Spectral and water analysis of experimentally heated CR carbonaceous chondrite with no effects of adsorbed and rehydrated water

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CR carbonaceous chondrites are one of the major groups of carbonaceous chondrites and are known to have experienced aqueous alteration to variable extents. They contain large chondrules with metallic particles and chondrule abundance is the highest among hydrated carbonaceous chondrites.

In this study, LAP 04721 CR2.4 chondrite was experimentally heated at three different temperatures, 400, 600 and 900˚C in order to investigate changes in water contents, reflectance spectra, and mineralogy and to understand correlations between these properties. Unheated samples were also analyzed in the same way. A N_2-filled and dry glove box was used to separate the heated samples from atmosphere, so that the effects of absorbed and rehydrated water can be minimized during transfer to water analysis and spectral measurement.

The synchrotron X-ray diffraction patterns of matrix of this CR chondrite show that it consists mainly of serpentine and magnetite, which indicates hydration is pervasive in matrix. 600˚C-heated matrix shows decomposition of serpentine and formation of secondary olivine, and 900˚C-heated matrix shows formation of secondary low-Ca pyroxene and Fe-Ni metals in addition to olivine. The Karl Fischer titration (KFT) method that can measure very precise water contents was used to determine the dehydration degrees of samples. Water contents of unheated, 400, 600 and 900˚C samples are 2.8, 1.0, 0.2, 0.0, respectively. Unheated sample released water from terrestrial weathering product Fe oxyhydroxides and indigenous serpentine, while in the 900˚C-heated sample both phases are completely decomposed and dehydrated.

For spectroscopy, reflectance spectra of unheated and heated samples were measured and the results show that 0.9 μm band attributed to Fe oxyhydroxides disappears at 400˚C indicative of decomposition. On the other hand, the strength of the 3-μm band attributed to OH-stretching vibration of serpentine still remains at 400˚C, but disappears at 600˚C. The center position of the 3-μm band shifts with increasing heating temperature. The relationship of the 3-μm band depth and position of CR chondrite LAP 04721 is similar to that of CM chondrite Murchison (Mogi et al., 2017).

We determined the relationships between mineralogy, spectral features, and water contents of CR chondrite as a function of heating temperatures. These results can be applied to estimate the heating degree of surface material of the primitive asteroids such as Ryugu that will be observed by ONC multiband camera and NIRS3 spectrometer onboard Hayabusa2 spacecraft.

Keywords: reflectance spectra, C-complex asteroids, aqueous alteration

