

PHASE EQUILIBRIA IN ULTRA-POTASSIC SYSTEMS AT HIGH PRESSURES

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We present a review of recent experimental data on phase equilibria with participation of ultra-potassic (> 10 wt. % of K_2O) aluminosilicate, carbonate-silicate, and chloride-silicate melts at $P > 3$ GPa. These melts are three major constituents of liquids included in diamonds from kimberlites [1].

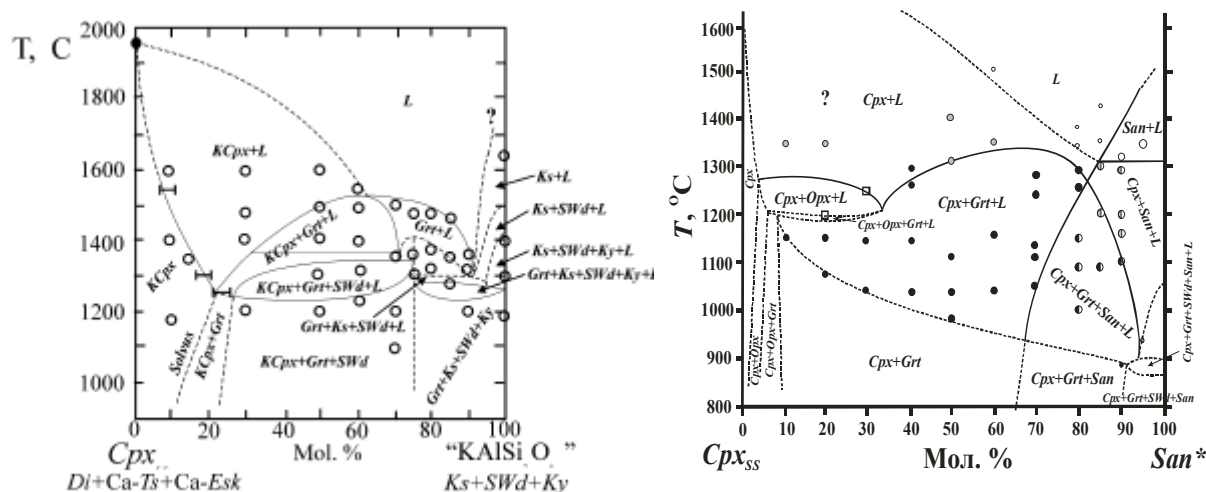


Fig.1. Preliminary phase diagrams for the pseudo-binary joins $\text{CaMgSi}_2\text{O}_6\text{-KAlSi}_2\text{O}_6$ at 7 GPa [2] and $\text{CaMgSi}_2\text{O}_6\text{-KAlSi}_3\text{O}_8$ at 6 GPa. *Cpx* – clinopyroxene (*KCpx* – potassium-bearing clinopyroxene); *Grt* – garnet, *Ks* – kalsilite, *Ky* – kyanite, *Opx* – orthopyroxene, *San* – sanidine, *SWd* – Si-wadeite.

The characteristic phase of the ultra-potassic systems is potassium-bearing clinopyroxene (*KCpx*). This mineral crystallizes at liquid of aluminosilicate and carbonate-silicate systems. The K₂O content in Na-free *KCpx* reaches 5.0-5.6 wt. % (23-25 mol. % of KAlSi₂O₆ or *KJd*) at 7 GPa [2, 3] (Fig. 1a). Presumably, it is the maximal *KJd* content in Na-Fe-free *KCpx* at least for 7 GPa, since at higher *KJd* content the *KCpx* solid solution is unstable being replaced by garnet+K₂Si₄O₉ [2]. Concentration of K clinopyroxenes irregularly decreases with decompression (Fig. 2). However, the K₂O content of 0.5-1.5 wt. %, known for eclogitic clinopyroxenes, can be reached at pressures about 5-6 GPa in equilibrium with the ultra-potassic melts. Cooling assists to accumulation of K in clinopyroxene. Jadeite (*Jd*) and Ca-Tschermak (Ca-*Ts*) components strongly limit the *KJd* content in *KCpx* (Fig. 2).

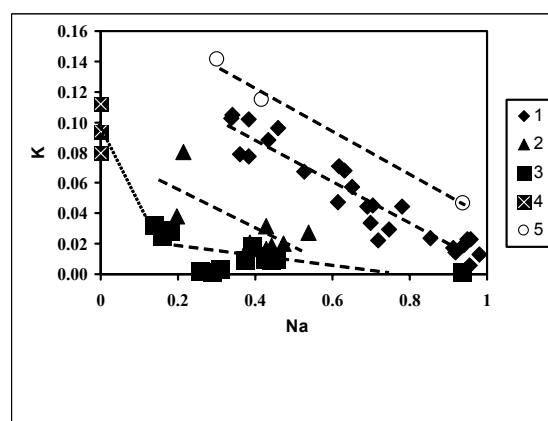


Fig.2. The influence of pressure and the limiting influence of the jadeite component on the K substitution into omphacites at 7 GPa (1), 6 GPa (2), 5 GPa (3) [see 4 for details]. Data for 10 GPa (5) are for the carbonate-bearing system [5]. Dashed lines illustrate the limiting influence of *Jd* on solubility of *KJd*. Dotted line shows a relative abrupt increase of the *KJd* solubility in Na-free *KCpx* at 5 GPa (4). Similar leap is observed at 7 GPa as well [2]. Deviation of some data points from the isobar 5 GPa reflects a limiting effect of Ca-*Ts* component on the K substitution into clinopyroxene.

