Academy of Sciences of the Czech Republic

# Institute of Geophysics

Report 2008–2009

# Contents

# Institute of Geophysics of the Academy of Sciences of the Czech Republic

The Institute of Geophysics of the Academy of Sciences of the Czech Republic is a public research institution. The mission of the Institute is to conduct fundamental research in physics of the solid Earth and its immediate space environment, in order to increase the level of general scientific knowledge as well as to contribute to practical application of the results of scientific research.

Geophysical interpretations include studies of the lithosphere and sub-lithosphere structure, crustal studies, geodynamics of the seismoactive regions, climatic changes, solar-terrestrial relations, environmental geomagnetism, and many others. Theoretical modelling and numerical simulations of geophysical fields are integral parts of the research programme of the Institute. The activities of the Institute of Geophysics comprise regular observatory monitoring of Earth's physical fields as well as a broad collaboration with worldwide network services and data centers.

A significant part of the Institute's activity is focused on higher education: many researchers lead and co-lead university courses and supervise research students, especially at the doctoral level, at universities both in the Czech Republic and abroad.

The Institute of Geophysics employs approximately 60 researchers organized in five research departments: seismology, geothermics, geomagnetism, geoelectricity, and tectonics and geodynamics. The research activities are supported by approximately 10 technicians at the research departments and 30 staff members of the operating division (IT centre, library, administrative and technical services). In 2008-2009, 13 research staff members were PhD students. Because a significant part of the mission of a research institution is exchange and dissemination of knowledge, the Institute organizes scientific meetings and seminars at both national and international levels, and publishes a scientific journal Studia Geophysica et Geodaetica (the 5-years IF of 2008 is 0.799).

A direct successor to the State Institute of Geophysics founded in 1920, the Institute of Geophysics was incorporated into the Czechoslovak Academy of Sciences in 1953. Currently it is one of 53 public scientific institutes of the Academy. (Detailed information about the structure of the Academy of Sciences of the Czech Republic and other institutes can be found at: www.cas.cz/en/).

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(December, 2009)
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*Illustration photos document the breadth of basic and applied research at the Institute of Geophysics: gravity measurements around the Devils Tower volcanic body (Wyoming; page 2, left), measurements of soil magnetism (Portugal, page 2, right), geological field work in the Kaoko orogenic belt od Namibia (page 3, left) and downhole temperature logging on a geothermal test site in Litoměřice, Czech Republic.*

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# Research departments

## Department of Geoelectricity

***Head: RNDr. Josef Pek, CSc.***

- investigations of the crustal and upper mantle electrical conductivity
- theoretical and methodological research of electromagnetic fields and their numerical modelling
- study of external geoelectromagnetic fields
- investigations of solar-terrestrial relationships

## Department of Geomagnetism

***Head: RNDr. Eduard Petrovský, CSc.~***

- observations of the Earth's magnetic field
- field measurements of secular variations of geomagnetic field
- geodynamo modelling
- space weather studies
- research in effects of solar and geomagnetic activities on climatic changes
- research in rock and environmental magnetism

## Department of Geothermics

***Head: RNDr. Jan Šafanda, CSc.***

- experimental and theoretical investigations of the temperature field of the Earth's crust and upper mantle
- temperature logging in boreholes
- experimental studies of the thermo-physical properties of crustal rocks, thermal conductivity and diffusivity and radiogenic heat production
- instruments for geothermal research, portable thermometers for borehole logging and systems for a long-term temperature monitoring
- reconstruction of climatic changes from temperature-depth profiles in deep boreholes
- study of the air, ground and bedrock temperature coupling and of the thermal regime within the soil and the underlying bedrock.

## Department of Seismology

***Head: RNDr. Jan Šílený, CSc.***

- operating a regional network of broadband seismological stations, compilation of earthquake catalogs and bulletins, data exchange with European and world data centers
- collecting macroseismic data related to seismicity on the territory of Czech Republic
- monitoring and interpreting the seismicity and gas emanation in the geodynamically active region of West Bohemia
- study of deep geological structures down to the mantle litosphere by active and passive seismological experiments
- theoretical research on seismic waves generation and propagation in complex structures
- theoretical modeling of fracturing the rock massif – investigation of foci of earthquakes and events induced by industrial activities

## Department of Tectonics and Geodynamics

***Head: RNDr. Aleš Špičák, CSc.***

- study of processes at convergent plate margins, focused on tectonic interpretation of earthquake distribution and mechanisms
- study of orogenic processes and rheology of Earth's crust and mantle in ancient orogens
- experimental and field study of processes of magma ascent and diapirism
- research on evolution of sedimentary basin fills as sensitive records of the interaction between tectonic processes, sea-level fluctuations and climate changes
- study of recent crustal movements in tectonically active regions using gravity and geodetic methods
- monitoring and analysis of Earth tides, slope stability monitoring based on tilmeter and groundwater observations
- studies of oriented microporosity of rocks and its relation to elastic properties and permeability, e.g. for planning of radioactive waste repositories
- microgravity measurements in engineering geology and archaeology

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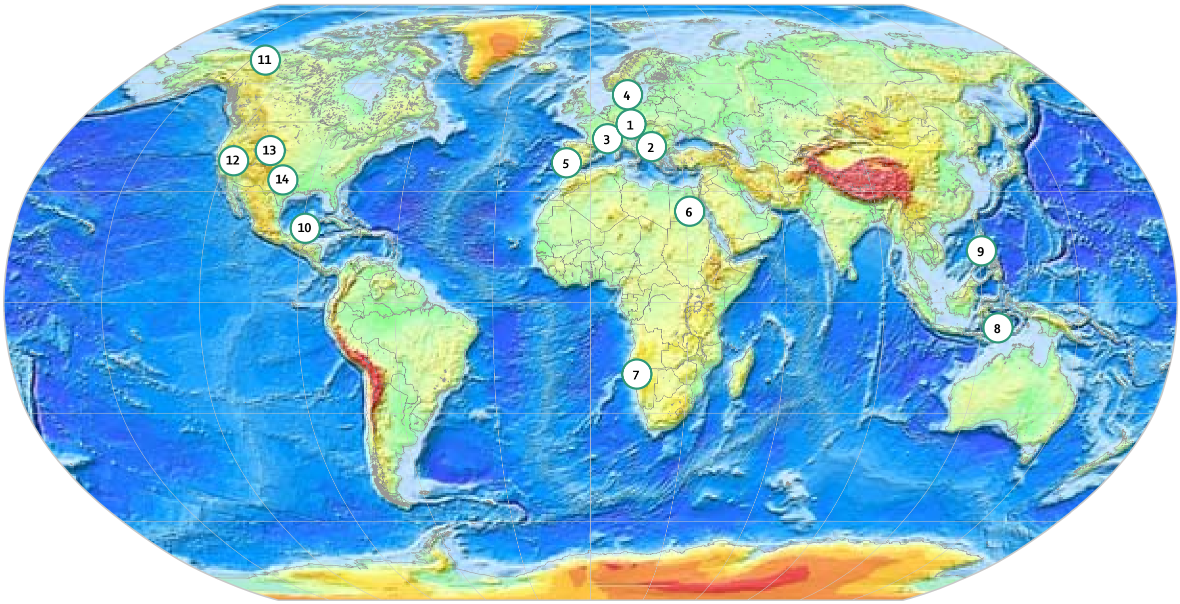
# Main research topics

—— The core of the yearbook is devoted to short communications summarizing the principal results achieved in various lines of research at the Institute during the years 2008 and 2009.

—— The topics studied and methods applied cover a very broad range, our researchers are commonly involved in multi-disciplinary teams and collaborate with colleagues from many institutions worldwide. Therefore the organization of the text does not strictly follow the administrative structure of the Institute's departments. The topics are arranged in several more or less loosely tied groups, following a direction from continental- and regional-scale studies of geodynamics, lithosphere structure and tectonics, through studies focused on development of geophysical methods, applications of geophysical methods in the energy industry, geophysical characterization of environmental changes, to research of the outer Earth and Solar System processes.

The global focus of research undertaken at the Institute of Geophysics is illustrated by the map below




*World map constructed using the GMT software: Wessel, P. and Smith, W. H. F. 1998. New, improved version of the Generic Mapping Tools released, EOS Trans. AGU, 79, 579.*

| 1 Deep electromagnetic soundings across the Teisseyre-Tornquist Zone in Pomerania, NW Poland

| 2 Study of crustal electrical parameters at the western slope of the Ukrainian Shield and the Volyno-Podolian Plate

| 3 Microseismic experiments in the Soultz-sous-Forets geothermal facility, Alsace, France

| 4 Passive seimological experiment in Scandinavia

| 5 Study of magnetic susceptibility of soils, coastal regions of Portugal

| 6 Gravity measurements in Aswan, Egypt

| 7 The Kaoko Belt, Namibia: Field research of tectonic controls of repeated magmatic activity during formation of orogenic belts

| 8 Deep structure and tectonic evolution of the Banda Arc region, SE Asia

| 9 Geodynamics of the Izu-Bonin-Mariana arc-trench system, SE Asia

| 10 Geothermal research of the Chicxulub impact structure, Yucatán, Mexico

| 11 Study of formation of gas hydrates in a warming arctic region, the Beaufort-McKenzie Basin, Canada

| 12 Study of pre- and post-collisional plutons penetrating the Klamath Mts. accretionary complex, California / Oregon, USA

| 13 Structural and geophysical study of volcanics emplacement in the Devils Tower National Monument, Wyoming, USA

| 14 Microseismicity related to microfracturing in boreholes, Cotton Valley natural gas reservoir, Texas, USA

# Convergent plate margins: strong earthquake occurrence reveals magmatic plumbing system beneath volcanoes

—— As earthquake occurrence belongs to the most pronounced manifestations of recent subsurface dynamics, it is widely used as a tracer of magma transport from the source/reservoir of magma to the Earth surface. Differences in seismicity pattern should reflect differences in magmatic/volcanic processes and in lithospheric environment. Our working tool - hypocentral determinations and focal mechanisms derived from global seismological data (Engdahl-van der Hilst-Buland database – EHB Bulletin (see http://www.isc.ac.uk), Global Centroid Moment Tensor Solution database – GCMTS (http://www.globalcmt.org/) - enables us to detect uncommon seismic events/series that cannot be usually revealed by short-term on-site regional observations during expeditions, namely because their recurrence interval may be 40 years and more.

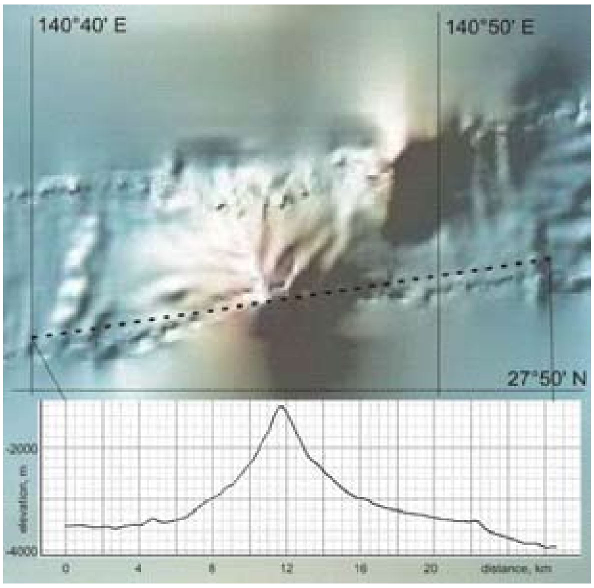



*Fig. 1: A detail of sea floor morphology in the region of seamounts between Tori-shima and Nishino-shima volcanoes in the Izu-Bonin arc and an elevation profile.*

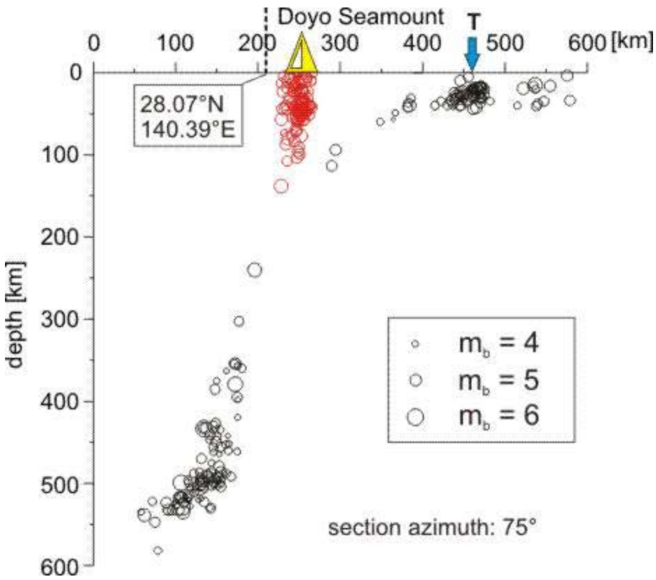



*Fig. 2: Vertical section showing the depth distribution of earthquake foci with respect to distance from the trench axis (blue arrows). Section width is 50 km. Earthquakes in the lithospheric wedge of the overriding Philippine plate are denoted by red symbols, earthquakes belonging to the Wadati-Benioff zone of the subducting Pacific plate by black symbols, submarine volcanic seamount by yellow triangle. $m_b$ is body wave magnitude.*

—— **Izu-Bonin subduction zone** (Špičák et al., 2009): A detailed spatio-temporal analysis of teleseismic earthquake occurrence ($m_b$ > 4.0) along the convergent margin of the Izu-Bonin-Mariana arc system revealed an anomalously high concentration of events between 27° – 30.5°N, beneath a chain of seamounts between Tori-shima and Nishino-shima volcanoes. This seismicity is dominated by the 1985/86 earthquake swarm represented in the EHB hypocenter database by 146 earthquakes in the body wave magnitude range 4.3-5.8 and focal depth range 1-100 km. The epicentral cluster of the swarm is elongated parallel to the volcanic chain. Available focal mechanisms are consistent with an extensional tectonic regime and reveal nodal planes with azimuths close to that of the epicentral cluster. Earthquakes of the 1985/86 swarm occurred in seven time phases. Seismic activity migrated in space from one phase to the other. Earthquake foci belonging to individual phases of the swarm aligned in vertically disposed seismically active columns. The epicentral zones of the columns are located in the immediate vicinity of seamounts Suiyo and Mokuyo, recently reported by the Japanese Meteorological Agency as volcanically active. The three observations – episodic character of earthquake occurrence, column-like vertically arranged seismicity pattern, and existence of volcanic seamounts at the sea floor above the earthquake foci – led us to interpret the 1985/86 swarm as a consequence of subduction-related magmatic and/or fluid activity. The 1985/86 deep-rooted earthquake swarm in the Izu-Bonin region represents an uncommon phenomenon of plate tectonics. The portion of the lithospheric wedge that was affected by the swarm should be composed of fractured rigid, brittle material so that the source of magma and/or fluids which might induce the swarm should be situated at a depth of at least 100 km in the aseismic part of the subduction zone.

—— **Sunda Arc** (Špičák et al., in press): Spatial and temporal analysis of EHB hypocentral data 1964-2005 reveals a distinct teleseismic earthquake activity producing a column-like formation in the continental wedge between the Krakatau volcano at the surface and the subducting slab of the Indo-Australian plate. These earthquakes occur continuously in time, are in the $m_b$ magnitude range 4.5-5.3 and in the depth range 1-75 km. The Krakatau earthquake cluster is vertical and elongated in the azimuth of 35°, suggesting existence of a deep-rooted fault zone cutting the Sunda Strait in the SSW-NNE direction. Possible continuation of the fault zone in the SW direction was enlightened by an intensive 2002/2003 aftershock sequence, elongated in the azimuth of 55°. Beneath the Krakatau earthquake cluster, an aseismic gap exists in the Wadati-Benioff zone of the subducting plate at the depths 100–120 km. Whereas we interpret this aseismic gap as a consequence of partial melting inhibiting stress concentration necessary to generate stronger earthquakes, numerous earthquakes observed in the overlying lithospheric wedge exclusively beneath the volcano probably reflect the recent plumbing system of a steady magma transport to the Krakatau volcano. According to this approach, individual earthquakes of the Krakatau cluster occur along the fault zone that is pre-stressed by tectonic processes related to plate convergence. Without additional stress from magma injection the fault zone ruptures only occasionally; in the vicinity of Krakatau volcano, the earthquake occurrence is regular and relatively frequent due to stress added by processes related to the magma ascent.

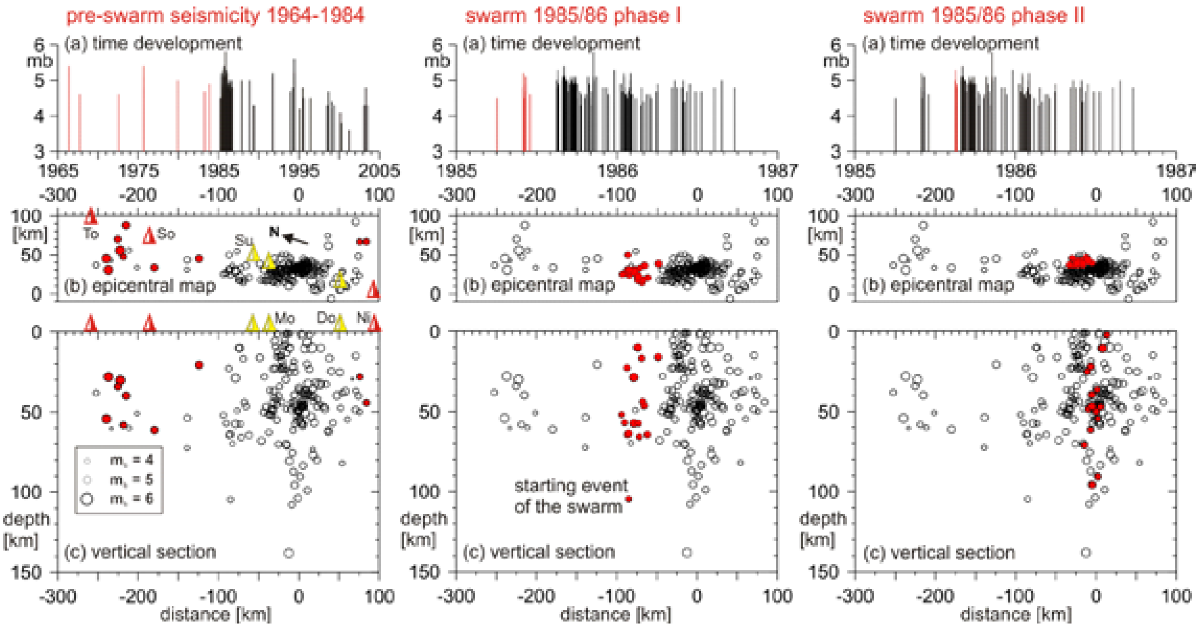



*Fig. 3:* *Migration of earthquake occurrence in the lithospheric wedge of the overriding Philippine plate in the studied area before (1964 - 1984) the 1985/86 earthquake swarm and during the first and second temporal phases of the swarm. Rows: (a) - time development, (b) - map view of epicenters, and (c) - vertical section along the epicentral zone in the azimuth of 155°; vertical exaggeration is 2:1. Earthquakes belonging to the appropriate time interval/swarm phase are shown in red color against the background of the entire dataset (open circles). Active subduction-related volcanoes on islands and submarine volcanic seamounts are denoted by red and yellow triangles, respectively. To - Tori-shima, So - Sofugan, Sui - Suiyo, Mo - Mokuyo, Do - Doyo, Ni - Nishino-shima.*

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## References:


***Špičák, A., Vaněk, J., and Hanuš, V., 2009.*** *Seismically active column and volcanic plumbing system beneath the island arc of the Izu-Bonin subduction zone. Geophys. J. Int., 179, 1301-1312,*

***Špičák A., Hanuš V., and Vaněk J., in press.*** *Recent plumbing system of the Krakatau volcano revealed by teleseismic earthquake distribution. International Journal of Earth Sciences.*

# Structure of continental mantle lithosphere

—— Intensive research of the continental mantle lithosphere (Plomerová et al., 2008b) concentrated into two European regions – the Precambrian Fennoscandia and the Variscan Bohemain Massif (BM). A detailed body-wave analysis – shear-wave splitting and P-travel time residuals - detected anisotropic structure of the upper mantle also beneath the Swedish part of Fennoscandia (Eken et al., 2010). The fabric of individual mantle domains is internally consistent, usually with sudden changes at their boundaries (Fig. 1). Distinct back-azimuth dependence of SKS splitting excludes single-layer anisotropy models with horizontal symmetry axes for the whole region. Based upon joint inversion of body-wave anisotropic parameters, we instead propose 3D self-consistent anisotropic models of the well-defined mantle lithosphere domains with differently oriented fabrics approximated by hexagonal aggregates with plunging symmetry axes. The domain-like structure of the Precambrian mantle lithosphere, most probably retaining fossil fabric since the domains' origin, supports the idea of the existence of an early form of plate tectonics during formation of continental cratons already in the Archean. Tomographic images of velocity perturbations (based on data corrected for the effect of anisotropy; Fig. 1, bottom) are simpler (less laterally inhomogeneous) at greater depths than those calculated without considering seismic anisotropy. This suggests that the significant lateral velocity variations deduced from the isotropic analysis for depths of 250km, or more, could be artifacts produced by anisotropic structures

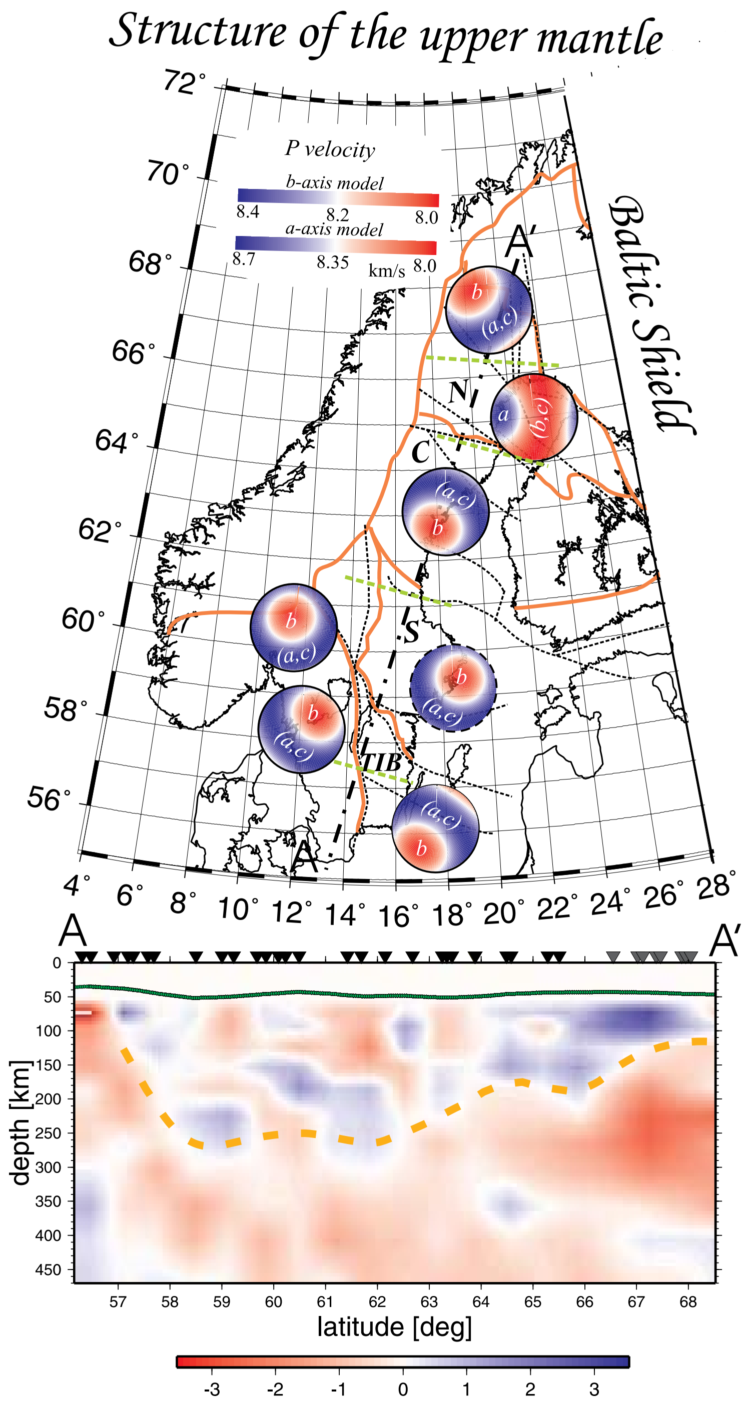
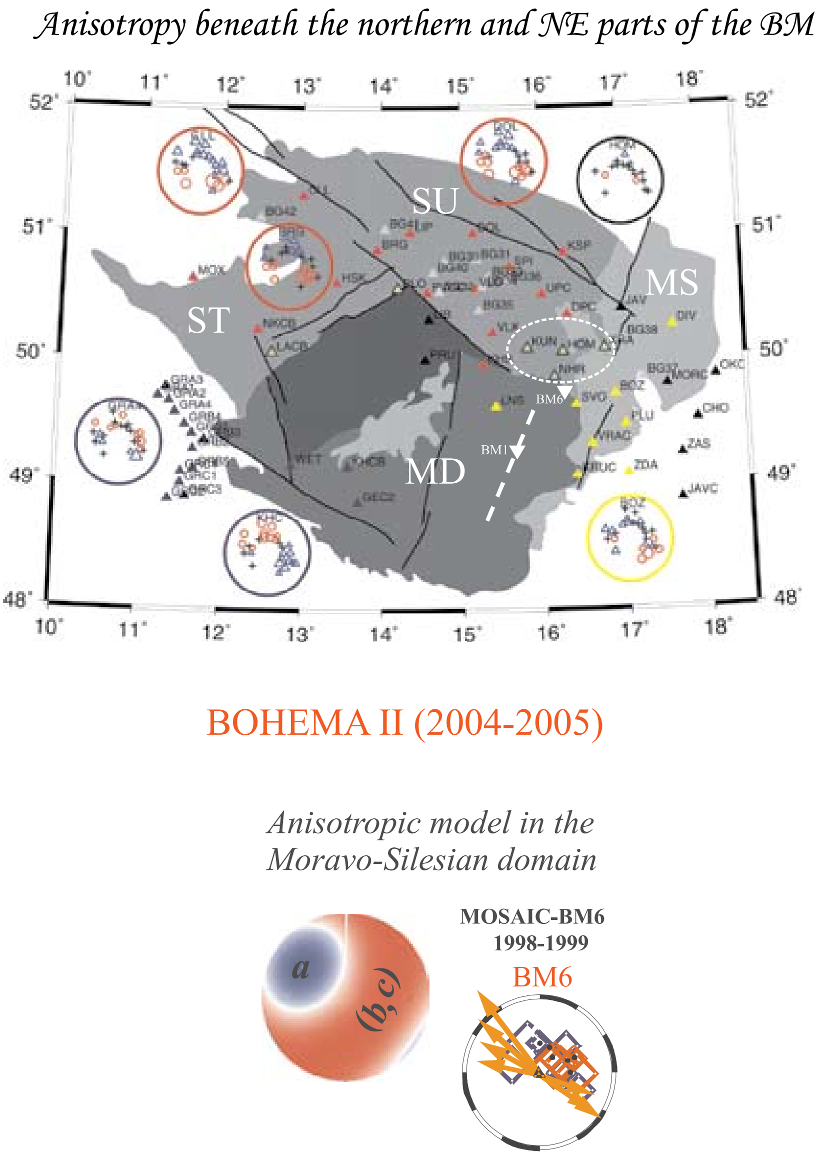



*Fig. 1: 3D self-consistent anisotropic models (velocity spheres) of individual mantle lithosphere domains derived by joint inversion of body-waves anisotropic parameters. Boundaries of the domains (dashed green) correlate with those of major crustal terranes (orange curves). The mantle lithosphere domains of the Proterozoic part of Fennoscandia seem to be sharply bounded and separated by a narrow and steep contact (suture) zones cutting the whole lithosphere. The cross-section below shows velocity perturbations from data corrected for anisotropy. Dashed curve indicates the lithosphere-asthenosphere boundary.*

within the upper 250km. The lower boundary of the high-velocity heterogeneities correlates with the lithosphere-asthenosphere boundary modelled beneath the Baltic Shield (Plomerová et al., 2008a; Plomerová and Babuška, 2010).




"Scanning" the BM mantle lithosphere focused on its north and north-eastern parts. Analysis of both the P-wave and S-wave anisotropy identified fabrics beneath the Sudetes (SU) to be close to the anisotropic structure of the Saxothuringian (Fig. 2) modelled by the high-velocity (*a,c*) foliations dipping to the N-NNW (Vecsey et al., 2008). The high-velocity lineation (*a*) dipping to the NW approximate the fabric of the easternmost Moravo-Silesian (MS) domain separated from the Sudetes by a group of stations with "no anisotropy". The surface trace of the inter-domain boundary appears as the northward continuation of the formerly found contact of the MS and Moldanubian (MD) domain further to the south.

The western BM is known by a considerable present-day geodynamic activity manifested by earthquake swarms, neotectonic crust movements and emanations of CO2 dominated gases of mantle origin, channelled to the surface along rejuvenated deep-seated lithosphere boundaries (Babuška and Plomerová, 2008). Tectonics of the region is controlled by junction of three domains of mantle lithosphere (Fig. 3) with different olivine fabrics revealed by consistent orientations of seismic anisotropy (Babuška et al., 2008). The domains represent mantle components of the major tectonic units (micro-plates): Saxothuringian (ST), Teplá-Barrandian (TB) and Moldanubian (MD), which

***Fig. 2:*** *High- and low-velocity directions of the P-wave propagations (blue triangles and red circles, respectively) at selected stations. Stations exhibiting similar P-sphere patterns are coloured correspondingly. The MD and MS lithosphere domain boundary is marked in white dashed line, stations with no pattern related to the SU/MS are in a dashed white ellipse. The 3D anisotropic model (below) with the a lineation dipping to NW comply with body-wave anisotropic parameters evaluated from P and SKS recorded at the Moravo-Silesian during BOHEMA II (2004-2005) field experiment.*

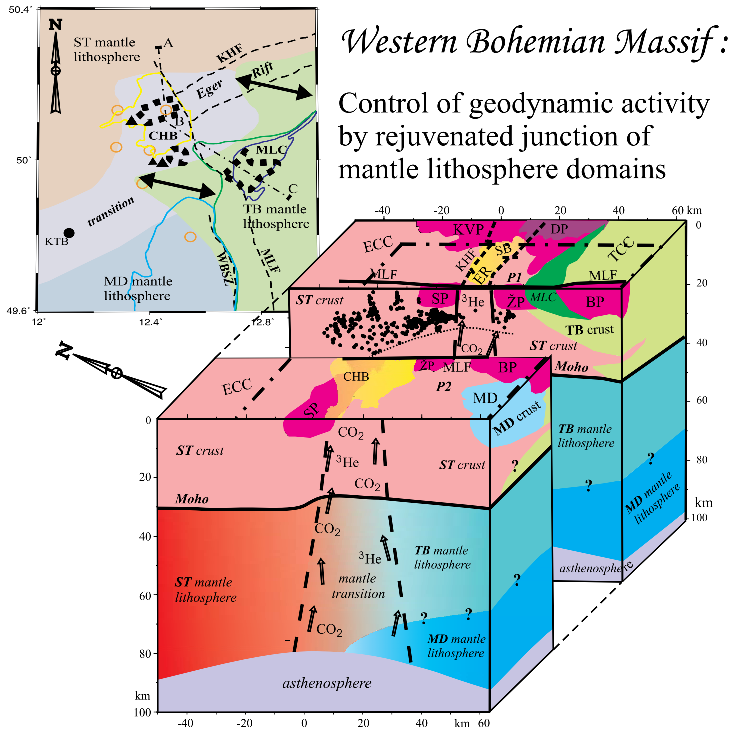



*Fig. 3: Schematic cartoon shows the near surface geology and deep tectonics of the geodynamically most active part of the western Bohemian Massif. Black dots are earthquake hypocentres, the arrows indicate possible paths of mantle-derived fluids to the surface. Note the Saxothuringian (ST) crust, mainly formed by the Erzgebirge Crystalline Complex (ECC), is thrust over the junction with the Teplá-Barrandian (TB) and Moldanubian(MD) mantle lithosphere (upper left). Double arrows indicate the shift between the boundaries of the mantle domains (coloured) and the crustal units (contoured). MLC – Mariánské Lázně Komplex. Variscan granitoids: SP – Smrčiny (Fichtlgebirge) Pluton, KVP – Karlovy Vary Pluton, ŽP – Žandov Pluton, BP – Bor Pluton. DP – Cenozoic volcanics of the Doupovské hory Mts. CHB – Cheb Basin, SB – Sokolov Basin. KHF – Krušné hory Fault, MLF - Mariánské Lázně Fault.*

assembled during the Variscan orogeny. The ST-TB boundary, reactivated during the Cenozoic extension, controlled the position and development of the Eger Rift (ER) and the Cheb Basin (CHB; Babuška et al., 2009). We show that the CHB originated above the rejuvenated ST-TB-MD mantle "triple junction". Though the basin is located within the ST crust domain, it is the mantle suture, which controls the CHB shape and its development through the allochtonous ST crust. Seismically active Mariánské Lázně Fault limits the basin against the uplifted block of the Erzgebirge Crystalline Complex. Similarly to the western BM, also in other continental regions many intraplate earthquakes may be located at more or less healed paleoplate boundaries.

## IG research staff involved:

*Vladislav Babuška, Jaroslava Plomerová, Luděk Vecsey*

## References

**Babuška V. and Plomerová, J, 2008.** *Control of paths of quaternary volcanic products in western Bohemian Massif by rejuvenated Variscan triple junction of ancient microplates. Studia Geophys. Geod. 52, 607-629.*

**Babuška V., Plomerová J. and Vecsey, L., 2008.** *Mantle fabric of western Bohemian Massif (central Europe) constrained by 3D seismic P and S anisotropy, Tectonophysics, 462, 1-4, 149-163.*

**Babuška V., Fiala J and Plomerová, J., 2009 (on line).** *Bottom to top lithosphere structure and evolution of western Eger Rift (central Europe), Int. J. Earth Sci., doi: 10.1007/s00531-009-0434-*

**Eken, T., Plomerová, J., Roberts, R., Vecsey, L., Babuška, V., Shomali, H. and Bodvarsson, R., 2010.** *Seismic anisotropy of the mantle lithosphere beneath the Swedish National Seismological Network (SNSN), Tectonophysics, 480, 241-258.*

**Plomerová, J., Babuška, V., Kozlovskaya, E., Vecsey, L., and Hyvonen, L.T., 2008a.** *Seismic anisotropy – a key to resolve fabrics of mantle lithosphere of Fennoscandia. Tectonophysics, 462, 1-4, 125-136.*

**Plomerová, J., Frederiksen, A., and Park, J., 2008b.** *Seismic Anisotropy and Geodynamics of the Lithosphere-Asthenosphere System.Preface. Tectonophysics 462, 1-6.*

**Plomerová, J. and Babuška V., 2010 (on line).** *Long memory of mantle lithosphere fabric - European LAB constrained from seismic anisotropy. Lithos, 10.1016/j.lithos.2010.01.08.*

**Vecsey, L., Plomerová, J. and Babuška, V., 2008.** *Shear-wave splitting measurements – problems and solutions. Tectonophysics, 462, 1-4, 178-196.*

**Wilde-Piórko, M., Geissler, W.H., Plomerová, J., Grad, M., Babuška, V., Brückl, E., Cyziene, J., Czuba, W., England, R., Gaczyński, E., Gazdova, R., Gregersen, S., Guterch, A., Hanka, W.,Hegedűs, E., Heuer, B., Jedlička, P., Lazauskiene, J., Keller, G.R.,. Kind, R., Klinge, K., Kolinsky, P., Komminaho, K., Kozlovskaya, E., Krüger, F., Larsen, T., Majdański, M., Málek, J., Motuza, G., Novotný, O., Pietrasiak, R., Plenefisch, T., Růžek, B., Sliaupa, S., Środa, P., Świeczak, M., Tiira, T., Voss, P., and Wiejacz, P., 2008.** *PASSEQ 2006-2008: passive seismic experiment in Trans-European Suture Zone. Studia Geophys. Geod., 52, 439-448.*

# Refraction and wide-angle reflection experiments in central Europe – results of seismic modelling and possible tectonic implications

Central Europe has experienced a complex tectonic history that includes periods of mountain building due to accretion of terranes during the Caledonian and Variscan orogenies, and the collisional events of the Alpine orogeny. To reveal the evolution of this area including Trans-European Suture Zone, the southwestern portion of the East European Craton, the Carpathians, the Alps, the Pannonian Basin and the Bohemian Massif, central Europe has been covered by an unprecedented network of seismic refraction experiments. These experiments (CELEBRATION 2000, ALP2002, and SUDETES 2003) provided new insights into the structure and evolution of the litosphere in this region.

