

## Effect of water on carbonate-silicate liquid immiscibility in the system $\text{KAlSi}_3\text{O}_8$ - $\text{CaMgSi}_2\text{O}_6$ - $\text{NaAlSi}_2\text{O}_6$ - $\text{CaMg}(\text{CO}_3)_2$ at 6 GPa: Implications for diamond-forming melts

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### ABSTRACT

To clarify the effect of water on carbonate-silicate liquid immiscibility in the diamond stability field, we performed experiments in the system  $\text{KAlSi}_3\text{O}_8$ - $\text{CaMgSi}_2\text{O}_6$ - $\text{NaAlSi}_2\text{O}_6$ - $\text{CaMg}(\text{CO}_3)_2$  under nominally dry and hydrous conditions by adding 1.5 wt%  $\text{H}_2\text{O}$  at a pressure of 6 GPa and temperatures of 1000 to 1500 °C. Both systems start to melt at 1050–1100 °C. Under anhydrous condition the melting occurs via the following reaction:  $6\text{KAlSi}_3\text{O}_8$  (K-feldspar) +  $6\text{CaMg}(\text{CO}_3)_2$  (dolomite) =  $2(\text{Ca}_n\text{Mg}_{1-n})_3\text{Al}_2\text{Si}_3\text{O}_{12}$  (garnet) +  $\text{Al}_2\text{SiO}_5$  (kyanite) +  $11\text{SiO}_2$  (coesite) +  $3\text{K}_2(\text{Ca}_{1-n}\text{Mg}_n)_2(\text{CO}_3)_3$  (carbonatitic melt) +  $3\text{CO}_2$  (fluid and/or liquid), where  $n \sim 0.3$ – $0.4$ . The carbonatitic melt has the following composition  $38(\text{K}_{0.92}\text{Na}_{0.08})_2\text{CO}_3 \cdot 62\text{Ca}_{0.62}\text{Mg}_{0.38}\text{CO}_3$ . A second immiscible silicic melt containing (in wt%, volatile free)  $\text{SiO}_2 = 68.8$ ,  $\text{Al}_2\text{O}_3 = 12.6$ ,  $\text{CaO} = 3.7$ ,  $\text{MgO} = 2.4$ ,  $\text{Na}_2\text{O} = 1.1$ , and  $\text{K}_2\text{O} = 11.3$  appears at 1250 °C. Both melts remain stable up to 1500 °C and coexist with the clinopyroxene ± garnet ± coesite residue. In the presence of water stored away in phengite, the melting begins with silicic melt, which contains (in wt%, volatile free)  $\text{SiO}_2 = 61.4$ ,  $\text{Al}_2\text{O}_3 = 15.3$ ,  $\text{CaO} = 4.8$ ,  $\text{MgO} = 3.0$ ,  $\text{Na}_2\text{O} = 2.2$ , and  $\text{K}_2\text{O} = 13.3$ , and coexists with phengite, dolomite, clinopyroxene, and coesite. The phengite + dolomite assemblage remains to 1100 °C and disappears at 1200 °C producing two immiscible melts carbonatitic with approximate composition,  $19(\text{K}_{0.89}\text{Na}_{0.11})_2\text{CO}_3 \cdot 81\text{Ca}_{0.57}\text{Mg}_{0.43}\text{CO}_3$ , and silicic containing (in wt%, volatile free)  $\text{SiO}_2 = 63.3$ ,  $\text{Al}_2\text{O}_3 = 15.6$ ,  $\text{CaO} = 4.5$ ,  $\text{MgO} = 3.0$ ,  $\text{Na}_2\text{O} = 2.0$ ,  $\text{K}_2\text{O} = 11.6$ . The present results imply that partial melting of continental material subducted to a depth of 200 km can yield simultaneous formation of two immiscible melts, K-dolomitic and K-aluminosilicate. Under dry conditions, carbonatitic melt appears earlier (at a lower temperature). Given the low density and high mobility of this melt, it must rapidly percolate upward, leaving a refractory eclogite-like residue and leaving no chance for the formation of a second aluminosilicate melt. However, under hydrous conditions silicate melt appears earlier than carbonatitic melt, leaving a phengite- and dolomite-bearing residue, which finally yields the formation of two immiscible silicic and carbonatitic melts. The compositions of these melts fall in the compositional range of carbonatitic and silicic high-density fluids (HDFs) in diamonds worldwide. Thus, we suggest that the presence of water is a necessary requirement for the formation of immiscible HDFs inclusions in diamonds, and this suggestion is strongly supported by natural data from HDFs.

**Keywords:** Carbonate-silicate liquid immiscibility, K-feldspar, phengite, carbonated pelites, high-density fluids, diamond formation, high-pressure experiment, Earth's upper mantle; New Advances in Subduction Zone Magma Genesis