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The role of magma source and evolution in the formation of porphyry copper deposits – a comparative study in central Chile

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Copper is critical for the energy transition. With three-quarters of the world's Cu production coming from porphyry Cu deposits, improving our understanding of the magmatic-hydrothermal processes that form them is now more important than ever. Most studies of porphyry magma fertility have focused on ore-related intrusions, but little has been done on intrusions that formed under similar tectono-magmatic conditions and did not form economic deposits. The Andes of central Chile offers an ideal region for magma fertility studies because it hosts some of the world's largest porphyry Cu deposits (e.g. Rio Blanco-Los Bronces and El Teniente) along with coeval barren intrusions. We have collected and compared whole-rock and zircon chemical data from two supergiant deposits and three barren suites from Central Chile, covering a range of compositions and ages. Our results show that the ore-related and barren intrusions have similar zircon O-Hf isotopes indicative of a common magma source (arc mantle), but distinctive whole-rock (e.g. Y, Sr/Y) and zircon geochemical signatures (e.g. Eu/Eu*, P, ΔFMQ). Therefore, these differences are acquired and enhanced during magma differentiation and evolution by different processes (e.g., increase in water content, extensive fractionation) that are the key to porphyry Cu formation. These differences lead to their distinctive geochemical signature and allow discrimination between barren and fertile intrusions. We are developing a multimineral approach for magma fertility discrimination through the analyses of multiple magmatic-hydrothermal mineral phases (e.g., apatite, titanite, rutile), with the integration of these tools showing promising results as an effective method for porphyry fertility assessments.