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Origin of chloride xenoliths of Udachnaya-East kimberlite pipe, Siberia. Evidence from fluid and saline melt inclusions.

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Introduction

Occurrence of alkali chlorides in kimberlites from the Yakutian diamondiferous kimberlite province (Udachnaya-pipe and Mir) are not rare, however there origin is ambiguous. Several papers have reported the primary magmatic origin of alkali evaporitic chlorides and alkali carbonates from Udachnaya (Kamenetsky et al., 2004, 2006; 2007a, b; Maas et al., 2005). Most recent paper suppose evaporitic source of xenoliths (Sharygin et al., 2007).
This study provides the first extensive database on inclusion associations in halite from chloride xenoliths in kimberlites through: (1) a very detailed microstructural study of saline melt inclusion, from which some of the mechanisms of entrapment can be deduced, (2) the characterization of inclusion compositions in different textural locations within the xenoliths. We described not only fluid and melt inclusions, but cavities, microveins and mineral inclusions, presuming they are rock-forming minerals, important to understand the nature of former salt melts.

Analytical techniques

SEM images were obtained from carbon-coated freshly broken surfaces of inclusions with a scanning electron microscope LEO 143 OVR. Infrared spectra were recorded with a Bruker Vertex 70 FTIR spectrometer fitted with a Hyperion 2000 IR microscope. Laser Raman analyses were performed with a OMARS 89 microspectrometer.

Description of inclusions

We present documentation of fluid and mineral inclusions in halite from 5 dominantly chloride xenoliths (containing more than 80% of halite) of Udachnaya kimberlite pipe. Special sampling have been made to provide the possibility to identify core and rim in two xenoliths. This samples display pronounced differences among the inclusion associations at the core of xenoliths and at the rims that corresponds to different halite generations. Halite generations have been identified in according to distributions of mineral and saline melt inclusions, their composition and structure. These two halite generations have strongly contrasting textural, structural and compositional characters, although some petrographic, mineralogical and chemical features are common to each generation.

Inclusions in the core of chloride xenoliths are similar to the inclusions of thermal metamorphic halite found at the vicinity with dolerite intrusion (Grishina et al, 1992). They consist of isolated inclusions of euhedral crystals $CaCl_2·KCl$, KCl, $CaSO_4$ and water-free CO_2 inclusions of low density.

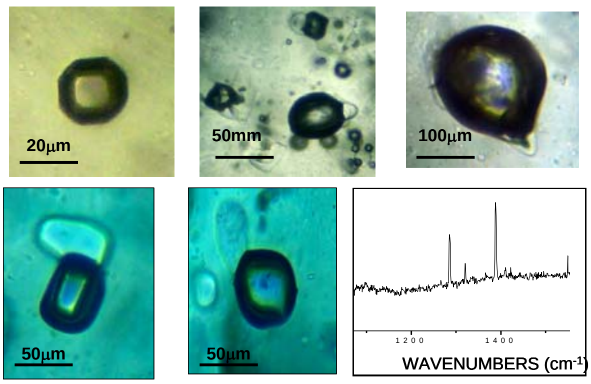

Fig.1 Morphology of CO2 inclusions at the core of xenoliths

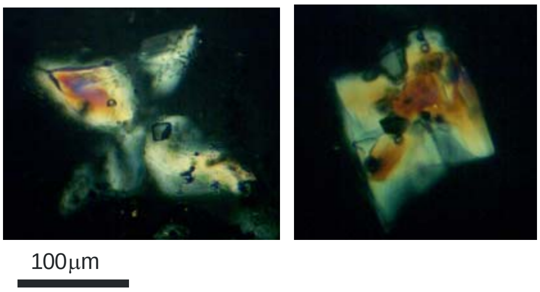

Fig.2 $CaCl_2·KCl$-rich inclusions microphotography in crossed nicoles

Fig. 3. Euhedral mineral inclusions at the core of xenoliths: anhydrite along with $CaCl_2 \cdot KCl$-rich inclusions

Inclusions at the rims of chloride xenoliths and along the fractures in the centre of chloride xenoliths are mostly combined and composed of saline melts and the same type of water-free CO_2 inclusions.

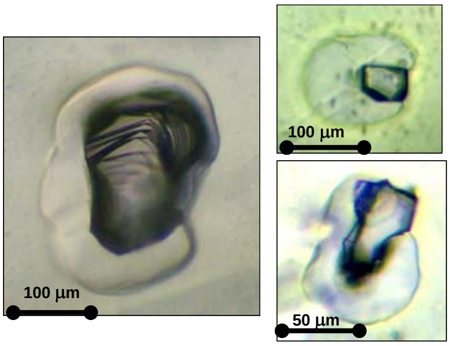

Fig.4 Morphology of CO_2-bearing inclusions at the rim of xenoliths

Inclusions of saline melts consist of several crystalline phases: sylvite, $KCl \cdot CaCl_2$, anhydrite and gas phase. $CaSO_4$-bearing combined inclusions differ in most respects if compare with isolated $CaSO_4$-inclusions at the core of xenoliths. They are characterized by typically mixed potassium-sulphate segregations. These segregations mostly contain sulphate globules and anisotropic phase of $KCl \cdot CaCl_2$ inside sylvite inclusions. Sulphate droplets represent a quenched liquid, resulting from unmixing within the inclusions of a sulphate rich melt into separate KCl- and NaCl-rich phases. Petrography, composition and the sculpture structure of the inclusions are evidence of a high temperature water-absent origin. (Grishina et al., 2007)

