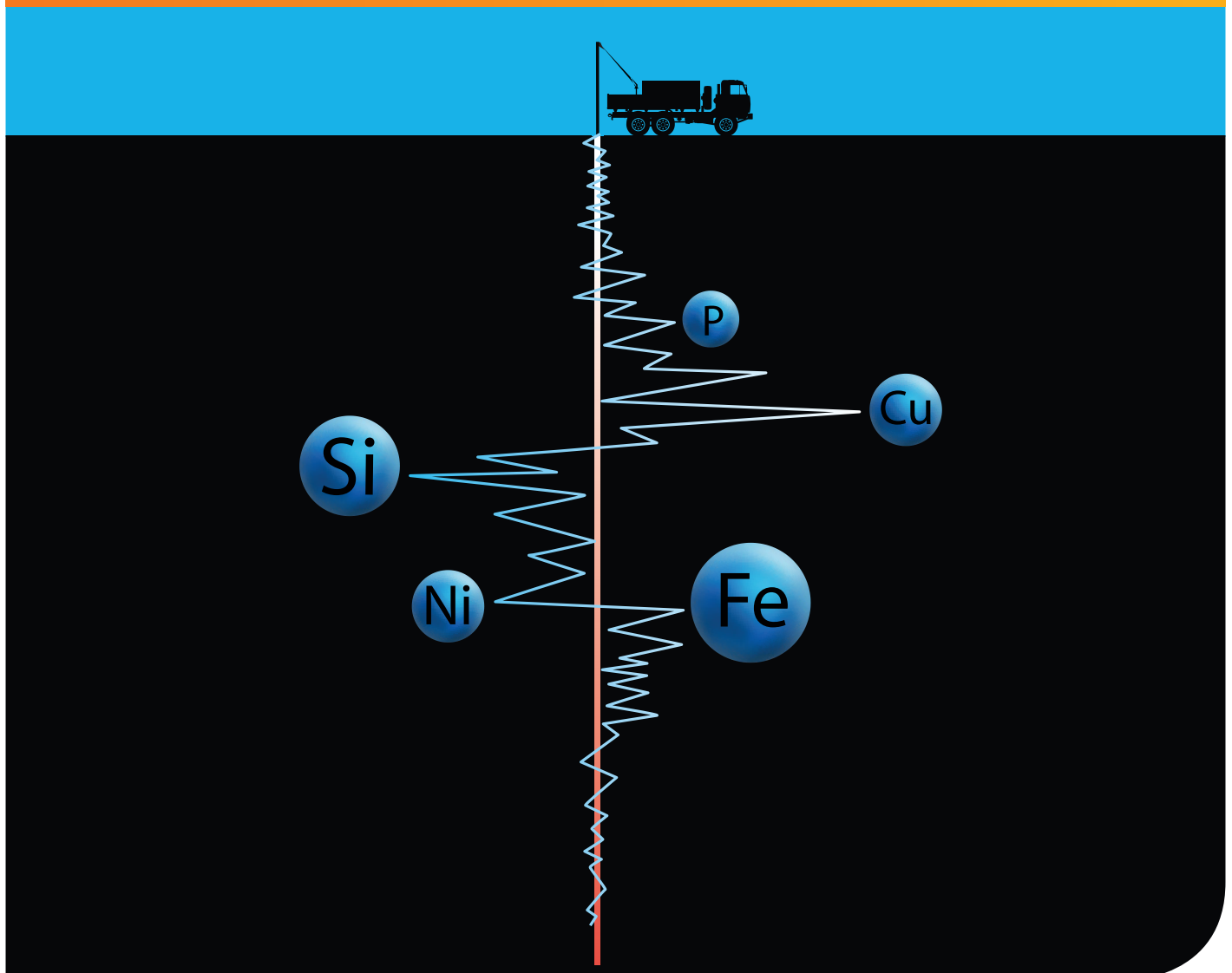


# FASTGRADE™ LOGGING TOOL: PULSED NEUTRON TECHNOLOGY

Exploring New Dimensions





Open-pit blast hole logging with FastGrade™

## ADDRESSING YOUR PRODUCTIVITY CHALLENGES

› FastGrade™ is an opportunity for the mining sector to rethink and optimize, in real time, its production cycle, based on the ore grade.

