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Microbial Hydrogen consumption by sulfate reduction: Implication for Underground Storage and Geological Production of H_2

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Hydrogen (H_2), as a low-carbon energy carrier, is a strategic resource for the energy transition. The consumption of H_2 via microbial sulfate reduction can be significant for both the H_2 produced through water electrolysis using renewable energy and stored in saline aquifers [1], as well as for the natural and stimulated geological H_2 produced by the serpentinization of ultramafic rocks [2].

H_2 is a key electron donor in microbial metabolism and can therefore be utilized by microbial communities, leading to the loss of stored or produced H_2. Sulfate-reducing bacteria (SRB) in the groundwater of sedimentary rock formations (e.g., sandstone) and shallow ultramafic rock formations (e.g., peridotites) can use $H_{2(aq)}$ to reduce sulfate (SO_4^{-2}) to dissolved sulfide (HS^-). This process increases the groundwater pH, thereby promoting the dissolution of minerals and altering the formation rock properties.

We have studied this process by performing two batch experiments using SRB as (1) Deltaproteobacteria strains contained in a biofilm sediment and (2) a pure strain (*Desulfovibrio desulfuricans*) reacting with Na-Cl-$SO4^{2-}$-rich water equilibrated with $H_{2(g)}$ at 2 bar and 30 °C.

In both experiments, after an initial adaptation time, SRB consumed $H_{2(aq)}$ based on the increase in HS^- and pH and the reduction of initial sulfate. The results indicate that sediment-associated Deltaproteobacteria produced 9.2×10^{-3} mol/L of HS^- and reached a pH of 9.1 after 8 months, whereas *Desulfovibrio desulfuricans* produced 8.1×10^{-3} mol/L of HS^- and reached a pH of 9.5 after 4 months. Overall, the consumption of H_2 was approximately 0.2 mol, but it was slower with the bacteria contained in the sediment.

[1] El-Sayed, Menefee, & Wang (2025), *International Journal of Hydrogen Energy* 175, 151344.

[2] Templeton, Ellison, Kelemen, Leong, Boyd, Colman & Matter (2024), *Frontiers in Geochemistry* 2, 1366268.