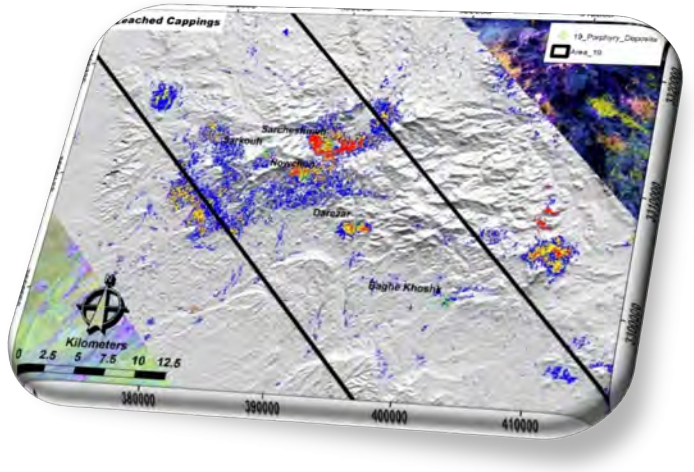
AI in Mineral Exploration: From Code to Core.

Hojat Shirmard Elnaz Heidari Ehsan Farahbakhsh R Dietmar Müller



PhD in Mineral Exploration at EarthByte Group
(The University of Sydney)
Geophysical Data Scientist at Fender Geophysics

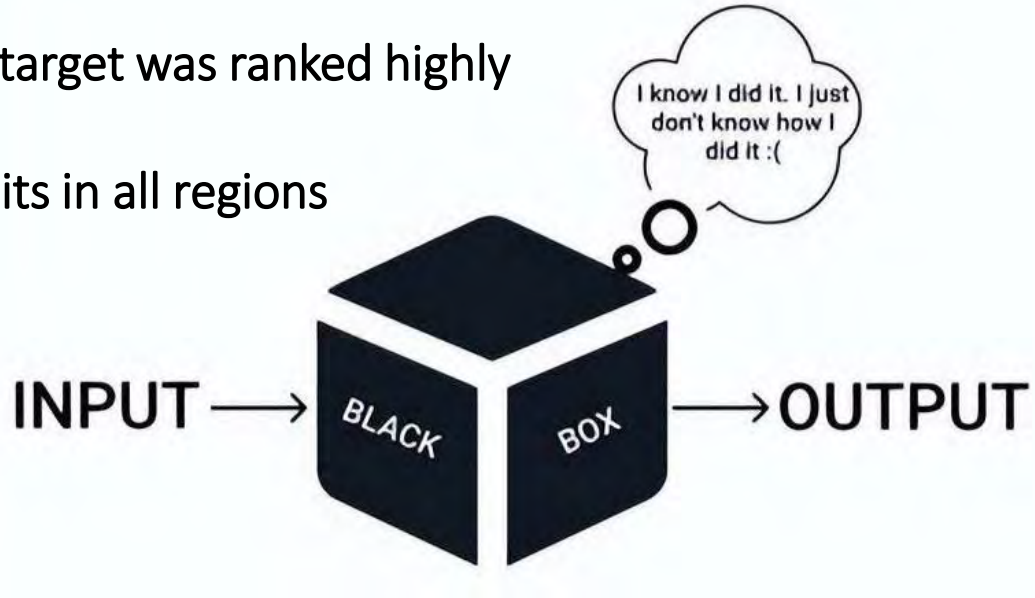
Talk structure

1. Dangers of Using AI
2. Dangers of Not Using AI
3. AI in Geology, Geophysics, Geochemistry, MPM
4. Why AI is Inevitable
5. Real-world examples
6. Takeaways

1- Dangers of Using AI

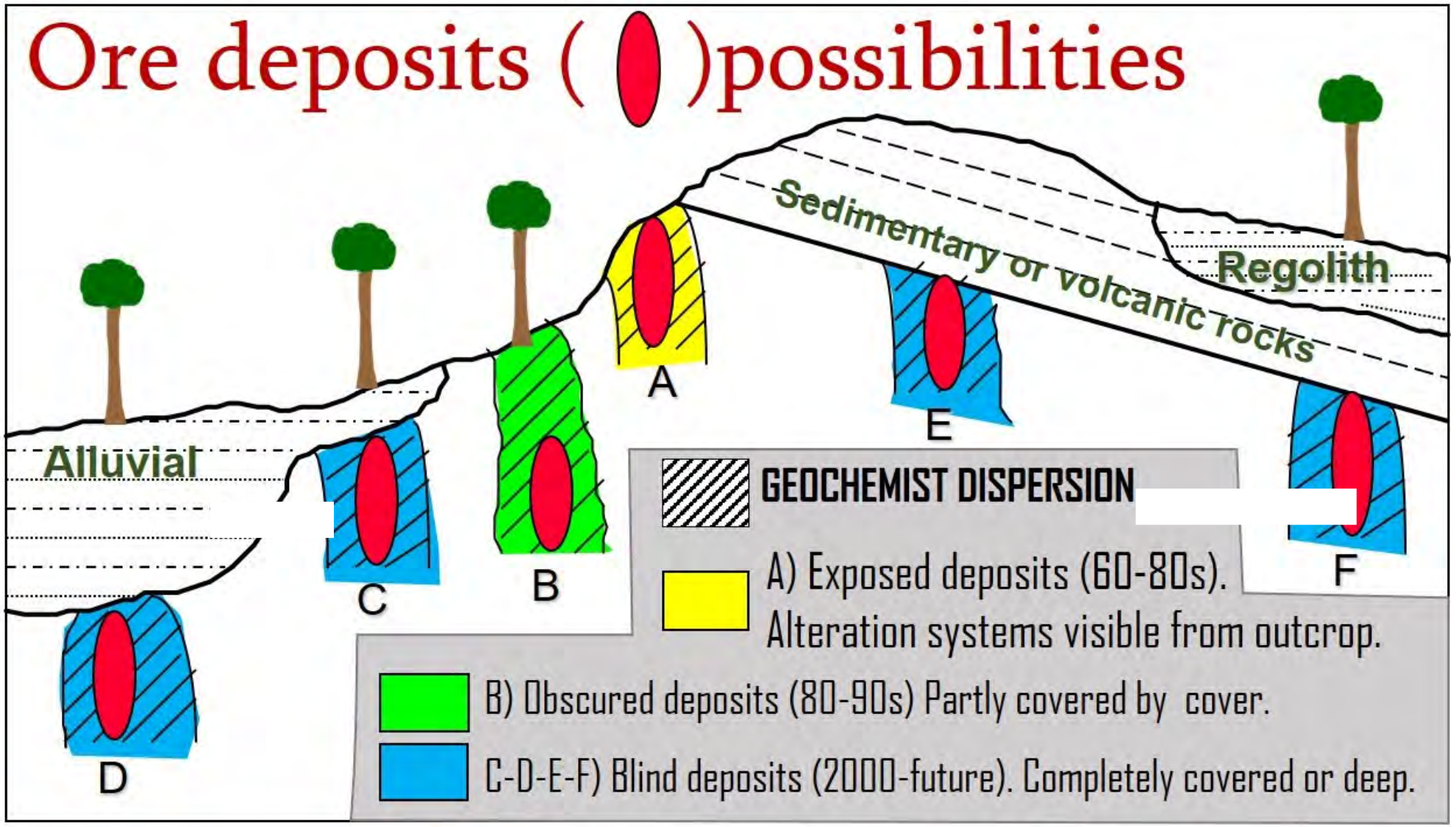
- Black Box Decision-Making in most models
- Garbage In, Garbage Out (GIGO)
- Wrong understanding of how to use data logically -----> e.g.
- Bias toward well-explored regions and known deposit types
- Reinforcement of old exploration biases instead of new discoveries -----> e.g
- Lack of transparency: Geologists cannot easily explain *why* a target was ranked highly
- Assuming geophysical signatures are unique for target deposits in all regions

False positives (wasting millions on drilling)
False negatives (missing viable deposits)

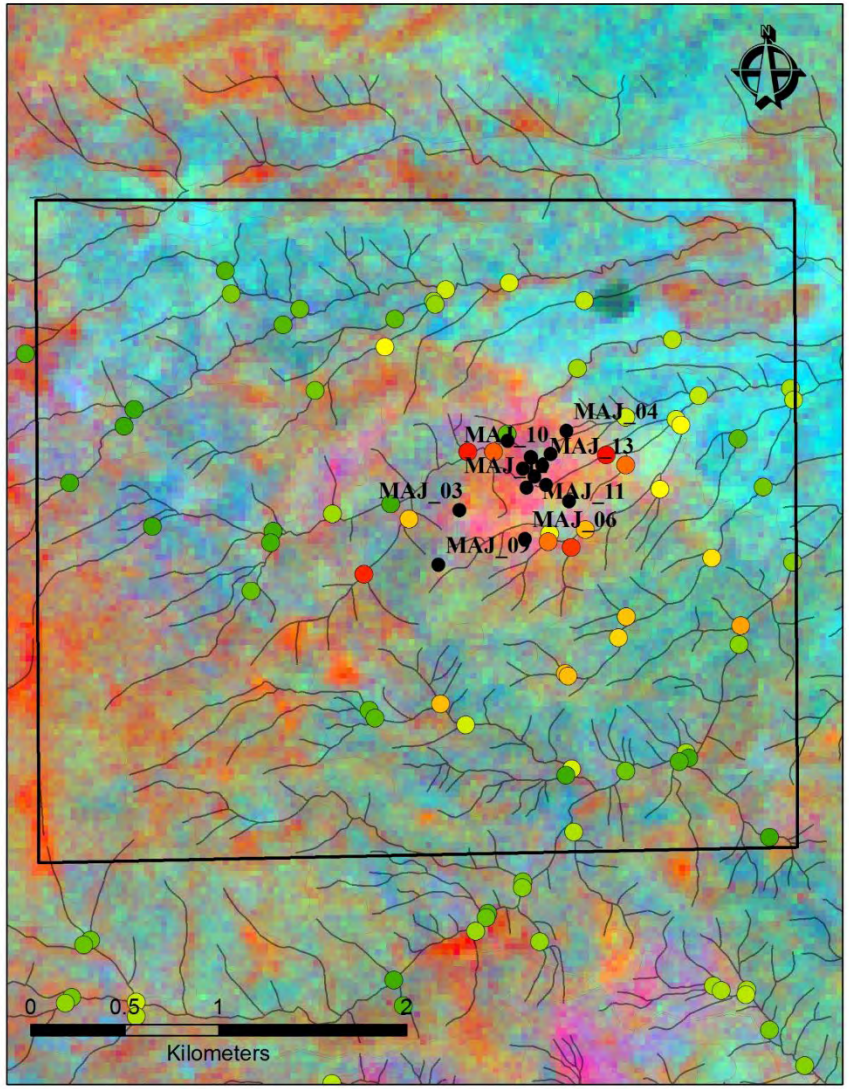


1- Dangers of Using AI

Ore deposits become more complex when they are distributed across different depths.

