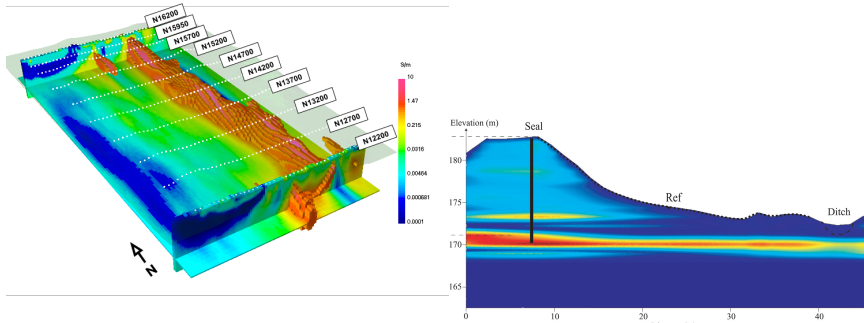


Summary and the Future

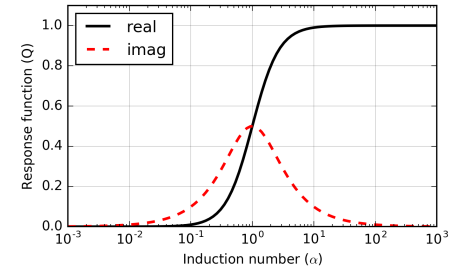


What have we covered?

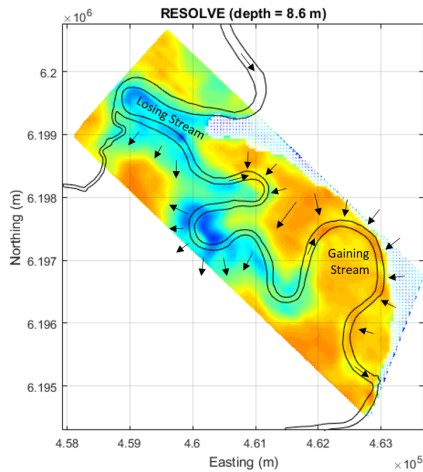
DC Resistivity



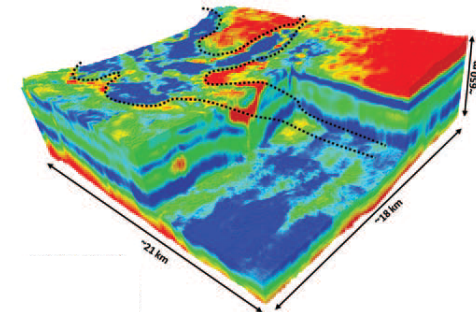
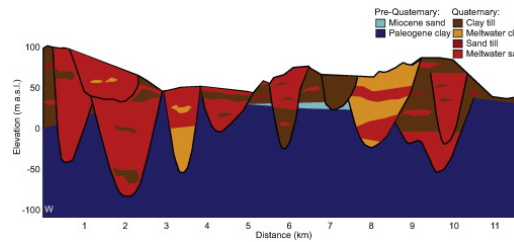
EM Fundamentals



Inductive Sources: Frequency

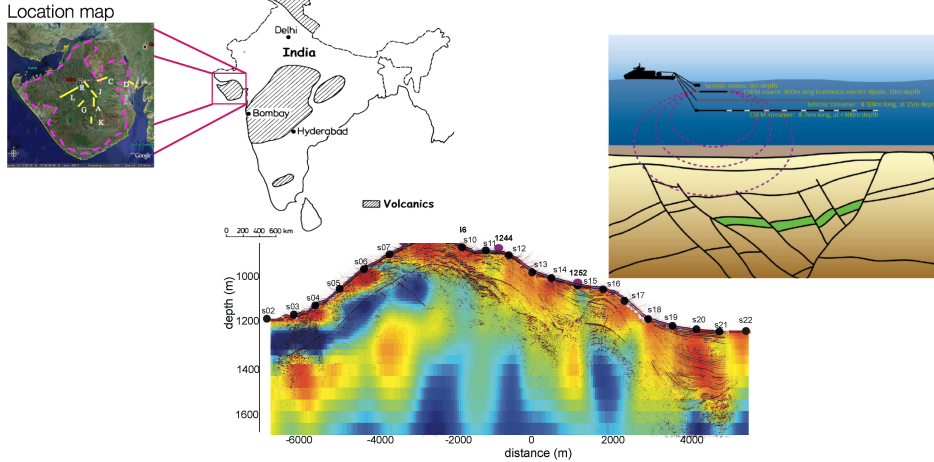


Inductive Sources: Time

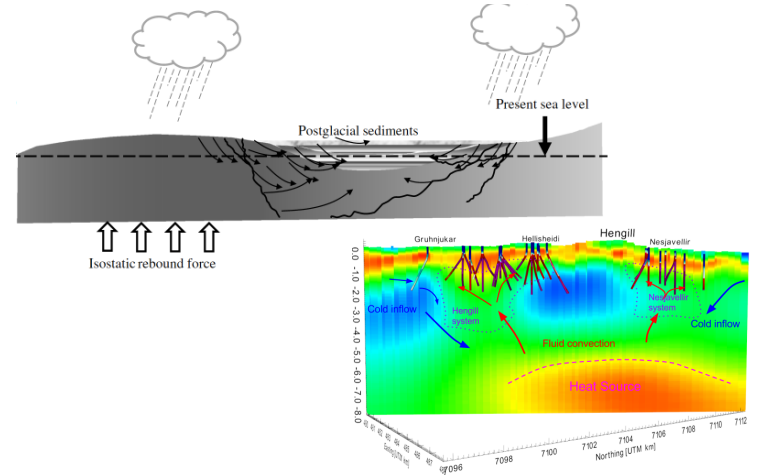


What have we covered?

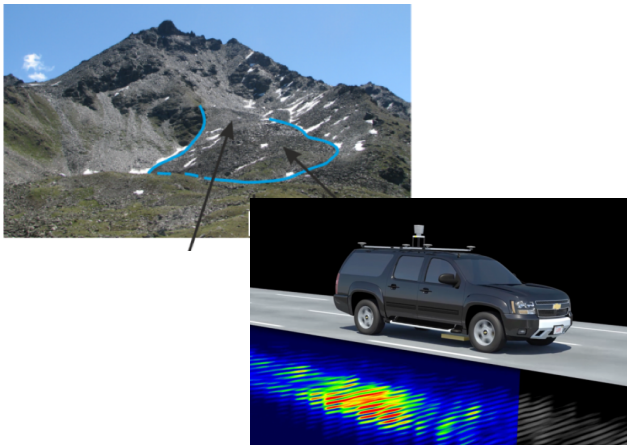
Grounded Sources



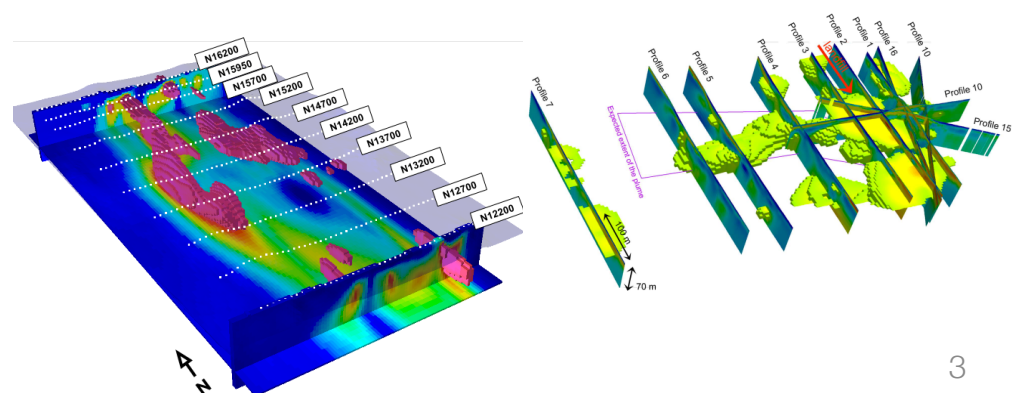
Natural Sources



Ground Penetrating Radar



Induced Polarization



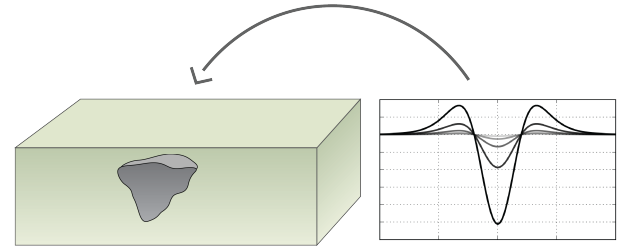
What does the future hold?

What does the future hold?

