American Mineralogist, Volume 109, pages 384–391, 2024

The equilibrium boundary of the reaction $Mg_3Al_2Si_3O_{12} + 3CO_2 = Al_2SiO_5 + 2SiO_2 + 3MgCO_3$ at 3–6 GPa

Yulia G. Vinogradova[1], Anton Shatskiy[1,*], Anton V. Arefiev[1], and Konstantin D. Litasov[2,†]

[1]Vernadsky Institute of Geochemistry and Analytical Chemistry of the Russian Academy of Science, Moscow 119991, Russia
[2]Vereshchagin Institute for High Pressure Physics of the Russian Academy of Science, Troitsk, Moscow, 108840, Russia

Abstract

The stability of CO_2 fluid in the Earth's mantle is restricted by the carbonation of rock-forming minerals. Among those, the reaction with garnet is of particular interest because it constrains the stability of CO_2 fluid in eclogites, whose minerals have been found in the CO_2-bearing diamonds. In this work, we determined the equilibrium boundary for the reaction $Mg_3Al_2Si_3O_{12}$ (Prp) + $3CO_2$ (fluid) = Al_2SiO_5 (Ky) + $2SiO_2$ (Coe/Qz) + $3MgCO_3$ (Mgs) over the pressure interval 3–6 GPa using a multi-anvil press. Owing to the slow kinetics, the reaction was studied in both forward (left to right) and reverse (right to left) directions in experiments with durations extending up to 260 h. Our newly determined boundary is situated 3 GPa/950 ± 50 °C, 4.5 GPa/1150 °C, and 6 GPa/1350 ± 50 °C and has the equation P(GPa) = 0.0075 × T (°C) – 4.125. The boundary crosses the graphite-to-diamond transition curve near 4.7 GPa and 1180 °C. Thus, the assemblage garnet + CO_2 fluid is stable in the diamond (Dia) stability field under P-T conditions of the continental geotherm with a heat flow of 41 mW/m^2.

Keywords: CO_2 fluid, pyrope, carbonation, garnet, phase relations, high pressure, multi-anvil experiments, Earth's mantle