.67 $ng \cdot m^{-3}$ in the polluted flood plain near the Skalka water reservoir in year 2021 indicated that the floodplain substrate acts as a source of Hg emissions. Air Hg levels determined near the ground (40 cm) were elevated at 2.45 $ng \cdot m^{-3}$ and when the vegetation cover was removed it increased to 3.08 $ng \cdot m^{-3}$. Developed vegetation later in the vegetation season (i.e., May, June) protects the floodplain surface from UV radiation and Hg emission from soils decrease.

A contamination of the Kossein and Reslava rivers was indicated by elevated mean filtered Hg concentrations of 5.8 and 6.9 $ng \cdot l^{-1}$. The mean concentration of filtered Hg in the Ohře River sampled as a control was substantially lower, at 1.7 $ng \cdot l^{-1}$. Much more pronounced was the difference between the unfiltered Hg concentrations, where Hg in Kossein and Reslava averaged at 26 and 62 $ng \cdot l^{-1}$, i.e., an order of magnitude greater Hg concentrations with respect to dissolved Hg. In the Reslava River, the highest filtered and unfiltered concentrations of Hg were recorded during the July episodic flooding when they increased to 32 and 117 $ng \cdot l^{-1}$. Mercury concentration of the Reslava suspended particulate material (SPM) was 6,900 $\mu g.kg^{-1}$ Hg, while SPM transported to the Skalka reservoir by the Ohře River contained 390 $\mu g \cdot kg^{-1}$. Using these data, we will be able to estimate the amount of Hg entering and leaving the Skalka Reservoir. Preliminary results indicate greater Hg concentrations in the water and SPM of the Reslava River when compared to the Kossein River.

***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. Kouklíková*; M. Košťák, M. Mazuch, L. Vaňková, Faculty of Science, Charles University, Prague; P. Skupien, P. Doupovcová, Faculty of Mining and Geology, VSB – Technical University in Ostrava; M. Bubík, L. Švábenická, Czech Geological Survey, Praha; 2020–2022)**

The innovative way of research in this project significantly contributes to the global definition of the Jurassic–Cretaceous formations in marine facies. The last boundary of stratigraphic periods has not yet been defined by the International Commission on Stratigraphy (ICS). The processing and evaluation of new geochemical data, and their integration with high-resolution magnetostratigraphy, biostratigraphy and sedimentology are the basis for the creation of a database of integrated stratigraphy. For integrated research, fieldworks at Jahodná, Ropice (Czech Republic), Rettenbacher (Austria, **Fig. 31**) and Golubac (Serbia) were organized. The sections were lithologically documented and subjected to laboratory analyses by multiple methods including mercury (Hg) and calcareous nannofossil (Ca-nanno) analyses.

FIG. 31 Early Berriasian sedimentary rock sequence in the Rettenbacher Quarry (Austria). Photo by J. Geist.

A combination of field measurements of K, U, Th concentrations in limestones and laboratory measurements was applied. The research of classic key profiles of Kurovice (Czech Republic) and Brodno (Slovakia) was supplemented by new ones: Snežnica (Slovakia), Rettenbacher, Silesian Unit (Jahodná, Ropice) and Golubac in cooperation with the International Subcommittee on Cretaceous Stratigraphy. Additionally, rock magnetic properties of upper Jurassic cherts were analysed and could be used for Carpathian stratigraphy as well as for archaeology investigations. Calcareous nannofossil analysis of Ropice, Goleszów (Poland) and Rettenbacher samples was finished together with the biostratigraphic analysis of selected samples from Golubac. A comparison of ichnological data (**Fig. 32**), magnetic susceptibility and $\delta^{13}C_{carb}$ values at the Kurovice locality was completed. Furthermore, analyses of Hg contents and X-ray fluorescence spectrometry, for identifying of Hg host phase, were made for Kurovice, Ropice, Sněžnice and Goleszów, and indicated variations in Hg concentrations. Gamma-ray logs from Kurovice and Goleszów sections were also evaluated. In addition to the Carpathian realm, the Berrias section (France) was investigated and data from magnetic and ichnological records were integrated with other methods to the manuscript.

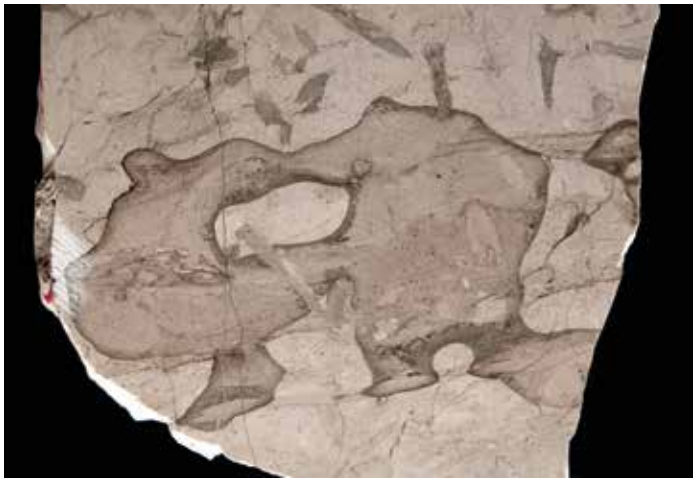

FIG. 32 Ichnofabric features in the magnetically studied profile at Kurovice (central Moravia, eastern Czech Republic) ca. 30 m above the Jurassic/Cretaceous boundary. Vertical section of Bed 104 shows sub-vertical shafts (Trypanites isp.) that disrupted the surface of an extensive system of chambers and tunnels classified as Balanoglossites isp. The identified ichnotaxa indicate a stiff consistency of the substrate (firmground or hardground). The reduced sedimentation rate, evidenced by the depicted ichnofabric, is also reflected in magnetic and isotopic data measured in the profile. Photo by R. Mikuláš.

***No. GA20-13644S*: Cherts and carbonates as geochemical proxies of paleoenvironmental conditions and Ocean Plate Stratigraphy (*L. Ackerman, M. Svojtka, K. Žák, J. Rejšek, J. Ďurišová, J. Sláma, L. Polák*; J. Pašava, F. Veselovský, J. Hora, O. Pour, Czech Geological Survey, Prague; J. Žák, J. Hajná, F. Tomek, J. Trubač, Faculty of Science, Charles University, Prague; 2020–2022)**

The second year of the project was still significantly affected by the Covid-19 pandemic which did not permit to pursue sampling campaign in Wales. Nevertheless, the work on the project in 2021 closely followed the modified plan presented in the last report. Most importantly, Franck Poitrasson (France) spent 4 weeks at the Institute of Geology and Czech Geological Survey helping the establishment of Si isotope analytical protocol. As a result, the protocol was successfully established, and the veracity of the whole method was demonstrated by the analyses of several reference materials. Furthermore, a pilot set of cherts from the Bohemian Massif was also analyzed for their Si isotopic compositions. Within the framework of this project, triple oxygen isotopic data were collected for the set of 40 cherts from the

FIG. 33 Laminated texture of chert from a graywacke-dominated succession, Teplá-Barrandian Unit. Photo by L. Ackerman.

Bohemian Massif at the University of Göttingen (Germany). Finally, the new collaboration with colleagues from Wales (National Resources Wales, Cardiff University, Geomon) has been established to plan sampling at the Mona Complex during 2022.

The most important achievements in 2021 can be summarized as follows. (1) An extensive dataset for variable chert types (**Fig. 33**) from the Teplá-Barrandian Unit in terms of Sr-Nd-Hf-O-Mo isotopic compositions was finalized. These data were also paralleled with in situ LA-ICP-MS trace element data and altogether are currently interpreted in terms to provide insights into the chert petrogenesis, depositional conditions and significance of cherts as part of Ocean Plate Stratigraphy. (2) Occurrence and significance of stromatolitic cherts within the Teplá-Barrandian Unit was elucidated in detail. The work includes detailed mapping of stromatolitic bodies, sampling, petrography, bulk-rock and in situ geochemical analyses to reveal the possible role of biogenic processes. (3) A complex study that includes field relations, petrography and geochemistry of Neoproterozoic–Cambrian limestones (**Fig. 34**) and carbonate-bearing rocks from the Teplá-Barrandian Unit was accomplished. (4) Silicification as a widespread phenomenon affecting trench-slope sediments was studied in detail using a subset of Cambrian black shales in the Teplá-Barrandian Unit and the results were published. (5) Some of the studied cherts show anomalously high V-Cr-Ti concentrations that might be connected with metal remobilization. We pursuit a detailed study of the associated black shales that can serve as a potential source of these elements. The results of the study were published.

FIG. 34 Alternation of sandy limestone (yellow) and black shale (black), Plzeň-Černice, Teplá-Barrandian Unit. Photo by K. Žák.

***No. GA20-14292S*: Mercury – overlooked threat in the Czech ecosystems responding to global change (*T. Navrátil*; F. Oulehle, Czech Geological Survey, Prague; 2020–2022)**

In the second year, we successfully continued monitoring of the deposition and output fluxes (bulk, throughfall and stream water) with monthly step at

FIG. 35 Exposed passive sampler for monitoring atmospheric mercury 35 m above the ground at the top of a monitoring tower, Načetín experimental site. Photo by T. Navrátil.

all 14 GEOMON catchments. Due to continued dieback of the forests throughout the whole area of the Czech Republic, sampling equipment had to be replaced due to damage caused by falling dead or broken trees at several sites. Sampling of litterfall proceeded at all catchments every 3 months, so that at the moment we are processing litterfall samples for Hg analyses. We added the experimental site of Načetín (**Fig. 35**) in the Krušné hory Mts. to the study site list with respect to a study of archived litterfall samples since covering a period of 25 years. Mercury concentrations in spruce litterfall components decreased significantly since the beginning of monitoring in year 1994. The most remarkable decrease of Hg occurred in the bark where it decreased from 367 $\mu g \cdot kg^{-1}$ in 1994 to 163 $\mu g \cdot kg^{-1}$ in 2018. Overall, litterfall Hg deposition at Načetín increased at a rate of 1.5 $\mu g\ m^{-2} \cdot yr^{-1}$ but this increase was due to elevated biomass deposition at a rate of 17.5 $g\ m^{-2} \cdot yr^{-1}$. Over the period of 25 years, total litterfall deposition amounted at 1.3 $mg \cdot m^{-2}$ and the relevant total amount of litterfall biomass was 11,723 $g \cdot m^{-2}$ (i.e., 117 $t \cdot ha^{-1}$). So, a quarter of a century of litterfall Hg deposition represents 23 % of the O horizon Hg pool. The current air Hg concentrations at Načetín were low, at 1.38 ± 0.09 $ng \cdot m^{-3}$.

The results of air Hg measurements using the passive samplers at all 14 GEOMON sites indicated that in general the air Hg concentrations in the Czech forest ecosystems are low, averaging 1.33 ± 0.17 $ng \cdot m^{-3}$. Elevated air Hg levels of 1.61 $ng \cdot m^{-3}$ were observed at the Jezeří site in the Krušné hory Mts., where Hg emissions originated from the coal burning power generation nearby. Another site with an elevated air Hg concentration was Polomka with 1.51 $ng \cdot m^{-3}$. We suggest that the possible source of emissions near Polomka could be the cement plant of Prachovice at a distance of 14 km or the Chvaletice coal-burning power plant 35 km away. Comparing air Hg concentrations in forested stands and in open country, we did not find any significant differences.

Quantification of soil pools at all 14 GEOMON sites indicated that the mean O horizon and mineral soil pools amounted at 4.4 ± 3.4 and 37.9 ± 8.3 $mg \cdot m^{-2}$. The largest O horizon Hg soil pools of 14.1 and 8.1 $mg \cdot m^{-2}$ were at U dvou louček and Uhlířská catchments located in the Orlické hory Mts. and Jizerské hory Mts., respectively. The third largest O horizon pool of 6.2 $mg \cdot m^{-2}$ occurred in the Jezeří catchment, where we identified the highest concentration of gaseous Hg in the atmosphere. The size of the mineral soil pool depends primarily on mineral soil thickness. We will further link soil Hg pools to the fluxes and air Hg according to the project plan.

***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; 2020–2022)**

Large amount of new graptolite and conodont data was obtained in the second year of the project, in particular through additional sampling focused on imperfectly known stratigraphic intervals of the Silurian System. A detailed study focused on Sheinwoodian/Homerian and Pridoli succession in the Kosov Quarry. Little known lower Rhuddanian graptolite fauna was collected from a small section excavated at Běleč. The Estana section in Spanish Pyrenees served as a primary reference in our search for precise stratigraphical delimitation of the early–middle Rhuddanian and Ordovician/Silurian boundary hiatuses of sequence-stratigraphical significance. Lower Telychian sections were studied at Litohlavy and Želkovice. Conodonts isolated from scarce Sheinwoodian and early Homerian strata limestone beds at Loděnice-Špičatý vrch, Kosov Quarry, Svatý Jan – U elektrárny and Beroun-Lištice represent the oldest, Sheinwoodian and early Homerian conodont faunas preserved in the Silurian succession of the Prague strata. New data are promising for filling significant gaps in the stratigraphic record and integrated biostratigraphy in central Europe.

Bed by bed sampling of numerous, richly fossiliferous sections of the Prague Synform allowed for a recognition of 46 graptolite biozones and 7 subzones in the first such compilation of high-resolution graptolite biostratigraphy of the Silurian System in central Bohemia. Stratigraphic duration of these graptolite biozones, deduced from the correlation with Geological Time Scale 2020 age model and global standard graptolite biozonation, ranges between ca 0.1 and 1.74 Myr. Each biozone is defined as an interval zone named after zone index species, characterized by typical zone assemblage and delineated by bounding horizons with stratigraphically lowest and/or highest occurrences of the respective index

taxa. The *Petalolithus folium* Biozone is introduced as a replacement of nearly equivalent *Pribylograptus leptotheca* Biozone based upon a less common and less well-identifiable index taxon. Detailed range charts of 382 species of planktonic graptolites recorded *in situ* at 87 localities and section logs in the offshore Silurian succession of the Prague Synform provided a solid data source for the proposed zonal scheme and following study of regional graptolite faunal dynamics traced by means of Species richness per zone and Time-related species richness (Mean standing diversity). Graptolite diversity rises from the early Rhuddanian post-extinction recovery to the mid-Aeronian maximum succeeded by stepwise decline forced by five major, world-wide recognized extinction events (mid-Aeronian *sedgwickii* Event, early Sheinwoodian *murchisoni* Event, mid-Homerian *lundgreni* Event, early Ludfordian *leintwardinensis* Event, and mid-Ludfordian *kozlowskii* Event). Each crisis, although succeeded by recovery and adaptive radiation, resulted in progressive step-wise reduction of graptolite diversity.

