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Advanced Geophysical Interpretation Centre

Model building to support exploration undercover

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Acknowledgements

- Glenn Pears (Mira Geoscience)
- Peter Fullagar (Fullagar Geophysics)

(for doing 100% of the work)

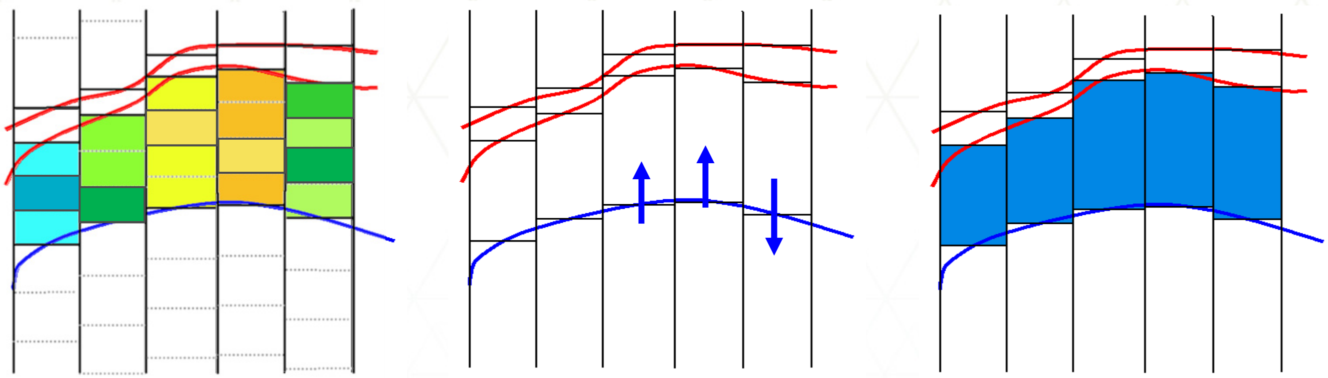
Advantages of explicitly modelling cover

- Rapid model validation/testing through forward modelling
- A variety of inversion styles:
  - physical property inversion or updating geological boundaries
- Imposition of geological constraints
  - e.g. drill hole pierce points or litho-based property constraints
- Control over inversion is now possible
  - restrict changes to selected geological boundaries or selected domains
- A driver for integrated interpretation
  - minimise ambiguity associated with non-uniqueness
  - inverted cover model is geological

VPmg / VPem1D inversion styles overview

- Geological model parameterisation lends itself to a variety of inversion styles

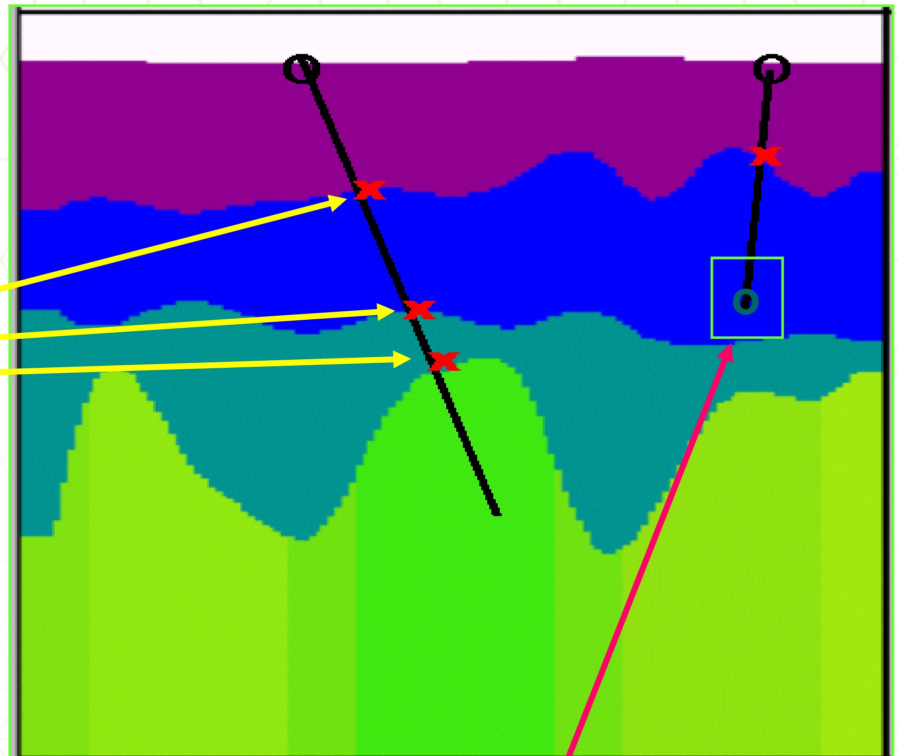
Heterogeneous unit inversion | Geometry inversion | Homogeneous unit inversion



Drill-Hole Constrained Inversion

VPmg constrains the model geometry according to drill hole intercepts and drill hole paths.

During inversion, the model is fixed at the drill hole 'pierce points'



