# The Formation of Phyllosilicates in Chondrule Forming Shock Waves

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Phyllosilicate minerals are present in many primitive meteorite classes including CI, CM, and CV carbonaceous chondrites and type-3 ordinary chondrites [1-4]. Their origin has been a scientific puzzle for many years. Thermochemical equilibrium calculations show that serpentine, a phyllosilicate mineral that is abundant in the CM chondrites, is stable below 225 K in the canonical solar nebula [5]. However, kinetic considerations suggest that the rate of serpentine formation is too slow to occur within the lifetime of the solar nebula under these conditions [5]. Because of this kinetic consideration, it has long been accepted that serpentine and other phyllosilicate minerals, particularly those found in chondrule rims, formed during aqueous alteration on a small body in the early solar system.

Petrologic studies of the CM chondrites show that phyllosilicate minerals occur as fine-grained rims around chondrules and other coarse-grained components [2,6]. The rims have many features that suggest formation by accretion of fine-grained minerals. This association between chondrules and fine-grained rims is inconsistent with in situ phyllosilicate formation on the CM chondrite parent asteroid. To resolve this problem, a complex history for the origin of fine-grained phyllosilicate minerals has been proposed [2]. Since serpentine formation is inhibited in the solar nebula, aqueous processes on a precursor parent body have been invoked. This body was then disrupted by a catastrophic impact, dispersing the fine-grained material back into free space. Chondrules and other coarse-grained minerals then encountered this dust, accreted their fine-grained rims, and then became incorporated into the final parent body.

In this study we present an alternative formation mechanism for fine-grained phyllosilicate-rich chondrule rims. We investigate the environmental conditions that result from an adiabatic shock wave in an icy region of the solar nebula. Such a mechanism is a leading candidate for chondrule formation [7].

We have altered the model that we developed to study chondrule formation [8], and tracked the evolution of water vapor behind the shock wave for a range of initial conditions. Using these values to redo the calculations of [5], we find that the kinetics of this reaction can be increased by over six orders of magnitude.

**References:** [1] Tomeoka and Buseck 1990, *GCA* **54** 1745-1754. [2] Metzler et al. 1992, *GCA* **56** 2873-2897. [3] Keller et al. 1990, *GCA* **54** 2113-2120. [4] Alexander et al. 1989, *E&PSL* **95** 187-207. [5] Prinn and Fegley 1989, in *Origin and Evolution of Planetary and Satellite Atmospheres*, 78-136. [6] Lauretta et al. 2000, *GCA* **64** 3263-3273. [7] Rubin 2000, *Earth-Sci. Rev.* **50** 3-27. [8] Ciesla and Hood 2002, *Icarus, in press*