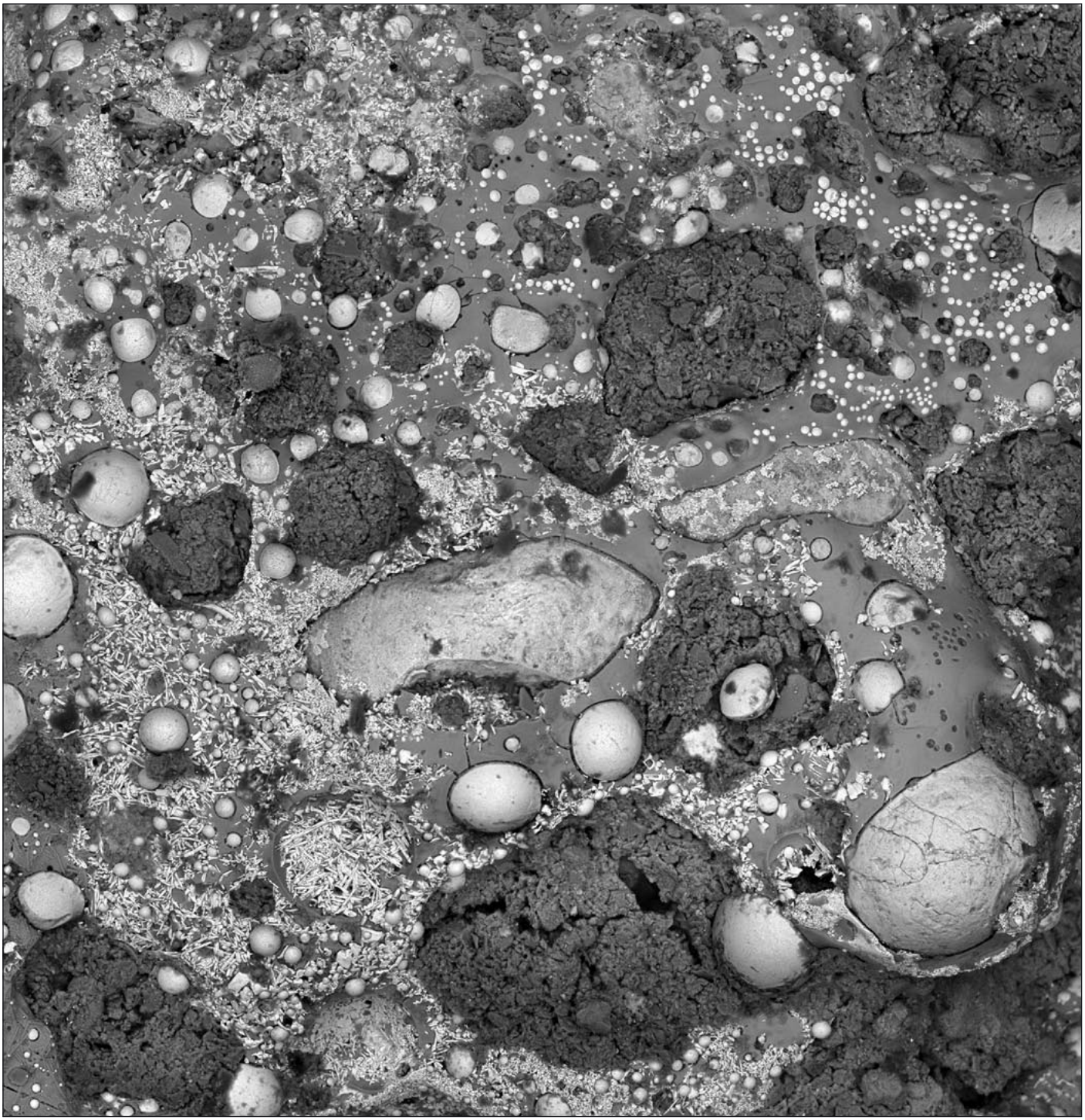
RESEARCH REPORTS

2019

Institute of Geology of the Czech Academy of Sciences



Published by the Institute of Geology of the Czech Academy of Sciences

Praha, December 2020

Cover photo: Coating on the inner side of a smelting cup (a crucible) of Early Medieval age from the Vyšehrad Castle acropolis. Photo by E. Pecková.

Research Reports 2019

Institute of Geology of the Czech Academy of Sciences

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

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KATALOGIZACE V KNIZE - NÁRODNÍ KNIHOVNA ČR

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2019

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of the Czech Academy of Sciences

Contents

Director's Introduction

Dear readers,
In your hands is the Research Report of the Institute of Geology of the Czech Academy of Sciences for the year 2019. For Czech and Slovak people, this year was connected with remembrance of the 30th anniversary of the Velvet Revolution, and the life of a large part of the society was filled with celebrations and official events.

The geological community also celebrated the 220th anniversary of the birth of distinguished French geologist and palaeontologist Joachim Barrande, who was also related to geological research in the Bohemia from 1830s. At this occasion I was honoured to pay tribute, together with representatives of the Paleontological Department of the National Museum and the Society of the National Museum, to this eminent researcher at his grave in Lanzenkirchen (Austria). The Institute of Geology also prepared, together with the National Museum, Administration of the Bohemian Karst Protected Landscape Area (Nature Conservation Agency of the Czech Republic) and Czech Academy of Sciences, a seminar to remind various aspects of life and work of Joachim Barrande.

Normal life at the institute was related with usual research stuff, such as running various research projects, publishing results, preparation of grant proposals and field research and, among others, we also started to prepare first steps for the evaluation planned for 2020.

Last but not least, I would also like to mention the Department of Physical Properties of Rocks: after a long preparation, the reconstruction of its building at Puškinovo náměstí has finally begun.

Tomáš Přikryl
Director

2. General Information

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

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The Institute of Geology is a public research institute belonging to the Czech Academy of Sciences. It concentrates on the 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 1957 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. 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.

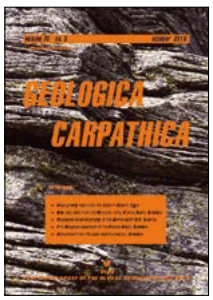
On January 1, 1993, the Academy of Sciences of the Czech Republic was established by a transformation from the ČSAV, and the Geological Institute became a part of the Academy. The Institute belongs to the 1st Department of Mathematics, Physics and Earth Sciences and to the 3rd Section of Earth Sciences. 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. Publishing Activity of the Institute of Geology

a) Geologica Carpathica



Published: Vol. 70, Nos. 1–6 (February to December), 2019; 31 articles, 530 printed pages; IF 2019 = 1.535 (co-publisher)

b) Other Journals and Books Published or Co-published by the Institute of Geology

Dašková, J., ***Bosák, P.*** Eds. Research Reports 2017. Czech Academy of Sciences, Institute of Geology, Prague. 2019, 1– 80.

Dašková, J., ***Bosák, P.*** Eds. Research Reports 2018. Czech Academy of Sciences, Institute of Geology, Prague. 2019, 1–48.

4. Organization Units

4a. Management, Executive Board, Supervisory Board

Management

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

Executive Board

prof. RNDr. Pavel Bosák, DrSc. . . . . Chairman
Mgr. Michal Filippi, Ph.D. . . . . Vice-Chairman
doc. RNDr. Emil Jelínek, CSc. (Charles University) . . Member
prof. RNDr. Martin Mihaljevič, Ph.D.
(Charles University) . . . . . Member
Ing. Petr Pruner, DrSc. . . . . Member
RNDr. Tomáš Přikryl, Ph.D. . . . . Member
RNDr. Ladislav Slavík, CSc.. . . . . Member
Mgr. Martin Svojtka, Ph.D.. . . . . Member
Ing. Petr Uldrych (Ministry of the Environment
of the Czech Republic, Prague) . . . . . Member

Supervisory Board

prof. Jiří Chýla, CSc. (Head Office
of the Czech Acad Sci) . . . . . Chairman
(until October 30, 2019)
prof. Jan Řídký, DrSc. (Inst Phys,
Czech Acad Sci, Prague) . . . . . Chairman
(from October 30, 2019)
RNDr. Radek Mikuláš, CSc., DSc. . . . . Vice-Chairman
RNDr. Pavel Hejda, CSc. (Geophys Inst,
Czech Acad Sci, Prague) . . . . . Member
doc. RNDr. Václav Kachlík, CSc.
(Faculty of Science, Charles University). . . Member
prof. RNDr. Stanislav Opluštil, Ph.D.
(Faculty of Science, Charles University). . . Member

4b. Scientific Departments

The staff of the **Department of Analytical Methods** primarily provides analytical service to cover the needs of other institutional departments. Nevertheless, own research focused largely on the application of instrumental methods to Earth and planetary sciences is carried out as well.

Researchers of the Department continued their research focused on tektites and archaeological glasses. Special attention has been given to Australasian tektites from central Laos, particularly to layered and heterogeneous ones (so-called Muong Nong-type). Ongoing process of design and improvement of analytical protocols in the analytical laboratories was focused, in addition to other topics, on analyses of garnets using Raman and photoluminescence spectroscopies.

In 2019, globally relevant topics as well as topics of local importance were studied at the **Department of Environmental Geology and Geochemistry.** Extensive work was also done on spreading the gained knowledge to the public, especially in the form of radio/TV broadcast, science-promotion articles and monographs.

The first working area was geochemistry of toxic elements in natural environment. Traditionally, main attention was paid to mercury geochemistry. Mercury geochemical archives in tree rings of larch (*Larix decidua*) were studied in detail, recovering the history of environment pollution. The study of decreasing litterfall mercury deposition in central European coniferous forests and the effects of bark beetle infestation was performed in relation with the actual situation in Czech forests. It evaluated one of the longest litterfall Hg deposition timespans, covering the period from 2003 to 2017.

Biogeochemical studies of toxic elements like Zn, Cd, Cu, Ag in fungi proceeded, the factors of contrasting silver and copper accumulation in sporocarps were identified and dis-

cussed. Further, the mechanism of Zn uptake was correlated with Zn detoxification processes. A new analytical protocol for high-precision Cd isotopic analyses in biological materials using thermal ionization mass spectrometry (TIMS) was successfully established.

Speleological discoveries in the cave area of Shaanxi (China), and speleothems and related hydrology of the granite Gobholo Cave in Eswatini were published. Works on sandstone weathering proceeded with unflagging extent combining the field, laboratory experimental and numerical modelling approaches. The evolution of arcades and rock pillars was described in detail and and a more profound understanding of the problem was achieved.

In 2019, ongoing CSF projects: „*Cadmium hyperaccumulation in macrofungi: from isotopes to proteins and bacterial communities*" (No. 19-06759S) and „*Stress-and hydraulic field-controlled weathering and erosion of granular rocks*" (No. 19-14082S) were solved. The project "*Coupled solid phase speciation and isotopic record of thallium in soils – a novel insight into metal dynamics*" (No. 17-03211S) was finished. The industrial grant project Multigenerational non-active (Watrad s. r. o., Progeo s. r. o., Faculty of Civil Engineering, Czech Technical University) was successfully finished. The result of this project, in the form of a functional sample of fluorescent tracers and working procedure, was presented and defended.

The book "*Granite Landscapes of Central Bohemia*" obtained the Award of Egon Ervín Kisch in the category of non-fiction literature. Silver Memorial Award of the Senate of Czech Republic for life-long publishing activity was awarded to Václav Cílek. The extensive popularisation activity of V. Cílek was further acknowledged by the Award of Ministry of Education for the documentary film "*Landscape of the next century in several scenes*" and by the Award of the Librarians for children literature.

The **Department of Geological Processes** utilizes a combined approach using a range of methods in petrography, mineralogy, geochemistry and geochronology.

In 2019, a novel method was introduced in the Department of Geological Processes, which allows a precise measurement of ultra-low concentrations of Sr and Nd (<1 ng) using amplifiers with a resistivity of 10^13 ohms combined with the present thermal ionization mass spectrometer (TIMS). This launched a new collaboration with the Faculty of Science of Charles University and led to financial support within a 3-year project from the Czech Science Foundation to be started in 2020. Reference materials of rutile, apatite and titanite were newly tested for the analysis of U-Pb dating using laser ablation ICP-MS; this method will be used from 2020 onwards within a new joint project with the Polish Academy of Sciences. Jan Černý continued his studies of earthquake activity and tsunamis within his post-doc project at the Universidad Nacional Autónoma de México (Mexico City). Another staff member of the Department – Ladislav Polák – obtained the prestigious Fulbright scholarship for Czech doctoral students: he is involved in the study of Lu-Hf geochemistry and Fe stable isotopes in carbonatites at University of South Carolina (USA). Jiří Sláma continued his study of rock materials using the Lu-Hf isotopic system and U-Pb zircon dating within the "*J. E. Purkyně Fellowship for outstanding promising scientific workers*". The staff of the Department were working on several grant projects supported by the Czech Science Foundation, including the study of black shales (principal investigator Lukáš Ackerman), two projects in geoarcheology (co-investigator Lenka Lisá), the study of greisenization and albitization of granites (principal investigator Karel Breiter), dating and geochemistry of Archean granites (co-investigator Martin Svojtka) and a junior project from the Czech Science Foundation aimed at processes of magma emplacement in collapsing orogens (Filip Tomek). Filip Tomek was awarded the Otto Wichterle Award, which is granted to selected outstanding and promising scientific workers of the Czech Academy of Sciences who contribute to the development of scientific knowledge with their excellent achievements.

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

In 2019, members of the Department of Paleobiology and Paleoecology contributed to several important results published in prestigious geological journals. These included taphonomic bias in exceptionally preserved biotas published in the Earth and Planetary Science Letters journal and detection of orbital forced cyclicity of climate changes in sedimentary record published in the Geology journal. L. Slavík was elected a Chairman of the International Subcommission on Devonian Stratigraphy (SDS/ICS of the IUGS), his term will officially start during the International Geological Congress in New Delhi in 2020. L. Laibl continued his prestigious fellowship at the University of Lausanne (Switzerland) during the entire year 2019. Members of our department R. Mikuláš and M. Kočová-Veselská organized the 15th International Ichnofabric Workshop in Prague. P. Štorch and L. Slavík co-organized meetings of international stratigraphic subcommissions (ISSS and SDS) that were held jointly with the International Congress on Stratigraphy in Milan. T. Weiner and F. Scheiner successfully accomplished their PhD theses; the latter was awarded the Prize of the Dean (*cum laude*) of the Faculty of Science in Prague. In 2019, three projects of the Czech Science Foundation passed the competition and will start their 3-year periods in 2020. An important part of the Department's production was also popular science, namely in connection with the 220th anniversary of birth of Joachim Barrande.

The **Department of Paleomagnetism** focuses on rock magnetism and paleomagnetism of stratigraphic system boundaries, cave sediments, terrestrial and meteoritic materials.

In 2019, researchers of the Department of Paleomagnetism continued to study cave sediments in Czech, Slovak, Polish and Slovenian caves as well as the Jurassic/Cretaceous boundary sections. Several important results were produced. These include the contribution to the Berriasian Working Group's

effort to find the GSSP site for the Berriasian Stage of the Cretaceous System, dating of cave sediments in relict and unroofed cave sediments in Slovenia and multi-proxy research of cave sediments in the Krkonoše National Park. The Department was also involved in two Czech Science Foundation grant projects: a new multidisciplinary project to estimate the consequences of the Cretaceous/Paleogene boundary causal events in local Carpathian sections (launched in 2019; principal investigator T. Elbra), and the archeomagnetic study of Olomučany-type chert (co-investigator P. Schnabl). In addition, the members of the Department were involved in studies of meteoritic materials and space weathering, and in the international UNESCO IGCP project. The data interpretations by the Department include stratigraphic and paleoenvironmental reconstructions, and research results were published in several prestigious journals.

The **Department of Physical Properties of Rocks** deals with the study of mechanical properties of rocks under uniaxial or triaxial load.

The Department studies acoustic emission monitored during brittle fracturing of rocks. As a fracturing model, shear-tensile mechanism is used. This model represents the simplest model, which combines shear and tensile component. The Department also deals with the study of elastic anisotropy of rocks under high hydrostatic stress. The study is carried out by ultrasonic sounding of longitudinal and transversal waves through spherical samples. The aim of the study is the determination of full stiffness's tensor and its changes according to the different values of hydrostatic stress. Staff members of the Department were involved in 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 (continued) – co-investigator – T. Lokajíček. In addition, they were involved in an international project, by the study of elastic anisotropy and properties of lithosphere materials using neutron diffraction and ultrasonic sounding and elastic anisotropy of layered rocks. Results of the research conducted by staff of the Department were published in prestigious geophysical and geological journals in 2019. Most of the published data in these journals were produced by the laboratory of the Department. Preferred journals for publication: Rock Mechanics and Rock Engineering.

4c. Laboratories and Library

Clean Chemistry Laboratory (Head: E. Haluzová; supervised by L. Ackerman)
Laboratories for processing of samples destined for (ultra) trace and isotopic analyses (Fig. 1). Both labs are supplied with HEPA filtered air. One lab (class-100000 filtered air) is using for sample decomposition and labware cleaning. It contains 1 × fume-hood designed for the work with strong acids hosting two digitally controlled hotplates, 1 × device for the preparation of clean water (Millipore Essentials), 1 × analytical weight (Kern, 0.0000X g) and 2 × teflon distillation apparatus (Savillex) for the preparation of ultraclean acids The other lab (class-10000 filtered air) is using for a clean chemistry (e.g., ion exchange chromatography separation, special chemical procedures for separation of certain elements) and final preparation of the samples for mass spectrometry (HR-ICP-MS, MC-ICP-MS, TIMS). It contains 2 × originally designed laminar flow hoods (class-100 filtered air), 1 × open laminar flow work space (class-100 filtered air), 1× analytical weight (Sartorius Cubis, 0.0000X g), 2 × device for the preparation of (ultra) clean water (Millipore Essentials + Millipore Milli-Q Element) and 1 × centrifuge.

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 and back-scatted electrons, energy-dispersive (ED)

■ **Fig. 1.** Clean Chemistry Laboratory. Photo by M. Svojtka.

spectrometer Bruker QUANTAX 200, low vacuum secondary electron detector (LVSTD), and colour cathodoluminescence detector (CL).

Electron probe microanalyzer (EPMA) JEOL JXA-8230 (installed in November 2019, Fig. 2) is used mainly for non-destructive quantitative analysis of solid-state materials on the micrometre scale. The instrument is equipped with five wave-dispersive crystal spectrometers. Two of them carry 4 individual standard-sized crystals each, two other house two so-called large crystals each (i.e., crystals where lower detection limits can be attained) and the last spectrometer carries 2 so-called high-sensitivity crystals to measure low element contents. 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 ED spectrometer JEOL (OEM product of RaySpec).

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. 2.** Electron microprobe analyzer JEOL JXA-8230 installed at the Laboratory of Electron Microanalysis in November 2019. Photo by R. Skála.

Laboratory of X-ray Powder Diffraction (Supervised by R. Skála)
X-ray powder diffractometer Bruker D-8 DISCOVER is a multipurpose powder X-ray diffraction instrument with a variable measuring radius designed to study powder samples or solid polycrystalline blocks (polished (thin)sections, rock chips etc.). 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.

Department of Paleomagnetism (Head: P. Schnabl)
The laboratory is situated in the Průhonice Park and is well equipped for rock-magnetic and paleomagnetic research. The laboratory features state-of-the-art instruments such as 2G 755 4K SUPERCONDUCTING ROCK MAGNETOMETER: highly sensitive and accurate instrument for measurement of remanent magnetization of rocks and conducting alternating-field (AF) demagnetization; AGICO JR-5A and JR-6A Spinner Magnetometers: sensitive automatic magnetometers, MAVACS – Magnetic Vacuum Control System – a unique system to create and maintain virtual magnetic vacuum for thermal demagnetization; MAGNETIC MEASUREMENTS MMTD80 Thermal Demagnetizer: standard instrument for thermal demagnetization; MAGNETIC MEASUREMENTS MMPM10 Pulse Magnetizer (Fig. 3): instrument for creating isothermal remanent magnetizations up to 9T; AGICO MFK1-FA Kappabridge: highly sensitive apparatus for measuring magnetic susceptibility in variable magnetic fields, frequencies and temperatures, as well as anisotropy; AGICO LDA-5 and PAM-1 Specimen Unit: multifunctional device for anhysteretic magnetization and AF demagnetization up to 200 mT, which can be used also as a pulse magnetizer in weak fields (1 to 20 mT), and others.

