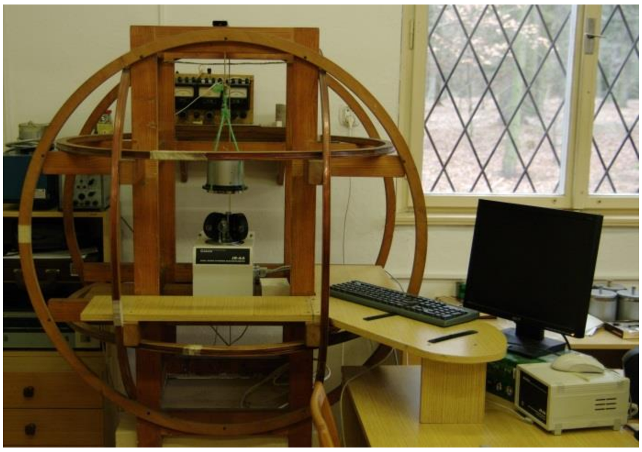
Department of Paleomagnetism

The Laboratory of Paleomagnetism, Prague was originally established in 1960 as a part of Institute of Applied Geophysics, Prague by Miroslav Krs. Since 1991 the laboratory belongs to the Institute of Geology of the Czech Academy of Sciences as the Department of Paleomagnetism. Current laboratory is situated in the magnetically quiet environment of the Průhonice Park. It was built in 1969 using non-magnetic materials to guarantee strict requirements of paleomagnetic research. The laboratory is equipped with modern instruments for paleomagnetic and rock magnetic studies.

Instrumentation

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. Multi-component analysis of the structure of remanent magnetization and reproduction of paleomagnetic directions, even in rocks with secondary magnetization of 97 to 99 % of the magnitude of natural remanent magnetization, can be achieved accurately with this 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 < 10E-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. The data are collected and displayed using **2G Acquisition** software.



AGICO JR-6A and **JR-5A Spinner Magnetometers** with **Power Supply Unit** and a combined **Pick-up and measuring Unit** are sensitive (2.4 µA/m) laboratory instruments used for measurements of remanent magnetization. JR-6A and JR-5A are equipped with automatic specimen holders which enable automatic measuring of all components of remanence vector. The option of using four or six position holders and repeat mode are possible. The JR-6A 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 the fragile specimens, soft specimens placed in perspex container and specimens with considerable deviations in size and shape. The JR-6A and JR-5A are fully controlled by an external computer and data are processed with **REMA6W** and **REMA5A** software's, respectively.

AGICO LDA -3A Alternating Field Demagnetizers are used for demagnetizing of rocks in an alternating field (up to 100 mT). Demagnetization is performed in the **Specimen Unit** equipped with a solenoid (coil) which is shielded from the external magnetic field by three layers of mu-metal. The generated electrical current for producing demagnetizing field is free of the higher harmonic components that may produce parasitic magnetization. The demagnetization process is automated and microprocessor-controlled by **Control Unit**. LDA-3A with **AMU-1A Anhysteretic Magnetizer** enables a rock specimen to be magnetized anhysteretically. AMU-1A produces a weak direct magnetic field that is superimposed on the relatively strong alternating magnetic field generated in the LDA-3A demagnetizer. AMU-1A is useful in physical magnetization and magnetic fabric studies and was designed for investigating the anisotropy of anhysteretic remanent magnetization.

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

AGICO MFK1-FA Kappabridge is the most sensitive (< 2x10^{-8} SI) laboratory instrument for measuring of 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 wide field range (2-700 A/m). MFK1-FA kappabridge with **3D-Rotator** allows rapid measurements with full auto-ranging and enables to determine 640 directional susceptibilities during a single anisotropy measurement. The measurements are controlled by the **SAFYR4W** (magnetic susceptibility, anisotropy) and **SUFYTE5W** (temperature dependence) softwares.

AGICO KLF-4 magnetic susceptibility meter is a sensitive (up to 1×10^{-6} SI) instrument designed for rapid magnetic susceptibility measurements of rocks, soils and environmental materials in variably adjustable fields (5−300 A/m; operating frequency 2 kHz).

AGICO KLY-4S Kappabridge with **CS3/CSL temperature control unit** is a sensitive (2 x 10^{-8} SI), modular system for measuring magnetic susceptibility (in variable fields from 3-450 A/m, frequency 875 Hz, measuring range 0-0.2 SI), its anisotropy and temperature dependence (from –192 to 700°C). KLY-4S is a precision fully automatic inductivity bridge which is fully controlled by external computer. The quasi-continuous measurement processes are fully automated and controlled by the SUFAR (bulk susceptibility and anisotropy), SUFTE (high temperature variations) and SUFTEL (low temperature variations) softwares.

