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The Fate of Chromium in Weathered Ultramafic Rocks and Their Derivative Soils in Cuba: Clues from Spectroscopic Studies

Andrea L. FOSTER*

U.S. Geological Survey, 345 Middlefield Road, MS 901, Menlo Park, CA, USA, ZIP 94025

1 Abstract

In its cationic, trivalent form, Chromium (Cr) it is a micronutrient, and exhibits low environmental mobility. In hexavalent form, however, it is a human carcinogen and also highly mobile. Climate is a key environmental factor controlling weathering rates and stability of primary and secondary Cr-bearing minerals. Knowledge of Cr oxidation state and mineral residence is therefore essential to estimating the risk posed by Cr in serpentinites, chromite mine wastes, and soils developed on these parent materials. X-ray absorption spectroscopy (XAS) is currently the best available technique for determination of the relative abundance of Cr(III) and Cr(VI) in situ (that is, without digestion of solid phases). A brief review of relevant XAS studies of is presented below, focusing on studies in tropical climates¹, as they will be most relevant to eastern Cuba's extensively serpentinized ophiolite belt.

Cr(III)-bearing spinels are usually the dominant and most refractory Cr host in ultramafic rocks. Previous XAS studies² indicate that in tropical climates, Cr-spinels weather rapidly to form Cr(III)-bearing secondary Fe(III) (hydr)oxides (goethite, hematite). Manganese (Mn) is also enriched in ultramafic rocks²; as Mn(IV), it can also co-precipitate with Fe(III) (hydr)oxides, or form its own secondary (hydr)oxides. A previous study found up to 20% Cr(VI) in a tropical, serpentine soil that contained substantial Mn, and a strong correlation between the amounts of Cr(VI) and Mn(IV) in the soil profile². The

results of several XAS studies suggest that a close association of Mn(IV) and Cr(III) in secondary Fe (hydr)oxides is necessary for oxidation of Cr(III) to Cr(VI) via electron transfer reactions with Mn(IV); however, additional XAS studies have shown that organic matter³ and Cr-bearing aluminosilicates⁴ may also be important sources of Cr(III) to the environment under specific conditions. The stability and fate of Cr has not been studied in detail for these two host phase types, to the best of our knowledge.

Access to XAS facilities to perform Cr geochemical experiments is limited and will only become more so in the future. We are working to develop and apply (micro)Raman spectroscopy to evaluate Cr oxidation state and mineral residence (in crystalline and amorphous materials). In addition to standard Raman scattering, we are employing resonance Raman (785 nm laser) to enhance signal from Cr(VI)-bearing phases and laser-stimulated photoluminescence to identify Cr(III) associated with Al-rich alteration products

References

- ¹Tropical climates are warm > 18°C and wet all year.
- ²Fandeur et al., 2009. *American Mineralogist*, v. 94: 710–719; Fandeur et al., 2009. *Environmental Science and Technology*, 43: 7384–7390.
- ³Doelsch et al., 2006. *Env. Sci. Technol.*, 40:7602–7608.
- ⁴Cr clays, Cr-mica, Cr-chlorite, Cr-garnet, and Cr-epidote; Oze et al., 2004. *Int. Geol. Rev.* 46: 97–126.

* Corresponding author. E-mail: afoster@usgs.gov