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Model of kimberlite formation

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The critical goals in recognizing the nature of kimberlites are to find out: (1) the primary composition of melt of these rocks and (2) the principal processes of evolution of primary composition of kimberlites while ascending from mantle depth towards earth surface.

Suppose, that the primary composition of kimberlite melt-fluid was in fact the composition of asthenosphere melt geochemically being close to alkaline-basalt (Hi-μ) saturated with high CO_2. The genetic relation of kimberlites with basaltoids is indicated by a spatial and temporal affinity of their formation (Carlson et al, 2006; Lehmann et al, 2010; Tappe et al, 2012), similarity of the pattern of incompatible elements distribution, presence of megacryst minerals in alkaline basaltoids, Pyr-Alm garnet included, and finally, model calculation of parent melt composition for low-Cr megacryst minerals; it showed this composition to be typical for the alkaline basaltoid (Jones, 1980).

At the asthenosphere level there was differentiation of basaltoid melt-fluid which was responsible for formation of its different parts with varying melt to fluid ratio and possibly varying content of alkalis (K2O).

The outbreak of asthenosphere substance through lithosphere mantle proceeded by different scenarios:

(a) With a noticeable dominance of fluid component kimberlites were formed by the capture and contamination of high-Mg, high-Cr rocks of lithosphere mantle that caused formation of high-Mg kimberlites. That corresponds to model of Russell (2012).

(b) With a considerable proportion of melt phase depending on saturation in fluid there formed magnesium-ferriferous and ferriferous-titaniferous petrochemical types of kimberlites. There is no doubt that in formation of these kimberlite types the contamination of lithosphere material was the case, at the much lower level than in formation of high-Mg kimberlites.

This model logically explains steady differences of petrochemistry of kimberlites making up clusters of different pipes, fields of pipes and even province. The model clarifies presence or absence of low-Cr, high-Ti megacryst association of minerals, with its crystallization proceeding in the melt phase of asthenosphere source of kimberlites.

The role of hybridism in kimberlite emplacement is vivid in considering the features of composition of breccias and massive kimberlites composing pipe and dyke bodies of Kuoiksky field, in particular Obnazhennaya pipe. The former compared to massive varieties the kimberlites show much higher contents of SiO_2, MgO and much lower CaO and CO_2. Massive varieties of kimberlites are more ferriferous and titaniferous. The onset of breccias formation should evidently be attributed to the time of passing kimberlite melt-fluid through the lithosphere mantle. It is triggered by the processes of disintegration and capture of its rocks.

Considering the composition of mantle xenoliths captured by the ascending flow of kimberlite mantle-fluid, the onset of the hybridization process should be referred to the boundary of asthenosphere and mantle lithosphere. The most deep-seated xenoliths are deformed lherzolites, which experienced the direct metasomatic effect of asthenosphere melt (Nixon, Boyd, 1973; Burgess & Harte, 2004). The hybrid nature of kimberlites assumes both the mechanic capture of fragmented material of lithosphere mantle and its inevitable partial assimilation causing a significant change of primary melt composition.