
**Mineralogy and potential recovery of rutile (TiO₂)
as a by-product in porphyry copper deposits**

T. FINLAYSON¹, A. ARNOTT¹, M.C. GRAVES¹,
A. PUIG², AND M. ZENTILLI¹

*1. Department of Earth Sciences, Dalhousie University, Halifax, NS B3H 3J5,
Canada ¶ 2. CODELCO, Casa Matriz, Casilla 1500, Santiago, Chile*

Rutile is a common accessory phase in altered porphyry copper ores (up to 1 wt. % of the host rock), yet it is generally lost to tailings, despite its relatively high price. Ti metal (sponge) is about 5 times the price of Cu, and high-grade rutile concentrate for pigment is comparable in price to copper-sulphide concentrate. This pilot study assesses the feasibility of rutile recovery from ores going through the mill of large mining operations. As a first step, ores and heavy mineral concentrates from Chuquicamata, Chile were analyzed using microscopy, electron probe microanalysis, and various mineral separation techniques.

Rutile commonly forms by alteration of sphene (titanite), titanomagnetite, or biotite. In the potassic alteration zone of Chuquicamata, rutile occurs as individual grains surrounding biotite or pseudomorphing sphene, in habits that could lead to easy liberation. In the quartz-sericite alteration zone rutile is intergrown with pyrite, thus decreasing the likelihood of effective separation.

Electron microprobe analysis reveals that rutile is zoned with respect to varying amounts of trace elements such as Nb (up to 2.7 wt. %) and Ta (up to 0.21 wt. %), which are potential by-products. This geochemical characterization could facilitate the use of refractory rutile in geochemical exploration for porphyry copper deposits. The U and Th content detected in rutile suggest it is datable by U/Pb methods. Image analysis in the microprobe allows determining the relative abundance of rutile in polished grain mounts of heavy mineral concentrates, which can be satisfactorily compared with microscope point-counting data. It also gives sizes and aspect ratios of grains, and permits useful imaging of degree of liberation.

Statistically, there is a high positive correlation r between rutile and chalcopyrite, rutile and bornite, and a consistently high negative correlation between rutile and pyrite. This behaviour mimics a high positive correlation between Ti and Cu in the least overprinted potassic alteration zone (Cu/Ti \sim 15/1; $r = 0.82$). Geochemically, the element Ti behaved as immobile element during alteration. A high negative correlation between Ti and Cu observed in the quartz-sericite alteration zone, suggests a fresh input of Cu into a constant reservoir of Ti during this hydrothermal event.

The results suggest that full liberation of rutile would require excessively fine milling (to ca. 10 μm) making it uneconomic, but partial recovery may be possible. Alternatively, rutile could be recovered from dry tailings using a combination of gravity and electrostatic methods to separate it from sulphides and silicates.