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Seismic Attributes as the Framework for Data Integration Throughout the Oilfield Life Cycle The Handbook of Borehole Acoustics and Rock Physics for Reservoir Characterization combines in a single useful handbook the multidisciplinary domains of the petroleum industry, including the fundamental concepts of rock physics, acoustic logging, waveform processing, and geophysical application modeling through graphical examples derived from field data. It includes results from core studies, together with graphics that validate and support the modeling process, and explores all possible facets of acoustic applications in reservoir evaluation for hydrocarbon exploration, development, and drilling support. The Handbook of Borehole Acoustics and Rock Physics for Reservoir Characterization serves as a technical guide and research reference for oil and gas professionals, scientists, and students in the multidisciplinary field of reservoir characterization through the use of petrosonics. It overviews the fundamentals of borehole acoustics and rock physics, with a focus on reservoir evaluation applications, explores current advancements through updated research, and identifies areas of future growth. Presents theory, application, and limitations of borehole acoustics and rock physics through field examples and case studies Features "Petrosonic Workflows" for various acoustic applications and evaluations, which can be easily adapted for practical reservoir modeling and interpretation Covers the potential advantages of acoustic-based techniques and summarizes key results for easy geophysical application

Quantitative Analysis of Geopressure for Geoscientists and Engineers

Microtextural, Elastic and Transport Properties of Source Rocks A significantly expanded new edition of this practical guide to rock physics and geophysical interpretation for reservoir geophysicists and engineers.

Introduction to the Physics of Rocks Seismic reservoir characterization methods aim to provide an accurate description of rock and fluid properties using measured seismic data and geophysical models. Reservoir properties include static properties, such as porosity and lithology, and dynamic properties, such as water saturation and fluid pressure. At well locations, these properties can be measured using...
borehole data. At other locations, they should be estimated from surface geophysical measurements, such as seismic data. The prediction of the properties of interests is an inverse problem. This dissertation focuses on the development of new mathematical methods for the estimation of static and dynamic rock properties from seismic data. The goal is to develop probabilistic inversion methods in a Bayesian framework to estimate the most likely model of the properties of interest and the associated uncertainty. Three innovative methods are proposed to predict reservoir properties. The first method is a joint estimation of facies and elastic properties from pre-stack seismic data based on a geostatistical approach by sampling from the posterior distribution of the elastic properties and simultaneously classifying the lithology conditioned by seismic data. The second method is based on a linearized forward model obtained using a convolutional model and a new AVO approximation formulation. The proposed formulation combines Gray's linearization of reflectivity coefficients with Gassmann's equation and Nur's critical porosity model. The third method includes a new rock physics model to describe the relation between saturation-pressure changes and seismic changes and a probabilistic workflow to quantify the changes in saturation and pressure from time-lapse seismic changes. The proposed methods are tested on synthetic examples and real datasets for validation.

Geophysics and Geosequestration As our speculative understanding of the physics behind seismic waves has developed, physical and numerical modeling have prominently innovative and now augment applied seismology for better prediction and engineering practices. The interest in seismic inversion techniques has been growing steadily over the last couple of years. Integrated studies are essential to hydrocarbon development projects and inversion is one of the means to extract additional information from seismic data. This has led to some novel applications such as using artificially-induced shocks for exploration of the Earth's subsurface and seismic stimulation for increasing the productivity of oil wells. Obviously, drilling a well and running a set of logging tools gives us much more information. However, the advantage of the seismic method is that coverage can be made over large areas of the earth's surface. This is especially true of the large three-dimensional surveys that are now routinely being acquired. For this reason, seismic inversion is an important processing tool. This book demonstrates the latest techniques and advances in seismic inversion from theoretical approach, data acquisition and interpretation, to analyses and numerical simulations, as
well as research applications. The main objective of this work is the development and implementation of a stochastic model algorithm for seismic inversion to improve reservoir characterization. Underground fractures play an important role in the storage and movement of hydrocarbon fluid. Fracture rock physics has been the useful bridge between fracture parameters and seismic response. In this book, we aim to use seismic data to predict subsurface fractures based on rock physics and also proposed the method which uses seismic data to invert the elastic and rock physics parameters of fractured rock. The base idea of this work is precisely to incorporate stochastic simulation and co-simulation methodologies to conceive and implement a model of global seismic inversion and creating uncertainty linked to areas with different seismic quality.

