# 3d Geomechanical Modeling Of Complex Salt Structures

This book is one out of 8 IAEG XII Congress volumes, and deals with the theme of applied geology, which is a critical theme for the global economy. In the international, multidisciplinary approach to major engineering projects (either to macro- or mega-scale), the application of geological investigation techniques is fundamental for properly selecting the location sites, planning the construction and maintaining the infrastructures. The contributions in this book include not only engineering constructions but also case studies related to large projects on geo-resources exploration and extraction (minerals, petroleum and groundwater), energy production (hydropower, geothermal, nuclear and others), transportation (railway and highway) and waste disposal as well as the environmental management of these and other activities. The Engineering Geology for Society and Territory volumes of the IAEG XII Congress held in Torino from September 15-19, 2014, analyze the dynamic role of engineering geology in our changing world and build on the four main themes of the congress: Environment, processes, issues, and approaches. The congress topics and subject areas of the 8 IAEG XII Congress volumes are: 1. Climate Change and Engineering Geology 2. Landslide Processes 3. River Basins, Reservoir Sedimentation and Water Resources 4. Marine and Coastal Processes 5. Urban Geology, Sustainable Planning and Landscape Exploitation 6. Applied Geology for Major Engineering Projects 7. Education, Professional Ethics and Public Recognition of Engineering Geology 8. Preservation of Cultural Heritage.

The increasing demand for hydrocarbons and decreasing reserves have created the necessity to produce oil and gas

more efficiently and economically. Increasingly, oil and gas companies are focusing on unconventional hydrocarbons; oil sands, shales and CBM. For this class of reservoir materials, the geomechanical response of the reservoir can play an important role in the recovery process. For naturally fractured, stress sensitive reservoirs or thermal recovery processes, geomechanical processes play an even greater role in efficient, economic recovery. For simulations of these processes, most research efforts have been focused on reservoir geomechanical simulations using conventional reservoir simulators coupled to geomechanical codes. While coupled reservoir-geomechanics modeling has been recently widely studied in the literature, there is no applicable methodology implemented or proposed to mitigate the challenging computational cost involved with the inclusion of geomechanics in large multimillion-cell reservoirs. Past studies so far have focused on different coupling schemes, but not on the efficient and robust simulation workflows. This research was conducted with the aim of development and application of various different strategies to include geomechanics into reservoir simulation workflows in large scale reservoirs and in a timely fashion process. The research was performed to allow the future simulators to perform high resolution reservoir-geomechanical simulations in a large scale (near field and far field) with long simulation time windows and lowest computational cost. Initially, analytical proxies were developed and recommending for implementation in lieu of complex reservoir simulations. The analytical model was for prediction of heavy oil geomechanical responses everywhere in the reservoir. The model adopted the use of the mathematical domain decomposition technique and a novel temperature front tracking developed in the very early stage of the research. As opposed to classical analytical models, the proxy predicted

reservoir flow and mechanical behavior (on a synthetic case geometry with real hydraulic data) everywhere in the reservoir and in dynamic and transient flow regimes. Subsequent research was aimed at reservoir-geomechanics coupled model order reduction by use of a numerical proxy. The proxy took advantage of streamline linear space behavior and power in decomposition of the reservoir domain into sub-systems (delineation/drainage areas). The combination of localization and linearization allowed predicting both mechanical and fluid flow responses of the reservoir with only solving the pressure equation in Cartesian underlying 3D grids and the solution of saturation transport equation along only one streamline. Following this, a streamline-based reservoir-geomechanics coupling was proposed and was implemented within a Fortran-C++ based platform. The new developed technique was compared in terms of computational cost and results accuracy with the conventional hydromechanical coupling strategy that was developed on a C++ based platform by use of collocated FV-FEM discretization scheme. One of the final stages of the research explored different streamline-based reservoir-geomechanics coupling strategies for full-field reservoir simulations. Various coupling strategies including sequential coupling schemes and a semi-fully coupling scheme to embed geomechanics into streamline simulation workflow was developed and performed. Numerical software with advanced GUI was coded on QT programming language (C++ based) developed to couple mechanical simulator to streamline simulation engine. While streamline simulations were the center of the research, the last stage of research was conducted on numerical and physical stability, convergence and material balance errors of SL-based reservoir-geomechanics class of couplings. The results provided a solid foundation for proper selection of time-steps in SL-based coupling to ensure a