An upper bound is imposed on the interface(s) below the EOH

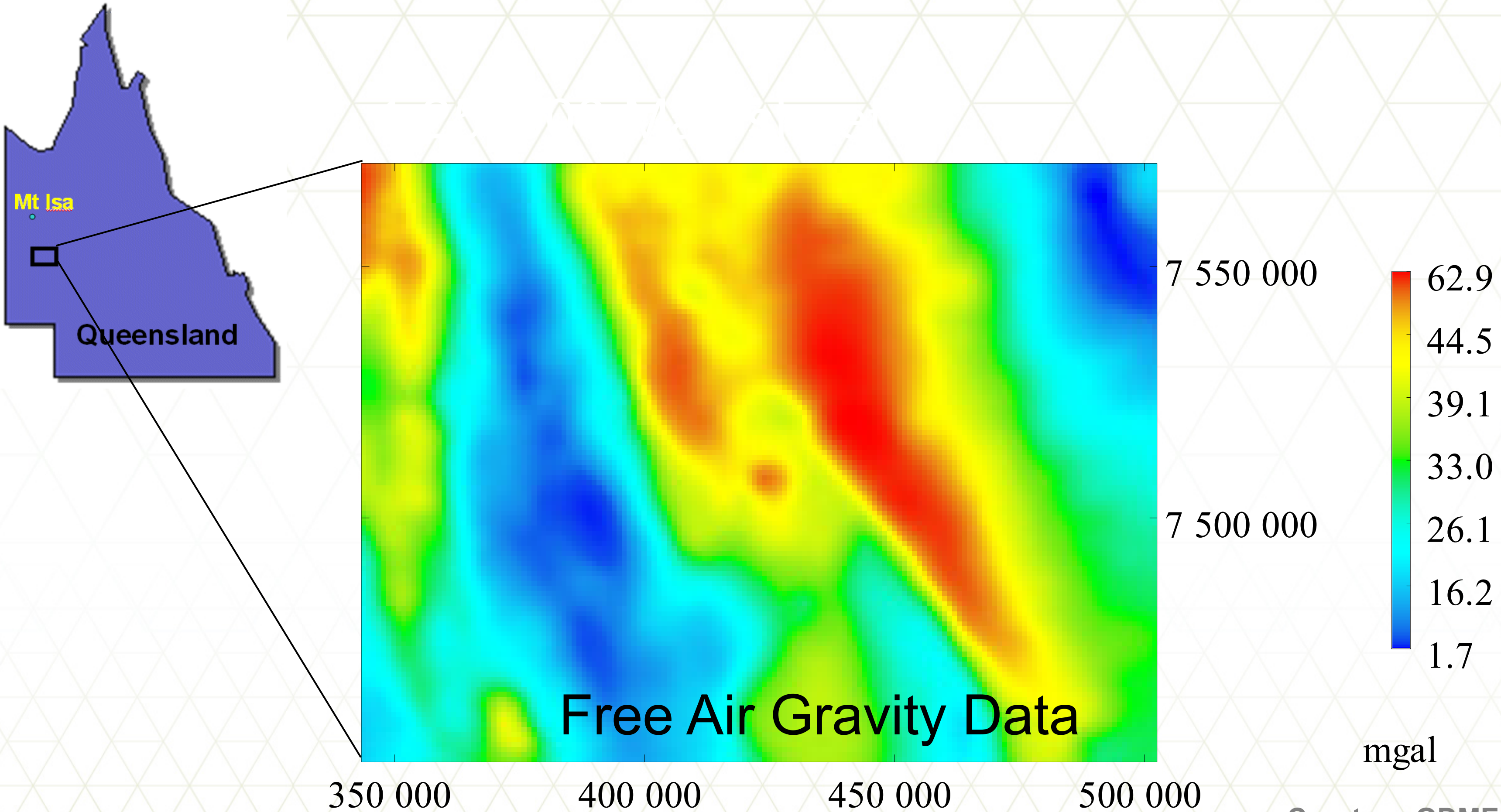
Boulia Gravity Inversion, QLD

- Sedimentary cover thickness strongly influences area selection for exploration in Proterozoic and Archean terranes.
- Construct basement unconformity consistent with gravity data.
- Natural application for geometry inversion…
  …but fraught ambiguity.

- **Demonstrate via two inversions;**
  - Simply assume Proterozoic basement denser than the overlying Paleozoic cover. Basement contact is flat initially at an estimated depth (~700m).
  - Incorporate all available *a priori* information (eg drilling, aeromagnetic interpretations).

Courtesy QDME

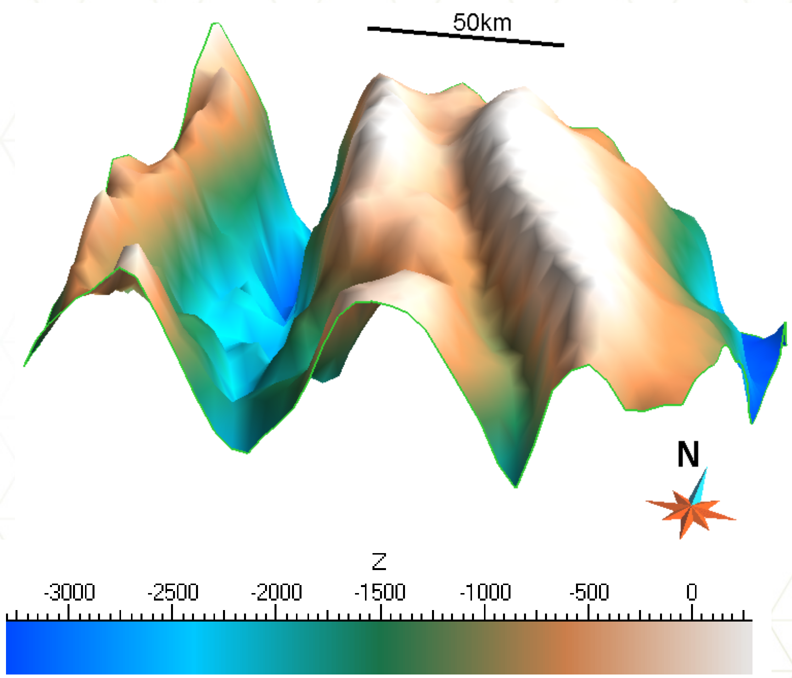
Boulia Gravity Inversion, QLD

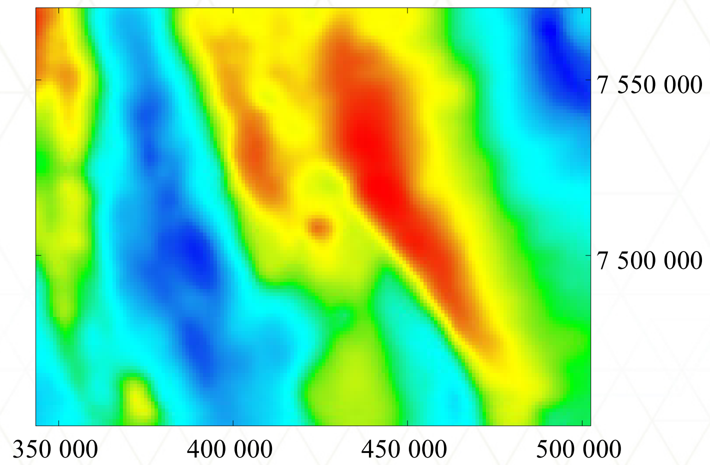


Courtesy QDME

Simple interpretation (inversion)

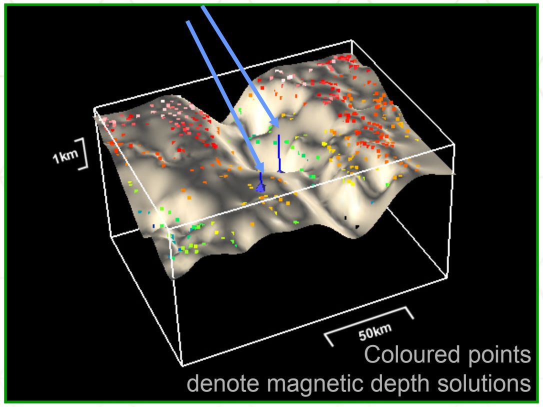
- Geometry inversion assuming homogeneous cover overlying homogeneous basement, starting model elevation = flat.