The layout of the experiments was a network of interlocking recording seismic profiles where refraction and wide-angle reflection data were acquired. The data have been interpreted by tomographic inversion of the first arrival travel times and by two-dimensional ray-tracing of the first and later arrivals, as well as by calculation of synthetic seismograms for the P wave arrivals. Additional interpretation included reflectivity modelling, anisotropic velocity evaluation or comparison with the gravity modelling of the crust and upper mantle.

The above research resulted in a geological/tectonic representation as is shown for one profile in Figure 1. Here, the interpretation is outlined for a joint profile along CEL10 and ALP04 lines of SW-NE direction, which starts in the Alps, and continues along the eastern margin of the Bohemian Massif towards the Trans-European Suture Zone (TESZ). Our effort to model these data showed the thickennning of the crust beneath the Eastern Alps in a consequence of large-scale collision of the Adriatic and European plates during the Tertiary, broad high velocity gradient lower crust at the eastern margin of the Bohemian Massif, and deepening of the Moho towards the axial zone of TESZ as a transition zone between the Paleozoic Platform and the East European Craton.

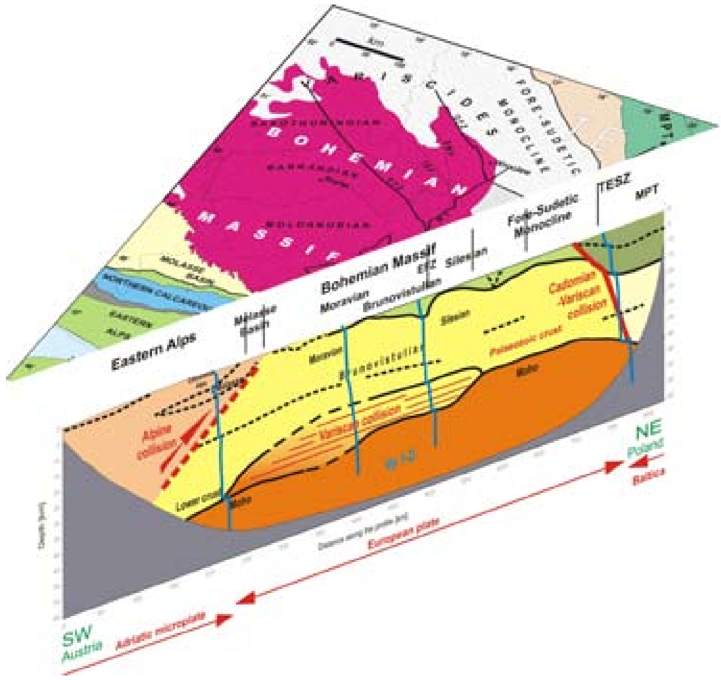



*Fig. 1: Schematic geological/tectonic representation along joint profile from CELEBRATION 2000 and ALP 2002 experiments with simplified tectonic map. Superimposed, there are 1-D Vp velocity characteristics for different parts of the profile. EFZ, Elbe Fault Zone; TESZ, Trans-European Suture Zone; MPT, Mid-Polish Trough.*

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## References

**Hrubcová P., P. Środa, and CELEBRATION 2000 Working Group, 2008.** *Crustal structure at the easternmost termination of the Variscan belt based on CELEBRATION 2000 and ALP 2002 data, Tectonophysics, 460, 55-75.*

**Grad, M., A. Guterch, S. Mazur, G. R. Keller, A. Špičák, P. Hrubcová, W. H. Geissler, and SUDETES 2003 Working Group, 2008.** *Lithospheric structure of the Bohemian Massif and adjacent Variscan belt in central Europe based on Profile S01 from the SUDETES 2003 experiment, J. Geophys. Res., 113.*

**Brückl, E., F. Bleibinhaus, A. Gosar, M. Grad, A. Guterch, P. Hrubcová, G.R. Keller, M. Majdański, F. Šumanovac, T. Tiira, J. Yliniemi, E. Hegedüs, and H. Thybo, 2008.** *Crustal Structure Due to Collisional and Escape Tectonics in the Eastern Alps Region Based on Profiles Alp01 and Alp02 from the ALP 2002 Seismic Experiment, J. Geophys. Res., 112, B06308.*

# Strain coupling between mantle and crust within a transpressional arc system, Bohemian Massif

—— Strain coupling versus decoupling between mantle and crust during orogeny has been the subject of mainly seismic studies. In some orogenic zones, seismic anisotropy data from the uppermost mantle show that the strain fabric is geometrically coherent with that in the hanging-wall continental crust, suggesting strain coupling (e.g. Vauchez & Nicolas, 1991; Little et al., 2002). In the orogenic root zone of the Bohemian Massif, anisotropy of seismic P and SKS waves (e.g. Babuška & Plomerová., 2006) suggests that planes of high seismic velocities in the present upper mantle differ from crustal high temperature foliations. It indicates strain decoupling between mantle and crust during Variscan convergence in the Bohemian Massif (Schulmann et al., 2005, 2009). In the meso to microscale, however, there is no detailed structural study of mantle rocks enclosed in high-grade lower crust rocks in order to verify the results of seismic studies and evaluate the role of lithospheric mantle on orogenic processes.

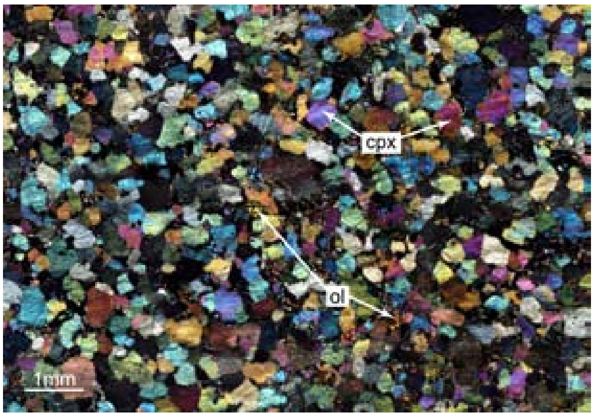
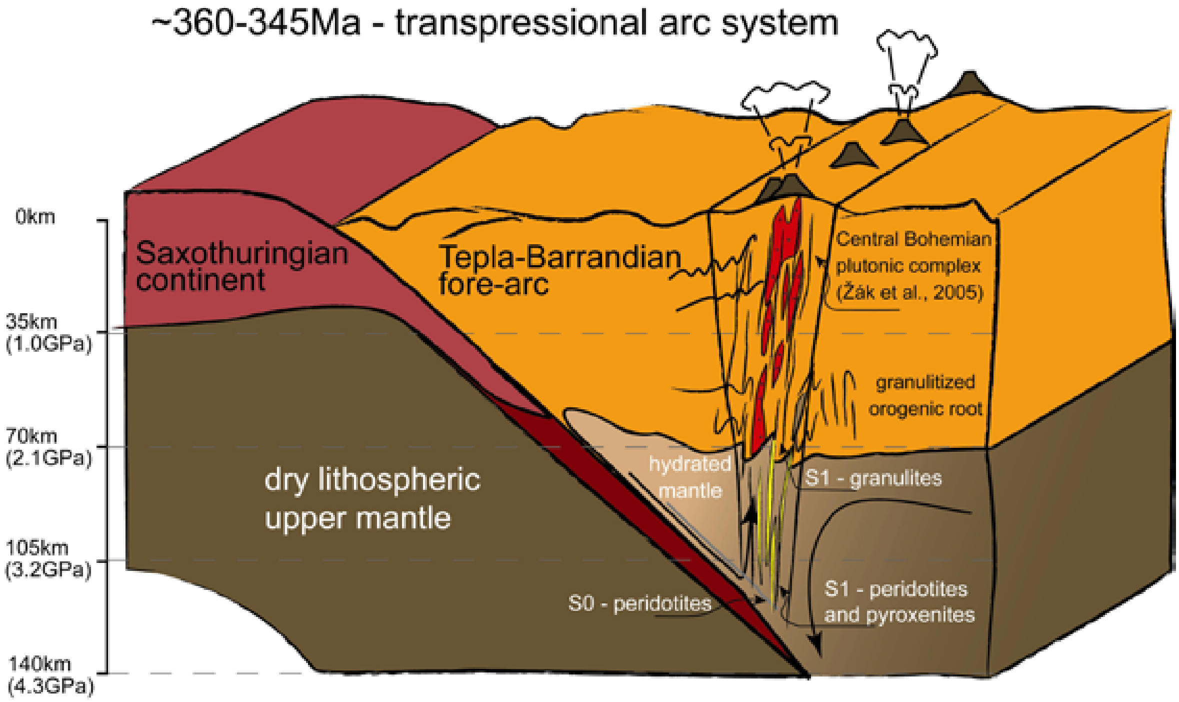



*Fig. 1: Photomicrograph of clinopyroxenite taken in cross-polarized light shows coarse-grained microstructure with big clinopyroxene (cpx) and small olivine (ol) and garnet (black) grains.*

—— Strain patterns within mantle rocks and surrounding coarse-grained felsic granulites from the Kutná Hora Crystalline Complex in the Variscan Bohemian Massif have been studied in order to assess their strain coupling. The studied rock association occurs within low-strain domains surrounded by fine-grained granulite and migmatite. The Doubrava peridotite contains closely spaced and steeply dipping layers of garnet clinopyroxenite, which are parallel to NE-SW-striking, high-temperature (HT) foliation in nearby granulites, while Úhrov peridotite is lack of such layering. Geochemistry shows that clinopyroxenites represent a cumulate-rich product of interaction between transient basaltic melts and the sub-arc mantle (Fig. 1). Electron backscattered diffraction (EBSD) measurements revealed superposition of S1 fabric developed in granulites and clinopyroxenites on older S0 fabric recorded in peridotites. The (010)[001] type (B-type) of olivine LPO and peak metamorphic conditions of 950 °C and 4 GPa characterize the oldest S0 foliations in both peridotites dipping at high angles to the south and bearing sub-vertical lineations. The S1 in clinopyroxenites (960 °C/3.4 GPa) and coarse-grained granulites (920 °C/2.2 GPa) is associated with the LS-type of cpx LPO and prism <c> slip in quartz, respectively. The S1 fabric is accompanied invariably with sub-vertical stretching lineation that underlines perfect strain coupling between clinopyroxenites and granulites. The peridotites with the S0 fabric are interpreted as relics of mantle wedge above the Variscan subduction zone that reached UHP conditions. Strain coupling between clinopyroxenites and granulites records a link between tectonic and magmatic processes during orogenic thickening. Juxtaposition of peridotites and granulites could be explained by a rheological heterogeneity connected to the development of clinopyroxenite layering in the upper mantle. The model invokes vertical shearing along the cpx layering, which had to be weaker than the surrounding mantle, facilitating an emplacement of mantle bodies into the granulitized sub-arc orogenic root (Fig. 2 et al., 2009). Such transpressional arc systems (De Saint Blanquat et al., 1998) could represent an important pathway for an emplacement of deeply-seated rocks to the orogenic lower crust.

—— Strain coupling between the upper mantle and the lower crust in the Bohemian Massif has not been expected either in tectonic models based on detailed field structural analysis (e.g., Schulmann *et al.*, 2005) or in models derived from anisotropy of seismic-wave velocities (e.g., Babuška & Plomerová, 2006). The reason for the latter can be seen in the fact that seismic methods have a resolution too low




for identification of localized, high-strain zones. On the small scale, however, lithological heterogeneity in the mantle wedge caused by melt percolation would be a model feasible for facilitating strain partitioning and coupling with crustal rocks.

*Fig. 2: A lithospheric-scale, three-dimensional model of a transpressional arc system for the Bohemian Massif, adapted from De Saint-Blanquat et al. (1998). The tectonic and magmatic processes are linked, facilitating the upward movement of melt. Arrows indicate positions of P-T equilibrations of studied rocks. Rheological heterogeneity in the mantle wedge due to the development of vertical clinopyroxenite layering caused strain coupling between granulites and clinopyroxenites and emplacement of upper-mantle rocks to the lower granulitized crust.*

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## References


***Babuška, V. and Plomerová, J., 2006.*** *European mantle lithosphere assembled from rigid microplates with inherited seismic anisotropy. Physics of the Earth and Planetary Interiors, 158, 2–4, 264–280.*

***De Saint Blanquat, M., Tikoff, B., Teyssier, C. and Vigneresse, J. L. 1998.*** *Transpressional kinematics and magmatic arcs. Geological Society Special Publication 135, 327-340.*

***Little, T.A., Savage, M.K., and Tikoff, B., 2002.*** *Relationship between crustal finite strain and seismic anisotropy in the mantle, Pacific-Australia plate boundary zone, South Island, New Zealand. Geophysical Journal International, v. 151, p. 160-169.*

***Schulmann, K., Kröner, A., Hegner, E., Wendt, I., Konopásek, J., Lexa, O. and Štípská, P., 2005.*** *Chronological constraints on the pre-orogenic history, burial and exhumation of deep-seated rocks along the eastern margin of the Variscan orogen, Bohemian massif, Czech Republic. American Journal of Science 305, 407–448.*

***Schulmann, K., Konopásek, J., Janoušek, V., Lexa, O., Lardeaux, J.-M., Edel, J.-B., Štípská, P. and Ulrich, S., 2009.*** *An Andean type Palaeozoic convergence in the Bohemian Massif, C. R. Geoscience, 341, 266-286.*

***Vauchez, A. and Nicolas, A., 1991.*** *Mountain building: strike-parallel motion and mantle anisotropy. Tectonophysics, 185: 183-201.*

# Electromagnetic induction anomalies in Central Europe studied by approximate inverse techniques

—— Anomalies of the electrical conductivity in the Earth's crust indicate special tectonic settings connected with anomalous thermodynamic conditions or with crustal disturbances that allowed for accumulation and effective large-scale interconnection of either fluid or electronic conductor fractions in certain domains of the Earth's crust. On a regional scale, anomalies of the crustal electrical conductivity are often studied by interpreting surface patterns of induced vertical or anomalous horizontal geomagnetic variation fields, expressed as induction arrows or horizontal geomagnetic interstation transfer functions, respectively. Large collections of long period geomagnetic induction data are available across a number of areas of Central and Eastern Europe, contrary to more detailed but also more demanding magnetotelluric data.

—— At interpreting long-period geomagnetic induction data, integrated thin sheet models are often suitable approximations to real crustal structures. For long enough periods, the anomalous structures can be replaced by a laterally non-uniform sheet buried at a specified depth in an otherwise layered Earth. We have been studying two inverse techniques to recover the integrated conductivity in the sheet (conductance) from a set of observed geomagnetic transfer functions. The first approach is a stochastic sampling by a Monte Carlo method with Markov chains (MCMC). The procedure generates a series of models that represent a sample from the aposteriori probability density of the model parameters conditioned on the observed data, and gives thus, in an ideal case, a fully probabilistic description of the solution to the inverse problem. As an example, Fig. 1 shows a smoothed conductance model obtained by MCMC inverting a set of 100 induction arrows measured across the Transeuropean Suture Zone (TESZ) in Pomerania, NW Poland, within a recent

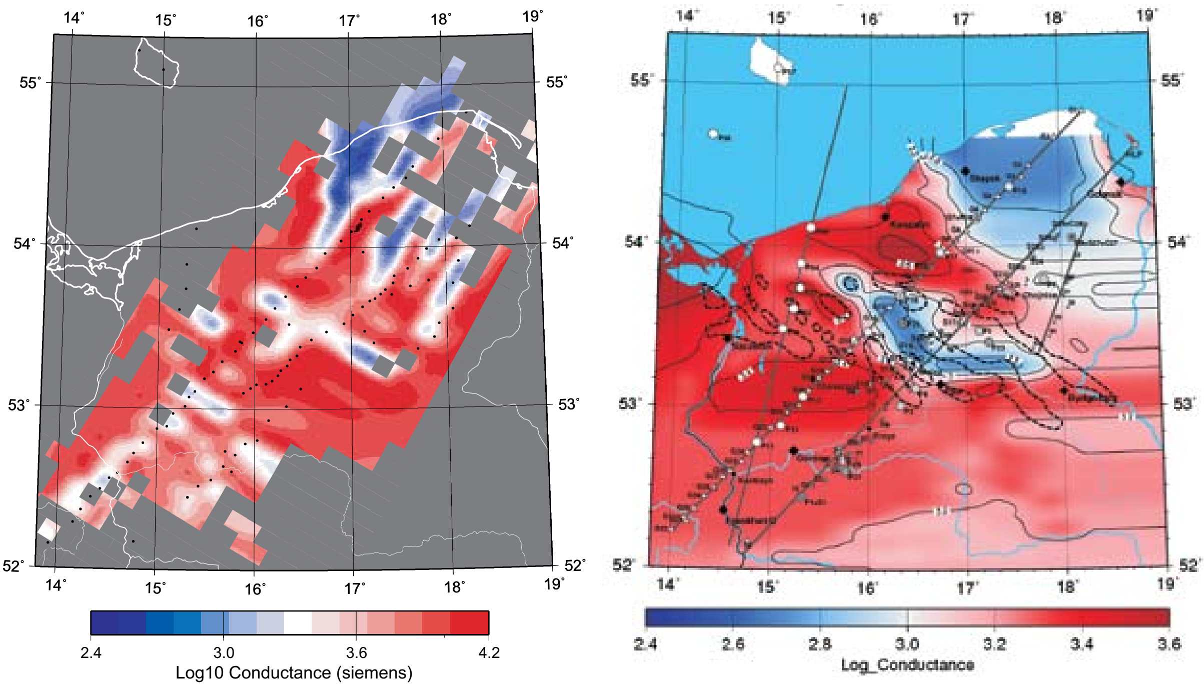


*Fig. 1: Left – Smoothed model of cell averages of the integrated crustal electrical conductivity across the TESZ in Pomerania, NW Poland, obtained by the MCMC stochastic thin sheet inversion of induction arrows from the EMTESZ experiment for the period of 1024 s. Model cells with 90 per cent confidence intervals for the conductance exceeding one third of a decade are considered non-informative and have been grayed off. Right – Estimates of the conductance of the sedimentary cover across the same area; data compiled and the figure kindly provided by I. M. Varentsov, GEMRC IPE RAS, Moscow.*

international experiment EMTESZ (Electromagnetic Probing of the TESZ; Ernst *et al.*, 2008; Semenov *et al.*, 2008).

The other inverse technique employs a standard iterative linearization optimization procedure to minimize the misfit between the thin sheet model response and the observed induction data. The procedure is used with a simplified, unimodal induction model (anomalous currents are confined to the thin sheet) for the direct solution and sensitivity evaluation. By this approach, we studied crustal electrical parameters at the western slope of the Ukrainian Shield and the Volyno-Podolian Plate, representing the southwest margin of the East European Platform. The results of the inversion of 110 induction arrows for a conductive layer at the depth of 8 to 16 km revealed zones of incresed conductance along the boundary of the East European Platform, the Pre-Carpathian Depression and the Carpathian Conductivity Anomaly in Ukraine. A stitched conductance model for the West and Ukrainian Carpathians is presented in Fig. 2. Currently, multiple sheet versions of the algorithms are under development.

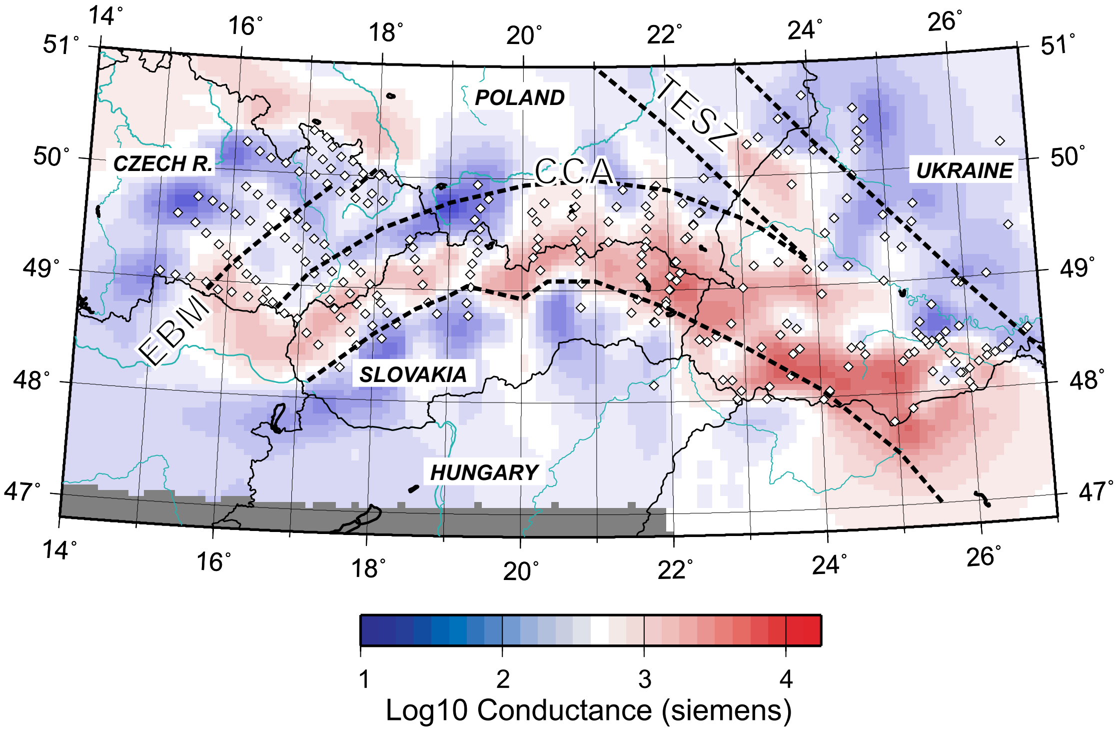


*Fig. 2: Smoothed model of the conductance across the eastern slope of the Bohemian Massif, the West and Ukrainian Carpathians. MCMC stochastic inversion for the conductance in a thin sheet was used for the West Carpathians data while linearized inversion with a unimodal thin sheet approximation was employed to model the data from Ukraine. White diamonds show locations of the observation sites. TESZ – Trans-European Suture Zone, CCA – zone of the Carpathian conductivity anomaly, EBM – approximate position of the axis of the induction anomaly on the eastern margin of the Bohemian Massif.*

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## References:


***Ernst, T., Brasse, H., Červ, V., Hoffmann, N., Jankowski, J., Jozwiak, W., Kreutzmann, A., Neska, A., Palshin, N., Pedersen, L. B., Smirnov, M., Sokolova, E. and Varentsov, I. M., 2008.*** *Electromagnetic images of the deep structure of the Trans-European Suture Zone beneath Polish Pomerania, Geophys. Res. Lett.,* ***35****, doi: 10.1029/2007GL034610.*

***Semenov, V. Yu., Pek, J., Ádám, A., Jóźwiak W., Ladanyvskyy, B., Logvinov, I. M., Pushkarev P., and Vozar, J. and Experimental Team of CEMES Project, 2008:*** *Electrical structure of the upper mantle beneath Central Europe: Results of the CEMES Project, Acta Geophys.,* ***56****, 957-981.*

# Depth-recursive refraction tomography resolved the Eger Rift structures in West Bohemia and the low-velocity zone at KTB Site

—— SUDETES 2003 data tomography along the Eger rift in West Bohemia. The developed DRTG method (Depth Recursive Tomography on Grid) utilizes the Claerbout's imaging principle incorporated in wave-equation migration and widely used in seismic prospection by reflected waves. The DRTG method uses a regular system of refraction grid rays covering uniformly the mapped domain (Fig.1). Performing the linearized inversions in iterative mode, the DRTG method yielded a fine-grid velocity model with required level of RMS travel-time fit and model roughness. The travel-time residuals, assessed at single depth levels, were used to derive the statistical lateral resolution of velocity anomalies.

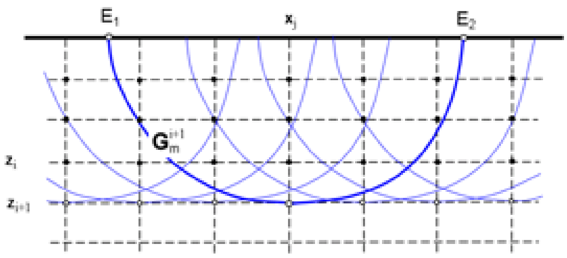
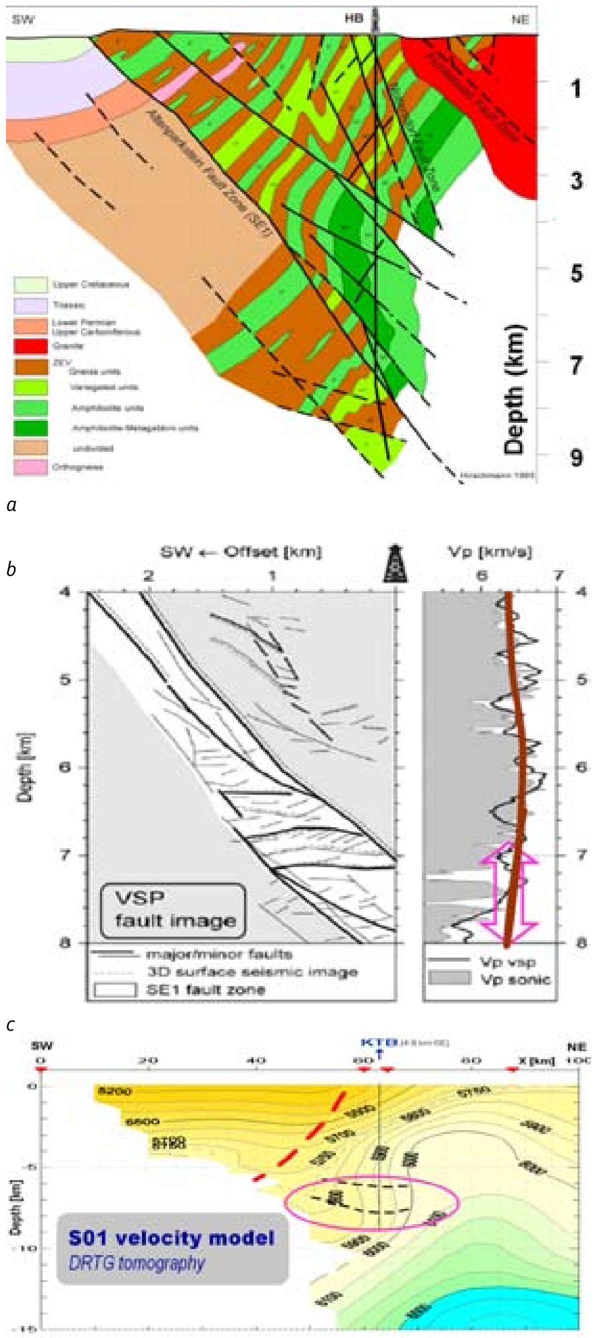



*Fig. 1: Refraction grid rays used for DRTG tomography*

*Fig. 2 (right-hand column): **a)** location of the KTB superwell in a geological cross-section, after Hirschmann (1996)*
***b)** Fault system near the KTB site and comparison of P-wave velocity-depth functions derived from VSP and sonic logging and S01 refraction tomography after correction on anisotropy.*
***c)** DRTG tomography on S01 profile involving the Franconian fault.*

—— Global optimization of the tomographic models usually tends to a minimum-feature model with sweeping out any Low Velocity Zone (LVZ). The DRTG tomography on the S01 profile succeeded in resolving a significant regional LVZ bound to the Franconian lineament near the KTB site (Fig. 2). The velocities derived by the depth-recursive refraction tomography relate to the horizontal directions of wave propagation. This was proven at the KTB site where pronounced anisotropic behavior of a steeply tilted metamorphic rock complex has been previously determined. Anisotropy of 7% was observed here with the "slow" axis of symmetry oriented coincidentally in the horizontal SW-NE direction of the S01 profile. The horizontal P-wave velocities derived for the KTB site from the DRTG model



and increased by 7% model agree fairly well with the vertical log velocities at the KTB site.

The DRTG fine-grid velocity model elucidated the relationship of major geological units of Bohemian Massif as they manifested in the obtained P-wave velocity image down to 15 km. Although the contact of Saxothuringian and the Teplá-Barrandian Unit (TBU) is collateral with the S01 profile direction, several major tectonic zones are rather perpendicular to the Variscan strike and so fairly imaged in the S01 cross-section. They exhibit a weak velocity gradient of sub-horizontal directions within the middle crust. In particular, the Moldanubian and TBU contact beneath the Western Krušné hory/Erzgebirge Pluton, the buried contact of the Lugicum unit and the TBU within the Elbe fault zone were identified. The maxima on the 6100 -1 isovelocity in the middle crust delimitated the known ultrabasic Erbendorf complex and implied also two next ultrabasic massifs beneath the Doupovské hory and the České středohoří volcanic complexes. The intermediate mid-crustal P-wave velocity lows are interpreted as granitic bodies. The regional geological model implied by the high-resolution DRTG tomography also involves available gravity, aeromagnetic and petrophysical data.

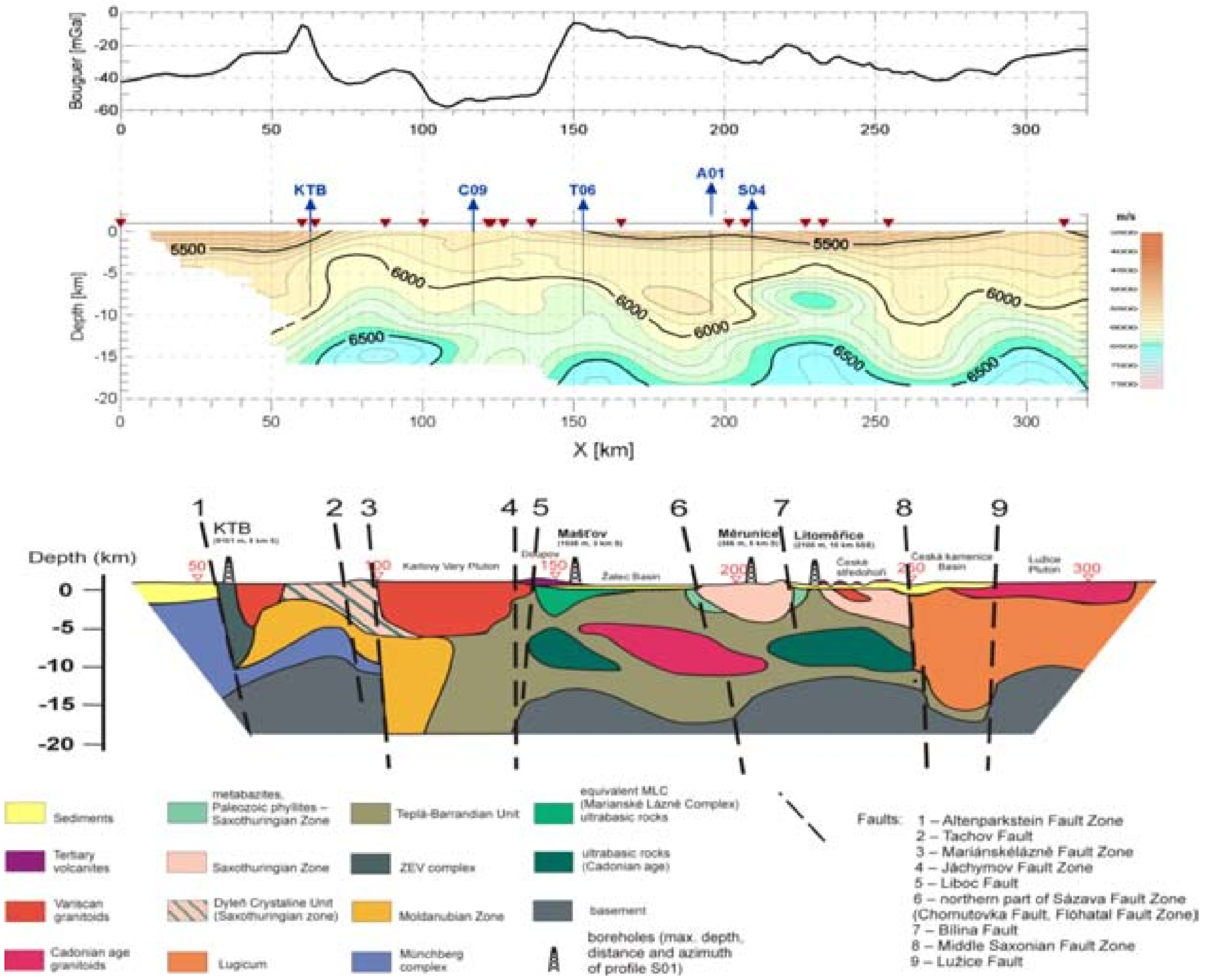



*Fig. 3* (above): *Bouguer anomalies for reduction density of 2.67 g.m$^{-3}$ along the S01 profile (top), the P-wave velocity image at the 100 m/s contour step aquired by DRTG tomography (middle) and its geological interpretation (bottom).*

## I.G. research staff

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## References


***Hirschmann, G., 1996.*** *KTB - The structure of a Variscan terrane boundary: Seismic investigation - Drilling - Models. Tectonophysics, 264, 1-4, 327-339.*

***Novotný, M., Skácelová, Z., Mrlina, J., Mlčoch, B., and Růžek, B., 2009.*** *Depth-recursive tomography along the Eger Rift using the S01 Profile refraction data: Tested at the KTB Super Drilling Hole, structural interpretation supported by magnetic, gravity and petrophysical data. Surveys in Geophysics, 30, 561-600.*

# Earthquake swarms in West Bohemia – Vogtland

The region of West Bohemia (Czech Republic) and Vogtland (Germany) is well known by periodical reoccurrence of intraplate earthquake swarms, with magnitudes $M_L< 5$. The strongest earthquakes in the last century occurred during the 1908 swarm ($M_L$~5.0), 1985/86 swarm ($M_L$=4.6) and 2000 swarm ($M_L$=3.2). Since early 1990s the region has permanently been monitored by the WEBNET network jointly operated by the Institute of Geophysics and the Institute of Rock Structure and Mechanics of the AS CR in Prague. It consists of 13 three-component digital seismic stations and 10 temporary stations with the sampling rate of 250 Hz (Fig. 1).

