

FE-XANES STUDY OF CI AND CM CHONDRITES MATRIX MINERALOGY

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Introduction: Carbonaceous chondrites present fingerprints of an aqueous alteration process that took place early in the Solar System history [1]. This process produced the oxidation of silicate and opaque minerals into -OH and H₂O bearing phases [1-2]. This hydrated mineralogy has been studied previously by a variety of techniques and several workers have intended to build an alteration scheme based on various chemical, mineralogical or spectroscopic criterions [3-5]. Here, we use Fe-XANES to characterize the redox state and local environment of iron within mineral phase of CI and CM matrix. We use the unique full field set-up available at the European Synchrotron Radiation Facility (ESRF), which gives information on Fe redox state within a petrographical context.

Samples, method, and analysis: We studied 1 CI (Orgueil) and 7 CM. For CM meteorites, we selected samples that show the full range of aqueous alteration as defined by Rubin et al. [3] (Murchison, QUE97990, Murray, Nogoya). We also studied two anomalous CM meteorites (PCA 91008, WIS 91600). Matrix chunks were extracted and embedded into iron-free resin. Double polished sections were manually prepared for transmission measurement. Measurements were performed on ID21 beamline (ESRF) using the full-field set-up [6]. A large monochromatic X-ray beam is sent to the sample and multiple transmission image were obtained at energies ranging between 7.135 keV to 7.300 keV. The data product is a 1376 x 1040 Fe-XANES hyperspectral datacube (248 energy steps). Two types of analysis were performed. In a first step matrix averages were calculated in order to provide a basis for meteorite comparison. Spectra were analyzed according to [7], in order to obtain estimated of the Fe²⁺/Fe³⁺ ratio. We also performed a bulk data analysis to provide maps of Fe speciation distribution within the studied samples.

Results and Discussion: Bulk matrix analysis reveals variation among our sample suite. We performed calculations of the pre-peak centroid position (PPC) and integrated pre-peak intensity (IPPI) which appears to reveal a trend among CM from a low PPC energy (~7113 keV) and a low integrated pre-peak intensity toward higher values of both IPPI and PPC energy. This trend might be attributed to enrichment in Fe³⁺ of the matrix minerals as well as an increase in the amount of tetrahedral Fe³⁺. Such an evolution might be due to an evolution of the crystal chemistry of the cronstedite phase. Orgueil is located aside from this trend as it shows a high value of PPC energy (high amount of Fe³⁺) but with low value of its IPPI. This observation is suggestive that the iron mineralogy of Orgueil matrix is dominated by an octahedral coordinated Fe³⁺ phase, likely ferrihydrite. The anomalous CM do not appear to be distinguishable from the CM trend suggesting that there is a XANES memory preserved despite of the metamorphic event.

References: [1] Brearley A.J., 2006, MESSII, University of Arizona Press. [2] Howard K.T. et al. 2009 GCA 73, 4576-4589. [3] Rubin A.E. et al. 2007, GCA 71, 2361-2382. [4] Browning et al. 1996, GCA 60, 2621-2633. [5] Beck P. et al. (2010), 41st LPSC. [6] DeAndrade et al., Analytical Chemistry, submitted [7] Wilke et al., 2001, Am. Min. 86, 714-730.