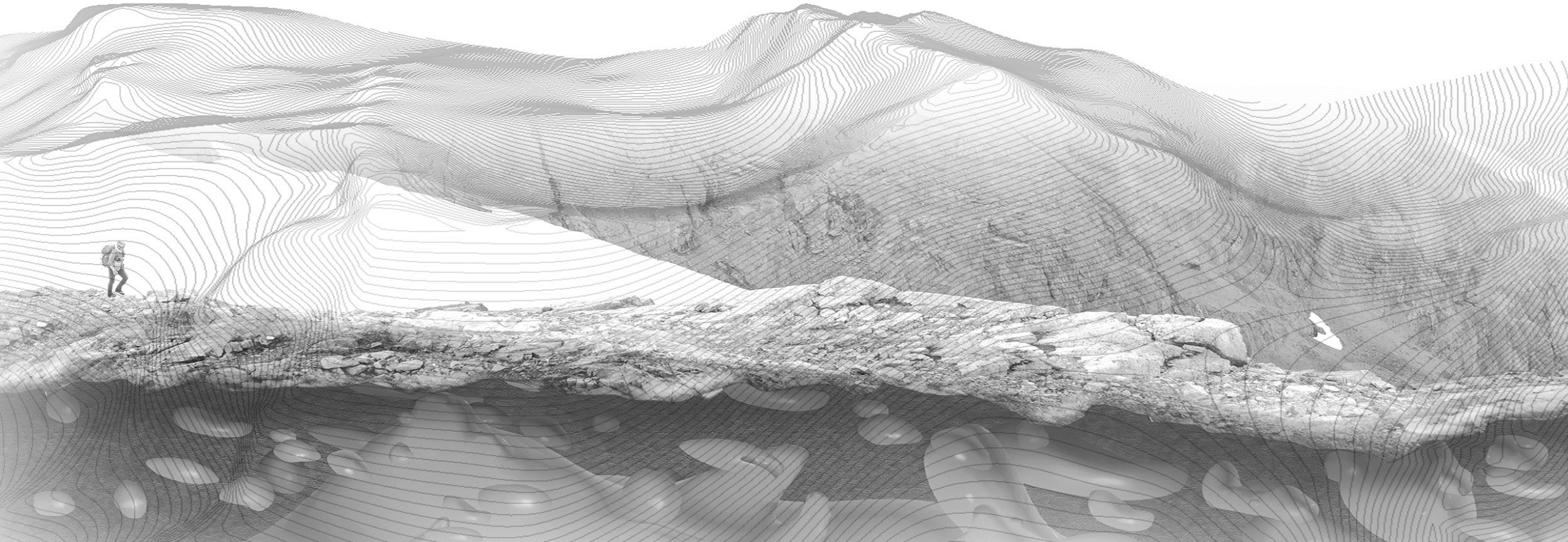
DIAS

LEADING GROUND AND AIRBORNE GEOPHYSICAL

Examples of the Value of Full Tensor Magnetic Gradiometry (QMAGT)

Authors: Ryan Olson (Dias Airborne), Jonathan Rudd (Dias Geophysical)



QMAG^{T} – Full Tensor Magnetic Gradiometry (FTMG)

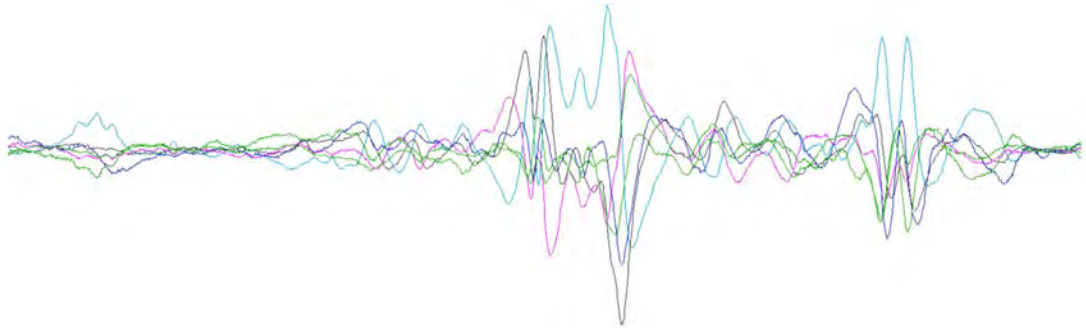
Measured with Superconducting Quantum Interference Devices

Conventional Total Field Mag

B

Full Tensor Magnetic Gradiometry

$$T = \begin{bmatrix} Bxx & Bxy & Bxz \\ Byx & Byy & Byz \\ Bzx & Bzy & Bzz \end{bmatrix}$$



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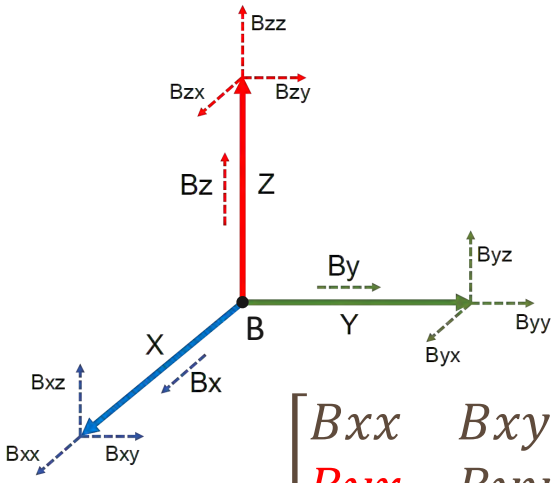
QMAG^T – Full Tensor Magnetic Gradiometery (FTMG)

Measured with Superconducting Quantum Interference Devices

Measured Tensor Components

- Bxx
- Bxy
- Bxz
- Byy
- Byz
- Bzz*

$= (-B_{xx} - B_{yy})$



$$\begin{bmatrix} Bxx & Bxy & Bxz \\ Byx & Byy & Byz \\ Bzx & Bzy & Bzz \end{bmatrix}$$

Calculated

- Tensor Invariants I^1 & I^2
- Total Horizontal Curvature (THC)
- Total Horizontal Gradient (THG)
- Calculated Total Magnetic Intensity (TMI)

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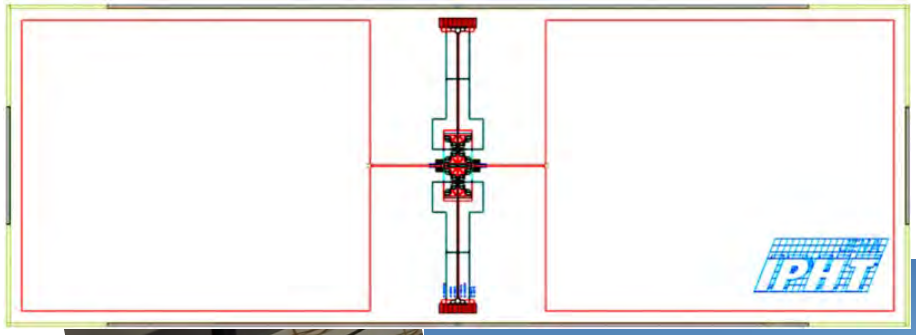
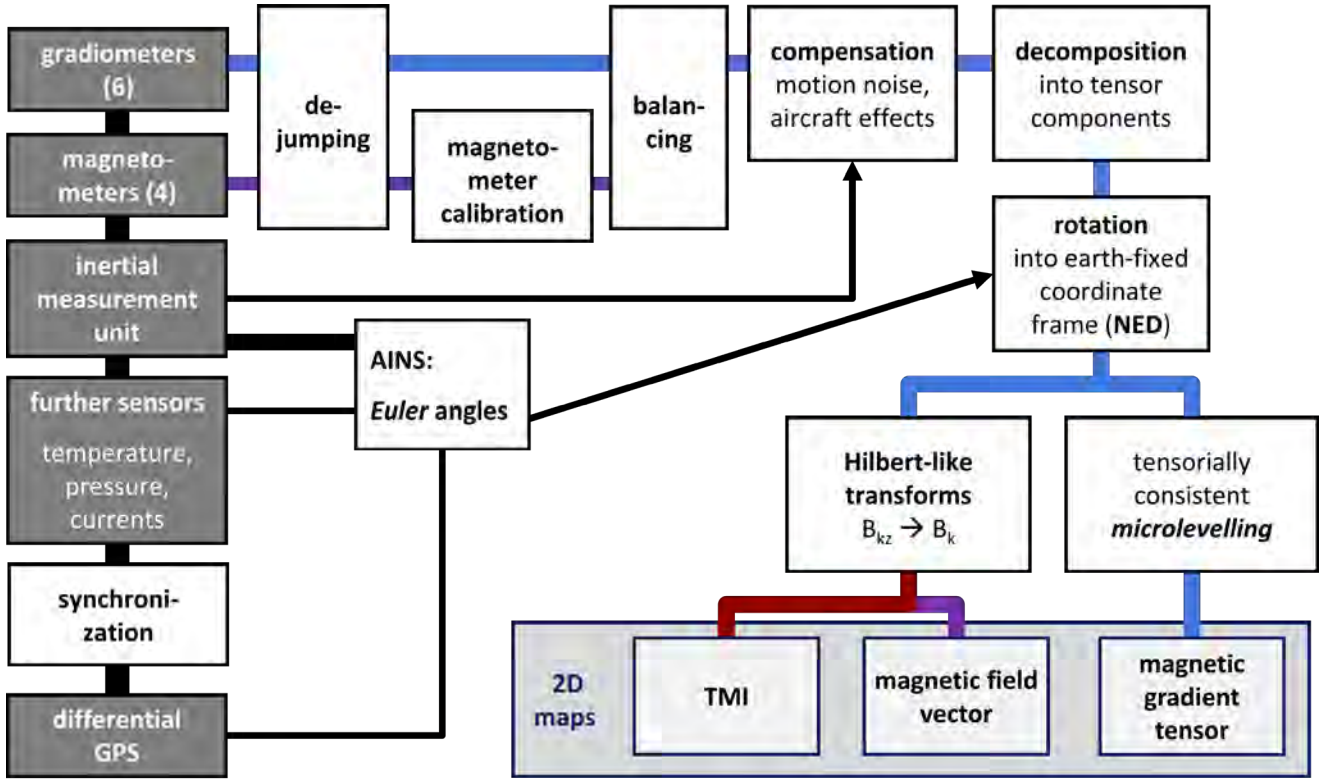
SQUID Gradiometer

- Helium Cooled Superconducting Quantum Interference Device
  - 4.2 Kelvin
- 6 channels of first order planar gradiometers
  - Intrinsic noise: <100 fT / (m√Hz)
- 4 channels of magnetometers
  - Intrinsic noise: 2 pT / √Hz



FTMG Processing

- Time synchronization (SQUID, GPS, IMU data)
- Mechanical processing:
  - GPS post-processing -> track/location
  - IMU processing -> Euler angles
- Magnetometer:
  - Calibration using HDGM, Euler angles and GPS track
- Gradiometer processing:
  - Corrections for flux jumps
  - Balancing using magnetometer data -> denoised gradiometer signals
  - Unmix tensor components -> tensor components in body system
  - Rotation into ECEF using Euler angles -> tensor components in ECEF
  - Compensation for denoising
  - Brid mapping - various options
  - Tensor consistent micro-levelling
  - Noise reduction
  - Calculate TMI from magnetometer/tensor components etc.



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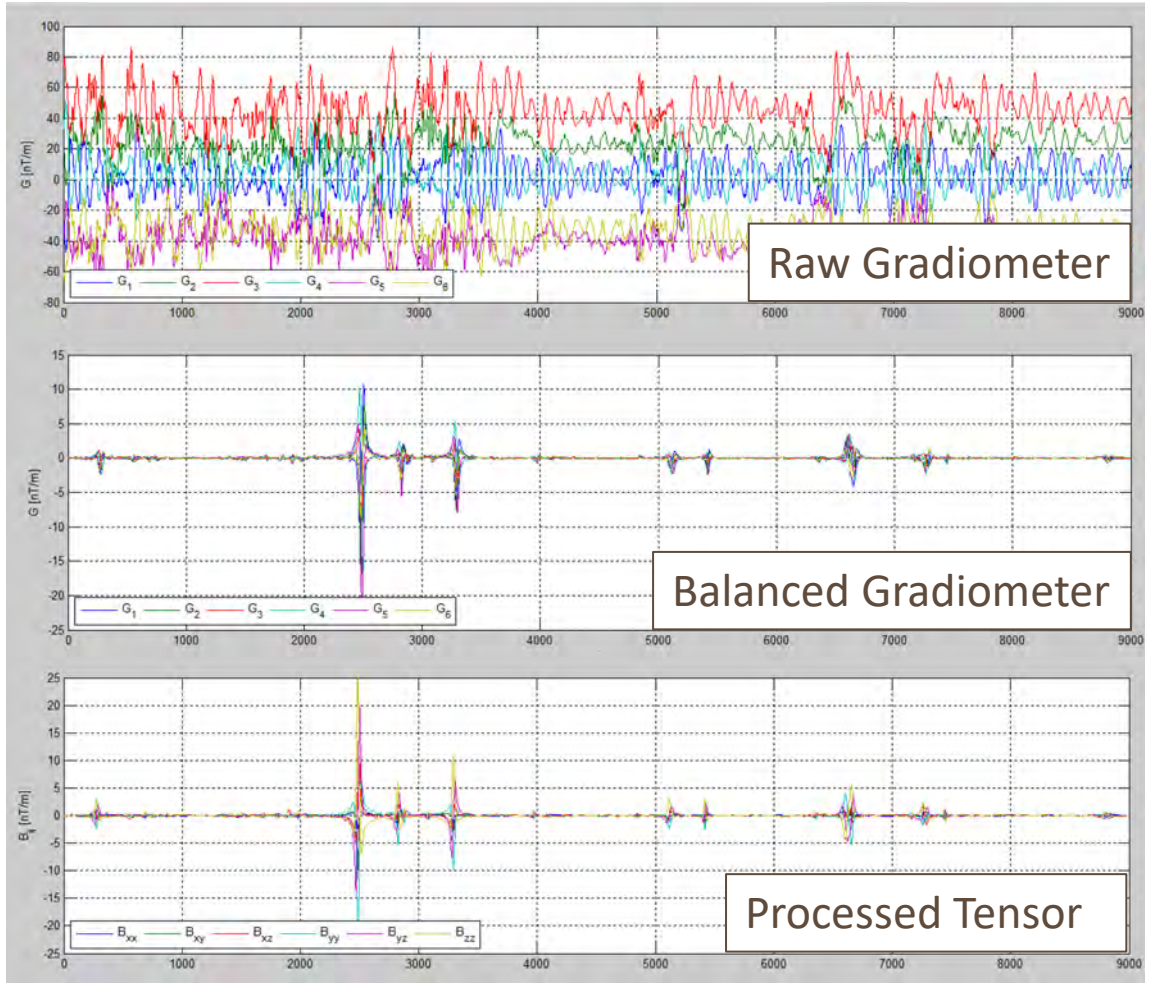

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Case Studies:

- Ni-Cu-PGE - Sudbury Basin - Ontario
- Ni-Cu-Co - Murchison HPM Project - Quebec
- Lithuim - LCT Pegmatites
- Iron Ore - Blötberget - Sweden

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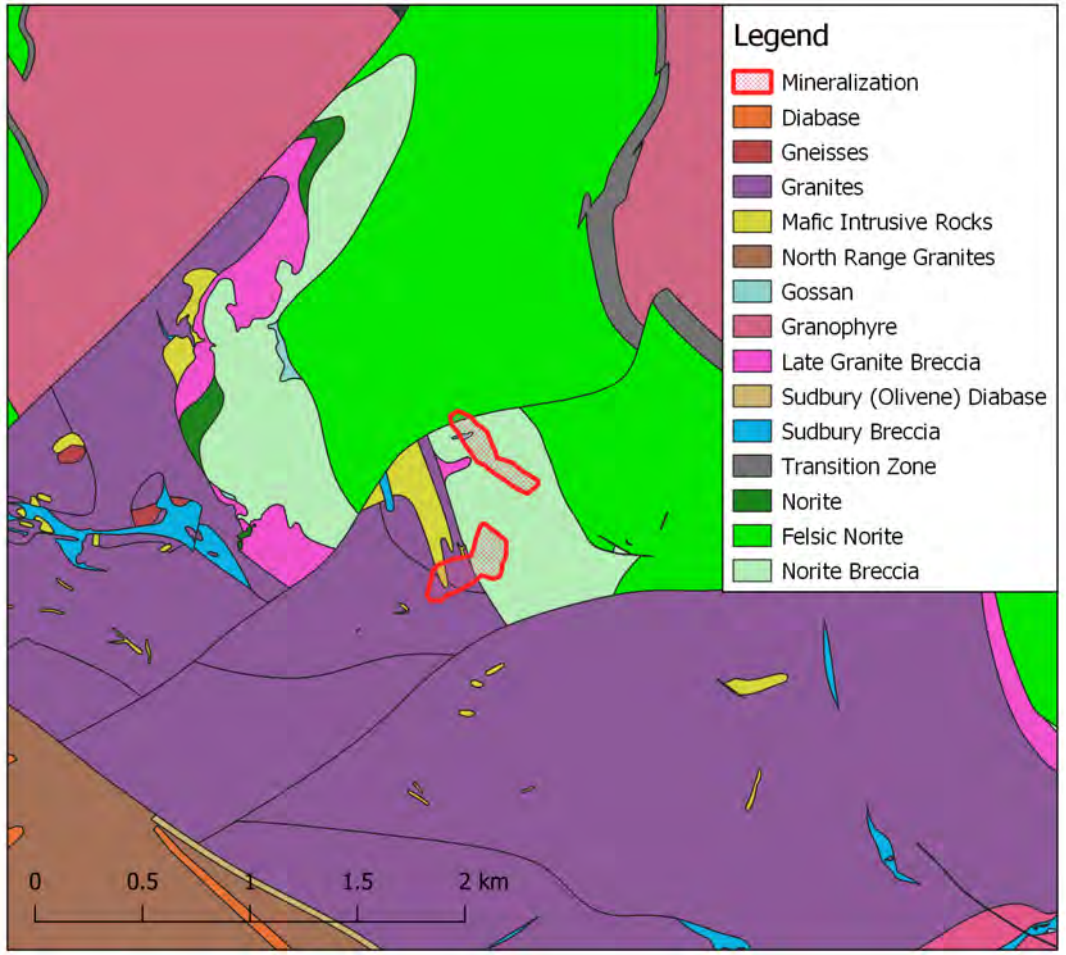
Case Study: Ni-Cu-PGE Sudbury Basin

