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Formation Evaluation and Numerical Modeling on Hydraulic Fracturing for an Emerging Marine Shale Gas Reservoir Chenji Wei 2013 Shale gas development has more than 3 decades of history and remains one of the hottest topics in the petroleum industry. Shale gas development in China is underway. Our study focuses on an emerging marine shale gas reservoir in southern China, with its huge reserves that have attracted strong attention. The first part of this dissertation is the petrophysical characterization, which is an important step for a new shale gas play to better understand the geology of the formation, and it provides vital data to optimize a production plan and stimulation design. A systematic petrophysical study was conducted for the marine shale gas reservoir by conducting a series of 6 parallel experiments for 12 groups of samples to measure the total organic content (TOC), vitrinite reflectance (Ro), porosity, permeability, mineralogy, and gas content. Second, the extra-low porosity and permeability of shale formations complicate the mechanisms of shale gas storage and flow. Understanding the microstructure is significant for evaluating a new shale gas play toward accurate reserve estimation and recovery prediction. Both physical measurement (nitrogen adsorption experiment) and visualization technology (Scanning Electron Microscope) were used to characterize the nanopore structure of the Longmaxi Shale. Isotherms were obtained from adsorption experiments, and specific surface area and pore size distribution were calculated from the experimental results. Combining with the TOC, gas content, and mineralogy of the Longmaxi Shale, the significance and the controlling factors of the specific surface area and the nanopore volume were discussed. In addition, various types of porosity and several microfractures were observed from SEM images. Third, preliminary interpretation of the imaging logs revealed natural fractures in the formation that can significantly affect the production performance of shale gas wells since preexisting natural fractures will influence hydraulic fracture propagation. Thus, numerical simulation was conducted focusing on the interaction between hydraulically induced fractures and preexisting natural fractures. A hydraulic fracturing model considering the in-situ stress response to turbulent flow process was developed and validated with regression tests of a bi-wing hydraulic fracture model. Field-scale simulation results indicate that our model is capable of capturing the interactions between hydraulic fractures and the preexisting natural fractures defined by the initial fracture maps. Finally, a new model was built to model the actual network of hydraulic and preexisting fractures from geological interpretations and microseismic mapping results. The discrete fracture modeling (DFM) approach was applied to represent each fracture individually and explicitly. The near-well effects were modeled in detail by refining the unstructured 3D grid to the point where we fully resolve stimulated fractures. Simulations of the detailed model of an actual shale gas reservoir considered various mechanisms including adsorption/desorption, matrix/fracture transfer, and non-Darcy effects. Furthermore, the dissertation illustrates upscaling from the discrete fracture model to a coarse continuum model using multiple subregion (MSR), and the high degree of accuracy provided by this technique is demonstrated by comparing the solution of the upscaled model with the corresponding fine-grid solution for a synthetic case.

Hydraulic Fracturing in Unconventional Reservoirs Hoss Belyadi 2019-06-18 Hydraulic Fracturing in Unconventional Reservoirs: Theories, Operations, and Economic Analysis, Second Edition, presents the latest operations and applications in all facets of fracturing. Enhanced to include today’s newest technologies, such as machine learning and the monitoring of field performance using pressure and rate transient analysis, this reference gives engineers the full spectrum of information needed to run unconventional field developments. Covering key aspects, including fracture clean-up, expanded material on refracturing, and a discussion on economic analysis in unconventional reservoirs, this book keeps today's petroleum engineers updated on the critical aspects of unconventional activity. Helps readers understand drilling and production technology and operations in shale gas through real-field examples Covers various topics on fractured wells and the exploitation of unconventional hydrocarbons in one complete reference Presents the latest operations and applications in all facets of fracturing

Numerical Simulation in Hydraulic Fracturing: Multiphysics Theory and Applications Xinpu Shen 2017-03-27 The expansion of unconventional petroleum resources in the recent decade and the rapid development of computational technology have provided the opportunity to develop and apply 3D numerical modeling technology to simulate the hydraulic fracturing of shale and tight sand formations. This book presents 3D numerical modeling technologies for hydraulic fracturing developed in recent years, and introduces solutions to various 3D geomechanical problems related to hydraulic fracturing. In the solution processes of the case studies included in the book, fully coupled multi-physics modeling has been adopted, along with innovative computational techniques, such as submodeling. In practice, hydraulic fracturing is an essential project component in shale gas/oil development and tight sand oil, and provides an essential measure in the process of drilling cuttings reinjection (CRI). It is also an essential measure for widened mud weight window (MWW) when drilling through naturally fractured formations; the process of hydraulic plugging is a typical application of hydraulic fracturing. 3D modeling and numerical analysis of hydraulic fracturing is essential for the successful development of tight oil/gas formations: it provides accurate solutions for optimized stage intervals in a multistage fracking job. It also provides optimized well-spacing for the design of zipper-frac wells. Numerical estimation of casing integrity under stimulation injection in the hydraulic fracturing process is one of major concerns in the successful development of unconventional resources. This topic is also investigated numerically in this book. Numerical solutions to several other typical geomechanics problems related to hydraulic fracturing, such as fluid migration caused by fault reactivation and seismic activities, are also presented. This book can be used as a reference textbook to petroleum, geotechnical and geothermal engineers, to senior undergraduate, graduate and postgraduate students, and to geologists, hydrogeologists, geophysicists and applied mathematicians working in this field. This book is also a synthetic compendium of both the fundamentals and some of the most advanced aspects of hydraulic fracturing technology.