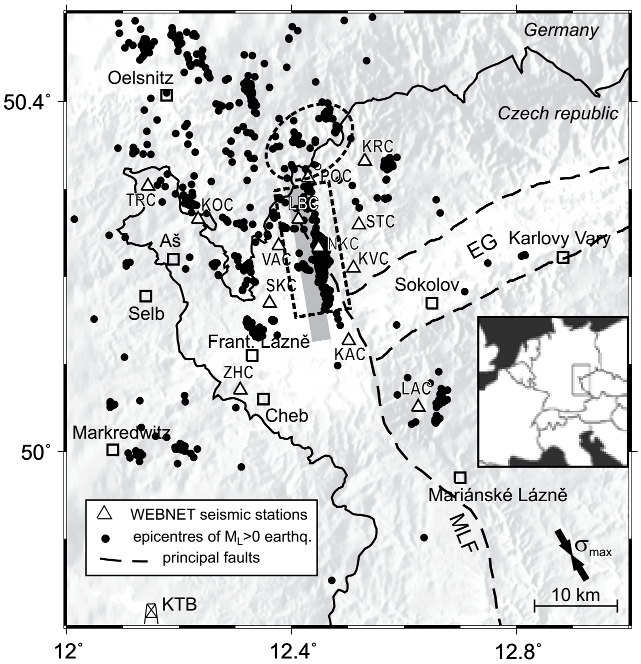


*Fig. 1: West Bohemia/Vogtland region with the earthquake epicentres, WEBNET seismic stations and principal faults (EG - Eger rift, MLF - Mariánské Lázně fault).*

The period between 2004 and 2008 was characterized by an increasing microswarm activity that occurred at the edges of the fault segment activated by the 2000 swarm, as shown by Fischer and Michálek (2008). Other studies were focused on various aspects of the earthquake swarm area. A detailed shear-wave splitting analysis (Vavryčuk and Boušková, 2008) of the swarm earthquake records showed a complex anisotropy structure. Analysis of the fracture mechanical models of intrusions by Dahm et al. (2008) shows that the 2000 swarm could be interpreted as a result of dyke intrusion into an unfavourably oriented fault. Horálek and Fischer (2008) critically reviewed the proposed models of earthquake swarm triggering and suggested that the activity in the area is probably controlled by a regionally acting triggering force.

The swarm of October 2008 occurred as a culmination of the microswarm activity gradually growing since 2004. It took place in the main focal zone NK, it lasted about two months and about 20 000 $M_L \leq 3.8$ events were detected in the WEBNET recordings in its course. The main swarm period took place between October 6 and October 31, see Fig. 2. A high swarm event rate during the most intensive swarm phase of October 10 is illustrated in the drum-like seismogram from NKC in Fig. 3.

The relative locations of about 2200 events of the swarm show that the 2008 swarm took place at the depths between 6.5 km and 11 km on the main fault plane NK, similarly to the swarms of 1985/86, 1997 and 2000 (Fig. 4). Reactivation of the same fault segment after eight years seems to be an issue worth investigating. The striking similarity of the 2000 and 2008 swarms is underlined by similar focal mechanisms showing left lateral strike slip with small normal component (see Fig. 5).

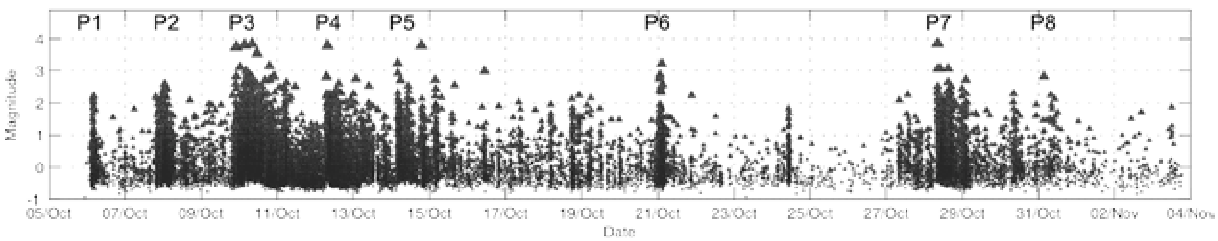


*Fig. 2: Magnitude-time distribution of the 2008 swarm*

The 2008 swarm surprised by its intensity and rapidity. In its course, nine shocks of magnitudes from $M_L \approx 3.0$ to 3.8 shook the region. It is the strongest swarm which has occurred in the West Bohemian/Vogtland region since 1986. Above, it ranks among the largest swarm activities in this region since the beginning of the twentieth century.

During the macroseismic survey a total of 778 questionnaires related to the 2008 swarm was collected. The territory comprised mainly the area of the West Bohemia and the majority of collected data (about 70%) were concentrated in big towns; about 85% of questionnaires were related to six strongest shocks with the local magnitude of $M_L \geq 3.0$. People reported trembling or swinging of buildings, some of the stronger shocks caused non-structural damages like cracks in walls. Acoustic effects were reported in 85% of cases where people experienced noises of different kind ranging from sounds of vibrations or explosions to rumbling and thundering.

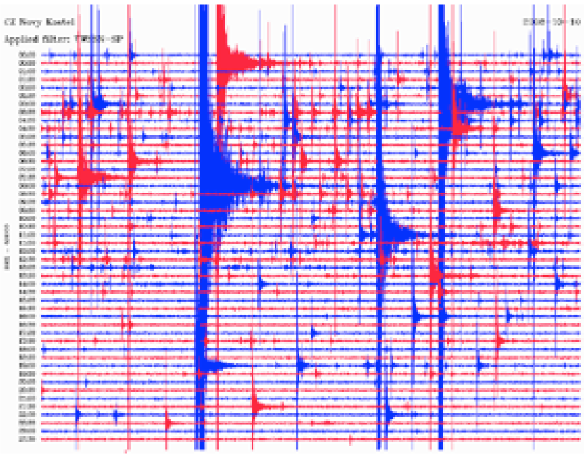

*Fig. 3: The daily monitor-seismogram from the station NKC from October 10, 2008. The 30-minute intervals are plotted in turn in read and blue.*

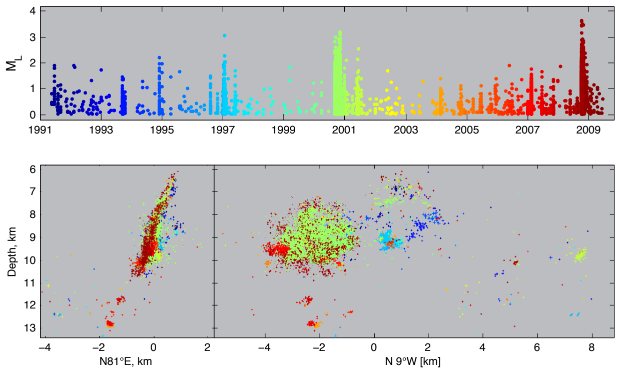


*Fig. 4: Seismicity in the focal zone NK from 1991 to 2009, magnitude-time distribution (top) and depth cross-section of the focal zone along and across the fault (bottom). The time-proportional color coding in the top and bottom plots correspond.*

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## References


***Horálek, J. and Fischer, T., 2008.*** *Role of crustal fluids in triggering the West Bohemia/Vogtland earthquake swarms: just what we know (a review). Stud. Geophys. Geod., 52, 455-478.*

***Fischer T. and Michálek J., 2008.*** *Post 2000-swarm microearthquake activity in the principal focal zone of West Bohemia/ Vogtland: space-time distribution and waveform similarity analysis, Stud. Geophys. Geod., 52, 493-511.*

***Dahm T., Fischer T. and Hainzl S., 2008.*** *Mechanical intrusion models and their implications for the possibility of magma-driven swarms in NW Bohemia region, Stud. Geophys. Geod., 52, 529-548.*

***Vavryčuk, V. and Boušková, A., 2008.*** *S-wave splitting from records of local micro-earthquakes in West Bohemia/Vogtland: An indicator of complex crustal anisotropy, Stud. Geophys. Geod., 52, 631-650.*


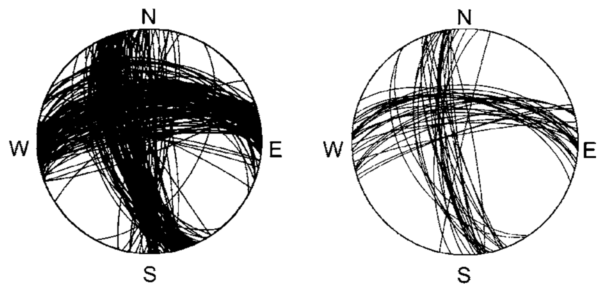


*Fig. 5: Focal mechanisms for the 2000 swarm (left) and 2008 (right), lower hemisphere projection is used.*

# Discovery of the first Quaternary maar in the Bohemian Massif

—— Tertiary and Quaternary volcanism played a significant role in forming the final geological composition of the western and northwestern parts of the Bohemian Massif. It was related mainly to the development of the so called Ohře (Eger) Rift, as part of the European Cenozoic Rift System. The Quaternary volcanic phase took place in the area of the crossing of three principal tectonic zones: Ohře/Eger Rift (ENE-WSW), the Cheb-Domažlice graben (NNW-SSE) and Regensburg–Leipzig-Rostock Zone (N-S). This area is also characterized by the highest frequency of low magnitude earthquakes in the Bohemian Massif, and extensive fluids emissions ($CO_2$, He) indicating still active magmatic process in the lithosphere (upper mantle-lower crust).

—— Based on results of previous investigations of tephra-tuff volcaniclastic deposits and a scouting geophysical survey (Mrlina et al., 2007) in the surroundings of the Železná hůrka Quaternary volcano, we performed a detailed geophysical surveys using gravimetry, magnetometry and electrical conductivity techniques. The target was an unusual morphological depression of isometric, crater-like shape near Mýtina, West Bohemia (Fig. 1). Striking geophysical anomalies were revealed in the depression and interpreted as strong evidence of the assumed maar-diatreme structure (Mrlina et al., 2009). The sharp isometric gravity low of – 2.30 mGal, as well as the corresponding positive magnetic anomaly of 200 nT with a negative rim on its northern side indicated steeply dipping geological body of low density and containing magnetic rocks/minerals. Magnetic survey also showed pronounced local anomalies outside the depression that can reflect relicts of the tephra rim of the maar (Fig. 2).

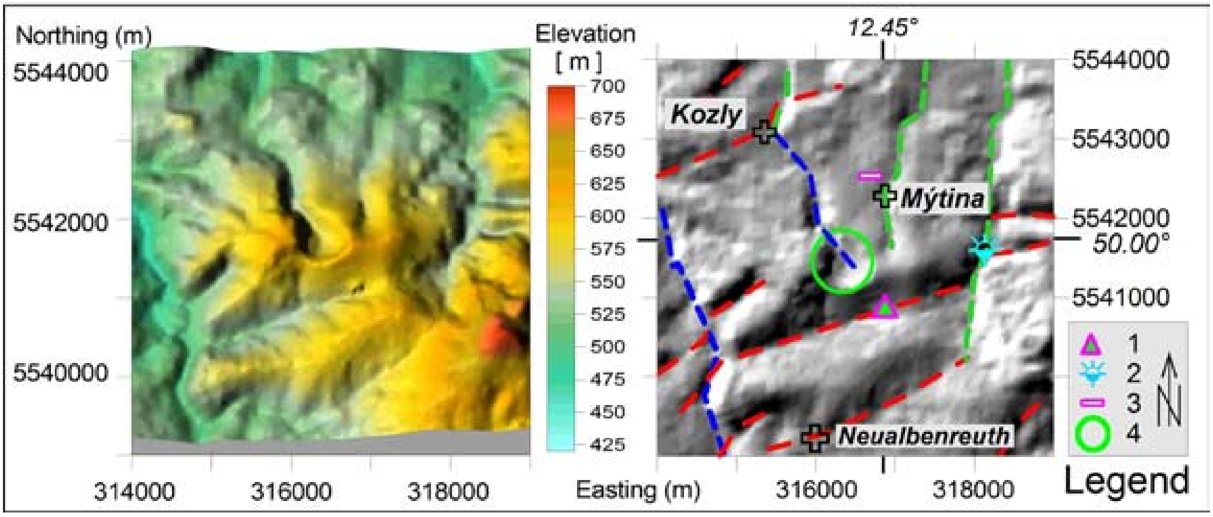


*Fig. 1: Two Digital Elevation Model views of topography: Left – morphological features with the Mýtina depression in the centre, on top of a hilly massif. Right – drainage system indicated by blue and red dashed lines. Legend: 1 – the Železná hůrka volcano, 2 – site of $CO_2$ emissions, 3 – exploratory trench, 4 – morphological depression interpreted as the maar crater.*

—— This geophysical evidence was subsequently verified by an exploratory borehole MY-1 near the centre of the gravity anomaly. Macroscopic on-site evaluation of the core, and more detailed sedimentological, petrochemical, palynological and microbiological laboratory analyses further confirmed the existence of a maar structure filled by 84 m of lake sediments reflecting a succession of several warm and cold climatic periods. Results of palynological analyses confirm the presence of a continuous palaeoclimate record, with at least three successive warmer periods of most probably interstadial character from the upper Quaternary Saalian complex. Therefore, this recovered sediment sequence holds strong potential for in-depth paleoclimate reconstruction and deep biosphere studies.

—— The discovered volcanic structure is considered to be the first known Quaternary maar-diatreme

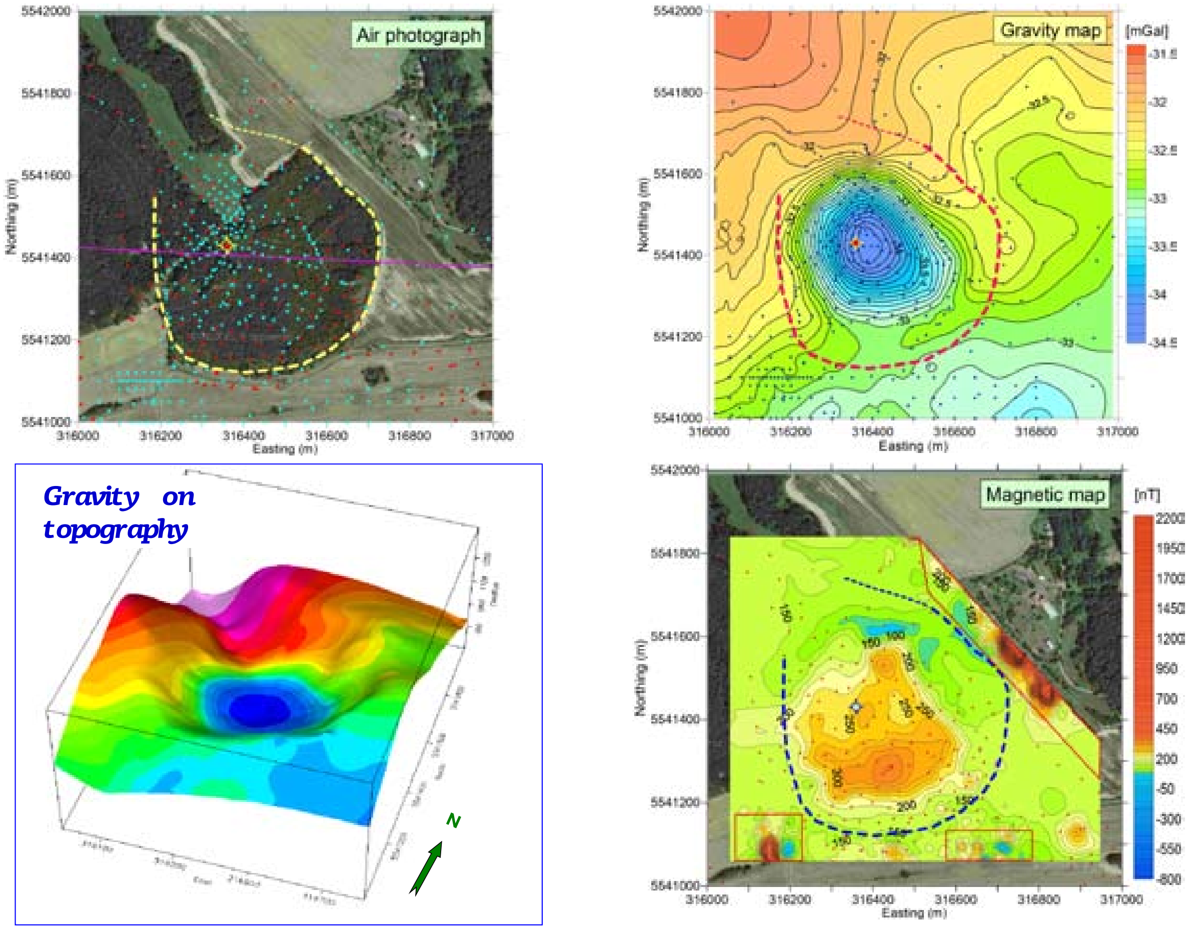


*Fig. 2:* *Geophysical survey location map with gravity (cyan) and magnetic (red) points, location of modelling profile (purple line) and the position of MY-1 well. Geophysical maps: gravity – contour interval 0.1 mGal; magnetics - contour interval 25 nT, and image of gravity superimposed on topography.*

*Fig. 3:* *At the bottom of the MY-1 borehole (84 – 85.5 m), country rock debris was found, but, importantly, also volcanic bombs (red circle in Fig. 3) and lapilli.*

volcano on the territory of the Bohemian Massif. Because of hidden magmatic processes documented by fluids emissions, in combination with earthquake swarm seismicity ca. 20-30 km north of the Mýtina maar, the reconstruction of volcanic evolution has importance for evaluation of recent magmatic activity in the region of the Cheb basin.

## IG research staff involved:

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## References:

***Mrlina, J., Kämpf, H., Geissler, W.H., van den Bogaard, P., 2007.*** *Proposed Quaternary maar structure at the Czech/German boundary between Mýtina and Neualbenreuth (western Eger Rift, Central Europe): geophysical, petrochemical and geochronological indications. – Z. Geol. Wiss. 35, 213-230.*

***Mrlina, J., Kämpf, H., Kroner, C., Mingram, J., Stebich, M., Brauer, A., Geissler, W.H., Kallmeyer, J., Matthes, H. and Seidl, M., 2009.*** *Discovery of the first Quaternary maar in the Bohemian Massif, Central Europe, based on combined geophysical and geological surveys. – J. Volc. Geoth. Res., 182, 97-112. doi: 10.1016/j.jvolgeores.2009.01.027*

# The mechanism of flow and fabric development in mechanically anisotropic trachyte lava

Internal fabrics of a partly eroded trachyte lava dome were investigated to explain the extrusion dynamics of mechanically anisotropic crystal-rich lavas such as trachyte or plagioclase rich dacites (Závada et al., 2010). Trachytes represent the second volcanic stage (31-25 Ma in age) of Tertiary volcanic episode in the České středohoří Mountains (Cajz et al., 1999). Related to Eger Graben rifting, folded fabrics with steep axial planes and axes were identified in SW part of the body. These fabrics are marked by a distinct anomaly of low Anisotropy of Magnetic Susceptibility (AMS) intensity in contrast to the rest of the cupola. Detailed microstructural research

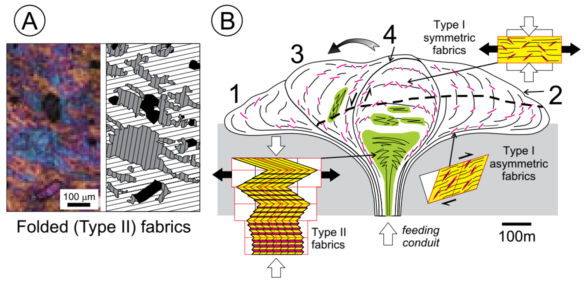


*Fig. 1: Diagrams illustrating the microscopic fabrics of the folded trachyte (A) and the fabric development during emplacement of the trachyte lava (B). Micrograph in (A) was taken with crossed nicols and gypsum plate. Associated sketch shows close spatial relationship of crystals (black) and Type II textural domains (gray). Alignment trends of sanidine crystals in the domains is indicated by hatching. The (B) diagram summarizes the probable textural evolution of the trachyte within the kinematic framework of the extrusion: 1) vertical fabrics fold above the conduit and Type II fabrics diminish according to the fibre slip theory, 2) domains of incompletely transposed Type II fabrics can be preserved in a rotated lobe (lobe 3). Margins of the body are marked by asymmetric Type I fabrics, central part shows symmetric Type I fabrics. The morphology of today's exposure is depicted in thick dashed line in this WSW-ENE profile.*

including Electron Back-Scatterred Diffraction (EBSD) of sanidine crystals, AMS and image analysis of sanidine groundmass textural domains revealed two types of trachyte fabric. The more common Type I fabrics is found throughout the entire cupola except the SW folded part and shows low-angle alignment domains of sanidine crystals similar to extensional kink bands. In contrast, folded fabrics revealed another textural type (Type II), marked by high-angle alignment domains with irregular boundaries similar to compressional kink-bands typically developed during layer parallel shortening of strongly mechanically anisotropic rocks. The fabric development during emplacement of the trachyte can be explained using "fibre slip" theory of Cobbold and Gapais (1986) and analogue modeling of internal fabric development in complex lava domes (Závada et al., 2009). First, analogue modeling of Závada et al., (2009) implies that the vertical fabrics of the extruding material from the conduit collapses and folds due to diffluence of the material on the free surface and folds with horizontal fold planes form. Second, the trachyte deforms according to the fibre slip theory by sliding along large faces of sanidine crystals ((010) planes) and by readjustment of boundaries between textural domains that consist of crystals with different crystallographic orientation. The latter is clearly illustrated by decreasing content of Type II textural domains with increasing fold amplification, which was identified on a sequence of five samples. In most amplified folds, Type II fabrics diminish and Type I fabrics probably start to form due to continuous radial extension of the lava. Marginal parts of the exposed trachyte reveals lineations parallel to lateral margins, which are explained by circumferential stretching (Buisson and Merle, 2004). Vertical axial planes of folds in the peripheral part of the exposed cupola are explained by emplacement of lava lobes and their rotation and translation by rise of newer lava lobes (Závada et al., 2009). Combination of AMS, EBSD and image analysis methods is a powerful approach for investigation of internal fabrics and flow mechanisms of magnetite bearing trachyte lavas.

## IG research staff involved:

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## References

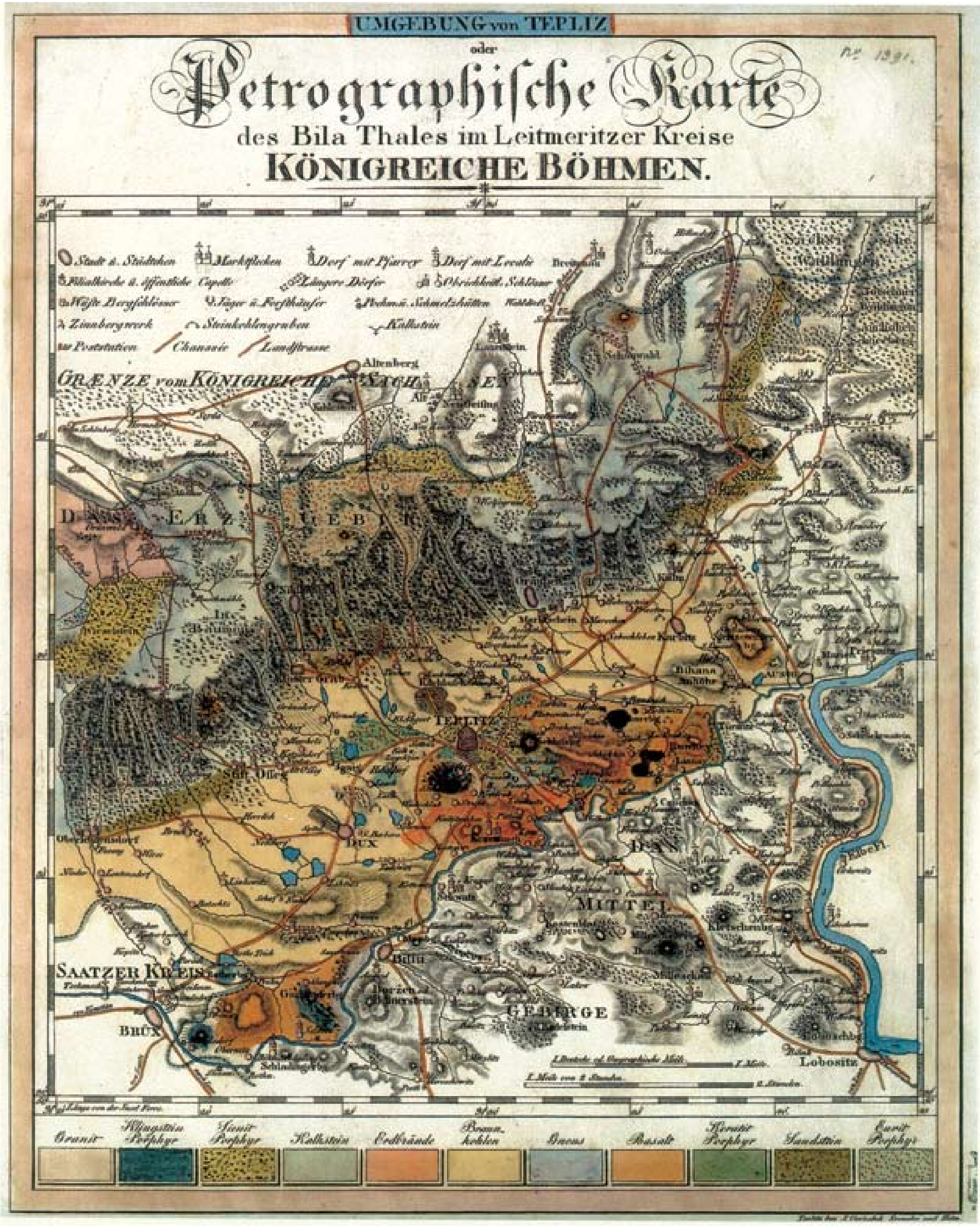

***Buisson, C., Merle, O., 2004.*** *Numerical simulation of strain within lava domes, Journal of Structural Geology* **26***(5), 847–853.*

***Cobbold, P.R. and Gapais, D., 1986.*** *Slip-system domains.1. Plane-strain kinematics of arrays of coherent bands with twinned fiber orientations. Tectonophysics, 131, 1-2, 113-132.*

***Cajz, V., Vokurka, K., Balogh, K., Lang, M. and Ulrych, J., 1999.*** *The České Středohoří Mts.: volcanostratigraphy and geochemistry, Geolines* **9***, 21–28.*

***Závada, P., Kratinová, Z., Kusbach, V. & Schulmann, K., 2009.*** *Internal fabric development in complex lava domes, Tectonophysics* **466***(1-2), 101–113.*

***Závada, P., Schulmann, K., Lexa, O., Hrouda, F., Haloda, J. and Týcová, P., (in press).*** *The mechanism of flow and fabric development in mechanically anisotropic trachyte lava, Journal of Structural Geology.*




The Eger Graben (or, Eger / Ohře Rift), a Cenozoic rift structure of the Bohemian Massif, is a subject of study by several research groups of the Institute, featured here on pages 10-11 and 18-27.

The early geological map ("petrographic" map with 11 rock formations identified) figured above shows the central part of the Eger Graben in N Bohemia and was created by Franz Ambrosius Reuss in 1829. The original of the map is located in the archives of the Czech Geological Survey, Prague. The most prominent features in the map are volcanics of the western part of the České Středohoří Mts. and the complex fault scarp of the Krušné Hory (Erzgebirge) Mts.

# Tectonics and sedimentation in the Eger Graben: clues to the evolution of an incipient continental rift

—— The Eger Graben, the easternmost part of the European Cenozoic Rift System (ECRIS), is currently a subject of intense research and controversy regarding the causes and mechanisms of extension as well as post-rift deformation. Plume-related, collisional compression-driven, or slab-pull-driven mechanisms of extension in the ECRIS are discussed, e.g., by Michon & Merle (2005) and Dezes et al. (2004, 2005, and references therein). Špičáková et al. (2000) and Uličný et al. (2000), based on the study of relationships of basin tectonics and stratal architecture, have suggested a signicant role of Oligo-Miocene oblique extension, later replaced by orthogonal extension, in the Eger Graben evolution. However, an understanding of the exact timing of these extensional phases and their relationship with post-rift deformation and uplift of this part of Alpine foreland requires analysis of new datasets. New data on tectonic evolution of the Eger Graben should contribute towards a better understanding of the dynamics of ECRIS as a whole.

—— The Most Basin situated within the Eger Graben of Central Europe offers an excellent opportunity to study the evolution of a fossil intra-continental extensional domain that features several distinct fault systems, with so far poorly known spatio-temporal relationships between individual fault populations and the basin's depositional history. A range of observational scales and types of data: (i) large- scale exposures of syntectonic strata in lignite mines; (ii) exposures of fault planes allowing mesoscopic structural observations to be made; (iii) dense regional borehole coverage; (iv) regional geophysical maps; and (v) several 2D seismic reflection lines combined with a wealth of subsurface and regional geophysical data. Work by Rajchl et al. (2008, 2009), based on doctoral research supervised from the IG, has brought new insights into the tectono-sedimentary history of the Most Basin that helps to shed more light also on the entire Eger Graben and ECRIS evolution.

—— The Most Basin provides a good illustration of initiation, gradual growth and linkage of normal fault arrays (Fig. 1) in a strongly oblique- extensional situation, overprinted by a post-depositional phase of orthogonal extension that caused significant deformation of the basin fill (Rajchl et al., 2009). The fault geometries compare well with published analogue models of rifts undergoing oblique to orthogonal extension, although the different basement fabrics in the crustal blocks separated by the rift axis influenced the local expression of some fault populations. The preserved stratigraphic record shows that the basin evolution stopped shortly after the transition from the initial rifting stage to a more mature stage with subsidence accelerated along major depo-

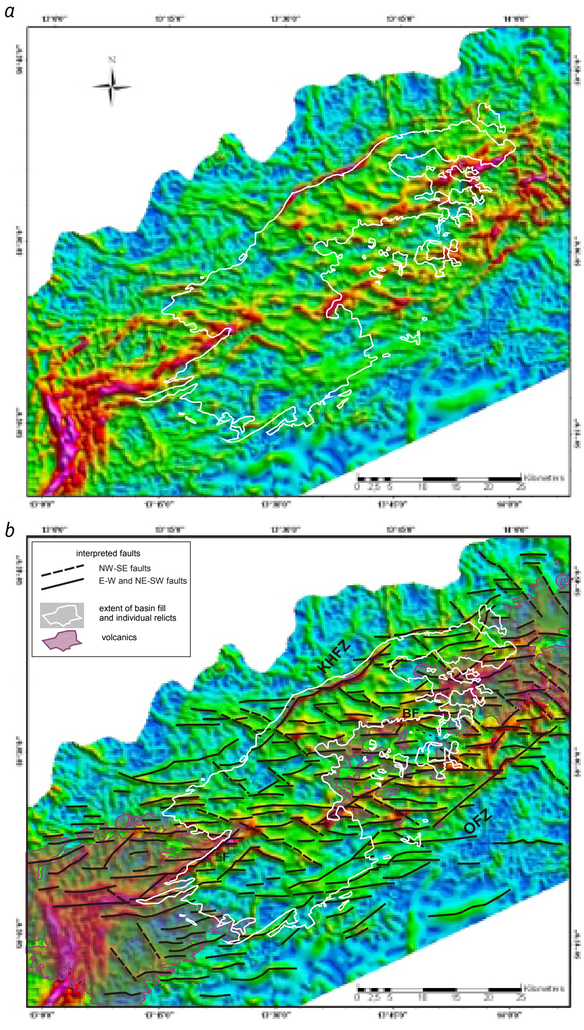



*Fig. 1: Uninterpreted (top) and interpreted (bottom) map of horizontal gravity gradients of the Most Basin and the surrounding area, from Rajchl et al. (2009). The black lines in (b) mark those horizontal gravity gradients interpreted as fault structures.The fault pattern is represented by E-W, NE-SW and NW-SE fault systems. (BF, Bílina Fault; KHFZ, Krušné Hory Fault Zone; OFZ, Ohře Fault Zone; SF, Střezov Fault).*

centre-bounding faults.The post-depositional faulting and formation of an adjacent uplift resulted from a localised extensional collapse along the crest of a growing lithospheric fold. The timing of the basin filling as well as its destruction correlate well with events occurring elsewhere in the Eger Graben, and also with the timing of onset of rifting (ca. 37 Ma) and the presumed lithospheric folding (ca. 18Ma) in the entire ECRIS. The origin of the N-S extensional stress field of the earlier extensional phase remains controversial and can be attributed either to the effects of the Alpine lithospheric root or (perhaps more likely because of the dominant volcanism at the onset of EgerGraben formation) to doming due to thermal perturbation of the lithosphere.

The Early Miocene Bílina Delta depositional system of the Most Basin consists of fluvio-deltaic and lacustrine clastics. It shows evidence of repeated advances of an axial deltaic system across a thick accumulation of organic material and clay in the hangingwall of an active fault. Exposures up to ca 4-5 km long in the Bílina open-cast mine help bridge the gap between seismic scale and typical outcrop scale of observation and thus allow the relationships between small-scale and basin-scale stratal geometries to be evaluated (Rajchl et al., 2008). On the largest temporal and spatial scales, variable tectonic subsidence controlled the overall advance and retreat of the delta system. The medium-term transgressive-regressive history was probably driven by episodes of increased subsidence rate. However, at this temporal scale, the architecture of the deltaic sequences (deltaic lobes and correlative lacustrine deposits) was strongly affected by: (i) compaction of underlying peat and clay which drove lateral offset stacking of medium-term sequences; and (ii) growth of a fault-propagation fold close to the active Bílina Fault. On the smallest scale, the geometries of individual mouth bars and groups of mouth bars (short-term sequences) reflect the interaction among sediment loading, compaction and growth faulting that produced high-frequency relative lake-level fluctuations and created local accommodation at the delta front.

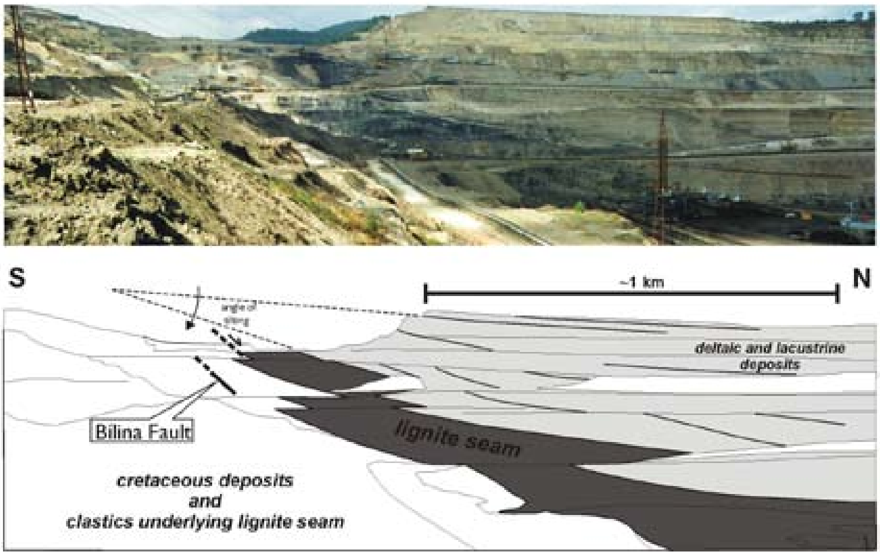



*Fig. 2: Deformation of the main lignite seam and clastics of the Bílina Delta along the Bílina Fault, at the southern margin of the Bílina open-cast mine.The clastic wedge of the Bílina Delta prograded generally westward, aligned with the active segments of the Bílina Fault. Basinward divergence of deltaic and lacustrine strata suggests syn-depositional tilting of a sedimentary surface caused by fault propagation folding.*

## IG research staff involved:

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## References:

**Dèzes, P., Schmid, S.M. and Ziegler, P.A., 2004.** *Evolution of the European Cenozoic Rift System: interaction of the Alpine and Pyrenean orogens with their foreland lithosphere. Tectonophysics,* **389**, *1-33.*

**Dèzes, P., Schmid, S.M. and Ziegler, P. A., 2005.** *Reply to comments by L. Michon and O. Merle on "Evolution of the European Cenozoic Rift System: interaction of the Alpine and Pyrenean orogens with their foreland lithosphere" by P. Dèzes, S.M. Schmid and P.A. Ziegler, Tectonophysics 389 (2004) 1-33. Tectonophysics,* **401**, *3-4, 257-262.*

**Michon, L. and Merle, O., 2005.** *Discussion on "Evolution of the European Cenozoic Rift System: interaction of the Alpine and Pyrenean orogens with their foreland lithosphere" by P. Dèzes, S.M. Schmid and P.A. Ziegler, Tectonophysics 389 (2004) 1-33. Tectonophysics,* **401,** *3-4, 251-256.*

**Rajchl, M., Uličný, D., Grygar, R., and Mach, K. , 2009.** *Evolution of basin architecture in an incipient continental rift: the Cenozoic Most Basin, Eger Graben (Central Europe). Basin Research* **21**, *269-294.*

**Rajchl, M. Uličný, D., and Mach, K., 2008.** *Interplay between tectonics and compaction in a rift-margin, lacustrine delta system: Miocene of the Eger Graben, Czech Republic. Sedimentology,* **55**, *1419-1447.*

**Špičáková, L., Uličný, D. & Koudelková, G. 2000.** *Tectonosedimentary evolution of the Cheb Basin (NW Bohemia, Czech Republic) between Late Oligocene and Pliocene: a preliminary note. Studia Geophys. et Geod.,* **44**, *556-580.*

**Uličný, D., Rajchl, M., Mach, K. and Dvořák, Z., 2000.** *Sedimentation and synsedimentary deformation in a rift-margin, lacustrine delta system: the Bílina Delta (Miocene), Most Basin. Geolines, 10, 84-95.*

# Palaeodrainage systems of the Bohemian Cretaceous Basin and their relationship to basement tectonics

Palaeodrainage systems develop on subaerial unconformity surfaces on all temporal scales, from geologically instantaneous through short-term cycles such as climate-driven glacio-eustatic changes, to major cycles of continental encroachment. The location, dimensions, morphological patterns, and longitudinal profiles of a palaeodrainage are the result of a multitude of factors, of which the structural fabric and lithology of the bedrock are clearly the leading ones.

