

DETERMINATION OF THE BEHAVIOUR OF VALUABLE METALS DURING THE CONTROLLED COOLING OF COPPER SMELTING SLAGS TO CLARIFY THEIR RECOVERY BY GRINDING AND FLOTATION

Copper Slag Processing: controlled cooling of copper slags prior to flotation treatment

Leandro Voisin ^{1,2}, Camila Pizarro ^{1,2}, Julio Ossandón ^{1,2}



Introduction

During the first stage of the pyrometallurgical production of metallic copper from copper sulphide concentrate, large amounts of slag are generated and subsequently treated in electric furnace in order to recover the entrained copper. This reduced slag that is usually discarded although it still contains large amounts of iron and silica, and minor valuables elements such as copper (0.6 to 1.3 wt%), molybdenum (up to 0.5 wt%), and silver (2 to 20 ppm), between others.

Previous researches show that in copper smelting slag, molybdenum is preferentially present in high iron and low silica copper slags, which suggests that it forms part of a spinel structure type magnetite. In the case of silver, its distribution coefficient between matte and slag varied between 100 and 200 in the matte grade range of 50 to 70 wt% of copper.

In the treatment of smelting slags involving controlled cooling, grinding and froth flotation, the cooling rate is an important variable of control because it has effects on sedimentation and coalescence of the entrained valuables, and crystallinity of the slag matrix, as well. The remaining slag formed and solidified after controlled cooling is sent to grinding and froth flotation.

Slow cooling may result in a the formation of a sulphide phase because significant crystallization of slag components. On the other hand, fast cooling may produce an amorphous slag where a more homogeneous copper metal distribution occurs into the slag, in this case, energy consumption during grinding will increase due to ductility of copper. The objective of this research was to determine the behaviour of molybdenum and silver contained into copper smelting slag during its controlled cooling process at two different rates to clarify their later recovery by grinding and froth flotation.

Experimental

In this work, experiments considering 70 g of industrial copper smelting slag doped with 0.3, 1.4 and 2.4 and 10, 100, 200 ppm of high purity molybdenum and silver, respectively, were charged in a high alumina crucible and melted at 1300°C under controlled partial pressure of oxygen of 10^{-8} atm. according to industrial conditions of Teniente Converter technology. The molten slags were kept inside the furnace for 8 hours to reach the equilibrium and then taken outside and cooled at two different rates of, instant quenching into water (fast cooling), and N_2 natural convection (slow cooling). Finally, after solidification, representative samples of formed matte and remaining slag were taken and characterized by using optical microscopy, SEM, XRD, XRF and ICP.

