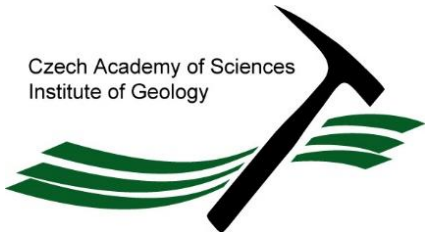
Instrumental Equipment

of the Institute of Geology of the Czech Academy of Sciences

This text is a fragment of a more comprehensive document titled "***Introduction to the Institute of Geology"***, which is presented elsewhere on this webpage (see link Institute/Introduction to the Institute).

The text below presents basic information about the instrumental equipment of the Institute of Geology. For more detailed information please consult staff of particular departments and laboratories.



CONTENT

Current analytical equipment is in good condition, expired equipment has been refurbished. The new instruments enable the introduction of new methods. Laboratories of the GLI are frequently used by partners from other institutes of the Czech. Acad. Sci., universities, museums and from the private sector. Department of Physical Properties of Rocks provides the best technical equipment in the CR for all basic tests in rock mechanics, including the world-unique apparatus for the determination of high-pressure rock elastic anisotropy using P- and S-waves in spherical samples.

The most important acquisitions for Department of Geological Processes are represented by a brand new 193nm *excimer laser system (Cetac/Teledyne)* to the existing laser ablation ICP-MS lab (2016) and a novel generation of *thermal ionization mass spectrometer (TIMS) Triton Plus (Thermo)* in 2017.

The important instrumental investments were also directed to laboratories of Department of Analytical Methods. *Raman micro-spectrometer S&I MonoVista CRS+* (purchased in 2015) allows a collection of Raman and photoluminescence spectra from a sample with spatial resolution of 1 µm laterally and 2 µm axially. In 2017, a Fourier-transform infra-red spectrometer (FTIR) *Thermo ScientificNicolet iS-50* was acquired with a built-in mid- and far-IR capable diamond attenuated total reflectance (ATR) accessory. Cutting and grinding machine *Buehler PetroThin* was acquired in 2017 to expand the possibilities of manufacture of polished thin sections. In addition, a brand new *electron probe microanalyzer (JEOL JXA 8230)* was installed in November 2019. It provides quantitative chemical composition data for major and minor elements in polished solid state samples including a wide variety of materials covering minerals, rocks, archeological artefacts, glass fibres, catalysts and other synthetic products. For quantitative applications, it is equipped with five wave-dispersive spectrometers housing together 14 analytical crystals. A proprietary JEOL energy-dispersive spectrometer is installed in the instrument to collect overview spectra to determine major constituting elements. Imaging is possible *via* secondary or back-scattered electron detectors. Panchromatic cathodoluminescence detector allows to image fine details in microfabrics otherwise unseen with standard imagery.

An important acquisition for the Department of Physical Properties of Rocks is the **Ergotech Triaxial Cell**, which is a special triaxial cell for hydrostatic loading (up to 100 MPa) under temperatures up to 200 °C. These attributes allow the simulation of loading in natural conditions or in the expected conditions of a nuclear waste repository. It is equipped for 16 channel acoustic emission measurements for seismic monitoring of stress-induced fracturing.

This is not a complete list of instrumental investments which support all departments and the Institute as a single unit but shows the most significant acquisitions (often with a significant financial support from the Czech Acad Sci). It is also necessary to mention an effort to expand or improve the spaces for detached workplaces of the Institute.

Price list for services of the Institute.

On the next pages you can find a list of the most important instruments, laboratory equipment and other facilities with brief explanations and comments. For other relevant information see the price list of the Institute.

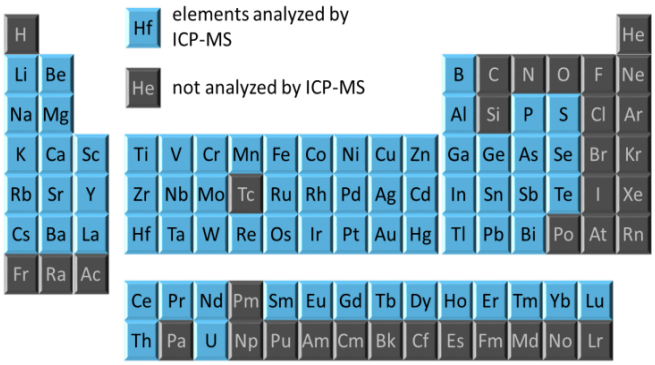
The Department of Geological Processes conducts a complex research in the field of processes, past and present, acting within the lithosphere – the Earth crust and the upper part of the Earth's mantle. The analysis of geochemical, geochronological and structure record preserved in the available rocks permits us to describe the dynamics of large lithospheric blocks in the past, to reconstruct time–temperature and pressure histories of large magmatic and volcanic complexes including the evolution of sedimentary basins from the Early Paleozoic to the present. Good knowledge of these processes in the geological history together with extensive research activities at a global scale enable us to present results of general validity and universal use in the realm of Earth sciences.

Element 2 (Thermo Fisher) inductively coupled plasma mass spectrometer (ICP-MS) is used for trace and ultra-trace element analysis (down to a sub-ppm level) and for the determination of isotope ratios (with a precision of up to 0.1% relative standard deviation). Both solution and solid-state analyses are available. The instrument is equipped with a double focusing magnetic sector field mass analyzer based on a reverse Nier-Johnson geometry, which allows high-speed multielement analysis. A high mass resolution mode of operation enables the elimination of polyatomic interferences. Typical applications include multi-element analysis of digested inorganic and organic materials, ultra-trace analysis of natural waters, determination of $^{206}Pb/^{207}Pb$ and $^{208}Pb/^{206}Pb$ isotope ratios in environmetal samples. Preparation of samples is carried out in a specialized clean laboratory (see next page).

The ICP-MS is equipped with optional sample introduction systems:

- **Aridus II** desolvating nebulizer for the elimination of oxide interferences in solution analyses. It can be also used for simultaneous aspiration of a tracer solution during laser ablation analyses.
- **Hydride generator** provides sub-ppb detection limits for hydride-forming elements such as As, Se, Sb.

