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Getting more out of drill hole survey data: Refining depth resolution of magnetic data inversions with borehole magnetic vector data at the Nickel Mountain project, BC.

ROUND UP 2020
INNOVATION STAGE

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Outline

1. Introduction
2. Borehole orientation survey data
3. About magnetic data and inversions
4. Hybrid magnetic inversion concept & technology
5. Case study: Nickel Mountain Project, Garibaldi Resources Corp.

1. Getting more from your drill hole orientation survey?

► Could a wealth of geophysical data be a by-product from a routine survey process?

► Would such data be usable at all?

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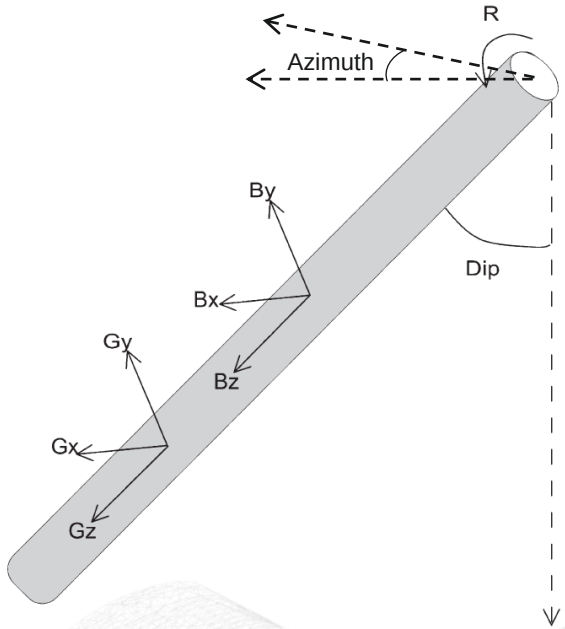
2. About borehole orientation survey data

Borehole survey tools:

- three-component fluxgate magnetometer to measure the magnetic field (*Bx, By, Bz*)
- a three-component accelerometer to measure gravity field (*Gx, Gy, Gz*)
- Sensors (probe) orientation based on orienting the measured magnetic or acceleration vectors in Earth's magnetic or gravity fields
- Final data are depth, azimuth & dip



Modified from K. Frankcombe, 2015.

► What about the magnetic vector data?

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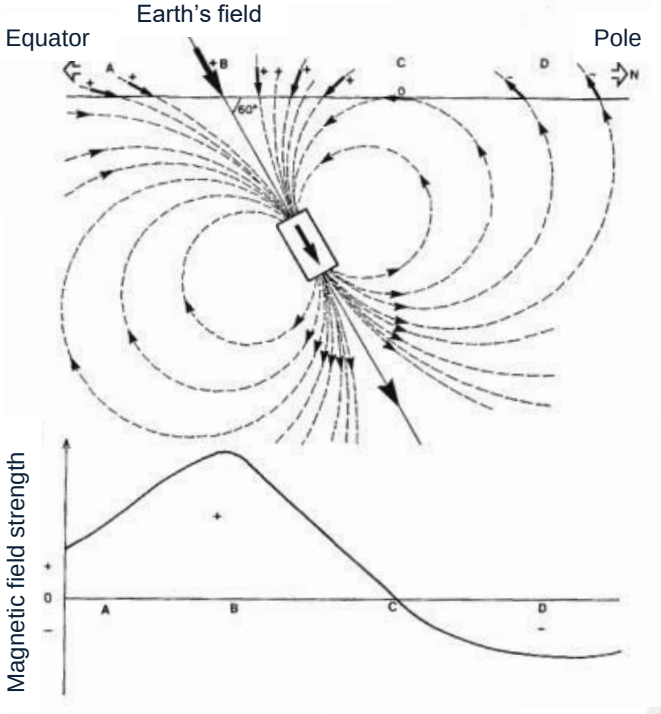
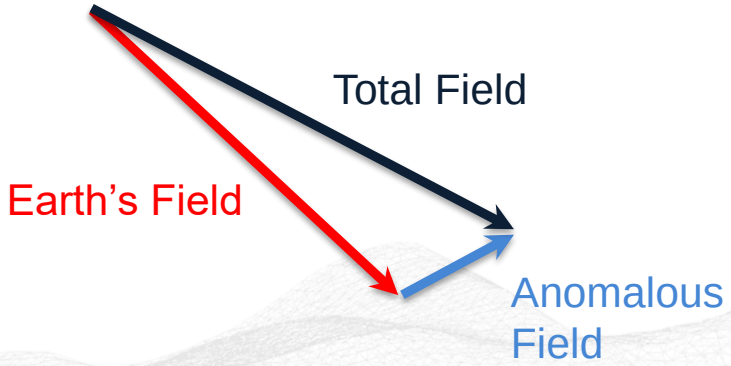
3. About magnetic data and inversions



