MobileMT: Applications in exploration for basement-hosted uranium deposits (on the Shadow project example)

from innovations to discoveries

Airborne EM Surveying for Uranium Exploration

- EM surveys can aid in identifying faults and favorable lithologies
- Can detect basement features where they coincide with graphitic zones – classic approach for uranium exploration
- The **MobileMT system** has a superior depth of investigation compared with other airborne EM systems, even in conductive environments, and under flat-lying conductive units (i.e., sediments)
- It is also sensitive to resistivity differentiations in the thousands and tens of thousands of ohm-m's range

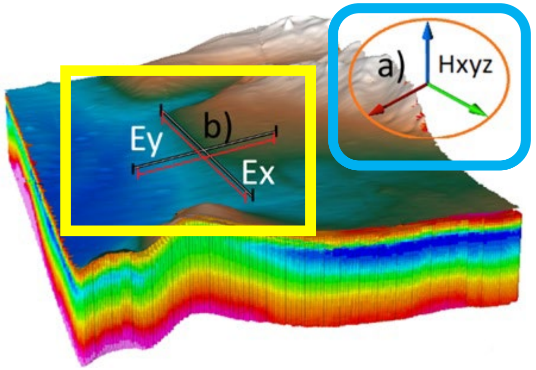
MobileMT System

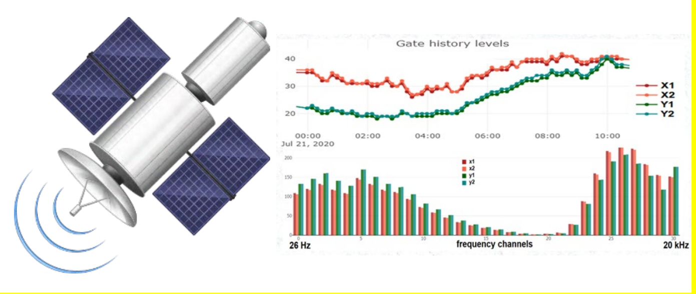
- Utilizes naturally occurring EM fields, over a broad frequency to understand variations in subsurface electrical structure
  - Data at higher frequencies → shallow geoelectrical variations
  - Data at lower frequencies → deeper structure
- Capable of detecting resistivity contrasts in any direction (i.e., horizontal/vertical)
- Depth of investigation in conductive environments exceeds several hundreds of meters, and in resistive environments can be > 2 km

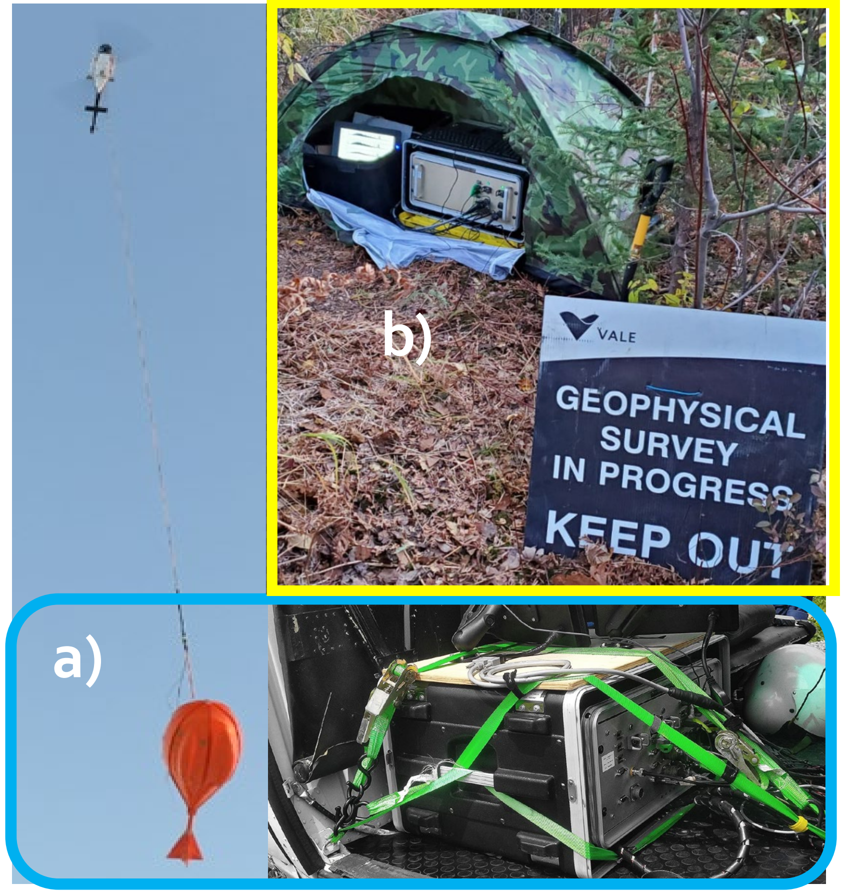
BASELODE ENERGY

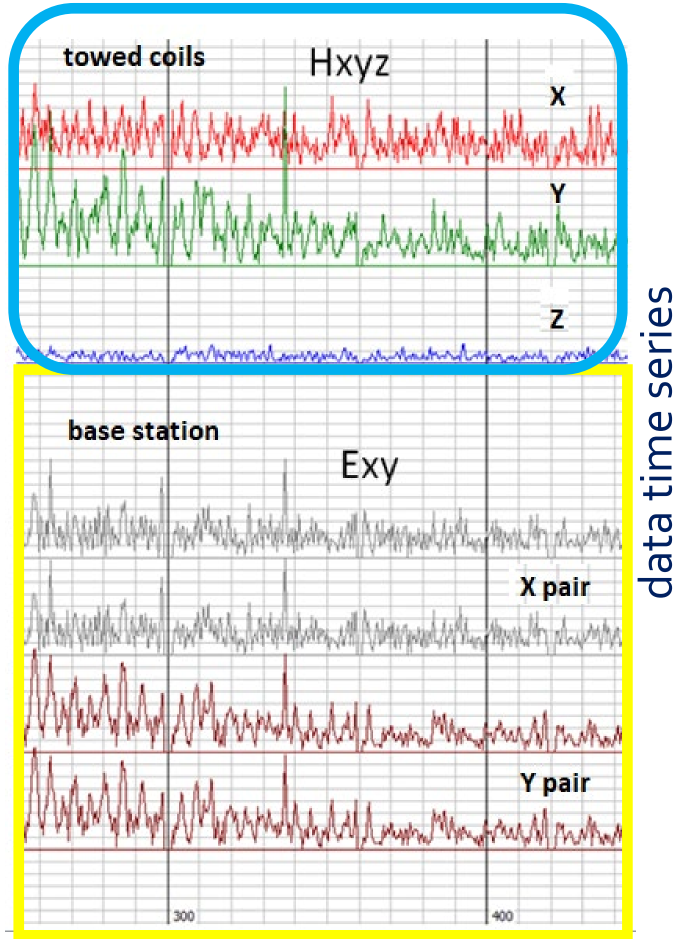
EXPERT GEOPHYSICS

MobileMT – data acquisition and processing









H **towed coils**

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

E **base station**

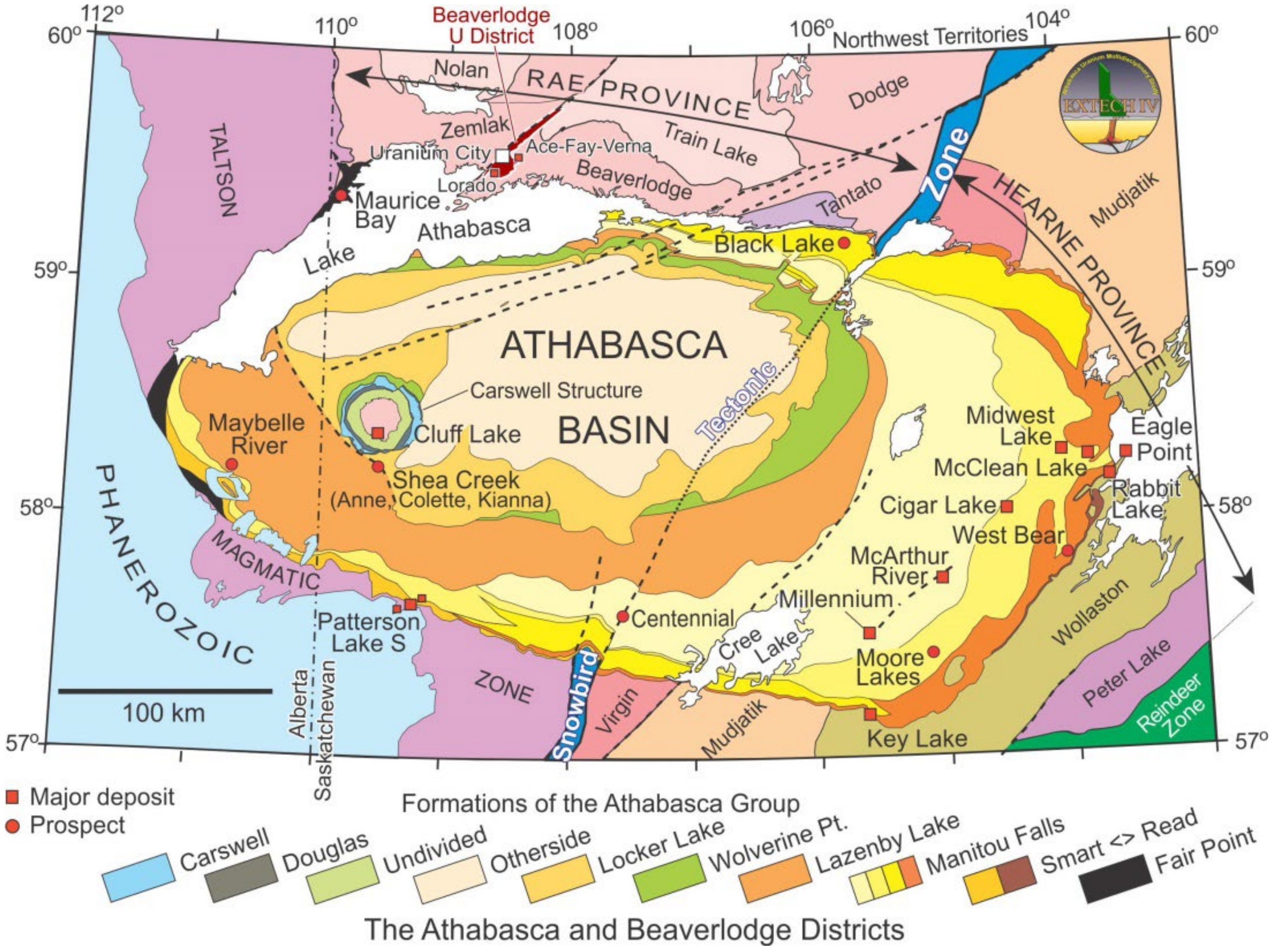
$$E = \begin{bmatrix} Ex \\ Ey \\ 0 \end{bmatrix}$$

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

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

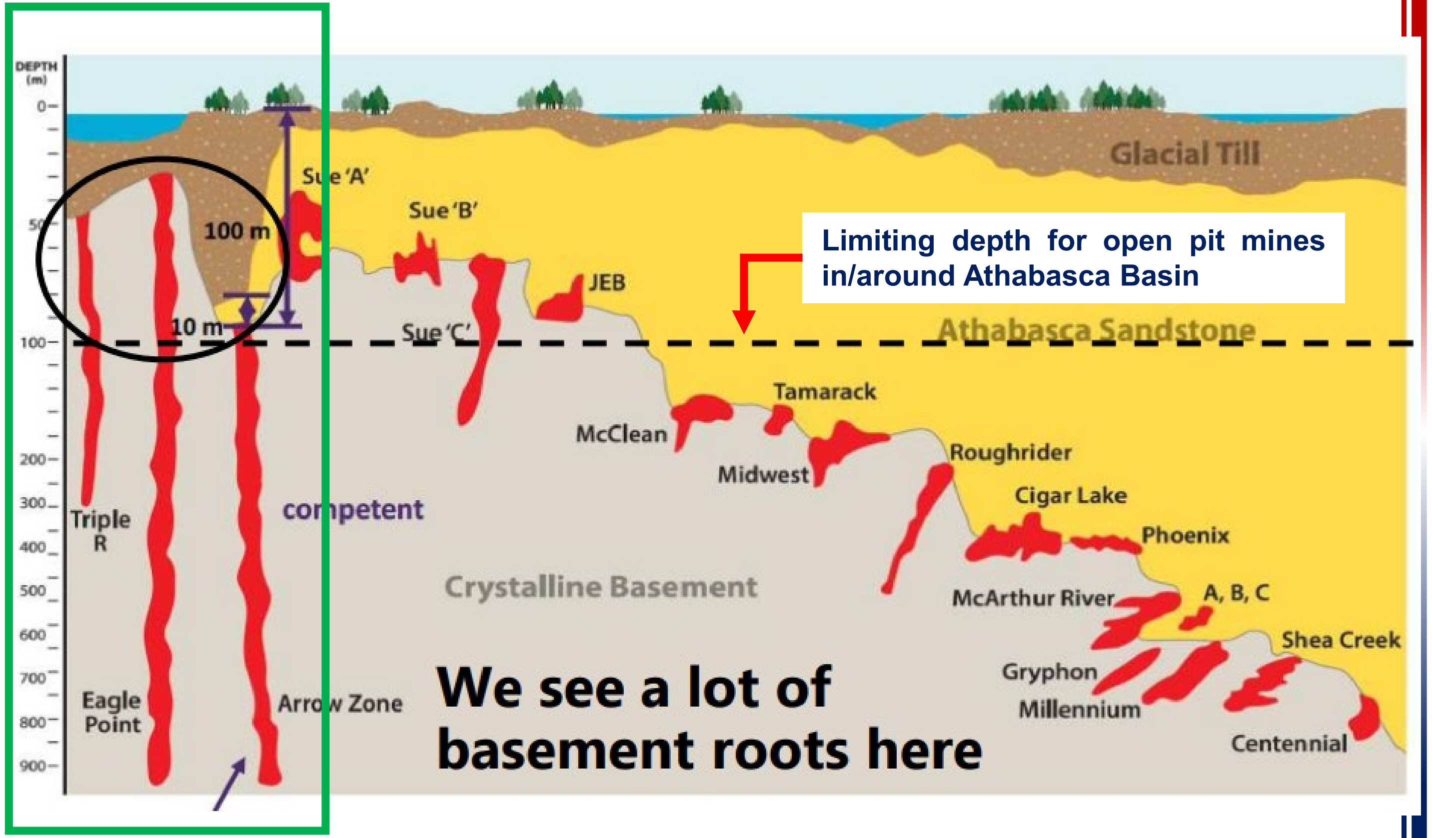
Athabasca Basin Uranium Deposits

- Athabasca Basin is a Proterozoic sedimentary basin where Athabasca Group sandstones unconformably overlie granitic and metasedimentary basement rocks, including graphite-rich lithologies
- Eastern Athabasca region has been the hub for uranium exploration and mining for the past ~50 yrs
- In the Athabasca Basin, the uranium deposits consist of massive pods, veins and disseminated uraninite



Unconformity Related Uranium Deposits

- Distinction between 3 types of Atahbasca uranium deposits
  1. Sandstone hosted mineralization **ABOVE** the unconformity
  2. Mineralization **AT** the unconformity
  3. Basement-hosted, fracture controlled or vein mineralization **BELOW** the unconformity
- Unconformity related uranium deposits represent the largest high-grade U ore-bodies
- Exceptional grade and size results from combined efficiency of a series of U-fractionation mechanisms, including a strong geochemical trap at the unconformity



The goal is to avoid sandstone cover, and focus on near surface mineralization.

From Baselode Energy corporate presentation (2020).

Pros of Basement-Hosted Deposits

Basement-Hosted Deposits

- "Simpler" geology; no sandstone
- More competent rock
- Easy mineability
- Examples: Arrow, Rabbit Lake, Eagle Point, Uranium City

The goal is to avoid sandstone cover and focus on near surface mineralization.

