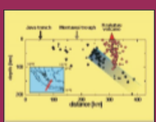
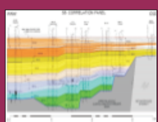
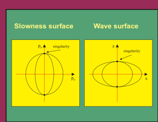
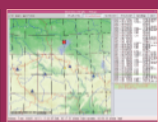
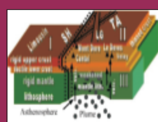
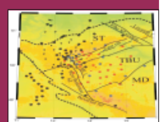
Academy of Sciences of the Czech Republic

# Geophysical Institute



report 2002/2003

ACADEMY OF SCIENCES OF THE CZECH REPUBLIC

# Geophysical Institute Prague

GFÚ

## Report 2002 - 2003


Main building of the Academy of Sciences of the Czech Republic, Prague, Národní 3. (Photo Dept. of Public Relations, AS CR, Archive.)

## **Academy of Sciences of the Czech Republic** (http://www.cas.cz)

The Academy of Sciences of the Czech Republic was established in 1992 as the Czech successor of the former Czechoslovak Academy of Sciences. It is structured as a network of 58 research institutes and five supporting institutions, and staffed by 6500 employees, approximately one-half of whom are university-trained scientists and Ph.D. researchers.

The chief objective of the Academy is to carry out fundamental and strategic applied research in natural, technical, and social sciences as well as in the humanities. This research is distinguished by adherence to high scientific standards whether it is interdisciplinary in nature or highly specialised. The Academy's institutes are involved in education by supervising Ph.D. theses, by providing post-graduate courses to young researchers and by lecturing at universities. The Academy promotes contacts with both the applied research and industrial sectors in order to foster technology transfer and exploitation of scientific knowledge.

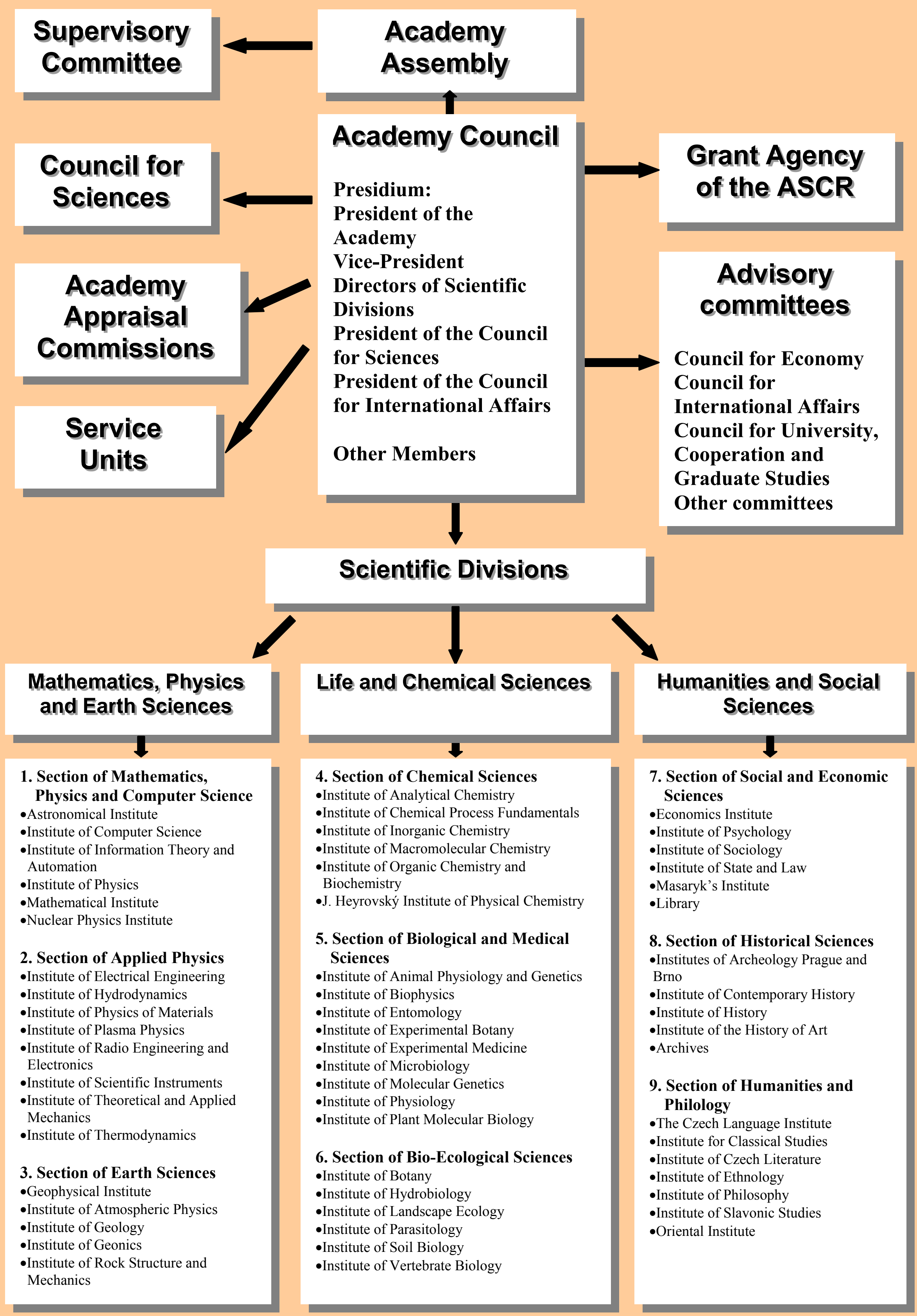
The Academy of Sciences is financed primarily from the state budget. Further sources of income include funds acquired from grant agencies in competitions of scientific projects. The Academy has also its own grant agency to support smaller-scale projects.

The present-day Academy of Sciences of the Czech Republic builds upon the tradition of the former Czechoslovak Academy of Sciences as well as upon its predecessors. The first society that brought together scientists in the Czech lands was Societas Incognitas, active between 1746 and 1751. The oldest, truly long-existing (1773-1952) learned society was the Bohemian Learned Society, which encompassed the natural sciences and humanities. Its founders included mineralogist, geologist and natural scientist Ignác Born (1742-1791), philologist Josef Dobrovský (1753-1829), the historian Gelasius Dobner (1719-1790) and the mathematician and founder of the Prague University observatory Joseph Stepling (1716-1778). In later years, historian František Palacký led the Society. As early as in 1861, the famous biologist Jan Evangelista Purkyně (1787-1869) proposed in his work 'Academia' that a self-governing, non-university research institution be formed which would incorporate scientific institutes representing the main branches of science of that time. This vision of an institution devoted to interdisciplinary research was very close to the concept and structure of today's Academy of Sciences.

All research Academy's institutes are grouped according to the objective of their research into nine sections. Each section contains from 5 to 10 institutes. The Section of Earth Sciences consisting of five institutes includes the Geophysical Institute. The Section of Earth Sciences has a total of 470 employees, of which 260 are graduate research workers.

Library of the AS CR (Photo Dept. of Public Relations, AS CR, Archive).

## Structure of the Academy of Sciences



## **Geophysical Institute** (http://www.ig.cas.cz)

The Geophysical Institute of the Academy of Sciences of the Czech Republic has followed a considerably long tradition connected with the interest in natural sciences. Abrupt increase in demanding more scientific knowledge in natural sciences was caused by an extensive exploitation of metals, metal ores and other minerals during the Middle-Ages. There is well-documented historical mining activity in Bohemia in areas of Kutná Hora, Jihlava and Příbram, among others. As a consequence great scientific progress has been done in geology and mineralogy. As far as the Charles University in Prague (founded in 1348 by the emperor Charles IV.) was the education centre within the former Central Europe, natural sciences were lectured there since 1622. In 1760 the first mining Academy in Europe was established in Banská Bystrica (in Slovakia, former part of Czechoslovakia) where all the fundamental mining and geo-physical disciplines, including forestry, were lectured and practiced. Ten years later, in 1770, Private Society for Sciences (forerunner of today's Academy of Sciences) was established in Prague, being promoted and finally accomplished by Ignác Born, a top mid-European mineralogist and geologist of the time. Starting with the year 1771, the systematic daily measurements of the surface air temperature have been made in the Jesuit Academy in the Clementinum College in Prague. Also the sequence of regular precipitation measurements began in 1804 as one of the eldest ones in Central Europe. Geomagnetic measurements were started here in 1839, when Carl Kreil put into operation one of the eldest geomagnetic observatories at the German University in Prague. The first relative pendulum measurements of gravity were carried out in the mines of Příbram in 1882 by R. Sterneck-Doudlebský and were conducted with pendulum of his own original construction. In the mine area of Příbram, the seismological experiments made by H. Bendorf took place in 1903/5 (two Wiechert seismographs installed). In 1908, the seismological station, led by G. Irgang, began to operate permanently in Cheb in order to provide for instrumental records of earthquake swarms occurring in the region of Vogtland.

After the declaration of the Czechoslovak Republic in 1918, the State Institute of Geophysics was created in 1920. The first director was Václav Láska, and main research activities consisted in regular field measurements and interpretation of results for gravitational, seismic, geomagnetic, geoelectric, geothermic and radioactive geophysical fields. Systematic geophysical mapping of the state territory was performed. In 1924, a 1000 kg Wiechert horizontal seismograph was installed in the seismic station of Charles University in Prague. During the Second World War, the State Institute of Geophysics

### Czech Geophysical Milestones

- 1760 – Mine Academy in Banská Bystrica established
- 1770 – Private Society for Sciences founded in Prague, in 1773 renamed as the Royal Czech Learned Society
- 1771 – beginning of the surface air temperature daily measurements in Clementinum
- 1804 – beginning of the precipitation measurements in Clementinum
- 1839 – geomagnetic measurements in the German University in Prague
- 1882 – establishment of the Czech Academy of Sciences and Arts
- 1882 – first gravity measurements using pendulum in Příbram
- 1903 – two Wiechert seismographs installed in Příbram
- 1908 – seismic station Cheb (Belar-Zlatorog seismograph)
- 1920 – establishment of the State Institute of Geophysics in Prague
- 1924 – seismic station Prague (Wiechert seismograph)
- 1945 – re-establishment of the State Institute of Geophysics
- 1952 – foundation of the Czechoslovak Academy of Sciences, including the Geophysical Institute
- 1952 – permanent geomagnetic measurements in Průhonice
- 1960-1970 – foundation of permanent observatories of the Geophysical Institute
- 1986 – beginning of systematic geophysical explorations in seismically active West Bohemia/Vogtland region
- 1993 – establishment of the Academy of Sciences of the Czech Republic

was dissolved, and the geophysical activities were partly carried out in the Institute for Geophysics of the Prague German University, partly they declined. In the post-war period it was namely Alois Zátopek who formulated new program of Czechoslovak geophysical research and organised lecturing of geophysical disciplines at the Charles University. The state Geophysical Institute, re-established and reconstructed after 1945, was implemented in 1950 into the new state institution of fundamental research – the Czechoslovak Academy of Sciences. New permanent geophysical observatories were founded there during the 60-th and 70-th, e.g. geomagnetic, seismological and telluric observatory in Průhonice, electromagnetic and telluric observatory in Budkov, a tidal station in the mines of Příbram and the seismic station in Kašperské Hory. In this period, Vít Kárník, whose Mid-European, Balcan and All-European seismic catalogues have served as a basic tool for European seismicity studies, reached fundamental achievements in the field of seismicity. His macroseismic intensity scale (Medveděv-Sponheuer-Kárník, MSK 1964) is up to now used for earthquake intensity assessments.

Scientific reputation of the Geophysical Institute in the international geophysical community is quite high. Many ideas, algorithms, results of experimental works developed and obtained in the institute are used worldwide. One example among others is the very broadband seismic recording equipment developed by researchers of the Geophysical Institute. The equipment was put into operation at seismic station Kašperské Hory in 1973, and made the station one of the first very broadband seismic stations operated routinely in the world. Due to their reputation, researchers of the Geophysical Institute are often invited to participate in various international geophysical projects, conferences and other activities.

The Geophysical Institute represents today a fairly compact body subdivided into five scientific departments covering major geophysical disciplines: seismology, heat-flow and radiometry, geomagnetism, geoelectricity, gravity and geodynamics. The activities of the Geophysical Institute include, above all, observatory and field measurements for the purpose of continuous monitoring of various geophysical fields on the territory of the Czech Republic connected with adjacent areas within central Europe. It also covers co-operation with world-wide data network services and data centres, geophysical studies of the lithosphere structure, laboratory investigations of physical properties of rocks, crustal studies, theoretical and numerical modelling of geophysical fields, interpretation of geophysical data, climatic changes in connection with solar activity and solar motion.

***Director***
***Management***
***Scientific Council***
***Technical Support***

***Department of Seismology***
16 researchers
5 technicians

***Department of Geothermics***
3 researchers
2 technicians
1 PhD student

***Department of Geomagnetism***
8 researchers
11 technicians
1 PhD student

***Department of Geoelectricity***
8 researchers
1 technician

***Department of Tectonics and Geodynamics***
14 researchers
4 technicians

***Computing Centre***
***Library***
5 specialists

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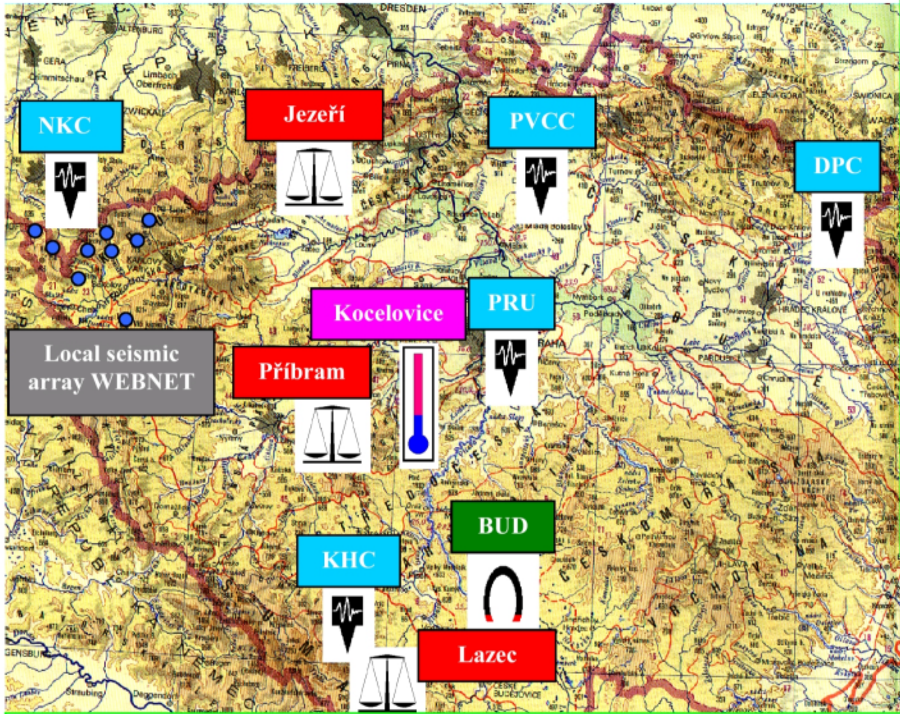
# Observatories of the Geophysical Institute




**Local seismic network WEBNET -Western Bohemia Network**
**Operated jointly with the Institute of Rock Structure and Mechanics AS CR Prague**
**All stations are 3-component short period, recording in trigger mode at 250 Hz**

| Station | Coordinates | Instrumentation | Station | Coordinates | Instrumentation |
|---|---|---|---|---|---|
| Nový Kostel (NKC) | 50.2331N 12.4479E | SM-3 Nanometrics | Skalná (SKC) | 50.1698N 12.3611E | Le-3D Nanometrics |
| Kraslice (KRC) | 50.3316N 12.5304E | | Kopaniny (KOC) | 50.2652N 12.2336E | SM-3 Lennartz 5800 |
| Studenec (STC) | 50.2591N 12.5197E | | Lazy (LAC) | 50.0508N 12.6250E | |
| Vackov (VAC) | 50.2354N 12.3772E | | Trojmezí (TRC) | 50.3032N 12.1448E | Le-3D Lennartz M88 |
| Luby (LBC) | 50.2656N 12.4123E | | | | |

**Gravimetry**

| | | |
|---|---|---|
| Příbram | 49.6861N 13.9972E | Tiltmeters N,E<br>Analogue autonomous line recorders |
| Jezeří | 50.5553N 13.5052E | Tiltmeters N,E<br>Analogue autonomous line recorders |
| Lazec | 48.8367N 14.2828E | Tiltmeters N,E; Gravimeter Z; Quartz-tube extenzometers N,E<br>Analogue autonomous line recorders |

**Geomagnetism**

| | | | |
|---|---|---|---|
| Budkov (BUD) | 49.0667N 14.0167E | Narod Ring Core Magnetometer X,Y,Z<br>Elsec Proton Magnetometer F<br>Digital Dial up | Hard Disk digital data storage |
| | | Quartz magnetometer H,D,Z<br>LaCour variometer H,D,Z | Analogue drum recording |

**Stations of the Czech National Seismological Network - CNSN**

| Station | Coordinates | Sensors | Data acquisition | Station | Coordinates | Sensors | Data acquisition |
|---|---|---|---|---|---|---|---|
| Kašperské Hory (KHC) | 49.1308N 13.5792E | Short-Period Z<br>Broad-Band Z,N,E | Earth Data digitizer<br>SeisComp datalogger | Nový Kostel (NKC) | 50°13'59''N 12°26'53''E | Broad-Band Z,N,E | Earth Data digitizer<br>SeisComp datalogger |
| Průhonice (PRU) | 49.98833 14.54167 | Short-Period Z,N,E<br>Broad-Band Z,N,E | Earth Data digitizer<br>SeisComp datalogger | Dobruška-Polom (DPC) | 50°21'03''N 16°19'34''E | Very-Broad-Band Z,N,E | Digital 140 dB<br>Quanterra |
| | | | | Panská Ves (PVCC) | 50°31'42''N 14°34'08''E | Broad-Band Z,N,E | Earth Data digitizer<br>SeisComp datalogger |

**Geothermics**

| | | |
|---|---|---|
| Kocelovice | 49.4672N 13.8386E | borehole temperature monitoring |

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# Geophysical Institute September 2003

# Departments of the Geophysical Institute

## Department of Seismology

The Department of Seismology of the Geophysical Institute participates from the long-term point of view in the following traditional research directions:

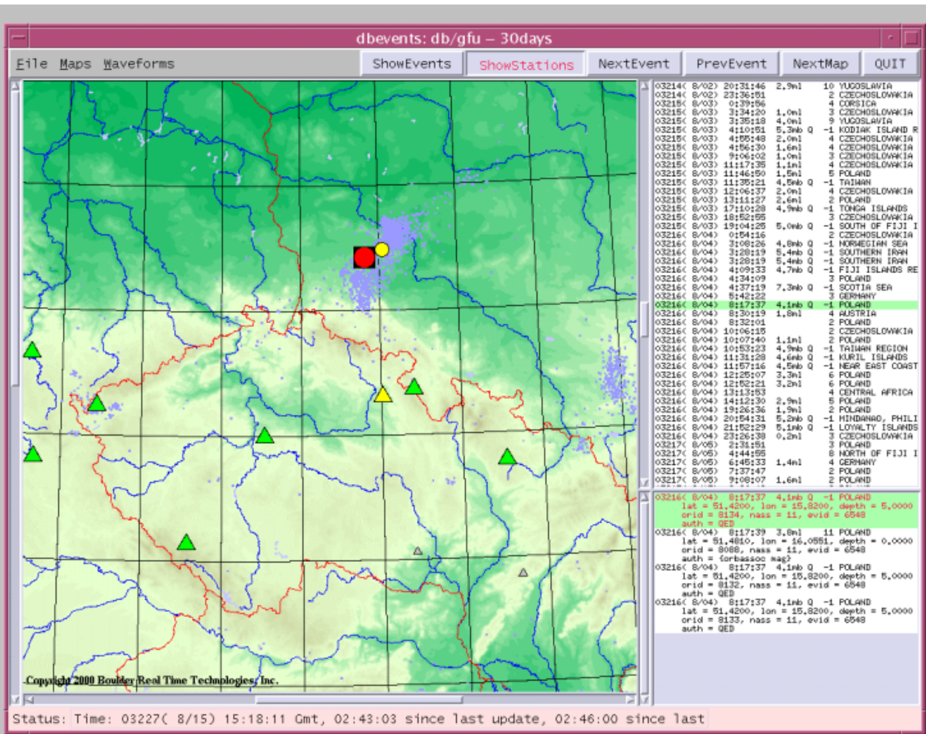
- Observatory practice using network of permanent seismological stations
- Monitoring and interpreting the swarm-like seismicity in West Bohemia
- Theoretical research on seismic waves generation and propagation in complex structures
- Study of the crustal and upper mantle anisotropy

Other short-term projects are solved mainly thanks to the support of Czech grant agencies.

a) Czech Regional Seismic Network (CRSN)

Seismological observations on the territory of the Czech Republic have a tradition of nearly 100 years. The first seismic stations were established in Příbram in 1903 and later in Cheb in 1908. Since that time, seismic observations have been carried out permanently. At present, Geophysical Institute operates these stations of CRSN : Průhonice (PRU, since 1957), Kašperské Hory (KHC, since 1961), Dobruška/Polom (DPC, since 1992), Nový Kostel (NKC, since 1997) and Panská Ves (PVCC, since 2003). Most of these stations were upgraded in 2003 by installing EartData digitizers and SeisComp dataloggers, funded by the Academy of Sciences. Following services are provided:

- ♦ Automated data acquisition of continuous broadband and short-period seismic data by Antelope and SeedLink packages.
- ♦ Daily analysis of seismograms, location and magnitude estimation of local and regional seismic events, analysis of distant earthquakes.
- ♦ Compiling and publishing seismological catalogues and bulletins on the web pages, collection and evaluation of macroseismic reports about earthquakes felt on the territory of the Czech Republic.
- ♦ International data exchange.
- ♦ Archiving of digital records.




A snapshot of the Antelope location screen. Antelope is a commercial software package for real-time data acquisition and processing. The automatic location of a strong mining-induced seismic event in the Lubin copper-mine region is depicted by a yellow circle, NEIC Data Center location by a red circle. Available stations used by Antelope for the automatic location are plotted as green triangles.

b) WEst Bohemia NETwork (WEBNET)

The WEBNET local seismic network has been monitoring the earthquake-swarm area of Western Bohemia since 1993. It is operated by the Geophysical Institute in co-operation with the Institute of Rock Structure and Mechanics of the Academy of Sciences of the Czech Republic. WEBNET consists of 11 short-period digital stations distributed uniformly across the area of study so that a high sensitivity microeartquakes down to $M_L \approx 0.5$ is achieved. The signal from 10 digital stations is continuously transmitted to the data centre situated in the area of study and subsequently via Internet to the Geophysical Institute. Six WEBNET stations were upgraded by NANOMETRICS digitizers in 2001, other three stations are planned to be upgraded using the same instrumentation in 2003. In order to provide full connectivity of all WEBNET stations radio telemetry will be built also at the station TRC, so far operated in a stand-alone recording.

The up to date results have shown that 10 permanent stations are not sufficient for the detailed investigation of swarm earthquakes. As a supplement to the existing stations we plan to deploy a pool of mobile seismic stations in the course of seismic swarms to provide a sufficiently dense coverage of the studied area. In order to allow for fast deployment of mobile data loggers and to assure their reliable operation and high quality measurements a network of 10 small-size seismic cellars was built in the northern part of the swarm area. The cellars of 1.5 m depth comprise a small seismic pier suitable for a short period or a broadband seismometer and enough space to house the complete equipment.

Typical WEBNET seismic station.

The most recent results from this network can be found in the part 'Key projects solved in 2002-2003'.

c) Theoretical seismology

Theoretical research is focused to generation and propagation of seismic waves in complex structures. It includes theoretical analyses, development of algorithms and programs for computing seismic wavefields propagating in laterally varying, perfectly elastic or anelastic, isotropic or anisotropic layered structures. Special attention is devoted to studies of seismic wave propagation in weakly anisotropic media.

Source studies include development of methods of waveform inversion for retrieval of the source mechanism and its time function. Particular attention is given to assessment of errors imposed on the reconstructed source parameters by noise in the data, and especially by mismodeling of the medium and mislocation of the hypocentre. Reliability of determination of non-double-couple components of the mechanism is studied in this context.

d) Upper mantle anisotropy

The anisotropic structure of the Earth's upper mantle was studied in international cooperation both by body and surface waves. Research of the deep structure of the lithosphere was focused on the three regions - the Trans-European Suture Zone around the transition from the southern Sweden to Denmark and the northern Germany, the French Massif Central and the western part of the Bohemian Massif. Based on tomographic images of teleseismic body-wave velocities and a joint inversion of anisotropic data - P-residual spheres, fast shear-wave polarisation and split times - individual domains in lateral extent of several hundred kilometres were distinguished. The domains characterized by consistent orientation of anisotropy may represent individual cycles of accretion processes in the continental lithosphere. Boundaries of these domains are zones of potential weakness for later tectonic processes like rifting, volcanism and 'intraplate' earthquakes.

## Department of Geomagnetism

Research activities of the department involve several topics, ranging from observations of the geomagnetic field through geodynamo modelling, solar-terrestrial-climatic relationship to rock magnetism and its applications to environmental problems. Geomagnetic field is measured at the Budkov Observatory (South Bohemia), which contributes the data to the INTERMAGNET (www.intermagnet.org) Programme. The observatory uses Narod ringcore magnetometer, ELSEC Proton Precession magnetometer, and declination and inclination theodolite. In addition to regular measurements, forecasts of geomagnetic activity, performed on the basis of geomagnetic records and data on solar activity (NOAA, Boulder, USA), are submitted daily to the Regional Warning Center. Permanent measurements of the geomagnetic activity are complemented by regular field measurements of secular variations, carried out every other year on a net of 7 secular points covering the whole of Czech Republic. Last, but not least, solar and geomagnetic activities are studied from the point of view of their effect on the climatic changes.

