

Introduction to the special Issue of the Leading Edge on “Geomechanics”

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The term *Geomechanics* means different things to different people. We assert that in the petroleum industry the broad consensus for a definition would probably be something like this:

Geomechanics is the discipline that investigates rock mechanical behavior in the subsurface (i.e., at the wellbore wall, the overburden, caprock and/or the reservoir) under present day in-situ stress and pore pressure conditions or those changed through human activity/intervention (e.g., production, injection, stimulation) during the life of a well.

In other words, geomechanics provides an understanding and prediction of hydro-mechanical, hydro-chemo-mechanical, and even thermo-hydro-chemo-mechanical (THCM) behavior of subsurface rocks and enables optimization of drilling and/or field development processes. In this context, rock mechanical failure is mitigated or managed such that it does not cause any delays in drilling and reduction or full breakdown of production/injection. As such, geomechanical processes affect the entire life cycle of a reservoir from exploration, through production, to rejuvenation utilizing improved oil recovery (IOR) and/or enhanced oil recovery methods (EOR) methods. In recent years, this also involves activities related to renewable resources such as geothermal and carbon sequestration and utilization (CCUS). With these activities, over-, side- and under-burden formations need attention in addition to the reservoirs themselves. For example, cap rock integrity is a critical aspect for CO₂ sequestration and storage.

In this context, developing renewable and unconventional resources present geoscientists and engineers with understanding the physical processes coupling rock, fluid types and flow anew, in a different manner and at different scales. To predict the impact of production, injection, and stimulation, an in depth understanding of hydro-chemo-mechanical behavior of the reservoir rock and over-, under- and side-burdens are required. Geophysics plays a crucial part in this aspect. Advanced data acquisition and modelling techniques need to be augmented with machine learning algorithms to tackle these challenges.

For this special issue we collated four papers that highlight and illustrate recent technical developments and case studies related to the integration of geomechanics and geophysics – including machine learning algorithms – to estimate geomechanical properties, predict in-situ stresses for reservoir characterization, and (micro-) seismic monitoring. These are emphasized on heterogeneous carbonate formations, unconventional assets and CCUS.

Ramdani et al. predict uniaxial compressive strength (UCS) for a depositionally complex and heterogeneous Jurassic carbonate sequence. The approach exploits a positive linear correlation between UCS and acoustic impedance (AI), that provides input for a seismic colored inversion based on neural network multi-attribute analysis. Results indicate a high degree of consistency with absolute UCS error of ~5%.

A second manuscript by Kempinski et al. presents a case study from a shale gas play in the Polish Peri-Baltic Syncline. It highlights the complexities and challenges associated with drilling horizontal wells in such plays as well as the predictive power of a robust geomechanical model for well planning when a variety of accurate field and well data were available.

Mandal et al., investigate creep prediction in gas shales from measurements of specific surface area. Utilizing a fast and cost-effective measurement technique on powdered shale samples and cuttings, their results reveal a strong global empirical correlation spanning a broad range of clay content, organic matter, maturity, and porosity values. Such results promise to be effective in estimating creep parameters to predict long-term deformation and stress relaxation.

Finally, Bondarenko et al. discuss geomechanical aspects of induced microseismicity during CO₂ injection in the Illinois Basin. The project focuses on a laboratory-based rock mechanical characterization of samples to evaluate the risk for (micro-) seismicity. The samples from the formations are known to have responded seismically to CO₂ injection. The authors verify and calibrate the results with geophysical log data and petrographic analysis.

We trust you will enjoy and agree that these four contributions highlight the value of geomechanics.