In the Bohemian Cretaceous Basin (BCB) (Fig. 1), the base-Cretaceous unconformity is a composite, polyhistory surface that separates strata of Cenomanian age (ca 99–93.5 Ma) from the underlying Variscan basement of the Bohemian Massif and from post-orogenic sedimentary and volcanic infills of basins of Late Palaeozoic to Triassic and, locally, Jurassic ages (cf. Voigt et al., 2008, and references therein; Uličný et al., 2009).

A synthesis of available data on the distribution of Cenomanian-age palaeodrainage systems, filled by fluvial and estuarine strata, and an interpretation of their relationships to the base-

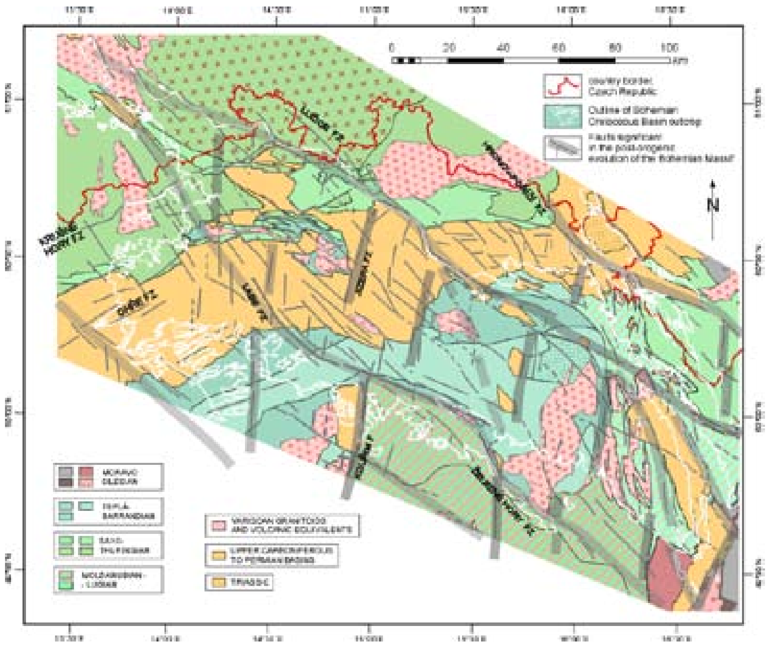


*Fig. 1 (above): Simplified geological subcrop map of the basement of the Bohemian Cretaceous Basin. Thick grey lines indicate fault zones interpreted as important in the kinematics of the Basin (cf. Uličný et al. 2009).*

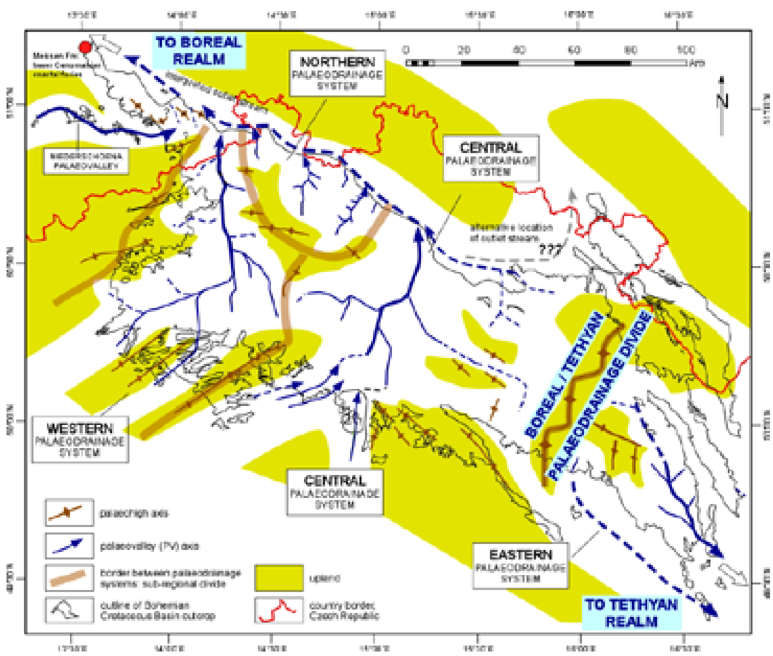


*Fig. 2: Schematic map of the tectonic and palaeogeographic setting of the Bohemian Cretaceous Basin before the beginning of deposition on the base-Cretaceous unconformity. The reconstruction of palaeodrainage corresponds to late early to early middle Cenomanian time. Main topographic palaeohighs (yellow) and lows with generalized palaeodrainage axes are illustrated, together with proven occurrences of early Cenomanian coastal facies in the NW (Meissen area) and tide-influenced to estuarine facies in the SE (Blansko Graben).*

ment units and fault systems, was finished recently (Uličný et al., 2009). Much of the progress, compared to previous studies, was made possible by a recent basin-scale evaluation of Cenomanian genetic sequence stratigraphy in approximately 2,600 boreholes, supplemented by data from natural exposures.

The tectonic layout of the Bohemian Cretaceous Basin played a dominant role in determining the orientation of palaeovalleys and the general palaeosurface slopes towards the basin-bounding faults. The distribution of basin-scale topographic lows was similar to distribution of depocentres during later depositional phases of late Cenomanian–Coniacian times. Individual palaeodrainage systems were separated by drainage divides of local importance and one major divide – the Holice–Nové Město Palaeohigh – which separated the drainage basins of the Tethyan and Boreal palaeogeographic realms (Fig. 2). This divide was located in the eastern part of the basin and followed the same strike as the modern North Sea/Black Sea drainage divide.

While bedrock lithology had the subordinate effect of narrowing or broadening valleys on more vs. less resistant substratum, respectively, the locations and directions of palaeovalleys were strongly controlled by positions of inherited Variscan basement fault zones (Fig. 3). The intrabasinal part of the palaeodrainage network followed the slopes toward the WNW – striking basin-margin faults of the Labe Fault Group. Most palaeovalley axes followed the NNE- striking structures of the Jizera Fault Group, prominent also in the alignment of modern streams in the area. The outlet streams that drained the basin area are interpreted to have followed the Lužice Fault Zone toward the Boreal province to the Northwest, and the Železné Hory Fault Zone toward the Tethyan province to the Southeast. At both the northwestern and southeastern ends of the BCB, shallow-marine or estuarine conditions are proven to have existed during the early Cenomanian.

The onset of deposition by fluvial backfilling of the PDSs, followed by incremental marine flooding of the basin area throughout the Cenomanian, was caused mainly by the long-term, stepwise rise in global sea level. The earliest basin-scale episode of tectonic subsidence, accompanied by establishment of new source areas and by local intrabasinal uplifts, is documented from the late Cenomanian. Direct evidence for syndepositional subsidence during the early to mid-Cenomanian fluvial to estuarine phase is very rare. It is inferred that subtle surface warping, mostly without detectable discrete faulting, was caused by the onset of the palaeostress regime that later, with further stress accumulation, led to the onset of subsidence in fault-bounded depocentres of the BCB and to the uplift of new source areas.

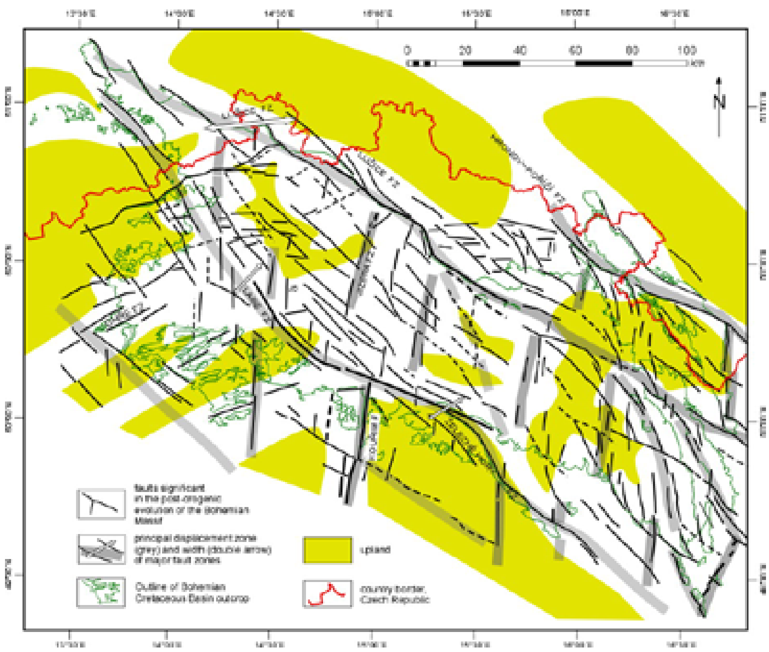


*Fig. 3: Map showing the principal faults and fault zones significant in the post-orogenic evolution of the Bohemian Massif. Most of the Oligo–Miocene faults in the Ohře Graben region are omitted for clarity. Thick grey lines indicate fault zones interpreted as important in the kinematics of the BCB (cf. Uličný et al. 2009). Relationship to palaeorelief shown in Fig. 2 is indicated by the areas of palaeohighs (yellow).*

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## References:


***Uličný, D., Špičáková, L., Grygar, R., Svobodová, M., Čech, S. and J. Laurin, J., 2009.*** *Palaeodrainage systems at the basal unconformity of the Bohemian Cretaceous Basin: roles of inherited fault systems and basement lithology during the onset of basin filling. Bulletin of Geosciences,* **84***, 577-610.*

***Voigt, S., Wagreich, M.., Surlyk, F., Walaszczyk, I., Uličný, D. Čech, S., Voigt, T., Wiese, F., Wilmsen, M., Niebuhr, B., Reich, M., Funk, H., Michalík, J., Jagt., J.W.M., Felder, P.J., and Schulp A.S., 2008.*** *Cretaceous. In: Geology of Central Europe, Volume 2: Mesozoic and Cenozoic (ed. by T. McCann), 923-997. The Geological Society, London.*

# Earthquake rotational effects – a rediscovered sub-discipline of seismology

—— Earthquake rotational effects have been observed for centuries: since late 18th century numerous examples of seismic rotations have been observed and recorded throughout the world; most of them occurred at high constructions (towers, chimneys, tombstones) consisting of vertically organized segments (e.g., Vivenzio, 1783). Soon it was established and confirmed that the rotational components of seismic waves, which are strong enough to twist heavy objects on the earth surface in the epicenter zone of an earthquake, decrease rapidly with distance and may easily vanish in standard seismograms displaying translational displacement.

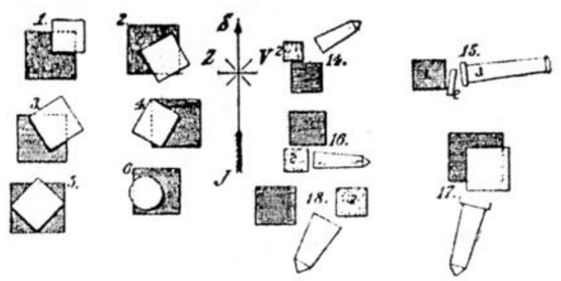

*Fig. 1. Rotated tombstones from the 1906 San Francisco earthquake. Lawson et al. (1908-1910).*

—— Especially in the second half of the 19th century, rotational seismic effects attracted attention. Numerous hypotheses appeared explaining the nature of these mysterious *vorticose movements.* The first coherent theory of the earthquake rotations´ nature based on classical Newtonian mechanics was presented by R. Mallet (1862) in his voluminous work, in which he analyzed the 1857 Napolitan earthquake. Half a century later H. F. Reid (Lawson et al. 1908-1910) completed Mallet's classical prospect when describing and explaining numerous rotational effects that accompanied the 1906 Great San Francisco earthquake. A scientific reflection of the 1906 earthquake in Bohemia is shown in Jeništa (1906-1907).

—— It seemed that after the exhaustive analytical explanation of the rotational effects presented by Reid initial interest in seismic rotations would slowly decline. In the 1970s, important new results in rotational seismology were attained: modern physical approaches in the analysis of seismic energy release in seismic foci were adopted, conversion of seismic waves was analyzed in detail, and propagation of seismic waves in asymmetric media was proposed and applied. These new possibilities have been reflected in a new wave of interest in rotation phenomena in 1980s and in 1990s, which continues up to present time. This is partly because of the idea that the rotational components of seismic ground motion, even though negligibly weak in a far-field, may grow stronger in the near zone due to conversion of seismic waves on the discontinuities separating homogeneous and composite (=structured, micromorphic) media. As shown by Teisseyre at the turn of the 20th century, such a conversion of seismic waves may result in a non-negligible increase of rotational components.

—— New centres of study of rotational effects were first established in Poland in late 1970s (R. Teisseyre), in Japan (M. Takeo), and before 2000 also in Germany (H. Igel) and elsewhere. The strongest group of researchers engaged in the rotation-studies appeared in the USGS, California, USA, under the supervision of William Lee, who organized the first *International Workshop on Rotational Seismology and Engineering Applications* in Menlo Park, California, in 2007.

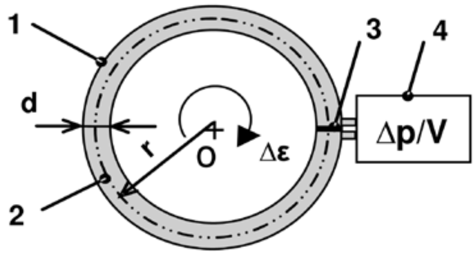


***Fig. 2:** The strong-motion fluid rotation sensor, designed, constructed and tested in the Institute of Geophysics, Prague. 1- circular-shaped ring, 3 – tube cross-wall, 4- pressure p to voltage v convertor, r – ring diameter, d – tube cross-section area.*

—— Czech seismologists participate in the research of seismic rotational effects takes places on three levels:

— 1. In cooperation with Polish specialists different kinds of rotational effects were classified, differentiated and type-specified. Pertinent type-analyses of seismic rotation phenomena were published in 2003 and in 2006 by Teisseyre & Kozák citace and by Kozák citace. In these papers "technical" types of rotational effects originating due to specific position of rotated solid body-fixing to the subsoil while the rotated body is subjected to *translational* seismic wave's impact were discriminated from these ones of "physical" character originating due to non-linear processes in seismic foci and its vicinity and from these having their origin in asymmetric (structured) media.

— 2. History, i.e., time advancement of observing, recording, depicting, explaining and interpreting rotational effects. An overview of the development of rotational seismology discussing the principal historical milestones of the sub-discipline in question and including detailed citations from R. Mallet's and H.F. Reid's classical analyses of earthquake rotations is provided by Kozák (2009).

— 3. Construction of new types of rotational seismometers (details below).

Except the near earthquake zone where rotational effects are strong and apparent and well recordable, in the far zone rotational components are weak and often hidden in much stronger standard body waves and surface waves. Also a high value of sensitivity (η), $\eta \approx 10^{-7}$ up to $10^{-9}$ rad/s is required for proper function of the far-field rotational seismometers. Needless to say that the resulting devices based on top laser and on chemical-isotope techniques are very costly, often spacious and therefore not applicable for field measurements. Seismometers suitable for recording rotation effects in the near zone have been developed because seismic ground rotations occurring there represent the largest danger in this region (seismometer sensitivity $\eta \approx 10^{-5}$ rad/sec is sufficient in the near zone).

A new type of rotational seismometer, designed by seismologists of the Institute of Geophysics, (Fig. 2) had to meet several specific criteria:

— the new seismometer should be simple, reliable and cheap to enable satisfactorily dense coverage of the near zone for a detailed rotations mapping.

— Inertial mass in translational seismometers is made of a solid body. For common, non-translational ground movements an inertial mass could be taken, which easily moves along any non-linear path, i.e., a *liquid*, which can move in a vessel of suitable shape.

— in order to *visualize* the rotational component hidden in the common wave field of a seismogram, a special circular arrangement of the sensor was designed, in which the translational components are mutually compensated so that weak rotational components become apparent.

— The resulting sensor for which the above criteria were respected is shown in Fig. 3. A circular tube filled with special viscous oil-based liquid acts on the pressure→voltage converter when the ground carrying the sensor rotates. A selected version of the seismometer of this type was calibrated and tested both in laboratory and in field conditions in the laboratories of the Institute of Geophysics. In Fig. 3, the rotational component accompanying a rockburst event in the Silesian copper mine in Polkowice (region Gliwice-Glogów) of April 19, 2008 is shown. For detailed description of the sensor and its testing see Jedlička et al. (2009).

It is expected that besides recording rotational effects from natural earthquakes the designed sensors could be also used to monitor directly the undesirable rotations occurring in large engineering constructions, such as towers, chimneys, highways, high edifices, water dams, silos, etc. due to their natural (wind) or anthropogenic (transport, etc.) dynamical loading.

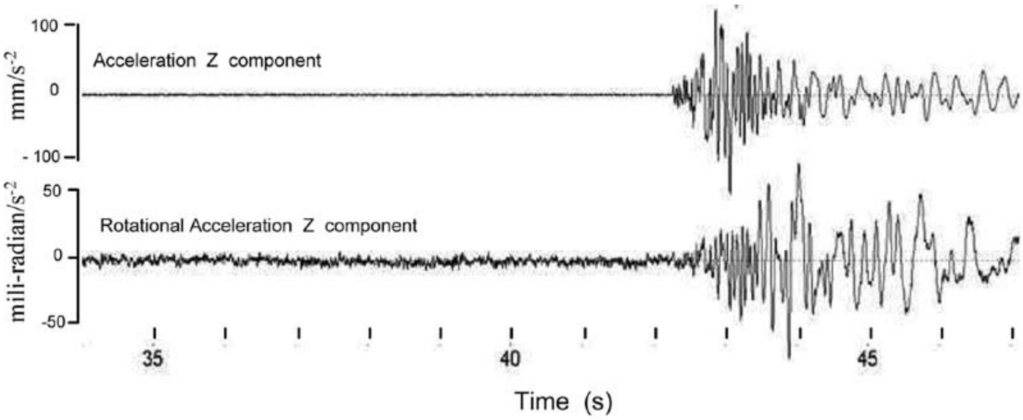


***Fig. 3:*** *Seismograms of a rockburst in the Polish copper mine in Polkowice, Silesia of April 19th, 2008, recorded at the Walbrzych seismic station. The upper trace shows the record obtained by translation seismometer SM-3. At the bottom, the record by the fluid rotational accelerometer is shown.*

## IG research staff involved:

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## References


***Jedlička, P., Buben, J. and J. Kozák, J., 2009.*** *Strong-Motion Fluid Rotation Seismograph. Bull. Seismol. Soc. Am., **99**, 2B, 1443-1448.*

***Jeništa, J., 1906-1907.*** *O seismometrech (On seismometers). Vynálezy a pokroky Vol. **III.**, pp. 10-164, Prague.*

***Kozák, J., 2009.*** *Tutorial on Earthquake Rotational Effects: Historical Examples. Bull. Seismol. Soc. Am., **99**, 2B, 998-1010.*

***Lawson, A.C., Gilbert, G. K., Reid, H. F. , Leuschner, A. D., Davidson, G., Burghalter, C. K. and Campbell, W. W., 1908-1910.*** *Report upon the California Earthquake of April 18, 1906. **1-3,** The Carnegie Institution of Washington, Washington, D.C.*

***Vivenzio, G., 1783.*** *Istoria e teoria de tremuoti in generale, et in particulare di quelli della Calabria e di Messina del 1783. Stamperia Reale, Napoli.*

# Perturbation approaches in seismic-wave propagation studies

—— Perturbation approaches play important role in physics. They allow to seek approximate, but relatively simple and transparent solutions of problems, whose exact solution is otherwise difficult, if not impossible, to find. We apply perturbation approaches to variety of seismic wave propagation problems, mostly to studies of wave propagation in weakly anisotropic media or in media with weak dissipation. In the former case, we consider as the perturbation the deviation of anisotropy from isotropy, in the latter case, the deviation of dissipation from perfect elasticity.

—— Another important application of the perturbation approach is approximate modelling of seismic wavefields in inhomogeneous, weakly anisotropic media media. After developing complete theory for P waves, we concentrated on the case of the two S waves propagating in anisotropic media. In weakly anisotropic media, they exhibit an interesting phenomenon: S-wave coupling (Farra & Pšenčík, 2008). The perturbation approach allows sufficiently accurate description of coupling while the standard ray theory fails to describe it at all. Fig.2 shows synthetic seismograms for inhomogeneous, weakly anisotropic

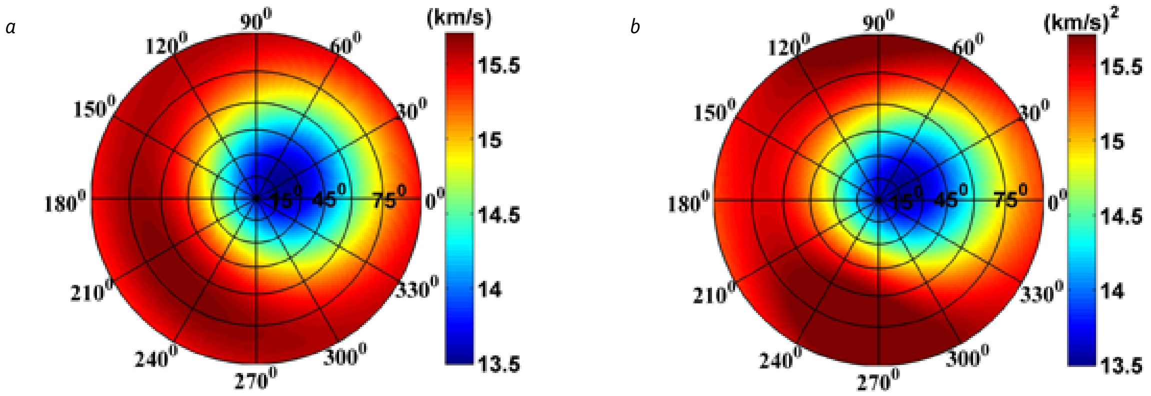


*__Fig. 1:__ Stereographic projection of the square of the P-wave phase velocity: (a) in the model used to generate synthetic data; (b) in the model obtained from inverted parameters. (c – facing page) Relative errors of data in (b).*

—— We used the perturbation formulae to derive an expression, which allows the determination of local anisotropy at receivers in a borehole from travel times and polarizations of P waves generated by sources distributed on the surface and recorded in the borehole (Gomes, Silva & Pšenčík, 2009). Knowledge of local anisotropy is important for seismic exploration purposes. Oil companies like BP, Petrobrás or WesternGeco are testing the proposed approach for processing their borehole data. In Fig.1, we show, as an illustration, results of a synthetic test. Fig.1a shows stereographic projection of distribution of the square of the P-wave phase velocity in a synthetic model. Fig.1b shows results of inversion based on the application of the approximate expression to data of direct and reflected P waves generated along five profiles, each with 197 sources. In Fig.1c, we can see the distribution of relative errors of inverted results. The errors are less than 2%.

media with varying strength of anisotropy: QI (1-4%), QI2 (4-7%) and QI4 (11-13%). All traces for QI model and left-hand traces for QI2 model are affected by coupling while in the rest of traces for QI2 and in all traces for QI4 model, we can observe clear S-wave separation. The approximate coupling ray theory is capable to describe coupled as well as separated S waves in isotropic, weakly anisotropic and moderately anisotropic media. As a byproduct, the theory also provides traveltime formulae of separate S waves (Iversen, Farra & Pšenčík, 2009), which are important for inversion and migration purposes.

—— Perturbation approaches play also important role in studies of wave propagation in weakly dissipative media (majority of seismic structures exhibits weak dissipation). In our theoretical studies, we investigated behaviour of inhomogeneous waves (Červený & Pšenčík, 2008a) and generalized concept of the quality factor Q describing dissipative properties of isotropic media to Q describing dissipation in anisotropic media (Červený & Pšenčík, 2008b). We also studied possibilities of use of alternative perturbation formulae leading to more accurate approximate results (Červený, Klimeš & Pšenčík, 2008; Červený & Pšenčík, 2009).

In all above studies, our goal was to derive formulae applicable in seismic exploration, i.e., in 3D laterally varying anisotropic structures of higher symmetry. An efficient and accurate way how to perform ray tracing and dynamic ray tracing in such media is proposed by Iversen & Pšenčík (2008).

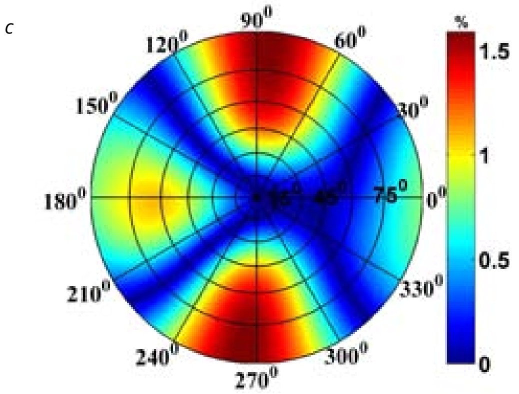


*Fig. 1 (c)*

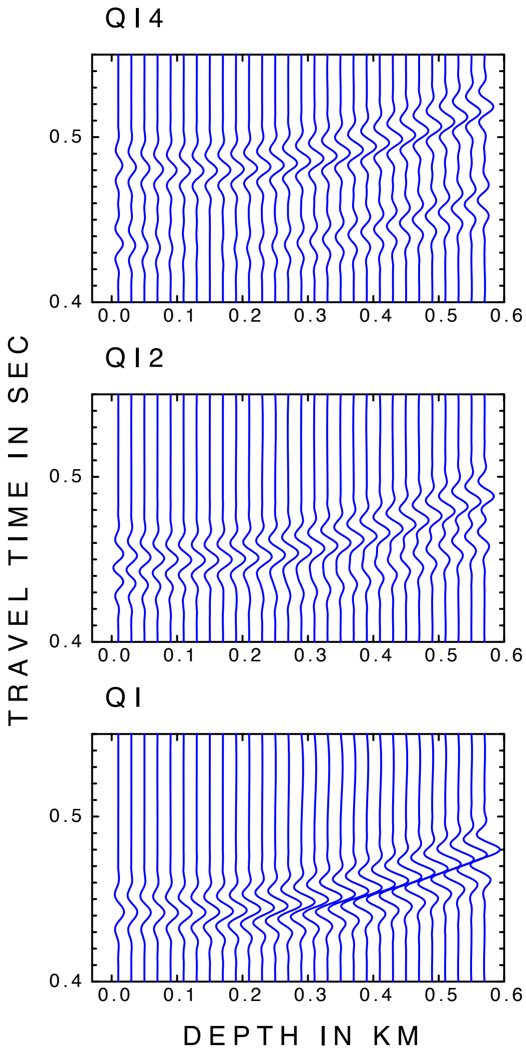


*Fig.2: Synthetic seismograms of transverse component of displacement vector of coupled and split S waves in inhomogeneous anisotropic media with varying strength of anisotropy; from very weak (QI) to moderately strong (QI4).*

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## References:


***Červený,V. & Pšenčík,I., 2008a.*** *Weakly inhomogeneous plane waves in anisotropic, weakly dissipative media, Geophys.J.Int., 172, 663—673.*

***Červený,V. & Pšenčík,I., 2008b.*** *Quality factor Q in dissipative anisotropic media. Geophysics, 73, T63—T75.*

***Červený,V. & Pšenčík,I., 2009.*** *Perturbation Hamiltonians in heterogeneous anisotropic weakly dissipative media. Geophys.J.Int., 178, 939—949.*

***Červený,V., Klimeš,L. & Pšenčík,I., 2008.*** *Attenuation vector in heterogeneous, weakly dissipative, anisotropic media. Geophys.J.Int., 175, 346—355.*

***Farra,V. & Pšenčík,I., 2008.*** *First-order ray computations of coupled S waves in inhomogeneous weakly anisotropic media. Geophys.J.Int., 173, 979–989.*

***Gomes,E.N., Silva,S. & Pšenčík,I., 2009.*** *Estimativa da orientacao do eixo de simetria de um meio TI a partir de dados de onda P em experimentos de VSP Walkaway. 11th International Meeting, SBGf, Expanded Abstracts, 2104.*

***Iversen,E. & Pšenčík,I., 2008.*** *Ray tracing and inhomogeneous dynamic ray tracing for anisotropy specified in curvilinear coordinates. Geophys.J.Int., 174, 316-330.*

***Iversen,E., Farra,V. & Pšenčík,I., 2009.*** *Shear-wave traveltime in inhomogeneous weakly anisotropic media. 79th Annual International Meeting, SEG, Expanded Abstracts, 28, 3486—3490, doi: 10.1190/1.3255587.*

# Seismic methods help in natural gas and oil exploitation

The permeability of hydrocarbon-bearing sediments is usually improved by high-pressure fluid injection aimed to fracture the rock surrounding the borehole. The process ordinarily induces microseismicity, the monitoring of which enables determine the parameters of the created fractures. Contrary to collection of data in earthquake seismology, here the sensors are usually not distributed on the surface but as linear (mostly vertical) arrays in monitoring wells. A typical setup of the hydrofracture experiment is the treatment well where the injection is performed, and a single monitoring well, in less frequent cases the seismicity is monitored from two wells. The parameters of interest are locations of hypocentra of the induced microearthquakes, displaying the extent of the fractured medium in space and time, their magnitudes yielding information on their size, and their mechanisms, which indicate the type of fracturing of the rock mass.

In a standard single monitoring well experiment, the knowledge of both wave arrival times and their azimuths is needed for location of the seismic events. The azimuth is usually estimated using P-waves, however S-waves are more advantageous as they exhibit higher signal-to-noise ratios. Eisner et al. (2008) developed a new algorithm for determining the azimuth just from S-waves. Tests using synthetic and real data showed that this way the wave azimuths of a bigger number of induced events with better accuracy than using P-waves can be obtained. The algorithm was applied by Fischer et al. (2008) for location of seismicity accompanying a hydraulic fracture in a gas reservoir in Texas. The position of multiple thousands microearthquakes delineated a vertical fracture growing predominantly horizontally. Comparison of its growth rate with the injection rate yielded a fracture width ranging 7-10 mm. It turned out that most of the fluid volume was utilized for the fracture creation while the fluid lost to the rock formation by infiltration was negligible.

Focal mechanism retrieval demands extended observation. In a single monitoring well experiment, it is not possible to recover the complete moment tensor (Vavryčuk, 2007), limited information however can be obtained. Jechumtálová and Eisner (2008) demonstrated on a dataset from a hydrofracturing experiment in an oil well in Texas that, even after accounting for the measurement errors, most of the analyzed seismograms required the presence of volumetric, non-shear deformation.

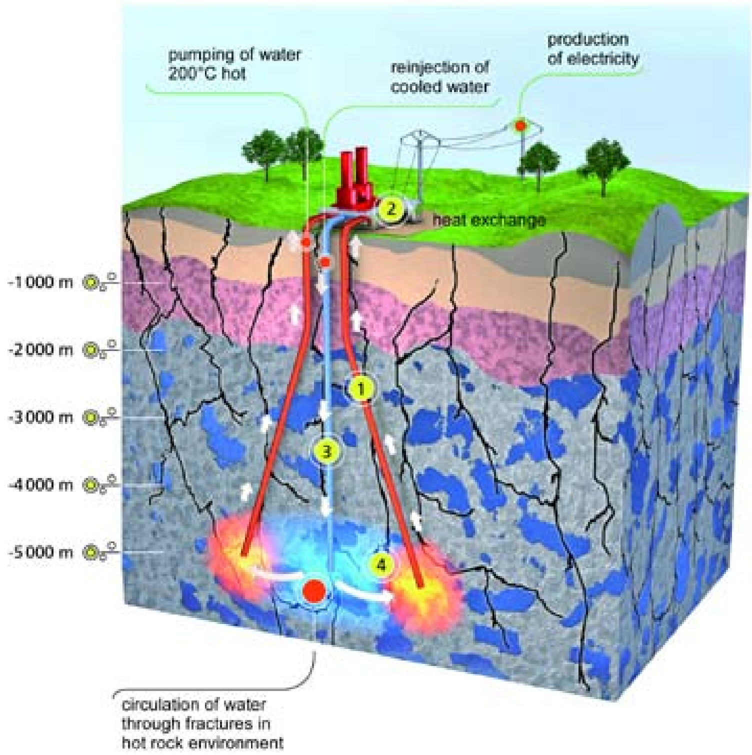


***Fig. 1:*** *Scheme of the Soultz geothermal facility showing the location of fracture systems. Image courtesy of Albert Genter (GEIE Exploitation Minière de la Chaleur, France), adapted after Genter et al. (2009).*

Complete moment tensor (MT) determination requires two-well monitoring at least, and even then it suffers from a limited quality of the focal sphere coverage by the observations. Nevertheless, the MT can be obtained with sufficient confidence granting valuable information on the type of fracturing having occurred during the injection. Šílený et al. (2009) re-interpreted data from the Cotton Valley, east Texas, gas field, formerly processed by Rutledge et al. (2004) who assumed a priori shear-slip mechanisms implying the double-couple (DC) mechanism. In the full MT approach applied to strong events from the dataset, significant non-DC mechanisms were detected which can be interpreted as force equivalents of tensile cracks which are opened during the injection. This is important information for assessment of the success of the hydrofracturing, as tensile cracks are crucial for increasing the permeability of a hydrocarbon reservoir.

