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SULFUR ISOTOPES AS A PROXY FOR EARLY EARTH ATMOSPHERE: CONSTRAINTS FOR HABITABILITY ON OTHER PLANETS

Abstract

Background Information and Current Knowledge: The geologic sulfur isotope record can be used as a proxy for atmospheric oxygen. The sulfur isotope record can be broadly divided into two parts. In rocks younger than about 2.5 billion years (Ga) relationships among the sulfur isotopic ratios are predictable on the basis of relative isotopic mass differences. However, in rocks older than 2.5 Ga sulfur isotopic ratios do not follow these predictable relationships, and instead reflect anomalous isotopic effect, known as mass independent fractionation (MIF-S). Currently, the only known mechanism for producing MIF-S involves ultraviolet photolysis of sulfur dioxide gas in an oxygen poor atmosphere. Therefore, the disappearance of the anomalous isotopic signal in sulfur isotopes after 2.5 Ga has been interpreted as a drastic change in atmosphere composition from anoxic to oxic. Due to a similar distribution of MIF-S prior to 3.2 Ga and between 2.7 and 2.5 Ga, the atmospheric origins of the isotopic signature at these times is interpreted as anoxic. However, the large MIF-S values that characterize these time periods diminish between 2.8 and 3.0 Ga. The diminished variability in sulfur isotopes between 2.7 and 3.2 Ga is attributed to atmospheric composition changes including fluctuations in atmospheric oxygen, variations in volcanic SO2:H2S, and high-altitude methane hazes. An alternative, but unexplored, possibility is that the published set of MIF-S analyses from 2.8 to 3.0 Ga rocks reflect a sampling bias rather than an atmosphere composition change.

Hypothesis and Objectives: Most of these analyses from 2.8 to 3.0 Ga rocks are from organic matter-poor clastic sedimentary rocks. Deposition of these clastic rocks represents the end product of physical weathering rather than a direct record of the biogeochemical environment. I hypothesize that the sulfur isotope signal between 2.8 and 3.0 Ga may represent a lithological artifact arising from analyzing clastic rocks.

Significance of the Proposed Research: Understanding the origins and evolution of life on Earth provides a starting point to look for clues of similar atmospheric and environmental conditions when searching for habitable extraterrestrial planets. Furthermore, understanding whether the evolution of Earth surface conditions has been progressive (for example if the 2.8-3.0 Ga MIF-S record is lithologically

biased) or cyclic (for example if the MIF-S record is not) will put the search for habitable exosolar planets on firmer observational grounding.