■ **Fig. 3.** A new Magnetic Measurements MMPM10 Pulse Magnetizer. Photo by T. Elbra.

Grinding and Polishing Shop (Supervised by R. Skála)
Reliable quantitative point chemical analyses and/or acquisition of element distribution maps using EPMA/SEM require planar polished conductive surfaces. Such prerequisites are fulfilled when bulky solid samples are sectioned and polished. For that purpose a suite of cutting, grinding, lapping and polishing machines to prepare polished sections or thin sections is available (cutting and grinding machines Buehler PetroThin and Struers Discoplan TS, grinding machines 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).

Laboratory of Raman and infrared spectroscopy (Supervised by R. Skála)
Raman dispersive micro-spectrometer S&I MonoVista CRS+ is based on Olympus BX-51 WI upright microscope, Princeton Instruments SpectraPro SP2750 spectrometer and a CCD detector

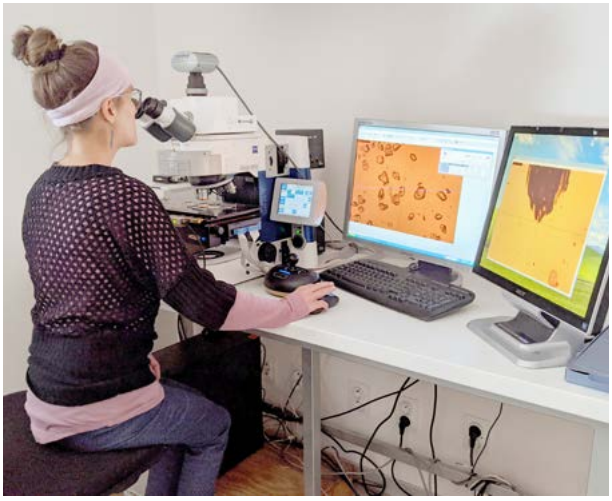
ANDOR iDus 416. Excitation lasers have wavelengths of 488, 532 and 785 nm. The microscope is designed for sample observation in either reflected or transmitted light. Objective lenses with following magnifications are installed: 4×, 10×, 50×, 50× LWD and 100×. Samples are placed on a computer-controlled motorized stage. Spatial resolution with 100× objective is 1 μm laterally and 2 μm axially. The system allows collection of spectra within the range of 60–9,300 cm^{-1} with 488 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 infrared 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 ATR mode, the wavenumbers covered are 4,000–100 cm^{-1} depending on used beam-splitter.

Laboratory of rock processing and mineral separation (Head: M. Šťastný)
Equipment of the lab for mineral and rock separation (Fig. 4): laboratory table WILFLEY 13B; vibration processor VT 750; crusher CD 160*90; laboratory mill RETSCH; crusher ŽELBA D 160/3; mill SIEBTECHNIK; muffle oven LAC LMH 11/12; hydraulic slab cutter 4H HYDROTRONK MONTOLIT; electromagnetic separator FRANTZ, and air-compressor GÜDE.

Fission-track Laboratory (Head: D. Kořínková)
The laboratory provides fission-track dating analysis for determining the age and time-low temperature evolution (t/T modelling) of minerals and rocks (Fig. 5). Analytical system for fission track analysis: AXIOPLAN ZEISS microscope and Trackscan AUTOSCAN system; ZEISS IMAGER M1m microscope and AUTOSCAN computer-controlled microscope stage, and MTH APX 010 polishing and grinding machine.

Laser ablation ICP-MS Laboratory (Head: J. Ďurišová and Š. Matoušková; supervised by M. Svojtka)
The laboratory (Fig. 6) 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

■ **Fig. 4.** Laboratory of rock processing and mineral separation. Photo by M. Svojtka.



■ **Fig. 5.** Fission-track Laboratory. Photo by M. Svojtka.

■ **Fig. 6.** Laser ablation ICP-MS Laboratory. Photo by M. Svojtka.

to access spectrally interfered isotopes and is used for: (1) multi-element trace analysis across the periodic table covering a $mg \cdot l^{-1}$ to sub $pg \cdot l^{-1}$ concentration range, and (2) measuring of isotope ratios. The Element2 ICP-MS is coupled with an ANALYTE EXCITE excimer 193 nm laser ablation system (Cetac/Teledyne) for analysing solid samples and with an Aridus II desolvating nebulizer (Teledyne).

TIMS Laboratory (Head: J. Rejšek, supervised by L. Ackerman)
The laboratory (Fig. 7) is equipped with TRITON Plus (ThermoFisher Scientific), 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 supplied with five 10^{13} Ω technology amplifiers along with 3.3 pA current calibration board, the central dual-channel detector (SEM/Faraday cup), oxygen bleeding valve and RPQ device. The filament bakeout device (ThermoFisher Scientific) is placed in the TIMS laboratory for the filament degassing and PCR box Airstream (ESCO) for sample loading.

■ **Fig. 7.** TIMS Laboratory. Photo by M. Svojtka.

Geoarchaeology Laboratory (Supervised by L. Lisá)
Laboratory for basic sedimentary samples processing. The laboratory is equipped with 1 × fume-hood designed for the work with strong acids. The lab serves mainly for the sedimentary samples processing as for example basic sample descriptions, micromorphological sample preparations, pH measurements and particle size analyses. A dryer and a vacuum chambre are available for micromorphological sample impregnations as well as the centrifuge and Cillas 2000 laser particle size analyser (purchased in 2011) with the range of 0.004–2,500 micrometres, and sets of sieves for the different types of grain size analyses.

Micropaleontological Laboratory (Supervised by P. Lisý & L. Slavík)
The laboratory of micropaleontology disposes of a room for sample preparation with standard equipment and chemicals and a laboratory of sample processing with hoods and levigation sinks.

Sedimentary Laboratory (Head: A. Žigová)
The laboratory is equipped with an apparatus for sample preparation and pH measurements: Analytical balance SETRA EL–2000S (1999), WST 5010 (1991): laboratory dryer, FRITSCH (1986): planetary mill, pH-meter pH 330 / SET (2000), TESLA (1985): ultrasonic cleaner.

Laboratory of liquid and solid samples (Head: J. Rohovec)
The laboratory is equipped with: 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 balances, B-2A Epi/FL (1996): filtration blocks, SARTORIUS Basic analytical (1992): analytical balances, DTA /DSC (2018)

Mercury analysis Laboratory (Head: T. Navrátil)
The laboratory is equipped with: New AMA 25 mercury analyser with autosampler for solid samples (2019), Speciation oven for RA-915 M Lumex analyser: upgrade (2019), two zone cylinder furnace Clasic (2018) Total mercury and methylmercury analyser MERX (2017), RA-915M Lumex mercury analyser: real time direct detection of mercury vapour 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), AMA 254 mercury analyser: mercury analysis in solid and liquid samples on CV-AAS principle. (2008).

5. Awards and reserach fellowships

Cílek V.
Silver Memorial Award of the Senate of the Czech Republic for life long publishing activity (September 27, 2019).

Cílek V., Rohovec J. and collective of authors
The award of Egon Ervín Kisch for the book "*Granite Landscapes of the Central Bohemia*" in the category of Non-fiction literature (October 4, 2019).

Cílek V.
The award of the Ministry of Education for the documentary film by M. Slunečko (director; V. Cílek – guide): "Stark

Images of the Czech Landscape in 100 Years", Life Science Film Festival organized by Czech University of Life Sciences, Prague (November 4–8, 2019).

Cílek V. and other authors (Sokol J., Fučíková R., Sůvová Z.)
The award of the Librarians of children literature "We all read" for the book "*Europe, our home*" organized by the National Pedagogic Museum and other institutions (April 11, 2019).

Černý J.
The postdoctoral fellowship focused on Active tectonics of the Mexican subduction zone at the Institute of Geography, National Autonomous University of Mexico, Mexico (March 1, 2018–February 28, 2020).

Krmíček L.
Letter of Thanks awarded (Fig. 8) for invited lecture at the Mineralogical-Petrological Conference Petros 2019, Mineralogical Society of Slovakia, Bratislava (May 29, 2019).


Slovenská mineralogická spoločnost

Letter of Thanks

Mineralogical Society of Slovakia

thanks

Assoc. Prof. Lukáš Krmíček

for his invited lecture

on the Mineralogical-Petrological Conference Petros 2019

In Bratislava, May 29th, 2019

Assoc. Prof. Peter Bačík, PhD.
Chairman of
Mineralogical Society of Slovakia

■ **Fig. 8.** A Letter of Thanks for L. Krmíček.

Krmíčková S.
Brno PhD Talent award for talented Ph.D. students of natural sciences from Brno universities (Fig. 9; February 28, 2019)

Krmíčková S.
Dean's award for the excellent MSc. thesis, Faculty of Science, Masaryk University, Brno (Fig. 10; June 10, 2019).

■ **Fig. 9.** S. Krmíčková was awarded the Brno PhD. Talent scholarship. On February 28, 2019, she received a symbolic cheque from the hands of the mayor of the statutory city of Brno. Photo by L. Krmíček.

■ **Fig. 10.** S. Krmíčková was awarded the Dean's Award for the excellent MSc. thesis on 10th June 2019. Photo by Faculty of Science, Masaryk University, Brno.

Mészárosová N.
Short-term visit to Antarctic Meteorite Research Department in the NIPR (Japanese Polar Research Institute) in Tokyo within the Czech Academy of Sciences cooperation activity with leading research institutions in South and Southeast Asia: Japan, Singapore, South Korea and Taiwan, 2019 (VAJVA-19-21; July 15–August 2, 2019)

Polák L.
Fulbright-Masaryk scholarship, University of South Carolina, USA (Fig. 11; October 2019–March 2020).

■ **Fig. 11.** L. Polák in the laboratory (Center for Mass Spectrometry) at University of South Carolina during his Fubright-Masaryk scholarship. Photo by E. R. Kolomiets.

Roček Z.
Visiting Scientist under the Chinese Academy of Sciences President's International Fellowship Initiative (PIFI; 2019)

Scheiner F.
The Dean's Prize *cum laude* to a doctoral degree graduate, Faculty of Science, Charles University, Prague (December 2, 2019).

Sláma J.
J. E. Purkyně Fellowship for outstanding creative scientists, Institute of Geology of the Czech Academy of Sciences, Prague (2016–2020).

Svobodová A.
Sepkoski Grant, the Paleontological Society (for 2019)

Tomek F.
Otto Wichterle Award, Czech Academy of Sciences (May 2019)

6. Projects

6a. Foreign Grants, Joint Projects and International Programmes

Finished projects

Australian Research Council No. LP160101353: **Tectonic Geography of the World's Oldest Petroleum Play**, **the McArthur Basin** (A. Collins, University of Adelaide, Australia; University of South Australia, Australia; University of Wollongong, Australia; Northern Territory Geological Survey, Australia; Santos Ltd., Adelaide, Australia; Origin Energy, Adelaide, Australia; ***L. Ackerman***, ***E. Haluzová***, ***J. Rejšek***, ***J. Ďurišová***; 2017–2019)

This project represents a collaboration between several universities and mining companies in Australia, where the Inst Geol, Czech Acad Sci serves as the partner investigator responsible for Re-Os geochronology of black shale horizons in the McArthur Basin, northern Australia. During the last year of the project, we finalized three remaining Re-Os datasets for black shale successions suggesting Mesoproterozoic (~1.36 Ga) age for the analysed successions.

Bilateral co-operation between Czech Geological Survey, Prague and Geologische Bundesanstalt Wien, Austria: **Palynology of Gosau Group sediments in Salzkammergut, in particular on maps 95 St. Wolfgang and 96 Bad Ischl** (H. Lobitzer, Geologische Bundesanstalt, Vienna, Austria, Austria; L. Švábenická, Czech Geological Survey, Prague; ***M. Svobodová***; 2019)

The palynofacies of the Lower and Upper Radgraben Formation of the Lower Gosau Group (Northern Calcareous Alps) contain palynomorphs, prevailingly pteridophyte spores and gymnosperm pollen, together with very rare dinoflagellate cysts and agglutinated foraminiferal linings, scolecodonts corresponding to the Berriasian age. Other samples from the Aussee Weissenbach contain a palynological assemblage of Middle Coniacian age – determined especially on the presence of triporate angiosperm pollen of the Normapolles group *Conclavipollis burgeri*, *Complexiopollis complicates*, *Complexiopollis normis*, *Plicapollis* sp. Samples are comparable to the nannoplankton zone UC10 according the presence of *Micula staurophora* (L. Švábenická).

Bilateral Mobility Project No. PAN-17-22: **Reconstruction of paleoenvironment in Middle and Late Pleistocene based on cave deposits from Poland and Czech Republic** (H. Hercman, M. Gąsiorowski, J. Pawlak, M. Błasczyk, P. Sierpień, I. Sekudewicz, Institute of Geological Sciences, Polish Academy of Science, Warsaw, Poland; ***P. Bosák***, ***P. Pruner***, ***Š. Kdýr***, ***Š. Matoušková***, ***J. Rohovec***; 2017–2019)

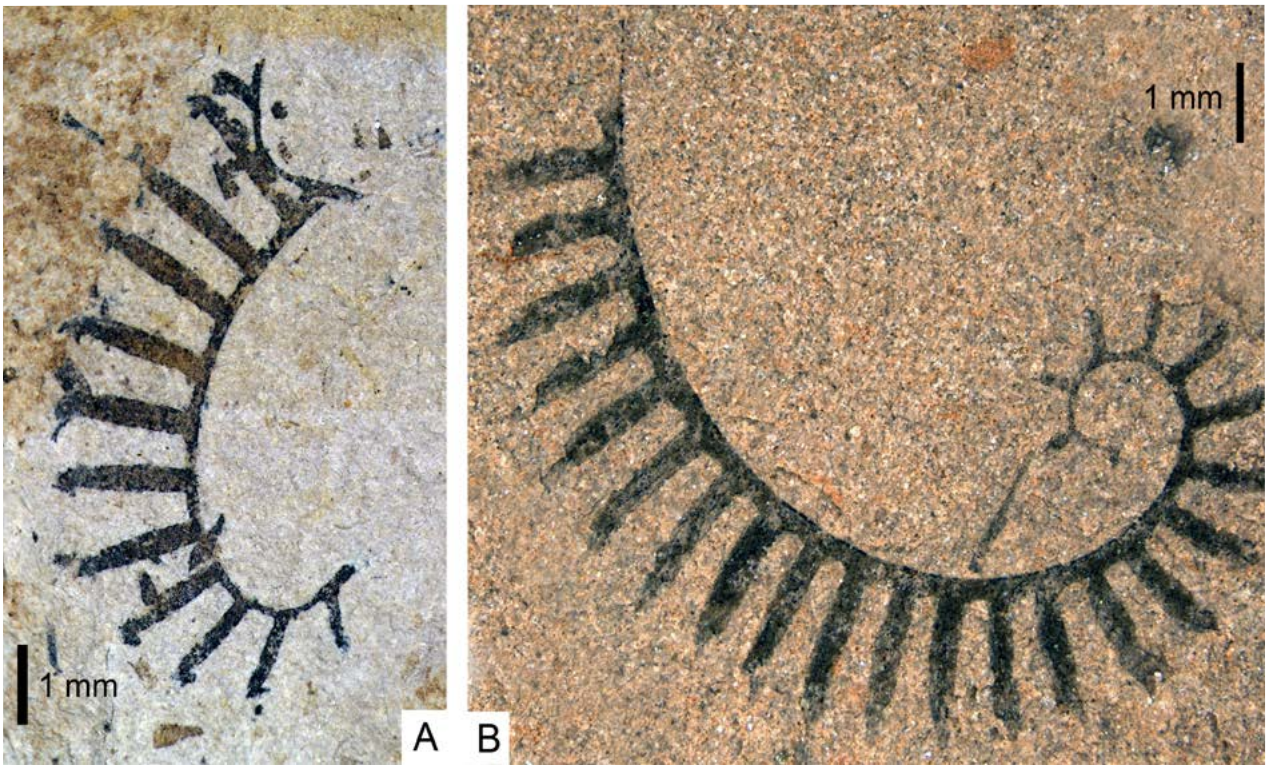
The quality of paleoenvironmental reconstruction based on speleothem records depends on the accuracy of used proxies and chronology of the studied record. As far as the dating method is concerned, in most cases, the best solution is the use of U-series method to obtain a precise chronology. However, for older periods (over 0.5–0.6 Ma), dating has become a serious challenge. Theoretically, older materials can be dated by the U-Pb dating method. However, that method requires a relatively high uranium (U) content (minimum of several ppm), whereas typical speleothems from the whole Central Europe have U concentrations below 0.1 ppm. Therefore, we applied oxygen isotope stratigraphy (OIS) as a tool for correct speleothem dating. The OIS as an alternative tool allows to create a chronology in flowstones. It was found that the studied flowstone from the Głęboka Cave (Kraków-Częstochowa Upland, Poland) crystallized from 975 to 470 ka with three major breaks (hiatuses). The obtained isotopic record can be correlated with oxygen isotopic stages from MIS 24 to MIS 12.

State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology (NIGPAS), Chinese Academy of Sciences, Project No. 16302: **Graptolite marker species of Rhuddanian/Aeronian boundary interval of the Czech Republic and China** (Z.Y. Sun, NIGPAS; ***P. Štorch***; 2017–2019)

Global correlation of Silurian rocks relies primarily on planktic graptolites. Our study dealt with morphological and morphometric analysis and comparison of selected graptolite taxa of great importance for identification and high-resolution correlation of the Rhuddanian/Aeronian boundary strata. The results are based upon rich material from the Czech Republic and South China supplemented by specimens from northern Canada, western Siberia, Spain, and published data from around the world.

Critical systematic re-evaluation focussed on early and middle Aeronian representatives of distinctive monograptid genus *Rastrites* which is easily recognizable and of primary importance for biostratigraphic correlation world-wide. The genus and its closely similar associate *Stavrites* with palaeobiogeographic distribution limited to low paleolatitudes of Northern Hemisphere are characterized by their dorsally curved rhabdosome with long, slender, isolated and widely spaced tubular metathecae, almost perpendicular to the rhabdosome axis. *Rastrites* and *Stavrites* were supplemented by early Aeronian species of foliate, ancora-bearing biserial *Petalolithus*. A systematic revision of 19 species corrected a significant number of earlier misidentifications (Fig. 12).

Many Ordovician graptolites employed in biostratigraphic correlation were specific to either Atlantic cool-water realm (Europe, eastern North America, North Africa, Middle East) or Pacific warm-water realm (China, Siberia, northern Canada). These faunal paleoprovinces were prominent and well constrained in pre-Hirnantian Ordovician successions whereas Silurian graptolite faunas were believed to be largely cosmopolitan. However, as more detailed studies on Silurian faunas have been published from previously little known regions, a solid evidence emerged on close paleobiogeographic affinities between Llandovery graptolite faunas of China, Siberia and northern North America and their striking difference from coeval faunas of Europe.



■ **Fig. 12.** The necessity of modern taxonomic revisions for any palaeobiogeographic analyses is exemplified by the two illustrated species. A – *Rastrites approximatus* Barrande from the middle Aeronian *leptotheca* Biozone of Tmaň, Czech Republic. B – *Stavrites rossicus* Obut & Sobolevskaya from the lower Aeronian upper *triangulatus* Biozone of Yuxian section, Sichuan Province, China. The latter one is a senior name for *Rastrites guizhouensis* Mu *et al*. and *Rastrites confertus* Chen & Lin subsequently described from China. The same form was referred to *Rastrites approximatus* in Canada. Photo by P. Štorch.

