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Low-temperature serpentinization reactions can explain molecular hydrogen production on Saturn's moon Enceladus: implications for potential microbial life

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Abstract

The findings of the last decades that icy moons may harbor a large amount of liquid water under their ice shells have opened new horizons in the emerging field of Astrobiology. Several aspects have to be ascertained to determine if the subsurface aquifer of a certain celestial body may be able to harbor life-as-we-know-it. Here we focus on water-rock interaction processes during low-temperature serpentinization (T< 100°C) as potential source for hydrogen (H_2) production on Saturn's icy moon Enceladus. H_2 can serve as a potential substrate for hydrogenotrophic methanogenic life on Enceladus. In the course of serpentinization, the metasomatic hydration of olivine and pyroxene produces various minerals including serpentine minerals, magnetite, brucite, and carbonates. H_2 production only occurs if ferrous iron within iron-bearing minerals is oxidized and incorporated as ferric iron into magnetite. The PHREEQC code was used to model the pH- and temperature-dependent dissolution of olivine and pyroxene to form serpentine, magnetite, and H_2 under pressure and temperature conditions that may exist on Enceladus. Various model setups were run to assess the influence of environmental parameters on H_2 production. The combined results offer a constraint on H_2 production over time, and may aid habitability assessments of extraterrestrial bodies where serpentinization could occur.

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