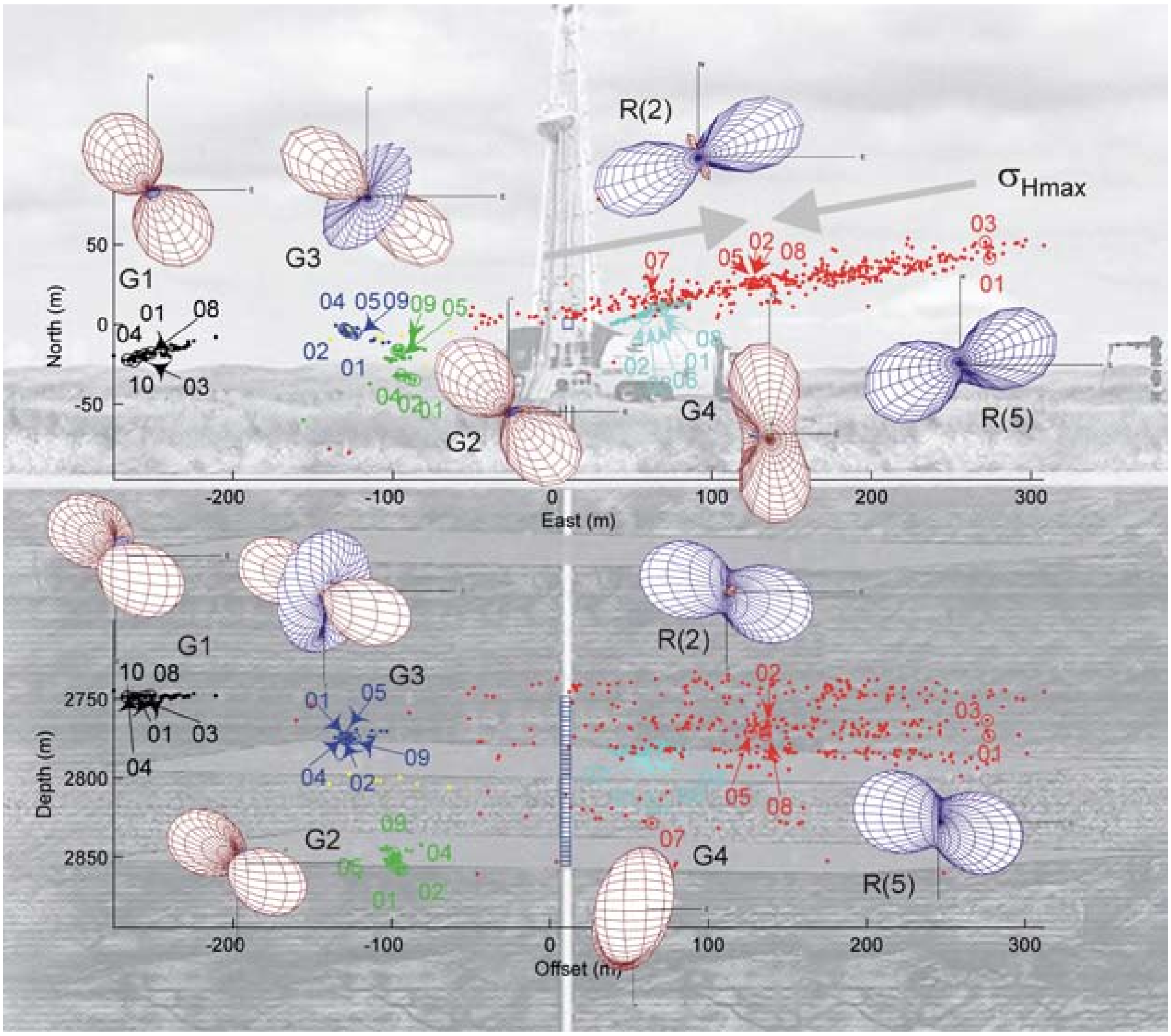


*Fig. 2: Mechanisms of selected microearthquakes induced during the Cotton Valley, Texas, hydrofracture experiment (upper part – map view, bottom – depth section). G1-G4, R – individual groups within the seismicity accompanying the injection, 3-D wire-frame plots – mechanisms displayed as the P-wave radiation patterns (red – extension lobes, blue – compression ones). The mechanisms in the G1 and G2 groups are extensional dipoles, indicating a tensile crack in the focus.*

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*Jan Šílený, Tomáš Fischer, Zuzana Jechumtálová, Václav Vavryčuk*

## References:


***Eisner, L., Fischer T. and Rutledge J., 2008.*** *Determination of S-wave slowness from a linear array of borehole receivers, Geoph. J. Int.*

***Fischer, T. Hainzl, S., Eisner L., Shapiro S. and Le Calvez J., 2008.*** *Microseismic signatures of hydraulic fracture growth in sediment formations: Observations and modeling, J. Geophys. Res., 113, B02307.*

***Jechumtálová, Z. and Eisner, L., 2008.*** *Seismic source mechanism inversion from a linear array of receivers reveals non-double-couple seismic events induced by hydraulic fracturing in sedimentary formation. Tectonophysics, 460, 124-133.*

***Rutledge, J.T., W.S. Phillips and M.J. Mayerhofer, 2004.*** *Faulting Induced by Forced Injection and Fluid Flow Forced by Faulting: An Interpretation of Hydraulic-Fracture Microseismicity, Carthage Cotton Valley Gas Field: Bull. of Seism. Soc. of Am.,* **94**, *1817-1830*

***Genter, A., Fritsch, D., Cuenot, N., Baumgärtner, J. and Graff, J.-J., 2009.*** *Overview of the current activities of the European EGS Soultz Project: from exploration to electricity production. Proceedings, Thirty-Fourth Workshop on Geothermal Reservoir Engineering , Stanford University, Stanford, California, February 9-11, 2009, SGP-TR-187.*

***Šílený, J., Hill, D.P., Eisner, L., and Cornet, F.H., in press.*** *Non-double-couple mechanisms of microearthquakes induced by hydraulic fracturing, J. Geophys. Res.*

***Vavryčuk, V., 2007.*** *On the retrieval of moment tensors from borehole data. Geophysical Prospecting,* **55** *(3), 381-391.*

# Tidal modulation of temperature oscillations monitored in borehole Yaxcopoil (Yucatán, Mexico)

As a part of the International Continental Deep Drilling Programme (ICDP) Institute of Geophysics conducted detailed geothermal research in a 1.5 km deep borehole Yaxcopoil drilled within the Chicxulub impact structure (Yucatan, Mexico). This crater structure of about 180 kilometers in diameter presents one of the largest impact structures in the world. Four field expeditions were perfomed (2004-2008), which enabled repeated temperature logging (Šafanda et al. 2005, 2007, 2008). While temperature in the hole generally increases linearly with depth with a mean gradient of 41 mK/m, the detailed T(z)-structure displayed several local variations caused by groundwater convection within surrounding karstic rocks. A very specific feature of all T(z)-profiles is an expressive local high-gradient-zone (HGZ) with temperature gradient well above 200 mK/m in a relatively narrow depth interval of only several metres, where temperature suddenly increased by about 0.8 °C suggesting a transition between the heat convection-dominated and heat conduction-dominated sections of the hole (Šafanda et al., 2005). As an explanation of this unusual phenomenon the downward migration of the drilling mud lost during the drilling operation was proposed; when sinking down from the uppermost cooler layers the drilling mud cools the surrounding rock matrix.

In addition to the routine T(z)-logging we have performed very precise high resolution temperature-time monitoring at several selected depths to understand the main components forming the temperature signal and to detect the deterministic part in the fine-scale temperature variations (Čermák et al., 2008a,b). Owing to the unique existence of sharp temperature gradient contrasts (25 up to 250 mK/m), the range of the potential critical parameters, causing the intra-hole oscillatory convection, was extremely favorable and helped estimate the limits of the accuracy to what temperature can be measured in a “noisy” environment. The obtained data provided additional material for behavior studies of

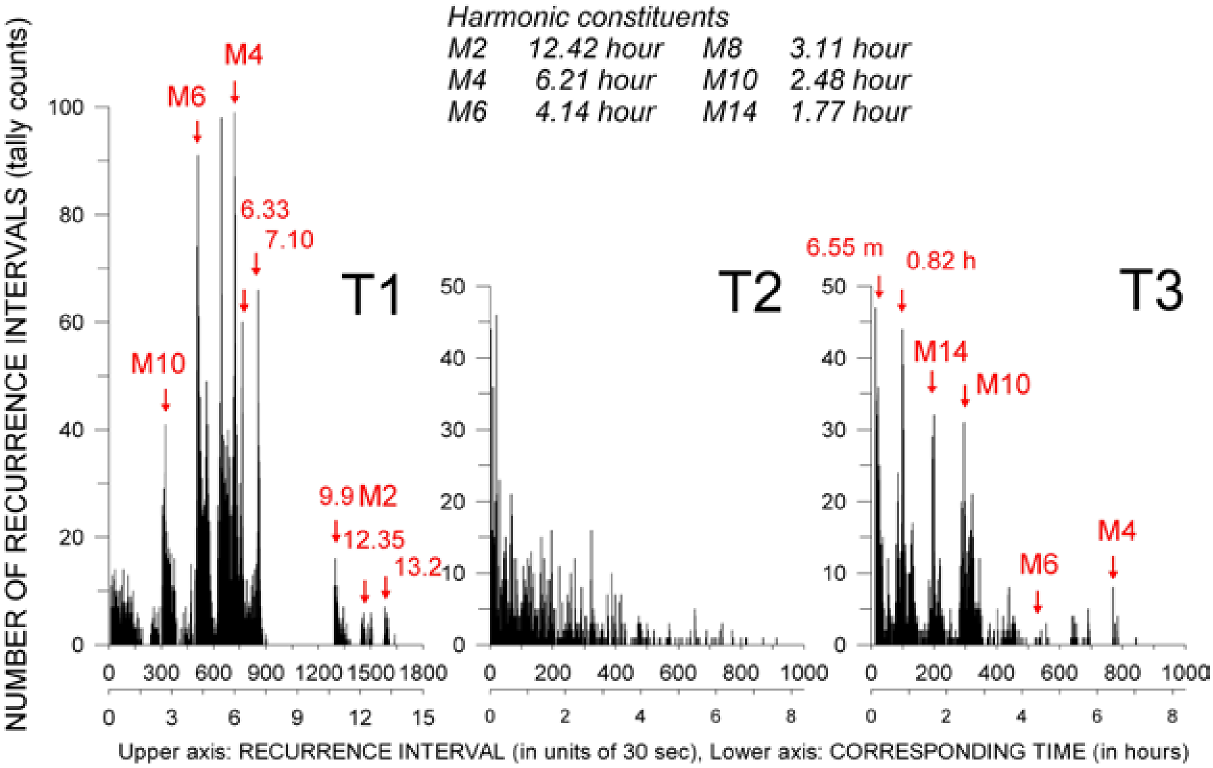


*Fig. 1: Typical histograms of the number of the recurrence intervals. Histograms were constructed for 40001-43000, 1- 10000 and 36001-37000 data points sections for the series T1, T2 and T3, respectively.*

fluid dynamics as well as nonlinear heat transport in heterogeneous, highly permeable subsurface rocks. All T(t)-records contained a noticeable tidal modulation and the spectral analysis revealed several weak peaks of diurnal, semi-diurnal and quarter-diurnal constituents. Due to low resolution of the spectral analysis in low frequency domain, two more sensitive methods were applied for the detection of the tidal forcing, namely the Recurrence quantification interval (RQI) analysis and the Histograms Cumulation (HiCum) technique to separate the constituents with tidal periodicities from temperature-time oscillations

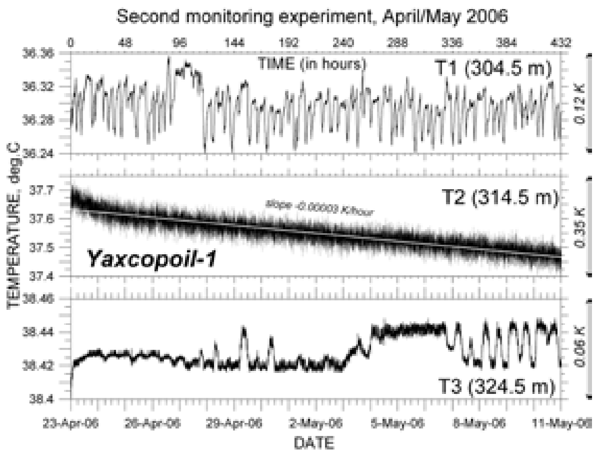


*Fig. 2: Temperature-time monitoring experiment in hole Yaxcopoil: T(t) at 304.5, 314.5 and 324.5 m depths. Note completely diverse appearance of temperature oscillations at different depth levels. Oblong boxes limit the data sections used for further detailed analyses.*

(Čermák, 2009). Both analyses revealed that temperature series contain perceptible tidal components (Čermák et al., 2009a,b). Few explanations of why the borehole fluid temperature varies in response to the tidal forcing were proposed. The correlation of high tide and high temperature in borehole suggests that the tide may act as a hydraulic pump. Tidal currents may affect subsurface temperature by moving water of different temperatures back and forth from a fixed spot or temperature oscillations may result from weak flow oscillations caused by hydro-elastic Helmholtz type borehole-cavity resonance excited by pressure fluctuations of turbulent origin. All these hypotheses imply a strong environmental dependence of temperature response to tidal forcing. While the pressure changes in groundwater due to high elasticity of water confined in the aquifer are transmitted rapidly, the actual physical water movement strongly depends on the aquifer permeability. It may appear as slow soaking through low permeability strata or rapid fluid motion in coastal karst aquifers, where conduit flow is dominant. Accurate modeling is difficult because of the general lack of sufficient information on the permeability-transmissivity of the porous media where a borehole is located and because tides are not the only forcing affecting the borehole temperature data.

## IG research staff involved:

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## References

***Čermák, V., Šafanda, J., and Krešl, M., 2008a.*** *Intra-hole fluid convection: High-resolution temperature time monitoring. Journal of Hydrology. 348, 464-479.*

***Čermák, V., Šafanda, J., and Krešl, M., 2008b.*** *High-resolution temperature monitoring in a borehole: Detection of the deterministic signal in noisy environment. Stud. Geophys. Geod., 52, 1-25.*

***Čermák, V., 2009.*** *Recurrence Quantification Analysis of Borehole Temperatures: Evidence of Fluid Convection. Journal of Bifurcation and Chaos, 19, 889-902.*

***Čermák, V., Šafanda, J, and Bodri, L., in press.*** *Thermal instability of the fluid column in a borehole, application to the Yaxcopoil hole (Mexico). Int. J. Earth Sci.*

***Čermák, V., Šafanda, J and Bodri, L., 2009.*** *Tidal modulation of temperature oscillation monitored in borehole Yaxcopoil-1 (Yucatan, Mexico). Earth Planet. Sci. Letts., 282, 131-139.*

***Šafanda, J., Heidinger, Ph., Wilhelm, H. and Čermák, V., 2005.*** *Fluid convection observed from temperature logs in the karst formation of the Yucatán Peninsula, Mexico. J. Geophys. Eng., 2, 326-331,.*

***Šafanda, J., Heidinger, Ph., Wilhelm, H. and Čermák, V., 2007.*** *Post-drilling destabilization of temperature profile in borehole Yaxcopoil-1, Mexico. Hydrogeology Journal, 15, 423-428.*

***Šafanda, J., Wilhelm, H., Heidinger, P. and Čermák, V., 2009.*** *Interpretation and mathematical modeling of temporatl changes of temperature observed in borehole Yaxcopoil-1 within the Chicxulub impact structure, Mexico. J. Hydrology, 372, 9-16.*

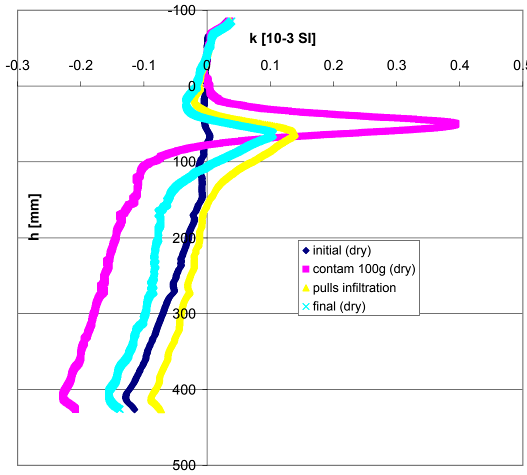
# Experimental study of fly-ash migration under controlled water regime

Soil magnetometry can serve as proxy for industrial imissions as well as heavy-metal contamination. An important methodological question related to measurements of topsoil magnetic susceptibility is whether migration of deposited anthropgenic ferrimagnetics influences the measured values. In spite o the fact that reliable mapping of magnetic susceptibility requires a high temporal stability of accumulated industrial imissions in topsoils, precise knowledge on the mobility of anthropogenic ferrimagnetics in vertical soil profile (and factors affecting this process) is still lacking (Kapička et al., in press)

a

In our model experiments in laboratory we used three technical sands with different particle sizes (0.10 – 1.25 mm). Sands in plastic cylinders were contaminated on the surface by fly-ashes from coal-burning power plant. Micro-tensiometers T5 for pressure head measurements were placed 10, 20 and 30 cm below the sand surface to monitor water regime within the sand columns after controlled rain simulation. Vertical migration of ferrimagnetic particles-tracers presented in the fly-ash was measured by SM400 Kappameter. The final magnetic susceptibility within the soil profile and consequently fly-ash distribution was measured when no significant water flow and consequently no fly-ash transport was observed As a first step, calibration measurements were carried out in order to define the effect of temperature and different moisture on susceptibility values measured by SM400 (Kapička et al., 2008). The initial distribution, profile with applied fly-ash and final (fly-ash after the pulls infiltration) dispersion of magnetic susceptibility within the medium-sand column packed in the plastic cylinder are shown in Fig. 1b.

Magnetic particles migration was indicated into the following depths: 4-6 cm in the fine sand, ~10 cm in medium and 20 cm in coarse sand. The lowest peak value of magnetic susceptibility was measured for the coarse sand due to the intensive migration of magnetic particles within the sand column (Kodesova et al). After the pulls infiltration of defined water volume, gradual decreases of susceptibility peak values were detected in all studied sand formations. Fly-ash migrated more or less freely in coarse sand material. In medium and fine sand the contaminants moved only to the depths of several cm due to the pore-space blocking and water flow decrease.




b

*Fig. 1: a- column experiments: sand in cylinders with micro-tensiometers T5, thermometers and Kappameter SM400. b- magnetic susceptibility distribution (initial, infiltrated, final) in contaminated medium sand*

## IG research staff involved:

*Aleš Kapička, Eduard Petrovský, Hana Fialová*

## References.

***Kodešová, R., Kapička, A., Fialová, H., Lebeda, J., Kopáč, J., and Petrovský, E., 2007.*** *Experimental study of fly-ash migration in sands of various particle size distributions. Proc. 15th Int.Conf. "Transport of Water, Chemicals and Energy in the Systém Soil-Crop Canopy-Atmosphere", Bratislava 2007, 256-263.*

***Kapička, A., Petrovský, E., Fialová, H., Podrázský, V., and Dvořák, I., 2008****. High resolution mapping of anthropogenic pollution in the Giant Mountains National Park using soil magnetometry. Studia Geoph. Geod., 52, 271-284.*

***Kapička, A., Fialová, H., Petrovský, E.,Kodešová, R., and Kopáč, J., 2008.*** *Laboratory experiments on dynamics of anthropogenic ferrimagnetics in sand formations. Contr. to Geophysics and Geodes, 38, 52-53*

***Kapička, A., Petrovský, E., Fialová, H., Kodešová, R., in press.*** *Factors Influencing Reliability of Magnetic Pollution Mapping – a Review. Advances in Geophysics.*

# Onset of formation of gas hydrates and their stability under permafrost in an environment of climatic change

Modeling of the onset of permafrost formation and succeeding gas hydrate formation in the changing surface temperature environment has been done for the Beaufort-Mackenzie Basin (BMB). Numerical 1D modeling is constrained by deep heat flow from deep well bottom hole temperatures, deep conductivity, present permafrost thickness and thickness of gas hydrates. Latent heat effects were applied to the model for the entire ice bearing permafrost and gas hydrate intervals. Modeling for a set of surface temperature forcing during the glacial-interglacial history including the last 14 Myr, the detailed Holocene temperature history and a consideration of future warming due to a doubling of atmospheric CO2 was performed. Two scenarios of gas formation were considered; case 1: formation of gas hydrate from gas entrapped under deep geological seals and case 2: formation of gas hydrate from gas in a free pore space simultaneously with permafrost formation. In case 1, gas hydrates could have formed at a depth of about 0.9 km only some 1 Myr ago. In case 2, the first gas hydrate formed in the depth range of 290 – 300 m shortly after 6 Myr ago when the ground surface temperature dropped from -4.5 °C to -5.5. °C. The gas hydrate layer started to expand both downward and upward subsequently. More detailed modeling of the more recent glacial–interglacial history and extending into the future was done for both BMB onshore and offshore models. These models show that the gas hydrate zone, while thinning will persist under the thick body of the Beaufort-Mackenzie Basin permafrost through the current interglacial warming and into the future even with a doubling of atmospheric $CO_2$.

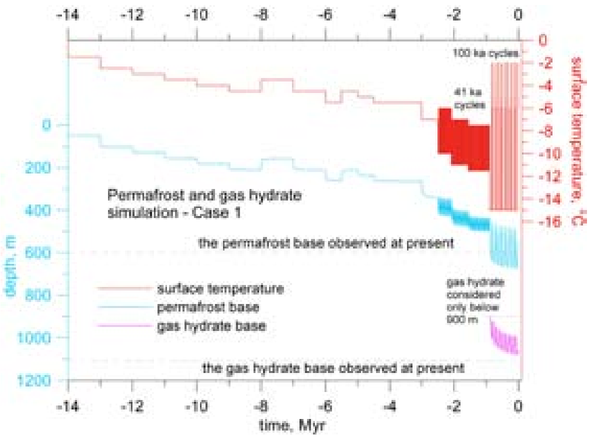



*Fig. 1: 14 million year history of surface temperature forcing together with simulated depth variations of permafrost and gas hydrate bases – Case 1 model, where the gas hydrate formation was considered possible below 900 m only due to impermeable sedimentary layers above this depth.*

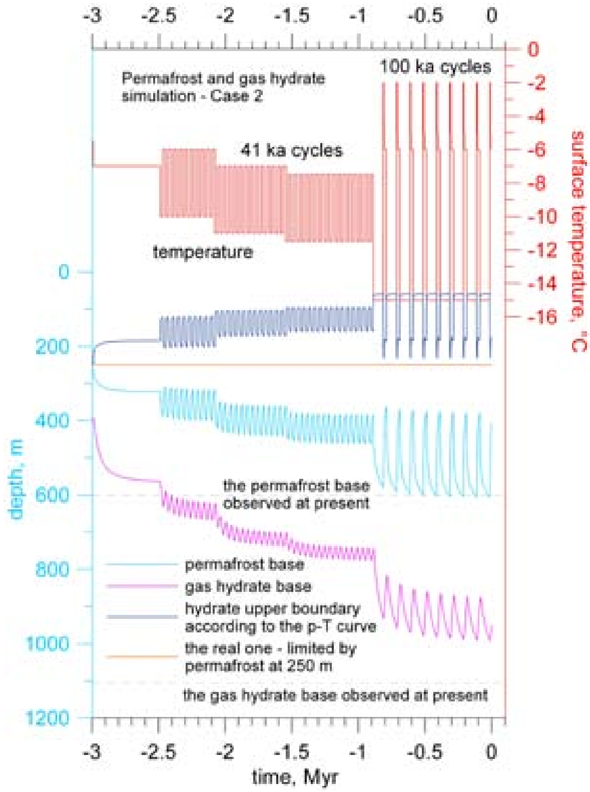



*Fig. 2: The last 3 million years of permafrost and gas hydrate simulated history in Case 2 model, where the simultaneous occurence of ice bearing permafrost and gas hydrate was considered.*

## IG research staff involved:

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## References


***Majorowicz J., Osadetz K. and Šafanda J., 2008.*** *Onset and stability of gas hydrates under permafrost in an environment of surface climatic change – past and future. Proceedings of the 6th International Conference on Gas Hydrates (ICGH 2008), Vancouver, British Columbia, Canada, July 6-10, 2008. The paper is available at https://circle.ubc.ca//handle/2429/1161*

# Does geomagnetic activity affect the global surface temperature?

The effect of solar radiation, in view of its decrease particularly during the period 1976-2004 (Bucha, 2009) is not considered significant. On the contrary, the opinion now prevails that the cause of global warming is the increasing concentration of greenhouse gases. Short-term changes within two or more years are ascribed to the dynamic processes in oceans and especially to the La Niña – El Niño cycle, defined by the Southern Oscillation Index (SOI). The purpose of this study was to investigate the chain of processes in the atmosphere, which tie in with one another and, in their final stage, contribute to global warming. Bucha (2009) pointed out that there exist statistically significant relations between the increasing global temperature and geomagnetic activity in the month of October and December, which displays a similar increase in the past decades. The SOI displays statistically significant relations not only with the global temperature, but also with geomagnetic activity (AA index). Based on these results and using composite maps, we have suggested a possible explanation of the causes affecting global warming.

As a consequence of geomagnetic storms, indicating the enhancement of the solar wind, energetic particles penetrate from the magnetosphere into the region of the polar stratospheric vortex. There they take part in perturbing the processes in the polar region and in changing the direction of flow of the polar air to lower latitudes (Fig. 1). This relatively weak signal, given the considerable instability of the on-going processes in the stratosphere, may cause significant changes (Bucha, in review).

At the time of La Niña and under low values of the geomagnetic AA index, the wind blows from the polar region over North America and from the Atlantic towards the pole via Greenland. Surface temperatures in Eurasia are below-normal (Fig. 2a). Under El Niño and increased values of the AA index, the vortex shifts towards Europe and rotates counter-clockwise. A pronounced change can be observed in the direction of the vector wind.

The wind blows from the polar region southwards over Greenland and the Norwegian Sea (Fig. 1) and diverts the warm flow proceeding northwards over the Atlantic eastward along the extended Icelandic low (Bucha, in review). This leads to the increase of surface temperatures in Eurasia (Fig. 2b) and increases the global temperature.

Then, the significant increase in global temperature in the course of 30 years (1976 – 2004) is

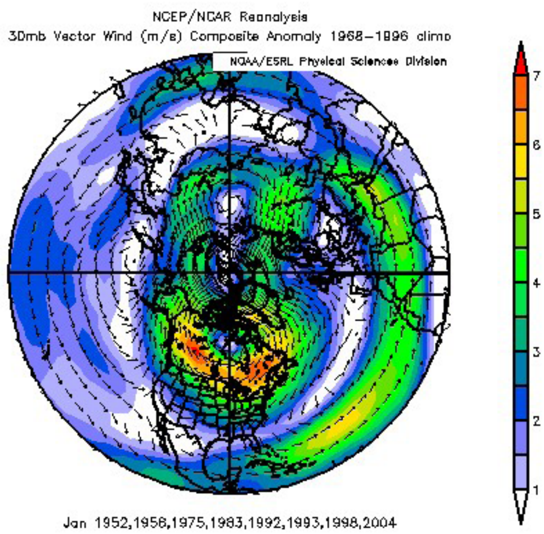



***Fig. 1:** Composite map for eight January configurations of the northern polar vortex at the 30mb isobaric level of geopotential height. At the time of El Niño Southern Oscillation and increased AA values, anomalous vector wind blows southwards (see arrows) across Greenland and Norwegian Sea. Image provided by the NOAA/ESRL, Boulder.*

affected by enhancing geomagnetic activity mainly in October of the preceding year. The enhanced geomagnetic activity in the course of the year (mainly in February, November and December) intensifies the zonal flow and the gradual displacement of the regional pressure formations eastwards. Thereby it also affects the generation of the El Niño events that *a*

*b*

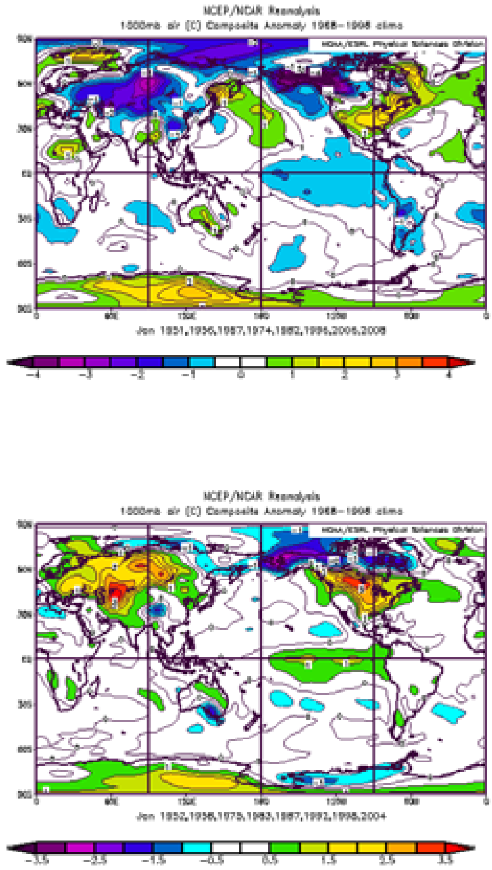


*Fig. 2: Composite maps of eight January monthly averages of the anomalous distribution a) of below-normal temperature in Eurasia (blue) in the years when La Niña occurred and when the geomagnetic activity AA was low in the preceding year, and b) of above-normal temperature in Eurasia (red) under the occurrence of El Niňo and enhanced values of AA. Images provided by the NOAA/ESRL, Boulder.*

take part in the short-term increases in global temperature.

The long-term increase in the surface global temperature then depends on gradually increasing values of geomagnetic activity in December (1869-1974) and especially in October (1975-2003), contributing to the prevailing occurrence of zonal flow. A certain part of the global warming may be affected by anthropogenic factors, but the consequence of external processes, contributing as the geomagnetic signal to change in pressure and temperature, as described herein, is evidently also significant. Even if geomagnetic activity affects global warming, the necessity of taking effective steps against environmental pollution, of course, continues to be topical.

In some shorter periods with very low geomagnetic activity, the processes in the atmosphere may be chaotic and mostly affected by seasonal changes. Nevertheless, the results achieved, describing the links of the whole chain of processes between the magnetosphere and troposphere, may contribute to the cognition of the causes leading to the changes in global temperature.

## IG research staff involved:

*Václav Bucha*

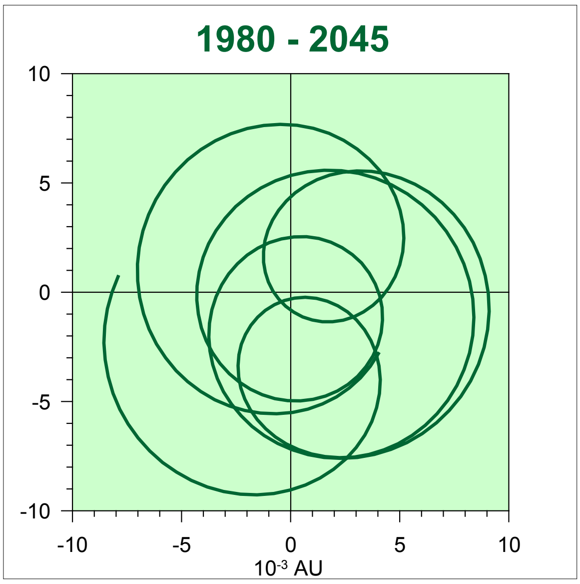
## References:


***Bucha, V., 2009.*** *Geomagnetic activity and the global temperature. Studia Geophysica et Geodaetica,53, 571-573.*

***Bucha, V., in review.*** *Does Geomagnetic Activity Affect the Global Surface Temperature? Studia Geophysica et Geodaetica (in review).*

# Long-term predictive assessments of solar and geomagnetic activities made on the basis of the close similarity between the solar inertial motions (SIMs) in the intervals 1840-1905 and 1980-2045

A close similarity between the solar inertial motions (SIMs) in the years 1840-1905 and 1980-2045 was found. This has been employed for long-term predictive assessments of solar and geomagnetic activities.



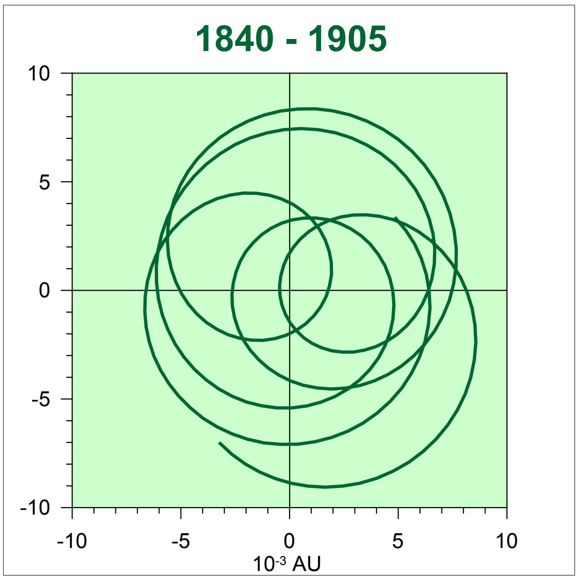




**Fig. 1:** *The SIMs ( the orbits of the centre of the Sun around the barycentre of the solar system) in the interval 1840-1905 (right) and in the interval 1980-2045 (left), in units of $10^{-3}$ AU. The similarity becomes apparent with rotation of c. 90°.*

The basic data was taken from http://ftp.ngdc.noaa.gov/stp/stp.

If solar variability is really caused by the SIM (Charvátová, 1990), the motion of the Sun along the same orbit (under the same motion characteristics such as the velocity, the acceleration, the radii of curvature, ...) should produce similar series of sunspot cycles. Unfortunately the quality of data before 1850 for solar activity and before 1868 for geomagnetic activity (index *aa*) is lower. Nevertheless the results shown in Figs. 2,3 indicate that both activities are non random processes. If the coincidences between the respective series gradually increase over the next few years, the predictions would become more and more reliable. The coincidences between the series could be used as further evidence supporting the idea that the variabilities are connected to the SIM.

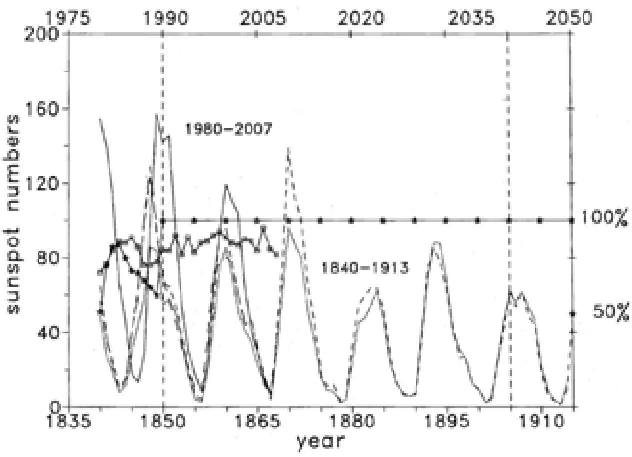



*Fig. 2: The sunspot numbers in the years 1840-1905 (dashed line) and in the years 1980-2007 (solid line). The lower numbers of daily observations are plotted by solid line with squares in case of Schwabe's Clusters of spots or by solid line with asterisks in case of sunspot numbers. The curve in the years 1868-1905 could represent a development of solar activity up to 2045.*

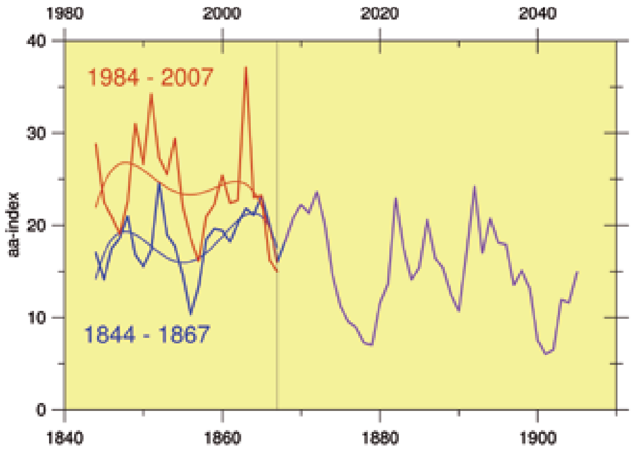



**Fig. 3** *The geomagnetic index aa in the years 1844-1867 (the data was taken from Finnish meassurements – Nevanlinna and Kataja 1993, blue line) and 1984-2007 (red line). The data before 1868 was taken from Nevanlinna and Kataja (1993). The series is therefore not so reliable. Inspite of this, the correlation coeficient is equal to 0.61. Courses of the best fit lines (always the polynomials of the fourth order) are similar, a coincidence of their extrema is possible to see. The purple line could reperesent an estimate of future evolution of the aa-index up to 2045.*

## IG staff involved:

*Ivanka Charvátová*

## References


***Charvátová, I., 1990.** On the relation between solar motion and solar activity in the years 1730-80 and 1910-60, Bull. Astr. Inst. Czech. 41, 200-204.*

***Charvátová, I., 2009**. Long-term predictive assessments of solar and geomagnetic activities made on the basis of the close similarity between the solar inertial motions in the intervals 1840-1905 and 1980-2045, New Astronomy 29, 1-14.*

***Nevanlinna, H. and Kataja, E., 1993.** An extension of the geomagnetic index aa for two solar cycles 1844-1868, Geophys. Res. Lett. 20 (23), 2703-2706.*

# Research student supervision and co-supervision

Every year, a number of PhD and MSc – level projects are supervised by the researchers of the Institute of Geophysics, and commonly also funded by research grants to the Insitute.

