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ANISOTROPY OF GARNETS FROM THE KHOVU-AKSY Co-Ni ORE FORMATION (TUVA REPUBLIC, RUSSIA)

Abstract: The early stage of hydrothermal–metasomatic processes altered the Early Paleozoic terrigenic and carbonate sediments in the Khovu-Aksy region **(**Tuva Republic, Russia) what led to the skarn formation. At this process huge (up to 3 cm in size) black garnets grew. The garnets exhibit variation in their composition, with significant oscillatory zonation of yellow anisotropic and green isotropic lamellae. The undertaken studies revealed differences in the Fe and Al content in the neighbouring lamellae. Microscopically green isotropic zones are built of almost pure andradite garnet, whereas yellow anisotropic zones are built of grandite composed of 71.5 mol. % of andradite and of 28.5 mol. % of grossular.

Keywords: andradite, grandite, zonation, anisotropy

INTRODUCTION

The Khovu-Aksy (Tuva Republic, Russia) ore deposits of Ag, Au, Bi, Ni and Co belong to the Ubsunur-Khovu-Aksy Co-Ni arsenides formation (Shishkin 1973; Lebedev 1998). The ores are associated with geologically and tectonically complicated blocks, and emplaced at a junction of deep NEE-SWW and WN-SW trending faults (Lebedev 1998). Ore mineralization has the highest grade in the anticline, the core of which is built of the Lower Cambrian schists and flanked by the Silurian terrigenic-carbonate sediments, the Lower Devonian tuffaceous-volcanic rocks and the Givetian sandstones and marls. These sedimentary rocks are cut through by postorogenic gabbroid and granosyenite intrusions, and diabase, plagiophyres, granophyres dykes of the late Variscan and Mesozoic age (Lebedev 1998).

Two stages of hydrothermal-metasomatic processes leading to the skarn and ore formation were described in the Khovu-Aksy region (Lebedev 1998 and references cited therein). The products of the first one are pyroxene, garnet-pyroxene and pyroxene-scapolite skarns developed at the expense of the Silurian siliciclastics, carbonates and the Lower Devonian sedimentary-volcanic sequences. The second stage resulted in ore mineralization comprising Ag, Au, Bi, Ni and Co sulphides

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and arsenides (Lebedev 1998). The skarn zone has a varying thickness from centimetres to tens of meters. In the late skarn formation stage, the garnet-pyroxene skarn was replaced by prehnit-plagioclase and quartz–plagioclase metasomatites, which developed also at the expense of the primarily unaltered Silurian siliciclastics and carbonates and the Devonian tuffs and volcanics (Kondratev 1973, Shishkin 1973).

METHODS OF INVESTIGATION

Samples were collected in the southern field of the Khovu-Aksy ore deposits from the outer skarn zone. They were investigated with optical microscope and scanning electron microscope coupled with energy dispersive spectrometer (field emission HITACHI SEM S-4700 microscope and NORAN VANTAGE analytical system). IR absorption spectrometry (BIO-RAD FTS 135) as well as X-ray diffractometry (Philips X-pert diffractometer) was performed on separated garnet crystals.

RESULTS

The samples analysed are build almost exclusively of garnets. Only the interstices among euhedral crystals are filled with quartz or calcite (Fig. 1). Commonly, the garnets are discontinuously overgrown by Fe-Ni sulphides. The garnet crystals are macroscopically black with perfectly shaped faces showing the combination of rhomb dodecahedron and didodecahedron Their size range from millimetres to several centimetres. In thin section euhedral garnet crystals exhibit yellow and green zonation. The widths of zones vary from about 5 μm to more than 500 μm in both periodic and non-periodic mode. The green zones are isotropic, while the yellow ones exhibit strong anisotropy. In some crystals symmetrically distributed green isotropic spots (ca. 100μm) were encountered (Fig. 1).

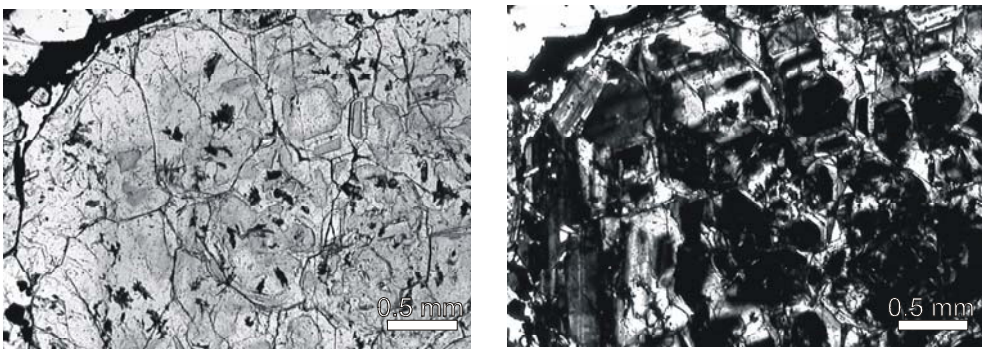

Fig. 1. Complex garnet crystals from Khovu-Aksy in plane polarized light and under crossed polars. Light and anizotropic zones are grandites, darker and isotropic zones are andradites.

