

# Reservoir Geomechanics

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praise for reservoir geomechanics

geomechanics is the basic science for many engineering fields including oil and gas recovery mining civil engineering water supply etc as well as for many environmental sciences including earthquake prediction ecology landscape dynamics and explosion works historically the major concepts of geomechanics were founded on the methods of

the elasticity theory and the static equilibrium of joints with solid friction underground hydrodynamics was developed quite separately and included only simple conventional ideas of elastic pore space deformation today the situation is drastically different tremendous achievements in numerical computer technique have eliminated many of the routine difficulties of problem solution with respect to selected mathematical models as the result major efforts now are applied to sophisticated experimental studies and to new applications of generalized continuum theories of course traditional rheological schemes have been adjusted to be into account the real properties of such geomaterials as soils rocks and ice the main changes have been connected with the kinematics of the internal structure of geomaterials that influences their strength and that can play unusual roles in dynamic processes the theoretical considerations are in good agreement with experimental observations in situ because of precise measuring devices impact of modern physics concepts and large scale monitoring

a comprehensive overview of the key geologic geomechanical and engineering principles that govern the development of unconventional oil and gas reservoirs covering hydrocarbon bearing formations horizontal drilling reservoir seismology and environmental impacts this is an invaluable resource for geologists geophysicists and reservoir engineers

conventional geomechanics cannot provide suitable modes of behavior and performance for today s unconventional reservoirs such as the evolution of porosity permeability relationships with multiphysics coupled effects which ultimately help determine production rates unconventional reservoir geomechanics delivers a reference that discusses a variety of approaches tailored in developing geomechanical models and provides a smarter tool to predict hydrocarbon extraction specifically for unconventional reservoirs starting with a full explanation on a more unified theoretical framework discussing permeability characterization the authors advance to offer a full range of new modelling solutions followed by a series of lab scale and field scale applications to match the history verified models bridging a gap for engineers to fully understand the interactions of multiple processes in field scales from theory to practice going a step further other applications such as co2 sequestration in coal seam or shale gas reservoirs are explained to illustrate how unconventional reservoir geomechanics can be extended to solve related and even more complex challenges combining both theoretical and practical models backed by data unconventional reservoir geomechanics gives reservoir engineers a smarter and more sophisticated tool to approach today s more complex geomechanical modeling challenges provides a foundation of solutions for the extraction of unconventional resources and other related areas introduces a completely new theoretical framework of coupled multi spatial and multi temporal multi physics in rocks with significant contracts of physical properties among components focuses on understanding and inclusion of four characteristics of unconventional rocks with applications to areas such as shale gas coal seam and co2

sequestration

course held may 19 20 2011 during the 2011 joint cspg cseg cwls convention recovery energy environment economy

this thesis presents an important step towards a deeper understanding of naturally fractured carbonate reservoirs nfcrs it demonstrates the various kinds of discontinuities using geological evidence mathematical kinematics model and computed tomography and uses this as a basis for proposing a new classification for nfcrs additionally this study takes advantage of rock mechanics theory to illustrate how natural fractures can collapse due to fluid flow and pressure changes in the fractured media the explanations and mathematical modeling developed in this dissertation can be used as diagnostic tools to predict fluid velocity fluid flow tectonic fracture collapse pressure behavior during reservoir depleting considering stress sensitive and non stress sensitive with nonlinear terms in the diffusivity equation applied to nfcrs furthermore the book presents the description of real reservoirs with their field data as the principal goal in the mathematical description of the realistic phenomenology of nfcrs

applied petroleum geomechanics provides a bridge between theory and practice as a daily use reference that contains direct industry applications going beyond the basic fundamentals of rock properties this guide covers critical field and lab tests along with interpretations from actual drilling operations and worldwide case studies including abnormal formation pressures from many major petroleum basins rounding out with borehole stability solutions and the geomechanics surrounding hydraulic fracturing and unconventional reservoirs this comprehensive resource gives petroleum engineers a much needed guide on how to tackle today s advanced oil and gas operations presents methods in formation evaluation and the most recent advancements in the area including tools techniques and success stories bridges the gap between theory of rock mechanics and practical oil and gas applications helps readers understand pore pressure calculations and predictions that are critical to shale and hydraulic activity

