



# CSPG ROCK ANALYSIS WORKSHOP

March 21-22, 2019 | University of Calgary & AER Core Research Centre

## **Instrumented Indentation Testing of Drill Cuttings as a Method of Characterizing the Mechanical Properties of a Horizontal Wellbore**

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### **Summary**

Instrumented indentation is a standard technique in materials science for determining the mechanical properties down to the nanoscale of homogeneous materials, including metals, coatings, and ceramics. More recently, indentation testing has been applied to characterizing the mechanical properties of heterogeneous materials, including cement, asphalt, and rock formations.

In our study we evaluate the utility of instrumented indentation of samples from shale reservoirs with the hypothesis that such data may provide a quick and inexpensive index of the mechanical properties useful for geomechanical modeling and completion design. Our research builds on some previous works that have demonstrated that indentation results from shale drill cuttings can be used to create a geomechanical profile of a horizontal wellbore.

To fully evaluate the utility of instrumented indentation as an index of the mechanical moduli of the reservoir, there is a series of inferences that must be tested. This series includes: 1) are drill cuttings samples representative of the reservoir rock that will be completed?; 2) are cuttings samples large and homogeneous enough to yield precise, accurate, and reproducible indentation measurements?; 3) is sample preparation sufficiently consistent to yield useable and comparable data; 4) is the grain size fine enough that rock rather mineral moduli is being measured? 5) do the values from cuttings scale up to core samples used for mechanical tests?; and 6) do the analyses of cuttings samples scale to the reservoir?

Initially, we confirmed the methodology of instrumented indentation by testing homogeneous mineral samples of dolomite, calcite, and quartz as standards. We compared samples crushed to various particle size and preparation procedures, confirming indentation moduli results of particle size greater than 0.088 mm (170 mesh) yield reliable and repeatable values. These indentation moduli values were comparable to literature geomechanical moduli values from traditional techniques.

Instrumented nanoindentation was then performed on sub-samples of Montney core from NE BC and Alberta, on which mechanical properties were previously determined by triaxial testing. The effects of sample size, sample preparation, indentation properties (such as load, sample spacing, number of indentations, type of indentation), and methods of analysis were determined. Our results show that mean nanoindentation moduli in shale are reproducible within a sample, differentiable between samples within a well, and differentiable between different



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wells and formations. The data shows that the utility of instrumented indentation, as an index for the mechanical characterization of shale, varies significantly with the heterogeneity and fabric of the rock. Studies in progress will further test the scalability of indentation measurements, as well as determine their utility as a proxy for conventional proppant embedment tests and various dynamic mechanical moduli.