

# Alternate uses for map2loop/model outputs

## An iron ore prospectivity example

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6IAS  
3D modelling and Loop workshop

Saturday 22<sup>nd</sup> July, 2023

# Acknowledgements

MRIWA Project 557 “Iron Ore – Hamersley Province, WA”



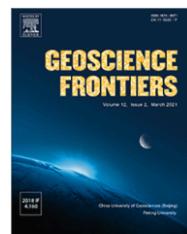
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Research Paper

Assessing the impact of conceptual mineral systems uncertainty on prospectivity predictions

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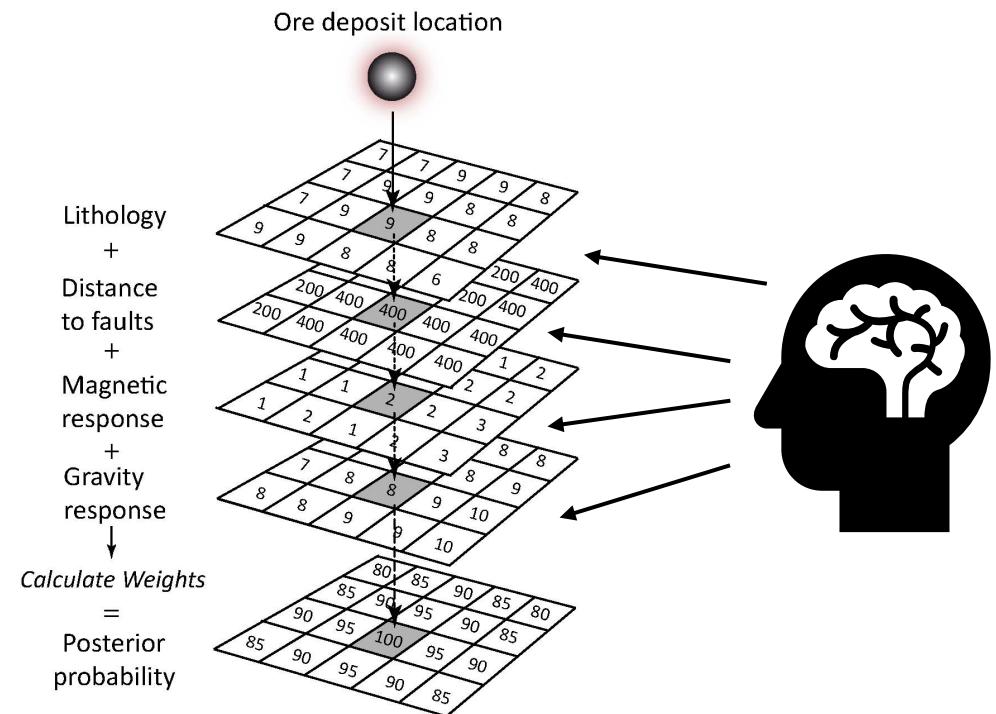
# Concepts to models

- Mineral exploration begins with:
  1. Business strategy
  - 2. Creation/application of targeting model**
  3. Follow-up detection in high priority domains

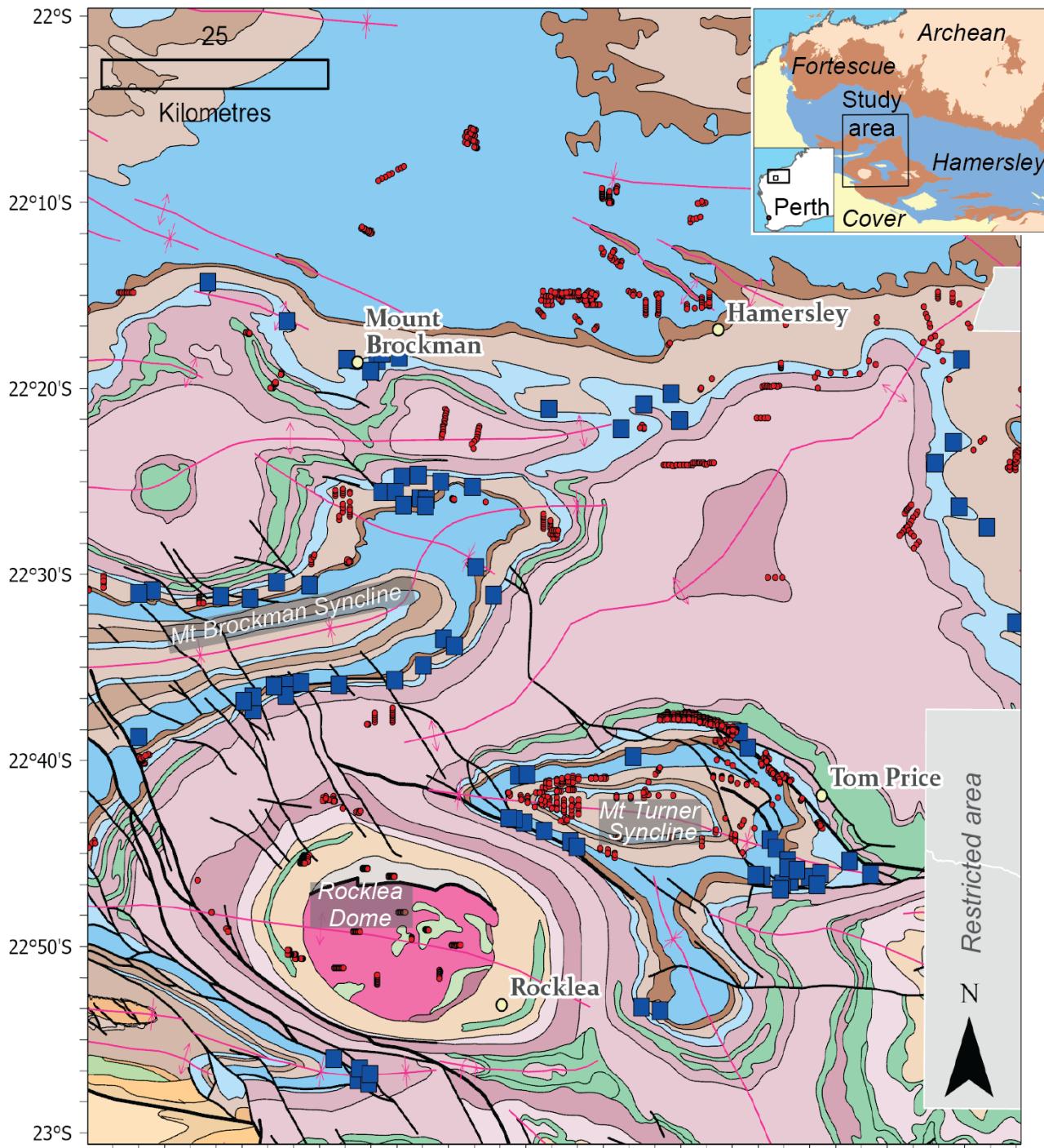
Geoscience challenge:  
Conceptual targeting ->

1. De-risk
2. Cost-effective detection

- Codifying exploration knowledge
- Tacit -> models

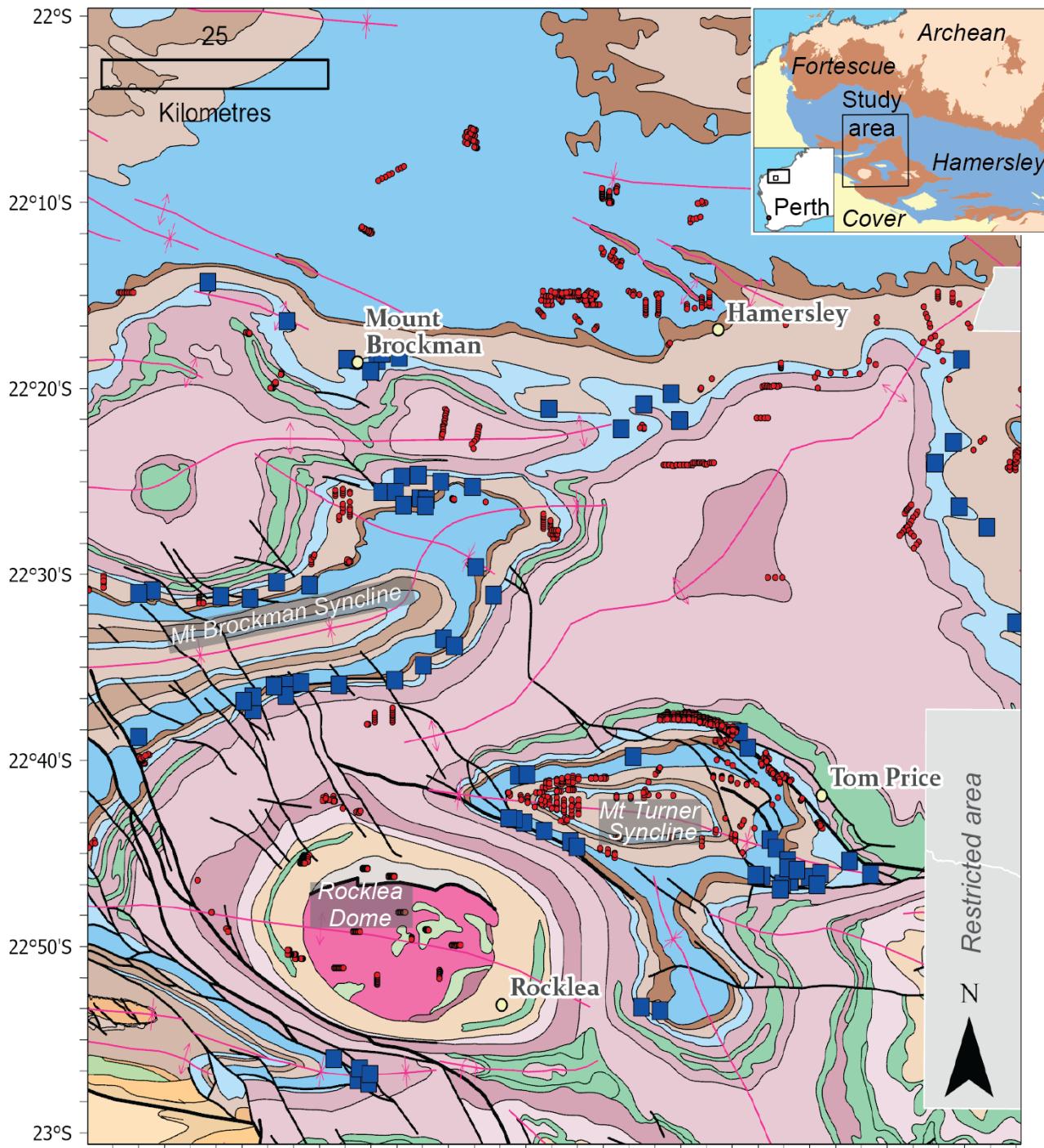


# Geological Context



- Pilbara Craton, Western Australia
- Mt Bruce Supergroup overlying Archean gneisses / greenstones
- Hamersley Group
- Marra Mamba / Brockman Iron Formations - ~ 50B Tonnes
- Deformation more intense to south

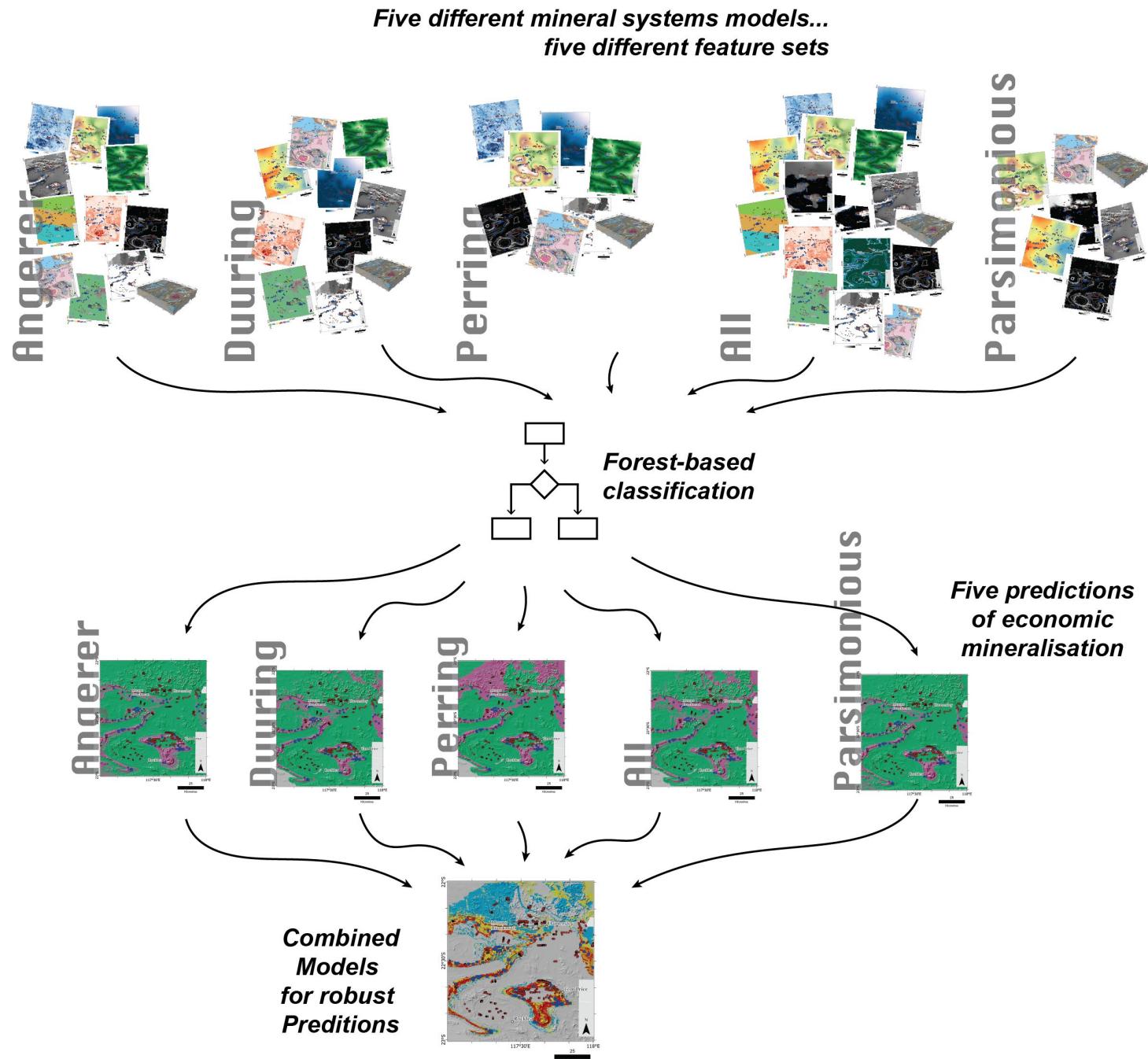
# Training Set



- Deposit (positive evidence)
- Drilling (negative evidence)