$$B_{Total} = B_{Earth} + B_{Anomalous}$$



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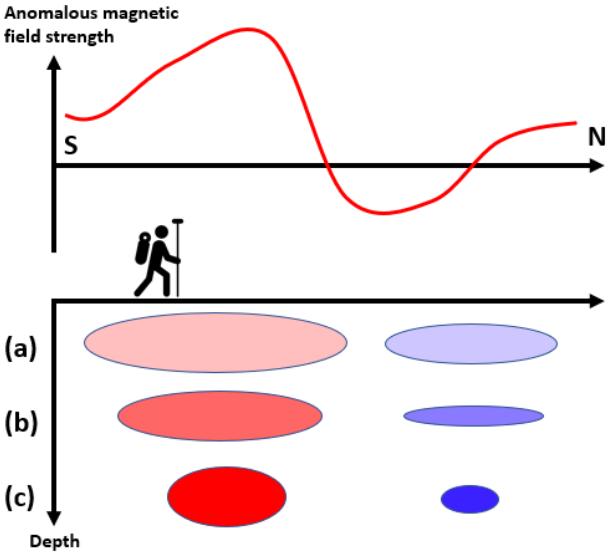
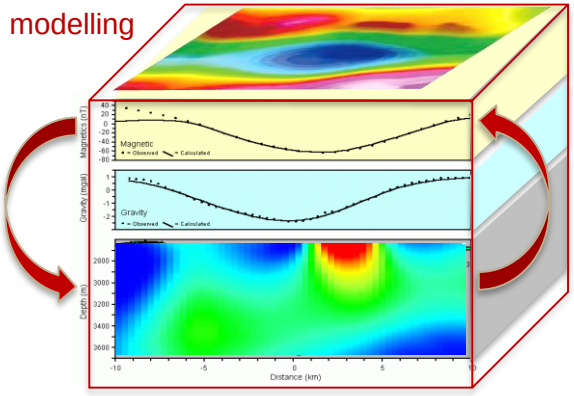
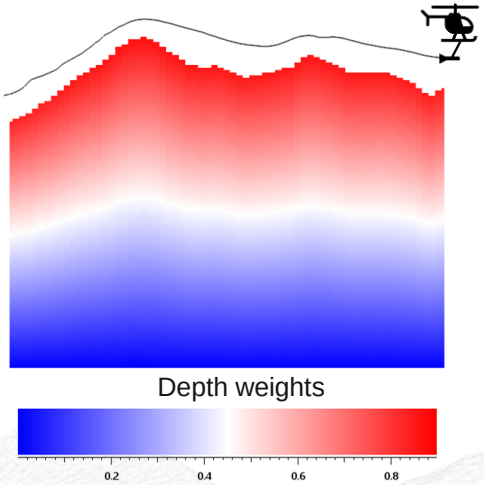
3. About magnetic data and inversions



Which is the best model: (a), (b) or (c)?