The other research topic is focused on basic rock magnetism and its applications to environmental studies. The main interest is identification and magnetic characterization of different iron-bearing minerals, occurring in various environments. In cooperation with 3 foreign laboratories, magnetic susceptibility of topsoils over large area of Central Europe has been examined within an EU 5FP Project MAGPROX.

Susceptometer SM400 for real-time measurements of vertical distribution of magnetic susceptibility in soils (developed within EU 5FP Project MAGPROX).

## Department of Geothermics

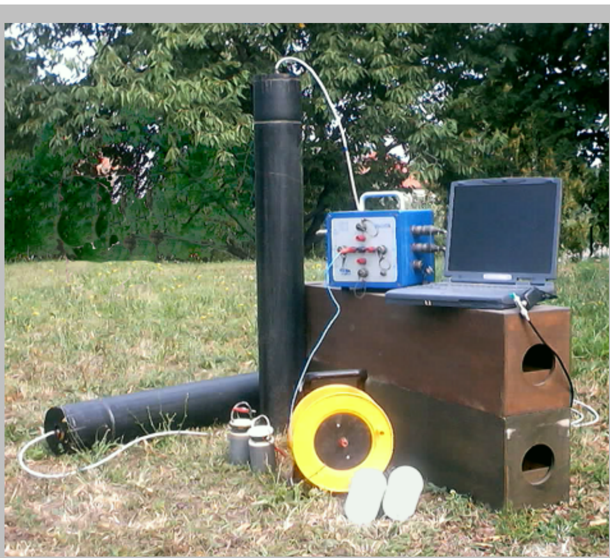
The Department of Geothermics focuses on research into the temperature field of the Earth's crust and upper mantle. The temperature distribution is studied both experimentally by temperature logging in boreholes and theoretically by extrapolation of the borehole temperature data to a greater depth. The extrapolation is based on solving the heat transfer equation in the geothermal model of the studied part of the Earth's interior. In order to compile the model, information about the distribution of heat sources, thermal conductivity and diffusivity is necessary together with knowledge of the boundary conditions (surface temperature and its gradient) and the initial temperature field. The instrumental equipment necessary for carrying out this research consists of a portable thermometer for borehole logging, rock thermal conductivity and diffusivity meters and the gamma-ray spectrometer for determination of the radiogenic heat production of the rocks.

The recent research efforts have concentrated on regional studies on the temperature distribution within the lithosphere and on the reconstruction of the past climatic changes by inversion of the borehole temperature profiles within the Czech Republic and in several sites abroad in joint activities with Canadian, German, Hungarian, Japanese, Korean, Mexican, Polish, Portuguese and Russian colleagues. Ability of the department to carry out precise temperature logging in boreholes all over the world has recently considerably improved after acquiring a self-contained small temperature probe, which does not require communication with the surface during the logging. Due to the very light-weight configuration (less than 100 kg) of the logging equipment, two members of the Department were able to carry out successful temperature logging campaign in boreholes within the Chicxulub Impact Structure in Mexico in May/June 2003 supported by the Czech Grant Agency. The probe was also used to measure temperature in boreholes in Portugal in 2002 and in NE Poland in 2003 as well as to participate in the joint Czech/Japanese/Russian expedition to Kamchatka in 2002 within several international studies on the climate changes detected in boreholes.

Geothermic field observatory in Kocelovice.

## Department of Geoelectricity

Department of Geoelectricity carries out both methodological and experimental research in time variable electromagnetic fields of the Earth. Particularly, the staff of the department concentrates on two principal research directions, (i) geoelectrical investigations of the solid earth, and (ii) studies on external geoelectromagnetic fields and solar-terrestrial relations.



Magnetotelluric measurement system GMS-06 with the central unit ADU-06, induction coil magnetometers MFS-05, and a pair of Pb-PbCl non-polarizable electrodes.

The solid earth geoelectrical studies aim at investigating the crustal and upper mantle distribution of the electrical conductivity as an indicator of geological and tectonic structures and processes, by employing passive electromagnetic induction methods, magnetotelluric and geomagnetic depth soundings in particular. The main target areas of large-scale geoelectric induction investigations have recently been the eastern margin of the Bohemian Massif and its transition to the Western Carpathians, as a first-order tectonic boundary between the Variscean and Alpine systems on the territory of former Czechoslovakia, and the western margin of the Bohemian Massif, with relation to the deep borehole KTB in Germany, as well as within a complex research programme of the West Bohemia-Vogtland seismo-active region. Newly, first broadband magnetotelluric experiments have been performed across the Teisseyre-Tornquist Zone in northwest Poland, within an international EMTESZ project. For carrying out the magnetotelluric experiments, two Metronix broadband five-component digital systems GMS-06 are available in the Institute, based on the ADU-06 electronic units and MFS-05 induction coil magnetometers. Methodological research on the theory and numerical modelling of electromagnetic fields in the heterogeneous and anisotropic earth contribute to the development of inter-pretation techniques for deep geo-electrical soundings.

Research on external geoelectro-magnetic fields and solar-terrestrial relations involves several special topics, in particular (i) theory of the propagation of electromagnetic waves in the ionospheric Alfvén resonator, with special regard to Pc1 and IPDP phenomena in the auroral zone, (ii) spatio-temporal variability of external geomagnetic variations and its relation to the IPMF, (iii) correlation of the solar and geomagnetic activity with non-geophysical fields, with special regard to meteorological, climatological, as well as to bio-medical records, (iv) relations of solar and solar-terrestrial processes to the fine dynamics of the solar planetary system.

## Department of Tectonics and Geodynamics

Department of Tectonics and Geodynamics was established in 2002 and consists of four research groups:

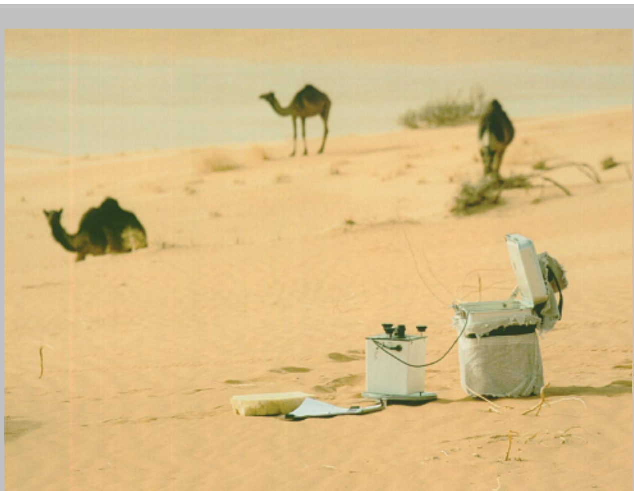
- sedimentary basins group
- gravity and geodynamics group
- laboratory of rock anisotropy
- laboratory of plate tectonics and metallogeny.

a) Sedimentary Basins Research Group

This group, established at the GFU in 2001, focuses on geological and geophysical study of sedimentary basins. The history of filling and deformation of sedimentary basins provides detailed data elucidating the evolution of the lithosphere in varying plate-tectonic situations and the interactions between processes in the lithosphere, earth surface, oceans and atmosphere, at a wide range of temporal and spatial scales. Main research areas include stratigraphic analysis of sedimentary basins of various tectonic regimes, using geological and geophysical data and numerical modelling; physical sedimentology of clastic depositional systems; study of relationships between sea-level fluctuations, palaeoclimate and paleocenanography. Group members currently carry out research in the strike-slip – dominated Bohemian Cretaceous Basin (Czech Republic), the Western Interior foreland basin system of North America, the Eger Graben extensional basin system (Czech Republic) and in the post-orogenic, Late Palaeozoic extensional/transtensional basins of the Sudetes area at the border between the Czech Republic and Poland. Results of the studies in the area of the Bohemian Massif contribute to multi-disciplinary studies of the post-orogenic tectonic evolution of the Variscan collisional belt.

b) Gravity and Geodynamics Group

This group comprises two main research fields – gravimetry and geodesy on one side, and the Earth tides observations and analysis on the other side.



High accuracy gravity measurements were performed also in difficult desert conditions.

Precise gravity and geodetic (GPS and levelling) measurements are applied in various research projects. The principal one is the investigation of crustal dynamics related to the seismic energy release in active tectonic regions. Detailed study is carried out in the West Bohemia seismoactive region. From repeated observation campaigns significant anomalies of non-tidal temporal gravity changes were determined, as well as vertical movements related to earthquake swarm periods. Similar investigation is performed in the Aswan area in Egypt, where increased seismicity is related to the Aswan Lake water level variations. In the Gulf of Corinth area, Greece, both gravity monitoring and gravity survey aimed at the location and geometric definition of active faults, are supported by an EC Project. Microgravimetric measurements contribute to the solution of problems in other fields, especially engineering geology, archaeology, geological mapping, etc. The tidal group has recently increased the scope of research. Besides the running tidal observatories with data being sent to the world data bank in Brussels, research is focused on the relation between the Earth tides and other geo-factors, groundwater level, $CO_2$ emissions, earthquakes and, last but not least, gas storage regime and rock deformation. Original processing procedures are being developed to increase the accuracy of mutual correlation, especially the elimination of barometric effects.

c) Laboratory of Rock Anisotropy

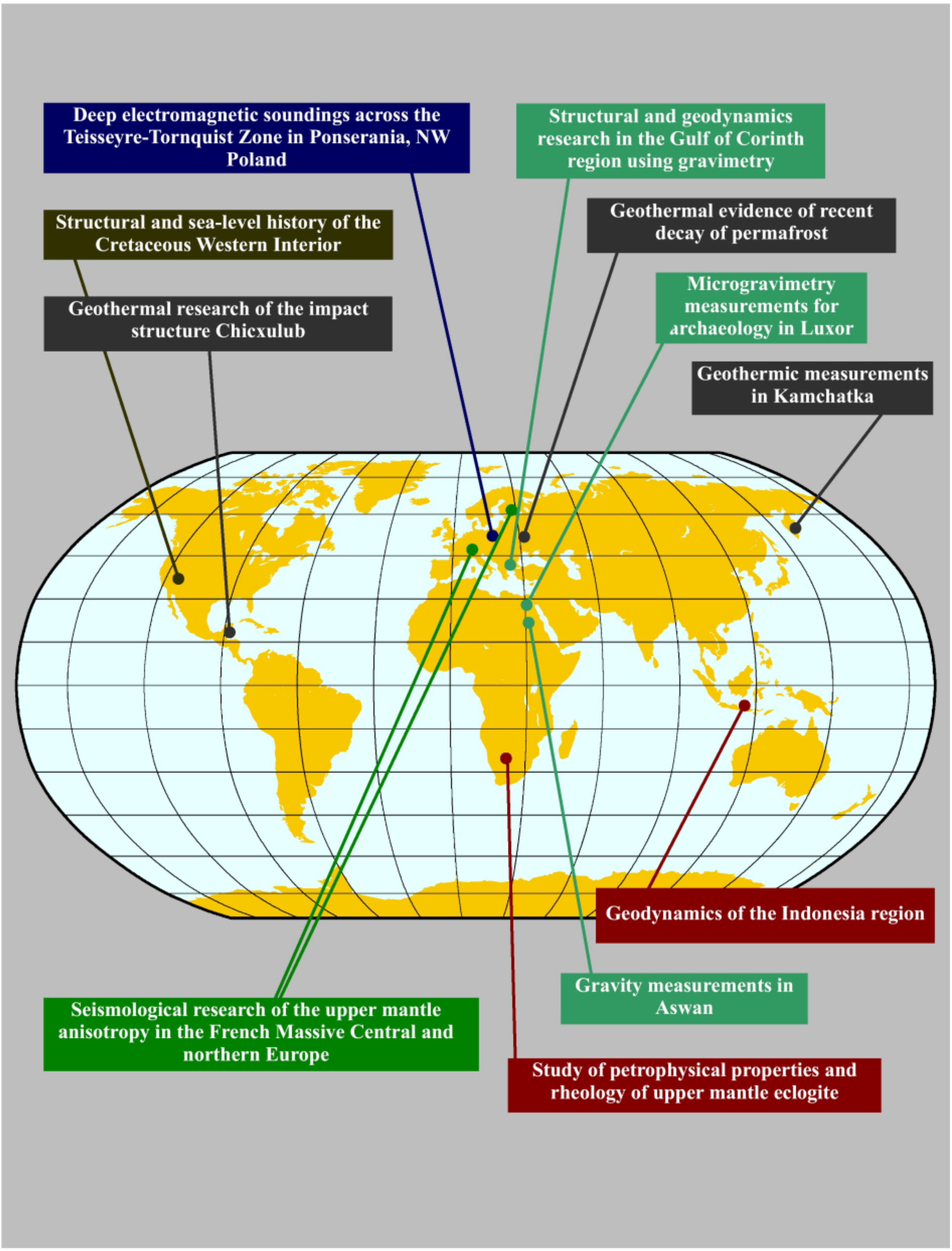
Research in the Laboratory of rock anisotropy is focused on petrophysical properties and rheological behaviour of naturally deformed rocks. The principal areas of our current interest are the following: (1) petrophysical properties of upper mantle eclogites that were taken to the surface as xenoliths in kimberlite eruptions. A database of crystallographic preferred orientations of clinopyroxene and garnet helps to constrain an appropriate composition model of mantle transition zone; (2) experimental measurement of velocities of acoustic waves through spherical samples in various directions in order to determine the elastic anisotropy in a rock; (3) boudins of mantle rocks in orogenic root domains and their tectonic significance during orogenesis. The identification of strain patterns and PT evolution in the mantle and surrounding rocks in the orogenic root domain of Bohemian Massif helps to understand tectonic role of a mantle during orogenesis. Generally, this research includes extensive fieldwork on outcrops of mantle rocks, measurement of crystallographic preferred orientation of principal rock-forming minerals using the EBSD method, detailed microstructural study and identification of operative deformation mechanisms.

d) Laboratory of Plate Tectonics and Metallogeny

The laboratory has traditionally devoted its effort to analysis of global seismic data at convergent plate margins and to tectonic interpretation of earthquake distribution and mechanisms. Two available sets of data has been used – ISC hypocentral determinations relocated by Engdahl et al. (1998), covering the period 1964-1999, and focal mechanisms of stronger events determined by Harvard group (HCMTS) covering the period 1976-present.

The activity of the lab between 1999-2003 concentrated mainly on the causes and location of primary source of active calc-alcaline volcanism at convergent plate margins and on the seismic activity related to contemporary volcanic activity. The lab recently focuses on data from two prominent regions at convergent plate margins – SE Asia and Middle America.

## Current experimental activities of the Geophysical Institute abroad



# Key Research Projects in 2002-2003

## Gravity investigations in the Gulf of Corinth region focused on active faults

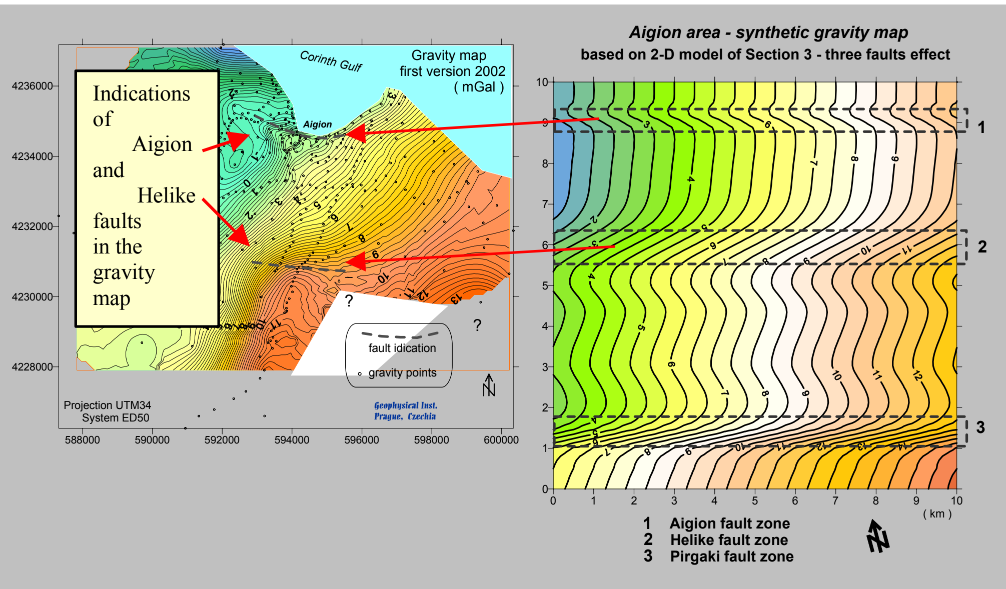
One of the most seismoactive regions of the Corinth Rift is the area around Aigion on the south-west coast of the Gulf of Corinth. The system of active normal faults was determined by both geological and seismological studies. However, many questions persist on the total slip rates on the faults, as well as the thickness and geometry of sedimentary cover of the basement formed by Mesozoic carbonates. Moreover, not enough information is available on the structural and tectonic setting between the Helike and Aigion faults.

From this reason a field gravity survey had been proposed within the frame of EEC Project CRL (Corinth Rift Laboratory, Project 3F-Corinth) in order to locate structural and tectonic features and to estimate some quantitative parameters of the geological setting. Collections of rock samples prepared during the period 2000 - 2003 were measured in a lab in order to obtain grain, bulk and wet densities and porosity. The analysis proved that the density contrast of 0.12 - 0.17 g.cm$^{-3}$ between the two principal rock types (limestone, conglomerate) is significant enough to provide signals in gravity data.

In the preparatory stage of the project two tentative simplified profiles were used for 2D gravity modelling. Resulting gravity effects of the faults were manifested in the form of gradients or non-symmetrical anomalies. Gravity response of particular sections was used for the compilation of a synthetic gravity map that was expected to demonstrate a possible image of a real field gravity map.

Although the definitive gravity map is not yet available due to the on-going field measurements and the work on terrain corrections evaluation, the expected features from the modelling have been observed in the up-to-date version of the map. Moreover, the data of the first epoch of the field survey around Aigion showed a more complicated composition of gravity anomalies, providing indications of various tectonic and structural features of 3D character. In general, the preliminary gravity map represents a combination of regional W-E gradient, caused by deep crustal composition (thrust tectonics of the Hellenides), with local N-S gradients resulting from the E-W trending active faults. From the map the existence of other faults (fault system) in the SW-NE direction may be indicated as well. Determination of structural and tectonic features will contribute to the understanding of active fault dynamics in the region.

Beside gravity survey, the long-term repeated measurements of gravity had been started in 1994, while in 1997 the network of observation points was set on both sides of the Gulf, with ties by ferry boats at two places. The high precision gravity monitoring data show significant decrease of gravity south of the Helike fault, which can be related to Peloponnesos uplift, relative to Central Greece on the




Comparison of theoretical pre-modelled effects of the faults under study (right), and real measured gravity data (left).

northern side of the Corinth Gulf. However, this process does not seem to be regular, as indications of certain slow-down or reverse motion were observed as well (Mrlina, 2001, 2002). Within the EEC Project this network was densified in the Aigion area in 2002, with the aim to focus on dynamic behaviour of the upper crust in this seismically high-risk region.

Similar investigations are performed in Western Bohemia (Czech Rep.) and in the Aswan region (Egypt), where correlation with earthquake swarms and water load effect, respectively, were observed (Mrlina et al. 2003a, Mrlina et al. 2003b).

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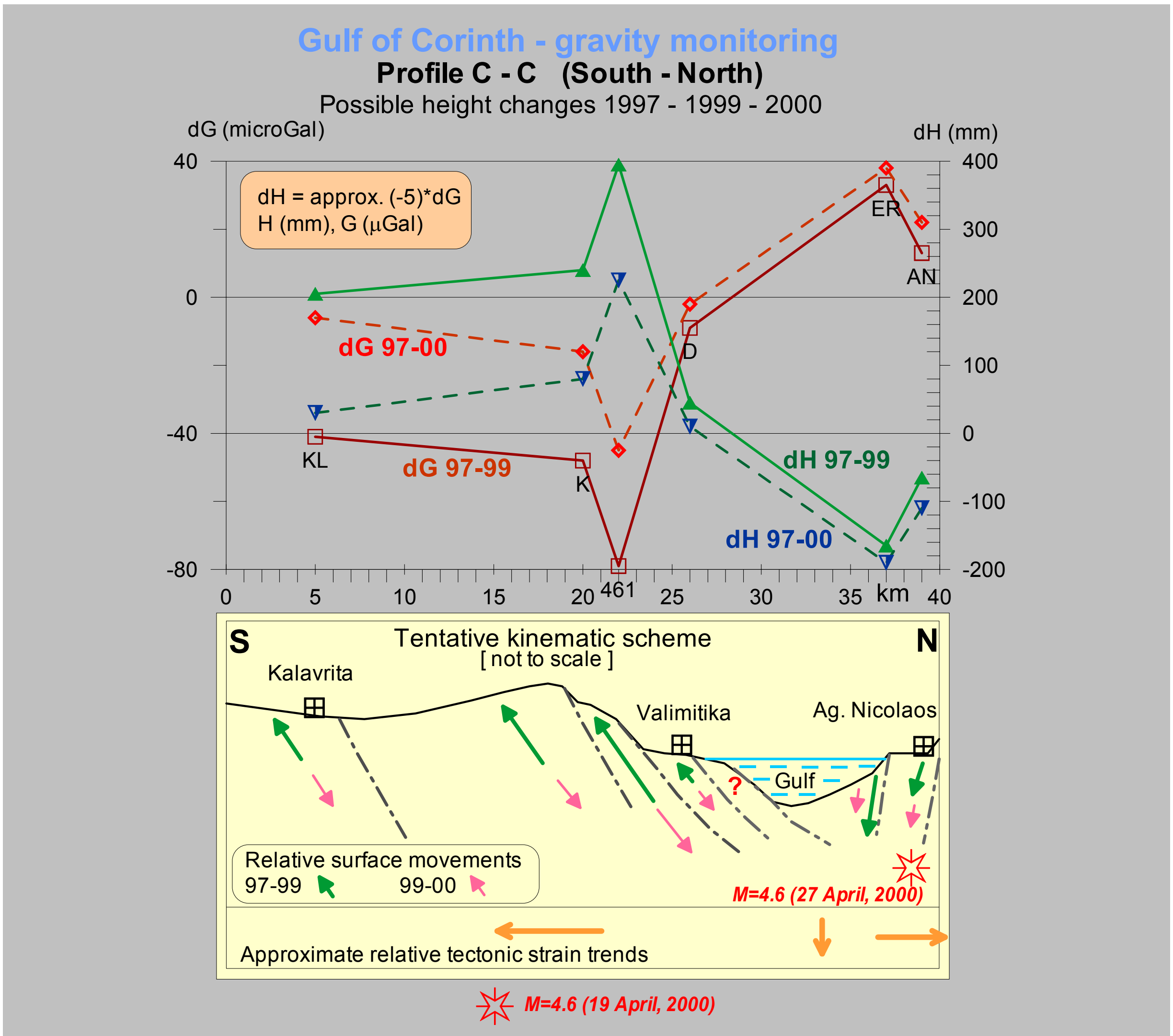
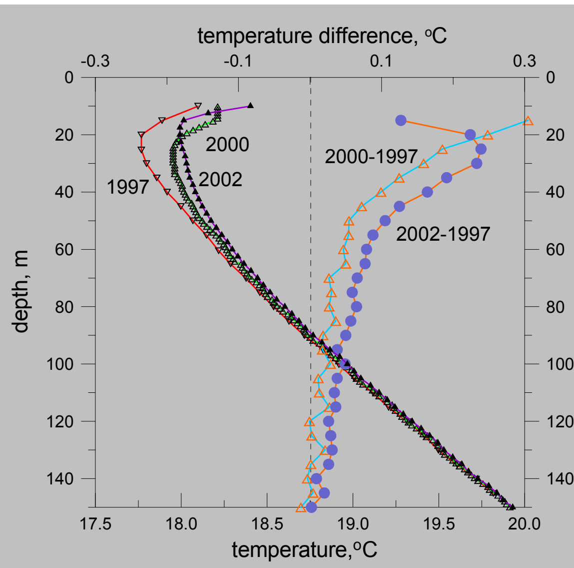



Temporal changes of gravity along a N – S profile crossing the Gulf. Tentative theoretical vertical displacement is presented in the graph. Scheme of stress-strain dynamics demonstrate possible explanation of observed gravity signals.

## Borehole climate change

There is clear evidence that the world climate has been undergoing a warming, which in the last three/four decades has become accelerating. This warming is characterised by changes in many environmental variables, above all in the increasing mean annual surface air temperature (SAT). The real causes of the present-day warming are not quite clear; however, one of the major problems is to distinguish between the role of the natural climate variability and the potential anthropogenic contribution. This means to evaluate the impact of human activities such as air pollution by the production of greenhouse gases, industrialisation and massive deforestation or changes in land use accompanying the population growth. The knowledge of the geographical distribution of the present-day rate of climate warming and its environmental confidence is extremely useful for such assessments.

Changes in the annual air temperature produce temperature variations on the Earth's surface; increasing SAT produces increasing ground surface (soil) temperature (GST) and the response to these changes penetrates downwards into the subsurface. Subsurface temperature field at depth of several tens to several hundreds metres thus contains a record of long-term ground surface temperature history. This information can be recovered from borehole temperature-depth profiles, which allow reconstruction of the GST-history of several past centuries.




Upper parts of three temperature - depth profiles measured in a 200 m deep borehole TGQC-1 by repeated logging in March 1997, March 2000 and November 2002 together with 2000 - 1997 and 2002 - 1997 profile differences. The observed time changes confirmed the transient character of the subsurface temperature indicated by a shape of the individual profiles.

The increasing mean annual air temperature is usually used as the measure of the climate warming and the representative magnitude of this warming is calculated as the statistical trend of the long-term SAT-series observed at meteorological stations. As the air temperature is generally variable, relatively long time span is necessary to obtain a reliable result. Since the earth's surface smoothes down the surface temperature extremes, the magnitude of the present day climate warming, as the reflection of the long-term climate evolution, may be more easily obtained by the temperature monitoring at the depth just below the penetration of the seasonal variations.

