STRATUM: Corporate Case Study

Underground High Grade Copper Modelling

June, 2023

STRATUM AI

STUDY CASE
COPPER DEPOSIT

LARGE IRON OXIDE COPPER GOLD IN NORTHERN CHILE

THE DEPOSIT

- High grade underground copper deposit of manto and breccia mineralization.
- Has over ~120,000m drillhole assays, ~180,000m un-assayed drillholes, ~80,000m RC drillholes for grade control
- High cutoff of 0.5% reflects the selective nature of the operation.

STUDY CASE
COPPER DEPOSIT

LARGE IRON OXIDE COPPER GOLD IN NORTHERN CHILE

PROBLEM

The mine is underground with high grade Cu & complex structural variation; this makes it easy to miss mineralization zones in the mine plan.

OBJECTIVE

Create model that identified missed areas of mineralization without increasing the false positive rate of HG estimation.

OUTCOME

A model that reconciles better while identifying 80Mlbs of new mineralization in areas previously identified as waste by kriging-based site model.

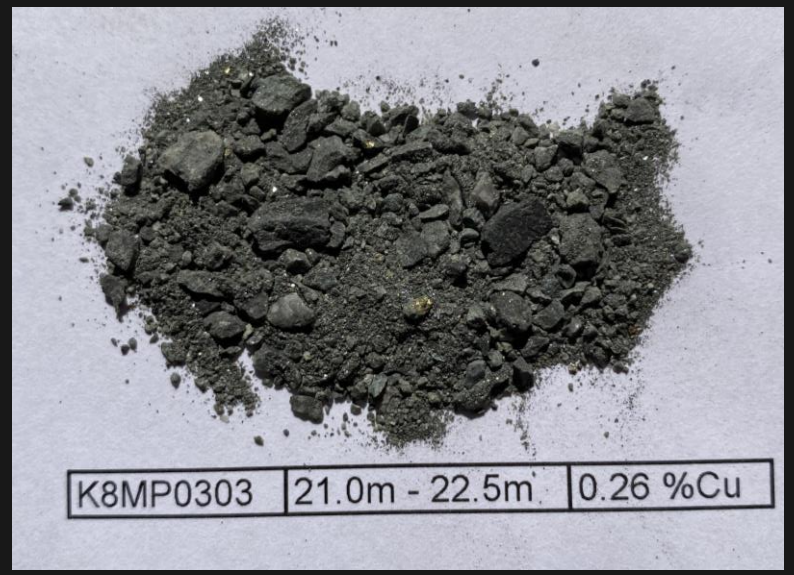
SOLUTION

AI outperforms Kriging by learning geological patterns from 380k samples worth of historical drillholes to identify **missing mineralization zones**.

COPPER MODELLING
INPUT DATA

UNASSAYED DRILLHOLES
(180,000 SAMPLES)

- The mine only assays core expected to be mineralized, otherwise it is unassayed and considered to be country rock.
- Upon inspection, it' difficult to visually tell apart true country rock (0% copper) from uneconomic ore of 0.05-0.2% copper with assay-comparable confidence.

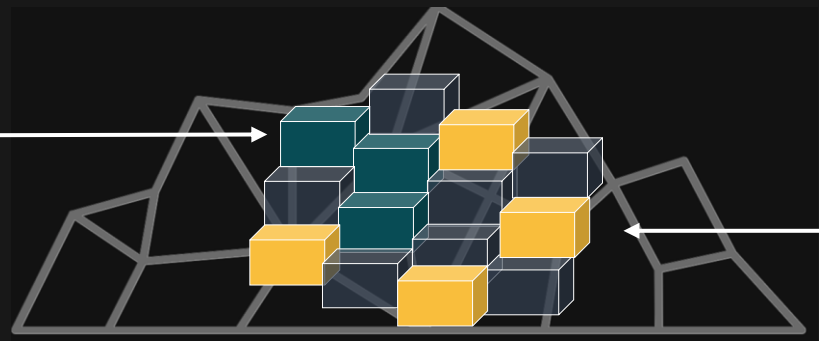


COPPER MODELLING
INPUT DATA

ZFC INPUT CHANNEL

- Through the training phase, we treat unassayed core as 0% Cu but preserve a distinct channel whether an assay was collected there so that the model can distinguish between 0% Copper assayed and core visually presumed to be 0% Copper. This can mitigate error from visually logged country rock actually being ~0.1-0.2% Copper rather than 0% Copper.

VISUAL
INPUT CHANNEL



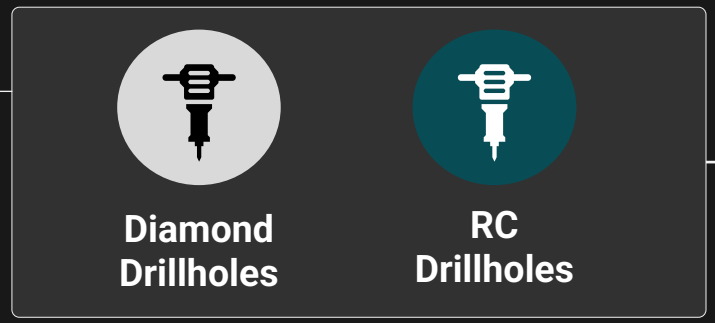
The model receive two distinct channels inputs. This is useful from telling apart somewhat different waste rock cases

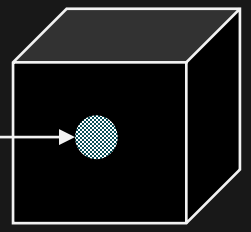
ASSAY
INPUT CHANNEL

COPPER MODELLING
INPUT DATA

RECONCILIATION TEST SET

2021 – 2022 Data

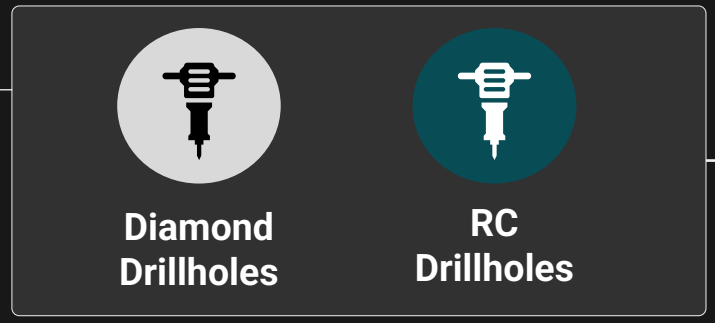


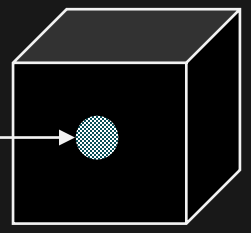


4mx4mx4m

Reconciliation Test Set

Pre-2021 Data





4mx4mx4m

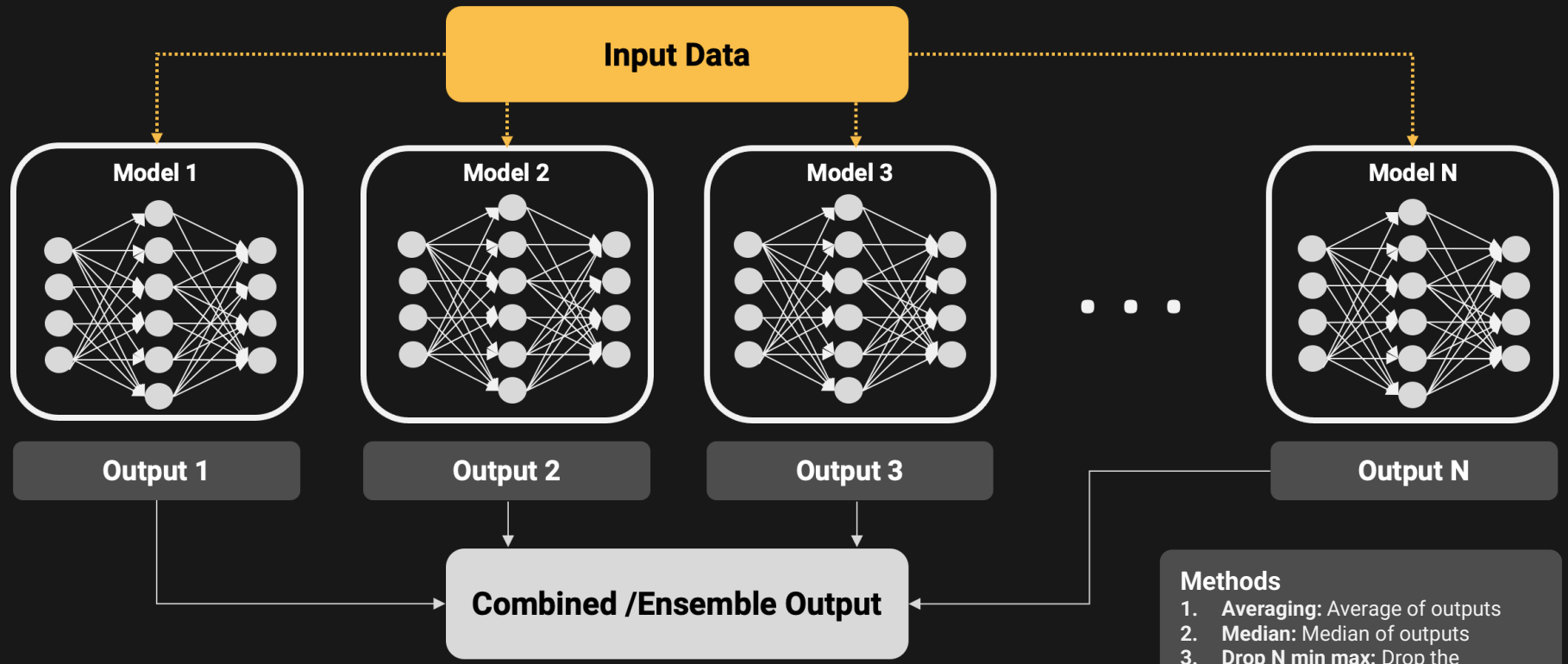
Input Data

All models will **only have access** to data before Jan 2021 as input

STRATUM MODELS
AI MODEL STRUCTURE

ENSEMBLE NETWORKS

Ensemble Networks:
Combining the outputs of multiple learning models together usually creates more accurate models. We create separate models from different input features and then combine them through an ensemble network. This includes Kriging!



