POLSKIE TOWARZYSTWO MINERALOGICZNE – PRACE SPECJALNE
MINERALOGICAL SOCIETY OF POLAND – SPECIAL PAPERS
Zeszyt 24, 2004; Volume 24, 2004

Marek Łodziński[1], *Marek Michalik*[2]

MINERAL INCLUSIONS IN BERYL FROM SHERLOVAYA GORA (CHITINSKAYA OBLAST, RUSSIA)

Abstract: Beryls with abundant assemblage of solid inclusions were investigated. Specimens were collected in Sherlovaya Gora in Transbaikalia, from metasomatically altered granites and greisens. Mineral and chemical compositions of inclusions suggest a long-lasting and multi-stage process of beryl crystallization. Three types of beryl crystals were distinguished on the basis of inclusion assemblages. Type I is related to crystallization from highly evolved magma and type II is connected to hydrothermal ore-bearing solutions. Type III devoid of inclusions has not been genetically classified.

Keywords: metasomatosis, alteration, granite, greisen, highly evolved magma, beryl, xenotime, zircon, niobian-tantalian rutile, Fe-Ti-Nb-Ta oxides, Transbaikalia

INTRODUCTION

The aim of the study was to determine mineral inclusions in beryl crystals from Sherlovaya Gora. Gem-quality crystals from this famous locality have been found since XVIII century (Sinkankas, Read 1986).

The Sherlovaya Gora granitioid massif (Transbaikalia, Chitinskaya Oblast) forms together with the Adun-Chilon massif, large igneous body (outcrop surface ca. 40 km^2). Sherlovaya Gora and Adun-Chilon massifs are the shallow and deep part of the same intrusion respectively. Granitic magma was emplaced in Late Jurassic-Early Cretaceous into Palaeozoic schists, cherts and sandstones. Granite from Sherlovaya Gora often exhibits porphyric structure and differs in grain-size (Aristov et al. 1961). It is characterized by low content or absence of mica. Relics of mafic minerals are rare. Smoky quartz is typical of this rock. Granitoids are enriched in F and REE.

Both the Sherlovaya Gora and Adun-Chilon granitic massif were strongly altered metasomatically what resulted in formation of greisen veins and nests. Topaz-bearing subvolcanic rock varieties of porphyric appearance are often referred to ongonites (e.g. Grebenshchikova et al. 1984). According to Grebenshchikova et al. (1984), ore bearing fluids are closely genetically related to ongonites. Kosukhin (1980), on the basis of fluid inclusions study, determined that

[1] *AGH University of Science and Technology, Department of Mineralogy, Petrography and Geochemistry, Al. Mickiewicza 30, 30-059 Kraków, Poland, e-mail: mareklodz@poczta.onet.pl*
[2] *Institute of Geological Sciences, Jagiellonian University, ul. Oleandry 2a, 30-063 Kraków, Poland, e-mail: michalik@geos.ing.uj.edu.pl*

temperature of crystallization of "quartz porphyries" magma was significantly higher than temperature of crystallization of granitoids.

The study area belongs to the Mongol-Okchotsk zone (over 1300 km long) with more than 900 Early to Late Mesozoic granitoid massifs.

SAMPLES AND ANALYTICAL TECHNIQUES

Samples of different colour beryls (blue aquamarines and yellow heliodors) were selected for studies. Hand specimens were collected in small pits near Viershina village (18 km west of the Sherlovaya Gora railway station).

Studied beryls occur in nests, lenses and veins of metasomatically altered granites and greisens in association with smoky quartz, topaz, cassiterite, molibdenite, wolframite and arsenopyrite. The biggest crystals, more than 10 cm in diameter, were found in druses with smoky quartz. Beryl specimens with topaz are rare. Blue aquamarines occur also in sulphide nests with arsenopyrite, scorodite, native bismuth, bismuthinite and bismuthite.

Samples were investigated in terms of optical microscopy, infrared absorption spectroscopy (BIO-RAD FTR 165 spectrometer), Raman spectroscopy (Jobin-Yvon Raman), X-ray diffraction (Philips X`Pert APD diffractometer), chemical analysis (ICP-OES Jobin-Yvon JY36), scanning electron microscopy with energy dispersive spectrometry (HITACHI S-4700 field emission microscope with Thermo NORAN vantage analytical system).

RESULTS

Chemical composition. Beryl crystals from the Sherlovaya Gora can be classified as alkali-poor. The average composition (in wt.%) is: SiO_2 – 64.22; Al_2O_3 – 18.91; BeO – 11.39; Fe_2O_3 – 0.68; MgO – 0.10; Na_2O – 0.054; Cr_2O_3 – 0.036; CaO – 0.031; K_2O – 0.021; TiO_2 – 0.018; Li_2O – 0.006; MnO – 0.004; Rb_2O – 0.002; H_2O^+ (at 1000°C) – 0.94.

