THE EVIDENCE OF UNUSUAL MELTS FROM MELT INCLUSIONS IN POCKET QUARTZ OF THE OKTYABRSKAYA PEGMATITE MINE MALKHAN RIDGE, CENTRAL TRANSBAIKALIA.

SMIRNOV, S. Z.[1], PERETYAZHKO, I. S.[2], ZAGORSKY, V. Ye.[2], MIKHAILO, M. Yu.[1]
[1] IMP SB RAS, Koptyga, 3, Novosibirsk 90, Russia.
[2] IGC SB RAS, Favorskogo, 1a, Irkutsk, Russia.
E-mail: ssmr@uiggm.nsc.ru

Magmatic nature of pegmatites has long been established and traced up to the early stages of pocket formation (Kosukhin et al., 1984). Nevertheless, the information about compositions of the latest pegmatitic melts remains scarce. This is especially true for the pegmatites containing relatively large crystal-bearing cavities (pockets) with rare-metal mineralization. These pegmatites provide good examples of magmatic-hydrothermal transition taking place within a relatively closed system. This paper presents the data on compositions and P-T conditions of the latest pegmatitic melts, entrapped in the roots of pocket quartz crystals of the single pocket cavity of the Oktyabrskaya pegmatite body.

Oktyabrskaya is one of the largest pegmatites, productive for gem tourmaline within Malkhan pegmatite field. It is a 250-m long gently dipping lenticular pegmatite body, up to 17 m thick. The central part of the body contains numerous pocket cavities ranging in volume from tens of cubic centimeters to first cubic meters. Typically, the pocket walls are lined by quartz-K-feldspar-albite mineral complex with subordinate lepidolite and color tourmaline protruding into the cavity as well-formed crystals. The pocket infilling contains various color tourmaline, as well as subordinate pink beryl, hambergite, danburite, mica and clay materials. The material discussed in study was obtained from a small (about 15 cm across) pocket, lined by clevelandite albite-quartz drusy complex with minor lepidolite and accessory cassiterite and apatite. The pocket is surrounded by medium- to coarse-grained oligoclase pegmatite with minor schorl tourmaline and almandine-spessartine garnet.

The quartz grains of oligoclase pegmatite were found to contain very small (1-10 μm) primary melt inclusions (MI), which associate with rare fluid inclusions (up to 15 μm). Larger (up to 100+ μm) crystallized melt inclusions appear in coarse-grained quartz nearby the pocket wall. These inclusions are omnipresent in the roots of the pocket quartz crystals and typically associate with abundant multiphase fluid inclusions (FI).

The MIs typically consist of aggregate of silicate minerals and a fluid isolation. The latter contains water solution, a gas bubble and a daughter sassolite crystal. Silicate/fluid ratio varies significantly even within a single group of MIs, indicating heterogeneous entrapment of coexisting fluid and melt. Silicate phases dominate the MIs in the crystals roots. Raman spectra of MIs without visible fluid isolations, nevertheless, display a prominent line at 880 cm^{-1}. Therefore, daughter sassolite and water solution exist in these inclusions and are distributed within interstices of crystalline aggregate. MIs with well-separated fluid isolations become dominant toward the middle parts of pocket crystals. The MIs have not been observed in the latest zones of studied crystals.

Raman spectroscopy, SEM EDS and EMPA demonstrate that the aggregate of daughter silicate minerals is composed mainly of mica. Some mica crystals appear to have unusually high (up to 20-24 wt. %) Cs_2O content. Taking into account ratios of K_2O, Al_2O_3 and Cs_2O the micas should be considered a mixture of muscovite, nanpingite and probably lepidolite. The minor minerals are topaz, K-feldspar and several undetermined minerals.

The small melt inclusions in pegmatite quartz were homogenized at atmospheric pressure. The first melting occurs ≤ 550-580°C, while total homogenization was observed at 600-650°C. The large MIs in coarse-grained pegmatite and pocket quartz have been re-melted under external water pressure of 2.0-2.5 kbar in an autoclave at 500, 550, 600 and 650±10°C during 14-24 hours. The melting of crystalline aggregate occurs within 550-610°C. After the final quench at 650±10°C the samples contain melt inclusions with glass, unmelted muscovite and topaz, and fluid isolation. The fraction of fluid within re-melted MI varies significantly even within single group of inclusions. Total homogenization was not observed in large inclusions under the experimental conditions applied.

