PDAC 2022 90th Anniversary
THE WORLD'S PREMIER MINERAL EXPLORATION & MINING CONVENTION

Mineral exploration case studies with airborne EM natural fields

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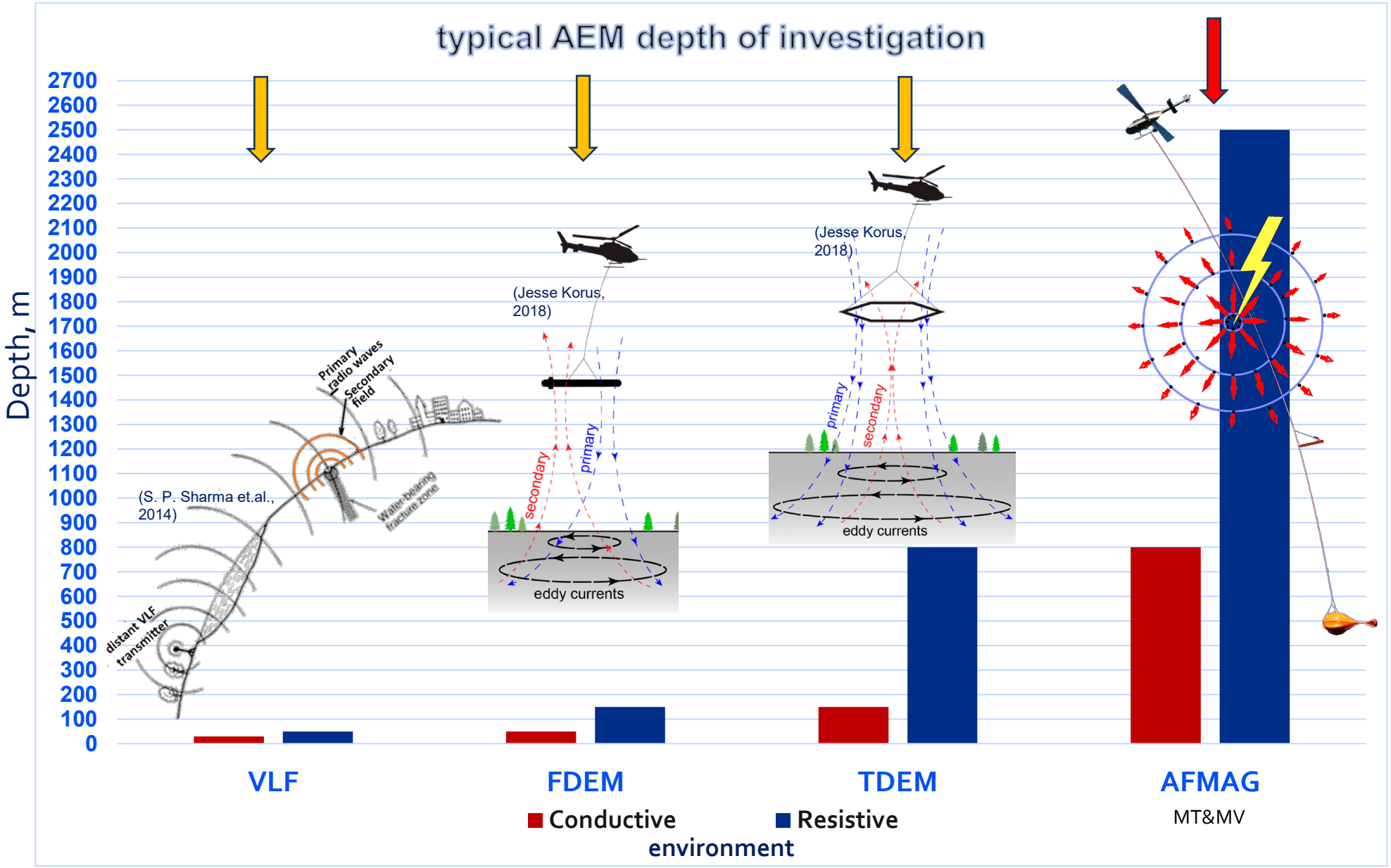
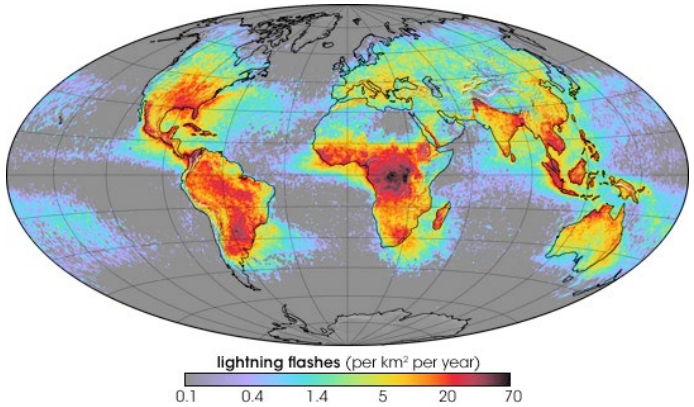
Presentation Outline

- Capabilities and limitations of airborne EM methods
- Advantages of using natural energy source
- Data acquisition and data processing
- Field examples
  - Athabasca Basin (uranium)
  - Tien Shan orogenic gold
  - Epithermal and porphyry (BC and PNG)
  - Copper-cobalt (South Australia and Tasmania)
  - Kimberlites (Ontario)

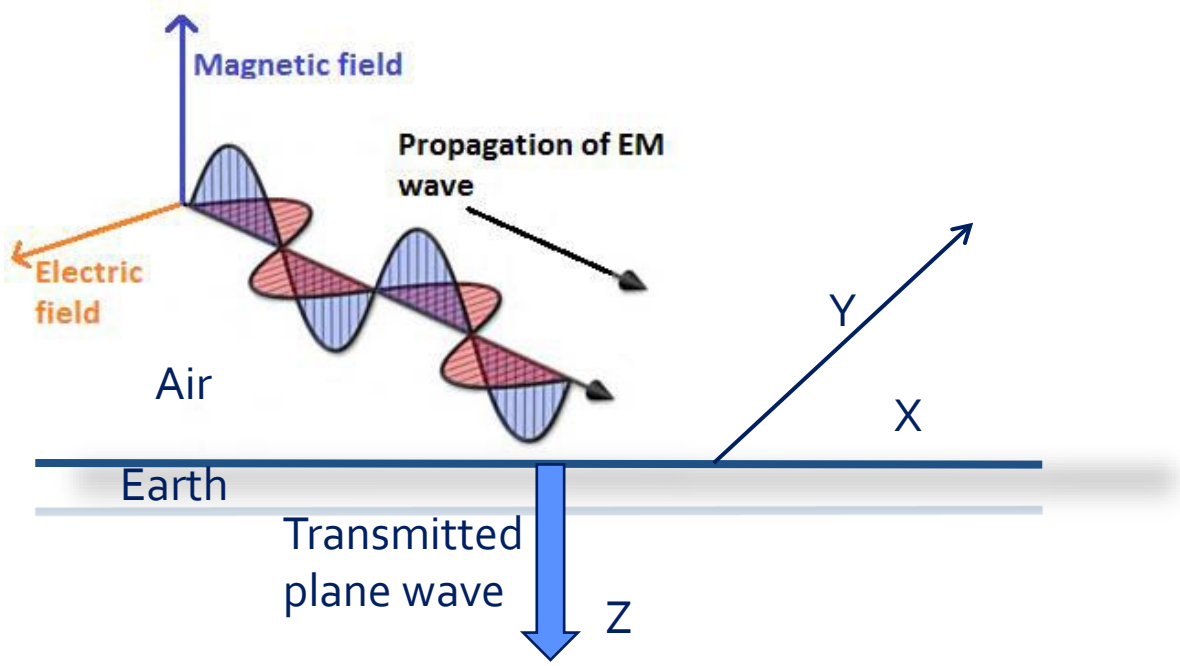

typical AEM depth of investigation
Depth, m
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
(S. P. Sharma et.al., 2014)
Primary radio waves
Secondary field
Water-bearing fracture zone
distant VLF transmitter
(Jesse Korus, 2018)
secondary
primary
eddy currents
(Jesse Korus, 2018)
primary
secondary
eddy currents
VLF
FDEM
TDEM
AFMAG
MT&MV
Conductive environment
Resistive

A typical lightning flash is **about 300 million Volts and about 30,000 Amps (weather.gov)**

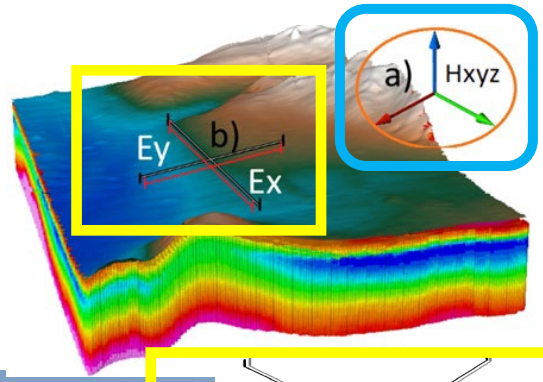
On Earth, the lightning frequency is **approximately 44 (± 5) times per second**, or nearly 1.4 billion flashes per year **(Lightning - Wikipedia)**

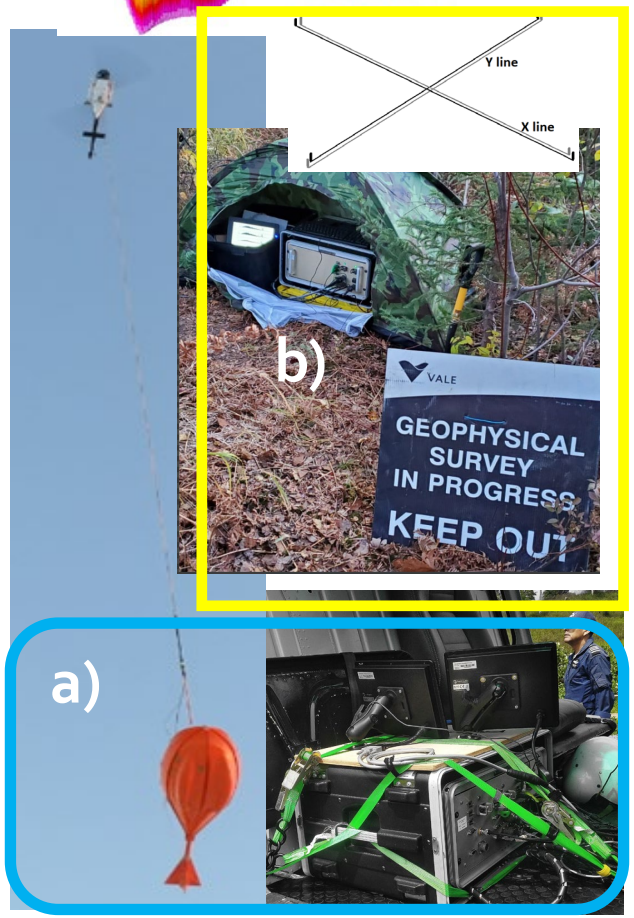


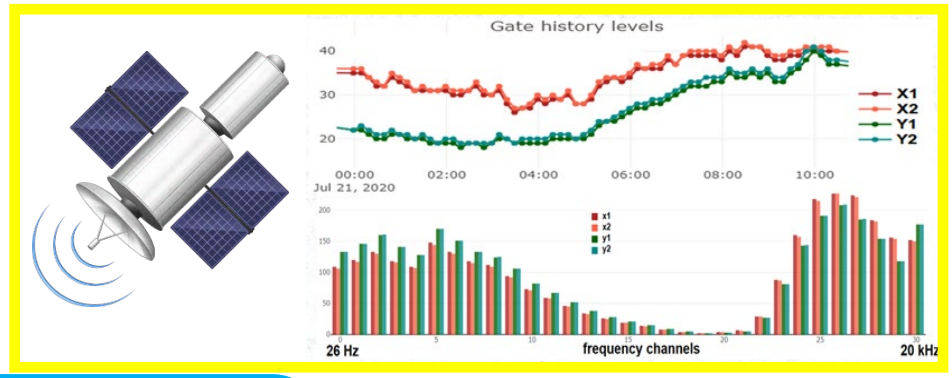
Average yearly counts of lightning flashes per square kilometer, based on data collected by NASA satellites between 1995 and 2002. (NASA, Visible Earth)

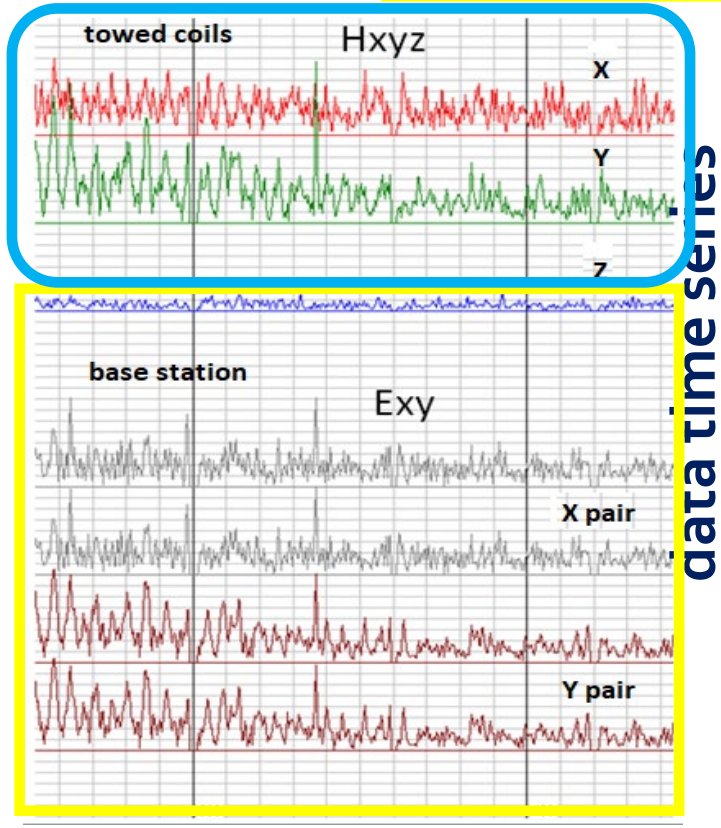


data acquisition and processing









data time series

H towed coils

$$H = \begin{bmatrix} Hx \\ Hy \\ Hz \end{bmatrix}$$

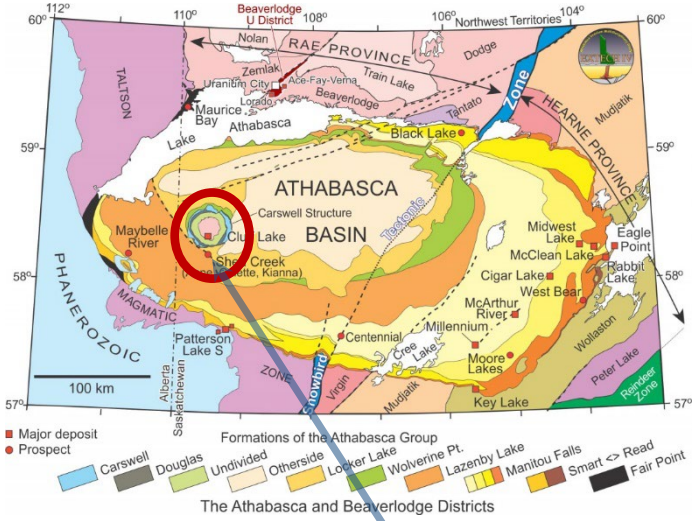
E base station

$$E = \begin{bmatrix} Ex \\ Ey \\ 0 \end{bmatrix}$$

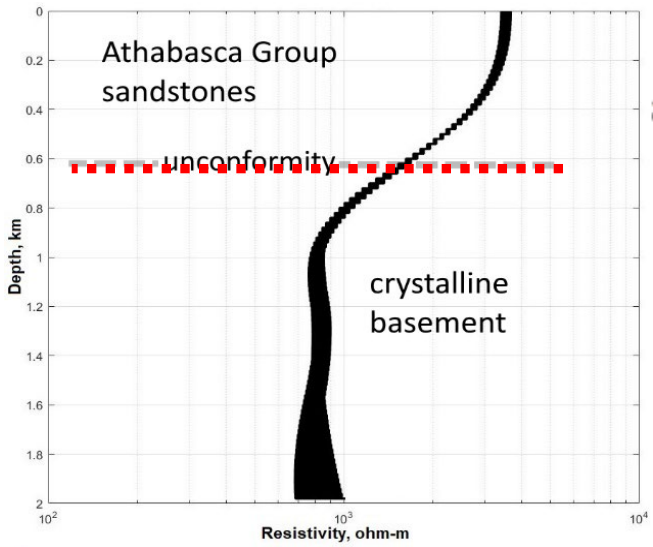
$$\begin{bmatrix} Hx \\ Hy \\ Hz \end{bmatrix} = \begin{bmatrix} Yxx & Yxy \\ Yyx & Yyy \\ Yzx & Yzy \end{bmatrix} \begin{bmatrix} Ex \\ Ey \end{bmatrix}$$