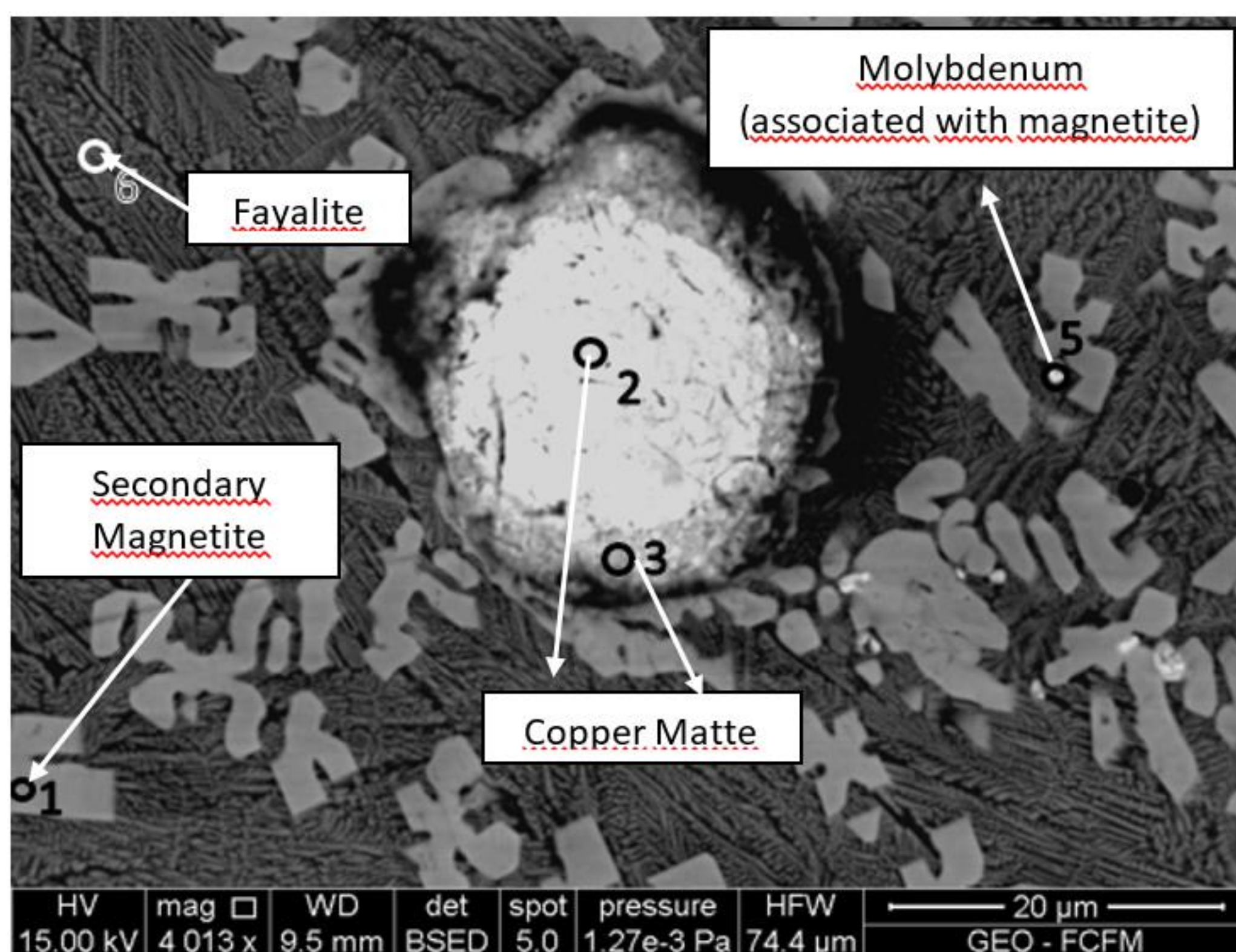


Figure 1: SEM of remaining slag obtained after cooling at natural convection rate a smelting slag doped with 2.4 wt% of Mo and 200 ppm of Ag in the charge.