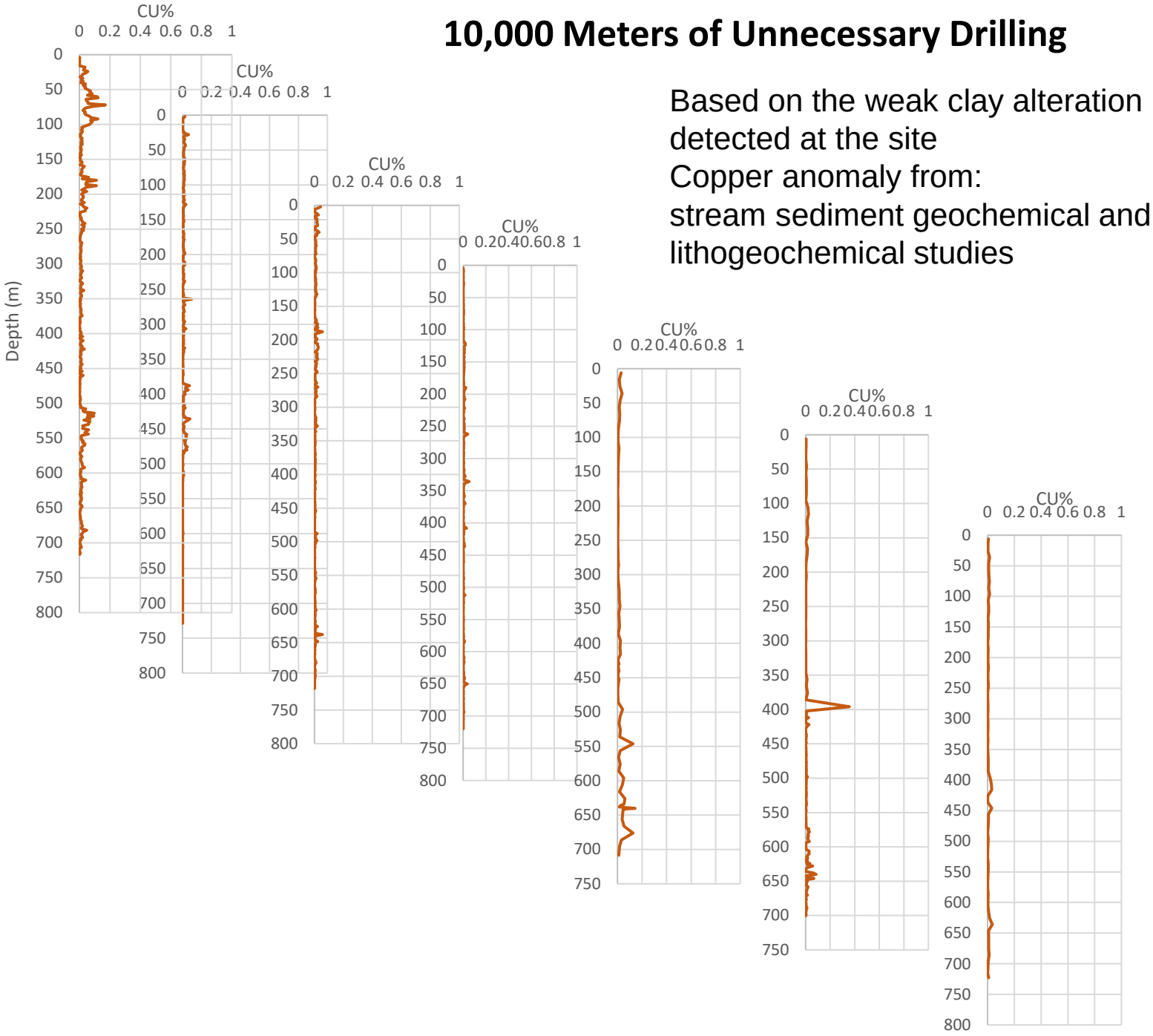


2- Dangers of Not Using AI



10,000 Meters of Unnecessary Drilling

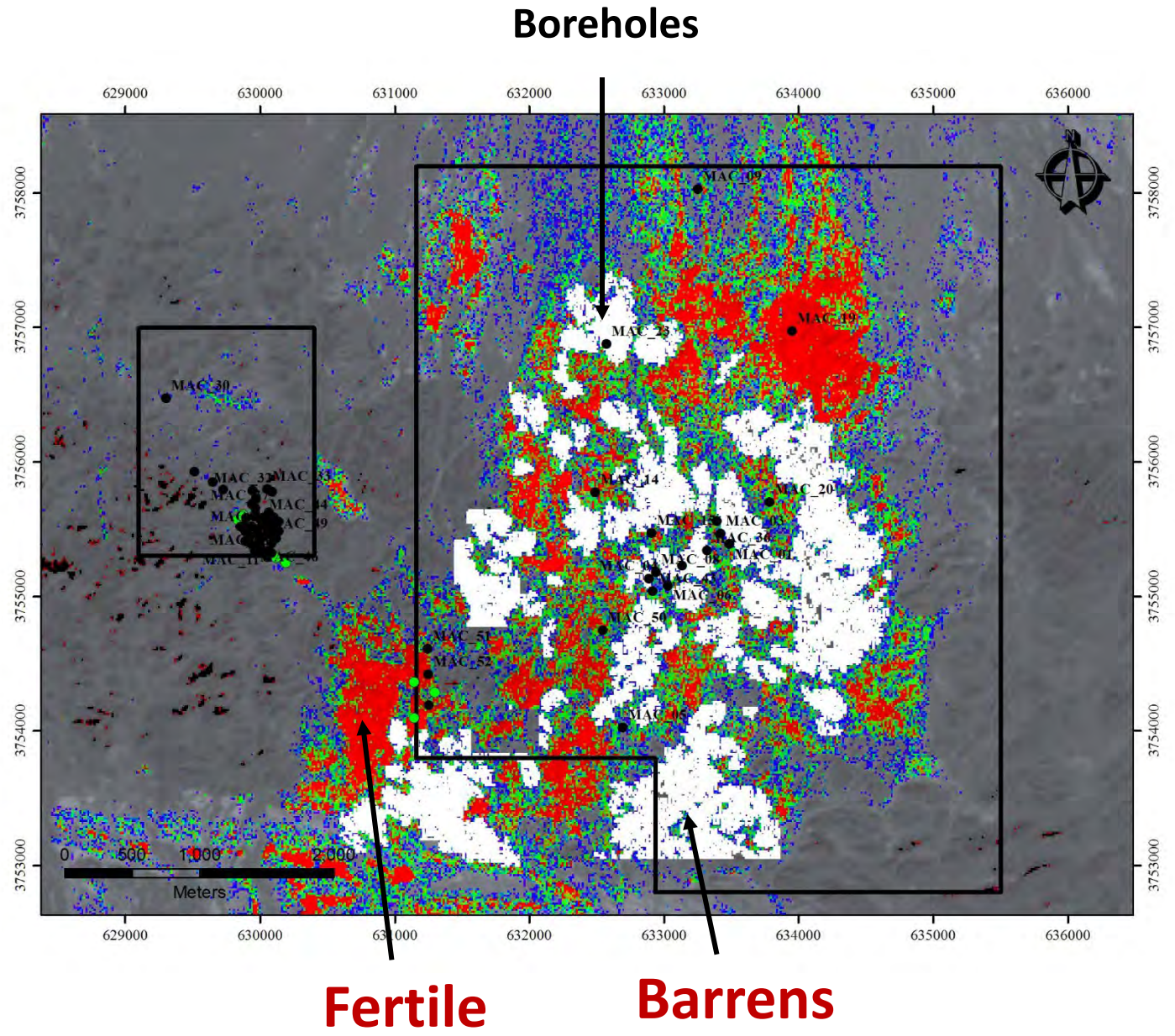
Based on the weak clay alteration detected at the site
Copper anomaly from:
stream sediment geochemical and lithogeochemical studies



2- Dangers of **Not** Using AI

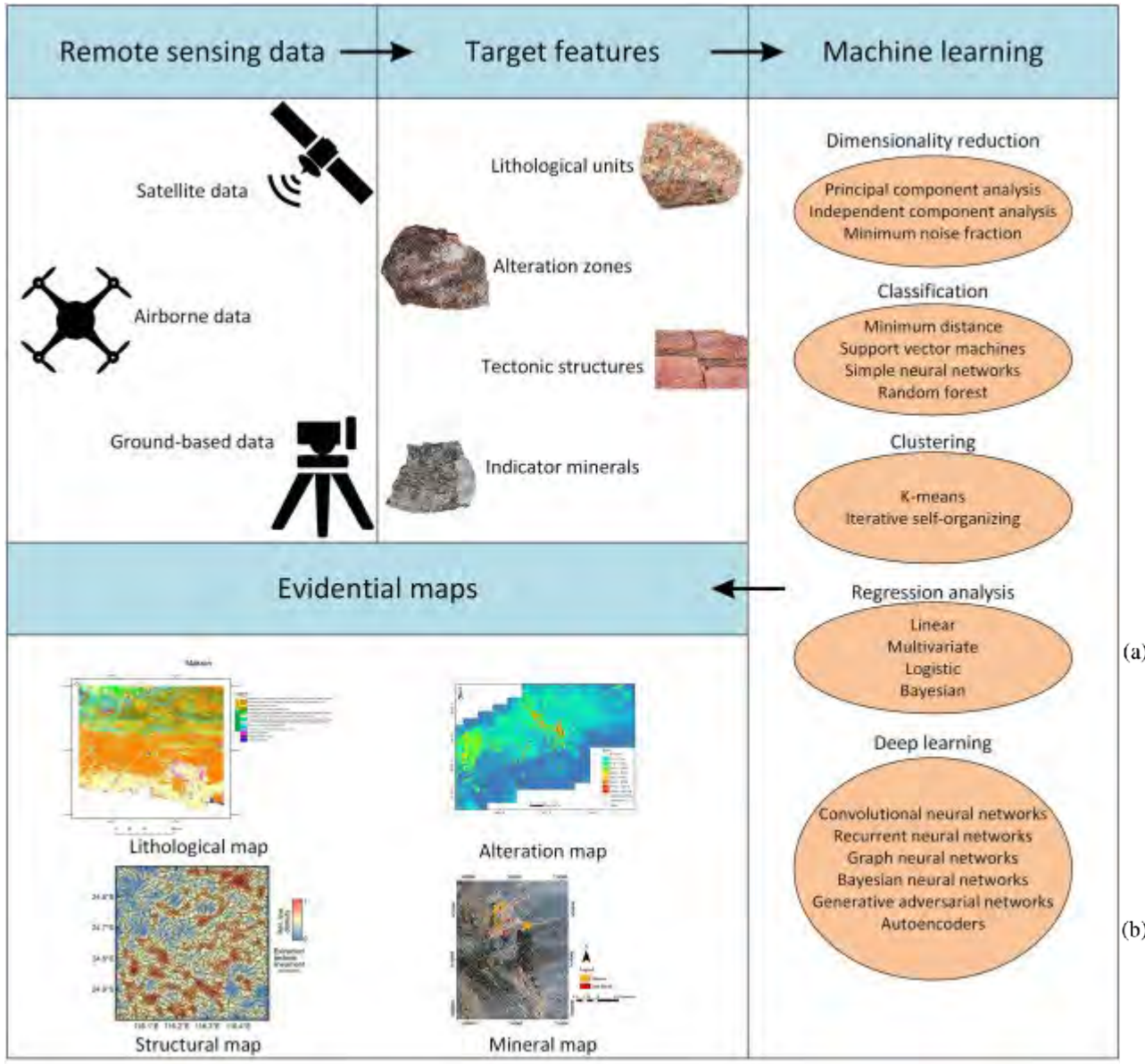
20,000 Meters of Unnecessary Drilling

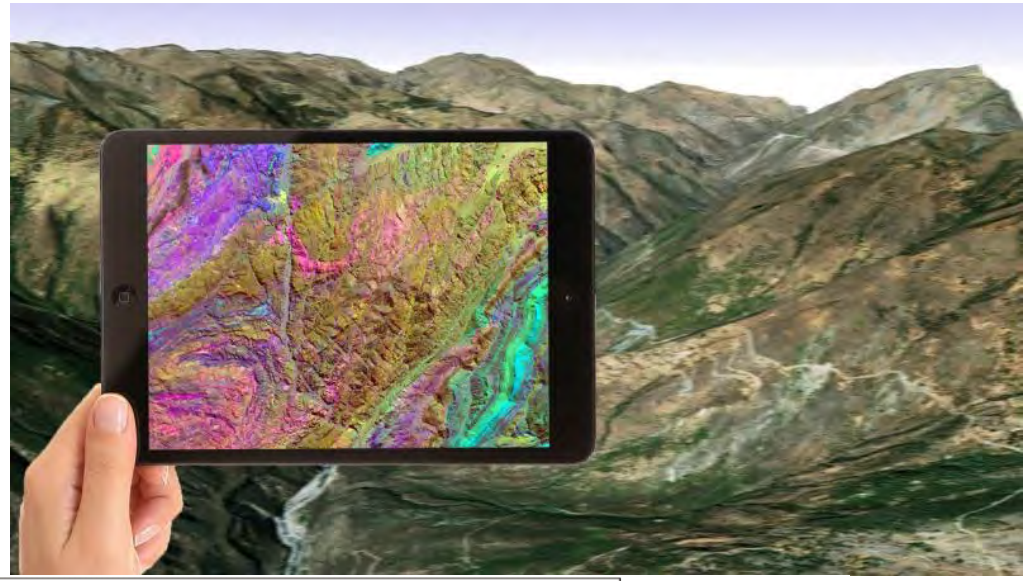
Target selection was based solely on:
Geological maps, field observations and local geophysical studies