Magnetic Measurements Pulse Magnetiser MMPM 10 is a high field instrument for creating Isothermal Remnant 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.

PFEIFFER VACUUM HiCube 80 Eco is a compact pumping station for high vacuum applications. It is used to pump the vacuum space in **2G 755 4K SRM** prior to cooling to operating temperatures to remove the outgassing contaminants that have accumulated.

Research

Scientific team of the laboratory consists of highly experienced professionals with scientific interests broadly exceeding the framework of classical rock- and paleomagnetism. In addition to the original research in fields of paleomagnetism, magnetostratigraphy, rock and mineral magnetism, geology and development of new laboratory techniques the scientific team members are involved also in numerous national and international co-operations. Together with excellent up-to-date equipment the results of the laboratory are applicable to solve various geological and geophysical problems.

Research team:

Scientists

Ing. Petr Pruner, DrSc. (Head of department)
Dr. Tiiu Elbra, PhD
Mgr. Martin Chadima, PhD
RNDr. Gunther Kletetschka, PhD
RNDr. Tomáš Kohout, PhD
Mgr. Petr Schnabl, PhD
prom.fyz. Otakar Man, CSc.

Graduate specialists

Mgr. Kristýna Čížková Šifnerová
Mgr. Petr Petráček
Mgr. Stanislav Šlechta
RNDr. Daniela Venhodová

Technicians

Jiří Petráček

Research topics:

1. Paleomagnetism
   1.1. Paleomagnetic and rock magnetic investigation of the Prague Basin.
   1.2. Paleomagnetism and magnetostratigraphy of Cenozoic cave sediments in Slovakia, Poland, Slovenia and Austria.
2. Magnetostratigraphy
   2.1. Magnetostratigraphy of the Jurassic/Cretaceous boundary strata in the Tethyan and sub-Boreal Realms.
   2.2. Reference climate curve for the beginning of the Miocene Climatic Optimum in Central Europe
3. Rock magnetism
   3.1. Temperature dependence of magnetic susceptibility: implications for volcanism in Prague Basin
   3.2. Pressure induced changes in the magnetic properties of iron oxides and sulfides (from 2016)
   3.3. The magnetic scanning of volcanic rocks
   3.4. The magnetic record in sandstone concretions from Utah and Czech Republic
4. Planetary studies
   4.1. Magnetic and optical properties of meteorites, micrometeorites, microspherules, cometary dust and interpretation of observations by Rosetta space mission
   4.2. Low temperature magnetic properties of the iron-bearing sulfides in extraterrestrial materials
   4.3. Space weathering, shock-related spectral changes in asteroid reflectance spectra and shock darkening in ordinary chondrites
   4.4. Magnetic minerals and anomalies in Mars
   4.5. The magnetic and temperature records of bullets – implications to impact studies
5. Other topics

Important results:

1. Paleomagnetism

   1.1. **Paleomagnetic and rock magnetic investigation of the Prague Basin:** Multidisciplinary investigations were carried out on samples from various localities around Prague Basin. The new paleomagnetic database with information of palaeomeridians, –latitudes, –rotations, and the approximate ages was defined and built. Paleomagnetic and paleogeographic investigations of five Silurian localities (Kosov Quarry section, Černidla, Třebáň, Vinařice, Vyskočilka) showed that paleomagnetic pole positions fit well with the theoretical model paths simulating the distribution of pole positions due to horizontal palaeotectonic rotations. The mean palaeolatitude of 22.5° ± 6.6° calculated from all localities positioned in the southern hemisphere was computed for the Silurian. These investigations support the opinion that the Prague Basin was a continental rift basin, situated on the presumed Perunica microplate which drifted at southern subtropical palaeolatitudes of 24° in Late Silurian time and experienced either 170° counter clockwise or 190° clockwise rotation during the Variscan orogeny. The paleomagnetic data of Lištice area, however, is different than in the areas mentioned above and prove quite a strong remagnetization in the late Carboniferous – early Permian with no significant rotation.

