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Eclogite-associated potassic silicate melts and chloride-rich fluids in the mantle: a possible connection

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Relics of potassium-rich (4–14 wt. % of K_2O and $K_2O/Na_2O > 1.0$) melts are a specific features of some partially molten diamondiferous eclogite xenoliths in kimberlites worldwide [1, 2]. In addition, potassic silicic melt inclusions with up to 16 wt. % of K_2O are associated with eclogite phases in kimberlitic diamonds (O. Navon, pers. comm.). According to available experimental data, no such potassium contents can be reached by "dry" and hydrous melting of eclogite. These data point to close connection between infiltration of essentially potassic fluids, partial melting and diamond formation in mantle eclogites [2]. Among specific components of these fluids, alkali chlorides, apparently, play an important role. This conclusion follows from assemblages of the melt relics with chlorine-bearing phases in eclogite xenoliths [1], findings of KCl-rich inclusions in diamonds from the xenoliths [3], and concentration of Cl up to 0.5-1.5 wt. % in the melt inclusions in diamonds. In this presentation, we review our experimental data on reactions of KCl melts and KCl-bearing fluids with model and natural eclogite-related minerals and assemblages.

Experiments in the model system jadeite(±diopside)-KCl(±H_2O) at 4-7 GPa showed that, being immiscible, chloride liquids provoke a strong K-Na exchange with silicates (jadeite). As a result, low-temperature ultrapotassic chlorine-bearing (up to 3 wt. % of Cl) aluminosilicate melts form. These melts is able to produce sanidine, which is characteristic phase in some partially molten eclogites. In addition, in presence of water Si-rich Cl-bearing mica (Al-celadonite-phlogopite) crystallizes in equilibrium with sanidine and/or potassic melt and immiscible chloride liquid. This mica is similar to that observed in some eclogitic diamonds bearing chloride-rich fluid inclusions [4], as well as in diamonds in partially molten eclogites [2].

Interaction of KCl melt with pyrope garnet also produce potassic aluminosilicate melt because of high affinity of Al and Si to potassium. Additional products of this interaction are spinel and, possibly, olivine. These minerals are common products of garnet breakdown within the zones of partial melting of eclogite xenoliths [1, 2].

It is evident that simultaneous action of fluid species (H_2O, CO_2) and chlorides would produce much stronger effect. Following to this assumption, we further performed experiments on melting of model and natural eclogites with participation of the H_2O-CO_2-KCl fluids at 5 GPa. Comparison with the KCl-free melting (i.e. H_2O-CO_2 fluid only) shows that addition of KCl to the fluid intensifies melting. This effect is related both to high Cl content (up to 3-5.5 wt. %) in the newly formed silicate melt and its enrichment in K_2O via K-Na exchange reactions with the immiscible chloride melt. Owing to these reactions, the ratio K_2O/Cl in the melts increases with the increase of the KCl content in the system and reaches 2.5-3.5 in the melts coexisting with immiscible chloride liquids. However, the KCl/(H_2O+CO_2) ratio in the fluid does not influence on the K_2O/Cl ratio in the melts suggesting that solubility of KCl in the melts practically does not depends on a presence of the H_2O-CO_2 fluid.

Thus, the experiments imply that the KCl-bearing fluids or aqueous(±carbonic) KCl liquids could serve as a possible factor assisting to formation of the K-rich Cl-bearing aluminosilicate melts during the eclogite melting in the mantle. In turn, it means that the KCl content in such rock-melt-fluid systems could exceed 5 wt. %.

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