



Advancing Geometallurgical Modelling with Machine Learning: Recovery and Comminution Hardness Estimation at Mogalakwena Platinum Mine

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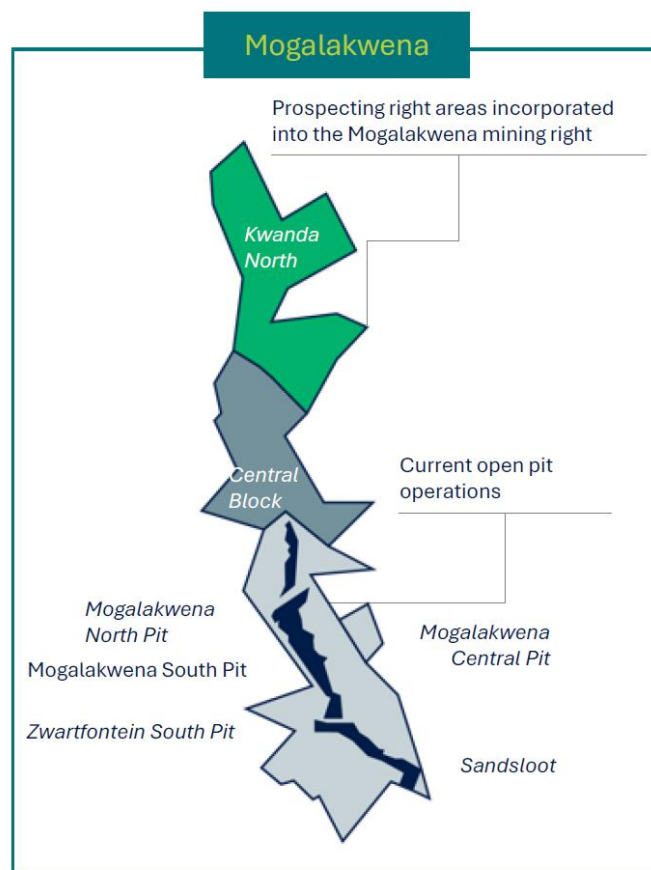
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INTRODUCTION

SITE LOCATION



Location	Northern Limb, 30 km north-west of Mokopane, Limpopo
Life of Mine	86 years
Infrastructure	Four Open Pits Two Concentrators Twin Exploration decline shafts at Sandsloot Underground
Mining Method	Conventional drill, blast, load and haul surface-mining methods Long hole open stoping for future underground
Metals	Polymetallic deposit - Pt, Pd, Rh, Au, Ru, Ir, Cu, Ni, Co. 30-100m thick reef

Source: Ore Reserves and Mineral Resources Report 2023 of current operations; AAP Strategy 2024

GEOLOGICAL AND GEOMETALLURGICAL CONTEXT

Lithology and Stratigraphy:

- Platreef: Pyroxenite, Altered-Pyroxenite, Granofels and Calc-silicate
- Footwall: Archean Granites and Dolomite
- Hangingwall: Main Zone Norite.

Platreef-footwall Interaction:

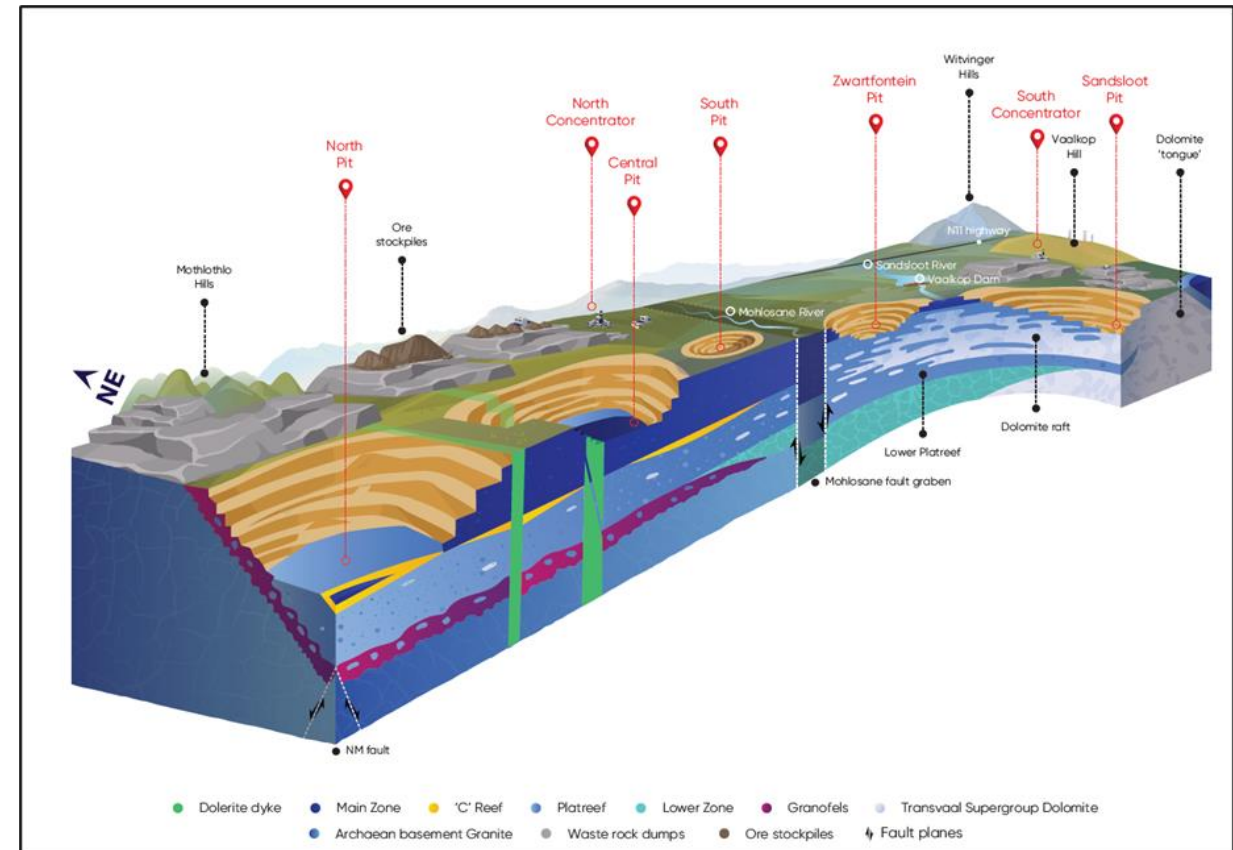
- Platreef ⇔ Granite: Granofels
- Platreef ⇔ Dolomite: Calc-silicate

Structures:

- Faults, dykes, footwall xenoliths

Geometallurgical Implications:

- Variable bulk mineralogy
- High Phyllosilicate content
- Variable ore hardness
- Variable PGM compositions and mineral associations



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GEOMETALLURGY MODEL OVERVIEW

ROCK CHARACTERISATION WORKFLOWS

ROUTINE ANALYSIS

RC and Resource Drilling:

- FTIR mineralogy
- XRF major element oxides
- Metals & Density
- 5% Mineralogy Standards

High spatial density datasets
> 250 000 Bulk Modal Mineralogy results

GEOMETALLURGICAL TESTWORK

Selected Resource Drilling Samples (5-15m interval composites)

- Comminution
 - SMC-Drop Weight
 - Geopyöra
 - Bond Ball
 - Mini Bond
- Mineralogy
 - Bulk Modal & BMS – QXRD, TIMA-X, XRF major element oxides
 - PGM Deportment (selected samples)
 - FTIR mineralogy
- Recovery
 - Bench-scale rougher flotation

