MAGNESIUM ISOTOPIC COMPOSITIONS OF IGNEOUS CAIS IN THE CR CARBONACEOUS CHONDRITES: EVIDENCE FOR AN EARLY AND LATE-STAGE MELTING OF CAIS. I. D. Hutcheon[1], A. N. Krot[2], K. Marhas[3], and J. Goswami[4]. [1]Lawrence Livermore National Laboratory L-231, Livermore, CA 94551, USA (hutcheon1@llnl.gov), [2]Hawai'i Institute of Geophysics and Planetology, SOEST, University of Hawai'i at Manoa, Honolulu, HI 96822, USA (sasha@higp.hawaii.edu), [3]Max-Planck-Institute for Chemistry, Cosmochemistry Department, D-55020 Mainz, Germany (kkmarhas@mpch-mainz.mpg.de), [4]Physical Research Laboratory, Ahmedabad, India (goswami@prl.ernet.in).

Introduction: It has been recently shown that AOAs, non-igneous CAIs, and several igneous (compact Type A and Type B) CAIs in CR chondrites are uniformly enriched in ^{16}O (Fig. 1), suggesting that formation and melting of the CAIs occurred in an ^{16}O-rich gaseous reservoir [1]. In contrast, three igneous Type C CAIs in CR chondrites and a Type C in the CO3.0 chondrite Y-81020 are ^{16}O-depleted and have heterogeneous O-isotopic compositions with spinel enriched in ^{16}O relative to anorthite, melilite and diopside (Fig. 1) [1,2]. These observations have been interpreted as indicative of incomplete oxygen isotope exchange during CAI melting in an ^{16}O-poor gaseous reservoir. Based on mineralogy, petrology and O-isotopic compositions of Al-rich chondrules in CR chondrites, Krot et al. [3,4] concluded that these chondrules formed by melting of ^{16}O-rich Ca,Al-rich and ^{16}O-poor ferromagnesian precursors. The melting occurred in an ^{16}O-poor gaseous reservoir and resulted in varying degrees of oxygen isotope exchange in the Al-rich chondrules. Krot et al. [4] suggested that the ^{16}O-poor igneous CAIs in CR chondrites could have experienced oxygen isotope exchange during chondrule melting. If this is the case, Al-Mg isotope study of ^{16}O-poor igneous CAIs may provide key information on the possible time difference between the CAI and chondrule formation.

Analytical techniques: In order to test this hypothesis, Mg isotope compositions of the ^{16}O-poor and ^{16}O-rich CAIs in CR chondrites were measured using, the modified Cameca IMS-3f and Cameca IMS-4f ion microprobes at LLNL and PRL; the operating conditions and procedures described in [5,6]. The Mg isotope ratios were corrected for both instrumental and intrinsic fractionation assuming the standard ratios of $^{25}Mg/^{24}Mg = 0.12663$ and $^{26}Mg/^{24}Mg = 0.13932$. The corrected ratios $(^{26}Mg/^{24}Mg)_c$ were used to calculate $\delta^{26}Mg = [(^{26}Mg/^{24}Mg)_c/0.13932 - 1]\times1000$.

Results: Both ^{16}O-rich igneous CAIs in GRA95229, a compact Type A CAI #3 (Fig. 1a) and a spinel-pyroxene-anorthite CAI #22 (Fig. 1b), as well as seven non-igneous melilite-rich and grossite-rich CAIs in CR chondrites have canonical $(^{26}Al/^{27}Al)_0$ ratios of ~$(4 – 5)\times10^{-5}$. The only ^{16}O-poor igneous CAI analyzed so far, the Type C CAI, El Djouf 001 #10, has no detectable $^{26}Mg^*$: $(^{26}Al/^{27}Al)_0 < 5\times10^{-6}$. These observations suggest that the ^{16}O-rich igneous CAIs experienced melting close in time to the formation of non-igneous inclusions. In contrast, the ^{16}O-poor Type C CAIs were melted at least 2 Ma later. This conclusion is consistent with the low abundance or lack of $^{26}Mg^*$ in Al-rich chondrules in CR chondrites [7] and in Type C CAIs from CV chondrites [8].

