CALCIUM IN FORSTERITIC OLIVINES IN TYPE IA CHONDRULES: AN EXPERIMENTAL STUDY. Harold C. Connolly Jr. and Roger H. Hewins. Dept. of Geological Sciences, Rutgers University, New Brunswick, N.J. 08903.

INTRODUCTION The olivine in unequilibrated chondrules contains quite high CaO concentrations (0.1 - 0.6 wt%) and, whereas in Type II chondrules (porphyritic, ferroan) it shows strong normal zoning, Type I chondrules (microporphyritic/ granular, magnesian) show little zoning in olivines. Experiments (e.g. 1,2) have reproduced most aspects of chondrules quite well, except for Ca in olivine. We report here experiments which duplicate the high Ca contents of natural chondrule olivine and show that we can obtain normal zoning even in forsteritic olivines.

EXPERIMENTS We used compositions containing magnesian olivine, calcic pyroxene and plagioclase, with various (very low) Fe/Mg ratios, and CaO contents about 8 wt%. Charges were held at subliquidus temperatures (1557-1623°C) for 30 minutes and quenched from 1100 and 1150°C.

Fig. 1 shows Semarkona Type I olivine with very little Fe-Ca zonation and synthetic olivine with higher Ca overall, and Ca-rich rims. Runs with the most magnesian bulk composition crystallized approximately Fo_{99}, but with some variation and with both normal and reverse Fe-Mg zonation, probably due to variable Fe loss to the Pt wire. Ca always increased to rims. In more ferroan charges, normal zonation in olivine of core composition Fo_{98} is seen for both Fe and Ca (Fig. 2).

DISCUSSION The concentration of Ca in olivine clearly depends on the bulk Ca, and earlier chondrule experiments had low Ca in olivine because the bulk Ca was low. It is always difficult to estimate partition coefficients for samples roughly half solid and half liquid. Here we assume the cores of the olivine crystals were in equilibrium with the bulk liquid. With this assumption, olivine in liquids with 1-3 wt% CaO (1,2) and 8 wt% CaO (this work) show approximately the equilibrium CaO partition coefficient of 0.03 (3,4).

Applying the same approach to natural Type I olivine chondrules (e.g. 5), we find an excess of Ca relative to the bulk Ca concentration. For Type I chondrules, (5) report approximate equilibrium partitioning between olivine and mesostasis. Possibly temperatures were sufficiently high for Ca to requilibrate continuously during crystallization. Olivine in some Type I chondrules shows no zoning, and in others weak normal (Fig. 3) or even slight reverse zoning (5) and in our experiments we see similar patterens (Fig 4). Type II chondrules always shows strong normal Ca zoning in unequilibrated olivine, which has been duplicated experimentally (1), perhaps because Ca diffusion cannot keep up with crystallization at the lower temperatures.

The difference between Type I and II olivine chondrules is most apparent in texture (granular/micropophyritic vs. porphyritic) which allows them to be distinguished. There is also a large hiatus in olivine Fe contents for truely unequilibrated Type I and II chondrules, i.e. in Semarkona and carbonaceous chondrites (6). Calculated liquidus temperatures (2) for such Type I chondrules are naturally higher than for Type I. We do not completely understand the different Ca distributions in experimental charges and chondrules, but the high Ca in forsteritic olivine in Type I chondrules may be related to the high liquidus temperatures. We cannot rule out the idea that the condensate forsterite of (7) suffered incomplete equilibration during partial melting.

CONCLUSION The Ca contents of olivine in Type I chondrules can be duplicated experimentally using charges with high bulk Ca. However, the melting and crystallization of Type I chondrules remains incompletely understood.

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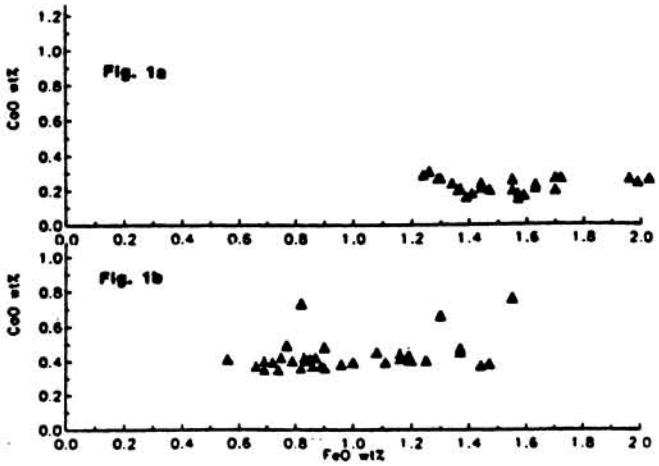

Fig. Ia A plot of Type I chondrules from Semarkona.

Fig. Ib A plot of a synthetic chondrule.

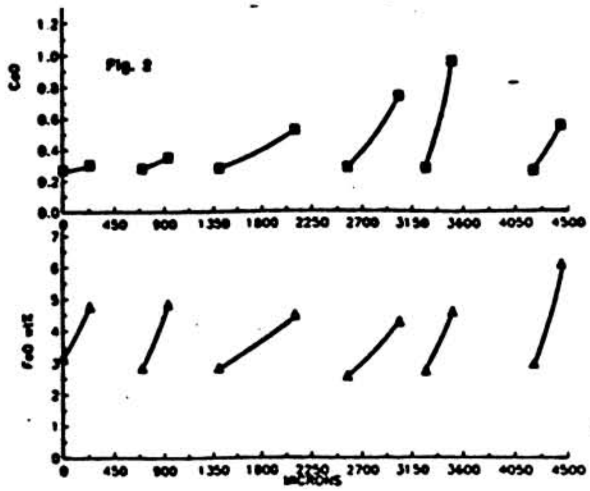

Fig. 2 Core to rim plots of the more ferroan synthetic chondrules.

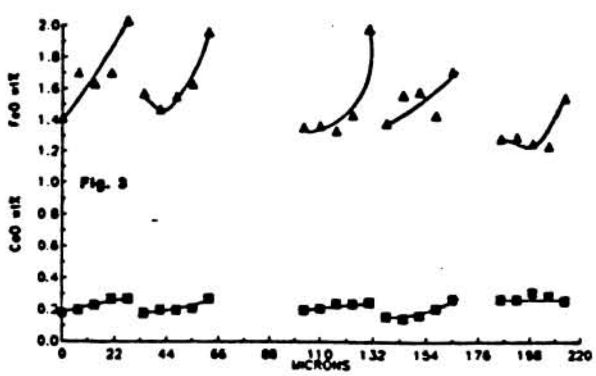

Fig. 3 A plot of line scans of a Type I chondrule from Semarkona. (Core to rim data)

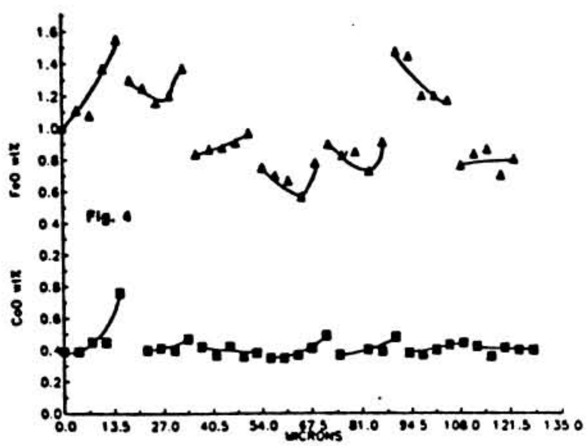

Fig. 4 A plot of core to rim line scans for 5 olivine grains in a synthetic chondrule.