Determining the mean residence age of Precambrian fluid systems

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Hydrogen, helium, nitrogen and hydrocarbon-rich brines associated with mineral deposits in the South African crystalline basement have been shown to support microbial life [1]. Hydrogen production in the Precambrian crust, representing some 70% of the continents, suggests that far larger regions of the Earth are capable of supporting microbial life than previously thought [2]. To understand how the deep continental crust is inoculated, how microbial life evolves in isolation and the extent of their communication with both the surface and other deep subsurface microbial communities it is essential to develop tools that define the fluid environment: What are the residence times of the fluids; where are these fluids sourced; what are the key water-rock reactions producing energy; how widespread are such biomes?

Fluids with similar H_2, He, N_2, CH_4-rich compositions from 2400m depth in a Cu-Zn mine in the Timmins region of Ontario, Canada, have a closed system noble gas mean residence age >1 Ga [3]. Here we extend the Holland et al. (2013), study to fluid flowing from fractures ~600m deeper yet in the Timmins mine, and to similar fluids found at depth in two additional mines on the Canadian Shield also. Preliminary data from Timmins show $^{136}Xe/^{130}Xe$ ratios 93% above modern air values compared with a 20% excess found in the 2400m samples. $^{124}Xe/^{130}Xe$ values are consistent with an atmospheric Xe age [4] close to the mineral deposit formation age at 2.7 Ga. Data from the two new sites in Sudbury also show fissiogenic $^{136}Xe/^{130}Xe$ ratios between 10 and 38% above air. We are currently obtaining data on the light Xe isotopic composition and the other noble gases to obtain noble gas mean residence ages and compare the Timmins and Sudbury systems. Additionally we are applying the new noble gas data to validate the original assumption that these ancient fluids originate from closed systems [3].

[1] Lin et al. (2006) *Science* **314**, 479-482. [2] Sherwood Lollar et al. (2014) *Nature* **516**, 379-382. [3] Holland et al. (2013) *Nature* **497**, 357-360. [4] Pujol et al. (2011) *Earth. Planet. Sc. Lett.* **308**, 298-306.