SULFIDES PARAGENESIS AND ZONING OF VETA 4–ALIANZA-LLACSACOCHA AND POZO D VEIN STRUCTURES, HUARÓN DISTRICT, CENTRAL PERUVIAN ANDES

Pedro Acosta Góngora
William X. Chavez, Jr.

pacosta@nmt.edu, wxchavez@nmt.edu
New Mexico Institute of Mining and Technology, USA 87801

Cordilleran Vein ore deposits contribute substantially to worldwide production of Ag, Pb, and Zn, and numerous base and precious metal systems; as such, the general understanding of Huarón District vein system mineralogy and zoning would contribute to geological and geochemical understanding of Cordilleran Vein systems.

This project is an attempt to understand the processes that took place during ore deposition in a series of E-W and NE-SW vein structures and to determine the mineralogical and geochemical "fingerprints" of each vein, that distinguish different stages of ore emplacement. Zoning characterization in an ore district is very important in mineral exploration, not only for local implications, but also for interpretation of regional geological framework. The significance of zoning also permits comparison of ore deposits having similar ore alteration and ore assemblages.

The Huarón district is located in the central Peruvian Andes and comprises polymetallic Pb + Zn + Ag +/- Cu Cordilleran Vein System. This mine is known for important Ag and Zn production.

Ore mineralogy consists of galena-sphalerite and paragenetically late tetrahedrite and enargite. Ore comprises veins, mantos and lenses within the Casapalca Fm. redbeds; this sequence has been intruded by quartz monzonite stocks, which altered hostrock carbonate marlstone to very silicified and propylitized rock.

The main purpose of this study is to determine if the veins in study (Veta 4, Alianza, Llacsacocha and Pozo D) behave as a single system, or if they are geochemically distinct in space and time. In order to determine this, samples of wallrock and vein material have been sampled with the final aim of establishing the mineralogical zoning of these veins. Vein samples characterize the paragenesis of ore mineral emplacement, and zonation of base metals (Zn, Pb, Cu, Ag). A third step in this investigation consists of analyzing the available grade data from mine stopes in order to model metal ratio zoning (Zn/Pb, Cu/Ag, Cu/(Zn+Pb)).

Finally the zoning studies will be correlated to confect a general ore zoning for Huarón District that should help to better understand the district's metal environment and distribution.

Huarón is an underground mine, having lowest and highest levels of 4250 m.a.s.l and 4600 m.a.s.l respectively; the surface is 4700 m.a.s.l. The total length of the four vein systems studied is approximately 2.5 km. Depending on the availability of the workings samples have been taken every 10 to 30 meters (horizontal distribution). The sampling consisted of an extensive sampling of the Veta 4, Alianza, Llacsacocha and Pozo D veins, from the 4250 level to the 4600 levels.

The following describes and interprets mineral occurrence and paragenesis of the Veta 4-Alianza-Llacsacocha and Pozo D vein system. This is a preliminary report of an on-going investigation, and much more data is to be analyzed in order to reach realistic model concepts and conclusions.

Importantly, mineralogy of all four systems is very similar and consists of volumetrically major amounts of pyrite as an early mineral phase, with subsequent sphalerite (marmatite) and chalcopyrite in the form of chalcopyrite disease. Chalcopyrite development is probably due to replacement (or exsolution) during sphalerite formation.

The paragenetic sequence continues with galena development; galena can be weakly to strongly replaced by chalcopyrite, which can be weakly to strongly replaced by tetrahedrite-tennantite. Such replacement indicates introduction of arsenic, antimony, iron and copper to the system.

Veta 4 and Alianza veins share the same mineralogy, textures and relative abundance of minerals. The association of pyrite (py)-galena (gal)- sphalerite (sl) are consistent from the 4450 to the

4237 level. The most important difference between Veta 4 and Alianza veins is the depth at which sulfosalts, especially tetrahedrite, occur. In Veta 4, the tetrahedrite is observed at the 4450 level; sulfosalts in the Alianza vein are observed at deeper levels (4279 m.a.s.l). Another important feature of Alianza vein is the presence of microveinlets (<5 μm) veins of sulfosalts which are strongly replaced by chalcopyrite. Because chalcopyrite is scant in these veins, and because much of chalcopyrite observed is either as "chalcopyrite disease" within sphalerite, or as a component of sulfosalt-bearing intervals, it is surmised that chalcopyrite represents local changes in a_{Fe++} and a_{Cu+} respect to the temperature.

The Llacsacocha system is more complex than Alianza-Veta 4 system, due to its different mineralogy. This structure was defined as a sigmoid that has an NE-SW trending; in terms of the mining operation, the northern part of a sigmoid is called North Llacsacocha and the southern part South Llacsacocha.

North Llacsacocha at lower levels (4193-4250 m.a.s.l) basically consists of a mineralogy similar to the Alianza-Veta 4 systems, because of complex ore paragenesis and mineralogy comprising: pyrite as the most abundant mineral, then sphalerite and galena as second and third most abundant mineral, respectively; sulfosalts (~1%) are minor, are minor, as is molybdenite (<<1%). The occurrence of molybdenite indicates the influence of a high temperature hypothermal fluid. In contrast, Llacsacocha South vein is dominated by pyrite and sulfosalts as the main sulfide phases, with important quartz as gangue. The pyrite-sulfosalt association is seen in the upper part of the vein (4630 level) to the 4193 level. At the 4630 level.], a weak replacement of sulfosalts by covellite which suggests a transition to lower temperature system is taking place. Furthermore, the emplacement of centimeter-scale (~1.8 cm) veins of weathered stibnite in upper part of the vein (4600 level), also suggests also a transition to lower temperature system. Nevertheless, shallower levels (4400-4630 m.a.s.l) of Llacsacocha vein have major amounts of quartz and tetrahedrite, and are diminished in galena.

Pozo D vein mineralogy is a very similar to that of Alianza –Veta 4 systems. This consists of major amounts of pyrite, sphalerite-chalcopyrite and galena, with minor amounts of tetrahedrite at the 4250 level.

Current ore mineral zoning suggest that Pozo D, Alianza and Veta 4 systems could represent a single zoning pattern, with these structures representing proximal ore-forming , NE structures such as Llacsacocha, may represent a different ore fluid stage of deposition (different system).