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Elevated cobalt and nickel in Swedish postglacial deposits – host phases and geochemical reactivity

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Nickel (Ni) and cobalt (Co) are often slightly elevated in postglacial deposits of SE Sweden, sometimes exceeding contamination guidelines for "sensitive land use" (40 and 15 mg kg^{-1}, respectively). As a result, fertile soil excavated during construction projects may be sent to landfills instead of being reused for other purposes.

To assess the geochemical reactivity and host phases of Co and Ni, we analyzed 23 soil samples, primarily from postglacial deposits in the Stockholm-Uppsala area, SE Sweden. Based on the USDA classification, 14 samples were loams and 9 were clays, with 12 containing carbonate minerals (mostly calcite). Nitric acid-digestible concentrations of Co ranged from 4.7 to 18.3 mg kg^{-1} and Ni from 11.7 to 42.7 mg kg^{-1}. The geochemically active fraction, extracted using 0.43 M HNO_3, was below 20% in most soils. Desorption partitioning coefficients (K_d), defined as the ratio of total metal to $CaCl_2$-extractable metal (L kg^{-1}), ranged from log K_d = 3.4 to 6.4 for Co and 3.2 to 5.3 for Ni, with geometric means of 5.5 and 4.4, respectively.

These results indicate that Co and Ni are mostly bound within primary mineral structures, leading to low solubility. Quantitative X-ray powder diffraction further revealed strong correlations between total Co or Ni and trioctahedral phyllosilicate minerals. Multiple regression analysis identified chlorite, trioctahedral smectite, and trioctahedral mica as the most important host phases, with metals likely bound in octahedral sheets.

Eight soils (4 of which were calcareous) underwent batch desorption experiments to apply a "multisurface" geochemical model in Visual MINTEQ, assuming reactions with organic matter, Fe oxides, and clay. Here, the concentrations of geochemically active metal were used as input. Model predictions agreed well for Co and Ni in non-calcareous soils but significantly overestimated Co desorption (by 1 to 3 orders of magnitude) in calcareous soils. The mechanism behind the strong Co fixation in these soils remains unclear and requires further investigation. In summary the results show that clays with naturally elevated Ni and Co do not pose a risk and can be reused.