

Nickel Hydroxide–Nickel Carbonate Competitive Growth on Carbonate Surfaces

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While Ni is a vital micronutrient for many organisms, it is toxic at high concentrations and, as a result, Ni industrial production and utilization can be a source of soil and groundwater contamination. The importance of carbonates in calcareous environments and the affinity of Ni for carbonate surfaces means that a quantitative understanding of the interactions between Ni and carbonate minerals could help predict the fate and transport of Ni in the subsurface. Formation of carbonate minerals is also of interest as a natural process that strongly influences the carbon cycle and one that offers a stable, long-term storage mechanism for CO₂.

In this study, calcite (CaCO₃) and magnesite (MgCO₃) powders were reacted with NiCl₂ (0–600 μM) for 7 days at 22 °C and 5 °C. The reacted powders were analyzed with X-ray photoelectron spectroscopy (XPS), scanning electron microscopy, and energy-dispersive X-ray spectroscopy to identify and characterize the Ni surface precipitates formed. Evidence from these techniques pointed to the formation of mixed Ni carbonate–Ni hydroxide amorphous surface precipitates. On calcite, XPS detected primarily Ni(OH)₂ despite the initial solutions being more supersaturated with respect to NiCO₃ than to Ni(OH)₂ by a factor of 17–18. In contrast, NiCO₃ was the dominant component on magnesite in the same conditions. Decreasing the temperature had the effect of increasing the proportion of NiCO₃ to the detriment of Ni(OH)₂. The experimental observations were consistent with the lower lattice mismatch of NiCO₃ with respect to magnesite compared to calcite favoring NiCO₃ nucleation and temperature most influencing Ni(OH)₂ nucleation. Additionally, Ni(OH)₂ growth was faster than that of NiCO₃ and Ni(OH)₂ was therefore able to form on carbonate surfaces despite the reduced thermodynamic driving force relative to NiCO₃. Overall, this work shed light on the factors that control the competition between surface precipitates when groundwater is supersaturated with respect to multiple phases.