Low spatial density datasets
~100 - 1000's of hardness and recovery results

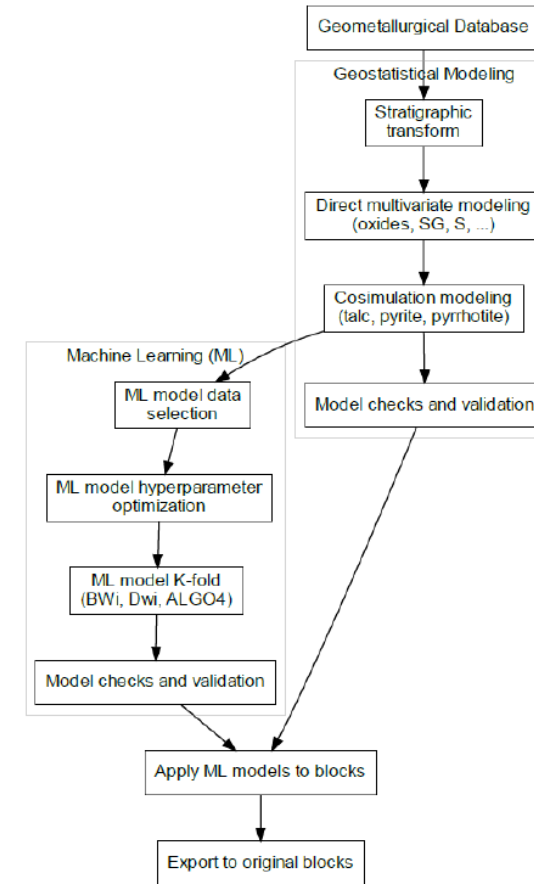
MODELLING WORKFLOWS

Geomet Spatial Modelling:

- Conducted using a suite of python tools through Resource Modelling Solutions Platform (RSMP)

Key Steps in Workflow:

- EDA
- Coordinate transformations
- Simulation (mineralogy and oxides – high density data)
- Machine Learning (BWi/DWi/Recovery) using simulated variable as input predictors
- Apply ML models to blocks
- Coordinate Back transformations
- Merge Resource and Geomet models into One Model



Model Attributes

talc
chlorite
serpentine
clinopyroxene
orthopyroxene
pyrite
pyrrhotite
K-feldspar
plagioclase
mica
amphibole
chalcopyrite
pentlandite
Ore class
UCS
BWi
DWi
4T Rec
Pt Rec
Pd Rec
Rh Rec
Au Rec
Cu Rec
Ni Rec
Co Rec
Ir Rec
Ru Rec

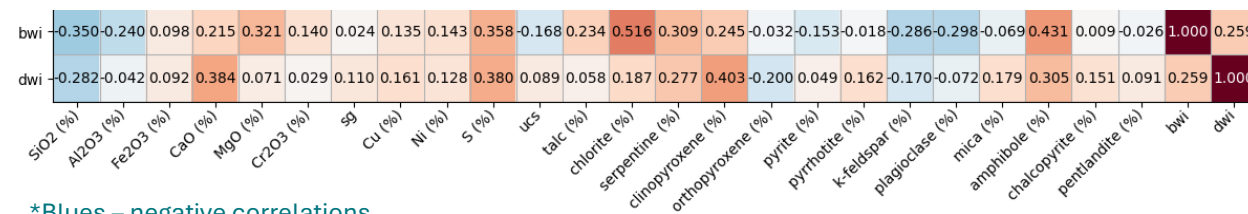
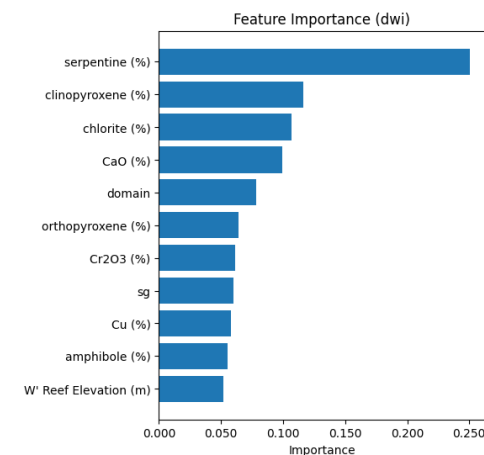
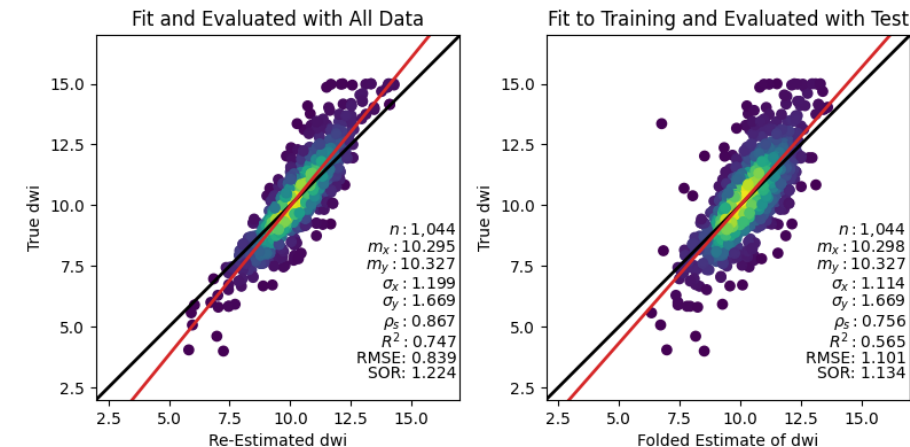
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DWi ML MODEL

