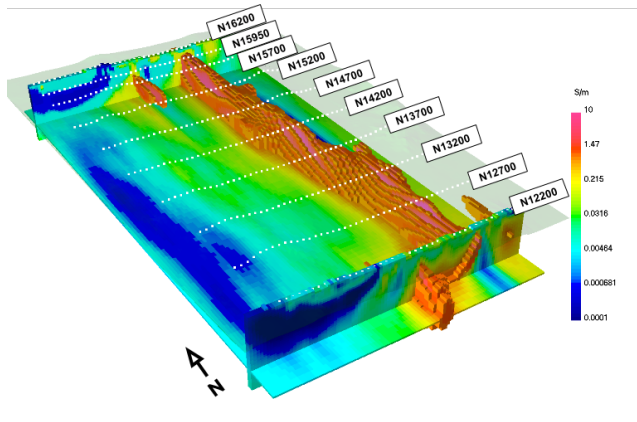


# Summary and the Future

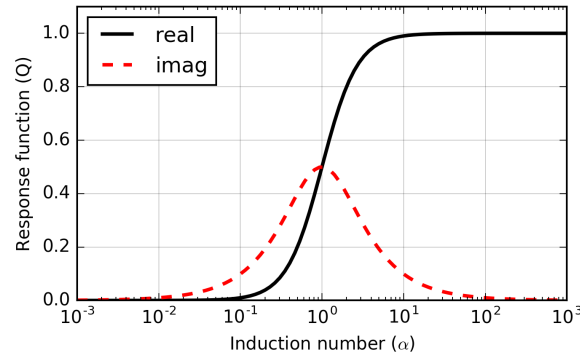


# What have we covered?

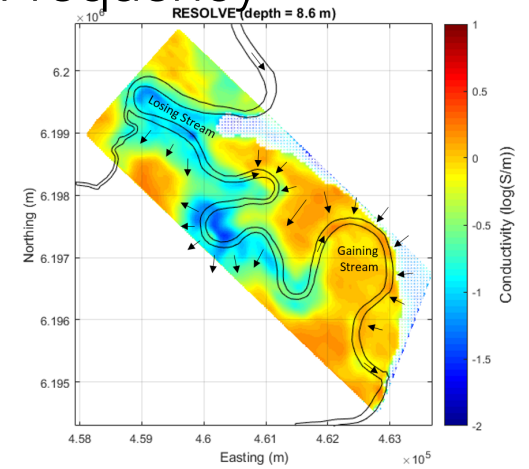
## DC Resistivity



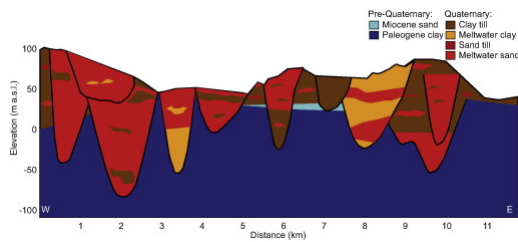
## EM Fundamentals



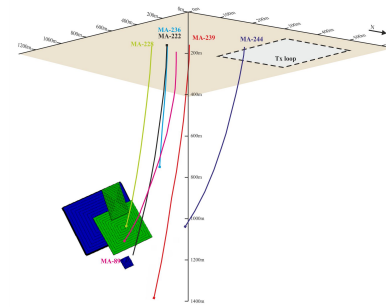
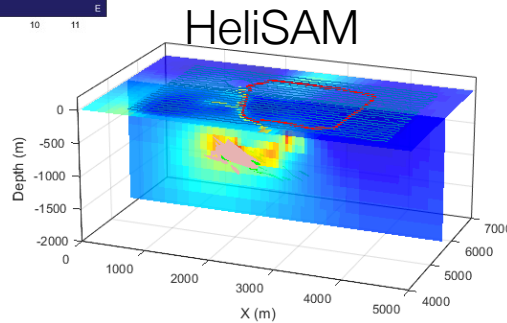
## Inductive Sources: Frequency



## Inductive Sources: Time

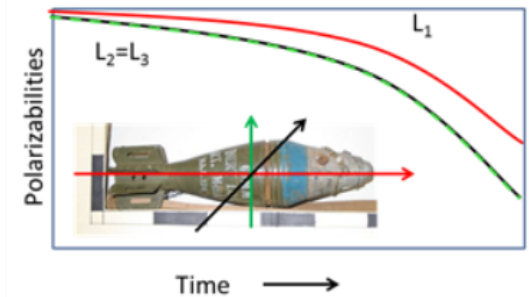


## Mapping paleochannels



## Multi-stage exploration

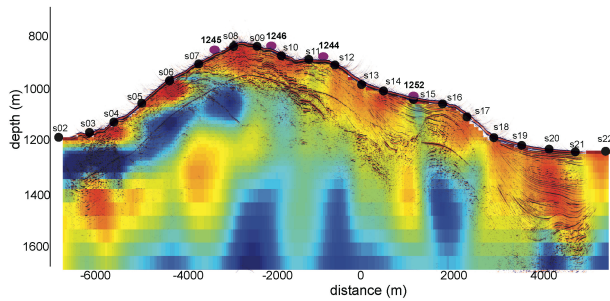
## UXO



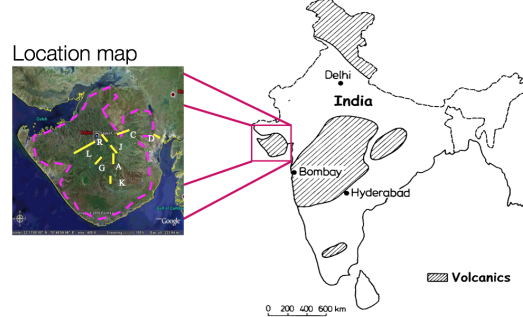
# What have we covered?

## Grounded Sources

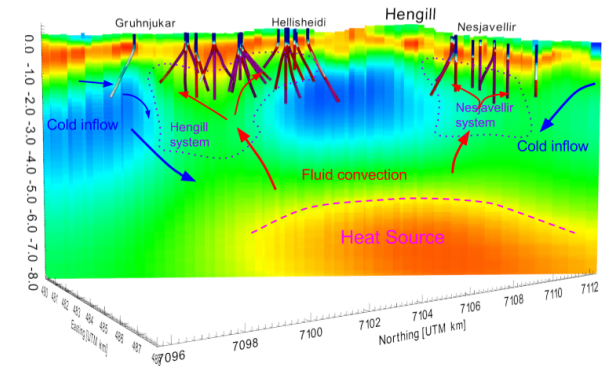
### Methane hydrates



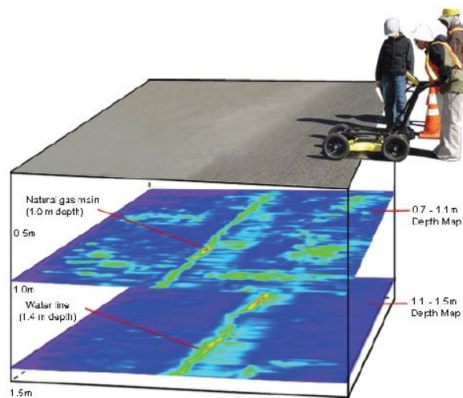
### Mapping sediments beneath basalt



## Natural Sources

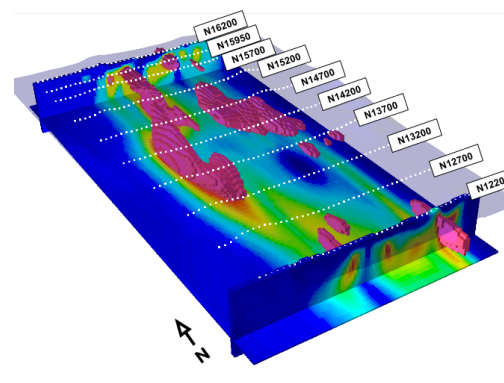


## Ground Penetrating Radar

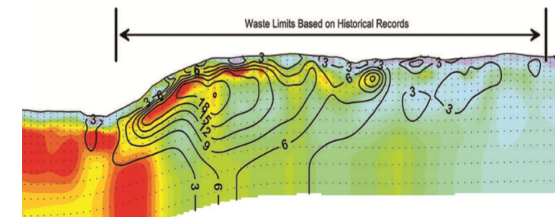


## Induced Polarization

### Minerals



### Landfills



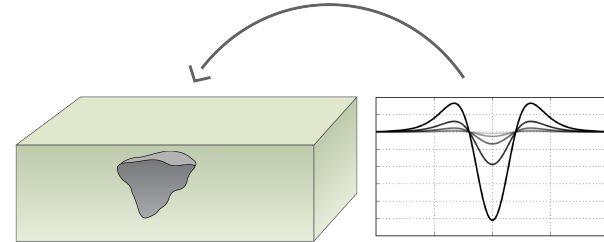
What does the future hold?