***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, P. Štorch*; J. Pšenička, M. Uhlířová, West Bohemian Museum in Pilsen; J. Kvaček, M. Libertín, National Museum, Prague; V. Žárský, Department of Experimental Plant Biology, Faculty of Science, Charles University, Prague; J. Frýda, B. Frýdová, M. Mergl, Czech University of Life Sciences in Prague; 2021–2023)**

The research combines records of the earliest land plants, spores and cryptospores with results of geochemical analysis from area of Silurian volcanic islands in the Prague Basin. The first global event in the history of early land plants after Homerian glaciation (427 Ma) was recognized based on a detailed analysis of global palynological data from all paleocontinents. This important event shows when the first land plants colonized the Land in higher numbers for the first time. Another research focused on environmental and paleoclimatic changes during the Silurian and on seawater chemistry in the Prague Basin and stressed importance of relationships between flora evolution and paleoenvironmental changes. A detailed study of the important large plant *Tichavekia grandis* from Silurian volcanic islands of the Prague Basin contributed to our understanding about the early land plant diversity.

***No. GA21-21829S*: Proposal for the GSSP of the Basal Emsian Boundary in the Prague Synform (*L. Slavík, J. Hladil, H. Weinerová, T. Weiner*; 2021–2023)**

During the first year of the project, we concentrated on Pragian–Emsian sections in the Prague Synform in order to obtain large biostratigraphical and chemo-physical datasets. The Bohemian Graptolite Event (BGE) is a representative correlation horizon in the upper parts of the Praha Formation with a great potential for future redefinition of the Basal Emsian global stratotype (GSSP). The most promising sections were chosen for study regarding to the presence of the BGE with good accessibility and diverse sedimentology – Pod Barrandovem, Mramorka Quarry and Požáry 3 Quarry. These were sampled for microfacies study and faunal content: conodont samples in dense intervals, sampling of available microfauna and macrofauna, samples for magnetic susceptibility (MS) logs, samples for isotopes $\delta^{13}C$ and $\delta^{18}O$, samples for INAA geochemical analyses and GRS (Gamma Ray Spectrometry) measurements. In some sections we used also previously obtained data (from MS and GRS). Some of the laboratory work has been already finished, such as processing of biostratigraphic samples, preparation of fine powder samples for geochemistry, MS sample measurements and gamma-ray spectrometry measurements evaluation. Maceration of biostratigraphic samples is almost finished and the heavy liquid concentration of insoluble residues is planned for the beginning of 2022.

The microfacies study of the Mramorka section showed enhanced dolomitization in the studied interval of the uppermost part of the Praha Formation. Several other sections were checked and evaluated for prospective additional sampling and study in order to strengthen the correlation of prospective GSSP candidate section. Conodont material was also obtained from other localities for correlation – Skalice Hill near the village of Měňany, and Špička Quarry in Praha–Radotín. The *steinachensis beta – brunsvicensis* and *brunsvicensis – celtibericus* conodont Biozones were recognized at both localities. The latter conodont biozone was documented in the Špička Quarry within the assumed equivalent of the BGE in the upper part of the Praha Fm. The isotope analyses of total of 168 samples, processed in GeoZentrum Nord Bayern, Universität Erlangen-Nürnberg, have been already evaluated. Bulk carbonate samples from the Mramorka, Požáry-3 and pod Barrandovem sections have $\delta^{18}O$ and $\delta^{13}C$ in the range of -10.45 to -2.08 ‰ V-PDB and -1.43 to 2.43 ‰ V-PDB (n = 175), respectively. The $\delta^{13}C$ values show a marked increase within and/or closely above the BGE interval in the Mramorka and Požáry 3 sections. The isotope record also correlates with the estimated BGE equivalent in the Pod Barrandovem section. GRS measurements have been already evaluated for all three studied sections, and MS samples have been measured. The contents of radionuclides ^{40}K (expressed in %), ^{238}U, ^{232}Th (expressed in ppm) and total natural gamma-ray (tot eU expressed in ppm) were determined. The measured GRS data from Mramorka show the same increase around the BGE, similarly as in the Pod Barrandovem and in the Požáry sections.

***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. Weishauptová, D. Řimnáčová, Inst Rock Struct Mechan, Czech Acad Sci, Prague; 2021–2023)**

Postgenetic alteration processes (e.g., hydrothermal alteration) accompanied with brittle deformation and secondary mineral fillings are common in granites used as building stone. 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 behaviour during the weathering processes has been neglected in previous studies. This can be partly explained by the fact that the above mentioned discrete changes in original rock magmatic fabric have negligible impact on examined strength characteristics but can significantly influence stress-strain behaviour which is still scarcely examined on materials from cultural heritage structures. Similarly, the influence of the type of mineral filling on deformational characteristics and on durability has not been studied yet.

***No. GA21-33751S*: The Late Pliocene lower vertebrates (fishes and frogs) from the konservat-lagerstätte Camp dels Ninots (north-eastern Spain) (*T. Přikryl*; 2021–2023)**

The Late Pliocene (Piazencian stage; ca 3.6–2.6 Ma) is a remarkable period: at around 3.3–3.0 Ma, during the Pliocene thermal maximum, temperatures were similar to those projected for the end of this century, about 2–3 °C warmer globally on average than today. The Pliocene Konservat-Lagerstätte of Camp dels Ninots (north-eastern Spain), has been preliminary described for the first time in 2012. The particular geological conditions of the site, which correspond to lacustrine sedimentation in a maar, made it ideal for the preservation of fossils. The coexistence of rhinoceros *Stephanorhinus* cf. *jeanvireti* and large bovid *Alephis tigneresi* suggests an age of about 3.2 Ma (Pliocene) for the Camp dels Ninots, near the MN15–MN16 transition, a period that have delivered very few localities in Europe compared to other periods. At present, faunal remains from the Pliocene Konservat-Lagerstätte of CdN consist in large mammals, rodents, reptiles, amphibians, and fishes.

Although epidemiologic restrictions related with COVID disease affected travelling opportunities to scientific collections, the systematic studies of the lower vertebrate specimens from the site started, together with reflection of paleoecological and taphonomical aspects and related analyses. Collected specimens from the earlier collecting campaigns were (partially) prepared, examined, and conserved.

Fish specimens from CdN (genera *Squalius* and *Luciobarbus*) were studied, and detailed anatomical descriptions were initiated. General morphological characters were completed with detailed knowledge of the morphology and proportions of selected bones. Specimens of frogs from earlier CdN excavations campaigns were documented graphically and carefully compared with articulated fossil frog specimens from the Miocene locality of Libros (Teruel, Spain), that are crucial for correct interpretation of CdN frogs.

A total of 60 specimens of frog long bones were analysed skeletochronologically. Preparations were made following different approaches due to difficulties in the cut and assembly of preparations, mainly recrystallization and low definition of bone structure. Different observation procedures were applied (petrographic microscope, binocular microscope, optical microscope, ESEM electron microscope and HIROX microscope). In all cases, results were not conclusive to be judged as relevant.

***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 in Brno; *L. Lisá*; 2021–2023)**

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. The case study relates to the Rokštejn Castle which has been excavated since 1981, and which will allow observation of the evolution of the castle kitchens, not only in relation to time, but also to the dynamic remodellings of the castle with the changes in its ownership. Archaeological features with artefactual/ecofactual material were selected to be related to the operation 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, either osteological or ceramic components, and what economic models can be applied for castle kitchens.

***No. GC20-05011J*: The Urals: a unique natural laboratory of crustal growth and supercontinent assembly (J. Žák, V. Kachlík, M. Košťák, K. Holcová, J. Hajná, F. Tomek, F. Vacek, M. Mazuch, O. Fatka, Faculty of Science, Charles University, Prague; *M. Svojtka, J. Sláma, J. Rejšek, J. Ďurišová, D. Kořínková*; 2020–2022)**

In 2021, we planned two expeditions to the Urals (on June and September), however, both the disastrous covid-19 pandemic situation in Russia and the political situation after the Vrbětice case in May, when no visa was issued, prevented the Czech research team to get to the field area. To save the project as much as possible, we had to look for alternative research targets that would match closely with the original proposal. We "remotely" collaborated on early Carboniferous volcano-plutonic complexes of Southern Urals (geochronology and tectonic setting), preliminary results have now been submitted as an abstract to the EGU meeting in Vienna in April 2022 and will also be included in a separate publication. Also, in search of a possible alternative and closest topic (an amalgamation of Pangea), we started an informal collaboration with the University of St. Kliment Ohridski in Sofia, Bulgaria, and explored the still poorly documented Variscan belt in the Balkanides, which shares several features with the Urals and may be considered its southern equivalent (peripheral orogen rimming the Baltica–Moesia collage). We took 9 samples for detrital U-Pb zircon geochronology from various Paleozoic units that will allow broader correlations between Bohemian Massif, southern Variscan belt, and the Urals. These samples were already measured and the data are now processed and will be compiled into a publication. As well, we focused on intra-Pangea post-orogenic basins in the Bohemian Massif to decipher post-orogenic processes and reactivations. In total, 16 detrital samples were collected from the Carboniferous, Permian units of the Bohemian Massif and the Cretaceous strata of the cover units. Six of the samples yielded enough apatite grains for the apatite Fission Track (AFT) analyses. The samples were

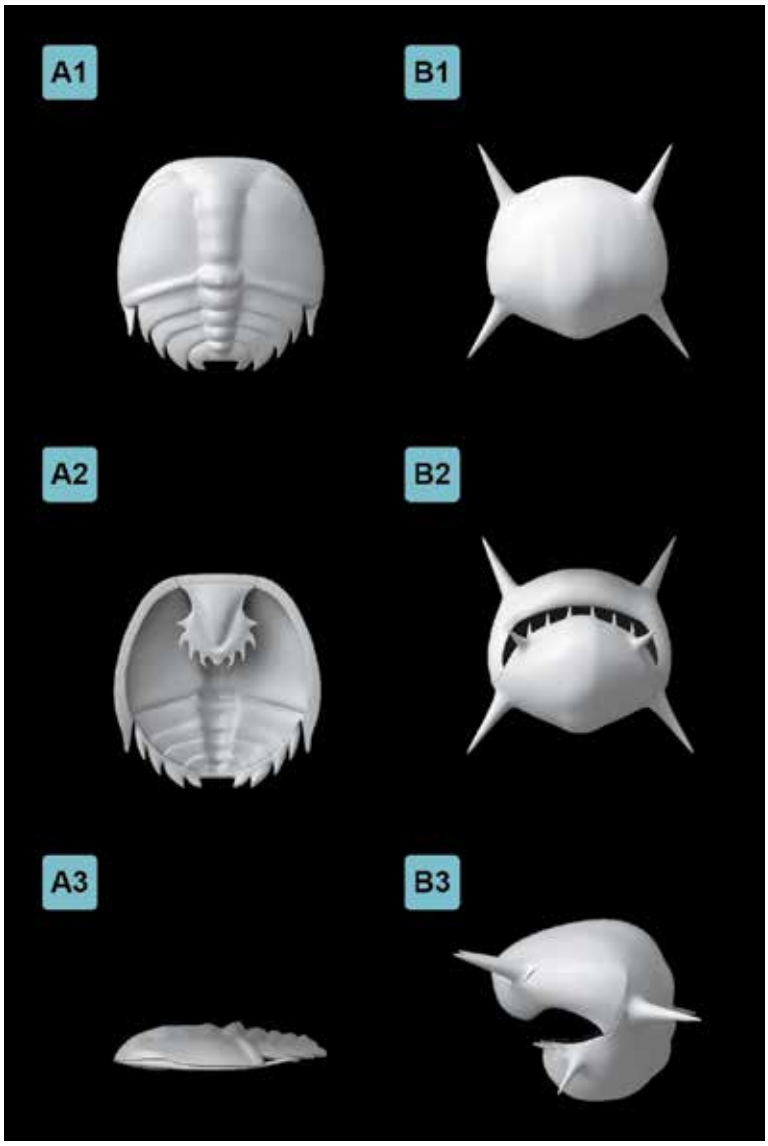

FIG. 36 A – a benthic larva of a Cambrian trilobite in dorsal (A1), ventral (A2) and lateral (A3) views; B – a planktonic larva of an Ordovician trilobite in dorsal (B1), ventral (B2) and lateral (B3) views. Models by M. Šafka under supervision of L. Laibl.

analyzed by a combination of laser ablation ICP-MS and AFT method and yielded intriguing results documenting unexpected burial during the middle Triassic and Jurassic.

***No. GJ19-02177Y*: Magma transfer and emplacement processes in collapsing orogens (*F. Tomek, J. Černý, J. Rejšek, P. Vitouš*; 2019–2022)**

Two papers were published by the team members. The paper accepted in the International Geology Review linked the pyroclastic deposits in post-orogenic basins with volcanism of the late-Variscan Altenberg–Teplice Caldera (ATC). The second paper (Journal of Geophysical Research) deals with the understanding of the significance of inverse magnetic fabrics for geological interpretations, a new, more detailed classification of inverse magnetic fabrics types is formulated in this paper. The manuscript submitted to Bulletin of Volcanology investigates eruptive vent locations, flow directions, and post-emplacement processes of the ATC. We further prepared a manuscript on the anatomy and stress control of a dike swarm that fed caldera-forming eruption of the ATC. A major step forward was achieved in the case of analogue modeling in cooperation with the Hans Ramberg Tectonic Laboratory, Uppsala University, Sweden. Using various combinations of silly putties, plasticine, and silicon, we have modeled the granite-migmatite core complex exhumation on the example of the Pelhřimov complex of the Moldanubian batholith.

***No. GJ20-23550Y*: Exploring developmental aspects in fossil arthropods during Cambrian explosion and Ordovician biodiversification (*L. Laibl*; 2020–2022)**

The project is focused on the evolution of arthropod development between two major events in Earth history – the Cambrian explosion and the Ordovician biodiversification. In particular, the project describes minute larval stages of long-extinct trilobites and relatives of today's crabs or spiders. These arthropod larvae were in many ways similar to their recent equivalents but might have differed in some important aspects (e.g., size, morphology, speed of the development, number of larval stages, the structure of appendages, etc.). Subsequently, the project analyzes and compares these data to understand the evolutionary changes between various arthropod groups. Such research allows us to understand the developmental beginnings of the most diverse group of animals that exist today. Three papers were submitted during the second year of the project and published in Arthropod Structure & Development, Acta Palaeontologica Polonica (both published in 2021) and Biological Journal of the Linnean Society.

During the third year of the project, L. Laibl finished the description of larval stages of a Moroccan arthropod. This arthropod is distantly related to recent crustaceans. Appendages of its larvae are virtually identical with those of the adult individuals, suggesting very similar locomotion and feeding in both larvae and adults. Another research was related to the invasion of trilobite larvae to marine open waters. Robust database of trilobite developmental strategies was created and analyzed. The results show that majority of Cambrian trilobite larvae were living close to the seafloor (**Fig. 36**). At the end of the Cambrian and the beginning of the Ordovician, some trilobite larvae moved to the water column (**Fig. 36**), becoming a member of the plankton and a key component of the marine food web. Interestingly, this evolution of planktonic larval stages of trilobites corresponds to the rapid diversification of the phytoplankton that happened at about the same time. The manuscript is currently under review in Palaeogeography, Palaeoclimatology, Palaeoecology.