DROP WEIGHT INDEX

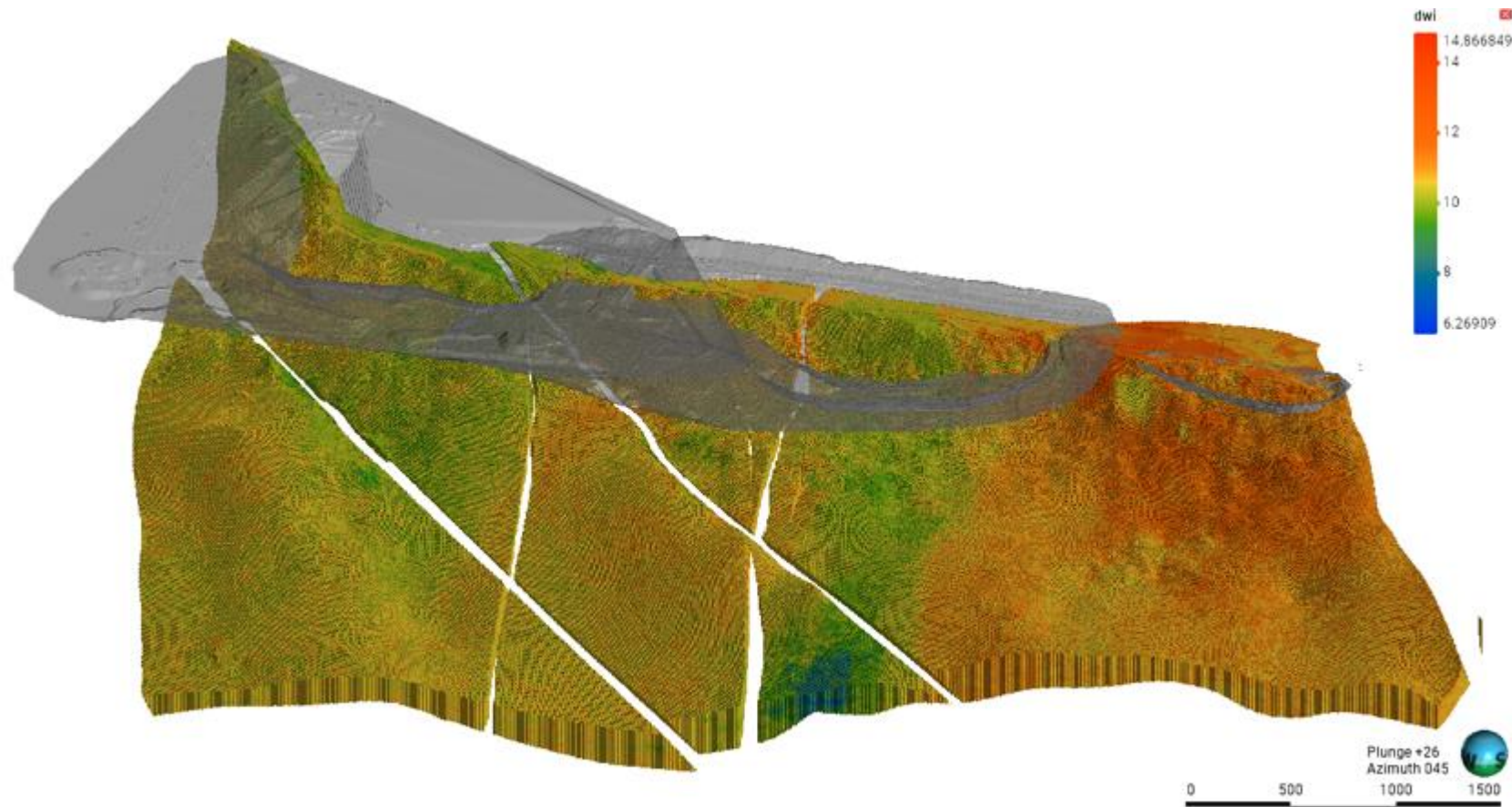
- DWi data: SMC-Drop Weight Test and Geopyrö
- Model trained on 1044 samples using XGBoost (Decision-tree ML algorithm)
- Full dataset: $R^2 = 0.747$ & RMSE = 0.839
- K-fold validation: $R^2 = 0.565$ & RMSE = 1.101
- Model Overfitting
 - Acquire additional data
 - Review tree-depths
 - Input parameters/feature selection
 - Sub-domaining
- Featural Importance: Serpentine, Clinopyroxene, Chlorite, CaO the strongest predictors



