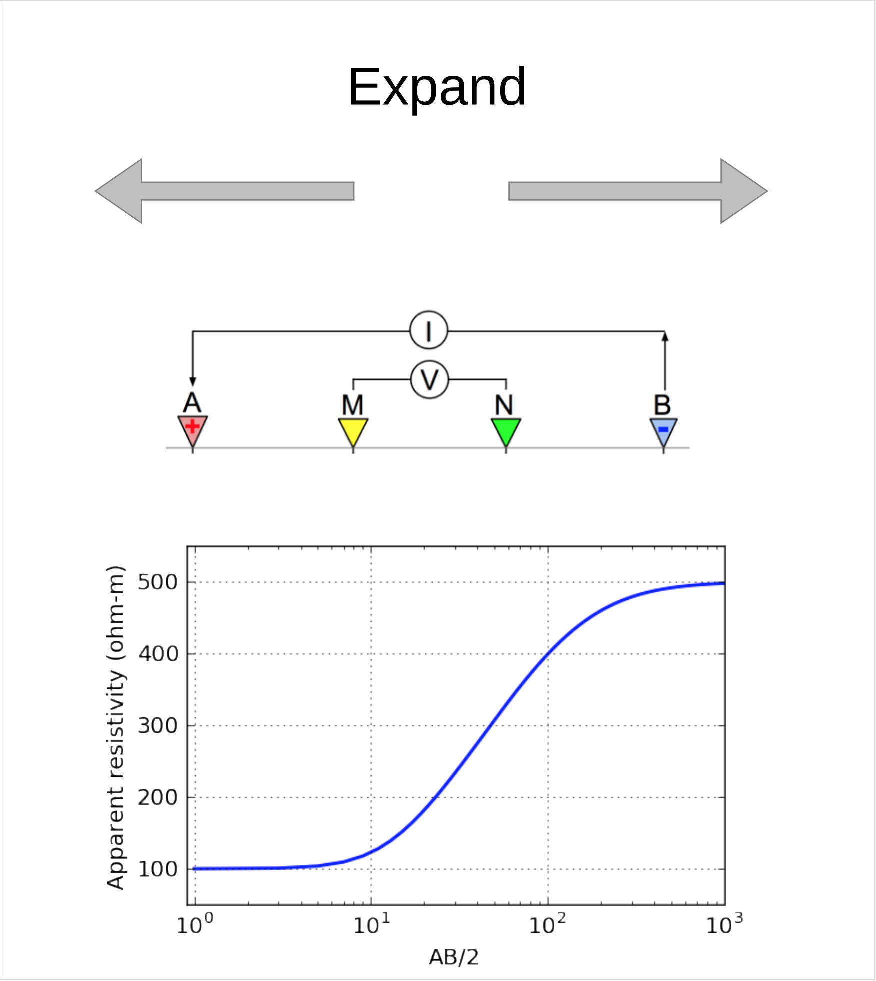
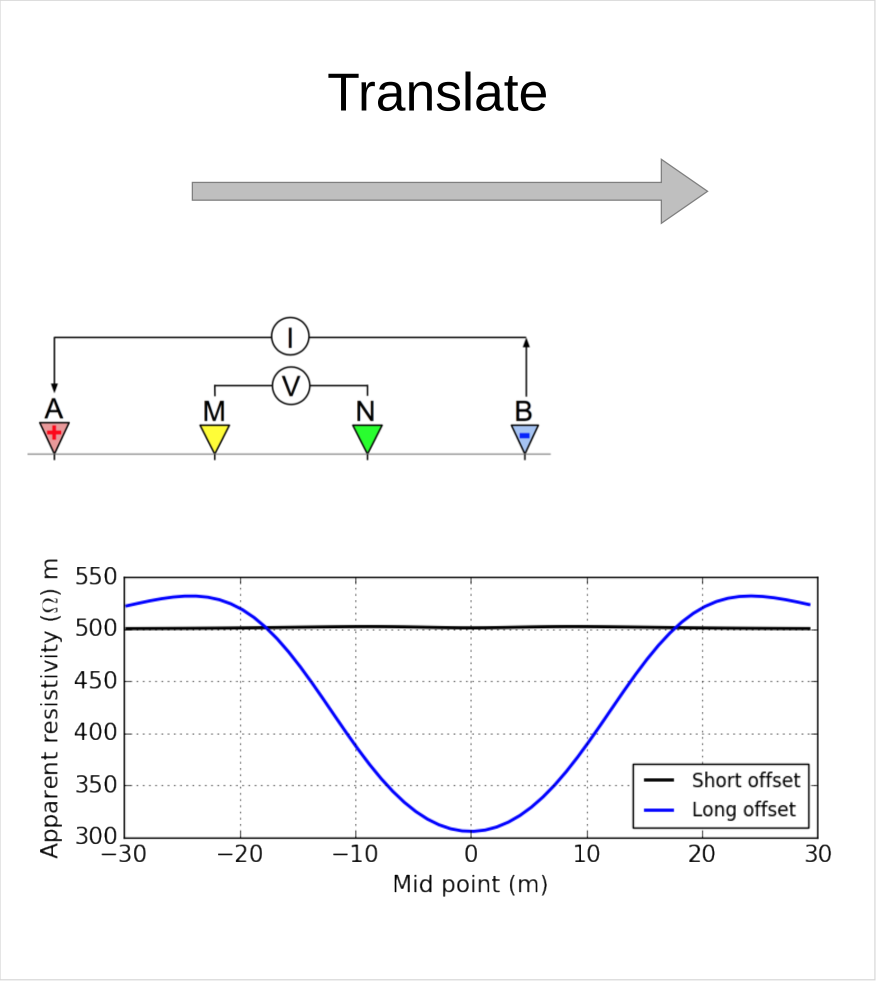
# From Last Time

## Sounding




## Profiling



# From Last Time

**Profiling:** Current and potential electrodes moved along a line (e.g. Real Section, Wenner and Schlumberger)

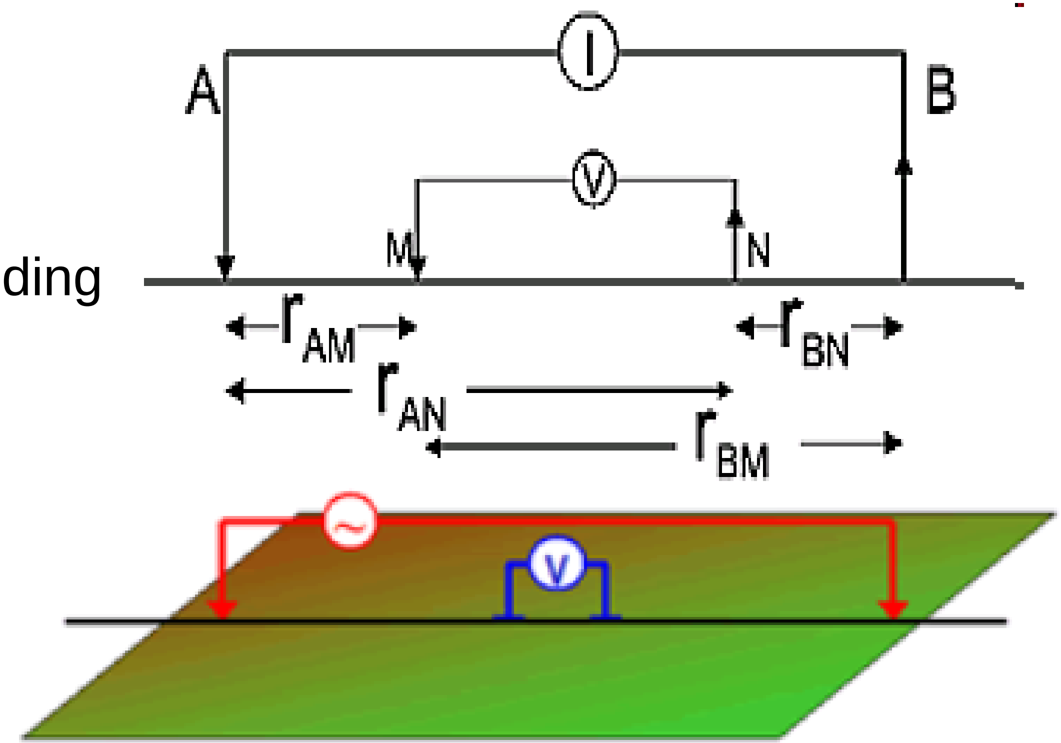
→ Lateral changes in resistivity

**Sounding:** Current and potential electrodes expanded symmetrically about a central point (e.g. Wenner and Schlumberger)

→ Vertical changes in resistivity

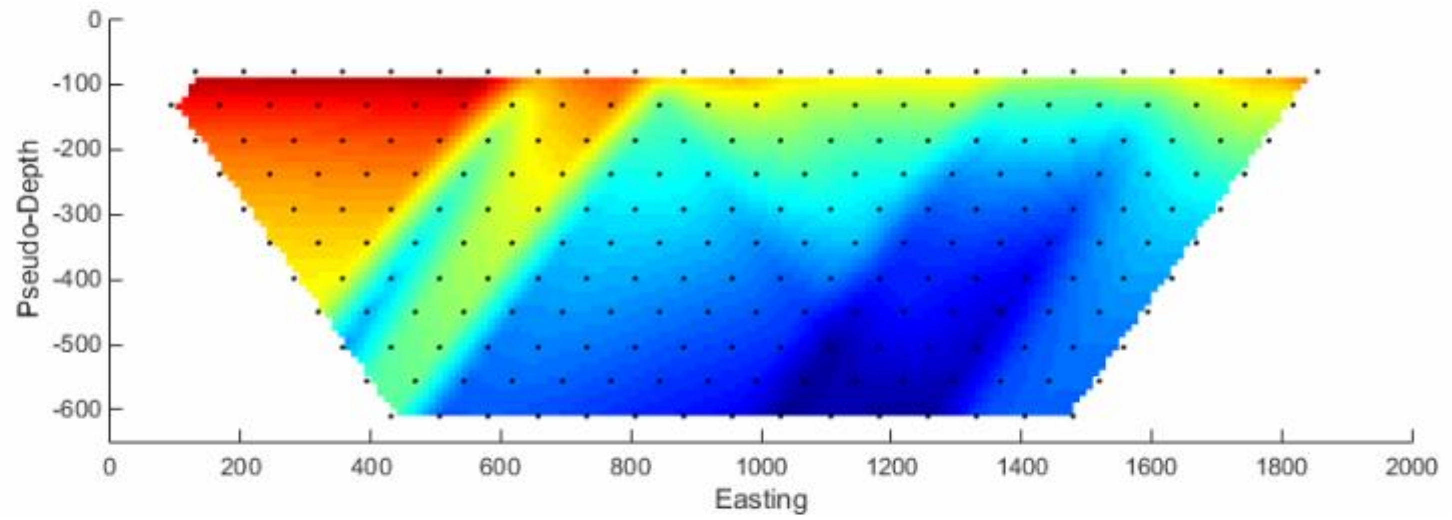
**General Configuration:** Uses a combination of profiling and sounding

→ Vertical and lateral changes in resistivity



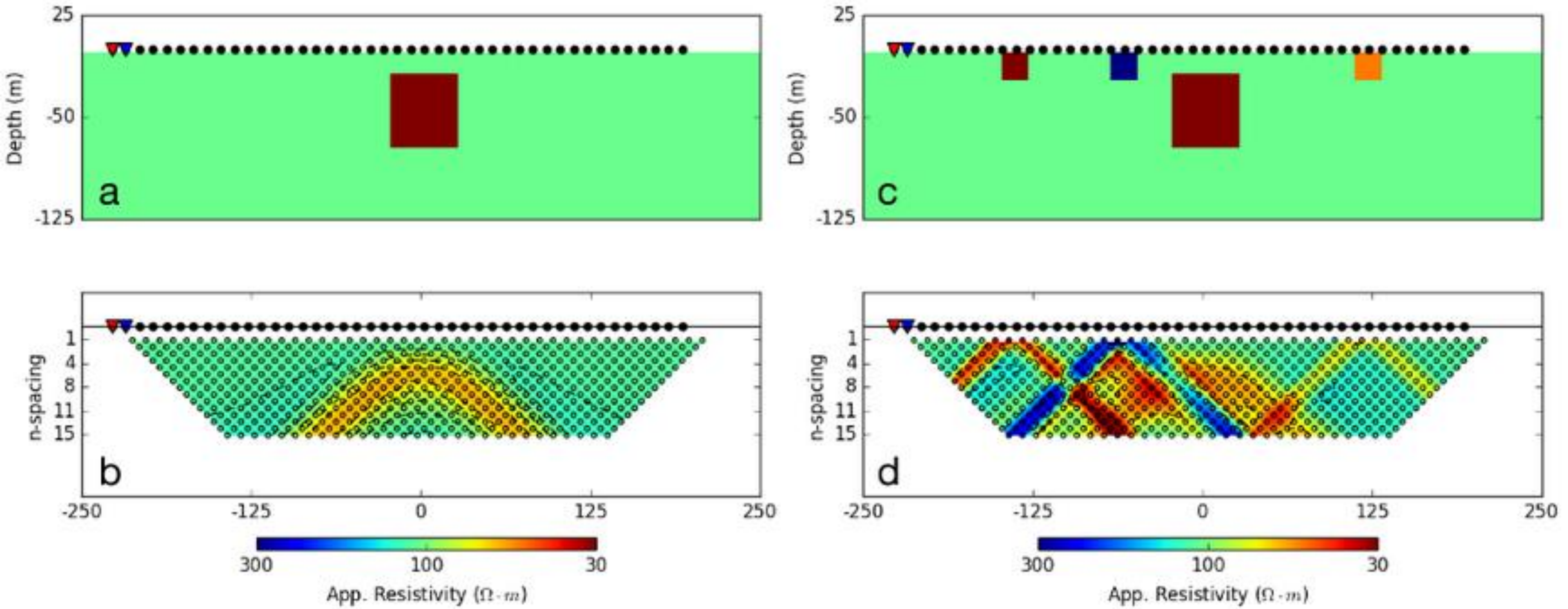
# From Last Time

- Visualize apparent resistivities when sounding and profiling
- Apparent resistivity (color scale) plotted as a function of electrode position
- Easy to interpret for simple geologies



# From Last Time

- Compact bodies → arc signature for dipole-dipole survey
- Depth of arc signature → depth of target
- Thickness of arc → size of target



# Today's Topics

- Processing and Interpretation
  - Geophysical Inversion
  - Inversion Requirements
  - Sensitivity