6C GRANT AGENCIES OF UNIVERSITIES

FINISHED PROJECTS

***GAUK No. 1094119*: Review of Tertiary turtles from the Most Basin (Czech Republic) and their global importance (*M. Chroust*; 2019–2021)**

Turtles (Testudinata) are a diversified group of reptiles of 365 extant living species, and belong to the longest living terrestrial animals. Turtles are common in sediments because a typical shell is resistante to biodegradation and lot of turtles live in aquatic or semi-aquatic environment with high potential for fossilization. Tertiary deposits from the Czech Republic have a lot of important findings of fossil turtles. Four genera have been described from the Most Basin: *Chelydropsis*, *Ptychogaster*, *Testudo* and *Trionyx*. Most of the material since the description has never been revised, and most of the taxa are invalid. Since the beginning of the last century, the peak of turtle paleontology, new material has been found, waiting for a scientific study. This project is to revise the historical material and describe new material using modern methods.

***GAUK No. 1090119*: A clue for the origin of enstatite-rich meteorites from Cr-Ti-bearing troilites (*N. Mészárosová, R. Skála*; 2019–2021)**

Meteorites, as witnesses of processes of solar nebula evolution, and the formation and alteration of their parent bodies, can provide additional information about the evolution of the universe. Enstatite-rich meteorites, consisting of enstatite chondrite, aubrite, and anomalous enstatite-rich meteorites, are expected to have formed under highly reducing conditions. These conditions of formation are reflected in their unusual mineralogy. Troilite, which contains various amounts of titanium and chromium, receives the most attention in this study. The idea of the presence of nanoscale inclusion of Ti- and Cr-rich sulfides in troilites was proposed. The last year of the study was focused on providing a valid answer. Many previously unobserved phenomena were identified by FEG-SEM (**Fig. 37**). The lamellae for the TEM study of troilite were prepared by the FIB technique from selected meteorites of various types. TEM study revealed the presence of Cr-rich nano-inclusions. It was also focused on the determination of troilite crystal structure and the presence of various nanostructure defects.

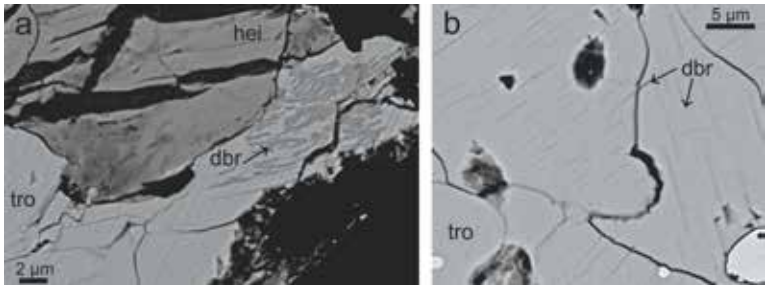

FIG. 37 a) A troilite grain from Yamato 793592 aubrite meteorite with daubréelite inclusions in association with heideite. b) A close-up view of troilite grains with nano-inclusions of daubréelite from Yamato 691 enstatite chondrite. Originally, troilites of this meteorite were mistakenly thought to be free of daubréelite inclusions. Abbreviations: Tro – troilite, dbr – daubréelite, hei – heideite. Photo by P. Harcuba.

ONGOING PROJECTS

***GAUK No. 354821*: Caldera volcanism of the European Variscan belt: insights from structure and rock-magnetism (*P. Vitouš, F. Tomek*; 2021–2023)**

The project focuses on collapse calderas and their eruptive products in different geotectonic environments of the European Variscan orogenic belt. Geological field mapping, structural and rock-magnetic survey of lavas and pyroclastic deposits are planned to be conducted on the example of the Permo-Carboniferous Gréixer rhyolite complex located in the Catalan Pyrenees (Spain). A detailed analysis of magnetic petrofabrics using the anisotropy of magnetic susceptibility (AMS) and anisotropy of anhysteretic remanent magnetization (AARM) complemented by a quantification of the magnetic mineralogy will allow the identification of caldera source of the felsic volcanism in the Permo-Carboniferous Castellar de N'Hug sedimentary basin (Spain).

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

The project is focused on the study of cuticles and other structures of macrofossils, of both plant and metazoan affinities, e.g., to apply palynological method separately to individual parts of macrofossil remains. This means, to extract parts of bodies of various compositions (mainly carbonaceous and phosphatic in composition) from macrofossil utilizing acid maceration methods. This will allow a direct comparison of micro- to mesoscopic elements with the given part of the macroscopic organism and allow possible direct correlation of microscopic and macroscopic remains. Ultimately, this can result in a much better understanding of both the macroscopic and microscopic fossil record of the studied taxa. The aim of the project is to find a combination of techniques utilized for the study of microfossils and macrofossils. Such approach will extend our knowledge of the morphology of the selected macrofossils, and also will allow an assignment of remains of micro- to mesoscopic size to a specific producer.

To test the applicability of the maceration technique, fossils from several stratigraphic levels of the Cambrian through Silurian of the Barrandian area (Czech Republic) will be studied. The general aim will be to describe cuticles and other recalcitrant structures recovered from selected macrofossils *via* palynological maceration. The stratigraphic levels were chosen based on the preservation and abundance of suitable macrofossils (of both plant and metazoan affinity); these include the Cambrian Paseky Shale of the Příbram-Jince Basin; several levels in the Ordovician, and selected sites of the Silurian and Devonian, all in the Prague Basin. Each of the units contains specific fossils and is characterized by a suitable lithological development; therefore, the methodology will be developed and tested on various samples.

6D GRANTS OF THE STATE DEPARTMENTS

FINISHED PROJECTS

***Administration of the Krkonoše National Park/Ministry of Environment of the Czech Republic, EU Operation Programme: Environment, Priority axis 4.1 no. CZ.05.4 .27/0.0/0.0/15_009/0004533*: Inventarization of the Krkonoše karst areas; subproject: Scientific evaluation of cave sediments (R. Tásler, Speleoalbeřice ZO 5-01 ČSS, Svoboda nad Úpou; *P. Bosák, M. Šťastný, P. Mikysek*; 2018–2022)**

Speleogenesis in the Krkonoše Mountains took part at substantial depths under the surface without any link to the present morphology. Phreatic speleogenesis was connected with the oldest surfaces of the Krkonoše Mts. – a flat and slightly undulating peneplain, and with the first stage of shallow valley incision. Caves were disconnected from their original hydrological and hydrogeological regimes, and their function in modern systems is negligible. Therefore, the caves are relic or rejuvenated karst, i.e., *paleokarst s.l.* Present near-surface position of most of the caves **(Fig. 38**) reflects denudation during younger tectonic movements and incision of river systems. The uplift was cyclic; a system of flat ceilings (*Laugdecken*) in some caves indicates stabilization phases during the uplift. Originally phreatic caves were much later re-shaped in epiphreatic and vadose zones. Sub-/vertical phreatic channels (*feeders*) dominate in original cave morphologies. They served as routes for ascending bathy- and deep phreatic waters and follow regional fault systems, a. o., hydrological structures of Jánské Lázně spa. Ceiling half-channels, scallops and ceiling cupolas clearly indicate such environment. The role of thermal waters has not been proved, as respective speleogens and/or diagnostic minerals are missing, but it cannot be excluded (with respect to the thermal Jánské Lázně system). Rare gypsum in sediments indicates rather dry conditions (evapotranspiration), than sulfuric acid speleogenesis. Tectonically-driven rock fragmentation led to opening of vadose routes and to substantial water infiltration loaded with clastic sediments eroded from the surface. Older caves were partly or fully filled. Coarse-grained particles were sieved by fissure porosity, leaving only lutitic load. The primary source of cave clastic sediments was in weathering products of crystalline rocks, mature and immature, or polycyclic, mixed in different proportions according to the morphological position of the site and lithology of the surrounding crystalline rocks. Coarser-grained material was transported by mudflows and debris flows via older karst channels and chimneys, probably from younger collapses on the surface. No allogenic deposits were detected. Intensive drip from open fissures contributed to local re-distribution of sediments in the caves. Speleothem dating indicates that the caves were filled and exhumed several times, partially or fully, with the cycles being separated by hiatuses (speleothems, iron-rich crusts or carbonate cementation). Internal cyclic/rhythmic style of the sediments proves changing paleoenvironmental conditions on the surface. Normal polarity of samples proved their age of <773 ka (Bruhnes Chron). Speleothems date clastic sediments to >400 ka. The speleothems crystallized mostly during interglacials (namely MIS 5a, MIS 5e, MIS 7a, MIS 7c, MIS 7e), but also during cold and extremely cold periods (glacials, like MIS 2, MIS 6c to 6a, MIS 8b, MIS 10c to 11a). Tectonic and near-surface marble fragmentation and corrosion along fissures and cleavage substantially contributed to re-shaping of the created cave spaces by rockfalls of variable size, most probably in repeating phases. The role of cryogenic processes during cave evolution is indicated by modifications of cave walls (congelifraction), but also by damaged speleothems (fractures, opening of isotopic equilibria by corrosion).

FIG. 38 Entrance to the Davidova Cave in a shallow subsurface position at the top of a morphological ridge. Photo by R. Tásler.

FIG. 39 Fieldwork sampling of phyllites near the Mooserboden Reservoir, Kaprun (Tauern Window, Austria). Photo by M. Svojtka.

***Ministry of Education, Youth and Sports, "Mobility", Project No. 8J20AT004*: Geological correlation of intra-Alpine crustal fragments with the Bohemian Massif (*M. Svojtka, J. Sláma, F. Tomek*; J. Žák, K. Verner, J. Hajná, Faculty of Science, Charles University, Prague; F. Finger, University of Salzburg, Austria; 2020–2021)**

Despite the restrictions due to the pandemic, work on the project continued and communications between the Czech and Austrian teams took place in an online environment. The first publication concerning high-temperature granites in the Moldanubian Zone of the Bohemian Massif ("Ultra-high-temperature granites and a curious thermal eye in the post-collisional Variscan South Bohemian Batholith" by Finger et al.) was

prepared and accepted for publication in the journal "Geology". Cooperation continued on the processing of geochronological data from samples taken in 2020 from the Tauern Window (Eastern Alps, Austria; **Fig. 39**). By the present day, all samples have been completely measured and processed, and another joint publication of the Czech and Austrian teams is being prepared.

ONGOING PROJECTS

***Ministry of the Interior of the Czech Republic, "Program bezpečnostního výzkumu České republiky 2015–2022", Identification No. VI20192022148*: Complex instrumental protocol for the characterization of selected mineral phases with a link to specific geographic origin (D. Matějka, M. Racek, L. Strnad, J. Zachariáš, Faculty of Science, Charles University, Prague; *R. Skála, L. Ackerman, Š. Matoušková, L. Polák, N. Mészárosová, P. Mikysek*; M. Kotrlý, I. Turková, J. Wolker, Institute of Criminalistics, Police of the Czech Republic, Prague; J. Sejkora, Z. Dolníček, J. Hyršl, J. Ulmanová, National Museum, Prague; 2019–2022)**

Gemstones are often counterfeited in various ways. Such fake stones can be synthetic phases chemically and structurally completely different from the gemstones they simulate in appearance. Further, counterfeited stones can be synthetic analogues of the gemstones they imitate. Also, we may encounter so-called "treated stones", which are natural minerals that underwent some physical procedures (heating, irradiation, etc.), which, for example, changed the original color to meet the coloring of the gemstone. Consequently, it is always important that one is able to resolve genuine natural gemstones from potential fakes. One of the suitable procedures is chemical analysis. Many analytical methods require a certain pre-treatment of the objects to be studied (cutting, polishing); however, cut gemstones cannot be handled that way. Most potent analytical procedures which may help to determine chemical composition of gemstones include EPMA and LA-ICP-MS. Reliable results are attained from flat polished surfaces in both methods. To simulate possible limitations due to the character of the stones, EPMA and LA-ICP-MS were tested with loose grains and gem cuts. Despite of great efforts to orient irregular surface elements to optimum geometry with respect to the analytical instrument, the results of both EPMA and LA-ICP-MS display marked differences to reference element concentration values. In addition, laser ablation produces craters on the surfaces, which deteriorate gemstone cuts yet the degree of this deterioration depends not only on instrument setting but also on the type of the studied mineral (**Fig. 40**).

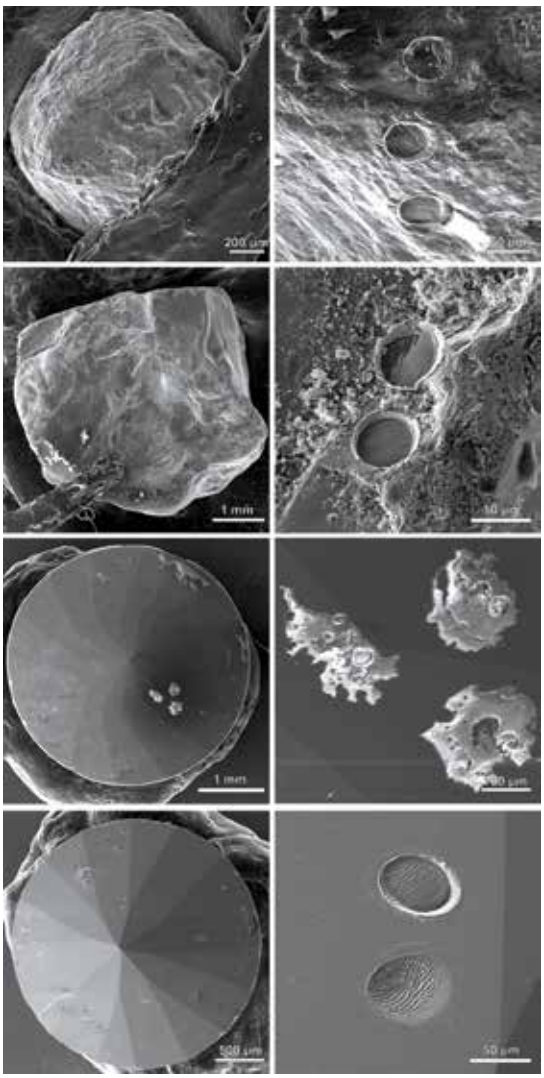

FIG. 40 Craters induced by laser ablation in loose grains (top 2 rows) and cuts (bottom 2 rows) of different types of garnets during measurements of minor and trace element contents. Note the different appearance of craters in individual garnet types. Photo by N. Mészárosová.

In recent years, two rusty metal-rich objects have been found on waste dumps of medieval mines close to Potůčky in the Krušné hory Mts. They were identified by the finder to represent new samples of the historical find of Steinbach iron meteorite. Since such type of material possesses not only a high historical value but also may be worth of significant amount of money, an investigation to prove its identity with the known historical meteorite was started. Small specimens of less than 2 mm across were taken from each of the stones for testing using a complex of methods including optical microscopy, scanning electron microscopy supplemented with energy-dispersive X-ray spectrometry and elemental mapping, electron probe microanalysis, laser ablation inductively coupled plasma mass spectrometry and thermal ionization mass spectroscopy. Elemental maps acquired with SEM-EDS illustrate a well developed Widmanstätten pattern (**Fig. 41**), which confirms the meteoritical origin of the samples unequivocally. Chemical compositional data for individual minerals constituting the meteorite markedly resemble those published in literature for samples of Steinbach from the museum collection, further establishing a firm connection to this meteorite.