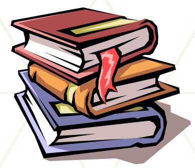


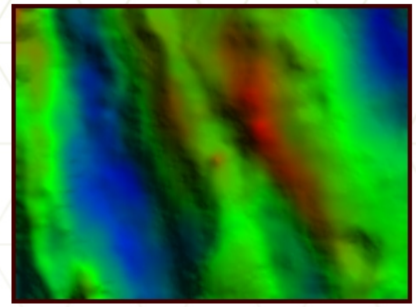


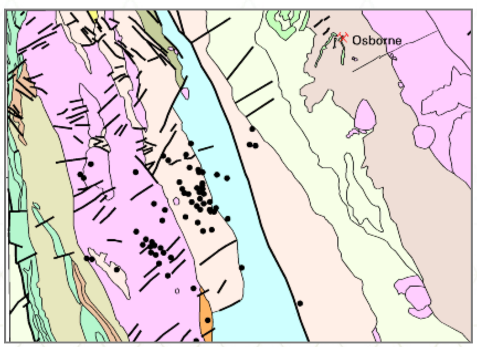
Courtesy QDME

Incorporate *a priori* information

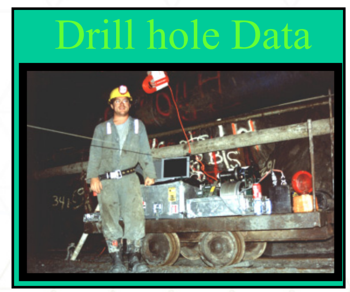








Common Earth Model

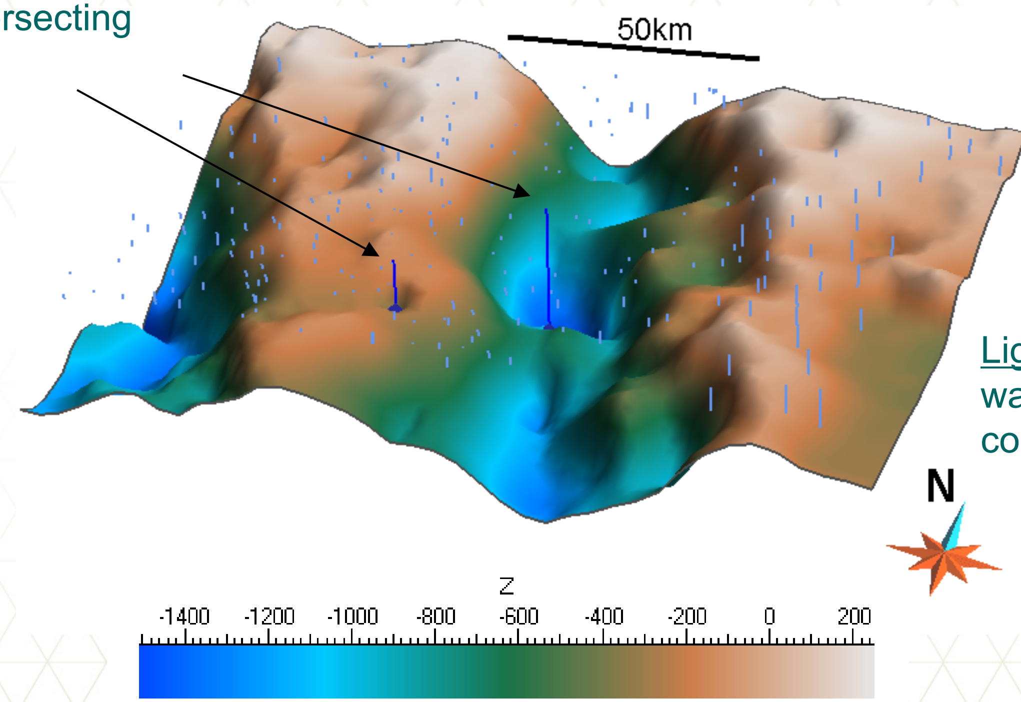


Courtesy QDME

Incorporate a priori information

- Integrated approach implementing drill hole constraints

Basement intersecting drill holes



Light blue holes represent water bores (upper constraints)

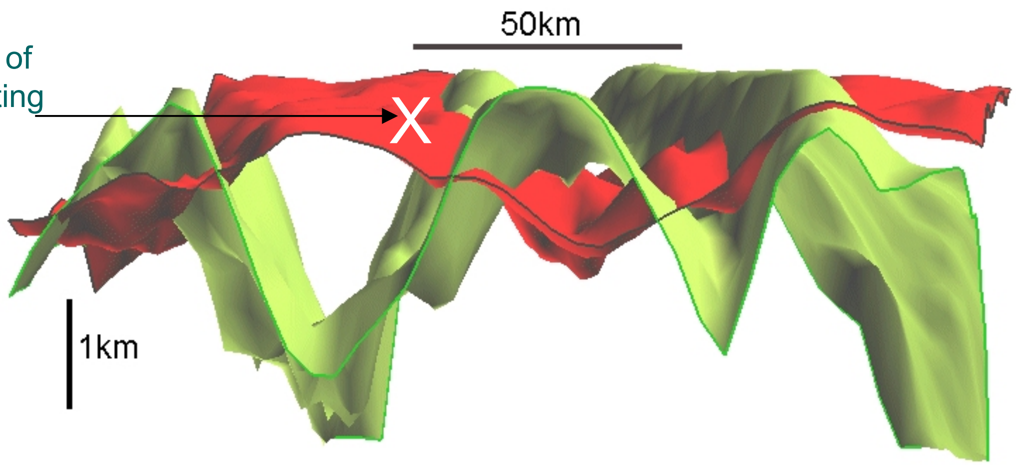
VA =20x

Courtesy QDME

Boulia remarks

- Conventional result in this case is notably different from the integrated approach.
- No more than two basement intersecting drill holes successfully guided interpretation away from the conventional style
- (gravity high = basement high)

Approx location of one of the basement intersecting holes

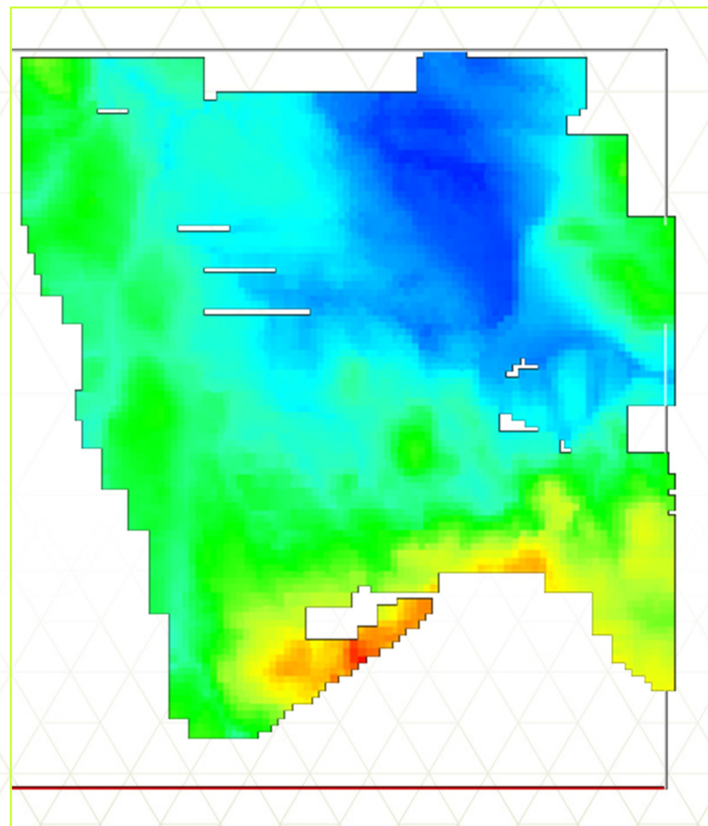


Red depicts the integrated approach
Green depicts an unconstrained conventional interpretation

Courtesy QDME

Malhadina Gravity Inversion - Portugal

- gravity data
- 30 mgal range
- primary control is overburden thickness
- secondary control is basement density
- basement density highs reveal new targets