- DCR Example: Mt. Isa

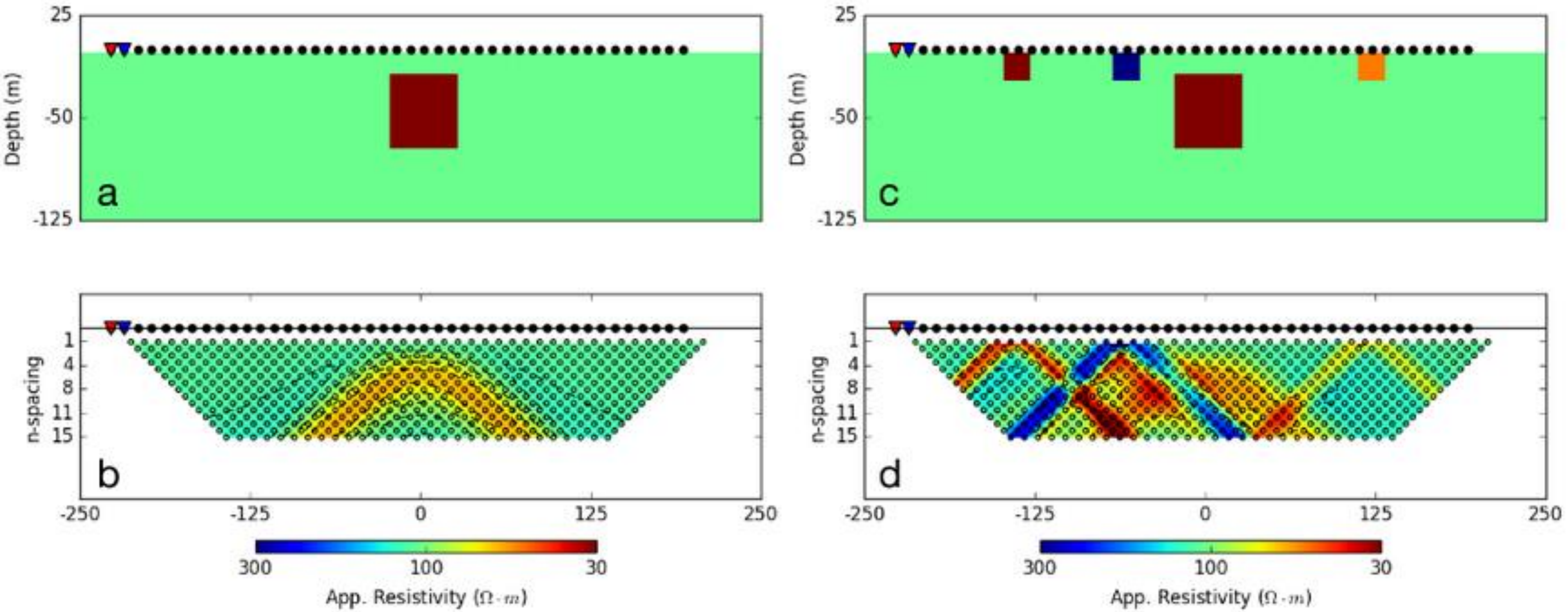
# Processing and Interpretation

Reading on the GPG:

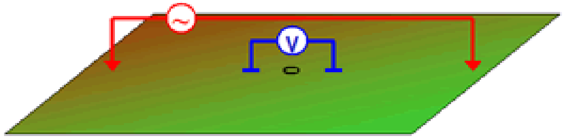
https://gpg.geosci.xyz/content/DC_resistivity/DC_interpretation.html

# Simple vs. Complex Geologies

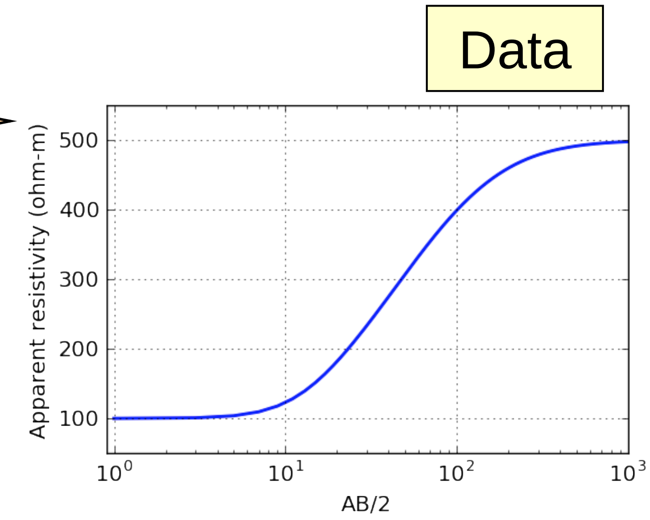
- Complex geologies → Complex data
- How can we interpret in this case?

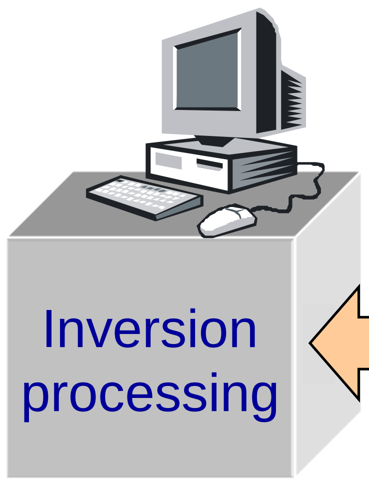


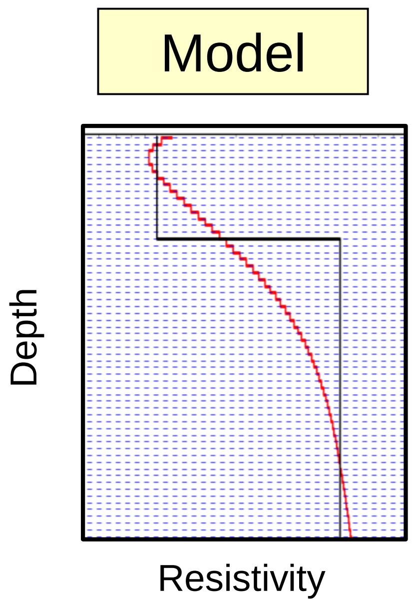
# Geophysical Inversion



Measurements over the Earth are data.




Inversion estimates Earth models based upon data and prior knowledge.

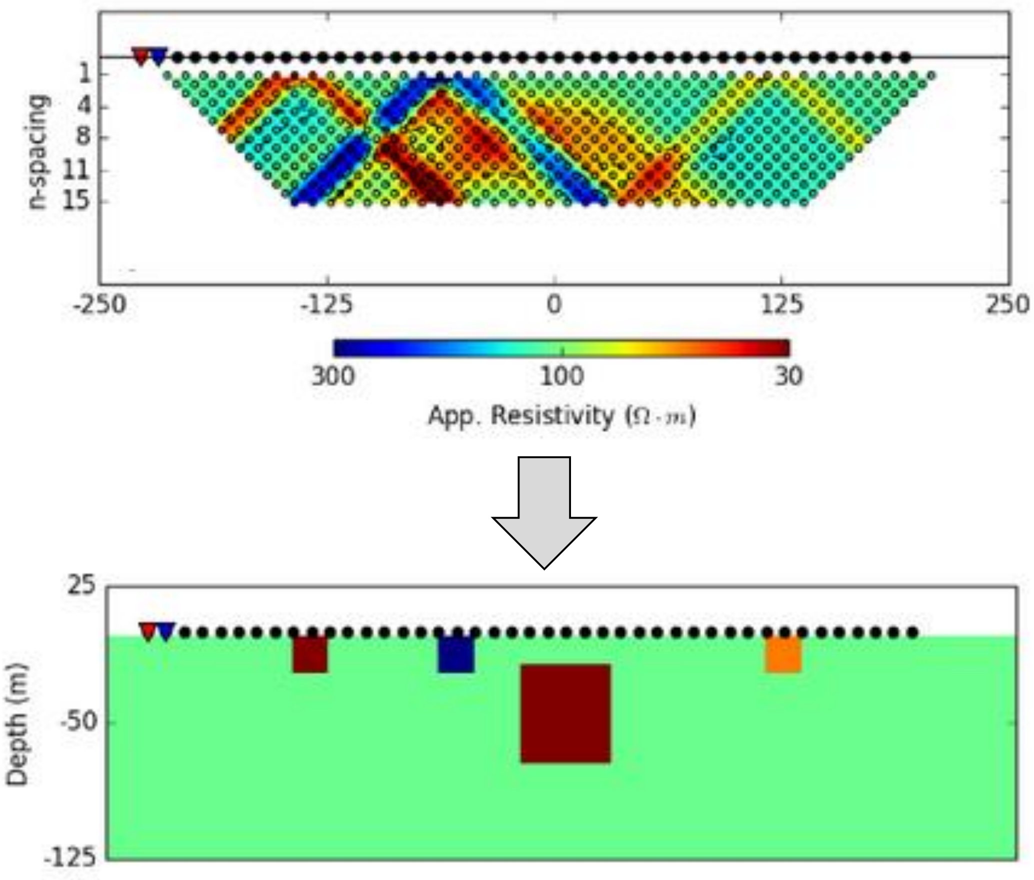
# Geophysical Inversion

Goal of Inversion:

Find a resistivity (conductivity) model which:

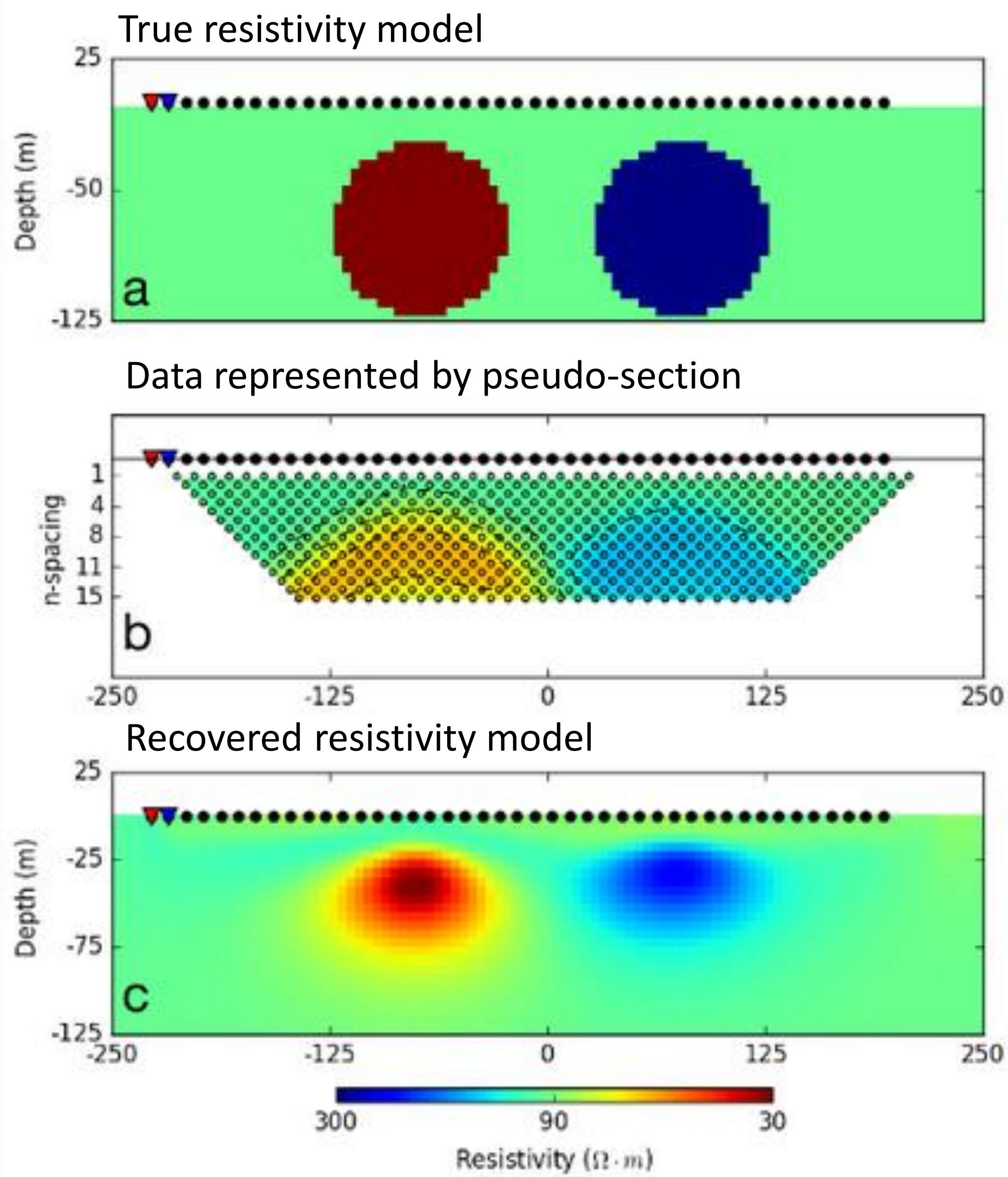
1) Explains all the data

2) Is representative of the true geology

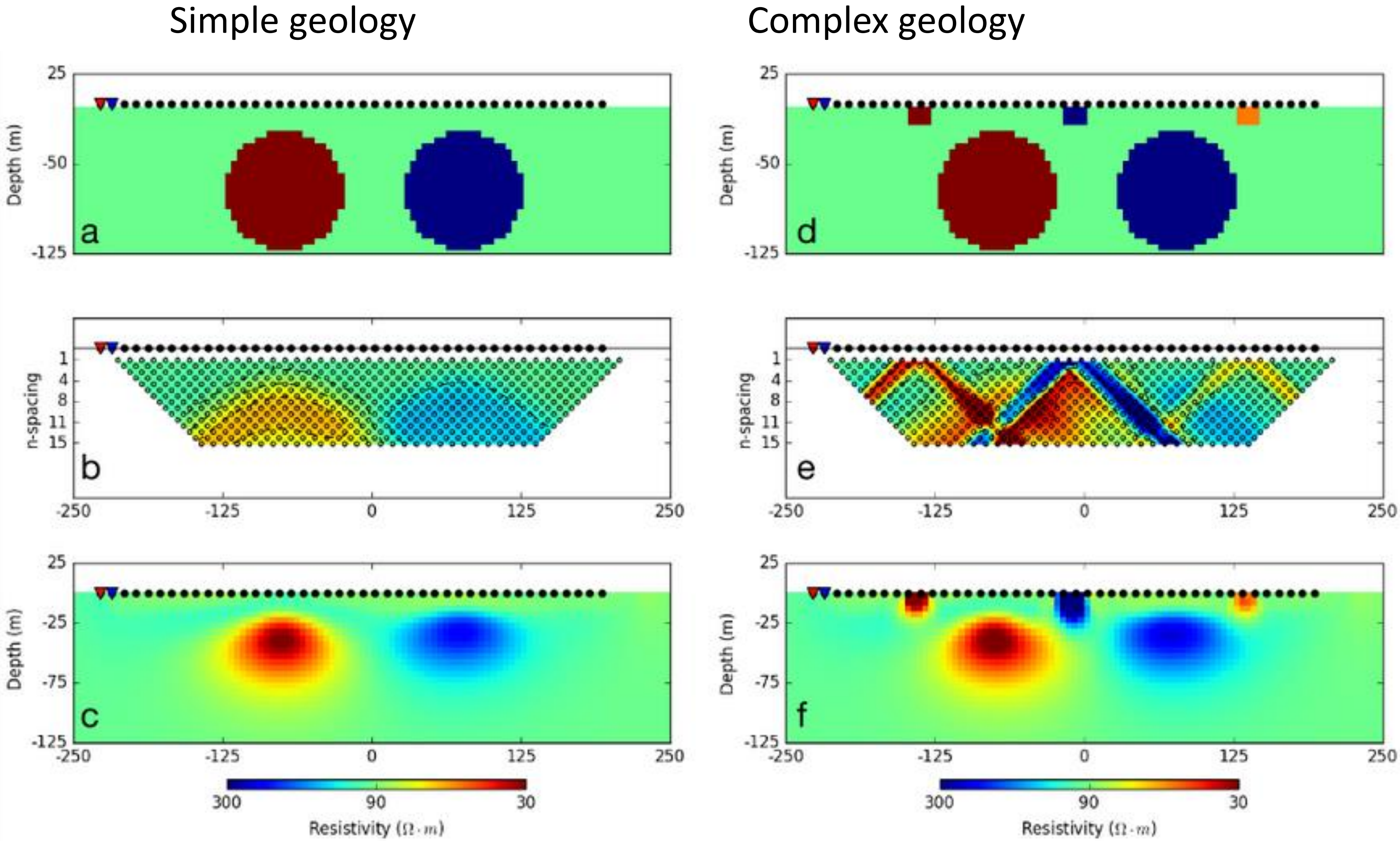


# Geophysical Inversion

- Inversion does **not** recover true model
- Recovers a geologically approximate model
- Solution is **non-unique**
- Recovers structures represented in the data



# Pseudo-Section vs Inversion



# Inversion Requirements

1) A physical model (respect physics)

$$\nabla \cdot (\sigma \nabla V) = -I\delta(r - r_s)$$

2) Field observations (must fit data)

$$data = V_N - V_M$$

3) A starting model (initial guess)

4) Reference model (impose structures)

5) Constraints
→ geologically reasonable solution

Geologically representative resistivity model

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Geologically representative resistivity model

Q: If the recovered model

- doesn't fit the data
- is geologically reasonable

is it a good solution?

