

## A Geophysical Inverse Theory Primer Andy Ganse

Here is a clearly written introduction to three central areas of inverse problems: inverse problems in electromagnetic scattering theory, inverse spectral theory, and inverse problems in quantum scattering theory. Inverse problems, one of the most attractive parts of applied mathematics, attempt to obtain information about structures by nondestructive measurements. Based on a series of lectures presented by three of the authors, all experts in the field, the book provides a quick and easy way for readers to become familiar with the area through a survey of recent developments in inverse spectral and inverse scattering problems.

A fundamental part of geophysics is to make inferences about the interior of the earth on the basis of data collected at or near the surface of the earth. In almost all cases these measured data are only indirectly related to the properties of the earth that are of interest, so an inverse problem must be solved in order to obtain estimates of the physical properties within the earth. In February of 1999 the U.S. Department of Energy sponsored a workshop that was intended to examine the methods currently being used to solve geophysical inverse problems and to consider what new approaches should be explored in the future. The interdisciplinary area between inverse problems in geophysics and optimization methods in mathematics was specifically targeted as one where an interchange of ideas was likely to be fruitful. Thus about half of the participants were actively involved in solving geophysical inverse problems and about half were actively involved in research on general optimization methods. This report presents some of the topics that were explored at the workshop and the conclusions that were reached. In general, the objective of a geophysical inverse problem is to find an earth model, described by a set of physical parameters, that is consistent with the observational data. It is usually assumed that the forward problem, that of calculating simulated data for an earth model, is well enough understood so that reasonably accurate synthetic data can be generated for an arbitrary model. The inverse problem is then posed as an optimization problem, where the function to be optimized is variously called the objective function, misfit function, or fitness function. The objective function is typically some measure of the difference between observational data and synthetic data calculated for a trial model. However, because of incomplete and inaccurate data, the objective function often incorporates some additional form of regularization, such as a measure of smoothness or distance from a prior model. Various other constraints may also be imposed upon the process. Inverse problems are not restricted to geophysics, but can be found in a wide variety of disciplines where inferences must be made on the basis of indirect measurements. For instance, most imaging problems, whether in the field of medicine or non-destructive evaluation, require the solution of an inverse problem. In this report, however, the examples used for illustration are taken exclusively

from the field of geophysics. The generalization of these examples to other disciplines should be straightforward, as all are based on standard second-order partial differential equations of physics. In fact, sometimes the non-geophysical inverse problems are significantly easier to treat (as in medical imaging) because the limitations on data collection, and in particular on multiple views, are not so severe as they generally are in geophysics. This report begins with an introduction to geophysical inverse problems by briefly describing four canonical problems that are typical of those commonly encountered in geophysics. Next the connection with optimization methods is made by presenting a general formulation of geophysical inverse problems. This leads into the main subject of this report, a discussion of methods for solving such problems with an emphasis upon newer approaches that have not yet become prominent in geophysics. A separate section is devoted to a subject that is not encountered in all optimization problems but is particularly important in geophysics, the need for a careful appraisal of the results in terms of their resolution and uncertainty. The impact on geophysical inverse problems of continuously improving computational resources is then discussed. The main results are then brought together in a final summary and conclusions section.

This collection of papers on geophysical inversion contains research and survey articles on where the field has been and where it's going, and what is practical and what is not. Topics covered include seismic tomography, migration and inverse scattering.

A comprehensive text on resistivity and induced polarization covering theory and practice for the near-surface Earth supported by modelling software.

Just a few meters below the Earth's surface lie features of great importance, from geological faults which can produce devastating earthquakes, to lost archaeological treasures! This refreshing, up-to-date book explores the foundations of interpretation theory and the latest developments in near-surface techniques, used to complement traditional geophysical methods for deep-exploration targets. Clear but rigorous, the book explains theory and practice in simple physical terms, supported by intermediate-level mathematics. Techniques covered include magnetics, resistivity, seismic reflection and refraction, surface waves, induced polarization, self-potential, electromagnetic induction, ground-penetrating radar, magnetic resonance, interferometry, seismoelectric and more. Sections on data analysis and inverse theory are provided and chapters are illustrated by case studies, giving students and professionals the tools to plan, conduct and analyze a near-surface geophysical survey. This is an important textbook for advanced-undergraduate and graduate students in geophysics and a valuable reference for practising geophysicists, geologists, hydrologists, archaeologists, and civil and geotechnical engineers.

