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EXCESS ^{41}K IN ALLENDE CAI: A HINT RE-EXAMINED

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The timescale for injection of fresh nucleosynthetic material and for the formation of the first solids in the early solar system is determined by the existence and abundance of short-lived nuclei. The presence of live ^{26}Al with $^{26}Al/^{27}Al \sim 5 \times 10^{-5}$ in numerous CAI from C2 and C3 meteorites places an upper limit to this timescale of $\sim 8 \times 10^{6}$ y but the lower limit is poorly constrained. The short half-line of ^{41}Ca ($\tau = 0.19 \times 10^{6}$ y), which decays to ^{41}K, makes the abundance of ^{41}K a very sensitive indicator of the minimum time interval. Initial evidence for excess radiogenic ^{41}K(^{41}K*) was reported by HAW (1981) and HAW (1984), who found ^{41}K* in fassaite from Allende CAI at a level $^{41}K^{*}/^{40}Ca \sim 0.5\text{-}1 \times 10^{-7}$. The search for ^{41}K* is a difficult experiment because very high Ca/K ratios are required with K < 200 ppb. The resulting $^{41}K^{+}$ signal in fassaite is < 0.5 c/s with $^{41}K^{*+} \sim 0.1$ c/s. A major concern of HAW (1981) and HAW (1984) was the magnitude of molecular ion interferences in the region of ^{41}K, particularly $^{40}Ca^{42}Ca^{++}$, which is indistinguishable from $^{41}K^{+}$ at any available mass resolution. Both HAW (1981) and HAW (1984) evaluated the intensity of $^{40}Ca^{42}Ca^{++}$ by measuring the K isotopic composition of optical calcite containing < 50 ppb K. In the present study we have directly measured $^{40}Ca^{43}Ca^{++}$ in calcite and fassaite (typically ~ 0.06 c/s) and find that the yield of doubly-charged species is strongly matrix dependent; the intensity of $^{40}Ca^{42}Ca^{++}$ relative to $^{42}Ca^{+}$ in fassaite is ~ 10 times that in calcite. These new data indicate that in Allende fassaite $^{40}Ca^{42}Ca^{++}$ comprises up to 80% of the signal at mass 41 and that the ^{41}K excesses previously reported were overestimated by a factor of ~ 8 to 12. This report, therefore, supercedes our previous studies.

After correcting for $^{40}Ca^{42}Ca^{++}$ (using the measured $^{40}Ca^{43}Ca^{++}$ signal), fassaites from two Allende Type B1 CAI, Egg 3 and 3529Z, show excesses at mass 41 of up to 350%, which are linearly correlated with $^{40}Ca/^{39}K$ in each sample. The extent to which this correlation may be attributed to in situ decay of ^{41}Ca requires additional measurements and more careful characterization of contributions from possible interferences such as $^{26}Mg^{56}Fe^{++}$. Assuming the excesses are from ^{41}K*, the data define a line with slope $^{41}K^{*}/^{40}Ca = (8 \pm 3) \times 10^{-9}$ (2σ) and intercept $^{41}K/^{39}K = 0.072$. The present data clearly show that ^{41}Ca was not abundant when two Allende

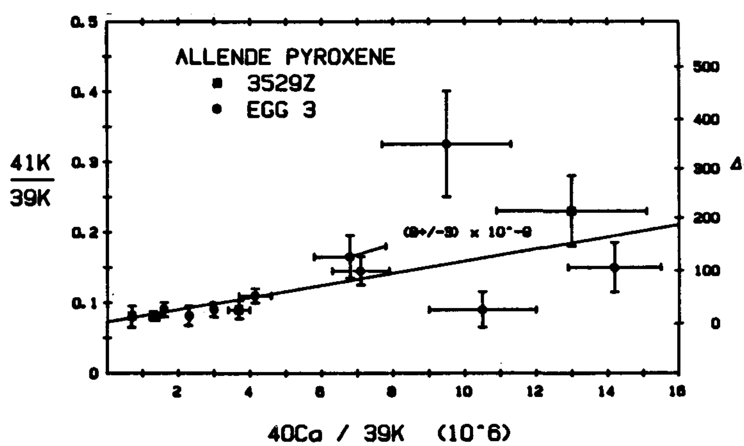

Fig. 1 **Ca-K evolution diagram for Allende fassaite.**

CAI formed and place a firm upper limit on the abundance of $^{41}K^*$, ⟨ 1 ppb. In contrast, $^{26}Mg^*$ is ; 5 ppm in these CAI. The near absence of $^{41}K^*$ requires either that $^{41}K^*$ was lost during CAI metamorphism or that the time interval between ^{41}Ca production and CAI formation was $\sim 2 \times 10^6$ y, an interval fully compatible with that inferred from ^{26}Al.

