ANALYSIS OF DARK INCLUSIONS FROM ALLENDE. **P.C. Buchanan[1], M.E. Zolensky[2], S.J. Wentworth[3], and A.M. Reid[4]** [1]Geology Dept., Univ. of the Witwatersrand, Private Bag 3, Wits 2050, Johannesburg, South Africa. [2]SN2, NASA Johnson Space Center, Houston, TX 77058. [3]C23, Lockheed Martin, NASA Johnson Space Center, Houston, TX 77058. [4]Dept. of Geosciences, Univ. of Houston, Houston, TX 77204.

INTRODUCTION: Fruland et al. [1] described dark inclusions found in the meteorite Allende as "black to light gray lithic inclusions (xenoliths) that have been found to be different from the bulk meteorite, both petrographically and chemically." Similar dark inclusions have been described from other CV3 meteorites (e.g., Leoville and Vigarano; [2]). Most authors have concluded that these clasts are petrogenetically related to the meteorites in which they occur, even though textures can be strikingly different [1]. These inclusions apparently represent materials that have been affected by different processes from those that affected typical CV3 meteorites, or by the same processes either in a different sequence or to different degrees. This abstract reports and interprets new geochemical and mineralogical data for several of these clasts.

DESCRIPTIONS: Petrographic classification of the four types of Allende dark inclusions considered in this abstract was provided by Krot et al. [3]. Type C dark inclusions are composed of fine-grained, opaque material macroscopically similar to Allende matrix material. SEM/EDS analysis of this material indicates that it is predominately composed of fine-grained olivine with minor Fe/Ni metal and clinopyroxene. The Type C clast analyzed for this study contained no Na-, K-rich feldspathoid grains as have been reported in matrices of CV3 meteorites by other workers (see Krot et al. [3] for a recent discussion of matrix minerals in CV3 meteorites). Types A, A/B, and B dark inclusions make up a textural sequence of materials which apparently represents increasing amounts of aqueous alteration followed by thermal metamorphism [3,4,5,6]. Type A clasts contain chondrules, inclusions, and opaque, fine-grained matrix material and are similar in texture to CV3 meteorites, though average size of chondrules and inclusions generally is smaller than the average size of similar objects in Allende [1]. SEM/EDS analysis of matrix material in Type A clasts indicates that it is similar to material in Type C clasts being predominately composed of olivine, minor Fe/Ni metal, and clinopyroxene without Na-, K-rich feldspathoid grains. Type B clasts contain opaque matrix and olivine-rich aggregates, which Kojima and Tomeoka [5] interpret as chondrules and inclusions that have been altered to phyllosilicates by aqueous processes and, later, dehydrated by thermal metamorphism. Sizes of these olivine-rich aggregates range from those similar to chondrules and inclusions in Allende (e.g., clast All-AF [5]) to smaller sizes (e.g., clast 3a2) similar to those of chondrules and inclusions in Type A clasts. In contrast to Types A and C dark inclusions, grains of Na-, K-rich feldspathoids are abundant in matrix material and in olivine-rich aggregates in Type B clasts. In many cases, these feldspathoids enclose (Fig. 1) and thus postdate olivine grains [3]. Type A/B clasts apparently represent materials that have undergone intermediate amounts of aqueous alteration followed by thermal metamorphism [6]. In clast 5a2, chondrule- and inclusion-like objects have centers similar in texture to chondrules, but are surrounded by mantles of fine-grained material similar to that found in olivine-rich aggregates in Type B clasts.

Compositions of bulk samples of these four types of clasts were determined by INAA. These data, along with previously reported data for several clasts acquired by direct current plasma emission spectrometery [2], normalized to the composition of the Allende Reference Sample [7], are plotted in Fig. 2. Type C clasts show relative depletions in Na_2O, K_2O, and Br. Most other elements have abundances similar to those of bulk Allende, except for possible slight enrichments in Ba, Au, and As. Type A clasts are also depleted, relative to bulk Allende, in Na_2O, K_20, and Br, with enrichments in Au and As. The Type B clast has abundances of Na_2O, K_2O, and Br typical of bulk Allende with slight depletion in Se and Ca and significant enrichment in Au and As. Type A/B clasts show a range of depletions in Na_2O, K_2O, and Br and enrichments in Au and As. All Type A/B clasts display significant enrichments in Ba; unfortunately, comparable Ba data are not available for Type B clasts.

DISCUSSION AND CONCLUSIONS: The different textural types of Allende dark inclusions also show distinctive characteristics in bulk chemical composition. Type C clasts are composed of material that is mineralogically similar to the matrix of Type A clasts; bulk compositions of these two types of clasts also are similar. Types A, A/B, and B dark inclusions apparently have been affected by increasing amounts of aqueous alteration. Just as textures of Type A/B clasts are intermediate to those of Types A and B clasts, geochemical characteristics also are intermediate. Increased abundances of Na_2O, K_2O, Br, Ba, Au, and As correlate with increased effects of aqueous alteration followed by thermal metamorphism. In the case of Na_2O and K_2O, increased abundances correlate with increased proportions of fine-grained, secondary Na-, K-rich feldspathoid. The presence in the matrix of Allende of significant proportions of this feldspathoid and the similarity of Na_2O and K_2O abundances in bulk Allende and Type B dark inclusions support the suggestion of McSween [8] and Krot et al. [3] that alteration has played a significant role in the petrogenetic history of Allende.

