Microbial Adaptations to Biosustainabilitiy in Deep-Subsurface Environments on Earth

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Exploration for life on Mars and icy moons in our solar system necessitates development of innovative techniques for life-detection followed by field testing in analogue environments on Earth. A collaborative international effort is underway to drill and sample within regions of persistent permafrost in northern Canada for the purpose of characterizing microbial ecosystems adapted to long-term cold conditions. In 2001 and 2002, Finnish and Canadian scientists installed an instrumented borehole array in a commercial gold mine with sampling valves at 890 and 1130 meters below the surface. Numerous water and gas samples from the Lupin borehole array have been analyzed for molecular and isotopic compositions of organic and inorganic chemical constituents. Boreholes with the lowest concentration of methane and largest ^{34}S fractionation between dissolved sulfate and sulfide are the focus of microbiological sampling. Microbial diversity at Lupin is being assessed by culturing, sequencing, and direct detection of microbial reactions. Cell counts indicate a low biodensity, ranging from 100 to100,000 cells/ml. Phylogenetic analysis using 16S rDNA indicates low biodiversity with the planktonic biota dominated by a distinctive new phlyotype having 95-97% similarity to Thiohalobaccili. Similarly, the subsurface brines sampled at depths of 1500 to 3500 meters in the Witwatersrand basin of South Africa yield low biodensity and biodiversity with the dominant phylotype being a Desulfotomaculum-like organism that appears to represent a new species and new family. Microbes sampled in fracture water at kilometer depths below the surface are significantly different from surface extremophiles and show specific genetic adaptations to biosustainability in deep-subsurface environments.