# What does the future hold?

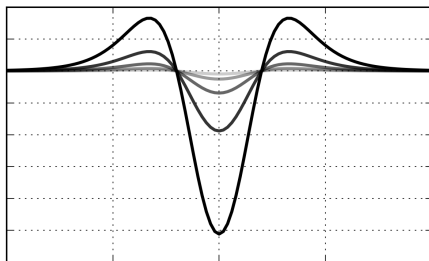
Problems



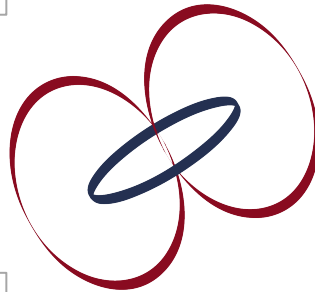
Inversion capabilities



High quality data

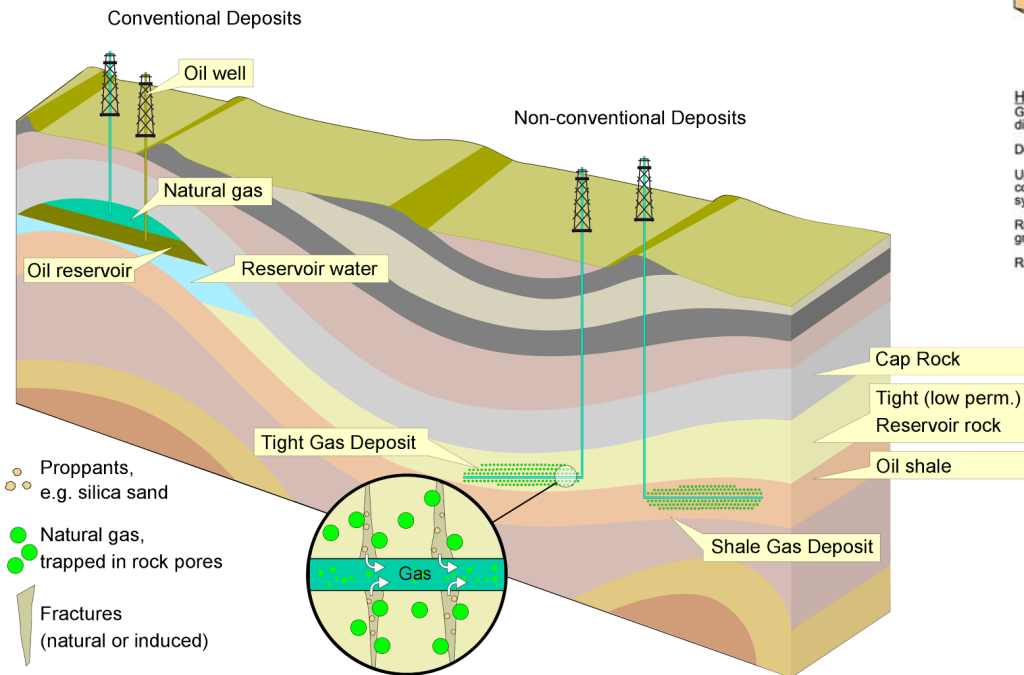
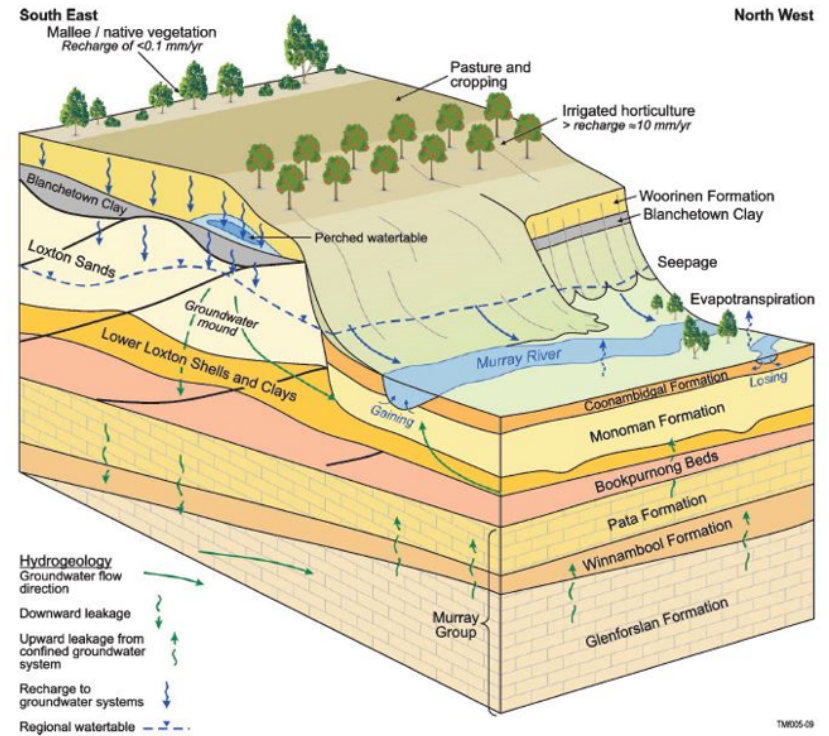


Web tools to  
communicate



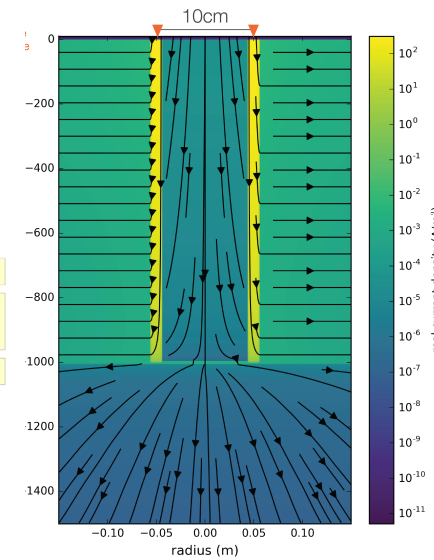
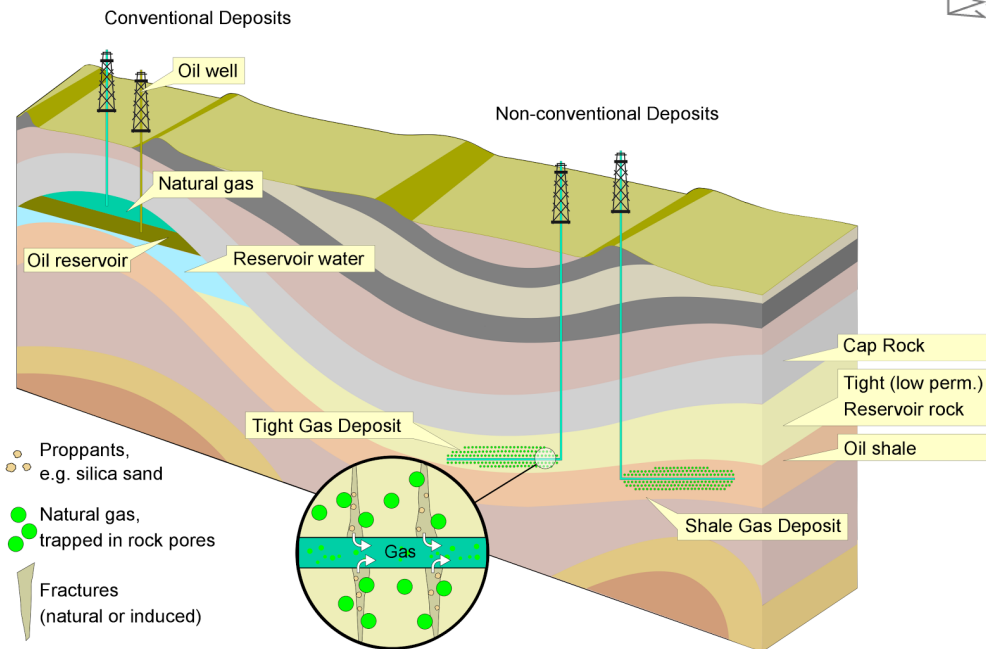
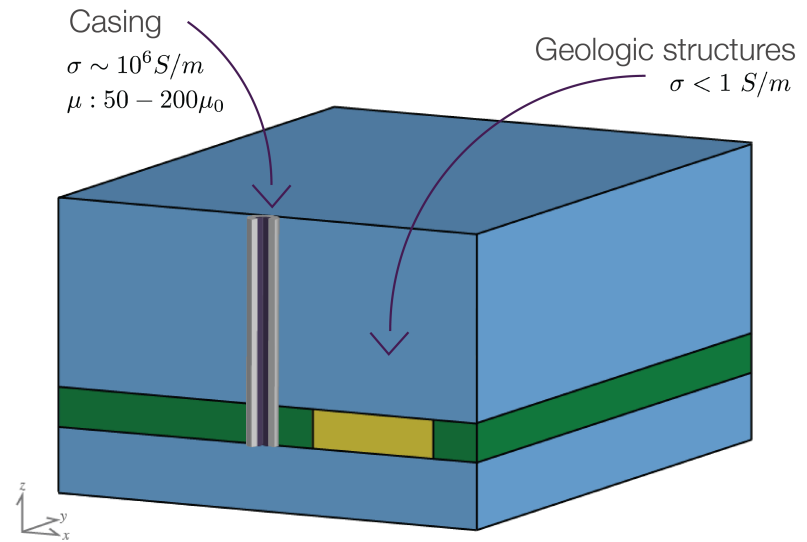
# The Future: Monitoring

- Aquifers
- Enhanced oil recovery
- Hydraulic Fracturing
- CO<sub>2</sub> sequestration
- Coal seam gas



# The Future: Monitoring

- Steel Casing
  - Mechanism for getting current to depth
  - Challenges:
    - Scales
    - Physical properties

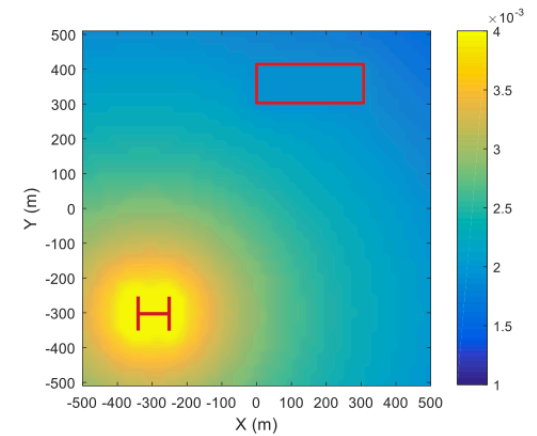
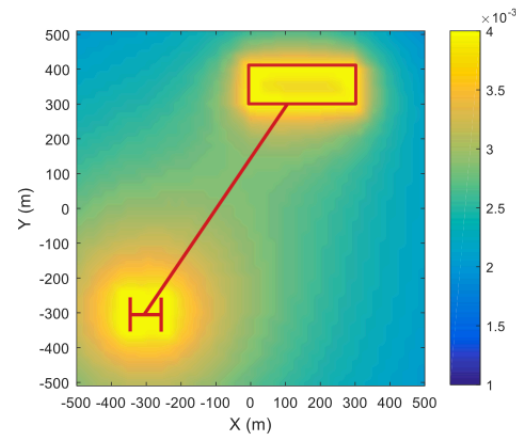
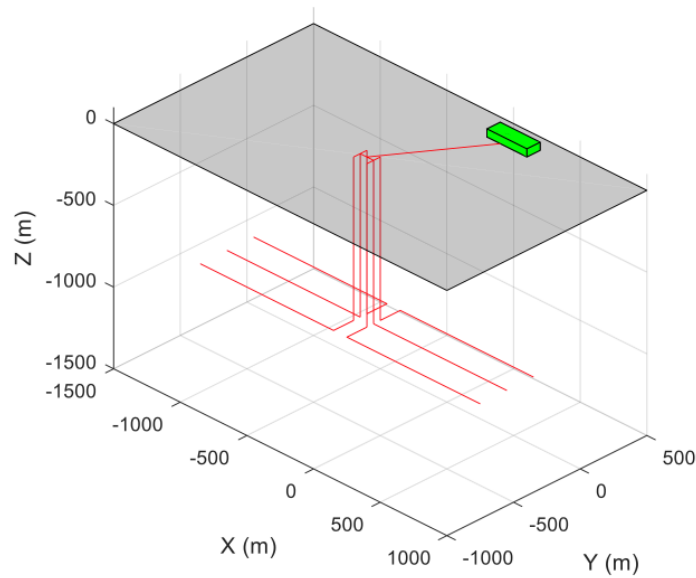
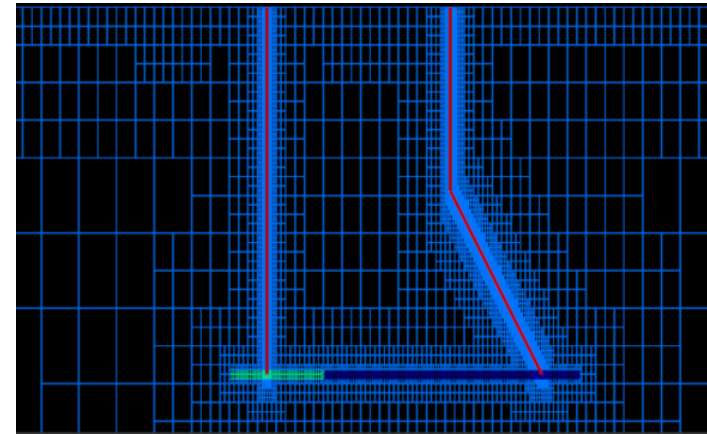
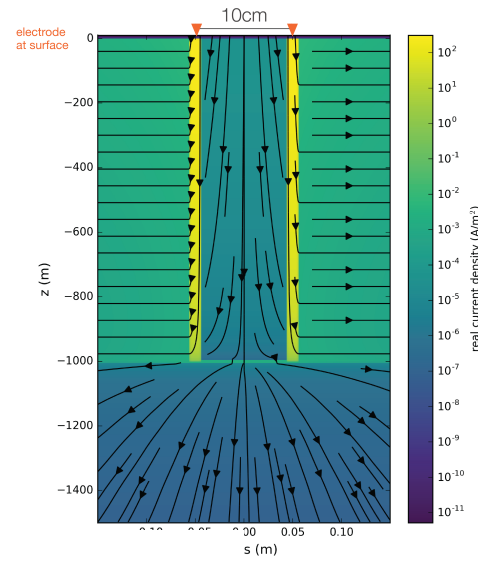


