Generating ore body knowledge fit for manufacturing purpose - future trends and challenges in geometallurgy

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TRENDS

The emergence of geometallurgy over the last decade has resulted in formalised practice groups within the mining industry leading to routine inclusion of geometallurgical attributes in mine scheduling and planning. The purpose of geometallurgy is to generate ore body knowledge fit for manufacturing purpose which can be used to predict and optimise key mining and processing performance operations leading to highest value saleable product and sustainable waste storage.

Current geometallurgical programs are designed around systematic testing of representative future ores involving composite samples of drill core. Testing involves either physical protocols representing specific processing performance (e.g. laboratory testing for breakage functions and flotation recovery) or proxies for processing performance (e.g. predictive multivariate functions based on chemical assays or bulk mineralogy). This has been supported by development of field and laboratory-based small-scale tests suitable for application to drill core, with cost structures that enable application to many hundreds or thousands of geometallurgical tests suitable for geostatistical population into long term resource block models.

CHALLENGES

The primary use of geometallurgical-enabled resource models is to provide inputs for long-term mine scheduling and optimization that modify primary value drivers such as feed grade. However, current practice typically involves provision of geometallurgical testing data at 1-2 orders of magnitude lower than routine drill core assays. This reduces confidence in sparse geometallurgical data and makes reconciliation against actual production performance difficult and imprecise over time periods below quarterly duration.

Very few operations employ geometallurgical testing in the short-term planning cycle due to the time required to undertake testing and integrate outcomes into daily production. This means that there are very limited feedback loops between actual performance data and dynamically updated resource models. This is particularly evident in what can be referred to as the ‘dig and deliver’ interface where ore and waste are drilled with close spacing, blasted and excavated resulting in short-lived maximum exposure. As material is further size reduced and subject to blending and recovery downstream, amenability to on-line measurement increases on conveyor belts and slurries but conversely the degree of mixing and blending degrades meaningful geometallurgical feedback loops into the resource model.

The major challenge for geometallurgy is provision of on-line ore and waste characterisation data in the dig and deliver interface which feeds back into dynamic resource model updating and feeds forward into optimisation of processing and blending. This requires use of on-line sensors capable of analysing parcels of relatively unmixed in-mine material without the need to undertake additional sample preparation or remove sub-sampled material to a separate facility.

ROLE OF GEOSENSING

GeoSensing can be defined as the ability to routinely measure or infer rock properties at a range of scales using non-destructive devices capable of providing real time information and data flows which support integrated decision making across the mining value chain.

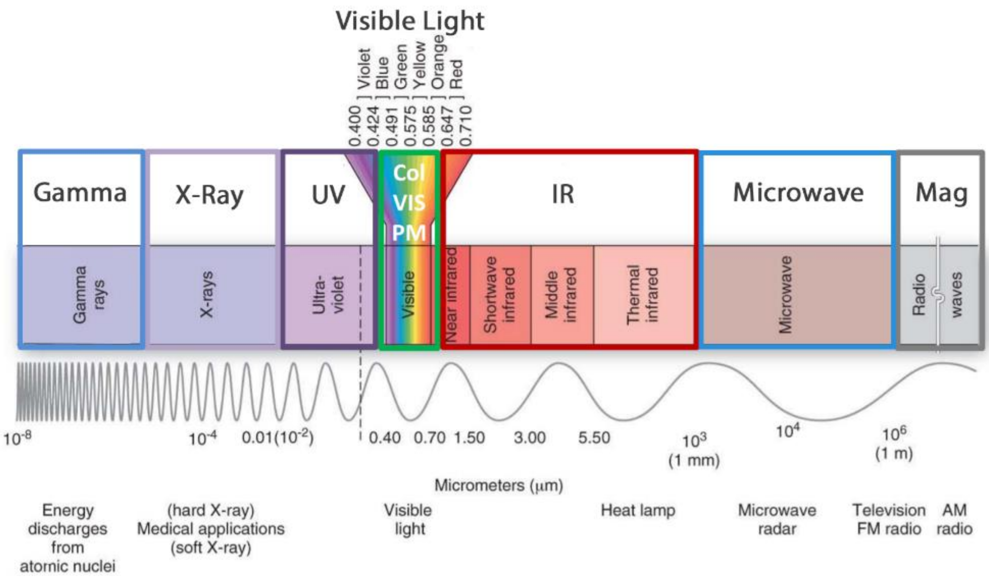
GeoSensing is a robust and widely applied approach in mineral exploration mainly involving geophysical and spectral techniques with proven success for locating mineral deposits at increasing depth. However, there is a lack of analogous real-time GeoSensing data streaming in the ‘dig and deliver’ interface involving a range of physical rock-machine interactions.

