DEVELOPING IN-SITU µ-XRD OF HYDRATED METEORITES AND THEIR COMPONENTS

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Rationale: The CI and CM chondrites experienced extensive aqueous alteration resulting in the near-complete transformation of precursor silicate components (e.g. chondrules, CAIs and matrix) to secondary mineral assemblages [e.g. 1]. The spatial distribution of phyllosilicates, oxides, carbonates and sulfides within CI and CM chondrites can provide details on the environmental conditions under which hydration occurred and the nature of the reacting fluids. However, the CI and CM chondrites are extremely fine grained (<1 µm) and challenging to analyze using methods such as optical and electron microscopy. Transmission electron microscopes (TEM) can study the minerals at the nm-scale but the samples must be prepared as electron transparent foils (<200 nm) and extracted from thin sections. We are therefore developing non-destructive X-ray diffraction (XRD) techniques capable of investigating the in-situ mineralogy of fine-grained meteorites at the µm-scale.

Results & Discussion: As a first approach we used the Diamond Light Source, UK, to perform µ-XRD analysis of fine-grained rims (FGRs) and matrix areas in a ~150 µm thick section of the Murchison (CM2) meteorite [2]. XRD patterns were collected as maps (~100 × 100 µm) in transmission mode and the spot size of the beam on the sample was ~3 µm. We observe spatial variations in minerals such as Fe-cronstedtite, tochilinite, carbonates and silicates, suggesting that aqueous alteration was heterogeneous at the µm-scale. This probably reflects variations in the initial mineralogy, shielding of some areas from fluids and reactions that did not reach completion.

In addition, we have used a Rigaku Rapid II XRD to examine the mineralogy of a number of CI and CM thin sections. At the shallow angles required to obtain diffraction from the phyllosilicates, which typically have peaks at high d-spacings, we can achieve a spot size on the sample of ~50 × 200 µm. XRD patterns were collected in reflectance at points (~100 µm apart) along traverses (~500 µm long) across the thin sections. For several minerals we see changes in the intensity of their diffraction peaks that represent differences in their crystallinity and abundance.

As the Dawn spacecraft approaches Ceres (2015), and the Hayabusa-2 and Osiris-Rex missions prepare to return samples of B/C-type asteroids, in-situ µ-XRD is enabling us to better understand the characteristics and extent of hydration on primitive bodies in the early Solar System.

References: [1] Brearley A. J. 2006. In: *Meteorites and the Early Solar System II* (D. S. Lauretta and H. Y. McSween, eds.), pp. 587–624. [2] King A. J. et al. 2014. Abstract #5251. 77th Annual Meteoritical Society Meeting.