

AI in Mineral Exploration: From Code to Core.

Hojat Shirmard



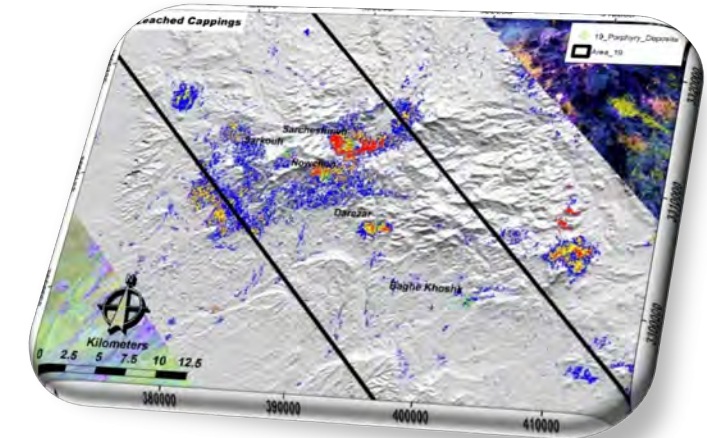
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Talk structure

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

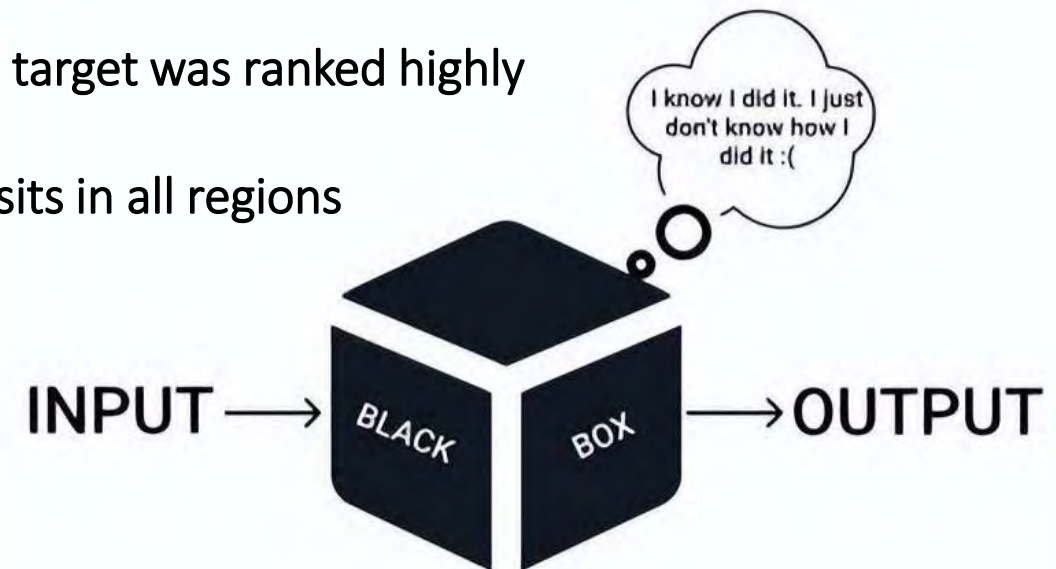
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Takeaways

1- Dangers of Using AI

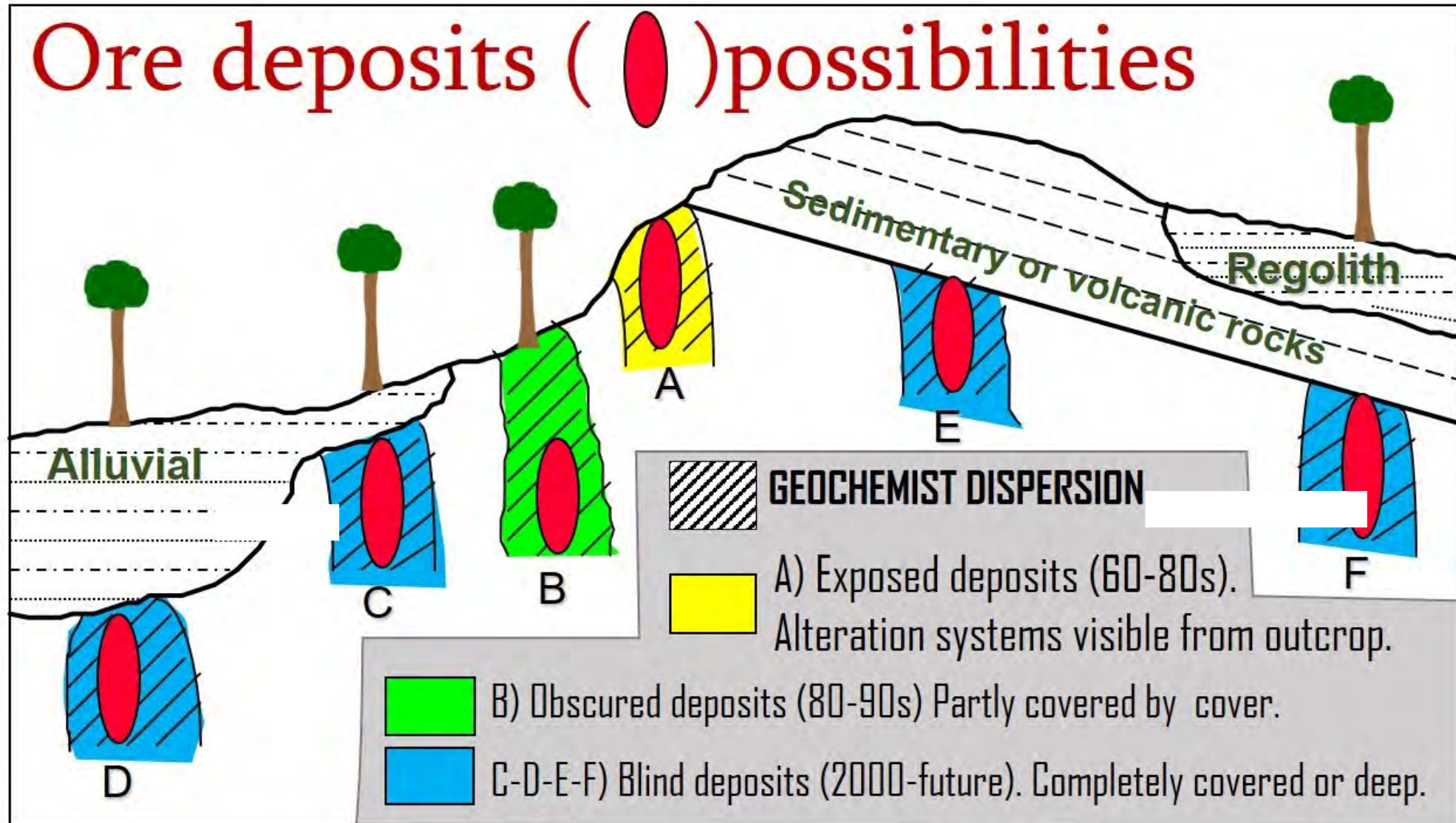
- Black Box Decision-Making in most models
- Garbage In, Garbage Out (GIGO)
- Wrong understanding of how to use data logically -----> e.g.
- Bias toward well-explored regions and known deposit types
- Reinforcement of old exploration biases instead of new discoveries -----> e.g.
- Lack of transparency: 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)

