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Geochemical features of the hydrothermal alterations and base-metal ore mineralization near the village of Babyak, Western Rhodopes (Bulgaria): preliminary results

Геохимични особености на хидротермалните изменения и полиметалната рудна минерализация в района на с. Бабяк, Западни Родопи (България): предварителни резултати

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Geological setting

The Babyak base-metal deposit is situated in Western Rhodopes, about 180 km SE of Sofia. It is part of the Western Rhodopes ore region that belongs to the Oligocene–Miocene Serbomacedonian-Rhodopes Pb-Zn and Cu-Au metallogenic belt in the Balkans (Heinrich, Neubauer, 2002). The deposit is related to the Upper Eocene post-metamorphic granites and pegmatites (±aplites) (Kamenov et al., 1999) of the Rila-West Rhodopes batholith formed during an extensional stage of the Late Alpine tectonic evolution of the Western Rhodopes Massif (Ivanov, 2017). Granites are intruded into various gneisses, schists, marbles, amphibolites from Sarnitsa lithotectonic unit with a presumable Jurassic age (Sarov et al., 2008, 2010). The latest magmatic activity is represented by scarce spessartitic dykes. Ore-bearing zones are hosted mainly in the brittle contacts between different lithologies or cross-cut the rocks, which are affected by moderate to strong wall-rock alterations. About 10 big zones with many apophyses are distinguished, with width ranging from few cm to 5–10 m, a length between 300 and 1500 m and depth about 350–400 m. The altered zones mark the main trend of the faults in the area – one main system of NNE-SSW faults steeply dipping to the west, and secondary NW-SE fault system with a steep dip to the NE or SW. These tectonic deformations are most likely related to the main tectonic structure in the region – Babyak–Grashevo dislocation (Sarov et al., 2010).

Characteristic of ore and alteration zones

Samples from zones of alteration including ore mineralization in gneisses, pegmatites and granites were collected from drill holes and surface outcrops. Major elements in sericite, chlorite, epidote, garnet, pyrite, molybdenite and sphalerite were obtained by EPMA analyses (SEM JEOL JSM-6610LV) at the University of Belgrade, Serbia. Trace elements were measured by LA-ICP-MS (PerkinElmer ELAN DRC-e ICP-MS with New Wave UP193FX LA system) at the Geological Institute, Bulgarian Academy of Sciences.

The main hydrothermal alteration types are phyllic, silicification, greisen-like and argillic, locally also propylitic, skarn type mineralization, carbonatization, and zeolitization. Related ore mineralization (Mo-Cu-Pb-Zn-As-Bi-Ag-Au) occurs as sulfide and sulfosalt veinlets, disseminations and nests in quartz to quartz-pegmatite veins. The main ore minerals are pyrite, molybdenite, sphalerite, galena, chalcopyrite, ±bismuthinite and some sulfosalts (tennantite, lillianite). Based on the mineral associations and mineral composition we distinguished 5 stages of hydrothermal mineralization and related alterations: (1) a high-temperature stage, represented by grossular-andradite skarns that contain also epidote, diopside, vesuvianite, plagioclase, potassic feldspar, ±magnetite; (2) a second stage – quartz, muscovite, fluorite, pyrite, molybdenite, chalcopyrite, ±rutile, scarce Bi- and W-bearing phases in microcracks, veinlets and impregnations; (3) a third stage – quartz, sericite, chlorite, calcite, pyrite, molyb-

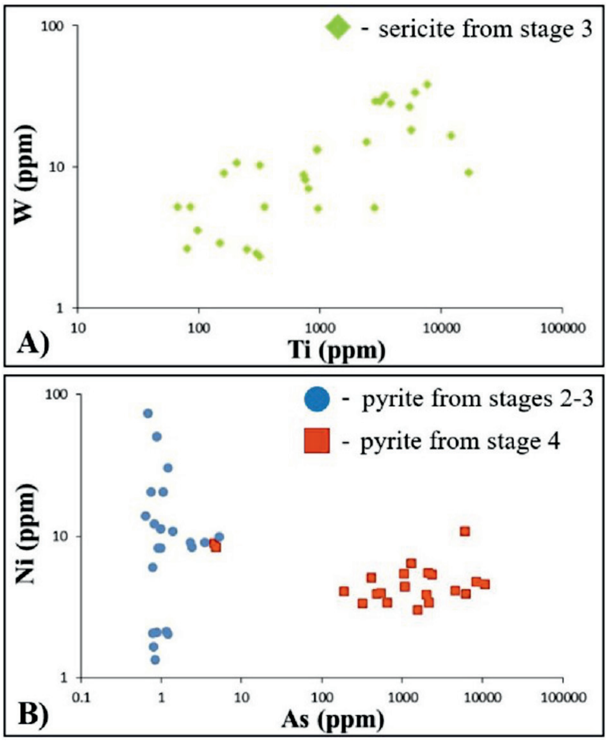

Fig. 1. *A*, W vs. Ti in sericite; *B*, Ni vs. As in pyrite plots

denite, ±rutile, ±hematite, ±epidote, ±clay minerals as veinlets, massive nests or filling cracks; (4) a fourth stage – precipitation of the main Au- and Ag-bearing ore minerals (pyrite, sphalerite, galena, ±chalcopyrite, ±sulfosalts) in veins with variable thickness; (5) low-temperature stage of quartz, calcite, zeolites, ±sericite, ±pyrite veins or veinlets.

Muscovite (stage 2) and sericite (stage 3) reveal distinct geochemical features. The higher temperature muscovite is enriched in Fe and depleted in Li, Na, Mg, Ti, Mn, Sr, Ba, W unlike sericite (Fig. 1A). Enrichment of some elements (Ti, V, Li, Mn) is established in chlorite from stage 3. High-temperature association includes mainly silicates as garnet, epidote, etc. enriched in Mn, Ti, Sn, and depleted in REE.

Typical minor and trace elements in pyrites are Ti, Cr, Mn, Co, Ni, As, Ag, Au, Sb, Bi, with distinct distribution in the different stages. The main difference is found between pyrites from stages 2–3 (enriched in Cr, Ni, Co and depleted in As) and stage 4 (As-bearing with low Cr, Ni, Co) (Fig. 1B). Higher temperature pyrites (stages 2–3) associate with molybdenite (enriched in Ti, Cd, Fe, Re, Pb), while lower temperature pyrites (stage 4) associate with sphalerite (enriched in Fe, Mn, Cd, In) and galena (enriched in Zn, Ag, Bi).

Discussion and conclusions

Preliminary results for the distribution and behaviour of major and trace elements in products of alteration and ore minerals suggest intensive multistage post-magmatic hydrothermal processes. Hydrothermal fluids are mainly acid and precipitate predominantly chalcophile elements. The most typical geochemical features are established for pyrite and muscovite/sericite. The chemical composition of alteration and ore minerals could be used as a vector to the mineralized core of the magmatic-hydrothermal system near Babyak (e.g. McClenaghan, Layton-Matthews, 2017). There is a good potential for discrimination of different stages that could help for the elaboration of a well-constrained model of the deposit.

The close relationships to the granites, as well as the type of mineralization show some specific characteristics of the intrusion-related gold systems (IRGS). Similar examples are the Au-(Ag-W-Bi) Tran deposit, Western Bulgaria (Peytcheva et al., 2014); Pisani Skali ore occurrence, Western Rhodopes (Vidinli, Mladenova, 2016); the Bi-Te-Pb-Sb±Au deposit of Palea Kavala and the Cu-Fe-Mo-Bi-W-Au deposit at Kimmeria, Xanthi, Northern Greece (Voudouris et al., 2016).

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