   Publications:

   Krs M. et al. (2001): Tectonophysics, 332, 93-114
   Patočka F. (2003): Physics and Chemistry of the Earth, 28, 735-749
   Aïfa T. et al. (2007): Geol. Soc. of America Spec. Paper, 423, 249-265
   Koptíková L. et al. (2010): Geologica Belgica, 13/4, 407–430
   Vacek F. et al. (2010): Geologica Carpathica, Roč. 61, č. 4, s. 257-272
   Hladil J. et al. (2011): Stratigraphy, 8, 4: 217-235.
   Cajz V. et al. (2012): Geologica Carpathica, Roč. 63, č. 5, s. 423-435
   Kletetschka G. et al. (2013): Studia geophysica et geodaetica, Roč. 57, č. 1, s. 103-117
   Tasáryová Z. et al. (2014): GFF, Roč. 136, č. 1, s. 262-265

   1.2. **Paleomagnetism and magnetostratigraphy of Cenozoic cave sediments in Slovakia, Poland, Slovenia and Austria:** For the first time in Slovenia, Slovakia and Poland biostratigraphic data contributed to the correlation of magnetostratigraphy logs with the GPTS and to allocate the ages of cave fill more precisely to pre-Quaternary times. The evolution of caves took part within one post-Eocene karstification period, which began with the regression of Eocene sea and limestone exposition during Oligocene to early Miocene orogenic phase. The period contains three distinct phases of massive deposition in caves with still preserved sediments dated to about 5.4–4.1 Ma (Miocene–Pliocene), 3.6–1.8 Ma (Pliocene) and Quaternary, following the cessation of Miocene deposition in Slovene part of the Pannonian Basin, and the last, but principal, change of the tectonic regime at about 6 Ma.

   Publications:

   Horáček I. et al. (2007): Acta Carsologica, 37/3, 451-466.
   Zupan Hajna N. et al. (2008): Palaeomagnetism and Magnetostratigraphy of Karst Sediments in Slovenia. ZRC SAZU (Carsologica), 266 pp.
   Pruner P. et al. (2010): Studia Geophysica et Geodaetica, 54, 28-48.
   Zupan Hajna N. et al. (2010): International Journal of Speleology, 39 (2): 47–60.
   Bosák P. et al. (2010): Acta Carsologica, 39, 3: 529–549.

Bella P. et al. (2011): Aragonit, 16, 1–2 : 64–68.
Krajcarz M.T. et al. (2014): Quaternary International, 326-327, 2014: 6-19.

2. Magnetostratigraphy

2.1. **Magnetostratigraphy of the Jurassic/Cretaceous boundary strata in the Tethyan and sub-Boreal Realms:** On several pilot localities (e.g. Bosso – Italy, Brodno – Slovakia, Puerto Escaño – Spain; Nutzhof – Austria; Nordvik Peninsula – Russia, Le Chouet – France), we successfully applied the high-resolution magnetostratigraphy together with detailed microbiozonation. According to present knowledge, the actually used provisional Boreal and the Tethyan J/C boundaries are heterochronous. All attempts to correlate the boundary J/K beds between the Boreal and the Tethyan realms by biostratigraphic methods failed due to differences in biotas. We determined individual magnetozones and subzones and we correlated profiles in both realms. International Commission on Stratigraphy (Subcommission on Cretaceous) submitted the new proposal of fixing J/C boundary based on our results. The base of M18r reverse polarized zone (M18r / M19n interval) was selected as principal correlation event.

Publications:

Chadima M. et al. (2006):Tectonophysics, 418: 145–162.
Houša V. et al. (2007): Stratigraphy and Geological Correlation,15, 3: 297-309.
Man O. (2008): Studia Geophysica et Geodaetica, 52: 173-186.
Pruner P. et al. (2010): Cretaceous Research, 31: 192-206.
Lukeneder A. et al. (2010):Geologica Carpathica, 61, 5: 365–381.
Man O. (2011): Geophysical Journal International, 185, 1: 133–143.
Žák K et al. (2011): Palaeogeography, Palaeoclimatology, Palaeoecology, 299, 1-2: 83-96.
Man O. et al. (2012): Studia Geophysica et Geodaetica, 56: 735-750.
Wimbledon W. A. P. et al. (2013): Geologica Carpathica, 64, 6: 437–460.
Zakharov V. A., et al. (2014): Polar Research 2014, 33: 19714.

3. Rock magnetism

3.1. **Temperature dependence of magnetic susceptibility: implications for volcanism in Prague Basin:** The rock magnetic investigations of Lištice, Černidla and Kosov show presence of Ti-magnetite, goethite and traces of hematite, with no significant frequency dependence and only minor amount of superparamagnetic particles. The Ti-magnetite within amygdales of Lištice samples was found to be carrying the characteristic remanent magnetization and reflects probably the Permo-Carboniferous remagnetization of volcanic phases.

Publications:

Elbra T. et al. (2015): Estonian Journal of Earth Sciences, 64, 1, 31-35.

4. Planetary studies [1] [2]
5. Other topics