

Structural Controls on Kestanelik Epithermal Vein System, Lapseki, NW Turkey: Implications for Permeability Enhancement Processes During Epithermal Gold Mineralization

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The most favorable and principal mineral deposition process in low-sulfidation (LS) epithermal systems is boiling. Mineralization in these systems occurs dominantly as veins and stockworks; therefore, structures play a major role in the localization of epithermal fluid flow. Epithermal fluids rise from depth along structural conduits at high temperatures under enough pressure to prevent boiling. When the pressure drops suddenly (for instance, through faulting or any fracturing), boiling occurs and causes first the base metals and then the ore and gangue minerals to deposit in a well-recognized temporal and vertical sequence until all open spaces are filled. Vein infill in epithermal deposits indicates that mineralization is multiphase and associated with repeated and episodic fluid flow. How can permeability enhancement be achieved after deposition of minerals in fractures and faults chokes permeable pathways and restricts fluid flow? Although geochemical aspects of LS epithermal systems are well known, limited studies exist on the permeability enhancement mechanisms in LS epithermal veins. The main aim of the study is to understand the permeability enhancement mechanisms in epithermal gold deposits by focusing on the structures and quartz textures of a well-preserved low-sulfidation epithermal quartz vein/breccia system in Lapseki, NW Turkey. We revealed the kinematics of the structure-vein network by mapping the geometries of epithermal quartz veins and associated structures and collecting detailed structural data from them. We determined the different phases of fluid flow and mineralization with the crosscutting and structural relationships among them by examining the quartz textures and breccias and mapping their spatial distribution on vein outcrops and in drill cores with the help of thin section analyses. In addition, we modeled the 3D geometry of the major veins in Midland Valley-MOVE Software using the log and geochemistry data of 396 boreholes (255 diamond holes, 141 reverse-circulation holes) to see how the geometry of the veins relates to host rocks and gold grades and to help understand the structural controls on the vein emplacement and the likely evolution of the vein system.

Our results suggest that after sealing of the veins due to the previous mineralization phases, permeability was created by an earthquake rupturing event due to the horizontal NE-SW-oriented compression dominant in the area during epithermal mineralization. Structures hosting the mineralized veins should have been activated along the vein-host rock contact in this compressional regime; E-W-oriented veins were opened as a left-lateral strike slip fault, an N-S-oriented vein was opened as right-lateral strike slip fault; and NE-SW-oriented veins were opened as extensional fractures.

This study emphasizes the importance of understanding the structural controls on the multievent history of vein emplacement for gold exploration on the mine and regional scales. In addition, the results will shed light on the behavior of hydrothermal fluids at high crustal levels.