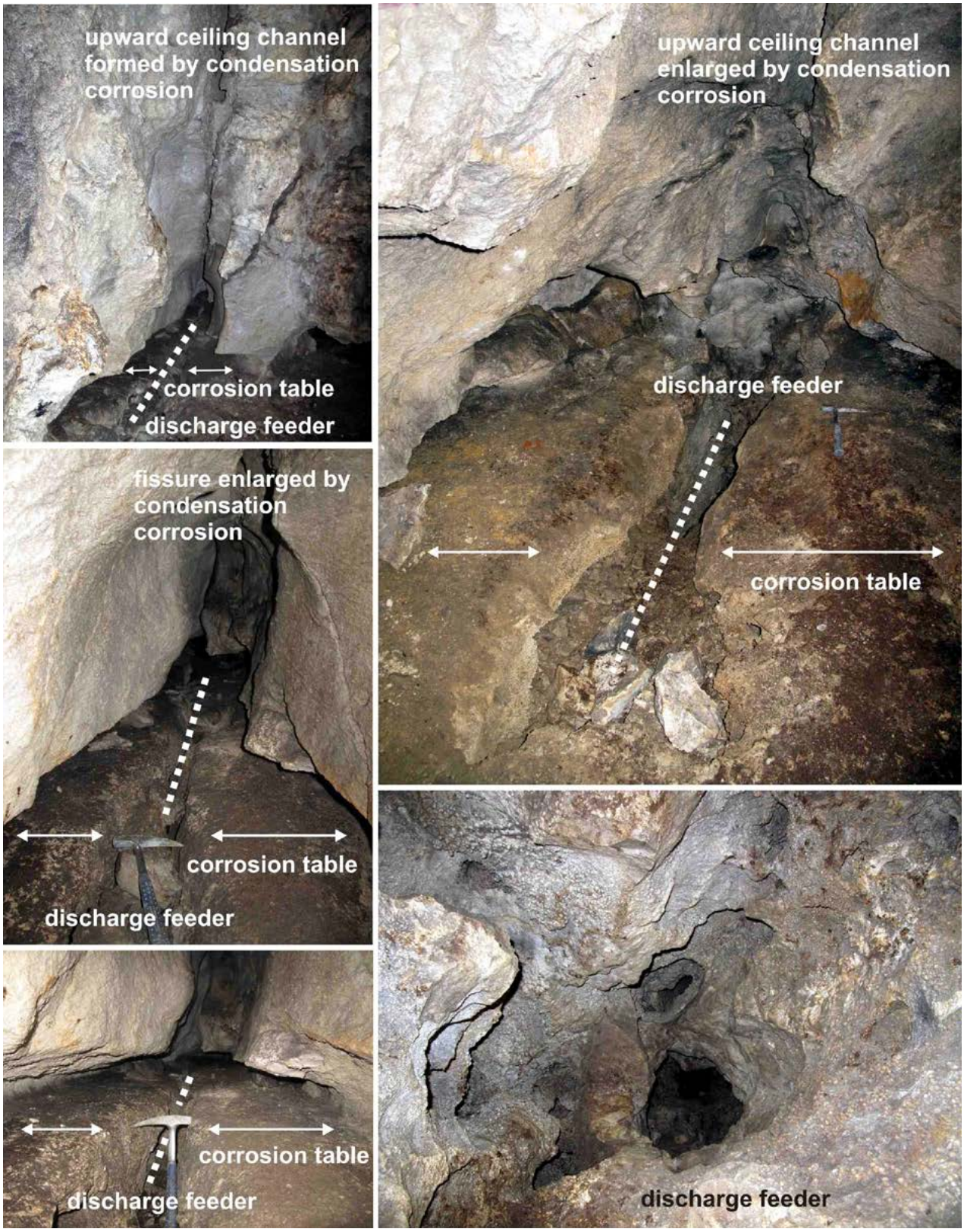
Our principal objectives were to test the supposed palaeobiogeographical affinities of the lower and middle Aeronian graptolite faunas world-wide based upon species distribution exemplified by strictly taxonomically revised early and middle Aeronian species of the cosmopolitan genera *Rastrites* and *Petalolithus* along with paleogeographically more restricted *Stavrites*. Taxonomic revision coupled with palaeobiogeographical cluster analysis have revealed a distinct palaeogeographical distribution indicating that similar two provinces existed in the early and middle Aeronian pelagic realm: low-latitude Northern Hemisphere Province of South China, Siberia and northern North America, and largely mid-latitude Southern Hemisphere Province comprising Avalonian British Isles, southern Baltic area, central Europe, western and southern Europe, and North Africa. None of the examined species exhibits cosmopolitan distribution.

Ongoing projects

Bilateral co-operation between the Institute of Geology of the Czech Academy of Sciences, and Karst Research Institute, Scientific Research Centre, Slovenian Academy of Sciences and Arts: **Paleomagnetism and magnetostratigraphy of Cenozoic cave sediments in Slovenia** (N. Zupan Hajna, A. Mihevc, Karst Research Institute ZRC SAZU, Postojna, Slovenia; P. Sierpień, H. Hercman, M. Gąsiorowski, J. Pawlak, Institute of Geological Sciences, Polish Academy of Science, Warsaw, Poland; ***P. Pruner***, ***P. Bosák***; in co-operation with MOBILITY Nos. PAN-17-22, SAZU-16-03 and SAZU-19-01 (since 1997)

There are only several speleothem records older than the Last Interglacial, and Slovenian caves are a very important source of climatic information for much older periods. The Račiška pečina Cave (RP), located in the SE part of the Classical Karst (SW Slovenia), contains a unique series of alternating clays and flowstones deposited in the last 3.2 My (from Marine Isotope Stage /MIS/ km3 to MIS 5). The application of Oxygen Isotopic Stratigraphy (OIS) combined with paleomagnetic results enabled the establishment of more detailed chronology for RP section. A total of 21 hiatuses were detected by data correlation using the Gen-Corr. Hiatuses correspond principally to clay intercalations in flowstones. The section splits into two segments separated by a principal unconformity at ~2.6 Ma including 4 MIS stages (MIS 102 to MIS 99, duration of ~100 ka). Stable isotopic records in the lower segment correlate better with the regional oxygen isotopic MEDI curve, while the upper one with the global LR04 curve. This suggests changes in the main factors controlling paleoclimatic conditions in the area from regional (Mediterranean) to global (Atlantic) ones connected with the Northern Hemisphere Glaciation (NHG) and with the change in ocean circulation. After the MIS 76/75 transition (break in deposition), the glacial – interglacial cycles are well visible. A change from a higher-frequency and lower-amplitude $\delta^{18}O$ signal (41-ka cycle) to a higher-amplitude and lower-frequency

one (100-ka cycle) is visible at ~1.52 Ma. The Brunhes/Matuyama boundary (0.78 Ma) occurred at MIS 19, and changes in the isotopic records reflect interglacial climate with an increase in temperature and a decrease in humidity at that time. The studied part of the Račiška pečina section terminates with the end of MIS 5, at around 80 ka.



■ **Fig. 13.** Principal forms of rock relief in the Plavecká Cave. Photo by P. Bella.

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

The hypogene origin of the Plavecká jaskyňa Cave, Plavecká priepasť Shaft as well as the Pec Cave is indicated by morphological features. These objects are situated at the western fault edge of the Malé Karpaty Mountains (MKM) near the village of Plavecké Podhradie. Cave development was controlled by active faults related to the horst-graben structure at the contact of the MKM and Záhorská nížina Lowland (NE part of the Vienna Basin). New characteristics of the specific morphology of the Pec Cave were obtained. The cave consists of three subhorizontal passages and halls with cupolas, ceiling spherical holes, water table notches, flat corrosion bedrock floor surfaces (corrosion tables), wall niches as well as upward wall channels. These subhorizontal segments are interconnected by steep to vertical oval feeders (Fig. 13). Allochthonous fluvial sediments are completely missing in all caves. Based on tectonic control, hydrogeological conditions and morphological features, the Pec Cave was originated by solution of carbonates of Triassic Wetterstein Formation (Hronic Unit) by probably slightly heated waters ascending along a marginal fault of the MKM. Some morphologies (as cupolas above water table notches on the edges of corrosion tables, associated wall niches and upward wall channels, fissure discharge feeders) are identical with the morphology of sulphuric acid caves. The Pec Cave represents the highest-lying and the oldest (probably Early Pleistocene or pre-Quaternary) known cave level segment in the Plavecký hradný vrch (Plavecký Castle Hill).

Bilateral Mobility Project No. SAZU-19-01: **Cave sediments: multi-proxy for interpretation of karst processes** (N. Zupan Hajna, A. Mihevc, A. Švara, Karst Research Institute ZRC SAZU, Postojna, Slovenia; M. Vrabec, University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Geology, Ljubljana, Slovenia; ***P. Pruner***, ***Š. Kdýr***, ***P. Bosák***; 2019–2021)

Some areas along the active collisional boundary between the Adriatic microplate and Eurasia are undergoing transpression. This is clear in the Dinarides of Slovenia (NE corner of the Adria–Eurasia boundary zone), where earthquake focal mechanisms GPS data and tectonic geomorphology demonstrate predominantly transpressive strike-slip deformation on the NW–SE-striking dextralfaults which run parallel or subparallel to the plate boundary. Known deformation rates inferred from GPS geodesy and tectonic geomorphology of Quaternary features indicate that fault slip-rates do not exceed 1 $mm \cdot a^{-1}$, and that deformation is highly dispersed in space. The onset of strike-slip deformation and transpression coincided with a major change in Adria kinematics and associated tectonic reorganization in the East Alpine – Pannonian – Dinaric system at ~6 Ma, but little is known about the subsequent deformation history.

We used paleomagnetic declination data obtained from cave sediments to document neotectonic (0–5 Ma) vertical-axis rotations. Magnetostratigraphy, radiometric dating, biostratigraphy, and geomorphological constraints were combined to establish a robust chronology in the spatially and temporally highly discontinuous sediment record preserved in karst areas. Derived rotation rates range from 2 to 10°/My with peak activity from 3.0 to 1.5 Ma. Post-1.5 Ma slowdown of rotations correlates with a decrease in fault-slip rates and the onset of inversion in Quaternary strike-slip basins, which has not been well-constrained in time yet. We distinguish two tectonic domains from the rotation patterns: (1) the Adriatic coastal thrust belt, which exhibits early clockwise, probably syn-emplacement rotations, (2) followed by post-1.5 Ma counterclockwise (CCW) rotations, whereas the continental interior displays persistent CCW rotations suggesting domino-like rotation of rigid blocks bound by NW–SE-striking faults. Our reconstructed block rotation rates suggest that the northeastern peri-Adriatic belt is fully detached from the Adria microplate, which rotates at a significantly slower rate of <0.5°/Ma in a CCW sense. We correlate the episodes of change in rotation rates with post-Miocene changes in the Adria microplate kinematics, caused by a change in Nubia and Eurasia motion and by Adria fragmentation.

Grant of the National Science Centre, Poland, NCN 2026/21B/NZ8/02443, Późnokredowa ekspansja roślin kwiatowych na tle transgresji morza środkoeuropejskiego: **Palynology of the Rakowicze section, SW Poland** (A. T. Halamski, Institute of Paleobiology, Polish Academy of Sciences, Warszawa, Poland; J. Kvaček, Z. Heřmanová, National Museum, Prague, Czech Republic; E. Durska, Faculty of Geology, University of Warsaw, Warsaw, Poland; ***M. Svobodová***; 2019)

Palynomorphs from mudstones of the Rakowicze section characterize very low marine admixture of broken dinocysts, acritarchs and foraminiferal linings. Changing conditions of marine environment (from marsh to shallow marine) is documented through the section. Biostratigraphy is based on the presence of angiosperm pollen from the Normapolles group *Interporopollenites* cf. *turgidus, Pecakipollis* and *Neotriangulipollis* which appear near the Coniacian/Santonian boundary.

International Geoscience Programme (IGCP) of UNESCO & IUGS, Project Code IGCP No. 653: **The onset of the Great Ordovician Biodiversification Event** (International Leader: T. Servais, French National Centre for Scientific Research, France; Czech representative: O. Fatka, Faculty of Science, Charles University, Prague, Czech Republic; other Czech workers: ***R. Mikuláš***; P. Budil, Czech Geological Survey, Prague, Czech Republic; 2016–2020).

Several tens of morphologically anomalous exoskeletons of trilobites have been collected and documented from Cambrian to Devonian clastic sediments and carbonates of the Prague Basin. An exceptionally preserved articulated and partly enrolled exoskeleton of the Ordovician nektobenthic trilobite *Parabarrandia bohemica* (Novák, 1884) exhibits a prominent palaeopathological anomaly of its pygidium, which can be attributed

both ichnotaxonomically and ethologically to the trace fossil *Oichnus ovalis* Bromley, 1993 observed in the Recent as an octopus-produced praedichnial structure. For this reason, large cephalopods are proposed as potential candidates for durophagous predators responsible for the described trilobite injury. For other results, see also the ongoing project No18-05935S of the Czech Science Foundation.

Project of Joint Institute for Nuclear Research, Dubna, Russia, No. 04-4-1121-2015/2020: **Investigations of Condensed Matter by Modern Neutron Scattering Methods** (T. Ivankina, I. Zel, R. Vasin, Joint Institute for Nuclear Research, Frank Laboratory of Neutron Physics, Dubna, Russia; ***T. Lokajíček***, ***M. Petružálek***, ***T. Svitek***; 2015–2020)

Subproject 1: Comprehensive analysis of the lithosphere elastic anisotropy and properties of lithosphere materials using neutron diffraction and ultrasonic sounding. Westerly granite (WG) was studied by ultrasonic sounding on spherical samples under hydrostatic pressure up to 400 MPa, neutron diffraction on identical samples and scanning electron microscopy (SEM TIMA). The samples were thermally treated at 100 °C, 200 °C, 400 °C and finally 600 °C. TIMA operates on the principle of energy-dispersive X-ray spectroscopy (EDS) combined with the detection of backscattering electrons (BSE). Neutron diffraction measurements (SKAT time-of-flight diffractometer, beamline 7A2 of the IBR-2 pulsed reactor, FLNP JINR, Dubna) was used in samples heated to 100 °C and 600 °C to determine the texture of WG and to document its changes due to the thermal treatment. Four spherical samples (treated to the four above mentioned temperatures) were ultrasonically sounded under hydrostatic pressure up to 400 MPa (Institute of Geology). The main mineral components are quartz (23.8 wt.%), orthoclase (24.4 wt.%) plagioclase (40.2 wt.%) and biotite (5.4 wt.%). The 3D distribution of P-wave velocities at low pressures shows orthorhombic symmetry. On the other hand, the 3D distribution of P-wave velocities at high pressures reflects intrinsic structure and even though the anisotropy is low, the orientation of the minimum velocity corresponds to the highly preferred orientation of plagioclase (010) and biotite (001). Nevertheless, while the orientation of plagioclase and biotite coincide, P-wave velocities of crystals act against each other. The 3D distribution of P-wave velocities at high pressures is then more influenced by the strong anisotropy of biotite rather than the high volume of plagioclase. Image analyses showed that there is also a preferred orientation of microcracks regardless of their size and thermal treatment level. Neutron diffraction measurements confirm weak intrinsic elastic anisotropy, which remains unchanged due to the thermal treatment. We can assume that in Westerly granite there are two types of anisotropy: crystal-preferred orientation formed during igneous crystallization and second one due to orientated microcracks which have been formed during tectonic exhumation or during sample excavation in the quarry. Both seem to be unrelated.

Subproject 2: Elastic anisotropy of layered rocks: ultrasonic measurements and texture-based theoretical predictions. We continued the study of seismic anisotropy in layered rocks with the application of different experimental (texture and elastic velocity measurements, elastic tensor inversion) and theoretical (effective media modelling) approaches. Internal structures in geological media that can lead to anisotropy are orientated cracks, orientated grains (crystallographic preferred orientations [CPO]), parallel fractures, compositional layering (periodic sequences of thin layers) and orientation of plate-like minerals. Accordingly, for this project we propose a complex investigation of different specimens of mica gneisses collected from the Sibishel Shear Zone, located in the South Carpathian Mountains (Fagaras Mts.), Romania. The XRF results showed a relative diversity in the contents of major elements, a wide variability being registered in the case of Al_2O_3 the contents of which varied between 8.3 % in the case of sample Ro04 and 17 % in the case of sample Ro02. This variability was correlated with the mineral composition of the same specimens, whose main minerals were quartz, plagioclases (anorthite and albite), hornblende, magnesiohornblende, clinochlore, talc and muscovite. Only sample Ro02 could not be analysed by XRD due to its extremely high muscovite content. Moreover, sample Ro01 showed the presence of at last three zones with different mineral compositions, which needed a detailed investigation. Three samples of spherical shape were prepared for measurements. One sample was damaged during the preparation, so it was not suited for ultrasonics. The crystallographic textures of four biotite gneisses (including one sample of irregular shape) were obtained using neutron diffraction. CPOs of major rock-forming minerals were measured at the neutron texture diffractometer SKAT at the pulsed reactor IBR-2 in Dubna, Russia.

The complete 3D P-wave distributions at confining pressures ranging from 0.1 to 400 MPa were measured for three samples at the Inst Geol, Czech Acad Sci (Prague). All samples exhibit almost transversally-isotropic symmetry in Vp distribution that reflects the large amount of mica grains (up to 20 %) in the samples. All measured samples are characterized by high levels of elastic anisotropy at atmospheric pressure (about 18 %). It was shown that the bulk elastic anisotropy of the sample is basically controlled by the CPO of the phyllosilicate minerals.

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, Kangwon 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 most recent warmest period in the Phanerozoic Eon. Compared to the present, it was characterized by elevated atmospheric CO_2 levels and considerably higher global sea level. The project aims to reveal the Cretaceous 'Greenhouse' oceanic and terrestrial climate, environmental conditions and their evolution and will lead to an in-depth knowledge of the existing characteristics of rapid climate and environmental changes and global warming. To understand biodiversity evolution

under greenhouse climate conditions, three main topics are addressed: (1) Cretaceous geological records of sea and land facies in Asia; (2) climate and environment, and (3) the nature of linkages between major geological events and rapid climate and environmental changes.

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 the Asian countries, including some countries outside Asia.

6b. Czech Science Foundation

Finished projects

No. *17-03211S*: **Coupled solid-phase speciation and isotopic record of thallium in soils: A novel insight into metal dynamics** (A. Vaněk, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences, Prague, Czech Republic; M. Mihaljevič, Faculty of Science, Charles University, Prague, Czech Republic; ***J. Rohovec***; 2017–2019)

In the course of the project, we studied model samples of synthetic mineral phases present in soils, soil samples rich in thallium as well as samples of coal originated at Bogatynia and Sokolov, which represent sources of Tl for the geochemical cycle. We developed methods of thallium thermal desorption (TD) in synthetic air and implemented it for speciation study. The expected thallium release from the solid phase into the gas one was observed for all samples investigated. Due to very low abundance of Tl, it was possible to follow it only by ICP MS technique. TD was quantitatively described as a dependence of released amount of Tl on temperature. Thallium TD occurs at appreciable higher temperatures than TD for, e.g., Hg or As. The shape of the TD curve can offer only modest information, as it is quite similar for groups birnessite/ferrihydrite/goethite and illite/calcite, respectively, but the desorption temperature onsets differ between groups. In the case of sulphidic phases (pyrite, sphalerite), more complex behaviour was found. Combined with the results of differential thermal analysis/differential scanning calorimetry (DTA/DSC) study, signals can be ascribed to Tl release accompanying sulphur release from the pyrite disulphidic units. The shape of thallium TD curves of soil samples led to only inconclusive results. Curves resemble each other regardless of the locality and soil horizon. The differences in onset temperatures were more diagnostic, pointing out to groups of thallium bearing mineral phases.

In order to differentiate TD records of soils, we tested Tl TD in reducing and/or oxidizing atmosphere. Thallium present in soils is not activated for TD by reducing atmosphere, while the oxidizing atmosphere improves its release. Focusing on work in pure O_2, it was observed that the thallium amount released is higher compared to the reducing or inert conditions, but no significant shift of onset temperature occurs. This way, it was also possible to identify Tl bound to group of illite from group of birnessite in soils. Soil samples containing both Tl(I) and Tl(III) gave practically identical Tl TD records, thus the oxidation state of Tl in the soil could not be identified. In the case of sulphidic species of Tl, strong activation of TD was observed, which is ascribed to simultaneous oxidation of sulphide.