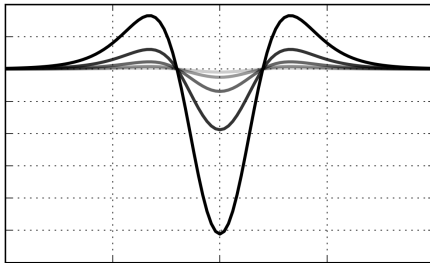
Problems



Inversion capabilities



High quality data

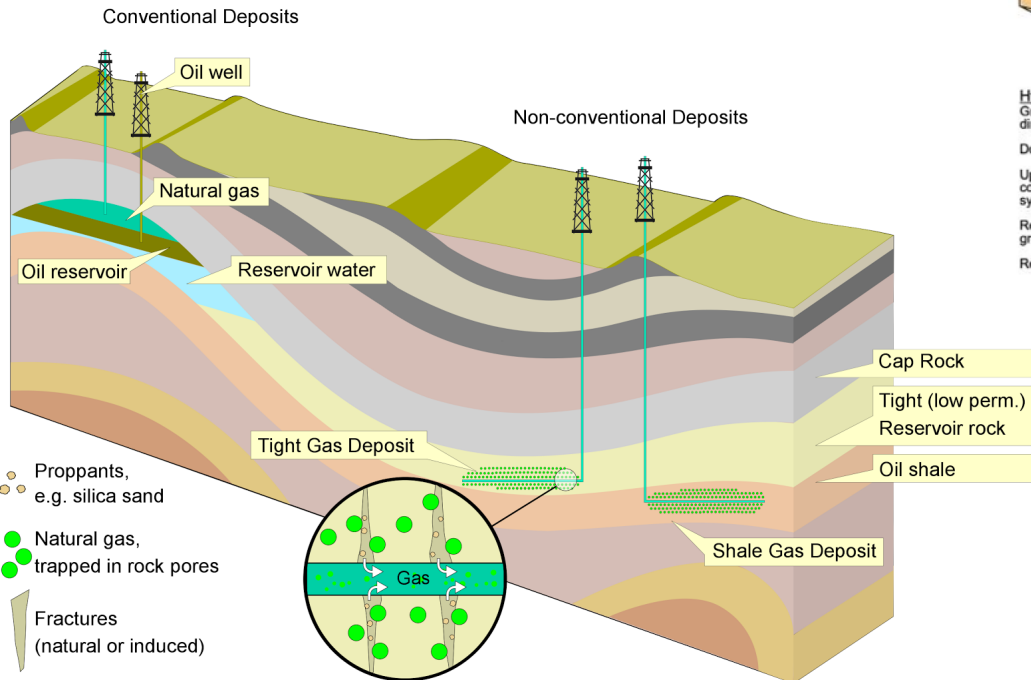
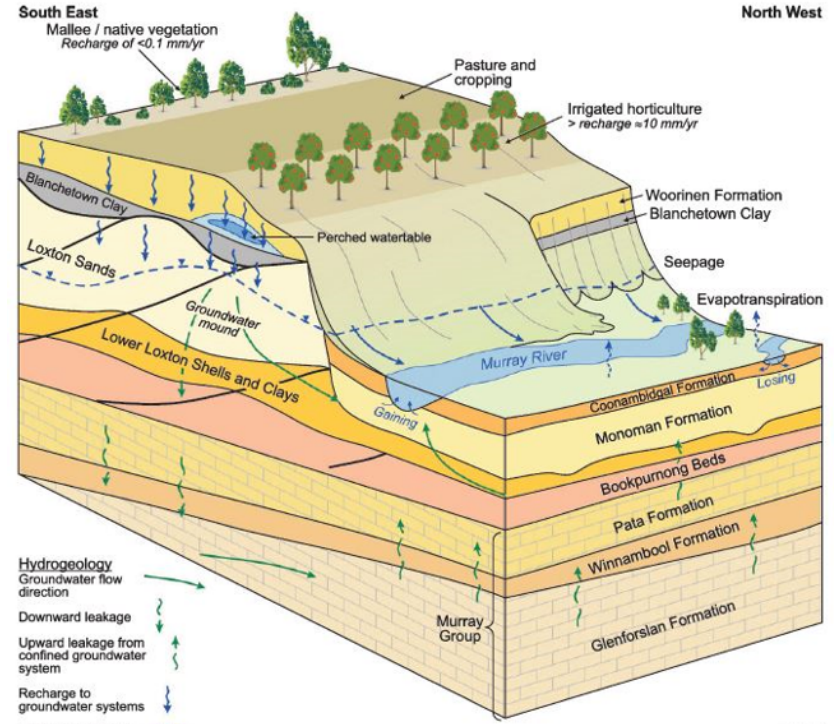


Web tools to
communicate



The Future: Monitoring

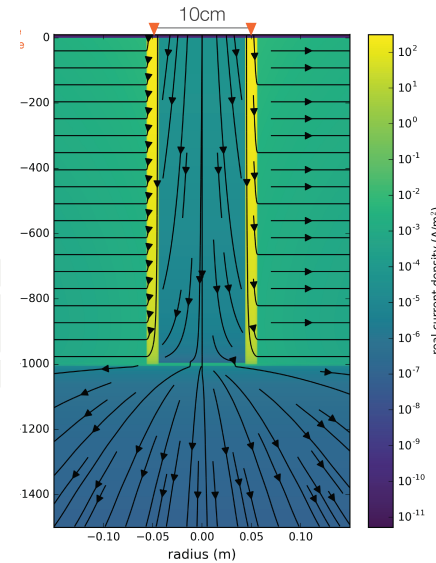
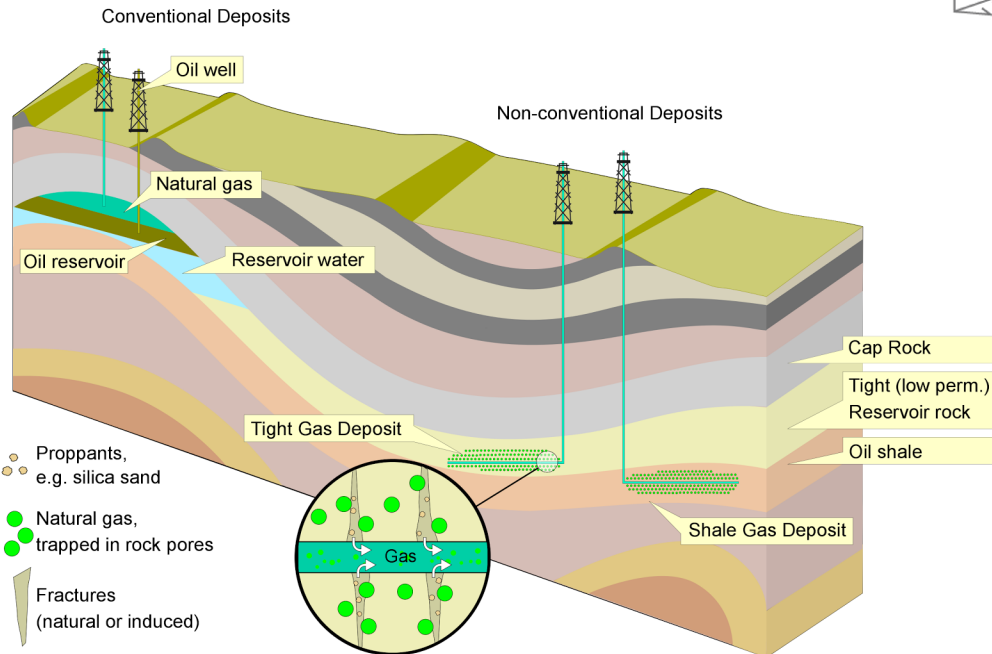
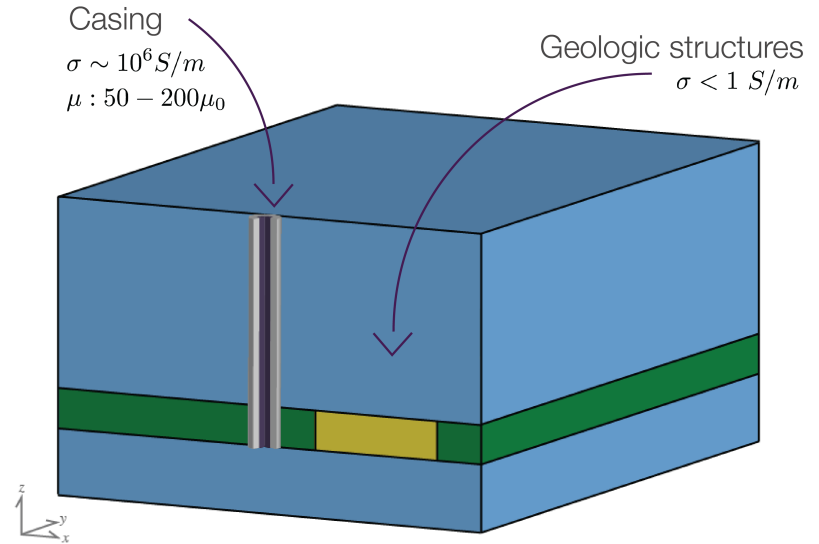
- Aquifers
- Enhanced oil recovery
- Hydraulic Fracturing
- CO₂ sequestration
- Coal seam gas



TM005-09

The Future: Monitoring

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

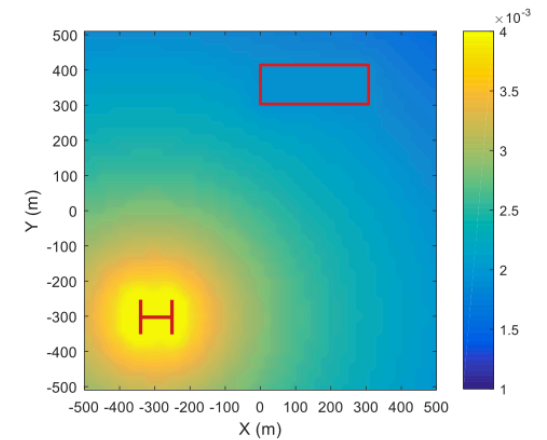
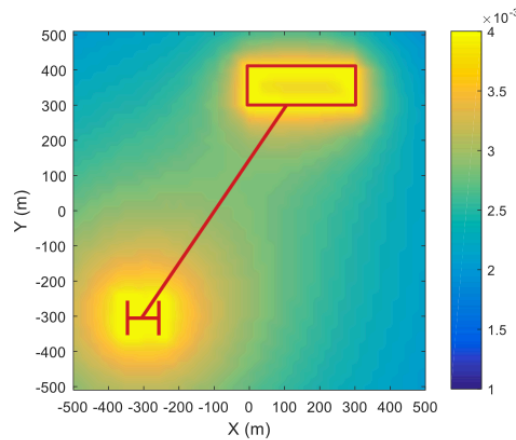
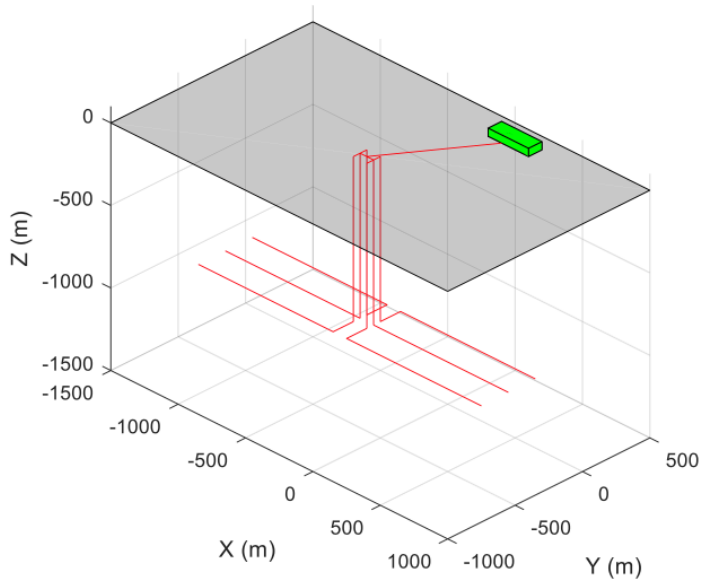
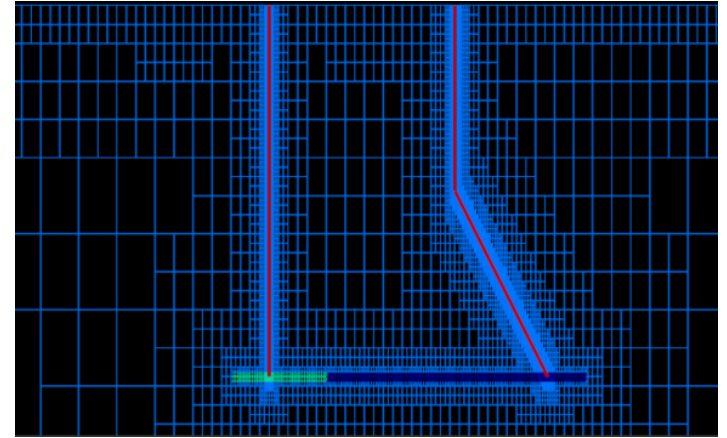
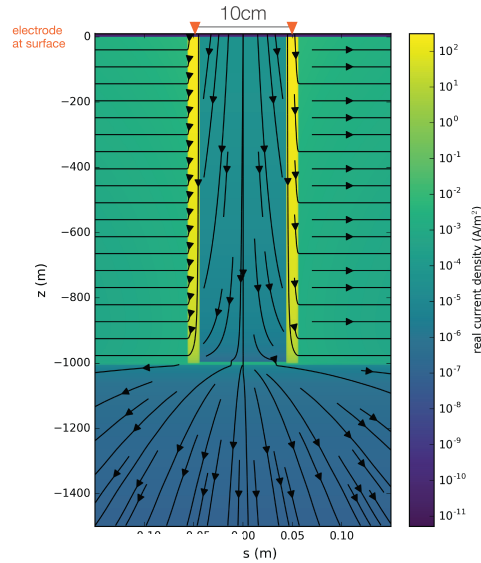