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4. Hybrid magnetic inversion concept & technology

The goal is to improve the depth resolution of the unconstrained inverted magnetic susceptibility model through a two-step process:

1. Inverting the above-ground data alone
2. Refining existing model by adding magnetic vector data to the inversion

The unconstrained 3D inversion relies on Mira's VPmg software:

- Allows for simultaneous inversion of two magnetic data types
- Supports both above- and under-ground data locations
- Computes the true total magnetic anomaly vector (not an approximation!)
- Data errors can be specified for each data component
- Custom weights can be applied

5. Nickel Mountain Project, Garibaldi Resources Corp.

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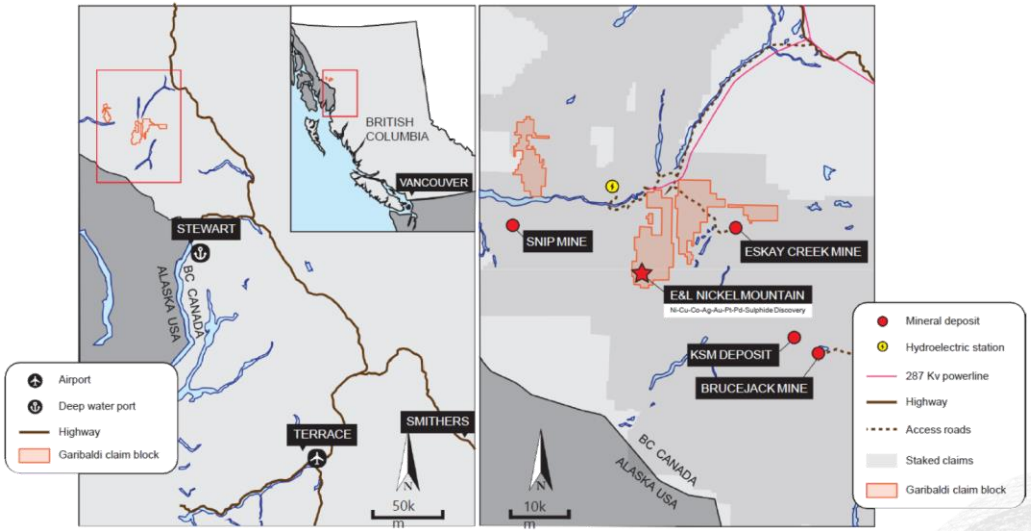
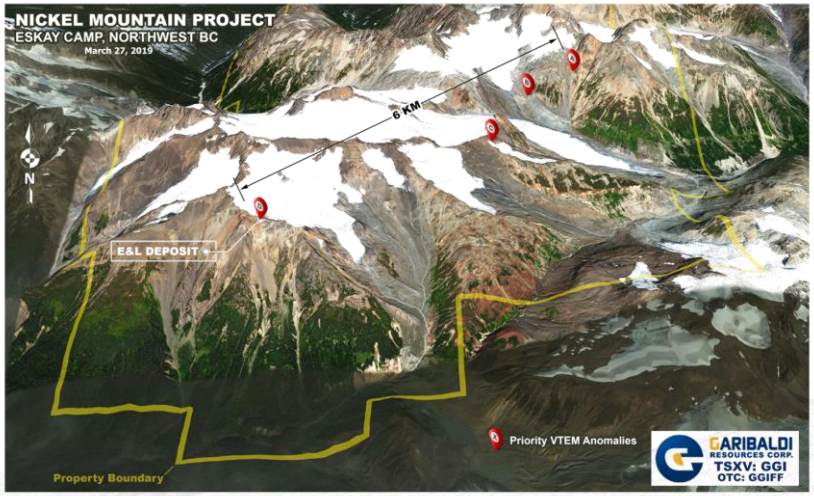
5. Nickel Mountain Project, Garibaldi Resources Corp.

Location:

