

Ore-Forming Tempo at the Filo del Sol Cu–Au–Ag Porphyry–Epithermal System, Argentina–Chile: New Bulk and In-Situ $^{40}\text{Ar}/^{39}\text{Ar}$ and Zircon U–Pb Geochronology

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The giant Filo del Sol (FDS) deposit, located in the Central Andes along the Argentina–Chile border, represents an exceptionally well-preserved telescoped porphyry-epithermal Cu–Au–Ag system. However, the temporal relationship between high-sulfidation epithermal mineralization and the underlying porphyry is not well established. This study presents new comprehensive bulk and in situ $^{40}\text{Ar}/^{39}\text{Ar}$ ages from alunite, biotite, and K-feldspar that constrain the age of alteration and mineralization. In addition, new zircon U–Pb dates are integrated with previously published molybdenite Re–Os and zircon U–Pb data to determine the timing of magmatism relative to mineralization. Zircon U–Pb ages from ore-related porphyry intrusions range between 16.0 ± 0.4 and 14.9 ± 0.4 Ma and partially overlap with published molybdenite Re–Os ages of 15.1 ± 0.1 to 14.1 ± 0.1 Ma. These, in turn, broadly coincide with new biotite and K-feldspar $^{40}\text{Ar}/^{39}\text{Ar}$ ages for potassic alteration in porphyry-related mineralized veinlets, ranging between 14.0 ± 0.1 and 13.8 ± 0.7 Ma. Advanced argillic alteration associated with high-sulfidation mineralization is characterized by two principal age populations of hypogene alunite at ca. 13.87 ± 0.1 Ma and ca. 12.65 ± 0.4 Ma, and steam-heated alunite dated at 13.73 ± 0.10 and 13.62 ± 0.01 Ma. The oldest alunite population overlaps with potassic alteration, whereas the youngest group shows no clear association with any dated magmatism in the area. These results suggest a temporal link between magmatism and mineralization as well as the synchronous formation of porphyry and high-sulfidation mineralization. However, the youngest alunite ages associated with high-sulfidation mineral assemblages suggest late-stage ore-forming fluids released either during the waning stages of magmatism or from unrecognized intrusions at depth. Overall, FDS records episodic magmatic–hydrothermal pulses within a time span of ~5 m.y., highlighting the protracted dynamic evolution that characterizes large porphyry–epithermal systems.