Constraining Fault Kinematics Associated with Porphyry Mineralisation in the Central Andes using U-Th/He Chronometry

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The late Eocene porphyry Cu-Mo province in the Central Andean Precordillera accounts for approximately 40% of global copper production. Structurally controlled advanced argillic alteration and high sulfidation style mineralisation is commonly superimposed on the porphyry centres and masks early structural controls on porphyry emplacement. Cenozoic uplift of the Precordillera commenced in the middle Eocene and was concomitant with volcanic attenuation and the emplacement of voluminous shallow to moderate depth intrusions. Decline of this tectonic phase between 40 and 30 Ma. is temporally associated with the emplacement of mineralised porphyries and the cessation of magmatism in the Eocene arc. However, the association between convergent tectonics, orogenesis, and porphyry emplacement is poorly constrained. To attempt to resolve the kinematic behaviour of major faults, we analysed samples from four sub-blocks in the Collahuasi district using the U-Th/He technique on zircon (ZHe) and apatite (AHe). One of the source sub-blocks experienced no Tertiary magmatism, whereas others host major mid-late Eocene barren and mineralised intrusions. ZHe analyses from near the Rosario porphyry return cooling ages from 29.0 $\pm$ 0.6 to 33.8 $\pm$ 0.6 Ma, whereas those from the Guatacondo block cooled through the ~190^{0}C blocking temperature between 30.7 $\pm$ 0.6 and 37.9 $\pm$ 0.7 Ma.

Interpretation of U-Th/He chronometry is complex in this environment because of high topographic relief, shallow magmatic emplacement, rapid unroofing, and highly transient geothermal conditions. Ambiguity arises partly because the temperature-time paths described by a suite of samples close to shallow intrusions are similar for both isobaric cooling and exhumation. Uncertainties in paleogeothermal gradients and other parameters preclude resolution of the relative uplift behaviour of the Rosario block using ZHe. However, results from blocks that experienced no late-tectonic magmatism can be used to demonstrate the sequence of sub-block uplift within the orogen. The lower blocking temperature of the AHe chronometer permits evaluation at Quebrada Blanca of the amount of vertical offset across a strand of the Domeyko Fault System (DFS); a major arc-parallel lineament about which the major porphyry systems are concentrated. Combined with field mapping and U-Pb geochronology, this reveals the NNW-trending fault as a shallowly oblique-slip normal fault with sinistral displacement of <2.5 km during the Oligocene. The DFS was apparently not reactivated as a high angle reverse fault during Miocene compressive tectonism.