We have found that it is possible to study thallium speciation in natural samples by TD techniques, in spite of trace levels of this element, requiring the ICP MS detection. Oxidizing atmospheres of air or oxygen are more feasible for this study than reducing or inert ones. The identification of Tl species in soil remains only approximate. The method is based on a comparison with known materials, thus incorporating the results of DTA, DSC and other methods is helpful. Nevertheless, based on the TD onset temperature, at least a group of Tl-bearing species can be judged. Similarly to other thermal analysis methods, Tl TD is a comparative technique.

No. *17-06700S*: **Přídolí Series in the Prague Synform - proposal for chronostratigraphic subdivision** ***(L. Slavík***, ***P. Štorch***; Š. Manda, Z. Tasáryová, P. Čáp, Czech Geological Survey, Prague, Czech Republic; 2017–2019)

The principal aim of the project was chronostratigraphic subdivision of the Přídolí Series. Solution of such a complex problem required several steps as follows:

1. Refinement of conodont biozonation and formal establishment of the first multi-zonal conodont scale for the Přídolí in its stratotype area: This most important task for the carbonate successions has been accomplished and the new regional conodont zonation was published.
2. Systematic revision and description of conodont taxa where appropriate and definition of major morphological changes within conodont clades in response to paleoenvironmental changes and mid-late Přídolí isotopic excursions: This has been done and partly published. The major morphological changes enabled definitions of zonal indexes, and, also a new promising marker for the base of the Devonian (and termination of the Přídolí). The response of conodont faunas to the IE of the late mid Přídolí is, however, rather indistinctive.
3. Revision and extension of available graptolite data using so far unstudied section in the most off-shore settings preserved in the Prague Synform, and correlation with to-date employed global graptolite biozones: The graptolite zonation has been re-evaluated and new schemes will be included in the publication in preparation. The major problem seems to be the cancellation of the taxon *perneri* – a former important late Přídolí marker, that appeared to be a group of different or misidentified taxa.
4. Detailed study of environmental and faunal changes across early-late Přídolí boundary and correlation with graptolite and conodont biozones; the use of non-graptolite macrofaunas for intra-basinal correlations and correlation within peri-Gondwana and more distant areas (Fig. 14): This point has been mostly done. In some cases, the major problem was the precise correlation in those parts of the sections where conclusive biostratigraphic data were missing.
5. Paleoenvironmental interpretation based on both published and new geochemical data: (i) whole-rock geochemistry – major and selected trace elements (REE, transition metals);

■ **Fig. 14.** Fieldwork in Southern Tien Shan, Uzbekistan. Photo by L. Slavík.

(ii) mineral chemistry, and (iii) carbon and oxygen isotopes: extensive datasets with geochemical data from several late Silurian sections have been obtained. These will be partly included in the next publication. Volatility of the geochemical signal and open system environment in some sections, however, will not contribute significantly to paleoenvironmental interpretations, and, to the biostratigraphic subdivision either.

6. Integration of published and newly obtained biostratigraphic data and integration of conodont and graptolite biozones with data on biotic changes in other marine faunas, geochemical ($\delta^{13}C$ and $\delta^{18}O$ isotopes) and petro-physical data (established magnetic susceptibility and gamma-ray spectrometry logs from the Přídolí strata) into the generalized correlation chart: This has been accomplished and presented at the International Congress on Stratigraphy.
7. Proposal of subdivision of the Přídolí Series into two stages based on integrated studies of selected sections in the Prague Synform (lithology, sedimentology, biostratigraphy, faunal content, geochemistry and petro-physical data): The final step and the main goal of the project has been achieved; three options for the subdivision have been presented and offered to the International Subcommission on Silurian Stratigraphy (ISSS/ICS), publication is in preparation.

No. *17-10233S*: **The oldest vascular land plants and palynomorphs from the Silurian-Lower Devonian of the Barrandian area, Czech Republic** ***(J. Bek***; J. Pšenička, West Bohemian Museum, Plzeň, Czech Republic; J. Kvaček, National Museum, Prague, Czech Republic; 2017–2019)

Important contribution of this project is the publication of a new and the oldest species of the genus *Cooksonia* – *Cooksonia barrandei* in the prestigious journal Nature Plants. The paper made it clear that the find of *C. barrandei* rewrites textbooks; it shifts the earliest record of land plants to 432 Ma and represents the oldest vascular plant globally. Additionally, *C. barrandei* is very large compared to other species of *Cooksonia*. Its robustness undermined the hypothesis that first plants were not able to reach photosynthesis because of their small size. Using the example of *C. barrandei* the hypothesis can be ruled out. Our additional studies on early land plants broadened our knowledge about the first polysporangiate plants occurring in the Barrandian area. We published a paper describing further details of *C. barrandei* and associated flora including dispersed spores occurring at the Loděnice locality. Dispersed spores are the oldest sculptured trilete spores in the world. During the project, we have studied in detail further plant material coming from the Silurian of the Barrandian area. We critically revised *Cooksonia bohemica* in parallel with attempts of sampling spores *in situ*. Further material from the Karlštejn locality yielded a new species of *Aberlemnia karlstejnica* sp. nov. Another important publication of the team described a rich association of six species of 15 specimens of embryophyte plants, which were discovered from the upper Silurian (Přídolí) of the Prague Basin. A new genus and species of *Tichavekia grandis* Pšenička et al. was

established and published in the journal Palaeoecology, Palaeoclimatology, Palaeogeography.

In 2019, *in situ* microspores were discovered in the holotype slab of *Tichavekia grandis* and the species was subsequently subjected to a revision submitted to the Botanical Journal of Linnean Society. The plant colonization in the studied region implies a significant role for islands in plant dispersion. The Prague Basin is apparently among those playing a key role in this process of colonization, strongly influenced by local environment dynamics as well as by global climatic and sea level changes. The global Initial Plant Diversification and Dispersal Event (IPDDE) in the Přídolí attaining a local diversity and distribution maximum in the Givetian (Middle Devonian) are major palaeobotanical features of this region in the Early Palaeozoic. Thus, the key events of plant evolution are now completed in the unique Central European area providing a very rich fossil record through the whole history of plant evolution.This conclusion will strongly influence the view of early plant colonization of the terrestrial environment worldwide.

No. *17-15700S*: **Black shale formations as geochemical markers of paleoenvironmental changes and tectonic setting along active continental margins *(L. Ackerman*, *M. Svojtka*, *E. Haluzová, J. Ďurišová***; J. Pašava, F. Veselovský, V. Erban, O. Šebek, Czech Geological Survey, Prague, Czech Republic; J. Žák, J. Hajná, Jakub Trubač, Faculty of Science, Charles University, Prague, Czech Republic; 2017–2019)

This project was focused on black shale-greywacke successions to: (1) elucidate the influence of different geotectonic settings on their composition, (2) provide new insights on the oxygenation of the Earth`s atmosphere and oceans in the past, and (3) improve our knowledge on the compositional and temporal evolution of accretionary wedges.

(1) The Teplá-Barrandian (TBU) black shales form fragments within the siliciclastic successions (*Type I*), they are intimately related to MORB-like basalts (*Type II*) or they overlie volcanic arc (*Type III*). An extensive dataset of combined major/trace element and Cu-Zn-Mo-Cr-S-Os isotopic data revealed marked differences among these suites. The *Type I* black shales were deposited in anoxic–euxinic conditions in restricted or open environments with the former expressed by high terrigenous flux and elemental and isotopic Cu-Zn-Cr-Os-Ni modifications. We document that the inputs and sinks of these elements were closely related to the extent of terrigenous flux and reveal that organic-rich sediments at active continental margins play an important role in the burial of isotopically light Cu and Zn in the ocean. The *Type II* black shales are characterized by only moderately heavy Mo and Cr isotopic signatures suggesting deposition in anoxic conditions. Finally, the *Type III* black shales (Fig. 15) underwent silicification and yield largely light Mo and Cr isotopic signatures indicating suboxic to anoxic conditions, perhaps related to the collapse of the nearby arc.

■ **Fig. 15.** Silicified black shales of the Lečice Member, right bank of the Vltava River near the Štěchovice dam. Photo by M. Svojtka.

(2) Possible fluctuations of oxygen levels during the Proterozoic were investigated using TBU black shales and Paleoproterozoic rocks from Brazil. Combined Cu-Cr-Os isotopic data of the *Type I and II* black shales suggest high levels of surface oxygenation during the Neoproterozoic–Cambrian transition while the $^{187}Os/^{188}Os$ composition did not confirm the previous suggestion of a rapid increase in $^{187}Os/^{188}Os$ towards the Cambrian boundary. We show that the extent of Mo isotopic fractionation between the Paleoproterozoic (1.9–2.1 Ga) Mn-silicate–cabonate ore (Fig. 16) and the graphitic schist is similar to modern Mn-oxide precipitates and seawater indicating an oxic–anoxic -stratified Palaeoproterozoic ocean.

■ **Fig. 16.** A rhodonite vein (pink) in queluzite (Mn ore) from the Morro da Mina mine, Brazil. Photo by A. R. Cabral.

(3) Basaltic rocks of the Blovice accretionary complex (Fig. 17) represent volcanic members of Ocean Plate Stratigraphy and indicate that the oceanic realm consumed by the Cadomian subduction was a complex mosaic of intra-oceanic subduction zones, volcanic island arcs, and back-arc basins with a mantle plume impinging the spreading centre and subsequently also the active margin. Using field observations, U–Pb ages and geochemistry, we also present a new model for the origin of the chert-greywacke association representing a rarely documented case of submarine, outer trench slope deposit representing a new type of subduction-related mélanges.

Within the framework of this project, we also developed and established a new Mo isotopic protocol for high-precision isotopic analyses.

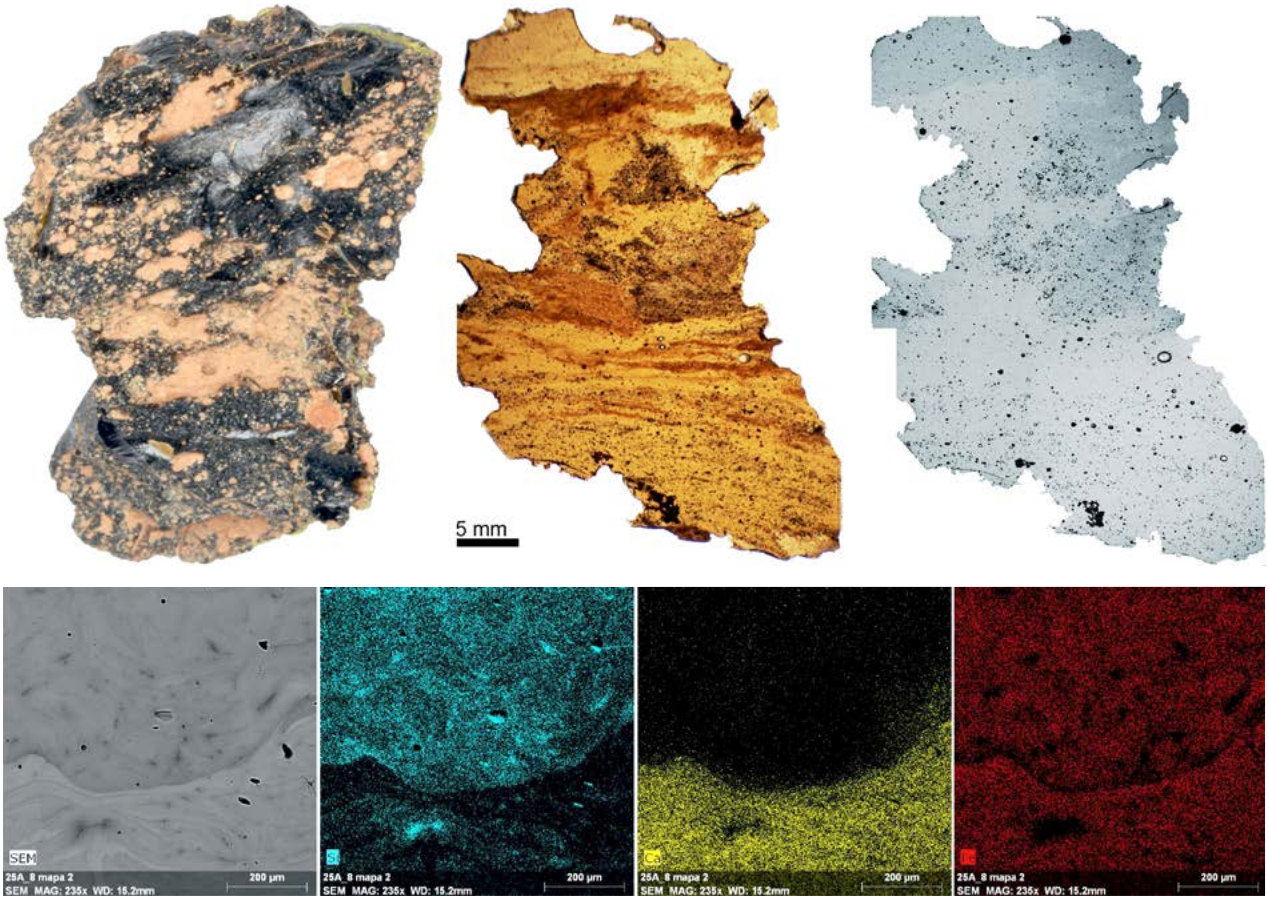
No. *17-23836S*: **Transformation of the Burgher House in the 13th Century (Brno-Prague-Wroclaw)** (M. Peška, Archaia Brno, public benefit company, Czech Republic; ***L. Lisá***; Tomasz Cymbalak, Institute of National Monuments, Prague, Czech Republic; 2017–2019)

During three years of the project, all preset goals were addressed, and the results were both expected and surprising, mainly in the field of geoarchaeology. Many outputs were already published; others are prepared for print in several professional periodicals, including the monograph "Transformation of urban houses in the 13th century", and will be published in the course of 2020. These outputs, summarizing the present knowledge from Moravia and from the cities of Prague and Wrocław, are partly published in foreign language. In the following decade, they will create the foundations of research on the oldest

■ **Fig. 17.** An outcrop of submarine pillow lavas within the Blovice accretionary complex. Photo by J. Hajná.

urban architecture in East Central Europe. As regards the summary of finds from Moravia and Prague, we paid a great deal of attention to the construction of timber-and-earth buildings. Several examples from the cities of Uherský Brod and Brno indicate the existence of aboveground uncellared parts. Post constructions can be regarded as a domestic tradition, which survived in rural areas until the beginning of the Modern Era. Interesting would be an ethnological comparison with the oldest preserved rural log buildings. Frame constructions, on the other hand, were predominantly built in towns and are related to German-speaking immigrants. In a separate publication, we also paid attention to methodology of analyses of burnt clay daub. It came to the light that the analysis of finds from infills is very problematic. As regards the definition of primary urban architecture as temporary structures, we rather reject this opinion. The high number of basements in Brno and Prague enabled their categorisation and comparison, which refers to striking similarities. The oldest masonry architecture sporadically appeared before the mid-13th century, in Jihlava already since the 1260s, which is given by the wealth of this town associated with silver mining. However, wooden architecture, except for the main town square, survived deep into the 15th century. Urban architecture in the cities of Brno, Opava, Jihlava and Olomouc came to the fore at the end of the 13th century. For Znojmo we unfortunately lack sufficient archaeological data. The research results probably indicate that masonry architecture in peripheral royal towns and liege towns was not widespread until the mid-15th century. The principal aim of micromorphological research was to evaluate the information potentially coming from the floor composition. The first part of the project was to compare floors of different contexts. One of them represents Recent and former domestic floor from Dolní Němčí, the second one studied Subrecent floors in the area of Moldova/Romania border along the Prut River. The second part of the project was to find suitable references for the understanding of formation processes of medieval floors. Some case studies from Brno medieval contexts were finished, the other papers are under preparation.

No. *17-27099S*: **Variability of the Australasian tektites in wider vicinity of Muong Nong in Laos – Constraints on their source rocks and a parent crater location.** ***(R. Skála***, ***Š. Křížová***, ***K. Žák***, ***L. Ackerman***; 2017–2019)



■ **Fig. 18.** Appearance and fabric of typical Muong Nong-type Australasian tektite (MNAAT) from Laos. Upper row from left to right: macroscopic appearance, 400 µm-thick polished section in transmitted light, and mosaic of back-scattered electron (BSE) images taken at low magnification. Both optical and BSE images illustrate pronounced heterogeneity of MNAAT. Bottom row shows the fabric at higher magnification in BSE image and X-ray element distribution maps. Note that heterogeneous appearance is present on various scales. Photo by Z. Korbelová, Š. Křížová, R. Skála.

Principal goals of the project comprised finding of a potential signature of extraterrestrial component in Australasian tektites (AAT) from the centremost region of occurrence of Muong Nong-type tektites in Laos (Fig. 18), constraining probable tektite parent rocks, and locating the place of the potential parent impact crater through the study of chemical composition of AAT and country rocks that might represent tektite precursors. The studied sample set included 37 AAT involving Muong Nong-type (MNAAT) and splashform type (SFAAT) specimens. In addition, a suite of 28 samples of sediments from Laos representing potential AAT parent materials was available. The samples were characterized in thin sections, bulk chemical data were acquired for sediments, AAT were analysed by EPMA and LA-ICP-MS.

Sr-Nd-Pb isotopes indicate Paleozoic to Mesozoic sedimentary parentage. However, late Neogene to early Quaternary re-deposition and formation of a thick silt-sized vertically stratified sedimentary sequence is required. Lead isotopes document at least three different components sorted during the transport and final deposition of the target sediments.

HSE contents and Re–Os isotopic compositions in MNAAT suggest mingling of crustal-derived and extraterrestrial materials. Fractionation of HSE as well as extremely low contents of Os in MNAAT require an impact targeted to a shallow sea to form these tektites. The contents of HSE and values of the $^{187}Os/^{188}Os$ ratio indicate less than 0.005 % addition of a chondritic impactor in this type of AAT.

Triple oxygen isotope analyses of AAT provided data that lie within the range typical for terrestrial crustal rocks. They also indicate that the tektites were not modified either by the substantial projectile matter admixture or by an interaction with the atmosphere.

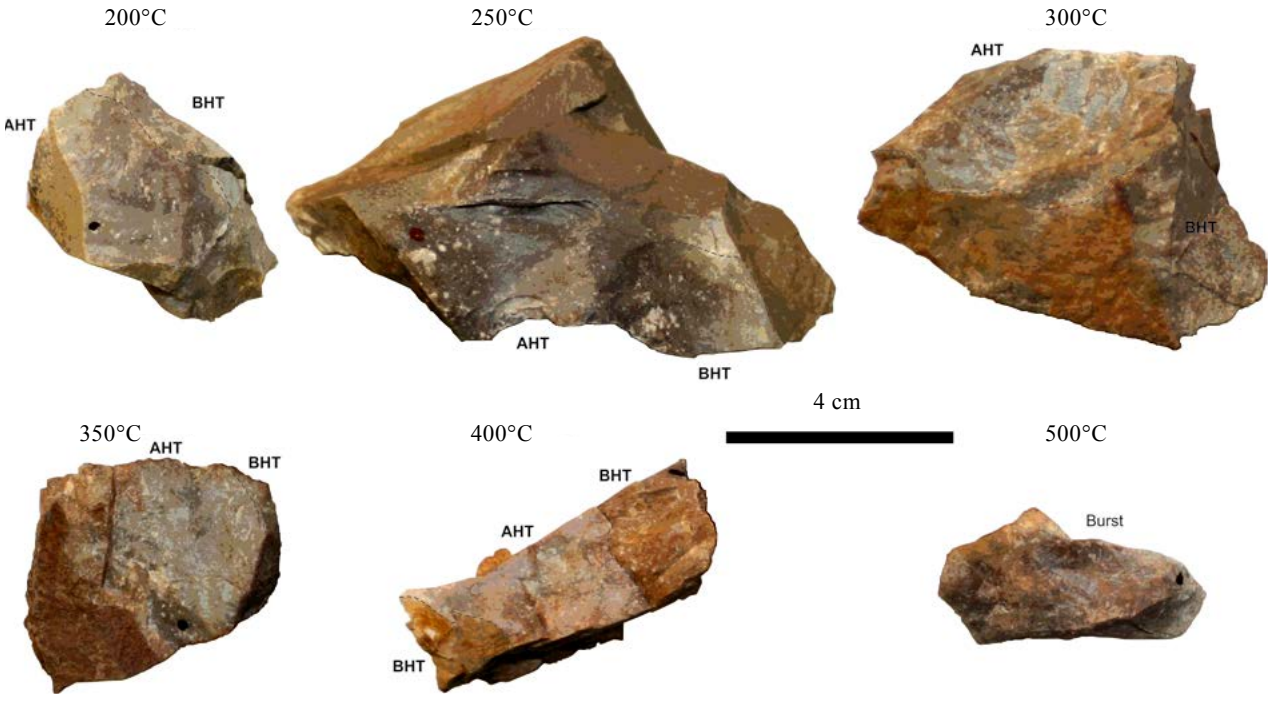
Carbon content in glass and its isotopic composition indicate that the carbon is of organic origin, i.e., inherited from the target sediments. In these sediments, organic carbon dominated over carbonate carbon. In a few MNAAT, a unique assemblage of <10 μm across sulphide globules was encountered. Rare mineral shenzhuangite, $NiFeS_2$, was identified among other sulphides, which may indicate a meteoritic component. Potassium elemental and isotope systematics were determined for moldavites and sediments from the Ries crater and its vicinity as an analogue to AAT. Wider K isotope range in moldavites compared to sediments is paralleled by overall enrichments in K contents indicating no K loss from moldavite melt as a consequence of high temperature.