numerically stable and physically robust hydromechanical simulation. As a result we showed that use of streamline simulation in both proxy forms and simulator forms have significant added value in full-field reservoir-geomechanics simulations.

This book analyzes new theories and practical approaches for promoting excellence in human resource management and leadership. It shows how the principles of creating shared value can be applied to ensure faster learning, training, business development and social renewal. In particular, it presents novel methods and tools for tackling the complexity of management and learning in both business organizations and society. Discussing ontologies, intelligent management systems, and methods for creating knowledge and value added, it offers novel insights into time management and operations optimization, as well as advanced methods for evaluating customers' satisfaction and conscious experience. Based on three AHFE 2020 Virtual Conferences: the AHFE 2020 Conference on Human Factors, Business Management and Society, the AHFE 2020 Conference on Human Factors in Management and Leadership, held on July 16–20, 2020, the book provides researchers and professionals with extensive information, practical tools and inspiring ideas for achieving excellence in a broad spectrum of business and societal activities.

A surge of interest in the geomechanical and petrophysical properties of mudrocks (shales) has taken place in recent years following the development of a shale gas industry in the United States and elsewhere, and with the prospect of similar developments in the UK. Also, these rocks are of particular importance in excavation and construction geotechnics and other rock engineering applications, such as underground natural gas storage, carbon dioxide disposal and radioactive waste storage. They may greatly influence the stability of

natural and engineered slopes. Mudrocks, which make up almost three-quarters of all the sedimentary rocks on Earth, therefore impact on many areas of applied geoscience. This volume focuses on the mechanical behaviour and various physical properties of mudrocks. The 15 chapters are grouped into three themes: (i) physical properties such as porosity, permeability, fluid flow through cracks, strength and geotechnical behaviour; (ii) mineralogy and microstructure, which control geomechanical behaviour; and (iii) fracture, both in laboratory studies and in the field.

This book gathers the latest advances, innovations, and applications in the field of computational geomechanics, as presented by international researchers and engineers at the 16th International Conference of the International Association for Computer Methods and Advances in Geomechanics (IACMAG 2020/21). Contributions include a wide range of topics in geomechanics such as: monitoring and remote sensing, multiphase modelling, reliability and risk analysis, surface structures, deep structures, dams and earth structures, coastal engineering, mining engineering, earthquake and dynamics, soil-atmosphere interaction, ice mechanics, landfills and waste disposal, gas and petroleum engineering, geothermal energy, offshore technology, energy geostructures, geomechanical numerical models and computational rail geotechnics.

This book presents the results of the major EU project Promine. For the first time there is now a European database available on mineral deposits, as well as 3D, 4D and predictive models of major mineral belts in Europe: Fennoscandia (Skellefteå and Vihanti-Pyhäsalmi), the Fore-Sudetic basin (Kupferschiefer deposits in Poland and Germany), the Hellenic belt in northern Greece, and the Iberian Pyrite belt and Ossa Morena zone in Spain and Portugal. The book also describes the modelling techniques

applied and how different types of software are used for three- and four-dimensional modelling. Furthermore, fundamental descriptions of how to build the database structure of three-dimensional geological data are provided and both 2D and 3D predictive models are presented for the main mineral belts of Europe.

