NOVEL ISOTOPIC DISCOVERIES ON THE BIOGEOCHEMISTRY OF THE DEEP EARTH AND THE HABITABILITY OF PLANETARY SUBSURFACE ENVIRONMENTS. B. Sherwood Lollar[1], L. Li[2], B.A. Wing[3], O. Warr[1], C.J. Ballentine[4], T. Giunta[1], J.M.M. McDermott[1], G.S. Lollar[1], and J. Telling[5], [1]Department of Earth Sciences, 22 Russell St., University of Toronto, Toronto, ON, Canada, M5S 3B1 bslollar@chem.utoronto.ca, [2]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada T6G 2E3, long4@ualberta.ca, [3]Department of Geological Sciences, University of Colorado Boulder, Boulder CO 80309, boswell.wing@colorado.edu, [4]Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, OX1 3AN, United Kingdom, chris.ballentine@earth.ox.ac.uk, [5]School of Civil Engineering and Geosciences, Drummond Building Newcastle University, Newcastle, United Kingdom, NE1 7RU, jon.telling@newcastle.ac.uk.

Introduction: Since reports of subsurface lithotrophic microbial ecosystems (SLiMEs) focused attention on H_2-driven chemoautotrophy in the late 1990s', interest in H_2-producing water-rock reactions as a basis for a subsurface microbial biosphere has captivated fields as diverse as astrobiology, origins of life studies, planetary exploration and oceanography. Discovery of new environmental systems that facilitate investigation of biodiversity, microbial metabolism, life's adaptation to extreme conditions, and limits to life, have expanded our conception of Earth's habitability and informed search strategies for life elsewhere in the solar system. While chemolithotrophic microbial ecosystems in the marine biosphere have been investigated for decades, the geobiology of terrestrial systems is undergoing a recent expansion, in particular to include the > 70% of the continental lithosphere comprised of Precambrian rocks - the oldest rocks on Earth and analogs for the Mars crust in mineralogy and age.

Rich in reduced dissolved gases such as CH_4 and H_2 [1-2], fracture waters deep within the Earth's oldest rocks have been shown, like hydrothermal vents (e.g. "black/white smokers") to host extant microbial communities of chemolithoautotrophs dominated by H_2-utilizing sulfate reducers and, in some cases, methanogens [3]. Recent estimates of global H_2 production via water-rock reaction (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 [1]. This talk will address some of the highlights of recent exploration of the energy-rich deep hydrosphere, and connections to deep subsurface life and astrobiology.

Underground research laboratories and mines worldwide provide access to the deep subsurface in Precambrian settings, and targets for investigation of thre deep biosphere. Kidd Creek Mine located in Timmins Ontario on the Canadian Shield is an iconic site for a number of reasons. Investigation of fracture fluids to depths of 3 km revealed H_2 production via radiolysis and serpentinization [1]; production of methane and higher hydrocarbons via abiotic organic synthesis [2]; and fracture fluids with mean residence times ranging from tens of millions [4] to on the order of a billion years [5] at some sites. In the latter case, geochemical components in the dissolved noble gases of Archean provenance were discovered. Recently, investigation of the sulfur cycle in these fluids has revealed a mass independent sulfur isotope signature in the dissolved sulfate, whereby oxidants from radiolysis oxidize Archean sulfide minerals, providing a mechanism to supply both electron donors (H_2) and electron acceptors (sulfate) that could fuel a deep microbial biosphere on geologic timescales [6]. Recent most-probable-number counts demonstrate the presence of sulfate-reducing bacteria in these waters in the present day. Beginning in 2016 the deep levels at this site are providing access to international teams of researchers to collaborate with the University of Toronto in a multi-year program to characterize the deep CHONS cycles, constrained by noble residence times, and expanding our understanding of the habitability of the Earth and by extension of the potential habitability of planets and moons elsewhere in the soar system.

References:

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