Traditional Unconformity Deposits

- Complex geology; sandstone
- Incompetent
- Mine engineering difficulties (water infiltration from overlying sandstones)
- Deeper mines require freezing and therefore higher grades are required to mine
- High CAPEX
- Examples: McArthur River, Cigar Lake, Phoenix, Midwest

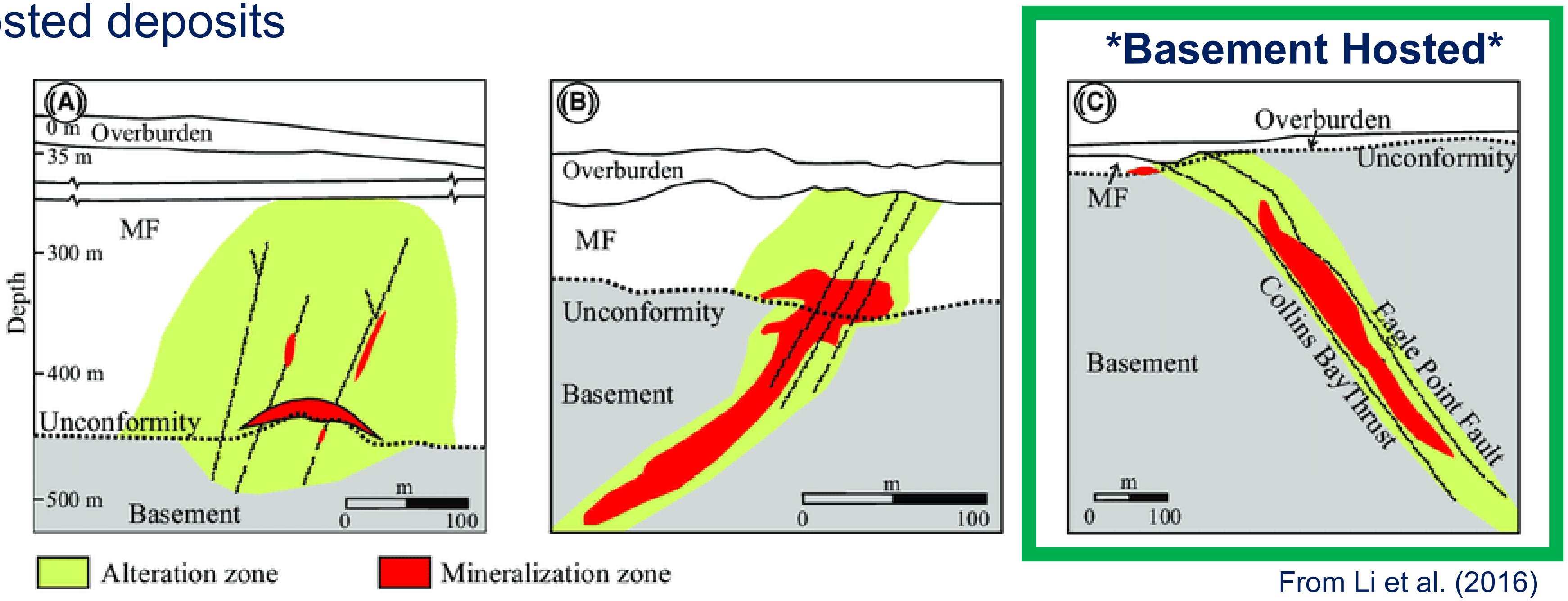
From Baselode Energy corporate presentation (2020).

Basement Hosted Uranium Deposits

- Uranium mineralization requires:

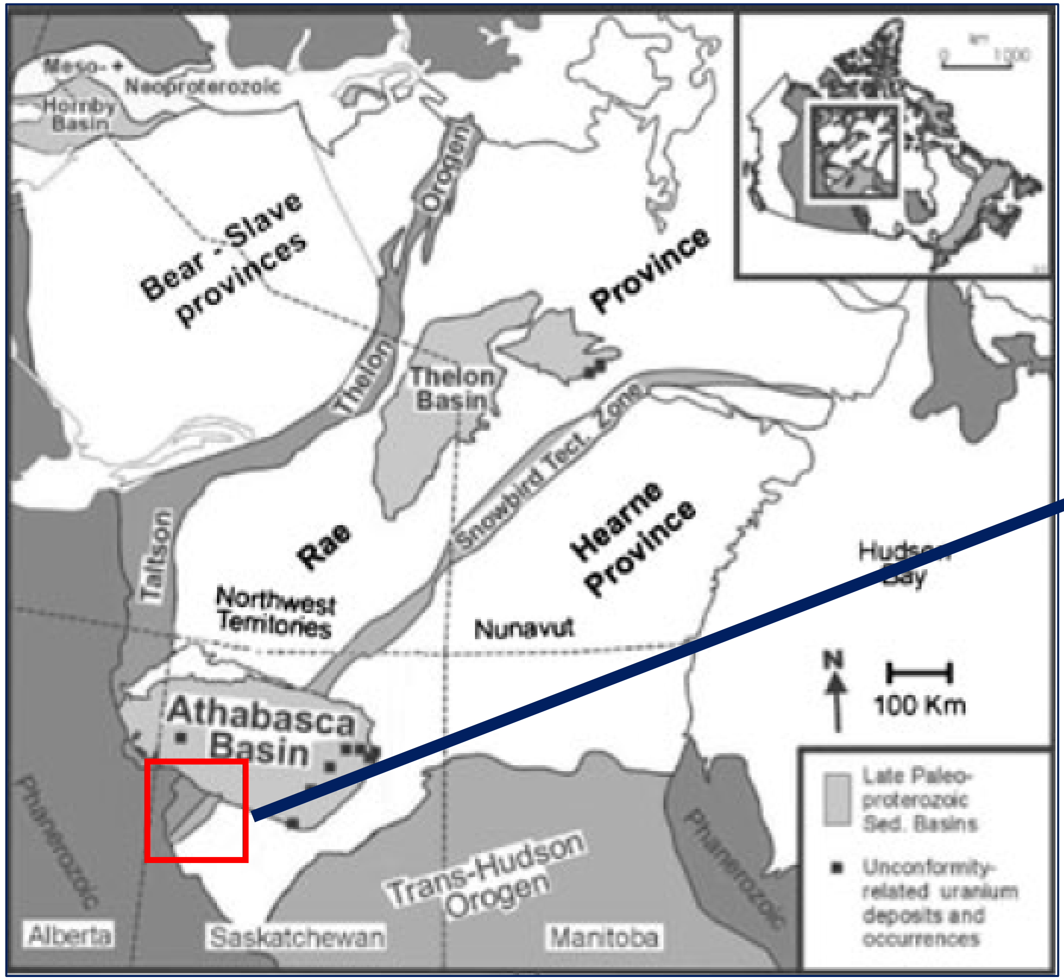
1. Fluids with right composition (i.e., uranium-bearing)
2. Structural traps with the right geometry to help induce precipitation
3. Geochemical traps with right agents that produce precipitation (i.e., redox)

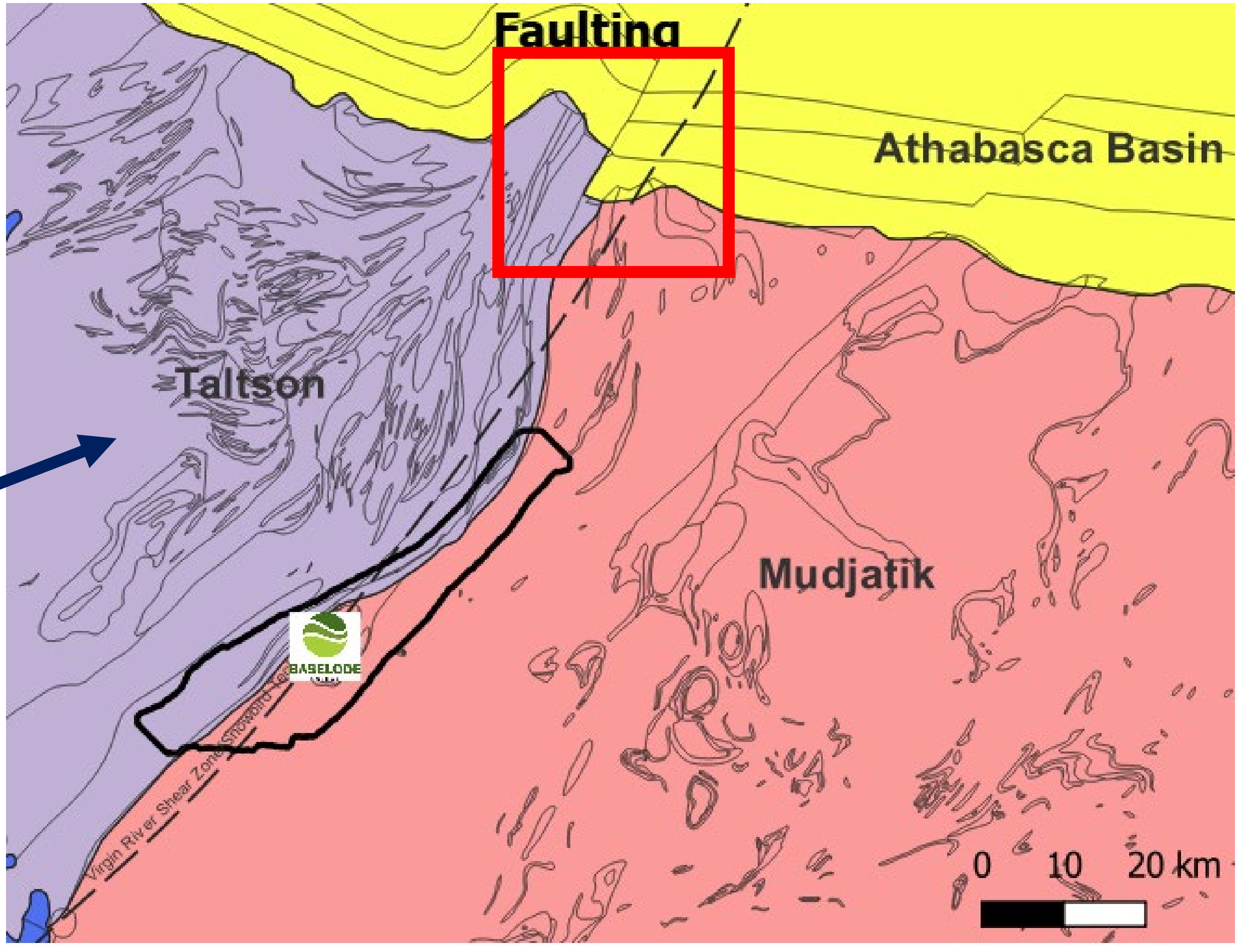
- Athabasca Basin is optimal for all 3 features
- Same features occur in sandstone/unconformity deposits as they do in basement hosted deposits



From Li et al. (2016)

Baselode Energy Shadow Project: Potential for Uranium Deposits

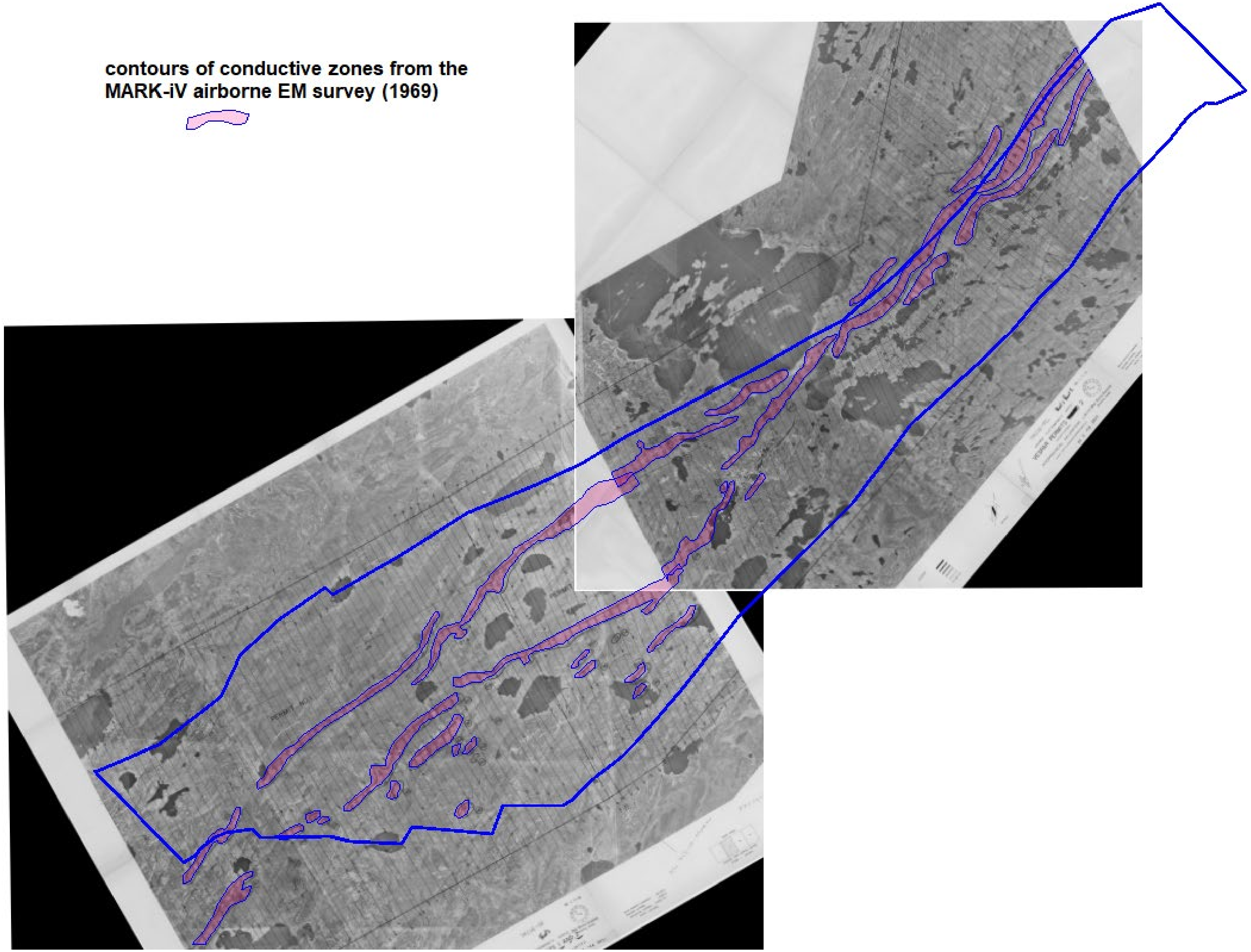




From Cloutier et al. (2011).

