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Coordinated micro- and nano-analyses of phyllosilicate matrices and carbonates in Ryugu samples using FIB-TEM and SIMS techniques

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The initial analyses of Ryugu samples indicate they have CI-like mineralogy, bulk chemical and isotopic compositions, and represent the most chemically pristine materials currently available [1]. CI chondrites appear to have been significantly modified during their residence time on Earth. Such modification resulted in formation of sulfates and ferrihydrites; it may have also affected the structures of organics and phyllosilicates [1-2]. One of the striking differences between the Ryugu samples and CI chondrites is the amount of water in phyllosilicates [1-2]. In the Ryugu phyllosilicates, the amount of structural water is comparable to that in CIs, but the interlayer water is essentially absent, suggesting its loss to space. In contrast, the amounts of interlayer and structural water in CI chondrite phyllosilicates are nearly equal; however, the former could in part due to water of terrestrial origin [3]. Thus, it is important to study Ryugu samples, as they avoided terrestrial modification.

Ryugu’s phyllosilicate-rich matrices are composed of multiple lithologies [1], showing heterogeneous elemental and isotopic distributions [4]. Some phyllosilicates may have retained interlayer water. Oxygen and H isotopic compositions of the Ryugu phyllosilicates could provide important constraints on the isotopic compositions of water, mechanism(s) of retention/escape of interlayer water, and potentially temperature that these phyllosilicates have experienced. In this study we measure O and H isotopic compositions of phyllosilicates in different lithologies of the Ryugu samples using the UH isotope microscope (Cameca ims-1280+SCAPS). The lithologies are identified using BSE and X-ray elemental mapping and ion imaging; their mineralogy is studied using variable transmission electron microscopy (TEM) techniques. In addition, we analyze carbonates for their chemical composition in detail at a nanometer scale using TEM. The goal is to constrain the possible local variations that could reflect on local geochemical microenvironments within the Ryugu's parent asteroid by investigating if carbonates grew from isolated reservoirs of fluid during aqueous alteration.

[1] Yokoyama et al. (2022) Science, 7850.

[2] Sakamoto et al. (2022) Japan Geoscience Union Meeting, #PPS08-08.

[3] Young et al. (2022) 53rd Lunar Planet. Sci. Conf., abstract#1377.

[4] Sakamoto et al. (2022) Science 317, 231-233.