Corrosion



# The Future: Monitoring

- Steel Casing

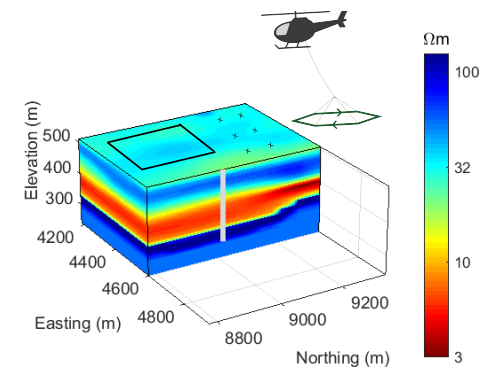
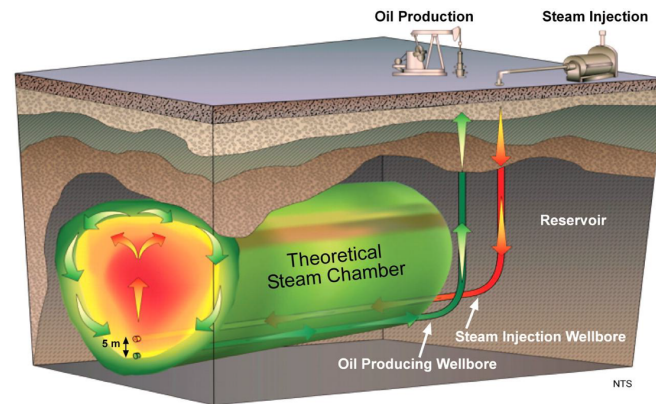




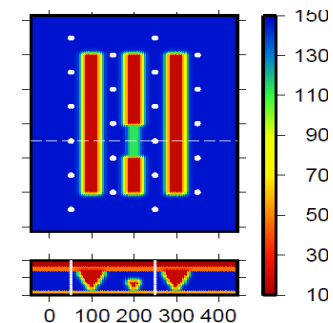
# Monitoring: Choosing the appropriate survey

Different EM surveys needed to answer different questions

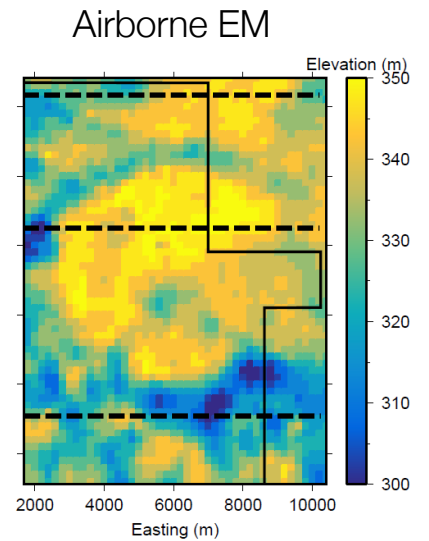
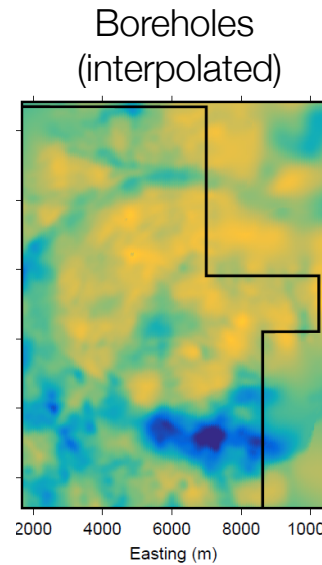
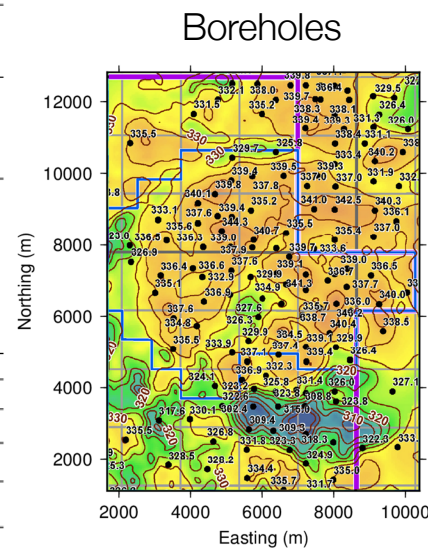
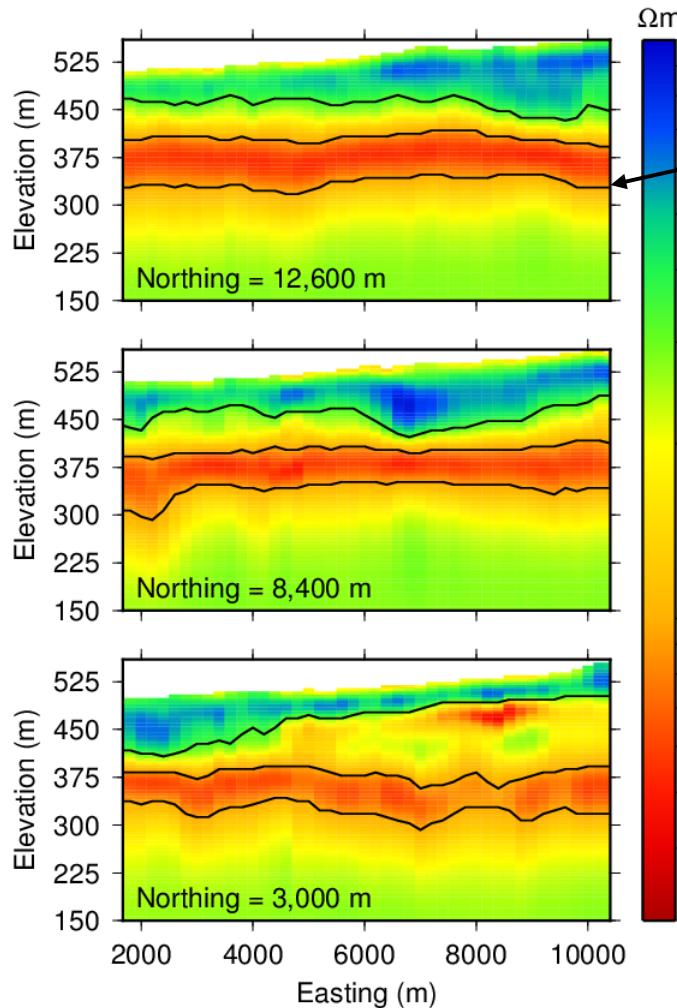
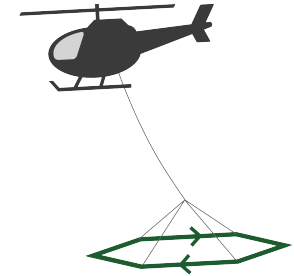
SAGD (Injection and monitoring steam flooding)



- Stage 1: Airborne reconnaissance survey
- Stage 2: Surface and borehole for pre-injection
- Stage 3: Monitoring array

