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Stable Isotope Geochemistry of Breccias and Fills in the Upper Devonian Grosmont Bitumen Reservoir, Alberta, Canada

Kevin L. Carriere*[a]
and
Hans G. Machel[a]

[a]Earth and Atmospheric Sciences
University of Alberta
Edmonton, Alberta
Canada

*kevin.carriere@ualberta.ca

Abstract

The Upper Devonian Grosmont carbonate platform in Alberta hosts the largest carbonate bitumen reservoir in the world. Estimated reserves are 318 billion barrels OIP, with API gravities ranging from of 5° to 9°. Because of engineering and geological uncertainties, as well as economic constraints, this bitumen resource is yet not under commercial production.

Due to multiple phases of porosity generation and destruction, most notably dolomitization and karstification, the Grosmont is a highly heterogeneous reservoir. Our study focuses on unravelling the timing and origin of karst-diagenetic phases. The basis for this investigation is an analysis of 39 wells near the erosional edge of the platform adjacent to the Canadian Shield. The carbonates in this area range in thickness between 80 to 120 m and are buried between 250 and 350 m. The maximum burial was about 1.5 km and the platform is apparently free from tectonic deformation, except for blockfaulting.

Our database is comprised of core catalogue, thin section, XRD, SEM and magnetic susceptibility observations, along with 137 $\delta^{13}C/\delta^{18}O$ analyses, and 27 $^{86}Sr/^{87}Sr$ measurements from clast-supported to corroded breccias, karst fills, as well as marls and inter/intraformational shale breaks.

Thin sections depict both matrix and clast supported brecciated textures, microlaminated facies, and karst collapse textures. Fabrics are variably leeched and corroded, and are dominated by microcrystalline rhombic dolomite and to lesser extent by cryptocrystalline calcite. XRD data define mixed carbonate and siliciclastic systems. Magnetic susceptibility data are in agreement with data from publicly available down-hole γ-ray logs. SEM data are in agreement with published Grosmont microtextures (eg. Luo et al., 1994, Luo and Machel, 1995).

$\delta^{18}O$ and $\delta^{13}C$ values of calcites range from -0.42 to -17.54‰ PDB and from +2.6 to -6.7‰ PDB, respectively (Figure 1, upper left). $\delta^{18}O$ and $\delta^{13}C$ values of dolomites range from +1.73 to -14.5‰ PDB and +2.62 to -7.1‰ PDB, respectively (Figure 1, upper right). The stable isotope values are highly variable near the regional unconformity and variability generally decreases with depth (Figure 1, lower left and right). Notable exceptions to these trends are exhibited along restricted fractures/faults and in breccia karst fills. Variability in $\delta^{18}O$ and $\delta^{13}C$ as related to latitude is obscure. The values are depleted near the eastern platform margin.