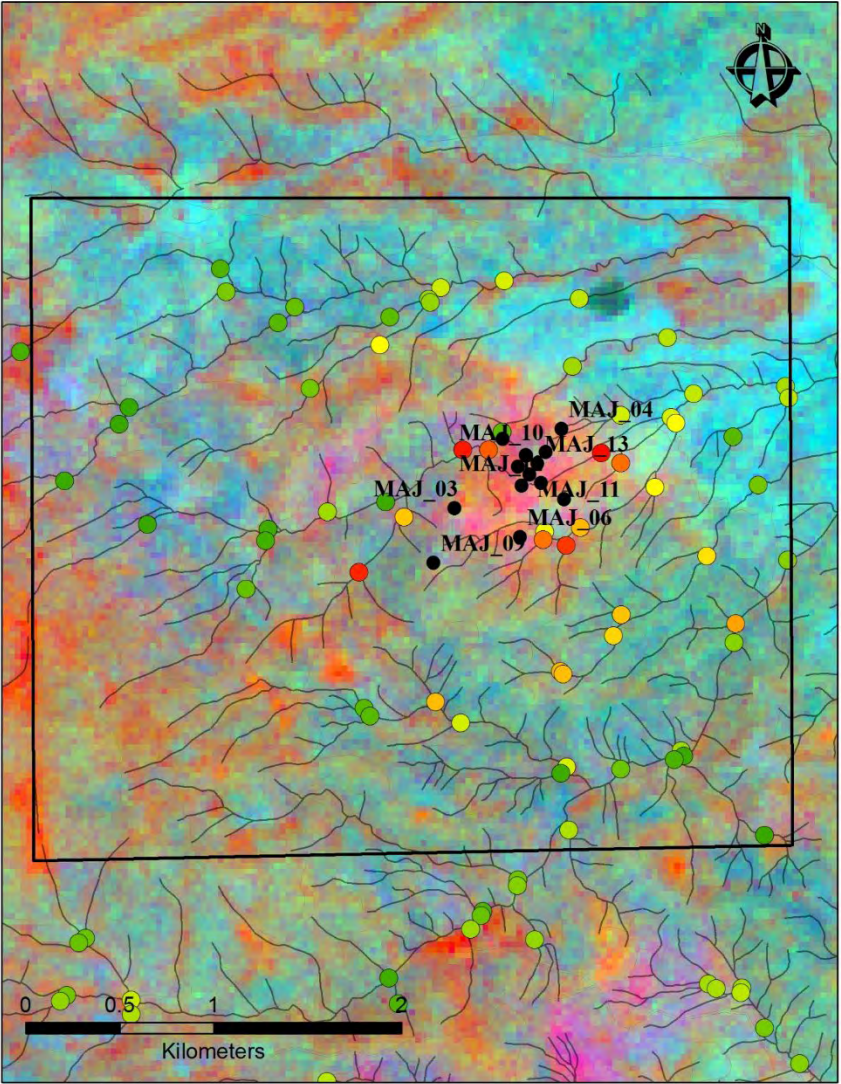


1- Dangers of Using AI

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

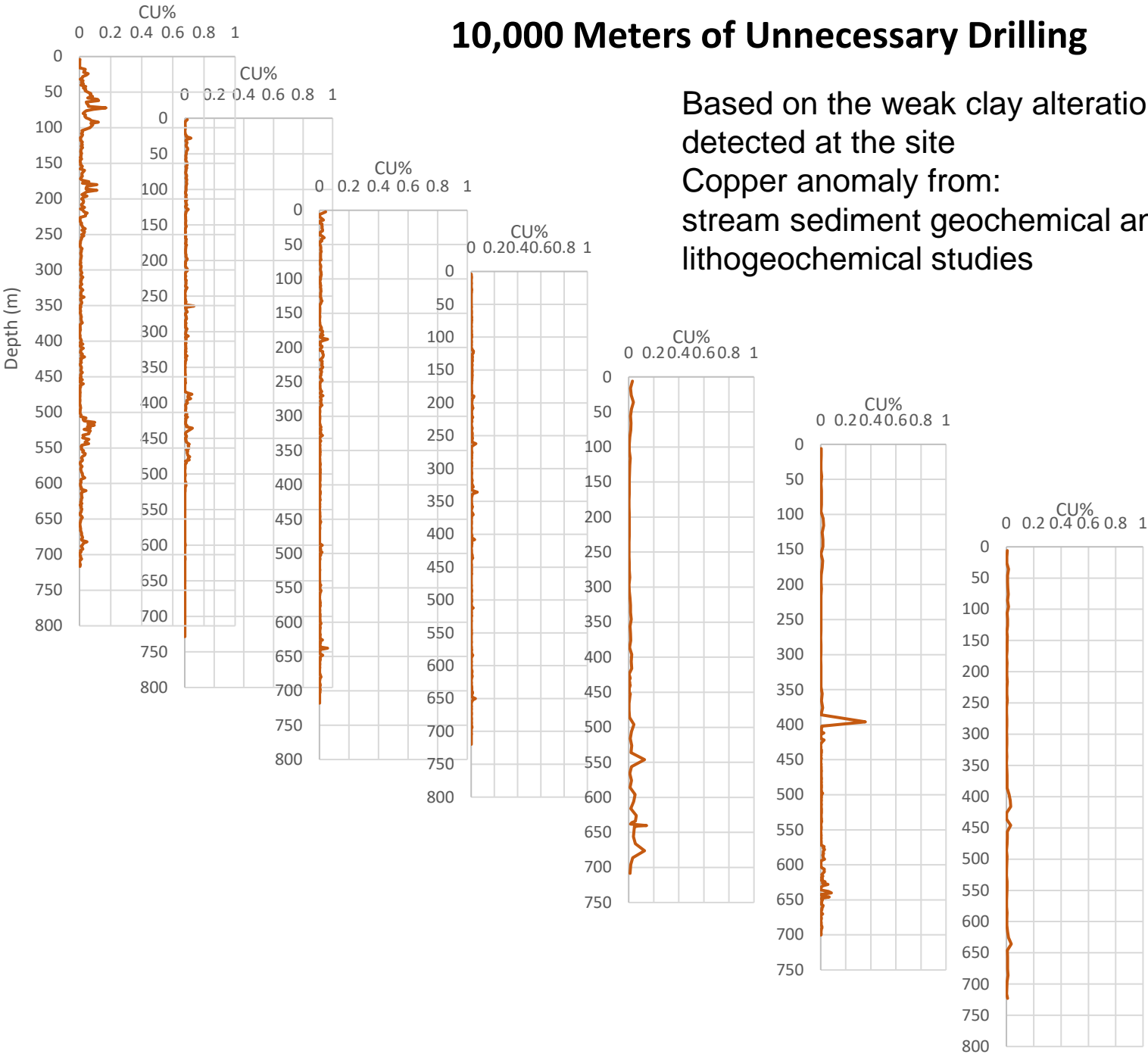


2- Dangers of Not Using AI



10,000 Meters of Unnecessary Drilling

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

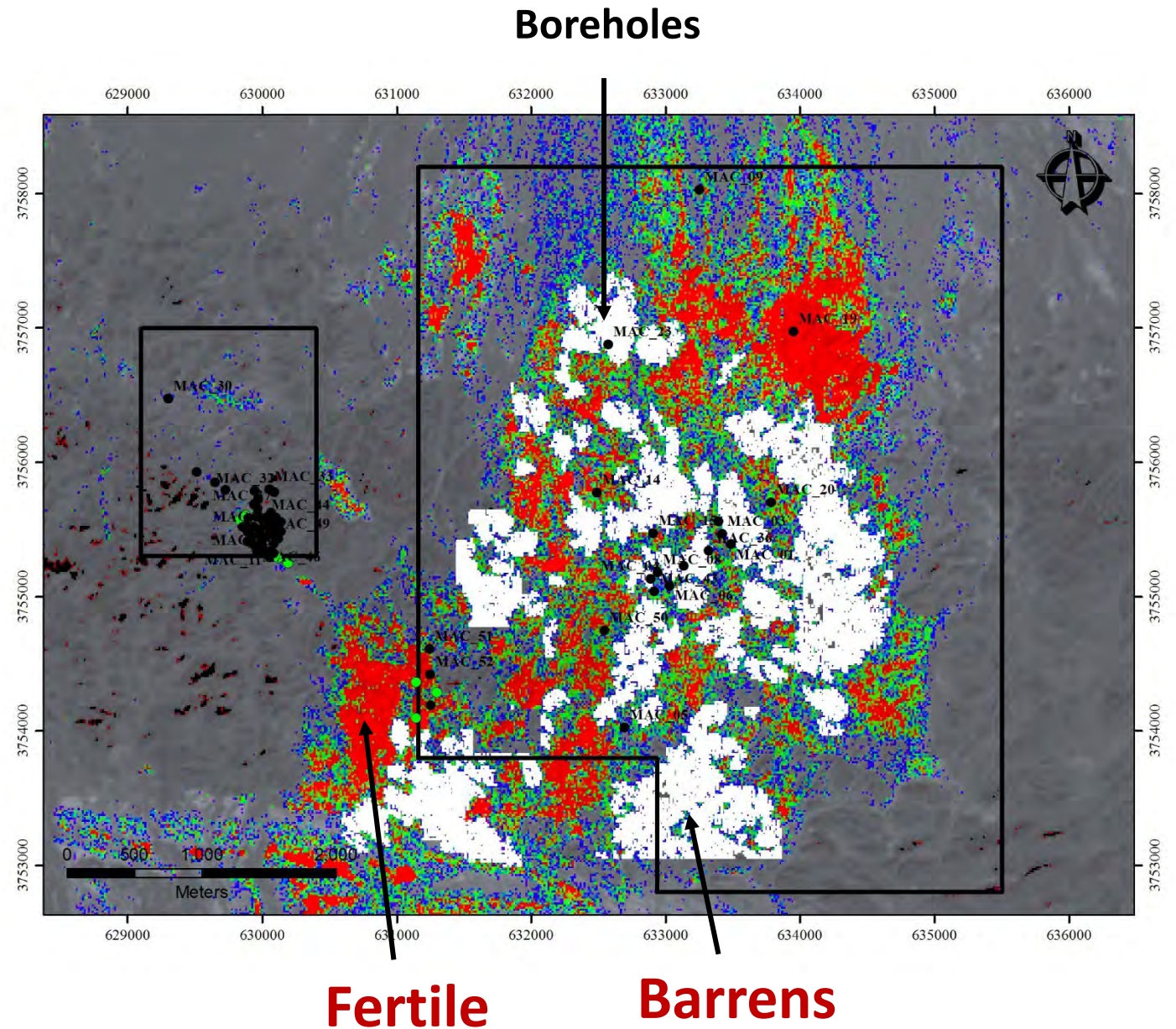


2- Dangers of **Not** Using AI

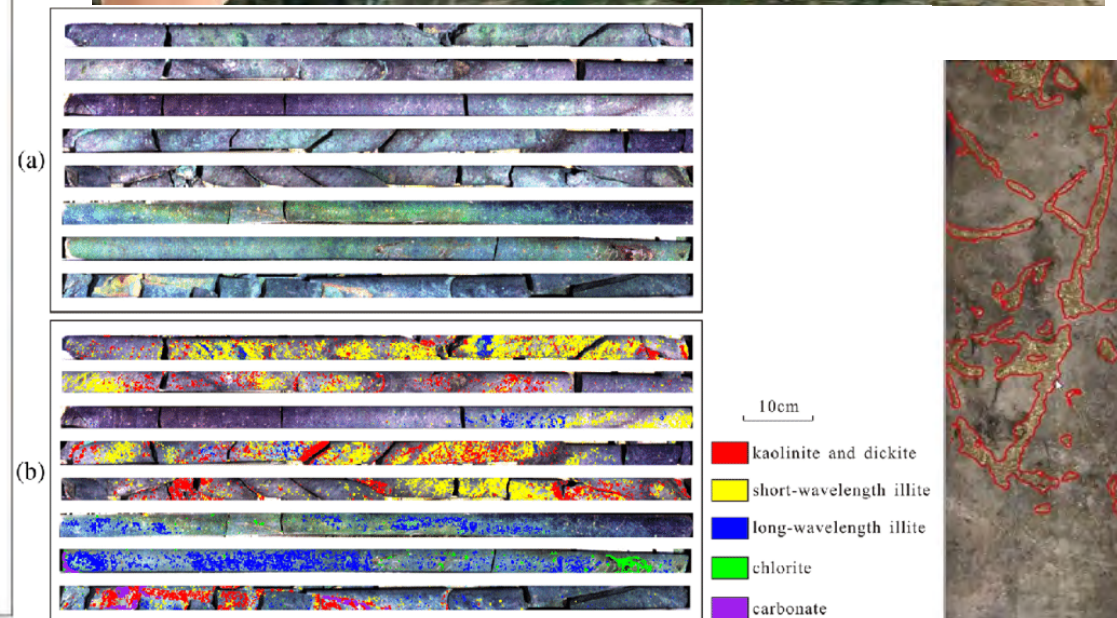
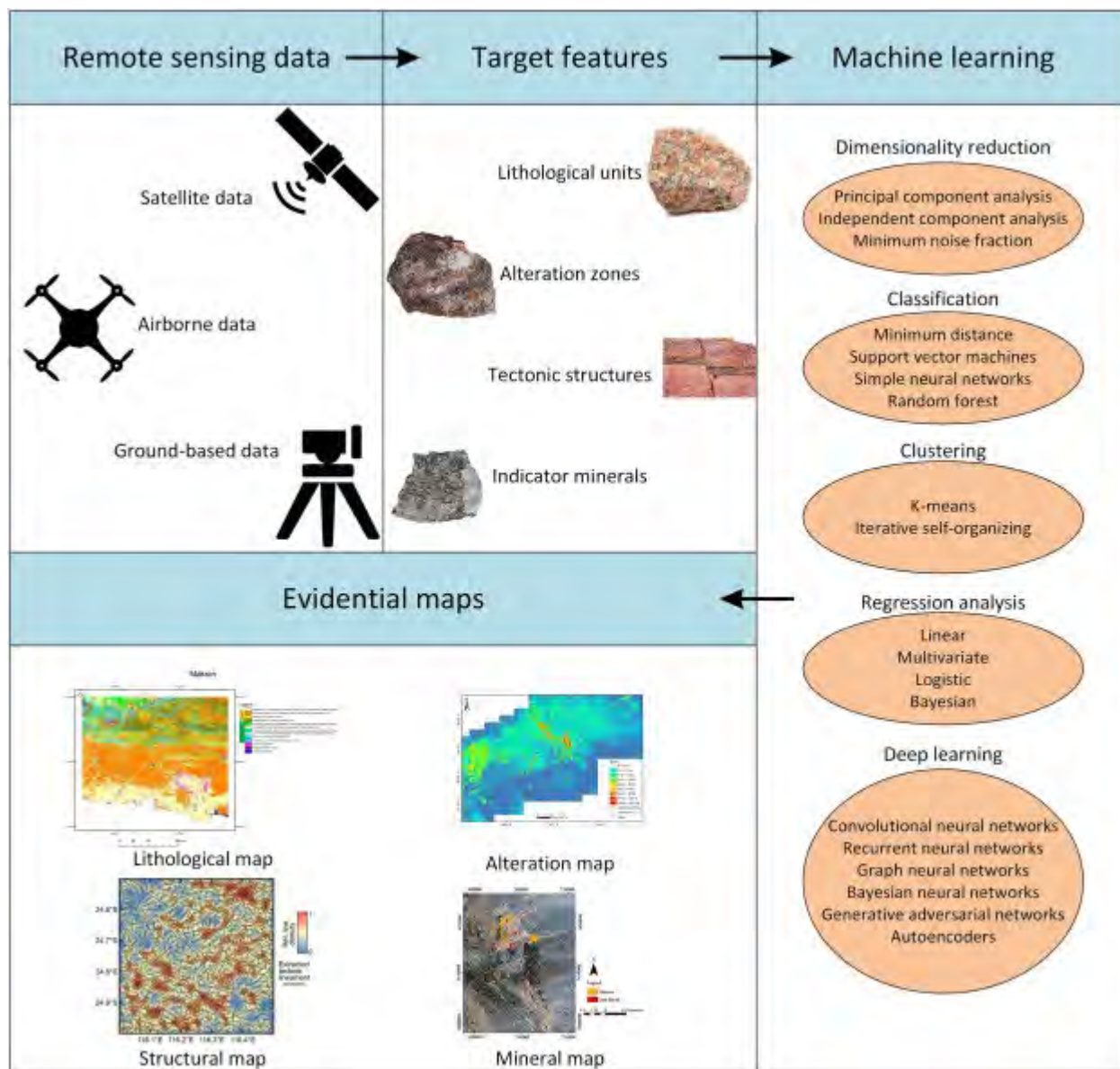
**20,000
Meters of
Unnecessary
Drilling**