Ongoing projects

No. *18-02606S*: **Non-destructive determination of heated artifacts in Upper Palaeolithic assemblages** (M. Moník, Faculty of Science, Palacký University Olomouc, Czech Republic; Z. Nerudová, Moravian Museum, Brno, Czech Republic; ***P. Schnabl***; 2018–2020)

Tectonic breakage, in the form of poorly healed cracks, may cause problems in the production of stone tools. The cleavability of these rocks can, however, be improved by heat treatment which was successfully practiced by prehistoric people around the world. The earliest evidence of heating method in Europe comes from the culture of Solutrean (around 24,000-17,000 uncal BP) in France and the Iberian Peninsula. The method was re-discovered in the Mesolithic (from 9500 uncal BP).

Current research aims to identify this technique in the Magdalenian (15,000–11,500 uncal BP) in Moravia (Czech Republic), where the Olomučany-type chert was used Outcrops of the Olomučany chert are located 5–10 km NNE of Brno in



■ **Fig. 19.** Heated Olomučany chert. Photo by M. Moník.

relics of Jurassic sediments in the SSE part of the Olomučany municipality. Limestone strata of Callovian to Kimmeridgian age, 50 m-thick, contain intercalations and lenses of chert. Chert is macroscopically grey to greyish black, with microfossils and opaque matter, probably also of organic origin. Some cherts are coloured in a rusty-brown colour due to the presence of secondary iron oxides. Microfossils are mainly represented by marine sponge spicules. At low magnification, the original rock structure is sometimes visible. Siliceous matter is mostly composed of chalcedony with rare occurrences of crystalline quartz. Chalcedony forms both cryptocrystalline matrix (a very fine mass) and larger spherules, most likely replaced by up to 0.2 mm sized microfossils. It is therefore coarser-grained than most other cherts in northern Moravia and Silesia. Exceptionally, this chert also contains grains of green glauconite.

A combination of three methods was used to identify heating: Fourier Transform Infrared Spectroscopy (FTIR), Mass Magnetic Susceptibility (MS_{mass}), and Isothermal Remanent Magnetization (IRM) measurement. The FTIR is suitable for the identification of heat-treated cherts that have been exposed to temperatures of up to 300 °C. The explanation of this process lies in the composition of magnetic minerals where, at temperatures between approximately 200 and 400 °C, iron oxides are hydrated by water released from chalcedony. Above 500 °C they dehydrate again and at the same time reduce to hematite and magnetite (Fig. 19). Temperatures of about 250 °C are sufficient to improve the cleavability of fine-grained cornea; mechanical changes of the Olomučany chert together with heating will be the subject of an article planned by our team for 2020. Heating above 300 °C was probably undesirable because mechanical properties of the Olomučany chert rapidly deteriorate above 350 °C.

The newly designed methodology is therefore suitable for the study of thermal treatment of artifact splitting material in the whole range of raw material stability.

No. *18-05935S*: **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, Czech Republic; Z. Heřmanová, National Museum, Prague, Czech Republic; M. Vohník, Inst Botan, Czech Acad Sci, Průhonice, Czech Republic; ***R. Mikuláš***, ***L. Slavík***; M. Mergl, University of West Bohemia, Plzeň, Czech Republic; 2018–2020)

Unusual combinations of trace fossils (with limited information from body fossils) enabled to interpret the uppermost interval of the Lesser Himalaya Synform as Ordovician in age. This contradicts previous dating of these strata to the Upper Cambrian. In the Bohemian Massif (the Šárka Formation; early and middle Darriwilian), a specific kind of trace fossils are preserved within siliceous nodules. They are associated with almost all taxonomic groups composing a rich and diversified fossil assemblage of the formation. *Arachnostega*, *Pilichnus* and *Palaeophycus* are the most abundant ichnogenera observed. The preferred distribution of feeding traces in each shell reflects the topology of the soft tissues serving as food. All studied feeding traces were found in nodules, never in shales of the Šárka Formation. Considering all circumstances, we interpret the abundance of the described kind of feeding traces as an illustration of the prosperity of this feeding behaviour during the Darriwilian. An increase in the abundance, diversity and complexity of communities that fed within the internal ecospace of shells is considered to be a primary effect related to increased ecosystem complexity during the Great Ordovician Biodiversification Event.

No. *18-08826S*: **Resistance to brittle damage: use of petrographic/ rock mechanical data for the technological-mechanical behaviour and serviceability of crushed stone** (R. Přikryl, Faculty of Science, Charles University, Prague, Czech Republic; ***T. Lokajíček***, ***M. Petružálek***, ***T. Svitek***; Z. Weishauptova, M. Vorokhta, Inst Rock Struct Mech, Czech Acad Sci, Prague, Czech Republic; 2018–2020)

Experimental material was sampled from 25 localities with exploited volcanic rocks and from 7 localities with exploited greywackes. At each locality, 2–4 compact homogeneous blocks of approx. 30 × 30 × 25 cm in size and end-products – crushed stone of specific size fractions – were sampled. The sampled material was used for petrographic analyses, laboratory rock-mechanical tests (larger blocks), and for laboratory tests of technological-mechanical performance (various size fractions). For petrographic analyses, series of thin sections were prepared for optical microscopy (ordinary thin sections) and scanning electron microscopy with microanalysis (polished thin sections). Microscopic study focused both on the identification of present mineral phases and their quantification (by employment Petrographic Image Analysis – PIA), and on the study of rock microfabric (also facilitated by PIA). A special set of thin sections prepared from specimens with pore space impregnated by a mixture of epoxy resin/fluorescent dye allowed for visualisation of pore spaces in more porous rocks as studied by fluorescent incident light microscopy. This part of observation was coupled with information on pore space obtained by an indirect method – high pressure mercury porosimetry which was applied to 2/3 of the studied specimens. Petrographic study of the sampled rocks was supplemented with powder X-ray diffraction (phase analysis of phases which are hardly recognized by microscopic study) and wet-silicate analyses (providing supplementary data for petrographic classification of studied rocks). In the case of sampled blocks, a set of specimens was prepared by diamond drilling and sawing. For each intact block, 5 cylindrical specimens (height of 100 mm, diameter of 50 mm) and 5 disc-shaped specimens (thickness of 25–30 mm, diameter of 50 mm) were obtained. These specimens were subject to laboratory rock-mechanical testing by uniaxial compression (in the case of cylindrical specimens) and by indirect tension ("Brazilian" test in the case of disc-shaped specimens). For uniaxial compression test, 2 of the tested specimens of each rock type were analysed for their stress/strain behaviour in order to obtain data necessary for computation of elastic and/or energetic parameters. During the second year of study, 160 tests for uniaxial compression (of 64 with stress-strain recording) and 160 tests for indirect tension were performed. Remaining specimens (100) will be analysed in 2020. The sampled end-products (respective size fractions of crushed stone) were used for the preparation of laboratory batches by sieving as required for specific technological-mechanical tests (e.g., Los Angeles attrition test, micro-Deval test,

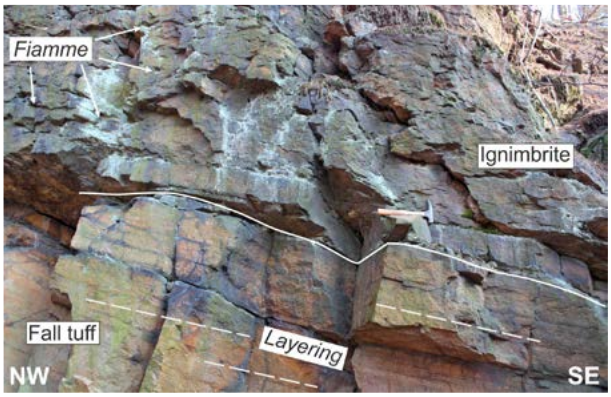
ACV, AIV, NA). During 2019, technological-mechanical testing encompassed all remaining materials sampled in 2018 and volcanic rocks sampled in 2019. The remaining material sampled in 2019 (greywackes) will be tested during the first half of 2020.

No. *19-02177Y*: **Magma transfer and emplacement processes in collapsing orogens** (***F. Tomek***, ***J. Černý***, ***J. Rejšek***, ***Minh Phuong Le***, ***E. Vosáhlová***; 2019–2021)

Laboratory work involved series of centrifuge experiments in order to simulate strain field in a rising elongated diapir in the Hans Ramberg Tectonic Laboratory (Uppsala University, Sweden). Scaling of the set-up was designed based on published parameters. The material included 15 one-millimetre layers of plasticine of different colours and the same rheological properties (host-rock paragneiss) and underlying layers of coloured silicone (magma). Two sets of material boxes (rigs) were prepared with different ratios between host-rock and magma volume and thickness. The procedure involved centrifuging in 500 g for 12 minutes and was repeated 4 times. After each run, we documented extension magnitude and took pictures of the rig. After that, we cut the rig in several parallel sections and documented the rig interior. In both cases, we produced a diapiric structure with upwelling magma and down-going host rock. This was allowed, however, only by a fault introduced in the experimental rig. Without it, the silicone would not be able to propagate through the rather stiff plasticine itself. The deformation pattern in the upwelling silicone revealed a gradient of vertical displacement and progressive folding of weak silicon situated beneath the diapiric channel in the source region. Another important result is the presence of descending streams in the feeding channel between the source layer and the surface dome. We plan to continue with different materials in 2020.

Field works in 2019 were focused on: (1) the Tharandter Wald caldera; (2) the Teplice rhyolite, and (3) the Sayda dyke swarm. (1) In the Tharandter Wald caldera (Fig. 20), we conducted initial mapping as a base for targeted sampling of AMS and geochemistry planned for 2020. In addition, we also collected three samples for radiometric dating. (2) From the Teplice rhyolite (an intracaldera fill of the Altenberg–Teplice caldera; Fig. 21) we sampled 74 AMS stations, which will be analysed

■ **Fig. 20.** A fan of columnar cooling joints in crystal-poor ignimbrite, Tharandt Wald caldera. An abandoned quarry near Mohron, Germany. Photo by F. Tomek.



■ **Fig. 21.** The Teichweg member (formerly Western margin) of the Altenberg–Teplice caldera. The photo shows a fiamme-rich ignimbrite resting above air-fall deposit with apparent layering. The tilt of the originally horizontal layers reflects a trap-door style of caldera collapse dipping towards the east. An outcrop 400 m NE of the Mikulov v Krušných horách train stop, Czech Republic; hammer for scale. Photo by F. Tomek.

and interpreted in 2020, and (3) The Sayda dyke swarm is related to the Altenberg–Teplice caldera, and possibly represents its rhyolite feeding system (Fig. 22). Here we collected over 50 samples for AMS and petrographic analyses complemented by two samples for geochronology and 15 samples for geochemistry. A preliminary data analysis indicates that this dyke swarm is geochemically compatible with volcanic rocks of the caldera, and that the activity of both complexes was synchronous. In addition, the magnetic fabrics revealed a complex inner architecture of such feeding system.

■ **Fig. 22.** Inclined cooling columns in a shallow rhyolitic feeding structure of the Sayda dyke swarm. Quarry Röthenbacher Berg (Germany). Photo by F. Tomek.

Most interesting output of our project involves linking the Altenberg–Teplice caldera with tuff and volcaniclastic horizons in the West and Central Bohemian Carboniferous basins. Based on the new and recent published geochronology data of our team, we interpret the magmatic activity of the Altenberg–Teplice caldera between 325–312 Ma, whereas the main volcanism occurred between 317–313 Ma; peaked around 314 Ma. This interval and peak largely overlap with dating of tuff layers. We employed an analysis of grain size of the 314 Ma Bělka tuff,

a layer which is widespread in both the West and Central Bohemian Carboniferous basins. The map distribution suggests a decreasing size of quartz fragments and Bělka thickness from stations close to the caldera towards southwest. Our results represent first solid evidence that the Bělka tuff was sourced from the Altenberg–Teplice caldera, the only volcano large enough to produce such large-volume eruption that deposited fall-tuffs at least 120 km away from the source.

No. *19-02606S*: **Oppidum as an urban landscape: multidisciplinary approach to the study of space organisation "intra muros"** (P. Goláňová, Faculty of Arts, Masaryk University, Brno, Czech Republic; ***L. Lisá***; 2019–2021)

During April 2019, pedological sampling of previously geophysically surveyed areas of La Terasse was conducted at the site (Bibracte, France; Fig. 23). Main archaeological works were done during the summer of 2019: geophysical survey and archaeological test pits, connected with samples for archaeobotanical, palynological, phytological, parasitological, anthracological, and diatomal analyses. Profiles of test pits served as places for micromorphological analysis. Now, a part of micromorphological samples is already interpreted and published as a part of Bibracte year report. Pedological sampling (by drilling) continued as well, unfortunately, sampling around the water source in the central area of the site showed disruptions caused by modern activities. Since September 2019, analyses of obtained samples have been in progress. During 2019 the French regional administration did not release the newly obtained (spring 2019) LiDAR data, and the LiDAR analysis could not have been undertaken, as a result. Data should be available in 2020.

■ **Fig. 23.** Documentation of ditch infill surrounding the La Terrasse site, Mt Beuvray/Bibracte. The infill is a sedimentary archive covering the timespan from the Celtic period to medieval times. Photo by L. Lisá.

Preliminary results were presented at international conferences and workshops Keltové/The Celts/Die Kelten 2019 (Stará Lesná, Slovakia), International Workshop on Archaeological Soil Micromorphology (Nancy, France), at the DIG Conference in Basel (Switzerland) and a seminar Kvartér/Quaternary (Brno, Czech Republic), and also during the scientific council of Bibracte (Glux-en-Glenne, France). Three papers have been submitted, one of which concerns the waterlogged environment.

No. *19-05198S*: **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, Brno, Czech Republic; 2019–2021)

Highly fractionated granites and LCT-type pegmatites (Li, Cs, Ta-enriched) are worldwide important sources of rare metals Sn, W, Nb, Ta, and alkalis Li, Rb, Cs. Gradual concentrations of these elements in magmatic rocks up to economically exploitable sources are closely related with the transition from magmatic to hydrothermal stage of their evolution. Greisenization and albitization – two chemically complementary metasomatic processes – play the most important role in the concentration of rare elements. The aim of the project is to identify hydrothermal (metasomatic) processes in typical rare element-enriched magmatic systems and to assess their significance for transport and concentration of metals.

Our activities in the first year of the project were focused at (i) laboratory work on samples collected in previous period or supplied by the foreign partner, and (ii) collecting new samples from type localities in the Krušné hory Mts. and in Portugal (Fig. 24).

■ **Fig. 24.** Join Czech-Portuguese team during fieldwork at Argemela. Photo by K. Breiter.lic. Photo by J. Borovička.

The impressively vertically zoned structure of the Orlovka granite cupola has been attracting an interrupted attention of geologists since its discovery. Through numerous publications, the Orlovka deposit has become well-known worldwide as a type locality of "albitized granites". The aims of cooperation with University of St. Petersburg were: (a) to assess the degree of

affinity of individual granite facies, (b) to evaluate the effect of magmatic *versus* hydrothermal processes on their formation, and (iii) to compare general trends of quartz, micas and zircon evolution at Orlovka in comparison with similar granite systems worldwide. Micas shows strong vertical evolution from biotite only slightly enriched in Li (0.65–0.80 wt.% Li_2O) in deeper-seated biotite granites through Li-rich phengite with a smooth transition to muscovite (0.3–2.0 wt.% Li_2O) in the central part of the cupola to zinnwaldite-trilithionite (2.4–4.0 wt.% Li_2O) in the uppermost part of the cupola. Quartz from biotite granites is generally more enriched in Ti and Li (5–95 ppm and 10–35 ppm, respectively) than quartz from the medium-level snow-ball granite (5–10 ppm Ti, 1–12 ppm Li) and the even more evolved upper granite types (<1 ppm Ti, 0.5–10 ppm Li). On the other hand, the contents of Al increased from 60–150 ppm in biotite granites to mostly 80–300 ppm in evolved rocks with large variability in all samples. Comparing the contents of Ti with CL-zoning, bright domains of crystals contain higher Ti than the dark domains regardless of their core/rim position. The evolution of quartz and mica is generally consistent with the already proposed model of two comagmatic intrusions: deeper-seated biotite granites underwent a complicated magmatic evolution with repeated episodes of crystallization and resorption of quartz, only a limited degree of fractionation, and a small – if any – reaction with fluid. Li-mica granites, taking position within the cupola, strongly fractionated upwards. The upward transfer of Li and rare metals was, moreover, supported by fluid unmixed at the middle level of the cupola.

We finished a systematic study of quartz chemistry started already within the GAČR project P210/10/1105 "*Trace elements in quartz*". A comprehensive review of all data obtained in the period 2012–2019 from ore-bearing magmatic/hydrothermal systems allow to distinguish quartz of magmatic or hydrothermal origin.

The Argemela granite stock in central-eastern Portugal represents a P, F, Li,Ta-enriched magmatic/ hydrothermal system evolved in several steps of fractionation. In cooperation with University of Porto we undertook a salvage research of just reclaimed quarry. A chemical and mineralogical study based on the data obtained is in progress.