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Mg ISOTOPIC STUDIES OF LEOVILLE "COMPACT" TYPE A CAI

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One long-standing problem in the application of Al-Mg isotopic systematics to the chronology of CAI is the enigmatic Mg isotopic record of hibonite. Hibonite (ideally, $CaAl_{12}O_{19}$) is one of the first major element bearing phases to appear in the condensation sequence [1] and occurs as a major constituent only in CAI whose bulk composition is considerably more refractory than Allende Type B1 CAI. The Mg isotopic composition of hibonite, however, fails to reflect its presumed early origin with $^{26}Mg^*/^{27}Al$ ranging from $\sim 7 \times 10^{-5}$ to $< 2 \times 10^{-7}$ [2,3]. Hibonite is abundant in two "compact" Type A CAI (CTA) from Leoville and we have begun a petrographic and Mg isotopic study of coexisting phases to investigate the degree to which events of formation and metamorphism are reflected in the Mg isotopic record.

Leoville 575 (described in [4]) and 776 are both large elongated CTA's comprised predominantly of melilite (mel) (Åk ~ 3-30) enclosing abundant hibonite (hib) and spinel. Large (up to ~ 1 mm) mel laths in 575 are highly kink-banded and evidence of pervasive cataclastic deformation is extensive. Hib occurs as bladed and blocky crystals (up to ~ 100 μm) intimately intergrown with spinel. Minor polycrystalline plagioclase (plag) (up to ~ 20 μm) is also present. Mel in 776 occurs as smaller (50-300 μm) relatively strain free equant crystals with 120° triple grain boundaries. Hib is strongly pleochroic and occurs as clusters of 10-20 μm crystals often bounded by spinel. The general fabric appears to reflect metamoprphic recrystallization.

Both CAI have similar Mg isotopic patterns with hib containing much larger ^{26}Mg excesses (up to 75‰ in 575 and 16‰ in 776) than coexisting mel or plag. ^{26}Mg excesses in hib in both CAI are well correlated with $^{27}Al/^{24}Mg$ and all data lie along a correlation line with slope $^{26}Mg^*/^{27}Al = 5 \times 10^{-5}$, characteristic of Allende Type B1 CAI. Mel and plag in 575 also contain $^{26}Mg^*$ but these data fall well below the hib line and define a linear array with slope $^{26}Mg^*/^{27}Al = 3 \times 10^{-5}$. Mel in 776 contains no $^{26}Mg^*$ with $^{26}Mg^*/^{27}Al < 1.5 \times 10^{-5}$. The isotopic and petrologic data from these two CTA and a previously analyzed Allende CTA [2] suggest that CTA formed contemporaneously with Allende B1 CAI with uniform $^{26}Al/^{27}Al \sim 5 \times 10^{-5}$ in all phases. Subsequent metamorphism affected CTA to varying degrees and caused partial (in 575 and 3529-26 [2]) or complete (in 776) re-equilibration of the Al-Mg system. The petrologic evidence of greater recrystallization in 776 is consistent with the more extensive isotopic re-equilibration obscured in 776. Hib in CTA appears to be more resistant to element redistribution than either plag or mel.

	Leoville 575		**Leoville 776**	
	δ^{26}Mg(‰)	**^{27}Al/^{24}Mg**	**δ^{26}Mg(‰)**	**^{27}Al/^{24}Mg**
Hb1	25 ± 4	56 ± 1	6 ± 3	18 ± 1
2	41 ± 4	100 ± 2	10 ± 2	30 ± 2
3A	56 ± 5	143 ± 5	16 ± 3	42 ± 2
3B	75 ± 7	201 ± 6	—	—
Ml1	10 ± 4	36 ± 2	0 ± 2	12 ± 1
2	20 ± 3	57 ± 3	0 ± 2	15 ± 1
Pg1	34 ± 12	173 ± 10	—	—

[1] *GCA* **36**, 597 (1972).