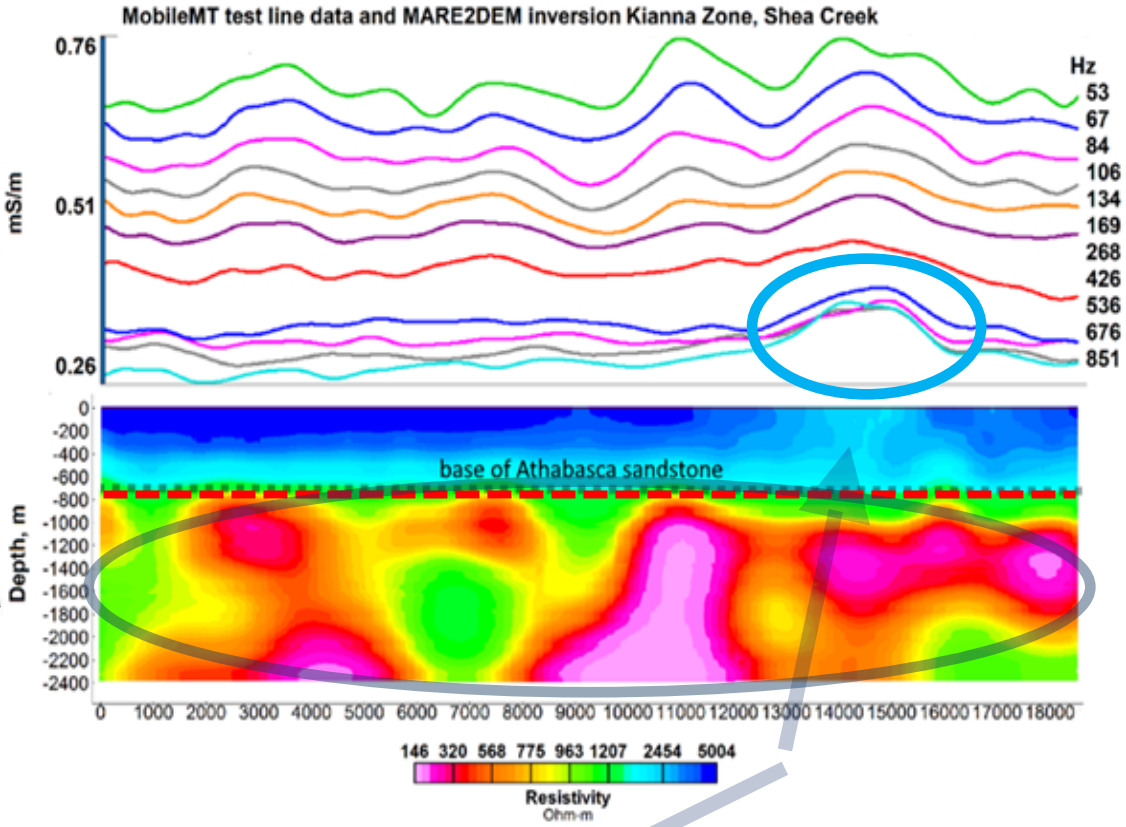
$$\sigma = \mu\omega|Y^2|$$

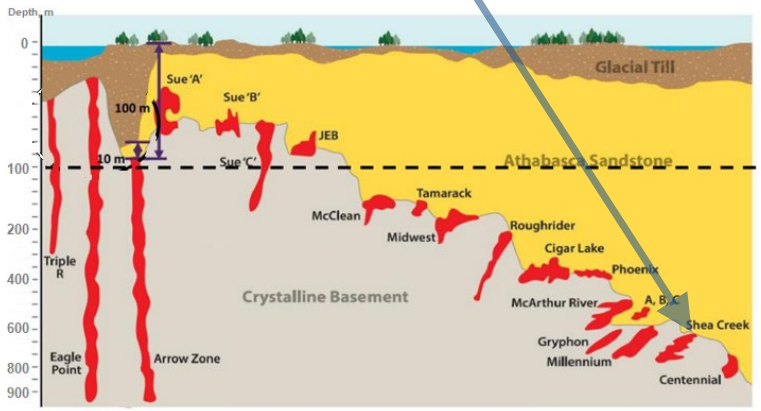
Athabasca Basin (central part). Shea Creek



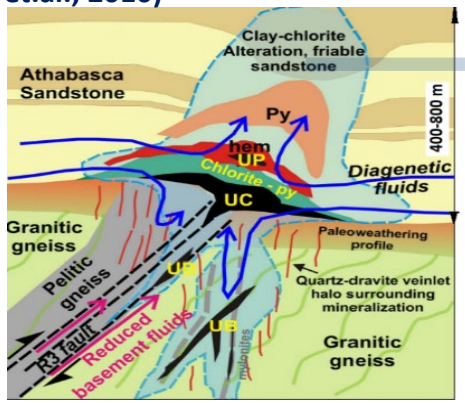
resistivity curves alone the line



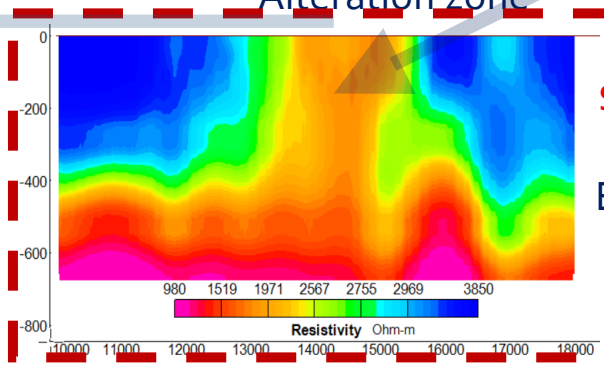




Typical schematic Shea Creek geological cross-section (after Rhys et.al., 2010)



Alteration zone

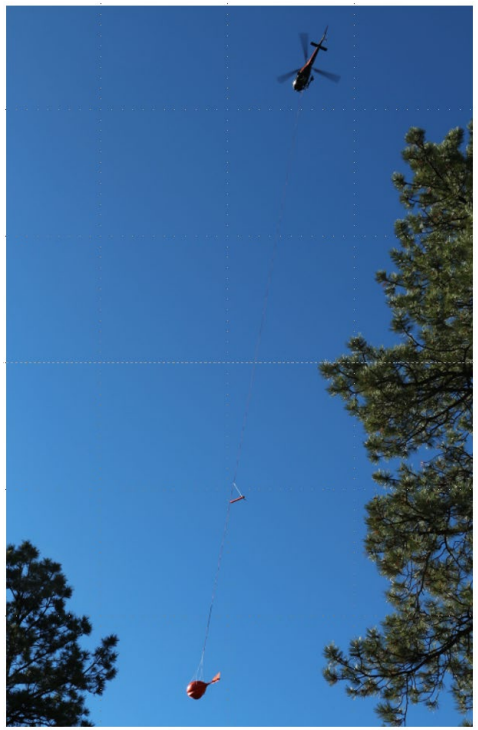


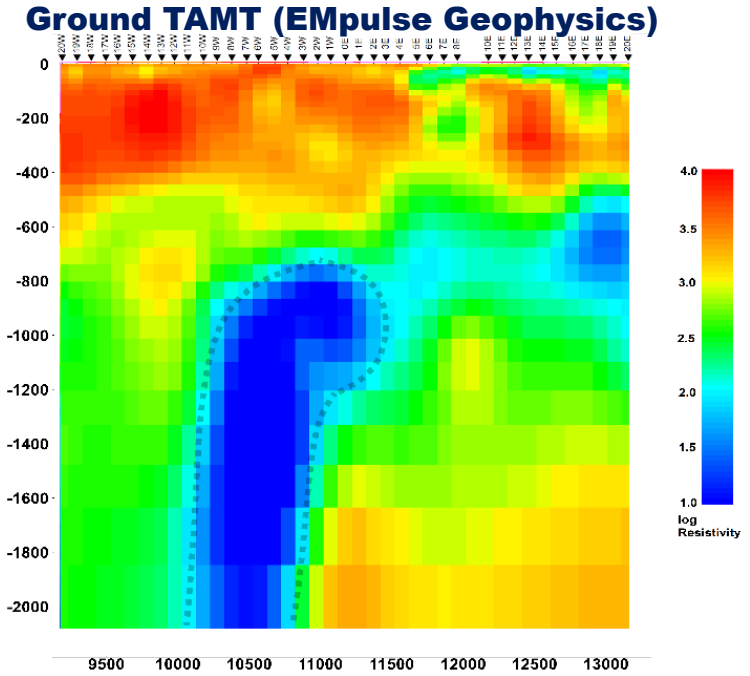
Sandstone depth range

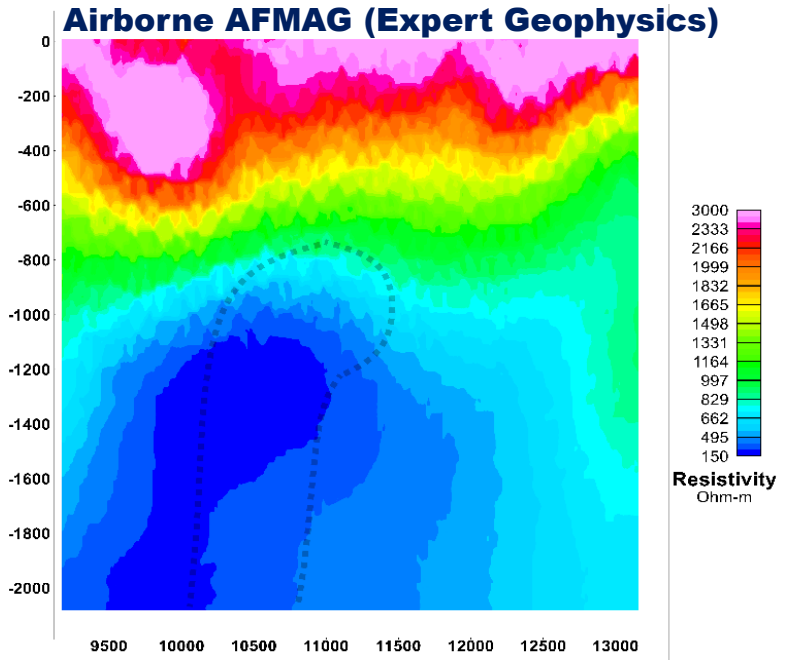
Basement boundary

Comparison between
EM natural fields ground (TAMT)
and airborne (MobileMT)