- SIC contact hosted mineralization
- Northern Lens ~50 m depth, South lenses ~300-500 m
- Dip ~50° to the East



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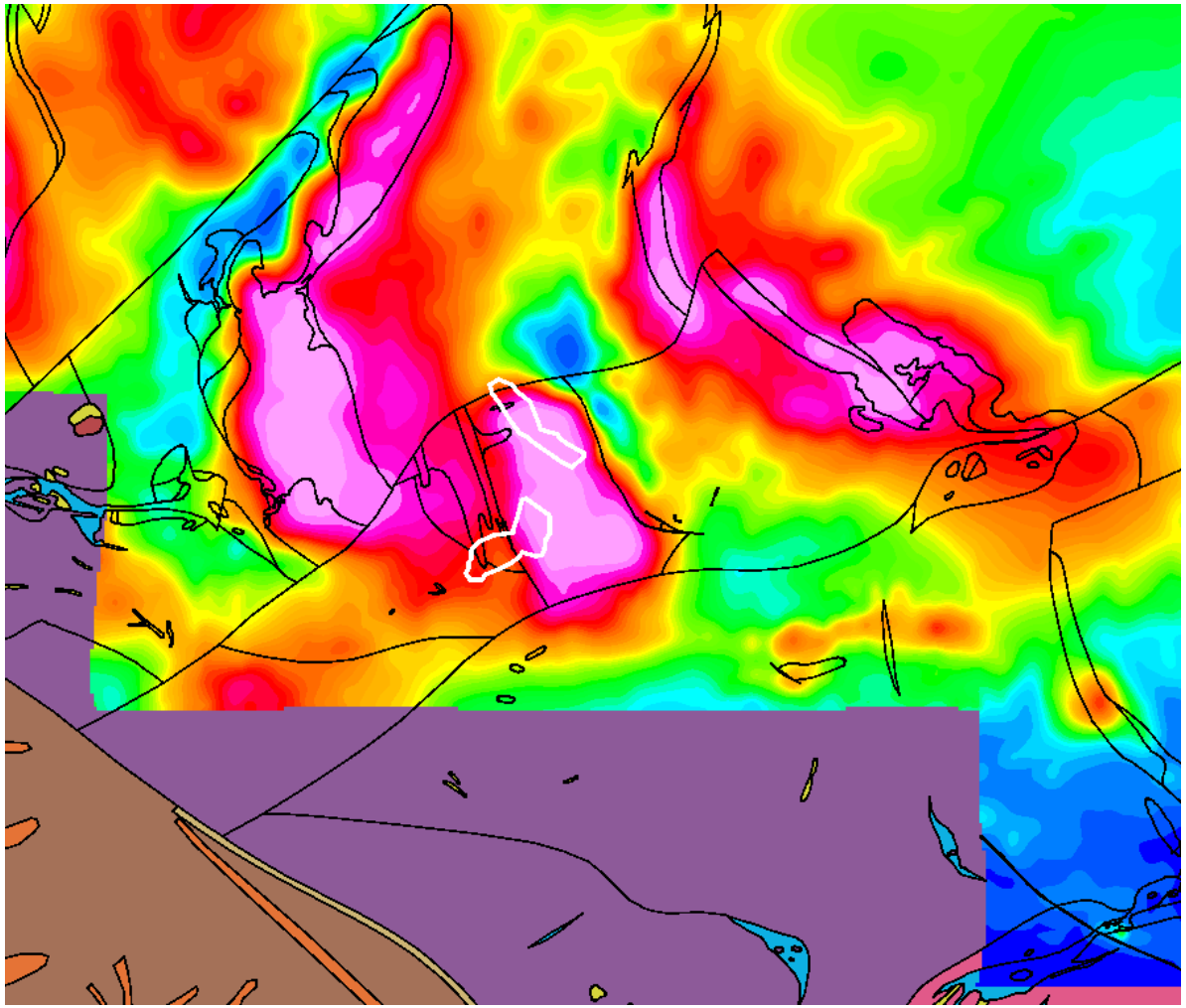
Case Study: Ni-Cu-PGE Sudbury Basin

- Client Provided (100 m line-spacing)
  - Measured TMI
  - Calculated 1VD
- QMAG^{T} Survey (75 m line-spacing)
  - Calculated TMI
  - Bzz
  - Bxx
  - Bxy
  - Bxz
  - Byy
  - Byz
  - Rotational Invariants:
    - I1
    - I2
    - THC – Total Horizontal Curvature
    - THG – Total Horizontal Gradient



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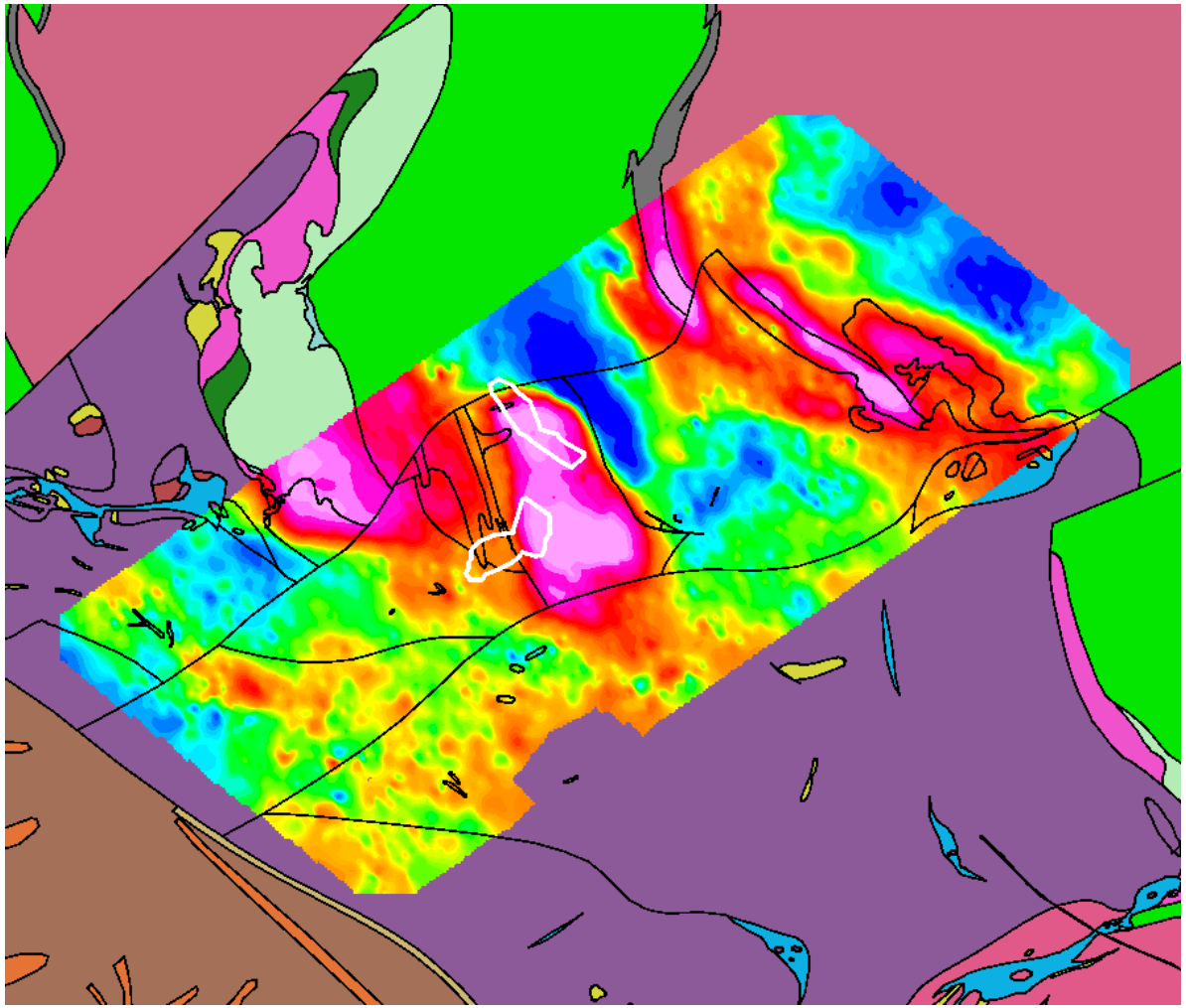

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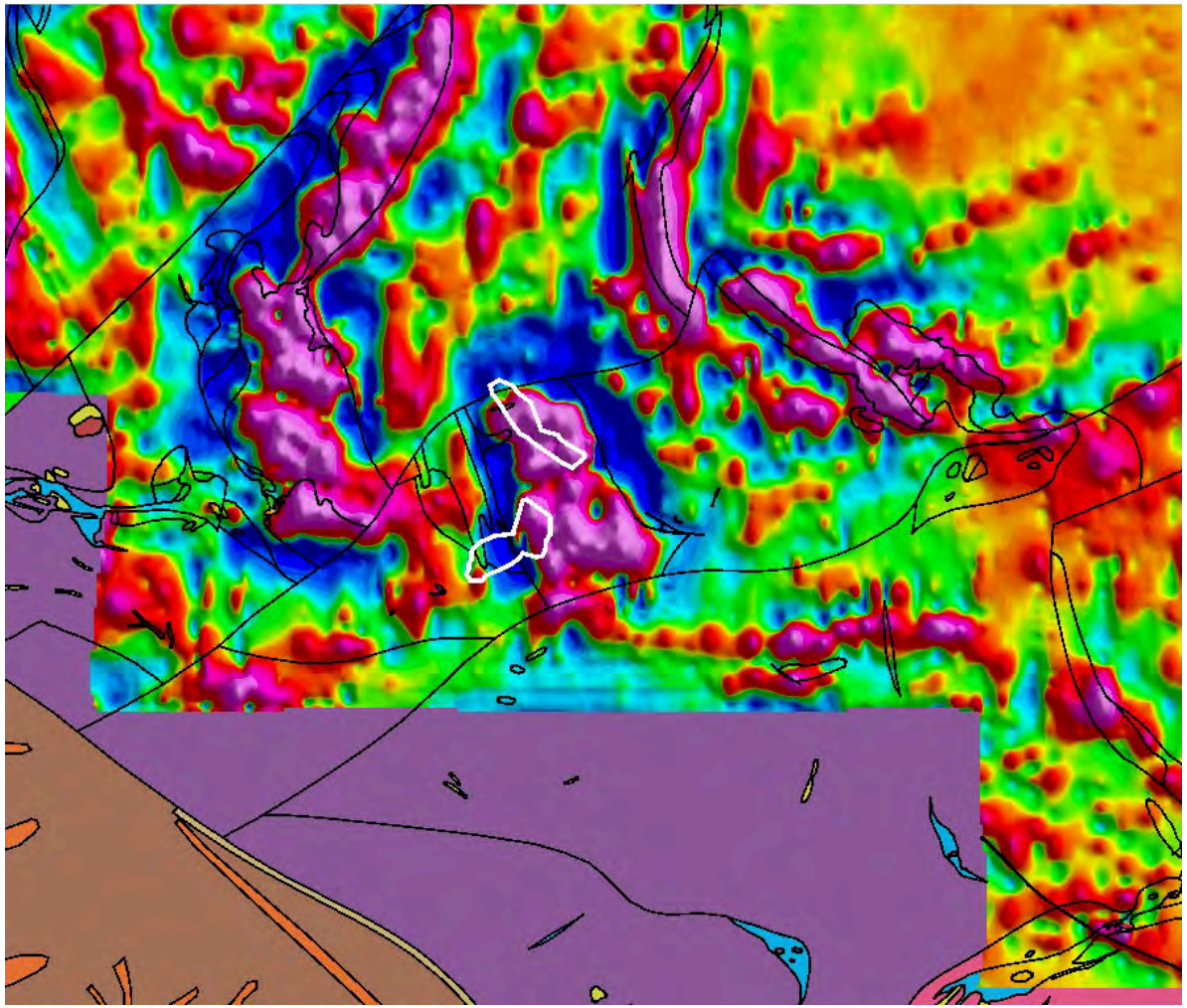

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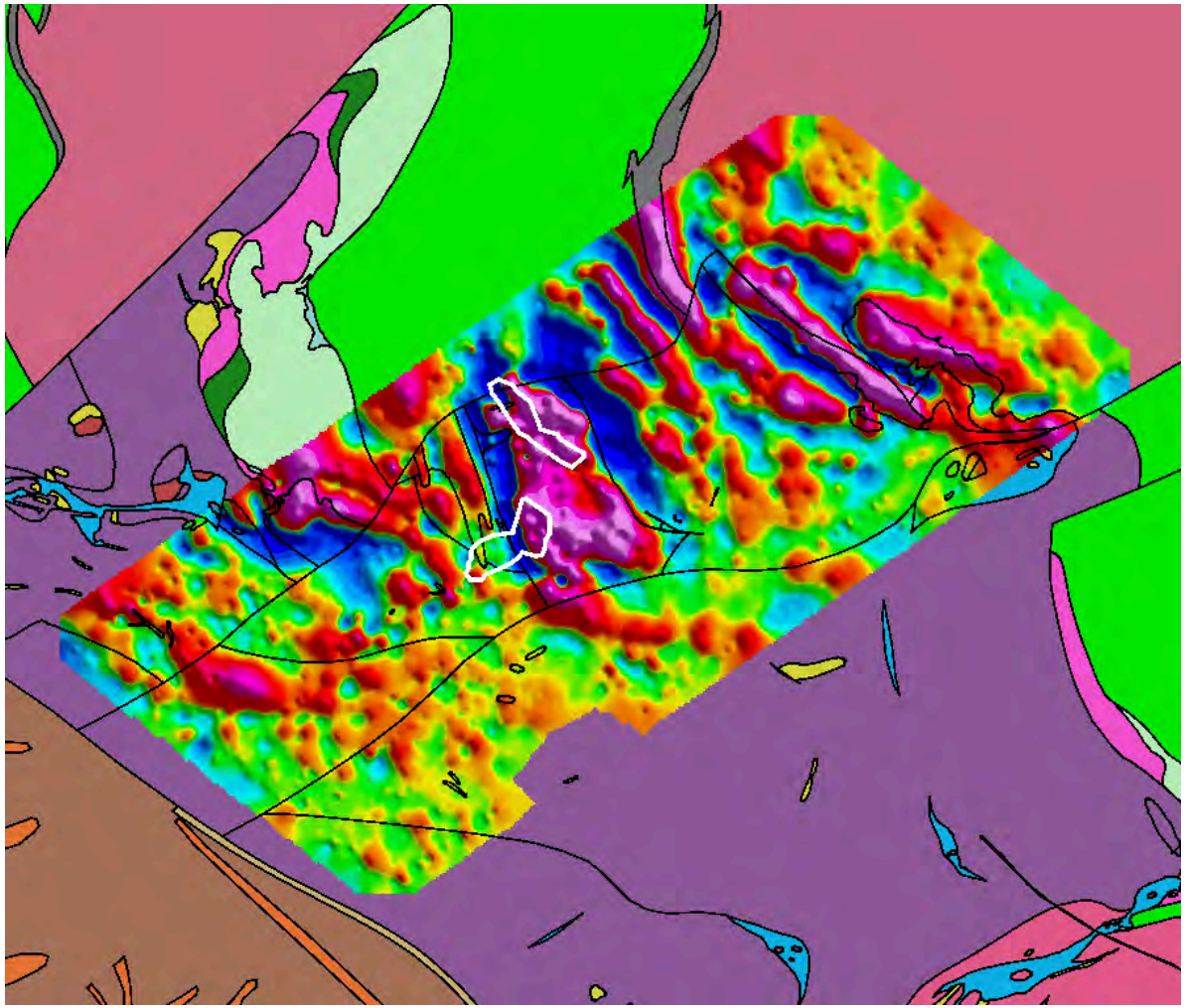
Analogous to traditional Total Field 1VD



