IMPACT-INDUCED CHONDRULE DEFORMATION AND AQUEOUS ALTERATION OF CM2 MURCHISON

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Introduction: Deformed chondrules in CM2 Murchison have been found to define a prominent foliation [1,2] and lineation [3] in 3D using X-ray computed tomography (XCT). It has been hypothesized that chondrules in foliated chondrites deform by "squeezing" into surrounding pore space [4,5], a process that also likely removes primary porosity [6]. However, shock stage classification based on olivine extinction in Murchison is consistently low (S1-S2) [4-5,7] implying that significant intracrystalline plastic deformation of olivine has not occurred. One objective of our study is therefore to determine the microstructural mechanisms and phases that are accommodating the impact stress and resulting in relative displacements within the chondrules.

Another question regarding impact deformation in Murchison is whether it facilitated aqueous alteration as has been proposed for the CMs which generally show a positive correlation between degree of alteration and petrofabric strength [7,2]. As pointed out by [2], CM Murchison represents a unique counterpoint to this correlation: it has a strong petrofabric but a relatively low degree of aqueous alteration. However, Murchison may not represent an inconsistency to the proposed causal relationship between impact and alteration, if it can be established that the incipient aqueous alteration post-dated chondrule deformation.

Methods: Two thin sections from Murchison sample USNM 5487 were cut approximately perpendicular to the foliation and parallel to lineation determined by XCT [1,3] and one section was additionally polished for EBSD. Using a combination of optical petrography, SEM, EDS, and EBSD several chondrules were characterized in detail to: determine phases, find microstructures indicative of strain, document the geometric relationships between grain-scale microstructures and the foliation and lineation direction, and look for textural relationships of alteration minerals (tochilinite and Mg-Fe serpentine) that indicate timing of their formation relative to deformation event(s).

Preliminary Results: Deformed chondrules are dominated by forsterite and clinoenstatite with lesser amounts of Fe-Mg serpentine, sulfides, and low calcium pyroxene. Olivine grains are commonly fractured but generally show sharp optical extinction. The pyroxene, in contrast, is not only fractured but also often displays undulose extinction. In addition, the clinoenstatite is frequently twinned but it is unclear whether the twins are the result of mechanical deformation or inversion from protoenstatite [8]. EBSD work is currently ongoing to determine if areas of higher crystallographic strain can be imaged and mapped, and to determine the pyroxene twin orientations. In regards to alteration, we have found evidence for post-deformation formation of tochilinite and Mg-Fe serpentine indicating that aqueous alteration has indeed post-dated the deformation of the chondrules.

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