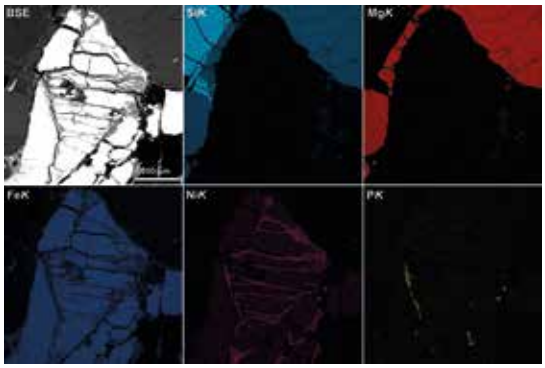

FIG. 41 Back-scattered electron image and element distribution maps clearly show the Widmanstätten pattern attesting of the meteoritical origin of the sample. Minerals observed in the metallic part of the meteorite include kamacite, taenite, enstatite, tridymite, schreibersite, and troilite. Photo by N. Mészárosová.

6E INDUSTRIAL GRANTS AND PROJECTS

***Biol Centre, Czech Acad Sci, České Budějovice, Project No. 7004*: Platinum-group element concentrations in paleolakes in the Šumava Mts. and USA (*L. Ackerman, J. Ďurišová*)**

A joint project with E. Stuchlík, dealing with platinum-group element concentrations in paleolake sediments.

***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*)**

Increased bulk precipitation amounted 1,077 mm in hydrological year 2020, which resulted in elevated deposition of sulfate ($SO4^{2-}$) 14 kg·ha^{-1}. In contrast, nitrate (NO^{3-}) deposition at 12 kg·ha^{-1} decreased with respect to previous hydrological year. Bulk deposition of the main cations and risk elements either slightly increased or varied a little. The year 2020 was typical with the lowest deposition of H^+ thus it was the year with the highest volume weighted annual pH 5.27 since the beginning of monitoring in 2002. Due to evapotranspiration, the throughfall amount was 693 mm in 2020. Similarly to bulk deposition, SO_4^{2-} throughfall deposition increased to 22 kg·ha^{-1} and NO^{3-} throughfall deposition decreased to 37 kg·ha^{-1} with respect to previous hydrological year. Moreover, throughfall in 2020 was typical with the highest mean volume weighted pH 5.07 since the beginning of monitoring. This resulted from a major increase in throughfall deposition of K from 19 to 39 kg·ha^{-1}. Mercury bulk deposition increased from 2.0 µg m^{-2}·yr^{-1} in 2019 to 2.6 µg m^{-2}·yr^{-1} in 2020. The database of atmospheric deposition in the Bohemian Switzerland National Park started in year 2002 and includes 215 monthly records up to date.

***Charles University, Project No. 7012*: Dissolution and reprecipitation of garnet during eclogite-facies metamorphism (*M. Svojtka, J. Ďurišová*)**

A joint project focused on compositional relations in garnet with partly developed atoll textures from eclogite-facies rocks. We described the major and trace element zoning measured by laser ablation ICP-MS technique. Finally, the reaction sequence and partitioning of elements during garnet growth were shown.

***Czech Geological Survey, Prague, ČGS 500336, Project No. 7026*: Salvage paleontological survey before reclamation of the Špička Quarry in Praha-Radotín (P. Budil, O. Švagera, E. Kadlecová, M. Nohejlová, M. Polechová, J. Vodička, Czech Geological Survey, Prague; *L. Slavík, R. Mikuláš*)**

In summer 2021, a team of both partners realized salvage paleontological survey in the Špička Quarry in Praha-Radotín, which is scheduled for reclamation in the near future. A number of macrofauna samples were obtained – mostly trilobites and cephalopods from the Emsian Dvorce-Prokop Limestone facies. In various parts of the quarry, numerous traces were ichnotaxonomically evaluated. Micropaleontological analyses based on chitinozoans and conodonts provided a more precise relative dating of the Lochkovian–Pragian boundary and of the middle and upper parts of the Praha Formation.

***European Space Agency, Project no. 78034000131925/20/NL/GLC-S-GLI, Project No. 7803*: Hera CubeSat 2 Programme (*T. Kohout, K. Chrbolková*)**

The project is a part of the ESA Hera mission to the binary asteroid of Didymos/Dimorphos. Hera spacecraft will deploy a small CubeSat Milani with hyperspectral imager ASPECT. ASPECT will map the target asteroids at high spatial and spectral resolution, generating huge volumes of data. The objective of this project is to prepare and test onboard algorithms for evaluation of hyperspectral image quality. The algorithms will identify the highest quality data for download to the Earth in order to reduce data volume.

***Inst Archaeol, Czech Acad Sci, Prague; National Museum, Prague; Charles University in Prague; Muzeum and Gallery of the Orlické hory Mts., Rychnov nad Kněžnou; Villa Nova, Uhřínov, Project No. 7004*: Strontium and lead isotopic compositions of selected burial grounds (*L. Ackerman, J. Rejšek*)**

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

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

A further and extended continuation of a joint project aimed at *in situ* U-Pb and TE LA-ICPMS analyses of accessory phases, mostly in order to define the absolute age of crystallization or alteration of U-Th-Pb ages due to fluid action. The U-Th-Pb analysis of apatite has been established in the ICP-MS lab and used for analysis of apatite from the Panasqueira tin-tungsten deposit (Portugal). Since then, a higher number of apatite dating were performed on a variety of samples, thus making apatite dating an integral part of routine analyses that can be performed in the ICP-MS facility. Additional TE and U-Pb analyses were made on zircon-xenotime intergrowths from pegmatite from the Pilawa Gorna in Poland, which extends the former study from 2018. This, together with a detailed geochemical and Raman investigation of phosphates subjected to alteration processes, was the main focus of this collaboration in 2021. Beside that, the usual routine U-Pb analyses of zircon for various side-projects linked to the Polish Academy of Sciences in Krakow resulted in a number of other high-ranked publications in international journals.

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

FIG. 42 Historical objects in the Zahrádky area and sandstone quarries producing the material for their construction. A – Vřísek, Renaissance chateau, B – Vřísek, a quarry at the N foot of the chateau, where dimension stone was taken, C – Nový Zámek, a quarry at the NW foot of the chateau, where dimension stone was extracted by undercutting and used for the Baroque rebuilding of the chateau, D – Nový Zámek, Renaissance chateau, recently damaged by fire. Photo by J. Adamovič.

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

***Istanbul Technical University, Turkey, Project No. 7004*: Highly siderophile element and Re-Os isotopic compositions of volcanic rocks from Antarctica (*L. Ackerman, V. Renčiuková, J. Ďurišová, J. Rejšek*)**

A joint project with S. Altunkaynak dealing with the nature of sources parental to magmatic rocks from the Antarctic Peninsula.

***Jan Evangelista Purkyně University in Ústí nad Labem, Philosophical Faculty, Project No. 7464*: Petrographic study for NAKI II Project – *Hortus Montium Mediorum*. Documentation, research and presentation of cultural heritage of selected sites of northeastern České středohoří Mts., No. DG 18P02OVV066 (*J. Adamovič*)**

The project on construction history (Renaissance to Classicist) of specific areas in the eastern part of the České středohoří Mts. includes studies of building stone provenance. Activities in 2021 concentrated on several objects in the Zahrádky area (**Fig. 42**). The Renaissance chateau of Nový Zámek at Zahrádky is built from quartzose sandstone of the Jizera Formation from quarries (levels 2 and 3) lying to the S and W of the chateau. Quarries from the lowermost level 1 NW and N of the chateau were rather used for its Baroque reconstruction. The Renaissance chateau of Vřísek is built from local material: quartzose sandstone of the Jizera Formation quarried at its N foot. More than 120 historical objects from the Zahrádky area (buildings and quarries) are included in the thematic map and the accompanying database to be completed in 2022.

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

A joint project with M. Putiš focused on the petrogenesis of volcanic and plutonic rocks from the Carpathians.

***Masaryk University in Brno, Project No. 7004*: Molybdenum isotopic compositions of Ordovician carbonates from southern Sweden (*L. Ackerman, L. Polák*).**

A joint project with Masaryk University (. Bábek) and Palacký University (Dr. Tomáš Kumpan) focusing on the determination of Mo isotopic composition of carbonates from selected boreholes from southern Sweden.

***Middle East Technical University, Turkey No. 7004*: Strontium isotopic compositions of geoarchaeological materials (*L. Ackerman, J. Rejšek, V. Renčiuková*).**

A joint project dealing with Sr isotopic compositions of enamels from selected burial grounds in Turkey.

***Munzur University, Turkey, Project No. 7004*: Highly siderophile element and Re-Os isotopic compositions of volcanic rocks from eastern Turkey (*L. Ackerman, J. Ďurišová, J. Rejšek*).**

A joint project with O. Cimen dealing with the nature of sources parental to magmatic rocks within the Cenozoic volcanic province in Turkey.

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

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

***University of Hong Kong, Project No. 7004*: Highly siderophile element and Re-Os isotopic compositions of dunites from Pilbara and Isua cratons (*L. Ackerman, L. Polák, J. Ďurišová, J. Rejšek*).**

A joint project with J. Zhuo focused on highly siderophile element systematics of cumulate dunites from Australia and Greenland.

***University of Hong Kong, Project No. 7004*: Sm-Nd systematics of Archean metavolcanics and mantle rocks from China (*L. Ackerman, V. Renčiuková, J. Rejšek*).**

A joint project with Ch. Wang focused on Sm-Nd geochronology of selected rocks from China.

***University of Wrocław, Project No. 7001*: Trace elements analysis by LA-ICP-MS (*J. Ďurišová*)**

A joint project with M. Matusiak-Małek focused on in situ analysis of trace elements for studying the variable origin of clinopyroxene megacrysts carried by Cenozoic volcanic rocks from the eastern limb of the Central European Volcanic Province.

6F PROGRAMMES OF STRATEGY AV21 OF THE CZECH ACADEMY OF SCIENCES

***Project No. 9223 within the Water for Life Programme*: Innovative monitoring and modelling techniques for hydroecological analysis in a small catchment (*T. Navrátil*; M. Tesař, Inst Hydrodyn, Czech Acad Sci, Prague; F. Oulehle, Global Change Res Inst, Czech Acad Sci, Brno; J. Kopáček, Inst Hydrobiol, Biol Centre, Czech Acad Sci, České Budějovice)**

After a successful assessment of stream sediment transport and measurement of air Hg levels, we installed an innovative sensor for the groundwater level oscillation measurements. A shallow groundwater well 4.5 m deep near the Lesní potok catchment Thomson weir was equipped with the Fiedler TSH22 sensor. The results of water level and temperature changes of groundwater will be used for improved quantification of groundwater contribution to the streamflow. In year 2022, new information panel will be installed, covering the Lesní potok Stream monitoring. Furthermore, the monitoring of air Hg levels using innovative passive samplers continued at all the studied sites: Lesní potok, Plešné jezero Lake and catchment Liz. Results from the three years of measurements in 2019, 2020 and 2021 indicate a slow decrease in air Hg concentrations at catchments Liz and Lesní potok.

***Project No. 9229 within 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).**

A set of otoliths for measurements on laser ablation ICP-MS technique was carried out at Inst Geol. In cooperation with Biol Centre, it has been shown that the micro elemental composition of pikeperch otoliths is a very accurate tool to assess the natal origin of fishes,

FIG. 43 The interior of the motorboat that serves for the Biology Centre, Czech Acad Sci, to fish collection and studying fish behavior. Photo by M. Svojtka.

even in areas subjected to multiple stocking sources. Four chemical elements were found to differ between stocked and wild pikeperch. Wild pikeperch had a significantly higher concentration of rubidium than stocked fish from all sources, highlighting that this chemical element is an important marker for the wild population in the Lipno Reservoir. The concentration of the other chemical elements (strontium, potassium, and magnesium) was also important in the discrimination of the pikeperch natal origin, but to a much less relevant degree when compared to rubidium (**Fig. 43**).

***Project No. 9230 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*)**

In June 2021, we installed sampling equipment to the Poledník site. In particular, two passive samplers for air Hg measurements and one bulk precipitation sampler for the mercury deposition were installed. The individual sampling campaigns were processed according to the plan. The initial results indicate low Hg concentrations and deposition fluxes similar to reference sites in the Bohemian Forest area. Catchments of the Plešné and Čertovo lakes were selected as a control.

6G PROGRAMMES OF INSTITUTIONAL RESEARCH PLAN

***Project No. 9331*: Origin of the P, F, Li, Sn-enriched orthogneisses, granite, pegmatites and ore veins at Přibyslavice (*K. Breiter, J. Ďurišová, Z. Korbelová*)**

***Project No. 9344*: Geochemical and isotopical characteristic of phonolitic magma sources in the Lužické hory Mts. area (*J. Ulrych, S. Krmíčková, L. Ackerman*)**

***Project No. 9346*: Soil conditions of the Kokořínsko-Máchův kraj Protected Landscape Area (*A. Žigová, J. Adamovič, P. Mikysek, M. Šťastný*)**

***Project No. 9354*: Molybdenum isotope signature of the Quaternary lamproite Gaussberg volcano, Antarctica (L. Krmíček, L. Ackerman)**

***Project No. 9388*: The oldest modern humans in the Bohemian Karst (*K. Žák, J. Adamovič, S. Čermák, P. Mikysek*)**

***Project No. 9389*: Verification of new materials and technologies for research and development of special sensors of the MAVACS system (*L. Kouklíková, P. sPruner, P. Schnabl, Š. Kdýr, J. Petráček, T. Elbra*)**

***Project No. 9390*: Application of methods for determining paleointensity of a geomagnetic field (*P. Schnabl, Š. Kdýr, T. Elbra*)**

7. PUBLICATION ACTIVITY

7A PAPERS

12.779* Wang, J., Hilton, J., Pfefferkorn, H. W., Wang, S., Zhang, Y., ***Bek, J.***, Pšenička, J., Seyfullah, L. J., Dilcher, D. Ancient noeggerathialean reveals the seed plant sister group diversified alongside the primary seed plant radiation. *Proceedings of the National Academy of Sciences of the United States of America*. 2021, 118(11), e2013442118.

10.753* ***Nováková, T.***, ***Navrátil, T.***, Demers, J. J., ***Roll, M.***, ***Robovec, J.*** Contrasting tree ring Hg records in two conifer species: Multi-site evidence of species-specific radial translocation effects in Scots pine versus European larch. *Science of the Total Environment*. 2021, 762, 144022.

8.943* Braeuer, S., ***Borovička, J.***, Glabonjat, R. A., Steiner, L., Goessler, W. Arsenocholine-O-sulfate: A novel compound as major arsenic species in the parasitic mushroom *Tolypocladium ophioglossoides*. *Chemosphere*. 2021, 265, 128886.

