THE INTRIGUING INTERACTION BETWEEN THE NORTHWEST AFRICA NWA 2364 CV3$_{OxA}$ CHONDRITE AND ITS LITHIC INCLUSION: IMPLICATIONS FOR POST EMPLACEMENT PARENT BODY AQUEOUS ALTERATION

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Introduction: The oxidized and reduced subgroups of the CV3 chondrites contain a range of primitive solar system material that has undergone various amounts of aqueous and thermal processing. Both subgroups contain Calcium-Aluminum-Rich Inclusions (CAIs), chondrules, and dark inclusions (DIs) [1-2], but the oxidized subgroup has magnetite as the result of oxidation of the Fe, Ni metal, whereas the reduced group has retained Fe, Ni metal. The complex secondary processing of the oxidized CV3 chondrites provide unique insights into the conditions and timing of processing of nebular materials and also provide constraints on the nebular versus parent body alteration hypotheses [3,4] for the CV chondrites. The mm- to cm-sized DIs found in CV3 chondrites also play an important role in understanding the alteration history of these chondrites [2,5,6]. In this study, we have examined the relationship between the host rock and a large lithic inclusion(LI) in the NWA 2364$_{OxA}$ chondrite using mineralogical and stable isotopic techniques to better understand their alteration histories, as well as the relative timing of the alteration processes.

Methods: A polished thin section of NWA 2364 was studied using an FEI Quanta 3D Field Emission Gun SEM. High resolution BSE images and X-ray elemental maps were taken of the host, lithic inclusion, and the contact between them. Bulk oxygen isotope analyses of the host, lithic inclusion, and contact were measured using the laser fluorination oxygen isotope analysis technique in the Center for Stable Isotopes at the University of New Mexico.

Results: The NWA 2364 host meteorite is a typical oxidized CV3 chondrite, consisting of moderately altered chondrules, CAIs, and AOAs, set in a fine-grained olivine-rich matrix. The LI is finer-grained and shows a higher degree of alteration than the host. It consists largely of matrix material dominated by fine-grained ferroan olivines, with extensively-altered type IA and type IIA chondrules embedded within it. Chondrule phenocrysts exhibit cross cutting alteration veins that consist of platy, oriented ferroan olivines and the edges of forsteritic chondrule phenocrysts have been altered to a more ferroan composition. Fine-grained rims of relatively densely-packed ferroan olivines surround all the altered chondrules. X-ray mapping shows that there is a rim of Ca-rich pyroxene at the contact between the host and LI that appears to be correlated with a depletion in Ca-rich phases in the outer area of the LI (Figure 1). Oxygen isotope analyses of two host meteorite samples, one LI sample, and one sample of material from a distinct rim around the LI, all show isotope heavy isotope enrichments, displaced from the CCAM line. These compositions lie at the ^{16}O-rich end of a linear array defined by DIs in the reduced CV3 chondrite Leoville.

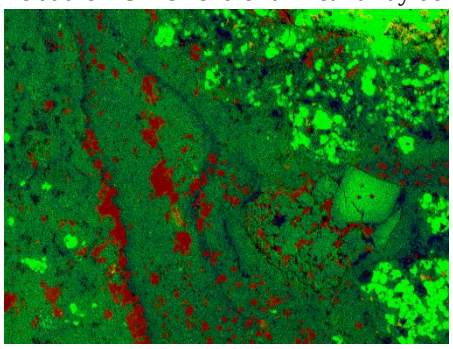

Figure 1. Ca(R)Mg(G)Fe(B) X-Ray map of a portion of the rim around the LI. Note the enrichment of linear Ca-rich phases separating the LI from host.

Discussion: The NWA 2364 chondrite and LI record a complex alteration history. The LI has undergone significant alteration before emplacement into the host, which textural and compositional data indicate involved interaction with an aqueous fluid. The absence of Na- and S-bearing phases, such as sodalite, nepheline, and sulfides in the LI is highly suggestive of significant metasomatic loss of these elements. The significant replacement of chondrule phenocrysts by platy ferroan olivine, as well as the distinctive porous, olivine-filled veins also supports alteration via an aqueous fluid. The heavy oxygen isotopic composition of the LI, is also indicative of aqueous alteration [7], although the displacement from the CCAM line appears relatively modest compared with the apparent degree of alteration of the LI, based on mineralogical criteria. After emplacement into the host meteorite, fluid-rock interaction between the host and LI occurred that leached Ca from the exterior of the LI. The Ca lost from the DI appears to have precipitated as a discontinuous rim of Ca-rich pyroxene at the interface between the host and LI. [8] have previously reported evidence of a similar interaction between a DI and its host in Allende. NWA 2364 and its LI exhibit a complex alteration history: further analyses are needed to fully understand the detailed nature of this alteration, especially the role of aqueous fluids.

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