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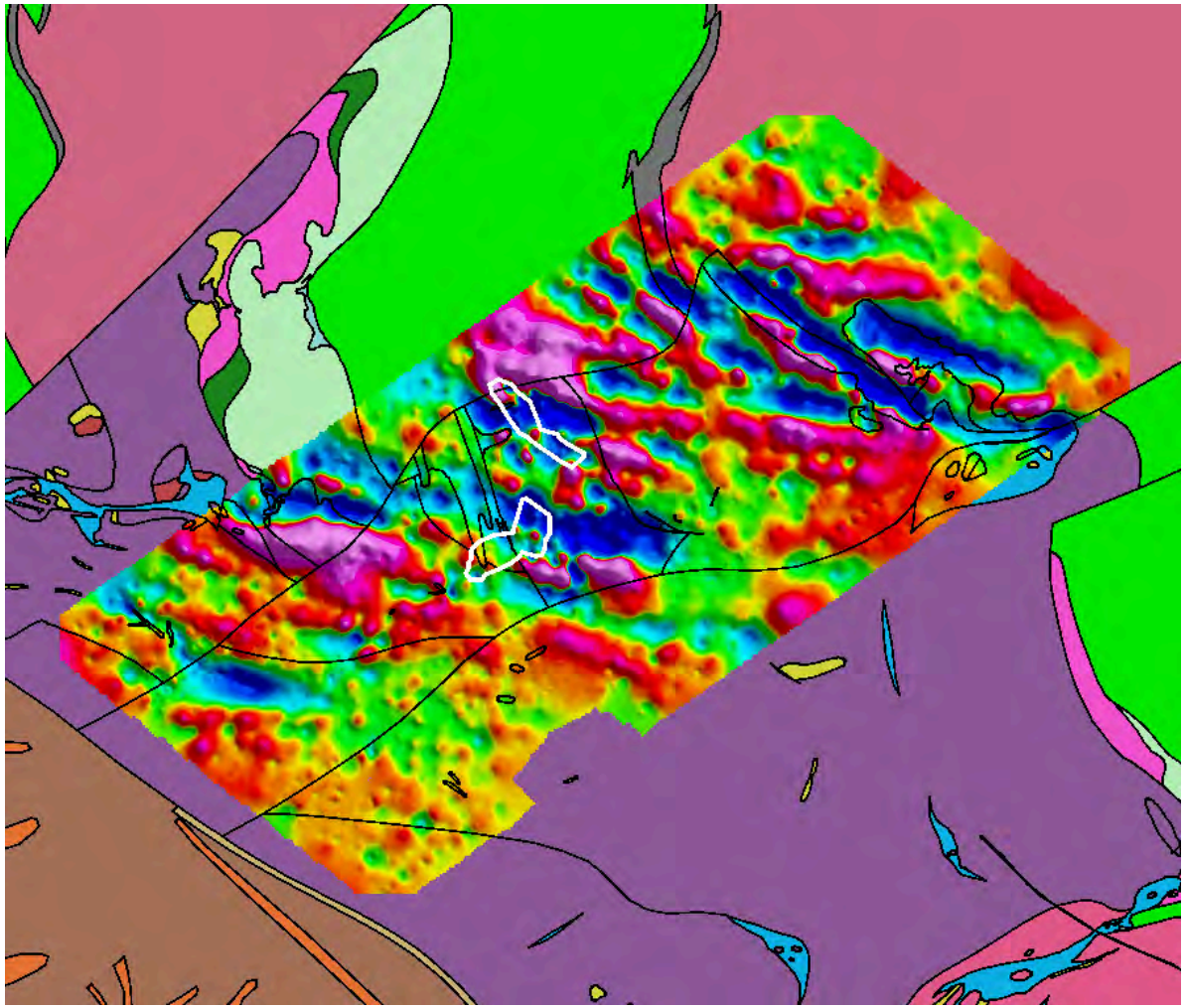

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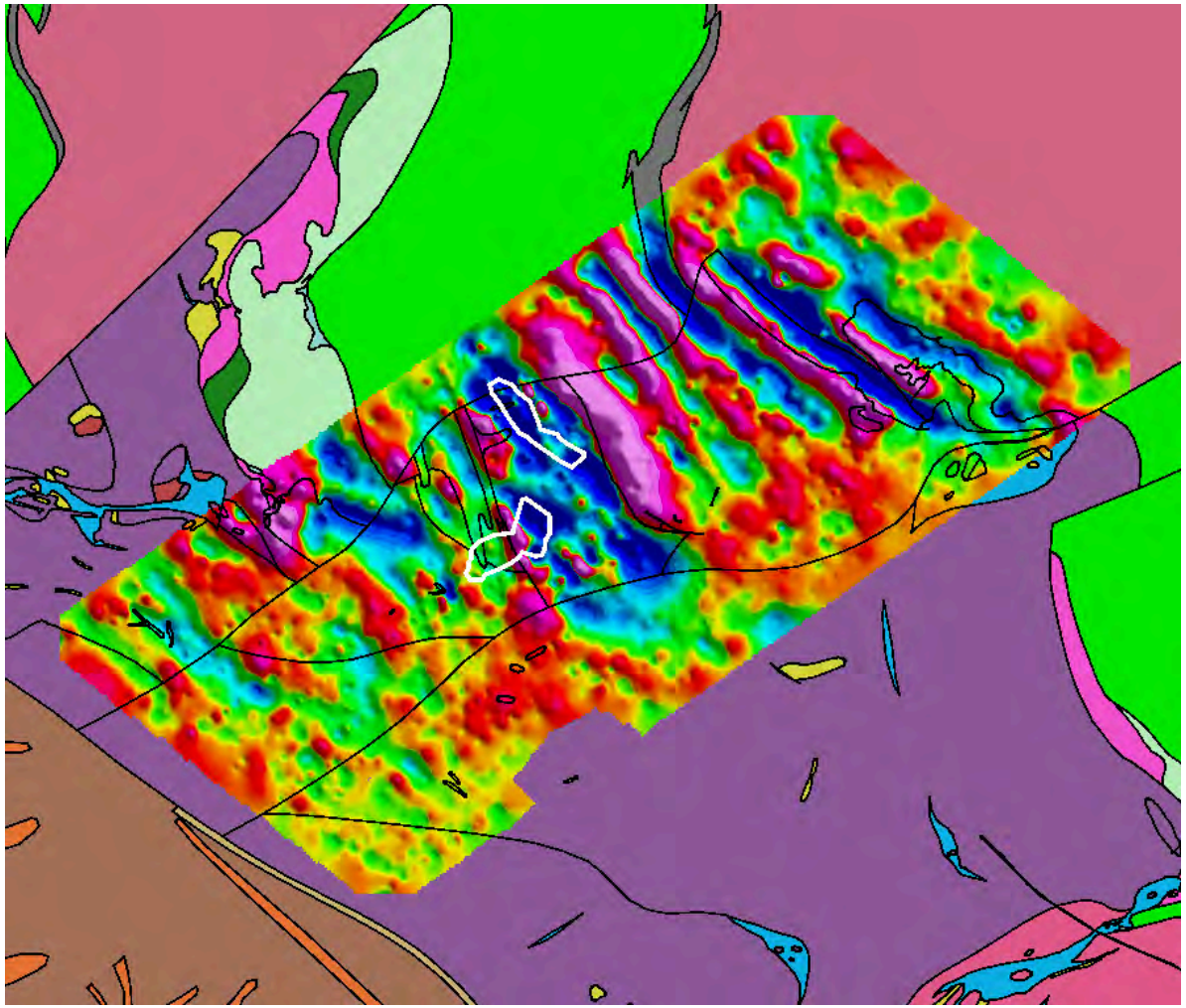

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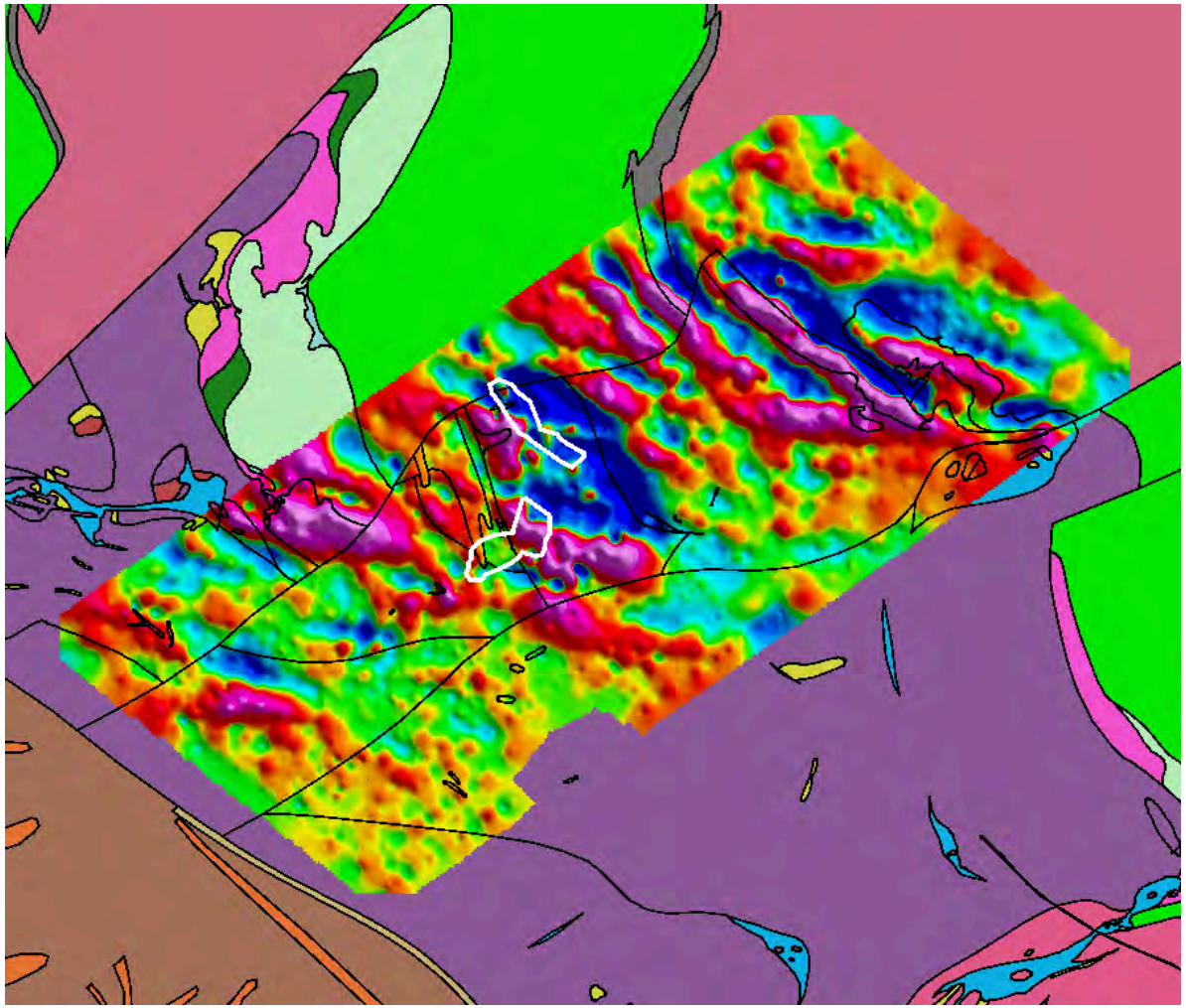

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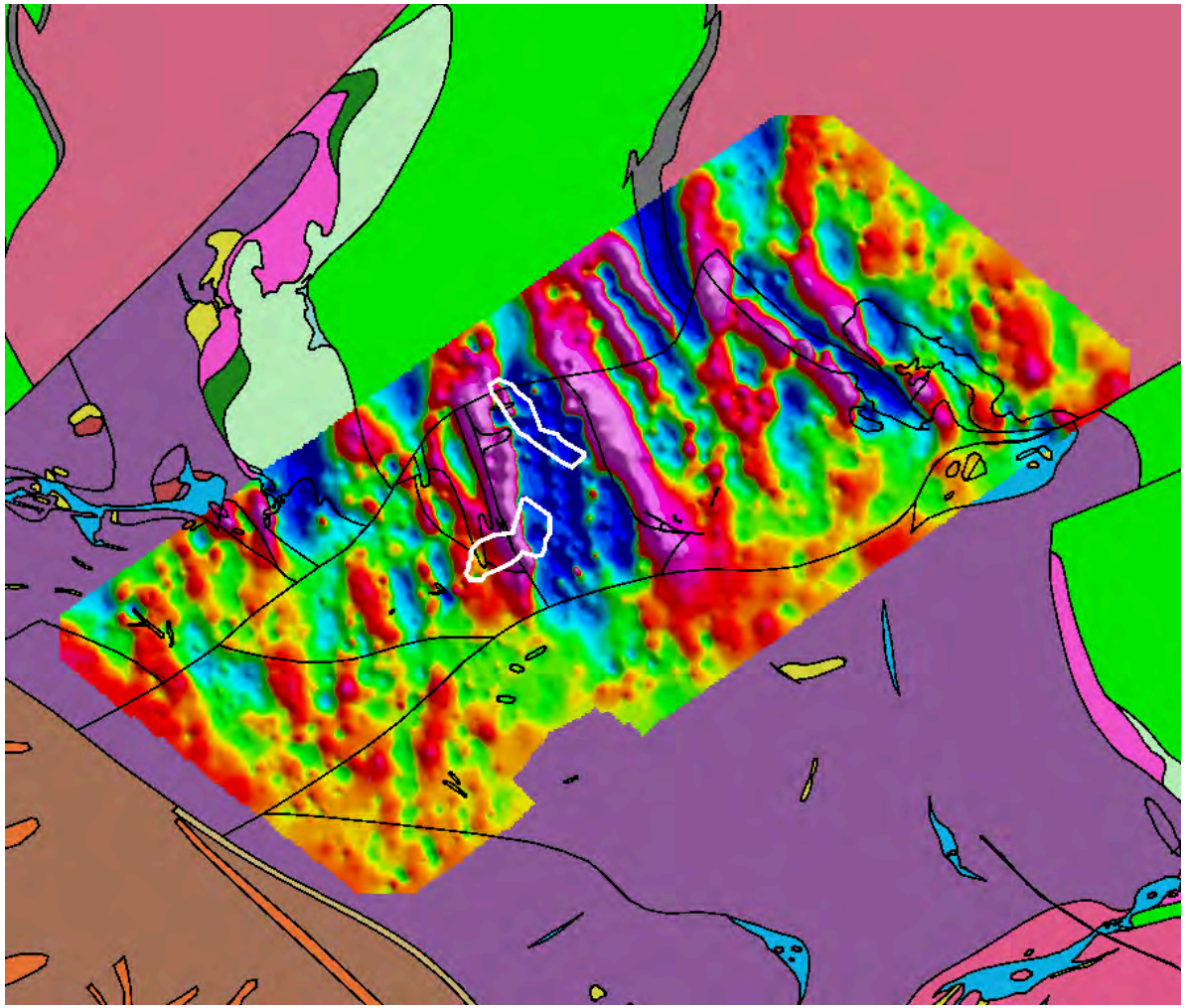