*Blues – negative correlations

*Reds – positive correlations

Spatial DWi model image

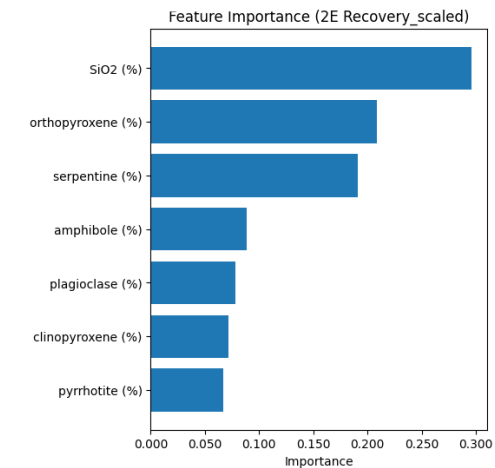
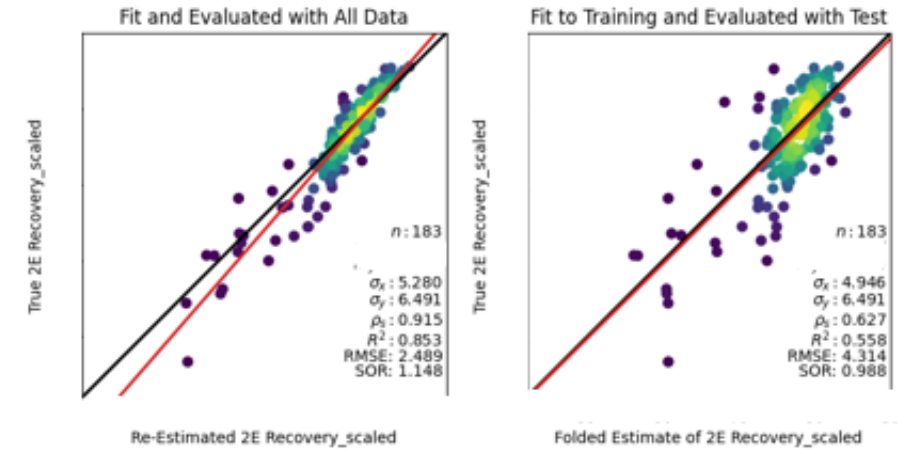


