Micro- and Nano-Scale Petrological and Compositional Analysis of Chondrule and CAI Rims

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Chondrules (mm-sized quenched silicate melt droplets) and calcium-aluminium-rich inclusions (CAI, refractory), the major components within chondrite meteorites, represent the most abundant and earliest materials to have solidified from the solar nebula. Despite extensive petrological and compositional study, the exact formation mechanisms of these clasts remain unconstrained. Here, we are combining micro- and nano-scale techniques, to investigate the rim morphologies of these clasts to better understand their formation mechanisms.

The targets for this research are Wark-Lovering rims (WLR), and fine-grained rims (FGR), seen to surround CAIs and chondrules respectively in many chondrites. The WLRs (~10-20 µm thick) consist of different compositional layers, and likely formed by flash-heating shortly after CAI formation, thus recording nebular conditions. By contrast, some FGRs (up to ~100 µm thick), have been shown to contain presolar grains, which predate the formation of our Solar System, suggesting FGR formation under nebular conditions. A detailed multi-scale study of these respective rims will enable us to better understand their formation histories and determine the potential for commonality between these two phases, despite reports of an observed formation age difference of up to 2-3 Myr.

We are using the following complimentary techniques on our selected target areas: 1) Micro-scale characterization using standard microscopic and compositional techniques (SEM-EBSD, EMPA); 2) Nano-scale characterization of structures using transmission electron microscopy (TEM) and elemental, isotopic and tomographic analysis with NanoSIMS and atom probe tomography (APT). Our preliminary nano-scale APT analysis of an Allende (CV) chondrule has successfully discerned complex chondritic mineralogies and compositional differences across boundaries. Further data reduction will allow us to characterize the exact phases present, and further chondrite analyses are in progress.