

Trap and Seal Analysis: Theory and Application (G090)



Tutor(s)

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Overview

This course introduces the concepts and methods in trap and seal analysis, particularly in relation to fault characterization, including fault mapping and fault seal, as applied to cross-fault flow resistance in traps for hydrocarbons and carbon containment in subsurface reservoirs. The course additionally includes the analysis of caprock (top seal) for predicting seal capacity and evaluating risks associated with capillary and mechanical controls. Overall, the course emphasizes the importance of an integrated approach to trap and seal analysis in subsurface reservoirs. The lectures introduce fundamentals and advanced concepts for faulting and flow for the prediction of fault behavior in subsurface traps and the concepts discussed are applied in simple exercises to reinforce learning.

Duration and Logistics

Classroom version: A 4-day classroom course, comprising a mix of lectures (65%) and hands-on exercises (35%). The manual will be provided in digital format and participants will be required to bring a laptop or tablet computer to follow the lectures and exercises.

Virtual version: Five 4-hour interactive online sessions presented over five days. Digital course notes and exercise materials will be distributed to participants before the course. Some exercises may be completed by participants off-line.

Level and Audience

Intermediate. The course is intended for geoscientists (geologists and geophysicists) and petroleum engineers, so they can apply these principles in their subsurface projects.

Objectives

You will learn to:

1. Analyze fault geometries and architecture, apply this knowledge to make robust fault interpretations.
2. Assess fault rock types and properties and likely impacts on fluid flow across and along faults.
3. Conduct juxtaposition seal analysis and employ triangle diagrams.
4. Apply algorithms, such as SGR and CSF, for predicting clay contents across faults.
5. Assess the relationship between threshold pressure and fault seal capacity against the clay content predicted across fault surfaces.
6. Characterize faults as potential migration and leakage pathways.
7. Evaluate the geomechanical and capillary properties of top seal units.

Course Content

Course Details

The course is divided into ten topics:

- 1. Introduction to fault mapping and trap and seal characterization**
- 2. Fault geometry mapping and fault zone architecture**
 - Introduction to fundamental characteristics of fault geometry, fault linkage and fault throw distribution, and development of fault zones and fault rock
 - Interpretation techniques and pitfalls
- 3. Fault Rock Properties**
 - Different fault rock types are discussed with examples showing differences in mechanical and chemical deformation that may impact fluid flow
 - Description, examples at macro- and micro-scale and deformation mechanisms
- 4. Flow Basics**
 - A theoretical introduction to the basic concepts of flow through porous media including capillary and permeability controls and differences for hydrocarbon and CO₂
 - Permeability and Darcy's Law
 - Capillarity threshold pressure
 - wettability
 - interfacial tension
 - Sealing capacity
 - Relative permeability
- 5. Fault Mapping**
 - Juxtaposition seal
 - Fault rock seal
 - Shale Gouge Ratio (SGR)
 - Clay Smear Factor (CSF)
 - Effective Shale Gouge Ratio (ESGR)
 - Relationship between threshold pressure and sealing capacity of faults
 - Relationship between threshold pressure, permeability and clay content
- 6. Triangle Diagrams**
 - A quick and efficient method to evaluate the sealing capacity of faults based on modeled stratigraphy from well logs or derived from the expected depositional setting
 - Discussion of application and pitfalls of this methodology
- 7. Faults in simulation**
 - Review and methods of fault rock properties in reservoir flow simulation
- 8. Geomechanics as applied to up-fault flow risks**
 - Faults as migration routes and paths
 - Fault reactivation and along fault flow risks
- 9. Fundamentals of top seal (caprock) analysis**
 - Mechanical and capillary controls
- 10. Validation, Risk and Uncertainty**
 - A discussion of validating the fault seal from available behavior and discussion of

associated risks and uncertainty

Customization

Additionally, the course offers an optional fifth day for an in-house group, which serves as a workshop for participants interested in analyzing their own data and discussing specific trap and seal issues. This workshop provides an opportunity to explore potential solutions and gain practical experience in applying the principles covered throughout the course.