RESETTING AND DISTURBANCE TO THE Al-Mg SYSTEM IN ALLENDE TYPE B CAIs. B. Jacobsen[1], G. J. Wasserburg[2], K. D. McKeegan[3], I. D. Hutcheon[1], A. N. Krot[4], Q.-Z. Yin[5], and J. E. Matzel[1], [1]Glenn Seaborg Institute, Lawrence Livermore National Laboratory, Livermore, CA 94551 (jacobsen5@llnl.gov), [2]Lunatic Asylum, Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125, [3] Earth and Space Sciences, University of California, Los Angeles, CA 90095, [4]School of Ocean and Earth Science and Technology, Hawai‘i Institute of Geophysics and Planetology, University of Hawai‘i at Manoa, Honolulu, HI 96822, [5]Department of Geology, University of California, Davis, One Shields Avenue, Davis CA 95616.

Introduction: Most Calcium-Aluminum-rich Inclusions (CAIs) – with exception of the FUN, PLACs, and very refractory (corundum-, grossite- and hibonite-rich) inclusions – show ^{26}Mg excesses (^{26}Mg*) in their primary minerals correlated with the respective ^{27}Al/^{24}Mg ratios, indicative of *in situ* decay of now-extinct ^{26}Al [e.g. 1, 2]. On an Al-Mg isotope evolution diagram, the data define an internal isochron with a slope corresponding to $(^{26}Al/^{27}Al)_0 \approx 5\times10^{-5}$ thought to represent the initial value of the early solar system [2−4]. The initial work on ^{26}Al-^{26}Mg systematics in CAIs was primarily done on mineral separates and bulk samples using thermal ionization mass-spectrometry (TIMS) [e.g., 1, 5]. Subsequent Al-Mg studies of CAIs by multi-collector inductively coupled plasma mass-spectrometry (MC-ICPMS) [e.g., 6-9] are in agreement with the TIMS data but have greater precision. In comparison, *in situ* studies of ^{26}Al-^{26}Mg systematics by secondary ion mass-spectrometry (SIMS) reveal that the excellent correlation between ^{26}Mg* and ^{27}Al/^{24}Mg in CAIs was not always observed on a sub-mineral scale [e.g., 10, 11] and most *in situ* work in phases with Al/Mg ratios >50 define a somewhat lower $(^{26}Al/^{27}Al)_0$ of 4.5×10^{-5} [2]. CAI data falling below or above the 5×10^{-5} line were consistently found to be correlated with petrographic evidence for remelting [10, 12] or with late-stage disturbance during mineralogical alteration or thermal metamorphism [e.g., 4, 11]. The extent to which this resetting and disturbance is due to open or closed system behavior and the spatial scale at which resetting occurred has never been fully explored. Here, we compare new *in situ* multi collector SIMS data for two Allende Type B CAIs – AJEF and Egg-3 – with published MC-ICPMS whole rock and mineral separates Al-Mg data [7, 9]. Combining bulk rock and mineral separate data with *in situ* MC-SIMS results allows us to evaluate the extent and spatial scale of disturbance to the Al-Mg system.

Samples: AJEF is a large Type B1 CAI consisting of coarse-grained, melilite, anorthite, Al,Ti-pyroxene (fassaite) and fine-grained spinel. The inclusion has the highest reported excess of ^{36}S* (inferred $^{36}Cl/^{35}Cl \sim 2\times10^{-5}$) observed in the secondary mineral, wadalite [13]. The ^{26}Al-^{26}Mg systematics of bulk fragments and mineral separates were measured by MC-ICPMS by [7].

Egg-3 is a ~1.5 cm in diameter, Type B1 CAI composed of coarse-grained melilite, anorthite, fassaite, and fine-grained spinel [14]. In addition to isotopic anomalies in Ca and Ti [15], Egg-3 shows mass fractionation effects in Mg isotopes of ~ 6‰⁄amu [9, 16]. The Al-Mg systematics have been investigated by TIMS, SIMS and MC-ICPMS [9−10, 16]. Anorthite data define an ^{26}Al-^{26}Mg isochron with $(^{26}Al/^{27}Al)_0 \sim 4.9\times10^{-5}$ [10, 17]. Data for pyroxene and spinel measured by TIMS [16] show a range in δ^{26}Mg* of −0.9 to +0.8‰ and indicate an apparent deficit in $(^{26}Mg/^{24}Mg)_0$ of ~ −1‰. Recent efforts by Jacobsen et al. [17] and Wasserburg et al. [9] did not find any evidence for a deficiency in ^{26}Mg as large as reported by Esat et al. [16].

In both AJEF and Egg-3, secondary minerals (grossular, nepheline, sodalite, Na-bearing plagioclase, wadalite), replace melilite or occur in veins cross-cutting melilite and anorthite.

Methods: Mg-isotope compositions and ^{27}Al/^{24}Mg ratios were measured using the CAMECA ims-1270 at UCLA. Analyses were preformed in multi-collection mode with Faraday cups, simultaneously measuring secondary ion intensities on masses $^{27}Al^+$, $^{26}Mg^+$, $^{25}Mg^+$, and $^{24}Mg^+$. A mass resolving power of ~3000 was used to avoid isobaric interferences from hydrides and doubly charged ions. A $^{16}O^-$ primary beam of ~20 nA was focused to a size of ~20 μm. Terrestrial mineral and glass standards of melilite, pyroxene and spinel were measured between measurements on the CAI samples to determine the instrumental mass fractionation of the Mg isotopes and the relative sensitivity factor of ^{27}Al/^{24}Mg.