In the last few years the Department of Geothermics has focussed on the application of the 'geothermal method' to invert the subsurface temperature-depth profiles to assess the GST-history. Several grant projects have solved related problems ranging from the general application of the inversion methods on the existing T(z)-profiles, evaluation of the climate warming on the territory of the Czech Republic in last millennium to detailed temperature monitoring at selected sites to assess the present-day magnitude of climate warming and its correlation with the meteorological SAT data. The Department was the principal investigator of the UNESCO/IGCP (international geological correlation programme) 'Borehole and Climate' (1998-2002) which terminated in 2002.

High-frequency temperature variability was investigated in the temperature-time series at Praha-Spořilov from interval 1994-2001. The calculation was performed for time series of SAT averaged for 6-hour intervals. Variability was detected by the method of absolute difference of temperature anomalies between two adjacent discrete time periods. The results indicated a frequency dependence of variability. For 24-hour intervals the variability exhibits an irregular character and decreases with time in the whole eight-year observation period. Variability time series calculated for 6-hour intervals did not reveal any significant trend, however, quasi-seasonal oscillation exists. A significant correlation between the North Atlantic Oscillation (NAO) activity and temperature variability was observed. Higher NAO-index values at all frequencies tend to be associated with higher variability (Bodri and Čermák, 2003a).

This study was later completed with time series for 12 and 18-hour intervals and with 5 and 10-day daily means and extended by the results from the Kocelovice site, which broadened both the frequency range and regional applicability. The decreasing trend for longer time interval was interpreted as the manifestation of the climate warming and discussed in the potential relation to the effect of urbanisation in the case of the Spořilov site (Bodri and Čermák, 2003c).

For the eight-year interval of the temperature time series from the depth of 40 m in Spořilov hole the mean climate warming was assessed ranging in the interval 0.026-0.030 K/year. The characteristic trends documenting SAT warming from 30 local meteorological station in the Czech Republic for 1960-2000 were calculated and formally assigned to three categories according to the dominant ecological character of the area: 'mostly industrial', 'miscellaneous' and 'mostly farming'. The mean warming trend in the last four decades decreases from the 'industrial' areas to the 'farming' areas: 0.031±0.008 K/yr to 0.022±0.005 K/yr and 0.018±0.006 K/yr and agree relatively well with the 'borehole' data.

Artificial time-delay feed-forward neural networks (NN) with one hidden layer and error back-propagation learning were used to predict surface air temperatures (SAT) for six hours up to one day. The networks were trained and tested with the use of data covering a total of 26280 hours (three years) monitored in the period 1998-2000 in location Spořilov. The NN models provided a good fit with the measured data. Phase diagrams as well as the results of the variability studies of SAT revealed a fundamental difference between summer temperatures (April-September) and winter temperatures (October-March). Results of the trial runs indicated that NN models perform better when both periods are trained separately. The results show that relatively simple neural networks, with an adequate choice of the input data, can achieve reasonably good accuracy in one-lag as well as in multi-lag predictions. For the 'summer' period the total errors give 0.055 and/or 0.044 mean accuracy of predicted values in training and testing sets, respectively. Similarly high mean accuracy of the simulated values of 0.057 and 0.065 was obtained for the training and testing sets in the winter season. Good results with the mean error of 0.028 were obtained for the summer period of the year 2001, which were used for additional testing. Higher accuracy obtained for the year 2001 is due to the fact, that warm temperature extremes, which are generally predicted with less accuracy, did not occurred in the summer 2001 (Bodri and Čermák, 2003b).

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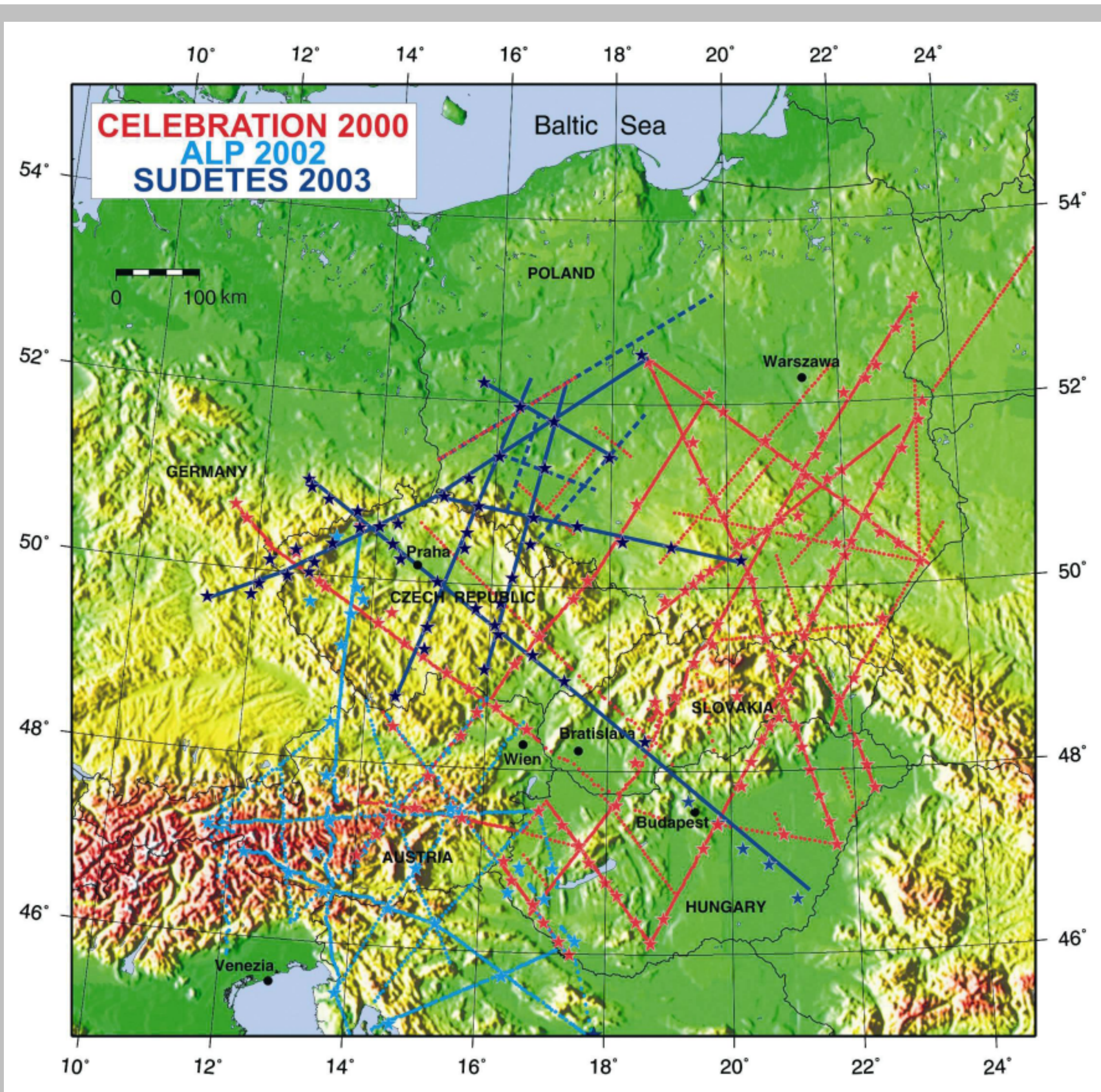
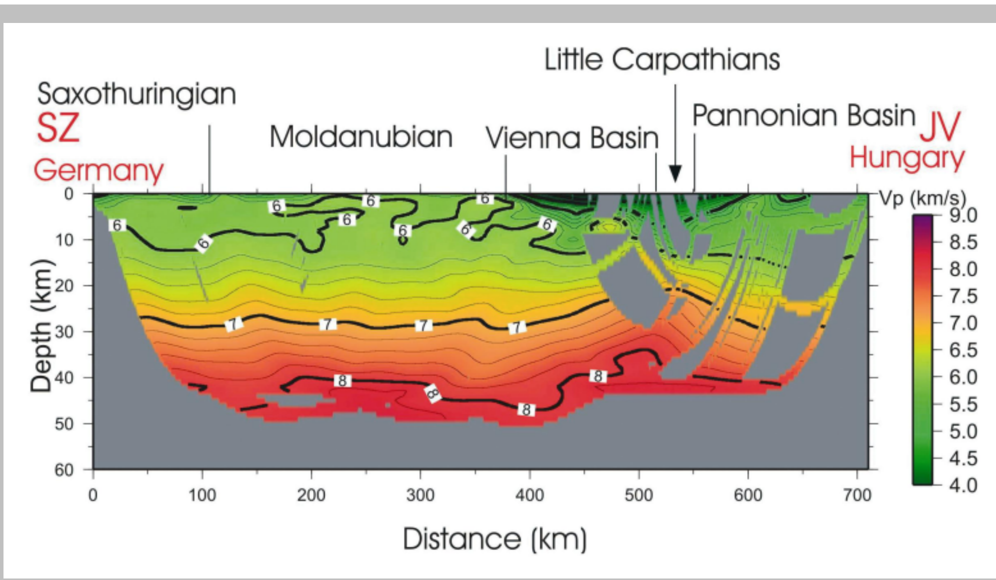
## Seismic Refraction Experiments in Central Europe

CELEBRATION 2000 (Central Europe Lithospheric Experiment Based on Refraction) belongs to a new generation of seismic refraction experiments in Central Europe (Guterch et al., 2003a,b; Brückl et al., 2003). Together with further experiments ALP 2002 and SUDETES 2003 they concentrate on investigation of crustal and uppermost mantle structure. They have only been possible due to a massive international co-operative effort of many scientific institutions in different countries and also due to advancing technology of newly developed seismic recorders called 'TEXAN'. The layout of these experiments represents a network of interlocking recording profiles with station spacing along the profiles 3-4 or 6 km and shot points with spacing ~ 30 km.

An example of the crustal structure modelling for CELEBRATION 2000 profile CEL09 in the Bohemian Massif using tomographic approach for the first arrival travel-times (Hole, 1992) is shown on the next page. P-wave velocity models show high gradient velocity zone between the surface and the depth of 5-7 km with velocity ranging from 5.1 to 6.1 km/s followed by small gradient and laterally homogeneous velocity in the lower crust. The Moho may be represented by the velocity isoline, which is an average for the lowermost crust and uppermost mantle and corresponds with velocity ~ 7.5 km/s.




Index map showing the locations of major seismic refraction experiments in Central Europe.




Tomographic crustal model for CELEBRATION 2000 profile CEL09.

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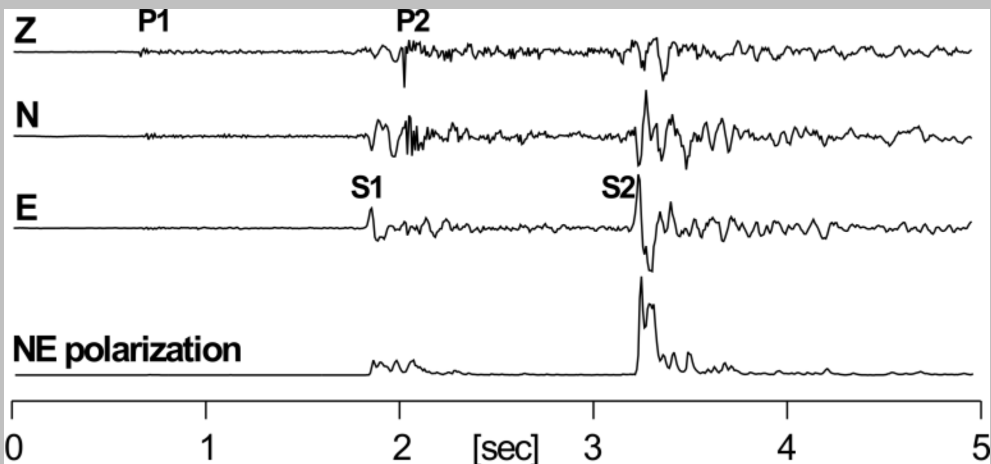
## Investigation of earthquake swarms in West Bohemia - detailed analysis of the 2000-swarm

The most interesting earthquake swarm of the last years was the year 2000 swarm, which occurred in the area of Nový Kostel in the period from August to December 2000. This seismic activity belonged to the largest swarms of the 20th century and provided a big number of high quality seismic data; the number of observed events exceeds the number of all observations of local earthquakes in the NW-Bohemia/Vogtland region over the preceeding period of ten years (Fischer and Horálek, 2003).

The 2000-swarm sparkplugged further activities in swarm investigations, which resulted either in developing a new method for automatic seismogram processing, or in deeper studies of statistical characteristics of seismic energy release, which help understand the mechanisms responsible for earthquake swarm generation. The new method for automatic event detection, phase picking and event location (Fischer, 2003) is designed for processing of records of swarm earthquakes occurring in the NW-Bohemia region and takes advantage of the nearly horizontal polarisation of S-waves, which is typical for the waveforms of local earthquakes in this area . The phase picker is applied in two steps: first, S-wave groups are identified in the points of local maxima of horizontal polarisation. Then the peaks of vertical polarisation, which represent the P-wave groups corresponding the detected S-wave groups, are searched for. The times of maxima of P- and S- wave groups are then used as starting points for an accurate P- and S- arrival time search. The closest station to the swarm area (NKC) is used as master, and the phase search at the remaining stations is governed by P- and S- phases identified at the master station. Each combination of the candidate P- and S- phases is checked by preliminary hypocentre location. Due to the use of apriori information on the approximate position of the event hypocentres the method does not detect regional and quarry blast events and is partially capable of picking pairs of mixed P- and S- phases of rapid sequences of multiple swarm events, which are common in earthquake swarms.

Application of the automatic method to the data of 2000-swarm provided first representative results of space-time distribution of the swarm earthquakes and of their prevailing focal mechanisms (Fischer, 2004). It allowed efficient processing of a huge amount of data, whose classical interactive processing takes several years of human effort. Altogether 7017 microearthquakes in the magnitude range of $M_L$ = 0 - 3.3 were identified; the swarm consisted of 9 periods of activity referred to as swarm phases. It was shown that the decay of activity of individual swarm phases followed the modified Omori law, which points to a partial similarity with aftershock sequences of tectonic earthquakes. The space-time distribution of a subset of 2913 events with low location residuals shows a strong space clustering of the earthquake hypocentres and their pronounced migration between individual swarm phases. Most of the activity took place along an elliptical, nearly vertically dipping, 6 km long N-S oriented fault plane in depths ranging from 6.5 to 10.5 km. The P and T axes were estimated by FOCMEC software for the 782 strong events and three groups of earthquakes with similar faulting type were distinguished. In contrast to the normal and strike-slip faulting events that created the prevailing portion of the swarm and were distributed uniformly within the focal area, the reverse events were clustered in time and space.

The resulting catalog was analyzed by Hainzl and Fischer (2002) in detail to find the underlying mechanism responsible for swarm generation. They showed that the spatial spreading of the swarm activity was a function of the cumulative seismic moment release; it was not proportional to time as would be expected if the diffusion of penetrating mantle fluids triggered the earthquakes directly. The swarm earthquakes themselves are found to trigger aftershocks, which preferably occur at the edge of the rupture zone of preceding events. The relationship between the spreading of the swarm activity and the cumulative moment release is in good agreement with observations of tectonic earthquakes. This indicates that the swarm activity results from a stick-slip type fracture propagation due to stress transfer from previous events. The role of fluids was probably important in the initial part of the swarm activity when a fluid intrusion in the bottom part of the seismogenic zone took place. In later swarm phases locally induced fluid flows may have affected pore pressure changes influencing rupture growth.




A record of two swarm 2000 events (3-Sep-00, 21:53:10, $M_L$ = 0.4 and $M_L$ = 0.7, station NKC) with overlapping waveforms. The bottom trace shows the maximum eigenvalue of the signal covariance matrix in the horizontal plane, which is used as the S-wave detector. P- and S- phases of individual events are indicated.

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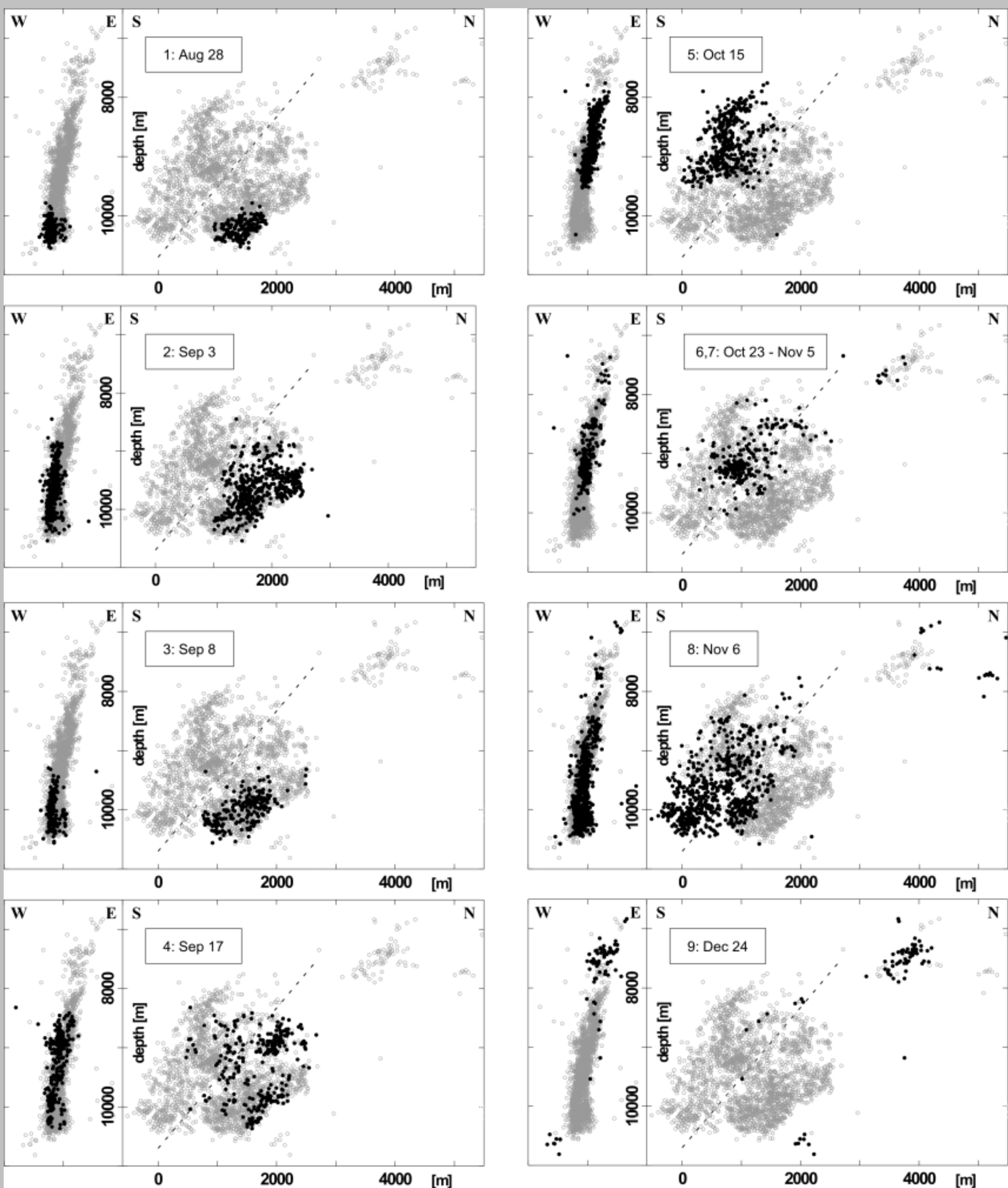


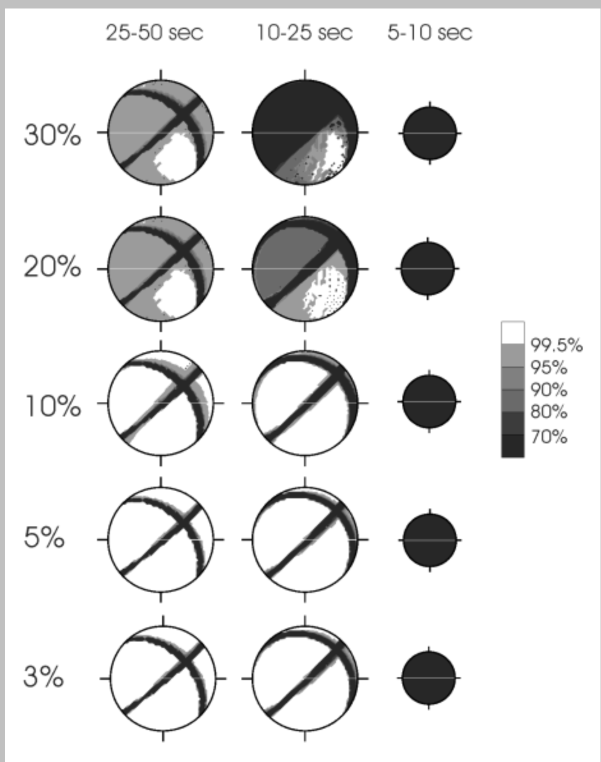

Migration of the 2000-swarm events. Two vertical cross sections are used to display the relative position of each swarm phase. Left: view from south to north. Right: view from east to west. A counter-clockwise migration of activity is apparent.

## Seismic wave generation and propagation

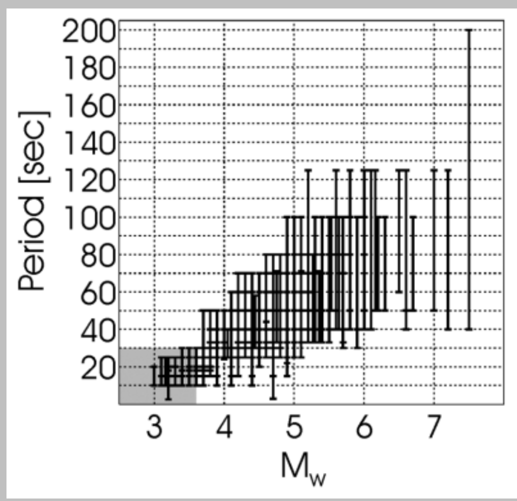
Theoretical studies of generation and propagation of seismic body waves in complicated isotropic and anisotropic structures have long tradition in the Geophysical Institute. During the period 2002/2003, we concentrated, among others, on the following problems:

a) Regional moment tensor uncertainty due to mismodeling of the crust

Retrieval of earthquake moment tensor (MT) requires knowledge of the response of the medium in which seismic waves travel from the hypocenter to the stations. When inverting long-period (LP) seismic data (teleseismic and LP regional records), a gross-earth model is sufficient. With decreasing period a more detailed model is needed. This is the case of waveforms of weak earthquakes at regional distances. Regional moment tensors (RMT) of earthquakes mostly from Mediterranean region are determined on routine basis by Swiss Seismological Survey (SED) and Italian National Institute of Geophysics and Volcanology (INGV) by using averaged models of the Earth crust. By inverting broad-band records of the Mw=4.8 earthquake near Udine, N Italy, on Feb 2, 2002, we tested the sensitivity of the moment tensor (MT) solution with respect to possible errors in the Earth model and in the earthquake source depth. We perturbed the P- and S-wave velocities and the thickness of a 1-D Earth model in the range from 3 to 30% of the parameter values and constructed estimates of confidence regions of the MT and error bars of the source time function and scalar moment in three frequency bands (Šílený and Hofstetter, 2002). Similarly, these error characteristics were determined perturbing the hypocenter depth. We found that in the band of periods from 25 to 50 sec (which is the interval selected by SED in their RMT catalogue), the mechanism is resolved well (in the confidence level 95% at least) up to the Earth-model uncertainty reaching 30%, in the passband 10-25 sec up to about 10%, but it is not determined completely in the periods from 5 to 10 sec. Error in the hypocenter




Confidence regions of the fault plane solution (FPS) in the passbands 25-50 sec, 10-25 sec and 5-10 sec due to mismodeling of the crust amounting from 3 to 30% of the values of the 1-D model parameters. The smaller the size of the confidence region, the higher is the quality of the FPS.




Range of periods of waveforms inverted for retrieval of regional moment tensors (RMTs) by Swiss Seismological Survey (SED). Earthquakes mostly from Europe and Mediterranean are treated, starting at Mw about 3. Gray area – events below Mw = 3.5, the RMTs of which are determined from periods below 30 sec and may be biased due to mismodeling of the crust.

depth reaching as much as twice the value reported by the location procedure does not destroy the resolution of the mechanism in the periods above 10 sec. In the RMT catalogue of the SED, earthquakes of Mw greater than about 3.5 are processed in the periods above 30 sec, thus the solutions for these events are robust with respect to a possible uncertainty in the Earth model. Mechanisms of weaker earthquakes, retrieved from short periods, should be interpreted with caution.

b) Ray tracing in anisotropic media with singularities

Singularities are very common in all kinds of anisotropy. They are defined as the directions, in which two waves propagate with equal phase velocities. Singularities complicate computations of ray amplitudes and often cause troubles in tracing rays in inhomogeneous anisotropic media. Some ray tracing algorithms can breakdown in the vicinity of the singularities, because the medium becomes nearly degenerate and the right-hand sides of the ray tracing equations contain indefinite expressions.

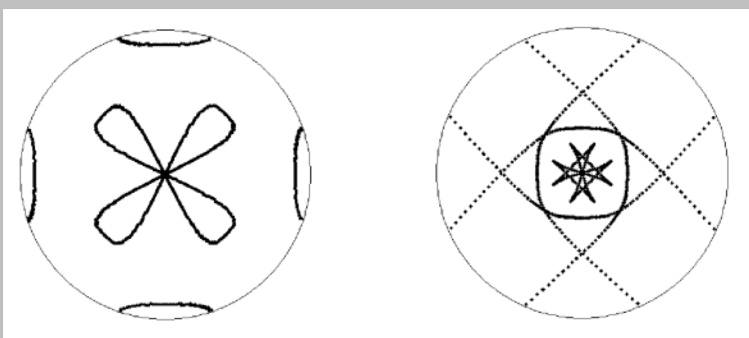
We proposed a modified ray-tracing approach (Vavryčuk, 2001), which is numerically stable and yields correct results for all the following difficult situations: for transition between isotropy and anisotropy, for very weak anisotropy and for all kinds of singularities in strong anisotropy. The proposed approach is a slight modification of the ray tracing based on equations whose right-hand sides are expressed in terms of the polarization vectors of the traced wave.