Careful QAQC on deposit and drilling locations

# Multiple concepts, Multiple models



Model	Features (exploration criteria)	Concept
Angerer et al. (2015)	10	Broad synthesis of BIF-hosted Fe Ore, Hamersley and Yilgarn
Duuring et al (2016; 2021)	9	Multistage hypogene & supergene geothite / hematite
Perring et al (2020)	7	Martite-geothite specific to local region. Three stage fluid and mass flux
All	14	All available features
Parsimonious	6	The 'top-six' features

**This is an exercise in understanding how conceptual models drive feature selection, and impact on feature and model performance**

**This is *not* an exercise in falsifying conceptual models, or establishing which is 'best'**

# Models

## Forest-based classification

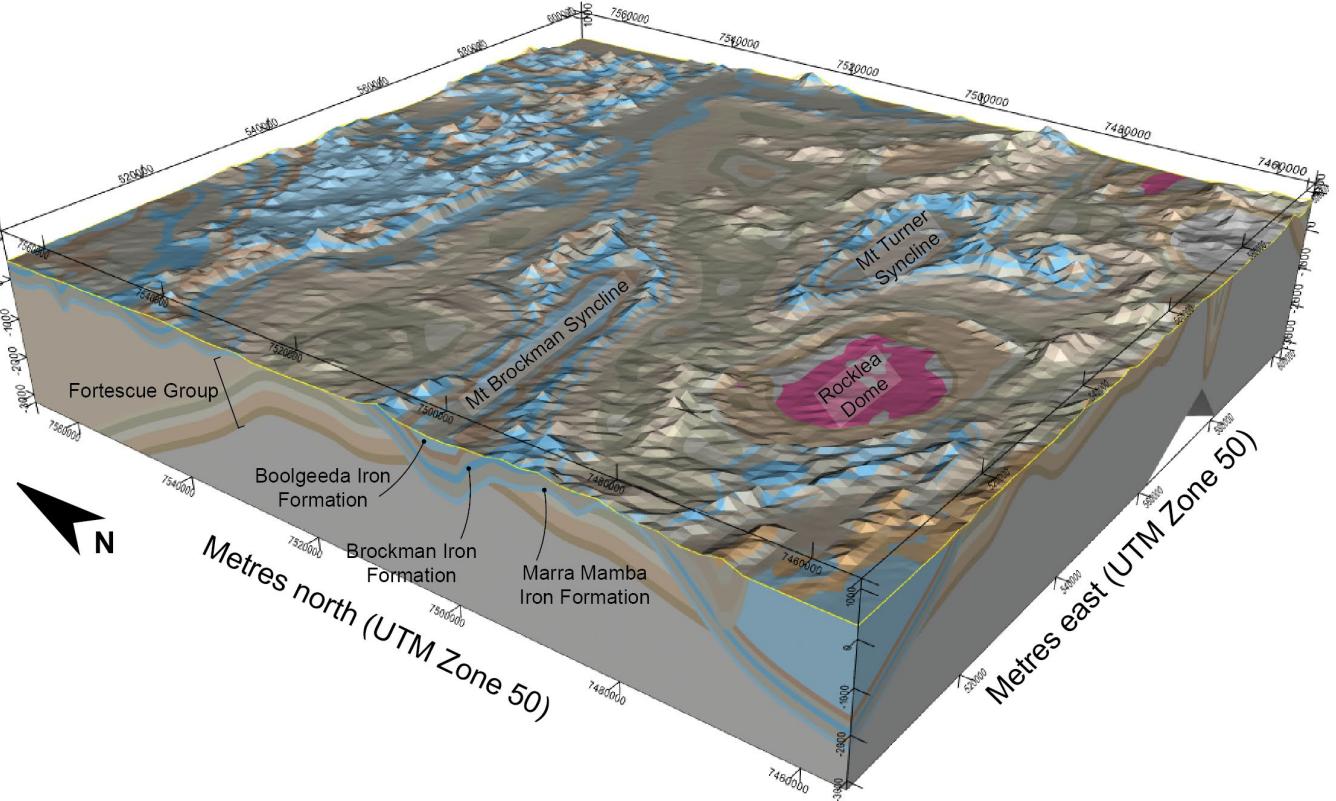
Deposit locations  
(Positive examples)

Gravity  
 $\leq 1000 \mu\text{m}/\text{s}^2$   
False: 10, True: 90

RTP  
 $\leq 10\text{k nT}$   
False: 0, True: 10

Distance from fault  
 $\leq 5 \text{ eK \%}$   
False: 35, True: 55

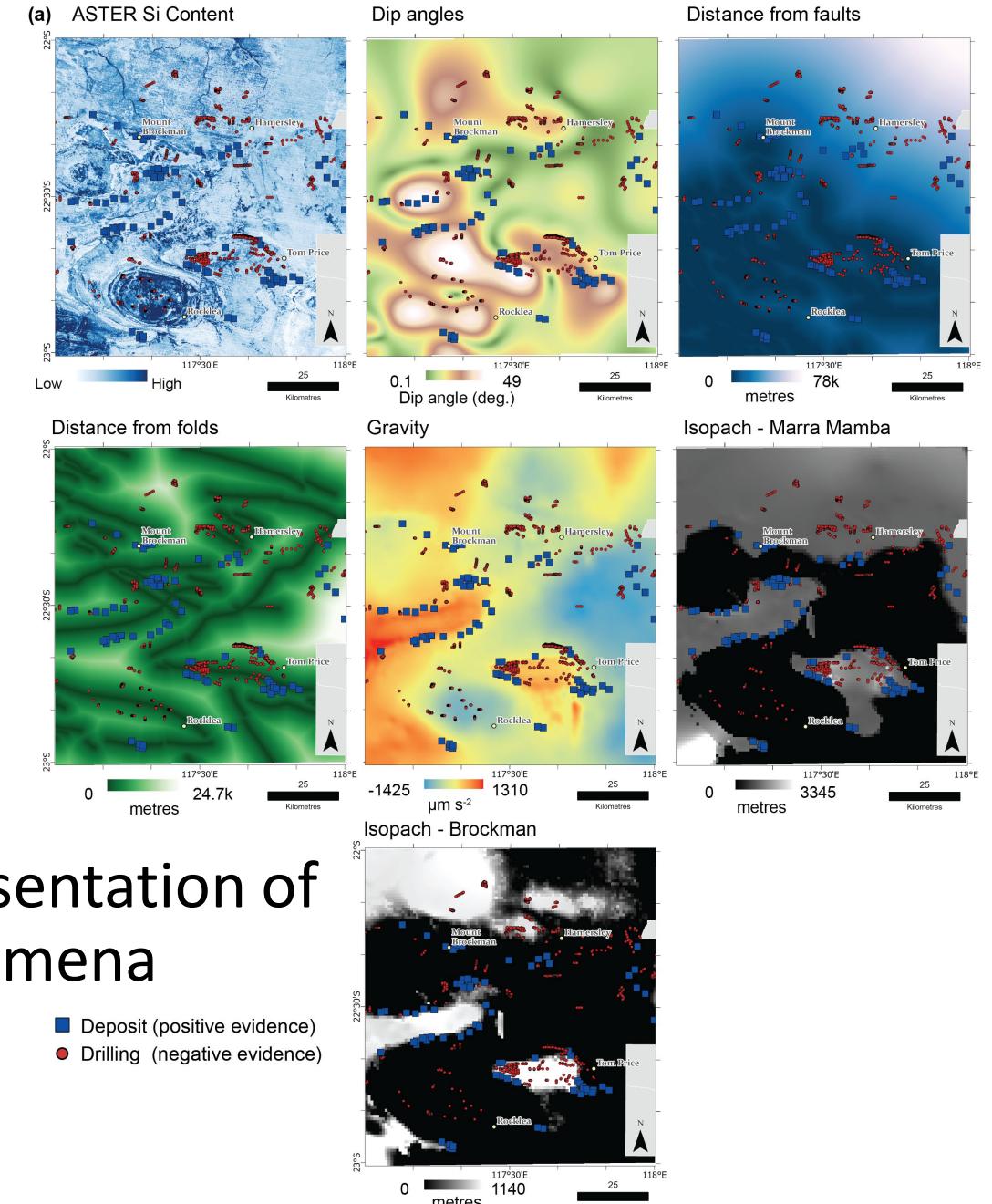
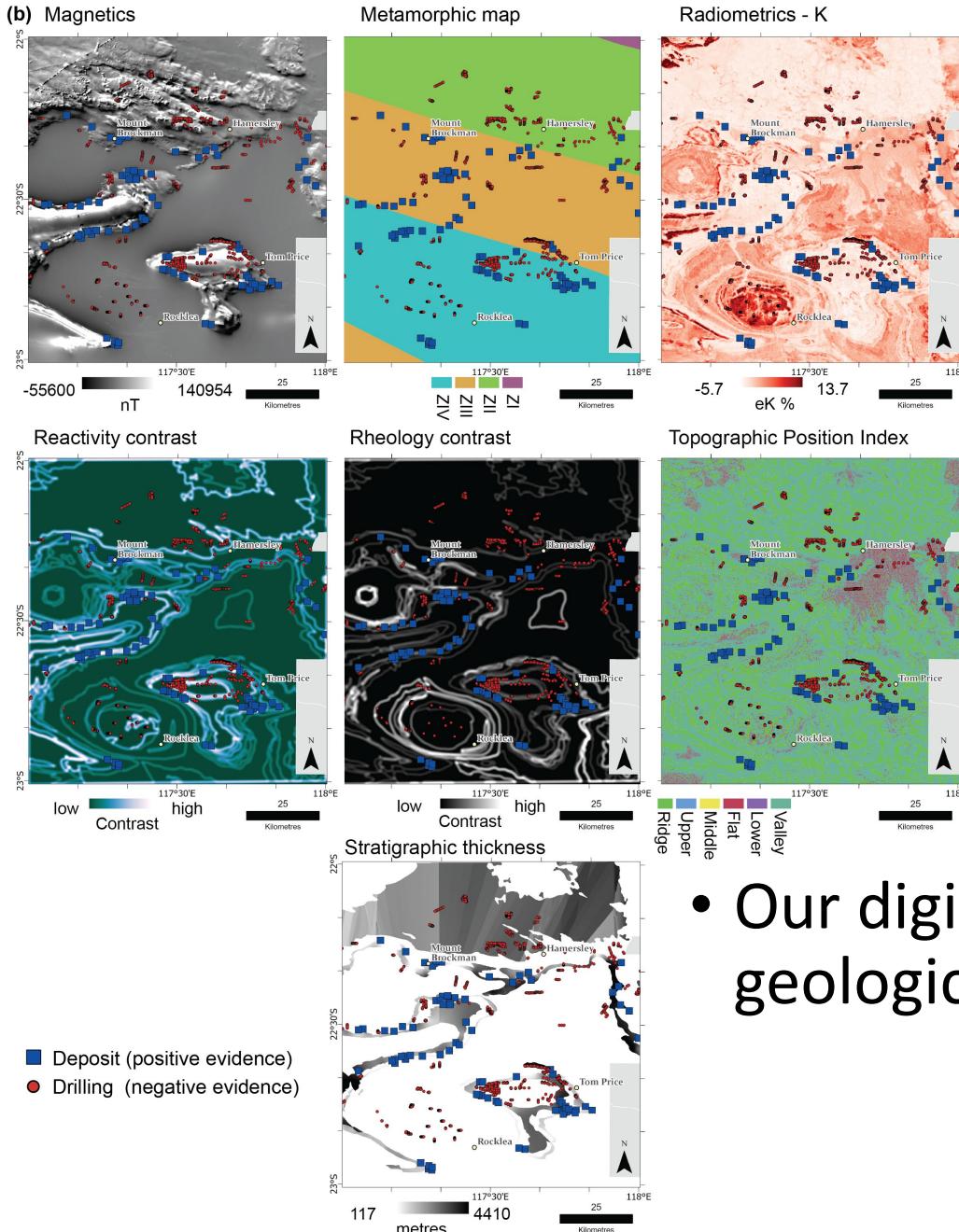
Elevation (metres)