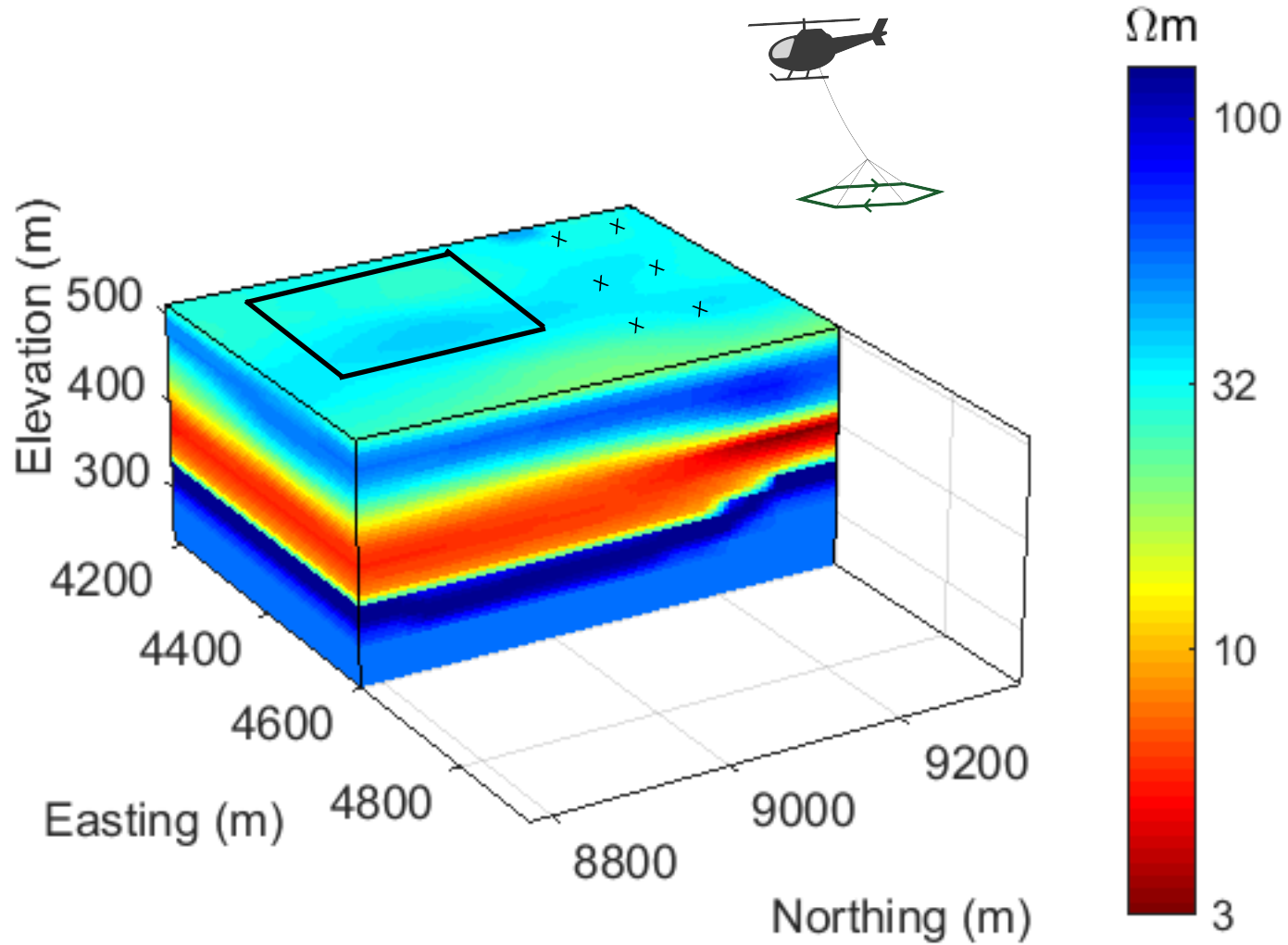


# Large scale reconnaissance (SAGD)



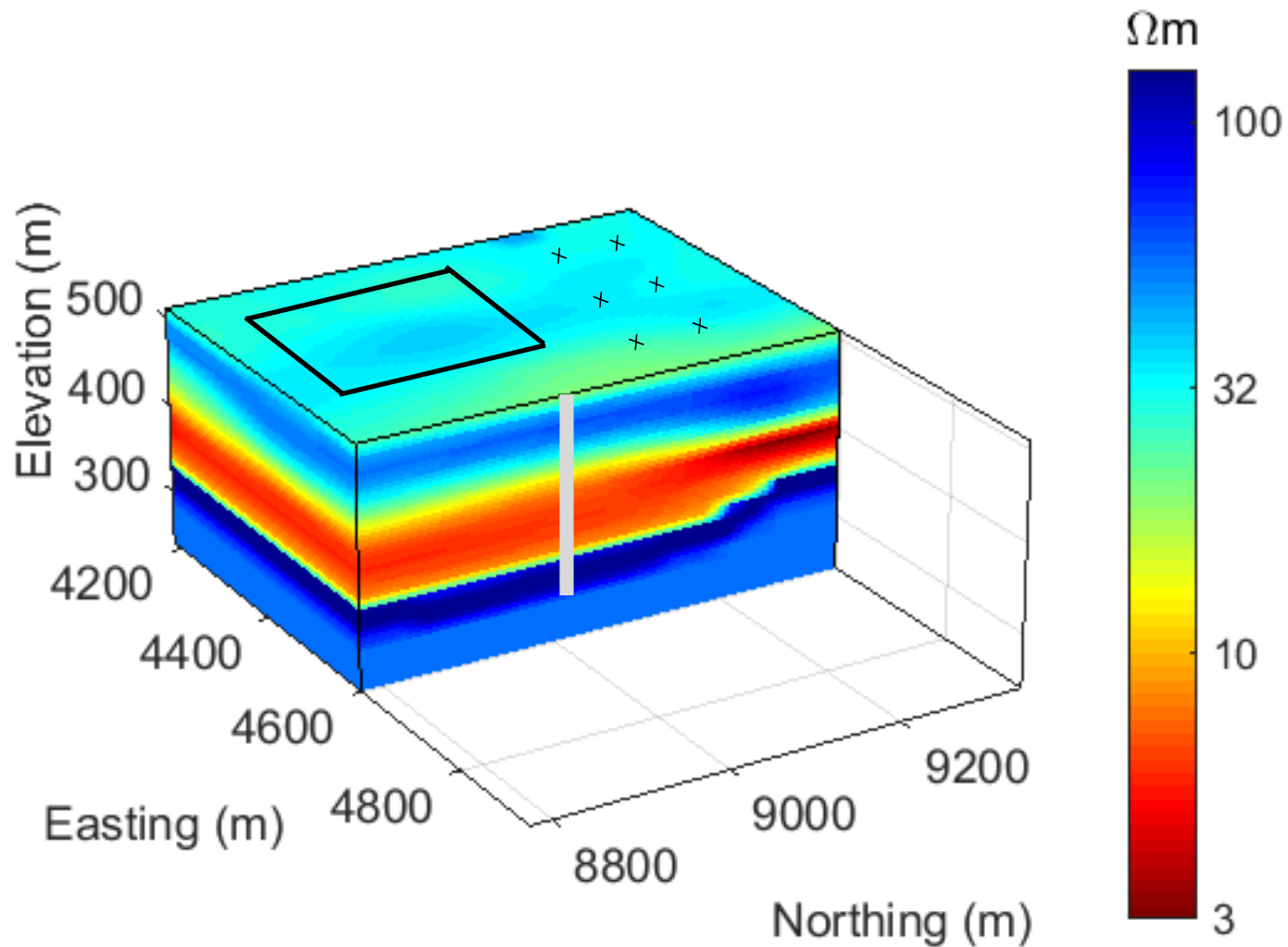
# Pre-injection (SAGD)

Local background: airborne + ground



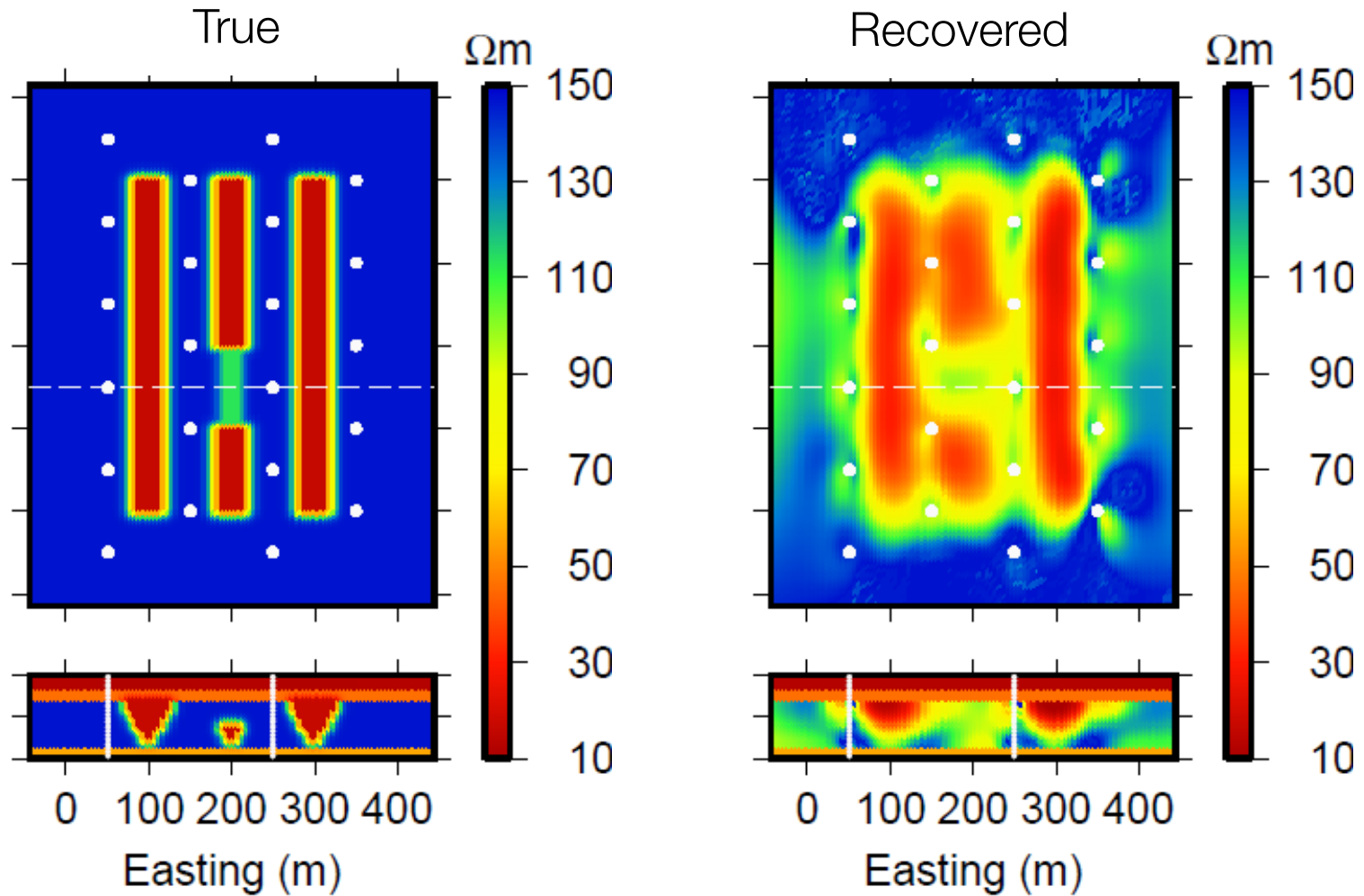
# Monitoring array (SAGD)

Pre-injection: surface sources, borehole receivers



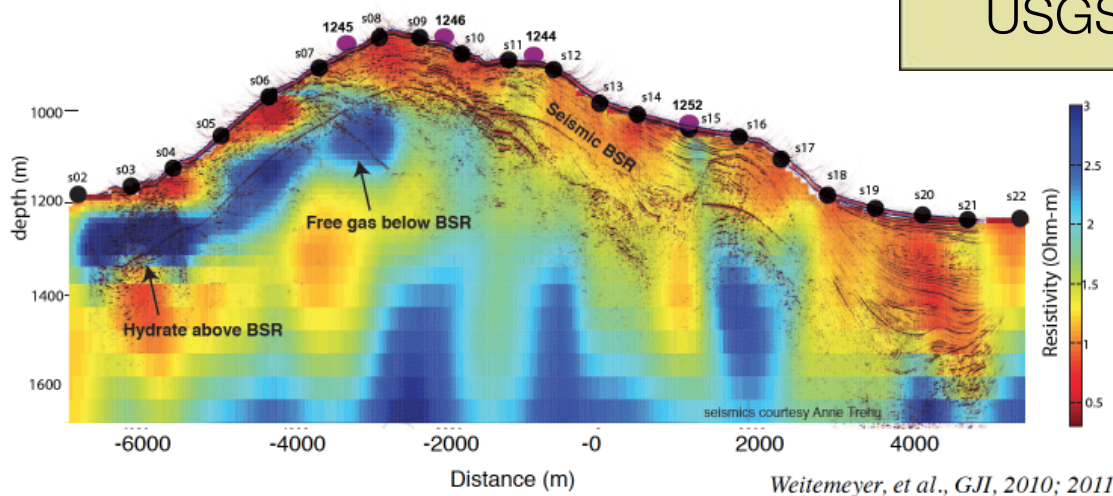
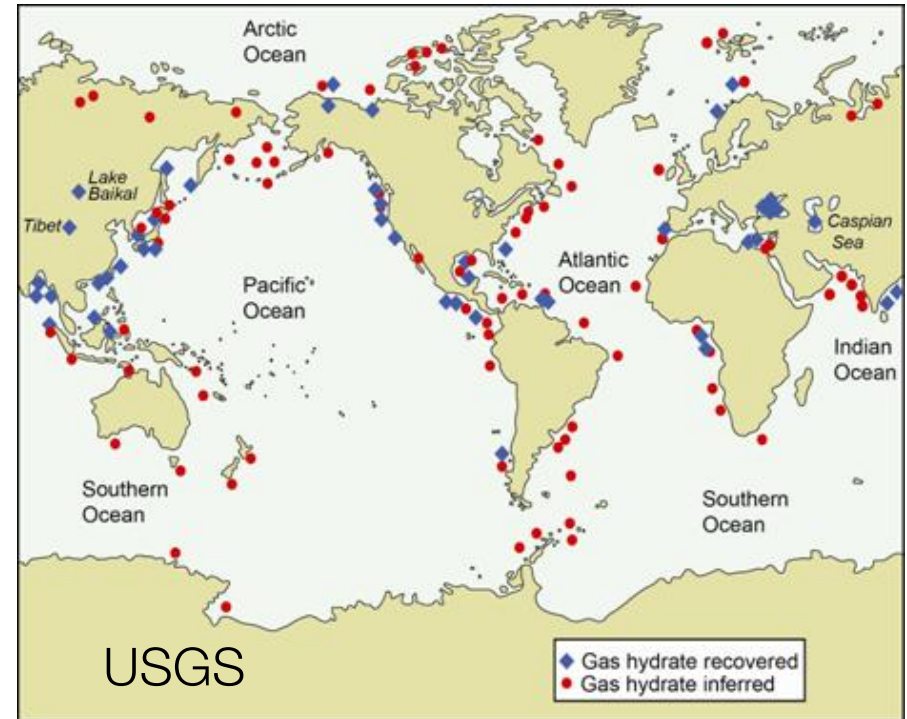
# Multi-stage EM for monitoring