Results: Although showing greater scatter, the new MC-SIMS data for AJEF are in good agreement with previous MC-ICPMS results (Fig. 1). A regression through the SIMS data yields a ^{26}Al/^{27}Al slope of $(4.66 \pm0.10)\times10^{-5}$, within error of the slope obtained by MC-ICPMS data of $(4.96\pm0.24)\times10^{-5}$. In contrast, the MC-SIMS data for pyroxene, spinel and melilite in Egg-3 (Fig. 2), show considerable scatter compared to the MC-ICPMS data [9], indicating resetting and disturbance to the ^{26}Al-^{26}Mg system not recorded by the bulk measurements. Mg isotopes in spinel enclosed by pyroxene appear to be partially reset, as the δ^{26}Mg* is indistinguishable from the surrounding pyroxene despite higher Al/Mg (Fig. 3); e.g., a measured δ^{26}Mg of 0.5-0.6‰ compared to an expected value of 0.9‰. In contrast to TIMS data [4, 16], spinel always shows excess ^{26}Mg*; values of ~0 are absent.

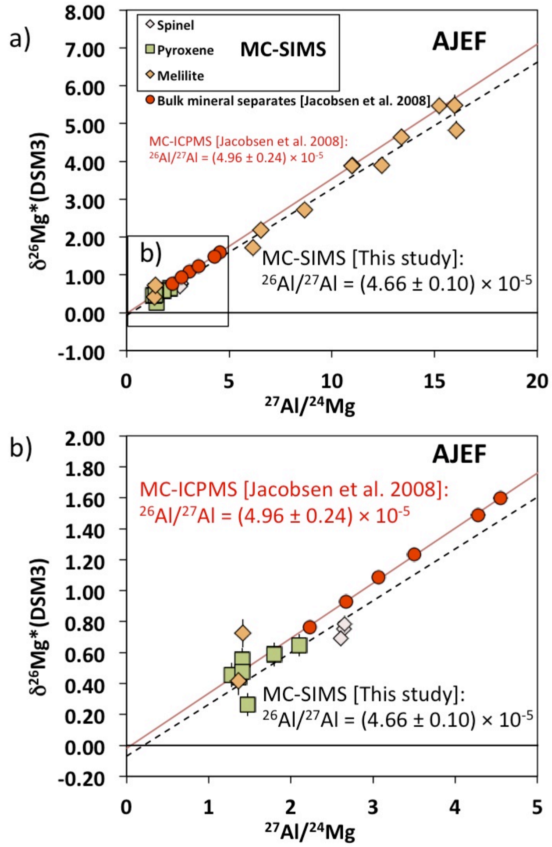

Fig. 1. MC-SIMS data obtained for pyroxene, spinel and melilite in Type B CAI AJEF from Allende. Also shown are bulk MC-ICPMS data from [7].

Conclusions: In agreement with MC-ICPMS data [9], we find no evidence of negative δ^{26}Mg in Egg-3 pyroxene or spinel and cannot confirm the initial δ^{26}Mg of −1.5‰ [4]. Egg-3 spinel has indentical δ^{26}Mg* to host pyroxene, in contrast to the large difference between spinel and host melilite reported by [4]. The apparent lack of disturbance in MC-ICPMS data for melilite separates (>1 mg) compared to MC-SIMS data suggests (1) localized disturbance of the Al-Mg system on a spatial scale >20 μm but <1 mm, (2) the isotopically disturbed part of individual melilites sampled revealed by MC-SIMS data must constitute a small fraction of the total Mg and (3) the "missing" ^{26}Mg* should be detected in SIMS analyses of melilite with high Al/Mg adjacent to plagioclase.

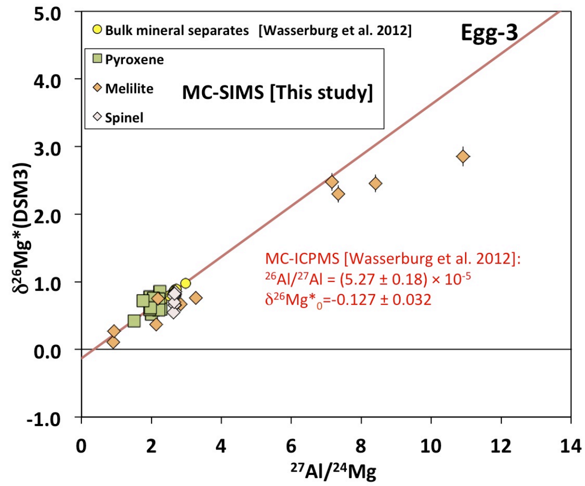

Fig. 2. MC-SIMS data for Egg-3 shown with density separate MC-ICPMS data from [9].

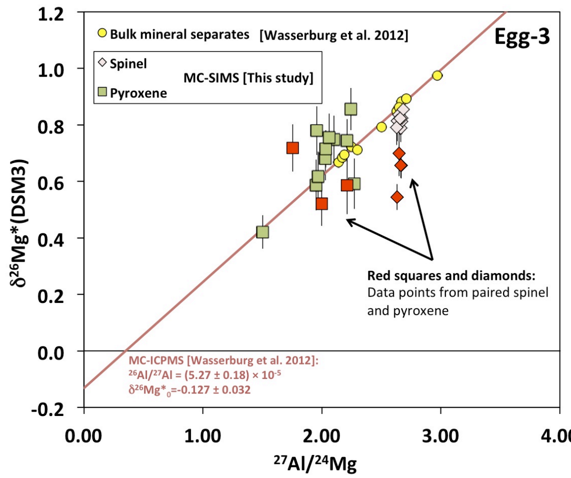

Fig. 3. MC-SIMS data for pyroxene and spinel in Egg-3.

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