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Geologically representative resistivity model

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Q: If the recovered model

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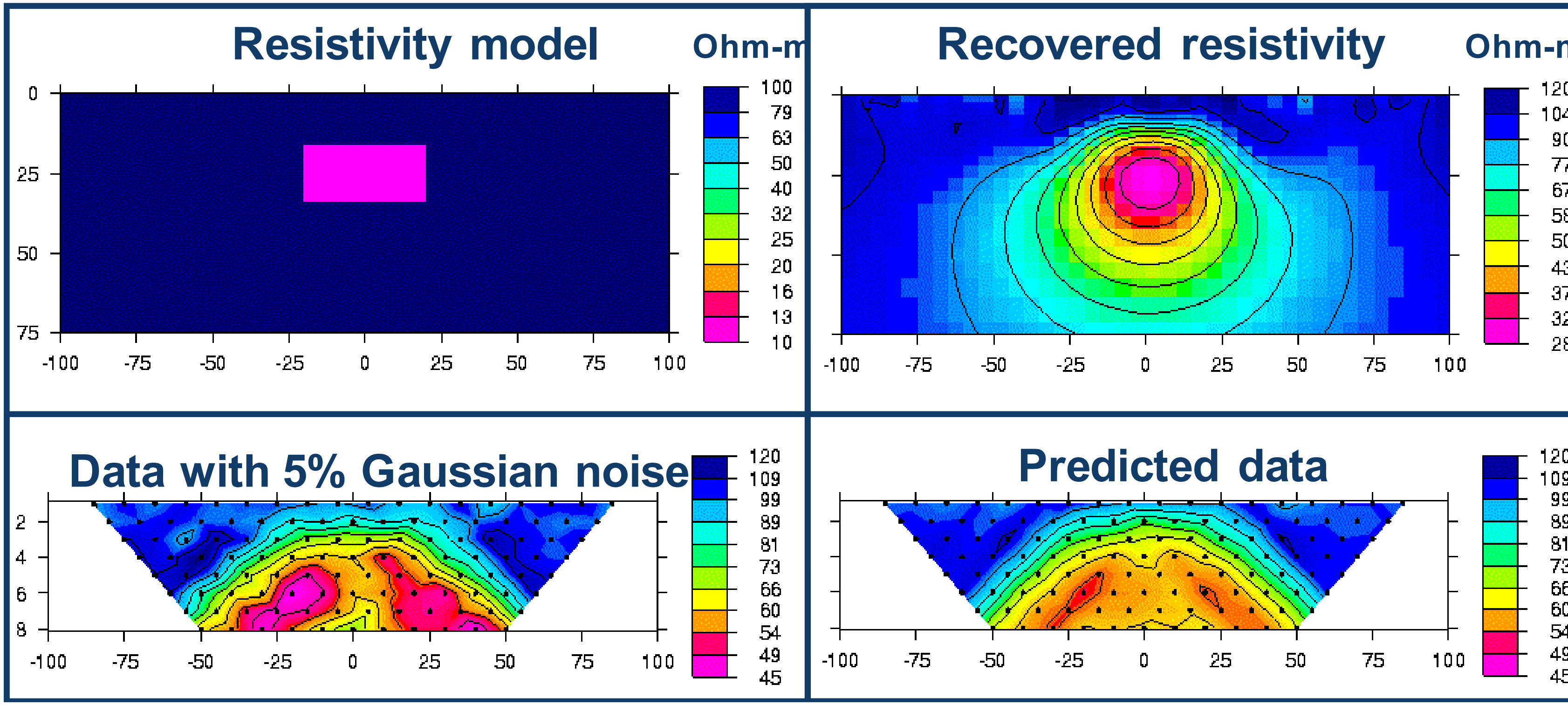
- isn't geologically reasonable

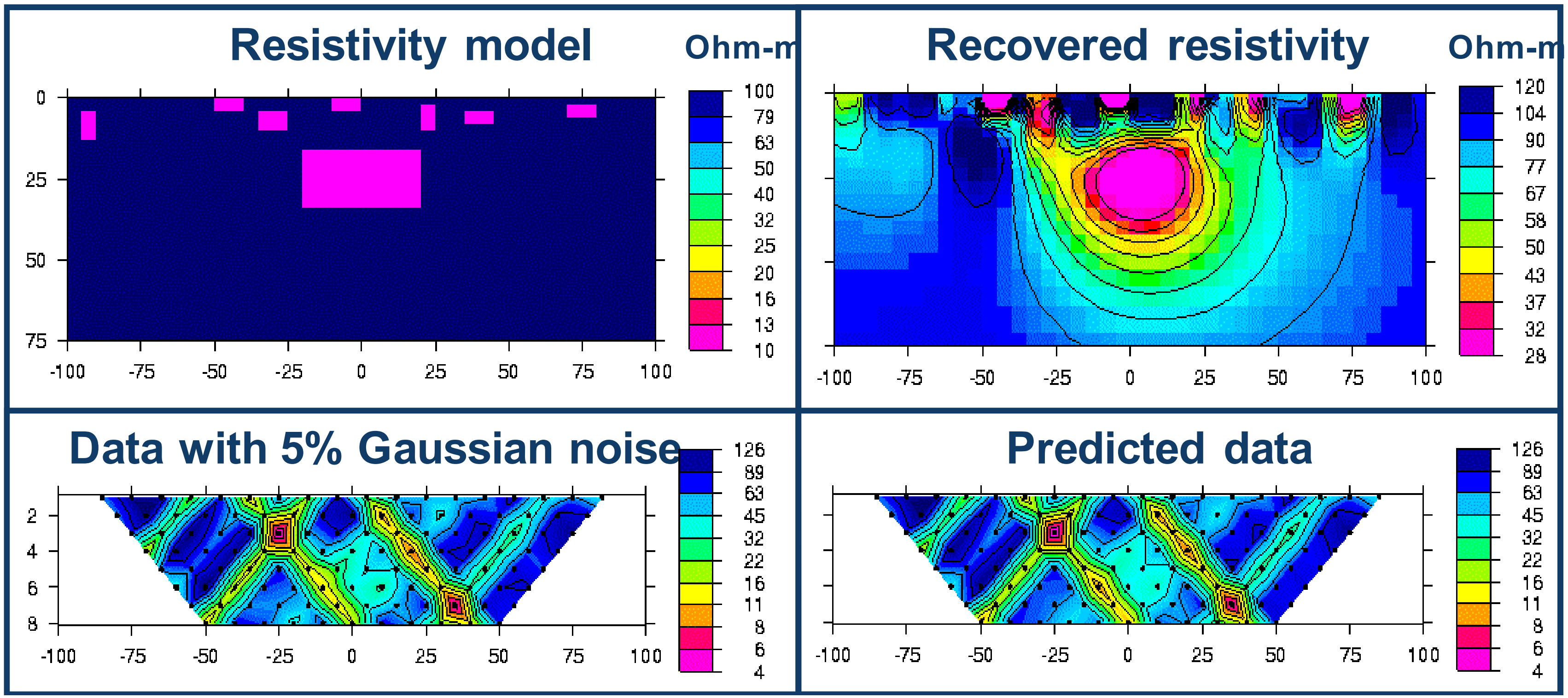
is it a good solution?

# Example 1: buried prism



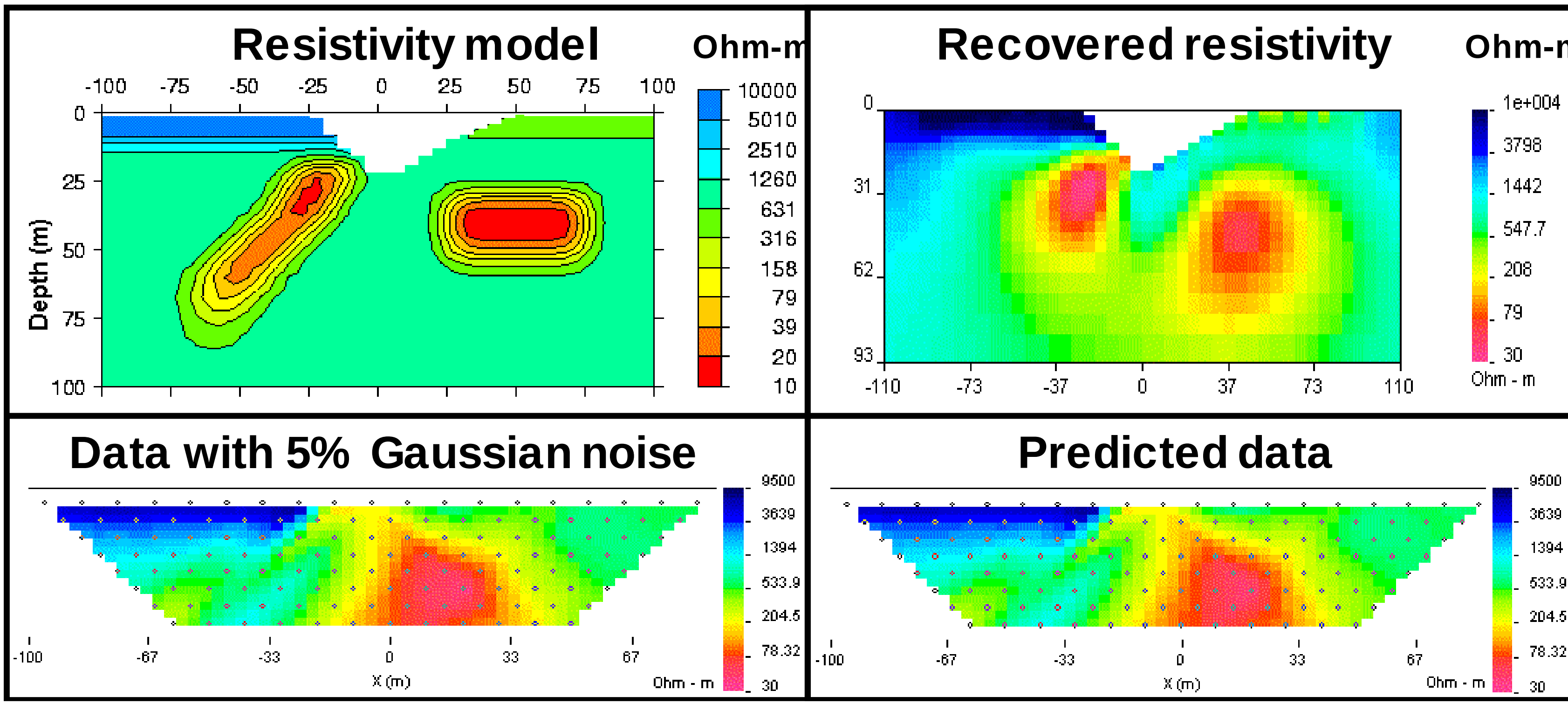

- Pole-dipole; n=1,8; a=10m; N=316; $(\alpha_s, \alpha_x, \alpha_z)=(.001, 1.0, 1.0)$

# Example 2: prism with geologic noise




- Pole-dipole; n=1,8; a=10m; N=316; $(\alpha_s, \alpha_x, \alpha_z)=(.001, 1.0, 1.0)$

# Example 3: UBC-GIF model



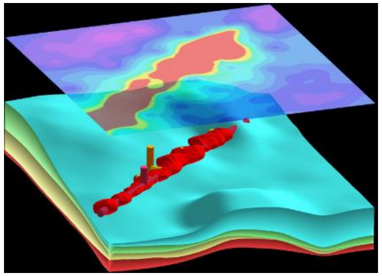

- Pole-dipole;  n=1,8;  a=10m

# The world is 3D

- Target
  - Size, shape, depth
- Background
  - Variable resistivity
- Questions
  - Where to put currents? 2D acquisition? 3D?
  - Where to make measurements?
  - Which measurements?
  - Effects of topography?
- These are survey design questions
- Crucial element is the **sensitivity**

Host

Ore body



Topography

Water underground

# Sensitivity

# Sensitivity and Inversion

- To recover a geological structure:

  → Data must be sensitive to that structure
  (e.g. structure must generate signatures in data)

- Things to consider:

  - Are current and potential electrodes coupled with target? (e.g. see signatures in data)

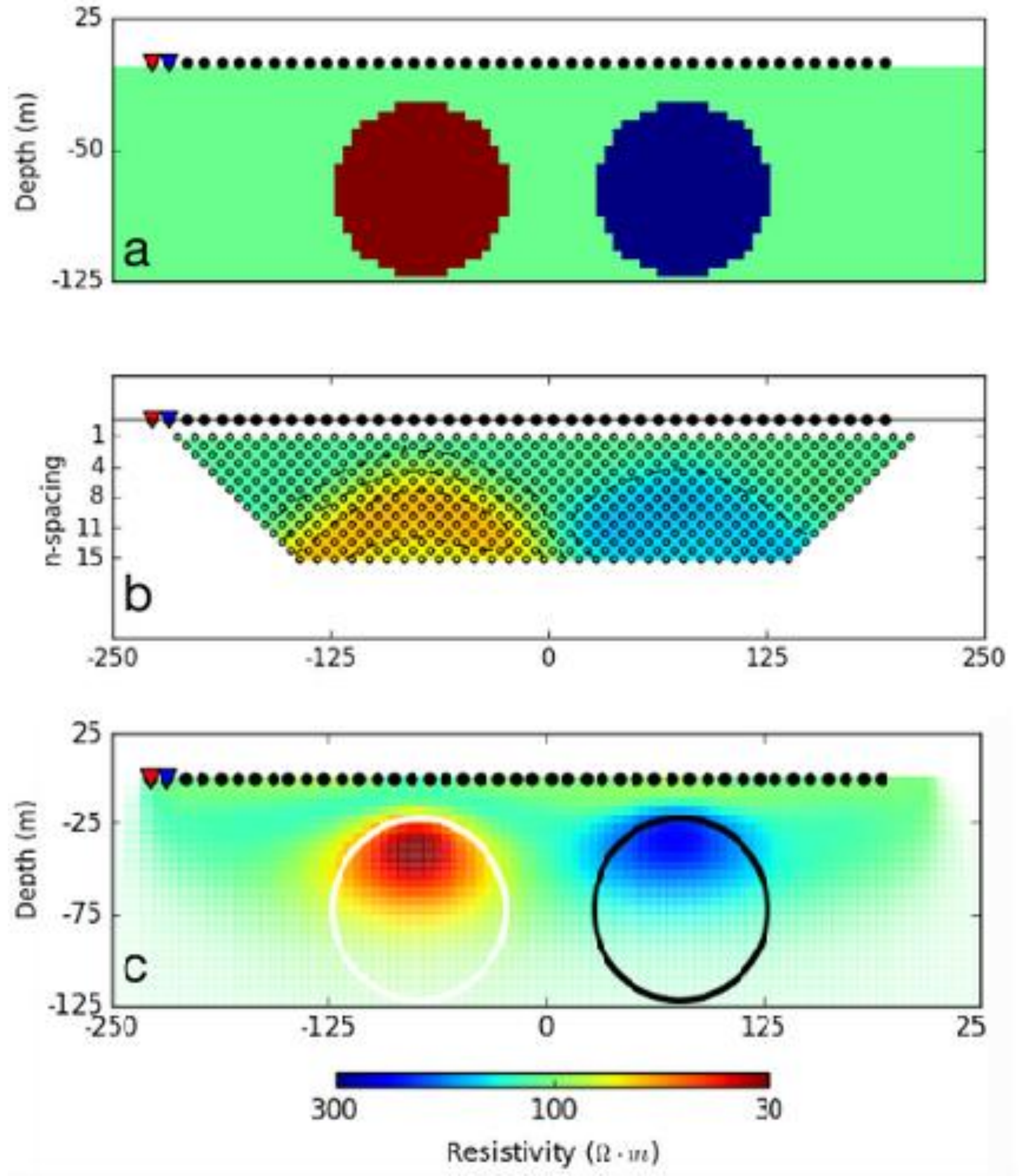
  - Is electrode spacing large enough to see deep enough?

