TWO-STAGE ASTEROIDAL ALTERATION OF THE ALLENDE DARK INCLUSIONS. A. N. Krot[1], C. M. Hohenberg[2], A. P. Meshik[2], O. V. Pravdivtseva[2], H. Hiyagon[3], M. I. Petaev[4], M. K. Weisberg[5], A. Meibom[6], and K. Keil[1]. [1]University of Hawaii, [2]Washington University, [3]University of Tokyo, [4]Harvard-Smithsonian Center for Astrophysics, [5]Kingsborough College, [6]Stanford University.

Introduction: The Allende dark inclusions (DIs) are lithic chondritic fragments having similar secondary alteration features to those of the Allende-like subgroup of the oxidized CV chondrites. In order to understand location, conditions and time of the alteration, we studied mineralogy, O-isotope compositions and I-Xe ages of the Allende DIs and CAIs.

Mineralogy and petrology: The Allende DIs 4301, IV-1, IV-2, 3b-1, and IVa consist exclusively of secondary minerals: ferrous olivine (Fa_{35-45}), salitic pyroxenes ($Fs_{10-30}Wo_{45-50}$), andradite, nepheline, sodalite, and FeNi-sulfides. Chondrules in the DIs are pseudomorphed by ferrous olivine and nepheline, and are rimmed by salitic pyroxenes; matrices are crosscut by pyroxene and sulfide veins. The DIs are surrounded by Ca-rich, Al-poor rims composed of diopside-hedenbergite pyroxenes, wollastonite, andradite, and kirschsteinite. These rims are mineralogically similar to those around altered CAIs in Allende. The outer portions of the DIs are depleted in Ca; abundant Ca-Fe-pyroxene-andradite-wollastonite nodules occur in the neighboring Allende matrix; the nodules are intergrown with the Allende matrix and DI rims.

Oxygen isotope data: Oxygen isotope compositions of andradite, wollastonite and Ca-Fe-pyroxenes in the DI rim and matrices analyzed by ion probe plot near TF-line (-3‰<Δ^{17}O<-1‰) and overlap with compositions of magnetite and fayalite in the oxidized CVs [1, 2].

I-Xe isotope data: I-Xe ages of the DIs are 1.0-1.8 ±0.2 Ma before the Shallowater reference standard. The I-Xe ages of three Allende CAIs are 3.0-3.7 ±0.2 Ma after Shallowater.

Discussion: The presence of chondrule pseudomorphs surrounded by interconnected Ca-Fe-pyroxene rims and the presence of Ca-Fe-pyroxene veins crosscutting matrices of the DIs suggest that the DIs experienced alteration after aggregation and lithification, but prior to incorporation into the Allende. This alteration, recorded by the I-Xe ages of the DIs, resulted in replacement of primary chondrule minerals by ferrous olivine, nepheline and sodalite; Ca lost from the chondrules was re-deposited as Ca-Fe-rich veins and Ca-Fe-pyroxene nodules in the DI matrices.

The second stage of alteration, recorded by the Na-rich phases in the Allende CAIs, occurred *in situ*, contemporaneously with the hydrothermal alteration of Allende, and resulted in dissolution of the DI Ca-Fe-rich phases and their re-deposition as Ca-rich rims around DIs and Ca-rich nodules in the neighboring Allende. This is consistent with the similar O-isotopic compositions of the Allende magnetite and Ca-rich rims around DIs. The difference in I-Xe ages of the Allende DIs and CAIs indicates that the second stage of alteration, did not reset the initial I-Xe ages of the DIs. Due to the lack of unaltered phases, no nepheline or sodalite formed in the DIs during this stage of alteration and they retained the initial I-Xe ages. Undisturbed I-Xe systematics of the DIs implies that the aqueous solution responsible for the alteration of the Allende CAIs should have been in equilibrium with the I and Xe bearing phases of the DIs.

References: [1] Choi B.-G. et al. (1997) *EPSL, 146*, 337; [2] Krot A. N. et al. (1998) *Meteorit. Planet. Sci., 33*, 623.