

Fundamentals Of Fractured Reservoir Engineering

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Unlocking the Secrets

Fundamentals of Fractured Reservoir Engineering

Meta Dive deep into the fundamentals of fractured reservoir engineering

This comprehensive guide explores reservoir characterization, stimulation techniques, and production optimization, offering practical tips and addressing common FAQs.

fractured reservoir, reservoir engineering, hydraulic fracturing, reservoir characterization, fracture modeling, well testing, production optimization, stimulated reservoir volume, unconventional reservoirs, shale gas, tight oil.

Fractured reservoirs represent a significant portion of the world's hydrocarbon reserves. From conventional reservoirs with natural fractures to unconventional plays like shale gas and tight oil formations, understanding the intricacies of these complex systems is crucial for efficient and sustainable production.

This post delves into the fundamentals of fractured reservoir engineering, providing a comprehensive overview for both seasoned professionals and those new to the field.

I. Characterizing the Complexity

Reservoir Description and Modeling

Understanding a fractured reservoir begins with comprehensive characterization. This involves integrating various data sources to build a robust geological model that accurately reflects the reservoir's architecture. Key aspects include:

- Geological Characterization:** This involves studying geological maps, core samples, well logs (e.g., gamma ray, density, neutron porosity), and seismic data to identify the presence, orientation, density, and aperture of fractures.
- Advanced techniques:** Like microseismic monitoring, can help visualize fracture networks generated during hydraulic fracturing.

Petrophysical Analysis

Determining porosity, permeability, and fluid saturation within the matrix and fractures is crucial. These properties influence fluid flow and reservoir productivity.

Nuclear magnetic resonance (NMR) logging provides valuable information on pore size distribution and fluid mobility.

Fracture Network Modeling

Building a 3D model of the fracture network is a complex but critical step. Various techniques exist, ranging from simplified discrete fracture network (DFN) models to more sophisticated stochastic models that capture the variability and uncertainty inherent in natural fracture systems.

These

models are essential for simulating fluid flow and predicting production performance. Data Integration and Uncertainty Quantification Combining geological petrophysical and seismic data requires sophisticated integration techniques. Uncertainty quantification is vital to account for the inherent variability in the reservoir properties and model parameters.

II Stimulating Production Hydraulic Fracturing and Other Techniques Hydraulic fracturing or fracking is a widely used technique to enhance production from low-permeability fractured reservoirs. However, effective stimulation requires careful planning and execution. Fracture Design Optimal fracture design involves selecting appropriate fluids, proppants, and materials used to keep fractures open and pumping schedules to create a network of interconnected fractures that effectively connect the wellbore to the reservoir. Numerical simulation plays a crucial role in designing effective fracture treatments.

Fracture Monitoring Microseismic monitoring and other techniques are used to track fracture growth during hydraulic fracturing, providing valuable insights into fracture geometry and effectiveness.

Other Stimulation Techniques Besides hydraulic fracturing, other techniques like acidizing, dissolving minerals to improve permeability, and matrix stimulation enhancing permeability of the rock matrix can be used to improve reservoir productivity.

III Optimizing Production Well Testing and Reservoir Simulation Once a well is completed and stimulated, monitoring its performance is crucial for optimizing production. Well Testing Various well testing techniques, including pressure buildup and drawdown tests, are used to estimate reservoir properties such as permeability and skin factor, a measure of wellbore damage or stimulation effectiveness.

Reservoir Simulation Numerical reservoir simulation is used to predict future production performance, optimize well placement and completion strategies, and assess the impact of different operating conditions. These simulations incorporate the characterized fracture network and the results from well testing.

Production Optimization This involves adjusting operating parameters like well pressure, production rate, and water injection rates to maximize hydrocarbon recovery and minimize operating costs. Artificial intelligence and machine learning techniques are increasingly being used for real-time production optimization.

IV Practical Tips for Success in Fractured Reservoir Engineering

1. Integrate diverse datasets. Don't rely on a single data source. Combine geological, geophysical, and engineering data for a holistic understanding.
2. Embrace uncertainty. Acknowledge the inherent uncertainties in reservoir characterization and modeling. Use probabilistic methods to assess the range of possible outcomes.
3. Utilize advanced modeling techniques. Employ sophisticated numerical simulation techniques to accurately model complex fracture networks and fluid flow.
4. Continuously monitor and adapt. Continuously monitor and adapt to the reservoir's performance and adjust the production strategy as needed.

