

COMPOSITIONAL VARIABILITY IN DIOGENITE PYROXENE: CONSTRAINTS FROM EXPERIMENTS ON MAGNESIAN EUCRITE PARENT MAGMAS; T.L. Grove, Dept. of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139

Melting experiments were performed on magnesian eucrite parent magmas at 1 bar and 1000 bars buffered at iron-wustite (IW). The compositions of low-Ca pyroxenes have been determined in olivine + low-Ca pyroxene + spinel - saturated liquids over the temperature range of 1190 to 1230 °C. The purpose was to test whether these liquids could produce pyroxenes that resemble the compositions of low-Ca pyroxenes preserved in diogenites. The experimentally produced trend parallels that determined for the diogenite group [1,2] and spans a range of pyroxene Mg# from 0.69 to 0.76 over a temperature interval of 1190 to 1230 °C. The experimentally produced pyroxenes overlap with the composition of diogenite pyroxenes at high Mg#. At an Mg# of < 0.72, the experimental pyroxenes contain higher Wo contents (Wo<sub>5</sub> in experiments vs Wo<sub>3</sub> in diogenites). The minor element abundance variations for Ti and Al are comparable in the experimentally produced and natural diogenite pyroxenes. Cr abundances are higher in the experimental pyroxenes by up to a factor of 2. The most magnesian pyroxenes in diogenites are found in Manegaon and Tatahouine and have Mg#s of about 0.80. These compositions have not yet been produced experimentally. Best estimates indicate that these high Mg# pyroxenes crystallized from a parental magma with an Mg# of 0.49 and at a temperature of about 1250 °C.

*Experimental methods* The experimental methods were similar to those described by Bartels and Grove [3]. As discussed by these authors, Fe loss or gain to the silicate charge was carefully monitored and alkali loss was kept at a minimum. Low-Ca pyroxenes that had not been analyzed in high temperature experiments reported in Bartels and Grove [3] are included here. Additional experiments were carried out on a Kapoeta rho starting composition [3] to determine the high temperature stability of low-Ca pyroxene. To stabilize low-Ca pyroxene to higher temperatures a mix of 90 wt. % Kapoeta rho and 10 wt. % Kragero [4] orthopyroxene was prepared. These compositions were run under oxygen buffered conditions similar to those described in [3].

*Results* The compositions of low-Ca pyroxenes produced in the experiments are plotted with pyroxene compositions from natural diogenites [1,2] in Fig. 1 in the quadrilateral. The experimental pyroxenes follow the trend defined by diogenite pyroxenes, but are offset to higher Wo contents at low Mg# and merge and overlap with the diogenite trend at high Mg#. In the Kapoeta rho composition, low-Ca pyroxene disappears at 1215 °C at 1 bar and at 1225 °C at 1000 bars. The composition of this liquidus low-Ca pyroxene is Wo<sub>4.9</sub>En<sub>68.4</sub> (Mg# = 0.72). At higher temperatures olivine + spinel coexist with liquid. Grove and Bartels [4, Table 1] noted that potential parent magmas that will crystallize low-Ca pyroxene at higher temperatures must be higher in normative pyroxene and estimated a bulk composition. The Kragero + Kapoeta rho mix approximates this estimated melt and stabilizes low-Ca pyroxene with Mg#s and Wo contents identical to those found in Johnstown and Roda (Table 1). The low-Ca pyroxene in the 1230 °C experiment coexists with Fo<sub>70</sub> olivine and a Cr-rich spinel (Cr<sub>2</sub>O<sub>3</sub> = 55 wt. %, Al<sub>2</sub>O<sub>3</sub> = 13 wt. %, Mg# = 0.33). The mass balance calculations carried out by Grove and Bartels [5] should be updated in light of the experimental results reported here, but the use of a lower Wo content pyroxene in modeling should not substantially affect their conclusions.

Table 1. Comparison of pyroxene produced in eucrite parent magma at 1230 °C, 1 bar, IW buffer with analysis of a pyroxene from Johnstown [1].

	SiO <sub>2</sub>	TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	FeO	MgO	MnO	CaO	sum
Exptl. pyx	55.2	0.11	0.69	0.92	15.2	27.5	0.46	1.36	101.4
Johnstown	54.1	0.11	0.99	0.66	15.4	26.5	0.50	1.24	99.5

## Grove: Diogenites

Several authors have pointed out that the pyroxene and associated minerals in diogenites show evidence of metamorphic reequilibration [1,6]. Mineral - mineral thermometry using orthopyroxene - spinel, orthopyroxene - olivine and orthopyroxene - hi-Ca pyroxene yield temperatures that range from 650 to 980 °C, substantially lower than magmatic values. The compositions of minerals that coexist with orthopyroxene in diogenites differ significantly from the compositions of these phases that would be expected if diogenites were unperturbed cumulate residues of fractional crystallization. Olivine is Fe-rich relative to the composition of olivine that would coexist at magmatic temperatures. Spinel is compositionally variable and ranges from spinel that resembles those produced at magmatic temperatures [3] to nearly pure chromite. If the low-Ca pyroxenes of diogenites are to be used to infer compositional characteristics of the magmas from which they crystallized, these metamorphic effects must be understood. To examine some possible mechanisms of element redistribution during metamorphism the compositions of the pyroxenes produced in the experiments were compared with pyroxene in diogenite. Ca and Cr are the two elements whose abundances differ most markedly between the experimental and natural pyroxenes. Assuming that the experimental pyroxenes are a suitable analog for the pre-metamorphic diogenite pyroxenes, a mass balance that involves orthopyroxene, hi-Ca pyroxene, and chromite from [1] reproduces the composition of the experimentally produced low-Ca pyroxenes. The proportions of hi-Ca pyroxene and chromite vary from < 1 wt. % in the high Mg# diogenites to ~ 4 wt. % hi-Ca pyroxene and 1 % spinel in the low Mg# diogenites. Such subsolidus metamorphic reequilibration may also serve to modify the trace element compositions of diogenite pyroxene.

*References* [1] Mittlefehldt D. W. (1994) *Geochim. Cosmochim Acta* 58, 1537-1552. [2] Fowler G. W. et al. (1994) *Geochim. Cosmochim Acta* 58, 3921-3929. [3] Bartels K. S. and Grove T. L. (1991) *Proc. Lunar and Planet. Sci.* 21, 351-365 [4] Grove T. L. and Juster T. L. (1989) *Contrib. Mineral. Petrol.* 103, 287-305. [5] Grove T. L. and Bartels K. S. (1992) *Proc. Lunar and Planet. Sci.* 22, 437-445. [6] Sack et al. (1991) *Geochim. Cosmochim Acta* 55, 1111-1120.

Figure 1. Comparison of the compositions of pyroxenes from diogenites (shaded area, data from [1] and [2]) and low-Ca pyroxenes produced in experiments (crosses) on Kapoeta rho (1190 - 1210 °C) and 90% Kapoeta rho + 10 % Kragero orthopyroxene (1230 °C).

