PTX evolution of mineralizing fluids in the porphyry copper-high idation epithermal system at Red Mountain, AZ

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Red Mountain is a Laramide-age porphyry copper deposit located in southern Arizona near the border with Mexico. Porphyry copper systems are abundant in this region and, due to a complex structural evolution, the various deposits show variable degrees of erosion. Within this context Red Mountain, with its shallow level of erosion and well-preserved lithocap, provides an exceptional example of the transition from the deeper porphyry copper environment to the shallow high-idation epithermal system.

Two main mineralization zones occur in this deposit: a chalcopyrite-bornite zone in the deeper porphyry system and an enargite-chalcocite zone in the shallow high-idation epithermal system.

In the present study, we have conducted detailed petrographic and microthermometric analysis of fluid inclusions (FI) related to specific mineralization and alteration types to characterize fluid evolution in the Red Mountain magmatic-hydrothermal system.

FI petrographically associated with chalcopyrite mineralization typically contain chalcopyrite daughter minerals and large vapor bubbles and are classified as inclusion type "B60" (according to the classification of Rusk et al., 2004, Fig. 1). These inclusions have homogenization temperatures (T_h) between 350 – 380 °C and salinities between 3 and 5 eq mass% NaCl. Later fluid inclusions in chalcopyrite-bearing samples are frequently characterized by halite-bearing FI that homogenize by halite disappearance at temperatures of 350 - 420°C (Fig. 2).

FI within well-defined fluid inclusion assemblages (FIA) in chalcopyrite-mineralized samples often have constant T_h but T_m that varies by as much as 80°C. The constant T_h implies that no stretching has occurred. The variability in T_m could be a result of halite entrapment or necking down after halite began to precipitate in the FI but before a vapor phase had nucleated. If the variability in T_m is a result of halite entrapment, this indicates that FI were entrapped under halite-saturated conditions and the maximum pressure of entrapment would be between 70 MPa and 200 MPa. If the variability in T_m is due to necking, 70 - 200 MPa constitutes a range of *minimum* pressures of entrapment. Corn (1975) proposed that a few thousand meters of volcanics were probably eroded from Red Mountain following the mineralization event. If that eroded material was added to the sample depths (1 – 1.5 km) the expected lithostatic pressure at the given depth would be on the order of 100 MPa.

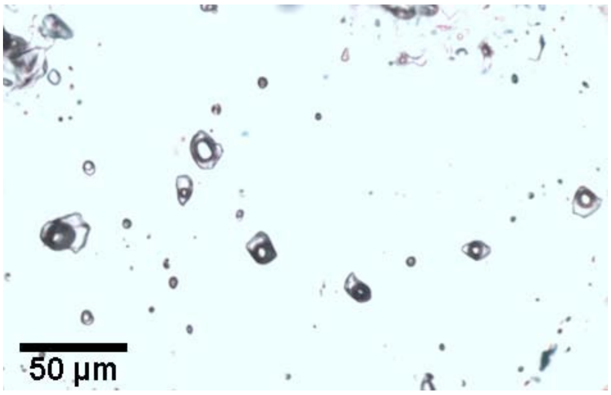

Fig. 1. FIA of chalcopyrite-bearing B60 FI in a chalcopyrite-bearing sample.

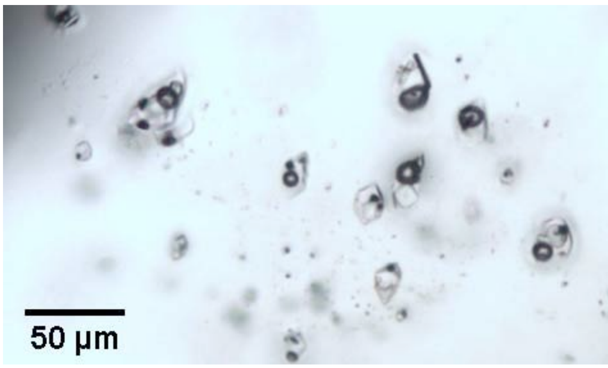

Fig. 2. FIA in a chalcopyrite bearing sample, containing halite-bearing FI that homogenize by halite disappearance.