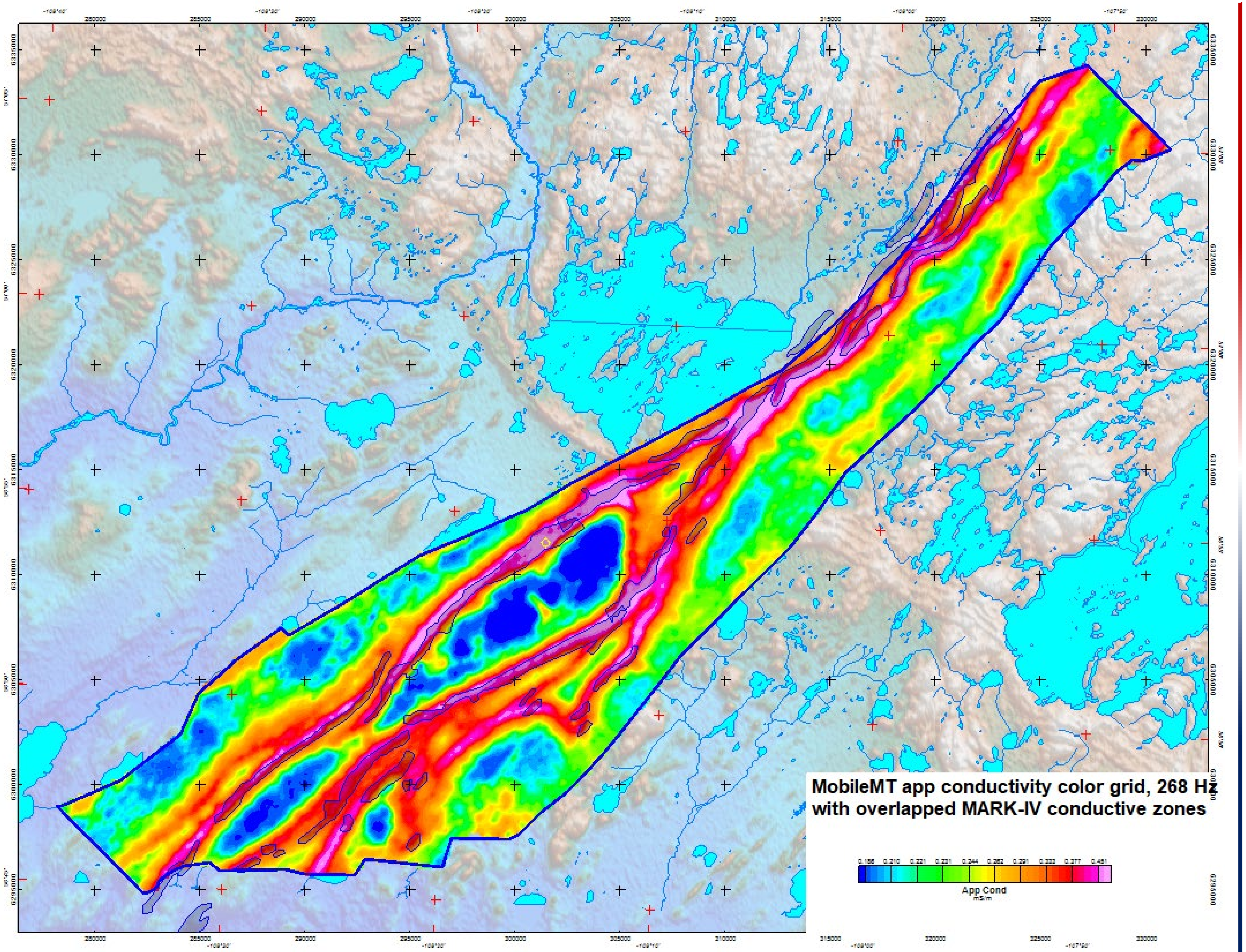
Historical (1969) Airborne EM Survey

- Historic "Mark IV" airborne EM survey successfully defines a series of conductors over 30 km strike length within the Shadow project area



MobileMT Airborne Survey (2020)

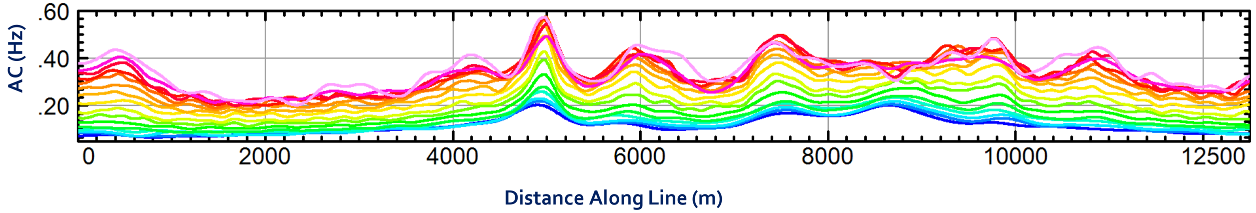
- September 2020 - Expert Geophysics conducted an ~1370 line km geophysical survey over the Shadow project for Baselode Energy
- Acquired magnetic, magneto-telluric, and VLF-EM data
- Final products include inverted resistivity-depth data
- Range of inverted resistivities between 800 to 20,000 ohm-m (from 1D inversion model)
- Excellent correlation of apparent conductivity results with historic Mark IV EM survey conductor anomalies



Shadow Project MobileMT Data

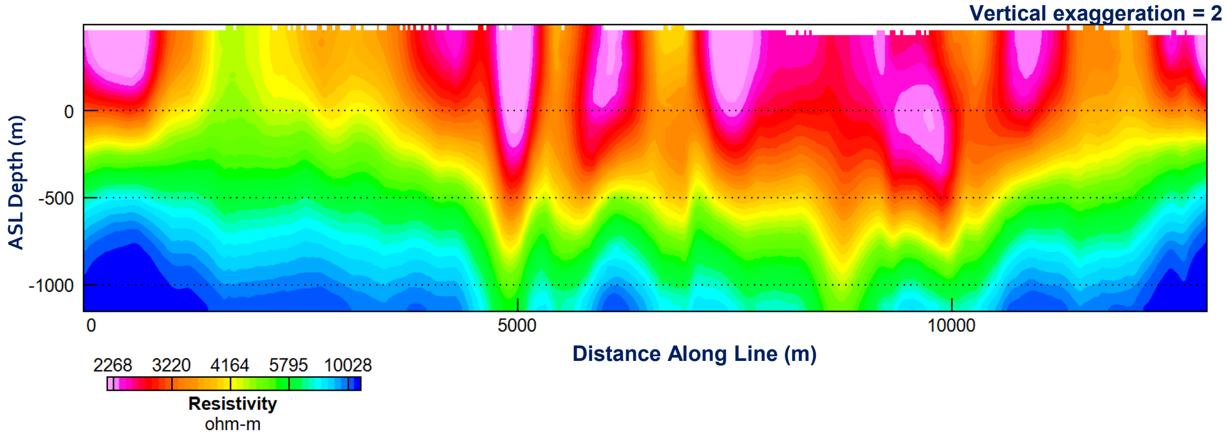
- Output from MobileMT system is apparent conductivity at a number of frequencies for each data point

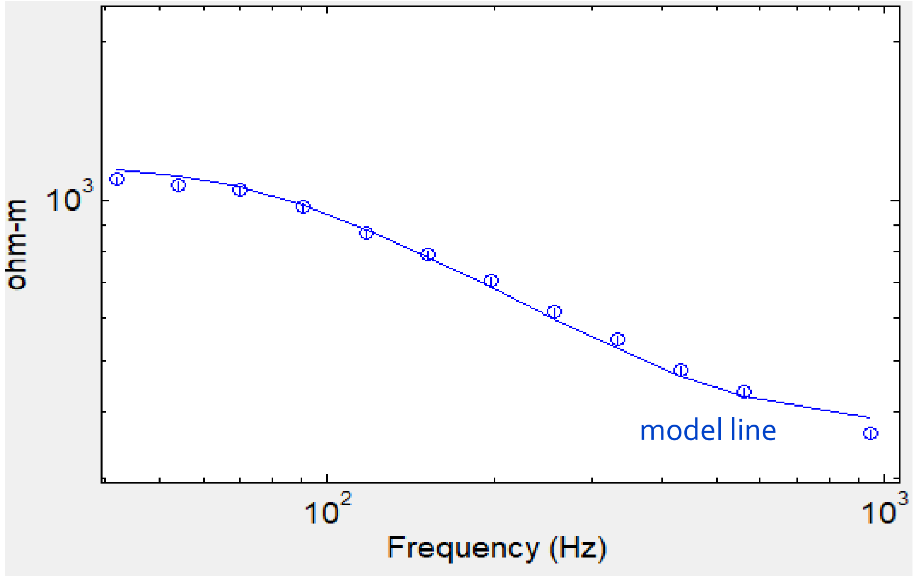
Example profile data from ~25 Hz (cool colors) to 900 Hz (warm colors)



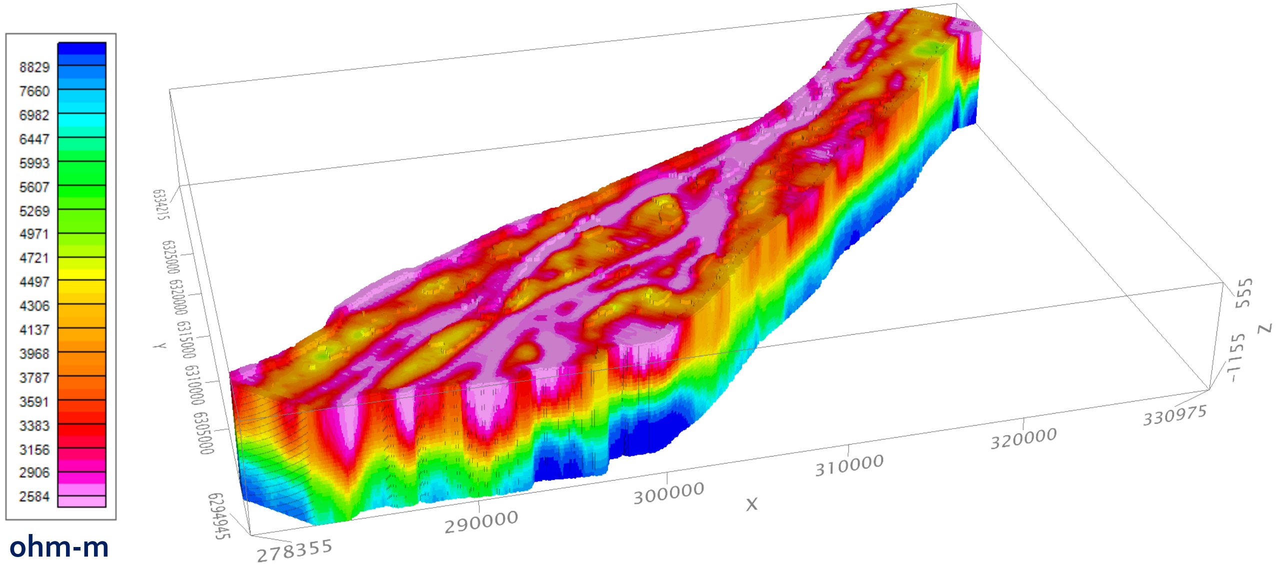
- Apparent conductivity frequency data are inverted to provide resistivity depth information for **each measurement point** along a line

- 1-D res-depth models for each measurement can be used to construct 2-D sections along line, and 3-D voxels

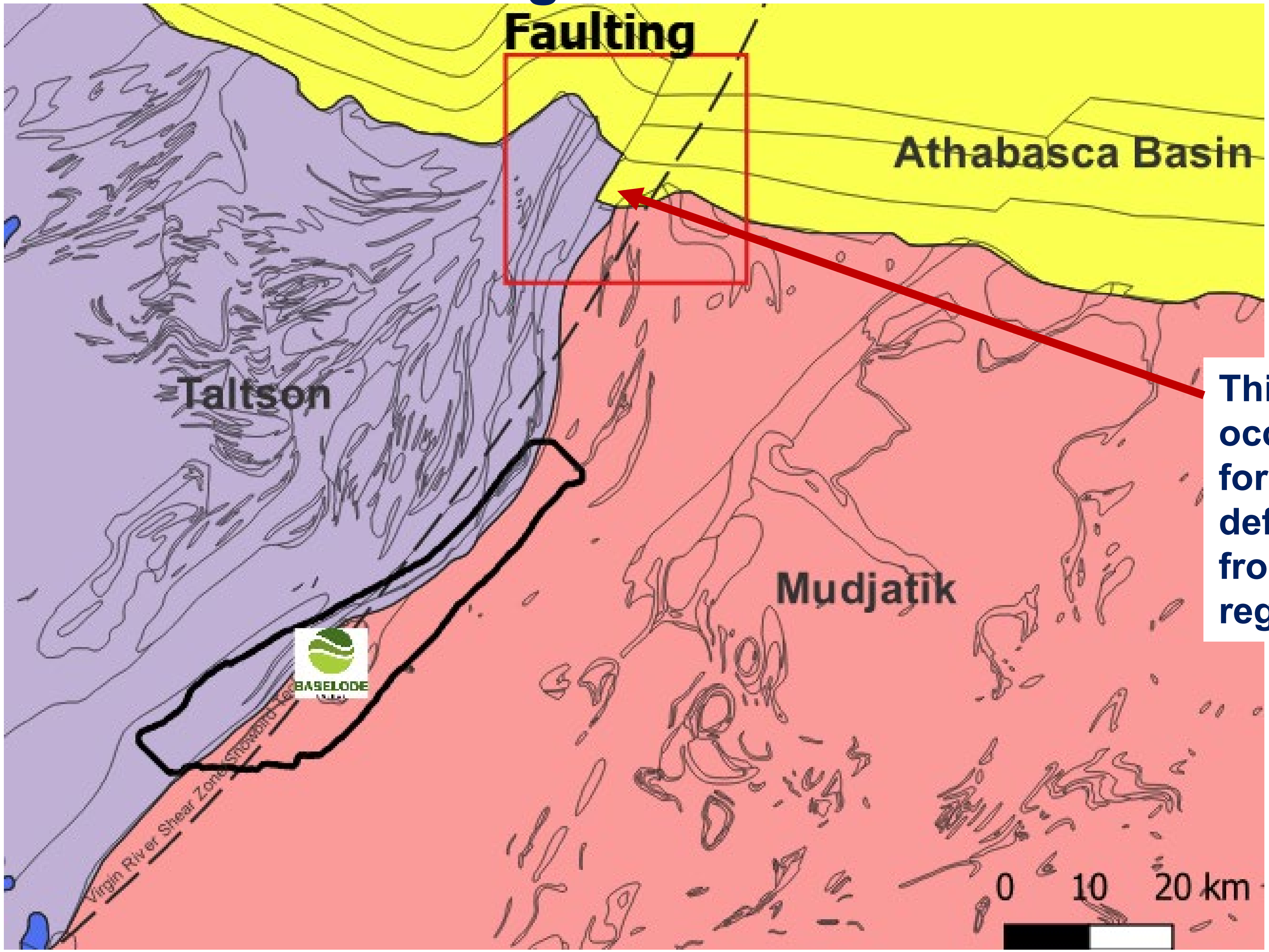




Apparent resistivity (res = 1/cond) curve for each data station is input to inversion routine, which attempts to find an optimal model, based on certain constraints to fit the empirical data.



Defining Structures with MobileMT Data

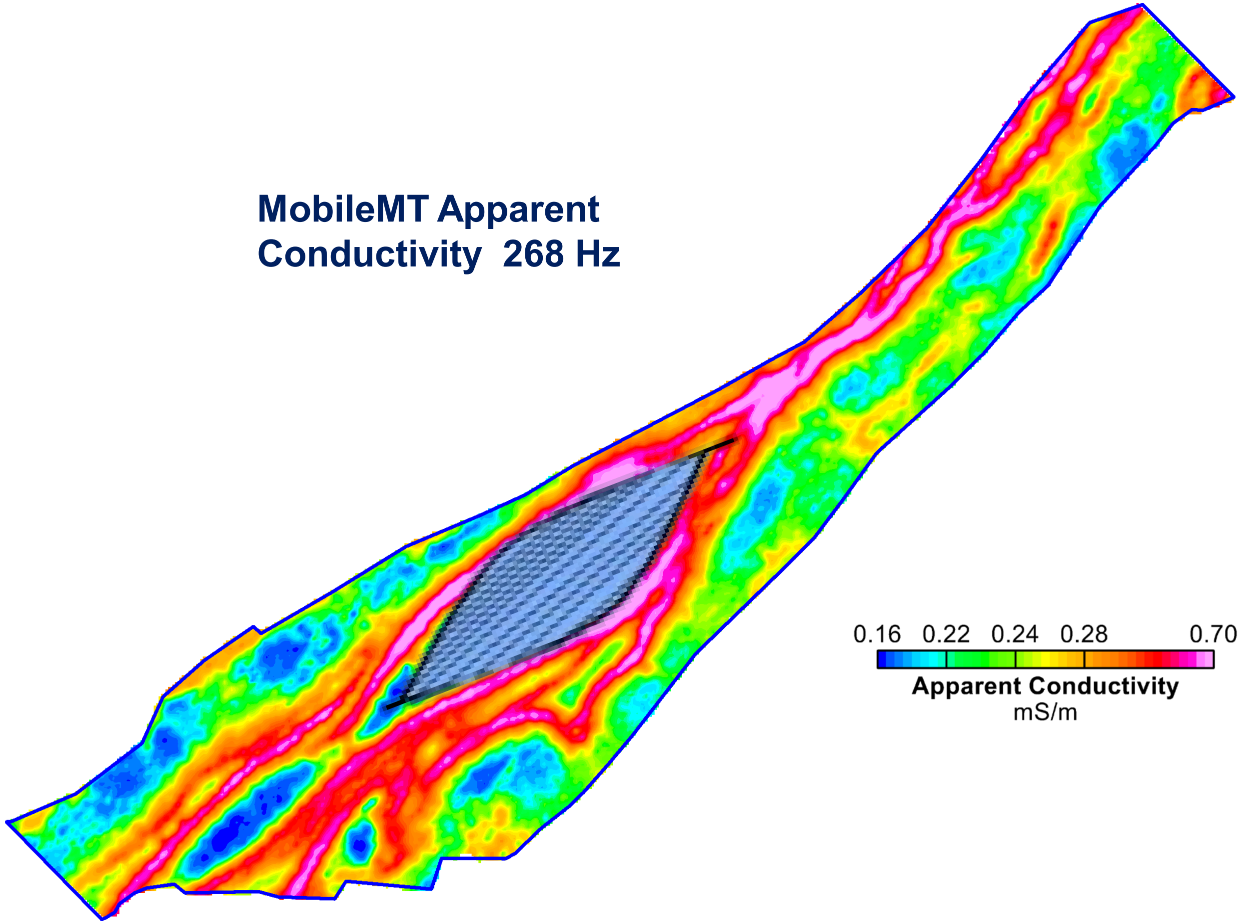


General structural position

This offset must have occurred after basin formation and due to brittle deformation (transition from ductile to brittle regime)

