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Lithospheric Architecture of the Central Andes and the Localization of Giant Porphyry Copper Deposits

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The central Andes (14°S-35°S) is the most important copper province on the planet, accounting for 40% of the world's annual copper supply. The decades leading up to the year 2000 were a period of abundant greenfields porphyry copper discovery in the central Andes. However, since 2000, reports of significant new greenfields porphyry copper deposits (PCD) in the central Andes have drastically declined. Giant PCDs tend to group in discrete multideposit geographic clusters of similar age, indicating that exceptional transient geologic processes have affected localised regions of the crust prior to and during the age of mineralisation and that the formation of giant porphyry deposits is nonrandom. Key predictive geologic features of giant porphyry Cu deposits are the structural pathways (basement faults) that focus fluid flow from the lower to upper crust. Nevertheless, these translithospheric faults (TLFs) are notoriously difficult to identify in the field due to their subtle surficial characteristics and continental scale. As a result, the notion of TLFs has been treated with scepticism by some members the geologic community. If TLFs are a fundamental control on porphyry localisation, then knowledge of the geographic areas where favourable permeability and geodynamic preconditioning established effective structural architectures for giant PCD formation would be of great benefit to mineral explorers, especially in regions with large amounts of postmineral cover, such as the central Andes.

This research focuses on identifying and mapping the continental-scale translithospheric structural architecture of the central Andes by integrating multiple geoscience data sets supported by field observations. Data sets used in the analysis include geophysical inputs such as airborne magnetics, regional gravity, and seismic epicentres, as well as geologic reconstructions through time from the Proterozic to present, which map out inherited basement architecture as well as regions of rapid crustal thickening or thinning. Our field work demonstrates that the surface expression of a TLF is a consistent zone of structural features that are traceable for >100 km in strike and 10-40 km in width and is spatially consistent with the trace of lineaments in regional geophysical and geologic data sets. This is interpreted to reflect the upper crustal propagation of the underlying zone of basement weakness through younger sequences in the geologically active convergent plate margin. A striking characteristic of the results of this study are the nested scales of structural features that define a TLF and the regular orientation and spacing to TLF distribution, both displaying characteristics of self-organizing critical systems. A prominent relationship exists with the location of known giant porphyry deposit camps occurring where two or more TLFs meet. Such regions are inferred to have been zones of deep dilation, triggered during transient changes to the regional stress field. Regions adjacent to the intersection of two or more TLFs that overlap with the magmatic arc during metallogenic epochs are deemed to represent valid exploration targets in this model.