Methods
1. **Averaging:** Average of outputs
2. **Median:** Median of outputs
3. **Drop N min max:** Drop the largest/smallest N predictions for each block and average the middle predictions

STRATUM MODELS
AI MODEL STRUCTURE

MODELS IN ENSEMBLE

Top 9 Models + Kriging

We combine a diverse set of 9 AI models as well as existing Kriging model into an ensemble

Legend:

- special sampling method in training
- Additional inputs channel (ZFC or GEO= Geological info)
- Composite methods (1or 2)

MODEL 1 INPUTS
Diamond & RC Drillholes

MODEL 2 INPUTS
Diamond Drillholes

MODEL 3 INPUTS
Diamond & RC Drillholes
ZFC 1

MODEL 4 INPUTS
Diamond & RC Drillholes
ZFC

MODEL 5 INPUTS
Diamond & RC Drillholes
ZFC OFF

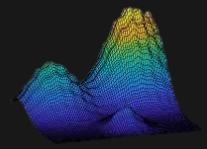
MODEL 6 INPUTS
Diamond & RC Drillholes
GEO

MODEL 7 INPUTS
Diamond & RC Drillholes
ZFC 2

MODEL 8 INPUTS
Diamond & RC Drillholes
ZFC 1

MODEL 9 INPUTS
Diamond & RC Drillholes

+ **KRIGING MODEL**

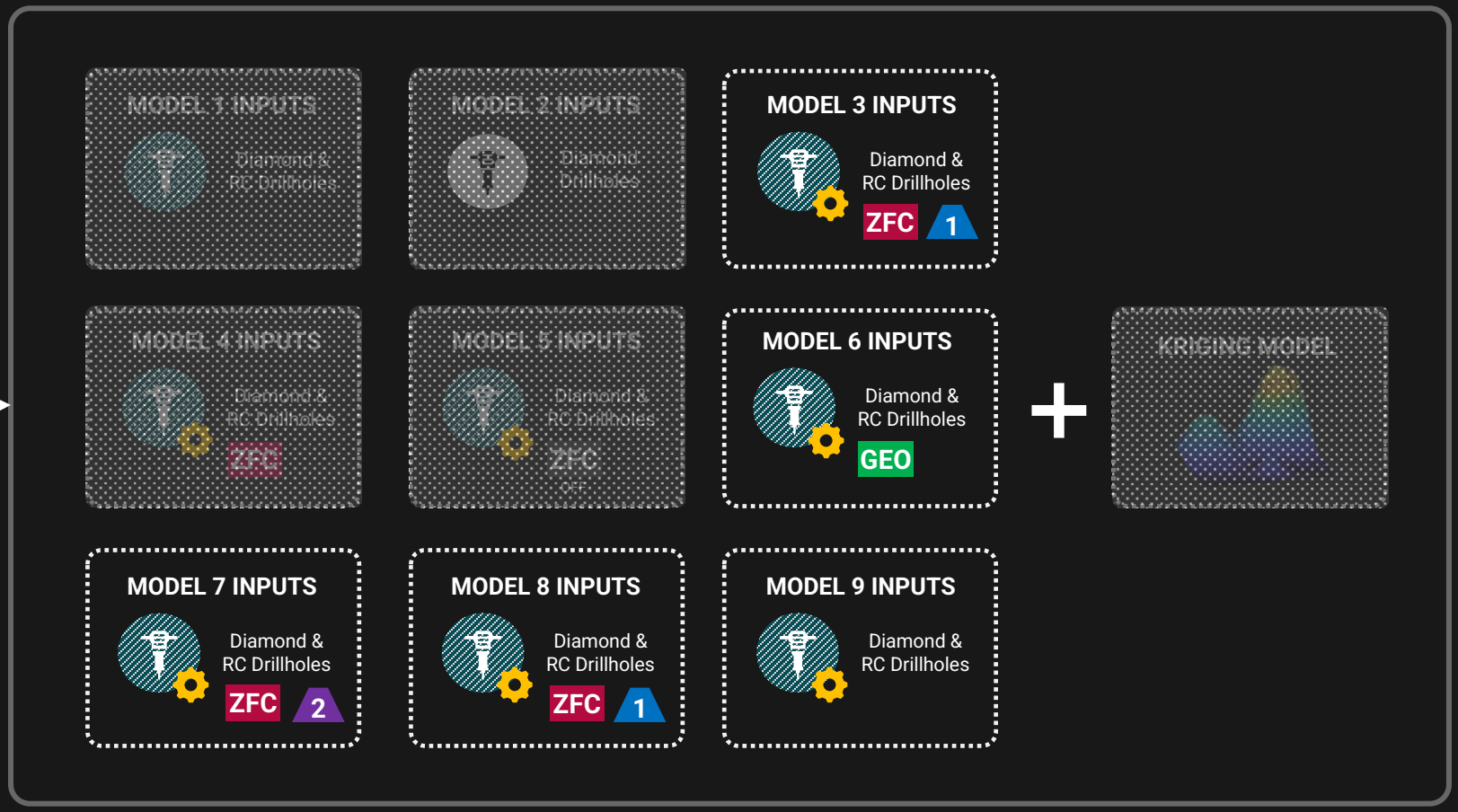


STRATUM MODELS
AI MODEL STRUCTURE

MODELS IN ENSEMBLE
AI ONLY

Top 9 Models + Kriging

We combine a diverse set of 9 AI models as well as existing Kriging model into an ensemble



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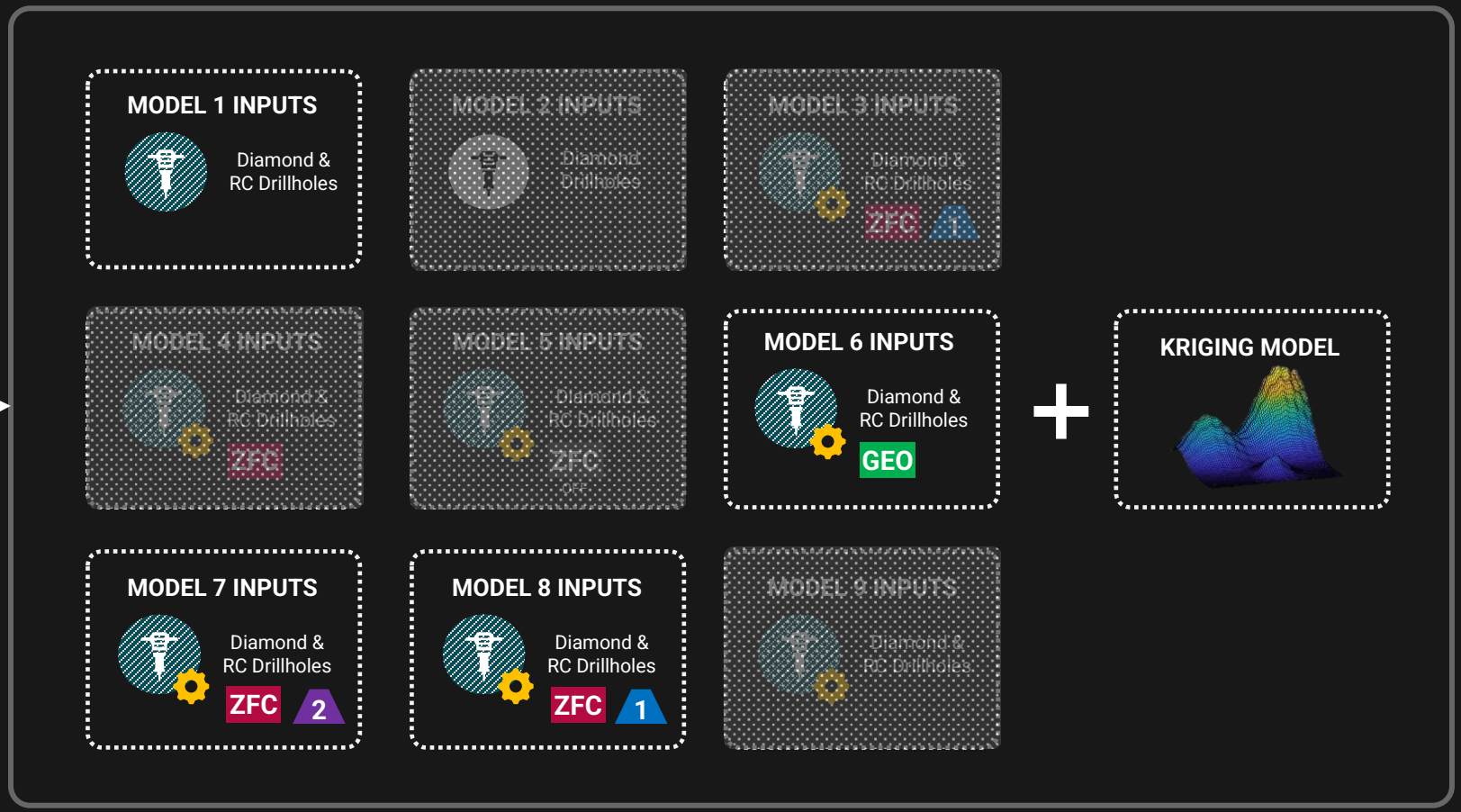
STRATUM MODELS
AI MODEL STRUCTURE

MODELS IN ENSEMBLE
AI + Kriging

Top 9 Models + Kriging

We combine a diverse set of 9 AI models as well as existing Kriging model into an ensemble

