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Formation of Garnet and Dense CO_2-Fluid in Liquid-Phase Reaction in the $NaAlSi_2O_6$ – $CaCO_3$ Join at Pressure of 7.0 GPa: Implication for Evolution of Mantle Carbonatites

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$NaAlSi_2O_6$ (jadeite) – $CaCO_3$ join of the $NaAlSiO_4$ (nepheline) – $CaCO_3$– $MgCO_3$ – SiO_2 system is chosen for experimental study at high pressure of 7.0 GPa and temperatures compatible with mantle geotherms and conditions of diamond formation. $CaCO_3$ is among representative carbonate components of mantle carbonatites, fluid-carbonatite primary inclusions in diamonds and mantle minerals, and forms a groundmass material in unaltered kimberlites. Jadeite is stable under high mantle pressures and known as a key component of omphacite clinopyroxene. Experimental study of chemically similar $NaAlSi_3O_8$ (albite) – $CaCO_3$ join was carried out at pressures up to 2.5 GPa, and the effect of carbonate-silicate liquid immiscibility reported (Lee, Wyllie, 1996).

Melting phase relations in the $NaAlSi_2O_6$ – $CaCO_3$ join were studied at 7.0 GPa and 1000 – 1600^{o}C using high-pressure "anvil-with-hole" apparatus calibrated against the diamond-graphite equilibrium curve. New reaction of jadeite and Ca-carbonate components is revealed for jadeite-rich compositions. The reaction is initiated by the formation of carbonate melts at over solidus temperatures. Preliminary equation of the reaction may be expressed as $2NaAlSi_2O_6$ (solid) + $3CaCO_3$(melt) = $Ca_3Al_2Si_3O_{12}$ (solid) + Na_2CO_3(melt)+ SiO_2 (solid) + $2CO_2$ (fluid). The formation of garnet of grossular ($Ca_3Al_2Si_3O_{12}$) composition occurs in the result of jadeite dissolution inside liquid carbonate droplets. We observed single-crystal grossulars inside each of these carbonate droplets (the sequence of grossular growth is documented by a SEM

study). In the course of the reaction, a dense CO_2-fluid seems to be released and dissolved in Ca-Na-carbonate liquid. The reaction under discussion is of interest as an example of chemical mechanism of formation of mantle carbonatite melts saturated with dissolved dense CO_2-fluid. In the course of carbonatitic magmas chemical evolution and a change of P-T conditions, the dense CO_2-fluid might escape and form its own fluid phase. Perhaps, this mechanism is realized in kimberlite magmas during their explosive upwelling.

For compositions of the experimental $NaAlSi_2O_6$ – $CaCO_3$ join rich in $CaCO_3$-component, melting relations at 7.0 GPa are characterized by the effect of complete carbonate-silicate liquid miscibility (aragonite is a liquidus phase). The experimental results show essential influence of high pressure on chemical and phase reactions in the mantle carbonatite systems. Support: RFBR and SciTech Ministry grant 04-05-97220, RAS program on high-pressure research (2005/#7).