OXYGEN ISOTOPES AND HIGH ^{26}Mg EXCESSES IN A U- DEPLETED FINE-GRAINED ALLENDE CAI.
M-C. Liu[1], H. Tang[1], K.D. McKeegan[1], F.L.H. Tissot[2] and N. Dauphas[2], [1]Department of Earth, Planetary, and Space Sciences, UCLA; [2]Origins Lab, Department of the Geophysical Sciences and Enrico Fermi Institute, the University of Chicago

Introduction: CAIs are among the first solids formed in the early Solar System (ESS). As such, they are prime samples to study when (1) investigating ESS high-temperature processes, and (2) searching for evidence of short-lived radionuclides at the time of formation of the SS. A recent systematic study of fine-grained CAIs characterized by Group II REE patterns from Allende [1], found an extremely large ^{235}U excess (δ^{235}U >50 ‰ rel. to CRM-112a) in one sample: ME-3364 3.2. The discovery of this large ^{235}U excess provides convincing evidence of the existence of live ^{247}Cm in the ESS, as previously suggested by [2]. In this study, we analyzed the oxygen isotope compositions and Al-Mg systematics of CAI ME-3364 3.2 to constrain the conditions of its formation.

Method: Petrologic and mineralogical studies were carried out by an SEM equipped with an EDS at UCLA. Secondary minerals such as nepheline, sodalite, Fe-rich pyroxene, and Fe-rich spinel were observed in ME-3364 3.2. Analyses for oxygen isotopes and Al-Mg systematics were performed on the IMS 1270 and IMS 1290 ion probes at UCLA. The instrumental mass fractionation for both oxygen and Mg isotopes was corrected for by comparison to San Carlos olivine, pyroxene, Burma spinel and an NBS610 glass. Excesses in ^{26}Mg (Δ^{26}Mg*) were calculated by adopting an exponential law with a mass fractionation exponent of 0.516 obtained from the analysis of standards.

Results and Discussion: Despite being U-anomalous and full of secondary phases, the oxygen isotopic compositions of this fine-grained CAI are not too different from those of other non- FUN CAIs. The Δ^{17}O values of sodalite and nepheline range from −15‰ to −5‰, similar to values previously obtained on Efremovka fine-grained CAIs [e.g., 3]. Large excesses in ^{26}Mg have been identified in ME-3364 3.2 over a large range of ^{27}Al/^{24}Mg values (from 42 to 667), yet the data do not define an isochron. Instead, the ^{26}Mg excess is approximately uniform across all spots analyzed. All the spots are characterized by large but variable negative δ^{25}Mg (from ~ −9‰ to −19‰).

The elevated, yet homogenous, Δ^{26}Mg* and negative δ^{25}Mg in ME-3364 3.2 indicates Mg isotope exchange must have taken place in a closed system to avoid dilution with chondritic Mg, although our data cannot constrain a reliable timescale of the formation of secondary phases. Further investigation is required to explain ^{26}Mg excesses and negative δ^{25}Mg associated with U depletion in this fine-grained inclusion.

References: [1] Tissot F.L.H. et al., (2015) Lunar and Plane- tary Science Conference #2819. [2] Brennecka G.A. et al., (2010) Science, 327, 449-451. [3] Aléon J. et al., (2005) Meteoritics & Planetary Science 40: 1043-1058.

HIGH-TEMPERATURE RIMS AROUND CAIs FROM THE CR, CB AND CH CARBONACEOUS CHONDRITES.
A. N. Krot[1,2], K. Nagashima[1], E. M. M. van Kooten[2], and M. Bizzarro[2]. [1]HIGP/SOEST, University of Hawaiʻi at Mānoa, USA, [2]Centre for Star and Planet Formation, University of Copenhagen, Denmark

We describe the mineralogy, petrology and oxygen isotopic compositions of high-temperature rims (not all of them are Wark-Lovering rims) around Ca,Al-rich inclusions (CAIs) from the CR, CH, and CB carbonaceous chondrites.

Wark-Lovering (WL) rims: In CR chondrites, most CAIs are surrounded by WL rims; the only exception are rare igneous CAIs extensively melted during chondrule formation, which lack the rims. A complete multilayered WL rim sequence (spinel + hibonite + perovskite → melilite replaced to a various degree by anorthite → Al-diopside → forsterite) is rarely observed around CR CAIs; Al-diopside ± forsterite rims are more common. In CH chondrites, most CAIs are surrounded by WL rims mineralogically similar to those in CR chondrites; however, anorthite replacing rim melilite is rare. The CR and CH CAIs and their WL rims are uniformly ^{16}O-rich (Δ^{17}O ~ −24‰), indicating formation in an ^{16}O-rich (solar-like) gaseous reservoir. Based on the mineralogy, petrology and O-isotope compositions, we infer that WL rims formed by evaporation, condensation, melting, and thermal annealing in the CAI-forming region. There is no correlation between O-isotope compositions and the presence or absence of ^{26}Al in the CAIs surrounded by WL rims, suggesting that the ^{16}O-rich gaseous reservoir in the CAI-forming region existed during addition and homogenization of ^{26}Al in the protoplanetary disk.

Wark-Lovering rims melted during chondrule formation: Some ^{16}O-rich CR and CH CAIs are surrounded by Al-diopside rims depleted in ^{16}O to varying degrees (Δ^{17}O range from ~ −10 to ~ +2‰). These rims are typically thick and compact. They are often intergrown with ferromagnesian (chondrule-like) olivine and low-Ca pyroxene grains and contain inclusions of Fe,Ni-metal nodules, suggesting incomplete melting and O-isotope exchange during brief heating events, most likely during formation of porphyritic chondrules.

Igneous rims formed in an impact-generated plume: All CB CAIs and about 10% of CH CAIs are surrounded by single- or double-layered igneous rims composed of Ca-rich forsterite or Al-diopside + Ca-rich forsterite. Host CAIs have diverse mineralogy (grossite-rich, hibonite-rich, melilite-rich, spinel-rich, and Al-diopside-rich) and appear to be igneous. The CB CAIs, CB-like CAIs in CH chondrites and their igneous rims are uniformly ^{16}O-poor (Δ^{17}O ~ −5‰), indicating formation in an isotopically distinct gaseous reservoir. We suggest that (*i*) this reservoir is related to an impact-generated plume of gas and melt invoked for the origin of magnesian non-porphyritic chondrules in CB and CH chondrites, and (*ii*) the ^{16}O-poor igneous rims formed during melting of the originally ^{16}O-rich host CAIs in the plume followed by gas-melt O-isotope exchange, condensation of SiO and Mg into the CAI melts, and crystallization.

We conclude that rims around CAIs from CR, CH, and CB chondrites recorded high-temperature processing in gaseous reservoirs with different oxygen isotopic compositions, prior to and during chondrule formation. In contrast to CAIs surrounded by isotopically heterogeneous WL rims from hydrothermally altered CV chondrites, our data provide no evidence that CAIs surrounded by WL rims were transported between ^{16}O-rich and ^{16}O-poor gaseous reservoirs multiple times.