FE-MG DIFFUSION PROCESSES IN COMPOUND CHONDRULES IN THE NWA505 CHONDRITE. J. M. Sierchio, D. S. Lauretta, and J. Davidson, Lunar and Planetary Laboratory, The University of Arizona, Tucson AZ 85721 USA, jsierchi@email.arizona.edu

Introduction: The study of compound chondrules is essential to understand the conditions under which chondrules formed in the solar nebula [1]. Previous studies have shown that the most likely mechanism for compound chondrule formation is via collisions [2, 3]. Laboratory experiments performed by [3] found that compound chondrules are only formed via collisions.

One way to determine the formation environment is to study the diffusion timescales within compound chondrules [4]. NWA505 is an LL3.4 chondrite and contains abundant compound chondrules, making it ideal to determine collisional timescales.

Experiment and Modeling: A thin section (1.8 x 1.6 cm; partly shown in Fig. 1a) of NWA505 was analyzed using focused-beam electron microprobe analysis (EPMA) with the Cameca SX-50 microprobe at the University of Arizona. Eight compound chondrules within the thin section were analyzed; one in particular showed clear evidence of diffusion (Fig. 1b,c; Fig. 2).

Fick's diffusion law applies to the regions of the chondrules in question:

$$\frac{\partial c}{\partial t} = D\frac{\partial^2 c}{\partial x^2}$$

where C = Mg number, t = time elapsed, D = diffusion constant, and x = distance traversed. An explicit method for solving the equation numerically can be derived by using Taylor expansions and making a change of variables as shown in [5].

Using Matlab, the diffusion equation was solved by minimizing the total χ^2. Once the best solution was found, diffusion coefficients from [6, 7] were used to compute the total time elapsed for the diffusion to take place. In both cases, D is a function of temperature. We made two assumptions: (1) that the diffusion took place isothermally so that the diffusion coefficients do not evolve with time, and (2) that the diffusion coefficients do not depend on distance.

Results: The Mg#s for this compound chondrule vary with distance (Fig. 2); there are clearly three distinct regions (two chondrules and matrix). Diffusion occurred between the Fe-rich chondrules and matrix.

Gradients in chondrules 1 and 2 were fit with a solution to the diffusion equation (Fig. 3 and 4). Matrix is of variable mineralogy and the diffusion coefficients from [6, 7] are not applicable. The number of iterations needed to achieve the minimum χ^2 was 19 and 24 for the chondrules, respectively. The diffusion timescales range from a minimum of a few minutes to a maximum of ~20 days (Table 1).

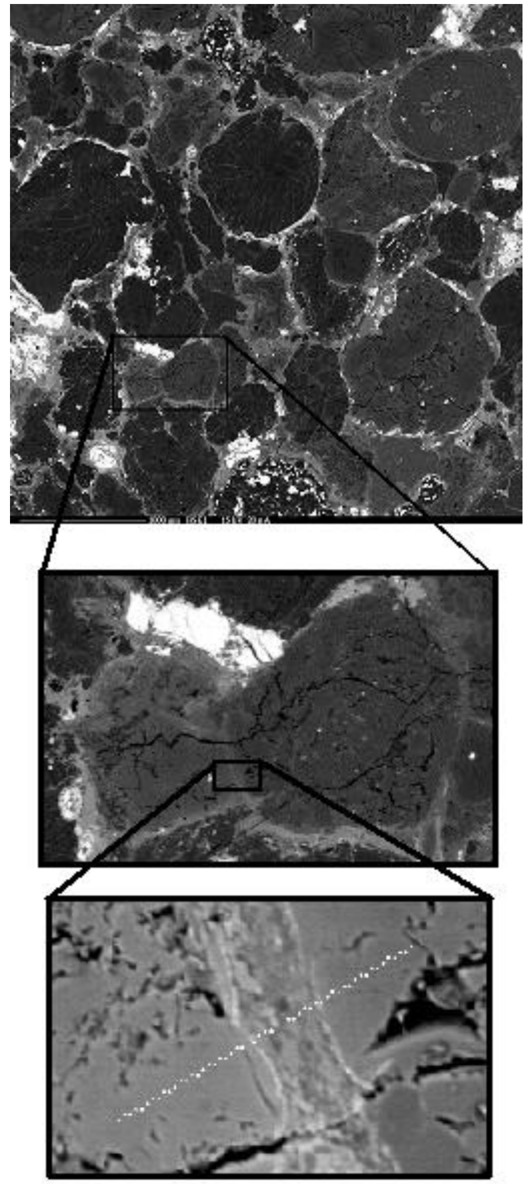

Figure 1: a) Portion of thin section of NWA 505, b) Zoom of compound chondrule studied, c) Zoom of traverse with matrix shown.

