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LETTER

SPECIAL COLLECTION: NANOMINERALS AND MINERAL NANOPARTICLES

Previously unknown mineral-nanomineral relationships with important environmental consequences: The case of chromium release from dissolving silicate minerals

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ABSTRACT

Risk assessments that take into account the formation of environmentally dangerous hexavalent chromium in Cr-containing mine tailings, and associated soils and sediments, require an understanding of the occurrence and speciation of Cr in silicate minerals and glasses. Silicates are more soluble and generally more susceptible to weathering than the refractory mineral chromite, the principal ore mineral of Cr. Studies at the nanoscale using a combination of advanced sample preparation via microtoming and focused ion beam techniques, in combination with state-of-the art analytical transmission electron microscopy and electron diffraction, reveal the occurrence of chromite nanoparticles held within clinochlore and lizardite grains in chromitite ore (an igneous cumulate consisting primarily of chromite) from the Black Thor Chromium deposit in Northern Ontario, Canada, and the Mistake Mine, Fresno County, California, U.S.A., respectively. Nanoscale examinations of altered chromitite ore samples from the Black Thor deposit after dissolution experiments in sulfuric acid-bearing solutions of pH 2.5 show that clinochlore alters to amorphous silica depleted in chromite nanoparticles. This observation suggests the release of chromite nanoparticles rather than Cr^{3+} aqueous species during the weathering of chromite-bearing silicate minerals. This will in turn have an impact on the environmental behavior of Cr^{3+} and its potential oxidation to Cr^{6+}. The formation of Cr^{6+}_{aq} species in this case will require either the initial dissolution of the nanoparticles or the oxidation of Cr^{3+} species on the surface of the nanoparticles, either process being a rate limiting step in the formation of Cr^{6+}_{aq} species.

Keywords: Chromite, nanoparticles, silicates, clinochlore, lizardite, California, Black Thor deposit, Ontario, Nanominerals and Mineral Nanoparticles