HYDROGEN ISOTOPIC COMPOSITION OF WATER IN RYUGU SAMPLES RETURNED BY THE HAYABUSA2 MISSION

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Introduction: The first series of analyses on Ryugu's fragments from the two collection sites have shown that the Hayabusa2 samples resemble CI chondrite-like materials [1]. These rock fragments underwent extensive aqueous alteration and are predominantly composed of hydrated minerals (serpentine, saponite) and other secondary minerals (carbonates, magnetites, sulfides) likely formed on Ryugu under the presence of liquid water. The isotopic composition of these phases can help understanding the source and distribution of water and volatile elements in the protoplanetary disk [e.g., 1-5]. However, direct estimates of the water D/H ratios cannot be obtained easily in chondritic rocks due to the difficulty in estimating the organic matter (OM) contribution to the whole H budget.

Water D/H ratio in chondritic rocks is often approximated by the bulk D/H composition or estimated by mass balance calculations to remove the contribution of the organic components (e.g., [2]). In mass balance calculations, OM concentration and D/H composition are generally measured after solvent extraction [3] or chemical isolation from minerals [4], but about half of the total OM is not accessible with these techniques (e.g., [5]). In this study, we are using an analytical method by secondary ion mass spectrometry (SIMS) [6-7] to estimate the D/H ratio of water retained in the hydrated minerals of Ryugu's rock fragments and compared these results to water D/H ratios measured in different carbonaceous chondrites.

Methods: H, D and C data were obtained with a SIMS IMS 1280-HR2 and the D/H ratios were corrected from instrumental mass fractionation using hydrous silicates and organic standards [6-7]. We previously determined the D/H ratios of hydrated minerals without hindrance from H in adjacent organic materials in carbonaceous chondrites from different groups and petrological types: we found that each group shows a distinct and unique water D/H signature [7]. We now have applied the same method on Ryugu's samples and estimated the Ryugu's water D/H ratio.

Results and discussion: We obtained 95 analyses of the D/H and C/H ratios in the three fragments of Ryugu C0002, A0040 and A0094. All but 5 points follow a nice positive correlation between the D/H and the C/H ratios ($R_{Pearson} = 0.72$). Using this correlation, we estimated that the water D/H in Ryugu is of $\delta D_{Ryugu} = +74 \pm 117$ ‰ (2σ). This value is similar within error to the water D/H measured for the CI carbonaceous chondrite Orgueil in the same session of measurement ($\delta D_{Orgueil} = +63 \pm 138$ ‰) and for CI and CV chondrites in our previous work ($\delta D_{CI} = +98 \pm 103$ ‰ and $\delta D_{CV} = -43 \pm 64$ ‰) [7], but it is disctinct from the water D/H measured for CM carbonaceous chondrites ($\delta D_{CM} = -358 \pm 26$ ‰) or in the ungrouped carbonaceous chondrites Bells and Essebi ($\delta D_{Bells/Essebi} = +380 \pm 64$ ‰) [6-7]. Compared to Orgueil, Ryugu's data have higher C/H and D/H ratios consistent with bulk measurement showing that Ryugu's rocks contain less hydrogen than CIs [1]. It is possible that a part of the interlayer water in Orgueil might be of terrestrial origin [1, 8]. Five analyses show clear D-enrichments compared to the other points and could include some D-rich organic hotspots. The hydrogen isotopic compositions will be used to discuss the isotopic distribution of water in the protoplanetary disk at the time and place of the Ryugu asteroid formation.

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