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Po Chen
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Full-3D Seismic Waveform Inversion

Theory, Software and Practice

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Full 3d Seismic Waveform Inversion Theory Software And Practice Springer Geophysics

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Full 3d Seismic Waveform Inversion Theory Software And Practice Springer Geophysics:

Full-3D Seismic Waveform Inversion Po Chen,En-Jui Lee,2015-09-10 This book introduces a methodology for solving the seismic inverse problem using purely numerical solutions built on 3D wave equations and which is free of the approximations or simplifications that are common in classical seismic inversion methodologies and therefore applicable to arbitrary 3D geological media and seismic source models Source codes provided allow readers to experiment with the calculations demonstrated and also explore their own applications

Fault-Zone Guided Wave, Ground Motion, Landslide and Earthquake Forecast Yong-Gang Li,2018-03-19 The book covers multi disciplinary topics in observational computational and applied geophysics in aspects of solid earth system The authors provide an up to date overview for methods and techniques in seismology with a focus on fault structure strong ground motion and earthquake forecast based on full 3D earth structure models Abundant of case studies make it a practical reference for researchers in seismology and applied geophysics

Earthquake and Disaster Risk: Decade Retrospective of the Wenchuan Earthquake Yong-Gang Li,2019-05-04 This book presents review papers and research articles focusing on the 2008 Wenchuan earthquake in Sichuan China discussing cross disciplinary and multiple thematic aspects of modern seismological geophysical geological and stochastic methodology and technology Resulting from international and regional earthquake research and disaster mitigation collaborations and written by international authors from multiple institutions and disciplines it describes methods and techniques in earthquake science based on investigations of the Wenchuan earthquake It also includes extensive reference lists to aid further research The book helps both senior researchers and graduate students in earthquake science to broaden their horizons in data analysis numerical modeling and structural retrieval for the tectonic geological geophysical and mechanical interpretation of the 2008 M8 Wenchuan earthquake to support a global and regional cooperation for preparedness and the mitigation and management of seismic risk

Full Seismic Waveform Modelling and Inversion Andreas Fichtner,2010-11-16 Recent progress in numerical methods and computer science allows us today to simulate the propagation of seismic waves through realistically heterogeneous Earth models with unprecedented accuracy Full waveform tomography is a tomographic technique that takes advantage of numerical solutions of the elastic wave equation The accuracy of the numerical solutions and the exploitation of complete waveform information result in tomographic images that are both more realistic and better resolved This book develops and describes state of the art methodologies covering all aspects of full waveform tomography including methods for the numerical solution of the elastic wave equation the adjoint method the design of objective functionals and optimisation schemes It provides a variety of case studies on all scales from local to global based on a large number of examples involving real data It is a comprehensive reference on full waveform tomography for advanced students researchers and professionals

Seismic Inversion Methods: A Practical Approach S. P. Maurya,N. P. Singh,K. H. Singh,2020-05-28 This book introduces readers to seismic inversion

methods and their application to both synthetic and real seismic data sets Seismic inversion methods are routinely used to estimate attributes like P impedance S impedance density the ratio of P wave and S wave velocities and elastic impedances from seismic and well log data These attributes help to understand lithology and fluid contents in the subsurface There are several seismic inversion methods available but their application and results differ considerably which can lead to confusion This book explains all popular inversion methods discusses their mathematical backgrounds and demonstrates their capacity to extract information from seismic reflection data The types covered include model based inversion colored inversion sparse spike inversion band limited inversion simultaneous inversion elastic impedance inversion and geostatistical inversion which includes single attribute analysis multi attribute analysis probabilistic neural networks and multi layer feed forward neural networks In addition the book describes local and global optimization methods and their application to seismic reflection data Given its multidisciplinary integrated and practical approach the book offers a valuable tool for students and young professionals especially those affiliated with oil companies

