Explaining the hydrosphere and biosphere: saline fracture fluids in the deep subsurface Precambrian Shield

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Fluids discharging from fractures over 2.8 km deep in a South African mine have been isolated from the crust for up to 25 Myr and sustain microbial communities of H_2-utilizing methanogens and sulphate reducers [1,2]. Recently, noble gas-derived residence times of more than a billion years were determined for a series of saline fracture fluids from a mine in Timmins, Ontario at 2.4 km depth [3]. Our team is currently investigating the prevalance of this ancient deep hydrosphere, the distribution of such trapped fluids in the crust, and the nature and biodiversity of any microbial communities hosted in these hydrogeologically isolated fracture networks.

Here we present new geochemical and isotopic data for fluids and gases collected at the same Timmins mine, documenting temporal and spatial variability over 6 years and over a vertical depth from levels between 2km and 3km below surface. New fluids from the deepest levels of the mine show δ^2H-$\delta^{18}O$ signatures similar to those previously seen at this site, and extend to values even more elevated above the Global Meteoric Water Line (δ^2H=-30.9‰; $\delta^{18}O$=-17.5‰) consistent with extensive water-rock interaction over long residence times. Samples from a new site at Sudbury, Ontario show δ^2H-$\delta^{18}O$ signatures elevated above the GMWL comparable to those at Timmins and of similar, but lesser, salinity. Intriguingly, the dissolved gases from the Sudbury site are significantly different than those seen elsewhere on the Shield. Associated gases contain significant CH_4 (~15%) and traces of C_2H_6, but differ from those of the Timmins site in their very high N_2 (~53%) and He (32%). The elevated δ^2H-$\delta^{18}O$ signature of Sudbury fluids may be indicative of isolation in the deep crust on similar timescales to those of Timmins. Noble gas analyses and residence time calculations for these and other sites are currently underway.

[1] Lin *et al* (2006) *Science* **314**, 479-482. [2] Lippmann-Pipke *et al* (2011) *Chemical Geology* **283**, 287-296. [3] Holland *et al* (2013) *Nature* **497** (7449): 367-360.