Kianna Zone

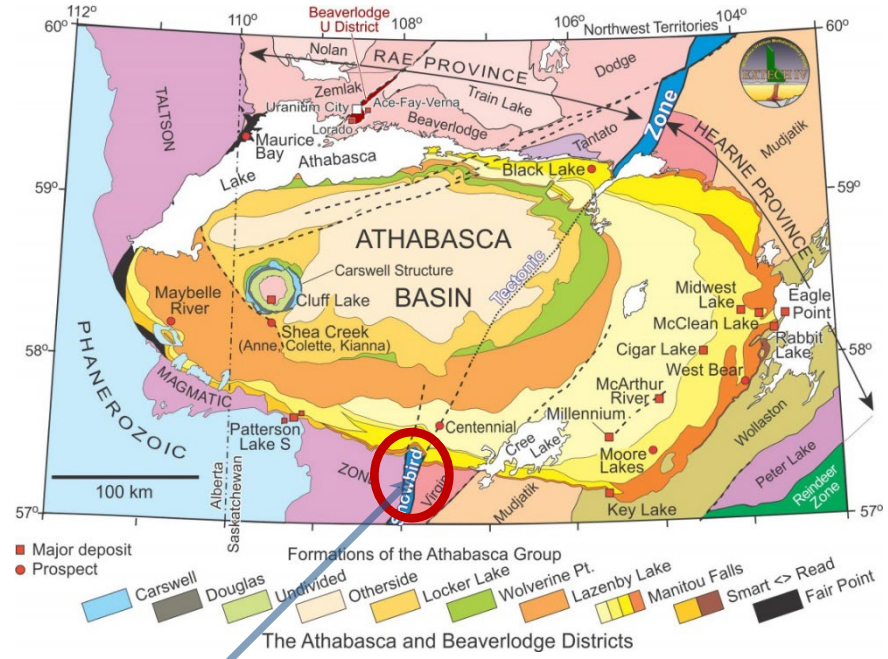




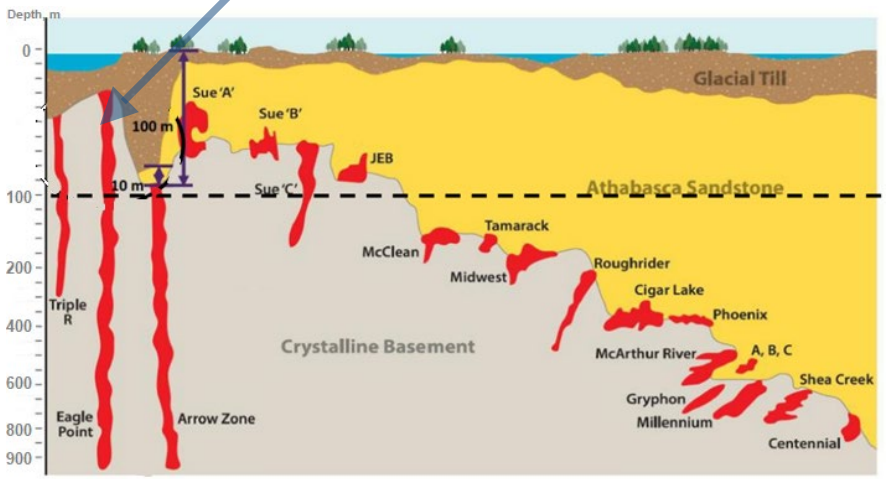


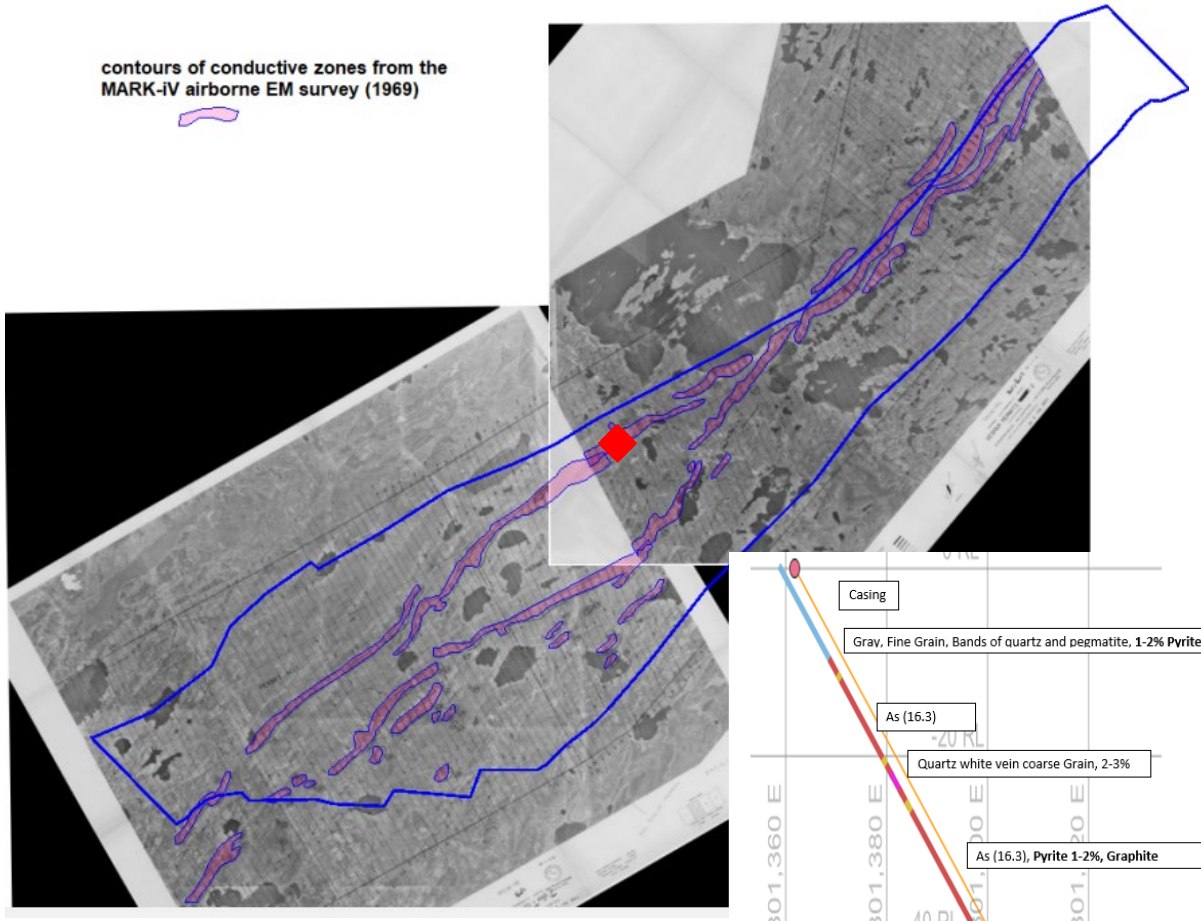
SHADOW PROJECT. Virgin River shear zone
Athabasca 2.0

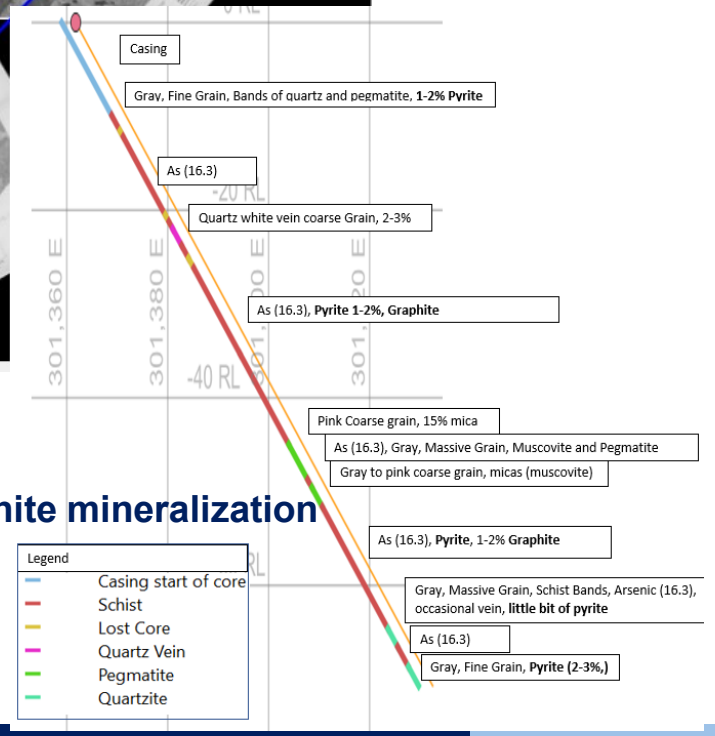
1969 FDEM 320 Hz



The Athabasca and Beaverlodge Districts

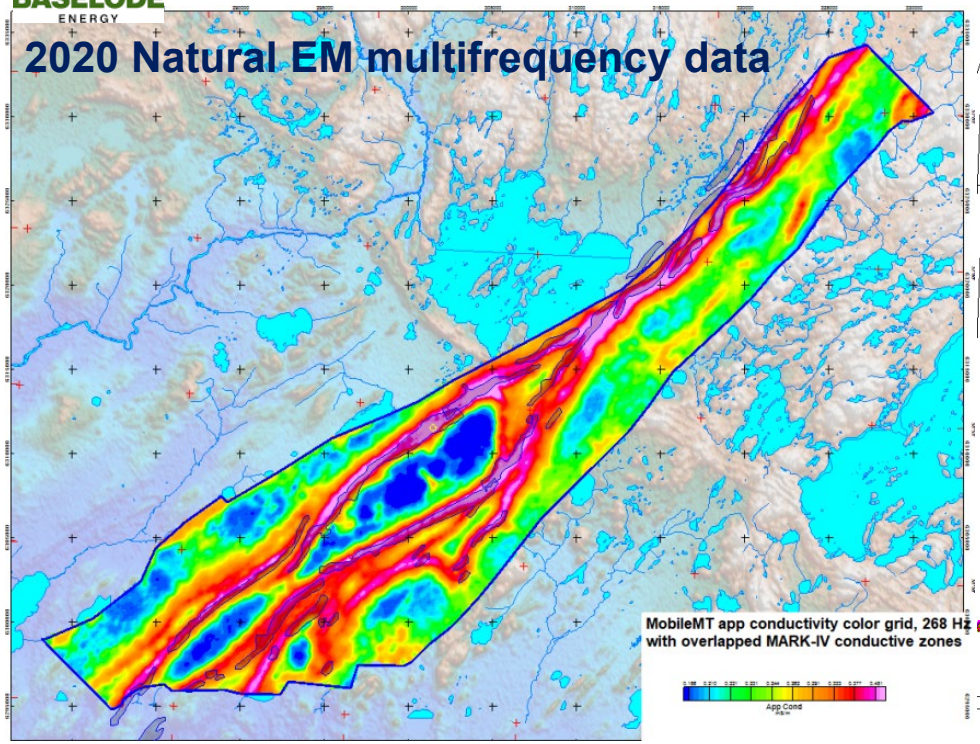


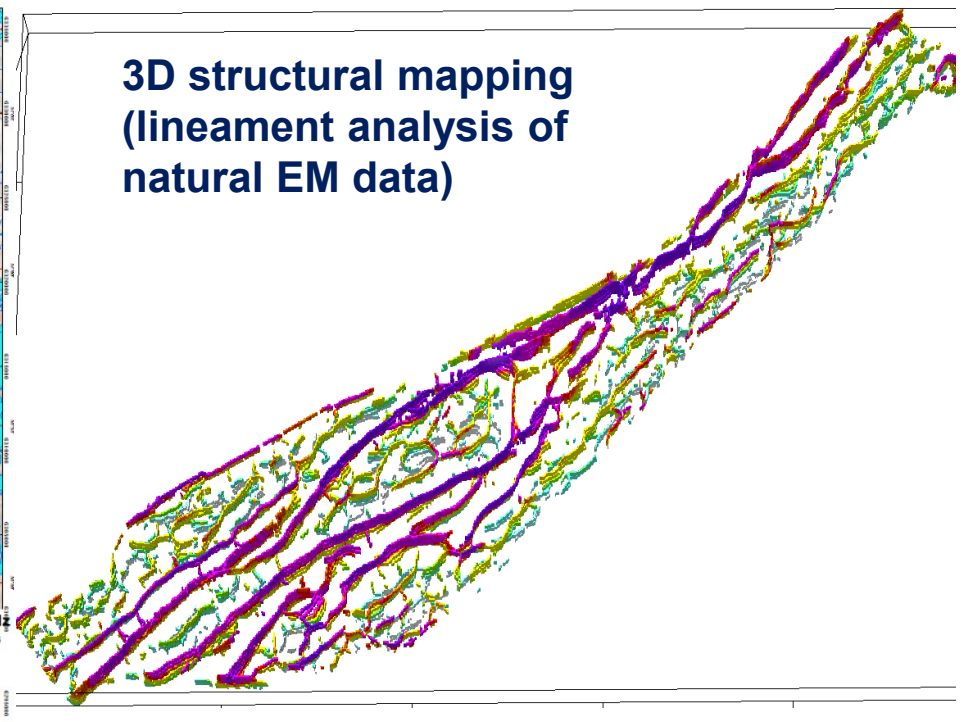


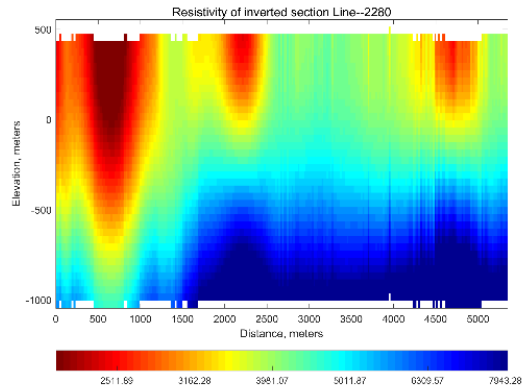


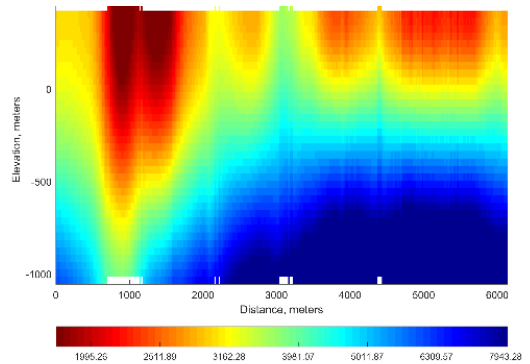
1972 drillhole
with sulfide and graphite mineralization

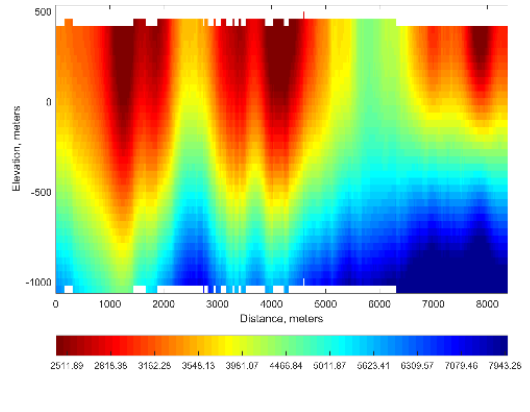
MobileMT data over the Virgin River Shear Zone

