

GEOOTHERMOMETRY AND GEOBAROMETRY OF SYNTHETIC SPINEL LHERZOLITE IN THE SYSTEM $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$

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The usefulness of the compositions of pyroxenes coexisting with spinel and forsterite (spinel-lherzolite) for geothermometry and geobarometry has been investigated experimentally in the system $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$. Experiments were performed on glass starting materials in welded (hydrothermal) or folded (anhydrous) platinum capsules with piston-cylinder apparatus. W3Re/W25Re thermocouples were used and all experiments were of piston-out type with no pressure correction. Run durations were 24 to 141 hours. Phases were identified and analyzed with an electron microprobe. All runs consisted of forsterite + enstatite + diopside + spinel + liquid. Uncertainty in the Ca/Ca + Mg ratios of the diopside is less than or equal to 0.001, and the uncertainty of the Al_2O_3 content of the enstatite is a maximum of ± 0.4 weight percent.

Presnall (1976) suggested that the Al_2O_3 content of enstatite in synthetic spinel-lherzolite may be marginally sensitive to pressure, and thus useful as a geobarometer. In contrast, theoretical studies have indicated that Al_2O_3 isopleths in the spinel lherzolite field are nearly independent of pressure (for example, see Wood, 1975; Obata, 1976). The results of the present study support the conclusions of Presnall (1976). Figure 1 shows Al_2O_3 -isopleths of enstatite in equilibrium with diopside, forsterite, and spinel (spinel-lherzolite assemblage). Even considering the maximum uncertainty of the data, negatively sloping alumina isopleths are needed in order to fit the data. The exact position of the spinel- to garnet-lherzolite transition curve is uncertain (shown as a shaded zone between the limits of published determinations), but it is encouraging that the intersections of our Al_2O_3 -isopleths and the Al_2O_3 -isopleths of enstatite in the garnet-lherzolite field (Akella, 1976) occur in the region of the transition.

Because the isopleths are sloping in P-T space, determination of pressure from the alumina content of enstatite requires accurate knowledge of the temperature of equilibration. In the past, this temperature has usually been estimated by comparing the Ca/Ca + Mg ratio of diopside coexisting with enstatite to the pure end-member Di-En solvus. Al, Cr, Ti, and Na affect the Ca/Ca + Mg ratio of the diopside limb of the pyroxene solvus, but the magnitude of the changes has not previously been examined experimentally. We have determined the effect of aluminum saturation in pyroxenes, with respect to spinel (Figure 2). Compared to the 15 kbar solvus of Lindsley and S. A. Dixon (1976) without alumina, the amount of Di dissolved in the aluminous enstatite changes little or not at all. However, the Ca/Ca + Mg ratios of the alumina-saturated diopside are significantly higher than the two-component diopside. If the temperature of the run at 1275°C were to be determined from the pure end-member solvus, its temperature would be underestimated by approximately 100 degrees, an error so large that the aluminous enstatite geobarometer would be

completely useless. Within the uncertainty limits of our data, the alumina-saturated solvus is insensitive to pressure even though the Al_2O_3 content of diopside and enstatite may vary with fixed temperature. Thus, for essentially four-component spinel-lherzolite, the temperature of equilibration may be estimated from the alumina-saturated solvus using only the $\text{Ca}/\text{Ca} + \text{Mg}$ ratio of diopside; no correction for Al^{+3} is necessary.

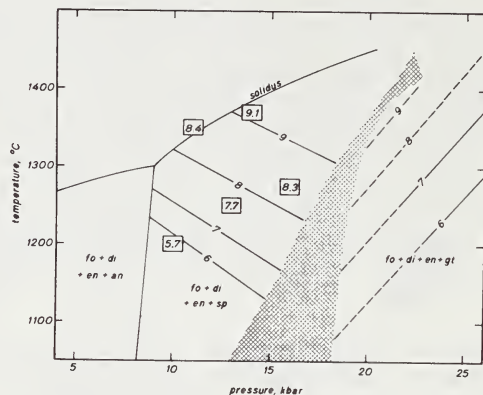


Figure 1. Stability fields of plagioclase-, spinel-, and garnet lherzolite in the system $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$ and Al_2O_3 -isopleths of enstatite. Size of rectangles represents maximum uncertainty of run conditions; number inside is wt. % Al_2O_3 in enstatite. Shaded region indicates limits of published transition curves between spinel- and garnet-lherzolite.

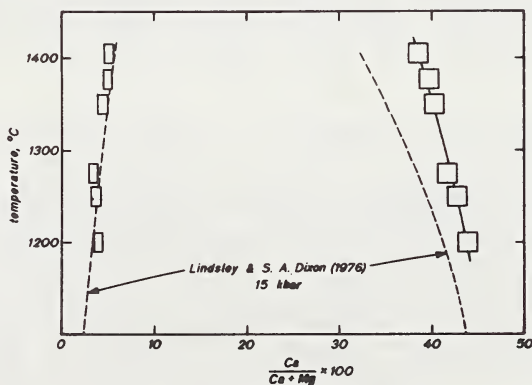


Figure 2. Aluminum-saturated pyroxene solvus compared to the 15 kbar Di-En solvus of Lindsley and S. A. Dixon (1976). Pressures of runs vary between 10 and 17.5 kbar. Size of rectangles represents maximum temperature and compositional uncertainty.

References

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