Rapid release of molecular hydrogen during anaerobic weathering of basaltic glass

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Sampling strategies for the Mars 2020 rover mission require a better understanding of water-rock interactions in basalt-derived sediments and sedimentary structures that can be produced by these interactions. Millimeter-scale early diagenetic nodules and spindle-shaped ridges associated with early diagenetic cements in the Sheepbed mudstone of the Yellowknife Bay formation in Gale crater present intriguing examples of such structures [1,2]. These nodules and ridges are tentatively attributed to the production of gas within sediments and subsequent lithification. We experimentally constrain conditions conducive to the abiotic generation of gases in Mars-analog sediments incubated in sterile water in equilibrium with 0.05-0.2 bar CO_2/N_2 at pH 6.5-7 and 22 °C. The most vigorous H_2 release, 23 nmol(H_2) hr^{-1} g^{-1}(sediment), was measured during the anaerobic weathering of basaltic glass. This process released dissolved Fe and silica and was accompanied by the formation of millimeter-sized gas bubbles. The bubbles were trapped within clay-sized sediments that were highly magnetic. Within weeks, the topography of the sediment surface roughened and exhibited linear ridge-like structures. These experiments identify the weathering of basaltic glass under a high-pCO_2 atmosphere as a plausible mechanism for the production of H_2 gas during sediment deposition in martian lakes. This process may have contributed to the warming of Mars' climate, formation of authigenic minerals such as magnetite [3] and the supply of H_2. It may also explain the origin of magnetite-rich sediments observed at Gale and the strong magnetization of martian crust. The rapid released H_2 may have served as an electron donor for any abiotic, prebiotic, and biotic redox reactions that took place during the formation of river networks and lakes on Mars.

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[3] Tosca, N. J. et al. (2018), Nature Geoscience 11, 635-639.