Instrumented micro-indentation tests for improved proppant embedment prediction in Montney formation

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Summary

Correctly predicting proppant embedment into rock formation is vital for selecting proper proppants to place in hydraulic fractures. This talk introduces an efficient approach to predict proppant embedment based on the laboratory measurement of instrumented micro-indentation tests. Using Montney samples at a depth of 2068-2270 m, a series of instrumented Brinell indentation tests were performed (Fig. 1). The laboratory force-displacement measurements were used to develop a relationship between the indentation force and its contact area with rock surfaces (Fig. 2). The developed force vs. contact area relationship was used in a mathematical model of a monolayer proppant-rock system to predict proppant embedment under varying compressive stresses/proppant sizes. The prediction of proppant embedment on Montney formation was compared with the results from laboratory proppant embedment tests (Fig. 3). The results show that laboratory proppant embedment tests could exhibit some large deviations that may result from the complexity of sample preparation and testing procedures. The developed mathematical model integrated with the lab-derived indentation force - contact area relationship can well predict proppant embedment (Fig. 4), and therefore offers a fast alternative approach for estimating proppant embedment and fracture aperture. Using this approach, the saturation influence of water and KCl fluids on proppant embedment on rock surfaces was conveniently quantified.

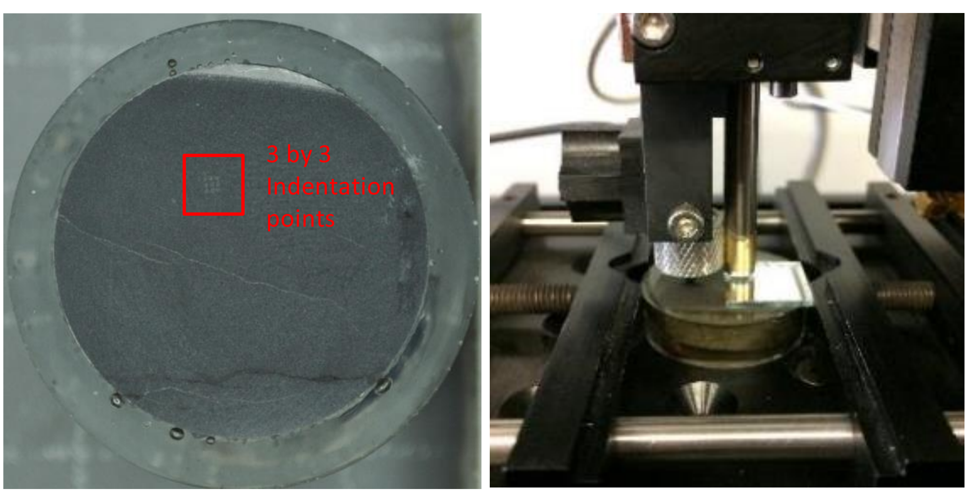

Fig. 1. Sample (left) and indenter (right) for hardness test

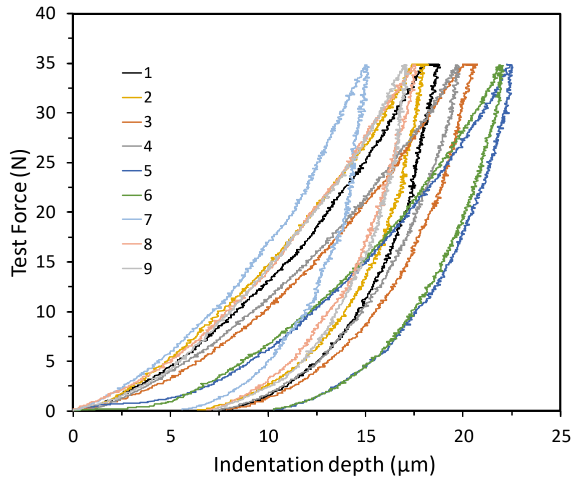

Fig. 2. Force-indentation curve from indentation tests

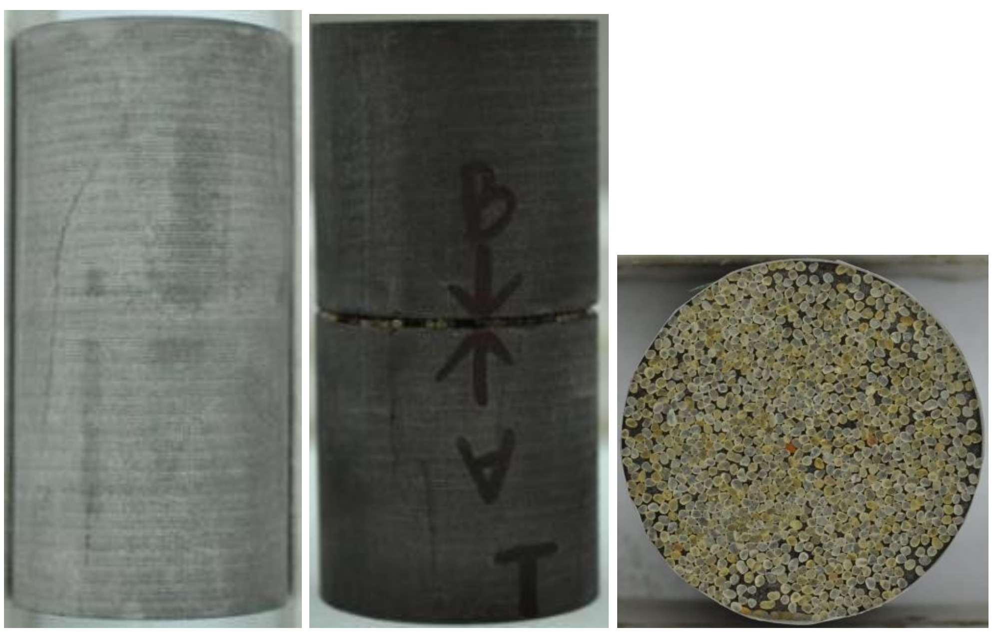

Fig. 3. (a) intact sample for elastic triaxial test; (b) sample split to two halves for proppant embedment test; (c) monolayer of proppants between two split halves

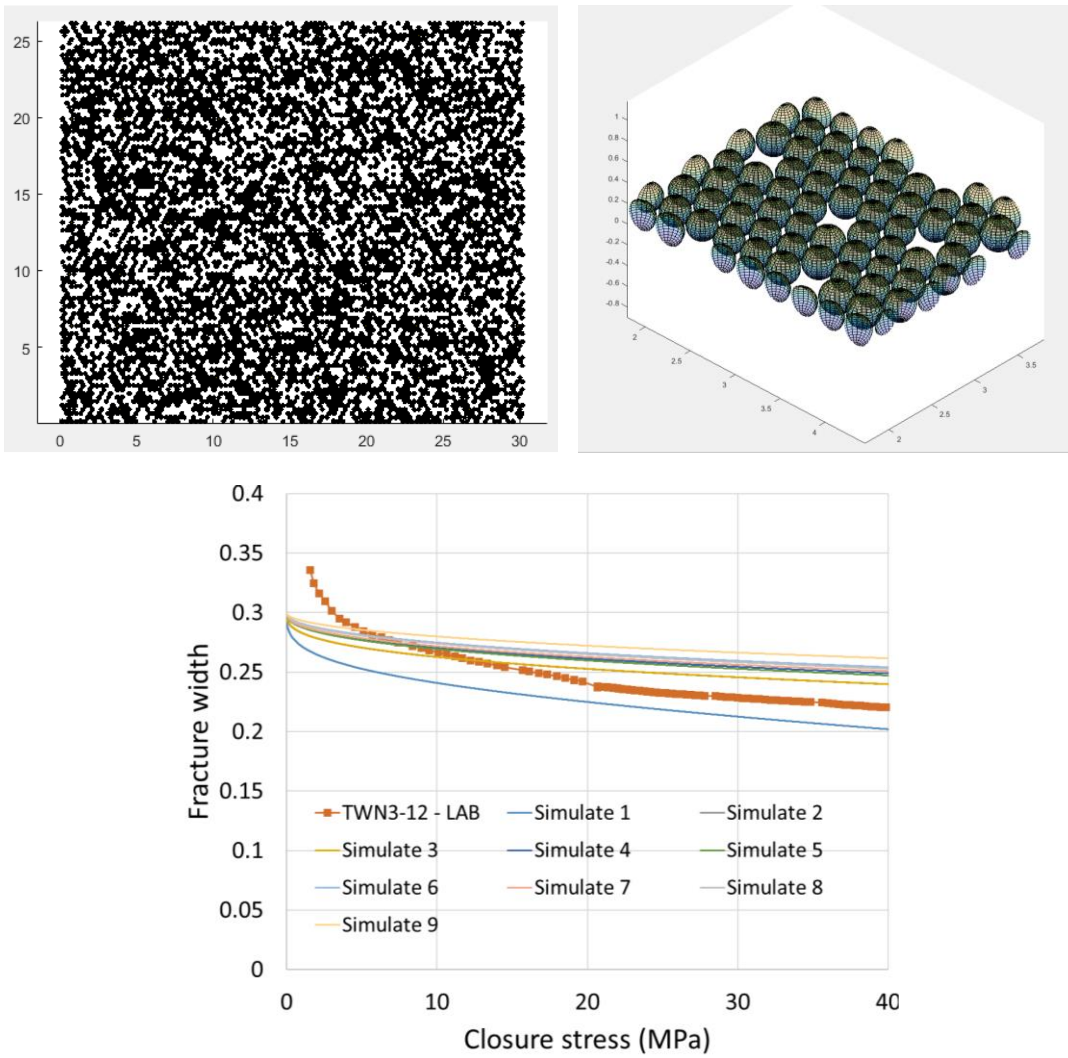

Fig. 4. Planview of monolayer proppant particles (top left) and zoom-in proppant particles (top right), and comparison between prediction and lab measurement of proppant embedment (bottom)