Designing an efficient drilling program is a key step for the development of an oil and/or gas field. Variations in reservoir pressure, saturation and temperature, induced by reservoir production or CO2 injection, involve various coupled physical and chemical processes. Geomechanics, which consider all thermohydromechanical phenomena involved in rock behavior, play an important role in every operation involved in the exploitation of hydrocarbons, from drilling to production, and in CO2 geological storage operations as well. Pressure changes in the reservoir modify the in situ stresses and induce strains, not only within the reservoir itself, but also in the entire sedimentary column. In turn, these stress variations and associated strains modify the fluids flow in the reservoir and change the wellbore stability parameters. This book offers a large overview on applications of Geomechanics to petroleum industry. It presents the fundamentals of rock mechanics, describes the methods used to characterise rocks in the laboratory and the modelling of their mechanical behaviour ; it gives elements of numerical geomechanical modelling at the site scale. It also demonstrates the role of Geomechanics in the optimisation of drilling and production : it encompasses drillability, wellbore stability, sand production and hydraulic fracturing ; it provides the basic attainments to deal with the environmental aspects of heave or subsidence of the surface layers, CO2 sequestration and well abandonment ; and it shows how seismic monitoring and geomechanical modelling of reservoirs can help to optimise production or check cap rock integrity. This book will be of

interest to all engineers involved in oil field development and petroleum engineering students, whether drillers or producers. It aims also at providing a large range of potential users with a simple approach of a broad field of knowledge.
This book is a result of a career spent developing and applying computer techniques for the geosciences. The need for a geoscience modeling reference became apparent during participation in several workshops and conferences on the subject in the last three years. For organizing these, and for the lively discussions that ensued and inevitably contributed to the contents, I thank Keith Turner, Brian Kelk, George Pflug and Johnathan Raper. The total number of colleagues who contributed in various ways over the preceding years to the concepts and techniques presented is beyond count. The book is dedicated to all of them. Compilation of the book would have been impossible without assistance from a number of colleagues who contributed directly. In particular, Ed Rychkun, Joe Ringwald, Dave Elliott, Tom Fisher and Richard Saccany reviewed parts of the text and contributed valuable comment. Mohan Srivastava reviewed and contributed to some of the geostatistical presentations. Mark Stoakes, Peter Dettlaff and Simon Wigzell assisted with computer processing of the many application examples. Anar Khanji and Randal Crombe assisted in preparation of the text and computer images. Klaus Lamers assisted with printing. The US Geological Survey, the British Columbia Ministry of Environment, Dave Elliott and others provided data for the application examples. My sincere thanks to all of them.
Structurally Complex ReservoirsGeological Society of

London

This book is the second edition of the well-known textbook Modelling Rock Fracturing Processes. The new and extended edition provides the theoretical background of rock fracture mechanics used for modelling of 2-D and 3-D geomechanics problems and processes. Fundamentals of rock fracture mechanics integrated with experimental studies of rock fracturing processes are highlighted. The computer programs FRACOD 2D and 3D are used to analyse fracture initiation and propagation for the three fracture modes: Mode I, II and III. Coupled fracture modelling with other continuous and distinct element codes including FLAC, PFC, RFPA, TOUGH are also described. A series of applications of fracture modelling with importance for modern society is presented and discussed by distinguished rock fracture modelling experts.

Man's intensifying use of the Earth's habitat has led to an urgent need for scientifically advanced 'geo-prediction systems' that accurately locate subsurface resources and forecast the timing and magnitude of earthquakes, volcanic eruptions and land subsidence. As advances in the earth sciences lead to process-oriented ways of modeling the complex processes in the solid Earth, the papers in this volume provide a survey of some recent developments at the leading edge of this highly technical discipline. The chapters cover current research in predicting the future behavior of geologic systems as well as the mapping of geologic patterns that exist now in the subsurface as frozen evidence of the past. Both techniques are highly relevant to humanity's

need for resources such as water, and will also help us control environmental degradation. The book also discusses advances made in seismological methods to obtain information on the 3D structure of the mantle and the lithosphere, and in the quantitative understanding of lithospheric scale processes. It covers recent breakthroughs in 3D seismic imaging that have enhanced the spatial resolution of these structural processes, and the move towards 4D imaging that measures these processes over time. The new frontier in modern Earth sciences described in this book has major implications for oceanographic and atmospheric sciences and our understanding of climate variability. It brings readers right up to date with the research in this vital field.

