CONSOLIDATED MINERALS

Airborne Electromagnetics for definition of manganese mineralisation: a case study in the Eastern Pilbara region, Western Australia

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Contents

- Previous work
- Case study area
  - Location + design
  - AEM system specifications
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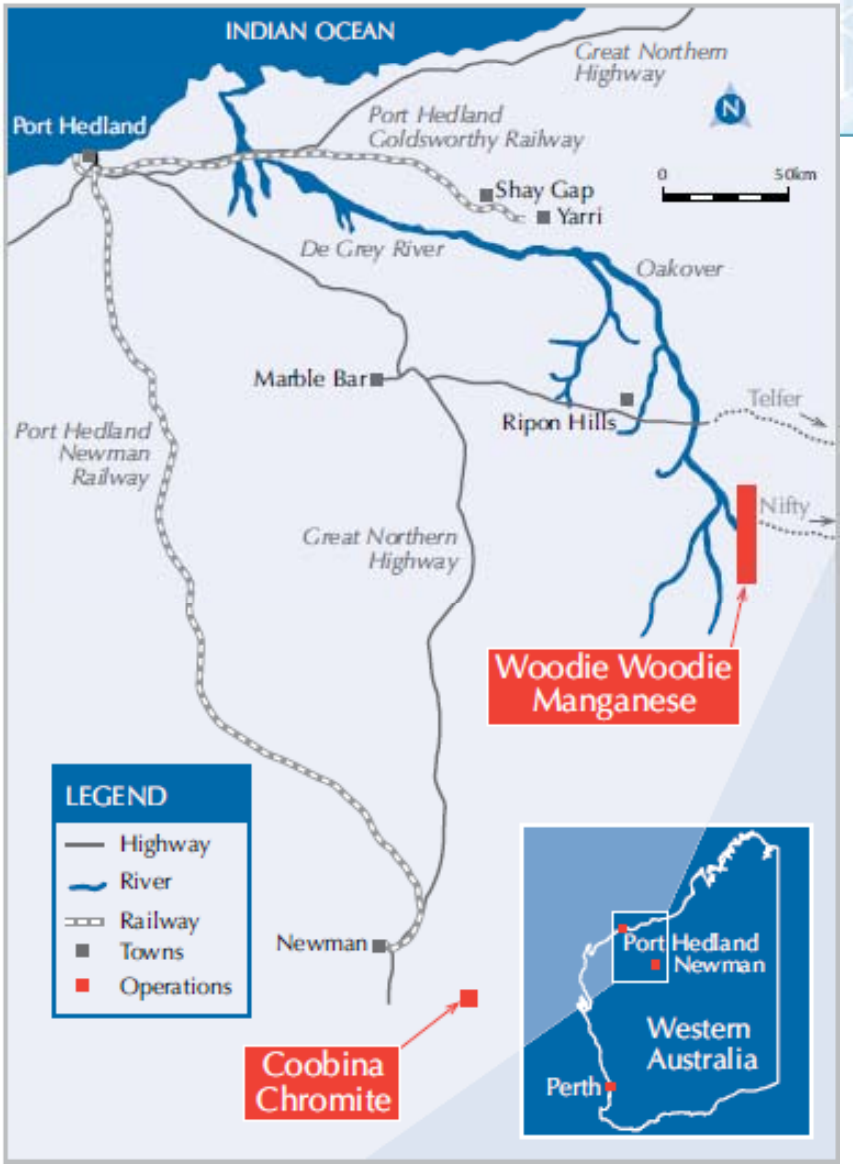
- Conclusions

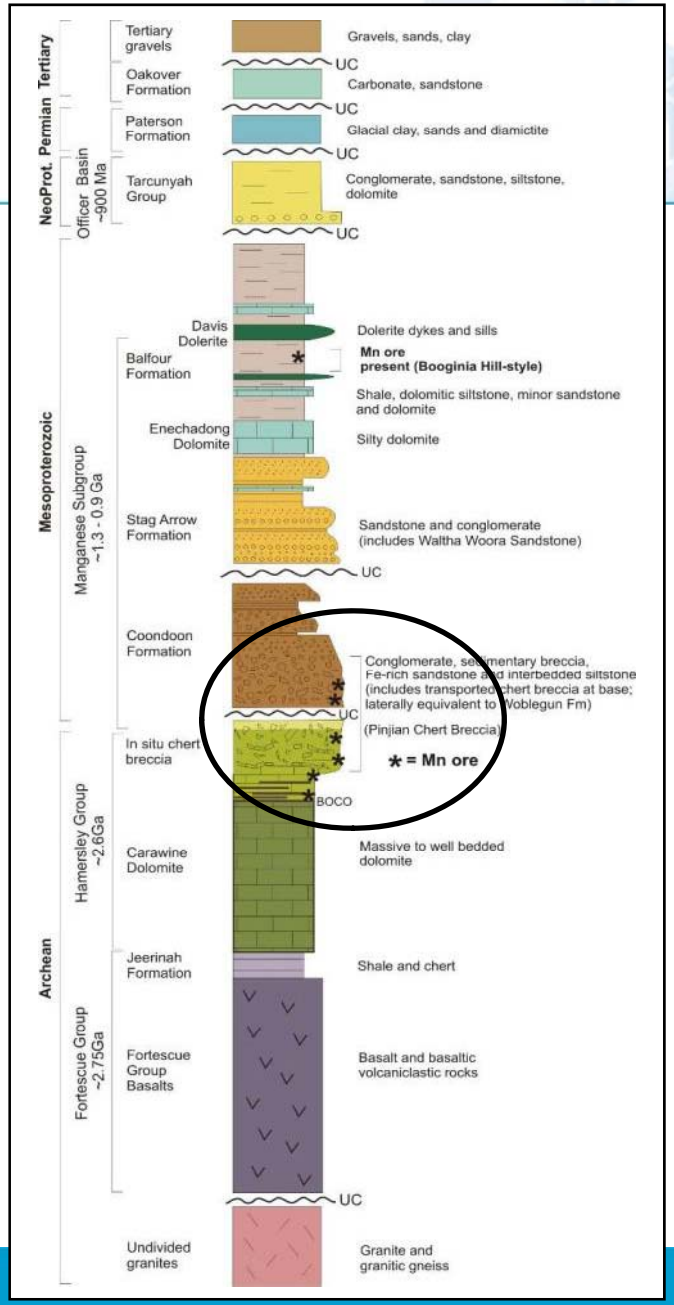
Location

- Woodie Woodie Manganese mine is located in the East Pilbara region of Western Australia
- The mine consists of approximately 100km^2 of mine corridor and 5500km^2 of greenfields area outside of this corridor
- Pilbara Manganese supplies high-grade ore to the international steel industry



Stratigraphy

- Manganese in the Woodie Woodie region is hosted by Carawine Dolomite, chert breccia, and the overlying Manganese Subgroup sedimentary rocks
- Orebodies show a range of orientations, from stacked bedding-parallel lenses (stratabound) to steeply dipping or plunging bodies (fault hosted)
- Average deposit size is 0.5Mt (0.2 – 5.5Mt), generally 50-100m wide, 100-600m long and deepest ore zones extend 200m below surface (open at depth)



From Jones, 2011

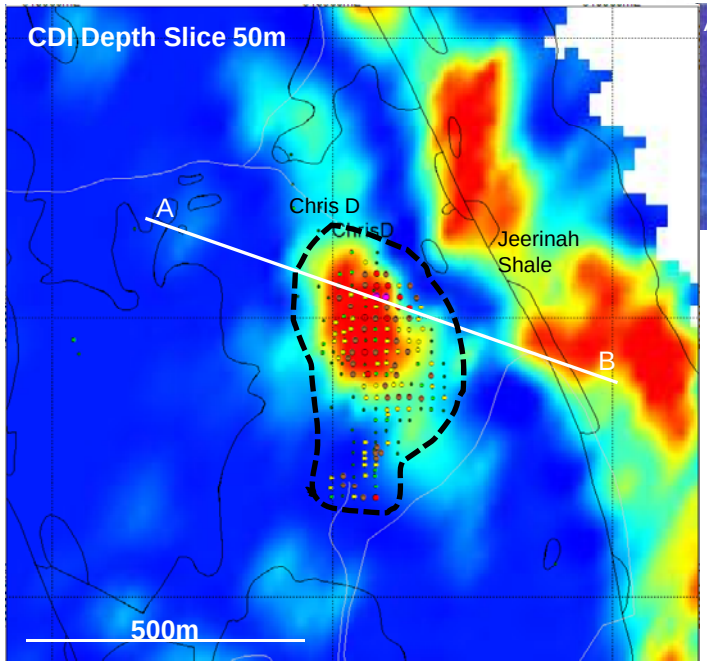
Physical Properties

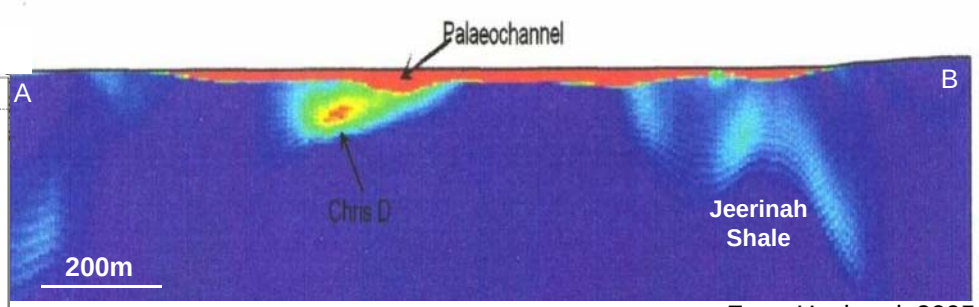
- Manganese (Mn) is often conductive compared to host rocks
  - Chert and dolomite are resistive
  - Permian clays and Jeerinah formation black shales are conductive and must be accounted for during processing/interpretation

