Applied Concepts in Fractured Reservoirs with Discussions on Production, EOR, CO2 Sequestration and Geothermal Energy (G039)

Tutor(s)

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Overview

This course explores the wide range of structures that fall under the term ‘fracture’ and examines the effects of different fracture types on permeability in conventional and unconventional hydrocarbon reservoirs, and for EOR, CO2 sequestration and geothermal energy applications. The course establishes an understanding of natural fractures by explaining fracture mechanics and the origins of fractures, and then presents practical approaches to analyzing and working with fractures. Topics will include: collecting fracture data; measuring fracture attributes; differentiating natural from induced fractures; calibrating fracture data (from core, CT scans, outcrops, image logs and seismic); and determining in situ stresses. The course also describes how to predict fracture types in different structural domains and in different types of reservoirs, how the differences between extension and shear fractures control both individual fracture permeability and fracture network interconnectedness, and how to assess the interaction between natural and hydraulic stimulation fractures. Discussions of the applications to CO2 sequestration, geothermal energy, hydrocarbon reservoirs and enhanced recovery are included.

Duration and Logistics

Classroom version: A 3-day classroom course comprising a mix of lectures (80%) and hands-on exercises (20%). The manual will be provided in digital format and participants should bring a laptop or tablet computer to follow the lectures and exercises. A highlight of the classroom version is the inclusion of a hands-on, 65-plus piece teaching collection of natural and induced fractures in core.

Virtual version: Five 4-hour interactive online sessions presented over 5 days. A digital manual and exercise materials will be distributed to participants before the course. Some reading and exercises are to be completed by participants off-line.

Level and Audience

Advanced. Intended for geoscientists, reservoir and completion engineers, and petrophysicists, who wish to characterize and understand fracture systems and their effects on reservoir permeability and fluid flow. The class includes assessing how fracture permeability is affected by the in-situ stress system, and the interaction of natural fractures with hydraulic stimulation fractures.

Objectives

You will learn to:

1. Appreciate how different fracture types have different effects on reservoir permeability and fluid flow.

2. Assess how fracture types can vary by lithology within the same structural setting.
3. Establish how fracture types can vary by structural setting within the same lithology.
4. Assess fracture permeability and how it can be sensitive to changes in the in-situ stress during production and injection.
5. Recognize fracture type using the small sampling of a reservoir offered by core and how this can provide a conceptual model for differentiating radial from anisotropic drainage, or flow away from the well during injection.
6. Appreciate the interaction of natural fractures with hydraulic stimulation fractures as utilized in hydrocarbon, sequestration and geothermal industries, depending on fracture type and orientation relative to the in-situ stresses.
7. Use insights into fracture mechanics and the origins of fractures, and gain an understanding of natural fractures and their potential effects on fluid flow.

Course Content

Part 1: Understanding natural fractures – types, dimensions and origins

- Nomenclature and fracture classification systems
- Fracture characteristics and dimensions – individual fractures, fracture populations and fracture systems
- Identifying natural fracture types
- The geologic origin of stress systems capable of fracturing rock
- The mechanics of fracturing rock in extension and shear
- The essential importance of pore pressure in fracture mechanics
- Correlating laboratory and outcrop fracture observations to theoretical fracture mechanics
- Mechanical stratigraphy: fracturing in carbonates vs sandstones vs shales
- Fractures related to faults and anticlines: the characteristics of fracture corridors and sweet spots
- Additional fracture types

Part 2: Measuring and analyzing natural fractures

- Planning a fracture study: getting the most out of fracture measurements
- Fracture data sources: core, CT scans, outcrops, image logs and seismic data
- Fracture data from engineering tests
- Techniques, methodologies and work flows
- Coring and core processing protocols
- Logging core for optimum fracture characterization
- Distinguishing natural from drilling-induced fractures
- Analyzing fracture data for use in fluid-flow models
- Case studies: estimating fracture effectiveness from core data

Part 3: The effects of natural fractures

- Fractured-reservoir classification
- Effects of fractures on drilling and coring
- Fracture volumetrics
- Case studies: the Midale Field, the Rulison Field and the Spraberry Formation
- The permeability behavior of individual fractures
- The permeability and flow behavior of fracture systems
- The sensitivity of individual fractures and fracture-system permeability to changing stresses during production and injection
- The effects of fault and fracture-controlled sweet spots and barriers
- Completions: the interaction between natural and hydraulic fractures