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Large Scale NanoIR Mapping of Ryugu Samples: First Results and Implications for Ryugu's Formation

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The return of asteroid samples by the Hayabusa2 mission has allowed us to use laboratory-scale analytical instrumentation to better understand the interrelationship between remote sensing observations and the nano to micron scale mineral variations found on Ryugu. One emerging laboratory technique combines the chemical resolving power of infrared spectroscopy with the spatial resolution of atomic force microscopy (AFM) to produce information about the infrared absorption properties of materials. One challenge in producing large spectral stacks (hyperspectral) is instrument drift induced by temperature variations and vibrational noise. To circumvent this limitation, we have we have developed drift correction of spectral image stacks using the AFM topography. This technique has allowed us to acquire large (>15 micron x 15 micron) spectral images of returned samples surfaces with ~ 40 nanometer pixel sizes. Furthermore, using RGB images produced from drift corrected image stacks (hyperspectral), we were able to visualize chemical variations (See Figure 1) of Ryugu sample A0026-pFIB02 at the micron and sub-micron scales. In addition to finding minerals such as carbonates, our technique also allows us to visualize phyllosilicate variations (e.g., Serpentine vs. Saponite) and their relationship to carbonate inclusions. Ongoing work is focused on acquiring elemental maps (Fe, Ca, Mg etc.) to correlate with and better understand the sub-micron IR spectral variations of Ryugu and their relationship to far-field IR (remote) observations. Finally, we discuss physical-chemical mechanisms that may help us understand the power-spectrum of these IR variations and their connection to the formation and alteration history of Ryugu.

Figure 1 (left) RGB image (FOV=11.4 microns) created using IR image stack method. Red is the average intensity between 1050-1067 cm^{-1} corresponding to an Si-O stretch present in both serpentine and saponite, green is 1087-1100 cm^{-1}, an Si-O mode present in serpentine, but not saponite, and blue is 1117-1150cm^{-1}, a mode present in saponite but not serpentine. Dark inclusion, ~ 4 microns in size, has IR spectra consistent with carbonate. (Right) IR power spectral variations of phyllosilicate matrix as a function of length scale (l_x) for regions away from carbonate grain.