SEG 2017 Conference

Fluid evolution of the Batu Hijau porphyry Cu-Au deposit, Indonesia

Michael Schirra*, Christoph A. Heinrich, and Thomas Driesner

ETH Zürich, Zürich, Switzerland, *e-mail, michael.schirra@erdw.ethz.ch

The giant Cu-Au porphyry deposit Batu Hijau, Sumbawa Island, Indonesia, is associated with multiple generations of low-K porphyritic tonalite intrusions emplaced at shallow depths (≤ 2km) into volcano-sedimentary sequences around 3.7 Ma ago (Meldrum et al., 1994; Garwin, 2000). Principal ore minerals are chalcopyrite and bornite together with minute blebs of native gold (Arif & Baker, 2004). The copper-iron sulfides typically occur within different generations of quartz veins formed during early alteration or less frequently as later sulfide veinlets associated with transitional alteration (Clode et al., 1999). Fluid inclusions (FIs) entrapped within different vein generations record the chemical and physical evolution of the hydrothermal fluid and can provide valuable information about sulfide precipitation conditions.

Based on phase proportions at room temperature, different FI-types can be distinguished: intermediate-density (ID), low-density low-salinity vapor (V), high-density high-salinity brine (B), and low-salinity aqueous (A) inclusions. The distribution of these types throughout the hydrothermal system at Batu Hijau shows a specific pattern, which is also described from other porphyry copper deposits (e.g. Redmond et al., 2004; Landtwing et al., 2005). At greater depths, remnants of the initial magma-derived fluid are present in the form of ID FIs entrapped within a dense but barren network of quartz veins. Cooling and depressurization during ascent of this fluid led to phase separation, which produced abundant V and B inclusions in the mineralized zone. However, careful petrographic observations are necessary to validate that ore minerals were precipitated from the same fluids that are now present as FIs in mineralized quartz veins.

In several porphyry deposits, cathodoluminescene-imaging showed a complex growth history of vein quartz involving dissolution and re-precipitation of quartz. Ore minerals, thereby, are genetically related to the formation of a later and minor quartz generation, introduced by reopening of previously formed quartz veins (e.g. Redmond et al., 2004; Landtwing et al., 2005; Stefanova et al., 2014). Hydrothermal quartz at Batu Hijau show a comparable growth history, which clearly indicates a later introduction of ore minerals relative to the hosting quartz veins.

The fluid evolution at Batu Hijau show strong similarities to other porphyry copper deposits (e.g. Bingham Canyon in Utah and Elatsite in Bulgaria). The common distribution pattern of FI-types throughout the hydrothermal system indicates comparable fluid evolution paths including phase separation of the initial magmatic fluid during ascent and later incursion of meteoric water. Furthermore, sulfide precipitation at Batu Hijau also took place during reopening of previously formed quartz veins at lower temperatures. Microthermometric measurements of simultaneously entrapped FIs show constant phase proportions from different quartz generations, indicating a temperature range of ore formation between around 380°C and 250°C, which is in agreement with results from other porphyry deposits. The similarities between Batu Hijau and other porphyry deposits worldwide support the assumption that fluid evolution and sulfide precipitation initialized by cooling are common features of porphyry copper deposits.