  - Does enough current pentrate the conductive overburden?

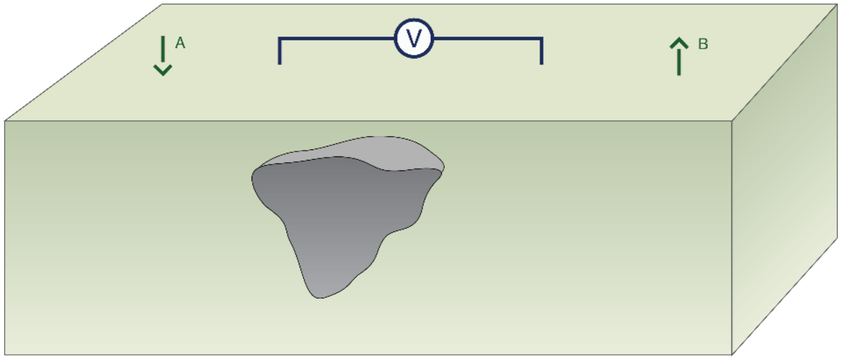
# Example: Two Spheres

- Electrodes coupled with spheres
- Data sensitive to top of spheres
- Data not sensitive to bottom of spheres

→ why?



# Sensitivity




Defines how a change in the model would change the data

Quantified by the sensitivity

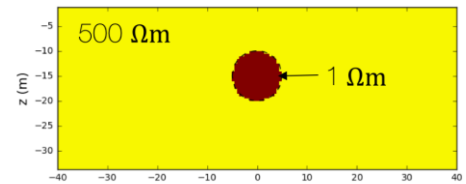
$$G = \frac{\Delta d}{\Delta p} = \frac{\text{change in data}}{\text{change in model}}$$

- Collect the data that are sensitive to the target
  - Need to **excite** the target
  - Need to have sensor **close** to the target

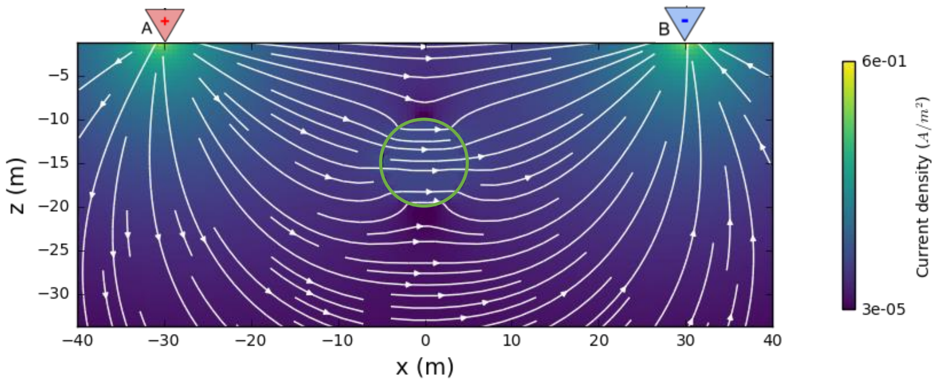
→ Need "good coupling"

# Exciting the target

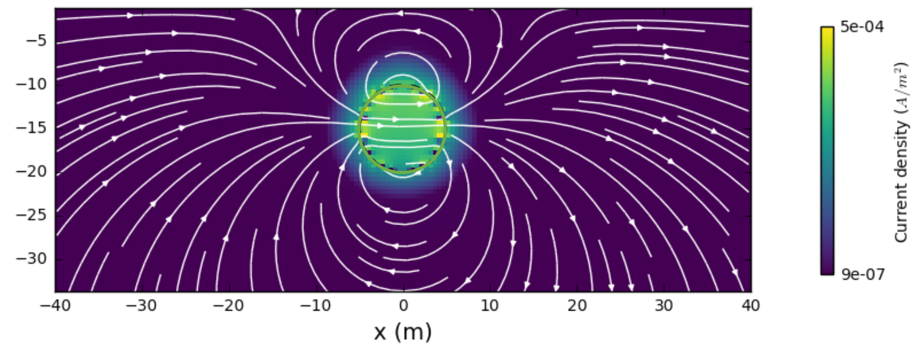
Resistivity model



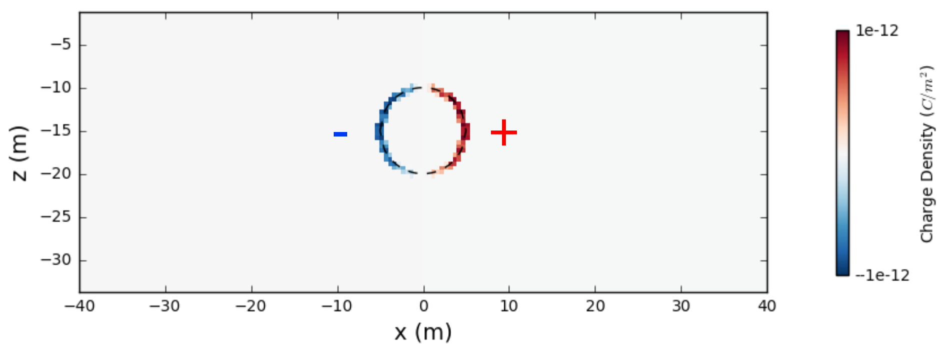

Total currents: **J**



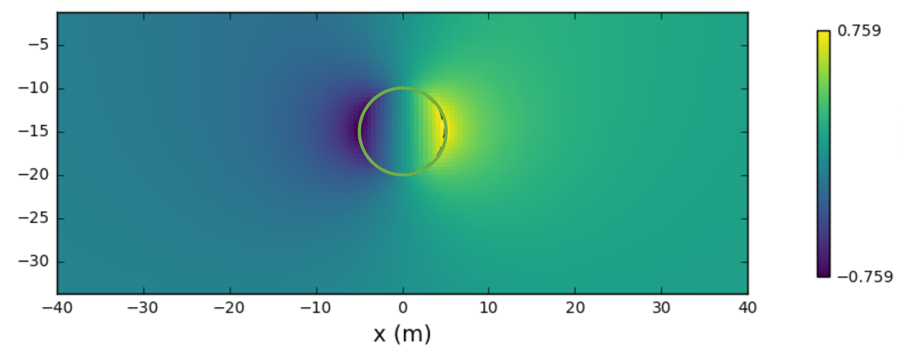

Secondary currents: $\mathbf{J}_s$




Secondary charges: $Q_s$

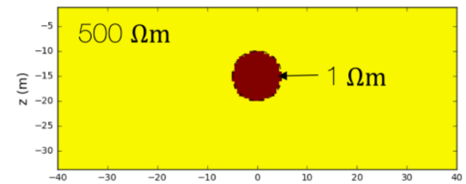



Secondary potential: $\phi_s$

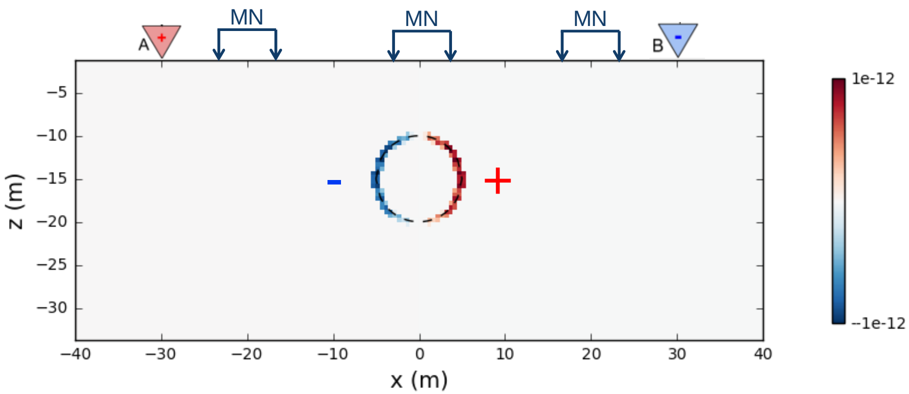


# Measurements

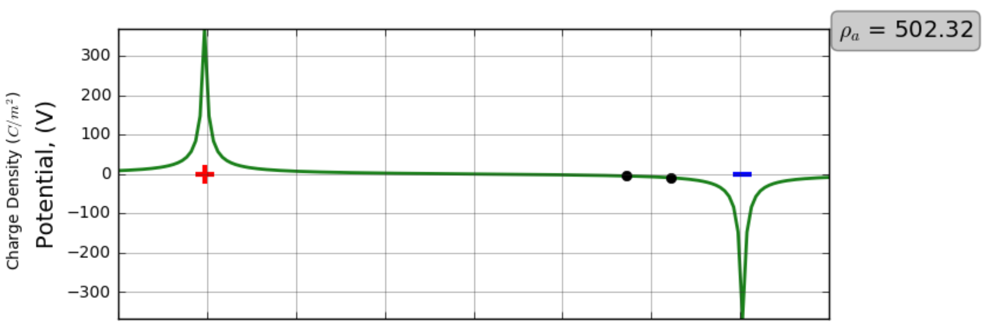
Resistivity model



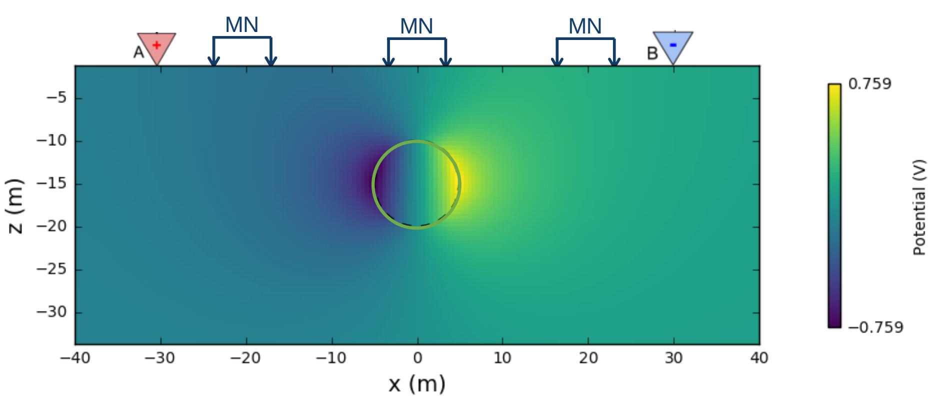

## Secondary charges: $Q_s$




## Potential profile

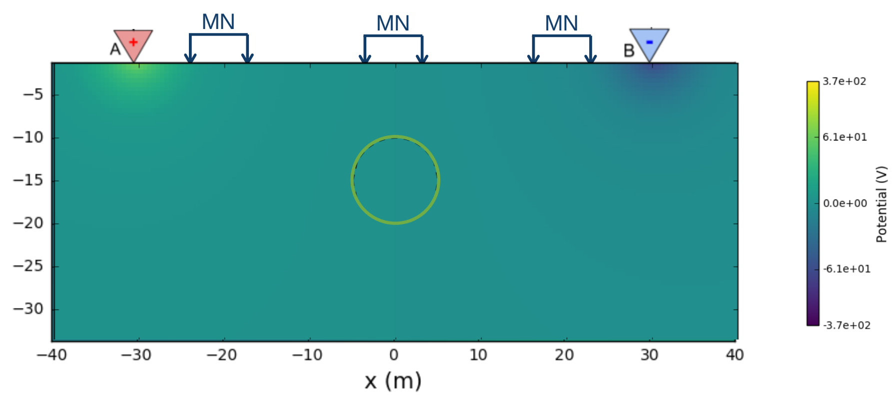



## Secondary potential: $\phi_s$




## Total potential: $\phi$

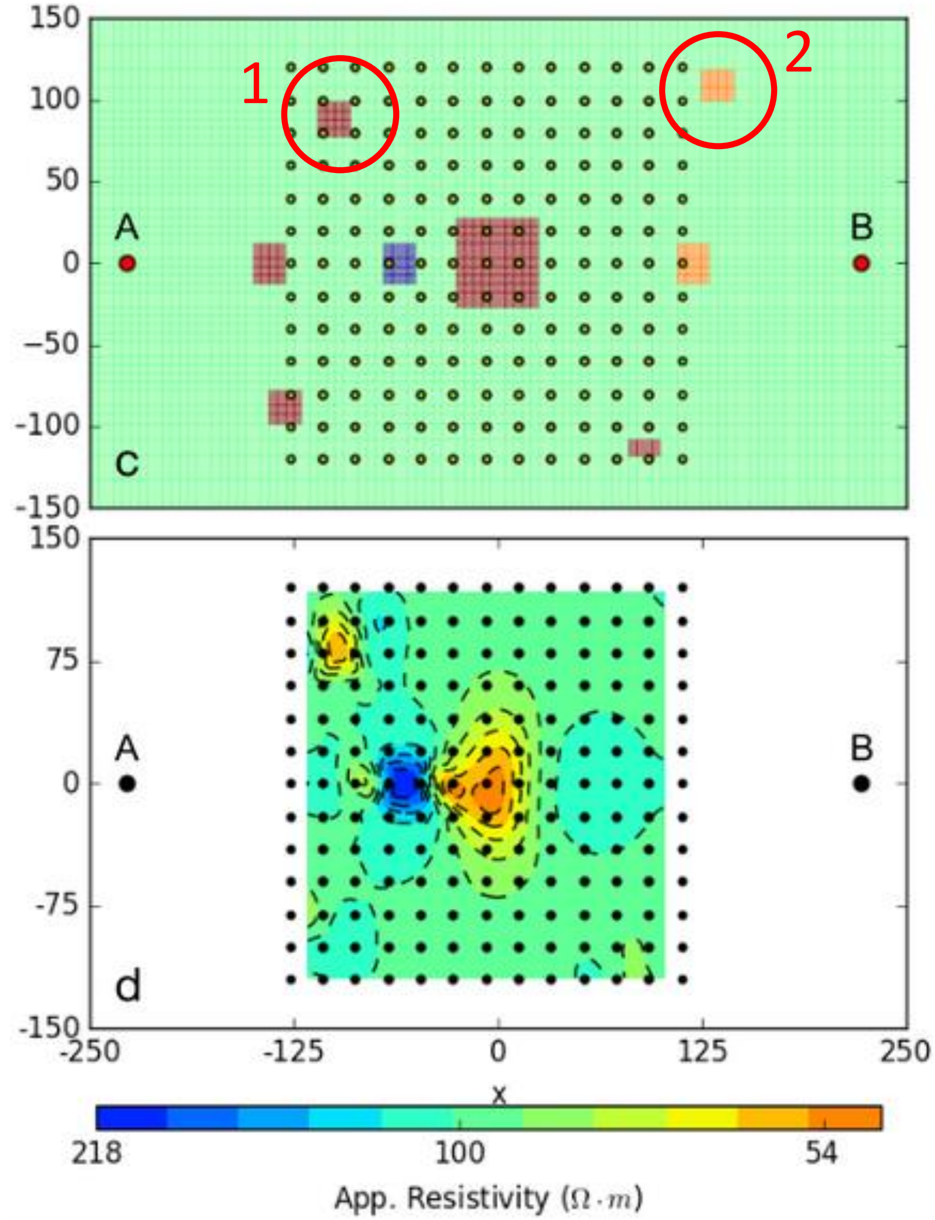
$\rho_a = 502$ $\rho_a = 430$ $\rho_a = 502$



# Coupling: Gradient Array

- Q: Do you expect to recover block 1? Why/why not?

