

B62A-05 1455h

The Witwatersrand Deep Microbiology Project: Observations Pertaining to Hypothetical Microbial Ecosystems Beneath the Surface of Mars

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The geochemical, isotopic and microbial attributes of over 100 water and gas samples taken from South African deep mines in at 0.8 to 3.3 km depth, temperatures up to 60°C and over 40,000 km² area have been analyzed. Noble gas isotopic estimates of the subsurface residence times for some of the deepest, most saline water samples from the 2.7 Ga Ventersdorp Group volcanics range up to 400 Myr. H₂ and hydrocarbon concentrations are quite high in these samples and cellular concentrations quite low (1000 cells/ml). SO₄ concentrations can also be quite high and are isotopically enriched by microbial fractionation. Mass balance considerations and theoretical arguments suggest that H₂

and sulfate may have originated from radiolytic reactions with water and sulfide. Isotopic data indicate that the hydrocarbons formed by abiotic reduction of inorganic carbon. The 16S rDNA sequences of environmental samples and the microbial enrichments are dominated by heterotrophic, sulfate and metal reducing bacteria with few autotrophs. These results suggest that: 1) abiogenic synthesis or organic carbon may obviate the need for an autotrophic community supporting a heterotrophic one; 2) H₂, He and CH₄ may be abundant in the Martian cryosphere; and 3) radiolysis can lower the freezing point of brines by increasing their salinity and bivalent anion concentration.

B62A-06 1510h

Dress Warm, Focus on the Fluids and Be Patient: Studying Ice Habitats and Constraints on Microbial Life at Low Temperatures

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Studies of low-temperature environments on Earth can help guide exploration of other planetary environments that are of interest in the search for potential traces of life (or absence thereof) elsewhere in the solar system. Ice environments and habitats on Earth range from terrestrial permafrost to the polar ice caps or floating sea and lake ice. Despite the complexity of these different environments, the physical chemistry of unfrozen water - generally deemed a prerequisite for active life - and the pore microstructure can help in describing and categorizing different types of ice from an astrobiological perspective.

In northern Alaska, we have studied constraints on microbial life in two types of ice, sea and lake ice, that bracket the range of availability of liquid water and solid surfaces. The latter have been found to be important for bacterial activity at very low temperatures, with active bacterial cells in sea ice documented down to temperatures of -20 C. Standard and epi-fluorescence microscopy adapted to studies at very low in-situ temperatures can help in locating individual cells and yield insight into the distribution of liquids, organisms and potential biomarkers in icy habitats. As the distribution of fluids, organisms and impurities is governed by segregation processes on different spatial scales, such work can aid in the planning of exploration campaigns (e.g., on Mars and Europa) and help guide the identification of intensive-study sites or the design of sampling equipment.

Apart from such specific lessons, three major conclusions emerge: (1) The use of improved or new methods continues to push the envelope for activity of microbial life to lower temperatures, boding well for planetary exploration campaigns. (2) While the thermodynamics of water activity in ice may constitute an ultimate boundary, the low-temperature kinetic constraints currently present a significant challenge for the study of low-temperature life processes. This may call for dedicated laboratory studies of cells maintained in vitro or in synthetic low-temperature ice environments. (3) Ice-fluid systems lend themselves readily to studies of synthetic environments, extending all the way out to conditions likely to be encountered in Martian or European settings.

B62A-07 1525h INVITED

Europa: Prospects for Life and for the Origin of Life

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Life as we know it could exist on Europa as we know it. That is, our current understanding of Europa seems to allow the existence of certain microorganisms that we know on Earth. Europa almost certainly has an ocean of liquid water and a supply of biogenic elements sufficient for a biosphere. Potential sources of free energy that could fuel a European microbial ecosystem can be identified, but several of them depend on the extent to which Europas crust communicates with its ocean (Chyba and Phillips, *Origins of Life* 32, 47-68 (2002)). This communication seems possible in both thin-ice and thick-ice scenarios, but it may require another mission before we are confident about which geophysical models are in fact correct.

The prospects for the origin of life on Europa are much trickier to evaluate. If the origin of life had to occur under the present ice cover, the abundant energy of the Sun's ultraviolet light would not have been available to drive prebiotic chemistry. Some current models for the origin of life on Earth would seem not to be troubled by this, but recent experimental results suggest that the concentration of salts in the early terrestrial ocean could have been an important impediment to the polymerization of early organic monomers and the formation of prebiotic vesicles implying that life may have originated in freshwater environments on early Earth. The implications of these results for the origin of life in Europas ocean will be discussed.

URL: <http://www.seti.org>

B62B MCC: 134 Saturday 1600h

Sagan Lecture (joint with P)

Presiding: S Trumbore, University of California, Irvine

B62B-01 1600h

From Genomes to Life to the Planet and the Cosmos: In Appreciation of Carl Sagan

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The Earth and life have evolved in tandem; It is impossible to separate the two over most of geologic time. Geological and geochemical processes create and define the conditions necessary for life. In turn, life has shaped geological processes in ways that are understood, and ways that are not yet understood.

The reciprocal interaction between the planet and its inhabitants has driven changes in the molecules, metabolisms, and morphologies of terrestrial organisms. Today, with the emergence of complete genome sequences and tools from molecular biology, we are now better able, more than ever before, to tell stories of how we came to be, on a planet and in a cosmos that has both nourished us and (from time to time) threatened to extinguish us.

The stories to be told in this talk combine information from the geological and paleontological records, analysis of genome sequence data, and experiments that resurrect ancient, extinct life forms for study in the laboratory. The talk will emphasize the non-recurring, progressive feature of the dance between Earth and Life. We will show how the emergence of humans was influenced by the environment, and how humans placed their irreversible mark on the genes of organisms that they touched. We will show how the global environmental crisis that began in the Oligocene irreversibly transformed the plant and animal kingdoms. We will proceed back to the Cretaceous, to explore how plants and dinosaurs influenced each other, and the genomes of surviving fungus and flies. From there we will go to the Jurassic, as the first placental mammals reconstructed their reproductive systems in response to the planetary changes. We will ask how cosmic events, from asteroids to supernova, may have influenced life on Earth. We will ask what consequential features of life that we see around us might be unique to Earth, and what features might be found universally in life elsewhere.

The talk will also review some of the methodological issues associated with converting just-so stories into experimentally testable hypotheses. We will emphasize the "present day backwards" strategy, where tools developed for the recent past can be tested in a regime where testing is possible, and then applied to more ancient events. We also will show how a natural history approach to the analysis of human biology has practical value, offering approaches to treating human diseases as diverse as obesity and cancer, by understanding these diseases in the context of the history through which they have passed.