THERMAL HISTORY AND EXSOLUTION MICROSTRUCTURES OF TWO CLINOPYROXENES FROM THE THABA PUTSOA KIMBERLITE PIPE, LESOTHO

Robert H. McCallister: Department of Geosciences
Henry O.A. Meyer: Purdue University
Ricardo Aragon: West Lafayette, Indiana 47907

Two specimens of clinopyroxene from sheared and discrete lherzolites from the Thaba Putsoa Kimberlite pipe, Lesotho, have been examined by means of transmission electron microscopy. (Both were collected by P.H. Nixon and analyzed by F.R. Boyd, who kindly provided them.) The clinopyroxene in the sheared lherzolite (PHN 1611) has a Ca/Ca+Mg of 0.315, whereas the ratio is equal to 0.320 in the discrete lherzolite (PHN 1600E4). Crushed grain mounts of each sample were prepared and observed on a Siemens Elmiskop I, operating at 100kV. For each bright field image that contained lamellae, a corresponding diffraction pattern was taken in order to correct the apparent lamellae thicknesses, and calibration of the magnification was done by imaging and photographing a carbon replica of a waffle grating with spacing equal to 0.50 ± 0.01 μ. In both specimens the lamellae appear to be parallel to (001) with the "exsolved" phase being pigeonite. The average of at least 4 measurements yields values of lamellae thicknesses of 187 ± 8 Å for PHN 1600E4 and 192 ± 12 Å for PHN 1611. The appearance of reflections corresponding to pigeonite in both x-ray single-crystal and electron diffraction photographs is evidence for exsolution. However, the scale of the exsolution microstructures or wavelength indicates that the process occurred rapidly.

From the recent experimental results of McCallister and Yund (in press) on exsolution mechanisms and microstructures in iron-free pyroxenes, it is possible to delineate the (001) coherent spinodal for diopside solid solutions with Ca/Ca+Mg ≥ 0.27. For a Ca/Ca+Mg = 0.317 the (001) coherent spinodal is at 1275°C (see Fig. 1). Above this temperature, although well within the solvus, no exsolution occurred in the experimental runs; below 1275°C, exsolution occurred by spinodal decomposition with a resulting exsolution microstructure remarkably similar to that observed in the natural clinopyroxenes. In an attempt to arrive at a thermal history of the latter specimens, a continuous cooling experiment was made on a synthetic diopside solid solution (Ca/Ca+Mg = 0.317) with a rate of cooling equivalent to 40°C/hr over the temperature range of 1275°C to 1000°C. It is obvious from a recent study by McCallister (in press) that the rate constants associated with the coarsening of a fine-scale exsolution microstructure below 1000°C are sufficiently small, such as to contribute little to the final microstructure. The wavelength of the 40°C/hr experiment is 181 ± 15 Å, which is to be compared with the average of the two natural clinopyroxenes: 190 ± 10 Å. While the similarity in wavelength is apparent, the amplitude of the fluctuations or composition difference as reflected in the respective electron diffraction patterns appears greater for the natural samples, which indicates either a slightly slower cooling rate and/or a difference in kinetics associated with the presences of small amounts of ferrosilite and jadeite molecules in the natural clinopyroxenes. The former of these is currently being investigated; however, assuming that the 40°C/hr run does reflect a value close to the true rate, the samples cooled from 1275°C-1000°C and the microstructure was developed in excess of 7 hours.

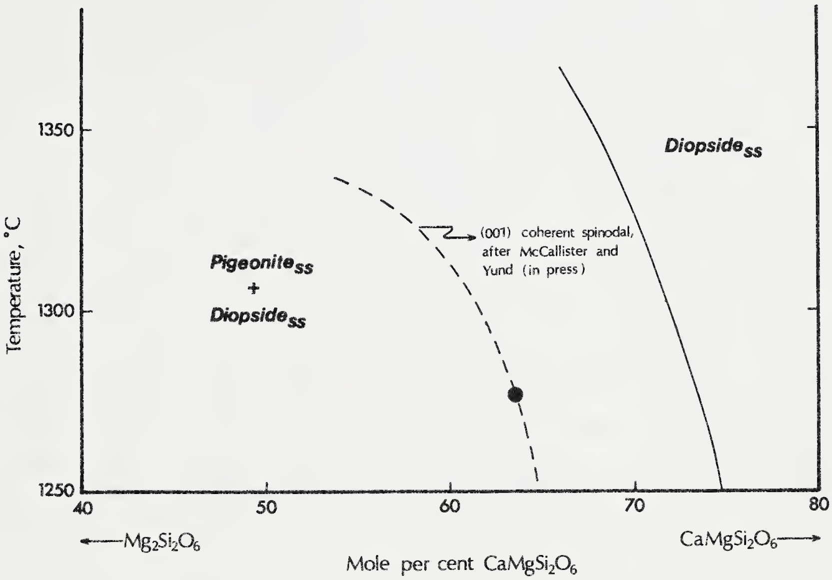

Figure 1. The diopside solid solution solvus on the $CaMgSi_2O_6$-$Mg_2Si_2O_6$ join above 1250°C (Kushiro, 1972). The solid dot: on the coherent spinodal at 1275°C represents the point at which spinodal decomposition is initiated for a clinopyroxene of relatively low ferrosilite content and a Ca/(Ca+Mg) of 0.317.

References

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