# HYDROGEN ISOTOPIC COMPOSITION OF HYDROUS MINERALS IN PARTICLES FROM BENNU

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**Introduction:** On September 24, 2023, NASA's OSIRIS-REx mission delivered to Earth ~121 g of pristine carbonaceous regolith from asteroid Bennu. A first series of mineralogical observations and chemical/isotopic analyses of Bennu aggregate samples (fine to coarse particles up to a few mm) revealed that this material resembles the most chemically primitive chondrites and the samples returned by the JAXA's Hayabusa2 mission from the carbonaceous asteroid Ryugu [1,2]. Laboratory studies have confirmed the story gleaned from the spacecraft encounter that Bennu's rock fragments underwent extensive aqueous alteration and are predominantly composed of hydrated minerals (serpentine, smectite) and other secondary minerals (e.g., magnetite, carbonates) [3,4]. The secondary phases were likely formed under the presence of liquid water on Bennu's parent asteroid [1]. The isotopic compositions of hydrous minerals and secondary phases can increase our understanding of the source and distribution of water and volatile elements in the protoplanetary disk [e.g., 5-8]. However, direct estimates of the hydrogen isotopic ratios (D/H) in hydrous minerals cannot be obtained easily in primitive rocks due to the difficulty in estimating the organic matter (OM) contribution to the whole H budget. In order to obtain hints on the initial constituents of Bennu's parent asteroid and to test if Bennu's parent asteroid have formed beyond the snow line (hypothesis 4 of [9]), we measured the D/H and C/H ratios in chondritic matrices by secondary ion mass spectrometry (SIMS) and obtain information on the D/H ratio of water retained in the hydrated minerals [6-8,10]. The method also gives clues on the hydrogen isotope variability among different Bennu rock fragments made available for measurement.

**Methods:** SIMS data were obtained with an IMS 1280-HR2 instrument at CRPG (Nancy, France) on different individual fine- to intermediate-sized particles separated from the OREX-800045-0 aggregate sample at CRHEA (Nice, France). The particles (sub-sample named OREX-800045-113) were pressed one by one in indium on the same 1-inch mount in a clean room at CRPG. Scanning electron microscope (SEM) images of the pressed particles were used to select flat areas of ground mass fine-grained matrix for the SIMS measurements. The SIMS data were obtained using a $Cs^+$ primary beam accelerated at 10 kV, and $H^-$, $D^-$, $^{13}C^-$ and $^{29}Si^-$ ions were collected from 12 x 12 $\mu m^2$ areas following the procedure described in [6,8,10]. After SIMS analyses, the location of each analysis was checked with the SEM and the analyzed area containing cracks or holes were removed.

**Results and discussion:** We obtained isotopic data from three distinct particles of Bennu sample OREX-800045-113 with a total of 20, 13, and 15 analyses per particle, respectively. Analyses of the CI-type Orgueil chondrite were also performed during the same session using identical analytical conditions. The C/H ratios measured in these Bennu particles are generally higher than C/H ratios measured in Orgueil. This observation was also reported for Ryugu fragments [10]. This appears consistent with bulk measurements showing that the returned samples contain less hydrogen than CIs [1], possibly because a part of the interlayer water in CI chondrites might be of terrestrial origin [11,2]. The average D/H ratios measured in the Bennu particles are generally of the same order as for Ryugu and similar to or above the average D/H ratios measured in Orgueil. However, we observed hydrogen isotopic differences among the three measured particles, indicating an inhomogeneous hydrogen isotopic composition of the Bennu aggregate samples. New microscope observations and SIMS analyses are planned to understand the nature of the hydrogen isotopic heterogeneities in Bennu samples. We will use the isotopic results to discuss the distribution of water in the protoplanetary disk at the time and place of Bennu's asteroid formation.

**Acknowledgments:** Supported by NASA under Contract NNM10AA11C and Award NNH09ZDA007O. Analyses performed at CRPG were supported by the Centre national d'études spatiales (CNES).

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