Dark Energy from the Deep Hydrosphere and Biosphere

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Geochemists have long relied on fluid inclusions, microscopic time capsules of fluid and gas encased in host rocks and fracture minerals, to access preserved samples of ore-forming fluids, metamorphic fluids, and remnants of the ancient atmosphere and hydrosphere. Until recently, groundwaters were thought to reflect only much younger periods of water-rock interaction (WRI) and Earth history, due to dilution with large volumes of yourngger fluids recharging from surface (terrestrial) or mixing from the over-lying oceans. The earliest periods of Earth's fluid history were largely thought to have been overprinted by mixing, and/or geochemically reset, at least on a macroscopic scale

Global investigations in the world's oldest rocks have recently revealed groundwaters flowing at rates > L/min from fractures at km depth in Precambrian cratons. With mean residence times ranging from Ma to Ga [1-2] at some sites, and in the latter case, geochemical signatures of Archean provenance, not only do these groundwaters provide unprecedented samples for investigation of the Earth's ancient hydrosphere and atmosphere, they are opening up new lines of exploration of the history and biodiversity of extant life in the Earth's subsurface.

Rich in reduced dissolved gases such as CH_4 and H_2 [3-4], these fracture waters have been shown to host extant microbial communities of chemolithoautotrophs dominated by H_2-utilizing sulfate reducers and, in some cases, methanogens [5]. Recent estimates of global H_2 production via WRI including radiolysis and hydration of mafic/ultramafic rock (e.g. serpentinization) show that the Precambrian continents are a source of H_2 for life on par with H_2 production estimates for WRI from the marine lithosphere [4]. To date this extensive deep terrestrial habitable zone has been significantly under-investigated compared to the marine deep biosphere. This talk will address some of the highlights of recent exploration of the energy-rich deep hydrosphere, and connections to deep subsurface life.

[1] Lippmann-Pipke et al. (2011) *Chemical Geology* **283**:287-296. [2] Holland et al. (2013) *Nature* **497**:367-360. [3] Sherwood Lollar et al. (2002) *Nature* **416**:522-524. [4] Sherwood Lollar et al. (2014) *Nature* **516**:379-382. [5] Lin et al. (2006) *Science* **314**:479-482.