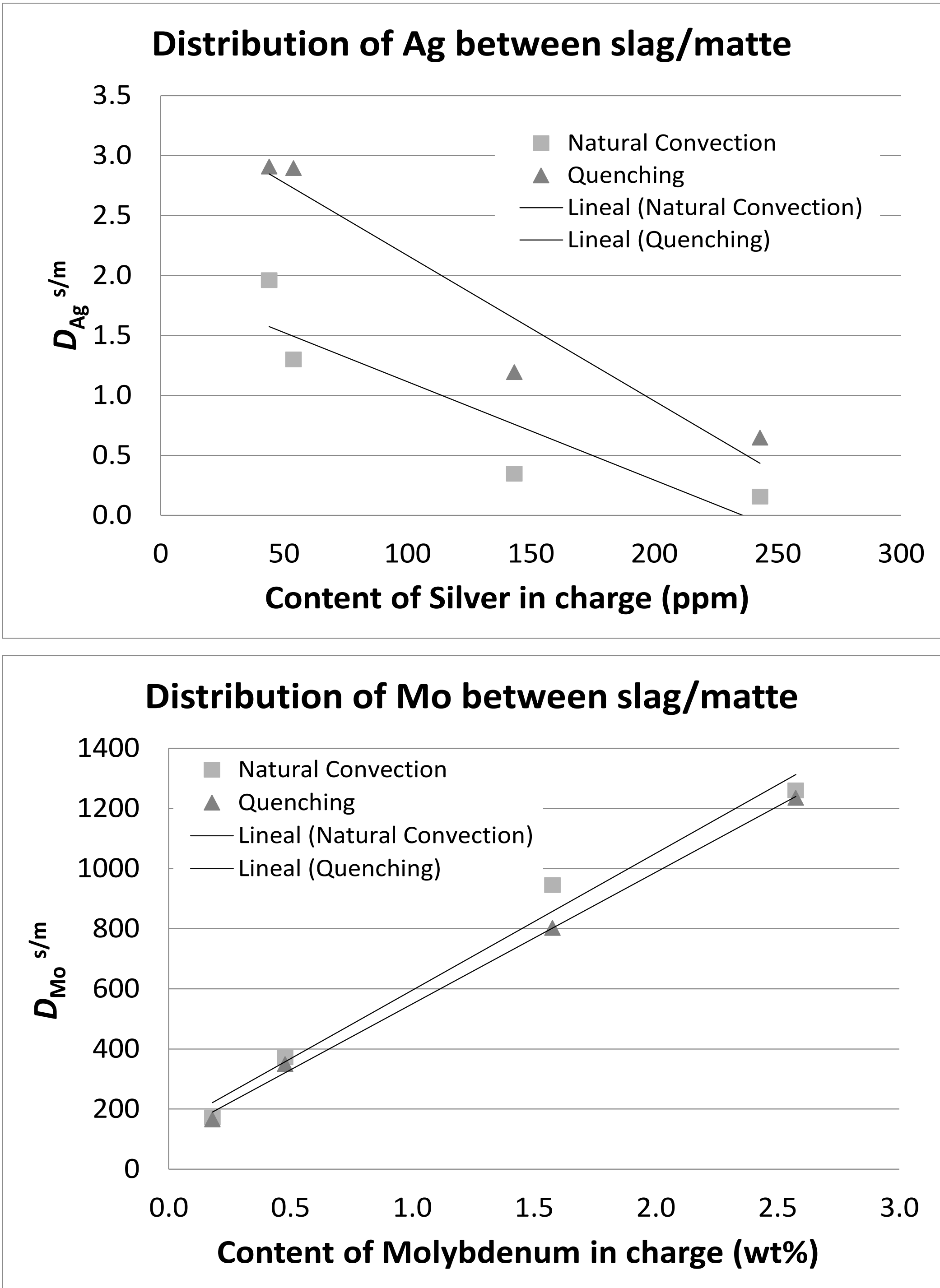


Figure 2: Distribution coefficients of silver (up) and molybdenum (down) between remaining slag and matte after cooling against their content in the smelting slag

Table1: Quantitative XRD analyses of remaining slag obtained after cooling smelting slag doped with 2.4 wt% Mo and 200 ppm of Ag in the charge

Type of cooling rate	Main phases (wt%)	
	Fayalite (Fe ₂ SiO ₄)	Magnetite (Fe ₃ O ₄)
Quenching	94.2	5.8
Natural Convection	59	41

Results and Discussion

The main phases and their corresponding composition results obtained by using QXRD normalized to 100 wt% for the slags doped with 2.4 wt% of Mo and 200 ppm of Ag quenched into water and natural convection are shown in Table 1. In addition, in some cases SEM was used to clarify some phases and the distribution of valuable minor elements between them, Figure 1 is shown a SEM photo of a remaining slag.

From the results, it was noted that at slower natural convection cooling rate increased the content and size of the magnetite crystals in the remained matrix slag, and also copper appears more widespread on it, this can be attributed to the greater sedimentation and coalescence of copper entrained species, metallic and sulphide, towards the formed matte phase on the bottom of the crucible.

According to the obtained results, it can be expected that an slow cooling of smelting slag may enhanced the recovery of copper and silver into the produced button matte that is sent to converting stage. On the other hand, since most contained molybdenum tends to quickly be oxidized, it will be caught by magnetite into that remaining slag as well, making difficult its recovery during froth flotation and therefore will go into the tailing.

A super slowly cooling could be the solution to treat smelting copper slag in order to recover copper and silver into the produce matte and generate a remaining slag with large crystal size of magnetite that allow to release molybdenum.

FOR FURTHER INFORMATION

Leandro Voisin
e lvoisin@ing.uchile.cl
w pyrolab.amtc.cl

Camila Pizarro
e capizarro@ing.uchile.cl
w pyrolab.amtc.cl

Julio Ossandón
e julio.ossandon@ing.uchile.cl
w pyrolab.amtc.cl

AFFILIATIONS

¹ Advanced Mining Technology Center, University of Chile, Santiago, Chile
www.amtc.cl

² Department of Mining Engineering, DIMin, University of Chile, Santiago, Chile
www.minas.uchile.cl

