# Contents

1 Introduction—Geostatistical Methods for Integrating Seismic Reflection Data into Subsurface Earth Models ........................ 1
  1.1 Spatial Resolution Gap ........................................ 1
  1.2 Seismic Inversion .............................................. 2

2 Fundamental Geostatistical Tools for Data Integration ........ 5
  2.1 Spatial Continuity Patterns Analysis and Modeling ............ 6
    2.1.1 Bi-point Statistics ....................................... 6
    2.1.2 Complex Morphologic Patterns: Auxiliary and Reference Images ........................................ 8
    2.1.3 Spatial Random Fields ..................................... 8
    2.1.4 Variograms and Spatial Covariances ......................... 9
    2.1.5 Spatial Representativeness of the Variogram ............. 12
    2.1.6 Spatial Continuity for Multivariate Systems .............. 13
    2.1.7 Variogram Modeling Workflow .............................. 15
    2.1.8 Theoretical Variogram Models ............................. 16
    2.1.9 Linear Combinations of Variogram Models: Imbricated Structures ........................................ 18
    2.1.10 Co-regionalized Models of Multivariate Systems ........ 23
  2.2 Estimation Models ............................................. 24
    2.2.1 Linear Estimation of Local Statistics ..................... 24
    2.2.2 Probabilistic Model of the Geostatistical Linear Estimator ........................................ 24
  2.3 Kriging Estimate .............................................. 26
    2.3.1 Kriging System Resolution ................................ 27
  2.4 Linear Estimation of Non-stationary Phenomena: Simple Kriging ........................................ 28
  2.5 Co-kriging Estimate .......................................... 29
  2.6 Co-estimation with a Secondary Variable in a Much Denser Sample Grid: Collocated Co-kriging ............. 31
  2.7 Estimation of Local Probability Distribution Functions ......... 31
    2.7.1 Gaussian Transform of the Experimental Data ............ 32
  2.8 Estimation of Categorical Variables ................................ 33

3 Simulation Models of Physical Phenomena in Earth Sciences .... 37
  3.1 Stochastic Simulation Models ................................... 37
  3.2 Sequential Simulation Models .................................... 39
3.3 Sequential Gaussian Simulation
3.4 Direct Sequential Simulation from Experimental Distributions
3.4.1 Direct Sequential Simulation
3.4.2 Direct Sequential Co-simulation
3.4.3 Stochastic Sequential Co-simulation with Joint Probability Distributions
3.4.4 Stochastic Simulation with Uncertain Data: DSS with Point Probability Distributions
3.5 Simulation of Categorical Variables
3.5.1 Indicator Simulation
3.5.2 Alternative Simulation Methods for Categorical Variables
3.5.3 High-Order Stochastic Simulation of Categorical Variables

4 Integration of Geophysical Data for Reservoir Modeling and Characterization
4.1 Seismic Inversion
4.2 Bayesian Framework for Integrating Seismic Reflection Data into Subsurface Earth Models
4.3 Iterative Geostatistical Seismic Inversion Methodologies
4.3.1 Frequency Domain of Geostatistical Seismic Inversion
4.3.2 Trace-by-Trace Geostatistical Seismic Inversion Methodologies
4.3.3 Global Geostatistical Seismic Inversion Methodologies
4.3.4 Global Geostatistical Acoustic Inversion
4.3.5 Global Geostatistical Elastic Inversion
4.3.6 Geostatistical Seismic AVA Inversion
4.3.7 Application Example with Geostatistical Seismic AVA Inversion
4.3.8 Seismic Inversion with Structural Local Models
4.4 Integration of Low-Frequency Models into Geostatistical Seismic Inverse Methodologies

5 Deriving Petrophysical Properties with Seismic Inversion
5.1 Characterization of Petrophysical Properties Based on Acoustic and Velocity Models
5.2 Direct Inversion of Porosity Models
5.3 Geostatistical Seismic Inversion Directly for Petrophysical Properties
5.3.1 Geostatistical Seismic AVA Inversion to Facies
5.3.2 Application Examples with Geostatistical Seismic AVA Inversion Directly to Facies
5.4 Integration of Rock Physics Models into Geostatistical Seismic Inversion
6 Data Integration with Geostatistical Seismic Inversion Methodologies ........................................ 109
   6.1 Integration of Electromagnetic and Seismic Data into Geostatistical Simultaneous Inversion .......... 109
       6.1.1 Application to a Synthetic Case Study ........................................ 112
   6.2 Integration of Dynamic Production Data:
       Global Inversion .................................................................................. 116
       6.2.1 Geostatistical History Matching ...................................................... 117
       6.2.2 Iterative Global Seismic Inversion in History Matching ..................... 118
       6.2.3 Selection of Petro-Elastic Models .................................................... 120
       6.2.4 Application to a Synthetic Case Study .......................................... 122
       6.2.5 Final Remarks. ............................................................................. 129

7 Afterword ........................................................................................................... 131

References ............................................................................................................. 133

Index ....................................................................................................................... 139
Geostatistical Methods for Reservoir Geophysics
Azevedo, L.; Soares, A.
2017, XXVI, 141 p. 114 illus., 84 illus. in color., Hardcover
ISBN: 978-3-319-53200-4