A forward modeling of infrared reflectance spectra of asteroids

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The mineral assemblages on asteroids are useful to constrain the aqueous environments, the temperature (T), pressure (P), water to rock ratio (W/R), and bulk chemical composition, existed in them or in their parent bodies. Near- to mid-infrared (IR) reflectance spectroscopy of asteroids contains the information of the surficial minerals in their characteristic absorption features, spectral slopes, and overall brightness or darkness. Recent remote-sensing of asteroids by Hayabusa2, OSIRIS-Rex, and Dawn spacecrafts as well as telescopic observations by AKARI infrared space telescope provided detailed IR reflectance spectra of many types of asteroids. These observations would allow us to discuss the diversity of asteroids in their principle parameter space of paleo-aqueous environments: T, P, W/R, and the bulk chemical compositions. This study aims to connect the observed IR spectra of asteroids to the original bulk compositions and T-Pconditions of them or their parent bodies. We performed a series of chemical equilibrium calculations to obtain the mineral compositions. We computed the model IR reflectance spectra from the obtained mineral compositions. The chemical equilibrium calculations assumed the rocky bulk compositions of CV chondrites. We treated W/R as a parameter (0.2-10). We fixed the relative abundance of volatiles to water. The model IR reflectance spectra were calculated by adopting the radiative transfer theory for granular surfaces. The reflectance of a model mineral assemblage was computed from the weighted average of the single scattering albedos (SSAs) of endmembers. We found that the model reflectance spectra vary according to the equilibrium mineral compositions. Reducing W/R led to the darkening in overall reflectance as the dominant minerals change from bright carbonate to serpentine, gibbsite, and dark phases: pyrite, troilite, magnetite, and organics. The change in the dominant phase is visible in the characteristic absorption features: carbonate at 3.5 micro m and 4.0 micro m and serpentine at 2.7-2.8 micro m. We note that, though carbonate has a broad absorption from 2.7 to 3.2 micro m, the absorption feature of serpentine is sharp and distinguishable.Ammonia-bearing saponite more than a few wt.% shows its characteristic absorption feature at 3.1micro m in the reflectance of mixture. In this presentation, we discuss the implications for Haybusa2 and AKARI observation results.

Keywords: Asteroids, Near-infrared spectra