8.943* Lajin, B., Braeuer, S., ***Borovička, J.***, Goessler, W. Is the water disinfection by-product dichloroacetic acid biosynthesized in the edible mushroom *Russula nigricans*? *Chemosphere*. 2021, 281, 130819.

8.044* De Lange, R., Adamčík, S., Adamčíková, L., Asselman, P., ***Borovička, J.***, Delgat, L., Verbeken, A. Enlightening the black and white: species delimitation and UNITE species hypothesis testing in the *Russula albonigra* species complex. *IMA Fungus*. 2021, 12(1), 20.

8.044* De Lange, R., Adamčík, S., Adamčíková, L., Asselman, P., ***Borovička, J.***, Delgat, L., Verbeken, A. Correction to: Enlightening the black and white: species delimitation and UNITE species hypothesis testing in the *Russula albonigra* species complex. *IMA Fungus*. 2021, 12(1), 28.

7.483* Oriolo, S., Schulz, B., Geuna, S., González, P. D., Otamendi, J. E., ***Sláma, J.***, Druguet, E., Siegesmund, S. Early Paleozoic accretionary orogens along the Western Gondwana margin. *Geoscience Frontiers*. 2021, 12(1), 109–130.

7.483* Roberts, N. M. W., Žák, J., Vacek, F., ***Sláma, J.*** No more blind dates with calcite: Fluid-flow vs. fault-slip along the Očkov thrust, Prague Basin. *Geoscience Frontiers*. 2021, 12(4), 101143.

7.483* ***Krmíček, L.***, Novák, M., Trumbull, R. B., Cempírek, J., Houzar, S. Boron isotopic variations in tourmaline from metacarbonates and associated calc-silicate rocks from the Bohemian Massif: Constraints on boron recycling in the Variscan orogen. *Geoscience Frontiers*. 2021, 12(1), 219–230.

6.947* Oulehle, F., Goodale, C. L., Evans, C. D., Chuman, T., Hruška, J., Krám, P., ***Navrátil, T.***, Tesař, M., Ač, A., Urban, O., Tahovská, K. Dissolved and gaseous nitrogen losses in forests controlled by soil nutrient stoichiometry. *Environmental Research Letters*. 2021, 16(6), 1–11, 064025.

6.556* ***Borovička, J.***, ***Ackerman, L.***, ***Rejšek, J.*** Cadmium isotopic composition of biogenic certified reference materials determined by thermal ionization mass spectrometry with double spike correction. *Talanta*. 2021, 221, 121389.

6.367* Adameková, K., ***Lisá, L.***, Neruda, P., Petřík, J., Doláková, N., Novák, J., Volánek, J. Pedosedimentary record of MIS 5 as an interplay of climatic trends and local conditions: Multi-proxy evidence from the Palaeolithic site of Moravský Krumlov IV (Moravia, Czech Republic). *Catena*. 2021, 200, 105174.

6.300* Kříbek, B., Bičáková, O., Sýkorová, I., Havelcová, M., Veselovský, F., Knésl, I., ***Mészárosová, N.*** Experimental pyrolysis of metalliferous coal: A contribution to the understanding of pyrometamorphism of organic matter and sulfides during coal waste heaps fires. *International Journal of Coal Geology*. 2021, 245, 103817.

6.240* ***Chrbolková, K.***, Brunetto, R., Ďurech, J., ***Kohout, T.***, Mizohata, K., Malý, P., Dědič, V., Lantz, C., Penttilä, A., Trojánek, F., Maturilli, A. Comparison of space weathering spectral changes induced by solar wind and micrometeoroid impacts using ion- and femtosecond-laser-irradiated olivine and pyroxene. *Astronomy & Astrophysics*. 2021, 654, A143.

6.137* Křenek, T., Pola, J., Docheva, D., Stich, T., Fajgar, R., Kovářík, T., Pola, M., Martan, J., Moskal, D. S., Jandová, V., Kupčík, J., ***Mikysek, P.*** Porous micro/nano structured oxidic titanium surface decorated with silicon monoxide. *Surfaces and Interfaces*. 2021, 26, 101304.

5.921* Magna, T., Jiang, Y., ***Skála, R.***, Wang, K., Sossi, P. A., ***Žák, K.*** Potassium elemental and isotope constraints on the formation of tektites and element loss during impacts. *Geochimica et Cosmochimica Acta*. 2021, 312, 321–342.

5.361* ***Ackerman, L.***, Pašava, J., Žák, J., ***Žák, K.***, Kachlík, V., Šebek, O., Trubač, J., ***Svojtka, M.***, Veselovský, F., Strnad, L., ***Santolík, V.*** Arc-related black shales as sedimentary archives of sea-level fluctuations and plate tectonics during the late Neoproterozoic. An example from the Bohemian Massif. *Marine and Petroleum Geology*. 2021, 123, 104713.

5.190* Matys Grygar, T., Faměra, M., Hošek, M., Elznicová, J., ***Robovec, J.***, ***Matoušková, Š.***, ***Navrátil, T.*** Uptake of Cd, Pb, U, and Zn by plants in floodplain pollution hotspots

contributes to secondary contamination. *Environmental Science and Pollution Research*. 2021, 28(37), 51183–51198.

4.778* Křenek, T., Jandová, V., Kovářík, T., Pola, M., Moskal, D., Pola, J., Stich, T., Fajgar, R., ***Mikysek, P.***, Kolská, Z. Micro/nano-structured titanium surfaces modified by NaOH–CaCl2-heat-water treatment: Biomimetic calcium phosphate deposition and hMSCs behavior. *Materials Chemistry and Physics*. 2021, 272, 124896.

4.685* Budzyń, B., ***Sláma, J.***, Corfu, F., Crowley, J., Schmitz, M., Williams, M. L., Jercinovic, M. J., Kozub-Budzyń, G. A., Konečny, P., Rzepa, G., Włodek, A. TS-Mnz – A new monazite age reference material for U-Th-Pb microanalysis. *Chemical Geology*. 2021, 572, 120195.

4.685* Budzyń, B., Wirth, R., ***Sláma, J.***, Birski, L., Tramm, F., Kozub-Budzyń, G. A., Rzepa, G., Schreiber, A. LA-ICPMS, TEM and Raman study of radiation damage, fluid-induced alteration and disturbance of U-Pb and Th-Pb ages in experimentally metasomatised monazite. *Chemical Geology*. 2021, 583, 120464.

4.472* Jastrzębski, M., Budzyń, B., Żelaźniewicz, A., Konečný, P., ***Sláma, J.***, Kozub-Budzyń, G. A., Skrzypek, E., Jaźwa, A. Eo-Variscan metamorphism in the Bohemian Massif: Thermodynamic modelling and monazite geochronology of gneisses and granulites of the Góry Sowie Massif, SW Poland. *Journal of Metamorphic Geology*. 2021, 39(6), 751–779.

4.406* ***Filippi, M.***, Slavík, M., Bruthans, J., Weiss, T., Řihošek, J. Accelerated disintegration of in situ disconnected portions of sandstone outcrops. *Geomorphology*. 2021, 391, 107897.

4.371* Kulhánek, J., Faryad, S. W., Jedlička, R., ***Svojtka, M.*** Dissolution and Reprecipitation of Garnet during Eclogite-facies Metamorphism, Major and Trace Element Transfer during Atoll Garnet Formation. *Journal of Petrology*. 2021, 62(1), 1–22.

4.261* Jastrzębski, M., Żelaźniewcz, A., ***Sláma, J.***, Machowiak, K., Śliwiński, M., Jaźwa, A., Kocjan, I. Provenance of Precambrian basement of the Brunovistulian Terrane: New data from its Silesian part (Czech Republic, Poland), central Europe, and implications for Gondwana break-up. *Precambrian Research*. 2021, 335, 106108.

4.261* Paszkowski, M., Budzyń, B., Mazur, S., ***Sláma, J.***, Środoń, J., Millar, I. L., Shumlyanskyy, L., Kędzior, A., Liivamägi, S. Detrital zircon U-Pb and Hf constraints on provenance and timing of deposition of the Mesoproterozoic to Cambrian sedimentary cover of the East European Craton, part II: Ukraine. *Precambrian Research*. 2021, 362, 106282.

4.261* Percival, J. J., Konopásek, J., Eiesland, R., ***Sláma, J.***, de Campos, R. S., Battisti, M. A., Bittencourt, M. d. F. Pre-orogenic connection of the foreland domains of the Kaoko–Dom Feliciano–Gariep orogenic system. *Precambrian Research*. 2021, 364, 106060.

4.261* Verner, K., Buriánek, D., ***Svojtka, M.***, Peřestý, V., Megerssa, L., Tadesse, T., Kussita, A., Alemayehu, D., Hroch, T. Tectonometamorphic evolution and U–Pb dating of the high-grade Hammar Domain (Southern Ethiopian Shield), implications for the East-African Orogeny. *Precambrian Research*. 2021, 361, 106270.

4.261* Žák, J., ***Tomek, F.***, ***Svojtka, M.***, Vacek, F., Kachlík, V., ***Ackerman, L.***, Ježek, J., Petronis, M. S. Distributed crustal shortening followed by transpressional shearing in the Superior Province, northeastern Canada: A Late Archean analogy to modern accretionary plate margins? *Precambrian Research*. 2021, 362, 106322.

4.166* ***Navrátil, T.***, ***Nováková, T.***, Shanley, J. B., ***Rohovec, J.***, ***Vaňková, M.*** Distribution and pools of mercury in forest soils near recent and historical mercury emission sources in the central Czech Republic. *Journal of Geochemical Exploration*. 2021, 226, 106782.

4.130* ***Lokajíček, T.***, ***Petružálek, M.***, ***Svitek, T.***, Kuchařová, A., Šachlová, Š., Přikryl, R. Dynamic elastic properties of hardened experimental mortar bars affected by accelerated alkali–silica reactivity test: a laboratory approach. *Bulletin of Engineering Geology and the Environment*. 2021, 80(12), 8921–8933.

4.020* Soejono, I., Peřestý, V., Schulmann, K., Čopjaková, R., ***Svojtka, M.***, Štípská, P., Buriánek, D., Janoušek, V., Lexa, O. Structural, metamorphic and geochronological constraints on Palaeozoic multi-stage geodynamic evolution of the Altai accretionary wedge system (Hovd Zone, western Mongolia). *Lithos*. 2021, 396–397(September), 106204.

4.020* Tramm, F., Wirth, R., Budzyń, B., ***Sláma, J.***, Schreiber, A. LA-ICP-MS and TEM constraints on the magmatic and post-magmatic processes recorded by the zircon-xenotime intergrowth in pegmatite (Piława Górna, Góry Sowie Block, SW Poland). *Lithos*. 2021, 404–405, 106480.

3.923* Keppler, R., Vasin, R., Stipp, M., ***Lokajíček, T.***, ***Petružálek, M.***, Froitzheim, N. Elastic anisotropies of deformed upper crustal rocks in the Alps. *Solid Earth*. 2021, 12(10), 2303–2326.

3.883* Sácký, J., Černý, J., Šantrůček, J., ***Borovička, J.***, Leonhardt, T., Kotrba, P. Cadmium hyperaccumulating mushroom *Cystoderma carcharias* has two metallothionein isoforms usable for cadmium and copper storage. *Fungal Genetics and Biology*. 2021, 153, 103574.

3.810* Bábek, O., Vodrážková, S., Kumpan, T., Kalvoda, J., Holá, M., ***Ackerman, L.*** Geochemical record of the subsurface redox gradient in marine red beds: A case study from the Devonian Prague Basin, Czechia. *Sedimentology*. 2021, 68(7), 3523–3548.

3.784* ***Navrátil, T.***, Shanley, J. B., ***Rohovec, J.***, ***Dobešová, I.***, ***Roll, M.***, ***Nováková, T.***, Oulehle, F. Mercury cycling during acid rain recovery at the forested Lesní potok catchment, Czech Republic. *Hydrological Processes*. 2021, 35(6), e14255.

3.784* Oulehle, F., Fischer, M., Hruška, J., Chuman, T., Krám, P., ***Navrátil, T.***, Tesař, M., Trnka, M. The GEOMON network of Czech catchments provides long-term insights into altered forest biogeochemistry: From acid atmospheric deposition to climate change. *Hydrological Processes*. 2021, 35(5), e14204.

3.714* ***Mikysek, P.***, Zikmund, T., Dosbaba, M., Břínek, A., Slobodník, M., ***Adamovič, J.***, ***Mészárosová, N.***, Trojek, T., Kaiser, J. Multi-scale visualization of uranium-rich domains dispersed in U-Zr mineralization of sandstone-type (Břevniště, Czech Republic). *Ore Geology Reviews*. 2021, 138, 104358.

3.714* Hreus, S., Výravský, J., Cempírek, J., ***Breiter, K.***, Vašinová Galiová, M., Krátký, O., Šešulka, V., Škoda, R. Scandium distribution in the world-class Li-Sn-W Cínovec greisen-type deposit: Result of a complex magmatic to hydrothermal evolution, implications for scandium valorization. *Ore Geology Reviews*. 2021, 139A, 104433.

3.660* Zel, I. Y., ***Petružálek, M.***, ***Lokajíček, T.***, Ivankina, T. I., Kichanov, S. E., Kozlenko, D. P., Porosnicu, I., ***Schnabl, P.***, ***Pruner, P.***, Duliu, O. G. Assessment of structural, magnetic, and P-wave velocity anisotropy of two biotite gneisses from X-ray and neutron tomography. *Tectonophysics*. 2021, 812, 228925.

3.565* Laurin, J., Uličný, D., Čech, S., Trubač, J., Zachariáš, J., ***Svobodová, A.*** Chronology and eccentricity phasing for the Early Turonian greenhouse (~93–94 Ma): constraints on astronomical control of the carbon cycle. *Paleoceanography and Paleoclimatology*. 2021, 36(4), e2020PA004188.

3.565* Pašava, J., ***Ackerman, L.***, Žák, J., Veselovský, F., Creaser, R. A., ***Svojtka, M.***, Luais, B., Pour, O., Šebek, O., Trubač, J., ***Vosáhlová, E.***, Cividini, D. Elemental and isotopic compositions of trench-slope black shales, Bohemian Massif, with implications for oceanic and atmospheric oxygenation in early Cambrian. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 2021, 564, 110195.

3.565* Soták, J., ***Elbra, T.***, ***Pruner, P.***, Antolíková S., ***Schnabl, P.***, Biroň, A., ***Kdýr, Š.***, Milovský, R. End-Cretaceous to middle Eocene events from the Alpine Tethys: Multi-proxy data from a reference section at Kršteňany (Western Carpathians). *Palaeogeography, Palaeoclimatology, Palaeoecology*. 2021, 579, 110571.

3.508* Wright, D., Hughes, P., Skopal, N., Kmošek, M., Way, A., Sullivan, M., ***Lisá, L.***, Ricardi, P., Škrdla, P., Nejman, L., Gadd, P., Nývltová Fišáková, M., Mlejnek, O., Králík, M. The archaeology of overburden: Method within the madness at Švédův Stůl, Czech Republic. *Journal of Archaeological Science*. 2021, 132, 105429.