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 litho-geochemistry across the entire study area, approximately 8 million tonnes of gold @1 ppm has identified



3- AI in Geology

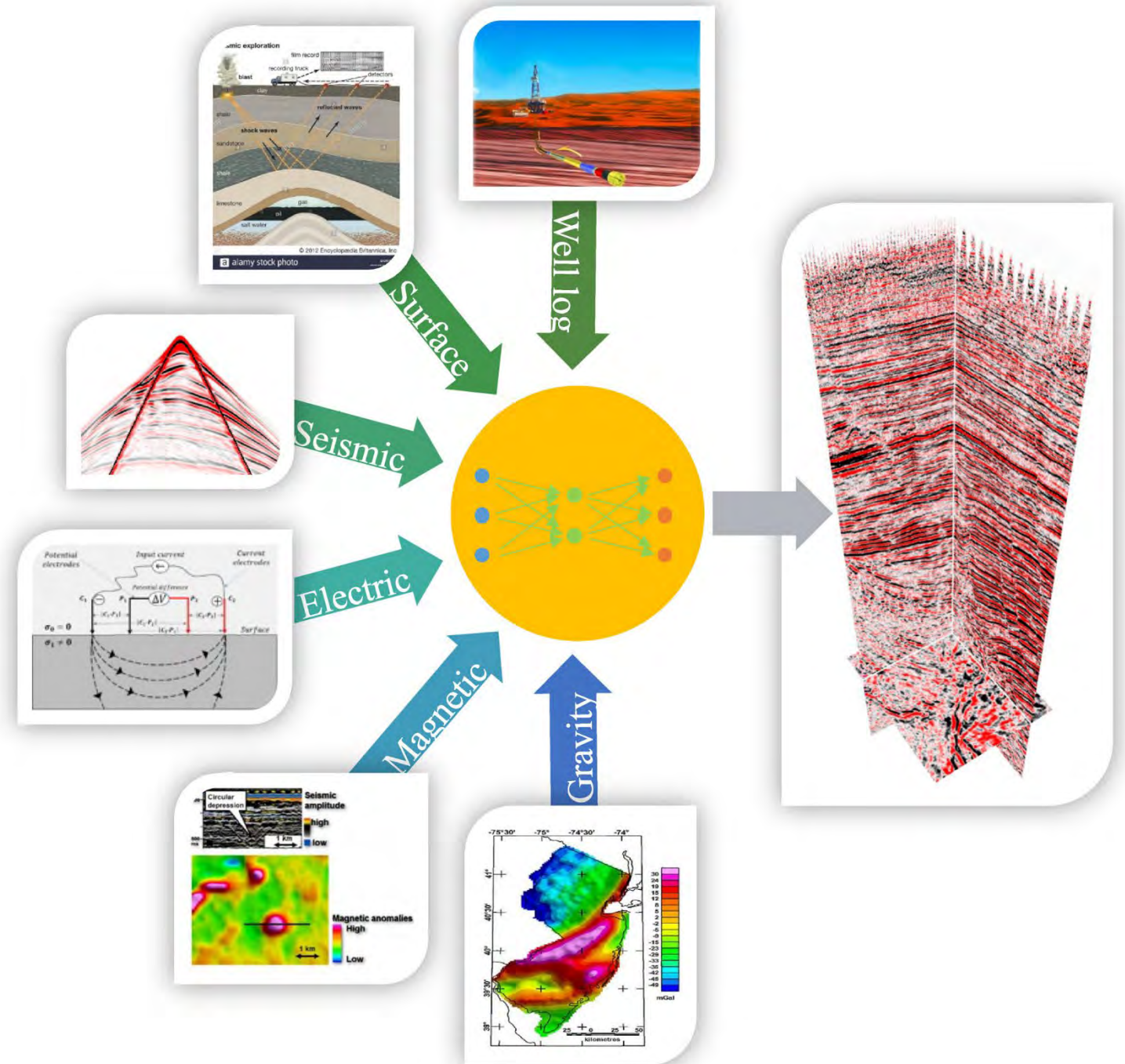


3- AI in Geophysics

Multigeophysical data

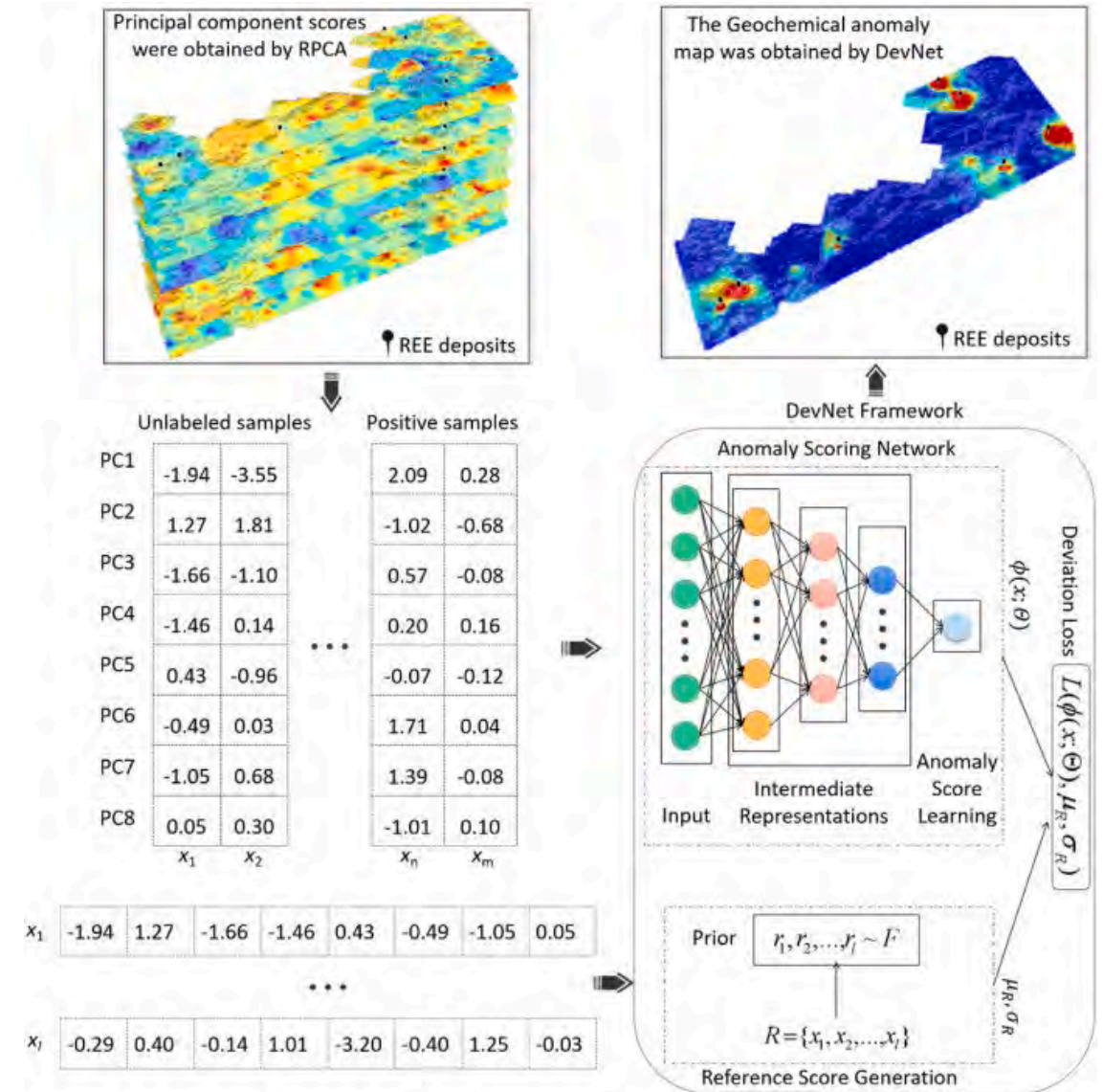
Processing

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

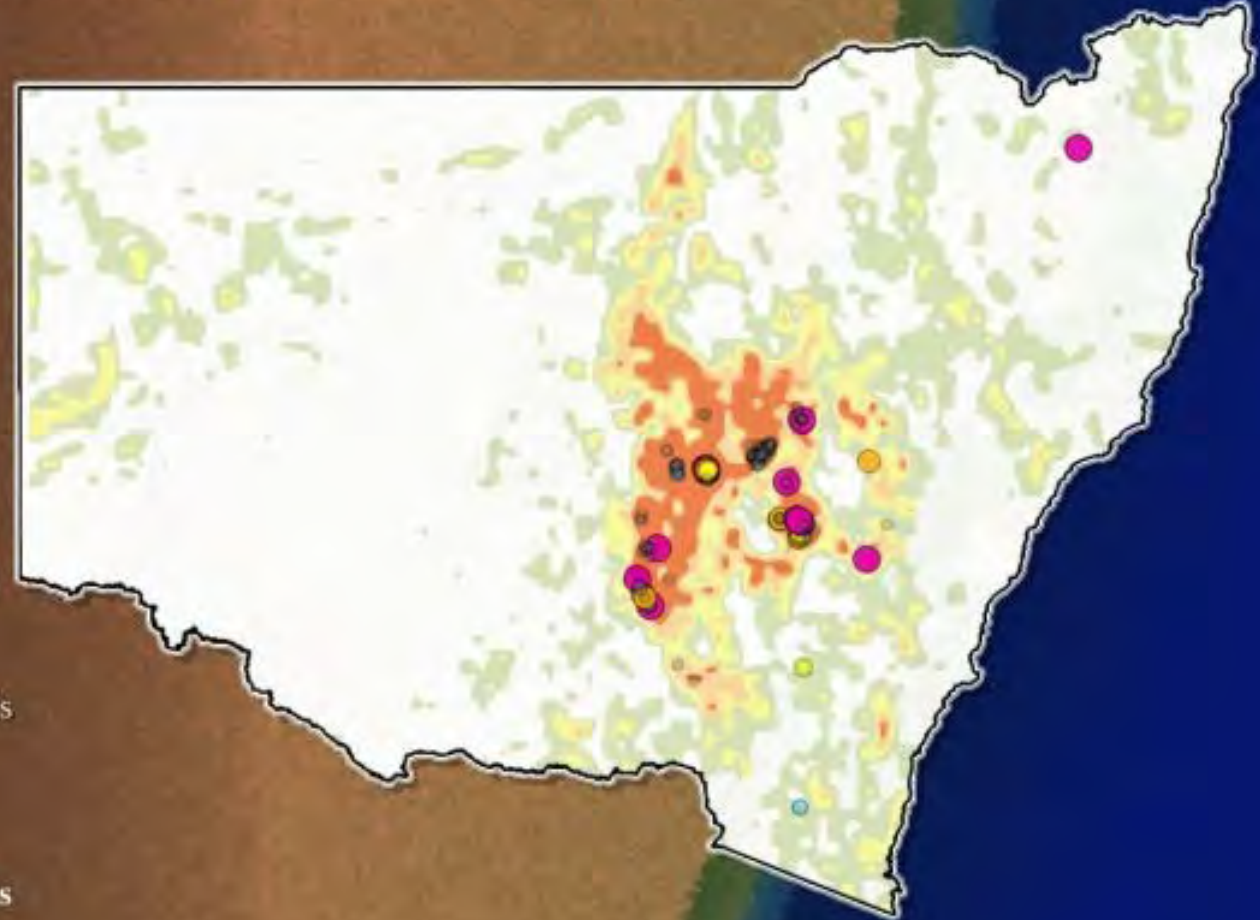
Mineral Prospectivity Mapping

Machine learning framework for prospectivity mapping of Cu–Au porphyry mineralisation in the Lachlan Fold Belt, eastern Australia

Key outcomes:

- ✓ Positive–Unlabelled Bagging and Random Forest address limited data challenges in mineral exploration.
- ✓ The model captures 95% of known mineral occurrences in 5% of the study area.
- ✓ Diverse geological, geophysical, and remote sensing datasets are integrated for precise prospectivity mapping.
- ✓ Greenfield zones and prioritised targets are delineated in the porphyry-rich Fold Belt within NSW.

