**Links between Type I and Type II chondrules: implications on chondrule formation.**

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One of the most important unresolved problem in the formation of the first solids in the solar system is understanding the nature of the relations between type I and type II chondrules. In unequilibrated chondrites, the ferromagnesian silicates in chondrules exhibit wide ranges of Mg/(Mg + Fe). On this basis, chondrules can be divided into either type I [Mg/(Fe+Mg) of olivine and pyroxene <0.9] or type II [Fe/(Fe+Mg) of olivine and pyroxene >0.9]. From these chemical observations [1], it is generally inferred that type I and type II chondrules record different oxidation states. Whether this difference was established during chondrule formation, or if it reflects differences in their precursors is a matter of debate.

The relative enrichment of type II chondrules in volatiles and moderately volatiles elements, i.e. Na, K, Mn, Cr, Si, and Fe with respect to type I chondrules, the bigger size of type II and the existence of dusty olivines, i.e. magnesian olivines with small metal inclusions, in type II chondrules, have led several authors (see [2] and [3] for review] to propose that type I chondrules could have been formed from type II chondrules by reduction and evaporation processes during heating events. However, several observations indicate that if that reduction scenario could have existed, it can not explained the formation of most chondrules [3]. For instance (i) no or extremely weak isotopic fractionation for volatiles and moderately volatiles elements is observed in chondrules, (ii) metal grains in dusty olivines (Ni-poor) and metal in type I chondrules (Ni-rich) do not have the same origin, (iii) chemical gradients of volatiles and moderately volatiles elements and mineralogical zoning in some chondrules argue in favour of condensation rather than evaporation.

More recent studies [4,5] have shown that the formation of both type I and type II chondrules is incompatible with canonical nebula conditions and most probably occurred in region with high concentrations of gas and dust. For instance, the relatively high $fO_2$ measured in type II chondrules can be achieved for dust enrichments higher than 500 times the solar nebula abundance. Conversely, the fact that type II chondrules contain evidence of reduced component, e.g. relict magnesian olivines and trivalent Ti [5], suggests that part of their precursors were reduced.

In order to take into account these differences in oxidation states, we will present in this talk the results of an experimental study aimed to test the existence of an *alternative chemical pathway* between type I and type II chondrules. We studied the chemical and the petrographic evolution with time (from 1 min 30 to 24h) of type I PO proxies (forsterite + Fe metal + CMAS glassy phase) exposed to isothermal $fO_2$ shocks (at 1450°C and 1500°C under oxidizing conditions between IW and NNO buffer curves).

The oxidizing conditions during the experiments yield a $fO_2$ shock which bring together two systems initially uncoupled: the silicates (magnesian olivines + mesostasis) and the Fe metal. The chemical disequilibrium induced by the oxidation of the Fe metal blebs, acting as a flux, leads to the formation of ferroan olivines. FeO in type II chondrules are interpreted to a certain extent, as the result of the oxidation of Fe metal from type I chondrules, according to the simple chemical reaction: $Fe_{(metal)} + 1/2O_{2(gas)} = FeO_{(silicate)}$. Depending only on the heating time and the initial amount of Fe metal, these experiments reproduce indeed all the intermediate textural types between type I PO chondrules enriched in magnesian olivines and type II PO chondrules with ferroan olivines with or without magnesian olivine relicts.

Reactive mechanisms caused by the $fO_2$ shocks and their kinetics will be thoroughly discussed in this talk in order to show that such a process is a viable mechanism for chondrule formation. Finally, we will show that this finding of formation of type II from type I chondrules induced by oxidation shocks have profound implications on how and where chondrule formed. An alternative to the classical spatial dichotomy for the formation of these two types of chondrules (i.e., either in reducing or oxidizing nebular environments) will be then proposed.

**References:** [1] R.H. Hewins (1997) *Rev. Earth Planet. Sci.* 25, 61. [2] R.H. Jones et al. (2005) *In: Chondrites and the Protoplanetary Disk, ASP Conferences Series* 341, 251. [3] R.H. Hewins et al. (2005) *In: Chondrites and the Protoplanetary Disk, ASP Conferences Series* 341, 286. [4] L. Grossman et al. (2008) *Rev. Mineral. Geochem., 68,* in press. [5] Simon S. B. et al. (2008) *LPS XXXIX,* Abstract #1352.