HETEROGENEITY OF Mg ISOTOPES AND VARIABLE $^{26}Al/^{27}Al$ RATIO IN FUN CAIs.

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Introduction: CAIs with fractionation and unidentified nuclear effects (FUN CAIs) [1] are characterized by low initial $^{26}Al/^{27}Al$ ratios, large mass-dependent fractionation in Mg (F_{Mg}), Si, and O isotopes, and nucleosynthetic anomalies in several elements (e.g., Ca, Ti). Most Mg-isotope studies of FUN CAIs were performed more than 30 years ago with TIMS. Here we report high-precision Mg-isotope data of individual minerals from the *Axtell 2271*, *BG82DH8*, *EK1-4-1*, *C1*, *TE*, and *CG14* FUN CAIs measured with the UH Cameca ims-1280. We followed the procedure described in [2]. Measured Mg-isotope data were corrected for fractionation using terrestrial standards assuming that their isotopic compositions are the same as values of [3], and an exponential law with a coefficient $\beta = 0.514$ [4]. The overall conclusions of this study do not change with the choice of β.

Results and Discussion: In *Axtell 2271*, F_{Mg} in spinel and melilite is 15.1±1.7‰/amu (2σ), whereas F_{Mg} in hibonite is 4.0±1.6‰/amu. The diverse F_{Mg} may reflect crystallization sequence during melt evaporation or incomplete mixing with an isotopically-unfractionated gas during multistage thermal processing. The CAI minerals define an internal Al-Mg isochron with $(^{26}Al/^{27}Al)_0$ of $(2.9\pm1.7)\times10^{-6}$ and an intercept, $\delta^{26}Mg_0$, of 0.52±0.06‰.

In *BG82DH8*, F_{Mg} in olivine, spinel, Al,Ti-diopside, melilite, and hibonite are 27.3±2.1, 36.9±4.6, 33.4±1.7, 33.7±2.1, 39.6±2.5‰/amu, respectively. The internal ^{26}Al-^{26}Mg isochron defined by hibonite and minerals with low Al/Mg ratios has slope = $(3.8\pm1.5)\times10^{-6}$ and $\delta^{26}Mg_0$ of −0.27±0.04‰. Anorthite has high $^{27}Al/^{24}Mg$ (~8000) and no resolvable excess of $\delta^{26}Mg$, most likely due to metamorphic disturbance of the Al-Mg system.

In *EK1-4-1*, spinel and Al,Ti-diopside exhibit uniform F_{Mg} (22.8±2.3‰/amu) and deficits in $\delta^{26}Mg$ (−1.89±0.09‰). The upper limit of internal $(^{26}Al/^{27}Al)_0$ is $\sim3\times10^{-5}$.

In *C1*, spinel, Al,Ti-diopside, and melilite show uniform F_{Mg} (32.0±1.5‰/amu) and small deficits of $\delta^{26}Mg$ (−0.21±0.17‰). The internal isochron defined by the minerals with low Al/Mg ratios (this study) and anorthite [5] has $(^{26}Al/^{27}Al)_0$ of $(3.2\pm0.7)\times10^{-6}$.

In *TE*, F_{Mg} in olivine and Al,Ti-diopside are 13.0±0.6 and 16.1±0.6‰/amu, respectively. The inferred $(^{26}Al/^{27}Al)_0$, $(5.3\pm0.9)\times10^{-5}$, is consistent with the previously reported value from hibonite ($\sim4.7\times10^{-5}$) [6]. The $\delta^{26}Mg_0$ is −0.05±0.05‰.

In *CG14*, olivine and Al,Ti-diopside exhibit F_{Mg} of 18.6±2.7 and 24.5±0.3‰/amu and deficits of $\delta^{26}Mg$ of −0.44±0.08 and −0.28±0.05‰, respectively. The upper limit of internal $(^{26}Al/^{27}Al)_0$ is $\sim3\times10^{-5}$.

The observed variations of $\delta^{26}Mg_0$ (from ~ −2‰ in *EK1-4-1* to ~ +0.5‰ in *Axtell 2271*) in FUN CAIs indicate Mg-isotope heterogeneity in the early Solar System [7]. The wide variations in $(^{26}Al/^{27}Al)_0$ in FUN CAIs (from $<3\times10^{-6}$ to $\sim5\times10^{-5}$) [2, 8, this study] suggest that either the FUN CAI formation lasted over ~3 Myr or ^{26}Al was heterogeneously distributed in the solar nebula.

References: [1] Wasserburg et al. (1977) *GRL* 4:299 [2] Holst et al. (2013) *PNAS*:in press. [3] Catanzaro et al. (1966) *J. Res. NBS A* 70A:453. [4] Davis et al. (2005) *LPSC* 36:2334 [5] Esat et al. (1978) *GRL* 5:807. [6] El Goresy et al. (1991) *LPSC* 22:345. [7] Wasserburg et al. (2012) *MAPS* 47:1980. [8] Williams et al. (2012) *MAPS* 47:#5102.