Corrosion



The Future: Monitoring

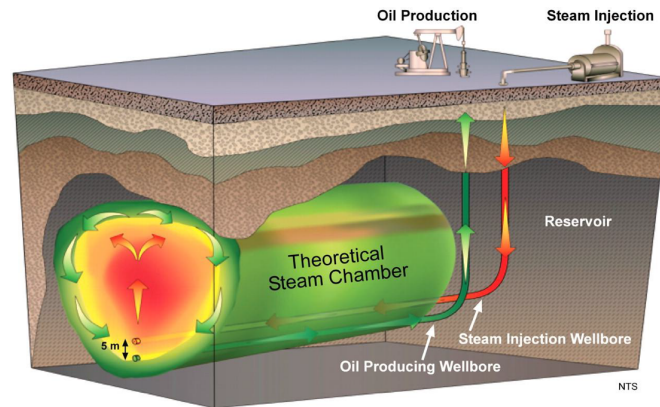
- Steel Casing



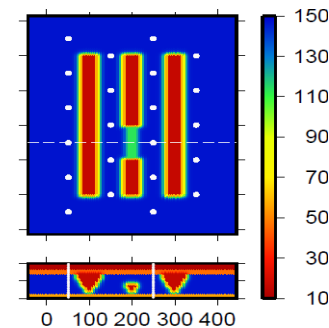
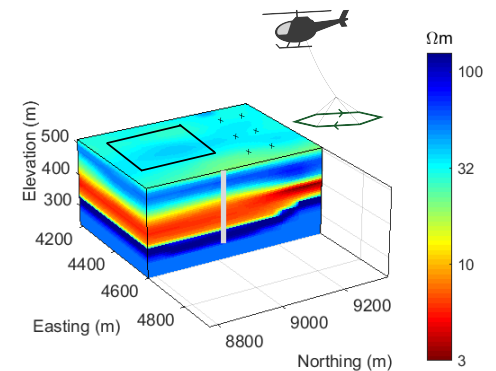
Monitoring: Choosing the appropriate survey

Different EM surveys needed to answer different questions

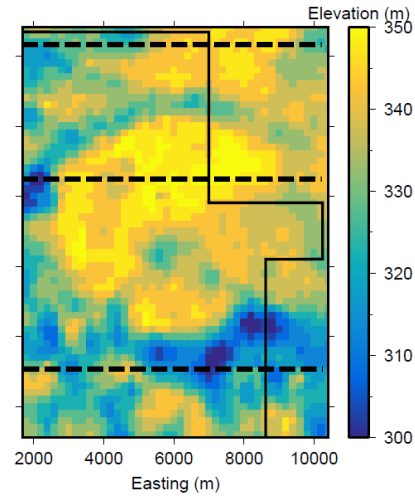
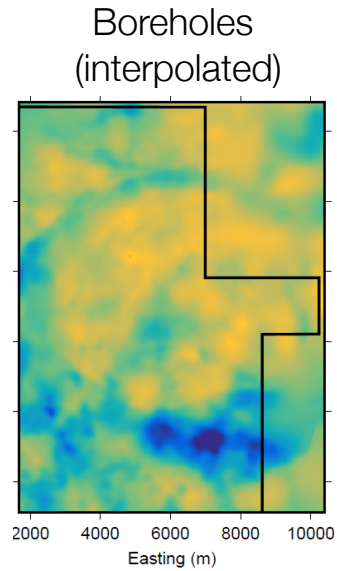
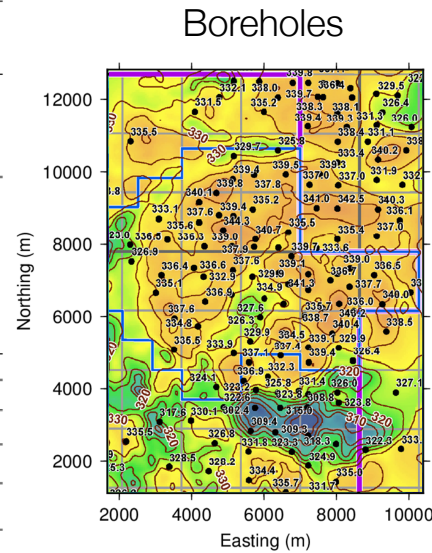
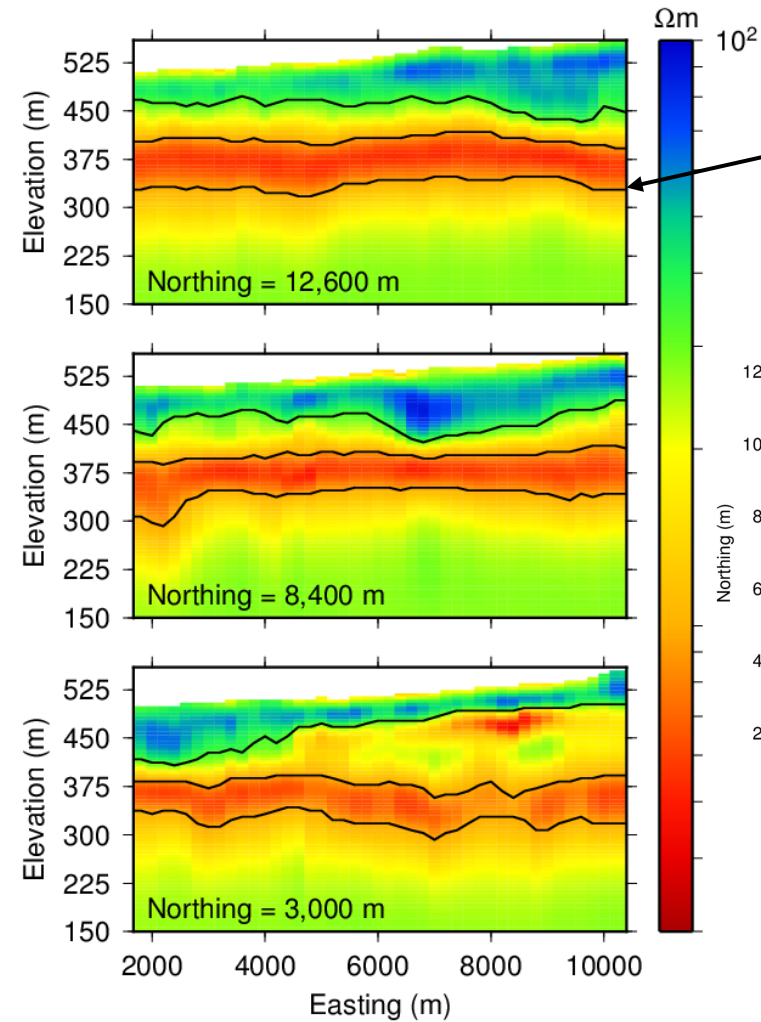
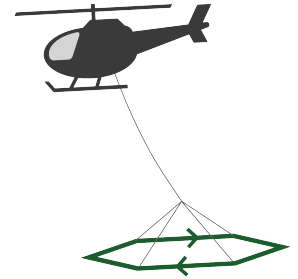
SAGD (Injection and monitoring steam flooding)



