The genesis of the Chuquicamata porphyry copper deposit in northern Chile in relation to Tertiary Andean tectonics

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The principal copper deposits of the Andes of northern Chile, of which Chuquicamata (*ca.* latitude 22°16.5'S/longitude 68°54'W) is the largest, are porphyry type deposits related genetically to the epizonal emplacement of late Eocene-early Oligocene (41-31 Ma) stocks. The large porphyry copper deposits are distributed preferentially within the domain of a regional north-south shear system, that roughly coincides with the western limit of a large uplifted block in the Pre-Cordillera, cored by Paleozoic crystalline rocks. The Paleozoic basement, which remained under the sea during the Jurassic and part of the early Cretaceous, has been uplifted to 4000 and 5000 m.a.s.l. Apatite samples from Paleozoic intrusive rocks of the Domeyko Cordillera give fission track (FT) ages ranging from 45 to 35 Ma. The ages show a regular variation with altitude, and track-length modelling indicates that the region underwent relatively fast cooling due to exhumation in the Late Eocene (Incaic tectonic phase) and that exhumation continued at a steady, but slower pace until a renewed faster episode in the Miocene (Quechua tectonic phase). Crustal thickening associated with the Incaic tectonic phase appears to have depressed the zone of magma generation into a homogenized, undepleted deep- or sub-crustal source, to form magmas with a restricted range of Sr, Pb, Nd, S and O isotopes, and steep REE patterns typical of Chilean porphyry coppers of Tertiary age.

Apatite FT ages from Chuquicamata are similar to $^{40}Ar/^{39}Ar$ dates on hydrothermal micas and K-feldspars, compatible with fast cooling and shallow emplacement of the ore system. FT data in the vicinity of the Falla Oeste, a large north-south neotectonic structure that truncates the orebody, indicates that part of it cooled for the last time under *ca.* 100°C in the Pliocene.

Our working model envisages Chuquicamata developing at the roots of an explosive volcanic complex such as a Cascades volcano. Mineralized porphyries would have been intruded at *ca.* 34 Ma, into a relatively deep, active, dextral, ductile shear related to oblique subduction. Potassic alteration, fracturing and low-grade (*ca.* 0.5% Cu) bornite-chalcopyrite mineralization ensued, dominated by magmatic fluids. Uplift and erosion followed, removing the epithermal domains of the hydrothermal system. A new pulse of porphyry intrusion, quartz-sericite alteration and renewed mineralization with a net input of Cu, Mo and As, occurred at *ca.* 31 Ma, controlled by brittle fractures at a shallower depth than the older potassic alteration, still responding to a dextral shear system. Continued exhumation in the Oligocene enhanced the wholesale supergene enrichment of the deposit into Miocene times, coinciding with a period of sinistral strike-slip movement of the Falla Oeste system.