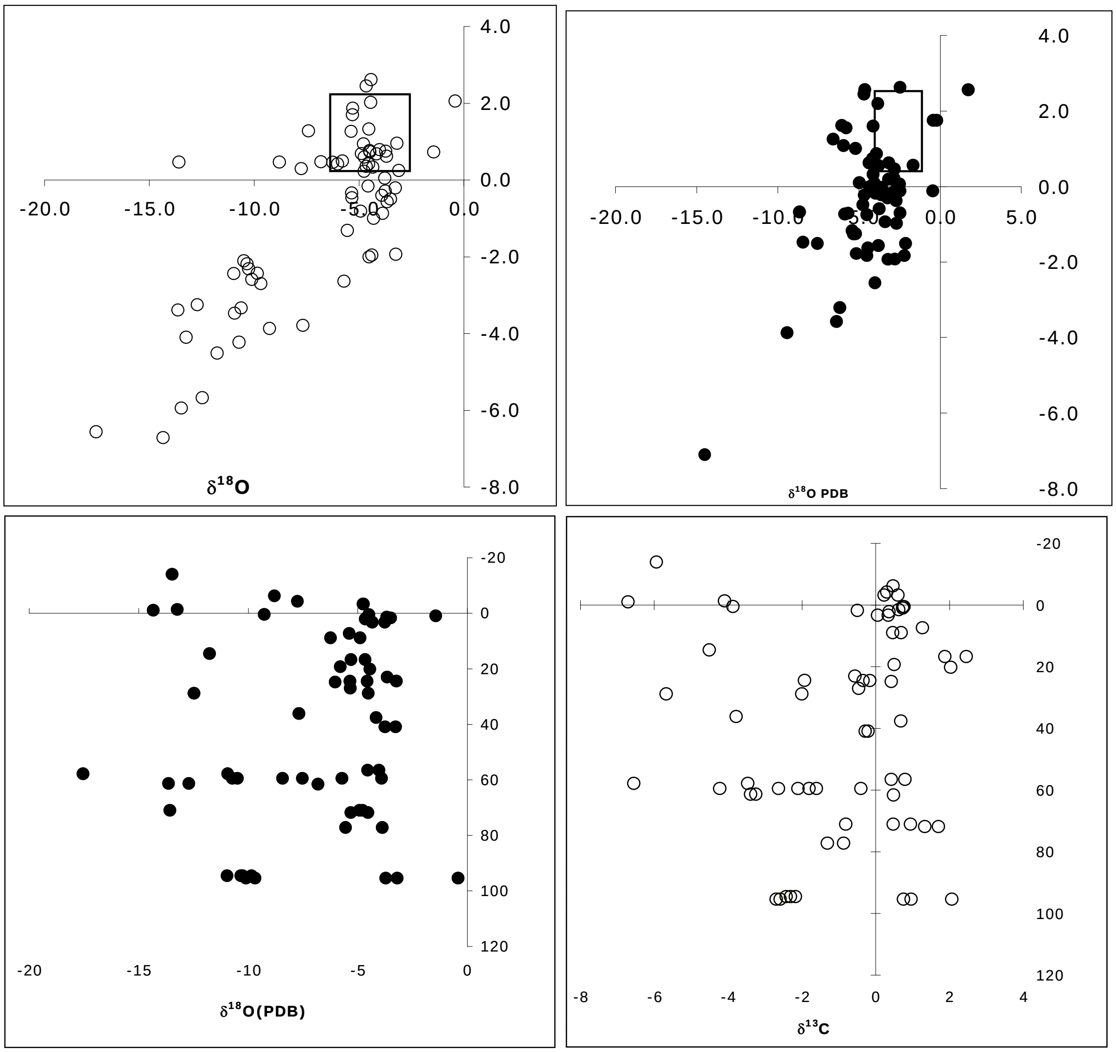

Figure 1: Calcite sourced (upper left) and Dolomite sourced (upper right) $\delta^{18}O/\delta^{13}C$ PDB stable isotope distributions from samples along the eastern subcrop margin of the Grosmont Platform. Boxes respectively represent estimated isotope ranges for Calcite and Dolomite in seawater during the Upper Devonian after Hurley and Lohmann (1989). Sample depletion may be affected by burial diagenesis, and/or two or more phases of meteoric diagenesis. $\delta^{18}O$ (lower left) and $\delta^{13}C$ (lower right) values plotted against depth below Cretaceous unconformity. Variability is high near unconformity surface, and generally decreases. Variability down-hole is related to fractures/faults in the subsurface. All isotope signatures are relative to PDB standard.

The $^{86}Sr/^{87}Sr$ measurements range from 0.70797 to 0.71177. The maximum value in carbonates is 0.70865, whereas shale and/or marls range upwards from 0.70916 (Firgure 2). Depth related stratification is absent in this dataset. All values are lower than the Devonian MASIRBAS.

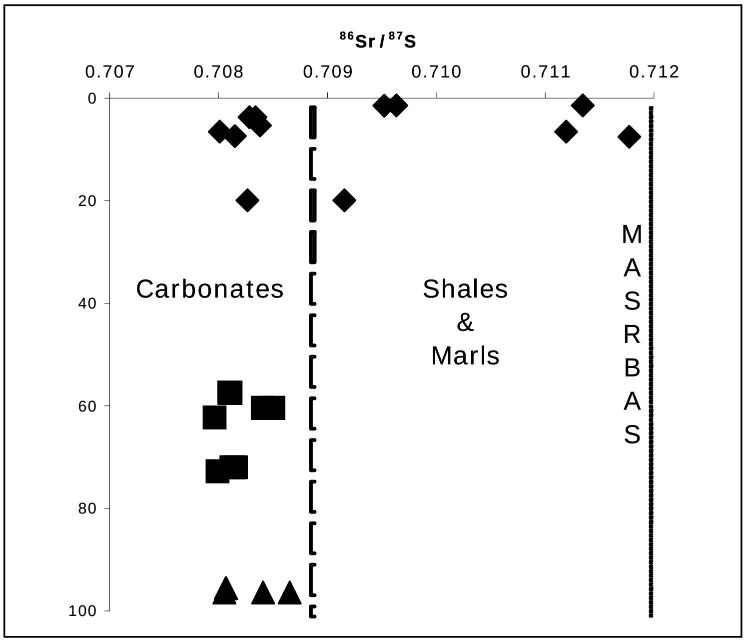

Figure 2: $^{86}Sr/^{87}Sr$ values of Upper Devonian Grosmont stratigraphies, Nisku Fm. (Diamonds), Upper Ireton Fm. (UIRE, Square) and Unit 3 of Upper Grosmont Fm., (UGM3, Triangles), in township 89-23 West of the 4th Meridian. Samples plotted versus depth below unconformity. Ratios are influenced by lithologic variation, but are independent of stratigrapic variability. Dashed line marks informal boundary between Carbonate and Clastic Strontium ratio values. MASRBAS after Machel and Cavel, 1999.

Though other researchers (Zhao and Machel, *personal communication*) interpret hydrological partitioning of the reservoir into semi-isolated units, our data suggest that the Grosmont Platform and its constituent stratigraphies represent a homogeneous aquifer. Grasby and Chen (2005) suggest that, at least during the Pleistocene, subsurface fluids originating from one or more continental ice caps migrated westward through the Canadian Shield into Devonian carbonates of the Western Canada Sedimentary Basin. Our strontium data suggest the platform carbonates appears to be isolated from the influence of fluids migrating through the Canadian Shield.

References

Grasby, S. E. and Chen, Z., 2005. Subglacial recharge into the Western Canada Sedimentary Basin—Impact of Pleistocene glaciation on basin hydrodynamics. *GSA Bulletin*. v. 117, No. 3/4, p. 500-514.

Luo, P., Machel, H. G. and Shaw, J., 1994. Petrophysical properties of matrix blocks of a heterogeneous dolosotne reservoir – the Upper Devonian Grosmont Formation, Alberta, Canada. *Bulletin of Canadian Petroleum Geology*. v. 42, no. 4, p. 465-481.

Luo, P. and Machel, H. G., 1995. Pore Size and Pore Throat Types in a Heterogeneous Dolostone Reservoir, Devonian Grosmont Formation, Western Canada Sedimentary Basin. *AAPG Bulletin*. v. 79, no. 11, p1698-1720.

Machel, H. G. and Cavel, P. A., 1999. Low-flux, tectonically-induced squeegee fluid flow (“hot flash”) into the Rocky Mountain Foreland Basin. *Bulletin of Canadian Petroleum Geology*. v. 47, no. 4, p. 510-533.