Assays from cored and reverse circulating (RC) boreholes or blast hole samples, do not always provide truly representative analyses and are very expensive. However, borehole logging provides in situ elemental analysis, making the use of altered samples no longer necessary.

Used for many years in the oil & gas industry, the technology is based on a neutron analytical technique called Pulsed Fast & Thermal Neutron Activation (PFTNA). This technology explores new dimensions and is going to be a game changer for the mining industry.

### Provide bench grade control on time

FastGrade™ 170 is to be used in blast holes of 200 mm diameter and beyond.

The grade obtained by FG 170, in real time, makes the optimization of explosive charging holes possible. The creation of a particle-sized separation of ore, based on its grade, makes it easy to extract low-grade material through the processing cycle.

It is currently controlled from a dedicated truck and could be ultimately paired with an autonomous mining vehicle.

Logging time is 10 minutes per hole, thanks to a large high-resolution gamma ray detector that is linked to a very fast electronic data acquisition system.

### Enhance your blocks model for less

FastGrade™ 100 was created to help improve and streamline exploration programs and resource management.

It is controlled by a single operator and produces a complete borehole (PQ and beyond) logging of up to 400 meters deep with a resolution of around 30cm.

Thanks to its accurate data, which enhance 3D resource modeling, FastGrade™ can significantly reduce the number of cored boreholes and reverse circulation drilling (according to the nature of the deposit and the frequency of assays required).

FG100 «Dual» can be operated in blast holes environment as well.

# AT THE HEART OF NEUTRON TECHNOLOGY

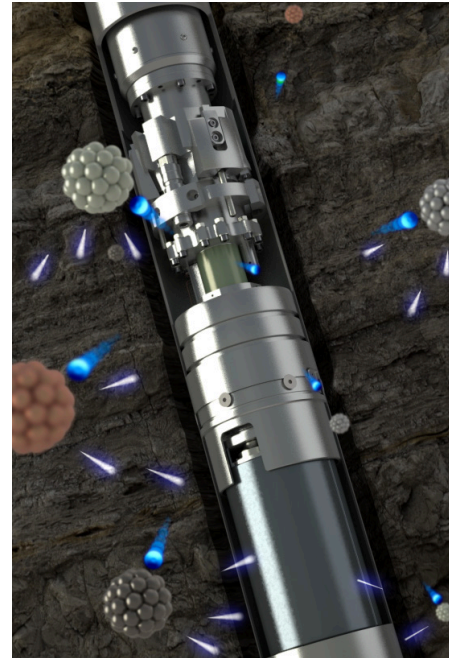
Neutrons emitted by the pulsed neutron generator penetrate the surrounding rock and lose their energy when colliding with nuclei.

As they penetrate, they initiate different interactions, as fast inelastic collisions or neutron captures that result, nearly instantaneously, in the emission of gamma photons.

Each element produces a set of characteristic energies, which is the key to identifying and quantifying them.

A high resolution, LaBr3 scintillating material coupled with a photomultiplier converts the photons into electrical pulses and a fast processing, specialized circuit digitizer sorts and counts them to build their spectrum.

At this point a computer can unfold element footprints out of the spectrum to reveal the chemistry of the formation.



Pulsed Fast & thermal Neutron Activation



FG100 operated by Kinetic in WA

## Innovative Calibration based on numerical model

FastGrade™ becomes operational after appropriate training that align spectral variation with rock geochemistry.

Digital calibration based on Monte Carlo numerical modelling is used for factory characterization and minimize final on-site calibration adjustment.

