Free energy distribution in fluid mixing zones in Gale crater: insights into potential habitability on early Mars

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Recent geochemical and mineralogical analyses on fluvial-lacustrine deposits in Gale crater, Mars revealed that liquid water that existed on early Mars was likely to be neutral pH and low salinity, which would have been suited to support a Martian biosphere [1]. However, to create a habitable environment for microorganisms, not only the presence of liquid water, but also the source of energy is required. The aim of this study is to assess the chemolithoautotrophic habitability of early Mars based on metabolic energy.
Recently, we evaluated energy yields from aerobic Fe^{2+} oxidation on ancient Gale crater in areas where chemical gradients may have been presented (e.g., groundwater-lake water mixing area). Lake water and groundwater compositions were modeled through thermodynamic calculations in water-rock-gas systems under various temperatures, gas compositions, and water/rock mass ratios. The modeling indicates that free energy released from aerobic Fe^{2+} oxidation in the fluid mixing zone where Fe-rich groundwater and oxic lake water may mix, is similar to that estimated for a fluid-mixing zone on Earth actually inhabited by aerobic Fe^{2+}-oxidizing microbes. The results suggest that the fluid mixing-zone on early Mars may have had the potential to provide sufficient energy for aerobic Fe^{2+}-oxidizing microbes [2].
In this presentation, we will present free energy yield from other aerobic and anaerobic reactions (e.g., methanogens, sulfate reduction, iron oxidation, sulfide oxidation) that potentially support chemolithotrophy on early Mars. Comparison of energy yields for various redox reactions will provide a more comprehensive view of energetics-based Mars habitability.

References

[1] Grotzinger et al. (2014) Science, 343, 1242777.
[2] Kikuchi and Shibuya (2021) Minerals, 11, 341.

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