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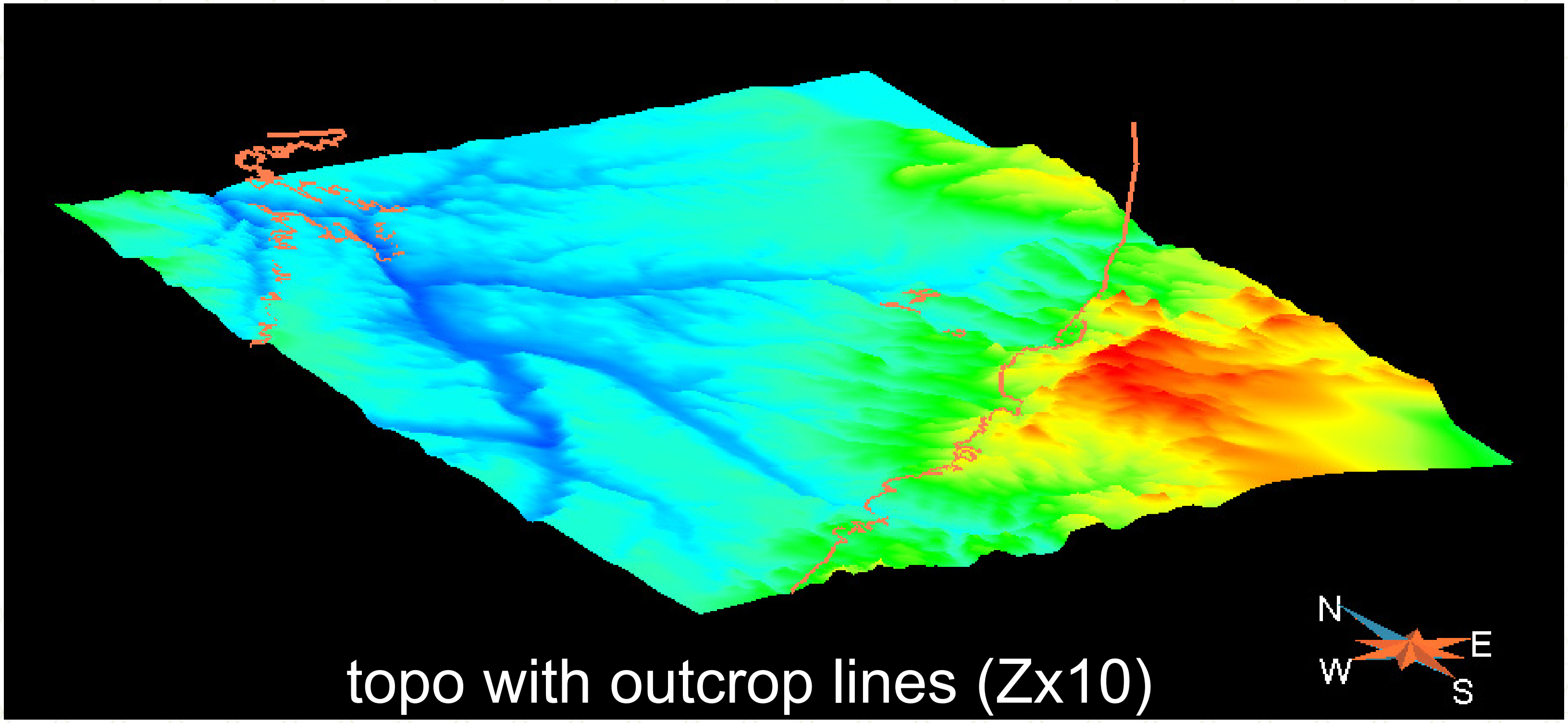
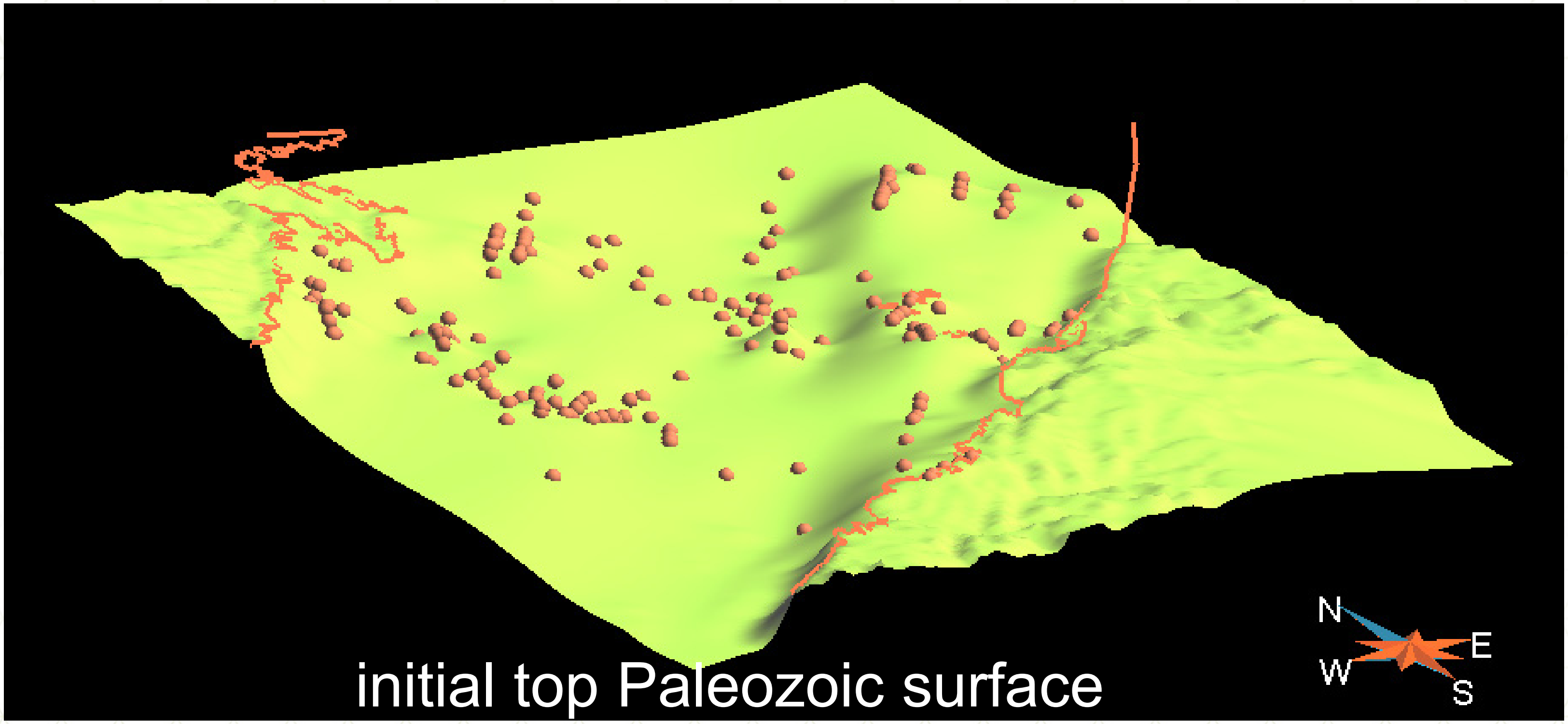
Malhadina Gravity Inversion - Portugal



topo with outcrop lines (Zx10)