The concentrations of water, major and some trace elements in quenched glasses were measured using EMPA and SIMS microanalysis. The glasses are enriched in Cs, F, B and H_2O, whereas Fe, Mg, Mn, P, and Cl appear to be below the detection limits of the EMPA. K and Cs are dominant alkaline metals, while Li, Na and Rb are minor. SIMS demonstrated that quenched glass contains elevated amounts of Li, Be and extremely high concentrations of Ta and Nb, while Sn and W appear to be below the detection limits. However, even after combination the EMPA and SIMS data, analytical totals remain significantly less than 100%. This could be explained by loss of water during SIMS analysis. Assuming that, water concentration could be estimated up to 12-15 wt. %.

The composition of fluid inclusions and fluid isolations of MI was assessed using the micro-thermometric data. FIs associated with MIs show very wide range of eutectic temperatures (-28 ÷ -6.5°C) and ice melting temperatures from -6.5 to -2.9°C. Several measurements of fluid isolations in MIs display relatively high eutectic (-9.5°C) and ice melting temperatures (-3.7 ÷ -7.6). H_3BO_3 concentrations in FIs and fluid isolations of MIs are estimated at 12-20 and 15-17 wt. % respectively. Salt concentration in NaCl-eq ranges from 5 to 9 wt % in both. Thus, compositions of fluids trapped in FIs and MIs are quite similar. The compositions of fluids in re-melted at 650°C and 2.5 kbar MIs appear to be similar to that of the fluids in the unheated MIs. Meanwhile, gas-water solution homogenization temperatures of re-melted MIs are some 100° higher than those of the unheated MIs. This indicates dissolution of fluid components in the inclusion melt. The homogenization temperature difference demonstrates that in the course of crystallization of MI the pressure should increase from 2.2 to 3.7 kbar when temperature decreases from 615 to 550°C.

According (Kosukhin et al., 1984; Kovalenko et al., 1996) the late melts of the topaz-beryl pegmatites originate from deep differentiation of initial granite pegmatite magmas. However, recent experiments by (Veksler et al., 2002) clearly indicate that at appropriate P-T-X conditions the melts with compositions similar to those determined in this work coexist with water fluids and the so-called hydrosaline melts (that in fact are hydrous alumino-borosilicate melts). Co-genetic FIs and MIs in the coarse-grained pegmatite and pocket quartz indicate clearly coexistence of immiscible hydrous silicate melt and boric acid-water fluid at the final stage of magmatic pegmatite crystallization within at least 650-500°C and up to 4 kbar.

The determined chemical compositions and the domination of micas among daughter crystals provide evidence for unusual composition of late-stage melts, participating in crystallization of pegmatite and pocket quartz. Our data indicate that these unusual melts can accumulate H_2O, B, F in addition to rare granitophyle elements like Cs, Li, Be, Ta and Nb. The concentrations of these elements exceed, by one or two orders of magnitude, the bulk composition of Malkhan pegmatites determined by (Zagorsky and Peretyazhko, $1992_{1,2}$). Concentrations of most major elements in studied MIs are close to the compositions of MIs in quartz from pegmatites of Ehrenfriedersdorf Sn-W deposit, Germany (Thomas et al., 2003). However, the compositions of MIs from the studied pocket differs significantly from the latter pegmatites in higher Cs, Li content along with the absence of Cl, P and Sn. This indicates that compositions of the latest pegmatitic melts may vary significantly.

The most unusual feature of studied melts is lack of consistency between the MI's daughter mineral assemblages and the pocket mineral assemblage. One explanation of this phenomenon is preferential crystallization of quartz from fluid that coexisted with melt. The minerals that crystallized from the melts in this case must be scarce and could be found as crystalline inclusions within coeval growth zones of pegmatite and pocket minerals. However, in some cases these unusual melts could be accumulated in appropriate places of the pegmatite chamber and participate in formation of albite-tourmaline-lepidolite near-pocket complexes with minor pollucite, beryl and several Ta-Nb minerals. Such complexes are typical of a number of pegmatites in the Malkhan field.

The finding of the MIs representing the latest portions of the pegmatite magma capable of concentration of rare metals is very important for investigation of the origin of the ore-forming solutions, derived from granitic magma.

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