Handbook of Borehole Acoustics and Rock Physics for Reservoir Characterization This dissertation addresses recurrent questions in hydrocarbon reservoir characterization. In particular, the major focus of this research volume is microtextural characterization of source rock fabric as well as elastic and transport properties of source rocks. Source rocks are one of the most complicated and intriguing natural materials on earth. Their multiphase composition is continually evolving over various scales of length and time, creating the most heterogeneous class of rocks in existence. The heterogeneities are present from the submicroscopic scale to the macroscopic scale, and all contribute to a pronounced anisotropy and large variety of shale macroscopic behavior. Moreover, the effects of the multiphase composition are amplified within organic-rich rocks that contain varying amounts of kerogen. Despite significant research into the properties of kerogen, fundamental questions remain regarding how the intrinsic rock-physics properties of the organic fraction affect the macroscopic properties of host rocks. Because we do not fully understand the elastic properties of either the organic matter or the individual clay minerals present in source rocks, seismic velocity prediction in organic-rich shales remains challenging. Conventional measurements of 'macroscopic' or 'average' properties on core plugs are not sufficient to fully address the degree of property variation within organic-rich rocks. Alternatively, most analyses of organic matter rely on samples that have been isolated by dissolving the rock matrix. The properties of the organic matter before and after such isolation may be different, and all information about sample orientation is lost. In addition, comprehensive characterization of organic-rich rocks has been hindered by several
factors: sample preparation is time-consuming, and the nanogranular nature of this rock type makes it difficult to link effective elastic properties to maceral properties, such as elastic moduli, composition, maturity, and quality. These difficulties have prevented us from building large databases, without which we cannot establish the accurate rock-physics models needed for inverting field geophysical data. I approach this issue using atomic-force microscopy based nanoindentation, coupled with scanning electron and confocal laser-scanning microscopy as a tool for visualization and identification of the organic part within shale, and to perform nanoscale elastic-property measurements. First, the microfabric of a set of source rock samples is characterized. The spatial and temporal link between organic matter and the stiff silicate mineral matrix is established, which leads to proposal of alternative Rock Physics modeling approach to organic-rich source rocks. Based on the nanoindentation measurements, I obtain elastic properties of source rock phases and provide several applications of these (nanoindentation-derived) elastic properties within a number of geomechanical problems. Finally, transport properties of various source rock formations are discussed based on comparison to more conventional reservoir rocks.

Integrating Geology, Rock Physics, and Seismology for Reservoir-quality Prediction This comprehensive textbook presents an overview of petroleum geoscience for geologists active in the petroleum industry, while also offering a useful guide for students interested in environmental geology, engineering geology and other aspects of sedimentary geology. In this second edition, new chapters have been added and others expanded, covering geophysical methods in general and electromagnetic exploration methods in particular, as well as reservoir modeling and production, unconventional resources and practical petroleum exploration.

Petro-physics and Rock Physics of Carbonate Reservoirs Quantitative Seismic Interpretation demonstrates how rock physics can be applied to predict reservoir parameters, such as lithologies and pore fluids, from seismically derived attributes. The authors provide an integrated methodology and practical tools for quantitative interpretation, uncertainty assessment, and characterization of subsurface reservoirs using well-log and seismic data. They illustrate the advantages of these new methodologies, while providing advice about limitations of the methods and traditional pitfalls. This book is aimed at graduate students,
academics and industry professionals working in the areas of petroleum geoscience and exploration seismology. It will also interest environmental geophysicists seeking a quantitative subsurface characterization from shallow seismic data. The book includes problem sets and a case-study, for which seismic and well-log data, and Matlab codes are provided on a website (http://www.cambridge.org/9780521816014). These resources will allow readers to gain a hands-on understanding of the methodologies.

The Impact of the Allochthonous Salt and Overpressure Development on the Petroleum System Evolution in the Thunder Horse Mini-basin, Gulf of Mexico Abstract: This study performs a petrophysical analysis and rock-physics modeling of the Traverse Formation, using eleven different wells. In the first part of this study, well logs, crossplots, and mineral identification were used to determine the rock components, lithology, and to predict the sonic velocities of carbonate rocks using conventional methods for two of those wells. In the second part of this study, rock-physics modeling methods were used to predict the sonic velocities using the Kuster-Toksoz equations. Sonic velocities are very difficult to predict in carbonate rock because of their complex pore systems. To overcome this difficulty, multiple aspect ratios for porosity were used to calculate sonic velocities for the limestone, dolomite, quartz, anhydrite, and shale mixtures. Having determined the lithology from conventional log analysis, the matrix moduli and densities were estimated. Then the Kuster-Toksoz equations were used to calculate the elastic properties, using different aspect ratios in an effort to obtain the best estimate for the observed P-wave velocities, and to predict S-wave velocities (which had not been recorded), and compare them with the predicted S-wave from Greenberg and Castagna equations.

Quantitative Seismic Interpretation An overview of the geophysical techniques and analysis methods for monitoring subsurface carbon dioxide storage for researchers and industry practitioners.

Probabilistic pore pressure prediction in reservoir rocks through compressional and shear velocities Shear waves and closely related interface waves (Rayleigh, Stoneley and Scholte) play an important role in many areas of engineering, geophysics and underwater acoustics. In some cases interest is focused on large-amplitude waves of low frequency such as those associated with earthquakes and nuclear explosions; in other cases low amplitude waves, which have often
travelled great distances through the sediment, are of interest. Both low
and high frequency shear and interface waves are often used for seafloor
probing and sediment characterization. As a result of the wide spectrum of
different interests, different disciplines have developed lines of research
and a literature particularly suited to their own problems. For example
water-column acousticians view the seafloor sediment as the lower
boundary of their domain and are interested in shear and interface waves
in the near bottom sediments mainly from the standpoint of how they
influence absorption and reflection at this boundary. On the other hand,
geophysicists seeking deep oil deposits are interested in the maximum
penetration into the sediments and the tell-tale characteristics of the
seismic waves that have encountered potential oil or gas bearing strata. In
another area, geotechnical engineers use shear and interface waves to
study soil properties necessary for the design and the siting of seafloor
structures.

