01 - GEOMECHANICS FOR UNCONVENTIONAL DEVELOPMENTS

This is a very successful training course, one that OFG has been providing to the industry for many years. It has been updated with new aspects and issues that have emerged in the last years, like cube developments and frac hits. The course starts with a brief geomechanics fundamentals part and then the aspects relevant to Unconventionals are developed, especially the effect of fabric and heterogeneity. Within this course we challenge "common knowledge" and popular procedures in the light of geomechanics fundamentals and concepts. This is an in-depth but fun training course and one we enjoy teaching several times per year.

OUTLINE

PART I. 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

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PART II: GEOMECHANICS FOR UNCONVENTIONALS

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.
- 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) 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.

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- Parent -child evaluations, cluster efficiency, drainage volumes.
- Frac hits – types.
- Microseismic depletion delineation, cube evaluations.
- Refracturing – candidates, case histories, lessons.
- Geomechanics of refracs.
- Refrac economics, refrac activity, examples.
- Refrac 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 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.

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02 - GEOMECHANICS FUNDAMENTALS FOR SUBSURFACE APPLICATIONS

This training is intended to provide greater detail on fundamental aspects of geomechanics including concepts and procedures to build 1D and 3D geomechanical models. Intended for engineers and scientists that need to understand what geomechanics brings to different application to subsurface activities including exploration, drilling, mining, reservoir production and fluid injection.

OUTLINE

Module 1. Introduction to geomechanics

- What is geomechanics? Definitions, history, relevance.
- General applications in exploration, drilling, mining, hydraulic fracturing, compaction and subsidence, unconventional developments, sand production.

Module 2. Principles of stress and strain

- Stress, strain definition.
- Mohr circle stress representation.
- Effective stress concept, role of pore pressure.

Module 3. Mechanical rock behavior

- Stress-strain relationship – constitutive laws.
- Elasticity, plasticity, poroelasticity, viscoelasticity.
- isotropic and anisotropic rocks.
- Rock strength, failure in rocks, compression tension and shear.
- Failure criteria.

Module 4. Laboratory testing and mechanical properties from field data

- Laboratory testing, measurements, interpretation.
- Use of logs for mechanical properties, calibration, correlations.
- Influence of faults and fracture, anisotropy.

Module 5. In situ stress regime and stress determination

- Geological aspects, field stress variations, structural effects.
- Stress bounds, stress polygon.
- Stress determinations; overburden stress.
- Minimum horizontal stress calculation – DFITS, LOT, XLOT, sonic log solutions.
- Maximum horizontal stress, magnitude and orientation – Image log analysis.
- Stresses around boreholes, breakouts and drilling induced fractures.
- Depletion effects in the stress field.

Module 6. Pore pressure evaluation

- Basic concepts and causes of overpressure, mechanisms.
- Pore pressure prediction from porosity, resistivity sonic velocity – Eaton, Bowers', NCT, effective stress methods.
- Pore pressure calibration.

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Module 7. Natural fractures

- Mechanical behavior of natural fractures.
- Lab and field methods.

Module 8. Geomechanical modeling - concepts and tools

- 1D, 3D geomechanical earth models – seismic data.
- Geomechanical analytical and numerical simulators.
- Coupled fluid flow and geomechanical modeling. Iterative coupling, one-way, fully coupled models.

03 - DRILLING GEOMECHANICS

As a necessary foundation, this course starts with a review of basic geomechanics principles and concepts in order to then tackle the procedures for borehole stability analysis during drilling. State-of-the-art procedures around drilling geomechanics are explained considering field data and examples. RT operations and AI developments with respect to data collection and interpretation are presented as are their role in future drilling practices and operations.

OUTLINE

Module 1. Geomechanics fundamentals

- Introduction - Definition of geomechanics history, applications in the oil and gas industry, the geomechanical model as starting point of a geomechanics analysis.
- Definition of stress; stresses in the earth – stress regimes.
- Definition of strains; stress-strain behavior – elasticity and anisotropy, plasticity, viscous behavior.
- Strength and failure of the rock.
- Stresses concentrations around a wellbore.
- Exercises for: Mohr circles, normal and shear stresses over fractures, stresses around a borehole.

Module 2. Geomechanical earth models - 1D and 3D

- Pore pressure determination – methods and procedures – examples.
- Sv – Vertical stress determination.
- Shmin - LOTs,DFITS, minifracs.
- SHmax – image logs and stress polygon evaluations.
- Data collection – lab, log and field data.
- Exercises for calculations of Sv, Shmin, SHmax.
- 3D geomechanical models - seismic data.