3.352* Hrouda, F., Ježek, J., ***Chadima, M.*** On the origin of apparently negative minimum susceptibility of hematite single crystals calculated from low-field anisotropy of magnetic susceptibility. *Geophysical Journal International*. 2021, 224(3), 1905–1917.

3.349* ***Laibl, L.***, Maletz, J., Olschewski, P. Post-embryonic development of Fritzolenellus suggests the ancestral morphology of the early developmental stages in Trilobita. *Papers in Palaeontology*. 2021, 7(2), 839–859.

3.329* Bábek, O., Kumpan, T., Calner, M., Šimíček, D., Frýda, J., Holá, M., ***Ackerman, L.***, Kolková, K. Redox geochemistry of the red 'orthoceratite limestone' of Baltoscandia: Possible linkage to mid-Ordovician palaeoceanographic changes. *Sedimentary Geology*. 2021, 420, 105934.

3.282* Shafiei Bafti, B., ***Svojtka, M.***, Abdolahi, M. Geochemistry of Rhenium and Other Trace Elements in Molybdenite, Sar Cheshmeh Porphyry Cu-Mo Deposit, Iran. *Acta Geologica Sinica-English Edition*. 2021, 95(4), 1217–1235.

3.251* Pšenička, J., ***Bek, J.***, ***Žárský, V.***, Uhlířová, M., ***Štorch, P.*** Dynamics of Silurian Plants as Response to Climate Changes. *Life*. 2021, 11(9), 906.

3.234* Gotvaldová, K., Hájková, K., ***Borovička, J.***, Jurok, R., Cihlářová, P., Kuchař, M. Stability of psilocybin and its four analogs in the biomass of the psychotropic mushroom *Psilocybe cubensis*. *Drug Testing and Analysis*. 2021, 13(2), 439–446.

3.152* Fang, X., Pohle, A., Kröger, B., ***Aubrechtová, M.***, Burrett, C., Zhang, Y., Zhang, Y. Phylogeny of Middle–Late Ordovician lituitid cephalopods based on cladistic analysis. *Journal of Systematic Palaeontology*. 2021, 19(9), 633–650.

3.152* ***Přikryl, T.***, Kaur, J., Murray, A. M. New Oligocene Pseudocrenilabrinae cichlid fishes (Teleostei, Cichlidae) from freshwater deposits of Libya. *Journal of Systematic Palaeontology*. 2021, 19(19), 1343–1366.

3.133* Jaranowski, M., Budzyń, B., Rzepa, G., ***Sláma, J.***, Sawłowicz, Z. Geochemical constraints on the distribution of trace elements and volatiles in fluorapatite from the Panasqueira tin-tungsten deposit (Portugal). *Chemie der Erde-Geochemistry*. 2021, 81(2), 125765.

3.061* Lustri, L., ***Laibl, L.***, Bicknell, R. D. C. A revision of *Prolimulus woodwardi* Fritsch, 1899 with comparison to other highly paedomorphic belinurids. PeerJ. 2021, 9, 10980.

2.818* ***Breiter, K.***, Förster, H.-J. Compositional Variability of Monazite–Cheralite–Huttonite Solid Solutions, Xenotime, and Uraninite in Geochemically Distinct Granites with Special Emphasis to the Strongly Fractionated Peraluminous Li–F–P-Rich Podlesí Granite System (Erzgebirge/Krušné Hory Mts., Central Europe). *Minerals*. 2021, 11(2), 127.

2.818* Mandal, A., Tripathy, G. R., Goswami, V., ***Ackerman, L.***, Parcha, S. K., Chandra, R. Re–Os and Sr Isotopic Study of Permian–Triassic Sedimentary Rocks from the Himalaya: Shale Chronology and Carbonate Diagenesis. *Minerals*. 2021, 11(4), 417.

2.698* Janoušek, V., Hanžl, P., ***Svojtka, M.***, Hora, J. M., Kochergina, Y. V., Gadas, P., Holub, F. V., Gerdes, A., Verner, K., Hrdličková, K., Daly, J. S., Buriánek, D. Correction to: Ultrapotassic magmatism in the heyday of the Variscan Orogeny: the story of the Trebic Pluton, the largest durbachitic body in the Bohemian Massif. *International Journal of Earth Sciences*. 2021, 110, 1137–1138.

2.698* Janoušek, V., ***Svojtka, M.*** How old is the Třebíč durbachitic Pluton? Reply to comment on "Ultrapotassic magmatism in the heyday of the Variscan Orogeny: the story of the Třebíč Pluton, the largest durbachitic body in the Bohemian Massif" by Schaltegger et al.

International Journal of Earth Sciences. 2021, 110(3), 1133–1136.

2.698* Terbishalieva, B., Timmerman, M. J., Mikolaichuk, A., Altenberger, U., ***Sláma, J.***, Schleicher, A. M., Sudo, M., Sobel, E. R., Cichy, S. B. Calc-alkaline volcanic rocks and zircon ages of the late Tonian: early Cryogenian arc-related Big Naryn Complex in the Eastern Djetim-Too Range, Middle Tianshan block, Kyrgyzstan. *International Journal of Earth Sciences*. 2021, 110, 353–375.

2.656* Pérez-Peris, F., ***Laibl, L.***, Lustri, L., Gueriau, P., Antcliffe, J. B., Bath Enright, O. G., Daley, A. C. A new nektaspid euarthropod from the Lower Ordovician strata of Morocco. *Geological Magazine*. 2021, 158(3), 509–517.

2.656* Saleh, F., Vidal, M., ***Laibl, L.***, Sansjofre, P., Gueriau, P., Pérez-Peris, F., Lustri, L., Lucas, V., Lefebvre, B., Pittet, B., El Hariri, K., Daley, A. C. Large trilobites in a stress-free Early Ordovician environment. *Geological Magazine*. 2021, 158(2), 261–270.

2.645* Pawlak, J., Blaszczyk, M., Hercman, H., ***Matoušková, Š.*** Palaeoenvironmental conditions during MIS 6/MIS 5 transition recorded in speleothems from the Tatra Mountains. *Boreas*. 2021, 50(1), 224–241.

2.493* ***Bek, J.*** Palynological grouping of Paleozoic marattialean miospores. Review of Palaeobotany and Palynology. 2021, 284, 104341.

2.493* ***Bek, J.***, Wang, J. A comparative study on *in situ* spores of some Paleozoic noeggerathialeans and their implications for dispersed spore assemblages. *Review of Palaeobotany and Palynology*. 2021, 294, 104379.

2.493* Guo, Y., Zhou, Y., ***Bek, J.***, Yang, S.-L., Feng, Z. *Qasimia yunnanica* sp. nov., a marattialean fern with bivalvate synangia from the Lopingian of Southwest China. *Review of Palaeobotany and Palynology*. 2021, 293, 104497.

2.493* Libertín, M., ***Bek, J.***, Wang, J., Opluštil, S., Pšenička, J., ***Votočková Frojdová, J.*** New data about three sphenophylls and their spores from the volcanic tuff of Wuda, Taiyuan Formation, earliest Permian, China. *Review of Palaeobotany and Palynology*. 2021, 294, 104484.

2.493* Liu, L., Pšenička, J., ***Bek, J.***, Wan, M., Pfefferkorn, H. W., Wang, J. A whole calamitacean plant *Palaeostachya guanglongii* from the Asselian (Permian) Taiyuan Formation in the Wuda Coalfield, Inner Mongolia, China. Review of Palaeobotany and Palynology. 2021, 294, 104245.

2.493* Opluštil, S., Pšenička, J., Šimůnek, Z., Simonetto, L., Kustatscher, E., ***Votočková Frojdová, J.*** The Late Pennsylvanian flora of the Italian Carnic Alps. *Review of Palaeobotany and Palynology*. 2021, 258, 104360.

2.493* Opluštil, S., Wang, J., Pfefferkorn, H. W., Pšenička, J., ***Bek, J.***, Libertín, M., Wang, J., Wan, M., He, X., Yan, M., Wei, H., ***Votočková Frojdová, J.*** T^0 Early Permian coal-forest preserved in situ in volcanic ash bed in the Wuda Coalfield, Inner Mongolia, China. *Review of Palaeobotany and Palynology*. 2021, 294, 104347.

2.493* Pšenička, J., Wang, J., ***Bek, J.***, Pfefferkorn, H. W., Opluštil, S., Zhou, W., ***Votočková Frojdová, J.***, Libertín, M. A zygopterid fern with fertile and vegetative parts in anatomical and compression preservation from the earliest Permian of Inner Mongolia, China. *Review of Palaeobotany and Palynology*. 2021, 294, 104382.

2.493* ***Votočková Frojdová, J.***, Wang, J., Pšenička, J., ***Bek, J.***, Opluštil, S., Libertín, M. A new leptosporangiate fern *Oligosporangiopteris zhongxiangii* gen. and sp. nov. from the lowermost Permian of Inner Mongolia, China – morphology, anatomy and reproductive organs. *Review of Palaeobotany and Palynology*. 2021, 294, 104479.

2.493* Wan, M., Sun, W., ***Bek, J.***, Liu, F., Hill, C., Wang, J. *Scolecopteris minuta* sp. nov., a marattialean fern from the early Permian Wuda Tuff Flora of Inner Mongolia, China. *Review of Palaeobotany and Palynology*. 2021, 294, 104246.

2.493* Wang, J., Wan, S., Kerp, H., ***Bek, J.***, Wang, S. A whole noeggerathialean plant Tingia unita Wang from the earliest Permian peat-forming flora, Wuda Coalfield, Inner Mongolia. *Review of Palaeobotany and Palynology*. 2021, 294, 104204.

2.493* Zhou, W., Pšenička, J., ***Bek, J.***, Wan, M., Boyce, C. K., Wang, J. A new anachoropterid fern from the Asselian (Cisuralian) Wuda Tuff Flora. *Review of Palaeobotany and Palynology*. 2021, 294, 104346.

2.493* Zhou, Y., Guo, Y., Pšenička, J., ***Bek, J.***, Yang, S.-L., Feng, Z. A new marattialean fern, *Pectinangium xuanweiense* sp. nov., from the Lopingian of Southwest China. *Review of Palaeobotany and Palynology*. 2021, 295, 104500.

2.454* Zupan Hajna, N., Mihevc, A., ***Bosák, P.***, ***Pruner, P.***, Hercman, H., Horáček, I., Wagner, J., ***Čermák, S.***, Pawlak, J., Sierpień, P., ***Kdýr, Š.***, Juřičková, L., Švara, A. Pliocene to Holocene chronostratigraphy and palaeoenvironmental records from cave sediments: Račiška pečina section (SW Slovenia). *Quaternary International*. 2021, 605-606, 5–24.

2.432* ***Kočová Veselská, M.***, Kočí, T., Jäger, M., ***Mikuláš, R.***, Heřmanová, Z., Morel, N., Šamánek, J. Sclerobionts on tubes of the serpulid *Pyrgopolon (Pyrgopolon) deforme* (Lamarck, 1818) from the upper Cenomanian of Le Mans region, France. *Cretaceous Research*. 2021, 125, 104873.

2.432* Michalík, J., Grabowski, J., Lintnerová, O., Reháková, D., ***Kdýr, Š.***, ***Schnabl, P.*** Jurassic – Cretaceous boundary record in Carpathian sedimentary sequences. *Cretaceous Research*. 2021, 118, 104659.

2.432* Ősi, A., Szabó, M., Tóth, E., Bodor, E., Lobitzer, H., Kvaček, J., ***Svobodová, M.***, Szente, I., Wagreich, M., Trabelsi, K., Sames, B., Magyar, J., Makádi, L., Berning, B., Botfalvai, G. A brackish to non-marine aquatic and terrestrial fossil assemblage with vertebrates from the lower Coniacian (Upper Cretaceous) Gosau Group of the Tiefengraben

locality near St. Wolfgang im Salzkammergut, Austria. *Cretaceous Research*. 2021, 127, 104938.

2.432* ***Vaňková, L.***, Košťák, M., Mazuch, M. Lower Cretaceous belemnites of Štramberk klippen (Czech Republic): Implications for geological history of the outer Western Carpathians. *Cretaceous Research*. 2021, 126, 104905.

2.326* ***Čermák, S.***, Angelone, C., Moncunill-Solé, B. *Prolagus* Pomel, 1853 (Lagomorpha, Mammalia) in the framework of the Pliocene faunal rearrangements in central Europe. *Academie des Sciences. Comptes Rendus Palevol*. 2021, 20(28), 597–617.

2.303* Grosch, E. G., ***Sláma, J.*** On the volcanic architecture, petrology and geodynamic setting of the 3.48 Ga Barberton komatiite suite, South Africa. *South African Journal of Geology*. 2021, 124(2), 343–352.

2.213* Moník, M., Hadraba, H., Milde, D., Chlup, Z., Nerudová, Z., ***Schnabl, P.*** Heat treatment and mechanics of Moravian Jurassic cherts. *Archaeological and Anthropological Sciences*. 2021, 13(10), 158.

2.213* Vytlačil, Z., Drtikolová Kaupová, S., Jílková, M., Poláček, L., ***Ackerman, L.***, Velemínský, P. Residential mobility in Great Moravia: strontium isotope analysis of a population sample from the early medieval site of Mikulčice-Valy (ninth–tenth centuries). *Archaeological and Anthropological Sciences*. 2021, 13(1), 8.

2.108* Pérez-Peris, F., ***Laibl, L.***, Vidal, M., Daley, A. C. Systematics, morphology, and appendages of an Early Ordovician pilekiine trilobite Anacheirurus from Fezouata Shale and the early diversification of Cheiruridae. *Acta Palaeontologica Polonica*. 2021, 66(4), 857–877.

2.075* Lerosey-Aubril, R., ***Laibl, L.*** Protaspid larvae are unique to trilobites. *Arthropod Structure & Development*. 2021, 63, 101059.

2.059* Bárta, O., Melichar, R., ***Černý, J.*** How many extensional stages marked the Variscan gravitational collapse in the Bohemian Massif? *Annales Societatis Geologorum Poloniae*. 2021, 91(2), 121–136.

2.011* ***Krmíček, L.***, ***Ulrych, J.***, Jelínek, E., ***Skála, R.***, ***Krmíčková, S.***, ***Korbelová, Z.***, Balogh, K. Petrogenesis of Cenozoic high-Mg (picritic) volcanic rocks in the České středohoří Mts. (Bohemian Massif, Czech Republic). *Mineralogy and Petrology*. 2021, 115(2), 193–211.

1.942* ***Roček, Z.***, Halámková, L., Muzzopappa, P. Developmental dynamics of two closely related species *Bombina bombina* and *B. variegata* (Amphibia: Anura) in the context of their fossil evidence. *Historical Biology*. 2021, 33, 3384–3401.

1.929* ***Přikryl, T.*** *Krumvirichthys brzobohatyi* gen. et sp. nov. – the oldest record of the deep-sea smelts (Bathylagidae, Argentiniformes). *Rivista Italiana di Paleontologia e Stratigrafia*. 2021, 127(3), 585–594.

