Understanding the drivers of extreme isotopic enrichment in a modern microbialite forming environment

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Microbialites are sedimentary structures formed from the interaction of biological and geological processes. These structures are among the oldest and most extensive records of life on Earth and act as a target in astrobiological studies. Yet, interpreting the paleoenvironmental information preserved in microbialites, and often even their biogenicity, can be difficult. The isotopic compositions of carbon and oxygen in carbonate minerals arise from the interaction of biological, geochemical, and hydrological processes, thus the isotopic composition of the carbonate minerals that comprise microbialites can provide information about the environment in which they formed. However, resolving the processes that are responsible for an isotopic signature is often challenging as the isotopic signature of a particular process may be non-unique. Understanding the genesis and preservation of isotopic signatures in modern microbialite forming environments can enhance our ability to interpret these signatures in the rock record. The microbialites and abiogenic carbonates of the evaporative lake Laguna Negra in Argentina contain extreme enrichments in ^{13}C and ^{18}O and record timewise trends in lake conditions. In order to better understand these signatures, we studied the processes controlling the isotopic evolution of water and DIC spatially at the lake. The isotopic compositions of lake waters are in equilibrium with those measured previously in carbonates and can be explained through the abiotic processes of evaporation, degassing, and carbonate precipitation. This implies that the spatial patterns seen today are longstanding or at least recurrent at the lake and can be recognized from the isotopic composition of carbonates. In addition, this indicates that similarly large isotopic fractionations seen in the geologic record associated with microbialite facies can occur due to processes unrelated to those causing microbialite formation. Our results indicate that a detalied facies analysis should be performed in order to more fully constrain environmental controls and understand isotopic trends preserved in microbialites.