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Fluid evolution of Cerro Colorado Porphyry Copper Mine

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The Cerro Colorado porphyry copper deposit is the northernmost currently active copper mine in Chile, producing 90.5kt copper per year. It belongs to one of the Paleocene to early Eocene porphyry copper deposits that are distributed along the western slope of the main Andean Cordillera in Northern Chile (Bouzari & Clark, 2002). Active commercial production began in 1994, and the estimated reserves within the supergene blanket can sustain further 12 years of copper mining. Field studies of the well-exposed geology around the mine site and the access to drilled cores that penetrate into the hypogene zone provide a good opportunity to study the temporal relationship between magmatism, hypogene and supergene ore formation of the region.

The geological evolution of Cerro Colorado area can be generalized as follows. The Cretaceous Cerro Empexa Formation, consisting of a sequence of volcanic rocks, mainly andesitic lava and breccia, lahars, some ignimbrite intercalations and dacitic tuff (Charrier, Pinto & Rodrigues, 2007), was intruded by tonalitic to dioritic magma in Middle-Eocene. Magmatic activities generated brecciated rocks accompanying with different alteration zones radiate outward from the intrusion. The mineralized hypogene protore later interacted with ground water, creating the supergene blanket, which is now the principal mining target of Cerro Colorado.

Several plutonic lithologies with slight but distinct compositional differences were exposed in the valleys around the mine site. The presence of these several phases of small-scale intrusions suggests the ore genesis may be related to multiple pulses of heating and associated fluid flow. Complementarily, on-site geologists have reported occurrences of early stage biotites vein cutting into phyllitic alteration zone, or across terminal stage quartz-pyrite veins in the drilled cores. These observations are direct evidences of at least two major distinct phases of fluid flow, and imply the ore mineralization could be related to more than one fluid flow event.

The current study focuses on the vein samples obtained from on-site drill cores that penetrated the hypogene zone. The principle aim is to determine the forming conditions of ore mineralization by using fluid inclusions trapped in associated vein minerals, in majority, quartz.

Preliminary results have been obtained from petrographic studies and Raman analysis of fluid inclusions trapped within metal carrying quartz-rich veins. The fluid inclusions generally show good negative crystal shapes and range in size up to 25 μm. Arrays of inclusions do not generally cut grain boundaries and crystals are not deformed around molybdenite crystals. These imply that the inclusions are formed with the crystallization of the vein minerals, and very likely, mineralization.

Samples from the alteration zones contain 2-phase fluid inclusions, commonly with halite as an additional solid phase. Roughly half of the molybdenite-bearing veins contain fluid inclusions with halite crystals. In contrast, pyrite-bearing veins show a great variation in the proportion of fluid inclusions that contain halite: 30% to 90% depending on the sample. The observations suggest the action of fluids with very different salinities, possibly due to multiple pulses of fluid flow. Additional data on the compositions and homogenization temperatures of the fluid inclusions will help constrain the conditions at the time of ore genesis.

References:

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