- Conductivity response related to mineralisation can depend on Mn mineral type, grade and iron content

Initial AEM Surveying

- A HoisTEM survey was flown by GPX surveys over the Woodie Woodie mine corridor in 2002
  - Discrete targets were interpreted and a number tested by drillholes
  - Chris D deposit was an EM discovery – mineralisation below 30-50m of conductive cover





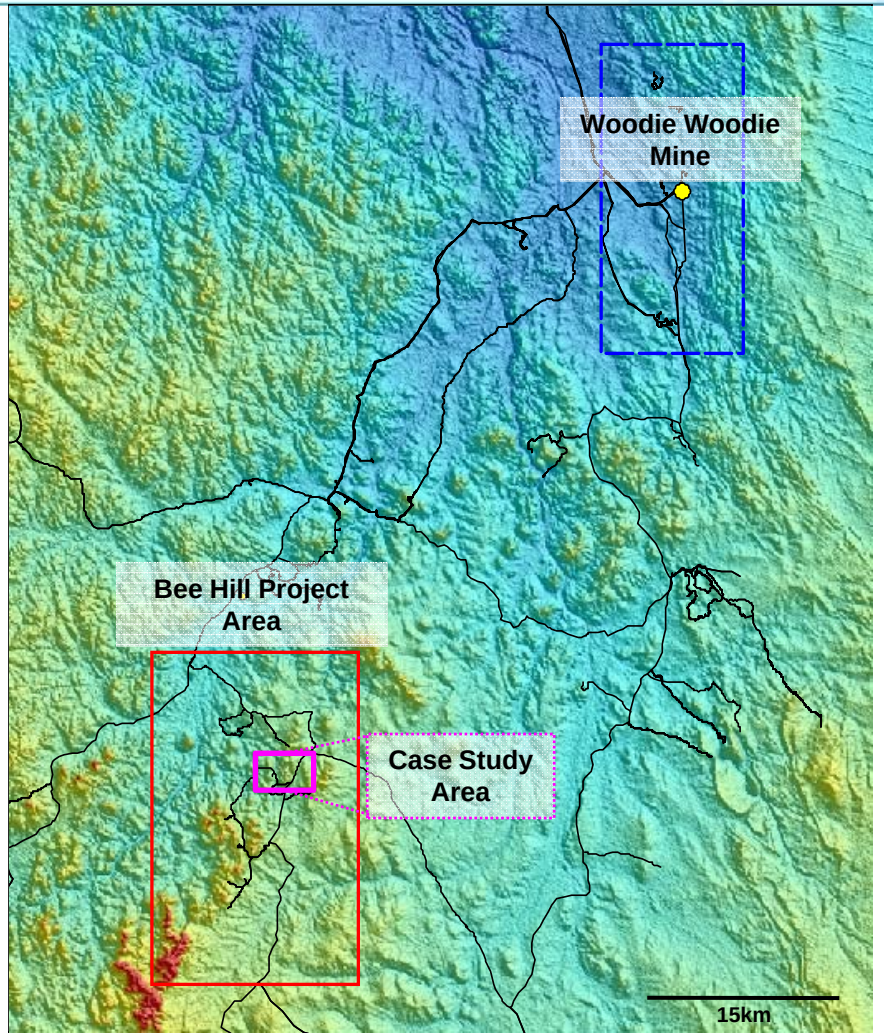
From Hashemi, 2005

- AEM surveys were flown over regional project areas based on the success of targets from the HoisTEM survey

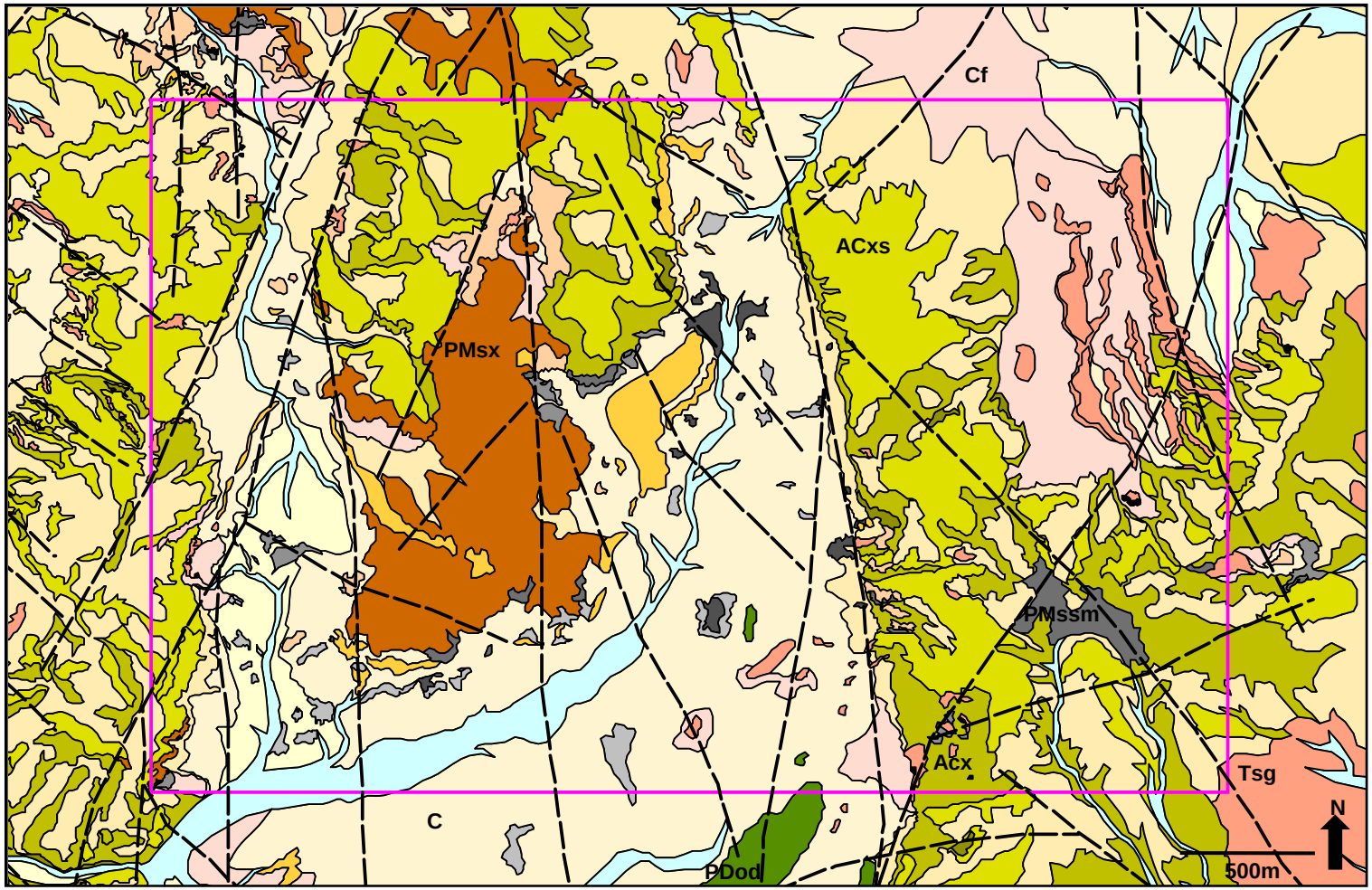
Case Study Area Location

- Bee Hill
  - Regional project area
  - Approximately 60km SW of Woodie Woodie mine

- Case study area chosen based on detailed geological mapping, previous drilling and geophysical surveying

