Experimental study on the incorporation of Na in Mg-cordierite in the presence of different fluids (Na(OH), NaCl-H₂O, albite-H₂O)

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Experimental investigations have shown that the Na content of orthorhombic cordierite can be used as a geothermometer. Mirwald (1986) has shown in the model system Mg-cordierite – 1n Na(OH) that the Na-content under basic reaction conditions is inversely related to T and is largely independent of P. The incorporation of Na in cordierite also shifts the upper stability boundary towards higher P by 75 MPa compared to the Na-free reaction $Crd + H_2O = Tc + Q + Ky$ (Mirwald, 1984). Furthermore, Knop and Mirwald (1998) extended the work using albite as sodium donator in the presence of H_2O. The presence of albite gave rise to eutectic melting which yielded a slightly higher sodium content in the temperature range 650 to 800°C. In this study we investigated the Na-incorporation in Mg-cordierite using different NaCl-rich solutions [$X(H_2O)= H_2O/H_2O+NaCl$; $X(H_2O)$: 1, 0.9, 0.75, and 0.46]. In contrast to the previous investigations the reaction environment may be considered slightly acidic. The experiments were conducted at 700 and 750°C in the pressure range 0.85 – 1.1GPa.

The experiments were performed in a piston cylinder apparatus using a conventional NaCl cell set up. The starting materials were synthetic anhydrous Mg-cordierite, which was obtained by annealing Al-Si disordered high cordierite at 1400°C for 168 hours and natural quartz, kyanite and talc. The duration of the runs was 70 hours. The reaction products were examined by electron probe analysis.

The Na data obtained at $X(H_2O)= 0.96$ and 0.75 are in close agreement with Mirwald

(1986) showing practically the same inverse T-relation. This indicates that the pH of the incorporation reaction is of no influence on the incorporation reaction. The experiments at $X(H_2O)= 0.46$ produced significant amounts of albite as buffering phase in addition to melt. The Na-content of cordierite from these experiments systematically higher values as obtained in the runs with $X(H_2O) =0.9$ and 0.75. These Na data are in agreement with the data by Knop and Mirwald (1998). Again, with respect to P, no P-dependence within the P-range of 0.85 – 1.1GPa has been observed.

The following T-Na (a.p.f.u.) correlations were obtained for the two sets of experiments: 1) $Na(a.p.f.u.) = 0.323+/-0.003 –0.000369*T(°C)$ for the data by Mirwald (1986) and the high $X(H_2O)$ experiments of this study; and 2) $Na(a.p.f.u.) = 0.318+/-0.015 – 0.000326*T(°C)$ for the higher Na content experiments by Knop and Mirwald (1998) and the low $X(H_2O)$ experiments of this study.

Although when comparing the Na-content data of Mg-cordierite obtained from different fluid environments no differences occur indicating that the inverse T-Na relation in cordierite is robust, but the higher Na contents obtained in the experiments in the presence of albite + melt indicates that the bulk chemistry of the investigated system is of considerable significance. This observation is supported by the results of Thompson et al. (2002) who studied the alkali content of cordierite in the presence of a granitic melt and Wyhlidal et al. (2007) who performed a study using natural quartzphyllites with different Na_2O contents. Therefore for a thermometric application of this inverse T-Na relation, the bulk Na content has to be taken into account.

References

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