

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

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### **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: CaMgSi<sub>2</sub>O<sub>6</sub>+2MgCO<sub>3</sub> (Di+2Mgs); CaMgSi<sub>2</sub>O<sub>6</sub>+NaAlSi<sub>2</sub>O<sub>6</sub>+2MgCO<sub>3</sub> (Di+Jd+2Mgs); CaMgSi<sub>2</sub>O<sub>6</sub>+Na<sub>2</sub>Mg(CO<sub>3</sub>)<sub>2</sub> (Di+Na<sub>2</sub>Mg); and CaMgSi<sub>2</sub>O<sub>6</sub>+K<sub>2</sub>Mg(CO<sub>3</sub>)<sub>2</sub> (Di+K<sub>2</sub>Mg). The Di+2Mgs system begins to melt at 1400 °C via the approximate reaction CaMgSi<sub>2</sub>O<sub>6</sub> (clinopyroxene) + 2MgCO<sub>3</sub> (magnesite) = CaMg(CO<sub>3</sub>)<sub>2</sub> (liquid) + Mg<sub>2</sub>Si<sub>2</sub>O<sub>6</sub> (orthopyroxene), which leads to an essentially carbonate liquid (L) with composition Ca<sub>0.56</sub>Mg<sub>0.44</sub>CO<sub>3</sub> + 3.5 mol% SiO<sub>2</sub>. The initial melting of the Di+Jd+2Mgs system occurs at 1350 °C via the reaction 2CaMgSi<sub>2</sub>O<sub>6</sub> (clinopyroxene) + 2NaAlSi<sub>2</sub>O<sub>6</sub> (clinopyroxene) + 8MgCO<sub>3</sub> (magnesite) = Mg<sub>3</sub>Al<sub>2</sub>Si<sub>3</sub>O<sub>12</sub> (garnet) + 5MgSiO<sub>3</sub> (clinopyroxene) + 2CaMg(CO<sub>3</sub>)<sub>2</sub> (liquid) + Na<sub>2</sub>CO<sub>3</sub> (liquid) + 3CO<sub>2</sub> (liquid and/or fluid), which yields the carbonate liquid with approximate composition of 10Na<sub>2</sub>CO<sub>3</sub>·90Ca<sub>0.5</sub>Mg<sub>0.5</sub>CO<sub>3</sub> + 2 mol% SiO<sub>2</sub>. The systems Di+Na<sub>2</sub>Mg and Di+K<sub>2</sub>Mg start to melt at 1100 and 1050 °C, respectively, via the reaction CaMgSi<sub>2</sub>O<sub>6</sub> (clinopyroxene) + 2(Na or K)<sub>2</sub>Mg(CO<sub>3</sub>)<sub>2</sub> (solid) = Mg<sub>2</sub>Si<sub>2</sub>O<sub>6</sub> (orthopyroxene) + (Na or K)<sub>4</sub>CaMg(CO<sub>3</sub>)<sub>4</sub> (liquid). The resulting melts have the alkali-rich carbonate compositions Na<sub>2</sub>Ca<sub>0.4</sub>Mg<sub>0.6</sub>(CO<sub>3</sub>)<sub>2</sub> + 0.4 mol% SiO<sub>2</sub> and 43 K<sub>2</sub>CO<sub>3</sub>·57Ca<sub>0.4</sub>Mg<sub>0.6</sub>CO<sub>3</sub> + 0.6 mol% SiO<sub>2</sub>. These melts do not undergo significant changes as temperature rises to 1400 °C, retaining their calcium number and a high Na<sub>2</sub>O, K<sub>2</sub>O, and low SiO<sub>2</sub>. 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 K<sub>2</sub>Mg(CO<sub>3</sub>)<sub>2</sub> compound. Such a decrease in solidus temperature has been previously observed in the K-rich carbonated lherzolite system. Although a presence of eitelite, Na<sub>2</sub>Mg(CO<sub>3</sub>)<sub>2</sub>, 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, K<sub>2</sub>Mg(CO<sub>3</sub>)<sub>2</sub>, partial melting, carbonated peridotite, Earth's mantle, high-pressure experiment