PGNAA ONLINE SLURRY ANALYZER FOR IRON ORE AND BASE METAL FLOTATION

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ABSTRACT

Mineral processing plants rely on online slurry analyzers for real-time elemental analysis, crucial for optimizing extraction processes. However, complex ore structures pose challenges that traditional methods cannot address, necessitating advanced techniques for effective response to variable feedstocks. Prompt Gamma Neutron Activation Analysis (PGNAA) technology revolutionizes process control in iron ore flotation plants by providing accurate, real-time elemental analysis of multiple slurry streams, including light and heavy elements. Unlike X-ray fluorescence (XRF), PGNAA measures elements lower than calcium and handles coarse particles while analyzing large slurry volumes. The PGNAA Slurry analyzer enhances flotation circuit control by monitoring contaminant elements, which enables optimized reagent dosage, and improved circuit stability, leading to better product grades, increased recovery rates, and reduced penalty costs. Factory-calibrated for slurry applications, it supports rapid start-ups and handles multiple streams, making it versatile for various mineral processing environments. This paper presents case studies demonstrating PGNAA's effectiveness in improving flotation operations' efficiency and economic viability.

Keywords: PGNAA, slurry analyzer, mineralogy, elemental analysis, slurry streams, base metal flotation, iron ore flotation, process control, mineral processing.

INTRODUCTION

Prompt Gamma Neutron Activation Analysis (PGNAA) is a powerful technique for real-time, non-destructive elemental analysis of bulk materials. The process begins with the emission of fast neutrons from a radioactive source, typically Californium-252. These fast neutrons are initially too energetic to interact effectively with the material, so they are slowed down—or thermalized—using a combination of radiation shielding, specialized moderator materials, and the slurry material itself. Once their energy falls to 0.025 eV, they become thermal neutrons, which are ideal for interacting with atomic nuclei.

When thermal neutrons are absorbed by the nuclei of elements within the material, the nuclei enter an excited state. As they return to a stable state, they emit gamma rays with energy signatures unique to each element. These gamma rays are detected by sodium iodide (NaI) scintillation detectors, which convert them into light pulses. A photomultiplier tube then transforms the light into electrical signals, which are processed by high-speed electronics to generate a composite gamma-ray energy spectrum. The Operator Console continuously analyzes this spectrum to quantify elemental concentrations, calculate oxide levels, and derive quality control parameters.

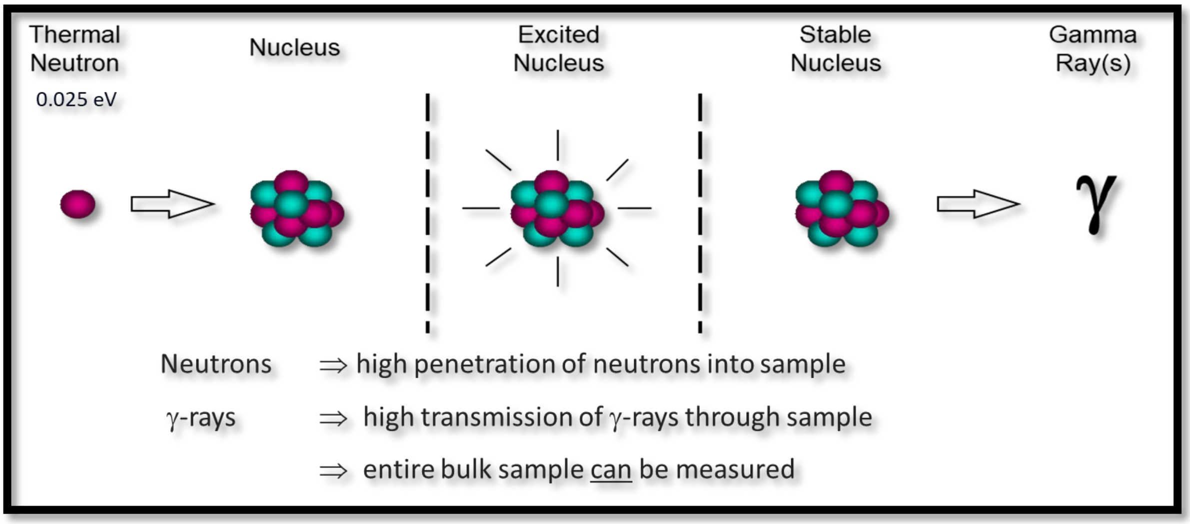

Figure 1 Prompt Gamma Neutron Activation Analysis (PGNAA)

This paper presents case studies and performance data that highlight the effectiveness of PGNAA technology in improving online elemental measurement in flotation operations. Unlike X-ray fluorescence (XRF), PGNAA can directly detect light elements below calcium on the periodic table and analyze coarser particle sizes s, up to 5mm in the GS Omni slurry analyzer. It is particularly effective for measuring elements such as Fe, S, Si, Mg, and Al in iron ore slurries, and Cu, Fe, S, and Si in copper and polymetallic slurries. PGNAA technology, as used in the GS Omni analyzer, can also directly report elemental ratios such as Cu:Fe, Fe:S, and Cu:S. These ratios are valuable for interpreting mineral associations, such as pyrite and chalcopyrite.

