EXPERIMENTAL REDUCTION OF OLIVINE: CONSTRAINTS ON FORMATION OF DUSTY RELICT OLIVINE IN CHONDRULES. Lisa R. Danielson and Rhian H. Jones, Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131.

Some chondrules contain "dusty" olivine grains that are foreign to the chondrules in which they are observed [1-3]. The dusty appearance of these olivine grains results from the presence of iron metal blebs of micron size or less dispersed throughout the interior of the olivine grain, often in a well aligned pattern. These iron rich metal blebs are the product of a solid state reduction reaction occurring either before or during chondrule formation. However, the kinetics of this reaction are not well understood and the reaction products are unknown. We have conducted preliminary experiments in an attempt to reproduce the textures observed in the dusty relict olivine grains in meteorites, determine the time and temperature constraints on this reaction, determine the reaction products, and investigate the possible reducing agents that are present during chondrule formation.

Previous experimental studies have investigated different aspects of the reaction. Boland and Duba [4] showed that reduction of olivine involving Fe metal nucleation occurs in a few hours in the temperature range 1200 to 1400° C. These experiments were carried out in reducing atmospheres using an H_2/CO_2 mixture. Experiments by Connolly et al. [5] show that graphite is a potential reducing agent during chondrule formation. Our experiments provide further constraints on the possibility of the reduction reaction taking place either before chondrule formation, when the grain is surrounded by solar nebula gas, or during chondrule formation, if no carbon is present.

Experimental Setup: Experiments were carried out in an Astro 1 atmosphere furnace. We performed experiments in the temperature range 1200 to 1500° C with time scales of 1 to 24 hours. Grains of San Carlos olivine, 3 to 5 mm in size, were used as starting material. The grains were suspended in an alumina crucible by either platinum or palladium wire. Experiments were conducted in one of two ambient atmospheres, hydrogen or argon, in order to investigate differences in reaction mechanisms under these conditions. The crucible was inserted into the furnace at the run temperature and quenched from this temperature after the experiment. A section cut through the middle of the crystal was polished and examined using the SEM and electron microprobe.

Results: We successfully produced a reduction reaction in these experiments in both a hydrogen and an argon atmosphere. In thin section, reaction zones are observed along the edges and cracks in the grain. Textures of reduced areas within the San Carlos olivine are similar to those observed in dusty relict olivines in meteorites. Iron metal grains produced in the experiments range in size from 0.1 to 2 μm, with the distance between grains ranging from 2 to 4 μm. The density of these metal grains remains constant with varying time, suggesting that grains "ripen" around a nucleation site rather than nucleating around more sites as reduction progresses. Experiments of a longer duration produce wider reaction zones and larger iron metal grains. At a temperature of 1300°C in an H_2 atmosphere the reaction zone was 5 μm wide after 2.5 hours,

10 μm wide after 5 hours, and 30 μm after 24 hours. Metal grains in the reduced olivine also show preferential alignment directions, similar to those found in meteorites.

Two possible mechanisms have been proposed for the reduction reaction, olivine → silica + metal or olivine → pyroxene + metal. While the metal is easily identifiable, the silica rich reaction product has so far eluded us. Boland and Duba [4] observed pyroxene grains up to 5 μm across as a run product. We observed a fine-grained texture, which may contain the reaction products, adjacent to the iron rich region. However, the grain size is too small for identification with the electron microprobe. The table below compares the composition of olivine in the reduced zone to the original composition of the San Carlos olivine. The FeO and NiO contents are lower for the experiment of longer duration.

	SiO_2	FeO	MnO	MgO	NiO	Total
San Carlos	41.0	8.8	0.12	50.1	0.43	100.45
1300 °C, 2.5 hrs	42.2	3.1	0.05	54.8	0.03	100.18
1300 °C, 24 hrs	43.2	0.67	0.07	56.3	0.00	100.24

Comparison with Relict Grains in Chondrules: We examined dusty olivine in several unequilibrated ordinary chondrites, including Semarkona (LL3.0), Chainpur (LL3.4), Ragland (LL3.5), Inman (L3.4) and Murchison (CM2). The grain sizes of the olivine relicts range from 70 to 200 μm. The metal grain size in the chondrule relicts is 0.2 to 3 μm with an inter grain distance of 0.4 to 7 μm. FeO content ranges from 1 to 8 weight percent.

Conclusions: Reduction reactions in H_2 and Ar are viable mechanisms for producing dusty olivine grains. The size and distribution of metal grains observed in the experiments is similar to that seen in chondrules. The fact that the reduction reaction is observed in an Ar atmosphere suggests the absence of O_2 rather than the presence of H_2 drives the reaction. At 1300 °C the maximum width of the reaction zone, 30 μm, is less than typical widths of dusty relicts observed in chondrules. Also the time required, 24 hours, to form this zone is longer than time scales suggested for transient heating events. We are investigating the possibility that at higher temperatures (e.g. 1500 °C) time scales necessary to produce wider reaction zones are more consistent with time scales for chondrule formation. Although the reduction reaction products have not yet been identified we are hopeful that future TEM analyses will reveal the dominant reaction.

References. [1] Nagahara H. (1981) *Nature* **292**, 135-136. [2] Rambaldi E.R. (1981) *Nature* **293**, 558-561. [3] Rambaldi E.R. and Wasson J.T. (1982) *GCA* **46**, 929-939. [4] Boland J.N. and Duba A. (1981) *Nature* **294**, 142-144. [5] Connolly H.C. Jr. et al. (1994) *Nature* **371**, 136-139.

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