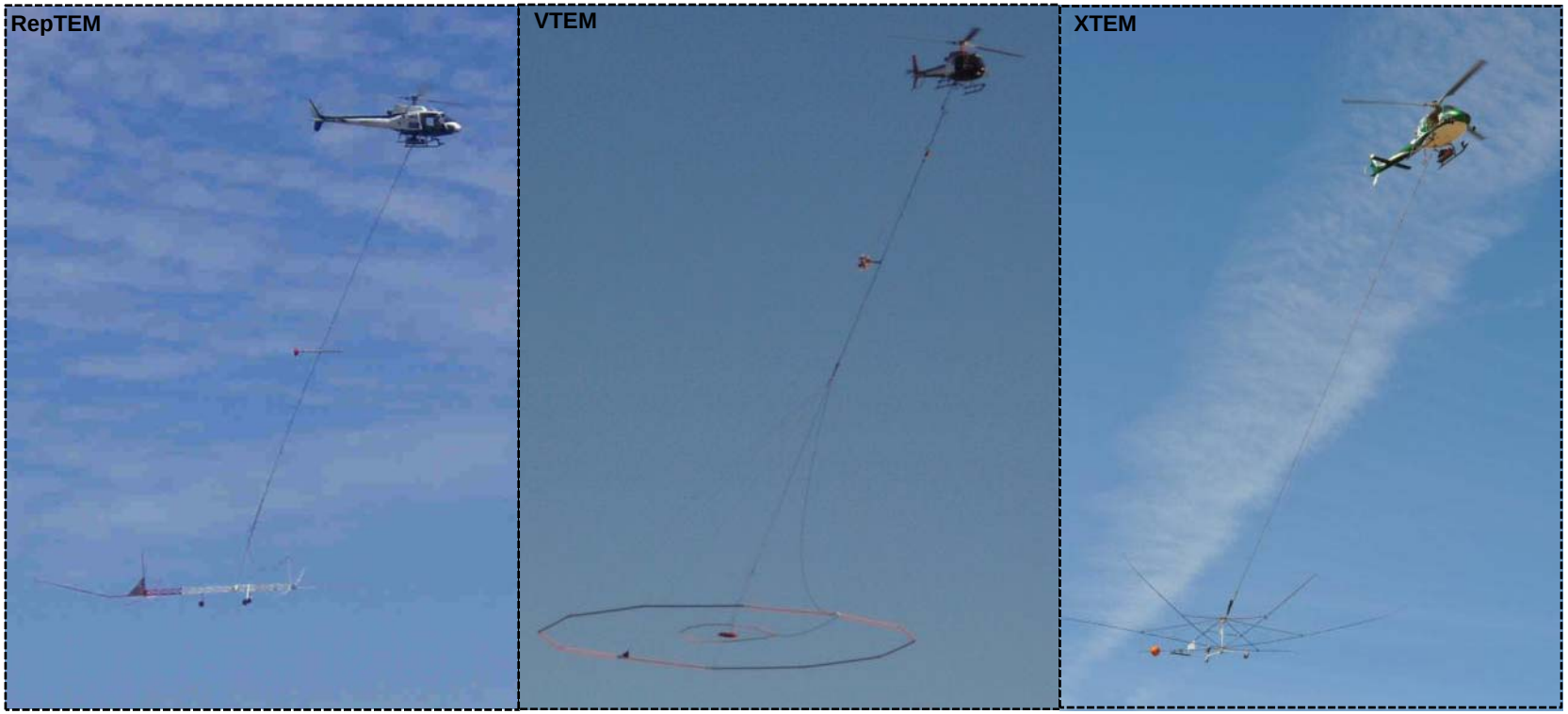


Case Study Area
Geology



Case Study Area
AEM Systems

- Three heli-borne AEM systems were flown over the case study area
  - RepTEM in May 2008 by GPX Surveys
  - VTEM in May 2009 by Geotech Airborne
  - XTEM in November 2009 by GPX Surveys



Case Study Area
System Specifications

	RepTEM	VTEM (12)	XTEM
Moment (Am^2)	112 000	400 000	102 000
Duty Cycle (%)	25	36.7	25
Waveform shape	Square	Trapezoidal	Square
Ramp Off (µs)	40	1340	45
Data Channels	21	28 (35*)	30
Along line sampling (m)	9	2	9

Power

Transmitter turn off time

- Historically, systems with resolution in the early times were considered ideal for near-surface, moderately conductive bodies

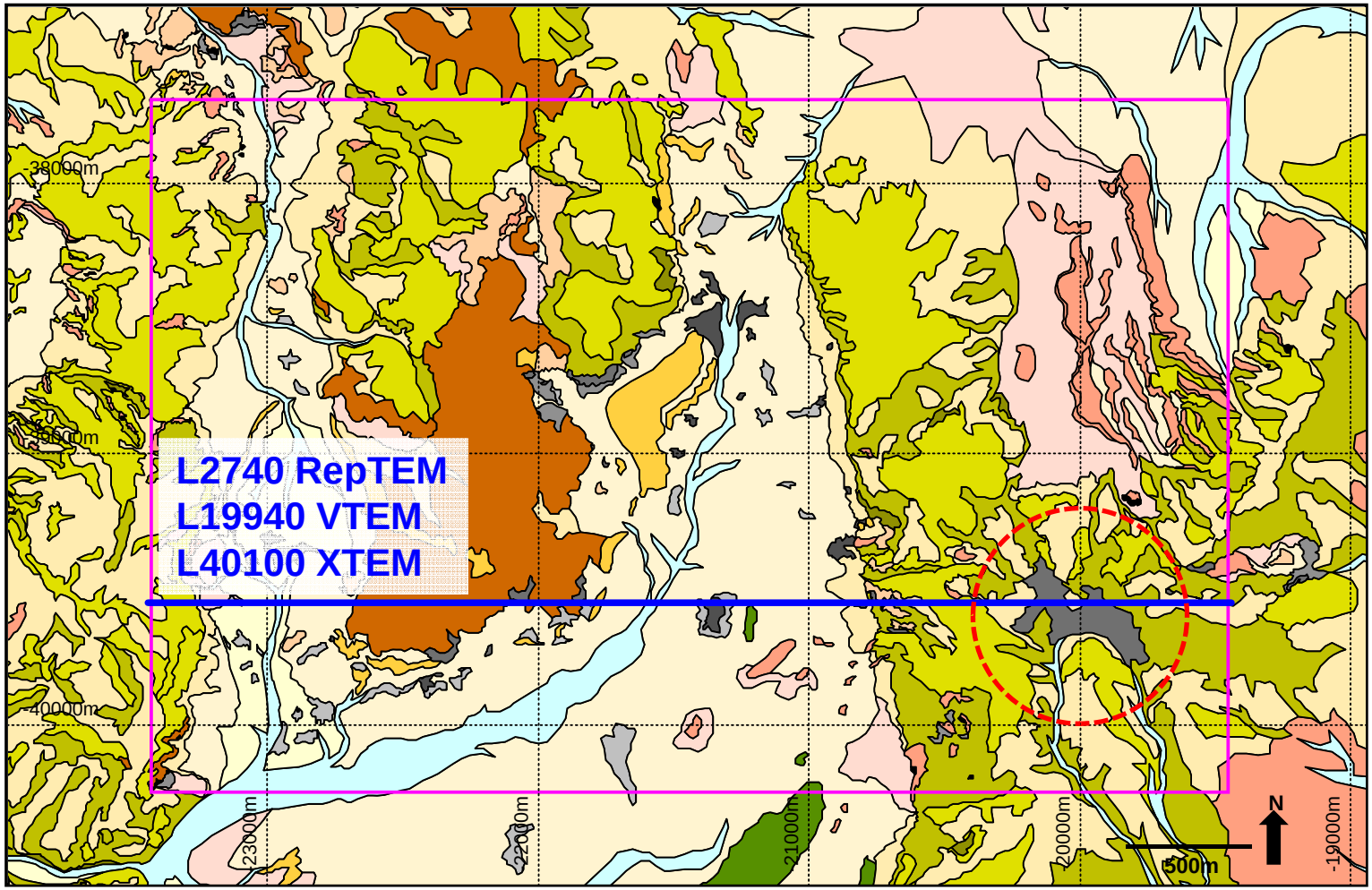
- New geology model suggested deeper bodies and structural relationship important

Case Study Area
Survey Specifications

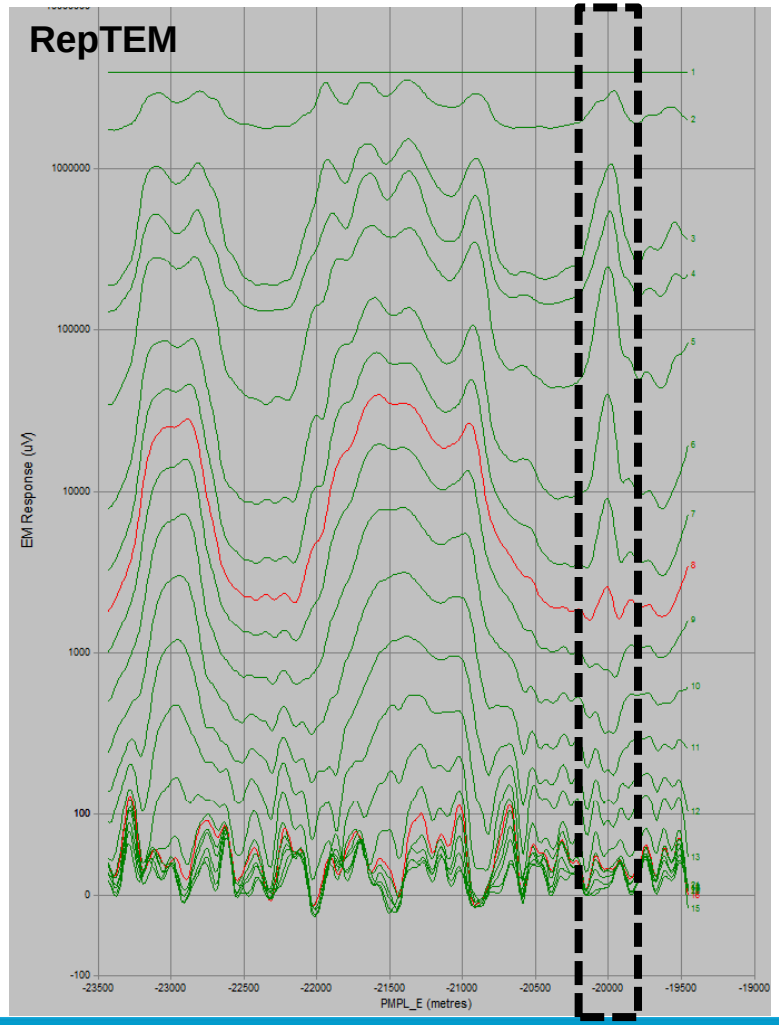
- Flight line direction for all systems was E-W, perpendicular to geology and structures of interest
- Line spacing was determined for each system based on the transmitter parameters and resolution of manganese targets
  - 80m for RepTEM and XTEM
  - 100m for VTEM

