

Ni recovery by precipitation of amorphous Ca-, Ca-Mg- and Mg-carbonates and their crystalline transformation products

AVNI S PATEL¹, SASHA WILSON¹, ANNA HARRISON²
AND MAIJA RAUDSEPP¹

¹University of Alberta

²University of Bern

Presenting Author: avn1@ualberta.ca

Carbonation of ultramafic mine tailings offers a viable method for mitigating anthropogenic CO₂ emissions. The accelerated weathering of gangue silicate and hydroxide minerals releases Ca- and Mg-, which then react with dissolved CO₂ in meteoric water—precipitating carbonate minerals and storing CO₂ in a form that is stable over geological time scales. Trace metals, such as Ni, are also mobilized during mineral dissolution and may be sequestered into secondary carbonate precipitates [1]. The hydrated Mg-carbonates, nesquehonite (MgCO₃·3H₂O), dypingite [Mg₅(CO₃)₄(OH)₂·~5H₂O] and hydromagnesite [Mg₅(CO₃)₄(OH)₂·4H₂O], are the most frequently observed secondary carbonate precipitates in ultramafic tailings [2, 3]; however, recent studies suggest that amorphous Mg-carbonate (AMC) is an important sink for storing CO₂ in these settings, too [2]. Amorphous Mg- and Ca-carbonate minerals are metastable and transform to increasingly stable, crystalline phases—typically via pathways comprising several metastable intermediates, such as dypingite or hydromagnesite. The effects of these phase transformations on the mobility of transition metals are currently unknown. Here, we constrain the extent of Ni uptake into amorphous Ca-Mg carbonates and trace the release of Ni during the amorphous-to-crystalline and subsequent phase transformations. Our results show that the initial precipitation of amorphous Ca-, Ca-Mg- and Mg-carbonates removes ≥92% of Ni in solutions beginning with 10 and 100 ppm Ni, respectively. Corresponding increases in Ni concentrations in the solid phases suggest that amorphous carbonates effectively sequester Ni by non-selective incorporation during precipitation. As the reaction proceeds, we show that Ni is retained during phase transformations in Mg-carbonate transformation pathways (>99.8% aqueous Ni removal) and released during certain Ca-carbonate phase transformations (92.5% to 54.3% aqueous Ni removal). These results suggest that precipitation via an amorphous precursor favours the uptake and retention of Ni in Ca-, Ca-Mg- and Mg-carbonates, despite the incompatibility of Ni in some of the observed crystal structures (e.g., calcite and vaterite). These results have important implications for the environmental remediation of Ni—a potentially hazardous contaminant—during mineral carbonation.

[1] Hamilton et al. (2018) IJGGC, 71, 155.

[2] Turvey et al. (2018) IJGGC, 79, 38.

[3] Wilson et al. (2014) IJGGC, 25, 121.