- BC's Golden Triangle



Garibaldi Rsc. 2020



Garibaldi Rsc. 2020

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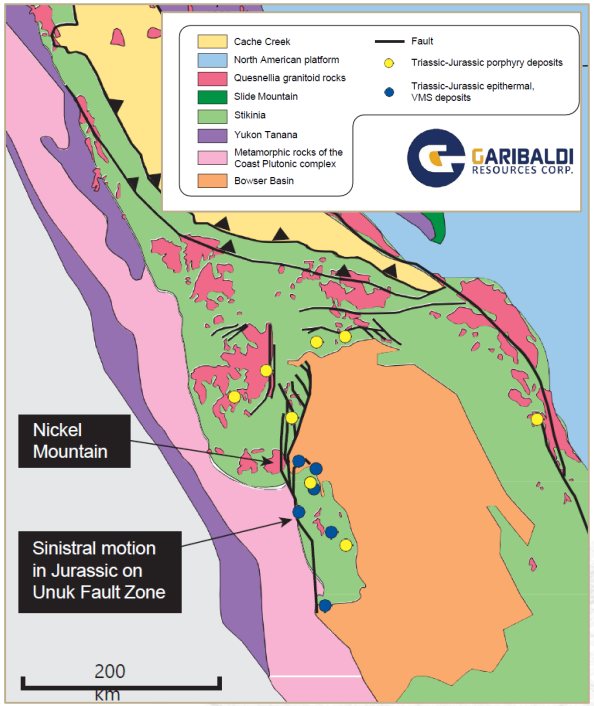
5. Nickel Mountain Project, Garibaldi Resources Corp.

Geological setting:

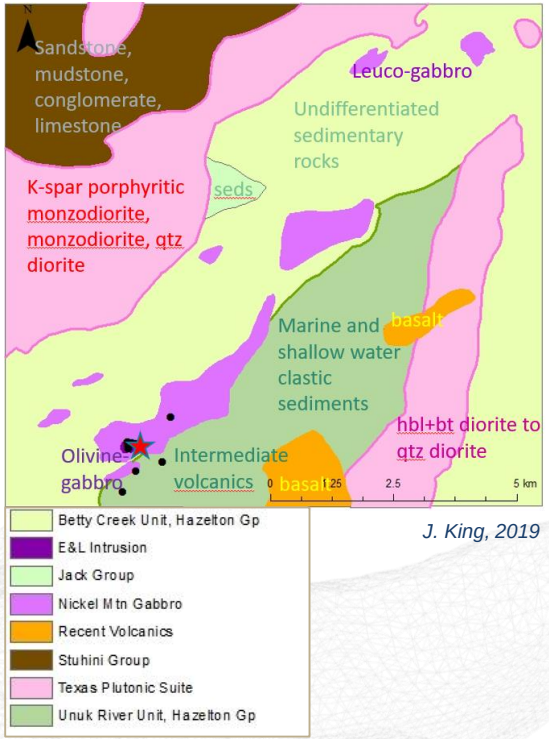
- In the Stikine terrane along the western margin of the Jurassic Eskay rift
- Regional geophysics suggest large volumes of mafic/ultramafic rocks at depth
- Intrusive complex with magmatic nickel-copper-rich massive sulphide
- Gabbro hosted mineralization
- Petrophysics shows strong susceptibility contrast between mineralized and unmineralized zones

