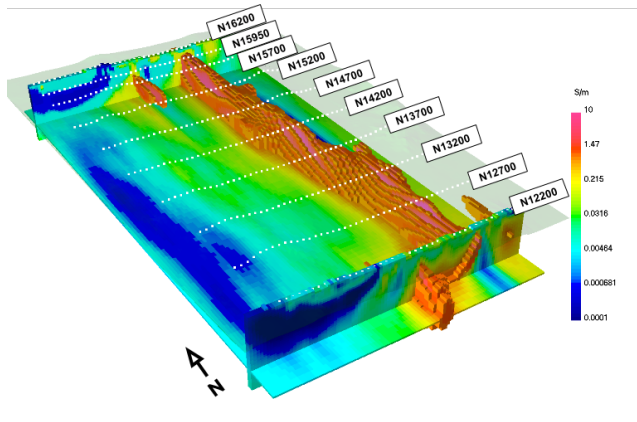


Summary and the Future

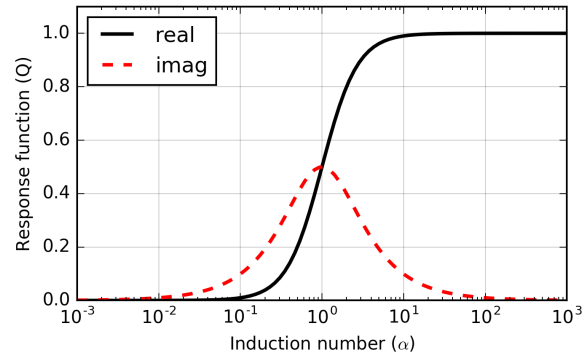


What have we covered?

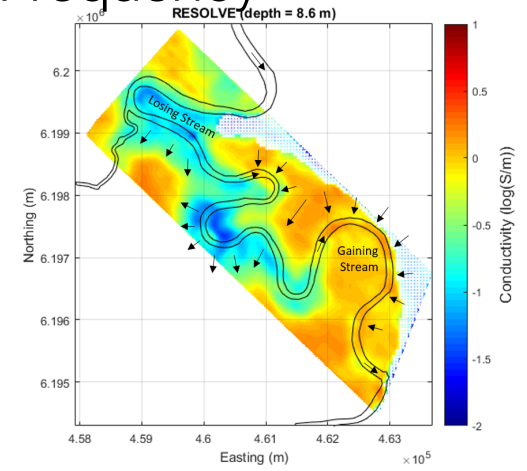
DC Resistivity



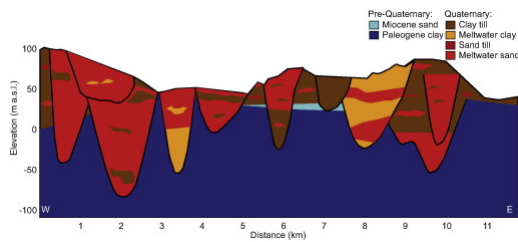
EM Fundamentals



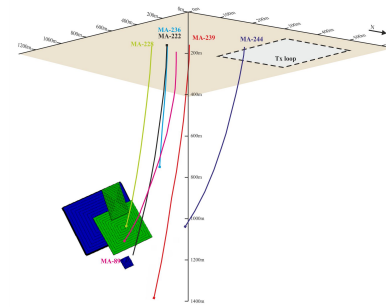
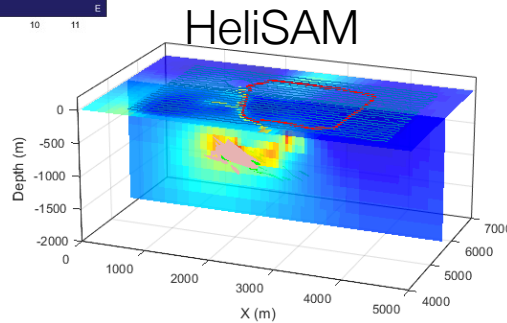
Inductive Sources: Frequency



Inductive Sources: Time

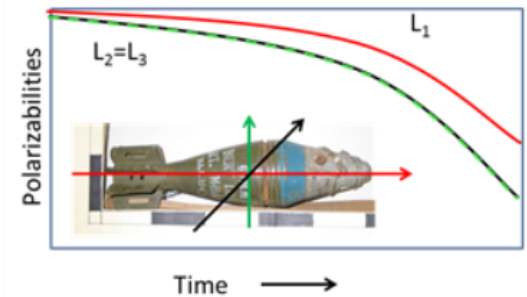


Mapping paleochannels



Multi-stage exploration

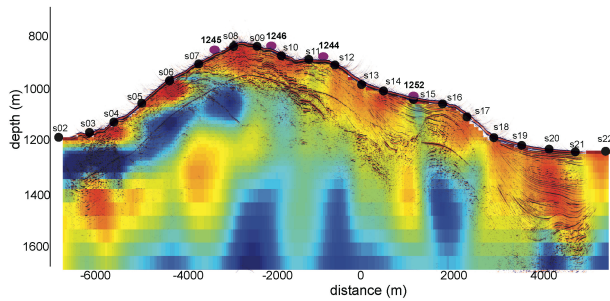
UXO



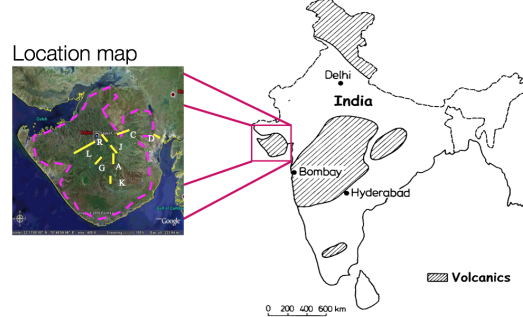
What have we covered?

Grounded Sources

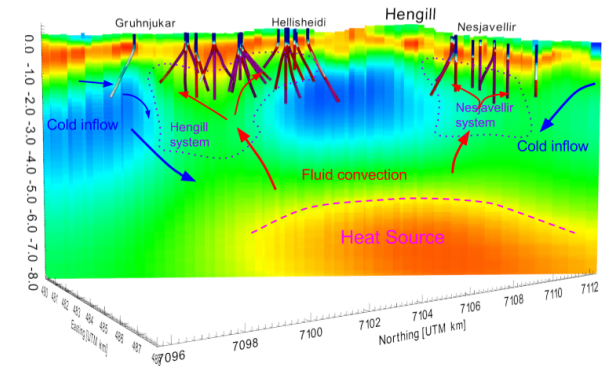
Methane hydrates



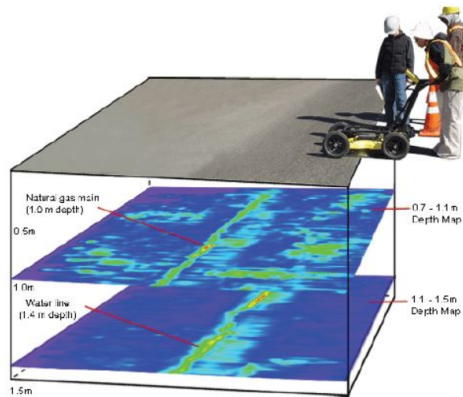
Mapping sediments beneath basalt



Natural Sources

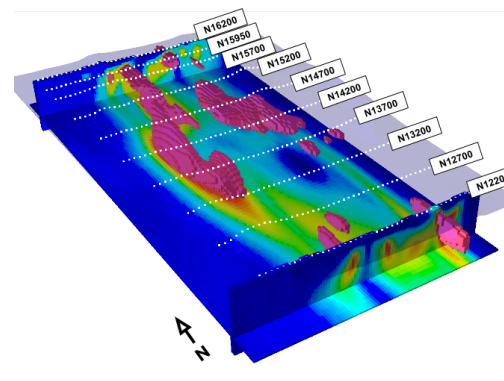


Ground Penetrating Radar

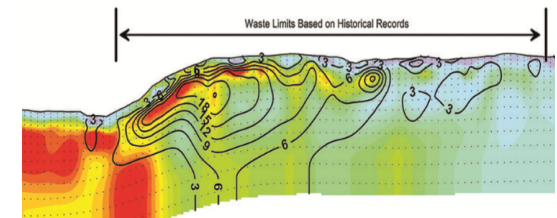


Induced Polarization

Minerals



Landfills



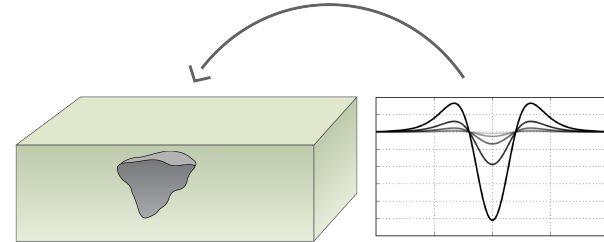
What does the future hold?

What does the future hold?

