

N437: Geomechanics for Unconventional and Tight Reservoirs

Instructor(s): Neal Nagel and Marisela Sanchez-Nagel

Format and Duration

Classroom - 4 Days

Virtual - 8 Sessions

Summary

Business Impact: Improving **recovery and volume** in horizontal wells by **optimizing multistage hydraulic fracturing operations** in the most productive intervals.

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.

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.

Training Method

This is a classroom or virtual classroom course comprising a mixture of lectures, discussion, case studies, and practical exercises.

Who Should Attend

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

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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: Geomechanics Fundamentals

Module 0. Introduction to Unconventional Geomechanics

- What makes a good play – geomechanics point of view
- Unconventional Play scenarios
- What is geomechanics? Definitions, history, relevance

Modules 1 - 2. Principles of Stress and Strain - Field Stress Measurements

- Basic of stress-strain and Mohr circles - application of natural fractures
- Effective stress concepts, role of pore pressure
- Field stress variations, structural effects
- Stresses around boreholes
- Stress determinations

Module 3. Pore Pressure Evaluation

- Basic concepts and causes of overpressure

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- Pore pressure analysis – Eaton, Bowers', NCT, effective stress methods
- Analysis workflow
- Challenges in unconventional, field examples

Modules 4 – 5. Mechanical Rock Behavior

- Mechanical properties, elasticity plasticity, poroelasticity, viscoelasticity
- Failure in rocks, failure criteria
- Influence of faults and fracture, anisotropy
- Laboratory testing, measurements, interpretation
- Use of logs for mechanical properties, calibration, correlations

Module 6. Geomechanical Modeling and Workflows

- Concepts and tools
- 1D, 2D and 3D models
- Geomechanics workflows in unconventional

Part 2: Geomechanics for Unconventionals

Module 7 - 8. Hydraulic Fracturing Fundamentals

- Basic, objectives, parameters
- Frac containment, net pressure
- Injection testing, DFITs
- Horizontal wells
- Perforating, Proppants – 100 mesh and proppant transport,
- Fracturing fluids
- Role of natural fractures. Injection zone selection

Module 9. Stress Shadows - Multi-stage Multi-well

- Mechanics of stress shadows
- Effect on multi-stages and clusters
- Multi-well stress shadows
- Tip shear stresses, Modeling examples

Module 10. Rock Fabric Characterization

- Description and quantification of rock fabric attributes – cores
- Mechanical behavior, hydraulic behavior, testing in unconventional
- Stresses - critically stress fractures and hydraulic conductivity
- Geometry and spatial occurrence, DFN models.
- Examples of evaluation in unconventional plays

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Module 11. Shale Geomechanics

- Unconventional shale plays – shale types – challenges, critical issues
- Geological scenarios for completions
- Geomechanics of interfaces – HF interaction with interfaces, effect of fracture toughness
- HF models: traditional and advanced models
- Shale properties static and dynamics examples from different plays – elastic parameters, time dependency, frictional properties
- Shale and Shale like behavior – mineralogic content, shale and flow

- Myths to debunk – brittleness, complexity, SRV and microseismic, sand volume per lateral length

Module 12. Hydraulic Fractures (HFs) and Natural Fractures (NFs)

- HFs propagation with NFs – effect of NF orientation
- Dual HF propagating in a fractured media
- Pressure Diffusion – coupled effects – stimulation benefits
- Interaction HF – NF - crossing rules.
- Influence of NF characteristics – Dense vs sparse DFN, stress anisotropy, NF connectivity, parametric studies. Modeling examples.
- Influence of operational parameters, effects of fluid viscosity, injection rates – injection time,
- Influence of the stress field and in-situ pore pressure on HF behavior.
- Microseismicity response with anisotropic stresses – dry and wet MS events. Effect of initial aperture of the NFs.

Module 13. Depletion – Refracs

- Depletion effects on HFs, depletion and in situ stresses.
- Parent-child evaluations, Cluster efficiency, drainage volumes
- Frac hits - types.
- Microseismic depletion delineation, Cube evaluations
- Refracturing – candidates, case histories, lessons.
- Geomechanics of refracs.
- Refracs economics, refrac activity, examples.
- Refracs methods, engineered refracs.

Module 14. Multi-well completions

- Zipper fracs, stress perturbations, induced shear around zipper fracs
- Interaction of HFs, overlapping HFs, models
- Zipper fracs stress shadows.
- Effect of multiple well completion in fractured rock mass – sheared fabric – friction angle effect, geometry of zipper fracs. Effect on fabric stimulation.
- Sheared length, pressure diffusion.

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Module 15. HF Monitoring and models (Extra session)

- Temperature Logs, strengths and weaknesses, procedures. Effect of wellbore and completion.
- RA logging procedures, strength and weaknesses, tracer applications
- Microseismic monitoring – MS as a geomechanics issue. Events, field data, MS imaging, passive seismology, triggered or induced seismicity, array design, surface vs downhole, source mechanisms,
- SRV from MS and drainage volume.
- Tiltmeters- direct fracture monitoring, measurements, patterns, cases.
- DAS/DTS Basics, production estimations, cluster efficiency, integrated analysis.
- HF Models - advanced models fundamentals, input data, 2D models, pseudo (planar) 3D, Cell/Grid based models, lumped pseudo 3D, Fully 3D, HF reservoir simulators.