OLIVINE SINTERING EXPERIMENTS AND LITHIC CLASTS IN CHONDRULES. S.A. Whattam and R.H. Hewins, Geological Sciences, Rutgers University, 610 Taylor Rd, Piscataway, NJ 08854 (sawhatta@gmail.com).

Introduction: Libourel and colleagues have shown that many features of chondrules are inconsistent with closed-system crystallization, particularly the variations in glass compositions, which cannot be explained by olivine crystallization [1]. Some Type I chondrules contain aggregates of polygonal olivine grains, with textures suggesting formation in a parent body before incorporation in Al-rich melts in chondrules [2]. Other Type I chondrules might have formed by disaggregation and dissolution of such dunite clasts in the chondrule melts [2]. We have investigated experimentally whether the olivine aggregate textures seen in such type I chondrules are compatible with a 'normal' chondrule thermal history or require the accumulation of planetesimals which are recycled into chondrules, and under what conditions such precursor aggregates survive or form typical porphyritic textures in chondrule analogues.

Methods: Starting materials for the sintering experiments consisted solely of either <43 μm or <63 μm San Carlos olivine. Materials for the dissolution experiments included aggregates of sintered olivine, and a mixture of <63 μm Bamble enstatite ($Wo_1En_{88}Fs_{11}$) and <63 μm Miyakejima anorthite (An_{94}). We heated pressed pellets of <43 μm and <63 μm SC olivine at 1350°C, 1400°C, 1450°C, 1500°C and 1550° for periods ranging from 1-100 hours to examine sintering. We subsequently heated fragments of San Carlos aggregates sintered at 1350°C or 1400°C for 100 hours in a mixture of an equal amount of An+En (total mass ~40-45 mg) for 30 seconds, 1 minute, 5 minutes, 1 hour and 4 hours at IW -0.5 to examine chondrule formation. All samples were hung from Re wire loops suspended on Pt wires in a DelTech DT-31-VT-OS muffle tube furnace housed in Wright Labs, Department of Geological Sciences, Rutgers University. Charges were quenched within 5 seconds of removal from furnace.

Results:

Sintering experiments. Grain coarsening is limited in the lower T (1350-1400°C) runs (Fig. 1a-b), which have meta-clastic textures. The aggregates sintered at 1450°C and above after 100 hours develop equigranular metamorphic textures (Fig. 1c-d). An enlargement of pores is seen from low to high T (e.g., 1500-1550°C, Fig. 1c-d), but is more conspicuous for runs made with finer grained (<43 μm) starting materials. The equigranular textures approach those observed within chondrules by [2], but we are unable to eliminate pores within 100 hours. Partial melting of the olivine commences between 1450 and 1500°C.

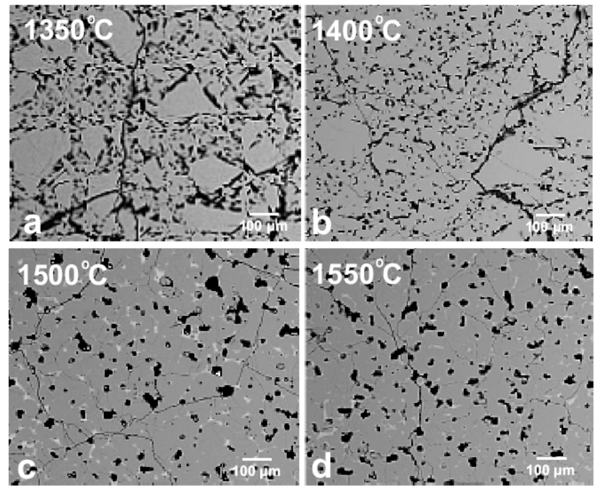

Figure 1 <63 μm SC olivine sintered for 100 hours.

Dissolution experiments. Disaggregation of clasts is very rapid as the An+En melt invades grain boundaries and fractures in the dunite. Only for 30 seconds at 1450°C are the clasts reasonably intact (Fig. 2a and c) and by 5 minutes, clast disaggregation is well under way (Fig. 2b and d). The penetration of melt along fractures and grain boundaries shown in Fig. 3a is more obvious for coarser starting material (prepared from <63 μm olivine). In these runs, the larger olivine grains are obvious relicts with reverse zoning (Fig. 3 a-b).

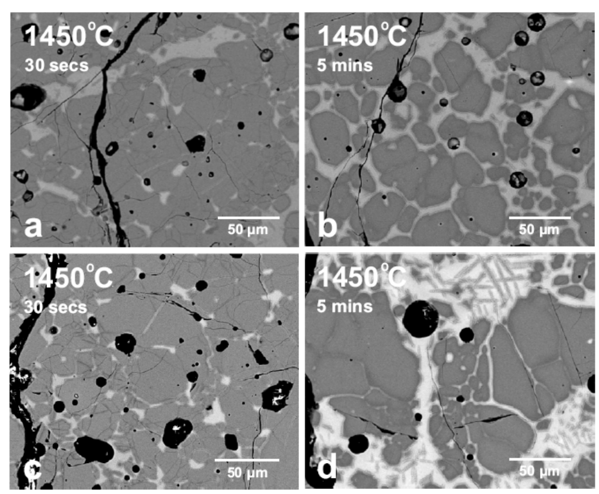

Figure 2 <43 μm-1400°C-100 hr sintered SC olivine (a-b) and <63 μm-1400°C-100 hr sintered SC olivine (c-d) heated with An+En mixture.

