The Geometallurgy of Arsenic in Copper Ores: An Analysis of Ore Supply vs. Smelter Treatment Capacity and Implications for Exploration Models and Deposit Valuations

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Recent copper ore discoveries, especially in the South American porphyry environment, have been accompanied by an increase in the contained arsenic content. At the same time, environmental and health considerations have reduced the available smelting capacity to treat copper concentrates with significant (>0.5% As) levels.

The historical trend and current situation for global arsenic in copper concentrates supply vs. smelter treatment capacity is analyzed, with particular reference to the Andean copper porphyry belt and recent interpretations of some supergiant copper porphyries in terms of high sulfidation overprints, which bring not only enhanced copper values but also significant arsenic levels. A systems approach to these giant porphyries that often transcend individual deposits and their associated epithermal overprints is advocated. The reasons for the decline in smelting capacity for arsenic are considered along with projections for the future.

Arsenic in the high sulfidation environment typically occurs as enargite (and/or luzonite), tennantite, and arsenian pyrite. This has significant implications for copper metallurgy, as well as associated gold metallurgy. The copper arsenides and sulfosalts cannot be treated by physical means, e.g., froth flotation, to separate copper and arsenic, and arsenian pyrite typically contains gold that is refractory to conventional cyanide leaching.

Treatment options for these arsenic-bearing copper (and copper-gold) orebodies include blending (within limits) and various oxidation options including bioleaching, pressure oxidation, and roasting. This last option has had a resurgence in recent years with improvements in roaster-gas treatment technology to not only remove sulfur dioxide but also fix arsenic in environmentally stable forms. The potential impact of these treatment options on processing infrastructure requirements, deposit valuations, and geometallurgical domaining needs to be taken into account early in the project evaluation process in order to avoid shortfalls in metallurgical recovery and unforeseen losses in concentrate net smelter returns.

Examples are drawn from the northern Chile copper porphyry belt and from Peruvian high sulfidation gold deposits which are hosted within larger copper porphyry–high sulfidation overprint systems. A district approach is proposed whereby the arsenic provenance within various levels of the system can be better understood and, where possible, some geometallurgical optimization of metal production with respect to arsenic content achieved.

The correct imputation of the losses associated with arsenic to the in-ground metal values has implications not just for specific project economics but also for exploration models and priorities. Finally, a geometallurgical "phase diagram" has been proposed in order to summarize copper-arsenic relationships and ore-to-market implications.