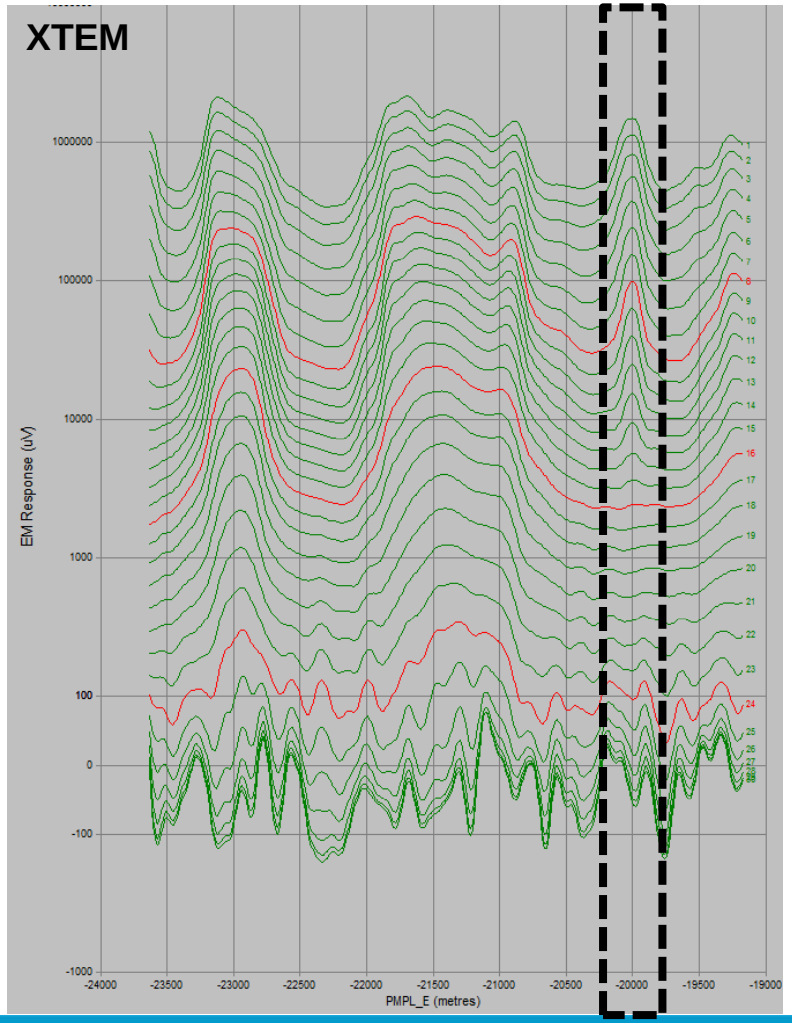
- Traditionally, AEM systems measure the time rate of change of the magnetic field (dB/dt) = RepTEM and XTEM
- VTEM calculates the B-field data from dB/dt, equivalent to a direct measurement of the magnetic field

