Microbial nitrate-dependent Fe(II) oxidation: mechanisms and astrobiological significance

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Abstract

Key environmental parameters such as pH and redox state, availability of electron acceptors and donors, the carbon inventory and the presence of liquid water shape understanding of the potential habitability of early Mars for microorganisms. Evidence suggests that localised aqueous environments that were anoxic, largely reducing, circumneutral, rich in organic carbon, inorganic electron donors and in oxidants such as nitrates and perchlorates existed on Mars (Grotzinger et al., 2015; Eigenbrode et al., 2018). These conditions could have allowed chemolithotrophic microbial metabolisms, such as nitrate-dependent Fe(II) oxidation (NDFO), to thrive (Price et al., 2018).
We have previously reported the capability of some NDFO strains, such as *Acidovorax sp.* strain BoFeN1, to grow using a Mars-relevant olivine Fe(II) source and a variety of martian simulant brines developed from *in situ* ("Rocknest", "Paso Robles" and "Hematite") and meteorite ("Shergottite") geochemical data (Ramkissoon et al., 2019).

In addition to the results of further simulation experiments, we will present new findings on the biochemical mechanisms of NDFO *via* genomic analyses and a knockout mutant experiment. These quantify the relative contributions of the Nar respiratory nitrate reductase enzyme, putative ferroxidase enzymes and nitrite accumulation to the oxidation of Fe(II) in NDFOs.

The apparent ability of selected strains to grow on Mars-relevant Fe(II) sources and brine conditions is supportive of the plausibility of NDFO in the deep martian past, and gene knockout experiments shed light on the underlying mechanisms of NDFO and the extent of contribution to energy metabolism. From this, we can draw more robust conclusions as to the viability of this metabolism as a driver of microbial life on early Mars.

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