Regional geology



Garibaldi Rsc. 2020

Property geology



J. King, 2019

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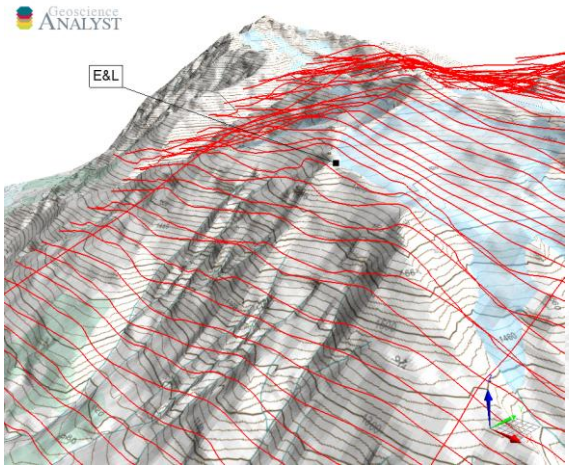
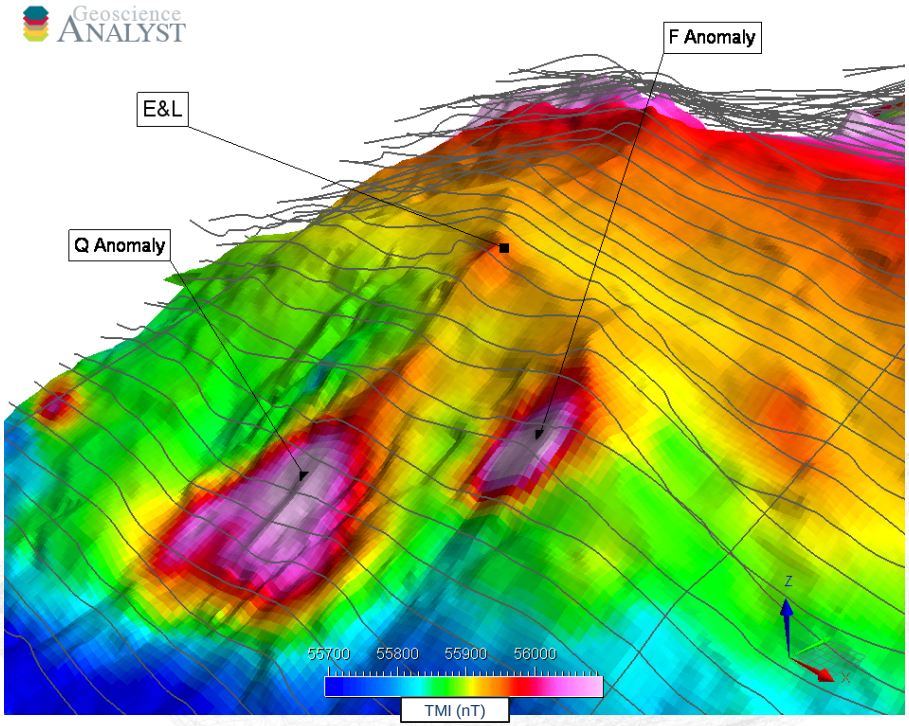
5. Nickel Mountain Project, Garibaldi Resources Corp.

Data: 2017 Geotech VTEM airborne survey

- Heliborne magnetic bird (TMI)
- 100 m line spacing
- ~112 m mean sensor ground clearance

Data range
~900 nT





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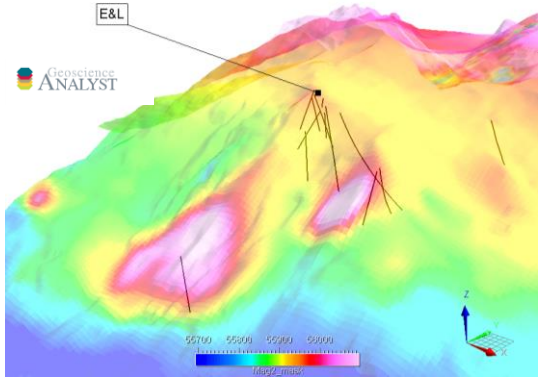
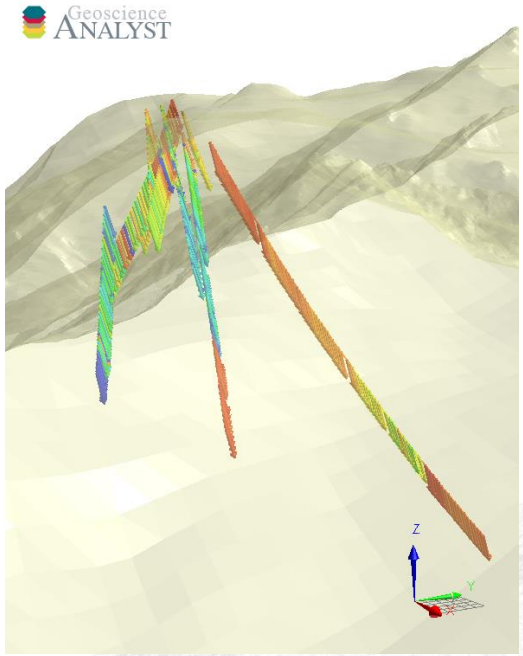
Data: 2018 Lamontagne BHUTEM survey

- 3-component BHEM survey
- Incidental magnetic vector data
- 13 holes logged with a ~10 m mean sample spacing