No. *19-06728S*: **How precisely can we reconstruct Carboniferous tropical forests? Examples from the Czech Republic and Chin**a (S. Opluštil, Faculty of Science, Charles University, Prague, Czech Republic; ***J. Bek***; J. Pšenička, West Bohemian Museum, Plzeň, Czech Republic; M. Libertín, National Museum, Prague, Czech Republic; 2019–2021)

Combined anatomical and morphological studies of plants are the key themes in research concentrated mainly on material collected at the Wuda locality, China. Together with the team of Chinese palaeobotanists, we studied the following understorey plant taxa of the Wuda peat-forming forest: *Alethopteris ascendens*, *Nemejcopteris haiwangii*, *Oligosporangiopteris zhongxiangii*, *Holmopteris uncinatus*, *Palaeostachya guanglongii*, *Wudaeophyton wangii* and *Tingia unita*. Selected specimens were examined for their morphology, cuticles, anatomy and spores *in situ*. A unique combination of these features significantly extended the diagnoses of the studied species and, *via* improved knowledge of rachis/stem anatomy, also significantly contributed to better understanding of physiology and autecology of the studied plant species. Among the many interesting findings described was the oldest known twiner. The specimens are interpreted as evidence of the dual-climbing phenomenon known from modern tropical and subtropical forests, which has never been documented in the fossil record. Described was a new genus and species of callistophytalean liana-like pteridosperm *Wudaeophyton wangii*. Results of long-term Czech-Chinese collaboration on tuff flora aroused attention globally. International journal Review of Palaeobotany and Palynology offered to prepare a special issue dedicated only to the results of Czech and Chinese palaeobotanists and palynologists. In all, about nine common Czech-Chinese manuscripts with dedication to the project have been already submitted to this special issue. Palynological study included mainly *in situ* spores obtained by maceration of reproductive organs (e.g., *Palaeostachya guanglongii*, *Sigillariostrobu*s sp., *Tingia unita*, *Paratingia wudensis*, *P.* sp.*, Sphenophyllum parvifolium*, *S. angustifolium*, *S. oblongifolium*, *Eocycas wuhaia*, *Holmopteris uncinatus*, *Scolecopteris minuta, Nemejcopteris haiwangii*). These results will be also published in the Special Issue on the Wuda Lagerstätte. Forest reconstruction was addressed by a detailed analysis of data from the Wuda excavation. We also addressed two new targets related to the diversity through time and to ecological transect across Carboniferous landscape. We have already examined miospore diversity of the Czech part of the Intra-Sudetic Basin in a high stratigraphic resolution and compared it with the diversity of macroflora in the same stratigraphic resolution. This represents a novel approach to the synthesis of palaeobotanical and palynological data.

No. *19-06759S*: **Cadmium hyperaccumulation in macrofungi: from isotopes to proteins and bacterial communities** ***(J. Borovička***; P. Kotrba, University of Chemistry and Technology, Prague, Czech Republic; 2019–2021)

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

A new analytical protocol for high-precision Cd isotopic analyses in biological materials using thermal ionization mass spectrometry (TIMS) was established at the Inst Geol, Czech Acad Sci. This includes decomposition of the biogenic samples in the presence of a newly prepared ^{116}Cd–^{106}Cd double spike, ion exchange chromatography for Cd isolation, and TIMS analyses. This results in gathering high-precision Cd concentration data (calculated though the isotopic dilution technique) as well as $\delta^{114/110}Cd$ (calculated using double spike approach for mass bias correction). The results on Cd NIST 3108 solution yield an overall external precision for $\delta^{114/110}Cd$ of -0.006 ± 0.029 ‰ (2SD, n = 43). The veracity of the whole procedure was thoroughly tested on biogenic and geological certified reference ma-

terials with different compositions including soil, Mn nodules, oyster/mussel tissue, and plant tissues (needles, leaves) with the results in satisfactory agreement with those previously reported.

In 2019, we particularly focused on sampling of Cd-accumulating mushrooms and corresponding soils, namely *Agaricus crocodilinus* (Fig. 25), *Amanita muscaria,* and *Thelephora* spp. Cultivation experiments with *Agaricus bisporus* and *Stropharia rugosoannulata* were conducted and we succeeded in obtaining sporocarps of *A. bisporus* from artificially Cd-enriched substrates. Concentration analyses in *A. bisporus* sporocarps from this experiment revealed a surprisingly high accumulation of Cd (up to nearly 400 mg kg^{-1} in lamellae, dry matter). cDNA library constructed from the Cd-accumulating fungus *Cystoderma carcharias* was screened in the Cd- and Cu-sensitive *Saccharomyces cerevisiae*. Two MT genes were discovered and named CcMT1 and CcMT2. CcMT peptides were confirmed in Cd-/Cu-containing cell fractions by UHPLC-ESI-Q-TOF-MS/MS. Site-directed mutagenesis of CcMT2 was conducted to assess metal selectivity of CcMTs. In conclusion, both CcMTs are functional peptides apparently contributing to Cd and Cu tolerance in *C. carcharias*.

■ **Fig. 25.** Cadmium-hyperaccumulating fungus Agaricus crocodilinus in its natural habitat in eastern Bohemia, Czech Republic. Photo by J. Borovička.

No. *19-07516S*: **Cretaceous-Paleogene boundary in the Carpathians – multidisciplinary search for local variations in global cataclysm event** (***T. Elbra***, ***Š. Kdýr***, ***T. Kohout***, ***P. Pruner***, ***P. Schnabl***, ***G. Kletetschka***, ***R. Skála***; M. Bubík, Czech Geological Survey, Brno, Czech Republic; P. Skupien, VŠB – Technical University of Ostrava, Ostrava, Czech Republic; 2019–2021)

The Cretaceous-Paleogene boundary (K-Pg) has been recognized only at a few localities within the Central European part of the Carpathians. The new project aims at systematic record and evaluation of local magnetic and biotic changes in order to gain insights to local variations in the global cataclysm event.

During the first year of the project, the paleomagnetic team (Inst Geol, Czech Acad Sci) concentrated on detailed rock magnetic studies of samples from the Žilina drill core, Slovakia, and revealed pronounced changes in magnetic properties at the K-Pg interval. These changes could be related to paleoenvironmental variations.

Additionally, pilot samples were collected from Czech and Polish sections. The general range of strata was established by CGS and VŠB teams for the Czech sections (e.g., Maastrichtian and middle- to upper Paleocene strata in the Bystřice section). Preliminary assessment by the paleomagnetic team revealed that most of the samples are magnetically relatively weak. PGE contents and Re-Os isotope systematics of selected samples from Uzgruň were analysed, and showed slightly elevated Ir values at the K-Pg boundary. Mineral composition of Uzgruň samples is more or less uniform, dominated by clay minerals, and provides no solid clue to recognize the particular strata in the section.

The paleomagnetic team members were also involved in magnetic characterization of several Chicxulub ejecta pebbles from Belize and found signs of electric discharge which magnetized/demagnetized portions of material with a non-homogeneous magnetic field during the formation of the Chicxulub ejecta blanket.

No. *19-08066S*: **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, Czech Republic; ***M. Svojtka***, ***L. Ackerman***, ***J. Sláma***, ***J. Rejšek***, ***J. Ďurišová***, ***E. Haluzová***; 2019–2021)

The field work in Canada was pursued during June 2019 (Fig. 26). First, this involved field and structural mapping along a N–S-trending, ca 500 km long transect across all the key units (Opatica, Opinaca, La Grande, Bienville) along the James Bay and Trans-Taiga routes and a highly detailed mapping along the southern margin of the Bienville, a presumed magmatic arc between Chisasibi and Radisson (Fig. 1). A large body of field and structural data were acquired and are now being further processed into structural maps and cross-sections. Furthermore, about 40 stations were sampled in the Bienville unit for anisotropy of magnetic susceptibility (AMS). The samples were measured late in 2019 and the data are now being processed, including strain modelling. Nevertheless, a preliminary evaluation of the data shows that the granites were emplaced syntectonically within a major strike-slip shear zone, similar to modern ones, a point that may be of great interest for future interpretations. Second, about 40 samples were collected from these units for geochemical analyses. These predominantly include ca 2.7 Ga granitic rocks, representing separate magmatic pulses, but also amphibolites and surrounding metasedimentary rocks. For all lithologies, major (wet-chemistry) and trace (ICP-MS) element compositions were determined as well as Rb– Sr and Sm–Nd isotopic compositions. Collectively, all the granitic rocks are calc-alkaline and exhibit LREE-enriched patterns with a negative Eu anomaly and initial epsilon Nd values ranging from -1.1 to +2.3. Together with the detected variable, sometimes very high Ni and Cr contents, this suggests a large involvement of mantle-derived basaltic melts in the granite petrogenesis. Third, some of the amphibolites, metasediments, and selected granitic rocks were also analysed for Pb isotopic composition. Zircons extracted from 7 magmatic rocks (Bienville and La Grande) and

7 metasediments (Opinaca) were dated by U–Pb laser ablation ICPMS technique at the Academy of Sciences. The magmatic rocks show intrusion ages within a narrow window of ca 2.73–2.70 Ga with scarce inherited xenocrysts with slightly older ages (ca 2.85 Ga). The metasedimentary rocks are in most cases characterized by a strong population corresponding to the magmatic rocks in the area (ca 2.75–2.7 Ga) with a minor population of ca 3.2–2.8 Ga and some individual grains ca 3.4 Ga in age.

■ **Fig. 26.** Eastern shore of James Bay, above: homes and tepee in Cree reserved land, bottom: an outcrop of Archaean monzogranite with a typical local nature scenery. Photo by M. Svojtka.

No. *19-08614S*: **Biogeochemistry of mercury isotopes in anthropogenically affected area**s (***M. Vaňková***; J. Trubač, Faculty of Science, Charles University, Prague, Czech Republic; 2019–2021)

Mercury (Hg) stable isotopes provide a new approach to fingerprint and quantify Hg sources, the sinks and transformations in the environment. Information about the geochemistry of Hg isotopes in contaminated soils is surprisingly minimal. The questions on the role of soil processes in Hg isotope fractionation have not been clearly answered at all. Within this project, soil profiles affected by Pb-Zn and Fe ores and energy coal combustion are studied. The obtained results help to characterize and understand anthropogenic Hg fluxes to soils, Hg alteration and accumulation and also indicate the role of vegetation cover and phase composition of the soil in the Hg isotope variations. Further studies will show whether soil profiles can be used for tracing historic atmospheric Hg pollution.

The aims of the project are to: identify and quantify different anthropogenic Hg sources in soils impacted by mining/smelting and coal combustion; assess the effect of vegetation cover on Hg isotopic composition of soils; evaluate the role of soil phase composition on Hg fractionation in soils.

No. *19-14082S*: **Stress- and hydraulic field-controlled weathering and erosion of granular rocks** (J. Bruthans, Faculty of Science, Charles University, Prague, Czech Republic; ***M. Filippi***; J. Schweigstillová, Inst Rock Struct Mechan, Czech Acad Sci, Prague, Czech Republic; 2019–2021)

The seemingly well-defined terms such as weathering or erosion in fact include a number of interrelated processes. In the last few years, the present team has demonstrated crucial roles of stress and hydraulic fields using simple physical experiments and numerical modelling (Fig. 27). This approach led to the explanation of the origin of some of the enigmatic forms in sandstone. Its applicability is, however, much broader. Current project is aimed at the study of weathering processes in granular rocks. Data obtained from advanced weathering experiments and field measurements will be used as input parameters for the advanced numerical modelling. This will allow a prediction of erosion in granular rocks. We plan to explain phenomena like granular disintegration, flaking, origin of vaults, etc. Some of the main activities in the first year of the project are as follows: (i) long-term tests with cubes in compression/tension were started in steel frames with granite and arenites applying salt and freezing weathering cycles. Other samples were encased in reinforced concrete and were exposed to cyclic frost weathering; (ii) samples of granite, shale, quartzite, rock salt, loess and various arenites were collected, and tensile strength was measured on rock exposures already in the field. Selected samples were studied by SEM and uCT; (iii) pilot laboratory experiments were performed with sandstone, and conditions where flaking disintegration occurred were documented, and (iv) two cubic blocks of red Fe-rich Střeleč sandstone with artificially incised overhangs were placed in an open-air lab within the Faculty of Science facility in summer 2019. The blocks were instrumented as suggested and are monitored regularly. Climatic station owned by the Faculty of Science is used for this purpose.

■ **Fig. 27.** One of the freezing/melting experiments with differently loaded Střeleč sandstone cubes: a) initial state, b) after 10 cycles, c) after 60 cycles. Loading of cubes from left: 30N, 65N, 122N, 240N, 480N. The experiment clearly shows that higher loading reduces the erosion. Photo by M. Filippi.

6c. Grant Agency of Charles University in Prague

Ongoing projects

Grant Agency of Charles University in Prague
GAUK No. 1090119: **A clue for enstatite-rich meteorites origin from Cr-Ti-bearing troilites** (***N. Mészárosová***, ***R. Skála***, Faculty of Science, Charles University, Prague, Czech Republic; 2019–2021)

Meteorites are some of the oldest materials in our Solar System. They record the processes that had taken place in solar nebula evolution as well as the processes of formation and alteration of their parent bodies. Enstatite-rich meteorites are expected to have formed under highly reducing conditions, and include enstatite chondrites (EH and EL groups), enstatite achondrites (aubrites) and anomalous enstatite-rich meteorites. This fact is reflected in their overall chemical composition as well as in their mineralogy. The investigation of their unusual mineralogy is mainly focused on Cr-Ti-bearing troilites and their mineral association. Particular attention is paid to the concentration of Cr and Ti in troilite across different enstatite-rich meteorites,the influence of Cr and Ti on troilite crystal structure and its thermal stability. Various nanostructure defects like stacking faults and the presence of precipitates are observed in meteoritic and terrestrial pyrrhotites (including troilite as 2H polytype). Such defects are routinely used as indicators of technological processes in material science. Consequently, troilites may give evidence about processes like thermal metamorphism or hydrous alteration on the surfaces of meteorites' parent bodies since the nanostructure in terms of the degree of ordering or presence of defects sensitively reflects various conditions ruling the mineral formation.

GAUK No. 192218: **Highly siderophile elements geochemistry and Re-Os isotopic composition of Fen carbonatite complex, Norway** (***L. Polák***, ***L. Ackerman***, Faculty of Science, Charles University, Prague, Czech Republic; 2018–2020)

Carbonatites are igneous extrusive/intrusive rocks derived from the Earth's upper mantle by processes like melting of CO_2-rich material, immiscibility of carbonatite and silicate melt and fractionation of CO_2-rich alkaline melt. Owing to their extremely low viscosity and melt temperature, carbonatite magmas are rapidly taken from the place of origin and therefore, they can provide unique geochemical fingerprint of magma source, significantly better than other upper mantle-derived melts. In addition, carbonatites are increasingly perceived as important economic deposit not only for REE but also for PGE like the Phalaborwa Mine in South African Republic. A large amount of trace element and Sr-Nd-Pb-C-O isotopic data exist for carbonatites worldwide but detailed information on the distributions of highly siderophile elements (HSE–Os, Ir, Ru, Pd, Pt, Rh and Au) and Re-Os-S isotopic compositions is sparse. However, it is crucial for our understanding of sulphur saturation of carbonatite melts and their impact on overall HSE balance in the Earth's upper mantle as well as possible modification of Re-Os isotopic composition during metasomatism. This project is focused on the petrology and geochemistry of the Proterozoic (~560 Ma) Fen carbonatite complex in Norway with emphasis om highly siderophile elements and Re-Os-S isotopic composition.

GAUK No. 1698119: ***Zieglerodina petrea*** **sp. nov. and** ***Zieglerodina paucidentata*****: phylogenetic models and their application in the global stratigraphy of the Silurian/Devonian boundary** (***A. Hušková***, ***L. Slavík***, Faculty of Science, Charles University, Prague, Czech Republic; 2019–2020)

This project is a follow-up study to the previous project No. 922216 (2015–2018) of the Grant Agency of the Charles University. One of the outputs of the previous study was the description of the new species of *Zieglerodina petrea*. This new taxon has a potential to become a promising conodont marker for the Silurian/Devonian boundary in the carbonate environment. The principal aim of this project is to verify this result outside of the Prague Synform and to see if *Z. petrea* could work as a biostratigraphic marker not only within the Bohemian Massif, but also globally. Another important point will be the study of phylogenetic relationships between *Zieglerodina petrea* and *Zieglerodina paucidentata*, which could specify the position of *Z. petrea* within the Spathognathodontidae family.

The next step will be to compare the newly obtained material with other samples from the Prague Synform and other sections around the world – e.g., the Cellon section (Carnic Alps) or Tafilalt (Morocco). Another main objective will be a phylogenetic model of the taxa of *Z. petrea* and *Z. paucidentata*. This model should prove essential for refinement of the present stratigraphic correlation of the Silurian/Devonian boundary at the global level.

6d. Grants of the State Departments

Ongoing 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: **Inventory of the Krkonoše karst areas; subproject: Scientific evaluation of cave sediments** (R. Tásler, Speleoalbeřice ZO 5-01 of the Czech Speleological Society, Svoboda nad Úpou, Czech Republic; H. Hercman, Institute of Geological Sciences, Polish Academy of Sciences, Warsaw, Poland; ***P. Bosák***, ***P. Pruner***, ***Š. Kdýr***, ***M. Šťastný***; in co-operation with MOBILITY PAN-17-22; 2018–2020)

Cave sediments from all caves are fine-grained (silty clays and clayey silts) with low sand-sized admixture in some samples. Sedimentary structures prove deposition in cave fluvial environment, mostly from slowly flowing waters. They mostly represent infiltration sediments redeposited within the caves. Unsorted deposits of debris flows or mudflows are characteristic for the Ponikelská Cave. The sediments are usually overlain by younger loose scree and also by flowstones of multiple generations. They contain a relatively high proportion of

organic matter (2–6 %). XRD records of bulk sample prove dominant muscovite/illite and quartz; subordinate components are kaolinite (2–3 %), chlorite (1–7 %) and feldspars (1–8 %); trace components include ephesite and smectite. The high proportion of dolomite in some XRD records (12–45 %) indicates the host rocks. Heavy mineral assemblages are composed mostly of zircon and rutile, ephesite, and lepidocrocite, haematite and goethite.

Complex paleomagnetic analyses in the Bozkovské dolomitové Caves, Ponikelská and Trucovna caves indicate only normal magnetic polarity, i.e. deposition within the Brunhes Chron (780 ka to present). Radiometric dating (U/Th method using ICP-MS) of 79 samples of speleothems (flowstones, stalagmites, rafts) yielded altogether 47 numerical results (the Bozkovské dolomite Caves, Albeřická, Krakonošova, Medvědí, Ponikelská and Trucovna caves). The dating proved that speleothem crystallization was active during several, relatively well-constrained periods: (1) ~371 to ~356 ka (MIS 11a to MIS 10c; Holstein Interglacial and beginning of Saalian Glacial [Mindel/Riss to Riss]; Fig. 28); (2) ~258 to ~234 ka (MIS 8b to MIS 7e; Saalian Glacial [Riss]); (3) ~212 to ~203 ka (MIS 7c to MIS 7a; Saalian Glacial); (4) ~186 to ~148 ka (MIS 6e to MIS 6b; Saalian Glacial); (5) ~130 to ~86 ka (MIS 5e to MIS 5c; Eemian Interglacial [Riss/Würm] to beginning of Vistulian Glacial [Würm]); (6) ~70 ka (MIS 5a; warm period at the beginning of Vistulian Glacial); (7) ~50 to ~45 ka (MIS 3c; Vistulian Glacial); (8) ~25 to ~22 ka (LGM core, MIS 2; Vistualian Glacial); (9) ~14 to ~11 ka (LGM termination and start of deglaciation, MIS 2; Vistulian Glacial); (10) ~8 to ~6 ka (MIS 1; Holocene), and one sample has Subrecent age. The richest populations are Nos. 5 and 6 including the Last Interglacial (MIS 5e; Eemian) and warm periods at the beginning of the Last Glacial (MIS 5c and MIS 5a; Vistulian).

Dating results suggest that (1) the permafrost was discontinuous and of lower thickness enabling the underground circulation of precipitations during MIS 2 and MIS 6c to 6a; (2) clastic allogenic material deposited prior to the speleothems can be dated mostly before 147 to >>398 ka (Saalian and older periods) and only rarely during the last deglaciation or in the Holocene, and (3) the ages of original phreatic speleogenesis and evolution in the vadose zone are rather high, implying a high age of relief of the studied part of the Krkonoše Mountains and their foreland.

■ **Fig. 28.** Medvědí (Bear) Cave at Svoboda nad Úpou. A partly corroded stalagmite about 13 cm high (sample MJK 03) growing on a flowstone crust overlying a thin layer of allogenic cave sediments. A sample ca 5 cm above the stalagmite base was dated to 371 +27/-25 ka. Photo by R. Tásler.

