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Data to Discovery
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Incorporating the AIG, ASEG, PESA, and WABS

# Update on the geophysical expression of the Abra sedimentary replacement Pb-Ag-Cu-Au deposit, Western Australia


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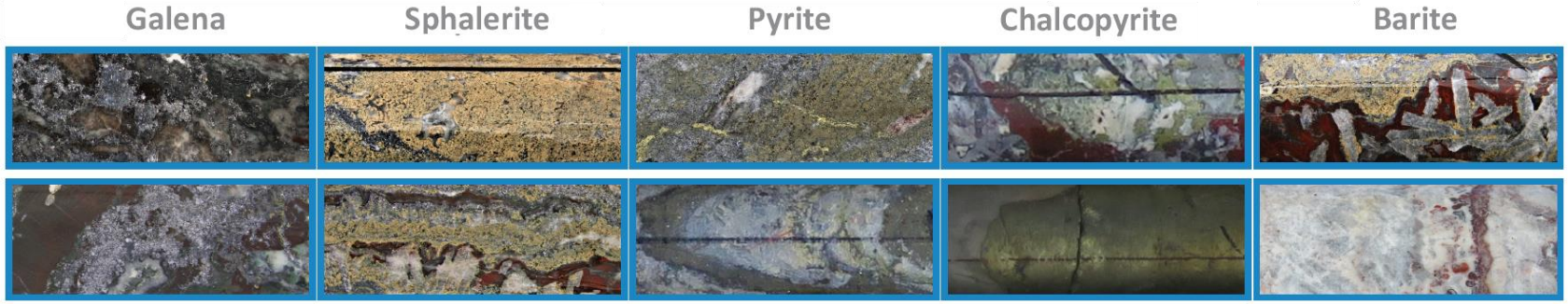
Resource Potentials

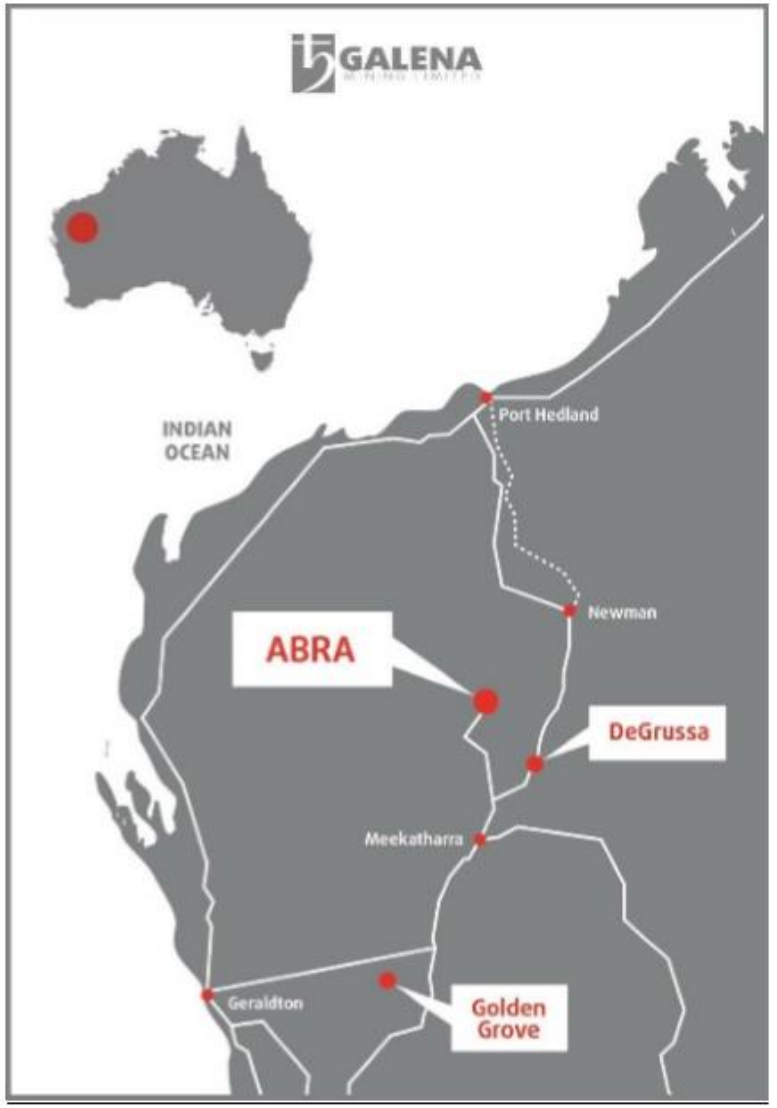
GALENA MINING LIMITED

# Introduction

Resource Potentials

- The Abra polymetallic base metal deposit (Pb-Ag-Cu-Au) is located in the Gascoyne region of Western Australia, approximately 900km NNE of Perth.
- It was discovered in 1981 by Geopeko Ltd and Amoco Minerals Australia following successful drill targeting of coincident magnetic and gravity high anomaly responses. The deposit starts at 250m depth and has no direct surface geochemical expression and no indication of a significant high-grade lead deposit can be inferred from limited outcrop geology. **Blind geophysical discovery**.
- The deposit had been considered sub-economic since discovery, and ownership has changed hands many times since.
- Project and surrounding exploration projects were purchased by Galena Mining Ltd in 2017 who aggressively drilled and proved-up a high-grade geological model, and the current total indicated and inferred resources stand at 37.4Mt at 7.5% Pb and 18g/t Ag (December 2018 JORC estimate). 43 deep drillholes totalling 18,200m completed at Abra in 2019.
- Construction of mining infrastructure scheduled to commence Q4 2019, and first ore production scheduled for 2021, 40 years after discovery.



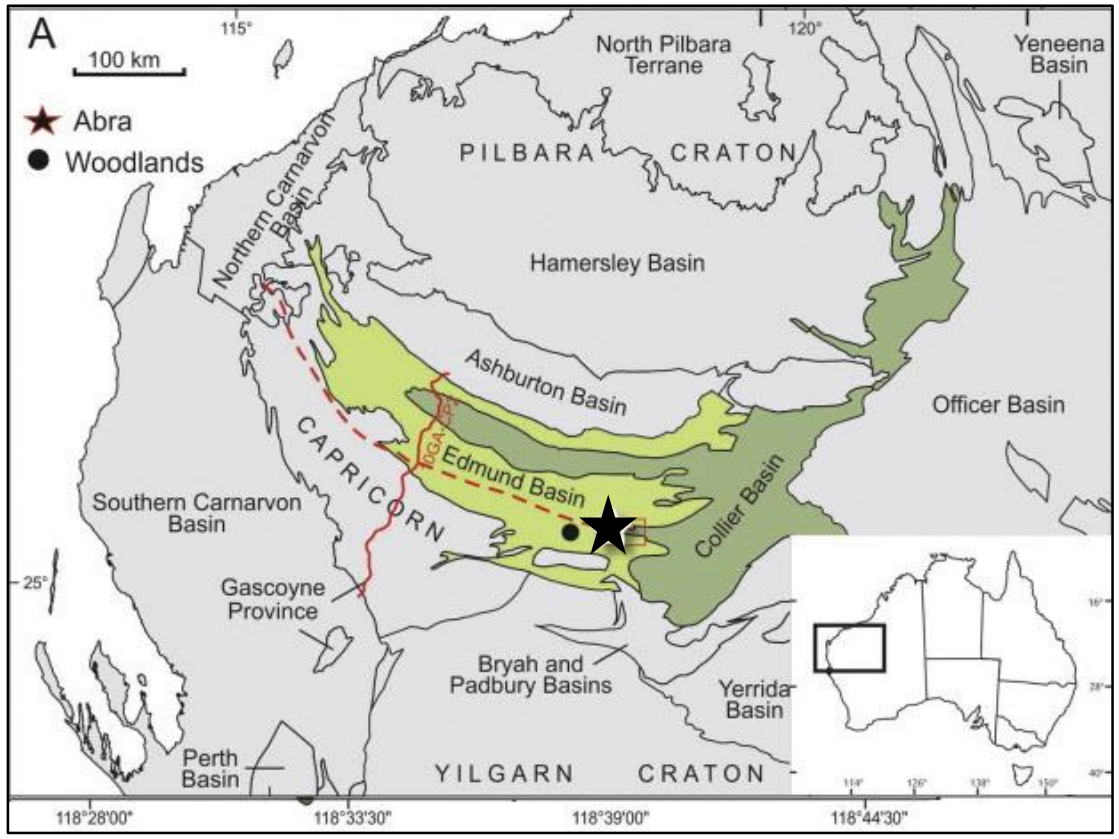

***Abra location and infrastructure (sourced from galenamining.com.au)***

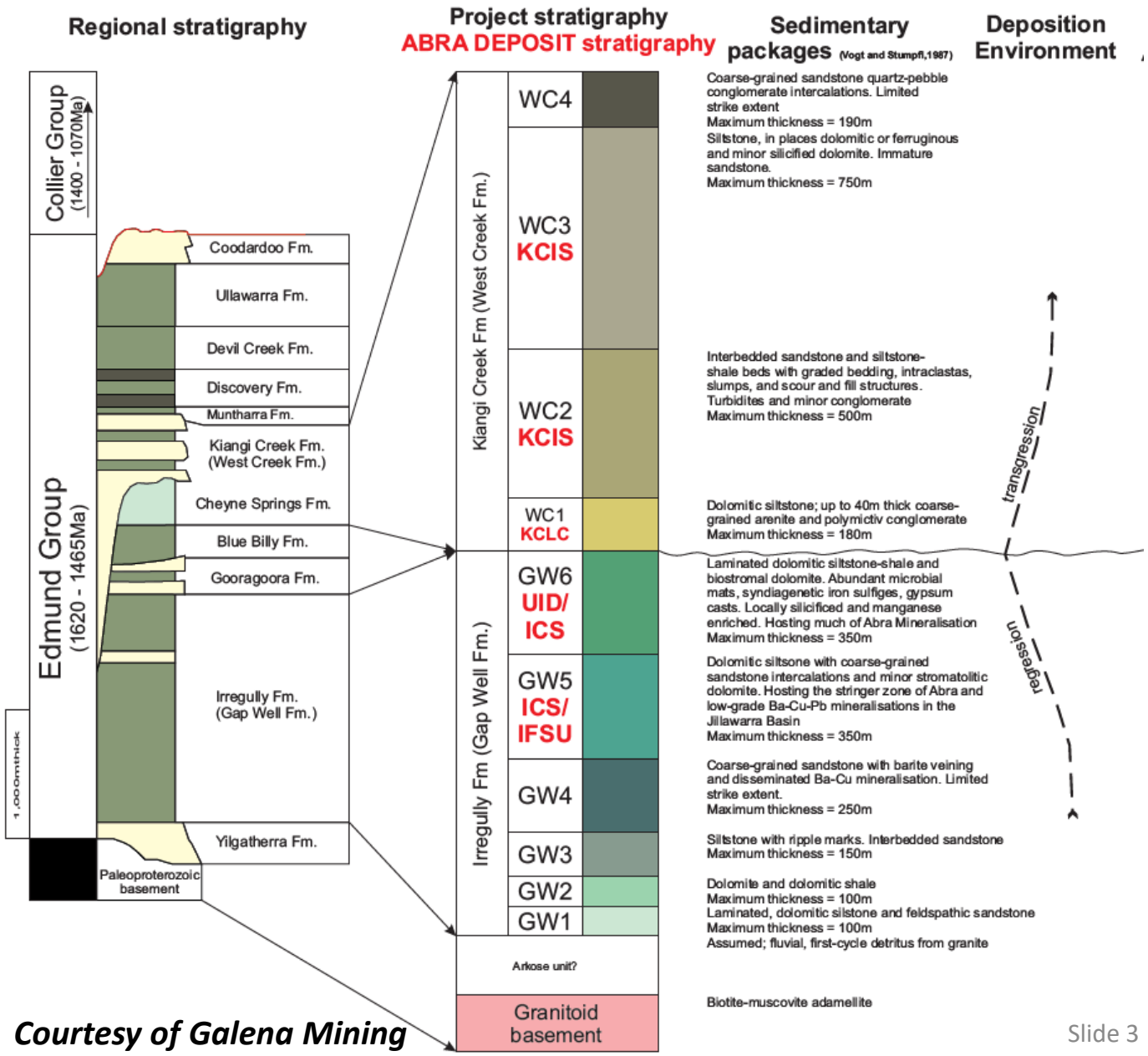
# Abra Project Setting and Stratigraphy

Resource Potentials

- Abra sits within the Jillawarra sub-basin of the Edmund Basin, which formed as part of Capricorn Orogen and is hosted within siliciclastic and carbonate deposits of the Edmund Group.

***Regional geological setting of the Edmund Basin, with Abra shown as a black star. Reproduced from Pirajno et al. (2016).***



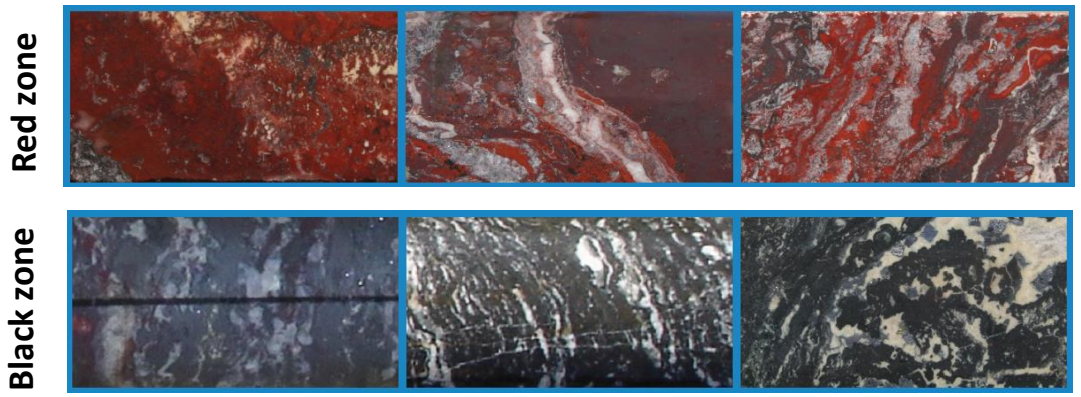




***Courtesy of Galena Mining***

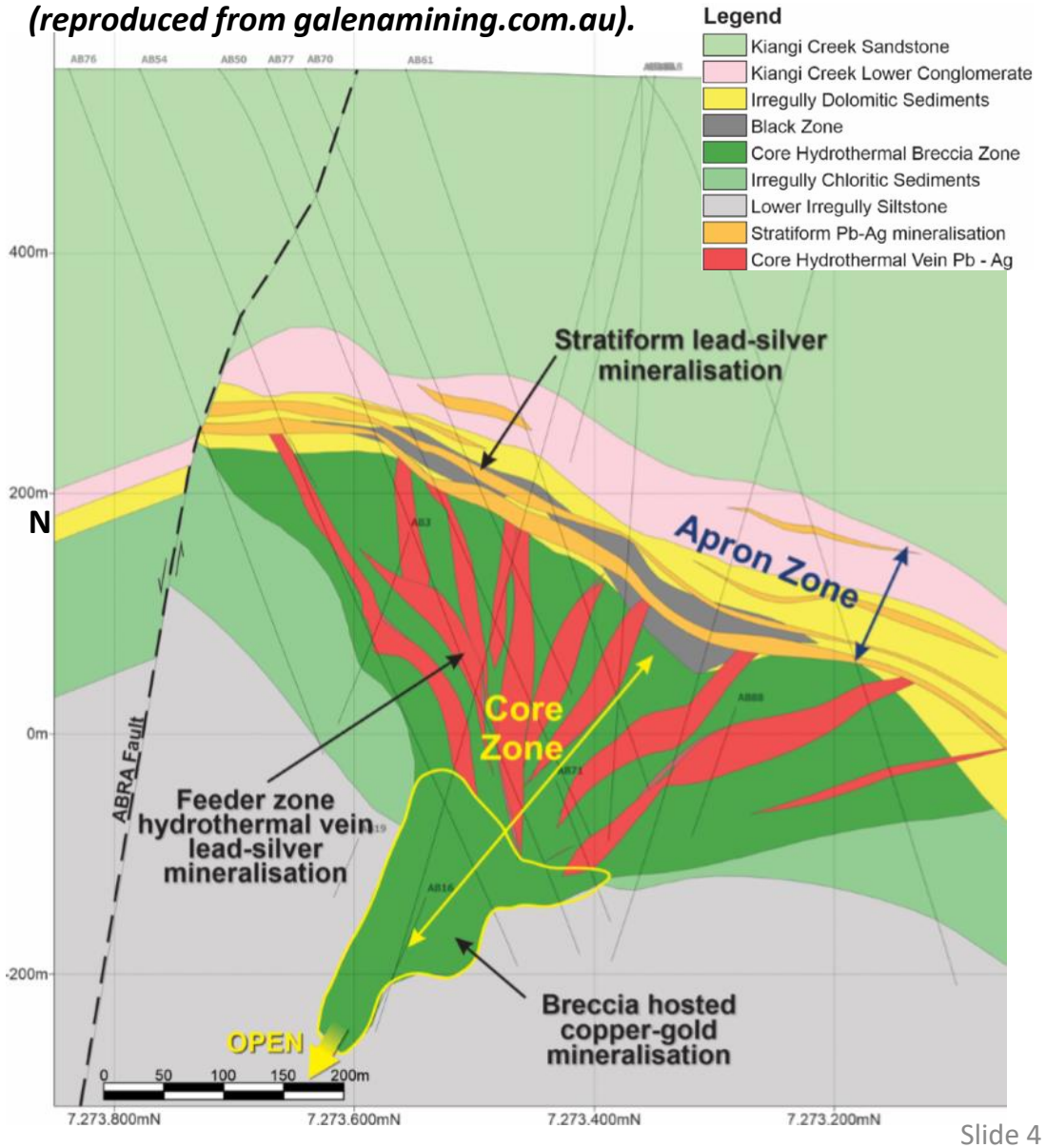
# Abra Mineralisation Model

Resource Potentials

- The deposit has two main parts:
  - Stratabound or ‘apron’ zone: Pb-Ag-Ba mineralisation associated with a laminated iron oxide and barite altered siltstone, which is divided into two domains, an upper oxidised ‘**red zone**’ identified by conglomerate and laminated to banded hematite-barite-jaspillite, and overlies the ‘**black zone**’ dominated by magnetite (>20%), barite, quartz and dolomite.
  - ‘Stockwork’ or ‘feeder’ zone: chlorite altered, brecciated and extensively veined carbonaceous siltstone, containing high-grade Pb-Ag veining in the core, and transitioning to more Pb-Cu and Cu-Au veined feeder zone mineralisation at depth.
- The red zone is an impermeable silica cap, which trapped mineralising fluids from migrating up through veins and faults, to react and replace dolomite to precipitate sulphide and oxide minerals. We consider Abra to be a form of sedimentary replacement deposit.

