ALUMINUM-MAGNESIUM ISOTOPE SYSTEMATICS IN WARK-LOVERING RIMS.

A. W. Needham[1,2], S. Messenger[2], L. P. Keller[2], J. I. Simon[2], J. Han[2,3], R. K. Mishra[1,2], K. K. Marhas[2,3,4]. [1]Oak Ridge Associated Universities (andrew.w.needham@nasa.gov), [2]NASA-Johnson Space Center, [3]Lunar and Planetary Institute, [4]Physical Research Laboratory, Ahmedabad, India

Introduction: Wark-Lovering (WL) rims represent the final high temperature stage of formation of Ca-Al-rich inclusions (CAIs). The timing, location, and mode of formation of WL rims are not certain. However, O isotopic heterogeneity within some WL rims provides evidence that CAIs migrated between near-solar and planetary nebular regions [1-3]. It is of great interest to obtain coordinated O isotopic compositions and Al-Mg systematics of WL rims and their host CAIs to constrain the dynamics and nebular lifetimes of early solar system condensates. Here we report an Al-Mg isotopic imaging study of the fine grained minerals within the core, mantle and rim of a coarse-grained Type B CAI having heterogeneous O isotopic compositions.

Sample and methods: The CAI named Big Guy is a 1200 µm x 750 µm fragment of a large Type B1 inclusion from the reduced *CV3* Vigarano. It is composed of a grossmanite core and thick, zoned melilite mantle, partially surrounded by a WL rim. The WL rim sequence has a base layer of hibonite+spinel+perovskite, followed by layers of gehlenite, anorthite, zoned pyroxene, and lastly, forsterite. A partial accretionary rim contains fine-grained forsterite, minor metal and several micro-CAIs. Its petrography, major element chemistry, and O isotopic heterogeneity have been reported recently [4].

We obtained Mg isotopic images of major mineral phases in the CAI interior and of the WL rim with the JSC NanoSIMS 50L. Isotopic images of ^{24,25,26}Mg, ^{27}Al, ^{28}Si, ^{40}Ca and ^{56}Fe were acquired in multi-detection mode using seven electron multipliers. Images ranged in size from 3-15 µm. San Carlos olivine, Madagascar hibonite, a terrestrial spinel and two terrestrial melilites were analyzed to evaluate instrumental mass bias.

Results and discussion: The WL rim hibonite and melilite contain resolvable ^{26}Mg excesses that are consistent with canonical initial ^{26}Al/^{27}Al, within error. Anorthite reveals no evidence of excess ^{26}Mg even at ^{27}Al/^{24}Mg ratios >300. This is consistent with late formation of anorthite, after rim hibonite and melilite. Melilite in the mantle of the CAI also reveals resolvable ^{26}Mg excesses consistent with canonical initial ^{26}Al/^{27}Al. Stable Mg isotope results reveal no resolvable mass dependent fractionation of Mg in the WL rim relative to terrestrial standards, consistent with [5]. However, isotopically heavy ^{25,26}Mg was found in the grossmanite core and melilite mantle of the CAI.

Conclusion: The combined Mg and O [4] isotope analyses suggest a complex heating history of the CAI. This included formation/alteration of the core CAI via evaporation under conditions suitable for Mg isotope fractionation and interaction with a planetary-like O isotope reservoir. WL rim formation occurred at a later time in an environment with solar-like O isotopes and conditions which precluded significant Mg isotope fractionation.

References: [1] Yurimoto H. et al. (1998). *Science* 282, 1874 [2] Ito M. & Messenger S. (2008) *MAPS* 71, #5100 [3] Simon J. I. et al. (2011) *Science* 331, 1175 [4] Needham et al. (2015) *46th LPSC [5] Simon J. I. (2005) EPSL* 238, 272 – 283