Understanding the origin of porewater geochemical profiles in the Michigan Basin, southwest Ontario

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With a view toward establishing a deep geological repository for low- and intermediate-level radioactive waste, a geoscientific site characterization program has been conducted on the eastern margin of the Michigan Basin at the Bruce nuclear site. Drilling and collection of cores within an ~ 860 m near-horizontally layered Paleozoic sedimentary sequence, resting atop the Precambrian basement, has provided an opportunity for porewater and groundwater sampling and analysis with an unprecedented level of detail. Utilizing geochemical data from groundwater and porewater, this paper describes a natural analogue study in which the distribution of natural tracers within the sedimentary sequence is explored to develop insight regarding the timing and processes governing solute migration.

Depth profiles for the natural tracers $\delta^{18}O$, $\delta^{2}H$, Cl and Br in porewater and groundwater are presented and interpreted in terms of advection and diffusion processes that have caused them to evolve from initial conditions. Illustrative numerical simulations have been performed which support current interpretations of solute transport.

The tracer profiles are characterized by first-order trends that result from diffusive mixing near the top and bottom of the section over hundreds of millions of years. Near the top of the section, hypersaline evaporated seawater brine in the Silurian was in contact with porewater of normal marine salinity in the Ordovician. Contrasting chemical and isotopic compositions resulted in diffusive mixing across the Ordovician – Silurian boundary. Similarly, differences in isotopic composition between porewater in the Precambrian shield and the overlying Paleozoic sedimentary rocks resulted in diffusive mixing across the lower boundary of the basin.

These ancient first-order features in the tracer profiles have been disrupted by seemingly episodic events in the geologic past. The shallow groundwater system (<180 mBGS) shows evidence of a glacial meltwater component (decrease in $\delta^{18}O$ and $\delta^{2}H$), as does a thin, isolated, aquifer in the Salina A1 (~325-328 mBGS). The infiltration of fresh water in these intervals is manifest by dilution of salinity. At depth, in the Black River Group, the tracer profiles are deflected toward higher values that reach maxima in the Cambrian aquifer. The composition of porewater in the Cambrian is similar to deep groundwater from petroleum wells elsewhere in the Michigan and Appalachian basins and these deflections at the base of the tracer profiles are interpreted to represent fluids of deep basin origin. The results of numerical simulations conducted to date suggest that the disruptions at both the upper and lower boundaries could be explained as relatively recent events (e.g. during the Pleistocence). However, data evaluation is ongoing in efforts to advance understanding of the evolution of the profiles.

Indications of geochemical and C-O isotopic compositions in the origin of the UAE carbonatites

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Carbonatite occurrences commonly associated with alkaline volcanic rocks in intracontinental rifting zones. In the UAE, few carbonatitic rocks occur as part of the metamorphic sole of the Semail ophiolite. They form pods, lenses and small layers within the deep sea meta-sediments and meta-volcanic rocks of Hawasina and Haybi Complexes at two different areas: Dibba and Hatta Zones. The previous little work attributed the UAE carbonatite existence to extrusive subaerial magmatic activities in an intra-oceanic setting associated with the Semail ophiolite emplacement. Although, they are internally undeformed, petrographic study reveals some metamorphic minerals in addition to the magmatic signatures. Geochemically, they show a significant enrichment in the REE and trace elements, close to but little above the average carbonatite composition. δ18O and δ13C analysis shows an increase in the isotopic composition of the studied rocks in array from the primary igneous carbonatite, indicating a heavier isotopic source affected these carbonatites. Combining field observation, petrographic study, geochemical and isotopic signatures, the UAE carbonatites might have formed in association with alkaline volcanic activities at the oceanic environment of the Semail ophiolite prior its obduction and final emplacement, and been affected by hydrothermal metasomatism .