Geophysical Research Abstracts,
Vol. 11, EGU2009-13387, 2009
EGU General Assembly 2009

The composition of Yakutian diamond-forming liquids

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Microinclusions in natural diamonds represent a bulk sample of fluids/melts from which they crystallized [e.g. Navon et al., 1988], and provide a unique opportunity to characterize diamond-forming liquids and to understand their origin and evolution within the mantle. Here we report the composition of microinclusions in Yakutian diamonds (fibrous, cloudy, coated). Diamonds were recovered from several major industrial kimberlite pipes (Udachnaya, Internatsionalnaya, Yubileinaya, Sytyksnskaya, Aikhal) and alluvial deposits (Ebelyakh area).

The major-element compositions of the subsurface microinclusions have been determined using EDS. All analyses are normalized to 100% on a carbon free basis (with excess oxygen for chlorine). Major- and trace-element compositions of the bulk microinclusion populations have been quantitatively analyzed by LA-ICP-MS. The abundances of carbonates, water and silicates in the diamonds were determined by FTIR.

The major-element composition of microinclusions in Yakutian diamonds shows wide variations. Some important inter-element correlations between silica and chlorine content and the water/carbonate ratio of microinclusions are observed. In comparison with the worldwide database, the fluids in most of the studied diamonds define a continuous range of carbonatitic to silicic compositions and only a few fall into the starting interval of the carbonatitic to saline range. The silicic microinclusions are rich in water, SiO2, Al2O3, K2O and P2O5. The silicic end-member, constrained from combined EDS and FTIR data, carries $\sim$80 wt % silicates, 11 wt % water, 6 wt % carbonates and 3 wt % apatite. Carbonatitic microinclusions are rich in carbonate, CaO, MgO and FeO. The carbonatitic end-member comprises 82 wt% carbonates, 12 wt% silicates, 2 wt% water, 2 wt% apatite and 1 wt% halides. Samples with saline components are slightly enriched in water, K2O, Na2O and Cl. The most saline inclusions in Yakutian diamonds consist of 49 wt% carbonates, 25 wt% halides, 12 wt% silicates, 9 wt% water, 3 wt% sulfides and 2 wt% apatite.

The trace-element compositions of the microinclusions are generally similar to those of kimberlites and carbonatites, but there are significant differences in major elements. The bulk analyses of the microinclusions in Yakutian diamonds have smooth PM-normalized patterns for the LILE. Some samples show enrichment in Cs. The relative abundance of K in the fluids is significantly higher than observed in the host kimberlite and carbonatites. The pattern of HFSE in the microinclusions shows some depletion in Ti, Zr and Hf relative to Ta, Nb and Mo. The REE pattern reveals low abundances of the heavy REE and high light REE concentrations. The La/Dy of the microinclusion populations varies widely, gradually decreasing from carbonatitic to silicic compositions. Many samples with carbonatitic composition have a negative anomaly in Y. Yakutian diamonds have low contents of transition metals and most of them are significantly depleted in Ni and Co.

The observed geochemical features are consistent with a genetic link between the diamond-forming fluids and ephemeral carbonatitic liquids (fluids/melts) which sometimes may be precursors of the host kimberlite. These fluids/melts may originate either from the metasomatic influx of volatile agents and/or from partial melting of previously carbonated eclogites and peridotites. Some elemental variations may be explained by the fractional crystallization of such fluids/melts, or mixing between liquids with different compositions. These processes result in diamond formation and kimberlite generation.