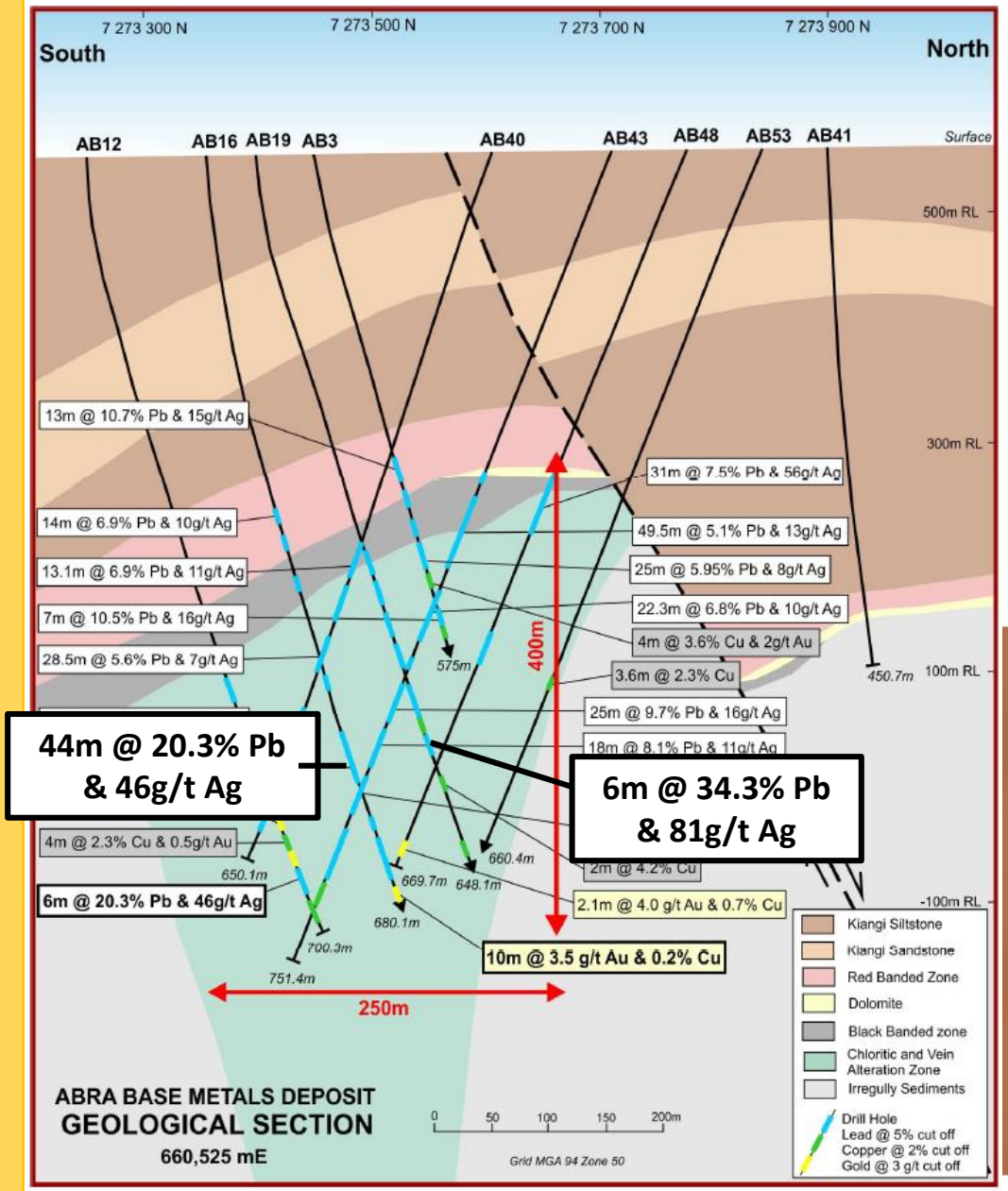



***Stylised geological cross-section of the Abra deposit looking east (reproduced from galenamining.com.au).***



# Abra Pb-Ag Resource (December 2018)

Resource Potentials




Abra JORC Mineral Resource estimate[1, 2]

| Resource classification | Tonnes (Mt) | Lead grade (%) | Silver grade (g/t) |
|---|---|---|---|
| Measured | - | - | - |
| Indicated | 15.0 | 8.7 | 22 |
| Inferred | 22.4 | 6.7 | 15 |
| Total | 37.4 | 7.5 | 18 |

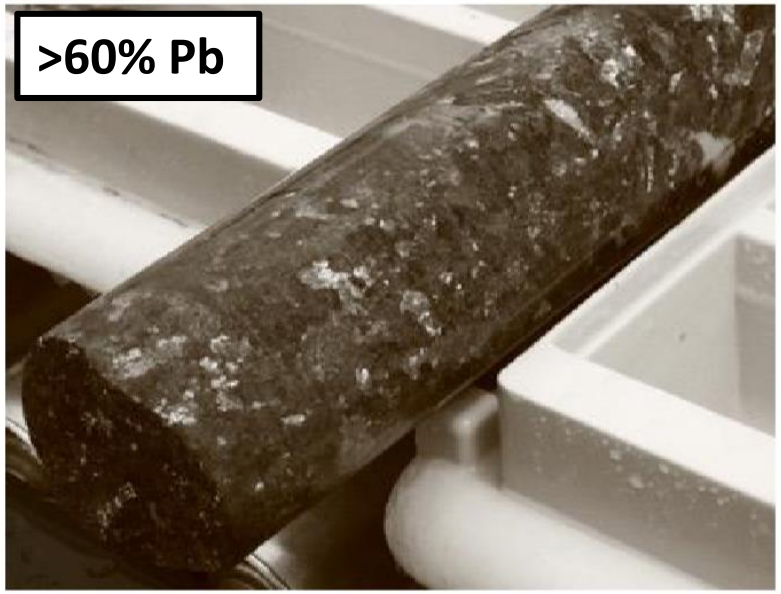
Abra JORC Ore Reserve statement[1, 2]

| Reserve classification | Tonnes (Mt) | Lead grade (%) | Silver grade (g/t) |
|---|---|---|---|
| Proved | - | - | - |
| Probable | 10.3 | 8.8 | 24 |
| Total | 10.3 | 8.8 | 24 |

*Notes: 1. See Galena ASX announcement of 18 December 2018. Galena confirms that it not aware of any new information or data that materially affects the information included in Galena's ASX announcement of 18 December 2018 and confirms that all material assumptions and technical parameters underpinning the ore reserve estimates continue to apply and have not materially changed. 2. Tonnages are rounded to the nearest 100,000t, lead grades to one decimal place and silver to the nearest gram. Rounding errors may occur when using the above figures.*

## Strata from Apron Zone

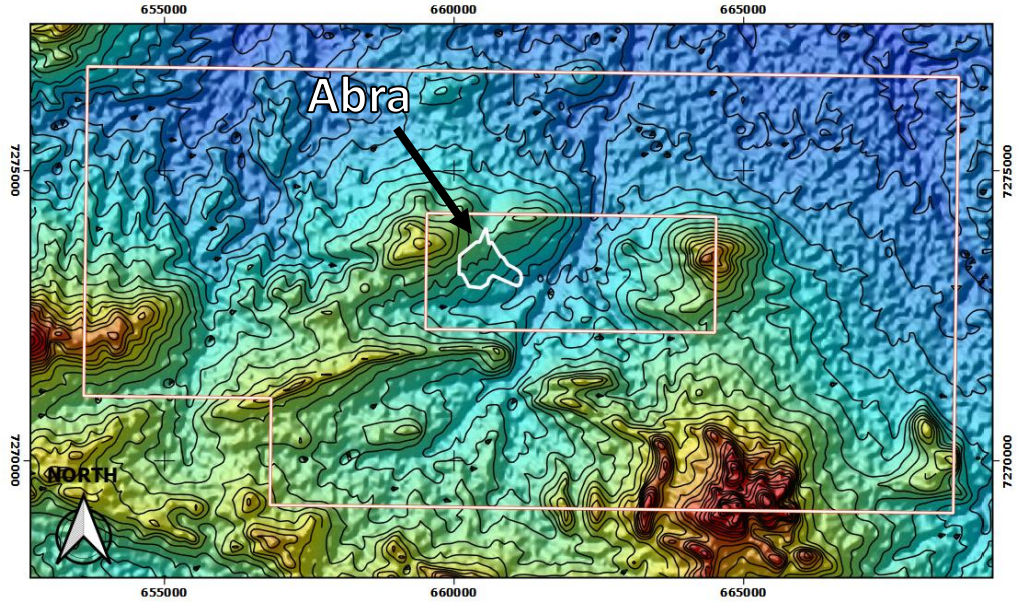
## Massive mineralisation in Core Zone



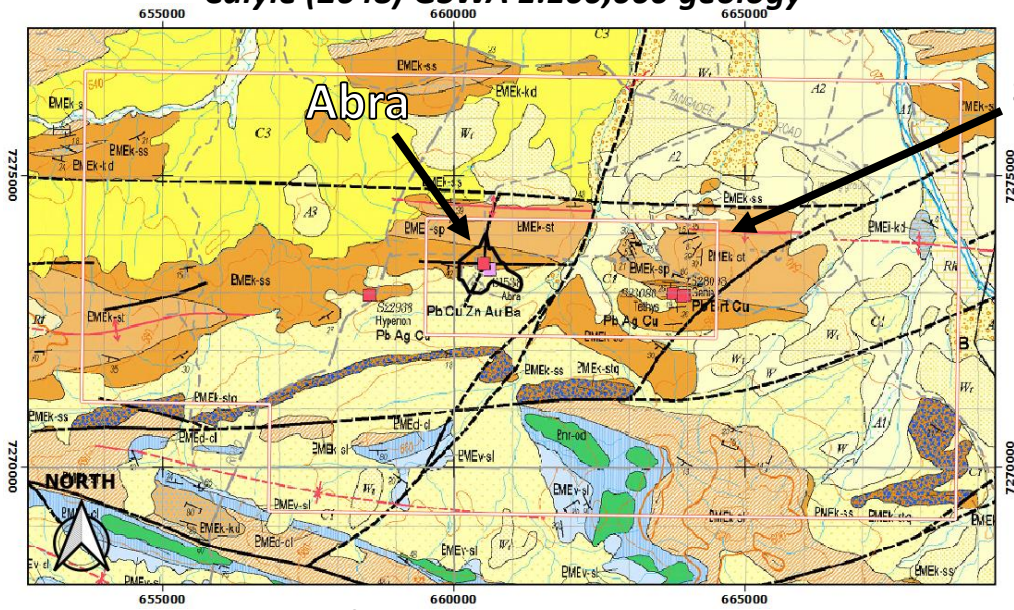
# Surface Expression of Abra

Resource Potentials

***SRTM 5m contours***

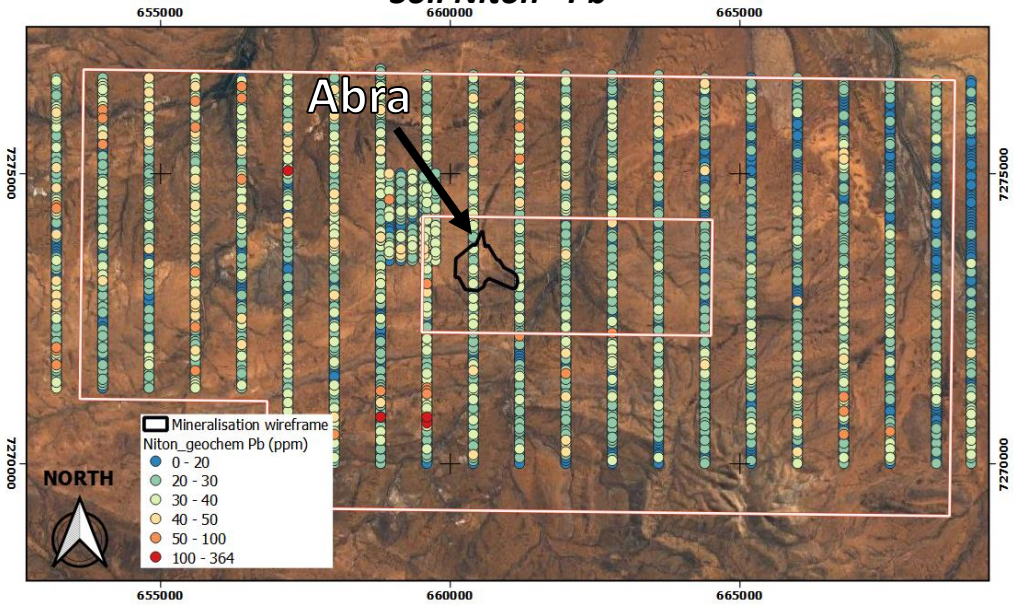



***Calyie (2648) GSWA 1:100,000 geology***

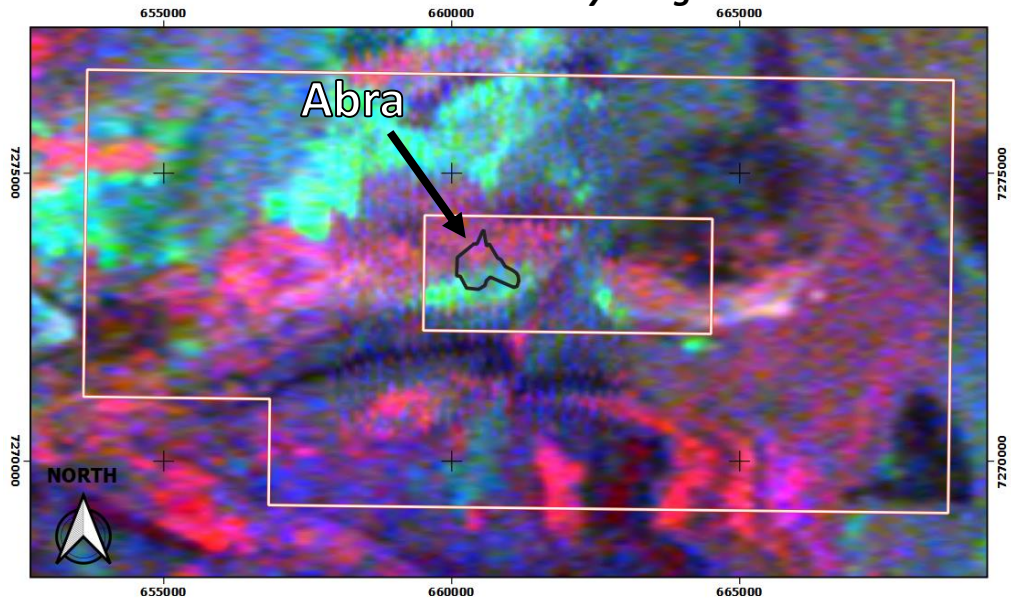


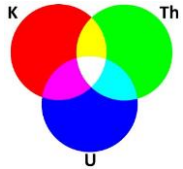

**Kiangi Creek Sandstone and Siltstone units**

***Soil Niton - Pb***




***Radiometric ternary image***



# Abra Petrophysical Studies

Resource Potentials

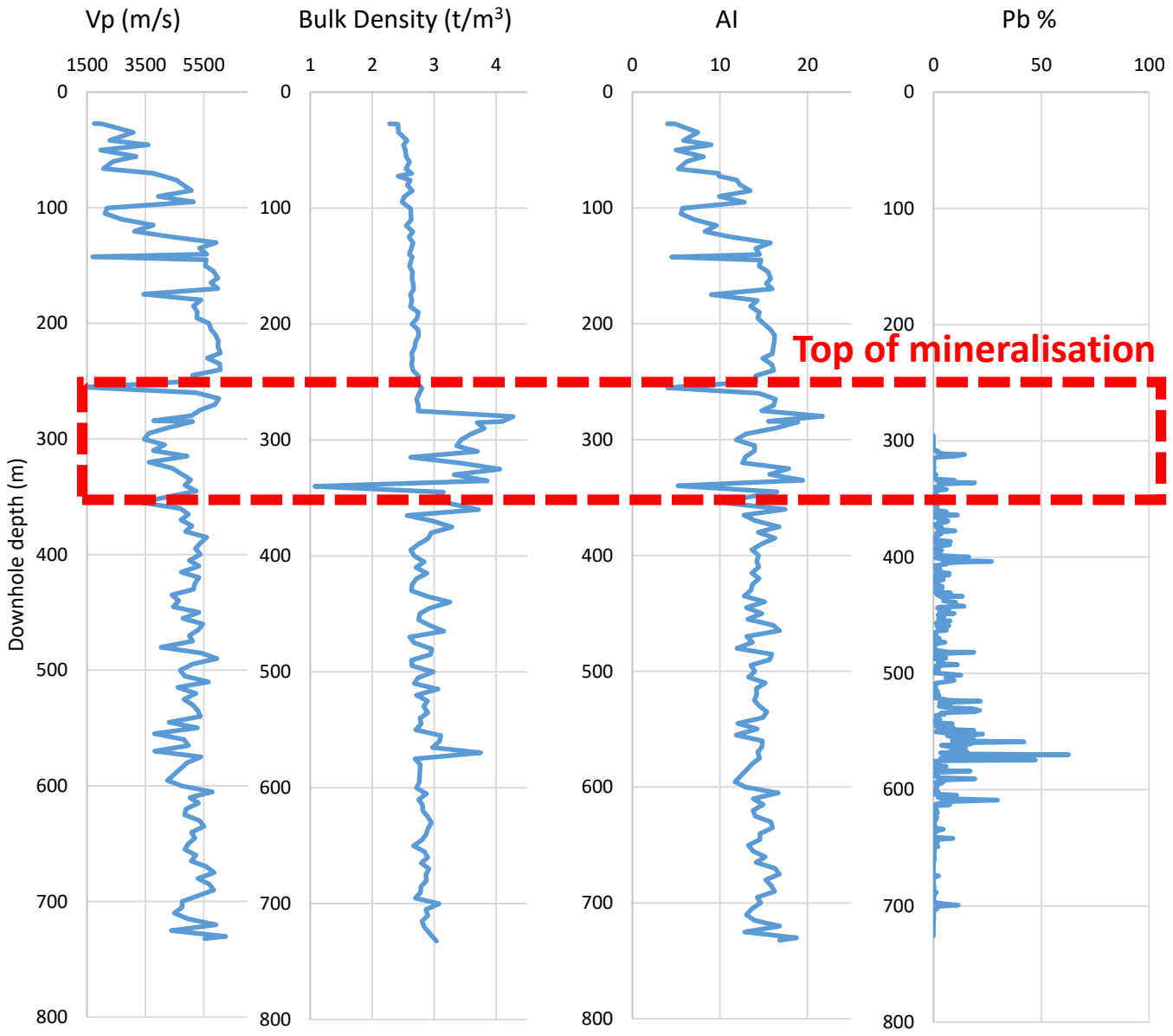
***Averaged petrophysical results from Abra core samples analysed in 2009 by System Exploration.***

| Sample | Depth | Lithology | Zone | Domain | Mag Sus | Density | EM Conductance* | Galvanic Resistivity | IP Chargeability |
|---|---|---|---|---|---|---|---|---|---|
| | m | | | | SIx10$^{-3}$ | t/m$^3$ | S/m | Ohm.m | ms |
| **1** | 375.49 | jasp, hem, mtt, bar | Stratabound | Red Zone | **225** | 3.59 | ≥0 | 50250 | 12 |
| **2** | 382.71 | conglom + jsp, bar | Stratabound | Red Zone | **60.3** | 3.86 | ->0 | 57804 | 24 |
| **3** | 397.3 | jsp-py-mtt-bar-gal | Stratabound | Red Zone | **22.4** | 3.68 | ->0 | 33654 | 50 |
| **4** | 262.27 | jsp-hem-mtt-bar | Stratabound | Red Zone | **745** | 3.83 | NA | 16490 | 83 |
| **5** | 392.16 | dolomite-py-gal | Stratabound | Dolomite banded | 1.96 | 3.78 | **16** | 8014 | **128** |
| **6** | 284.11 | bar-gal-py | Stratabound | Barite Zone | 0.1 | **4.42** | **15** | **0.06** | **212** |
| **7** | 272.92 | bar-gal-py | Stratabound | Barite Zone | 0.45 | **4.44** | **4-40** | 16356 | 70 |
| **8** | 316.25 | mtt-hem-qtz-bar-dol | Stratabound | Black Zone | **1120** | 3.58 | NA | **1.4** | 80 |
| **9** | 318.9 | hem-mtt-qtz-chl | Stratabound | Black Zone | **141** | 3.62 | NA | **14** | 72 |
| **10** | 401.46 | bar-gal-qtz vein | Feeder | Vein | 3.64 | **4.3** | **10** | **0.03** | **103** |
| **11** | 382.06 | qtz-bar-gal vein | Feeder | Vein | 0.08 | **4.37** | ->0 | 51183 | 78 |