## Sodern leads pulsed neutron technology today

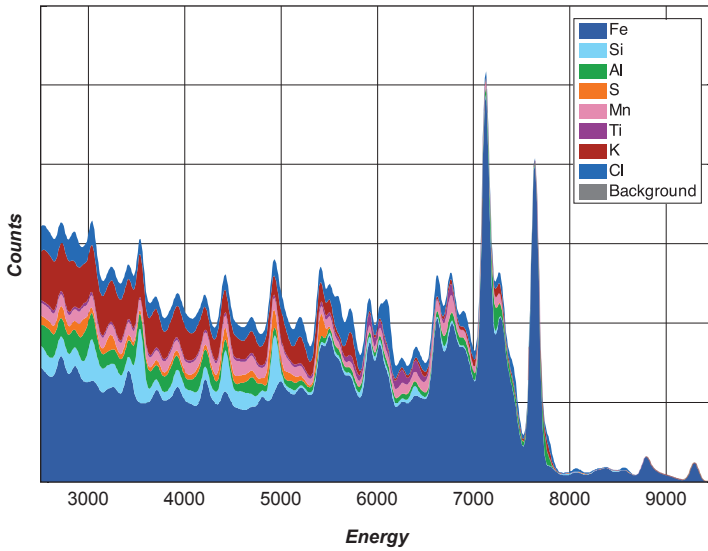


Thanks to over 50 years of experience in neutron technology, Sodern pulsed neutron tubes have been used for a wide range of industrial applications at a low cost of ownership.

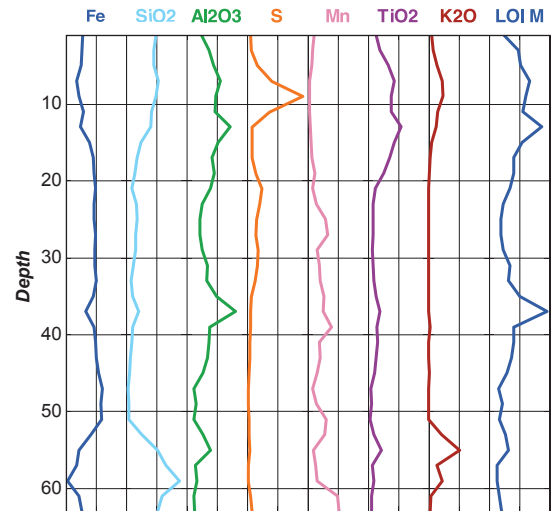
The tube lifetime and reliability have been significantly enhanced through a unique combination of ceramic technology and a unique hydrogen isotopes loading process.