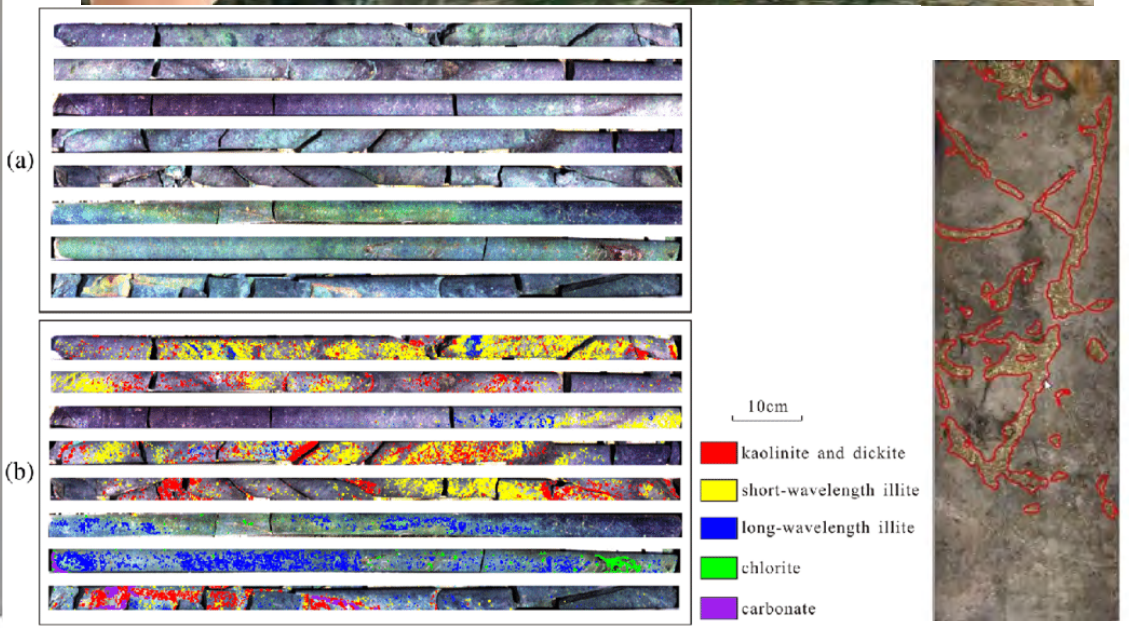


Hopefully, after AI-based analysis and completion of regional magnetometry and lithogeochemistry across the entire study area, approximately 8 million tonnes of gold @1 ppm has identified

3- AI in Geology





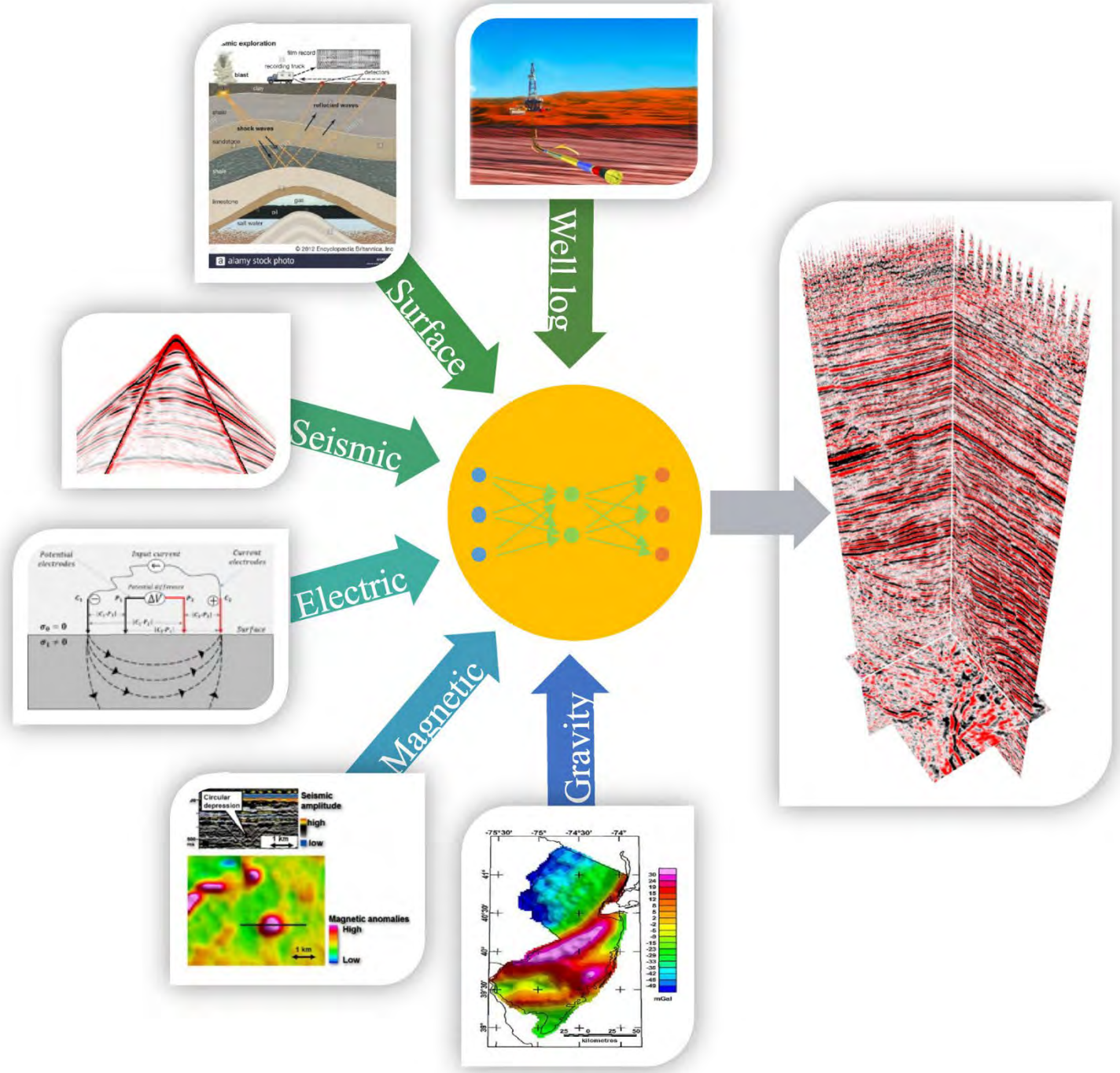


3- AI in Geophysics

Multigeophysical data

Processing

Integration



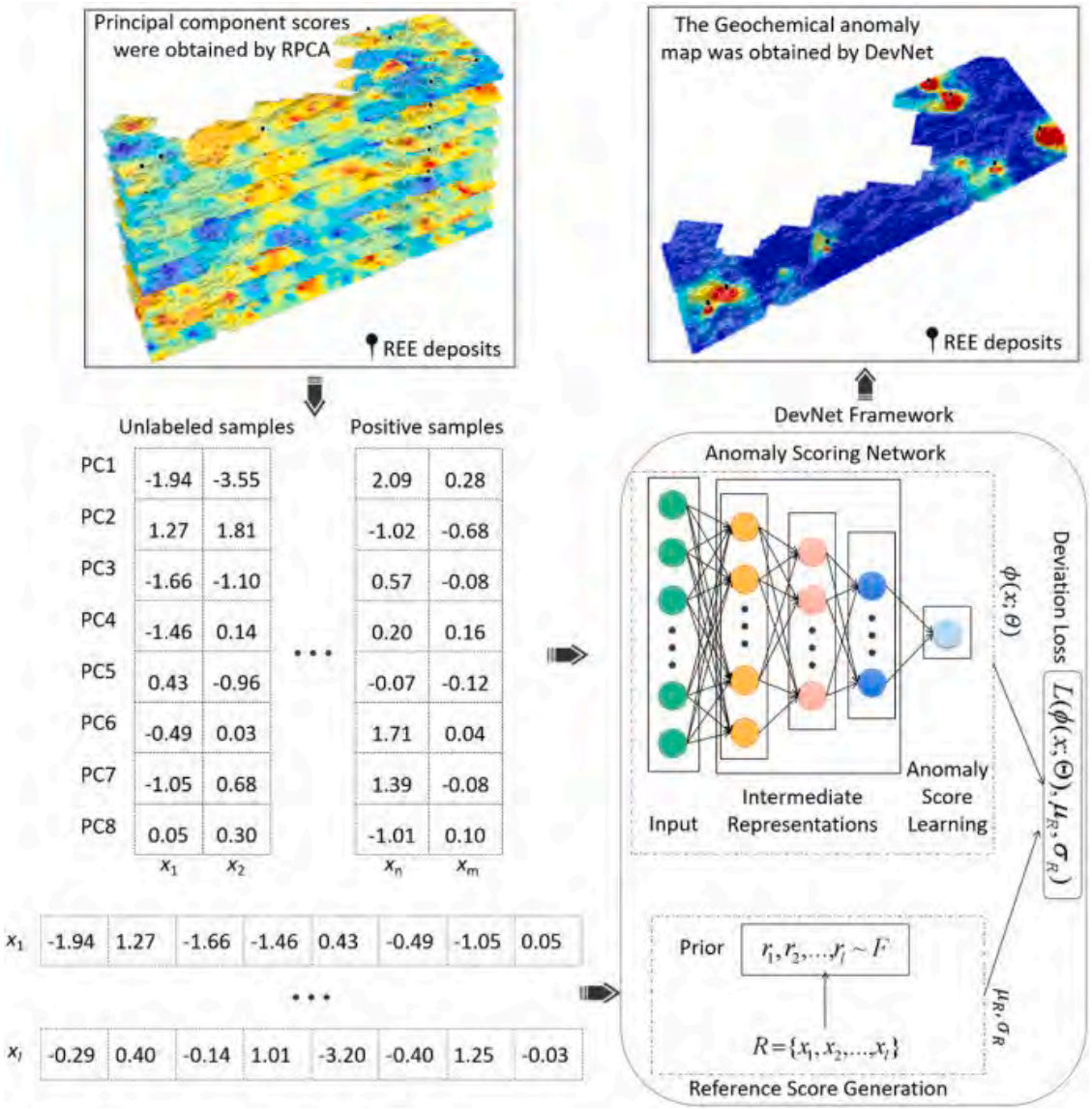
3- AI in Geochemistry

- Finding geochemical signals and fingerprints by

  Uncovering key indicators, smart ratios,

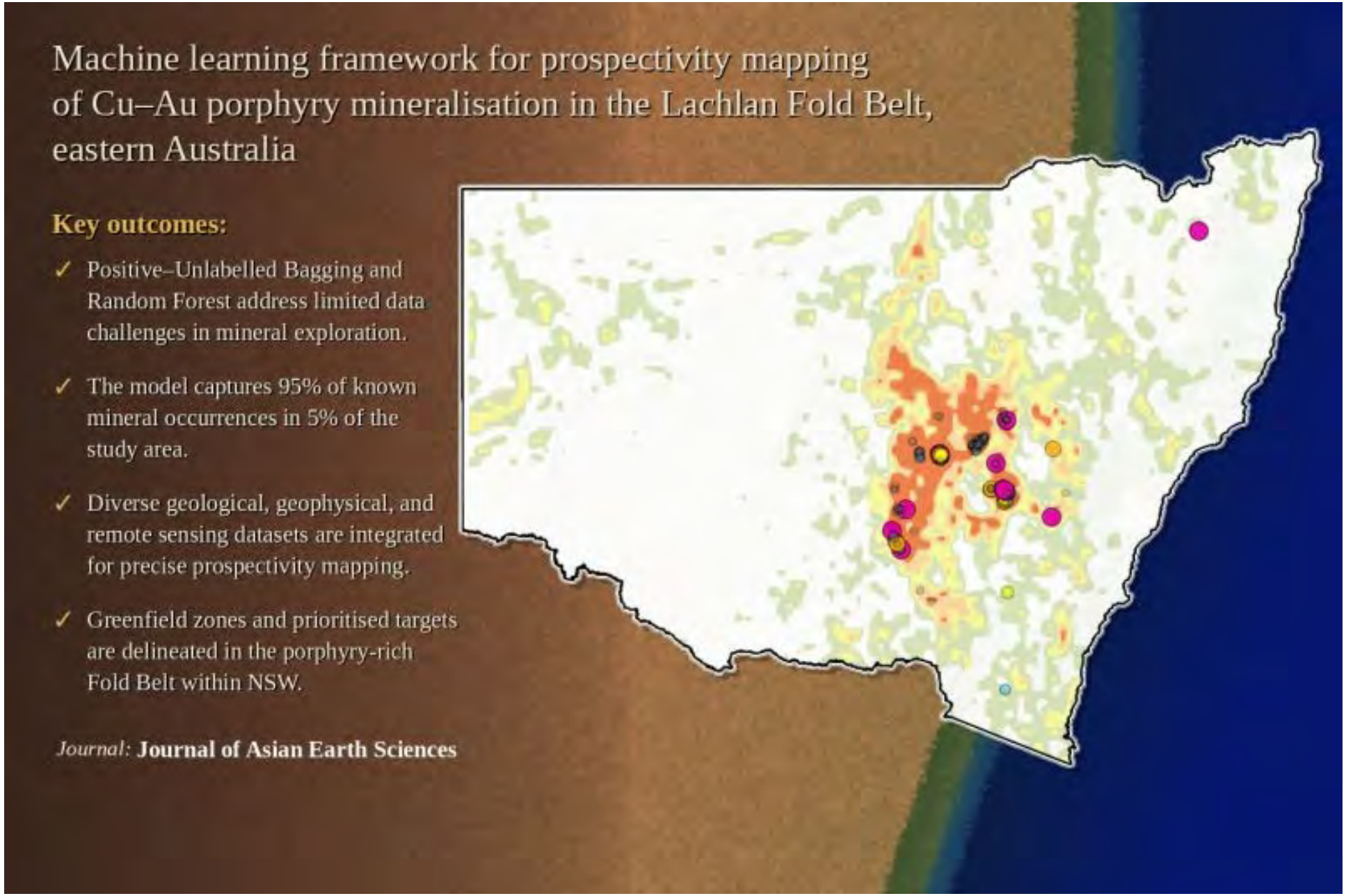
  Hidden footprints that pinpoint to ore deposits

