American Mineralogist, Volume 85, pages 1375–1382, 2000

Experimental study of intracrystalline Fe^{2+}-Mg exchange in three augite crystals: Effect of composition on geothermometric calibration

ELISABETTA BRIZI,[1] GIANMARIO MOLIN,[2] AND PIER FRANCESCO ZANAZZI[1,*]

[1]Dipartimento di Scienze della Terra, Universita' di Perugia, Perugia, Italia
[2]Dipartimento di Mineralogia e Petrologia, Universita' di Padova, Padova, Italia

ABSTRACT

Three augite crystals with differing chemical compositions [Fonualei dacite lava flow, Tonga (Fon39) ($En_{36}Fs_{27}Wo_{37}$), Alicudi andesitic dike (KC) ($En_{46}Fs_{11}Wo_{43}$), and Vulcano basalt dike (PD30) ($En_{42}Fs_{12}Wo_{46}$)] were equilibrated over the temperature range 700–1100 °C through both disordering and ordering reactions ("reversal technique") and then quenched at room temperature. Following each experiment, the partitioning of Fe^{2+}-Mg between M1 and M2 sites of clinopyroxene was determined by single-crystal structure refinement. The Fe^{2+}-Mg partitioning data of the order-disorder reaction, $Fe^{2+}_{M2} + Mg_{M1} = Fe^{2+}_{M1} + Mg_{M2}$, in terms of the partition coefficient $K_D\{= [(Fe^{2+}_{M1})(Mg_{M2})/(Fe^{2+}_{M2})(Mg_{M1})]\}$, were then used to calibrate the following geothermometric equations:

$$-\ln K_D = 2727\ (\pm 132)/T(\mathrm{K}) - 0.383\ (\pm 0.113);\ (r = 0.99)$$
$$-\ln K_D = 4204\ (\pm 214)/T(\mathrm{K}) - 1.570\ (\pm 0.183);\ (r = 0.98)$$
$$-\ln K_D = 5305\ (\pm 351)/T(\mathrm{K}) - 2.428\ (\pm 0.289);\ (r = 0.98)$$

respectively for Fon39, KC, and PD30. A situation in which thermodynamic parameters depend on crystal composition may be envisaged. It should be noted that such dependence is essentially controlled by the (Ca+Na) and R^{3+} contents of the clinopyroxene. On the basis of compositional dependence, the following geothermometric equation is proposed:

$$T(\mathrm{K}) = [12100\ (750) - 27700\ (1700)(\mathrm{Ca} + \mathrm{Na} + R^{3+}) + 20400\ (1000)(\mathrm{Ca} + \mathrm{Na} + R^{3+})^2]/[-\ln K_D + 7.1\ (0.6) - 20.3\ (1.4)(\mathrm{Ca} + \mathrm{Na} + R^{3+}) + 15.2\ (0.8)(\mathrm{Ca} + \mathrm{Na} + R^{3+})^2]$$