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

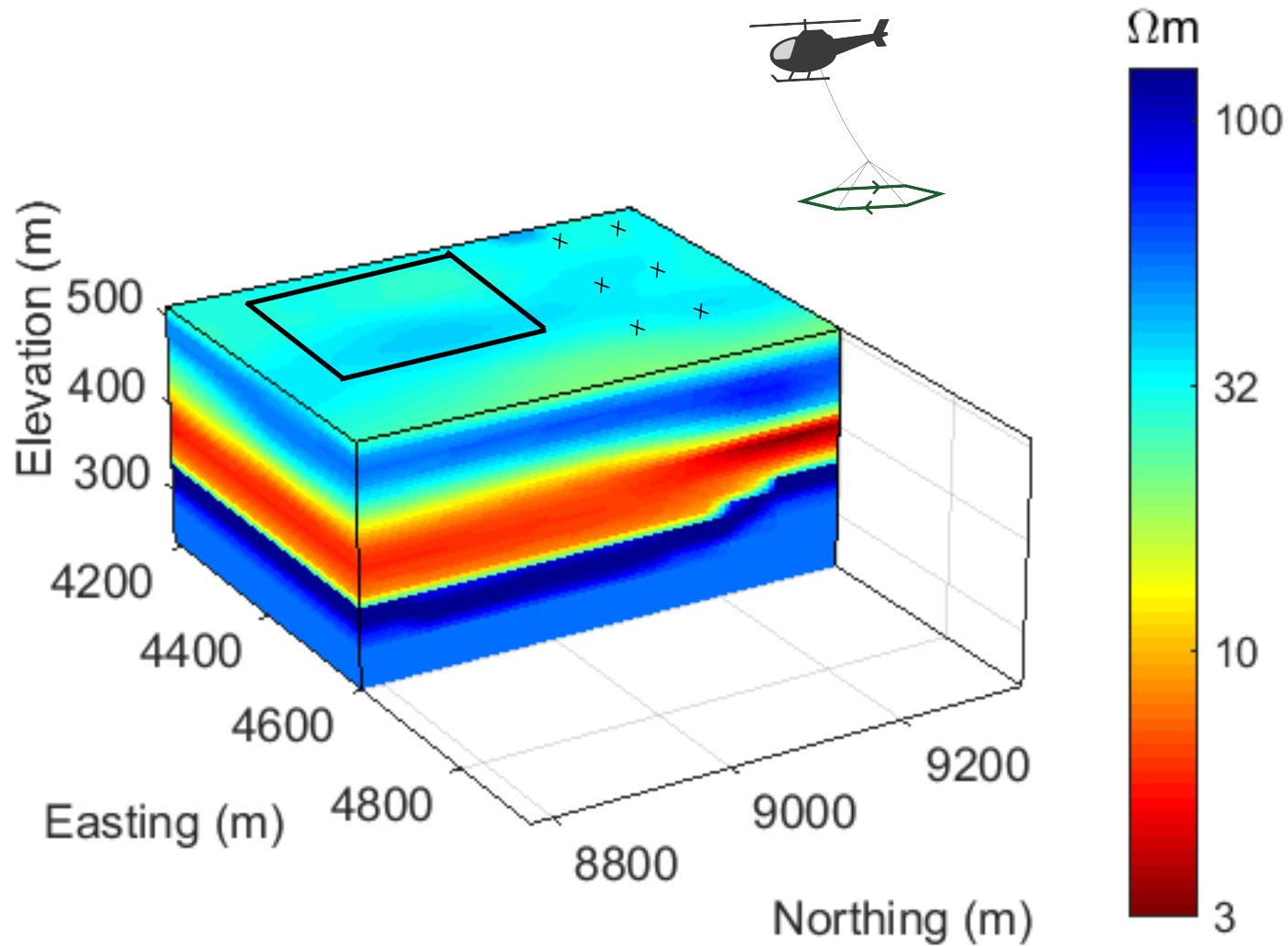


Large scale reconnaissance (SAGD)



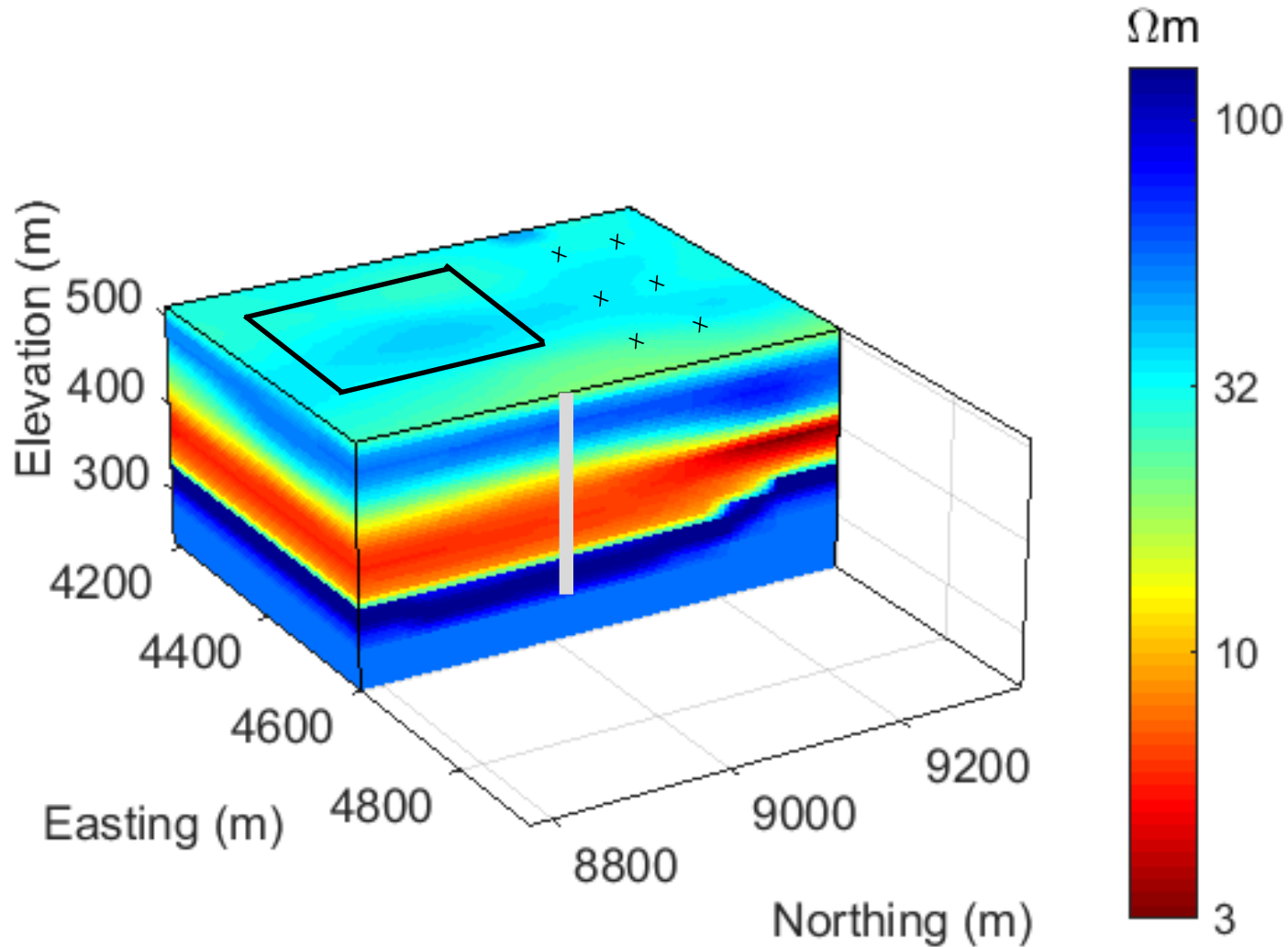
Pre-injection (SAGD)

Local background: airborne + ground



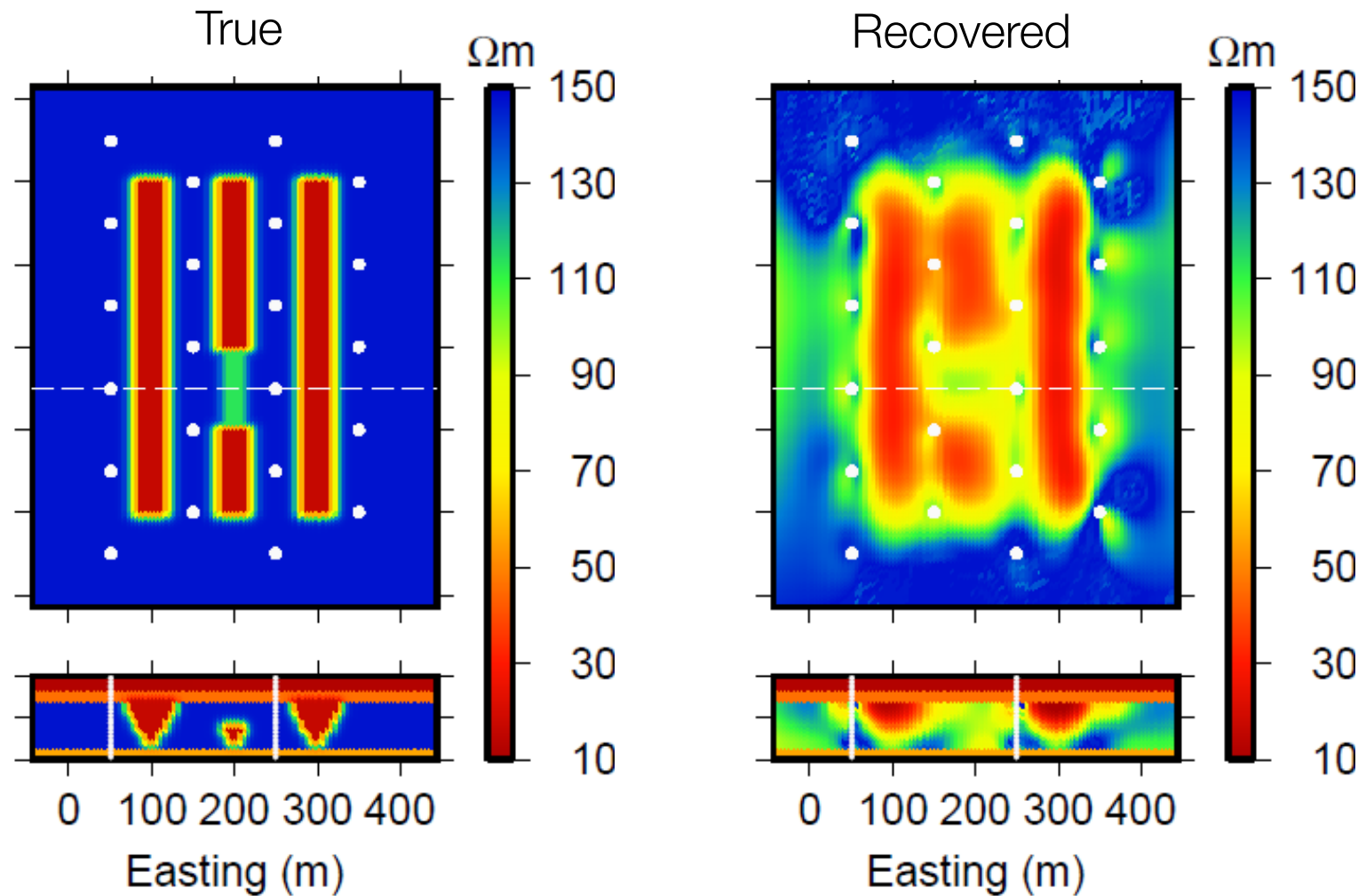
Monitoring array (SAGD)

