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Mineralogical, Geochemical, and Structural Constraints of the Vathi Porphyry Cu-Au ± U ± Mo Mineralization, N. Greece

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The Vathi Cu-Au ± U ± Mo porphyry-style mineralization occurs in the Serbo-Macedonian metallogenic province of the Western Tethyan metallogenic belt. It is located 18 km northwest of the Kilkis, northern Greece, and extends around two hills named Ragian 1 and Ragian 2. The main host rock (41°08'44.99"N, 22°57'47.67"E) is a trachydacite porphyry, but the ore, along with the spatially related hydrothermal alteration, is genetically linked to a subvolcanic quartz-monzonite stock (18–17 Ma, based on zircon U-Pb dating), which has intruded the crystalline basement rocks and the trachydacite porphyry. The emplacement of the magmatic rocks is structurally controlled by E-W–, NW-SE–, and NE-SW–trending groups of faults as a result of the Tertiary evolution of the Serbo-Macedonian massif. The trachydacite porphyry was affected locally by a weak potassic and a strong propylitic alteration, which are in turn overprinted by an extended feldspar-destructive sericitic alteration and by silicification. In contrast, the quartz-monzonite stock was affected by potassic alteration, which is overprinted by sericitic alteration. Stockworks, sheeted veins, and oxidized ENE-trending pyrite D-veins occur in the trachydacite porphyry, mainly on the eastern part of the Ragian 1 Hill. The quartz-monzonite is an E-W–trending, fault-controlled intrusion, which was affected by pervasive potassic alteration, subsequently overprinted by sericite alteration. Locally, an ENE-trending, hydrothermally altered phreatomagmatic breccia crosscut the trachydacite porphyry. The breccia consists of angular fragments of trachydacite and basement metamorphic rocks cemented by clays, white mica, and quartz, and disseminations of oxidized pyrite. Hematite, limonite, and malachite fill fractures of the breccia and form extended encrustations. Ore minerals, observed at the surface of the quartz-monzonite and the surrounding trachydacite porphyry, include pyrite and chalcopyrite, which form disseminations, veinlets, and small stocks. At depth, the drill cores from the trachydacite porphyry revealed that the mineralization contains an early disseminated chalcopyrite-bornite-molybdenite-magnetite assemblage, followed by vein-type pyrite-pyrrhotite-chalcopyrite and sphalerite-galena ± arsenopyrite associations. The trachydacite was affected by intense supergene oxidation, which extends up to a depth of 90 m. Associated mineralization includes malachite, azurite, hematite, and limonite near the surface, and cuprite, native copper, and metatorbernite at deeper levels. A spatially restricted secondary enrichment zone, approximately 2 m thick, occurs below the oxidation zone and includes chalcocite and covellite. The Vathi porphyry-style mineralization is exceptionally enriched in U and REEs, which is unusual in porphyry systems. Surface oxidized samples contain, on average, 2,607 ppm Cu, 335 ppm Mo, up to 330 ppm U, up to 500 ppm La, up to 715 ppm Ce, and up to 7 ppm Au (average 0.73 ppm). It shares several features in common with the Skouries porphyry Cu-Au deposit, in the adjacent Chalkidiki ore district, and is a promising future exploration target for gold and possibly REEs.