This book provides an up-to-date presentation of a broad range of contemporary problems in inverse scattering involving

acoustic, elastic and electromagnetic waves. Descriptions will be given of traditional (but still in use and subject to on-going improvements) and more recent methods for identifying either: a) the homogenized material parameters of (spatially) unbounded or bounded heterogeneous media, or b) the detailed composition (spatial distribution of the material parameters) of unbounded or bounded heterogeneous media, or c) the location, shape, orientation and material characteristics of an object embedded in a wellcharacterized homogeneous, homogenized or heterogeneous unbounded or bounded medium, by inversion of reflected, transmitted or scattered spatiotemporal recorded waveforms resulting from the propagation of probe radiation within the medium.

In this book the author presents the state-of-the-art electromagnetic (EM) theories and methods employed in EM geophysical exploration. The book brings together the fundamental theory of EM fields and the practical aspects of EM exploration for mineral and energy resources. This text is unique in its breadth and completeness in providing an overview of EM geophysical exploration technology. The book is divided into four parts covering the foundations of EM field theory and its applications, and emerging geophysical methods. Part I is an introduction to the field theory required for baseline understanding. Part II is an overview of all the basic elements of geophysical EM theory, from Maxwell's fundamental equations to modern methods of modeling the EM field in complex 3-D geoelectrical formations. Part III deals with the regularized solution of ill-posed inverse electromagnetic problems, the multidimensional migration and imaging of electromagnetic data, and general interpretation techniques. Part IV describes major geophysical electromagnetic methods—direct current (DC), induced polarization (IP), magnetotelluric (MT), and controlled-source electromagnetic (CSEM) methods—and covers different applications of EM methods in exploration geophysics, including minerals and HC exploration, environmental study, and crustal study. \* Presents theoretical and methodological findings, as well as examples of applications of recently developed algorithms and software in solving practical problems \* Describes the practical importance of electromagnetic data through enabling discussions on a construction of a closed technological cycle, processing, analysis and three-dimensional interpretation \* Updates current findings in the field, especially with MT, magnetovariational and seismo-electrical methods and the practice of 3D interpretations

Following Keller [119] we call two problems inverse to each other if the formulation of each of them requires full or partial knowledge of the other. By this definition, it is obviously arbitrary which of the two problems we call the direct and which we call the inverse problem. But usually, one of the problems has been studied earlier and, perhaps, in more detail. This one is usually called the direct problem, whereas the other is the inverse problem. However, there is often another, more important difference between these two problems. Hadamard (see [91]) introduced the concept of a well-posed problem, originating from the philosophy that the mathematical model of a physical problem has to have the properties of

uniqueness, existence, and stability of the solution. If one of the properties fails to hold, he called the problem ill-posed. It turns out that many interesting and important inverse in science lead to ill-posed problems, while the corresponding direct problems are well-posed. Often, existence and uniqueness can be forced by enlarging or reducing the solution space (the space of "models"). For restoring stability, however, one has to change the topology of the spaces, which is in many cases impossible because of the presence of measurement errors. At first glance, it seems to be impossible to compute the solution of a problem numerically if the solution of the problem does not depend continuously on the data, i. e. , for the case of ill-posed problems.

This book gives an introduction to the practical treatment of inverse problems by means of numerical methods, with a focus on basic mathematical and computational aspects. To solve inverse problems, we demonstrate that insight about them goes hand in hand with algorithms.