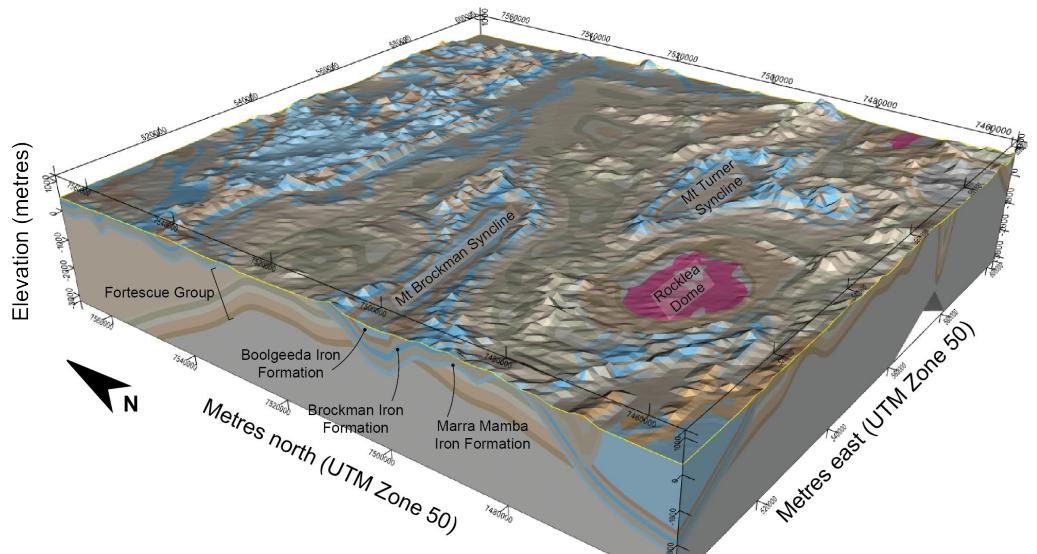
*map2loop / map2model*

- Dip angles
- Isopach thickness
- Stratigraphic thickness

# Features

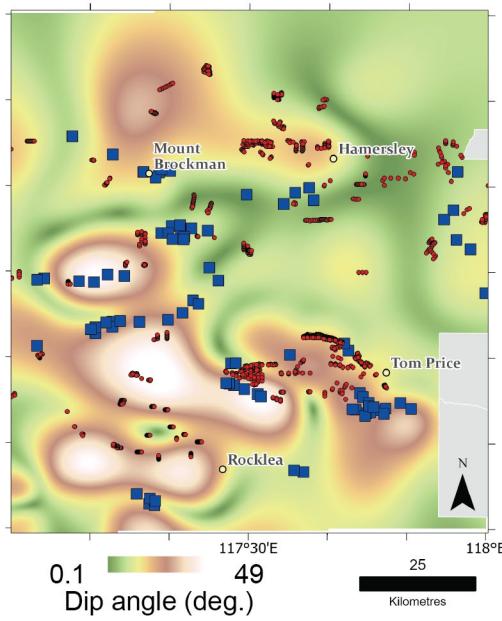


- Our digital representation of geological phenomena

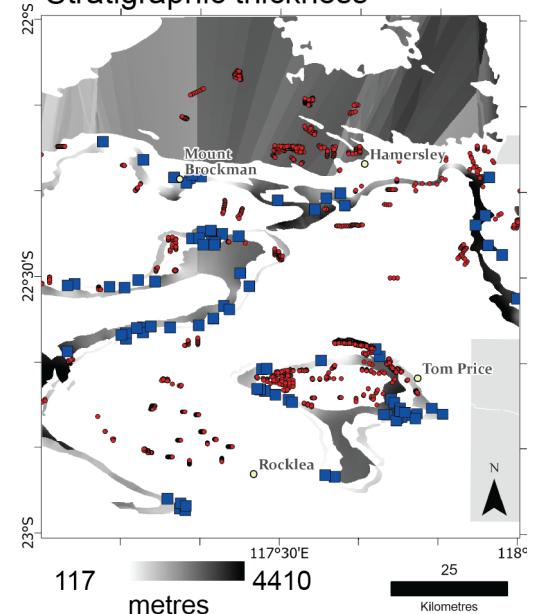


- Deposit (positive evidence) (Blue square)
- Drilling (negative evidence) (Red circle)

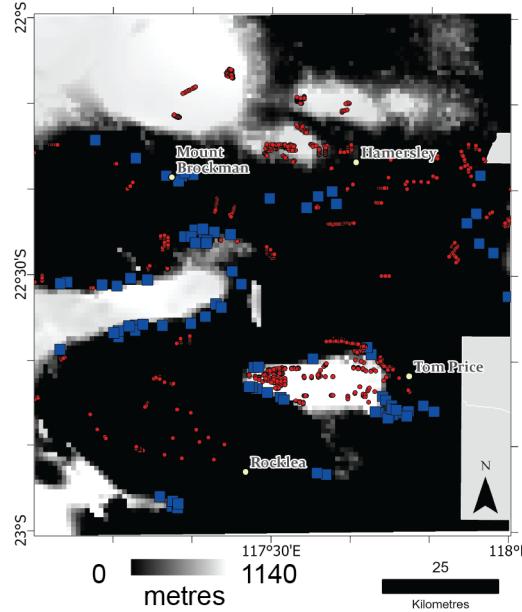
### Dip angles



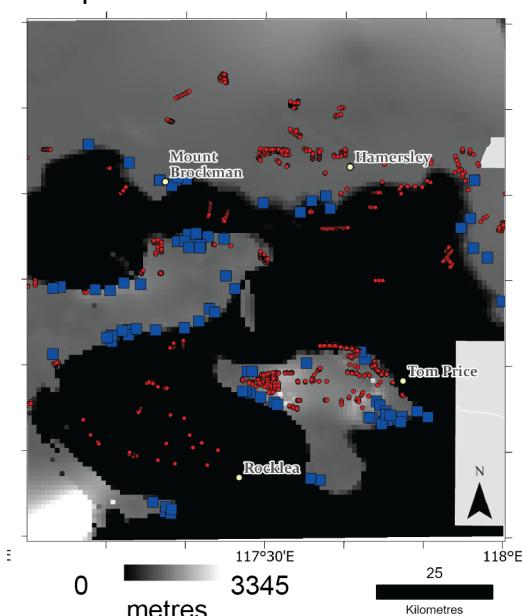
### Stratigraphic thickness



### Isopach - Brockman

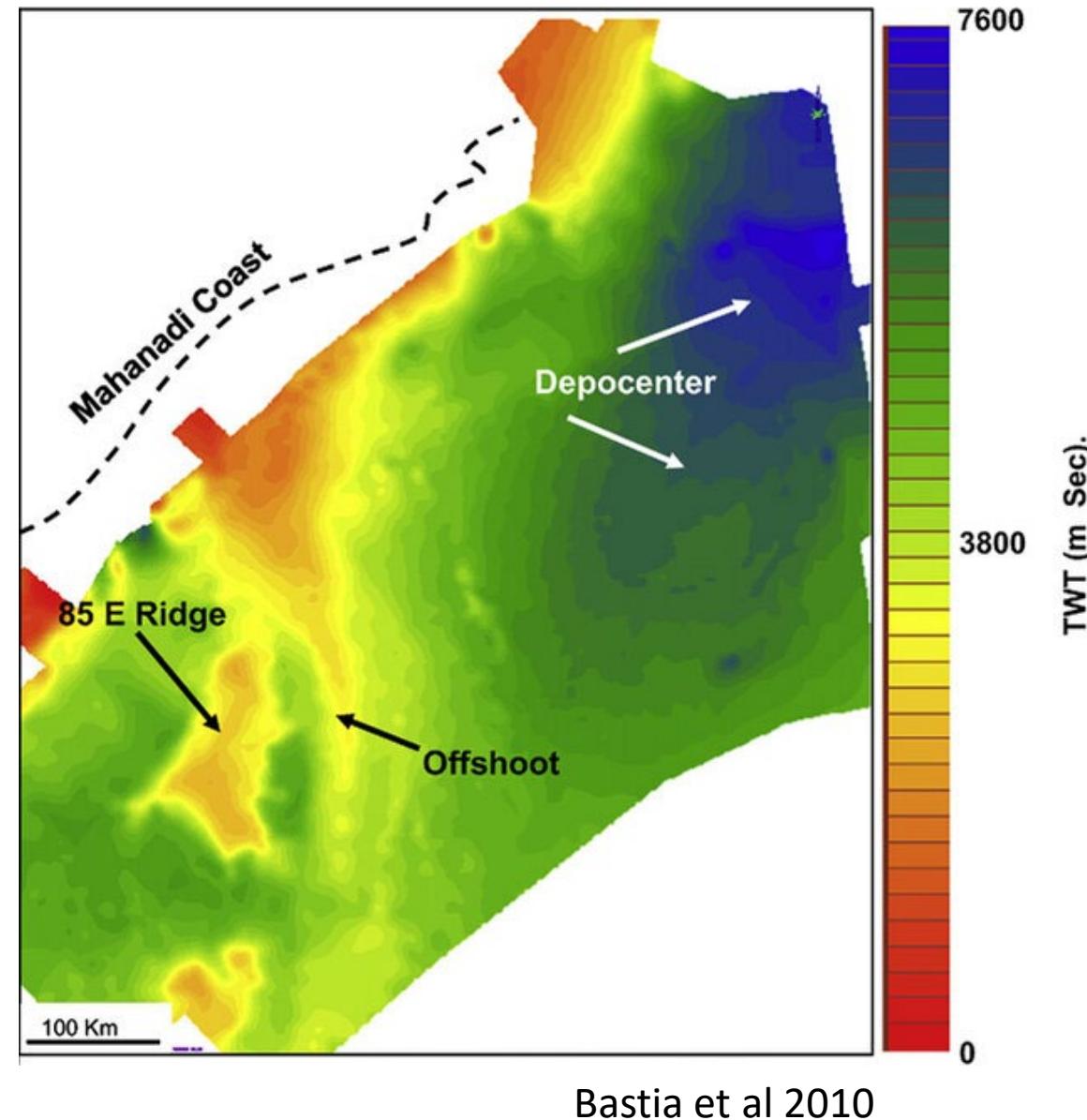


### Isopach - Marra Mamba



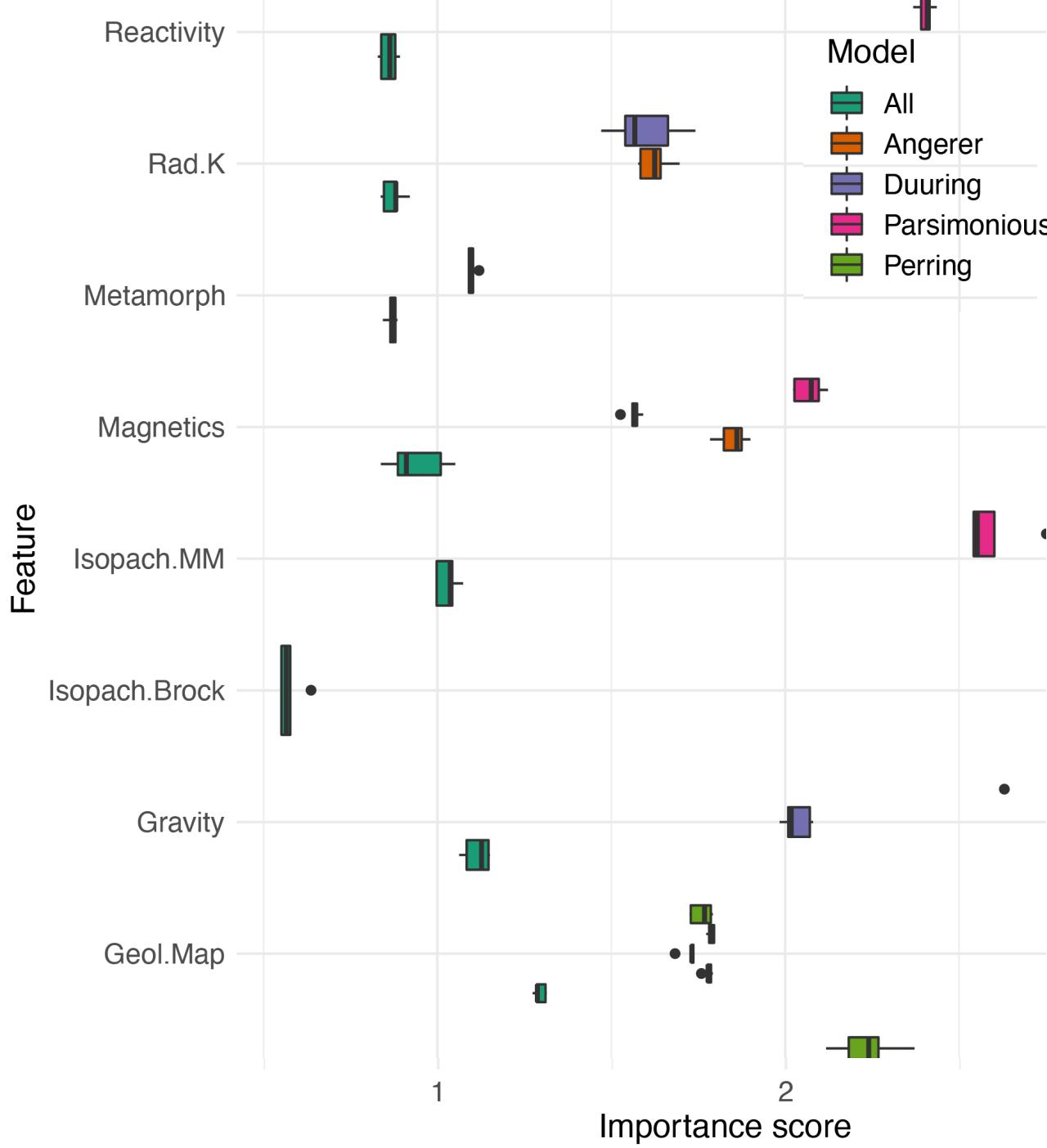
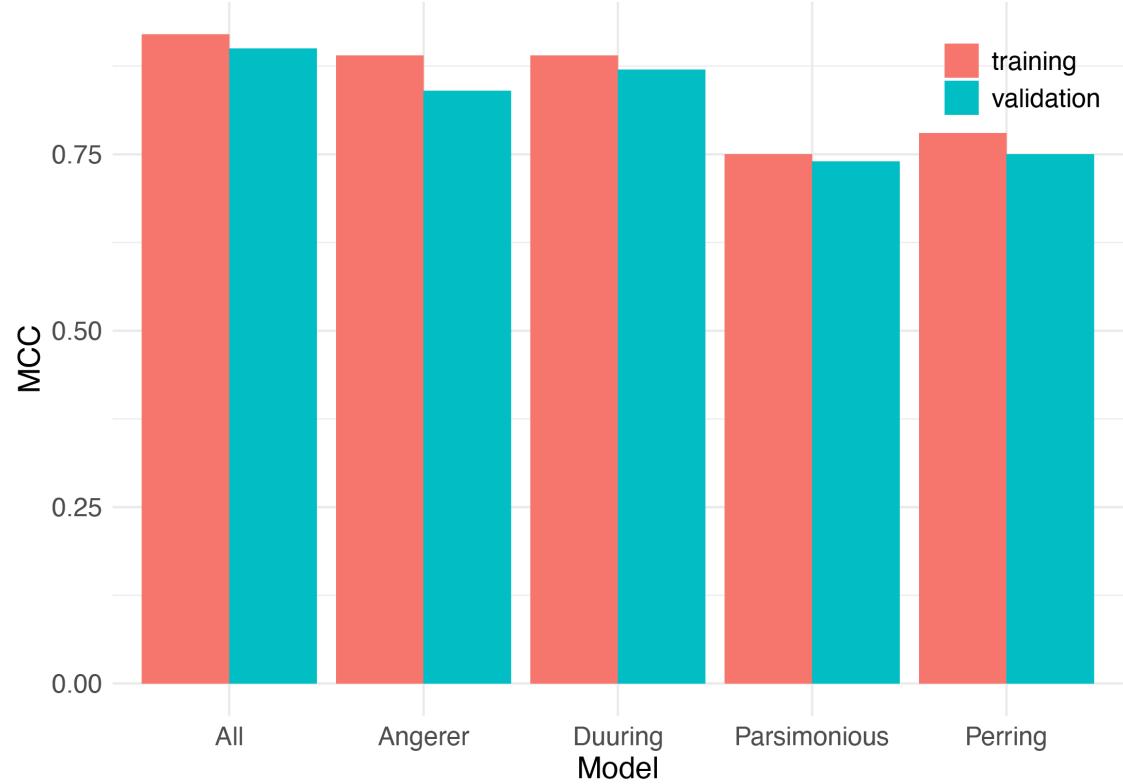
# Isopach estimate