* Multidisciplinary approach of risk assessment and management, which can provide more efficient earthquake mitigation. * Transfer of Geo-scientific and engineering knowledge to Civil Protection and insurance agents * Approaches and common practices directly related to the preparation of earthquake emergency plans * Illustrated examples of actual applications, including web sites * Case-studies and information on relevant international projects

This volume describes the nature, causes, and consequences of the diverse fluid movements that produce energy and mineral resources in sedimentary basins. The contained papers point to new capabilities in basin analysis methods and models. The processes that operate in the resource-producing thermo-chemical-structural reactors we call sedimentary basins are

reviewed. Efficient ways to infer the tectonic history of basins are described. Impacts on hydrocarbon maturation and migration of glacial tilting, magmatic intrusion, salt migration, and fracturing are illustrated. The conditions under which subsurface flow will channel with distance traveled are identified. Seismic methods that can image and map subsurface permeability channels are described. The surface maturation, surface charge, and chemical reaction foundations of creep subsidence are set forth. Dynamic aspects of the hydrogen resource in basins are analyzed. There is much that is new that is presented in these papers with the intent of stimulating thinking and enthusiasm for the advances that will be made in future decades.

This book presents selected articles from the 5th International Conference on Geotechnics, Civil Engineering Works and Structures, held in Ha Noi, focusing on the theme “Innovation for Sustainable Infrastructure”, aiming to not only raise awareness of the vital importance of sustainability in infrastructure development but to also highlight the essential roles of innovation and technology in planning and building sustainable infrastructure. It provides an international platform for researchers, practitioners, policymakers and entrepreneurs to present their recent advances and to exchange knowledge and experience on various topics related to the theme of “Innovation for Sustainable Infrastructure”.

This thesis presents an impressive summary of the potential to use passive seismic methods to monitor the sequestration of anthropogenic CO2 in geologic reservoirs. It brings

together innovative research in two distinct areas – seismology and geomechanics – and involves both data analysis and numerical modelling. The data come from the Weyburn-Midale project, which is currently the largest Carbon Capture and Storage (CCS) project in the world. James Verdon's results show how passive seismic monitoring can be used as an early warning system for fault reactivation and top seal failure, which may lead to the escape of CO2 at the surface.

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

Covering a wide range of topics involving both research developments and applications, resulting from the 10th International Conferecne on Computer Methods and Advances in Geomechanics (IACMAG) held in January 2001 in Tucson, Arizona, USA. The theme of the conference was Fundamentals through Applications. The up-to-date research results and applications in this 2-volume work (> 1900 pages) should serve as a valuable source of information for those engaged in research, analysis and design, practical application, and education in the fields of geomechanics and geotechnical engineering.

This thesis focuses on the contemporary stress state of a continental rift structure, the Upper Rhine Graben, and its present-day reactivation and kinematic behaviour. The graben is currently characterised by relatively slow tectonic deformation accompanied by low to medium seismicity and ongoing subsidence. In this context, the reactivation potential of pre-existing faults associated with the graben structure is one of the main goals of this thesis. Three dimensional finite element modelling is used for simulating the stress state of the study area. Based on the evaluation of the fault reactivation potential, a possible contribution of mechanical

earth modelling to earthquake hazard assessment is also investigated. Another task of this thesis is the development of a method and work process for the construction of complex model geometries based on the different data types available. In order to establish a procedure that is independent of local computing and software facilities, the work-flow used is predominantly based on commercial software packages. A brief introduction is given on crustal stresses, their definition, determination and classification. Two approaches of shear failure reactivation evaluation, independent of the rheological parameter of fault surfaces, are discussed. In addition, a summary of the finite element method is given. This includes the influence of mesh quality and the implementation of contact problems as well as the ABAQUS implementation of the material models used (elasticity and elasto-plasticity). The thesis also refers to the approach of multi-scale modelling, nesting or sub-modelling using ABAQUS. The consequences of this approach on the boundary conditions and the model geometries are discussed.