Discussion: The computed timescales are on of the same order for both chondrules. Thus, it is likely that they have the same thermal history. The timescales are short (a maximum of ~20 days), indicating that the chondrules could not have been at the center of an asteroid, where the diffusion could have taken place over thousands of years. Two possibilities remain: the compound chondrule (1) formed near the surface of the asteroid, or (2), as the result of hot accretion in the solar nebula. In (1), each pair of compound chondrules in the thin section would have a similar thermal history to the chondrules in question. In (2), the thermal histories of each pair would not necessarily be the same as it is possible that only this particular compound chondrule was accreted. The timescales from [6] suggest the former scenario is likely; those from [7] suggest the latter is likely.

Both Chondrules 1 and 2 have small perturbations approximately the same distance (14 vs. 12 μm) from their respective nearest matrix edge (see Fig. 2). To model the perturbations correctly, unphysical initial conditions were used. A likely explanation for this is that those measurements were taken near grain boundaries. However, the chondrules (Fig. 1b) show no evidence of grain boundaries at those distances. At least two of the other seven traverses show similar perturbations. More analysis is needed to determine the cause.

We plan to model non-isothermal diffusion for multiple compound chondrules from this sample and other chondrites with similar textures. This study will determine whether or not they have the same thermal history and constrain the accretion and alteration of the LL parent asteroid.

References: [1] Ciesla, F. J. et al. (2004) *MAPS*, 39, 531. [2] Gooding, J. L. and Keil, K. (1981) *MAPS*, *16*, 17. [3] Connolly Jr., H. C. et al. (1994) *Meteoritics*, *29*, 458. [4] Chakraborty, S. (2008) *AREPS*, *36*, 153. [5] Crank, J. (1975) *Mathematics of Diffusion*, 2nd Edition, Clarendon Press, Oxford 137. [6] Chakraborty, S. (1997) *JGR*, *102*, 12317. [7] Buening, D. K. and Buseck, B. J. (1973) *JGR*, *78*, 6852.

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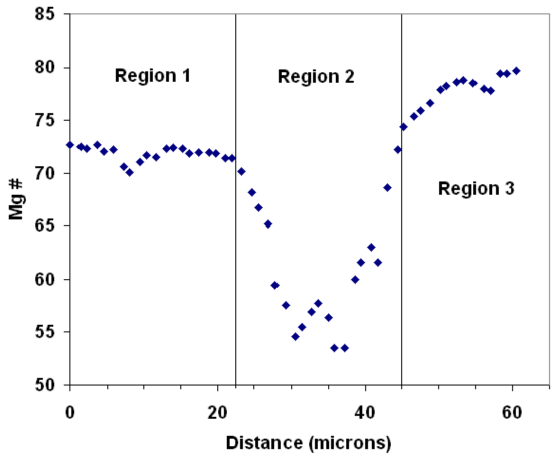

Figure 2: From left, regions 1, 2, and 3 (Chondrule 1, matrix, Chondrule 2).

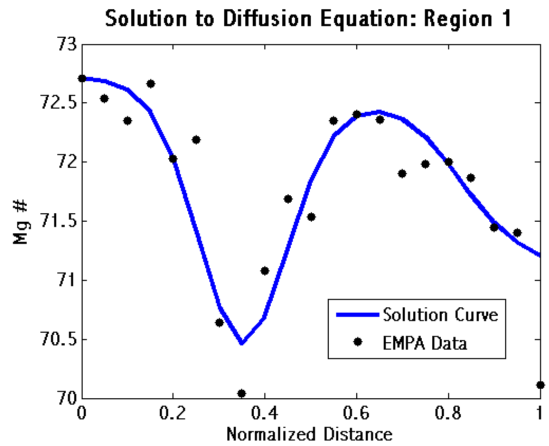

Figure 3: Solution to diffusion equation, chondrule 1.

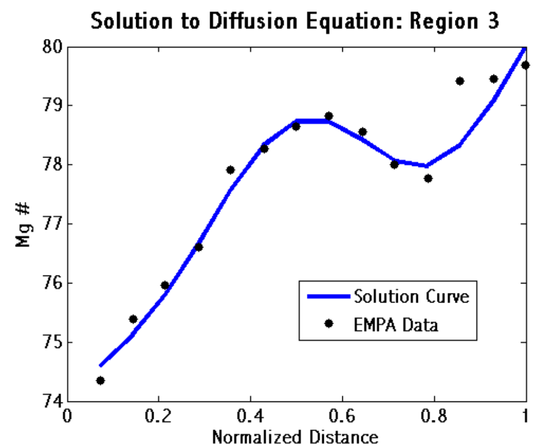

Figure 4: Solution to diffusion equation, chondrule 2.

Temp. (°C)	Time [6] (hrs)	Time [7] (min)
Region 1		
1000	398	57
1150	40	14
1300	6	2
Region 3		
1000	504	72
1150	50	18
1300	9	3

Table 1: Diffusion timescales for regions 1 and 3, using diffusion coefficients from [6] and [7].