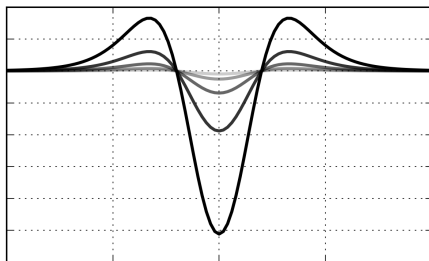
Problems



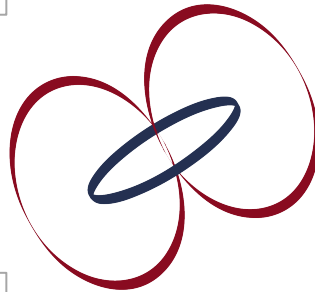
Inversion capabilities



High quality data

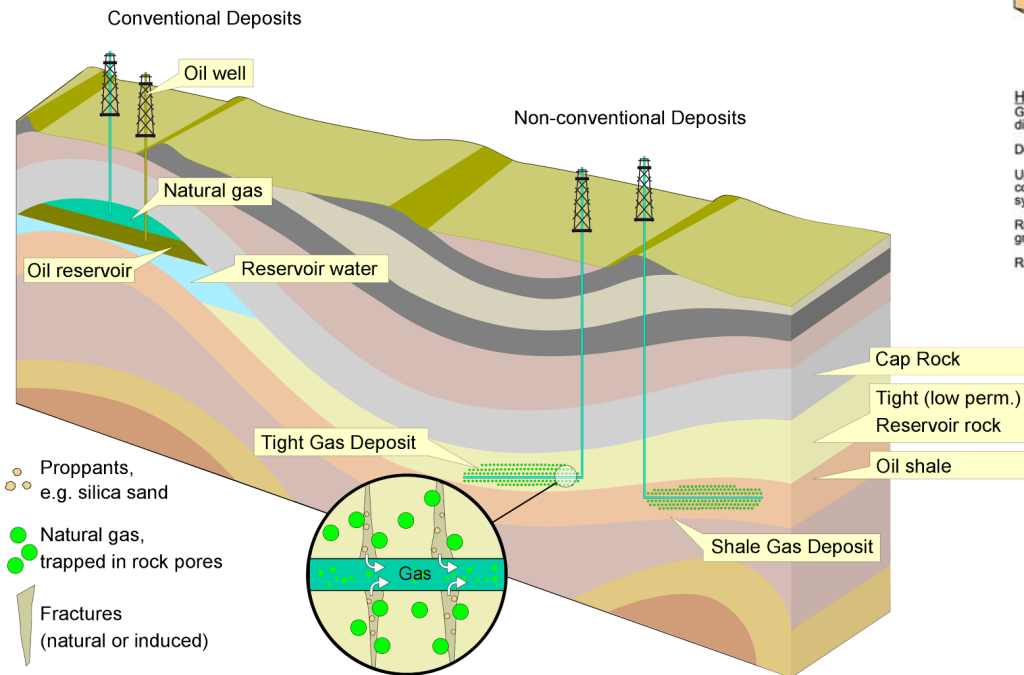
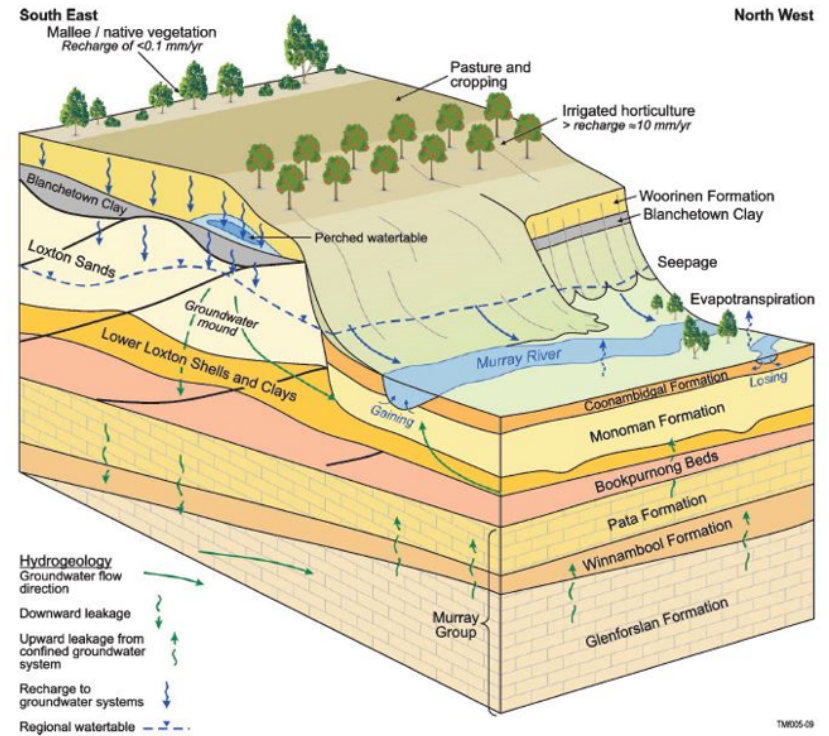


Web tools to
communicate



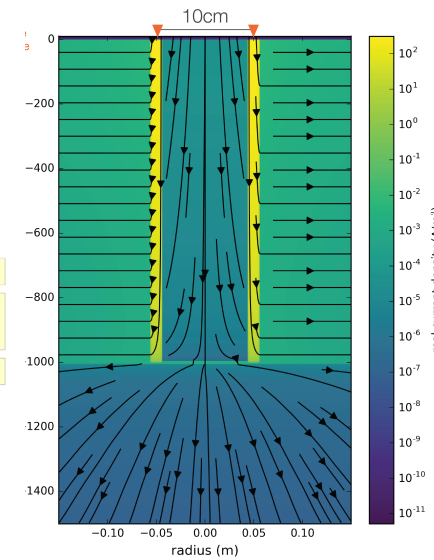
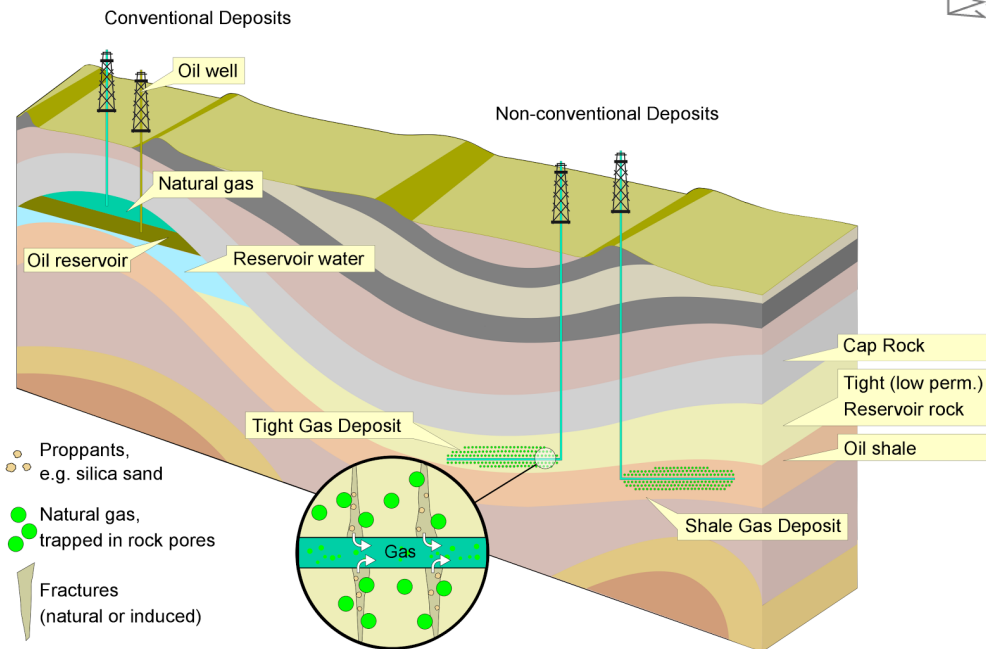
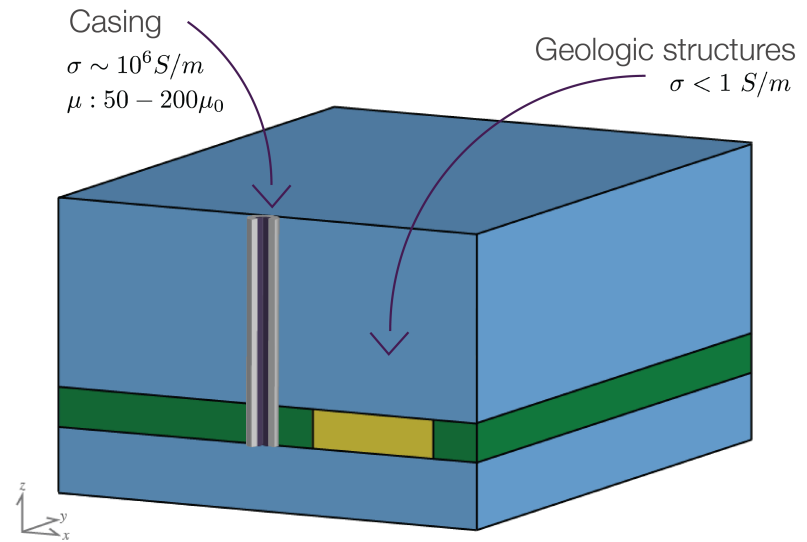
The Future: Monitoring

- Aquifers
- Enhanced oil recovery
- Hydraulic Fracturing
- CO₂ sequestration
- Coal seam gas



The Future: Monitoring

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

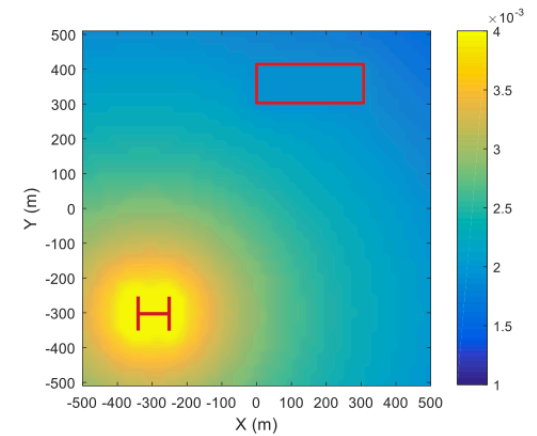
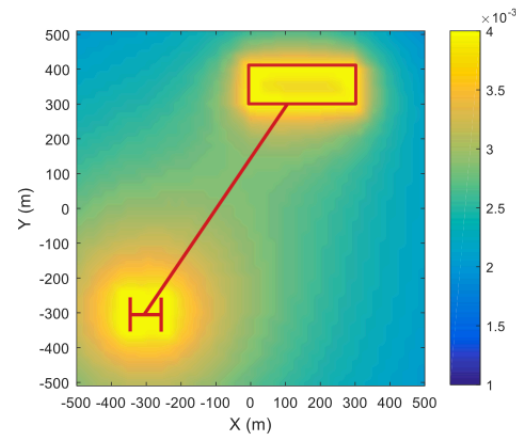
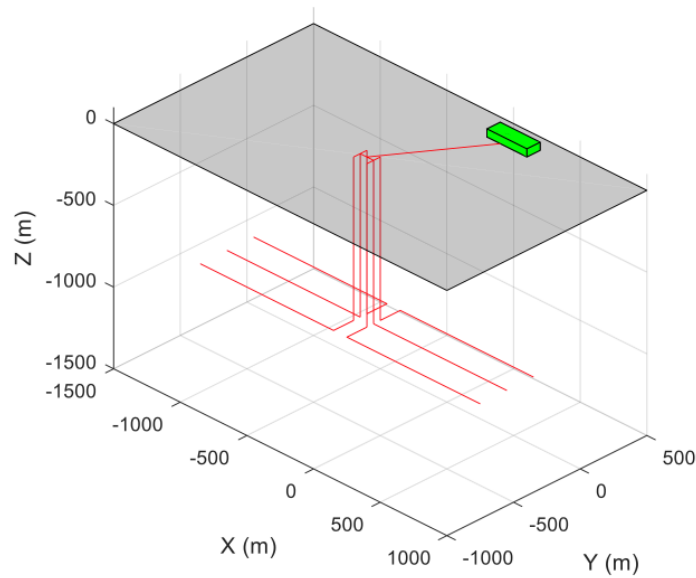
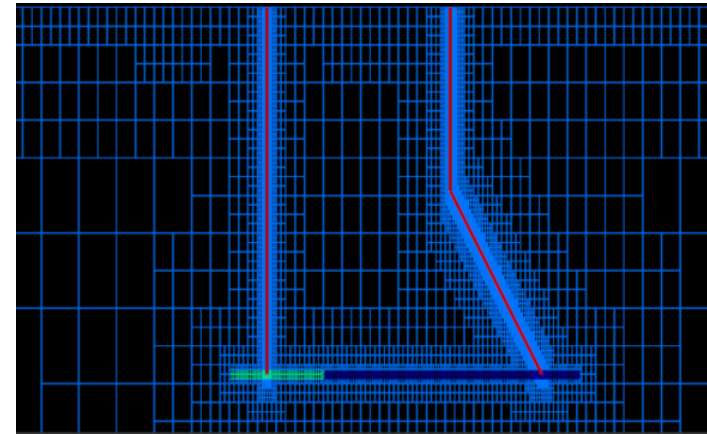
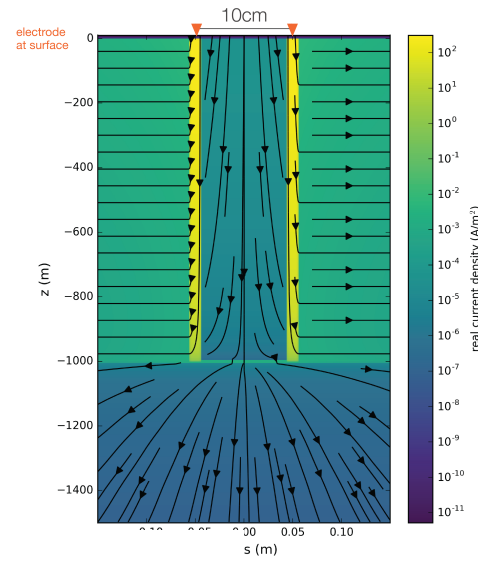