The contents of Ca-*Ts* and Ca-Eskola (Ca-*Esk*) molecules in *KCpx* produced in the ultra-potassic aluminosilicate systems are very similar to those in natural *KCpx*. Their concentrations in *KCpx* de-

pend on P and the composition of the coexisting melts. «Dilution» of the aluminosilicate melts by carbonates or chlorides, as well as decompression, result in the decrease of the Ca-*Esk* content, which is accompanied by the increase of the Ca-*Ts* concentration. Decompression produces a specific zoning in *KCpx*: the increase of the Ca-*Ts* component from cores of crystals toward their rims at expense of the *KJd* and Ca-*Esk* end-members.

Cooling of the ultra-potassic aluminosilicate and carbonate-silicate liquids at $P > 4$ GPa results in crystallization of Ca-rich garnet (20-50 mol. % of grossular) along with *KCpx* (Fig. 1a, b). Sanidine appears at $P < 6.5$ GPa only from «dry» aluminosilicate melts, containing above 70 mol. % KAlSi_3O_8 (Fig. 1b). At lower KAlSi_3O_8 content in the system, sanidine is unstable, while potassium accumulates in *KCpx*. Cooling at constant pressure (for example 6 GPa; Fig. 1b) results in partial decomposition of sanidine to form *KCpx* via the pseudo-peritectic reaction sanidine + melt = *KJd* (in *KCpx*) [6].

Ultra-potassic aluminosilicate melts are immiscible with the KCl-rich liquids at 4-6 GPa (Fig. 3). The Cl content in ultra-potassic aluminosilicate melts equilibrated with the KCl-rich liquid reaches 3 wt. % at 1300°C, but significantly decreases with pressure within 4-6 GPa (Fig. 4). The P - T dependence of the Cl wt. % in the KCl-saturated aluminosilicate melt is approximated by equation: $\text{Cl (wt. \%)} = -40.064(\pm 15.34) - 0.757(\pm 0.42)P^2 + 6.809(\pm 4.24)P + 0.022(\pm 0.005)T$ ($r^2=0.95$) for the range 4-6 GPa and 1150-1300°C. Carbonate-silicate melts do not show liquid immiscibility at these parameters [7].

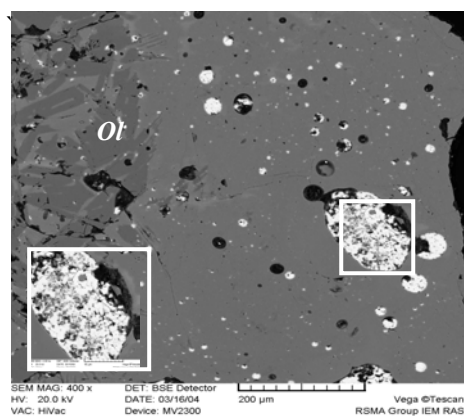


Fig.3. Liquid immiscibility between the potassic aluminosilicate melt (gray matrix) and the KCl-rich liquid (light globes) at 4 GPa; the inset shows a texture “globe-in-globe” clearly indicating liquid immiscibility.

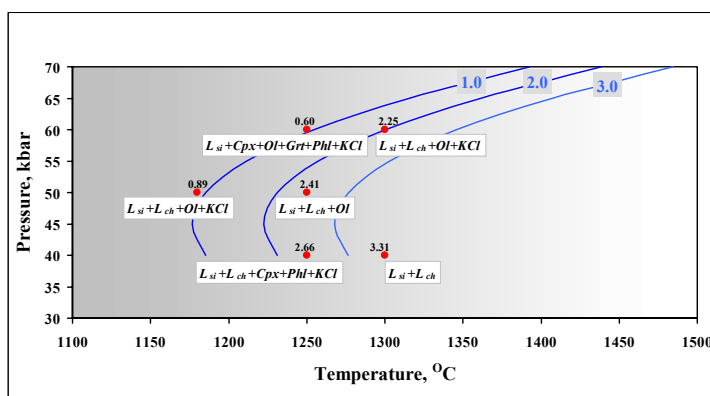


Fig.4. Preliminary data on the Cl content in the aluminosilicate melt equilibrated with the KCl-rich liquid at 4-6 GPa (see Fig. 3). Isopleths present the least square approximation of the experimental data indicated with figures (Cl, wt. %). L_{Si} – silicate melt, L_{Ch} – KCl-rich liquid, *Ol* – olivine, *Phl* – phlogopite, *Cpx* – clinopyroxene, *Grt* – garnet.

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