Pre-injection: surface sources, borehole receivers



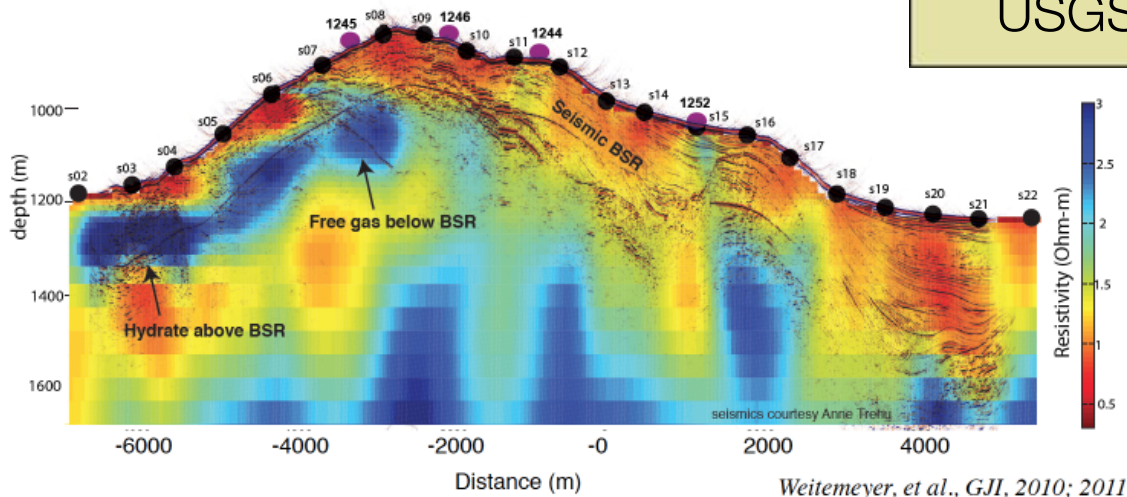
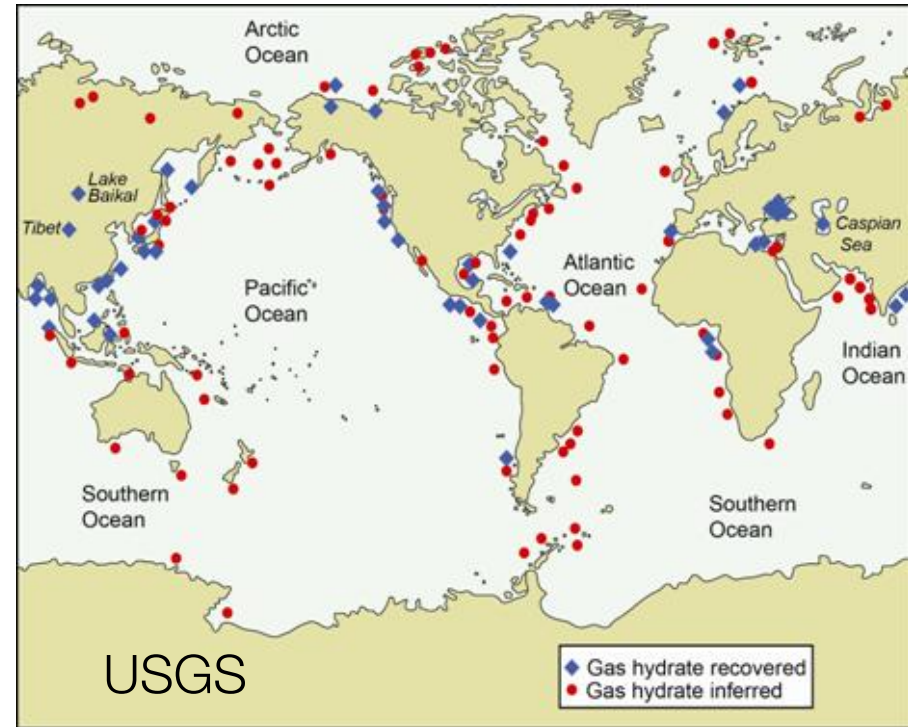
Multi-stage EM for monitoring

Post-injection: surface sources, borehole receivers



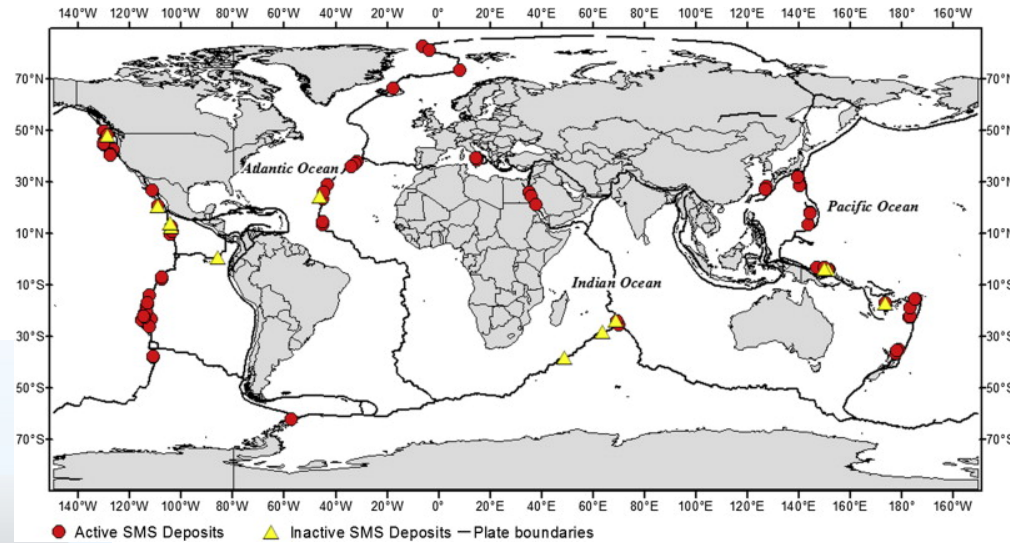
The Future: Marine EM

- Gas hydrates
 - Resistivity is diagnostic

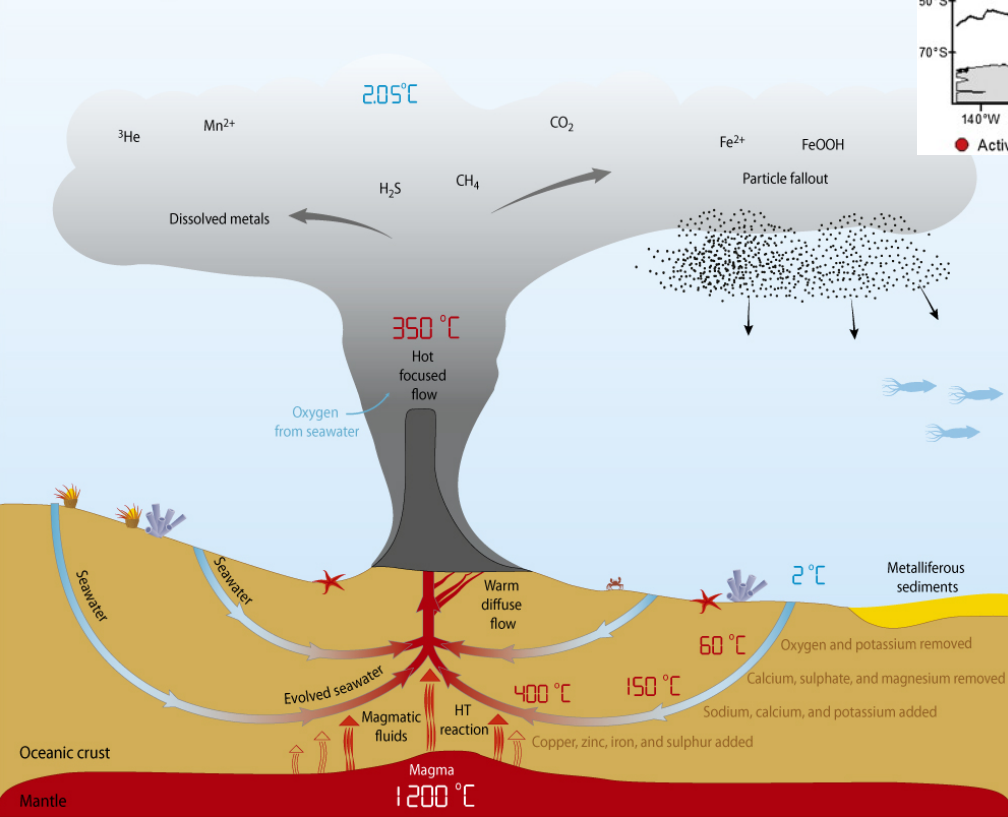


The Future: Marine EM

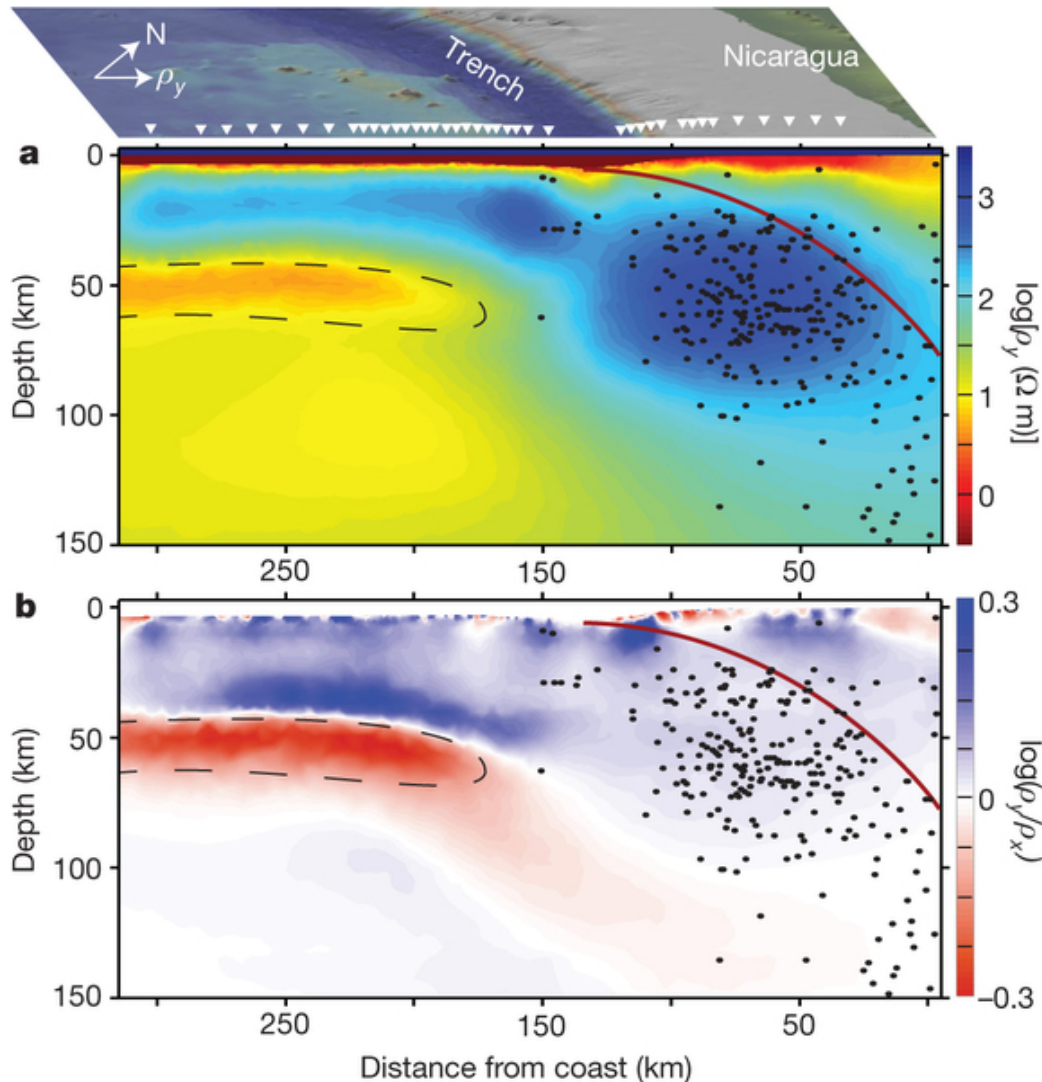
- Submarine massive sulfides
 - Conductive relative to background



