Practical Geomechanics: A Short Course

Instructor: Tom Bratton, PhD

Course description

In today's economy, engineers design and carry out drilling and completion operations and prepare for the energy transition with insight gained from geomechanical simulations. These simulations lead to significant cost reductions, improved hydrocarbon recovery, and technical support for carbon storage and geothermal operations. Thus, geoscientists contributing to engineering operations must understand the basics of geomechanical modeling, the integrated workflow, and supporting data to influence the engineering and financial decisions contributing to their organization's success. This workshop aims to give the geoscientist an overview of this highly leveraged process and some practical tools to help understand and evaluate geomechanical models used in downstream geomechanical and engineering simulations. I utilize short exercises in Excel spreadsheets to illustrate different geomechanical models.

Course content – Session 1

1) Introduction – This unit introduces and motivates the use of geomechanics in engineering design by illustrating the overall workflow and showing examples where geomechanical understanding led to significant cost reductions and improved hydrocarbon recovery.
2) Rock mechanics – This unit introduces and defines the nomenclature used in geomechanics: stress, strain, elasticity, elastic moduli, yield, failure, Mohr's circles, and stress polygons.
3) Calibration data – Laboratory measurements of elastic moduli and rock strength parameters are essential for comparing with the equivalent log-derived values. In-situ stress testing is necessary to calibrate the mathematical stress models. This unit introduces the use of calibration data to support a geomechanical model.
    a. Laboratory testing – This unit introduces the different laboratory tests used to measure rock properties and illustrates the derived rock properties.
    b. In-situ stress testing – This unit explains different in-situ stress tests and illustrates how they measure pore pressure and stress.

Course content – Session 2

4) Wellbore image and dipole acoustic logs – This unit explains wellbore image analysis, including identifying geomechanical features, differentiating natural from drilling-induced fractures, and quantifying fracture compliance. It also explains dipole sonic log processing, how to assess the quality of the sonic input data, and how to compute both isotropic and anisotropic dynamic elastic moduli. Finally, it explains how to develop a consistent interpretation of both wellbore images and dipole sonic results.
5) Static moduli and rock strength parameters – This unit explains how to integrate dynamic elastic properties with the static laboratory measurements conducted on the

core and introduces different correlations to estimate static moduli and rock strength parameters.

6) Overburden stress and pore pressure – This unit discusses the methods available to quantify overburden and pore pressure and how to select the best method for any given geological environment. I emphasize a rock physics approach for inverting P and S wave velocities for pore pressure and stress.
7) Horizontal stresses – This unit explains how horizontal stresses in the earth are modeled and calibrated to both in-situ measurements and observations from drilling and completion operations.

Course content – Session 3

8) Wellbore stability – This unit introduces wellbore instability and formation collapse leading to breakouts. In addition, it covers the diagnosis of different instability mechanisms and the standard mitigation practices for overcoming these instability problems.
9) Hydraulic fracturing – This unit introduces hydraulic fracturing and mud losses, leading to lost circulation. In addition, it covers wellbore breathing, also known as ballooning, and other drilling challenges, such as fault stability.
10) Case studies – Throughout the course, many case studies that illustrate the building of a mechanical earth model and the use of the model to solve geomechanical challenges will be presented.

The course materials include the Excel spreadsheets for building the mechanical earth model and wellbore stability exercises, presentation slides, information sources, websites, and references to critical technical publications.

Who should attend?

I have developed this course for geoscientists and engineers who want a better understanding of geomechanics and guidance in using geomechanical results to influence engineering decisions.

Prerequisites (Knowledge/Experience/Education required)

Students should have a basic understanding of wellbore logs and drilling and completion operations.

Instructor biography

Tom Bratton is currently a consultant to the oil & gas industry. He started his career with Schlumberger, working in the field as a wireline engineer. While at Schlumberger, Tom helped develop the Mechanical Earth Model concept and its introduction and commercialization. After successfully leading Schlumberger's global technical communities, he retired from his position as a Scientific Advisor to the company's senior management. After his Schlumberger career, Tom was a Visiting Professor and Research Associate in the Petroleum Engineering Department at Colorado School of Mines. While at CSM, he enrolled as a graduate student and earned his Ph.D. in Geophysics. Tom is a full member of the Society of Petroleum Engineers (SPE), Society of Petrophysicists and Well Log Analysts (SPWLA), Society of Exploration Geophysicists (SEG), European Association of Geoscientists and Engineers (EAGE), and the American Rock Mechanics Association (ARMA).