Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.38030

Nickel Sequestration by Iron Sulfide Minerals During Low-Temperature Heterogeneous Transformation

JONGHAN MOON[1], JENNIFER HOUGHTON[1], DAVID A. FIKE[1], YOON JI[2] AND HYO-IM KIM[2]

[1]Washington University in St. Louis
[2]Gyeongsang National University

Growing demand for critical metals including nickel and cobalt has increased interest in recovery from low-grade mafic and ultramafic ores through carbonation and sulfidization[1-3]. Sulfidization can concentrate nickel and cobalt into recoverable sulfide minerals, yet nickel capture mechanisms during post-carbonation sulfidization, particularly iron-sulfide reactivity and transformation as sulfur sources, remain poorly understood. We investigate how iron monosulfide (FeS) and iron disulfide (FeS_2, pyrite) transform in Ni-bearing solutions across pH 3.6–5.6 and 60–80°C, while monitoring dissolved Ni and Fe.

The initial conditions were 50 mM free [Ni^{2+}] and 3.7 mM [Fe^{2+}] for the FeS (synthetic mackinawite, 100–300 μm), and 0 mM [Fe^{2+}] for the FeS_2 (synthetic pyrite, <45 μm) experiment. FeS rapidly transformed into polydymite (Ni_3S_4) and violarite ($FeNi_2S_4$) within 3 hours. Except at pH 3.6 at 80°C, [Ni^{2+}] and [Fe^{2+}] in solutions showed consistent trends, with [Ni^{2+}] decreasing by ~20–25 mM and dissolved [Fe^{2+}] increasing equivalently ([increased Fe^{2+}]/[decreased Ni^{2+}] = ~1); under pH 3.6 at 80 °C, the ratio was ~ 0.8. Ni sequestration by FeS was more effective at higher temperatures and higher pH. Dendritic Ni-rich crystals formed on FeS surfaces, indicating active recrystallization and mineral replacement. In contrast to FeS, FeS_2 showed no measurable bulk transformation in products or change in solution chemistry, although limited Ni-rich dendritic crystallizations formed in localized areas of the original FeS_2 grain surface after 7 days.

Grain-scale mineralogical transformation is rarely reported in aqueous metal and solid-phase sulfide experiments, as previous studies have emphasized adsorption and surface-limited reactions[4]. In contrast, our experiments demonstrated that under more reactive conditions (higher temperature and [Ni^{2+}]), sulfidization can lead to complete grain-scale conversion, enabling iron sulfides to rapidly sequester dissolved nickel into Ni-rich sulfides. This highlights iron monosulfides as effective sulfur sources and reactive substrates for concentrating dissolved nickel into discrete sulfide phases, with implications for natural sulfidization mechanisms and engineered recovery strategies from low-grade ores.

[1] U.S Geological Survey (2022), *U.S Geological Survey*
[2] Wang. F. et al. (2021), *Chem. Eng. J. 406*, 126761
[3] McDonald, R. G. et al. (2008), *Hydrometallurgy*91, 35-55
[4] Wilkin, R. T., and Beak. D. G. (2017), *Chem. Geol.* 462, 15-29