Preservation and Spatial Distribution of Carbon Isotope Biosignatures in Microbialite Carbonate from Pavilion Lake, British Columbia.
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Understanding the formation and potential for preservation of biosignatures within geologic materials is a key aspect of our ability to identify and interpret biological presence within the geologic record on Earth, or as we search for evidence of life on other planets. Biological metabolisms cause deviations in $\delta^{13}C$ values of carbonate rocks from values expected for equilibrium precipitation from bulk dissolved inorganic carbon (DIC), providing one type of biosignature. Isotopic enrichments of carbonates above expected values for equilibrium precipitation can represent a record of autotrophic intake of ^{12}C during photosynthesis and a corresponding enrichment in ^{13}C of the DIC pool. Conversely, inputs of ^{12}C derived from heterotrophic respiration of organic matter can be recorded as depletions in ^{13}C relative to equilibrium precipitation. Understanding the dynamics of the formation and preservation of these signatures is a key component of our ability to identify and interpret them as evidence for life.

Pavilion Lake in British Columbia, Canada, is comprised of three major basins that are host to a large abundance of modern freshwater microbialites. Previous research has demonstrated $\delta^{13}C$ enrichments of carbonate minerals in surface biofilm and nodular microbial communities from the Central Basin [1, 2]. However, the distribution and potential variation of these isotopic biosignatures within the lake has yet to be well characterized. In addition, the extent to which this surface biosignature is preserved within the microbialite structure at centimeter to millimeter scales has not been constrained. The current study investigated the distribution of the enriched $\delta^{13}C$ biosignature in microbialite carbonates from the Cenral and South Basins of Pavilion Lake. ^{13}C enrichments of 1-2‰ above equilibrium precipitation were observed in both basins and on adjacent sides of the South Basin, indicating broad formation of this signature within the lake. Notably, these enrichments were only observed for shallower samples above 21metres deep. Samples below 21 metres had $\delta^{13}C$ values within the expected range of equilibrium precipitation and are therefore not representative of a robust biotic signal. This is consistent with decreased microbial growth and thus reduced biosignature generation at these depths, likely due to light limitation as originally proposed for this system [3].

Preservation of $\delta^{13}C$ enrichments into microbialite structures was also investigated. In other microbialite systems, it is proposed that heterotrophic activity below the surface of these structures also prompts carbonate precipitation. The carbonate precipitated from this heterotrophic influence may be either equal to the values predicted for equilibrium precipitation, or may be depleted if inputs from heteorotrophic respiration are significant [4]. This current study observed that $\delta^{13}C$ enrichments were present within the microbialite structures up to depths of ~1.5cm. However, below this, $\delta^{13}C$ carbonate fell within the range predicted for equilibrium precipitation. It is noteworthy that based on previous growth rate assessments of 0.05mm/year [5], this 1.5 cm depth suggests a biosignature lifespan of ~300 years.

The extensive observation of isotopic enrichments in carbonates in Pavilion Lake show that generation of an enriched $\delta^{13}C$ signature is occurring broadly in the system. However, the fact that this signature diminishes with additional accretionary growth at the microbialite surface suggests that other processes are overprinting it. Mass balance calculations indicated that precipitation of carbonate at expected equilibrium values is capable of overprinting the surface enrichment if at least ~40% of the total mass of carbonate is precipitated in this way. Understanding processes that act to create and preserve biosignatures has important implications to their value when interpreting the evidence for life in the geologic record, or on other planets.

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