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Mineralogy and ore formation conditions of the Malmyzh copper-gold porphyry deposit, Far East of Russia

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The Malmyzh deposit is located in Far East Russia, approximately 220 km northeast of Khabarovsk city. The project has excellent logistics and infrastructure, including high voltage power lines and a paved national highway. As well, the Amur River lies within 2 km of the project boundary and is directly linked to major shipping ports. The Malmyzh deposit porphyry is centered on Cretaceous diorite and granodiorite stocks that intruded and altered siltstone and sandstone sedimentary rock sequences.

There are four main and successive stages of ore formation, the first three of which are productive and include alkaline, acidic, ultra-acid, and late alkaline stages. The first stage is alkaline and it is characterized by quartz, biotite, and potassium feldspar alteration of rocks. There are several characteristic paragenetic mineral associations including biotite − magnetite ± apatite, quartz − chlorite − pyrite, quartz − K-feldspar − chalcopyric ± epidote, and quartz − chalcopyrite − bornite. The acid stage is associated with a chlorite, sericite, and quartz alteration event. There are widespread quartz − chlorite − chalcopyrite + sphalerite + galena ± molybdenite, quartz − chlorite ± magnetite / hematite, and sericite − quartz − pyrite associations. Products of the ultra-acid stage are represented by quartz alteration with pyrite and surrounding argillic assemblages. Where best developed, there is a sericite ± chalcocite − kaolinite association with sulfosalts, chalcopyrite, tellurides, and selenides. In the late alkaline stage, carbonate and zeolite alteration of the rocks remobilized some of the sulfides. This stage has no economic significance.

The main ore minerals are pyrite and chalcopyrite, with less common galena, sphalerite, bornite, and chalcocite. They are observed in the form of finely dispersed disseminations in altered rocks, form accumulations and nests in dark-colored silicate replacement zones, and also form sulfide and quartz − sulfide veins. Chalcopyrite is the main economic mineral in the deposit. Along with pyrite, the chalcopyrite is the dominant sulfide deposited as products of acidic and ultra-acidic stages. Commonly chalcopyrite is associated with both pyrite and magnetite. The earlier chalcopyrite and pyrite are usually corroded and later sulfides, sulfosalts, tellurides, and selenides occur in the cavities. Bornite and chalcocite are products of the ultra acidic stage, they often replace chalcopyrite, forming reaction rims surrounding the crystals. Bornite and chalcocite are sometimes closely associated with other products of the ultra acidic stage, such as sulfosalt minerals, selenium-containing galena, silver selenides, complex sulfides, and tellurides of bismuth and silver. Silver and gold are typomorphic elements of copper-porphyry ores as admixtures. The accumulation of silver occurs throughout the ore process, increasing in late acid and ultra acid stages. Silver is found in low grades in sulfides, and in the form of compounds with gold, tellurium, selenium, and sulfur. There are also selenides, sulfoselenides, and complex silver sulfides present.