Below, student research projects running or completed in 2008 and 2009 are listed, in alphabetical order of student's names and with the names of supervisors and co-supervisors from the Institute in bold letters.

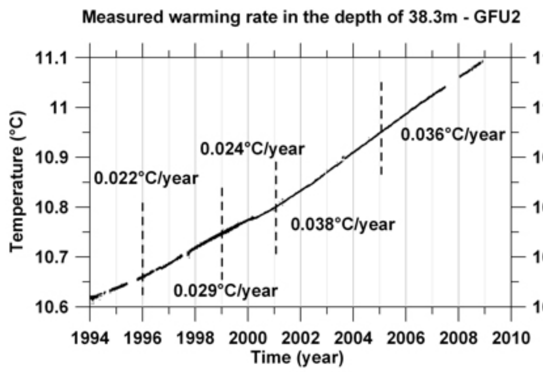
## 1. PhD-level projects

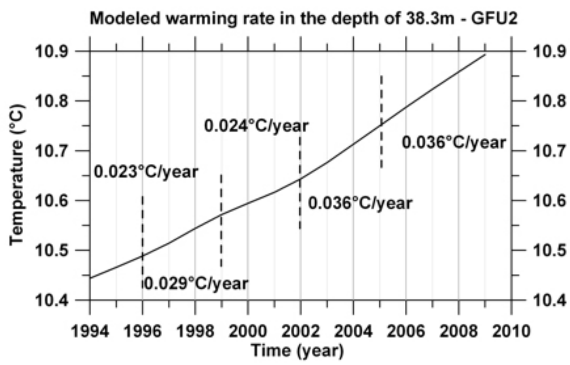
### Factors determining temperature of soils and heat transfer from the ground surface to the rock basement

Student: **Petr Dědeček,** Charles University, Prague, Faculty of Science, Department of Engineering geology, Hydrogeology and Geophysics
Supervisor: **Jan Šafanda**
2002–present
*Publications:* ***Šafanda, Rajver, D., Correia, A., and Dědeček, P. 2007.*** *Repeated temperature logs from Czech, Slovenian and Portuguese borehole climate observatories, Climate of the Past, 3, 453-462.*

***Dědeček, P., Rajver, D., Čermák, V., Šafanda, J., and Krešl, M. 2010.*** *Thermal diffusivity from subsurface temperature monitoring data: Malence, Slovenia. Studia geophysica et geodaetica (submitted).*

Research supported by the Grant Agency of the Academy of Sciences IAA300120603 to J. Šafanda




*Comparison of measured (left) and modelled (right) temperatures in a borehole located inside a "heat island". A 3D model was computed by FEM method in transient regime and conprises the influences of climate change, urbanization and changes in solar intensity. Material from PhD thesis of P. Dědeček.*

### Tomographic study of the upper mantle of the Bohemian Massif and modelling of the mantle seismic anisotropy

Student: **Hana Karousová,** Charles University, Prague, Faculty of Mathematics and Physics, Department of Geophysics
2008–present
Supervisor: **Jaroslava Plomerová;** Co-supervisor: **Vladislav Babuška**

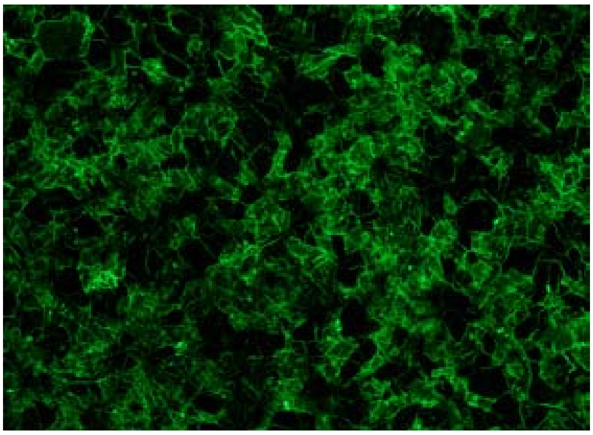
*Paper in preparation:* ***Karousová, H. and Plomerová, J.*** *Three-dimensional velocity model of crust of the Bohemian Massif.*

Research supported by the Grant Agency of the Academy of Sciences, grant No. IAA300120709 to J. Plomerová and Czech Science Foundation (GAČR) grant GA205/07/1088 to V. Babuška.

## Evolution of microporosity and permeability of rocks with different microstructure and mineral composition

Student: **Matěj Machek,** Charles University, Prague, Faculty of Science, Department of Structural Geology and Petrology
Supervisor: **Stanislav Ulrich**
2003–present
*Publication:* ***Machek M., Špaček P., Ulrich S., Heidelbach F., 2007****. Origin and orientation of microporosity in eclogites of different microstructure studied by ultrasound and microfabric analysis. Engineering Geology 89, 266–277.*

Research supported by SÚRAO/RAWRA (Radioactive Waste Repository Authority), Czech Republic, contract 60004319 2007/029/M, and Czech Science Foundation (GAČR) grant 205/08/0767 to L. Kalvoda (Czech Technical University – ČVUT, Prague), co-investigator M. Machek.

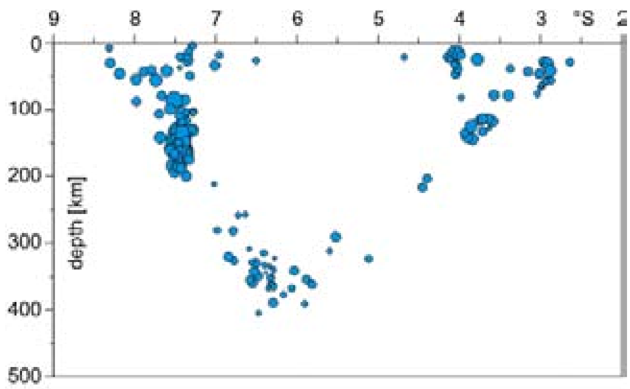


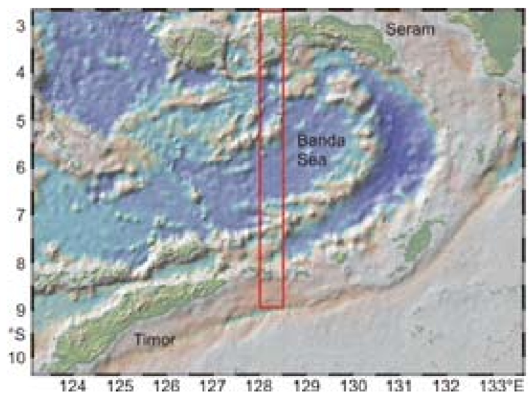
*Microphotograph of fine-grained granite from the Melechov granite massif, taken in UV light. Thin section of a sample vacuum-saturated by florescent epoxy resin. The image is used for quantitative microstructural analysis and analysis of connectivity of microcracks network. The long side of the picture is 22 mm long. Material from PhD thesis of M. Machek*

## Interpretation of tectonic structure and evolution of plate margins by an analysis of earthquake foci distribution and mechanisms

Student: **Radka Matějková,** Charles University, Prague, Faculty of Mathematics and Physics, Department of Geophysics
Supervisors: **Aleš Špičák** and Jiří Zahradník (Charles University, Prague, Faculty of Mathematics and Physics, Department of Geophysics)
2008–present

*Paper in preparation:* ***Matějková, R. and Špičák A.:*** *Seismological constraints of the evolution of the Banda Sea region. Geological Society Special Publication.*
Research supported by the Ministry of Education Project KONTAKT no. ME0901, to A. Špičák



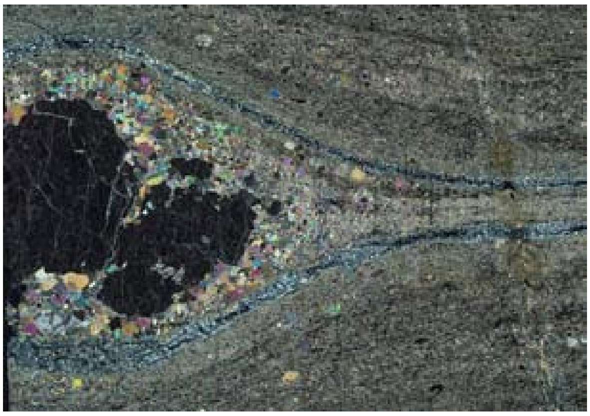

*Cross-section (left) showing the hypocentres of deep earthquakes along facing Wadati-Benioff zones, across a N-S line (right) in the Banda Sea. Material from PhD thesis of R. Matějková.*

## Exact automatic location and determination of source parameters of micro-earthquakes

Student: **J. Michálek,** Charles University, Prague, Faculty of Mathematics and Physics, Department of Geophysics
Supervisor: **Tomáš Fischer**
2006–present
*Publication:* ***Fischer, T. and Michálek, J. 2008.*** *Post 2000-swarm microearthquake activity in the principal focal zone of West Bohemia/Vogtland: space-time distribution and waveform similarity analysis. Studia geophysica et geodaetica. Vol. 52, no. 4 (2008), p. 493-511.*
Research supported by the Grant Agency of the Academy of Sciences, grants No**.** *IAA300120911 to J. Horálek and IAA300120905 to T. Fischer*

## Strain coupling versus decoupling of mantle and crust during orogenesis

Student: **Vladimír Kusbach**
Supervisors: **Stanislav Ulrich** and Karel Schulmann
University: Charles University, Prague, Faculty of Science, and Université Louis Pasteur, Strasbourg
2007–present
Research supported by the Czech Science Foundation (GAČR) grant No. 205/09/0539 to S. Ulrich.



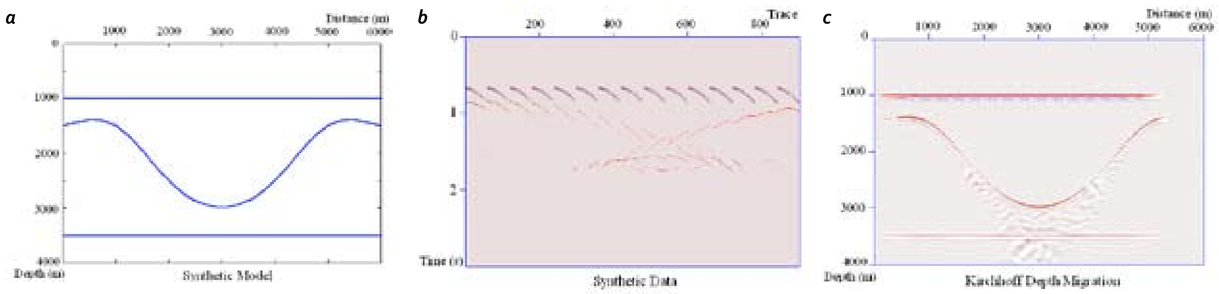
*Dynamic recrystallization of peridotite shown by fine-grained olivine, orthopyroxene and clinopyroxene (colourful) around a large garnet crystal (black). Late serpentinization (dark grey) breakdown of original peridotite minerals. Material from PhD thesis by V. Kusbach.*

## Structural and petrophysical characterisation of granites intended for nuclear waste repository site

Student: **Martin Staněk**
Supervisors: **Stanislav Ulrich** and Yves Geraud
Charles University, Prague, Faculty of Science, and Université Louis Pasteur Strasbourg
2008–present
Research supported by SÚRAO/RAWRA (Radioactive Waste Repository Authority), Czech Republic.

## Modelling and imaging complex anisotropic structures

Student: **Chuntao Zhang**, China University of Petroleum, Beijing, China and Edinburgh Anisotropy Project of British Geological Survey, Edinburgh, UK
Supervisor: Erika Angerer, OMV, Austria, External supervisor: **Ivan Pšenčík**
Research supported by OMV, Austria.




*Plots showing the synthetic model (a), the data from 15 shot gathers generated by the program package ANRAY (b) and the results of pre-stack depth migration obtained using Kirchhoff migration method (c). Material from PhD thesis by Chuntao Zhang. Presented by permission of OMV.*

## 2. MSc-level projects

### Magnetic response of Fe-mineral changes in the zone of groundwater fluctuation within hydrocarbon contaminated sites

Student: **James Baffoe,** Centre of Applied Geosciences, Institute for Geoscience, Eberhard Karl University of Tuebingen, Tuebingen, Germany

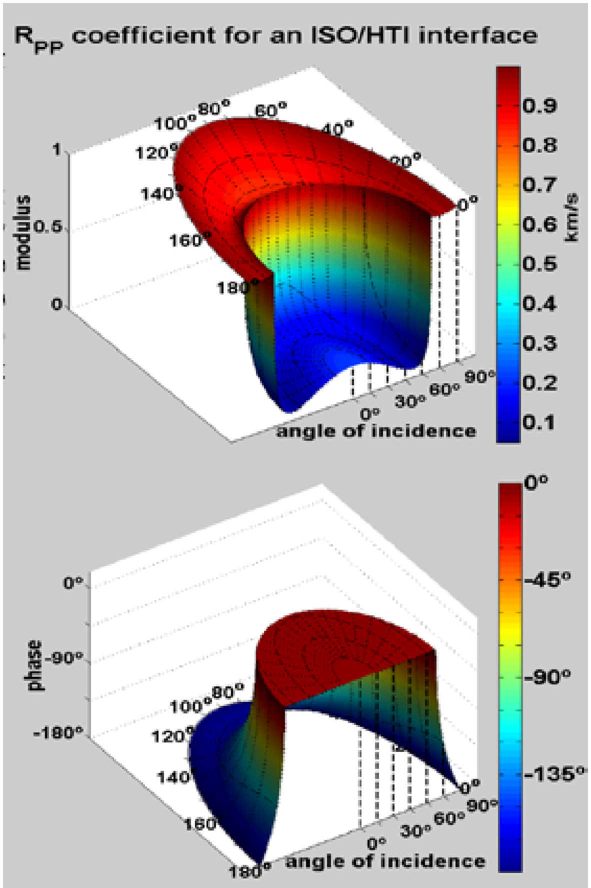
Supervisors: Erwin Appel (University of Tuebingen) and **Eduard Petrovský**
Thesis completed in 2009
Research supported by the University of Tuebingen

### Reflection/transmission (R/T) coefficients at interfaces separating two media of arbitrary anisotropy

Student: **Luís Fernando Katsuda Ito Cypriano,** State University of Campinas (Unicamp), SP, Brazil
Supervisor: Rodrigo Portugal (Unicamp),
2008–2010

External supervisor: **Ivan Pšenčík**
Research supported by the State University of Campinas, Brazil

*a*

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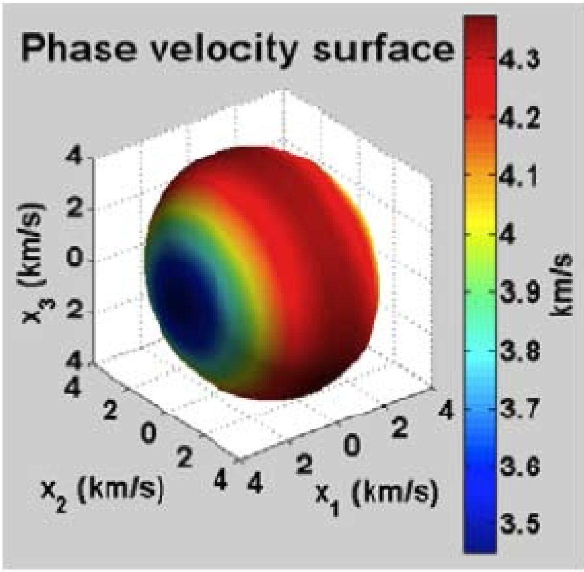



*The partitioning of energy at an interface between anisotropic media differs form that between isotropic media. In order to understand it, R/T coefficients must be studied. PP reflection coefficient for an interface separating isotropic and transversely isotropic medium with horizontal axis of symmetry (HTI) is shown in (a). The P-wave phase-velocity surface of the HTI medium is shown in (b). Due to the underlying HTI medium, the reflection coefficient does not exhibit symmetry expected in an isotropic medium. Material from PhD thesis by L.F. Katsuda Ito Cypriano.*

### Heavy metals content and magnetic properties of soils in the Krušné Hory Mts. region

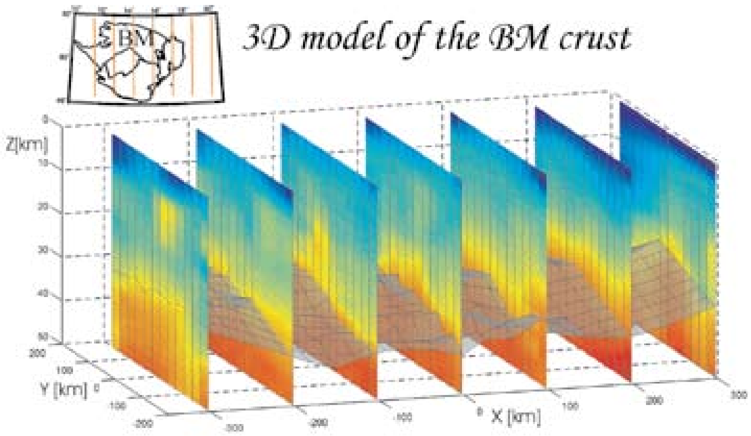
Student: **Pavel Křížek,** Czech University of Life Science Prague (CULS); Faculty of Environmental Science; Department of Ecology
2008–present

Supervisor: Vilém Podrázský (CULS), co-supervisor: **Aleš Kapička**
Research supported by Czech Science Foundation (GAČR) grant 205/07/0941 to A. Kapička

### A 3D velocity model of crust of the Bohemian Massif and its influence on upper mantle tomography

Student: **Hana Karousová** (Charles University, Faculty of Science, Institute of hydrogeology, engineering geology, and applied geophysics
Supervisor: ***Tomáš Fische***r; co-supervisor: ***Jaroslava Plomerová***

Thesis completed in 2008
Research supported by the Czech Science Foundation (GAČR) grant GA205/07/1088 to V. Babuška.




*Four 3D models of the crust of the Bohemian Massif were compiled from the results of deep seismic sounding measurements, both reflective and refractive methods, results of converted phases (receiver functions) and partly also from dispersion of surface waves. Although individual parameters differ in all parts of the four models of the Bohemian Massif crust, a south- and southeast-ward deepening of the Moho discontinuity appears as a general feature characterizing all the models. Synthetic tests show that tomographic images of velocity perturbations in the upper mantle can be considerably influenced by ignoring the crustal corrections or by applying an inadequate model of the crust.*

### Magnetic mapping of anthropogenic soil pollution in the Krušné Hory Mts. region

Student: **Veronika Lukešová,** Czech University of Life Science Prague; Faculty of Agrobiology, Food and Natural Resources; Department of Soil Science and Soil Protection
2009–present

Supervisor: Radka Kodešová (CULS), co-supervisor: **Aleš Kapička**
Research supported by Czech Science Foundation (GAČR) grant 205/07/0941 to A. Kapička

### Architecture and depositional regime of sandstone bodies of the Lower-Middle Turonian in the northwestern part of the Bohemian Cretaceous Basin.

Student: **Monika Skopcová,** Charles University, Prague, Faculty of Science, Institute of Geology and Palaeontology
2007–present

Supervisor: **David Uličný,** co-supervisor: Michal Rajchl (Czech Geological Survey / Charles University)
Research supported by the Grant Agency of the Academy of Sciences IAA300120609 to D. Uličný

### Architecture and depositional regime of sandstone bodies of the Upper Turonian in the northwestern part of the Bohemian Cretaceous Basin

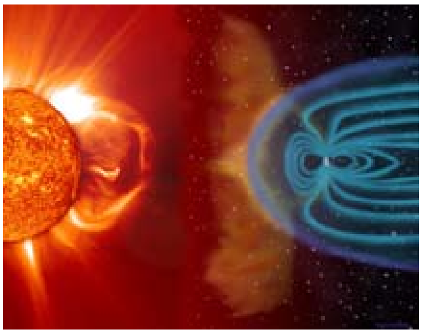
Student: **Lenka Vacková**
Charles University, Prague, Faculty of Science, Institute of Geology and Palaeontology
2007–present

Supervisor: **David Uličný**, co-supervisor: Michal Rajchl (Czech Geological Survey / Charles University)
Research supported by the Grant Agency of the Academy of Sciences IAA300120609 to D. Uličný

# University – level courses taught by instructors from the Institute of Geophysics

Specialized as well as fundamental courses are taught by researchers from the Institute of Geophysics at a number of universities in the Czech Republic and abroad..

The list below shows courses taught in 2008-9, fully or partly, by instructors whose main employer was the Institute of Geophysics. The list follows an alphabetical order of names of instructors from the I.G., indicated by bold letters.



*Earth's magnetic field affected by solar activity. Image from www.nasa.gov*

## Physics of the Earth

Faculty of Science, Charles University, Prague
BSc programme, 3 hrs./week, summer semester
Course code: MG452P04G
Instructor: **Tomáš Fischer** *(from 2009 employed by Charles University)*

Principles of physical fields and geophysical methods applied for study of the Earth; physical properties of the Earth's layers; gravity field; magnetic field; electromagnetic field; Earth's heat; seismology; geochronology; geological megastructures in physical fields.

## Geophysical fields theory

Faculty of Science, Charles University, Prague
BSc programme,  3 hrs./week, winter semester
Course code: MG452P20
Instructor: **Tomáš Fischer** *(from 2009 employed by Charles University)*

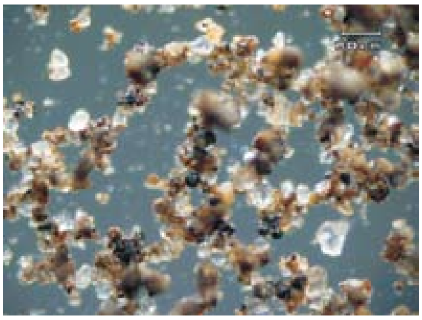
The aim of the course is to build the mathematical and physical background for further study in the areas of applied seismics, gravimetric and magnetic methods, electric exploration, well logging and radiometric methods in applied geophysics

*The sedimentary record of permanent and ephemeral lakes provides important information on the past climate. Shortwave infrared through red wavelength image of Lake Carnegie, Australia, courtesy NASA, Visible Earth (http://visibleearth.nasa.gov/).*

## Climatic changes  in the Earth's history

Faculty of Science, Charles University, Prague
Course Code:  MG421P4
MSc level, 2 hrs./week, winter semester
Instructor: **Jiří Laurin**

This course describes in detail the key components of Earth's climate system, and explains how these components evolved through the geological history, from the Precambrian to the Quaternary. Main focus is on the mechanisms of climate change at the time scales of thousands to millions of years. The origin of the three prominent climatic modes – greenhouse, icehouse and snowball – is discussed in detail. Certain methods of paleoclimate research, such as numerical modeling and time-series analysis, are demonstrated using both synthetic and real geological data.



*Magnetic extract of topsoil sample from the Ostrava region (N Moravia), with dark spherical magnetite of industrial origin.*

## Petrophysics

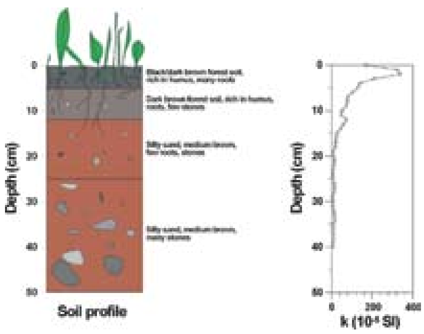
Faculty of Science, Charles University, Prague
Course Code: MG452P15
MSc programme, 3 hrs. /week, spring semester
Instructor: **Eduard Petrovský**

Rock as a physical environment. Mass property of rocks: density, porosity, permeability. Magnetic properties of rocks: anisotropy of magnetic susceptibility, paleomagnetic and archaeomagnetic research, magnetostratigraphy. Electrical properties of rocks: resistivity, permitivity, electrochemic activity, special electric properties. Radioactive properties of rocks. Thermal properties of rocks. Mechanical (engineering) properties of rocks. Inelastic and elastic constans of minerals and properties of rocks.

## Magnetomineralogy

Faculty of Science, Charles University, Prague
Course Code: MG452P68
MSc programme, 2 hrs. /week, autumn semester
Instructors: **Eduard Petrovský, Aleš Kapička**

The course is aimed at a general introduction into magnetic minerals as carriers of record of environmental changes. Magnetic record in geomaterials (environmental magnetism) reflects changes in geological histor of the Earth (paleomagnetism), past climatic changes (magnetic paleoclimatology) as well as environmental impact of recent and present human activities, such as industrial pollution. Students will acquire basic knowledge of identification and characterization of magnetic minerals using magnetic methods and will learn to use this knowledge in environmental applications.




*Typical vertical distribution of magnetic susceptibility in a soil profile, dominated by atmospheric deposition of dust particles.*

Analogous or closely related courses are also run at other universities under the following titles:

## Magnetomineralogy (Applications to Environmental Problems)

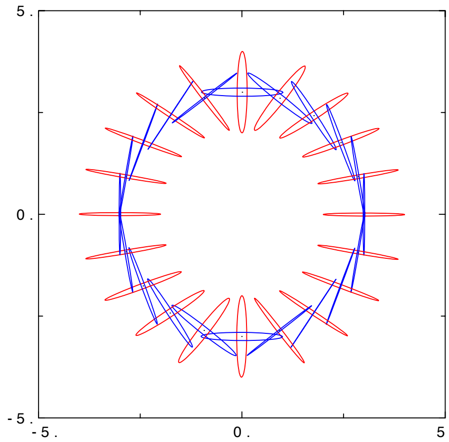
Faculty of Science, Masaryk University, Brno
Course Code: G9491
MSc programme, 2 hrs. /week, autumn semester
Instructors: **Eduard Petrovský, Aleš Kapička**

## Environmental Magnetism

Faculty of Science, Helsinki University, Helsinki, Finland
Course Code: 535050
MSc programme, 20 hrs., spring semester, each even year
Instructor: **Eduard Petrovský**

## Rock Magnetism Applied to Environmental Problems

Faculty of Sciences and Technologies, Sultan Moulay Slimane University, Beni Mellal, Morocco
Invited lectures
MSc programme, 20 hrs., spring semester 2008
Instructor: **Eduard Petrovský**




*Particle motion diagrams of P (red) and SV (blue) inhomogeneous waves in the symmetry plane of a VTI medium (transversally isotropic medium with a vertical axis of symmetry). Diagram by I.Pšenčík.*

## Seismic body waves in inhomogeneous anisotropic media

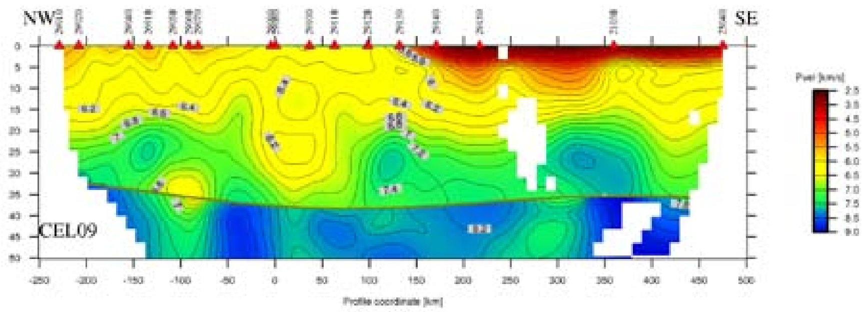
Faculty of Mathematics and Physics, Charles University, Prague
Course Code: NGE063
2hrs./week, winter semester
Instructor: **Ivan Pšenčík**

The goal of this advanced course is to introduce students to basics of the theory of seismic wave propagation in complex structures. The following topics are covered: basics of plane wave propagation in homogeneous isotropic or anisotropic media; effects of structural interfaces; differences in wave propagation in isotropic and anisotropic media; basics of the ray method for seismic body waves propagation in laterally inhomogeneous isotropic or anisotropic media with curved interfaces; wave propagation in layered, inhomogeneous, weakly anisotropic media using perturbation approaches; coupling ray theory for shear waves; wave propagation in isotropic or anisotropic, weakly dissipative media.

## Selected chapters on inverse problems

Faculty of Mathematics and Physics, Charles University, Prague
Course Code: DGF019
2 hrs./week, summer semester
Instructors: **Oldřich Novotný** (IRSM ASCR / Faculty of Mathematics and Physics, Charles University) and **Bohuslav Růžek** (Institute of Geophysics, ASCR)

The course is dedicated to PhD students and researchers dealing with real data and geophysical inversions. Examples from real projects are presented in MATLAB environment. Course topics include: the notion of forward and inverse problems; historical development of inverse problems in geophysics; linear algebra, matrix operations; least squares method and minimum norm method; matrix regularisation; inverse matrix, generalised inversion; linear inverse problem; resolution matrix; methods of non-linear inversion and non-linear optimisation; examples of inverse problems in geophysics: seismic tomography and seismic kinematic inversion, inversion of waveforms, inversion of magneto-telluric data, inversion of surface-wave dispersion curves.

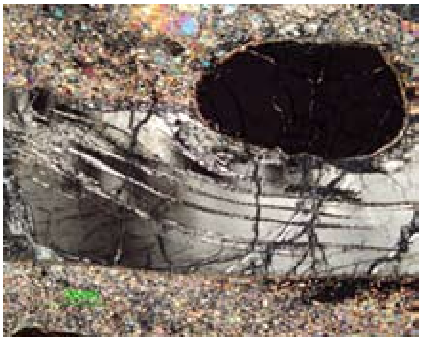



*Seismic tomography introduces a classical inverse problem. A typical result looks like the depth-velocity cross-section along the profile CEL09. Careful processing has to take into account all aspects of non-uniqueness and potential instability.*

A similar course is also run at the Faculty of Science of the Charles University, Prague:

## Inverse problems in geophysics

Course Code: MG452P73
3 hrs./week, winter semester
Instructor: **Bohuslav Růžek**



*Dynamic recrystallization of garnetiferous peridotite shown in a thin section, polarized light*

## Deformation microstructures of rocks

Faculty of Science, Charles University, Prague
Course Code: MG440P26
BSc programme, 3 hrs. /week, winter semester
Instructor: **Stanislav Ulrich,** Petr Jeřábek (Charles University)

An introductory course into the study of deformation microstructures and crystal plasticity. The aim of this course is to clarify physical background of deformation and recrystallization processes occurring in most common rock forming minerals and rocks. In thin sections, students learns to carry out both qualitative (identification of deformation microstructures) and quantitative (Poly LX toolbox) microstructural analyses.

*Onset of dynamic recrystallization of coarse-grained marble. This section, polarized light.*

## Microtectonics

Faculty of Science, Charles University, Prague
Course Code: MG440P27
MSc programme, 2 hrs. /week, winter semester
*Instructors:* Petr Jeřábek (Charles University)**, Stanislav Ulrich**

An advanced course in crystal plasticity and deformation microstructure focuses on identification, characterization, and interpretation of basic microstructural elements of deformed rocks. As mineral phases are basic constituents of these elements, part of the course will be dedicated to crystal structure, reference frames and projection methods, lattice preferred orientation and techniques leading to its determination (universal stage, EBSD, CIP).

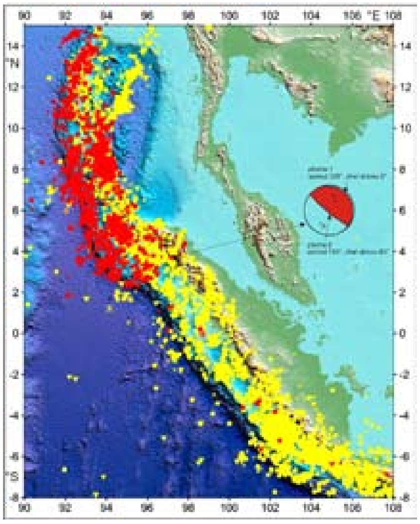
*Development of compressional cleavage in partially molten orthomigmatites*

## Geotectonics and dynamics of lithospheric processes

Faculty of Science, Charles University, Prague
Course Code: MG440P37
MSc programme, 3 hrs. /week, summer semester

*Instructors:* Petr Jeřábek, Ondrej Lexa (both Charles University), **Stanislav Ulrich**

An advanced course in geotectonics and lithosphere-scale deformation processes, designed for graduate students in structural geology, petrology and geology. Main subjects of the course are heat flow within oceanic and continental crust, mechanical properties of the lithosphere, rifted realms, and orogenic belts, concepts of isostasy and mantle dynamics.



*Map of epicentres (EHB data) of earthquakes in the Sumatra, Andaman and Nicobar Islands region. Yellow symbols – events from 1964 to Dec. 26, 2004; red symbols – from Dec. 26, 2004, to March 15, 2005. The GCMT focal mechanism of the main shock of Mw 9.1 is shown.*

## Fault tectonics and seismic activity

Faculty of Science, Charles University, Prague
Course Code: MG440P40
MSc programme, 2 hrs. /week, winter semester
Instructor: **Aleš Špičák**

The course concentrates on the causes of earthquake occurrence (tectonic stress concentration, brittle and inhomogeneous environment, movements of rock masses), explains earthquake distribution in the lithosphere and the phenomenon of deep earthquakes. Classifications of seismic events and seismic waves are discussed. Phenomena and processes accompanying tectonic stress concentration are analyzed from the viewpoint of earthquake prediction. The course gives a detailed view on the most seismically active regions on Earth, e.g. SE Asia, Andean South America, Central America, Tonga-Kermadec, East African Rift, Gulf of California, the Mediterranean, etc. Students analyse professional papers on related topics published recently in major scientific journals (e.g., EOS, Science, Nature).

*Tectonic megabreccia of the Chedabducto Fault Zone, one of major strike-slip faults in eastern North America that can be traced into Western Europe where they continued prior to North Atlantic rifting.*

## Geotectonics

Faculty of Science, Charles University, Prague
Course Code: MG440P15
BSc programme, 2 hrs. /week, winter semester
Instructor: Petr Jeřábek (Charles University), with guest instructors from the Institute of Geophysics: **Aleš Špičák, David Uličný**

The course provides the basic review of the inner composition of the Earth, in particular its crust and mantle, and the physical processes behind the plate tectonics. An introductory part is devoted to a review of main geophysical methods. The main part of the course is focused on the plate boundaries, their tectono-metamorphic evolution, relatinships to magmatism and sedimentary basin evolution.

*Regions of high geodynamic activity, such as the Gulf of Corinth, provide excellent case studies of relationships between tectonics and sedimentation (the photograph shows Pleistocene deltaic clastics uplifted above a modern delta).*

## Sedimentary record of geodynamic processes

Faculty of Science, Charles University, Prague
Course Code: MG440P76
primarily MSc level, but also available to BSc students; 2 hrs. /week, winter semester
Instructor: **David Uličný**

The course is focused on the tectono-stratigraphic evolution of sedimentary basins and on the sedimentary record of lithosphere evolution on time scales of basins as well as plate-tectonic cycles. Lectures are combined with exercises (including basics of geological interpretation of seismic reflection data) and reading seminars to provide the students with both theoretical and practical knowledge of the classical concepts as well as current issues in sedimentary basin research. Case studies for seminars and exercises are selected from extensional and foreland basins, passive margins, and other tectonic settings.

