EXTINCT GEOTHERMAL SYSTEMS IN THE CONTINENTAL RIFT ZONES OF THE MENDERES MASSIF, WESTERN ANATOLIA, TURKEY

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The Hg, Sb and Au deposits of Halıköy, Emirli and Küre are related to faults which strike preferentially NE-SW and NW-SE and are located diagonal to the general strike of the rift zone of the Küçük Menderes. The calcalkaline volcanics of Middle Miocene age, which occur in the E and NE part of the investigated ore fields indicate basic towards acidic features and crustal origin and seem to be closely related with tectonic features, ore deposits and active geothermal systems.

The intensively altered mica schists and quartzites, which form the host rocks for Hg, Sb and Au deposits, can be considered as source rocks for the metals, as supported by leaching tests. The hydrothermal alteration is distinguished by phyllic, argillic and silicic ± hematitization alteration zones which are comparable with those of active geothermal systems in the continental rift zones of the Menderes Massif. This type of alteration is comparable with adularia-sericite-type-mineralization due to presence of adularia and bladed calcite crystals. The homogenization temperatures of quartz and stibnite crystals range from 150 to 300 ºC, which can be compared with geochemical temperatures of thermal water reservoirs from 220 to 260. The ore-forming fluids of Halıköy, Emirli and Küre show a mean value of 6 NaCl eq wt %; it is comparable with the salinity of active geothermal fluids. The isotope ratios of $\delta^{18}O$ and $\delta^{2}H$ in fluid inclusions of quartz crystals of Halıköy, Emirli and Küre show a similarity with those of active geothermal fluids. The strong deviation of the $\delta^{18}O$ values from the meteoric water line shows the intensive fluid-rock interaction in the hydrothermal environment. The trend of deviation increases linearly from the active geothermal field to the epithermal ore fields indicating a relationship between the two.

Finally, it might be concluded that (i) the fluids of Hg, Sb and Au mineralizations of Halıköy, Emirli and Küre can be attributed to a meteoric origin due to stable isotopes of $\delta^{18}O$ and $\delta^{2}H$, (ii) the metamorphic rocks act as the source of metals of Hg, Sb, As and Au which are forming ore deposits in the rift zones and leached from the metamorphic rocks by fluid-rock interaction and transported as bisulfide complexes with circulating geothermal fluids to the subsurface environment between 500 to 1500 m in depth at temperature below 350 ºC. Ultimately, with the cooling of magma chamber, the Au mineralization of Küre was formed at temperatures below 300 ºC. Arsenopyrite is present in the ore mineral assemblages of investigated Hg, Sb and Au mineralizations. In connection with further cooling of magma chamber, the Sb mineralization of Emirli took place at temperatures from 180 to 250 ºC. The Hg deposit of Halıköy is generated as the last mineralization at temperatures from 128 to 200 ºC. The meteoric fluids percolate above permeable clastic sediments in the reaction zone of the roof area of magma chamber in depth of 2-3 km where the fluids are heated and ascend to the surface because low density. The volatile components of CO_2, SO_2, H_2S and HCl from magma reached the geothermal water reservoir as ascending gas phases where an equilibrium reactions between

altered rocks, gas components and fluids took place. The ascending fluids contain CO_2, H_2S and HCl particularly. Hydrothermal convection cells press the heated fluids toward the surface because of their lower density. Thus, geothermal waters ascend in tectonic zones of weakness. As geochemical pH-neutral fluids, the waters outlet at the surface as hot springs, gas and steam. The fluids indicate a reduced pH-neutral sphere in the reaction zone after equilibrium with host rocks. At the subsurface spheres, the ore deposits are generated in terms of stockwork mineralizations (veins, veinlets) and gangue minerals represented by quartz, calcite and adularia. The Hg, Sb and Au deposits of Halıköy, Emirli and Küre can be assigned to an epithermal type in connection with an calkalkaline volcanism in Middle Miocene age, comparable to other Hg, Sb and mineralizations in the rift zones of the Menderes Massif, similar to the epithermal Sb and Au deposits in the metallotect of Jiangnan, PR China and active and extinct geothermal systems of New Zealand, and considered as fossil equivalents of active geothermal systems.