Malhadina Gravity Inversion - Portugal



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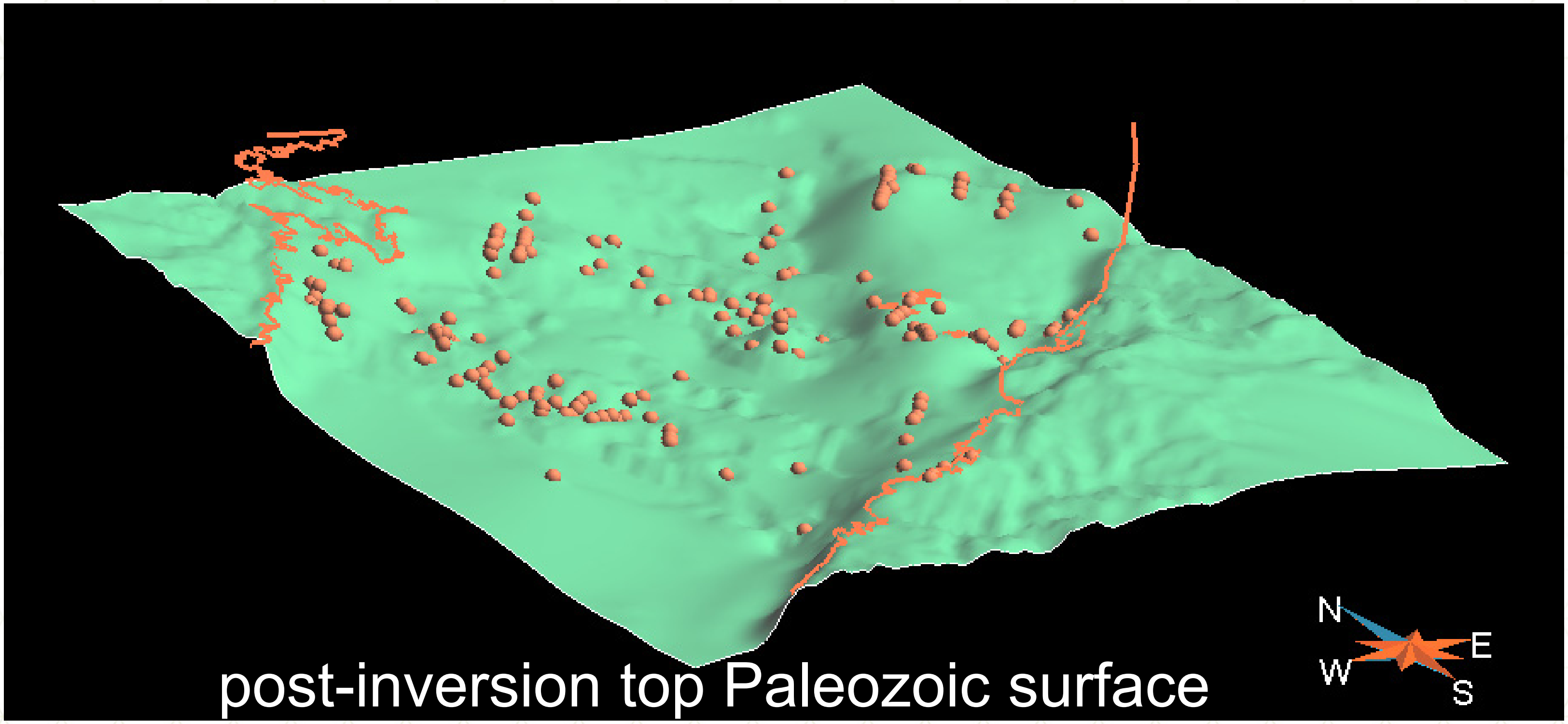
Malhadina Gravity Inversion - Portugal



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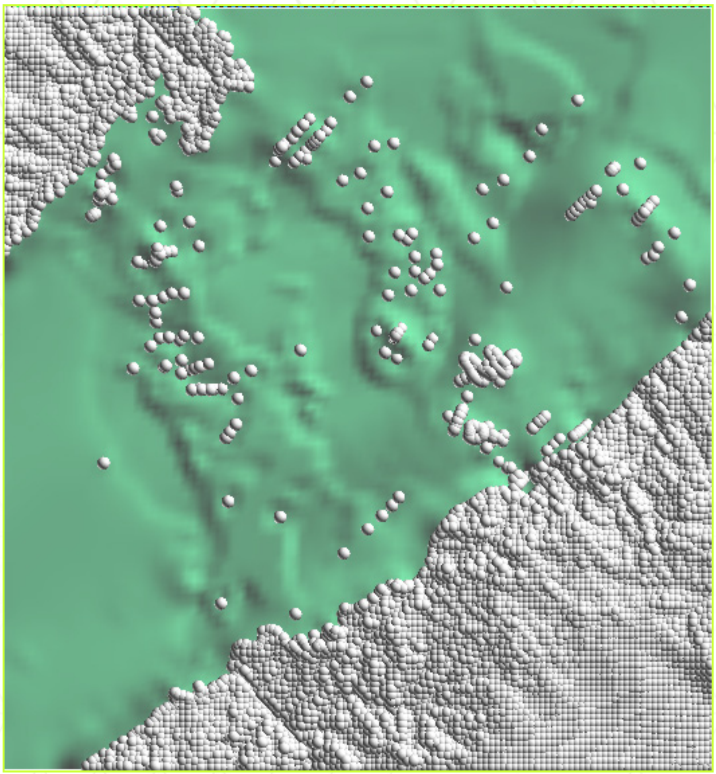
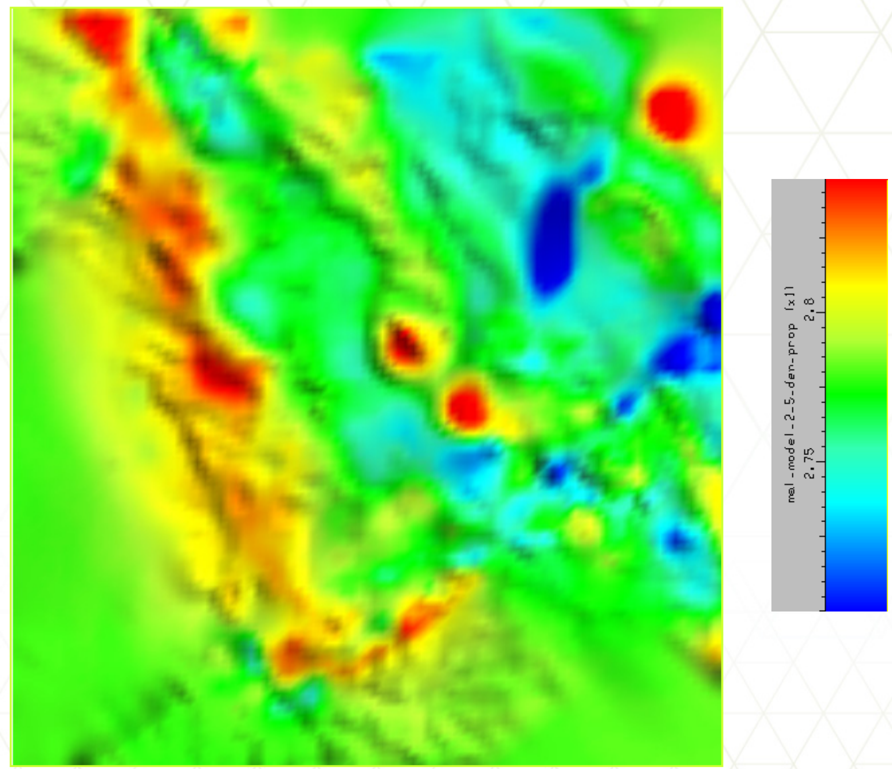
Malhadina Gravity Inversion - Portugal