Journal: **Journal of Asian Earth Sciences**



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

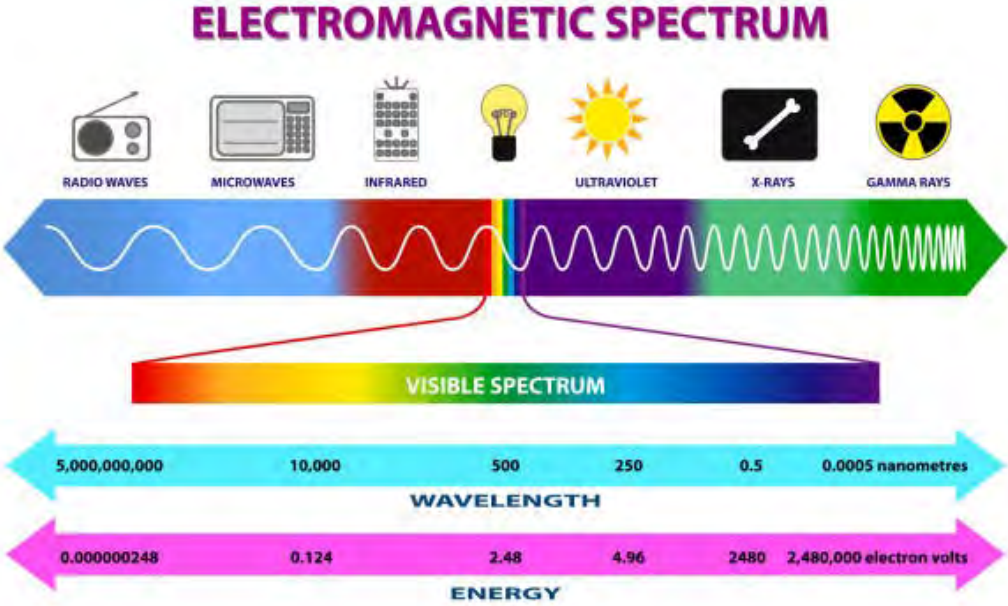
How many to choose?

With repetition ?

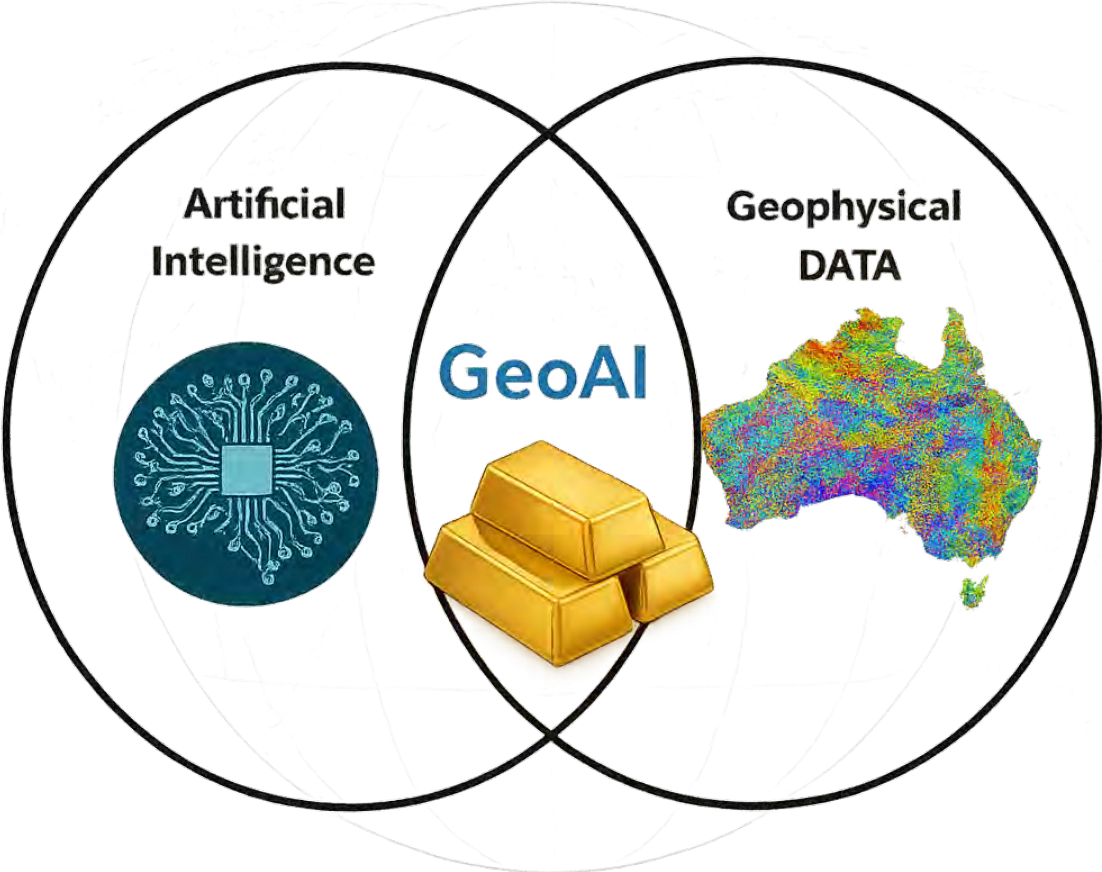
✓ Calculation results

Permutations **64,000,000**

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



5- Real-world Case Studies

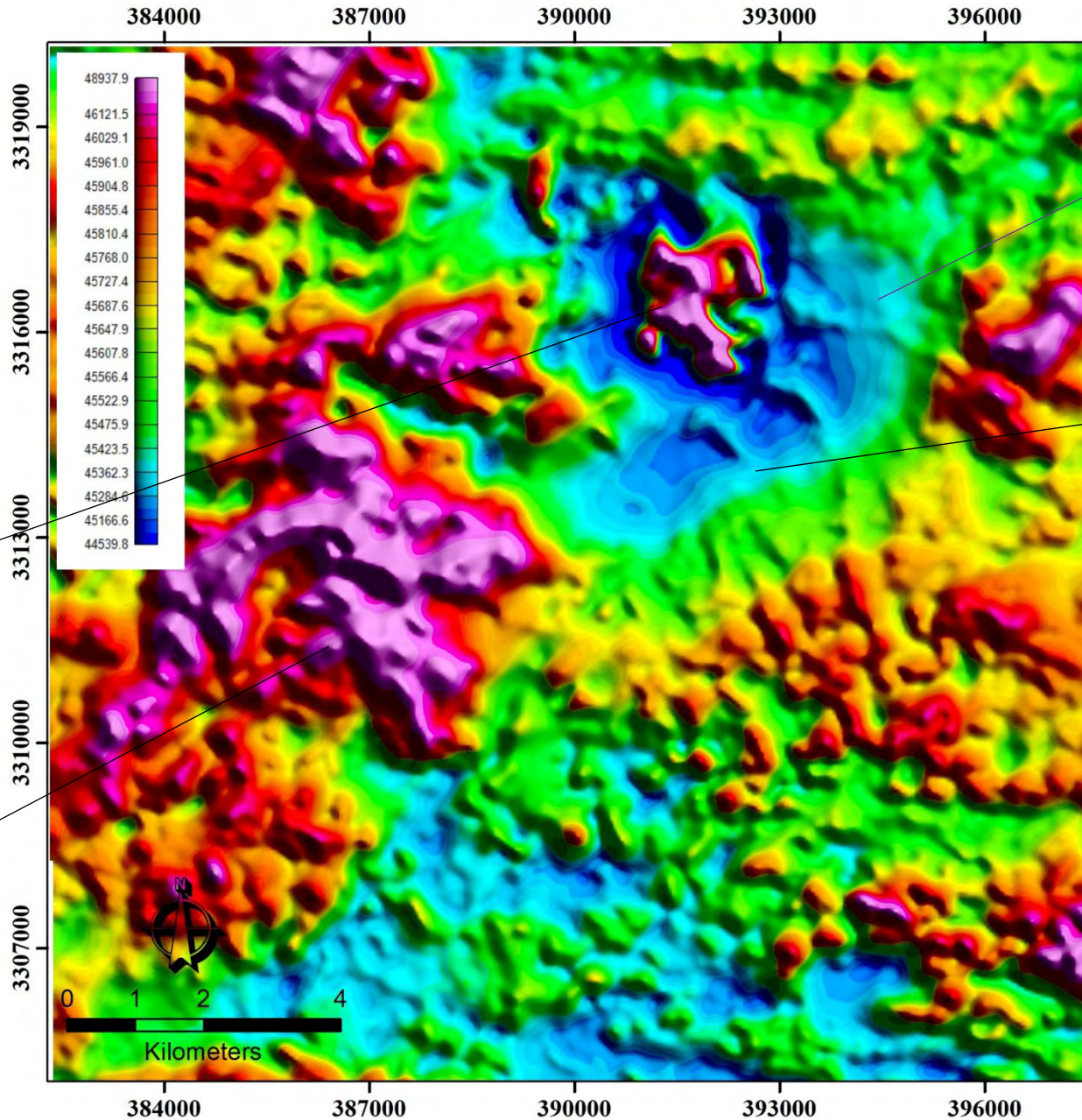


Case Study 1

Reduction to Pole

Dacite
(High Magnetization but barren)

Volcanic Rocks and Granodiorite



Newly Discovered Deposits Sereydoun

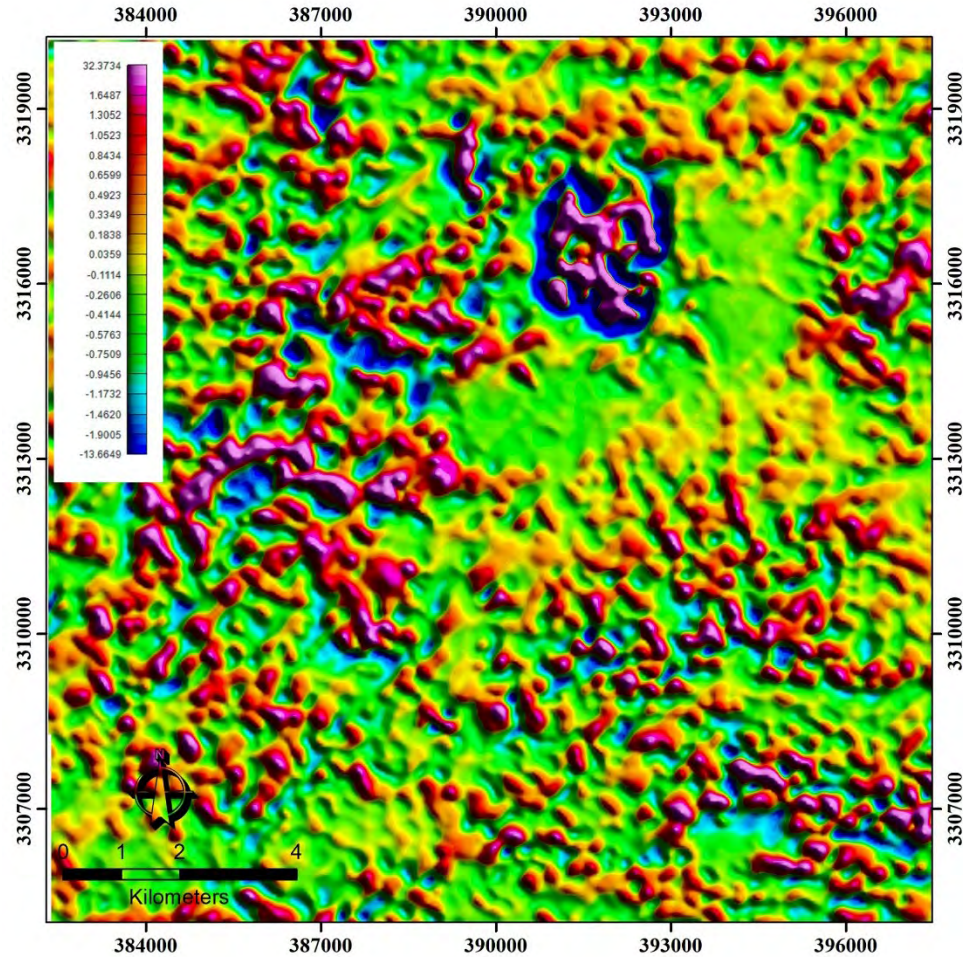
Mine Sarcheshmeh

Some proposals at that time included:
No further exploration studies are recommended!
6 drilling points up to 600 m depth without any copper result!

