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Porphyry Cu fertility in the Lhasa Terrane, southern Tibet: Insights from terrane-scale whole-rock geochemistry and zircon trace element and Hf-O isotopes

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Cenozoic porphyry Cu deposits in the Gangdese belt of the Lhasa Terrane, southern Tibet are the archetypal porphyry systems developed in continental collision zones. Understanding the temporal and spatial distribution of these deposits in the Lhasa Terrane will help unravelling the genesis of porphyry deposits in collision zones and exploration targeting of porphyry deposits in similar orogenic belts.

Whole-rock geochemical mapping using c. 1200 samples across the Lhasa Terrane showed that all porphyry deposits are located within high 10000*(Eu/Eu*)/Y (>500) domains. Other whole-rock fertility indicators such as V/Sc, Eu/Eu*, Sr/Y ratios are less effective in discriminating Cu-porphyries from barren ultrapotassic rocks. (Eu/Eu*)/Y ratio is the best whole-rock fertility indicator, and is interpreted to indicate extremely high magmatic water content which induces early and prolific hornblende fractionation and suppresses early plagioclase crystallization.

Zircon Lu-Hf isotopic mapping results using c. 400 zircon samples across the Lhasa Terrane demonstrated that the majority of porphyry Cu deposits are associated with isotopically juvenile domains. One exception is the Zhunuo porphyry deposit in the western Gangdese belt, which shows crust-like isotopic compositions. It suggests that isotopic maps should be used together with whole-rock geochemical maps for targeting porphyry Cu systems. The combined isotopic mapping and whole-rock 10000*(Eu/Eu*)/Y ratio mapping has the great potential to help focus exploration on prospective areas.

Zircon U-Pb and trace element data were obtained from 66 igneous samples aged from Jurassic to Miocene (181-11 Ma) in the eastern Gangdese belt. Both xenocrystic and magmatic zircons show systematic temporal evolution from Jurassic to Miocene. From c. 200 Ma to c. 55 Ma, zircon Eu/Eu* (0.1-0.4), 10000*(Eu/Eu*)/Y (0.1-10), and (Ce/Nd)/Y (0.001-0.05) ratios remain broadly similar. However, these zircon trace element ratios increase rapidly since c. 55 Ma and culminate at c. 13 Ma with Eu/Eu*, 10000*(Eu/Eu*)/Y, and (Ce/Nd)/Y ratios up to 1, 70, and 2, respectively. Similar temporal trends are also observed for whole-rock Sr/Y, La/Yb, and (Eu/Eu*)/Y ratios, although whole-rock Eu/Eu* appear to be similar throughout the Jurassic-Miocene period. In addition, Cretaceous samples show juvenile Hf-O isotopic signature, whereas Eocene-Miocene intrusions show increasing zircon $\delta^{18}O$ values and decreasing epsilon Hf values, suggesting increasing amounts of supracrustal materials incorporated in the magma genesis after c. 55 Ma. These whole-rock geochemical, zircon trace element and Hf-O isotopic trends are interpreted to indicate increasing maturation of the collision-related magmas, which interacted with an increasing length of the crustal column and propagation from deep towards shallower crustal levels through time. This was probably the result of a steadily increasing compression that has progressively slowed down magma ascent forcing magmas to evolve at a series of deep-intermediate level chambers between the lower and upper crust. Increased compression might have been related to the subduction of the buoyant Indian continental lithosphere.