
N371: Natural Fractures and Production in Different Reservoir Lithologies, Examples and Analogs from the San Juan Basin (*New Mexico and Colorado, USA*)

Instructor(s): John Lorenz, Scott Cooper and Bruce Hart

Format and Duration

Field - 6 Days
Moderate Physical Demand

Summary

This field seminar explores a wide range of fracture characteristics and their potential effects on shale, sandstone, carbonate and granite reservoirs.

Participants will learn how different fracture types form, what kinds of fracture distributions are likely and how to determine whether fractures will enhance or degrade reservoir production.

Learning Outcomes

Participants will learn to:

1. Assess the difference between shear and extension fractures and their significantly different effects on permeability anisotropy.
2. Assess the significantly different permeability effects of different shear fracture types.
3. Design and manage workflows for acquiring fracture data from cores and outcrops in order to better understand fractured reservoirs.
4. Assess and characterize some of the relationships between faults and fractures.
5. Evaluate the interaction between natural and hydraulic stimulation induced fractures.
6. Evaluate the interaction of mechanical properties, confining stresses, pore pressure and temperature in the generation of natural fractures in different rock types including shales, sandstones, carbonates and granites.
7. Assess and differentiate natural and induced fractures in cores and outcrops, and determine their relationship to the in situ stresses.
8. Estimate the effects on a reservoir of natural fractures based on outcrop data.
9. Evaluate faults and associated fractures seen in the outcrop and what their signature may be in seismic data.
10. Develop an appreciation and understanding of the wide range of structures and fracture types that are commonly lumped into the category of “fractured reservoir”.
11. Develop an understanding of the regional tectonic setting, stratigraphy and geologic history of the San Juan basin and surrounding mountains.

Training Method

A field seminar starting in Albuquerque, New Mexico, and ending in Durango, Colorado. The proportion of field time to classroom time is about 8:1.

This course is conducted primarily in the field, with discussions and exercises on the outcrop. Lectures and core viewing will be based on each tutor’s extensive field and industry experience.

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Physical Demand

The physical demands for this class are **MODERATE** according to the Tetra Tech RPS field course grading system. Fieldwork is in the San Juan basin area of northwestern New Mexico and southwestern Colorado, where the climate is cool-hot and dry with possible afternoon thunderstorms. The lowest elevation is 1600m (5600 ft) in Albuquerque with higher elevations at Mesa Verde National Park 2440 m (8000 ft); average elevation is approximately 2135 m (7000 ft). Participants will take several short to moderate hikes (less than 3.2 km (2 miles) each) over flat to hilly terrain with one hike having an elevation change of 275 m (900 ft). Transport is by SUVs. Most driving is on black-top roads, but some areas are reached by gravel or dirt roads. The total driving distance on this field course is approximately 1300 km (800 miles).

Who Should Attend

Geoscientists and engineers who need to characterize, assess and manage naturally fractured hydrocarbon reservoirs within a variety of lithologies will benefit from this class. Managers and geoscientists who need a basic understanding of the parameters and important features of fractured reservoirs, and/or who need to optimize data-collection and formulate work flows for both exploration and production from fractured reservoirs, should consider this class.

Course Content

The field course includes study of numerous outcrops, field exercises, and short lecture illustrating fractures and their variations in shale resource plays, in conventional sandstone and carbonate reservoirs, and in granitic facies. A hands-on teaching collection of over 50 fractured core samples will be utilized to let students assess various types of fractures and differentiate drilling-induced fractures from natural fractures. On the outcrop, discussions will include production in the unconventional reservoirs of the San Juan Basin. Students will leave the course with a working knowledge of applied fracture studies, and how to optimize the acquisition of fracture data in order to best understand fractured reservoirs.

Topics included in outcrop and lecture discussions:

1. Fracture types and variability in various lithologies and structural settings
2. Fractures and faults
3. Fracture surface ornamentation (fractography) and mineralization
4. Distinguishing natural fractures from induced fractures
5. Extrapolating outcrop fractures into the subsurface
6. Optimizing fracture data collection in core and outcrop
7. Mechanical stratigraphy
8. Fractures in shales vs. fractures in sandstones vs. fractures in carbonates
9. Effects of lithology and structure on fracture distribution

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10. Effects of different fracture types on reservoirs
11. Changes in fracture permeability during production
12. The interaction between natural fractures and hydraulic stimulation fracture
13. Fractures and seismic data

Itinerary

Day 0

- Arrive in Albuquerque, New Mexico
- Classroom: field trip overview presentations, logistics and safety, overview of regional stratigraphy, introduction to natural fractures in outcrop, characteristics, and identification of fracture types and their importance to hydrocarbon production
- Overnight in Albuquerque

Day 1

- Drive from Albuquerque to Bernalillo, New Mexico
- Classroom: petroleum geology and seismic, interaction between hydraulic stimulation fractures and natural fractures, differences of fracturing in carbonates vs sandstones and shales
- Field: outcrops of fractures, folds and faults in Pre-Cambrian granite, Paleozoic carbonates, Paleozoic shales, and Cretaceous sandstones
- Overnight in Bernalillo, New Mexico

Day 2

- Drive from Bernalillo to Santa Fe, New Mexico
- Field: outcrops of Cretaceous sandstones and shales in the vicinity of the normal fault and fracture zone complex near San Ysidro. Structures to be viewed include: conjugate deformation bands in the Morrison Formation, amalgamated deformation bands in the Dakota Sandstone, superimposed fracture systems, Mancos shale, fracture halos on faults, and fractures in folded strata
- Overnight in Santa Fe, New Mexico

Day 3

- Drive from Santa Fe to Chama, New Mexico
- Field: sheared extension fractures in Triassic sandstone at Abiquiu dam; fractures in the Mancos shale around El Vado and Heron lakes; fractures associated with faults and vertical extension fractures and conjugate thrust shears in the Dakota Sandstone at Heron Lake
- Overnight in Chama, New Mexico

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Day 4

- Drive from Chama, New Mexico to Durango, Colorado
- Field: the Archuleta igneous dike swarm (analog to hydraulic fractures); the Gasbuggy Nuclear Stimulation site; fractures in the Tertiary sandstones at Navajo Dam, San Juan River; outcrop discussion of San Juan Basin production additional discussion of surface vs subsurface fractures in outcrop; Hogback Monocline (fold-related vs. pre-fold fractures and shear vs. extension); fractures in the siltstones of the Lewis Shale.
- Discussion of production in "shales"
- Overnight in Durango, Colorado

Day 5

- Drive from Durango to Mesa Verde National Park, Colorado
- Field: Mesa Verde National Park visitor center; Point Lookout Sandstone overlook with review of fracture types and variability we have seen by lithology and structural setting and an overview of Mesa Verde Park geologic setting; stratigraphy and cleats/fractures in coal beds within the Menefee Formation; discussion of coal bed methane production. Cultural visits to Anasazi ruins at Mesa Verde National Park
- Overnight in Durango, Colorado

Day 6

- Field: a hike up Animas Mountain, to view the geologic setting of the Durango area, stratigraphy, and fractures in the Dakota Sandstone, and the terminal moraine of the latest glacier. Discuss compression to the south related to the San Juan uplift; stratigraphy and fractures in the Pictured Cliffs Sandstone and the Mancos Shale on the Hogback Monocline
- Classroom: morning lecture on natural and induced fractures in core with core workshop
- Overnight in Durango, Colorado

Day 7

- Depart from Durango, Colorado