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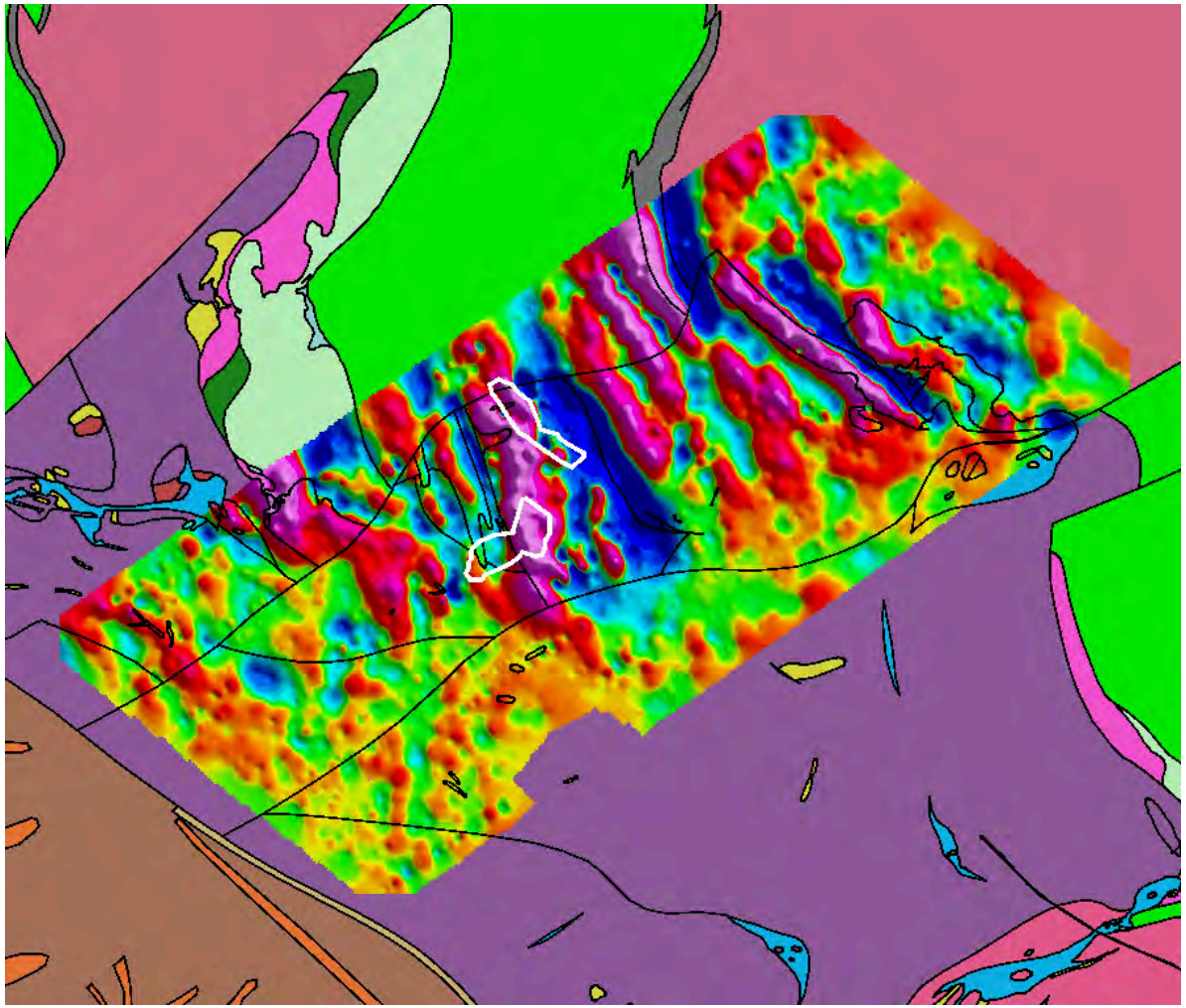

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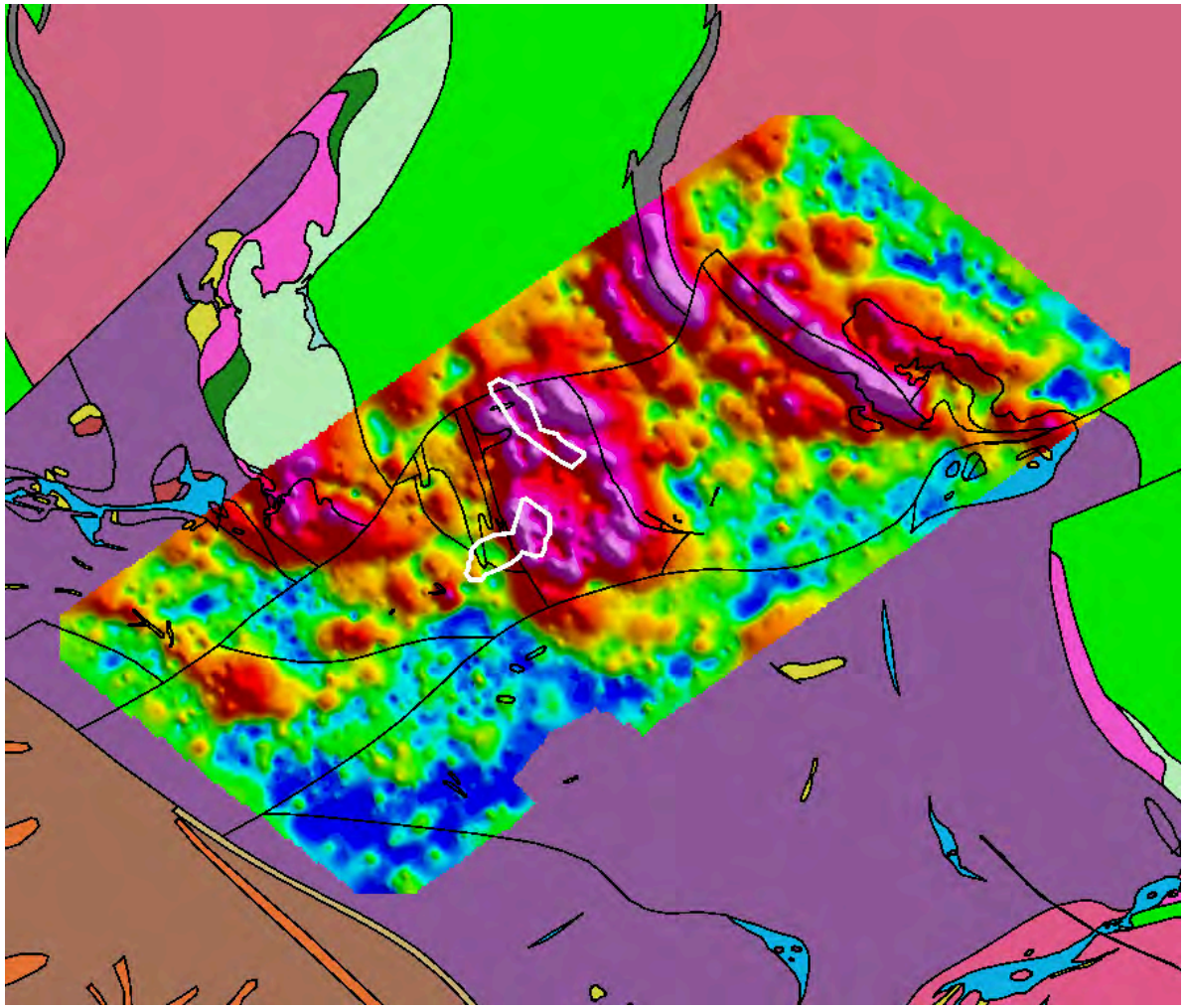
$$I_1 = \sqrt{\frac{1}{2} trace\left(\widehat{B_{ik}}^2\right)}$$



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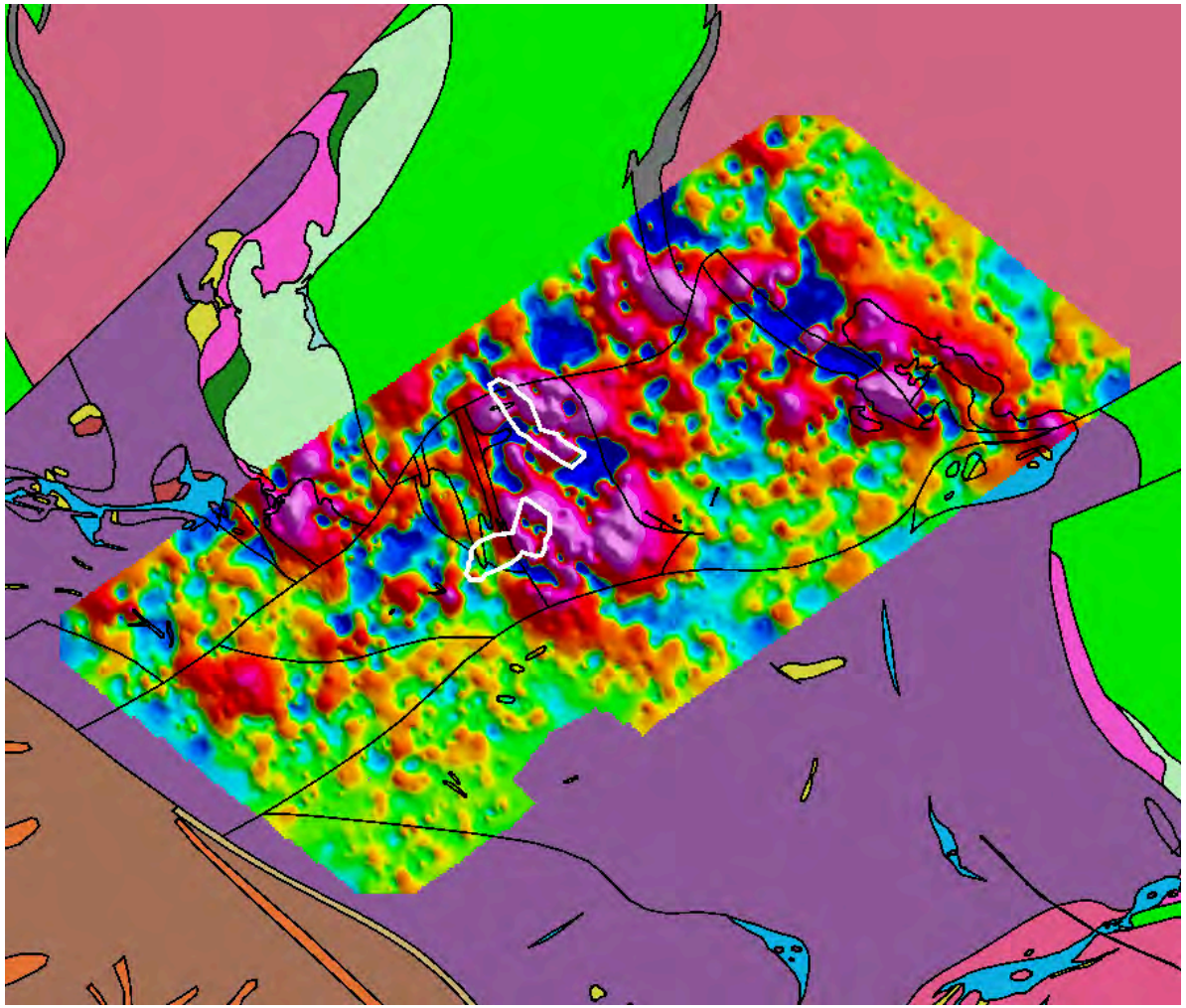
$$I_2 = \sqrt[3]{det(\widehat{B_{ik}})}$$



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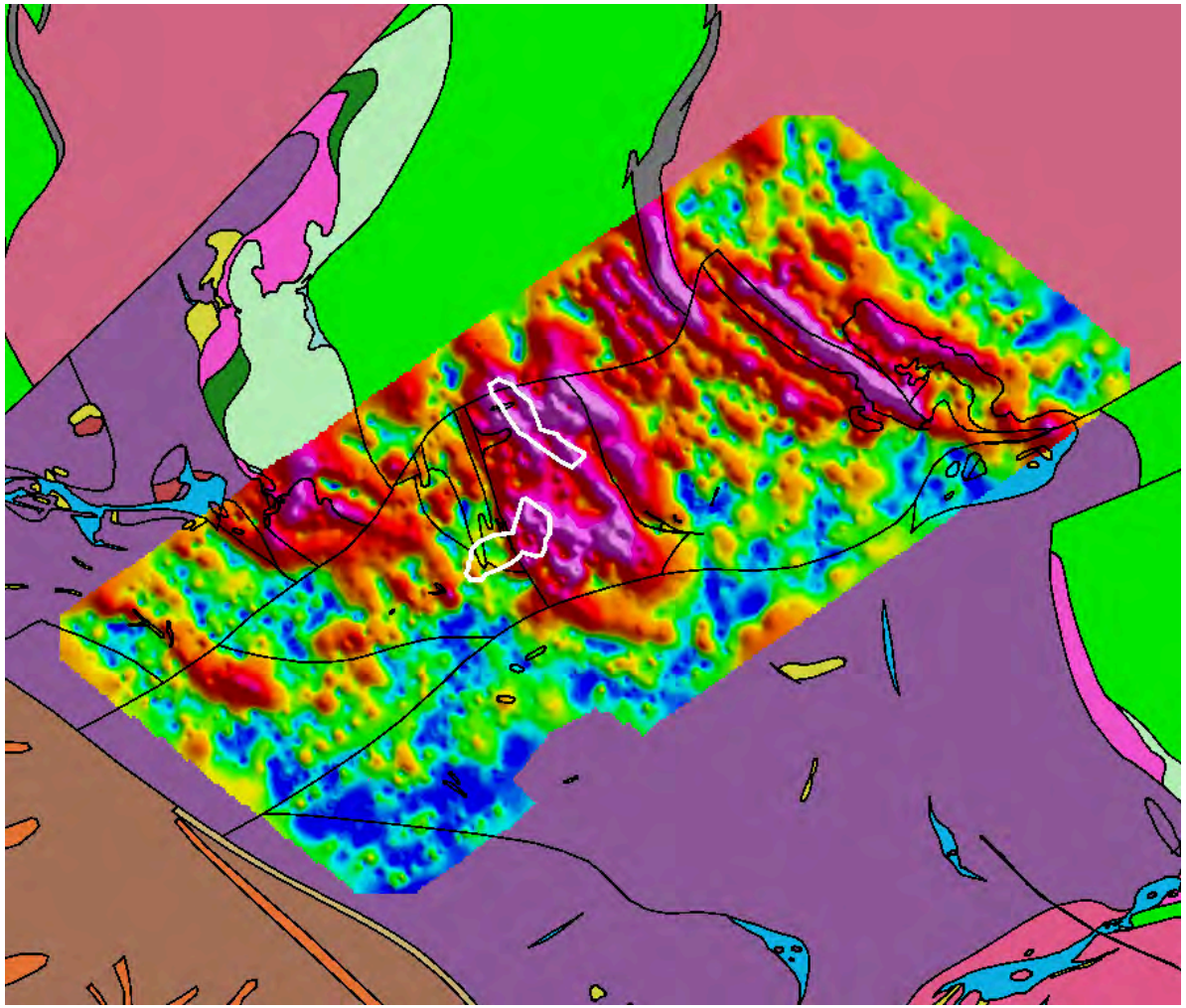

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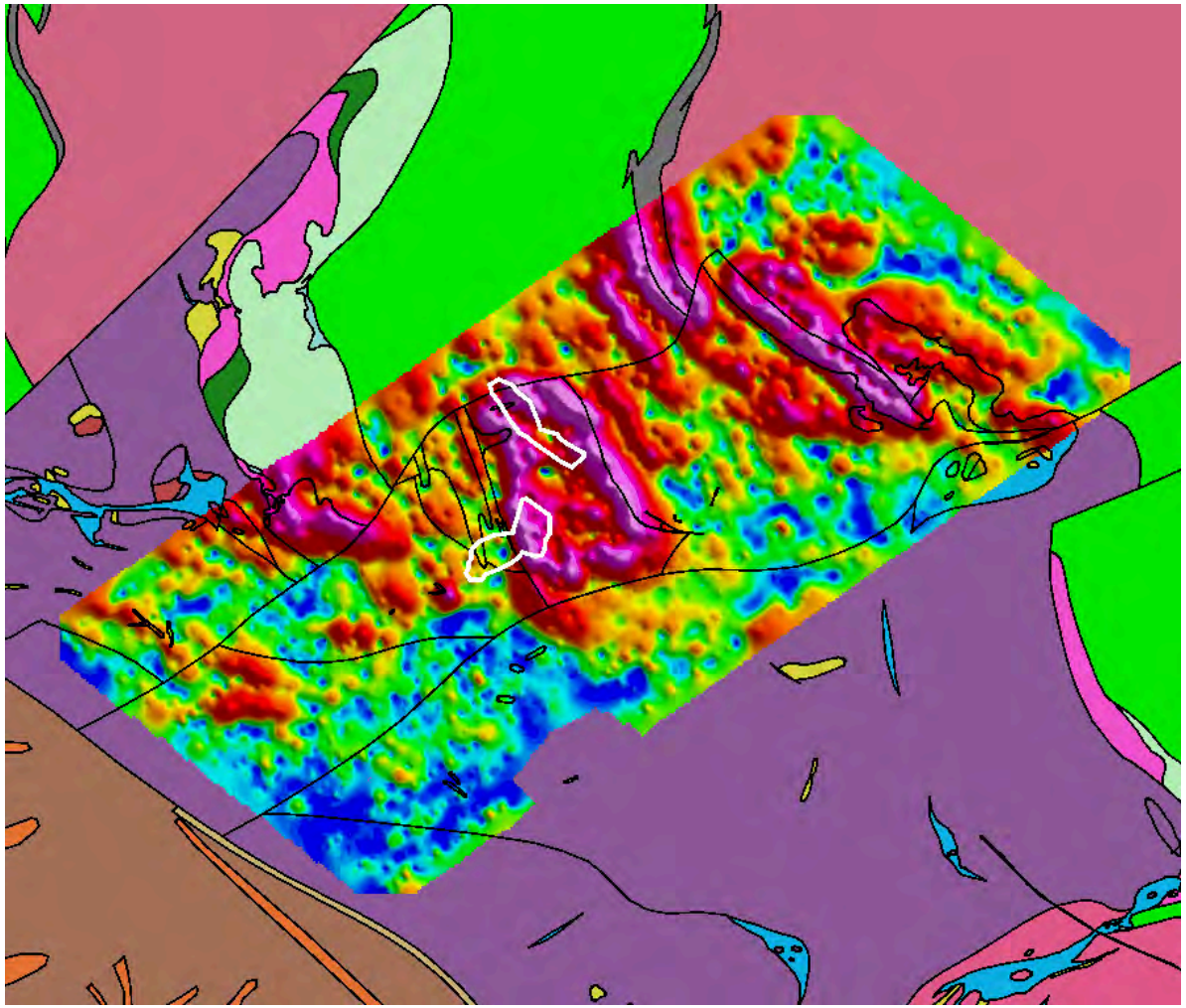