# DIRECT ACCESS TO ORE CHEMISTRY

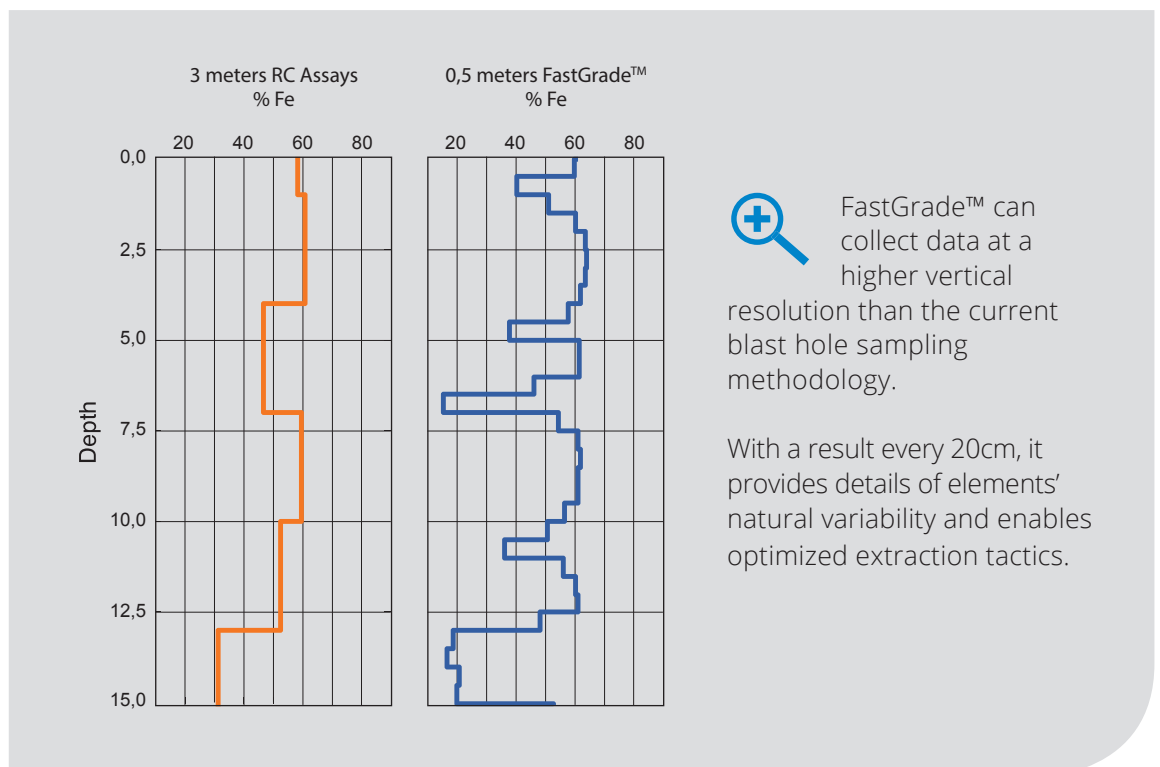
Individual elemental responses



Multi-element log



The emission rays appear in the form of vertical traces, more or less marked by the presence of the elements they characterize. Digital processing retrieves specific information about each element and thereby compensates for possible artifacts of measurement. Robust calibration translates this into mass fraction of the elements, and eliminates any subjective interpretation.

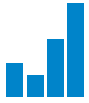


FastGrade™ can collect data at a higher vertical resolution than the current blast hole sampling methodology.

With a result every 20cm, it provides details of elements' natural variability and enables optimized extraction tactics.

# A NEW PULSED NEUTRON TOOL FOR NEW OPPORTUNITIES

## Knowledge



In a borehole logging configuration, the gamma signal collected by FastGrade™ and the derived elemental composition, is representative of a much larger volume of surrounding material than the delimited volume of the core material that is traditionally used to provide chemical assays. The main benefits are better sampling statistics and reliability in resource estimation, available in real time.

## Saving



The nature of information provided by FastGrade™ brings with it savings.

- Less energy spent needlessly, during low-grade material beneficiation operations
- Less samples collected and analyzed
- Less "cored-boreholes" which can be substituted by cheaper drilling technics.

## Resources stewardship

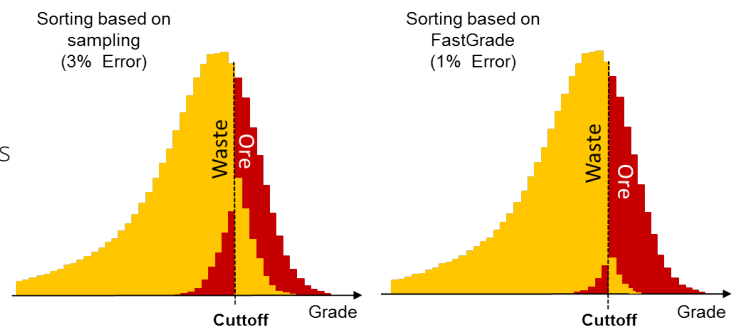


FastGrade™ is an essential link in the natural resources optimization program. Thanks to this tool, it is possible to sort only the high-grade and rich materials for the energy demanding transformation process, thus limiting the negative impact on the environment.

## Safety



Contrary to the radioactive chemical tools, FastGrade™ is equipped with an electric neutron tube that can be turned off (Zero Neutron) during surface handling operations and in cases of accidental blockage of tools in a borehole. Moreover, by removing the need for manual samples taken on site, FastGrade™ also limits the exposure of workers to the often hostile environment of the mine.



