

Effect of alkalis on the reaction of clinopyroxene with Mg-carbonate at 6 GPa: Implications for partial melting of carbonated lherzolite

**ANTON SHATSKIY^{1,2,*}, IVAN V. PODBORODNIKOV^{1,2}, ANTON V. AREFIEV^{1,2}, KONSTANTIN D. LITASOV^{1,2},
ARTEM D. CHANYCHEV^{1,2}, IGOR S. SHARYGIN¹, NIKOLAI S. KARMANOV¹, AND EIJI OHTANI^{1,3}**

¹V.S. Sobolev Institute of Geology and Mineralogy, Russian Academy of Science, Siberian Branch, Novosibirsk 630090, Russia

²Novosibirsk State University, Novosibirsk 630090, Russia

³Department of Earth and Planetary Material Science, Tohoku University, Sendai 980-8578, Japan

ABSTRACT

The reaction between clinopyroxene and Mg-carbonate is supposed to define the solidus of carbonated lherzolite at pressures exceeding 5 GPa. To investigate the effect of alkalis on this reaction, subsolidus and melting phase relations in the following systems have been examined at 6 GPa: CaMgSi₂O₆+2MgCO₃ (Di+2Mgs); CaMgSi₂O₆+NaAlSi₂O₆+2MgCO₃ (Di+Jd+2Mgs); CaMgSi₂O₆+Na₂Mg(CO₃)₂ (Di+Na₂Mg); and CaMgSi₂O₆+K₂Mg(CO₃)₂ (Di+K₂Mg). The Di+2Mgs system begins to melt at 1400 °C via the approximate reaction CaMgSi₂O₆ (clinopyroxene) + 2MgCO₃ (magnesite) = CaMg(CO₃)₂ (liquid) + Mg₂Si₂O₆ (orthopyroxene), which leads to an essentially carbonate liquid (L) with composition Ca_{0.56}Mg_{0.44}CO₃ + 3.5 mol% SiO₂. The initial melting of the Di+Jd+2Mgs system occurs at 1350 °C via the reaction 2CaMgSi₂O₆ (clinopyroxene) + 2NaAlSi₂O₆ (clinopyroxene) + 8MgCO₃ (magnesite) = Mg₃Al₂Si₃O₁₂ (garnet) + 5MgSiO₃ (clinopyroxene) + 2CaMg(CO₃)₂ (liquid) + Na₂CO₃ (liquid) + 3CO₂ (liquid and/or fluid), which yields the carbonate liquid with approximate composition of 10Na₂CO₃·90Ca_{0.5}Mg_{0.5}CO₃ + 2 mol% SiO₂. The systems Di+Na₂Mg and Di+K₂Mg start to melt at 1100 and 1050 °C, respectively, via the reaction CaMgSi₂O₆ (clinopyroxene) + 2(Na or K)₂Mg(CO₃)₂ (solid) = Mg₂Si₂O₆ (orthopyroxene) + (Na or K)₄CaMg(CO₃)₄ (liquid). The resulting melts have the alkali-rich carbonate compositions Na₂Ca_{0.4}Mg_{0.6}(CO₃)₂ + 0.4 mol% SiO₂ and 43 K₂CO₃·57Ca_{0.4}Mg_{0.6}CO₃ + 0.6 mol% SiO₂. These melts do not undergo significant changes as temperature rises to 1400 °C, retaining their calcium number and a high Na₂O, K₂O, and low SiO₂. We suggest that the clinopyroxene–Mg-carbonate reaction controlling the solidus of carbonated lherzolite is very sensitive to the carbonate composition and shifts from 1400 to 1050 °C at 6 GPa, which yields K-rich carbonate melt if the subsolidus assemblage contains the K₂Mg(CO₃)₂ compound. Such a decrease in solidus temperature has been previously observed in the K-rich carbonated lherzolite system. Although a presence of eitelite, Na₂Mg(CO₃)₂, has a similar effect, this mineral cannot be considered as a potential host of Na in carbonated lherzolite, because the whole Na added into the system dissolves as jadeite component in clinopyroxene if bulk Al/Na ≥ 1. The presence of jadeite component in clinopyroxene has little impact on the temperature of the solidus reaction decreasing it to 1350 °C at 6 GPa.

Keywords: Carbonatite, eitelite, K₂Mg(CO₃)₂, partial melting, carbonated peridotite, Earth's mantle, high-pressure experiment