This volume reviews our current understanding and ability to model the complex distribution and behaviour of fault and fracture networks, highlighting their fluid compartmentalizing effects and storage-transmissivity characteristics, and outlining approaches for predicting the dynamic fluid flow and geomechanical behaviour of these reservoirs. This collection of 25 papers provides an overview of recent progress and outstanding issues in the areas of structural complexity and fault geometry, detection and prediction of faults and fractures, compartmentalizing effects of fault systems and complex siliciclastic reservoirs and critical controls affecting fractured reservoirs.

These proceedings present high-level research in structural engineering, concrete mechanics and quasi-brittle materials, including the prime concern of durability requirements and

earthquake resistance of structures.

Forty one years ago, the International Society for Rock Mechanics (ISRM) held its 1st International Congress in Lisbon, Portugal. In July 2007, the 11th ISRM Congress returned to Lisbon, where the Portuguese Geotechnical Society (SPG), the Portuguese National Group of the ISRM, hosted the meeting. The Second Half Century of Rock Mechanics comprises the proceedings of the 11th ISRM Congress, and reviews how the discipline of Rock Mechanics has evolved over the past half century to become an important area of Geotechnical Engineering, and considers new perspectives and developments as well. The organization of the congress was co-sponsored by the Spanish Society for Rock Mechanics (SMR), who also organized two satellite workshops in Madrid ("Underground Works under Special Conditions" and "Preservation of Natural Stone and Rock Weathering"). The Congress also included another satellite workshop in the Azores ("2nd International Workshop on Volcanic Rocks"), several short courses, a selection of one-day technical tours in Portugal and other events. The Second Half Century of Rock Mechanics contains the complete papers presented by the ISRM National Groups, as well as transcripts of special lectures by invited speakers on key issues and recent research developments. The themes of general interest included: Rock Engineering and Environmental Issues; The Path from Characterization to Modelling; Slopes, Foundations and Open Pit Mining; Tunnel, Caverns and Underground Mining; Earthquake Engineering and Rock Dynamics; Petroleum Engineering and Hydrocarbon Storage; and Safety Evaluation and Risk Management. The Second Half Century of Rock Mechanics will be of interest to professionals, engineers, and academics involved in rock mechanics, rock engineering, tunnelling, mining, earth quake engineering, rock dynamics

and geotechnical engineering.

Carbon capture and geological storage (CCS) is presently the only way that we can make deep cuts in emissions from fossil fuel-based, large-scale sources of CO2 such as power stations and industrial plants. But if this technology is to be acceptable to the community, it is essential that it is credibly demonstrated by world-class scientists and engineers in an open and transparent manner at a commercially significant scale. The aim of the Otway Project was to do just this. Geologically Storing Carbon provides a detailed account of the CO2CRC Otway Project, one of the most comprehensive demonstrations of the deep geological storage or geosequestration of carbon dioxide undertaken anywhere. This book of 18 comprehensive chapters written by leading experts in the field is concerned with outstanding science, but it is not just a collection of scientific papers – it is about 'learning by doing'. For example, it explains how the project was organised, managed, funded and constructed, as well as the approach taken to community issues, regulations and approvals. It also describes how to understand the site: Are the rocks mechanically suitable? Will the CO2 leak? Is there enough storage capacity? Is monitoring effective? This is the book for geologists, engineers, regulators, project developers, industry, communities or anyone who wants to better understand how a carbon storage project really 'works'. It is also for people concerned with obtaining an in-depth appreciation of one of the key technology options for decreasing greenhouse emissions to the atmosphere.

