A Burial History Model for the Montney Formation - an insight to porosity distribution and hydrocarbon migration

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Summary

The integrated time-temperature-stress history of a formation is a key to understanding reservoir quality and hydrocarbon generation. The stress history controls compaction, while the temperature history controls some diagenetic processes such as silica cementation and clay alteration, which collectively affect porosity and permeability. Thermal cracking of organic matter to liquid hydrocarbons may also contribute to pore system development and the residual organic matter will affect the affinity of the rock to water and determine reservoir's water saturation.

We examine these relationships in the Montney Formation of the Western Canadian Sedimentary Basin, one of the largest tight gas reservoirs in North America. The Montney has a maximum burial depth of 4500 m in the western part of the basin and a minimum burial depth of 500 m at the eastern subcrop. Different burial depths and rock fabric lead to variations in compaction patterns and cement development over geological time. As hydrocarbon generation is a temperature controlled process, burial depth had also influenced generation and expulsion processes across the basin.

We have sampled Montney cores from several different wells representing the deep, medium depth and shallow Montney sections. Mineralogical study and intergranular volume (IGV) calculations were based on point counting performed on SEM images, topped off with EDX elemental mapping and SEM-CL analysis. Cements volumes were combined with diagenetic observations to develop a paragenetic model explaining the timing of occurrence for different cement types. This, together with thermal maturity and temperature profiles from well logs were used to build and calibrate a burial history model with the 'Basin Mod' software.

Our results show that quartz cement is present as both overgrowth and euhedral crystals. It is likely that quartz cement was formed from the silica released into the pore water as a result of the conversion of smectite to illite in the mixed layer illite-smectite clay. Dolomite and iron dolomite cements appear as overgrowths around detrital dolomite grains or as rhombohedral crystals. Calcite cement is in most cases poikilotopic and probably represents the last phase of cementation in the Montney Formation. Potassium and sodium feldspar cements are also found in the samples, though at smaller quantities, and mostly as overgrowths.

Porosity, combined with organic matter content in the deep basin is estimated from image analysis (2D) at about 15%. Mercury injection porosity averages at <4%, and helium porosimetry averages at 3-7%. TOC is <4 Wt% but the residual organic carbon (mostly bitumen) occupies 7-11% of the rock's volume. The residual, thermally matured bitumen plays an important role in pore structure of the Montney, as much of the porosity present in the rock today is developed within the organic matter much like in shales.