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Evolution of Metal Endowment in the Porphyry Au-Cu-Mo Deposits of the Long-Lived Sulphurets District, Canada: Implications for Fertile Magma Sources

Michelle E. Campbell[1, 2], John H. Dilles[1], Robert Creaser[3]
1. Oregon State University, Corvallis, OR, USA, 2. Seabridge Gold Ltd., Toronto, ON, Canada, 3. University of Alberta, Edmonton, AB, Canada

The Sulphurets district porphyry Au-Cu-Mo deposits, located in northwestern British Columbia, were formed in the Early Jurassic, during a prolific period of arc magmatism in the Stikine terrane. The four known deposits within the district are spatially and genetically associated with high-K calc-alkaline to alkaline Texas Creek suite porphyry intrusions. Owned by Seabridge Gold Inc., the porphyry ores are unusually gold rich and contain one of the largest global porphyry gold endowments, with >1,200 t Au (proven and probable reserves). New Re-Os molybdenite ages elucidate the age of mineralization at the Kerr (201.4 ± 0.9 Ma, 203.1 ± 0.9 Ma), Sulphurets (194.8 ± 0.9 Ma, 194.9 ± 0.9 Ma, 195.1 ± 0.9 Ma), and Iron Cap (194.1 ± 0.9 Ma, 194.3 ± 0.8 Ma) deposits, complementing existing geochronology data for mineralization at the Mitchell-Snowfield deposit (190.3 ± 0.8 to 192.0 ± 1.0 Ma; Febbo et al., 2019). The Re-Os molybdenite geochronology data thus reveal that the Sulphurets district was exceptionally long-lived, featuring one of the longest known lifespans among worldwide porphyry copper districts (11 ± 3.5 m.y.).

The determination of the chronology of deposit formation within the district reveals several compelling temporal trends. Notably, the Au/Cu and the Mo/Cu metal ratios of the Sulphurets district deposits increase progressively from the oldest Kerr deposit (Au/Cu ≈ $5.4 \cdot 10^{-5}$; Mo/Cu ≈ $1.2 \cdot 10^{-3}$; based on measured and indicated resource models) to the youngest Mitchell-Snowfield deposit (Au/Cu ≈ $4.3 \cdot 10^{-4}$; Mo/Cu ≈ 0.05). Furthermore, the volumetrically important synmineral plagioclase-hornblende diorite to monzodiorite Texas Creek suite porphyry intrusions become incrementally more evolved in the district deposits over time. The evolution of magmatic compositions is noted in systematic variations of whole-rock K_2O values and incompatible trace element ratios, such as Ce/V. The temporal covariation between increasing Au/Cu and Mo/Cu ratios with increasingly evolved and K-rich synmineral intrusions among the district deposits suggests an intimate association between magmatic composition and the potential for Au and Mo enrichment in porphyry Cu-(Au-Mo) deposits. Based upon the expansive ~11 m.y. history of the district, which surpasses the possible lifespans for upper crustal magmatic systems, the observed evolution of magmatic compositions must be linked to processes occurring in the mid- to deep-crust.

Febbo, G. E., Kennedy, L. A., Nelson, J. A. L., Savell, M. J., Campbell, M. E., Creaser, R. A., Friedman, R. M., Van Straaten, B. I., and Stein, H. J., 2019a, The evolution and structural modification of the supergiant Mitchell Au-Cu porphyry, Northwestern British Columbia: Economic Geology, v. 114, no. 2, p. 303–324.