Post-injection: surface sources, borehole receivers



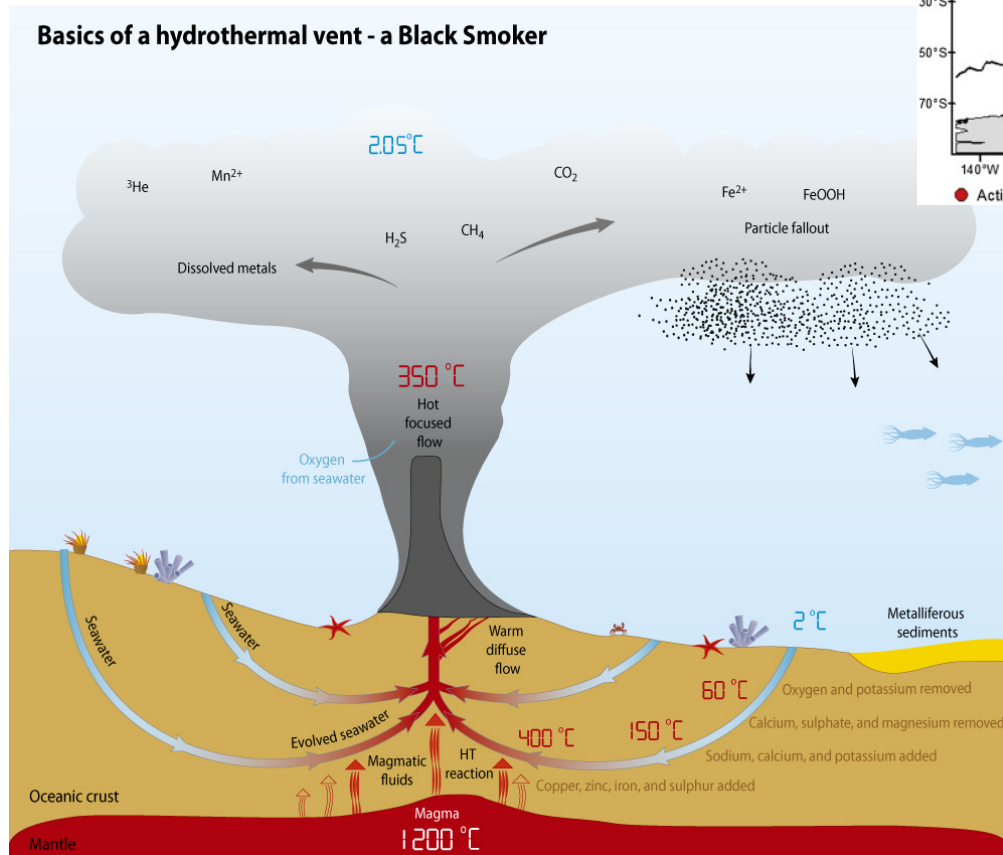
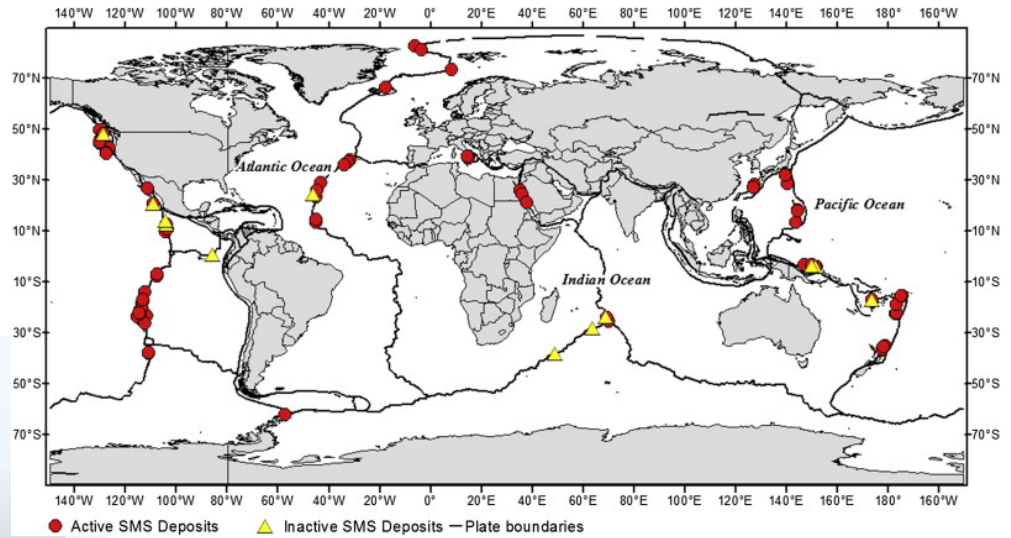
# The Future: Marine EM

- Gas hydrates
  - Resistivity is diagnostic

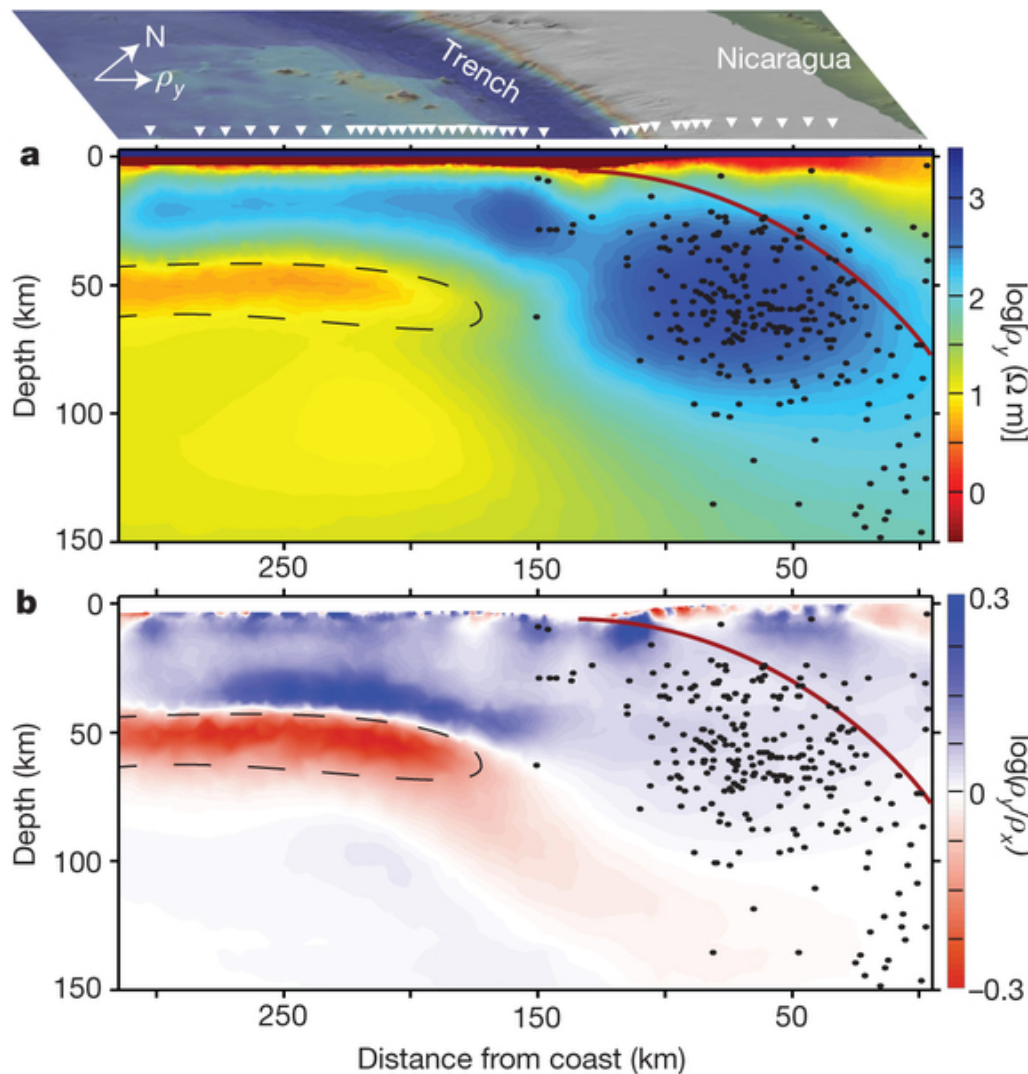


# The Future: Marine EM

- Submarine massive sulfides
  - Conductive relative to background



# The Future: Marine EM

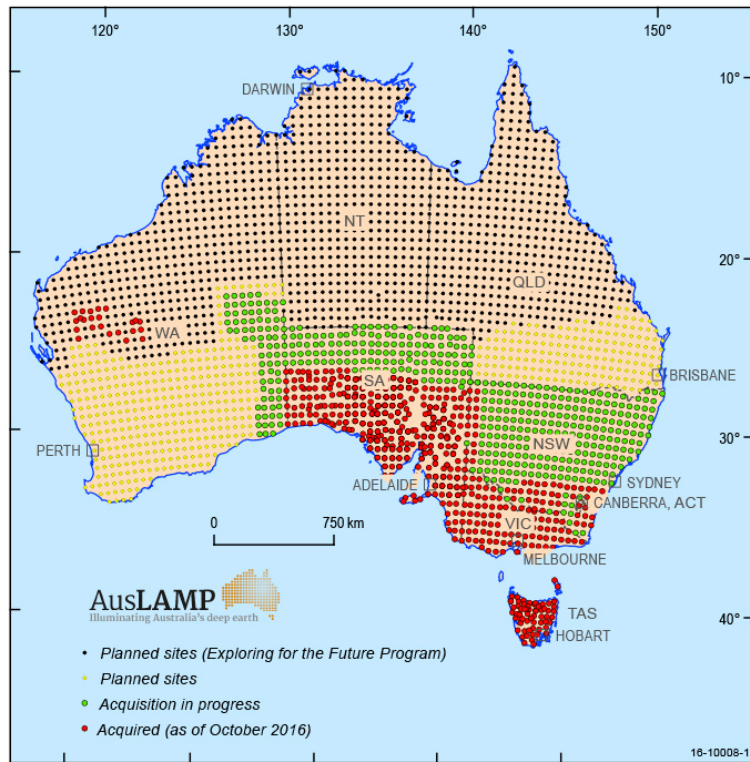


- Tectonic studies
- Natural Hazard
- Large anisotropy
  - indicative of melt-rich channel