- Identifying Complex Geochemical Patterns
- Predicting Mineralisation Zones
- Anomaly Detection and Target Prioritisation
- Data Integration and Multivariate Analysis



3- AI in MPM

Mineral Prospectivity Mapping



Heidari,E et al., (2025)

4- Why AI is Inevitable

The Need for Machine and Deep Learning Algorithms is Inevitable If we want to leverage the abundance of whole data

Calculators / Statistics / Permutation Calculator

Permutations Calculator

Use this calculator to easily calculate the number of permutations given a set of objects (types) and the number you need to draw from the set.

Objects to choose from 400

How many to choose? 3

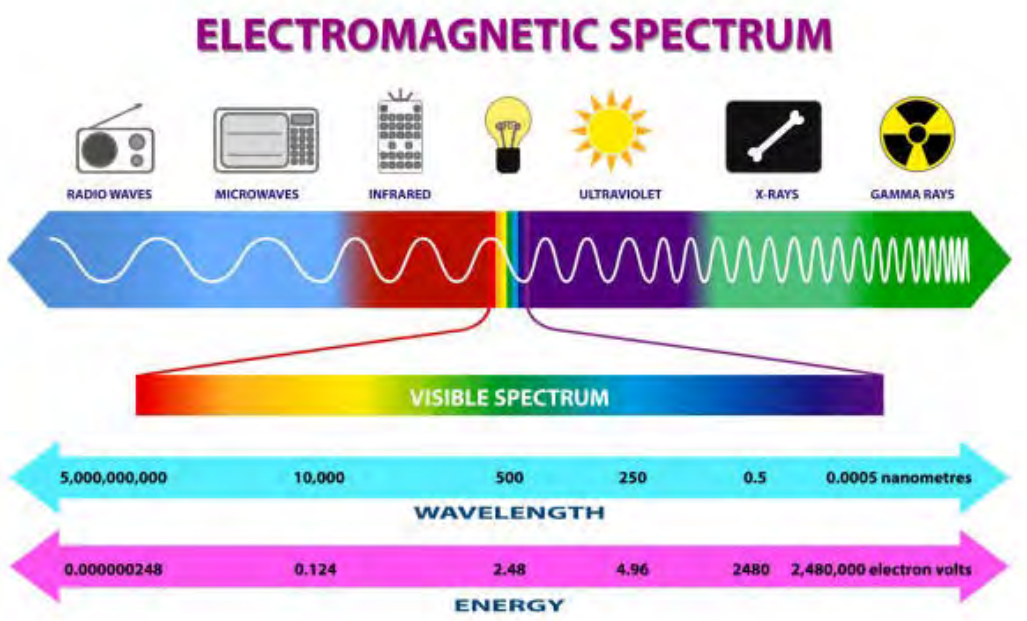
☑ With repetition ?

Calculate

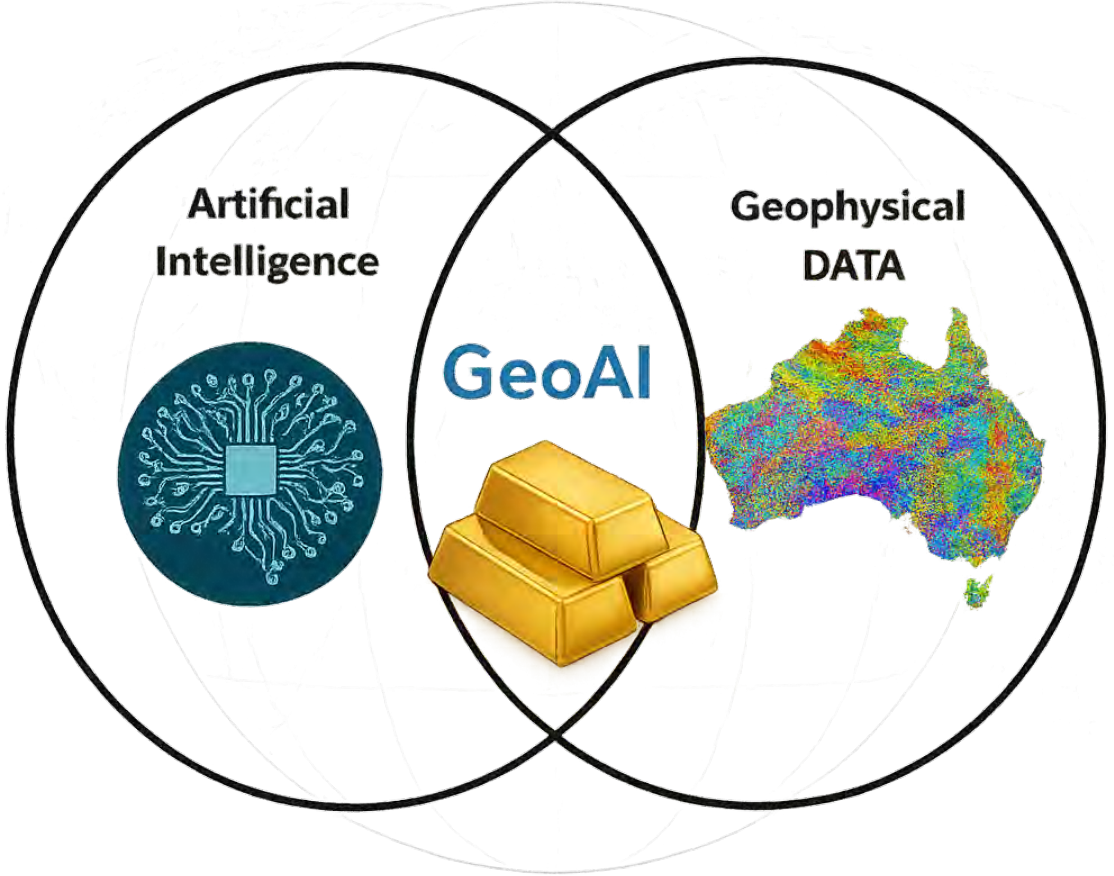
Calculation results

Permutations **64,000,000**

The number of Maps (RGB) we need to prepare RGB or ternary maps???

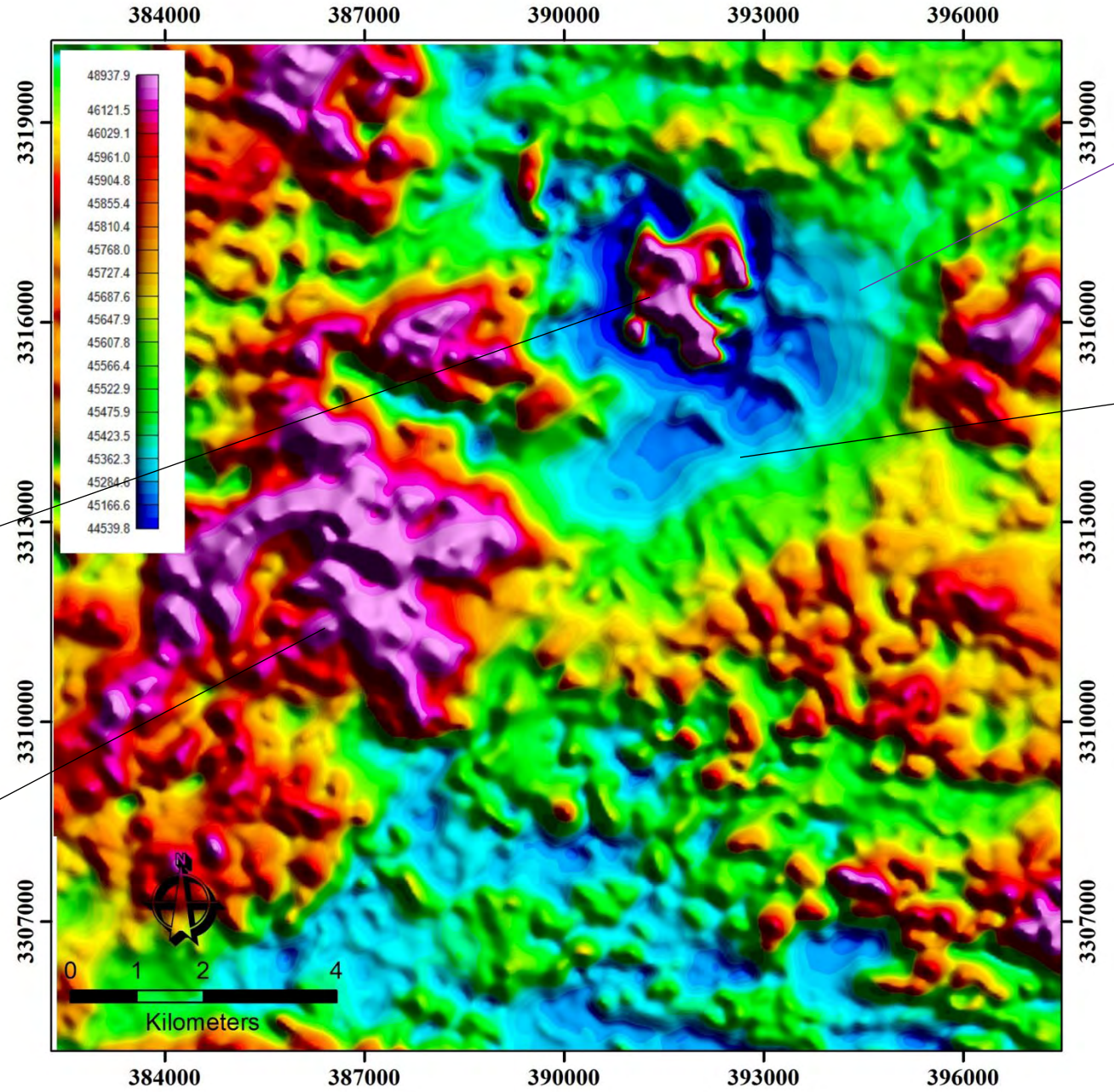


5- Real-world Case Studies



Case Study 1

Reduction to Pole



Newly Discovered Deposits Sereydoun

Mine Sarcheshmeh

Dacite (High Magnetization but barren)

Volcanic Rocks and Granodiorite

Some proposals at that time included:

No further exploration studies are recommended!