- Usually thickness of *sedimentary* layers
- Takes into account inclined angle of bedrock
- (Isochore assumes horizontal)

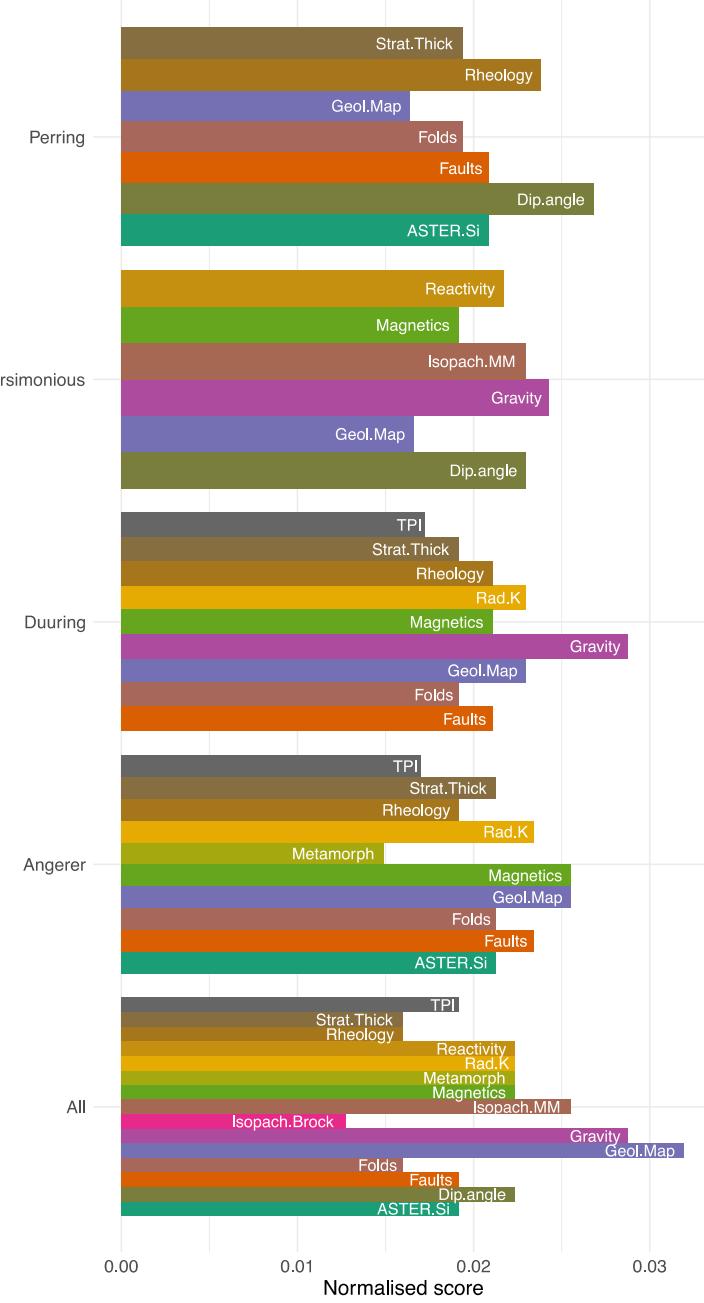


Bastia et al 2010

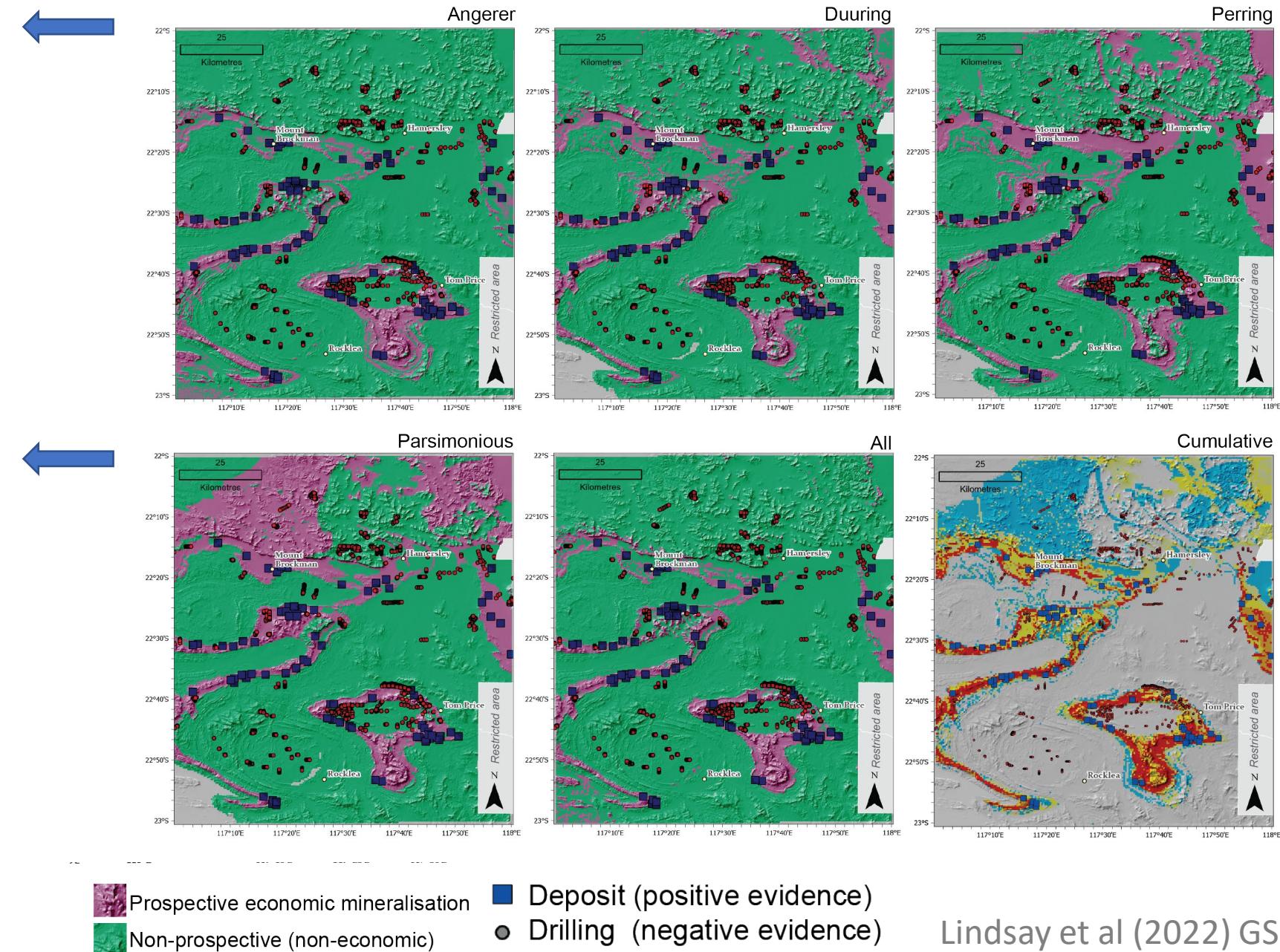
# Model performance



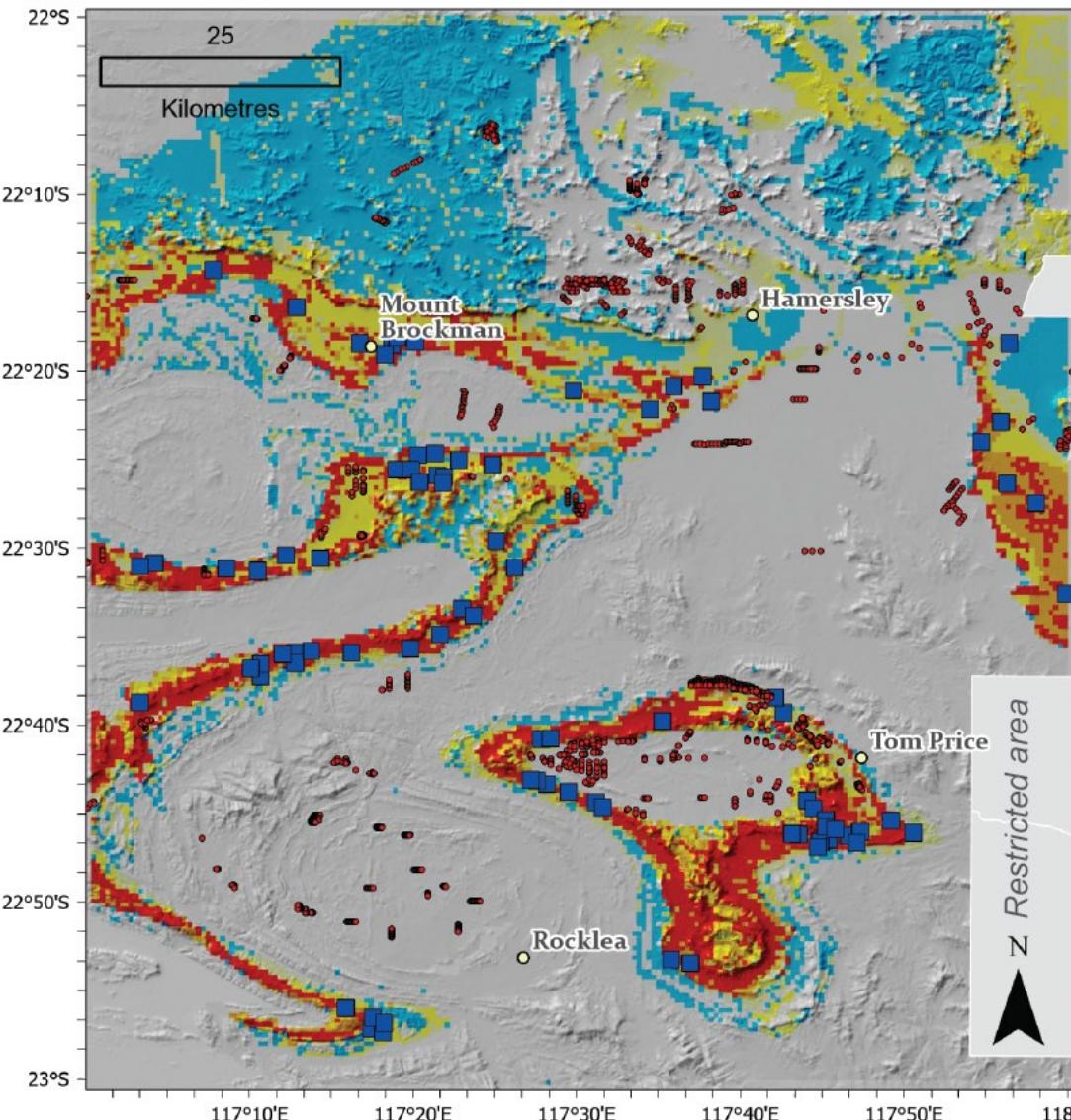
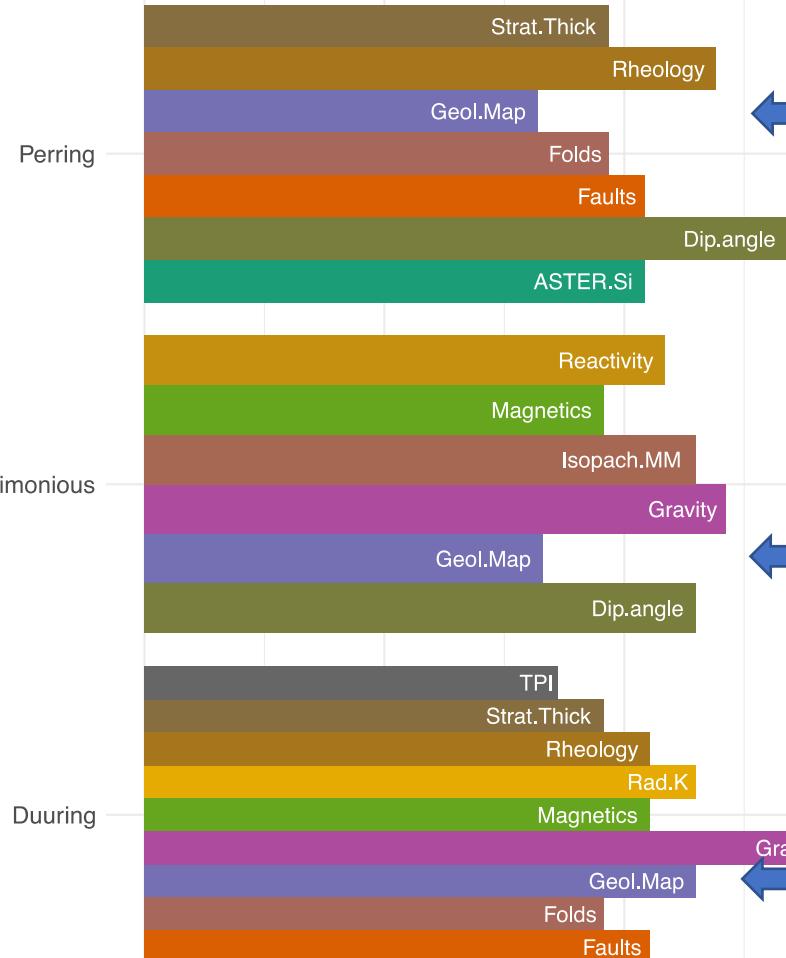
# Features



