

SEARCH FOR CORRELATED ISOTOPIC EFFECTS IN ALLENDE CAIs: II.
 COMPARISON WITH MINERALOGICAL DATA: Prombo, C.A.¹, Hashimoto, A.^{2 3}, Birck, J.L.¹, Lugmair, G.W.¹ and Grossman, L.²
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We report isotopic data from additional F-series inclusions and the relative proportions of some key elements residing in secondary phases obtained by point counting for these and other previously reported F-series inclusions [1]. The relationship between $\delta^{30}\text{Si}$ and the proportion of Si residing in alteration phases was reported in [2]. Here we address the following points: 1) correlation of Si and Mg isotopic fractionations, 2) ^{48}Ca - ^{50}Ti correlations and 3) alteration effects on isotopic compositions. Primary minerals are Mel, Fas, Sp, Pv and Hib; secondary minerals are Gros, Ne and Sod. Petrographic criteria determined whether Ans are primary or secondary. Point counting analyses were not performed on the fine grained and ol bearing (type B3) CAIs and amoeboid olivine aggregates (aoa). Mass dependent isotopic fractionations, F, are reported as negative when denoting an enrichment of light isotopes.

Table 1 lists Mg isotopic fractionations, F(Mg), and although not discussed, $\epsilon(26/24)$ values. F(Mg) values for the F-series inclusions range from 0.9 to 10.9‰/amu [1]. With the exception of F-3, the F-series inclusions fall into two groups defined by the correlation of their F(Mg) and F(Si) [3] values: 1) the spinel-rich inclusions (SRIs), F-6 and F-8, and 2) all others. Excluding the SRIs, F(Mg) values correlate well with their respective F(Si) values ($r=0.93$). When the values of the SRIs are included the linear fit is poorer ($r=0.83$). F-6 and F-8 have negative F(Si) values, -1.1 and -1.4‰/amu respectively, and positive F(Mg) values. Although a Ca double spike was not employed to determine F(Ca), the F(Ca) of F-8, -3 ± 1 ‰/amu, is large enough to resolve without use of a double spike. It is not possible to determine F(Ca) for F-6 from our data. The fact that F(Mg) does not correlate with F(Si) and F(Ca) is unexplained but is possibly related to the SRIs' high Sp contents. Sp, a primary mineral, is the major Mg reservoir in these SRIs. SRI Pxs could be either primary or secondary. Since they are the major reservoir of Si and Ca in these SRIs, that interpretation determines whether most of their Si and Ca resides in primary or secondary phases. See Table 2. The origin of the light Si and Ca could be as a condensate of an evaporative distillate, a condensate from a previous condensation episode, or related to alteration processes with material transport.

In F-3, F(Si) is about 1‰ lighter (towards normal Si) than it would be if its F(Mg) and F(Si) values correlated as well as those of the other type B and A CAIs analyzed. During open system alteration Si enters the CAI [4,5]. F-3 has the lowest proportion of Gros relative to other alteration phases and also the highest proportions of Ne and Sod of the type B F-series CAIs, indicating that open system alteration had proceeded to a more advanced degree in F-3 than in the other type B CAIs analyzed. Therefore one possible interpretation of this departure from the F(Mg)-F(Si) correlation, is that lighter or normal Si entered the CAI during open system alteration, consistent with the model proposed for FTAs by [6].

Table 3 lists ^{48}Ca and ^{50}Ti effects. The ^{48}Ca effects for the F-series inclusions range from +8.5 ϵ units for the least altered CAI, F-2, to +1.9 ϵ unit for the fine grained F-9 [1]. There is a rough inverse correlation between ^{48}Ca effects and alteration. ^{48}Ca effects do not correlate with the proportion of Ca residing in primary phases (see Table 3), but correlate reason-

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ably with the Gros/secondary An ratio ($r=0.77$). This correlation improves if the exceptional inclusion F-8 is excluded ($r=0.84$). This correlation may be due to the fact that Mel (42% CaO) and Gros (37% CaO) contain similar amounts of Ca, whereas secondary An (20% CaO) only contains half as much. Secondary An may result from a greater degree of open system alteration than does Gros [4], however this correlation is surprising considering that it is unlikely that all CAIs had the same ^{48}Ca effects before alteration. The inverse correlation of ^{48}Ca effects and alteration suggests either that the Ca lost from the Mel is more anomalous than Ca residing in other primary minerals or that normal Ca entered the CAI or both.

^{50}Ti and ^{48}Ca effects in Allende CAIs are qualitatively, although not quantitatively correlated [7,1]. The lack of a quantitative correlation between these effects in C2M hibonites [8] suggests that this may be a primary feature in Allende CAIs. We find no correlation between ^{50}Ti effects and alteration or an inclusion's volatile element content. The lack of a quantitative ^{48}Ca - ^{50}Ti correlation in Allende CAIs could in part be due to the fact that ^{48}Ca effects seem to be affected by alteration whereas ^{50}Ti effects do not seem to be affected by alteration.

REFERENCES: [1] Prombo, C.A. and Lugmair, G.W. (1986) LPSXVII 685. [2] Hashimoto, A. and Grossman, L. (1985) Met. 4, 658. [3] Clayton, R.N. et al. (1984) Protostars and Protopl. 2, 755. [4] Wark, D.A. (1981) LPS XII, 1145. [5] Hashimoto, A. and Grossman, L. (1987) sub. [6] Molini-Velsko, C.A. (1983) Ph.D. Thesis. [7] Jungck, M.H.A. et al. (1984) GCA 48, 2651. [8] Zinner E.K. et al. (1986) Ap. J. 311, L103.

Table 1

Mg Isotopic Compositions of Allende CAIs

CAI	TYPE	#	$\epsilon(26/24)$	F(Mg)*
F2	B2	B	6.8±3.6	7.9±0.4
		I	11.1±2.0	8.5±0.2
F3	B2	I	12.6±2.3	5.6±1.7
		S	3.9±2.7	5.2±0.6
F6	sp-ri	B	4.5±0.9	1.7±0.6
F7	B2	S		4.9±0.6
F8	sp-ri	I		1.4±0.6
		S	5.6±1.6	2.3±0.6
F1	aoa	B		0.9±0.6
F5	aoa	B	3.8±5.4	1.4±0.3
F15	B3	O		1.5±0.6

Table 2

Elemental Proportions in Primary Phases [%]

CAI	Mg	Si	Ca	Ti
F2	96	65	71	95
F3	100	62	72	97
F6	100	60	68	100
F6†	78	3	17	4
F7	98	78	80	100
F8	100	68	83	100
F8†	80	1	2	14
F11	97	77	84	77
F12	99	79	88	100

† If pyroxenes are secondary.

I = HF-HNO₃ insoluble residue, S = HF-HNO₃ soluble,

B = bulk, O = primarily olivine

* [%/amu]

Table 3

CAI	$^{48}\text{Ca}/^{40}\text{Ca}$ ϵ units	$^{50}\text{Ti}/^{46}\text{Ti}$ ϵ units
F3	+5.5±1.4	+11.8±1.5
F6	+3.9±1.8	+13.0±1.8
F7	+4.1±0.9	
F8	+5.5±2.9	+13.4±1.8
F9	+1.9±0.9	+9.3±0.4
F5	+4.4±1.7	+13.8±2.0