Corrosion



The Future: Monitoring

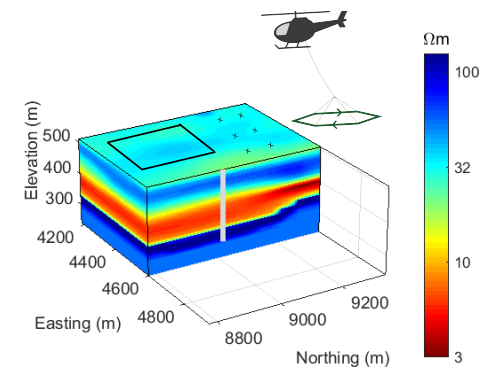
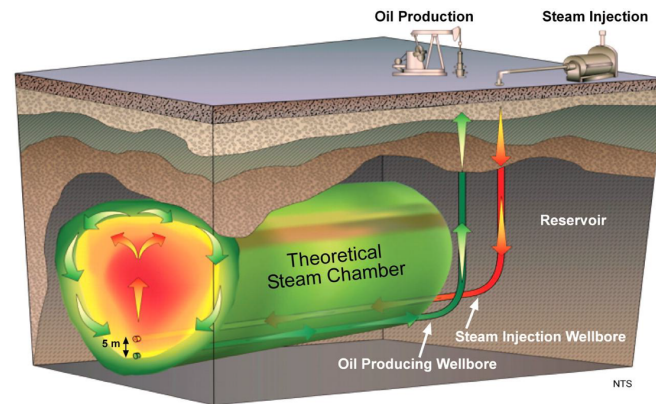
- Steel Casing



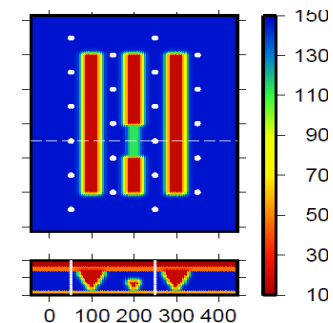
Monitoring: Choosing the appropriate survey

Different EM surveys needed to answer different questions

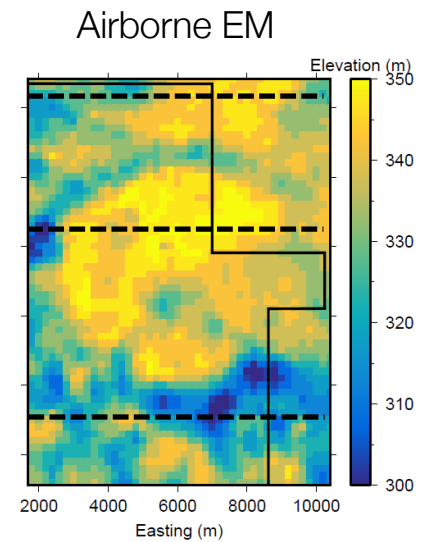
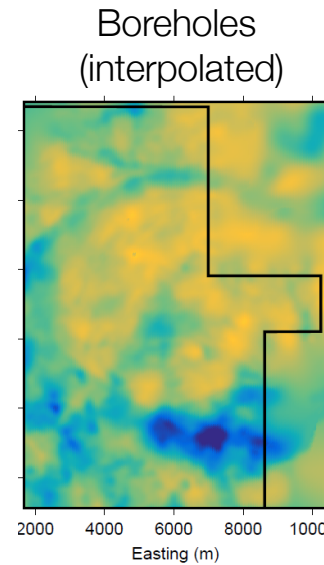
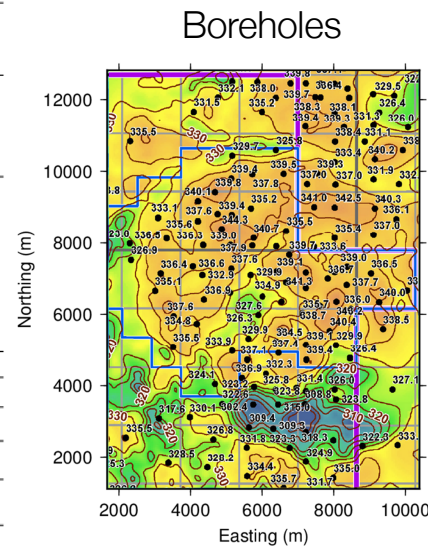
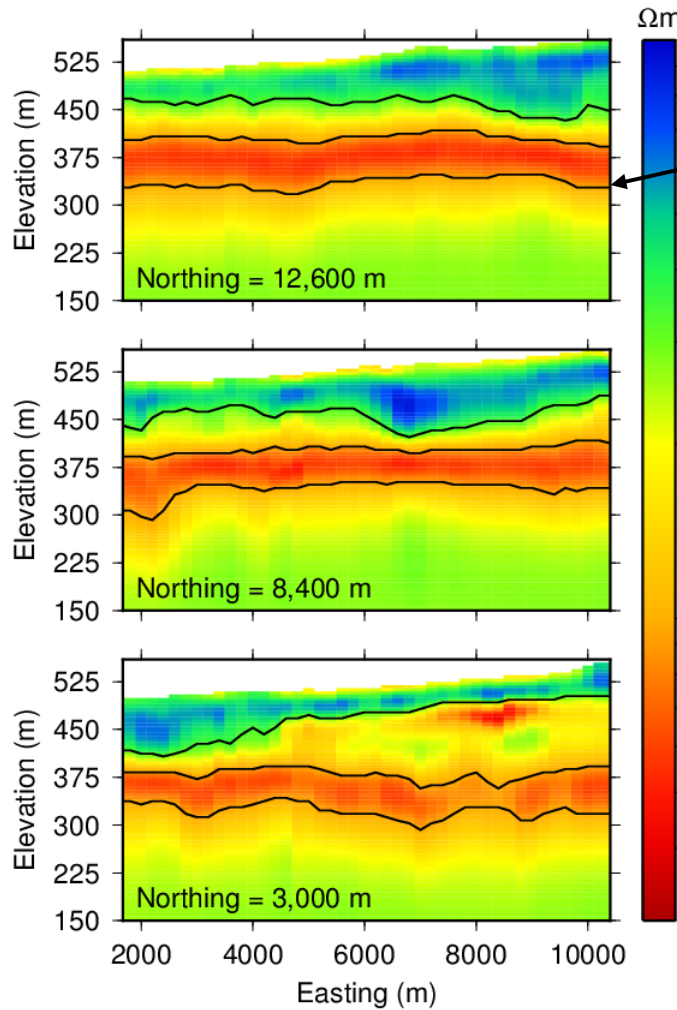
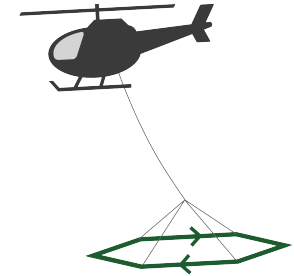
SAGD (Injection and monitoring steam flooding)