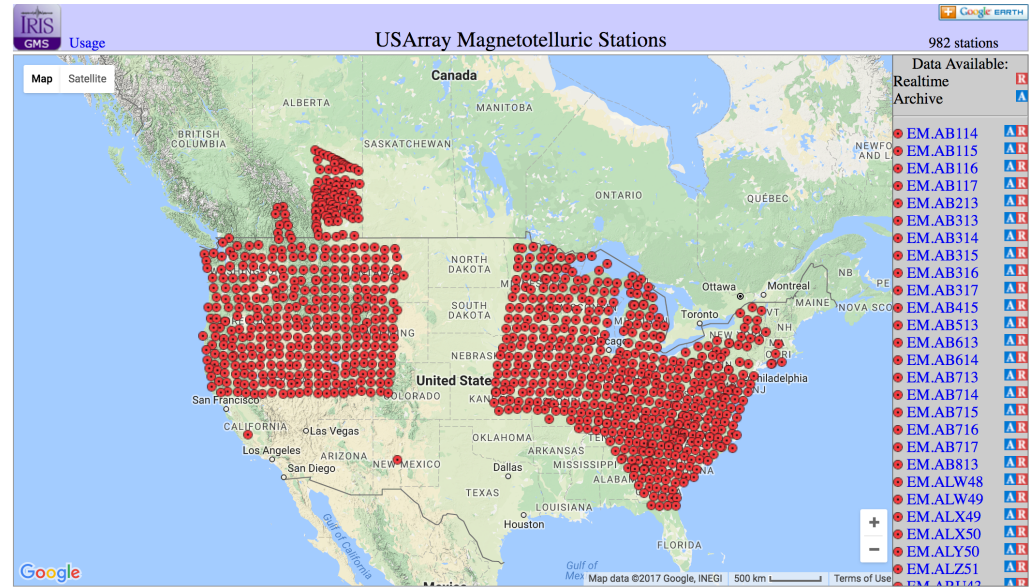


# The Future: Large Scale MT

## AusLamp

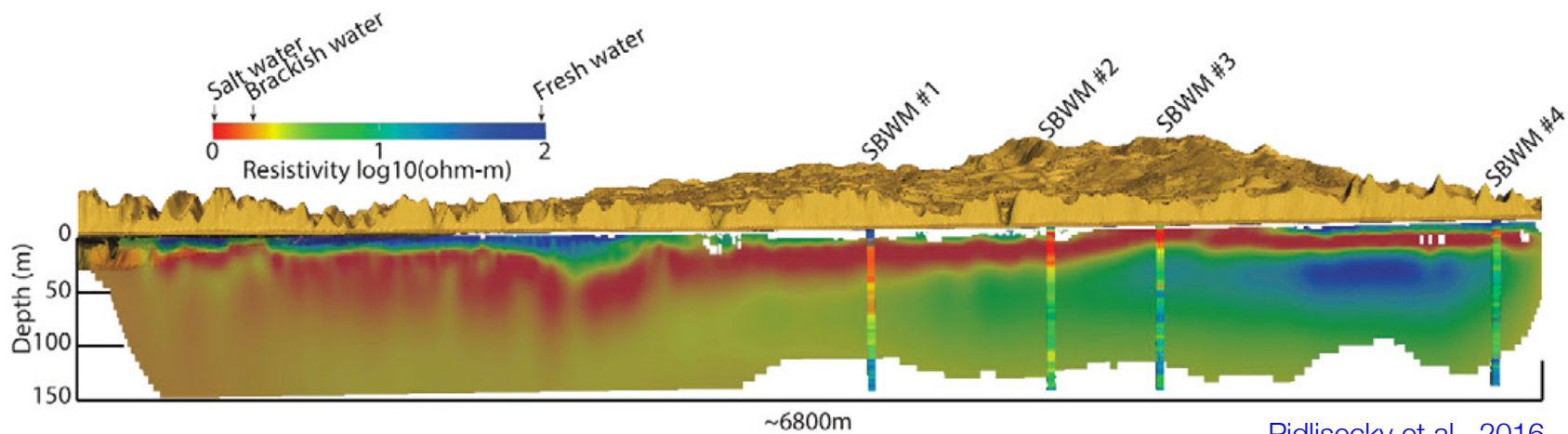
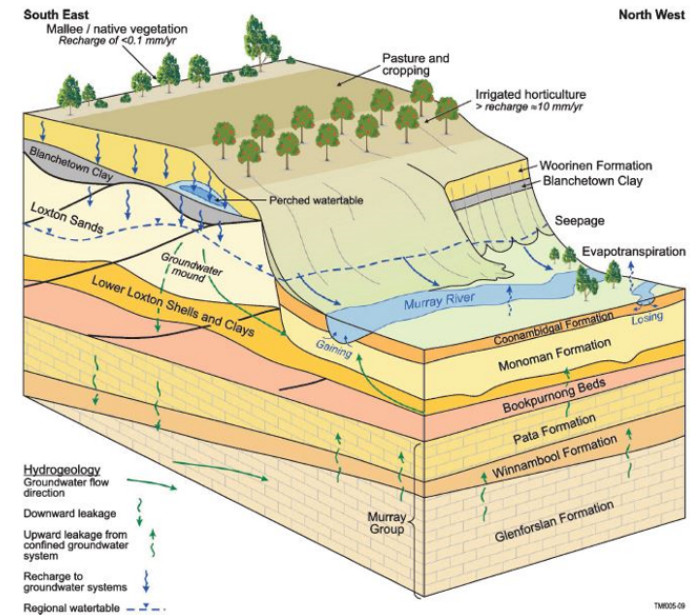


## Earth scope



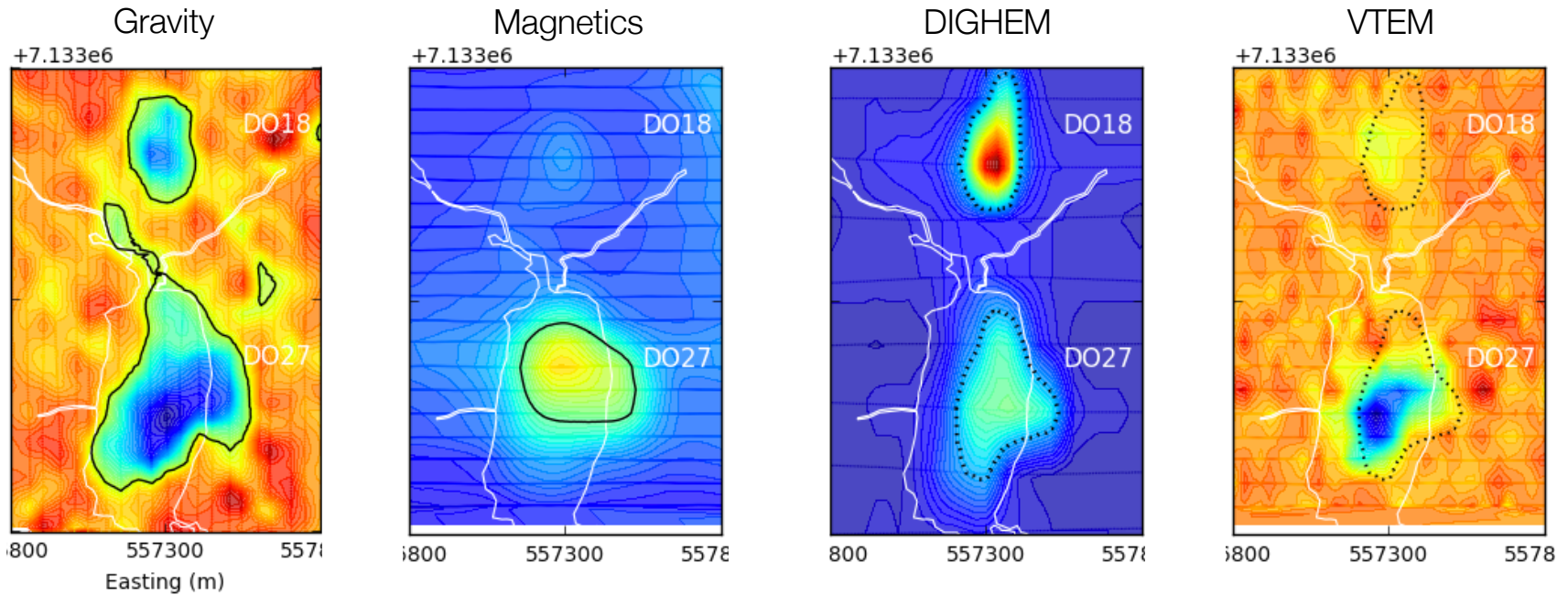
# The Future: Water

- Finding and delineating water
- Aquifer monitoring and management
- Salt water intrusions
- Pollutants

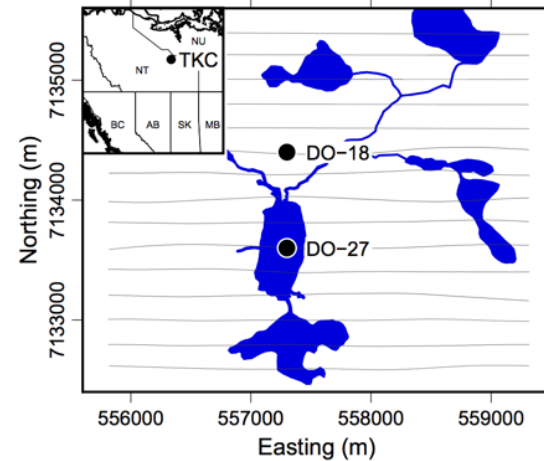
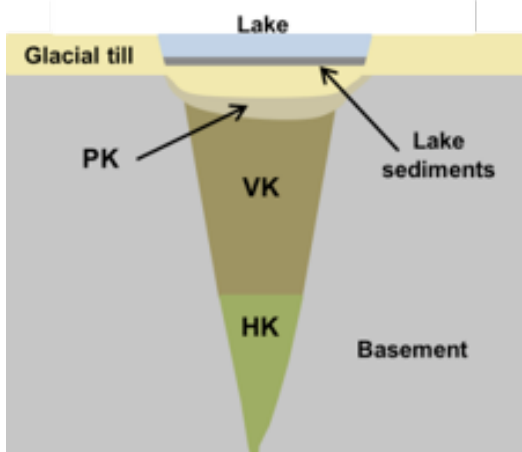


[Pidlisecky et al., 2016](#)

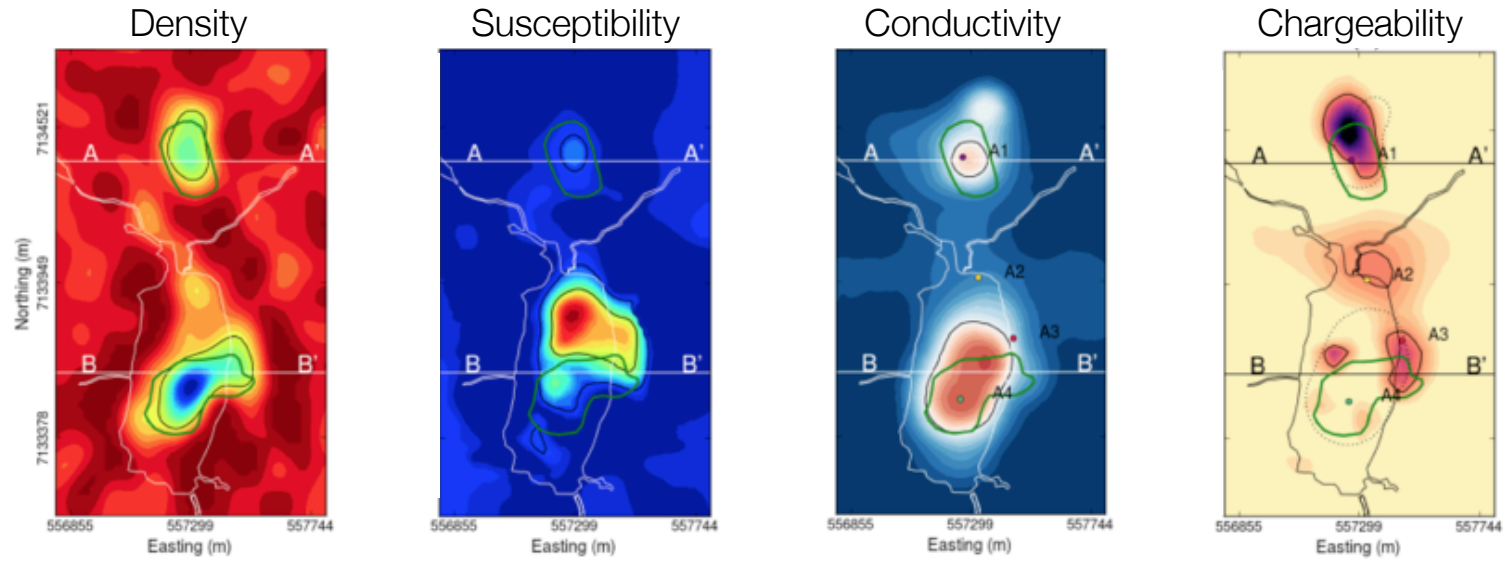
# The Future: Data Integration & Multi-physics



