TRACE ELEMENT ABUNDANCES IN WARK-LOVERING RIMS OF CAIs FROM A CV3 METEORITE: IMPLICATIONS FOR THEIR CHRONOLOGY.

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Introduction: The geochemical and isotopic signatures in calcium-aluminum-rich inclusions (CAIs) from primitive meteorites provide a record of early Solar System processes. The CAIs show characteristic layered rim sequences, termed as Wark-Lovering (WL) rims [1]. These rims, made of refractory minerals, record unique yet universal events in early Solar System history. Based on their textural and oxygen isotopic signatures two mechanisms have been proposed for their formation: flash heating (e.g., [2]) and condensation from the solar nebula (e.g., [3]). Recently, we attempted to date the WL rims with respect to the interior of the CAIs using the Al-Mg short-lived chronometer in two CAIs from NWA 8323, and found that the Al-Mg system was equilibrated in the WL rims ~2 My after the initial formation of the CAIs [4]. This equilibration event could either represent formation of the WL rims, or the timing of their secondary alteration. Here we present trace element analyses of these two CAIs and their WL rims to differentiate between these two scenarios.

Results and Discussions: NWA 8323 is an oxidized CV3 carbonaceous chondrite, with a low shock grade as well as low weathering grade. CAI-1 is a coarse-grained inclusion consisting of melilite, spinel, anorthite, and pyroxene. The WL rim sequence consists of olivine, spinel, and anorthite. CAI-2 is similarly a coarse-grained inclusion made up of spinel, anorthite, Ti-rich pyroxene, melilite and Fe-Ni metal. The WL rim sequence consists mainly of anorthite, spinel, and pyroxene. The total thickness of WL rims in each of these CAIs is ~50 μm, with monomineralic layers varying from 5 to 20 μm. Magnesium isotope analyses were conducted using a Cameca Ametek NanoSIMS 50L at ASU. Both the CAI interiors show canonical initial $^{26}Al/^{27}Al$ ratios and a time difference of ~2 My between the interior and the respective WL rim [4].

The characterization of the mineralogy of CAIs and their WL rim sequences was done using the JEOL JXA-8530F electron microprobe at ASU. Anorthites in these CAIs and their WL rims have Na levels below the detection limit, suggesting that this phase has not been significantly affected by secondary alteration. Trace lithophile, including rare earth element (REE), abundances were obtained using a CAMECA IMS 6f secondary ionization mass spectrometer (SIMS) at ASU, using an O^- primary beam with a 10 μm diameter analysis area. Individual phases (melilite, pyroxene and anorthite) were analyzed in the CAI interiors, and analyses were made along a traverse across WL rims in the two CAIs. Light REEs in the CAI interiors and WL rims show relatively flat patterns, indicating lack of LREE enrichment due to secondary alteration. Moreover, a plot of Ba/Sr *vs* Eu/Sr ratios shows no evidence for Sr loss due to alteration (as shown for some Allende CAIs [5]). As such, we suggest that the Al-Mg systematics in the WL rims record the timing of their original formation event.

References: [1] Wark D. A. & Lovering J. F. (1977) *LPSC IIX, 95-112*. [2] Wark D. A. & Boynton W. V. (2001) *MAPS, 36*, 1135-1166 [3] Simon J. I. et al. (2011) *Science 331*, 1175 1178. [4] Mane. P. et al. (2015) *LPSC XLVI*, #2898. [5] Davis A. M. et al. (1994) *LPSC XXV*, 315-316.