The Development of the Geological Model of the Antamina Copper-Zinc Skarn Deposit, Northern Peru

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Antamina is the world’s largest skarn deposit of copper and zinc and started production in 2001. This paper describes the development of the geological model for the feasibility study (1996 – 1998). Antamina is located in the eastern part of the Western Cordillera of north-central Peru at 9° 32’ S and 77° 03’ W at 4,200 to 4,800 m altitude. It is 270 km north of Lima and 130 km east of the Pacific Ocean.

Antamina has a long history of exploration and is a case study of creating an orebody out of a mineral resource. Small scale copper mining is recorded intermittently from 1860 and several major companies evaluated the project in the early 20th century. The first serious exploration was by Cerro de Pasco Corporation (1952 to 1970), followed by a Minero Peru and Geomin (Romania) partnership which carried out a feasibility study (1970 to 1976) with a reserve of 128.6 Mt @ 1.6% Cu and 1.3% Zn.

The project was privatized to Compañía Minera Antamina (CMA) in 1996, owned by Inmet Mining Corporation and Rio Algom Ltd. of Canada. CMA undertook a major exploration program and completed a full feasibility study in 18 months by 1998. This defined a mineable in-pit resource of 500 Mt @ 1.2% Cu, 1.0% Zn, 0.03% Mo and 12 g/t Ag within a global resource of 1,500 Mt. Current ownership is BHP-Billiton (Rio Algom) 33.75%, Noranda Inc. 33.75%, Teck Cominco Ltd 22.5%, and Mitsubishi Corp. 10%. Production is by open pit and flotation at 70,000 tpd to produce 270,000 t Cu and 162,000 t Zn in cons per year, making Antamina the 7th largest copper mine and 3rd largest zinc mine in the world.

Antamina is located in the Polymetallic Belt of Central Peru of Cu-Zn-Ag-Pb-Au deposits mostly related to Mid to Upper Miocene calc-alkaline stocks. The regional geology is Upper Jurassic to Late Cretaceous siliciclastic to carbonate sequence in a NW-trending foreland fold-thrust belt of Late Eocene, Inca 2 deformation age. Antamina is hosted by calcareous silts and mudstones of the Late Cretaceous Celendin Formation. Skarn mineralization forms a shell around and over the roof of a quartz-monzonite porphyry stock of Late Miocene age (9.8 Ma) which hosts low grade porphyry Cu-Mo mineralization. The skarn body is approximately 2,500 m long in a NE-direction by 1,000 m wide with a known vertical extent of 1,000 m. The skarn consists mainly of andradite garnet. It is symmetrically zoned around the intrusion from proximal brown garnet skarn outward to green garnet skarn, and with peripheral wollastonite-diopside skarn. Magnetite skarns and retrograde chlorite skarns are minor. The majority of the skarns are exoskarns.

The metals are also zoned laterally with a central Cu-only zone and a peripheral Cu-Zn zone. Copper as chalcopyrite is distributed throughout all skarn zones. The appearance of sphalerite coincides approximately with the transition from brown to green garnet. The Cu-Zn zone thins at depth and originally wrapped over the top of the intrusion, however most of this has been eroded. The main Cu mineral in the wollastonite-diopside skarn is bornite and this zone also has anomalous gold values. The minor metals Ag, Pb and Bi are highest in the outer part of the Cu-Zn zone and adjacent marble. Molybdenite occurs in the intrusion and adjacent skarns, and is also high in the wollastonite-diopside skarn. Sulfides were deposited during the late prograde and retrograde phases, and occur interstitial to garnet, as irregular massive sulfide zones, and as veinlets. The deposit was unroofed by Quaternary glaciation and is exposed in a glacial valley, and there is no significant oxidation or enrichment.

Antamina is an oxidized calcic copper skarn related to a calc-alkaline porphyry quartz-monzonite stock with subeconimic porphyry Cu-Mo mineralization. The outer zinc zone is unusually well developed. Features that may have contributed to the world-class size of the deposit include mantle-derived intrusions; the basin-margin sediment setting (favorable host rocks and structures); the overall lack of retrograde alteration (grade homogeneity and preservation of the zinc zone); and the partial preservation of the roof zone of the deposit.