CaO CONTENTS IN OLIVINE: AN EXPERIMENTAL STUDY; M. Miyamoto, Dept.
of Pure and Applied Sci., Univ. of Tokyo, Komaba, Tokyo 153, Japan, D. S.

It is generally considered that CaO contents in olivine have the potential to give significant information on crystallization, cooling, or reheating histories. For example, Miyamoto et al. (1) reported that olivines in ordinary chondrites show a wide variety of CaO contents (0.02-0.5 wt%) and they calculated cooling rates on the basis of CaO zoning profiles. Scott and Taylor (2) showed that there are significant negative correlations between mean CaO and Fa(=100xFe/(Mg+Fe)) concentrations in olivine among low-FeO, porphyritic olivine chondrules, but for high-FeO, porphyritic olivine chondrules, correlations when present are positive. Because the variation of CaO contents and these correlations between CaO and Fa component may be related to oxygen fugacity, we analyzed CaO contents in olivine of charges obtained by a series of melting experiments as a function of both temperature and oxygen fugacity. These experiments were formerly designed to obtain information on the magma composition of the HED meteorites from LL chondrite-like source material (3).

Experiments: Starting material for heating experiments was the PCA82507 LL6 chondrite. Samples suspended on Pt-wire loops were heated at constant temperatures 1050, 1125, 1200, 1275, 1350, 1425, and 1500 °C in a vertical 1-atm CO/CO2 gas-mixing furnace at constant oxygen fugacities ranging from 3 log units below to 4 log units above the iron-wüstite (IW) buffer. Our experiments cover relatively reduced conditions. Oxygen fugacity was measured by a zirconia cell (4), but the value of oxygen fugacity less than 2 log units below IW may be somewhat inaccurate. Details of experiments are described in (5).

Results: Fig. 1 shows plots of CaO(wt%) vs. Fa of olivines in experimental charges as a function of oxygen fugacity. Abrupt changes in Fa components correspond to metallic Fe precipitation, because significant amount of Fe is present in the charges under the reduced condition. Although CaO contents in olivines of the charges under the reduced condition slightly increase compared with those under the oxidized condition (above IW) at 1275, 1350, and 1425 °C, there are no clear negative correlations between CaO and Fa components in olivine. The CaO content in olivine decreases as temperature increases (Fig. 1). Furthermore, there is a positive correlation between CaO and Fa of olivines of the charges under the oxidized condition (that is, no significant Fe precipitation is present).

Fig. 2 shows the partition coefficients for Ca in olivine as a function of oxygen fugacity. The partition coefficient is defined as the weight ratio, Dca = C(CaO)OL/C(CaO)LI. The range of Dca is consistent with those previously reported (e.g., 6). Dca appears to show a positive correlation with oxygen fugacity at lower temperatures (1200, 1275 °C), although higher values of Dca for the charges may be due to failure to achieve equilibrium. As oxygen fugacity changes, Dca does not change very much except for the 1200 and 1275 °C charges.

Fig. 3 shows CaO contents in olivine and in liquid. In more oxidizing systems (>-11 log units), the CaO content of the olivines inversely correlates with the temperature of crystallization. The CaO content in the liquid increases rapidly at low oxygen fugacities at all temperatures below about -12 log units. Because the bulk CaO content of the starting material is about 1.7 wt%, CaO contents in liquid under the reduced condition are
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5-6 times larger than that of the starting material.

Conclusions: Although there are no clear negative correlations between CaO and Fa in olivine, high CaO contents of low-FeO olivines in chondrules may be formed from melts which were produced under the most reducing conditions. For high-FeO olivines, the positive correlation may be related to temperature where they formed.


Fig. 1. CaO (wt%) vs. Fa of olivines obtained by melting experiments. Numbers on lines indicate temperature. Numbers on symbols indicate -log oxygen fugacity.

Fig. 2. Partition coefficient of Ca as a function of oxygen fugacity.

Fig. 3. CaO in olivine and in liquid as a function of oxygen fugacity.