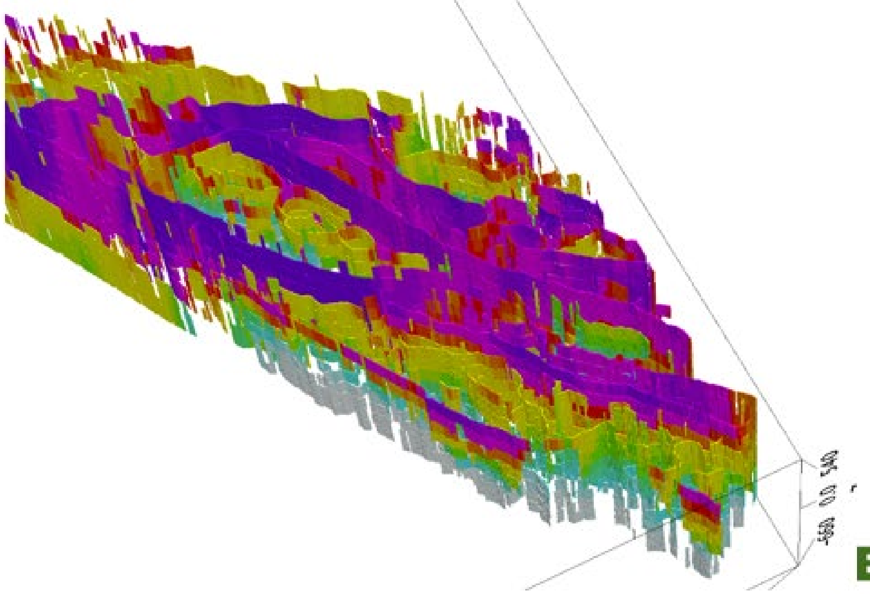
Defining Structures with MobileMT Data

- Lozenge-shape is indicative of shear tectonic zone, tells us the structure in the region is intense
- This shape is observable in the apparent conductivity data from the MobileMT survey (*one large-scale example shown) and allows delineation of conductive features straddling this feature for further analysis

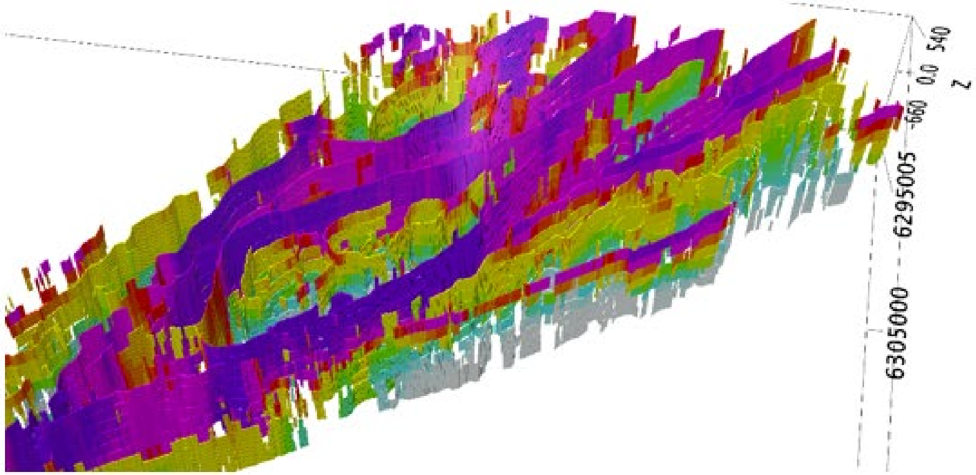


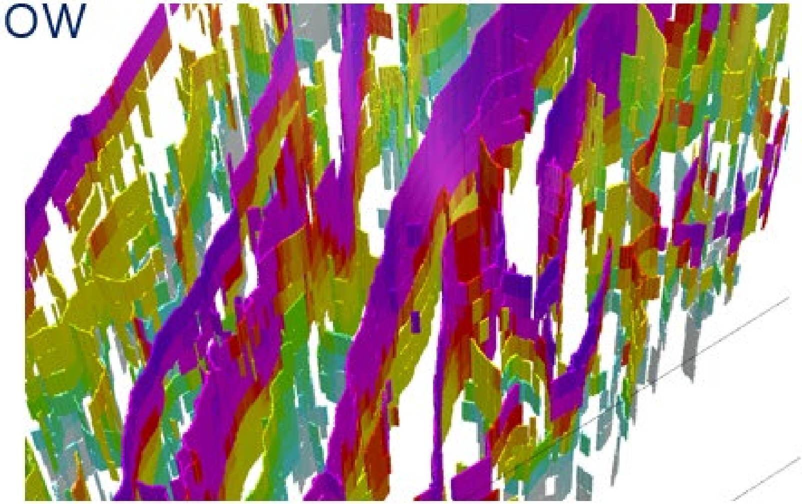
Low resistivity axes in 3D (1 km depth range)

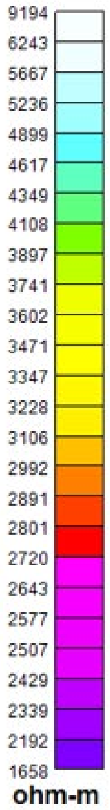
Proterozoic crystalline basement, Virgin River Shear Zone (Northern Saskatchewan)



BASELODE
ENERGY
SHADOW

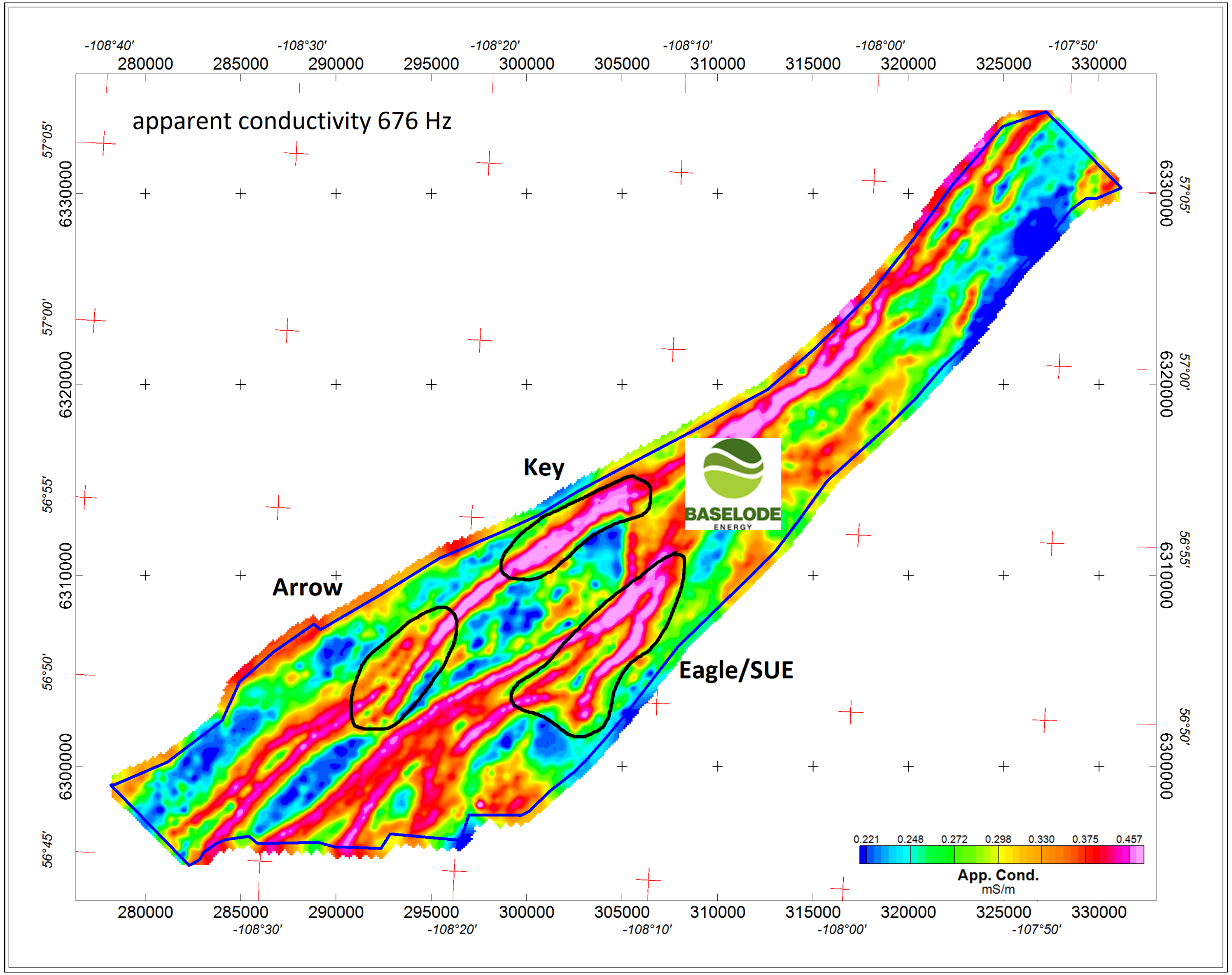




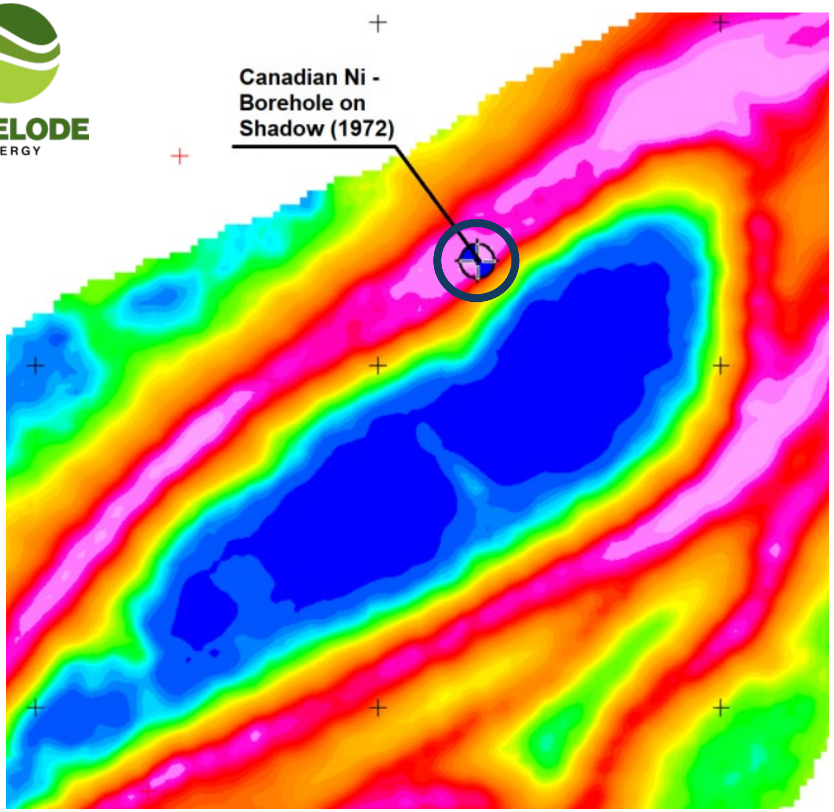


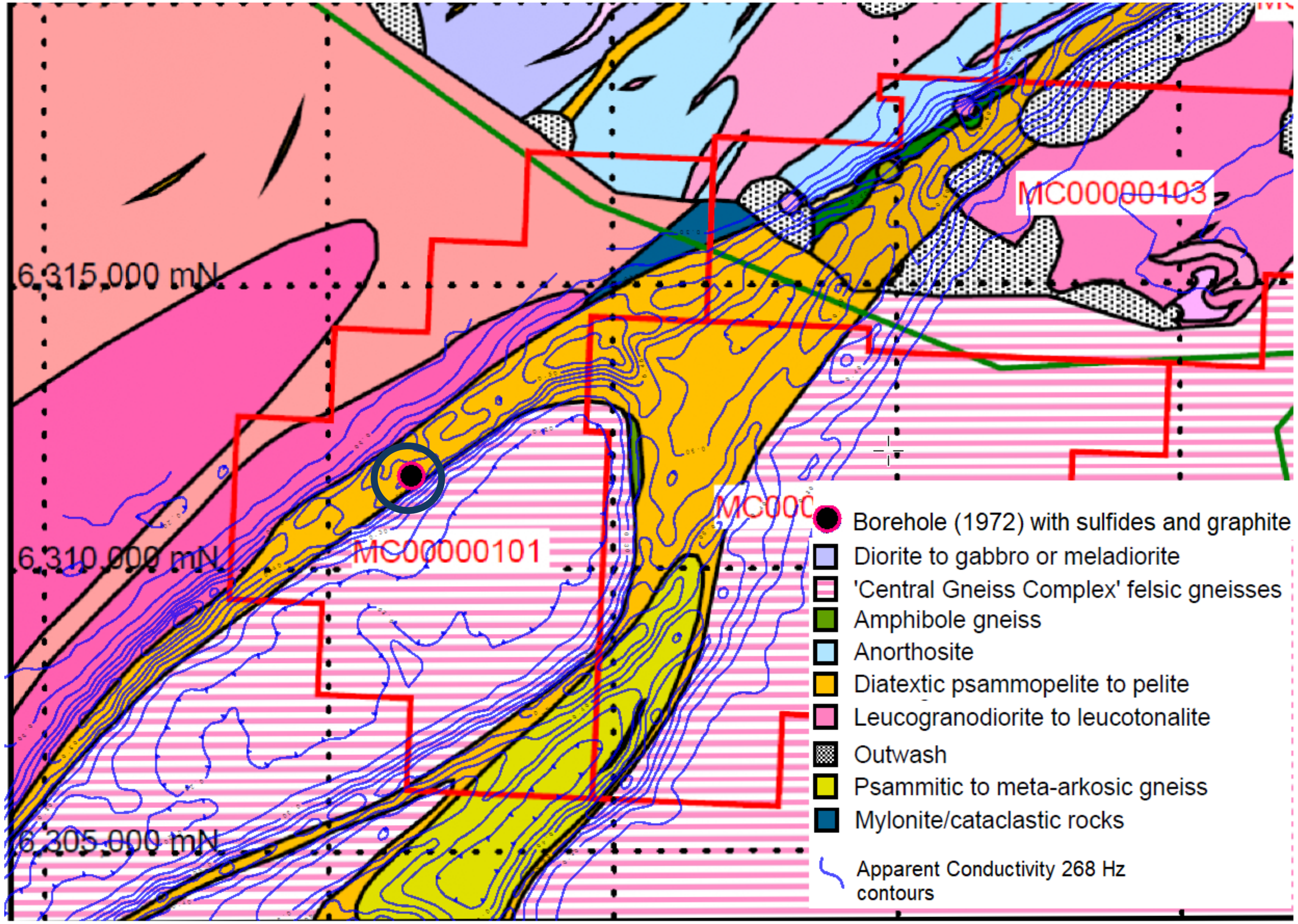
Results of Survey – Target Generation

- 3D low resistivity axes instrumental in defining 3 areas of interest identified by Baselode Energy
- Target areas share similar geophysical characteristics with other high-grade uranium deposits, such as Key Lake, Arrow and Eagle/SUE, hence the target area names
- Target areas coincide with linear, NE-SW trending conductors (along VRSZ)