REFERENCES: [1]Fruland R.M., et al. (1978) *Proc. 9th Lun. Planet. Sci. Conf.*, 1305-1329. [2]Johnson C.A., et al. (1990) *Geochim. Cosmochim. Acta* **54**, 819-830. [3]Krot A.N., et al. (1995) *Meteoritics* **30**, 748-775. [4]Zolensky M.E. and Buchanan P.C. (1995) *LPSC* **XXVI**, 1565-1566. [5]Kojima T. and Tomeoka K. (1994) *Meteoritics* **29**, 484. [6]Kojima T. and Tomeoka K. (1995) *Meteoritics* **30**, 529. [7]Jarosewich E., et al. (1987) Smithsonian Contrib. Earth Sci. 27, 49 p. [8]McSween H.Y. Jr. (1977) *Geochim. Cosmochim. Acta* **41**, 1777-1790.

ALLENDE DARK INCLUSIONS: Buchanan P.C. et al.

Figure 1. Back-scattered electron image of medium grey feldspathoid (f) enclosing light grey olivine (o) in the Type B dark inclusion 11b5 from Allende. Width of image is approximately 16.4 microns.

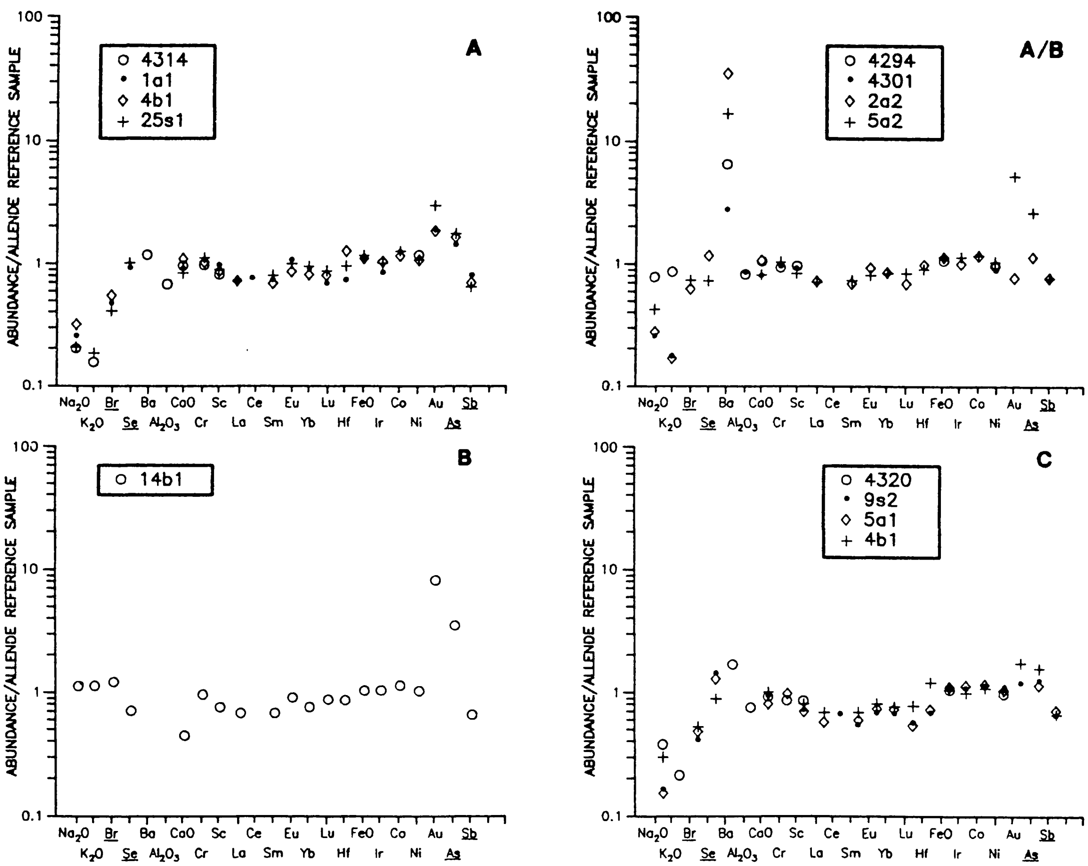

Figure 2. Compositions of bulk samples of Types A, A/B, B, and C dark inclusions from Allende normalized to composition of Allende Reference Sample [7]; underlined elements are normalized to abundances in bulk samples of Allende analyzed in the same run. Compositions of clasts 4314, 4294, 4301, and 4320 were determined by Johnson et al. [2] using direct current plasma emission spectrometry.