***Conductivity due to presence of galena**

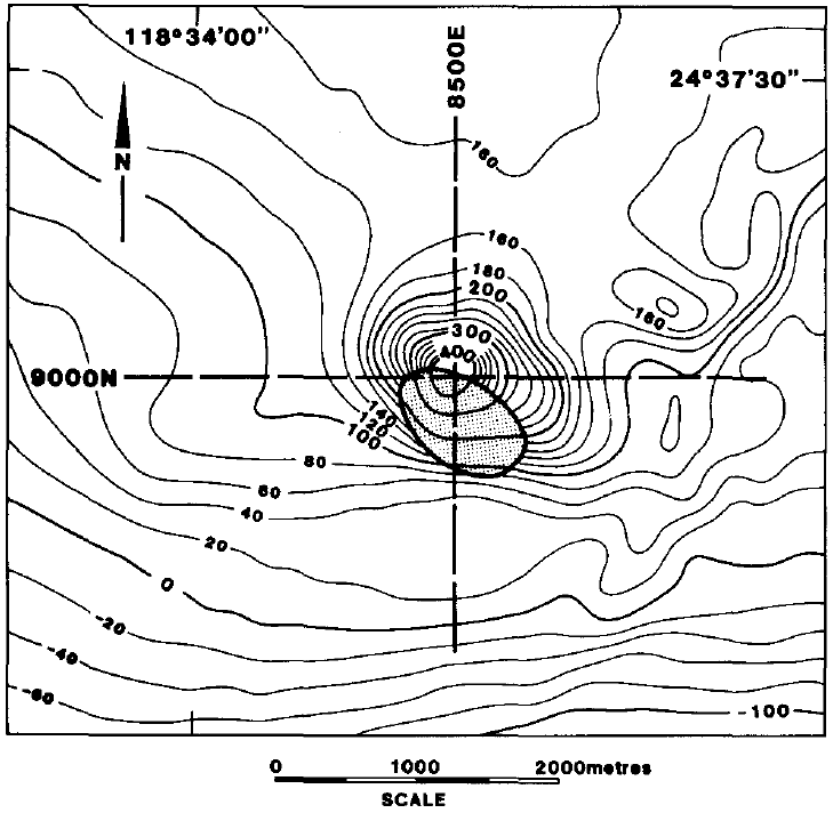
# Abra Petrophysical Studies

- Handheld P-wave velocity measurements and bulk density measurements acquired on representative diamond drilling core samples extending through the deposit as part of a 3D seismic de-risking study by Resource Potentials and HiSeis.
- The Vp values do not show a large degree of variation through stratigraphy and mineralisation, but bulk density measurements clearly show a sharp increases within mineralised intervals, and therefore an acoustic impedance (AI) contrast should occur between mineralisation and host rocks.
- An AI contrast is estimated to occur at around 300m, corresponding to the top of mineralisation.

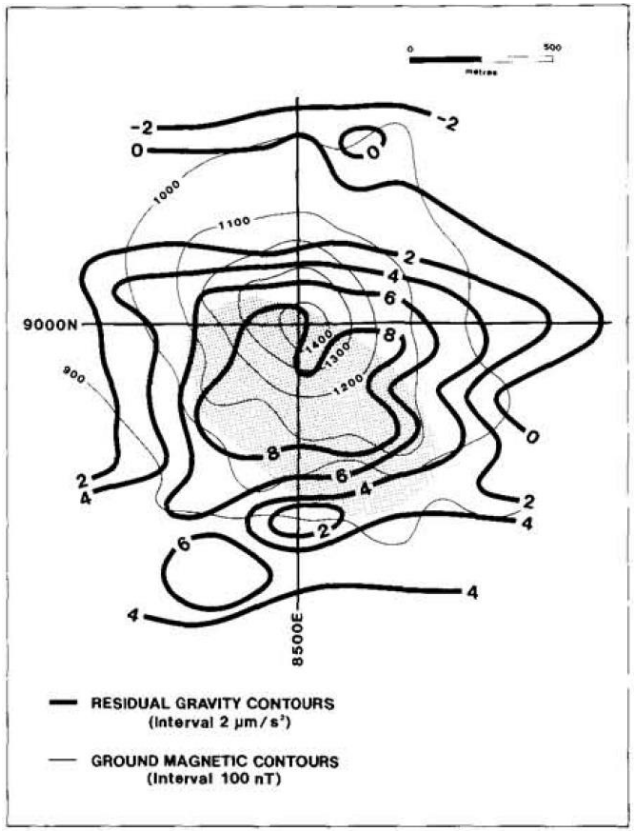


# Abra Geophysical Responses: Data to Discovery

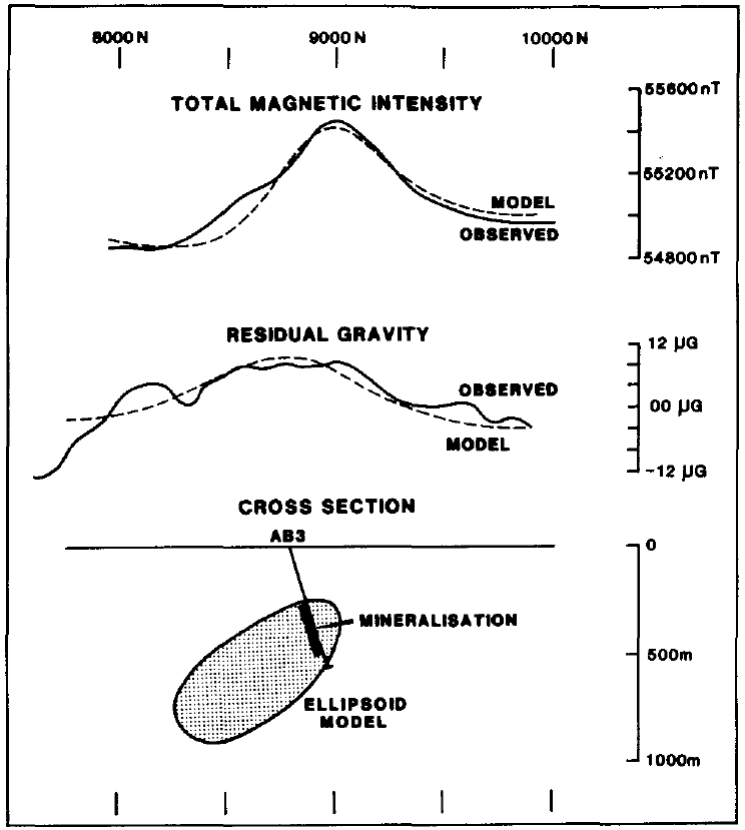
- Figures reproduced from Mutton and McInerney (1987) and McInerney et al. (1994) show bullseye magnetic and gravity anomaly responses, and 3D ellipsoidal polygonal body modelling results.
- Drill testing of the modelled body in 1981 intersected 255m of Fe-Ba-Pb-Ag-Cu-Au mineralisation from below 260m.




Magnetic contour map




Gravity and ground magnetic contour map

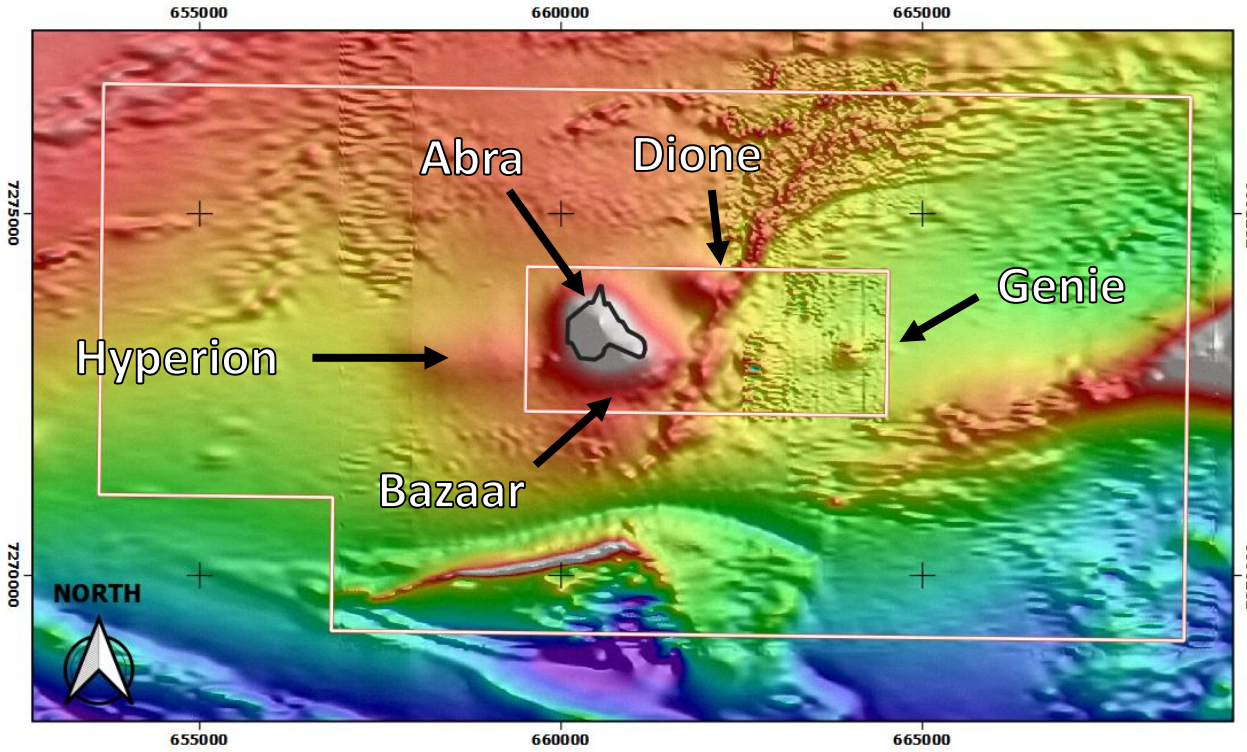



Polygonal modelling of magnetic and gravity anomaly responses

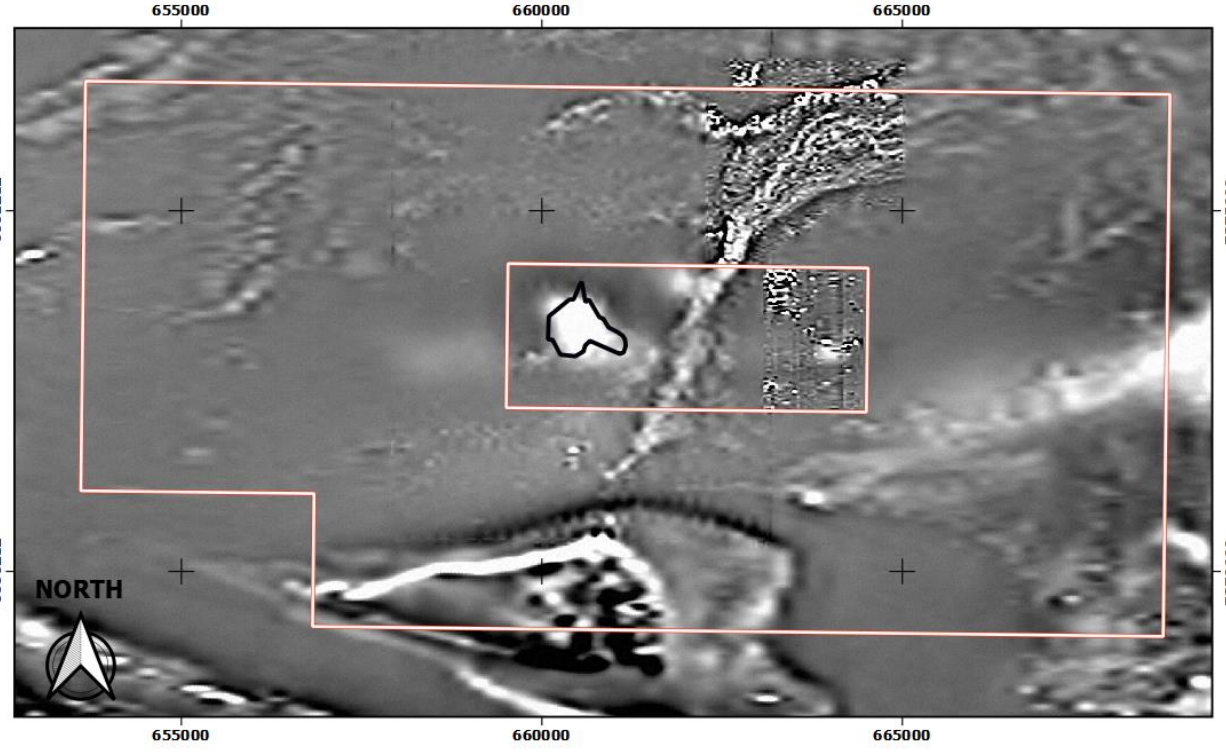
# Abra Geophysical Responses: Magnetics

- Airborne magnetic survey data resolves Abra as a +450nT magnetic anomaly surrounded by magnetically quiet sedimentary deposits of the Kiangi Creek Formation, with some magnetic chatter caused by maghemite in the regolith.
- Smaller discrete magnetic anomalies in the ML and surrounding EL have had sporadic drill testing, and similar stratabound and vein mineralisation as observed at Abra has been intersected at Hyperion.
- Some weakly magnetic trends associated with sedimentary stratigraphy, and strong anomalies to the south caused by dolerite sills.

***TMI-RTP***



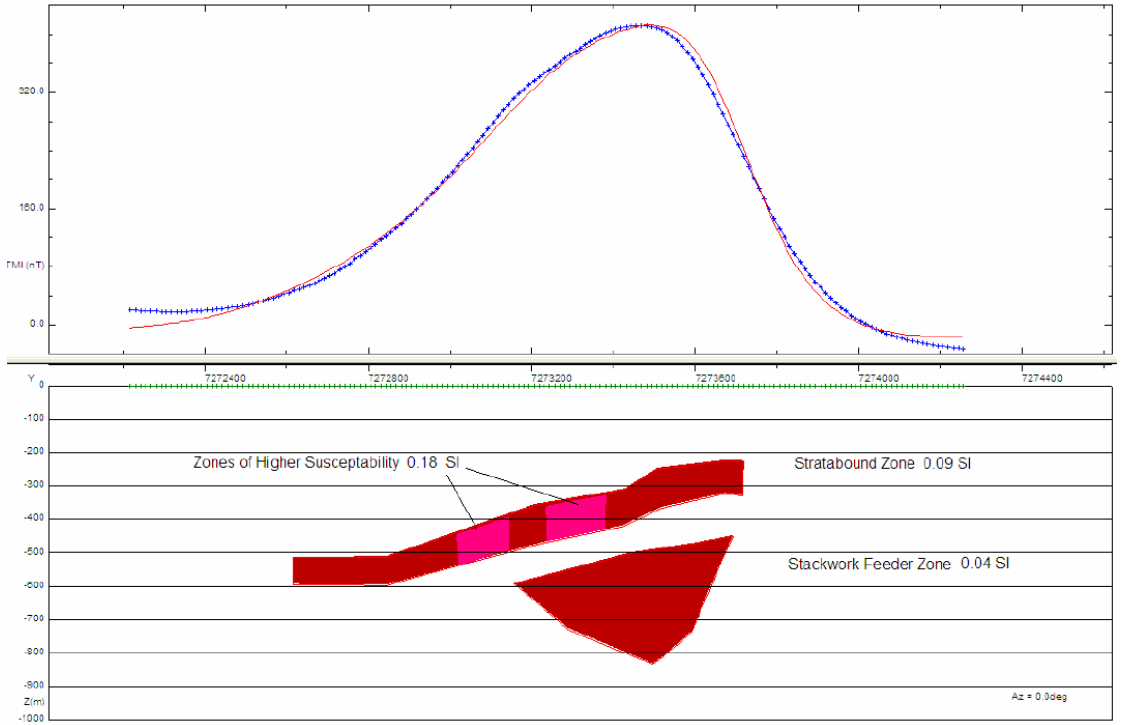

***TMI-1VDAGCRTP***



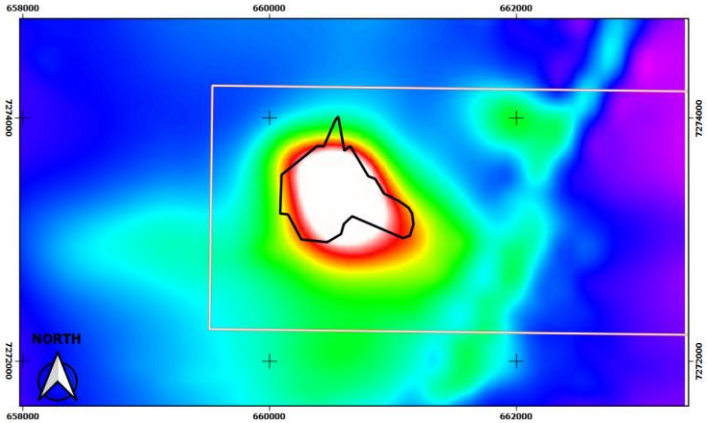
# Abra Geophysical Responses: Magnetics

- The magnetic expression of Abra and surrounding project area has been subjected to various 2D and 3D model and inversion studies, and magnetic data continues to assist exploration for extensions of known mineralisation.
- A constrained potential field inversion study (Eden, 2011, Curtin Honours thesis) showed that the known magnetic mineralisation from resource modelling explained most of the observed magnetic anomaly pattern, except in the NW part of the main anomaly zone, which has since been drill tested and intersected stratabound mineralisation.

