Early Solar System Chronometry using Presolar Grains

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Introduction: Knowledge of the chemical compositions, and abundances of presolar silicate grains have revealed complex conditions [e.g., 1, 2, 3, 4] in circumstellar environments, supernova ejecta and in the early solar system. [2] identified presolar grains in Adelaide that exhibit enhanced Fe contents, and Fe-rich rims. These features provide evidence towards thermal annealing of the meteorites' fine-grained matrix, an event that was argued to have occurred in the solar nebula, under high dust/gas ratios [2, 5]. We propose to investigate the time-scales during which the thermal annealing occurred.

Method: We did diffusion modeling for three presolar grains A5a-18o1, A4b-7o1 and A3c_6o1 from Adelaide. They have condensed in low-mass red giant or asymptotic giant branch stars and exhibit Fe-rich rims. The Fe concentration profiles derived from elemental maps were modeled using an analytical solution to the diffusion equation with a Monte Carlo approach, to find the temperature and time interval that produce the 'best' solution between the modeled and measured Fe concentration profile, in a temperature range 0-600°C and within 0-10 Ma time-scales.

Results and Discussion: The diffusion time-scales for the presolar grains lie in the range 86k-214k years in the 550-570°C temperature range. Mm- to cm-sized dust clumps form quickly in 10-100year timescales and can be iron-rich due to thermodynamic non-equilibrium locally in the solar nebula. Presolar grains encapsulated in the dust clumps were annealed for <200kyrs at 550-570°C temperatures. Such temperatures can exist <1.5 AU within the first Ma of Solar System evolution [6]. Large-scale movement of the dust clumps caused by the formation and migration of the giant planets may have resulted in their transportation to the asteroid forming regions, where mixing with organic-rich material occurred.

References: [1] Bose M. et al. (2010) ApJ, 714, 1624–1636. [2] Floss C. and Stadermann F. J. (2012) Meteorit. & Planet. Sci., 47, 992–1009. [3] Vollmer C. et al. (2007) ApJ, 666, L49–L52. [4] Haenecour P. et al. (2017) *GCA, 221,* 379–405. [5] Brearley A. (1991) LPSc Lunar & Planet. Sci. Conf., 22, p 133. [6] Desch S. et al. (2018) *ApJ*, in revision.