Basics of a hydrothermal vent - a Black Smoker



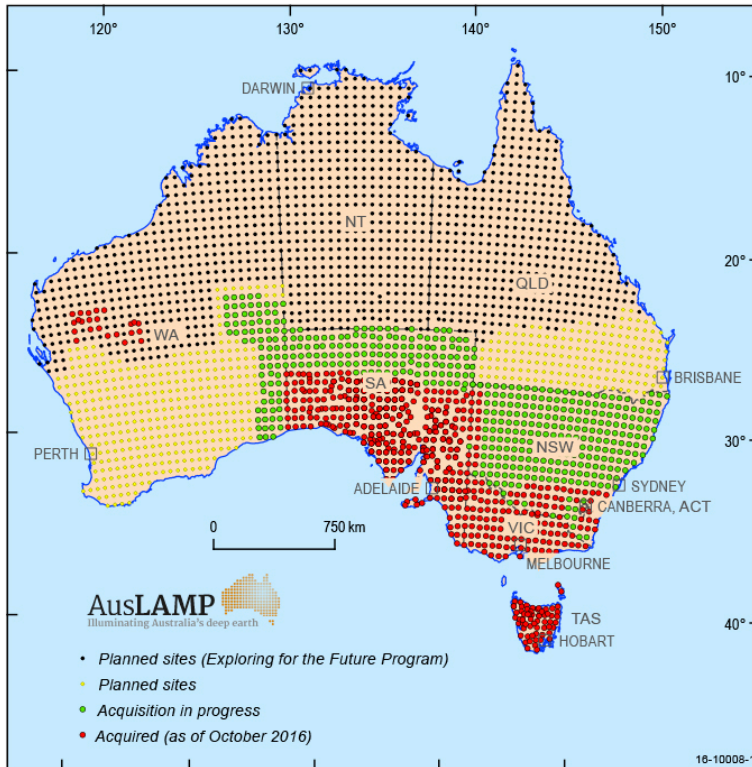
The Future: Marine EM



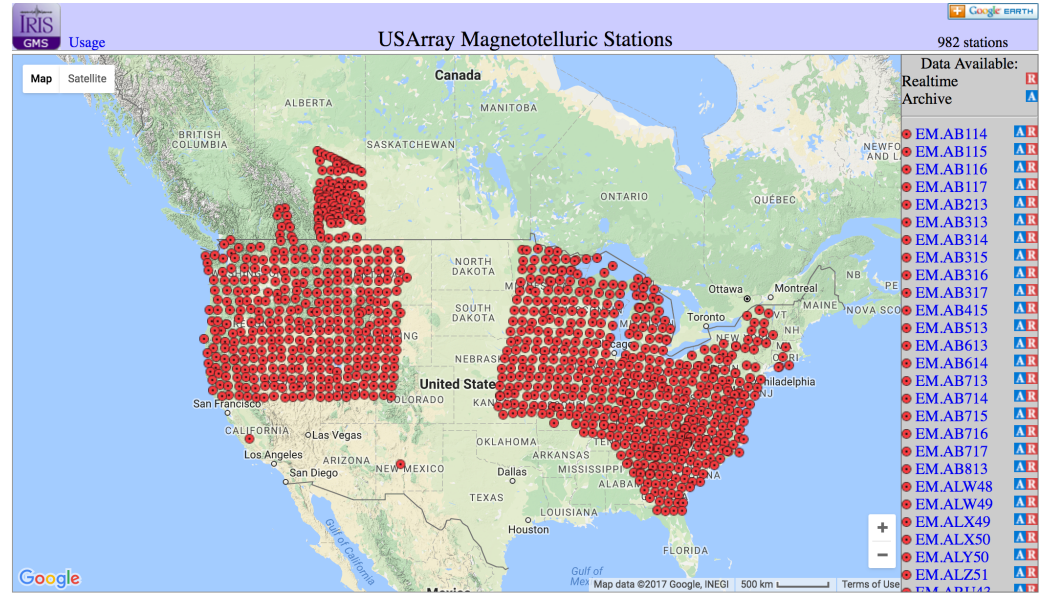
- Tectonic studies
- Natural Hazard
- Large anisotropy
 - indicative of melt-rich channel

The Future: Large Scale MT

AusLamp

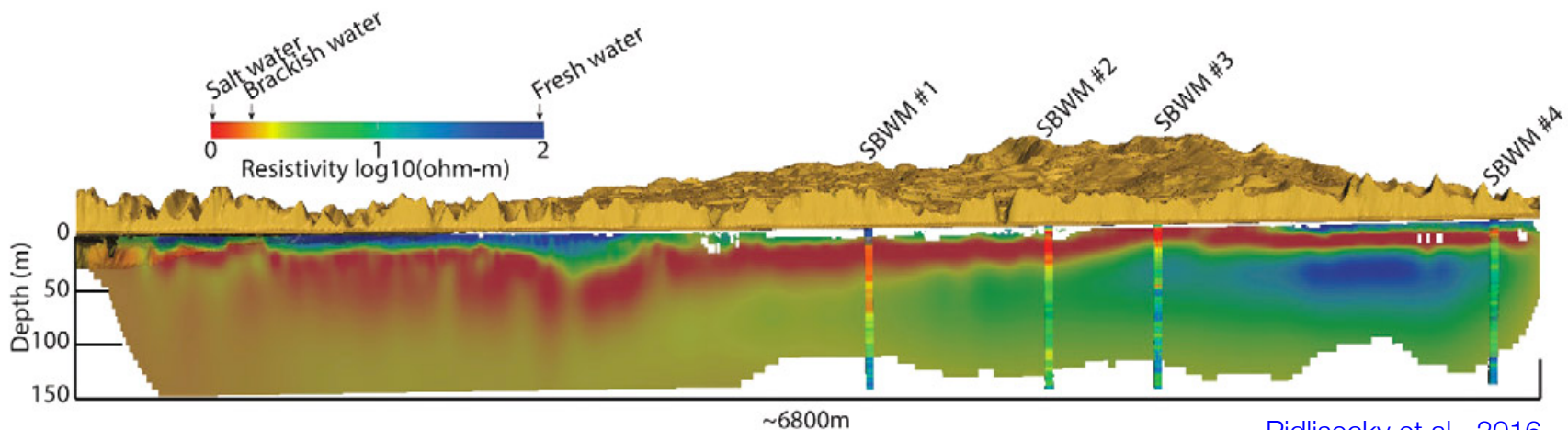
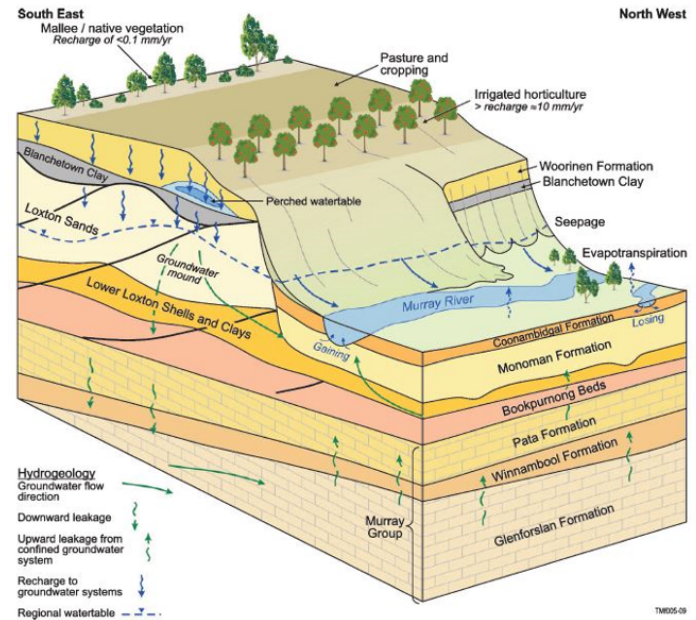


Earth scope



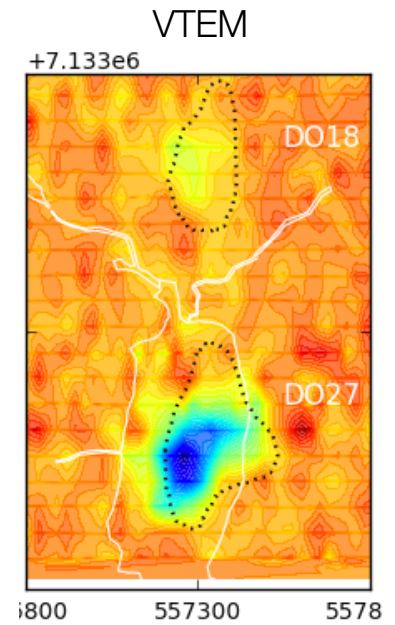
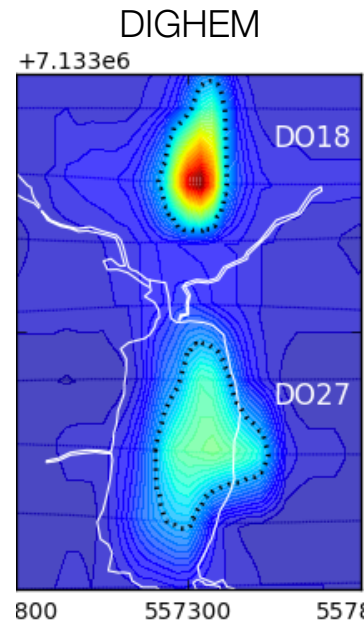
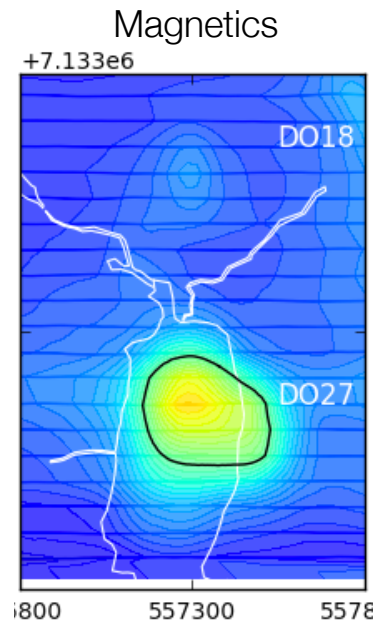
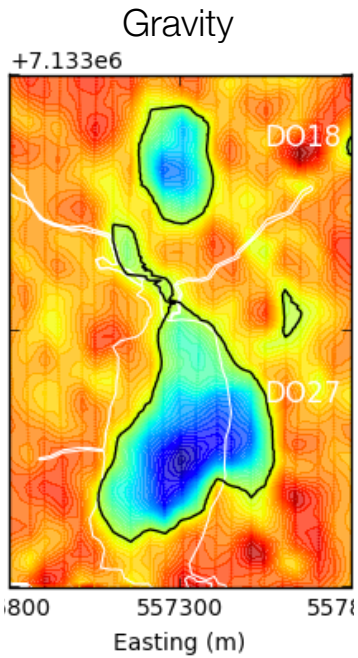
The Future: Water