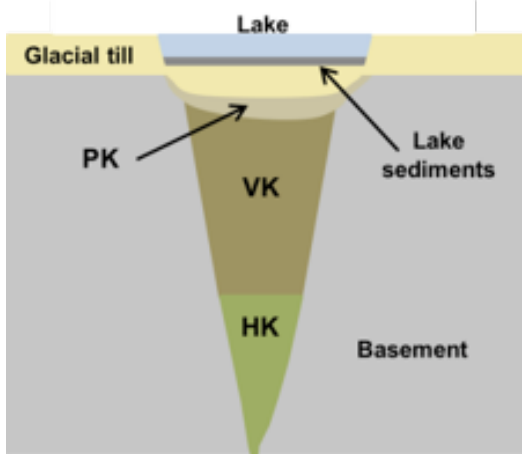
Kimberlite Model



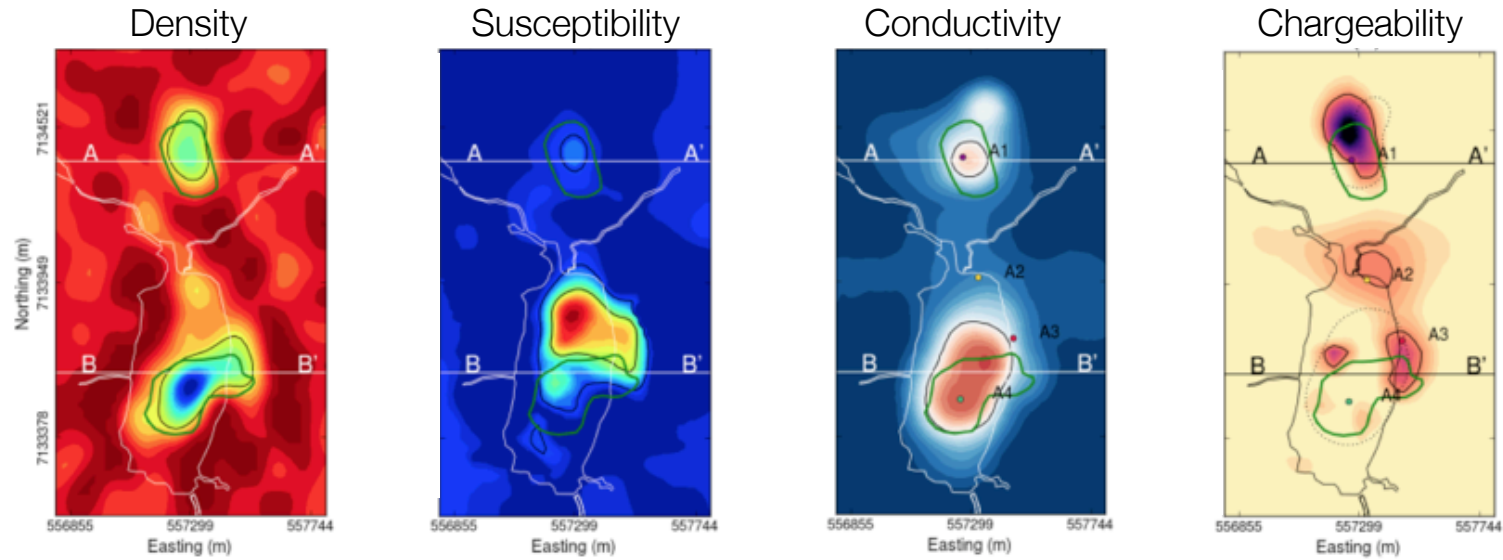
# The Future: Data Integration & Multi-physics



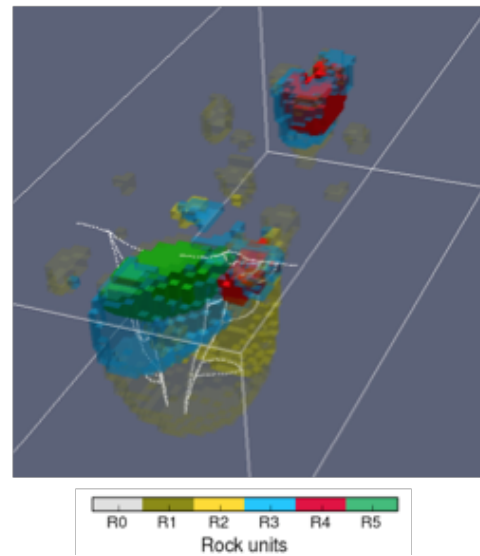
Kimberlite Model



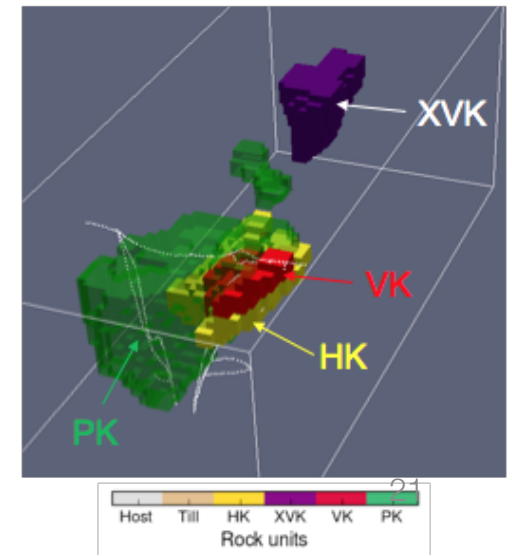
# The Future: Data Integration & Multi-physics



