Nanoscale element mapping and XANES spectroscopy of interplanetary dust particles

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The Scanning X-ray Microscope, operating on Beamline I08 of the Diamond synchrotron, provides a new opportunity for x-ray fluorescence (XRF) and x-ray absorption near-edge structure (XANES) spectroscopy, with a spatial resolution down to ~20 nm. The incident beam is tunable from 250 to 4,200 eV, covering the K- or L-lines of most major and minor elements in extraterrestrial materials.

We obtained XRF spectra, producing maps of the K-line intensities of C, N, and O and the L-line intensity of Fe, in 25 nm steps over a ~10 micron hydrous interplanetary dust particle (IDP) L2083E47, an aggregate of micron and sub-micron grains of diverse compositions. Figure 1 shows the 3-color overlay of the C, O, and Fe maps, allowing identification of carbonaceous material and location of some minerals, e.g. Fe spots with no O or C are likely Fe-sulfides (e.g., S1 in Fig. 1). We obtained an absorption image stack (145 images over the energy range from 280 to 310 eV) and extracted XANES spectra at C hot-spots in the XRF image as well as over the whole area of the particle (excluding the C hot spot at the bottom center of the image). The C hot spot at the bottom center of the particle (S2) has a C-XANES spectrum similar to disordered graphite, while the spectrum over the whole particle shows strong C=C and C-O_3 (carbonate) absorptions and a weaker C=O absorption. This instrument provides new capabilities for XRF and XANES characterization of IDPs at a size scale comparable to their generally sub-micron grain size.

Figure 1: (left) Three color map of C (red), O (blue), and Fe (green) for IDP L2083E47, white scale bar is 1 micron. (right top) C-XANES spectra of the entire particle and (right bottom) C hot-spot at bottom (S2).