Characterization of copper in weathered non-ore grade rock from a magmatic Ni-Cu sulphide deposit: implications for copper mobilization from potential future waste rock

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Multiple magmatic Ni-Cu sulphide deposits associated with the 1.1 BYA mid-continental rifting event that occurred in the modern-day Lake Superior region, USA, are subjects of mineral exploration, mine development, environmental review, and/or production. Robust conceptual models for metal mobility from potential future mine waste rock support sustainable development of this emerging mining district by providing a framework for the predictive geochemical models used to ensure that mines will meet environmental criteria.

Here we report on a study to characterize copper-bearing weathering products in rocks from naturally exposed outcrops of troctolite associated with a Lake Superior-region magmatic Ni-Cu sulphide deposit. These weathering products are indicative of attenuation mechanisms that may limit the mobility of copper from potential future waste rock from this, or a similar, deposit. Weathered samples from the site were characterized via synchrotron-based X-ray fluorescence (XRF) and X-ray absorption spectroscopy (XAS) at Stanford Synchrotron Radiation Lightsource, as well as, by multiple offline X-ray and electron beam methods.

Weathering products included a compositionally banded iron oxide-rich material that is ubiquitous as surface coating and fracture infill and contains variable amounts of silicon, aluminium, sulphur, and copper (typically present at or greater than multiple wt%). Chemical maps suggest that copper concentration in fluid evolves at micron-scale as it migrates through fractures away from primary copper sulphide mineral source. The extended X-ray absorption fine structure (EXAFS) data collected from various sample locations supports the presence of multiple distinct copper species within the sample, including observations of copper sulphide near the primary copper source, and oxidized copper species associated with the iron oxide bands.