Kostovite Au(Cu, Ag, Au)Te₄ – conditions of formation and replacing minerals in hydrothermal gold deposits

Костовит Au(Cu, Ag, Au)Te₄ – условия на образуване и заместващи минерали в хидротермални златни находища

Ernst M. Spiridonov
Ернст М. Спиридонов

Lomonosov State University, Department of Mineralogy, Moscow, Russia; E-mail: ernstspiridon@gmail.com

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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 AuCuTe₄ modulated structure is similar to the monoclinic sylvanite AuAgTe₄ (Van Tendeloo, Amelinks, 1986) and rhombic krennerite Au₃(Ag,Au)Te₈ (Chvileva et al., 1988). May be this is the reason for kostovite composition variation from close to the theoretical AuCuTe₄ up to rich of silver Au(Cu₀.₅Ag₀.₅)Te₄ 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 formations there is not reactive Cu; 2) copper affinity to sulfide S is much higher than copper affinity to Te; 3) for kostovite formation a\textsubscript{te} >> a\textsubscript{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, tellurantimonite, newly formed goldfieldite and tennantite, sphalerite, famatinite, corroded As-tetrahedrite, galena and calaverite. Probably proto-phase for Kochbulak kostovite is calaverite. Presence of tellurantimonite indicated a source of reactive copper — tetrahedrite. Possible reaction of Kostovite formation is: 2Cu\textsubscript{10}Cu\textsubscript{2}Te\textsubscript{2}S\textsubscript{13} + 2ZnS → 2Cu\textsubscript{10}Zn\textsubscript{2}Te\textsubscript{2}S\textsubscript{13} + Cu\textsubscript{10}Zn\textsubscript{2}AsS\textsubscript{3} + 4Cu\textsubscript{3}AsS\textsubscript{4} + 4AuTe\textsubscript{2} + PbS + 2Cu\textsubscript{3}FeS\textsubscript{2} + Cu\textsubscript{10}Cu\textsubscript{2}Te\textsubscript{2}S\textsubscript{13} + Cu\textsubscript{10}Zn\textsubscript{2}AsS\textsubscript{3} + 4Cu\textsubscript{3}AsS\textsubscript{4} + 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 tennantite-tetrahedrite were replaced, As-tellurantimonite and Cu tellurides were developed and Se is abundant (Spiridonov, 1994). Possible reaction of the Ozernovskoye kostovite formation is: 2AuTe\textsubscript{4} + 3PbS + 3Cu\textsubscript{10}Zn\textsubscript{2}AsS\textsubscript{3} + 12Te\textsubscript{sol} → 2Cu\textsubscript{10}Cu\textsubscript{2}Te\textsubscript{4} + 3PbTe (altaite) + 2Sb\textsubscript{2}Te\textsubscript{3} (tellurantimonite) + Cu\textsubscript{10}Cu\textsubscript{2}Te\textsubscript{2}S\textsubscript{13} + Cu\textsubscript{10}Zn\textsubscript{2}AsS\textsubscript{3} + 2Cu\textsubscript{3}SbS\textsubscript{4} (famatinite) + 4ZnS (mineral composition is real). In Panormos Bay (Greece) kostovite occurs in aggregates of kostovite with tellurium and chalcopyrite (Terziev, 1966), replacement golgfieldite or native gold and sylvanite to tellurantimony in volcanogenic hydrothermal gold deposits. Why kostovite is much rarer? Because: 1) during cementation zone of gold-telluride deposits Aginskoye 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\textsubscript{4} + 10PbS + 24Cu\textsubscript{2}FeS\textsubscript{2} + 21Te\textsubscript{sol} + 71 O\textsubscript{2} + 0.5H\textsubscript{2}O → 6AuCuTe\textsubscript{4} + 10PbTe + 2Ag\textsubscript{2}Cu\textsubscript{3}Te\textsubscript{2} (henryite) + Cu\textsubscript{10}Te\textsubscript{2} (rickardite) + Cu\textsubscript{6}Fe\textsubscript{4}S\textsubscript{13} + + 11FeO\textsubscript{3} + FeOOH + 54SO\textsubscript{2}↑.

Kostovite is not stable in weathering cover conditions. Hypergenic Au-Cu-Fe (Ag) plombotellurides: biliibinskite, bogdanovite and other and also cuprian gold group minerals originated at the expense of kostovite (and altaite) in a cementation zone (Chvileva et al., 1988; Spiridonov, 2008, 2011). Biliibinskite 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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