Saline melt inclusions at the rim of xenolith

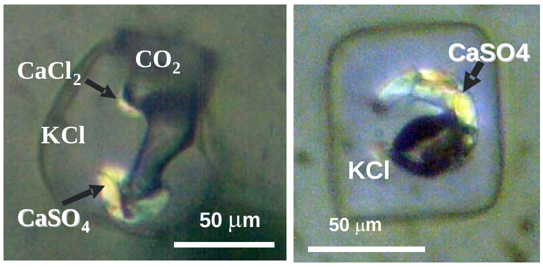

Fig 5 Saline melt $CaSO_4$-$CaCl_2$-KCl –bearing inclusions. Microphotography in crossed nicoles

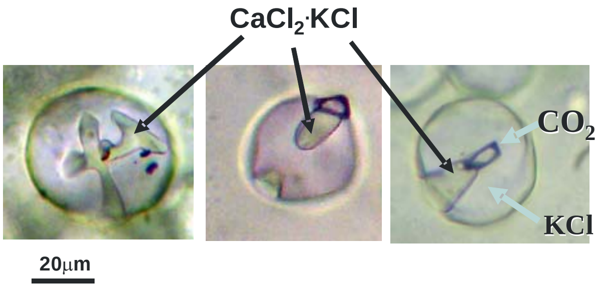

Fig 6 Saline melt $CaCl_2 \cdot$ KCl-KCl –bearing inclusions.

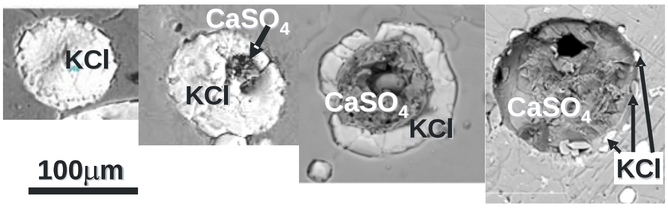

Fig 7 Saline melt $CaSO_4$-KCl –bearing inclusions have rounded shapes and consist mainly of mixed $CaSO_4$-$CaCl_2$-KCl phases with very scattered degree of filling, often enclosing a round anhydrate globule, and gas phase

Microveins (up to 100-500 µm thick) consist of alkali chloride material (KCl and $KCl \cdot CaCl_2$) + cryptocrystalline Si-aggregates, ± anhydrite blebs, ± euhedral amphibole, apatite and ore phases (Fig.8, Fig.9).

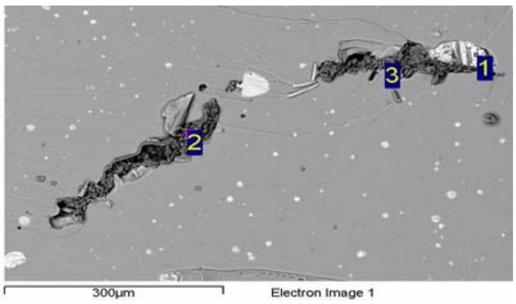

Fig .8

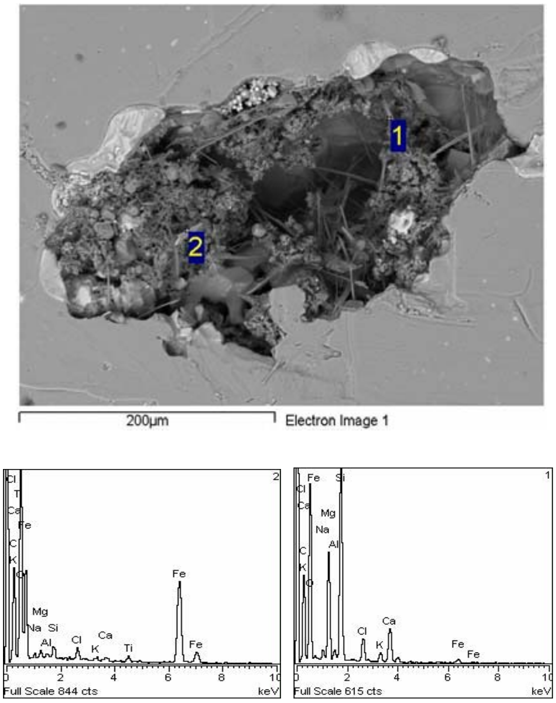

Fig.9

Conclusions

Distribution of inclusion types in chloride xenoliths allows us to identify several events:

- Heating by the host magma producing metamorphic inclusions retained at the core of xenoliths.
- In-situ melting of chlorides leading to heterogeneous trapping of saline melts at the rims of chloride xenoliths and along the fractures.
- Metasomatic reaction between an alkali-carbonated melt and mantle minerals producing combined inclusions in microveins.

We interpret inclusions at the rims and along the fractures of xenoliths as partial melting of crustal halite providing heterogeneous trapping of inclusions.

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