Preface -- 1. Introduction -- 2. Linear Regression -- 3. Discretizing Continuous Inverse Problems -- 4. Rank Deficiency and Ill-Conditioning -- 5. Tikhonov Regularization -- 6. Iterative Methods -- 7. Other Regularization Techniques -- 8. Fourier Techniques -- 9. Nonlinear Regression -- 10. Nonlinear Inverse Problems -- 11. Bayesian Methods -- Appendix A: Review of Linear Algebra -- Appendix B: Review of Probability and Statistics -- Appendix C: Glossary of Notation -- Bibliography -- Index

Linear Regression -- Discretizing Continuous Inverse Problems -- Rank Deficiency and Ill-Conditioning -- Tikhonov Regularization -- Iterative Methods -- Other Regularization Techniques -- Fourier Techniques -- Nonlinear Regression -- Nonlinear Inverse Problems -- Bayesian Methods.

Foundations of Geophysical Electromagnetic Theory and Methods, Second Edition, builds on the strength of the first edition to offer a systematic exposition of geophysical electromagnetic theory and methods. This new edition highlights progress made over the last decade, with a special focus on recent advances in marine and airborne electromagnetic methods. Also included are recent case histories on practical applications in tectonic studies, mineral exploration, environmental studies and off-shore hydrocarbon exploration. The book is ideal for geoscientists working in all areas of geophysics, including exploration geophysics and applied physics, as well as graduate students and researchers working in the field of electromagnetic theory and methods. Presents theoretical and methodological foundations of geophysical field theory Synthesizes fundamental theory and the most recent achievements of electromagnetic (EM) geophysical methods in the framework of a unified systematic exposition Offers a unique breadth and completeness in providing a general picture of the current state-of-the-art in EM geophysical technology Discusses practical aspects of EM exploration for mineral and energy resources

This book addresses the problem of inferring the state of the ocean circulation, from a mathematical perspective.

The problems of making inferences about the natural world from noisy observations and imperfect theories occur in almost all scientific disciplines. This 2006 book addresses these problems using examples taken from geophysical fluid dynamics. It focuses on discrete formulations, both static and time-varying, known variously as inverse, state estimation or data assimilation problems. Starting with fundamental algebraic and statistical ideas, the book guides the reader through a range of inference tools including the singular value decomposition, Gauss-Markov and minimum variance estimates, Kalman filters and related smoothers, and adjoint (Lagrange multiplier) methods. The final chapters discuss a variety of practical applications to geophysical flow problems. Discrete Inverse and State Estimation

Problems is an ideal introduction to the topic for graduate students and researchers in oceanography, meteorology, climate dynamics, and geophysical fluid dynamics. It is also accessible to a wider scientific audience; the only prerequisite is an understanding of linear algebra. While the prediction of observations is a forward problem, the use of actual observations to infer the properties of a model is an inverse problem. Inverse problems are difficult because they may not have a unique solution. The description of uncertainties plays a central role in the theory, which is based on probability theory. This book proposes a general approach that is valid for linear as well as for nonlinear problems. The philosophy is essentially probabilistic and allows the reader to understand the basic difficulties appearing in the resolution of inverse problems. The book attempts to explain how a method of acquisition of information can be applied to actual real-world problems, and many of the arguments are heuristic.

It has now been almost ten years since our first book on scattering theory appeared [32]. At that time we claimed that "in recent years the development of integral equation methods for the direct scattering problem seems to be nearing completion, whereas the use of such an approach to study the inverse scattering problem has progressed to an extent that a 'state of the art' survey appears highly desirable". Since we wrote these words, the inverse scattering problem for acoustic and electromagnetic waves has grown from being a few theoretical considerations with limited numerical implementations to a well developed mathematical theory with tested numerical algorithms. This maturing of the field of inverse scattering theory has been based on the realization that such problems are in general not only nonlinear but also improperly posed in the sense that the solution does not depend continuously on the measured data. This was emphasized in [32] and treated with the ideas and tools available at that time. Now, almost ten years later, these initial ideas have developed to the extent that a monograph summarizing the mathematical basis of the field seems appropriate. This book is our attempt to write such a monograph. The inverse scattering problem for acoustic and electromagnetic waves can broadly be divided into two classes, the inverse obstacle problem and the inverse medium problem.

