MICROMEGA DETECTIONS OF CARBONATES IN RUYGU RETURNED SAMPLES WITHIN THE HAYABUSA 2 JAXA EXTRATERRESTRIAL CURATION CENTER.

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Introduction: The Ryugu samples brought back by the Hayabusa2 spacecraft in December 2020 have been delivered to the JAXA Extraterrestrial Curation Center [1]. Bulk samples and then individual grains have been picked up and stored into sapphire dishes, weighted, and analyzed with an optical microscope, FTIR spectroscopy, and MicrOmega hyperspectral imaging [2-4] for initial description. The MicrOmega instrument used in the JAXA Extraterrestrial Curation Center is a NIR hyperspectral microscope. It has a total field of view of 5 mm x 5 mm, with resolution of ~22 µm/pixel in the focal plane. It covers the spectral domain from 0.99 µm to ~3.6 µm. Its capabilities enable the identification of organic matter and of different minerals in the returned samples [5]. Initial analyses with MicrOmega were first made on the bulk samples from chambers A and C of the Hayabusa 2 returned capsule, and then on individual grains stored in their sapphire dishes. 179 extracted grains have been analyzed with MicrOmega by the end of 2021 [4].

MicrOmega spectral detection: Spectra of the Ryugy samples at the mm scale share common features: a very low reflectance (2-3%), an absorption band centered around 2.715 µm attributed to OH, a weak absorption centered around 3.4 µm mainly attributed to a variety of CH-rich compounds [2]. However, some local spectral variations show are very clear, and include the detection of carbonates.

Carbonate spectral detection: In the spectral domain of MicrOmega, carbonates have a strong characteristic double absorption band in the 3.3-3.5 µm area, accompanied by two other weaker bands around 2.5 and 2.3 µm. The exact spectral position of these bands varies with the cation content of the carbonate [6]. Iron-bearing carbonates also show a strong absorption below 1.5 µm.

Concerning the detections with MicrOmega on the Ryugu samples (see 3 examples in figure 1), spectra all present a double band at 3.31-3.47 µm and a band centered at 2.71 µm (this last band is largely present throughout the samples). The largest grains and inclusions also exhibit spectral bands at 2.51 and 2.30 µm, also characteristic of carbonates, and a deep absorption below 1.5 µm. Some detections also have a band at 2.77 µm (present in many carbonate reference spectra), and another band between 3.07 and 3.10 µm.

The presence of a strong absorption below 1.5 µm indicates the likely presence of Fe^{2+} in the carbonate mineral, although the position of the bands around 2.3, 2.5 and 3.4 µm is shifted to shorter wavelength compared to a purely Fe^{2+} carbonate (siderite), and would better fit Mg-bearing carbonates like dolomite or magnesite. A Fe-bearing dolomite or the Fe-bearing magnesite breunnerite is a likely candidate for these detections. Some grains and inclusions do not show the absorption below 1.5 µm, while the other absorptions are centered around the same positions than for the larger grains (figure 1-C). Likely candidates include dolomite and magnesite.

If present, Ca-rich carbonates would be below the size detection limit of MicrOmega (<50 µm).

Variations in the shape of the double band at 3.31-3.47 are visible in some detections. They may either reveal small variations in cations presence within the carbonate structure, or the presence of CH-rich compounds.

Carbonate detection sizes: First detections of carbonates were made in grains included in the bulk samples from both chambers A and C (i.e. figure 1-B and 1-C). Some small grains seem to be entirely carbonate-rich and are up to ~450 µm, down to <50 µm in size. Carbonate inclusions were also detected in larger grains, with sizes up to ~380 µm in a >1.5 mm-sized grain, and down to <50 µm (figure 1-A).

From the first 130 analyzed extracted grains, MicrOmega detected carbonate inclusions with high confidence in 19 of those grains. The largest detection was made on grain C0041, covering ~0.25 mm², or ~10% of the visible surface of the grain (figure 1-A). This grain is one of the grains with “White regions” as described in Nakato et al. [7].

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References: [1] Yada et al. (2021) *Nature Astronomy*. [2] Pilorget et al. (2021) *Nature Astronomy*. [3] Pilorget et al. (2022) *this conference*. [4] Yogata K.. et al. (2022) *this conference*. [5] Pilorget C. and Bibring J.-P. (2014) *PSS 99, 7-18*. [6] Hunt G.R. and Salisbury J.W. (1971) *Visible and near infrared spectra of minerals and rocks. II. Carbonates. Modern Geology 2, 23–30*. [7] Nakato A. et al. (2022) *this conference*.

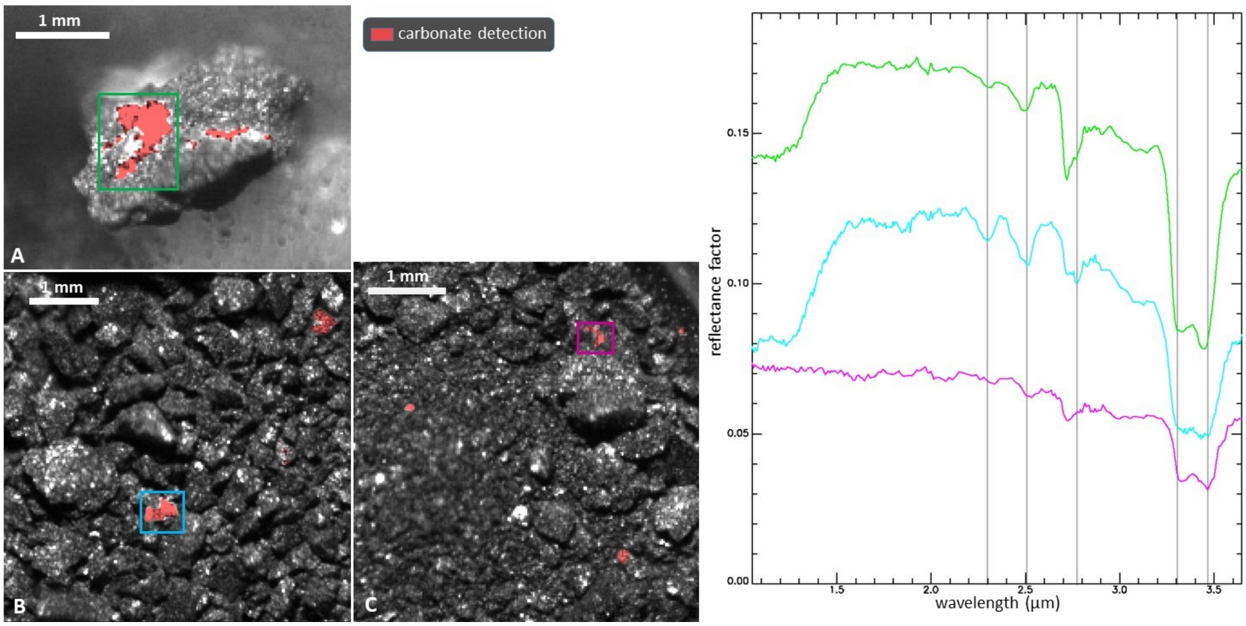

Figure 1. Example of carbonate detections with MicrOmega on bulks from chamber A and C, and on an extracted grain from chamber C. Left: MicrOmega images with red pixels where carbonate is detected. A: extracted grain C0041. B: bulk samples from chamber A. C: bulk samples from chamber C. Right: Average spectra of pixels with carbonate detections within the colored boxes in the left images

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