TETRA TECH RPS ENERGY | TRAINING

N379: Application of Geomechanics to Reservoir Characterization, Management and Hydraulic Stimulation *(Wyoming, USA)*

Instructor(s): Peter Hennings and Jon Olson

Format and Duration

Field - 5 Days
Moderate Physical Demand

Summary

The goal of this field workshop is to provide geoscientists and engineers with a thorough and practical exposure to the range of topics required to understand, characterize and predict the geomechanical response of reservoir rocks to geologic processes, field management, and hydraulic fracturing.

The deep integration of geological mechanics and reservoir engineering is a primary goal of the course and is woven throughout via integrated and interactive class projects worked by interdisciplinary teams.

Business Impact: Participants will acquire an improved geomechanical perspective which will enable them to better discern superior vs. marginal prospects and completion strategies, enhancing value and reducing costs in day to day company operations.

Learning Outcomes

Participants will learn to:

1. Assess how rock type relates to mechanical behavior and mechanical properties.
2. Assess the role of mechanical stratigraphy and its evolution with deformation.
3. Evaluate changes in rock properties from burial, uplift, pore pressure, deformation, and diagenesis.
4. Characterize in situ stress from engineering and wellbore data and geologic constraints.
5. Evaluate mechanisms of rock failure including jointing, shearing, reactivation, folding.
6. Create predictive models that link natural fracture character with geologic drivers and relate to hydrofractures.
7. Judge how structural heterogeneities impact reservoir flow performance.
8. Judge how geologic heterogeneities impact hydraulic fracture geometry and performance.
9. Understand reservoir structural hierarchy from reservoir to trap to basin scale.
10. Gain an introductory understanding of Laramide Rockies petroleum systems including sources, reservoirs, traps, and seals.

Training Method

This field workshop interweaves fundamental background material from lectures, first-hand field observations, and interactive group exercises to yield a robust technical discussion leading to an understanding of how the application of geomechanics can be used for quantitative reservoir characterization and management applications, including reservoir stimulation.

Approximately 70% of the course time is dedicated to fieldwork, with the remaining 30% spent in the classroom.

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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 central Wyoming, where conditions can range from cold and wet to warm and dry. Participants will be taking numerous short walks and several longer hikes that range in length between 0.6 to 2.5 mi (1 - 4 km) with elevation gains ranging up to 330 ft (100 m). One hike is 4 miles (6.5 km) in length and has an elevation gain of 500 ft (150 m). The field locations are generally at elevations around 4,600 ft (1400 m). Activities at these higher elevations may lead to unexpected fatigue or shortness of breath for some participants. Transport is by SUVs. Driving to field locations is on public roads and improved dirt roads. Pontoon boats will be used to access field locations at Alcova reservoir.

Who Should Attend

This field workshop is tailored for geoscientists and petroleum engineers who are active in petroleum asset appraisal, field development, and management.

Course Content

The class is based in the Laramide Rockies of central Wyoming. All of the outcrops visited are within a one hour drive of Casper, which is the home base of the course. An important element of the course is the quantitative comparison in the field and in lecture of the geomechanical behavior of all important petroleum reservoir rock types including high-quality sandstone, tight sandstone, carbonate, unconventional shale, and fractured basement. Participants will learn applications of geomechanical analysis that can be directly applied to reservoir characterizations and for field management decisions. Important learning vehicles of the course are five group exercises/projects that begin with direct outcrop analysis and end with discussion/presentation of reservoir characterization with field management implications.

The main topics addressed are:

1. How rock mechanical properties govern deformation character
2. Reservoir types considered: unconventional/shale, eolian, tight sandstone, carbonate, fractured basement
3. Methods for interpretation of in situ stress and stress analysis applications
4. Approaches for fractured reservoir characterization
5. Approaches for assessing geologic controls on natural fracture development
6. Estimating how natural fractures couple with stress state to influence reservoir performance
7. Relationship between deformation, fracturing, diagenesis, and evolution of mechanical stratigraphy
8. Structural hierarchy from basin to trap to reservoir scale

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Agenda

Day 0: Travel to Casper, Wyoming

Day 1: Introductory Lectures and Field Stops

- Course introduction and safety briefing
- Introductory lectures
  - Understanding rock mechanical properties, testing, and data
  - Rock failure and earth stress
  - Mechanics of fracture
  - Geology of central Wyoming
- Field stops at Casper Mountain and Emigrant Gap
  - Regional geological setting and structural architecture
  - Fault damage zones and collection of Project 2 observations
  - Large-scale structural fabric and importance of structural inheritance
- Evening lecture, ice breaker, and dinner (Fire Rock Brew Pub, 5:00-8:00 pm)
  - Basics of fracture characterization

Day 2: Rock Deformational Response, Outcrop Fracture Characterization, Development of a Geologic Fracture Model

- Field stops in the Oil Mountain area
  - Fracturing and shearing of the Teapot Sandstone
  - Fracturing and properties of the Frontier Sandstone
  - Basics of quantitative fracture characterization methods
  - Linking fracture development to local and external geologic drivers
  - Mechanics of folding and deformation in well-stratified stratigraphy
- Project 1 (classroom): Building and assessment of a predictive fractured reservoir model
- Oil Mountain discussion: example of geologically-driven fracture model and geostatistical techniques

Day 3: Hydraulic Fracturing, Wellbore Fracture Characterization, Stress Analysis, Subsurface Geologic Integration

- Lectures and Exercises
  - Hydraulic fracturing in horizontal wells and geomechanics of unconventionals
  - Interpreting fractures and stress from image logs
  - Integrating data to develop a wellbore stress model
- Project 2: Fracture and fault stress analysis, application to reservoir characterization
- SE Asia case study (integration of stress, fractures, structure, and production)

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- Field Stops at Alcova Reservoir East Side
  - Alcova area overlook
  - Archean basement fracturing (optional)
  - Tensleep Sandstone at Fremont Canyon (Project 3a set-up)
  - Fracturing and FRAC'ing of Mowry shale
- Evening discussion and BBQ picnic
  - Project 3: Natural fracturing in the Tensleep Sandstone at Alcova Anticline (prediction)

Day 4: Coupled Processes, Mechanical Stratigraphy Evolution, Structural Diagenesis

- Alcova Reservoir pontoon boat trip
  - Fracturing and properties of the Tensleep Sandstone
  - Mechanics of Madison Limestone
  - Mechanics of jointed basement

- Alcova Anticline and Project 3 (characterization and interpretation)
  - Fracturing and properties of the Tensleep Sandstone
  - Influence and evolution of mechanical stratigraphy
  - Mechanics of folding and deformation in poorly-stratified, isotropic units
  - Relationship between deformation, fracturing, and diagenesis
  - Project 3 wrap-up and presentations

Day 5: Concluding Lectures and Exercises and Travel Home

- Concluding lectures, exercises, and discussions
  - Project 4: concluding exercise: matrix of outcrop geomechanical behavior
  - Mechanics of induced seismicity (optional)
  - Discussion of strategies for application of course learning outcomes
  - Course evaluation and feedback
  - Afternoon flights out of Casper, WY