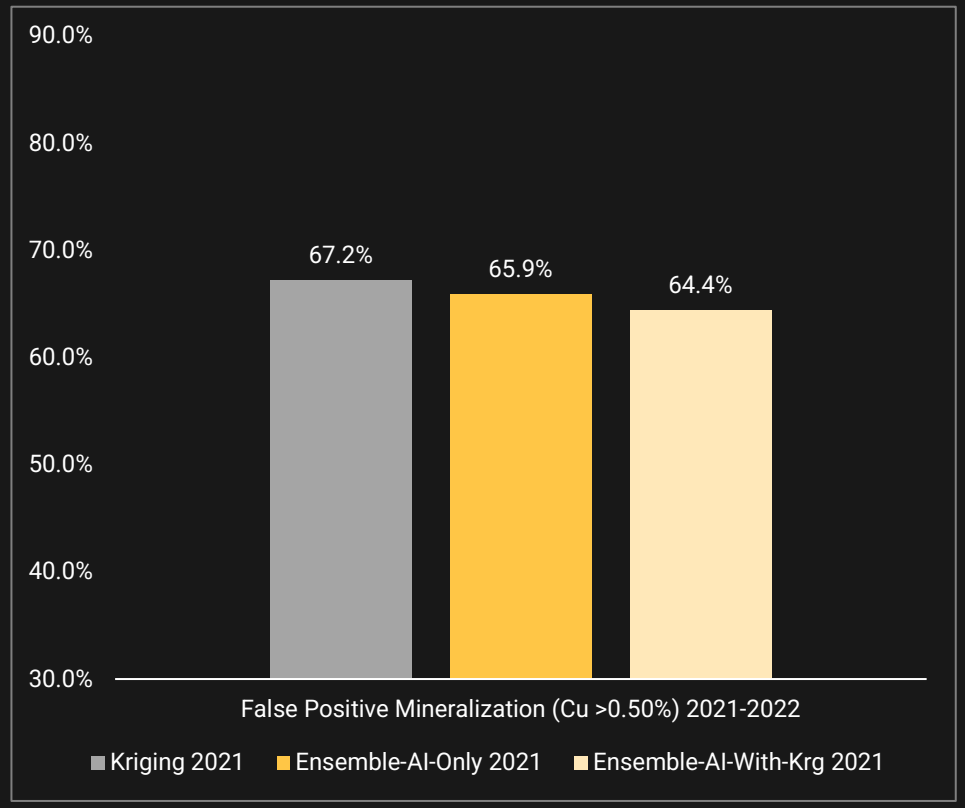


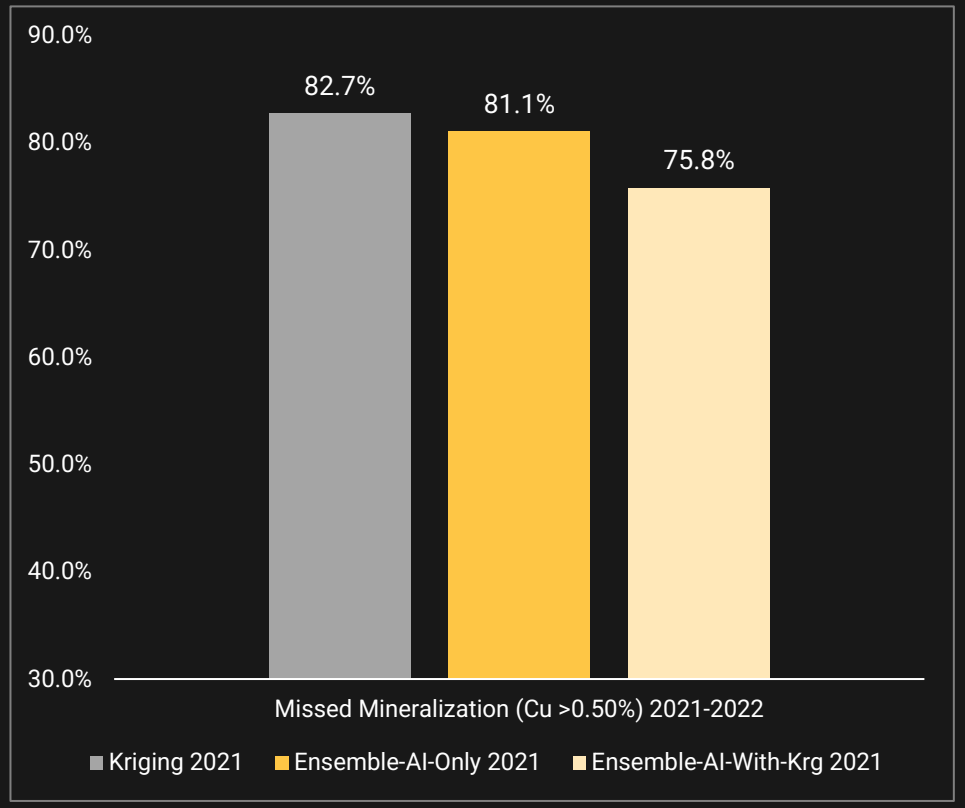
Legend:

- special sampling method in training
- Additional inputs channel (ZFC or GEO= Geological info)
- Composite methods (1or 2)

COPPER MODELLING
DDH RECONCILIATION

ENSEMBLE MODELS RESULTS



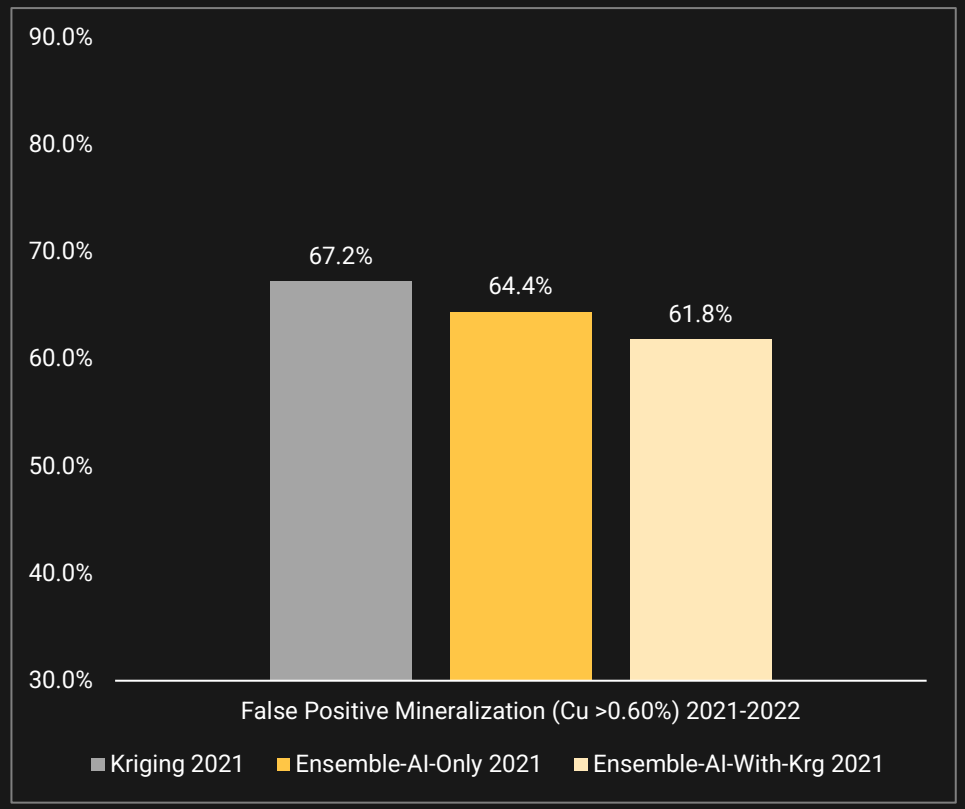


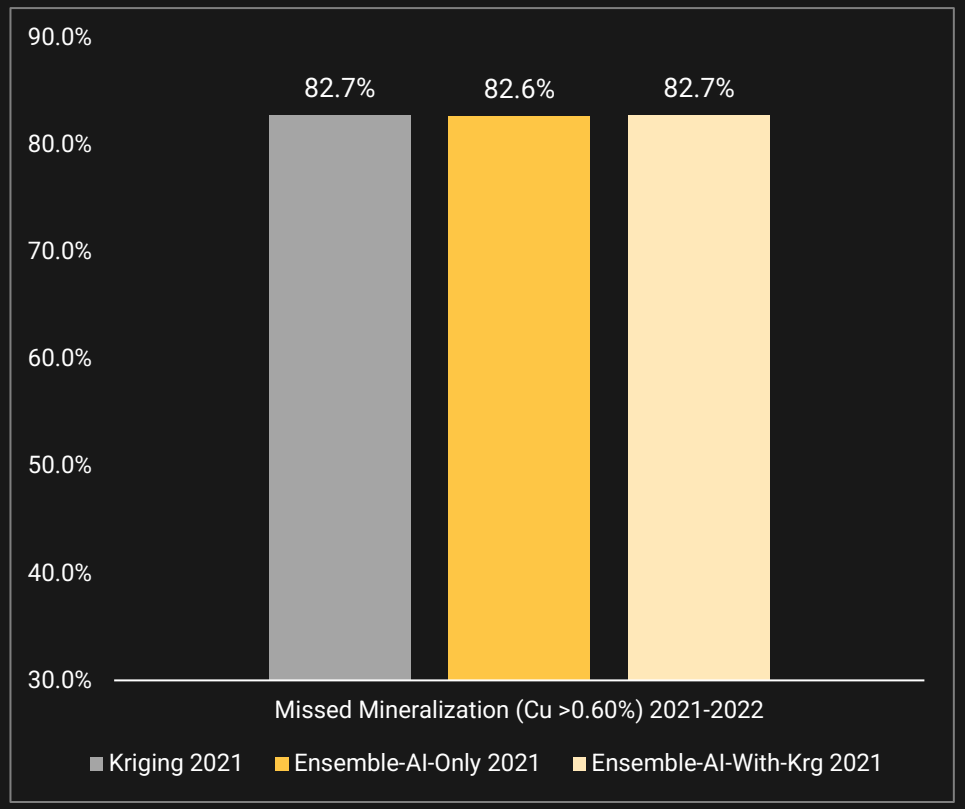
Ensemble models have reduced rates of false positive mineralization and missed mineralization over kriging. Ensemble-AI-With-Krg 2021 which integrates AI & Kriging has the greatest improvement.

COPPER MODELLING
DDH RECONCILIATION

We raise the sensitivity of the AI model by only considering blocks predicted above 0.6% as HG to evaluate confidence of model in HG estimates.

