

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 (Chadwick 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 DEICORP 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

J. Leliwa-Kopystynski, Roman Teisseyre



Seismic Modeling Of The Earths Crust:

Postroenie Seismicheskoi Modeli Zemnoi Kory Igor' Nikolaevich Galkin,1975 **Seismic Modeling of the Earth's Crust**,1972 Seismic Modeling of the Earth's Crust Igor' Nikolaevich Galkin,1975 **Air Force Research Resumés**, **Geophisica**,1991 **Seismic Modelling of the Earth's Crust** I. N. Galkin,1996 **Journal** Canadian Society of Exploration Geophysicists,1990 Scientific and Technical Aerospace Reports,1972 Lists citations with abstracts for aerospace related reports obtained from world wide sources and announces documents that have recently been entered into the NASA Scientific and Technical Information Database Constitution of the Earth's Interior J. Leliwa-Kopystynski,Roman Teisseyre,2016-07-29 Constitution of the Earth s Interior discusses the physical and evolutionary principles connecting various elements of the knowledge about structure and dynamics of the Earth s interior This work is divided into eight chapters that primarily focus on the physical chemical and petrological state This text contains general data on a general stationary model which is described by equations of state combining the basic parameters including pressure temperature density gravity acceleration and mineral composition within the Earth s interior Considerable chapters concern the chemical and petrological composition of the matter in the Earth s interior The remaining chapters describe models containing inhomogeneities used to illustrate processes connected with phase transitions This book will be of great value to geologists physicists and researchers 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 Earths 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 Earths 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 Natural Disasters - Volume I Vladimir M. Kotlyakov,2010-08-19 Natural Disasters theme in two volumes is a component of Encyclopedia of Earth and Atmospheric Sciences in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty one Encyclopedias Natural hazards arise unexpectedly without any discernible regularity and leave an indelible trace in nature sometimes for many decades to come

At present they are appreciably complicated by anthropogenic influence lending them an adverse and often catastrophic character. The susceptibility of a society to the impact of natural disasters is conditioned by the natural environment and the vulnerability of the society to such phenomena is historically associated with the type of the nature management. Natural disasters can be of geological and hydrometeorological origin; the specific group of such phenomena is presented by natural disasters in mountains. This volume deals with the natural disaster and covers several topics with a myriad of issues of great relevance to our world such as Geological Catastrophes, Climate Related Hazards, Mountain Disasters and Snow Avalanches which are then expanded into multiple subtopics each as a chapter. These two volumes are aimed at the following five major target audiences: University and College Students, Educators, Professional Practitioners, Research Personnel and Policy Analysts, Managers and Decision Makers, NGOs and GOs.

Treatise on Geophysics, 2015-04-17. *Treatise on Geophysics* Second Edition is a comprehensive and in depth study of the physics of the Earth beyond what any geophysics text has provided previously. Thoroughly revised and updated, it provides fundamental and state of the art discussion of all aspects of geophysics. A highlight of the second edition is a new volume on Near Surface Geophysics that discusses the role of geophysics in the exploitation and conservation of natural resources and the assessment of degradation of natural systems by pollution. Additional features include new material in the Planets and Moon, Mantle Dynamics, Core Dynamics, Crustal and Lithosphere Dynamics, Evolution of the Earth and Geodesy volumes. New material is also presented on the uses of Earth gravity measurements. This title is essential for professionals, researchers, professors and advanced undergraduate and graduate students in the fields of Geophysics and Earth system science. Comprehensive and detailed coverage of all aspects of geophysics. Fundamental and state of the art discussions of all research topics. Integration of topics into a coherent whole.