Seismic Inversion Gerard T. Schuster, 2017-07-01 This book describes the theory and practice of inverting seismic data for the subsurface rock properties of the earth The primary application is for inverting reflection and or transmission data from engineering or exploration surveys but the methods described also can be used for earthquake studies Seismic Inversion will be of benefit to scientists and advanced students in engineering earth sciences and physics It is desirable that the reader has some familiarity with certain aspects of numerical computation such as finite difference solutions to partial differential equations numerical linear algebra and the basic physics of wave propagation For those not familiar with the terminology and methods of seismic exploration a brief introduction is provided To truly understand the nuances of seismic inversion we have to actively practice what we preach or teach Therefore computational labs are provided for most of the chapters and some field data labs are given as well

Full-waveform Inversion to 3D Seismic Land Data Ahmed Musallam Ali Al-Yaqoobi, Mike Warner, 2013 Full waveform inversion FWI is a technique that seeks to find a high resolution high fidelity model of the Earth's subsurface that is capable of matching individual seismic waveforms within an original raw field dataset trace by trace The method begins from a best guess starting model which is then iteratively improved using a sequence of linearized local inversions to solve a fully non linear problem In principle FWI can be used to recover any physical property that has an influence upon the seismic wavefield but in practice the technique has been used predominantly to recover P wave velocity and this is the route that is followed here Full waveform tomographic techniques seek to determine a highly resolved quantitative model of the subsurface that will ultimately be able to explain the entire seismic wavefield including those phases that conventional processing and migration seek to remove such as refracted arrivals Although the underlying theory of FWI is well established its practical application to 3D land data and especially to seismic data that have been acquired using vibrators in a form that is effective and robust is still a subject of intense research In this study 2D and 3D FWI techniques have been applied to a

vibrator dataset from onshore Oman Both the raw dataset and the subsurface model cause difficulties for FWI In particular the data are noisy have weak early arrivals are strongly elastic and especially are lacking in low frequency content The Earth model appears to contain shallow low velocity layers and these compromise the use of first arrival travel time tomography for the generation of a starting velocity model The 2D results show good recovery of the shallow part of the velocity models The results show a low velocity layer that extends across the velocity model but lacking in a high resolution image due to the absence of the third dimension The seismograms of the final inversion models give a good comparison with the field data and produce a reasonably high correlation coefficient compared to the starting model An inversion scheme has been developed in this study in which only data from the shorter offsets are initially inverted since these represent the subset of the data that is not cycle skipped The offset range is then gradually extended as the model improves The final 3D model contains a strongly developed low velocity layer in the shallow section The results from this inversion appear to match p wave logs from a shallow drill hole better flatten the gathers and better stack and migrate the reflection data The inversion scheme is generic and should have applications to other similar difficult datasets

Seismic Wave Propagation and Scattering in the Heterogeneous Earth : Second Edition Haruo Sato, Michael C. Fehler, Takuto Maeda, 2012-01-28 Seismic waves generated both by natural earthquakes and by man made sources have produced an enormous amount of information about the Earth's interior In classical seismology the Earth is modeled as a sequence of uniform horizontal layers or spherical shells having different elastic properties and one determines these properties from travel times and dispersion of seismic waves The Earth however is not made of horizontally uniform layers and classic seismic methods can take large scale inhomogeneities into account Smaller scale irregularities on the other hand require other methods Observations of continuous wave trains that follow classic direct S waves known as coda waves have shown that there are heterogeneities of random size scattered randomly throughout the layers of the classic seismic model This book focuses on recent developments in the area of seismic wave propagation and scattering through the randomly heterogeneous structure of the Earth with emphasis on the lithosphere The presentation combines information from many sources to present a coherent introduction to the theory of scattering in acoustic and elastic materials and includes analyses of observations using the theoretical methods developed The second edition especially includes new observational facts such as the spatial variation of medium inhomogeneities and the temporal change in scattering characteristics and recent theoretical developments in the envelope synthesis in random media for the last ten years Mathematics is thoroughly rewritten for improving the readability Written for advanced undergraduates or beginning graduate students of geophysics or planetary sciences this book should also be of interest to civil engineers seismologists acoustical engineers and others interested in wave propagation through inhomogeneous elastic media