- Q: Do you expect to recover block 2? Why/why not?



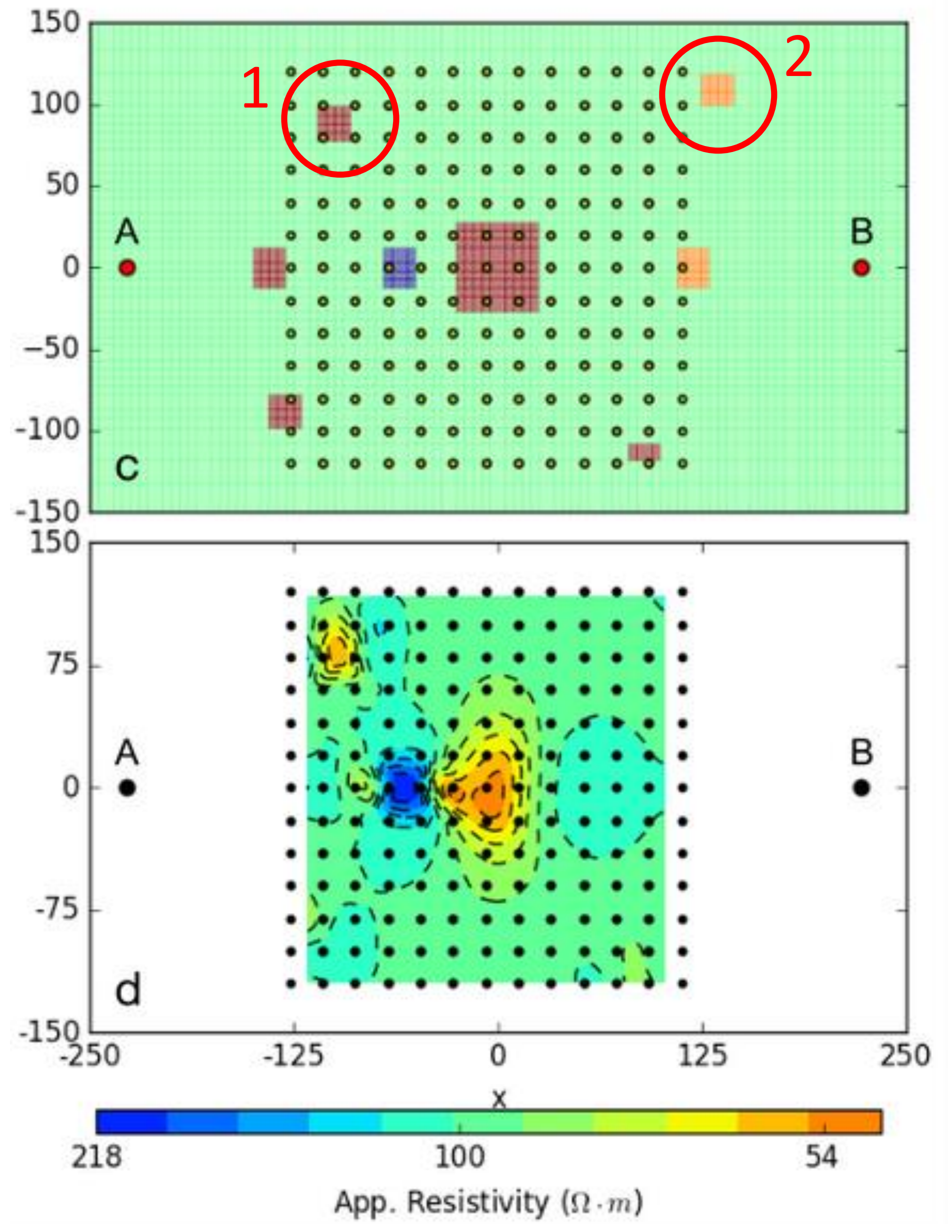
# Coupling: Gradient Array

- Q: Do you expect to recover block 1? Why/why not?

  - Yes
  - Creates signatures in data
  - Good coupling

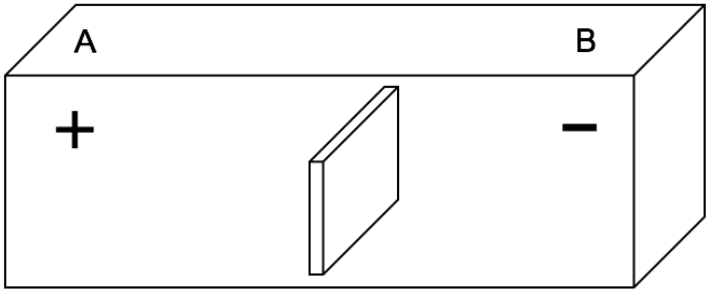
- Q: Do you expect to recover block 2? Why/why not?

  - No
  - No signatures in data
  - Poor coupling of receivers

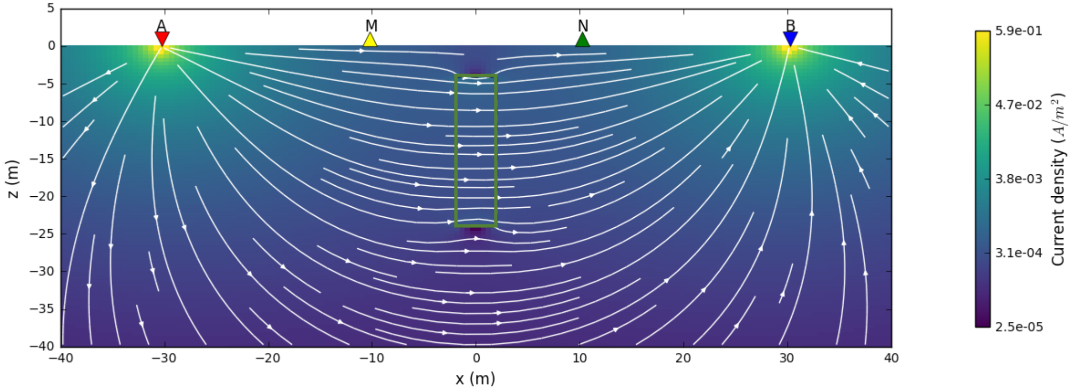


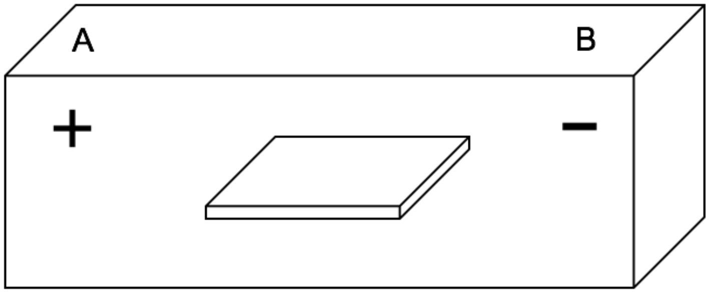
# Coupling: Thin Plate

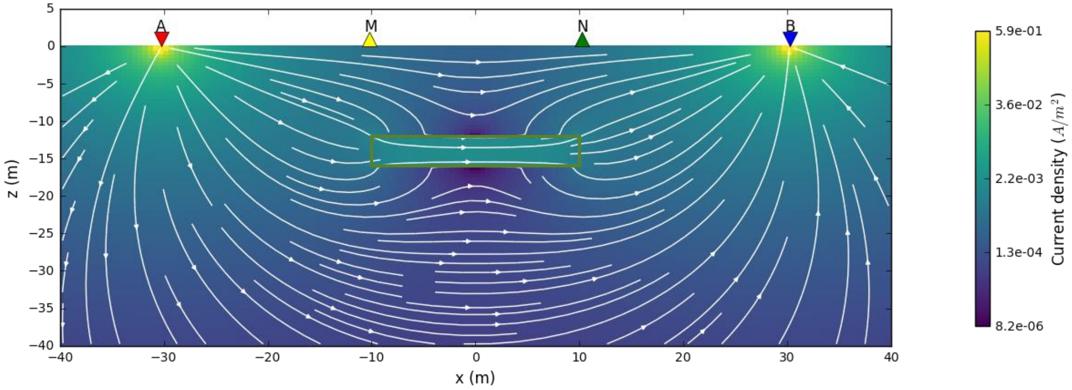
- Different orientation → Different coupling → Different Data




Total currents: **J**



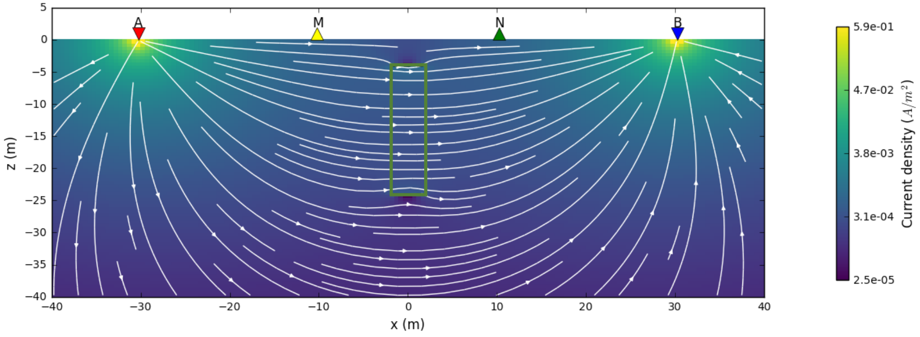



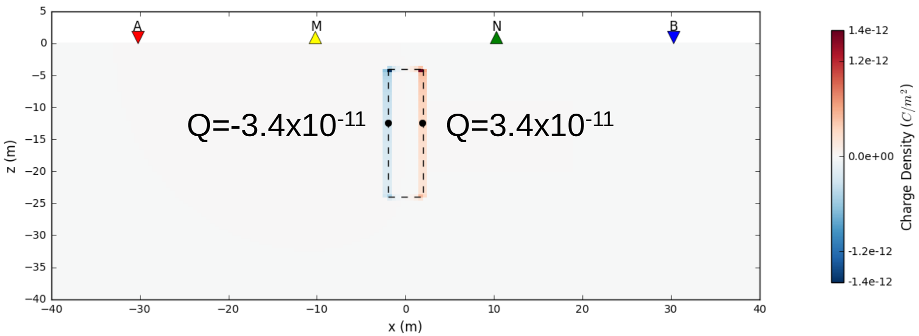
# Conductive vs. Resistive Target

## Conductive Target

Total currents: **J**

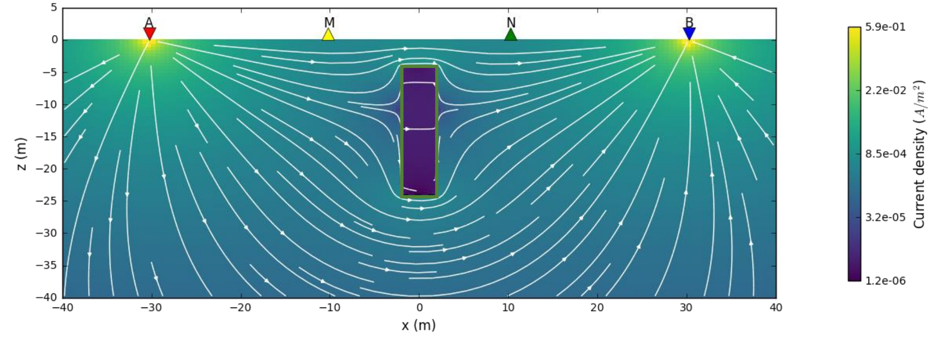



Secondary charges: $Q_s$

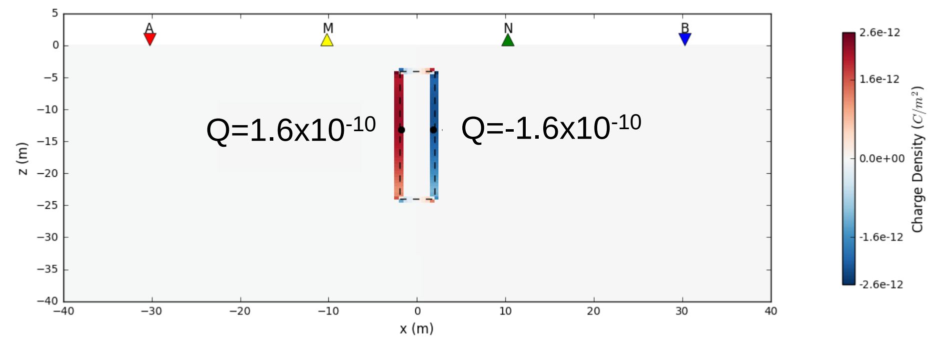



## Resistive Target

Total currents: **J**



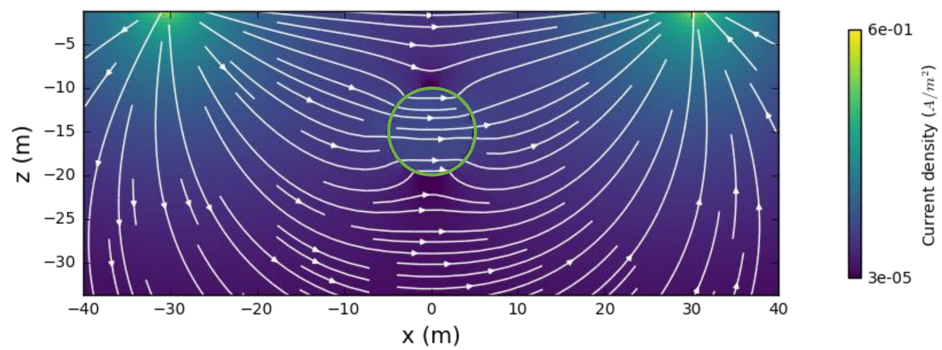

Secondary charges: $Q_s$



# Summary: Sensitivity

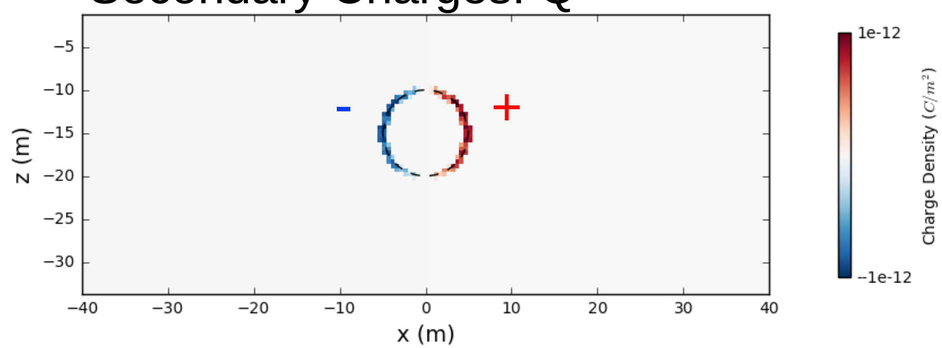
- "Excite" the target
  - Drive currents to target
  - Need good coupling with target