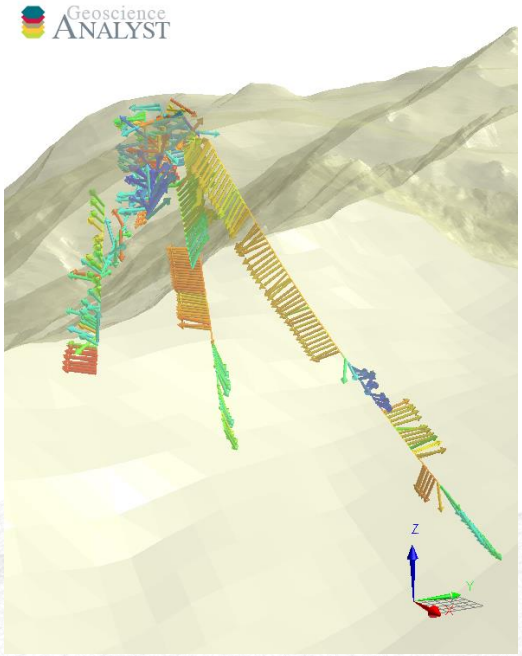
Data range ~5,000 nT



Total magnetic intensity (Geotech)



Total magnetic field vector



Anomalous magnetic field vector

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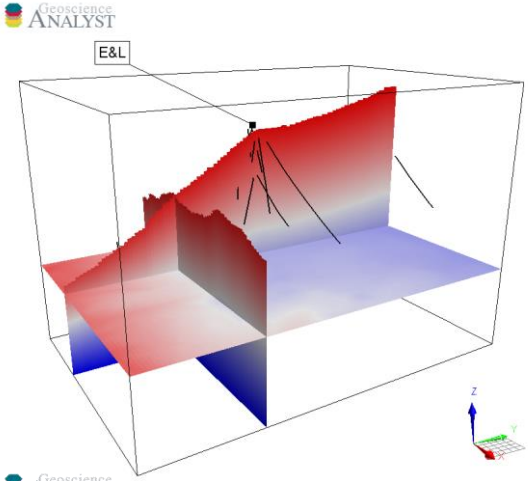
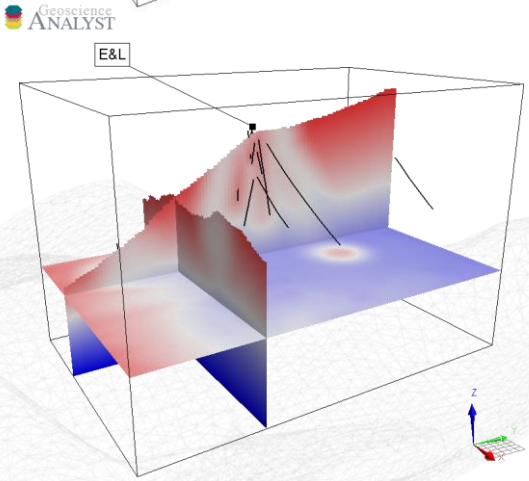
Unconstrained 3D inversions at E&L:

Inversion	#1 - Standard	#2 - Hybrid
Scale	50x50x25m *Property wide*	25x25x10m *E&L area focused*
Data	VTEM *TMI*	VTEM + BHUTEM *TMI, Bx, By, Bz*
Weights	Depth (*0.9*)	Hybrid depth (*0.9*) & distance to BH (*0.7*)
Errors	10% of σ	10% of σ of each component
TMI RMS misfit	~6.14 nT	~6.25 nT