Fluid inclusions spatially associated with enargite-chalcocite mineralization frequently show evidence of boiling (Fig. 3). A reconnaissance study of FI in this part of the system has yielded T_h values above 480 °C and salinities between 30 - 35 mass% NaCl. While these inclusions are spatially associated with enargite mineralization, a genetic relationship is yet to be identified. Slow ascent of fluids through the host rock would result in thermal equilibration between rocks and fluids and result in lower fluid temperatures. The existence of high temperature fluids in the shallow part of the system indicates a rapid fluid ascent from depth. These high temperatures observed in the high-idation part of the system are also consistent with recent observations by Mavrogenes et al. (2010).

Fig. 3. Coexisting liquid-rich and vapor-rich inclusions in an FIA from the shallow, high-idation part of the system (100 m present day depth).

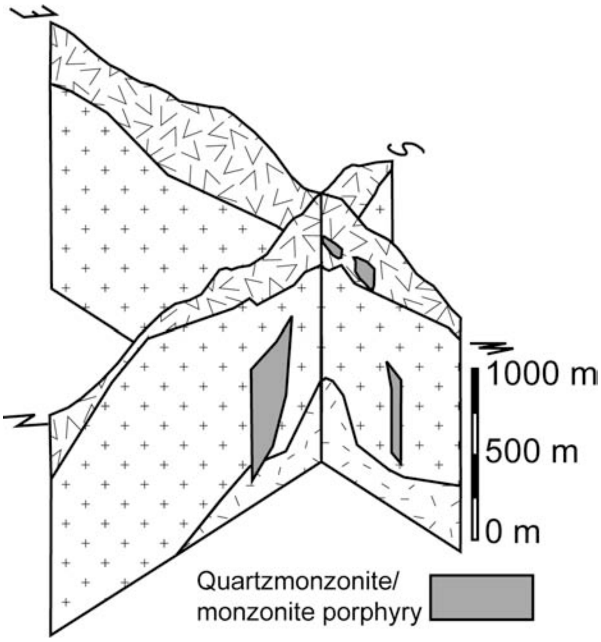

Fig. 4. Spatial distribution of porphyritic dykes and sills intersected during drilling at Red Mountain. The lithologies cut by the porphyry are from the surface downwards: trachyte, andesite and latite.

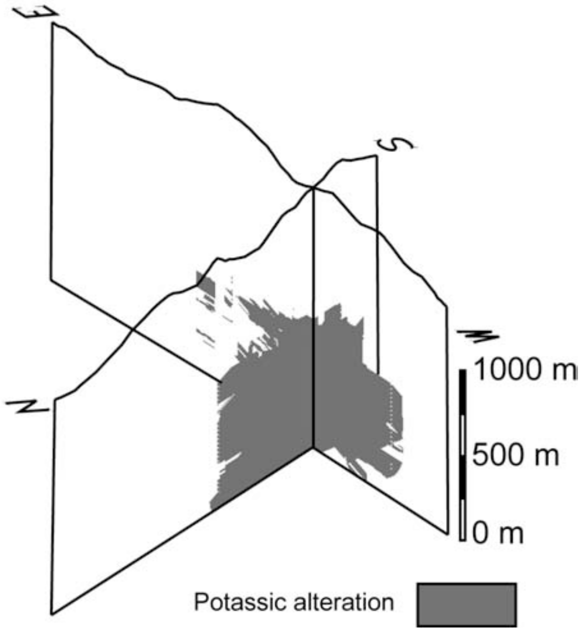

Fig. 5. Spatial distribution of potassic alteration at Red Mountain.

A three-dimensional model of Red Mountain (Fig. 4 & 5) shows that the alteration zones are not on the intersected porphyry dikes or sills. Therefore, a deeper porphyry intrusion may be the major contributor of mineralizing fluids to the system and the core of the Cu mineralization may be below the current depth of exploration.

Fluid inclusions at Red Mountain indicate that the observed chalcopyrite mineralization occurred at temperatures around 350°C and likely at pressures below 100 MPa. However, the lithology and alteration distribution indicates that the drill core has not intercepted the main porphyry intrusion. Therefore deeper chalcopyrite mineralization may occur at Red Mountain. The enargite-mineralizing fluid has not been conclusively characterized although spatially related fluids have temperatures above 480°C.

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