

Phase relations and liquid immiscibility in KAlSi_3O_8 - and $\text{CaMg}(\text{CO}_3)_2$ -bearing systems at 6 GPa: Implications for origin of fibrous diamonds

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The reaction between potassium feldspar (Kfs) and dolomite (Dol) could define the solidus of carbonated pelite below 7 GPa under nominally anhydrous conditions (Grassi and Schmidt, 2011). To investigate this reaction subsolidus and melting phase relations in the systems $\text{KAlSi}_3\text{O}_8 + \text{CaMg}(\text{CO}_3)_2$ (Kfs + Dol), $\text{KAlSi}_3\text{O}_8 + \text{CaMgSi}_2\text{O}_6 + \text{NaAlSi}_2\text{O}_6 + \text{CaMg}(\text{CO}_3)_2$ (Kfs + Di + Jd + Dol), and $\text{KAlSi}_3\text{O}_8 + \text{Na}_2\text{CO}_3 + \text{CaMg}(\text{CO}_3)_2$ (Kfs + Na_2 + Dol) have been examined at 6 GPa and compared with those established in dry carbonated pelite (DG2).

In the system Kfs+Dol at 1000 °C, the subsolidus assemblage consists of Kfs and Dol. Besides, Kfs contains numerous inclusions of $\text{K}_2\text{Si}_4\text{O}_9$ wadeite (K-wad), kyanite (Ky), coesite (Coe). At lower temperature 900 °C, Kfs and Dol are not stable and the assemblage includes K-wad, Ky, Coe, aragonite (Arg) and magnesite (Mgs). The system begins to melt at 1100 °C via reaction $6\text{KAlSi}_3\text{O}_8$ (Kfs) + $6\text{CaMg}(\text{CO}_3)_2$ (Dol) = $2(\text{Ca}_n\text{Mg}_{1-n}\text{Al}_2\text{Si}_3\text{O}_{12})$ (Grt) + Al_2SiO_5 (Ky) + 11SiO_2 (Coe) + $3\text{K}_2(\text{Ca}_{1-n}\text{Mg}_n)_2(\text{CO}_3)_3$ (L) + 3CO_2 (F and/or L), where $n \sim 0.3$ - 0.4 , leading to essentially carbonate liquid, L(C), with composition of $32\text{K}_2\text{CO}_3 \cdot 68(\text{Ca}_{0.63}\text{Mg}_{0.37})\text{CO}_3 + 1$ - 2 mol% $\text{SiO}_2 + 0.5$ - 1 mol% Al_2O_3 . Kfs and Dol completely disappear at 1150 °C. Starting from 1300 °C, immiscible silicate melt, L(S), coexists with L(C). L(S) contains (in mol%): 64 SiO_2 , 9 Al_2O_3 , 2 MgO , 2 CaO , 11 K_2O , and 12 CO_2 . The Grt + Coe + Ky + L(C) + L(S) phase assemblage remains stable up to 1500 °C.

Adding Di-Jd clinopyroxene in the Kfs + Dol system does not affect phase relations. At 1000 °C, the subsolidus assemblage is Kfs + CPx + Dol. Kfs is partially replaced by K-wad + Ky + Coe assemblage. Above the solidus at 1150 °C, Cpx, Grt, Ky, Coe coexist with L(C) [$34(\text{K}_{0.92}\text{Na}_{0.08})_2\text{CO}_3 \cdot 66(\text{Ca}_{0.62}\text{Mg}_{0.38})\text{CO}_3 + 3$ mol% $\text{SiO}_2 + 1$ mol% Al_2O_3]. L(S) appears at 1250 °C and contains (in mol%): 67 SiO_2 , 7 Al_2O_3 , 4 MgO , 4 CaO , 1 Na_2O , 7 K_2O , and 10 CO_2 . The Cpx + Grt + Ky + Coe + L(C) + L(S) phase assemblage was established at 1250 and 1350 °C, whereas at 1500 °C only CPx remains in coexistence with L(C) and L(S). At 900 °C in the Kfs + Na_2 + Dol system, the subsolidus assemblage consists of Cpx ($\text{Jd}_{87-90}\text{Di}_{10-13}$), $(\text{Na}_{0.55}\text{K}_{0.45})_2\text{Mg}_{0.90}\text{Ca}_{0.10}(\text{CO}_3)_2$ (NaKMg), $(\text{Na}_{0.63}\text{K}_{0.37})_2(\text{Ca}_{0.93}\text{Mg}_{0.07})_3(\text{CO}_3)_4$ (NaKCa₃), Coe, and Mgs. As temperature increases to 1000 °C, NaKMg and NaKCa₃ disappear, while minor amount of Mgs and Coe remains. The sample consists of Cpx ($\text{Jd}_{78}\text{Di}_{22}$) and L(C) [$44(\text{Na}_{0.51}\text{K}_{0.49})_2\text{CO}_3 \cdot 56\text{Ca}_{0.57}\text{Mg}_{0.43}\text{CO}_3$]. Thus, an addition of Na_2CO_3 into the Kfs+Dol system yields formation of Cpx, NaKMg and NaKCa₃ at the expense of K-wad, Ky, Mgs, and Arg. Molar abundances of phases and their compositions change slightly with further temperature increase up to 1500 °C. Thus, Na_2CO_3 causes redistribution of K_2O into carbonate phases, whereas SiO_2 and Al_2O_3 are consumed on jadeite formation: $\text{Na}_2\text{CO}_3 + \text{KAlSi}_3\text{O}_8$ (Kfs or L(S)) = $\text{NaAlSi}_2\text{O}_6 + \text{SiO}_2 + \text{NaKCO}_3$ (L(C)). As a result, immiscible L(S) does not appear in this system.

In dry carbonated pelite (DG2), subsolidus assemblage established at 1000 °C is represented by Cpx, Grt, Ky, Coe, Dol, and $\text{K}_2\text{Ti}_{1-n}\text{Si}_{3+n}\text{O}_9$ wadeite. Two immiscible liquids were established at 1350 and 1500 °C in coexistence with Cpx, Coe, Grt, Ky and CO_2 fluid. At 1350 °C, L(S) contains (in mol%): 56.6 SiO_2 , 1.8 TiO_2 , 8.3 Al_2O_3 , 2.9 FeO , 1.3 MgO , 3.2 CaO , 1.4 Na_2O , 9.7 K_2O , and 15.0 CO_2 , whereas L(C) composition is $(\text{K}_{0.74}\text{Na}_{0.26})_2(\text{Ca}_{0.58}\text{Mg}_{0.18}\text{Fe}_{0.24})_4\text{CO}_3 + 4.2$ mol% $\text{SiO}_2 + 1.7$ mol% $\text{TiO}_2 + 1.4$ mol% Al_2O_3 .

The obtained immiscible L(C) and L(S) resemble compositions of melt inclusions in fibrous diamonds worldwide. Thus, the K-aluminosilicate and K-Na-rich carbonatite melts entrapped by fibrous diamonds

could be derived by liquid immiscibility during partial melting of carbonated pelite subducted down to 180 km depth and heated to 1300 °C or higher temperature.

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