HIGH THRESHOLD RESULTS



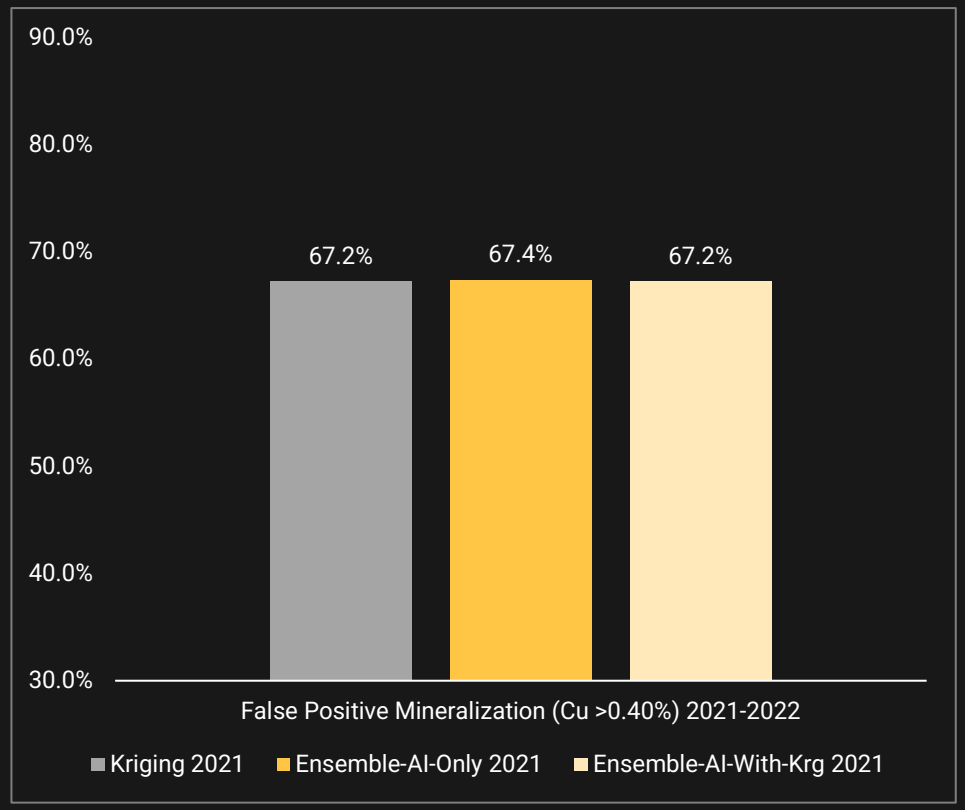


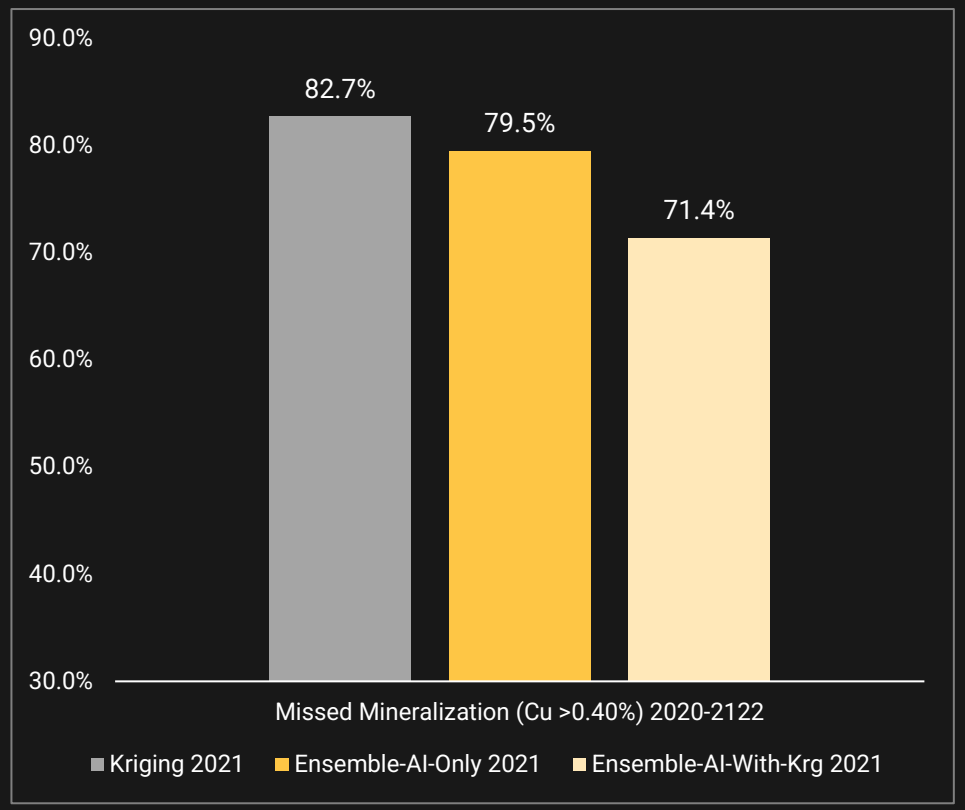
When evaluating on drillholes, Ensemble-AI-With-Krg 2021 achieves the best performance at higher sensitivity. When the model predicts HG, it has a **16% (**(67.2-61.8)/(100-67.2)=16%) higher chance of being HG than kriging's estimate while missing equal mineralization as kriging.

COPPER MODELLING
DDH RECONCILIATION

We raise the throughput of the AI model by considering blocks predicted above 0.4% as HG to evaluate quality of model in finding missed mineralization.

LOW THRESHOLD RESULTS

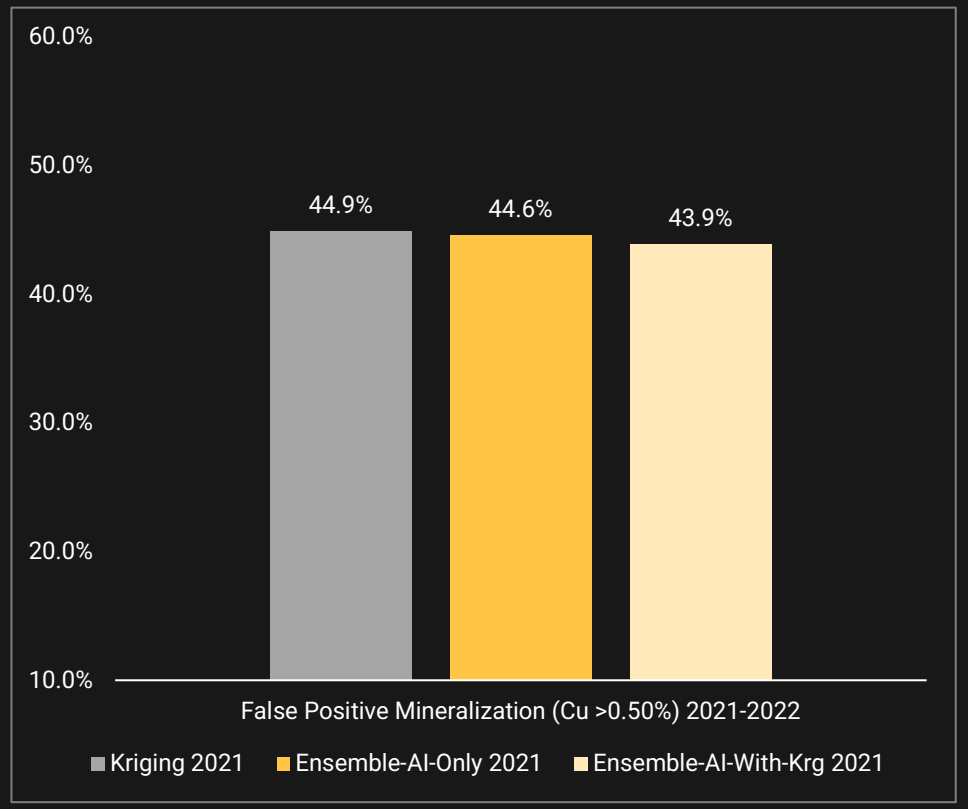


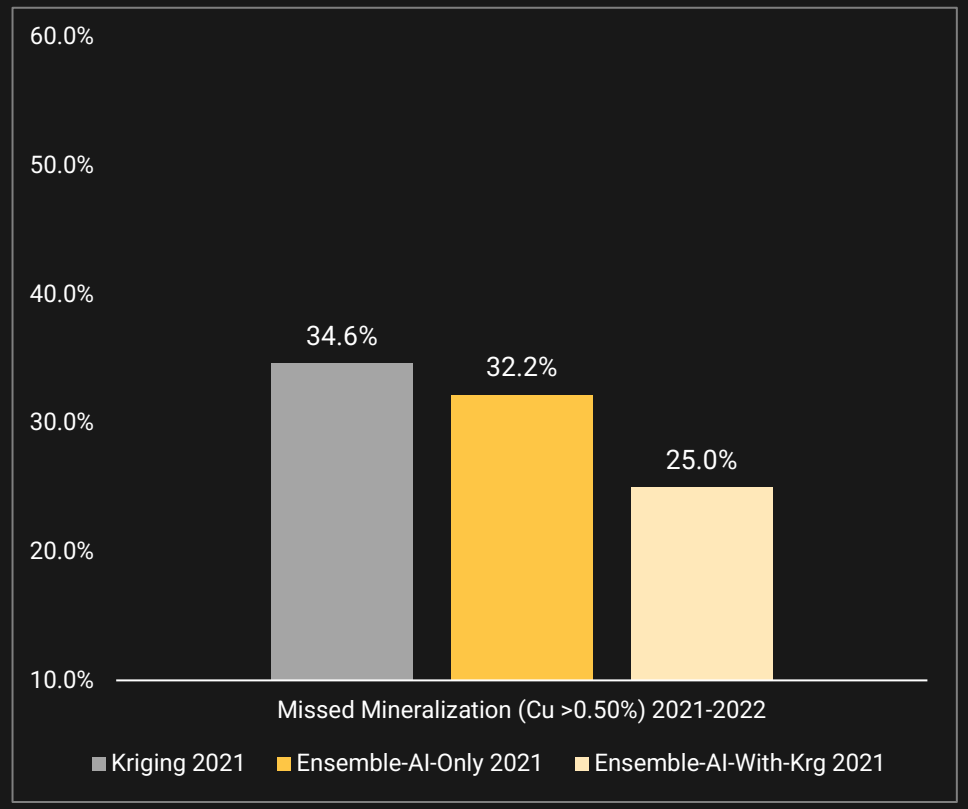


When evaluating on drillholes Ensemble-AI-With-Krg 2021 achieves the best performance at finding missed mineralization. It finds **65%** ((82.7-71.4)/(100-82.7)=65) more reconciled mineralization than kriging while having the same false positive rate. This is attributed to the synergy between AI & the kriging-based site model.

