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Revision of the $CaCO_3$–$MgCO_3$ phase diagram at 3 and 6 GPa

Anton Shatskiy[1,2,*], Ivan V. Podborodnikov[1,2], Anton V. Arefiev[1,2], Daniil A. Minin[1,2], Artem D. Chanyshev[1,2], and Konstantin D. Litasov[1,2]

[1]V.S. Sobolev Institute of Geology and Mineralogy, Russian Academy of Science, Siberian Branch, Novosibirsk 630090, Russia
[2]Novosibirsk State University, Novosibirsk 630090, Russia

Abstract

Subsolidus and melting relationships for the system $CaCO_3$–$MgCO_3$ have been reexamined using a Kawai-type multi-anvil apparatus at 3 and 6 GPa in graphite capsules. Phase boundaries were delineated according to the chemical composition of phases measured by electron microprobe in energy dispersive mode and identification of crystal phases by Raman spectroscopy.

At 3 GPa, the dolomite-magnesite solvus intersects the melting loop at about 1250 °C, and the isothermal three-phase line so produced represents the peritectic reaction: dolomite (Ca# 43) = magnesite (Ca# 13) + liquid (Ca# 48), where Ca# = 100·Ca/(Ca+Mg). The melting loop for the $CaCO_3$–$MgCO_3$ join extends from 1515 °C ($CaCO_3$) to 1515 °C ($MgCO_3$) through a liquidus minimum at 1230 °C (near 53 mol% $CaCO_3$). Starting from 1425 °C at ≤30 mol% $CaCO_3$ in the system, the liquid quenches to dendritic carbonate and periclase and contains rounded voids, indicating an incongruent melting reaction: $MgCO_3$ (magnesite) = MgO (in liquid) + CO_2 (fluid and/or liquid).

At 6 GPa, aragonite + magnesite assemblage is stable up to 1000 °C. The reaction aragonite + magnesite = dolomite locates between 1000 and 1050 °C. The presence of dolomite splits the system into two partial binaries: aragonite + dolomite and dolomite + magnesite. The dolomite-magnesite solvus intersects the melting loop between 1400 and 1450 °C, and the isothermal three-phase line so produced represents the peritectic reaction: dolomite (Ca# 31) = magnesite (Ca# 21) + liquid (Ca# 57). The melting loop for the $CaCO_3$–$MgCO_3$ join extends from 1660 °C ($CaCO_3$) to 1780 °C ($MgCO_3$) through a liquidus minimum at 1400 °C and 62 mol% $CaCO_3$.

The compositions of carbonate crystals and melts from the experiments in the carbonated eclogite (Yaxley and Brey 2004) and peridotite (Dalton and Presnall 1998) systems are consistent with the geometry of the $CaCO_3$–$MgCO_3$ melting loop at 3 and 6 GPa: Ca-dolomite melt coexists with Mg-calcite in eclogite and peridotite at 3 GPa and dolomite melt coexists with magnesite in peridotite at 6 GPa.

Keywords: $CaCO_3$–$MgCO_3$, phase relations, high-pressure, magnesite, dolomite, calcite, aragonite, Earth's mantle