The modification consists in imposing an additional condition requiring the polarization vector of the traced wave to be continuous along a ray. This condition is automatically satisfied when tracing rays in regular directions, but must be explicitly required in singular directions. The ray field can display a complicated pattern near singularities in inhomogeneous anisotropic elastic media (Vavryčuk, 2003b). The peculiarities in the ray field arise particularly near conical and wedge singularities, which generate linear, circular or elliptical anticaustics in their vicinities. The anticaustics represent barriers for rays and prevent the rays from crossing them. If the rays approach the anticaustic, they can be strongly curved and deflected from their original direction. The rays outside the anticaustic are forced to move around the anticaustic. The rays inside the anticaustic are captured and forced to pass the caustic generated by the singularity.

c) Parabolic lines and caustics in weakly anisotropic solids

The pattern of parabolic lines and caustics in strongly anisotropic media can be very complicated. Generally, the stronger the anisotropy, the more complicated the pattern of parabolic lines and caustics. Peculiarities in the pattern of parabolic lines and caustics also arise in the vicinity of singular directions.

Parabolic lines and caustics simplify in weakly anisotropic media (Vavryčuk, 2003a). No parabolic lines and caustics appear on the S1 slowness and wave sheets under sufficiently weak anisotropy. They can appear for the S2 wave, but only in the directions close to conical or wedge singularities. Each conical or wedge singularity in weakly anisotropic media generates parabolic lines, caustics and anticaustics in its vicinity. The size of caustics and anticaustics decreases with decreasing strength of anisotropy. For infinitesimally weak anisotropy, caustics and anticaustics contract into one common point. For the limiting case of isotropy, the conical and wedge singularities disappear together with the caustics and anticaustics associated with them.

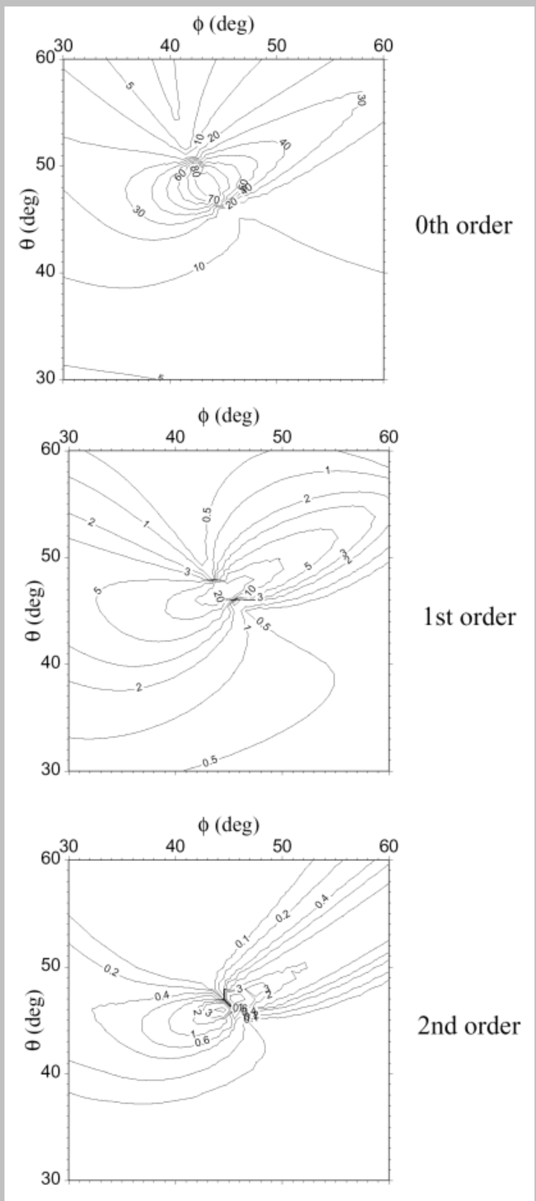


Parabolic lines (left) and caustics (right) for the S2 wave (slower of the S waves) near the kiss singularity in cubic anisotropy. The circles correspond to the deviation of 13 degrees of the slowness (left) or ray (right) directions from the kiss singularity. Equal-area projection is used.

d) Higher-order perturbation theory for anisotropic media

First-order perturbation formulae for the phase velocity and polarization vectors have found many applications in forward and inverse modeling. They allow an insight into the relation of parameters of a medium and their effects on the wavefield. They play, for example, an important role in tomographic studies, in the local determination of anisotropy from observed measurements of travel times and polarization. First-order formulae are, however, only approximate. It is thus important to study their behaviour and compare it with exact or more accurate formulae.

An example of such a study is presented in a figure (see Farra and Pšenčík, 2003). It shows exact (top), first-order (middle) and second-order (bottom) maps of relative differences of S1 and S2 phase velocities as functions of the polar angle θ and the azimuth ϕ in an orthorhombic medium. There are four singularities, which correspond to directions with zero differences in S-wave velocities. Two are on the left and one on the right vertical border, one in the middle of the map. Comparison of the exact and first-order maps shows that the first-order approximation shifts, falsely, the singularities to a slightly different positions. This can be corrected when the second-order formula is used. Its results practically coincide with exact results.




Exact, first-order and second-order maps of relative differences of S1- and S2-wave phase velocities as functions of azimuth ϕ and polar angle θ for an orthorhombic medium.

e) Estimates of qP-wave anisotropy from the qP-wave slowness and polarization measurements

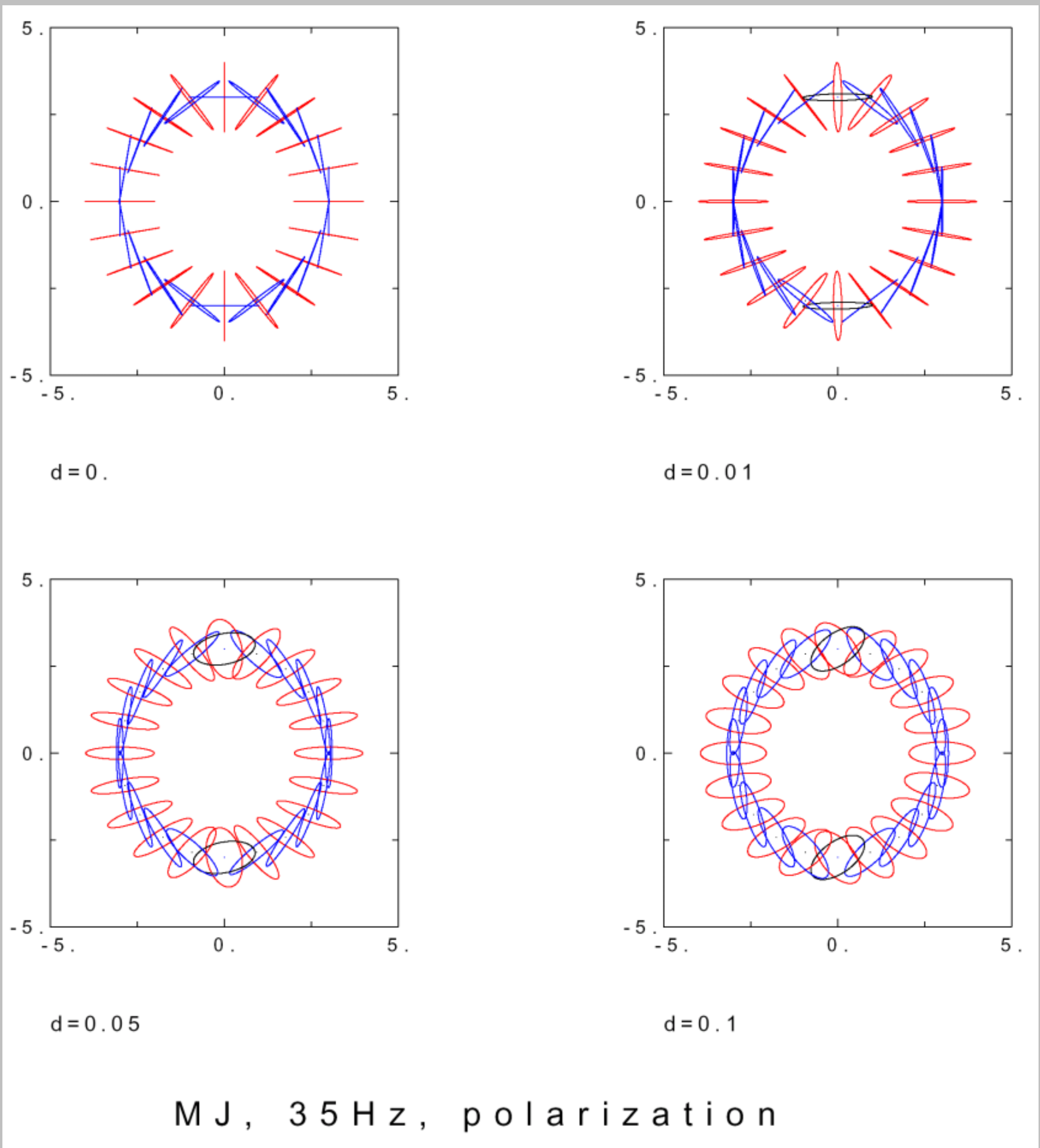
First-order perturbation formulae can be used for the determination of parameters of an anisotropic medium. We developed a procedure for the determination of parameters of an arbitrary anisotropic medium at a receiver in a borehole from the qP-wave data obtained from a multi-azimuth multiple-source offset VSP experiment. The data are travel times at several receivers in a borehole and polarization information at the considered receiver.

The proposed procedure was used by Gomez et al. (2004) to invert the walkaway VSP data from an experiment in the Java Sea region. From the measurements along a single profile, only five weak anisotropy (WA) parameters specifying the medium can be determined. The parameters $\varepsilon_z$, $\varepsilon_{15}$ and $\varepsilon_{35}$ are the parameters with the smallest values of standard deviation. They also have least sensitivity to perturbations of observed data. They can thus be estimated with a rather high reliability. The standard deviations of the remaining parameters are about an order greater and thus their estimates are very unreliable. Zero values of the parameters $\varepsilon_{15}$ and $\varepsilon_{35}$ would indicate that the studied medium has a vertical axis of symmetry. Non-zero values of the mentioned parameters seems to indicate inclination of the symmetry axis if there is any.

f) Inhomogeneous harmonic plane waves in viscoelastic anisotropic media

A new way of specification of slowness vectors in viscoelastic anisotropic media, so-called mixed specification was proposed by Červený (2004). It allows simple determination of a slowness vector of an homogeneous or inhomogeneous wave in an arbitrary isotropic or anisotropic, perfectly elastic or viscoelastic medium. This is generally impossible with commonly used specification. Červený and Pšenčík (2003) used this specification to calculate, for example, phase velocities, attenuation, attenuation angle, particle motion diagrams for varying strength of inhomogeneity of a wave. It was shown that the inhomogeneous plane waves propagating in anisotropic viscoelastic media exhibit certain phenomena, not known from elastic anisotropic or viscoelastic isotropic media. For example, the inhomogeneous plane qP wave may propagate with the same phase velocity as one of inhomogeneous plane qS wave. It is also shown that the attenuation angles of inhomogeneous plane waves can attain values greater than $\pi/2$ even for very weakly inhomogeneous plane waves.

Effects of increasing strength of inhomogeneity (measured by the parameter *d*) of qP, qSV and SH wave in a symmetry plane of a transversely isotropic viscoelastic medium with vertical axis of symetry on the polarization are shown in the figure. The polarizations are calculated in each frame for




Variation of the polarization diagrams with propagation direction (within each frame) and with increasing inhomogeneity strength *d*.

varying direction of propagation. Red colour corresponds to the fastest wave (qP wave), the blue colour to the slowest wave (mostly qSV wave). Black colour is reserved for the intermediate wave (mostly SH wave). The most pronounced phenomenon is increased ellipticity of polarization with increasing *d*. Another interesting phenomenon is inrease of nonsymmetry of particle motion diagrams with respect to the axis of symmetry with increasing *d*. We can also see that for nonzero *d*, the slowest qSV wave becomes faster than SH wave along the axis of symmetry.

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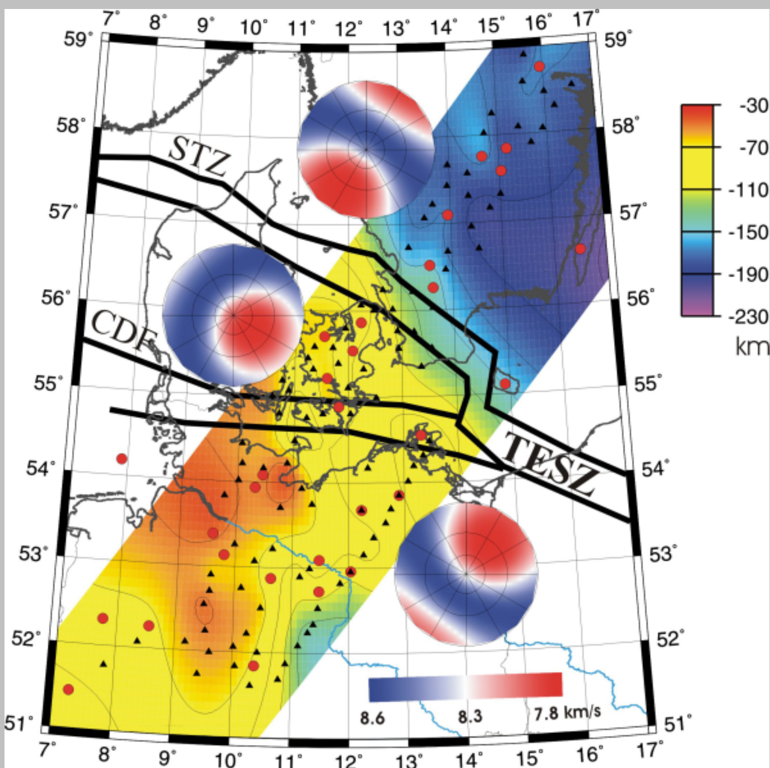
## Seismic anisotropy of the upper mantle

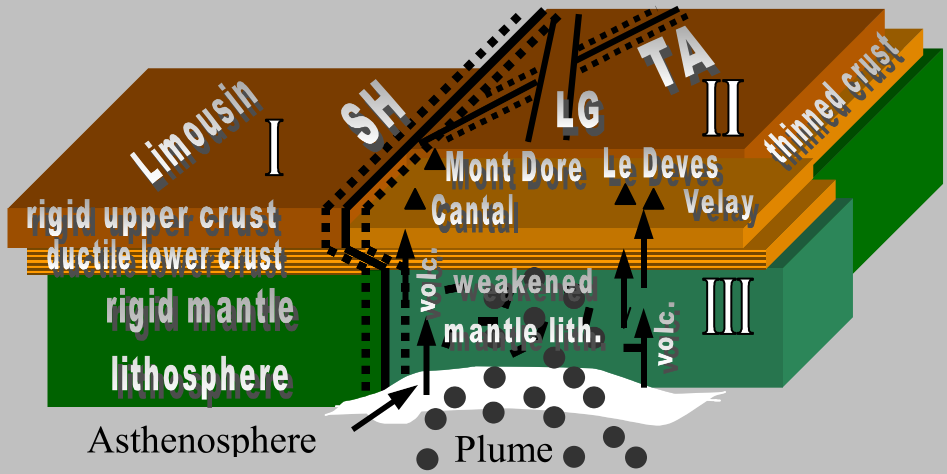
Research of the deep structure of the lithosphere-asthenosphere system is based on tomographic images of teleseismic body-wave velocities and a joint inversion of anisotropic data: P-residual spheres, fast shear-wave polarisation and split times. It was focused on the following regions: Trans-European Suture Zone around the transition from the southern Sweden to (a) Denmark and the northern Germany; (b) French Massif Central; (c) Bohemian Massif.

a) An international passive teleseismic experiment (TOR), traversing the northern part of the Trans-European Suture Zone (TESZ), recorded data for tomography of the upper mantle with a lateral resolution of few tens of km, as well as for a detailed study of seismic anisotropy (Plomerová et al., 2002). A joint inversion of teleseismic P-residual spheres and shear-wave splitting parameters retrieved 3-D orientation of dipping anisotropic structures in different domains of the sub-crustal lithosphere. We distinguish three major domains of different large-scale fabric divided by first-order sutures cutting the whole lithosphere thickness. The Baltic Shield north of the Sorgenfrei-Tornquist Zone (STZ) is characterised by lithosphere thickness around 175 km and the anisotropy is modelled by olivine aggregate of hexagonal symmetry with the high-velocity (a,c) foliation plane striking NW-SE and dipping to NE. Southward of the STZ, beneath the Norwegian-Danish Basin, the lithosphere thins abruptly to about 75 km. In this domain, between the STZ and the so-called Caledonian Deformation Front (CDF), the anisotropic structures strike NE-SW and the high-velocity (a,c) foliation dip to NW. To the south of the CDF, beneath northern Germany, we observe a heterogeneous and even thinner lithosphere with its base shallowing up to 55 km and anisotropic structures with high velocity dipping predominantly to SW. Most of the anisotropy observed at TOR stations can be explained by a preferred olivine orientation, frozen in the sub-crustal lithosphere. Beneath northern Germany, a part of the shear-wave splitting is probably caused by a present-day flow in the asthenosphere.

b) The lithosphere thickness and seismic anisotropy was studied from spatial variations of P-wave delay times and the shear-wave splitting observed at a dense network of mobile and permanent stations within the French Massif Central (MC). Three major lithosphere domains with different seismic anisotropy are distinguished (Babuška et al., 2002). A suture in the deep lithosphere limits the

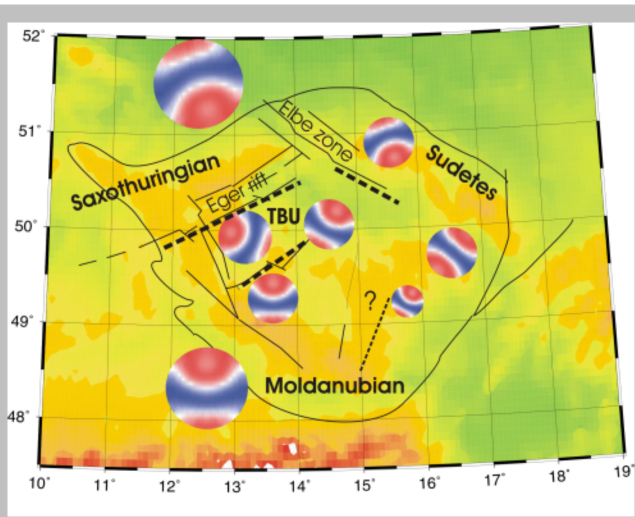



Lateral changes of the lithosphere thickness derived from the static means of relative P residuals across the Trans-European Suture Zone (TESZ), which divides the Precambrian Baltic Shield to the north-east from the Phanerozoic Europe to the south-west. Three major domains are characterised by different orientation of anisotropic structures in the mantle lithosphere, modelled by an olivine aggregate, in projection of lower hemisphere. Blue belts in the spheres indicate orientation of the dipping high-velocity (a,c) foliation plane, perpendicular to the low-velocity axis (red) of the hexagonal symmetry.

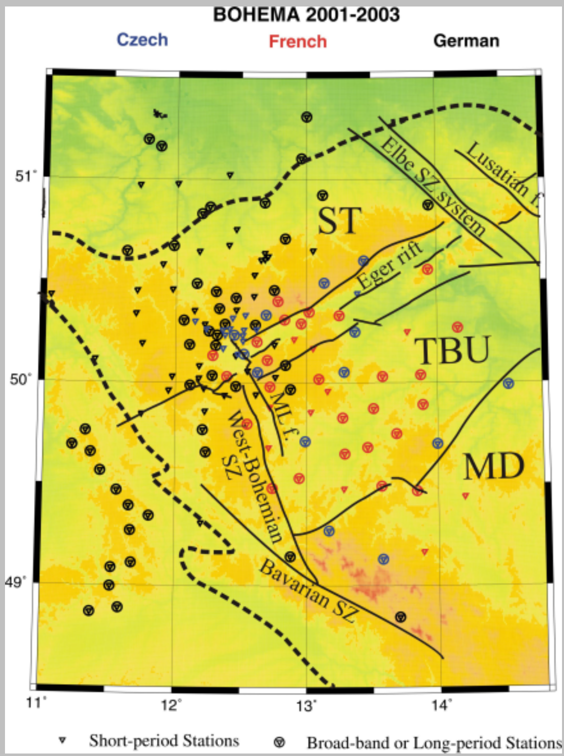



Schematic 3D sketch of the French Massif Central (MC) showing three lithosphere domains determined from seismic anisotropy. The suture between domains I and III, marked at the surface by the Sillon Houiller fault (SH), and its continuation to the north between domains I and II, marked at the surface by the Tauve-Aigueperse fault (TA), cuts the entire lithosphere, but its crustal and mantle parts are shifted. The thick and rigid mantle lithosphere of domain II was apt to rifting during the Cenozoic extension. On the other hand, a large part of the mantle lithosphere of domain III, which is less rigid above a mantle plume, thinned during the extension and its original fabric weakened. The reactivated (Variscan) mantle suture and peripheral parts of the weakened mantle lithosphere acted as a predisposition for creating open

100-140 km thick lithosphere of the Limousin (western MC), characterised by a consistent anisotropic pattern with high velocities (lineation corresponding to a maximum of olivine *a* axes of an orthorhombic aggregate) dipping to the west. The eastern MC, comprising two different domains with the lithosphere thinned to 60-80 km and a weakened mantle fabric in the southern domain. The mantle fabric in the eastern MC is modelled by a hexagonal olivine aggregate with the high velocities (a,c foliation) dipping systematically to the east. The mantle suture between the western and eastern MC parallels the major crustal boundary, the late Variscan Sillon Houiller (SH) transfer fault in the south and the Tauve-Aigueperse fault (TA) in the north, with an offset of 10-20 km to the east. The offset of the crustal and mantle parts of the same suture indicates that the rigid upper crust might be detached from the mantle lithosphere. We suggest that the mantle suture, hidden beneath an allochthonous crust, was reactivated during the Cenozoic extension of the weakened and thinned lithosphere in the south of the eastern MC and predestined a space for the major volcanism (Mont Dore, Cantal). The rigid northern domain, characterised by a thicker lithosphere with a well-preserved mantle fabric, reacted to the extension predominantly by rifting (e.g., the Limagne Graben, LG).




Tectonic sketch of the Bohemian Massif with a tentative model of orientations of anisotropic structures in the mantle lithosphere shown in projection of lower hemisphere. Blue belts indicate dipping high-velocity (a,c) foliation planes of olivine aggregate of hexagonal symmetry. TBU stands for the Teplá-Barrandian Unit.




Simplified map of the western Bohemian Massif with the BOHEMA network of seismic stations and major tectonometamorphic units: ST - Saxothuringian, TBU - Teplá-Barrandian Unit, MD - Moldanubian. SZ and f. are shear zones and faults, respectively.

c) Data for studying deep structure of the lithosphere of the Bohemian Massif (BM) were recorded by a portable array of digital three-component stations operating in the region for 8 months within the co-operation between the geophysical institutions in Prague and Strasbourg (project MOSAIC, 1998-2000). Velocity anomalies are strongly affected by dipping anisotropic structures within the mantle lithosphere. There are also distinct lateral variations of the shear-wave split time δt and the fast shear-wave azimuths. While in the western and central parts of the BM a large δt and a general E-W orientation of the fast split wave prevail, in the eastern part the δt is smaller and the fast polarisation rotates to the WNW-ESE direction. The mantle lithosphere of the BM appears to consist of at least three domains characterised by different orientations of the large-scale fabric. While in the Saxothuringian and Sudeten parts of the BM the (a,c) foliations dip prevailingly to the NW, in the Moldanubian part they dip to the S. Boundaries of the units are characterised by no or small shear-wave splitting, as well as by small values in the P-residual spheres.

The BOHEMA project team, formed by scientists from 10 institutions of the Czech republic, Germany and France (Babuška et al., 2003), will try to answer the question about a possible existence of a thermal plume beneath the western BM around the crossing of the Eger Graben (EG) with the Mariánské Lázně Fault (MLF). A dense network of stations, consisting of 61 permanent and 84 temporary stations, has been deployed to operate from 2001 to 2003. The array was centred in the geodynamically active part of the western Bohemia. A three-dimensional anisotropic tomographic model will be one of major results of the experiment. Special attention will be paid to spatial variations of the $v_P/v_S$ ratio with the aim to map concentrations of fluids, which probably play an important role in triggering the earthquake swarms, which periodically occur in the region. The resulting geodynamic model of the lithosphere-asthenosphere system, based on all available geophysical, geological and petrological data, will shed light on possible causes of earthquake swarms, as well as on a deep-seated source of the numerous $CO_2$ and He gas emanations.

