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Geology of the Escondida Porphyry Copper Deposit, Antofagasta Region, Chile

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Abstract

The Escondida porphyry copper deposit, located in northern Chile, was one of the two largest copper producers of the world in the 1990s. The hydrothermal evolution of this deposit is associated with the emplacement of a late Eocene-Oligocene quartz monzonitic to granodioritic intrusive stock complex composed of at least three intrusive phases and hosted by Paleocene andesite. This Paleocene andesite is underlain by Mesozoic and Paleozoic sedimentary and volcanic rocks, which are characteristic of the basement of the Precordillera de Domeyko province in northern Chile. We propose that the intrusive stock associated with the mineralization at Escondida was emplaced in a tensional gash formed between sinistral strike-slip faults of the regional Domeyko fault system.

The complete evolution of the porphyry system is characterized by overprinting of pervasive and vein-associated alteration-mineralization styles grouped in three main hydrothermal stages. The early stage includes a zone of pervasive biotitization of andesite and development of a silicification shell around the intrusive complex, propylitic alteration around the biotitic zone, and a vein-associated orthoclase-quartz ± anhydrite-biotite alteration that mark the end of stage one. This early alteration contains magnetite, chalcopyrite, and bornite, with less than 0.5 vol percent of sulfides and a hypogene copper grade of ≤0.2 wt percent.

The second hydrothermal stage is represented by vein and vein selvage-associated chlorite-sericite ± quartz and by quartz-sericite with sulfides including chalcopyrite, pyrite, and molybdenite. In the chlorite-sericite and quartz-sericite zones the content of sulfides ranges from less than 0.5 to 2 vol percent with a chalcopyrite to pyrite ratio of 3 to 1 and copper grades that range between 0.4 and 0.6 wt percent. The intrusion of a rhyolite dike and a dome are at least 3 m.y. younger than the first and second hydrothermal stages and separate them in time from the late hydrothermal stage.

The late hydrothermal stage is represented by an acid-sulfate mineral association that includes pyrophyllite, alunite, and quartz as alteration minerals and a variety of sulfides that include bornite, chalcopyrite, pyrite, chalcocite, covellite, enargite, sphalerite, tennantite, and galena. This acid-sulfate event occurred mainly in west-northwest–striking veins and also along the contact of the rhyolite and its host rock. Where sulfides from this event overprint previous sulfides, the primary copper grades range from 0.6 to higher than 1.0 wt percent. In the Escondida deposit, the highest hypogene and supergene copper grades occur in areas where all three hydrothermal stages are present.