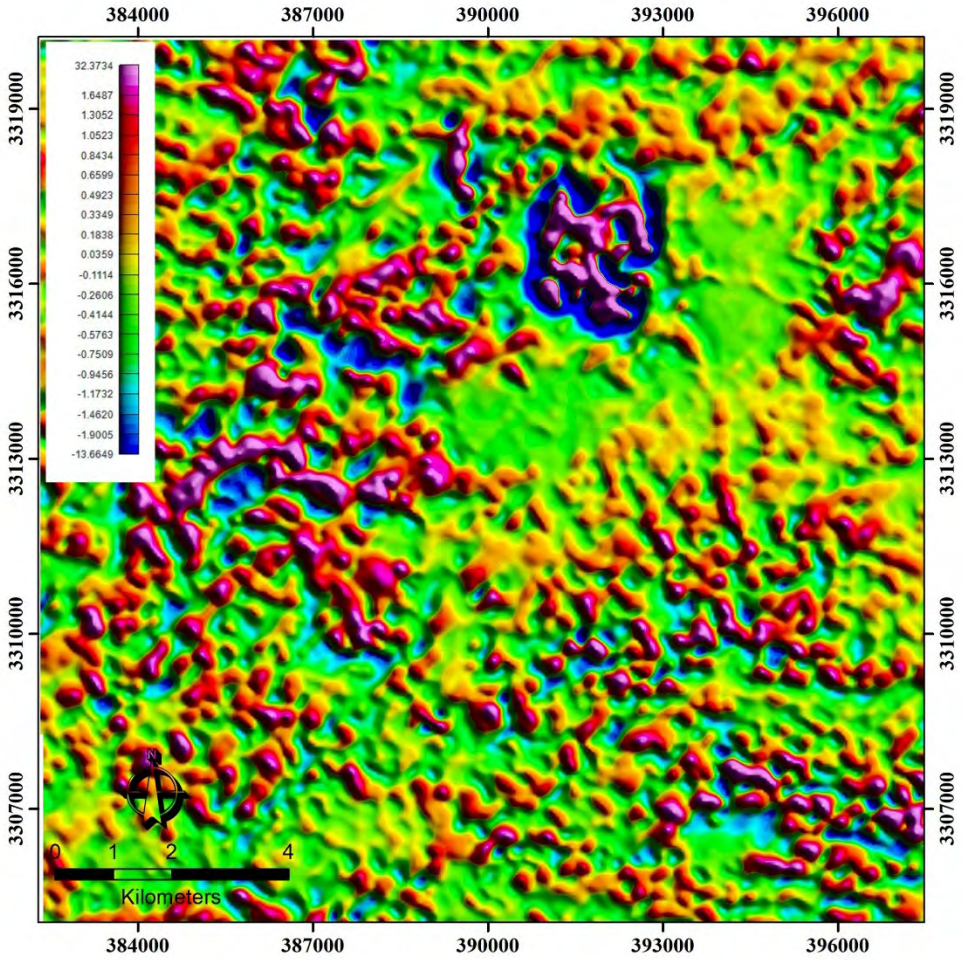
6 drilling points up to 600 m depth without any copper result!

Shirmard, H., et al. (2022)

Case Study 1

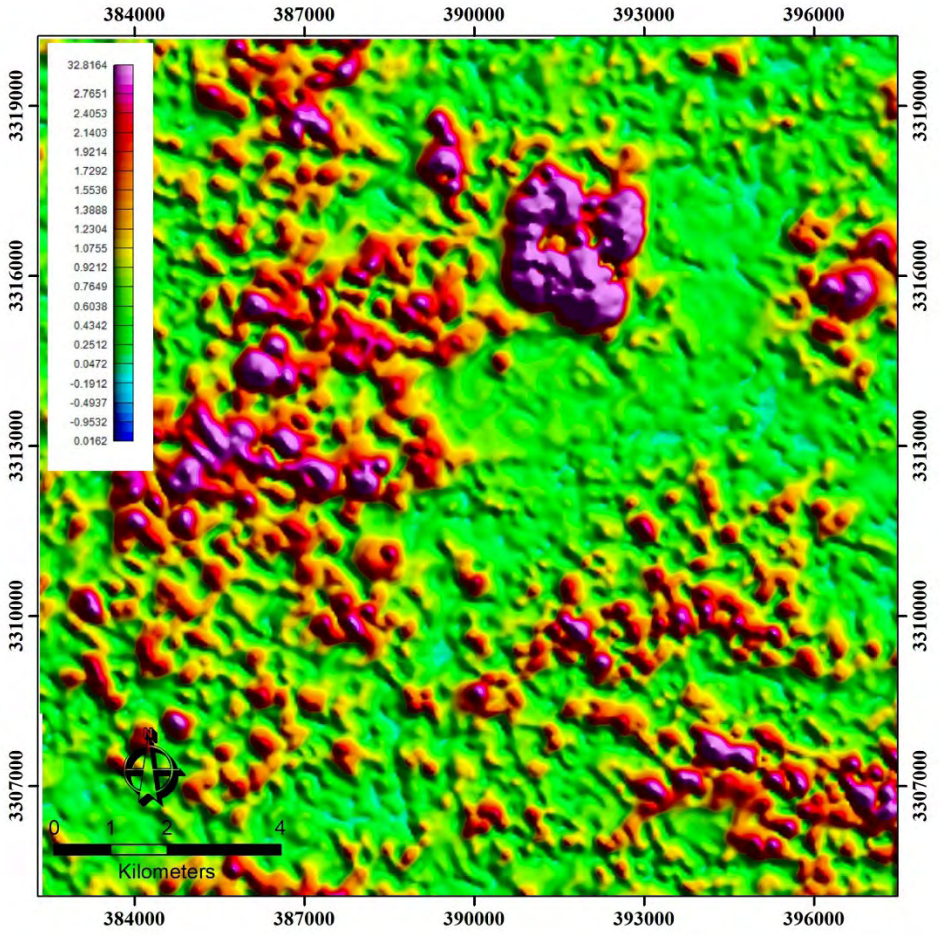
Ordinary processing pathway.

Vertical Derivate



$$VDR = \frac{\partial T}{\partial z}$$

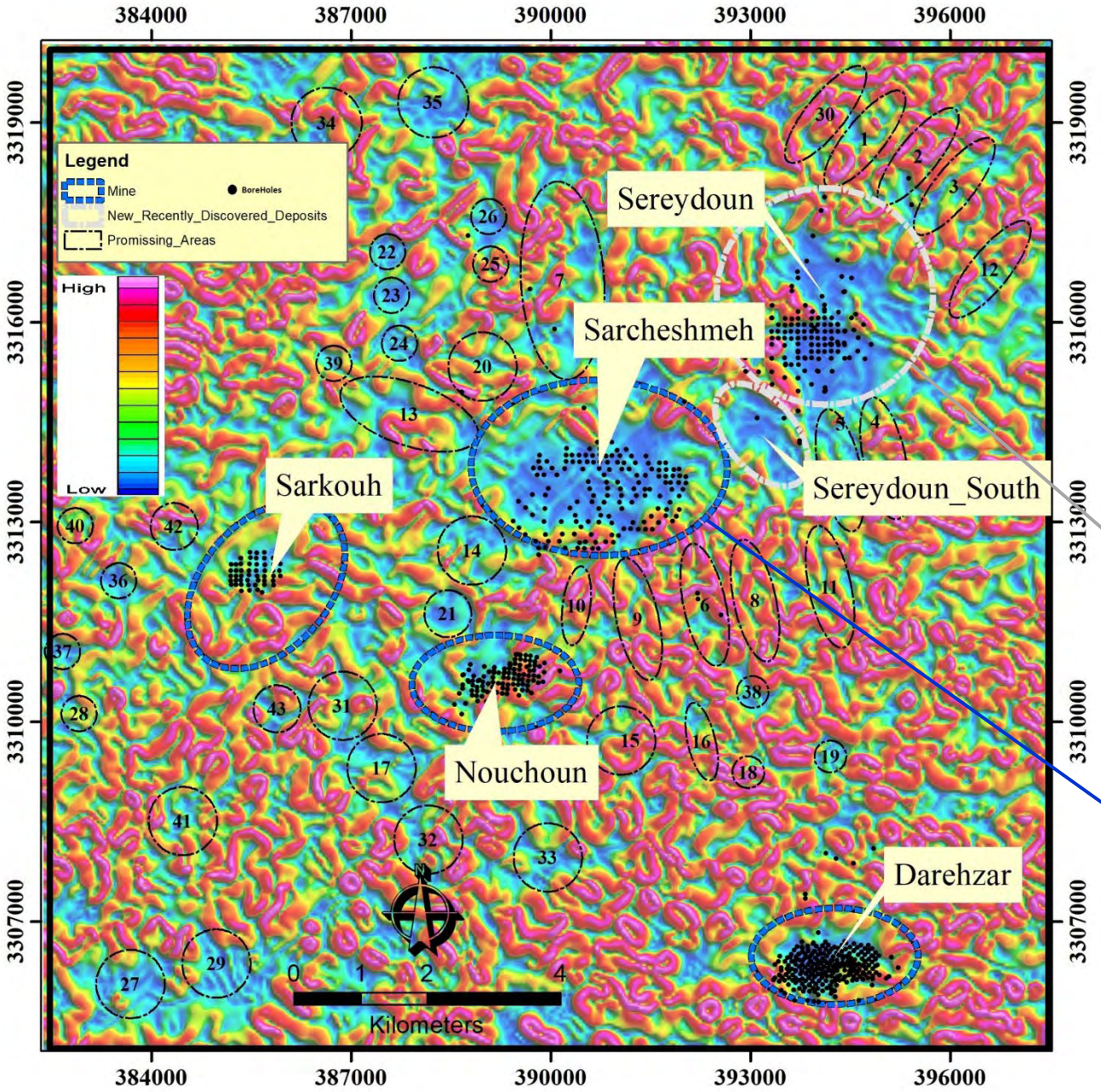
Analytic Signal



$$AS = \sqrt{\left(\frac{\partial T}{\partial x}\right)^2 + \left(\frac{\partial T}{\partial y}\right)^2 + \left(\frac{\partial T}{\partial z}\right)^2}$$

Shirmard, H., et al. (2022)

Case Study 1

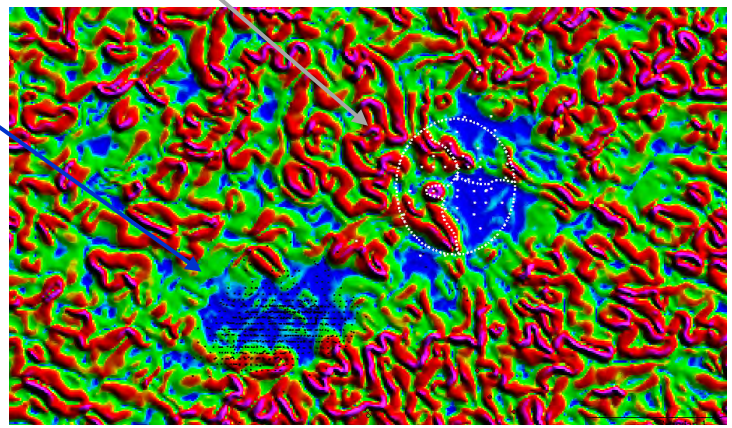


Normalised Horizontal Derivative Angle Map

Mines

Recently discovered Deposits (Sereydoun)