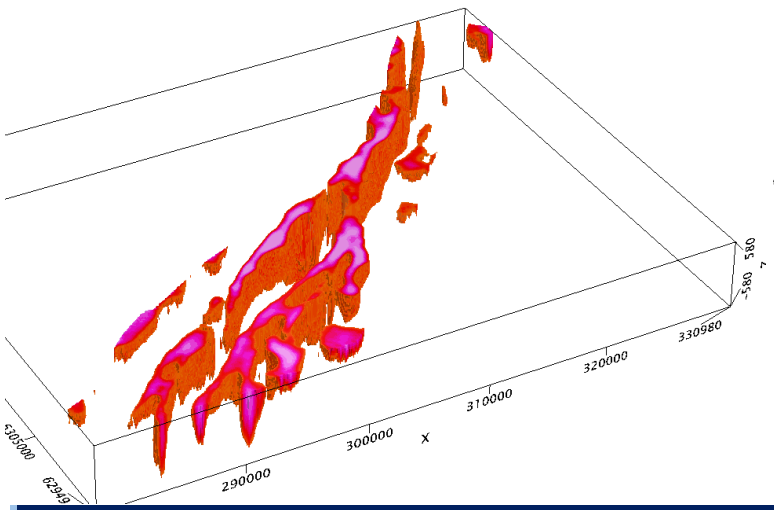


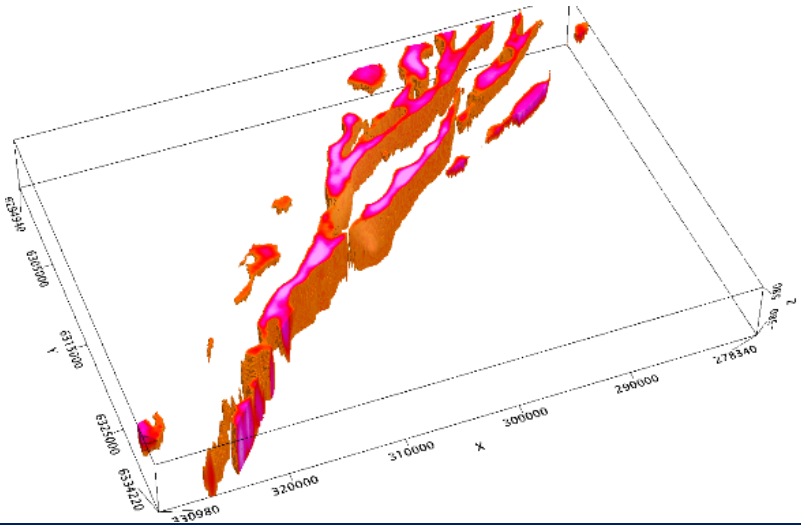




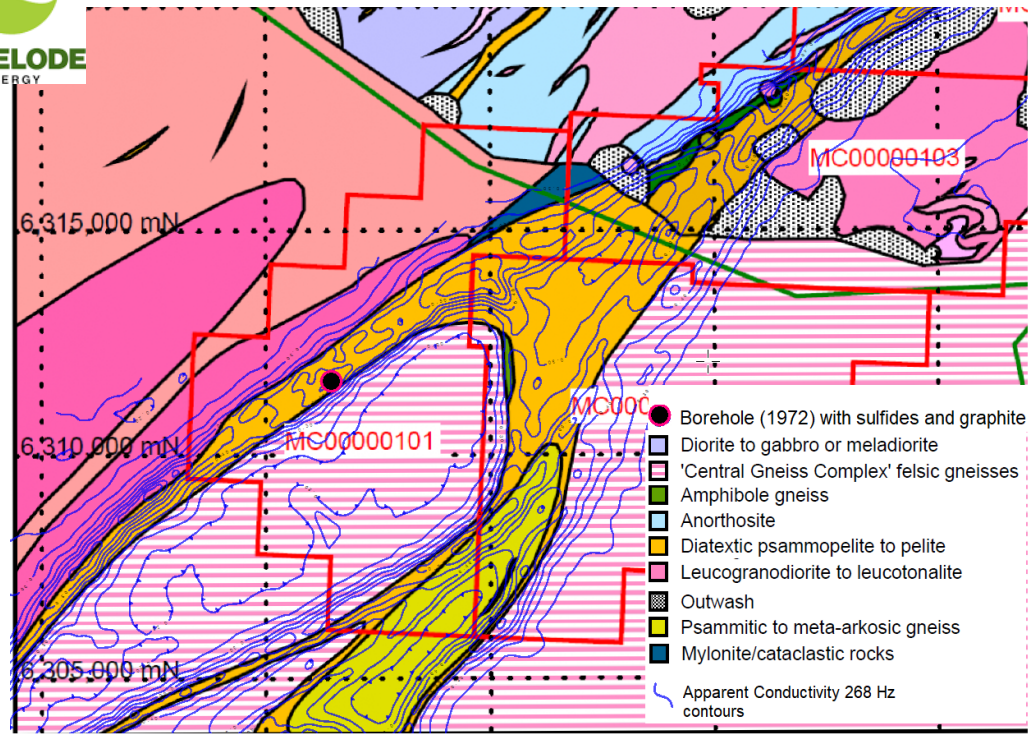




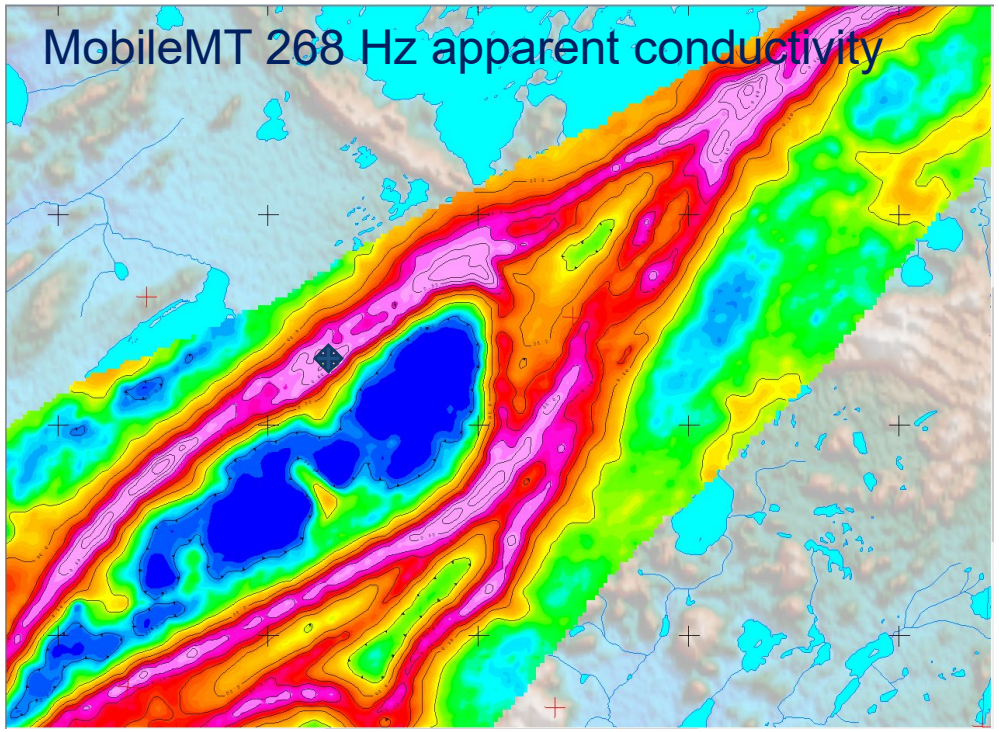


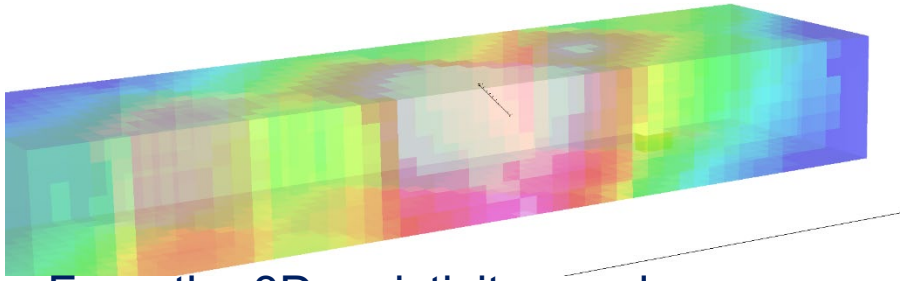


Historical drilling

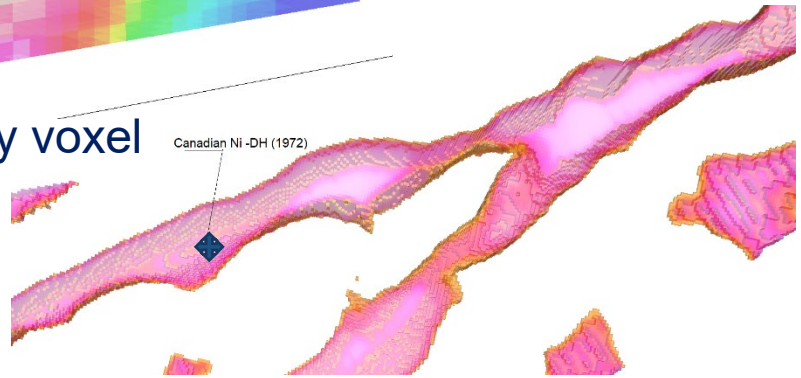


Geology from "Eagle Plains Resources Ltd. Tarku Project. 2013 Exploration Program" by Dave Billard



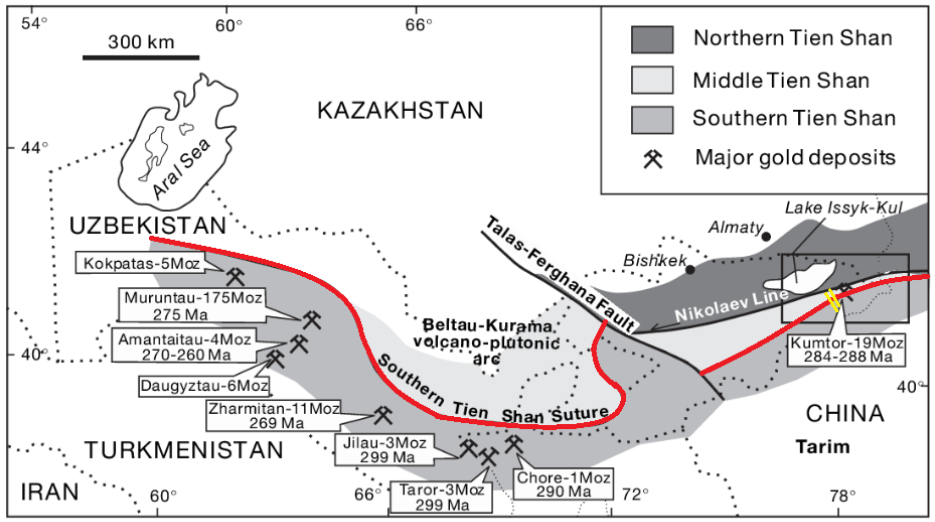


From the 3D resistivity voxel

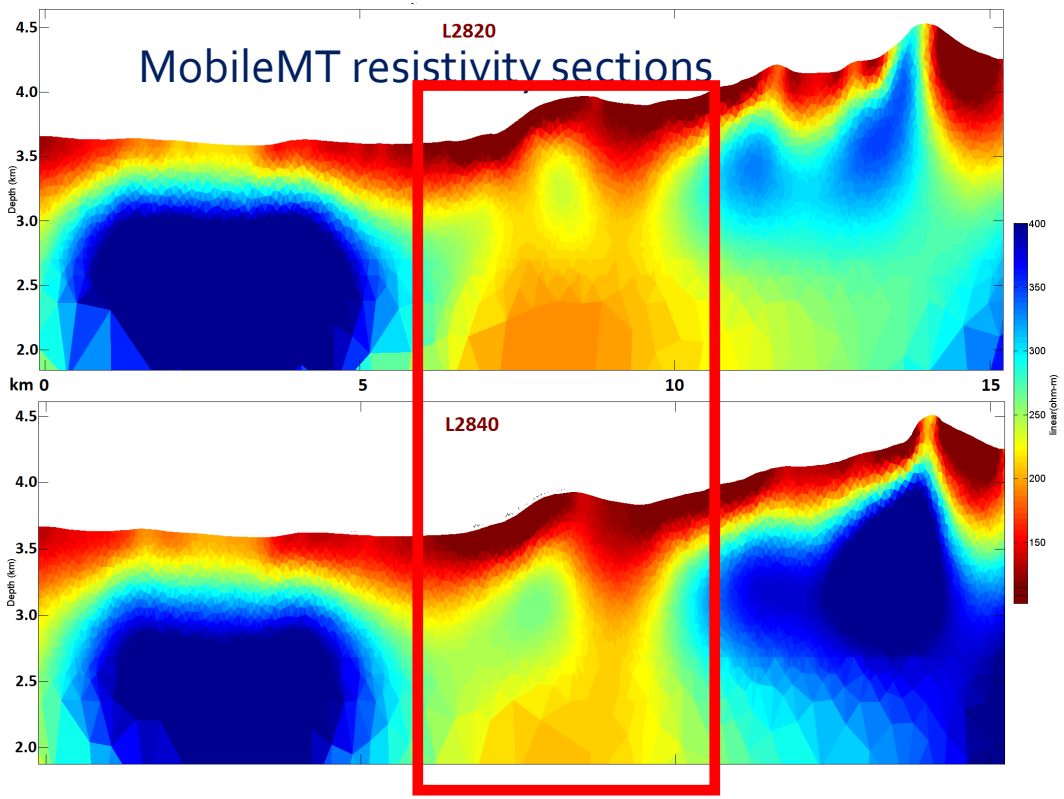


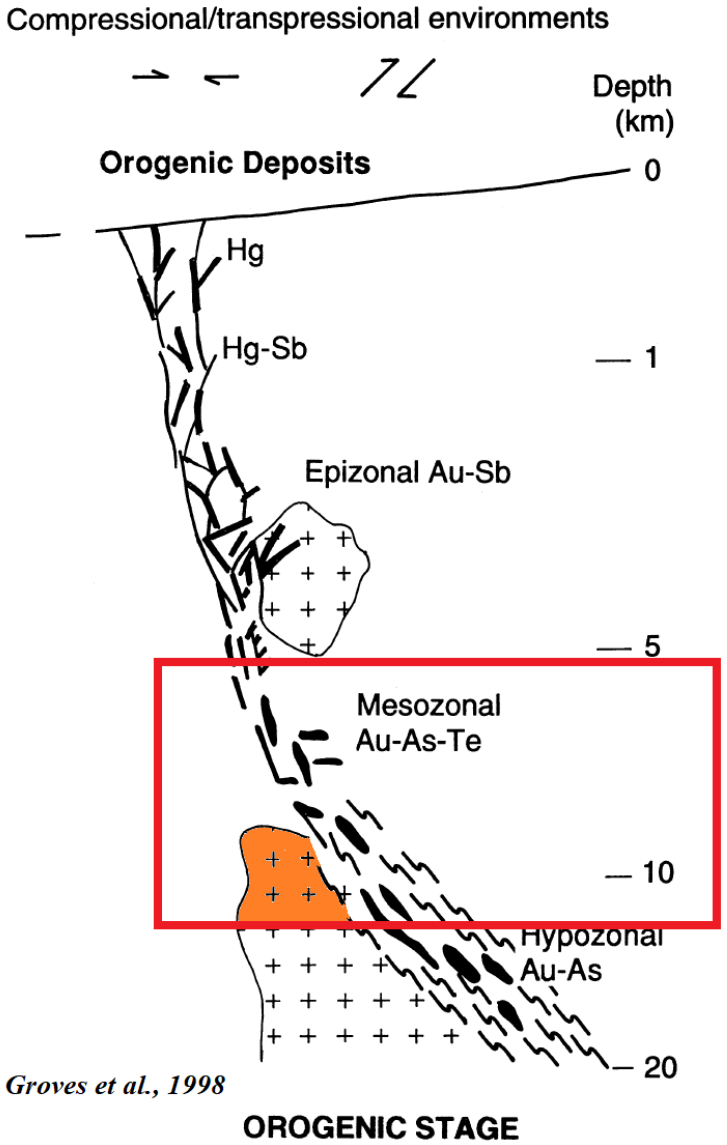
SHADOW PROJECT
Virgin River shear zone

Orogenic gold



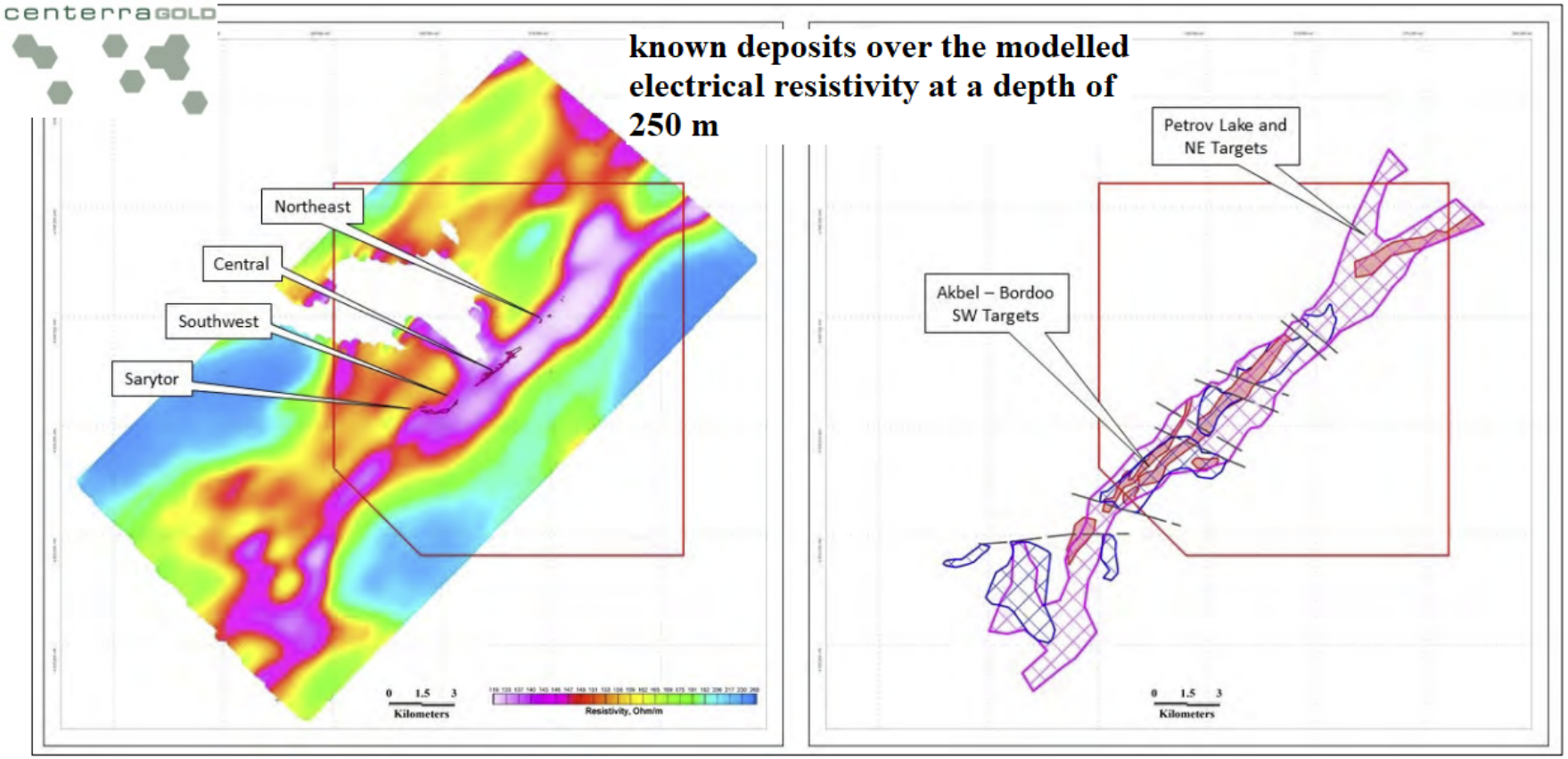
Distribution of late Paleozoic gold deposits in the southern Tien Shan. Modified from Yakubchuk et al. (2002).