Regularly monitor well performance and adapt operating strategies based on observed data. Invest in data analytics. Leverage data analytics and machine learning to optimize production and reduce operational costs. Conclusion: Fractured reservoir engineering is a multifaceted and challenging field requiring a deep understanding of geology, geophysics, petrophysics, and reservoir simulation. Success in developing these complex reservoirs hinges on integrating diverse data sources employing advanced modeling techniques and continuously adapting to changing conditions. As the demand for energy continues to grow, mastering the complexities of fractured reservoir engineering will be crucial for ensuring a secure and sustainable energy future.

FAQs:

1. What are the main challenges in modeling fractured reservoirs? The main challenges include the complexity and heterogeneity of fracture networks, the difficulty in accurately characterizing fracture properties, and the computational demands of simulating large-scale fracture networks.
2. How does hydraulic fracturing impact the environment? Hydraulic fracturing can have potential environmental impacts including water usage, wastewater disposal, and the potential for induced seismicity. Careful planning, mitigation strategies, and regulatory oversight are crucial to minimize these impacts.
3. What is the role of artificial intelligence (AI) in fractured reservoir engineering? AI and machine learning are increasingly used for reservoir characterization, fracture modeling, production optimization, and real-time decisionmaking, leading to improved efficiency and reduced costs.
4. What are the differences between conventional and unconventional fractured reservoirs? Conventional reservoirs typically have naturally occurring fractures that enhance permeability, while unconventional reservoirs like shale gas have very low permeability and require hydraulic fracturing to become productive.
5. How can I learn more about fractured reservoir engineering? Numerous resources are available, including academic courses, industry conferences, online tutorials, and professional societies like the Society of Petroleum Engineers (SPE). Consider pursuing advanced degrees in petroleum engineering or related fields for a more in-depth understanding.

The Reservoir Engineering Aspects of Fractured Formations
Fundamentals of Fractured Reservoir Engineering
Well Test Analysis for Fractured Reservoir Evaluation
Reservoir Engineering of Fractured Reservoirs
Fundamentals of Fractured Reservoir Engineering
Multiphase Fluid Flow in Porous and Fractured Reservoirs
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Embedded Discrete Fracture Modeling and Application in Reservoir Simulation
Essentials of Reservoir Engineering
Hydraulic Fracture Modeling
Dynamic Description Technology of Fractured Vuggy Carbonate Gas Reservoirs
Fundamentals of Reservoir Rock Properties
Fractured

Reservoirs Naturally Fractured Reservoir Characterization Tight Oil Reservoirs Introduction to Petroleum Reservoir Analysis Petroleum Reservoir Engineering Practice Fluid Flow in Porous Media Physical Model of a Fractured Reservoir SPE Reservoir Engineering Louis H. Reiss T.D. van Golf-Racht G. Da Prat Ali M.. Saidi Theodor D. Golf-Racht Yu-Shu Wu Roberto Aguilera Kamy Sepehrnoori Pierre Donnez Yu-Shu Wu Hedong Sun Tarek Al-Arbi Omar Ganat Thomas E. Hoak Wayne Narr Hadi Belhaj Leonard Koederitz Nnaemeka Ezekwe Robert Wayne Zimmerman

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in the modern language of reservoir engineering by reservoir description is understood the totality of basic local information concerning the reservoir rock and fluids

which by various procedures are extrapolated over the entire reservoir fracture detection evaluation and processing is another essential step in the process of fractured reservoir description in chapter 2 all parameters related to fracture density and fracture intensity together with various procedures of data processing are discussed in detail after a number of field examples developed in chap 3 the main objective remains the quantitative evaluation of physical properties this is done in chap 4 where the evaluation of fractures porosity and permeability their correlation and the equivalent ideal geometrical models versus those parameters are discussed in great detail special rock properties such as capillary pressure and relative permeability are reexamined in the light of a double porosity reservoir rock in order to complete the results obtained by direct measurements on rock samples chap 5 examines fracturing through indirect measurements from various logging results the entire material contained in these five chapters defines the basic physical parameters and indicates procedures for their evaluation which may be used further in the description of fractured reservoirs

