OXYGEN AND MAGNESIUM ISOTOPIC COMPOSITIONS OF GROSSITE-BEARING INCLUSIONS IN DOM 08004 (CO3.1) AND DOM 08006 (CO3.0) CHONDRITES.

S. B. Simon[1], A. N. Krot[2*], and K. Nagashima[2]. [1]Department of the Geophysical Sciences, University of Chicago, Chicago, IL 60637, USA (sbs8@uchicago.edu). [2]HIGP/SOEST, University of Hawai'i at Mānoa, Honolulu, HI 96821, USA (*sasha@higp.hawaii.edu).

Introduction: Ca,Al-rich inclusions (CAIs) in the least metamorphosed chondrites show a bimodal distribution of the initial $^{26}Al/^{27}Al$ ratio [$(^{26}Al/^{27}Al)_0$] with peaks at ~0 and ~5×10^{-5} [1–5], most likely indicating heterogeneous distribution of ^{26}Al in the protoplanetary disk during an apparently brief epoch of CAI formation [2]. Most CAIs in these chondrites are uniformly ^{16}O-rich ($\Delta^{17}O$ ~ –24‰) suggesting formation in a gas of ~solar composition [3,4]. The important exceptions are isotopically anomalous ^{26}Al-poor CAIs with fractionation and unidentified nuclear effects (FUN) [5], ^{26}Al-poor platy hibonite crystals (PLACs) [6], and ^{26}Al-poor grossite-rich CAIs in CH chondrites showing a range of $\Delta^{17}O$, from ~ –35‰ to ~ –10‰ [7,8]. Grossite, $CaAl_4O_7$, is one of the most refractory minerals predicted to condense from a cooling gas of solar composition [9]. Grossite-bearing inclusions are a relatively rare type of CAIs in most chondrite groups, except CH chondrites, the only group where they have been extensively studied [10–13]. Here, we report on the mineralogy, petrography, O and Al-Mg isotope systematics of six grossite-bearing CAIs in DOM 08004 (CO3.1 [14]) measured *in situ* with the UH Cameca ims-1280. For analytical conditions during SIMS measurements see [12]. Isotopic compositions of grossite-bearing CAIs in DOM 08006 (CO3.0) will be reported at the meeting.

Mineralogy and Petrography: For details, see [14].

***DOM 08004*:** CAI *16-1* has a hibonite (in wt%: ~0.9 MgO, ~1.9 TiO_2) –grossite–perovskite core surrounded by the layers of spinel, melilite ($Åk_{1–18}$), Al-diopside (0.6–9.6 Al_2O_3, 0–1 TiO_2), and forsterite (Fig. 1a). CAI *26-1* consists of platy hibonite (~0.7 MgO, ~1.6 TiO_2) crystals surrounded by grossite (Fig. 1b). CAIs *44-2* (Fig, 2a), *75-1* and *77-1* consist of several mineralogically-zoned bodies composed of grossite and perovskite, and surrounded by layers of spinel and melilite ($Åk_{1–12}$). CAI *55-1* occurs inside a magnesian porphyritic olivine-pyroxene chondrule (Fig. 2b). Its core consists of grossite, melilite ($Åk_{3–11}$), and perovskite; it is surrounded by layers of spinel+perovskite and plagioclase (Fig. 1f). The spinel layer is corroded by plagioclase and overgrown by Cr-bearing spinel. Grossite in all CAIs experienced incipient replacement by a secondary Fe-rich phase ("sec" in Figs. 1, 2).

***DOM 08006*:** CAI *31-2* has a core composed of hibonite (~0.9 MgO, ~1.8 TiO_2), grossite, and perovskite; it is surrounded by the layers of melilite ($Åk_{2–44}$), Ti-free diopside (~0.2 Al_2O_3), forsterite (Fa_1) + FeNi-metal (oxidized to magnetite), and low-Ca pyroxene ($Fs_1Wo_{0.1}$) (Fig. 3a). CAI *56-1* has a corundum–hibonite (~0.6 MgO, ~1.1 TiO_2)–grossite core surrounded by the melilite ($Åk_{11}$) and Al-diopside rims. Corundum and hibonite are corroded by hibonite and grossite, respectively. CAI *99-1* is an aggregate of several concentrically-zoned objects having spinel–hibonite (~2 MgO, ~5 TiO_2)–perovskite or grossite cores which are surrounded by the layers of melilite ($Åk_2$) and spinel-melilite ($Åk_2$), respectively (Fig. 3c).

