


# Geometallurgy as a foundation for operational excellence



Every mine plan makes a promise about how an orebody will perform. That promise extends beyond tonnes and grade to the metal recovered, the energy and water consumed, the quality of the product sold, and the waste left behind. Its credibility depends on how well we understand the material that will enter the plant. Geometallurgy should therefore be a non-negotiable part of responsible project development and operational management. This special themed edition of the SAIMM Journal, focused on Smart *Sensors and Data Intelligence for Risk Management and Operational Excellence Through Geometallurgy*, addresses that responsibility. It brings attention to a fundamental challenge, that is, translating measurements of heterogeneous rock into reliable decisions about mining and processing. The significance of this theme lies in the connection between orebody knowledge and the consequences of acting on it. Grade alone cannot describe processing behaviour. Two parcels with similar metal content can differ substantially in hardness, mineral associations, liberation characteristics, and metallurgical response. Those differences can alter throughput, recovery, reagent demand, and concentrate quality. When they are absent from the planning model, their consequences emerge during production, when the options for responding may be costly or constrained. Geometallurgy makes these relationships explicit and allows their implications to inform decisions before the material reaches the plant.

A central difficulty is the imbalance between abundant geological and geochemical observations and comparatively sparse metallurgical testwork. Laboratory tests remain indispensable, but extending their results across an orebody requires evidence that the relationships remain valid beyond the tested samples. Sample representativity, geological domains, and changes in scale all matter. Blending and operating conditions can further modify the response. A credible geometallurgical model must preserve the connection between measurements and predictions, making its assumptions and uncertainty visible wherever its outputs influence a decision. Smart sensors can strengthen this connection by expanding the coverage and frequency of observations, from core characterisation to material movement and plant performance. Their usefulness depends on calibration, quality assurance and quality control, and an understanding of what each measurement represents. Measurements collected at different locations, times, and scales must be reconciled before they can support a common interpretation. More data become valuable when they resolve uncertainty that matters to an operational choice.

The same discipline applies to machine learning and digital twins. Predictions must remain grounded in geology, mineralogy, and process behaviour, with validation appropriate to the decisions they support. A model that performs well on familiar samples may be unreliable in an untested ore domain. Quantified uncertainty helps identify where additional testwork is justified, where a blend needs caution, and where a production forecast requires contingency. As an operation advances, reconciliation with actual performance should inform model updates and expose assumptions that no longer hold. Operational excellence requires this knowledge to change practice. Geometallurgical predictions should inform mine scheduling, blending, and process settings, with clear responsibility for acting on them. Performance should be assessed through outcomes such as more dependable throughput and recovery, improved product quality, and better management of energy, water, and waste. These outcomes depend on geologists, metallurgists, mining engineers, and data specialists working from a shared understanding of the orebody and its uncertainty. Developing that capability deserves sustained investment alongside the technology.

The case for geometallurgy is ultimately a case for accountable decisions. Understanding variability does not eliminate risk; it allows us to recognise its sources, assess its consequences, and choose how to respond. The scope of a geometallurgical programme should befit[HS1.1] the deposit and the decision at hand. The obligation to understand material variability and its effect on performance should be non-negotiable. I invite readers to approach this edition with a practical question: what must change in our own operations to make that understanding part of every consequential decision?

**G.T. Nwaila**

*Director of the African Research Centre for Ore Systems Science (CORES) and Deputy Head of School*

*School of Geosciences | Faculty of Science*