MOKOIA CA-AL INCLUSIONS (CAIs) WITH NEGATIVE AND POSITIVE CE ANOMALIES-INTERIM REPORT #2; Y.-G. Liu*, R.S. Rajan+, and R.A. Schmitt*, *Depts. of Chemistry and Geology and the Radiation Center, Oregon State University, Corvallis, OR 97331; +Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Mokoia is a CV3 chondrite which may be more primitive chemically and mineralogically than Allende as indicated by rare gas [1] and mineralogical [2-6] studies. Last year we reported the results on the basis of a combined min-pet-INAA-IMP study of 18 Mokoia inclusions (MI) [7].

Ten MIs (57-387μg) and two Mokoia matrix (MM) samples were analyzed this year with an improved INAA procedure using both a Ge(Li) and a 5 mm thick planar intrinsic Ge detector. Four MIs (CL7-1, CL9, CH2 and CH7), reported last year [7] and which indicated possible depletion of HREE characteristic of Allende Group II REE patterns, were reanalyzed with this procedure. Among these inclusions, the MI10 shows a REE pattern typical of Allende CAI Group II [8, 9] with a possible negative Ce anomaly, a steep HREE depletion and an apparent peak at Tm (Fig. 1). Ce/Ce* is 0.6 for MI10, which is slightly more depleted in Ce than is the Group II pattern reported [10] in the CV3 Efremovka E14 CAI. The negative Ce anomaly suggests that the MI10 inclusion formed under oxidizing conditions, under which Ce^{+3} was oxidized to more volatile CeO_2 and separated from the condensing trivalent REE oxides [10]. In Allende there are two reported CAIs which exhibit negative Ce anomalies, C1 [11] and HAL [12], both of which are "FUN"-CAIs.

A dome-shaped, lithophile diagram [9, 10] (Fig. 2) also suggests a CAI Group II pattern. The lines for Allende CAIs Groups I + V and Group II Ca-rich and Ca-poor are also shown [9]. The most refractory and least refractory elements are depleted, which is consistent with the hypothesis that the CAI Group II inclusions condensed from the nebula where the ultra-refractory component had been removed and the volatile components were not completely condensed yet.

On the other hand, compared with a typical Group II REE pattern, CL7-1 and CL9 CAIs may exhibit positive Ce anomalies, with a slight Eu depletion. Ce/Ce* ratios are equal to 1.7 and 1.5 for CL7-1 and CL9, respectively (Fig. 3). The only reported case with a positive Ce anomaly in a C3 chondritic specimen is an Allende olivine chondrule [13]. If the interpretation is correct that the Group II inclusions were the condensates of gaseous residues in which a large fraction of the most refractory elements had been depleted, and the negative Ce anomalies of Efremovka E14 and Mokoia MI10 are the result of oxidizing conditions, then the positive Ce anomaly could probably be attributed to scavenging complementary Ce either under lower temperatures and/or more reducing conditions at a later stage. Both trivalent Ce and Eu oxides have lower condensation Ts of 1532° and 1398°K, respectively, at 10^{-3} bars relative to Sm and La oxides of 1633° and 1621°K, respectively [9]. The positive Ce anomaly and lower Eu depletion are consistent with lower temperature condensation of their trivalent oxides. To achieve the observed lower La abundance relative to Sm, the condensation temperature at the first stage must have been between the 12-28°K interval for the Sm and La oxide condensation Ts at 10^{-9}-10^{-3} bars [9].

Because the chondrite normalized Ce values are at the same level as Sm within 2σ (1σ errors are shown), negative La anomalies <u>without</u> positive Ce anomalies cannot be ruled out as indicated by the

dashed and dotted lines for LREE. The lower Nd abundances with their large errors do not support such a proposition because the Nd abundances with 2σ errors would both fall below the extrapolated dashed and dotted lines. A negative La anomaly relative to normal Ce and Sm abundances presents interpretative difficulties because the condensation Ts of the trivalent Ce oxide lies far below the Sm and La Ts for pressures of 10^{-9}-10^{-3} bars. We assume normal Ce and Sm abundances demand a trivalent Ce under relative reducing conditions. An alternative distillation process would preferentially drive off Ce relative to La and Sm under both oxidizing and reducing conditions. Presently we favor the existence of positive Ce anomalies in CL7-1 and CL-9 [7].