# Prediction

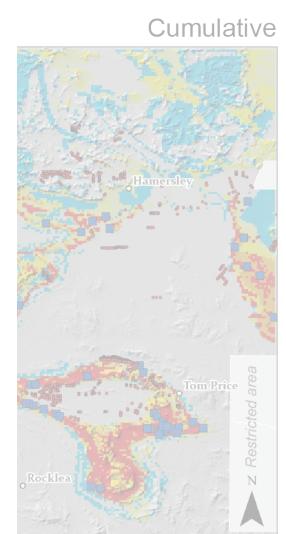
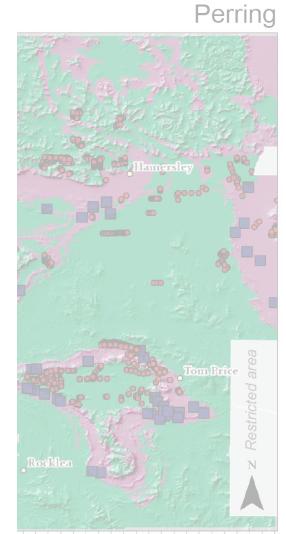


## Features



## Cumulative

Prediction

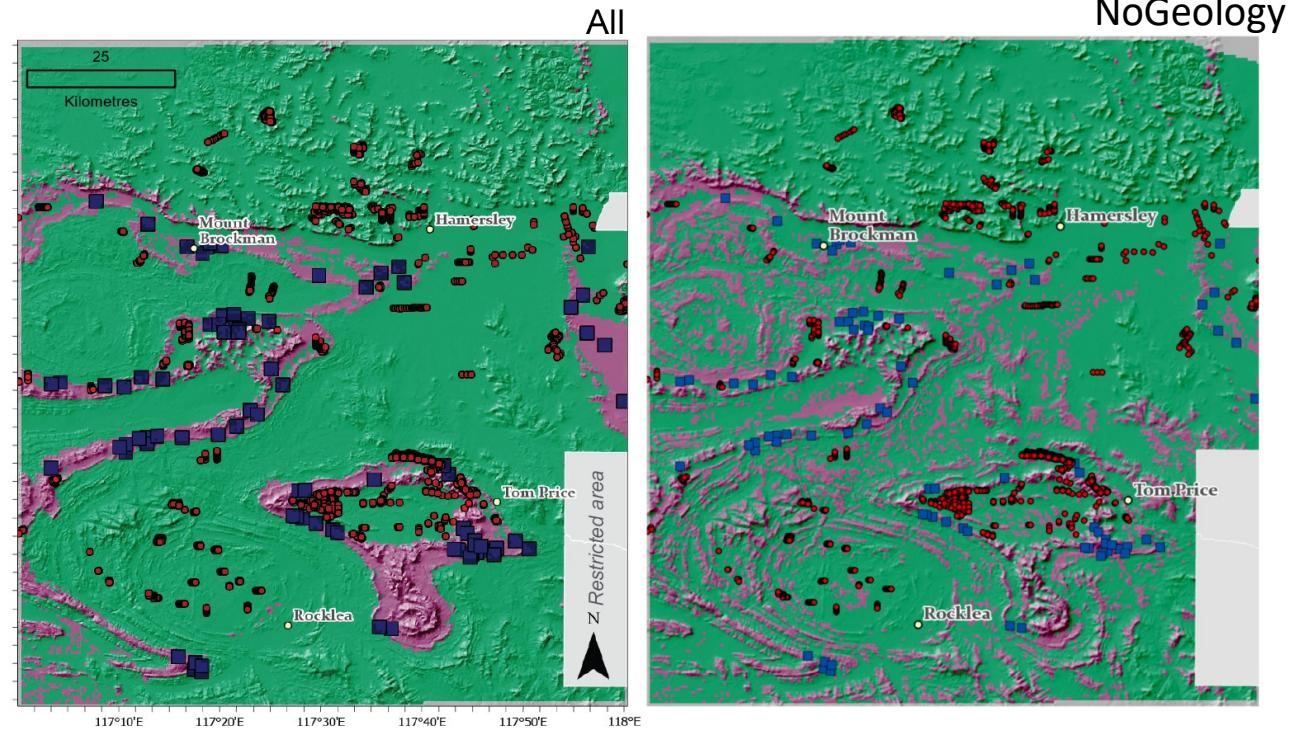
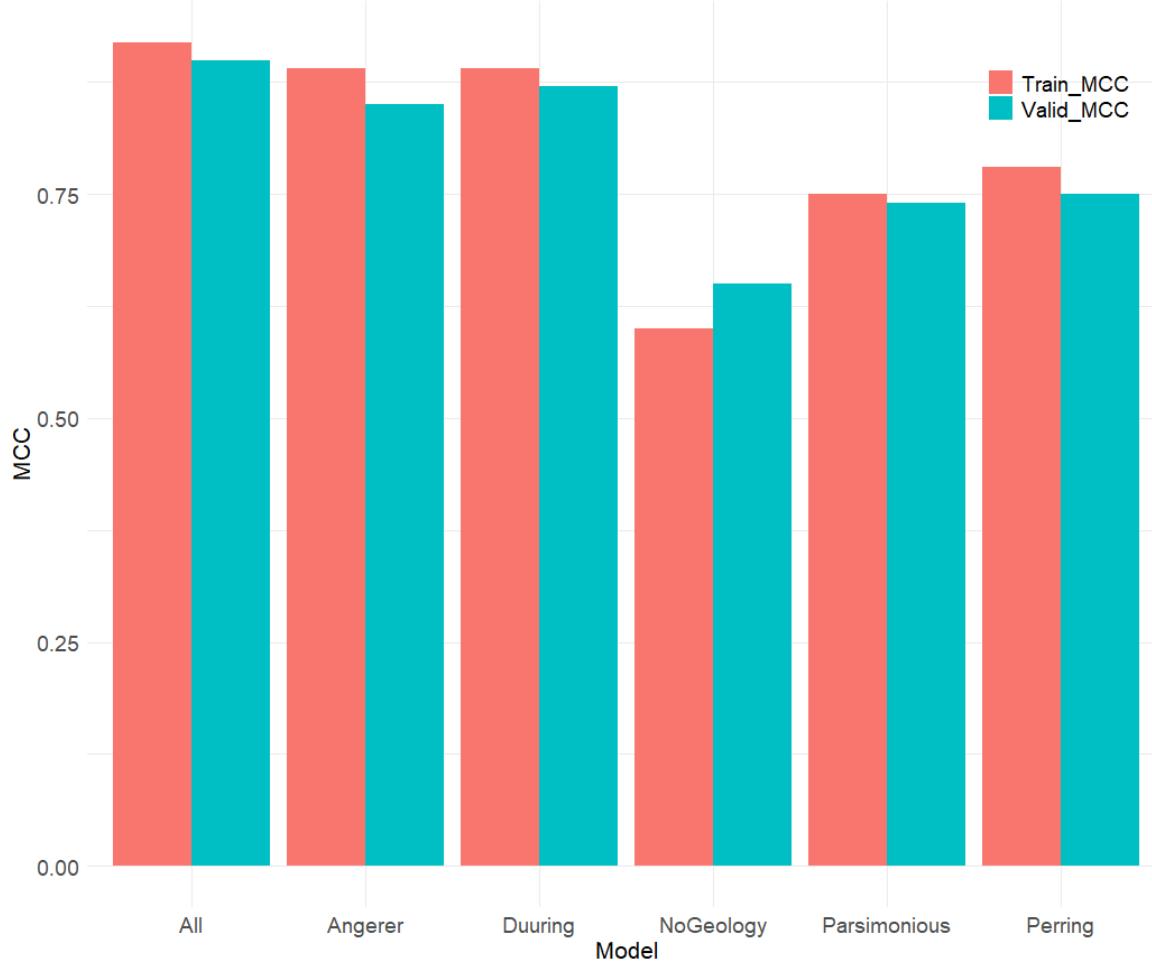


Prospective economic mineralisation  
Non-prospective (non-economic)

Deposit (positive evidence)  
Drilling (negative evidence)

Lindsay et al (2022) GSF

# Model performance – no geological map

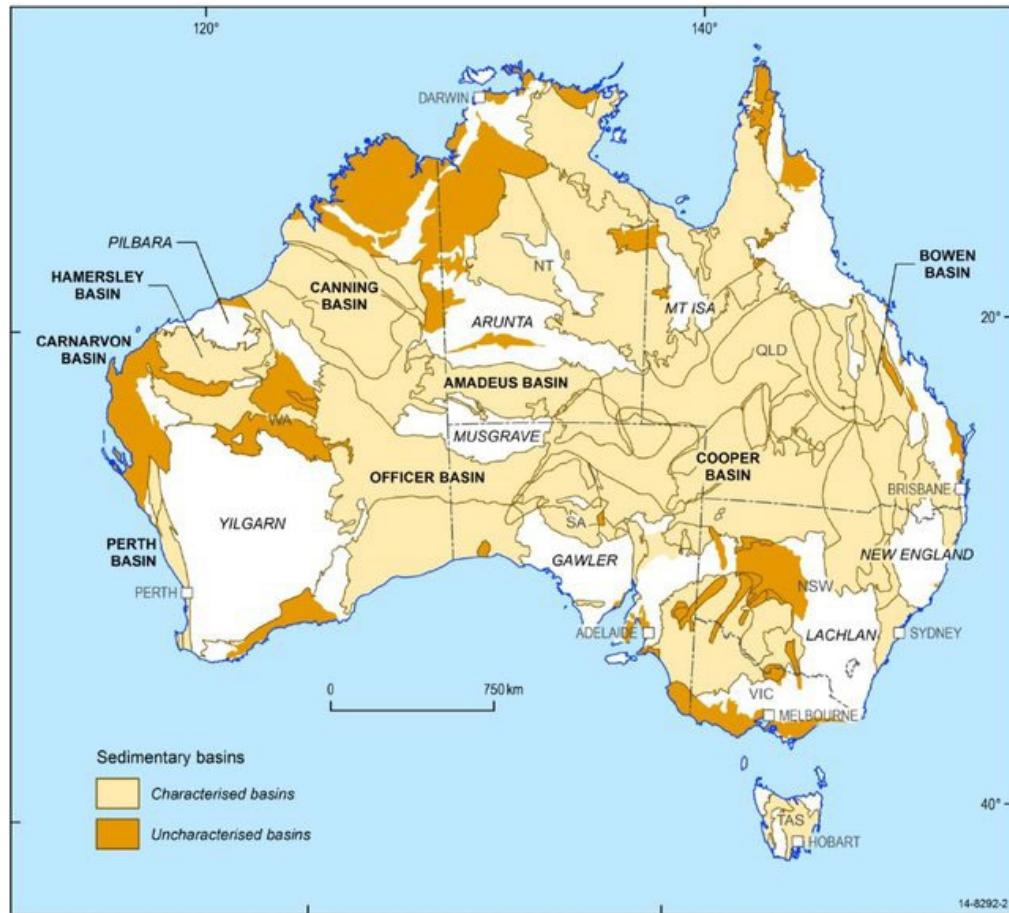


# Basins

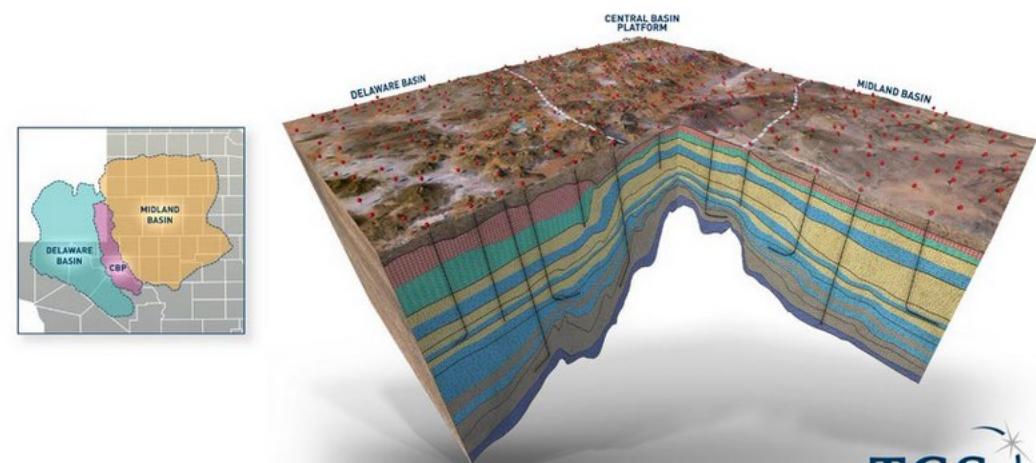
Typical prospectivity studies largely fail in flat-lying basin terranes