Please use extracts from reviews of first edition Key Features \* Updated and thoroughly revised edition \* additional material on geophysical/acoustic tomography \* Detailed discussion of application of inverse theory to tectonic, gravitational and geomagnetic studies Geophysical inversion is an ill-posed problem. Classical local search method for inversion is depend on initial guess and easy to be trapped in local optimum. The global optimization is a group of novel methods to deal with the problems mentioned above. The book introduces the geophysical inversion theory, including the classical solving approaches firstly. Then, it introduces several typical global inversion approaches including particle swarm optimization (PSO), differential evolution (DE), and multiobjective optimization methods, as well as some examples to inverse the geophysical data, such as gravity, MT sounding, well logging, self-potential, seismic data, using these global optimization approaches.

Extracting information from seismic data requires knowledge of seismic wave propagation and reflection. The commonly used method involves solving linearly for a reflectivity at every point within the Earth, but this book follows an alternative approach which invokes inverse scattering theory. By developing the theory of seismic imaging from basic principles, the authors relate the different models of seismic propagation, reflection and imaging - thus providing links to reflectivity-based imaging on the one hand and to nonlinear seismic inversion on the other. The comprehensive and physically complete linear imaging foundation developed presents new results at the leading edge of seismic processing for target location and identification. This book serves as a fundamental guide to seismic imaging principles and algorithms and their foundation in inverse scattering theory, and is a valuable resource for working geoscientists, scientific programmers and



theoretical physicists.

Annotation Rodgers (U. of Oxford) provides graduate students and other researchers a background to the inverse problem and its solution, with applications relating to atmospheric measurements. He introduces the stages in the reverse order than the usual approach in order to develop the learner's intuition about the nature of the inverse problem. Annotation copyrighted by Book News, Inc., Portland, OR.

The advent of accessible student computing packages has meant that geophysics students can now easily manipulate datasets and gain first-hand modeling experience - essential in developing an intuitive understanding of the physics of the Earth. Yet to gain a more in-depth understanding of physical theory, and to develop new models and solutions, it is necessary to be able to derive the relevant equations from first principles. This compact, handy book fills a gap left by most modern geophysics textbooks, which generally do not have space to derive all of the important formulae, showing the intermediate steps. This guide presents full derivations for the classical equations of gravitation, gravity, tides, earth rotation, heat, geomagnetism and foundational seismology, illustrated with simple schematic diagrams. It supports students through the successive steps and explains the logical sequence of a derivation - facilitating self-study and helping students to tackle homework exercises and prepare for exams.

This graduate-level textbook introduces the reader to the area of inverse problems, vital to many fields including geophysical exploration, system identification, nondestructive testing, and ultrasonic tomography. It aims to expose the basic notions and difficulties encountered with ill-posed problems, analyzing basic properties of regularization methods for ill-posed problems via several simple analytical and numerical examples. The book also presents three special nonlinear inverse problems in detail: the inverse spectral problem, the inverse problem of electrical impedance tomography (EIT), and the inverse scattering problem. The corresponding direct problems are studied with respect to existence, uniqueness, and continuous dependence on parameters. Ultimately, the text discusses theoretical results as well as numerical procedures for the inverse problems, including many exercises and illustrations to complement coursework in mathematics and engineering. This updated text includes a new chapter on the theory of nonlinear inverse problems in response to the field's growing popularity, as well as a new section on the interior transmission eigenvalue problem which complements the Sturm-Liouville problem and which has received great attention since the previous edition was published.

This book introduces the principles of gravitational, magnetic, electrostatic, direct current electrical and electromagnetic fields, with detailed solutions of Laplace and electromagnetic wave equations by the method of separation of variables. Discussion includes behaviours of the scalar and vector potential and the nature of the solutions of these boundary value problems, along with the use of complex variables and conformal transformation, Green's theorem, Green's formula and Green's functions.