southern Tien Shan metallogenic belt (Central Asia)
Sediment hosted intrusion related orogenic gold

Orogenic gold



High conductivity zone anomalies interpreted as Vendian altered and potentially Au-bearing rocks along the Kumtor Gold Trend

High residual gravimetric anomalies interpreted as uplifted areas of Vendian altered rock

Low magnetic anomalies interpreted as a strongly altered and mineralized rocks

Inferred cross cutting Alpine faults

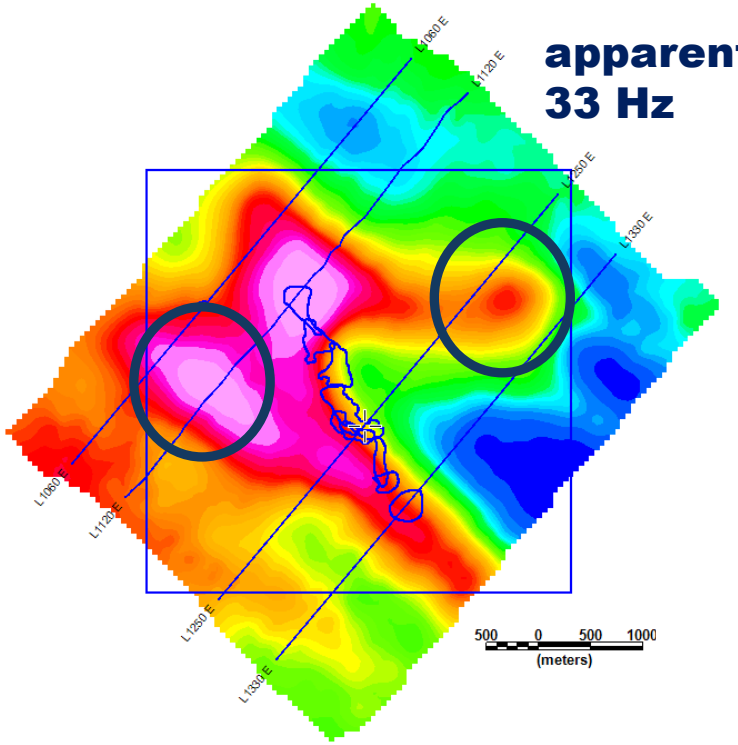
Note: Left: Map of modelled electrical resistivity at a depth of 250 m. Airborne electromagnetic survey, 2019.
Right: Interpretation of airborne and ground geophysical data.

southern Tien Shan metallogenic belt (Central Asia)
Sediment hosted intrusion related orogenic gold

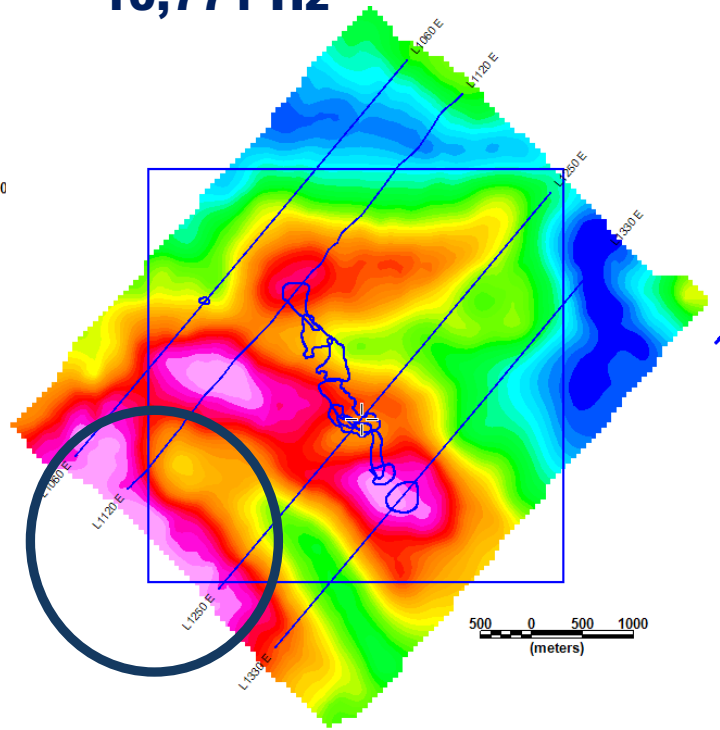
CENTERRA GOLD INC.
TECHNICAL REPORT ON THE KUMTOR MINE, KYRGYZ REPUBLIC
NI 43-101 Technical Report, 2021

the Thor Ag-Au-Pb-Zn-Cu **epithermal mineral deposit** located near Trout Lake, SE of British Columbia