Taking a top-down map view disallows important geometries to be detected

3D representation in 2D features is required



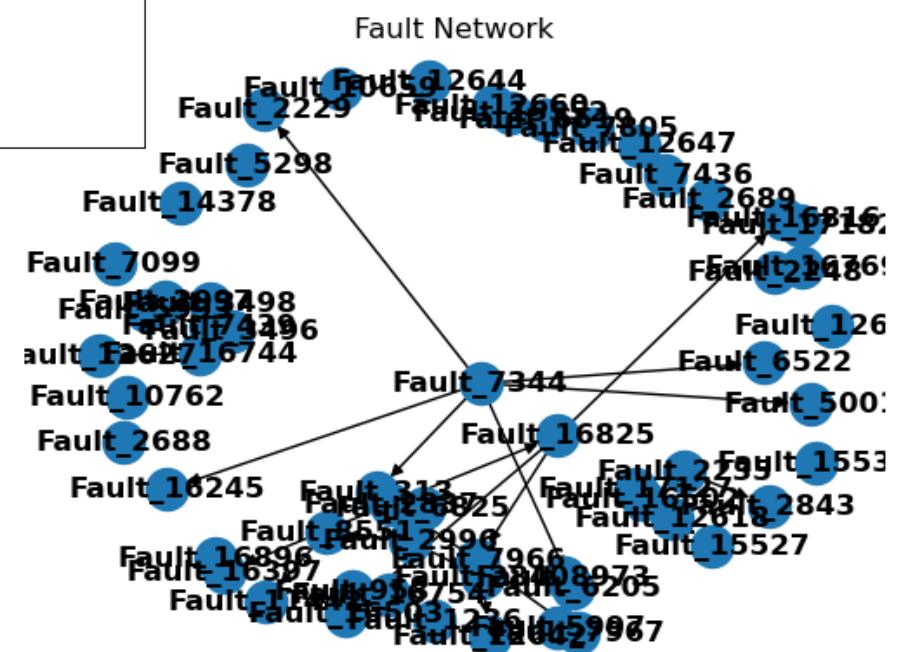
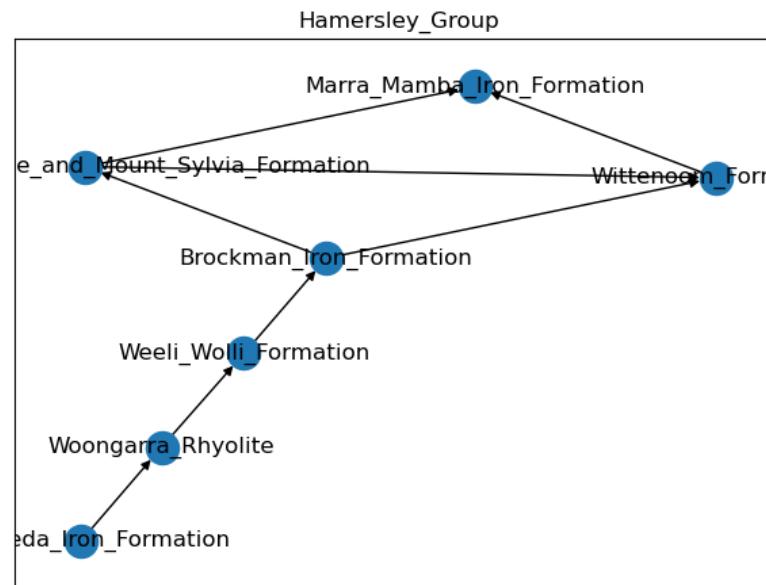
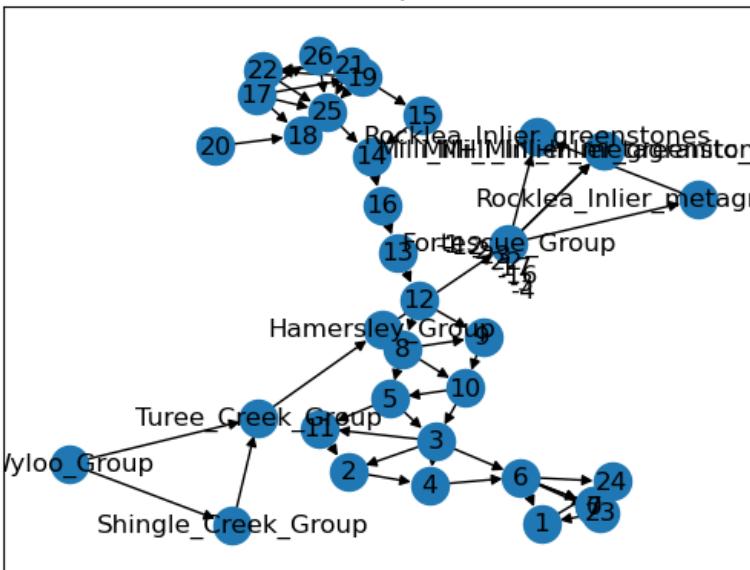
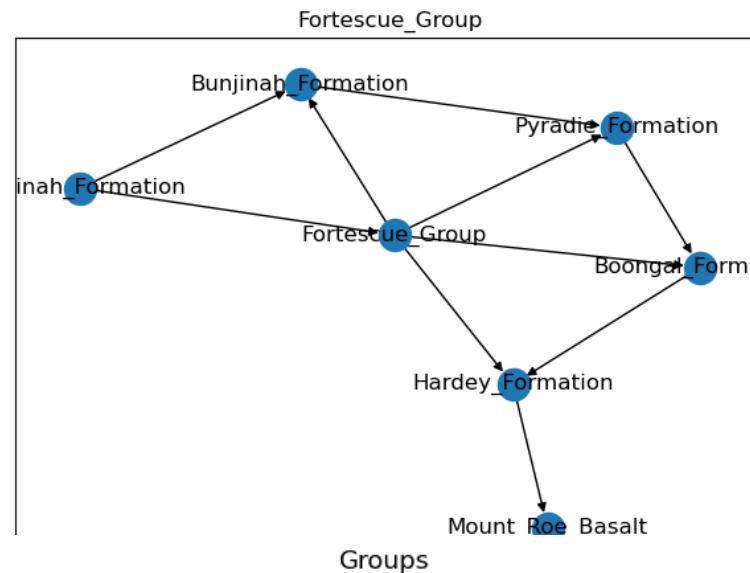
Haynes et al 2015



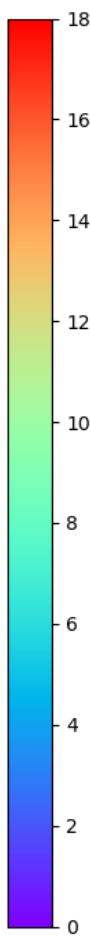
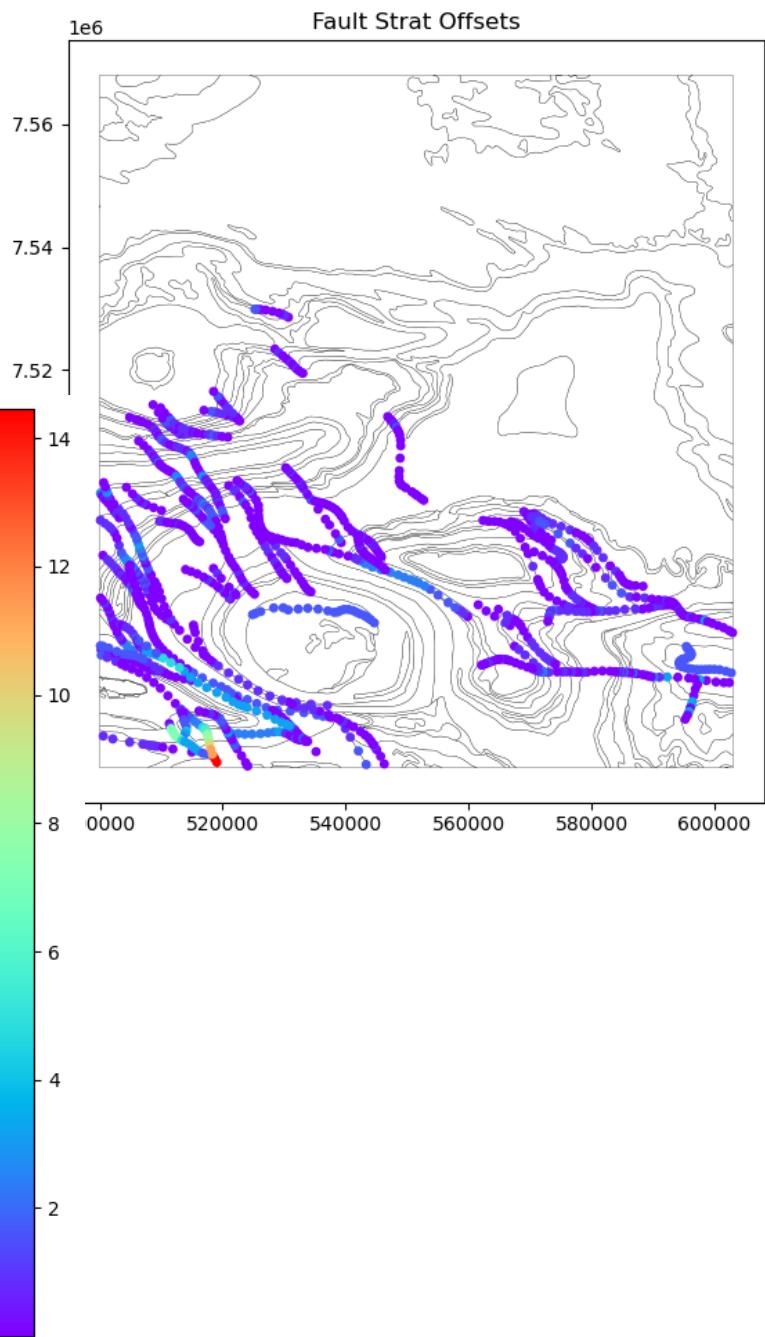
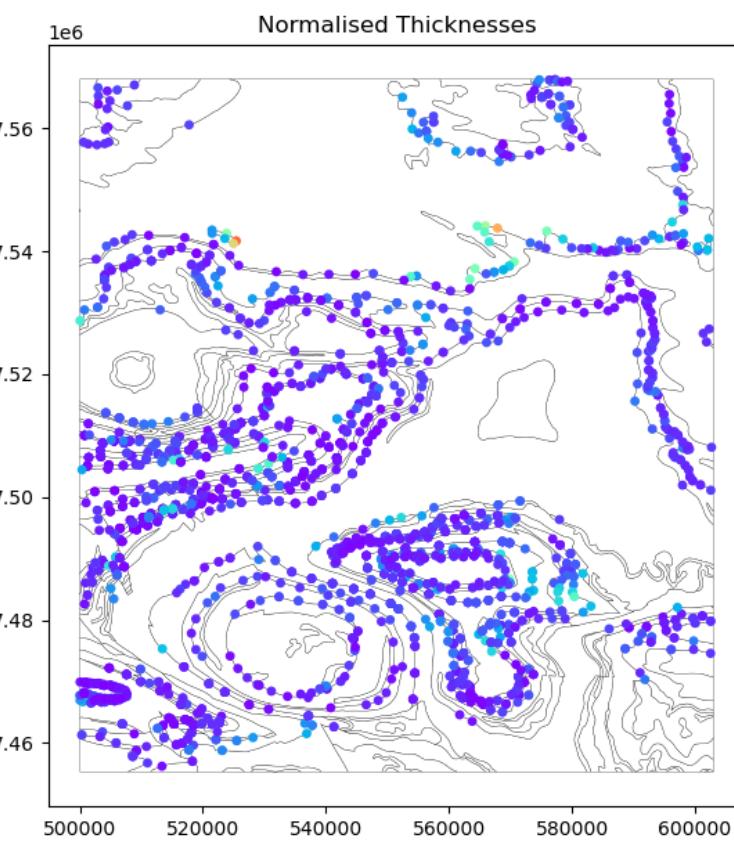
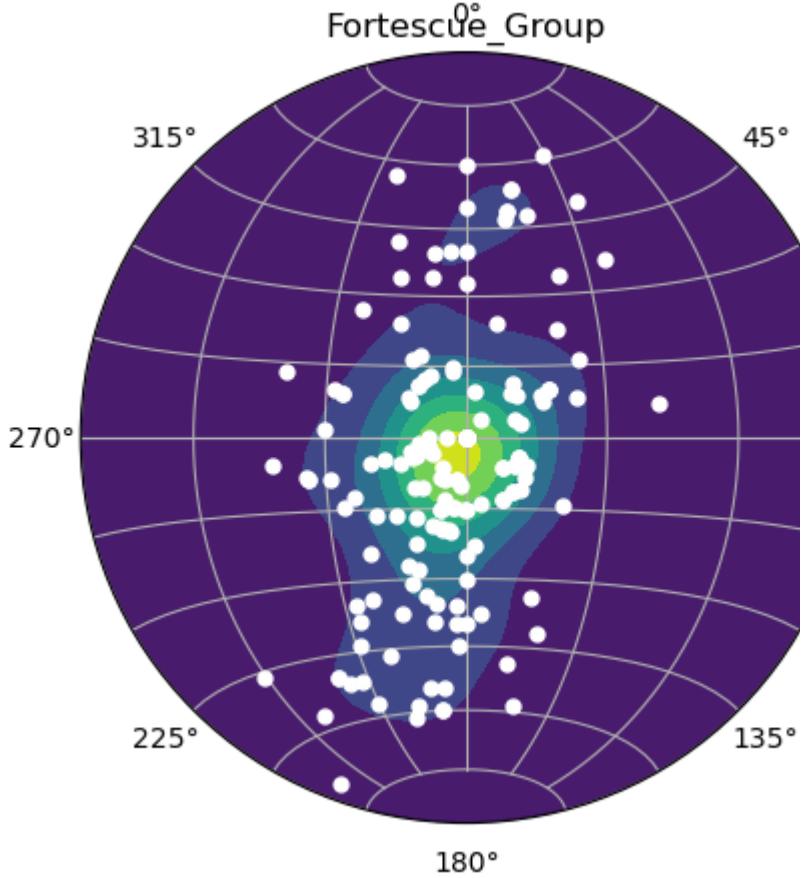
Permian Basin Structural Model