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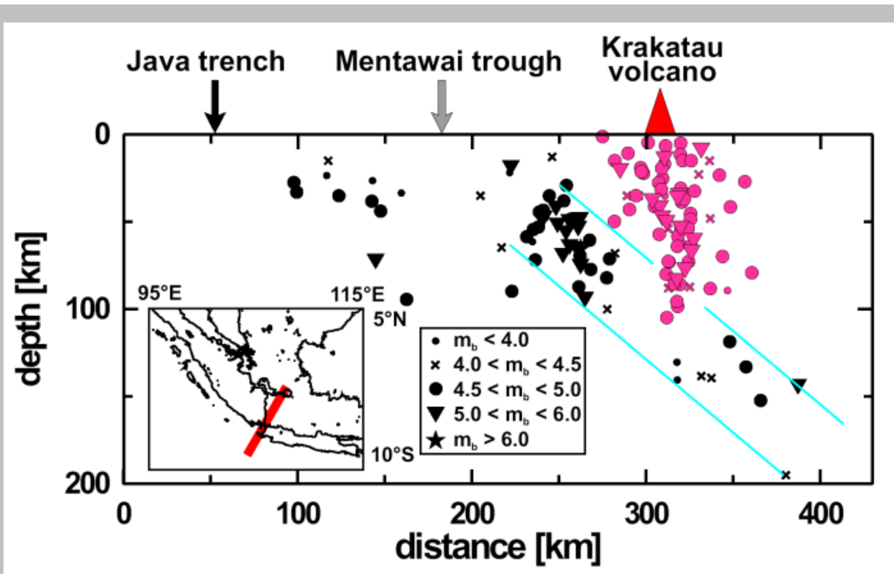
## Deep structure, seismotectonics and volcanism of convergent plate margins

Systematic investigation focused on the geometry of distribution of earthquake foci at different convergent plate margins, based on ISC data relocated by Engdahl et al. (1998), served as the major tool for solving the following key problems related to the process of subduction: (a) interpretation of a unique seismicity pattern below and around the Krakatau volcano, (b) application of the seismicity pattern below active volcanoes of different subduction domains for finding the source region of calc-alkaline volcanoes, (c) solution of the origin of the intermediate depth seismicity of the Peruvian 'flat slab", (d) interpretation of the strip of earthquakes in the vicinity of the Java and Sunda trenches in terms of the cyclic course of the subduction process.

a) We have found a very well developed cluster of earthquake foci below Krakatau volcano. This cluster, clearly separated from earthquake foci belonging to the Indonesian Wadati-Benioff zone, consists of 77 events within the magnitude (mb) range 4.0-5.3 which occurred in the period 1964-99. The existence of an uninterrupted column of earthquakes down to the upper boundary of the subducting slab at a depth of 100 km is evidence for brittle character of the continental wedge below the Krakatau volcano. This fact casts doubt on the existence of large-scale melting of the mantle material in the lithospheric wedge above the subducting slab and favours the concept of the generation of primary magma for Krakatau volcano within the aseismic gap observed in the subducting slab. We suppose that the material generated in the partially melted aseismic gap of the slab, advancing towards the surface, may serve as trigger of earthquakes.

b) The case of Krakatau pointed to the possibility of using the seismicity pattern at volcanically active convergent plate margins for solution the problem of source region of calc-alkaline volcanism. In order to support the concept of generation of primary magma inside the subducting slab or in the overlying continental wedge we investigated several active volcanoes from different convergent plate margins. The study of seismicity pattern below and around the active volcanoes Korovin, Cleveland, and Makushin (Aleutian arc), Yake-Dake (Japan arc), Oshima (Izu-Bonin arc), Lewotobi (Sunda arc), Fuego (Middle America arc), Nisyros (Aegean arc) and Montagne Pelée (Lesser Antilles arc) demonstrated that an aseismic gap in the Wadati-Benioff zone directly below all above named volcanoes occurred, but that the occurrence of a seismically active column below individual volcanoes in the overlying continental wedge might be present or absent (Špičák et al., 2004a,b). Also the systematic study of all Central American active volcanoes demonstrated that the existence of an aseismic gap in the Wadati-Benioff zone represented the necessary condition for the occurrence of




Verical section across the Java trench giving the distribution of earthquake foci under Krakatau volcano, Indonesia. Section azimuth 30°, section width 55 km. Hypocentral determinations of the International Seismological Centre (Regional Catalogue of Earthquakes 1964-1999) relocated by Engdahl et al. (1998).

calc-alkaline volcanoes. The occasionally occurring seismically active column in the wedge above the subducting slab does not support the general concept of generation of magma in the mantle overlying the subduction zone.

c) Detailed investigation into the geometry of distribution of earthquake foci in the region of Andean South America between 6˚S and 12˚S resulted in the presentation of an alternative interpretation of the so-called 'flat slab". This phenomenon, represented by an almost horizontally distributed strip of earthquake foci in the depth around 100 km, is generally explained as a continuation of the subducting oceanic lithosphere (Špičák et al., 2004c). Application of the concept of the cyclic course of Andean subduction process, finding of an expressive aseismic region between the normally inclined slab and the 'flat slab", and the deep seismic activity exclusively below this Peruvian domain, allowed us to interpret the horizontal strip of earthquakes as a result of activation of the upper part of fossil slabs, buried in the upper mantle, by its collision with the lowermost part of the westward moving South American plate.

d) The study of the geometry of distribution of earthquake foci in 35 vertical sections perpendicular to the Java trench and 18 sections perpendicular to the Sunda trench allowed us to differentiate the earthquake foci that cannot spatially belong to a well defined Indonesian Wadati-Benioff zone. These earthquakes are grouped in a 50-100 km broad discontinuous strip parallel to the corresponding trench. This strip of earthquakes occurs directly in the trench or in its immediate vicinity. Its significant feature is a division into segments 50 to 300 km long. In the region of Java five segments, in the region of Sunda arc between 111˚E and 122˚E seven segments were delimited. The shallow depth of the earthquakes in this near-trench strip and their isolated occurrence in the distance of 100-150 km from the projection of the upper boundary of the Wadati-Benioff zone on the surface seem to indicate the initial stage of a new subduction cycle, starting to penetrate into the upper mantle in front of the present subduction zone.

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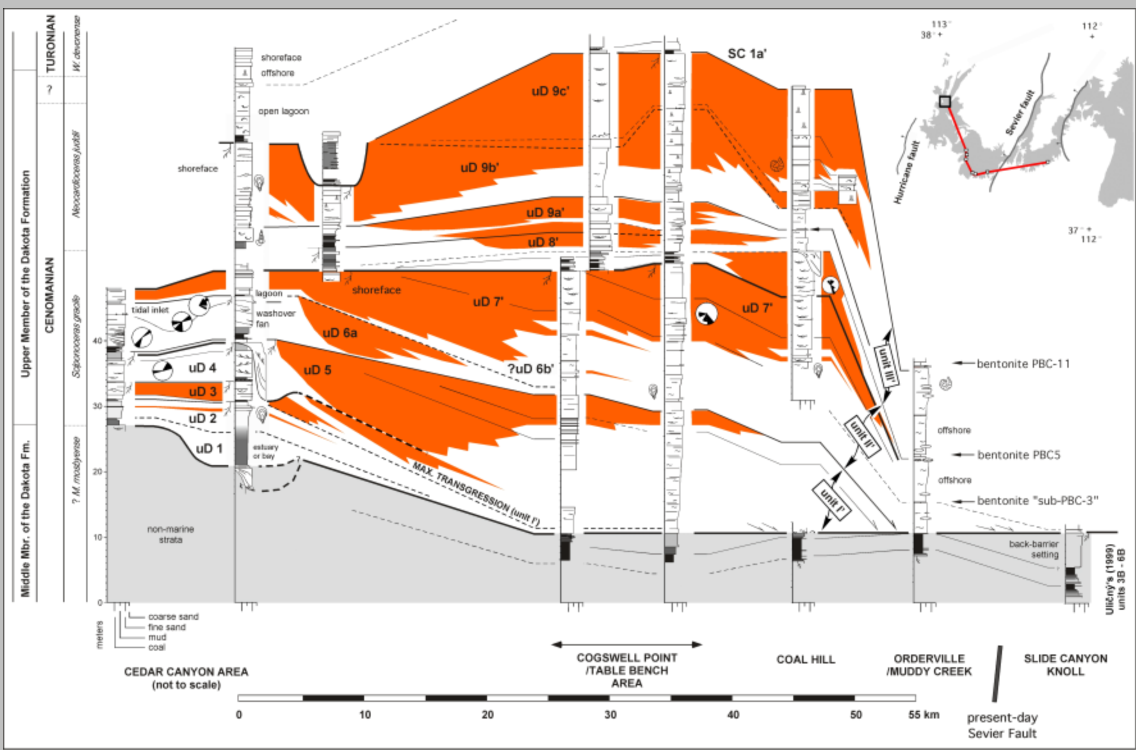
## Sequence stratigraphy of the Upper Cenomanian to Lower Turonian of the Western Interior Basin, southwestern Utah: keys to structural history of foreland basin and sea levels in greenhouse climate

Current research in the Upper Cretaceous infill of the Western Interior Basin of North America represents a continuation of earlier work by the members of the Sedimentary Basins Group (Uličný, 1999; Laurin and Sageman, 2001). The aim of the ongoing research efforts is generally twofold: (i) to improve the understanding of the tectonic evolution of the basin by studying the interaction of the fluvial and shallow-marine depositional systems with the evolving structures of the retro-arc foreland basin system, and (ii) to help unravel the record of Cenomanian through early Turonian relative sea-level changes, which may contain evidence of orbital-driven eustasy during the peak Cretaceous greenhous interval. The study is based based on high-resolution sequence stratigraphy of this interval of the Western Interior as well as on numerical modelling of stratigraphy.

The western margin of the U.S. Western Interior Basin in the area of present-day southwestern Utah experienced relatively high rates of both long-term relative sea level rise and sediment input during late Cenomanian and early Turonian time. As such, the area provides a remarkably sensitive and detailed record of relative sea level changes for this climatically and oceanographically distinct interval of Earth's history.

A combination of outcrop sedimentology and well-log and outcrop-based sequence-stratigraphic correlation of marginal to shallow-marine strata suggests that the uppermost Cenomanian interval (*Sciponoceras gracile* and *Neocardioceras juddii* Zones), which represents approximately 500 kyr, records three hierarchical orders of relative sea level change in southwestern Utah. The highest order of the relative sea level change is represented by a long-term (3$^{rd}$-order) sea level rise, which culminated during or soon after the Early Turonian *V. birchbyi* Zone. The two lower orders of Cenomanian sea level change fall within the Milankovitch band (the maximum average durations of the lowest-order sea level cycles range from 25 to 90 kyr). In spite of being relatively poorly represented in our data, partly due to syndepositional tectonic deformation of the proximal foredeep, the Turonian interval (*Watinoceras devonense* through *Mammites nodosoides* Zones) displays transgressive-regressive cycles with estimated durations that overlap the long-eccentricity orbital component.

The timing and hierarchy of the interpreted relative sea level changes are strongly suggestive of Milankovitch-driven eustatic forcing. However, the nearshore sedimentologic and stratigraphic data analyzed so far do not allow us to completely reject the alternative hypothesis of tectonic forcing of the relative sea level history. Further support for the Milankovitch hypothesis must come from a direct comparison of the nearshore record with the coeval, Milankovitch-controlled hemipelagic succession of the Bridge Creek Limestone.




Stratigraphic cross-section showing Cenomanian-Turonian shallow-marine succession of the proximal part of the Sevier foreland basin (Utah, U.S.A.). Transgressive-regressive units uD1 through uD9c formed due to short-term oscillations in relative sea level, which can be attributed to climatic oscillations related to the Milankovitch cycles of axial precession (quasi-period 20 kyr). Units I' through III' represent longer-term (~ 100 kyr) sea level oscillations. The marked westward thinning of unit uD9c is interpreted to record an uplift of the proximal foredeep due to a blind-thrust emplacement during an eastward approach of the Sevier thrust belt.

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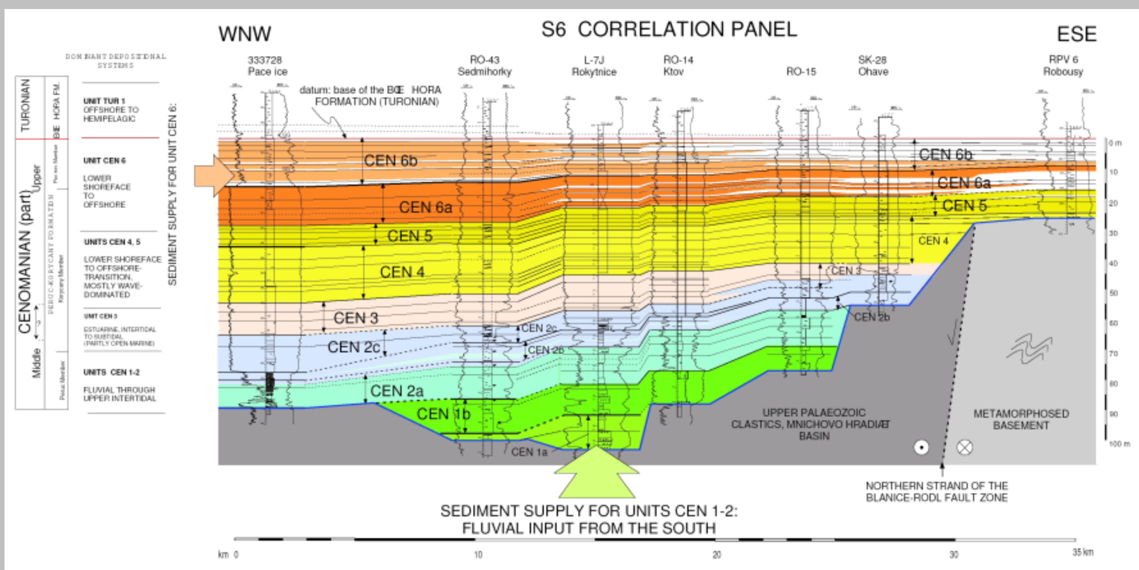
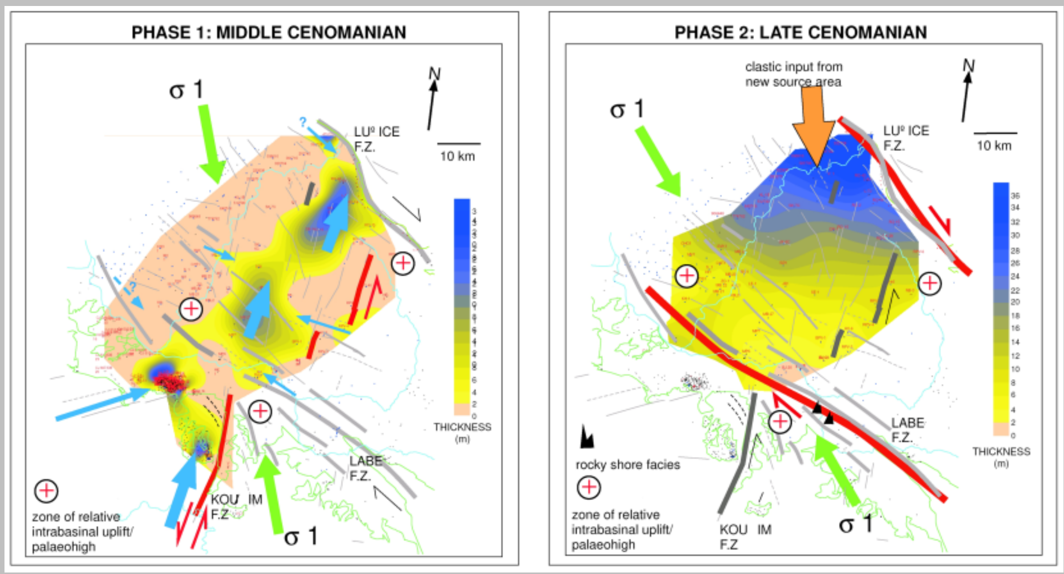
## Stratigraphic architecture of Cenomanian strata of the Bohemian Cretaceous Basin: relationships of depositional systems and reactivation of basement fault zones

The aim of the project is to reconstruct the kinematic evolution of the reactivated basement fault zones during the initial phase of filling of the Bohemian Cretaceous Basin, which occupies the Elbe Zone, a major crustal weakness of Central Europe. The basin began to form during the Cenomanian time (c. 99-93.5 My), and the earliest deposits are represented by fluvial, estuarine and shallow-marine strata (e.g. Uličný and Špičáková, 1996). The project is expected to shed light on the relationships between sedimentation and the kinematic evolution of an intracontinental strike-slip basin, and to help link the events in the basins of the Alpine foreland and the processes within the orogen.

In 2002 and 2003, acquisition of geophysical data (gravity maps, well logs) and sedimentological data took place, followed by detailed genetic-stratigraphic correlation of Cenomanian units in the central and east-central parts of the basin. Individual genetic units were defined based on the detailed genetic-stratigraphic framework of the depositional system. 2D correlation sections and isopach maps




An example of high-resolution genetic stratigraphic correlation of Cenomanian strata in the north-central part of the Bohemian Cretaceous Basin. The lower part of the cross-section shows (in green and blue) fluvial strata of units CEN1 and CEN2, deposited in a palaeovalley that followed the Rodl Line trend (approximately normal to the line of cross-section). Note the eastward-thinning and muddying wedges within Late Cenomanian unit CEN 6; these prograding wedges recorded the onset of subsidence in a new depocentre along the Lužice Fault Zone, and of sediment supply from the emerging uplift to the north of this fault zone. The correlation is hung on the Cenomanian-Turonian boundary as the datum.




Simplified kinematic interpretation of the evolution of the conjugate system of the Elbe Fault System (WNW trending) and the Rodl Line system (NNE trending), based on representative isopach trends of units CEN 1 (Phase 1, left) and CEN 6 (Phase 2, right). Green arrows mark the interpreted orientation of principal horizontal stress. Blue arrows: river palaeoflow direction;  orange arrows: direction of shallow-marine sediment input.

constructed for each unit, together with fault systems interpretations based mainly on gravimetric and geological maps, allowed to interpret movement within the fault systems at time resolution of tens of ky.

Current results show that the earliest stage of the Cretaceous deposition in the region (Middle Cenomanian) was characterized by fluvial infills of palaeovalleys supplied from the S-SW and controlled mainly by the NNE–trending, sinistral  Blanice-Rodl fault system (conjugate to the NW-trending faults of the Elbe Zone). This stage was followed by a transition towards an estuarine system resulting from further flooding of the palaeovalley system, and, finally, towards widespread shallow-marine deposition in a setting of generally uniform subsidence rates, with the exception of several intra-basinal palaeohighs. During this time, the clastic input from the southern-southeastern source areas, which dominated the initial fluvial phase, decreased. A marked change in stratigraphic geometries occurred during the Late Cenomanian when a new depocenter formed along the WNW-trending Lužice Fault Zone, sourced from a block uplifted along the northern margin of this zone. This led to formation of a new basin-fill geometry dominated by a wedge of shallow-marine sandstones prograding from the active marginal faults of the Lužice Fault Zone and thinning towards the S-SE, accompanied by a rapid flooding of remaining local source areas within the basin. This change is interpreted as due to an increased rate of dextral displacement along the Elbe Fault System, which prevailed during the rest of the basin lifetime.

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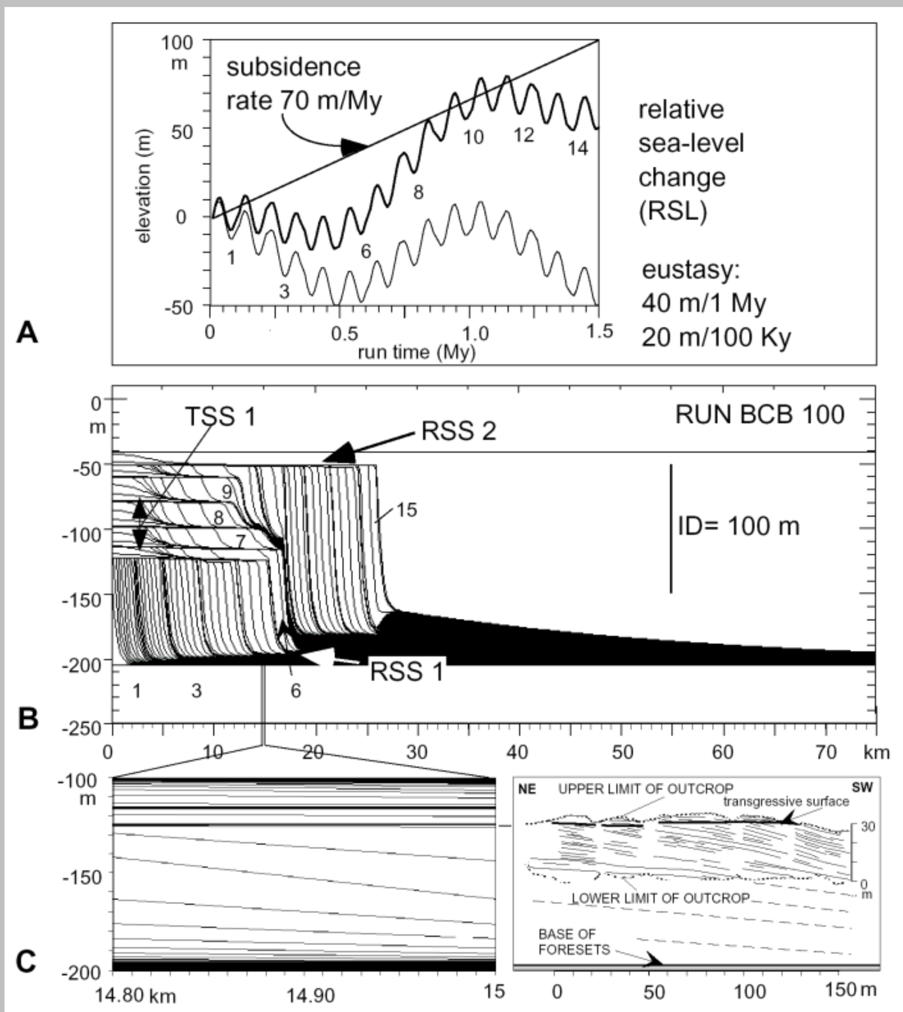
## Controls on basin-fill architecture in intra-continental extensional and strike-slip basins: examples from the Cretaceous and Neogene, Bohemian Massif

The research project, involving sequence-stratigraphic analysis and numerical modelling, aims to contribute to the knowledge of three-dimensional aspects of sedimentary basin infill styles, especially with respect to fault-bounded, tectonically active basins. The main focus of the research is on the controls on sedimentary geometries and stacking patterns of clastic, mainly deltaic, depositional systems, and their relationships to linked depositional settings such as hemipelagic offshore or lacustrine realms. The depositional geometries are studied in two intracontinental basin systems of the Bohemian Massif: the Bohemian Cretaceous Basin and the Eger (Ohře) Graben.




(A) Parameters of a conceptual model used to simulate the stacking pattern of the late Turonian-early Coniacian deltaic succession, after Uličný et al. (2002). Relative sea-level change produced by combining the subsidence rate of 70 m.Ma$^{-1}$ with an arbitrary, composite sea-level change curve. Numbers 1-14 denote the lowstands of the short-term sea-level cycles superimosed on the long-term sea-level curve. (B) A forward stratigraphic model run (BCB100) simulating a simplified geometry of the deltaic sequences. Initial depth (ID) before onset of deposition was 100 m. RSS, TSS - regressive and transgressive sequence sets, respectively. 127x vertical exaggeration, time line interval 10 ky. (C) A closeup view, without vertical exaggeration, of the architectures of high-frequency sequences generated by the run BCB 100, in a location along depositional dip that approximately coresponds to that of the Plakánek Valley outcrop. A drawing of the outcrop section is shown for comparison, with the subsurface part interpreted from borehole data, and underlying mudstones shown in grey colour. Time line interval in the model is 2 ky.

Some of the main problems addressed are the following:

- How did the interplay between sea/lake-level change, change in sediment supply and carbonate productivity affect the stacking patterns of delta bodies and coeval offshore strata?
- How did the generally low subsidence rates, coupled with block faulting in both basins influence the short-term (10's-100's ky) and long-term (My) dynamics of the depositional systems and the resulting sequence-stratigraphic signatures?
- What was the relative importance of tectonic subsidence and sediment load (compaction) - driven subsidence in creating accomodation in the Eger Graben basins? Can the compactional phenomena influence the stratigraphic architecture on basinal scale?
- How did the differences in hydraulic processes governing the delta behaviour in marine and lacustrine conditions influence the depositional geometries? And what was the role of marine (tidal, storm-induced) currents and lacustrine water circulation in modifying basinwide stratal patterns?

Uličný et al. (2002) focused on modelling the effects of the interplay between a cyclical relative sea-level change of two frequency orders and the faulted basin-margin topography. The 'initial depth" controls the geometry of the first stratal units deposited at the basin margin and thus modifies the response of the depositional system to subsequent, syndepositional changes in accommodation. In the simplified cases modelled using parameters based on early Coniacian deltas from the Bohemian Cretaceous Basin, it is the relationship between the initial depth and the net increase in depth over the interval of a relative sea level cycle that governs long and short term stacking patterns. Variations in stacking pattern caused by different initial depths could be misinterpreted as due to relative sea level or sediment supply changes and it is necessary to consider initial bathymetry in modelling and interpretation of stacking patterns, especially in fault-bounded basins.

Laurin and Uličný (2004) interpret the controls on cyclic and secular changes in a shallow-water hemipelagic system of the Bohemian Cretaceous Basin, linked to a coeval nearshore siliciclastic system. Several scale orders orders of hemipelagic rhythms are interpreted to reflect coupled, reciprocal changes in mud and/or freshwater inputs and carbonate production that followed transgressive-regressive movements at the adjacent coast. Spectral analyses of gamma-ray signatures of the hemipelagic strata suggest that the higher-order cycles were driven by the Milankovitch cycles of eccentricity (c. 100 and 400 ky, respectively). A secular onset of carbonate-dominated conditions in the distant part of the basin is interpreted to reflect an increase in the background carbonate production in the basin due to a geographically and/or climatically induced change in circulation and associated acceleration of water-mass exchange with the pelagic-carbonate factory of northwestern Europe.

Exposure in the Bílina open-cast lignite mine in the Eger Graben shows the internal architecture of a steep-faced, "Gilbert-type" , mouth bar of the Miocene Bílian Delta. The syndepositional tilting detectable in the convergence of strata towards the left, is due to a combination of compaction of underlying peat and clays and probably also an upward propagation of the Bílina Fault (just beyond the left-hand edge of the photograph). Person (centre) for scale.