“ Better grade control early removes waste from your ore. ”



# THE FASTGRADE™ TOOL: FIRST IN IRON AND COPPER

## ...Already endorsed by a leading global resources company

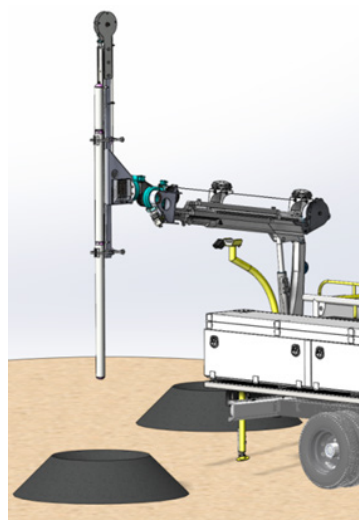
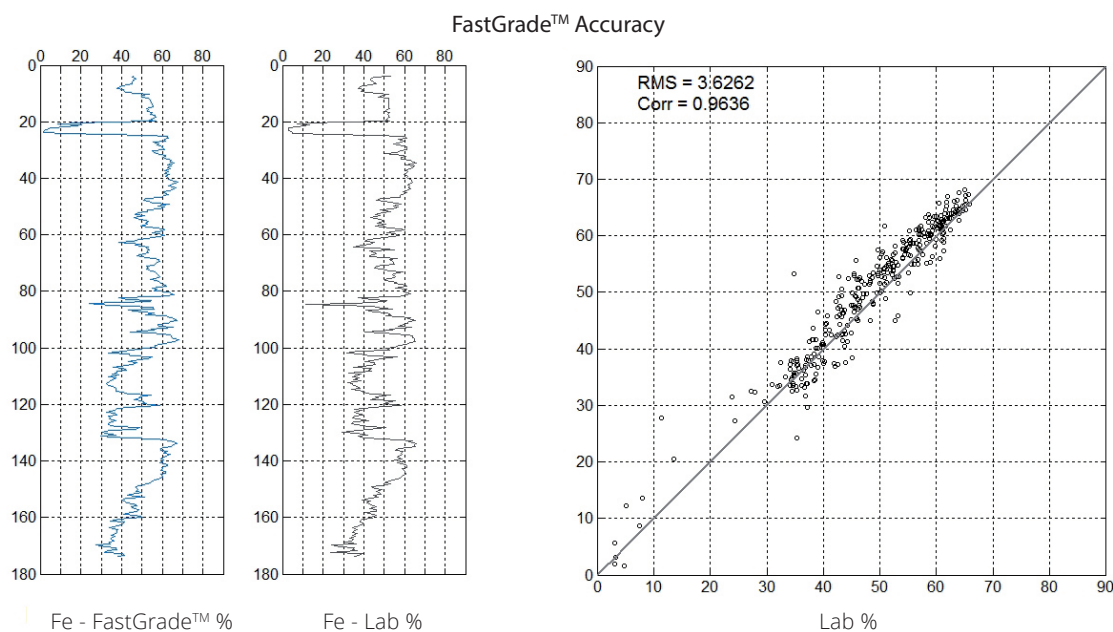
The first unit operated in the Pilbara iron ore-mining district, in 2012, when BHP Billiton started the PFTNA tool experience with FastGrade™ 100.

This tool primarily aims at measuring boreholes drilled for exploration and resource estimations. One tool logs more than 100 kilometers a year by measuring the numerous 140 mm diameter (PQ) holes commonly drilled on sites, using reverse circulating drilling. Operators quickly promoted the tool and its immediate benefits.

In 2015, BHP chief executive Andrew MacKenzie reported **"BHP has eliminated the need to drill expensive diamond core drillholes for validation of data saving more than US\$10 million in 2015."** \*

Today, BHP owns a fleet of FG tools that can be used either for resource evaluation or mining benches grade control.

\* The Sydney Morning Herald, December 15th, 2015



Automatised Blast Holes Logging  
(Conceptual drawing courtesy of Kinetic)

## ...Automatised for production use in Iron and copper

For blast holes monitoring, operating implies intensive logging rate and, in a real mine environment, measurement cycle time between holes should be as short as possible.

The new generation of FastGrade™ tool meets this challenge by implementing innovative features such as the Neutron Quick Start system. By reducing the tube warm-up time to few tens of seconds, this proprietary feature reduces the logging time cycle by 30% and consequently increases the productivity by the same rate.

FastGrade™ is suitable for the new generation of "smart" trucks and even probably ready for emerging autonomous mining solutions.

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