THE NATURE AND TIMING OF REFRACTORY ELEMENT FRACTIONATION EVENTS IN THE EARLY SOLAR NEBULA

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Volatility-controlled elemental fractionation occurred in the pre-solar nebula at 4.56 Ga. The classic model [1] is equilibrium condensation of a hot solar-composition gas within a monotonically-cooling disk. Solid and melt evaporation contributed to further fractionation [2]. Evidence of these nebular processes is preserved in chondrules and calcium-aluminum-rich inclusions (CAIs; the first solid objects formed in the solar system) from chondrite meteorites.

^{26}Al ($t_{½}$~ 0.7 my) existed in the early solar nabula, and it can serve as a high-precision relative chronometer. Histograms of initial ^{26}Al/^{27}Al ratios derived from internal isochrons in CAIs are trimodal, with peaks at 5×10^{-5}, 4.2×10^{-5}, and 0. Including data from chondrules adds a fourth peak at $0.7\times10^{-5.}$ If CAI formation / reprocessing was a continuous process, no peaks would be expected. Discrete events must have occurred and, as CAIs formed very near the infant Sun [3, 4], events in the Sun itself likely were responsible. [5] proposed that major FU Orionis flare-ups in the Sun were the cause. Such flare-ups wax and wan very quickly (few years) at infrequent intervals and may be due to non-uniform accretion of disk material onto the protostar. The effects can be profound: a recent outburst in *V883 Ori* may have expanded its ice line (water/snow boundary) out to ~40 AU [6]. A presumed similar effect on the rock line leads to the possibility of *multiple condensation and re-condensation events in the earliest solar system,* greatly affecting how we view elemental fractionation. Fractional, dis-equilibrium condensation is the more realistic model.

Our new measurements of initial ^{26}Al/^{27}Al in fine-grained CAIs having Group II REE patterns (signatures of fractional condensation) indicate a major re-condensation event when ^{26}Al/^{27}Al=5×10^{-5}, requiring a prior event that conceivably formed those CAIs with little or no ^{26}Al.

References: [1] Grossman L (1972) *GCA* **36:** 597–619. [2] Davis A. M. and Richter F. M. (2014) *In Treatise on Geochemistry 2nd edition*, 361-395; [3] McKeegan K. D. et al. (2011) *Science* **332**, 1528. [4] McKeegan K. D. *et al.* (2000) Science **289**: 1334–1337. [5] MacPherson G. J. (2017) *48th LPSC, Abst. #2719;* [6] Cieza L. A. *et al.* (2016) *Nature* **535**, 258-261.