The studies of basin-fill architectures in the Most Basin of the Eger Graben (Rajchl et al., 2002; 2003) underline the role of compaction of peat underlying and surrounding deltaic and fluvial clastic systems, as the main control on rate of creation of accommodation, significantly faster than the tectonic subsidence rate at the basin-bounding normal and oblique-slip faults.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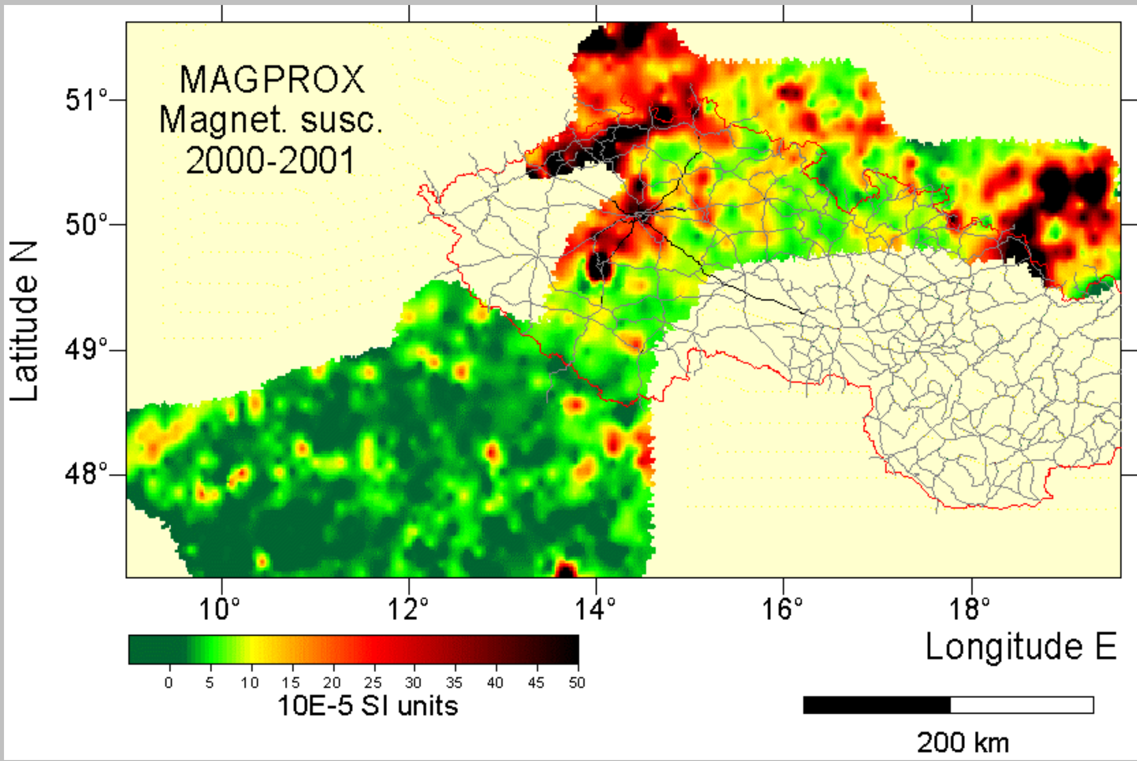
## Environmental rock magnetism

Soil represents interface between solid lithosphere on one side, and atmosphere, hydrosphere and biosphere on the other. It is formed by long-lasting weathering of rock basement through physical and chemical processes, resulting from interactions with atmosphere, hydrosphere and biosphere. Soil is thus rich in minerals of various origin, either primary, derived directly from the lithosphere weathering, or secondary, resulting from diagenetic transformations in the soil. Moreover, soil acts as natural sink of atmospherically deposited dust particles, buffering them from penetration to ground waters. Possible mechanisms of magnetic enhancement of soils due to increased concentrations of secondary ferrimagnetic minerals are discussed in, e.g., Maher and Taylor (1988), Stanjek et al. (1994) and Singer et al. (1996). Besides pedogenic and biogenic processes, atmospherically deposited ferrimagnetic particles of anthropogenic origin contribute to a great deal to concentration-dependent magnetic properties of soils (e.g., Kapička et al., 2001, 2003).

Among soil minerals, magnetic particles (in particular iron oxides and sulphides) play important role. In our research, we focus on soil iron oxides, their origin and fate, and methods of identification. This knowledge is crucial in interpreting various magnetic anomalies observed on, or above the Earth’s surface. For instance, atmospherically deposited industrial fly ashes, rich in iron oxides, accummulate in surficial layers and can be detected by surface measurements of soil magnetic susceptibility. However, this interpretation is obscured in cases with strong lithogenic contribution. Therefore, anomalies in spatial distribution of surface soil magnetic susceptibility require much more detailed investigation in order to validate and justify the above assumption.

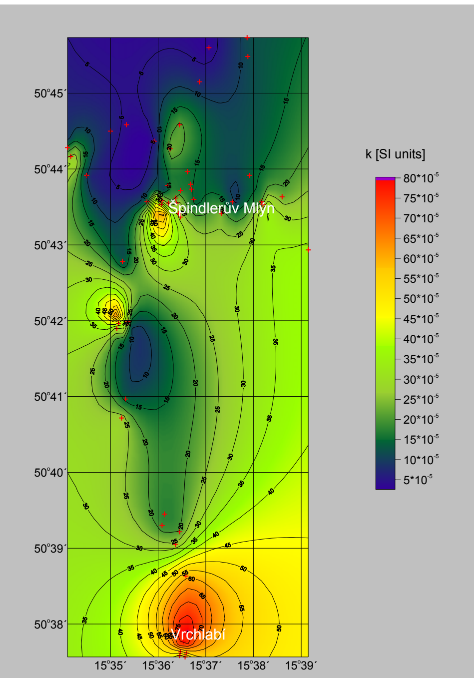
Present instruments and methods enable very sensitive determination of concentration of strong ferrimagnetics (for instance magnetite), in the order of ppm. Magnetic properties of soils have been recently beneficially used in examining industrial pollution. Methods of ‘environmental magnetism’ are sensitive and enable detection of small changes in concentration of magnetic particles in soils (e.g., Petrovský and Ellwood, 1999). Deposited dust of anthropogenic origin comprises high portion (5-10%) of highly (ferri)magnetic particles, produced primarily during combustion of fossil fuels containing pyrite. Dissociation and oxidation processes during combustion form ferrimagnetic iron oxides from Fe ions. Resulting anthropogenic magnetite ($Fe_3O_4$) or maghemite ($\gamma$-$Fe_2O_3$) form specific spherules with diameter from several micrometers to several tens of micrometers and their magnetic properties are different from particles of lithogenic origin. Besides combustion, industrial magnetic particles also result from, e.g., steel and cement industry and from road traffic (e.g., Petrovský and Ellwood, 1999).




Magnetic susceptibility of top soil layers over central European region.

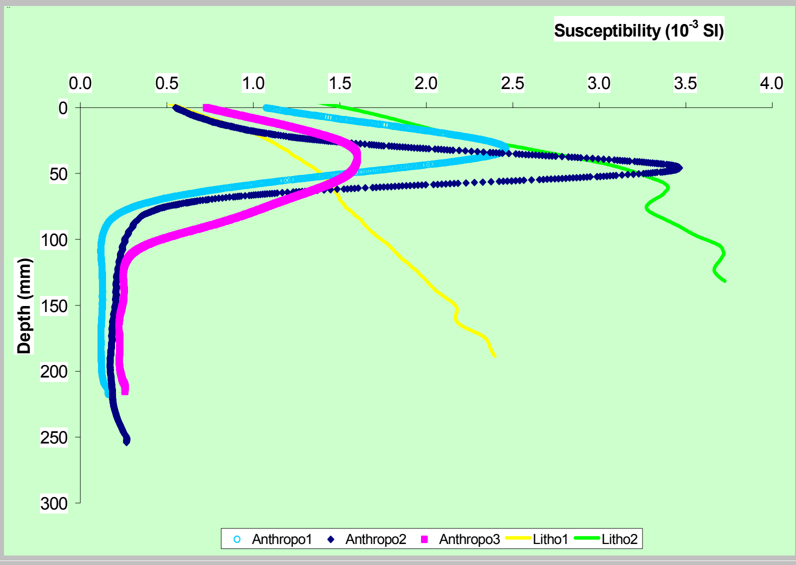
Magnetic susceptibility represents one of major parameters indicating concentration of (ferri)magnetic particles in soils and sediments. Magnetic mapping (measurements of magnetic susceptibility of top soil layers) can be thus used as fast, effective and low-cost method approximate determination of contamination of soils due to atmospheric deposition of pollutants. In case of undisturbed soils this magnetically enhanced layer reaches depths of some 5-10 cm. In particular, the method can be advantageously used in outlining hot-spots for further (more expensive and time consuming) chemical analysis of contaminated soils.

In our contribution, a method of magnetic mapping of anthropogenic pollution will be introduced using a review of our recent case studies. Magnetic susceptibility of contaminated top soils was measured in situ using a portable loop-shaped hand probe Bartington MS2D. Since these measurements are fast and easy, large data sets can be obtained on any grid of measuring points over the area in concern. The data are represented in a form of 2-D maps, delineating magnetic susceptibility of top soils. In order to determine the undesired effect of basement rock (lithogenic contribution), magnetic parameters in dependence of depth were studied on selected sites to depths of 30-60 cm.




Magnetic susceptibility of top soil layers around local sources of pollution in the Krkonoše National Park.

Measurements of soil magnetic susceptibility were used to delineate areas contaminated by a strong local source – brown-coal burning power plant in Czech Republic (Kapička et al., 1999). High values of magnetic susceptibility were observed within 20 km off the power




Comparison of different types of vertical distribution of magnetic susceptibility in soils.

plant, with strong maximum at the very neighbourhood of the power plant. At larger distance, magnetic susceptibility was significantly lower, except for other maxima linked to another pollution sources. In directions without these local sources, magnetic susceptibility typically decreased following exponential behaviour. Limits of contamination due to deposition of dust produced by the power plant were found at distance of 5-7 km.

Magnetic mapping can be also applied in areas with comparatively low contamination levels, with concentration of anthropogenic ferrimagnetic particles in soils much lower than in the neighborhood of major pollution sources. On the basis of in-situ and laboratory measurements, it was proved that anthropogenic ferrimagnetic particles are unambiguously the reason of increased values of magnetic susceptibility of soils in Krkonoše National Park. Spatial distribution of magnetic susceptibility in this region outlines areas of increased soil contamination, resulting from local pollution sources (see the contour map on previous page). Large-scale mapping of topsoil magnetic susceptibility over Central Europe was carried out within 5FP EU Project MAGPROX (EVK2-CT-1999-00019). Contrast in magnetic susceptibility can be interpreted in terms of lithogenic, anthropogenic or combined contributions, mainly using vertical distribution of magnetic susceptibility measured on soil cores or in situ (using a newly developed SM400 susceptibility meter), and using other laboratory methods (e.g., geochemical analysis). The plot above shows typical vertical distribution of susceptibility, with magnetically enhanced layers due to atmospheric deposition of dust particles, dominant lithogenic contribution, and ploughing boundary layer, respectively.

Magnetic method, once correlated with concentrations of heavy metals at specific site, can serve as fast and low-cost tool for approximate screening and monitoring the pollution load.

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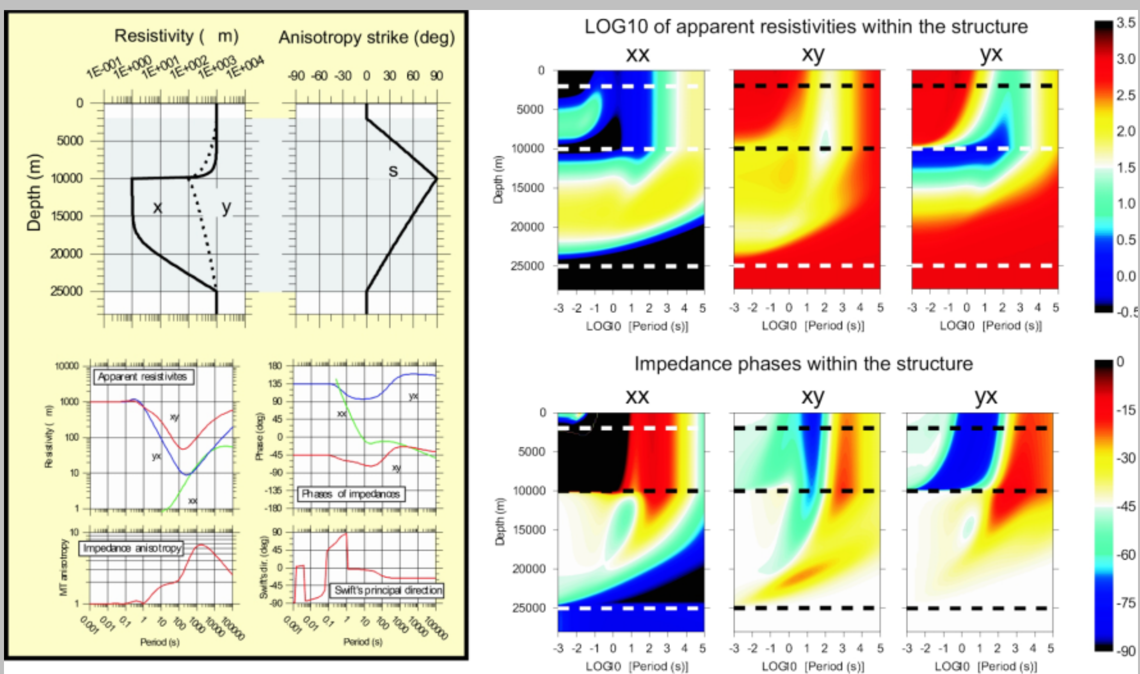
## Electromagnetic depth soundings

Structures with marked electrical anisotropy present suitable models of intricate fracture and suture zones and complex geological environments where several strikes may affect the electromagnetic data simultaneously. Recently, we have concentrated on developing modelling and inversion tools for anisotropic magnetotelluric models both in horizontally homogeneous and inhomogeneous media, as well as on analyzing effects of the electrical anisotropy of simulated earth's structures on the electromagnetic induction data.

For laterally homogeneous arbitrarily anisotropic media, the theory of the propagation of electromagnetic waves has been generalized to models with spatially non-homogeneous source fields, and to structures in which the elements of the conductivity tensor are represented by piecewise smooth functions of depth. Unlike the classical matrix propagation method for layered media, our approach is based on solving a system of generalized Riccati equations, derived in the wave number domain, for the depth variations of the spectral impedance elements within the medium. By Fourier synthesizing the wave number results, we can obtain solutions to the direct induction problem for arbitrary configurations of primary sources, e.g. for particular tasks in the geoelectrical exploration, as well as for estimating effects of finite source geometry on long period electromagnetic soundings for anisotropic mantle models (Kováčiková and Pek, 2002a, b; Pek 2002).

On proceeding towards a 1-D inversion for generally anisotropic conductivities, we have extended

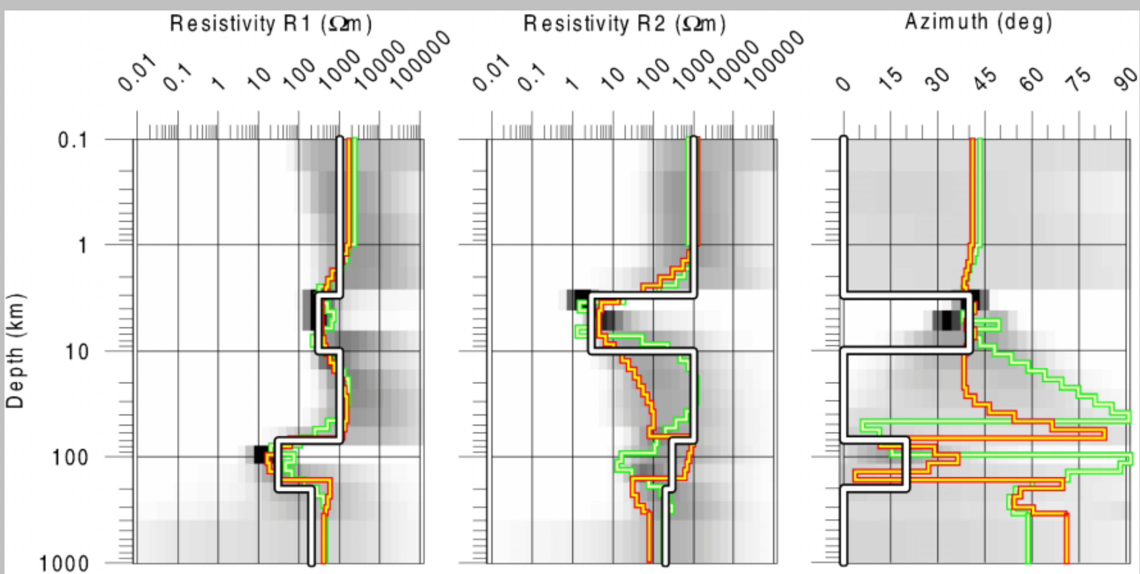



Period and depth dependence of the apparent resistivities and impedance phases obtained by the solution of a generalized Riccati system for a model with piecewise smoothly varying principal resistivities $\rho_x$, $\rho_y$ and anisotropy strike $\alpha_s$

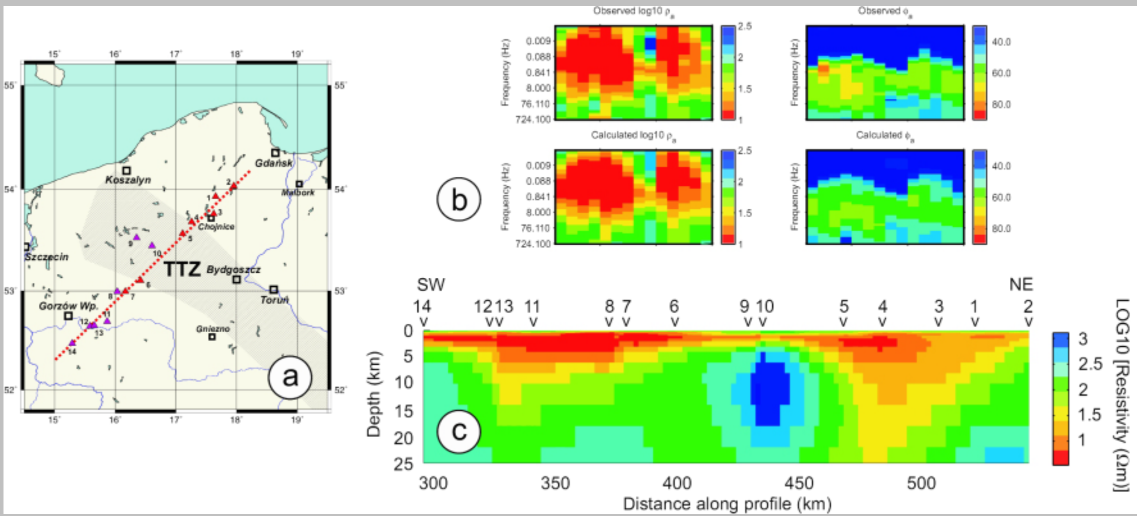
the algorithm for the direct magnetotelluric problem to further provide numerically stable parametric sensitivities of the magnetotelluric functions with respect to the parameters of the variable anisotropic conductivity within the model (Pek and Santos, 2002). On this basis, we have developed a 1-D Occam inversion procedure for anisotropic layered media. With regard to specifics of the earth's electrical anisotropy, which does not necessarily conform the standard concept of a minimum roughness of the recovered model, various approaches to the regularization of the inverse problem have been tested, including non-smooth regularization penalties, as well as multi-criterium optimization techniques aimed at minimizing the spurious anisotropy within the inverse model (Pek and Santos, 2003). Alternatively, stochastic inference procedures may be used with advantage to recover models with distributed anisotropy, where complex ambiguity and cross-correlation patterns may prevail. Though simple global optimization methods, like controlled random search or differential evolution, mostly failed to converge to the true parameters in simulated inversion runs, most likely due to an excessive number of the model parameters involved, we could observe very good performance of the Markov chain Monte Carlo (MCMC) procedure on recovering the distribution of the model parameters and assessing their significance within the geoelectrical section.

The main targets of our recent experimental activities have been broadband magnetotelluric studies in the West Bohemia-Vogtland seismo-active area and across the Teisseyre-Tornquist Zone (TTZ) in Poland. While magnetotellurics in the former region could not penetrate deep enough to properly sample the earthquake focal zone, mainly due to excessive cultural noise, and tentative recordings with a long-offset remote reference have only been initiated, first electrical modelling results have been already obtained from the latter area.

TTZ represents a Polish segment of the Trans-European Suture Zone (TESZ), a first-order contact zone separating the Phanerozoic and Proterozoic parts of Europe. Within the international initiative EMTESZ, assuming magnetotelluric studies of TESZ along several transects, preferentially coinciding with recent seismic refraction profiles in Poland, we carried out the first pilot magnetotelluric measurements within the period range of $10^{-3}$ to about $10^{3}$ s across the northwestern part of TTZ in Pomerania, NW Poland, in 2001, 2002. A thick sedimentary cover, with a pronounced conductivity maximum at very shallow depths of several hundreds meters to few kilometers, screens deeper crustal structures effectively off. Therefore, long period magnetotelluric soundings to periods as long as $10^{4}$ s have been suplied at selected sites by colleagues from the IG PAN, Warsaw. The preliminary




Comparison of 1-D inversion results for a synthetic layered anisotropic model with two anisotropic layers situated at different depths in the crust and upper mantle (empty line). Color lines show Occam inverse models for only the standard rougness penalty applied (red-yellow line), and for additional penalization of the anisotropy within the structure (green-yellow line). The gray shade map on the background visualizes the marginal probabilities of the model parameters obtained from the MCMC sampling.




Location of AMT/MT sites along a profile across the TTZ in Pomerania, NW Poland. (b) Profile pseudosections of the observed and modelled magnetotelluric resistivities and phases derived from the determinant of the impedance tensor. (c) Resistivity section beneath the profile across the TTZ obtained by a 2-D Occam inversion of the determinant of the impedance tensor. (Results of the Occam inversion kindly provided by M. Smirnov, Univ. Uppsala, Sweden).

interpretation indicates that the inhomogeneous structures of the sedimentary cover and/or crust can reach as deep as 15 to 20 km down beneath our profile. The conductance shows a high degree of apparent anisotropy and, perhaps, a 2-D model has to include a resistive uplift within the TTZ to explain the observed split of the perpendicular and parallel magnetotelluric resistivity and phase curves.

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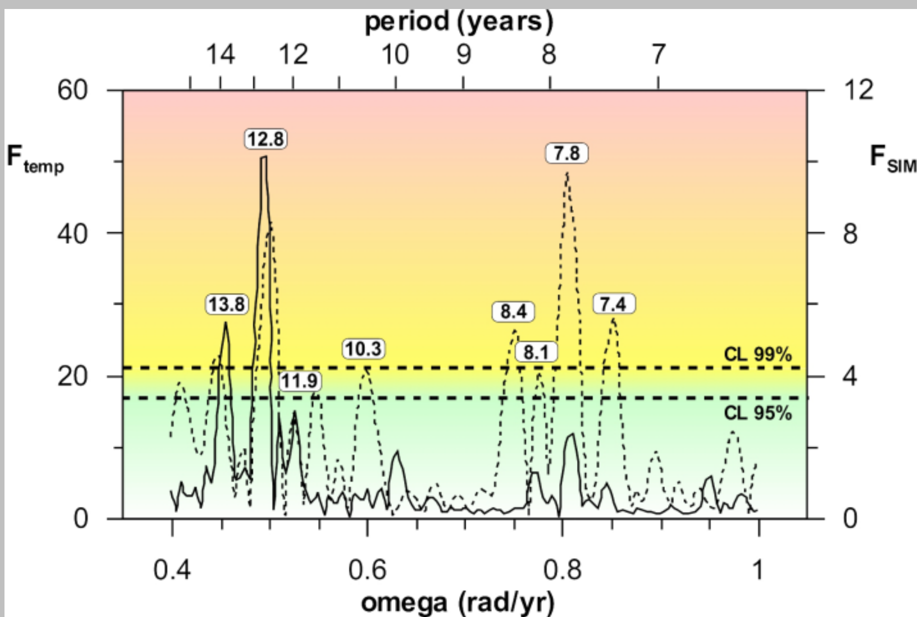
## Solar-terrestrial research

Eight time series of surface air temperature from central Europe and also the summarised series have been processed in relation to the solar inertial motion. The period range between 6 and 16 years has been studied (Charvátová and Střeštík, 2004). The prominent periods of 12.8 years and 7.8 years have been detected. They, together with further detected periods of 13.8, 11.9, 10.3, 8.4, and 7.2 years, mostly correspond to the orbital periods of the giant planets. The peak lack occurs between the periods of 8 and 10 years in both the cases. The period of 11.15 years, which is the mean length of the solar cycles, has not been detected. The above mentioned periods have also been detected in geomagnetic activity (aurora occurrence). The variable periods detected in the partial intervals of the series of surface air temperature correspond to those computed for the same intervals of the SIM. The basic period of the SIM has been found to be 179 years. The geometry of the SIM has not been so far taken into account. The results indicate that not the solar activity (the solar irradiance itself) but rather the solar motion gives a key to solution of climatic changes. The solar motion is computable in advance, this opens a possibility of predictive assessments.

