Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34642

Mineral dissolution control on carbon mineralization within the Paraná–Etendeka volcanism: experimental insights from variable-salinity systems

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The Paraná–Etendeka volcanic province represents one of the largest onshore basaltic magmatic expressions on Earth. As such, carbon storage (CS) in these flood basalts has been recurrently proposed. However, these lava flows record not only igneous processes but also late-magmatic alteration and intense fracturing events, adding complexity to large-scale injection strategies. This complexity highlights the need for prior experimental assessment of potential reservoir lithologies. In this study, fractured pahoehoe flow cores dominated by igneous phases (plagioclase and pyroxene) and late-magmatic phases (K-feldspar and Fe-saponite) were experimentally evaluated through CO_2–fluid–rock interaction runs lasting 5, 10, and 20 days. Two injection fluids with low and high salinity were tested to assess the influence of salinity and ionic strength on CS-related reactions. Solid products were characterized by X-ray diffraction, electron microprobe, Raman spectroscopy, and scanning electron microscopy. Aqueous samples were analyzed by atomic absorption spectroscopy, inductively coupled plasma mass spectrometry, ion chromatography, and alkalinity titration. Geochemical modelling was conducted to evaluate saturation states of observed precipitates and to predict longer-term system evolution. The low-salinity fluid promoted dissolution of primary igneous minerals as early as 5 days, mobilizing Ca^{2+} and Mg^{2+} into solution. In contrast, the high-salinity fluid showed limited dissolution at 5 and 10 days, with dissolution intensifying at 20 days. While Fe-saponite remained stable in the low-salinity system, progressive dissolution occurred under high salinity, releasing additional divalent cations. In both experimental series, cation-exchange reactions in Fe-saponite acted as an independent source of divalent cations. Precipitates in the low-salinity system include calcite, aragonite, dolomite, and amorphous silica. The high-salinity system, however, is characterized by a simplified carbonate assemblage dominated by magnesite, due to Ca^{2+} competition with calcium sulfates in solution. Although mineralogically less diverse, the high-salinity system produced more stable carbonate phases, characterized by well-developed rhombohedral crystals, in contrast to the poorly crystalline carbonates formed in the low-salinity experiments. Therefore, both fluids demonstrate carbonation potential in the Paraná–Etendeka volcanism. However, despite delayed dissolution of primary igneous phases, high-salinity fluids exhibit significant potential, as evidenced by the precipitation of well-formed magnesite and intensified dissolution of Fe-saponite.