Case Study Area
Prospect of Interest

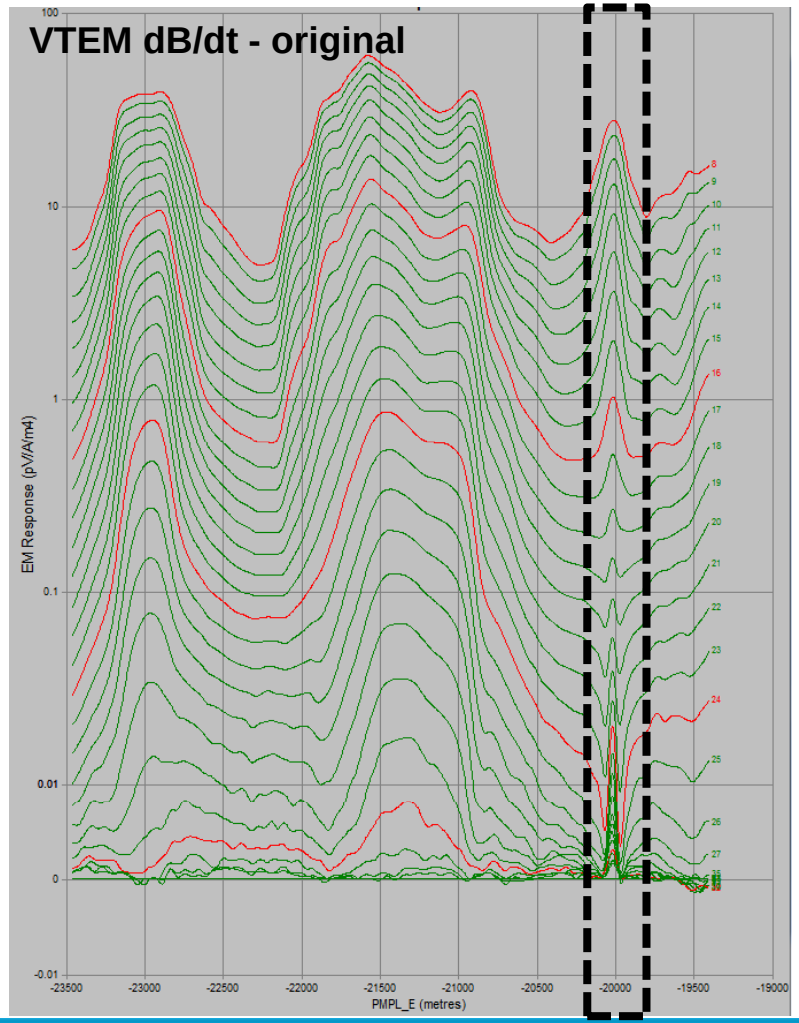


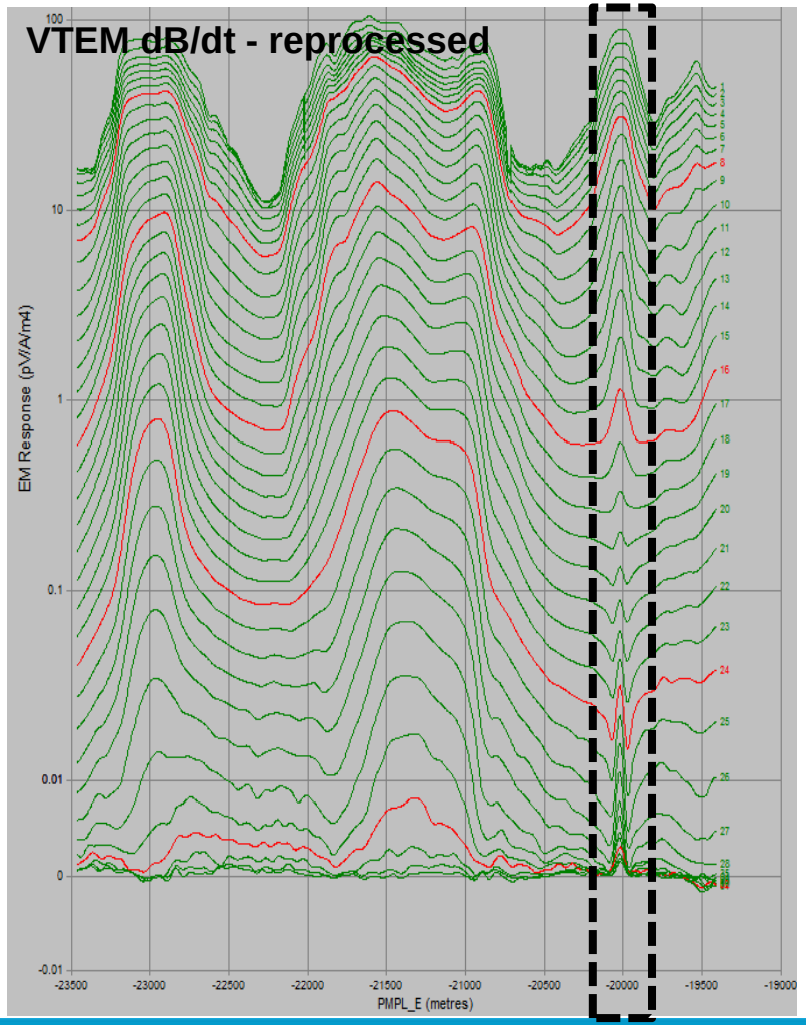
Case Study Area
Data Profiles



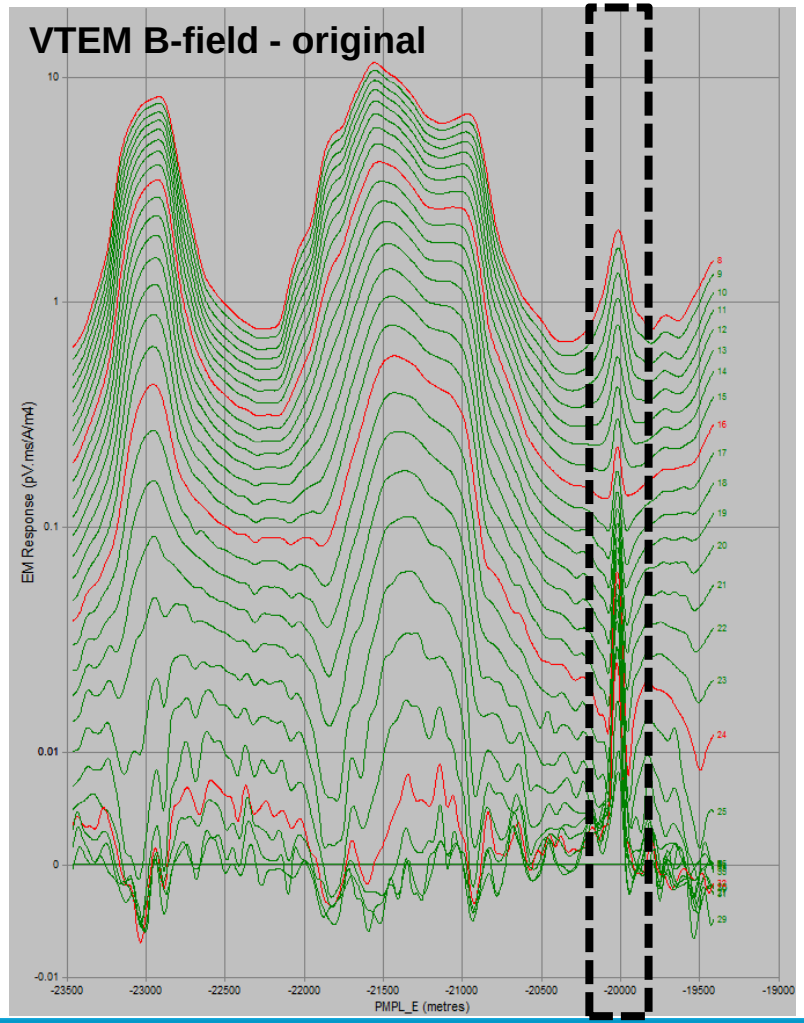


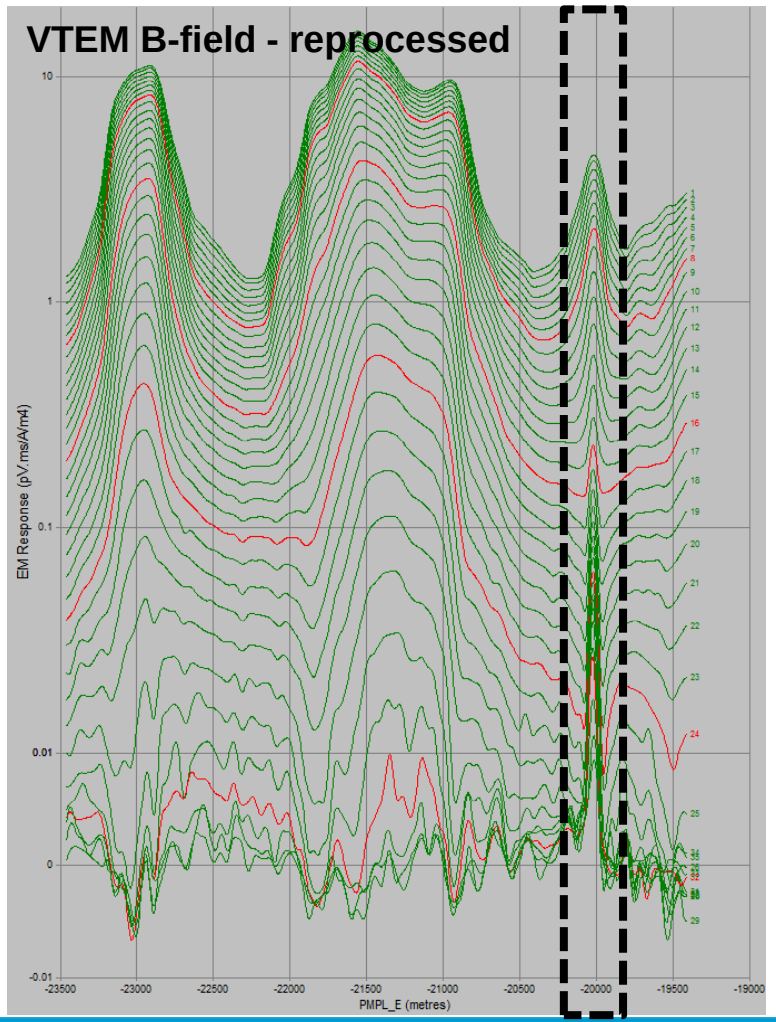
Case Study Area
Data Profiles





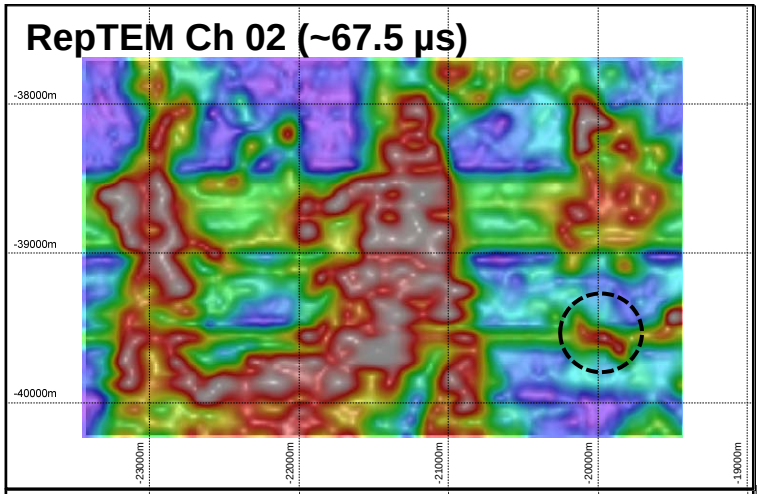
Case Study Area
Data Profiles

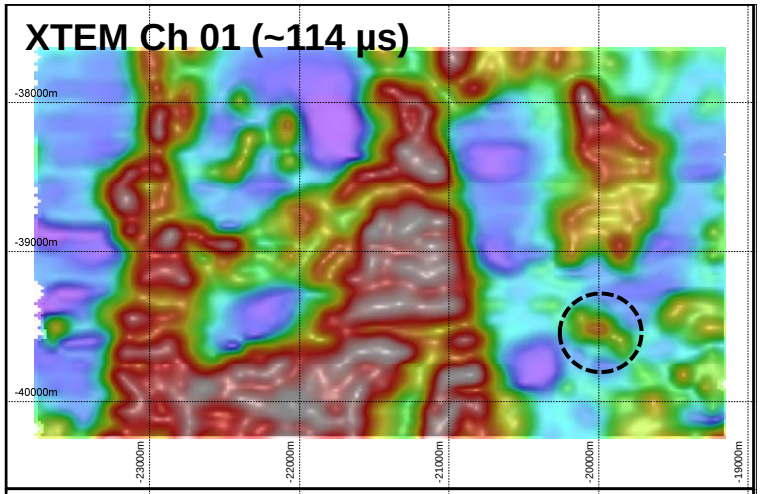


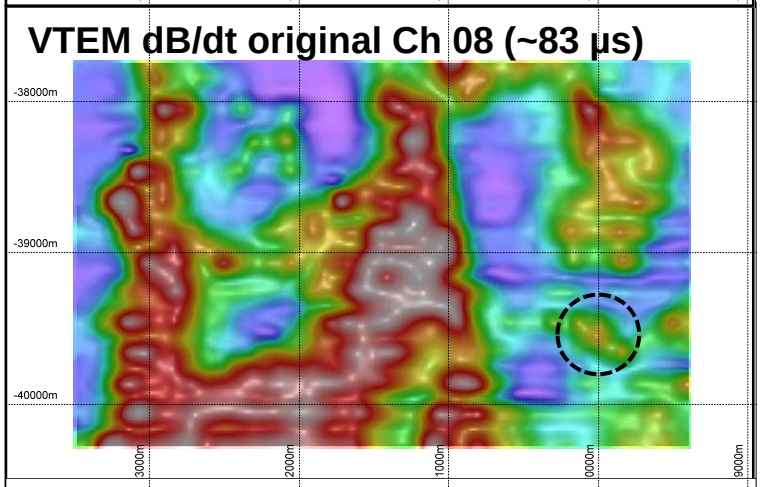


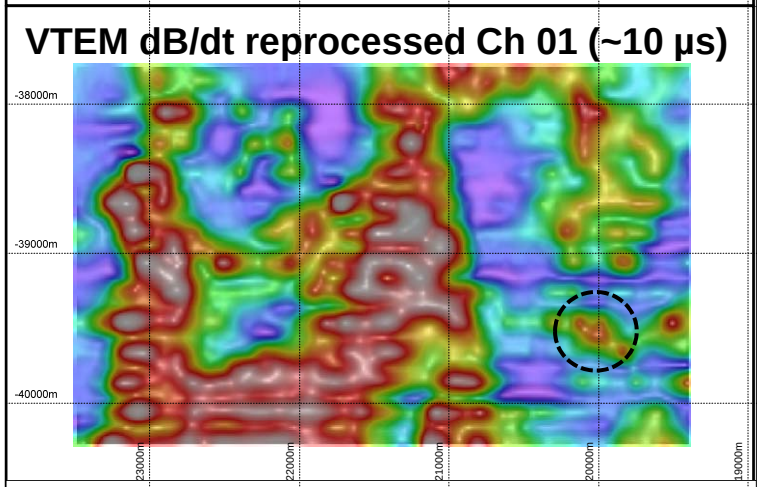
Case Study Area
Channel Grids

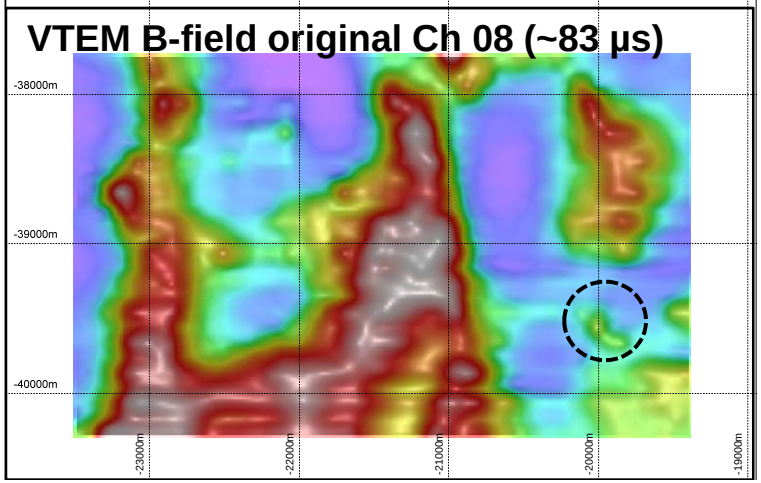
- Each time channel was gridded for the three systems, including both B-field and dB/dt, original and reprocessed data for the VTEM survey
  - Earliest time channel available (not noise)
  - Mid-time channel
  - Latest time channel (before signal over-ridden by noise)