1.854* Audra, P., Heresanu, V., Barriquand, L., El Kadiri Boutchich, M., Jaillet, S., Pons-Branchu, E., ***Bosák, P.***, Cheng, H., Edwards, R. L., Renda, M. Bat guano minerals and mineralization processes in Chameau Cave, Eastern Morocco. *International Journal of Speleology*. 2021, 50(1), 91–109.

1.778* ***Ackerman, L.***, Rapprich, V., Polák, L., Magna, T., McLemore, V. T., Pour, O., Čejková, B. Petrogenesis of silica-rich carbonatites from continental rift settings: A missing link between carbonatites and carbonated silicate melts? *Journal of Geosciences*. 2021, 66(2), 71–87.

1.778* ***Mészárosová, N.***, ***Skála, R.***, ***Mikysek, P.***, Drábek, M. Miscibility between synthetic FeS and TiS: An insight into the phase relations in natural Ti-bearing iron monosulfides. *Journal of Geosciences*. 2021, 66(4), 215–225.

1.778* Veselovský, F., Pašava, J., Pour, O., ***Ackerman, L.*** Origin of V–Cr–Ti-mineralization in thermally overprinted metal-rich black shales from the Teplá–Barrandian Unit (Bohemian Massif) and implications for metal remobilization during metamorphism. *Journal of Geosciences*. 2021, 66(4), 263–275.

1.628* Pereira, S., Colmenar, J., Mortier, J., Vanmeirhaeghe, J., Verniers, J., ***Štorch, P.***, Harper, D. A. T., Gutiérrez-Marco, J. C. 2021. *Hirnantia* fauna from the Condroz Inlier, Belgium: another case of a relict Ordovician shelly fauna in the Silurian? *Journal of Paleontology*. 2021, 95(6), 1189–1215.

1.600* ***Chroust, M.***, Mazuch, M., Ivanov, M., Ekrt, B., Luján, À. H. First remains of *Diplocynodon* cf. *ratelii* from the early Miocene sites of Ahníkov (Most Basin, Czech Republic). *Bulletin of Geosciences*. 2021, 96(2), 123–138.

1.576* ***Bek, J.***, Opluštil, S., Pšenička, J., ***Votočková Frojdová, J.*** Quantitative relationship of spore and plant assemblages from the Radnice Basin, Middle Pennsylvanian of the Czech Republic: preliminary results. *Geological Quarterly*. 2021, 65(4), 59.

1.415* Bendella, M., Benyoucef, M., ***Mikuláš, R.***, Bouchemla, I., Martinell, J., Ferré, B. Shallow to marginal marine ichnoassemblages from the Upper Pliocene Slama Formation (Lower Chelif Basin, NW Algeria). *Geologica Carpathica*. 2021, 72(6), 529–548.

1.412* Kaur, R., Singh, B. P., Bhargava, O. N., ***Mikuláš, R.***, Singla, G., Prasad, S. K., Stopden, S. Ichnology and biostratigraphic significance of Cambrian trace fossils from the lowest stratigraphic level of Kunzam La Formation, Chandra Valley, Lahaul and Spiti, India. *Ichnos*. 2021, 28(3), 176–207.

1.404* ***Bek, J.***, Opluštil, S. Early Pennsylvanian to early Permian (Bashkirian–Asselian) miospore and pollen assemblages of the Czech part of the Intra-Sudetic Basin. *Bulletin of Geosciences*. 2021, 96(3), 341–379.

1.404* Bonilla-Salomón, I., ***Čermák, S.***, Luján, À. H., Horáček, I., Ivanov, M., Sabol, M. Early Miocene small mammals from MWQ1/2001 Turtle Joint (Mokrá-Quarry, South Moravia, Czech Republic): biostratigraphical and palaeoecological considerations. *Bulletin of Geosciences*. 2021, 96(1), 99–122.

1.404* ***Hušková, A.***, ***Slavík, L.*** Morphologically distinct P1 elements of Zieglerodina (Conodonta) at the Silurian–Devonian boundary: review and correlation. *Bulletin of Geosciences*. 2021, 96(3), 327–340.

1.404* ***Přikryl, T.***, Brzobohatý, R., Carnevale, G. Skeletal remains with otoliths in situ of the

Miocene croaker *Trewasciaena* cf. *kokeni* (Teleostei, Sciaenidae) from the Pannonian of the Vienna Basin. *Bulletin of Geosciences*. 2021, 96(1), 19–28.

1.404* ***Weiner, T.***, ***Weinerová, H.***, Kalvoda, J., Viktorýn, T. The first lower Viséan trilobite association from limestone facies of the Moravian Karst and its relation to the sedimentary environment (Líšeň Formation, Czech Republic). *Bulletin of Geosciences*. 2021, 96(2), 217–249.

1.400* ***Bek, J.*** Paleozoic in situ sporen and pollen. Sphenopsida. *Palaeontographica Abteilung B-Palaeophytologie Palaeobotany-Palaeophytology*. 2021, 301(4-6), 141–201.

1.133* Sierpień, P., Pawlak, J., Hercman, H., ***Pruner, P.***, Zupan Hajna, N., Mihevc, A., ***Bosák, P.*** Flowstones from the Račiška Pečina Cave (SW Slovenia) Record 3.2-Ma-Long History. *Geochronometria*. 2021, 48(1), 31–45.

1.050* Dovana, F., Boccardo, F., ***Borovička, J.***, Vizzini, A., Saar, G., Albert, L., Mikšík, M., Clericuzio, M., Dima, B. *Cortinarius pseudocisticola* (Agaricales, Cortinariaceae), a new species in section *Calochroi* from Europe. *Phytotaxa*. 2021, 518(1), 14–24.

1.050* Ševčíková, H., ***Borovička, J.***, Gates, G. *Pluteus hubregtseorum* (Pluteaceae), a new species from Australia and New Zealand. *Phytotaxa*. 2021, 496(2), 147–158.

1.042* Šimůnek, Z., ***Zajíc, J.*** Stephanian C fauna and dispersed cuticles from a borehole in the Líně Formation, Mšeno-Roudnice Basin (Czech Republic). *Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen*. 2021, 299(3), 291–308.

1.000* Kolář, P., ***Petružálek, M.*** Type analysis of laboratory seismic events by convolutional neural networks. Acta geodynamica et geomaterialia. 2021, 18(2), 267–277.

1.000* ***Žigová, A.***, ***Šťastný, M.***, ***Mikysek, P***. Soil development on Proterozoic and Paleozoic rocks of central Bohemia. *Acta geodynamica et geomaterialia*. 2021, 18(4), 437–450.

1.412* Šamánek, J., ***Mikuláš, R.***, Hájková, L. A fossil carbonate rocky shore in the Kalcit Quarry: a new insight into echinoid shallow marine bioerosion (Miocene, Czech Republic). *Ichnos*. 2021, 28(4), 271–289.

0.723* Klokočník, J., Kostelecký, J., Bezděk, A., ***Cílek, V.*** The spatial distribution of the strike angles derived from EIGEN 6C4 gravity model – a new possibility for oil and gas exploration? *International Journal of Oil, Gas and Coal Technology*. 2021, 28(3), 306–332.

Bella, P., ***Bosák, P.*** Zavedenie a vymedzenie pojmu *sinter* v českej a slovenskej speleologickej terminológii. *Slovenský kras.* 2021, 59(1), 91–111.

Bokr, P., ***Mikuláš, R.***, Budil, P., Kraft, P. Early complex tiering pattern: Upper Ordovician, Barrandian area, the Czech Republic. *Fossil Imprint*. 2021, 77(1), 17–35.

Cílek, V., Storch, D. Les a voda. Složitá hra od stromů po kontinenty. *Vesmír*. 2021, 100(3), 154–161. (In Czech)

Gutiérrez-Marco, J. C., Loydell, D. K., ***Štorch, P***. The outstanding Silurian section of the Valle syncline (Sierra Norte de Sevilla UNESCO Global Geopark, Spain) as an international standard for graptolite biostratigraphy. *Geoconservation Research*, 2021, 4 (1), 131–135.

Gutiérrez-Marco, J. C., ***Štorch P.*** The Checa Silurian section, an outstanding fossil site in the Molina-Alto-Tajo UNESCO Global Geopark, Spain. *Geoconservation Research*. 2021, 4(1), 136–143.

Horáček, I., ***Čermák, S.***, Wagner, J. Prof. Dr. Oldřich Fejfar, CSc., a Český kras. *Český kras*. 2021, 47(1), 61–67. (In Czech)

Janebová, R., ***Mikuláš, R.*** Potenciální výskyt analogie "red beds" v bohdaleckém souvrství (svrchní ordovik Barrandienu, Česká republika): paleontologická charakteristika. *Zprávy o geologických výzkumech*. 2021, 54(1), 37–41. (In Czech)

Lisá, L., Bajer, A. A tribute to Smolíková (1971): Principles of soil development in the Quaternary. *E&G Quaternary Science Journal*. 2021, 70(2), 247–250.

Lisá, L., Holub, P., Peška, M., Zůbek, A. Poznámky k problematice interiéru nezděných staveb středověkého Brna (konfrontace archeologických poznatků a mikromorfologické analýzy podlahových úrovní vybraných staveb). *Přehled výzkumů*. 2021, 62(2), 127–158. (In Czech)

Mencl, V., ***Mikuláš, R.***, Nedvědická, B. Late Paleozoic Petrified Trees of the Bohemian Paradise – An Insight into the Tropical Forest in Central Europe. *Geoconservation Research*. 2021, 4(1), 235–244.

Mikuláš, R. Měnící se klima a povodně na Blanici. *Pod Blaníkem*. 2021, 24(4), 21–23. (In Czech)

Moník, M., Nerudová, Z., ***Schnabl, P.*** Investigation of heat-treated artefacts from Pleistocene sites. *Journal of Archaeological Science*: Reports. 2021, 37, 102920.

Roček, Z., Rage, J.-C., Venczel, M. Fossil frogs of the genus *Palaeobatrachus* (Amphibia: Anura). *Abhandlungen der Senckenberg Gesellschaft für Naturforschung*. 2021, 575, 1–151.

Roll, M., ***Borovička, J.***, ***Nováková, T.*** Kdo hledá rtuť, najde. *Vesmír*. 2021, 100(1), 40–43.

Tásler, R., Fediuk, F., ***Hladil, J.*** Devonské tafocenózy s korály v dolomitu Ponikelské jeskyně (krkonošsko-jizerské krystalinikum) – předběžná zpráva. *Opera Corcontica*. 2021, 58, 275–280

Žák, K., Kolčava, M., Hejna, M., Živor, R. Databáze jeskyní Českého krasu: doplňky a změny za období od 1. října 2019 do 30. září 2021. *Český kras*. 2021, 47(1), 45–54. (In Czech)

Žák, K., Venclová, N. Zlomek švartnového artefaktu z hradiště Kotýz u Tmaně – zpráva o nálezu. *Český kras*. 2021, 47(1), 19–24. (In Czech)

Žák, K., Veselovský, F., Sidorinová, T., Knésl, I., Hejna, M., Majer, M. Historická těžba zlata u obce Srbsko v Českém krasu: geovědní a archeologické aspekty. *Český kras*. 2021, 47(1), 25–31. (In Czech)

7B BOOKS AND CHAPTERS IN BOOKS

Angelone, Ch., ***Čermák, S.***, Moncunill-Solé, B. I lagomorfi di Cava Monticino (Brisighella, RA). In: ROOK, Lorenzo, ed. *La fauna messiniana di Cava Monticino (Brisighella, RA)*. Bologna: FSRER, 2021, s. 109–119. (In Italian)

Borůvka, L., ***Žigová, A.*** Nejběžnější půdy ČR i jiných oblastí světa. In: ŠARAPATKA, B., ed. *Půda – přehlížené bohatství*. Olomouc: Univerzita Palackého v Olomouci, 2021, s. 37–48. (In Czech)

Gutiérrez-Marco, J. C., Rábano, I., Romero, S., Colmenar, J., Herranz, P., ***Štorch, P.*** Fósiles del Paleozoico inferior (Ordovícico y Silúrico). In: CALONGE, A., CARCAVILLA, L., eds. *Guía de Fósiles del Geoparque Molina-Alto Tajo*. Asociación de Amigos del Museo de Molina. Molina de Aragón, 2021, s. 19–54. (In Spanish)

Chytráček, M., ed., Chvojka, O., Cícha, J., Egg, M., Hauser, F., ***Hladil, J.***, John, J., Koník, P., Kozáková, R., Křivánek, R., Kyselý, R., Lutovský, M., Majer, A., Michálek, J., Novák, J., Patocka, T., Pavelka, J., Puchinger, L., Rašková-Zelinková, M., Ritter, S., Šálková, T., Sauter, F., Stránská, Petra, Světlík, Ivo. *Fürstengrabhügel der Hallstattzeit bei Rovná in Südböhmen. Manifestationen der sozialen Eliten der Eisenzeit im Böhmischen Becken*. Mainz: Verlag des Römisch-Germanischen Zentralmuseums, 2021, 338 s.

Kvaček, Z., ***Dašková, J.***, Libertín, M. *Catalogue of Plant Fossils Described in Works by Kaspar M. Sternberg*. 2nd ed., revised. Prague: National Museum, 2021, 309 s.

Mikuláš, R. Jak se neminout v čase a prostoru? In: TREJBAL, J., ed. *Pohyb tvůrce. Průzkum území jako forma uměleckého výzkumu*. Praha: Vysoká škola uměleckoprůmyslová v Praze, 2021, s. 441–447. (In Czech)

7C UNPUBLISHED REPORTS

Borovička, J. *Mykologický průzkum zásahových ploch na hadcích u Bernartic*. Průběžná zpráva, ČSOP Vlašim, 2021. 1–10. (In Czech)

Bosák, P. *Odborné zpracování jeskynních sedimentů pro projekt Inventarizace krasu Krkonoš č. projektu CZ.05.4.27/0.0/0.0/15_009/0004533. Závěrečná zpráva č. 1. Petrologické, mineralogické a geochemické zhodnocení klastických sedimentů*. Inst Geol, Czech Acad Sci for Czech Speleological Society, ZO 5-02 Albeřice. Praha. 2021, 1–142. (in Czech)

Bosák, P. *Odborné zpracování jeskynních sedimentů pro projekt Inventarizace krasu Krkonoš č. projektu CZ.05.4.27/0.0/0.0/15_009/0004533. Souhrn*. Inst Geol, Czech Acad Sci for Czech Speleological Society, ZO 5-02 Albeřice. Praha. 2021, 1–26. (in Czech)

Bosák, P. *Postup těžebních stěn Velkolomu Čertovy schody–západ. Akce sanace a rekultivace severní stěny. Období: leden až prosinec 2020*. Inst Geol, Czech Acad Sci for Velkolom Čertovy schody, a. s. Praha. 2021, 1–10 + 1–17. (in Czech)

Bosák, P., ***Šťastný, M.*** *Odborné zpracování jeskynních sedimentů pro projekt Inventarizace Krasu Krkonoš č. projektu CZ.05.4.27/0.0/0.0/15_009 /0004533. Etapová zpráva č. 5. Mineralogické a geochemické zhodnocení klastických sedimentů, 3*. Inst Geol, Czech Acad Sci for Czech Speleological Society, ZO 5-02 Albeřice. Praha. 2021, 1–60. (in Czech)

Bosák, P., ***Šťastný, M.*** *Odborné zpracování jeskynních sedimentů pro projekt Inventarizace Krasu Krkonoš č. projektu CZ.05.4.27/0.0/0.0/15_009 /0004533. Etapová zpráva č. 6. Mineralogické a geochemické zhodnocení klastických sedimentů, 4*. Inst Geol, Czech Acad Sci for Czech Speleological Society, ZO 5-02 Albeřice. Praha. 2021, 1–12. (in Czech)

Bosák, P., Zupan Hajna, N., Švara, A., ***Kdýr, Š.***, ***Pruner, P.*** *2TDK Railway, profile P 19. Paleomagnetic research. Final Report*. Czech Acad Sci, Inst Geol, v. v. i and Karst Research Institute ZRC SAZU. Praha–Postojna. 2021, 1–22.

