SEG 2017 Conference

The Relationships of Au-Cu Skarn and Au-Bi-Te Mineralization: Examples from the Alati-Sayan Fold Belt, Russia and Kazakhstan

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One of the issues for a number of gold deposits combining two or more types of mineralization is the relationship between them. Gold-Ag-Te-Bi mineralization associated with granitoid and dike magmatic complexes occurs in many Au-Cu skarn deposits of the Altai-Sayan fold belt of Russia and Kazakhstan. There are several contradictory ideas about their spatial, temporal, and genetic relationships. We studied a number of gold-skarn deposits in Siberia (Sinyukhinskoye, Choya, Topolninskoe, Lebedskoe, Tardan) and Kazakhstan (Raygorodok, Sayak) to address this problem.

At the Sinyukhinskoye deposit, gold mineralization formed in single stage within the Cu-Bi-Te mineral assemblage of the post-magmatic skarns developed in limestone. The gold-sulfide mineralization is spatially associated with the felsic dikes of the Sinyukhinsky complex that occurs near the ore-bearing faults. The highest grade gold mineralization forms stockworks and veins in the exocontact zone of the Sinyukhinsky granite massif.

The combination of Au-Cu skarn and Au-Bi-Te mineralization is most common in the Choya ore field at the periphery (20 km) of the Sinyukhinsky district. Productive mineralization includes Mo-W skarns, stratiform Cu-Zn-Au-Te, and Au-Te mineralization in skarn. Skarns and all types of ores are spatially associated with granitoids and lamprophyres of the Choya magmatic complex. The Au-Te mineralization is confined to the area of garnet-pyroxene-wollastonite skarns, which has a zonal structure along the strike. The high fineness (917–986‰) of gold reflects its appearance as free grains in quartz with tetradimite and rarely with hedleyite, tellurobismuthite, and native bismuth.

At the Tardan deposit, late gold-bearing mineralization (gold, tetrahedrite, sphalerite, bismuthin, schapbachite, tellurobismuthite, tetradimite, altaite) developed after gold-copper skarn. In this case, native gold is characterized by increased contents of mercury, tellurium, and silver.

The mineralization at Raygorodok extends from the the endocontact into the exocontact of the Raygorodok monzogabbro-diorite massif. Skarns developed within conglomerates and sandstones. Early garnet-pyroxene skarns were associated with wall rock alteration (propylitic and berezitizite) which was followed by late gold-sulfide mineralization. Two gold-bearing stages have been identified: an earlier and rare high-fineness gold most often associated with pyrite-chalcopyrite mineralization in altered skarn and a later low-fineness gold that is the main resource and associated closely with Ag-Pb-Te-Bi mineralization. Some workers note that at the Raygorodok deposit, the early stage developed as an Au-Cu skarn or an Au-Cu-Mo porphyry and the late stage as a mesozonal gold stockwork. Gold is commonly associated with chalcopyrite, as well as with Bi and Te minerals.

In the Sayak skarn deposit, ore mineralization was formed in six stages: skarn, epidote-actinolite, feldspar-aksinite, quartz-calcite-chlorite, sulfide, and carbonate. Gold was deposited in the hydrothermal sulfide stage developed after the skarns. The main commodity is copper, with secondary molybdenum, cobalt, bismuth, selenium, tellurium, and iron in the form of magnetite.

Thus, two possible genetic models might be proposed based on the studied examples of the complex deposits with spatially combined Au-Cu skarn and Au-Bi-Te mineralization: 1) deposits formed by one evolving ore-forming system, and 2) two different ore-forming systems overlap, each characterized by its own magmatism and geochemical signature.