Ministry of the Interior of the Czech Republic, Program bezpečnostního výzkumu České republiky 2015–2022, Project No. VI3VS/780: **Complex instrumental protocol for 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, Czech Republic; ***R. Skála***, ***L. Ackerman***, ***J. Ďurišová***, ***N. Mészárosová***, ***P. Mikysek***; M. Kotrlý, I. Turková, J. Wolker, Policie ČR, Kriminalistický ústav, Prague, Czech Republic; J. Sejkora, Z. Dolníček, J. Hyršl, J. Ulmanová, National Museum, Prague, Czech Republic; 2019–2022)

In the early stage of this project, the individual analytical protocols have been tested and adequately modified to meet the needs of the planned research. For reliable determination of the band positions in Raman spectra, calibration of the CCD detector was performed, i.e. calculation of its dispersion function, followed by calibration of this function with respect to spectra of standard samples. This two-stage process ensures maximum accuracy of the determined positions of the spectral bands of real samples. After the spectrometer calibration, Raman spectra of garnets from various localities in the wider area of the České středohoří Mts. were obtained to verify the suitability of the proposed methodology. The acquisition of polarized spectra was also tested. The spectra obtained are in good agreement with the data published in the literature both in term of the position of the vibration bands and the proportions of their intensities. Also, the directional dependence of vibrations in polarized spectra corresponds to the spectra given in the literature.

Other topic covered in this stage of the study was the study of mineral inclusions in garnets. Both the relative number and the character of the inclusions were assessed. The total content of inclusions was found to be different, likewise their mineral composition. Some contains only one species of mineral, others contain up to 4 different minerals. The minerals identified in the inclusions include quartz, mica, amphibole, olivine, rutile, minerals of the spinel group.

Laser-induced luminescence peaks are an important part of observed garnet spectra. These peaks may even exceed the intensity of the Raman signal by their intensity. Another advantage is that these signals do not interfere with each other and can be well distinguished. A detailed study of their positions and relative intensities would probably allow to define the individual types of garnets.

An analysis of the very few available published data has shown that the so-called “Bohemian garnets” of the pyrope composition typically contain very low concentrations of Sr and Pb (<0.2 ppm), and highly accurate isotopic analyses of these elements are therefore rather excluded. For this reason, the methodology of garnet decomposition and subsequent separation and analysis of Nd isotopic composition in several prepared samples were tested during the first months of the project. The resulting analysis also indicated very low concentrations

of Sm and Nd (<1 ppm). Therefore, relatively high weights of garnet separates (300–400 mg) would have to be used to accurately determine the isotopic composition of Sm and Nd. However, preliminary data for several garnets from peridotites show that the garnets have a rather radiogenic composition of $^{143}Nd / ^{144}Nd$ with an ε_{Nd} value between +2 and +6.

6e. Industrial Grants and Projects

Biological Centre of the Czech Academy of Sciences and Charles University, Czech Republic, Project No. 7004: **Platinum-group element concentrations in paleolakes in the Šumava Mts. (*L. Ackerman*, *J. Ďurišová*)**

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

Czech Geological Survey, Czech Republic Project No. 7004: **Re-Os isotopic composition of the Kutná Hora crystalline complex (ultra)mafic rocks (*L. Ackerman*, *J. Rejšek*, *J. Ďurišová*)**

A joint project dealing with Re-Os isotopic composition of peridotites, pyroxenites and eclogites from the Kutná Hora Crystalline Complex

Czech University of Life Sciences, Czech Republic, Project No. 7004: **Molybdenum isotopic compositions of Paleozoic black shales and carbonates from the Bohemian Massif (*L. Ackerman*)**

A joint project with Czech University of Life Sciences (Prague, Czech Republic; J. Frýda) focusing on the determination of Moisotopic composition of selected Paleozoic black shale–carbonate sedimentary profiles of the Prague Basin.

Indian Institute of Science Education and Research, India, Project No. 7004: **Re-Os geochronology of black shales from Himalaya (*L. Ackerman*, *E. Haluzová*, *J. Ďurišová*, *J. Rejšek*)**

A joint project with the Indian Institute of Science Education and Research (Gyana Ranjan Tripathy) focused on the determination of Re-Os ages for two black shales from Himalaya.

Institute of Archaeology of the Czech Academy of Sciences, National Museum, Palacký University and Charles University, Czech Republic, 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.

Czech Geological Survey, Project No. 7012: **Tectonometamorphic evolution and U-Pb dating of high-grade Hammar Domain (Southern Ethiopian Shield) (*M. Svojtka*, *J. Ďurišová*)**

A joint project with Czech Geological Survey (Prague, Czech Republic) focused on the determination of U-Pb age dating and p-T modelling of the high-grade rock assemblage and granitoid rocks in various tectonic settings cropping out in the Hammar Domain (Southern Ethiopian Shield) to resolve the open questions in the geodynamic evolution of the southernmost Arabian-Nubian Shield as a crucial aspect of the East-African Orogeny.

Archeologické centrum Olomouc, příspěvková organizace, Project No. 7020: **Geoarchaeological research of highway D11 (*L. Lisá*)**

The final stage of geoarchaeological research of highway D11 was finished during 2019 year by a set of unpublished reports. The principal aim of research was the evaluation of formation processes which took a part in landscape from the beginning of the Holocene to the Recent. A number of shallow valleys were eroded at the beginning of the Holocene, and the Chernozem soil type developed in their vicinity. Human-induced erosion is visible in the bottoms of these valleys. Medieval erosion was also detected, but planation of the landscape took place during the Communist era.

Institute of Geological Sciences, Polish Academy of Sciences, Krakow, Wroclaw, Project No. 7042: **In-situ U-Th-Pb LA--ICPMS dating of basement rocks and sedimentary cover of the Cadomian orogen (*J. Sláma*; B. Budzyn, M. Jastrzębski, A. Żelazniewicz, Institute of Geological Sciences, Polish Academy of Sciences, Wrocław, Poland).**

A joint project aimed at the reconstruction of plate tectonics and evolution of the NE part of Bohemian Massif and adjacent units along the Trans European Suture Zone (TESZ). Within the project, various aspects of the evolution are studied including the character and origin of magmatic rocks of the Brunovistulian Unit and related small terranes displaced along the TESZ in Poland and into the platform cover of the East European Platform. The Inst Geol, Czech Acad Sci provided crucial datasets of U-Pb data obtained from zircon and monazite.

Velkolom Čertovy schody, Inc., Project No. 7302: **Velkolom Čertovy Schody: documentation of progress of quarry walls – reclamation of the Quarry–West (*P. Bosák*)**

The end of excavations at the lowermost level of the Quarry––West towards the north uncovered sequences of uncommon or completely unknown limestone lithologies. Besides the traditional thin-bedded and very fine-grained limestones with shale schlieren (Kotýz Limestone, Lochkovian, Devonian) and crinoidal-bryozoan grainstones (fine-grained Lower Koněprusy facies and coarse-grained Upper Koněprusy facies, Pragian, Devonian), lithologically variable limestone facies of an unknown age appeared. Their position could suggest thatthey belong to a transition from Kotýz to Koněprusy limestone units. At higher levels of the quarry, the transition is characterized by a prolonged hiatus of a few millions of years. Uplift-related submarine erosion removed the upper part of the Kotýz Limestone and only the Upper Koněprusy facies is overlain by a truncation surface.

The missing link is probably preserved at the depth of the deposit. In the west, we observed unknown nodular development of the Kotýz Limestone with dark-coloured clayey matrix and its transition to limestone breccias composed of Kotýz Limestone clasts in dark clay matrix (mostly matrix-supported). Further to the east, laminated to banded calcilutites (mudstones to wackestones) with shale schlieren appeared. In upper parts they contained grainstone bands to thin layers. Limestones were brownish and greyish green to greenish and brownish grey, crinoidal grainstones often possessed red matrix or cement. Shale schlieren were rather green in colour. We also observed a tectonically limited and boudined body of dark grey to black nodular to brecciated limestones with black clayey matrix situated between the Kotýz Limestone and the overlying limestone units. They represent most probably a tectonic slice of some older Lochkovian lithologies (Fig. 29).

■ **Fig. 29.** Velkolom Čertovy schody – West, the lowermost level (bench height of ~11 m), the western part of thenorthern face. A boudined tectonic slice of dark-coloured limestones of unknown age emplaced at thetransition from the Kotýz Limestone (Lochkovian) to underlying units (Pragian). Photo by P. Bosák.

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***)

Since the year 2002, monitoring of the wet deposition chemistry at the Bohemian Switzerland National Park has been running for more than 17 years. Apart from the precipitation volume, we keep track of basic chemical composition in open areas (wet deposition) and in spruce stands (throughfall). The long-term results indicate ongoing improvement of rainwater quality, e.g., a decreasing acidity. In 2017, we started monitoring of potentially neurotoxic and environmentally significant element – mercury. Initial results indicate that the wet deposition in the Bohemian Switzerland National Park is rather low. But the most important pathway of mercury deposition to the forest ecosystems is the litterfall, which relates to the occurrence of gaseous mercury species in the air. Thus in 2019, we expanded our monitoring portfolio using a passive sampler to gaseous elementary mercury.

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***)

With the rising accent on material precision in restoration of historical monuments, this project continued to study historical building stone used in the construction of specific objects in the

■ **Fig. 30.** Construction of the chateau at Konojedy (A) employed mostly dimensioned stone from the extensive sandstone quarries at Úštěk, as confirmed by the material study. In contrast, the later-built garden wall (B) was probably made of local material (Držovice Quarry). Photo by J. Adamovič.

eastern part of the České středohoří Mts. The team of the Inst Geol, Czech Acad Sci is responsible for material composition of sandstone/sandy marlstone and the determination of its provenance, employing optical microscopy, scanning electron microscopy, X-ray diffraction analysis, helium pycnometry and mercury intrusion porosimetry as the main tools. In 2019, the study of the church and the chateau at Zahořany was completed, and the study of the complex of historical buildings (church, chateau and brewery) at Konojedy was extended by additional sampling of sandstone quarries in wider surroundings. Besides, a study of Renaissance castle of Vřísek (or Žižkův vrch) near Holany was started with the acquisition of samples from the building and from the near quarries.

The church at Zahořany was found to employ sandy marlstone from nearby quarries, although spiculitic marlstones from the nearest vicinity (Velký Újezd, Zahořany, Sedlec) were not used. Arkose of the main portal shares material characteristics with Carboniferous arkoses sampled in former quarries at Olovnice (Kralupy area). The use of the Mšené sandstone (quarries at Mšené-lázně and Martiněves) for the church or the chateau at Zahořany is less probable, as indicated by different mineral composition of the samples, and most sandstone ashlars were probably imported from the Děčín area along the Elbe River. Some elements from the Zahořany chateau (cellar) and Konojedy chateau (garden wall; Fig. 30) are composed of locally arkosic sandstone of the Březno Formation, e.g., that quarried south of Držovice. Most sandstone ashlars for the Konojedy church and chateau were, however, extracted in the quarries at Úštěk, as has been already suggested by an archival study. According to historical records, local "Hrušovany sandstone" was used for the Zahořany/Encovany boundary stones in mid-19th century. Although most quarries of this sandstone type have been already reclaimed/backfilled, a good fit in material characteristics was found between the boundary stone from Holý vrch Hill and calcareous sandstone from a small quarry at Encovany. Preliminary results for the Vřísek chateau suggest a local source for the sandstone and silicified sandstone used in the construction.

Geophysical Institute of the Czech Academy of Sciences, v. v. i., Prague, Project No. 7516: **Palynological investigation of samples from the Kostelecké Horky, Sedlec and Střeleč boreholes (*M. Svobodová*)**

A total of 23 samples from three boreholes (Kostelecké Horky near Kostelec nad Orlicí 4270-01W, Sedlec near Litoměřice 4523A and Střeleč V-800) were palynologically investigated. The aim was to characterize the type of environment and the biostratigraphy of the deposition. A middle Turonian palynomorph assemblage was ascertained in the Kostelecké Horky and Sedlec boreholes. Abundant agglutinated foraminiferal linings, jaws of polychaete annelids are related to shallow littoral conditions in the dysoxic environment. The palynofacies of the Střeleč borehole contain angiosperm pollen of Coniacian age.

Senckenberg Museum für Naturkunde Görlitz, Sektion Paläozoologie und Geologie, Project No. 7516: **Palynology of Lausche volcano samples (*M. Svobodová*)**

The aim was to confirm or exclude the Tertiary age of a clay bed from the area of the Lausche volcano. Based on angiosperm pollen from the Normapolles group (i.e. *Oculopollis baculatus*, *Trudopollis*), prevailingly of Coniacian age, we can exclude Tertiary age. Two samples 3A and 3B were deposited in non-marine environment. The palynofacies of samples 4a-1A-1B and 2A-2B consists of marine dinoflagellate cysts and some gymnosperm pollen *Classopollis classoides* characterizing marsh environment. The question of a limnic maar sediment is further discussed with the above mentioned palynological results and it is supposed that the palynomorph assemblage is a redeposited one.

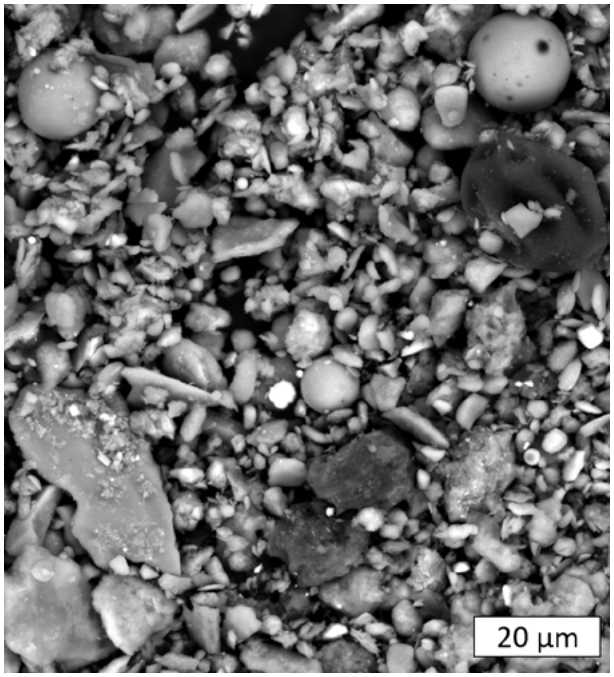
Watrad, spol. s. r. o., ProGeo, spol. s. r. o., Faculty of Civil Engineering, Czech Technical University, Prague, Project No. 7801: **Multigenerational non-active tracers** (J. Baier, M. Milický, L. Gvoždík, J. Uhlík, M. Polák, M. Černý, ProGeo, spol. s. r. o.; P. Bílý, P. Novák, H. Semíková, L. Kelnar, M. Vaněček, M. Zbraněk, Watrad, spol. s. r. o.; ***J. Rohovec***; R. Vašíček, J. Svoboda, Faculty of Civil Engineering, Czech Technical University, Prague)

Standard tracing tests in fissure collectors focus on instant hydrogeological parameters, while the detailed geometry of fissure structures remains unexplored. The aim of this project was the development of a set of easily identifiable fluorescent tracers capable of strong binding and marking of freshly opened surfaces of fissure structures. Tracers of different colours subsequently applied into hydrogeologically communicating structures permitted the identification of higher-order generations of fissures. Another aim of the project was the optimization of conditions for efficient application of a tracer set and verification of functionality upon *in situ* conditions. Granted by the Ministry of Industry and Trade of the Czech Republic, project No. CZ.01.1.02/0.0/0.0/15_019/0004643 (MPO).

6f. Programmes of Strategy AV21 of the Czech Academy of Sciences

Project No. 9221 within the Natural Hazards Programme: **Development of algorithms for automatic detection of components of deposited dust (*T. Hrstka, J. Hladil, L. Chadimová*)**

The project is a continuation of successful research focused on a better understanding of individual constituents of the deposited dust and their potential effects related to human health and the environment. Air quality plays an important role in our current society. A clearer understanding of the influence of airborne particles and their source is one of the critical aspects of today's effort to reduce risks related to air pollution. Our work is focused on advanced spectroscopic analysis of individual deposited dust particles (Fig. 31). The automated mineralogy approach for data collection, labelling, and interpretation through the implementation of machine learning is its central



■ **Fig. 31.** Example of dust particles, mixed mineral and organic matter. Photo by T. Hrstka.

part. In collaboration with the University of Ljubljana, new .hmas multidimensional data cube format was implemented to the visual programming software Orange https://orange.biolab.si/. This format expands the capabilities of using the ML and AL approaches on the spectral data. It also provides a multidimensional alternative to 2D.msa data format implemented earlier. AVCR in-house software platform DUST was also introduced.

Project No. 9222 within the Natural Hazards Programme: **Causes of rock instabilities in sandstones of the Bohemian Cretaceous Basin** (***J. Adamovič***; F. Hartvich, Inst Rock Struct Mech, Czech Acad Sci, Prague, Czech Republic)

Fossil, historical and – most notably – recent rockfall events were documented in sandstone areas of the Bohemian Cretaceous Basin. The year 2019 focused on the area of the Broumovsko Protected Landscape Area where tens of rockfalls were studied based on the suggestions of the PLA staff (Fig. 32). All such cases are presented in a public-open database on webpage http://rockfall.gli.cas.cz, established for this purpose in 2016. Some of the specific cases were subjected to a more profound study by 3-D modelling and geophysical survey to assess the causes of stabilityloss and to predict future geodynamic development of the outcrop.

■ **Fig. 32.** The rockfall at Starozámecký vrch near Adršpach is specific by the relatively large volumes of wasted rock (60 m^3) and by the destruction along bedding planes. A large block on this photo was easily cleaved after a collision with a spruce tree. The age of this event can be estimated as the break of years 2018/2019. Photo by J. Adamovič.

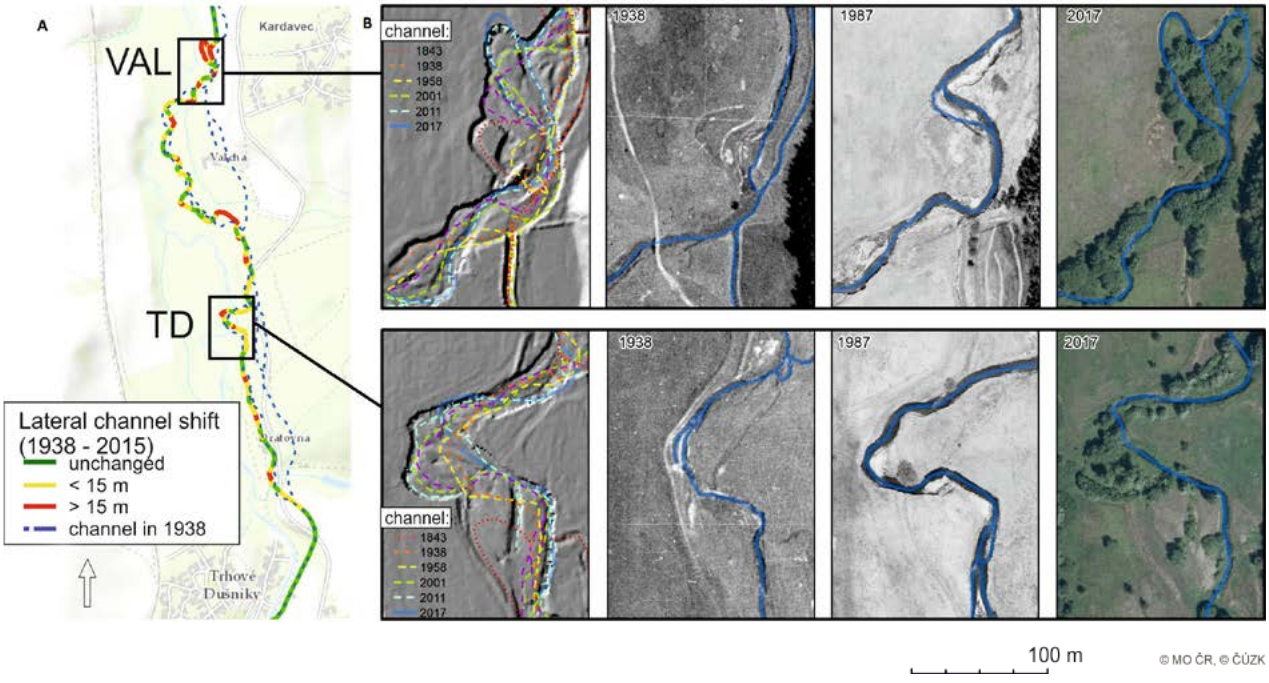
Rockfall events in the Broumov area occur in sandstones of the Teplice Formation, which constitute a body as much as 100 m thick, locally transected by two orthogonal joint sets which result in the evolution of perfect rock cities. In spite of the lithological homogeneity of this body, a wide variation was found in the intensity and incidence of rockfall phenomena. In the Adršpach–Teplice area, the incidence clearly increases southward in the direction Křížový vrch – Adršpach rock city – Teplice rock city, and so do the volumes of wasted rock. With the same observed relief dynamics, this difference should be rather attributed to the distance from the Skály Fault. In low-risk areas, most of the recent events were due to wind-induced tree uprootings and were of minor extent of max. several cubic metres. In high-risk areas, all ridges possess thick slope aprons composed of fallen rock pillars, and many valleys are impassable due to block accumulations. A specific phenomenon, not observed elsewhere in the Bohemian Cretaceous Basin, is the deterioration of the rock massif along bedding planes: these mostly dip at an angle of 10–25°, being accompanied by deep-reaching arcade pits and notches. Rockfall is a relatively rare phenomenon in the more strongly cemented Jizera Fm. sandstones of the Broumov Cliffs.

