Using PGNAA for bulk ore sorting: key factors that influence analyzer performance and process efficiency

Introduction

The global transition to clean energy is driving increased demand for critical minerals, especially copper. Meeting this demand is increasingly difficult due to declining ore grades, complex ore bodies, and tightening ESG regulations. Bulk ore sorting is one of the solutions being used to achieve the required improvement in processing efficiency.

Bulk ore sorting is a preconcentration strategy that allows miners to maintain or increase head grade when processing a heterogenous ore body. It involves separating waste/below grade material from material that can be blended to consistently maintain an economically viable feed stream. Effective bulk ore sorting can extend the productive lifetime of a mine, reduce the scale of new processing plants, and help to minimize the amount of energy, water and tailings associated with producing each tonne of useful material.

A significant degree of ore body heterogeneity is essential for bulk ore sorting to be effective. For assets that meet this requirement, sorting efficiency relies on accurate and precise measurement of the ore exiting the mine, to reliably differentiate waste from material worth processing. The performance of the analyser chosen for this measurement is therefore crucial.

Thermo Scientific™ CB Omni™ Agile Online Elemental Cross-Belt Analyzer

Using PGNAA for bulk ore sorting

Bulk ore sorting relies on sensing technology that is capable of:

- representatively analysing the bulk material
- differentiating processable ore from waste; in other words, differentiating ore that is above or below the required head grade.

Prompt Gamma Neutron Activation Analysis (PGNAA) is well-matched to these requirements.

A non-destructive technique, it determines elemental composition from analysis of the gamma ray ‘signatures’ emitted when an atomic nucleus, excited by thermal neutron capture, returns to its ground state (see Figure 1).

The neutrons used in PGNAA are highly penetrating and the gamma rays produced have high transmission through the sample. Figure 2 illustrates the high penetrability of PGNAA compared to other analytical methods, by plotting penetrability (x-axis) against the relative detection capabilities (y-axis) of alternative techniques. PGNAA uniquely combines deep material penetration with sufficient sensitivity for bulk stream analysis, enabling accurate characterization of heterogeneous ore across the entire material cross-section.

In addition, PGNAA is a fast technique capable of providing the real-time measurement needed for responsive control. Sorting continuously on the basis of such measurements allows miners to divert small increments of the feed, relative to a truck or shovel, thereby improving the precision of the sorting process.

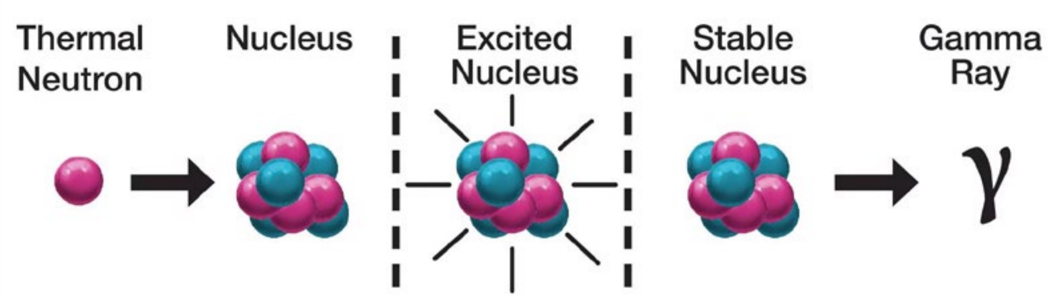

Figure 1: Schematic illustrating the principle of measurement of PGNAA.

