

## Perspectives in Modern Seismology

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# Introduction

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This volume reflects interdisciplinary research in international cooperation at the Geophysical Institute of Karlsruhe University. A considerable part is contributed from the unique cooperation of Earth Sciences and Civil Engineering in the field of strong earthquakes in the Vrancea region of Romania and its capital Bucharest (Part 1). Part 2 is reviewing the results of deep seismic tomography from mantle plumes, deep lithospheric properties from Russian Nuclear explosion data and high-resolution imaging in applied seismics. Part 3 is dealing with the effect of tectonics on plate motions and its effects on civilisation.

The first part of this book reflects efforts of the geoscience and the civil engineering community in earthquake mitigation. Earthquake early warning systems (EWS) as components of earthquake information systems can be utilised by a number of 'customers' ranging from chemical plants to transportation services. The paper by F. Wenzel discusses the most recent developments in this field and highlights the specific future of the EWS for the Romanian capital Bucharest. Another result of collaboration between civil engineers and geoscientists is presented in Fäcke et al. who study the seismic safety of long-span bridges crossing the river Rhine. Key questions refer to the appropriate level of ground motion that has to be expected but also to the construction type. The authors reveal specific failure mechanism for a box girder bridge. Ground motion modelling is often done with empirical laws adopted from several areas without consideration of information on the geology of the earthquake source and the geology of the medium in which the source-generated waves propagate. Gottschämmer et al. demonstrate that these shortcomings can be surpassed if modern tools, such as three-dimensional modelling techniques for elastic wave propagation are used. In this case the strike-slip sources and the sedimentary in-fill

of the Dead Sea Rift cause considerable wave-amplification in the rift, which must be taken into account in hazard assessment. The role of nonlinearity in seismology is an on-going debate that can be resolved only if seismologists, geotechnical engineers and geologists join efforts and develop a consistent picture of seismological strong motion observations, geotechnical laboratory experiments and physical models of nonlinear wave propagation. Marmueranu et al. make an attempt in this direction with emphasis on observations of strong Vrancea seismicity in Romania.

The second part of the book presents examples of seismic exploration techniques that range from ore and hydrocarbon exploration problems to the deeper mantle of the earth. J. Ritter studies mantle upwellings with passive seismology on continents in the Massif Central and more recently in the German Eifel region. A major challenge for geoscientists in the next decades is to identify more of these small-scale plumes and provide models that are based on observations. Complementary fluid- and geodynamic simulations and petrophysical modelling is necessary to fully understand the dynamics of small-scale mantle plumes as well as their contribution to the mixing of mantle material.

Ryberg et al. provide an overview on two decades of active upper mantle investigations in Northern Eurasia that revealed features previously hidden to passive seismology. Among them is clear evidence for a 520 km discontinuity and a fine-structure of the sub-lithospheric mantle that allows for efficient high-frequency wave propagation. Jäger et al. demonstrate the huge progress made in seismic imaging of hydrocarbon reservoirs. By applying suitable weight functions in the migration process the geometrical spreading effects of propagating waves can be compensated. Such an approach is called 'true-amplitude migration'. In this way, the output amplitudes are related to the reflection coefficient. As a consequence, detailed amplitude versus offset (AVO) or angle (AVA) analysis may be performed and, thus, the search for, e.g., reservoirs is improved.

Duveneck et al. present a novel migration technique that utilises all 3 recorded components of Vertical Seismic Profiling (VSP) data. The Polarisation Migration is successfully tested on synthetic elastic Finite Difference seismograms of the pure scattering response of a complex object in a simple VSP geometry. A VSP dataset measured near a known orebody is processed and migrated using the described Polarisation Migration. The migration result shows a clear anomaly at the actual position of the orebody.

The third part of this book deals with tectonics, on a plate scale, with modern approaches to modelling plate tectonics, and simultaneously understanding the implications of tectonics on civilisation. Ben-Avraham et al. argue that the present physiography of the Dead Sea Rift developed

slightly before man started his way out of Africa. This can be understood as one example where tectonic processes controlled the paths of human migration and development. The Dead Sea Rift is part of the African-Arabian-European collision scenario. D. Heidbach presents results of large-scale mechanical modelling of this collision with a Finite Element technique. The Aegean-Anatolian region belongs to the areas with the highest seismicity on a global scale. It influenced human societies since thousands of years and unfortunately even today.

Sperner et al. discuss the evidence that by looking at the Romanian Vrancea earthquake region as the site of a process in the deep earth, where a previously subducted oceanic slab segment is currently detached and will be returned to the deeper earth's mantle. This modern view on the recent tectonics of SE-Romania is a result of interdisciplinary research with the Collaborative Research Center 461 'Strong Earthquakes: A Challenge for Geosciences and Civil Engineering' during the past years. Ismail-Zadeh et al. provides quantitative modeling of this geodynamic process that allows a physical understanding of the detachment process.

The papers of this volume have been presented during a symposium in honour of Professor Karl Fuchs' 70<sup>th</sup> birthday. Karl Fuchs was born in 1932 in Stettin. He studied Geophysics in Hamburg, London, and Clausthal. After two years of hydrocarbon exploration in Algeria and Brazil he returned to Clausthal, where he finalised his Ph.D. in 1963. After research work on crustal structure and its effect on seismic spectra in St. Louis and Dallas he returned to Germany, where he joined Stephan Müller in 1965, who had established the Geophysical Institute of Karlsruhe University in 1964. In 1971 Karl Fuchs became a professor of Geophysics and director of the Geophysical Institute. Within the next 30 years he developed the institute to an international key player in lithospheric geophysics. He became an emeritus in 1999 but continues research and supports geophysics until today. Karl Fuchs supervised 150 diploma students and 70 Ph.D. theses. Karl Fuchs initiated a number of international research initiatives. Between 1981 and 1995 he was head of the Collaborative Research Center 'Stress and Stress Release in the Lithosphere'. The World Stress Map (WSM) task force of ILP was a result of this project. Since 1995 the WSM is run by the Heidelberger Academy of Sciences and Humanities with Karl Fuchs as Principal Investigator. He initiated EUROPROBE that was sponsored by the European Science Foundation and bridged the gap between eastern and western Europe when the iron curtain fell. He played a key role in setting up the International Continental Drilling Program during his time as President of the International Lithosphere Program (ILP) between 1985-1990.

Karl Fuchs is a member of the Heidelberg Academy, an honorary member of the American Geophysical Union, the American Association of the

Advancement of Science (AAAS), the British Royal Astronomical Society (RAS), and the Deutsche Geophysikalische Gesellschaft (DGG). He is Honorary Professor of Bucharest University and a member of the Academia Europea. In 2002 he received the Heitfeld-Prize by the Alfred-Wegener Foundation for his outstanding contributions to propagation of seismic waves and international cooperation in the Earth sciences.