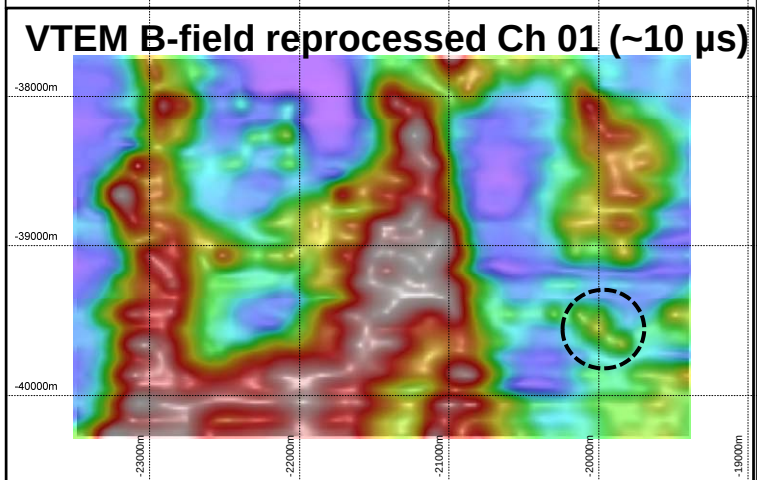

RepTEM Ch 02 (~67.5 µs)
-38000m
-39000m
-40000m
-23000m
-22000m
-21000m
-20000m
-19000m


XTEM Ch 01 (~114 µs)
-38000m
-39000m
-40000m
-23000m
-22000m
-21000m
-20000m
-19000m

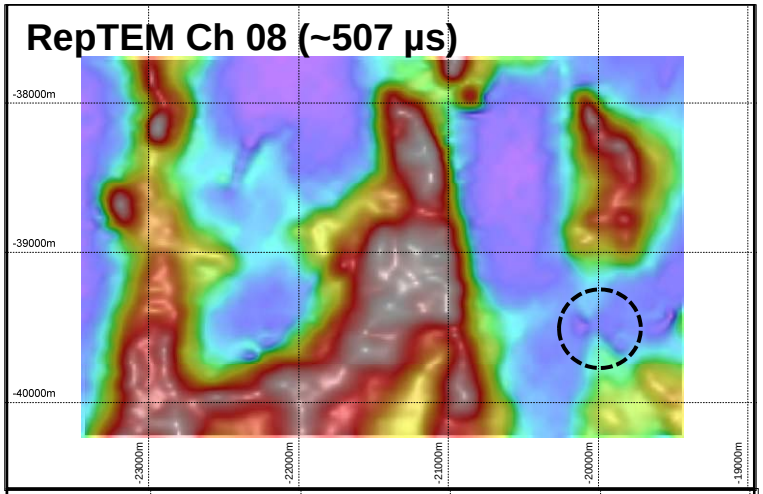

VTEM dB/dt original Ch 08 (~83 µs)
-38000m
-39000m
-40000m
3000m
2000m
1000m
0000m
9000m


VTEM dB/dt reprocessed Ch 01 (~10 µs)
-38000m
-39000m
-40000m
23000m
22000m
21000m
20000m
19000m


VTEM B-field original Ch 08 (~83 µs)
-38000m
-39000m
-40000m
-23000m
-22000m
-21000m
-20000m
-19000m


VTEM B-field reprocessed Ch 01 (~10 µs)
-38000m
-39000m
-40000m
-23000m
-22000m
-21000m
-20000m
-19000m

1km


RepTEM Ch 08 (~507 µs)
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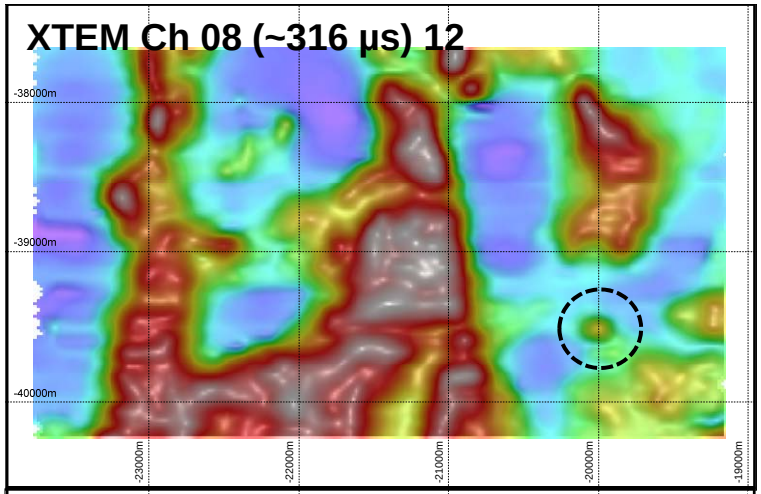
-39000m
-40000m
-23000m
-22000m
-21000m
-20000m
-19000m


XTEM Ch 08 (~316 µs) 12
-38000m
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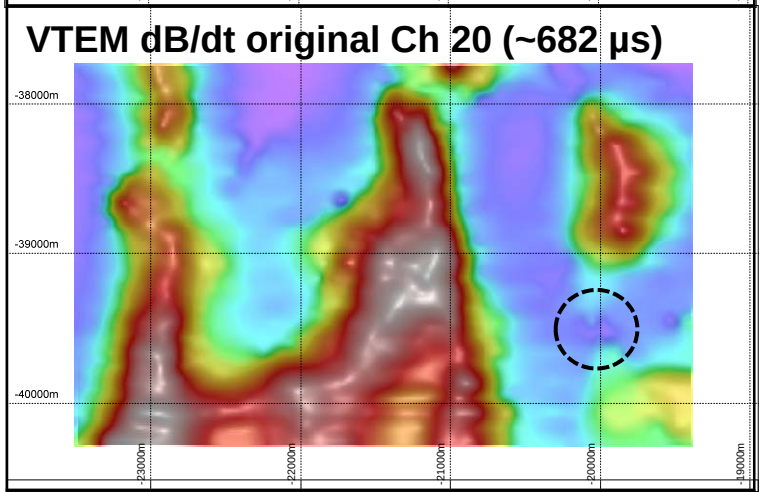
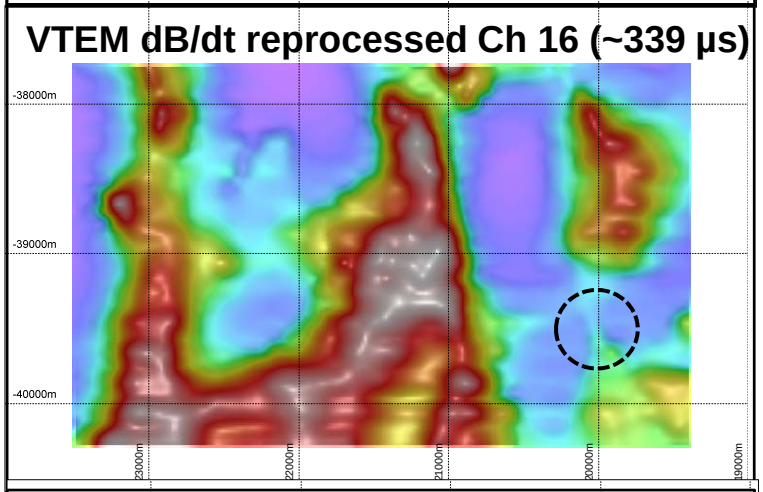
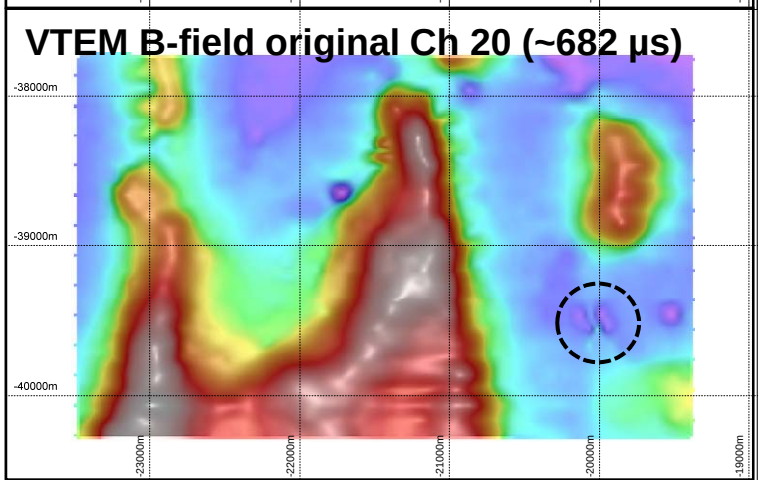
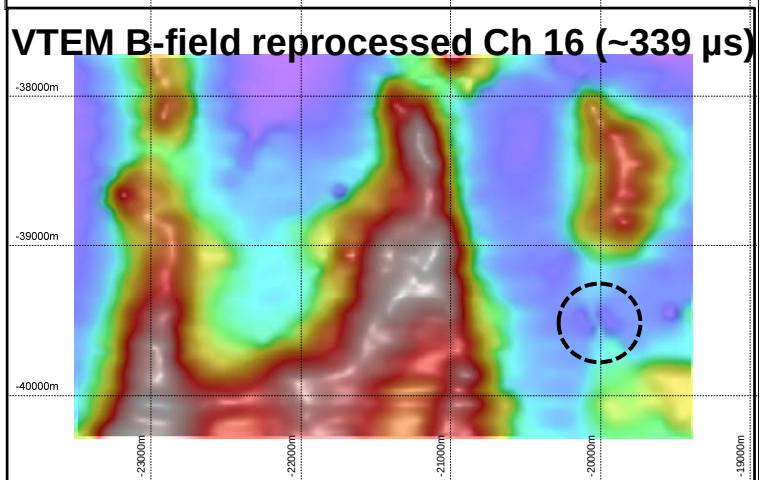
-40000m
-23000m
-22000m
-21000m
-20000m
-19000m