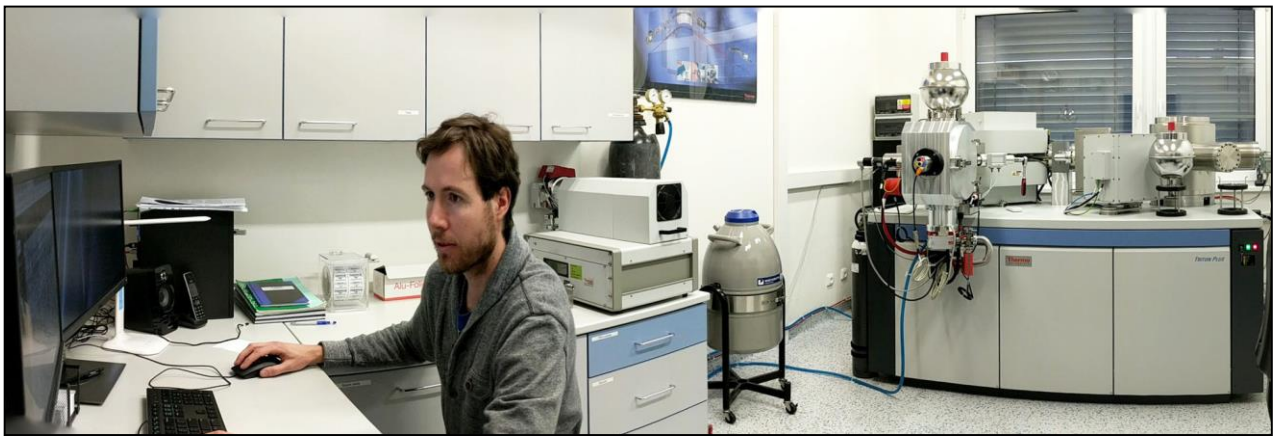
193 nm ArF excimer laser ablation system (Analyte - Excite by Cetac/Teledyne) in connection with the ICP-MS is used for analyses of solid-state materials. The main applications are isotopic analyses, such as U–Pb geochronology of zircons and monazites, space-resolved quantitative analyses of trace elements in mineral grains of silicates (pyroxenes, quartz, etc.) or sulphides (molybdenite, chalcopyrite etc), elemental profiling and mapping. The spatial resolution of the laser beam is in the range of tens of micrometers. Planar polished surface and compact structure of resin-blocks or thin sections are necessary for any analysis using LA-ICP-MS.



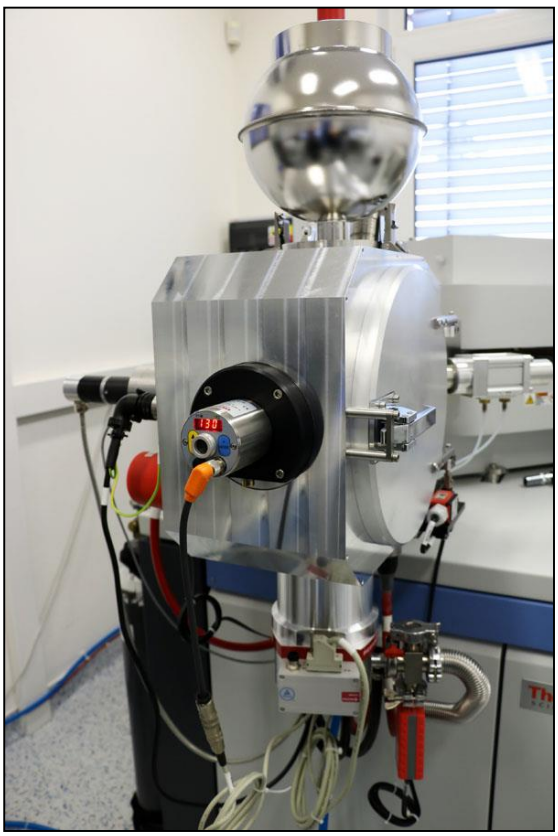
Lab digital analytical balance scale is used for precise sample weighing.

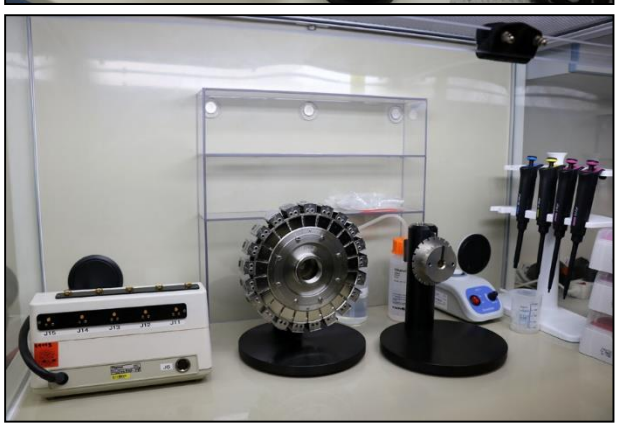
Ultraclean laboratory of the Institute consists of two independent labs with different degree of air quality. The **first lab** (picture upper left) with a HEPA-filtered air of class D is using for sample decomposition in acid-resistant fume hood and acid purification (HNO_3, HCl, HF using two Savillex Distillation Units). The **second lab** (upper right and bottom pictures) with HEPA-filtered air of class C is devoted to low-blank chemistry, which includes sample decomposition and separation of the elements (e.g., Os, Sr, Nd, Mo, Cd, Pb, Lu, Hf) from the matrix for subsequent isotopic analyses. This room is equipped with 2 custom-designed laminar flow hoods with HEPA-filtered air of class A, system for preparation of ultraclean Milli-Q water Millipore IQ 7000 + QPOD Element and high precision weighting device Sartorius Cubis.

Currently, the clean lab is mainly used for research projects dealing with radiogenic (Sr-Nd-Pb-Hf) and stable (Mo, Cd) isotopic analyses and Re-Os, Lu-Hf and Sm-Nd geochronology.

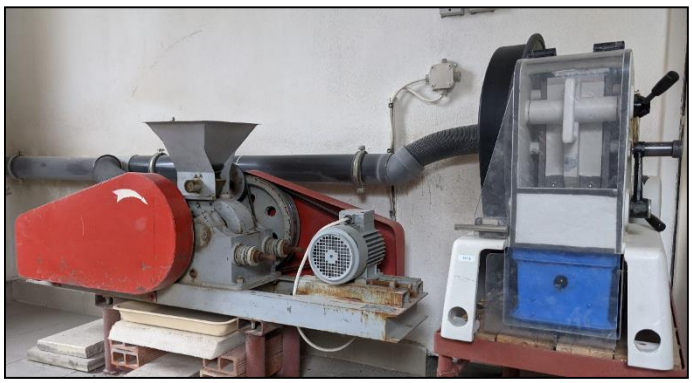


The **Thermo Triton Plus Thermal Ionization Mass Spectrometer (TIMS)** is used for ultra-high precision determinations of isotopic ratios of selected elements (e.g., Sr, Nd, Os, U, Pb) providing an outstanding opportunity to several research topics in the field of rock and environmental geochemistry, paleontology and paleoecology, but also archaeometry and anthropology. The thermal ionization source is characterized by a very small kinetic energy spread of the ions (~0.5 eV), and a single focusing geometry that focuses for angular divergence only is therefore fully sufficient. The ions are detected with either nine Faraday cups or a discrete dynode electron multiplier. The Faraday detectors are laser machined from solid carbon to guarantee uniform response, high linearity and low noise. The discrete dynode electron multiplier is equipped with retarding potential quadrupole lenses that act as high-selectivity filers for ions with disturbed energy or angle. The machine is then equipped with five 10^{11} Ω and five highly sensitive 10^{13} Ω amplifiers coupled to the virtual amplifier concept which eliminates calibration biases. The TIMS lab also includes a vacuum degassing unit, a laminar flow hood with ultralow penetration air (ULPA) filtration and the UPS system.