Shale Gas and Tight Oil Reservoir Simulation Wei Yu 2018-08-10 Shale Gas and Tight Oil Reservoir Simulation delivers the latest research and applications used to better manage and interpret simulating production from shale gas and tight oil reservoirs. Starting with basic fundamentals, the book then includes real field data that will not only generate reliable reserve estimation, but also predict the effective range of reservoir and fracture properties through multiple history matching solutions. Also included are new insights into the numerical modelling of CO2 injection for enhanced oil recovery in tight oil reservoirs. This information is critical for a better understanding of the impacts of key reservoir properties and complex fractures. Models the well performance of shale gas and tight oil reservoirs with complex fracture geometries Teaches how to perform sensitivity studies, history matching, production forecasts, and economic optimization for shale-gas and tight-oil reservoirs Helps readers investigate data mining techniques, including the introduction of nonparametric smoothing models

Shale Thomas Dewers 2019-09-16 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

Numerical Simulation in Hydraulic Fracturing: Multiphysics Theory and Applications Xinpu Shen 2017-03-27 The expansion of unconventional petroleum resources in the recent decade and the rapid development of computational technology have provided the opportunity to develop and apply 3D numerical modeling technology to simulate the hydraulic fracturing of shale and tight sand formations. This book presents 3D numerical modeling technologies for hydraulic fracturing developed in recent years, and introduces solutions to various 3D geomechanical problems related to hydraulic fracturing. In the solution processes of the case studies included in the book, fully coupled multi-physics modeling has been adopted, along with innovative computational techniques, such as submodeling. In practice, hydraulic fracturing is an essential project component in shale gas/oil development and tight sand oil, and provides an essential measure in the process of drilling cuttings reinjection (CRI). It is also an essential measure for widened mud weight window (MWW) when drilling through naturally fractured formations; the process of hydraulic plugging is a typical application of hydraulic fracturing. 3D modeling and numerical analysis of hydraulic fracturing is essential for the successful development of tight oil/gas formations: it provides accurate solutions for optimized stage intervals in a multistage fracking job. It also provides optimized well-spacing for the design of zipper-frac wells. Numerical estimation of casing integrity under stimulation injection in the hydraulic fracturing process is one of major concerns in the successful development of unconventional resources. This topic is also investigated numerically in this book. Numerical solutions to several other typical geomechanics problems related to hydraulic fracturing, such as fluid migration caused by fault reactivation and seismic activities, are also presented. This book can be used as a reference textbook to petroleum, geotechnical and geothermal engineers, to senior undergraduate, graduate and postgraduate students, and to geologists, hydrogeologists, geophysicists and applied mathematicians working in this field. This book is also a synthetic compendium of both the fundamentals and some of the most advanced aspects of hydraulic fracturing technology.

Flow Mechanisms and Numerical Simulation of Gas Production from Shale Reservoirs Chaohua Guo 2015 "Shale gas is one kind of the unconventional resources which is becoming an ever increasing component to secure the natural gas supply in U.S. Different from conventional hydrocarbon formations, shale gas reservoirs (SGRs) present numerous challenges to modeling and understanding due to complex pore structure, ultra-low permeability, and multiple transport mechanisms. In this study, the deviation against conventional gas flow have been detected in the lab experiments for gas flow through nano membranes. Based on the experimental results, a new apparent permeability expression is proposed with considering viscous flow, Knudsen diffusion, and slip flow. The gas flow mechanisms of gas flow in the SGRs have been studied using well test method with considering multiple flow mechanisms including desorption, diffusive flow, Darcy flow and stress-sensitivity. Type curves were plotted and different flow regimes were identified. Sensitivity analysis of adsorption and fracturing parameters on gas production performance have been analyzed. Then, numerical simulation study have been conducted for the SGRs with considering multiple mechanisms, including viscous flow, Knudsen diffusion, Klinkenberg effect, pore radius change, gas desorption, and gas viscosity change. Results show that adsorption and gas viscosity change will have a great impact on gas production. At last, the numerical simulation model for SGRs with multi-stage hydraulic fracturing horizontal well has been constructed. Sensitivity analysis for reservoir and fracturing parameters on gas production performance have been conducted. Results show that hydraulic fracture parameters are more sensitive compared with reservoir parameters. The study in this project can contribute to the understanding and simulation of SGRs"--Abstract, page iv.

Rock Mechanics Contributions and Challenges W. Hustrulid 2020-12-17 The theme of the 31st US Symposium on Rock Mechanics is 'Rock Mechanics contributions and challenges', having as objective the examination and quantification of the progress that has been achieved in addressing the major practical challenges facing the science of rock mechanics and mine design. The 124 papers included in the proceedings cover areas such as: experimental studies (laboratory and field); conceptual, analytical, and numerical modeling; design and construction methods. 35 papers deal with practical mining problems and include information on rock reinforcement technology, blasting, rock bursts, open pit mining, remote sensing and borehole geophysics, mechanical fragmentation, and subsidence. Areas emphasized are coal and metal mine design problems. Other papers deal with the newest computer models, new instruments, fracture mechanics, new laboratory testing techniques, and in situ testing.

Porous Rock Fracture Mechanics Amir Shojaei 2017-05-05 Porous Rock Failure Mechanics: Hydraulic Fracturing, Drilling and Structural Engineering focuses on the fracture mechanics of porous rocks and modern simulation techniques for progressive quasi-static and dynamic fractures. The topics covered in this volume include a wide range of academic and industrial applications, including petroleum, mining, and civil engineering. Chapters focus on advanced topics in the field of rock's fracture mechanics and address theoretical concepts, experimental characterization, numerical simulation techniques, and their applications as appropriate. Each chapter reflects the current state-of-the-art in terms of the modern use of fracture simulation in industrial and academic sectors. Some of the major contributions in this volume include, but are not limited to: anisotropic elasto-plastic deformation mechanisms in fluid saturated porous rocks, dynamics of fluids transport in fractured rocks and simulation techniques, fracture mechanics and simulation techniques in porous rocks, fluid-structure interaction in hydraulic driven fractures, advanced numerical techniques for simulation of progressive fracture, including multiscale modeling, and micromechanical approaches for porous rocks, and quasi-static versus dynamic fractures in porous rocks. This book will serve as an important resource for petroleum, geomechanics, drilling and structural engineers, R&D managers in industry and academia. Includes a strong editorial team and quality experts as chapter authors Presents topics identified for individual chapters are current, relevant, and interesting Focuses on advanced topics, such as fluid coupled fractures, rock's continuum damage mechanics, and multiscale modeling Provides a 'one-stop' advanced-level reference for a graduate course focusing on rock's mechanics

