Tracking Fe-oxidation in spheroidal weathering of basalts

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Spheroidal weathering is a well-documented pattern in which saprolite shows unweathered corestones enclosed by concentric weathering rinds separated by fractures. Dissolved oxygen in pore fluids controls the extent of oxidation in a weathering corestone. In basalts, the silicate minerals susceptible to oxidation are fosteritic olivine and augite pyroxenes, plus spinel phases such as magnetite and ilmenite. During weathering of basalts, most of these minerals dissolve to form incongruent oxidized weathering products such as ferrihydrite, goethite and even hematite. According to reactive transport basalt weathering models, pyroxenes and olivines gradually dissolve, whereas magnetite is more refractory and only disappears from the bedrock under intense weathering conditions (e.g. high soil CO2 and organic acids)(1). Corestones and weathering rinds from spheroidally weathered basalts provide an excellent opportunity to investigate the evolution of the oxidative-weathering sequence.

In this study, we combine petrographic and spectroscopic techniques to assess how the Fe(III)/Fe(II) ratio changes during across weathering rinds and corestones. Optical microscopy and SEM energy dispersive X-ray spectrometry (EDS) data are used to identify primary mineral grains and generate elemental maps of FeT, Si, Al and Ti. Micro X-ray fluorescence imaging plus X-ray absorption near edge spectra (XANES) is used to map oxidation of primary phases, by calculating the proportion of Fe(III)/Fe(II). Petrography of polished thin-sections from weathering rinds and corestones shows that primary minerals are completely absent in the outermost rinds, whereas magnetite-ilmenite grains are still present in inner rinds and corestones. The scarce primary Fe-silicates remain in corestones and show varying degrees of weathering. The XAS data will be used to recognize incipient oxidation reaction of Fe-silicate and spinel-phases. We can model the oxidation reactions as a function of Fe(III)/Fe(II) ratios obtained from the basalt samples to better comprehend the oxidative-weathering sequence in basalts.

1. A. Perez-Fodich, L. A. Derry, Understanding intense weathering patterns of Hawaiian basalts using reactive transport models. Submitted to Geochimica Et Cosmochimica Acta.