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

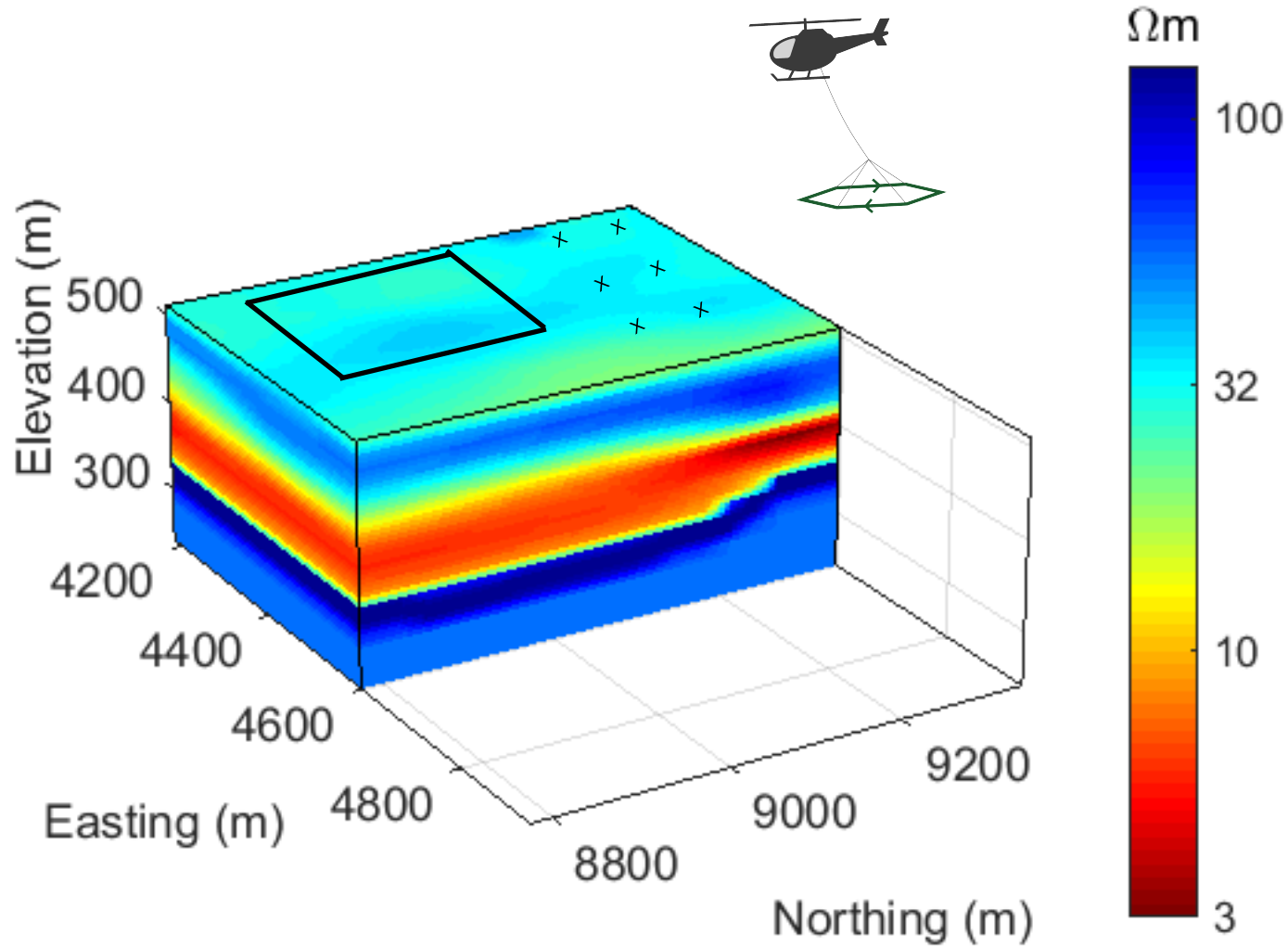


Large scale reconnaissance (SAGD)



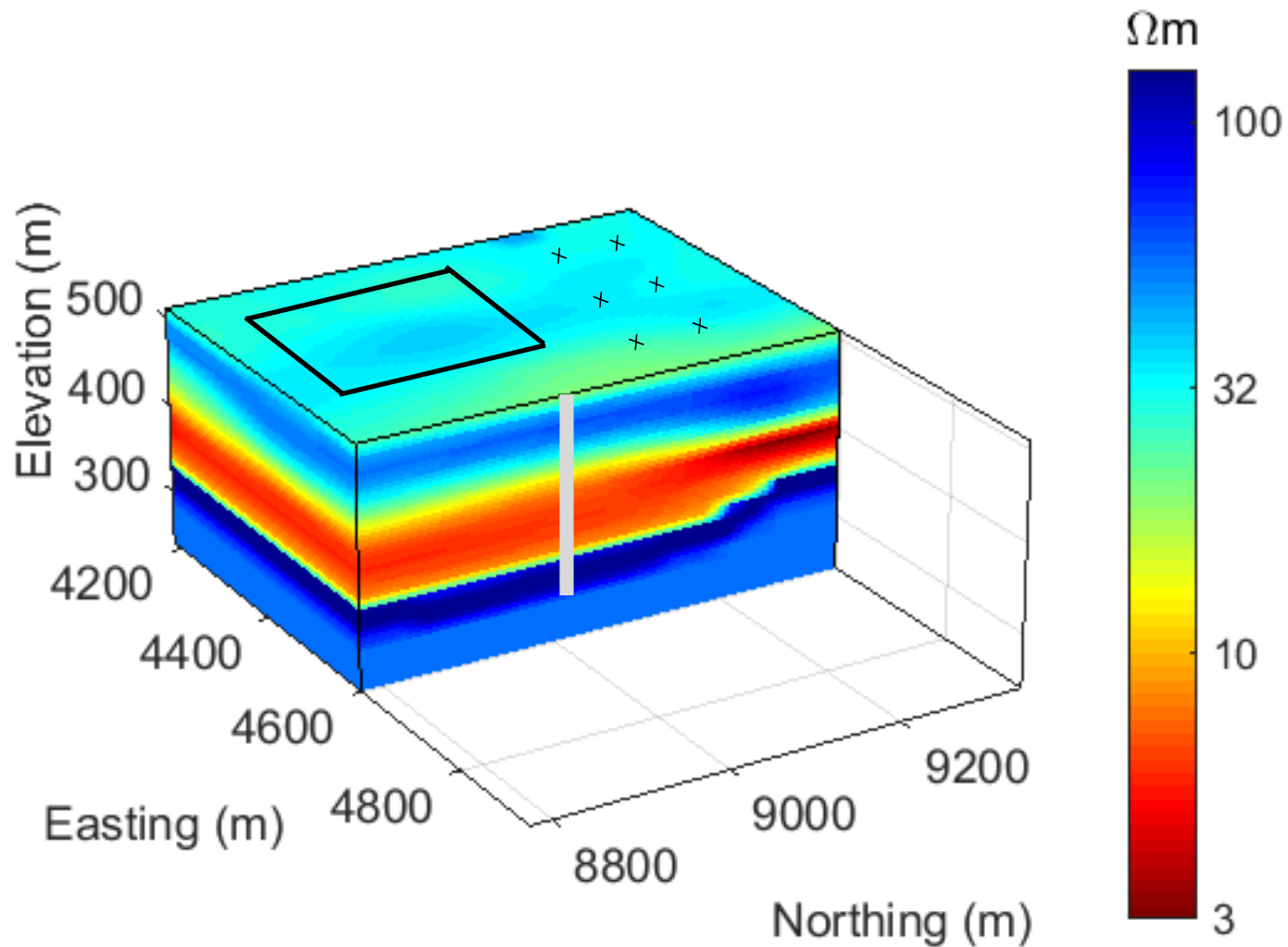
Pre-injection (SAGD)

Local background: airborne + ground



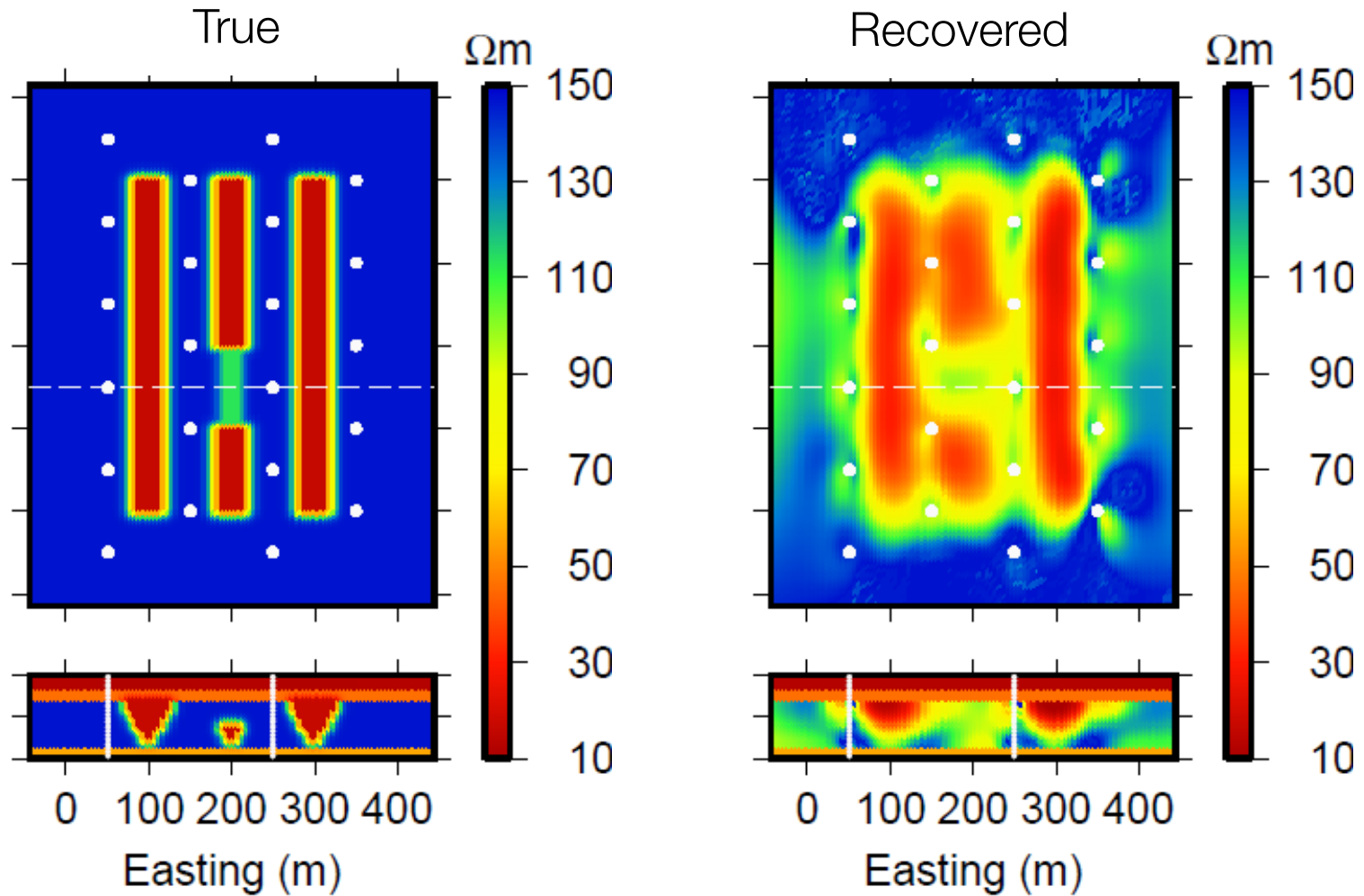
Monitoring array (SAGD)

