



Morphology and stability of mineralized carbon influenced by magnesium ions

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Abstract

Ex situ mineralization of CO₂ is a promising technology that employs Ca- and Mg-rich industrial wastes but it simultaneously produces end products. Although Mg is a major mineralization source, it can adversely impact carbonate precipitation and crystal stability during co-precipitation in combination with Ca²⁺. In this study, the effects of Mg²⁺ ions on the mineralization process and its products were investigated using precipitates formed at different aqueous concentrations of Mg²⁺. The final phases of the precipitates were quantitatively evaluated at the end of each process. The alterations undergone by the calcite crystals, which constituted the dominant carbonate phase in each experiment, were analyzed using a sophisticated crystallographic approach. Aragonite was detected at high Mg²⁺ concentrations (Mg²⁺/Ca²⁺ ratio of 2.00), although brucite was the sole phase of the Mg crystal. The increase in Mg²⁺ ion concentration induced the formation of an amorphous solid. The results revealed that a drastic transformation of the calcite lattice occurred when the ratio of Mg²⁺/Ca²⁺ exceeded 1.00, agreeing with the shifts observed in the calcite structure upon comparing the precipitates formed at the Mg²⁺/Ca²⁺ ratios of 1.00 and 2.00, wherein microstrain and crystallite sizes changed from 0.040 and 55.33 nm to 0.1533 and 12.35 nm, respectively. At a Mg²⁺/Ca²⁺ ratio of 2.00, 6.51% of the Ca²⁺ ions in the calcite structure were substituted by Mg²⁺, increasing the surface energy of the crystal and the solubility of the carbonate. Therefore, Mg²⁺ is a potential hindrance that can impede the precipitation of carbonates and increase instability at certain concentrations.

Keywords Carbonate morphology · Precipitation · Calcite · Carbon dioxide · Stability

Introduction

Carbon dioxide (CO₂), a primary greenhouse gas, is a major contributor to global warming. According to the report of the Scripps Institution of Oceanography, the atmospheric CO₂ level has reached a significant milestone of 400 mg L⁻¹ (Chang et al. 2017). Among carbon capture, utilization, and storage (CCUS) technologies, mineralization of CO₂ has been suggested as a method for its disposal, wherein it could react with calcium silicate, as suggested by Seifritz (1990). Mineralization is an inexpensive and safe geochemical approach for isolating CO₂ in carbonate form. Unlike physical and biological methods, this is akin to the natural weathering process in which dissolved CO₂ reacts with magnesium or calcium silicate in rocks having a high content of either of the two to yield chemically stable forms of carbonate minerals (Stephens and Keith 2008). Other alkaline earth metals also form carbonates, although their abundance is insufficient for

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