Sustainable Natural Gas Reservoir and Production Engineering David A. Wood 2021-10-30 Sustainable Natural Gas Reservoir and Production Engineering, the latest release in The Fundamentals and Sustainable Advances in Natural Gas Science and Engineering series, delivers many of the scientific fundamentals needed in the natural gas industry, including improving gas recovery, simulation processes for fracturing methods, and methods for optimizing production strategies. Advanced research covered includes machine learning applications, gas fracturing mechanics aimed at reducing environmental impact, and enhanced oil recovery technologies aimed at capturing carbon dioxide. Supported by corporate and academic contributors along with two well-distinguished editors, this book provides today's natural gas engineers the fundamentals and advances in a convenient resource Helps readers advance from basic equations used in conventional gas reservoirs Presents structured case studies to illustrate how new principles can be applied in practical situations Covers advanced topics, including machine learning applications to optimize predictions, controls and improve knowledge-based applications Helps accelerate emission reductions by teaching gas fracturing mechanics with an aim of reducing environmental impacts and developing enhanced oil recovery technologies that capture carbon dioxide

Hydraulic Fracture Modeling Yu-Shu Wu 2017-12-12 Hydraulic Fracture Modeling delivers all the pertinent technology and solutions in one product to become the go-to source for petroleum and reservoir engineers. Providing tools and approaches, this multi-contributed reference presents current and upcoming developments for modeling rock fracturing including their limitations and problem-solving applications. Fractures are common in oil and gas reservoir formations, and with the ongoing increase in development of unconventional reservoirs, more petroleum engineers today need to know the latest technology surrounding hydraulic fracturing technology such as fracture rock modeling. There is tremendous research in the area but not all located in one place. Covering two types of modeling technologies, various effective fracturing approaches and model applications for fracturing, the book equips today's petroleum engineer with an all-inclusive product to characterize and optimize today's more complex reservoirs. Offers understanding of the details surrounding fracturing and fracture modeling technology, including theories and quantitative methods Provides academic and practical perspective from multiple contributors at the forefront of hydraulic fracturing and rock mechanics Provides today's petroleum engineer with model validation tools backed by real-world case studies

Performance Evaluation of Wells With Single and Multiple Fractures in Tight Formations Feng Zhang 2014

Abrasive Water Jet Perforation and Multi-Stage Fracturing Zhongwei Huang 2017-10-19 Abrasive Water Jet Perforation and Multi-Stage Fracturing gives petroleum engineers, well completion managers and fracturing specialists a critical guide to understanding all the details of the technology including materials, tools, design methods and field applications. The exploitation and development of unconventional oil and gas resources has continued to gain importance, and multi-stage fracturing with abrasive water jets has emerged as one of the top three principal methods to recover unconventional oil and gas, yet there is no one collective reference to explain the fundamentals, operations and influence this method can deliver. The book introduces current challenges and gives solutions for the problems encountered. Packed with references and real-world examples, the book equips engineers and specialists with a necessary reservoir stimulation tool to better understand today’s fracturing technology. Provides understanding of the fundamentals, design and application of water jet perforation Examines the pressure boosting assembly in all phases including initiation, hydraulic isolation and production stage Evaluates production analysis, pump pressure predictions and the latest design software Introduces current challenges and gives solutions for the problems encountered

Low-Carbon Technologies for the Petroleum Industry Kaiqiang Zhang 2021-11-24

Geomechanics and Geodynamics of Rock Masses - Volume 2 Vladimir Litvinenko 2018-05-20 This book is Volume 2 of the EUROCK 2018 proceedings. Geomechanics and Geodynamics of Rock Masses contains contributions presented at EUROCK 2018, the 2018 International Symposium of the International Society for Rock Mechanics (ISRM 2018, Saint Petersburg, Russia, 22-26 May 2018). Dedicated to recent advances and achievements in the fields of geomechanics and geotechnology, the main topics of the book include: - Physical and mechanical properties of fractured rock (laboratory testing and rock properties, field measurements and site investigations) - Geophysics in rock mechanics - Rock mass strength and failure - Nonlinear problems in rock mechanics - Effect of joint water on the behavior of rock foundation - Numerical modeling and back analysis - Mineral resources development: methods and rock mechanics problems - Rock mechanics and underground construction in mining, hydropower industry and civil engineering - Rock mechanics in petroleum engineering - Geodynamics and monitoring of rock mass behavior - Risks and hazards - Geomechanics of technogenic deposits Geomechanics and Geodynamics of Rock Masses will be of interest to researchers and professionals involved in the various branches of rock mechanics and rock engineering. EUROCK 2018, organized by the Saint Petersburg Mining University, is a continuation of the successful series of ISRM symposia in Europe, which began in 1992 in Chester, UK.

Rock Mechanics for Natural Resources and Infrastructure Development - Full Papers Sergio A.B. da Fontoura 2019-09-03 Rock Mechanics for Natural Resources and Infrastructure Development contains the proceedings of the 14th ISRM International Congress (ISRM 2019, Foz do Iguaçu, Brazil, 13-19 September 2019). Starting in 1966 in Lisbon, Portugal, the International Society for Rock Mechanics and Rock Engineering (ISRM) holds its Congress every four years. At this 14th occasion, the Congress brings together researchers, professors, engineers and students around contemporary themes relevant to rock mechanics and rock engineering. Rock Mechanics for Natural Resources and Infrastructure Development contains 7 Keynote Lectures and 449 papers in ten chapters, covering topics ranging from fundamental research in rock mechanics, laboratory and experimental field studies, and petroleum, mining and civil engineering applications. Also included are the prestigious ISRM Award Lectures, the Leopold Muller Award Lecture by professor Peter K. Kaiser. and the Manuel Rocha Award Lecture by Dr. Quinghua Lei. Rock Mechanics for Natural Resources and Infrastructure Development is a must-read for academics, engineers and students involved in rock mechanics and engineering. Proceedings in Earth and geosciences - Volume 6 The ‘Proceedings in Earth and geosciences’ series contains proceedings of peer-reviewed international conferences dealing in earth and geosciences. The main topics covered by the series include: geotechnical engineering, underground construction, mining, rock mechanics, soil mechanics and hydrogeology.