Pre-injection: surface sources, borehole receivers



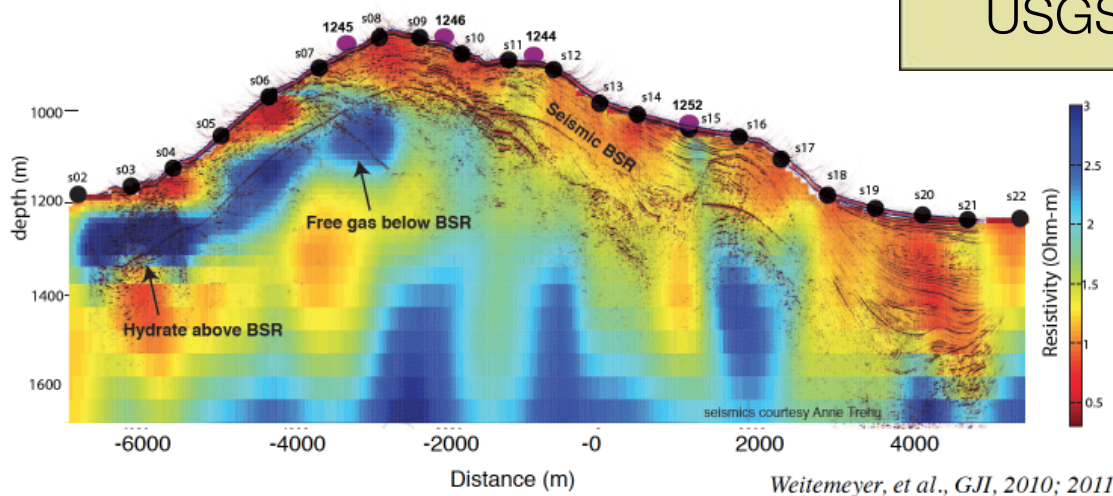
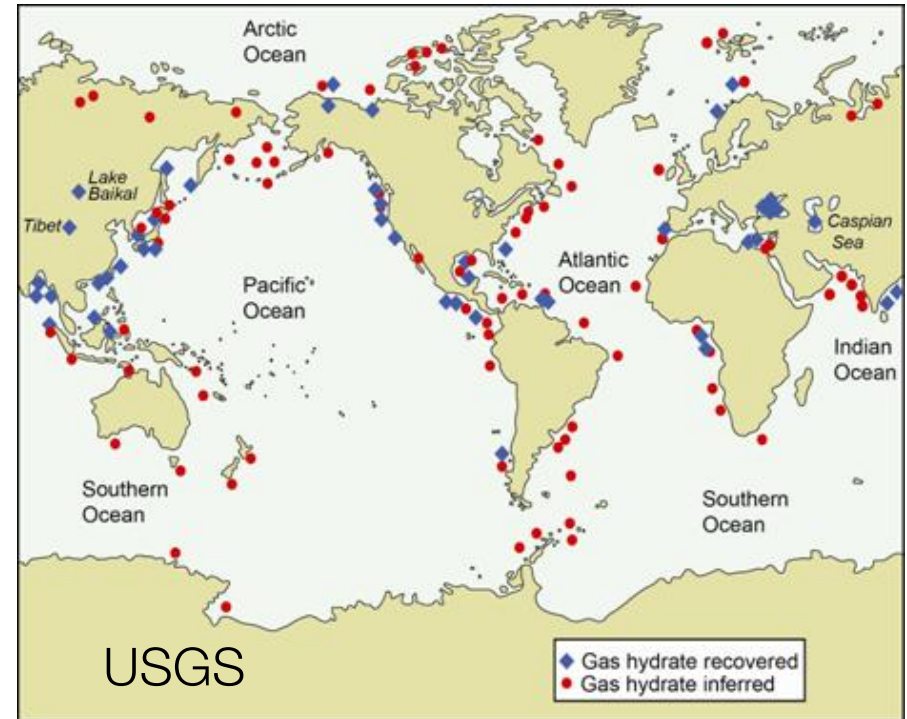
Multi-stage EM for monitoring

Post-injection: surface sources, borehole receivers



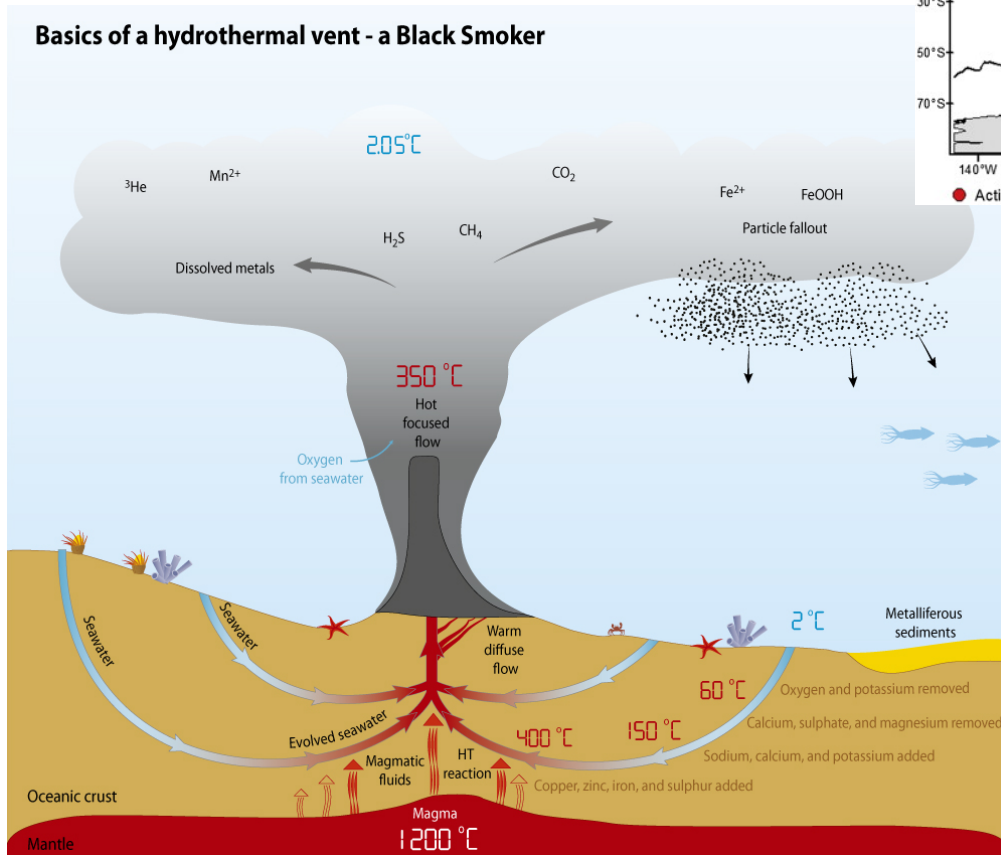
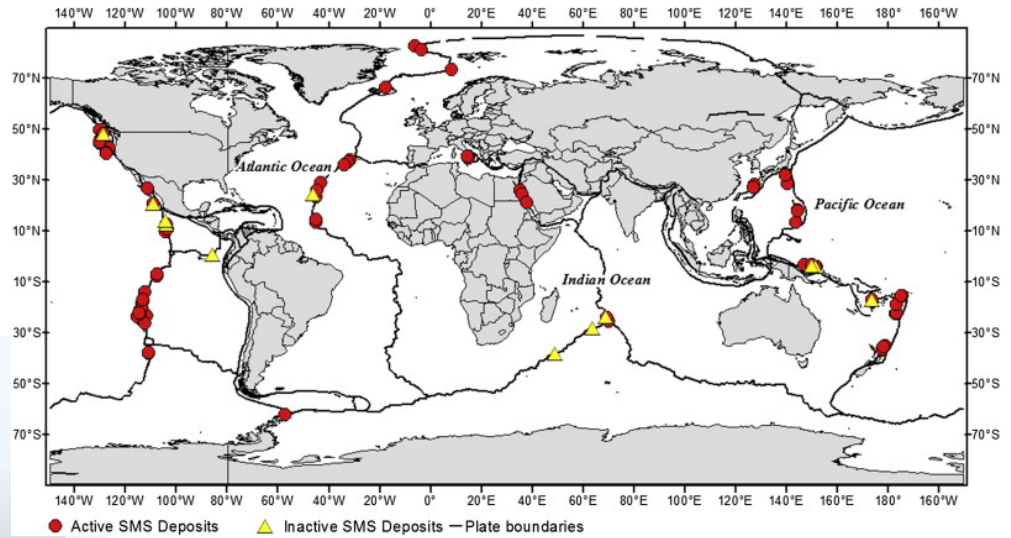
The Future: Marine EM

