

## **Using magnetite chemistry to discriminate mineralised from barren porphyry copper systems**

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There is increasing interest in the use of magnetite as a petrogenetic indicator to interpret ore-forming processes. Trace element concentrations in magnetite vary considerably between different ore deposit types, recording the diverse formation histories of ore-forming systems. However, the ultimate goal from an exploration perspective is to use magnetite chemistry to identify not only the type of ore deposit, but to discriminate economically-mineralised from less-mineralised systems. Consequently, we studied the chemistry of magnetite associated with 35 porphyry copper deposits covering a range of metal associations and varying degrees of mineralisation using laser-ablation inductively-coupled-plasma mass-spectrometry (LA-ICP-MS).

Prior to embarking on collection of a large dataset of magnetite compositions by LA-ICP-MS, it is important to develop a consistent and reliable method of analysis. Various factors, such as exsolution, alteration and impurities, create complications and uncertainties in the analysis of Fe-Ti oxides. Thus, a study was conducted to research and develop a method which optimises the use of LA-ICP-MS to accurately and reliably measure their composition. Key aspects of this study include the effect of laser spot size when analysing grains with exsolution, the applicability of various external calibration materials for processing data, and uncovering which isotopes of certain elements suffer least from interferences by other species.

Using the optimised analytical method, over 2000 magnetite grains were analysed from our sample set using LA-ICP-MS. The sample set consists of rocks mostly from porphyry intrusions, but also includes other intrusive phases associated with porphyry copper systems and coeval volcanics. The style of alteration in the samples was documented so the effect of alteration on the magnetite chemistry could be evaluated. Importantly, all magnetite grains analysed were subject to detailed petrographic study prior to LA-ICP-MS analysis to assess the formation process of magnetite and document textures which could be related to compositional variations.

The magnetite grains analysed included both igneous and hydrothermal types. Whereas hydrothermal magnetite typically contains Ti < 0.5 wt. %, igneous magnetite generally contains greater than 1.5 wt. % Ti. For the various deposits studied, there are distinct breaks in the Ti content of magnetite, usually between 1 and 2 wt. % Ti. This can be used to define a customised cut-off to separate the two types in each deposit. Once hydrothermal and igneous magnetite were identified, we investigated the potential effects of porphyry system type, host lithology, alteration type and degree of mineralisation on magnetite composition. Most notably, there are clear distinctions in the composition of hydrothermal magnetite between Cu-Au and Cu-Mo porphyry deposits. We also developed plots that discriminate the chemistry of hydrothermal magnetite between strongly mineralised, less mineralised and barren porphyry intrusions. Factors responsible for these chemical distinctions in magnetite have been investigated to elucidate key processes necessary for the formation of giant porphyry copper deposits.