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Geochemical evolution of hydrothermal fluids and alteration model of the Afyon-Sandikli porphyry copper deposit, Turkey

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Turkey, located in the western Tethyan Metallogenic belt, hosts several types of magmatic-hydrothermal deposits including porphyry Cu-Au, epithermal Au, skarn, and volcanogenic massive sulfide deposits. They formed from the successive magmatism in response to a collision between the Eurasian and Afro-Arabian plates between the Late Cretaceous and Late Miocene.

The Kışladağ gold deposit, and Inlice and Afyon-Sandıklı porphyry Cu deposits, are associated with relatively young alkaline magmatic activity in western Anatolia. The mineralization in the Afyon-Sandıklı deposit is hosted by a magmatic suite consisting of feldspar porphyry monzonite, feldspar porphyry latite, K-feldspar syenite, latite porphyry, trachyte, trachytic dike, micromonzonite porphyry dike, pyroclastic rocks and lava flows, and hydrothermal breccia. Feldspar porphyry monzonite is the oldest intrusive phase in the prospect, and is host to the alteration and mineralization.

The host rocks were subjected to varying degrees of hydrothermal alteration, mapped and identified by portable XRD device (terraspec) and petrographic analyses. The potassic, phyllic, propylitic, and advanced argillic assemblages are the main alteration types in the Afyon-Sandıklı porphyry deposit. The potassic alteration is exposed along the banks of a river that has deeply incised the alteration zone from south to north. Mineralization is observed only in the potassic alteration and partly within the levels in where stockwork veins predominate in the phyllic alteration. Chalcocite, chalcopyrite, molybdenite, and tetrahedrite(?) are common ore minerals in the potassic alteration.

Microthermometric analyses in this study indicate that average homogenization temperature of potassic and phyllic alteration pahses are >590 °C and 381 °C, respectively, with salinities ranging from 29.1 to 48.3% NaCl equiv. The inclusions in the potassic alteration appear to be formed by high salinity solutions. The fluid inclusions contain daughter crystals of sylvite and halite. These brine-rich inclusions are considered to have been trapped after boiling that resulted in a high-density hypersaline residual fluid. Thus, boiling and subsequent cooling of a magmatic water is considered to be viable mechanism for ore formation, based on the available homogenization temperatures and salinities for inclusions from potassic and phyllic alteration zones.

Stable isotope studies indicate that the calculated $\delta^{18}O$(fluid) and δD(fluid) values for sericite-bearing samples from the phyllic alteration are 1.34‰ and 3.74‰, and -96‰ and -94‰, respectively. The calculated $\delta^{18}O$(fluid) and δD(fluid) values for secondary biotites from the potassic alteration are 10.63‰ and -31‰, respectively. The fluids that show a negative trend from primary magmatic water towards the meteoric water line are indicative of depletion both in H and O isotopes and suggest interaction with wallrocks of the Afyon-Sandıklı deposit. Additionally, inclusion studies are consist with the fact that boiling and cooling enabled formation of the potassic alteration assemblage. As the phyllic alteration overprinted the potassic alteration, it is highly likely that the low salinity fluids exsolved by the boiling of a magmatic fluid circulated through the areas of potassic alteration, and equilibrated with the minerals in the potassic alteration zone to form minerals in the phyllic assemblage.