Modularized Iterative Full Seismic Waveform Inversion for 3D-heterogeneous Media Based on Waveform Sensitivity Kernels Florian Schumacher, 2014

Isotropic and Anisotropic Seismic Tomography Using Active Source

and Earthquake Records Yu-Pin Lin, 2017-06-16 This book presents investigations on the Earth's seismic structure using both active source and natural earthquake records. It discusses the ground truth data obtained from the Taiwan Integrated GEodynamics Research TAIGER active source experiments that provides excellent and unique insights into the shallow crustal structures beneath Taiwan. It also explores the full wave sensitivity kernels which account for the effects of all possible wave interferences involved in shear wave splitting and therefore loosen the restrictions on source receiver geometry amenable to shear wave splitting analysis. Moreover, it describes the 3D Frchet kernels which enable us to resolve the vertical and lateral variations in seismic anisotropy and obtain 3D images of the Earth's anisotropic structure as well as the practice in Southern California that enables us to infer the state of the stress and strain in the lithosphere and the dynamics of the asthenospheric mantle flow for a better understanding of the strength and deformation in the upper mantle beneath the San Andreas Fault system.

Full Waveform Inversion of 3D Seismic Data Akela Silverton, 2011

Seismic Wave Propagation and Scattering in the Heterogeneous Earth Haruo Sato, Michael C. Fehler, 2008-12-17 Seismic waves generated both by natural earthquakes and by man-made sources have produced an enormous amount of information about the Earth's interior. In classical seismology the Earth is modeled as a sequence of uniform horizontal layers or spherical shells having different elastic properties and one determines these properties from travel times and dispersion of seismic waves. The Earth, however, is not made of horizontally uniform layers and classic seismic methods can take large scale inhomogeneities into account. Smaller scale irregularities on the other hand require other methods. Observations of continuous wave trains that follow classic direct S waves known as coda waves have shown that there are heterogeneities of random size scattered randomly throughout the layers of the classic seismic model. This book focuses on recent developments in the area of seismic wave propagation and scattering through the randomly heterogeneous structure of the Earth with emphasis on the lithosphere. The presentation combines information from many sources to present a coherent introduction to the theory of scattering in acoustic and elastic materials and includes analyses of observations using the theoretical methods developed.

3-D Full Waveform Inversion of Seismic Data ; Part I. Theory, 2003 Full waveform inversion of seismic data is a challenging subject partly because of the lack of precise knowledge of the source. Since currently available approaches involve some form of approximations to the source inversion results are subject to the quality and the choice of the source information used. A new full waveform inversion scheme has been introduced Lee and Kim 2003 using normalized wavefield for simple two dimensional 2-D scalar problems. The method does not require source information so potential inversion errors due to source estimation may be eliminated. A gather of seismic traces is first Fourier transformed into the frequency domain and a normalized wavefield is obtained for each trace in the frequency domain. Normalization is done with respect to the frequency response of a reference trace selected from the gather so the complex valued normalized wavefield is source independent and dimensionless. The inversion algorithm minimizes misfits between measured normalized wavefield and

numerically computed normalized wavefield In this paper the full waveform inversion is extended to three dimensional 3 D problems