COPPER MODELLING
RC RECONCILIATION

ENSEMBLE MODELS RESULTS





When evaluating on RC-drillholes, Ensemble-AI-With-Krg 2021 achieves the best performance. It finds **4%** ((21.7-18.9)/(100-21.7)=22) more mineralization than kriging at a lower false positive rate.

COPPER MODELLING

MODEL QUALITY

AT VARIOUS THRESHOLDS

Ensemble-AI-With-Kriging 2021 is the optimal model that leverages benefits of AI and kriging as part of ensemble for maximal performance. Below is an overview of the model performance at different estimation thresholds (>0.4% Cu, >0.5% Cu, >0.6% Cu)

MODEL	ADVANTAGES	KEY METRICS
Ensemble-AI-With-Kriging 2021 (>0.50%)	Best for Guidance and Mid-Term Mine Planning	**40%** More mineralization found in 2021-2 drillhole reconciliation over kriging. **9%** higher probability in drillhole reconciliation any block predicted as HG is reconciled as HG over kriging
Ensemble-AI-With-Kriging 2021 (>0.60%)	Best for De-Risking Major Developments	**16%** Higher probability in 2021-2022 drillhole reconciliation any block predicted as HG is reconciled as HG over kriging without missing more ore. This will significantly reduce risk of capital misallocation into unprofitable developments.
Ensemble-AI-With-Kriging 2021 (>0.40%)	Best for Guided Drilling to Increase In-Situ Value	**65%** More mineralization found in 2021-2022 drillhole reconciliation over kriging without increasing false positive rate. This ensures minimal mineralization is left behind in the mine plan.

COPPER MODELLING
MODEL SUMMARY

RESULTS

The mine is underground with high grade & structural variation making it very easy to miss mineralization zones from the mine plan.

AI-Kriging Ensemble misses **40% less mineralization** than Kriging over two years mining.

Complex structural variation creates need for dense grade control drilling to reduce risk of poor capital allocation.

AI-Kriging Ensemble (>0.6% threshold) has an **16% higher probability** any block predicted as HG will be HG when mined.

COPPER MODELLING
MODEL SUMMARY

ECONOMIC VALUE OF ADOPTION

AI-Kriging Ensemble misses **40%** less mineralization than Kriging over two years mining.

Reduction in missed mineralization leads to **80Mlbs** of new mineralization in areas previously expected as waste by kriging

AI-Kriging Ensemble (>0.6% threshold) has an **16%** higher probability any block predicted as HG will be HG when mined.

Improved model confidence frees up **29% of drilling resources** for new targets as less resource/GC drilling required to achieve same mine plan confidence.

*This project is a unique in how substantial the increase in unique mineralization is – likely attributed to structural complexity and large undrilled zones within the mine property. The client is currently investing drilling resources to gradually confirm these zones.

Cross-Sections

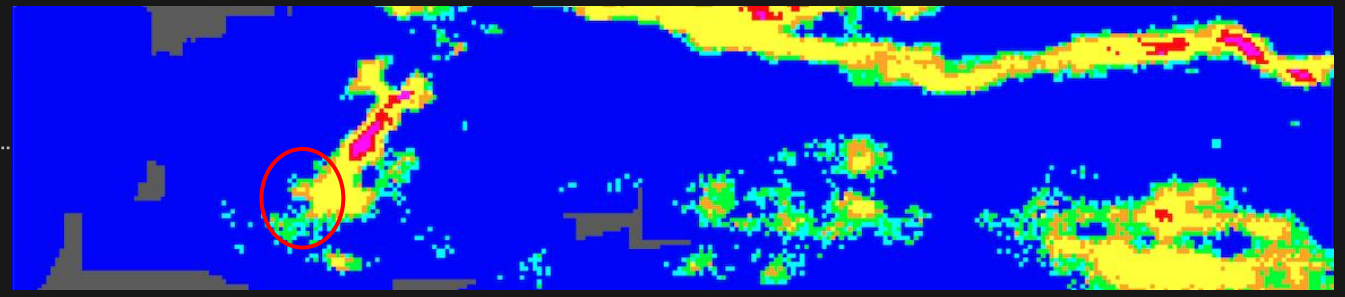
(Reconciliation Drillholes 2021-2022)

COPPER MODELLING
CROSS SECTION ANALYSIS

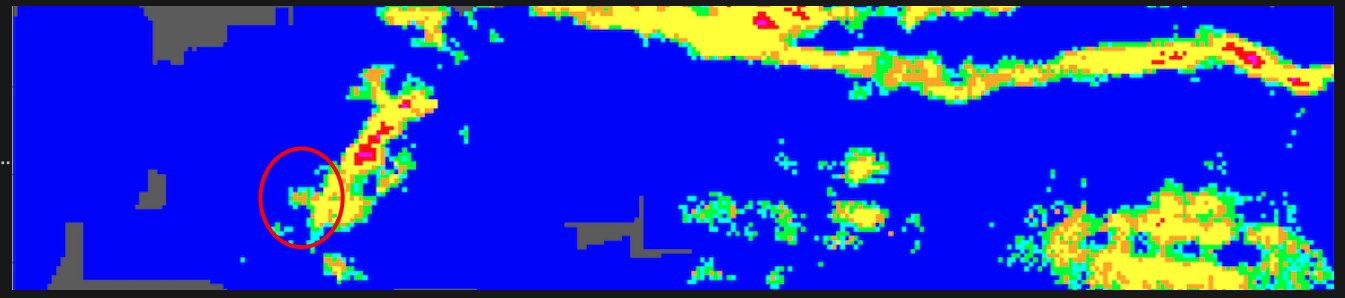
VIEW EAST = 4043
Block Size (4m x 4m x 4m)

AI & AI-Kriging Ensembles identify mineralization extension from known vein structure missed by kriging confirmed with recent drilling.

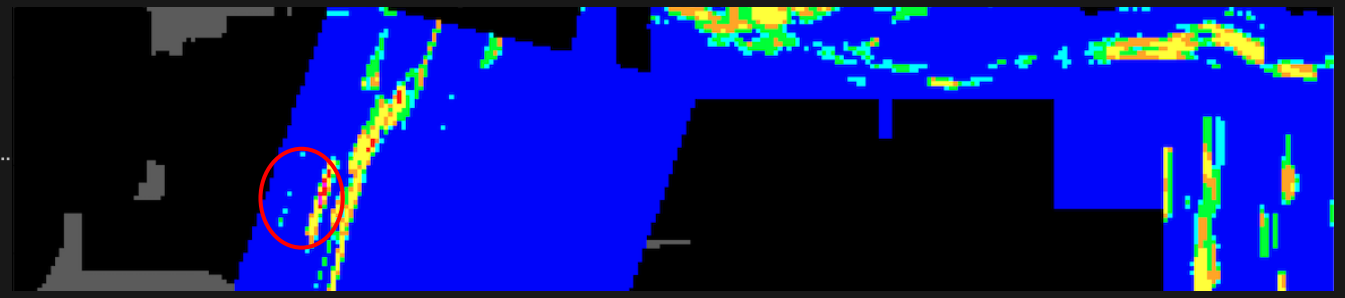
AI Ensemble 2021



AI-Kriging Ensemble 2021



Kriging Ensemble 2021



COPPER MODELLING
CROSS SECTION ANALYSIS

VIEW EAST = 4043
Block Size (4m x 4m x 4m)

AI & AI-Kriging Ensembles identify mineralization extension from known vein structure missed by kriging confirmed with recent drilling.

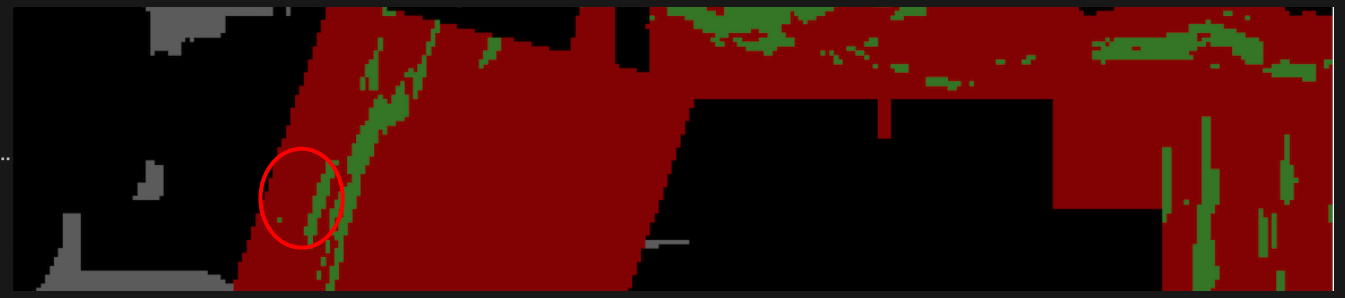
Ore | Waste

Cut-off grade 0.50% Cu

AI Ensemble 2021

AI-Kriging Ensemble 2021

Kriging Ensemble 2021



COPPER MODELLING
CROSS SECTION ANALYSIS

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Ore | Waste

Cut-off grade 0.50% Cu

DDH & RC Drillholes
2021-2022

COPPER MODELLING
CROSS SECTION ANALYSIS

VIEW EAST = 4043
Block Size (4m x 4m x 4m)

AI & AI-Kriging Ensembles identify mineralization extension from known vein structure missed by kriging confirmed with recent drilling.