Historic Drilling Confirms Presence of Graphite



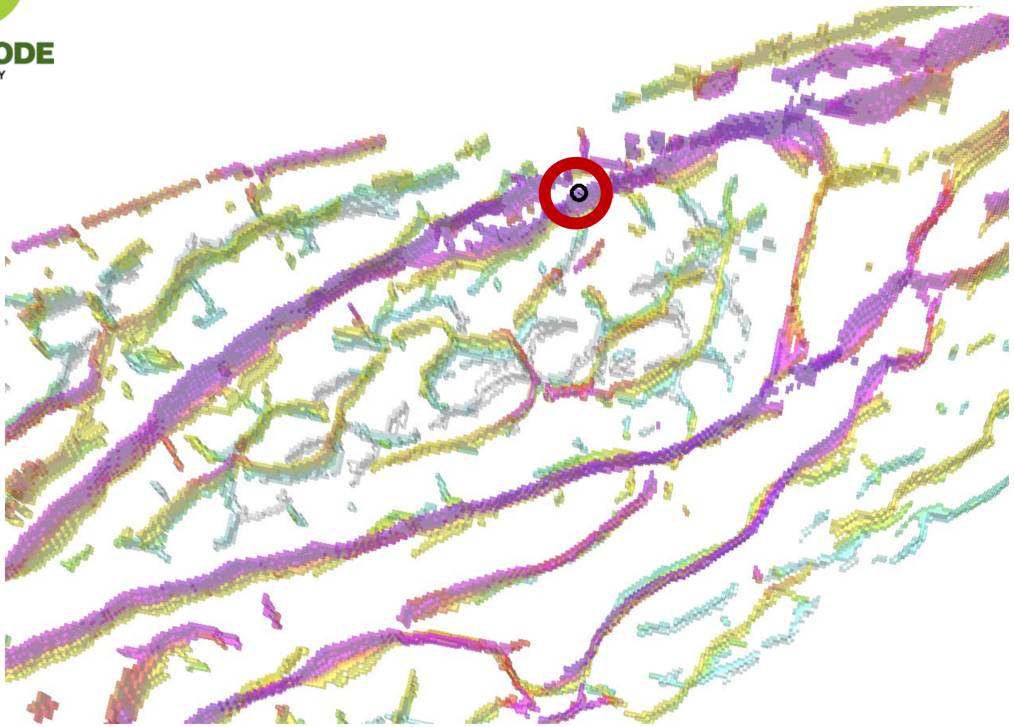


Geology from "Eagle Plains Resources Ltd. Tarku Project. 2013 Exploration Program" by Dave Billard

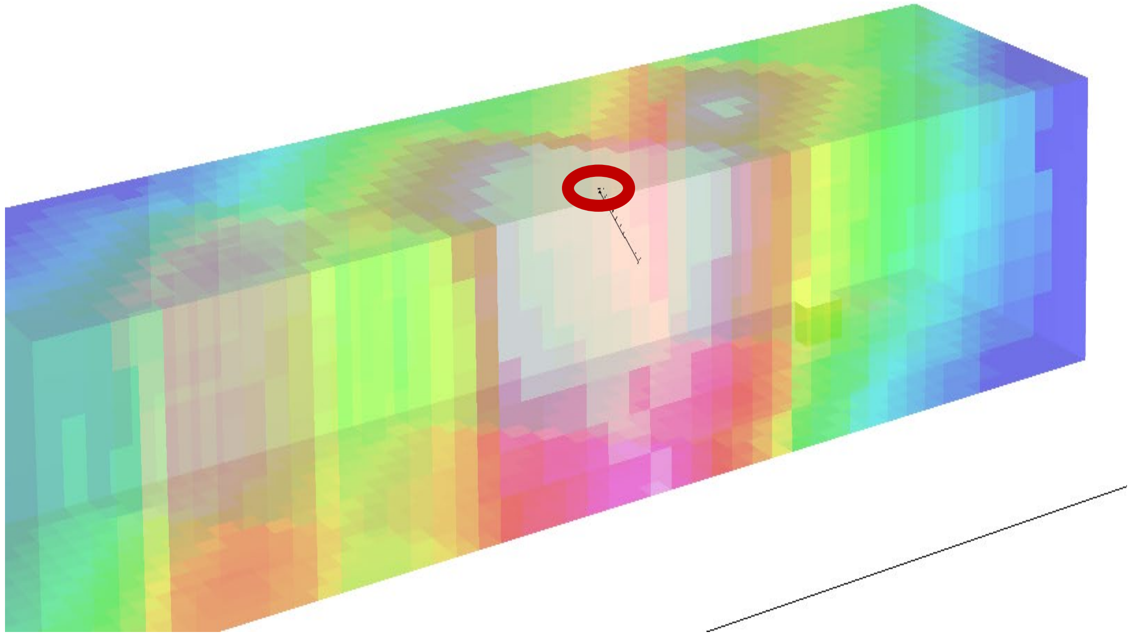
Conductive rocks

- Diatextic psammopelite to pelite
- Psammitic to meta-arkosic gneiss

Historic Drilling Confirms Presence of Graphite



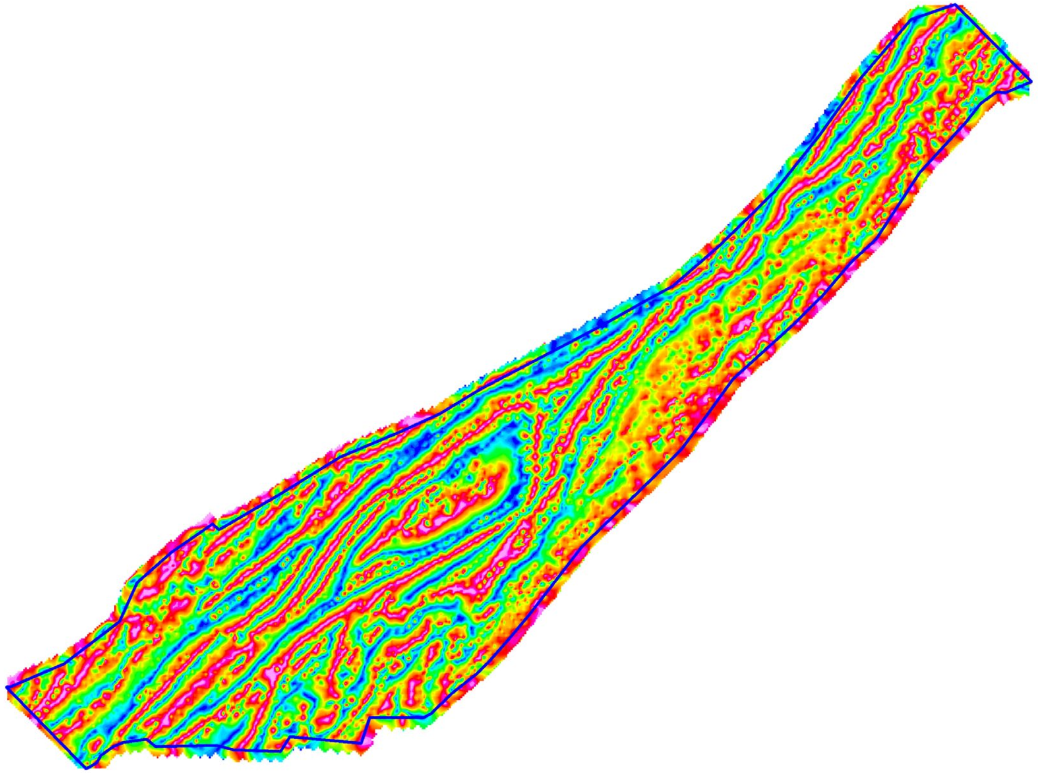
Canadian Nickel historical (1972) drillhole with sulphide and graphite mineralization over the MobileMT survey results



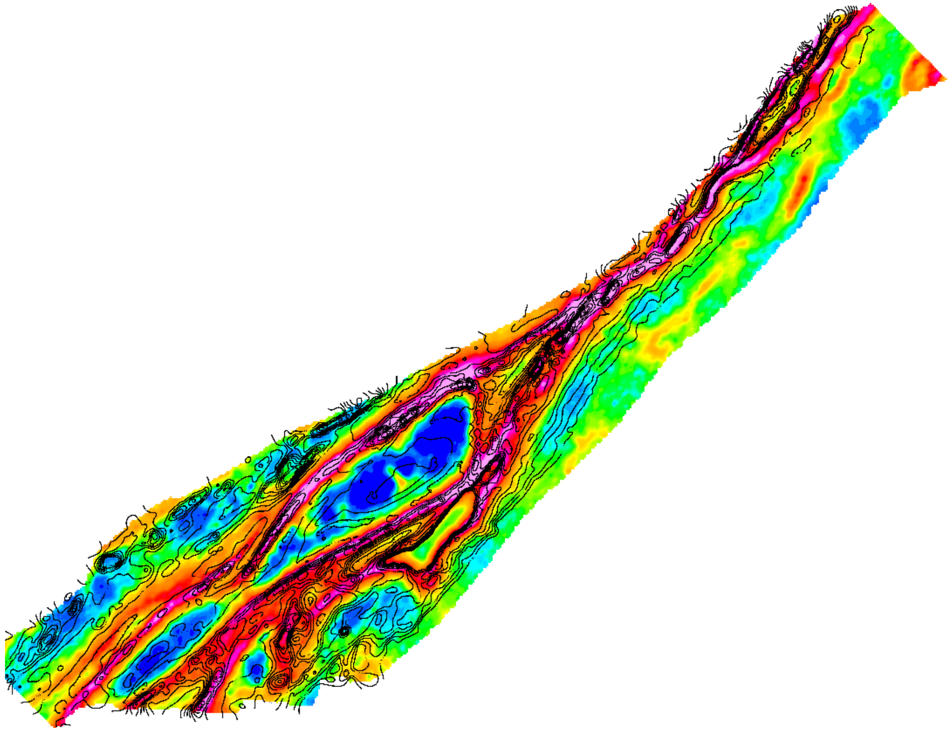
Comparing Magnetics and EM

- Magnetic and conductive features correlate very well
- Magnetic trends identify lithological changes

- Conductive features, especially long and discrete, often identify fractures and faults, essential to allow fluid flow
- Structures + fluids = necessary ingredients for uranium mineralization

