VARIATIONS OF INITIAL ABUNDANCE OF ^{26}AL AMONG THE MICRON-SIZED ^{16}O-RICH, SOLAR CORUNDUM GRAINS FROM ORDINARY AND CARBONACEOUS CHONDRITES. K. Makide*, K. Nagashima, A. N. Krot, and G. R. Huss. Hawai'i Institute of Geophysics and Planetology, School of Ocean and Earth Science and Technology, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA. *makide@higp.hawaii.edu

Introduction: Corundum ($\alpha-Al_2O_3$) is predicted to be the first condensate from a cooling gas of solar composition [1]. As a result, O and Mg isotopic compositions of corundum condensates can potentially provide important constraints on the evolution of oxygen isotopes, as well as initial abundance and degree of heterogeneity of ^{26}Al in the early solar system. We have recently reported the results of high-precision O isotopic measurements, made with the UH Cameca ims-1280 ion microprobe, of ~60 individual µm-sized corundum grains in the acid-resistant residues from unequilibrated ordinary (UOCs) and unmetamorphosed carbonaceous chondrites (CCs) [2]. We showed that all corundum grains, except two of possibly presolar origin, are ^{16}O-rich (Δ^{17}O = −22.7±8.5‰, 2σ), and compositionally similar to the mineralogically pristine CAIs from the CR carbonaceous chondrites (−23.3±1.9‰, 2σ) [3], and solar wind returned by the Genesis spacecraft (−27±6‰, 2σ) [4]. We concluded that the ^{16}O-rich corundum grains in the acid-resistant residues from UOCs and unmetamorphosed CCs are gas-solid condensates that recorded initial O isotopic composition of the solar nebula, and, hence, of the Sun. The origin of ^{26}Al (external, stellar *vs.* local, irradiation), its initial abundance abundance (canonical *vs.* supracanonical (^{26}Al/^{27}Al)$_0$ ratio: $\sim5\times10^{-5}$ *vs.* $>5.85\times10^{-5}$), and degree of homogeneity in the early solar system remain controversial [e.g., 5−10]. Here we present ^{26}Al-^{26}Mg systematics of µm-sized corundum grains previously measured for oxygen isotopes.

Samples and Analytical Techniques: Mg isotopic compositions were measured with the UH Cameca ims-1280 ion microprobe in µm-sized corundum grains from acid-resistant residues of Semarkona (LL3.0), Bishunpur (LL3.1), Roosevelt County 075 (H3.2) and Alan Hills A77307 (CO3.0) prepared by [11, 12]. An ^{16}O$^-$ primary beam, either defocused (~30 µm) or focused (~3 µm), was used. A field aperture of 1000×1000 µm^2 corresponding to ~7 µm on the sample was used to minimize contribution of Mg signals from the substrate and any other grains surrounding the grain of interest. The contribution of this background Mg is estimated to be <1% of the sample Mg. The mass resolving power (MRP) was set to ~3500−3800, sufficient to separate interfering hydrides and ^{48}Ca^{++}. Secondary ions of ^{24}Mg$^+$, ^{25}Mg$^+$, ^{26}Mg$^+$ were measured simultaneously using a monocollector electron multiplier (EM) and two multicollector EMs; subsequently ^{27}Al$^+$ was measured with the monocollector EM by peak-jumping. The primary beam current was adjusted so that the ^{27}Al$^+$ count rate did not exceed 4.5×10^5 cps. Acquisition times for Mg isotopes and ^{27}Al were 15 s and 1 s, respectively. Each measurement consisted of 20 cycles. The typical reproducibility of standard measurements was ~10‰ (2σ) in Δ^{25}Mg and Δ^{26}Mg. Instrumental mass fractionation was corrected using a polished Yogo sapphire standard. Excess ^{26}Mg (δ^{26}Mg*) was calculated using the following equation: $\delta^{26}Mg^* = \Delta^{26}Mg - 2\times\Delta^{25}Mg$, where Δ^{25}Mg and Δ^{26}Mg are standard delta values calculated from the measured ^{25}Mg/^{24}Mg and ^{26}Mg/^{24}Mg ratios, respectively. The relative sensitivity factor for Al and Mg in corundum was estimated from measurements of Yogo sapphire standard by SIMS and an electron microprobe (JEOL JXA-8500F FE-EPMA). Because of very low concentration of Mg in Yogo sapphire (~100 ppm), the sensitivity factor may not be accurate. We are currently working on measuring the Mg concentration in the standard using MC-ICPMS and LA-MC-ICPMS.

Results and Discussion: Mg isotopic compositions were measured in 28 ^{16}O-rich, solar corundum grains. The data are plotted in Figures 1 and 2. Seventeen out of 28 corundum grains (57%) show resolvable δ^{26}Mg*. Despite the small sizes of corundum grains, we were able to measure each grain several times (Fig. 1). Model isochrons calculated with the measured data and normal magnesium give (^{26}Al/^{27}Al)$_0$ values ranging from (3.8±0.5) to $(0.12\pm0.03)\times10^{-5}$. The highest (^{26}Al/^{27}Al)$_0$ is significantly lower than the canonical (^{26}Al/^{27}Al)$_0$. This might be due to use of incorrect sensitivity factor value. Thirteen out of 28 (43%) corundum grains show no resolvable δ^{26}Mg*. Two possible presolar grains [3] were also measured; one of them has resolvable δ^{26}Mg*.

These observations may reflect (*i*) condensation of solar corundum grains started prior to injection and homogenization of ^{26}Al in the protoplanetary disk (PPD); (*ii*) prolonged duration of condensation of corundum grains; (*iii*) partial-to-complete resetting of ^{26}Al-^{26}Mg system of corundum grains during mild thermal metamorphism on the chondrite parent asteroids, and (*iv*) local heterogeneity of ^{26}Al distribution in the early solar system.