**TGS**

# Geological topology

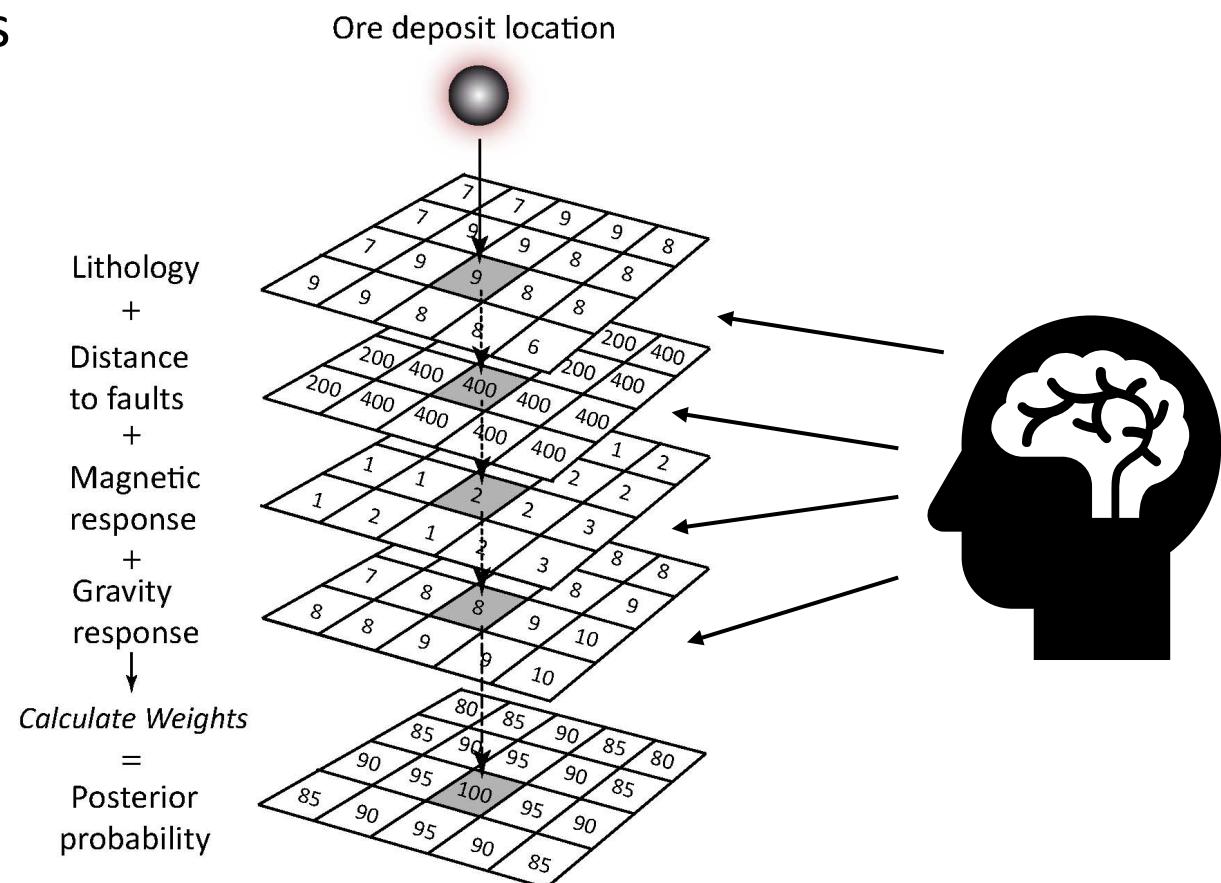


# Structural Geology



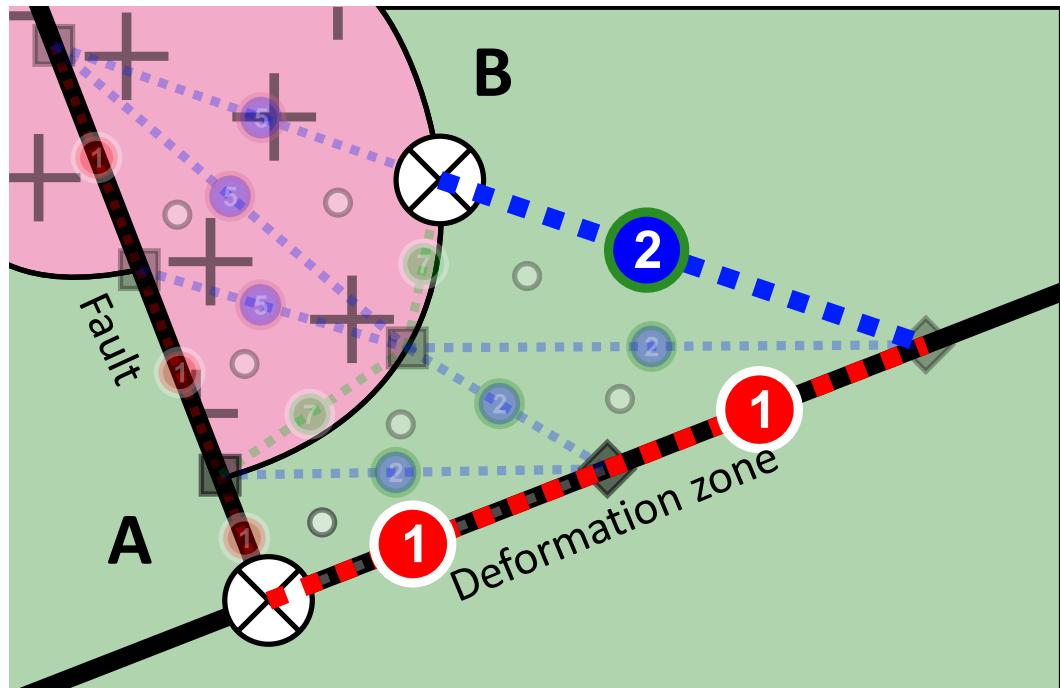
# Conclusions

- 3D derived features from map2loop can provide important prediction support
- Predictions are sensitive to conceptual models
- Exploration criteria (feature) importance changes
- What we need:
- rapid knowledge extraction (NLP) methods to generate conceptual models (knowledge representation)



# Fluid travel paths and distance

## Non-Euclidean distance

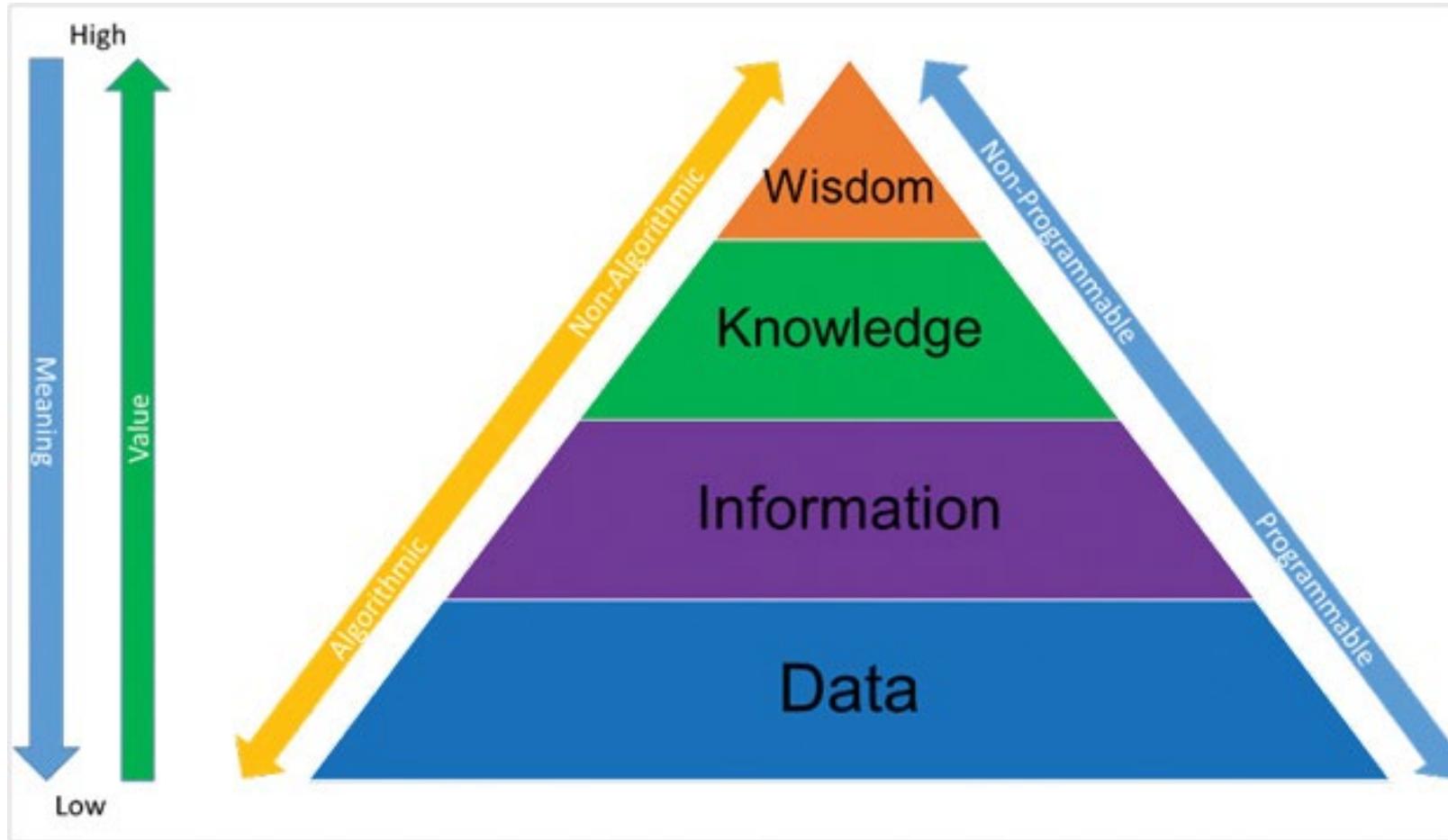


Distance = min. ( $\sum$  weighted nodes)

Fast ↑  
↓ Slow

Weight	Feature
1	Deformation zone (trans-crustal)
2	Deformation zone (secondary splay)
5	Unconformities
5	Intrusive contacts
6	Conformable volcanic contacts
6	Chemical sed. (BIF/chert)
7	Clastic sedimentary
7	Felsic volcanic
8	Ultramafic/Mafic volcanic
10	Intrusive body (all compositions)

# A reminder – ‘DIKW’ diagram



**The knowledge and wisdom gained from this process is often lost and can be the most valuable**

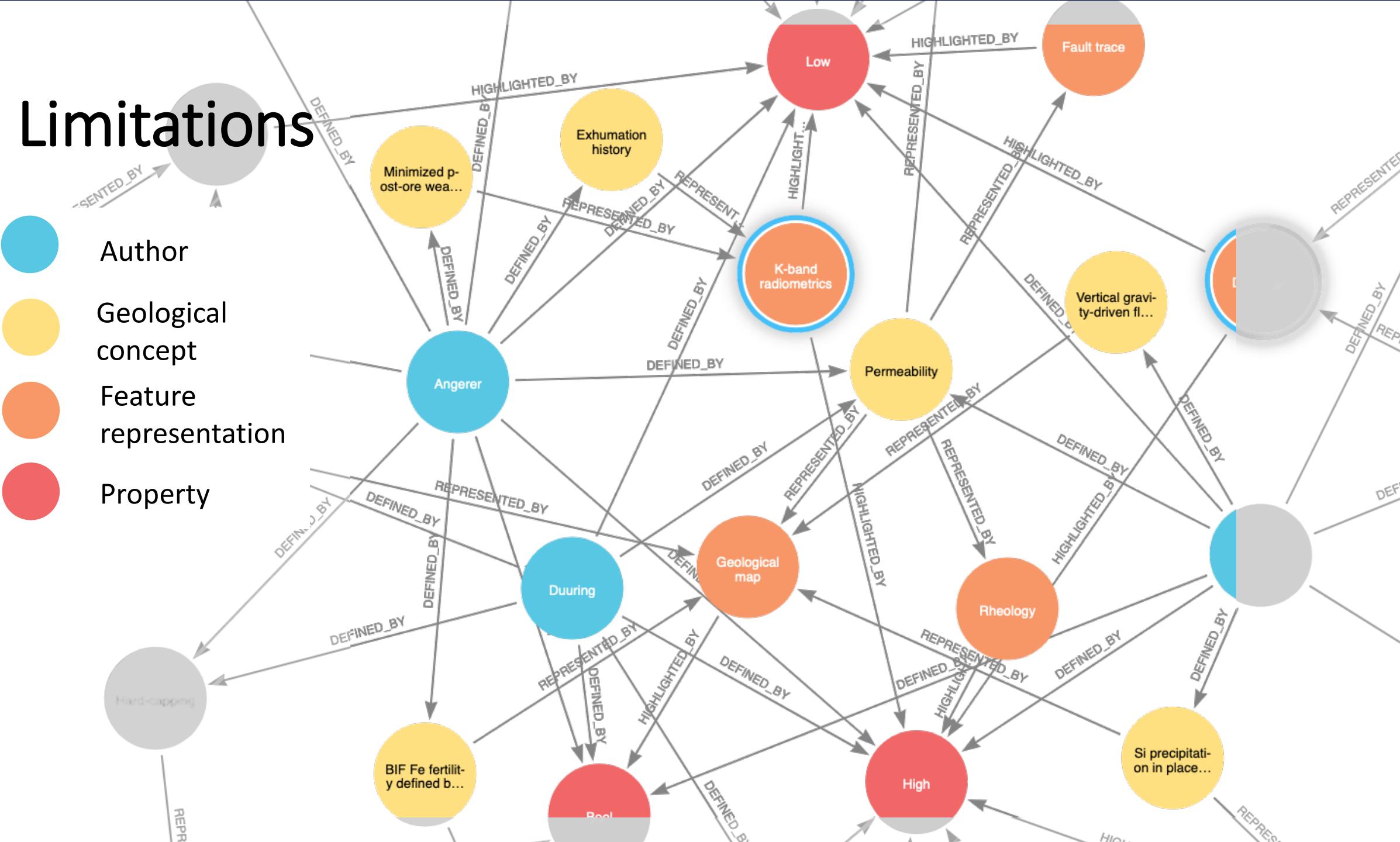
Defining geodynamic setting with interp.  
Testing 3D model with drill targeting

