Fundamentals Of Fractured Reservoir Engineering

Fundamentals Of Fractured Reservoir Engineering 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 worlds 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 reservoirs architecture Key aspects include Geological Characterization This involves studying geological maps core samples well logs eg 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 2 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 lowpermeability fractured reservoirs However effective stimulation requires careful planning and execution Fracture Design Optimal fracture design involves selecting appropriate fluids proppants 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 realtime production optimization IV Practical Tips for Success in Fractured Reservoir Engineering 3 Integrate diverse datasets Dont rely on a single data source Combine geological geophysical and engineering data for a holistic understanding Embrace uncertainty Acknowledge the inherent uncertainties in reservoir characterization and modeling Use probabilistic methods to assess the range of possible outcomes Utilize advanced modeling techniques Employ sophisticated numerical simulation techniques to accurately model complex fracture networks and fluid flow Continuously monitor and adapt 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 largescale 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 realtime 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 4 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 indepth understanding

Fundamentals of Fractured Reservoir EngineeringThe Reservoir Engineering Aspects of Fractured FormationsApplied Concepts in Fractured ReservoirsWell Test Analysis for Fractured Reservoir EvaluationNaturally Fractured ReservoirsFundamentals of Fractured Reservoir EngineeringAdvances in the Study of Fractured ReservoirsGeologic Analysis of Naturally Fractured ReservoirsPhysical Aspects in Upscaling of Fractured Reservoirs and Improved Oil Recovery PredictionReservoir Engineering of Fractured ReservoirsSimulation Studies to Evaluate the Effect of Fracture Closure on the Performance of Fractured Reservoirs ; Final ReportNaturally Fractured Reservoir CharacterizationNumerical Investigation of Fractured Reservoir

Response to Injection/extraction Using a Fully Coupled Displacement Discontinuity MethodGeomechanical Development of Fractured Reservoirs During Gas ProductionThe Reservoir Engineering Aspects of Fractured FormationsDevelopment of an Efficient Embedded Discrete Fracture Model for 3D Compositional Reservoir Simulation in Fractured ReservoirsCarbonate ReservoirsFractured ReservoirsProduction of Oil from Fractured Reservoirs by Water DisplacementPhysical Model of a Fractured Reservoir T.D. van Golf-Racht Louis H. Reiss John C. Lorenz G. Da Prat Roberto Aguilera Theodor D. Golf-Racht G.H. Spence Ronald A. Nelson Hamidreza Salimi Ali M.. Saidi Wayne Narr Byungtark Lee Jian Huang L. H. Reiss Ali Moinfar Clyde H. Moore Thomas E. Hoak Jon Kleppe Fundamentals of Fractured Reservoir Engineering The Reservoir Engineering Aspects of Fractured Formations Applied Concepts in Fractured Reservoirs Well Test Analysis for Fractured Reservoir Evaluation Naturally Fractured Reservoirs Fundamentals of Fractured Reservoir Engineering Advances in the Study of Fractured Reservoirs Geologic Analysis of Naturally Fractured Reservoirs Physical Aspects in Upscaling of Fractured Reservoirs and Improved Oil Recovery Prediction Reservoir Engineering of Fractured Reservoirs Simulation Studies to Evaluate the Effect of Fracture Closure on the Performance of Fractured Reservoirs ; Final Report Naturally Fractured Reservoir Characterization Numerical Investigation of Fractured Reservoir Response to Injection/extraction Using a Fully Coupled Displacement Discontinuity Method Geomechanical Development of Fractured Reservoirs During Gas Production The Reservoir Engineering Aspects of Fractured Formations Development of an Efficient Embedded Discrete Fracture Model for 3D Compositional Reservoir Simulation in Fractured Reservoirs Carbonate Reservoirs Fractured Reservoirs Production of Oil from Fractured Reservoirs by Water Displacement Physical Model of a Fractured Reservoir *T.D. van Golf-Racht Louis H. Reiss John C. Lorenz G. Da Prat Roberto Aguilera Theodor D. Golf-Racht G.H. Spence Ronald A. Nelson Hamidreza Salimi Ali M.. Saidi Wayne Narr Byungtark Lee Jian Huang L. H. Reiss Ali Moinfar Clyde H. Moore Thomas E. Hoak Jon Kleppe*

in the modem 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

contents 1 introduction 2 production geology of fractured reservoirs 3 use of production data in fractured reservoirs 4 recovery mechanisms in fractured reservoirs 5 simulation of fractured reservoirs 6 application to the development and exploitation of fractured reservoirs appendices well logging in fractured reservoirs well performance and well tests in fractured reservoirs relationship between the fracture parameters compressibility of fractured reservoirs multiphase flow in fractured reservoirs mathematical simulation of fractured reservoirs bibliography index

