A Comparison of Dynamic and Static Geomechanical Properties of the Montney Formation: An integrated Experimental Study

N. Riazi[1], S. McKean[2], A. Ghanizadeh[1,], C.R. Clarkson[1], J. Priest[2], R.C.K Wong[2], A. Vahedian[1]*

[1] Department of Geoscience, University of Calgary

[2] Department of Civil Engineering, University of Calgary

Summary

The Montney Formation is one of the most prominent Canadian tight rock formations, comprising a massive hydrocarbon accumulation in the Western Canadian Sedimentary Basin. Characterization of the geomechanical properties of the Montney Formation is important to plan/optimize hydraulic fracturing and hydrocarbon recovery processes. In this work, we present results from an ongoing laboratory study investigating the geomechanical, geophysical and petrophysical properties of the Montney Formation. The primary objectives are to 1) compare different methods (dynamic, static) for determining rock mechanical properties in the Montney, 2) derive the elastic anisotropies and Biot coefficients from simultaneous geomechanical and petrophysical analyses and 3) analyze the potential interrelationships between different petrophysical (porosity, permeability) and geomechanical properties of the Montney Formation.

Three core plug samples (orientated at 0, 45, and 90 degrees relative to the core axis) were analyzed in this study. Pulse-decay permeability and ultrasonic velocity measurements were conducted under controlled effective stresses ranging between 3.4 and 17.2 MPa. The application of a sonic coreholder in the pulse-decay permeameter device enabled ultrasonic velocity measurements to be performed simultaneously with permeability measurements. Dynamic elastic moduli were estimated from ultrasonic velocities (compressional and shear) measured at approximate frequency of 100 kHz. Low-damage multi-stage triaxial (ASTM D7012) and Brazilian tests (ASTM D3967) were performed to evaluate the indirect tensile rock strength and elastic moduli in compression and indirect tension. All the analyses (pulse-decay permeability, ultrasonic velocities, triaxial compression and Brazilian test) were conducted on identical samples and at different effective stress conditions to 1) mitigate the impact of heterogeneity on the experimental outcomes and 2) monitor the variations of geomechanical/petrophysical parameters with effective stress.

For one analyzed core plug[1], the apparent pulse-decay gas (N_2) permeability values range between $1 \cdot 10^{-5}$-$5 \cdot 10^{-4}$ mD, depending on mean pore pressure (2.8-11 MPa) and effective stress (3.4-17.2 MPa) conditions. The experimental observations indicate that compressional and shear velocities increase (up to 13%) with increasing effective stress (3.4-17.2 MPa). Shear wave splitting (difference between S1 and S2) shear velocities) decreases slightly (up to 2.5%) with increasing effective stress (3.4-17.2 MPa).

Through combining multiple experimental techniques, this study provides an integrated geomechanical petrophysical dataset comparing dynamic and static geomechanical properties of the Montney Formation. The findings of this study will be beneficial to operators developing the Montney resource by allowing them to understand the variation in geomechanical properties measured using different techniques for the purpose of optimizing stimulation design.

[1] The analyses for the other two core plugs are currently ongoing.

Acknowledgements

We gratefully thank Seven Generations Energy Ltd for providing funding and core plug samples for this study.