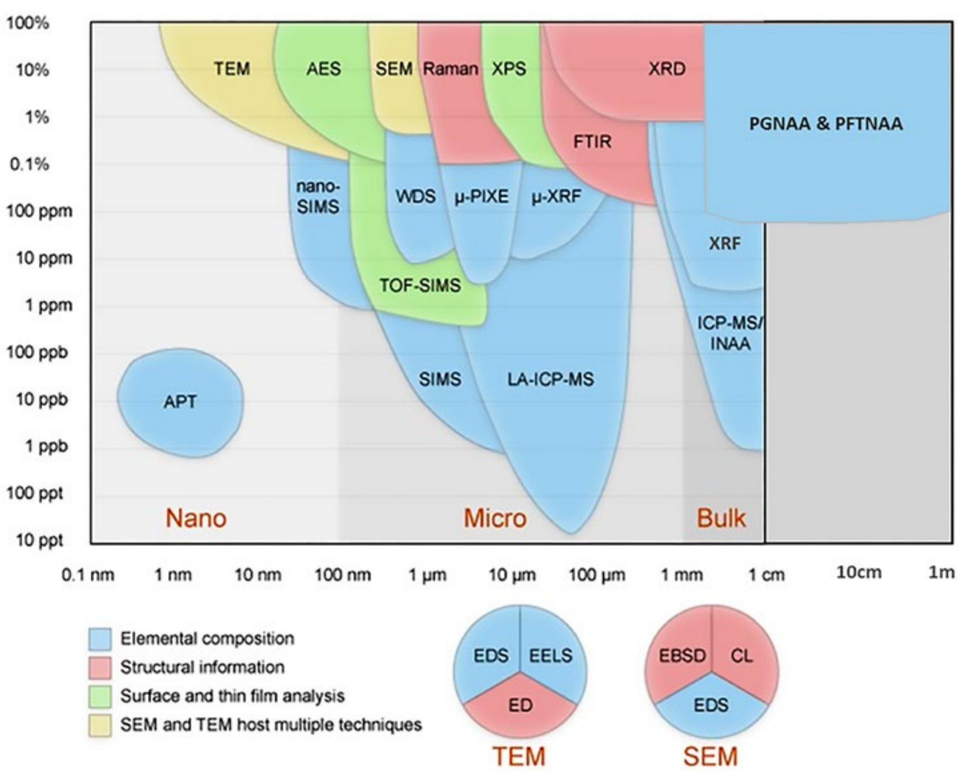

Figure 2: Performance characteristics – detection (y-axis) and penetration (x-axis) – for a range of analytical techniques highlights the unique suitability of PGNAA for bulk ore sorting.

Analyzer performance

Assessing the suitability of a PGNAA system for bulk ore sorting calls for the consideration of both accuracy and precision (see Figure 3). Accuracy is a measure of agreement with a "true" or accepted reference value and is most affected by systematic errors; precision is a measure of agreement with other like measurements and is defined by the magnitude of random errors.

The Thermo Scientific™ CB Omni Agile™ Elemental Analyzer is designed, configured and calibrated to minimize both systematic and random errors, to deliver exemplary accuracy and precision for each application.