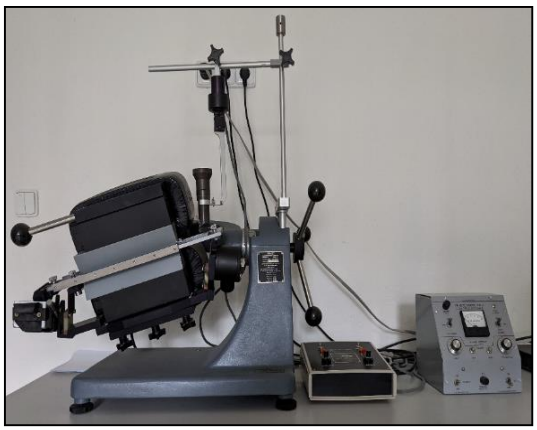
Certain kinds of mineral concentrates are needed for the study of minerals and their properties. This is obtained by separation of minerals from the rocks. First, the rock is crushed in a big **jaw crusher** into smaller fragments, then in **crusher roller mills** to obtain small grains. A **dust-tight jaw crusher** is used for low-volume samples. Sieving of samples to various fractions is the subsequent procedure needed for other processes. Using a **shaking table** and a **magnetic separator**, the grains are separated into light/heavy fractions and into magnetic and non-magnetic minerals. Finally, the mineral grains are separated in heavy liquids based on their density.



Jaw rock crushers

Dust-tight jaw crusher

Vibratory disc mill



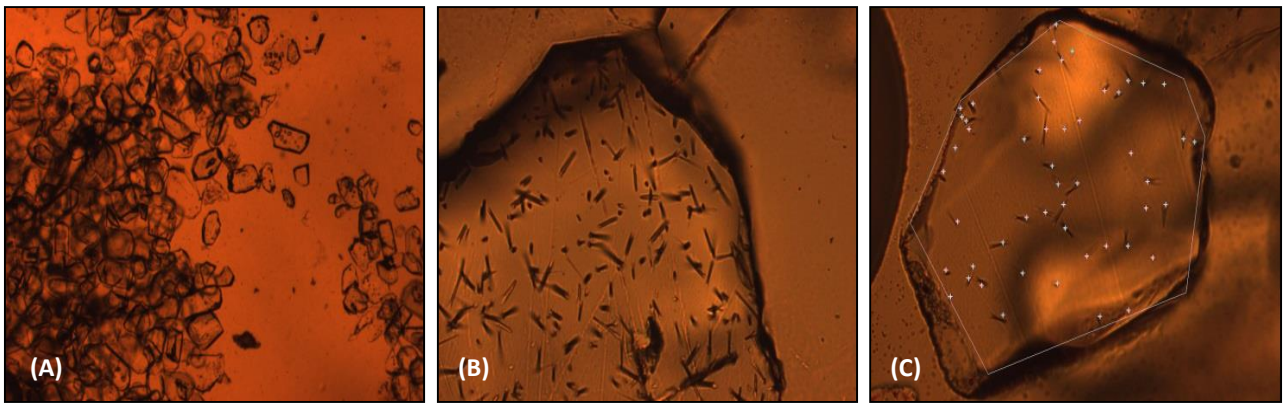
Frantz magnetic separator

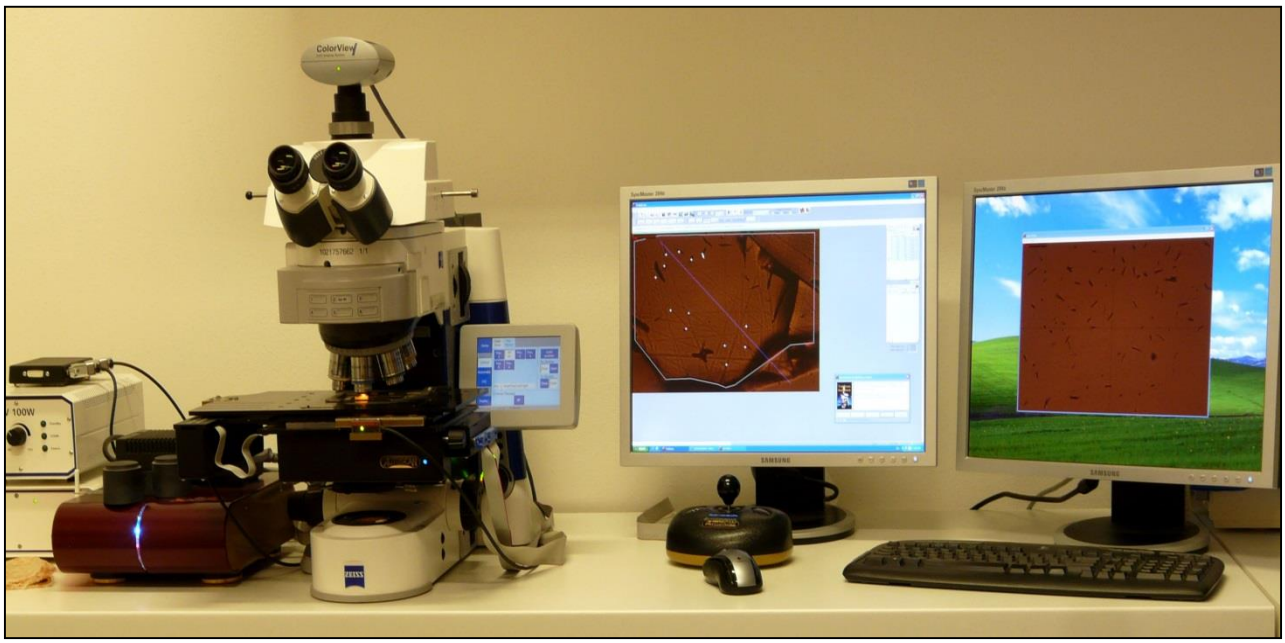
Wilfley shaking table

Laboratory of heavy liquid separation

Fission track analysis is a radiometric dating method based on the analysis of radiation damage trails ("fission tracks") within U-bearing minerals (such as apatite, zircon, titanite, …). This method allows to determine simultaneously time and temperature evolution of rocks by counting fission tracks in individual grains and length-measuring of the confined tracks. This results in time-temperature curves for each sample and in the reconstruction of the uplift/burial history in areas of tectonically active fault zones, sedimentary basins and their source areas.