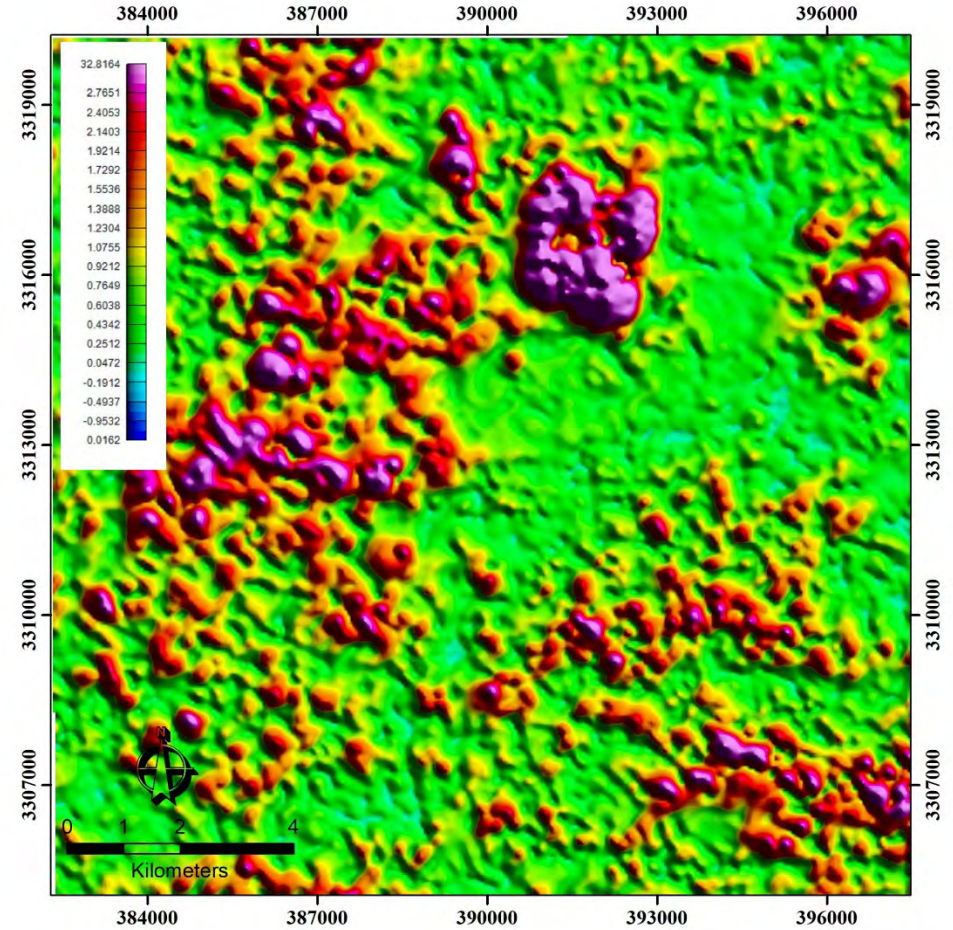
Case Study 1

Ordinary processing pathway.

Vertical Derivate



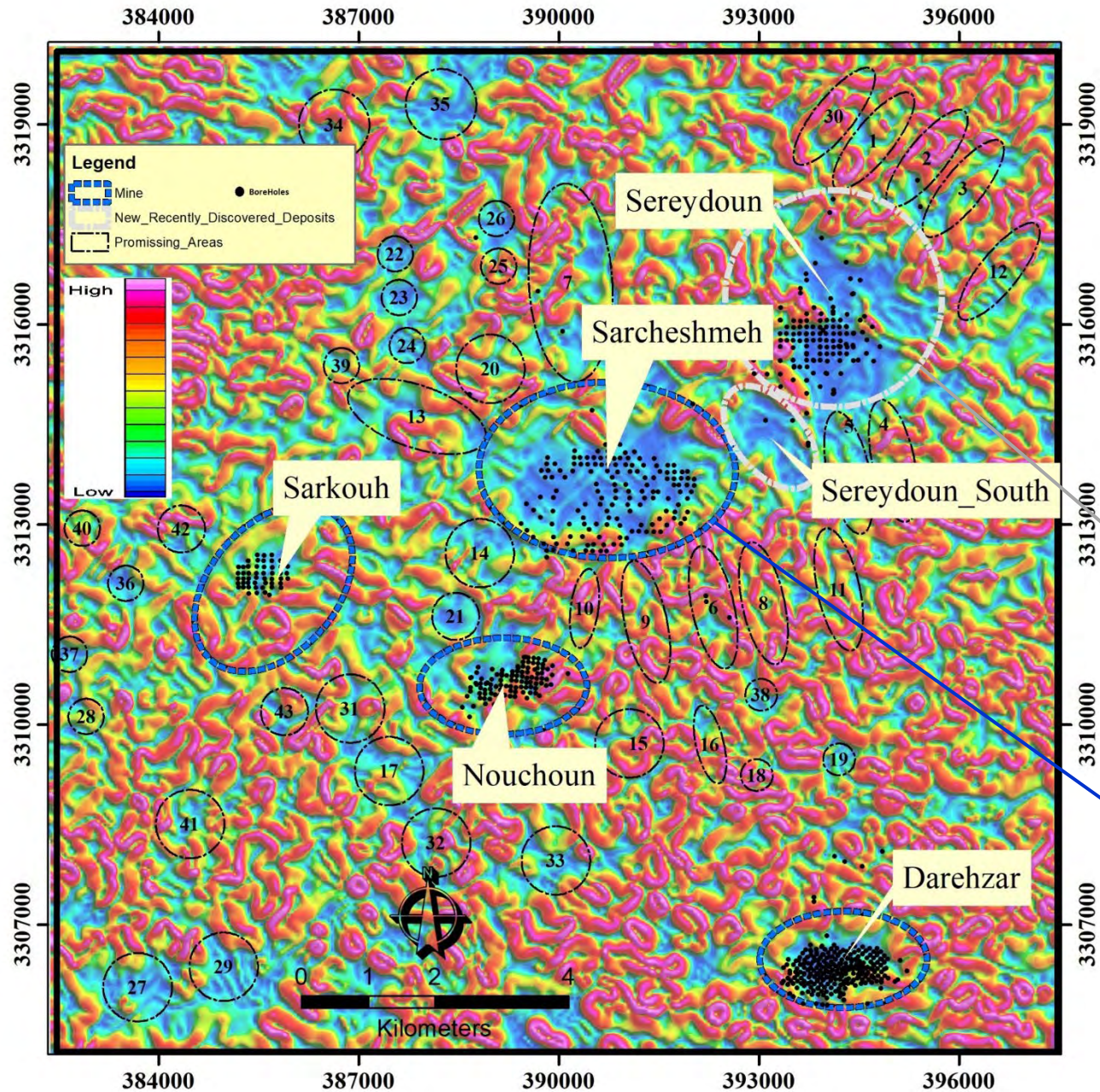
Analytic Signal



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

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

Case Study 1

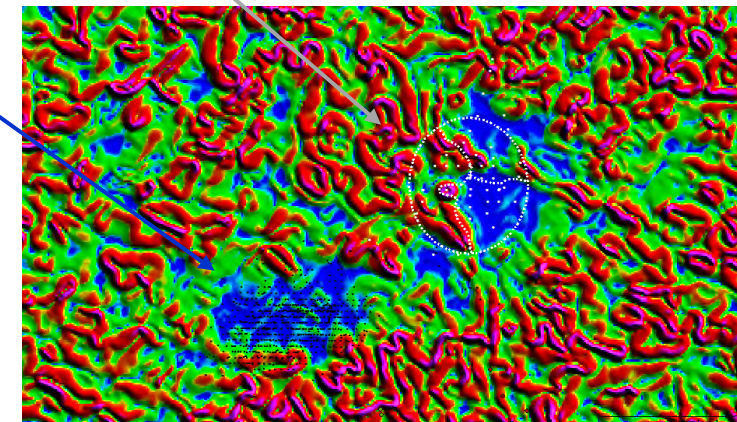


Normalised Horizontal Derivative Angle Map

Mines

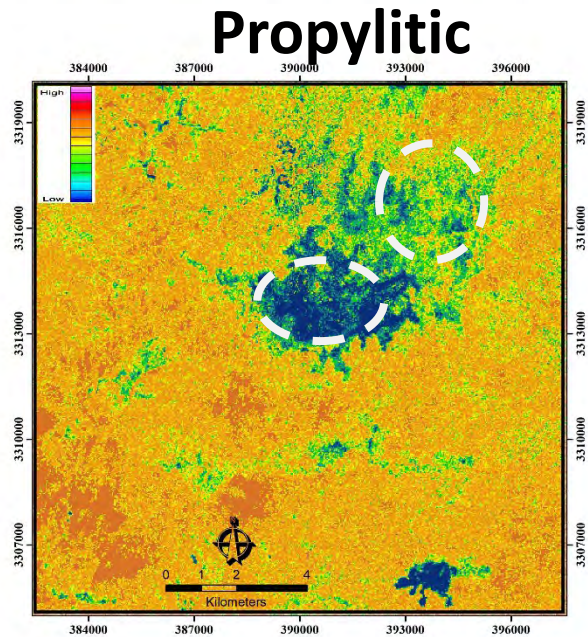
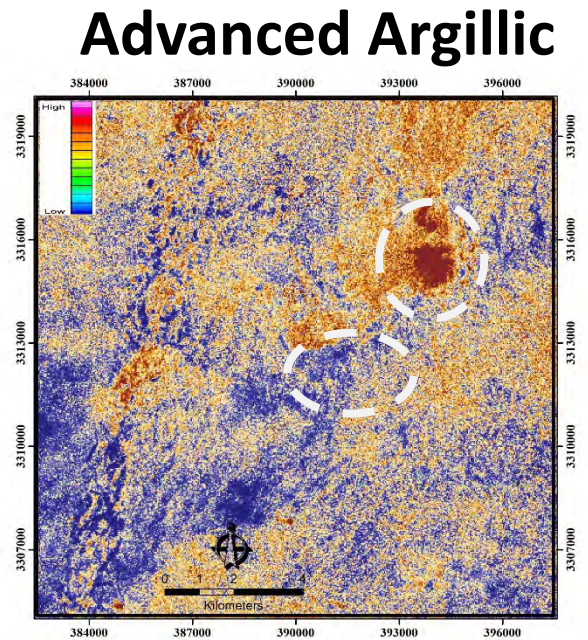
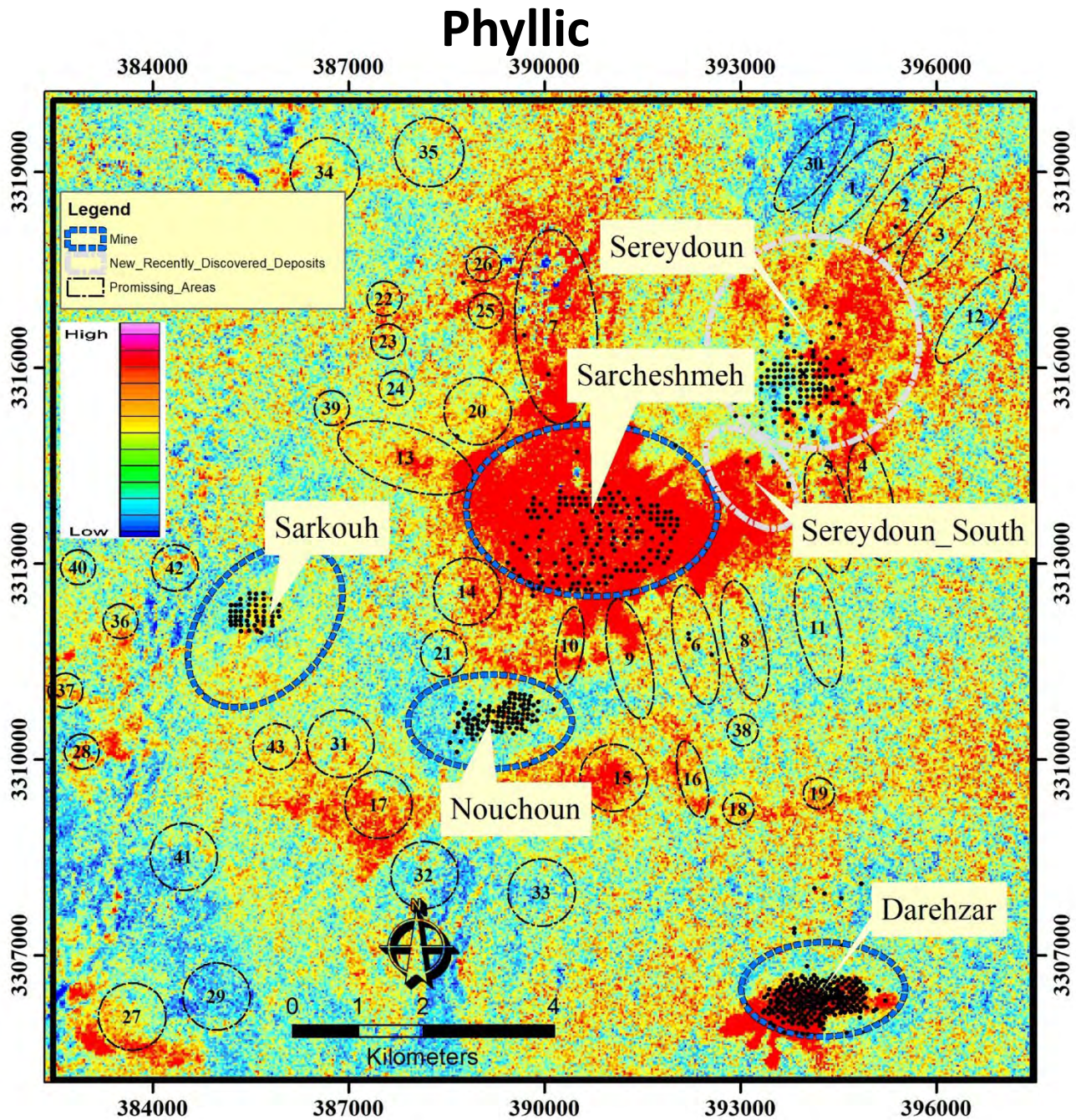
Recently discovered Deposits (Sereydoun)