Hydraulic fracturing in tight gas and shale gas reservoirs is an essential stimulation technique for production enhancement. Often, hydraulic fracturing induces fracture patterns that are more complex than the planar geometry that has been assumed in the past models. These complex patterns arise as a result of the presence of planes of weakness, faults and/or natural fractures. In this thesis, two different 3D geomechanical models have been developed to simulate the interaction between the hydraulic fracture and the natural fractures, and to observe the impact of geomechanics on the potential microseismicity in these naturally fractured formations. Several cases were studied to observe the effects of natural fracture geometry, fracturing treatment, mechanical properties of the sealed fractures, etc. on the propagation path of the hydraulic fracture in these formations, and were found to be consistent with past experimental results. Moreover, the effects of several parameters including cohesiveness of the sealed natural fractures, mechanical properties of the formation, treatment parameters, etc. have been studied from the potential microseismicity standpoint. It is shown that the impact of geomechanics on potential microseismicity is significant and can influence the desired fracture spacing. In this thesis, the presented model quantifies the extent of potential microseismic volume (MSV) resulting from hydraulic fracturing in unconventional reservoirs. The model accounts for random geometries of the weak planes (with different dip and strike) observed in the field. The work presented here shows, for the first time, a fracture treatment can be designed to

maximize the MSV, when the fractures form a complicated network of fractures, and in turn influence the desired fracture spacing in horizontal wells. Our work shows that by adjusting the fluid rheology and other treatment parameters, the spatial extent of MSV and the desired fracture spacing can be optimized for a given set of shale properties.

Rocks and soils can behave as discontinuous materials, both physically and mechanically, and for such discontinuous nature and behaviour there remain challenges in numerical modelling methods and techniques. Some of the main discontinuum based numerical methods, for example the distinct element method (DEM) and the discontinuous deformation analysi

Since the 1990s five books on ‘Applications of Computational Mechanics in Geotechnical Engineering’ have been published. Innovative Numerical Modelling in Geomechanics is the 6th and final book in this series, and contains papers written by leading experts on computational mechanics. The book treats highly relevant topics in the field of geotechnics, such as environmental geotechnics, open and underground excavations, foundations, embankments and rockfill dams, computational systems and oil geomechanics. Special attention is paid to risk in geotechnical engineering, and to recent developments in applying Bayesian networks and Data Mining techniques. Innovative Numerical Modelling in Geomechanics will be of interest to civil, mining and environmental engineers, as well as to engineering geologists. The book will also

be useful for academics and researchers involved in geotechnics.

This book systematically introduces readers to the simulation theory and techniques of multiple media for unconventional tight reservoirs. It summarizes the macro/microscopic heterogeneities; the features of multiscale multiple media; the characteristics of complex fluid properties; the occurrence state of continental tight oil and gas reservoirs in China; and the complex flow characteristics and coupled production mechanism under unconventional development patterns. It also discusses the simulation theory of multiple media for unconventional tight oil and gas reservoirs; mathematic model of flow through discontinuous multiple media; geological modeling of discrete multiscale multiple media; and the simulation of multiscale, multiphase flow regimes and multiple media. In addition to the practical application of simulation and software for unconventional tight oil and gas, it also explores the development trends and prospects of simulation technology. The book is of interest to scientific researchers and technicians engaged in the development of oil and gas reservoirs, and serves as a reference resource for advanced graduate students in fields related to petroleum.

The UK became a net importer of natural gas in 2004 and by 2020 will import up to 90% of its requirements, leaving it vulnerable to increasing energy bills and risk of disruption to supply. New pipelines to Europe and improvements to interconnectors will meet some demand, but Government recognises the need for increased gas storage capacity: best met by the

construction of underground storage facilities. Energy security has also raised the likelihood of a new generation of coal-fired power-stations, which to be environmentally viable, will require clean-coal technologies with near-zero greenhouse gas emissions. A key element of this strategy will be underground CO2 storage. This volume reviews the technologies and issues involved in the underground storage of natural gas and CO2, with examples from the UK and overseas. The potential for underground storage of other gases such as hydrogen, or compressed air linked to renewable sources is also reviewed.

