

Studia breviora

Polyelemental (with As, Sn, V, Bi, Ag, Te, Ge, Se, etc.) mineralizations in the Asarel porphyry copper deposit (Bulgaria)

The Panagjurište ore zone which occupies the central part of the Srednogorie metallogenic zone is known to host two major types of copper deposits formed during the Late Cretaceous: copper pyrite (volcanogenic) and porphyry copper (plutonogenic). The former are of much more varied mineral and metal composition than the latter. Generally, the two types are quite near each other both in space and in time of their formation, and in some cases they are even found together.

The Asarel porphyry copper ores occur in secondary quartzites developed in Late Cretaceous medium-acid volcanic and subvolcanic rocks. The main ore mineral paragenesis is dominated by pyrite and chalcopyrite. It also includes the minerals of polyelemental composition. A lead-zinc mineralization of minor occurrence has been formed later.

At the beginning of the ore-forming process, small oval inclusions of pyrrhotite, chalcopyrite, native gold, calaverite (?) and bornite were formed in pyrite. This mineral assemblage, which we call copper-gold-tellurium partial paragenesis, had been formed in a reducing environment. Another partial paragenesis — arsenic-tin-bismuth-tellurium (with lead, vanadium and germanium) — was formed in a medium of higher oxidation potential. It occurs as small impregnations and veinlets consisting of enargite, digenite, goldfieldite, aikinite, colusite, arsenosulvanite, sulvanite, galena and wittichenite. The chemical formulas of some minerals, based on microprobe analyses, are as follows: aikinite $(\text{Cu}_{0.90}\text{Fe}_{0.09})_{0.99}\text{Pb}_{0.95}\text{Bi}_{0.93}\text{S}_{3.14}$, goldfieldite $(\text{Cu}_{11.72}\text{Zn}_{0.10}\text{Fe}_{0.10})_{11.92}(\text{Te}_{1.91}\text{As}_{1.71}\text{Bi}_{0.29}\text{Sb}_{0.19})_{4.10}\text{S}_{13}$, arsenosulvanite $(\text{Cu}_{24.43}\text{Zn}_{0.15})_{24.58}(\text{V}_{1.77}\text{Fe}_{0.13})_{1.90}(\text{As}_{4.80}\text{Ge}_{0.57}\text{Sn}_{0.40})_{5.77}\text{S}_{32}$ and $(\text{Cu}_{23.03}\text{Zn}_{0.18}\text{Fe}_{0.08})_{23.29}(\text{V}_{1.81}\text{Fe}_{0.12})_{2.00}(\text{As}_{4.62}\text{Sb}_{0.73}\text{Ge}_{0.28}\text{Sn}_{0.23})_{5.86}\text{S}_{32}$, sulvanite $(\text{Cu}_{2.93}\text{Zn}_{0.04}\text{Fe}_{0.01})_{2.98}(\text{V}_{0.73}\text{As}_{0.11}\text{Ge}_{0.02}\text{Sn}_{0.01}\text{Sb}_{0.01})_{0.88}\text{S}_4$, and colusite $(\text{Cu}_{24.43}\text{Fe}_{0.77}\text{Zn}_{0.49})_{25.62}(\text{V}_{1.86}\text{Fe}_{0.11})_{2.00}(\text{As}_{3.67}\text{Sn}_{2.34})_{6.01}\text{S}_{32}$. Towards the end of the main mineralization event, processes of mobilization and redeposition produced coarse-grained quartz-chalcopyrite veins, locally containing pyrite and sphalerite and hosting the fine-grained minerals of a copper-silver-bismuth-tellurium partial paragenesis which also shows increased selenium contents. It consists of galena $\text{Pb}_{1.01}(\text{S}_{0.90}\text{Se}_{0.09})_{0.99}$, aikinite $\text{Cu}_{0.90}\text{Pb}_{0.99}\text{Bi}_{1.02}(\text{S}_{2.93}\text{Se}_{0.16})_{3.09}$ and hessite $\text{Ag}_{2.00}\text{Te}_{1.00}$.

In order to explain the origin of the polyelemental mineral parageneses we assume that a polyelemental copper-pyrite mineralization was the first to form in the deposit. It was of restricted occurrence and became unstable in the fluids of the later extensive porphyry copper mineralization which began with ore deposition in a reducing environment. The earlier polyelemental minerals were thus dissolved and a portion of the constituent elements was redeposited in minerals typical of a reducing environment. However, there were also localities where (due, for instance, to penetration of some vadose water) the oxidation potential was higher and redeposition occurred again in a mode similar to the original polyelemental mineralization.

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