N435: The Analysis of Fractured Reservoirs *(Wyoming, USA)*

Instructor(s): Paul MacKay and Hutch Jobe

Format and Duration

Field - 5 Days
Moderate Physical Demand

Summary

The course uses outcrop analysis, lectures, and exercises to develop the skills required to analyze and interpret fractured reservoirs. An integrated and practical approach to data-gathering, reservoir characterization, and reservoir modelling is developed by demonstrating a range of field techniques for fracture measurement. Discussion of rock / fluid interactions is included. A multi-disciplinary approach addresses interpretation of fracture data from seismic, geological, and engineering perspectives.

Learning Outcomes

Participants will learn to:

1. Characterize fractured reservoirs (tight sandstones, carbonates and shales).
2. Analyze how fractures form.
3. Evaluate the behaviors of fracture patterns across differing rock types and structural styles.
4. Assess the role of fractures in fluid transfer.
5. Create a development strategy for a fractured reservoir.
6. Implement subsurface techniques for recognizing fractures.
7. Measure outcrops in the field.
8. Gauge the role of bed thickness.
9. Assess outcrop imagery acquired by drones for fractures.

Training Method

This five-day field course is based in Lander, Wyoming, and visits outcrops in the Wind River and Big Horn basins. Fieldwork (50% of time) is supported by lectures, team exercises and discussion (50% of time). The course is structured so that the week is an ongoing group discussion on fractured reservoirs. Participants are encouraged to share their own experiences with fractured reservoirs and to bring examples and presentations for discussion.

Physical Demand

The physical demands for this class are MODERATE according to the Nautilus field course grading system. A good general level of fitness is required. There are a number of stops above an altitude of 2000 m (6500 feet), with the highest stop being 2700 m (8860 feet). Many of the hikes are less than 2 km (1.3 miles) but with the increased altitude apparent physical ability may be affected. Weather conditions can be highly variable during the week.

Who Should Attend

The course integrates geoscience and engineering topics and is designed to appeal to geologists, geophysicists, reservoir engineers, completion engineers and drilling engineers. When geoscientists and engineers working on the same asset have attended in the past, they have remarked that the course is a

powerful tool to help them develop an integrated approach to fractured reservoirs.

Course Content

In many petroleum systems, the challenge is not to find the hydrocarbon accumulation but rather how to produce it at economically viable production rates. Natural fracture systems that create permeability pathways can enhance well bore drainage and yield higher production rates. Fracture concerns have traditionally been associated with structurally complex reservoirs; however, the recent emphasis on resource plays has shown that fractures are naturally occurring phenomena in most petroleum reservoirs and their evaluation has become an integral component of economic risk analysis.

Fracture systems are complex. Fracture analysis is difficult and at times appears to be unpredictable. Collection of fracture data can be expensive and is often overlooked in the effort to complete a well in a cost-efficient manner. However, wells that grossly overproduce their predicted rates and volumes are generally assumed to be enhanced by fracture systems and many corporations now design their well location strategy to maximize the potential to intersect natural fracture systems.

The study of fractures in outcrops can provide a clear picture of natural fracture systems. Data collected at the surface can be integrated into a subsurface data base to aid in tasks such as well trajectory placement, reservoir management, reservoir simulation models, resource development plans and exploration design.

Despite the advantages of studying fractures in outcrop, few groups do so. One of the reasons is that the task is initially daunting and it is difficult to develop a sound strategy that will allow the study of the fracture systems in a time-effective manner. Another is uncertainty in how to integrate the data, once acquired, into subsurface geological, geophysical, and engineering interpretations.

In terms of understanding how fluid moves through a reservoir, the recognition of the role that fractures play has been revolutionary: seismic techniques have been developed to help identify fracture systems, reservoir simulation models routinely incorporate fracture anisotropy into their design, well logging programs are built around acquiring good well bore images, and design of well completions programs begins with knowledge of the natural fracture system. In all of these new advances, much of the analysis is based on an assumption that fracture patterns are regular and predictable. Where does this assumption come from? Is this reliable and if so what inherent risks lie within this assumption? To answer this question and to truly understand fracture systems the modern geoscientist must return to their roots, the outcrop.

This course is designed to address these issues. The course is field-based, but there will be a strong emphasis on integrating field observations with subsurface data to create a three dimensional view of the reservoir in the subsurface. The course is designed with the practitioner in mind. Although there is a certain degree of theoretical material to review, the emphasis will be directed to a discussion on how the information can help the geoscientist develop a more thorough model of a hydrocarbon reservoir and how can this knowledge be applied to improve the ultimate economic results of the project.

N435: The Analysis of Fractured Reservoirs *(Wyoming, USA)*

Instructor(s): Paul MacKay and Hutch Jobe

Format and Duration

Field - 5 Days
Moderate Physical Demand

There will be some discussion of the regional geology so that the outcrops can be put into tectonic context. The Wind River and Big Horn areas have several excellent outcrop exposures of fractured carbonate and clastic strata that produce hydrocarbons nearby. Participants will be shown how to collect and analyze field data; field exercises will allow participants to work through some of the issues associated with fracture analysis. There will be morning lectures to provide background information and to present case studies that will be useful templates for integration of surface and subsurface data.

Itinerary (subject to change)

Day 0

- Travel to Riverton, WY, and transfer to Lander, WY.
- Class: Introductory lecture, safety brief and what to expect; dinner.
- Overnight: Lander.

Day 1

- Class: Introduction to fracture systems, regional geology.
- Field: Dubois, Wilderness, Sinks Canyon.
- Overnight: Lander.

Day 2:

- Class: Unconventional plays and the role of permeability; case studies.
- Field: Muddy Gap, Sheep Mountain.
- Overnight: Lander.

Day 3

- Class: Analytical techniques to describe fracture and investigate their impact on fluid flow; case studies.
- Field: Red Grade, Deep Creek (for fractures)
- Overnight: Lander.

Day 4

- Field: Wind River Canyon, Waugh, Hamilton Dome; case studies.
- Overnight: Lander.

Day 5

- Class: Deep basin gas, fluid flow through sedimentary basins; case studies.
- Field: Frontier outcrop.
- Class: Course wrap-up and feedback.

- Overnight: Lander.

Day 6

- Travel home from Riverton, WY.