VTEM dB/dt original Ch 20 (~682 µs)
-38000m
-39000m
-40000m
-23000m
-22000m
-21000m
-20000m
-19000m

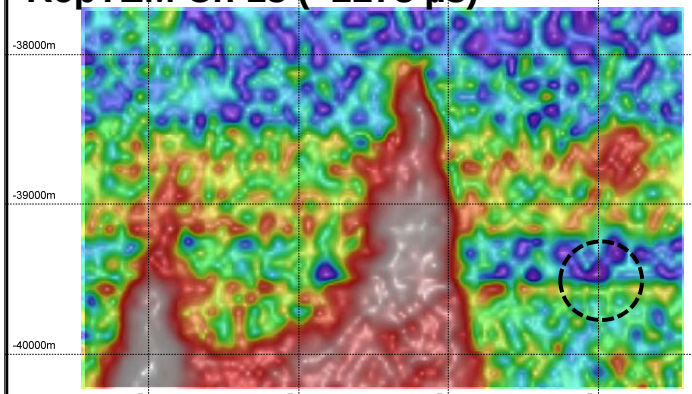

VTEM dB/dt reprocessed Ch 16 (~339 µs)
-38000m
-39000m
-40000m
-23000m
-22000m
-21000m
-20000m
-19000m


VTEM B-field original Ch 20 (~682 µs)
-38000m
-39000m
-40000m
-23000m
-22000m
-21000m
-20000m
-19000m

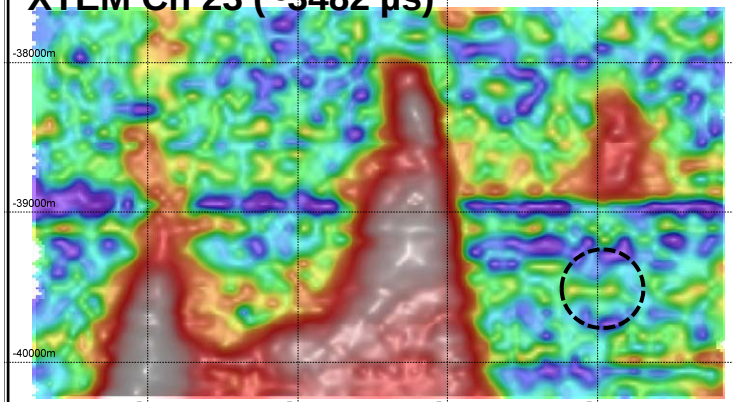

VTEM B-field reprocessed Ch 16 (~339 µs)
-38000m
-39000m
-40000m
-23000m
-22000m
-21000m
-20000m
-19000m

1km

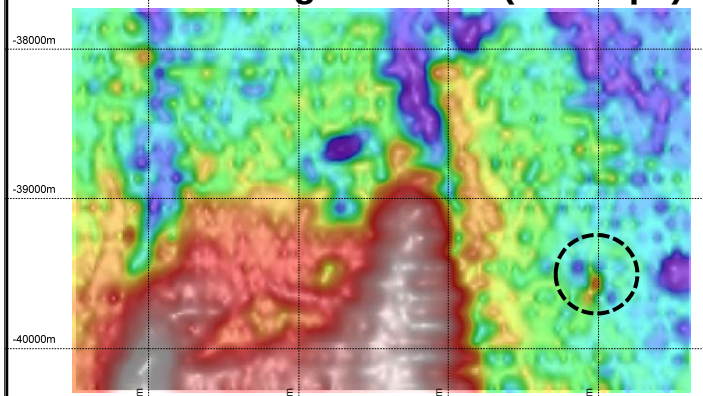
RepTEM Ch 13 (~2278 µs)



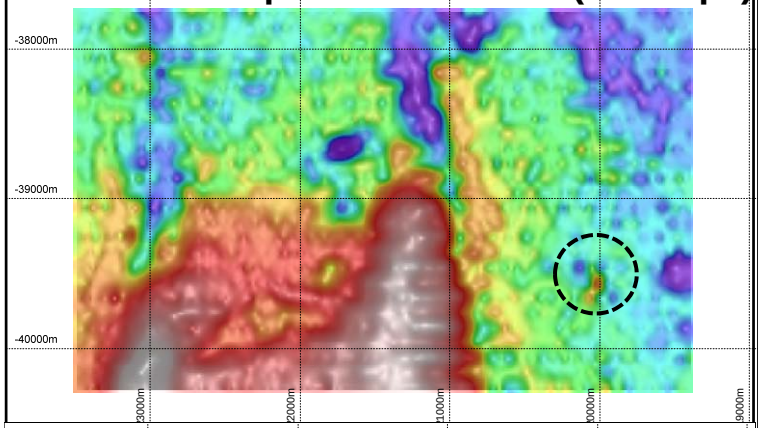
XTEM Ch 23 (~3482 µs)



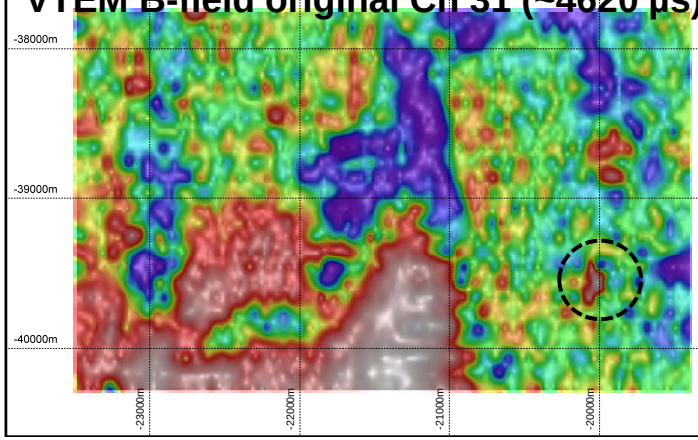
VTEM dB/dt original Ch 31 (~4620 µs)



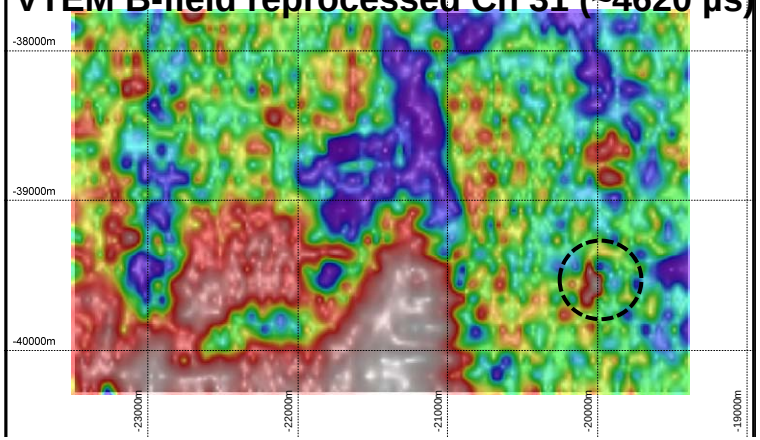
VTEM dB/dt reprocessed Ch 31 (~4620 µs)



VTEM B-field original Ch 31 (~4620 µs)



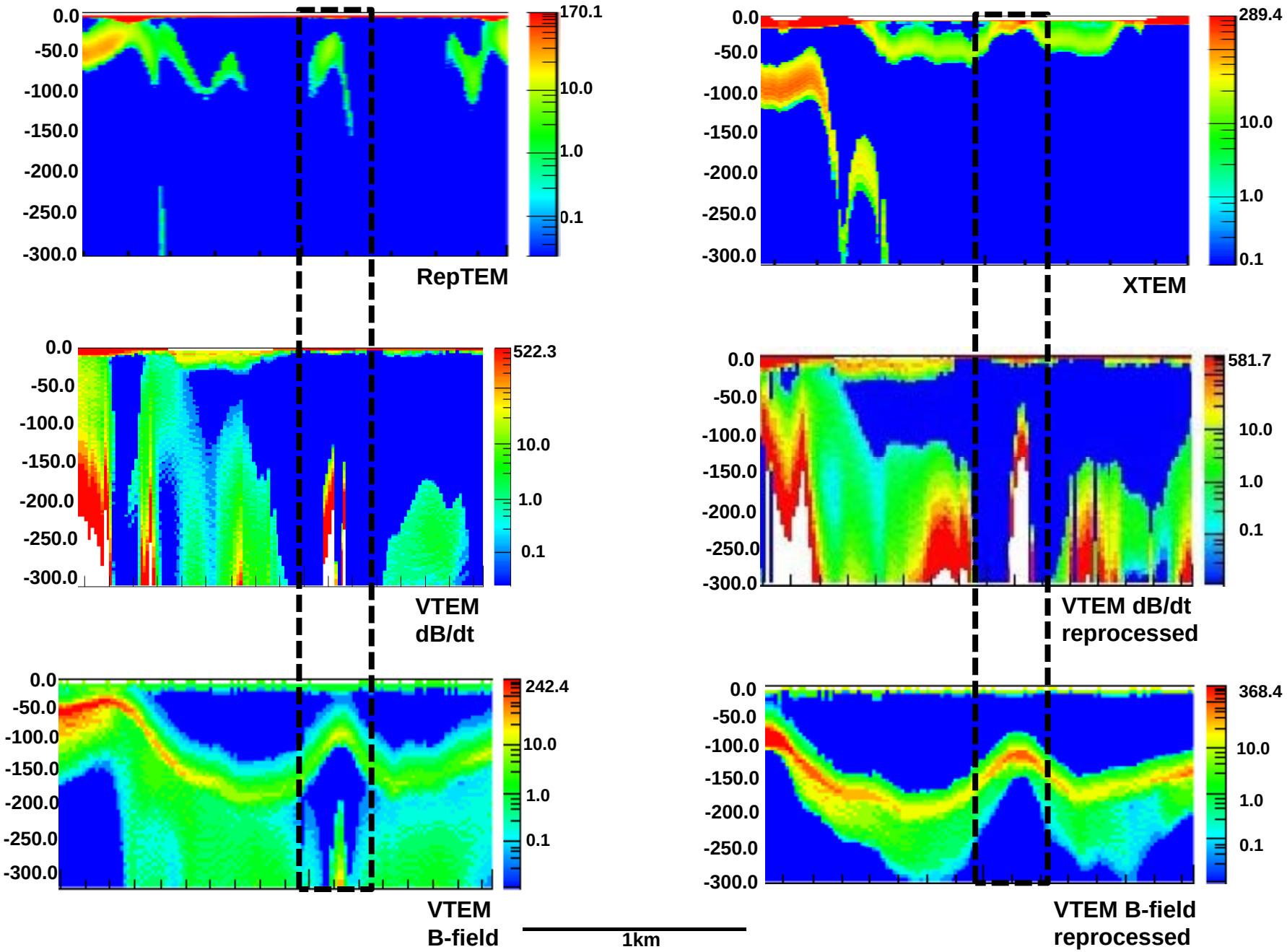
VTEM B-field reprocessed Ch 31 (~4620 µs)