Module 3. Wellbore stability from planning to post-drill evaluations

- Stability workflows.
- Drilling event analysis – pore pressure and stress indicators, drilling parameters, cavings.
- Failure modes in a wellbore.
- Borehole stability calculations, failure tolerance.
- Verification/calibration of the 1D geomechanical model.
- Failure along bedding planes – anisotropy.
- Stability of shales.
- Exercises/examples of effect of different parameters – wellbore orientation, pore pressure, mechanical properties, stresses.
- Uncertainty analysis, QRA.
- RT operations.
- Field cases – high stress, structural complexity, deep water wells, salt, depleted reservoirs.
- Future data analysis and AI in drilling related geomechanics.

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04 - GEOMECHANICS DATA: LAB, LOG AND FIELD SOURCES

This course addresses the different sources and procedures to obtain the data to define the geomechanical components in a project: in-situ stresses, pore pressure, and mechanical properties over a specific geometry of interest - a well, a fault, natural fractures, a reservoir or underground structure. Each of the primary sources of data (laboratory, core-based; wireline log; and field and seismic) are reviewed with a particular emphasis on: 1) accuracy; 2) coverage; 3) timing; and 4) cost.

OUTLINE

Module 1. Introduction to geomechanics

- What is geomechanics? Definitions, history, relevance.
- Components of a geomechanical model: in-situ stresses, pore pressure, mechanical properties, geometry.
- Geomechanics data flow.

Module 2. Mechanical property data from laboratory testing

- Core data planning from office to well to lab.
- Testing frames and monitoring.
- Test types: UCS, Triaxials, TWC; drained and undrained testing.
- Elastic, poroelastic parameters; plasticity and creep testing.
- Block testing.
- Designing a test program according to the geomechanical application.

Module 3. Geomechanical data from wireline logs

- Basic geomechanics logs: GR, resistivity, porosity, density, sonic logs.
- Image logs – analyzing/detecting stress features and natural fractures for SHmax inversion.

Module 4. Geomechanical field data

- Pore pressure data, well testing, drilling indicators.
- Fracturing data – drilling lost circulation, mini-fracs, step-rate test, DFITs, LOT, XLOT

Module 5. Structural models and seismic data

- Structural models to define geometry.
- Different types of seismic data.
- Interval velocities for pore pressure analysis.
- Elastic Inversion for elastic parameters.
- Seismic and stresses.
- Calibration of seismic-derived parameters.

Module 6. Geomechanical monitoring tools and methods

- INSAR and gravimetrics
- Microseismic data
- Tiltmeters
- Fiber optic – DAS/DTS

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05 - GEOMECHANICS FOR HYDRAULIC FRACTURING (HF)

This course provides the key geomechanical aspects of hydraulic fracturing (HF) including: a) how rocks fail in tension (and not shear); b) net pressure and its geomechanical meaning; c) effect of stresses and mechanical properties of the rocks (pay and surrounding rocks) on HF geometry; d) geological aspects like fracturing in highly laminated rocks and the presence of natural fractures; e) Stress Shadows and in-situ stress changes around HFs; and f) monitoring and looking under the hood of the available HF models.

OUTLINE

PART I. GEOMECHANICS FUNDAMENTALS

Module 0. Introduction to geomechanics

- What is geomechanics? Definitions, history, relevance.
- Why geomechanics in hydraulic fracturing?
- The geomechanics paradigms in HF.

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

- Basics of stress-strain and Mohr circles - applications on 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.
- Pore pressure analysis – Eaton, Bowers', NCT, effective stress methods.
- Analysis workflows.

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.

PART II. GEOMECHANICS FOR HYDRAULIC FRACTURING

Module 6. Fracture mechanics and how rocks fail in tension

- Failure modes.
- Stresses at the tip of a fracture, stress intensity factor and fracture toughness.
- Natural fractures and the mechanical behavior of discontinuities.

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Module 7 - 8. Hydraulic fracturing fundamentals and definitions

- Basics, objectives, and critical parameters.
- Frac containment, net pressure.
- Hydraulic fracture geometry and stresses.
- Injection testing, DFITs.
- Horizontal wells.
- Perforating, proppants and fracturing fluids.
- Impact of natural fractures and rock heterogeneity.
- Injection zone selection.

Module 9. Hydraulic fracturing – geological effects

- Stress contrasts.
- Effects of pore pressure.
- Effects of discontinuities and rock fabric, HFs propagation with NFs – effect of NF orientation.
- Interaction HF – NF - crossing rules. Influence of NF characteristics – dense vs sparse DFN's, stress anisotropy, NF connectivity, effect of laminations.

Module 10. Depletion effects, refracs, and cap rock integrity

- Depletion effects on HFs, depletion and in situ stresses.
- Refracturing – candidates, case histories, lessons.
- Geomechanics of refracs.
- Refrac economics, refrac activity, examples.
- Cap rock integrity and injection rates in waterflooding projects – modeling and field data.

Module 11. HF monitoring and models

- 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 model fundamentals, input data, 2D models, pseudo (planar) 3D, cell/grid based models, lumped pseudo 3D, fully and "fully" 3D, HF reservoir simulators.

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