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

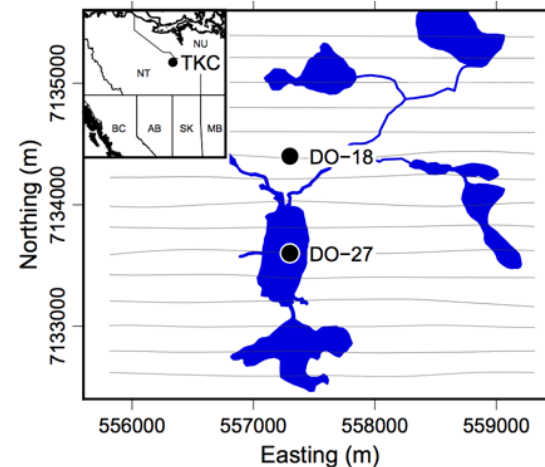
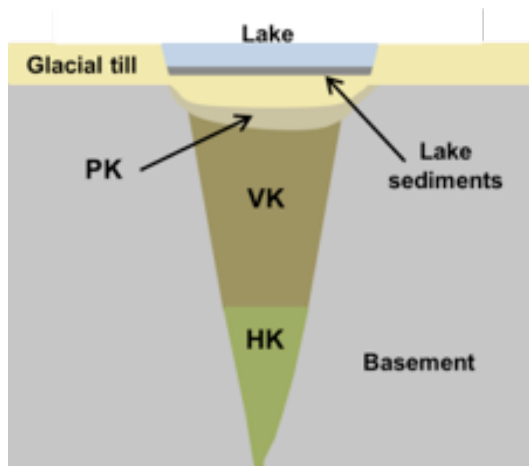


Pidlisecky et al., 2016

The Future: Data Integration & Multi-physics

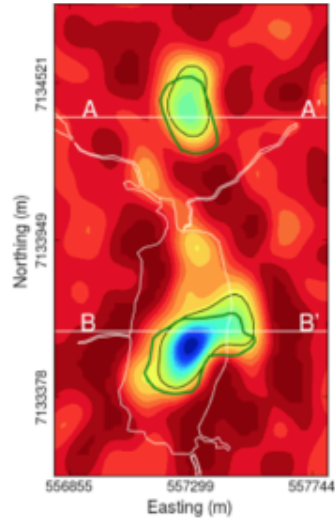


Kimberlite Model

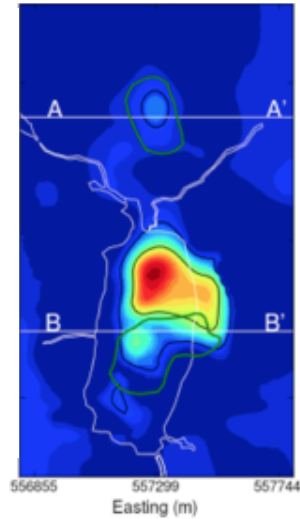


The Future: Data Integration & Multi-physics

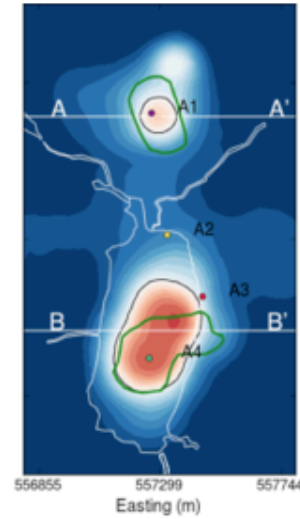
Density



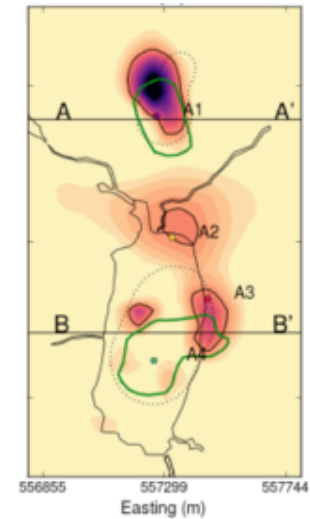
Susceptibility



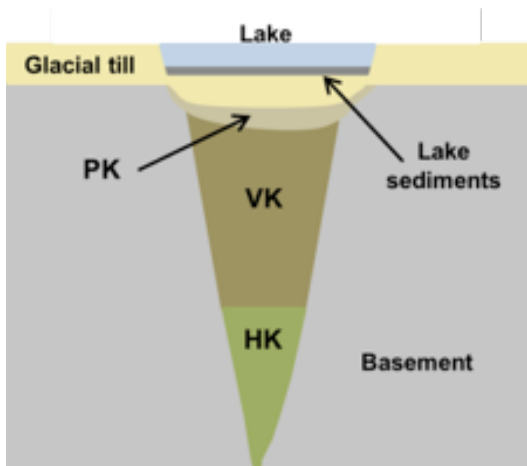
Conductivity



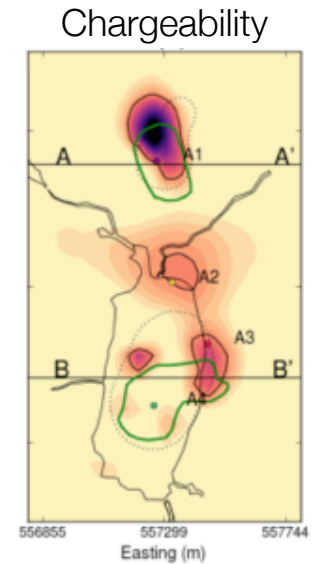
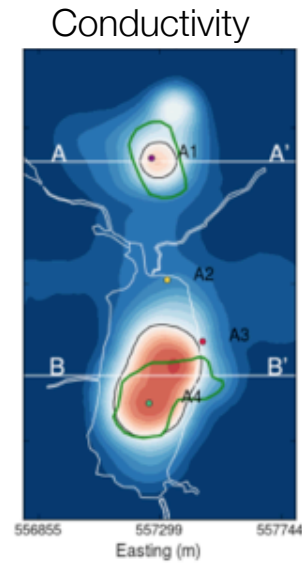
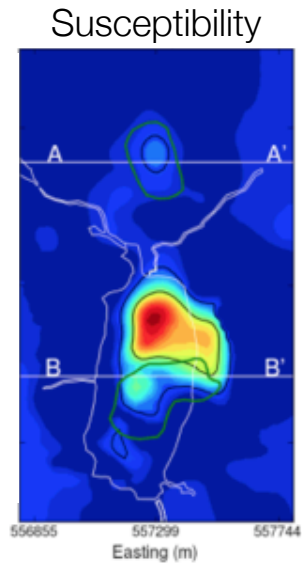
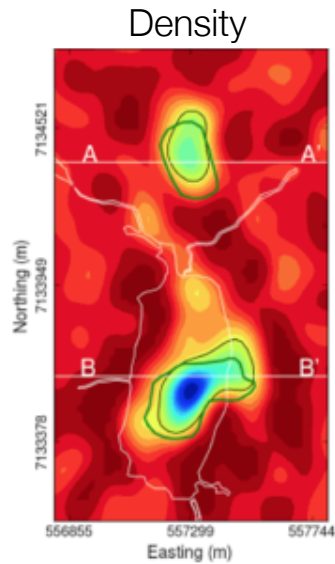
Chargeability



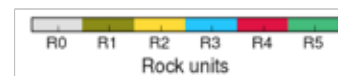
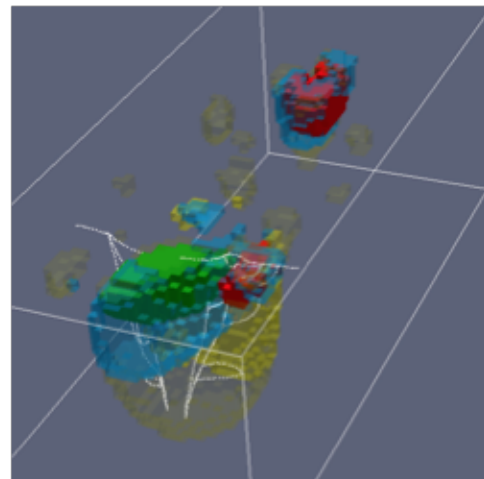
Kimberlite Model



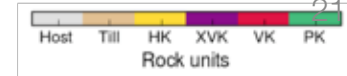
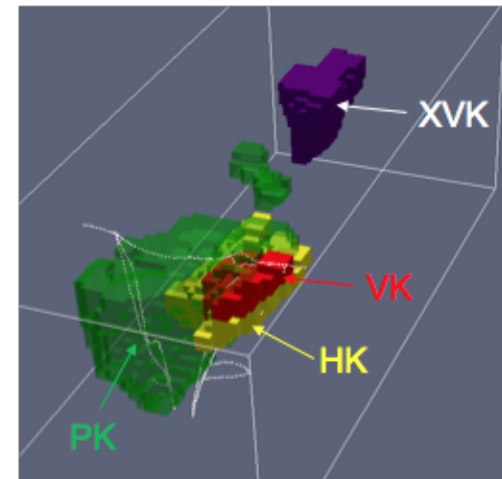
The Future: Data Integration & Multi-physics