Microtextural Elastic and Transport Properties of Source Rocks This
dissertation addresses recurrent questions in hydrocarbon reservoir
characterization. In particular, the major focus of this research volume is
microtextural characterization of source rock fabric as well as elastic and
transport properties of source rocks. Source rocks are one of the most
complicated and intriguing natural materials on earth. Their multiphase
composition is continually evolving over various scales of length and time,
creating the most heterogeneous class of rocks in existence. The
heterogeneities are present from the submicroscopic scale to the
macroscopic scale, and all contribute to a pronounced anisotropy and
large variety of shale macroscopic behavior. Moreover, the effects of the
multiphase composition are amplified within organic-rich rocks that
contain varying amounts of kerogen. Despite significant research into the
properties of kerogen, fundamental questions remain regarding how the
intrinsic rock-physics properties of the organic fraction affect the
macroscopic properties of host rocks. Because we do not fully understand
the elastic properties of either the organic matter or the individual clay
minerals present in source rocks, seismic velocity prediction in organic-
rich shales remains challenging. Conventional measurements of
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Alternatively, most analyses of organic matter rely on samples that have
been isolated by dissolving the rock matrix. The properties of the organic
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about sample orientation is lost. In addition, comprehensive characterization of organic-rich rocks has been hindered by several factors: sample preparation is time-consuming, and the nanogranular nature of this rock type makes it difficult to link effective elastic properties to maceral properties, such as elastic moduli, composition, maturity, and quality. These difficulties have prevented us from building large databases, without which we cannot establish the accurate rock-physics models needed for inverting field geophysical data. I approach this issue using atomic-force microscopy based nanoindentation, coupled with scanning electron and confocal laser-scanning microscopy as a tool for visualization and identification of the organic part within shale, and to perform nanoscale elastic-property measurements. First, the microfabric of a set of source rock samples is characterized. The spatial and temporal link between organic matter and the stiff silicate mineral matrix is established, which leads to proposal of alternative Rock Physics modeling approach to organic-rich source rocks. Based on the nanoindentation measurements, I obtain elastic properties of source rock phases and provide several applications of these (nanoindentation-derived) elastic properties within a number of geomechanical problems. Finally, transport properties of various source rock formations are discussed based on comparison to more conventional reservoir rocks.

Shear Waves in Marine Sediments This book provides an accessible guide to using the rock physics-based forward modeling approach for mapping the subsurface, systematically linking rock properties to seismic amplitude. Providing practical workflows, the book shows how to methodically vary lithology, porosity, rock type, and pore fluids and reservoir geometry, calculate the corresponding elastic properties, and then generate synthetic seismic traces. These synthetic traces can then be compared to actual seismic traces from the field: a similar actual seismic response implies similar rock properties in the subsurface. The book catalogs various cases, including clastic sediments, carbonates, and time-lapse seismic monitoring, and discusses the effect of attenuation on seismic reflections. It shows how to build earth models (pseudo-wells) using deterministic and statistical approaches, and includes case studies based on real well data. A vital guide for researchers and petroleum geologists, in industry and academia, providing sample catalogs of synthetic seismic reflections from a variety of realistic reservoir models.

Seismic Reservoir Modeling An overview of the processes related to
geopressure development, prediction and detection using state-of-the-art tools and technologies.

