# Introduction to Petroleum Rock Mechanics

The mechanics of rocks play an important role in all aspects of hydrocarbon exploitation. Their faulting and folding control the movement and trapping of hydrocarbons in the reservoir. During seismic investigations, their elastic properties control how much of the subsurface we can see. During drilling, rock failure around the wellbore can lead to expensive lost rig time and stuck pipe, and rock failure under the bit partly controls the rate of drilling. During production, the rock itself can fail and be produced to surface; if this is likely to be a problem, costly sand exclusion methods may be needed. Wells may need to be hydraulically fractured for stimulation or formation damage bypass; the stress in the rock around the wellbore strongly influences this process. Finally, the reservoir itself may deform during production, sometimes benefiting us with compaction drive, sometimes causing us problems with subsidence and permeability decreases.

Rock mechanics has become an important tool for engineers and geologist working with oil field problems. However, very few specialists still exist that are fully conversant in rock engineering. We give a short introduction to the science of rock mechanics, and discuss how it can be used to help improve the effectiveness of hydrocarbon exploitation, with the emphasis on planning for wellbore stability control during drilling, and understanding hydraulic fracturing stimulation and completion strategy. This intensive course can help understand the essential aspects of geomechanics enabling an engineer or geoscientist to make better field development decisions.

**Afterwards**, you will have learnt:

* The value that Geomechanics can add to drilling and completion operations
* An understanding of the requirements from Geomechanics work
* Basic knowledge to structure and conduct Geomechanics projects for wellbore stability and sand prediction
* Knowledge of the data requirements for Geomechanics studies

**Language**, English, Portuguese or Spanish

## Bibliography to be used

R.E. Goodman; *Introduction to Rock Mechanics*, John Wiley &Sons.

E. Fjaer, R.M. Holt, P. Horsrud, A.M. Raaen and R.Risnes; *Petroleum Related Rock Mechanics;* Elsevier

## Agenda

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| --- | --- | --- |
| **Start**  | **End**  | **Topic** |
| 8:30  | 10:00  | Introduction |
| 10:00  | 11:00  | Elasticity and Rock strength |
| **11:00**  | **11:15**  | **Coffee break** |
| 11:15  | 11:45  | Rock properties from logs |
| 11:45  | 12:30  | State of stress in the earth |
| 12:30  | 13:00  | Stresses around wellbore and borehole failure criteria |
| **13:00**  | **14:00**  | **Lunch** |
| 14:00 | 16:00  | Planning for wellbore stability |
| 16:00 | 17:30 | Hydraulic fracturing stimulation |

## Detailed agenda

**Introduction**

What is meant by Geomechanics

Mechanical Earth Model (1D, 2D and 3D)

Applications (wellbore stability control, sand prediction, hydraulic fracture design, drilling optimisation and reservoir stress management)

Key participants in building the MEM

**Elasticity and Rock strength**

 Stress

Mohr’s circle

Strain

 Stress-strain behaviour

 Linear and non-linear elasticity

 Anisotropy

 Modes of rock failure

 Common laboratory strength tests

 Stress-strain behaviour in compression

 Effect of the confining pressure

 Failure surface

 Mohr-Coulomb failure criteria

 Anisotropic rocks

Rock properties from logs

 Acoustic wave propagation in rocks

Dynamic elastic properties

 Static elastic properties

 Strength properties (UCS and FANG)

**State of stress in the earth**

 Introduction

 Overburden stress

 Horizontal stress models

Stress direction

Measurement of stress

 Overburden

 Pore pressure

Minimum horizontal stress

Maximum horizontal stress

**Stresses around wellbore and borehole failure criteria**

 State of stress around the wellbore

 Borehole failure criteria

Exercise

 Influence of trajectory

**Planning for wellbore stability**

 Data gathering - rock properties, stress state, drilling hazards, …

 Unstable boreholes – Failure mechanism

 Shear failure

 Tensile failure

 Plane of weakness

 Reactivity

 Unstable boreholes – Time dependent effects

 Cavings - A component of real time wellbore stability monitoring

 Mud window calculations

History case

**Hydraulic Fracturing**