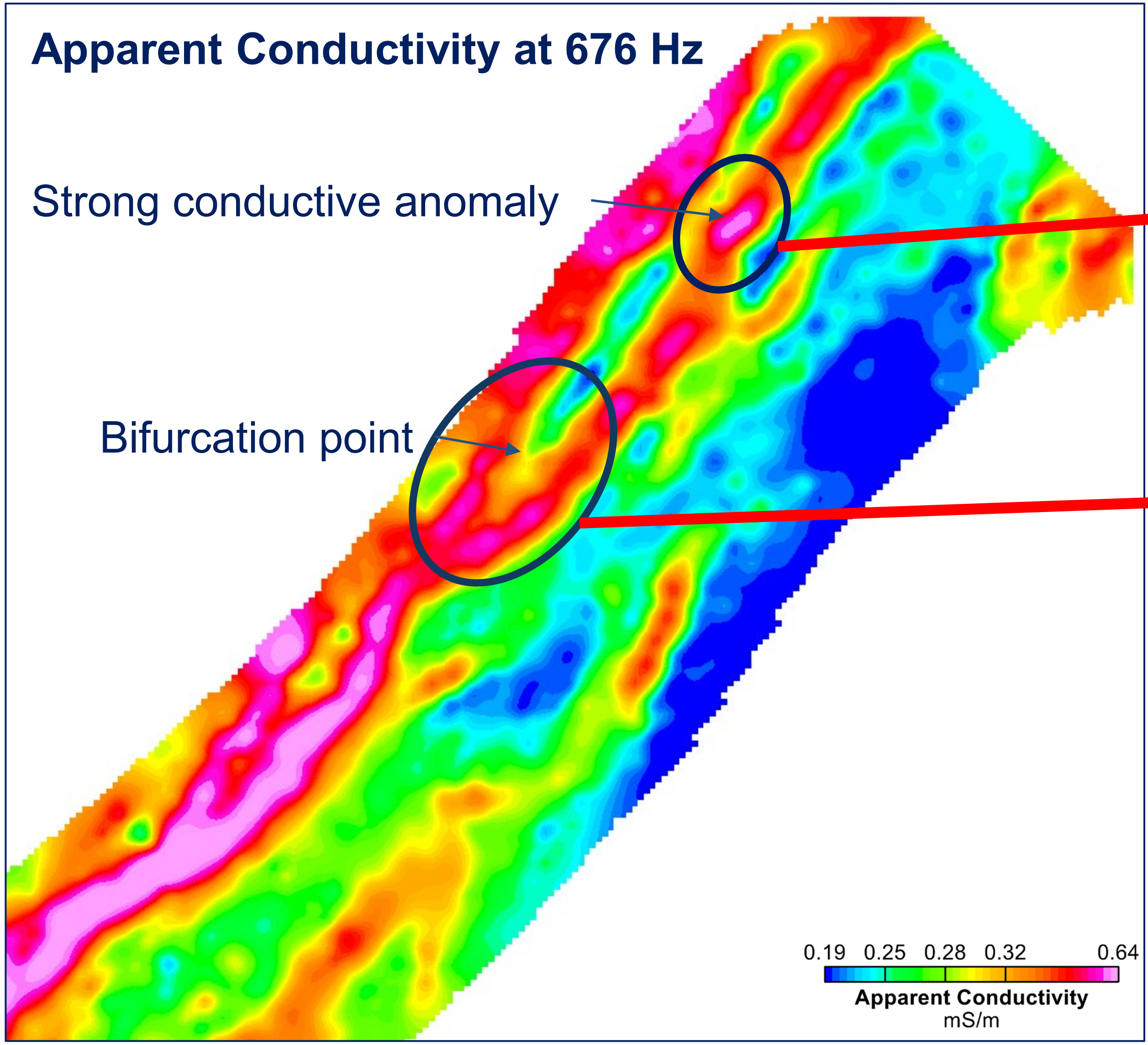


Magnetic Tilt Derivative

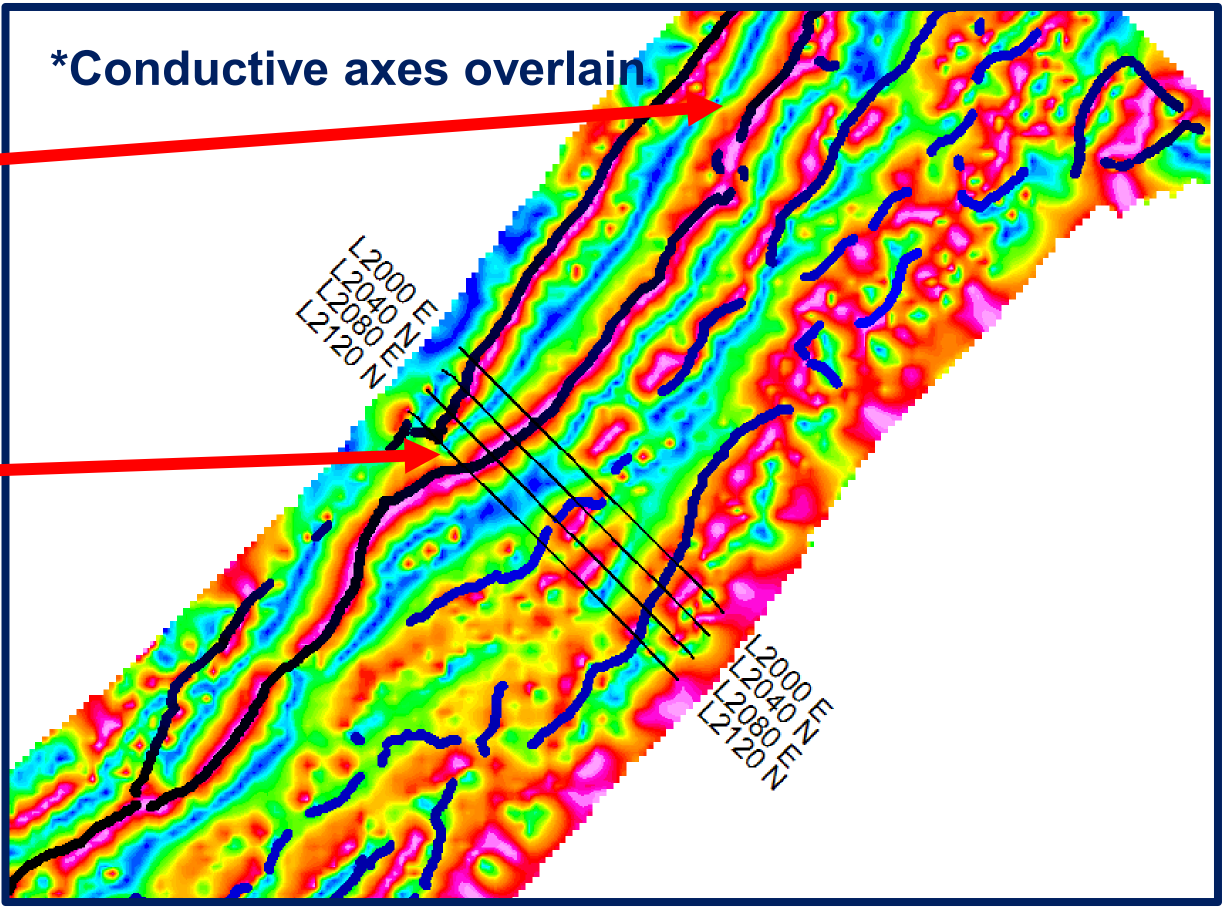


App Cond @ 268 Hz with Total Magnetic Intensity Contours Overlain

Comparing Magnetics and EM

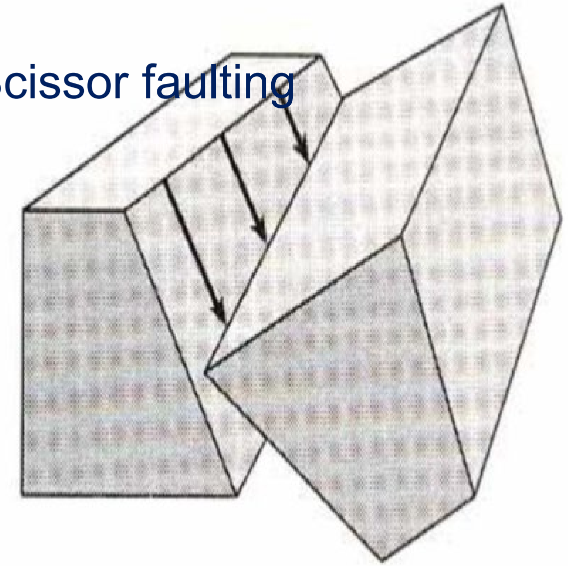


Magnetic Tilt Derivative



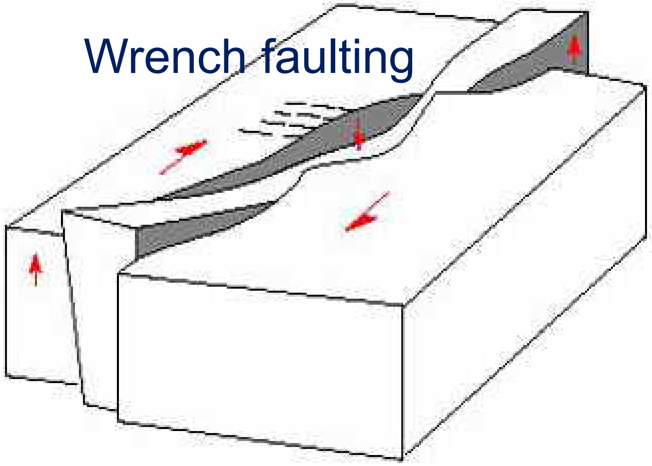
- Magnetic derivatives can be used to identify structures
- Break in smooth linear features can be indicative of fractures/breaks, which can coincide with areas that facilitate fluid migration and support mineralization

Scissor faulting

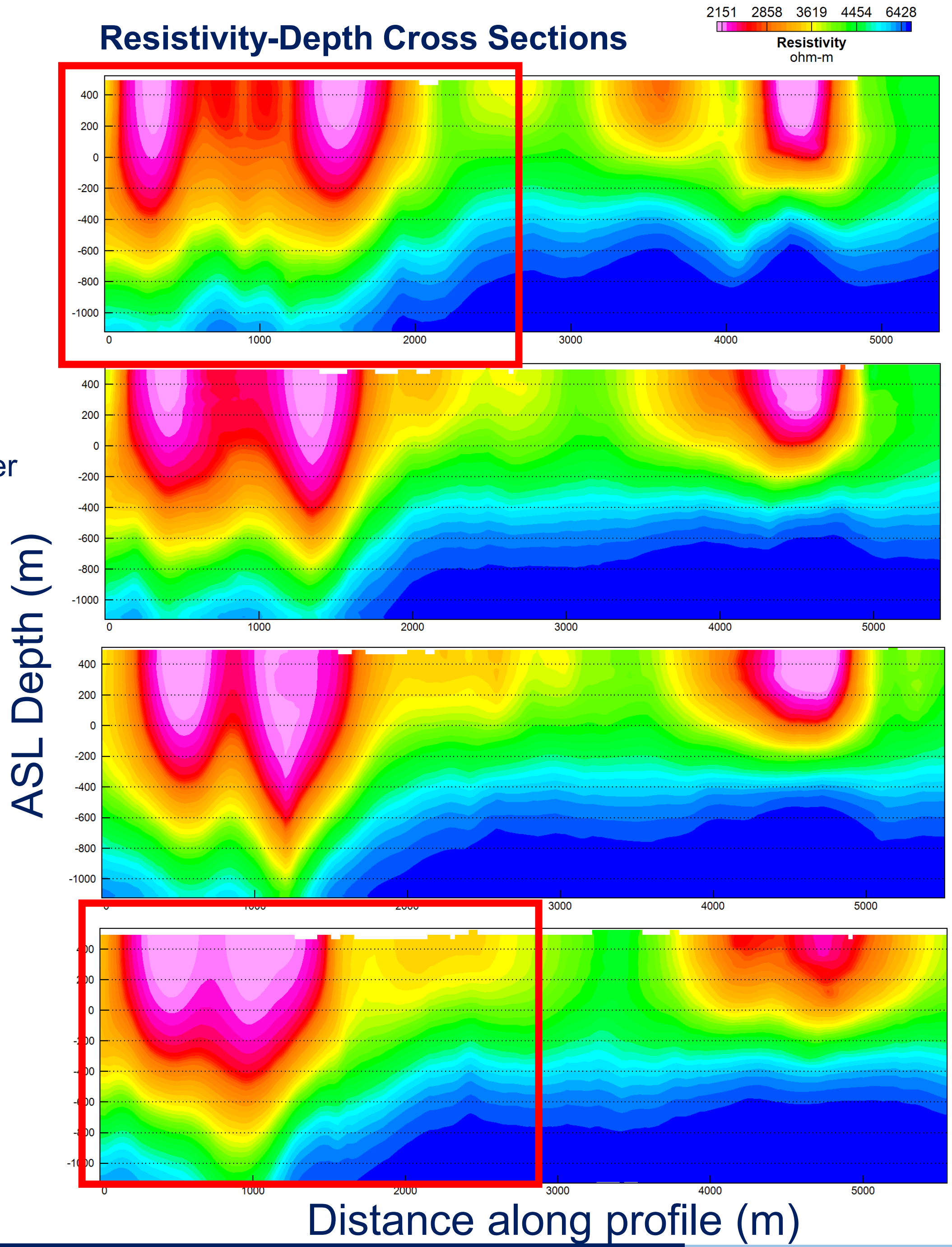


- Flower structures with pivot points (ideal places for fluids)
- Two broad conductors merge toward the south at the bifurcation point
- For northernmost line, the western conductor is deeper than the eastern conductor; this switches moving north to south, and where they merge, the right conductor penetrates deeper than the left
- This could be due to scissor faulting (flower structures with pivot points, fault ramps)

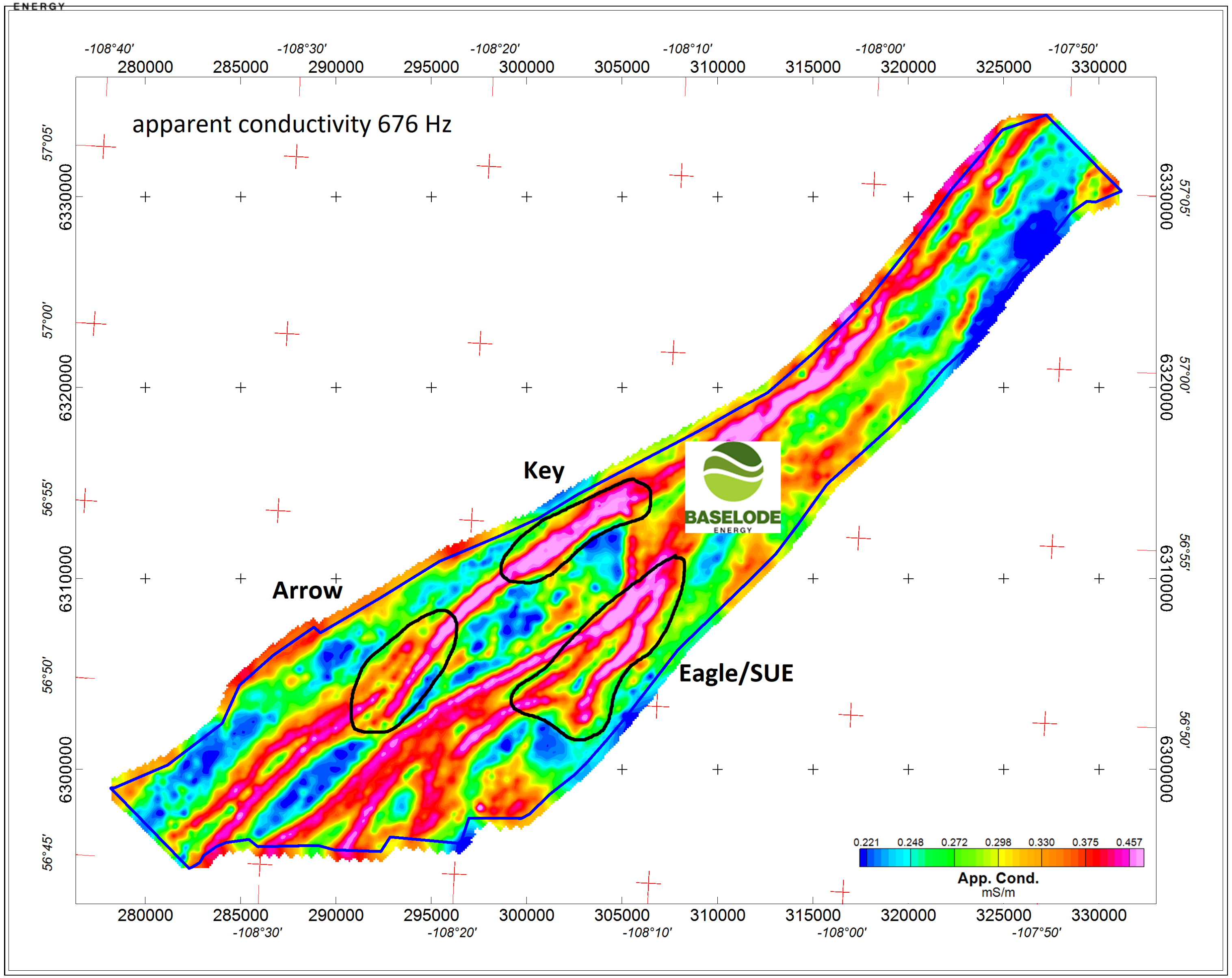
Wrench faulting



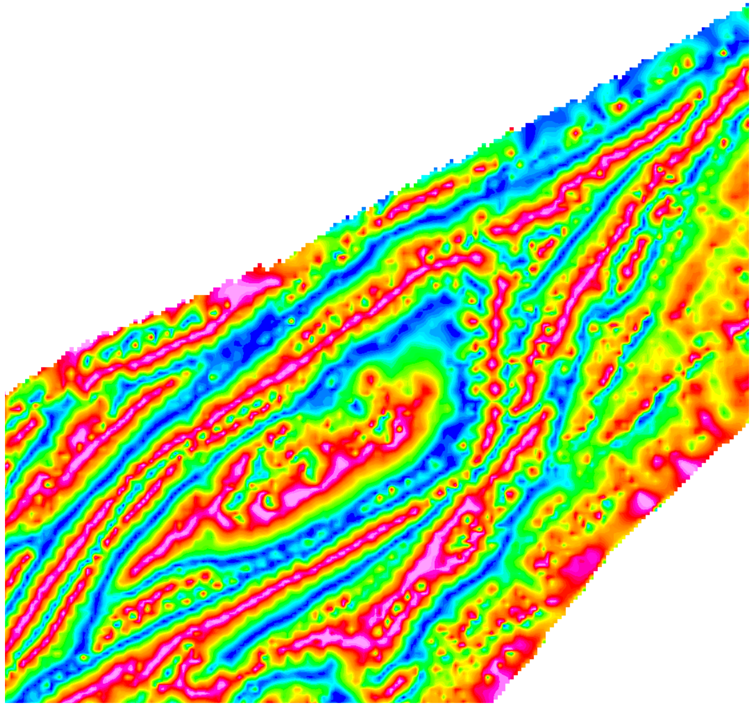
This block diagram of a wrench-fault zone shows that vertical movement is often very complex. Faults may appear to be normal or reverse along the fault zone, and fault reversals and scissoring are common; horizontal displacement is greater than these vertical complications.



Key, Arrow, Eagle/SUE Target Area Comparisons



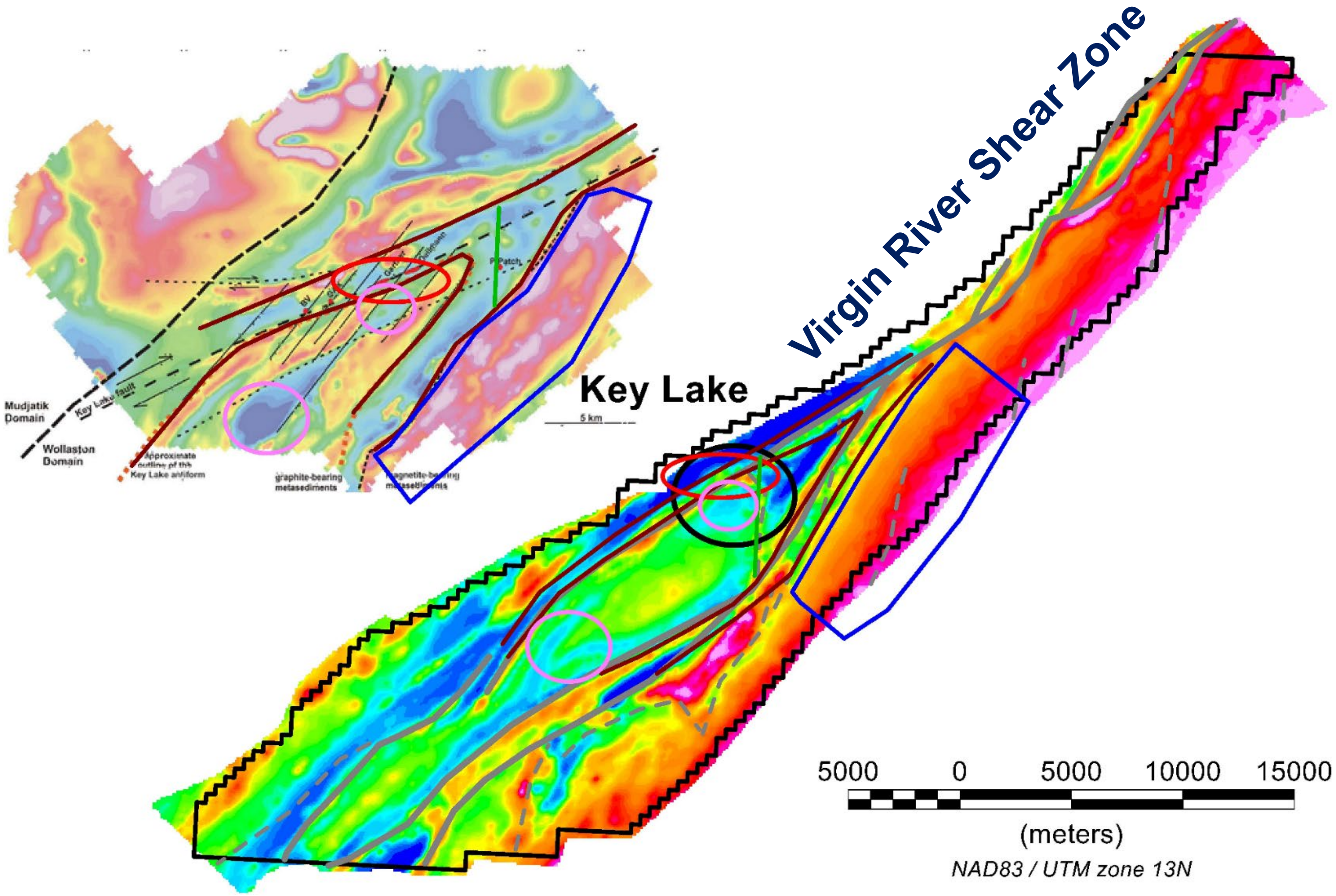
Deviations from "smooth", "linear" features in the EM and magnetic data