References: [1] Aléon J. et al. (2002) *MAPS*, *37,* 1729-1755. [2] Itoh S. et al. (2004) *GCA, 68,* 183-194. [3] Krot et al. (2004) *LPS, XXXV*. [4] Krot A. and Keil K. (2002) *MAPS*, *37,* 91-111. [5] Hutcheon I. D. et al. (1987) *GCA, 51*, 3175. [6] Marhas K. et al. (2001) *MAPS, 36,* A121. [7] Wark D. A. (1987) *GCA, 51*, 221-242. [8] Hutcheon I. D. et al. (2004) *GCA, in prep.*

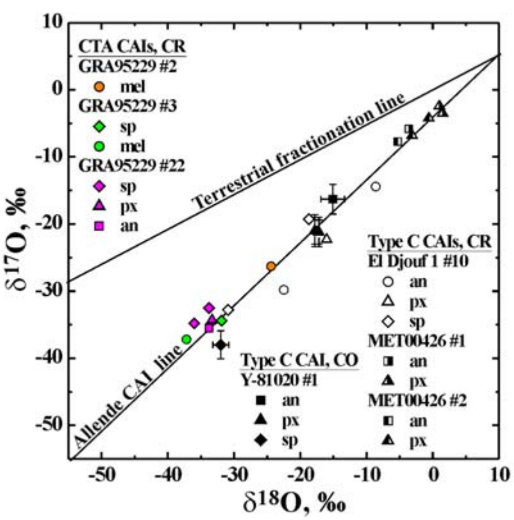
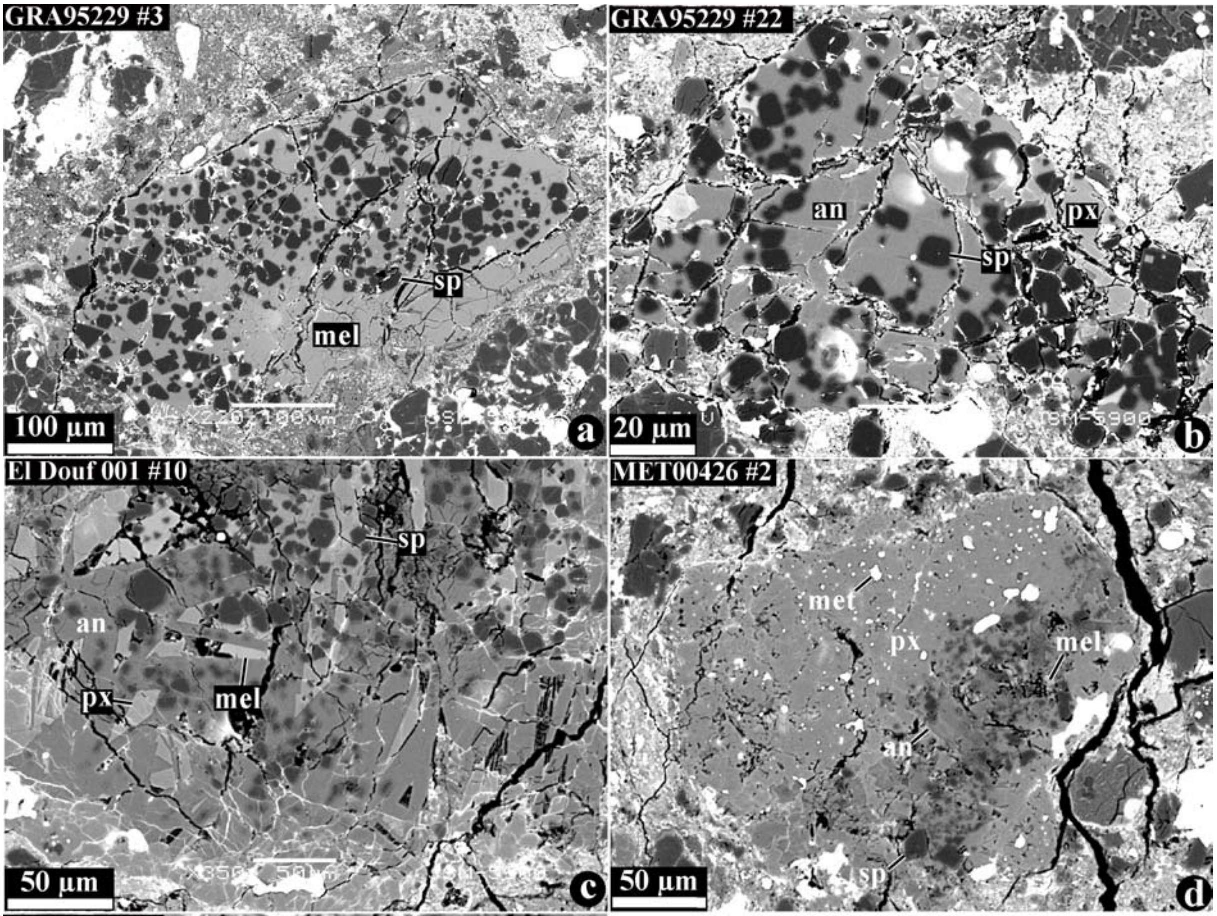