A simplified procedure for FTA using the ZEISS Imager M1m microscope: apatite grains in a sample at a magnification of 5x (A); a part of the selected grain with fission tracks at a magnification of 50x (B); apatite grain with the defined area and counted fission tracks for age determination (C); confined track for thermal-condition determination.





ZEISS Imager. M1m Microscope connected to two monitors of a computer for a fission track analysis (FTA).
The Microscope is equipped with an AUTOSCAN table moving in directions x, y, z. controlled by a computer and manual joystick; two light sources using reflected and transmitted light. Another part of the microscope is a digitizing equipment for measuring lengths of specific tracks parallel to the surface of the mineral grain (i.e., confined tracks).

RS-230 instrument is a portable radiation detector (Georadis Ltd., Brno, Czech Republic) with Bismuth Germanate detector (103 cm^3) with a high sensitivity (approximately 3 x higher in comparison to the same size NaI detector). Counts per seconds (cps) in selected energy windows are directly converted to the concentrations of potassium, K (%), uranium, U (ppm), thorium, Th (ppm) and total dose (nGy/h). The instrument offers an assay mode (provides sample concentrations of K, U and Th in selectable time intervals), scan mode (numeric display on front panel scanned to memory and audio response) and survey mode (cps at 1/sec rate display on front panel). It has bluetooth and USB data connections.

Gamma-ray spectrometry (GRS) can be used for direct detection of the concentrations of K, U and Th in geological mapping by detecting and delineating the lateral distribution of these elements in surface rocks and soils. Field GRS is very effective method – low-cost, fast, non-destructive and large data sets can be acquired. GRS in sediments is used as a principal tool for correlations in palaeoenvironmental studies and high-resolution stratigraphy. It can reveal information on the quality of impurities trapped in the sediments where Th and K concentrations usually reflect the presence of some minerals.

GR-320 Envispec Portable Gamma-ray Spectrometer (Exploranium, Canada and Geroadis, Czech Republic) is another portable gamma-ray spectrometer which can be used in the field. It has external detector, and the system utilizes 256/512 channel and a high-sensitivity 76x76 mm (3" x 3") Sodium-Iodide detector. Counts per seconds (cps) in selected energy windows are directly converted to the concentrations of potassium, K (%), uranium, U (ppm), thorium, Th (ppm) and total exposure or dose rate (nGy/h). It can be used for the same purposes as the RS-230 device.

Vacuum chamber con-nected with an air-pump is used for preparation of non-solid samples for thin sectioning in the geoarcheological laboratory. When the samples are cured enough, they are processed in a thin sectioning lab (samples 3×4 cm in size).

The **CILAS 1190 LD laser granulometer** is used to provide measurements of grain size distribution in a range from 0.04 to 2,500 µm. The measurement is based on a small amount of material and might be easily repeated. The use of different types of dispersion allows to obtain information on the primary or secondary given grain size distribution. Data can be reported in different fractions set by the user.

The department is focused on:

- paleontological and paleoenvironmental interpretations and reconstructions of biological evolution in selected fossil groups
- reflection of major changes and turnovers in biota – the study of causes of important (often catastrophic) events in the Earth history
- climatic oscillations and paleoenvironmental changes
- high-resolution stratigraphy; precise dating and correlation of sedimentary strata
- paleogeographic reconstructions based on migration of paleobiota
- intersections with sedimentology, geochronology, ecology, archaeology, and other scientific disciplines

The research concentrates to the four principal directions: 1. Paleozoic stratigraphy and paleoenvironments – based on invertebrate fossil groups (especially conodonts, graptolites, trilobites, cephalopods and paleoichnology in a broad stratigraphic range), 2. evolution of vertebrate groups (fishes, amphibians and mammals), 3. Paleozoic–Cenozoic plants and palynology, and 4. Cretaceous research.

The department has **rooms for maceration and processing of micropaleontological samples** equipped with levigation facility and fume hoods.

OLYMPUS SZX 16 Optical binocular microscope with the **CANON digital photocamera** and specialized **QuickPHOTO Micro software** and a **Deep Focus module** is used for the documentation of samples, various sample separations and imaging of objects.

Olympus BX53 light microscope with the **Olympus UC 90 digital camera** equipped with an immersion objective of ×100 magnifications for micropaleontological observations.

is a multi-disciplinary research team, disposing with respectable knowledge from various fields of Earth sciences such as: mineralogy, geochemistry, sedimentology, geomycology, pedology, hydrology, climatology, geomorphology and ecology. Therefore, the department is able to perform a wide range of studies. From "traditional" regional geology, genesis of sandstone rock cities or karst and cave research, to the latest research topics, namely: anthropogenic contaminations of flood plains and forest ecosystems with mercury and lead, the use of fungi as biomarkers in areas affected by industrial activity and studies of environmental archives, like tree rings, peat bogs and lake sediments. The department is also focused on long-term studies of climatic oscillations in small experimental areas as well as in national parks of the Czech Republic.

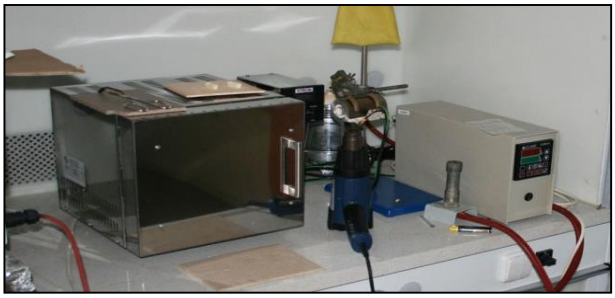
Collection of an environmental sample: **Passive collector** for collection of rain water.

A set of **iceboxes** is used for storage of environmental samples.

We operate with several preparatory laboratories that serve for prime preparation of samples for subsequent analyses.

Before analysis, majority of solid samples are prepared by decomposition in acids. In the **HPA-S Anton Paar high pressure asher**, samples are dissolved at temperatures up to 300 °C and pressures up to 100 atm.

Microwave oven is not only useful in a house kitchen, but with a special teflon PTFE pressure vessels it is equally useful for sample decomposition. Of course, the microwave power inserted on sample is far more higher than in the kitchen models.



Another approach to the decomposition of minerals is based on melting in a resistance oven upon regulated temperature up to 1,300 °C in platinum, silver or quartz crucibles.

SPECIAL EQUIPMENT AND TECHNIQUES FOR WORKUP, PREPARATION AND STUDY OF SAMPLES

Some samples collected in geochemical study sites are air sensitive, prone to decomposition, lost of target analytes or sensitive to contamination. For these samples, special workup procedures are required.