1km

Case Study Area
Conductivity Depth Imaging

- EM data from each system was inverted using EMFlow software to produce a conductivity depth model
- Equivalent lines from each system windowed to the prospect of interest are presented
  - L2740 RepTEM
  - L19940 VTEM
  - L40100 XTEM


0.0
-50.0
-100.0
-150.0
-200.0
-250.0
-300.0
170.1
10.0
1.0
0.1
RepTEM
289.4
XTEM
522.3
VTEM
dB/dt
581.7
VTEM dB/dt
reprocessed
242.4
VTEM
B-field
368.4
VTEM B-field
reprocessed
1km

Case Study
Drilling

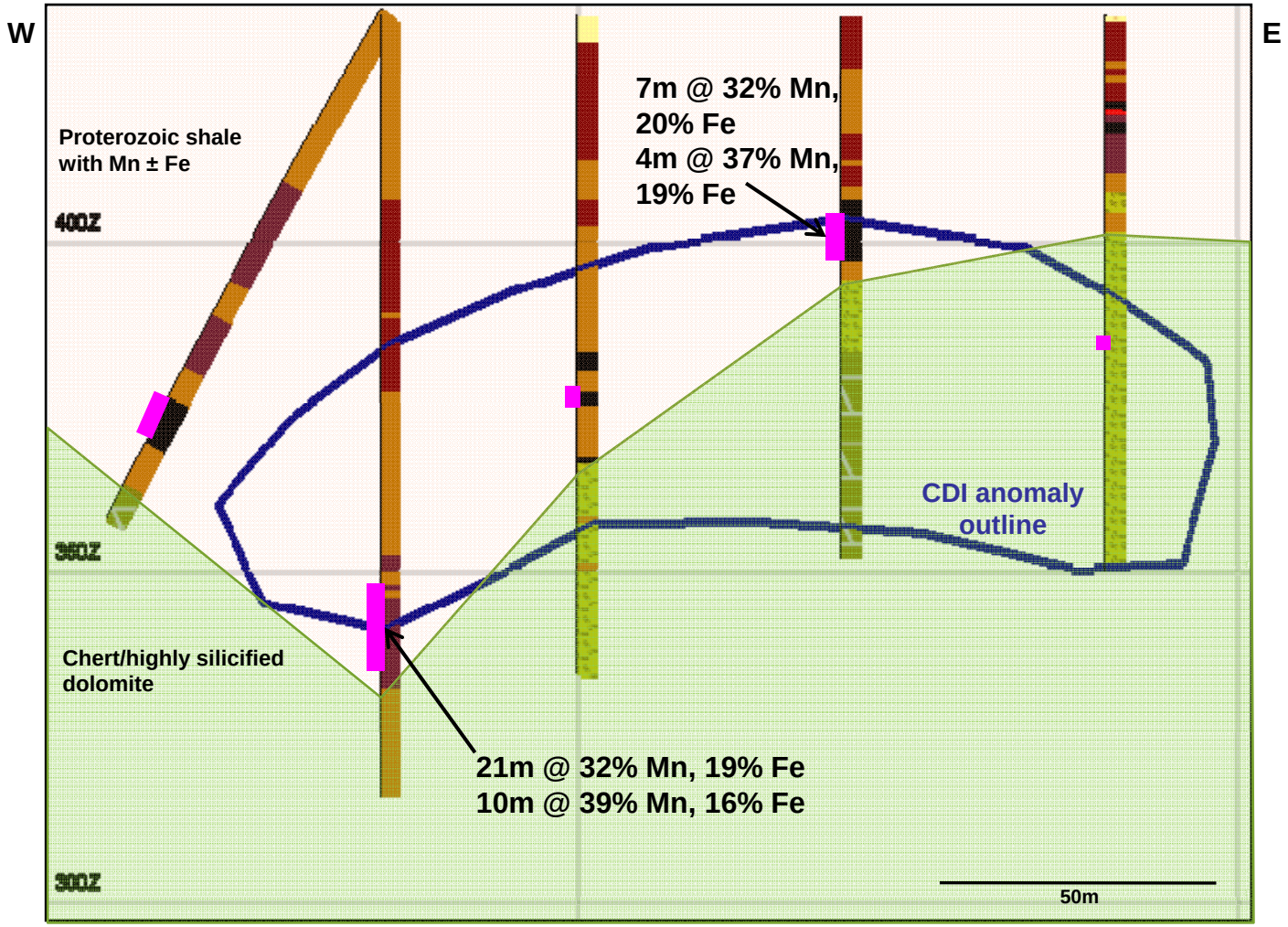
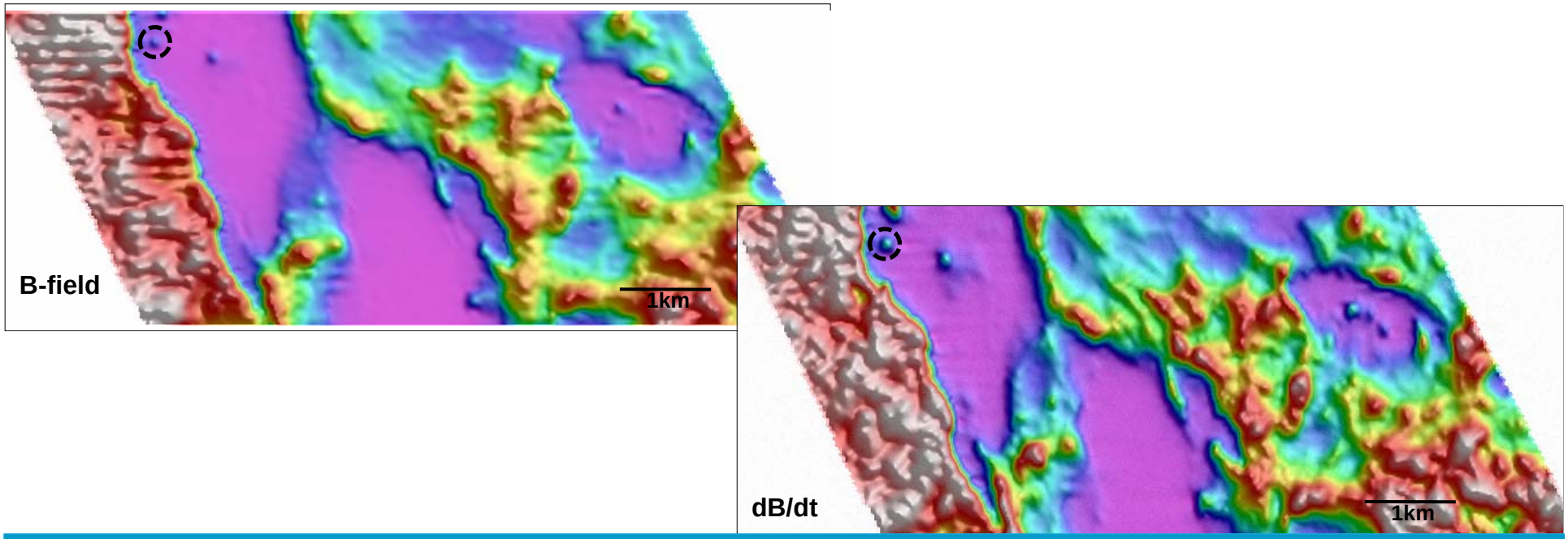


Fig Tree – a quick comparison

- Project area approximately 40km South of Woodie Woodie mine
- VTEM survey flown in 2009 using 100m line spacing with lines oriented perpendicular to major structures and lithology trends

- Dominantly resistive host geology, dB/dt and B-field responses very similar



Conclusions

- Three time domain airborne EM systems flown over a case study area with known manganese mineralisation
- Each system showed a discrete anomalous response in channel time data and a conductor in the CDI related to Mn
- High signal to noise and the B-field option of the VTEM system provides an advantage over traditional dB/dt systems
  - shows target into late time channels when conductive overburden response has decayed
- Geology of the survey area should be considered when targeting Mn using AEM
  - Conductive overburden = B-field data for target discrimination
  - Dominantly outcropping resistive geology = dB/dt data provides reasonable targets

References

Hashemi, A., 2005. Innovative geophysical exploration for high-grade manganese ore under regolith and sedimentary cover in the East Pilbara of Western Australia, Curtin University of Technology Doctor of Philosophy thesis, 226p.

Jones, S., 2011. Proterozoic deformation in the east Pilbara Craton and teconic setting of fault-hosted manganese at the Woodie Woodie mine, Australian Journal of Earth Sciences, 58, p. 639-673