Porphyry Copper-Molybdenum Deposits in Chile

"The Chilean Copper Belt"

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Porphyry copper deposits are the most abundant type of mineralization in the Chilean Andes. Porphyry Cu-Mo deposits occur in six longitudinal belts along the Andes of northern Chile. The porphyry belts are:

Late Palaeozoic-Triassic (298-230Ma) note: Ma=Millions of years
Early Cretacceous (132-97 Ma)
Palaeocene-early Eocene (60-50 Ma)
Late Eocene-early Oligocene (43-31 Ma)
Late Miocene-early Pliocene (12-4.3 Ma)

The two youngest porphyry belts are unquestionably the most important from an economic viewpoint, these having the largest deposits and concentrating most current mining operations.

Late Eocene-early Oligocene porphyry Cu-Mo belt

This is the most significant Chilean porphyry belt. It extends for more than 1400km along the Domeyko Cordillera ad can be traced from the border of Peru (18^0S to latititude 31^0S). This arc-parallel belt includes 30 prophyry Cu-Mo deposits and prospects with the highest amount of copper resources. Overall it constitutes the largest copper concentration in the world, totaling about 220 million tonnes (Mt) of copper (resources plus production: (Camus 2002). The most distinctive geological characteristic of this porphyry belt is its spatial relationship with the Domeyko Fault System which is an arc-parallel regional fault zone that follow an uplifted crustal block (Domeyko Cordillera) cored by Upper Palaeozoic basement rocks (Maksaev & Zentilli 1998, 1999:Boric et al. 1990; Reutter et al. 1991, 1996) The copper-bearing stock occur along-strike of master faults in this regional system (e.g.Copaquire, Quebrada Blanca, Ujina(Collahuassi) Radiomiro Tomic, chuzuicamata, La Escondida and Cerro Zaldivar), as well as along W-trending subsidiary faults (e.g. Rosario of Collahuasi, El Abra, Portrerillos and La Fortuna).

The late Eocene-early Oligocene porphyry Cu-Mo deposits are not regularly distributed along this north-south trending belt, but rather form local clusters within areas of <200km^2. The clusters typically approximate alignments rather than equidimensional grouping of deposits, with the individual centres being strung out either parallel (e.g. Chuquicamata district) or transversely (e.g. **Copaquire,** Quebrada Blanca, Rosario de Collahuasi, and Ujina group of deposits at 21^0S; Sillitoe 2004). The copper-bearing stocks cluster in areas where late Eocene-early Oligocene pre-mineralization equigranular dioritic to granodioritic plutons occur (plutonic precursors of Sillitoe 1998). Some of these plutons have radiometric ages that are very close to, or overlap with, the age of mineralized porphyries. These plutons locally constitute the country rocks of mineralized stocks, which, in some cases, appear to be associated with porphyritic facies of otherwise more equigranular plutons.

The concurrence of the lucos of unmineralized and mineralized late Eocene-early Oligocene plutons suggest that several batches of magma followed a similar ascent path through the crust, and were emplaced at distinct centres of igneous activity. This is reminiscent of the separation of modern volcanic centres along the Southern Volcanic Zone of the Andes. The separation of the igneous centres may have resulted from long-term rheological contrast of the crust along the magmatic arc, with porphyry Cu-Mo clusters/igneous centres localized at zones of diapiric uprise of magmas as envisaged by Yanez & Maksaev (1994) for the Chilean porphryry belt. However Richards (2000) and Richards & Villeneuve (2002) have suggested instead a structural magma focusing. In addition, Behn & Camus (1997) and Behn et al. (2001) showed that the porphyry clusters match with regional magnetic anomalies. These lie transverse to Cordillera, and have been attributed to hypothetical batholiths at depth, which are thought to be common parental intrusive complexes for the mineralized stocks. Minor post-mineralization dykes and stocks commonly occur, which according to available geochronological data were emplace shortly after the mineralization (e.g. latite dyes at El Salvador (Gustafson & Hunt 1975), and the rhyolites dome and rhyolites dyke at La Escondida (Padilla et al. 2001)).

The uppermost several hundred metres of most major porphyry copper deposits in arid northern Chile have been affected by supergene oxidation and leaching, commonly giving rise to underlying chalcocite enrichment that made them economically viable.

In addition, lateral flow of copper-rich supergene solutions up to 8km from source porphyry copper deposits in northern Chile has resulted in some 12 ‘exotic’ copper deposits. These consist of oxidized copper mineral (mainly silicates, chlorides, oxides and carbonates) that impregnate gravels and underlying bedrock along palaeo-drainages (Munchmeyer 1996)

Abundant K-Ar, Rb-Sr and U-Pb radiometric ages have been reported for the porphyry Cu-Mo deposits of northern Chile (Camus 2002, 2003). The isotopic ages demonstrate that the copper mineralization took place within a discrete interval of geological time from 41 to 31 Ma. In fact according to the available radiometric data, most major deposits were formed within the period from 38 to 36 Ma (Copaquire, Quebrada Blanca, La Escondida, Zaldivar)