INVESTIGATING THE HISTORY OF AUBRITES USING X-RAY COMPUTED TOMOGRAPHY AND BULK PARTITION COEFFICIENTS.

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Introduction: The aubrites are a unique group of differentiated meteorites that formed on parent bodies with oxygen fugacities (fO_2) from ~2 to ~6 log units below the iron-wüstite buffer [1-2]. At these highly reduced conditions, elements deviate from the geochemical behavior exhibited at terrestrial fO_2, and may form FeO-poor silicates, Si-bearing metals, and exotic sulfides [1-3]. Geochemical examinations of aubrites, such as mineral major-element compositions, bulk-rock compositions, O isotopes, and crystallization ages, are crucial to understand their formation and evolution at extreme fO_2 conditions. In this study, we determine partitioning relationships of elements between bulk silicate, sulfide, and metal phases within aubrites, and compare the results to partition coefficients determined from petrologic experiments run under mercurian conditions [4]. While previous studies have described the petrology and 2D modal abundances of aubrites, this work provides the first 3D view of aubritic mineralogies, which are compared to the available 2D data. Constraints of 3D modal abundances will increase the accuracy of computed bulk distribution coefficients; therefore, 3D scans of aubrite samples are imperative. We utilize X-ray computed tomography (XCT) to non-destructively analyze the distribution and abundances of mineral phases in aubrites and locate composite clasts of sulfide grains for future analysis.

Samples: We investigate a large representative suite of aubrites (n = 14): Allan Hills (ALH) 78113, ALH 84007, Bishopville, Cumberland Falls, Khor Temiki, Larkman Nunatak (LAR) 04316, LaPaz Icefield (LAP) 02233, Miller Range (MIL) 07008, MIL 13004, Mount Egerton, Northwest Africa (NWA) 8396, Norton County, Peña Blanca Spring, and Shallowater. These samples have varying degrees of brecciation and originate from two or more parent bodies [1-2]. Miller Range 07008, MIL 13004, and NWA 8396 have not been previously studied in detail aside from their initial classification.

Results: While we have analyzed bulk rock and oxygen isotopic compositions, XCT and bulk partition coefficient results will be highlighted here.

XCT Modal Mineralogy and Textures. The Cumberland Falls, Mount Egerton, Norton County, Peña Blanca Spring, and Shallowater aubrites were scanned using a Nikon XTH 320 micro-XCT at NASA Johnson Space Center. The results of the XCT data have enabled the determination of abundances of silicate groundmass (i.e., enstatite, forsterite, albite, and diopside), sulfides (i.e. troilite [FeS], alabandite [MnS] and daubréelite [$FeCr_2S_4$]), and Fe,Ni metal by segmenting a density histogram in Volume Graphics Studio software. The discernable phases are within ~5% of the linear attenuation coefficients (LAC) [5]. Surprisingly, the Mt. Egerton sample contains vesicles and fractures with a preferred orientation along long axes. This may give insight into the temperature and pressure conditions on its parent body, as Mt. Egerton is considered anomalous and may not have formed on the main aubrite parent body, which had been subjected to pyroclastic volcanism [6].

Bulk Distribution Coefficients. The geochemical behavior of elements change as a function of fO_2 [3]. Bulk distribution coefficient calculations are underway for the studied aubrites. We use the formula $D_i=c_i^X/c_i^Y$, where c is the concentration of element i in phase X and Y (metal, sulfide, or silicate), and include modal abundances of silicate, sulfide, and metal phases and mineral major element data. Similar to the experimental mercurian D_i interpretations in [4], the aubrite D_i calculations show that Fe, Cr, and Mn should preferentially incorporate into sulfides over other chalcophile elements. If the combined abundances of Fe, Cr, and Mn are insufficient relative to the available sulfide component, then Ti, K, Ca, and Mg are expected to partition into sulfide phases.

Discussion: The aubrite bulk distribution coefficients from this study have important implications for understanding reduced magmatism on other bodies in our Solar System, such as Mercury [7]. The 3D modal mineralogical results in this study give similar volume percentages as 2D modal results. However, we have located composite clasts of metal and sulfide grains for future analytical study. The use of XCT is a powerful tool to nondestructively observe the internal composition of precious meteoritic material.

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