reservoir engineers today need to acquire more complex reservoir management and modeling skills principles of applied reservoir simulation fourth edition continues to provide the fundamentals on these topics for both early and seasoned career engineers and researchers enhanced with more practicality and with a focus on more modern reservoir simulation workflows this vital reference includes applications to not only traditional oil and gas reservoir problems but specialized applications in geomechanics coal gas modelling and unconventional resources strengthened with complementary software from the author to immediately apply to the engineer s projects principles of applied reservoir simulation fourth edition delivers knowledge critical for today s basic and advanced reservoir and asset management gives hands on experience in working with reservoir simulators and links them to other petroleum engineering activities

teaches on more specific reservoir simulation issues such as run control tornado plot linear displacement fracture and cleat systems and modern modelling workflows updates on more advanced simulation practices like eor petrophysics geomechanics and unconventional reservoirs

reservoir geomechanics investigates the implications of rock deformation strain localization and failure for completion and production of subsurface energy reservoirs for example effective hydraulic fracture placement and reservoir pressure management are among the most important applications for maximizing hydrocarbon production the correct use of these applications requires understanding the interaction of fluid flow and rock deformations in the past a considerable amount of effort has been made to describe the role of poroelastic and thermal effects in geomechanics however a number of chemical processes that commonly occur in reservoir engineering have been disregarded in reservoir geomechanics despite their significant effect on the mechanical behavior of rocks and therefore fluid flow this dissertation focuses on the mechanical effects of two particular chemical processes gas desorption from organic rich rocks and mineral dissolution in carbonate rich formations the methods employ a combination of laboratory studies field data analysis and numerical simulations at various length scales the following conclusions are the results of this work 1 the introduced numerical model for fluid flow with effects of gas sorption and shear failure impaired permeability captures the complex permeability evolution during gas production in coal reservoirs the simulation results also indicate the presence non negligible sorption stresses in shale reservoirs 2 mineral dissolution of mineralized fractures similar to pore pressure depletion or thermal cooling heating can increase stress anisotropy which can reactivate critically oriented natural fractures in situ stress chemical manipulation can be used advantageously to enlarge the stimulated reservoir volume 3 semicircular bending experiments on acidized rock samples show that non planar fractures follow high porosity regions and large pores and that fracture toughness correlates well with local porosity numerical modeling based on the phase field approach shows that a direct relationship between fracture toughness and porosity permits replicating fracture stress intensity at initiation and non planar fracture propagation patterns observed in experiments and 4 numerical simulations based on a novel reactive fluid flow model coupled with geomechanics show that mineral dissolution i lower fracture breakdown pressure ii can bridge a transition from a toughness dominated regime to uncontrolled fracture propagation at constant injection pressures and iii can increase fracture complexity by facilitating propagation of stalled fracture branches the understanding of these chemo mechanical coupled processes is critical for safe and effective injection of co<sub>2</sub> and reactive fluids in the subsurface such as in hydraulic fracturing deep geothermal energy and carbon geological sequestration applications

petroleum engineers have a difficult time making the leap between theory of rock mechanics and practical applications surrounding petroleum geomechanics especially

in more complex operations such as hydraulic fracturing applied petroleum geomechanics provides a bridge between theory and practice as a daily reference with direct industry application going beyond the basic fundamentals of rock properties this guide covers critical field and lab tests along with interpretations that follow within actual drilling operations and worldwide case studies including abnormal formation pressures from many major petroleum basins rounding out with borehole stability solutions and the geomechanics surrounding hydraulic fracturing and unconventional reservoirs applied petroleum geomechanics gives petroleum engineers a much needed resource to tackle today's advanced oil and gas operations understand a great wealth of methods in formation evaluation and the most recent advancements in the area including tools techniques and success stories bridge the gap between theory of rock mechanics and practical oil and gas applications learn pore pressure calculations and predictions critical to shale and hydraulic activity

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