Total currents: **J**

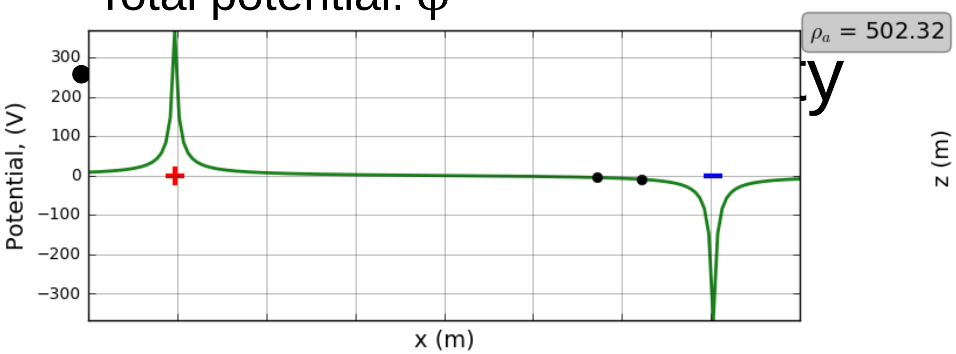



- Measuring a datum
  - Proximity to target
  - Electrode orientation and separation

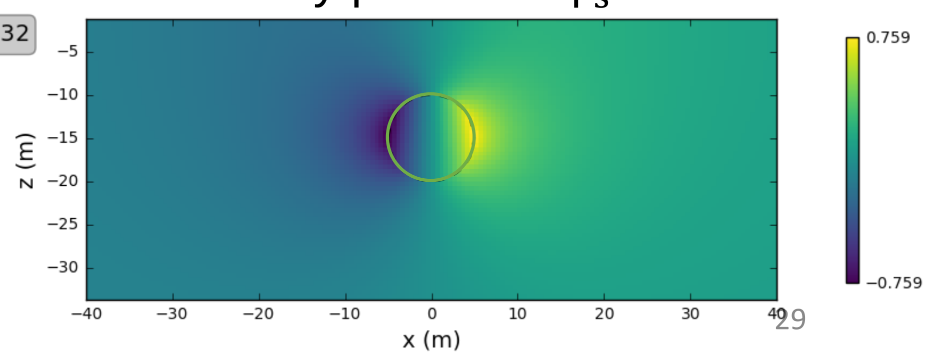
Secondary Charges: Q




Total potential: $\phi$




Secondary potential: $\phi_s$



# Inversion and Sensitivity Recap

- Recovers geologically reasonable model that fits data
- Does not recover true model
- Easier to interpret than pseudo-section
- Only recovers structures sensitive to survey

# Recap: Questions

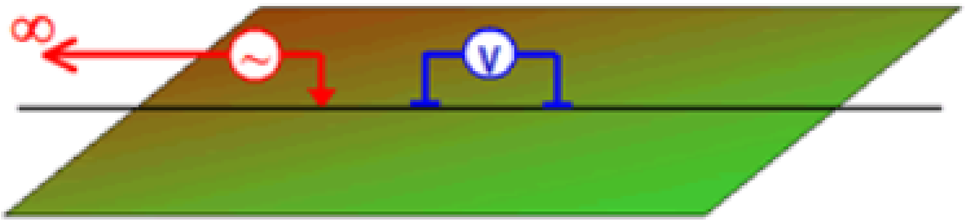
- What are reasons why survey might not be sensitive to a structure?

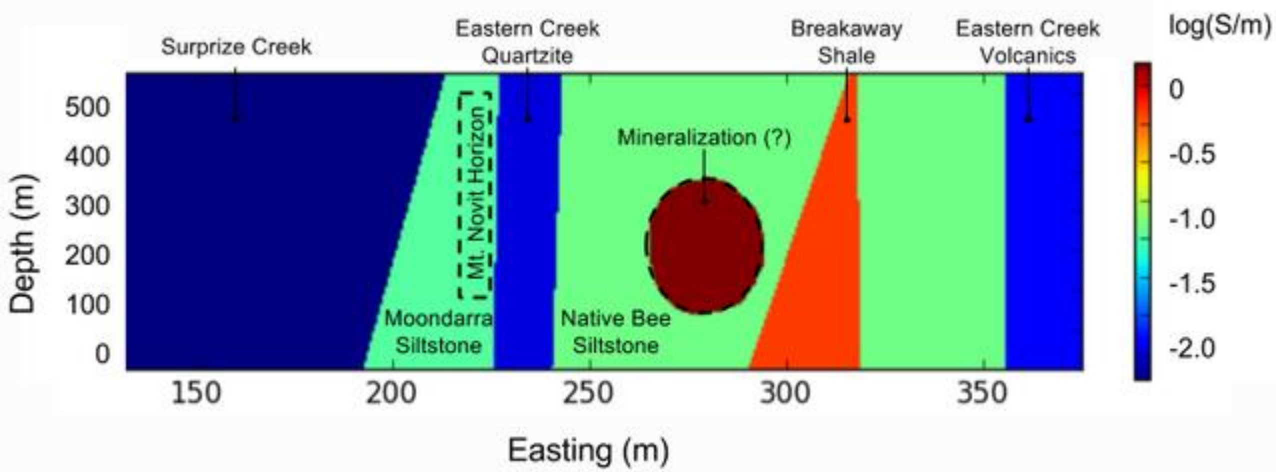
- What do we mean by “solution is non-unique”?

# DCR Example: Mt. Isa

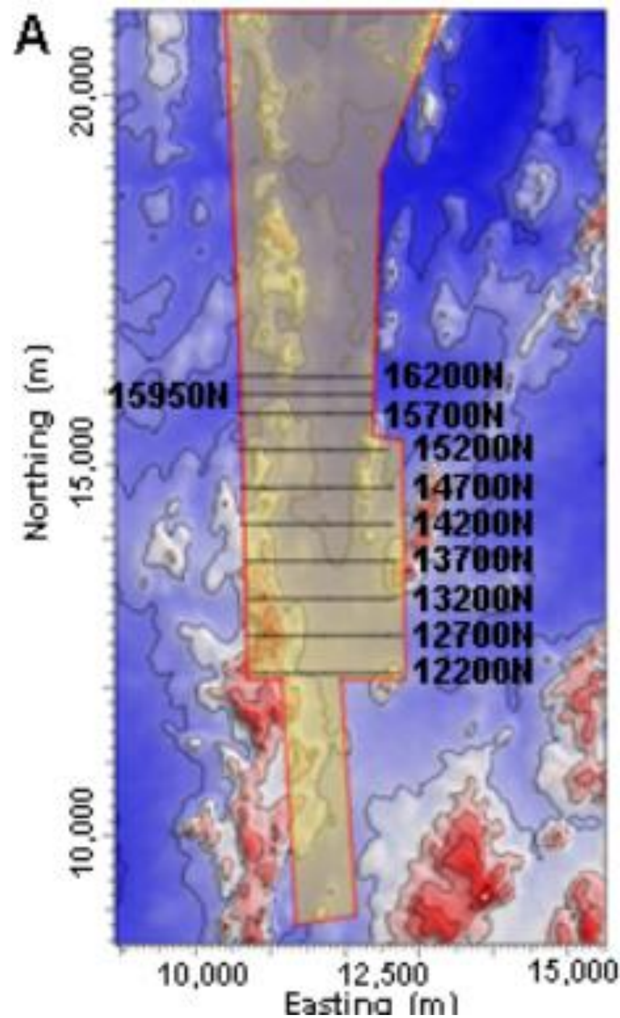
# Mt. Isa (Setup)

- Potential ore deposit (lead, zinc, silver, copper, gold?)
- Proposed survey with pole-dipole and dipole-pole configurations



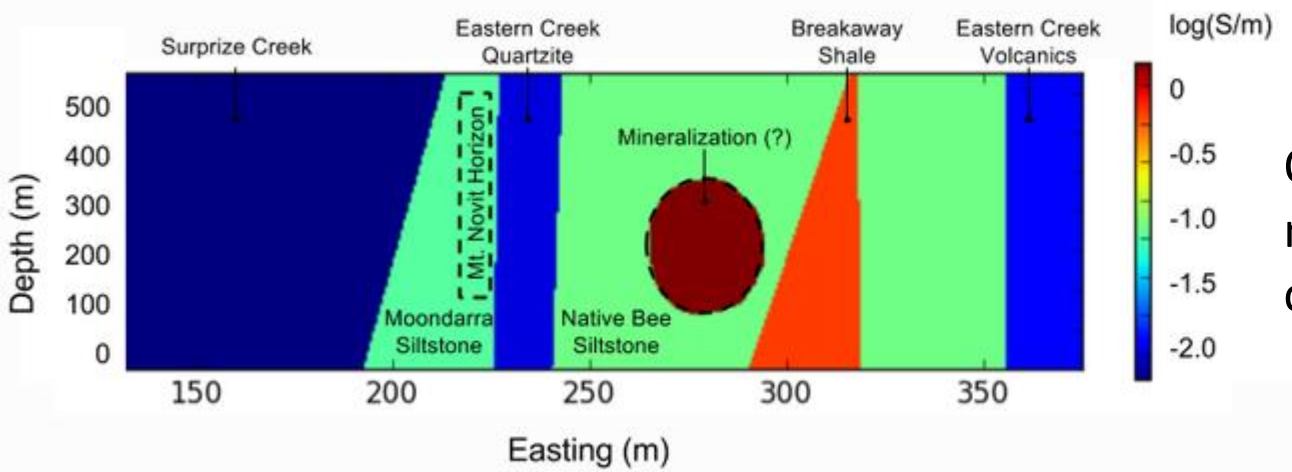




*Simplified (log) conductivity distribution expected at Mount Isa (N:12200m).*



# Mt. Isa (Properties)

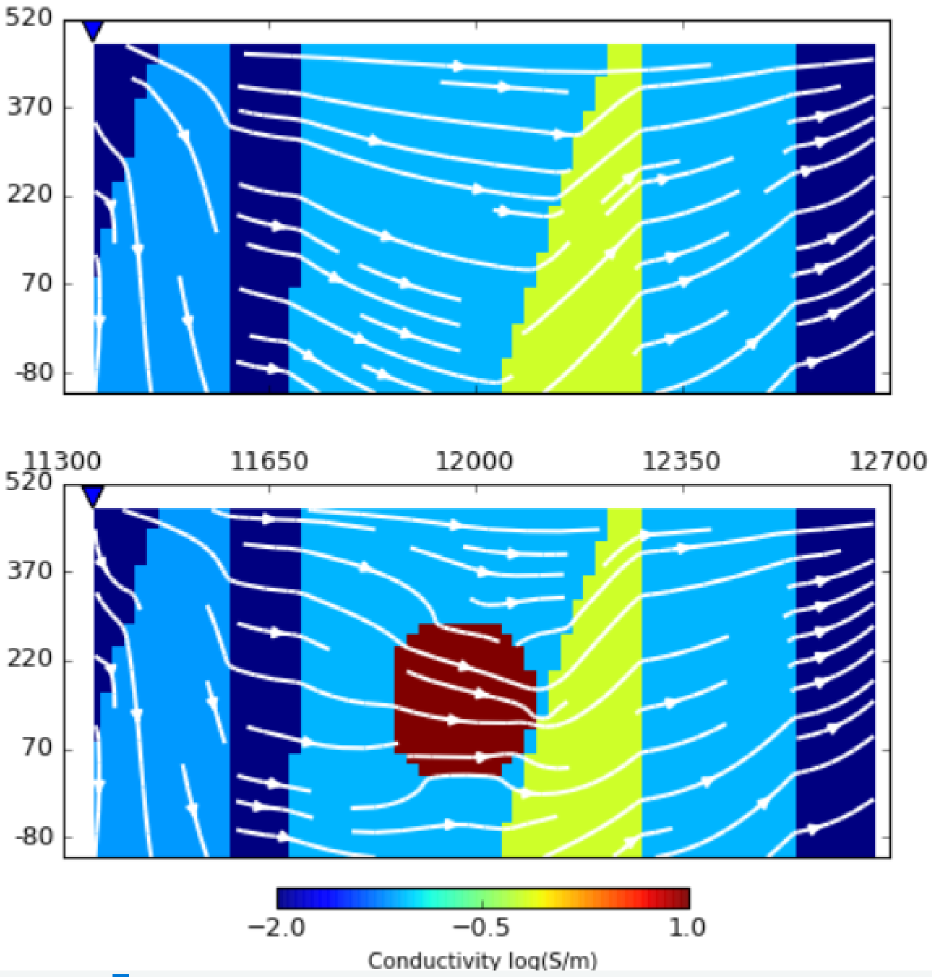
| Rock Unit | Conductivity | Resistivity ($\Omega \cdot m$) |
|---|---|---|
| Native Bee Siltstone | Moderate | Moderate (~10) |
| Moondarra Siltstone | Moderate | Moderate (~10) |
| Breakaway Shale | Very High | Very Low (~0.1) |
| Mt Novit Horizon | High | Low (~1) |
| Surprise Creek Formation | Low | High (~1000) |
| Eastern Creek Volcanics | Low | High (~1000) |




*Simplified (log) conductivity distribution expected at Mount Isa (N:12200m).*

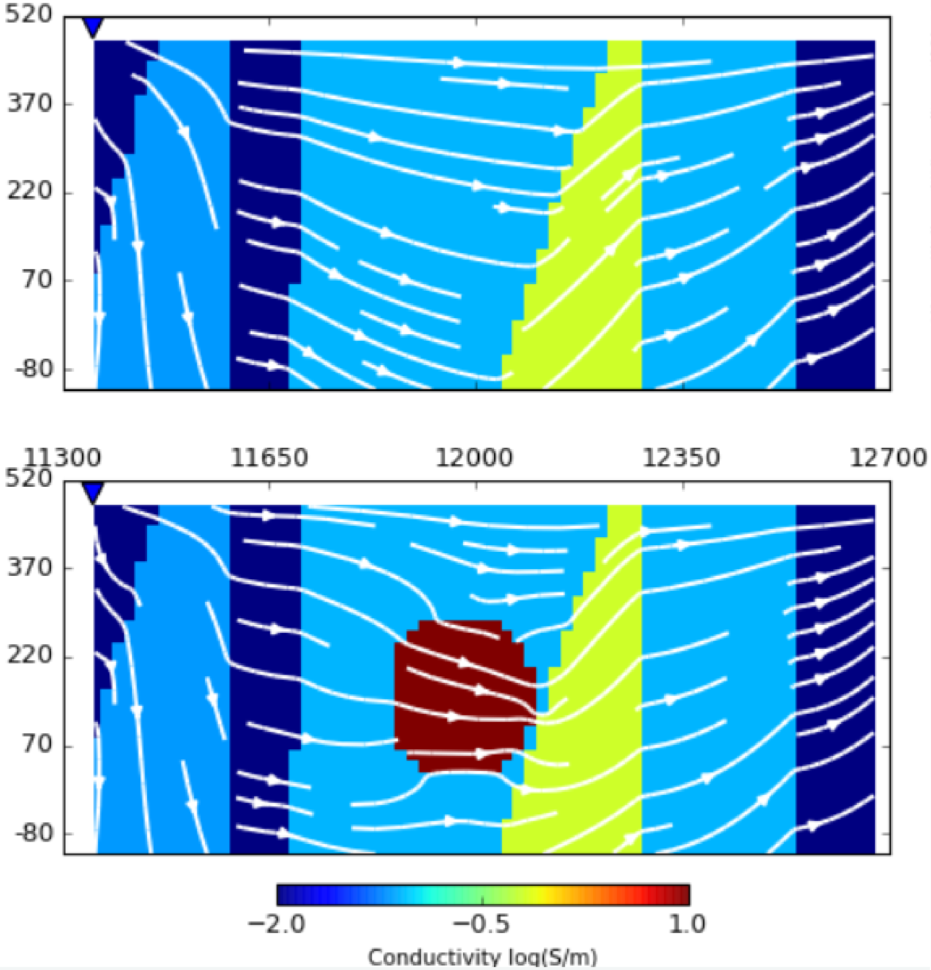
Q: Do you expect mineralization to be conductive or resistive?

