

ABSTRACT

The Ayawilca Cordilleran Zn-Pb-Ag-In-Sn-Cu deposit in the province of Pasco, central Peru, is considered one of the most relevant base metal recent discoveries in the Andes. It is located 40 km northeast to the world class Miocene (300-340°C) polymetallic deposit of Cerro de Pasco. The mineralization in this deposit does not reach surface level, in other words, it is a blind deposit, factor that represents a challenge in terms of exploration.

The mineralization is mainly hosted in limestones from the Pucará Group as 10-70 m- thick lenses, also known as mantos, and, subordinate, subvertical veins. Some of the main mantos, including those containing economic Sn grades, occur close to the contact between the Pucará Group and underlying Excelsior Group phyllites. Minor steep-dipping veins are hosted by detrital sedimentary rocks from the Cretaceous Goyllarisquizga Group, which overlie the Pucará Group.

Ayawilca, like other well-known Cordilleran polymetallic deposit (e.g Cerro de Pasco), consists of mineral assemblages that show increasing sulfidation with time. Four mineralization stages have been described in Ayawilca: Stage Pre-A, defined as a distal retrograde magnesian skarn, consisting of Mg-siderite + magnetite + cassiterite + talc + chlorite ± actinolite-tremolite; Stage A is volumetrically the most important and consists of a low sulfidation assemblage of quartz + pyrrhotite + arsenopyrite + Fe-rich sphalerite (up to 36 mol% FeS) + chalcopyrite ± stannite + herzenbergite; Stage B overprints the previously described stages by replacing pyrrhotite and arsenopyrite by pyrite + marcasite (intermediate product); and stage C, with an intermediate sulfidation assemblages consisting of Mn-Fe carbonate + Fe-poor sphalerite (up to 13 mol % FeS) + galena ± native bismuth + Cu-Pb-Ag sulfosalts + kaolinite + muscovite + dickite. This latter stage overprints all the aforementioned assemblages. The existence of stage Pre-A strongly suggests that the early mineralization at Ayawilca occurs in a transition environment from a retrograde skarn to a Cordilleran polymetallic deposit.

To obtain a detailed fluid inclusion study, the identification of different quartz families was necessary. Four quartz types have been defined in this deposit: 1) Stage Pre-A quartz, which did not have any fluid inclusions, 2) pre-pyrrhotite, also defined as early comb quartz, 3) milky quartz with apatite inclusions where fluid inclusions are not abundant or are too small for later microthermometry analyses, and 4) post-sphalerite quartz, which has been describes as a late prismatic quartz. For fluid inclusion studies, one sample of pre-pyrrhotite quartz and one of post-sphalerite quartz have been studied, in addition to them,

a sample of Mn-Fe carbonates from stage C was also analyzed. Sample location was also taken into consideration, so vertical variations could be studied.

A total of 107 fluid inclusion assemblages have been studied for this work. Pre-pyrrhotite quartz from stage A register fluid inclusions with homogenization temperatures between $304.8 \pm 2.4^\circ\text{C}$ and $398.3 \pm 3.4^\circ\text{C}$ and variable salinities ($4.3\text{-}17.7 \pm 0.3$ wt% NaCl eq.). Post-sphalerite quartz showed homogenization temperatures in the range of 279.1 ± 0.7 and $318.9 \pm 1.5^\circ\text{C}$ and salinities of 1.5 ± 0.1 and 4.8 ± 0.1 wt% NaCl eq. Stage C Fe-Mn carbonates contain fluid inclusion assemblages that records homogenization temperatures between $247.2 \pm 4.9^\circ\text{C}$ and $281.7 \pm 9.6^\circ\text{C}$ and salinities between 3.4 ± 0.2 and 6.6 ± 0.6 wt% NaCl eq.

LA-ICP-MS analyses have been conducted in 52 fluid inclusions from the previously mention samples. Data indicates that pre-pyrrhotite quartz in rich in metals (Zn, Pb, Fe, Mn), but it is depleted in Sn, this correlates to the paragenetic sequence since this type of quartz crystallizes after cassiterite precipitation. At this stage the fluid can contain up to 6.7 wt% Fe, 1855 ppm of Cu, 7897 ppm of Zn. Post-sphalerite quartz registers the opposite: all metals are either below the limit of detection or at least one order of magnitude below measures obtained from early quartz. Mn-Fe carbonates have increased values of Sn, Zn, Fe and incompatible elements. This has been attributed to a decrease in pH which allows the fluid to transport and reprecipitate metals in upper parts of the deposit.

The mineralization in this deposit is controlled by fluid cooling and boiling. Cooling occurs due to the host rock-fluid interaction, which also tends to neutralize the fluid. This buffering effect decreases when vein walls are sealed by early comb quartz, which, in combination with gentle boiling, could increase the acidity in the system allowing the mineralization to change from low-sulfidation assemblages to intermediate sulfidation assemblages.

Key words: Cordilleran polymetallic deposit, Miocene polymetallic belt, Central Andes, Fluid inclusion, Microthermometry