THE FORMATION OF PHYLLOSILICATES IN CHONDRULE FORMING SHOCK WAVES.
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Introduction: Phyllosilicate minerals are present in CI, CM, and CV carbonaceous chondrites and type-3 ordinary chondrites [1-4]. 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]. In part due to these kinetic considerations, it has long been accepted that serpentine and other phyllosilicate minerals formed during aqueous alteration on a small body in the early solar system. In this study we investigate phyllosilicate reaction kinetics after passage of an adiabatic shock wave in an icy region of the solar nebula.

Shock Waves: The thermal evolution of silicates encountering a shockwave in the solar nebula has been studied by many authors to explain the rapid heating required to form chondrules [6-9]. We have modified the model of [9] to look at the conditions produced by a shock wave that forms chondrules in an icy portion of the solar nebula. As the ice particles evaporate, we track the evolution of the water vapor behind the shock after the chondrules form.

Kinetic studies: We can use the water pressure that we find behind the shock in the Simple Collision Theory of [5] to calculate the timescale for the hydration of forsterite to brucite and serpentine. When a shock wave passes through a nebula of 150 K with a solar ratio of solids to gas and forms chondrules, the water vapor pressure increases to over two orders of magnitude greater than that of the canonical solar nebula. This increases the hydration reaction by two orders of magnitude. In addition, the enhanced water vapor pressure increases the stability temperature for serpentine. The combination of these two factors allows for the hydration of 10 nanometer sized grains in a timescale less than the lifetime of the solar nebula (roughly 300,000 years). The shocked region would dissipate in a shorter time than this. For the case where solids are enhanced by a factor of 10 over the solar ratio, the kinetics of the reaction are increased by six orders of magnitude. Under these conditions, 1 micron sized grains can be hydrated in a time less than the lifetime of the solar nebula and 10 nanometer sized grains can be hydrated in 2000 years.

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