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IRON-CONTROLLED CARBONATE FORMATION DURING CO_2–BASALT INTERACTION: EXPERIMENTAL INSIGHTS FROM HIGH-TI PARANÁ BASALTS

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Batch reactor experiments were conducted to evaluate mineral reactivity and secondary carbonate formation during CO_2–basalt interaction under hydrothermal conditions in high-Ti basalts from the Paraná Igneous Province. The basalt is composed of 54% labradorite, 25% augite, 6% pigeonite, 6% enstatite, and 5% ilmenite, with minor smectite as secondary phases. Experiments were performed at 150 °C and 70 bar for 10, 20, and 30 days. Basalt powder (<0.105 mm) was reacted with a synthetic seawater solution composed of 94 wt.% NaCl, 2.74 wt.% KCl, 0.88 wt.% $CaCl_2$, and 1.96 wt.% $MgCl_2$ at a 1:5 solid-to-fluid ratio. Solid-phase characterization by SEM and XRD revealed progressive alteration with reaction time. After 10 days, oxidation features were observed on basalt surfaces, followed by dissolution textures and incipient carbonate precipitation after 20 days. During advanced stages, amorphous silica formed due to silicate mineral dissolution. After 30 days, SEM revealed euhedral crystals of siderite and gypsum, and their presence was confirmed by XRD. Siderite represents the dominant carbonate phase. SEM revealed small magnesite crystals fine-grained, poorly ordered aggregates, commonly nucleating on silica precipitate surfaces, suggesting early-stage Mg-carbonate formation. The initial pH 7 and decreased to 5.6 during reaction, reflecting CO_2 dissolution and fluid acidification. Fluid analyses showed rapid elemental mobilization during early stages. After 10 days, Mg concentrations increased from 87 ppm to 243 ppm and Ca from 30 ppm to 220 ppm, indicating dissolution of silicate phases. At 20 days, Mg reached 247 ppm while Ca decreased to 148 ppm, suggesting secondary mineral precipitation. After 30 days, Mg decreased to 122 ppm, whereas Ca increased to 350 ppm, reflecting fluid–rock interaction. Dissolved Fe concentrations decreased from 400 ppm on day 0 to below detection limits after 30 days, indicating near-complete Fe consumption by siderite precipitation. The decrease in dissolved Fe coupled with the progressive formation of siderite indicates that silicate dissolution supplied Fe^{2+} to the fluid, which was subsequently immobilized through carbonate precipitation, directly linking mineral alteration to mineral trapping. These results highlight the role of iron availability in controlling carbonate precipitation and mineral trapping efficiency in basaltic CO_2 storage systems.