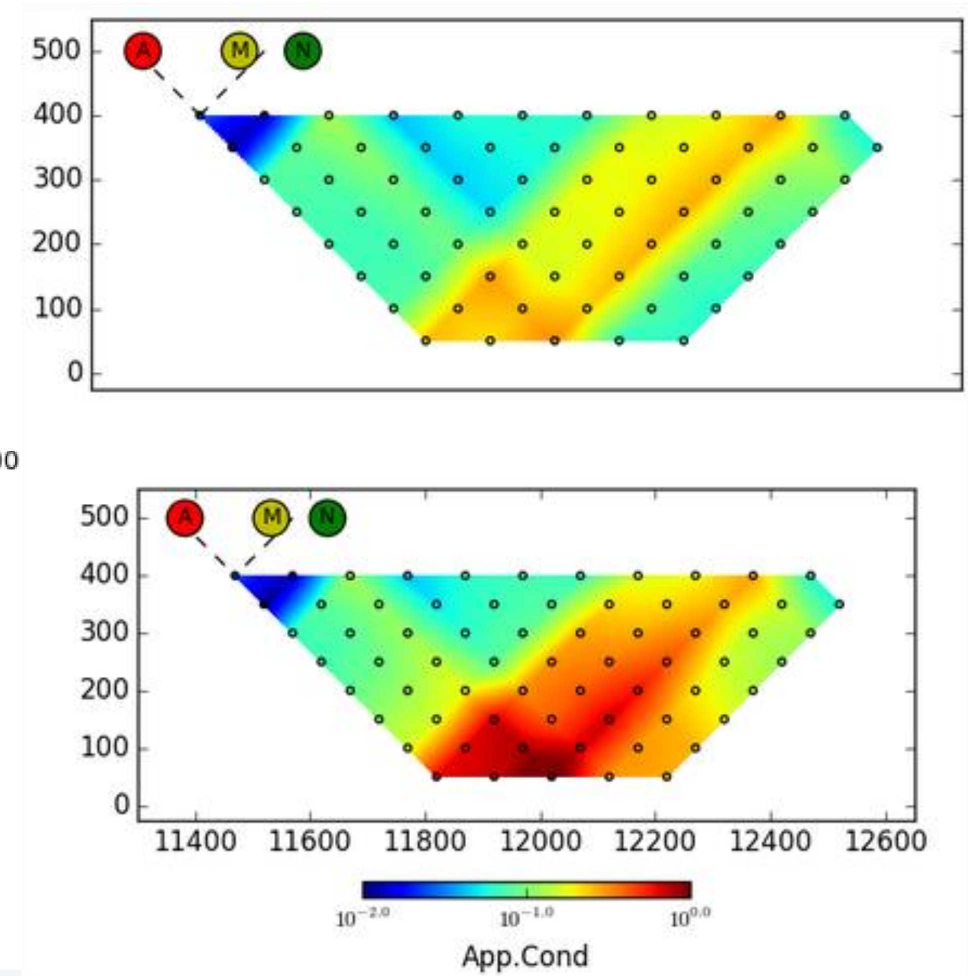
# Mt. Isa (Synthetic Modeling)




Q: What happens to currents, charges and potentials if mineralization exists?

# Mt. Isa (Synthetic Modeling)

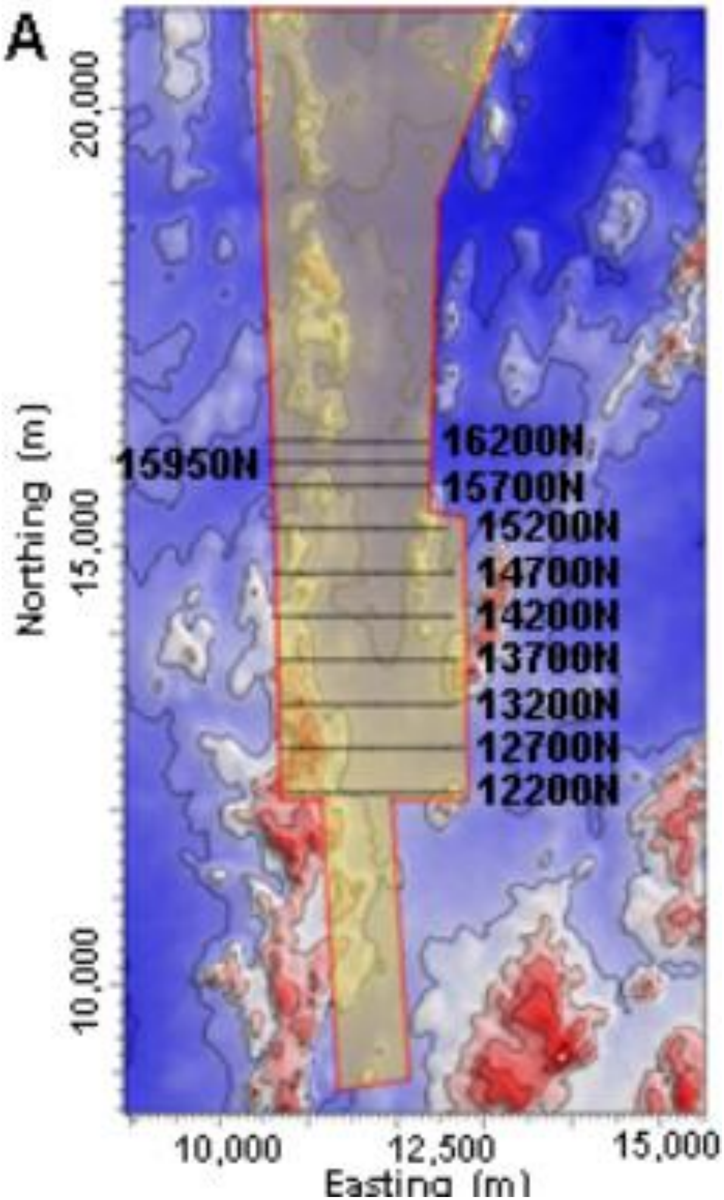


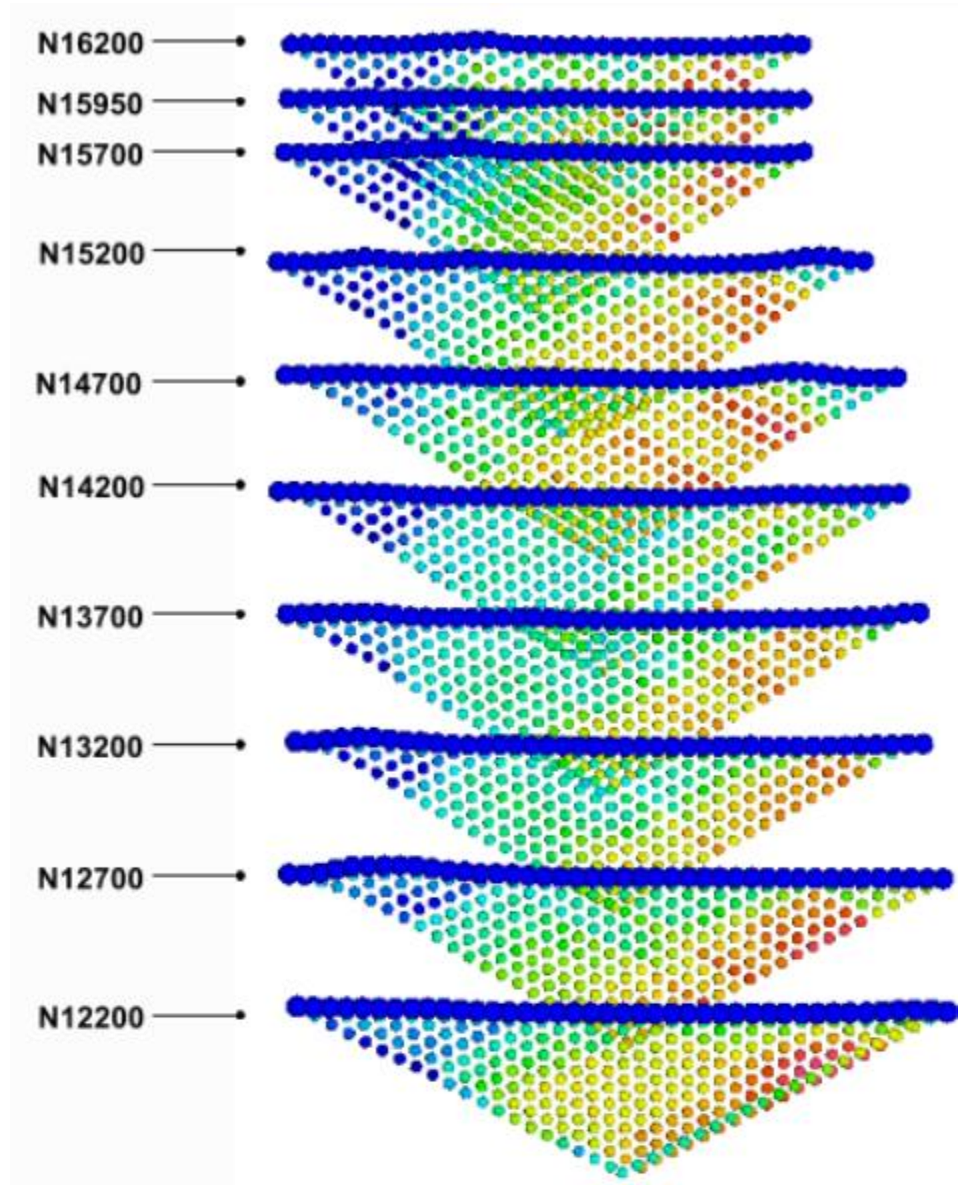




Q: What happens to currents, charges and potentials if mineralization exists?

Q: Are data sensitive to mineralization?

# Mt. Isa (Survey and Data)



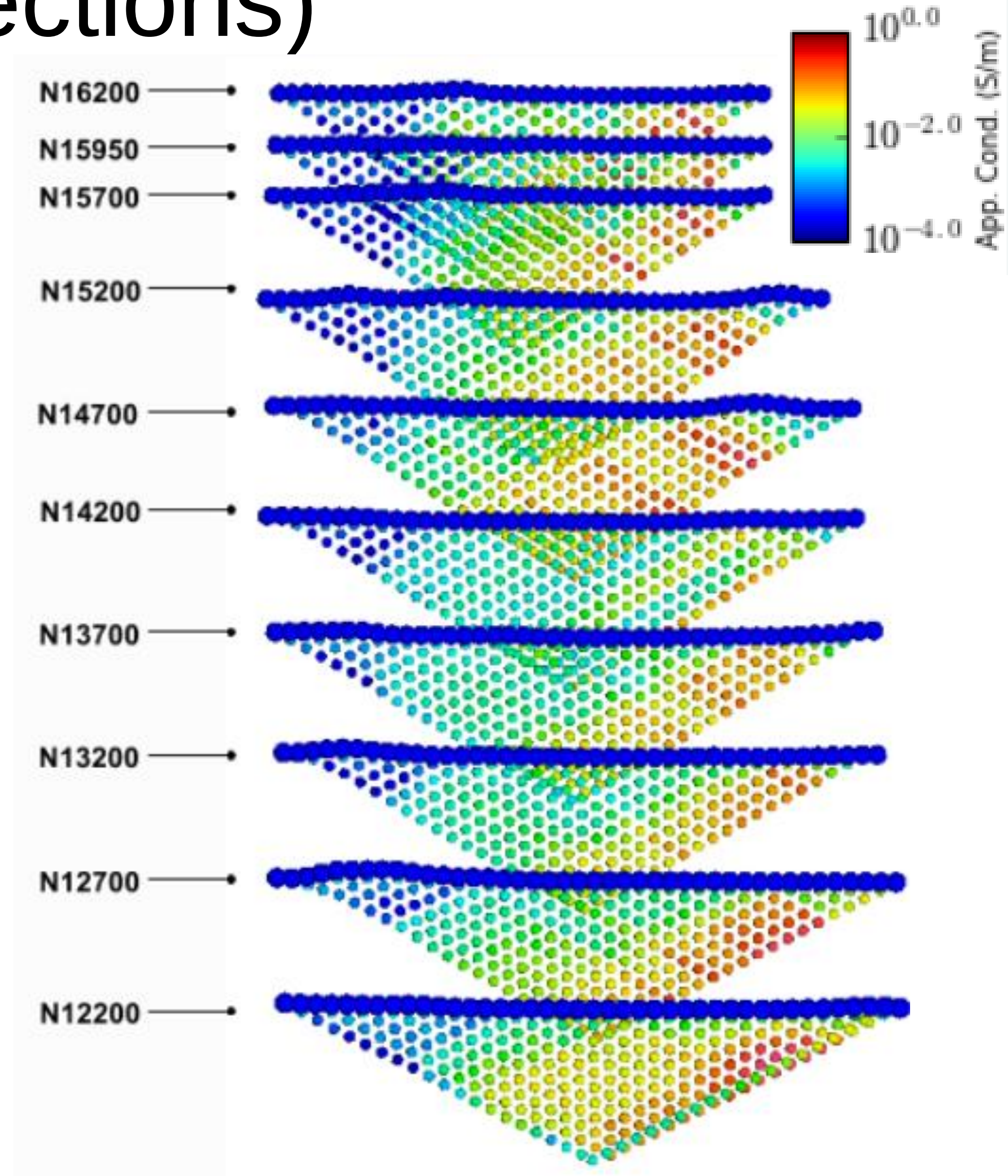



# Mt. Isa (Interpretation of Pseudo-Sections)

Q: How does the surface conductivity change from East to West?

