Reflectance spectra measurement of hydrated and dehydrated carbonaceous chondrites using the Near Infrared Spectrometer on Hayabusa 2 spacecraft. T. Nakamura[1], T. Iwata[2], K. Kitasato[3], M. Abe[2], T. Osawa[4], M. Matsuoka[1], Y. Nakauchi[2], T. Arai[2], M. Komatsu[5], T. Hiroi[6], N. Imae[5,7], A. Yamaguchi[5,7], H. Kojima[5,7], 1. Tohoku University, 2. Japan Aerospace Exploration Agency, 3. University of Aizu, 4. Japan Atomic Energy Agency, 5. Graduate University for Advanced Studies, 6. Brown University, 7. National Institute of Polar Research

Introduction:

Hydrated carbonaceous chondrites have relatively unfractionated elemental abundances and therefore they are regarded as very primitive solar system material. Reflectance spectra suggest that their parent bodies are C-type asteroids that are one of the most common type of asteroids. Sample recovery from C-type asteroids by the spacecraft is of importance, because the samples are expected to contain volatiles and organics such as pristine water and amino acids that are completely free of terrestrial contaminations. Such samples also retain rare minerals that are soluble to water and thus difficult to be recovered from Antarctic meteorites.

Hayabusa 2 mission is planned to recover materials from a near-earth C-type asteroid 1999JU3 that appears to consist of hydrated and dehydrated carbonaceous chondrite materials [1-3]. The spacecraft will be launched in late 2014 and return to the Earth in late 2020. The Near Infrared Spectrometer (NIRS3) is an on-board apparatus designated for near infrared spectroscopy to detect absorptions by structural water in phyllosilicates at 2.7μm wavelength and molecular and interlayer water at 2.9-3.0μm [4]. We are carrying out ground performance tests of NIRS3 flight model from November 2013, by measuring reflectance spectra of carbonaceous chondrites. The purpose of the tests is to know how precisely the NIRS3 flight model can detect mineralogical and compositional differences between hydrated and dehydrated carbonaceous chondrites.

Samples and experimental procedures:

Nine powdered samples of carbonaceous chondrites were measured by the NIRS3 flight model and a FTIR spectrometer at Tohoku University. The wavelength range measurable by the NIRS3 is 1.8 to 3.2μm, while that by the FTIR is 0.4 to 25μm. During measurement by both NIRS3 and FTIR, phase angle is set to 30° and meteorite samples are vacuumed. NIRS3 integration time is 1ms and the stacking number is 1024. Details of the experimental set up of NIRS3 measurement is shown in [5].

Seven CM, one CI, and one CV chondrites were measured. It is known that some of hydrous carbonaceous chondrites have experienced heating after aqueous alteration and the degree of heating is classified from heating stage I (almost unheated) to IV (heated to high temperature at which secondary olivine and pyroxene form at the expense of decomposed phyllosilicates) [6]. Heating stage (HS) of each hydrated carbonaceous chondrite was determined based on results of X-ray diffraction along with a procedure described in [6]: Murchison CM (HS=stage I), Murray CM (stage I), Y793321 CM (stage II), Jbilet Winselwan CM (stage II), Y982086 (stage II), Y980115 CI (stage II), Y86720 CM (stage IV), and B7904 CM (stage IV). As a reference sample that consists mostly of anhydrous minerals, Allende CV chondrite is also measured. Water contents of the five meteorites, Murchison, Y793321, Y86720, B7904, and Allende are known to be 8.9, 6.5, 4.8, 2.1, and ~0.1 wt%, respectively (e. g., [7]).

Results and discussion:

Reflectance spectra of nine carbonaceous chondrites were obtained at various grain size and temperatures of sample powders. In this paper, we report preliminary results of measurements by NIRS3 at room temperature (~25°C) and at 155μm grains size. All spectra from nine samples show a monotonous increase of reflectance from 1.8 to 2.7μm, a sudden decrease at 2.7μm due to absorption of structural water of serpentine, and a broad absorption due to molecular water at 2.9-3.0μm. Depth of the 3μm absorption band (a mixture of 2.7 and 2.9-3.0μm absorption) differs greatly between samples. Samples of heating stage I (Murchison and Murray) shows the deepest absorption. The four samples belonging to heating stage II show similar depths approximately 40% shallower than stage-I samples. The two stage-IV samples show different absorption features: Y86720 exhibits a deeper absorption being comparable to stage-II samples, while B7904 shows a shallower band (approximately 70% shallower than stage-I samples). This difference corresponds to that of water content: 4.8% for Y86720 and 2.1% for B7904. Anhydrous sample, Allende, shows shallowest absorption, consistent with the low (~0.1wt%) water content. The present results indicate that NIRS3 is able to determine the dehydration degree of carbonaceous chondrites and therefore is applicable to 1999JU3 observation.

References:

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