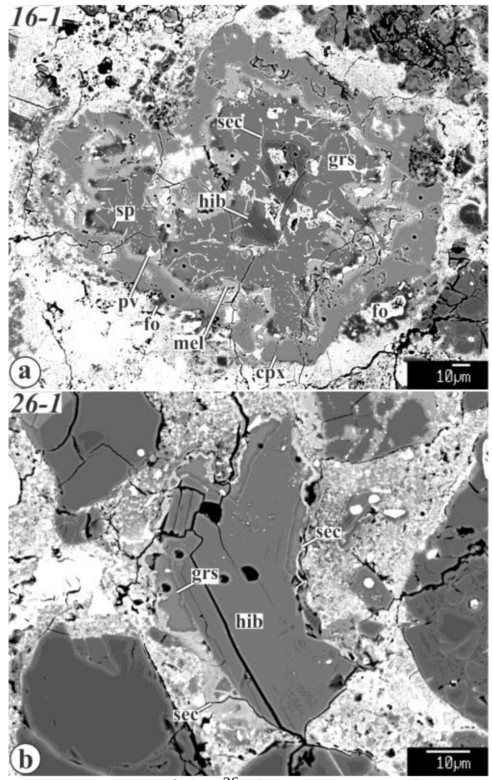

Fig. 1. BSE images of the ^{26}Al-poor grossite-bearing CAIs *16-1* and *26-1* from DOM 08004 (CO3.1). Hereafter: cor = corundum; cpx = high-Ca pyroxene; grs = grossite; hib = hibonite; mel = melilite; pv = perovskite; px = low-Ca pyroxene; sec = secondary phase; sp = spinel.

Diverse secondary minerals (magnetite, N-rich metal, Ni-bearing sulfides, Fe,Ni-carbides, phyllosilicates, and fayalite) are observed in matrices and chondrules of DOM 08004 and DOM 08006, suggesting that both meteorites experienced hydrothermal alteration [15].

Oxygen isotopes: On a three-isotope oxygen diagram ($\delta^{17}O$ *vs.* $\delta^{18}O$), compositions of the grossite-bearing CAIs in DOM 08004 plot along ~slope-1 line. In Fig. 4, we show $\Delta^{17}O$ values ($= \delta^{17}O - 0.52\times\delta^{18}O$) of individual minerals in these CAIs. All CAIs are isotopically heterogeneous, with grossite and, in most cases, melilite being ^{16}O-depleted relative to spinel, hibonite, and Al,Ti-diopside. Spinel in the relict CAI *51-1* shows a range of $\Delta^{17}O$ most likely refecting partial melting and overgrowth by Cr-bearing spinel during crystallization of the ^{16}O-poor host chondrule.

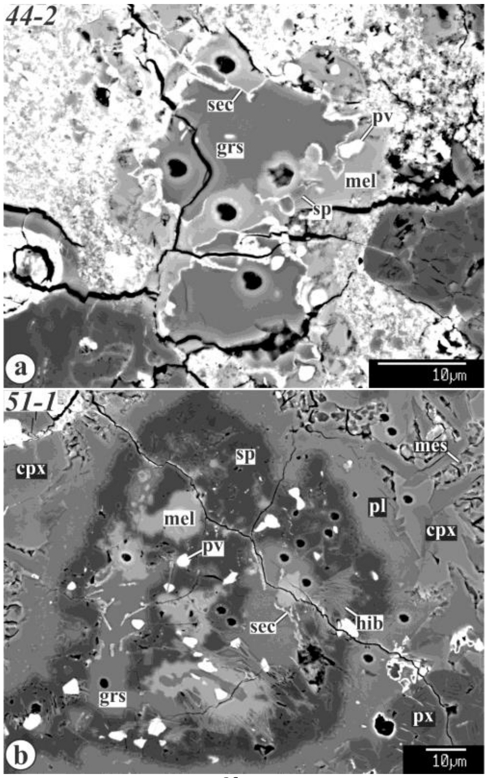

Fig. 2. BSE images of the ^{26}Al-rich grossite-bearing CAIs *44-2* and *51-1* from DOM 08004 (CO3.1).

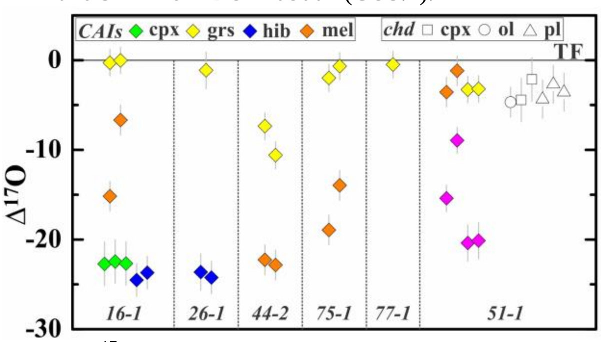

Fig. 4. Δ^{17}O values of the DOM 08004 grossite-bearing CAIs. TF = terrestrial fractionation line.

