
N464: Fractured Reservoir Assessment and Integration to Full Field Development (*Montana, USA*)

Instructor(s): Dave Cannon and Creties Jenkins

Format and Duration

Field - 6 Days

High Physical Demand

Summary

This course provides geoscientists and petroleum engineers the knowledge and understanding of how naturally fractured rocks should be integrated into unconventional development scenarios. It provides key, field-based examples of natural fractures occurring in multiple lithologies and structural settings. This course will include a Capstone group exercise culminating in a fully integrated development plan, that may change in response to variations in unconventional reservoir fabric.

Learning Outcomes

Participants will learn to:

1. Characterize natural fracturing in multiple structural settings.
2. Conduct key field measurements assessing fracture fabric characteristics associated with lithology and structural style.
3. Evaluate field examples of natural fracturing and integrate into structural models to be utilized in unconventional development.
4. Appraise natural fracture fabric for fluid flow capabilities in subsurface reservoirs.
5. Evaluate natural fracture fabric for operational risks.
6. Construct a development plan for unconventional reservoirs with a group of peers that integrates lithological variability, changes in structural setting, and the resulting natural fracture patterns.
7. Assess and prescribe action for complete operational implementation of a Capstone exercise development plan; this includes drilling, completions, and production.

Training Method

This six-day field course will consist of course discussions and materials derived from on-site geological investigation. The group exercise will provide limited, but key information from a hypothetical basin setting. At the end of the training period, an all-day wrap up will include informal group presentations of a Capstone project.

Physical Demand

The physical demands of this class are (HIGH) according to the Nautilus field course grading system. A strong level of fitness will be required. Starting elevation at field base of operations is 5000 feet and the highest elevation reached by foot will be 6400 feet. Some hikes will be longer than 2 miles and will require stream crossings. Weather conditions can be highly variable.

Participants attending N464 will be staying at the Deep Canyon Guest Ranch for the majority of the field course (Days 2-6). Instructors hand-picked this location because of the proximity to the Teton Anticline and the ideal setting for the course.

Lodging at the ranch consists of 3 duplex cabins and 2 large cabins that combined will house 21 participants, one person to a bed. **Please note participants will have to share rooms depending on the final number of attendees.**

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Who Should Attend

This field seminar is intended for geological and engineering professionals that undertake the appraisal and development of unconventional resources that involve natural fabric, which can cause variability in production and economic outcomes.

Course Content

Throughout the duration of the field course, it is encouraged that the groups find time after the daily field work to collaborate on their Capstone project. Additionally, synthesizing data from field collections will be necessary for final integration into the project deliverables. Key synthesized products will be fold profiles of all transects with fracture information posted in stereonet form, and regional fracture synthesis of difference in fabric according to structural domain. Course instructors will be mindful of the daily schedules, so teams have sufficient time to work on their projects prior to group dinners.

Day 0

- Travel to Great Falls, MT and transfer to Great Falls lodging.
- Class: Introductory lecture and group dinner – Introduce the geologic context of Sawtooth Range and Western Montana foreland basin, both stratigraphic and structural history. Also assign “team” members for the Capstone project to be completed at the end of the course.

Day 1

- Field: Observe and measure fracture trends in Cretaceous mixed lithology formations in a structurally “quiet” foreland basin setting.
 - Stop 1 – Rainbow Falls Overlook: Upper Kootenai Formation (Lower K) fractured outcrops along the Missouri River at Great Falls.
 - Stop 2 – Giant Springs State Park: Lower Kootenai Formation (Lower K) fractured outcrops along the Missouri River at Great Falls.
 - Stop 3 – Rainbow Falls Pavement: Lower Kootenai Formation (Lower K) fractured pavement outcrop in the Missouri River at Great Falls.
- Return to Great Falls lodging for brief classroom discussion and release for dinner.

Day 2

- Travel: Check out of Great Falls lodging and drive towards Choteau, MT.
 - Stop 1 – First People’s Buffalo Jump State Park: Vaughn and Bootlegger Members of Blackleaf Formation (Lower K), distal foreland basin overview.
 - Stop 2 – Fairfield Overview: Scenic overview stop to introduce the proximal foreland basin setting and Sawtooth Range.
 - Stop 3 – Priest Butte: Virgelle Formation (Upper K) fractured outcrops in proximal foreland setting.

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- Continue to lodging at Deep Canyon Guest Ranch for evening to check in and conduct brief classroom discussion of Teton Anticline and Greater Montana Disturbed Belt and group dinner.

Day 3

- Main Teton Anticline Traverse: Depart on foot from Deep Canyon Guest Ranch to traverse the main anticline (Teton Anticline) and parasitic anticline (Little Teton Anticline) twice, north and south of the North Fork Teton River
 - Stops will involve measurement of dip planes and fracture trends to begin construction of a fold profile and model for fracture generation in response to folding.
 - Traverse will involve river crossings on foot. Hike will be quite strenuous with frequent climbs on 30 to 35-degree dipping planes on uneven outcrop and talus.
- Return on foot to Deep Canyon Guest Ranch for brief classroom discussion and group dinner.

Day 4

- Southern Teton Anticline Traverse: Depart on foot from Deep Canyon Guest Ranch to traverse the southern portion of the field area.
 - Stops will involve measurements of dip planes and fracture trends to further construction of fold profile and fracture model.
 - Key observations about fold geometry changes should be made.
 - Will encounter both Mississippian carbonates and Jurassic/Cretaceous clastics (Lower Cretaceous Kootenai, Lower Cretaceous Mount Pablo, Upper Jurassic Ellis Group and Morrison Formation). Key observations about fracture pattern change based on lithology are important takeaways from this traverse.
 - Additionally, we will observe and measure an exposed concretion field that will display unique fracture trends that can be helpful for stress field reconstruction.
 - Traverse will involve river crossings on foot. Hike will be quite strenuous with frequent climbs on 30 to 40-degree dip planes on uneven outcrop and talus.
- Return on foot to Deep Canyon Guest Ranch for brief classroom discussion and group dinner.

Day 5

- Northern Teton Anticline Traverse: Depart on foot from Deep Canyon Guest Ranch to traverse the northern portion of the field area.
 - Stops will involve measurements of dip planes and fracture trends to further construct a fold profile and fracture model.
 - Key observations about fold geometry changes should be made.
 - Will encounter Cretaceous clastic sediments (Lower Cretaceous Kootenai, Lower Cretaceous Mount Pablo, Upper Jurassic Ellis Group and Morrison Formation). Key observations about fracture pattern change based on lithology and structural position.
 - Traverse will be quite strenuous with climbs on 30 to 40-degree dips on uneven outcrop and talus. No water crossings during this traverse.

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- Return on foot to Deep Canyon Guest Ranch for brief classroom discussion and group dinner.

Day 6

- Capstone Project: Distribute exercise data and utilize observations gathered in the field to construct a development plan for assigned asset area. Exercise and presentation of results will be done in a team setting.
- Dependent upon completion time, there may be additional time to venture out and observe additional outcrops and geologic features of interest to the group.

Day 7

- Check out of Deep Canyon Guest Ranch and drive to Great Falls, MT for individual travel home.