ATEM INVESTIGATION OF A SOLID STATE SINTERED CHONDRULE IN THE BISHUNPUR LL3.15 CHONDRITE.
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Introduction: Chondrules are spherical objects that formed from the crystallization of a melted or partially melted solid precursor in the early solar nebula [1,2]. However, some chondrules show little evidence of melting and may have formed by sintering of dust agglomerates [3,4]. If true, such objects may have preserved some properties of the precursor. Here we present an analytical transmission electron microscopy (ATEM) investigation of such a chondrule in the LL3.15 Bishunpur ordinary chondrite. We show that it likely formed by solid-state sintering of a fine-grained chondritic dust precursor.

Results: The chondrule is delimited from the matrix by a thin sulfide-rich rim and is composed of two distinct parts: a fine-grained (<5µm) inner part, surrounded by a very fine-grained (<1µm) outer part. In terms of mineralogy, both parts are dominated by olivines and pyroxenes cemented by an Si,Al-rich amorphous phase. Metals and/or sulfides inclusions (<1µm) are also abundant within this interstitial amorphous phase. Olivines and pyroxenes are FeO-poor in the inner part (Fa_8 and Fs_5 on average). In the outer part, pyroxenes have almost the same composition but olivines exhibit higher and variable Fe contents (Fa_{35} on average). Finally, the TEM images reveal that the inner part is more equilibrated and shows 120° triple junctions.

Discussion: Our results show a clear chemical and textural disequilibrium between the two parts of the chondrule, as illustrated by distinct olivine Fe contents. In the outer part, the partitioning of Mg and Fe between the coexisting olivine and pyroxene grains does not follow any equilibrium trend. The small grain-size of the silicates (<1µm) shows that this outer part was heated to a lower temperature and probably in a more oxidizing environment than the inner part. The increasing Fe content in olivine, from the inner to the outer regions, and the chemical disequilibrium with pyroxenes suggest that olivine grains are not inherited from the precursor material but likely crystallized during thermal annealing. Numerous experimental studies show that olivine is the first phase to crystallize from a vast range of amorphous precursors at moderate temperature [e.g., 5]. Interestingly, the compositions of the intergranular amorphous phase are peraluminous and rich in silica. It radically contrasts with the chondritic mesostasis and more generally with the compositions of natural liquids that can be quenched as glasses [6]. This suggests that this amorphous phase is most likely a residual product of a solid-state transformation, supporting the idea that olivines formed by sub-solidus crystallization. We conclude that this chondrule formed by solid-state sintering of fine-grained agglomerates with a closely chondritic composition. The thermal regime and the kinetics of its formation will be addressed based on mineralogical proxies.

References: [1] Grossman J. N. and Wasson J. T. 1982. *Geochim. Cosmochim. Acta* 46:1081-1099. [2] Hewins R. H. 1997. *Annu. Rev. Earth Planet. Sci.* 25:61-83. [3] Weisberg M. K. and Prinz M. 1996. *In Chondrules and the Protoplanetary Disk* pp. 119-127. [4] Ruzicka A., Floss C. and Hutson M. 2012. *Geochim. Cosmochim. Acta* 76:103-124. [5] Roskosz M. et al. 2011. *A&A* 529, A111. [6] Mysen B. O. and Richet P. 2005. *In Silicate Glasses and Melts, Properties and Structure* pp. 231-258.