OXYGEN ISOTOPE COMPOSITIONS OF THE ALLENDE TYPE C CAIS: EVIDENCE FOR ISOTOPIC EXCHANGE DURING NEBULAR MELTING AND ASTEROIDAL THERMAL METAMORPHISM. A.N. Krot1,*, M. Chaussidon2, H. Yurimoto3, N. Sakamoto3, K. Nagashima1, I.D. Hutcheon4, and X. Hua2. 1University of Hawai‘i at Manoa, USA. *sasha@higp.hawaii.edu. 2CNRS/CPPG, France. 3Hokkaido University, Japan. 4Lawrence Livermore National Laboratory, USA. 5Arizona State University, USA.

**Introduction:** Most CAIs in primitive chondrites (e.g., CR2, CO3.0) have uniformly 18O-rich compositions (Δ17O = -20%) and large 26Mg* indicating early formation in an 18O-rich gaseous reservoir [1,2]. Few CAIs in these meteorites subsequently experienced melting and isotopic exchange in the presence of an 18O-poor nebular gas [3-5]. In contrast, most CV CAIs, which appear to have formed very early, during a short time interval [6,7], show large O-isotopic heterogeneity: melilite and anorthite are typically 18O-depleted (Δ17O > -10%) compared to spinel and Al,Ti-diopside, which largely retain their original 18O-rich compositions [8]. Because some melilite and anorthite in CV CAIs have 18O-rich compositions, isotopic exchange with an 18O-poor external reservoir is required [9,10]. In addition, most isotopically heterogeneous (growing CV CAIs are surrounded by multilayered rims with the outermost layers of Al-diopside and forsterite being 18O-rich. Since these rims are formed from high-temperature gas-solid or gas-melt interaction, the final stages of CAI formation must have occurred in the presence of an 18O-rich nebular gas.

Several mechanisms have been proposed to explain the nature of this selective isotopic exchange, but all have some problems. (i) High-temperature gas-solid exchange in the solar nebula is inconsistent with the measured oxygen self-diffusion rates in melilite, anorthite, diopside, and spinel [9,10]. (ii) Isotopic exchange between the 18O-rich CAI melt and an 18O-poor nebular gas during CAI melting or crystallization is difficult to reconcile with the inferred crystallization sequence of CAI melts [11]. (iii) Isotopic exchange during disequilibrium melting [12,13] may avoid these problems, but has yet to be reproduced experimentally. If O-isotopic heterogeneity of CV CAIs resulted from gas-melt isotopic exchange in the solar nebula, rapid fluctuations of O-isotopic compositions of the nebular gas (from 18O-rich to 18O-poor to 18O-rich again) are required [12,14]. In order to understand the role of melting and asteroidal processing in O-isotopic exchange, we measured O-isotopic compositions of six coarse-grained, igneous, anorthite-rich (Type C) CAIs (100, 160, 6-1-72, ABC, TS26, and 93) from Allende previously characterized by [15-18].

**Results:** CAIs ABC and TS26 contain relic chondrule fragments composed of forsteritic olivine and low-Ca pyroxene; CAI 93 is overgrown by a coarse-grained igneous rim of pigeonite, augite, and anorthitic plagioclase. These three CAIs are similarly 18O-depleted (not shown in Fig. 1c), whereas grossular in 160 is 18O-enriched relative to melilite in Type B and C portions of ABC. Grossular in TS-26 is 18O-rich indicating that only diopside in ABC, TS26, and 93 experienced isotopic exchange during melting in the presence of 18O-poor nebular gas. Al,Ti-diopside in the Type B and C portions of 6-1-72 are also 18O-depleted relative to Al,Ti-diopside in 100 and 160, suggesting isotopic exchange during melting. Melilite in five CAIs is 18O-poor: in 100, 160, and 6-1-72, melilite is typically more 18O-depleted than anorthite. Grossular, monticellite, and forsterite replacing lacy melilit in 100 are similarly 18O-depleted (not shown in Fig. 1c), whereas grossular in 160 is 18O-enriched relative to melilite. Since the pseudomorphous replacement of lacy melilit by grossular, monticellite, and forsterite occurred during late-stage metamorphism [17,18,21,22], we infer that at least some of the O-isotopic exchange of melilit and anorthite in Type C CAIs continued after formation of grossular, probably during fluid-assisted thermal metamorphism. Similar processes may have affected melilit in the CO CAIs [23]. If correct, melilit and anorthite(?) grains in many CAIs from the least metamorphosed CV chondrites are expected to be 18O-enriched relative to typical 18O-depleted melilit grains from the Allende CAIs. The common presence of 18O-rich (Δ17O up to -25‰) melilit in Type A CAIs from the CV3.1 Kaba [24,25] suggests this conclusion.

Fig. 1. Oxygen isotopic compositions of the Allende Type C CAIs. CAIs TS26, ABC, and 93 were melted in the chondrule-forming region; CAIs 100 and 160 show no evidence for being affected by melting in this region; their fine-grained anorthite and lacy Al,Ti-diopside are $^{16}$O-enriched compared to coarse grained anorthite and Al,Ti-diopside in TS26, ABC, and 93. Both massive and lacy Al,Ti-diopside of a Type B and Type C portions of 6-1-72 are $^{16}$O-depleted relative to those in 100 and 160, possibly due to early melting. Melilite grains in all six CAIs are similarly $^{16}$O-depleted and may have experienced additional isotopic exchange during fluid-assisted thermal metamorphism. Points with black dots in “e” indicate compositions acquired at UH; other spots for this CAI are from CNRS/CRPG. an = anorthite; cpx = augite; Al,Ti-di = Al,Ti-diopside; grs = grossular; mel = melilaitie; $\delta^{18}$O = terrestrial fractionation line; CCAM = carbonaceous chondrite anhydrous mineral line.