Other Promising results



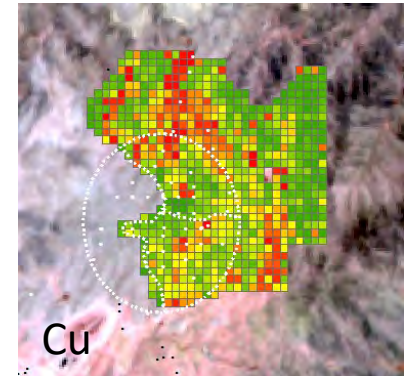
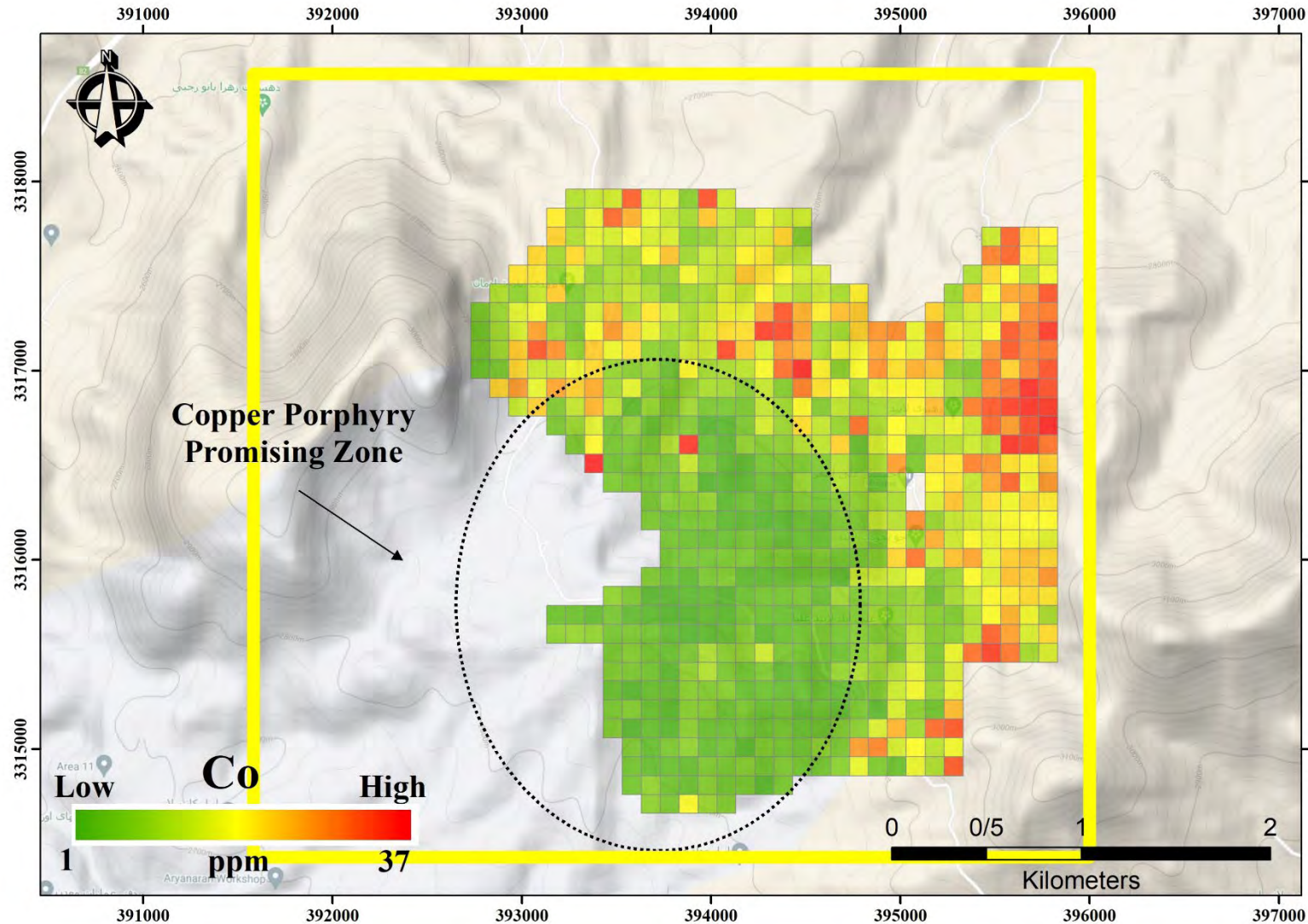
Case Study 1

AI-Driven Alteration Mapping Using ASTER Satellite Data



Case Study 1

Robust geochemical design and data processing



Elemental Enrichment and Depletion Patterns in Porphyry Copper Deposits

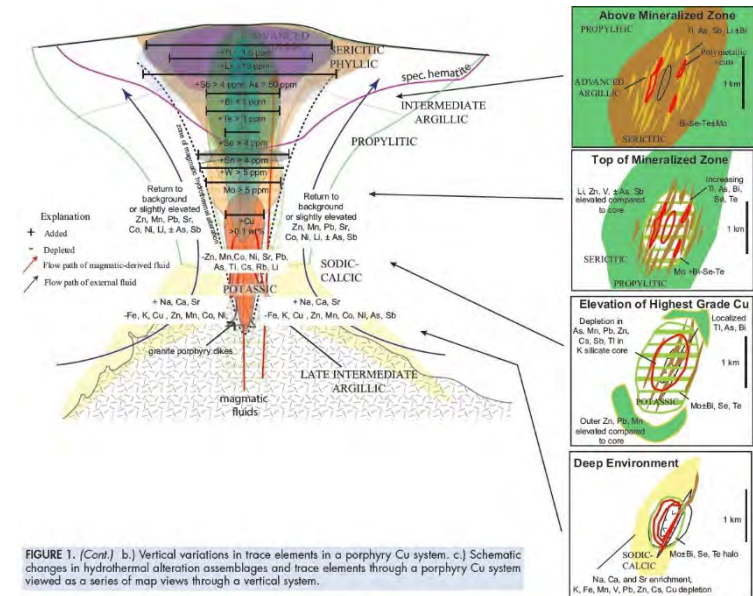
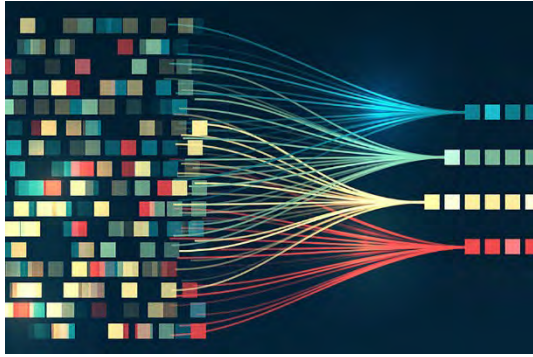
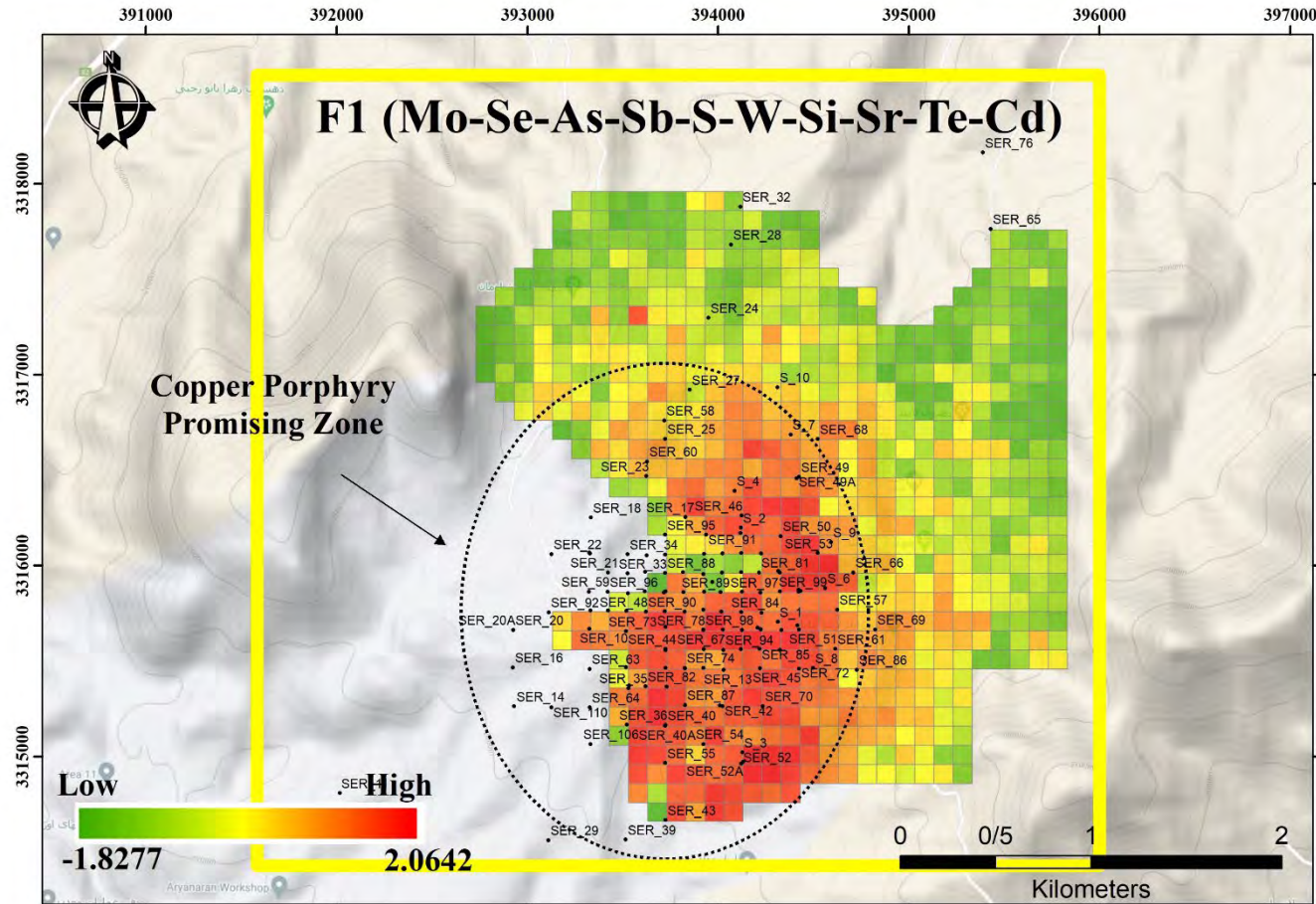


