COOLING RATES OF L AND LL CHONDRITES: THERMOMETRIC STUDIES, DIFFUSION KINETIC MODELING AND IMPLICATION FOR FRAGMENTATION AND REASSEMBLY OF ASTEROIDS.

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Introduction: We have recently shown [1] that several H-5 and H-6 chondrites had experienced similar peak metamorphic temperatures (~820-850 ^oC), and subsequent rapid cooling (~25-100 ^oC/ky) followed by much slower cooling (~15 ^oC/My) below ~700 ^oC, and suggested that these disparate cooling rates imply break-up and reassembly of the parent Asteroid. Similar high-T thermal histories of H-chondrites were also suggested in a later study [2]. In this work, we extend the study of cooling rates to L- and LL-chondrites and, in conjunction with earlier studies for H-chondrites [1, 2] and mesosiderites [3], discuss their implications for the dynamic history of Asteroids.

Thermometric and Cooling Rate Studies: We have measured the compositional profiles of coexisting Cpx-Opx pairs in several L and LL chondrite samples of the metamorphic types 5 and 6. The profiles are found to be uniform beyond a few of microns from the interfaces in all cases. The peak temperatures of the samples were determined on the basis of Ca and Fe-Mg fractionations between the two pyroxenes. The average T(peak) for each sample falls in the range 835-875 ^oC, and shows no correlation with metamorphic grade, as was also noted in [1]. Numerical simulations of diffusive exchange of Fe and Mg between Cpx and Opx during cooling and comparison with the measured profiles, accounting for the spatial averaging effect in the microprobe analysis, show similar rapid high temperature cooling rate, ~10^2 ^oC/ky, as found for the H-chondrites [1]. The slow cooling rate of ~3 ^oC/My for one sample, St. Severin (L6), determined from thermochronological studies [4], is grossly incompatible with the nearly uniform compositional profiles of coexisting Cpx and Opx in this meteorite. Both data sets may, however, be satisfied by a two-step cooling model: ~200 ^oC/ky at T > 450 ^oC and ~3 ^oC/My at T < 450 ^oC.

Dynamic Histories of Asteroids: Likewise the H-chondrites, we interpret the rapid high temperature cooling rates of the L and LL chondrites to be a consequence of the break-up of their parent Asteroids and exposure of the samples to near surface environments. In all cases we have studied so far [1, 3, and this study], the low temperature cooling rates constrained by metallographic and/or thermochronological methods are orders of magnitude slower than the high-T cooling rates reflected in the compositional profiles of Opx-Opx/Cpx couples, with the transition taking place prior to 3500 Ga. It, thus, seems likely that break-up and reassembly of Asteroids might have been quite common in the early history of the solar system, and chondritic meteorites of different metamorphic types were not derived from their locations in the original parent bodies.

References: [1] Ganguly J. et al. 2013. *Geochim Cosmochim Acta* 105: 206-220. [2] Scott E. R. D. 2014. Abstract #2374. 45th Lunar & Planetary Science Conference. [3] Ganguly J. et al. 1994. *Geochim Cosmochim Acta* 58: 2711-2723. [4] Mink K. et al. *Geochim Cosmochim Acta* 100: 282-296