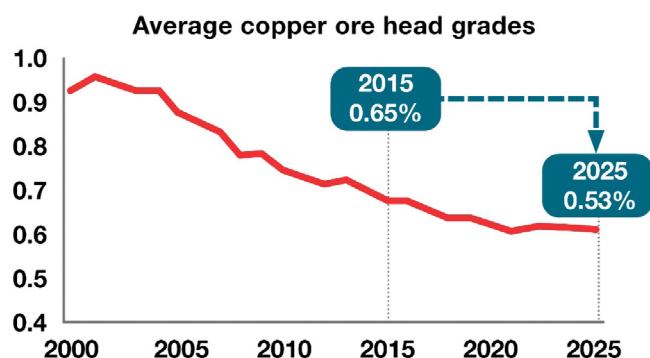


Using PGNAA for bulk ore sorting: exploring the impact of analyzer performance

Introduction

There is powerful motivation to increase the output from copper mines in the face of predictions of a 15 million tonnes per annum shortfall by 2034, largely due to escalating demand. However, copper miners face significant headwinds¹. The social licenses required to operate, and the strict environmental policies applied are making it increasingly difficult to bring new mines online, notably in countries such as Canada that have historically produced a significant percentage of the world's copper. At the same time average copper ore head grade is decreasing, both in established mines and for newly discovered ore bodies.



Ore sorting can help. It involves separating out gangue and low-grade ore at the earliest opportunity to reduce variability in the feed and deliver more value to the concentrator on an hourly basis. The Thermo Scientific™ CB Omni Agile Elemental Analyzer provides real-time elemental analysis for ore flowing on a conveyor belt and can provide the precise analytical differentiation required for success.

Differentiating ore

Choosing an appropriate sensor for ore sorting relies on careful assessment of the orebody with respect to heterogeneity, mineralogy, and elemental composition. Identifying a sensor with excellent sensitivity around the cut-off grade is crucial, as is measurement speed, to avoid limiting concentrator throughput. For some streams sorting with a couple of sensors, using orthogonal techniques, may be necessary to deliver the required level of differentiation.

Some sensors enable particle sorting. These differentiate individual particles by measuring properties such as color, density, magnetism, transparency, and conductivity allowing separation on a particle-by-particle basis. Bulk analysis methods, in contrast, measure the elemental composition of larger samples of the flowing feedstock. Prompt Gamma Neutron Activation Analysis (PGNAA) is especially suitable because of its ability to representatively measure the entire incoming ore stream in real-time.

PGNAA determines elemental composition from analysis of the gamma ray ‘signature’ produced as an excited nucleus returns to stability following initial bombardment with a thermal neutron (see figure 1). The source neutrons used are highly penetrating and the gamma rays released have high transmission, giving the technique sufficient penetrability to deliver representative analysis of the entire stream.

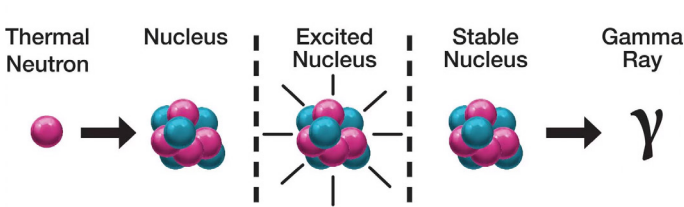


Figure 1: Schematic illustrating the principle of measurement of PGNAA

This sets PGNAA apart from alternatives such as X-ray fluorescence, which only scan surface composition, thereby analyzing a fraction of flowing material. Other important benefits include a measurement time of just 30 seconds and good detection capabilities for elements of interest in copper mining such as iron and sulfur.

The Thermo Scientific CB Omni Agile Elemental Analyzer is a cross-belt analyzer that harnesses the inherent benefits of PGNAA and simultaneously offers the flexibility to optimize performance for specific applications.

Comparing PGNAA analyzer performance

PGNAA systems differ in a variety of ways including, crucially, in terms of source strength and detector performance, which define neutron output and gamma ray capture respectively. The CB Omni Agile can be configured with up to 78 μg of ²⁵²Cf, more than any other commercially available PGNAA system, and uses larger volume NaI scintillation crystals (up to 12 times larger relative to commercial alternatives).

In this way the CB Omni Agile delivers market-leading accuracy – ‘trueness’ to a reference value – and precision, minimal scatter around the measurement value. In combination these characteristics define false rejection and false acceptance rate, both of which are directly impact ore sorting performance. Table 1 displays simulation data illustrating this effect; the specified head cut-off grade for the simulation is 0.2%.

	False rejection rate	False acceptance rate	Overall material rejection
CB Omni Agile	3.1 %	2.8 %	24.6 %
Low spec alternative analyzer	7.2 %	5.8 %	25.8 %

	Cu captured	Falsely rejected material with Cu	Average grade of Cu
CB Omni Agile	93.9 %	3.1 %	0.23 %
Low spec alternative analyzer	92.2 %	7.2 %	0.27 %

Table 1: The advanced design and precision of CB Omni Agile ensure minimal false rejection and false acceptance rates, maximizing copper recovery compared to less optimized systems

Falsely rejecting material that meets the required head grade specification increases the amount of recoverable copper lost to waste, while falsely accepting below cut-off grade material impacts the average grade of the feed stockpile. Here, the higher specification of the CB Omni Agile leads to better performance in both areas and a consequent reduction in overall material rejection rate. These results indicate that with this system 93.9 % of the Cu in the incoming stream is fed to the concentrator, with falsely rejected material having an average grade of 0.23 %. In contrast, with the lower specification system only 92.2 % of the Cu is recovered; a higher % of false material is rejected and it has a higher average Cu grade.

This may appear to be a relatively modest improvement in Cu recovery but assuming a nominal mining rate of 40,000 T per day it equates to a loss of over US\$15,000,000 per annum (based on a Cu price of \$9500).

Conclusion

Ore sorting relies on accurate and precise differentiation of the material flowing into the concentrator, a demanding analytical challenge. PGNAA is a powerful tool for bulk ore sorting with the speed and penetrability to deliver elemental analysis for the entire feedstock in real-time, in the face of significant ore heterogeneity. The CB Omni Agile harnesses this potential in a process analyzer that performs extremely well with respect to both false rejection and false acceptance rate, thereby maximizing copper recovery. By allowing miners to realize efficient bulk ore sorting it can reduce variability in the feed to the concentrator, minimize the loss of recoverable copper to waste and preserve concentrator capacity for the processing of economically viable ore.

References

1. O Da Silva. Rio Tinto Copper CEO: Copper Market to See Deficit by 2020s. Accessed 18th May 2022: <https://investingnews.com/daily/resource-investing/base-metals-investing/copper-investing/rio-tinto-ceo-copper-market-deficit/>