Unconventional Natural Gas Geoscience Jienan Pan 2022-08-05

Unconventional Tight Reservoir Simulation: Theory, Technology and Practice Qiquan Ran 2020-08-14 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.

Adaptive Analysis of Damage and Fracture in Rock with Multiphysical Fields Coupling Yongliang Wang 2020-08-31 This book mainly focuses on the adaptive analysis of damage and fracture in rock, taking into account multiphysical fields coupling (thermal, hydro, mechanical, and chemical fields). This type of coupling is a crucial aspect in practical engineering for e.g. coal mining, oil and gas exploration, and civil engineering. However, understanding the influencing mechanisms and preventing the disasters resulting from damage and fracture evolution in rocks require high-precision and reliable solutions. This book proposes adaptive numerical algorithms and simulation analysis methods that offer significant advantages in terms of accuracy and reliability. It helps readers understand these innovative methods quickly and easily. The content consists of: (1) a finite element algorithm for modeling the continuum damage evolution in rocks, (2) adaptive finite element analysis for continuum damage evolution and determining the wellbore stability of transversely isotropic rock, (3) an adaptive finite element algorithm for damage detection in non-uniform Euler–Bernoulli beams with multiple cracks, using natural frequencies, (4) adaptive finite element–discrete element analysis for determining multistage hydrofracturing in naturally fractured reservoirs, (5) adaptive finite element–discrete element analysis for multistage supercritical CO2 fracturing and microseismic modeling, and (6) an adaptive finite element–discrete element–finite volume algorithm for 3D multiscale propagation of hydraulic fracture networks, taking into account hydro-mechanical coupling. Given its scope, the book offers a valuable reference guide for researchers, postgraduates and undergraduates majoring in engineering mechanics, mining engineering, geotechnical engineering, and geological engineering.

Proceedings of the International Field Exploration and Development Conference 2019 Jia'en Lin 2020-07-11 This book gathers selected papers from the 8th International Field Exploration and Development Conference (IFEDC 2019) and addresses a broad range of topics, including: Low Permeability Reservoir, Unconventional Tight & Shale Oil Reservoir, Unconventional Heavy Oil and Coal Bed Gas, Digital and Intelligent Oilfield, Reservoir Dynamic Analysis, Oil and Gas Reservoir Surveillance and Management, Oil and Gas Reservoir Evaluation and Modeling, Drilling and Production Operation, Enhancement of Recovery, Oil and Gas Reservoir Exploration. The conference not only provided a platform to exchange experiences, but also promoted the advancement of scientific research in oil & gas exploration and production. The book is chiefly intended for industry experts, professors, researchers, senior engineers, and enterprise managers.

Numerical Investigation of Water Loss Mechanisms During Hydraulic Fracturing Flow-back Operation in Tight Oil Reservoirs Mingyuan Wang 2016 Multi-stage hydraulic fracturing is widely applied in tight reservoir exploitation. Production is enhanced significantly if hydraulic fractures can connect to regions with enhanced permeability due to the presence of micro (and induced) fractures. However, less than 50% of fracturing fluids are typically recovered. This study models the mechanisms of water loss and retention in fracture-matrix system. The effects of capillarity and geomechanics are systematically investigated, and the time scale of water imbibition under different reservoir conditions is tested. During the shut-in (soaking) and flow-back periods, the fracture conductivity decreases as effective stress increases due to imbibition. Previous works have addressed fracture closure during the production phase; however, the coupling of imbibition due to multiphase flow and stress-dependent fracture properties during shut-in is less understood. Numerical simulation results indicate the circumstances under which this phenomenon might be beneficial or detrimental to subsequent on tight oil production. A series of mechanistic simulation models consisting of both hydraulic fractures and stochastically distributed micro fractures are constructed to simulate fluid distribution during shut-in and flow-back. Three systems: matrix, hydraulic fracture and micro fractures are explicitly represented in the computational domain. Fluid loss and retention mechanisms are systematically investigated in this study by subjecting mechanistic model to different reservoir conditions. Water imbibition into the matrix would help to displace hydrocarbons into nearby micro and hydraulic fractures, and this process could lead to an increase in initial rate. Although other water loss mechanisms including water loss in desiccated matrix and water trapping in induced micro fractures were proposed in literature, detailed understanding of the roles of water trapping in these systems is still lacking. Impacts of secondary fracture distributions and properties, matrix permeability, multiphase flow functions, wettability, initial saturation, water injection rate and shut-in duration on fluid retention and the associated time scales are assessed. Increase in short-term oil production as a result of imbibition could be counteracted by the reduction in flow capability due to fracture closure. Therefore, the coupling of stress-dependent fracture conductivity and imbibition are studied next. Our results indicate that fracture compaction can enhance imbibition and water loss, which in turn leads to further reduction in fracture pressure and conductivity. Spatial variability in micro-fracture properties is also modeled probabilistically to investigate whether it is possible for fracturing fluid to be trapped in the micro fractures, or conversely, the micro fractures could provide alternate pathways for fluids to access the hydraulic fracture systems. This work presents a quantitative study of the controlling factors of water retention due to fluid-rock properties and geomechanics. It investigates the roles of multi-scale fractures in flow-back behavior and ensuing recovery performance. The results highlight 1) the crucial interplay between shut-in duration and properties of connected fractures in short- and long-term production performances; 2) the critical interaction between imbibition and geomechanics in short- and long-term production performances. The results would have considerable impacts on understanding and improving current industry practice on fracturing design and assessment of stimulated reservoir volume.

