

MINERALOGY, PETROLOGY, AND OXYGEN-ISOTOPE COMPOSITIONS OF AMOEBOID OLIVINE AGGREGATES FROM CH CHONDRITES. A. N. Krot and K. Nagashima. Hawai'i Institute for Geophysics and Planetology, University of Hawai'i at Manoa, Honolulu, HI, 96822, USA. sasha@higp.hawaii.edu

Introduction: Amoeboid olivine aggregates (AOAs) are refractory objects composed of Al,Ti-diopside, anorthite, spinel, Ca,Al-rich inclusions (CAIs), and forsterite condensates. The mineralogy, petrography, thermodynamic analysis, O- and Al-Mg isotope systematics of AOAs suggest they formed together with CAIs during the earliest stages of the Solar System evolution, and, therefore provide important constraints on the physico-chemical conditions and isotope heterogeneity in the solar nebula [1–3]. CAIs in most chondrite groups have ^{16}O -rich compositions ($\Delta^{17}\text{O} < -20\text{‰}$) and $(^{26}\text{Al}/^{27}\text{Al})_0$ of $(4\text{--}5)\times 10^{-5}$ [4]. In contrast, CH CAIs show a bimodal distribution of $(^{26}\text{Al}/^{27}\text{Al})_0$ and a large range of O-isotope compositions: about 80% of CH CAIs are very refractory (dominated by grossite, hibonite, gehlenitic melilite, perovskite, and Al-rich pyroxene), ^{16}O -rich ($\Delta^{17}\text{O} < -20\text{‰}$) and ^{26}Al -poor [$(^{26}\text{Al}/^{27}\text{Al})_0 < 10^{-6}$]; ~10% (typically less refractory) are similarly ^{16}O -rich, but have $(^{26}\text{Al}/^{27}\text{Al})_0$ of $(4\text{--}5)\times 10^{-5}$ [5–8]; ~10% are uniformly ^{16}O -depleted ($\Delta^{17}\text{O} \sim -10\text{‰}$) [9]. The nature of O- and Al-Mg isotope diversity of CH CAIs is not understood; it may reflect primary O and ^{26}Al heterogeneity in the solar nebula or late-stage resetting of their O and/or Al-Mg isotope systematics. To understand the nature of O-isotope and $^{26}\text{Al}/^{27}\text{Al}$ variations in CH refractory objects, we investigated the mineralogy, petrography, and O-isotope compositions of the CH AOAs (Figs. 1, 2).

Results: AOAs are less common in CH chondrites than CAIs; only 28 AOAs were identified in 10 polished sections mapped with a high spatial resolution ($\leq 5\text{ }\mu\text{m/pixel}$) in BSE and x-rays. The mineralogy and petrography of AOAs were characterized with the UH field emission JXA-8500F electron microprobe. ^{16}O , ^{17}O , and ^{18}O were measured *in situ* using the UH Cameca ims-1280 in multicollection mode (FC, EM, and EM, respectively) with $\sim 1\text{--}2\text{ }\mu\text{m}$ spot size (see [10]).

The CH AOAs are mineralogically pristine (show no evidence for alteration or thermal metamorphism) and composed of nearly pure forsterite ($\text{Fa}_{<3}$; $\text{CaO} = 0.1\text{--}0.8$, $\text{Cr}_2\text{O}_3 = 0.05\text{--}0.38$; $\text{MnO} < 0.46\text{ wt\%}$), anorthite, spinel, Al-diopside ($\text{Al}_2\text{O}_3 = 0.72\text{--}8.1$; $\text{TiO}_2 < 1\text{ wt\%}$), Fe,Ni-metal, and, occasionally, CAIs (Fig. 2). None of the CAIs within AOAs are very refractory; they consist of Al,Ti-diopside (Al_2O_3 up to 19.6; TiO_2 up to 13.9 wt%), spinel, melilite ($\text{Ak}_{13\text{--}44}$), and rare perovskite (Fig. 2a). Two AOAs contain low-Ca pyroxene ($\text{Fs}_1\text{Wo}_{2\text{--}3}$) replacing forsterite (Fig. 2b). Oxygen-isotope compositions of forsterite, anorthite and melilite in CH AOAs are shown in Fig. 1. The AOAs have isotopically uniform ^{16}O -rich compositions ($\Delta^{17}\text{O} = -23.5 \pm 2.2\text{‰}$) and on a three-isotope oxygen diagram

plot along ~slope-1 line. The only exception is the low-Ca pyroxene-bearing AOA #1-103 (Fig. 2b) showing a range of $\Delta^{17}\text{O}$ values (-24.3‰ to -15.2‰). None of the AOAs have ^{16}O -depleted compositions, like many CH CAIs [9], or very ^{16}O -rich compositions, like two grossite-rich CAIs from the CH chondrite Isheyevo [7, 8].