FIGURE 1. (Cont.) b.) Vertical variations in trace elements in a porphyry Cu system. c.) Schematic changes in hydrothermal alteration assemblages and trace elements through a porphyry Cu system viewed as a series of map views through a vertical system.

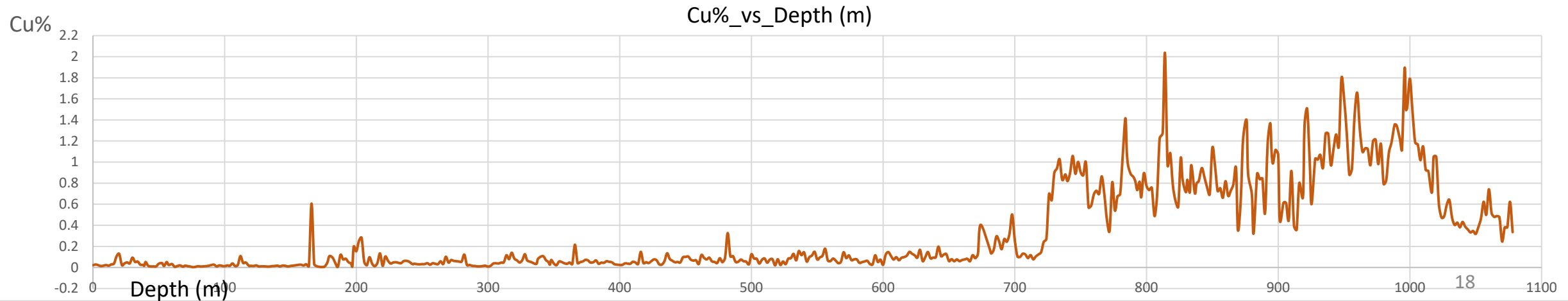
Case Study 1



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.



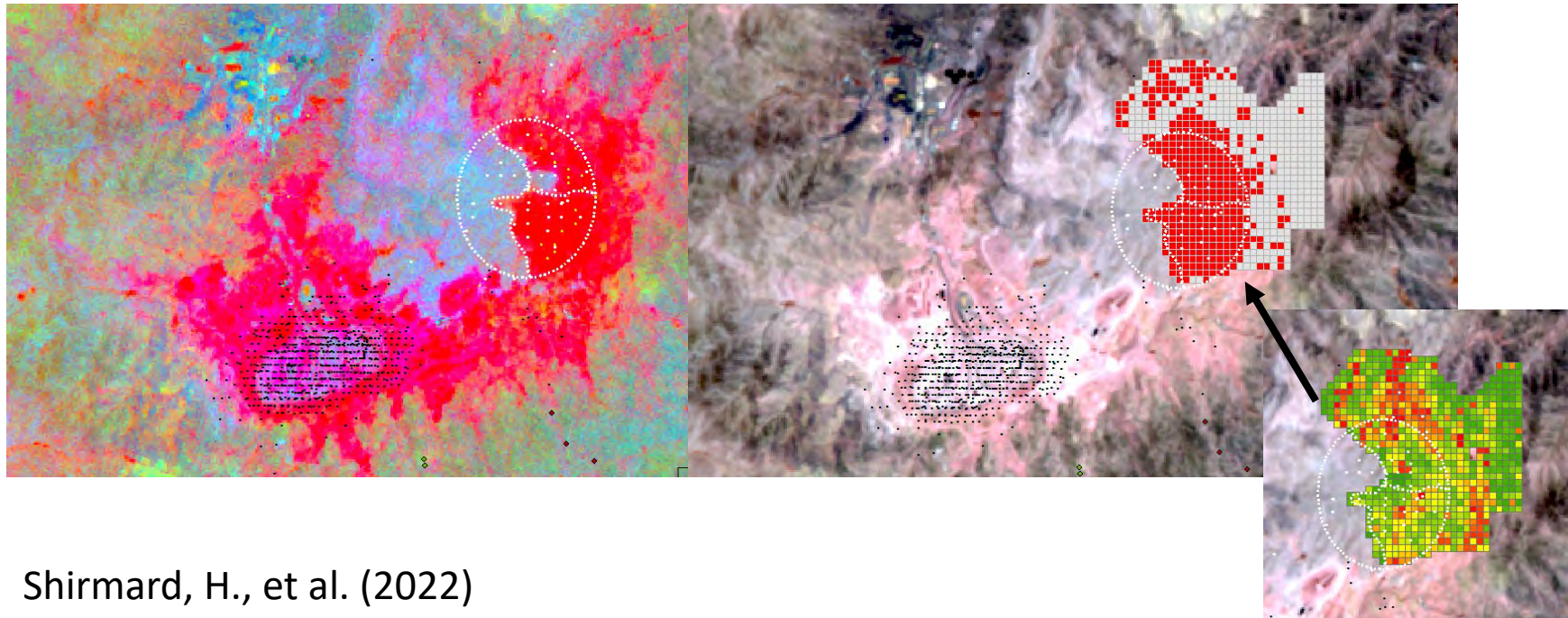
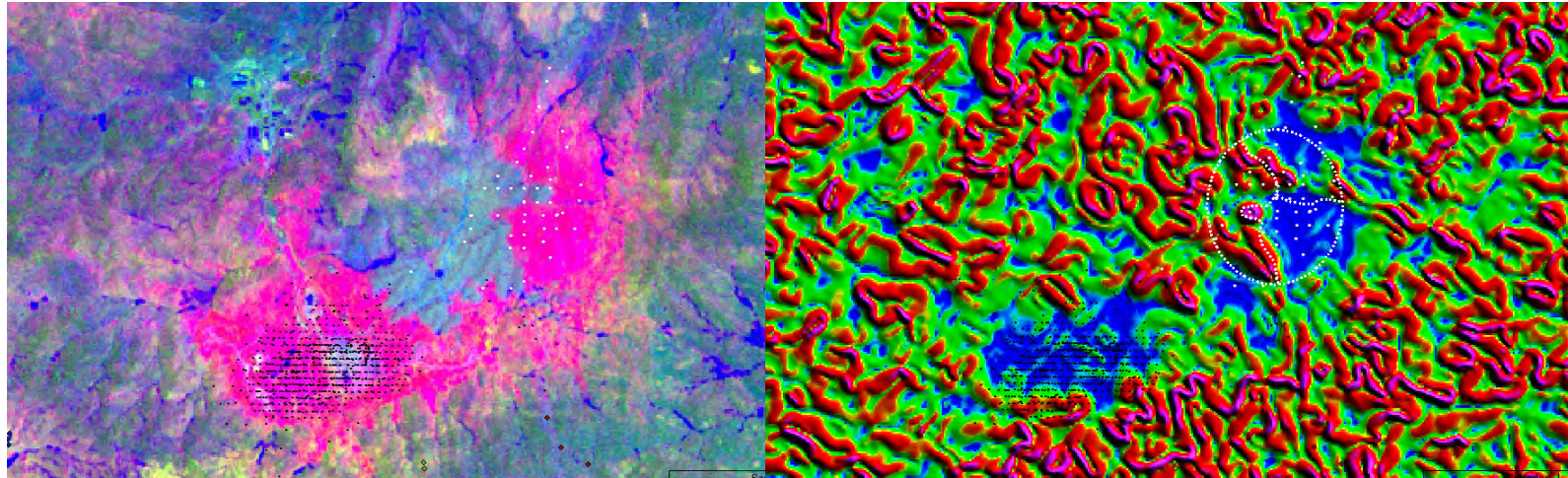
After drilling more than 100,000 meters of exploration boreholes, the reserve is approximately **3.5 billion tons of copper**, with an average grade of **0.4%**, and a cutoff grade of **0.15%**.



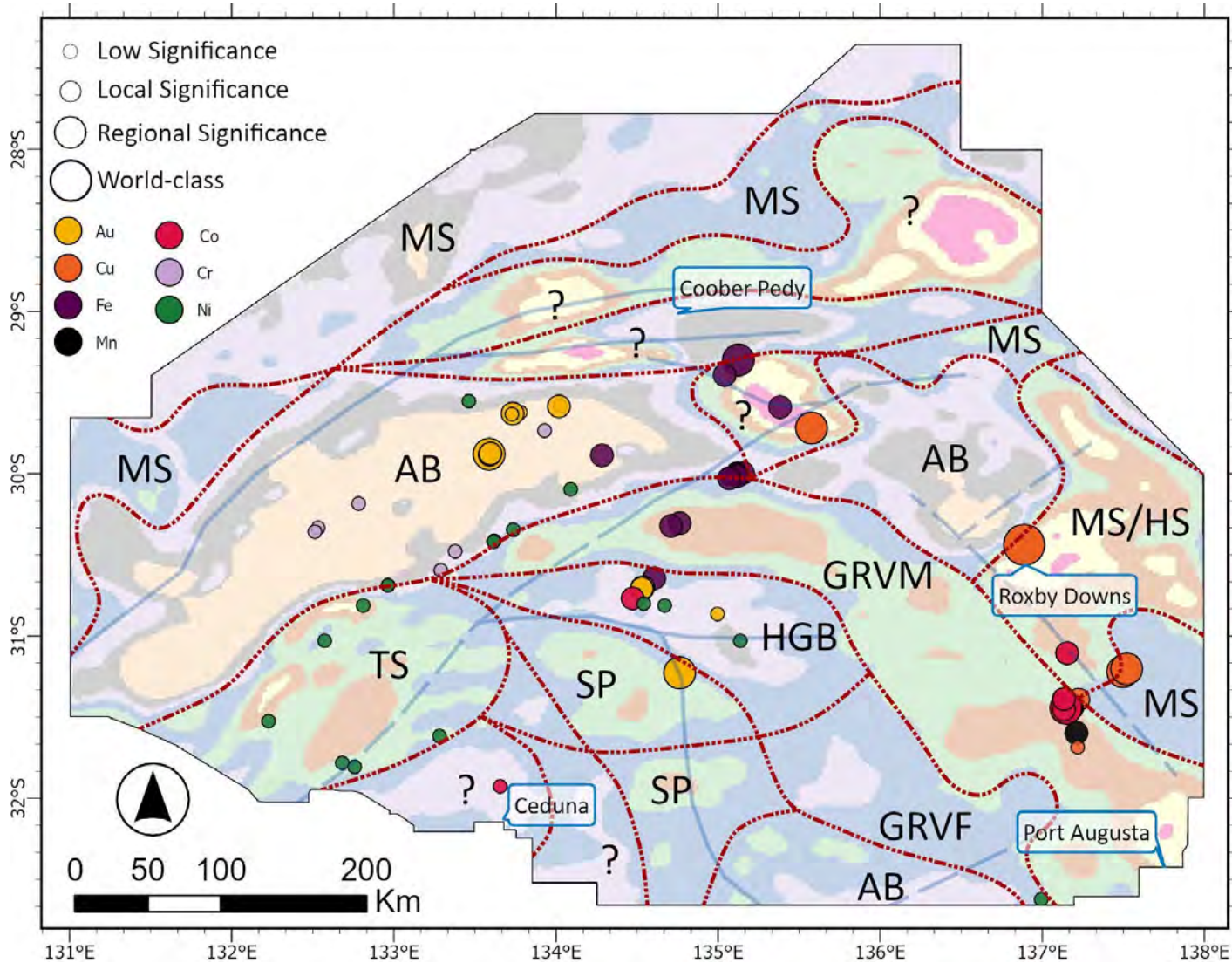
Several porphyry and epithermal copper-gold potential regions were also identified for further investigation.



