

Effect of variable carbonate concentration on the solidus of mantle peridotite

RAJDEEP DASGUPTA* AND MARC M. HIRSCHMANN

Department of Geology and Geophysics, University of Minnesota, 310 Pillsbury Drive SE, Minneapolis, Minnesota 55455, U.S.A.

ABSTRACT

To explore the effect of variable CO₂ concentrations on the solidus of natural carbonated peridotite, we determined near-solidus phase relations of three different nominally anhydrous, carbonated lherzolite bulk compositions at 6.6 GPa. Starting mixes (PERC, PERC2, and PERC3) were prepared by adding variable proportions of a carbonate mixture that has the same Ca:Mg:Fe:Na:K ratio as the base silicate peridotite [MixKLB-1: Mg no. = 89.7; Ca no. = molar Ca/(Ca + Mg + Fe*) = 0.05]. For all three bulk compositions, the subsolidus assemblage includes olivine, orthopyroxene, clinopyroxene, garnet, and magnesite solid solutions. Above the solidus, crystalline carbonate disappears and quenched Fe, Na-bearing dolomitic carbonatite melts were observed. For PERC3 (1.0 wt% bulk CO₂; Na₂O/CO₂ weight ratio = 0.30), the observed solidus is between 1190 and 1220 °C; for PERC (2.5 wt% bulk CO₂; Na₂O/CO₂ = 0.12), it is between 1250 and 1275 °C; and for PERC2 (5.0 wt% bulk CO₂; Na₂O/CO₂ = 0.06), it is between 1300 and 1330 °C. At 6.6 GPa, experimental solidi of natural magnesite peridotites are 100–200 °C lower than the CMAS-CO₂ solidus, chiefly owing to the fluxing effect of alkalis, and solidus temperatures increase with increasing bulk CO₂ (i.e., decreasing bulk Na₂O/CO₂), owing to dilution of Na₂O in near-solidus melt. The effects of Mg no. and Ca no. on carbonated peridotite solidi appear to be less significant than that of Na₂O/CO₂. Trends of decreasing solidus temperature with increasing Na₂O/CO₂ and with decreasing CO₂ indicate that natural mantle peridotite with ~100–1000 ppm bulk CO₂ will have solidus temperatures ~20° to ~100° lower than that determined experimentally. The solidus of peridotite drops discontinuously by ~600 °C (at 6.6 GPa) at the CO₂ bulk concentration (~5 ppm) at which carbonate is stabilized, but then varies little with increasing bulk CO₂. This result contrasts with the effect of H₂O, which lowers the solidus continuously with increasing concentration.

Keywords: Carbonated peridotite, carbonatite, mantle solidus, experimental petrology, partial melting