Magnetic tilt derivative

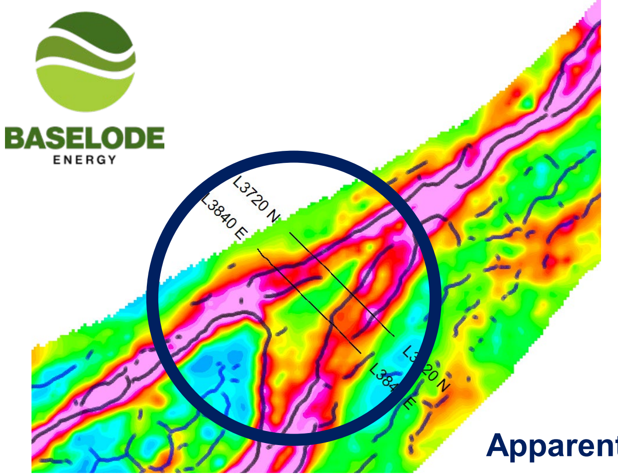
Key Target Area

- Brown lines – A-shaped magnetic corridor, interpreted as fold hinge
- Red circles – areas of high conductance (conductance not shown)
- Pink circles – magnetic low areas
- Blue polygons – interpreted granitic rocks (i.e., rigid structural buttress)
- Key target area on Shadow project shares numerous geophysical characteristics with Cameco's (TSX: CCO) and Orano's Key Lake deposit (~200 M lbs. U_3O_8)



Magnetic maps (TMI) of both Key Lake area and Shadow project
Key Lake image source: Wheatley et. al. (2006), CIM Saskatoon

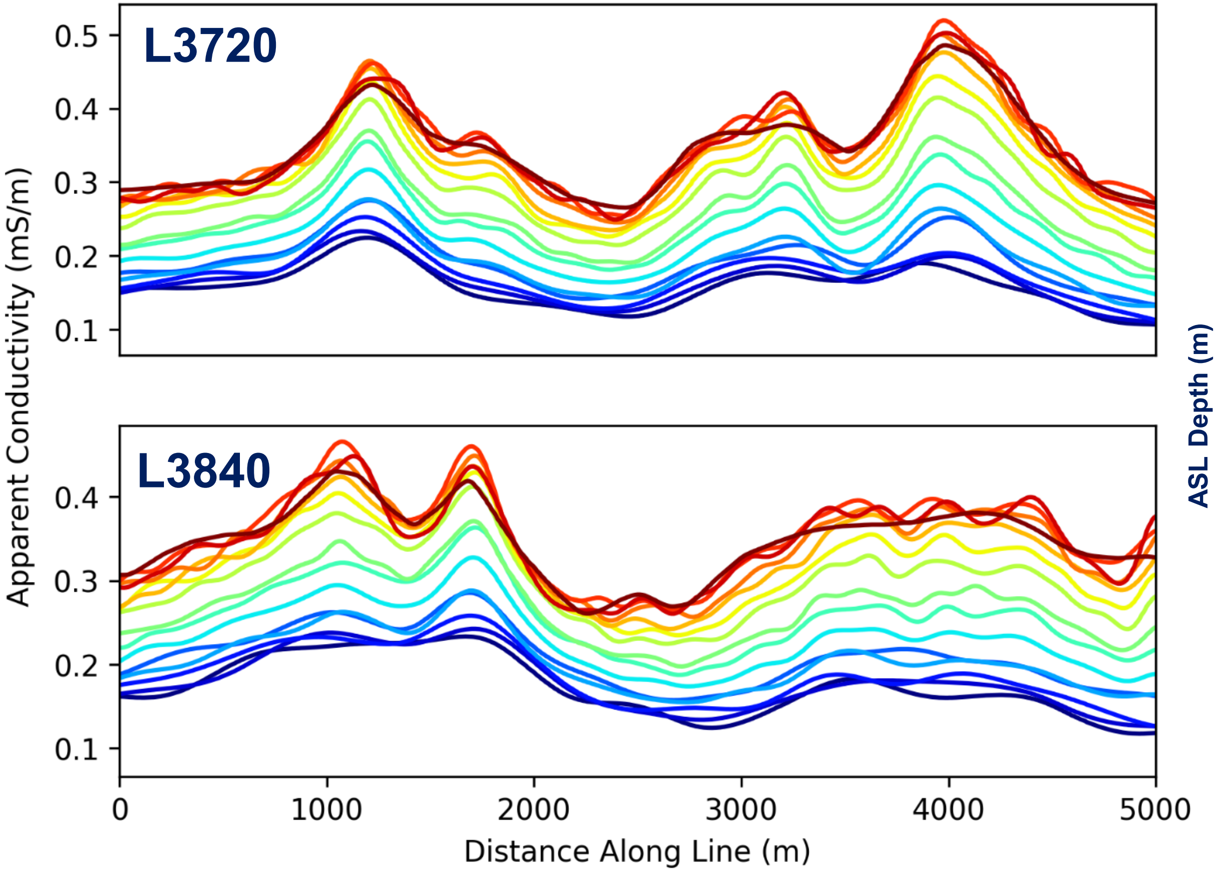
Key Target Area



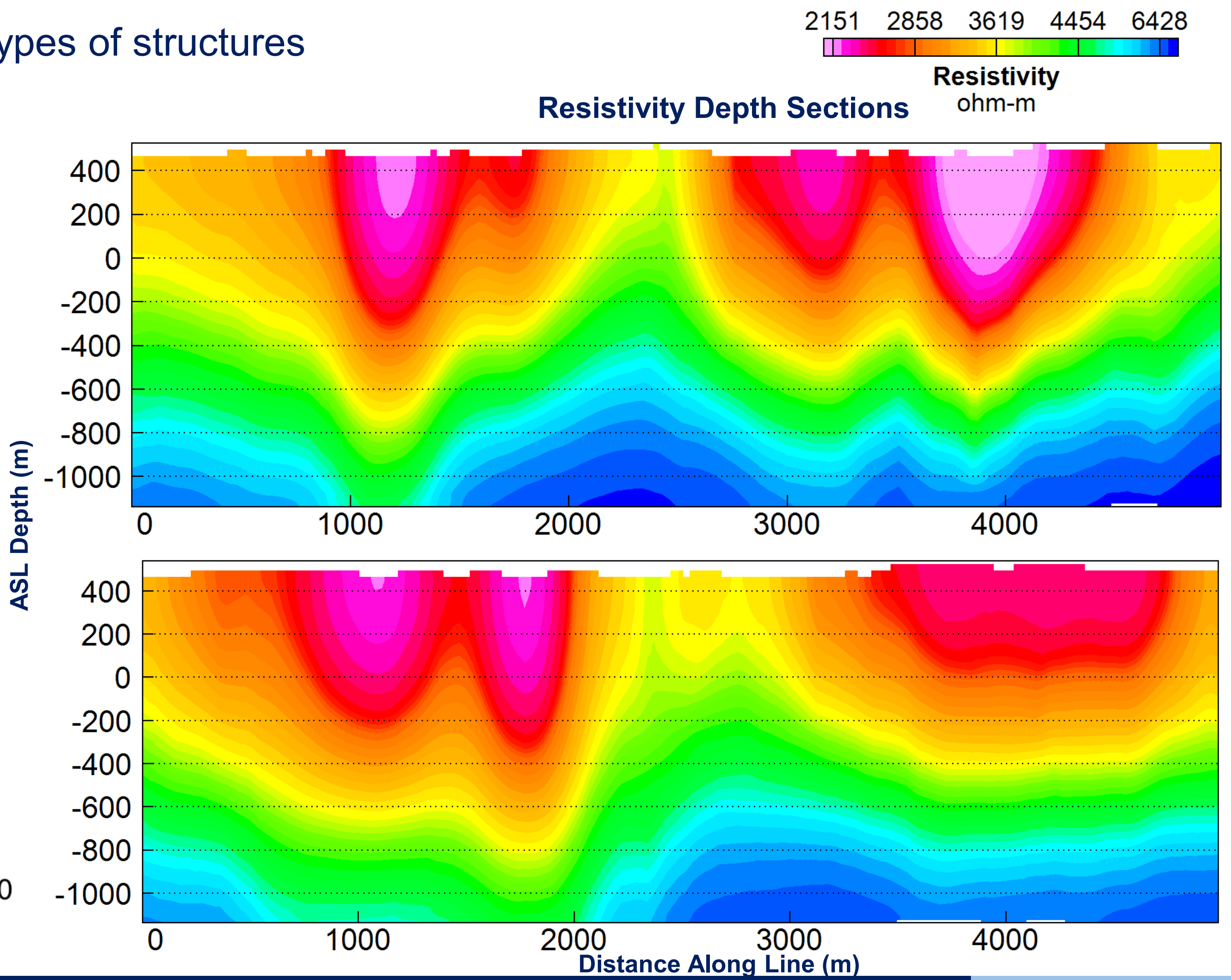
- Two separate conductive features
- Conductive feature on the west starts out as a single conductor in the north, and bifurcates at south (vice versa for eastern feature)

- Vertical displacement and horizontal shear
- We can see different types of structures

Apparent Conductivity Profiles

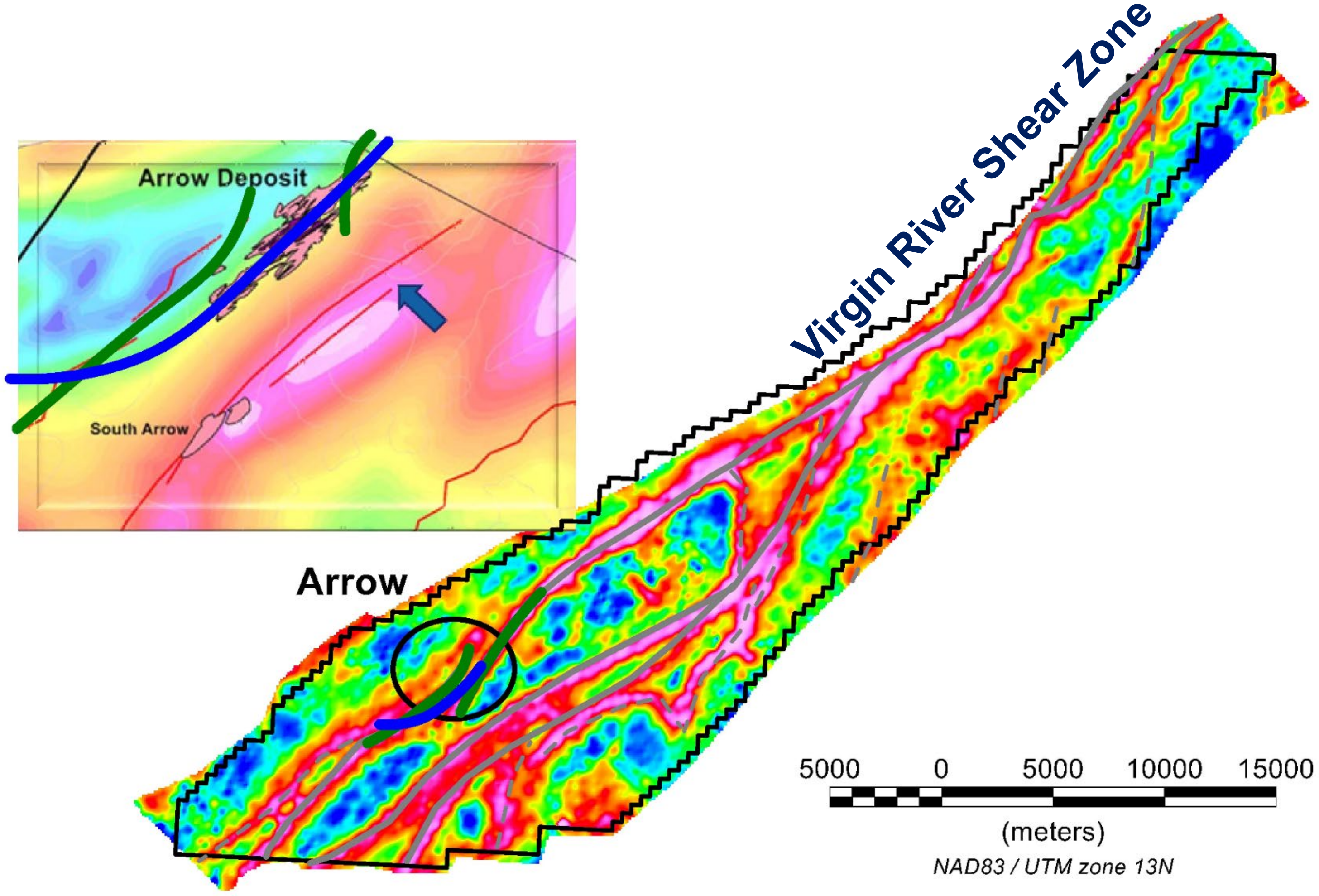


Resistivity Depth Sections



Arrow Target Area

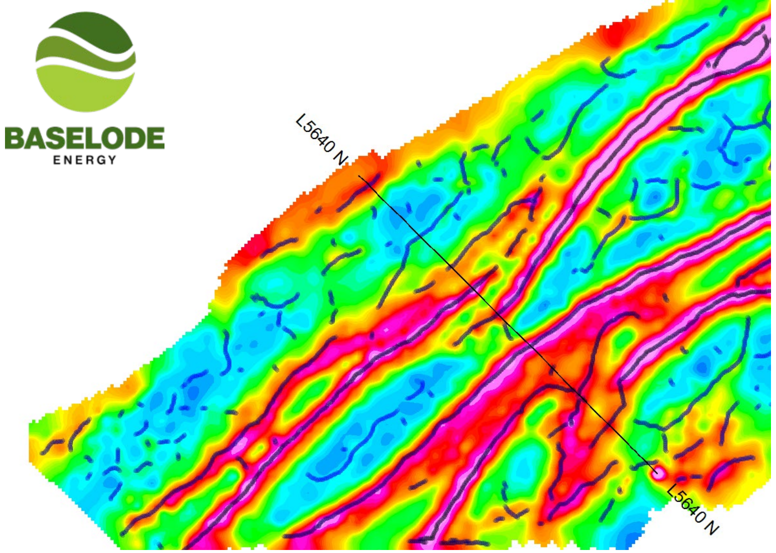
- Green lines – conductor axes
- Blue lines – magnetic low axes
- Conductor divergence associated with magnetic bend, all in the same orientation
- Indicative of shear zone structures
- Arrow target on Shadow project shares geophysical similarities that were used to target NexGen Energy’s (TSX: NXE) Arrow deposit (~350 M lbs U_3O_8)