the main purpose of this book is to provide the reader with a basic understanding of the behaviour of fractured reservoirs using evaluation techniques based on processing pressure and flow rate data resulting from production testing it covers the fundamental reservoir engineering principles involved in the analysis of fluid flow through fractured reservoirs the application of existing models to field cases and the evaluation and description of reservoirs based on processed data from pressure and production tests the author also discusses production decline analysis the understanding of which is a key factor influencing completion or abandonment of a well or even a field the theoretical concepts are presented as clearly and simply as possible in order to aid comprehension the book is thus suitable for training and educational purposes and will help the reader who is unfamiliar with the subject acquire the necessary skills for successful interpretation and analysis of field data one of the most important features of the book is that it fills the gap between field operations and research in regard to proper management of reservoirs the book also contains a computer program fortran language which can be incorporated in existing software designed for reservoir evaluation type curves generation test design and interpretation can be achieved by using this program petroleum engineers reservoir engineers petroleum geologists research engineers and students in these fields will be interested in this book as a reference source it can also be used as a text book for training production and reservoir engineering professionals it should be available

in university and oil company libraries

multiphase fluid flow in porous and fractured reservoirs discusses the process of modeling fluid flow in petroleum and natural gas reservoirs a practice that has become increasingly complex thanks to multiple fractures in horizontal drilling and the discovery of more unconventional reservoirs and resources the book updates the reservoir engineer of today with the latest developments in reservoir simulation by combining a powerhouse of theory analytical and numerical methods to create stronger verification and validation modeling methods ultimately improving recovery in stagnant and complex reservoirs going beyond the standard topics in past literature coverage includes well treatment non newtonian fluids and rheological models multiphase fluid coupled with geomechanics in reservoirs and modeling applications for unconventional petroleum resources the book equips today s reservoir engineer and modeler with the most relevant tools and knowledge to establish and solidify stronger oil and gas recovery delivers updates on recent developments in reservoir simulation such as modeling approaches for multiphase flow simulation of fractured media and unconventional reservoirs explains analytical solutions and approaches as well as applications to modeling verification for today s reservoir problems such as evaluating saturation and pressure profiles and recovery factors or displacement efficiency utilize practical codes and programs featured from online companion website

this book deals exclusively with naturally fractured reservoirs and includes many subjects usually treated in separate volumes a highly practical edition naturally fractured reservoirs is written for students reservoir geologists log analysts and petroleum engineers

the development of naturally fractured reservoirs especially shale gas and tight oil reservoirs exploded in recent years due to advanced drilling and fracturing techniques however complex fracture geometries such as irregular fracture networks and non planar fractures are often generated especially in the presence of natural fractures accurate modelling of production from reservoirs with such geometries is challenging therefore embedded discrete fracture modeling and application in reservoir simulation demonstrates how production from reservoirs with complex fracture geometries can be modelled efficiently and effectively this volume presents a conventional numerical model to handle simple and complex fractures using local grid refinement lgr and unstructured gridding moreover it introduces an embedded discrete fracture

model edfm to efficiently deal with complex fractures by dividing the fractures into segments using matrix cell boundaries and creating non neighboring connections nnCs a basic edfm approach using cartesian grids and advanced edfm approach using corner point and unstructured grids will be covered embedded discrete fracture modeling and application in reservoir simulation is an essential reference for anyone interested in performing reservoir simulation of conventional and unconventional fractured reservoirs highlights the current state of the art in reservoir simulation of unconventional reservoirs offers understanding of the impacts of key reservoir properties and complex fractures on well performance provides case studies to show how to use the edfm method for different needs

contents of volumes 1 and 2 give a general view of the essential material knowledge for students and professionals opportunity for deeper investigation is available from the extensive complementary references featured

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

dynamic description technology of fractured vuggy carbonate gas reservoirs delivers a critical reference to reservoir and production engineers on the basic

characteristics of fractured vuggy gas reservoirs combining both static and dynamic data to improve reservoir characterization accuracy and development based on the full lifecycle of well testing and advanced production decline analysis this reference also details how to apply reservoir dynamic evaluation and reserve estimation and performance forecasting offering one collective location for the latest research on fractured gas reservoirs this reference also covers physical models analysis examples and processes 3d numerical well test technology and deconvolution technology of production decline analysis packed with many calculation examples and more than 100 case studies this book gives engineers a strong tool to further exploit these complex assets