This is the first study to present simultaneously both deconvolution and inversion, two powerful tools of data analysis. Featured within this volume are various geophysical convolution models and a treatment of deconvolution for a time-varying signal. The single channel time-varying deconvolution is shown equivalent to the multichannel time-invariant deconvolution, thus a formalism and associated algorithms can handle both. Inverse theory as well as various inversion schemes are presented on the basis of a relationship between a small perturbation to the model and its effects on the observation. The information theory inversion scheme is discussed, and several types of norm of minimization presented. Additionally, concepts and results of inverse theory are applied to design a new deconvolution operator for estimating magnetization and density distribution, and the constraint of the Backus-Gilbert formalism of inverse theory is used to design a new prediction error filter for maximum entropy spectral estimates. Maximum likelihood, another high resolution method is also presented. This volume can

be utilised as a graduate-level text for courses in Geophysics. Some chapters will be of use for graduate courses in Applied Mathematics, Applied Statistics, and Oceanography.

This book presents state-of-the-art geophysical inverse theory developed in modern mathematical terminology. The book brings together fundamental results developed by the Russian mathematical school in regularization theory and combines them with the related research in geophysical inversion carried out in the West. It presents a detailed exposition of the methods of regularized solution of inverse problems based on the ideas of Tikhonov regularization, and shows the different forms of their applications in both linear and nonlinear methods of geophysical inversion. This text is the first to treat many kinds of inversion and imaging techniques in a unified mathematical manner. The book is divided in five parts covering the foundations of the inversion theory and its applications to the solution of different geophysical inverse problems, including potential field, electromagnetic, and seismic methods. The first part is an introduction to inversion theory. The second part contains a description of the basic methods of solution of the linear and nonlinear inverse problems using regularization. The following parts treat the application of regularization methods in gravity and magnetic, electromagnetic, and seismic inverse problems. The key connecting idea of these applied parts of the book is the analogy between the solutions of the forward and inverse problems in different geophysical methods. The book also includes chapters related to the modern technology of geophysical imaging, based on seismic and electromagnetic migration. This volume is unique in its focus on providing a link between the methods used in gravity, electromagnetic, and seismic imaging and inversion, and represents an exhaustive treatise on inversion theory.

This unique textbook provides the foundation for understanding and applying techniques commonly used in geophysics to process and interpret modern digital data. The geophysicist's toolkit contains a range of techniques which may be divided into two main groups: processing, which concerns time series analysis and is used to separate the signal of interest from background noise; and inversion, which involves generating some map or physical model from the data. These two groups of techniques are normally taught separately, but are here presented together as parts I and II of the book. Part III describes some real applications and includes case studies in seismology, geomagnetism, and gravity. This textbook gives students and practitioners the theoretical background and practical experience, through case studies, computer examples and exercises, to understand and apply new processing methods to modern geophysical datasets. Solutions to the exercises are available on a website at <http://publishing.cambridge.org/resources/0521819652>

Geophysical Inverse Theory and Applications, Second Edition, brings together fundamental results developed by the Russian mathematical school in regularization theory and combines them with the related research in geophysical inversion carried out in the West. It presents a detailed exposition of the methods of regularized solution of inverse problems based on the ideas of Tikhonov regularization, and shows the different forms of their applications in both linear and nonlinear methods of geophysical inversion. It's the first book of its kind to treat many kinds of inversion and imaging techniques in a unified mathematical manner. The book is divided in five parts covering the foundations of the inversion theory and its applications to the solution of different geophysical inverse problems, including potential field, electromagnetic, and seismic methods. Unique in its focus on providing a link between the methods used in gravity, electromagnetic, and seismic imaging and inversion, it represents an exhaustive treatise on inversion theory. Written by one of the world's foremost experts, this work is widely recognized as the ultimate researcher's reference on geophysical inverse theory and its practical scientific applications. Presents state-of-the-art geophysical inverse theory developed in modern mathematical terminology—the first to treat many kinds of inversion and imaging techniques in a unified mathematical way. Provides a critical link between the methods used in gravity, electromagnetic, and seismic imaging

and inversion, and represents an exhaustive treatise on geophysical inversion theory. Features more than 300 illustrations, figures, charts and graphs to underscore key concepts. Reflects the latest developments in inversion theory and applications and captures the most significant changes in the field over the past decade.