Optimization of Multistage Hydraulic Fracturing Treatment for Maximization of the Tight Gas Productivity Mengting Li 2018-12-17 Hydraulic fracturing is essential technology for the development of unconventional resources such as tight gas. So far, there are no numerical tools which can optimize the whole process from geological modeling, hydraulic fracturing until production simulation with the same 3D model with consideration of the thermo-hydro-mechanical coupling. In this dissertation, a workflow and a numerical tool chain were developed for design and optimization of multistage hydraulic fracturing in horizontal well regarding a maximum productivity of the tight gas wellbore. After the verification a full 3D reservoir model is generated based on a real tight gas field in the North German Basin. Through analysis of simulation results, a new calculation formula of FCD was proposed, which takes the proppant position and concentration into account and can predict the gas production rate more accurately. However, not only FCD but also proppant distribution and hydraulic connection of stimulated fractures to the well, geological structure and the interaction between fractures are determinant for the gas production volume. Through analysis the numerical results of sensitivity analysis and optimization variations, there is no unique criterion to determine the optimal number and spacing of the fractures, it should be analyzed firstly in detail to the actual situation and decided then from case to case.

New Frontiers in Oil and Gas Exploration Congrui Jin 2016-10-07 This contributed volume presents a multi-perspective collection of the latest research findings on oil and gas exploration and imparts insight that can greatly assist in understanding field behavior, design of test programs, and design of field operations. With this book, engineers also gain a powerful guide to the most commonly used numerical simulation methods that aid in reservoir modelling. In addition, the contributors explore development of technologies that allow for cost effective oil and gas exploration while minimizing the impact on our water resources, surface and groundwater aquifers, geological stability of impacted areas, air quality, and infrastructure assets such as roads, pipelines, water, and wastewater networks. Easy to understand, the book identifies equipment and procedural problems inherent to oil and gas operations and provides systematic approaches for solving them.

Geomechanics and Geodynamics of Rock Masses, Volume 1 Vladimir Litvinenko 2018-05-20 This book is Volume 1 of the EUROCK 2018 proceedings. Geomechanics and Geodynamics of Rock Masses contains contributions presented at EUROCK 2018, the 2018 International Symposium of the International Society for Rock Mechanics (ISRM 2018, Saint Petersburg, Russia, 22-26 May 2018). Dedicated to recent advances and achievements in the fields of geomechanics and geotechnology, the main topics of the book include: - Physical and mechanical properties of fractured rock (laboratory testing and rock properties, field measurements and site investigations) - Geophysics in rock mechanics - Rock mass strength and failure - Nonlinear problems in rock mechanics - Effect of joint water on the behavior of rock foundation - Numerical modeling and back analysis - Mineral resources development: methods and rock mechanics problems - Rock mechanics and underground construction in mining, hydropower industry and civil engineering - Rock mechanics in petroleum engineering - Geodynamics and monitoring of rock mass behavior - Risks and hazards - Geomechanics of technogenic deposits Geomechanics and Geodynamics of Rock Masses will be of interest to researchers and professionals involved in the various branches of rock mechanics and rock engineering. EUROCK 2018, organized by the Saint Petersburg Mining University, is a continuation of the successful series of ISRM symposia in Europe, which began in 1992 in Chester, UK.

Drilling and Completion in Petroleum Engineering Xinpu Shen 2011-10-19 Modern petroleum and petrotechnical engineering is increasingly challenging due to the inherently scarce and decreasing number of global petroleum resources. Exploiting these resources efficiently will require researchers, scientists, engineers and other practitioners to develop innovative mathematical solutions to serve as basis for new asset development designs. Deploying these systems in numerical models is essential to the future success and efficiency of the petroleum industry. Multiphysics modeling has been widely applied in the petroleum industry since the 1960s. The rapid development of computer technology has enabled the numerical applications of multiphysics modeling in the petroleum industry: its applications are particularly popular for the numerical simulation of drilling and completion processes. This book covers theory and numerical applications of multiphysical modeling presenting various author-developed subroutines, used to address complex pore pressure input, complex initial geo-stress field input, etc. Some innovative methods in drilling and completion developed by the authors, such as trajectory optimization and a 3-dimensional workflow for calculation of mud weight window etc, are also presented. Detailed explanations are provided for the modeling process of each application example included in the book. In addition, details of the completed numerical models data are presented as supporting material which can be downloaded from the website of the publisher. Readers can easily understand key modeling techniques with the theory of multiphysics embedded in examples of applications,and can use the data to reproduce the results presented. While this book would be of interest to any student, academic or professional practitioner of engineering, mathematics and natural science, we believe those professionals and academics working in civil engineering, petroleum engineering and petroleum geomechanics would find the work especially relevant to their endeavors.

The Combined Finite-Discrete Element Method Antonio A. Munjiza 2004-04-21 The combined finite discrete element method is a relatively new computational tool aimed at problems involving static and / or dynamic behaviour of systems involving a large number of solid deformable bodies. Such problems include fragmentation using explosives (e.g rock blasting), impacts, demolition (collapsing buildings), blast loads, digging and loading processes, and powder technology. The combined finite-discrete element method - a natural extension of both discrete and finite element methods - allows researchers to model problems involving the deformability of either one solid body, a large number of bodies, or a solid body which fragments (e.g. in rock blasting applications a more or less intact rock mass is transformed into a pile of solid rock fragments of different sizes, which interact with each other). The topic is gaining in importance, and is at the forefront of some of the current efforts in computational modeling of the failure of solids. * Accompanying source codes plus input and output files available on the Internet * Important applications such as mining engineering, rock blasting and petroleum engineering * Includes practical examples of applications areas Essential reading for postgraduates, researchers and software engineers working in mechanical engineering.

