

Preface

Rock stress is a key parameter in solid Earth sciences and technology. Long-term geological processes like plate tectonics are driven by mechanisms that generate different types of stresses in the Earth's crust. These stresses are acting as we extract raw materials from the crust and deposit human altered materials into the crust in boreholes, mines and underground constructions. To better use and save our resources there is an obvious need for a greater understanding of mechanical stresses in the Earth's crust. This book is directed toward graduate students, teachers and practitioners in geology, geophysics and civil, mining, petroleum and rock engineering. The book aims to fill the gap in the existing literature between principles in rock mechanics (Jaeger, Cook & Zimmerman 2007), rock stress measurements (Amadei & Stephansson 1997) and stress regimes in the lithosphere (Engelder 1993).

Mechanical stress and rock stress are fictitious terms as stress can never be directly measured. Stresses in rock originate from gravity and tectonic forces and can only be inferred by disturbing the rock by drilling a borehole, making a slot and coring the rock. The drill core can be brought to the laboratory and stresses determined by different physical methods. The complex nature of rocks prevents us from exactly determining the magnitudes and orientation of the components of the stress tensor and often we have to accept large variability and uncertainties. Stress in rock is usually described in the context of continuum mechanics. To introduce the *Stress Field of the Earth's Crust* to students in geosciences, one has to adopt methods from a number of otherwise self-supporting disciplines like the theory of elasticity, continuum mechanics, fracture mechanics, structural geology, geophysics, geodesy, experimental physics, rock and petroleum engineering.

This book starts by introducing the physical *Concept of Stress* from continuum mechanics, and continues to describe *Rock Failure* from classical to strength of material and modern fracture mechanics approaches. The chapter on *Rock Stress Terminology*, presented from a material sciences and rock engineering viewpoint, is followed by simple physical models describing the variation of stress magnitudes with depth in the Earth's crust. Then a chapter on the *Physics of Stress Measurements* is presented, where techniques from experimental physics are applied to determine residual stresses using material sciences standard. Methods for determining crustal stresses are separated into *Borehole Techniques* (e.g., overcoring,

hydraulic fracturing, borehole breakouts) and *Core-Based Methods* (e.g., anelastic strain recovery, Kaiser effect). The focus of the chapter *Local Stress Data* is to demonstrate facets of integrated stress measuring strategies as applied to scientific deep wells (*KTB*, Germany), to nuclear waste repository (*Olkiluoto*, Finland), and to monitor a seismically active fault zone (*SAFOD*, USA). The chapter *Generic Stress Data* reports on general trends in stress-magnitude profiles and stress-orientation maps, where stress-state scaling relations are used to find the best estimated stress model. In the last chapter the European and *World Stress Map* is interpreted in terms of *Plate Tectonics* by a thermally self-balancing planet Earth.

We wrote this as a classical *black and white textbook* (apart from 8 color figures) taking into account our experience and expertise in the topic. The reader will benefit from the presentation of the material as a textbook combined with *DVD movies*. Where a movie symbol is found in the margin of the body text of the book, the reader is able to click on the corresponding movie-file of the DVD. The movie material explains complex *scientific relationships*, demonstrates sophisticated experimental apparatus or *field testing equipment* for stress determination, and allows filing *interviews* with experts in rock stress and its measurements. After listening and watching the digital information, the reader returns to the textbook letters. In the case of getting lost while reading or watching, the reader can go directly to the *Note-Box* at the end of each section. From there, one can work backwards to obtain the full knowledge.

The content presented in this book is based on the many years of research and practical work of the two authors. In writing the book, we have made ample references to key publications in related fields and have tried to bring the reader up-to-date about theory, experiments, field tests and stress data compilations and analysis. In doing this, we may have omitted some references and hope the reader will forgive us. The material of this book was first compiled as lecture notes in 1999 when the first author started to teach a course entitled *Stress Field of the Earth's Crust* at the University of Potsdam for students in geosciences.

Potsdam
May 2009

Arno Zang and Ove Stephansson

Stress Field of the Earth's Crust

Zang, A.; Stephansson, O.

2010, XIX, 324 p., Hardcover

ISBN: 978-1-4020-8443-0