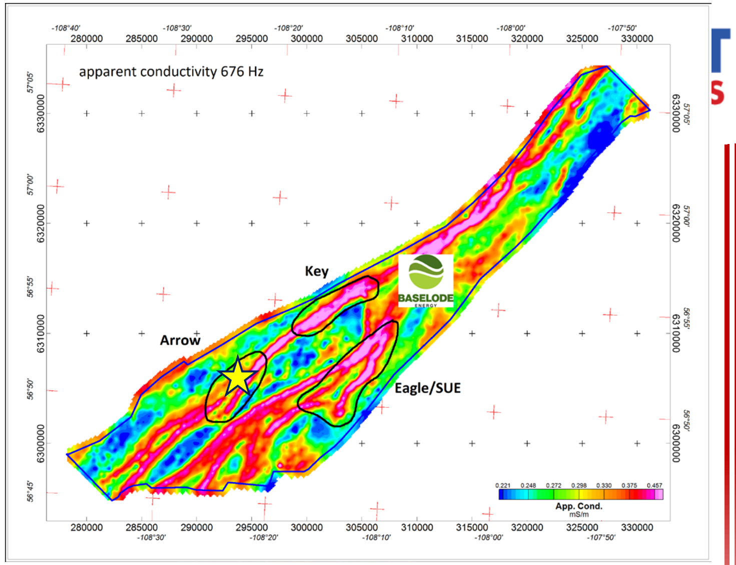


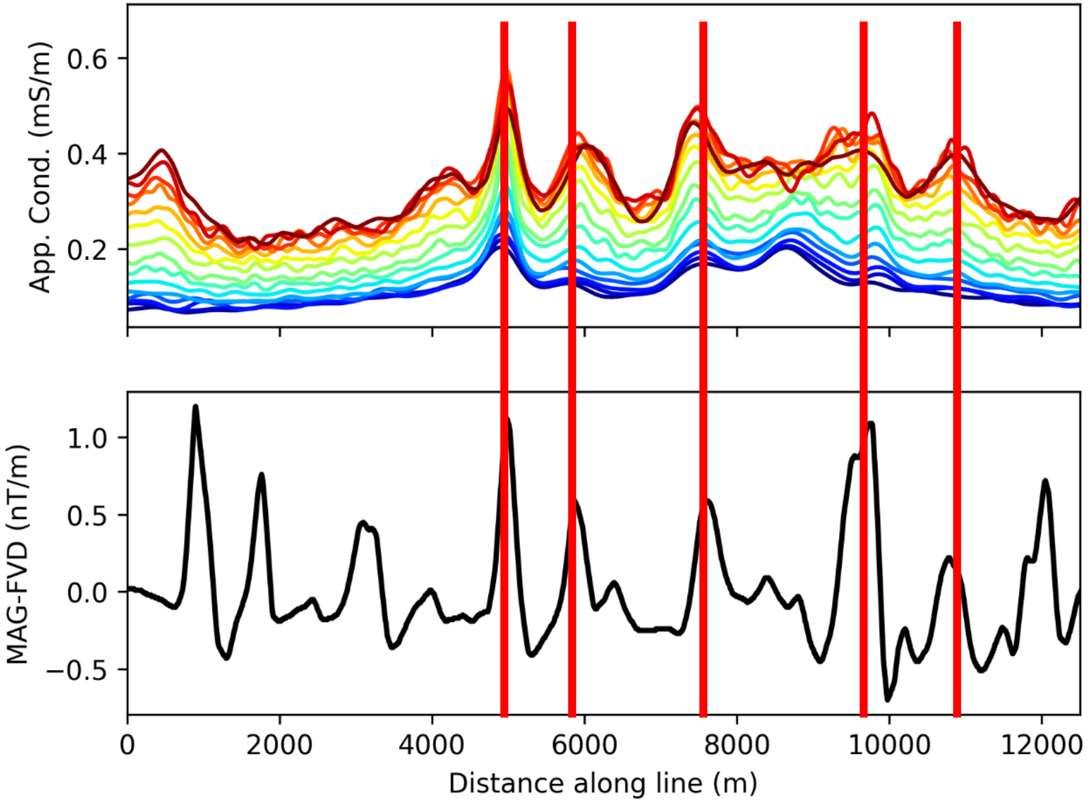
Apparent conductivity of 676 Hz at Shadow project
Magnetics (TMI) of Arrow deposits
Arrow image source: Standard Uranium (2020), corporate presentation

Arrow Target Area

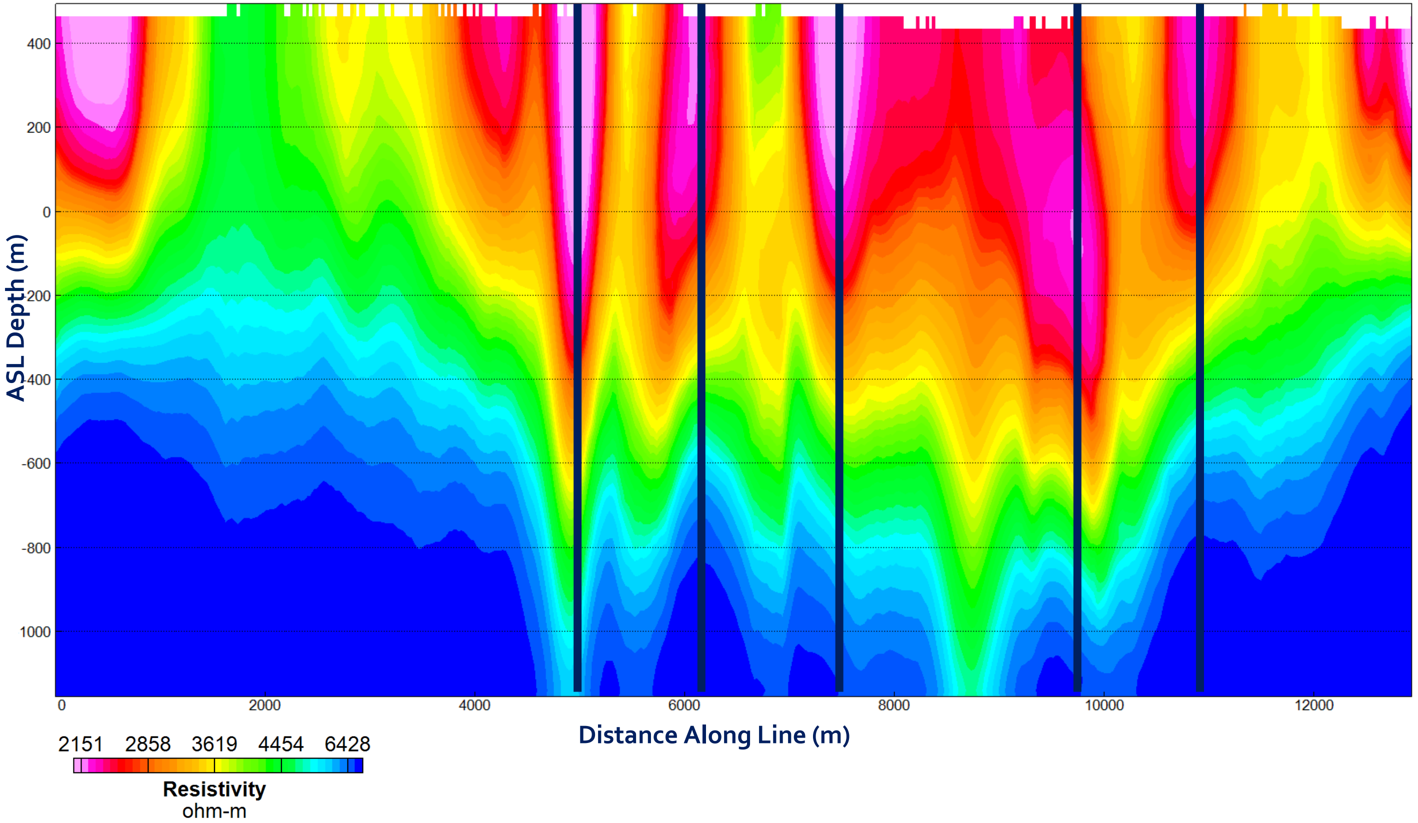
Where conductive and magnetic anomalies coincide, good indicator of structure + fluids, which are both necessary for uranium mineralization





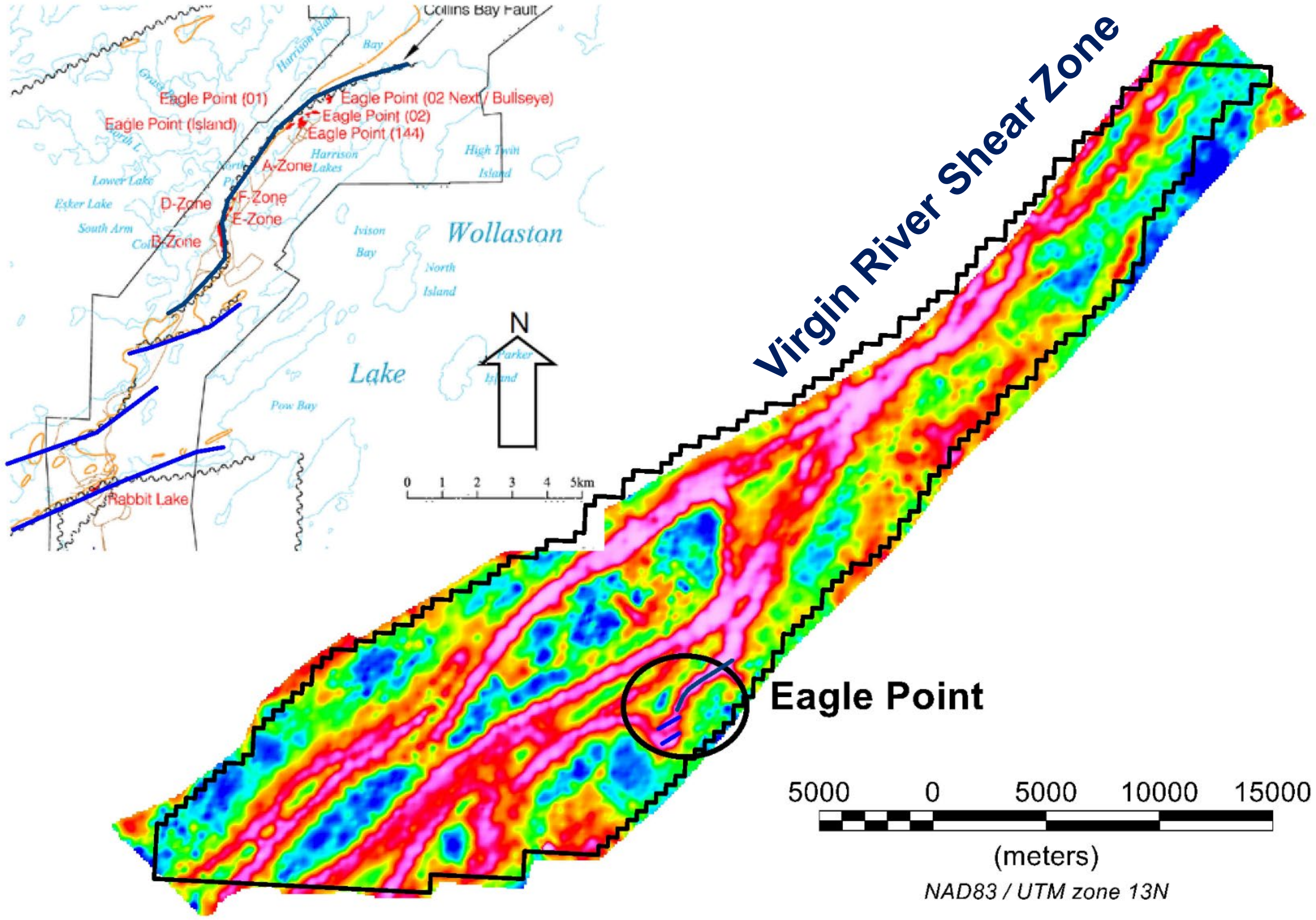


Vertical exaggeration = 3



Eagle/SUE Target Area

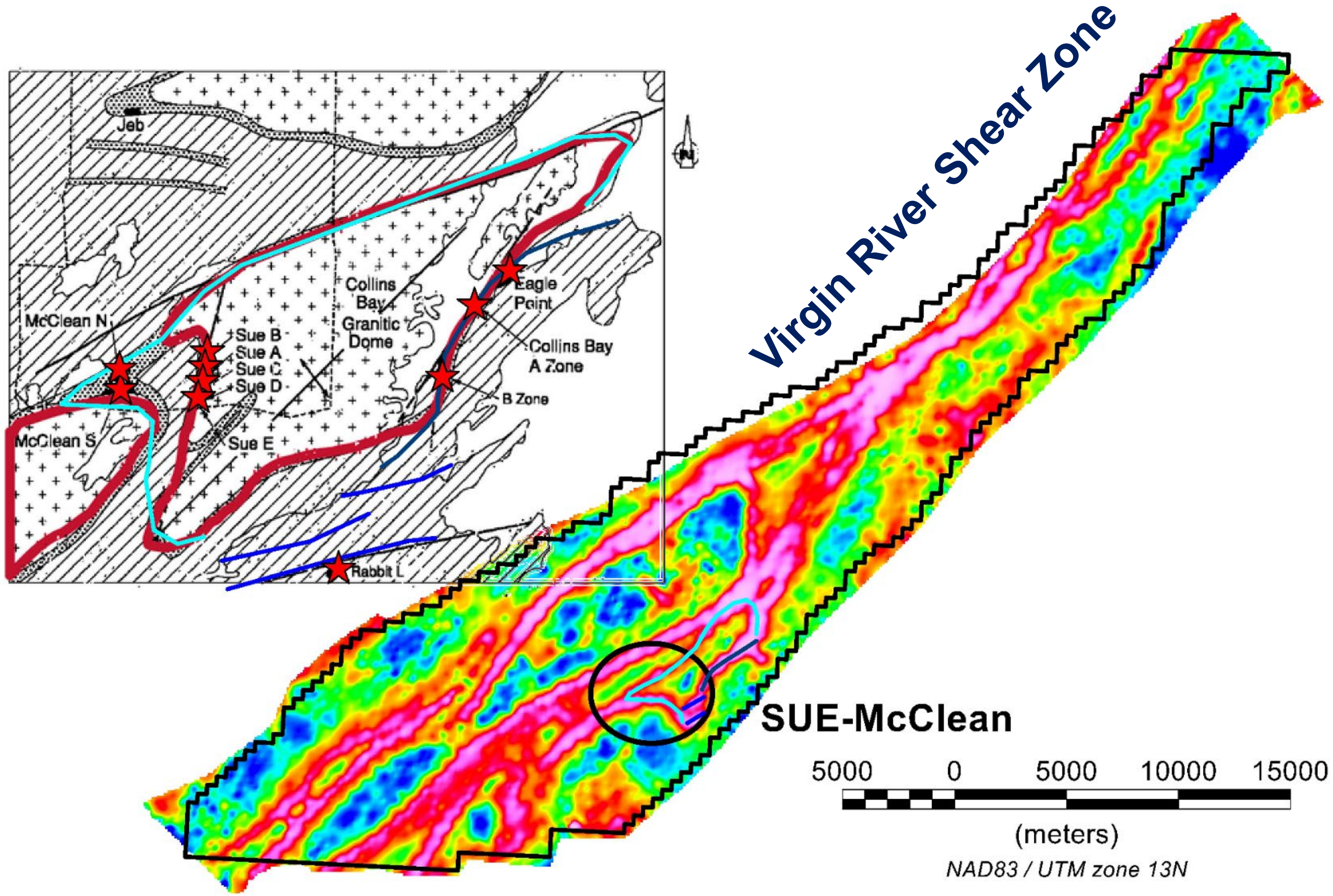
- Eagle Point – Rabbit Lake area
- Dark blue lines – long, linear strong conductors
- Royal blue lines – offset, short, strong conductors
- Geophysical anomalies could suggest rotated and offset main conductors, indicative of large structures and possible stacked faults



Apparent conductivity of 676 Hz at Shadow project
Eagle Point – Rabbit Lake image source: Renaud (2006), CIM Saskatoon

Eagle/SUE Target Area

- Continued from previous slide
- Light blue lines – continuation of conductive features (dark and royal blue lines) mantling a granitic dome
- Similar shape and overall morphology at Eagle/SUE
- Eagle/SUE target on Shadow project shares numerous geophysical similarities with numerous deposits outlined within the Cameco's and Orano's Eagle Point-Rabbit Lake-SUE-McClean Lake uranium deposit clusters of NE Athabasca Basin (~325 M lbs. U_3O_8)



Apparent conductivity of 676 Hz at Shadow project
Eagle Point – Rabbit Lake – McClean – SUE image source: Wheatley et. al. (2006), CIM Saskatoon