

High production of H₂ and CH₄ and abiotic hydrocarbons in ultramafic-hosted hydrothermal systems on the Mid-Atlantic Ridge

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The emplacement of serpentinized mantle at all ultramafic-hosted hydrothermal systems discovered along the slow-spreading Mid-Atlantic Ridge (MAR) where tectonic extension dominates over magmatic construction is a common feature leading to the production of high amounts of H₂ and abiotically-produced CH₄ and heavier hydrocarbons. The gas composition of ultramafic fluids sampled on the MAR at Rainbow (36°14'N), Lost City (30°N), Logatchev I and II (14°45'N), Ashadze I and II (12°58'N) is compared here. At each ultramafic-hosted field, all vented fluids are issued from a nearly identical source, are controlled by phase separation and show low H₂S content (<1 mmol/kg, extraordinary high H₂ (10 to 26 mmol/kg) endmember concentrations compared to basalt-hosted fluids. H₂ production represents between 40 to 80% of the total extracted gas volume. The total hydrogen discharge Φ_{H_2} is found to be between 2.5 to 7.5 millions standard cubic meters per year for the Rainbow single site. Based on Rainbow H₂³He and ³He/heat ratios, a global H₂ flux for slow-spreading ridges of 2×10⁹ m³ STP/yr is estimated. As a consequence of the high reducing power of these systems, isotopic measurements of light hydrocarbons (C₁ to C₄) show that abiogenic hydrocarbons are generated by catalytic Fischer-Tropsch type reaction, considering their isotopic pattern. These results show that in ultramafic environments, the existence of high concentrations of H₂ may be of interest for the future as a potential clean energy but many questions have still to be clarified.

Electrostatic potentials and charge distributions at structurally defined hematite/electrolyte interfaces

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The chemical behavior of mineral interfaces with aqueous solution is an important factor in soil evolution, microbe-mineral interaction, atmospheric chemistry, and waste remediation. Traditionally, aqueous mineral reactivity has been studied using colloidal mineral suspensions or isolated crystallographically well-defined surfaces. These approaches either average the contribution of all crystallographic faces or focus on one distinct crystal/solution interface. Consequently, with regard to semiconducting minerals, analysis of macroscopic kinetic phenomena has ignored the existence of spatially remote but coupled interfacial electron transfer reactions. Low-to-wide band gap iron oxides, such as hematite, are a major constituent in many natural soils. In wet environs the dissolution/crystallization of iron oxides is intimately linked with the presence of aqueous Fe²⁺ ions. Characterizing the complete electron transfer processes involved during interfacial Fe²⁺/Fe³⁺ redox reactions is key to understanding the role of iron oxides in water bearing environments.

Building on previous work [1], here we report measurements and molecular simulations of the electrostatic potential profile across crystallographically defined (α -Fe₂O₃) hematite-electrolyte interfaces. We use a combination of open circuit potential, cyclic voltammetry and impedance measurements to assess the potential distribution as a function of pH, electrolyte type, and equilibration time. In particular, we focus on the structural origins of surface-specific differences in rest potentials, flat-band potentials, depletion zones widths, and charging behavior for (001), (012), (110), (113), (125), (211) and (214) faces. By directly comparing the results from a variety of crystal faces we attempt to elucidate morphology-dependent average system behavior. Ultimately this line of investigation is expected to enable insight into the interaction between solid-state electron transport and surface/solution redox Fe³⁺-Fe²⁺ transformations in the iron oxide system.

[1] Yanina *et al.* (2008) *Science* **320**, 218–222.