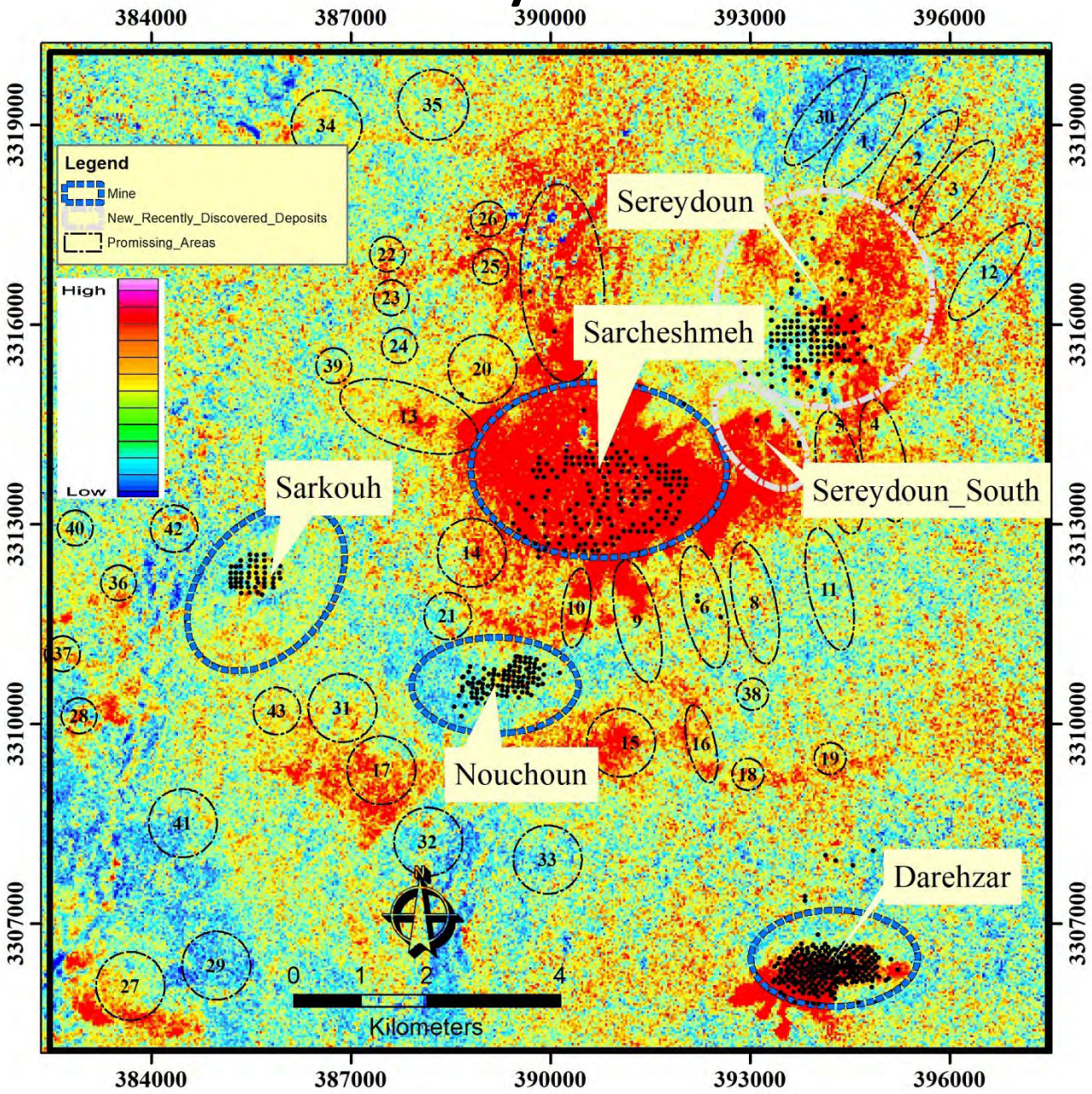
Other Promising results

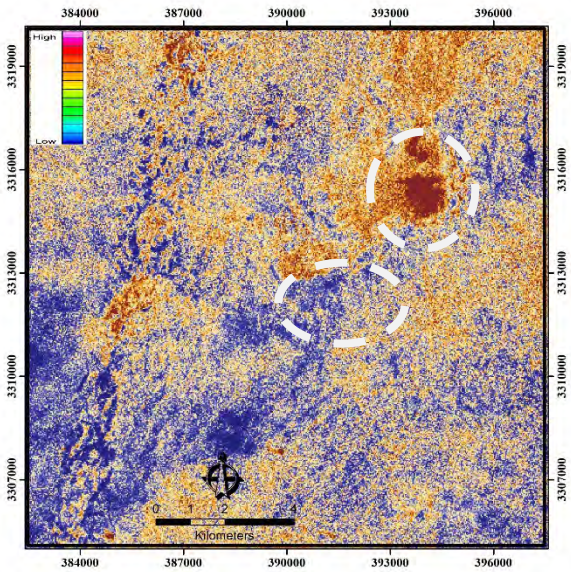


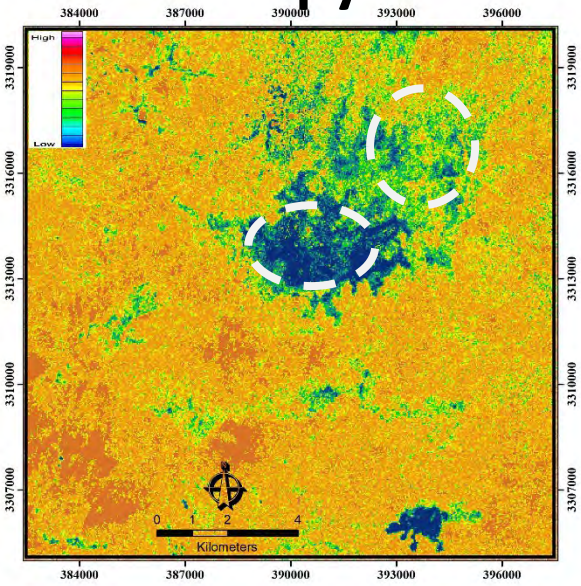
Shirmard, H., et al. (2022)

Case Study 1

AI-Driven Alteration Mapping Using ASTER Satellite Data







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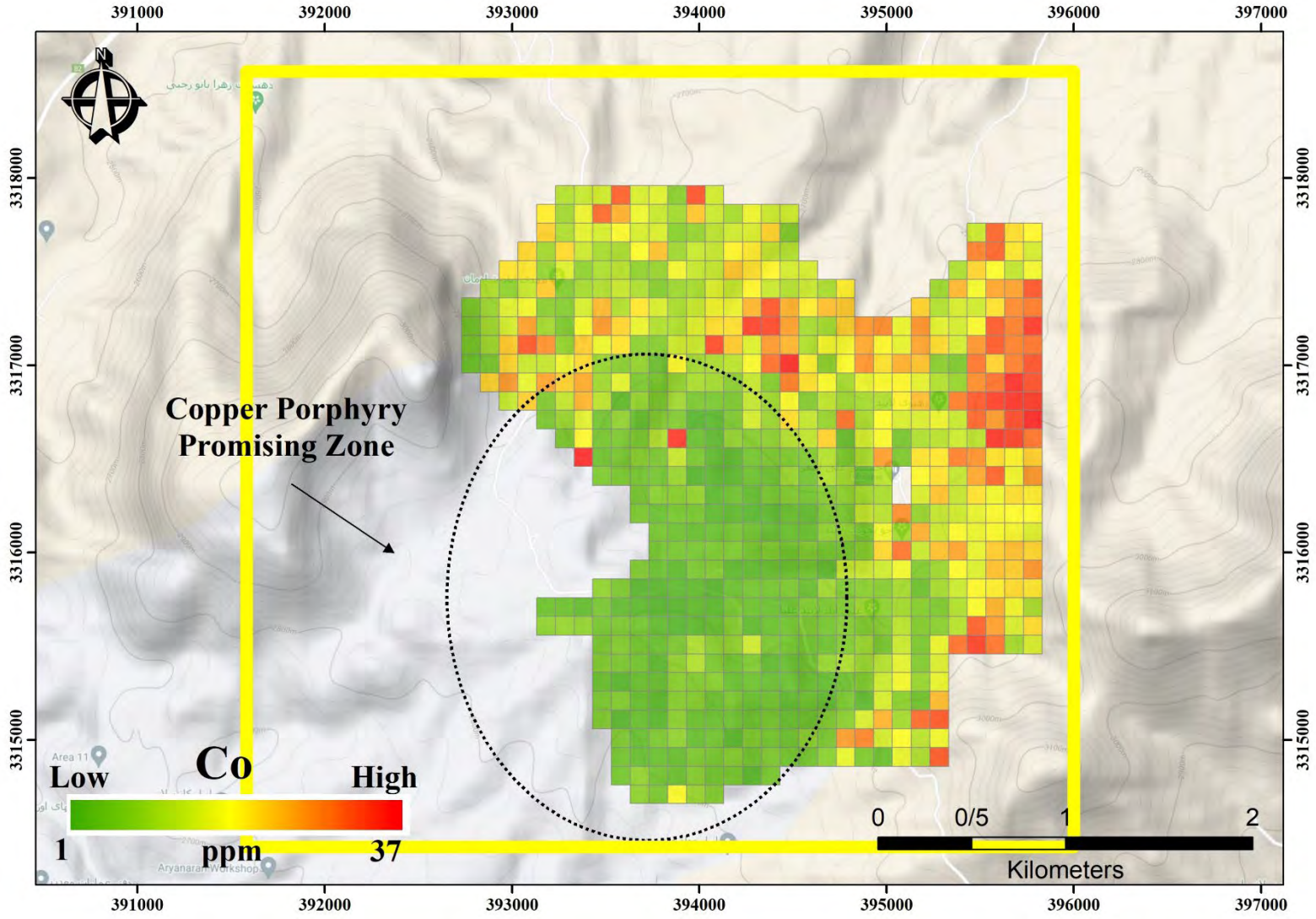
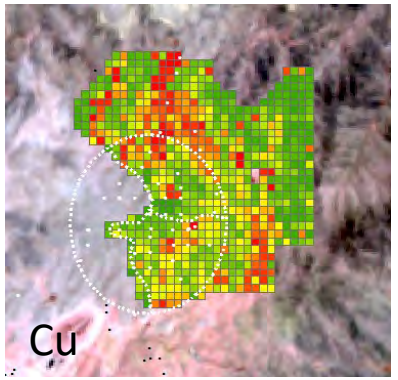
Case Study 1

Robust geochemical design and data processing





Elemental
Enrichment and Depletion Patterns in
Porphyry Copper Deposits

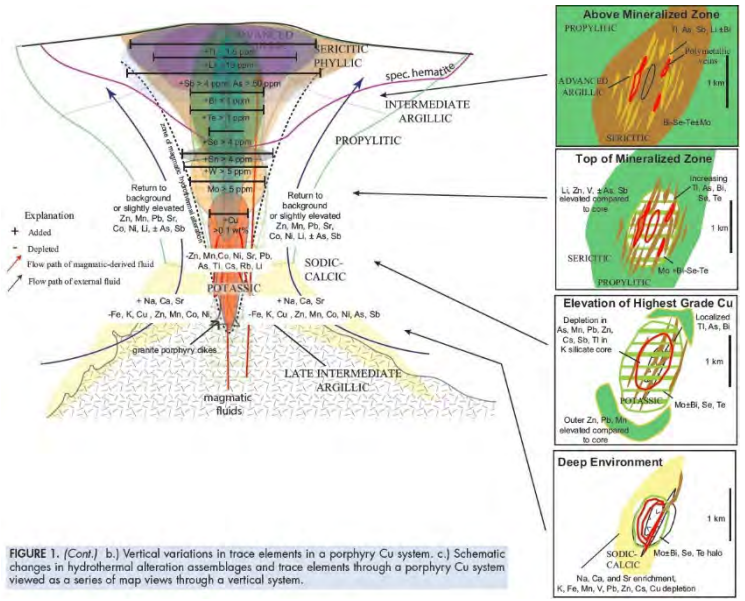


FIGURE 1. *(Cont.)* b.) Vertical variations in trace elements in a porphyry Cu system. c.) Schematic changes in hydrothermal alteration assemblages and trace elements through a porphyry Cu system viewed as a series of map views through a vertical system.