Integrated geological interpretation  
3D model

Geophysical dataset  
Drillhole logs and properties

Geological observation  
Geophysical measurement

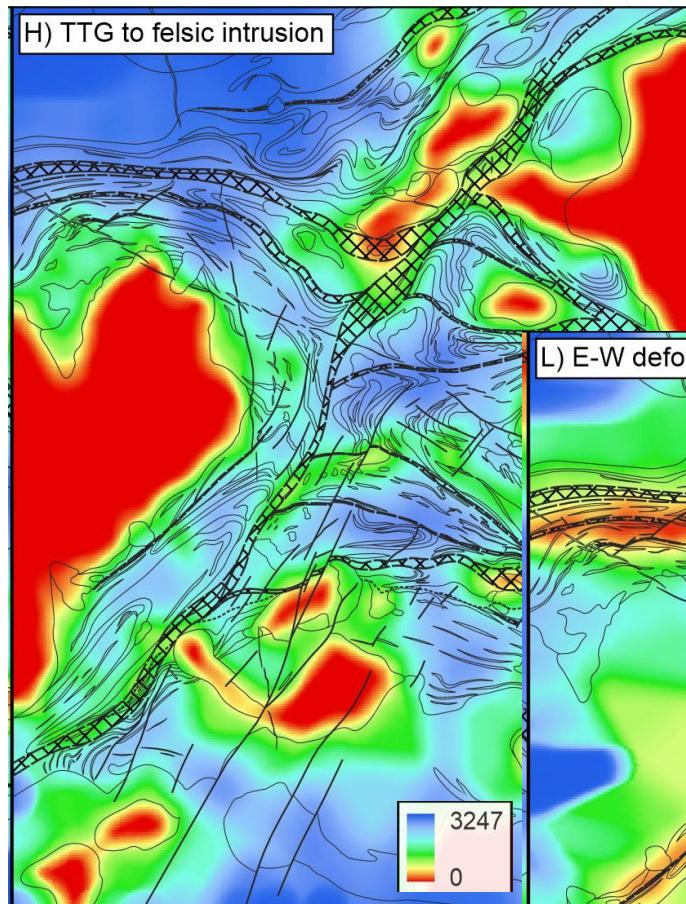
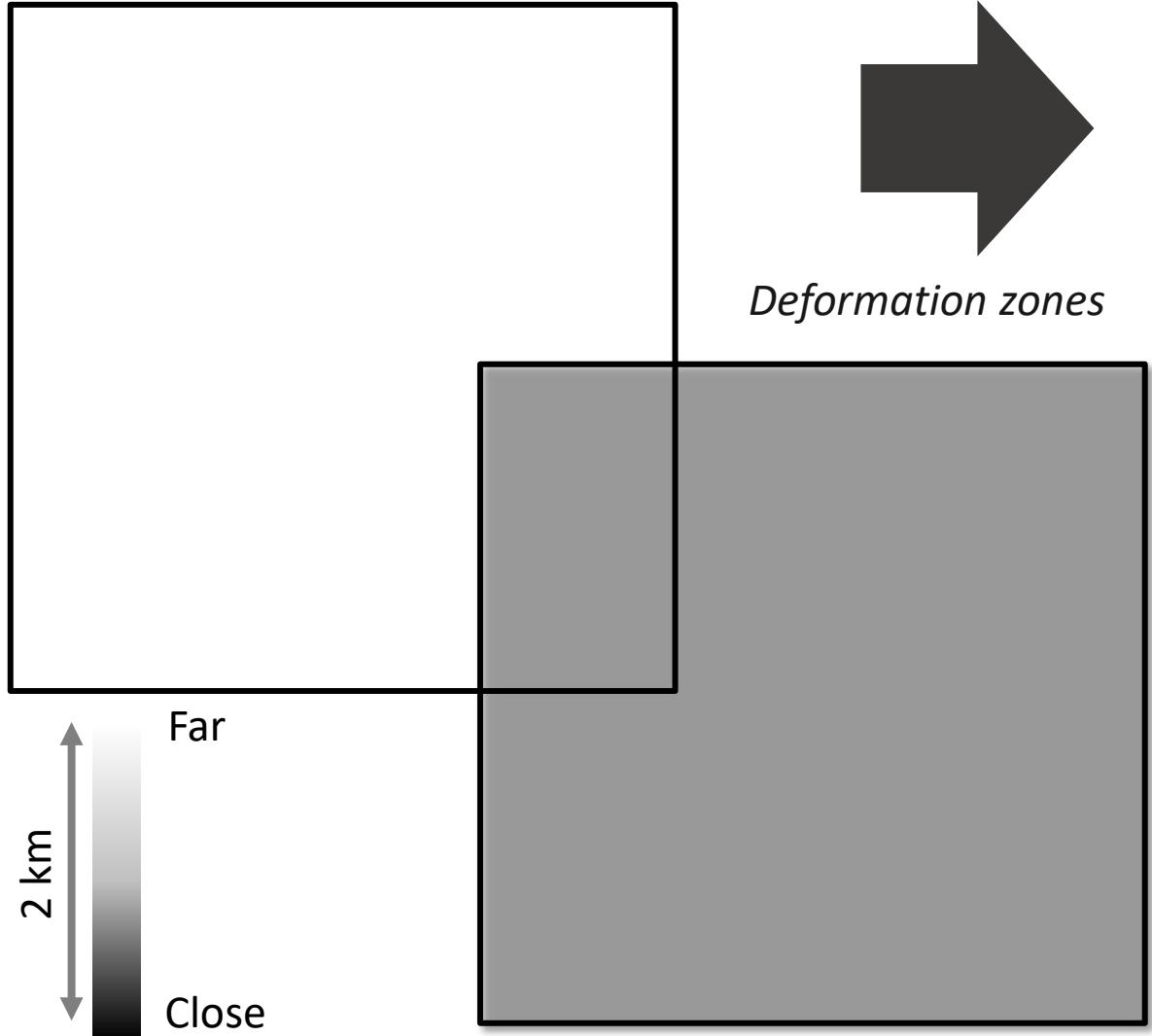
# Limitations



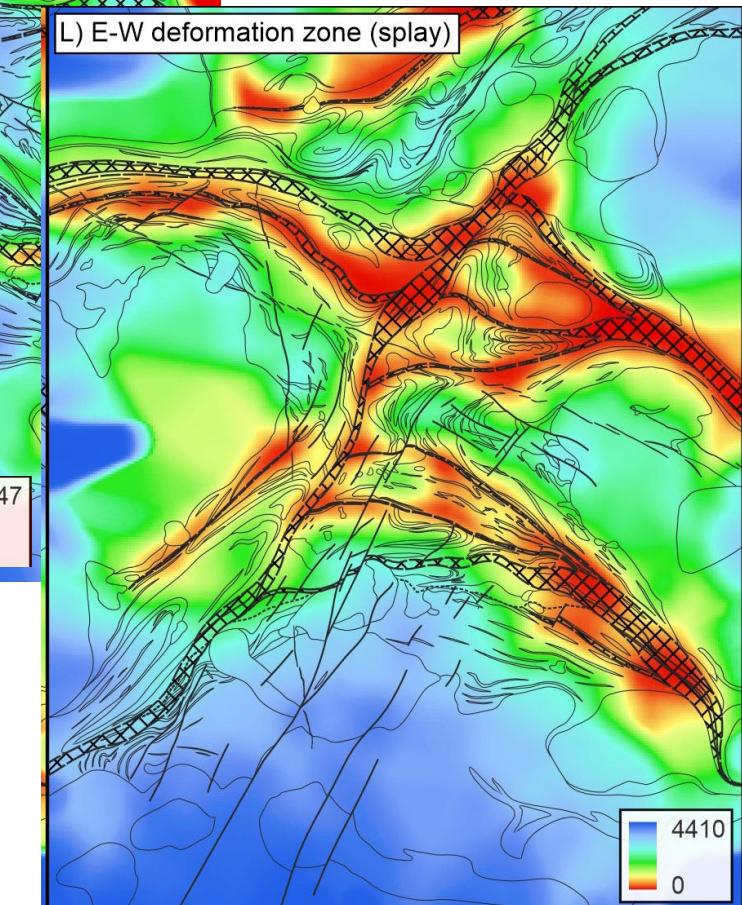
# Fluid travel paths and distance

## Non-Euclidean distance

*Intrusions*



Montsion 2023

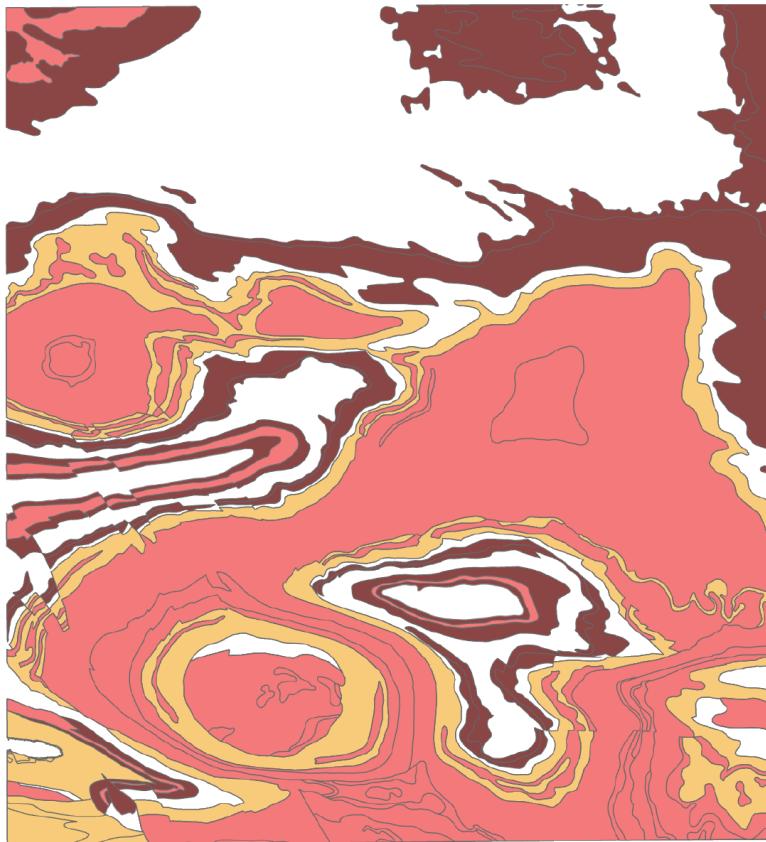


Far

Close

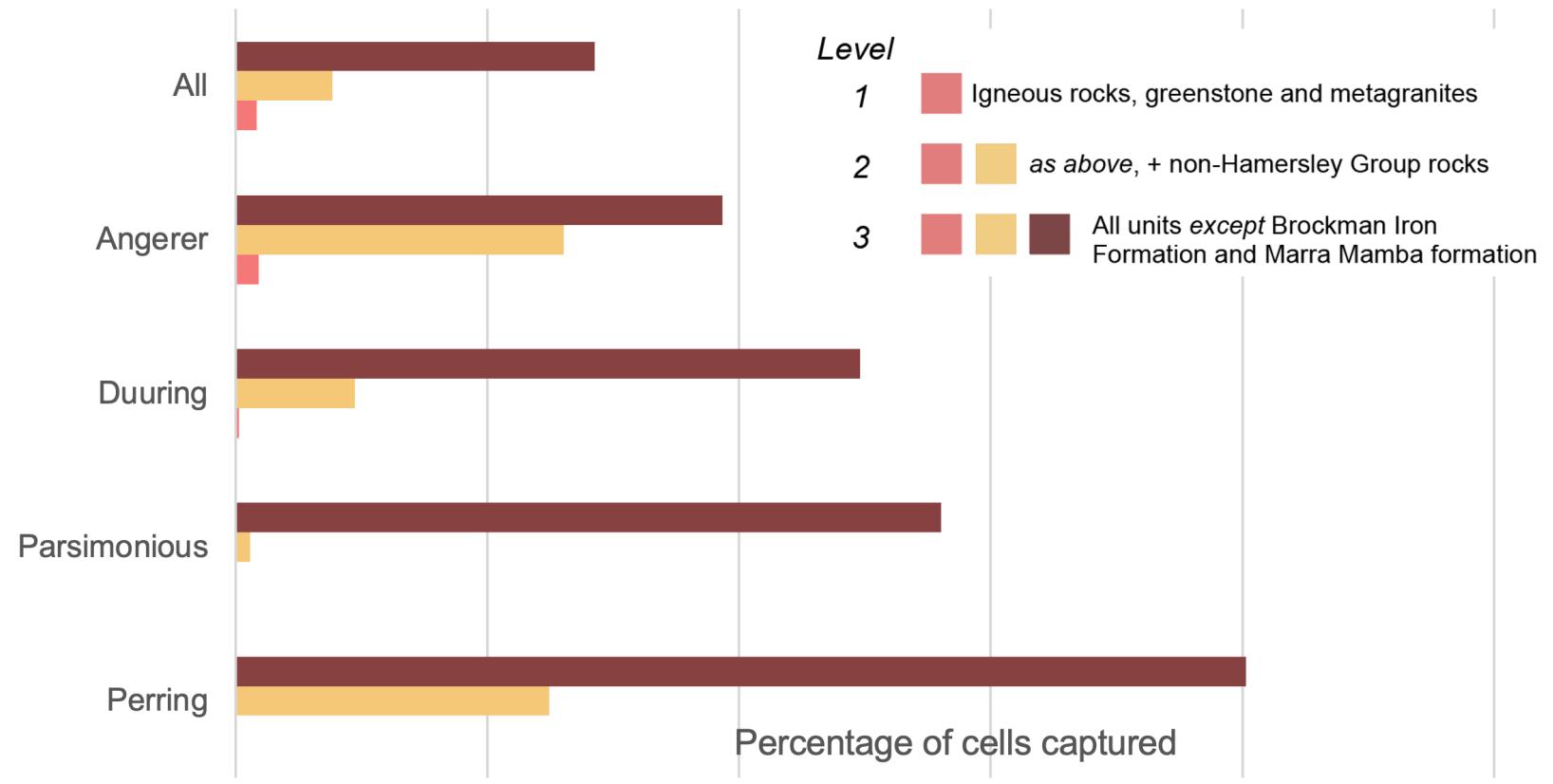
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# Plausibility



Level	Igneous rocks, greenstone and metagranites	as above, + non-Hamersley Group rocks	All units except Brockman Iron Formation and Marra Mamba formation
1			
2			
3			

**Question:**  
What percentage of predictions are in implausible locations?



	Perring	Parsimonious	Duuring	Angerer	All
■ Level 3	20.07	14.01	12.41	9.67	7.13
■ Level 2	6.23	0.30	2.38	6.52	1.92
■ Level 1	0.01	0.00	0.07	0.47	0.42