Seismic Characterization of Carbonate Platforms and Reservoirs The Northern Gulf of Mexico Basin is part of an ocean basin characterized by a complex structural framework. The complex structural framework is shaped by the dynamic interaction between salt tectonics and sedimentation. Salt withdrawal mini-basins are among the structural features produced by this interaction and are of particular interest to hydrocarbon exploration. The mini-basins provide significant accommodation in which thick packages of sediments can accumulate. The accumulation of sediments can be very rapid during episodes of high sedimentation, such as occurred in the middle Miocene episodes in the northeastern Gulf of Mexico. Rapid accumulation of sediment in turn changes the local topography of the mini-basin and also leads to significant buildup of overpressure. In such settings, the structure and stratigraphy in the vicinity of a mini-basin are influenced by salt movement. Moreover, the rock properties can be altered due to salt movement and overpressure development. Therefore, the factors of salt movement and overpressure development are crucial in understanding the evolution of the petroleum system in mini-basins. Insights on the roles of these factors in defining the evolution of the petroleum system are beneficial for hydrocarbon exploration. Such insights are of use in addressing practical problems in reservoir characterization, pore pressure prediction, and basin and petroleum system modeling (BPSM). This dissertation establishes insights on the roles of these factors through meticulous quantification of related geologic processes to address some of the stated practical problems above. Chapter 1 quantifies the spatial variations in sediment compaction and clay diagenesis to define spatial trends of elastic properties, which are used for seismic reservoir characterization. We demonstrate the advantages of using this integrated method in a frontier area. Chapter 2 studies the impact of high sedimentation and salt movement on the thermal history of a mini-basin to propose a workflow for predicting the effects of smectite to illite diagenesis on overpressure. Chapter 3 investigates the implications of lateral slip along salt-related faults to pressure and thermal history to address the proper application of BPSM techniques in constructing paleo-geometry when modeling these faults. All three chapters of this dissertation focus on the Thunder Horse mini-basin in the Mississippi Canyon area by integrating 3D seismic data with well logs, biostratigraphic data, and
borehole measurements of pore pressure and temperature. Chapter 1 evaluates spatial changes in effective stress and smectite to illite diagenesis across Thunder Horse mini-basin using a 2D basin model that accounts for salt movement and properly calibrated with a single well. The results from the 2D model indicate that the central part of the mini-basin known as Thunder Horse field is associated with higher effective stress and shallower zone of smectite to illite transformation than the northwestern part known as Thunder Horse North field. Proper rock physics models are subsequently built to link the basin modeling results to seismic impedances and use them for quantitative seismic interpretation with spatially limited well control. The rock physics models are designed to account for the effects of sediment compaction and smectite to illite diagenesis on seismic impedances. The results from the quantitative seismic interpretation with a single well and basin modeling extrapolations of seismic impedance (extrapolation workflow) are comparable in their quality with those results obtained through the quantitative seismic interpretation with multiple wells scattered across the area (reference workflow). The training data sets of the seismic impedances of lithofacies corresponding to both of these workflows are similar in terms of the distribution of values and the pronounced spatial trends. In addition, the seismic inversion results of both of them are similar in terms of the quality of inverted impedances. Ultimately, these two workflows are close to each other in estimating the net pay volume of the reservoir and show the same degree of uncertainty in mapping reservoir lithofacies. This chapter was published first in AAPG Bulletin in May, 2017 'Ahead of Print' and officially appeared in the April, 2018 Bulletin. The publication focused on showcasing the workflow of combining basin modeling with seismic reservoir characterization. A refined version of this workflow that rigorously addresses spatial variability of training data of seismic impedances of lithofacies and uncertainty was accepted for publication in Geophysics in March, 2018. Both publications are co-authored with Tapan Mukerji, Allegra Hosford Scheirer and Stephan A. Graham. Dr. Tapan Mukerji contributed to the conception and design of the study. Dr. Allegra Hosford Scheirer provided guidance on building the basin model. Dr. Stephan A. Graham provided guidance on relating seismic impedances to geologic processes in the subsurface. Chapter 2 simulates thermal history of the mini-basin to quantify the impact of high sedimentation and salt movement. Then, the chapter integrates the modeled thermal history with rock physics models to predict the generation of overpressure due to smectite to illite diagenesis. A time-dependent solution of thermal history,
simulated with a 2D basin model across Thunder Horse mini-basin, shows calibration to corrected bottom hole temperatures and illitic content of XRD data when combined with the proper kinetics. The time-dependent solution indicates fluctuations of the high heat flux by the middle Miocene due to high sedimentation. In addition, the solution suggests mitigation of the transient effects of high sedimentation by the high conductivity of the extruded salt sheet that completely covers Thunder Horse North field. Comparing the time-dependent solution with a steady state solution, the steady state solution overestimates temperature and illitic content through time and the differences between the two solutions are more significant in Thunder Horse field. After building rock physics models that account for thermal history to define a relationship between effective stress and both P-wave velocity and density on the basis of illite content, the rock physics models show a predictive power of pore pressure that is sensitive to the incorporated solution of thermal history. On one hand, incorporating a solution of thermal history that addresses the geologic factors of high sedimentation and salt movement (i.e., time-dependent solution) yields accurate prediction of pore pressure from seismic P-wave velocity based on the rock physics models. On the other hand, oversimplification of the solution of thermal history with a steady state solution leads to inaccurate estimation of pore pressure by the rock physics models. Therefore, addressing the geologic factors controlling the thermal history is essential to accurately predict pore pressure from seismic velocity using rock physics. This chapter is submitted into Marine and Petroleum Geology and co-authored with Tapan Mukerji, Nader C. Dutta and Allegra Hosford Scheirer. Dr. Tapan Mukerji contributed to the design of the study, rock physics modeling, pore pressure prediction, and thermal history modeling. Dr. Nader C. Dutta advised on the design of the study and the rock physics modeling and pore pressure prediction. Dr. Allegra Hosford Scheirer guided on constructing the basin model. Chapter 3 compares the techniques for constructing paleo-geometry in BPSM (i.e., pure porosity controlled backstripping vs imposing structural restorations on paleo-geometry) in terms of the simulated pore pressure and thermal history across a salt related structure of lateral slip. This chapter focuses on an expulsion rollover fault to the northeast of Thunder Horse mini-basin (i.e., listric fault that soles in a salt decollement). The two techniques of constructing paleo-geometry differ exclusively in the thickness of stratigraphic layers and stratigraphic contacts with salt through geologic time. These differences in paleo-geometry cause differences in the simulated pore pressure and thermal history. The technique of imposing
structural restorations on paleo-geometry results in higher pore pressure build up over time and higher temperatures earlier in the history of the mini-basin when compared to the technique of porosity-controlled backstripping. These differences between the two techniques are spatially concentrated in the vicinity of the expulsion rollover fault. Therefore, the lateral slip impacts pressure and thermal history across the structure and the spatial extent of this impact depends on the amount of lateral slip. This chapter is submitted to Basin Research and co-authored with Kristian E. Meisling, Tapan Mukerji and Allegra Hosford Scheirer. Dr. Kristian E. Meisling provided guidance on seismic interpretation across the salt structures and on the sequential structural restoration. Dr. Tapan Mukerji helped with the initial design of the study and with some of the interpretations of the basin models. Dr. Allegra Hosford Scheirer helped with some of the interpretations of the basin models.

Seismic Reflections of Rock Properties Brings together widely scattered theoretical and laboratory rock physics relations critical for modelling and interpretation of geophysical data.

