Unconventional Reservoir Geomechanics

Since the beginning of the US shale gas revolution in 2005, the development of unconventional oil and gas resources has gathered tremendous pace around the world. This book provides a comprehensive overview of the key geologic, geophysical, and engineering principles that govern the development of unconventional reservoirs. The book begins with a detailed characterization of unconventional reservoir rocks: their composition and microstructure, mechanical properties, and the processes controlling fault slip and fluid flow. A discussion of geomechanical principles follows, including the state of stress, pore pressure, and the importance of fractures and faults. After reviewing the fundamentals of horizontal drilling, multi-stage hydraulic fracturing and stimulation of slip on pre-existing faults, the key factors impacting hydrocarbon production are explored. The final chapters cover environmental impacts and how to mitigate hazards associated with induced seismicity. This text provides an essential overview for students, researchers and industry professionals interested in unconventional reservoirs.

Dr. Mark D. Zoback is the Benjamin M. Page Professor of Geophysics at Stanford University. He conducts research on *in situ* stress, fault mechanics, and reservoir geomechanics with an emphasis on shale gas, tight gas and tight oil production. His first book, *Reservoir Geomechanics*, published by Cambridge University Press in 2007 is now in its 15th printing. His online course in reservoir geomechanics has been completed by approximately 10,000 students around the world. Dr. Zoback has received a number of awards and honors, including election to the US National Academy of Engineering.

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Shale Gas, Tight Oil, and Induced Seismicity

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Preface

For the past eleven years, the students and researchers in the Stress and Reservoir Geomechanics group at Stanford University have been working to improve our understanding of a wide range of multi-scale processes related to unconventional reservoir development and induced seismicity. Research topics have ranged from imaging pores at the nanometer scale to studying the state of stress in basins hundreds of km across. In addition to studying fundamental processes in the laboratory and carrying out a number of theoretical studies, we have carried out over a dozen comprehensive case studies in collaboration with a number of oil and gas companies that have allowed us to examine basic research questions in a variety of field datasets. Examples from these studies are used throughout the book. While much remains to be learned about these highly complex reservoirs, in this book we attempt to address a number of fundamental issues that affect successful exploitation of these resources while minimizing the environmental impacts of production, in particular the occurrence of induced seismicity.

We would like to acknowledge the many Stanford researchers who made important contributions to the content of this book. These include, in alphabetic order: Gader Alalli, Maytham Al-Ismael, Richard Alt, Indrajit Das, Noha Farghal, Yves Gensterblum, Alex Hakso, Rob Heller, Sander Hol, Owen Hurd, Lei Jin, Madhur Johri, Wenhuan Kuang, Cornelius Langenbruch, Jens-Erik Lund Snee, Xiaodong Ma, Fatemeh Rassouli, Julia Reece, Ankush Singh, Hiroki Sone, John Vermylen, Rall Walsh, Randi Walters, Matt Weingarten, Wei Wu and Shaochuan Xu. Special thanks go to Jens, Kate Matney and Fatemeh for their help preparing a number of figures in the book. We also thank Usman Ahmed and Francesco Mele for providing several figures.

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