Oxidant regulation of hydrogen production in low temperature rock-water reactions

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Mechanisms that generate H_2 and H_2O_2 in rock-water reactions have generally been studied in isolation, preventing the development of a coherent model that connects these processes in low temperature geological settings [e.g. 1, 2, 3, 4]. Here we report the results of laboratory experiments in which we simulated the saltation of sand-sized (125 to 300 μm) quartz, olivine, feldspar and opal at between -80 and 0 °C, under a simulated Martian atmosphere. The abraded minerals were then warmed to 20 °C and oxygen free water added. The concentrations of H_2 and H_2O_2 were monitored over time and the concentration of dissolved iron was measured at the final time point. Except for opal, all of the minerals generated detectable H_2O_2 with a maximum of 181 ± 18 $nmolg^{-1}$. H_2 was only detected (maximum of 31 ± 3 $nmolg^{-1}$) in experiments with quartz containing trace quantities of a black magnetic mineral, coinciding with a final dissolved Fe (III) concentration of ≥ 0.1 μM. Correlations were observed between the temperature of abrasion and the net dominant products of the reactions. This was likely due to a negative effect of temperature on the degree of abrasion: a result with significant consequences for erosion rates and dust generation in cold aeolian regimes. A reaction scheme is proposed whereby H_2 production through spinel surface promoted electron transfer is inhibited by oxidants (e.g. hydroxyl radicals) generated from H_2O_2 via Fenton reactions. We suggest that our results can help reconcile some prior conflicting experimental evidence for low temperature H_2 generation from rock-water reactions.

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