CH2 has a Group II REE pattern without Eu and Ce anomalies (Fig. 4). CH7 is a chondrule which also shows the presence of a Group II REE component (Fig. 4).

The lithophile diagrams for CL7-1, CL9, CH2 and CH7 (Fig. 5) all show dome-shaped patterns, characteristic of Group II inclusions. Significant differences are apparent; e.g., CL7-1, CL9 and CH2 are Al and Ti rich while the CH7 chondrule is Ca and Al poor. For all of these Group II inclusions, including MI10, the Mg, Fe, Cr and Mn are far below the general loci.

References: [1] McSween (1977) G.C.A., 41, 1777-1790. [2] Peck (1983) L.P.S., XIV, 598-599. [3] Peck (1984) L.P.S., XV, 635-636. [4] Schmitt, et al. (1965), J.G.R., 70, 2419-2444. [5] Schmitt, et al. (1965), In Origin and Distribution of the Elements Perg., 273-282. [6] Cohen, et al. (1983) G.C.A., 47, 1739-1757. [7] Rajan, et al. (1985) Met., 20, 735-736. [8] Mason, et al. (1980) Smithsonian Contrib. to Earth Sci. No. 25, 30 pp. [9] Kornacki, et al. (1986) E.P.S.L. (in press). [10] Boynton (1978) L.P.S., IX, 120-122; Boynton, et al. (1986) L.P.S., XVII, 78-79. [11] Conard, R. (1976) M.S. Thesis, Oregon State University, 129 pp. [12] Tanaka, et al. (1979) L.P.S., X, 1203-1205. [13] Tanaka, et al. (1975) Nature 256, 27-28.

Fig. 1

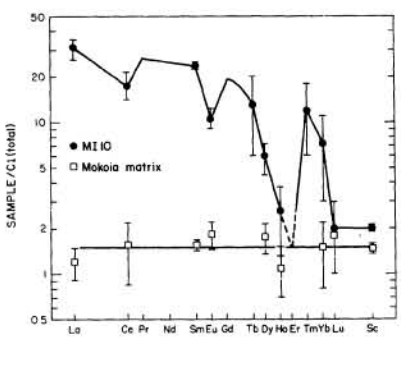

Fig. 2

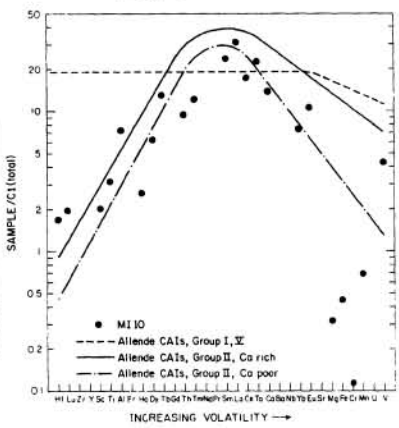

Fig. 3

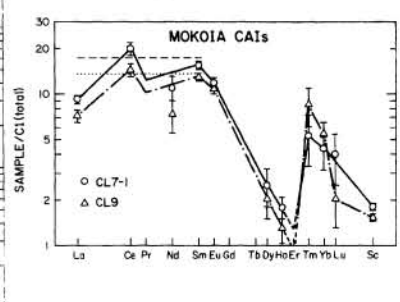

Fig. 4

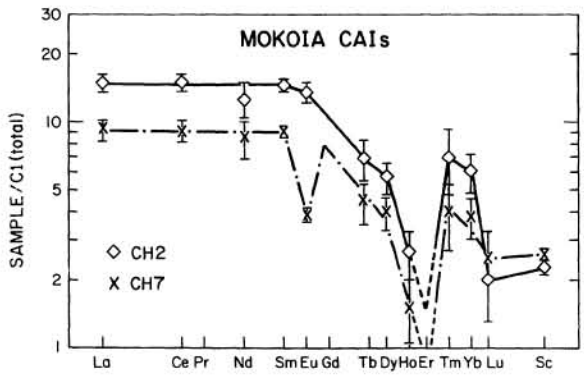

Fig.5