Standard weights



Hybrid weights



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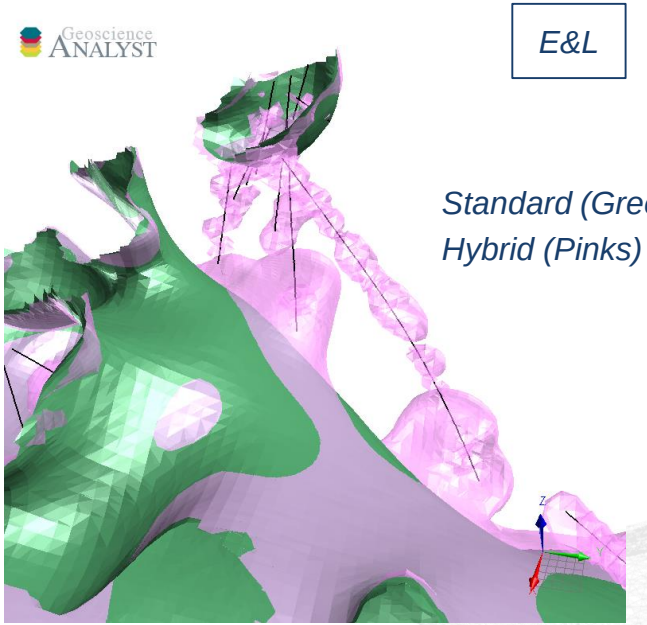
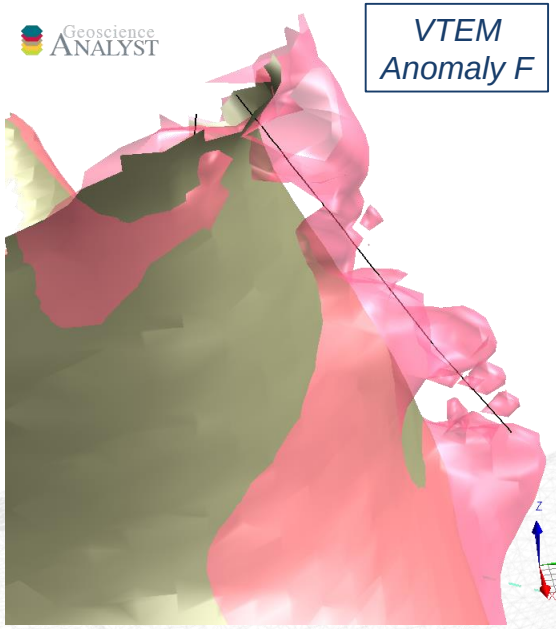
Unconstrained 3D inversions results:

- hybrid inversion provides local updates
- Standard inversion data fit not significantly affected



Iso-surfaces at 2.2 x10^{-3} SI



Iso-surfaces at 5.0 x10^{-3} SI

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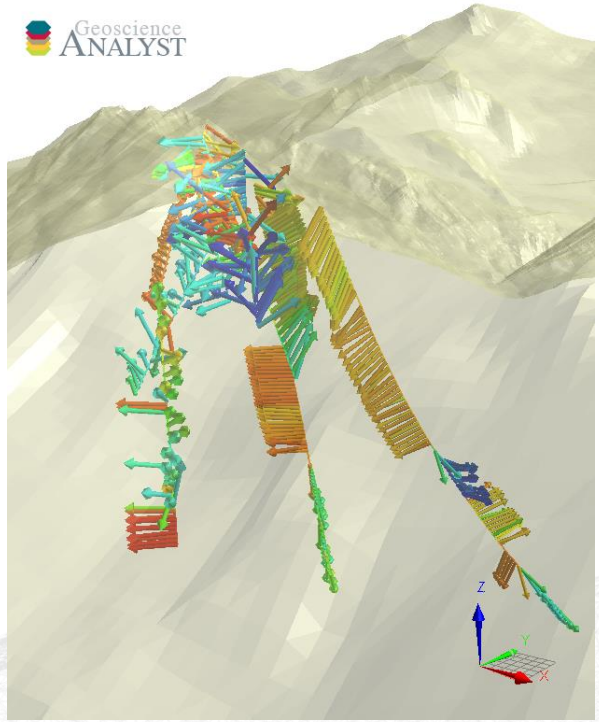
Conclusions:

- Already existing (almost free?) magnetic vector data from drill hole orientation probes can be leveraged to improve depth resolution of inverted models.
- Modelling trade-off between surface and borehole data resolutions managed with hybrid weights and data errors.
- Hybrid inversion provides local updates at depth without significantly compromising the fit with surface data.



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Acknowledgements

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