

VISUALIZATION OF IRON OXIDATION AS A PROXY FOR AQUEOUS ALTERATION OF PRIMITIVE COMPONENTS IN CARBONACEOUS CHONDRITE LAPAZ ICEFIELD (LAP) 02342.

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Introduction: A carbon-rich (> 50 vol.%) clast found within the fine-grained matrix of CR2 chondrite LAP 02342 contains a much higher abundance of presolar grains than the surrounding matrix [1], similar to that observed in the most primitive chondrites and interplanetary dust particles. The clast bears some similarity to ultracarbonaceous Antarctic micrometeorites [2,3], which are thought to originate from comets. TEM of several lamellae extracted from this clast by FIB methods revealed glass with embedded metal and sulfides (GEMS) grains, but also evidence of aqueous alteration, such as calcite and (Na,Ca)-sulfates [4]. These observations suggest that perhaps the carbonaceous matter in the clast acted as a protective shield for some GEMS and presolar grains that are otherwise readily destroyed by parent body aqueous alteration. Since asteroidal processing leads to geochemically homogenized silicates, the distribution of Fe oxidation states in ferromagnesian minerals can be used to visualize redox conditions of the fluids that altered the carbonaceous clast and surrounding matrix.

Methods: Four TEM lamellae were prepared from the LAP 02342 clast with an FEI Nova 600 or FEI Helios G3 FIB-SEM—one from within the carbonaceous clast, one from the border of the clast, another from an area on the border exhibiting a strong depletion in ¹⁶O, and one from nearby fine-grained matrix. Fe L_{2,3} XANES data were acquired with the scanning-transmission X-ray microscope on beamline 5.3.2.2 at the Advanced Light Source, Lawrence Berkeley National Laboratory. The oxidation state of Fe (Fe³⁺/ΣFe) was quantified by Gaussian fitting of Fe²⁺ and Fe³⁺ peaks present in spectra from each image pixel [5]. These valence state data were calibrated internally from grains that matched spectra from minerals of known Fe valence state, generating valence estimates with an error of ±0.1.

Discussion: Fine-grained material outside the clast is dominated by Fe³⁺-bearing minerals, consistent with pervasive alteration by oxidizing parent body fluids. Similar results have been observed in other CR chondrite matrices [6]. Material within the carbonaceous clast, in contrast, shows a much broader distribution of Fe valence, with a prominent peak of minerals with an average valency of Fe^{2.8+} [Figure 1]. This valence distribution indicates that the redox state of the fluid that altered the clast was distinct from that which altered the external matrix, with a redox chemistry controlled by materials interior to the carbonaceous clast. Given its ultracarbonaceous nature, the clast may have been ice-rich when accreted, which would have also influenced the local alteration microenvironment. In both FIB sections obtained from the border of the clast, including the ¹⁶O-depleted region, a complex valence distribution is observed, with a significant abundance of both Fe³⁺- and Fe^{2.8+}-bearing materials. This could be explained by infiltration of these regions by parent body fluids and mixing with clast-derived fluids, which did not penetrate further into the clast.

References: [1] Moyano-Camero C. E. et al. (2016) *LPSC XLVII*, abstract 2537. [2] Duprat J. et al. (2010) *Science* 328:742-745. [3] Dobrică E. et al. (2012) *GCA* 76:68-82. [4] Stroud R. M. et al. (2016) *M&PS* 51:A607. [5] Van Aken P. A. and Liebscher B. (2002) *Physics and Chemistry of Minerals* 29:188-200. [6] Le Guillou et al. (2015) *EPSL* 420:162-173.

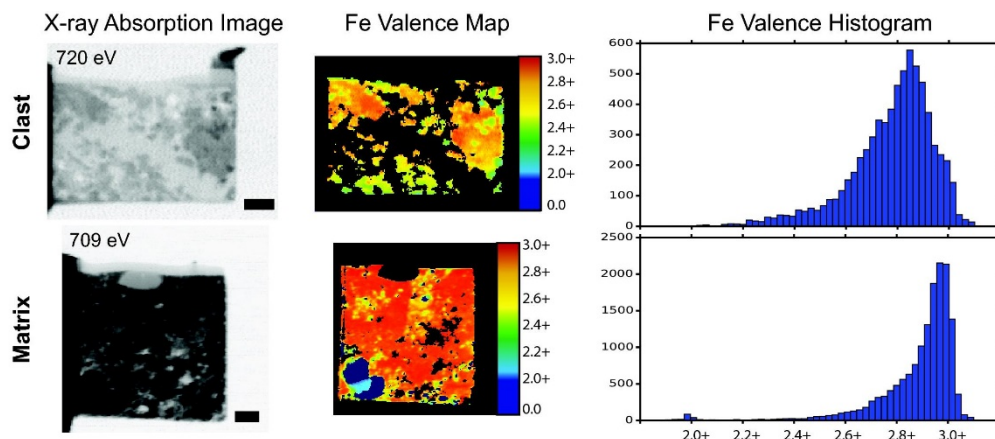


Figure 1. Fe valence data from a FIB lamella extracted from the primitive carbonaceous clast and nearby fine-grained matrix in LAP 02342. Scale bar is 1 μ m.