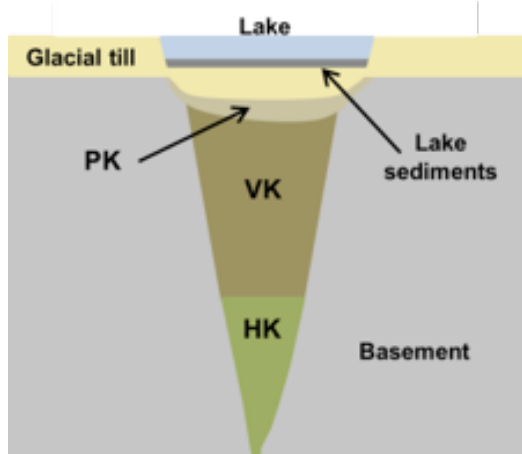
Rock Model from Geophysics



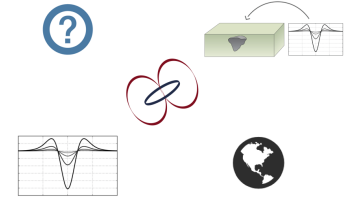
Rock Model from Drilling



Kimberlite Model



# The Future: Modelling and Inversion

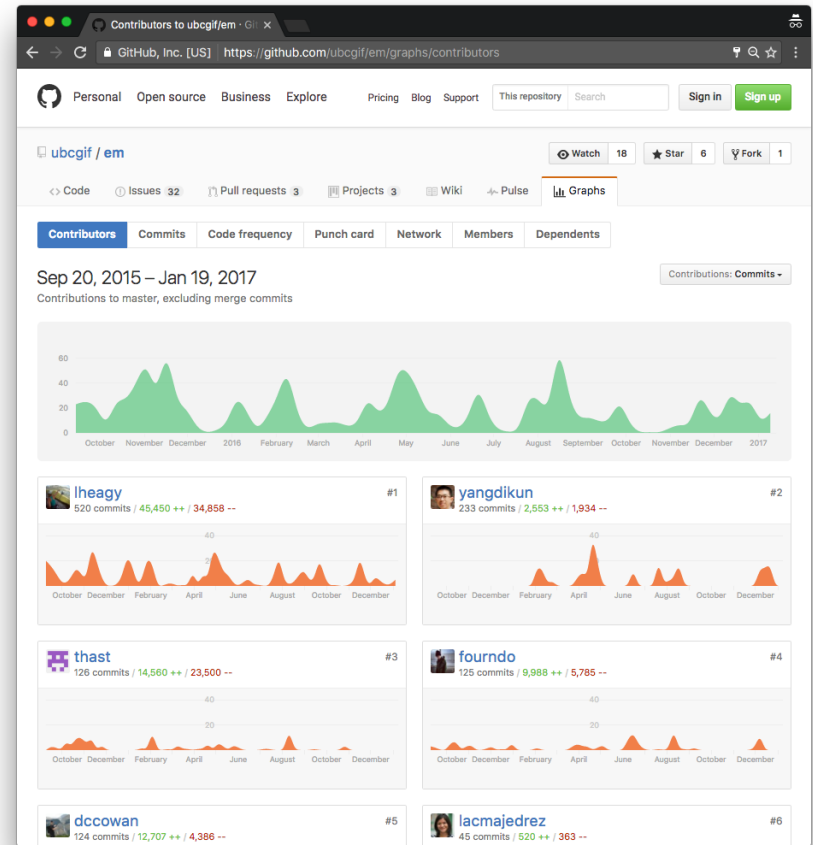


- HPC, Cloud computing
- Collaborative development
- Open source



Simulation and Parameter Estimation in Geophysics

<http://simpeg.xyz>



**GitHub**  
versioning, collaborating



**Travis CI**  
testing, deploy



**Jupyter**  
interactive computing

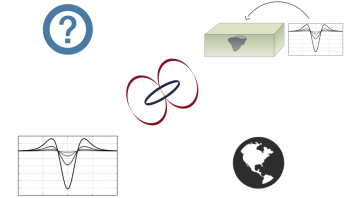


**Creative Commons**  
licensing, reuse



**Python**  
computation

# The Future: Modelling and Inversion



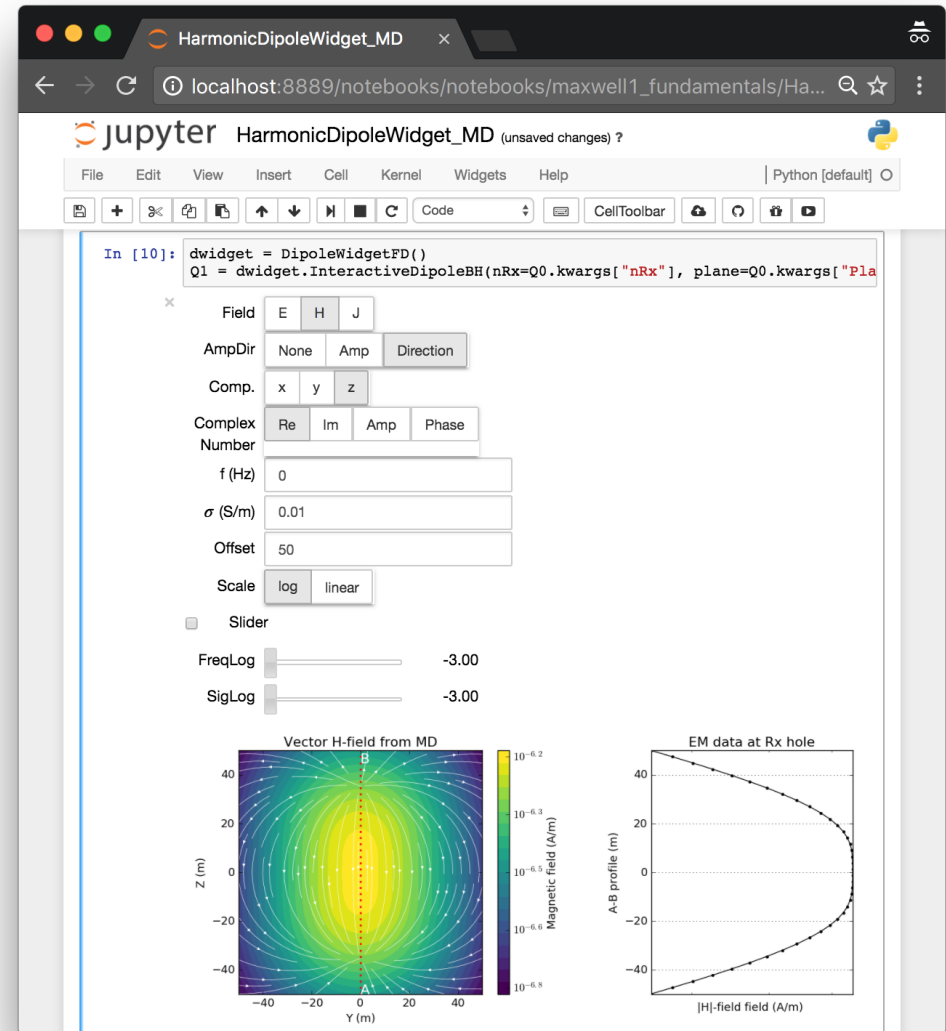
- Interactive computing
- Visualization

$$\nabla \times \mathbf{e} = - \frac{\partial \mathbf{b}}{\partial t}$$

$$\nabla \times \mathbf{h} = \mathbf{j} + \frac{\partial \mathbf{d}}{\partial t}$$

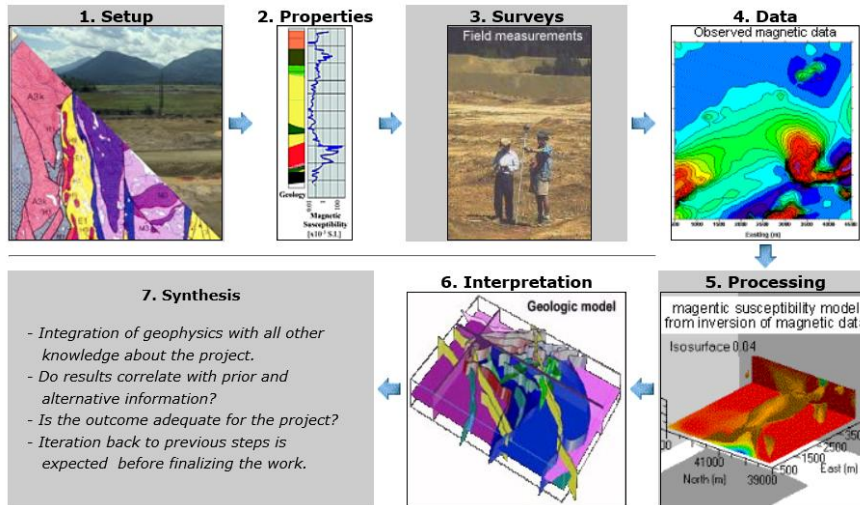
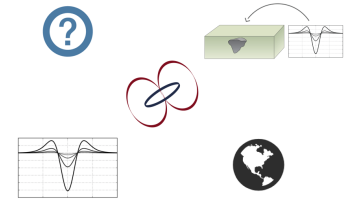


<http://simpeg.xyz>



<http://em.geosci.xyz/apps.html> 23

# The Future: Collaboration



Edit on GitHub

Case Histories — Electromagn...  
em.geosci.xyz/content/case\_histories/index.html

em

Search docs

Contributors  
Introduction  
Physical Properties  
Maxwell I: Fundamentals  
Maxwell II: Static  
Maxwell III: FDEM  
Maxwell IV: TDEM  
Geophysical Surveys  
Inversion

Case Histories

- Mt. Isa
- Bookpurnong
- Aspen
- Lalor
- Elevenmile Canyon
- Albany
- West Plains
- Furggwanhorn
- Norsminde
- Barents Sea
- Kasted
- The Balboa ZTEM Cu-Mo-Au porphyry discovery at Cobre Panama

Gallery

Equation Bank  
References

**Case Histories**

Case histories provide the context for our development of educational and research presented in em.geosci. Each case history focuses upon a particular problem to be solved and provides the motivation for working with particular surveys and shows the effectiveness of electromagnetics in answering the posed questions. For many people, a case history will be the entry point to this site. To facilitate transfer of knowledge we have developed a common framework (Seven Step Process) in which each case history is presented. Links are provided so that a reader can investigate fundamental aspects of EM, the survey, or interpretation. In some cases we are able to provide data sets and analysis/inversion software to enhance the user experience and to address important issues regarding reproducibility. Case histories for our initial launch of em.geosci are those that have been developed by past and present students at the Geophysical Inversion Facility. The titles, and EM systems used are provided below.

**Gallery**

**Mt. Isa**

- **Mt. Isa**
- **Contributors**
  - author: Dom Fournier
- **Tags**
  - geophysical survey: DC, IP
  - application: Mining
  - location: Australia

**Bookpurnong**

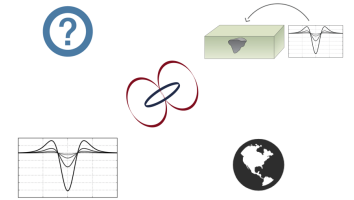
- **Bookpurnong**
- **Contributors**
  - author: Dikun Yang
- **Tags**
  - geophysical survey: Airborne FDEM, Airborne TDEM
  - application: Groundwater
  - location: Australia



<http://slack.geosci.xyz>



# Goals for the DISC



- Inspire
  - See the variety of potential applications
  - Illustrate effectiveness using case histories
- Build a foundation
  - Basic principles of EM
  - Exploration and visualization with Interactive apps
  - Open source resource: <http://em.geosci.xyz>
- Set realistic expectations
- Promote development of an EM community
  - Open source software
  - Capturing case histories world-wide

# Resources

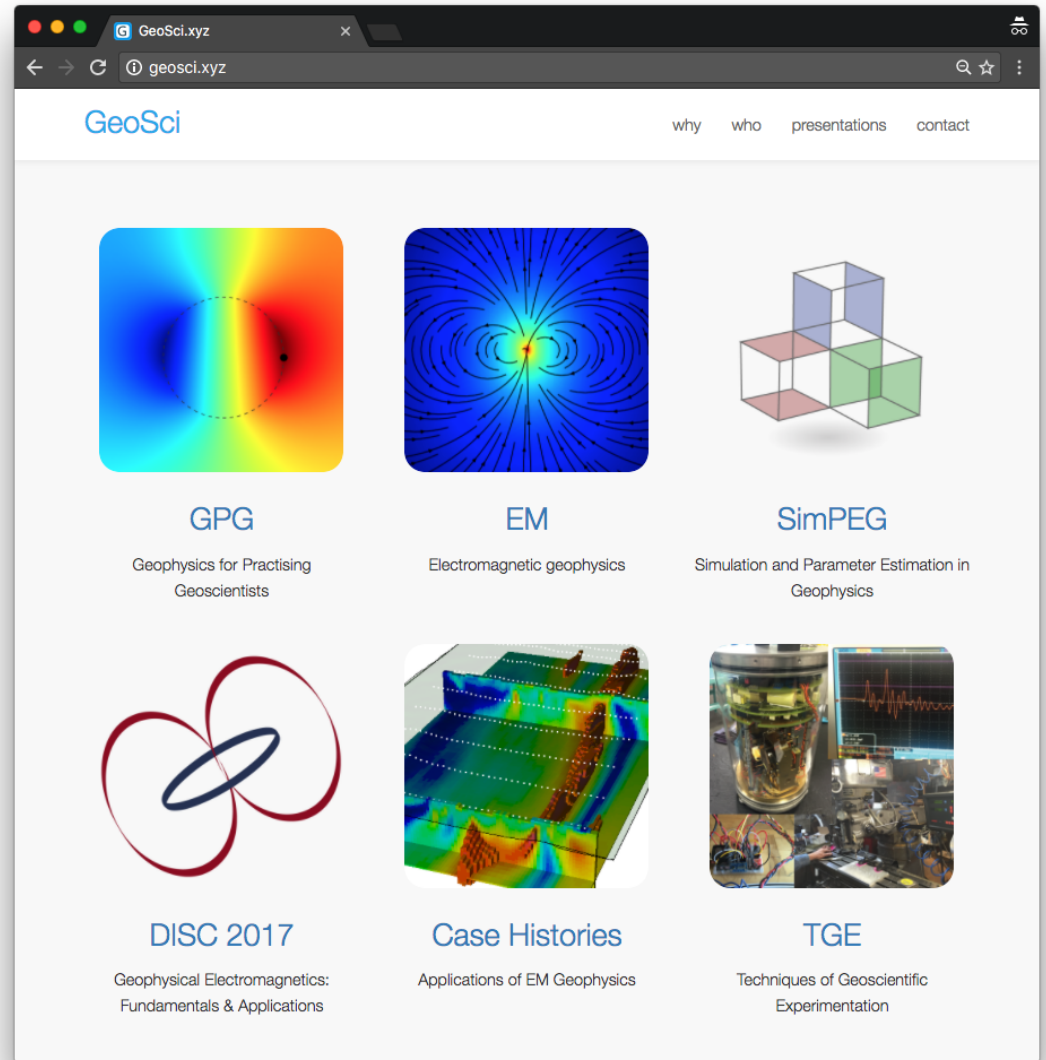
- GeoSci

<http://geosci.xyz>

- Web-textbooks
- Software
- Apps

- Apps:

<http://em.geosci.xyz/apps.html>



# GIF DISC Team



doug



lindsey



seogi

## UBC GIF Team



Thibaut



Patrick



Rowan



Devin



Kris



Sarah



Dom



Mike



Mike



Gudni



Dikun

# Join us tomorrow at DISC Lab

- Tell us what you are doing
- How EM is (or could!) play a role in the solution
- Continue the conversations
- Connect with other geoscientists
- Contribute to the development of a community

<http://disc2017.geosci.xyz>



# Thank You!

<http://disc2017.geosci.xyz>

