SEG-MJD 2016 Conference

Hydrothermal and Tectonic Processes Key to the Origin of the Efemçukuru Au Deposit, Western Turkey

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Efemcukuru is an example of a low- to intermediate-sulfidation, epithermal, high-grade gold deposit in Western Anatolia, located at the western end of the Izmir-Ankara suture zone. This marks the closure point of a subduction zone separating the Sakarya and Anatolide-Tauride microplates during the Late Cretaceous and early Paleocene. Mineralization is controlled by NW-SE–trending faults with two principal epithermal veins, Kestanebeleni and Kokarpinar, crosscutting hornfels, phyllites, and rhyolite dikes. Mineralization occurs in fracture spaces in the hornfels and as breccias. Minor amounts of pyrite, sphalerite, galena, and trace amounts of chalcopyrite occur in quartz veins, but, occasionally, there are veins of massive galena and sphalerite. The majority of the gold mineralization is very fine grained (0.5–30 microns), occurring as free grains in quartz and rhodonite with inclusions in pyrite, chalcopyrite, and sphalerite. High gold grades, however, are not directly related to sulfide content.

SEM-CL and element mapping reveal the complex multigeneration nature of the fractured and brecciated veins and mineralization. Fracture veins can have two or three generations where late quartz replaces and destroys the textures of earlier, large euhedral crystals, with the vein centers filled by sulfides. Brecciated veins also occur in the hornfels and appear to be caused by repeated tectonic events with the hornfels largely unaffected. Space created is filled by several generations of quartz and sulfides with fluorite filling and coating breccia fragments. The breccia is also cut by later quartz veins. BSE element mapping of these (Kokarpinar vein) shows that some larger free gold is associated with the late veins and more numerous, smaller gold particles infill space in the breccia.

Fluid inclusions in quartz and calcite from the Kestanebeleni vein (south vein) and quartz from the Kokarpınar vein (north vein) are two-phase (liquid + vapor) primary and secondary fluid inclusions and vapor-rich dark inclusions. The coexistence of liquid-rich and vapor-rich inclusions indicates periodic boiling of the fluid. Primary inclusions in quartz and calcite have similar homogenization temperatures, from approximately 310° to 210°C, with averages of 265°C (n = 58) for quartz and 264°C (n = 8) for calcite for Kestanebeleni and 279°C for Kokarpınar. A later generation of fluid with a lower temperature, ca. 180°C, but of similar salinity is present at Kokarpinar. Salinities in both veins are low at between 2 and 0.2 wt % NaCl equiv, with those from Kokarpinar lower than those from Kestanebeleni, but overall are the same as most epithermal deposits in western Turkey. The range of salinities would be consistent with a change from lithostatic to hydrostatic pressure at a depth of vein emplacement of ca. 500 m. Initial LA-ICP-MS analyses of fluid inclusions indicate Au concentrations of a few ppm to approximately 20 ppm, which would be consistent with the high Au grades in the veins.

The generation of the horfels in the country rocks provided a more competent zone, which fractured due to both tectonic events and hydrothermal pressure, thereby generating

space for mineralizing fluids to precipitate sulfides and Au by boiling and cooling of the fluid during pressure variations.