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Micropyrite: a promising biosignature?Insights from modern and ancient sediments

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The influence of microbial metabolic activities on the isotopic signatures in microbially-induced minerals is a key to understand both the modern and ancient biogeochemical cycles. Previous studies have documented in detail S isotope fractionation processes associated with the formation of sulfide by various strains of sulfate reducer bacteria in controlled laboratory conditions (e.g. 1). However, interpreting the S isotope composition of pyrite from the geological record is still challenging. Here, we present detailed mineralogical and isotope studies of ancient and modern sediments that highlight the potential of micropyrites to capture (and retain) biosignatures, notably from microbial sulfate (and iron) reduction pathways, through geological time. Our original approach combines high resolution microscopy with microscale S and Fe isotopes characterized SIMS and NanoSIMS. We investigated micrometric pyrites in two different microbialites, one from a hypersaline environment (Cayo Coco, Cuba) and one from a volcanic alkaline lake (Atexcac, Mexico). Both environments exhibit two distinct pyrite morphologies: framboidal vs. micropyrites with different ranges of S and Fe isotope compositions. However, with respect to the aqueous sulfate isotopic compositions, analyzed micropyrites display a similar and narrow range of Δ_{pyr} ($\Delta_{pyr} \equiv \delta^{34}S_{SO4} - \delta^{34}S_{pyr}$), consistent with sulfate-sulfide equilibrium fractionation associated with low microbial sulfate respiration rates (2). We will show the potential of micropyrites to capture isotopic signatures of microbial sulfur cycling. We propose that micropyrite can record the oldest signature of dissimilatory iron reduction and microbial sulfate reduction, and therefore can be considered as a potential biosignature.

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