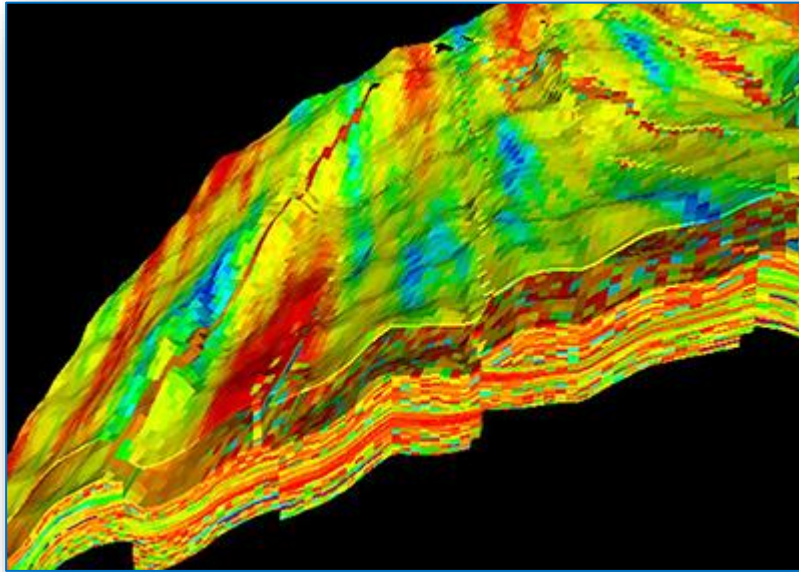




DE104

Fractured Reservoir Characterization, Evaluation and Modeling

Course Description:

This five-day course is designed for geologists, geophysicists and reservoir engineers who are part of multidisciplinary teams focusing on the integrated characterization, evaluation, modeling and development of naturally fractured reservoirs (NFR). The course not only provides an introduction to NFR and their development, but also covers state-of-art advances in fracture characterization and flow modeling technologies. The emphasis is on gaining understanding of how natural fractures impact subsurface flow and reservoir performance, and how to obtain and integrate geoscience and engineering data of NFR to best guide exploration, field development and engineering decisions.

The approach taught in this course is based on integration of engineering, geophysical and geological data at all scales and at all stages of field development. As such, the course provides specialized training in geological concepts of NFR for geologists and engineers to improve the engineer's use of geological and geophysical data, while simultaneously providing important concepts in fractured reservoir engineering for geoscientists to broaden their knowledge base of flow properties and fluid flow aspects of NFR.

Many of the topics covered in the course are accompanied by examples, case histories and periodic exercises to reinforce the key concepts, methods and results.

Course Objectives:

Upon successful completion of this course, the delegates will be able to:

- ✓ Characterize, evaluate and exploit naturally fractured reservoir resources
- ✓ Improve the engineer's use of geological and geophysical data, while simultaneously providing important concepts in fractured reservoir engineering for geoscientists to broaden their knowledge base of flow properties and fluid flow aspects of NFR.

Who Should Attend?

This course is intended for all geologists, geophysicists and reservoir engineers who are part of multidisciplinary teams to characterize, evaluate and exploit naturally fractured reservoir resources.

Course Outline:

Day 1:

FRACTURES IN SANDSTONES AND CARBONATES

- Clastic Depositional Systems
- Stratigraphic architecture of fluvial/deltaic systems & fracture development

- Examples from the Mesaverde Formation, Uinta Basin
- Stratigraphic architecture of aeolian systems & fracture development
- Examples from the Tensleep Formation
- Carbonate Depositional Systems
 - Stratigraphic architecture of carbonate systems
 - Carbonate precipitation, dolomitization & fracturing
 - Examples of carbonate systems from the Mideast & relation to fracture development
- Unconventional Reservoirs
 - Key aspects of fracturing in unconventional reservoirs
 - Characterization Strategies
 - Examples from the Appalachian Basin

STRUCTURAL GEOLOGY OF FRACTURES

- Geomechanics of Fracture Development
 - Stress/strain
 - Brittle vs. ductile deformation
 - Elements of fracture mechanics
- Fracture Formed During Folding
 - Common Classifications
 - Field Examples
- Fractures Formed During Faulting
 - Types of Faults
 - Fault Damage Zones
 - Riedel Model for Transpressive Tectonic Systems
- Determination of Fracture Development Timing Relative to Folding & Faulting
- Critical Stress

FRACTURE DETECTION (NON-SEISMIC)

- Core
 - What parameters can be obtained from core
 - Distinguishing natural fractures from artificial fractures
 - What to look for in core logging for fractures
- Outcrops
 - Lines surveys vs. areal surveys vs. non-systematic surveys
 - What parameters can be obtained from outcrop studies
 - Designing a field study of fracturing
- Lineament Data
 - What are lineaments?
 - Which type of lineament data is most useful?

- Field examples d. Fracture Image Logs
- What do FMI and related tools measure?
- How is fracture information obtained from an image log?
- What parameters can be obtained from an image log?
- Special considerations for estimating fracture size
- Comparison of core and image log data

Day 2:

SEISMIC DETECTION OF FRACTURES

- 3D P-wave volumes
 - Attributes
 - Ant Tracking
- 3D Multicomponent Data
 - Gaussian Curvature
 - Gaussian Curvature vs. Simple Curvature
- Pitfalls and Pre-Processing Steps
- Tomographic Fracture Imaging (TFI) Data
- Microseismic Data
- Case Histories

WIRELINE LOGS AND FRACTURING

- Conventional logs
- Dipole Sonic
- PLT
- Development of a Predictive Model for Fracture Intensity
 - Multivariate Regression
 - Multinomial Regression
 - Decision Trees
 - Neural Nets
 - Case Study

