

## **Structural and Fluid Characterization of the Shahumyan Polymetallic Epithermal Vein Deposit, Kapan District, SE Armenia**

Dharani Raja Yarra,\* Craig Hart, and Aleksandar Miskovic

University of British Columbia, Department of Earth, Ocean and Atmospheric Sciences-  
Mineral Deposits Research Unit, Vancouver, British Columbia, Canada

\*Corresponding author: e-mail, yarraraja@gmail.com

Understanding vein and ore-shoot geometry, mineral assemblages, and hydrothermal fluid characteristics is fundamental to understanding the genesis and exploration significance within an epithermal vein district, which provides both near-mine and district-scale targets. The Shahumyan deposit provides a unique opportunity to study and characterize an extensive vein system within the Kapan district, similar in character to the world-class Creede, Acupan, or Morococha vein districts. The Kapan district is located in the Syunik Province of southeast Armenia. The district consists of multiple vein-type deposits that have been dated to the Middle-Upper Jurassic. Shahumyan is the only actively producing deposit within the district, with an indicated and inferred resource of 15.87 Mt at 2.72 g/t Au, 48.5 g/t Ag, 0.5% Cu, 1.82% Zn, and 0.1% Pb cutoff.

The geometry of mineralized veins is characterized by subvertical, S-dipping and E-W-trending domains that contrast with the N-S- to NW-trending Central, Eastern, and Western Shahumyan faults. Detailed underground mapping reveals the veins to be anastomosing and comprising small bends, extensional jogs, soft and hard linked step-overs, pinch and swell structures, and cymoid loops. Kinematic analysis based on these features reveals a normal-dextral sense for vein propagation. These features are observed both along strike and down-dip of individual veins and are accompanied by increased metal grades relative to the rest of the vein. Along strike and down-dip, connectivity of these structural features defines high-grade ore shoots within mineralized veins. Three main hydrothermal stages associated with mineralization have been defined: stage 1 (pyrite, fine-grained quartz  $\pm$  chlorite); stage 2a and b (pyrite, chalcopryrite, sphalerite, galena, sulfosalts, Au-Ag tellurides, fine and coarse white quartz  $\pm$  calcite); and stage 3 (calcite, quartz, pyrite). Petrographic studies revealed Au-Ag-Pb tellurides to be associated with localized brecciation, with tellurides present within fractured sphalerite, pyrite, chalcopryrite, and galena, and they have been linked to boiling from texture and fluid inclusion studies. Fluid inclusion results indicate hydrothermal fluids responsible for base metal minerals (stage 2a) to have temperatures between 270° and 150°C ( $T_h$ ) with an average fluid salinity of 4.8 wt % NaCl. Fluids responsible for precious metals (stage 2b) are characterized by higher salinities and relatively lower temperatures (up to 13.31 wt % NaCl; 150°–130°C,  $T_h$ ). Increased mixing and dilution of hydrothermal fluids with cooler fluids begins at 140°C ( $T_h$ ) and results in a correlated drop in salinity and temperature of hydrothermal fluids to 1.56 wt % NaCl and 120° to 70°C ( $T_h$ ), precipitating stage 3 minerals.

The epithermal event at Shahumyan is characterized by punctuated periods of hydrothermal brecciation interspersed with more quiescent periods when coarsely banded vein material was precipitated. Localized brecciation associated with propagating normal faults provides ideal fluid pathways for mineralizing fluids. Mapping, petrographic observation, and fluid inclusion studies indicate localized boiling to be the primary control for Au-Ag tellurides and simple cooling to be responsible for precipitating base metals.