

DIFFERENT SOURCES OF KIMBERLITES AND CARBONATITE PARENT MAGMAS: EVIDENCE FROM HIGH PRESSURE EXPERIMENTS AND TRACE ELEMENT GEOCHEMISTRY.

I.D.Ryabchikov

Institute for Geology of Ore Deposits (IGEM), 35 Staromonetny
Per., Moscow 109017, Russia

An attempt was made to test the model which is capable of explaining the extreme differentiation of REE in kimberlites and lamproites. This model invokes the formation of small fraction melt in sublithospheric mantle, its transfer into lower continental lithosphere and second-stage melting of this enriched lithospheric material. Such sequence of events is likely to happen during the ascent of deep seated hot diapir: it reaches its solidus buffered by the presence of small amounts of volatile constituents during the decompression at some depth below the lithosphere, then volatile-rich near-solidus melt penetrates into the lithosphere and it is immobilized there due to the cooling or reaction with the lithospheric rocks. After this the melting in diapir may cease due to the loss of volatile components, which in turn results in the abrupt increase in solidus temperature. Later, diapir rises to the asthenosphere-lithosphere boundary and causes the heating of the lower part of lithospheric plate. As a consequence, the lithospheric blocks enriched in incompatible and volatile components by the preceding metasomatic event would preferentially suffer partial melting and produce magmas with even more differentiated patterns of incompatible elements. Similar mechanism was proposed to explain the geochemical characteristics of posterosional Hawaiian magmas (Watson, 1993).

The ranges of the extent of melting of enriched lithospheric and enriched lithospheric material (F1 and F3), the fraction of diapir-derived melt added to the lower lithosphere (F2) and fraction of garnet (FGa) in the enriched lithospheric material, from which kimberlite magma was derived, have been estimated on the basis of the modelling REE patterns in kimberlites.

The observed REE contents in kimberlite require that the primary melt be equilibrated with harzburgitic residual mineralogy. This is consistent with experimental data on the melting relations in carbonated peridotites and also with the suggested role of refractory harzburgites as traps for the near- solidus melts transporting incompatible elements (Ryabchikov et al, 1993b; Ryabchikov and Hamilton, 1993).

The compositions of carbonate-rich melts which may be in equilibrium with lherzolite mineral assemblage were studied experimentally at 50 kbar (Ryabchikov et al., 1993a). These results were used together with data (Takahashi, 1986) for dry melting of lherzolite permit to assess the composition of partial melts as the function of CO₂ content in them. The comparison of group IA kimberlite composition with this dependence shows that it is characterized by much lower Ca contents as compared to lherzolite equilibrated melts, which

implies that silicate liquids of these model compositions are more likely to be equilibrated with residual harzburgite. Similar conclusion may be reached on the basis of near-liquidus mineralogy in experiments on CO₂-saturated melting of the composition similar to group IA kimberlites (Brey et al., 1991): up to 40 kbar olivine only was observed as near liquidus mineral, and at higher P_{CO2} the appearance of orthopyroxene should be expected due to the carbonation of olivine.

The selective trapping of low fraction melts transporting incompatible elements from diapir to the overlying lower lithosphere by harzburgites may be due to the significantly higher solidus temperatures of these refractory rocks as compared to nondepleted in magmaphile elements lherzolites. This mechanism was previously proposed (Ryabchikov et al., 1993b; Ryabchikov and Hamilton, 1993) as an explanation of commonly observed confinement of metasomatic enrichment in highly incompatible elements to more refractory types of peridotites. It may be equally applicable also to the redistribution of incompatible elements caused by the migration of silicate melts.

The estimated melt fractions at various stages of the considered complex process were used to assess the behavior of CO₂, K₂O, P₂O₅ and H₂O. The balance of CO₂ during this process implies that primary kimberlite magmas are likely to be generated as carbonate-saturated melts. In this case CO₂ contents in them may approach 30 wt% (Brey et al., 1991). After rising to the depths with pressures below ca 50 kbar kimberlitic melts with 15 -30% CO₂ should evolve gas, and this may trigger fast transportation of the magma to the surface due to the hydraulic fracturing and crack propagation (Brey et al., 1991; Brey and Ryabchikov, 1994). Because in the case of relatively CaO-poor kimberlites it should happen in the depth range where diamond is still stable it may provide for its survival due to the very rapid ascent. By contrast, CaO-rich lherzolite-derived magmas will retain dissolved CO₂ until decompression well beyond the diamond stability field, and they are not likely transporting agents of this mineral. Such melts may be, however, parent magmas for crustal carbonatites.

Brey, G.P., Kogarko, L.N. and Ryabchikov, I.D. 1991. N. Jb. Mineralogie. Mh. H.4, 159-168.

Brey, G.P. and Ryabchikov, I.D. 1994. N. Jb. Mineralogie. Mh., H.10, 449-463.

Ryabchikov I.D., Brey G.P. and Bulatov V.K. 1993a. Petrology 1, 159 - 163.

Ryabchikov, I.D. and Hamilton, D.L. 1993. S. Afr. J. Geol. 96, 143-148.

Ryabchikov, I.D., Orlova, G.P., Senin, V.G. and Trubkin, N.V. 1993b. Mineralogy and Petrology 49, 1-12.

Takahashi, E. 1986. J. Geophys. Res. 91, 9367-9382.

Watson S. 1993. J. Petrol. 34, 763-783.