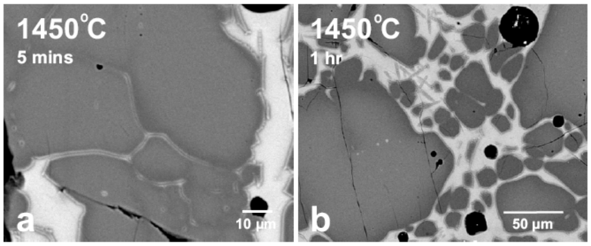

Figure 3 <63 μm-1400°C-100 hr sintered SC olivine heated with An+En mixture.

However, with finer-grained clasts, the textures are porphyritic, commonly with euhedral olivine crystals (Fig. 4a-b), and with continuous cooling the olivine would have become normally zoned euhedral crystals.

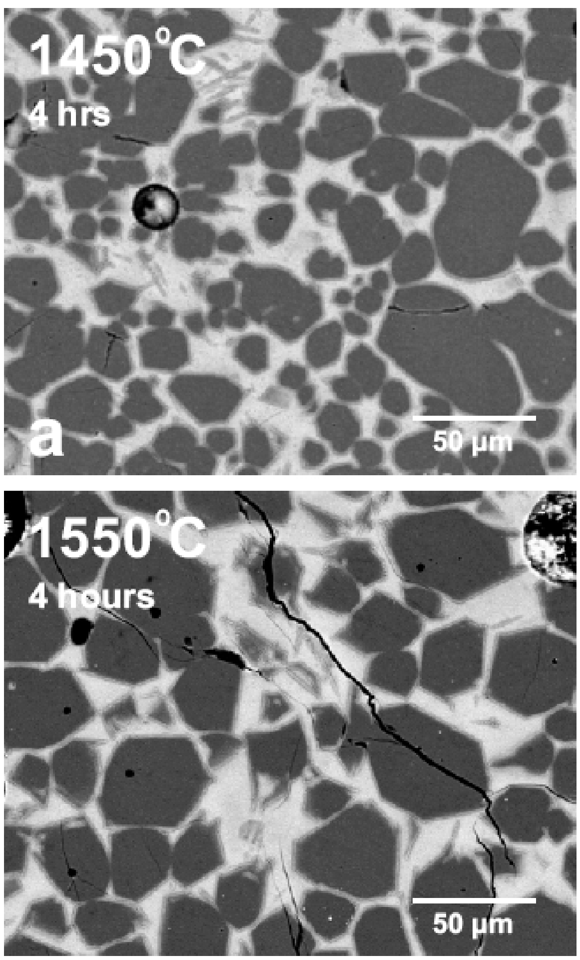

Figure 4 <43 μm-1400°C-100 hr sintered SC olivine (a) and <43 μm-1350°C-100 hr sintered SC olivine heated with An+En mixture.

Discussion:

Sintering. Aggregates possibly resembling chondrule precursors can be sintered to form equigranular metamorphic textures, but the times involved, 40 to 100 hours, are longer than those usually attributed with chondrule formation. In additon, pores coalesce and persist in the sintered aggregate (e.g., Fig. 1c-d). Certainly, a parent body origin is the simplest way to get the equigranular dunites, as suggested by [2]. However, conceivably there could be pore-free precursors, and objects other than chondrules have been heated for extended times in the nebula. For example evaporation rate data coupled to observe isotopic mass fractionation lead to heating times of up to 300 hours for type B CAI heated at 1400°C and 10^{-6} bars (Fig 6 in [3]). Thus, we cannot entirely exclude a nebular origin for these dunite aggregates

Dissolution. Chondrules preserving dunite clasts cannot have been heated to typical chondrule temperatures or their textures would have been modified by melt penetration leading to disaggregation. Near solidus temperatures seem plausible for such objects. Dunite clasts within chondrule precursors are not unreasonable for generating porphyritic and other textures. Some large relict grains might be seen but smaller relicts would tend to develop euhedral overgrowths and become equilibrated with the melt. They might be recognized as having relict cores from oxygen isotopic compositions [4].

Conclusions:

1. Sintering of olivine grains produces dunitic aggregates similar to those seen as clasts in some chondrules, but the heating times are long and pores persist. A parent body origin [2] is plausible for the clasts, but we cannot rule out a nebular origin.

2. Survival of the clasts in chondrules requires low (near-solidus) temperatures. Normal porphyritic chondrules might well have been produced by the disaggregation of such clasts with higher peak temperatures.

References: [1] Libourel G. et al. (2006) *Earth Planet. Sci. Lett. 251*, 232-240 [2] Libourel G. and Krot A.N. (2006) *LPS XXXVII* Abstract #1334. [3] Richter F.M. et al. (2006) *Meteoritics & Planet. Sci., 41*, 83-93. [4] Boesenberg et al. (2007) *LPS XXXVIII.*