ISOTOPIC AND FLUID INCLUSION TRENDS IN THREE REGIONAL DEVONIAN DOLOMITE CONDUIT SYSTEMS, WESTERN CANADA SEDIMENTARY BASIN: PREQU’ILE BARRIER, RIMBEY-MEADOWBROOK REEF TREND, AND SOUTHEAST PEACE RIVER ARCH FAULT CONDUITS.

Eric Mountjoy, Hairuo Qing, Eva Drivet, Xiomara Marquez, Steve Whittaker, and Anthony Williams-Jones, Department of Earth and Planetary Sciences, McGill University, 3450 University St., Montreal H3A 2A7; Geological Survey of Canada, Calgary T2L 2A7; Shell Canada Research, 3655 36 St. N.W., Calgary T2L 1Y8; Maraven S.A., Caracas 1010-A, Venezuela.

Data from three different parts of the Western Canada Sedimentary Basin are compared: the Middle Devonian Presqu’ile Barrier, fault controlled dolomites from the southeast side of the Peace River Arch, and the Upper Devonian Rimby-Meadowbrook reef trend. From northeastern British Columbia to Pine Point over a lateral distance of 400 km, dolomite cements show general trends of decreasing 87Sr/86Sr ratios (0.7106 to 0.7081) and homogenization temperatures (178 to 92°C), with some increase in δ18O values (-16‰ to -7‰PDB). These regional trends suggest that hotter and more radiogenic basinal fluids moved eastward updip along the Presqu’ile Barrier and mixed with cooler ambient formation waters. This barrier appears to have acted as a deeply buried regional conduit system that played an important role in focussing and channeling these basinal fluids (Qing and Mountjoy, 1992, 1994).

In the southeastern Peace River Arch the geochemistry of Upper Devonian replacement dolomites and dolomite cements from two stratigraphic levels (Frasnian Leduc and Famennian Wabamun) are similar. The distribution, geochemistry and fluid inclusion data from the Wabamun replacement dolomites and dolomite cements suggest that they formed from saline hydrothermal fluids (between 100 and 200°C) that moved upwards along an extensive fault and fracture systems, possibly as early as the Early Carboniferous. Their similarity with Leduc dolomites suggests that they were probably connected to the same fault conduit system.

C and O isotopes of the replacement dolomites are relatively uniform along the Rimbey-Meadowbrook reef trend. Southward along the reef trend, with increasing burial depth, dolomite and calcite cements are characterized by 1) a slight decrease in O isotopes (-4 to -7‰PDB); 2) slightly more radiogenic strontium, and 3) no trend in Sr isotope vs O isotope. Thus there is relatively uniform geochemistry along the reef trend, which contrasts markedly with the distinctive regional geochemical trends along the Presqu’ile barrier. Pressure corrected temperatures from the dolomite and calcite fluid inclusions are: 1) 20 to 70°C higher than a geothermal gradient of 30°C/km, assuming a surface temperature of 30°C, and 2) higher than temperatures reached during maximum burial in the Early Tertiary (allowing for more than 1 km of uplift since maximum burial). The dolomite cements show no depth trend supporting the interpretation that they formed during shallow burial from hydrothermal fluids. Homogenization temperatures of late calcite cements follow a 15 to 30°C/km geothermal gradient, and also suggest a higher than normal geothermal gradient or the upward movement of hydrothermal fluids. TSR-related calcites, above depths of 3000m, contain fluid inclusions with lower mean homogenization temperatures (115 to 120°C) than earlier late-stage calcites (130 to 145°C), but in the deep basin generally have higher homogenization temperatures of 150 to 167°C. Some saddle dolomites with low δ13C occur in the deepest dolomite reservoirs. Thus, in general, TSR products formed in deep dolomite reservoirs close to maximum burial during and after the conversion of crude oil to gas.

In all three regions, the large-scale movement of hydrothermal fluids appears to be related to tectonic compression and sedimentary loading in the Western Canada sedimentary basin, which occurred at least twice: during early burial between the Late Devonian and Early Carboniferous and during deep burial between the Late Jurassic and Early Tertiary.