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

Apart from monitoring mercury concentration in stream sediments at selected study sites, this project focused on testing new innovative passive samplers at four background forest sites in the Czech Republic. Commercially available passive samplers were exposed in an open area, and exposure-based timespan of monitoring was 6 months. The results indicate that the mean concentration of gaseous elemental mercury in the air at these four sites ranged from 1.51 to 1.67 ng·m^{-3}. A successful exposition and consequent analysis of passive samplers indicated the occurrence of low GEM (gaseous elemental mercury) concentration at Czech background sites alike to the globally accepted background concentration of GEM in the air at 1.65 ng·m^{-3}.

Project No. 9225 within the Natural Hazards Programme: **Evaluation of the environmental legacy within the Litavka River sediments** (***T. Nováková***, ***T. Navrátil***, ***M. Roll***; T. Matys Grygar, Inst Inorg Chem, Czech Acad Sci, Prague, Czech Republic)

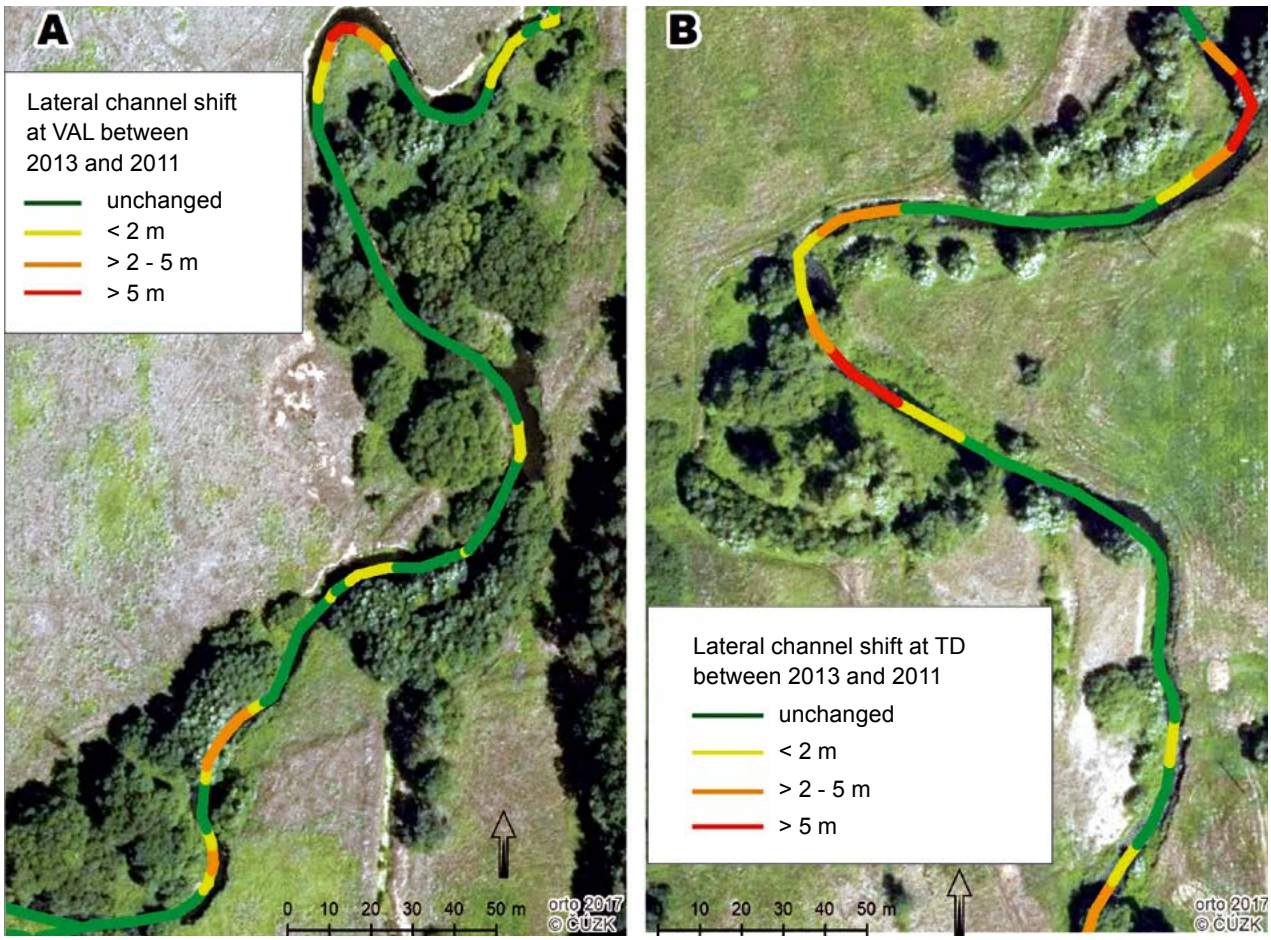
The main objective of the project was to determine the spatial distribution of toxic elements (Pb, Zn, Cu, Cd, Hg) in the floodplain of the Litavka River and to evaluate the amount of toxic elements released during annual floods back to the river system. Two study sites were selected based on the GIS analyses of aerial photographs from 1938 to 2015 to reveal the lateral displacement of the river channel, and geochemical analysis of the samples confirmed presence of toxic elements within the floodplain sediments at concentrations exceeding all legislative limits (Fig. 33). The calculation of a channel shift at study sites of Valcha (VAL) and Trhové Dušníky (TD) (Fig. 34, respectively) between 2011 and 2013 allowed a calculation of the volume of eroded material, including the amount of released elements.During this period, 227 t (TD) and 87 t (VAL) of sediment were eroded back to the river system, and the



■ **Fig. 33.** Lateral channels shifts of the Litavka River between 1938 and 2015 occurring in two study areas near Příbram.

estimated amounts of released toxic elements within this material were 490 and 415 kg of Pb, 900 and 546 kg of Zn at TD and VAL study sites, respectively.

Such re-release of polluted material presents a potential risk for the river environment. It is therefore necessary to prevent further erosion of river banks within this floodplain.



■ **Fig. 34.** Calculation of the Litavka River channel shifts between 2011 and 2013 at study sites Valcha (A) and Trhové Dušníky (B) in order to evaluate the amount of material released from both study areas during annual floods.

6g. Programmes of Institutional Research Plan

Project No. 9329: Paleomagnetic and magnetostratigraphy analyses, data acquisition for the definition of global Jurassic/Cretaceous boundary from Berrias (France) and Goleszów (Poland) sites (***P. Pruner***, ***T. Elbra***, ***Š. Kdýr***, ***P. Schnabl***)
Project No. 9344: Geochemical characteristics and genesis of Mg-rich (picritic) volcanic rocks of the Bohemian Massif (***J. Ulrych***, ***L. Krmíček***, ***L. Ackerman***, ***R. Skála***, ***S. Krmíčková***)
Project No. 9347: Taxonomical revision of selected ursid taxa (family Ursidae) from the Early and Middle Pleistocene of China (***J. Wagner***)
Project No. 9354: Hf isotope signature of orogenic lamproites of the Bohemian Massif (***L. Krmíček***, ***J. Sláma***)
Project No. 9358: Calcareous nannofossils and magnetostratigraphy as tools for the interdisciplinary correlations of selected Upper Jurassic and Lower Cretaceous sequences (***A. Svobodová***, ***P. Schnabl***)
Project No. 9372: Acquisition of data for magnetic map of the Tunguska epicentre and acquisition of control rock samples (***G. Kletetschka***)
Project No. 9381: Cooperation with the Earth Science Institute of the Slovak Academy of Sciences on lake sediment research as geochemical archives of the history of mercury pollution (***T. Nováková***, ***T. Navrátil***, ***M. Roll***, ***J. Rohovec***)
Project No. 9382: Ultratrace analyses of strontium and neodymium by thermal ionization mass spectrometry at the Institute of Geology of the Czech Academy of Sciences (***J. Rejšek***, ***L. Ackerman***)
Project No. 9383: Research of concentration of mercury in larch tree rings in Silesian region (***M. Roll***, ***T. Navrátil***, ***T. Nováková***)
Project No. 9385: Prolagus (Lagomorpha, Mammalia) in the Pliocene of Central Europe. (***S. Čermák***)
Project No. 9386: Petrogenesis of selected magmatic rocks of the Brunovistulian Microcontinent from the perspective of *in-situ* Hf isotope characteristics of zircon (***S. Krmíčková***, ***J. Sláma***)
Project No. 9387: Influence of basalt magnetic field on compass measurements in structural geology (***L. Nováková***, ***R. Kavková***, ***P. Schnabl***)

7. Publication Activity of Staff Members of the Institute of Geology

7a. Papers Published

7.683* Wu, S., Cajthaml, T., Semerád, J., Filipová, A., Klementová, M., ***Skála, R***., Vítková, M., Michálková, Z., Teodoro, M., Wu, Z., Martinez-Fernandez, D., Komárek, M. Nano zero-valent iron aging interacts with the soil microbial community: a microcosm study. *Environmental Science-Nano*. 2019, 6(4), 1189–1206.

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6.551* ***Borovička, J.***, Konvalinková, T., ***Žigová***, ***A.***, ***Ďurišová***, ***J.***, Gryndler, M., Hršelová, H., Kameník, J., Leonhardt, T., Sácký, J. Disentangling the factors of contrasting silver and copper accumulation in sporocarps of the ectomycorrhizal fungus *Amanita strobiliformis* from two sites. *Science of the Total Environment*. 2019, 694, 133679, 1–12.

6.551* ***Navrátil T.***, ***Nováková T.***, ***Roll, M.***, Shanley J. B., Kopáček J., Rohovec J., Kaňa J., Cudlín P. Decreasing litterfall mercury deposition in central european coniferous forests and effects of bark beetle infestation. *Science of the Total Environment*. 2019, 682, 213–225.

6.174* ***Ackerman, L.***, Hajná, J., Žák, J., Erban, V., ***Sláma, J.***, ***Polák, L.***, Kachlík, V., Strnad, L., Trubač, J. Architecture and composition of ocean floor subducted beneath northern Gondwana during Neoproterozoic to Cambrian: a palinspastic reconstruction based on Ocean Plate Stratigraphy (OPS). *Gondwana Research*. 2019, 76, 77–97.

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5.778* Leonhardt, T., ***Borovička, J.***, Sácký, J., Šantrůček, J., Kameník, J., Kotrba, P. Zn overaccumulating *Russula* species clade together and use the same mechanism for the detoxification of excess Zn. *Chemosphere*. 2019, 225, 618–626.

5.692* Pšenička, J., Zodrow, E. L., ***Bek, J.*** The compound synangial organ *Potoniea krisiae* sp. nov. and its plausible relationship with linopterids based on cuticles from the Late Pennsylvanian Sydney Coalfield, Canada. *International Journal of Coal Geology*. 2019, 210, 103200, 1–9.

4.823* ***Ackerman, L.***, ***Polák, L.***, Magna, T., Rapprich, V., ***Ďurišová, J.***, Upadhyay, D. Highly siderophile element geochemistry and Re–Os isotopic systematics of carbonatites: insights from Tamil Nadu, India. *Earth and Planetary Science Letters*. 2019, 520, 175–187.

4.779* Bukovská, Z., Soejono, I., Vondrovic, L., Vavro, M., Souček, K., Buriánek, D., Dobeš, P., Švagera, O., Waclawik, P., Řihošek, J., Verner, K., ***Sláma, J.***, Vavro, L., Koníček, P., Staš, L., Pécskay, Z., Veselovský, F. Characterization and 3D visualization of underground research facility for deep geological repository experiments: a case study of underground research facility Bukov, Czech Republic. *Engineering Geology*. 2019, 259, 105186.

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4.768* Řihošek, J., Slavík, M. Bruthans, J., ***Filippi, M.*** Evolution of natural rock arches: A realistic small scale experiment. *Geology*. 2019, 47(1), 71–74.

4.659* ***Ackerman, L.***, ***Skála, R.***, ***Křížová, Š.***, ***Žák, K.***, Magna, T. The quest for an extraterrestrial component in Muong Nong-type and splash-form Australasian tektites from Laos using highly siderophile elements and Re-Os isotope systematics. *Geochimica et Cosmochimica Acta*. 2019, 252, 179–189.

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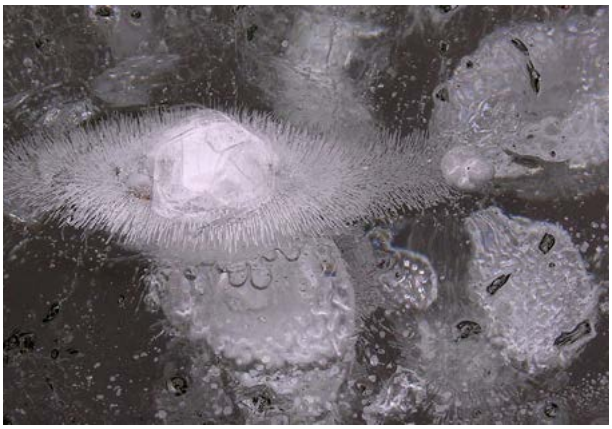

■ **Fig. 35.** Thin tubular bubbles formed during the winter season in natural ice on water surfaces. The structure of the phenomenon corresponds to the pattern of physical source field. Consequently, the natural ice must represent an extremely homogeneous environment despite of numerous visible cracks and similar irregularities. Photo by R. Mikuláš.

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Svobodová M. *Palynologické vyhodnocení z vrtů Kostelecké Horky (KH 42070-01W), Sedlec (4523A) a Střeleč (V-800)*. Institute of Geology of the Czech Academy of Sciences for Institute of Geophysics of the Czech Academy of Sciences, 2019. 1–20. (In Czech)

Svobodová M. *Palynology of the Lausche Vulkan samples*. Institute of Geology of the Czech Academy of Sciences for Senckenberg Museum für Naturkunde Görlitz, Sektion Paläozoologie und Geologie, 2019. 1–3.

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Šťastný M., ***Bosák P.***, Mihevc A. *Mineralogic analyses of samples from karst sediments in Slovenia, 8. Final Report*. Institute of Geology of the Czech Academy of Sciences and Karst Research Institute ZRC Slovenian Academy of Sciences and Arts, Praha–Postojna, 2019. 1–15.

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8. Organization of Conferences and Scientific Meetings

Seminar: ***Joachim Barrande – 220 years, Prague, October 25, 2019***. Organized by the Czech Academy of Sciences, National Museum, Bohemian Karst Protected Landscape Area Administration (Nature Conservation Agency of the Czech Republic) and Institute of Geology of the Czech Academy of Sciences. Organizing committee: Sklenář J., Sobotková K., ***Štorch P.***, Pojer F., ***Přikryl T.***

The distinguished French geologist and palaeontologist Joachim Barrande was born on 11 August 1799. His research work concentrated on Bohemia, starting in the 1830s. Barrande died at Frohsdorf (Austria) on 5 October 1883 and is buried at the cemetery at Lanzenkirchen. The seminar presented Joachim Barrande as an engineer, tutor, geologist and paleontologist and also provided an overview of selected localities in the Bohemian Karst with comments about their natural conditions.

International conference: ***XVth International Ichnofabric Workshop. Prague, April 27 – May 3, 2019***. Organized by the Institute of Geology of the Czech Academy of Sciences. Permanent web address: https://cppltd.wixsite.com/ichno2019/. Organizing structure: Convenor: ***R. Mikuláš***, Convenor Assistant: ***M. Kočová Veselská***; Regional Geology Board and Field Trip Co-Leaders: K. Mach (Tertiary, Most Basin), M. Košťák (Bohemian Cretaceous Basin), O. Fatka (Cambrian of the Bohemian Massif), P. Kraft (Ordovician of the Bohemian Massif), P. Budil (Silurian and Devonian), K. Martínek (Carboniferous to Triassic), ***L. Lisá*** (Quaternary). International Advisory Board: Gabriela Mángano and Luis Buatois (University of Saskatchewan, Canada); Andrew K. Rindsberg (Alabama State University, USA), Lothar H. Vallon (Geomuseum Faxe, Denmark).

The series of International Ichnofabric Workshops represents the longest-lasting event in the scope of the modern ichnology, taking place every two years since 1991. Soon, it remained a prestigious occasion to present regional geological units and their ichnological content to the most significant and influential group of word ichnologists (Fig. 36). In the past, highly authoritative ichnologists like R. G. Bromley, A. A. Ekdale, S. G. Pemberton, A. Weztel, J. F. Rodriguez-Tovar and M. Gingras convened the Ichnofabric Workshops. The readiness to organize the IIW in Prague was acknowledged in 2011 during the 11th IIW (for 2015). However, adverse health circumstances forced the main convenor to postpone the meeting in Prague. The workshop was visited by 32 participants with 30 scientists from abroad. It is difficult to select one or few key talks, but at least "Ichnofabrics from the aeolian systems", and "Ichnofabric" shall be noted. The main topic selected for discussion was the use of computed tomography of bioturbated substrates at present and in the future. The next IIW will be held in 2021 in Alabama under the guidance of Andrew K. Rindsberg. Conference Book: **Kočová Veselská, M., Adamovič, J.,**

Kernhoff, M., Rifl, M., Šamánek, J., **Mikuláš, R.** (eds.). *15th International Ichnofabric Workshop: Program, Abstracts, Field Guidebook.* 2019. Prague: Czech Academy of Sciences, Institute of Geology, 94 p.

■ **Fig. 36.** Participants of the 15th International Ichnologic Workshop, Prague, May 3, 2019, in the garden of the Vila Lanna. Photo by R. Mikuláš.

9. Degrees Obtained by the Staff of the Institute of Geology

PhD.

Scheiner F.
Geochemical markers from foraminiferal tests as a tool for reconstruction of paleoceanological environments: a case study from the Miocene of the Central Paratethys. (Institute of Geology and Paleontology, Faculty of Science, Charles University, Prague, Czech Republic; supervised by K. Holcová)

Weiner T.
Multiproxy study of the indications of glacieustacy in upper Devonian sediments of the Moravosilesian region. (Department of Geological Sciences, Masaryk University, Brno, Czech Republic; supervised by J. Kalvoda)

10. Financial Report

In thousands of Czech Crowns (CZK)		2019
A. INCOMES		
1.	From the annual budget of the CAS	43 601
2.	From the Czech Science Foundation (accepted research projects)	15 854
3.	From the internal research projects of the Czech Acad Sci	2 559
5.	From other public sources	696
6.	Applied research	6 147
7.	Investment (instruments)	16 548
8.	Investment (constructions)	3 525
TOTAL INCOMES		**88 930**
B. EXPENSES		
1.	Scientific staff (wages, insurances)	44 275
2.	Research and scientific activities	9 559
3.	Administration and technical staff (wages, insurances)	8 756
4.	General expenses (service, maintenance of buildings, energies, transport, office supplies, miscellaneous, etc.)	4 282
5.	Library	1 685
6.	Editorial activities	300
7.	Investment (instruments)	16 548
8.	Investment (constructions)	3 525
TOTAL EXPENSES		**88 930**