

## **Characterization of hydrothermal fluids and application to exploration vectoring of gold-copper mineralization in the Calamaca Project, La Libertad, northern Perú**

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The Calamaca Project is located in the Huamachuco district, which hosts several significant ore deposits and projects with Au resources >30 Moz. Geomorphologically, it is located in the eastern part of the Western Cordillera. The main rock types in the area include: (1) Jurassic shales and siltstones from the Chicama Formation; (2) Cretaceous sandstones with intercalations of siltstones; and (3) Miocene dioritic stocks. The district is structurally oriented along a NW trend within the Peruvian Andes, within the axis of a regional anticline in which the dominant rocks are those of the Jurassic sequences, with the Cretaceous rocks present along fold flanks.

The study area encompasses 5 km<sup>2</sup> and lies on the axis of the anticline along which the dioritic porphyries were emplaced. Within these host rocks, NW- and NE-oriented veins occur, mostly comprising quartz, sulfides, and oxides, the last commonly pseudomorphs after sulfides. These veins are hosted within both the dioritic porphyries and sedimentary rocks, and are associated with an extensive quartz + clay (kaolinite, smectite, dickite) + white mica (sericite, illite) hydrothermal alteration assemblage. At Calamaca, two stages of mineralization are recognized. The first is pyrite + arsenopyrite ± Fe-rich sphalerite with high gold grades, indicating a low sulfidation epithermal environment, and the second is chalcopyrite + Fe-rich sphalerite + galena + molybdenite + tennantite, indicating an intermediate sulfidation epithermal environment with minor gold.

Petrographic and SEM analyses demonstrate that Au in this deposit is related to arsenopyrite in the low sulfidation stage. Nevertheless, the tectonic and metallogenic trend in the region is dominated by high sulfidation epithermal and porphyry type environments. Thus, for a better understanding of this system, we have carried out a fluid inclusion study, which indicates temperatures from 220°C to 300°C and salinities of 2.5 to 5.6 % NaCl equiv. The vapor phase analyzed with a Raman shows the presence of CO<sub>2</sub> and CH<sub>4</sub>, suggesting the interaction of the fluids with the host rocks, a process which likely had a strong reduction effect.

In terms of exploration impact, we have identified three targets and one with a high potential to be linked to a porphyry system. This is based on: (1) systematic spectroscopy measurements that show zoning from an extensive argillic to phyllic alteration halo, with shifts in the 2200 nm Al-OH absorptions, with a superimposed low to intermediate sulfidation epithermal system; (2) geochemical zoning from distal Mn-Pb-Zn to Cu-Mo in the main target area; (3) fluid inclusion data for samples collected at similar elevations, 3500 +/- 50 m.a.s.l, and within the same mineralization event, showing a potential temperature gradient from 230°C in the outer border to 290°C in the potential porphyry proximal environment; and (4) magnetometry studies that also suggest a contrast anomaly consistent with porphyry interpretation and show the continuity of a possible body at depth with more than 1 km<sup>2</sup> total area.