Crystallization conditions of the potassium alkaline melts on the Ryabinovyi massif (Central Aldan, Russia)

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The Ryabinovyi massif is an intricate volcano-plutonic structure (Kochetkov et al. 2006, Kostyuk et al. 1990). It consists of volcanic and vein rocks varied from ultrabasic to more siliceous compositions. The common feature of these rocks is a high alkalinity at pronounced potassium specialization. Several areas of gold mineralization were found within the Ryabinovyi massif (Kochetkov et al. 2006). Micaceous shonkinites are gold hosting, the high-magnesian, Si-undersaturated rocks of the massif with the age - K_1 — K_2. They contain clinopyroxene, Fe-Mg mica, potassium feldspar, albite, apatite, magnetite, sphene and rutile. The rock texture is hypidiomorphic-granular.

Clinopyroxenes are represented mainly by aegirine (Ae) (Fe# = 0.22 - 0.26; Na = 0.12-0.14), less often by subcalcium salite (Sal) (Fe# = 0.36 - 0.42; Na = 0.14-0.19) and subcalcium diopside (Di) (Fe# = 0.36 - 0.6; Na = 0.21-0.55). All clinopyroxenes are significantly enriched by trace elements.

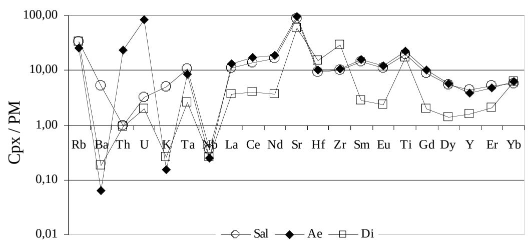

Fig. 1. Primitive mantle-normalized spidergram for grains of clinopyroxene.

Di has lower concentrations of trace elements in contrast with Sal, Ae (Fig.1). Di is different from Sal, Ae in indicator ratios Ce/Yb (2.1 vs. 8-10), Ti/Zr (7 vs. >20), La/Yb (0.81 vs. 2.7-2.9). During crystallization of clinopyroxene from Di to Sal, Ae there was an increase of the LREE relatively to HREE, what is evidence of the increase La/Yb, Ce/Yb ratios from Di to Sal, Ae. In addition, this crystallization for sequence clinopyroxene probably indicates the increase of fO_2, as evidenced by the increase Ti/V ratio from 4 (Di) to 6.7 (Sal, Ae)

Completely crystallized melt inclusions are observed in Sal, Ae. Silicate, silicate-carbonate, carbonate salt and carbonate inclusions were found among them.

Silicate-rich crystallized inclusions in Sal (Fig. 2) contain clinopyroxene, phlogopite, albite (Table 1), and rutile (99.3 mass% TiO_2).

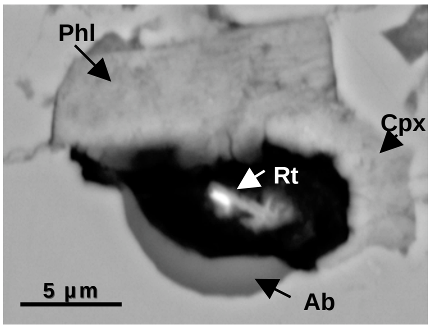

Fig. 2. Silicate-rich inclusion. Cpx – clinopyroxene; Phl – phlogopite; Ab – albite; Rt – rutile.

Component	Cpx	Phl	Ab
SiO_2	54.81	41.94	69.04
Al_2O_3	0.91	12.24	19.50
FeO	12.00	11.74	0.28
MgO	10.16	20.14	-
CaO	18.88	0.19	0.12
Na_2O	3.26	0.10	11.33
K_2O	-	10.09	-
Total	100.20	96.44	100.27

Table. 1 Composition of daughter phases from inclusions, mass%

Silicate-carbonate inclusions in Ae (Fig.3) consist of clinopyroxene, phlogopite (Table 1), and calcite (mass% - 53.48 CaO; 4.25 SrO; 0.52 FeO; 0.11 MnO; 0.12 MgO).