This lack of real-time GeoSensor data is partly a function that accurate in-mine sensing of coarse rock mass is a technical and logistical challenge. GeoSensors need to operate in hostile and transient environments where physical access to rock material is limited and variable coarse fragmentation presents difficult interface geometries and sampling statistics. Providing a range of real-time geometallurgical attributes also requires more than determination of bulk grade.

Despite these difficulties potentially suitable GeoSensor technologies exist either as commercial offerings or current R&D initiatives. However, these technologies have not yet been deployed or proven in the dig and deliver interface or integrated into providing real-time geometallurgical solutions. Providing this capability is the development focus of many of the major mining companies, commercial vendors and research consortia.

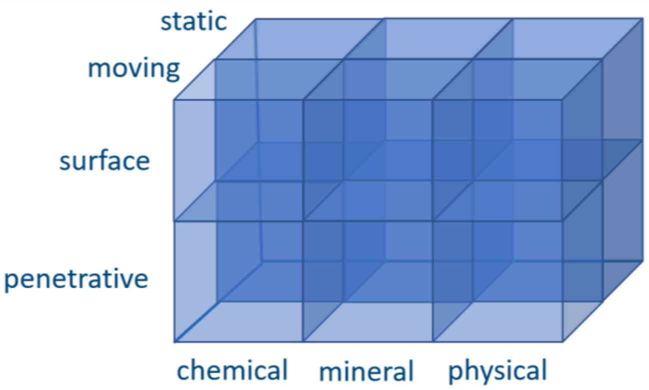
It is useful to group GeoSensor technologies around inherent signal frequencies which influence material interactions. This ranges from very high energy and short wave-length frequencies such as gamma and X-rays; to longer wavelength lower energy frequencies such as radio waves. The visible light spectrum includes image analysis methodologies (Figure 1).

FIG 1 – Wavelength frequencies which can be used to group GeoSensor technologies



It is also important to consider the nature of machine-rock interaction outcomes for specific GeoSensors and frequencies. The most important aspect of interaction is surface versus penetrative as this directly influences sampling statistics and representivity. UV, visible light and IR typically operate in surface 'reflectance' mode; while gamma, X-ray, microwave and electro-magnetic wavelengths provide more penetrative capabilities.

FIG 2 – Representation of key GeoSensor property groups and use cases



The three property groups directly relevant for geometallurgical characterisation involve chemical (typically elemental) responses; direct measures of specific mineral components either as a bulk percentage or as a distribution function of texture; and physical properties such as particle size distribution (Figure 2).

The other determining factor is speed to data influenced by presentation mode and geometry. GeoSensing of static material such as down hole logging, muck piles or truck payloads provides very different signal acquisition and integration opportunities compared to much more rapid signal acquisition requirements when scanning moving material such as conveyor systems. This directly impacts precision and accuracy of available data and the lot size (i.e. tonnage) of effective data resolution.

Examples will be given of GeoSensor technologies capable of being deployed in the short-term dig and deliver interface and their potential role in supporting real time geometallurgical characterisation. It is interesting to note that the main driver for bulk material sensor development outside of the minerals industry has been the industrial recycling and food processing sectors. The size and importance of these sectors has driven advanced sensing technology development and equipment manufacture with important lessons for the mineral industry.

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