Linking mineralogy and microtexture to thermal infrared spectra of weathered basalt

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Thermal infrared (TIR) spectroscopy is an important tool for remotely sensed mineralogical investigations of planetary surfaces. In particular, the suite of TIR spectrometers sent to Mars over the past decade have provided a wealth of data on martian surface mineralogy. These data can be used to constrain the petrologic diversity of Mars and to assess the history and degree of aqueous alteration. Success in interpreting TIR spectra of natural, weathered surfaces requires understanding how weathering affects the observations. We are investigating how weathering effects TIR spectra of basaltic rocks and to find methods to interpret these observations.

TIR spectra are particularly sensitive to lattice vibrations of network-forming bonds, which are principally Si-O bonds for silicate surfaces. Spectra differ between silicate minerals largely as a function of Si-O-Si polymerization and how those bonds are modified by additional metal-oxygen bonds. Weathering reactions for basalts redistribute SiO_2 to new minerals that tend to have higher degrees of polymerization than the bulk rock resulting in generally predictable changes to rock spectra, where the Si-O stretching mode (800-1200 cm^{-1}) shifts to higher frequencies. In addition, authegenic silicates tend to coat primary minerals in weathered rinds. Consequently, photons emitted from primary mineral grains are transmitted through fine-grained coatings of weathering products, which tends to suppress the spectral signal of primary minerals in the low-frequency end of the Si-O stretching region of the spectrum (800-1000 cm^{-1}).

TIR emission spectra of Mars are typically analyzed by linear deconvolution modeling, which assumes that the spectral contributions of minerals are proportional to their areal abundances on the rock surface. The microtextural configuration of secondary minerals in weathering rinds causes non-linear spectral mixing, resulting in (1) small volumes of weathering products having disproportionately large effects on spectra, (2) inaccurate modeled abundances of primary minerals, and (3) difficulties in determining the types of secondary products present using deconvolution modeling. These affects have important implications for mineralogical interpretions of lithology and alteration on the Martian surface from TIR data.