

Fate of Ni²⁺ during mineral carbonation of ultramafic rocks: Advantages and challenges of Ni mobilization

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Nickel is one of the most abundant metallic elements in ultramafic rocks, primarily hosted in forsterite and occasionally in oxides or sulfides. However, it may become mobilized during mineral carbonation, potentially posing environmental risks and presenting opportunities for metal recovery. To investigate the fate of Ni during mineral carbonation, we used 15 grams of powdered serpentinized peridotite (SePe), characterized by the whole rock 2034 mg/kg of Ni (whole rock analysis by ICP-MS). SePe, consisting of forsterite (48 wt.%), serpentine (14 wt.%), clinocllore (17 wt.%), tremolite (10 wt.%), and Fe-Cr oxides (0.5 wt.%), was carbonated in a batch-type reactor for 96 hours at 185°C under a PCO_2 of 100 bar. The experiment resulted in substantial forsterite dissolution (<6 wt.% left in post-experimental material) and extensive magnesite crystallization, demonstrating that the SePe used in this study is a highly efficient natural material for permanent carbon storage in ex situ carbonation procedure. In addition, the experiment yielded the formation of chalcedony and phase resembling in appearance and chemical composition a mineral of the smectite group. The chemical composition of the post-carbonation fluid, measured by ICP-OES, revealed that a small portion was mobilized into the fluid reaching a concentration of ~18 mg/kg after 96 hours. Low Ni content in the fluid indicates effective Ni redistribution from primary olivine to secondary phases.

To the best of our knowledge, there are no direct reports in the literature of Ni-phylosilicate crystallization, as a by-product, during the ex situ mineral carbonation of ultramafic rocks. The Ni-phylosilicates contained ~26 wt.% of Ni and were the main contributors to the Ni content in the post-experimental products. They accounted for 50% of the Ni budget in the post-experimental products, however, their overall proportion did not exceed 1%.

The observed Ni mobility raises important questions for further research. For example, could the Ni content in carbonate fluids, particularly in future large-scale direct CO₂ injection projects, pose an ecotoxicological risk? Additionally, could Ni be effectively recovered through Ni-phylosilicate synthesis as a complementary process to mineral carbonation?

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