3D Elastic Full-waveform Inversion Lluís Guasch, Mike Warner, 2012 Full Waveform Inversion FWI is a depth imaging technique that takes advantage of the full information contained in recorded seismic data FWI provide high resolution images of subsurface properties usually seismic velocities or related parameters although in theory it could image any property used to formulate the wave equation The computational cost of the methodology has historically limited its application to 3D acoustic approximations but recent developments in hardware capabilities have increased computer power to the point that more realistic approximations are viable In this work the traditional acoustic approximation is extended to include elastic effects by introducing the elastic wave equation as the governing law that describes wave propagation I have developed a software based on finite differences to solve the elastic wave equation in 3D which I applied in the development of a full waveform inversion algorithm The software is fully parallelised for both distributed and shared memory systems The first level of parallelisation distributes seismic sources across cluster nodes Each node solves the 3D elastic wave equation in the whole computational domain The second level of parallelisation takes advantage of present multi core computer processor units CPU to decompose the computational domain into different volumes that are solved independently by each core Such parallel design allows the algorithm to handle models of realistic sizes increasing the computational times only a factor of two compared to those of 3D acoustic full waveform inversion on the same mesh I have also implemented a perfectly matched layer absorbing boundary condition to reproduce a semi infinite model geometry and prevent spurious reflections from the model boundaries from contaminating the modelled wavefields The inversion algorithm is based upon the adjoint state method which I reformulated for the wave equation that I implemented which was based on particle velocities and stresses providing a comparison and demonstration of equivalence with previous developments To examine the performance of the code I have inverted several synthetic problems of increasing realism I have principally used only pressure sources and receivers to assess the potential of the method s application to the most common industry surveys streamer data for offshore and vertical geophones only one component for onshore exploration surveys The results show that the imaged properties increase with the heterogeneity of the models due to the increase in P S P conversions which provides the main source of information to invert shear wave velocity models from pressure sources and receivers It remains to demonstrate the inversion of field datasets and my future research project will focused on achieving this goal

Seismic Amplitude Versus

Offset Analysis and Amplitude Inversion Theory and Practice—A Comprehensive Review Hüseyin

Özdemir, 2025-07-06 This book provides an extensive critical review of seismic inversion methods and applications

Hydrocarbon reservoir extensions and properties cannot be accurately defined from information provided by geological data geophysical data and well log data Seismic data has adequate spatial coverage but lacks vertical resolution while well data has excellent vertical resolution but spatially sparse Seismic reflection amplitudes are related to pore fill and lithology

changes Seismic AVO analysis and inversion exploit variation of amplitudes with angle of incidence to derive useful attributes and elastic rock properties such as velocity impedance and density Seismic inversion attempts to fill the gap between and away from the already drilled wells with rock properties that are available from the measured and or interpreted well log data In this endeavour seismic data well log data and all available geological model data are integrated to predict rock and ultimately reservoir properties such as porosity water saturation shale content brittleness and pore pressure This book is aimed at graduate and postgraduate students academics and geoscientist exploiting earth resources It is especially directed to oil and gas industry professionals in supporting their efforts in quantitative reservoir description from seismic data While brief theoretical derivations are provided to understand power and limitations of inversion methods used emphasis has been on the practical applications A comprehensive critical review of the seismic inversion and AVO theory and applications published and presented at technical meetings is provided with ample references and further references for probing geoscientists

Seismic Inversion Yanghua Wang, 2016-12-14 Seismic inversion aims to reconstruct a quantitative model of the Earth subsurface by solving an inverse problem based on seismic measurements There are at least three fundamental issues to be solved simultaneously non linearity non uniqueness and instability This book covers the basic theory and techniques used in seismic inversion corresponding to these three issues emphasising the physical interpretation of theoretical concepts and practical solutions This book is written for master and doctoral students who need to understand the mathematical tools and the engineering aspects of the inverse problem needed to obtain geophysically meaningful solutions Building on the basic theory of linear inverse problems the methodologies of seismic inversion are explained in detail including ray impedance inversion and waveform tomography etc The application methodologies are categorised into convolutional and wave equation based groups This systematic presentation simplifies the subject and enables an in depth understanding of seismic inversion This book also provides a practical guide to reservoir geophysicists who are attempting quantitative reservoir characterisation based on seismic data Philosophically the seismic inverse problem allows for a range of possible solutions but the techniques described herein enable geophysicists to exclude models that cannot satisfy the available data This book summarises the author s extensive experience in both industry and academia and includes innovative techniques not previously published

Full Seismic Waveform Inversion for Structural and Source Parameters Andreas Fichtner, 2009