Simulation of Hydraulic Stimulation Mohammad Komijani 2018 Hydraulic Fracturing (HF) is an effective stimulation process for extracting oil and gas from unconventional low-permeable reservoirs. The process is conducted by injecting high-pressure fluids into the ground to generate fracture networks in rock masses and stimulate natural fractures to increase the permeability of formation and extract oil and gas. Due to the multiple and coupled-physics involved, hydraulic fracturing is a complex engineering process. The extent of the induced fractures and stimulated volume and reactivation of natural faults and fractures are some of the practical issues associated with hydraulic fracturing. Acoustic Emission (AE) monitoring and analysis are used to probe the behaviour of solid materials in such applications. The process of elastic wave propagation induced by an abrupt local release of stored strain energy is known as acoustic, microseismic, and seismic emission (depending on the context and the magnitude of the event). These emissions can be triggered by material bifurcation-instabilities like slope slipping, fault-reactivation, pore collapsing, and cracking - processes that are all categorized as localization phenomena. The microseismic monitoring industry attempts to relate acoustic emissions measured by geophones to the nature of the stimulated volume created during hydraulic fracturing. This process is full of uncertainties and researchers have not yet focused on both explicitly modeling the process of fracture reactivation and the accurate simulation of acoustic wave propagations resulting from the localization. The biggest gap in the modeling literature is that most of the previous works fail to accurately simulate the process of transient acoustic wave propagation through the fractured porous media following the elastic energy release. Instead of explicitly modeling fracturing and acoustic emission, most previous studies have aimed to relate energy release to seismic moment. To overcome some of the existing shortcomings in the numerical modeling of the coupled problem of interface localization-acoustic emission, this thesis is focused on developing new computational methods and programs for the simulation of microseismic wave emissions induced by interface slip instability in fractured porous media. As a coupled nonlinear mixed multi-physics problem, simulation of hydraulic stimulation involves several mathematical and computational complexities and difficulties in terms of modeling, stability, and convergence, such as the inf-sup stability problems that arise from mixed formulations due to the hydro-mechanical couplings and contact conditions. In AE modeling, due to the high-frequency transient nature of the problem, additional numerical problems emerging from the Gibbs phenomenon and artificial period elongation and amplitude decay are also involved. The thesis has three main objectives. The first objective is to develop a numerical model for simulation of wave propagation in discontinuous media, which is fulfilled in Chapter 2 of the thesis. In this chapter a new enriched finite element method is developed for simulation of wave propagation in fractured media. The method combines the advantages of the global Partition-of-Unity Method (PUM) with harmonic enrichment functions via the Generalized Finite Element Method (GFEM) with the local PUM via the Phantom Node Method (PNM). The GFEM enrichments suppress the spurious oscillations that can appear in regular Finite Element Method (FEM) analysis of dynamic/wave propagations due to numerical dispersions and Gibbs phenomenon. The PNM models arbitrary fractures independently of the original mesh. Through several numerical examples it has been demonstrated that the spurious oscillations that appear in propagation pattern of high-frequency waves in PNM simulations can be effectively suppressed by employing the enriched model. This is observed to be especially important in fractured media where both primary waves and the secondary reflected waves are present. The second objective of the thesis is to develop a mixed numerical model for simulation of wave propagation in discontinuous porous media and interface modeling. This objective is realized in Chapter 3 of the thesis. In this chapter, a new enriched mixed finite element model is introduced for simulation of wave propagation in fractured porous media, based on an extension of the developed numerical method in Chapter 2. Moreover, frictional contact at interfaces is modeled and realized using an augmented Lagrange multiplier scheme. Through various numerical examples, the effectiveness of the developed enriched FE model over conventional approaches is demonstrated. Moreover, it is shown that the most accurate wave results with the least amount of spurious oscillations are achieved when both the displacement and pore pressure fields are enriched with appropriate trigonometric functions. The third objective of the thesis is to develop computational models for the simulation of acoustic emissions induced by fracture reactivation and shear slip. This objective is realized in Chapter 4 of the thesis. In this chapter, an enriched mixed finite element model (introduced in Chapter 3) is developed to simulate the interface slip instability and the associated induced acoustic wave propagation processes, concurrently. Acoustic events are triggered through a sudden release of strain energy at the fracture interfaces due to shear slip instability. The shear slip is induced via hydraulic stimulation that switches the interface behaviour from a stick to slip condition. The superior capability of the proposed enriched mixed finite element model (i.e., PNM-GFEM-M) in comparison with regular finite element models in inhibiting the spurious oscillations and numerical dispersions of acoustic signals in both velocity and pore pressure fields is demonstrated through several numerical studies. Moreover, the effects of different characteristics of the system, such as permeability, viscous damping, and friction coefficient at the interface are investigated in various examples.

Geomechanics and Geodynamics of Rock Masses Vladimir Litvinenko 2018-05-24 Geomechanics and Geodynamics of Rock Masses – Selected Papers contains selected contributions from EUROCK 2018, the 2018 International Symposium of the International Society for Rock Mechanics (ISRM 2018, Saint Petersburg, Russia, 22—26 May 2018). Dedicated to recent advances and achievements in the fields of geomechanics and geotechnology, the book will be of interest to researchers and professionals involved in the various branches of rock mechanics and rock engineering. EUROCK 2018, organized by the Saint Petersburg Mining University, is a continuation of the successful series of ISRM symposia in Europe, which began in 1992 in Chester, UK.