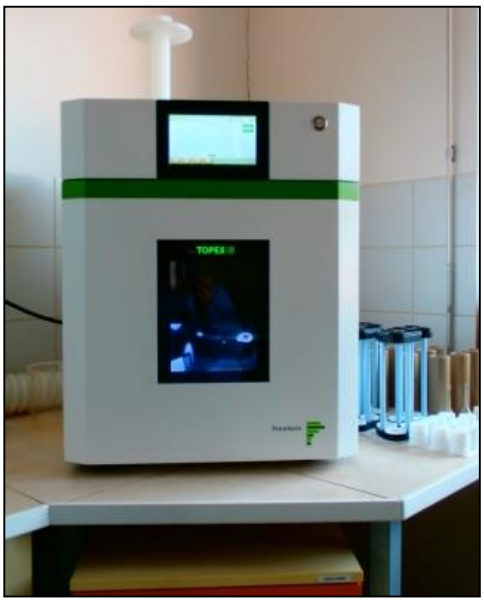
The freeze-drying apparatus is frequently used in biochemical and biological applications for careful drying of sensitive samples. Samples are frozen before drying *in vacuo*, water is removed from the sample by sublimation.

Diluted liquid samples can be preconcentrated before analysis on the **vacuum rotatory evaporator**. Samples are delivered in the plastic bottles, transferred into an evaporation flask and evaporated *in vacuo*. Concentrated sample resulting is present in a small flask connected to the apparatus.

Glove-box where inside the closed space, argon atmosphere is maintained to protect the sample from air influence and contamination from atmospheric dust. Samples are inserted by the port to the right site and handled by gloves connected to long plastic sleeves.

Quantification of inorganic carbon (carbonate) and organic carbon in natural liquid or solid samples is performed on **TOC analyser equipped with autosampler** for liquid samples introduction.

The presence and amount of nitrates, chlorides, sulfates and other anionic component is analysed on the **HPLC liquid analyser** by chromatography on anion exchanging chromatography with conductivity detection.

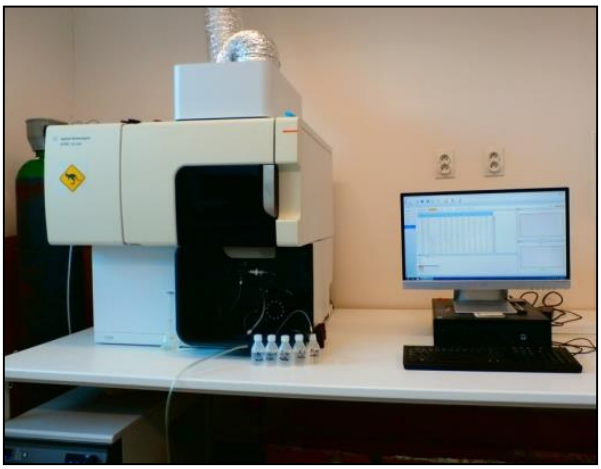


The **Preekem microwave oven** is a high-tech MW digestion unit, **loan of HPST company** for long-term tests at GLI. It uses two different types of rotors, bearing teflon digestion vessels. The maximum operating pressure limit (up to 90 bar) and the highest allowable temperature (approx. 220 °C) are sufficient for dissolution of even the most difficult/stable samples. The movement and state of vessels in the MW chamber can be followed using a built-in camera.

Elemental automatic analyser (vario Macro cube) – Geochemistry of toxic element (e.g. mercury) is tightly interlocked with absolute amount and type of organic materials present. We use the Elemental automatic CHNS analyser for the determination of C, H, N, S in solid samples (biomass, soil horizons etc). Samples, weighted in tin capsules, are burnt at high temperature in O_2 atmosphere into water, carbon dioxide, nitrogen and sulfur dioxide, which are then quantified and recalculated into weight percentages of elements.

Majority of chemical elements can be analysed in the Geochemical labs by ICP techniques.

Samples of various origin are studied. Besides minerals and rocks which are the main materials of interest in geology and geochemistry, the soils, rain, precipitation, water and fog are study subjects in geochemistry. Biogeochemistry concerns various biomaterials (wood, leaves, pines, organic soil horizons etc.).



Chemical composition of samples is studied on universal multielement spectrometers in an argon plasma discharge (**ICP EOS instrument Agilent 5100**). At temperatures about 10,000 K, chemical elements present in the sample emit visible or UV radiation, which is collected and processed. As a result, certain element is identified together with its content in the sample.

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac															

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

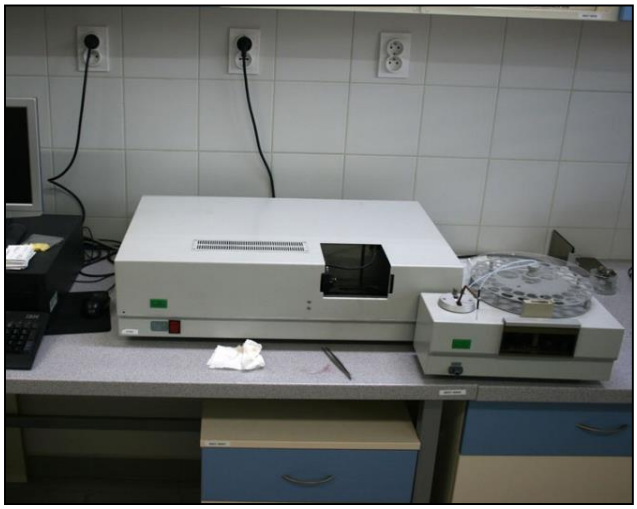
Be analyzed by AAS method

analyzed by ICP-OES method

Geochemical laboratories are also equipped with other standard instruments: **AAS analysers**, **microwave** and **UV digestion instruments**, **UV spectrometer** equipped with **CV-AFS** and **CV-AAS analysers**, **UV digestion** and of course **ICP-MS ELEMENT 2** with a laser ablation system shared with the Department of Geological Processes.

SPECIALIZED TECHNIQUE PERFORMED AT OUR DEPARTMENT IS UTLTRA-TRACE MERCURY ANALYSIS

Mercury is a highly toxic element, dangerous for the environment and humans even in minimum amounts. The analysis of mercury in ultra-trace amounts, especially in environmentally related samples, is demanding task and extraordinary sensitive machines are required. In the mercury lab at GLI we are working on two such instruments. Detection limits up to 0.1 ng/l of mercury can be reached.



The **AMA 254 advanced mercury analyser** is our basic instrument used for analyses of mercury contents in solid samples without need of prior sample preparation. At present, we are running two of these units. First one is used for Hg analyses in soil horizons, various biomass and general samples, while the second is used solely for readout of Hg content in wood of tree rings in projects dealing with tree ring geochemical archives.

