Geomechanics for Unconventional Developments (G051)

Tutor(s)

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Overview

The course starts with an introduction to geomechanics fundamentals and then aspects relevant to unconventionals are developed, especially as they relate to the effect of fabric and heterogeneity. “Common knowledge” is challenged and popular procedures are presented in the light of geomechanics fundamentals and concepts. Recent topics such as cube developments and frac hits are discussed. This is an in-depth but engaging training course.

Duration and Logistics

Classroom version: 3 days; a mix of lectures (80%) and hands-on exercises and/or examples (20%). The manual will be provided in digital format and participants will be required to bring a laptop or tablet computer to follow the lectures and exercises.

Virtual version: Five 4-hour interactive online sessions presented over 5 days. A digital manual and exercise materials will be distributed to participants before the course.

Interactive questioning and possibly breakout sessions will be utilized to reinforce learnings.

Level and Audience

Advanced. Intended for geoscientists, reservoir and completion engineers and petrophysicists who wish to understand how geomechanics can help them effectively develop their reservoirs.

Objectives

You will learn to:

1. Understand the fundamentals of geomechanics including stress and strain, pore pressure evaluation, mechanical rock behavior and geomechanical models.
2. Gain an understanding of conventional fracturing models in unconventional developments and the associated workflow.
3. Describe the properties of naturally fractured reservoirs including their influence on drilling, stimulation and production.
4. Perform reservoir quality evaluations including the assessment of poroperm, natural fractures, pressures and mechanical properties as quality indicators.
5. Characterize shale properties including shale types, brittle versus ductile behavior and geological scenarios for completions.
6. Assess the influence of the stress field and in-situ pore pressure on hydraulic fracture behavior.
7. Assess the microseismic response with anisotropic stresses and the use of numerical models for interpretation and characterization.
8. Characterize the effects of multiple well completions in a fractured rock mass.

9. Assess the types of hydraulic fracture monitoring including microseismic monitoring.

Course Content

Part 1: Geomechanics Fundamentals

Module 0. Introduction to Unconventional Geomechanics

- A few words about Oilfield Geomechanics
- What is geomechanics? Definitions, history, relevance

Modules 1 – 2. Principles of stress and strain with field stress measurements

- Basic of stress-strain and Mohr circles – applications to natural fractures
- Effective stress concepts, role of pore pressure
- Field stress variations, structural effects
- Stresses around boreholes
- Stress determination Module

3. Pore pressure evaluation

- Basic concepts and causes of overpressure
- Pore pressure analyses – 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; when and where appropriate
- Geomechanics workflows in Unconventionals

Part 2: Geomechanics for Unconventional Developments

Modules 7-8. Hydraulic fracturing fundamentals

- Basic, objectives, parameters
- Frac containment, net pressure
- Injection testing, DFITs
- Horizontal wells and perforating
- Proppants – 100 mesh and proppant transport

- Fracturing fluids
- Role of natural fractures
- Injection zone selection effects

Module 9. Stress Shadows for single frac, multi-stage and 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 unconventionals
- Stresses – critically stress fractures and hydraulic conductivity
- Geometry and spatial occurrence, DFN models
- Examples of evaluation in unconventional plays

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
- Shale properties static and dynamics examples from different plays – elastic parameters, time dependency, frictional properties
- Myths to debunk – brittleness, complexity, SRV and microseismic, sand volume per lateral length

Module 12. Hydraulic fractures (HFs) and natural fractures (NFs) with operational effects

- 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, with 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 effects and refracs

- Depletion effects on HFs, depletion and in situ stresses
- Parent -child evaluations, cluster efficiency, drainage volume
- Frac hits (fracture Driven Interactions -FDIs) – types
- Microseismic depletion delineation, cube evaluations

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 completions in fractured rock mass – sheared fabric – friction angle effect, geometry of zipper fracs. Effect on fabric stimulation
- Sheared length, pressure diffusion

Module 15. HF monitoring and models (extra session as time permits)

- 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