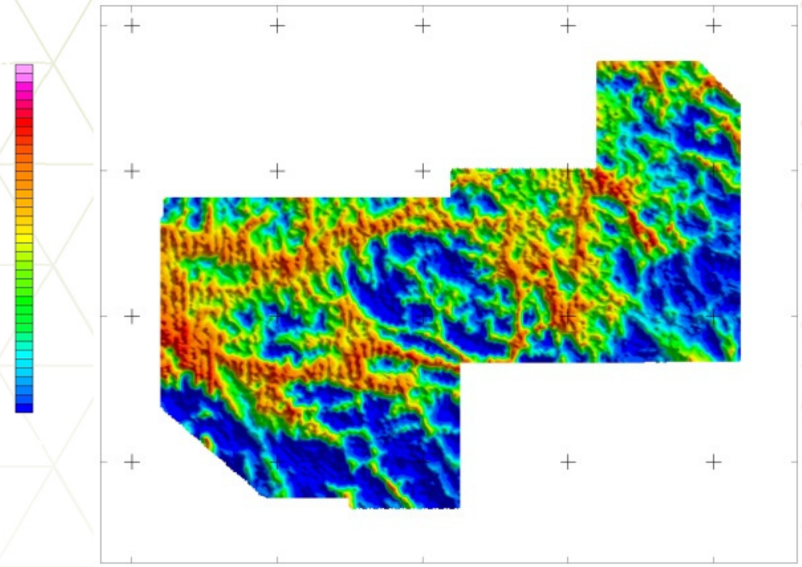


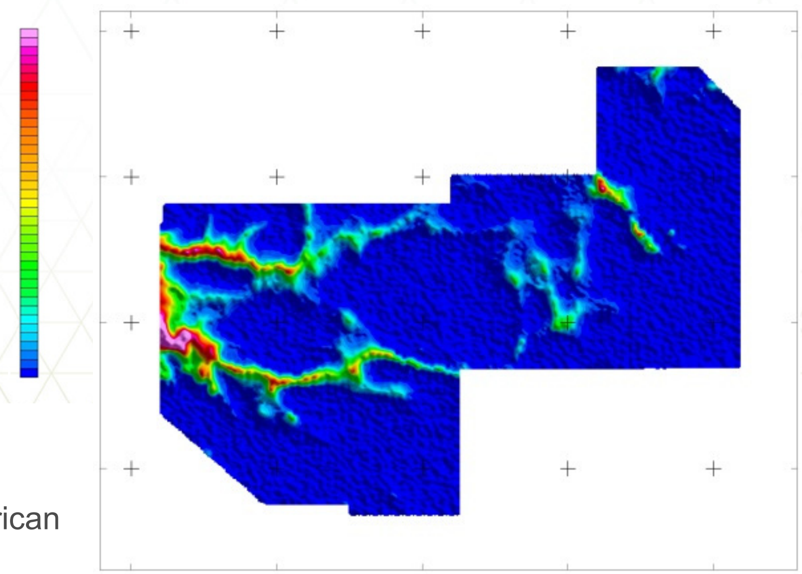


SPECTREM case study

- N-S flight lines
- 250m line spacing
- Bz (ppm) used for modelling
- Time from 26 micro.s to 9987 micro.s
- Towed bird (slingram)
- 50% duty cycle, processed to 100%.

- **Paleochannel modelling application.**





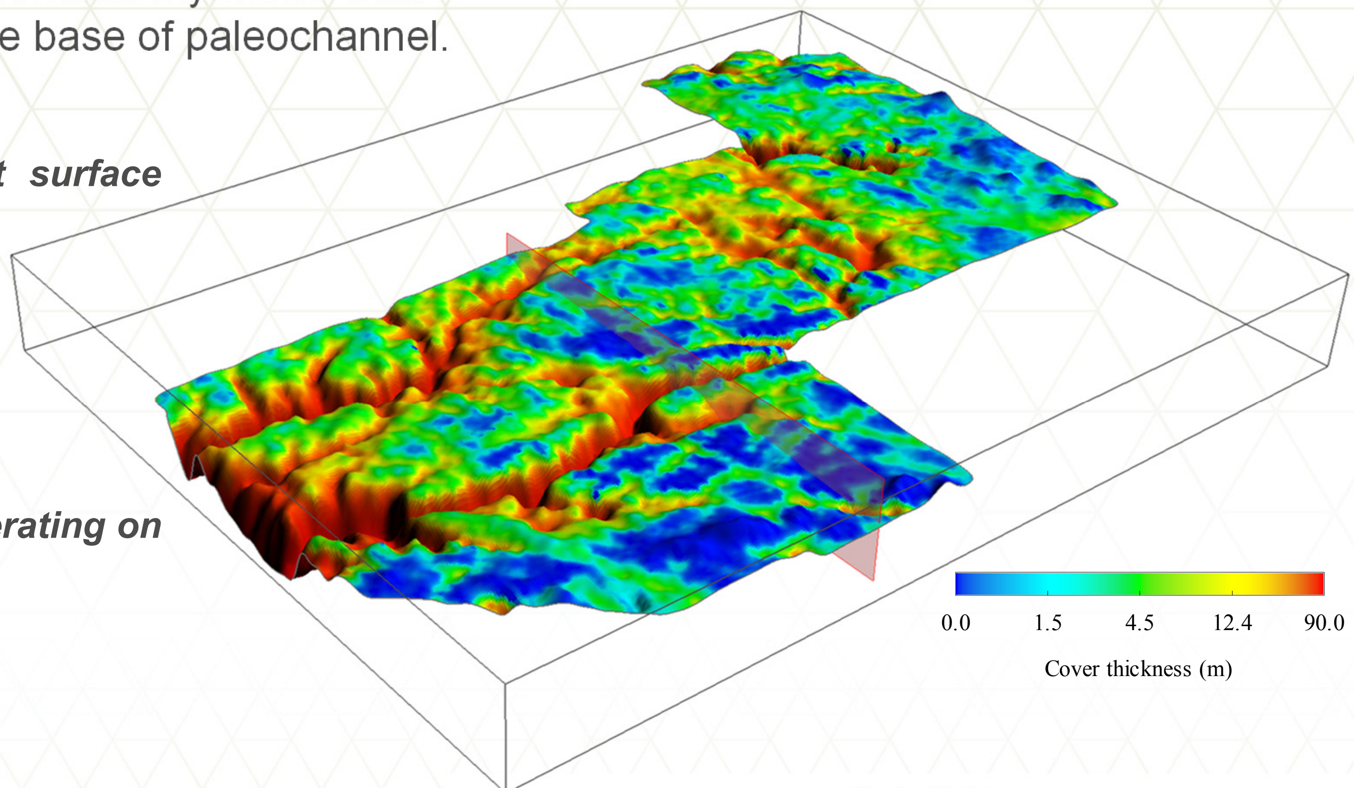
Data courtesy of Anglo American

Paleochannel modelling result.