a much needed precise and practical treatment of a key topic in the energy industry and beyond applied concepts in fractured reservoirs is an invaluable reference for those in both industry and academia authored by renowned experts in the field this book covers the understanding evaluation and effects of fractures in reservoirs it offers a comprehensive yet practical discussion and description of natural fractures their origins characteristics and effects on hydrocarbon reservoirs it starts by introducing the reader to basic definitions and classifications of fractures and fractured reservoirs it then provides an outline for fractured reservoir characterization and analysis and goes on to introduce the way fractures impact operational activities well organized and clearly illustrated throughout applied concepts in fractured reservoirs starts with a section on understanding natural fractures it looks at the different types their dimensions and the mechanics of fracturing rock in extension and shear the next section provides information on measuring and analyzing fractures in reservoirs it covers logging core for fractures taking measuring and analyzing fracture data new core vs archived core ct scans comparing fracture data from outcrops core and logs and more the last part examines the effects of natural fractures on reservoirs including the permeability behavior of individual fractures and fracture systems fracture volumetrics effects of fractures on drilling and coring and the interaction between natural and hydraulic fractures teaches readers to understand and evaluate fractures compiles and synthesizes various concepts and descriptions scattered in literature and synthesizes them with unpublished oil field observations and data along with the authors own experience bridges some of the gaps between reservoir engineers and geologists provides an invaluable reference for geologists and engineers who need to understand naturally fractured reservoirs in order to efficiently extract hydrocarbons illustrated in full color throughout companion volume to the atlas of natural and induced fractures in core

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

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

naturally fractured reservoirs constitute a substantial percentage of remaining hydrocarbon resources they create exploration targets in otherwise impermeable rocks including under explored crystalline basement and they can be used as geological stores for anthropogenic carbon dioxide their complex behaviour during production has traditionally proved difficult to predict causing a large degree of uncertainty in reservoir development the applied study of naturally fractured reservoirs seeks to constrain this uncertainty by developing new understanding and is necessarily a broad integrated interdisciplinary topic this book addresses some of the challenges and advances in knowledge approaches concepts and methods used to characterize the interplay of rock matrix and fracture networks relevant to fluid flow and hydrocarbon recovery topics include describing characterizing and identifying controls on fracture networks from outcrops cores geophysical data digital and numerical models geomechanical influences on reservoir behaviour numerical modelling and simulation of fluid flow and case studies of the exploration and development of carbonate siliciclastic and metamorphic naturally fractured reservoirs

this thesis is concerned with upscaled models for waterflooded naturally fractured reservoirs nfrs naturally fractured petroleum reservoirs provide over 20 of the world s oil reserves and production from the fluid flow point of view a fractured reservoir is defined as a reservoir in which a number of naturally occurring fractures have a significant effect on reservoir fluid flow the reservoir rock between the fractures is called the matrix system fractured reservoir simulations completely differ from conventional reservoir simulations the challenge of upscaling is to give an accurate representation of the interaction between fractures and matrix blocks from the geological point of view fractured reservoirs can exhibit a number of topologically different configurations these are reservoirs built from 1 matrix blocks that are bounded by fracture planes in all directions totally fractured reservoirs tfrs or sugar cube 2 matrix blocks that are bounded only by more or less vertical fracture planes vertically fractured reservoirs vfrs and 3 matrix blocks that form a connected domain interdispersed with fractures partially fractured reservoirs pfrs only the first configuration which only exceptionally occurs is considered in conventional simulators these simulators use the transfer function and shape factor approach the advantage of this approach is that it can quantify albeit in a semi empirical way in a large variety of cases the fracture matrix interaction moreover it is fast in terms of computational effort this thesis adopts a more fundamental approach based on an upscaling methodology called homogenization it has the advantage of allowing a physically more realistic description of recovery from fractured reservoirs in addition it can also be more directly related to the geological model e g the configurations mentioned above we expect that a comparison of the physically more realistic approach using homogenization with

