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The Source and Transport of PGEs in Tethyan Porphyry Deposits—Bi-Te-Se Melts as a Collector Mechanism for PGEs in the Skouries Cu-Au Deposit, Greece?

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Porphyry deposits are a potential alternative resource for platinum group elements (PGEs), yet the mechanisms and source of PGE enrichment in porphyry copper deposits are still not fully understood. The Skouries deposit is an Au-Cu porphyry system in the Chalkidiki peninsula, Greece, with associated Ag, Pd, Pt, Te, and Se credits. It is one of two significantly PGE enriched porphyry deposits in the Tethyan Belt, the other being Elatsite in Bulgaria.

The Skouries deposit is hosted by a series of overprinting intrusions within the schist and gneiss of the Vertiskos formation of the Serbo-Macedonian Massif. The earliest intrusion is a quartz-monzonite porphyry that contains a quartz-magnetite ± chalcopyrite-pyrite stockwork, which is cut by a set of syenite porphyry dikes that host quartz-chalcopyrite-bornite veins. The final intrusive phase consists of monzonite dikes with later sulfide veinlets, which are cut by a final late vein stage containing quartz-pyrite ± anhydrite. The compositions of the intrusive phases are similar, and are interpreted to share the same magma source, with their compositional evolution representing the fractionation of a hypabyssal stock.

The Pd and Pt in the deposit are hosted within telluride and selenide minerals that occur both as inclusions in chalcopyrite and as blebs within euhedral quartz crystals in the quartz-chalcopyrite-bornite veins associated with the second syenite intrusion. Electron microprobe and SEM-EDS analyses have shown the main platinum group minerals present are merenskyite ($(Pd, Pt)(Te, Bi)_2$) and sopcheite ($Ag_4Pd_3Te_4$), with minor telargpalite ($(Pd,Ag)_3Te$) and kotulskite ($Pd(Te,Bi)$). Gold and silver tellurides are also present as hessite (Ag_2Te), muthmannite ($AgAuTe_2$)-krennerite ($AuTe_2$) assemblages, with minor amounts of sylvanite ($(Au,Ag)_2Te_4$), empressite ($AgTe$), and volynskite ($AgBiTe_2$)-skippenite ($Bi_2Se_2(Te,S)$).

$\delta^{34}S$ values of the deposit range from –3.8‰ to +1‰, with an average of –1.4‰, with no difference seen between veins with and without Pd and Pt enrichment. This indicates a magmatic sulfur source for all stages of this deposit. Fluid $\delta^{18}O_{V\text{-}SMOW}$ ranges from 6.4‰ to 7.4‰, and fluid $\delta D_{V\text{-}SMOW}$ from –87.5‰ to –52.6‰, consistent with a magmatically equilibrated fluid source. Fluid inclusion studies have shown these fluids to be high temperature (>450°C) and highly saline (>21 wt %). Optical examination coupled with SEM-EDS analysis of daughter minerals from opened fluid inclusions suggests the presence of a large variety of daughter minerals, including sylvite, halite, hematite, jacobsite, tennantite, galena, pyrite, chalcopyrite, bornite, barite, and iron chloride.

These oxidized and highly saline fluid conditions may favor the hydrothermal transport of PGEs. However, Bi-Te melts can also exist at these temperatures, so an alternative PGE transport mechanism could be an immiscible metalloid melt ascending with the hydrothermal fluids. This Bi-Te-Se melt would act as a collector for PGEs before precipitating as blebs and thus would allow the formation of a PGE-enriched porphyry without the need for Pt and Pd fluid saturation. New LA-ICP-MS data will compare the precious metal content of the fluid inclusions and metalloid blebs in order to determine the main method of transport.