We infer CH AOAs originated together with CAIs in a ^{16}O -rich gaseous reservoir. Most AOAs have experienced thermal annealing in the solar nebula, but avoided extensive melting. Therefore, it seems likely that CH AOAs recorded distribution of ^{26}Al in the CAI-forming region during their formation, and, therefore, may provide a clue for the bimodal distribution of $(^{26}\text{Al}/^{27}\text{Al})_0$ among ^{16}O -rich CH CAIs. SIMS measurements of ^{26}Al - ^{26}Mg systematics of CH AOAs are in progress.

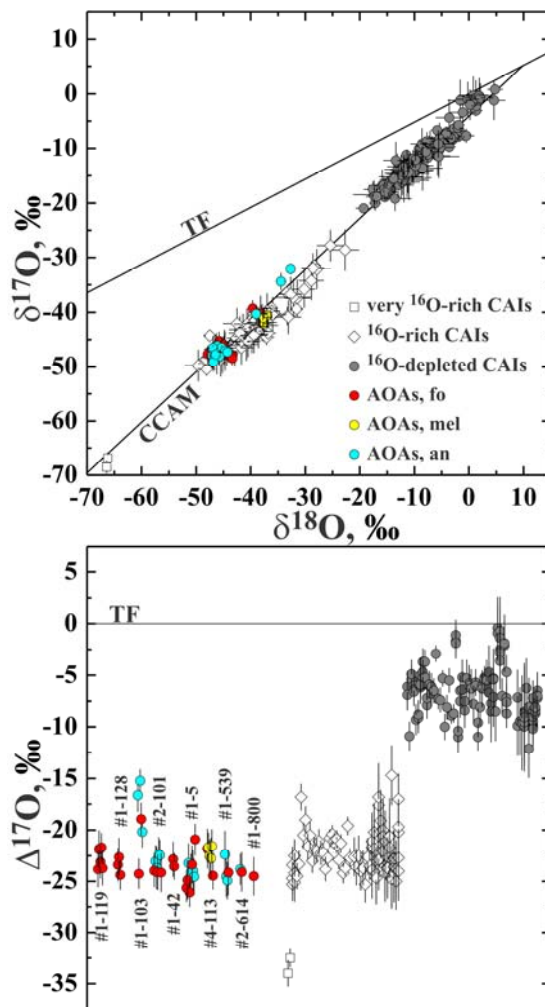


Fig. 1. Oxygen-isotope compositions of the CH CAIs [7–9] and AOAs. an = anorthite; fo = forsterite; mel = melilite.

References: [1] Krot et al. 2004. *Chem. Erde* 64:185. [2] Sugiura et al. 2009. *Meteorit. & Planet. Sci.* 44:559. [3] Weisberg et al. 2007. *Lunar Planet. Sci.* 38:#1588. [4] Krot et al. 2009. *Geochim. Cosmochim. Acta* 73:4963–4998. [5] Kimura et al. 1993. *Geochim. Cosmochim. Acta* 57:2329. [6] Weber et

al. 1995. *Geochim. Cosmochim. Acta* 59:803. [7] Krot et al. *Astrophys. J.* 672:713. [8] Gounelle et al. 2009. *Astrophys. J.* 698:L18. [9] Krot et al. 2012. *Geochim. Cosmochim. Acta* 83:159. [10] Krot et al. 2013. *Geochim. Cosmochim. Acta*, in press.

