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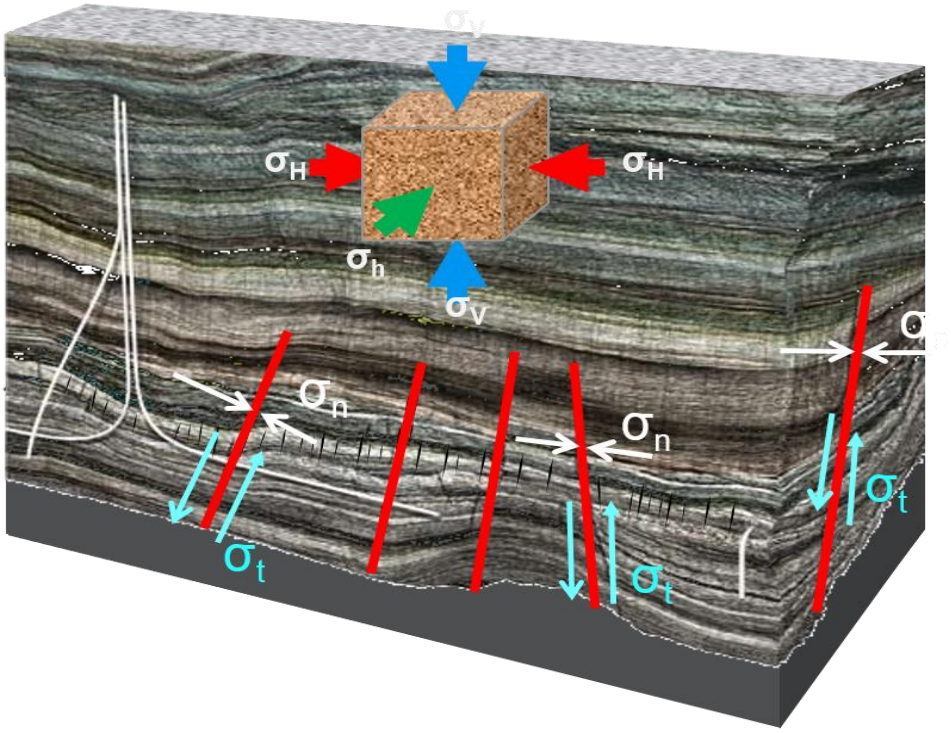
Practical petroleum geomechanics for engineers.
Software Platform GEONAFT



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Course: «Practical petroleum geomechanics for engineers. Software Platform GEONAFT»

The course is aimed to develop the skills in the field of geomechanical model construction and its application for drilling, stimulation and reservoir management.

Duration: 5 days, 40 hours

Venue: as per agreement

Lecturer: Chettykbayeva Kamilla (senior geomechanics engineer Geosteering Technologies Ltd).

Number of students in the group: 8-10 persons.

Target audience: geomechanics engineers, geologists, drilling engineers, reservoir engineers, other parties interested in the subject

Methodology: The course includes lections, analytical and simple modeling exercises

Course contents: the detailed course description is provided on the next page

In the end of the course the participants will be able to:

- Define the areas, where geomechanics can potentially optimize business processes and improve key performance indicators of the department or company
- Calculate elastic and strength properties, the profiles of pore pressure, far-field and near-wellbore stresses, perform wellbore stability calculations
- Understand the value of calibration information, perform simple sensitivity analysys to the missing input data
- Interpret the geomechanical results and develop the recommendations for drilling and hydraulic fracturing
- Develop a data acquisition program for geomechanical studies
- Discuss the different types of testing the mechanical properties of core, and understand the number and the tests needed for the given purposes
- Understand the basics of geomechanical support of drilling, when it is needed and what is the minimum required LWD for the purposes
- Construct a simple geomechanical model in GEONAFT platform

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Day 1

I. Introduction

II. Geomechanics Fundamentals

1. Petroleum geomechanics in the value chain
2. Rock mechanics fundamentals
   - Stress tensor, principal, normal and shear stresses, Mohr circle
   - Effective and total stresses
   - Strain tensor, plane strain
   - Hooke's law, elastic behavior, elastic properties of rocks
   - Failure mechanics, rock strength properties
   - Mathematical and engineering failure
   - Intermediate stress role in rock failure
   - Rock anisotropy, weak plane model
3. Modeling assumptions

Finger exercises:

1) Determination of normal and shear stresses at the given plane

Geomechanical model construction in GEONAFT

a) Software architecture, introduction to different modules
b) Data loading and organization
c) Logs visualization and setting up the cross sections

Day 2

III. Mechanical earth model construction

4. Rock elastic and strength properties determination
   - Interpretation of core tests (unconfined compressive test, pseudo triaxial compression test, multistage test, Brazil test, scratcher)
   - Empirical correlations to assess the rock properties from logs
5. In situ state of stress
   - Stress regimes (Anderson's fault theory)
   - The nature of horizontal stresses
   - The physical range of the underground stresses (lower and upper limits)
   - The measurement and estimation of horizontal stresses magnitude and direction (FIT, LOT, XLOT, mini-frac, images)
6. Pore pressure
   - Hydrostatic pressure
   - Overpressure, understanding the origin and evaluation methods
   - Reservoir depletion and its impact of stresses
7. The required data for robust geomechanical models, quality check
8. Model verification, understanding the
9. Further acquisition program to increase models' reliability

Finger exercises:

2) Stress-strain curve analysis – determination of Young's modulus, Poisson's ratio, and strength determination
3) Determination of the rock stresses' limits

Day 3

IV. Near-wellbore stresses and Wellbore Stability calculations

10 Wellbore stresses
- Lamé's solution, the assumptions
- Kirsch solution, the assumptions

11 Rock failure at the borehole wall
- Shear failure and its implication
- Tensile failure and its implication
- Other rock failure modes

12 Wellbore stability calculation (safe mud window)
- Best azimuth of the horizontal well
- Observations and Model verification

13 Well planning
- Sensitivity of the stability window to well inclination and azimuth
- Elaborating the recommendations for the planned well drilling
- Case study on Geomechanics applied to Drilling Engineering

Finger exercises

4) Calculating the safe drilling window for the given depth

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d) Pore pressure and vertical stress profiles' calculation for the offset well
e) Elastic and strength properties determination for the offset well
f) Horizontal stresses' calculation for the offset well
g) Wellbore stability calculation for the offset well

Day 4

V. Geomechanical support while drilling

14 Application and main objectives
15 Process organization, communication and interaction protocol
16 Trendology and the value of drilling mechanics in time
17 Recommended LWD scope for realtime drilling geomechanics
18 Data-driven real time assessment of hole conditions
19 The value of equivalent circulating density
20 Drilling practices (hole cleaning, wiper trips, tripping) and wellbore stability
21 The challenges of geomechanics while drilling

Geomechanical model construction in GEONAFT:

i) Propagating the mechanical data and stresses calculation for the given trajectory of the planned well
j) Wellbore stability calculation for the planned well
f) Sensitivity to input data, developing the recommendations

Day 5

VI. Geomechanics applied to Completion and Stimulation Engineering

22 Sand Control, Determination of Maximum Allowable Drawdown without solids, Oriented Perforating
23 Mechanics of Hydraulic Fracturing, fracture direction and geometry

VII. Introduction to Reservoir Geomechanics

24 Stress state in the depleted reservoirs (in reservoir under water injection)
25 Risks of infill drilling
26 Assessment of the Natural Fracture Network behavior
27 Reservoir compaction, surface subsidence

Geomechanical model construction in GEONAFT:

g) Demonstration of the obtained results