Isotopic Proxies for Microbial and Environmental Change:

Insights from Hydrogen Isotopes and the Ediacaran Khufai Formation

Thesis by

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ABSTRACT

Microbes have profoundly influenced the Earth's environments through time. Records of these interactions come primarily from the development and implementation of proxies that relate known modern processes to chemical signatures in the sedimentary record. This thesis is presented in two parts, focusing first on novel proxy development in the modern and second on interpretation of past environments using well-established methods. Part 1, presented in two chapters, builds on previous observations that different microbial metabolisms produce vastly different lipid hydrogen isotopic compositions. Chapter 1 evaluates the potential environmental expression of metabolism-based fractionation differences by exploiting the natural microbial community gradients in hydrothermal springs. We find a very large range in isotopic composition that can be demonstrably linked to the microbial source(s) of the fatty acids at each sample site. In Chapter 2, anaerobic culturing techniques are used to evaluate the hydrogen isotopic fractionations produced by anaerobic microbial metabolisms. Although the observed fractionation patterns are similar to those reported for aerobic cultures for some organisms, others show large differences. Part 2 changes focus from the modern to the ancient and uses classical stratigraphic methods combined with isotope stratigraphy to interpret microbial and environmental changes during the latest Precambrian Era. Chapter 3 presents a detailed characterization of the facies, parasequence development, and stratigraphic architecture of the Ediacaran Khufai Formation. Chapter 4 presents measurements of carbon, oxygen, and sulfur isotopic ratios in stratigraphic context. Large oscillations in the isotopic composition of sulfate constrain the size of the marine sulfate reservoir and suggest incorporation of an enriched isotopic source. Because this data was measured in stratigraphic context, we can assert with confidence that these isotopic shifts are not related to stratigraphic surfaces or facies type but instead reflect the evolution of the ocean through time. This data integrates into the chemostratigraphic global record and contributes to the emerging picture of changing marine chemistry during the latest Precambrian Era.

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