Day 3:

DISCRETE FRACTURE NETWORKS

- Overview of Discrete Fracture Network (DFN) Models
- Parameterization of DFN Models
 - Sets & Orientation Mechanical Stratigraphy/Facies
 - Intensity
 - Size
 - Intrinsic Flow Properties

- DFN Model Workflows
 - Transient flow modeling: RTA & PTA
 - Compartmentalization, Reserves and Well EUR
 - Full-Field Upscaling
 - Hydrofracturing Design
- Applications of DFN Models to Conventional & Unconventional Reservoirs (Case Studies)

NFR CHARACTERISTICS FOR RESERVOIR ENGINEERING

- Performance characteristics
 - Production mechanisms
 - Gas-oil-ratio, GOR, behavior
 - Fluid contact (GOC, WOC)
 - Water cut
 - Recovery mechanisms
 - Expansion
 - Imbibitions
 - Convection and diffusion
- Porosity modeling
 - Types of porosity
 - Effective fracture porosity
 - Correlating porosity to fracture density
- Permeability modeling
 - Types of permeability
 - Effective fracture permeability
 - Empirical fracture permeability model
 - Stress path-based fracture permeability prediction
 - Vugular fractured permeability
 - Porosity permeability cross plot anomalies
- Capillary pressure
 - Drainage and imbibitions
 - Measurement and estimation methods
- Classification of fractured reservoir types
 - Based on permeability
 - Example of 100 fractured reservoirs
 - Ranges of oil recovery factor

Day 4:

FRACTURED RESERVOIR MODELS

- Equivalent single porosity

- anisotropic model
 - calculation example
- Double porosity model
 - Pseudo steady state
 - Concept
 - Flow transport representation
 - Transient flow
 - Concept
 - Flow transport representation
 - Shape factor
- Double permeability model
 - Concept
 - Flow transport representation
- MINC model
- Sub-domain models
- Gravity drainage model

WELL TESTING OF FRACTURED RESERVOIRS

- Pressure transient flow modeling basics
- Storativity and interporosity flow parameters, ω and λ
- Well test characteristics and analysis methods
 - Apparent single porosity homogeneous model
 - Single fracture behavior
 - Conductive fractures
 - Double porosity models
 - Double permeability model
 - Triple porosity model for vugular NFR
 - Examples
- Stochastically distributed fractures
 - Fractal model behavior
 - DFN model behavior
- Well productivity index modeling
- Integration of core and well test permeabilities

MODELING SPECIAL TRANSPORT PROPERTIES OF FRACTURES

- Relative permeability
 - Matrix
 - Fracture
 - Correlations

- Capillary pressure, oil-gas and oil-water
 - Matrix
 - Fracture
 - Effect of water and gas injections
- Pseudo capillary pressure – combined gravity and capillarity
- Wettability
 - Definitions
 - Laboratory measurements
 - Significance in oil recovery
- Wettability alteration
 - Why there is need for it?
 - Impact on oil recovery

Day 5:

MODELING GRAVITY DRAINAGE IN NFR

- Gravity drainage mechanism formulation
- Sensitivity to fluid and transport properties
- Single block calculations
 - Capillarity
 - Wettability and imbibition
- Multiple block fractured stacked column
 - Capillary discontinuity model
 - Capillary continuity model
- Gravity drainage mechanism modeling in gas cap of NFR
- Gravity drainage mechanism modeling in water-invaded region of NFR
- Coning modeling in NFR
 - Gas coning
 - Water coning

OVERVIEW OF RESERVOIR SIMULATION OF NFR

- Fundamentals of fluid flow equations
- Transfer functions
 - Between matrix and fracture
 - Block to block interaction
- Pseudo capillary pressure model for integration of gravity and capillarity
 - Gas zone
 - Water zone
 - Examples
- Simulating oil recovery in NFR

- Single block
- Stack of matrix and fracture column
- Recovery factors for NFR

IOR/EOR CONCEPTS IN NFR

- Water and gas injections
- Chemical EOR potentials
- Reservoir management issues
 - Pitfalls
 - Technical awareness
 - Strategies for reservoir management
 - Illustrative field examples

CASE STUDIES ON INTEGRATED RESERVOIR MODELING OF NFR

- Shengli field – China
 - Geophysical aspects
 - Petrophysical considerations
 - Discrete fracture model
 - Integrated static model
 - Integrated dynamic model
 - Oil recovery scenarios
- Cantarell field – Mexico
 - Geological model
 - Fracture distribution
 - Fracture flow properties
 - Reservoir simulation model
 - Integrated reservoir performance
- Cactus field - Mexico
 - Dolomite for fracture intensity
 - PVT and fluid property linked to fracturing
 - Discrete fracture modeling
 - Well test characteristics
 - Intergraded reservoir model
 - IOR/EOR evaluations

Course Certificate:

International Center for Training & Development (ICTD) will award an internationally recognized certificate(s) for each delegate on completion of training.

Course Methodology:

A variety of methodologies will be used during the course that includes:

- (30%) Based on Case Studies
- (30%) Techniques
- (30%) Role Play
- (10%) Concepts
- Pre-test and Post-test
- Variety of Learning Methods
- Lectures
- Case Studies and Self Questionnaires
- Group Work
- Discussion
- Presentation

Course Fees:

To be advised as per the course location. This rate includes participant's manual, hand-outs, buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Course Timings:

Daily Course Timings:

08:00 - 08:20	Morning Coffee / Tea
08:20 - 10:00	First Session
10:00 - 10:20	Coffee / Tea / Snacks
10:20 - 12:20	Second Session
12:20 - 13:30	Lunch Break & Prayer Break
13:30 - 15:00	Last Session