***2.5D polygonal modelling***

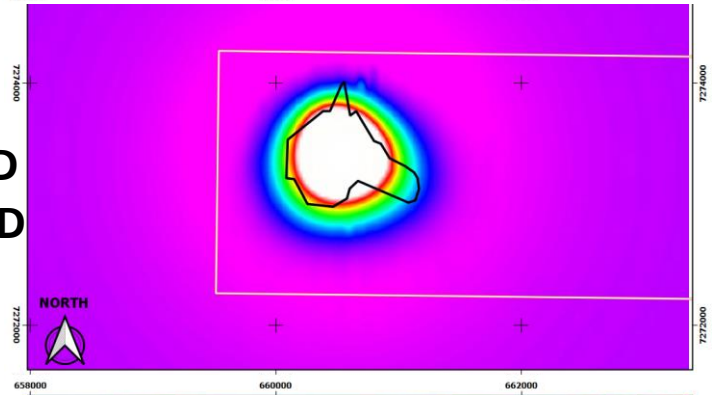



**TMI-RTP**




**-**

**FORWARD MODELLED**

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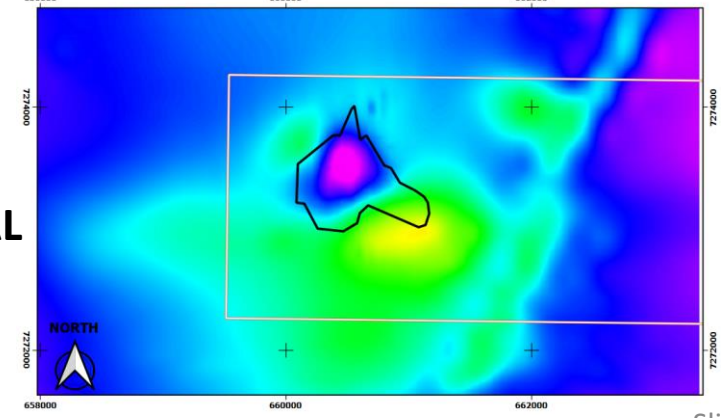
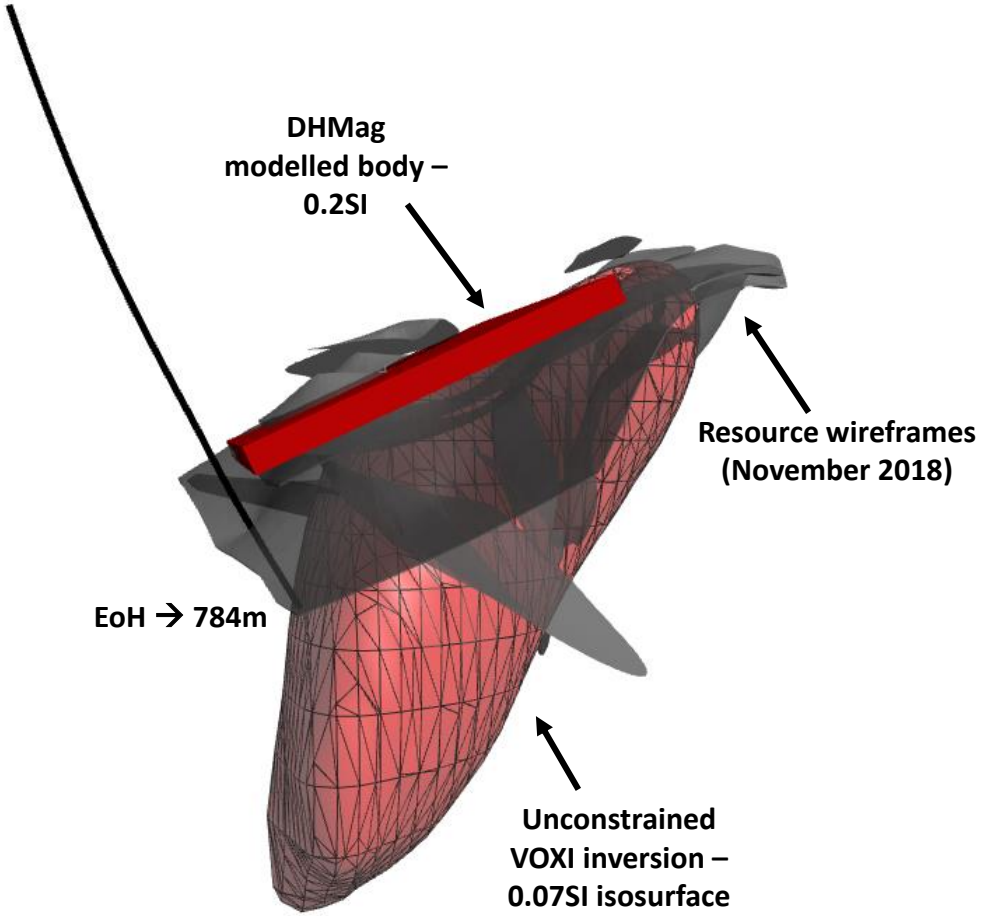
**RESIDUAL**

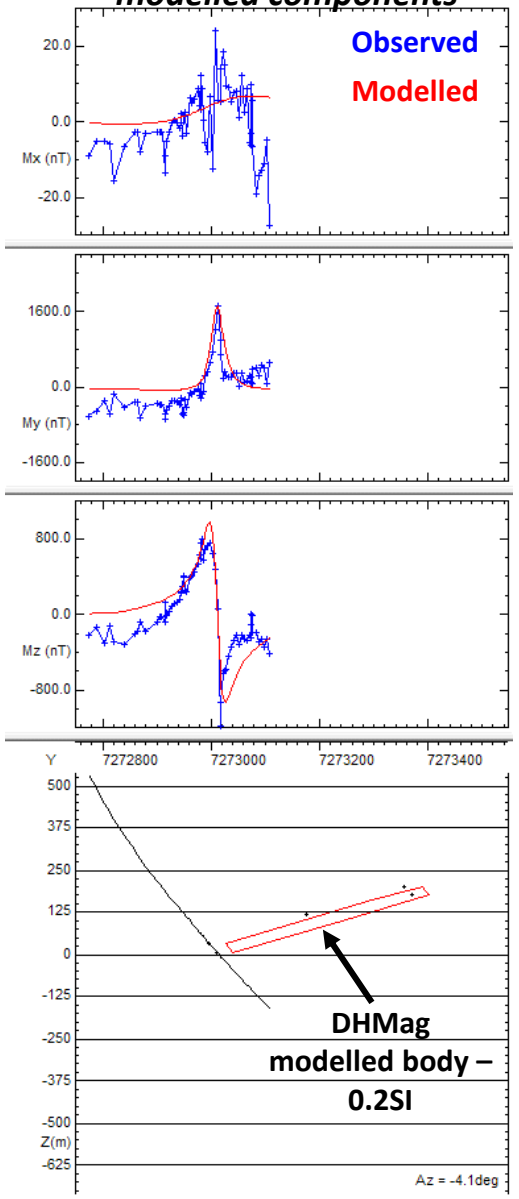


# Abra Geophysical Responses: Downhole Magnetics

- Downhole magnetic data are extracted from the digi-Atlantis B-field EM sensor when carrying out DHEM surveying in the project area.
- 3D polygonal modelling of broad off-hole magnetic responses matched the magnetic stratabound mineralisation.



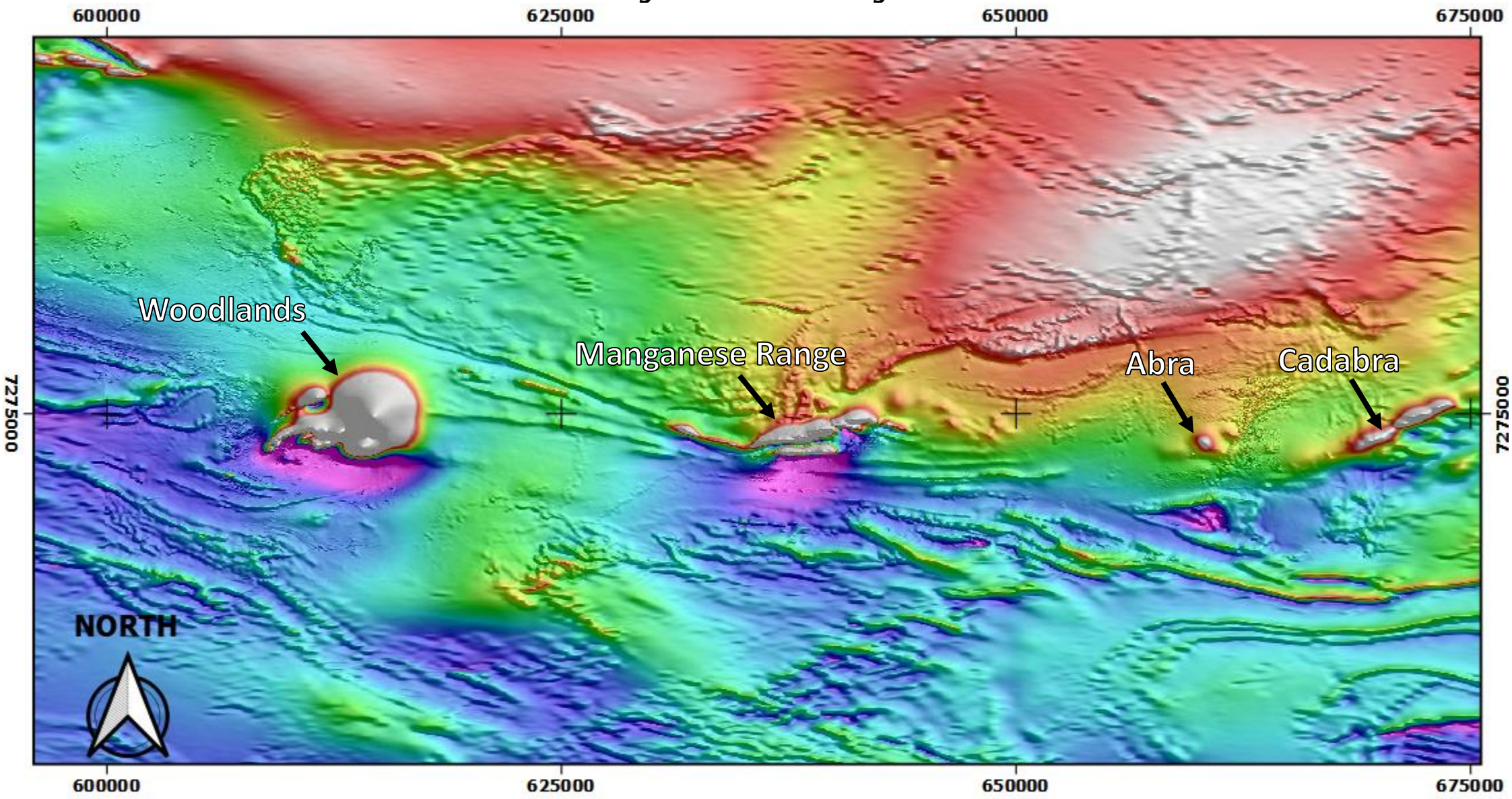

***Downhole magnetic surveying – modelled components***



# Abra Regional Magnetic Anomalies and Targets

Resource Potentials

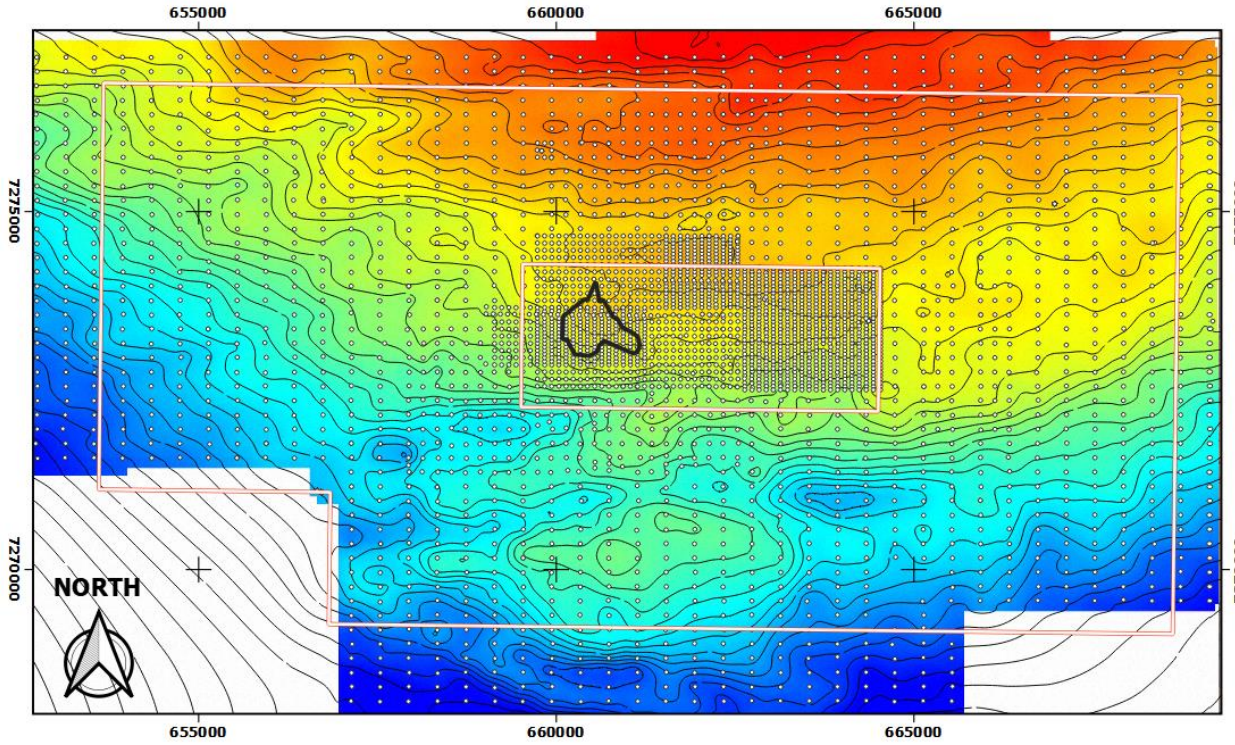
***Regional TMI-RTP image***



# Abra Geophysical Responses: Gravity

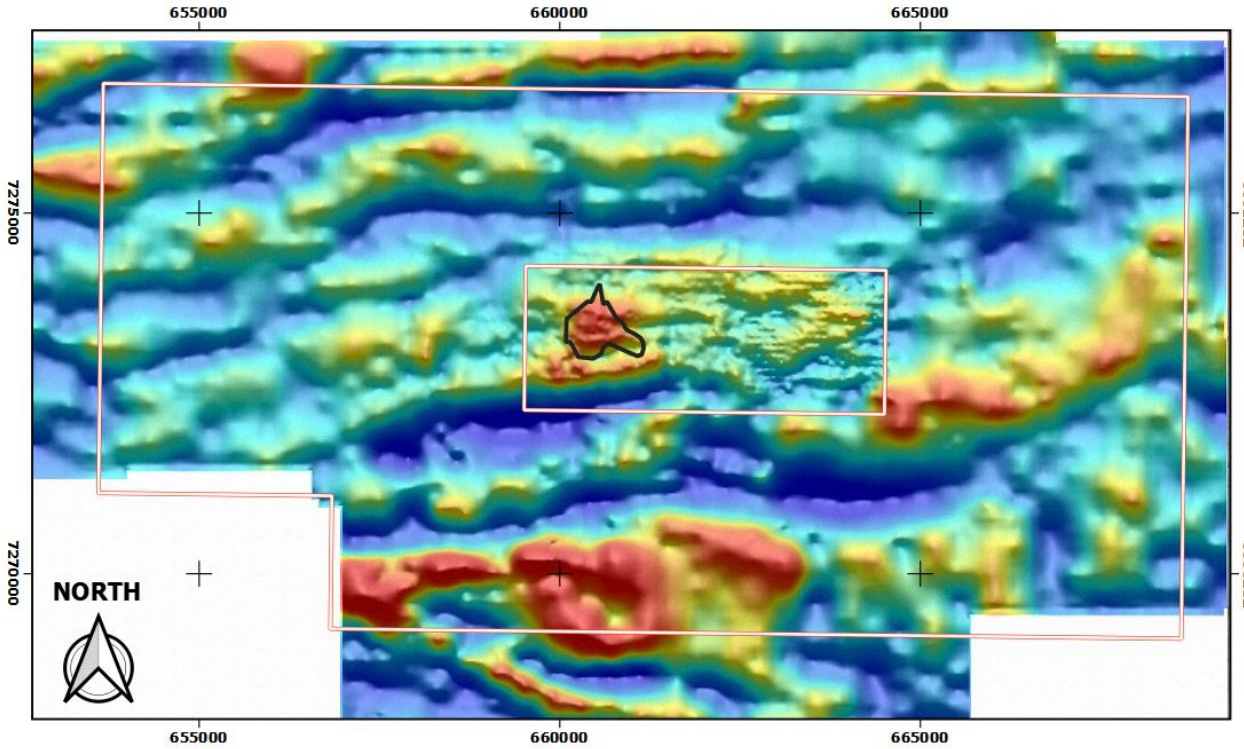
- High resolution gravity surveying carried out in 2005 by Haines.
- Abra is associated with a gravity anomaly high of up to +1mGal.
- The source of the gravity anomaly high is mainly dense iron oxide, galena and barite mineralisation in the stratabound zone (red and black), and galena-chalcopyrite mineralisation in the feeder zone surrounded by low-density sedimentary host rocks.

