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Svanbergite and other alunite group minerals in advanced argillic altered rocks from Chervena Mogila ore deposit, Central Srednogorie

Сванбергит и други минерали от алунитовата група в интензивно аргилизираните скали от находище Червена Могила, Централно Средногорие

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Introduction

Alunite and aluminium phosphate-sulphate (APS) minerals (Stoffregen, Alpers, 1987) have been object of increasing interest in the last 40 years. They are part of the alunite supergroup (Jambor, 1999) with general formula $DG_3(TO_4)_2(OH,H_2O)_6$, where *D* are large cations (K, Na, Ag, Ca, Sr, Ba, Pb, Bi, La, Ce, Nd) with coordination number larger or equal to 9. *G* site is occupied by cations in octahedral coordination (Al, Fe, Cu, Zn), and *T* site – by S, P, As in tetrahedral coordination. These minerals are widespread in the zones of advanced argillic alteration (AAA) in Bulgaria. Svanbergite and svanbergite-woodhouseite solid solutions (s.s.) are described in Asarel, Chelopech, Petelovo and Pesovets deposits (Central Srednogorie) and other occurrences from Srednogorie zone and the Rhodopes (Hikov et al., 2011). This study presents new data for svanbergite, alunite and other APS minerals from Chervena Mogila ore deposit.

Geological setting

Chervena Mogila intermediate sulphidation epithermal gold-copper-pyrite deposit (Popov et al., 2012) is situated in the northwestern part of the Radka volcanogenic strip 3 km west of Popintsi village. The location of the deposit is determined by the intense volcanic-tectonic faulting and the intruding of late small intrusion bodies (dacite to rhyolite and single granodiorite porphyry dykes) into the northern slope of the Elshitsa volcano, composed of andesite volcanic rocks (Popov et al., 1994).

The main hydrothermal alteration types are: propylite, propylite-argillic, intermediate argillic, sericite-argillic and sericite, whereas the advanced argillic (secondary quartzites) and silicic (monoquartz) types have limited development. The following minerals participate in the mineral assemblages of AAA rocks: kaolinite, dickite, pyrophyllite, sericite, alunite, topaz and tourmaline (Popov et al., 1994).

This study confirms the limited development of AAA rocks. They are more widespread in the southeast direction in the region of Varnishka Chukara, where they are likely to form a lithocap. Alunite, dickite-diaspore-pyrophyllite, monoquartz and mixed types are distinguished while in the latter case there is usually a brecciation and re-development of advanced argillic alteration. Except those mentioned above minerals we found permanent presence of diaspore and small amounts of APS minerals.

Characteristic of alunite group minerals

Alunite is rare in AAA rocks in Chervena Mogila and more widespread in Varnishka Chukara. It is fine- to coarse-grained, with tabular crystals in association with quartz, rutile and Fe-oxyhydroxides, often with diaspore, dickite, kaolinite, pyrophyllite and APS minerals. Studied alunites are with varied composition from potassium, sodium-potassium to natroalunites practically without other admixtures. APS minerals so far are only proven in Chervena Mogila, but their presence is supposed in Varnishka Chukara as well. Svanbergite can be seen as xenomorphic grains with a length of 0.2–0.3 mm in association with quartz and diaspore and also small amounts of alunite and sericite are found in this sample. Svanbergite has high Sr content – Sr is between 0.88 and 0.95 *a.p.f.u.* (SrO from 19.85 to 22.14 wt%). Admixtures are Ca (0.04–0.11 *a.p.f.u.*) and Ba (up to 0.01 *a.p.f.u.*), rarely potassium. Phosphorous predominates over sulphur being between 1.05 and 1.30 *a.p.f.u.* Fluorine is detected up to 0.35 *a.p.f.u.* In other places are observed zonal APS minerals with varied composition from svanbergite, svanbergite-woodhouseite s.s. to wooodhouseite in association with quartz, diaspore, sericite, dickite, rutile and Fe-oxyhydroxides. The cores are rich of Sr and get to svanbergite while peripheries are rich of Ca and respond to woodhouseite. In many cases the composition is intermediate and responds to svanbergite-woodhouseite s.s. and can be defined as APS minerals. Sr varied from 0.53 to 0.19 *a.p.f.u.* and Ca from 0.31 to 0.66 *a.p.f.u.* Admixtures are Ba (0.02–0.03 *a.p.f.u.*), K and rarely Na up to 0.10 *a.p.f.u.* They are poorer of phosphorus which fluctuates between 0.58 and 0.70 *a.p.f.u.* Jarosite is another mineral from alunite supergroup. It is common among all hydrothermal alteration types because it forms during weathering of pyrite in altered rocks. Admixtures in jarosite are mainly Na, less Ca, Sr, Ba and Pb, Al and P are also present.

Discussion and conclusions

Alunite and APS minerals now are concerned to be the most important feature for the advanced argillic alteration. Sillitoe and Hedenquist (2003) put them as key minerals for the hydrothermal alterations connected with high-sulphidation epithermal deposits. This increases their genetic importance regarding ore perspectives as well as regarding physicochemical condition of mineral formation. Alunite forms between 25 and 500 °C by low pH (0.8–5.3) sulphate rich fluids with high oxygen activity. High activity of PO_4^{3-} and broad interval of pH (3–8) is important for the APS minerals (Stoffregen, Alpers, 1987; Hikov et al., 2010). Their formation is connected to the destruction of apatite in magmatic rocks (Stoffregen, Alpers, 1987). Apatite is dissolved by low pH acid fluids causing AAA. Strontium is concentrated in AAA zones (Hikov, 2004) and together with PO_4^{3-} and Ca^{2+} fixed in svanbergite-woodhouseite s.s. APS minerals can coexist with all characteristic minerals of hypogene AAA as alunite, kaolinite, pyrophyllite, diaspore, zunyite at usual temperatures between 200 and 300 °C (Stoffregen, Alpers, 1987).

Svanbergiete from Chervena Mogila is very rich of strontium. It is richer than svanbergites from Asarel (Hikov et al., 2010) and Chelopech (Georgieva et al., 2002) and is approaching the theoretical composition but with phosphorous content it is approaching to goyazite. At the same time as a result of fluctuating physicochemical conditions svanbergite-woodhouseite s.s. and wooodhouseite are formed nearby. Zonal crystals have svanbergite cores and woodhouseite periphery. This means that strontium APS minerals form first and after exhaustion of Sr begin deposition of calcium bearing varieties. This is explained by the preferential inclusion of strontium in phosphate rich phases (goyazite) while calcium favours sulphate rich woodhouseite (Schwab et al., 2005).

Jarosite from Chervena Mogila have more admixtures than jarosites from other deposits in the region. This may indicate that at least part of jarosite is formed after dissolution of alunite and APS minerals during extreme acid and oxidizing conditions of its formation.

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