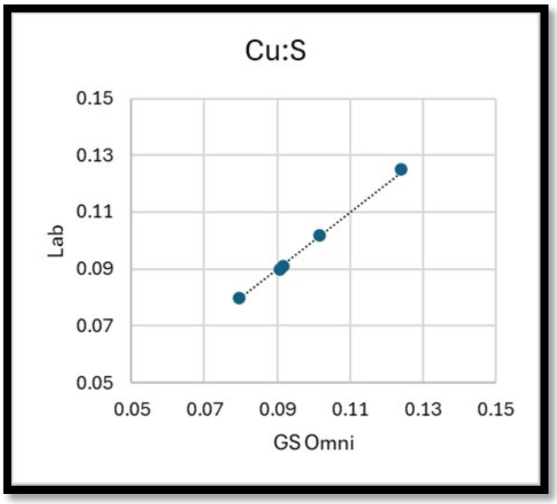

Figure 2 Elements Ratio Generate by GS Omni

Unlike sub-surface (XRF) or micron scale spot techniques such as Laser-Induced Breakdown Spectroscopy (LIBS), PGNAA performs bulk analysis of large slurry volumes—approximately 20 liters per cycle in the GS Omni analyzer, which incorporates a labyrinth-style flow cell. This configuration significantly reduces sampling error, a major contributor to variability in assay results. By allowing the slurry to circulate through multiple passes during each measurement cycle, the flow cell enhances sample representativeness and improves analytical precision. Additionally, the analyzer is factory-calibrated for slurry applications, enabling rapid start-ups and minimizing the need for extensive calibration sampling campaigns.

PGNAA Integration to Optimize Reagents and Recovery in Iron Ore Processing

Vale's Vargem Grande beneficiation and pelletizing complex in Brazil faced the challenge of processing lower-grade compact itabirite ores, which demand tighter process control to produce on-specification pellet feed. To overcome this, Vale implemented a PGNAA slurry analyzer integrated with a six-stream multiplexer, enabling continuous monitoring of feed, concentrate, and tailings streams.

Figure 3 PGNAA Installation on Iron Ore

The system delivered real-time measurements of iron and silica, supporting both feed-forward and feedback control of reagent dosing. For silica rejection, the analyzer enabled precise adjustment of amine dosages to optimize flotation efficiency. For iron recovery, starch dosing was dynamically controlled to minimize iron losses to tailings.

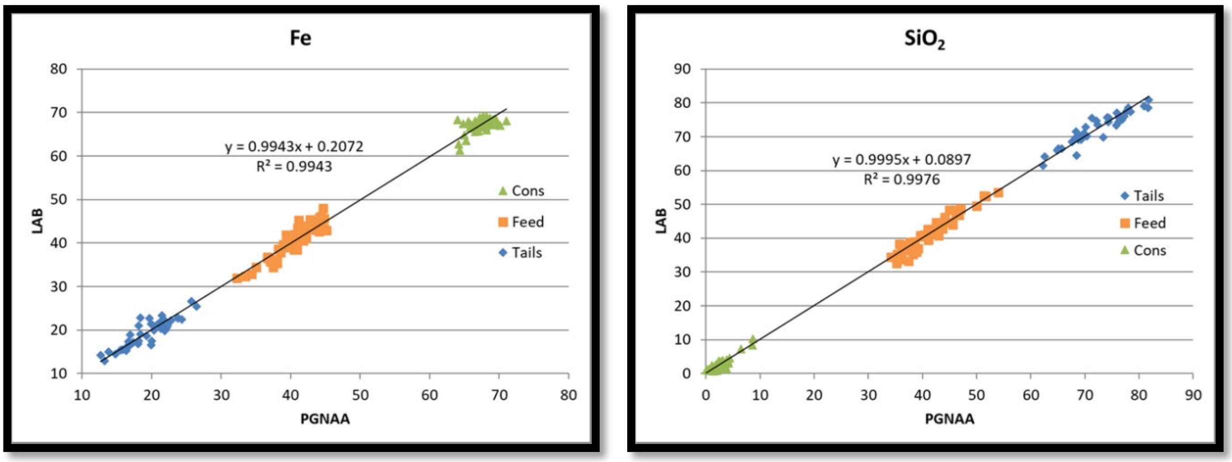

Figure 4 Slurry PGNAA Analytical Performance

The impact was immediate and measurable. Assay turnaround time dropped from four hours in the laboratory to just 20 minutes, empowering operators to make near real-time decisions. This faster response reduced iron content in tailings and lowered variability in concentrate quality, resulting in improved plant stability. Additionally, reagent consumption decreased, and It eliminates the need for manual sample collection, reducing safety risks and allowing personnel to focus on higher-value tasks, delivering both operational and economic benefits.