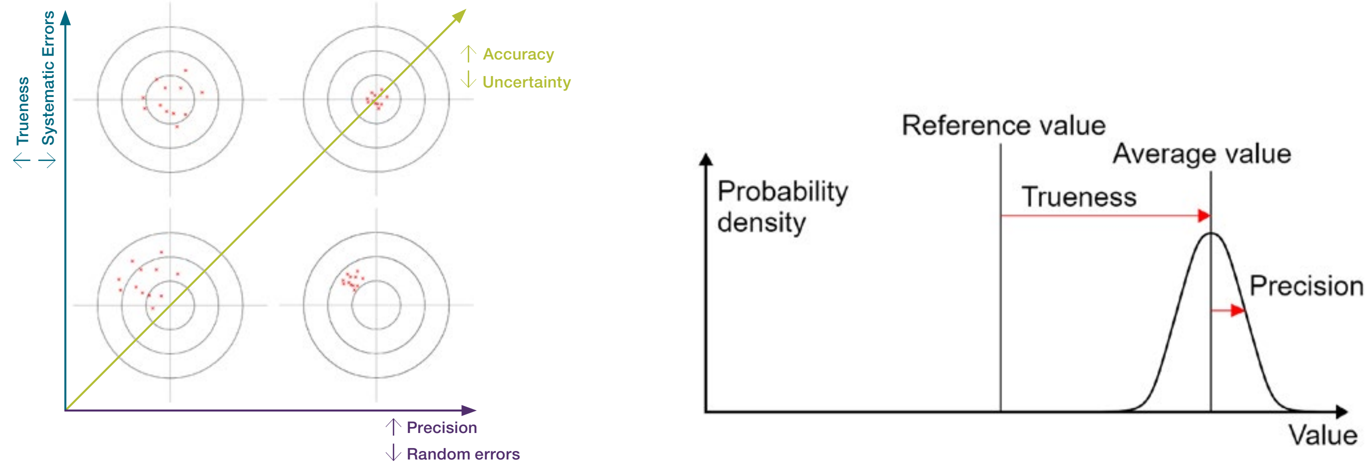

Figure 3: PGNAA systems may vary with respect to the accuracy or precision of measurements, or both.

Measurement uniformity is the primary determinant with respect to the accuracy of online PGNAA systems (see Figure 4). Incoming ore is inherently heterogeneous but may also be prone to segregation. Ensuring a uniform measurement across the belt is therefore critical, and closely akin to representative sampling, a prerequisite for any analytical measurement. The CB Omni Agile Analyzer offers the flexibility to configure both neutron source (isotope (Californium 252, ^{252}Cf) or electrical neutron generator) and detector volume to optimize measurement uniformity, thereby reducing systematic error. A rigorous factory calibration process spanning the full range of expected ore compositions and belt loading conditions further safeguards accuracy.

Turning to precision, this is largely governed by the number of detected neutron interactions; both neutron output and detection capability are therefore critical. The CB Omni Agile Analyzer supports up to 78 µg of ^{252}Cf – more than any other PGNAA system on the marketf – allowing for enhanced neutron flux and greater measurement precision. It also uses larger volume NaI scintillation crystals (up to 12 times larger relative to commercial alternatives) for enhanced detection. The resulting ability to generate high numbers of neutrons and effectively detect the resulting gamma rays gives the CB Omni Agile Analyzer market-leading precision for a given mass loading and measurement duration.

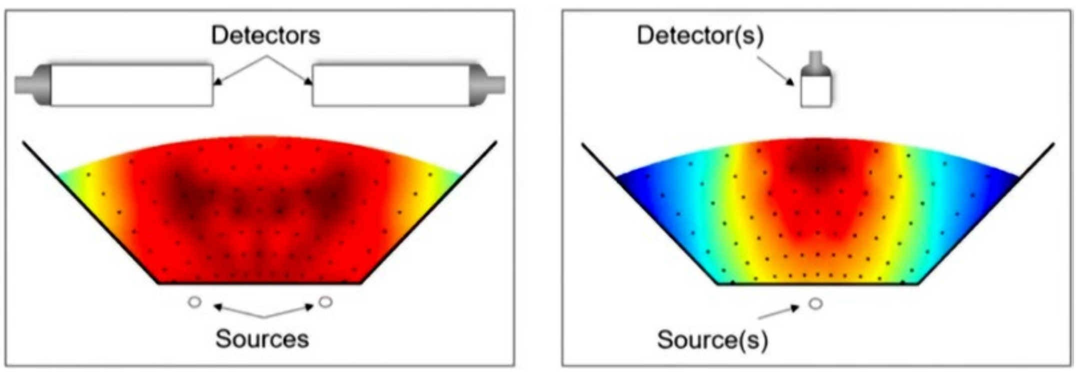

Figure 4: Uniform measurement is crucial for accurate PGNAA.

Comparing performance

Figure 5 illustrates the direct correlation between performance characteristics and the efficiency of bulk ore sorting. On the right is simulated data set for a PGNAA system with a single detector and a 50µg ^{252}Cf source; comparable data for a CB Omni Agile Analyzer with 4 detectors and an 78µg ^{252}Cf source is shown on the left.