TP
True Positive

FP
False Positive

TN
True Negative

FN
False Negative

AI Ensemble 2021

False positives [68.75%]
Missed mineralization [0.00%]

AI-Kriging Ensemble 2021

False positives [66.67%]
Missed mineralization [0.00%]

Kriging Ensemble 2021

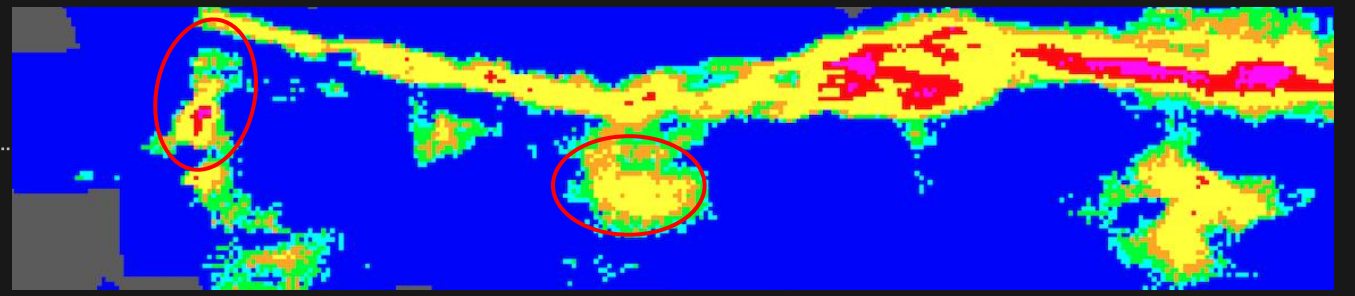
False positives [85.71%]
Missed mineralization [80.00%]

COPPER MODELLING
CROSS SECTION ANALYSIS

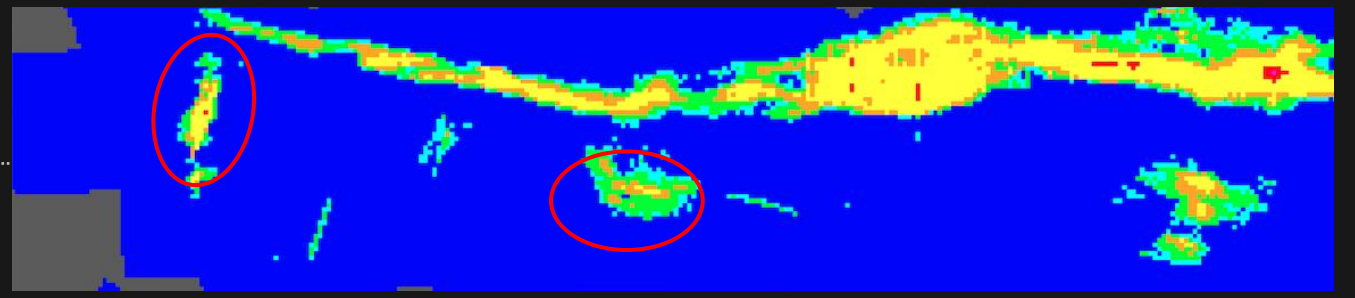
VIEW EAST = 4271
Block Size (4m x 4m x 4m)

Kriging and AI-Kriging underpredict mineralization (miss 55%, 48%) in two major areas while having a false positive rate of ~50%. AI has a false positive rate of 53% yet it only misses 14% of mineralization.

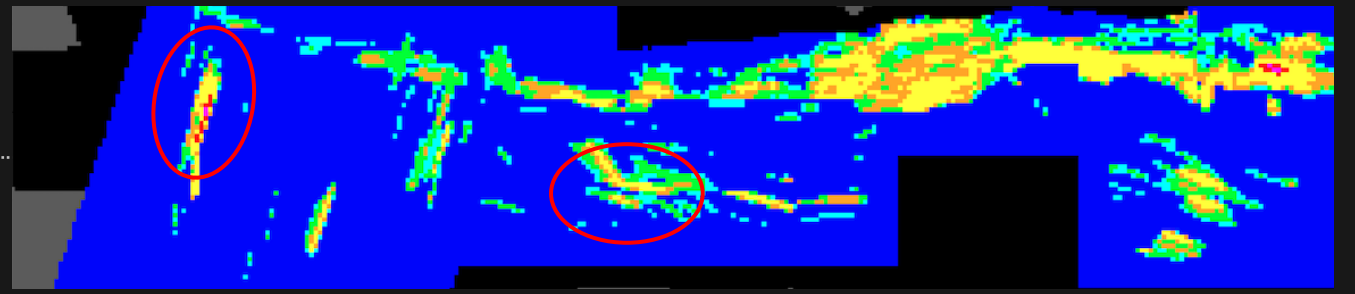
AI Ensemble 2021



AI-Kriging Ensemble 2021



Kriging Ensemble 2021



COPPER MODELLING
CROSS SECTION ANALYSIS

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Ore | Waste

Cut-off grade 0.50% Cu

AI Ensemble 2021

AI-Kriging Ensemble 2021

Kriging Ensemble 2021

COPPER MODELLING
CROSS SECTION ANALYSIS

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Ore | Waste

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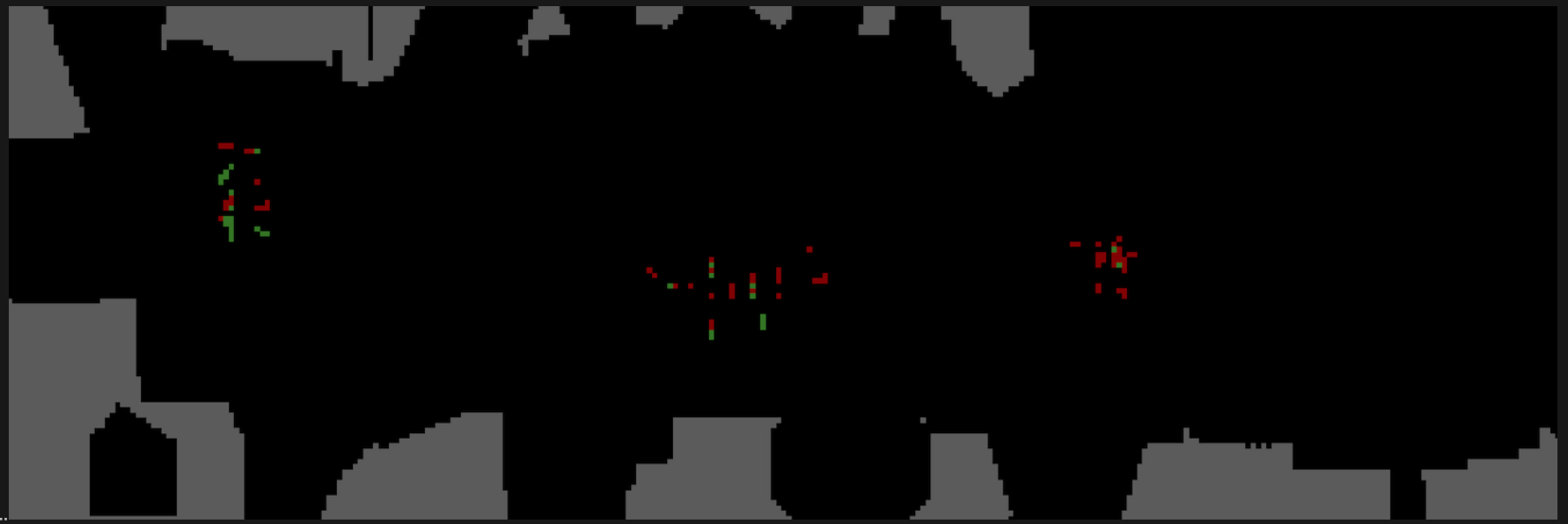


DDH & RC Drillholes
2021-2022

COPPER MODELLING
CROSS SECTION ANALYSIS

VIEW EAST = 4271
Block Size (4m x 4m x 4m)

Kriging and AI-Kriging underpredict mineralization (miss 55%, 48%) in two major areas while having a false positive rate of ~50%. AI has a false positive rate of 53% yet it only misses 14% of mineralization.

TP
True Positive

FP
False Positive

TN
True Negative

FN
False Negative

AI Ensemble 2021

False positives [52.83%]
Missed mineralization [13.79%]

AI-Kriging Ensemble 2021

False positives [50.00%]
Missed mineralization [48.28%]

Kriging Ensemble 2021

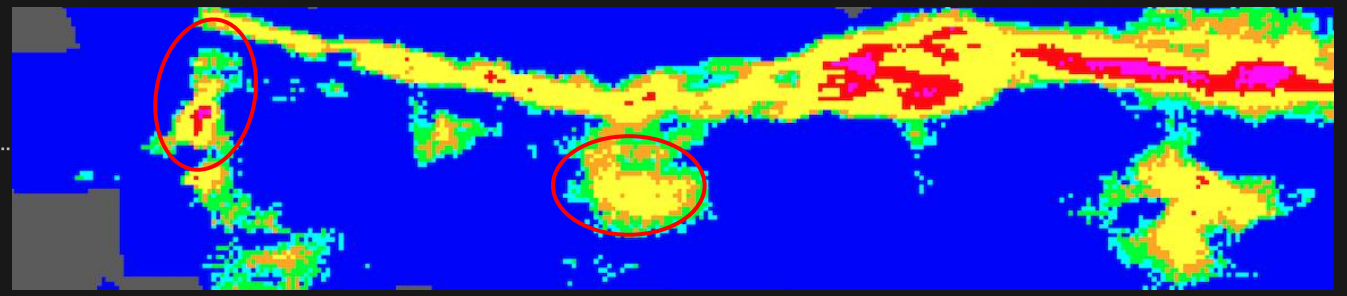
False positives [50.00%]
Missed mineralization [55.17%]

COPPER MODELLING
CROSS SECTION ANALYSIS

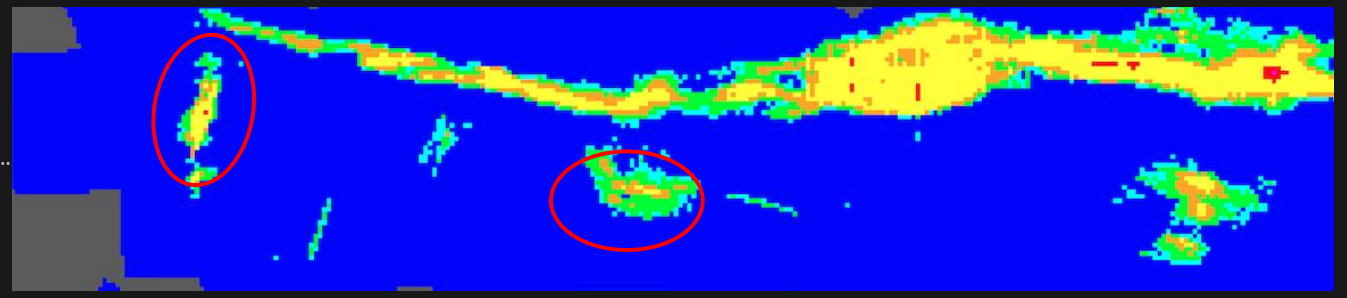
VIEW EAST = 4495
Block Size (4m x 4m x 4m)

Kriging underpredicts mineralization area correctly predicted by AI, AI-Kriging and later confirmed by drilling.