Magnesium isotopes: Hibonite and grossite in CAIs *16-1* and *26-1* show no resolvable excesses of ^{26}Mg*, $(^{26}Al/^{27}Al)_0 < 5.7\times10^{-7}$ and $<6.8\times10^{-7}$, respectively. Grossite in CAIs *44-2*, *51-1*, *75-1* and *77-1* shows large ^{26}Mg* excesses correlated with their Al/Mg ratios, corresponding to inferred $(^{26}Al/^{27}Al)_0$ of $(4.4\pm0.3)\times10^{-5}$, $(4.0\pm0.3)\times10^{-5}$, $(4.5\pm0.3)\times10^{-5}$ and $(4.3\pm0.3)\times10^{-5}$, respectively. The $(^{26}Al/^{27}Al)_0$ values systematically lower than the canonical ratio are probably due to use of an improper Al/Mg sensitivity factor for grossite, that was assumed to be the same as for hibonite [3].

Discussion: The ^{16}O-depleted compositions of grossite and melilite in DOM 08004 CAIs may have resulted from postcrystallization exchange during fluid-rock interaction on the CO chondrite parent body [15]. The alteration appears to not have affected the Al-Mg systematics of the CAIs. Therefore, the inferred $(^{26}Al/^{27}Al)_0$ likely reflect the heterogeneous distribution of ^{26}Al in the CAI-forming region. The ^{26}Al-poor CAIs could have formed prior to addition of ^{26}Al to the protoplanetary disk.

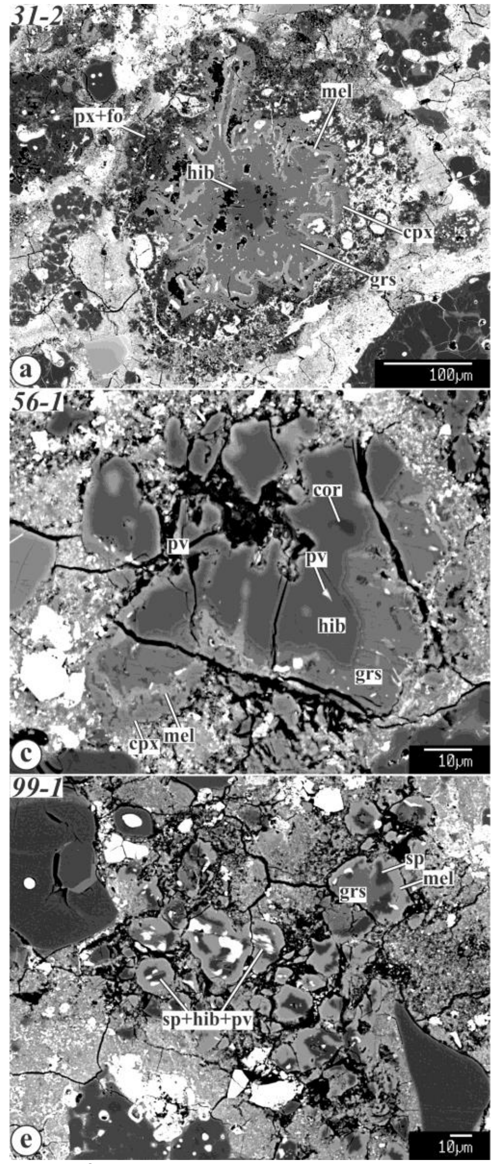

Fig. 3. BSE of the grossite-bearing CAIs *32-1*, *56-1*, and *99-1* from DOM 08006 (CO3.0).

References: [1] MacPherson G. et al. (2014) *LPS*, *45*, #2134. [2] Krot A. et al. (2012) *MAPS*, *47*, 1948–1979. [3] Makide K. et al. (2009) *GCA*, *73*, 5018–5051. [4] Kööp L et al. (2016) *GCA*, *184*, 151–172. [5] Krot A. et al. (2010) *ApJ*, *713*, 1159–1166. [6] Kööp L. et al. (2016) *GCA*, *189*, 70–95. [7] Krot A. et al. (2008) *ApJ*, *672*, 713–721. [8] Gounelle M. et al. (2009) *ApJ*, *698*, L18–L22. [9] Grossman L. (2010) *MAPS*, *45*, 7–20. [10] Kimura M. et al. (1993) *GCA*, *57*, 2329–2359. [11] Weber D. et al. (1995) *GCA*, *59*, 803–823 [12] Krot A. et al. (2017a) *GCA*, in press. [13] Krot A. et al. (2016) *LPS*, *47*, #1203. [14] Simon S. & Grossman L. (2015) *MAPS*, *50*, 1032–1049. [15] Krot A. et al. (2017) *LPS*, *48*, this issue.