The green zones are composed of andradite (99.5 mol. % of andradite), whereas yellow, anisotropic lamellae represent intermediate part of grandite series (75.5 mol. % of andradite and 28.5 mol. % of grossular). The grandite crystals contain significant amount of MnO_2 and TiO_2 reaching 0.4 wt. %, and 0.1 wt. % respectively. It is worth noting a high concentration of V_2O_3 which is perhaps a reflection of this metal high content in the mafic igneous rocks.

The XRD data when compared to JCPDF files (10-0288 andradite and 03-0826 grossular) confirm the presence of a mixture of andradite and grandite garnets (Fig. 2). Infrared absorption spectrum did not reveal the presence of absorption bands caused by hydroxyl groups, excluding the presence of hydrogarnet.

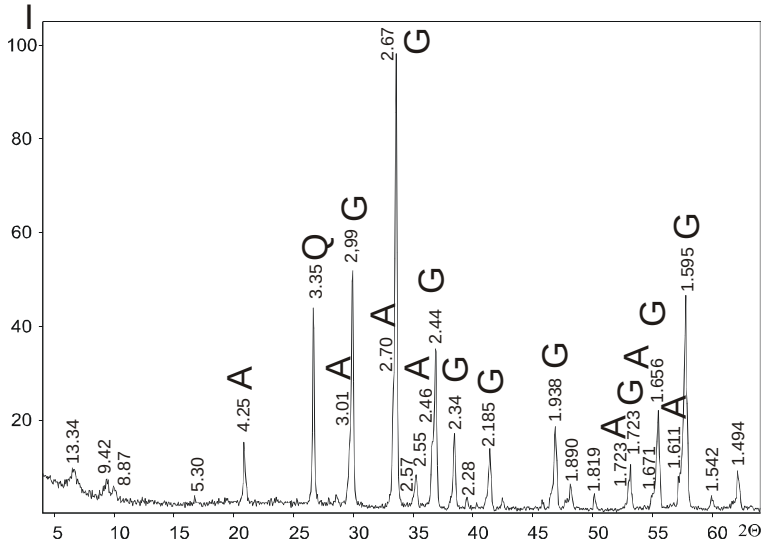

Fig. 2. X-ray diffractogram of the Khovu-Aksy sample (A-andradite, G-grandite, Q-quartz, the numbers over peaks denote the d_{hkl} in Å).

DISCUSSION

The oscillatory zoning and anisotropy are frequently described phenomena in grandite (grossular-andradite) series (Jamtveit et al. 1995; Lewandowska, Rospondek 2000; Pollok et al. 2001, Shtukenberg et al. 2001, 2002). Pure grossular and andradite are isotropic but the admixture of several percent of andradite to grossular causes anisotropy. Garnets with the Grs-50% and Adr-50% content show the highest birefringence (Shtukenberg et al. 2001). The low degree of ordering of Al^{+3} and Fe^{+3} in octahedral positions was proposed to explain this feature. The strain thus induced in the crystal results in the lattice mismatch, thereby reducing the cubic symmetry (Allen, Buseck 1988). In the Khovu-Aksy garnets the amount of grossular molecule in the yellow zones is high enough to reduce its cubic symmetry thus leading to crystal anisotropy.

The large-scale zonation patterns, similar to that encountered in the Khowu-Aksy garnets, are assumed to represent changes in parameters of crystal formation, such as temperature, fco_2, pH, salinity and composition of metasomatic fluids (Pollock et al. 2001, Jamtveit et al. 1995). The inclusions in the garnets are two phases inclusions, with homogenization temperatures ca. 280˚-350˚C with salinity reaching 36 wt. % of NaCl (Lebedev 1998). The correlation of garnet zonation and inclusion data in the Khovu-Aksy garnet still requires further detailed studies.

CONCLUSIONS

The studies of Khovu-Aksy garnets reveal the large-scale microscopic zonation visible both in plane polarized light (green and yellow lamellae) and under crossed polars (isotropic and anizotropic lamellae). The investigations revealed strong correlation of anisotropy with changes in chemical composition of garnets. The andradite zones are isotropic. The anisotropy is related to grandite zones composed in 71.5 mol. % of andradite and 28.5 mol. % of grossular, which is in agreement with literature data.

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