***Bouguer anomaly gravity response (0.5mGal contours)***




**50m station spacing, 100m line spacing throughout the mining lease**
**100m station spacing, 400m line spacing throughout greater project area**

***5km high pass filtered gravity image (terrain corrected)***

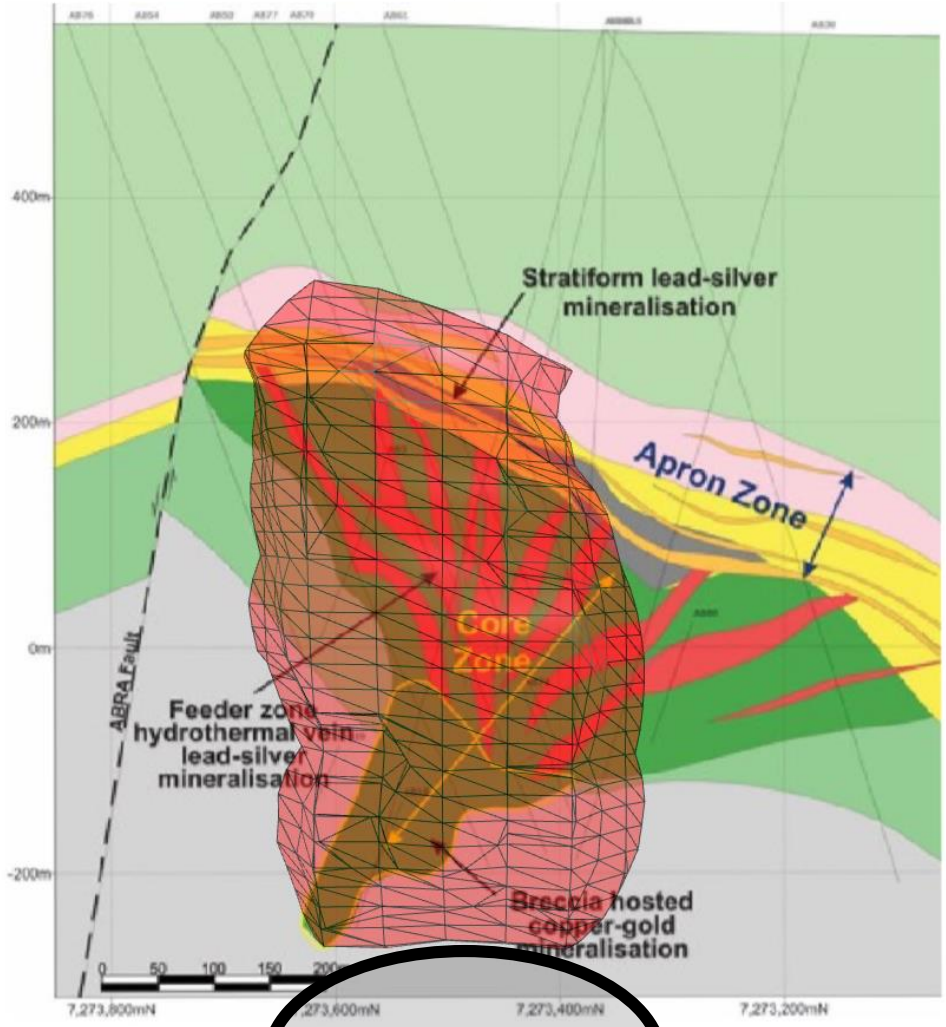



**Additional stratigraphic and structural information compared to magnetics**

# Abra Geophysical Responses: Gravity

- Unconstrained 2D and 3D modelling and inversions result in dense source bodies centred on the ‘feeder’ zone, agrees with petrophysical measurements, and is associated with very high grade mineralised zones.
- Constrained gravity inversion study by Eden (2011), showed that the known mineralisation could only account for 50% of the observed gravity anomaly response, with a higher density zone likely occurring below existing drilling at the time.
- The excess gravity expression is likely a combination of recent drilling results extending dense mineralisation at depth having high Pb grades, and an underlying excess mass yet to be tested, possibly dolomite or additional mineralisation at depth.

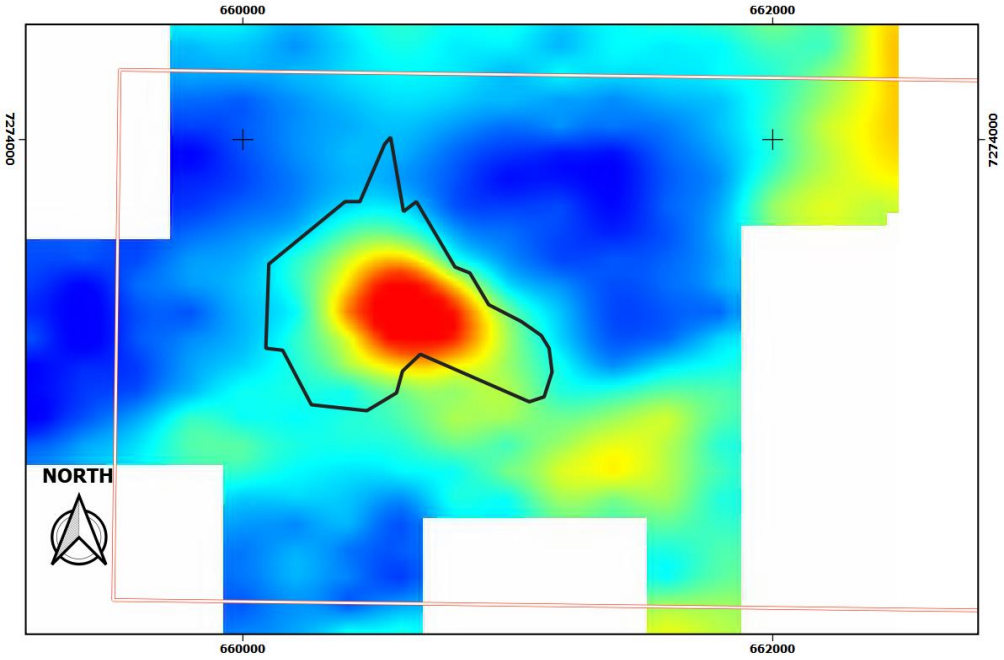
***Unconstrained gravity inversion isosurface (+0.8 t/m³ contrast) overlain on simplified geological cross-section***



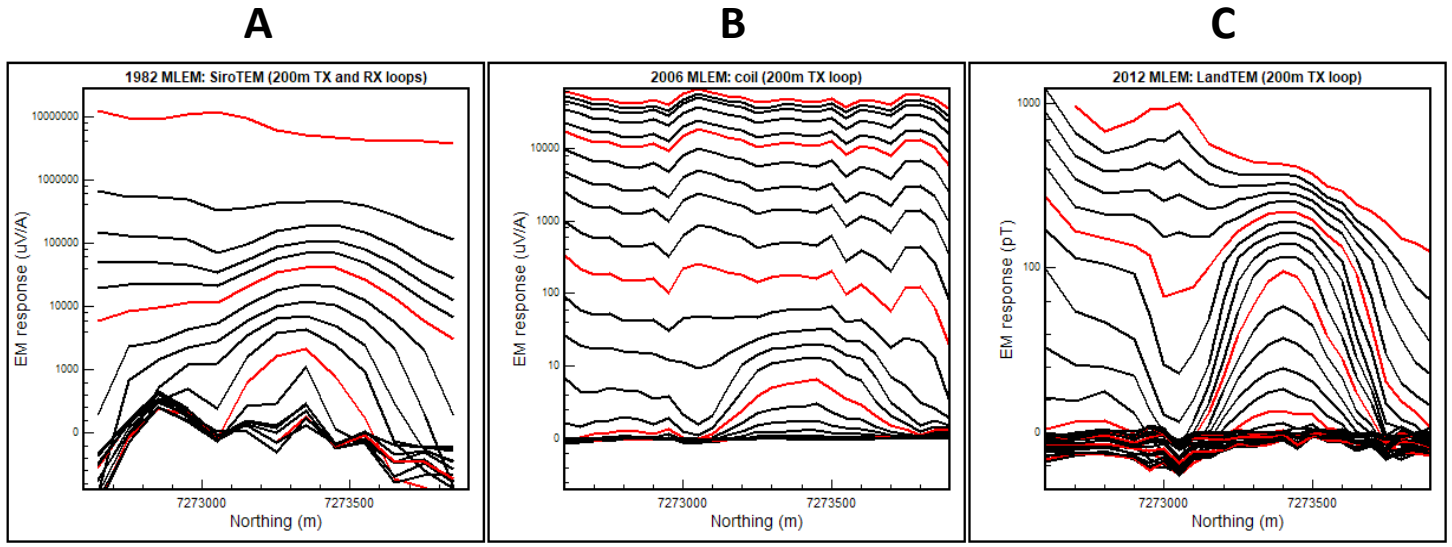
# Abra Geophysical Responses: Electromagnetics (Ground)

- Ground EM surveys resolve Abra as a broad, asymmetric single peak EM anomaly associated with a weakly conductive bedrock source sitting below weakly conductive weathered siltstone overburden. The most extensive surface EM surveying carried out across Abra was a 1982 SIROTEM MLEM survey, with further MLEM surveying carried out in 2006 using Curtin RVR coil and in 2012 using LANDTEM high-temperature B-field sensor.
- The results of petrophysical testing on core indicate that the source of the EM conductor responses is mainly massive galena (±pyrite) mineralisation.

***Gridded image of 1982 SIROTEM MLEM survey Z component channel 8***




***Coincident Z component EM response profiles from MLEM surveys carried out in A) 1982, B) 2006 and C) 2012. All surveys carried out using 200m x 200m TX loops.***




**5 Amps**
**5Hz**

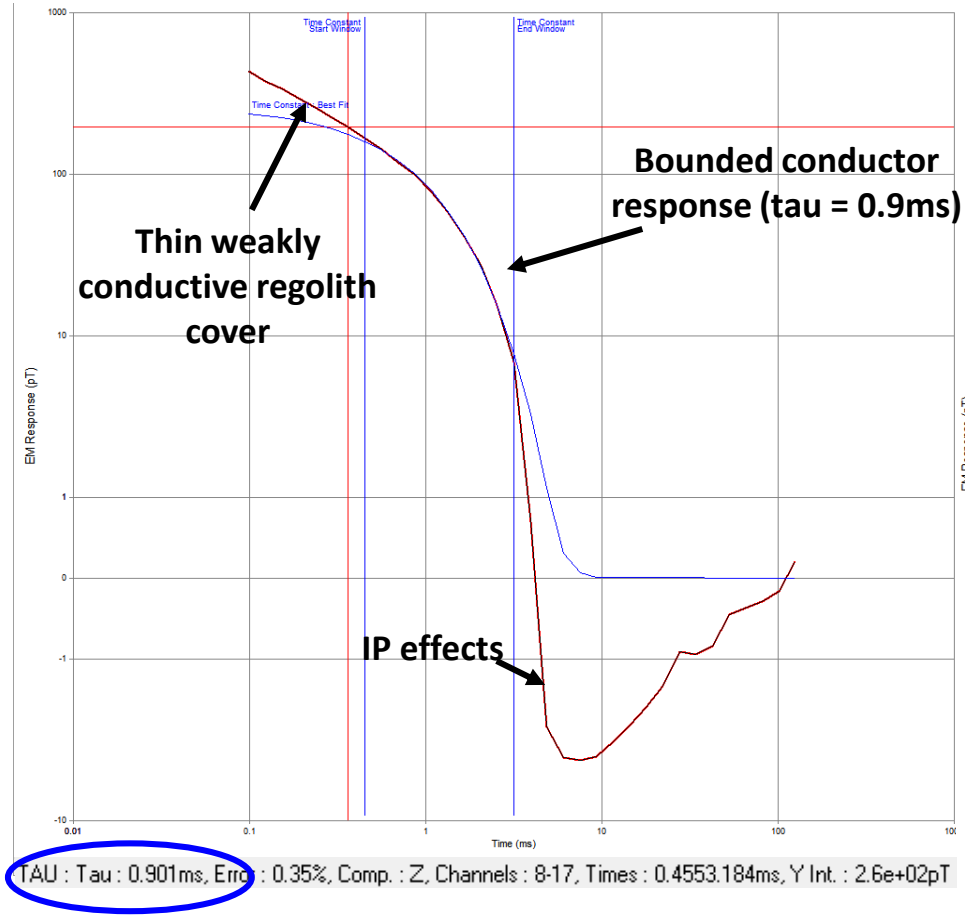
**25 Amps**
**2 Hz**

**40 Amps**
**1.5Hz**

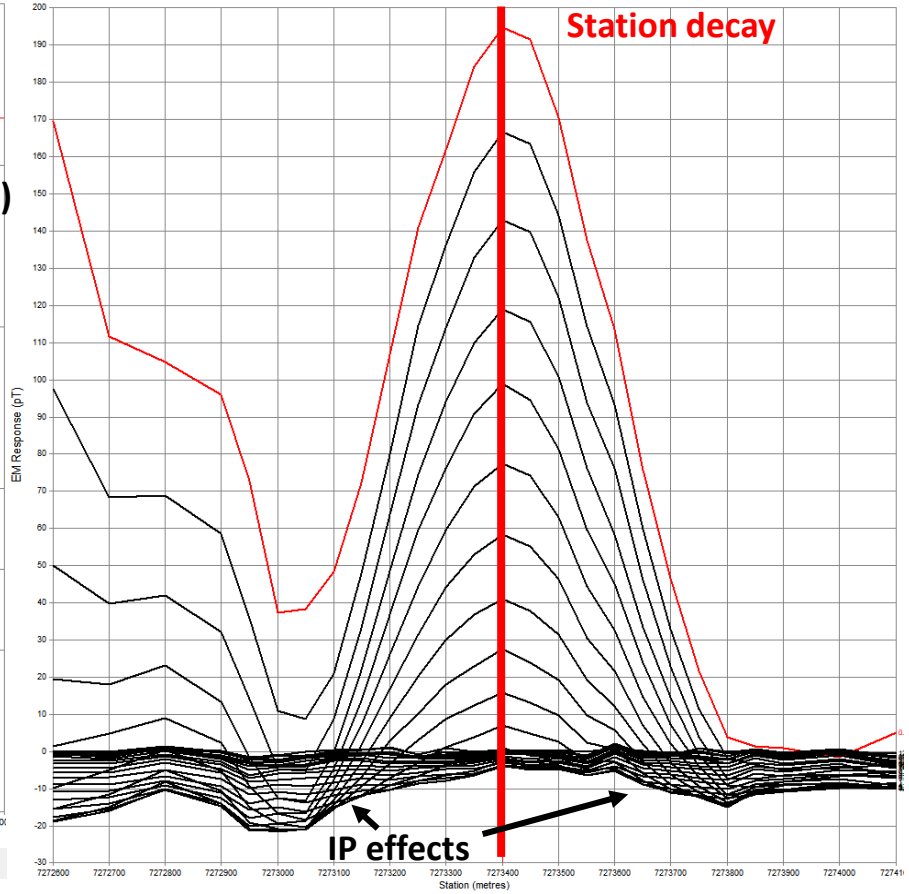
# Abra Geophysical Responses: Electromagnetics (Ground)

- 2012 LANDTEM MLEM survey resolved a mid-time single peak EM decay channel conductor anomaly in the Z component data, centred over known base metal mineralisation, within a background of weakly conductive bedrock and beneath thin regolith cover. Conductor plate modelling using all 3 MLEM datasets confirm a conductor source sitting within the stratabound mineralised zone.

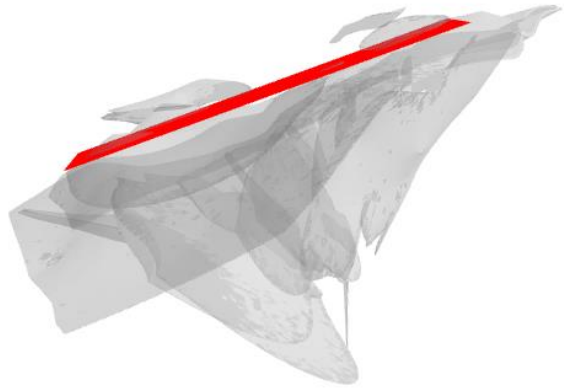
***Z component time decay***




***Z component EM response profiles from 2012 LANDTEM survey (>Ch 9).***




***Looking west at resource wireframes (grey) and modelled MLEM conductor plate (red)***

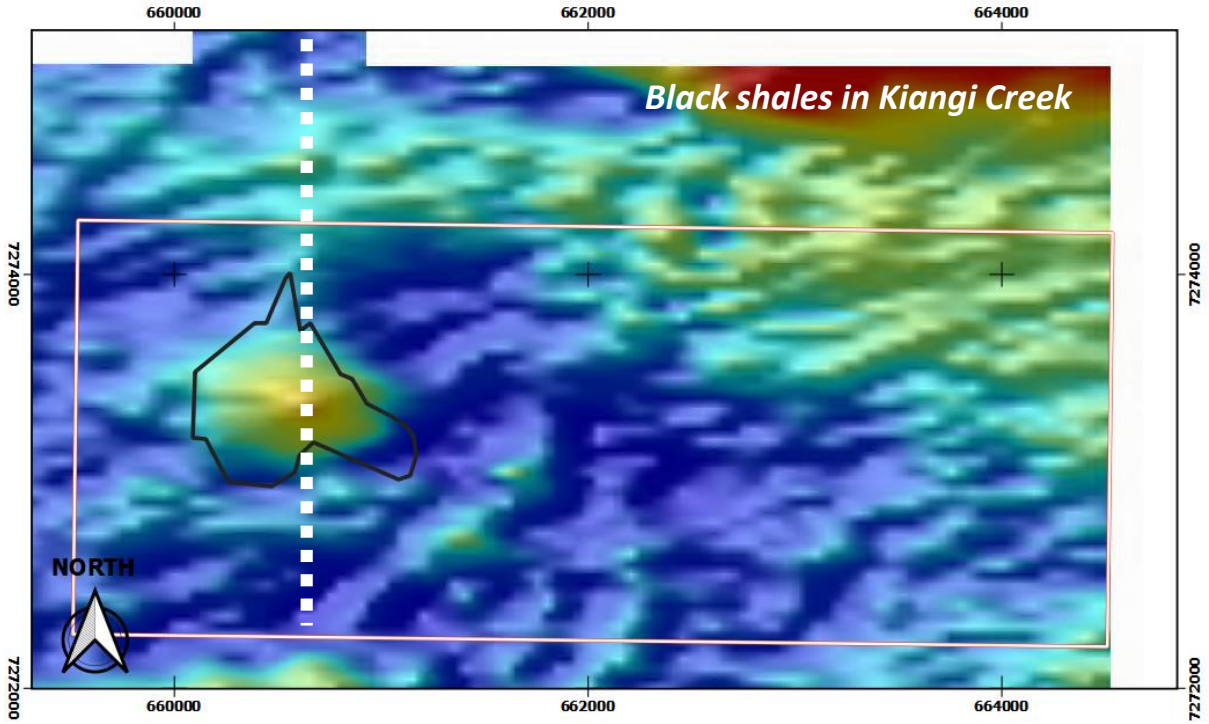


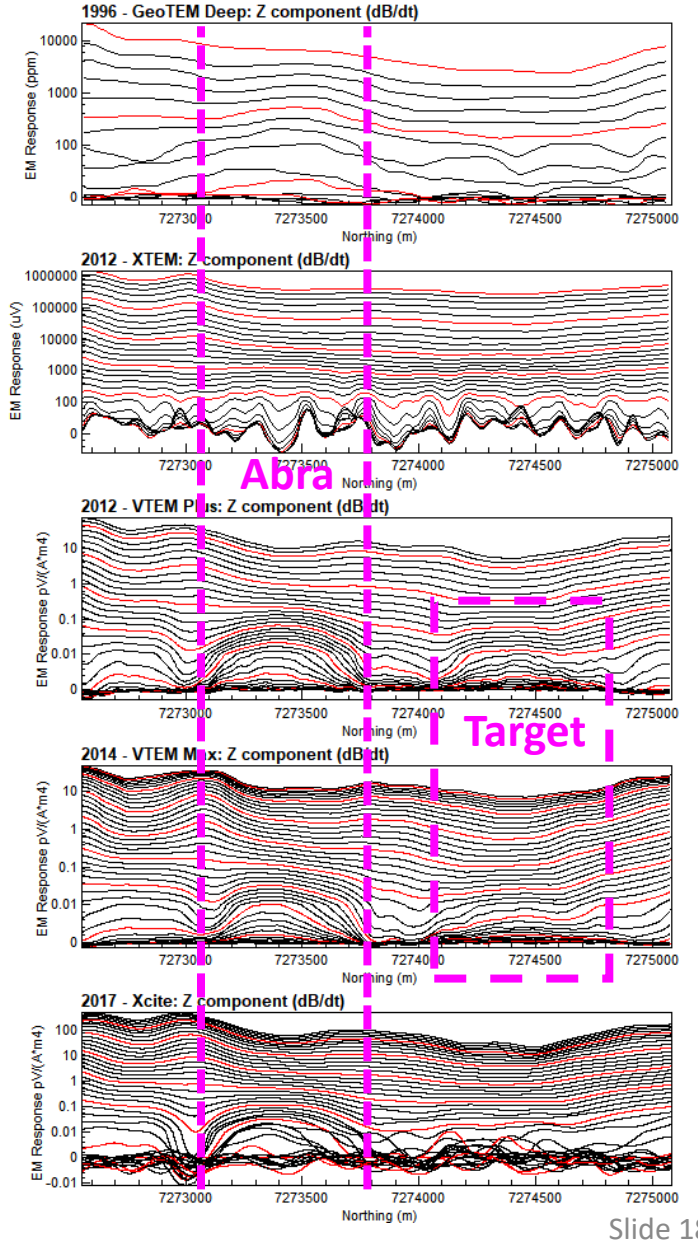
# Abra Geophysical Responses: Electromagnetics (Airborne)

Resource Potentials

- First airborne EM surveying carried out in 1996 using GeoTEM-Deep which barely resolved Abra above the noise envelope in both the Z and X receiver component data.
- This was followed by several different airborne EM systems, including: VTEM-Plus (2012), XTEM (2012), VTEM-Max (2014), and Xcite (2017); the ZTEM system was flown over Abra for CSIRO in 2014, results ambiguous and not shown here.
- VTEM results are similar to SIROTEM in terms of depth penetration.
- VTEM has detected a deep conductor anomaly to the north of Abra forming a drill target.

