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SHALE PORE STRUCTURE EVOLUTION AND ITS EFFECT ON PERMEABILITY

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ABSTRACT

The effect of compaction and burial on petrophysical characteristics of shales is investigated using shale samples from depths of 1000-4100 m in the Beaufort-MacKenzie Basin and 4500-5600 m in the Scotian shelf. The purpose is to obtain information on permeability and porosity evolution of shales with compaction and burial, to aid studies of hydrocarbon migration and accumulation in Canadian Frontier basins.

Results show that porosity decreases with compaction and burial depth until it reaches a value of 30 % at 1000 m, and continues to decrease to 5 - 10 % at greater depths of 2500 to 4000 m. The pore-structure generally shows a unimodal pore-size distribution, with modes at about 200 nm at 1000 m, which then decreases to 10 - 20 nm at greater depth. The permeabilities, which are in the range of 10^{-14} - 10^{-11} m^2 near the ocean floor surface, decreases to about 10^{-22} - 10^{-20} m^2 at greater depths. At those depths, diagenetic effects on pore structure become significant.

Around 4500-5600 m depth, shale effective porosities and pore-sizes are in the range of 1.5 to 12% and 0.3 nm to 60 μm, respectively. Seventy (70) to 80 % of their porosity is concentrated in the 0.5 to 100 nm range, forming a unimodal distribution of "nano-pores" with modes between 2.7 and 12 nm. While larger pores constitute part of the pathways for fluid flow, the nano-pores constitute the throats, therefore controlling permeability. About 60 % of the nano-pores are fluid-flow paths, except when the final diagenetic phase of the shale is cementation. For such shales, 70-80 % of the nano-porosity is due to dead-ended or larger storage pores.

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