Environmental Monitoring Feasibility Study for Sustainable Tailings Strategies with PGNAA

In a copper-gold operation located in North America, following the successful installation of a CB Omni cross-belt PGNAA analyzer, Thermo Fisher Scientific conducted a feasibility study to assess the performance of its slurry PGNAA analyzer, GS Omni, across multiple process streams. The study focused on evaluating the analyzer's capability to measure key elemental concentrations in feed, rougher concentrate, final concentrate, and both potentially acid-generating (PAG) and non-acid-generating (NAG) tailings.

Figure 5 CB Omni Installation on Belt Conveyor

The results demonstrated that PGNAA technology could achieve root mean square deviations (RMSD) within 5–10% for critical elements such as sulfur, calcium, and magnesium in feed and tailings. These levels of accuracy meet the requirements for Neutralization Potential Ratio (NPR) calculations, which are essential for predicting acid rock drainage (ARD) risks and guiding tailings management decisions.

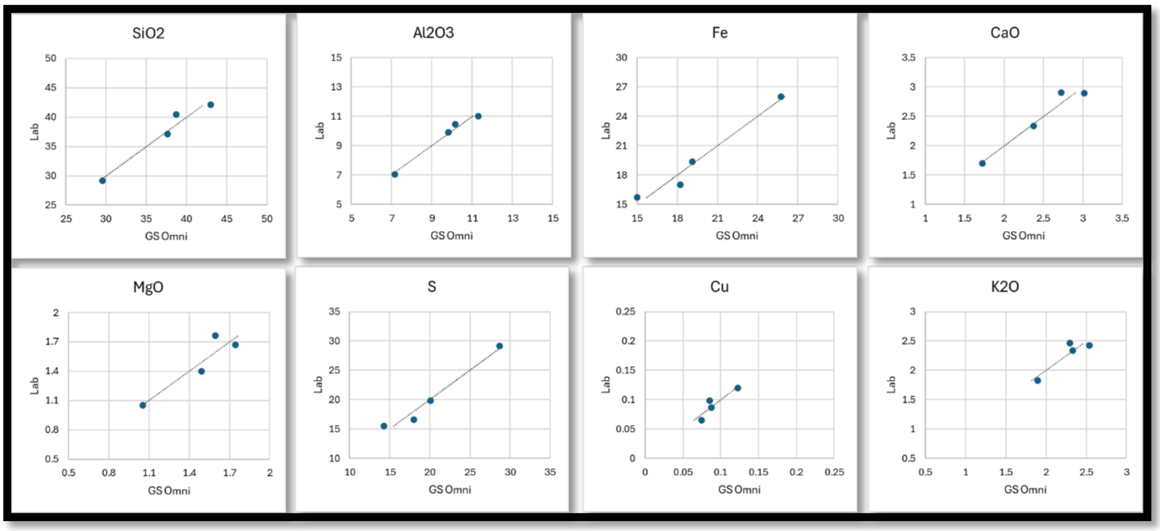

Figure 6 Feasibility Results of PGNAA Measurement on PAG Samples

In concentrate streams, the analyzer also provided accurate quantification of pyrite-associated iron and sulfur, enabling more precise control of reagent dosing during flotation. This contributes to improved metallurgical performance and operational efficiency.

Beyond metallurgical benefits, the GS Omni analyzer can be a valuable tool for environmental monitoring. By delivering continuous, real-time measurements of sulfur and carbonate-related oxides in tailings, operators can infer NPR dynamically. This capability supports proactive environmental compliance, offering early warnings of ARD potential and enabling timely adjustments to tailings deposition strategies.

The integration of PGNAA technology into tailings monitoring workflows represents a significant advancement in sustainable mining practices. Continuous elemental analysis not only enhances metallurgical performance but also strengthens environmental stewardship by mitigating long-term ecological risks associated with tailings storage.

Summary

PGNAA technology has proven to be a game-changer in mineral processing by enabling real-time, online elemental analysis of slurry streams. At Vale's Vargem Grande complex, its integration with a six-stream multiplexer allowed continuous monitoring of iron and silica, drastically reducing assay turnaround time from four hours to 20 minutes. This enabled dynamic control of reagent dosing—optimizing amine for silica rejection and starch for iron recovery—resulting in reduced iron losses, improved concentrate quality and lower reagent consumption. It also removes the necessity for plant personnel to enter the processing facility to collect physical samples, which reduces health and safety risks and improves productivity by freeing up plant personnel to work on higher value tasks.

Feasibility testing on North American copper-gold samples demonstrated PGNAA capable of analyzing sulfur, calcium, and magnesium across multiple streams, supporting accurate Neutralization Potential Ratio (NPR) calculations for tailings management. The technology not only enhanced metallurgical performance but also provided ability of continuous environmental monitoring, enabled proactive ARD risk mitigation and tailings deposition strategies.

The large volume of slurry, analyzed by GS Omni PGNAA system in real time, minimizes sampling error and provides a more representative analysis of the entire stream. This is an advantage over techniques like XRF and LIBS, which sample only small portions. This broader sampling improves accuracy and precision for key elements such as copper, iron, silica, sulfur, calcium, and magnesium.