The Rock Physics Handbook Exploration and characterization of conventional and unconventional reservoirs using seismic technologies are among the main activities of upstream technology groups and business units of oil and gas operators. However, these activities frequently encounter difficulties in quantitative seismic interpretation due to remaining confusion and new challenges in the fast developing field of seismic petrophysics. Seismic Petrophysics in Quantitative Interpretation shows how seismic interpretation can be made simple and robust by integration of the rock physics principles with seismic and petrophysical attributes bearing on the properties of both conventional (thickness, net/gross, lithology, porosity, permeability, and saturation) and unconventional (thickness, lithology, organic richness, thermal maturity) reservoirs. Practical solutions to existing interpretation problems in rock physics-based amplitude versus offset (AVO) analysis and inversion are addressed in the book to streamline the workflows in subsurface characterization. Although the book is aimed at oil and gas industry professionals and academics concerned with utilization of seismic data in petroleum exploration and production, it could also prove helpful for geotechnical and completion engineers and drillers seeking to better understand how seismic and sonic data can be more thoroughly utilized.
Bayesian Methods for Petrophysical Inversion of Seismic Data Using Rock Physics Models

A Textbook of Sound, Being an Account of the Physics of Vibrations with Special Reference to Recent Theoretical and Technical Developments

Issues in Biophysics and Geophysics Research and Application: 2011 Edition is a ScholarlyEditions™ eBook that delivers timely, authoritative, and comprehensive information about Biophysics and Geophysics Research and Application. The editors have built Issues in Biophysics and Geophysics Research and Application: 2011 Edition on the vast information databases of ScholarlyNews™. You can expect the information about Biophysics and Geophysics Research and Application in this eBook to be deeper than what you can access anywhere else, as well as consistently reliable, authoritative, informed, and relevant. The content of Issues in Biophysics and Geophysics Research and Application: 2011 Edition has been produced by the world’s leading scientists, engineers, analysts, research institutions, and companies. All of the content is from peer-reviewed sources, and all of it is written, assembled, and edited by the editors at ScholarlyEditions™ and available exclusively from us. You now have a source you can cite with authority, confidence, and credibility. More information is available at http://www.ScholarlyEditions.com/.

Seismic Inversion Engineers and geologists in the petroleum industry will find Petroleum Related Rock Mechanics, 2e, a powerful resource in providing a basis of rock mechanical knowledge - a knowledge which can greatly assist in the understanding of field behavior, design of test programs and the design of field operations. Not only does this text give an introduction to applications of rock mechanics within the petroleum industry, it has a strong focus on basics, drilling, production and reservoir engineering. Assessment of rock mechanical parameters is covered in depth, as is acoustic wave propagation in rocks, with possible link to 4D seismics as well as log interpretation. Learn the basic principles behind rock mechanics from leading academic and industry experts Quick reference and guide for engineers and geologists working in the field Keep informed and up to date on all the latest methods and fundamental concepts

Scale-dependence of Rock Physics Models and Transforms Knowledge of the presence of abnormally-high pressure zones (AHFP) prior to drilling
into them can prevent considerable economic losses and, possibly, save human lives. The various origins (undercompaction, tectonics, etc.) of AHFPs are discussed, followed by the description of predictive techniques in clastic, carbonate and salt-bearing formations. In addition to the well-logging predictive techniques, the authors discuss smectite-illite transformation and the chemistry of interstitial solutions. Other topics covered include (a) abnormally low formation pressures and subsidence, and (b) mathematical modelling. Loss of potential production may result if AHFPs are not properly identified and evaluated. Many hydrocarbon-bearing formations with AHFPs are erroneously "condemned". This book is of interest to engineers and geologists involved in the (a) evaluation, (b) drilling in, (c) completing, and (d) producing from hydrocarbon reservoirs with AHFPs.

**PETROPHYSICAL ANALYSIS AND ROCK-PHYSICS BASED PREDICTION OF SONIC VELOCITIES IN CARBONATES** Recognizing the need for education and further research in AVO, the editors have compiled an all-encompassing treatment of this versatile technology. In addition to providing a general introduction to the subject and a review of the current state of the art, this unique volume provides useful reference materials and data plus original contributions at the leading edge of AVO technologies.

Geophysics Today Geopressure, or excess pore pressure in subsurface rock formations that is higher than the hydrostatic pressure, is a worldwide phenomenon which impacts hydrocarbon resource estimation, drilling and drilling safety in operations. This book provides a comprehensive overview of geopressure analysis bringing together rock physics, seismic technology, quantitative basin modeling and geomechanics. It provides a fundamental physical and geological basis for understanding geopressure by explaining the coupled mechanical and thermal processes. It also brings together state-of-the-art tools and technologies for analysis and detection of geopressure, along with the associated uncertainty. Prediction and detection of shallow geohazards and gas hydrates is also discussed and field examples are used to illustrate how models can be practically applied. With supplementary MATLAB codes and exercises available online, this is an ideal resource for students, researchers and industry professionals in geoscience and petroleum engineering looking to understand and analyse subsurface formation pressure.
ICIPEG 2016 Useful attributes capture and quantify key components of the seismic amplitude and texture for subsequent integration with well log, microseismic, and production data through either interactive visualization or machine learning. Although both approaches can accelerate and facilitate the interpretation process, they can by no means replace the interpreter. Interpreter “grayware” includes the incorporation and validation of depositional, diagenetic, and tectonic deformation models, the integration of rock physics systematics, and the recognition of unanticipated opportunities and hazards. This book is written to accompany and complement the 2018 SEG Distinguished Instructor Short Course that provides a rapid overview of how 3D seismic attributes provide a framework for data integration over the life of the oil and gas field. Key concepts are illustrated by example, showing modern workflows based on interactive interpretation and display as well as those aided by machine learning.

