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Experimental assessment of the effect of pH jump on basalt dissolution rate: A key factor in carbon mineralization

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Basalt as a carbon mineralization feedstock is actively explored as a strategy to mitigate global warming through CO_2 removal [2]. The dissolution of basalt releases divalent metal cations (Such as Ca^{2+} and Mg^{2+}) into solution that can react with dissolved CO_2 to precipitate as stable carbonate minerals. Basalt dissolution, which governs the release of these cations, is often identified as the rate-limiting step in the carbonation process [3,4]. This study experimentally investigates the release of different cations under two distinct pH conditions using a pH-jump technique to assess the dissolution rates and mechanisms of a crystalline basalt. Experiments were conducted at 25°C with 500-1000 μm grains of crystalline basalt in 250 mL solutions of varying pH, containing 0.01m NaCl as a background electrolyte, on an orbital shaker. The basalt used consisted of andesine, anorthite, augite, diopside and forsterite as major constituents with minor clay phases and amorphous silica. Over 700 hours, the initial solution pH was set to 4. After 380 hours, the pH was deliberately adjusted from 4 to 2. Dissolved cation concentrations (Ca^{2+}, Mg^{2+}, Si^{4+}, Al^{3+}, and Fe^{2+}) in the solution were measured over time. The experiments reveal higher dissolution rates at pH=2 than at pH=4, as expected [1], but also that the ratios of cation release changed after the pH jump. For example, the Ca:Mg ratio declined. This behaviour could reflect changes in the dominant mineral releasing each element. These findings highlight in the influence of pH on mineral dissolution kinetics and can help improve modelling efforts to better predict the rate of CO_2 mineralization and weathering of crystalline basalts.

References:

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