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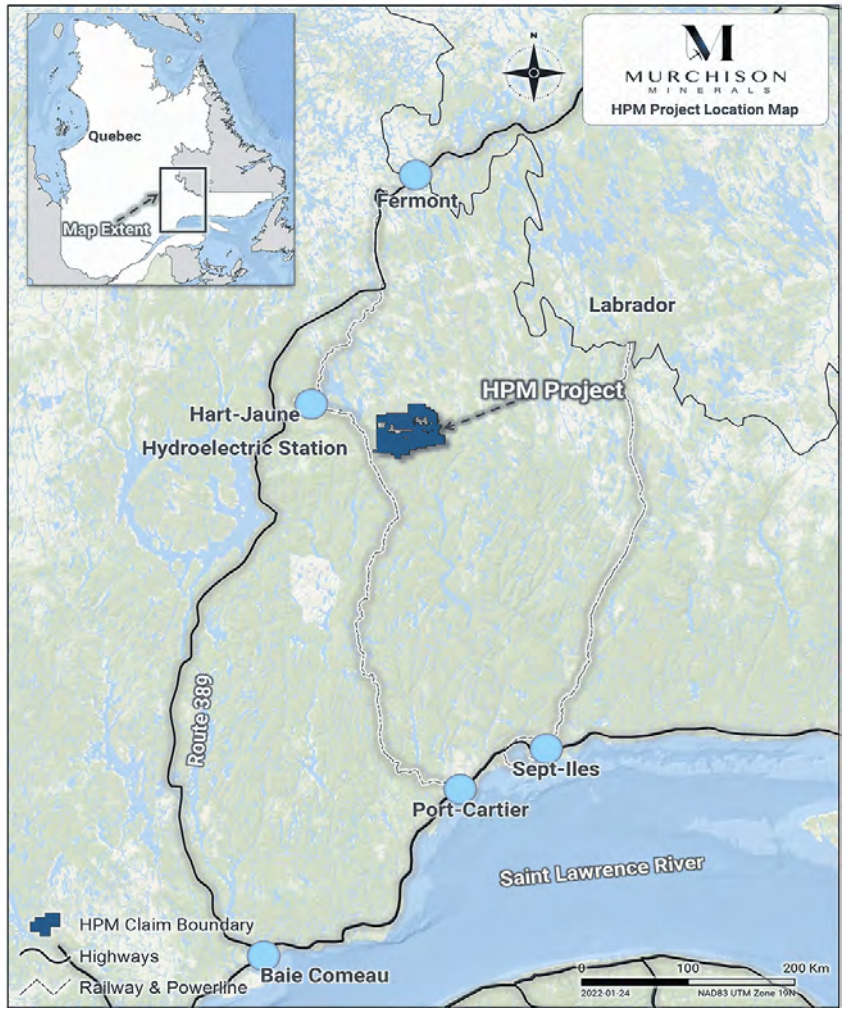
Case Study: Ni-Cu-Co Murchison – HPM Project

- Adjacent to the Manicouagan impact structure
- Mafic magma intruded sulphide-bearing metasedimentary rock
- Barre de Fer Zone:
  - Surface showings
  - Confirmed at depths up to 475m
  - Mineralization currently defined by extensive and ongoing drilling.



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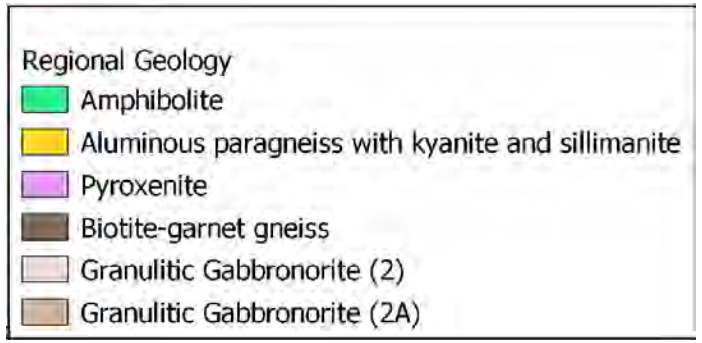
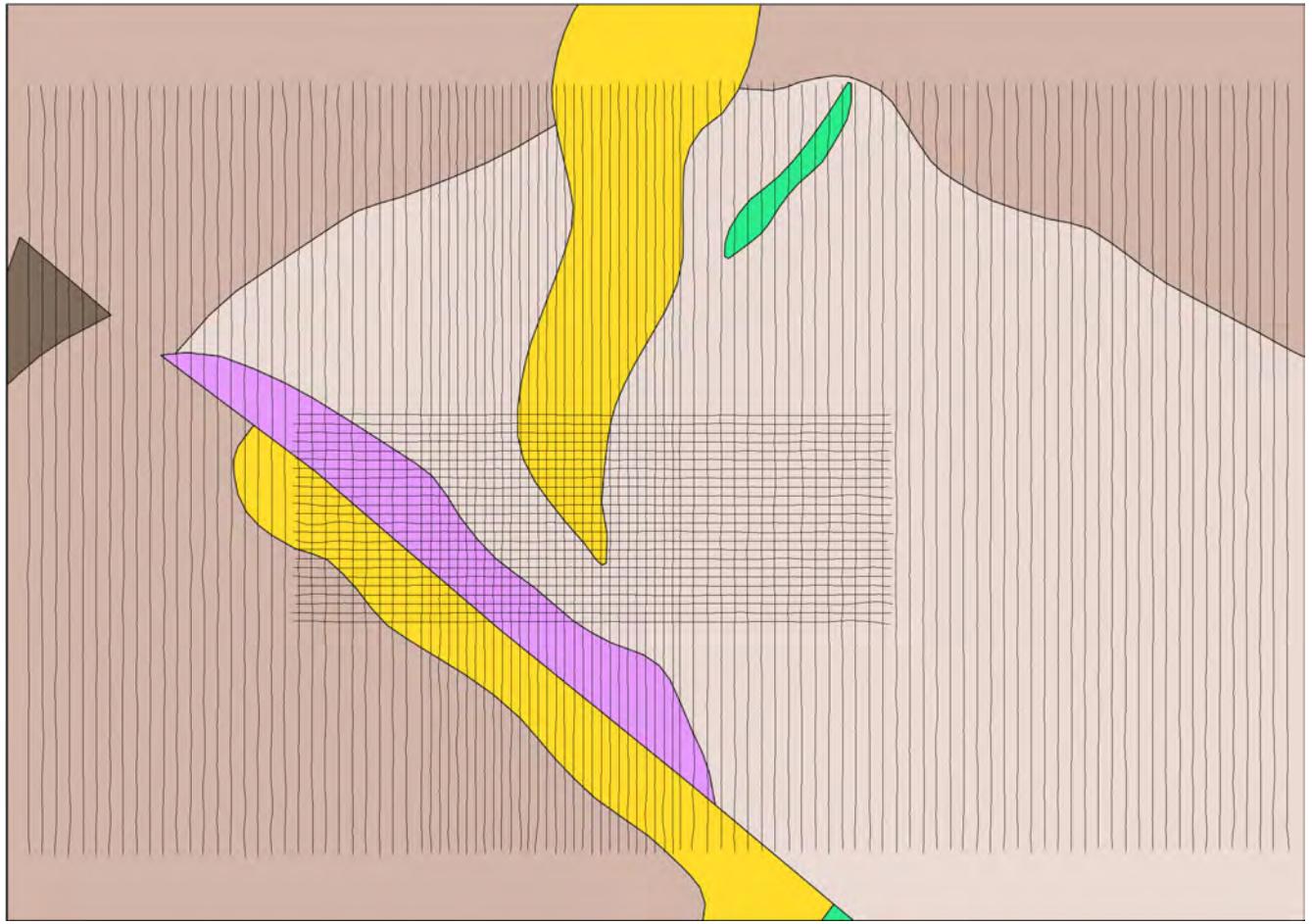
Case Study: Ni-Cu-Co Murchison – HPM Project

- Large section of the project area flown with QMAG^{T}
- Approximately 510 line-kms
- 75 m & 50 m line-spacing
- Average 55m above ground





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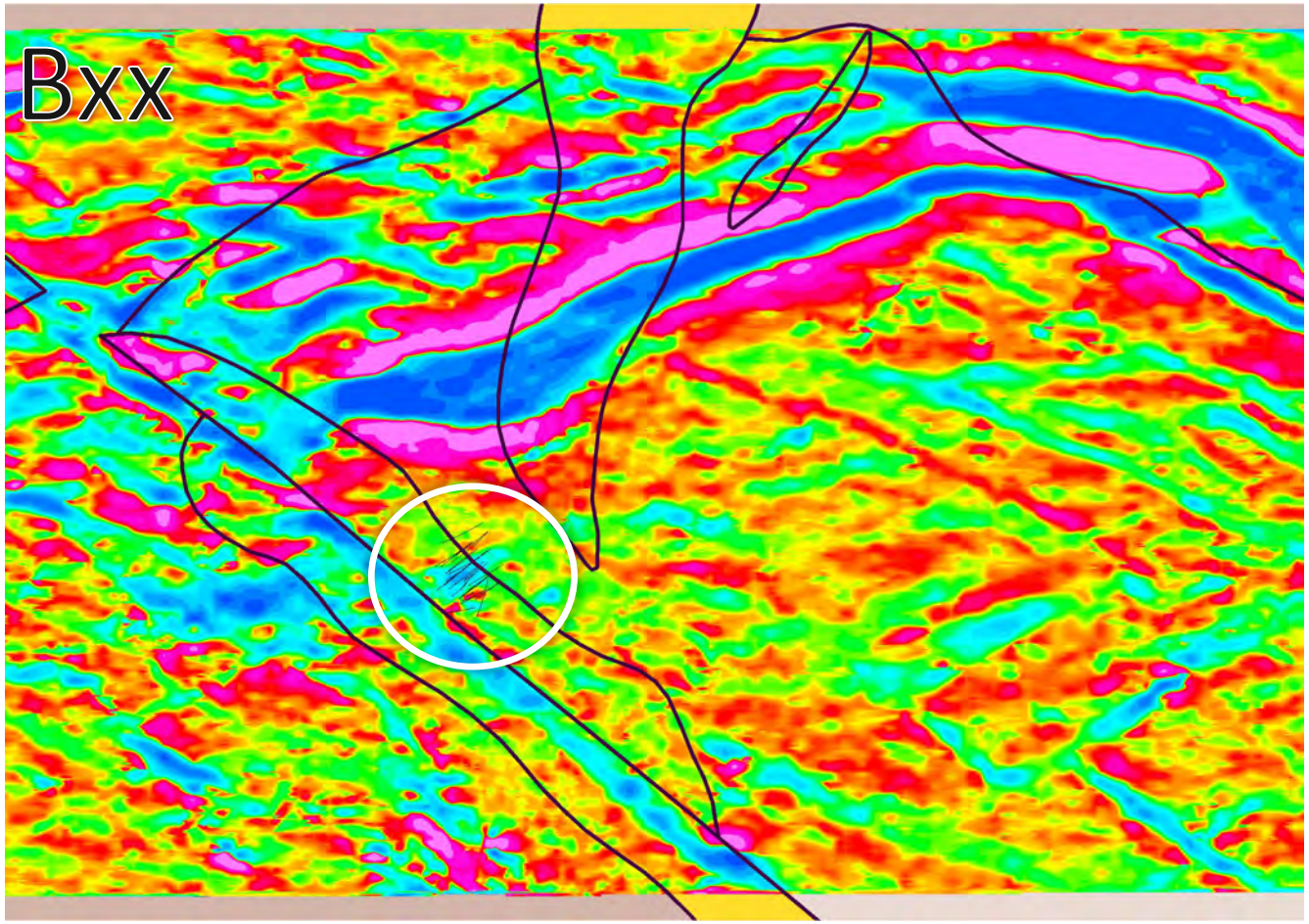

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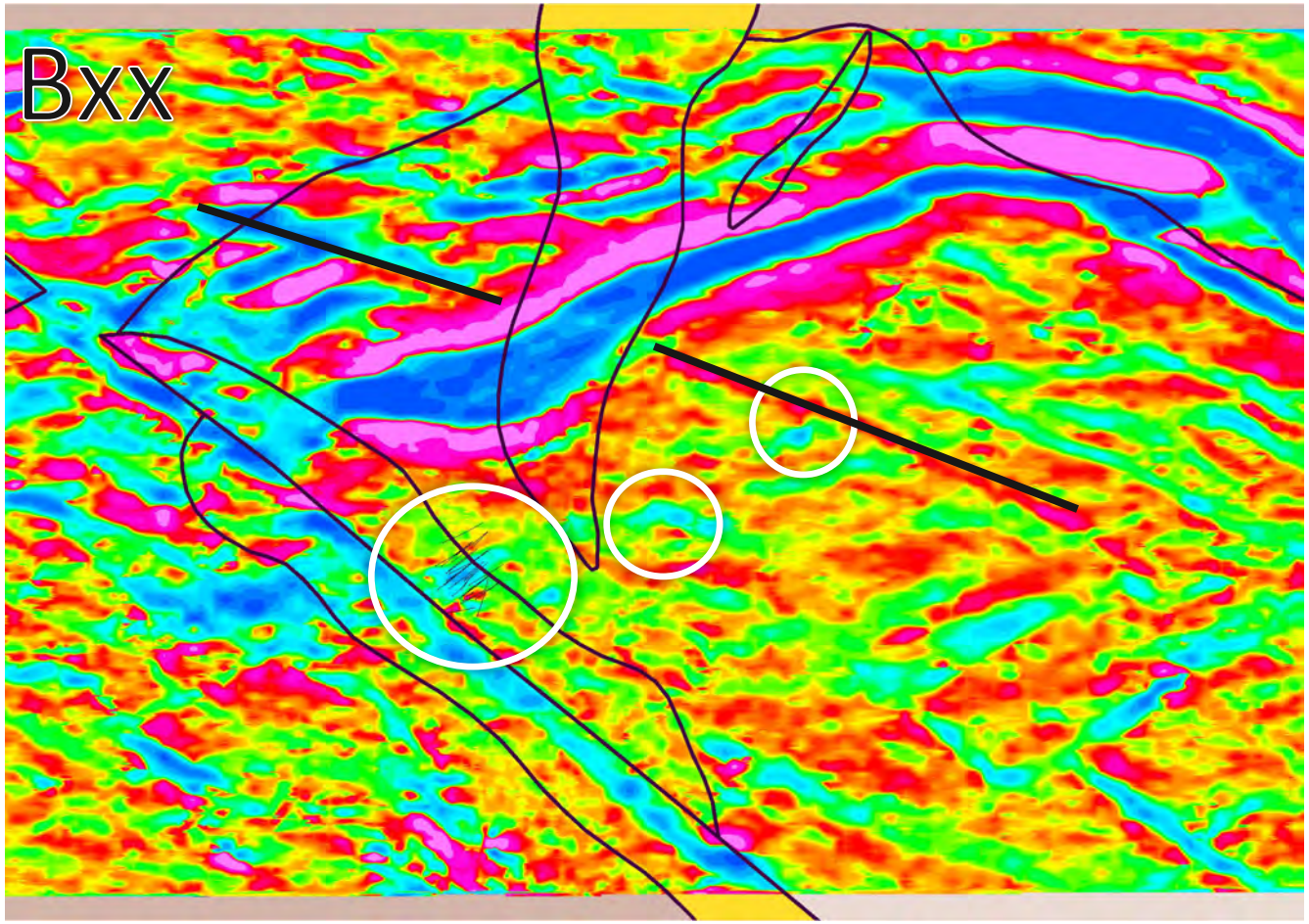

