MG ISOTOPE RATIOS AND MINOR ELEMENT ABUNDANCES OF AOAS: INSIGHTS INTO THEIR ORIGINS.

K. Fukuda[1], N. T. Kita[1], T. J. Tenner[2], and M. Kimura[3].
[1]Department of Geoscience, University of Wisconsin-Madison, Madison, WI 53706, USA (kfukuda2@wisc.edu), [2]Chemistry Division, Nuclear and Radiochemistry, Los Alamos National Laboratory, MSJ514 Los Alamos, NM 87545, USA. [3]National Institute of Polar Research, Tachikawa, 190-8518 Tokyo, Japan.

Introduction: Amoeboid olivine aggregates (AOAs) are irregularly shaped objects composed of olivine, Ca, Al-rich minerals, and FeNi metal. AOAs show variations in terms of their textures and minor element abundances, which are in some cases correlated with each other and suggest that they formed under various physicochemical conditions in the solar nebula [1]. Another important thing is that some AOAs have negative δ^{25}Mg values [2-5] relative to the Earth and bulk chondrites (δ^{25}Mg = –0.13‰ in DSM3 scale [6]). The light isotope enrichments imply that some AOAs condensed from the nebular gas [7]. Because AOAs appear to have escaped extensive melting after their genesis [e.g., 8 and reference therein], their formation processes would reflect specific physicochemical conditions in the solar nebula that AOAs had experienced. However, relationships between chemical, textural, and isotopic signatures of AOAs have not been systematically investigated extensively. In this study, we conducted SIMS minor element concentration analyses of AOAs with known O and Mg isotope ratios from our previous study [5], and discuss their origins.

Sample and methods: Eight AOAs, one from the Kaba (CV3.1) and seven from the DOM 08006 (CO3.01 [9]) chondrites, were analyzed. Olivines in these AOAs have no any ferroan rims. Oxygen and Mg isotope ratios of olivines in these AOAs have been determined by [5]. Eight AOAs studied here have variations in porosity and compactness. Three out of eight AOAs appear to be dense objects with little porosity (referred to as “compact” texture by [1]). The rest of the five AOAs have more irregular shapes and abundant porosity (“porous” texture by [1]). Minor element concentration analyses were performed with the Cameca IMS 1280 (WiscSIMS). Because of limited analysis areas on samples, we focused a primary O_2^- beam down to 1.3 µm in diameter (6 pA) that were placed inside the previous SIMS pits (5 µm in diameter) from Mg isotope analyses [5]. Secondary $^{23}Na^+$, $^{24}Mg^+$, $^{27}Al^+$, $^{28}Si^+$, $^{40}Ca^+$, $^{52}Cr^+$, $^{55}Mn^+$, $^{56}Fe^+$, and $^{60}Ni^+$ ions were detected by an axial EM with magnetic peak jumping mode. We re-evaluated previous Mg isotope analyses of the same AOAs [5] by applying a new SIMS bias correction method using Mg/Si ionization yields [10].

Results and Discussion: AOA olivines studied here show negative correlations between Ca and Cr, Mn abundances, such as Ca-rich olivines tend to show Cr, Mn-poor signatures. The trend is qualitatively explained by condensation and/or evaporation processes due to differences in their volatility [1]. In particular, porous AOAs are volatile rich and refractory poor (i.e., Ca-poor and Cr-rich) relative to compact AOAs. Similar textures and minor element systematics in AOA olivines have been indicated from a previous electron microprobe study [1], which were confirmed by the present SIMS analyses.

With the new bias correction method [10], Mg isotope ratios of the AOAs all show negative δ^{25}Mg values (–3.9 to –0.4‰ in DSM3 scale) that are systematically offset from those reported in [5]. Mg isotope ratios of porous AOAs show a larger variability and are positively correlated with Cr abundances. These results may be explained by slightly non-equilibrium condensation from the solar nebula at different temperatures (e.g., $P = 10^{-3}$ bars at T = ~1100-1400 K [7]). Mg isotope ratios of compact AOAs are near-chondritic and do not show a significant variation. Considering their textures, compact AOAs likely experienced reheating processes in the nebula. If so, less refractory Cr might be lost by volatilization during reheating, while Ca abundances in olivine might increase by diffusion from adjacent Ca, Al-rich halos and/or minerals [1].

Conclusions: The present results demonstrate that porous AOAs formed by non-equilibrium condensation from the nebula, but compact AOAs experienced reheating processes after their formation.

References: [1] Sugiura N. et al. (2009) *Meteoritics & Planetary Science* 44, 559-572. [2] Larsen K. K. et al. (2011) *The Astrophysical Journal* 735, L37 (7pp). [3] Olsen M. B. et al. (2011) *Meteoritics & Planetary Science* 46, 1688-1702. [4] MacPherson G. J. et al. (2012) *Earth and Planetary Science letters* 331-332, 43-54. [5] Fukuda K. et al. (2019) *LPS L*, Abstract #1989. [6] Teng F.-Z. et al. (2010) *Geochimica et Cosmochimica Acta* 74, 4150-4166. [7] Richter F. M. et al. (2004) *Geochimica et Cosmochimica Acta* 68, 4971-4992. [8] Krot A. N. et al. (2004) *Chemie der Erde* 64 185-239. [9] Tenner T. J. et al. (2018) *LPS XLIX*, Abstract #1510. [10] Fukuda K. et al. (2019) this meeting.