*Innovation in Near-Surface Geophysics: Instrumentation, Application, and Data Processing Methods* offers an advanced look at state-of-the-art and innovative technologies for near surface geophysics, exposing the latest, most effective techniques in an accessible way. By addressing a variety of geophysical applications, including cultural heritage, civil engineering, characteristics of soil, and others, the book provides an understanding of the best products and methodologies modern near surface geophysics has to offer. It proposes tips for new ideas and projects, and encourages collaboration across disciplines and techniques for the best implementation and results. Clearly organized, with contributions from leaders from throughout geophysics, *Innovation in Near-Surface Geophysics* is an important guide for geophysicists who hope to gain a better understanding of the tools and techniques available. Addresses a variety of applications in near-surface geophysics, including cultural heritage, civil engineering, soil analysis, etc. Provides insight to available products and techniques and offers suggestions for future developments. Clearly organized by techniques and their applications.

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.

This text bridges the gap between the classic texts on potential theory and modern books on applied geophysics. It opens with an introduction to potential theory, emphasising those aspects particularly important to earth scientists, such as Laplace's equation, Newtonian potential, magnetic and electrostatic fields, and conduction of heat. The theory is then applied to the interpretation of gravity and magnetic anomalies, drawing on examples from modern geophysical literature. Topics explored include regional and global fields, forward modeling, inverse methods, depth-to-source estimation, ideal bodies, analytical continuation, and spectral analysis. The book includes numerous exercises and a variety of computer subroutines written in FORTRAN. Graduate students and researchers in geophysics will find this book essential.

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.



This publication is designed to provide a practical understanding of methods of parameter estimation and uncertainty analysis. The practical problems covered range from simple processing of time- and space-series data to inversion of potential field, seismic, electrical, and electromagnetic data. The various formulations are reconciled with field data in the numerous examples provided in the book; well-documented computer programmes are also given to show how easy it is to implement inversion algorithms.

Parameter Estimation and Inverse Problems, Second Edition provides geoscience students and professionals with answers to common questions like how one can derive a physical model from a finite set of observations containing errors, and how one may determine the quality of such a model. This book takes on these fundamental and challenging problems, introducing students and professionals to the broad range of approaches that lie in the realm of inverse theory. The authors present both the underlying theory and practical algorithms for solving inverse problems. The authors' treatment is appropriate for geoscience graduate students and advanced undergraduates with a basic working knowledge of calculus, linear algebra, and statistics. Parameter Estimation and Inverse Problems, Second Edition introduces readers to both Classical and Bayesian approaches to linear and nonlinear problems with particular attention paid to computational, mathematical, and statistical issues related to their application to geophysical problems. The textbook includes Appendices covering essential linear algebra, statistics, and notation in the context of the subject. Includes appendices for review of needed concepts in linear, statistics, and vector calculus. Accessible to students and professionals without a highly specialized mathematical background.

Providing an up-to-date overview of the most popular global optimization methods used in interpreting geophysical observations, this new edition includes a detailed description of the theoretical development underlying each method and a thorough explanation of the design, implementation and limitations of algorithms. New and expanded chapters provide details of recently developed methods, such as the neighborhood algorithm, particle swarm optimization, hybrid Monte Carlo and multi-chain MCMC methods. Other chapters include new examples of applications, from uncertainty in climate modeling to whole earth studies. Several different examples of geophysical inversion, including joint inversion of disparate geophysical datasets, are provided to help readers design algorithms for their own applications. This is an authoritative and valuable text for researchers and graduate students in geophysics, inverse theory and exploration geoscience, and an important resource for professionals working in engineering and petroleum exploration.