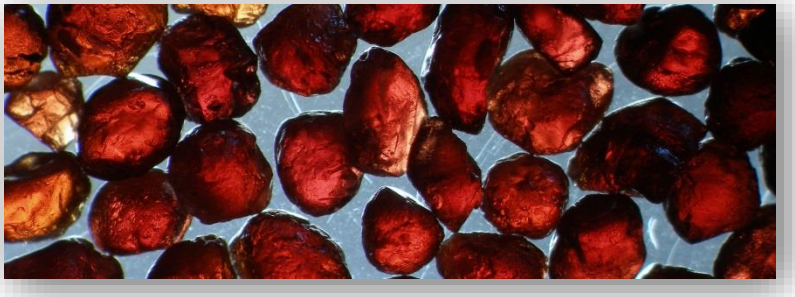
The **PS-Analyser** instrument is designed for mercury analyses in liquid samples and for speciation studies with HPLC separation.

In spite of its small size and modest appearance, this **Brooks Rand Merx system** is the most advanced instrument for mercury quantification on pg (picogram, 10^{-12} g) level. It is used also in mercury speciation analysis for determination of methylmercury, a highly poisonous mercury species formed in nature by methylation of mercury by microorganisms. Its amazing sensitivity imposes extraordinary requirements on cleanness of laboratory work in order to preserve the samples against contamination.

Lumex RA 915M is a portable spectrometer (weight about 6 kg) for field work targeted to gaseous Hg content in the atmosphere. We carry this unit through towns, industrial places, forests, meadows or even caves. It actively sucks ambient air into the instrument, where spectroscopic quantification of Hg proceeds in certain time steps. The registered values are stored in unit memory and finally transferred to PC for data workup and evaluation. In order to expand measuring abilities, the unit can be connected to a benchtop **PyroModule** (not shown on the photo) for Hg analyses in solid and liquid samples indoor.

OLYMPUS SZX 16 Optical binocular microscope with the **CANON digital photocamera** and specialized **QuickPHOTO Micro software** and a **Deep Focus module** is used for the documentation of samples, separation of sub-samples for other methods and, of course, for imaging of samples and details for publications.

OLYMPUS BX50 Optical polarizing microscope with the **DP 70 digital camera** and specialized **QuickPHOTO software** and a **Deep Focus module** is used for a detailed study of thin (for transmitted light) and polished (for reflected light) sections. Software enables documentation, image preparation and image analysis. The microscope is equipped also with a fluorescent source of different wavelengths.

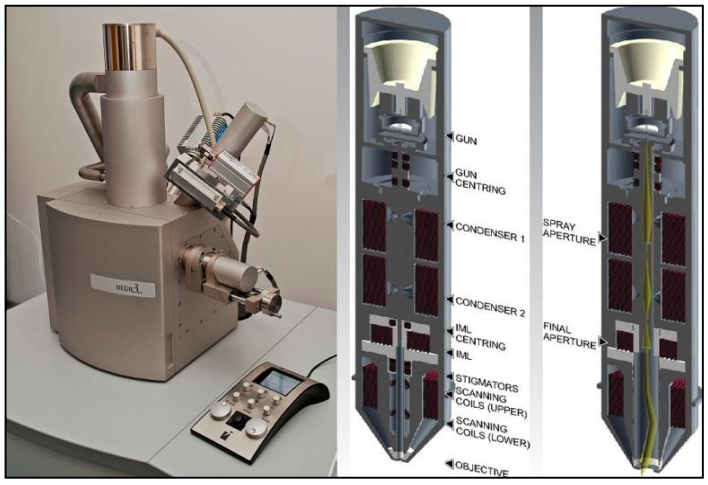


Examples of photos from the above characterized microscopes.

Most facilities of the Department of Analytical Methods are situated in the main research centre. The staff here provides a service for the needs of the other professional units, however, they also pursue their own high-quality research focused especially on the application of instrumental methods to geological sciences.



Reliable quantitative local chemical analysis and/or acquisition of element distribution maps using electron microprobe analyses and scanning electron microscopy (EPMA/SEM) require planar polished conductive surfaces. Such prerequisites are fulfilled when bulky solid samples are sectioned, polished and coated. For that purpose a suite of **cutting**, **grinding**, **lapping** and **polishing machines** to prepare polished sections or thin sections is available at this department. To make the specimens conductive for EPMA/SEM chemical analyses, a coating by carbon is used. For imaging of rough surfaces using secondary electrons in high vacuum, samples are sputtered with gold to prevent their charging. The department owns also all necessary instruments to **carbon-coat** or **gold-sputter** the specimens.



TESCAN VEGA3XMU scanning electron microscope (SEM) is an SEM of a variable pressure construction and 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 as well as energy-dispersive spectrometer (EDS) **Bruker QUANTAX 200**, which collects the entire spectrum allowing data acquisition typically within a minute. The spot which the analytical data are collected from may be on the order of 1 um in diameter. Element contents reliably measured with the device are as low as 0.X-X wt.%. Also available are low vacuum secondary electron (LVSTD) and color **cathodoluminescence** (CL) (detection range 350-850 nm) detectors. The source of electrons is a tungsten heated cathode. Under the optimum conditions the magnification of the SEM may reach up to 150,000× which translates to a resolution of 10 nm. The minimum magnification is 1.5× that means that objects as large as 127 mm across can be observed at once. 3D surface metrology is also possible.

Typical application of the SEM instruments are: observation and imaging of surface characteristics of both coated and uncoated 3D specimens (various objects in paleontology, mineralogy, material science, etc.); observation and imaging of samples (polished (thin)sections) by BSE detector to reveal compositional differences; mapping of element distribution; local standard-less or standard-based chemical analyses.

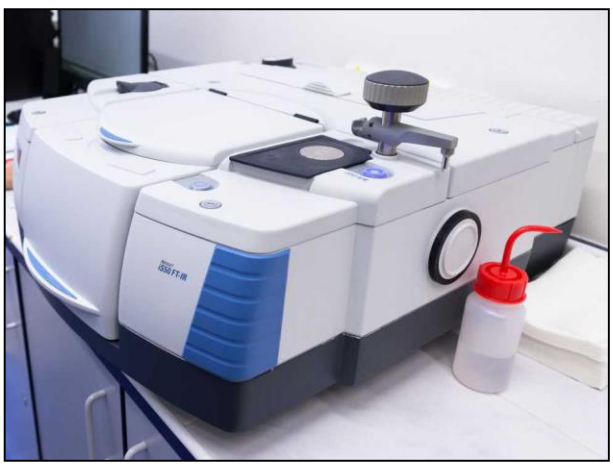
JEOL JXA 8230 electron probe microanalyzer with a tungsten filament, 5 spectrometers (14 crystals), an ED spectrometer and a panchromatic CL detector is used mainly for non-destructive quantitative analysis of solid-state materials on the micrometer scale from selected spots down to a few microns across. It allows analyses of specimens for elements from B to U. Element contents can be reliably measured from planar polished surfaces down to tens of ppm. All the measurements and imaging are carried out in high vacuum. Though the probe is usually used for point chemical analyses, it occasionally serves also for imaging or collection of element distribution maps.

