

# Structural Styles and Fault Characterization in Exploration and Production, Moab, Utah (G078)



## Tutor(s)

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## Overview

This field course utilizes outstanding exposures of faults, fault rocks and stratigraphy in Colorado and Utah to examine seismic and subseismic scale fault geometries, fault zone architecture and controls on cross-fault flow. The aim of the course is to improve the understanding of uncertainties in the mapping of complex fault zones and the processes that create potential seals and compartmentalization in reservoirs in the subsurface for oil and gas, as well as CO<sub>2</sub>. Field exercises complement classroom lectures on the interpretation of faults, seal assessment and associated risks. Group exercises are included as prospect interpretation of compartmentalization from outcrop exposures.

## Duration and Logistics

A 7-day field course with a mixture of outcrop examination and discussion (70%) and supporting classroom lectures (30%). Exercises on the outcrop are designed to apply common methodologies for fault seal analysis with observed fault zone characteristics.

## Level and Audience

**Intermediate.** This course is suitable for geologists, geophysicists and reservoir engineers engaged in the interpretation of faults and the assessment of fault seal in reservoirs for exploration, development and CO<sub>2</sub> containment.

## Exertion Level

The field component of this course requires a **MODERATE** exertion level. There will be some short hikes to outcrops (no more than 3.5 miles / 5.6km round trip), some over uneven and rocky ground with some short, steep inclines no greater than 700 feet (200 meters). The climate in southern Utah during the spring and fall is variable with temperatures from 50°F (10°C) to hot and dry up to 100°F (38°C). The elevation is between 4,000 and 5,000 feet (1200 to 1500 meters).

## Objectives

You will learn to:

1. Describe the regional geologic framework of the field area, the main stratigraphic units and the principal structural features.
2. Characterize the mechanisms of faulting, fault propagation and the controls on the size, distribution and population of normal faults.
3. Observe deformation and faults in outcrop to constrain likely structural and fault geometries in the subsurface.
4. Characterize common trapping mechanisms and seal potential of fault rocks.

5. Examine and assess fault rock properties and evidence of fluid flow at outcrop scale to better understand subsurface flow in reservoir and fault rocks.
6. Establish trap and seal controls.
7. Perform juxtaposition analysis and fault rock distribution mapping (SGR and CSF / SSF).
8. Employ and interpret triangle diagrams.
9. Understand key simulation techniques and modelling of faults.

## Course Content

### Course Details

The outcrops in western Colorado and southeastern Utah provide an outstanding natural laboratory for the study of fault processes, fault geometries and fault rocks. The field course examines basement-involved faulting and folding on the flanks of the Uncompahgre Uplift and the deformation in the adjacent Paradox Basin. The presence of a thick evaporite section in the Paradox Basin has reacted to, and is influenced by, the early extensional structural regime in the basin. The resulting salt-cored anticlines and salt withdrawal synclines were later enhanced by Laramide (late Cretaceous) shortening. The course will examine the beautifully exposed faults and folding developed around these structures.

The main objective of the trip is to use field exposures supported by classroom lectures and exercises to promote interpretation and understanding of the structural styles and fault seal processes that have operated during the tectonic history. The course will discuss methods to improve the interpretation of similar styles in the subsurface. At the conclusion of the training, participants should have a fundamental understanding of fault seal methods and the associated strengths and weaknesses to apply in their exploration and development projects.

The course may also be modified in duration or content based on a particular client's focus or interest.

### Day 1: Arrive in Grand Junction

Classroom:

- General logistics and safety
- Goals
- Fault geometry styles, particularly as related to extensional features and salt
- Regional geology

*Overnight in Grand Junction.*

## Day 2: Uncompahgre Plateau and Paradox Basin

Fieldwork:

- Overview of regional geology of the Uncompahgre Plateau and Paradox Basin, and observation of basement-involved deformation – Colorado National Monument and Fisher Towers
  - Overviews of structure and stratigraphy
  - Folding and fracturing in the sedimentary cover
  - Fault geometry styles
  - Exercises on basement-involved deformation

*Overnight in Moab.*

## Day 3: Arches National Park

Fieldwork:

- The day will be spent in and around Arches National Park examining normal fault styles and linkages and reservoir-scale fault compartmentalization – Moab Anticline and Salt Valley Anticline
  - Introduction to the local geology and examination of structures
  - Exercises and discussion of fold styles associated with normal faults, subseismic fault relationships and fault compartmentalization in reservoirs
  - Overviews within Arches National Park, ‘rift fault styles’, fault linkages (relay ramps), and the Salt Valley Anticline
  - Discussions of deformation bands and impacts on flow in reservoirs
  - Introduction to juxtaposition methods for fault seal analysis
  - Map exercise of normal fault geometry at ramp leading to Delicate Arch

*Overnight in Moab.*

## Day 4: Moab Fault Zone

Classroom:

- Lecture on fault seal analysis

Fieldwork:

- Investigation of Moab Fault segments, relay ramp geometries and associated fracture systems, fault seal analysis and fault rock characteristics -Moab Fault Zone and Mill Canyon
  - Mapping fault linkages and discussion of fault zone architecture along exposed segments of the Moab Fault
  - Mill Canyon – relay ramp overview and examination of fault contacts and breached relay ramp along Moab Fault
  - Map exercise to review normal fault linkages and associated deformation
  - Fault zone architecture involving clay-rich sediments with reservoir section
  - Observations and discussion of impacts of deformation in damage zones

*Overnight in Moab.*

## Day 5 Moab Fault

Classroom:

- Lecture on faults in reservoir flow simulation

Fieldwork:

- Moab Fault internal fault zone architecture and deformation around salt diapirs. Comparison of deformation in different stratigraphy, subseismic deformation and fluid flow impacts – Arches National Park
  - Subseismic faults and fault zone architecture
  - Fault zone processes in well-exposed fault zone with clay and sand smear
  - Group exercises and presentations

*Overnight in Moab.*

## **Day 6 Salt-related deformation, Moab to Grand Junction**

Fieldwork:

- The day will be spent travelling back to Grand Junction via Onion Creek to examine an exposed diapir and deformation in rocks marginal to the diapir.
  - Salt-related deformation
  - Deformation style changes from shallow to deep
  - Discussion of extensional structural styles and compressional influence

*Overnight in Grand Junction.*

## **Day 7: Departure**

*Departure and travel home.*