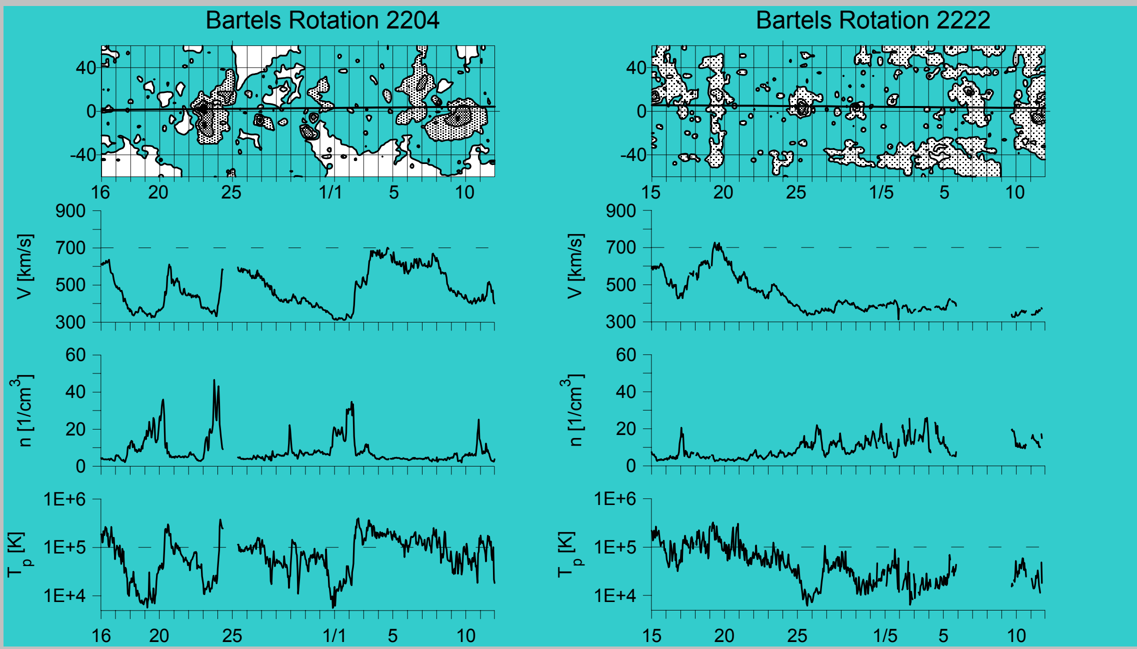
The steady-state high-speed streams typical for the inactive Sun, have their sources in the coronal holes, the regions of 'open" magnetic field lines extending into the heliosphere, dark as viewed with a soft X-ray telescope. The numbers and magnitude of those streams change in the years around the solar minimum and depend not only on the proper course of the solar cycle but also on the size, shape and location of those coronal holes on the solar disk. To investigate the dependence, all high-speed ($v \geq 600$ km/s) streams interacting with the Earth's magnetosphere during the solar minimum (1995-1996) were analyzed (Bochníček and Hejda, 2002a). Analysis of synoptic maps of relative intensity of soft X-rays, compiled from individual YOHKOH soft X-ray images, showed that:

(a) The areas of minimum intensity (intensity below 5 relative units) of soft X-rays were the source of most of all the high-speed ($v \geq 600$ km/s) streams, which in 1995 and 1996 interacted with the Earth magnetosphere.

(b) The areas of minimum intensity of soft X-rays associated with high-speed streams had, with the exception of two cases, the shape of wedge open towards the pole and were located almost exclusively on the solar hemisphere turned towards the Earth (the Northern Hemisphere in the fall and the Southern in the spring).




Solid line shows the Fourier amplitude spectrum of the SIM characteristic (the distance between the centres of the Sun and of the mass centre of the solar system) computed from the time series 500 years long (1601−2100). Dashed line shows the amplitude spectrum of the summarised air temperature series.




Synopic maps of Sun´s soft X-rays compiled from YOHKOH images – contours 5 (white), 25, 50 and 100 (black) relative units – and speed *V*, concentration *n*, proton temperature $T_p$ of solar wind. The figure demonstrates the decrease of the high-velocity streams around the solar minimum (Bartels rotation 2222).

(c) The value amounting to 5 relative units, which on the synoptic maps defines the areas of the minima of soft X-rays (corresponding to the areas of 'open" magnetic field lines) appears to be to high in the period of solar minimum.

(d) The frequency of the occurrence of the high-velocity streams sharply declines with the approach to solar minimum.

The influence of geomagnetic forcing on the variability of key climatic systems including the North Atlantic Oscillation, fluctuations of the temperature in Europe and North America and the El Niño - Southern Oscillation in the Pacific region was studied to identify possible causes. Statistically significant correlation coefficients were found between geomagnetic activity, the sea-level atmospheric pressure and temperature. Enhanced geomagnetic forcing is shown to lead to the intensification of the westerly zonal flow and to fluctuations of temperature in Europe, in the United States, and northern Asia. The obtained results enable us to suggest that 80% of the variability of temperatures in Europe in May-July can be predicted from information available in the preceding February (Bucha and Bucha Jr., 2002).

The study of causes leading to global mean sea surface temperature variability enabled us to judge that the strengthening of the zonal flow and the westward shift in the atmospheric circulation patterns occurred at times of high geomagnetic activity participating in the warming of middle latitudes and even in enhancing the global temperature (Bucha, 2002).

Using 40 years of global surface parameters, Bochníček and Hejda (2002b) detected a significant QBO/(solar as well as geomagnetic) activity dependence. They showed that winter periods distinguishing by high/low solar or geomagnetic activity and the east phase of the QBO are closely associated with the positive/negative NAO (North Atlantic Oscillation).

The electromagnetic ion–cyclotron waves (EMIC) propagating inside the Earth's magnetosphere rise due to the solar wind inhomogeneities. Their short period component (frequencies 0.1 – 5 Hz) propagate to the ground largely in form of the ordinary Alfvén waves along the geomagnetic field lines through the subauroral and auroral ionosphere. The ionosphere itself plays a role of an Alfvén resonator (IAR). The full-wave numerical simulation method was used to simulate subauroral IAR under the non-stationary conditions. The simultaneous ground signal measurements (pulsation Pc1 and IPDP) and the Scandinavian EISCAT radar measurements of the ionosphere plasma parameters were utilized in an attempt to model the inverse problem of the numerical simulation – high altitude profiling of the IAR. The problem of appearance (disappearance) of the ground signal observation was clarified on the basis of coincidence (non-coincidence) between the source EMIC-wave frequency spectrum and the IAR resonance frequency windows locating around the transmission coefficient peaks (Prikner et al., 2001, 2002).


*References*

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Prikner K., Mursula K., Kangas J., and Feygin F.T., 2001. Ionospheric Alfvén resonator control over the frequency-variable Pc1 event in Finland on May 14, 1997. *Stud. Geophys. Geod.*, **45**, 363-381,.

Prikner K., Mursula K., Kangas J., Feygin F.Z. and Kerttula R., 2002. Numerical simulation of the high-latitude non-stationary ionospheric Alfvén resonator during an IPDP event, *Stud. Geophys. Geod.*, **46**, 507-526,.


## Modelling of the Geodynamo

Finite volume method for the solution of a thermally driven dynamo in the spherical shell with the free rotating inner core was developed (Cupal et al., 2002). In contrast to the spectral or semispectral methods usually used in geodynamo simulations, all scalar and vector variables are expressed in physical space. The basic strategy of this numerical scheme is to write the differential equations at each point in the conservative form, to integrate them over the control volume (with the centre in this point) and convert each such integral into sum of integrals over the boundary faces by means of Gauss' theorem. As the area of the faces close to the axis of rotation is indirectly proportional to the singular coefficients, the resulting grid equations are non-singular. The control volume formulation of the problem allows utilizing a whole range of techniques which were developed in hydrodynamics or even in MHD simulations for the stabilization of convective terms. The fully implicit in time method of discretization for diffusion and non-linear terms is used. The systems of linear equations are solved by block Gauss-Seidel algorithm (Hejda and Reshetnyak, 2003).

The convergence and stability of the code were demonstrated on test calculations. It was shown that unsufficient resolution in the longitudial variable leads to a false shape of the solution (wrong number of convective cells) and that the minimal number of required longitudial grid points depends on the Ekman number. The hydrodynamic part of the solution (thermal convection) was checked by the Case 0 of dynamo benchmark and good convergence to the standard solution was obtained. It is the first confirmation of the benchmark by non-spectral method.

The turbulent phenomena appearing on small scales complicate the computer simulation of the convection in planetary interiors. Small-scale subgrid turbulent phenomena cannot be resolved by a global grid. To shed a bit more light into the problem, two scale model of turbulence was solved using the shell model approach. In the shell model two sets of equations are considered. The Navier-Stokes equation and the thermal flux equation are solved on a large scale due to a coarse grid. The small-scale solution is described by the shell model, which generates the second set of equations. This enables us to estimate the spectral energy flux on small scales. The turbulent coefficients depending on radial direction are then calculated and they are used in the large-scale solution. The behavior of other characteristics (spectra, helicity) was also studied in time and space. The stabilized solution of the large-scale convection was obtained for the Rayleigh number Ra = $10^{14}$ and Ekman number E = $10^{-6}$ based on the molecular values of viscosity and thermal diffusivity. The results correspond to Reynolds number Re $10^{9}$.

We assumed the Coriolis force to be neglected in our model. This is a acceptable simplification as this term does not put any energy into the system and takes part only in the redistribution of the kinetic energy. Of course, the full model should include the effects of anisotropy often considered in astrophysical applications. We suggest two possibilities how to do it. The most systematic way is to implement the shell model equations for each vector component of the original PDE. Then, in principal, all required properties of equations could be provided. The other way is to use some information about integral spectra and to consider only one 'integral' shell equation for all three components Cupal et al., 2004).

*References:*

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Cupal I., Hejda P. and Reshetnyak M., 2004. Turbulent thermal convection in a sphere. *Magnetohydrodynamics*, in print.

Hejda P. and Reshetnyak M., 2003. Control volume method for the dynamo problem in the sphere with the free rotating inner core. *Studia geoph. et geod.*, **47**,147-159.

# List of Grant Projects Solved During 2002-2003

| Title | Responsible Investigator | Funding | Duration |
|---|---|---|---|
| Geodynamics of the West Bohemia seismic region | J.Mrlina | GA AV ČR IAA 3012807 | 1998-2002 |
| Orogenic roots-processes, manifestation and implication for evolution of continental litosphere | J.Plomerová | GA ČR | 1998-2002 |
| Geophysical investigation in the regions with different degree of tectonic activity in Central Europe and Japan | V.Červ | Ministry of Education Project NJ-23 | 1998-2002 |
| Magnetic mapping and analysis of contaminated recent soil sediments | A.Kapička | GA AV ČR IAA 3012905 | 1999-2002 |
| Possibilities of geothermal sources exploitation for energy supply | J.Šafanda | Ministry of Environment | 1999-2002 |
| Elastic anisotropy of mantle rocks from the Bohemian Massif | A.Tomášková | GA ČR GP 205/01/P020 | 1999-2003 |
| World-wide scanning of seismic anisotropy of the litosphere | J.Plomerová | GA AV ČR IAA 3012908 | 1999-2003 |
| Structural-geological setting of West Carpathians and the basement based on geophysical data in the frontier regions with Poland and Slovakia | J.Mrlina | Ministry of Environment | 2000-2002 |
| Celebration 2000 | A.Špičák | Ministry of Environment | 2000-2002 |
| Updating of the tilt monitoring system in the hazardous environment of the ČSA mine, Most. | B.Chán | GA AV ČR IBS 3012008 | 2000-2002 |
| Detailed magnetic characteristics of power-plant fly ashes | E.Petrovský | GA ČR GA 205/00/1349 | 2000-2002 |
| Metodics of microgravity measurements and their applications to environmental geology | J.Mrlina | GA ČR GA 205/00/1470 | 2000-2002 |
| Model of a 3-D distribution of the electrical conductivity across Europe from long-period geomagnetic variations | O.Praus | GA ČR GA 205/00/1367 | 2000-2002 |
| Seismic waves in anisotropic media: applications | V.Vavryčuk | GA ČR GA 205/00/1350 | 2000-2002 |
| Deep structure, seismotectonics and state of stress in southeast Asia | A.Špičák | GA AV ČR IAA 3012002 | 2000-2003 |
| Screening and monitoring of anthropogenic pollution over central Europe by using MAGnetic PROXies | E.Petrovský | EU | 2000-2003 |
| Boussinesq's approximation of the hydrodynamic geodynamo | I.Cupal | GA AV ČR IAA 3012006 | 2000-2003 |
| Recent climate changes and its contingent anthropogenic component revealed by inversion of present temperature data measured in boreholes | V.Čermák | GA AV ČR IAA 3012005 | 2000-2004 |
| Gravimetric mapping 1:25 000 in the region of the Krkonoše – Jizerské hory crystalline complex | J.Mrlina | Ministry of Environment | 2001-2004 |

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|---|---|---|---|
| Controls on basin-fill architecture of intracontinental extensional and strike-slip basins: examples from the Cretaceous and Neogene of the Bohemian Massif. | D.Uličný | GA ČR<br>GA 205/01/0629 | 2001-2003 |
| Seismic anisotropy of the subcrustal litosphere of the Bohemian Massif | V.Babuška | GAČR<br>GA 205/01/1154 | 2001-2003 |
| Seismic tomography of the litosphere of western part of the Ohře rift | V.Babuška | Ministry of Environment | 2001-2003 |
| Collocated magnetotelluric and seismic reflection experiment across the Trans-European Suture Zone | V.Červ | GA ČR<br>GA 205/01/1153 | 2001-2003 |
| Structural aspects of the evolution of volcanic centers: the České středohoří Mts. as an example | J.Mrlina | GA AV ČR<br>IAA 3013102 | 2001-2004 |
| Impact of geomagnetic storm on ionosphere-atmosphere system | P.Hejda | GA AV ČR<br>IAA 3042102 | 2001-2004 |
| Study of temporal variations of the geomagnetic field based on the observatory and repeat station measurements | P.Hejda | GA AV ČR<br>IAA 3012105 | 2001-2004 |
| Re-interpretation of reflection-seismic data from the Most Basin: a new look at the sedimentary infill and deformation of a coal-bearing rift basin. | D.Uličný | Ministry of Environment<br>OG-13/02 | 2002 |
| Seismic and rheologic properties of carboniferous rocks and they role in the litosphere anisotropy. | P.Špaček | GA AV ČR<br>I006 | 2002 |
| Corinth Rift Laboratory – 3F Corinth | J. Mrlina | EC Project NNE5-2001-00501 | 2002-2003 |
| Petrophysical properties of upper mantle eclogites | S.Ulrich | GA AV ČR<br>GP 205/03/P065 | 2002-2003 |
| Stratigraphic architecture of Cenomanian-age units of the Bohemian Cretaceous basin: relationships between depositional systems and reactivation of basement structures. | D.Uličný | Ministry of Environment<br>OG – 9/02 | 2002-2004 |
| Processes and envciropnments of rhythmic deposition in a coal-bearing foreland basin: a sedimentological study of the upper Petřkovice Member, Upper Silesian Basin. | D.Uličný (P. Bezuško-ČGS) | GA ČR<br>GA 205/02/0171 | 2002-2004 |
| Sea level changes and Milankowitsch-driven climate cycles: were they linked during the 'greenhouse" Turonian? | J.Laurin | GA AV ČR<br>KJB 3012310 | 2003 |
| Updating of the tilt monitoring systemin the hazardous environment of the ČSA open-pit mine, Most, second stage | B.Chán | GA AV ČR<br>IBS 3012008 | 2003-2005 |

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|---|---|---|---|
| Petrophysical properties of upper mantle eclogites, their link to composition and rheology of upper matle | S.Ulrich | GAČR<br>GA 205/03/P065 | 2003-2005 |
| Kinematic and dynamic phenomena as indicators of seismo-tectonic activity in West Bohemia | J. Mrlina | GA AV ČR<br>IAA 3012308 | 2003-2007 |
| Seismic activity distribution as an indicator of volcanic sources in the regions of convergent litospheric plates | A.Špičák | GA AV ČR<br>IAA 3012303 | 2003-2006 |
| Seismic waves and seismic sources in anisotropic media | V.Vavryčuk | GA AV ČR<br>IAA 3012309 | 2003-2006 |
| Geophysical observations and the prediction of geophysical fields for the routine purposes. | J.Bochníček | GA AV ČR<br>IBS 3012007 | 2000-2004 |
| Application of the top-soil magnetometry for the pollution mapping in the Czech Republic. | E.Petrovský | IBS 3012354 | 2003-2005 |
| Complex geophysical research of the seismogenic west part of the Bohemian Massif | J.Horálek | GA ČR<br>GA 205/02/0381 | 2002-2004 |
| Tools for seismic data inversion – searching for non-shear seisic events | J.Šílený | GA ČR<br>GA 205/02/0383 | 2002-2004 |
| Geothermal research of the Chicxulub impact structure | J.Šafanda | GA ČR<br>GA 205/03/0997 | 2003-2005 |
| Climate change and global warming | V.Čermák | GA ČR<br>GA 205/03/0998 | 2003-2005 |
| Velocity model and shallow geologic building of the Moravo-Silesian Region inferred from seismic observations. | B.Růžek | GA ČR<br>GA 205/03/0999 | 2003-2005 |
| Deep geoelectric model of laterally inhomogeneous Earth, especially of Europe, using time variation of geomagnetic field | O.Praus | GA ČR<br>GA 205/03/1001 | 2003-2005 |
| Seismotectonics and deep geologic building of the Mid-America convergent margin | A.Špičák | GA ČR<br>GA 205/03/1203 | 2003-2005 |
| Modelling of resistivity distribution in the east margin of the Bohemian Massif and in west Carpathian. | S.Kováčiková | GA ČR<br>GP 205/02/D133 | 2002-2005 |
| Development of a new method of shear wave splitting determination | L.Vecsey | GA ČR<br>GP 205/03/P161 | 2003-2005 |
| International deep continental drilling project | A.Špičák | Ministry of Education<br>LA 150 | 2002-2006 |
| SLICE | A.Špičák | Ministry of Environment<br>SB/630/3/02 | 2002-2005 |
| Air-ground temperature coupling in various different climates | J.Šafanda | NATO Grant<br>CLG 980152 | 2003-2005 |

# Events

## Workshop/Summer School STRUCTURE AND TECTONICS OF CONVERGENT PLATE MARGINS, Castle of Zahrádky, July 1-6, 2002

The workshop/summer school was aimed at exchange of the latest results of research related to dynamics of active convergent margins, namely to the process of subduction, and at providing MSc and PhD students modern views and summaries on this problem. The topics presented and discussed at the workshop/summer school were as follows: Onset and cyclicity of subduction; subduction, seismicity pattern and volcanism; slabs imaged by seismic tomography; deep earthquakes; constraints on slab dynamics from focal mechanism studies; characteristics of individual convergent regions; slab rheology, phase transforms and numerical modelling of the process of subduction. The principal organizing institution was Geophysical Institute, and the workshop was co-organized by Faculty of Mathematics and Physics, Charles University, Prague. This event was headed by A. Špičák.

In the technical sessions, 18 invited lectures were given and 24 posters presented by 62 participants from Belgium, Canada, France, Germany, Great Britain, Italy, Japan, The Netherlands, Poland, Switzerland, USA and Czech Republic. Student participants formed 50 per cent of the audience. Elsevier publishing house offered a special issue of Physics of the Earth and Planetary Interiors for contributions presented at the meeting. The guest editors of the special issue are B. Engdahl, O. Čadek and A. Špičák.

## 8th Meeting on Rock, Paleo and Environmental Magnetism

The 8th Castle Meeting on Rock, Paleo and Environmental Magnetism, organised every other year since 1988, was held at Castle of Zahrádky on September 2-7, 2002. Over 50 participants from 18 countries worldwide attended the meeting, from Argentina through Mexico to Japan. The scope of the meeting followed the tradition of the previous seven meetings and covered all aspects of paleo, rock and environmental magnetism, including, e.g., Palaeomagnetism and Tectonics; Magnetic Anisotropy; Archeomagnetism; Assessment of Quality of the Palaeomagnetic and Rock-Magnetic Data; General Rock Magnetism and its Physical Background; Magnetostratigraphy; Environmental Magnetism; Relations between Palaeomagnetism and Global Changes and New Techniques and Approaches. An invited lecture, dealing with the geology of the region, was followed by a guided half-day trip to various locations of the region. The other invited talk focused on new, promising method of deteriming various iron oxides using voltammetry of microparticles. Active contributions of several PhD students and PostDocs were highly appreciated. The meeting was also used as presentation platform by a 5FP EU Project MAGPROX. Scientific programme of the meeting was complemented by various social activities, such as open-air barbecue party or performance of classical music in a chappel of a nearby Castle of Zákupy. Next, 9th Castle Meeting will be held in 2004 in Slovakia under the sponsorship of International Association of Geomagnetism and Aeronomy.

## Specialized exhibit in the *Karolinum* University Centre "Historical Earthquakes Portrayed in Old Engravings"

The researchers of the seismic department of the Geophysical Institute prepared – in cooperation with the Faculty of Geophysics, Charles University, Prague – a unique exhibit of 103 original engravings portraying the effects of disastrous historical world earthquakes (1493-1906). The exhibit installed in historical rooms of Prague *Karolinum* was open from March 18th till April 20th, 2003. Opening addresses were presented by the deputy vicechancellor of the Charlres University, Prof. Doc. RNDr. Jaroslava Svobodová, CSc., by the dean of the Faculty of Mathematics and Physics of the Charles University, Prof. RNDr. I. Netuka, by the director of the Fulbright Commission in Prague Dr. Hanka Ripková and by the director of the Geophysical Institute of the Academy of Sciences, RNDr. Aleš Špičák, CSc.

Archive "Collection Kozák" (Calabria, FEB 05, 1783, (Faro di Messina); Vue d'Optique (Lanterna Magica), Collection of prospects, Augsburg 1780's, private collection;  No. kz240).

The exhibit opening ceremony was completed by the performance of the Schola Gregoriana Pragensis, conducted by David Eben. The exhibit opening was attended by about 300 visitors; they were presented with richly illustrated exhibit bilingual catalogue.

The exhibit historical part – i.e., the old engravings – was complemented by an overlook over the recent achievements in the field of fundamental research in seismology reached at the Geophysical Institute AS CR and at the Faculty of Geophysics, Charles University.

The exhibit, which - in a given extent and as concerns the historical earthquake images - was the first one organized at all, was well accepted by the public. It follows from the possitive comments on it in the daily press, from commendatory radio broadcasting and visitors appreciations.

The exhibit could be understood as the final display of the long-term effort of some Institute's seismologists to collect and complete the set of images representing independent and not-yet-utilized macroseismic data for checking and verifying the European seismicity patterns: The task which was inspired by the 1986 Chernobyl disaster.

Thanks to the Fulbright stipendium awarded for 1994-95 the image collection – originally composed mostly by compositions from Europe and Asia – was complemented by the earthquake pictures from the Americas. The seismologists from the University of California displayed a serious interest in the Prague collection of the historical earthquake images. This interest resulted in awarding the Czech collector the 3-year Czech –American grant (1997-2000) in the framework of which all the Prague image series, under the name „Collection Kozak", was mounted into internet, see www.nisee.berkeley.edu/kozak. At present this collection consists of 1274 pre-photo images of the effects of historical earthquakes complemented by smaller series (92 items) of allegorical compositions. The collection has been regularly complemented by new increments.

At present the Collection Kozak is commonly accessible through web sites

## Meredian-2 Kick-off meeting January 23-24, 2003, Prague, Czech Republic.

The Meredian-2 proposal has become an amendment to the EC contract EVR1-CT-2000-400007 "Developing existing earthquake data infrastructures towards a Mediterranean-European Rapid Earthquake Data Information and Archiving Network (MEREDIAN)" with starting date April 15, 2002. Twenty two participants from eight MEREDIAN-2 countries (Czech Republic, Slovakia, Poland, Hungary, Bulgaria, Romania, Estonia and Malta) and five original Meredian consortium members (Netherlands, Switzerland, Italy, Germany, Greece) attended the "Kick-off Meeting" in Prague on January 23-24, 2003. The meeting was organized by the Geophysical Institute as the Meredian-2 regional coordinator and chaired by J.Zedník.

This meeting summarized in detail the present status at each MEREDIAN-2 participant, reviewing the objectives and set up a collaborative workplan. The following issues were discussed during the sessions: Real-time data exchange, format conversion and instrumental response determination, implementation of the AutoDRM software for data exchange by E-mail, development of SeisComp and SeedLink software packages for real-time data exchange, seismological software development and training. The presentations have been compiled on an accompanying CDROM. The next regional meeting of Meredian-2 participants will be held again in Prague in March 2004.

## 1st MEETING OF THE CENTRAL EUROPEAN TECTONICS GROUP (CETG) and 8th Meeting of the Czech Tectonic Studies Group (ČTS), Hrubá Skála 2003

The 1st Meeting of the Central European Tectonics Group (CETG) and 8th Meeting of the Czech Tectonic Studies Group (ČTS) was held in the Hrubá Skála Chateau in the scenic area of Český Ráj in NE Bohemia, between April 24 and 27, 2003. Principal organizing institution was Geophysical Institute, in co-organization institutions were ČTS - Czech Tectonic Studies Group; Faculty of Science, Charles University, Prague; SÚRAO (RAWRA) – Radioactive Waste Repository Authority, Czech Republic; and Ministry of Environment of the Czech Republic. The meeting was headed by D.Uličný. The scientific sessions were devoted to a broad range of topics: Geophysical research of crustal and upper mantle structure; Structural, petrological and geochemical clues to orogenic belt histories; Tectonic and climatic signals in sedimentary successions; Microstructural clues to rheology and deformation history; Structural styles of sedimentary basin formation and inversion; Magma formation and emplacement in orogenic belts.

Totally 106 presentations, both poster and oral, were presented by 121 participants from the Czech Republic, Poland, and Slovakia. Student participants formed about 30 per cent of the audience. Apart from the technical sessions, the social events included awards to the best presentations by student authors and the Radek Melka Award of the Czech Tectonic Studies Group, awarded each year to recognize an outstanding geoscience publication by a young author. Conference field trips focused on flow fabrics in the volcanics of the Oligo-Miocene Eger Graben (North Bohemia) and on the tectonics and depositional systems of the Bohemian Cretaceous Basin. The conference abstracts and field trip guides are published in the journal Geolines, Vol. 16 (2003).

The conference venue, Hrubá Skála chateau, was located in the Hrubá Skála "rock city", where the weathering and erosion of Cretaceous sandstone bodies led to development of areas of spectacular sandstone cliffs and spires. Sedimentological and tectonic features of these exposures were examined during one of the field trips.