Advances in theories, methods and applications for shale resource use Shale is the dominant rock in the sedimentary record. It is also the subject of increased interest because of the growing contribution of shale oil and gas to energy supplies, as well as the potential use of shale formations for carbon dioxide sequestration and nuclear waste storage. Shale: Subsurface Science and Engineering brings together geoscience and engineering to present the latest models, methods and applications for understanding and exploiting shale formations. Volume highlights include: Review of current knowledge on shale geology Latest shale engineering methods such as horizontal drilling Reservoir management practices for optimized oil and gas field development Examples of economically and environmentally viable methods of hydrocarbon extraction from shale Discussion of issues relating to hydraulic fracking, carbon sequestration, and nuclear waste storage

Instabilities Modeling in Geomechanics describes

complex mechanisms which are frequently met in earthquake nucleation, geothermal energy production, nuclear waste disposal and CO2 sequestration. These mechanisms involve systems of non-linear differential equations that express the evolution of the geosystem (e.g. strain localization, temperature runaway, pore pressure build-up, etc.) at different length and time scales. In order to study the evolution of a system and possible instabilities, it is essential to know the mathematical properties of the governing equations. Therefore, questions of the existence, uniqueness and stability of solutions naturally arise. This book particularly explores bifurcation theory and stability analysis, which are robust and rigorous mathematical tools that allow us to study the behavior of complex geosystems, without even explicitly solving the governing equations. The contents are organized into 10 chapters which illustrate the application of these methods in various fields of geomechanics.

The papers in this volume reflect the current research and advances made in the application of numerical methods in geotechnical engineering. Topics include: instabilities in soil behaviour; environmental geomechanics; and hydro-mechanical coupling in problems of engineering.

This book contains the Proceedings of EUROCK 2013 - The 2013 ISRM International Symposium, which was held on 23-26 September 2013 in

Wroclaw, Poland. The Symposium was organized by the ISRM National Group POLAND and the Institute of Geotechnics and Hydrotechnics of the Wroclaw Institute of Technology. The focus of the Symposium was on recent develo

This book is intended as a reference book for advanced graduate students and research engineers in shale gas development or rock mechanical engineering. Globally, there is widespread interest in exploiting shale gas resources to meet rising energy demands, maintain energy security and stability in supply and reduce dependence on higher carbon sources of energy, namely coal and oil. However, extracting shale gas is a resource intensive process and is dependent on the geological and geomechanical characteristics of the source rocks, making the development of certain formations uneconomic using current technologies. Therefore, evaluation of the physical and mechanical properties of shale, together with technological advancements, is critical in verifying the economic viability of such formation. Accurate geomechanical information about the rock and its variation through the shale is important since stresses along the wellbore can control fracture initiation and frac development. In addition, hydraulic fracturing has been widely employed to enhance the production of oil and gas from underground reservoirs. Hydraulic fracturing is a complex operation in which the fluid is pumped at

a high pressure into a selected section of the wellbore. The interaction between the hydraulic fractures and natural fractures is the key to fracturing effectiveness prediction and high gas development. The development and growth of a hydraulic fracture through the natural fracture systems of shale is probably more complex than can be described here, but may be somewhat predictable if the fracture system and the development of stresses can be explained. As a result, comprehensive shale geomechanical experiments, physical modeling experiment and numerical investigations should be conducted to reveal the fracturing mechanical behaviors of shale.

This proceedings book presents research papers discussing the latest developments and findings in the fields of mining, machinery, automation and environmental protection. It includes contributions from authors from over 20 countries, with backgrounds in computer science, mining engineering, technology and management, and hailing from the government, industry and academia. It is of interest to scientists, engineers, consultants and government staff who are responsible for the development and implementation of innovative approaches, techniques and technologies in the mineral industries. Covering the latest advances in fundamental research, it also appeals to academic researchers.