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

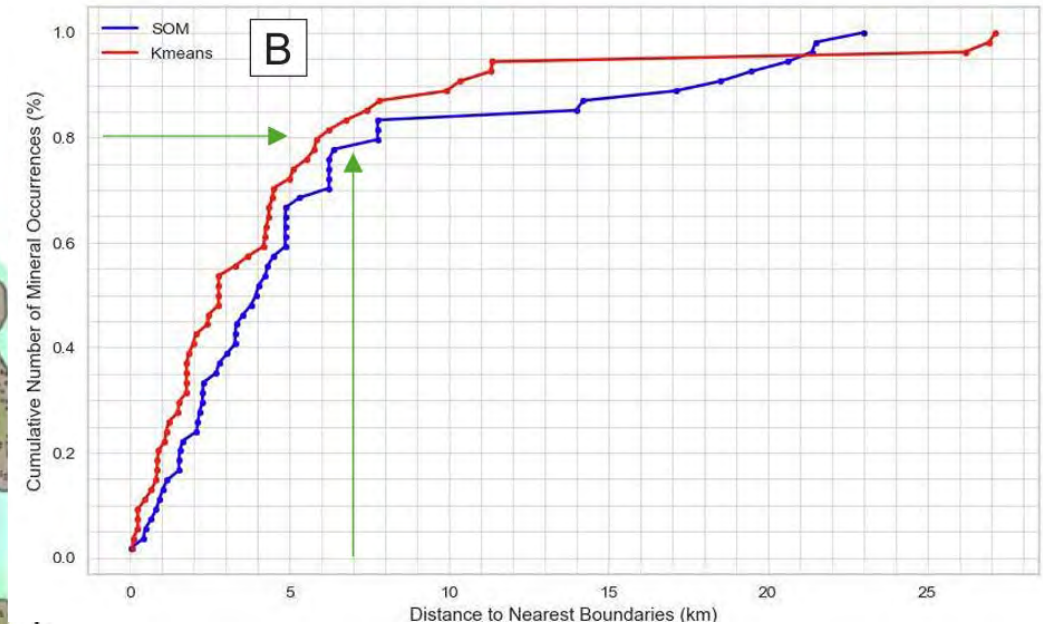
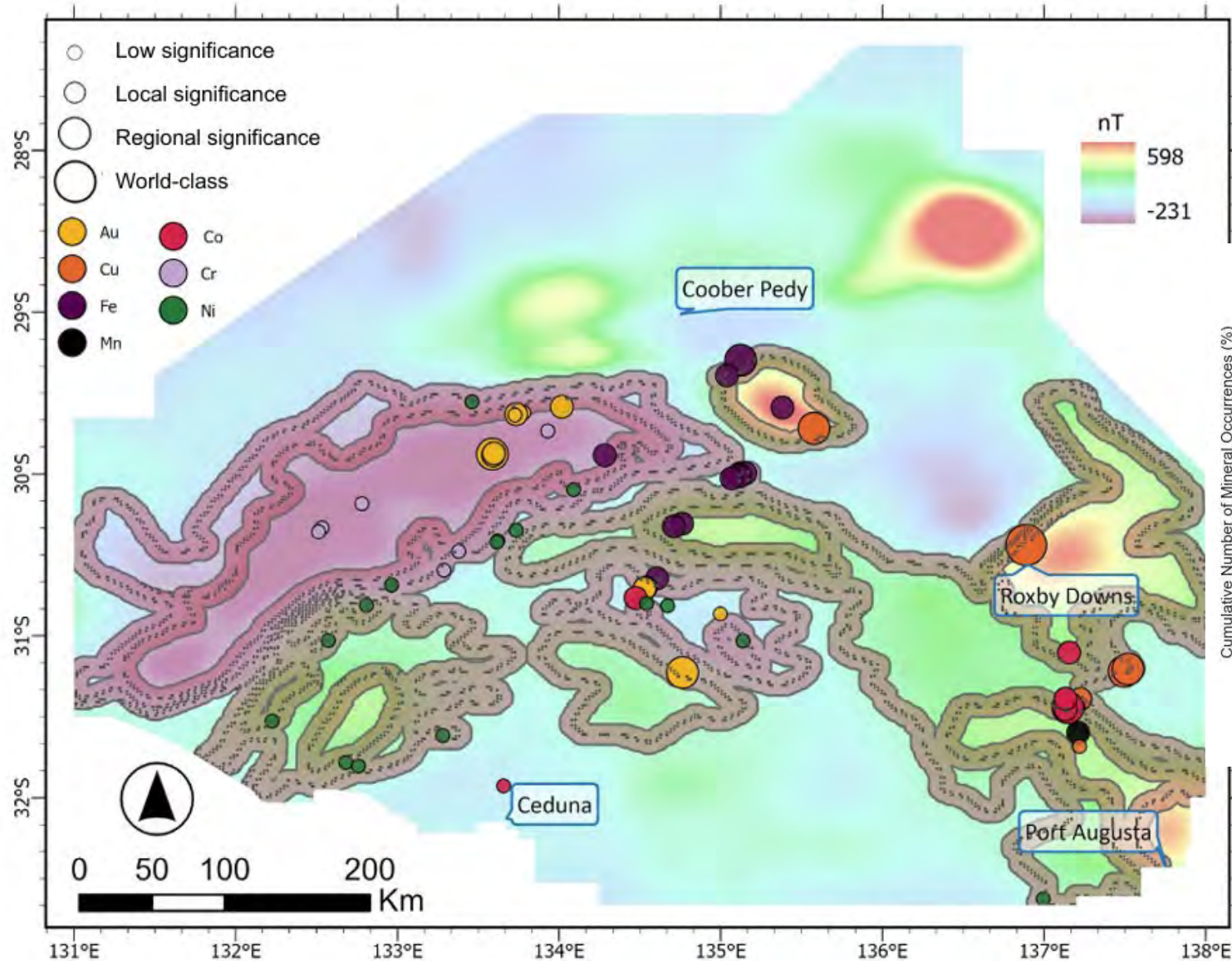


Case Study 2: Regional Data Engineering for MPM in Gawler Craton, South Australia (New Structural Map)



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

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



Takeaways

Using AI in mineral exploration is inevitable, but:

Artificial intelligence
needs real intelligence
behind it



AI should not be
Used as a black box



Data engineering is both
a science and an art.



The quality of the data
and how we use it
determine the quality
of the results.





Thank you!

Hojat Shirmard



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Ehsan Farahbakhsh



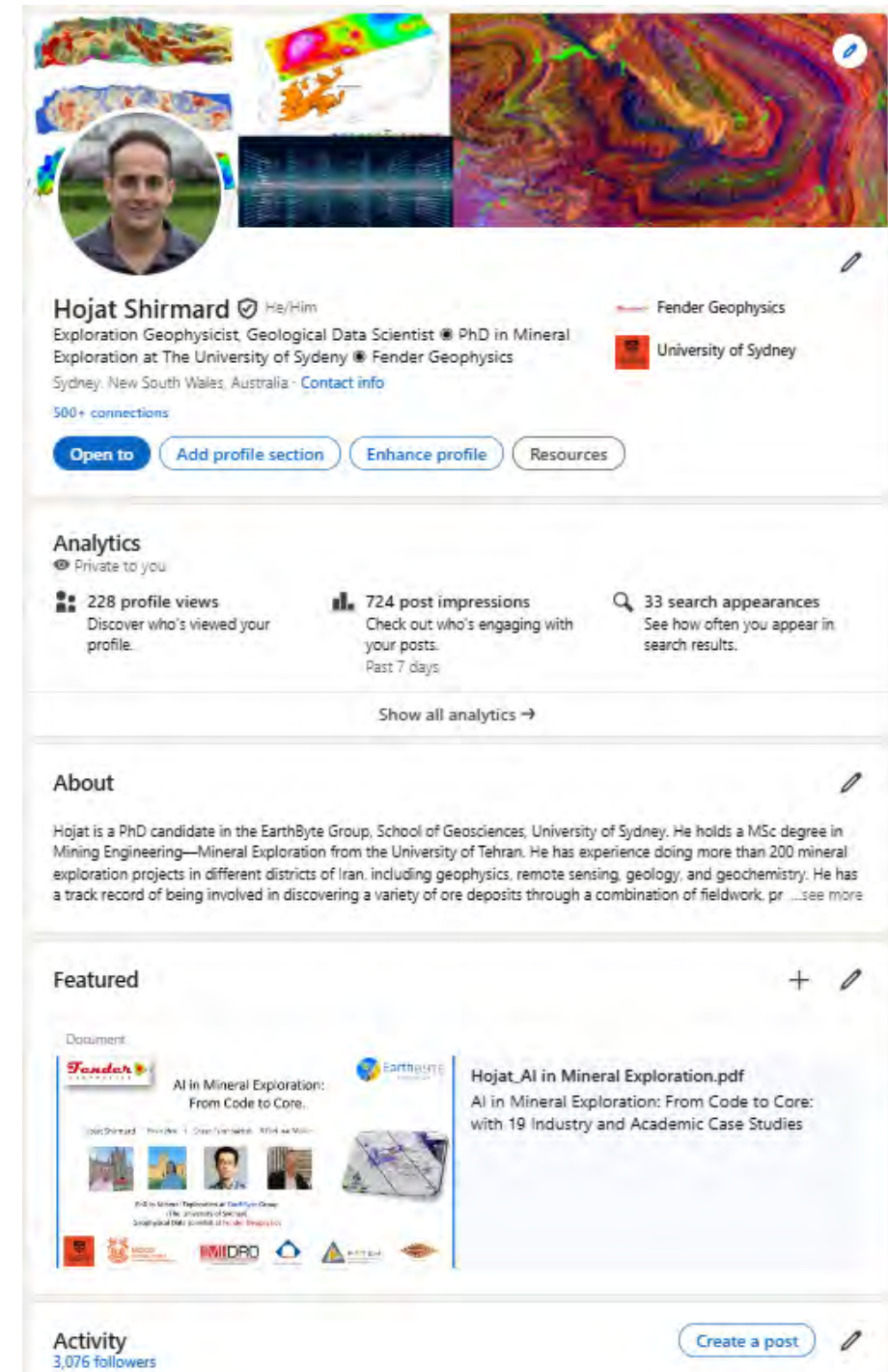
R Dietmar Müller



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More Industry Case Studies!

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-
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About

Hojat is a PhD candidate in the EarthByte Group, School of Geosciences, University of Sydney. He holds a MSc degree in Mining Engineering—Mineral Exploration from the University of Tehran. He has experience doing more than 200 mineral exploration projects in different districts of Iran, including geophysics, remote sensing, geology, and geochemistry. He has a track record of being involved in discovering a variety of ore deposits through a combination of fieldwork, pr...see more

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Fender Geophysics AI in Mineral Exploration: From Code to Core.

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AI in Mineral Exploration: From Code to Core: with 19 Industry and Academic Case Studies

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