## 8th European Workshop on Numerical Modeling of MANTLE CONVECTION AND LITHOSPHERE DYNAMICS, Castle of Hrubá Skála, September 13 - 18, 2003

A goal of this meeting is to bring together scientists who are focussed on modeling lithosphere and mantle dynamics, along with young scientists just entering this field. The program included a mixture of general scientific discussions and discussions of technical issues related to numerical modeling. Each day there were two or three invited oral presentations. All the other contributions were presented in poster sessions.

The workshop was organized together by the Department of Geophysics of the Fauculty of Mathematics and Physics, and by the Geophysical Institute. The organizers were O. Čadek, O.Šrámek, and A. Špičák.

## GI initiative: Czech Republic joined the International Continental Scientific Drilling Program (ICDP)

In February 2003, the Czech Republic joined the International Continental Scientific Drilling Program (ICDP), a research initiative established 7 years ago, in 1996. Currently Austria, Canada, China, Czech Republic, Germany, Iceland, Japan, Mexico, Norway, Poland, and U.S.A. are members through National Funding Organizations or major research institutions. In addition, UNESCO, ODP (Ocean Drilling Program) and Schlumberger Inc. are Corporate Affiliates. Annual Membership fees range from US $ 700,000 to 20,000 depending on the economic strength of the individual country.

Major Scientific Questions of the ICDP are:

- the physical and chemical processes responsible for earthquakes and volcanic eruptions, and optimal methods for mitigating their effects.
- the manner in which Earth's climate has changed in the recent past and the reasons for such changes.
- the effects of major impacts on climate and mass extinctions.
- the nature of the deep biosphere and its relation to geologic processes such as hydrocarbon maturation, ore deposition and evolution of life on Earth.
- how to safely dispose radioactive and other toxic waste materials.
- how sedimentary basins and hydrocarbon resources originate and evolve.
- how ore deposits are formed in diverse geologic settings.
- the fundamental physics of plate tectonics and heat, mass and fluid transfer through the Earth's crust.
- how to better interpret geophysical data used to determine the structure and properties of the Earth's crust.

The membership fee for the Czech participation in the next five years (2003 – 2007) has been covered by the Ministry of Education of the Czech Republic. Geophysical Institute was the author of the proposal at the Ministry. Czech scientists can join the research projects related to individual drilling sites of ICDP (for details see http://icdp.gfz-potsdam.de), to participate in the Training Program of ICDP and to prepare and later submit a new proposal for a deep drilling project.

Activities of GI in ICDP in 2003:

- July, 2003: the Department of Geothermics of the GI performed the temperature measurements in the 1.500 m deep borehole into the Chicxulub impact structure, Yucatan Peninsula, Mexico.
- September, 2003: four persons participated at the workshop in Zakopane, West Carpathians, Poland, that was organized by our Polish colleagues to discuss a possible future Orava Deep Drilling Project (ODDP).
- November, 2003: two persons participated at the ICDP training course at Shimabara, Kyushu, Japan, in the neighborhood of the Unzen Volcano deep drilling site.
- November, 2003: first informative seminar on an area suitable for a new drilling project in the Bohemian Massif was held in the GI. The seminar, attended by colleagues from GFZ Potsdam, Univ. Potsdam, Univ. Karlsruhe, Czech Geological Survey, Charles University and GI, favored the western part of the Eger Graben, a region of anomalously high heat flow, high mantle He content, repeated earthquake swarm occurrence, quaternary volcanoes, mofets, rich carbon dioxide emissions, numerous mineral water springs, sedimentary basins, voluminous granitic plutons.

## XIX. competition in cross-run „Geophysical run“ in Kunratice forest

Geophysical Institute has been organizing a cross-country race in a nearby forest since 1984. The race is organized every last Wednesday in September. It became quite popular among runners. In average 70 participants compete in four categories: men below 40 years and veterans over 40 years (two-3 km laps), women below 35 years and women over 35 years (3 km). First three runners in each category obtain prizes and books from the Czech publishing house “Lidové nakladatelství”.


Women waiting for the start of the 19th Geophysical race in 2003. Men had already started the race.

## Geological park in the campus of the Geophysical Institute

The Geological park was established with the financial support of municipal authorities of Praha 4 in a part of the campus surrounding the Institute. The park contains more than thirty blocks of rocks representing the broad geodiversity of the territory of the Czech Republic. Each item is provided by a description of its petrographical characteristics, geodynamic conditions and age of its formation, name and locality of its typical occurrence. The Geological park is accessible to public and the main reasons of its foundation were

- to collect and expose a representative set of rock samples demonstrating rich geological history and variability of rock complexes of the Bohemian Massif, one of the key units of Europe.
- to provoke public interest in geosciences.
- to contribute to education in modern geology.

Opening ceremony of the GEOPARK.

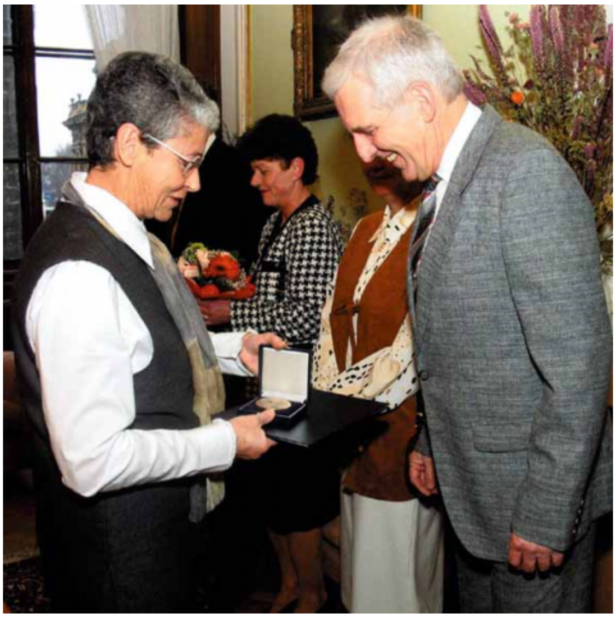
GEOPARK

## Awarded researchers

Since 1995, Academy of Sciences of the Czech Republic awards excellent scientists in the field of physics the Ernst-Mach Honorary Medal for Merit in the Physical Sciences. In recent two years, four leading scientists of the Geophysical Institute have been awarded this prestigious medal.

Dr. Vladislav Babuška is one of the most prominent representatives of a consequently integrative petrophysical, geological and geophysical approach to the investigation of the structure and dynamics of the Earth. Highly recognized in the international community is his pioneering work in investigating the seismic anisotropy on a wide range of characteristic dimensions, from laboratory studies of the elastic anisotropy of rock samples up to large-scale crustal and upper mantle investigations of the seismic anisotropy beneath continents and in the Earth as a whole. With his colleagues, he introduced and developed the concept of three-dimensional elastic anisotropy for the modelling of geodynamical processes, a concept that has proved highly productive in a series of regional studies of fundamental geological structures in Europe, Africa and America, and a methodology that has recently grown into one of the basic tools for studies into the structure and dynamics of the lithosphere. The research accomplishments of Vladislav Babuška and his team has had major impact both on the methodology and on forming modern views on the evolution of the continental lithosphere-asthenosphere system, and the informal reference to a 'Prague school' of the continental lithosphere studies is fully justified in this respect. Previously, the Czechoslovak Academy of Sciences awarded Vladislav Babuška the František Pošepný Medal for outstanding achievements in geological sciences.

Dr. Vladimír Čermák is one of the most renowned Czech geophysists who has decisively contributed to the progress in the geoscientific research, particularly in the field of geothermal studies. In the 60th of the past century he introduced the geothermal research in the Geophysical Institute of the Czechoslovak Academy of Sciences and founded a new department, which has rapidly evolved into an internationally recognized center of geothermal studies. The first heat flow map of the earlier Czechoslovakia and of Europe, models of the distribution of deep crustal temperatures and of the lithosphere thickness in Central Europe are only a few of the fundametal achievements, which were accomplished under his scientific management. His work on the reconstruction of past climatic changes based on the analysis of temperature logs from deep boreholes, published at the beginning of 70th, founded in fact a new methodological direction for the studies into the past climatic variations. During his whole scientific career, Vladimír Čermák has been fostering the scientific progress and cooperation by working actively in numerous national and international scientific societes, organizations and bodies. He could use his rich organizational experience as a first director of the Geophysical Institute after 1989. Vladimír Čermák was previously awarded the Edward A. Flinn III. Medal by the American Geophysical Union.



Prof. Miloš Pick's main research area is the Earth's gravity field, gravimetry and physical geodesy. During 45 years of his scientific career in the Geophysical Institute, he has achieved numerous fundamental results that have substantially contributed to the theoretical advancement of gravimetry and physical geodesy, and have had major impact on constituting a series of basic procedures of the gravimetric and geodetic practice as well. The international community largely recognized already his early works on relationships between various geodetic reference systems. Those investigations became later a theoretical basis for the transformation from the Unique Triangulation Catastral Network system of the former Czechoslovakia into the international reference system S-42, in which high quality military topographic maps were then published for a number of years. Further theoretical results of Prof. Pick set up a methodological basis for, e.g., constructing maps of gravity anomalies and terrain corrections of the former Czechoslovakia and for developing precise trigonometric techniques for use in mountainous areas. He has actively worked in the geophysical interpretation of gravity measurements and their implications for the geological structure and geodynamics. In 1960-1970 he was a director of the Geophysical Institute. Prof. Miloš Pick belongs to the most outstanding scientists who have substantially contributed to the development of the classical non-satellite gravimetry and physical geodesy.

Dr. Axel Plešinger belongs to the most outstanding Czech seismologists who has been largely recognized worldwide for his pioneering role in the field of the broadband and digital seismometry. Already in the 60$^{th}$ of the last century he anticipated the essential needs of a quantitative wave image processing and of employing cybernetical principles and digital signal processing in a modern seismological research. During his scientific career in the Geophysical Institute since 1957 he has achieved numerous highly recognized results in the field of the transfer function analysis and signal filtration. Along with his theoretical research he has actively worked on a series of significant application projects concerning, among others, the employment of the artificial intelligence in the seismic signal classification and recognition and the development of software for the digital record processing. Under his scientific management the first very broadband seismometric instrument was devised that was capable of providing undistorted images of seismic waves in the frequency range from regional earthquakes up to the free oscillations of the Earth. The instrument was installed at the Kašperské Hory seismic observatory, which thus became the first broadband seismic station worldwide. Highly appreciated are Axel Plešinger's educational activities as well as his work in international scientific organizations, in particular in the Commission on Practical Seismology of IASPEI, through which he has largely assisted in introducing the digital seismology in a number of countries.

Another appreciation awarded by the Academy of Sciences is the "Otto Wichterle Award". This award is aimed at researchers younger than 40, in order to recognise contributions by perpsective researchers to research in various fields of science. The Otto Wichterle award is given in all three scientific divisions present in the Academy: (1) Division of Mathematics, Physics and Earth Sciences, (2) Division of Life and Chemical Sciences, and (3) Division of Humanities and Social Sciences. The award consists of a Diploma of Honour and a financial support.

In May 2002, RNDr. David Uličný, CSc. obtained this award for his achievements in basic research in the field of sedimentary geology. The focus of his scientific interests is sedimentology and sequence stratigraphy of sedimentary basins of different tectonic regimes, with emphasis on shallow-marine and continental systems. Most recently, he focuses on the relationships between tectonics and the style of basin filling. Key field areas of his research are the basins of the Eger Graben and Bohemian Cretaceous Basin. Apart from research work, David Uličný participates in education of MSc and PhD students.

## Studia Geophysica et Geodaetica

Studia geophysica et geodaetica is an international scientific journal covering geophysics, geodesy, meteorology and climatology. It has been published quarterly since 1956. Since January 2002, the journal has been included again into the list of Scientific Citation Index. Its impact factor was 0.680 and 0.571 in 2002 and 2003, respectively; see the Journal Citations Report (www.jcrweb.com).

In 2002, the issues 2 and 4 appeared as special issues dedicated to Prof. V. Červený. In 21 contributions, the issues contain most recent results on seismic wave propagation in complex structures by authors from universities and institutions all over the world. The contributions are supplemented by the review of Červený's book "Seismic ray theory", Cambridge Univ. Press, Cambridge 2001.

In 2003, the issue 2 appeared as special issue dedicated to Prof. M. Krs. It contains 12 contributions dealing with most recent results in paleo- and rock-magnetics. The issue 3 contains detailed description of seismic experiments performed during the last four years in the central Europe. The issue 4 is again a special issue this time dedicated to seismic anisotropy. 17 contributions of experts from the whole world have been submitted. This special issue will appear at the beginning of 2004.

## In Memoriam Ivan Cupal, 1944 – 2003

RNDr. Ivan Cupal, CSc., succumbed to a terminal illness on Thursday, April 24, 2003.

He was born on December 29, 1944 in Rohožná in the District of Svitavy in the family of a village teacher of mathematics. He attended the secondary school in Česká Třebová from 1959 to 1962 and then enrolled in the Faculty of Mathematics and Physics of the Charles University in Prague to study physics. After two years of basic mathematics and physics, he elected geophysics as his major subject. The topic of his diploma thesis concerned the magnetohydrodynamics of the Earth's core. This was an audacious decision since this discipline was still in its beginnings, and nobody had devoted himself to this subject in our milieu before. It was also a decision of fortune because the geodynamo became the object of his lifelong scientific interest.

After graduating from the University and a year's National Service, he began to prepare for his scientific career in the Geophysical Institute of the Czechoslovak Academy of Sciences in 1968. His CSc. thesis, "Theory of the Hydromagnetic Dynamo and the Earth's Magnetic field", deals with solving the problem of the kinematical nearly symmetric dynamo model with spiral convection. His derivation of the fundamental equations was based on S.I. Braginsky's theory and the velocity field was adopted from the studies of Kahle, Ball and Vestine of the velocity field on the surface of the Earth's core. Ivan Cupal's subsequent specialisation in hydromagnetic models of the Earth's dynamo is apparent from the attached selection of his most significant papers.

The "Dynamo Community" became aware of Ivan Cupal due to his organisation of scientific meetings. The Dynamo Workshop, which he organised in Alšovice in 1979, was the first undertaking in which dynamo theory specialists from the former Eastern Block were able to meet their "Western" colleagues. It was the first time Prof. S.I. Braginsky was allowed to cross the borders of the Soviet Union. He then organised conferences in Liblice in 1988 and in Trest in 1997. He played a significant part in organising the Scientific Assembly of IAGA in Prague in 1985.

Since 1987 Ivan Cupal was member of the Executive Committee of the SEDI Project (Study of the Earth's Deep Interior) and since 1994 member of the Editorial Board of Geophysical and Astrophysical Fluid Dynamics. He was Head of the Department of Geomagnetism of the Geophysical Institute since 1995.

Ivan Cupal was a strong personality with all-round interests. He was well versed in literature and music. He went regularly to concerts of classical music, but was also keen on popular music of quality. He himself played the piano and guitar. He played basketball and, when younger, also soccer, and was an excellent skier, and devoted a part of his vacation to cycling tourism.

At the beginning of 2001 he became serious ill. He underwent several operations and courageously struggled with his insidious disease. He faced up to his responsibilities even when ill. Every time he was to go to hospital, he prepared everything so that the Department could carry on in its work in his absence. He resigned as Head of the Department of Geomagnetism in January 2003, and passed on at home in the morning of April 24, 2003.

The tens of e-mails and other responses we received in answer to the news of his demise are evidence that Ivan Cupal's departure affected painfully not only his family and his closest collaborators.

Pavel Hejda

### Selection of Ivan Cupal's most significant papers

Cupal I., 1972. Numerical treatment of a model of the hydromagnetic dynamo with a selected system of convection in the Earth´s core. *Studia geoph et geod.,* **16**, 230-239.

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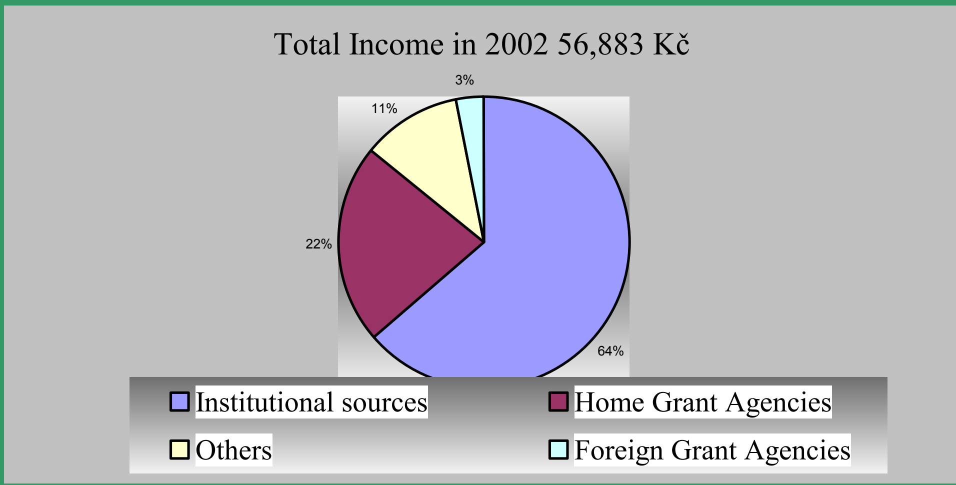
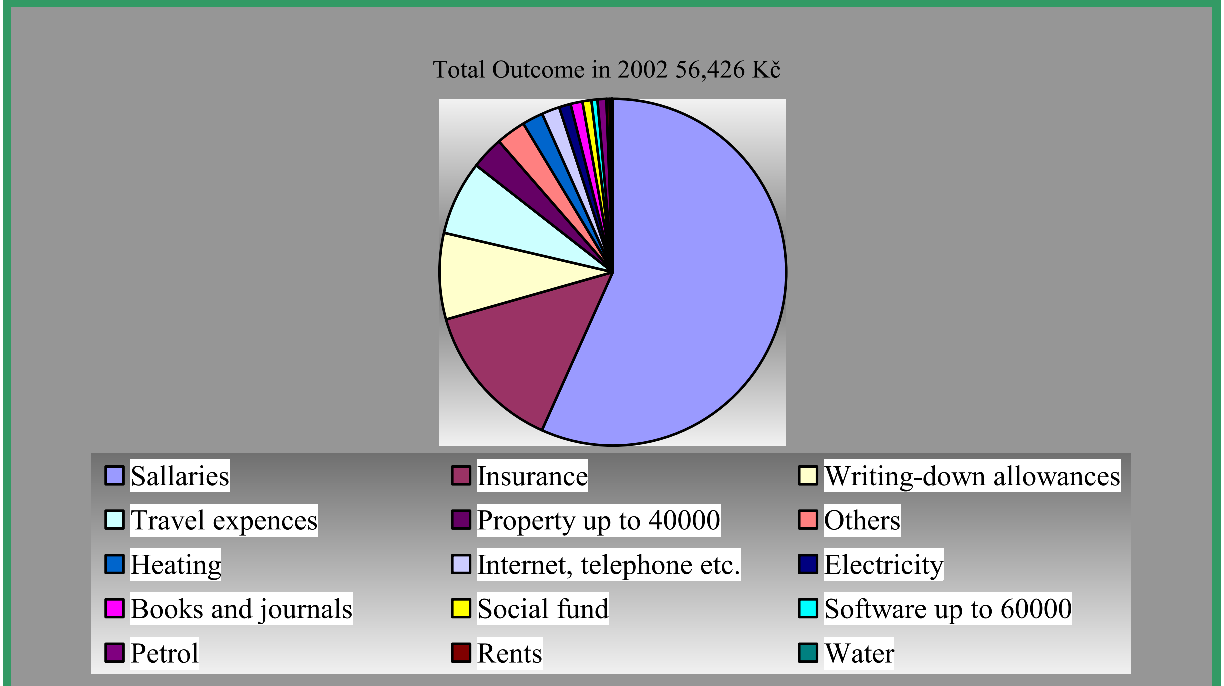
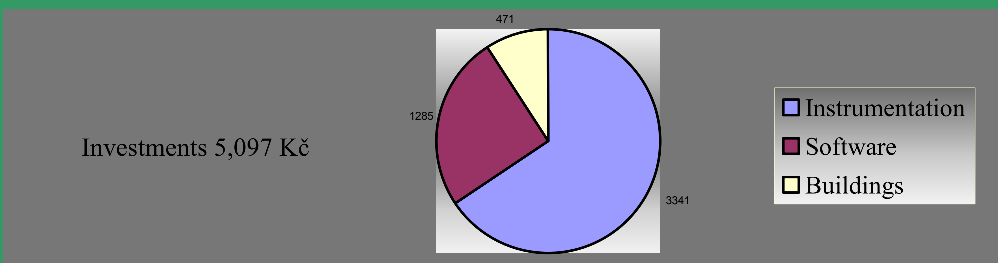
# The budget of the Geophysical Institute

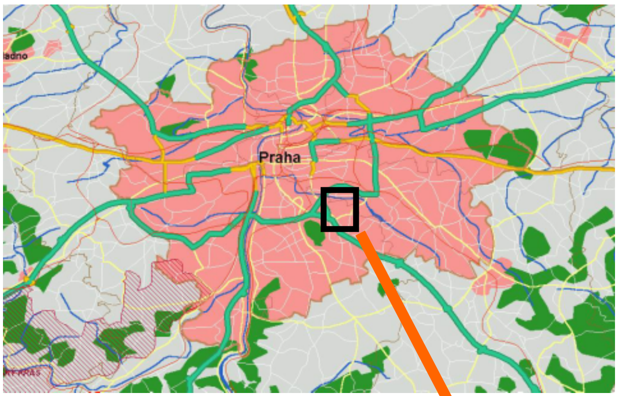
The budget of the Geohysical Institute is nearly the same from year to year. The following numbers are valid for year 2002. All items are in thousands of Czech crowns (Kč).



# How to get to the Geophysical Institute




♦ When arriving by car …

direction Brno, take Exit Spořilov and immediately another Exit Spořilov. Coming from Brno, take Exit Spořilov.


♦ When arriving by train…

Most probably you will arrive at the Main railway station or railway station Holešovice. Take Subway, Line C, direction Háje. Go until station Roztyly. When you get to the surface, you can see the new building of the T-MOBILE Company. The Geophysical Institute is beyond this building and beyond the highway. You can recognize it by the great white parabolic antenna with the label NEXTEL. The final walk will take about 10 minutes.

♦ When arriving by plane …

Take bus No.119 to the bus terminal Dejvická. Take Subway Line A (green color) to station Museum. Change to line C (red color), direction Háje. Get off at station Roztyly. You can see the building of the institute beyond the new building of T-MOBILE Company and beyond the highway. You can recognize it by the great white parabolic antenna with the label NEXTEL.

## Starvation Cove – The Tragedy of Franklin’s Polar Expedition

Since the middle of the sixties of the last century, a picture of colossal size, which the employees of the Institute have come to call jestingly “The Bear”, has been hanging on the wall of the Lecture Hall of the Geophysical Institute. The picture, which is officially referred to as “Starvation Cove”, was painted by the Austrian painter and polar explorer, Julius Payer (1841 – 1915). The theme of the picture is the tragic conclusion of the polar expedition led by Sir John Franklin. The vanishing of Franklin’s expedition, which set out in 1845 on the ships Erebus and Terror, to seek the North-west Passage, became an event of worldwide significance. The reward of 20 000 pounds, which the British Government offered for saving the expedition, as well as the reports of rescues expedition gradually confirming the ill foreboding of the tragedy, which were, moreover, augmented by indefeasible evidence of cannibalism, to which past of the unfortunate expedition resorted in their desperate struggle to survive, greatly excited not only public opinion, but also the imagination of artists. Payer’s “Starvation Cove” depicts the final act of the tragic epos. The last nine surviving members of the expedition, after a strenuous march and under inhuman stress managed to pull their boat as far as the open sea. Unfathomable fate, however, deprived them of their last strength just at the moment when expectations of being saved appeared to be running high. In 1880, an American polar expedition discovered their dead bodies on the coast of King William Island. The commander of the expedition, Frederick Schwatka, named the place of the discovery Starvation Cove. In painting the picture, Payer, attempting to capture the event as truly as possible, drew primarily on Schwatka’s testimony. In London he also studied all authentic objects, discovered by rescue expeditions, and, drawing on the photographs, sketched the portraits of the officer’s of Franklin’s expedition. The picture thus shows real historical persons. Captain Crozier, who took over the command of the expedition after Franklin’s death, is standing up, rifle in hand, to an attacking polar bear, Lieutenant Couche is lying in the boat with a prayer book in his hand, the Ice master Reid and the expedition’s physician Stanley are dying of exhaustion in the centre of the picture, and to their left is dying Lieutenant de Voeux with head bent backwards and half covered by snow.

Julius Payer, a native of the North Bohemian Šanov near Teplice, drew his picture, above all, to honour all the courageous, who do not hesitate to venture their own lives in the name of science and broadening the scope of human knowledge. The author himself was a well-known polar explorer. Together with Karl Weyprecht he headed the Austrian polar expedition, which during a two-years drift discovered the Franz-Joseph Land. The expedition, in which Payer proved his thorough cartographic education and experience with first-ever climbs in the Alps, nearly met with the same fate as Franklin’s last expedition. Payer summarised the scientific observations and experience in an extensive travel book with a large number of drawings and illustrations in his own hand. After returning from the expedition, Payer began his second and no less famous career. This officer of the Austrian Army, renowned cartographer and polar explorer decided to devote himself fully to painting. He gave up his scientific and military career and enlisted in the painters’ academy in Frankfurt, from where he went, via Munich, to Paris. “Starvation Cove”, painted in 1883, was Payer’s first masterpiece, which was exhibited in the galleries of the whole of Europe and ensured the author’s fame and acknowledgement. The picture was also exhibited in Prague, in the Ruch Gallery in 1886. The spectacular success of “Starvation Cove”, which no later Payer’s picture could out do, apparently prompted the painter in 1897 to paint a replica of the picture on a colossal scale. The Modern Gallery, predecessor of the National Gallery in Prague bought the picture from the painter. In 1964, the National Gallery handed the picture over to the Geophysical Institute of the Academy of Sciences of the Czech Republic, in whose care it has been ever since.

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