Geochemistry of fluids from the Bruce nuclear site: Evidence for a geologically ancient Ordovician porewater system

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Groundwater and porewater geochemistry data were collected at the Bruce nuclear site near Tiverton, ON, located on the northeastern margin of the Michigan Basin, as part of multi-disciplinary site characterization activities for the proposed development of a deep geologic repository (DGR) for low- and intermediate-level radioactive waste (L&ILW).

The site-specific geochemical data is consistent with regional data collected in various locations within the Michigan Basin, suggesting that the origin and evolution of the brines at the regional- and site-scales have been controlled by the same, or similar, processes. The natural tracer data ($\delta^{18}O$, $\delta^{2}H$, Cl, Br) collected at the Bruce nuclear site support the long-standing hypothesis that the sedimentary brines originated from seawater, or evaporated seawater (e.g. [1, 2]), and have been modified over hundreds of millions of years by various mixing and *in situ* water-rock interaction processes (e.g. dilution, halite dissolution, dolomitization). In addition, enriched $^{87}Sr/^{86}Sr$ isotopic signatures throughout the entire Ordovician sedimentary sequence suggest that solute residence times within the Ordovician brines are long and these values are consistent with regional observations (e.g. [3]).

Horizontal hydraulic conductivities (K_H) and matrix permeabilities were measured in the Ordovician formations and range between 10^{-15} and 10^{-12} m/s, and 10^{-20} to 10^{-15} m^2, respectively. Vertical hydraulic conductivities are estimated to be less than K_H by a factor of at least ten in the Ordovician formations, and the presence of high isotopic gradients in the methane and helium compositions ($\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$, and $^{3}He/^{4}He$) indicate that a barrier to vertical solute transport may exist at the base of the Cobourg Formation at the Bruce nuclear site. The geochemistry, when partnered with the physical data, suggests that the Ordovician porewater system is geologically ancient.

[1] Wilson & Long (1993a) *Applied Geochemistry* **8**, 81–100. [2] Wilson & Long (1993b) *Applied Geochemistry* **8**, 507–524. [3] McNutt *et al*. (1987) *Applied Geochemistry* **2**, 495–505.

Characterising the Earth: Exploiting seismology and mineral physics

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The dominant gradient in Earth properties is radial and this has enabled simple 1-D models to have considerable utility. Seismological reference models have been employed in ways that were not envisaged when they were created. In particular, the parameterizations were chosen for mathematical convenience rather than linked to any particular physical conditions. It should therefore come as no surprise that such seismological models do not conform to the properties expected for mineral physics predictions for reasonable mineral assemblage models and near adiabatic conditions. There will also be biases associated with lateral heterogeneity, e.g. the properties corresponding to the average temperature are not the same as the average of the same properties. Nevertheless seismology provides key tie points through well constrained discontinuities that can calibrate pressure scales, and mineral physics can investigate perfect aggregates and so explore a broad range of likely conditions. Rather than test a particular mineral physics configuration against a specific seismic reference model or a subset of seismological observations, we need to build new physical comparator models that recognise the limitations of both seismic and mineral physics models and provide explicit uncertainties on physical parameters. Such models should work with the standard seismological data sets and recognise the geodynamic state - non-adiabaticity is likely in a convecting system. We can examine the physical state implied by seismic tomography in terms of the predictions for different classes of parameter models and so gain insight into the controls we have on the Earth system.