

Seismic modeling study of the Earth's deep crust

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ABSTRACT

We use seismic modeling methods to validate the interpretation of deep-crust seismic exploration. An approximation of the stacked section is obtained with the nonreflecting wave equation and the exploding-reflector approach. Using this technique and ray-tracing algorithms, we obtain a geological model by comparing the synthetic section with the real stacked section. An isotropic constitutive equation is assumed in this phase. The exact synthetic stacked section is then obtained by applying the standard processing sequence to a set of synthetic common-shot profiles computed with the variable-density acoustic wave equation. We introduce elliptical P-wave anisotropy and the effects of small-scale inhomogeneities by using a von Kármán autocovariance probability function that simulates scattering Q effects. Verification of the geological model by poststack migration constitutes an additional test. The methodology, which is suitable for areas of complex geology, is applied to a seismic line acquired in the northern Apennines as part of the Italian deep-crust exploration project, CROC. This area is particularly difficult to interpret because of the presence of a complex tectonic setting.

INTRODUCTION

The objective of seismic numerical modeling is to predict the seismogram that a set of sensors would record, given an assumed structure of the subsurface. It is a valuable tool for seismic interpretation and an essential part of seismic inversion algorithms. It is also used to provide data for testing processing algorithms and for evaluating acquisition parameters and processing options for various targets of interests before field data acquisition (Chedevor et al., 1995).

Seismic modeling has been used for hydrocarbon exploration problems (Kang and McMechan, 1990; Fagin, 1992),

for earthquake seismology problems (Priolo, 1999), and for crustal studies (Yarnold et al., 1993; Monguile, 1998; Monguile et al., 1998). Modeling synthetic seismograms may then have different purposes. In exploration geophysics, for instance, it is important to perform a sensitivity analysis related to the detectability of a petrophysical variable, such as porosity, fluid type, or fluid saturation. In earthquake seismology the scale of the investigation can be of the order of kilometers for site-response problems (Priolo, 1999) or of the order of tens of kilometers for deep crustal studies (Poussini et al., 1995). We develop a methodology to validate the seismic response of the Earth's crust on a large-scale basis for the purpose of verifying the main geological features of the upper and lower crusts obtained during the interpretation process.

The interpretation of large-scale structures of the deep crust is mainly based on P-wave information [examples of seismic data are from the Italian CROC and the German DEDORP deep-crust exploration projects (Finetti, 1994; Picli et al., 1998; Rabbel and Gajewski, 1995)]. The source and acquisition parameters for the CROC-03 seismic survey are given in Table 1 (Berthelli and Mazzotti (1999); see also Mazzotti et al. (2000) for alternative parameters). The survey has been interpreted by Finetti et al. (2001). Amplitude information is relatively important, but a precise determination of the interval velocities is difficult because the residual NMO of reflection events beyond 4–5 s becomes very small. Additional problems are the complex tectonic regime and rough topography with outcrops of high-velocity layers. Moreover, the data are usually of low S/N ratio, thus invalidating the use of techniques such as prestack depth migration. Therefore, we should deal with almost zero-offset P-wave data, and the model design should be based on the stacked time section: well data are scarce, and only oil exploration wells down to 4 km depth are available. The data generally show a rather scarce reflectivity and diffractions, which may reveal the presence of fault planes. On the basis of these facts, it is unrealistic to use sophisticated modeling techniques. Therefore, we do not consider mode conversion (i.e., S-waves) and intrinsic attenuation, which, in this situation, constitute second-order effects. Anisotropic effects on the P-wave are modeled with an

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Seismic Modeling Of The Earths Crust

Michael Wiescher



Seismic Modeling Of The Earths Crust:

Seismic Modeling of the Earth's Crust, 1972 *Postroenie Seismicheskoi Modeli Zemnoi Kory* Igor' Nikolaevich Galkin, 1975 **Seismic Modeling of the Earth's Crust** Igor' Nikolaevich Galkin, 1975 *Seismology and Structure of the Earth* Barbara Romanowicz, Adam Dziewonski, 2010-04-20 *Treatise on Geophysics Seismology and Structure of the Earth* Volume 1 provides a comprehensive review of the state of knowledge on the Earth's structure and earthquakes. It addresses various aspects of structural seismology and its applications to other fields of Earth sciences. The book is organized into four parts. The first part principally covers theoretical developments and seismic data analysis techniques from the end of the nineteenth century until the present with the main emphasis on the development of instrumentation and its deployment. The second part reviews the status of knowledge on the structure of the Earth's shallow layers starting with a global review of the Earth's crustal structure. The third part focuses on the Earth's deep structure divided into its main units: the upper mantle, the transition zone, and upper mantle discontinuities, the D region at the base of the mantle, and the Earth's core. The fourth part comprises two chapters which discuss constraints on Earth structure from fields other than seismology: mineral physics and geodynamics. Self-contained volume starts with an overview of the subject then explores each topic with in-depth detail. Extensive reference lists and cross references with other volumes to facilitate further research. Full color figures and tables support the text and aid in understanding. Content suited for both the expert and non-expert. *Deep Seismic Sounding of the Earth's Crust and Upper Mantle* Irina P. Kosminskaya, 2012-12-06 Deep seismic sounding was proposed by G. A. Gamburtsev and developed under his guidance during the period 1948-1955 at the Institute of Physics of the Earth of the Academy of Sciences of the USSR. During that period also the first geophysical results concerning the deep structure of the Earth's crust in several regions in Tien Shan, the Pamir, and Turkmenia were observed. Beginning with 1956 the deep seismic sounding method has been used widely by geophysical research groups as well as by geophysical service organizations for regional studies in the USSR. Descriptions of this work have been given in reports by Yu. N. Godin, V. V. Fedynskii, D. N. Kazanli, and others. New variants of the deep seismic sounding method have been developed: continuous profiling (Yu. N. Godin and others) and point soundings (N. N. Puzyrev and others). Deep seismic soundings have been carried out outside of Russia also, and studies have been carried out on the use of the deep seismic sounding method in marine applications (E. I. Galperin, S. M. Zverev, I. P. Kosminskaya, Yu. P. Neprochnov, and others). Over the past decade the deep seismic sounding method has joined the suite of geophysical studies as a highly detailed method for studying the Earth's crust and upper mantle to depths of 50 to 100 km on land and of 15 to 25 km in the deep oceans. Active Geophysical Monitoring Hitoshi Mikada, Michael S. Zhdanov, Junzo Kasahara, 2025-09-12 *Active Geophysical Monitoring* covers the praxis of active geophysical monitoring in a broad range of applications including CCUS, hydrocarbon, geothermal reservoir development and management, groundwater, earthquake monitoring, and more. The editors and contributing authors thoroughly examine the latest developments and

technologies in this new edition The text begins with an in depth overview of active geophysical monitoring followed by a close look at active targets and the latest technology The theory of data analysis and interpretation follows in detail The text closes with 15 case histories in signal processing as well as carbon capture and storage This updated edition is an invaluable resource for geophysicists employing a range of monitoring applications Explains the general concepts of active geophysical monitoring and the relevant historical background Describes worldwide efforts of active geophysical monitoring and provides a perspective view on worldwide development Updated for the last decade s development and the latest technologies

The Three-ray Megacontinent of the Earth Yuri Bakulin, Anatoly Zhirnov, 2019-12-10 This book explores many mysterious features of the structure and evolution of the Earth s continents still unknown to the scientific community and a wider audience Science has now proved that the southern continents of South America Africa and Australia represent the southern ends of a single three beam megacontinent It began to form 4 4 billion years ago in a huge three beam cavity on the planet s surface and grew vertically up to its present state Proof of the reality of a single three beam megacontinent is a fundamental discovery in Earth sciences and represents a new level in the understanding of the planet s structure The text will appeal to researchers of Earth sciences university teachers and students and secondary school teachers of geography and geology as well as all readers with an interest in the history of our planet

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Planetary Sciences Imke de Pater, Jack J. Lissauer, 2015-01-29 An authoritative introduction for graduate students in the physical sciences this award winning textbook explains the wide variety of physical chemical and geological processes that govern the motions and properties of planets This updated second edition has been revised and improved while maintaining its existing structure and organization Many data tables and plots have been updated to account for the latest measurements A new Appendix focuses on recent discoveries since the second edition was first published These include results from Cassini Kepler MESSENGER MRO LRO Dawn at Vesta Curiosity and others as well as many ground based observatories With over 300 exercises to help students apply the concepts covered this textbook is ideal for graduate courses in astronomy planetary science and earth science and well suited as a reference for researchers Color versions of many figures movie clips supplementing the text and other resources are available at www.cambridge.org/depater