a three year research program to evaluate the effect of fracture closure on the recovery of oil and gas from naturally fractured reservoirs has been completed the overall objectives of the study were to 1 evaluate the reservoir conditions for which fracture closure is significant and 2 evaluate innovative fluid injection techniques capable of maintaining pressure within the reservoir the evaluations of reservoir performance were made by a modern dual porosity simulator tetrad this simulator treats both porosity and permeability as functions of pore pressure the austin chalk in the pearsall field in of south texas was selected as the prototype fractured reservoir for this work during the first year simulations of vertical and horizontal well performance were made assuming that fracture permeability was insensitive to pressure change sensitivity runs indicated that the simulator was predicting the effects of critical reservoir parameters in a logical and consistent manner the results confirmed that horizontal wells could increase both rate of oil recovery and total oil recovery from naturally fractured reservoirs in the second year the performance of the same vertical and horizontal wells was reevaluated with fracture permeability treated as a function of reservoir pressure to investigate sensitivity to in situ stress differing loading conditions were assumed simulated natural depletions confirm that pressure sensitive fractures degrade well performance the severity of degradation worsens when the initial reservoir pressure approaches the average stress condition of the reservoir such as occurs in over pressured reservoirs simulations with water injection indicate that degradation of permeability can be counteracted when reservoir pressure is maintained and oil recovery can be increased when reservoir properties are favorable

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

in geothermal reservoirs and unconventional gas reservoirs with very low matrix permeability fractures are the main routes of fluid flow and heat transport so the fracture permeability change is important in fact reservoir development under this circumstance relies on generation and stimulation of a fracture network this thesis presents numerical simulation of the response of a fractured rock to injection and extraction considering the role of poro thermoelasticity and joint deformation fluid flow and heat transport in the fracture are treated using a finite difference method while the fracture and rock matrix deformation are determined using the displacement discontinuity method ddm the fractures response to fluid injection and extraction is affected both by the induced stresses as well as by the initial far field stress the latter is accounted for using the non equilibrium condition i e relaxing the assumption that the rock joints are in equilibrium with the in situ stress state the fully coupled ddm simulation has been used to carry out several case studies to model the fracture response under different injection extractions in situ stresses joint geometries and properties for both equilibrium and non equilibrium conditions the following observations are made i fluid injection increases the pressure causing the joint to open for non isothermal injection cooling increases the fracture aperture drastically by inducing tensile stresses higher fracture aperture means higher conductivity ii in a single fracture under constant anisotropic in situ stress non equilibrium condition permanent shear slip is encountered on all fracture segments when the shear strength is overcome by shear stress in response to fluid injection with cooling operation the fracture segments in the vicinity of the injection point are opened due to cooling induced tensile stress and injection pressure and all the fracture segments experience slip iii fluid pressure in fractures increases in response to compression the fluid compressibility and joint stiffness play a role iv when there are injection and extraction in fractured reservoirs the cooler fluid flows through the fracture channels from the injection point to extraction well extracting heat from the warmer reservoir matrix as the matrix cools the resulting thermal stress increases the fracture apertures and thus increases the fracture conductivity v injection decreases the amount of effective stress due to pressure increase in fracture and matrix near a well in contrast extraction increases the amount of effective stress due to pressure drop in fracture and matrix

within fractured reservoirs such as tight gas reservoir coupled processes between matrix deformation and fluid flow are very important for predicting reservoir behavior pore pressure evolution and fracture closure to study the coupling between gas desorption and rock matrix fracture deformation a poroelastic constitutive relation is developed and used for deformation of gas shale local continuity equation of dry gas model is developed by considering the mass conservation of gas including both free and absorbed phases the absorbed gas content and the sorption induced volumetric strain are described through a langmiur type equation a general porosity model that differs from other empirical correlations in the literature is developed and utilized in a finite element model to coupled gas diffusion and rock mass deformation the dual permeability method dpm is implemented into the finite element model fem to investigate fracture deformation and closure and its impact on gas flow in naturally fractured reservoir within the framework of dpm the fractured reservoir is treated as dual continuum two independent but overlapping meshes or elements are used to represent these kinds of reservoirs one is the matrix elements used for deformation and fluid flow within matrix domain while the other is the fracture element simulating the fluid flow only through the fractures both matrix and fractures are assumed to be permeable and can accomodate fluid transported a quasi steady state function is used to quantify the flow that is transferred between rock mass and fractures by implementing the idea of equivalent fracture permeability and shape factor within the transfer function into dpm the fracture geometry and orientation are numerically considered and the complexity of the problem is well reduced both the normal deformation and shear dilation of fractures are considered and the stress dependent fracture aperture can be updated in time further a non linear numerical model is constructed by implementing a poroviscoelastic model into the dual permeability dpm finite element model fem to investigate the coupled time dependent viscoelastic deformation fracture network evolution and compressible fluid flow in gas shale reservoir the viscoelastic effect is addressed in both deviatoric and symmetric effective stresses to emphasize the effect of shear strain localization on fracture shear dilation the new mechanical model is first verified with an analytical solution in a simple wellbore creep problem and then compared with the poroelastic solution in both wellbore and field cases the electronic version of this dissertation is accessible from hdl handle net 1969 1 149448

