



Fig. 2. Experimental results in the System Garnet-cordierite. ○ only cordierite in products; △ only garnet in products; ● coexisting garnet and cordierite in products, with composition given by the x . The runs shown by solid circles marked "h" contained hypersthene in the products, plus garnet and/or cordierite with the composition shown by the x .

11.456 and 1.714 for pyrope, and 11.526 and 1.830 for almandine and that both varied linearly with composition. The cell edge was determined to ± 0.003 Å. Corresponding to about 5% error in the almandine content, while the refractive index was determined within 0.003, corresponding to a 3% error in almandine content. The two determinations agreed within 5% in all cases, and this is believed to be the approximate limit of error. Cordierite composition was determined by comparison of the X-ray powder patterns and refractive indices of the run products with the series of artificial cordierites of known composition used as starting materials. Both "d" spacings and maximum refractive index appear to vary linearly with composition, and, with the accuracy of determination noted above, give a determination of composition within 7%. The two determinations agreed within 9% in all cases.

The only phases other than garnet and cordierite detected were sillimanite, quartz, and hypersthene. The latter appeared only in three runs in composition $\text{Fe}/\text{Fe} + \text{Mg} = 0.20$. The results of the 46 runs are presented graphically in Fig. 2¹, which incorporates the data of Richardson (1968).

1 A table of the experimental results is available on request from the author.

Table 2. Calculation of dP from experimental runs

| T (Å) | P (kbars) | X_m^c | X_m^g | K | $\ln K$ | dP | avg. dP | avg. K |
|---------|-------------|---------|---------|-------|---------|------|-----------|----------|
| 873 | 6.0 | 0.64 | 0.32 | 3.18 | 1.156 | 3.24 | 3.24 | 3.18 |
| 973 | 5.0 | 0.41 | 0.11 | 5.62 | 1.726 | 5.27 | | |
| | 6.0 | 0.66 | 0.26 | 5.52 | 1.708 | 5.21 | 5.27 | 5.62 |
| | 7.0 | 0.83 | 0.46 | 5.73 | 1.746 | 5.33 | | |
| 1073 | 5.0 | 0.52 | 0.11 | 8.76 | 2.170 | 7.31 | | |
| | 6.0 | 0.67 | 0.19 | 8.65 | 2.157 | 7.26 | 7.28 | 8.68 |
| | 7.0 | 0.80 | 0.32 | 8.50 | 2.140 | 7.21 | | |
| | 8.0 | 0.86 | 0.41 | 8.83 | 2.178 | 7.33 | | |
| 1173 | 5.0 | 0.56 | 0.09 | 12.87 | 2.555 | 9.40 | | |
| | 6.0 | 0.69 | 0.16 | 11.63 | 2.457 | 9.04 | 9.28 | 1246 |
| | 7.0 | 0.80 | 0.24 | 12.67 | 2.359 | 9.35 | | |
| | 8.0 | 0.85 | 0.31 | 12.61 | 2.534 | 9.33 | | |

$$dP = \frac{RT \ln K}{dv} = 0.003138 T \ln K.$$

The results suggest that garnet-cordierite equilibrium, except for a relatively small region at the magnesium-rich end, can be represented by simple loops in P - X projection (constant T). This is the prediction made by the thermodynamic analysis and Fig. 2 shows the computed loops, from Eq. (9) and (10) using experimental P_g^c . The experimental work therefore strongly supports the hypothesis of ideality for Eq. (3). In P - X projection the area occupied by coexisting garnet and cordierite becomes larger with increasing temperature. Presumably the garnet-cordierite volume is terminated at high temperature by other reactions, probably involving hypersthene, (Henson and Green 1970).

Application of the Garnet-Cordierite Geothermometer

The experimental data may be applied to natural assemblages where garnet and cordierite are the only Fe and Mg bearing phases, or to groups of specimens of fixed mineral composition where the compositions of garnet and cordierite change composition in various specimens, but the other phases do not. In such assemblages, it is obvious from Fig. 2 that at a given temperature and pressure the compositions of coexisting garnet- and cordierite are fixed. However it may also be possible to find garnet-free or cordierite-free assemblages at the given P , T . The value of K from the coexisting garnet and cordierite may be converted directly to T , by noting that the relation between dP and T in Table 2 is linear. It may be expressed by

$$dP = 0.020 T - 14.18 \quad (11)$$

where dP is in kilobars, and T in absolute temperature. Substituting this in Eq. (9) and rearranging yields

$$T = \frac{14.18}{0.020 - \frac{R \ln K}{dv}} \quad (12)$$

substituting the appropriate values for R and dV into this equation gives

$$T = 4515 / (6.37 - \ln K). \quad (12a)$$