Proceedings of the 1980 Workshop of the International Association of Seismology and Physics of the Earth's Interior on the Seismic Modeling of Laterally Varying Structures International Association of Seismology and Physics of the Earth's Interior. Workshop, 1984

Technical Abstract Bulletin Defense Documentation Center (U.S.), 1964

Geophysical Abstracts , 1971-07

Upper Mantle Heterogeneities from Active and Passive Seismology K. Fuchs, 2013-03-14 600 km giving insight into the 3D structure of the upper mantle These data are confronted with the

requirements of the CTBT for 3D regional seismic models of the lithosphere asthenosphere system The two primary purposes of the present work are first to present these seismic observations on super long range profiles in digitised format using peaceful nuclear explosions PNE in the former USSR and second to present the joint thoughts of experts from the deep seismic sounding DSS and the comprehensive test ban treaty CTBT communities Implications for petrological and other earth science disciplines are presented Audience The CTBT community and earth scientists interested in the 3D structure of the lithosphere asthenosphere system *Scientific and Technical Aerospace Reports* ,1994 *Energy Potential of the Russian Arctic Seas* Alexey Piskarev,Mikhail Shkatov,2012-06-14 The structure of sedimentary basins of the Russian Arctic Seas is studied and illustrated by a number of maps cross sections and geophysical models The calculated density models of the Earth crust illustrate the deep structure of the main blocks of the crust Five major gas condensate and gas fields are discovered here three Shtokman Ludlov Ledovoe in the Barents and two Leningrad and Rusanov in the Kara Sea Geological and geophysical characteristics of the Russian Arctic Sea sedimentary basins allow an estimation of their hydrocarbon potential by comparison with the known world analogues Total potential resources of giant deposits of hydrocarbons in Russian Arctic Seas are estimated at 470 billion barrels of oil equivalent The richest resources are the Kara Sea and Laptev Sea Less rich is Barents Sea The relatively smaller contribution to the overall estimation of the resources makes the resources of East Siberian Sea and Chukchi Sea Development the energy capacity of the continental shelf of Russia can play a stabilizing role in the dynamics of oil and gas production in the period 2010 2020 A key role in developing the capacity of the Arctic shelf oil and gas play is the innovative technology in exploration production and management of the relevant investment projects World offshore experience indicates that the combination of these factors is achieved through the formation of international firms and organizations Comprehensively assesses the potential oil and gas resources in sedimentary basins within the Russian sector of the Arctic Ocean Describes the economic and legal challenges to the development of offshore fields in Russia Explores possible ways and timing to make these hydrocarbon resources available to the global market *Radioactivity* Michael Wiescher,2025-01-16 This book provides an accessible introduction to radioactivity The first in a two volume set this volume is presented in two parts covering radiation physics and natural radiation exposure It first explores the discovery and physics of the phenomenon of radioactivity covering the discovery of radioactive decay and the historical development of the physics and applications of radioactivity through to 1940 Chapters then present descriptive summaries of the physics of the atom and the atomic nucleus mass and energy conditions the nature of isotopes and the different decay patterns Chapter three discusses decay laws and introduces natural origins of radioactivity as well as methods for producing radioactive isotopes through nuclear reaction processes in reactor and accelerator The book then provides an introduction on dosimetry radiation chemistry and impact of radiation on biological systems The second half of the book details natural radioactivity and the role of radioactivity in the formation of the planetary

system and our Earth The author describes how the inner radioactivity of our planet determines its dynamics and how it could have contributed to the origins of life The volume concludes with an exploration of the external and internal radioactivity to which humans are exposed and their possible side effects This book will be of interest to non science undergraduate and physics graduate students alike as well as to interested lay people looking for an introduction to radioactivity Key Features Written in an accessible style to be understood by readers without a formal scientific education Highly illustrated throughout Authored by an expert in the field drawing from decades of experience in experimental nuclear physics *Oceanology* ,2006 **Principles of Seismology** Agustín Udías Vallina,Elisa Bufo,2018 This new edition features a completely new chapter on digital seismic data processing numerous examples and 100 problems *The Georges Bank Monitoring Program, 1984* ,1984 **U.S. Geological Survey Circular** ,1984

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