Hydraulic Fracturing Optimization Andreas Michael 2016 Hydraulic fracturing is a reservoir stimulation technique used in the petroleum industry since 1947. High pressure fluid composed mainly of water generates cracks near the wellbore improving the surrounding permeability and enhancing the flow of oil and gas to the surface. Advances in hydraulic fracturing coupled with developments in horizontal drilling, have unlocked vast quantities of unconventional resources, previously believed impossible to be produced. Fracture creation induces perturbations in the nearby in-situ stress regime suppressing the initiation and propagation of other fractures. Neighboring fractures are affected by this stress shadow effect, causing them to grow dissimilarly and they receive unequal portions of the injected fluid. Numerical simulation models have shown that non-uniform perforation cluster distributions with interior fractures closer to the exterior ones can balance out these stress shadow effects, promoting more homogeneous multiple fracture growth compared to uniform perforation cluster distributions. In this work, laboratory-scale tests on three perforation configurations are performed on transparent specimens using distinctly colored fracturing fluids such that fracture growth can be observed. A normal faulting stress regime is replicated with the introduction of an overburden load in a confined space. The results have shown that uniform perforation spacing configurations yields higher degree of fracture growth homogeneity, as maximum spacing minimizes stress shadow effects, compared to moving the middle perforation closer to the toe, or heel of the horizontal well. The experiments also showed a proclivity to form one dominant fracture. Time delay, neglected in most theoretical modelling studies, between fracture initiations is found to be a key parameter and is believed to be one of the major factors promoting this dominant fracture tendency along with wellbore pressure gradients. Moreover, in several cases, the injected bypassed perforation(s) to generate fracture(s) downstream. Finally, the compressibility of the fracturing fluid triggered somewhat unexpected transient pressure behavior. The understanding of the stress shadow effects and what influences them could lead to optimization of hydraulic fracturing treatment design in terms of productivity and cost. Therefore, achieving more homogeneous multiple fracture growth patterns can be pivotal on the economic feasibility of several stimulation treatments.

Modelling Rock Fracturing Processes Baotang Shen 2020-05-06 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.

Fracture Phenomena in Nature and Technology Davide Bigoni 2014-04-29 This book contains contributions presented at the IUTAM Symposium "Fracture Phenomena in Nature and Technology" held in Brescia, Italy, 1-5 July, 2012.The objective of the Symposium was fracture research, interpreted broadly to include new engineering and structural mechanics treatments of damage development and crack growth and also large-scale failure processes as exemplified by earthquake or landslide failures, ice shelf break-up and hydraulic fracturing (natural or for resource extraction or CO2 sequestration), as well as small-scale rupture phenomena in materials physics including, e.g. inception of shear banding, void growth, adhesion and decohesion in contact and friction, crystal dislocation processes and atomic/electronic scale treatment of brittle crack tips and fundamental cohesive properties. Special emphasis was given to multiscale fracture description and new scale-bridging formulations capable to substantiate recent experiments and tailored to become the basis for innovative computational algorithms.

Numerical Simulation of Pressure Transient Analysis in Tight Formation and Field Data Categorization and Typical Well Production Data Analysis Yue Zhu 2015

Numerical Modeling of Nonlinear Problems in Hydraulic Fracturing Endrina Rivas 2020 Hydraulic fracturing is a stimulation technique in which fluid is injected at high pressure into low-permeability reservoirs to create a fracture network for enhanced production of oil and gas. It is the primary purpose of hydraulic fracturing to enhance well production. The three main mechanisms during hydraulic fracturing for oil and gas production which largely impact the reservoir production are: (1) fracture propagation during initial pad fluid injection, which defines the extent of the fracture; (2) fracture propagation during injection of proppant slurry (fluid mixed with granular material), creating a propped reservoir zone; and (3) shear dilation of natural fractures surrounding the hydraulically fractured zone, creating a broader stimulated zone. The thesis has three objectives that support the simulation of mechanisms that lead to enhanced production of a hydraulically-fractured reservoir. The first objective is to develop a numerical model for the simulation of the mechanical deformation and shear dilation of naturally fractured rock masses. In this work, a two-dimensional model for the simulation of discrete fracture networks (DFN) is developed using the extended finite element method (XFEM), in which the mesh does not conform to the natural fracture network. The model incorporates contact, cohesion, and friction between blocks of rock. Shear dilation is an important mechanism impacting the overall nonlinear response of naturally fractured rock masses and is also included in the model--physics previously not simulated within an XFEM context. Here, shear dilation is modeled through a linear dilation model, capped by a dilation limiting displacement. Highly nonlinear problems involving multiple joint sets are investigated within a quasi-static context. An explicit scheme is used in conjunction with the dynamic relaxation technique to obtain equilibrium solutions in the face of the nonlinear constitutive models from contact, cohesion, friction, and dilation. The numerical implementation is verified and its convergence illustrated using a shear test and a biaxial test. The model is then applied to the practical problem of the stability of a slope of fractured rock. The second objective is to develop a numerical model for the simulation of proppant transport through planar fractures. This work presents the numerical methodology for simulation of proppant transport through a hydraulic fracture using the finite volume method. Proppant models commonly used in the hydraulic fracturing literature solve the linearized advection equation; this work presents solution methods for the nonlinear form of the proppant flux equation. The complexities of solving the nonlinear and heterogeneous hyperbolic advection equation that governs proppant transport are tackled, particularly handling shock waves that are generated due to the nonlinear flux function and the spatially-varying width and pressure gradient along the fracture. A critical time step is derived for the proppant transport problem solved using an explicit solution strategy. Additionally, a predictor-corrector algorithm is developed to constrain the proppant from exceeding the physically admissible range. The model can capture the mechanisms of proppant bridging occurring in sections of narrow fracture width, tip screen-out occurring when fractures become saturated with proppant, and flushing of proppant into new fracture segments. The results are verified by comparison with characteristic solutions and the model is used to simulate proppant transport through a KGD fracture. The final objective is to develop a numerical model for the simulation of proppant transport through propagating non-planar fractures. This work presents the first monolithic coupled numerical model for simulating proppant transport through a propagating hydraulic fracture. A fracture is propagated through a two-dimensional domain, driven by the flow of a proppant-laden slurry. Modeling of the slurry flow includes the effects of proppant bridging and the subsequent flow of fracturing fluid through the packed proppant pack. This allows for the simulation of a tip screen-out, a phenomenon in which there is a high degree of physical interaction between the rock deformation, fluid flow, and proppant transport. Tip screen-out also leads to shock wave formation in the solution. Numerical implementation of the model is verified and the model is then used to simulate a tip screen-out in both planar and non-planar fractures. An analysis of the fracture aperture, fluid pressure, and proppant concentration profiles throughout the simulation is performed for three different coupling schemes: monolithic, sequential, and loose coupling. It is demonstrated that even with time step refinement, the loosely-coupled scheme fails to converge to the same results as the monolithic and sequential schemes. The monolithic and sequential algorithms yield the same solution up to the onset of a tip screen-out, after which the sequential scheme fails to converge. The monolithic scheme is shown to be more efficient than the sequential algorithm (requiring fewer iterations) and has comparable computational cost to the loose coupling algorithm. Thus, the monolithic scheme is shown to be optimal in terms of computational efficiency, robustness, and accuracy. In addition to this finding, a robust and more efficient algorithm for injection-rate controlled hydraulic fracturing simulation based on global mass conservation is presented in the thesis.

