Summary

The application of geomechanical knowledge has become critical to the successful drilling and completion of unconventional plays. This course presents the basics of oil-field geomechanics (including stress/strain, pore pressure, rock behavior and wellbore applications) and then focuses on the geomechanical characterization and modeling of unconventional reservoirs with the goal of optimizing multistage hydraulic fracturing operations in horizontal wells.

Learning Outcomes

Participants will learn to:

1. Assess in-situ stresses with field, log and laboratory data.
2. Build and calibrate 1D and 3D geomechanical models as starting points for geomechanical analyses.
3. Assess the specifications of a geomechanics evaluation and design and QC a geomechanics testing program.
4. Assess the key shale geomechanical properties needed to determine the efficiency of hydraulic fracturing.
5. Gauge the effect of operational parameters in different geological/ geomechanical scenarios on hydraulic fracturing success.
6. Assess the differences, advantages and limitations of available modeling tools for hydraulic fracturing.
7. Determine the value and effectiveness of multi-well completions.
8. Determine the value of microseismic data and the effects of geology, geomechanics, and pore pressure on the microseismic response.
9. Gauge the role of natural fractures and weak planes on the overall behavior during stimulations and decide which type of analysis is needed in each case.
10. Assess the role of stress shadows and determine when they are critical factors.

Duration and Training Method

This is a three-day seminar-style classroom course featuring lectures from two specialists. Lectures are enhanced with classroom exercises, plenty of discussion and question from the instructors to the participants to challenge common knowledge and practices.

Who Should Attend

The course is intended for geoscientists, reservoir engineers, drilling engineers, and completions engineers currently working unconventional resources, and for managers seeking to understand geomechanics.

Prerequisites and Linking Courses

There are no prerequisites for this course, although a familiarity with resource plays, as presented in N313 (Evaluating Resource Plays), and completions (as presented in N940 (Modern Completion and Production Enhancement Techniques) and N959 (Hydraulic Fracturing for Conventional, Tight and Shale Reservoirs) would be useful.
A related classroom course is N411 (Fractures, Stress and Geomechanics), which emphasizes fracture characterization and analysis and includes building a numerical geomechanical model using finite element methods.

Several field courses explore the geomechanical response of reservoir rocks to geologic or reservoir stimulation: N379 (Application of Geomechanics to Reservoir Characterization, Management and Hydraulic Stimulation (Wyoming, USA)) and N381 (Influence of Tectonics and Mechanical Stratigraphy on Natural Deformation in the Permian Basin (Texas, USA)).

Course Content

The first portion of the course will address the fundamentals of oil-field geomechanics, including stress, mechanical properties and failure. Common near-wellbore and reservoir-scale geomechanics applications will be introduced. The second part of the course will focus on the characterization of unconventional reservoirs (heterogeneous rock masses with the presence of discontinuities and weakness planes) and present the tools and models that can be used to optimize single- and multi-well hydraulic fractures in these intervals. Examples from a variety of unconventional plays will be discussed.

Part 1 (day 1): Geomechanics for Petroleum Applications

1. Principles of Stress and Strain
   - Basics of stress/strain and Mohr circles
   - Effective stress concepts and the importance of pore pressure
   - Stress field variations and structural effects
   - Stress measurements and analysis
   - Examples and exercises
2. Pore Pressure Evaluation
   - Basic concepts and causes of over pressure
   - Analysis concepts: NCT, Bowers, Centroid-Effect
   - Analysis workflow
   - Examples and exercises
3. Mechanical Rock Behavior
   - Mechanical properties (elasticity, etc.)
   - Failure and beyond
   - Influence of faults and fractures
   - Laboratory vs. log vs. field data
   - Examples and exercises
4. Geomechanical Modeling and Workflow
   - Concepts and tools
   - 1D/2D modeling and 3D modeling
   - Example geomechanics workflow
5. Review of Main Petroleum Geomechanics Applications
   - Wellbore stability
   - Sanding
   - Solids (cuttings) injection
   - Monitoring/field/lab testing
Part 2 (days 2 and 3): Geomechanics for Unconventionals

1. Introduction to Unconventional Developments
   - The importance of unconventionals world-wide
   - Common play characteristics
   - Challenges in general and challenges from a geomechanics point-of-view
2. Shale and Shale-Like Properties and Behavior
   - Unconventional shales- shale types
   - 'Brittle' vs. ductile behavior
   - Geomechanics of shale plays
   - Mechanical properties, elastic and strength
   - Anisotropic properties, effect of laminations and bedding planes
   - Creep properties
   - Index properties (indentation, rebound, scratch) and its value
3. Natural Fractures
   - Characterization (seismic, well, core, thin sections)
   - Discrete Fracture Network (DFN) issues
   - Hydro-mechanical behavior of natural fractures
   - Influence on drilling and stimulations
4. Microseismicity
   - Basics
   - Geomechanics of microseismicity – key of the interpretation
   - Slow slip and aseismic slip - critically stressed fractures and permeability, effects on microseismicity
5. Unconventional Reservoir Quality Evaluations
   - Basic concepts
   - TOC, porosity/permeability, natural fractures, pressure, stresses and mechanical properties as quality indicators
   - The sweet spot from the geomechanics point of view, beyond brittleness
   - Set of parameters for a quality indicator Index
6. Hydraulic Fracturing Unconventional Plays
   - Basics
   - Models and design
   - Frac QC
   - Conventional models in unconventional developments
   - Advanced hydraulic fracturing models, geomechanical hydraulic fracturing models
7. Unconventional Completions: Geological Scenarios and Critical Geomechanical Aspects
   - Modeling and shale completions
   - Stress shadows, stage spacing, and stress rotations
   - Interactions with natural fractures and weakness planes
   - Role of pore pressure and stresses on hydraulic fracture efficiency
   - SRV and complexity
   - Landing location and perforation strategies
   - Interaction between cluster and limited entry
   - Proppant strategies in unconventional plays
8. Multi-well Completions
   - Multi-well completions (Zipper fracs, etc.)
   - Impact of operational parameters
   - Stress and pressure capture
   - Poroelastic effects
   - Workflow and key issues from published work and numerical simulations

9. Key Issues in the Major Unconventional Plays
   - Permian
   - Eagle Ford
   - Niobrara
   - Marcellus
   - Vaca Muerta
   - Pimienta