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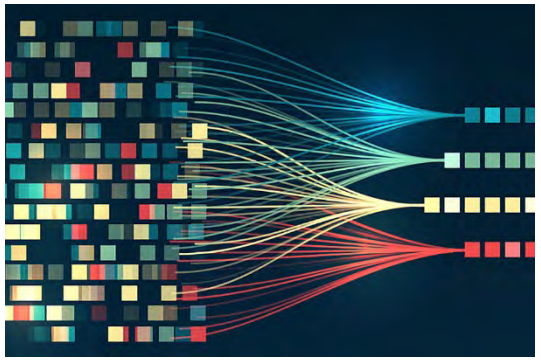
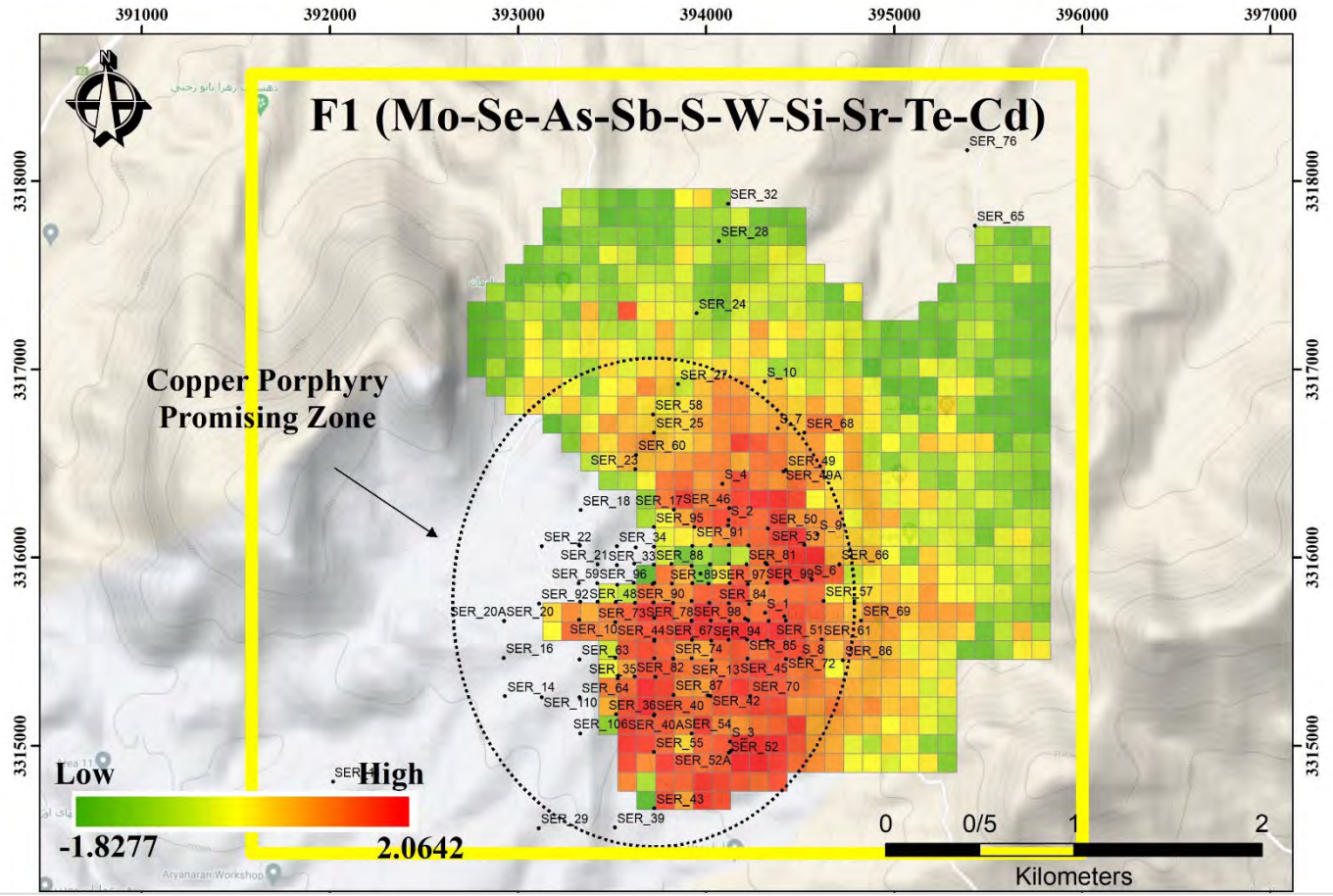
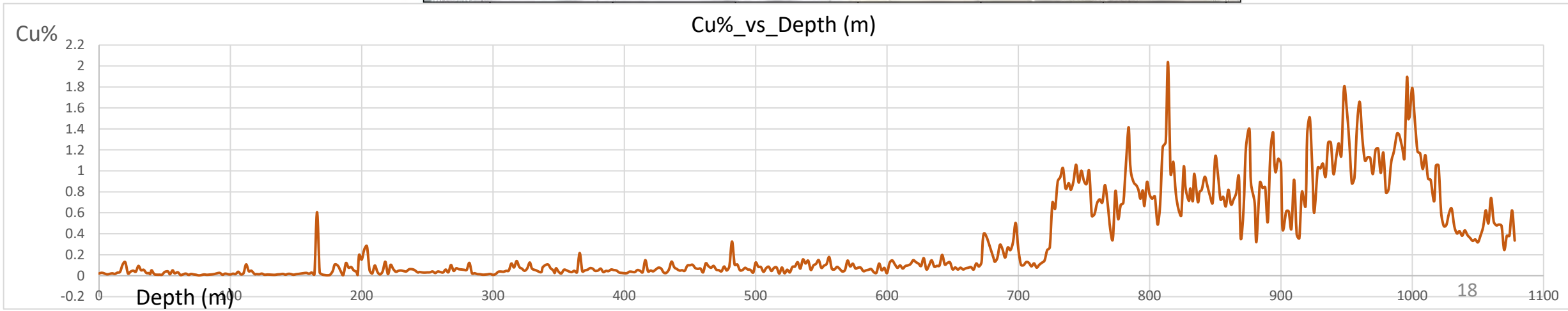
Case Study 1



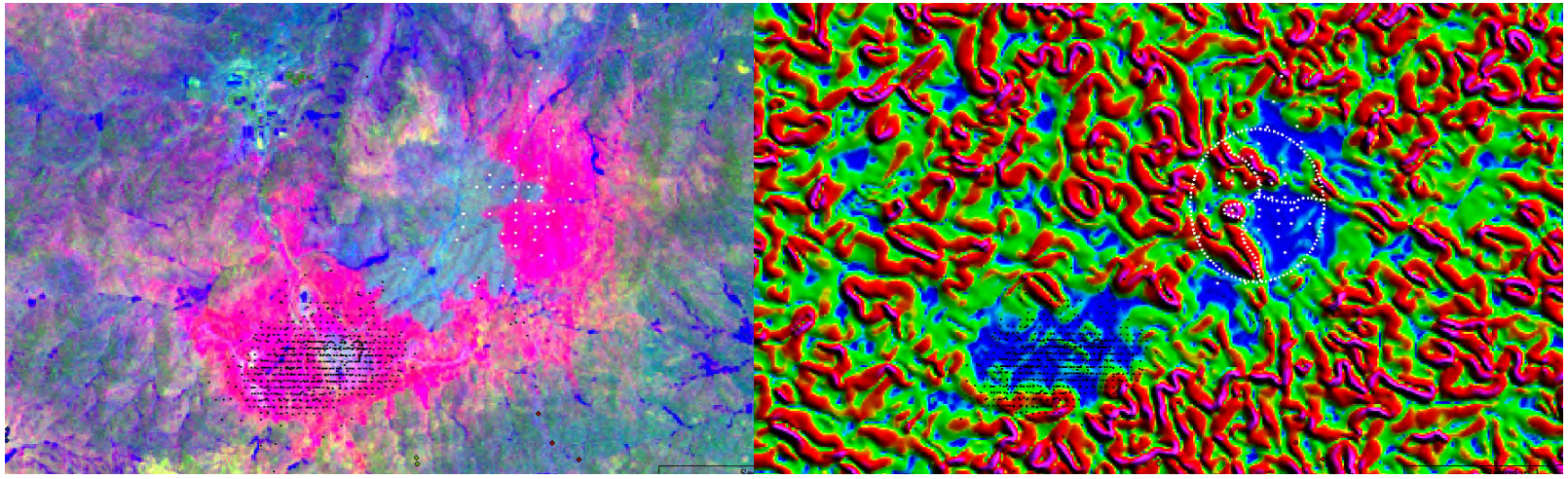
Drilling Result

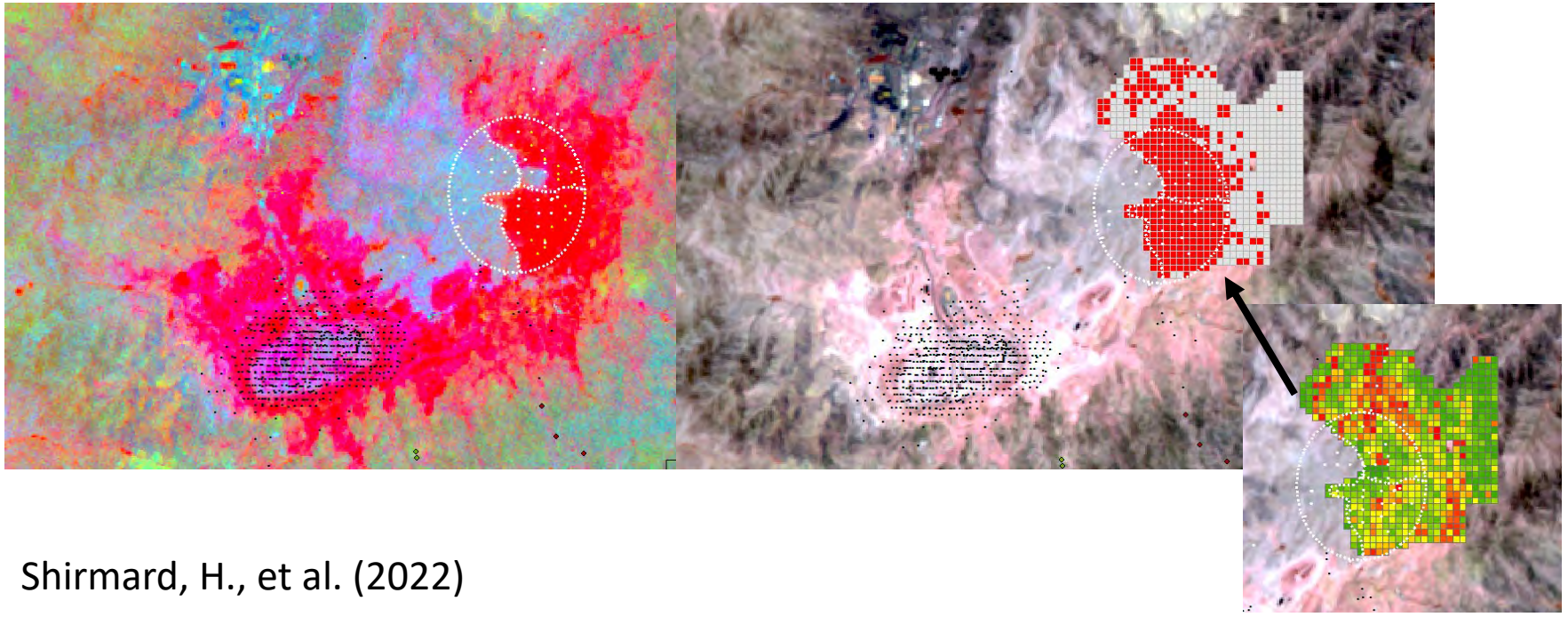


Factor Analysis



Case Study 1





The area was becoming a tailings dump for the Sarcheshmeh mine!

Now become one of Iran's largest porphyry copper deposits.

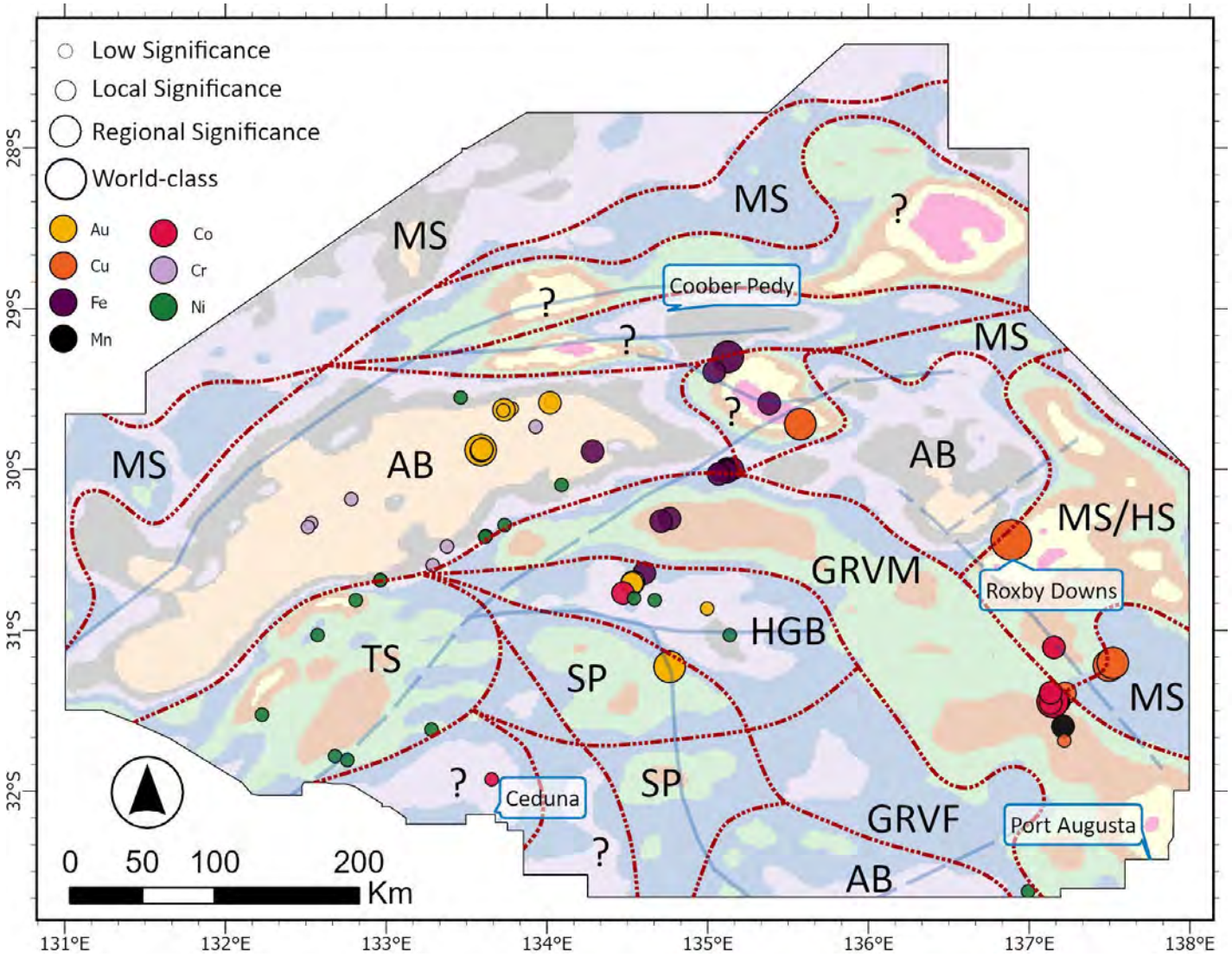
After drilling more than 100,000 meters of exploration boreholes, the reserve is approximately **3.5 billion tons of copper, with an average grade of 0.4%, and a cutoff grade of 0.15%.**

Several porphyry and epithermal copper-gold potential regions were also identified for further investigation.

