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Simultaneous Hydrogen Production and Carbon Mineralization in Experiments with CO_2-Charged Seawater and Basalt

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Subsurface carbon mineralization is considered the safest method of carbon capture and storage; a process where water dissolved CO_2 is injected into the subsurface, reacting with mafic or ultramafic minerals hosted in e.g., basalt to release cations (e.g., Ca^{2+}, Mg^{2+}, Fe^{2+}), ultimately precipitating into carbonate minerals. Existing methods of mineral carbonation are water intensive, thus sustainably implementing this carbon storage technique on the Gigatonne scale requires alternate co-injection fluids, and seawater is an attractive replacement. In low-temperature (50°C) batch experiments with CO_2-charged North-Atlantic-seawater and mid-ocean ridge basalt (MORB) glass, hydrogen and methane were produced and carbonates were formed. Biological sampling (DNA extraction, amplification of 16S rRNA gene sequences) showed no evidence of microbiological presence that could explain formation of the reduced gases. Here, we quantify CO_2 mineralization, H_2 and CH_4 production in experiments under mild conditions (50°C and 1.5 bar pCO_2) relevant to subsurface carbon mineralisation using the Carbfix method with MORB and seawater. We provide evidence for H_2 and CH_4 production via water rock reactions (i.e., low temperature serpentinization) using aqueous cation concentrations, x-ray diffraction data and FTIR data of reaction products. Findings of this work have implications for pilot-scale studies injecting CO_2-charged seawater into basalt formations, such as the Seastone project in southwest Iceland by Carbfix. This study highlights key variables to analyze in such studies to assess reduced gas formation, which can be sources of metabolic energy for microbial communities, a potential source of H_2 for energy or feedstock use, or an additional reaction pathway for injected CO_2. This study lays the foundation for future mechanistic investigations for low temperature serpentinization of basalt.