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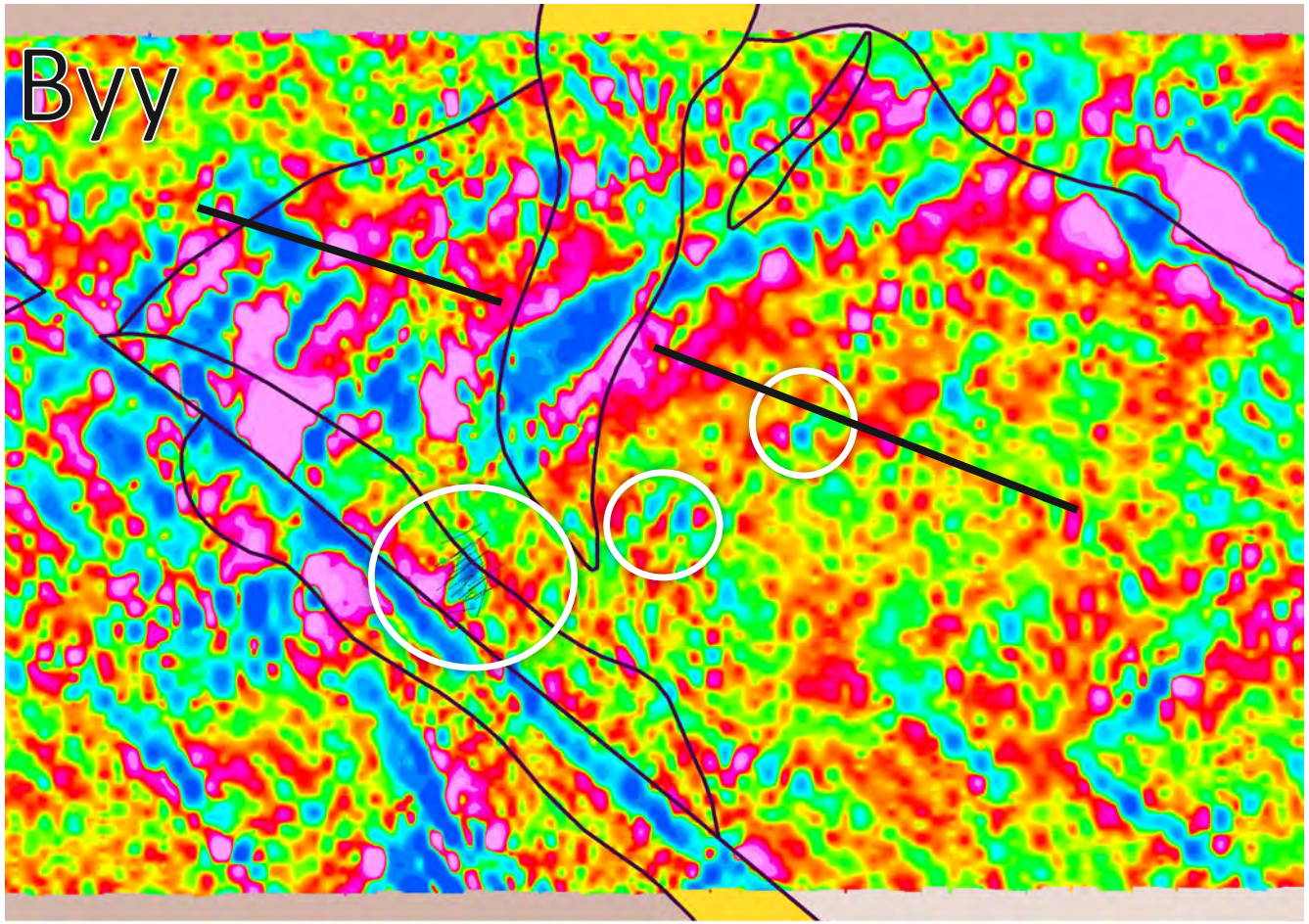

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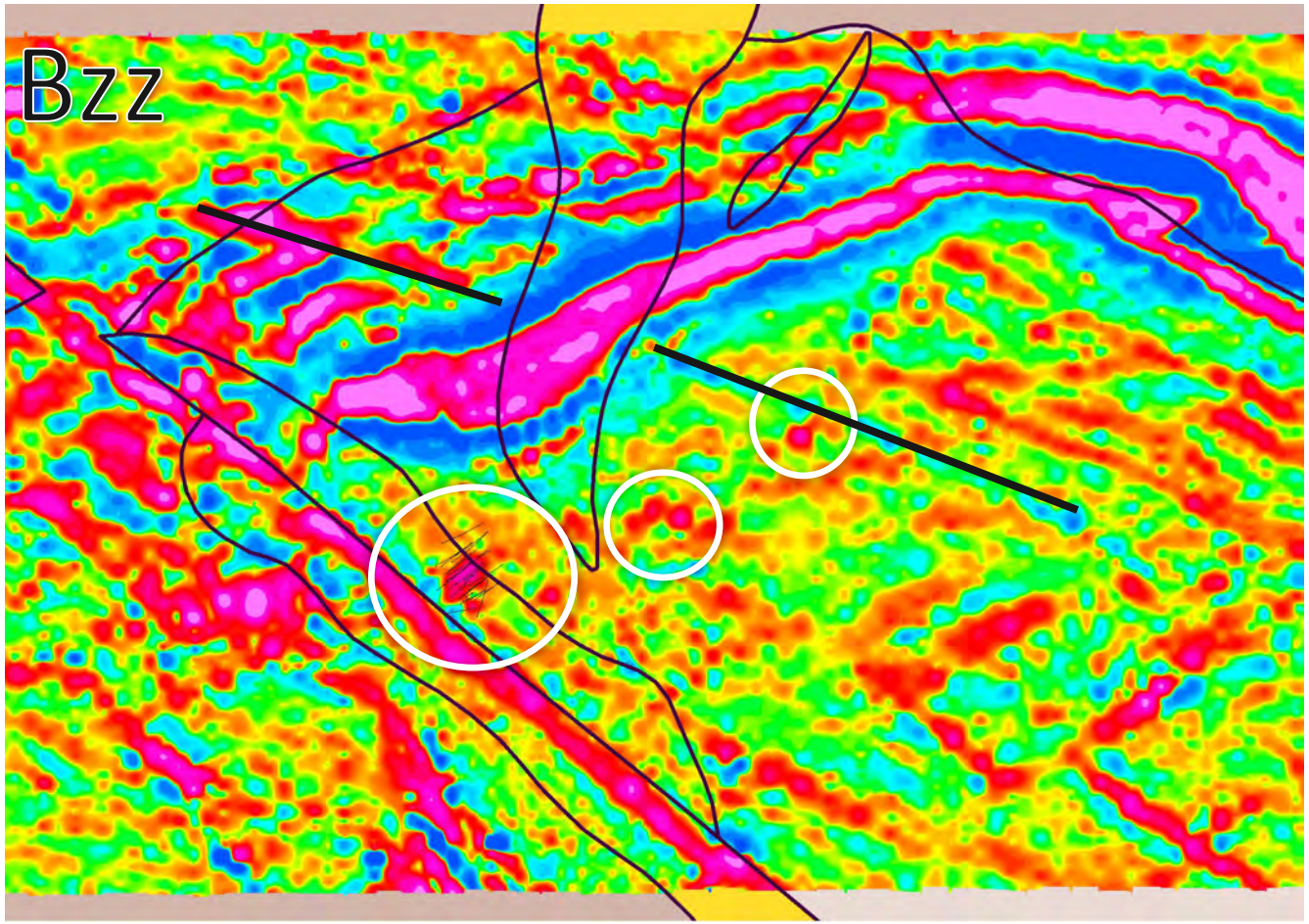

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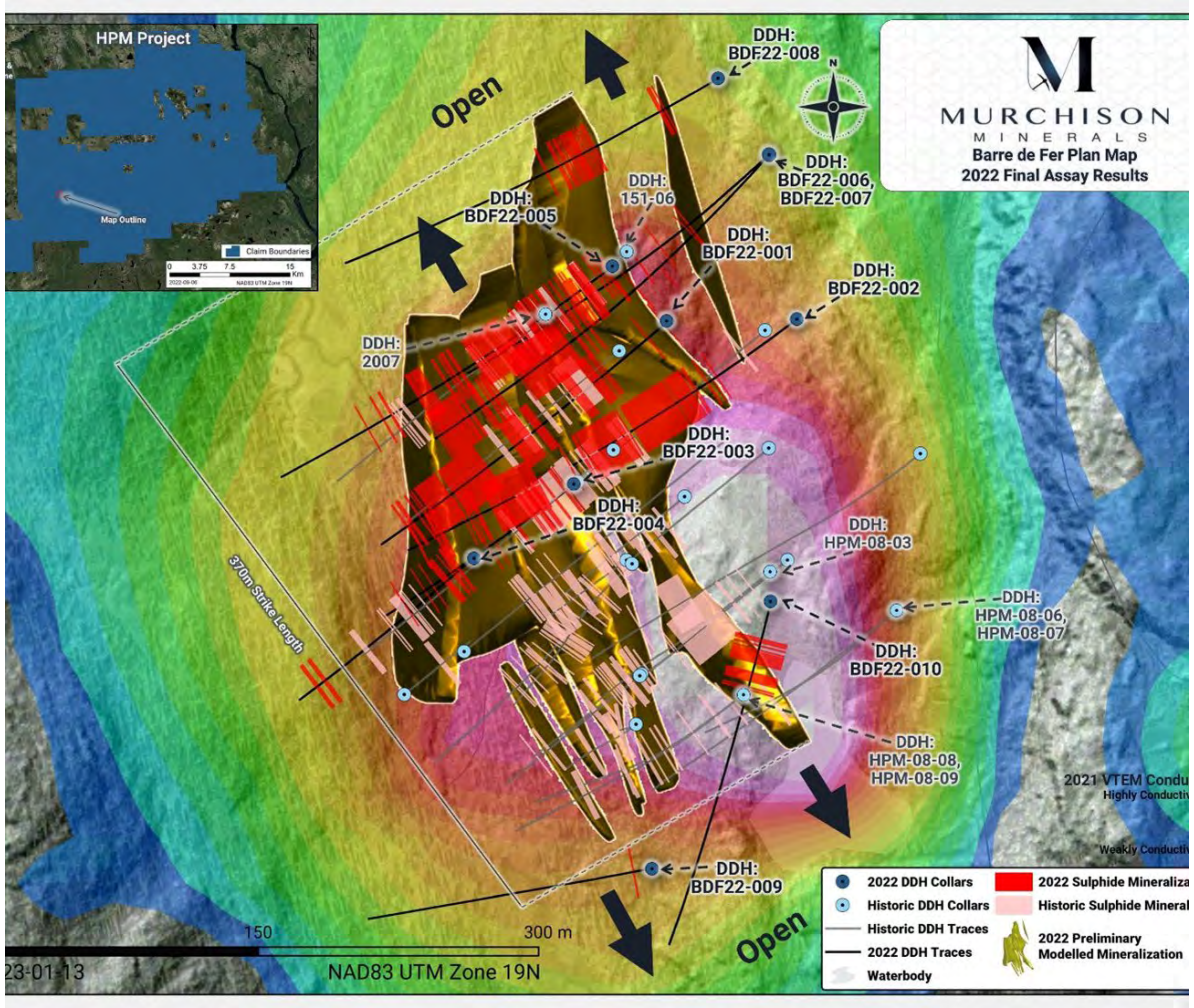
Case Study: Ni-Cu-Co Murchison – HPM Project

- Barre de Fer mineralization intersections overlain on VTEM Conductivity



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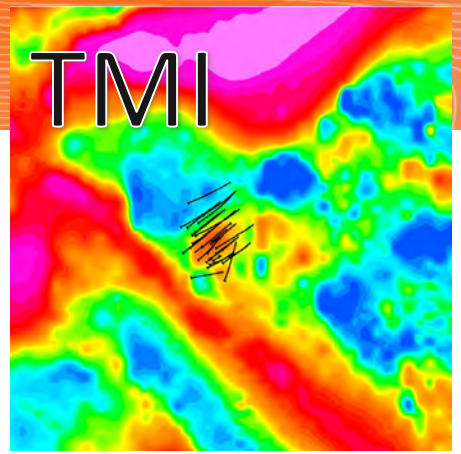
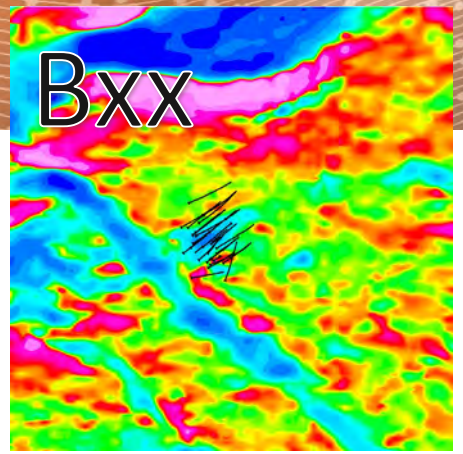
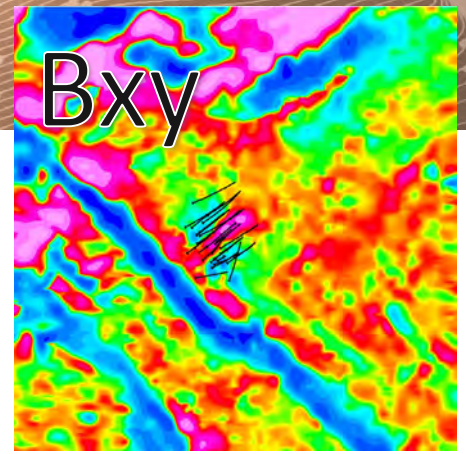
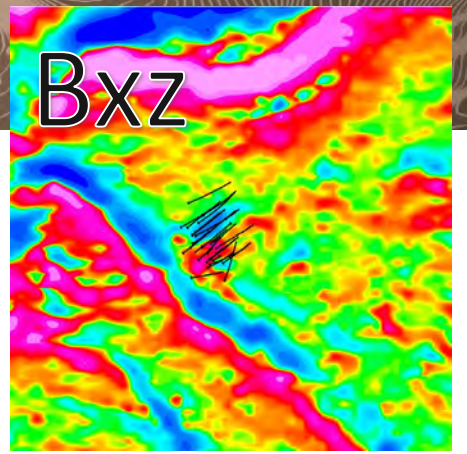
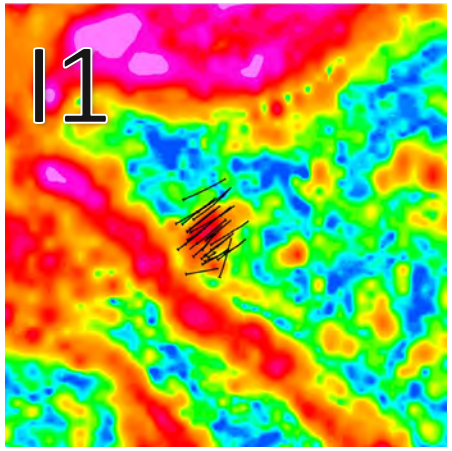


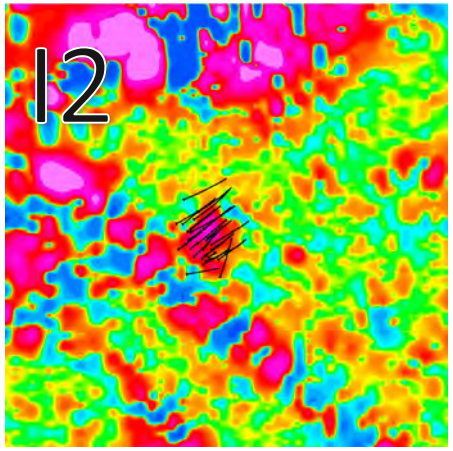
QMAGT Survey Results
over the Barre de Fer zone



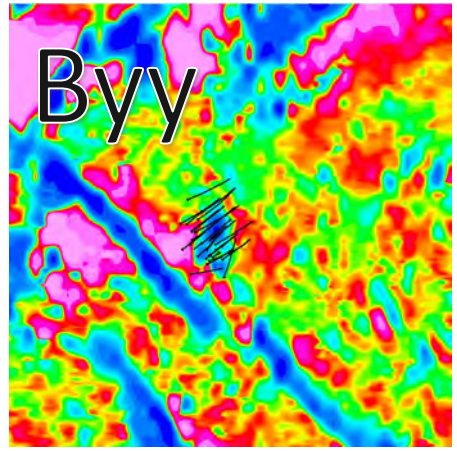


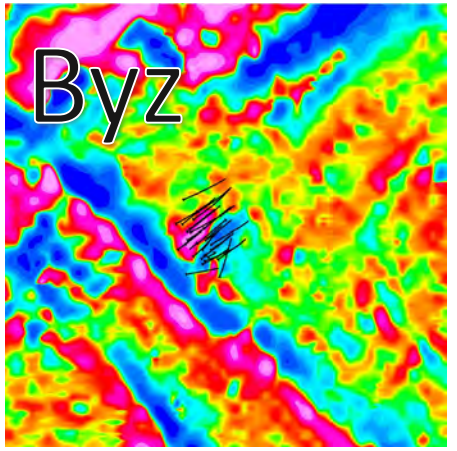


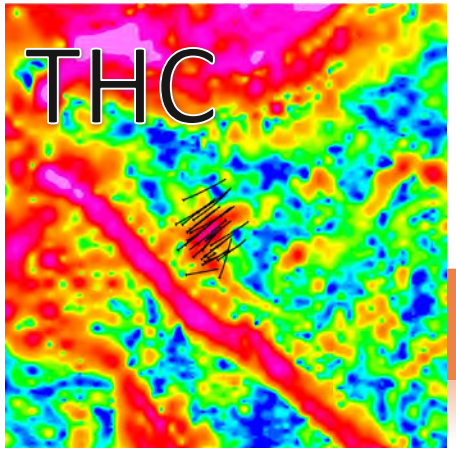


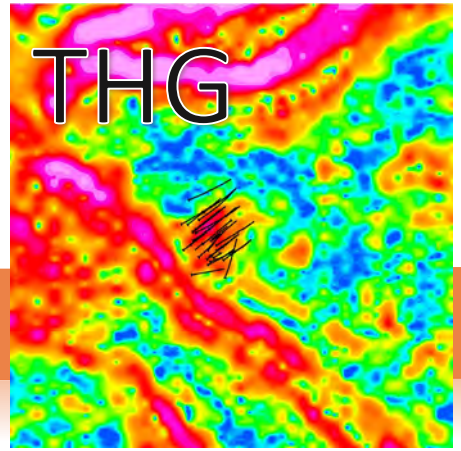


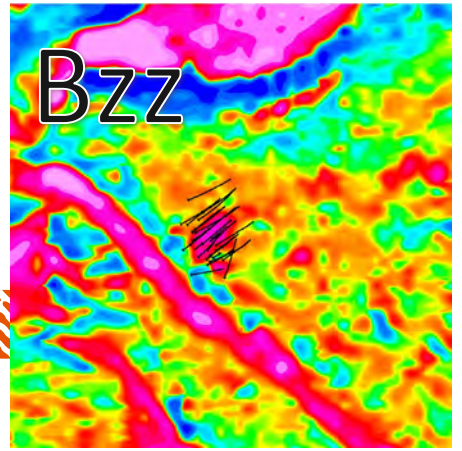
Strong magnetic signature correlating to the sulphide intrusion and VTEM Conductivity High