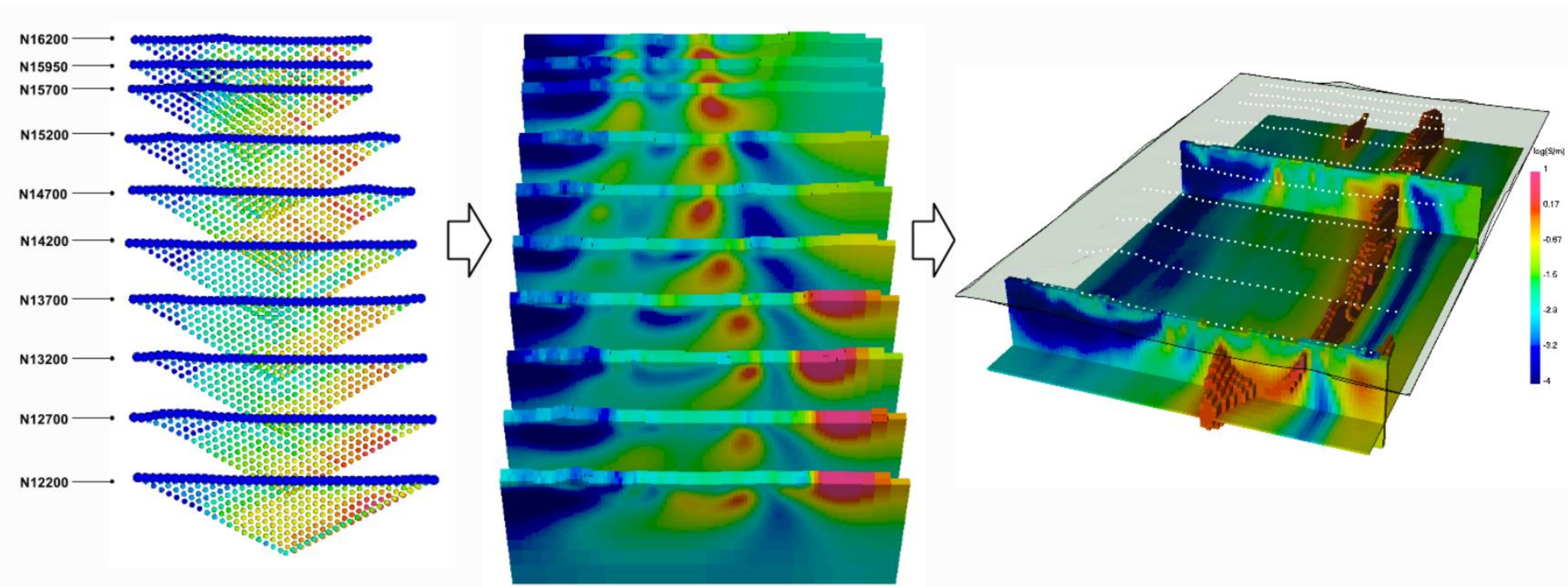
Q: Are there obvious features running North to South?

Q: Is existance of mineralization obvious?



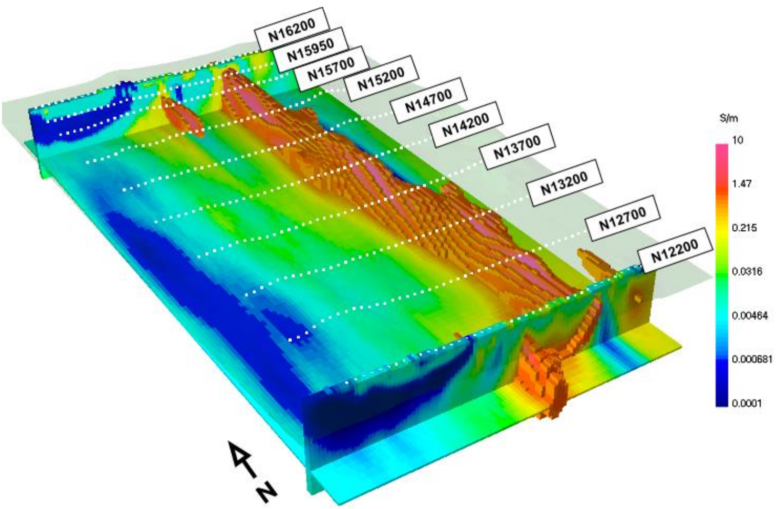
# Mt. Isa (Inversion)

Data Independent 2D inversions 3D inversion

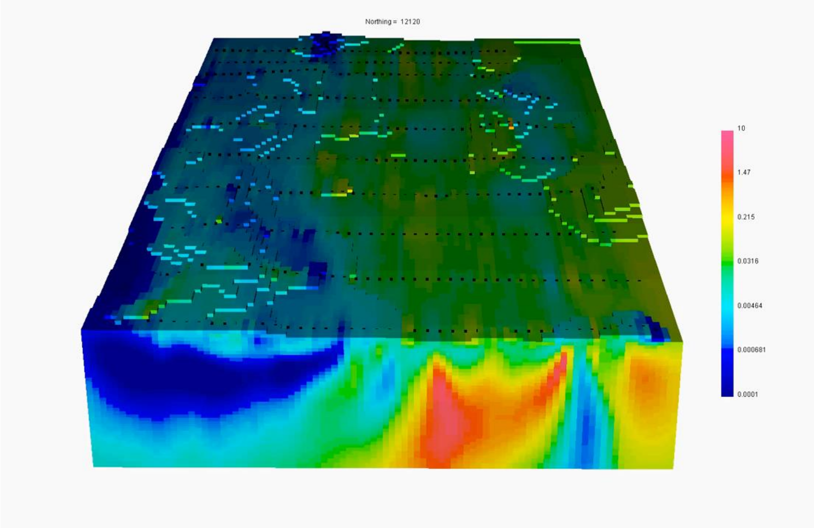


# Mt. Isa (Inversion)

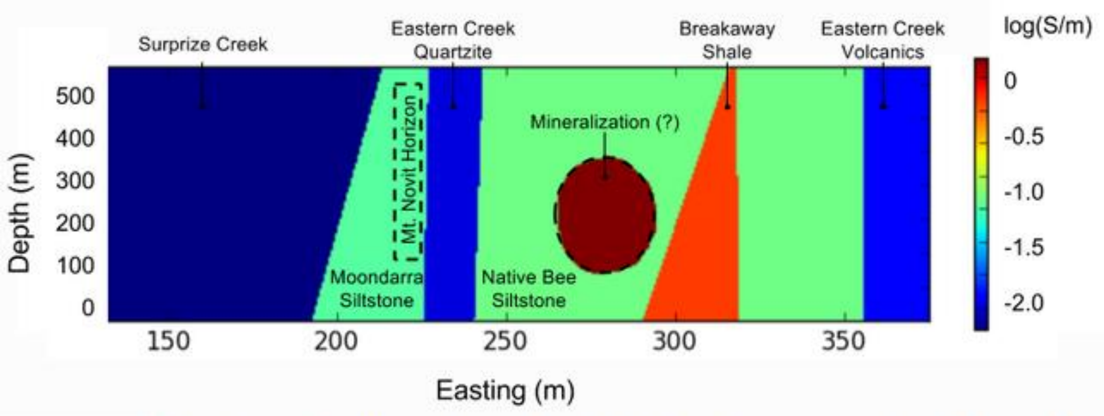
3D resistivity model




Animation

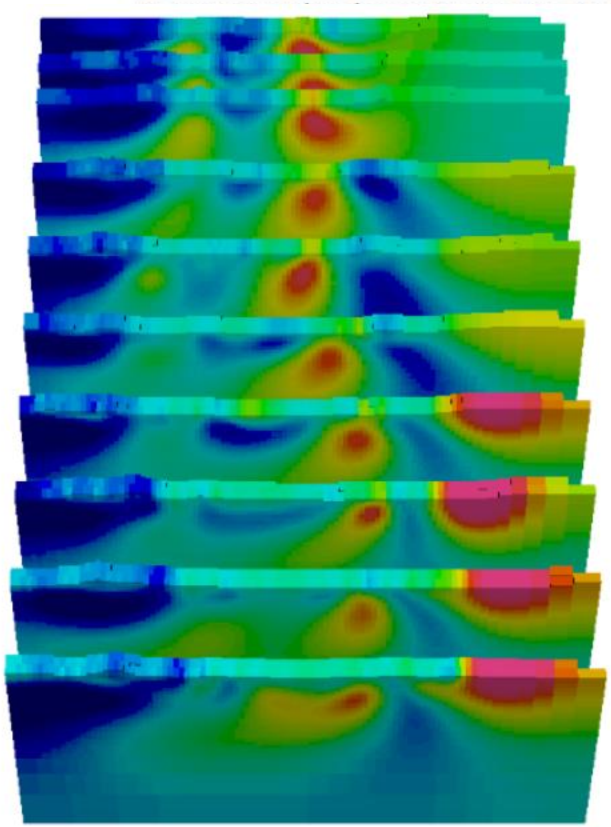


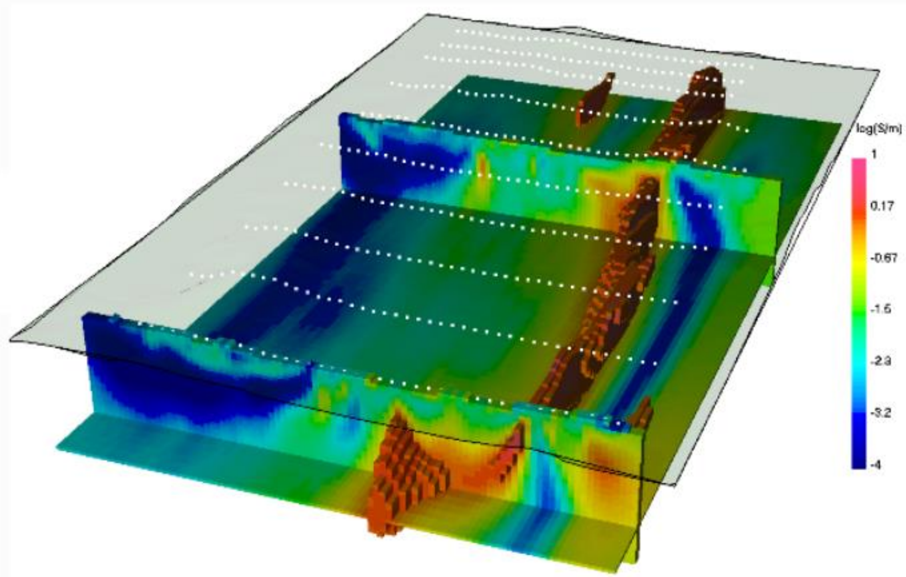
# Mt. Isa (Interpretion using Inversion)




Q: What units show up in the inversion?

Q: Can we differentiate mineralization from breakaway shale? (both conductive)

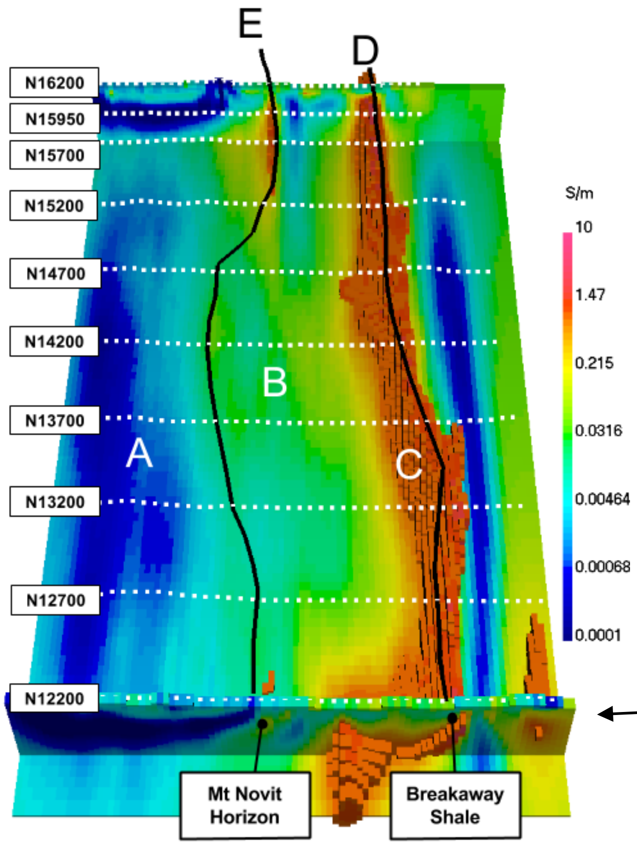




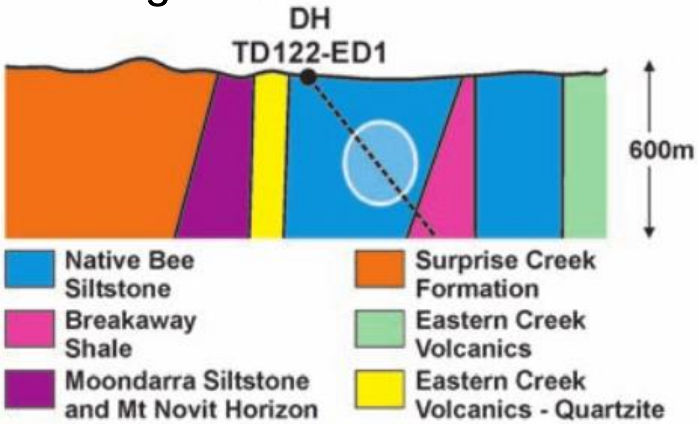
# Synthesis

- Identified a major conductor → black shale unit
- Some indication of a moderate conductor

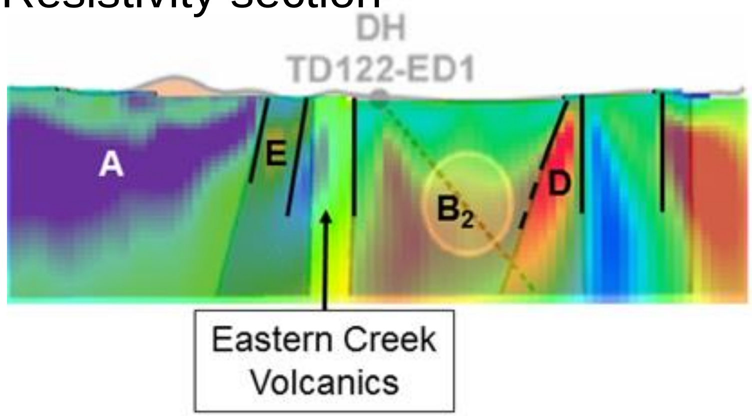
3D resistivity model




Geologic section




Resistivity section



# Unit Activities

- **Labs: (DC)**
  - Monday, October 28$^{th}$
  - Tuesday, October 29$^{th}$

- **Quiz:**
  - Friday, November 1$^{st}$