Fertile or Futile? Using Plagioclase Composition and Texture to Assess Copper Fertility in Magmas

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Despite the growing demand for copper in the green energy transition, new discoveries of copper deposits have plummeted in the past decade. As a result, research is needed to identify new mineral indicators that can support the exploration of poorly exposed deposits. Plagioclase has become a subject of interest due to its abundance in arc magmas and sensitivity to crystallisation conditions. Plagioclase form and preserve distinct growth zones due to its broad stability and slow diffusion, making it a valuable tracer of magma evolution, and potentially copper fertility. Hydrothermal alteration has hindered the development of plagioclase as a porphyry indicator mineral, but high-resolution techniques now allow precise in situ analysis. This study explores plagioclase textural features and chemical indices that may preserve magmatic processes conducive to mineralisation.

First, we build a global geochemical compilation of plagioclase from porphyry deposits and barren magmatic systems. Then, we compare the compilation with new data from two porphyry copper systems – the Yerington Cu-Mo deposit (USA) and the Northparkes Cu-Au deposit (Australia). Both deposits have well-characterised pre-, syn- and post-mineralisation stages that can be used to track variations in plagioclase with the evolution of copper fertility. We analyse crystal texture through polarised light imaging and analyse major and trace elements with electron microprobe and laser ablation mass spectrometry.

We find that the anorthite content (Ca-rich plagioclase end-member), Fe, Ba, and Sr vary between the mineralised and unmineralised intrusions. Barren plagioclase typically has patchy simple zoning and resorption textures indicative of disequilibrium. In contrast, pre- and syn-mineralisation plagioclase shows fine oscillatory zoning with normally zoned cores, indicating crystallisation from relatively evolved melts and multiple episodes of magma ascent and recharge with similar magmas. These differences in composition and texture provide potential fertility indicators that could improve copper exploration outcomes.