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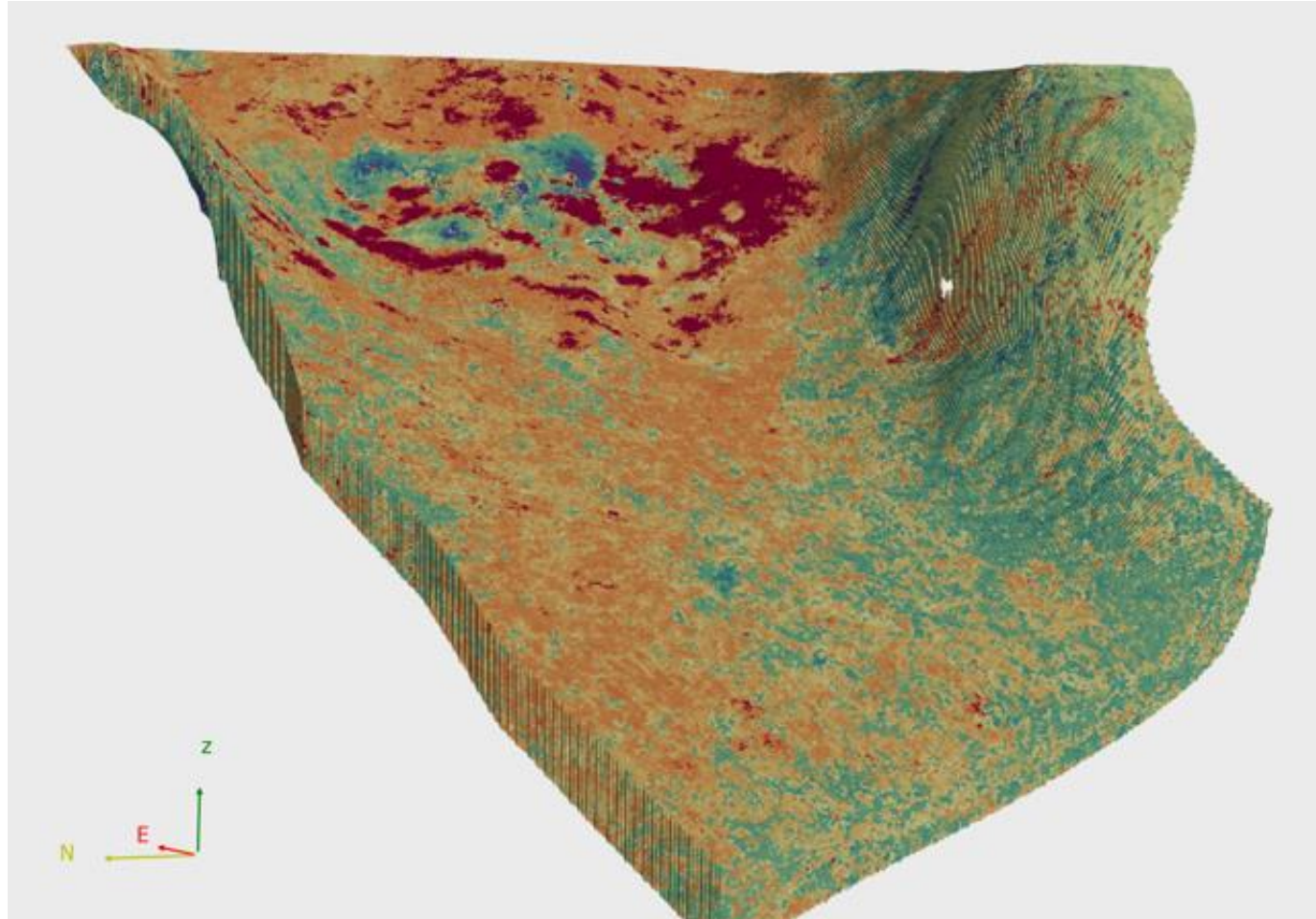
RECOVERY ML MODELS

FLOTATION RECOVERY

- Model developed for the Sandsloot domain – feasibility evaluation of the Underground Mine
- Data: Bench-scale flotation tests, standard conditions, fixed grind
- Models developed for 2E, Pt, Pd, Ni & Cu (with scaling factors)
- Model trained on 183 available flotation tests
- Full dataset: $R^2 = 0.853$ & $RMSE = 2.489$
- K-fold validation: $R^2 = 0.558$ & $RMSE = 4.314$
- SiO_2 , Orthopyroxene and serpentine are strongest predictors



Spatial Recovery model image (Pt Rec)

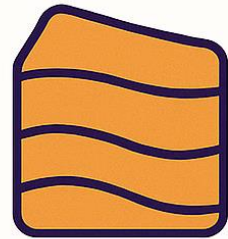


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Pathway to Applications

Pathway to Applications

Unlocking Geomet Value



Geology



Planning



Processing



Integration
puts data in
the hands of
decision-makers



Thank you