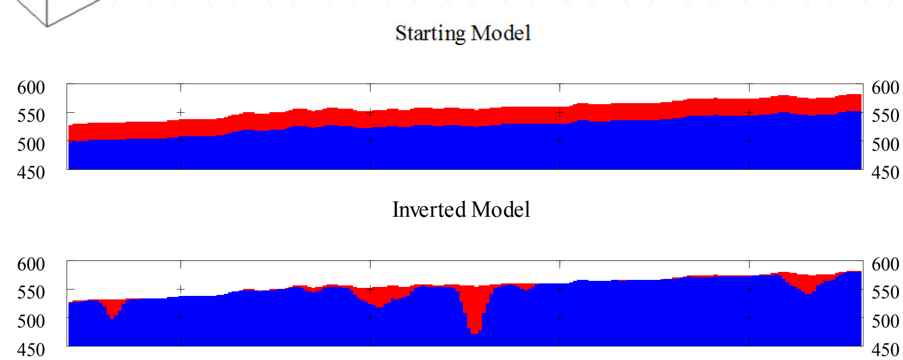
- The result is a 3D conductivity model that explicitly defines the base of paleochannel.

Extracted basement surface from inverted model

- Direct result of operating on a geological model



- Depth to basement maps are readily produced from the outputs.

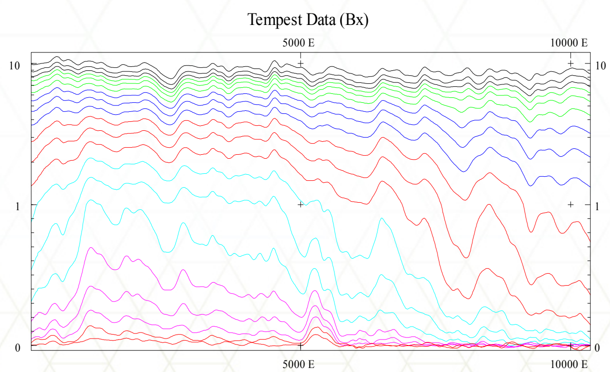


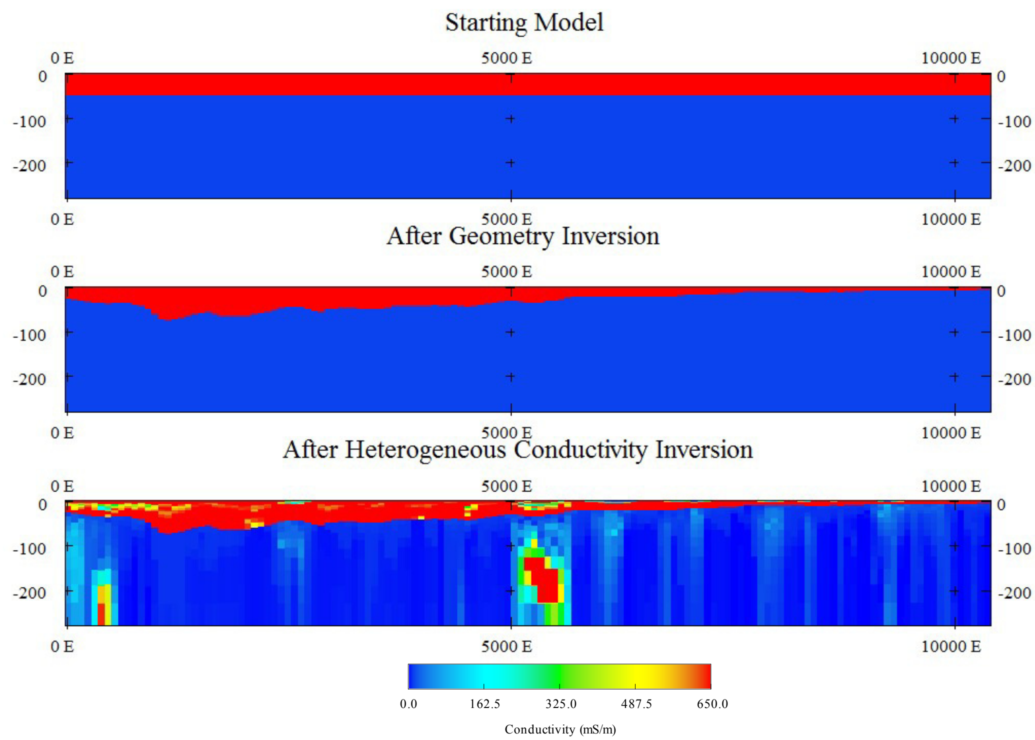
TEMPEST survey example – Bull Creek

- **Two phases of modelling were undertaken for the Bull Creek data set.**
- First pass inversion adopted the same strategy as the SPECTREM paleochannel case study, using two layer model comprising cover overlying basement.
- After geometry inversion, conductivity inversion further reduced the misfit by introducing cover and basement conductivity variations.
- In a second pass, the depth to basement was constrained locally by drill hole pierce points.

TEMPEST survey example – Bull Creek

- The starting model was represented by a two layer model.
- Starting model cover thickness was 50m.
- Cover conductivity was 800mS/m (inferred from VPem1D homogeneous conductivity inversion) overlying a resistive (10mS/m) basement.
- The model was submitted to depth to basement (geometry) inversion followed by heterogeneous conductivity inversion.





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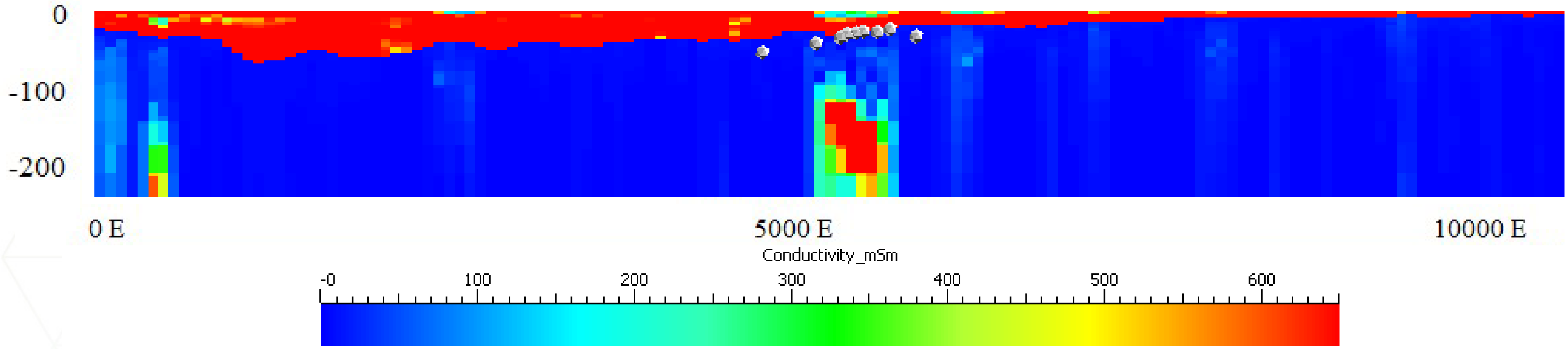
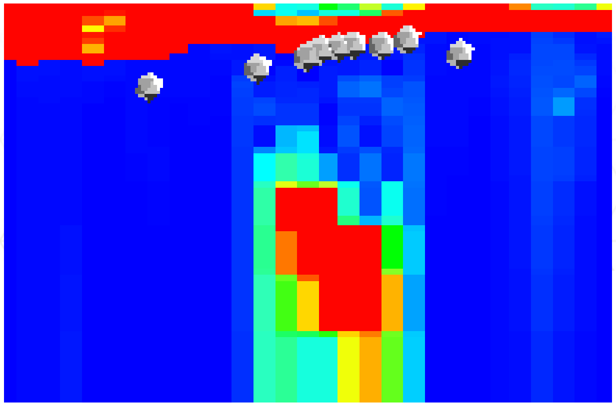
Detailed analysis of unconstrained geometry inversion