Fig. 1. Oxygen isotopic compositions of igneous CAIs in CR chondrites. Three igneous (compact Type A and Type B) CAIs are uniformly ^{16}O-enriched to a level found in non-igneous CAIs and AOAs in CR chondrites, suggesting formation in an ^{16}O-rich gaseous reservoir. Three igneous, Type C CAIs in CR chondrites and a Type C in Y-81020 (CO3.0) are ^{16}O-depleted and isotopically heterogeneous; spinel grains are ^{16}O-enriched compared to anorthite and diopside. This suggests that these Type C CAIs experienced oxygen isotope exchange in an ^{16}O-poor gaseous reservoir, possibly chondrule-forming region.



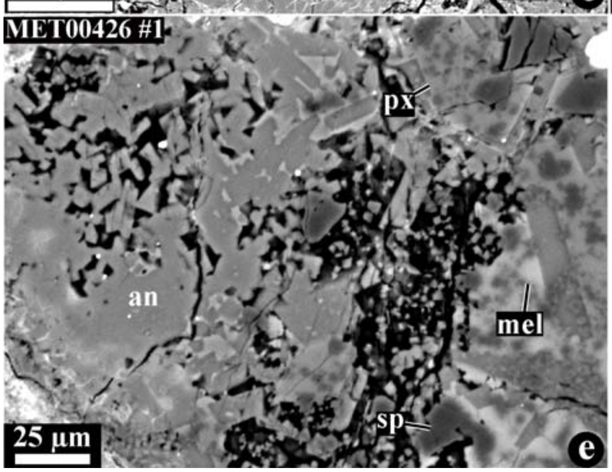


Fig. 2. BSE images of igneous CAIs in the CR carbonaceous chondrites GRA95229 (a,b), El Djouf 001 (c), and MET00426 (d,e). a - Compact Type A CAI fragment composed of euhedral spinel grains surrounded by melilite. b - Spinel-pyroxene-anorthite Type B (?) CAI. c-e - Type C CAI fragments composed of lath-shaped anorthite, Al-diopside and akermanite-rich melilite; all minerals poikilitically enclose euhedral spinel grains. Pyroxene in the MET00426 #2 contains abundant inclusions of Fe,Ni-metal. Oxygen isotopic compositions of these CAIs are plotted in Fig. 1. an = anorthite; mel = melilite; met = Fe,Ni-metal; px = Al-diopside; sp = spinel.