- Gas hydrates
 - Resistivity is diagnostic

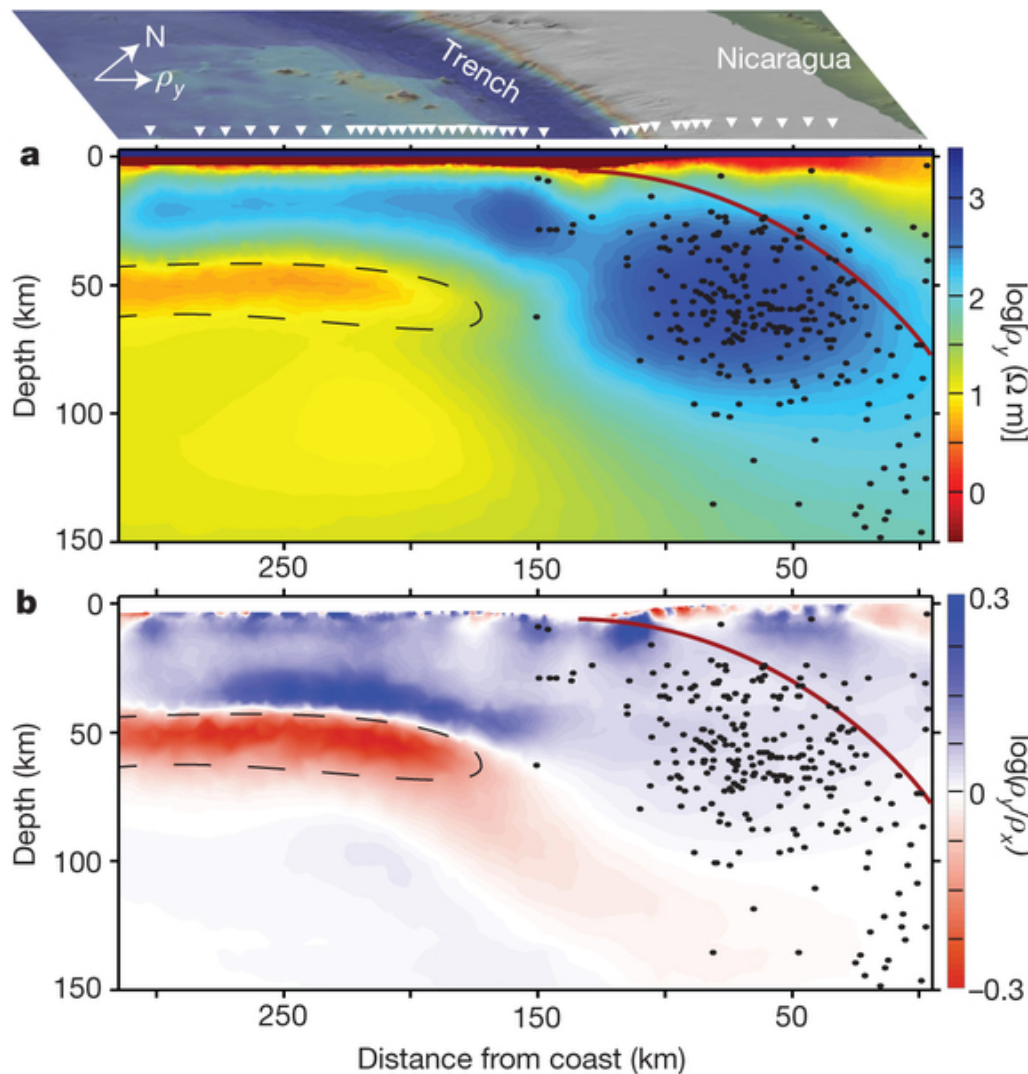


The Future: Marine EM

- Submarine massive sulfides
 - Conductive relative to background



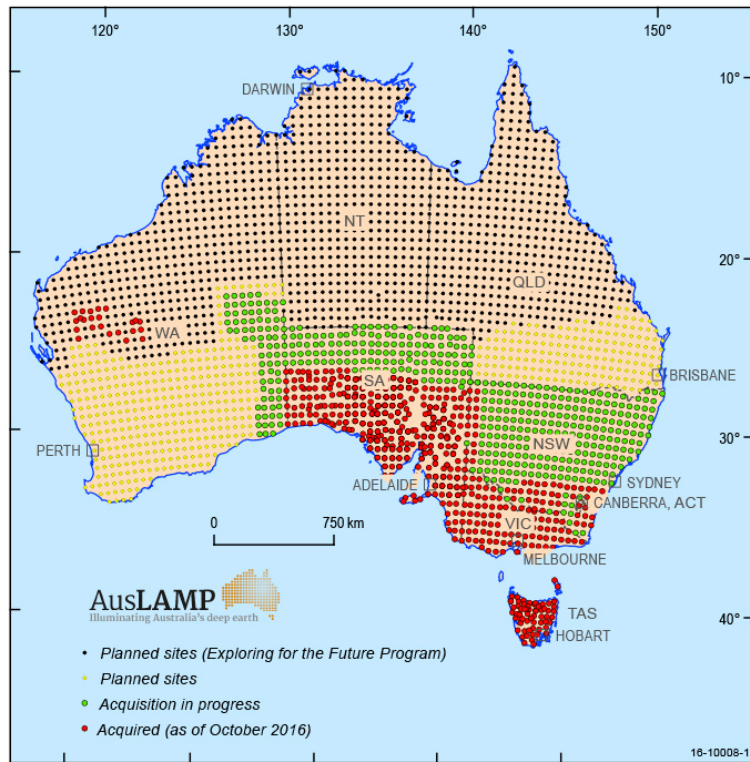
The Future: Marine EM



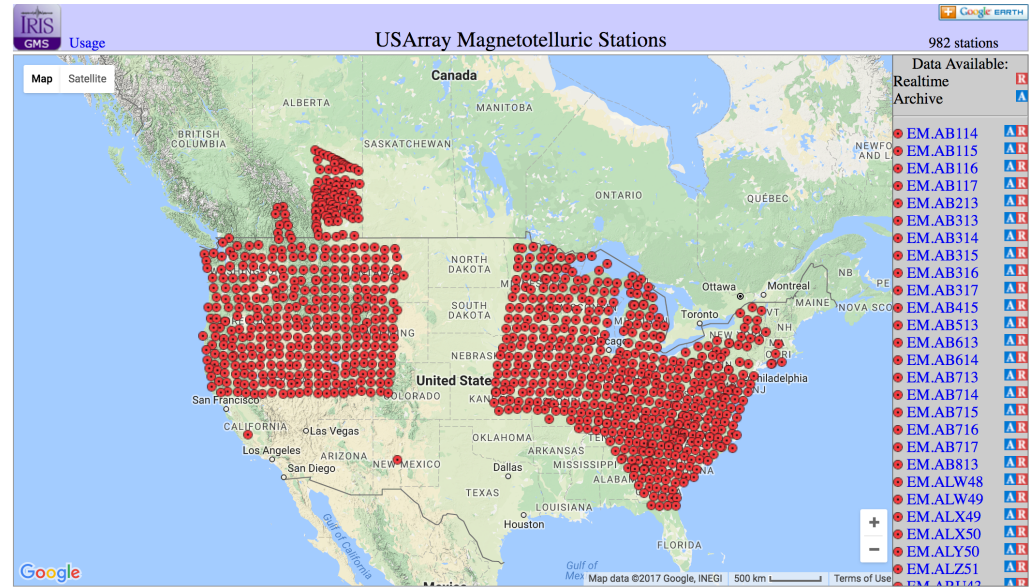
- Tectonic studies
- Natural Hazard
- Large anisotropy
 - indicative of melt-rich channel

The Future: Large Scale MT

AusLamp

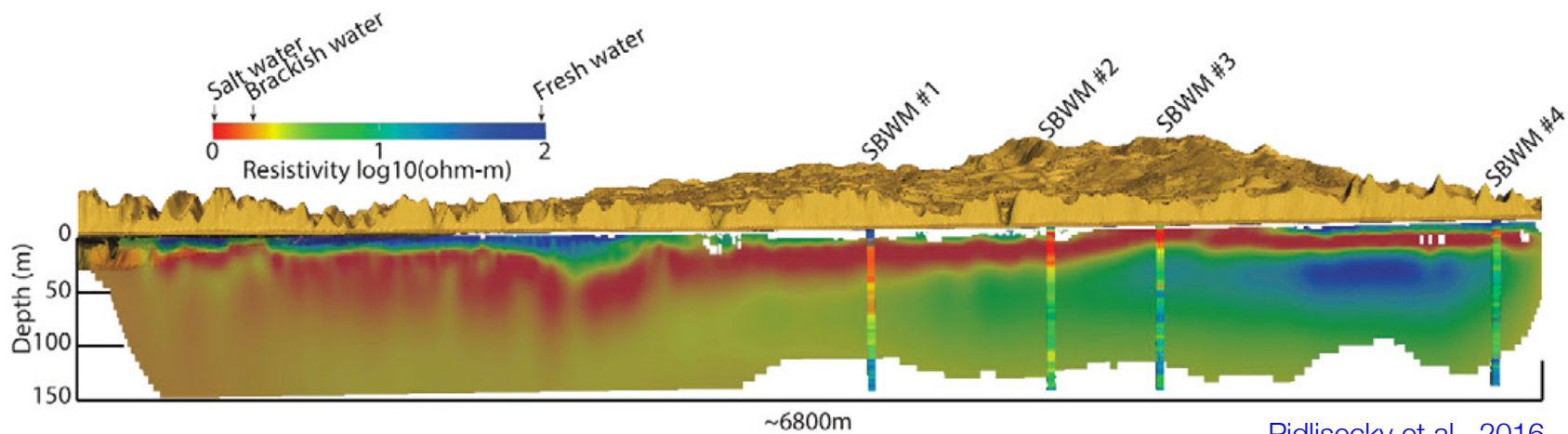
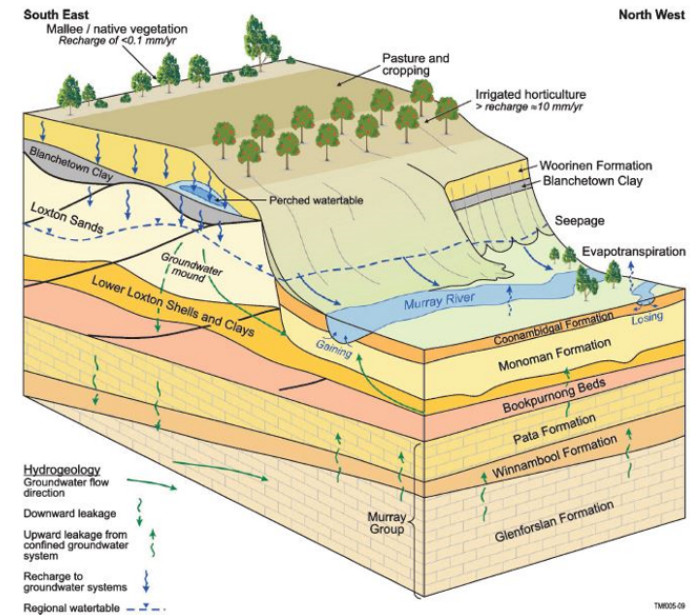