## EAGE Distinguished Lecturer

**Jan Mrlina**, specialist in gravimetry in the Institute of Geophysics, was selected by EAGE (European Association of Geoscientists and Engineers) as Distinguished Lecturer based on his previous lectures at various EAGE conferences, but mainly due to his presentation at the London 2007 EAGE Conference & Exhibition. His lecture "4D Gravity – fluids monitoring in reservoirs: chances and limitations" has been promoted by EAGE to the geoscience community. Until mid-2009, Jan Mrlina has presented this topic, enriched by short excursions to all scale applications of gravity in exploration, to various institutions, especially in the Middle East, the heart of the oil and gas research and exploration. We may list e.g. King Fahd University, Saudi Geological Survey, Saudi Aramco, King Abdulaziz City of Science (all Saudi Arabia), Petroleum Institute (Abu Dhabi), Qatar Geological Society (Qatar).
He also contributed to the winter semester 2008/2009 at King Fahd University, Saudi Arabia, by lecturing on practical geophysics focused mainly on the large scale, detailed and 4D gravity surveys, but also on applications of gravity, magnetics and electromagnetics to oil exploration. The audience included students of geophysics, petrophysics, and petroleum geology. He initiated and supervised a field course in gravimetry for geophysicists, as well as consulted in another field course.

# Observatories and mobile data acquisition systems

A significant part of the Institute's mission involves acquisition and sharing of primary geophysical data through a number of observatories and mobile measuring equipment.

More information, including technical details and geographic coordinates of the Institute's observatories, can be found at http://www.ig.cas.cz/en/structure/observatories/.

## Czech Regional Seismic Network (CRSN)

Seismological observations of the Institute of Geophysics have a long tradition and form the fundamental of its research. The Institute of Geophysics operated eight stations of the CRSN in the period 2008-2009: Průhonice (PRU, since 1957), Kašperské Hory (KHC, since 1961), Dobruška/Polom (DPC, since 1992), Nový Kostel (NKC, since 1997), Úpice (UPC, since 1987), Panská Ves (PVCC, since 2003), Třešť (TREC, since 2005), and Králíky (KRLC, since 2008) – see Figs 1 and 2. Digital data are transferred continuously from all stations to the IG by Internet. Software packages Antelope and SeisComP are used for automated data acquisition and international exchange with global data centers and a number of European national data centers and observatories. Virtual network of the IG consists at present of about 65 real-time seismological stations in central and southern Europe thanks to broad international cooperation of the IG established in the frame of EC projects Meredian (2000-2005) and Neries (2006-2010).

Seismological Data Center of the IG provides the following services:

- Automated near-real time data acquisition of continuous broadband and short-period seismic data by Antelope and SeedLink software packages.
- Global data exchange of both seismic phase readings and digital records with major international data centers (ISC, NEIC, IRIS, ORFEUS, EMSC) and a number of neighbouring national centers,
- Daily processing of digital seismograms by analysis program Seismic Handler.
- Archiving of digital continuous records on large raid systems.
- Compiling and publishing seismological catalogues and bulletins on the web, collection and evaluation of macroseismic reports about earthquakes felt on the territory of the Czech Republic.
- Recent automated locations of the CRSN and live seismograms of selected stations are displayed on the web pages of the GI.
- Informing the public through the media and web pages about strong and devastating earthquakes in Europe and worldwide.

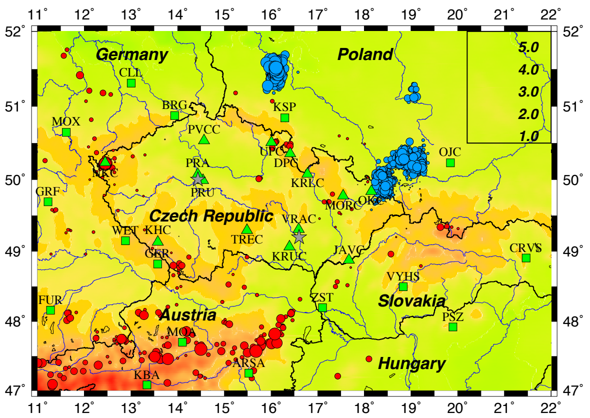



*Fig. 1: Stations of the Czech Regional Seismic Network (green triangles) and regional seismic events in central Europe in 2008-2009. Tectonic earthquakes are depicted as red circles, mining-induced shocks as blue circles. The size of the circles is proportional to magnitude.*

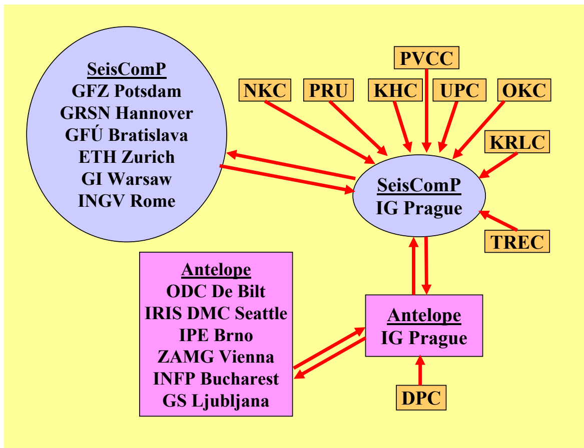



*Fig. 2: Data flow from/to the Institute of Geophysics (IG): software packages Antelope and SeisComP are used for automated data acquisition from seismic stations and international exchange of seismological data in Europe and globally. For names of the stations see the text.*

## MOBNET mobile seismic stations

The Institute of Geophysics owns a set of mobile seismic stations (MOBNET), deployed flexibly on the basis of immediate need in different research projects. This set consists of 32 short-period Le3D seismographs, 15 broad-band (BB) STS2 seismographs, and 55 GAIA acquisition systems. The GAIA recording instrumentation is fully compatible with other standard third-party seismic instrumentation and equipment, as regards built-in software and output data formats. Processing of seismic data is then easy and the data comply with all required standards. Stations of the pool participated in several passive experiments. Ten BB stations finished three year operation in the Northern Apennines in October 2006 within the project RETREAT 2002-2007 (Plomerová et al., 2006; Margheriti et al., 2006; Salimbeni et al., 2007). Stations were also installed within the project PASSEQ, which focused on the upper mantle structure beneath an elongated array running from Bavaria, through western part of the Bohemian Massif (Eger Rift) to Lithuania. Stations of the pool are deployed both on territory of the Czech Republic and in Poland. The stations were also included in experiment BOHEMA III (2005-2006) covering the southern part of the Bohemian Massif, and in experiment POLENET/LAPNET carried out in Finland (Kozlovskaya 2008).

Nine GAIA stations are installed in the West Bohemia seismoactive region as a part of the WEBNET network. Together with other 13 permanent seismic stations of WEBNET the total number reaches 22 stations thus ensuring both precise localization of local earthquakes and determination of the focal mechanism. In case of increased seismic activity the WEBNET network can be complemented by other MOBNET stations.

## References


*Plomerová, J., Margheriti, L., Park, J., Babuška, V., Pondrelli, S., Vecsey, L., Piccinini, D., Levin, V., Baccheschi, P., and Salimbeni, S., 2006. Seismic Anisotropy beneath the Northern Apennines (Italy): Mantle Flow or Lithosphere Fabric? Earth Planet. Sci. Lett.,* **247**: *157-170.*

*Margheriti, L., Pondrelli S., Piccinini D., Piana Agostinetti N., Lucente FP, Amato A., Baccheschi P., Giovani L., Salimbeni S., Park J., Brandon M., Levin V., Plomerova J., Jedlicka P., Vecsey L., Babuska V., Fiaschi A., Carpani B. and Ulbricht P., 2006. Retreat seismic deployment in the Northern Apennines. Annali di Geofisica, Annals of Geophysics,* **49**, *N. 4/5.*

*Salimbeni, S., Pondrelli S., Margheriti, L., Levin V., Park, J., Plomerova, J., Babuska V., 2007. Abrupt change in mantle fabric across Northern Apennines detected using seismic anisotropy. Geophys. Res. Letters,* **34**, *L07308.*

*Kozlovskaya E., 2008. POLENET/LAPNET – a multidisciplinary seismic array research in northern Fennoscandia: first results, Geophysical Research Abstracts, Vol. 10, EGU2008-A-07878, 2008.*


## Geodynamic and Earth tide observatories

Tidal observatories have been recording tidal data since 1952. At present, the tidal group of the Department of Tectonics and Geodynamics operate three of them. The Skalná observatory was included into the ICET (Int. Centre for Earth Tides) world network within the frame of the Global Geodynamic Project.

**1. Příbram observatory**, *Central Bohemia*

This observatory is located on top of an abandoned deep mine (depth 1300 m). Here, all istruments are maintained and undergo long-term tests in the mine gallery (tiltmeters, gravimeter, barographs, etc.). Data from all other sites are transmitted to this tidal centre for control and processing.

**2. Jezeří observatory** *North Bohemia*

The observatory was established in 1982 when a complex investigation of the slopes of the Krušné hory Mts. began, with the aim of controlling the stability of the slopes of an open-pit coal mine. The observatory consists of two sites in a horizontal gallery located under the Jezeří castle, equipped with Ostrovsky's and ASNS tiltmeters with permanent recording of tilts. The target is to record the stability of the marginal block of the basement massif suspected of rotation or sliding into the open-pit mine. This observatory is a part of the monitoring system of the mining company, focused on the mine risk mitigation. It has clearly recorded e.g. the 2002 flood effect on block stability with anomalous tilts caused by a huge water infill in a support pillar of sedimentary formation. At the same time, the data are a subject to long-term earth tide effects investigation.

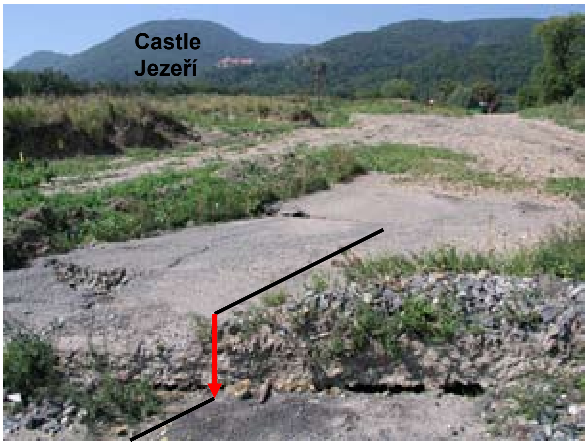



*Fig. 3. Effects of land-sliding at the distant edge of the open-pit coal mine; the castle Jezeří, located on the Krušné Hory Mts. fault scarp, is visible in the background.*

### 3. Skalná observatory, *West Bohemia*

This complex geodynamic observatory is located in the West Bohemia seismoactive region in an underground gallery inside a granite block in Skalná. The observatory should contribute to the monitoring of the ongoing geodynamic processes in the region. It is furnished with a seismograph, a couple of tiltmeters, a barometer and a strainmeter. Occasionally, continuous measurements of gravity are performed to test local changes of the gravity field. Significant gravity signal was recorded during the Sumatra earthquake 2004. In 2008, tilt records were affected by the October earthquake swarm (Fig. 4) taking place at about 7 km distant focal area. Some disturbances occurred already before the first swarm phase.

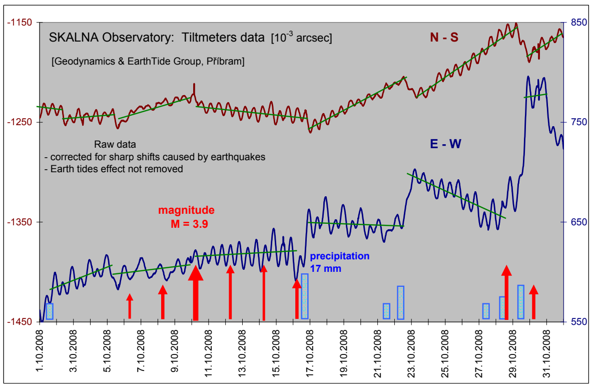



*Fig. 4: Tiltmeter records from the Skalná observatory, from the period of the 2008 earthquake swarm in West Bohemia.*

## Geomagnetic observatory

The long tradition of geomagnetic observations in Prague dates back to 1839. Due to the increasing influence of urban magnetic noise since the beginning of the 20th century, the Prague observatory was closed down in 1926, and was replaced in 1946 by the Průhonice observatory near Prague. Rapid expansion of the city and construction of DC – powered railways resulted in a deterioration of this location. In 1967, the observatory was moved to Budkov near Prachatice in south Bohemia, a sparsely populated area. Currently the observatory is equipped with two digital systems. CANMOS consists of a triaxial Narod S-100 ring-core magnetometer, an ELSEC 820 PPM magnetometer, and a control unit based on MS-DOS operating system. The main parts of GDAS system are DMI suspended fluxgate magnetometer, Overhauser proton magnetometer and Pentium-type embedded PC with QNX4 operating system. Absolute measurements are carried out by DI magnetometer (fluxgate sensor mounted on non-magnetic theodolite Zeiss 010B). The data are processed and transmitted via e-mail to the Geomagnetic Information Node (GIN) in Edinburgh, U.K. Yearly collections of definitive data are published on the INTERMAGNET CD-ROM. The observatory data are completed by (bi)-annual repeat station measurements coordinated in the frame of European MagNetE network.

The Department of Geomagnetics of the IG has been issuing daily forecasts of geomagnetic activity for Central Europe since 1994. Since 1998 the short term forecasts have been sent to Czech TV, where they are presented as part of the Weather Forecast. The forecasts, as well as reports of the actual state of the geomagnetic field in our region, are presented on the web pages of the Regional Warning Centre Prague (http://rwcprague.ufa.cas.cz/).

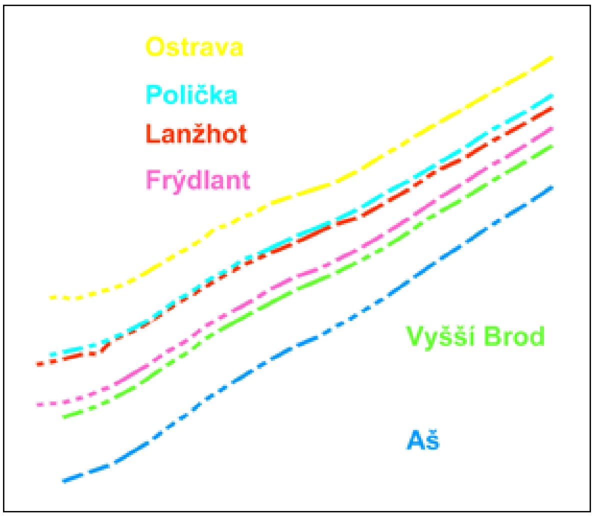



*Fig. 5: Changes in declination on the territory of the Czech republic from observatory Budkov and repeat stations Ostrava – North Moravia, Polička – East Bohemia, Lanžhot – South Moravia, Frýdlant – North Bohemia, Vyšší Brod – South Bohemia and Aš – West Bohemia. The annual change is about 6 arc minutes in the east and 5 arc minutes in the west of the Czech Republic.*

## Geothermal climate-change observatories

The geothermal climate-change observatories on the campus of the Institute of Geophysics at Spořilov, at the meteorological station Kocelovice (operated by the Czech Hydrometeorological Institute) and near Potůčky (Krušné Hory Mountains) were established in the years 1993, 1998 and 2002, respectively. The observatories monitor air, soil and bedrock temperatures at a sampling rate of 30 minutes with the aim to provide data on the air-ground temperature coupling and on a propagation of seasonal, interannual and secular surface temperature changes into the bedrock. The monitoring is expected to continue into the future, to map the tracking of the air and ground mean annual temperatures on an interannual time scale. The tracking is crucial for the proper climatic interpretation of the ground surface temperature history reconstructed from borehole temperature profiles.

The influence of vegetation cover on the soil temperatures is studied systematically using data from the fourth observatory located on the premises of the Institute of Geophysics in Prague – Spořilov. The monitoring system launched in 2002 provides data on the soil temperatures to the depth of 0.5 m under different surface conditions, namely under grass, barren soil, sand, and asphalt. The system was upgraded by installation of one pyranometer for monitoring the incoming short-wave radiation and four pyranometers for the short-wave radiation reflected by the individual surfaces. The monitoring provides data for a detailed study of the mean annual difference between air and soil temperatures, its long-term stability and dependence on the vegetation cover and provides useful data for an array of other disciplines like agronomy, forestry, ecological studies or alternative energy sources.

*Fig. 6. Air-ground temperature monitoring on the campus of the Institute of Geophysics.*

## The WEBNET network

West Bohemia/Vogtland earthquake swarm region belongs to the most closely monitored seismically active areas in Europe. The WEBNET network, jointly operated by the Institute of Geophysics (IG) and the Institute of Rock Structure and Mechanics (IRSM) of the ASCR in Prague, and a smaller network KRASNET, operated by the Institute of the Physics of the Earth of the Masaryk University in Brno, are located in the West Bohemian seismoactive region. Further networks providing relevant, high quality data have been working in NE Bavaria and SE Saxony. WEBNET includes thirteen broad band three-component digital seismic stations consisting of the SM-3 short-period seismometers and Janus-Trident/Nanometrics acquisition systems, and covers an area of about 900 km$^2$. Its configuration and the parameters of the seismograph systems guarantee high-quality recording of West Bohemia/Vogtland events of magnitudes –0.5 £ ML £ 5 in a frequency range of 0.5 to 80 Hz with a sampling frequency of 250 Hz. Thus, WEBNET makes it possible to record high-frequency waves generated by local events, short-period body waves of regional and distant earthquakes, and surface waves excited by quarry blasts fired in the neighbourhood of the region under study. Data from all stations are transmitted via Internet to IG, Prague. In addition, a three-component very broad band (VBB) system providing continuous digital records of seismic signals with periods up to 120 seconds has been operating at stations NKC (in the centre of the Nový Kostel zone) and LAC (southern part of the seismoactive region). To provide the best possible area and azimuth coverage with respect to the individual focal zones, ten seismic vaults consisting of a container with a concrete pillar about 2 m below the surface were built in the West Bohemia for deploying mobile stations in the case of enhanced seismic activity. The seismograms of all tectonic events (about 25000), recorded by the WEBNET and the VBB stations since, respectively, 1992 and 1998 are archived in a digital database. Data from other networks operating in the region are available on request.

See pp. 20–21 for the most recent research using the data from these observatories.

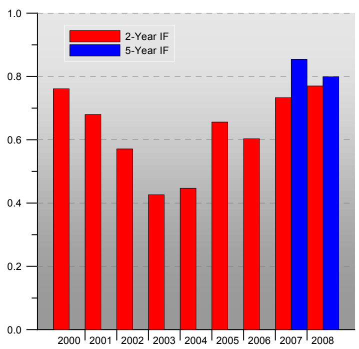
# Studia Geophysica et Geodaetica

Studia Geophysica et Geodaetica (SGEG), published by the Institute of Geophysics since 1956, is an international scientific journal covering all aspects of geophysics, geodesy, meteorology and climatology. In 2008 and 2009, the Editorial Board consisted of 27 experts from 12 countries (see list below). Electronic and printed versions of the journal are distributed by Springer.

At present, between 50 and 60 original reviewed papers are published per year. The mean submission to acceptance time is about 6 months. Rejection rate is about 35% of original submissions. Special issues are published on various occasions, commonly from scientific meetings. In the years 2008 and 2009, two special issues containing selected contributions presented at the workshop „Geodynamics of Earthquake Swarm Areas", held in Františkovy Lázně, Czech Republic, on October 16-19, 2007 were published (issues 4/2008 and part of 3/2009). Another special issue (2/2008) was devoted to contributions to the 10th meeting on Paleo, Rock and Environmental Magnetism, held in September 3-8, 2006 in Valtice, Czech Republic.

The Impact Factor for the period 2000-2008 is shown in Fig. 1, see also the ISI Journal Citations Report (www.jcrweb.com). According to IF in 2008, the journal is ranking as 10th among the total of 22 journals with Impact Factor published in the Czech Republic. The journal is abstracted or indexed in Current Contents: Physical, Chemical and Earth Sciences; ISI Alerting Services; Meteorol. and Geoastrophys. Abstracts and Elsevier/Geo Abstracts. Since October 2009, the journal uses the ScholarOne Manuscripts™ for automatic manuscript submission and reviewing (http://mc.manuscriptcentral.com/sgeg).

All the articles published in SGEG since 1956 can be found on the web page: http://springerlink.metapress.com/content/109194/



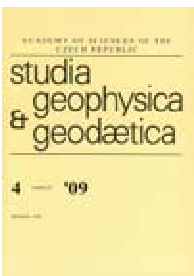




***Fig. 1:** Impact factor of Studia Geophysica et Geodaetica between 2000 and 2008. Red columns represent IF, blue columns 5 years IF.*

### The most cited paper, as of January, 2010, is as follows:

Jelínek, V. 1978. Statistical processing of anisotropy of magnetic-susceptibility measured on groups of specimens. Studia Geophysica et Geodaetica, 22, 1, 50-62.

*Times cited: 268 Average citations per year: 8.38*

*Data source: ISI Web of Knowledge, February 2010. Total citations, i.e. self-citations not filtered.*

*The h-index of the journal is 21 (as of December 2009).*

### Editorial Board of Studia Geophysica et Geodaetica, 2009

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B. Meurers, Vienna, Austria
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J. Pek, Prague, Czech Republic
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L.E. Sjoeberg, Stockholm, Sweden
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C. Thomson, Cambridge, U.K.
C.C.Tscherning, Copenhagen, Denmark

# List of supported research projects running in 2008-2009

Compiled from the data of CEP database (Central Register of Projects, see http://aplikace.isvav.cvut.cz/). This list includes only the projects with the Principal Investigator employed at the Institute of Geophysics.

**Funding bodies:**

*GAASCR = Grant Agency of the ASCR, GACR = Czech Science Foundation, MEYS = Ministry of Education Youth and Sports, MEnv = Ministry of Environment, ASCR = The Academy of Sciences of the Czech Republic*

| Project ID | Project Title | Funding Source | Responsible Investigator at the IG | Duration |
|---|---|---|---|---|
| GA205/09/0724 | Non-double-couple mechanisms - a tool for monitoring the mode of fracturing | GACR | Jan Šílený | 2009-2011 |
| GA205/09/1170 | Upper mantle beneath the neovolcanic zone of the Bohemian Massif: xenoliths and their host basalts | GACR | Petr Špaček | 2009-2012 |
| FP7-230669-AIM | Advanced Industrial Microseismic Monitoring (AIM) | EU | Václav Vavryčuk | 2009-2014 |
| ME09011 | Subduction Factory: Earthquake Production and Magma Emplacement | MEYS | Aleš Špičák | 2009-2012 |
| OC09070 | Space weather variability and short-term forecasts of geomagnetic activity | | Josef Bochníček | 2009-2012 |
| IAA300120905 | Dynamics of crustal fluids in the western part of the Bohemian Massif as a probe of the stress changes | GAASCR | Tomáš Fischer | 2009-2012 |
| IAA300120911 | Common characteristics of the West Bohemia/ Vogtland earthquake swarms and swarm-like seismicity triggered by fluid-injection into the HDR boreholes at Soultz-sous-Forets in Alsace | GAASCR | Josef Horálek | 2009-2012 |
| GA205/09/0539 | Internal strain fabric and rheology of orogenic peridotites and surrounding crustal rocks | GACR | Stanislav Ulrich | 2009-2012 |
| GA205/08/0332 | Seismic wave propagation in complex structures - perturbation approaches | GACR | Ivan Pšenčík | 2008-2010 |
| IAA300420805 | Extraterrestrial effects on atmospheric circulation in mid and high latitudes | GAASCR | Josef Bochníček | 2008-2011 |
| IAA300120801 | Seismic waves and sources in anisotropic media II | GAASCR | Václav Vavryčuk | 2008-2012 |
| IAA300120805 | Finite seismic source of West Bohemia seismic events inferred from stopping phases | GAASCR | Petr Kolář | 2008-2010 |
| KJB301110703 | Fabric development during emplacement of volcanic bodies and their dynamics of cooling and fracture formation studied by means of analogue and mathematical modeling. | GAASCR | Prokop Závada | 2007-2008 |
| GA205/07/0292 | Basic geoelectrical units at the eastern margin of Bohemian Massif and its contact with Carpathians by means of magnetoteluric sounding | GACR | Václav Červ | 2007-2010 |
| GA205/07/0941 | Application of soil magnetometry for pollution mapping in regional scale (Krušné Hory Mts. Region) | GACR | Aleš Kapička | 2007-2009 |
| GA205/07/1088 | Eger Rift - deep lithosphere structure, its origin and geodynamic development | GACR | Vladislav Babuška | 2007-2011 |
| IAA200120701 | A new optimizing algorithm ANNO and typical geophysical inverse problems | GAASCR | Bohuslav Růžek | 2007-2009 |
| IAA300120701 | Long-term monitoring and analysis of dynamics of atmospherically deposited magnetic particles in soils. | GAASCR | Aleš Kapička | 2007-2010 |

| Project ID | Project Title | Funding Source | Responsible Investigator at the IG | Duration |
|---|---|---|---|---|
| IAA300120703 | Effects of external inhomogeneous sources on the electromagnetic field of the Earth within the Central and Northeast Europe | GAASCR | Světlana Kováčiková | 2007-2010 |
| IAA300120704 | Numerical models of the hydromagnetic processes and geodynamo in the Earth's core | GAASCR | Ján Šimkanin | 2007-2011 |
| IAA300120706 | Amplitude modulation of hemipelagic cycles: a new tool for analysis of depositional distortion of climate signal | GAASCR | Jiří Laurin | 2007-2009 |
| IAA300120709 | Mantle lithosphere of north-central Europe – mosaic of micro-continents | GAASCR | Jaroslava Plomerová | 2007-2011 |
| KJB300120702 | Fabric patterns of granite diapirs in static and dynamic conditions: integrated analogue, field and numerical approaches. | GAASCR | Zuzana Kratinová | 2007-2009 |
| GA205/06/0557 | Electromagnetic induction and distribution of the electrical conductivity inside the Earth: 3-D inhomogeneous global, continental and regional models | GACR | Oldřich Praus | 2006-2008 |
| GA205/06/1181 | Temporal changes of subsurface temperature in the Chicxulub impact structure | GACR | Jan Šafanda | 2006-2008 |
| GA205/06/1780 | Earthquake swarms in the western part of the Bohemian Massif and their link with crustal fluids | GACR | Josef Horálek | 2006-2008 |
| GA205/06/1823 | Record of tectonic processes and sea-level change during inception of an intracontinental basin: Cenomanian of the Bohemian Cretaceous Basin | GACR | Lenka Špičáková | 2006-2008 |
| IAA300120609 | Interactions between water-mass circulation, hydrodynamic conditions of sedimentation, and relative sea-level changes in an epeiric seaway: the Bohemian Cretaceous Basin, Central Europe | GAASCR | David Uličný | 2006-2008 |
| KJB300120601 | Transient 3D modeling of anthropogenic influences on the subsurface temperature field | GAASCR | Petr Dědeček | 2006-2008 |
| KJB300120604 | Determination and characterization of ultra-fine superparamagnetic particles in soils | GAASCR | Hana Fialová | 2006-2008 |
| KJB300120605 | Shear wave splitting - extension of existing method to direct shear waves S and its application | GAASCR | Luděk Vecsey | 2006-2008 |
| IAA300120603 | Long-term monitoring and analysis of the ground temperatures under different surfaces | GAASCR | Jan Šafanda | 2006-2010 |
| IAA300120606 | Magnetic properties of atmospheric particulate matter and relationship with environmental pollution | GAASCR | Eduard Petrovský | 2006-2009 |
| IAA300120608 | Long-term and short-term variations of the geomagnetic field: data acquisition, analyses and forecasts | GAASCR | Pavel Hejda | 2006-2010 |
| IAA300460602 | Model of the upper crust in thwe Eger Rift and surroundings | GAASCR | Miroslav Novotný | 2006-2010 |
| 1QS300120506 | Development of methods for space weather forecasts and impacts of space weather on the ionosphere-atmosphere system | ASCR | Josef Bochníček | 2005-2009 |
| 1QS300460551 | Definition of geodynamic mobile zones on the Earth's surface and their assessment for applications in land planning and construction designing | ASCR | Zuzana Jechumtálová | 2005-2009 |
| IAA300120502 | Finite-extent earthquake source from higher-degree moment tensors: its resolution with uncertain crust-mantle model | GAASCR | Jan Šílený | 2005-2008 |
| IAA3012405 | Origin of large-scale anisotropic domains of continental mantle lithosphere | GAASCR | Jaroslava Plomerová | 2004-2008 |

# Professional events

—— Research groups at the Institute of Geophysics organize or take part in organizing a number of professional meetings each year. A complete overview, with supplementary materials for each event, is posted on http://www.ig.cas.cz/en/about-us/conferences/. The main events with the Institute's leadership or participation in 2008 and 2009are listed below:

**11th Castle Meeting on Paleo, Rock and Environmental Magnetism: New Trends in Geomagnetism**, Bojnice Castle, Slovakia, June 22-28, 2008. Organized jointly by the Institute of Geophysics of the Slovak Academy of Sciences, Basic Organisation of the Slovak Mining Society at GPI SAS, and the Institute of Geophysics, ASCR, Prague.

**6th Czech-Slovak Seismological Days**, Stará Živohošť, Czech Republic, June 9-11, 2009 (Main organizer: Institute of Geophysics, ASCR)

**Conference on Natural Dynamos**, Stará Lesná (High Tatras), Slovakia, August 30 – September 5, 2009 (Main organizers: the Institute of Geophysics of the Slovak Academy of Sciences, DAPEM, FMPHI of the Comenius University, Bratislava).

**4th Marie Curie Summer School – Knowledge-based Materials: Porous and Aqueous Materials**, Třešť, Czech Republic, August 19-29, 2008. (Host Institution: Institute of Geophysics, ASCR.)

# Geopark Spořilov

—— The GEOPARK of the Institute of Geophysics, open to the public, has been built on the premises of the Institute in several phases since 2003, with generous support from the Prague 4 municipal council and thanks to enthusiasm of companies that donated many rock specimens. The aim of the exhibition is to increase the awareness of the general public about processes operating in the Earth's interior and on its surface, and about their products. Currently the Geopark features over 40 large specimens of igneous, sedimentary, and metamorphic rocks from the Bohemian Massif and a collection of magmatic rocks from the Western Carpathians. Explanatory texts and accompanying posters about plate tectonics and the geological history of the Czech Republic are posted in the Geopark and on the Institute's website: http://www.ig.cas.cz/cz/o-nas/popularizace/geopark-sporilov/. In 2008, the rock collection of the Geopark became a basis of the book „Geological processes marked in rocks" written by the staff of the Department of tectonics and geodynamics of the Institute. The book which introduces basic principles of plate tectonics, Earth's evolution and rock formation is available free to visitors of the Geopark. All visitors - locals, casual visitors, and, commonly, schools – thus have the opportunity not only to appreciate the beauty of the rocks on display, or read the posters and the book, but they can also take part in a quiz-game named „The Alchemists' Stone", as an entertaining way to learn about minerals, rocks, and processes that create them. In 2008, new specimens were added to the Geopark: for instance, Tertiary phonolite and olivinic basalt from North Bohemia, sandstone slabs showing ripples and sand volcanoes of Triassic age, or silicified tree trunks from the Tertiary Eger Graben originally buried by volcaniclastics.

*One of the new rock specimens added to the Geopark collection in 2008 is a uniquely preserved sandstone slab showing a suite of sand volcanoes, of Early Triassic age (c. 245 – 250 Ma), from the Intra-Sudetic Basin in northeast Bohemia. This type of sedimentary structure results from fluidization of unsolidified layered sediments. Most commonly it forms due to seismic shaking, or sudeen saturation of sediment with water. In this case the cause was apparently flooding of interdune areas in a desert environment. The slab was donated by the company Krákorka, a.s.. More details about this and other specimens on http://www.ig.cas.cz/cz/o-nas/popularizace/geopark-sporilov/.*

# Public outreach activities

The Institute takes part in the annual "Science and Technology Weeks" organized by the Academy of Sciences. This is the main outreach activity of the Academy, aimed at informing the general public about the impact of science on daily life (details can

be found at http://press.avcr.cz/tyden-vedy-a-techniky/). The 8th Science & Technology Week in 2008 was devoted to planet Earth. In 2008 and 2009, researchers of the Institute of Geophysics contributed to public lectures given by researchers from all branches of science represented in the Academy of Sciences (http://videoserver.cesnet.cz/videoarchiv.php). In addition, the Institute organizes its Open Days which take place each year in November. In 2008, the Open Days were visited by more than 250 visitors (mostly students) who could learn about earthquakes, scientific drilling at the continents and ocean bottom, the use of geothermal energy, take a guided tour through the Institute's Geopark, or watch sandbox experiments simulating volcanic eruptions or building of a mountain range. In November 2009, about 100 people visited the Insitute.

Researchers of the Institute of Geophysics are frequently featured in the media, in particular in TV and radio broadcasts related mostly to earthquakes, volcanism and other geological hazards, but also to the Earth evolution and other topics of general interest. In 2008 and 2009, our colleagues made 36 TV and 30 radio appearances, for instance, after the devastating earthquake in Sichuan, China in May 2008 and during an earthquake swarm in West Bohemia in October 2008. The 100th anniversary of the most catastrophic European earthquake in Messina in 1908 was commemorated by several articles in newspapers.

Other outreach activities involved, for example, collaboration on the Otevřená Věda (Open Science) project: http://www.otevrena-veda.cz/ov/index.php?site=gfu. Individual researchers presented talks at

high schools, museums, and other public institutions, or led field trips for secondary school students. Pieces from the famous Jan Kozák collection of historical artworks related to geological catastrophes and natural history were featured in several exhibitions and presentations around the country.

# International Publications

The following list contains original scientific publications authored or co-authored by employees of the Institute of Geophysics (underlined in the reference heading), only in journals with the ISI Impact Factor. Publications from years 2008 and 2009 are listed separately, in alphabetic order of names of the authors employed by the Institute of Geophysics.

A complete list of all publications is available at http://www.ig.cas.cz/en/research-&-teaching/publications/, and on the homepages of individual researchers.