naturally fractured reservoirs nfrs hold a significant amount of the world s hydrocarbon reserves compared to conventional reservoirs nfrs exhibit a higher degree of heterogeneity and complexity created by fractures the importance of fractures in production of oil and gas is not limited to naturally fractured reservoirs the economic exploitation of unconventional reservoirs which is increasingly a major source of short and long term energy in the united states hinges in part on effective stimulation of low permeability rock through multi stage hydraulic fracturing of horizontal wells accurate modeling and simulation of fractured media is still challenging owing to permeability anisotropies and contrasts non physical abstractions inherent in conventional dual porosity and dual permeability models make these methods inadequate for solving different fluid flow problems in fractured reservoirs also recent approaches for discrete fracture modeling may require large computational times and hence the oil industry has not widely used such approaches even though they give more accurate representations of fractured reservoirs than dual continuum models we developed an embedded discrete fracture model edfm for an in house fully implicit compositional reservoir simulator edfm borrows the dual medium concept from conventional dual continuum models and also incorporates the effect of each fracture explicitly in contrast to dual continuum models fractures have arbitrary orientations and can be oblique or vertical honoring the complexity and heterogeneity of a typical fractured reservoir edfm employs a structured grid to remediate challenges associated with unstructured gridding required for other discrete fracture models also the edfm approach can be easily incorporated in existing finite difference reservoir simulators the accuracy of the edfm approach was confirmed by comparing the results with analytical solutions and fine grid explicit fracture simulations comparison of our results using the edfm approach with fine grid simulations showed that accurate results can be achieved using moderate grid refinements this was further verified in a mesh sensitivity study that the edfm approach with moderate grid refinement can obtain a converged solution hence edfm offers a computationally efficient approach for simulating fluid flow in nfrs furthermore several case studies presented in this study demonstrate the applicability robustness and efficiency of the edfm approach for modeling fluid flow in fractured porous media another advantage of edfm is its extensibility for various applications by incorporating different physics in the model in order to examine the effect of pressure dependent fracture properties on production we incorporated the dynamic behavior of fractures into edfm by employing empirical fracture deformation models our simulations showed that fracture deformation caused by effective stress changes substantially affects pressure depletion and hydrocarbon recovery based on the examples presented in this study implementation of fracture geomechanical effects in edfm did not degrade the computational performance of edfm many unconventional reservoirs comprise well developed natural fracture networks with multiple orientations and complex hydraulic fracture patterns suggested by microseismic data we developed a coupled dual continuum and discrete fracture model to efficiently simulate production from these reservoirs large scale hydraulic fractures were modeled explicitly using the edfm approach and numerous small scale natural fractures were modeled using a dual continuum approach the transport parameters for dual continuum modeling of numerous natural fractures were derived by upscaling the edfm equations comparison of the results using the coupled model with that of using the edfm approach to represent all natural and hydraulic fractures explicitly showed that reasonably accurate results can be obtained at much lower computational cost by using the coupled approach with moderate grid refinements

carbonate reservoirs are prone to natural fracturing fractures can act as enhanced permeability pathways which may increase decrease or complicate reservoir production and development healed fractures contribute to reservoir compartmentalization a primary focus is placed upon the predictability of fracture set patterns and orientations which vary according to carbonate lithofacies and the stress field s under which different types of fractures form extension fractures can form at the surface or at reservoir depths certain types of extension fracture sets e g syndepositional regional and to a lesser extent karst related fracture sets exhibit predictable patterns and orientations with respect to the stress field under which they originated surface outcrops commonly exhibit multiple fracture sets these are most frequently related to relaxation of compaction and or thermal cooling such fracture sets are considered unlikely to resemble fracture sets in nearby reservoirs at depth therefore the use of surface fracture patterns as analogs for same formation reservoirs without comparative analysis of burial stress histories is risky fault related fractures have very high permeability potentials when newly formed but their resulting role as fluid conduits typically leads to rapid healing and therefore a higher likelihood of causing reservoir compartmentalization these fractures typically cut across multiple beds fold related fracture patterns are complex typically consisting of both extension and conjugate shear pair fractures and show variable orientations in space and or over time however they tend to follow the geometries of individual beds and are often confined to single beds rather than aligning according to overall structural axes ekofisk field a naturally fractured north sea chalk reservoir is presented as an illustrative case of fold related fracture abundance and effectiveness in enhancing fieldwide permeability parameters without the drawback of creating major production problems during waterflooding

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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