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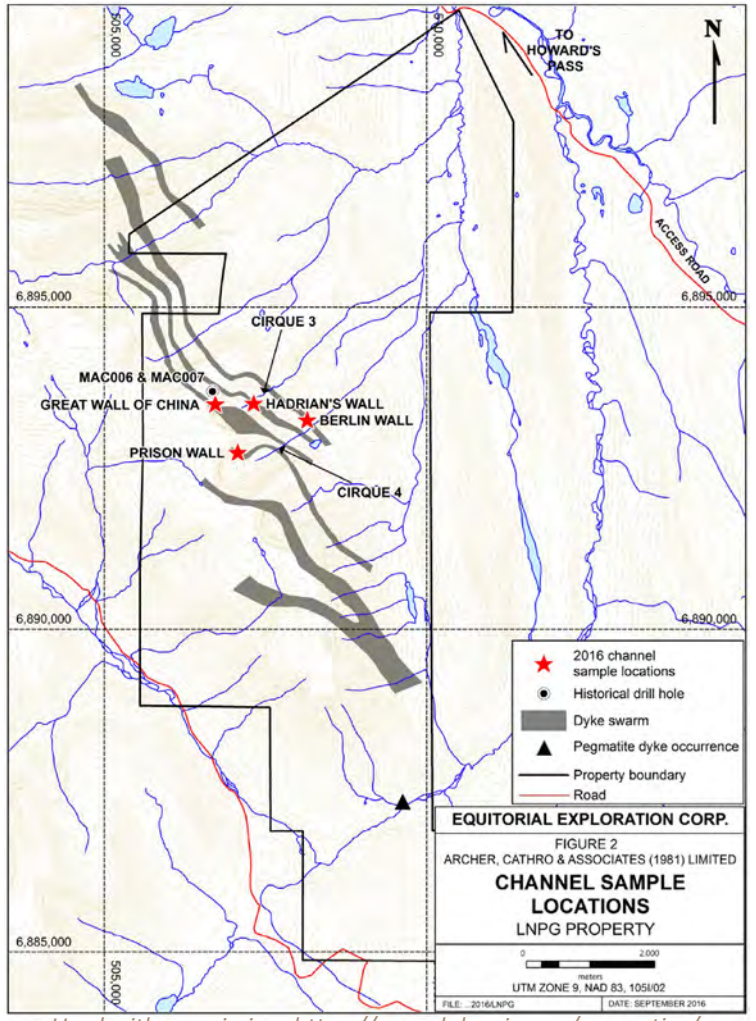
Case Studies:

- Ni-Cu-PGE - Sudbury Basin - Ontario
- Ni-Cu-Co - Murchison HPM Project - Quebec
- Lithuim - LCT Pegmatites
- Iron Ore - Blötberget - Sweden

Case Study: Lithium
Lake Winn Resources – (LNPG)
Little Nahanni Pegmatite Group

- Branching Pegmatite Branching Dyke Swarm
- LCT pegmatites at LNPG do not have a particularly strong magnetic response
- High sensitivity of the SQUID and resolution of the full tensor measurement should provide the best-case scenario for detection.
- Survey incomplete at the writing of this presentation.



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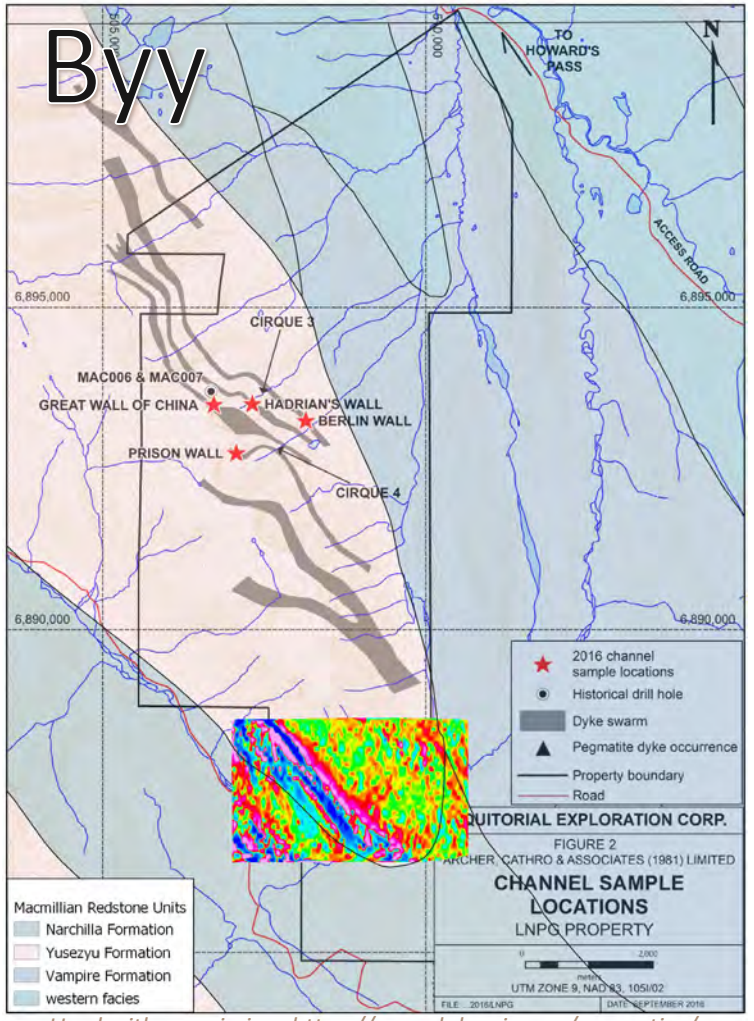
Case Study: Lithium
Lake Winn Resources – (LNPG)
Little Nahanni Pegmatite Group

- Byy tensor component overlaid on formational geology



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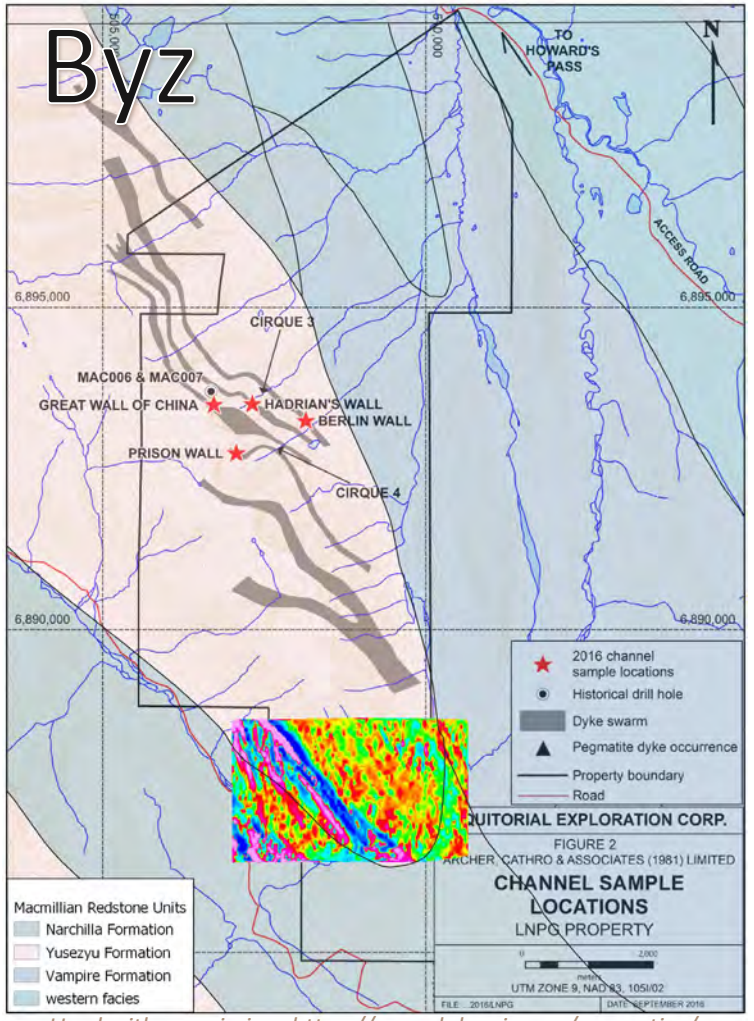
Case Study: Lithium
Lake Winn Resources – (LNPG)
Little Nahanni Pegmatite Group

- Byz tensor component overlaid on formational geology



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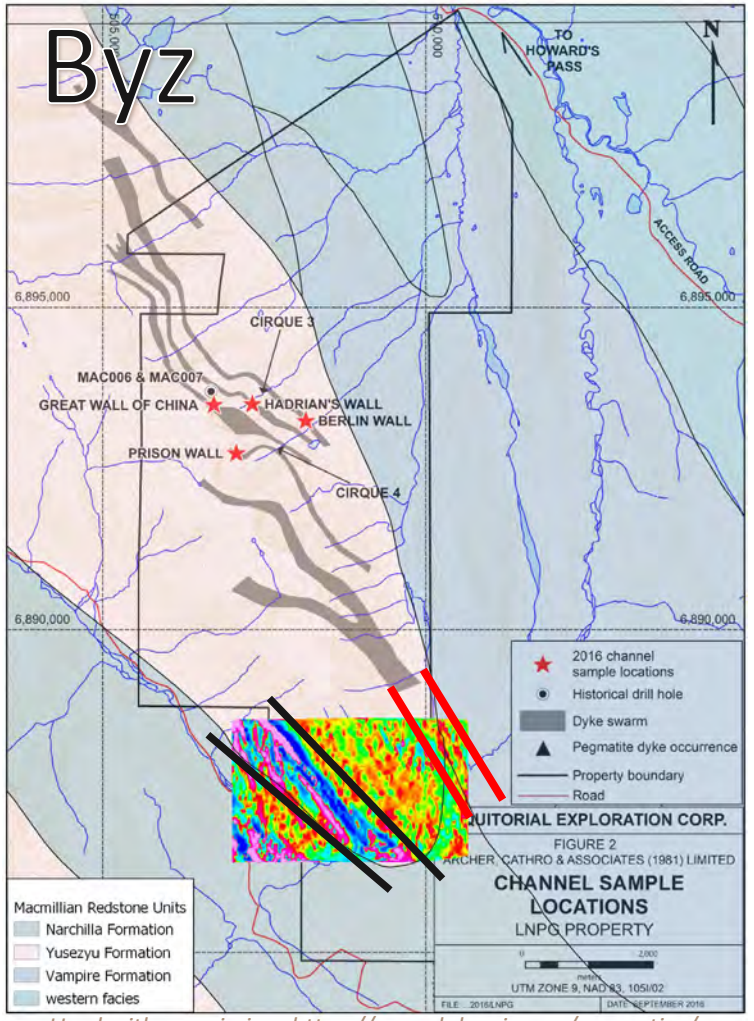
Case Study: Lithium
Lake Winn Resources – (LNPG)
Little Nahanni Pegmatite Group

- Byz tensor component overlaid on formational geology
- Subtle magnetic lineation in Byz, in line with the mapped Dyke swarm that may be indicative of continuation down strike (red)
- Strong magnetic lineation likely related to the boundary between the Narchilla / Yusezyu Formations, yet to be explained geologically in the scope of this project (Black)



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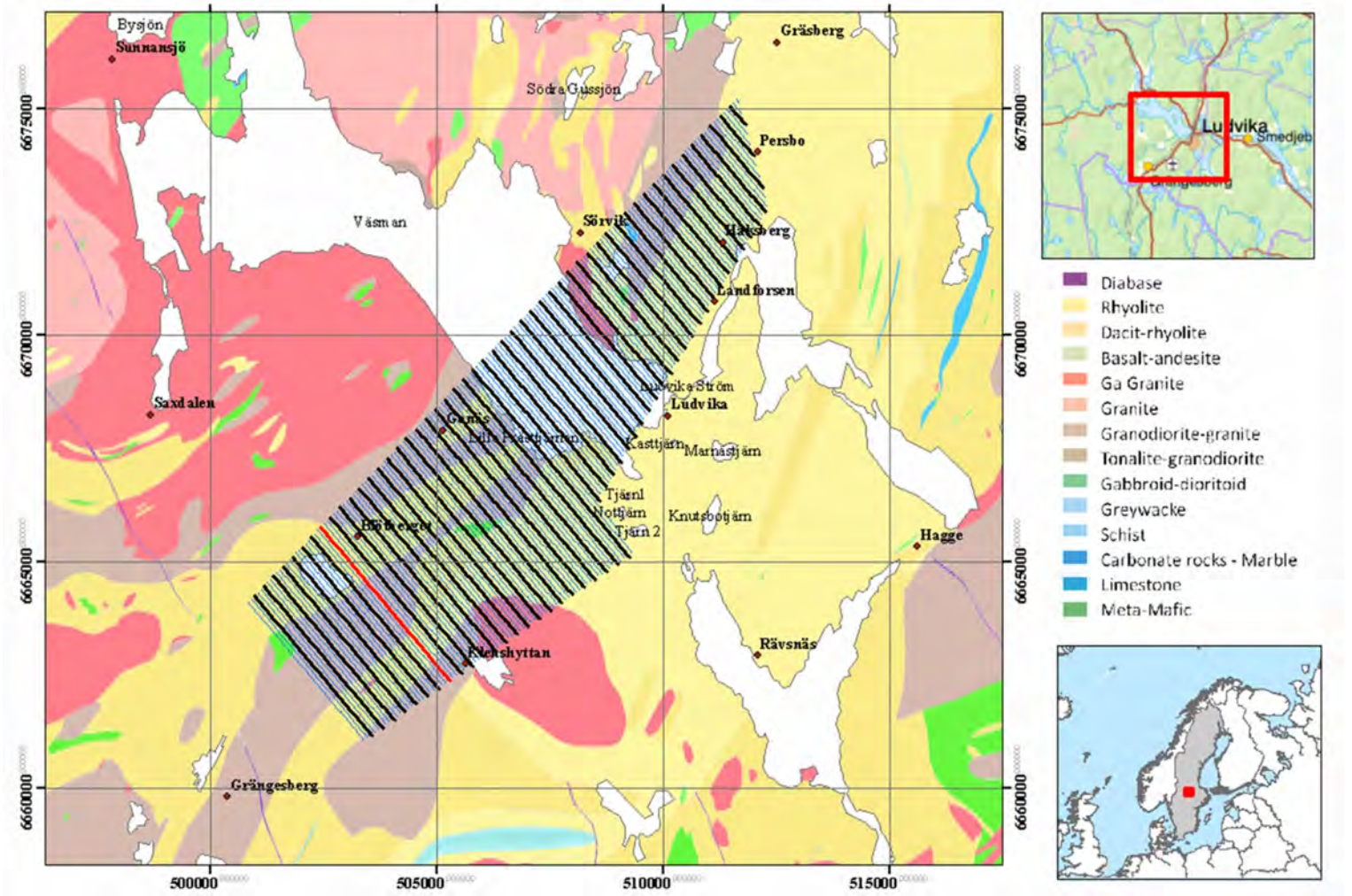
Case Studies:

- Ni-Cu-PGE - Sudbury Basin - Ontario
- Ni-Cu-Co - Murchison HPM Project - Quebec
- Lithuim - LCT Pegmatites
- Iron Ore - Blötberget - Sweden

Case Study: Iron Ore Sweden – Blötberget Project

- Simplified geology shown
- QMAG^{T} survey lines are thin blue – 100 m spacing.
- QAMT lines are black – 300 m.