***2012 VTEM Plus – Channel 40 Z component dB/dt***

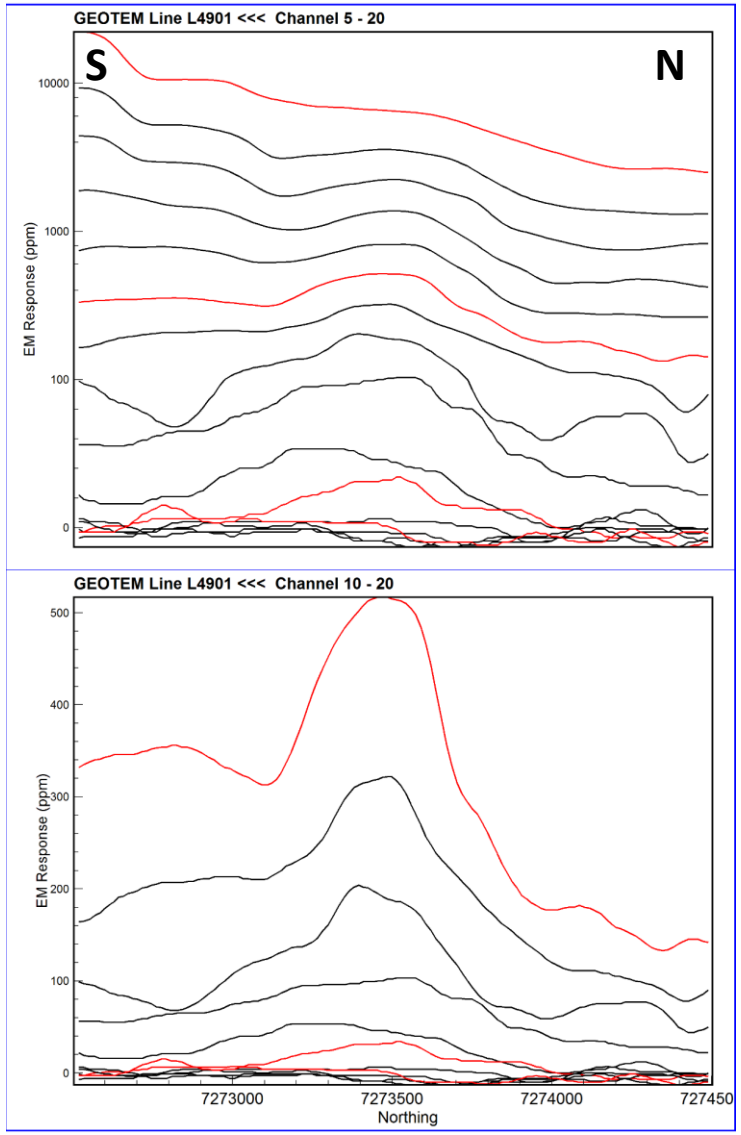


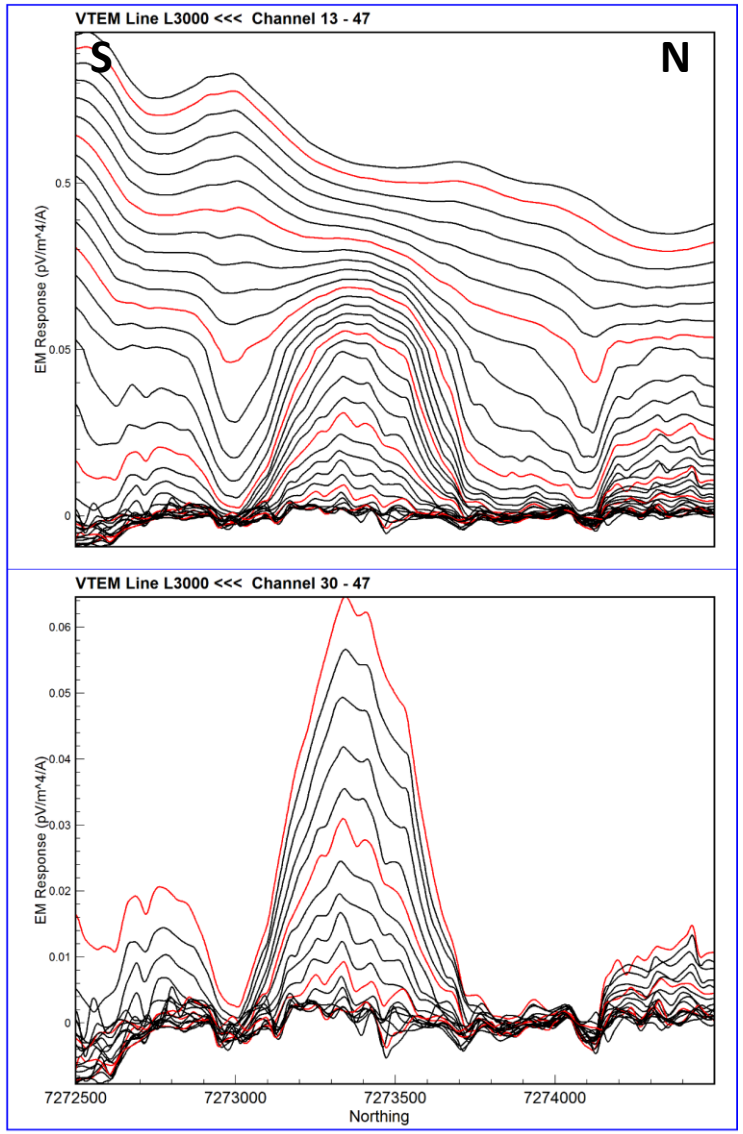
# Abra Geophysical Responses: Electromagnetics (Airborne)

Resource Potentials

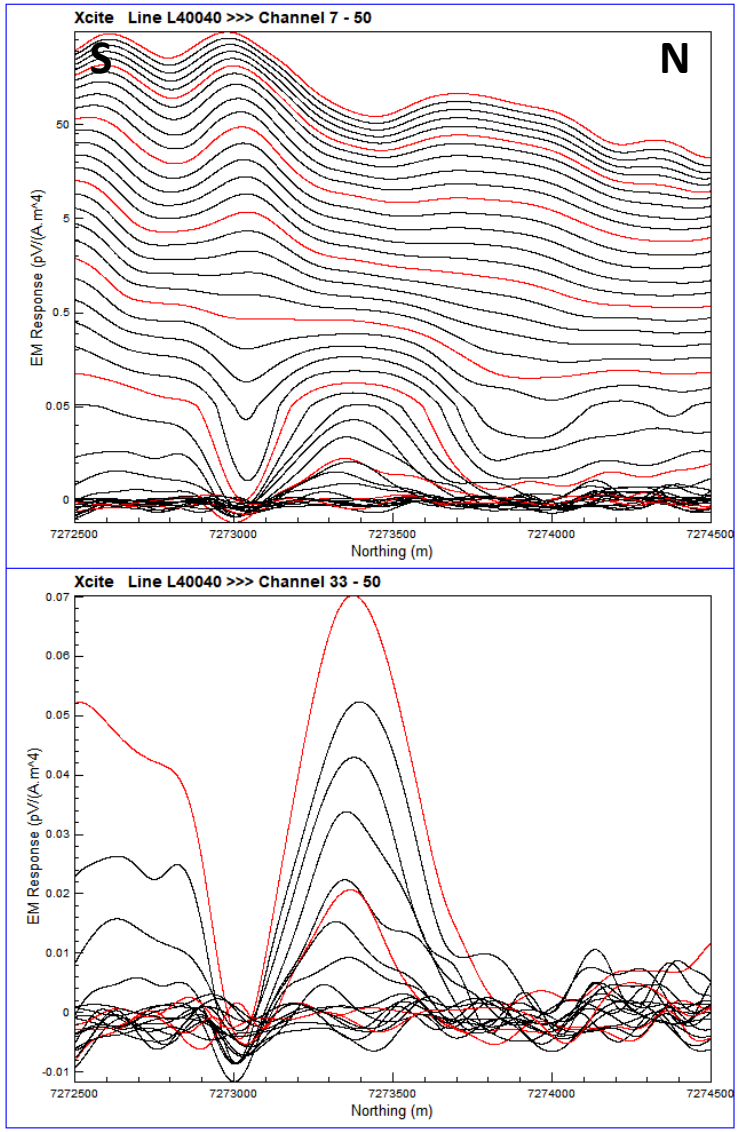
***GEOTEM - 1996***




***VTEM-Plus - 2012***

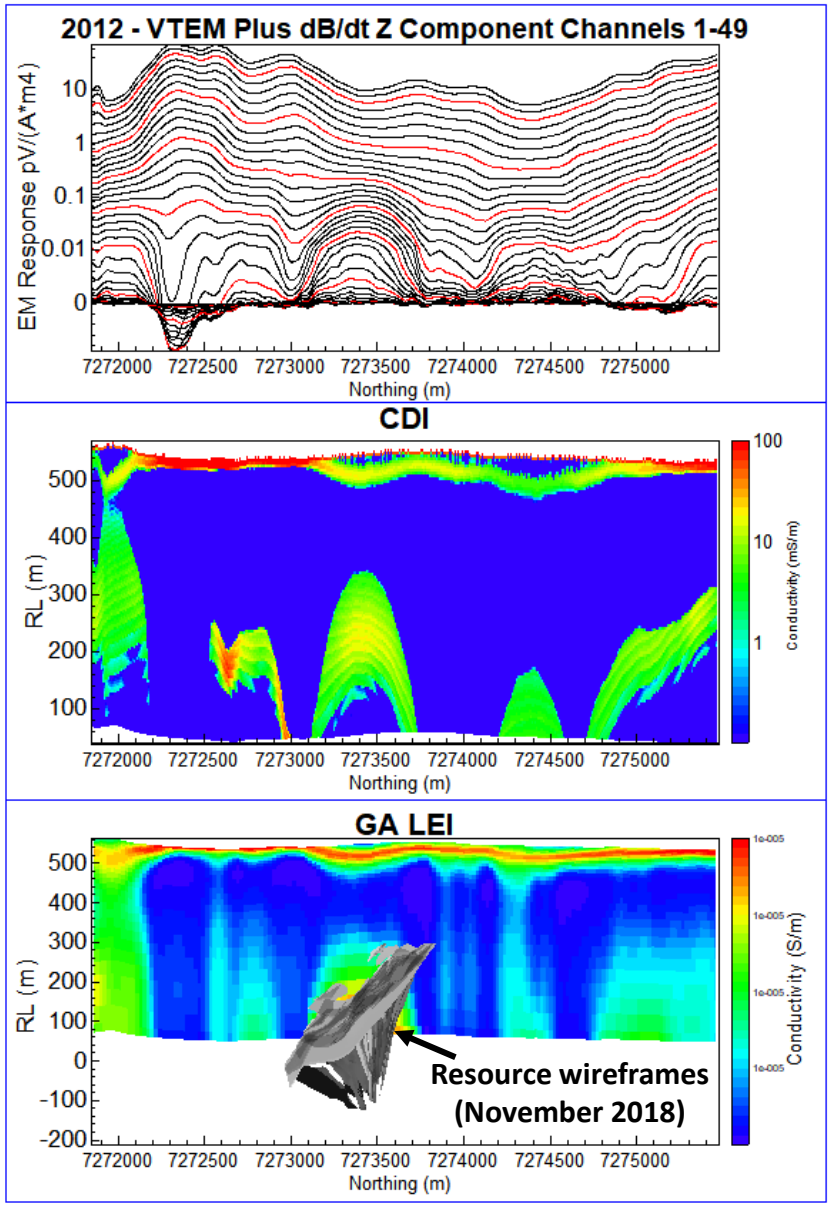


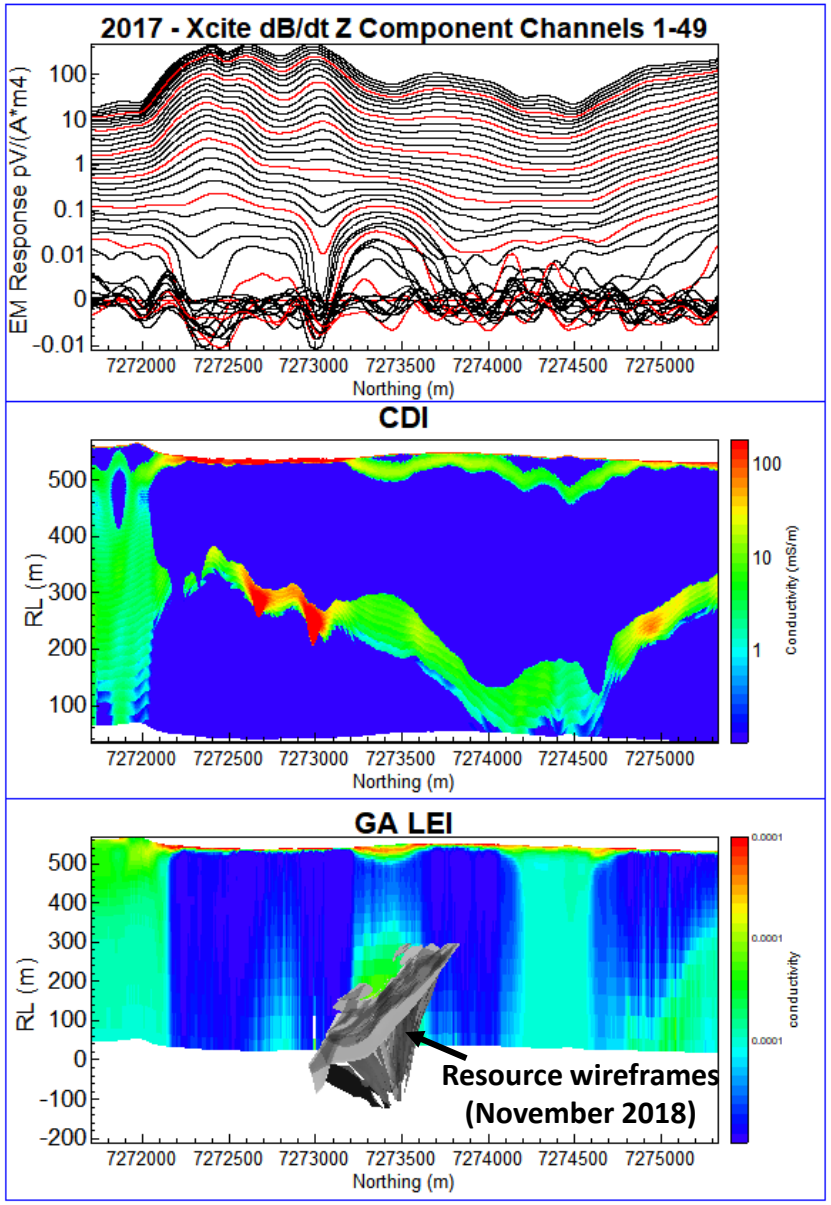

***Xcite - 2017***



# Abra Geophysical Responses: Electromagnetics (Airborne)

- Conductor plate modelling and 1D conductivity inversions (CDI and GA LEI) show that the model results correspond to stratabound mineralisation.
- Late-time EM decay channel conductor anomaly to the north of Abra will be drill tested by Galena Mining in 2020.