Compressibility of Sandstones Reliable and detailed information about the Earth’s subsurface is of crucial importance throughout the geosciences. Quantitative integration of all available geophysical and geological data helps to make Earth models more robust and reliable. The aim of this book is to summarize and synthesize the growing literature on combining various types of geophysical and other geoscientific data. The approaches that have been developed to date encompass joint inversion, cooperative inversion, and statistical post-inversion analysis methods, each with different benefits and assumptions. Starting with the foundations of inverse theory, this book systematically describes the mathematical and theoretical aspects of how to best integrate different geophysical datasets with geological prior understanding and other complimentary data. This foundational basis is followed by chapters that demonstrate the diverse range of applications for which integrated methods have been used to date. These range from imaging the hydrogeological properties of the near-surface to natural resource exploration and probing the composition of the lithosphere and the deep Earth. Each chapter is written by leading experts in the field, which makes this book the definitive reference on integrated imaging of the Earth. Highlights of this volume include: Complete coverage of the theoretical foundations of integrated imaging approaches from inverse theory to different coupling methods and
quantitative evaluation of the resulting models Comprehensive overview of current applications of integrated imaging including hydrological investigations, natural resource exploration, and imaging the deep Earth. Detailed case studies of integrated approaches providing valuable guidance for both experienced users and researchers new to joint inversion. This volume will be a valuable resource for graduate students, academics, industry practitioners, and researchers who are interested in using or developing integrated imaging approaches.

Integrated Imaging of the Earth Abstract: This work consists of conventional petrophysical analysis and sonic response determination from empirical relations, rock physics modelling, and fluid substitution for six wells in the Moki formation of New Zealand's Taranaki Basin. The project composed of three parts encompassing conventional log analysis, rock-physics modeling using empirical and theoretical approaches, and finally rock-physics modeling for shaley sands using semi-empirical adaptations to Gassmann fluid substitution. Finally, comparisons are made between results for the different wells, based on their depths and mineralogy. The first part of this study is presented as a petrophysical analysis, including crossplot analysis, conventional 3-mineral identification approach, and determination of water saturation profile, applied to several wells. After petrophysical analysis, we concluded that the Moki Formation may have well sorted grain size distribution or/and may be less compacted in the Tui Field than in the Maari Field although the formation is located at greater depths in the Tui Field. Furthermore, crossplot analysis indicates that these two fields have different types of clay; this may help explain the different compaction trends. In the second part of this study, empirical relations and rock physics modelling were used for sonic response prediction. The P-wave velocity was predicted from the empirical Wyllie's Time Average equation and from the Kuster-Toksoz rock physics model. The S-wave velocity was predicted from the empirical Greenberg-Castagna relation and from the Kuster-Toksoz rock physics model. After P-wave velocity predictions, we concluded that Kuster-Toksoz model works better in shale than Wyllie's Time Average equation due to the bound water in shale structure. This situation causes to have higher density response and to predict higher P-wave velocities calculated from Wyllie's Time Average equation in shale. Furthermore, less compaction in deeper depths causes to have higher porosity response; therefore, predicted P-wave velocities from Wyllie's Time Average equation are lower than P-wave velocities derived from sonic log. The
Kuster-Toksoz model optimizes parameters in order to obtain best fit with the observed P-wave velocity derived from sonic log since the P-wave results from Kuster-Toksoz fit well for each field. We note that the Greenberg-Castagna model predicts a lower S-wave velocity than the Kuster-Toksoz model, except in the highest-velocity streaks where limestone is likely present. Because there is no recorded an S-wave log, the comparison is not reliable in this study. In the last part of this study, Gassmann's equation was modified by using effective porosity for the sand-shale mixture. In order to estimate sonic velocities for different saturations, two different fluid substitution approaches were used: Dvorkin et al. (2007) and Simm (2007). The two methods yielded very similar results.

Geophysics and Ocean Waves Studies The book “Geophysics and Ocean Waves Studies” presents the collected chapters in two sections named “Geophysics” and “Ocean Waves Studies”. The first section, “Geophysics”, provides a thorough overview of using different geophysical methods including gravity, self-potential, and EM in exploration. Moreover, it shows the significance of rock physics properties and enhanced oil recovery phases during oil reservoir production. The second section, “Ocean Waves Studies”, is intended to provide the reader with a strong description of the latest developments in the physical and numerical description of wind-generated and long waves, including some new features discovered in the last few years. The section is organized with the aim to introduce the reader from offshore to nearshore phenomena including a description of wave dissipation and large-scale phenomena (i.e., storm surges and landslide-induced tsunamis). This book shall be of great interest to students, scientists, geologists, geophysicists, and the investment community.

The Rock Physics Handbook This book addresses the feasibility of CO2-EOR and sequestration in a mature Indian oil field, pursuing for the first time a cross-disciplinary approach that combines the results from reservoir modeling and flow simulation, rock physics modeling, geomechanics, and time-lapse (4D) seismic monitoring study. The key findings presented indicate that the field under study holds great potential for enhanced oil recovery (EOR) and subsequent CO2 storage. Experts around the globe argue that storing CO2 by means of enhanced oil recovery (EOR) could support climate change mitigation by reducing the amount of CO2 emissions in the atmosphere by ca. 20%. CO2-EOR and
Sequestration is a cutting-edge and emerging field of research in India, and there is an urgent need to assess Indian hydrocarbon reservoirs for the feasibility of CO2-EOR and storage. Combining the fundamentals of the technique with concrete examples, the book is essential reading for all researchers, students and oil & gas professionals who want to fully understand CO2-EOR and its geologic sequestration process in mature oil fields.