Encyclopedia of Solid Earth Geophysics Harsh Gupta, 2011-06-29. The past few decades have witnessed the growth of the Earth Sciences in the pursuit of knowledge and understanding of the planet that we live on. This development addresses the challenging endeavor to enrich human lives with the bounties of Nature as well as to preserve the planet for the generations to come. Solid Earth Geophysics aspires to define and quantify the internal structure and processes of the Earth in terms of the principles of physics and forms the intrinsic framework which other allied disciplines utilize for more specific investigations. The first edition of the *Encyclopedia of Solid Earth Geophysics* was published in 1989 by Van Nostrand Reinhold publishing company. More than two decades later, this new volume edited by Prof. Harsh K. Gupta represents a thoroughly revised and expanded reference work. It brings together more than 200 articles covering established and new concepts of Geophysics across the various sub-disciplines such as Gravity, Geodesy, Geomagnetism, Seismology, Seismics, Deep Earth Processes, Plate Tectonics, Thermal Domains, Computational Methods etc. in a systematic and consistent format and standard. It is an authoritative and current reference source with extraordinary width of scope. It draws its unique strength from the expert contributions of editors and authors across the globe. It is designed to serve as a valuable and cherished

source of information for current and future generations of professionals *Nuclear Science Abstracts* ,1973 *Initial Reports of the Deep Sea Drilling Project* Scripps Institution of Oceanography,1969 *Extreme Environmental Events* Robert A. Meyers,2010-11-03 Extreme Environmental Events is an authoritative single source for understanding and applying the basic tenets of complexity and systems theory as well as the tools and measures for analyzing complex systems to the prediction monitoring and evaluation of major natural phenomena affecting life on earth These phenomena are often highly destructive and include earthquakes tsunamis volcanoes climate change and weather Early warning damage and the immediate response of human populations to these phenomena are also covered from the point of view of complexity and nonlinear systems In 61 authoritative state of the art articles world experts in each field apply such tools and concepts as fractals cellular automata solitons game theory network theory and statistical physics to an understanding of these complex geophysical phenomena **Computational Geo-Electromagnetics** Viacheslav V. Spichak,2020-02-04 Computational Geo Electromagnetics Methods Models and Forecasts Volume Five in the Computational Geophysics series is devoted to techniques for building of geoelectrical models from electromagnetic data featuring Bayesian statistical analysis and neural network algorithms These models are applied to studying the geoelectrical structure of famous volcanoes i e Vesuvio Kilauea Elbrus Komagatake Hengill and geothermal zones i e Travale Italy Soultz sous Forets Elsass Methodological recommendations are given on electromagnetic sounding of faults as well as geothermal and hydrocarbon reservoirs Techniques for forecasting of petrophysical properties from the electrical resistivity as proxy parameter are also considered Computational Geo Electromagnetics Methods Models and Forecasts offers techniques and algorithms for building geoelectrical models under conditions of rare or irregularly distributed EM data and or lack of prior geological and geophysical information This volume also includes methodological guidelines on interpretation of electromagnetic sounding data depending on goals of the study Finally it details computational algorithms for using electrical resistivity for properties beyond boreholes Continental Rifts: Evolution, Structure, Tectonics K.H. Olsen,1995-11-24 This multi author book has been prepared by an international group of geoscientists that have been active in rift research since the late 1960s In 1984 an informal grass roots study group was initiated to compare individual research results and to explore in greater depth the apparent differences and similarities in the interpretations from various rift systems The group became known as the CREST working group an acronym of Continental Rifts Evolution Structure and Tectonics which not surprisingly became the title of this book Continental Rifts Evolution Structure Tectonics presents an overview of the present state of understanding and knowledge of the processes of continental rifting from a multidisciplinary lithospheric scale perspective The chapters have been structured on each rift system in approximately the same synoptic sequence so as to facilitate comparisons of rifts by the reader The book complements its predecessors by presenting a more unified picture It succeeds in presenting the status of a representative majority of the continental rift systems that have been at the forefront of recent research For students

and experienced researchers alike this book will be of significant value in assessing the current state of knowledge and in serving as a framework for future research **THE HYBRID GRAND UNIFIED THEORY** E. Escultura,V.

Lakshmikantham,2009-03-01 In this book an attempt is made to provide a hybrid grand unified theory to understand the universe both in its micro quantum aspects as well as macro galactic aspects The book describes a truly hybrid theory as it encompasses both the modern and ancient theories of the universe together with its functioning at all levels of human comprehension One of its authors Dr Escultura was nominated in 2005 for a Nobel Prize for his flux theory of gravitation From then on this theory has been improved clarified and is now known as the hybrid grand unified theory This book deals with this new bold theory unifying mathematics and physics and answering some open fundamental questions and paradoxes in these disciplines The book also describes what the ancient scientists knew about these matters *Cumulative Index*
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