Tectonic evolution of the Cerro Casale Au-Cu-porphyry system, Chile: Utilizing igneous geochemistry for exploration targeting

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The Cerro Casale porphyry Au-Cu deposit (1,300 Mt @ 0.7 g/t Au and 0.35% Cu) is located at the southern end of the Maricunga belt, near the northern boundary of the modern nonvolcanic, flat-slab region of the Chilean Andes (28-33°S). The Casale district comprises the Casale, Roman, Eva, Estrella, and Anfiteatro dioritic to granodioritic plutons. The Casale diorite is the main host to mineralization. The economic Au-Cu mineralization and associated potassic and phyllic alteration in Cerro Casale are all hosted in the Cerro Casale diorite porphyry, centered on late fine-grained granodiorite porphyry and intrusive/hydrothermal breccias.

Laser ablation ICPMS U-Pb zircon geochronology for the intrusions has shown a previously unrecognized complexity to the intrusive phases. The mineralized granodiorite in the Casale intrusion yielded an age of 13.9 ± 1.1 Ma whereas the Casale diorite porphyry yielded an age of 14.4 ± 1.0 Ma slightly younger than the Estrella (15.0 ± 0.8 Ma) in the east and Eva (15.8 ± 0.9 Ma) porphyries in the north. Diorite porphyries from the Roman and Romancito prospects in the north, yielded older ages of 17.2 ± 0.5 and 17.4 ± 0.6 Ma, whereas diorite samples from the barren Eva (19.9 - 28.0 Ma) and Jotabeche (27.6 - 28.0 Ma) intrusions yielded older ages. Significantly the Caspiche porphyry Au-Cu deposit (1,091 Mt @ 0.55 g/t Au; 967 Mt @ 0.23% Cu), located 15 km north of Cerro Casale, was emplaced at 25.38 ± 0.09 Ma based on Re-Os dating of molybdenite, suggesting that the magmatic and metallogenic history of the district is more complex than previously recognized.

The intrusive rocks from the district are predominantly medium-K andesites and diorites and show a trend to increasing Gd/Yb ratios in younger samples. Similar to trends in igneous rocks related to porphyry mineralization have been interpreted to be the result of subduction of the aseismic ridges and associated slab flattening. Calculated \( \varepsilon_{Nd} \) values for the intrusive rocks are uniformly negative (-0.6 to -2.8), consistent with contamination by older crustal sources, and show a weak trend to less negative values with time. \( ^{87}\text{Sr} / ^{86}\text{Sr} \) values range from 0.70490 to 0.70547 and increase in younger intrusions. The less negative \( \varepsilon_{Nd} \) in the younger intrusions in conjunction with a slight increase in Ni contents suggests a more primitive source for the mineralizing magmas. The trend at Casale to less negative \( \varepsilon_{Nd} \) values but increasing \( ^{87}\text{Sr} / ^{86}\text{Sr} \) suggests that the isotope systematics have been decoupled.

The combination of low cost geochronology and routine whole rock geochemistry provide a powerful tool for evaluating the tectonic evolution and prospectivity of intrusive phases within a mineralized district, in order to target exploration on more fertile intrusive phases.