Physics and Seismicity of Rocks This book is a comprehensive treatment of the elastic volumetric response of sandstones to variations in stress. The theory and data presented apply to the deformations that occur, for example, due to withdrawal of fluid from a reservoir, or due to the redistribution of stresses caused by the drilling of a borehole. Although the emphasis is on reservoir-type sandstones, results and methods discussed are also applicable to other porous rocks. Part One concerns the effect of stress on deformation and discusses porous rock compressibility coefficients. Elasticity theory is used to derive relationships between the porous rock compressibility coefficients, the porosity, and the mineral grain compressibility. Theoretical bounds on the compressibility coefficients are derived. The concept of effective stress coefficients is examined, as is the integrated form of the stress-strain relationships. Undrained compression and induced pore pressures are treated within the same general framework. Part One is concluded with a brief, elementary introduction to Biot's theory of poroelasticity. All the results in Part One are illustrated and verified with extensive references to published compressibility data. Part Two deals with the relationship between pore structure and compressibility, and presents methods that permit quantitative prediction of the compressibility coefficients. Two- and three-dimensional models of tubular pores, spheroidal pores, and crack-like "grain boundary" voids are analyzed. A critical review is made of various methods that have been proposed to relate the effective elastic moduli (bulk and shear) of a porous material to its pore structure. Methods for extracting pore aspect ratio distributions from stress-strain data or from acoustic measurements are presented, along with applications to actual sandstone data. Part Three is a brief summary of experimental techniques that are used to measure porous rock compressibilities in the laboratory. The information contained in this volume is of interest to petroleum engineers, specifically those involved with reservoir modeling, petroleum geologists, geotechnical engineers, hydrologists and geophysicists.
PETROPHYSICAL AND EMPIRICAL AND THEORETICAL ROCK PHYSICS MODELING FOR THE MOKI FORMATION IN TWO FIELDS IN THE TARANAKI BASIN, NEW ZEALAND Seismic reservoir characterization aims to build 3-dimensional models of rock and fluid properties, including elastic and petrophysical variables, to describe and monitor the state of the subsurface for hydrocarbon exploration and production and for CO2 sequestration. Rock physics modeling and seismic wave propagation theory provide a set of physical equations to predict the seismic response of subsurface rocks based on their elastic and petrophysical properties. However, the rock and fluid properties are generally unknown and surface geophysical measurements are often the only available data to constrain reservoir models far away from well control. Therefore, reservoir properties are generally estimated from geophysical data as a solution of an inverse problem, by combining rock physics and seismic models with inverse theory and geostatistical methods, in the context of the geological modeling of the subsurface. A probabilistic approach to the inverse problem provides the probability distribution of rock and fluid properties given the measured geophysical data and allows quantifying the uncertainty of the predicted results. The reservoir characterization problem includes both discrete properties, such as facies or rock types, and continuous properties, such as porosity, mineral volumes, fluid saturations, seismic velocities and density. Seismic Reservoir Modeling: Theory, Examples and Algorithms presents the main concepts and methods of seismic reservoir characterization. The book presents an overview of rock physics models that link the petrophysical properties to the elastic properties in porous rocks and a review of the most common geostatistical methods to interpolate and simulate multiple realizations of subsurface properties conditioned on a limited number of direct and indirect measurements based on spatial correlation models. The core of the book focuses on Bayesian inverse methods for the prediction of elastic petrophysical properties from seismic data using analytical and numerical statistical methods. The authors present basic and advanced methodologies of the current state of the art in seismic reservoir characterization and illustrate them through expository examples as well as real data applications to hydrocarbon reservoirs and CO2 sequestration studies.

Prediction of Reservoir Properties for Geomechanical Analysis Using 3-D Seismic Data and Rock Physics Modeling in the Vaca Muerta Formation, Neuquén Basin, Argentina
Rock Physics and Geo-fluid Detection The subsurface is a heterogeneous mixture of porous rocks volumes. Treating a rock volume that is intrinsically heterogeneous as a homogeneous body requires characterizing it with certain "effective" attributes. Numerous rock physics models and transforms implicitly treat rocks as homogeneous bodies as they require a single value for each of the rock's attributes as input. The question is if such rock physics models and transforms were established for rock samples at a given scale of measurement and treated as homogeneous bodies, will rock samples measured at coarser scale, yet once again treated as homogeneous bodies, still obey the model? This dissertation aims to find how to adapt/apply rock physics models and transforms that treat rocks as homogeneous bodies to a composite that is inherently heterogeneous. The key contributions of this dissertation are (1) estimations of effective elastic properties of heterogeneous bodies to be used in fluid substitution operations, (2) analysis of applicability of rock-physics models established at one scale of measurement (e.g., well-log scale) to coarse-scale measurements (e.g., seismic scale), (3) introduction of the notion of elastic mineral facies concept, (4) estimations of coarse-scale relations between the effective bulk modulus of the fluid to fluid saturation in a rock volume where two fluid phases are present, and (5) estimation and prediction of effective elastic properties of digital rock samples.