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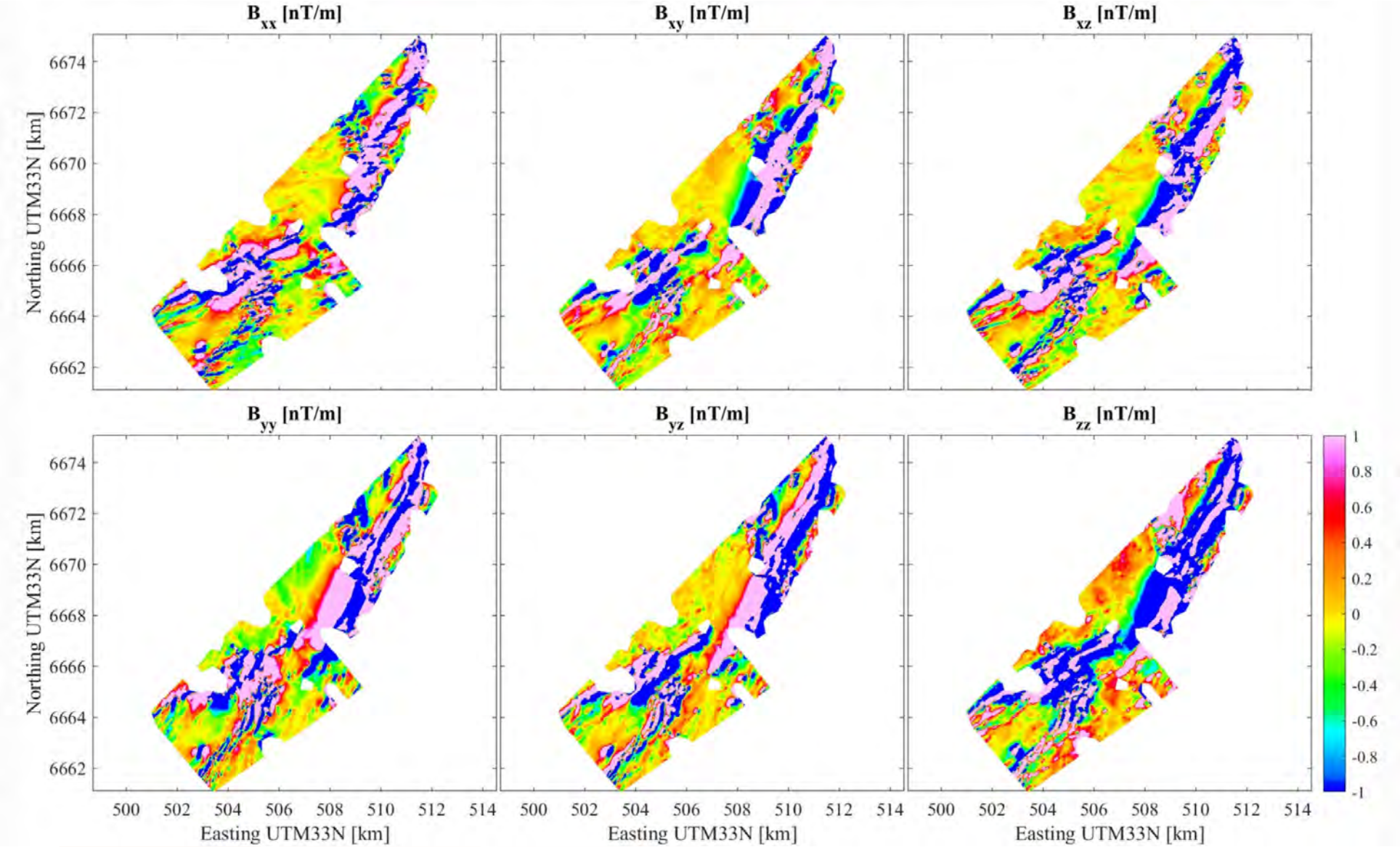
Case Study: Iron Ore



QMAG^T Tensor component images

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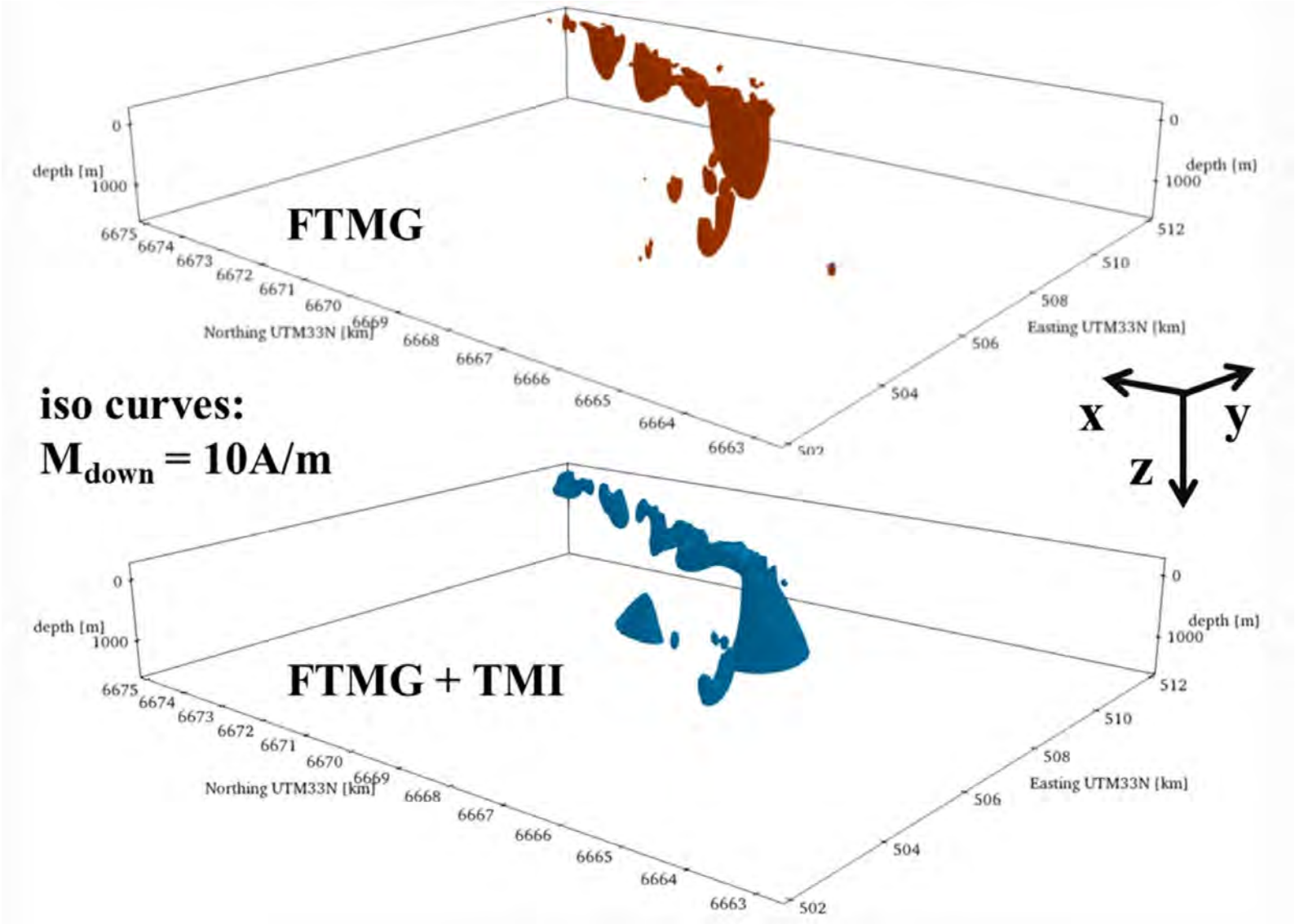
Case Study: Iron Ore



MVI inversion models comparing results with and without TMI

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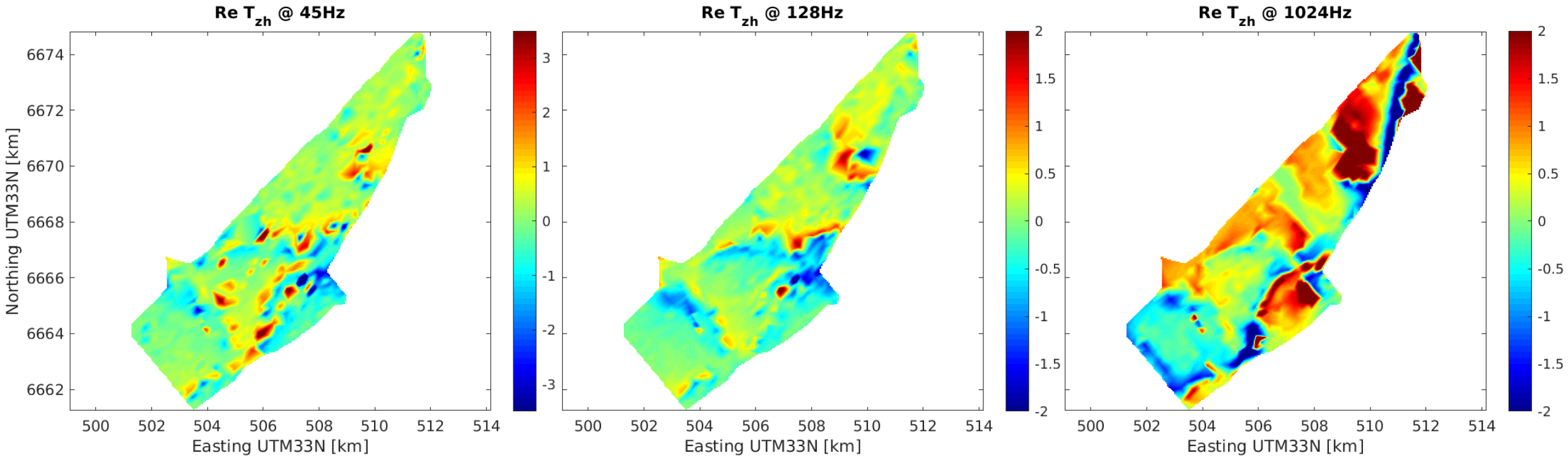
Case Study: Iron Ore – QAMT Transfer functions



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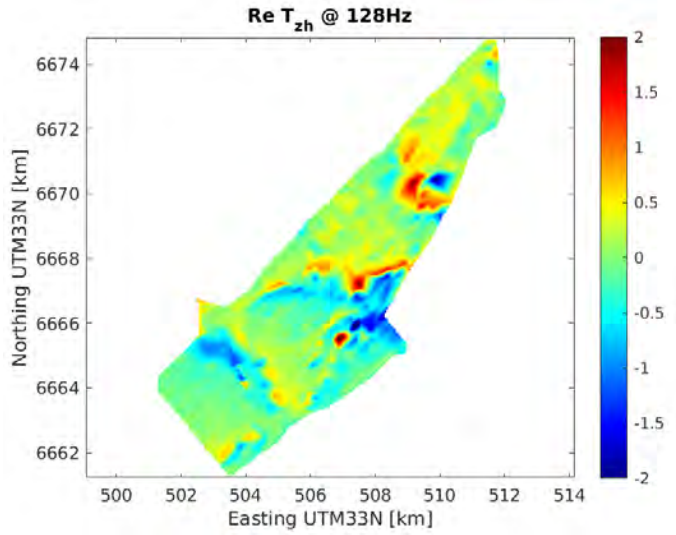
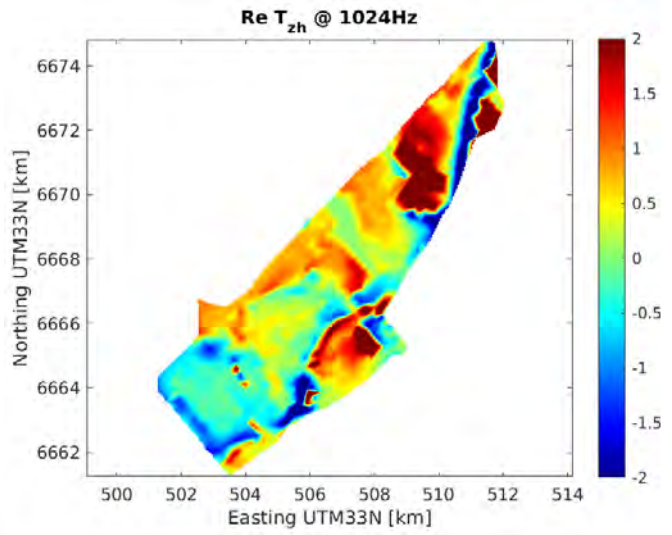
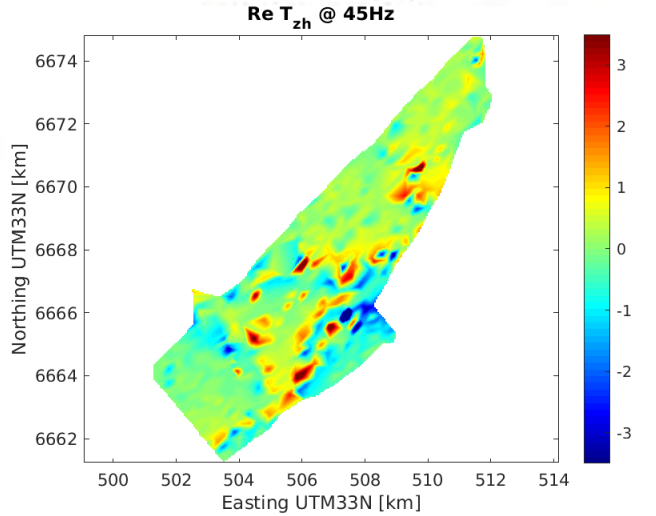
Future Development

- QAMT – 3-Component SQUID Magnetometer for AMT/CSAMT/EM
- Combined QMAG^{T} Full Tensor Magnetic Gradiometry incorporating the QAMT SQUID magnetometer for balancing and simultaneous collection of passive AMT.







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Applications

Current Exploration Environments

- Atypical Kimberlite Detection
- Iron Ore
- Lithium – LCT Pegmatites
- Ni-Cu-Co/PGE

Interpretation

- Structural analysis
- Joint Inversion
  - TechnoImaging
  - Mira Geoscience
- Remanent magnetisation analysis
- Depth Estimation, Susceptibility & Apparent Resultant Rotation Angle
  - Tensor Research

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Acknowledgement

GLENCORE Canada

MURCHISON MINERALS

LAKE WINN RESOURCES CORP.

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LEIBNIZ INSTITUTE of PHOTONIC TECHNOLOGY

LEADING GROUND AND AIRBORNE GEOPHYSICAL

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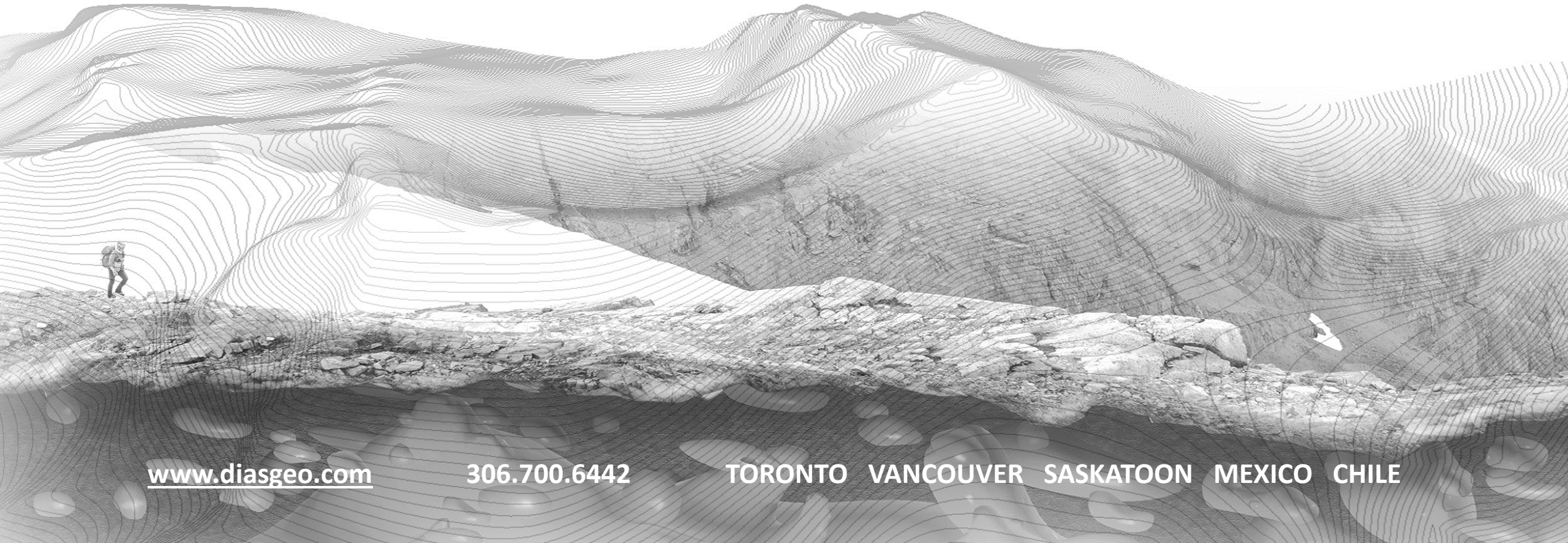
KNOWLEDGE THROUGH INNOVATION AND RESOLVE



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