**What are the Signs of Life on Anoxic Worlds?** H. E. Hartnett[1]. [1]School of Earth and Space Exploration and School of Molecular Sciences, Arizona State University, Box 876004, Tempe AZ 85287-6004. Email: h.hartnett@asu.edu

Although Earth today has an $O_2$-rich atmosphere, we know that was not always the case. For nearly 2 billion years of its history, life on Earth inhabited a very different world – an anoxic world – with chemistry and ecosystems very different from those with which we are familiar today. The early Earth was probably not unique. Anoxic worlds are common in our own Solar System and are likely to be common for exoplanets as well. The goal of this presentation is to consider what we need to know in order to recognize and detect the signs of life on **anoxic worlds** that are dominated by **anoxygenic photosynthesis**.

To search for life beyond Earth it is critical that we determine diagnostic biosignatures for anoxic metabolisms and devise strategies to search for them in diverse settings. In particular, understanding photosynthetic life on anoxic worlds is key for exploring exoplanets because ecosystems that can use light-energy from their stars are the most likely to generate high biomass or high metabolic rates. The evolution of oxygenic photosynthesis permanently changed Earth's atmosphere but $O_2$ did not dominate the biosphere until about 2.4 Ga [1]. The earliest photosynthetic life on Earth was anoxygenic; it did not evolve $O_2$ or use $H_2O$ as an electron donor [2]. Modern anoxygenic photoautotrophs use $H_2S$ as an electron donor (and potentially also $H_2$, $NO_2^-$, and $Fe^{2+}$) and generate elemental sulfur as byproduct, but we have not yet established clear, well-developed, biosignatures for this metabolism.

There are potentially many habitable anoxic worlds beyond Earth. In our Solar System, Mars's surface may have been habitable for <1 Ga [3-4]. In that short window, life could have had time to evolve anoxygenic photosynthesis, but probably not oxygenic photosynthesis. If the ocean worlds of Europa and Enceladus are inhabited, life will likely be dominated by chemoautotrophs using energy from reduced inorganic compounds instead of light. Although, there is the intriguing possibility of anoxygenic photosynthesis based on thermal IR, which has been observed at a deep-sea hydrothermal vent on Earth [5]. Finally, life on exoplanets is most likely to be detected if it is photosynthetic, because such biospheres are near the surface and have the potential to be large. However, if Earth's history is typical, we will encounter many inhabited exoplanets dominated by anoxygenic photosynthesis, as well as many on which the rate of $O_2$ production is insufficient to overwhelm geologic sinks for $O_2$.

In each case, we need to develop a knowledge-base that allows us to recognize the signs of life on anoxic worlds. In what ways are such worlds fundamentally different from the world we inhabit today? How long do habitable planets remain anoxic? How can we optimize our search for biosignatures to reflect the biology, biogeochemistry, and sedimentology of anoxic worlds? And importantly, how are such biosignatures degraded and preserved under anoxic conditions.

Achieving the astrobiology goals of understanding the *co-evolution of life and the physical environment*, and *identifying, exploring and characterizing environments for habitability and biosignatures* thus requires a better understanding of anoxic systems. Interdisciplinary investigation Earth's anoxic ecosystems (e.g., stratified lakes, deep sediments, high-temperatures systems) can reveal information about how these environments shape the evolution and complexity of anoxic life and record that story in the geologic and biomolecular materials that anoxygenic life produces.

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