Bruker D-8 DISCOVER X-ray powder diffractometer is a multi-purpose powder X-ray diffraction instrument designed to study powder samples or solid polycrystalline blocks, e.g., polished (thin) sections or rock chips. It allows studying materials in either reflection or transmission (foil or capillary) geometry. The X-ray beam is generated by a metal-ceramic sealed copper tube. The optional focusing primary asymmetric monochromator of Johansson type produces spectrally pure Kα1 radiation. Diffracted radiation is collected with a 1D position-sensitive detector. In the microdiffraction setup used for bulk samples, the beam is directed on the specimen by polycapillary optics and limited with a collimator, and a sample is placed on a motorized xyz-stage.

Typical applications of the diffractometer include: crystalline phase identification, (semi-)quantitative phase analysis of mixtures, and crystal structure and microstructure analyses.

Two complementary **vibrational spectroscopy techniques** are used for phase identification and molecular structure studies. **Raman spectra** are collected with the **S&I Monovista CRS+** microspectrometer. The system is equipped with excitation lasers of 488 nm, 532 nm and 785 nm wavelengths and may attain spatial resolution down to 1 µm laterally and 2 µm axially with 100× magnifying objective. It allows collection of overview spectra within the range of 60–9300 cm^{-1} with 488 nm or 532 nm excitation and 60–3500 cm^{-1} with 785 nm excitation. Spectral resolution better than 1.0 cm^{-1} may ultimately be attained in narrower spectral windows.

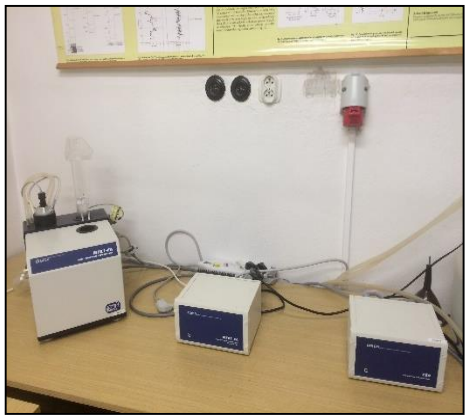
Mid-infrared spectra are acquired with the **Nicolet iS50** Fourier-transform spectrometer**.** It is equipped with a ceramic infra-red radiation source (9600 – 50 cm^{-1}) and a DLaTGS detector with KBr window. In transmission arrangement, the spectrometer covers the wavenumber range of 7800–350 cm^{-1}. Once an **attenuated total reflectance (ATR)** accessory is used, the wavenumbers covered are 4000–100 cm^{-1} depending on the used beam-splitter.



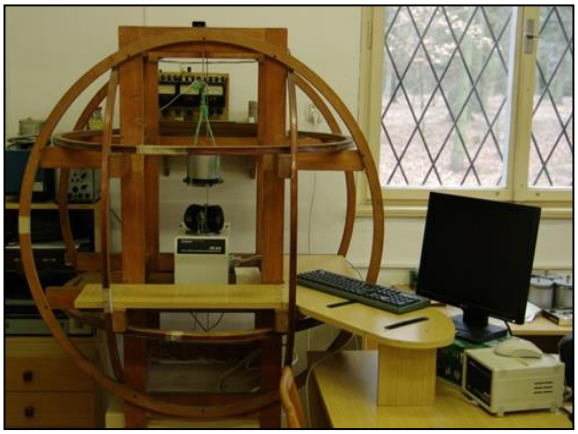
The department is situated in the magnetically quiet environment of the Průhonice Park. It was built using non-magnetic materials to guarantee strict requirements of paleomagnetic research. The team consists of highly experienced scientists and technicians with interests in paleomagnetism, magnetostratigraphy, rock and mineral magnetism, geology and planetology. The team is supported by mathematicians and programmers in order to develop new laboratory techniques. The scientific team members are involved in numerous national and international co-operations. The department is equipped with modern instruments for paleomagnetic and rock magnetic studies, the most important are listed below.

Magnetic Vacuum Control System MAVACS with triaxial **Helmholz Induction Coil System HELICOS**, **Rotating Coil Magnetometer ROCOMA** and **Induction Coil Control Unit ICCON** is a self-contained automatic system creating a limited non-magnetic space (magnetic vacuum < ± 2nT; typical offset of the magnetic field sensor < ± 0.1nT) for paleomagnetic investigations, i.e. for thermal demagnetization of the remanent magnetization is conducted in the oven situated in the center of the MAVACS system. The operation of MAVACS is based on the feedback loop principle where the Earth's magnetic field is compensated by HELICOS and continually monitored by ROCOMA. The output of the ROCOMA controls the ICCON, which supplies the HELICOS generating the compensating magnetic field.

2G 755 4K Superconducting Rock Magnetometer (SRM) with a **2G800 Automatic Sample Handler System** and **Applied Physics Systems 581 DC SQUID System** is a very sensitive (magnetic moment <10 E^{-12} Am^2), liquid helium-free measurement system for determining the intensity and direction of natural remanent magnetization and for conducting alternating field demagnetization of the remanent magnetization. The SRM measures current induced in 3 sets of superconducting pickup coils placed at the center of the rock measurement region. The system permits remanent magnetization measurement in three axes and is designed to process discrete samples with a volume of up to 10 cm^3. Data are collected and displayed using the **2G Acquisition** software.



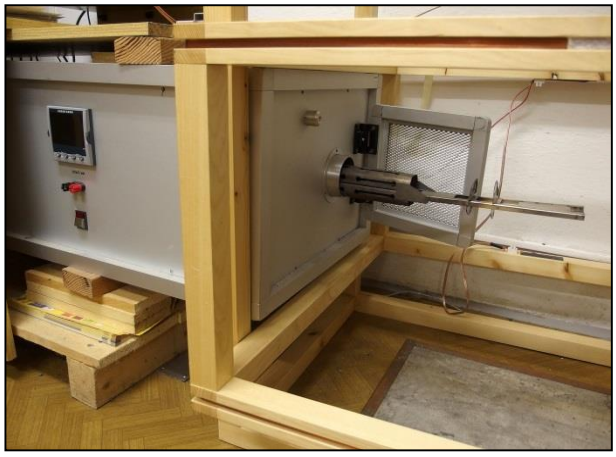
AGICO MFK1-FA Kappabridge is the most sensitive (<2 × 10^{-8} SI) laboratory instrument for measuring magnetic susceptibility and its anisotropy. In conjunction with a CS4/CSL temperature control unit it is further used for measuring temperature dependence of magnetic susceptibility over a temperature range of -192 °C to 700 °C. MFK1-FA represents a fully automatic inductivity bridge which allows high precision measurements at three different frequencies (976 Hz, 3904 Hz, 15616 Hz) and in a wide field range (2-700 A/m). The measurements are controlled by the SAFYR4W (magnetic susceptibility, anisotropy) and SUFYTE5W (temperature dependence) softwares.