Red data points represent misclassified materialf – either waste processed as ore (false positives) or ore discarded as waste (false negatives). These misclassifications directly reduce process efficiency and resource recovery.

Processing ore that has less Cu than the specified cut-off value erodes the efficiency of the process while an underestimate of Cu content routes valuable ore to waste. Both effects have a direct impact on the bottom line. By reducing the extent to which ore is incorrectly characterised, the CB Omni Agile Analyzer can be used to reduce variability in head grades. This enables more stable, predictable and controllable downstream mineral separation processes while at the same time reducing the amount of valuable material lost to waste or process capacity spent processing waste and below cutoff material.

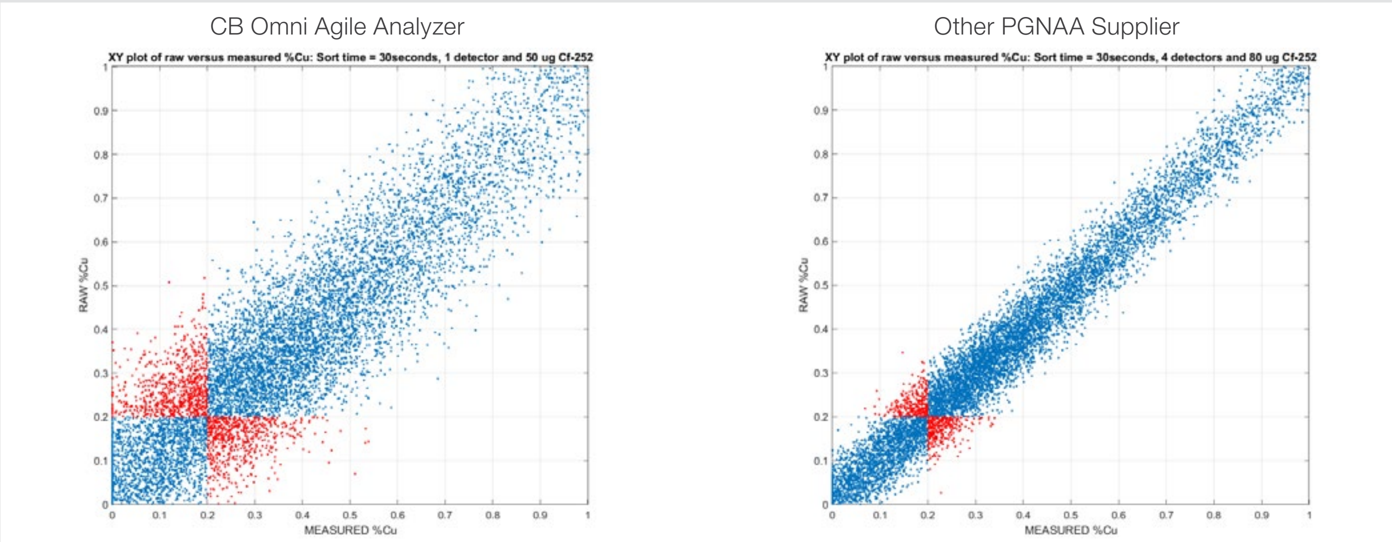

Figure 5: Measurement accuracy and precision directly impact the efficiency of bulk ore sorting.

Conclusion

Bulk ore sorting is a valuable preconcentration strategy for miners seeking to increase output and maximize asset value while at the same time reducing environmental impact. Success relies on sensing technology that can reliably and representatively characterize the bulk feed flow and robustly differentiate below grade material from that which can be profitably processed. The CB Omni Agile Analyzer uses the powerful technique of PGNAA to deliver the real-time elemental analysis required to support highly efficient bulk ore sorting. By delivering high accuracy and precision, it reduces both false rejections and false acceptances, maximizing asset utilization and minimizing processing of sub-economic material.

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