geoconvention
Calgary • Canada • May 15-19 2017

A comparison study of existing and new mineralogical, (geo)mechanical, and petrophysical brittleness indices of the Alberta Montney and their applicability for optimizing well stimulations

Albert Cui, Raphael Wust, Brent Nassichuk
Trican Geological Solutions, 621-37th Ave NE, Calgary, AB, T2E 2M1, acui@trican.ca

Summary

Optimal recovery and production of unconventional hydrocarbon resources require optimal placement and stimulation of multistage hydraulic fractures along a horizontal wellbore. For tight and shale reservoirs with low or ultralow permeability, it is generally accepted that the most effective stimulation is one that creates a complex network of induced (hydraulic) fractures and pre-existing natural fractures. The tendency to develop a complex fracture network by a hydraulic stimulation is controlled by many factors, such as stimulation fluid and schedule, in-situ stress regime, and formation mechanical properties. Out of many mechanical properties, the level of reservoir rock brittleness or ductility is likely the key parameter controlling the development of a complex fracture network. However, rock brittleness is poorly defined, and is even more difficult to quantify. Currently, there are over a dozen existing definitions of brittleness index to characterize rock brittleness but there is very little consistency between the definitions.

In this study, a comprehensive review of various definitions of brittleness in the literature is conducted. Different definitions of brittleness index are exercised to evaluate the brittleness of the Montney Formation in west central Alberta. A wide spectrum of rock properties are used to determine brittleness index, including mineralogy determined with x-ray diffraction (XRD) and fluorescence (XRF) analyses, mechanical properties (Young's modulus and Poisson's ratio) derived from direct laboratory core tests and interpretation of petrological logs, as well as deformation behavior of stress-strain curves of triaxial compression tests on cores from several Alberta Montney wells. As expected, different definitions of brittleness index result in quite different values. Brittleness index simply based on weight or volume ratio of minerals has become quite popular in recent years but also has raised criticism because of the lack of a mechanical basis. To better utilize mineralogical information, we propose several new definitions of brittleness index based on rock mechanical properties derived from mineralogy instead of the commonly-used weight or volume ratio of some minerals. A new brittleness index based on hardness is also presented, as a better alternative to existing mineral-based brittleness indices. The hardness of rock reflects the yield strength of rocks and in turn is related to rock brittleness and/or ductility. Comparison of high-resolution profiles of aforementioned existing and our proposed new brittleness indices with direct measurements of Leeb rebound hardness profiles highlights the similarities and differences among the different brittleness indices and thus applicability of each index for evaluating formation brittleness and selecting optimal entry locations and hydraulic fracture spacing for horizontal well stimulations.