Mineralogy and microtexture of weathered basalt effect TIR spectra

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Multiple thermal infrared (TIR) instruments have been sent to Mars, in part, to examine the mineralogical diversity of the martian surface, in order to determine petrologic variability and the extent and styles of aqueous alteration. Mars is primarily basaltic and numerous observations indicate that portions of its surface may be weathered. In order to interpret martian mineralogy from TIR spectra, it is important to understand how weathering affects these observations. We are investigating subaerially weathered basaltic rocks from semi-arid regions on Earth to start placing constraints on the affects weathering has on TIR emission spectra.

The changes that occur in a rock's TIR spectrum due to weathering must result from the physical and mineralogical changes caused by weathering. In the rocks we have examined, these changes are (1) the formation of microfractures within a few 100 μm of the surface, (2) the dissolution of primary minerals, and (3) the precipitation of secondary minerals and mineraloids.

While microfractures will affect TIR spectra by causing multiple scattering of photons, they also provide space for precipitation of most weathering products. Petrologic and back-scattered electron images show that secondary minerals form in cracks and, consequently, tend to from thin coatings on primary mineral grains. This coating configuration means that the relatively small amounts of secondary material can have pronounced effects on TIR spectra.

The weathering products in these rocks, determined from X-ray diffraction and electron microscopy, include different amounts of smectite clays, amorphous Si-Al-rich phases, halloysite, and poorly crystalline Fe-oxyhydroxides. Secondary phases comprise $<$ 20 vol% of the weathering rinds. Because these rocks are lightly weathered, signs of preferential dissolution are absent; the relative abundances of primary minerals is the same in the weathering rind as in the unweathered rock. The substantial spectral differences observed between unweathered and weathered rock surfaces result from the formation of secondary minerals and mineraloids rather than the loss of primary minerals. When using linear deconvolution to model the mineralogy of lightly weathered rocks, the small amounts of secondary materials, as coatings and fracture fillings, can result in incorrect modeled abundances primary minerals in the rock and incorrect identification of phases, such as glass. These issues may affect martian spectra even if surfaces are minimally weathered.