AGICO JR-6A Spinner Magnetometer is a sensitive (2.4 μA/m) laboratory instrument used for measurements of remanent magnetization. JR-6A is equipped with automatic specimen holders which enable automatic measuring of all components of the remanence vector. The magnetometer offers two rotation speeds, the higher (87.7 r,p,s) enabling the maximum sensitivity and the lower (16.7 r,p,s) to measure fragile specimens, soft specimens placed in perspex container and specimens with considerable deviations in size and shape. The JR-6A is fully controlled by an external computer and data are processed with REMA6W software.

Magnetic Measurements Pulse Magnetiser MMPM10 is a high field instrument for creating isothermal remanent magnetizations. The MMPM10 is equipped with 2 coils to generate accurate, short-duration (7 ms) high magnetic field pulse: the largest coil (max. field 3T) accommodates standard paleomagnetic samples in any orientation for IRM anisotropy studies. The smaller coil is 1.25 cm in diameter and generates pulsed field up to 9T. The magnetic field pulse is generated by discharging a bank of capacitors through the coil.

Magnetic Measurement Thermal Demagnetizer MMTD80A with **Eurotherm 3204 temperature controller** is a programmable thermal demagnetizer for up to 80 paleomagnetic samples up to 750 °C. The 4-layer closed Mu-metal shield guarantees a constant field of <10 nT during heating and cooling.



AGICO LDA-5 / PAM-1 Specimen Unit is a multifunctional device for laboratory demagnetization up to 200 mT, and for a deliberate acquisition of anhysteretic magnetization or low-field isothermal magnetization of rock samples. The sample is fixed in a special 2-axis tumbler for (de)magnetization in the desired direction. Automatic positioning (18 specimen orientations) allows the determination of anisotropy of magnetic remanence. Triple mu-metal shielding eliminates local magnetic fields.

Department of Physical Properties of Rocks (Reseacrh Centre at Puškinovo náměstí)

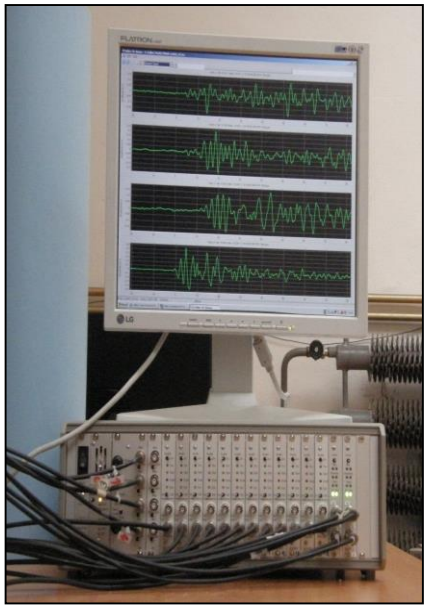
The department deals with the study of physical properties of rocks. The staff is mainly focused on basic research of rock physical properties; nevertheless, unique measuring systems are used to supply experimental data to the other professional units and to private sphere.

High-pressure chamber with max. pressure 400 Mpa is a unique device developed to study elastic anisotropy of rocks under high hydrostatic pressure on spherical samples. It is able to simulate pressures acting at a depth of 15–20 km. Because of the spherical shape of the studied samples properties of rock in 3D can be described, which is unique in the world. Experiment results yield reliable information about the orientation of rock structures, such as micro-crack systems or alignment of mineral grains. Measuring of shear waves gives allows to determine a complete set of elastic parameters and better describe qualities of rock under examination. Experiments done at several pressure levels provide information about process of closing of micro-crack systems.

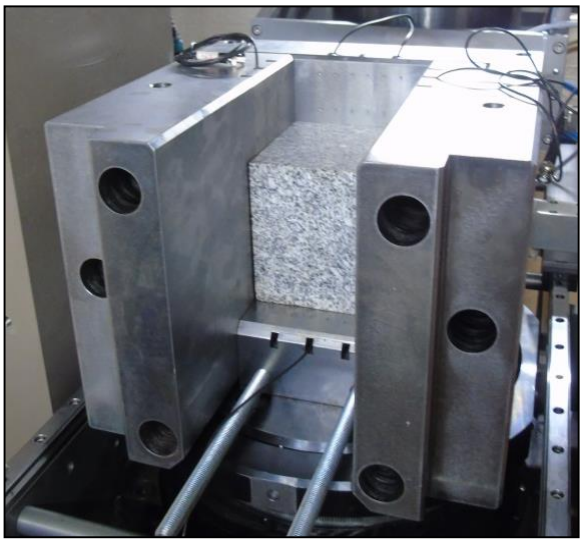
Uniaxial load frame MTS (max. force 4600 kN) is a computer-controlled servo-hydraulic loading system specifically adjusted for long-term testing. This system allows testing of rocks in regime of controlled force or controlled deformation. Together with triaxial cell, this equipment allows simulation of pressure–temperature conditions and permeability measurements.

Triaxial cell Ergotech (max. peressure 100 MPa) is a special triaxial cell that enables hydrostatic loading (up to 100 MPa) under the temperatures up to 200 °C. These attributes allow the simulation of loading in natural conditions or in the expected conditions of a nuclear waste repository. It is equipped for 16 channel acoustic emission measurements for seismic monitoring of stress-induced fracturing.

The **MTS 286.20-09S pressure intensifier** serves for generating and controlling **pressure up to 120 MPa.** It is used for the confining pressure or pore pressure control during triaxial tests or for generation of pressure for hydraulic fracturing. Generation and control of high pressures are necessary for laboratory simulations of natural stress conditions.



The **Vallen System AMSY-5** is a sixteen-channel transient recorder which allows to monitor the process of cracking during uniaxial loading of rock samples. A set of 16 sensors detects every single crack in the rock above the limit set. Recorded data are used to localize each crack and map the process of their propagation in time. This helps to understand better the behaviour of the rock failure process.



The **hydrofracturing unit (Strozatech)** serves for hydraulic fracturing of 15 cm cube rock specimens under a biaxial stress. It is designed for 24 channel acoustic emission monitoring, allowing to monitor the seismic response to hydrofracturing and to investigate the relation between hydraulic fractures and factors such as: rock structural and mechanical properties, acting stress, regime of pressurizing, viscosity of the fracturing fluid. A better understanding of these relations leads to an optimization of *in situ* hydraulic fracturing and is therefore important for hydrocarbon extraction and geothermal energy exploitation.

Thank you for your interest

Czech Academy of Sciences
Institute of Geology

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Notes