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The role of ultrapotasic liquids in metamorphic diamond genesis

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Experimental studies have revealed that carbonate, silicate-carbonate, silicate melts and COH fluids assist diamond crystallization under high P-T conditions (Sokol et al., 2004 and reference therein). The role of these liquids in the formation of natural diamonds such as in kimberlites and ultra-high pressure (UHP) metamorphic rocks has not yet been well understood. Here we present new data on the role of melts/fluids in the diamond-forming processes that occurred in the UHP rocks from Kokchetav massif. Detailed petrographic and geochemical investigations of polyphase carbonate and silicate inclusions within UHP marbles revealed that such inclusions derive from trapped silicate and carbonate melts that were present during peak UHP metamorphism (Korsakov and Hermann, 2006). The polyphase silicate inclusions contain abundant biotite and K-feldspar that crystallized during cooling of the trapped melt, indicating that the original silicate melt contained high amounts of K. Diamond is often associated with such former melt inclusions, providing evidence that the presence of silicate and carbonate melts promotes diamond growth. This is in agreement with a recent TEM study of microdiamonds from the Kokchetav massif, which revealed the presence of ultrapotasic and carbonatite-like fluid as inclusions in the diamonds (Hwang et al., 2005). The presence of ultrapotasic liquids (without distinction between fluid or melt) was used to explain the presence of K_2O-bearing clinopyroxenes with up to 1.5 wt. % K_2O (Perchuk et al., 2002). In the fluid-absent systems similar clinopyroxenes were synthesized only at P=10-12 GPa (Harlow and Davies, 2004). Such extremely high-pressure conditions have not been found so far for Kokchetav massif and P=4-6 GPa and T=950-1100ºC are the most reasonable P-T estimates of peak meta-

morphism (Sobolev and Shatsky, 1990; Shatsky et al., 1995; Hermann et al., 2001; Hermann, 2003; Korsakov et al., 2002; 2004). We suggest that such K-rich clinopyroxene can form at conditions reached by the Kokchetav massif as reaction product of ultrapotassic silicate melts with dolomite. While it is now evident that silicate and carbonate melts assist formation of metamorphic diamonds, it seems that additional prerequisites are needed. It is well known that diamond-bearing and diamond-free lithologies alternate within the Kokchetav massif (Shatsky et al., 1995; Ogasawara et al., 1997, Sobolev et al., 2001, Schertl et al., 2004). Even in diamond bearing rock-types, the diamond distribution is highly heterogeneous. Ogasawara et al. (1997) suggested that the composition of fluid phase (X_{CO2}) buffered by the mineral assemblage plays a crucial role for the presence or absence of diamond in marbles and calc-silicate rocks. Our findings of hydrous silicate and carbonate melts in such rock types makes it very difficult to estimate the activity of volatile species such as H_2O and CO_2 in the fluid phase that was present during diamond formation. Contrary to diamond, the K-rich clinopyroxenes are homogeneously distributed within diamond bearing marbles, but may be lacking in adjacent lithologies in a millimeter scale. This fact indicates that ultrapotasic liquids (fluid/melt) were present only in restricted zones of the marbles. The homogeneous distribution of the key minerals garnet, K-rich clinopyroxene and carbonate within such zones with heterogeneous diamond distribution indicates that the fluid compositions were buffered at least in small sample volumes ($<1 \text{ mm}^3$). Korsakov and Hermann (2006) proposed that hydrous granitic melts formed in adjacent metapelites and penetrated into carbonate rocks producing K_2O-bearing clinopyroxene, garnet and carbonate melts. De Corte et al. (2000) have shown that the carbon isotope composition of diamond is intermediate between the value of carbonate and organic matter and hence they concluded that the presence of graphite, carbonate and fluid/melt were an absolutely prerequisite for diamond formation. This observation in conjunction with our new discovery of carbonate and silicate melts provides evidence that diamond-forming processes took only place within the parts of the rocks that contained graphite and interacted with ultrapotasic silicate and/or carbonate melts. This work was supported by Russian Foundation for Basic Research (04-05-64360), MK-1041.2004.5.