Origin and Prediction of Abnormal Formation Pressures This book presents selected articles from the workshop on "Challenges in Petrophysical Evaluation and Rock Physics Modeling of Carbonate Reservoirs" held at IIT Bombay in November 2017. The articles included explore the challenges associated with using well-log data, core data analysis, and their integration in the qualitative and quantitative assessment of petrophysical and elastic properties in carbonate reservoirs. The book also discusses the recent trends and advances in the area of research and development of carbonate reservoir characterization, both in industry and academia. Further, it addresses the challenging concept of porosity portioning, which has huge implications for exploration and development success in these complex reservoirs, enabling readers to understand the varying orders of deposition and diagenesis and also to model the flow and elastic properties.
Petroleum Related Rock Mechanics Finding viable solutions to many of the problems threatening our environment hinges on understanding the rocks below the earth's surface. For those evaluating the relative hazards of radioactive waste sites, investigating energy resources such as oil, gas, and hydrothermal energy, studying the behavior of natural hazards like earthquakes and volcanoes, or charting the flow of groundwater through the earth, this book will be indispensable. Until now, there has been no book that treats the subject of the nature and behavior of rocks in a comprehensive yet accessible manner. Yves Guen and Victor Palciauskas first discuss the physical properties of rocks, proceeding by chapter through mechanical, fluid flow, acoustical, electrical, dielectric, thermal, and magnetic properties. Then they provide the theoretical framework for achieving reliable data and making reasonable inferences about the aggregate system within the earth. Introduction to the Physics of Rocks covers the important and most current theoretical approaches to the physics of inhomogeneous media, including theoretical bounds on properties, various effective medium theories, percolation, and fractals. This book will be of use to students and researchers in civil, petroleum, and environmental engineering and to geologists, geophysicists, hydrologists, and other earth scientists interested in the physics of the earth. Its clear presentation, with problems at the end of each chapter and selective references, will make it ideal for advanced undergraduate-or graduate-level courses.

Offset-dependent Reflectivity

Integrated Reservoir Studies for CO2-Enhanced Oil Recovery and Sequestration This book presents the proceedings of the 4th International Conference on Integrated Petroleum Engineering and Geosciences 2016 (ICIPEG 2016), held under the banner of World Engineering, Science & Technology Congress (ESTCON 2016) at Kuala Lumpur Convention Centre from August 15 to 17, 2016. It presents peer-reviewed research articles on exploration, while also exploring a new area: shale research. In this time of low oil prices, it highlights findings to maintain the exchange of knowledge between researchers, serving as a vital bridge-builder between engineers, geoscientists, academics, and industry.

Petroleum Geoscience Esta tese propõe uma metodologia de estimativa de pressão de poros em rochas resservatrated via atraves dos atributos seismicos velocidade compressional V(p) e velocidadecisalhante V(s). Na
metodologia, os atributos são encarados como observações realizadas sobre um sistema físico, cujo comportamento depende de um determinado número de grandezas não observáveis, dentre as quais a pressão de poros apenas uma delas. Para estimar a pressão de poros, adota-se uma abordagem Bayesiana de inversão. Através de uma função de verossimilhança, estabelecida através de um modelo de física de rochas calibrado para a região, e do teorema de Bayes, combina-se as informações pré-existentes sobre os parâmetros de rocha, fluido e estado de tensões com os atributos sísmicos observados, inferindo probabilisticamente a pressão de poros. Devido à linearidade do problema e ao interesse em realizar uma rigorosa análise de incertezas, um algoritmo baseado em simulações de Monte Carlo (um caso especial do algoritmo de Metropolis-Hastings) é utilizado para realizar a inversão. Exemplos de aplicação da metodologia proposta são simulados em reservatórios criados sinteticamente. Através dos exemplos, demonstra-se que o sucesso da previsão de pressão de poros depende da combinação de diferentes fatores, como o grau de conhecimento prévio sobre os parâmetros de rocha e fluido, sensibilidade da rocha perante a variação de pressões diferenciais e a qualidade dos atributos sísmicos. Visto que os métodos existentes para previsão de pressão de poros utilizam somente o atributo V(p), a contribuição do atributo V(s) na previsão é avaliada. Em um cenário de rochas pouco consolidadas (ou em areias), demonstra-se que o atributo V(s) pode contribuir significativamente na previsão, mesmo apresentando grandes incertezas associadas. Já para um cenário de rochas consolidadas, demonstra-se que as incertezas associadas às pressões previstas são maiores, e que a contribuição do atributo V(s) na previsão não é tão significativa quanto nos casos de rochas pouco consolidadas.

Seismic Petrophysics in Quantitative Interpretation Modern seismic data have become an essential toolkit for studying carbonate platforms and reservoirs in impressive detail. Whilst driven primarily by oil and gas exploration and development, data sharing and collaboration are delivering fundamental geological knowledge on carbonate systems, revealing platform geomorphologies and how their evolution on millennial time scales, as well as kilometric length scales, was forced by long-term eustatic, oceanographic or tectonic factors. Quantitative interrogation of modern seismic attributes in carbonate reservoirs permits flow units and barriers arising from depositional and diagenetic processes to be imaged and extrapolated between wells. This volume reviews the variety of
carbonate platform and reservoir characteristics that can be interpreted from modern seismic data, illustrating the benefits of creative interaction between geophysical and carbonate geological experts at all stages of a seismic campaign. Papers cover carbonate exploration, including the uniquely challenging South Atlantic pre-salt reservoirs, seismic modelling of carbonates, and seismic indicators of fluid flow and diagenesis.