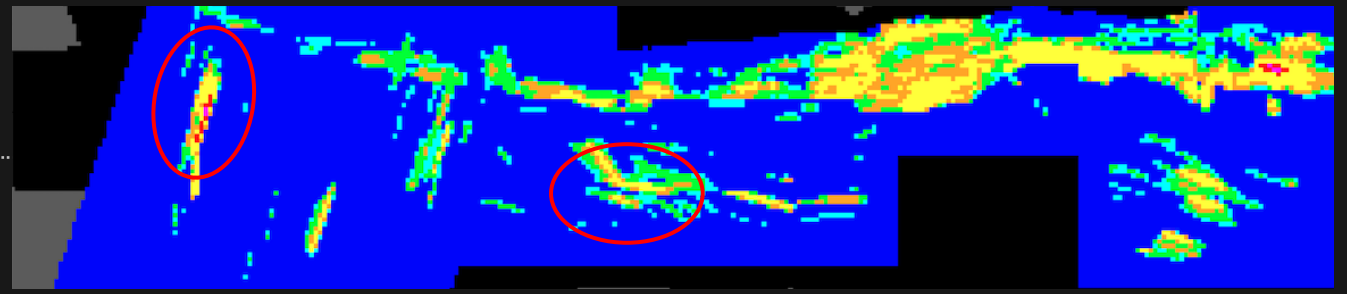
AI Ensemble 2021



AI-Kriging Ensemble 2021



Kriging Ensemble 2021



COPPER MODELLING
CROSS SECTION ANALYSIS

VIEW EAST = 4495
Block Size (4m x 4m x 4m)

Kriging underpredicts mineralization area correctly predicted by AI, AI-Kriging and later confirmed by drilling.

Ore | Waste

Cut-off grade 0.50% Cu

AI Ensemble 2021

AI-Kriging Ensemble 2021

Kriging Ensemble 2021

COPPER MODELLING
CROSS SECTION ANALYSIS

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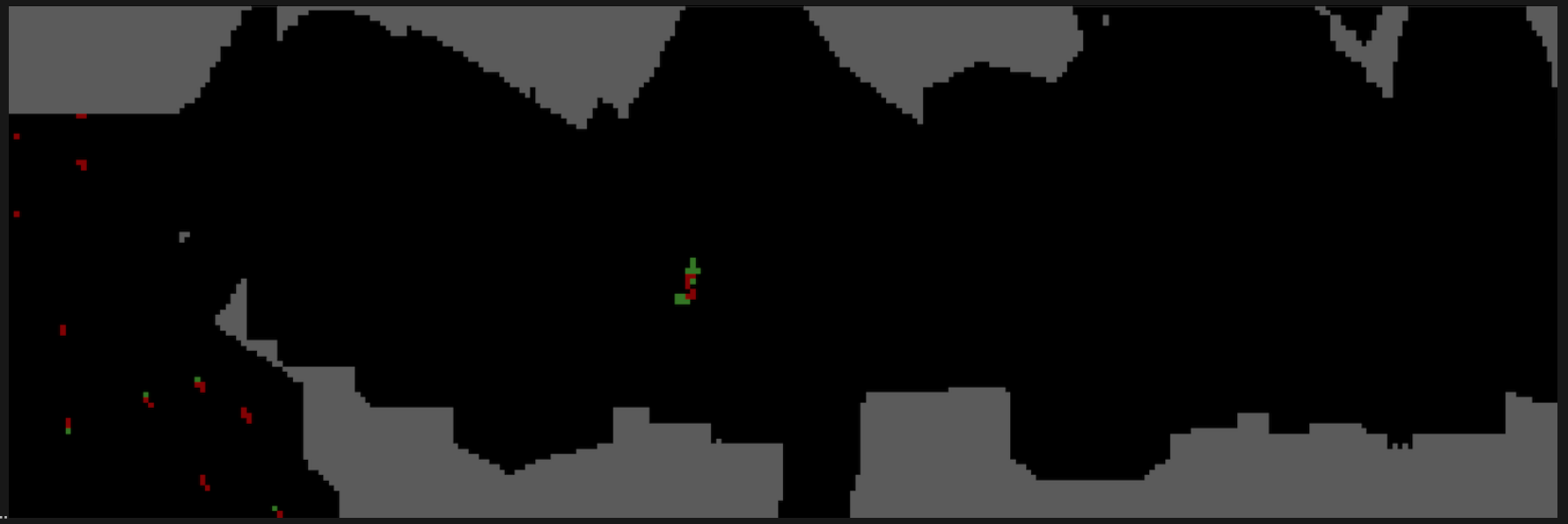


DDH & RC Drillholes
2021-2022

COPPER MODELLING
CROSS SECTION ANALYSIS

VIEW EAST = 4495
Block Size (4m x 4m x 4m)

Kriging underpredicts mineralization area correctly predicted by AI, AI-Kriging and later confirmed by drilling.

TP
True Positive

FP
False Positive

TN
True Negative

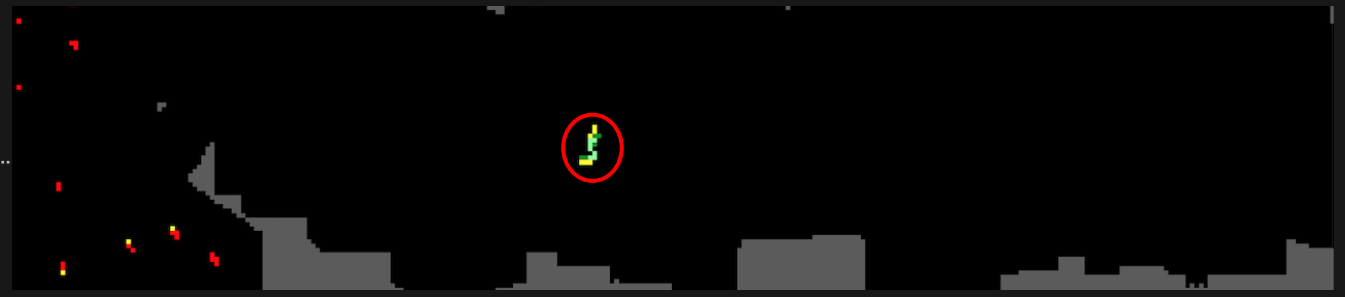
FN
False Negative

AI Ensemble 2021

False positives [41.18%]
Missed mineralization [33.33%]

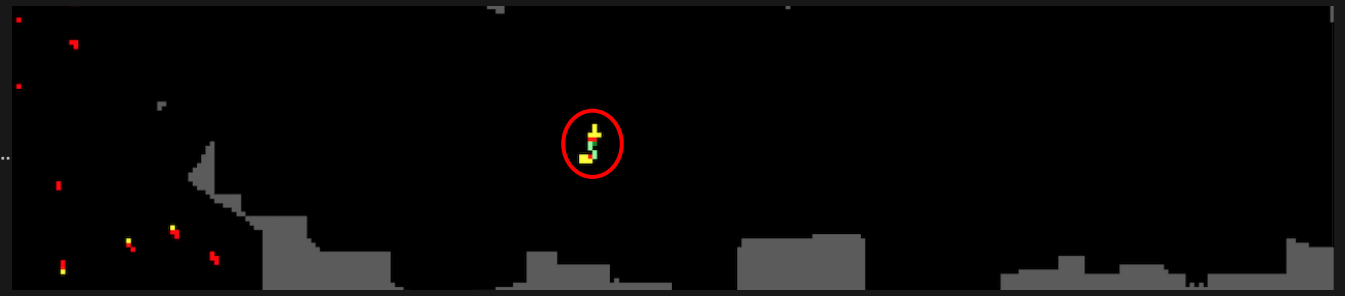
AI-Kriging Ensemble 2021

False positives [58.33%]
Missed mineralization [66.67%]



Kriging Ensemble 2021

False positives [80.00%]
Missed mineralization [93.33%]

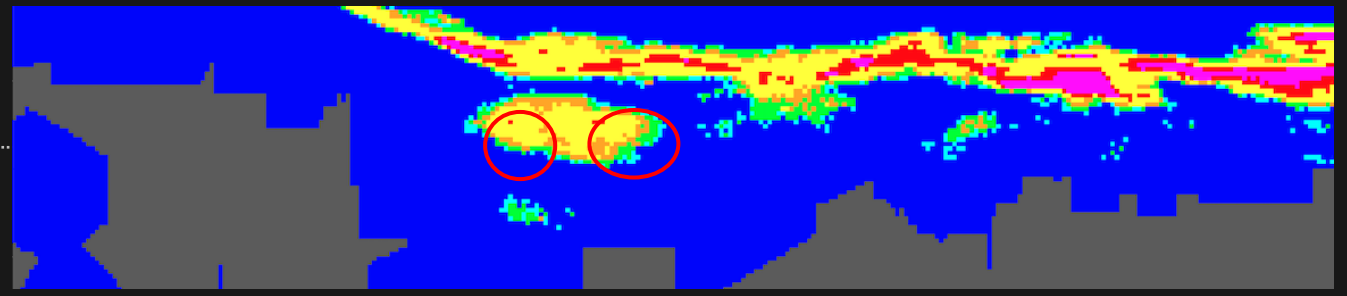


COPPER MODELLING
CROSS SECTION ANALYSIS

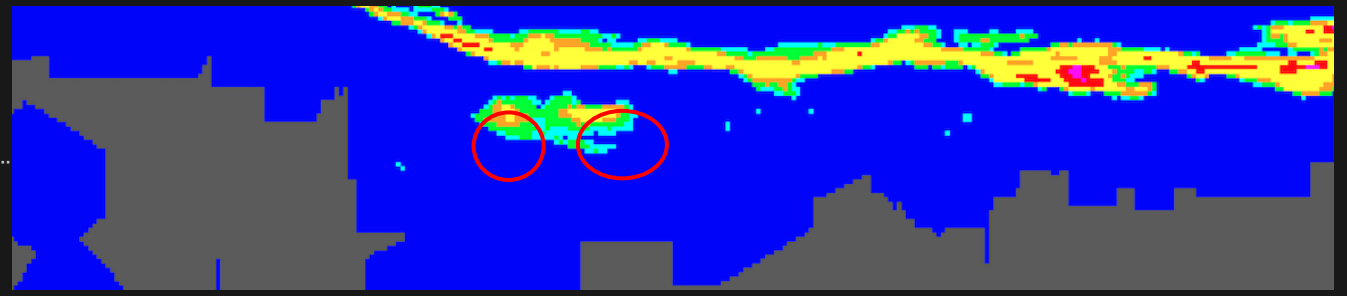
VIEW EAST = 4591
Block Size (4m x 4m x 4m)

AI overpredicted mineralization area, AI-Kriging correctly predicts mineralization area, Kriging misses most of mineralization area – as subsequently confirmed by drilling.