(*i*) Formation of ^{26}Al-free/poor corundum grains, as well as some refractory inclusions (FUN CAIs (fractionation and unknown nuclear isotope anomalies), platy hibonite crystals (PLACs), and most hibonite- and grossite-rich CAIs in CH chondrites [e.g., 13−16]), prior to injection and homogenization of ^{26}Al in the PPD was postulated by [17]. The lack of differences in O isotopic composition between ^{26}Al-rich and ^{26}Al-free refractory inclusions and grains is a potential problem for (*i*), because injection of ^{26}Al by a supernovae or an AGB star is expected to modify O isotopic of the solar nebula [18]. In addition, the probability of late-stage injection of ^{26}Al into the PPD is very low [19, 20].

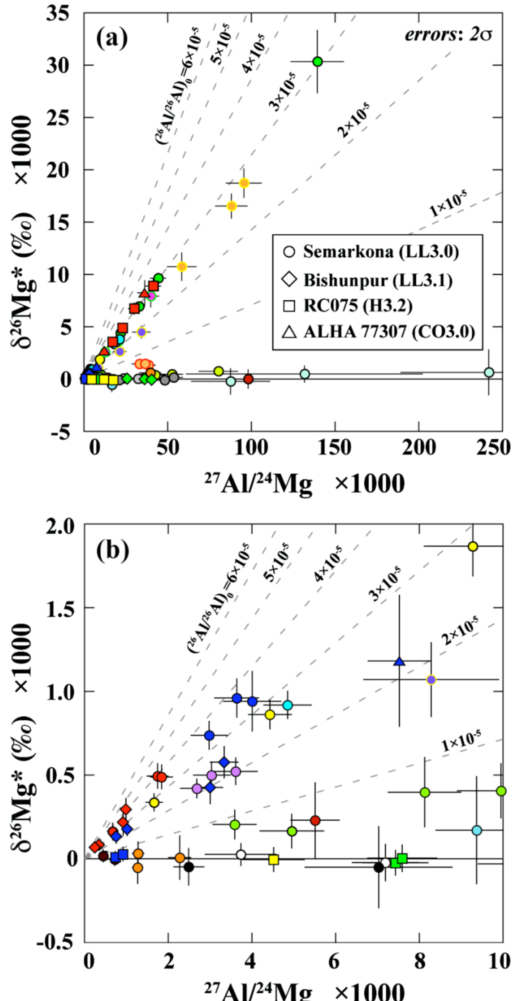

Fig. 1. Al-Mg evolution diagrams for ^{16}O-rich corundum grains [2] from Semarkona, Bishunpur, RC 075, and ALHA 77307. Symbols of the same color correspond to a single corundum grain measured several times. Region near origin in (a) is shown in detail in (b). Dashed lines corresponding different values of $(^{26}Al/^{27}Al)_0$ are shown for reference.

(*ii*) The prolonged duration of condensation of ^{16}O-rich corundum grains (> 6.8 Myr) appears to be inconsistent with the inferred brief formation interval for CAIs [8–10], the only known ^{16}O-rich solids formed in the early solar system. The hypotheses (*i*) and (*ii*) can be potentially tested by U-Pb isotope measurements of ^{26}Al-free and ^{26}Al-rich refractory inclusions.

(*iii*) Most µm-sized corundum grains analyzed in this study are from Semarkona (LL3.0), which experienced very low degree thermal metamorphism on the LL chondrite parent asteroid. Although the diffusion coefficient for Mg in corundum is not known, and thermal metamorphism cannot be excluded as an explanation for high abundance of ^{26}Al-free corundum grains, this explanation seems unlikely because ^{26}Al-poor ($(^{26}Al/^{27}Al)_0$ < 6×10^{-6}) corundum grains are also abundant in unmetamorphosed carbonaceous chondrite Murchison [15].

(*iv*) Heterogeneous distribution of ^{26}Al in the early solar system could be due to irradiation origin of ^{26}Al [21] or preferential destruction of ^{26}Al carrier in the inner solar system [22]. If this interpretation is correct, the significance of ^{26}Al-^{26}Mg systematics for dating of the earliest stages of evolution of the solar system may be limited.

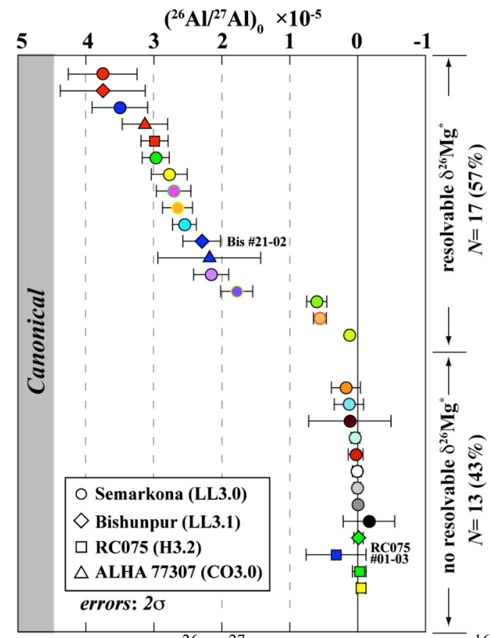

Fig. 2. Variations of $(^{26}Al/^{27}Al)_0$ among µm-sized ^{16}O-rich corundum grains. Color scheme is the same as in Figure 1. Bis #21-02 and RC075 #01-03 are corundum grains of possibly presolar origin.

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