DEHYDRATION PROCESS OF EXPERIMENTALLY HEATED MURCHISON WITHOUT ANY EFFECTS OF ADSORBED AND REHYDRATED WATER

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C-type asteroids are important objects for an understanding of ealy evolution of our solar system, because they contain primordial water and organics as well as primitive inorganic material. Reflectance spectra of some C complex asteroids show the evidence of dehydration by heating [1]. In order to reproduce the dehydration process, Murchison CM2 chondrite was experimentally heated and analyzed for reflectance spectra and water contents [e.g., 1, 2]. However, because the heated meteorite samples were exposed to the air before measurements of spectra and water, their results were severely affected by atmospheric water that are adsorbed on and rehydrated to the samples. The purpose of this study is to measure reflectance spectra and water contents of experimentally heated Murchison samples without being affected by adsorbed and rehydrated water.

In this study, powders (<155μm in grain size) of Murchison samples were experimentally heated at three different temperatures (400, 600, and 900°C) for 50 hours under vacuum (10^{-7}～10^{-6} torr) at IW oxygen fugacity. After heating experiments, the heated samples were transferred, in dry N_2 gas in a glove box, from a metallic heater tube to a sealed SUS holder with a sapphire glass window for visible and IRspectra measurement by FT-IR and also to a glassy tube for water analysis by Karl Fischer titration method. In the water analysis, the sample was heated stepwisely at temperatures of 105, 200, 300, 400, 600, 800, and 950°C and the concentrations of water released at each temperature are measured.

Synchrotron X-ray diffraction analysis showed that the unheated Murchison sample mainly consists of serpentine, tochilinite and pentlandite. At 400°C, tochilinite was decomposed completely and serpentine started to decompose. At 600°C, serpentine was replaced by olivine completely, and recrystallization of the secondary olivine was proceeded from 600°C to 900°C. At 900°C, sulfur seems to evaporate completely, FeNi metal forms abundantly and the olivine becomes highly crystalline.

Reflectance spectra showed that the depth and the shape of 3-μm absorption band and 0.7-μm band changed with increasing temperatures. Structural water of serpentine and tochilinite and adsorbed water on entire samples are responsible for the 3-μm absorption feature. At 400°C, the 3-μm band becomes shallower and shaper, and the peak position (the lowest reflectance position) shifts to shorter wavelength, probably because preferential breakdown of tochilinite and Fe-rich serpentine cronstedtite. The 0.7-μm absorption band, caused by phyllosilicate Fe^{2+}-Fe^{3+} charge transfer, disappears at 400°C because of decomposition of cronstedtite. At 600°C and 900°C, the 3-μm band disappers completely, which clearly indicates that structural water is removed from Murchison at 600°C. On the other hand, in previous studies [1, 2], 600°C and 900°C samples still remain shallow 3.0-μm band probably due to adsorbed and rehydrated water.

Water contents of Murchison are decreasing with increasing heating temperature: total water contents are 6.8, 2.5, 0.5, and 0wt% for unheated, 400°C, 600°C, and 900°C Murchison sample, respectively. In the stepwise heating analysis of water, the concentrations of water released at temperatures equal to or lower than the furnace-heating tenperature are decreased. The results of water analysis are consistent with those of mineralogical and spectral changes. The water contents correlate with the depth of the 3.0-μm absorption band. Comparison with the previous results [2] indicates that 4.0, 0.7, and 0.6 wt% of adsorbed and rehydrated water contaminate 400°C, 600°C, and 900°C Murchison sample, respectively, suggesting that atmospheric water severely increase total water contents.

In this study, we determined correct reflectance spectra, water contents and mineralogical features of the heated Murchison samples without any effects of adsorbed and rehydrated water. Our results are almost completely unaffected by the terrestrial atmospheric water and therefore will be applied for estimation of water contents, heating temperature, and mineralogy of dehydrated C complex asteroids based on signatures of reflectance spectra.

References: [1] Hiroi T. et al. (1993) Science 261:1016-1018. [2] Yamashita S. et al. (2015) the 78th Meeting of the Meteoritical Society, Abstract #5154.