Pre-Rift Labrador Shelf Carbonates, Hopedale Basin: Diagenetic Implications and Age Assessment

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Summary

The Labrador Shelf is a Mesozoic extensional margin containing the Saglek and Hopedale Basins, with separation between North America and Greenland occurring approximately 70 Ma. The Hopedale Basin, the site for past and present petroleum exploration, is located just north of the Orphan Basin and is situated between two basement highs, the Okak and Cartwright Arch. In total, five significant hydrocarbon discoveries have been made in the Hopedale Basin, which include the Snorri, Hopedale, North Bjarni, Bjarni, and Gudrid fields. Estimates of reserves are at 22 trillion cubic feet with approximately 4.2 Tcf of natural gas and 123 million barrels of NGL. Reservoir types include Cretaceous-Tertiary syn-rift alluvial to fluvial sandstones (i.e. Bjarni Formation) and unnamed pre-rift Paleozoic carbonates preserved on the top of basement highs.

Geology and some preliminary petrographic investigations of the pre-rift carbonates in the region have been documented. However, no previous detailed studies have focused on the relationships between early and late diagenetic events and porosity evolution. The age of carbonate sediments have questionable beyond the Paleozoic due to palynological ambiguities within certain wells (i.e. Gudrid H-55 palynomorphs). Therefore, a detailed study to properly characterize the reservoir at the micro-scale, with further age assessment, is of great value to the Labrador Shelf and for the Hopedale Basin in particular. Specifically, a petrographic and geochemical study of the Paleozoic carbonates from the drillholes Roberval K-92, Gudrid H-55 (gas discovery), and Indian Harbour M-52 will (1) identify and characterize the calcite and dolomite phases; (2) investigate their geochemical attributes; (3) study the influence of diagenesis, particularly the dolomitization, on porosity evolution; and (4) shed light, if possible, on the age of these carbonate sediments.

Core samples from Roberval K-92 (3578 – 3582 m and 3870 – 3873.5 m), Gudrid H-55 (2676 – 2680 m), and Indian Harbour M-52 (3952 – 3958 m) were collected for petrographic investigations and geochemical analyses. Two main types of carbonates are recognized; a wackstone with limited

dolomitization (Indian Harbour M-52) and dolostone (Roberval K-92 & Gudrid H-55). Three dolomite phases (D1, D2 and D3) have been petrographically and geochemically identified and correlated between wells. Their crystal sizes range from dolomicrosparite to saddle dolomite, ranging from 20 to 700 µm, with Fe content ranging between 499 ppm and 16607 ppm, while Mn ranging from 75 ppm to 1262 ppm. Using distribution coefficients of Sr in dolomite ($D1_{Sr}$ = 0.015 and 0.06) the calculated Sr/Ca molar ratios for the earliest dolomitizing fluid (0.0010 – 0.0060) suggest that initial dolomitization (D1) resulted from mixing marine and non-marine (meteoric) waters. The petrography, fluid inclusion microthermometry and stable isotope geochemistry suggest that D2 (50 to 300 µm) and D3 (250 to 750 µm) are possibly derived from hydrothermal fluids. From petrographic examination, visual estimates of porosity vary among wells and range from < 1 to 20%. Interstitial porosity likely developed during early dolomitization, whereas several phases of dissolution and late calcite cementation, led to the creation and destruction of vuggy porosity. $^{87}Sr/^{86}Sr$ values, sampled from calcite and dolomites, range from 0.708897 to 0.709264. Pristine micritic (C1) cements suggest that deposition likely started in the Early to Mid-Ordovician with early dolomitization occurring no later than this time. The δ13C signatures of the dolomicrite also match the global values documented for the Ordovician preserved carbonates.