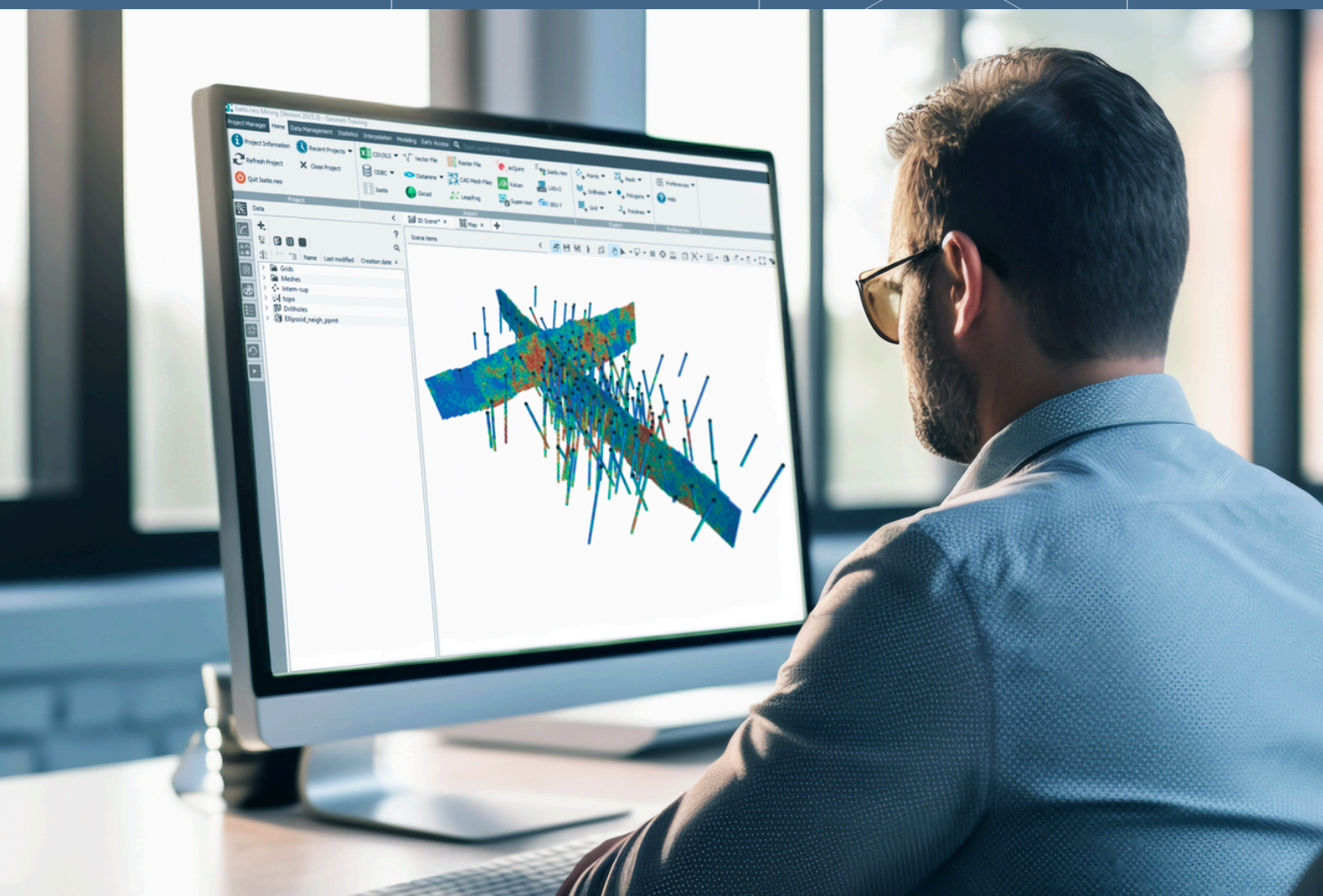
DATAMINE

BEYOND GRADE: USING GEOLOGY-LED MODELLING TO PREDICT ORE BEHAVIOUR AND RECOVERY



Grade has always been the headline number in resource evaluation. But anyone who has watched a processing plant struggle with 'good' ore knows that grade alone does not tell the full story.

Recovery, hardness, deleterious elements and mineralogical variability can make or break a project's economics. The challenge is that these behaviours are often far harder to model than grade itself.