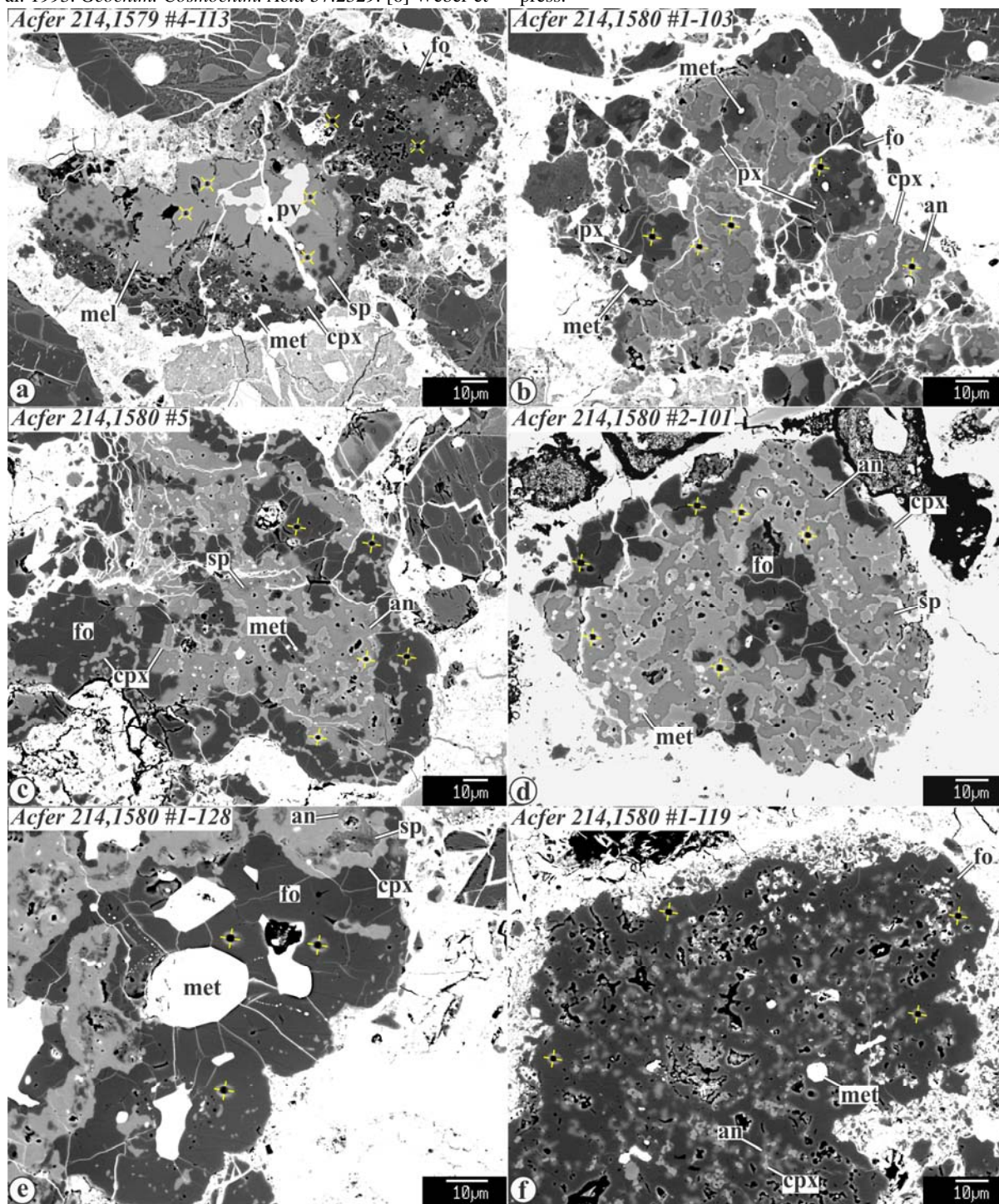


Fig. 2. BSE images of AOAs from the CH chondrite Acfer 214. The AOAs show large variations in modal abundances of the major minerals – forsterite (fo), anorthite (an), Al,Ti-diopside (cpx). Fe,Ni-metal (met) is generally minor and occurs as inclusions in forsterite. AOA #1-103 (b) contains low-Ca pyroxene (px) replacing forsterite. AOA #4-113 (a) contains melilite-rich compact Type A CAIs composed of melilite (mel), spinel (sp), and perovskite (pv), and rimmed by Al,Ti-diopside. Most AOAs have compact textures and appear to have experienced prolonged high-temperature annealing and possibly melting to a low degree. SIMS spots are indicated by yellow lines.