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Reviewing the igneous history of the Spence porphyry copper deposit, northern Chile

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The Spence porphyry copper deposit occurs within the Paleocene-Early Eocene metallogenic belt of northern Chile, and consists of mineralization centered upon granodioritic intrusives of late Paleocene age (Rowland & Clark, 2001). The deposit was emplaced into carbonaceous siltstones of the Jurassic Cerritos Bayos Formation and is overlain unconformably by Miocene gravels ranging from 50 to 100 m in thickness. The Spence intrusives show sub-parallel NNE-SSW alignment, which coincides with a fault zone along which saline groundwater has upwelled and may have influenced the emplacement geometry and distribution of the intrusives themselves (Cameron & Leybourne, 2005). The distribution of intrusives along the axis of the fault is focused into four zones of activity that demonstrate varying degrees of mineralization. These zones are referred to as the South, Central South, Central North and North zones respectively.

Three main phases of igneous activity are identified based upon direct observations from drill-core and exploration tunneling (Rowland, 2001). In all four zones, the earliest igneous phase is a suite of porphyritic dykes that intruded in several pulses, differentiated from each other by subtle textural variations, veining, and alteration styles. The second phase of magmatism occurs only in the South and South Central zones, where it cuts and brecciates the preceding dykes and their associated veins. This second igneous phase re-works the first phase through explosive brecciation, leading to the formation of magmatic breccias and, more distally, to porous breccias, cemented by sericite and hydrothermal sulfides. A heavily altered monzodioritic dyke intrudes the second phase of magmatism in the South zone, thus representing the latest phase of magmatism observed in the South.

The comprehensive igneous framework provided at Spence, in which intrusive, explosive and hydrothermal events can be discriminated by clear cross-cutting relationships provides an ideal scenario to investigate the timeframe required for intrusive and hydrothermal activity leading to porphyry copper deposit formation. In order to develop a high-resolution timeline of magmatic events at Spence, we integrate these observable intrusive relationships with chemical abrasion-isotope dilution-thermal ionization mass spectrometry (CA-ID-TIMS) U-Pb zircon geochronology on samples across the deposit. The results illustrate that the first intrusive phase intruded diachronously across the deposit over several hundred thousand years. Moreover, the first phase of magmatism emplaced in the Central North post-dates the full suite of magmatism in the South and Central South, indicating a northwards propagation of igneous activity with time. Our results reveal that the entire suite of Spence intrusives were emplaced over several hundred thousand years, with onset of magmatism progressing northwards. In order to further constrain the evolution of the deposit, the timing of mineralization will be precisely constrained within this prolonged igneous framework. The application of high-precision geochronological techniques, reveals diachroneity within texturally similar units which previously was unresolved, and emphasizes the importance of rigorous characterization when correlating igneous units.