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Melt and Fluid Inclusions in Shallow Porphyry Veins Recording High- to Low-Temperature Quartz Precipitation, Example from Cerro de Pasco (Peru)

Bertrand Rottier,[1,*] Kalin Kouzmanov,[1] Lluís Fontboté,[1] and Markus Wälle[2]

[1]Department of Earth Sciences, University of Geneva
[2]Institute of Geochemistry and Petrology, ETH Zürich, 8092 Zürich, Switzerland

*Corresponding author: e-mail, bertrand.rottier@unige.ch

The Miocene epithermal base metal deposit of Cerro de Pasco, located along the eastern margin of a large diatreme-dome complex, is the second largest known epithermal base metal (Cordilleran) deposit after Butte in Montana, USA. Recently, two porphyry mineralizing events at Cerro de Pasco have been reported: (i) hornfels and magmatic clasts with porphyry-type quartz-molybdenite veins incorporated in the diatreme-breccia and (ii) a shallow stockwork consisting of quartz-magnetite-chalcopyrite-pyrite veinlets in a porphyritic trachytic plug in the central part of the diatreme. This contribution focuses on results obtained on the shallow porphyry mineralization.

The trachytic plug is located at the same elevation as epithermal mineralization in the deposit. The total erosion is estimated at less than 1 km. The trachytic plug is affected by pervasive chlorite-epidote-magnetite alteration spatially associated with a network of up to 2-cm-thick quartz-magnetite-chalcopyrite-pyrite-(sphalerite) veinlets. Quartz veins are banded in places and SEM-CL imaging reveals two different quartz generations: (1) high-luminescence, sulfide-free quartz (Qz1) and (2) late dark quartz (Qz2) crosscutting and overgrowing Qz1 and intergrown with sulfides.

Qz1 represents more than 90% of the bulk volume of the veinlets and is characterized by high CL intensity and high Ti content (from 100 to 360 ppm). The cores of Qz1 are crowded by small heterogeneous silicate melt inclusions (HSMIs) formed by a silicate phase and a chlorine-rich liquid. The silicate phase has a rhyolitic composition: 73.04% SiO_2, 16.73% Al_2O_3, 6.96% K_2O, 1.99% Na_2O, 1.67% FeO, 0.4% TiO_2, 0.25% CaO, and <0.1% MgO, which contrasts with the trachytic composition of the porphyry plug. The chlorine-rich liquid is enriched in Zn, Pb, and Mn, but also in Fe, Ca, K, Mo, and W. The external margins/borders of Qz1 host primary and secondary hypersaline fluid inclusions (>70% NaCl equiv). The hypersaline inclusions contain numerous salt and opaque crystals, anhydrite, and no or little liquid water. Final homogenization is by vapor disappearance between 680° and 800°C. They are strongly enriched in metals, with up to several wt % Zn, Pb, Mn, and Cu, and several hundreds of ppm of Mo and W.

Qz2 occurs in microfractures crosscutting Q1, in cracks created by the microfractures subordinately in voids created by the dissolution of Q1. It is spatially associated with sulfides and characterized by low CL intensity and low Ti content (2–8 ppm). Qz2 hosts primary and secondary liquid-rich inclusions with homogenization temperatures from 270° to 330°C and salinity ranging from 0.2 to 25 wt % NaCl. It presents moderate to low base metal concentrations: Cu (192–1,231 ppm), Zn (683–861 ppm), Pb (11–446 ppm), and Mo (2–83 ppm).

The shallow banded porphyry veins record two high-temperature (>600°C) stages forming Qz1: (i) a stage representing magmatic-hydrothermal transition containing the HSMIs and (ii) a pure hydrothermal stage characterized by the hypersaline inclusions. The low-temperature event (<330°C) recorded by Qz2 is characterized by liquid-rich inclusions and is probably linked to sulfide precipitation.