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Nucleosynthetic Origin of 41K Excess in Soil Agglutinates

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NUCLEOSYNTHETIC ORIGIN OF ^{41}K EXCESS IN SOIL AGGLUTINATES, Donald D. Clayton, Dept. of Space Physics and Astronomy, Rice University, Houston, Texas 77001.

I argue that the highly fractionated state of the presolar nebula has led to an exotic isotopic fractionation process during formation of agglutinates in lunar soil. Church et al. (1) have found up to 2% enrichments of ^{41}K in the potassium within agglutinates, significantly augmenting previous studies. This difference is normally interpreted as a fractionation due to nuclear mass (2), but I wish to instead suggest that it reflects the preferential siting of ^{41}K in refractory Ca minerals within the micrometeorites whose bombardment is believed to have physically produced the agglutinates (3).

Clayton (4,5) pointed out that because ^{41}K is originally synthesized as ^{41}Ca in explosive oxygen burning, and since Ca condenses preferentially to K in the expansion of the supernova interior, the ^{41}K and ^{39}K should have been strongly fractionated from each other in the precondensed matter of the initial solar system. Supernova condensation of Ca accounts (5) for its great depletion from interstellar gas. The ^{41}Ca parent will have upon nucleosynthetic ejection resided almost exclusively in Ca-rich SUNOCONS, later to be diluted to about 1/3 of total ^{41}K by SUNOCON evaporation in stellar atmospheres and subsequent recondensation of Ca as STARDUST (6). Since K is rather volatile, a much smaller fraction of ^{39}K will reside in high-T minerals within the interstellar medium. I regard the early solar system as never having been hot enough to vaporize the refractory precondensed matter, so that primitive meteoritic accumulations will also be characterized as having about 1/3 of the ^{41}K trapped within high-T Ca condensates. Clayton (5) called for a physical study of meteorites to seek this microscopic fractionation, and I here suggest that such fractionation was routine in the micrometeorites that bombard the lunar surface.

Church et al. (1) presented convincing evidence for the correlation of ^{41}K excess to loss of volatiles. Their Fig. 3 shows that agglutinates have lower K/Ba ratios than do soils, and their Fig. 4 shows that Pb loss parallels K loss. My point is that the bulk of the K is more easily lost by impact volatilization than is the ^{41}K trapped in Ca-rich SUNOCONS. The $^{39}K/^{41}K$ ratio will vary inversely with the K/Ca ratio in agglutinates, as first predicted (4) for analogous meteoritic processes. This interpretation seems to fit the data of Church et al. (1) if up to 6% of agglutinate Ca was carried into it by micrometeorites (assuming that the lunar soil itself contains no target SUNOCON-derived minerals).

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The established approach to resolve these possiblities lies of course with a 3-isotope correlation plot. Mass fractionation will produce $^{41}\delta \simeq 2\,^{40}\delta$ relative to reference K. Clayton (5) described the ways in which nucleosynthetic K anomalies will show quite distinctive behavior. Unfortunately Church *et al.* (1) were unable to find any $^{40}K/^{41}K$ variations, a fact that, if it remains true at improved statistical significance, would offer little solace for supporters of either model.

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