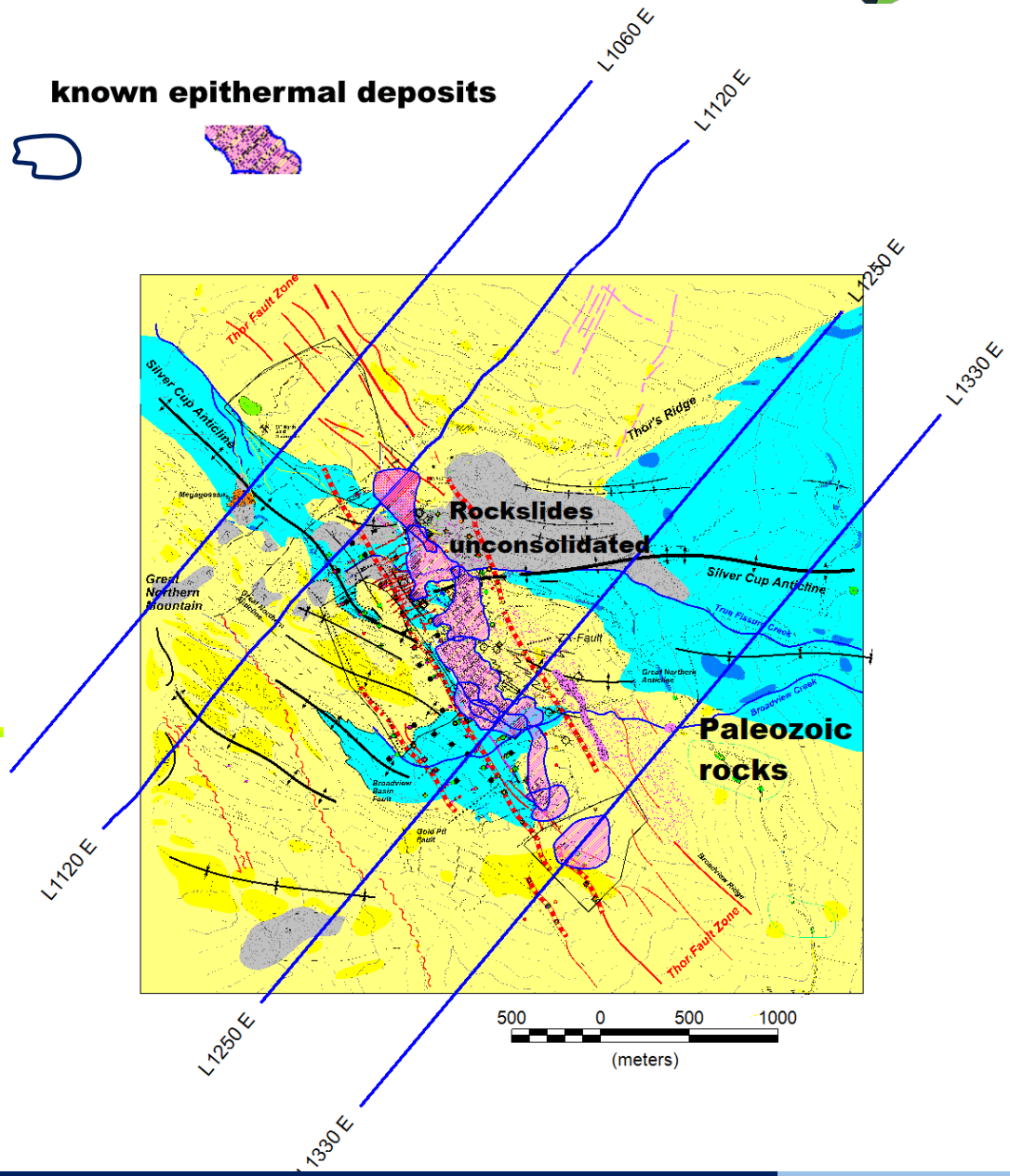
apparent conductivity 33 Hz



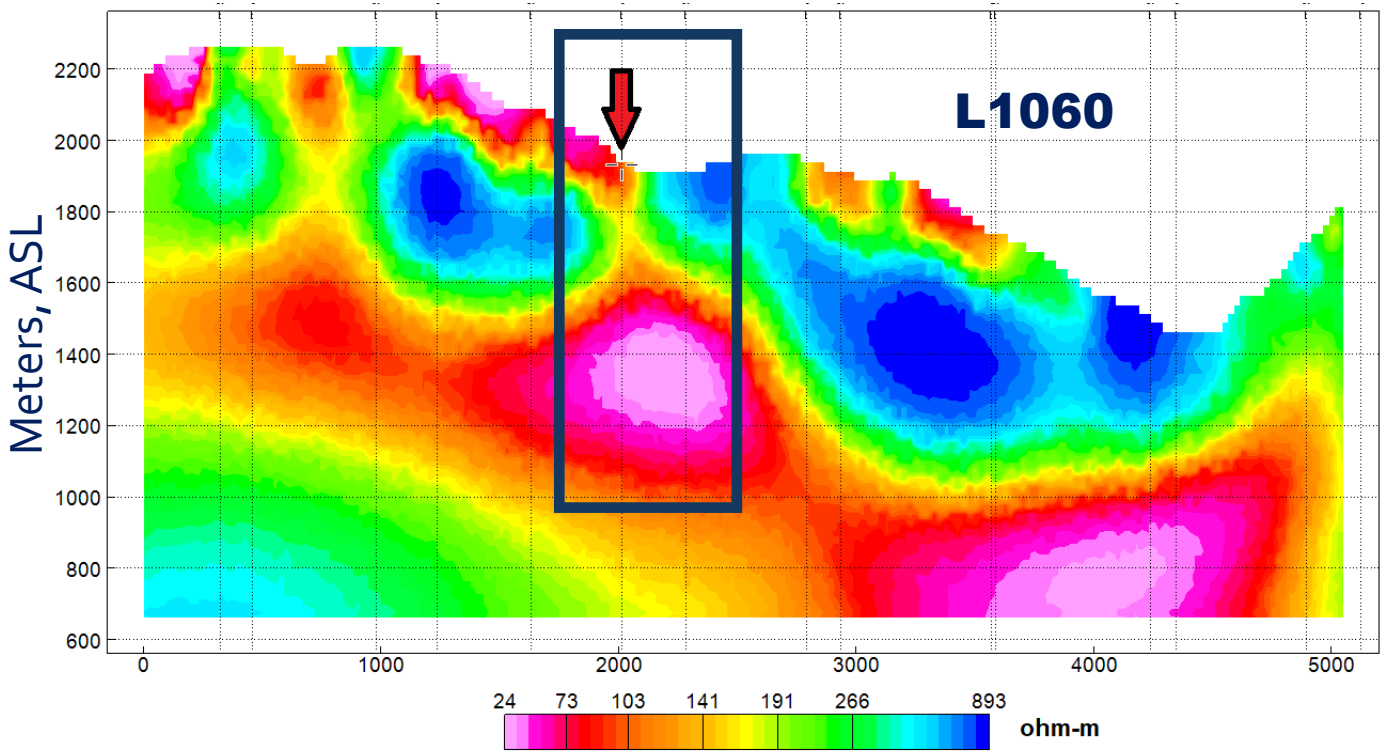
apparent conductivity 10,771 Hz

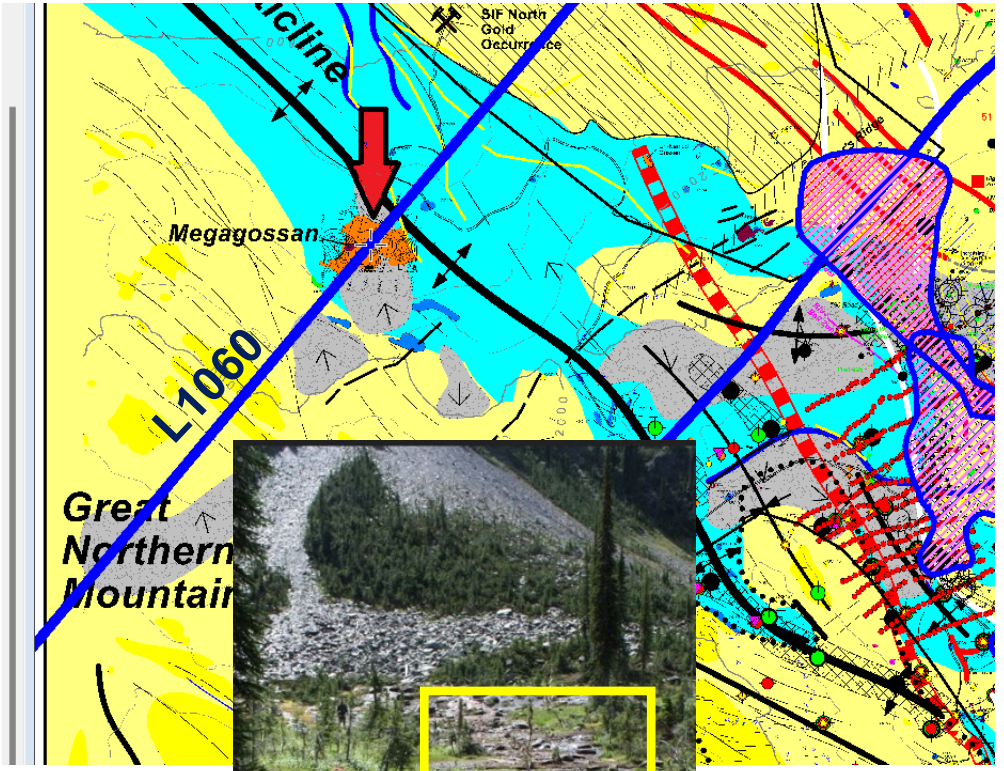


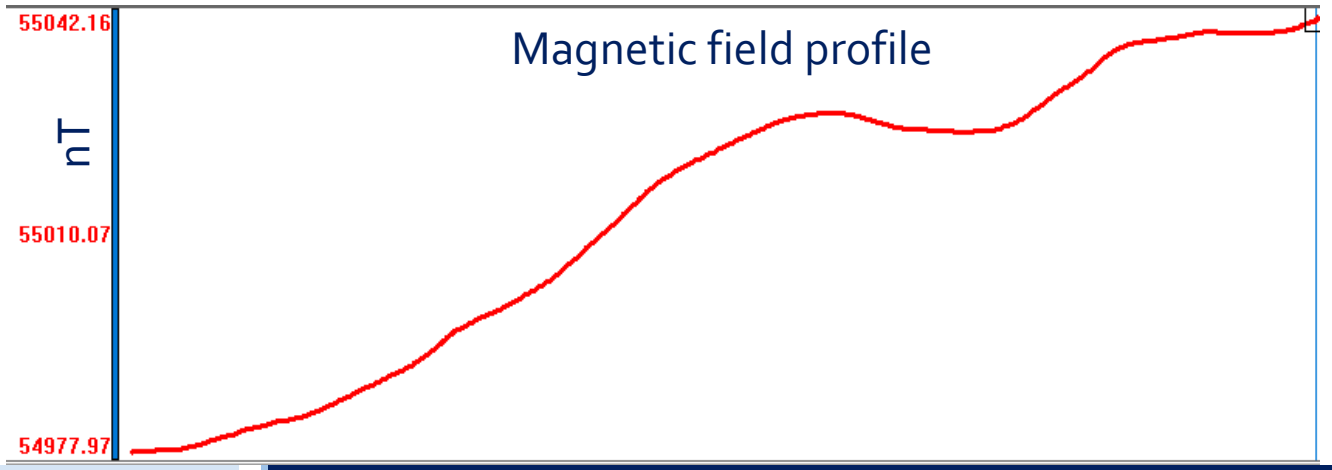
known epithermal deposits



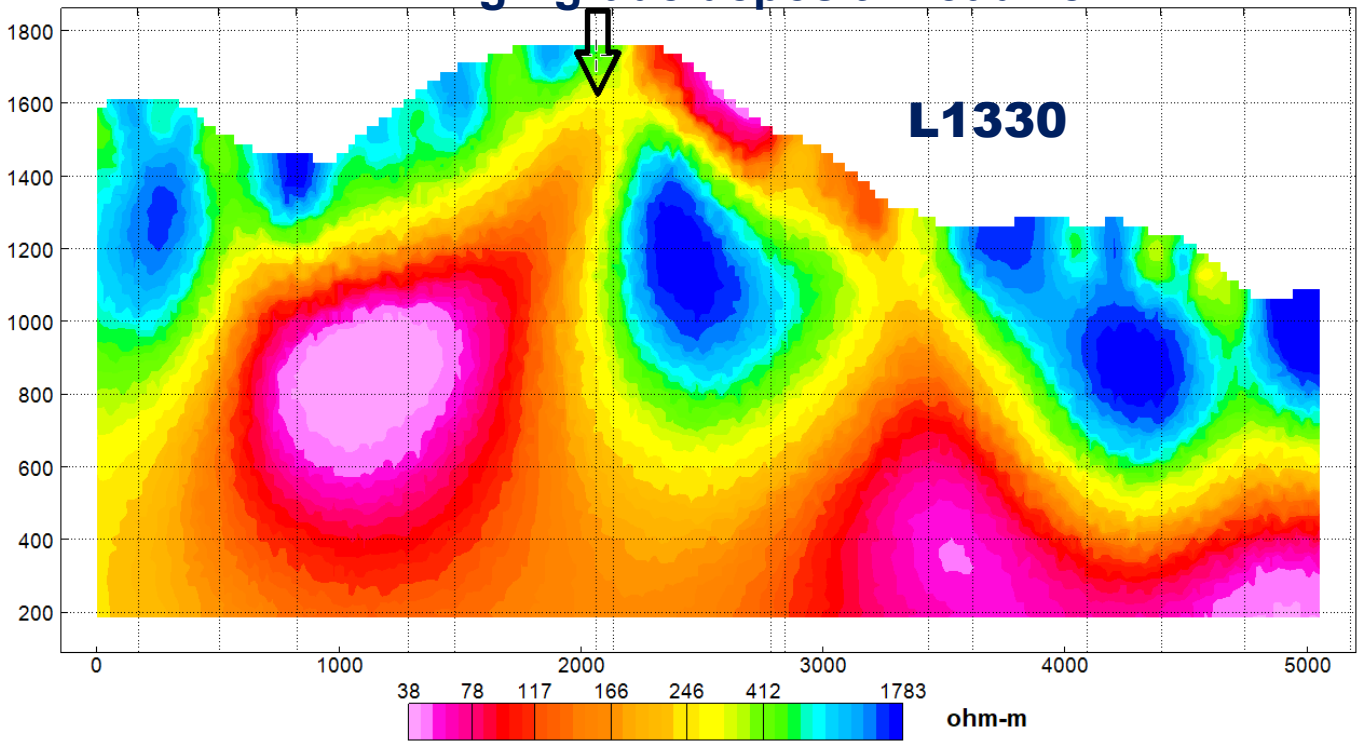
Megagossan – 40% iron, Ore-grade Ni and Co in soil samples

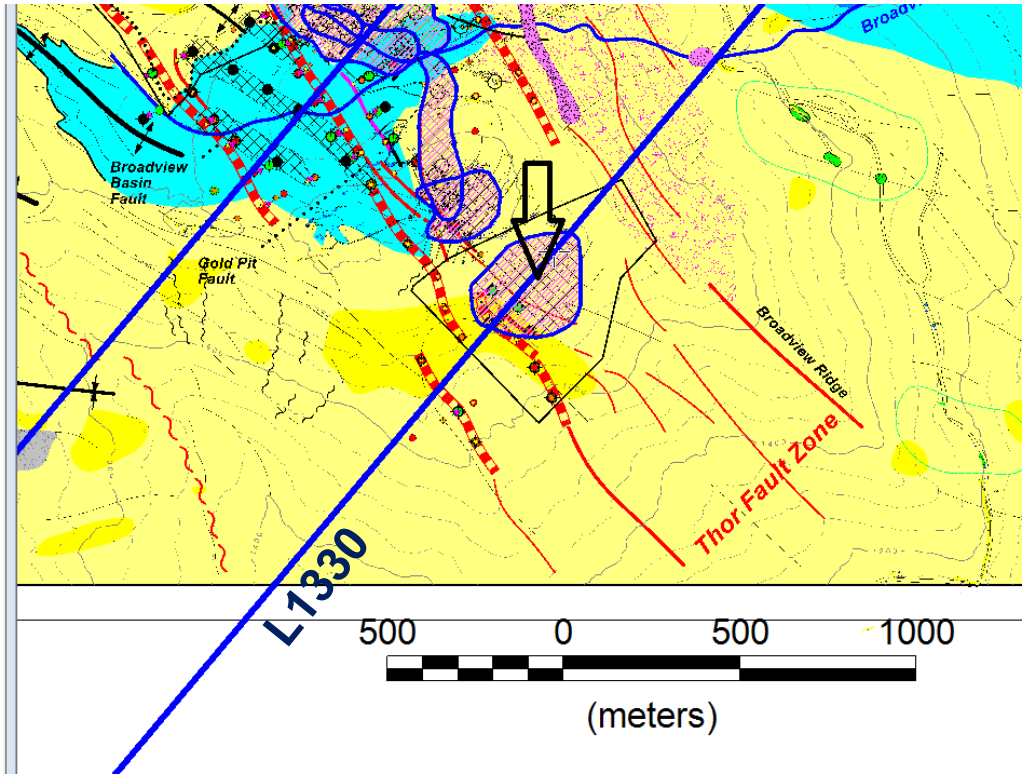


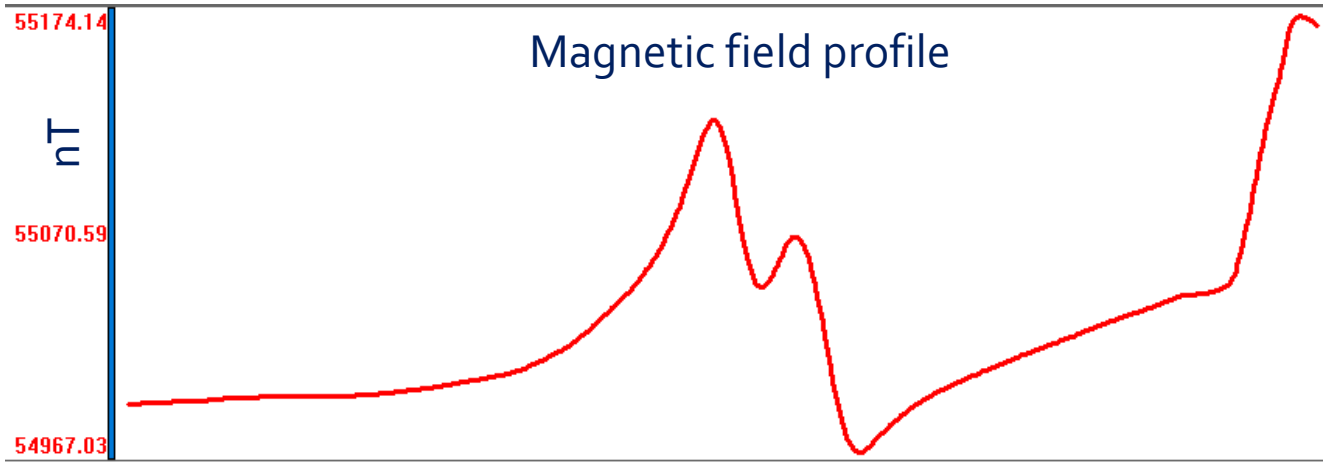




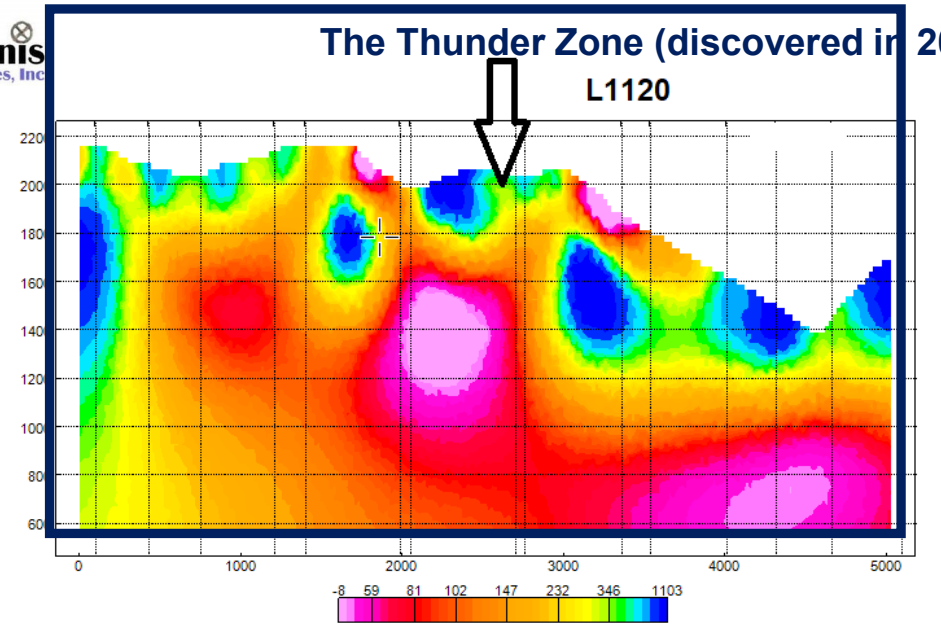
high-grade deposit Broadview

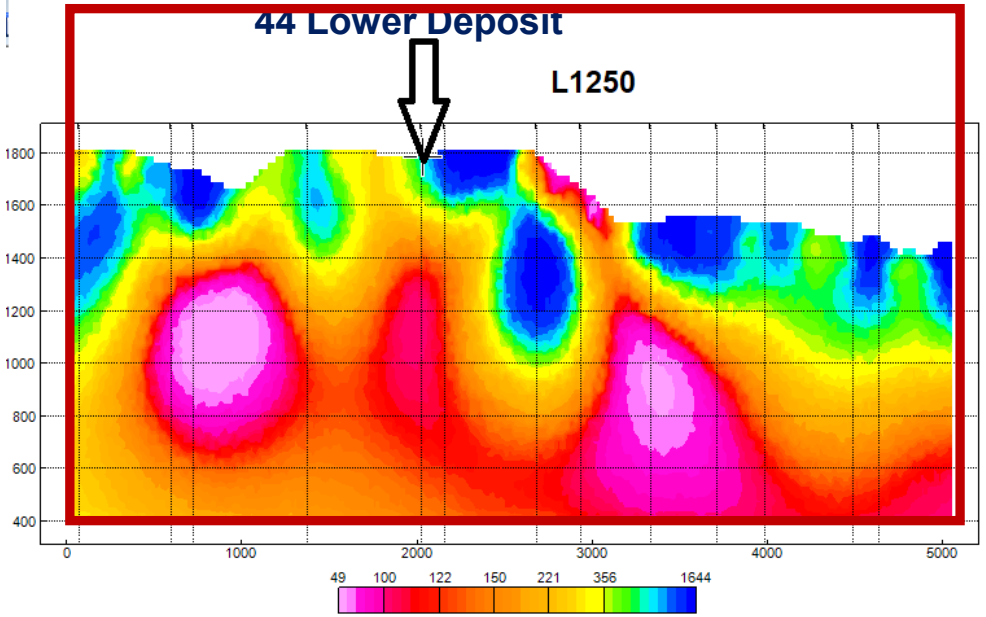


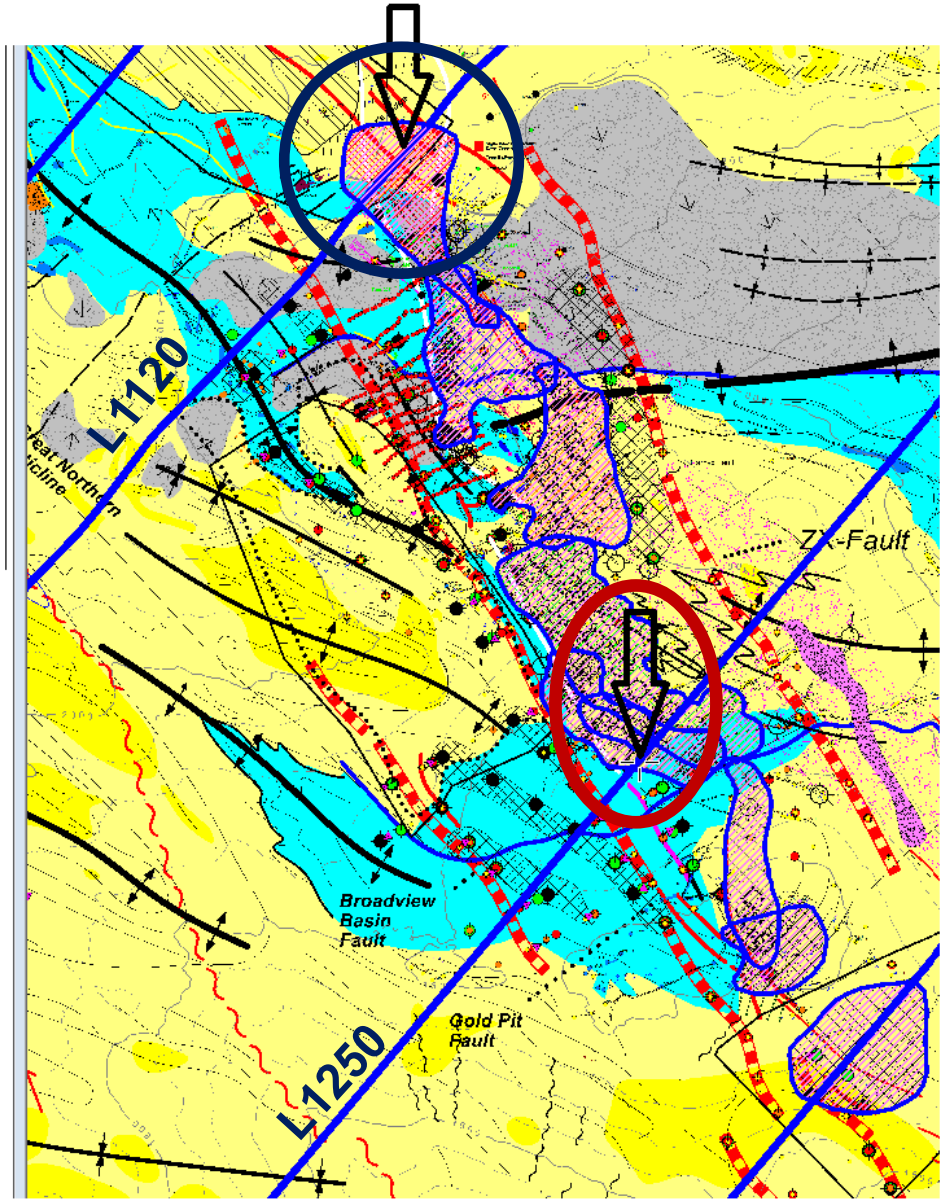




The Thunder Zone (discovered in 2022)



