The Control of Starting Rock Composition on Diagenetic Processes in Fine-grained Mudstones: an Example from the Middle and Upper Devonian Horn River Shale, Western Canada Sedimentary Basin

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ABSTRACT

Mudstones obviously undergo diagenetic processes including compaction, cementation, recrystallization and dissolution, which is analogous to sandstone and carbonate, however the diagenesis in mudstone reservoirs receive much attention. Diagenetic processes have significantly influenced the original mineralogy and fabric at deposition, and it will definitely affect the reservoir properties, like porosity, permeability and geomechanical properties. In order to examine the roles of starting rock composition on shale digenetic processes, forty samples with a wide range of rock compositions from the Middle and Upper Devonian Horn River Shale, Western Canada Sedimentary Basin were selected for an integrated analysis including TOC combustion, Rock-Eval pyrolysis, X-Ray Diffraction, ICP-MS analysis, thin section and scanning electron microscope (SEM) analysis.

Minerals identified by the initial X-Ray Diffraction includes quartz, K-feldspar, plagioclase, calcite, dolomite, anatase, pyrite and clay minerals. The clay fraction which is of both detrital and diagenetic origin is dominated by illite and mixed layer illite/smectite, plus a trace of chlorite. ICP-MS analysis indicates that the three stratigraphic units, the Evie, Otter Park Member and Muskwa Formation have contrasting rock compositions. The Evie Member is rich in carbonate and the Otter Park Member is rich in clay minerals, while the Muskwa Formation is rich in quartz content. High-magnification SEM images indicate the strong heterogeneity in both textures and mineralogy for samples from different stratigraphic units. Cathodoluminescene images indicate that quartz occurs as detrital silt, authigenic overgrowths and pore-filling microquartz. Early diagenetic processes involves mechanical compaction and late diagenesis was dominated by quartz cementation, clay mineral transformations, dolomitization, carbonate dissolution and the development of organic pores due to thermal cracking of kerogen into hydrocarbon.