

Mineral dissolution controls the rate of methanogenesis by hydrogenotrophic microbial communities utilizing carbonates

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Activities of molecular hydrogen fueled microbial communities are of interest to both subsurface hydrogen storage and the origin and early evolution of life on earth and perhaps other planets. Hydrogenotrophic methanogens are capable of capturing energy from dihydrogen and converting CO₂ to CH₄, thus playing a significant role in global carbon cycling. In many terrestrial and subsurface settings, carbonate minerals represent a significant pool for CO₂. Despite the well-established theories of kinetics and thermodynamics of reactions with dissolved species in aqueous systems, less is known about the controls on microbial mediated reactions involving mineral-derived reactants. Here we tested whether the rate of methanogenesis is governed by environmental thermodynamic constraints. We studied the rates of H₂ consumption and CH₂ production by anaerobic microbial communities obtained from a coastal sediment. The microbial communities were incubated with H₂ and carbonate minerals with a range of solubilities. Our main finding is that surface area of mineral particles is proportional to the initial rate of CH₂ production, independent of mineral solubility. Imaging revealed a significant association of microbial cells, likely methanogens, with mineral grain surfaces. This work indicates that mineral dissolution rates, possibly influenced by microbial processes at the water-mineral interface, can be the rate limiting step on microbial CH₄ production in the presence of excess H₂. This work contributes to the understanding of mineral dissolution and microbial activities at the water-rock interface.

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