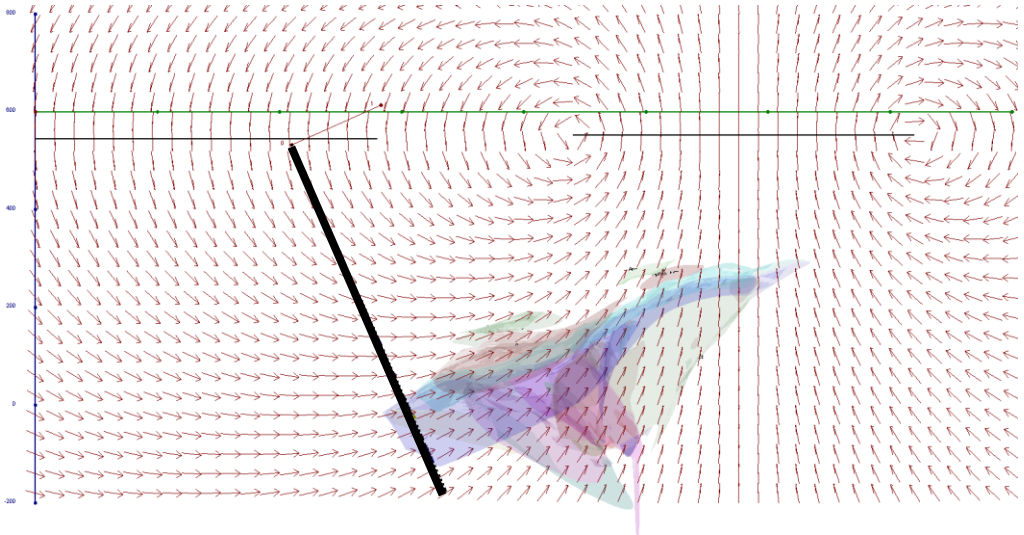


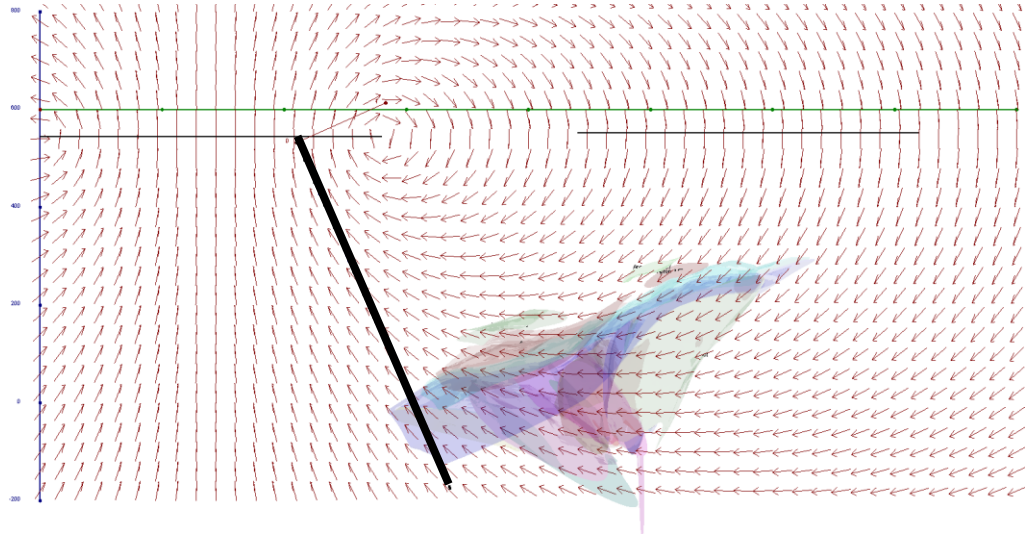
# Abra Geophysical Responses: Electromagnetics (Downhole)

- Various phases of DHEM surveying carried out at Abra since 1982. Recent DHEM surveying on an 784m deep drillhole located to the southern end of the Abra deposit. The drillhole failed to intersect the Red and Black mineralised zones, with only minor disseminated sulphide mineralisation intersected within dolomitic sediments.
- DHEM surveying carried out by Vortex Geophysics using a Zonge transmitter (Tx) and (EMIT) DigiAtlantis B-field probe at a base frequency of 1Hz. Tx current of 96A achieved.
- The drillhole was surveyed twice using two large single turn Tx wire loop layouts with dimensions of 700m x 700m, which were designed to provide good EM coupling with both shallow south dipping and steep vertical to north dipping conductor bodies close to the drillhole trace. Results shown on next slide.

***EM field vectors generated by northern Tx loop, providing good EM coupling with steep dipping conductors near the drillhole trace.***



***EM field vectors generated by southern Tx loop, providing good EM coupling with shallow south dipping conductors near the drillhole trace.***

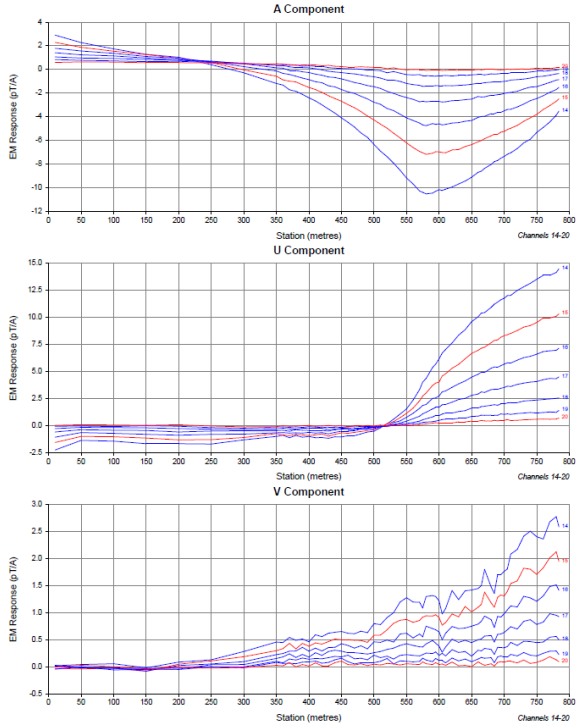


# Abra Geophysical Responses: Electromagnetics (Downhole)

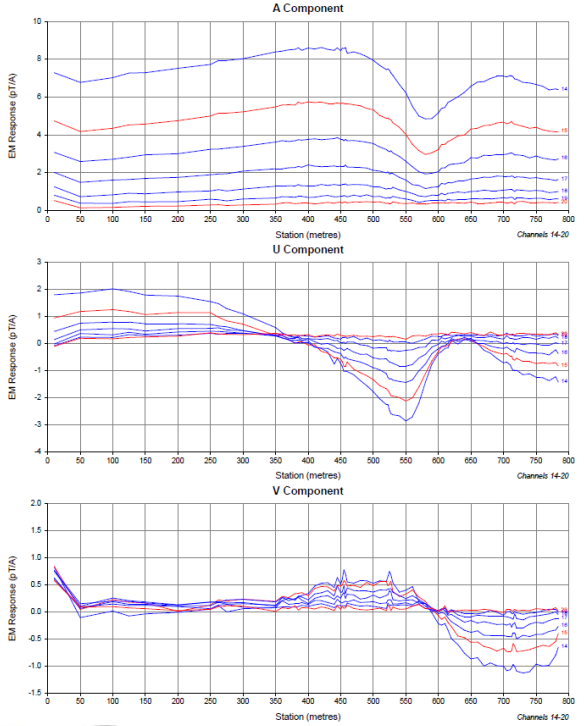
Resource Potentials

- DHEM data acquired using both Tx loop configurations were considered to be of good quality, with noise levels generally <0.1pT/A.
- Observed DHEM responses typically reflect weakly conductive regolith cover and host rock units in early to middle time decay channels.
- At mid-time decay channels (channels 14 - 20), moderate amplitude anomalous DHEM conductor responses are observed around 600m downhole as a negative or 'pull down' response in the A component receiver DHEM data, and as inflections / cross overs in the U and V component receiver DHEM data.
- Anomalous DHEM responses observed are typical of weakly to moderately conductive sources to the north and above the drillhole, correlating to known mineralised zones, with a potentially untested conductor sitting directly below the feeder zone.

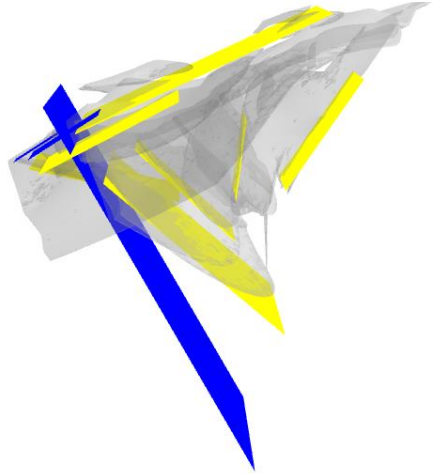
***Northern Tx loop (Ch 14 – 20)***




***Southern Tx loop (Ch 14 – 20)***




***Various DHEM conductor plates used to model the observed DHEM responses, with an untested conductor zone below the known mineralisation (grey) in blue.***



***Yellow DHEM conductor plates provide an equally good fit with the observed DHEM responses***

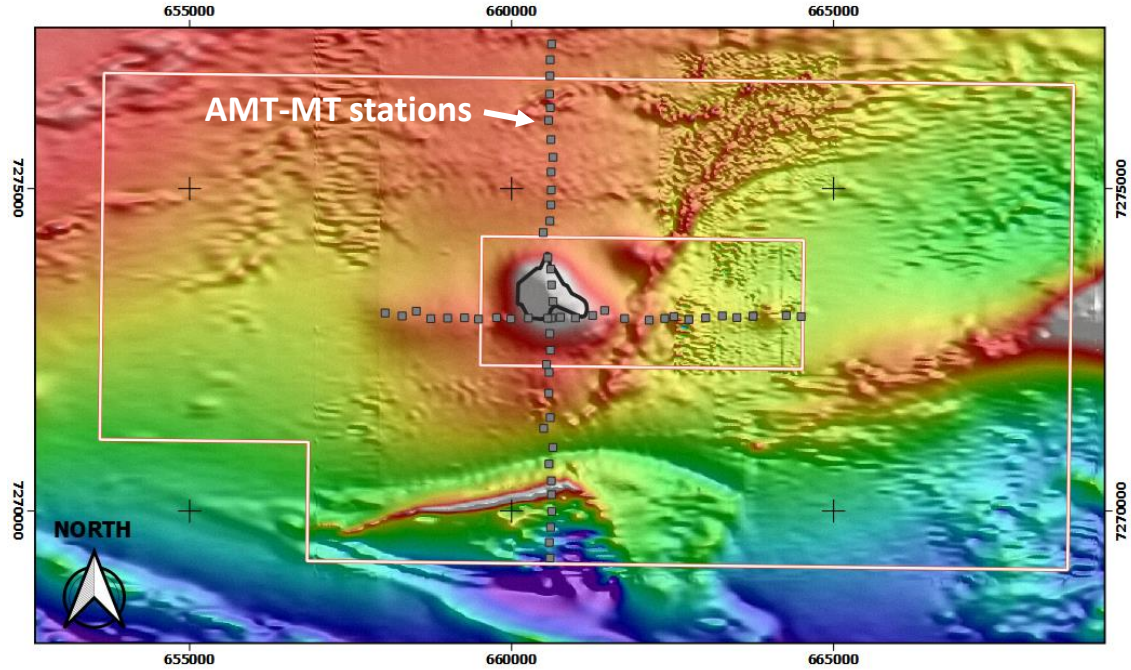
# Abra Geophysical Responses: Magnetotellurics

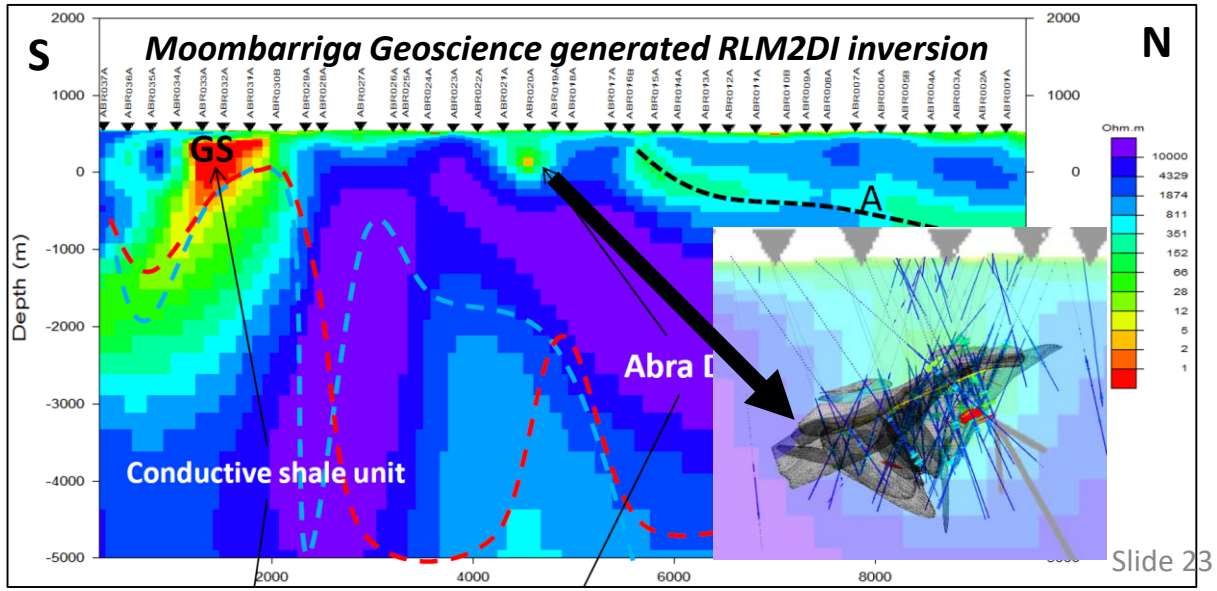
Resource Potentials

- Combined AMT-MT surveying carried out in 2014 to map conductive structures and stratigraphy to a depth of approximately 5km.
- Data acquisition was carried out by Moombarriga Geoscience along a 10km N-S orientated survey line and a 6km E-W orientated survey line.
- Contractor provided 1D and 2D inverted resistivity cross sections, and Resource Potentials also used two different inversion programs to generate similar results. Resource Potentials have begun 3D MT inversion modelling commissioned by Galena Mining.
- The existing 2D AMT-MT modelled cross section resolved Abra as a broad weakly conductive zone within a resistive host.
- Graphitic shale units of the upper Kiangi Creek Formation are resolved as anticlinal limbs dipping to the north and south of Abra, forming a broad fold and thrust structure from rift basin inversion.

**AMT/MT survey specs**

ADU-07e recorders and MFS06e induction coils
Hx, Hy, Hz and Ex and Ey components recorded
Dipole length 50m
AMT data recorded for 1-2 hours
MT data recorded for 10-16 hours

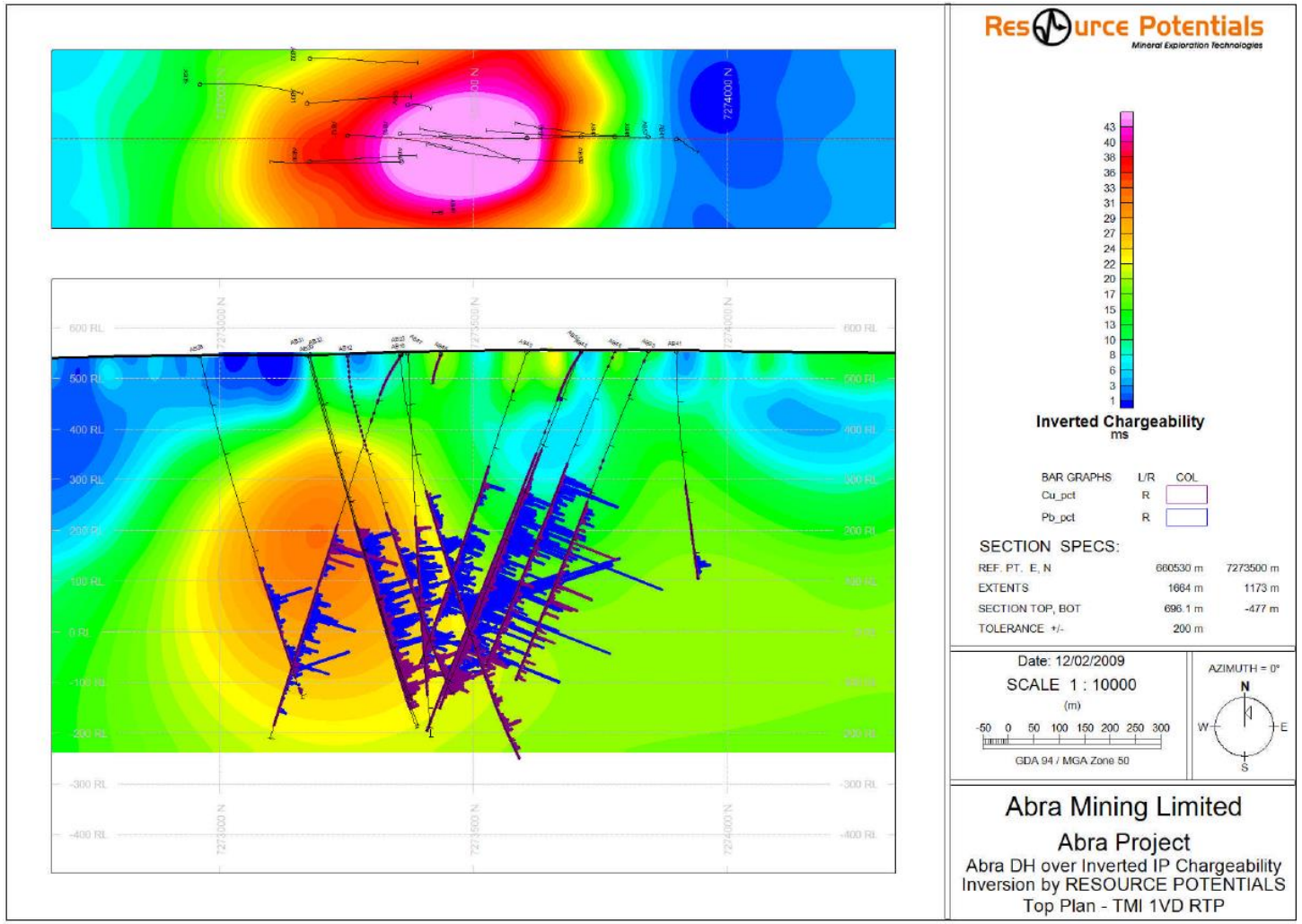


# Abra Geophysical Responses: Induced Polarisation

- Petrophysical studies indicate that high-grade parts of Abra should result in a moderate to strong IP chargeability anomaly.
- Dipole-dipole IP (DDIP) and Pole-dipole IP (PDIP) surveying was carried out between 2006-2008 by GPX Surveys.
- Inverted DDIP data resolved a high amplitude chargeability anomaly which was offset just to the south of the high-grade mineralisation, despite significant disseminated sulphide mineralisation occurring within the deposit.
- The observed offset chargeability anomaly likely represents a zone of intense alteration or disseminated sulphide minerals on the periphery of the deposit, with sparse chalcopyrite and barren pyrite mineralisation intersected in this zone.