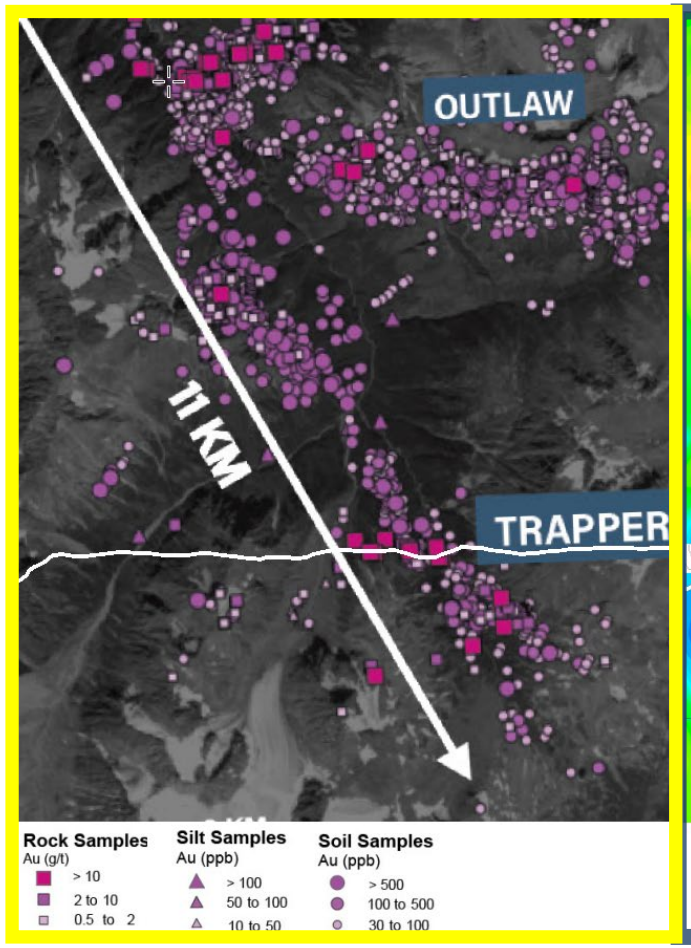


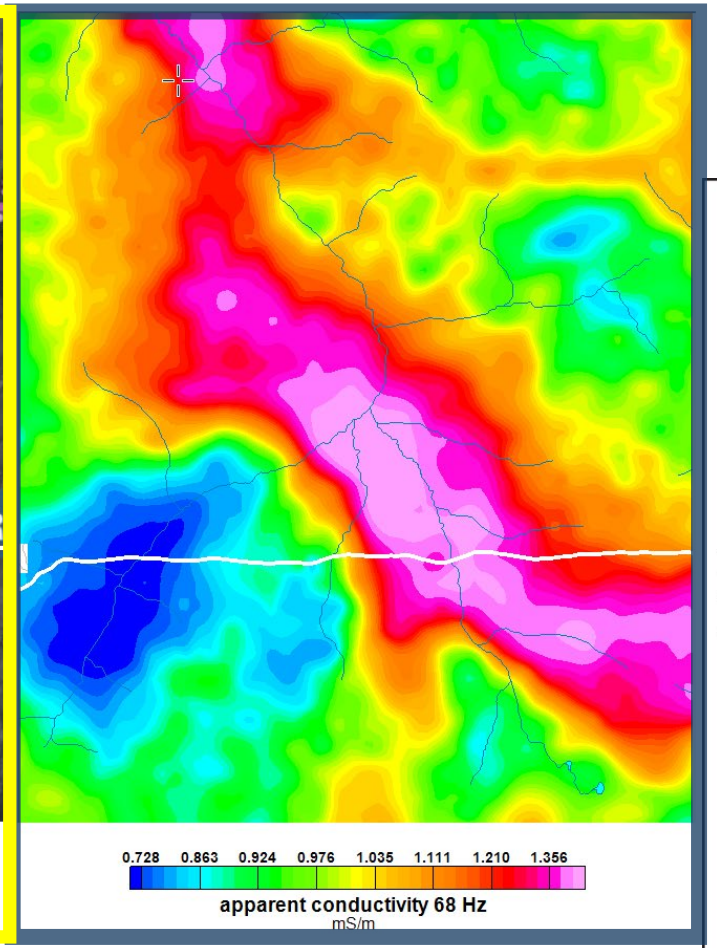


Thorn Project (British Colombia)

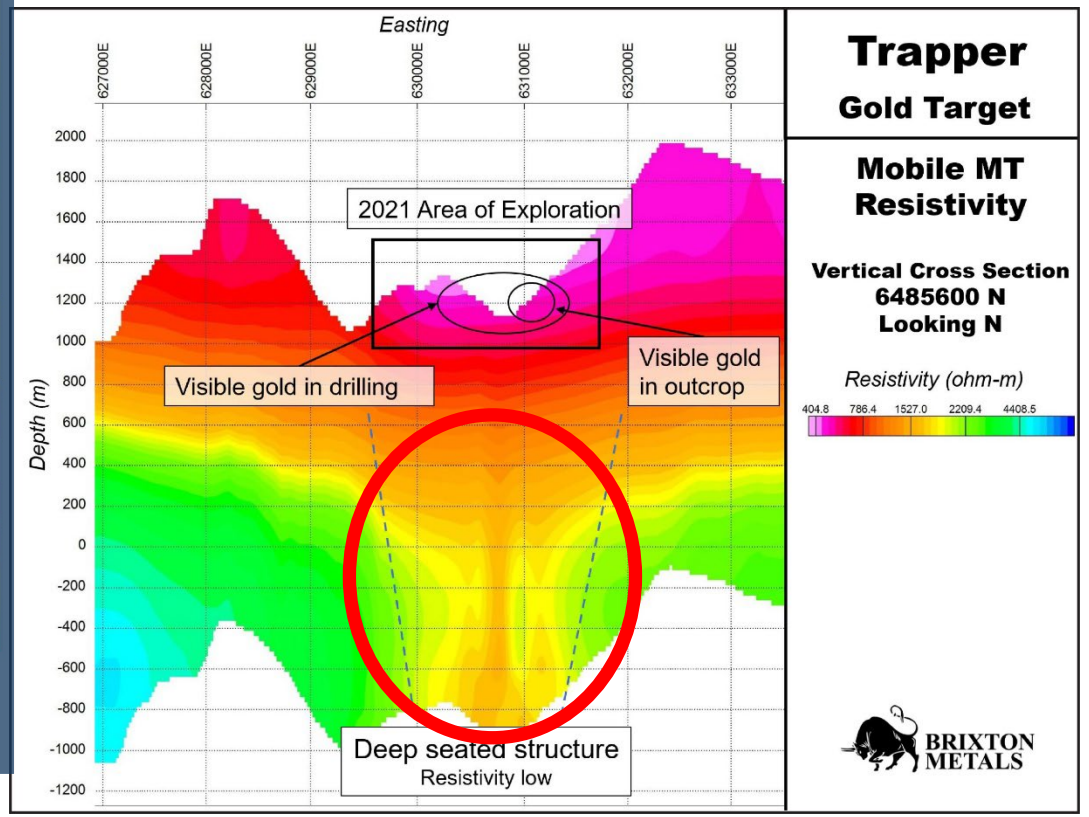
an epithermal to gold-porphyry system with evidence for low-sulphidation and high-sulphidation overprints

The Trapper Target is a deep-rooted multi-phase gold porphyry system

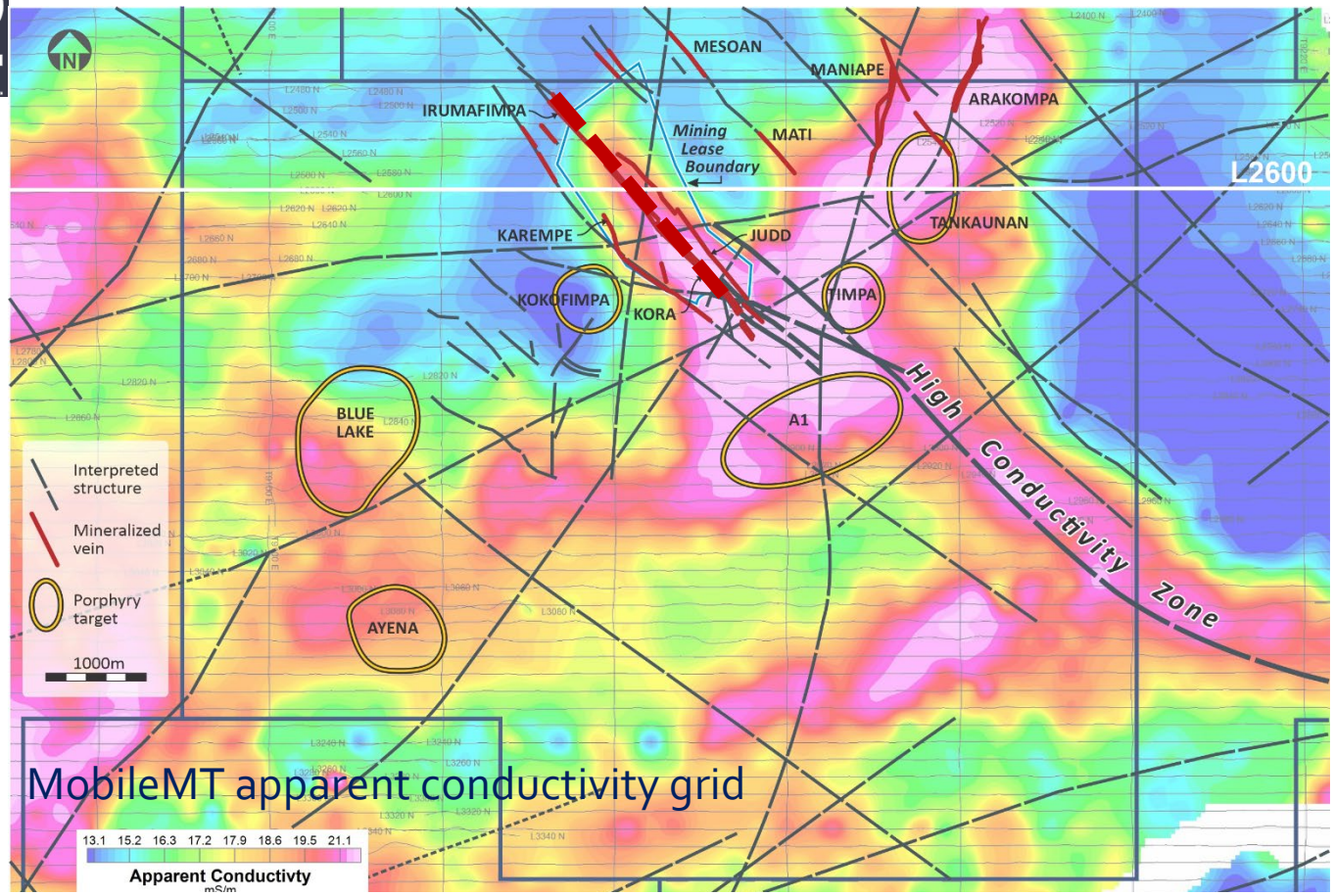


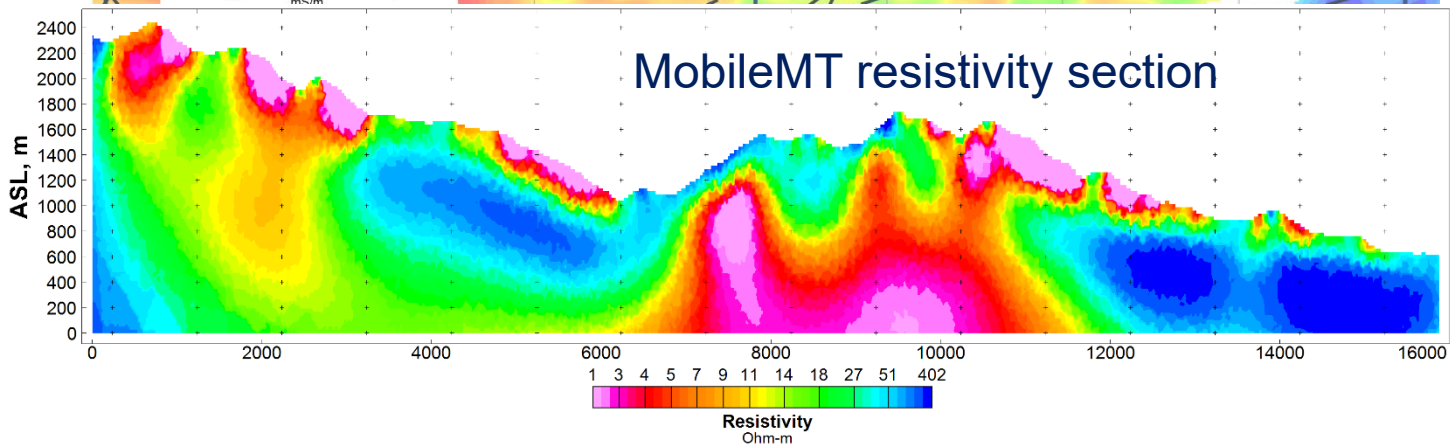


Hole THN21-186 (Trapper Target) yielded 11.0m of 19.25 g/t gold from 50m within 139.0m of 2.14 g/t Au



