

## **Mineralogical and Geochemical Characterization of the Kimmeria Intrusion-Related Deposit, Xanthi, NE Greece**

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Although intrusion-related systems have not been previously recognized in the European segment of the Tethyan Metallogenic Belt, the Rhodope metallogenic province of SE Balkan peninsula hosts numerous such occurrences.

The Kimmeria hydrothermal system incorporates two styles of ore mineralization: i) a massive Au-bearing magnetite-pyrrhotite skarn and ii) a Mo-Cu-Bi-W quartz vein-hosted mineralization, both of which are related to the Oligocene Xanthi pluton ( $25.5 \pm 1.2$  to  $30 \pm 1$  My, K-Ar in hornblende and biotite). The Xanthi pluton, consisting of I-type gabbros, monzonites and amphibole-biotite granodiorites, intrudes the basement gneisses, mica schists, amphibolites and marbles of the Southern Rhodope Core Complex; a dome that has gradually exhumed from Paleocene/mid Eocene to Miocene (starting between 65 and  $>42$  to 10 My). The Xanthi pluton emplacement and the magmatically derived hydrothermal fluid circulation were controlled by two major regional structures: the low-angle Kavala-Xanthi-Komotini detachment fault and the Nestos thrust fault.

The Kimmeria Au-Cu-Fe skarn mineralization features a well-preserved aureole at the contact between the granodiorite and the surrounding marbles. It consists of two paragenetic stages comprising magnetite and pyrrhotite-rich assemblages. Alteration minerals comprise chlorite and sericite. Bulk chemical analyses of the skarn mineralization revealed relatively high concentration of Cu (1 wt.%), Pb (288 ppm) and Zn (0.74 wt.%). The mineralization is also enriched in As ( $< 75.8$  ppm), W ( $< 82.1$  ppm), Bi ( $< 10.1$  ppm), Sb ( $< 331.9$  ppm), Ag ( $< 15.9$  ppm), and Sn ( $< 50$  ppm). Te and Au are found in low concentrations of less than 2 ppm and 0.4 ppm, respectively.

The Kimmeria Mo-Cu-Bi-W vein-type mineralization comprises a system of cross-cutting and sheeted quartz veins within the granodiorite, with pyrite, chalcopyrite and molybdenite as dominant sulfides. Minor sphalerite, tetrahedrite-tennantite, galena and rutile are also present, while sericite and chlorite as the alteration minerals. The Cu and Mo content of the vein type mineralization exceed 1.0 and 0.2 wt.% respectively, along with  $< 2.7$  ppm Au, 1.3 to 79.5 ppm W and 0.6 to 456 ppm Bi.

A first approach fluid study has revealed small variations in  $\delta^{34}\text{S}$  values of sulfides (0 - 2.3 ‰ VCDT) from both types of mineralization suggesting a magmatic source of sulfur. Silicate  $\delta^{18}\text{O}$  values of quartz show a narrow range between 10.3 and 11.2 ‰ (VSMOW) suggesting similar quartz formation for both mineralization types, at relatively low temperatures and probably from the same fluid. Oxygen isotopes values in calcite from the unmineralized marbles and ore specimens are scattered over a wide range from 12.1 to 41.7 ‰ (V-SMOW). They have relatively low carbon isotopic values (-4.8 to 2.1 ‰ V-PDB), indicative of a magmatic  $\delta^{13}\text{C}$  signature and a restricted isotopic exchange with hydrothermal fluids. Primary fluid inclusion studies have revealed the presence of  $\text{CO}_2$  in the ore fluid, which might have played an important role during the ore genesis irrespective of the mineralization style.

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