The approach used in this study can play a significant role in other areas seeking epithermal and deep porphyry copper and gold deposits.

Shirmard, H., et al. (2022)

Case Study 2: Regional Data Engineering for MPM in Gawler Craton, South Australia (New Structural Map)



AB = 3150-2530 Ma Archean basement

MS = ~1850-1640 Ma Metasedimentary rocks

BS = ~1560-1550 Ma Babbage Supersuite

SP = ~1620-1610 St Peter Suite

HGB = Harris Greenstone belt

GRVF = ~1592–1587 Ma GRV volcanics (? Felsic)

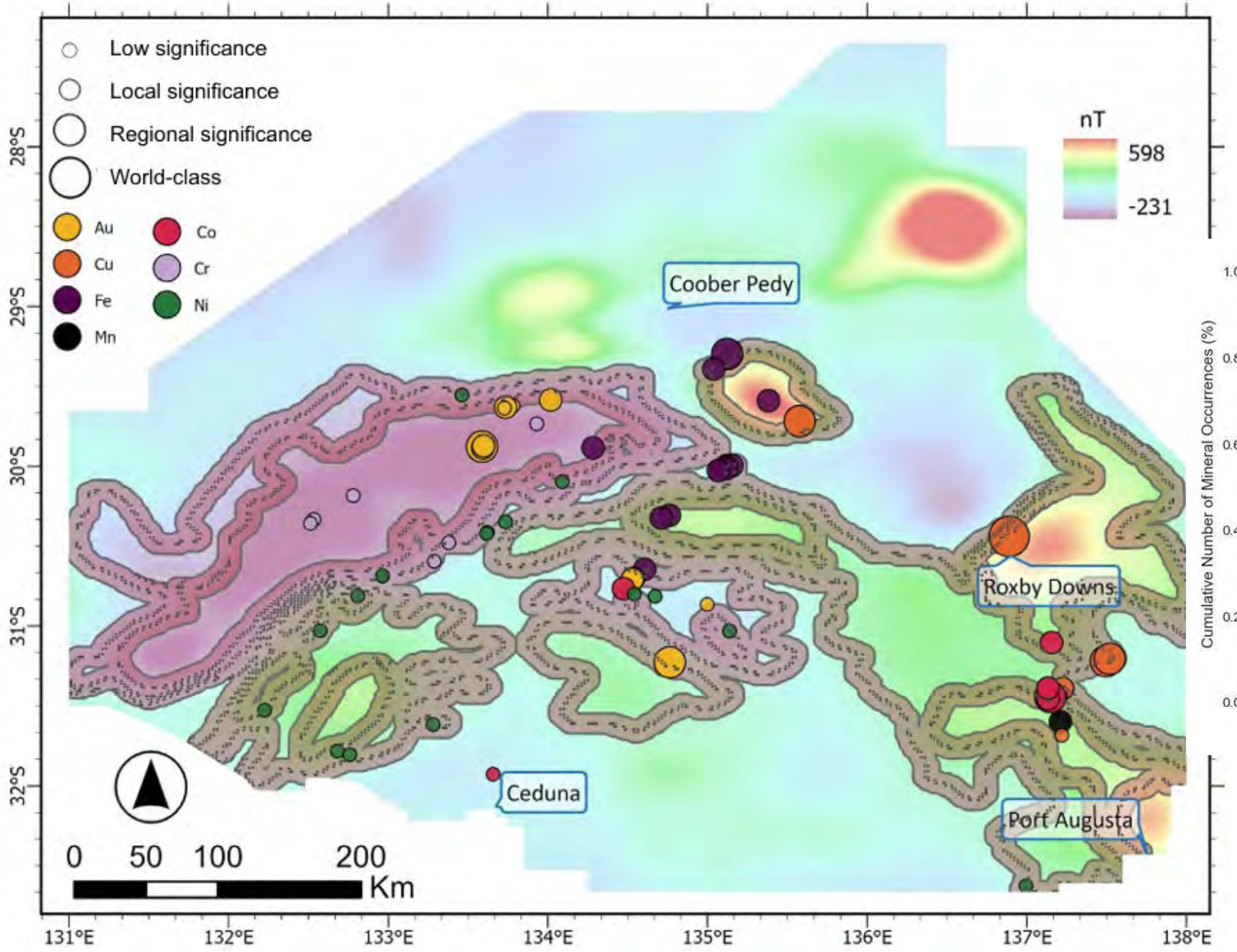
GRVM = ~1592–1587 Ma GRV volcanics (? Mafic)

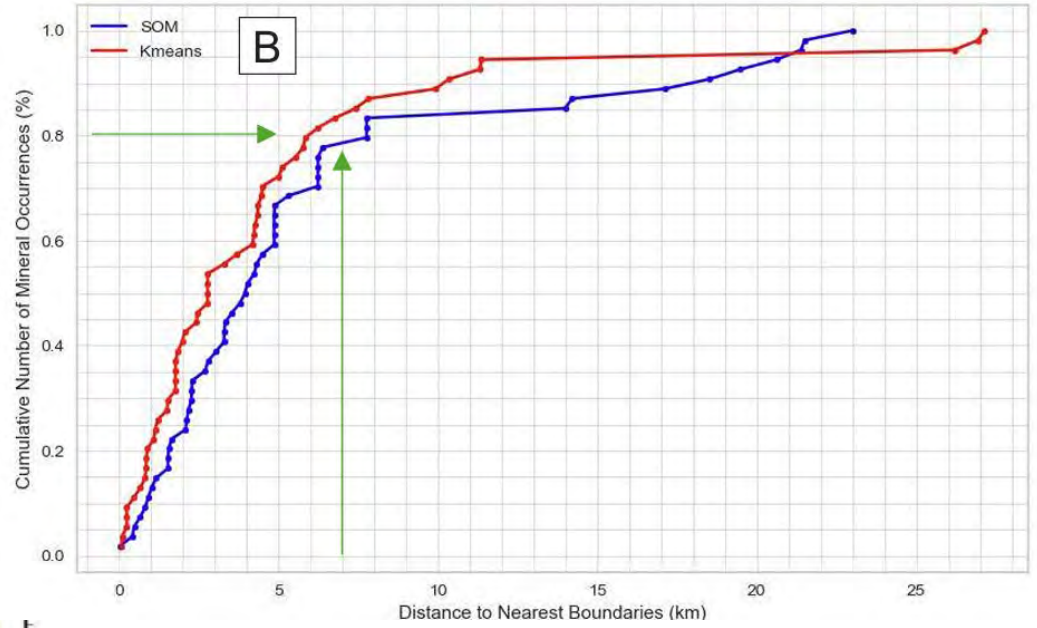
HS = ~1595–1575 Ma Hilltaba Suite

TS = ~1690–1670 Ma Tunkillia Suite

Shirmard, H., et al. (2025)

Case Study 2: Regional Data Engineering for MPM in Gawler Craton, South Australia (New Structural Map matching with metallic deposits)

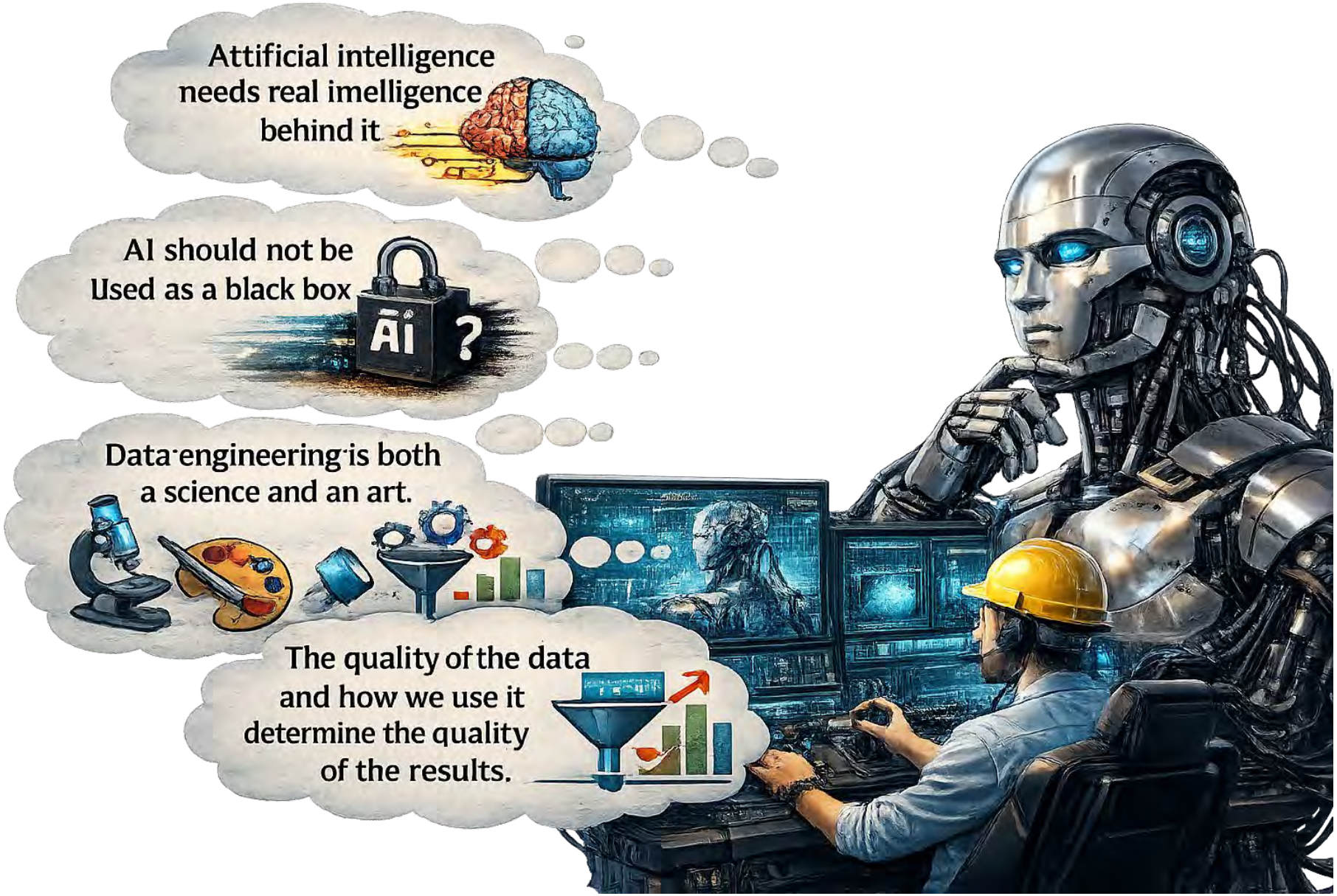




Shirmard, H., et al. (2025)

Takeaways

Using AI in mineral exploration is inevitable, but:



Thank you!

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More Industry Case Studies!

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