Kostovite Au(Cu, Ag, Au)Te_4 – conditions of formation and replacing minerals in hydrothermal gold deposits

Костовит Au(Cu, Ag, Au)Te_4 – условия на образуване и заместващи минерали в хидротермални златни находища

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In memory of Ivan Kostov, Georgy Terziev, and Ivan Bonev

Gold-copper telluride discovered in the Bulgarian Chelopech (VMS) deposit was named kostovite by Terziev (1966) in honor of the famous mineralogist Academician Ivan Kostov. Kostovite was found in 30 volcanogenic gold-telluride deposits ranging from sulfide-rich (VMS) to sulphide-poor epithermal ones. The best summary of kostovite finding was presented by Bonev et al. (2005).

Rhombic kostovite $AuCuTe_4$ modulated structure is similar to the monoclinic sylvanite $AuAgTe_4$ (Van Tendeloo, Amelinks, 1986) and rhombic krennerite $Au_3(Ag,Au)Te_8$ (Chvileva et al., 1988). May be this is the reason for kostovite composition variation from close to the theoretical $AuCuTe_4$ up to rich of silver $Au(Cu_{0.5}Ag_{0.5})Te_4$ often with excess of Au (Fig. 1). Nevertheless there is significant compositional in-

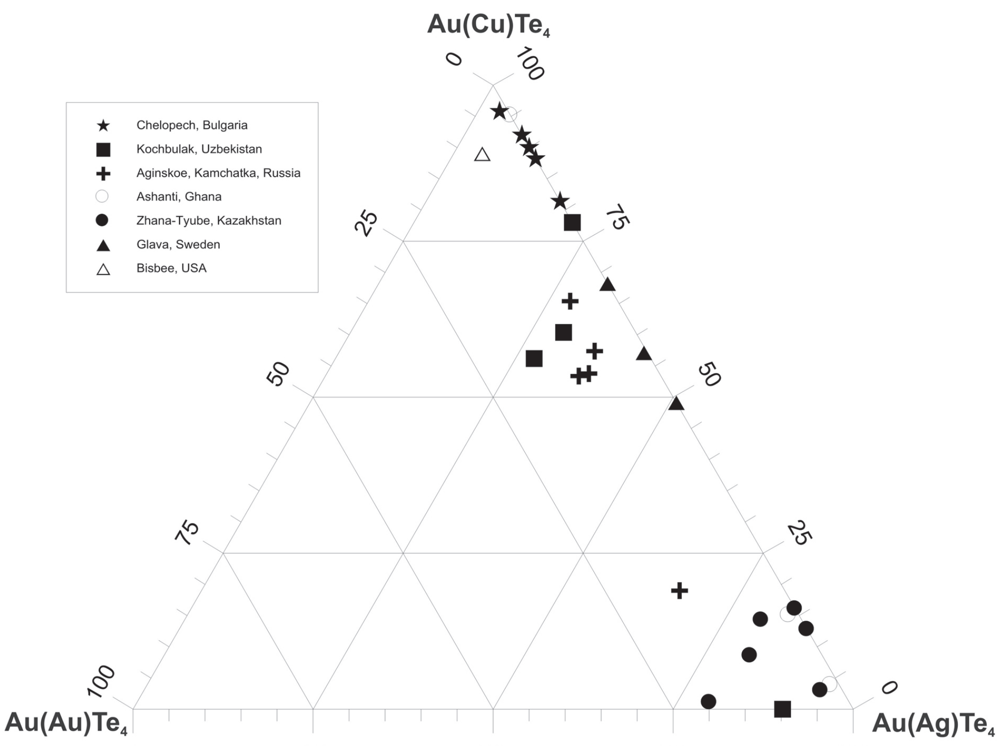

Fig. 1. Composition of kostovite and Cu-bearing sylvanite

terval between Ag-bearing kostovite and Cu-bearing sylvanite.

The metal associations in respect to Te affinity could be listed as follows: Pt, Pd > Fe, Co, Ni > Bi, Sb > Pb, Hg > Ag > Au, Cu (e.g. Spiridonov, 1994). This is the reason explaining why in the ores Bi, Pb, Ag, Hg, Ni and Fe tellurides are associated with native gold, Au-Ag and Au tellurides. Au-Ag and Au tellurides occur in small amounts in a number of hydrothermal porphyry-copper, plutonogenic gold-quartz, volcanogenic-plutonogenic gold-sulfide-quartz, volcanogenic from (VMS) to sulfide-poor epithermal deposits. Why kostovite is much rarer? Because: 1) during Au tellurides formation there is not reactive Cu; 2) copper affinity to sulfide S is much higher that copper affinity to Te; 3) for kostovite formation $a_{Te} >> a_S$ is required.