Earth scope



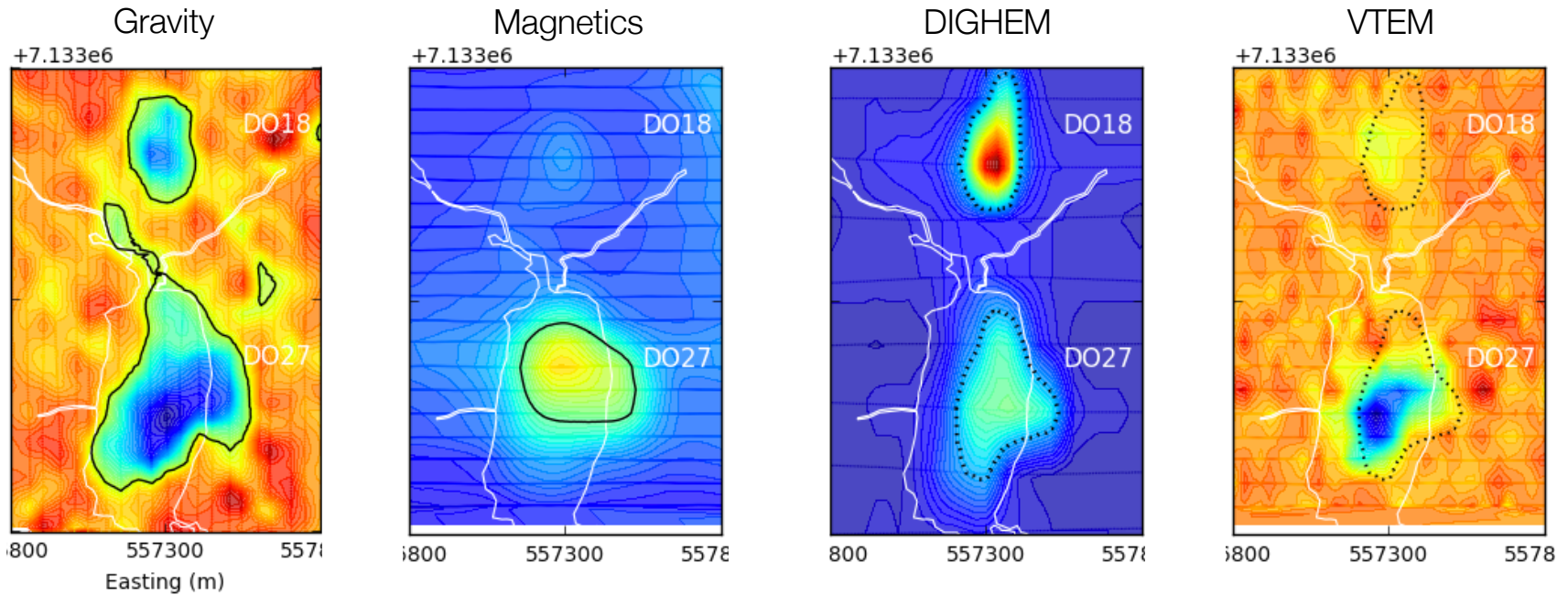
The Future: Water

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

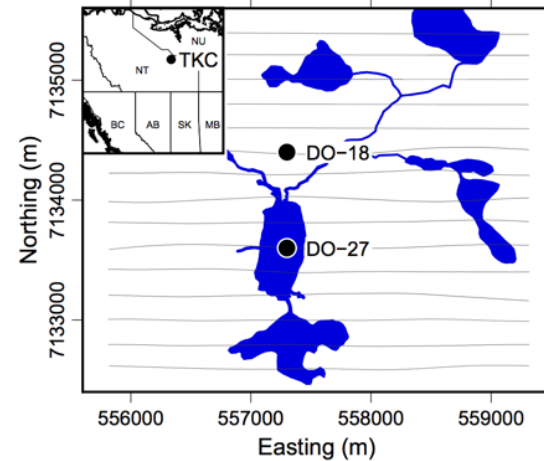
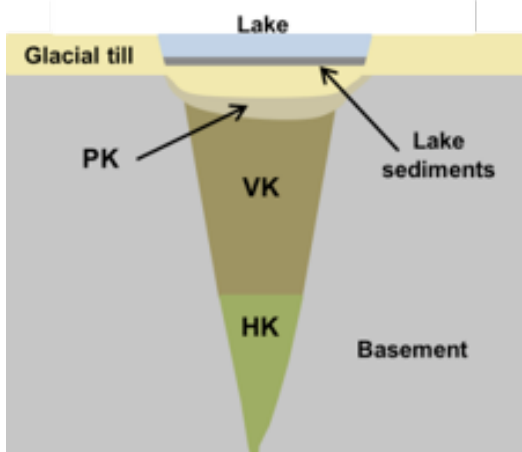


[Pidlisecky et al., 2016](#)

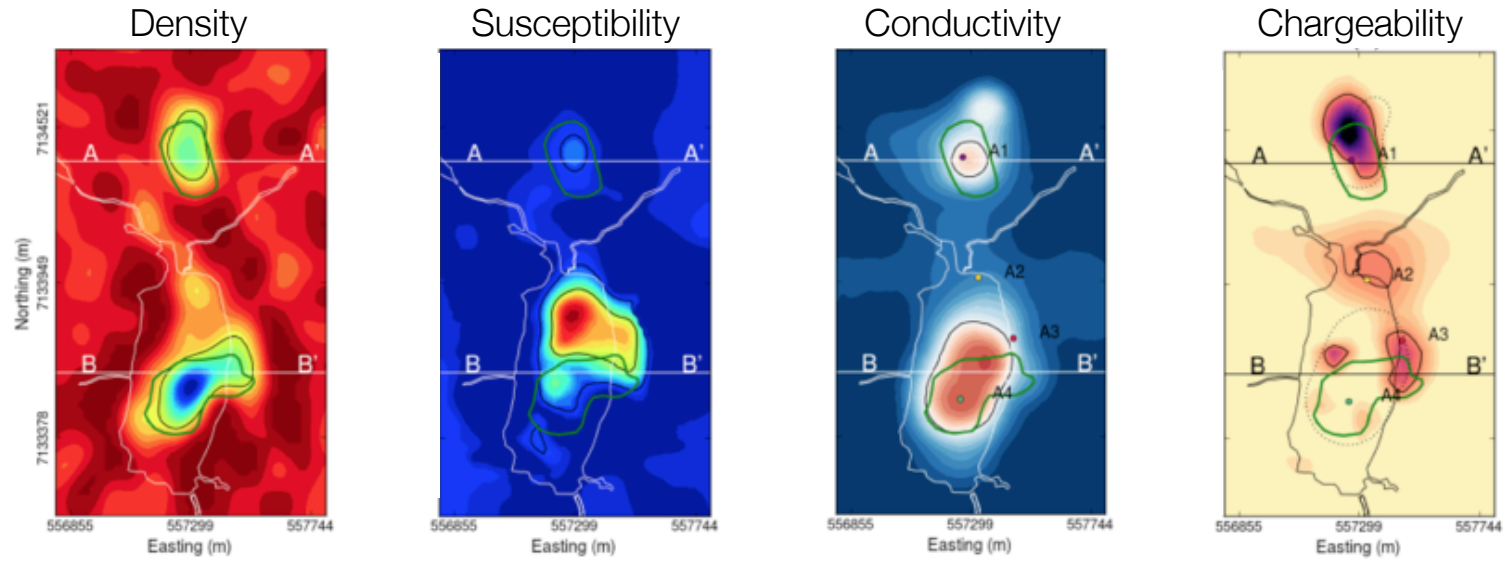
The Future: Data Integration & Multi-physics



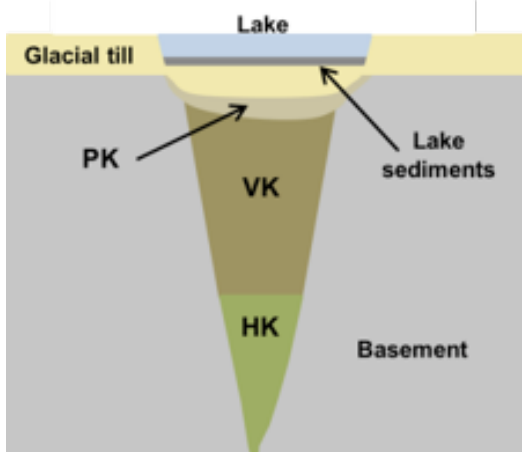
Kimberlite Model



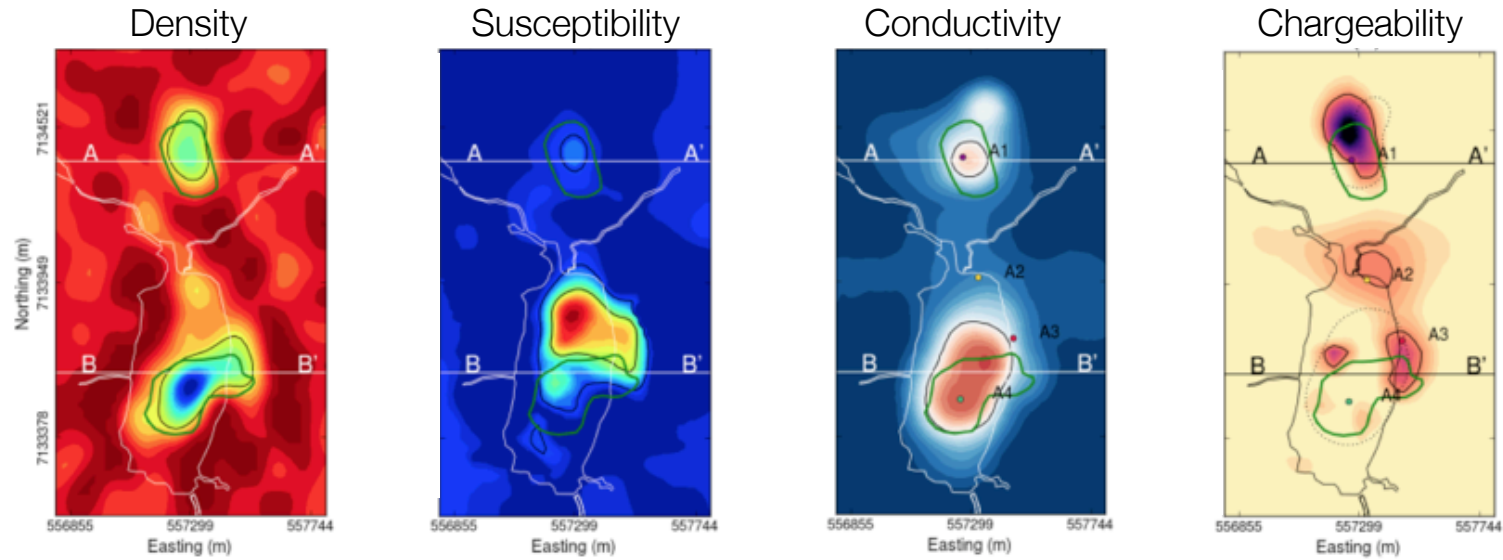
The Future: Data Integration & Multi-physics



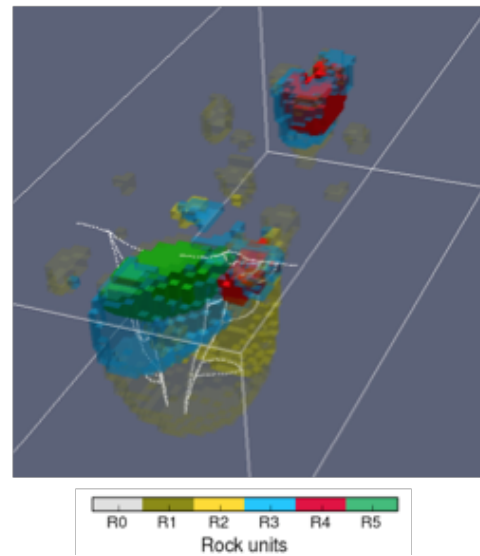
Kimberlite Model



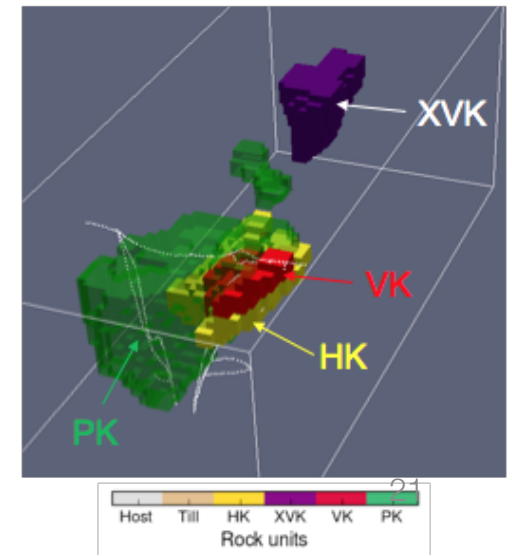
The Future: Data Integration & Multi-physics



