

## **Magnetite trace element chemistry as an indicator of the metallogenic fertility of arc magmas**

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Porphyry copper deposits supply up to three quarters of the global demand for copper, and are found in calc-alkaline volcanic sequences above subduction zones around the world. In particular, the Andes of central Chile and Peru are renowned for an unusual concentration of especially large and high-grade porphyry systems. Despite the wealth of high quality research in the field of porphyry deposit formation, a precise understanding of which processes determine the fertility of a porphyry system remains elusive.

This study provides insights into the temporal geochemical evolution of the magmatic systems associated with porphyry deposit genesis, through laser ablation inductively-coupled-plasma mass spectrometry (LA-ICP-MS) analysis of igneous magnetite from central Chile. The samples were collected from a 250 km segment of the Chilean magmatic arc, within which the porphyry centres of El Teniente and Los Pelambres are located, and span a time period of ~124 Ma to 5 Ma. They primarily comprise extrusive volcanics, including tuffs and ignimbrites, and range from basaltic to rhyolitic in composition. The samples were collected and discussed in terms of their whole-rock chemistry in previous work.

We provide evidence for a series of processes which could be responsible for the generation of large porphyry deposits in the belt. A regional shift toward increasingly water-rich and relatively more reduced magmas is inferred to have occurred over the ~30 My leading up to the formation of the deposits in the area. Reduction is indicated by the progressive increase of the ratio of V/Ga in magnetite, employed in this case as a relative redox ratio. Over the same time period, there is a decrease in the concentrations of As, Sb, and Pb in magnetite. These elements are highly fluid mobile and are associated with the propylitic alteration that accompanies porphyry mineralisation, thus the decrease in the concentration of these elements in magnetite could reflect partitioning into exsolving volatiles. This implies that the magmas became volatile saturated and progressively degassed over this time period. Finally, immediately prior to, or perhaps concurrent with, the period of mineralisation in the area, a divergence in the behaviour of the divalent metal cations Cu and Zn is observed. This is consistent with saturation of a magmatic sulphide phase. The subsequent dissolution of this magmatic sulphide phase in a magmatic volatile phase would produce an enriched fluid capable of producing fertile porphyry deposits.

This study indicates that a combination of processes, rather than any one single event, likely create the necessary conditions for the formation of the giant porphyry systems of central Chile. Importantly, this work demonstrates the validity of using magnetite trace element chemistry as a proxy to study the temporal geochemical evolution of magmatic systems. Avenues for future investigation are also provided to determine whether the trends outlined in this study are local, or symptomatic of porphyry mineralisation worldwide.