AN ASSESSMENT OF CURRENT MODELS OF CHONDRULE FORMATION. M.A. Morris[1,2], [1]State University of New York at Cortland, P.O. Box 2000, Cortland, NY 13045, melissa.morris@cortland.edu,
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Introduction: Chondrules are the most abundant early Solar System materials available for study and are some of the oldest [e.g., 1]. The formation age of chondrules spans a large range, from approximately 0-6 Myr after the oldest solids (calcium-rich, aluminum-rich inclusions, or CAIs) [1-5]. The duration over which chondrules formed and their prevalence throughout the meteoritic record, make them ideal probes of the evolution of the solar nebula. Although chondrules have been extensively studied, the process (or processes) by which they formed is not clear.

Constraints on Chondrule Formation Models: The formation mechanism of chondrules has been a matter of great debate for decades. Any single proposed model has been more or less fashionable than others at any given time. It is important to remember, however, that any credible chondrule formation model must meet the numerous thermal, chemical, isotopic, physical, and age constraints recorded in the meteoritic record. The strongest constraint against which chondrules are tested has long been considered to be the inferred thermal histories of chondrules. Experimental reproduction of observed chondrule textures in furnace experiments is typically the method used to determine the thermal histories of chondrules during crystallization [see 6]. However, some of these results have recently been called into question [7-9].

Chondrule Formation Models: Suggested chondrule-forming mechanisms include nebular shocks [e.g., 10-11], interaction of planetary bodies [e.g., 12], disk winds [13], lightning [e.g., 14], and magnetic current sheets [e.g., 15-16], to name a few. Nebular shock models can be broken down further into small-scale shocks, such as planetary bow shocks [e.g. 17], and large-scale shocks, such as those driven by gravitational disk instabilities [e.g., 18-19] or migrating massive planets [20]. The formation models proposed have claimed to meet several, if not all, of the meteoritic constraints on thermal histories. However, other than the models of [e.g., 10-11; 21], very few have included additional predictions that can be tested against the meteoritic record. Since thermal histories are deemed to be the first constraint against which chondrule formation models are tested, it should be noted that some proposed formation mechanisms previously ruled out (e.g., lightning), might need to be reconsidered.

Discussion: Although the formation of chondrules would not be predicted from astrophysics alone, based on the meteoritic evidence, chondrule formation clearly constitutes a major event (or events) in our protoplanetary disk. By analogy, similar events are likely in extrasolar protoplanetary disks. Chondrule formation in our Solar System apparently occurred prior to and during accretion of planetary bodies, yet the process or processes responsible have not been clearly defined. In this talk, a brief overview of several of the proposed chondrule formation models will be presented. Meteoritic constraints that the models do or do not meet will be discussed, as well as any further predictions made. The possible need to revisit some of the meteoritic constraints, such as inferred thermal histories, will be evaluated. Finally, we will discuss whether it is correct to assume that all chondrules formed by a single mechanism, or whether several different chondrule formation models need to be considered to explain the diversity of chondrules.

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