This is where geometallurgy earns its place.



GEOMETALLURGICAL MODEL FOR A INTEGRATED DECISION MAKING

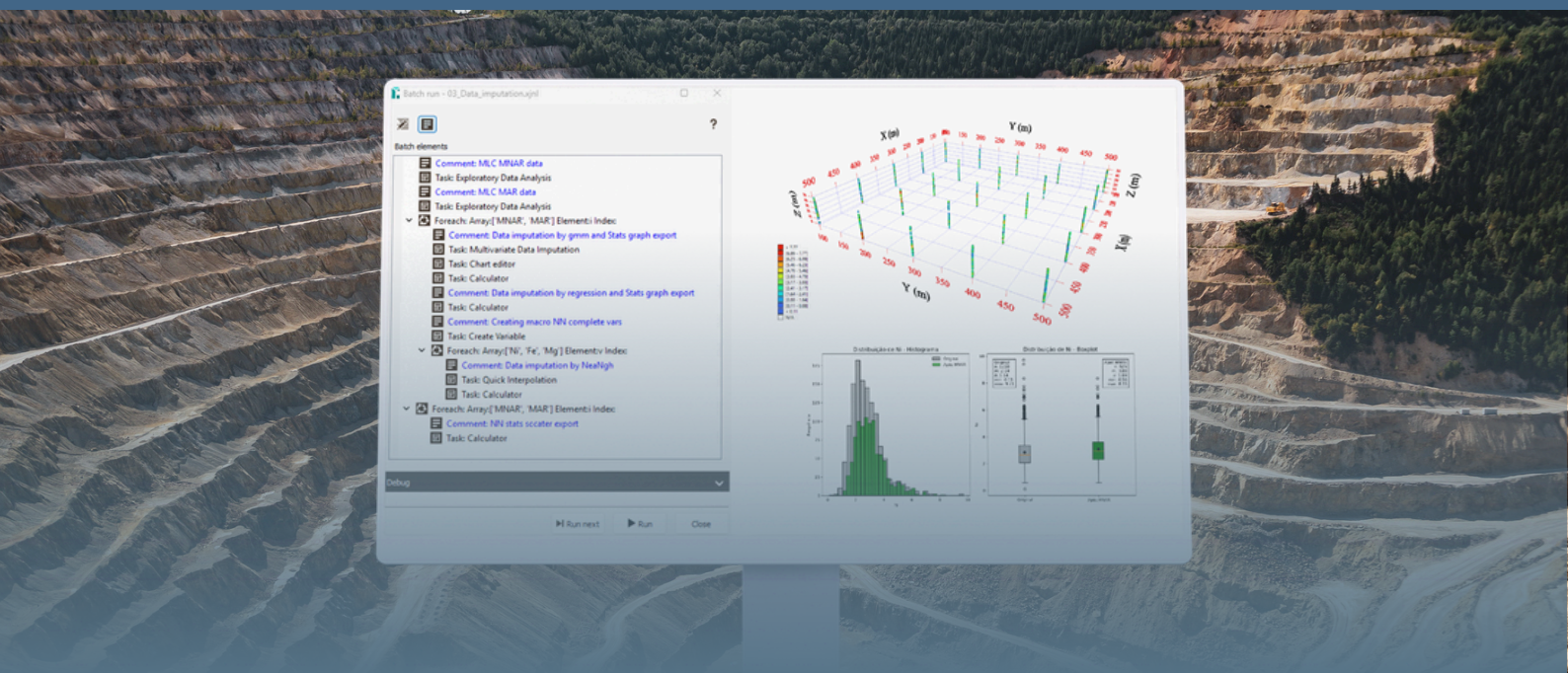
One connected picture, not four disconnected datasets. Integrate geology, mineralogy and metallurgy into a single model that reflects how the orebody will actually behave.