this book explains the basic technologies concepts approaches and terms used in relation to reservoir rocks accessible to engineers in varying roles it provides the tools necessary for building reservoir characterization and simulation models that improve resource definition and recovery even in complex depositional environments the book is enriched with numerous examples from a wide variety of applications to help readers understand the topics it also describes in detail the key relationships between the different rock properties and their variables as such it is of interest to researchers engineers lab technicians and postgraduate students in the field of petroleum engineering

naturally fractured reservoirs present unique and specialized challenges to hydrocarbon extraction this book seeks to confront many of these challenges by providing an introduction to the engineering and geological character of naturally fractured reservoirs the focus is on understanding fractures in a reservoir how to determine whether fractures are important to hydrocarbon producibility and if so how to analyze the fracture system for the purpose of improved reservoir management

tight oil reservoirs characterization modeling and field development the latest release in the unconventional reservoir engineering series delivers a full spectrum of reservoir engineering guidelines so that the engineer can focus on every stage of development specific to tight oil covering characterization micro and nano scale modeling drilling horizontally completing hydraulic fracturing and field development each section includes case studies practice exercises and future references for even deeper understanding rounding out with coverage on field economics and remaining challenges this book puts control in the engineer s hands in this ongoing series

each release will discuss the latest resources explain their importance in the market show the benefits of the resource through the latest research provide details and protocols on how to evaluate and develop the resource and give case studies and practice questions to gain practicality supports the petroleum engineer with a structured table of contents focused on one unconventional resource making research and solutions easier to find covers the full spectrum of reservoir engineering including modern research development field application and environmental considerations applies practicality with case studies exercises and references included in every chapter

the complete up to date practical guide to modern petroleum reservoir engineering this is a complete up to date guide to the practice of petroleum reservoir engineering written by one of the world s most experienced professionals dr nnaemeka ezekwe covers topics ranging from basic to advanced focuses on currently acceptable practices and modern techniques and illuminates key concepts with realistic case histories drawn from decades of working on petroleum reservoirs worldwide dr ezekwe begins by discussing the sources and applications of basic rock and fluid properties data next he shows how to predict pvt properties of reservoir fluids from correlations and equations of state and presents core concepts and techniques of reservoir engineering using case histories he illustrates practical diagnostic analysis of reservoir performance covers essentials of transient well test analysis and presents leading secondary and enhanced oil recovery methods readers will find practical coverage of experience based procedures for geologic modeling reservoir characterization and reservoir simulation dr ezekwe concludes by presenting a set of simple practical principles for more effective management of petroleum reservoirs with petroleum reservoir engineering practice readers will learn to use the general material balance equation for basic reservoir analysis perform volumetric and graphical calculations of gas or oil reserves analyze pressure transients tests of normal wells hydraulically fractured wells and naturally fractured reservoirs apply waterflooding gasflooding and other secondary recovery methods screen reservoirs for eor processes and implement pilot and field wide eor projects use practical procedures to build and characterize geologic models and conduct reservoir simulation develop reservoir management strategies based on practical principles throughout dr ezekwe combines thorough coverage of analytical calculations and reservoir modeling as powerful tools that can be applied together on most reservoir analyses each topic is presented concisely and is supported with copious examples and references the result is an

ideal handbook for practicing engineers scientists and managers and a complete textbook for petroleum engineering students

pressure diffusion equation for fluid flow in porous rocks line source solution for a vertical well in an infinite reservoir superposition and pressure buildup tests effect of faults and linear boundaries wellbore skin and wellbore storage production from bounded reservoirs laplace transform methods in reservoir engineering naturally fractured reservoirs flow of gases in porous media

the objectives of the physical modeling effort are to 1 evaluate injection backflow testing for fractured reservoirs under conditions of known reservoir parameters porosity fracture width etc 2 study the mechanisms controlling solute transport in fracture systems and 3 provide data for validation of numerical models that explicitly simulate solute migration in fracture systems the fracture network is 0 57 m wide 1 7 m long and consists of two sets of fractures at right angles to one another with a fracture spacing of 10 2 cm a series of injection backflow tests similar to those performed at the raft river geothermal field was conducted these included variable volume injection and injection backflow tests with varying quiescent periods between injection and backflow this latter series of tests was conducted with a range of flow fields passing through the model recovery is related to the flow field in the physical model and model parameters longer quiescent times and greater flow fields result in a lower tracer recovery a plot of the fractional tracer recovery against quiescent time results in a straight line this relationship combined with classical reservoir engineering data can be used to predict aquifer flow rate and porosity from known injection volumes and tracer recovery

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