Navrátil, T., ***Dobešová, I.*** *Monitoring chemismu srážkových vod na území NPČŠ – Závěrečná zpráva za rok 2020-2021*. Inst Geol, Czech Acad Sci – Správa Národního parku České Švýcarsko, 2021. 1–17. (In Czech)

Petružálek, M. *Detailní anizotropie rychlosti seismických vln měřená na pískovci z národního parku Česko Saské Švýcarsko, závěrečná zpráva*. Inst Geol, Czech Acad Sci for Faculty of Science, Charles University, 2021. 1–14. (In Czech)

Petružálek, M. *Mechanické vlastností hornin z lokality Lhota Rapotina, závěrečná zpráva*. Inst Geol, Czech Acad Sci for Faculty of Science, Charles University, 2021. 1–24. (In Czech)

Petružálek, M. *Stanovení Hoek Brownových obálek pro migmatizovanou pararulu z lokality Bukov, závěrečná zpráva*. Inst Geol, Czech Acad Sci for SG Geotechnika a. s., 2021. 1–19. (In Czech)

7D UTILITY MODELS AND SOFTWARE

XX. DUST software program for an automated detection of components of deposited dust (T. Hrstka) This developed software program is focused to provide support to research in the individual constituents of deposited dust and their potential effects related to human health and the environment. It is a part of the development of new analytical techniques that provide new tools for understanding air contaminants and also related soil pollution. The DUST software program platform for similarity analysis of EDS and other spectral data and their automated clustering is now available for research and government institutions as a free license.

8. SCIENCE PROMOTION

8A MAGAZINES, NEWSPAPERS AND BOOKS

Bella, P., Littva, J., ***Bosák, P.*** Tajuplný labyrint vo vrchu Mních. In: STRUHÁR, P., ed., Zachar, T., Soják, M., Bella, P., Littva, J., ***Bosák, P.***, Sliacká, S., Šimková, Z., Staneková, Z., Sabol, M., Drews, E., Schifer T., Vítek, P., Kudla, M., Lalkovič, M., Ambrušová, U., Tóth, C., Tvrdý, Z., Jarošová, I. *Mystérium Liskovskej jaskyne*. Ružomberok: ArcheológiaSK, 2021, s. 35–46. (in Slovak)

Cílek, V., Hladík, J., Havel, P., Turek, J., Záhora, J., Vopravil, J., Fučík, P., Khel, T., Meduna, P., Mudra, P., ***Navrátil, T.***, Sůvová, Z., Kinský, V., Keřka, J., Křížek, P. *Půda a život civilizací [Soil and the Life of Civilisations]*. Praha: Dokořán, 2021, 243 pp. (In Czech)

Cílek, V. Klima a budoucnost našich lesů [Climate and the future of our forests]. *Edition Science around us / Edice Věda kolem nás*. 2021, 117, 24 pp. (In Czech)

Cílek, V. Podzemní svět. Od bájí po výzkum jeskyní [Underground world. From myths to cave research.]. *Vesmír*. 2021, 100(12), 756–759. (In Czech)

Cílek, V. Zadržování vody v krajině od pravěku do dneška [Landscape water harvesting from prehistory to present]. *Edition Science around us / Edice Věda kolem nás*. 2021, 111, 24 pp. (In Czech)

Mikuláš, R. *Ichnofosilie. Edition Science around us / Edice Věda kolem nás*. 2021, 112, 19 pp. (In Czech)

Mikuláš, R., ***Borovička, J.*** A regular (each author at six-week intervals) column called "Science Lesson" (***Vědecká lekce***) in Saturday issue of ***Lidové noviny***, one of most-read newspapers published in Czechia.

Navrátil, T., ***Rohovec, J.*** Pasivní odběrová zařízení [Passive samplers]. *Vesmír*. 2021, 100(1), 44–45. (In Czech)

Vrtiška, L., ***Filippi, M.***, Franěk, J. Pseudoleucity z Loučné pod Klínovcem – odkrytí žíly v roce 2017. [Pseudoleucites from Loučná pod Klínovcem – vein exposure in 2017]. *Minerál*. 2021, XXIX, 1, 3–14. (In Czech)

Žák, K., ***Cílek, V.***, Majer, M., Bastl, J., Bláha, V., Budil, P., ***Čermák, S.***, Dušek, M., Garkish, M., Hejna, M., Heřman, P., Horáček, I., Juřičková, L., Moravec, P., Podroužková, Š., Pohunek, J., Řezáč, M., Sklenář, K., Stolz, D., Svoboda, D., Špryňar, P., Veselý, J., ***Wagner, J.*** *Srdce Českého krasu. Obec Srbsko a krajina v jejím okolí*. Praha: Dokořán, 2021, 299 s. (In Czech)

8B TELEVISION AND RADIO BROADCASTING

Adamovič J. Zajímavosti pískovcových skal v okolí Jestřebice. *Český rozhlas, Radiožurnál* [Scenic points in sandstone cliffs around Jestřebice]. 2021, Praha. (In Czech)

Cílek V. Půda a civilizace. Dokument: spoluautor a účinkující. *Český rozhlas, Leonardo* [Soil and Civilisation. Document: co-author and performer. *Czech State Radio/Leonardo*]. 2021, Praha. (In Czech)

Cílek V. O památné hoře Blaníku a jejím kraji. Dokument: spoluautor a účinkující. *Český rozhlas, Leonardo* [On memorable mountain Blaník and its landscape. Document: co-author and performer. *Czech State Radio/Leonardo*]. 2021, Praha. (In Czech)

Mikuláš R. Nationwide Radio Junior: Radek Mikuláš – an ichnologist. One-hour interactive broadcast for youth. 6. 4. 2021. (In Czech)

8C LECTURES FOR POPULAR AUDIENCE

Cílek V. Biomasa a její využití. Budoucnost české energetiky II. *iEquilibrium, V. Mařík.* [Biomass and its use in energy production. The future of Czech energy industry II. *iEquilibrium, V. Mařík*]. 18. 10. 2021, Praha – online. (In Czech)

Cílek V. Dunaj. *Slovenská národná galéria*. [Danube. *Slovak National Gallery*]. 22. 6. 2021, Bratislava. (In Czech)

Cílek V. Energetika a současný svět. *Škoda Auto a. s.* [Energy and contemporary world. *Skoda Auto Concern*]. 9. 3. 2021, Mladá Boleslav. (In Czech)

Cílek V. Klima a budoucnost českého lesa. *Česká lesnická společnost*. [Climate and the future of Czech forests. *Czech Forestry Organisation*]. 24. 7. 2021, Kostelec nad Černými lesy. (In Czech)

Cílek V. Klimatická změna a zemědělská produkce. *Mladí vinaři*. [Climate Change and agricultural production. *Young Wine Producers*]. 16. 3. 2021, Brno. (In Czech)

Cílek V. Současné environmentální problémy. Seminář pro učitele ekologického vzdělávání. *Středočeský kraj*. [Contemporary environmental problems, lecture for teachers of environmental studies. *Central Bohemia Region*]. 18. 10. 2021, Praha. (In Czech)

Kočová Veselská M., Kočí T. Polychétní červi z české křídy. Společnost *Národního muzea, z. s., paleontologická sekce*. [Polychaete worms from the Bohemian Cretaceous Basin. Society of the *National Museum, Paleontological Section*]. 20. 9. 2021, Praha. (In Czech)

Navrátil T. Are tree rings reliable indicators of recent and past atmospheric Hg pollution? *Soil Science Colloquium, University of Bern*. 23. 3. 2021, online.

Navrátil T. Rtuť – globální polutant v životním prostředí ČR. *Komise pro životní prostředí AV ČR*. [Mercury – global environmental pollutant. *Commission for the Environment of the Czech Academy of Sciences*]. 25. 11. 2021, Praha. (In Czech)

Navrátil T. Těžké kovy v půdě. Facebooková skupina Půda, voda, zdraví země, zdraví ze mě... [Heavy metals in soil. *Facebook group Soil, water, earth and my health...*]. 14. 4. 2021, Praha – online. (In Czech)

Rohovec J. Lokality kontaminované rtutí – poznatky z příkladových studií. *Komise pro životní prostředí AV ČR*. [Case studies on mercury contaminated localities. *Commission for the Environment of the Czech Academy of Sciences*]. 25. 11. 2021, Praha. (In Czech)

8D OTHER ACTIVITIES

Černý J. *Lektor geologie na letní škole Mezinárodní olympiády věd o Zemi* [Lector of geology in summer school for Czech students attending the International Earth Science Olympiad] – IESO. 21. – 25. 7. 2021, Kladno.

Filippi M. Věda fotogenická. Pořádá AV ČR. *Účastník a vítěz v kategorii Múzy ve vědě* [Photogenic Science. Participant of the competition and the winner in the category Muses in Science]. Praha.

Lisá L. Věda fotogenická. Pořádá AV ČR. *Účastník a vítěz v kategorii Vědci a práce domácí* [Photogenic Science. Participant of the competition and the winner in the category Scientists and homework]. Praha.

Lisý P. Věda fotogenická. Pořádá AV ČR. *Účastník, 2. místo v kategorii Vědci a práce domácí a 3. místo v kategorii Múzy ve vědě* [Photogenic Science. Participant of the competition and the winner in the category Scientists and homework]. Praha.

Žák K., Cílek V. Biskupová S. Srdce Českého krasu. Obec Srbsko a krajina v jejím okolí. *Slavnostní křest a prezentace knihy pro media* [The heart of the Bohemian Karst. Srbsko village and landscape of its surroundings. Ceremonial book launch and presentation for the media]. 2. 9. 2021. Srbsko.

Schnabl P. *Associate program to Amateur Exchange of Minerals in Říčany*. Workshop of cutting, grinding, and polishing minerals and conduction of commented visit to Geopark Říčany. The First Primary School at Říčany, Masarykovo náměstí. 19. 7. 2021.

9. PUBLICATIONS ISSUED

Geologica Carpathica
Published: Vol. 71, Nos. 1–6 (February to December), 2021; 30 articles, 548 printed pages; IF 2021 = 1.415 (co-publisher)

10. ORGANIZATION OF CONFERENCES AND SCIENTIFIC MEETINGS

***National Conference: Czech Republic in the next ten years, Tábor, October 21, 2021*. Organized by Město Tábor under the auspices of Hetmanship of South Bohemian Region.**

Member of organizing comittee and moderator of the event: ***Cílek V.***

From a multidisciplinary point of view, the two-day conference dealt with the vision of the Czech Republic over the next ten years in terms of climate change, the state of soils and food production, the economy and the development of the society. The first day was devoted to professional contributions, but the second day continued as a series of lectures for the local grammar school and other interested parties.

***International conference: 35th IAS Meeting of Sedimentology, Prague, June 21–25, 2021*. Organized by Guarant International spol. s r. o., Palacký University Olomouc, Olomouc; Czech Geological Survey, Prague; Masaryk University, Brno; Inst Geol, Czech Acad Sci; Geophys Inst, Czech Acad Sci, Prague.**

Organizing committee: Bábek O., Vodrážková S., Fryčová B., ***Chadimová L.***, Kumpan T., Lojka R., Nádaskay R., Nehyba S., Sedláček J., Šimíček D., Špičáková L., Uličný D., ***Weinerová H***.

IAS Meeting of Sedimentology represents an international conference dealing with a wide range of topics in the field of sedimentology. The meeting was organized in a virtual form and was attended by 522 registered participants from various countries. The researchers presented their results in 207 oral presentations, 62 short oral presentations and 228 posters. The meeting included also invited plenary lectures, awardee lectures, session keynote lectures, short courses, and various activities for early career scientists. Most of the previously planned field trips were cancelled with respect to the pandemic situation. Scientific contributions were published in the Book of Abstracts.

11. FINANCIAL REPORT

In thousands of Czech Crowns (CZK)		**2021**
A.	**INCOMES**	
1.	From the annual budget of the Czech Acad Sci	47 582
2.	From the Czech Science Foundation (accepted research projects)	24 509
3.	From the internal research projects of the Czech Acad Sci	839
4.	From other public sources	1 419
5.	Applied research	5 860
6.	Investment (instruments)	3 843
7.	Investment (constructions)	25 960
	TOTAL INCOMES	**110 012**

B.	**EXPENSES**	
1.	Scientific staff (wages, insurances)	49 070
2.	Research and scientific activities	14 949
3.	Administration and technical staff (wages, insurances)	12 053
4.	General expenses (service, maintenance of buildings, energies, transport, office supplies, miscellaneous, etc.)	3 287
5.	Library	610
6.	Editorial activities	63
7.	Investment (instruments)	4 020
8.	Investment (constructions)	25 960
	TOTAL EXPENSES	**110 012**

KATALOGIZACE V KNIZE – NÁRODNÍ KNIHOVNA ČR

Geologický ústav (Akademie věd ČR)
Research reports 2021 / Institute of Geology, Czech Academy of Sciences. – Praha : published by the Institute of Geology of the Czech Academy of Sciences, 2022. – 48 stran
Název z obálky. – Obsahuje bibliografie

ISBN 978-80-87443-19-4 (brožováno)

* 55:005.71 * 55 * 001-026.12 * 808.1/.2 * (437.311) * (047.1)
– Geologický ústav (Akademie věd ČR)
– 2021
– geologické ústavy – Česko
– geologie
– vědecká činnost – Česko – 2021–2030
– publikační činnost – Česko – 2021–2030
– Praha (Česko)
– výroční zprávy

55 – Vědy o Zemi. Geologické vědy [7]

RESEARCH REPORTS 2021 INSTITUTE OF GEOLOGY OF THE CZECH ACADEMY OF SCEINCES

The contents and scientific quality of the contributions of individual authors lie within the responibility thereof. The report was compiled by J. Dašková and English was revised by J. Adamovič.

Layout by Ondřej Zámiš / Printed by Chapiteau, s.r.o.

ISBN 978-80-87443-19-4
80 copies

2021