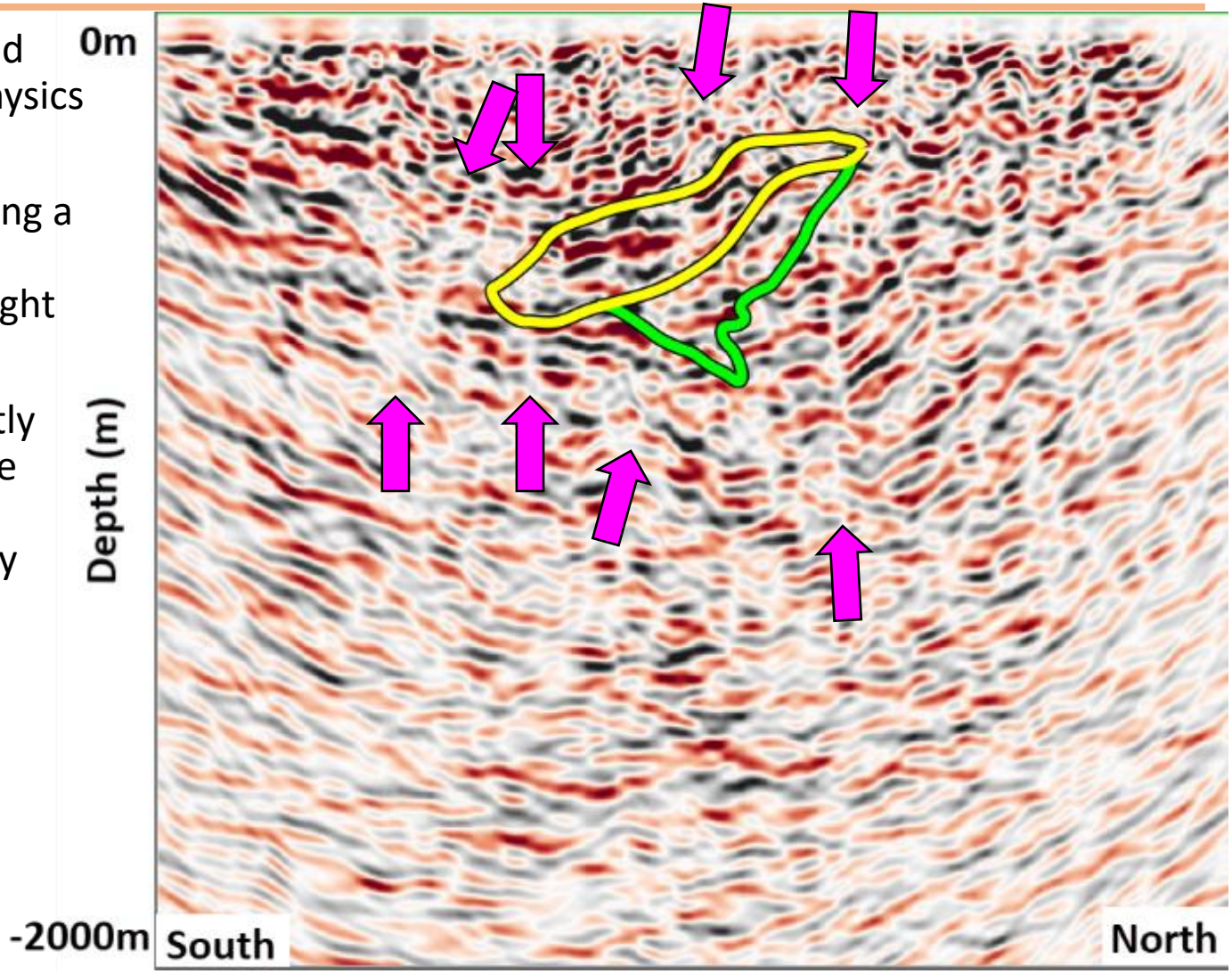
***Inverted chargeability IP section overlain by drillholes with Pb assay results shown as bar graphs to the right, showing a significant chargeable anomaly offset to the south of the main mineralised zone.***



# Abra Geophysical Responses: 2D Seismic Reflection

- 2D multichannel seismic reflection surveying was carried out in 2011 as part of a Curtin University 3rd year geophysics field program.
- Data acquisition carried out using HiSeis equipment along a 2.5km N-S orientated traverse centred directly over the Abra, coincident with MT line, using an accelerated weight drop source and 5m shot and 5m geophone spacing.
- Data were initially processed by Curtin, and then recently reprocessed by HiSeis in 2019, which better resolves the stratabound mineralisation as semi-coherent seismic reflectors, as well as better imaging fault zones that may have formed conduits for mineralising fluids.

***Curtin accelerated weight drop source mounted on a bobcat***

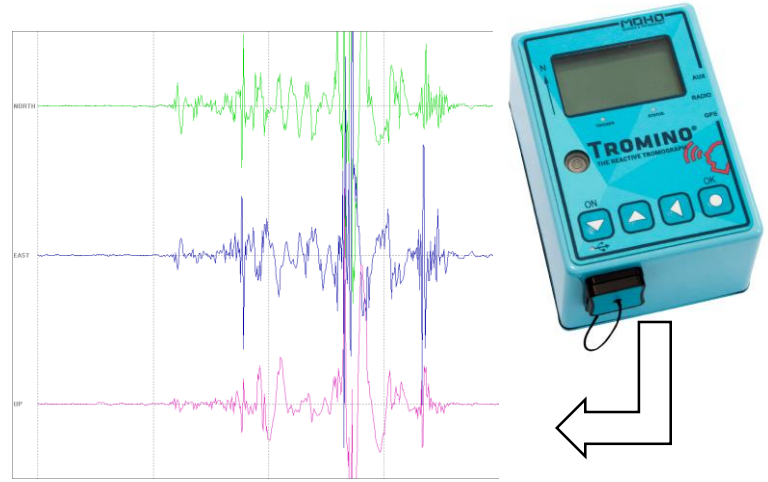



***View looking west of reprocessed migrated and depth converted seismic reflection cross section image overlain with outlines of Abra stratabound mineralisation in yellow and feeder zone in green.***

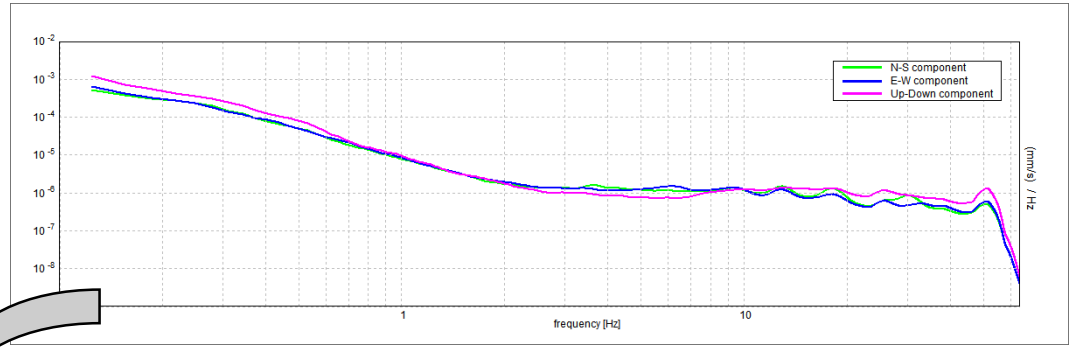
# Abra Geophysical Responses: Passive Seismic HVSR

- Trial passive seismic horizontal to vertical spectral ratio (HVSR) surveying was carried out over Abra in 2019 to acquire detailed information about regolith cover thickness, possibly provide static correction information to improve reprocessing of 2D seismic reflection data and future 3D seismic reflection surveying, and identify structural offsets.
- Data acquisition was carried out along the same N-S traverse as the 2D seismic reflection survey, along with an E-W traverse.
- The HVSR data at each recording station were amplitude normalised and converted to depth using a constant average shear wave velocity (Vs) of 3,000m/s, based on measured Vp data from core converted to Vs. Pixel plot HVSR normalised amplitude-depth cross sections were then generated.

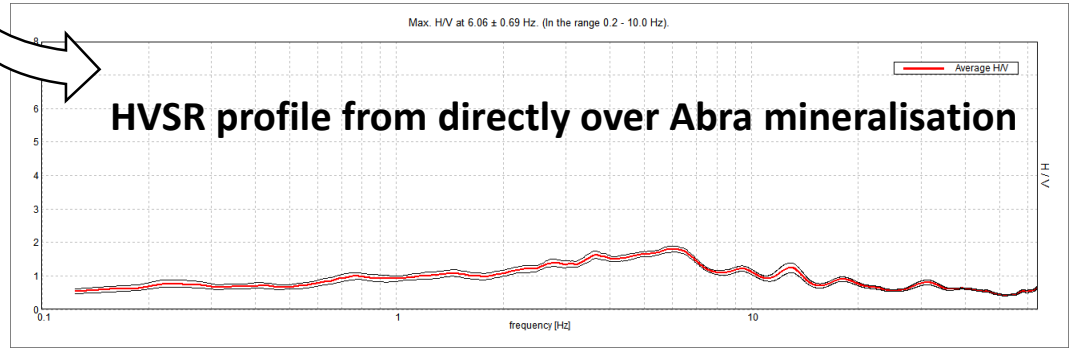
***Representative passive seismic data acquired at Abra***




**FFT**




**Horizontal spectra component / vertical component spectra profile response**

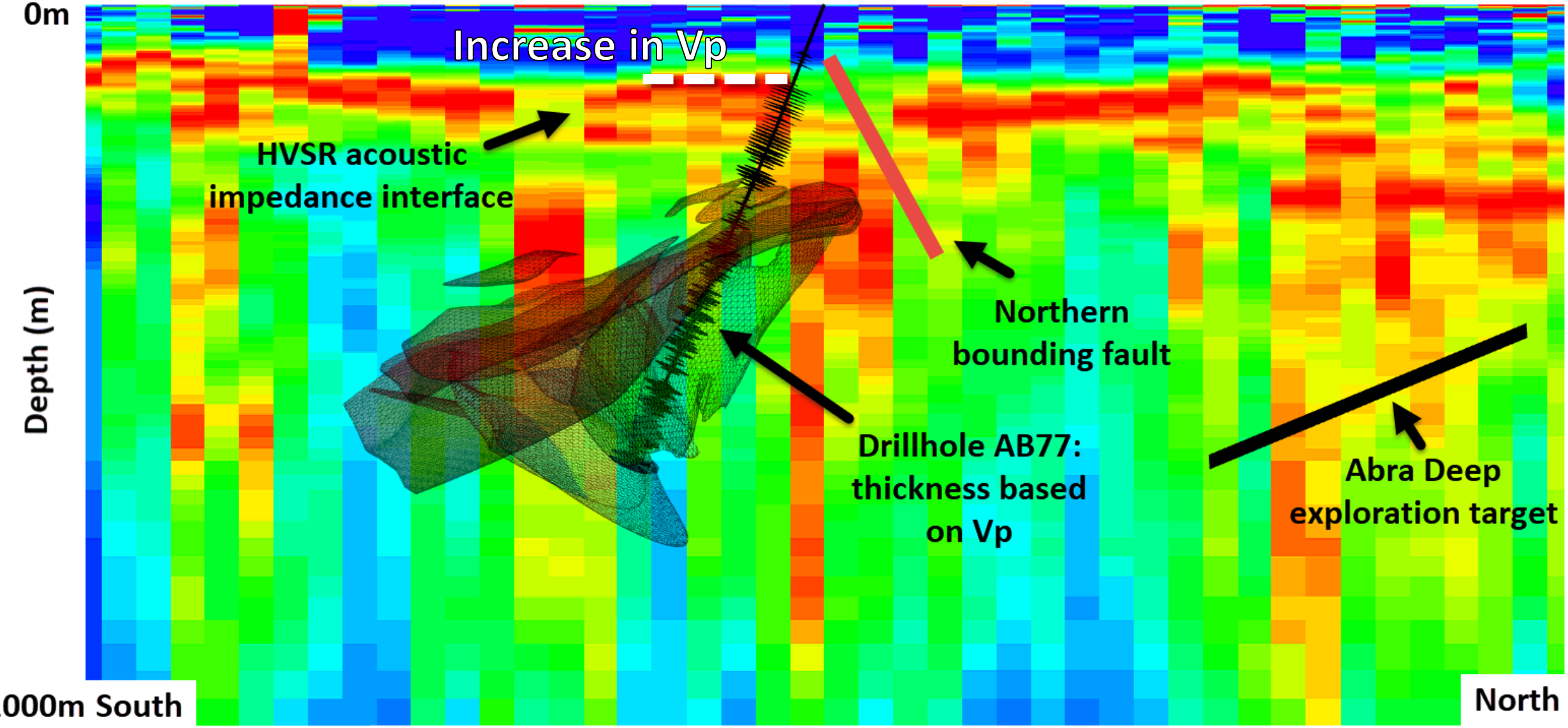



**Passive seismic HVSR survey specs**
8x Tromino seismometers
50m station spacing
30min recording time
**<u>Total field time → 1 day</u>**

# Abra Geophysical Responses: Passive Seismic HVSR

Resource Potentials

*Normalised HVSR amplitude-depth section*

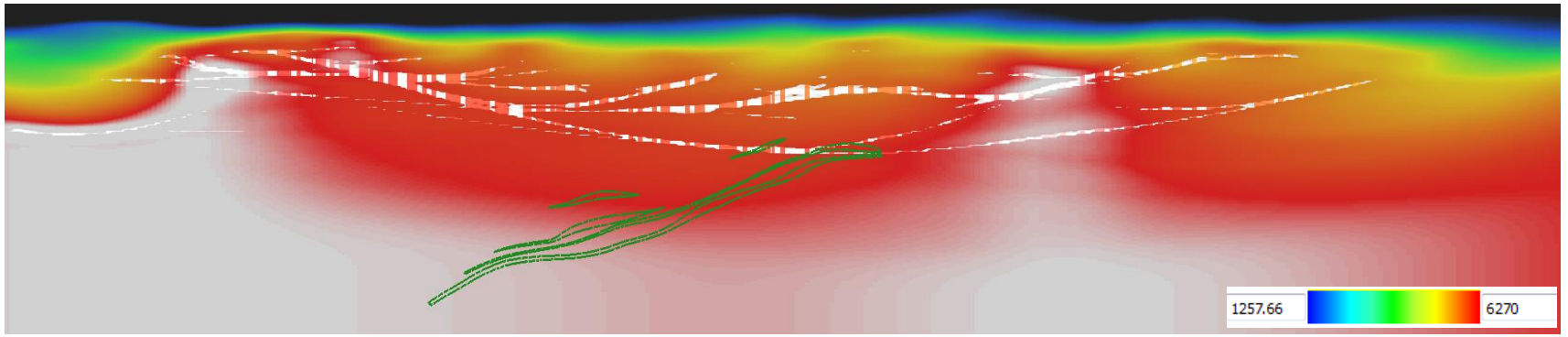


# Abra Geophysical Responses: Passive Seismic HVSR

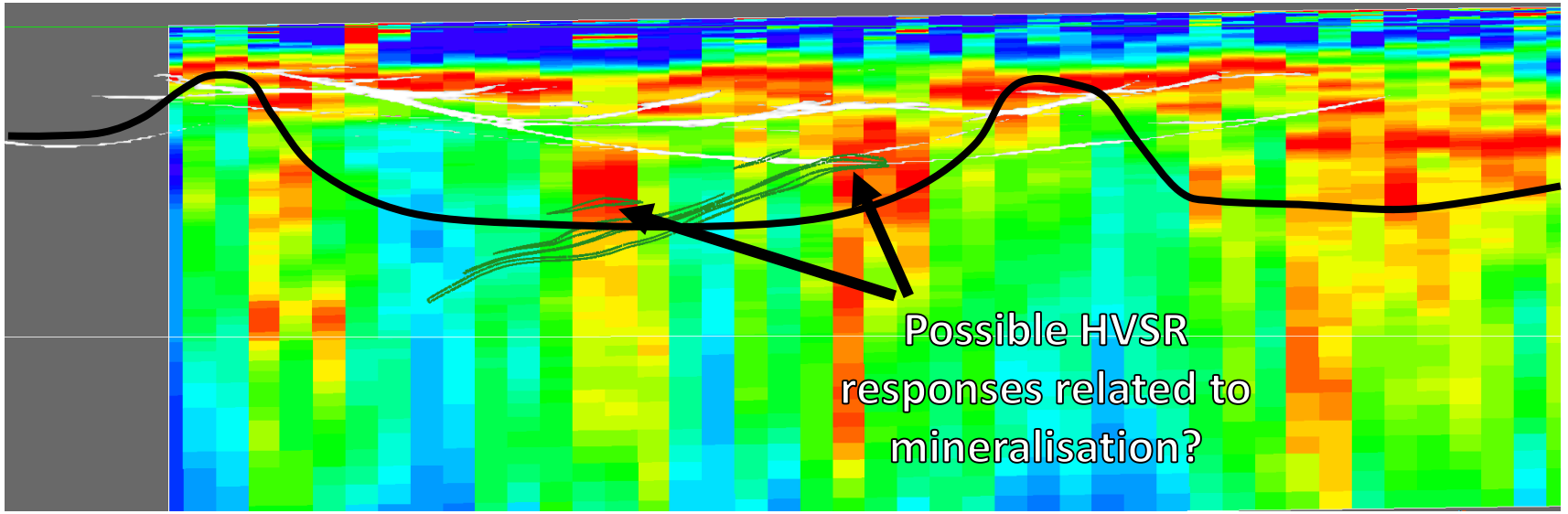
Resource Potentials

- Refraction tomography can be extracted from the 2D seismic reflection data processing, specifically first break picking to provide detailed velocity of the near surface to the top of fresh high velocity rock.
- The refraction tomography algorithm iteratively calculates velocity along ray paths from source to receiver using travel times derived from first break picks.
- HiSeis processed refraction tomography ray paths agree with HVSR acoustic interface layering, and this likely reflects diagenetic cementation zones between oxidised Kiangi Creek sediments (sand and siltstones) sitting above less weathered to re-cemented sediments below.

***Seismic refraction tomography and ray paths (from HiSeis, 2019)***




***Normalised HVSR amplitude-depth section overlain by seismic refraction ray paths***



# Summary of the Geophysical Characteristics of Abra

Resource Potentials

- The geophysical expression of the Abra polymetallic base metal deposit is characterised by discrete magnetic, gravity and electromagnetic anomaly high responses.
- The magnetic anomaly response is related to magnetite mineralisation primarily within the black zone of the stratabound mineralisation.
- Galena, iron oxide and barite mineralisation in the stratabound mineralisation zone, and galena-chalcopyrite mineralisation within the feeder zone, are the main sources of the gravity anomaly high.
- Downhole, ground and airborne EM surveying has resolved a main discrete EM conductor anomaly associated with known massive sulphide mineralisation, and this conductive response is mainly related to conductive galena. The deposit halo was also resolved as a broad and moderate conductor response in inverted AMT-MT data.
- Although petrophysical testing on selected core samples indicated that Abra should be associated with a chargeable IP anomaly, IP surveying carried out across the deposit has failed to identify a coincident chargeable anomaly with the main mineralised zone, likely due to the dominance of massive style sulphide deposition.
- The stratabound mineralisation zone is resolved in 2D seismic data as semi-coherent reflectors surrounded by a seismically bland zone, and seismic reflectivity is likely related to density contrast from galena, iron oxide and barite mineralisation within the stratabound zone with surrounding low density sedimentary host rocks to produce an AI contrast. The stratabound mineralisation is possibly resolved as subtle anomaly responses in normalised passive seismic HVSR data.

Barite, galena and pyrite veining

Galena vein

Galena and pyrite veining

Pyrite vein

Barite-quartz-galena vein cross cut by barite vein

Coarse crystaline barite vein