New Guinea Thrust Belt

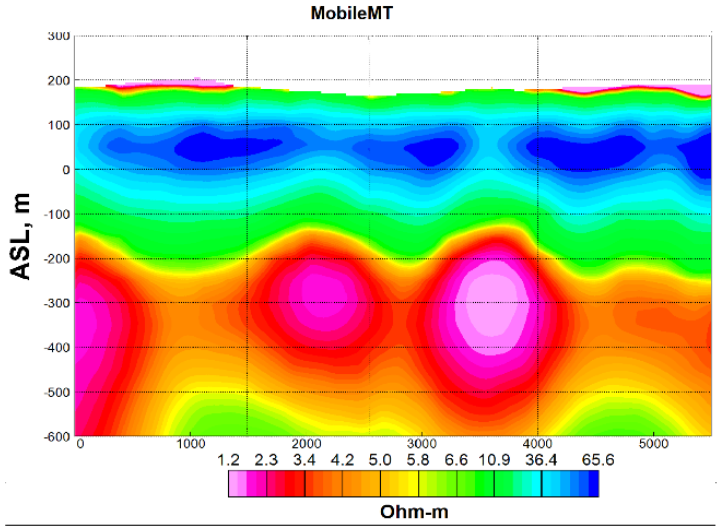




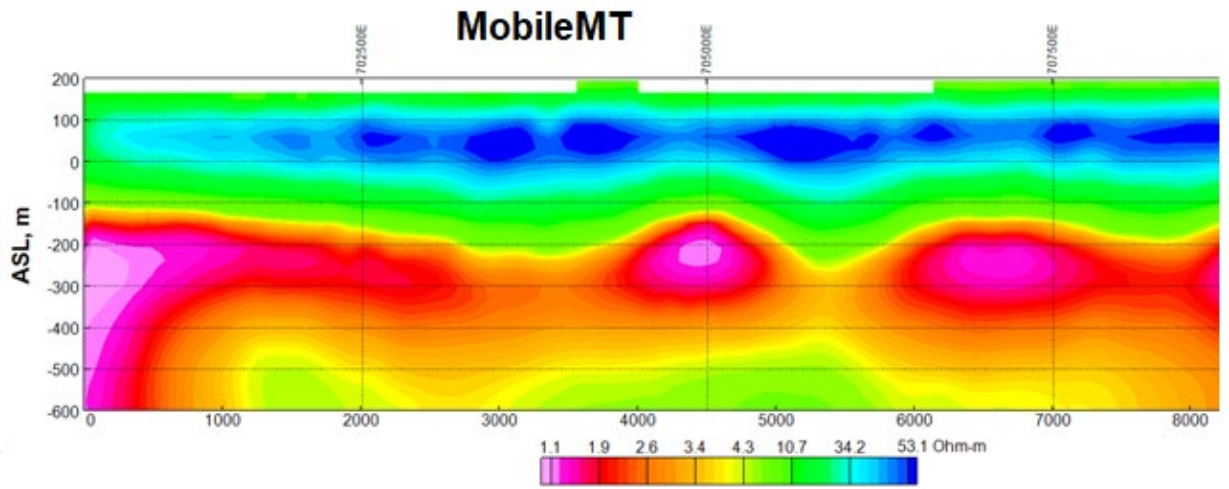
Au,Ag,Cu epithermal veins with less explored porphyry

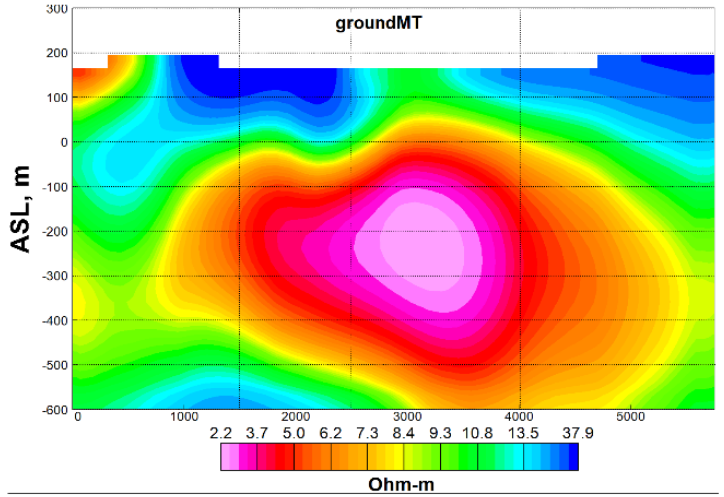
Kora		Irumafimba	
indicated	inferred	indicated	inferred
2.1 moz	2.5 moz	0.2 moz	0.2 moz
at 9.2 g/t Au Eq	at 9.5 g/t AuEq	at 10.4 g/t AuEq	at 13.4 g/t AuEq

Olympic Dam region (South Australia) copper-cobalt deposits at Elizabeth Creek (Emmie Bluff)

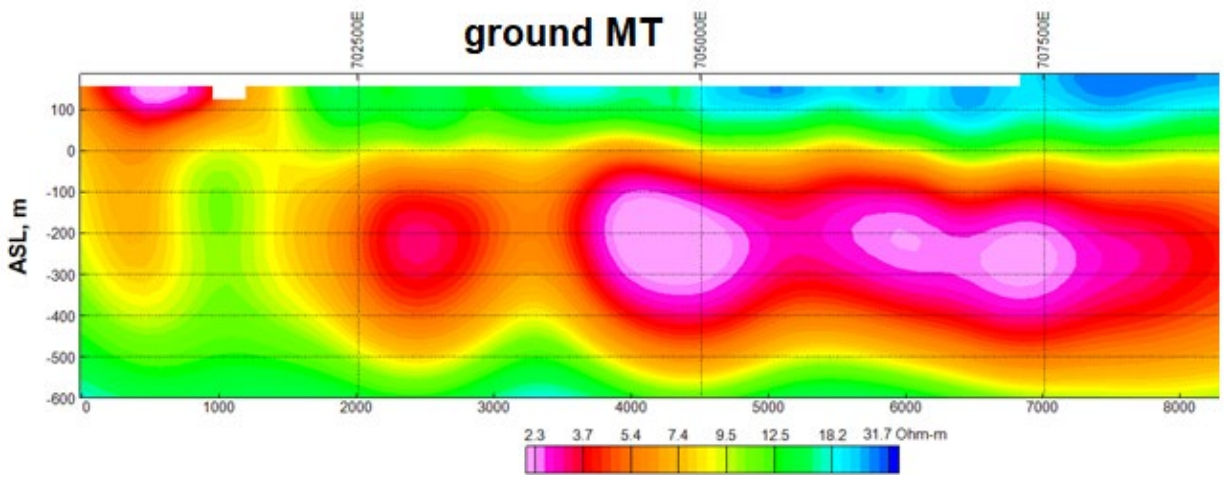


27-445 Hz with a station spacing ~12-15 m

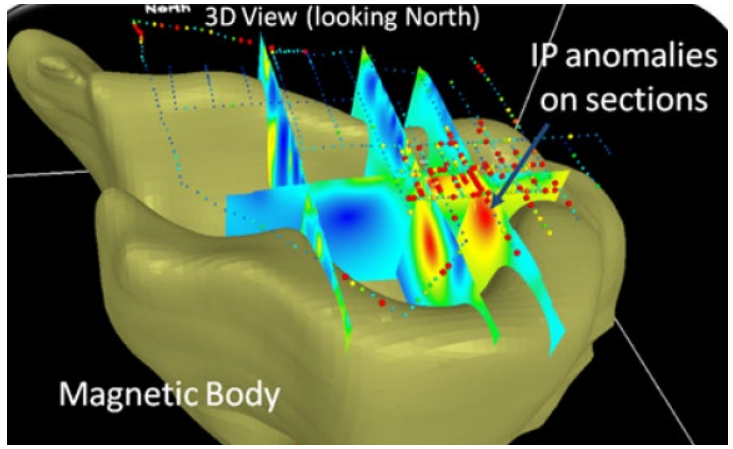


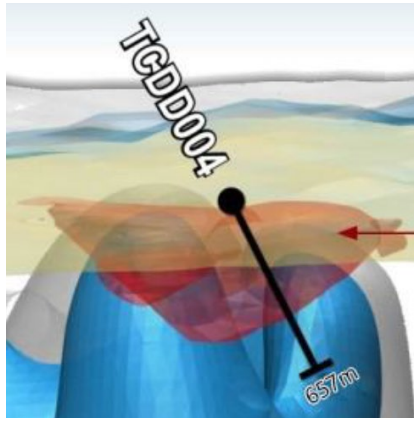


0.001 - 250 Hz with a site spacing ~500 m.



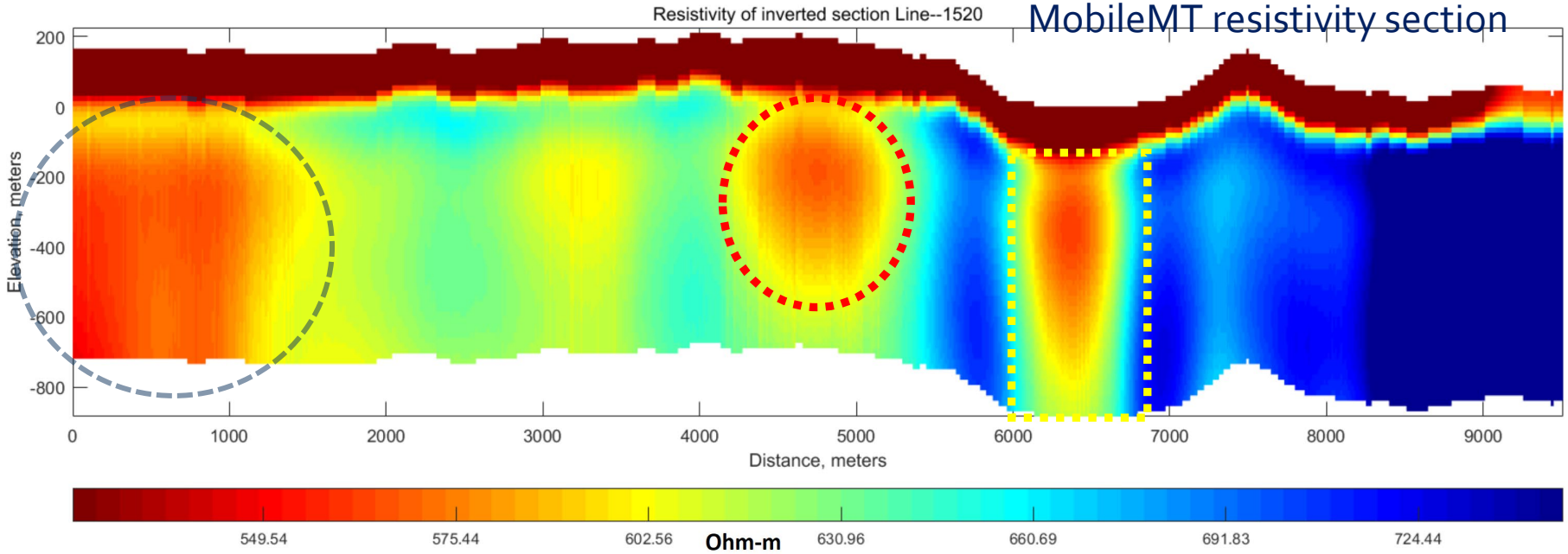
Thomas Creek Co-Cu sulfides (Mount Read Project, Western Tasmania)



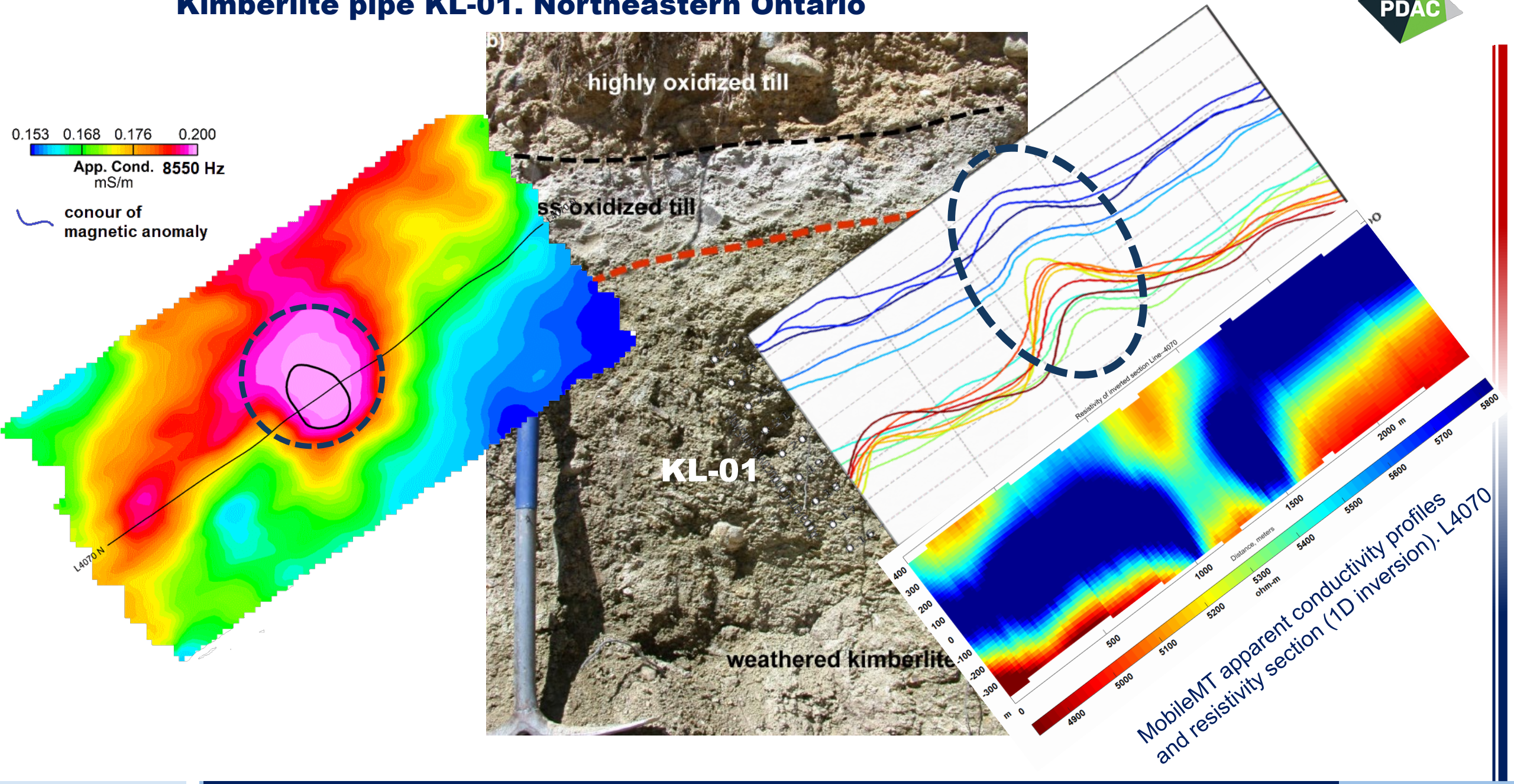


visible copper sulphides from 199m to 298m depth

MobileMT resistivity section



Kimberlite pipe KL-01. Northeastern Ontario



MobileMT apparent conductivity profiles and resistivity section (1D inversion). L4070

Conclusions

Electromagnetic surveys are now routinely performed from airborne platforms, but different principles have its own advantages and limitations.

The electromagnetic principle exploiting natural fields as a source of primary transmitting force, provides capability of deep exploration of the geological environment, sensitive in the broad range of resistivity differentiations, and much less dependent on terrain clearance at a limited height above the ground comparing to systems with controlled field sources.

As practice shows, at a combination of technical solutions, airborne EM systems based on natural fields, are capable to solve exploration tasks in a wide range of commodities in different conditions of the geological and geoelectrical environments.

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