## 2008


**Babuška, V. - Plomerová, J.**
*Control of paths of quaternary volcanic products in western Bohemian Massif by rejuvenated Variscan triple junction of ancient microplates.*
*Studia geophysica et geodaetica. Vol. 52, no. 4 (2008), p. 607-629.*
*DOI: 10.1007/s11200-008-0040-0*

**Babuška, V. - Plomerová, J. - Vecsey, L.**
*Mantle fabric of western Bohemian Massif (central Europe) constrained by 3D seismic P and S anisotropy.*
*Tectonophysics. Vol. 462, no. 1-4 (2008), p. 149-163. DOI: 10.1016/j.tecto.2008.01.020*

**Běhounková, M. - Čížková, H.**
*Long-wavelength character of subducted slabs in the lower mantle.*
*Earth and Planetary Science Letters. Vol. 275, no. 1-2 (2008), p. 43-53.*
*DOI: 10.1016/j.epsl.2008.07.059*

**Huth, R. - Kyselý, J. - Bochníček, J. - Hejda, P.**
*Solar activity affects the occurrence of synoptic types over Europe.*
*Annales Geophysicae. Vol. 26, no. 7 (2008), p. 1999-2004.*
*http://www.ann-geophys.net/26/1999/2008/*

**Čermák, V. - Šafanda, J. - Krešl, M.**
*High resolution temperature monitoring in a borehole, detection of the deterministic signals in noisy environment.*
*Studia geophysica et geodaetica. Vol. 52, no. 3 (2008), p. 413-437.*
*DOI: 10.1007/s11200-008-0029-8*

**Čermák, V. - Šafanda, J. - Krešl, M.**
*Intra-hole fluid convection: High-resolution temperature monitoring.*
*Journal of Hydrology. Vol. 348, no. 3-4 (2008), p. 464-479.*
*DOI: 10.1016/j.jhydrol.2007.10.016*

**Čermák, V. - Šafanda, J. - Bodri, L**
*Precise temperature monitoring in boreholes: evidence for oscillatory convection? Part 1: Experiments and field data.*
*International Journal of Earth Sciences. Vol. 97, no. 2 (2008), p. 365-373.*
*DOI: 10.1007/s00531-007-0237-4*

**Čermák, V. - Bodri, L. - Šafanda, J.**
*Precise temperature monitoring in boreholes: evidence for oscillatory convection? Part 2: Theory and interpretation.*
*International Journal of Earth Sciences. Vol. 97, no. 2 (2008), p. 375-384.*
*DOI: 10.1007/s00531-007-0250-7*

**Ernst, T. - Brasse, H. - Červ, V. - Hoffmann, N. - Jankowski, J. - Jóźwiak, W. - Kreutzmann, A. - Neska, A. - Palshin, N. - Pedersen, L. B. - Smirnov, M. - Sokolova, E. - Varentsov, I. M.**
*Electromagnetic images of the deep structure of the Trans-European Suture Zone beneath Polish Pomerania.*
*Geophysical Research Letters. Vol. 35, no. 15 (2008), L15307/1-L15307/5.*
*DOI: 10.1029/2008GL034610*

**Fischer, T. - Hainzl, P. - Eisner, L. - Shapiro, P. A. - Le Calvez, J. H.**
*Microseismic signatures of hydraulic fracture growth in sediment formations: Observations and modeling.*
*Journal of Geophysical Research. Vol. 113, no. B2 (2008), B02307/1-B02307/12.*
*DOI: 10.1029/2007JB005070*

**Fischer, T. - Michálek, J.**
*Post 2000-swarm microearthquake activity in the principal focal zone of West Bohemia/Vogtland: space-time distribution and waveform similarity analysis.*
*Studia geophysica et geodaetica. Vol. 52, no. 4 (2008), p. 493-511.*
*DOI: 10.1007/s11200-008-0034-y*

**Dahm, T. - Fischer, T. - Hainzl, P.**
*Mechanical intrusion models and their implications for the possibility of magma-driven swarms in NW Bohemia region.*
*Studia geophysica et geodaetica. Vol. 52, no. 4 (2008), p. 529-548.*
*DOI: 10.1007/s11200-008-0036-9*

**Reshetnyak, M. - Hejda, P.**
*Direct and inverse cascades in the geodynamo.*
*Nonlinear Processes in Geophysicp. Vol. 15, no. 6 (2008), p. 873-880.*

Horálek, J. - Fischer, T.
*Role of crustal fluids in triggering the West Bohemia/Vogtland earthquake swarms: just what we know (a review).*
*Studia geophysica et geodaetica. Vol. 52, no. 4 (2008), p. 455-478.*
*DOI: 10.1007/s11200-008-0032-0*

Hrubcová, P. - Środa, P.
*Crustal structure at the easternmost termination of the Variscan belt based on CELEBRATION 2000 and ALP 2002 data.*
*Tectonophysics. Vol. 460, no. 1-4 (2008), p. 55-75.*
*DOI: 10.1016/j.tecto.2008.07.009*

Jechumtálová, Z. - Eisner, L.
*Seismic source mechanism inversion from a linear array of receivers reveals non-double-couple seismic events induced by hydraulic fracturing in sedimentary formation.*
*Tectonophysics. Vol. 460, no. 1-4 (2008), p. 124-133. DOI: 10.1016/j.tecto.2008.07.011*

Kapička, A. - Petrovský, E. - Fialová, H. - Podrázský, V. - Dvořák, I.
*High resolution mapping of anthropogenic pollution in the Giant Mountains National Park using soil magnetometry.*
*Studia geophysica et geodaetica. Vol. 52, no. 2 (2008), p. 271-284.*
*DOI: 10.1007/s11200-008-0018-y*

Magiera, T. - Kapička, A. - Petrovský, E. - Strzyszcz, Z. - Fialová, H. - Rachwal, M.
*Magnetic anomalies of forest soils in the Upper Silesia–Northern Moravia region.*
*Environmental Pollution. Vol. 156, no. 3 (2008), p. 618-627.*
*DOI: 10.1016/j.envpol.2008.06.030*

Carcione, J. M. - Kozák, J.
*The Messina-Reggio earthquake of December 28, 1908.*
*Studia geophysica et geodaetica. Vol. 52, no. 4 (2008), p. 661-672.*
*DOI: 10.1007/s11200-008-0043-x*

Mikuška, J. - Pašteka, R. - Mrlina, J. - Marušiak, J.
*Gravitational effect of distant earth relief within the territory of former Czechoslovakia.*
*Studia geophysica et geodaetica. Vol. 52, no. 3 (2008), p. 381-396.*
*DOI: 10.1007/s11200-008-0027-x*

Mrlina, J. - Seidl, M.
*Relation of surface movements in West Bohemia to earthquake swarms.*
*Studia geophysica et geodaetica. Vol. 52, no. 4 (2008), p. 549-566.*
*DOI: 10.1007/s11200-008-0037-8*

Semenov, V. J. - Pek, J. - Ádám, A. - Jóźwiak, W. - Ladanyvskyy, B. - Logvinov, I. M. - Pushkarev, P. - Vozár, J.
*Electrical structure of the upper mantle beneath Central Europe: Results of the CEMES project.*
*Acta Geophysica. Vol. 56, no. 4 (2008), p. 957-981. DOI: 10.2478/s11600-008-0058-2*

Li, Y. - Pek, J.
*Adaptive finite element modelling of two-dimensional magnetotelluric fields in general anisotropic media.*
*Geophysical Journal International. Vol. 175, no. 3 (2008), p. 942-953.*
*DOI: 10.1111/j.1365-246X.2008.03955.x*

Wilde-Piórko, M. - Geissler, W.H. - Plomerová, J. - Grad, M. - Babuška, V. - Brückl, E. - Cyziene, J. - Czuba, W. - England, R. - Gaczyński, E. - Gaždová, R.- Gregersen, P. - Guterch, A. - Hanka, W. - Hegedüs, E. - Heuer, B. - Jedlička, P. - Lazauskiene, J. - Keller, G. R. - Kind, R. - Klinge, K. - Kolínský, P. - Komminaho, K. - Kozlovskaya, E. - Krüger, F. - Larsen, T. - Majdański, M. - Málek, J. - Motuza, G. - Novotný, O. - Pietrasiak, R. - Plenefisch, T. - Růžek, B. - Sliaupa, P. - Środa, P. - Świeczak, M. - Tiira, T. - Voss, P. - Wiejacz, P.
*PASSEQ 2006-2008: Passive Seismic Experiment in Trans-Europe Suture ZoneI.*
*Studia geophysica et geodaetica. Vol. 52, no. 3 (2008), p. 439-448.*
*DOI: 10.1007/s11200-008-0030-2*

Plomerová, J. - Babuška, V. - Kozlovskaya, E. - Vecsey, L. - Hyvönen, L. T.
*Seismic anisotropy - a key to resolve fabrics of mantle lithosphere of Fennoscandia.*
*Tectonophysics. Vol. 462, no. 1-4 (2008), p. 125-136. DOI: 10.1016/j.tecto.2008.03.018*

Červený, V. - Pšenčík, I.
*Weakly inhomogeneous plane waves in anisotropic, weakly dissipative media.*
*Geophysical Journal International. Vol. 172, no. 2 (2008), p. 663-673.*
*DOI: 10.1111/j.1365-246X.2007.03644.x*

Farra, V. - Pšenčík, I.
*First-order ray computations of coupled S waves in inhomogeneous weakly anisotropic media.*
*Geophysical Journal International. Vol. 173, no. 3 (2008), p. 979-989.*
*DOI: 10.1111/j.1365-246X.2008.03778.x*

Iversen, E. - Pšenčík, I.
*Ray tracing and inhomogeneous dynamic ray tracing for anisotropy specified in curvilinear coordinates.*
*Geophysical Journal International. Vol. 174, no. 1 (2008), p. 316-330.*
*DOI: 10.1111/j.1365-246X.2008.03812.x*

Červený, V. - Klimeš, L. - Pšenčík, I.
*Attenuation vector in heterogeneous, weakly dissipative, anisotropic media.*
*Geophysical Journal International. Vol. 175, no. 1 (2008), p. 346-355.*
*DOI: 10.1111/j.1365-246X.2008.03850.x*

Červený, V. - Pšenčík, I.
*Quality factor Q in dissipative anisotropic media.*
*Geophysics. Vol. 73, no. 4 (2008), T63-T75.*
*DOI: 10.1190/1.2937173*

**Majorowicz, J. - Šafanda, J. - Wróblewska, M. - Szewczyk, J. - Čermák, V.**
*Heat flow variation with depth in Poland: evidence from equilibrium temperature logs in 2.9-km-deep well Torun-1.*
*International Journal of Earth Sciences. Vol. 97, no. 2 (2008), p. 307-315.*
*DOI: 10.1007/s00531-007-0210-2*

**Šílený, J. - Milev, A.**
*Source mechanism of mining induced seismic events — Resolution of double couple and non double couple models.*
*Tectonophysics. Vol. 456, no. 1-2 (2008), p. 3-15.*
*DOI: 10.1016/j.tecto.2006.09.021*

**Šimkanin, J. - Tilgner, A.**
*Inverse dynamo problem in a cylinder.*
*Geophysical and Astrophysical Fluid Dynamics. Vol. 102, no. 2 (2008), p. 205-215.*
*DOI: 10.1080/03091920701523345*

**Jankovičová, D. - Vörös, Z. - Šimkanin, J.**
*The influence of solar wind turbulence on geomagnetic activity.*
*Nonlinear Processes in Geophysics. Vol. 15, no. 1 (2008), p. 53-59.*

**Jankovičová, D. - Vörös, Z. - Šimkanin, J.**
*The effect of upstream turbulence and its anisotropy on the efficiency of solar wind – magnetosphere coupling.*
*Nonlinear Processes in Geophysics. Vol. 15, no. 4 (2008), p. 523-529.*

**Kalvoda, J. - Bábek, O. - Fatka, O. - Leichmann, J. - Melichar, R. - Nehyba, P. - Špaček, P.**
*Brunovistulian terrane (Bohemian Massif, Central Europe) from late Proterozoic to late Paleozoic: a review.*
*International Journal of Earth Sciences. Vol. 97, no. 3 (2008), p. 497-518.*
*DOI: 10.1007/s00531-007-0183-1*

**Špičák, A. - Kozák, J. - Vaněk, J. - Hanuš, V.**
*The Krakatau volcano 125 years after the catastrophic eruption (August 27, 1883).*
*Studia geophysica et geodaetica. Vol. 52, no. 3 (2008), p. 449-454.*
*DOI: 10.1007/s11200-008-0031-1*

**Grad, M. - Guterch, A. - Mazur, P. - Keller, G. R. - Špičák, A. - Hrubcová, P. - Geissler, W.H.**
*Lithospheric structure of the Bohemian Massif and adjacent Variscan belt in central Europe based on profile S01 from the SUDETES 2003 experiment.*
*Journal of Geophysical Research. Vol. 113, no. B10 (2008), B10304/1-B10304/25.*
*DOI: 10.1029/2007JB005497*

**Rajchl, M. - Uličný, D. - Mach, K.**
*Interplay between tectonics and compaction in a rift-margin, lacustrine delta system: Miocene of the Eger Graben, Czech Republic.*
*Sedimentology. Vol. 55, no. 5 (2008), p. 1419-1447. DOI: 10.1111/j.1365-3091.2008.00951.x*

**Schulmann, K. - Martelat, J.-M. - Ulrich, S. - Lexa, O. - Štípská, P. - Becker, J. K.**
*Evolution of microstructure and melt topology in partially molten granitic mylonite: implications for rheology of felsic middle crust.*
*Journal of Geophysical Research. Vol. 113, no. B10 (2008), B10406/1-B10406/20.*
*DOI: 10.1029/2007JB005508*

**Hasalová, P. - Schulmann, K. - Lexa, O. - Štípská, P. - Hrouda, F. - Ulrich, S. - Haloda, J. - Týcová, P.**
*Origin of migmatites by deformation-enhanced melt infiltration of orthogneiss: a new model based on quantitative microstructural analysis.*
*Journal of Metamorphic Geology. Vol. 26, no. 1 (2008), p. 29-53.*
*DOI: 10.1111/j.1525-1314.2007.00743.x*

**Konopásek, J. - Košler, J. - Tajčmanová, L. - Ulrich, S. - Kitt, P. L.**
*Neoproterozoic igneous complex emplaced along major tectonic boundary in the Kaoko Belt (NW Namibia): ion probe and LA-ICP-MS dating of magmatic and metamorphic zircons.*
*Journal of the Geological Society. Vol. 165, no. 1 (2008), p. 153-166.*
*DOI: 10.1144/0016-76492006-192*

**Vavryčuk, V. - Bohnhoff, M. - Jechumtálová, Z. - Kolář, P. - Šílený, J.**
*Non-double-couple mechanisms of microearthquakes induced during the 2000 injection experiment at the KTB site, Germany: A result of tensile faulting or anisotropy of a rock?.*
*Tectonophysics. Vol. 456, no. 1-2 (2008), p. 74-93.*
*DOI: doi:10.1016/j.tecto.2007.08.019*

**Vavryčuk, V.**
*Real ray tracing in anisotropic viscoelastic media.*
*Geophysical Journal International. Vol. 175, no. 2 (2008), p. 617-626.*
*DOI: 10.1111/j.1365-246X.2008.03898.x*

**Vavryčuk, V. - Boušková, A.**
*S-wave splitting from records of local micro-earthquakes in West Bohemia/Vogtland: an indicator of complex crustal anisotropy.*
*Studia geophysica et geodaetica. Vol. 52, no. 4 (2008), p. 631-650.*
*DOI: 10.1007/s11200-008-0041-z*

**Vavryčuk, V.**
*Velocity, attenuation, and quality factor in anisotropic viscoelastic media: A perturbation approach.*
*Geophysics. Vol. 73, no. 5 (2008), D63-D73. DOI: 10.1190/1.2921778*

**Vecsey, L. - Plomerová, J. - Babuška, V.**
*Shear-wave splitting measurements – Problems and solutions.*
*Tectonophysics. Vol. 462, no. 1-4 (2008), p. 178-196. DOI: 10.1016/j.tecto.2008.01.021*

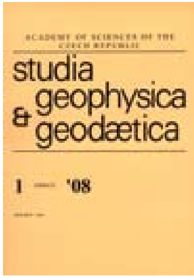
## 2009

Adamová, P. - Sokos, E. - Zahradník, J.
*Problematic non-double-couple mechanism of the 2002 Amfilochia Mw5 earthquake, Western Greece.*
*Journal of Seismology. Vol. 13, no. 1 (2009), p. 1-12.*
*DOI: 10.1007/s10950-008-9112-4*

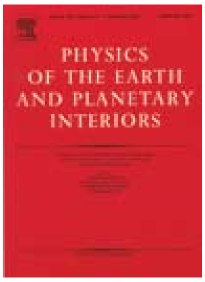
Babuška, V. - Fiala, J. - Plomerová, J.
*Bottom to top lithosphere structure and evolution of western Eger Rift (Central Europe).*
*International Journal of Earth Sciences. -, - (2009). DOI: 10.1007/s00531-009-0434-4*

Eisner, L. - Fischer, T. - Rutledge, J. T.
*Determination of S-wave slowness from a linear array of borehole receivers.*
*Geophysical Journal International. Vol. 176, no. 1 (2009), p. 31-39.*
*DOI: 10.1111/j.1365-246X.2008.03939.x*

Heinicke, J. - Fischer, T. - Gaupp, R. - Götze, J. - Koch, U. - Konietzky, H. - Stanek, K.-P.
*Hydrothermal alteration as a trigger mechanism for earthquake swarms: the Vogtland/NW Bohemia region as a case study.*
*Geophysical Journal International. Vol. 178, no. 1 (2009), p. 1-13.*
*DOI: 10.1111/j.1365-246X.2009.04138.x*










Huth, R. - Pokorná, L. - Bochníček, J. - Hejda, P.
*Combined solar and QBO effects on the modes of low-frequency atmospheric variability in the Northern Hemisphere.*
*Journal of Atmospheric and Solar-Terrestrial Physics. Vol. 71, no. 13 (2009), p. 1471-1483.*
*DOI: 10.1016/j.jastp.2009.04.006*

Valach, F. - Revallo, M. - Bochníček, J. - Hejda, P.
*Solar energetic particle flux enhancement as a predictor of geomagnetic activity in a neural network - based model.*
*Space Weather. Vol. 7, - (2009), S04004/1-S04004/7.*
*DOI: 10.1029/2008SW000421*

Čermák, V. - Bodri, L. - Šafanda, J.
*Tidal modulation of temperature oscillations monitored in borehole Yaxcopoil-1 (Yucatán, Mexico).*
*Earth and Planetary Science Letters. Vol. 282, no. 1-4 (2009), p. 131-139.*
*DOI: 10.1016/j.epsl.2009.03.009*

Čermák, V. - Šafanda, J. - Bodri, L.
*Thermal instability of the fluid column in a borehole: application to the Yaxcopoil hole (Mexico).*
*International Journal of Earth Sciences. -, - (2009), p. 1-15.*
*DOI: 10.1007/s00531-009-0472-y*

Čermák, V.
*Recurrence quantification analysis of borehole temperatures: evidence of fluid convection.*
*International Journal of Bifurcation and Chaos. Vol. 19, no. 3 (2009), p. 889-902.*
*DOI: 10.1142/S0218127409023366*

Fischer, T. - Hainzl, P. - Dahm, T.
*The creation of an asymmetric hydraulic fracture as a result of driving stress gradients.*
*Geophysical Journal International. Vol. 179, no. 1 (2009), p. 634-639.*
*DOI: 10.1111/j.1365-246X.2009.04316.x*

Blecha, V. - Štemprok, M. - Fischer, T.
*Geological interpretation of gravity profiles through the Karlovy Vary granite massif (Czech Republic).*
*Studia geophysica et geodaetica. Vol. 53, no. 3 (2009), p. 295-314.*
*DOI: 10.1007/s11200-009-0019-5*

Hejda, P. - Reshetnyak, M.
*Effects of anisotropy in geostrophic turbulence.*
*Physics of the Earth and Planetary Interiors. Vol. 177, no. 3-4 (2009), p. 152-160.*
*DOI: 10.1016/j.pepi.2009.08.006*

Chum, J. - Hruška, F. - Burešová, D. - Šindelářová, T. - Hejda, P. - Bochníček, J.
*Ionospheric oscillations caused by geomagnetic Pi2 pulsations and their observations by multipoint continuous Doppler sounding; first results.*
*Advances in Space Research. Vol. 44, no. 6 (2009), p. 667-676.*
*DOI: 10.1016/j.asr.2009.04.030*

Faber, E. - Horálek, J. - Boušková, A. - Teschner, M. - Koch, U. - Poggenburg, J.
*Continuous gas monitoring in the West Bohemian earthquake area, Czech Republic: First results.*
*Studia geophysica et geodaetica. Vol. 53, no. 3 (2009), p. 315-328.*
*DOI: 10.1007/s11200-009-0020-z*

**Horálek, J. - Fischer, T. - Boušková, A. - Michálek, J. - Hrubcová, P.**
*The West Bohemian 2008-earthquake swarm: When, where, what size and data.*
*Studia geophysica et geodaetica. Vol. 53, no. 3 (2009), p. 351-358.*
*DOI: 10.1007/s11200-009-0024-8*

**Hrubcová, P. - Geissler, W.H.**
*The crust-mantle transition and the Moho beneath the Vogtland/West Bohemian region in the light of different seismic methods.*
*Studia geophysica et geodaetica. Vol. 53, no. 3 (2009), p. 275-294.*
*DOI: 10.1007/s11200-009-0018-6*

**Charvátová, I.**
*Long-term predictive assessments of solar and geomagnetic activities made on the basis of the close similarity between the solar inertial motions in the intervals 1840–1905 and 1980–2045.*
*New Astronomy. Vol. 14, no. 1 (2009), p. 25-30.*
*DOI: 10.1016/j.newast.2008.04.005*

**Jedlička, P. - Buben, J. - Kozák, J.**
*Strong-motion fluid rotation seismograph.*
*Bulletin of the Seismological Society of America. Vol. 99, 2B (2009), p. 1443-1448.*
*DOI: 10.1785/0120080099*

**Schenk, V. - Schenková, Z. - Jechumtálová, Z.**
*Geodynamic pattern of the West Bohemia region based on permanent GPS measurements.*
*Studia geophysica et geodaetica. Vol. 53, no. 3 (2009), p. 329-341.*
*DOI: 10.1007/s11200-009-0021-y*

**Kozák, J.**
*Tutorial on earthquake rotational effects: historical examples.*
*Bulletin of the Seismological Society of America. Vol. 99, 2B (2009), p. 998-1010.*
*DOI: 10.1785/0120080308*

**Hrouda, F. - Faryad, S. W. - Chlupáčová, M. - Jeřábek, P. - Kratinová, Z.**
*Determination of field-independent and field-dependent components of anisotropy of susceptibility through standard AMS measurement in variable low fields II: An example from the ultramafic body and host granulitic rocks at Bory in the Moldanubian Zone of Western Moravia, Czech Republic.*
*Tectonophysics. Vol. 466, no. 1-2 (2009), p. 123-134.*
*DOI: 10.1016/j.tecto.2008.10.014*

**Vodrážka, R. - Sklenář, J. - Čech, S. - Laurin, J. - Hradecká, L.**
*Phosphatic intraclasts in shallow-water hemipelagic strata: a source of palaeoecological, taphonomic and biostratigraphic data (Upper Turonian, Bohemian Cretaceous Basin).*
*Cretaceous Research. Vol. 30, no. 1 (2009), p. 204-222.*
*DOI: 10.1016/j.cretres.2008.07.007*

**Faryad, S. W. - Dolejš, D. - Machek, M.**
*Garnet exsolution in pyroxene from clinopyroxenites in the Moldanubian zone: constraining the early pre-convergence history of ultramafic rocks in the Variscan orogen.*
*Journal of Metamorphic Geology. Vol. 27, no. 9 (2009), p. 655-671.*
*DOI: 10.1111/j.1525-1314.2009.00834.x*

**Machek, M. - Ulrich, S. - Janoušek, V.**
*Strain coupling between upper mantle and lower crust: natural example from the Běstvina granulite body, Bohemian Massif.*
*Journal of Metamorphic Geology. Vol. 27, no. 9 (2009), p. 721-737.*
*DOI: 10.1111/j.1525-1314.2009.00830.x*

**Mrlina, J. - Kämpf, H. - Kroner, C. - Mingram, J. - Stebich, M. - Brauer, A. - Geissler, W.H. - Kallmeyer, J. - Matthes, H. - Seidl, M.**
*Discovery of the first Quaternary maar in the Bohemian Massif, Central Europe, based on combined geophysical and geological surveys.*
*Journal of Volcanology and Geothermal Research. Vol. 182, no. 1-2 (2009), p. 97-112.*
*DOI: 10.1016/j.jvolgeores.2009.01.027*

**Jiang, Z. - Becker, M. - Francis, O. - Pálinkáš, V. - Jousset, P. - Kostelecký, J. - Dupont, F. - Lee, C. W. - Tsai, C. L. - Falk, R. - Wilmes, H. - Kopaev, A. - Ruess, D. - Ullrich, M. - Meurers, B. - Mrlina, J. - Deroussi, p. - Métivier, L. - Pajot, G. - Pereira Dos Santos, F. - Van Ruymbeke, M. - Naslin, p. - Ferry, M.**
*Relative gravity measurement campaign during the 7th International Comparison of Absolute Gravimeters (2005).*
*Metrologia. Vol. 46, no. 3 (2009), p. 214-226.*
*DOI: 10.1088/0026-1394/46/3/008*

**Novotný, M. - Skácelová, Z. - Mrlina, J. - Mlčoch, B. - Růžek, B.**
*Depth-recursive tomography along the Eger Rift using the S01 profile refraction data: tested at the KTB super drilling hole, structural interpretation supported by magnetic, gravity and petrophysical data.*
*Surveys in Geophysics. Vol. 30, no. 6 (2009), p. 561-600.*
*DOI: 10.1007/s10712-009-9068-0*

**Feygin, F. Z. - Kleimenova, N. G. - Khabazin, J. G. - Prikner, K.**
*Nonlinear character of ion cyclotron waves (Pc1 pulsations) with a spreading dynamical spectrum.*
*Geomagnetism and Aeronomy. Vol. 49, no. 3 (2009), p. 317-323.*
*DOI: 10.1134/S0016793209030050*

**Feygin, F. Z. - Prikner, K. - Kangas, J.**
*Pc1 with a broad frequency spectrum - "Goose pulsations".*
*Studia geophysica et geodaetica. Vol. 53, no. 4 (2009), p. 519-536.*
*DOI: 10.1007/s11200-009-0037-3*

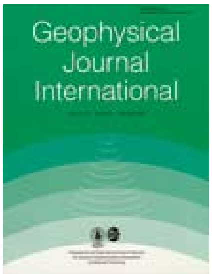
**Červený, V. - Pšenčík, I.**
*Perturbation Hamiltonians in heterogeneous anisotropic weakly dissipative media.*
*Geophysical Journal International. Vol. 178, no. 2 (2009), p. 939-949.*
*DOI: 10.1111/j.1365-246X.2009.04218.x*

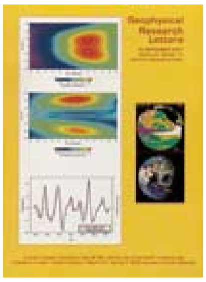
**Stejskal, V. - Kašpárek, L. - Kopylova, Galina N. - Lyubushin, Alexei A. - Skalský, L.**
*Precursory groundwater level changes in the period of activation of the weak intraplate seismic activity on the NE margin of the Bohemian Massif (central Europe) in 2005.*
*Studia geophysica et geodaetica. Vol. 53, no. 2 (2009), p. 215-238.*
*DOI: 10.1007/s11200-009-0014-x*

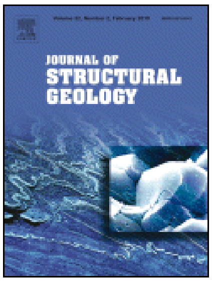
**Šafanda, J. - Wilhelm, H. - Heidinger, P. - Čermák, V.**
*Interpretation and mathematical modeling of temporal changes of temperature observed in borehole Yaxcopoil-1 within the Chicxulub impact structure, Mexico.*
*Journal of Hydrology. Vol. 372, no. 1-4 (2009), p. 9-16.*
*DOI: 10.1016/j.jhydrol.2009.03.023*

**Uličný, D. - Laurin, J. - Čech, S.**
*Controls on clastic sequence geometries in a shallow-marine, transtensional basin: the Bohemian Cretaceous Basin, Czech Republic.*
*Sedimentology. Vol. 56, no. 4 (2009), p. 1077-1114.*
*DOI: 10.1111/j.1365-3091.2008.01021.x*

**Schulmann, K. - Konopásek, J. - Janoušek, V. - Lexa, O. - Lardeaux, J.-M. - Edel, J.-B. - Štípská, P. - Ulrich, S.**
*An Andean type Palaeozoic convergence in the Bohemian Massif.*
*Comptes Rendus Geoscience. Vol. 341, no. 2-3 (2009), p. 266-286.*
*DOI: 10.1016/j.crte.2008.12.006*








**Šílený, J. - Hill, D. P. - Eisner, L. - Cornet, F. H.**
*Non–double-couple mechanisms of microearthquakes induced by hydraulic fracturing.*
*Journal of Geophysical Research. Vol. 114, B8 (2009), B08307/1-B08307/15.*
*DOI: 10.1029/2008JB005987*

**Šílený, J.**
*Resolution of non-double-couple mechanisms: simulation of hypocenter mislocation and velocity sructure mismodeling.*
*Bulletin of the Seismological Society of America. Vol. 99, no. 4 (2009), p. 2265-2272.*
*DOI: 10.1785/0120080335*

**Šimkanin, J. - Hejda, P.**
*Control volume method for hydromagnetic dynamos in rotating spherical shells: Testing the code against the numerical dynamo benchmark.*
*Studia geophysica et geodaetica. Vol. 53, no. 1 (2009), p. 99-110.*
*DOI: 10.1007/s11200-009-0006-x*

**Špičák, A. - Vaněk, J. - Hanuš, V.**
*Seismically active column and volcanic plumbing system beneath the island arc of the Izu-Bonin subduction zone.*
*Geophysical Journal International. Vol. 179, no. 3 (2009), p. 1301-1312.*
*DOI: 10.1111/j.1365-246X.2009.04375.x*

**Rajchl, M. - Uličný, D. - Grygar, R. - Mach, K.**
*Evolution of basin architecture in an incipient continental rift: the Cenozoic Most Basin, Eger Graben (Central Europe).*
*Basin Research. Vol. 21, no. 3 (2009), p. 269-294.*
*DOI: 10.1111/j.1365-2117.2008.00393.x*

**Vavryčuk, V.**
*Weak anisotropy-attenuation parameters.*
*Geophysics. Vol. 74, no. 5 (2009), WB203-WB213.*
*DOI: 10.1190/1.3173154*

**Závada, P. - Kratinová, Z. - Kusbach, V. - Schulmann, K.**
*Internal fabric development in complex lava domes.*
*Tectonophysics. Vol. 466, no. 1-2 (2009), p. 101-113.*
*DOI: 10.1016/j.tecto.2008.07.005*

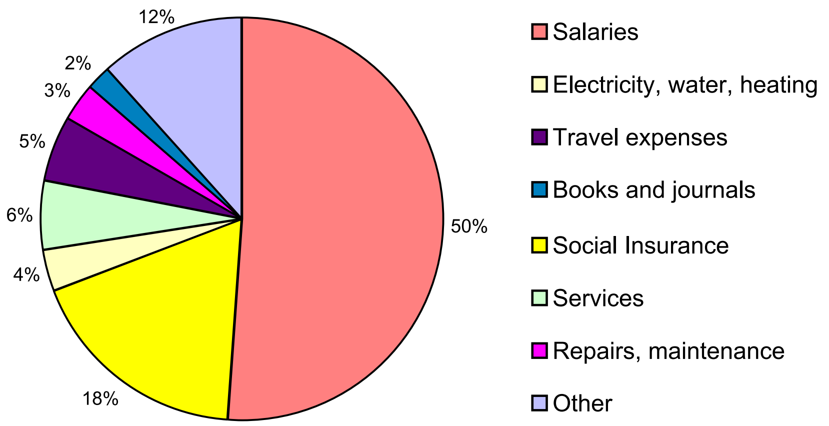
**Závada, P. - Schulmann, K. - Lexa, O. - Hrouda, F. - Haloda, J. - Týcová, P.**
*The mechanism of flow and fabric development in mechanically anisotropic trachyte lava.*
*Journal of Structural Geology. Vol. 31, no. 11 (2009), p. 1295-1307.*
*DOI: 10.1016/j.jsg.2009.04.002*

**Zedník, J. - Pazdírková, J.**
*Seismic activity in the Czech Republic in 2007.*
*Studia geophysica et geodaetica. Vol. 53, no. 2 (2009), p. 269-274.*
*DOI: 10.1007/s11200-009-0017-7*

# The budget of the Institute of Geophysics

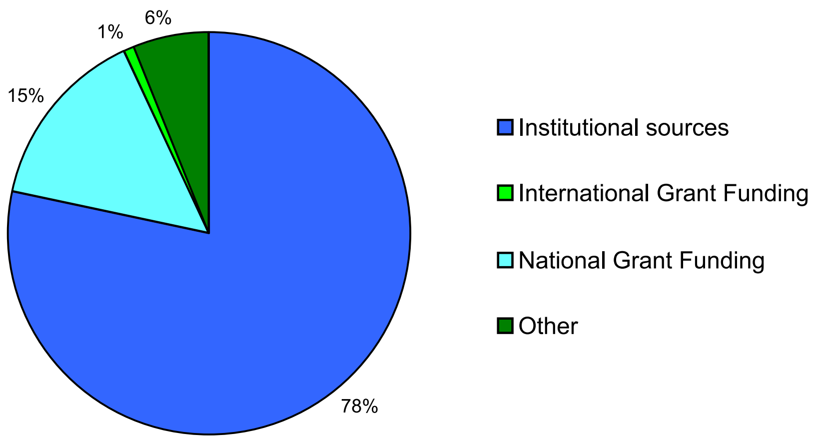
## Institute of Geophysics, Total Spending in 2009

CZK 75,000,000




## Institute of Geophysics, Total Income in 2009

CZK 75,000,000

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*Published by: The Institute of Geophysics,
Academy of Sciences of the Czech Republic
Prague, 2010*

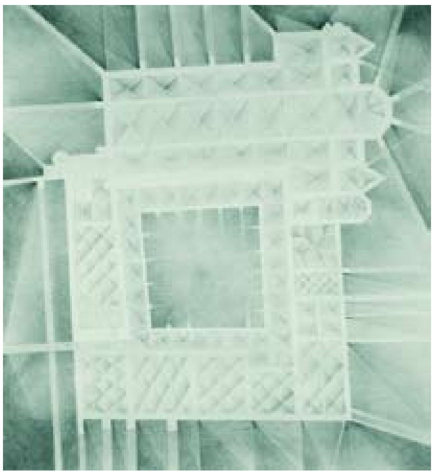
*Editor: D. Uličný
Design and layout: Carton Clan (cartonclan.cz)
Printed by Janova dílna, Třebestovice*

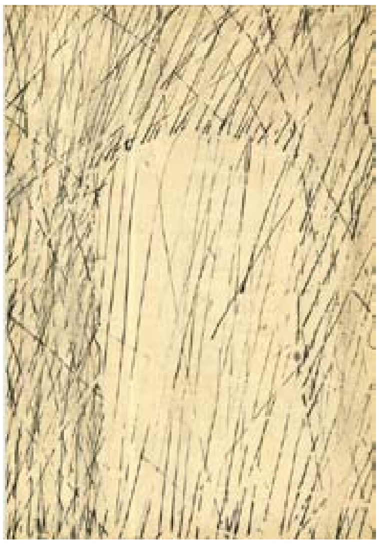
*ISBN 978-80-904072-2-0*

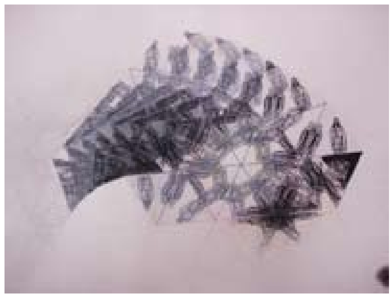
# Art exhibitions

In 2002, the Institute of Geophysics in cooperation with ARTARCHIV - the Archive of Fine Arts (http://www.artarchiv.cz/), launched a series of art exhibitions that take place in the Lecture Hall of the Institute. The exhibition series was entitled "ENCOUNTERS" ("Setkávání" in Czech), in order to emphasize the specific viewpoint of these exhibitions: researchers meet with artists whose works apply procedures commonly used in science, such as forethought concept, analogy, variation, similarity etc. By now, exhibitions of 25 artists have taken place at the Institute: Marie Blabolilová, Jiří Hůla, Pavel Rudolf, Josef Procházka, Inge Kosková, Eva Prokopcová, Jana Budíková, Miroslav Koval, Karel Adamaus, Pavla Francová, Václav Vokolek, Ryosuke Cohen, Pavel Wojnar, Pavel Mühlbauer, Jindřich Růžička, Vladimír Gebauer, Pavla Aubrechtová, Ladislav Daněk, Jiří Lindovský, Lubomír Přibyl, **Vladimír Havlík, Petr Veselý, Jaromír Zoul, Marie Molová, Pavel Hayek**; the last five exhibitions took place in 2008-2009. Two exhibitions of the series were topical – **Computer Graphics** and **Visual Poetry** (more on the artists and exhibitions at http://www.artarchiv.cz and http://www.ig.cas.cz/cz/o-nas/spolecenske-aktivity). Parallel to the exhibition series, the Gallery of the Institute of Geophysics was founded to collect works of all artists who exhibited at the Institute. The Gallery is placed in corridors and seminar rooms of the Institute and is thus accessible to the visitors of the Institute.

In addition to the Encounters series, exhibitions of artwork by local artists of the the Spořilov area, named Spořilovský salon III and IV took place in 2008 and 2009, and young employees of the Institute, Barbora Fabiánová and Hana Davídkovová, exhibited their art photographs in 2009.







123 **Vladimír Havlík**
123 **Petr Veselý**
123 **Marie Molová**