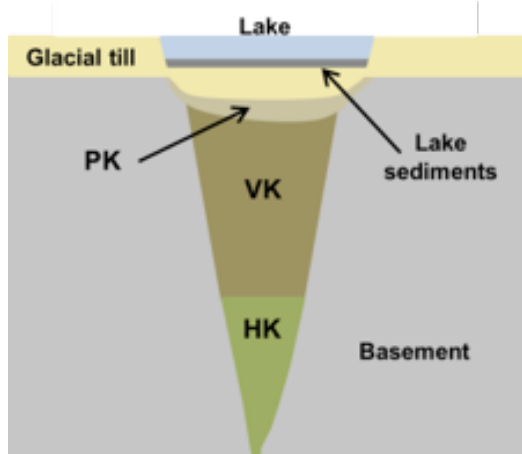
Rock Model from Geophysics



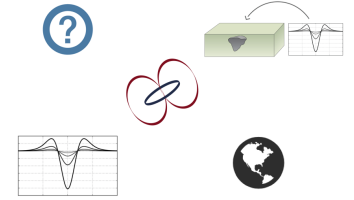
Rock Model from Drilling



Kimberlite Model



The Future: Modelling and Inversion

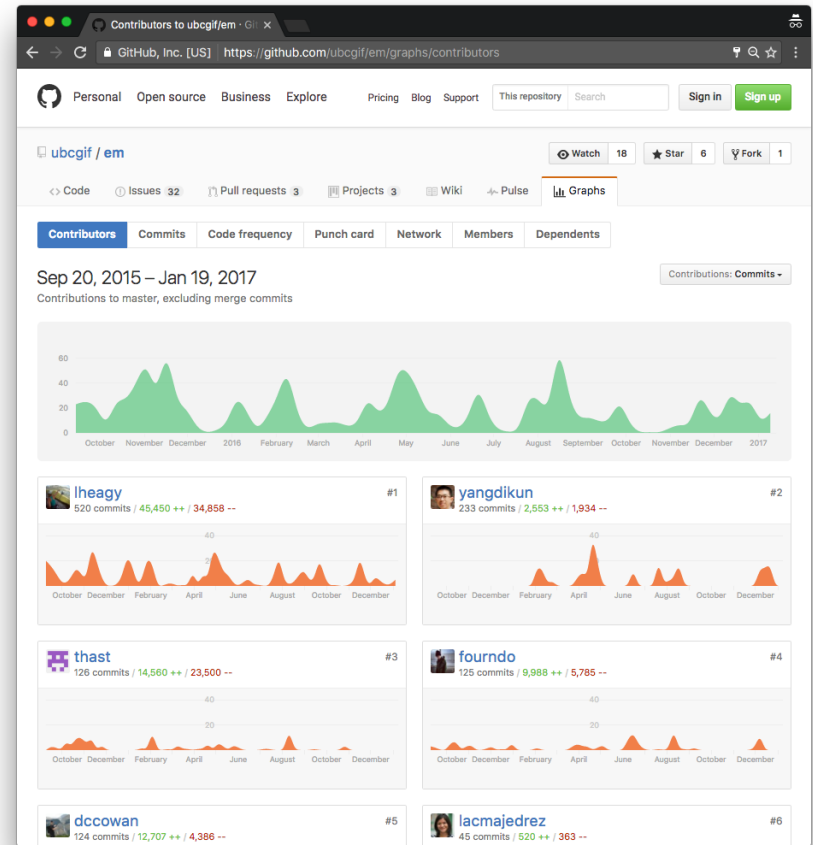


- HPC, Cloud computing
- Collaborative development
- Open source



Simulation and Parameter Estimation in Geophysics

<http://simpeg.xyz>



GitHub
versioning, collaborating



Travis CI
testing, deploy



Jupyter
interactive computing

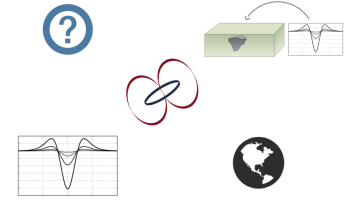


Creative Commons
licensing, reuse



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>

The screenshot shows a Jupyter Notebook window titled 'HarmonicDipoleWidget_MD'. The code cell contains the following Python code:

```
In [10]: dwidget = DipoleWidgetFD()
Q1 = dwidget.InteractiveDipoleBH(nRx=Q0.kwargs["nRx"], plane=Q0.kwargs["Pla
```

The output is an interactive widget with the following controls:

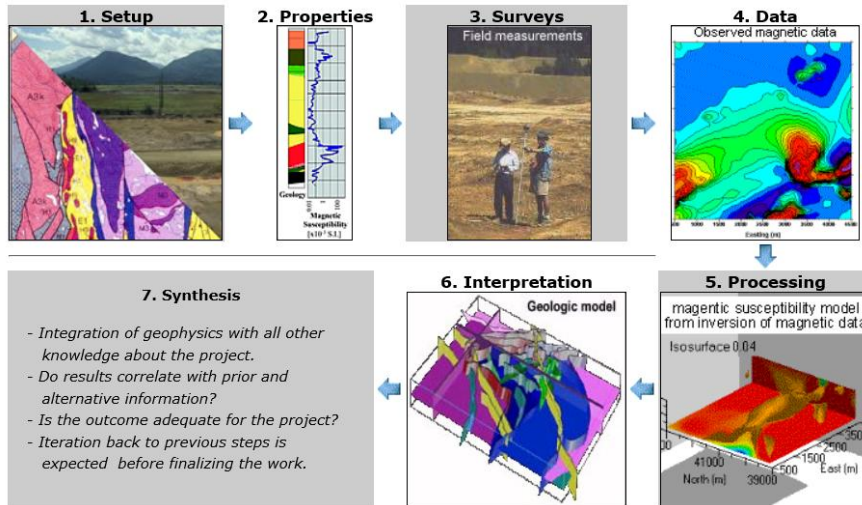
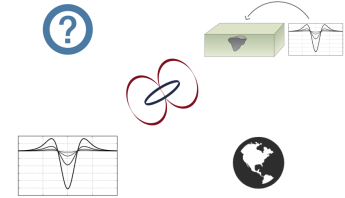
- Field: E, H, J
- AmpDir: None, Amp, Direction
- Comp.: x, y, z
- Complex Number: Re, Im, Amp, Phase
- f (Hz): 0
- σ (S/m): 0.01
- Offset: 50
- Scale: log, linear
- Slider:
 - FreqLog: -3.00
 - SigLog: -3.00

Two plots are displayed:

- Vector H-field from MD:** A 2D plot showing magnetic field lines in the Y-Z plane. The Y-axis ranges from -40 to 40 m, and the Z-axis ranges from -40 to 40 m. The field is concentrated around the Z-axis, with a color scale for magnetic field strength from $10^{-6.8}$ to $10^{-6.2}$ A/m.
- EM data at Rx hole:** A line plot showing the A-B profile. The vertical axis is 'A-B profile (m)' ranging from -40 to 40, and the horizontal axis is '|H|-field field (A/m)'. The plot shows a characteristic bell-shaped curve centered at zero.

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

The Future: Collaboration



Case Histories — Electromagn...
em.geosci.xyz/content/case_histories/index.html

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

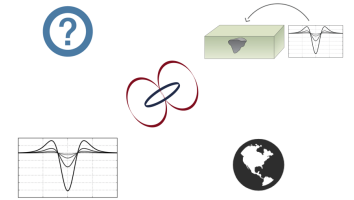
- **Bookpurnong**
- **Contributors**
 - author: Dikun Yang
- **Tags**
 - geophysical survey: Airborne FDEM, Airborne TDEM
 - application: Groundwater
 - location: Australia

Edit on GitHub



<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

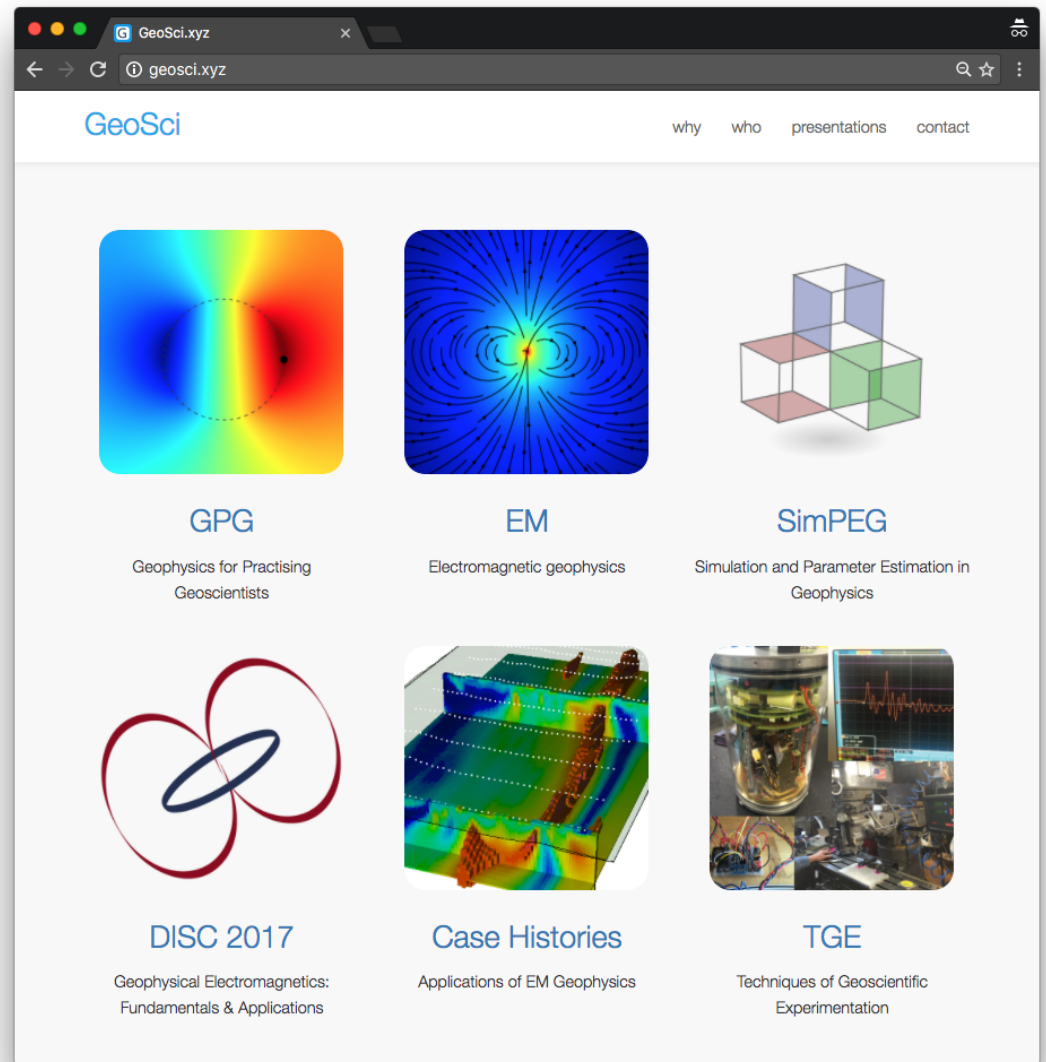
- GeoSci

<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>