Geology leads - geostatistics and machine learning explain the rest. Together they capture complex multivariate patterns, quantify uncertainty and manage risk - **keeping every prediction grounded in real geology.**

More value from the testwork you already have. Predict processing behaviour across the entire block model from limited, expensive metallurgical testwork. **no need to drill and test everything.**

Plan with confidence, not guesswork. Quantify the uncertainty in every prediction so teams can schedule, blend and forecast recovery knowing the risk

Better plant performance, fewer surprises. Anticipate how each block will process so the plant runs predictably - **optimising recovery and managing tailings before they become a problem.**



The question is no longer whether grade matters, but ***how geology can help explain what the plant will actually see.***

THE CORE PROBLEM: SPARSE DATA WHERE IT MATTERS MOST

Geometallurgy connects geological, mineralogical and metallurgical information to help predict how ore will actually behave from pit to plant. In theory, it is straightforward. In practice, it is anything but.

Metallurgical testwork is expensive and slow. Most projects have recovery data without representative mass and spatial distribution along all domains.

Meanwhile, the variables that matter most - recovery, grindability and reagent consumption - tend to be non-linear, spatially complex and tangled up with other geological attributes.

The result? Teams need to predict processing behaviour across an entire block model using a handful of expensive test results.



Geology & Mineralogy → **Metallurgy (Testwork)** → **Integration Model** → **Predict Performance (Pit to Plant)** → **Better Decisions, Better Outcomes**



Metallurgycal testwork is **expensive** and **slow**



Most project have recovery data for a **fraction** of their **drillholes**

WHAT TEAMS ARE TRYING TO SOLVE

A conventional resource model can tell teams what grade it contains without quantify uncertainty. But it may not explain how blocks behave differently through comminution, flotation or recovery.

That is the point where geology-led modelling becomes a planning tool: it uses the broader geological context to manage uncertainty where expensive testwork is scarce.

THE APPROACH: STARTS WITH GEOLOGY, NOT ALGORITHMS

A reliable geometallurgical model has to respect the geological knowledge of the deposit. Before algorithms, teams need coherent domains that separate zones with genuinely different geological formations processing behavior.



The model must be communicated, understood and actively used. It cannot remain in a report or become disconnected from the current state of the mine - orebody knowledge, equipment performance, market conditions and operational experience all change over time.



Regular review and updates are essential to ensure the plan reflects current operational knowledge, not outdated assumptions from earlier project phases.



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In a porphyry copper deposit, for exemple, the distinction between supergene and hypogene material is not just academic. It shapes how mineralogy varies and how the ore responds in the plant.

A PRACTICAL THREE-STAGE WORKFLOW

One approach that's proving effective combines the strengths of geostatistics and machine learning:

1. **Define geometallurgical domains** using geological context and multivariate information. This ensures the model honours both geological coherence and the natural clustering of similar samples.

2. **Model the abundant variables first.** Mineralogical and grade data are typically sampled more densely than metallurgical response data. Using multivariate geostatistical simulation, rather than simple estimation, preserves the variability and spatial structure that drive processing performance, and can access uncertainty.

3. **Use the simulated variables to predict recovery.** A supervised machine learning model (in one case study, K-Nearest Neighbours regression) trained on the available testwork can estimate recovery for blocks with similar mineralogical fingerprints.

The logic is intuitive: blocks that look mineralogically similar should behave similarly in the plant. The geostatistics provide spatial consistency and uncertainty quantification; the machine learning captures the complex, non-linear relationships that link mineralogy to metallurgical response.

WHAT THIS MEANS FOR PLANNING: FROM MODEL TO DECISIONS

A conventional model tells you where material is and what grade it contains. A geometallurgical model helps you anticipate how that material will perform during processing - useful for scheduling, blending, plant feed management, recovery forecasting, talling manage and risk assessment.

Perhaps more importantly, this approach makes better use of limited metallurgical data. Instead of treating sparse recovery results as an isolated dataset, it uses the broader geological and mineralogical context to inform predictions across the block model.

- **Connect geological and mineralogical context** to processing outcomes.
- **Make better use of limited metallurgical testwork** instead of treating sparse recovery results as an isolated dataset.
- **Model uncertainty more realistically** so block models reflect how the orebody behaves in practice.

LOOKING AHEAD

The future of geometallurgy isn't about replacing geological expertise with algorithms. It's about giving geologists and technical teams better tools to quantify complexity, integrate diverse datasets and make decisions with greater confidence.

As orebodies become more variable and margins tighter, models that go beyond grade aren't a luxury, they're a necessity. The opportunity for teams prepared to invest in this approach is straightforward: use the data you already have more intelligently, model uncertainty more realistically, and build block models that actually reflect how the orebody will behave in practice.

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