
Preface

The main motivation for writing this book is to report on an existing repertoire of geostatistical methods for handling the integration of geophysical information in reservoir modeling and for presenting the successful case studies that validate them.

Geostatistical methods were introduced in the 1960s (Matheron 1965) as tools for coping with large amount of similar data and to characterize, for example, grades dispersion in mineral deposits (David 1977; Journel and Huijbreghts 1978). When geostatistical methods become popular for oil reservoir characterization in the 1980s (Deutsch and Journel 1992), the lack of well data made it necessary for another type of data integration in geostatistical methods. Hence, a new paradigm—one based on data integration—developed in geostatistical methods through joint simulations and stochastic sequential simulations with soft data.

Since the beginning of this century, oil and gas discoveries have been mainly in deep and ultra-deep waters. Getting to these reservoirs involves ever-higher costs for drilling and well data sampling; it also involves increased investment in research and development (R&D) to successfully use cheaper and more efficient geophysical exploration methods. The recent high quality of geophysical data, particularly reflection seismic data, represented a breakthrough in reservoir modeling and characterization. However, the use of 3D and 4D seismic data has been a real challenge for geostatistical data integration methods.

Using seismic reflection data, stochastic seismic inversion methods are playing an important role in the characterization of oil and gas reservoirs, which can basically be divided into two groups: the first based on the linearized Bayesian approach to seismic inversion (Buland and Omre 2003; Tarantola 2005); the second based on geostatistical inversion methods that are essentially stochastic sequential simulations and optimization processes like genetic algorithms and simulated annealing (Bortolli et al. 1993; Haas and Dubrule 1994; Soares et al. 2007).

This book focuses on the geostatistical inversion methods, with Chap. 2 providing an overview of elementary geostatistics. Stochastic simulations and joint simulations are presented in Chap. 3, with the different versions used in the inversion approaches: joint simulation with joint distributions to deal with multivariate inversion and direct inversion and simulation with point distributions to access the data uncertainty.

In Chap. 4 we develop seismic inversion methods—acoustic, elastic and amplitude versus angle (AVA)—within the geostatistical framework. Chapter 5 encompasses the direct inversion of porosity, facies and rock physics models (RPM). Chapter 6 focuses on other methods of geophysical integration, such as joint electromagnetic and seismic inversion and the integration of seismic in history matching processes: that is, the integration of seismic and dynamic production data in numerical reservoir models.

This book is a natural extension and a summary of the Lisbon University Technical Institute's (IST—Instituto Superior Técnico) Master of Science program in Petroleum Engineering notes on reservoir characterization as well as those of the short courses given at other schools and oil companies. We are indebted to all the students whose critiques enriched this book.

The seismic inversion methods presented here were developed and implemented at the Centre for Modeling Petroleum Reservoirs research Centre, which is now the Petroleum Group of the Centre for Natural Resources and Environmental Research (CERENA—Centro de Recursos Naturais e Ambiente). We would like to express our thanks to Jean Paul Diet, who introduced us to the concept of geostatistical inversion and helped secure funding from CGG. We would also like to thank Thierry Colleau, who helped steer us in the right direction at the outset, and António Costa Silva, Luís Guerreiro and Carlos Maciel of Partex Oil and Gas, for their encouragement and support and for helping us find real applications for it in the Middle East.

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