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Biotite Geochemical Characteristics as Vectors to Barren and Mineralized Intrusions at the Sungun Porphyry Copper Deposit, Northwestern Iran

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The Sungun porphyry copper deposit (northwestern Iran), a typical high-grade Cu deposit, is situated in the Cenozoic Urumieh-Dokhtar magmatic arc, which is a part of the Tethyan metallogenic belt. Mineralized overlapping alteration zones and a barren, post-ore quartz diorite dike were sampled. Based on the optical features, backscattered electron microprobe images, and compositional criteria, 45 biotites are classified as least-altered magmatic biotites (LA-Mbt), least-altered equilibrated magmatic biotites (LA-Eq Mbt), equilibrated magmatic biotites (Eq-Mbt), secondary hydrothermal biotites (S-Hbt) of the mineralized zone, and least-altered magmatic biotites (LA-Mbt) of the barren dike. Biotite types plot in the field of calc-alkaline orogenic suites and fall within the compositional field between eastonite and phlogopite, but LA-Mbt of the mineralized zone are richer in Mg than LA-Mbt of the barren dike. The LA-Mbt of the mineralized zone show a high level of TiO_2 (3.92–4.33 wt %), in comparison to LA-Mbt of the barren dike (ave. 4.17 wt %) and S-Hbt (0.27–3.00 wt %) of the mineralized zone. The highest amount of Na_2O (0.39–0.58 wt %) is characteristic of the barren dike (LA-Mbt) compared to other types of biotite and especially to the LA-Mbt of the mineralized zone (0.08–0.15 wt %). The SiO_2 in LA-Mbt of the barren dike (ave. 36 wt %) is lower than that of LA-Mbt of the mineralized zone (ave. 37.00 wt %). Having the highest level of MnO (0.11–0.18 wt %) is another characteristic feature of LA-Mbt of the barren dike compared to LA-Mbt of the mineralized zone (0.03–0.14 wt %). S-Hbt of the mineralized zone have the lowest level of MnO (wt %). In this study, SO_3 of biotite types has been determined, which is complex to interpret. A plot of SO_3 vs. Cu in biotites from overlapping alteration zone samples indicates that the phyllic-high/argillic-low has the higher values for Cu (ave. 1.12 wt %) and the lower ones for SO_3 (ave. 0.04 wt %) than the potassic-high/phyllic-low, with 0.86 wt % Cu and 0.06 wt % SO_3, on average; this can be related to the formation of sulfide and magnetite in these zones, respectively. According to F and Cl contents, intercept values of F, Cl, F/Cl, and evidence of hydrothermal fluid halogen fugacity ratios of biotite types at Sungun Cu porphyry deposit, chlorine is an indicator for postmagmatic hydrothermal processes and fluorine is a diagnostic factor for vectoring to mineralized and barren porphyry Cu systems.

Calculated temperatures for LA-Mbt, LA-Eq Mbt, Eq-Mbt, and S-Hbt of the mineralized zones and the LA-Mbt of the barren dike range from 739° to 794°C, 736° to 798°C, 717° to 792°C, 581° to 693°C, and 764° to 770°C, respectively. The calculated oxygen fugacities for LA-Mbt of the mineralized zones range from 10 to 15.4 to 10 to 13.8, which lies within the range of typical oxygen fugacities for porphyry mineralization ($\log f_{O_2}$ > FMQ +2), where FMQ is the fayalite-magnetite-quartz oxygen buffer. Based on the study carried out, mineral chemistry of biotite can be efficient in the prediction of the mineralization potential of intrusive bodies.