

The Chloride Source for Atacamite Mineralization at the Radomiro Tomic Porphyry Copper Deposit, Northern Chile

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Abstract

Supergene mineralization at the Radomiro Tomic porphyry copper deposit involves the copper chloride atacamite, $\text{Cu}_4\text{Cl}_2(\text{OH})_6$, as the principal ore mineral, distributed in a thick oxide zone. Chloride-rich aqueous fluids were introduced during supergene mineralization causing this atypical variation in copper oxide mineralogy. The source of this chloride has been investigated using several geochemical techniques, including chlorine isotopes and bromide-chloride geochemistry. These methods have proven to be the most useful in evaluating the potential chloride sources and their likely influence on copper mineralization. Unmineralized, biotite-bearing, whole-rock protore samples from the Radomiro Tomic deposit have typical igneous values of <2 ppm Br and $\delta^{37}\text{Cl}$ values of 0.1 to 2.5 per mil. In contrast, elevated bromine contents (22–180 ppm Br) and lower $\delta^{37}\text{Cl}$ values near 0.0 per mil for the atacamite mineralization at Radomiro Tomic are clearly indicative of a nonmagmatic origin for the chloride. Moreover, atacamite mineralization at Chuquicamata (48–75 ppm Br, $\delta^{37}\text{Cl} = -0.1$ to $+0.2\text{‰}$) and Mina Sur (52–48 ppm Br, $\delta^{37}\text{Cl} = 0.0$ – 0.1‰) also has elevated bromine contents and lower $\delta^{37}\text{Cl}$ values, indicating a similar source for the introduction of chloride.

Upper Jurassic sediments (22–24 ppm Br, $\delta^{37}\text{Cl} = -0.8$ to $+0.5\text{‰}$) have geochemical characteristics indicating that they were the source of chloride for the oxide zone atacamite mineralization at Radomiro Tomic. A later mineralization event where chloride was derived from marine evaporites was responsible for the atacamite mineralization in the overlying gravel at Radomiro Tomic (63–180 ppm Br, $\delta^{37}\text{Cl} = 0.6\text{‰}$). Small, distal deposits containing atacamite with 20 to 100 ppm Br and $\delta^{37}\text{Cl}$ values of -0.1 to -3.2 per mil occur to the west and south of Radomiro Tomic and have geochemical signatures, which are indicative of Lower Jurassic sediment-derived chlorine (9–23 ppm Br, $\delta^{37}\text{Cl} = -0.3$ to -2.6‰). Bromide-chloride geochemistry of regional atacamite samples is quite variable and therefore argues against a meteoric chloride source, which would lead to regionally homogeneous values. Similarly, seawater was ruled out as the primary source of chloride at Radomiro Tomic due to the distance from the Pacific Ocean.

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