Physics of the Earth
results achieved at Department of Geophysics in 1999 (reported in May, 2000)

A new fundamental monograph, summarizing outstanding research contributions of Prof. V. Červený to the ray theory of seismic waves has been completed (Červený, in press),

Development of the algorithms for two-point ray tracing and travel-time interpolation in 3D media has continued. The first quantitative results have been achieved in the description of the ray chaos due to heterogeneities in the velocity model by means of the average Lyapunov exponents. Various kinds of the coupling ray theory for weakly anisotropic models have been studied and compared with the exact solution derived for the "twisted crystal" model. Particular attention has been devoted to the resolution of seismic inversion techniques, model fitting, conversion and smoothing with the application of medium correlation functions and Sobolev scalar products (Bulant 1999a,b; Bulant and Klimeš, 1999a,b; Klimeš, 1999).

Theoretical modelling has closely touched seismic exploration problems. Ray and finite-difference methods have been used to simulate a measured CDP seismic section for the shallow lignite deposit at the Domenico lignite site, Greece (Brokešová et al., submitted) An important theoretical problem of inhomogeneous waves in dissipative media has been studied in detail. Extensive calculations of reflection/transmission coefficients of inhomogeneous waves at plane interfaces in various dissipative models have been performed and compared with the corresponding coefficients in elastic non-dissipative media (Brokešová, in press).

Theoretical computations of Fresnel volumes of PKP Earth's core waves have provided a suitable tool for estimating resolution power of tomographic method (Kvasnička and Janský, 1999). The distribution of body wave amplitudes and strains inside the Earth's mantle caused by an earthquake has been simulated (Duda et al., in press). Evaluation of the velocity models and relocation of weak earthquakes in the Western Bohemia earthquake swarms region have been performed by innovated methods (Janský, in press; Janský et al., in press; Málek et al., submitted).

The dispersion relation for Love waves in a layer on a half-space has been modifies by introducing the wave number and its square instead of the phase velocity. The implicit function theorem has then been used to derive the analytical formulae for the group velocity and for the phase- and group-velocity partial derivatives with respect to the parameters of the medium. In comparison with the traditional formulation of the dispersion relation, this method is simpler and faster (Novotný, 1999).

New finite-difference methods for numerical simulation of seismic waves have been developed. The attention has been focused on stabilization procedures and the memory and time saving by means of irregular grids (Opršal and Zahradník, 1999a,b). A hybrid method has been developed and applied to earthquakes at EUROSEISTEST near Thessaloniki where it allowed a more realistic modeling than the conventional methods with plane waves (Riepl et al., 2000). The hybrid method has been supplemented by a stochastic component and used for the seismic-response analysis of the Tiber valley in Rome (Caserta et al., 1999). Disastrous Kobe earthquake of 1995 has been investigated within an international experiment (Opršal et al., 1999; Zahradník, 1999). New ASPO method for the focal-mechanism retrieval from earthquake amplitude spectra and polarities has been developed and applied in Corinth Gulf (Zahradník et al., in press). Seismic stations of the Charles University, operating in Greece, have contributed to the explanation of the damaging Athens 1999 earthquake (Tselentis and Zahradnik, in press a,b).

Viscoelastic response of elastically compressible Earth's models has been studied. It has been found that unstable modes can exist (Hanyk et al., 1999). In the contrary, incompressible viscoelastic models have been found stable. The method of lines has been incorporated to discretize the system in space and a new eigenvalue problem for time evolution of viscoelastic models was obtained (Hanyk et al., submitted). This approach yields a complete spectrum of normal modes of viscoelastic relaxation without solving a secular equation in the Laplacian domain. The gravitational viscoelastic relaxation of eccentrically nested spheres has been solved semi-analytically in order to provide test examples for other numerical techniques (Martinec, 1999b; Martinec and Wolf, 1999).

Classical Boussinesq approximation of thermal convection was employed in simulations of thermal convection by Vecsey and Matyska (submitted). They studied wavelet spectra of temperature, kientic energy and surface heat flow time series and clearly demonstrated the multiscale temporal dynamics of the convecting system. The extended-Boussinesq convection models have been used to extract the Bullen parameter. It has been shown that the profiles of the Bullen parameter have a definite potential of being useful in constraining the physical parameters and flow structures associated with the Earth's mantle convection (Matyska and Yuen, 2000). Numerical simulations of the magnetohydrodynamic system have demonstrated that adiabatic heating/cooling stabilizes convection pattern in the Earth's core (Velímský and Matyska, 2000). The effects of adiabatic heating/cooling and viscous dissipation on 3-D rapidly rotating thermal convection was also studied by Mistr et al. (submitted).

The investigation of the Earth's mantle rheology has concentrated on forward and inverse analysis of the long-wavelength geoid in conjunction with seismic tomographic information and tectonic data (Čadek and Fleitout, 1999). It has been demonstrated that the available information can only be explained by the partially layered flow model that shows a strong increase of viscosity with depth and a pronounced asthenosphere below oceanic regions. At present, the preferred viscosity model is tested against the models of seismic anisotropy in the upper mantle. Thermal and mechanical coupling between the upper and the lower mantle was studied by Čížková et al. (1999), who showed that a low viscosity zone just beneath the 670 km boundary can effectively suppress the mechanical coupling and increase thus the importance of the thermal coupling.

The problem of the electromagnetic induction in a spherical Earth has been formulated in a weak sense and solved by the spectral-finite element technique (Martinec, 1999a). The spherical harmonic analysis has been carried out for magnetic storms within the range of periods of 5 to 40 days (Průša and Martinec, 1999).

The theory of determination of precise geoid has been further developed in (Vaníček et al., 1999).

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