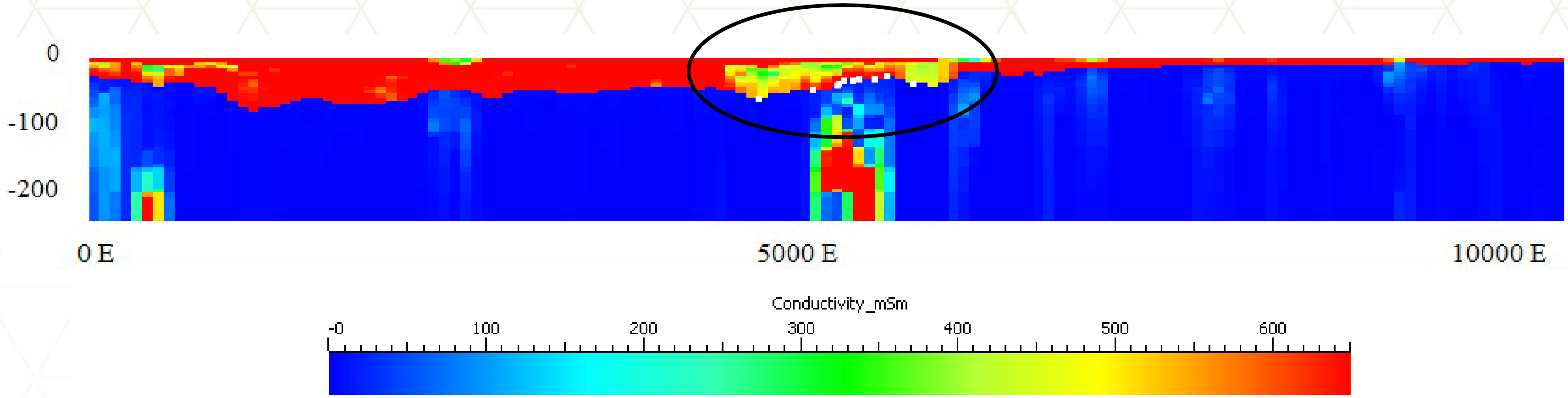
- Assess consistency to drill hole pierce points.





Drill hole constrained inversion

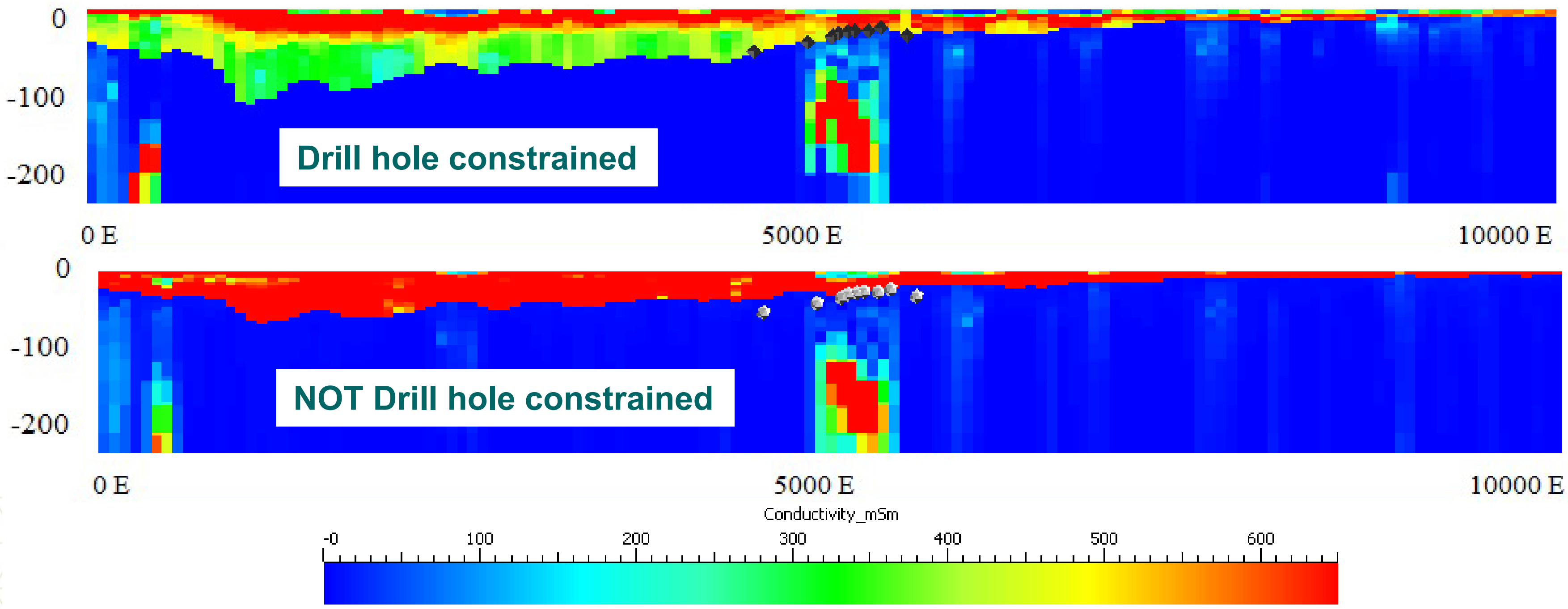
- Re-submit to conductivity inversion, with base of cover adjusted locally to honour drill hole constraints.



- Consistency with drill holes preserved – but the portion of the model constrained by drilling appears anomalous.
- Drill hole constrained inversion suggests that the previously assumed starting conductivity for cover was too high → impact on inverted depth to basement away from drilling.

Drill hole constrained inversion - Conclusions

- Updated model consistent with drilling - more geologically plausible
- Drill hole depth-to-basement constraints provided additional control on the starting model conductivity.
- Drill hole constrained inversion suggests multiple layers within thicker cover



Conclusions

- There are many advantages when inversion algorithms operate on a geological model:
  - Rapid model validation (forward modelling)
  - More flexible (more inversion options)
  - More control (operate on selected geological domains)
  - Explicitly incorporate geological constraints
  - A driver for integrated interpretation - the inverted model is geological.
- Explicit modelleing of cover is a natural application
- Pierce point constraints can have implications for physical properties as well as geometry

Acknowledgements

- Boulia data courtesy QDME
- Malhadina data courtesy Lundin
- Bull Creek TEMPEST data courtesy Exco Resources
- SPECTREM survey data courtesy Anglo American
- Mt Dore Geotem data courtesy Geological Survey of Queensland