Mechanics of Hydraulic Fracturing Ching H. Yew 2014-09-25 Revised to include current components considered for today's unconventional and multi-fracture grids, Mechanics of Hydraulic Fracturing, Second Edition explains one of the most important features for fracture design — the ability to predict the geometry and characteristics of the hydraulically induced fracture. With two-thirds of the world's oil and natural gas reserves committed to unconventional resources, hydraulic fracturing is the best proven well stimulation method to extract these resources from their more remote and complex reservoirs. However, few hydraulic fracture models can properly simulate more complex fractures. Engineers and well designers must understand the underlying mechanics of how fractures are modeled in order to correctly predict and forecast a more advanced fracture network. Updated to accommodate today's fracturing jobs, Mechanics of Hydraulic Fracturing, Second Edition enables the engineer to: Understand complex fracture networks to maximize completion strategies Recognize and compute stress shadow, which can drastically affect fracture network patterns Optimize completions by properly modeling and more accurately predicting for today's hydraulic fracturing completions Discusses the underlying mechanics of creating a fracture from the wellbore Enhanced to include newer modeling components such as stress shadow and interaction of hydraulic fracture with a natural fracture, which aids in more complex fracture networks Updated experimental studies that apply to today's unconventional fracturing cases

Fluid Flow in Fractured Porous Media Richeng Liu 2019-09-30 The fluid flow in fracture porous media plays a significant role in the assessment of deep underground reservoirs, such as through CO2 sequestration, enhanced oil recovery, and geothermal energy development. Many methods have been employed—from laboratory experimentation to theoretical analysis and numerical simulations—and allowed for many useful conclusions. This Special Issue aims to report on the current advances related to this topic. This collection of 58 papers represents a wide variety of topics, including on granite permeability investigation, grouting, coal mining, roadway, and concrete, to name but a few. We sincerely hope that the papers published in this Special Issue will be an invaluable resource for our readers.

New Advances in Geology and Engineering Technology of Unconventional Oil and Gas Yuwei Li 2022-09-21

Advances in Multi-scale Multi-physics Geophysical Modelling and Fluid Transport in Unconventional Oil and Gas Reservoir Wenhui Song 2022-08-12

Rock Mechanics Contributions and Challenges W. Hustrulid 1990-01-01 Proceedings of the 31st Symposium on Rock Mechanics, held at Golden, Colo., June 1990. The papers cover such areas as experimental studies; conceptual, analytical, and numerical modeling; and design and construction methods. Many address practical mining problems, with particular area emphasis on co

Flow and Transport Properties of Unconventional Reservoirs 2018 Jianchao Cai 2019-07-23 Unconventional reservoirs are usually complex and highly heterogeneous, such as shale, coal, and tight sandstone reservoirs. The strong physical and chemical interactions between fluids and pore surfaces lead to the inapplicability of conventional approaches for characterizing fluid flow in these low-porosity and ultralow-permeability reservoir systems. Therefore, new theories and techniques are urgently needed to characterize petrophysical properties, fluid transport, and their relationships at multiple scales for improving production efficiency from unconventional reservoirs. This book presents fundamental innovations gathered from 21 recent works on novel applications of new techniques and theories in unconventional reservoirs, covering the fields of petrophysical characterization, hydraulic fracturing, fluid transport physics, enhanced oil recovery, and geothermal energy. Clearly, the research covered in this book is helpful to understand and master the latest techniques and theories for unconventional reservoirs, which have important practical significance for the economic and effective development of unconventional oil and gas resources.

Coalbed Methane in China Yan Song 2021-02-09 The coalbed methane (CBM) reserve in China ranks third in the world with a total resource of 36.8×1012 m3. Exploitation of CBM has an important practical significance to ensure the long-term rapid development of China natural gas industry. Therefore, in 2002, the Ministry of Science and Technology of China set up a national 973 program to study CBM system and resolve problems of CBM exploration and exploitation in China. All the main research results and new insights from the program are presented in this book. The book is divided into 11 chapters. The first chapter mainly introduces the present situation of CBM exploration and development in China and abroad. Chapters 2 through 9 illustrate the geological theory and prospect evaluation methods. Then chapters 10 and 11 discuss CBM recovery mechanisms and technology. The book systematically describes the origin, storage, accumulation and emission of CBM in China, and also proposes new methods and technologies on resource evaluation, prospect prediction, seismic interpretation and enhanced recovery. The book will appeal to geologists, lecturers and students who are involved in the CBM industry and connected with coal and conventional hydrocarbon resources research.