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Experimental model for alkalic chloride-rich liquids in the upper mantle.

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Kimberlites and xenoliths in them locally show mineralogical evidences for activity of alkalic Cl-bearing liquids [1, 2], while inclusions in kimberlitic diamonds provide information on their compositional variations [3]. The alkalic liquids can be described as mixtures of silicate, carbonate, and chloride end-members [3]. Compositional trends connecting carbonate-rich inclusions with silicate-rich and chloride-rich ones imply genetic interrelation between these liquids and their possible origin from a single source [1]. Lack of trends between carbonate-silicate and carbonate-chloride liquids suggest that their evolution in the upper mantle is controlled by liquid immiscibility [3, 4].

Our experiments in the chloride-carbonate-silicate systems at 5 GPa have substantiated this model [4]. Although melts within the carbonate-silicate and chloride-carbonate boundary joins are homogeneous liquids, the immiscibility in the chloride-silicate boundary join results in the miscibility gap between Cl-saturated carbonate-silicate è Si-saturated chloride-carbonate melts in the ternary system. Precipitation of silicates at liquidus within a wide compositional interval shifts compositions of coexisting liquids along the gap boundaries toward the low-temperature alkali-carbonate region, while the miscibility gap becomes narrower expanding the compositional range of the homogeneous chloride-carbonate melt coexisting with crystalline silicates. This model is also available for the system kimberlite-(Na_2CO_3, $CaCO_3$)-KCl. Being immiscible with kimberlite melt at high temperatures, the chloride-carbonate liquid evolves toward the Cl-rich carbonatitic melt during cooling. Contrast between

SiO_2 and Al_2O_3 contents in silicates and chloride-carbonate melt results in “dissolution” of crystalline silicates with formation of Si and/or Al-undersaturated phases (olivine, spinel, periclase). Strong K-Na exchange between jadeite component and chloride-bearing liquid results in active interaction of eclogites with such liquids in comparison to peridotites and pyroxenites.

The experiments allow modeling of regular compositional trends for liquid inclusions in diamonds from Botswana, Brazil, and Yakutia [5-7]. Change in composition of Cl-rich carbonate-silicate melt inclusions from Si-rich varieties toward carbonate-rich ones is interpreted as evolution during cooling. An evolution of the chloride-carbonate inclusions in diamonds from the “Diavik” pipe [8] corresponds to the diamond growth during cooling, as well. K-Cl-rich carbonate liquids in diamonds of the “Udachnaya” pipe [7] are interpreted as the lowest-temperature liquids, which have evolved from the high-temperature carbonate-silicate melts equilibrated with the immiscible chloride-carbonate liquids. The experiments allow new interpretation of “mixed eclogite-peridotite” assemblages and Si-rich micas in diamonds as indicators of mantle rocks interaction with alkalic Cl-bearing liquids.

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