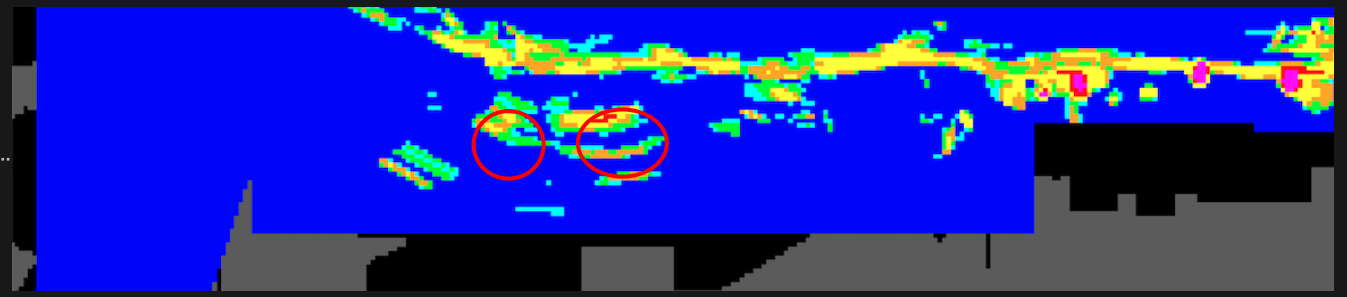
AI Ensemble 2021



AI-Kriging Ensemble 2021



Kriging Ensemble 2021



COPPER MODELLING
CROSS SECTION ANALYSIS

VIEW EAST = 4591
Block Size (4m x 4m x 4m)

AI overpredicted mineralization area, AI-Kriging correctly predicts mineralization area, Kriging misses most of mineralization area – as subsequently confirmed by drilling.

Ore | Waste

Cut-off grade 0.50% Cu

AI Ensemble 2021

AI-Kriging Ensemble 2021

Kriging Ensemble 2021

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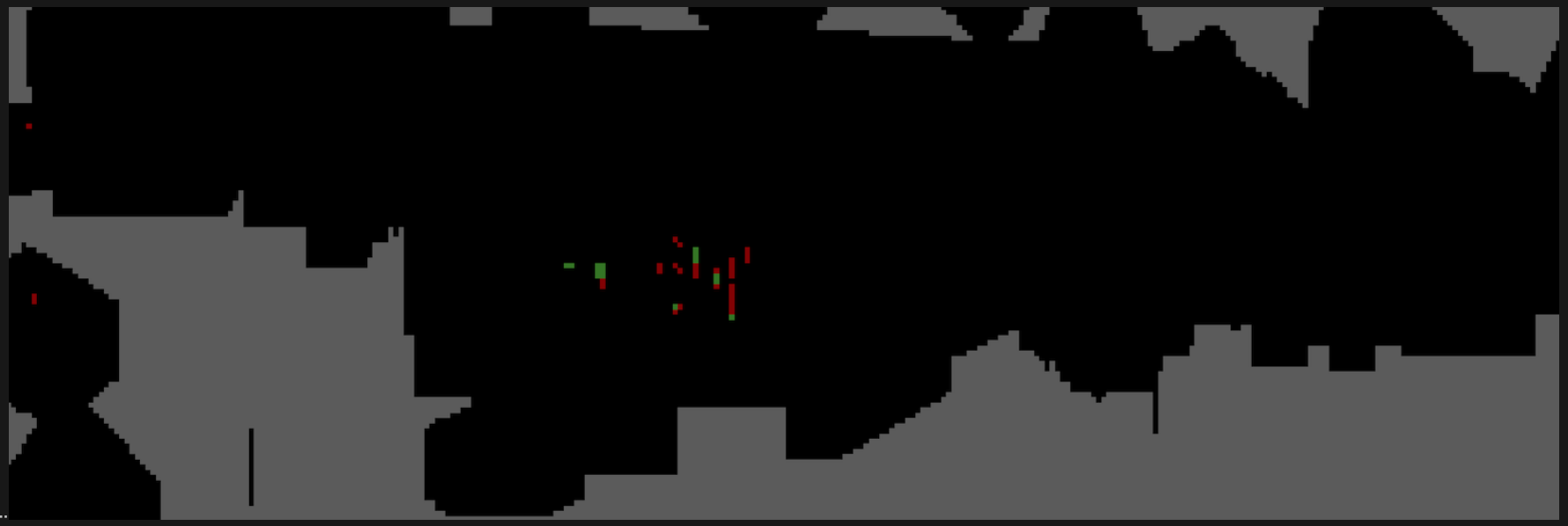


DDH & RC Drillholes
2021-2022

COPPER MODELLING
CROSS SECTION ANALYSIS

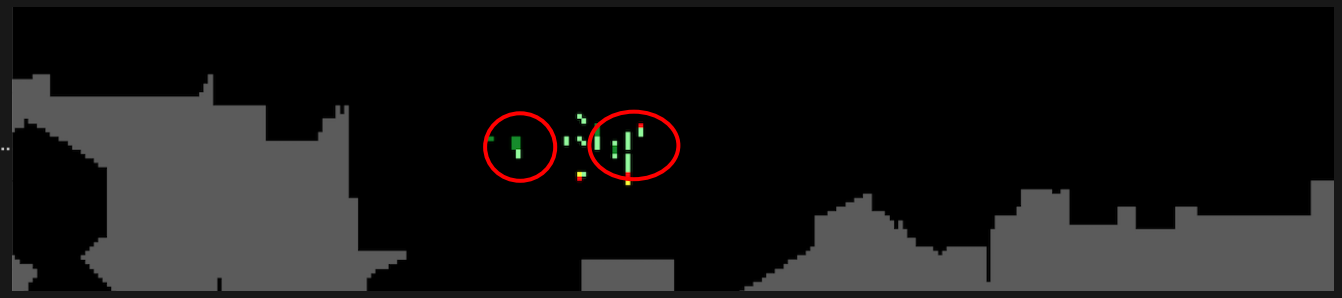
VIEW EAST = 4591
Block Size (4m x 4m x 4m)

AI overpredicted mineralization area, AI-Kriging correctly predicts mineralization area, Kriging misses most of mineralization area – as subsequently confirmed by drilling.

TP True Positive
FP False Positive
TN True Negative
FN False Negative

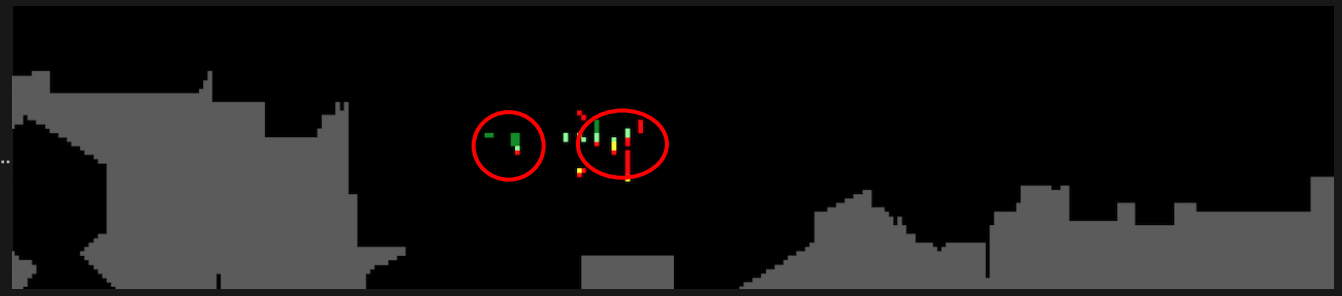
AI Ensemble 2021

False positives [64.86%]
Missed mineralization [13.33%]



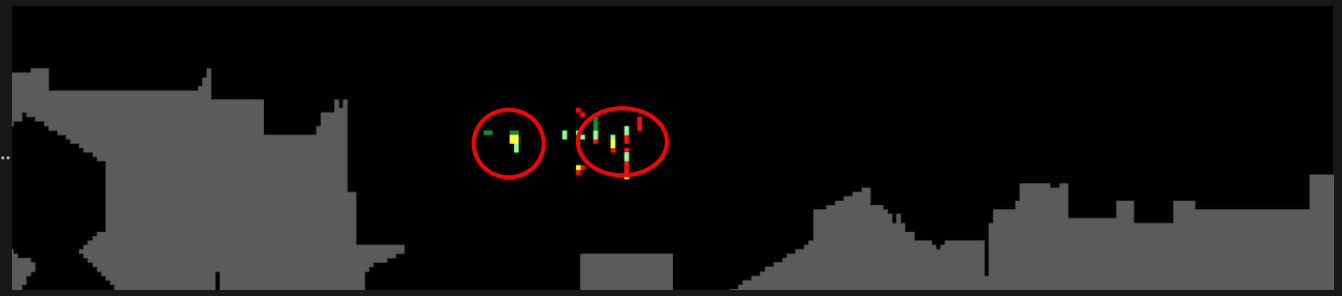
AI-Kriging Ensemble 2021

False positives [47.62%]
Missed mineralization [26.67%]



Kriging Ensemble 2021

False positives [65.00%]
Missed mineralization [53.33%]



STRATUM

LOW RISK – HIGH YIELD – AI DRIVEN