Spectroscopic studies. Two orientations of water molecules (I-type and II-type of water) (Wood & Nassau 1967) are visible according to IR and Raman spectra. Molecules of water are incorporated into structural channels in all the studied beryl crystals. At room temperature three diagnostic IR bands of water molecules and OH-groups can be noticed: 3700 cm^{-1} (band A), 3594 cm^{-1} (band B) and 3650 cm^{-1} (band C). Proportion of their relative intensity A>B>>C is typical of alkali-poor beryls.

Mineral inclusions. Three types of beryls can be distinguished according to the composition of mineral inclusion assemblages.

Type I. Mineral inclusions are relatively abundant in crystal margin and often oriented parallel to host crystal edges forming multilayer pattern. Crystal containing inclusions exhibits zonation (with phantoms). Mineral inclusion assemblage includes: xenotime-Yb, zircon, niobian-tantalian rutile, niobian-tantalian ilmenite (?), betafite (?) and other Ti-Fe-Nb-Ta oxides. Xenotime is characterized by low content of U and Th and high content of Yb, Lu, Dy and Er

(Yb_2O_3 up to 12.9 wt%; Lu_2O_3 up to 3.9 wt%; Dy_2O_3 up to 3.6 wt%; Er_2O_3 up to 2.7 wt%). Zircon contains high amount of Hf (HfO_2 up to 9.1 wt%; Zr/Hf ratio within a range 5.1 – 6.5), UO_2 content up to 2.5 wt%; Yb_2O_3 up to 1.5 wt%; Er_2O_3 up to 1.2 wt%. Niobian-tantalian rutile contains WO_3 up to 2.8 wt% and niobian-tantalian ilmenite contains WO_3 up to 5.4 wt%. Fe-Ti-Nb-Ta oxides contain Yb_2O_3 up to 2.1 wt%; Sm_2O_3 up to 0.9 wt%; Er_2O_3 up to 0.7 wt%. Mineral described as betafite contain relatively high amount of Fe (Fe_2O_3 – up to 8.8 wt%). All oxide minerals are characterized by relatively high Mn content.

Type II. Mineral inclusions are rare and their assemblage contains: cassiterite, wolframite (ca. 87-90 mol% of ferberite), sphalerite, pyrite, quartz, zircon rich in U (UO_2 content up to 2.5 wt%), anhydrite and barite (with high Sr content). Inclusions are dispersed in whole volume of crystals or concentrated in their centres. Their distribution is not related to macroscopically visible zonation.

Type III. This type of beryl crystal is devoid of inclusions.

DISCUSSION AND CONCLUSIONS

The presence of three types of beryl crystals (based on assemblages of mineral inclusions) suggests multi-stage process of their crystallization. This conclusion is also supported by variation of internal structure of beryl (zonality expressed in colour variations and distribution of inclusions). Multi-stage and long-lasting crystallization of beryl from pegmatitic stage to relatively low temperature condition has been described elsewhere (Markl, Schumacher 1997, Barton, Young 2002, Černy 2002).

Compositions of mineral inclusion assemblages as well as geological situation indicate that type I is older than type II, assuming decrease of temperature during crystallization. The second type is probably related to ore bearing fluids. Wolframite and cassiterite fill vugs and fissures in brecciated granitoids.

Chemical composition of mineral inclusions in the type I beryl indicates their origin from a highly evolved granite magma. Zr/Hf ratio is close to 5. According to Zaraisky et al. (2001) Zr/Hf ratio below 5 characterizes highly evolved albite-amazonite granites from Transbaikalia. Hf-rich zircon is typical of rare-metal-bearing granites and pegmatites with Nb, Ta, and Sn minerals (Kempe et al. 1997).

According to Dostal and Chatterjee (2000) highly evolved leucogranites and greisens are characterized by Nb/Ta ca. 2 (whereas in leucomonzogranites that ratio is about 14). The Nb/Ta ratio in the studied oxide minerals is below 2 (or Ta>Nb) what also indicates high degree of evolution of magma. Nb-rutile is often considered as mineral typical of rare-element pegmatites crystallized from volatile-rich melt (Lottermoser, Lu 1997).

Presence of wolframite, cassiterite, sulphides, barite and anhydrite as inclusions in type II beryl indicate that beryl origin is connected with activity of ore-bearing fluids.

ACKNOWLEDGMENTS: The authors thank Prof. A. Manecki for very useful discussion. M. Łodziński is a Foundation's for Polish Science scholarship holder in 2003 and 2004.

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