Geochemical characteristics of igneous and hydrothermal biotites from Elatsite porphyry-copper deposit, Bulgaria

Геохимична характеристика на магматични и хидротермални биотити в медно-порфирно находище Елаците, България

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Elatsite porphyry-copper deposit (PCD) is located in the northern parts of Panagyurishte ore region, situated in the Elastite-Chelopech ore field. Defined by its chemical and mineralogical characteristics the Panagyurishte ore region is part of the Apuseni-Banat-Timok-Srednogorie magmatic and metallogenic zone (Popov et al., 2000).

The rocks outcropping in the deposit are: (1) Lower Paleozoic metamorphic rocks (phyllites) exposed in the S and SE part of the deposit; (2) coarse-grained, granodiorites predominate in the Vezhen pluton ($^{206}Pb/U^{238}$ age on zircons ~314±4.8 Ma) with rare porphyry varieties (Kamenov et al., 2002); (3) Upper Cretaceous porphyritic intrusion dominated by quartz-monzodiorite porphyrites and granodiorite porphyries (92.10–91.42 Ma) estimate by von Quadt et al. (2002). The hydrothermal alteration of the rocks are determined as: K-silicate, propylitic, quartz-sericite, and quartz-adularia-carbonate alteration (Ivanov et al., 2014).

K-silicate alteration is the most common type of alteration in the deposit. It occurs in every type of rocks (granodiorites, porphyritic rocks, as well as in the Lower Paleozoic metamorphic rocks). Its mineral paragenesis is represented by secondary black mica, potassium feldspar, magnetite and small quantities of quartz and hematite. In Elatsite PCD at least two impulses of K-silicate alteration are determined (Ivanov et al., 2014). In previous study (Georgieva, Nedialkov, 2016) K-silicate alteration has been divided into two types, one with predominance of secondary black mica (phlogopite) and second one with predominance of K-feldspar.

In Elatsite PCD biotites from two different types are present and can be observed. First one is igneous biotites, related mainly with the granodiorites of the Vezhen pluton and the Upper Cretaceous porphyritic rocks. The second type is hydrothermal biotites from the K-silicate alteration. The purpose of the present study is to emphasize some particularities concerning the distribution of the two types of biotites, some morphological and compositional differences.

Biotites in the igneous rocks typically occurs as idiomorphic, medium-sized, with intense brown color. Biotites occurring in the granodiorites of the Vezhen pluton have a higher contents of MnO and FeO, lower contents of SiO_2, TiO_2, MgO, K_2O, and inconstant values for CaO, Na_2O in comparison with the biotites from the Upper Cretaceous porphyritic magmatites. The Mg/Mg+Fe (Mg#) ratio is established for the igneous biotites – for granodiorite 0.54–0.56 and for the porphyritic rocks 0.56–0.64.

Hydrothermal biotites are generally idiomorphic to subhedral and fine-grained (up to 0.2 mm), pale brown to colorless. They are determined as phlogopites (predominantly) and have 3 different types of repartition in the altered rocks: (1) as pseudomorphosis on the magmatic mafic minerals (amphiboles, biotites and rarely clinopyroxenes); (2) as "veinlets" infilling fractures; (3) uniformly distributed in milled zones (Georgieva, Nedialkov, 2016).

Hydrothermal biotites have higher contents of SiO_2, Al_2O_3, MgO and lower of FeO, MnO, K_2O compared to the igneous ones. The Mg# ration in secondary black micas appear to be evaluated to 0.72–0.80. The TiO_2 contents vary to 3.13–3.50 wt% in igneous biotites and 2.07–2.89 wt% in the secondary micas (Fig. 1).

The temperatures of crystallization are estimated by the contents of Ti in the two types of biotite (Henry et al., 2005). For igneous micas are established temperatures ~710–720 °C for biotites from the granodiorites, and temperatures ~720–730 °C for biotites from the Upper Cretaceous porphyritic rocks. For the hydrothermal biotites the temperatures are estimated ~640–700 °C. The determined temperatures for

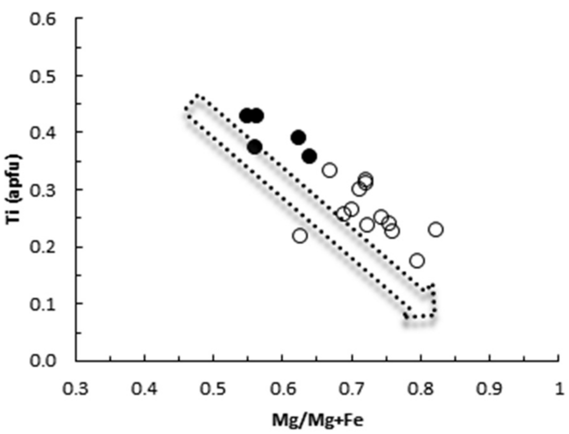

Fig. 1. Distribution pattern of Ti (apfu) vs (Mg/Mg+Fe) of the biotites. *Black points*, unaltered igneous biotites; *black circles*, hydrothermal biotites.

K-silicate alteration are higher than the temperatures established from fluid inclusions in quartz ~600 °C by Stefanova et al. (2014).

The igneous biotites have the higher values for Co, Ni, Cu, Zn, and Pb. Also in these types of black micas are estimated the higher values for Rb, Sr, Ba, Y, Zr, Hf, Nb, Cs, Ta, Th, and U. In igneous biotites are established higher values for all REE elements, heavy REE contents higher than those of light ones and the presence of a positive Eu anomaly.

The hydrothermal phlogopites from K-silicate alteration are depleted in all rare elements including REE, compared to the igneous biotites. The heavy ones again have higher values than the light ones. The positive Eu anomaly is absent.

From the geochemical characterization of the two types of biotites, it is clear that the hydrothermal biotites related with the K-silicate alteration have the lowest contents of all rare elements. During the alteration the majority of the rare and REE elements are leached and transported by the fluids. These elements are deposited in the higher parts of the hydrothermal system. Each impulse of K-silicate alteration is causing the decomposition of the primary magmatic micas, and in the case of imposing one K-silicate alteration on another, this cause further depletion of the secondary black mica.

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