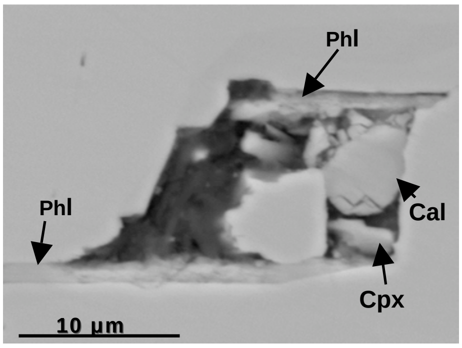

Fig. 3. Silicate-carbonate inclusion. Cal – calcite.

Carbonate-salt inclusions in Sal (Fig. 4) contain of crystals of calcite, alkali chlorides (mass% - 50.59 Cl; 18.48 Na; 9.54 K; 2.28 Ca) and sulphates (mass% - 31.4 SO_3; 29.35 SrO; 48.24 CaO), and sphene (mass% - 38.17 TiO_2; 30.20 SiO_2; 0.45 Al_2O_3; 27.02 CaO; 2.44 Fe_2O_3; 0.14 Na_2O; 0.03 MgO; 0.12 SrO).

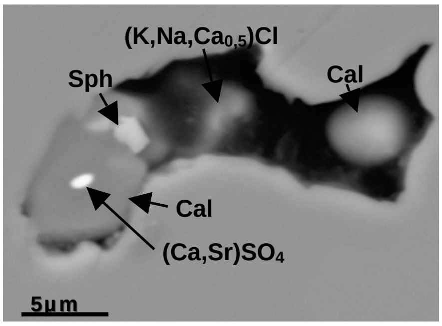

Fig. 4. Carbonate-salt inclusion. Sph – sphene.

Carbonate inclusions in Ae (Fig. 5) are rich in calcite, and portlandite (mass% - 73.64 CaO; 0.41 SrO; 0.6 FeO; 0.04 MnO; 0.09 MgO).

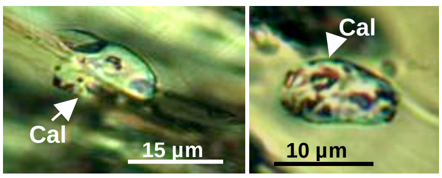

Fig. 5. Carbonate inclusion.

In *silicate*-rich inclusions daughter phases started to melt at above 900-1000 ºC and a gas bubble appeared. At 1150 – 1160 ºC daughter phases melted completely and the gas bubble disappeared. The composition of quenched homogenized glass of inclusion is as follows (mass% - 45.22 SiO_2; 2.48 TiO_2; 3.37 Al_2O_3; 13.93 FeO; 0.41 MnO; 5.62 MgO; 19.23 CaO; 3.84 Na_2O; 1.19 K_2O; 0.4 SrO; 0.84 P_2O_5). In carbonate-salt inclusions salt phases partly melted at 390-420 ºC but above 650 ºC the inclusions decrepitated even at slow increasing of temperature. We failed to completely homogenize such inclusions

Chromatographic analysis showed that fluid in clinopyroxene of shonkinites at 1000 ºC containing mainly CO_2 (3400 mg/kg), H_2O (2500 mg/kg).

Conclusions:

1. Shonkinites crystallized from magmatic melt enriched in CO_2 - H_2O fluid.

2. During crystallization of clinopyroxenes the melt was heterogeneous and represented by immiscible silicate, silicate-carbonate, carbonate-salt, and carbonate fractions. The carbonate-salt and carbonate melts separated from silicate magma were enriched in Ca, alkalies, CO_2, S, Cl and were, undoubtedly, an immiscible carbonatite fraction.

3. Homogenization temperature of silicate inclusions was 1150-1160 ºC, and that of carbonate-salt melts was much higher than 650 ºC.

4. Low-temperature sulphate-chloride and sulphate-carbonate fluids are commonly associated with gold mineralization (Borisenko et al. 2010). Thus, we can assume that on the magmatic stage carbonate-salt melts, which are spatially separated from carbonatite magma, could be transporters of gold.

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