GeoConvention
Calgary • Canada • March 7-11 2016
OPTIMIZING RESOURCES

The influence of geochemical composition on the geomechanical properties in Middle and Upper Devonian Horn River Shale, Northeast British Columbia, Canada

Tian Dong[a], Nicholas B. Harris[a], Korhan Ayranci[a], Sheng Yang[b]

a. Department of Earth and Atmospheric Sciences, University of Alberta, T6G 2E3

b. Chemical and Petroleum Engineering Department, University of Calgary, T2N1N4.

Abstract

Shale gas or oil have drawn a great deal of interest because of the application of horizontal drilling and hydraulic fracturing techniques to shale reservoirs. The geomechanical properties of a shale reservoir are essential to the formation's response to hydraulic fracture stimulation. It is apparent that the heterogeneity in shale composition results in the great difference in geochemical properties. Shale intervals with high Young's modulus and low Poisson's ratio are more brittle than intervals with low Young's modulus and high Poisson's ratio. Samples from the Middle and Upper Devonian Horn River Shale, comprising the Evie, Otter Park Members and the Muskwa Formation, were assessed with a variety of techniques to understand controls on geomechanical properties, including core hardness measurements, Young's modulus, Poisson's ratio and brittleness calculated from dipole sonic and density log data, and geochemical composition analysis. This analysis is set in the context of sequence stratigraphic framework, enabling us to project geomechanical properties across the Horn River Basin.

The results of the study suggest that clay content is the most significant factor controlling the brittleness of shale rocks, as it shows strongly negative correlation to hardness. Quartz, which is generally regarded as brittle minerals, has completely different behaviors depending on the type of the quartz where authigenic quartz enhance the brittleness while the detrital quartz has negative correlation with the brittleness. It is noteworthy that there was no correlation between hardness and TOC content, which is basically regarded as ductile materials. High carbonate content are more likely result in high values in the brittleness.

The identified five lithofacies: massive mudstone, pyritic mudstone, laminated mudstone, bioturbated mudstone and carbonate shows great difference in geochemical composition and therefore shows distinct difference in geochemical properties. Massive mudstone and pyritic mudstone have relatively high brittleness, while laminated and bioturbated mudstone have relatively low brittleness. SEM-CL images suggest that massive quartz cements could significantly enhancing the brittleness by forming rigid framework in massive and pyritic mudstone. Less quartz cements were observed in the laminated and bioturbated mudstones because of the presence of clay minerals coating around detrital quartz grains.

The geographic and stratigraphic variation in geochemical composition, which is related to sea level fluctuation, results in spatial and temporal variation in geomechanical properties. Brittleness is relatively high in distal areas than in proximal areas where more clay minerals were trapped nearshore. The Otter Park member, deposited in low sea level stage, is more ductile than the underlying Evie Member and the overlying Muskwa Formation, because more clay minerals are deposited during the falling sea level stage.