Seismic Amplitude Versus Offset Analysis and Amplitude Inversion Theory and Practice—A Comprehensive Review Hüseyin Özdemir, 2025-07-06 This book provides an extensive critical review of seismic inversion methods and applications Hydrocarbon reservoir extensions and properties cannot be accurately defined from information provided by geological data geophysical data and well log data Seismic data has adequate spatial coverage but lacks vertical resolution while well data has excellent vertical resolution but spatially sparse Seismic reflection amplitudes are related to pore fill and lithology changes Seismic AVO analysis and inversion exploit variation of amplitudes

with angle of incidence to derive useful attributes and elastic rock properties such as velocity impedance and density. Seismic inversion attempts to fill the gap between and away from the already drilled wells with rock properties that are available from the measured and/or interpreted well log data. In this endeavour, seismic data, well log data and all available geological model data are integrated to predict rock and ultimately reservoir properties such as porosity, water saturation, shale content, brittleness and pore pressure. This book is aimed at graduate and postgraduate students, academics and geoscientists exploiting earth resources. It is especially directed to oil and gas industry professionals in supporting their efforts in quantitative reservoir description from seismic data. While brief theoretical derivations are provided to understand power and limitations of inversion methods used, emphasis has been on the practical applications. A comprehensive critical review of the seismic inversion and AVO theory and applications published and presented at technical meetings is provided with ample references and further references for probing geoscientists.

Surface Wave Analysis for Near Surface Applications

Giancarlo Dal Moro, 2014-11-04. Seismic Wave Analysis for Near Surface Applications presents the foundational tools necessary to properly analyze surface waves acquired according to both active and passive techniques. Applications range from seismic hazard studies, geotechnical surveys and the exploration of extra-terrestrial bodies. Surface waves have become critical to near surface geophysics both for geotechnical goals and seismic hazard studies. Included in this book are the related theories, approaches and applications which the lead editor has assembled from a range of authored contributions carefully selected from the latest developments in research. A unique blend of theory and practice, the book's concepts are based on exhaustive field research conducted over the past decade from the world's leading seismologists and geophysicists. Edited by a geophysicist with nearly 20 years of experience in research, consulting and geoscience software development. Nearly 100 figures, photographs and examples aid in the understanding of fundamental concepts and techniques. Presents the latest research in seismic wave characteristics and analysis, the fundamentals of signal processing, wave data acquisition and inversion and the latest developments in horizontal to vertical spectral ratio (HVSr). Each chapter features a real world case study to bring the book's key principles to life.

Exploiting Seismic Waveforms Brian L. N. Kennett, Andreas

Fichtner, 2020-12-03. Exploiting Seismic Waveforms introduces a range of recent developments in seismology including the application of correlation techniques, understanding of multi-scale heterogeneity and the extraction of structure and source information by seismic waveform inversion. It provides a full treatment of correlation methods for seismic noise and event signals and develops inverse methods for both sources and structure. Higher frequency components of seismograms are frequently neglected or removed by filtering but they contain information about seismic structure on scales that cannot be revealed by seismic tomography. Sufficient computational resources are now available for waveform inversion for 3-D structure to be a practical procedure and this book describes suitable algorithms and examples reflecting current best practice. Intended for students and researchers in seismology, this book provides a physical understanding of seismic

waveforms and the way that different aspects of the seismic wavefield are revealed by the way that seismic data are handled

Full 3d Seismic Waveform Inversion Theory Software And Practice Springer Geophysics Book Review: Unveiling the Power of Words

In a world driven by information and connectivity, the power of words has become much more evident than ever. They have the ability to inspire, provoke, and ignite change. Such could be the essence of the book **Full 3d Seismic Waveform Inversion Theory Software And Practice Springer Geophysics**, a literary masterpiece that delves deep into the significance of words and their impact on our lives. Written by a renowned author, this captivating work takes readers on a transformative journey, unraveling the secrets and potential behind every word. In this review, we shall explore the book's key themes, examine its writing style, and analyze its overall effect on readers.

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