

ACTIVE SEISMIC TOMOGRAPHY

THEORY AND APPLICATIONS

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Active Seismic Tomography

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Theory and Applications

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Preface

The seismic method is one of the most promising geophysical methods that can help to explore the Earth's interior. Numerous technology developments have been introduced in seismic methods over the decades to either understand or to use the full recorded seismic data from the field. Seismic tomography is a seismic imaging technique used to delineate the subsurface linked with structures and numerical values of different physical parameters such as the seismic velocity, density, etc.

Seismic tomography has grown from a very simple to a complex scenario, i.e., at first, we started to use traveltimes data alone for seismic imaging in seismic tomography. Over the decades, seismic tomography has evolved to exploit comprehensive components such as traveltimes, amplitudes, frequencies, etc. of the seismogram. This all happened because of tremendous advancements in computer technologies; however, successful applications of full waveform tomography are still very limited, and more understanding of challenges like cycle-skipping, selection of suitable norms, frequency bands, and implementation to 3D domains is needed.

This book aims to introduce active seismic tomography starting from traveltimes tomography to full waveform tomography. It also covers both synthetic and real field data applications. It is divided into two sections. Section I is dedicated to theory. Chapter 1 introduces the pioneering history of seismic tomography along with developments occurring in the last two decades. Chapter 2 describes the derivation of wave equations and their different forms. Chapter 3 covers the forward problem of tomography and describes the methods for solving the seismic wave equation. Chapter 4 presents the inverse problem of tomography and describes its methods. Chapter 5 is dedicated to the subsurface parameterization to cover the variety of subsurface parameterizations in obtaining the best possible responses. This will include different types of parameterization, such as grids, cells, blocks, etc., and will discuss the pros and cons of each category for the proper selection that will lead to expected geological outcomes from the data without any bias.

Chapter 6 presents seismic traveltime tomography to discuss the theory of travel time tomography developed over the last two decades. This will summarize the advanced traveltime tomographic concepts scattered in research publications. The last chapter of section I, chapter 7, covers seismic full waveform tomography to summarize advanced concepts scattered in research articles.

Section II focuses on applying seismic tomography techniques for both travel-time and full waveform tomography. Chapter 8 is dedicated to applying seismic tomography to synthetic seismic data in understanding the role of several parameters involved in tomography for the best possible results. Chapter 9 covers the application of traveltime tomography to seismic data from the Kerala-Konkan offshore basin, western Indian margin. Chapter 10 is dedicated to the sophisticated full waveform tomography of seismic data to emphasize the importance of the technique over the traveltime tomographic approximation in obtaining high-resolution velocity models. Chapter 11 covers advanced seismic processing using tomographic results that showcase enhanced subsurface imaging using a tomographic velocity model. We have discussed the advanced seismic processing techniques like migration that needs proper velocity models to improve the image. We also summarize the future scope of the technique in chapter 12. This chapter covers the pros and cons of seismic tomography, hurdles, and a probable way to tackle the field data, future areas of research, etc. This chapter covers directions for future research in the emerging field of seismic tomography that may provide guidance to academicians and professionals for advancing research.

Since seismic tomography is one of the most prominent velocity-building techniques, we hope that this book will fill the gap among researchers, academicians, and explorationists in understanding the intricacies involved in seismic tomography for its successful applications to field data. We also believe that it will guide to young scientists in pursuing their careers in the frontier area of research.

We take this opportunity to convey our gratitude to our teachers and professors who nourished us from the beginning. The Director, CSIR-NGRI is acknowledged for according permission to publish this book. Mr. R.K. Srivastava, Director (Exploration), Oil & Natural Gas Corporation (ONGC) Ltd. is thanked profusely for his constant support of pursuing advanced research. We thank ONGC personnel Sri G.C. Katiyar, Mrs. Lata S. Pandurangi, Sri P.H. Mane and Mr. N. Chandrasekhar for their fruitful discussions from time to time and for providing seismic data. Generic Mapping Tools (Wessel et al. 2013) software was used for plotting some of the figures. Damodara Nara thanks to DST for providing the INSPIRE Faculty Fellowship.

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