One of the processes of kostovite formation was deciphered for Kochbulak ores (Spiridonov, 1994). They contain aggregates of kostovite with tellurium, altaite, tellurantimony, newly formed goldfieldite and tennantite, sphalerite, famatinite, corroded As-tetrahedrite, galena and calaverite. Probably proto-phase for Kochbulak kostovite is calaverite. Presence of tellurantimony indicated a source of reactive copper – tetrahedrite. Possible reaction of Kochbulak kostovite formation is: $2AuTe_2$ + 3PbS + $3Cu_{10}Zn_2AsSb_3S_{13}$ +$12Te_{sol.}$ → $2AuCuTe_4$ + 3PbTe (altaite) + $2Sb_2Te_3$ (tellutantimony) + $Cu_{10}Cu_2Te_2Sb_2S_{13}$ + $Cu_{10}Zn_2As_3SbS_{13}$ + $2Cu_3SbS_4$ (famatinite) + 4ZnS (mineral composition is real).

In a similar ore type of Ozernovskoye deposit (Kamchatka) the Te activity was higher. That is why all As-Sb tenanntite-tetrahedrite were replaced, As-tellurantimony and Cu tellurides were developed and Se is abundant (Spiridonov, 1994). Possible reaction of the Ozernovskoye kostovite formation is: $AuTe_2$ + PbS + $2Cu_{10}Zn_2AsSb_3S_{13}$ + $10Te_{sol.}$ + $Se_{sol.}$ → $AuCuTe_4$ + PbTe + $2Sb_2Te_3$ + CuTe (vulcanite) + $Cu_{10}Cu_2Te_2As_2S_{12}Se$ (Se-bearing goldfieldite) + $2Cu_3SbS_4$ + 4ZnS.

In the Chelopech ores kostovite forms aggregates with tellurium and chalcopyrite (Terziev, 1966), replacing golgfieldite or native gold and sylvanite together with chalcopyrite in small metasoms in tennantite, bornite, enargite aggregates (Bonev et al., 2005). Probably Chelopech kostovite originated under influence of Au and Te solution, or form sylvanite substance. A source of reactive copper was goldfieldite. O Possible reaction of the Chelopech kostovite formation is: $2Cu_{10}Cu_2Te_3AsS_{13}$ + 2ZnS + FeS_2 + $2Au_{sol.}$ + $2Te_{sol.}$ + $6As_{sol.}$→ $2AuCuTe_4$ + $CuFeS_2$ + $Cu_{10}Zn_2As_4S_{13}$ + $4Cu_3AsS_4$ (luzonite) (mineral composition is real).

In Panormos Bay (Greece) kostovite occurs in association with Cu tellurudes from the substabce of calaverite and goldfieldite.

In Obuasi ore zone, intersecting plutonogenic gold-quartz Ashanti deposit (Ghana), parageneses of the kostovite are significant. This kostovite together with endogenic hematite and goethite replaced sylvanite. According to the mineral associations (Bowell et al., 1990), possible reaction of Obuasi (Ashanti) kostovite formation is: $6AuAgTe_4$ +10PbS + $24CuFeS_2$ + $21Te_{sol.}$ + 71 O_2 + $0.5H_2O$ → $6AuCuTe_4$ + 10 PbTe + $2Ag_3Cu_4Te_4$ (henryite) + Cu_5Te_3 (rickardite) + Cu_5FeS_4 + + $11Fe_2O_3$ + FeOOH + $54SO_2$↑.

Kostovite is not stable in weathering cover conditions. Hypergenic Au-Cu-Fe (Ag) plumbotellurides: bilibinskite, bogdanovite and other and also cuprian gold group minerals originated at the expence of kostovite (and altaite) in a cementation zone (Chvileva et al., 1988; Spiridonov, 2008, 2011). Bilibinskite group minerals involve up to 10% of Au ore mass in some part of the columns in the cementation zone of Aginskoye deposit (Kamchatka). Obviously hypogenic ores of Aginskoye deposit partly were also extremely rich of kostovite.

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