### Geophysical Inverse Theory and Regularization Problems Elsevier

In many physical sciences, the most natural description of a system is with a function of position or time. In principle, infinitely many numbers are needed to specify that function, but in practice only finitely many measurements can be made. Inverse theory concerns the mathematical techniques that enable researchers to use the available information to build a model of the unknown system or to determine its essential properties. In Geophysical Inverse Theory, Robert Parker provides a systematic development of inverse theory at the graduate and professional level that emphasizes a rigorous yet practical solution of inverse problems, with examples from experimental observations in geomagnetism, seismology, gravity, electromagnetic sounding, and interpolation. Although illustrated with examples from geophysics, this book has broad implications for researchers in applied disciplines from materials science and engineering to astrophysics, oceanography, and meteorology. Parker's approach is to avoid artificial

statistical constructs and to emphasize instead the reasonable assumptions researchers must make to reduce the ambiguity that inevitably arises in complex problems. The structure of the book follows a natural division in the subject into linear theory, in which the measured quantities are linear functionals of the unknown models, and nonlinear theory, which covers all other systems but is not nearly so well understood. The book covers model selection as well as techniques for drawing firm conclusions about the earth independent of any particular model.

An overview of the current techniques used in the inversion of seismic data is provided. Inversion is defined as mapping the physical structure and properties of the subsurface of the earth using measurements made on the surface, creating a model of the earth using seismic data as input.

The contributions to this volume cover a wide spectrum of recent developments in geophysical data inversion, including basic mathematics and general theory, numerical methods, as well as computer implementation of algorithms. Most of the papers are motivated by problems arising from geophysical research and applications both on a global scale and with respect to local geophysical surveys, underlining the increasing importance of geophysical exploration methods in various fields, such as structural geology, prospecting for mineral and energy resources, hydro geology, geotechnology, environmental protection and archaeology. The first section of the book deals with basic mathematics and general theory underlying geophysical data inversion. Papers presented here are concerned with stabilization algorithms to solve ill-posed inverse problems, sensitivity of kernel function estimations to random data errors and reduction of errors in inverse modelling of response functions by linear constraints, numerical procedures for approximating the solution to boundary value problems, accuracy and stability of inverse ill-posed problems constituted by problems of moments, and fast Fourier transforms for solving potential field problems. The second section contains papers on gravity and magnetics, dealing with the solvability of the inverse gravimetric problem for sources represented by point masses and other elementary, solution of the inverse problem in cases of nonuniformly distributed data as obtained by palaeomagnetic studies, satellite observations, and surface projections of buried archaeological targets by inverse filtering of geomagnetic data.

Geophysical Data Analysis: Discrete Inverse Theory is an introductory text focusing on discrete inverse theory that is concerned with parameters that either are truly discrete or can be adequately approximated as discrete. Organized into 12 chapters, the book's opening chapters provide a general background of inverse problems and their corresponding solution, as well as some of the basic concepts from probability theory that are applied throughout the text. Chapters 3-7 discuss the solution of the canonical inverse problem, that is, the linear problem with Gaussian statistics, and discussions on problems that are non-Gaussian and nonlinear are covered in Chapters 8 and 9. Chapters 10-12 present examples of the use of inverse theory and a discussion on the numerical algorithms that must be employed to solve inverse problems on a computer. This book is of value to graduate students and many college seniors in the applied sciences.

Inverse Problem Theory is written for physicists, geophysicists and all scientists facing the problem of quantitative interpretation of

experimental data. Although it contains a lot of mathematics, it is not intended as a mathematical book, but rather tries to explain how a method of acquisition of information can be applied to the actual world. The book provides a comprehensive, up-to-date description of the methods to be used for fitting experimental data, or to estimate model parameters, and to unify these methods into the Inverse Problem Theory. The first part of the book deals with discrete problems and describes Maximum likelihood, Monte Carlo, Least squares, and Least absolute values methods. The second part deals with inverse problems involving functions. The book is almost completely self-contained, with all important concepts carefully introduced. Although theoretical concepts are strongly emphasized, the author has ensured that all the useful formulas are listed, with many special cases included. The book will thus serve equally well as a reference manual for researchers needing to refresh their memories on a given algorithm, or as a textbook in a course for undergraduate or graduate students.

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