Impact of Mineralogy and Diagenesis on Reservoir Properties of the Lower Cretaceous Upper Mannville Formation (Alberta, Canada)

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The Lower Cretaceous Upper Mannville Formation in West-Central Alberta have been intensively penetrated by wells targeting deeper reservoirs during the last decades. However, production and well log data in this area suggest that significant volumes of gas are present in both conventional and tight reservoirs.

The Upper Mannville reservoirs in West-Central Alberta consist of fluvial sandstones filling incised valleys. The valley infills are made of lithic sandstones with a complex mineralogy. These sandstones are made up of various amounts of quartz, feldspars, clay minerals and rock fragments. They were subjected to a complex diagenetic history and the resulting paragenesis influenced the actual reservoir properties. Consequently, heterogeneities in the petrophysical properties result in significant exploration risks and production issues.

We present in this paper the preliminary results of a diagenetic study performed within a well constrained stratigraphic framework, that aim at understanding the impact of mineralogy and diagenesis on porosity and permeability. Seventy core samples from eight wells were collected to perform a petrographic analysis, and to propose a paragenetic sequence. Four main diagenetic events were identified that occurred during burial: 1) clay coating around the grains; 2) compaction/dissolution of matrix grains; 3) quartz and feldspars dissolution that initiated smectite-illite transformation and kaolinisation; and 4) carbonate cementation in the remaining pore space.

Clay minerals transformations and carbonate cementation are the main factors that inhibited the porosity and the permeability of these sandstones. The Smectite-Illite transformation was initiated after potassium was released in the formation fluids due to K-Feldspars dissolution. This transformation proportionally increased with temperature during burial. Cations such as Ca^{2+}, Mg^{2+} and Fe^{2+} were also released as Smectite transformed into Illite, favouring carbonate cementation in the remaining pore space.

Porosity and permeability were measured on samples used for the diagenetic study. Additional SEM and XRD analyses allowed to characterize and quantify more accurately the different mineralogical phases occluding the porous network. The characterization of both mineralogy and petrophysical properties gives useful keys to locate the diagenetic phases in space and depth, and to predict the petrophysical properties distribution at the basin scale.