GEOCHEMISTRY AND STABLE ISOTOPES OF THE RIFT-RELATED QUARTZ-ADULARIA-TYPE GOLD-SILVER MINERALIZATION, IZMIR, TURKEY

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ABSTRACT

The Ovacık epithermal gold-silver deposit is located in the west Anatolian extensional province, adjacent to the ENE-trending Bergama graben, 100 kms north of the city of Izmir, western Turkey. This province hosts several other epithermal deposits such as quartz-adularia-type Efemçukuru (3.1 Mt at 14.6 g/t) and Küçükdere(1.4 Mt at 6.4 g/t Au) and porphyry-related high sulfidation Kisladag (276 mt/1.2 gt Au). Gold and silver of economic grades at the Ovacık deposit (4.19mt @ 7.6g/t) occur in epithermal quartz veins and display typical low-temperature epithermal textures, including crustiform banding, quartz pseudomorphs after bladed calcite, and multiphase hydrothermal breccias. Alteration minerals are dominated by smectite, mixed layer illite/smectite, quartz, adularia, calcite and pyrite with kaolinite overprint to a depth of 200 m. The total sulfide content is low (less than 2%) and is dominated by pyrite with traces of chalcopyrite, arsenopyrite, acanthite, argentite, tetrahedrite/ freibergite, pyrargyrite, stibnite, galena, chalcocite, bornite, covellite and sphalerite occurring mainly within the breccia clasts. The arsenopyrite and pyrite tend to be concentrated within certain bands, accentuating the banding in the breccia clasts with a dark coloration. Fluid inclusion studies reveal that main-stage quartz with liquid-rich inclusions with an average T_h of 200^0C and Tm ice of -04 to -1.2^0C (salinity<2 wt. Percent NaCl equiv) are dominant.

Geochemical variations in altered wall rocks are generally characterized by two-fold enrichments in K, Rb, Cs and 25 to 93 percent depletions in Sr, Ca, Mg, Na and more so (96 to 99 percent) in the quartz-adularia vein zone. La, Ce, Pr, Hf, Zr, Sm, Eu, Gd, Tb and Ho also exhibit up to 50 percent depletions in the wall rock and even more so (up to 90 percent for La and Nd) in the vein structure. The wall rock enrichments in Au, Ag, As, Hg and Sc are by factors of 60, 150, 88, 8 and 3, respectively. The ranges of REE in both the altered volcanic rocks and quartz-adularia veins are wide and reflect significant mobilization and fractionation of REE during alteration and mineralization. Low Rb/Sr ratios and corresponding low K values within kaolinite-altered areas is due to acid (high H^+) leaching of K in volcanic rocks whereas higher Rb/Sr ratios in adularia-illite-altered areas are closely related to the presence of these K-rich alteration minerals. Large variation in Rb/Sr ratios is due to changes in the concentration of both elements and follows the K addition and Ca leaching typical of wall-rock alteration of igneous rocks in shallow hydrothermal systems. Positive correlation coefficients of Au with Ag, Pb, Zn, Cd, Cu and Sb in epithermal quartz veins are remarkable, all of which are greater than 0.51. Silver and Sb are remarkably enriched at higher levels of the deposit. No correlation occurs between Au-As and Ag-As, indicating that they may be related to different mineralizing events and thereby possible introduction of Au, Ag and Sb in different phases of mineralization.

Quartz and pyrite minerals in gold-silver-bearing veins have $\delta^{18}O$ values ranging from +9.5 to +15.7‰ and δD values ranging from -89 to -125‰. Quartz results indicated that ore-forming hydrothermal fluids at Ovacik had $\delta^{18}O_{H2O}$ values ranging from -2.9 to 3.5‰ (average: -0.6‰), ^{18}O enriched compared with present-day hydrothermal meteoric water (-6.8‰ from hot springs). $\delta^{18}O$, $\delta^{18}O_{H2O}$ and δD values (from quartz) suggest that mineralizing solutions were a mixture of magmatic and meteoric waters. The $\delta^{34}S_{pyrite}$ data range from -2.1 to 3.3‰ ($\bar{x}$ =1.2) and $\delta^{34}S_{H2S}$ range from -3.0 to 3.0‰ ($\bar{x}$ =0.4). These $\delta^{34}S_{pyrite}$ and $\delta^{34}S_{H2S}$ values are consistent with a magmatic source for S. Narrow ranges of $\delta^{34}S_{pyrite}$ and calculated $\delta^{34}S_{H2S}$ values for fluid may suggest that $\delta^{34}S_{H2S}$ fractionation stayed relatively stable during evolution of the hydrothermal system.