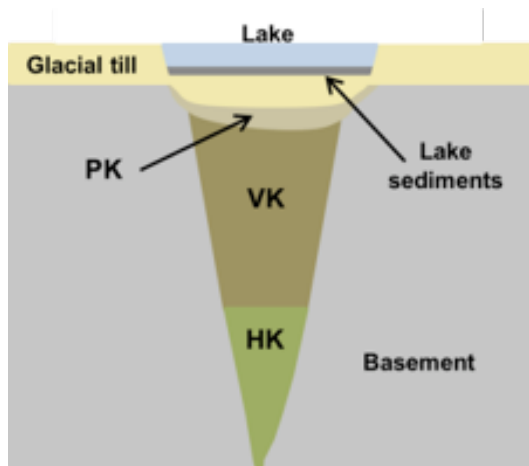
Rock Model from Geophysics



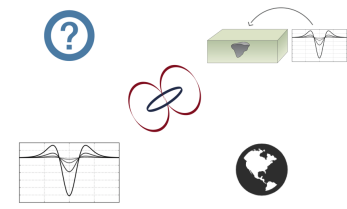
Rock Model from Drilling



Kimberlite Model



The Future: Modelling and Inversion

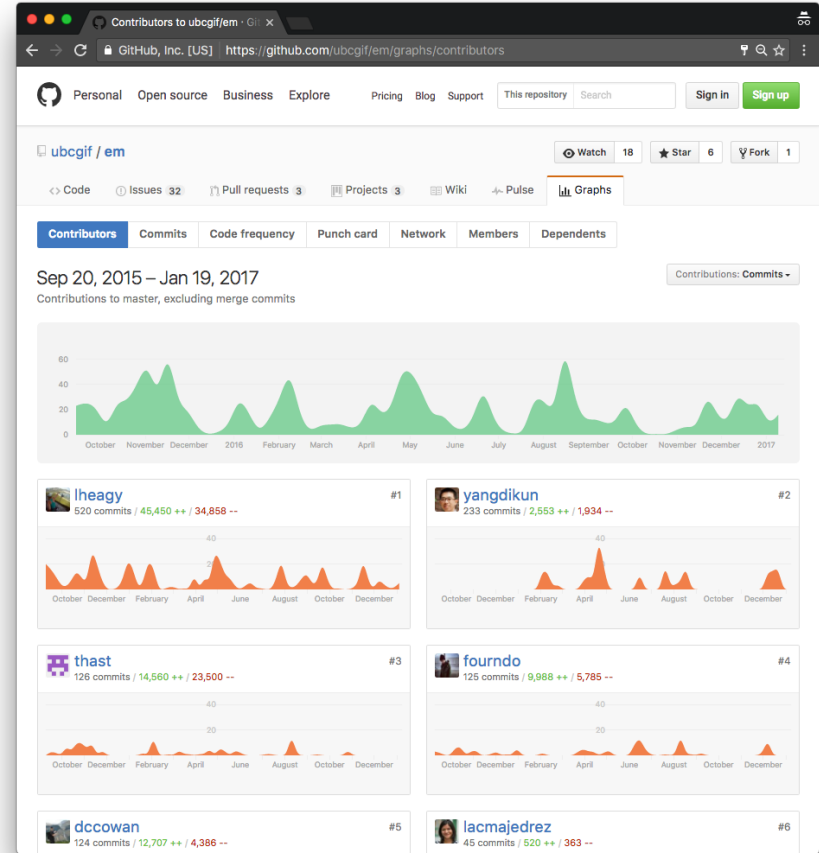


- HPC, Cloud computing
- Collaborative development
- Open source



Simulation and Parameter Estimation in Geophysics

<http://simpeg.xyz>



Github
versioning, collaborating



Travis CI
testing, deploy



Jupyter
interactive computing

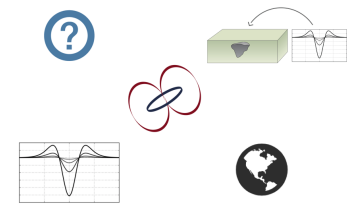


Creative Commons
licensing, reuse



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 widget interface includes the following controls:

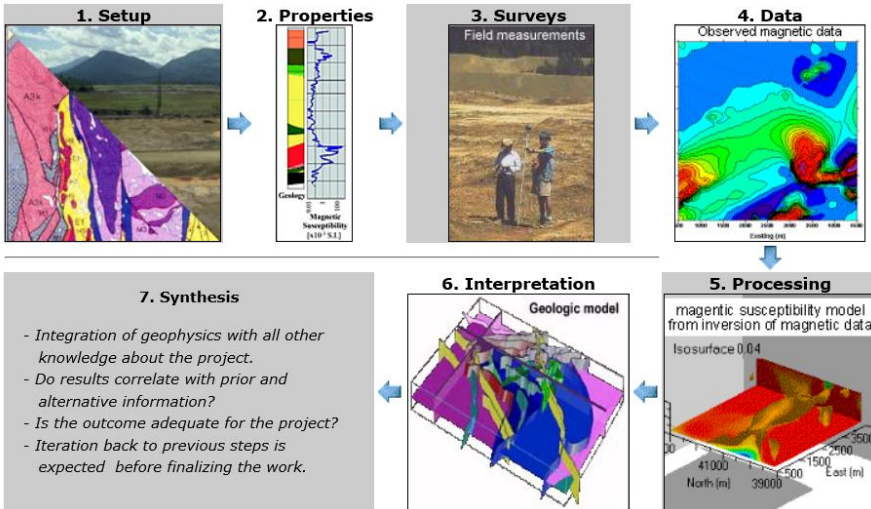
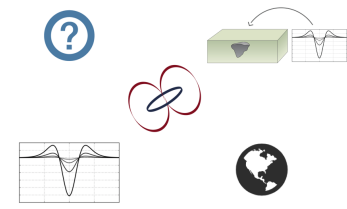
- Field: E, H, J
- AmpDir: None, Amp, Direction
- Comp.: x, y, z
- Complex Number: Re, Im, Amp, Phase
- f (Hz): 0
- σ (S/m): 0.01
- Offset: 50
- Scale: log, linear
- Slider: FreqLog (-3.00), SigLog (-3.00)

Two plots are displayed below the controls:

- 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 strength is color-coded from $10^{-6.8}$ A/m (dark purple) to $10^{-6.2}$ A/m (yellow).
- EM data at Rx hole:** A 1D plot showing the A-B profile. The vertical axis is 'A-B profile (m)' ranging from -40 to 40. The horizontal axis is '|H|-field field (A/m)' ranging from -40 to 40. The plot shows a bell-shaped curve centered at 0 m.

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

The Future: Collaboration



Case Histories — Electromag...
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 materials 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

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

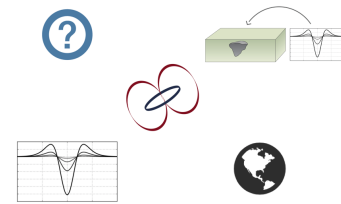
Bookpurnong

- 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

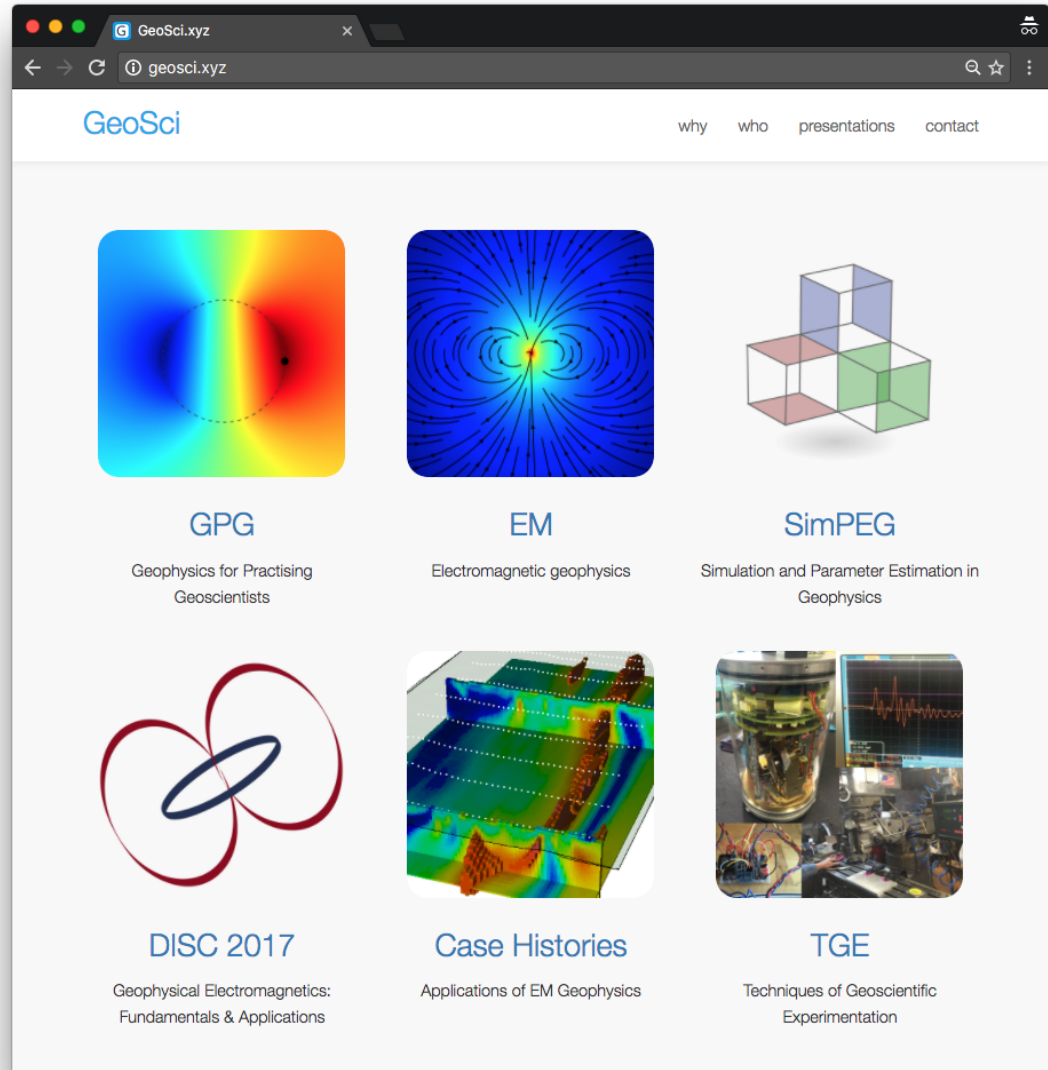
- GeoSci

<http://geosci.xyz>

- Web-textbooks
- Software
- Apps

- Apps:

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



GIF DISC Team



doug



lindsey



seogi

UBC GIF Team



Thibaut



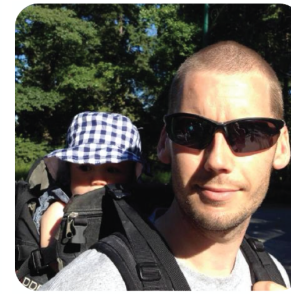
Patrick



Rowan



Devin



Kris



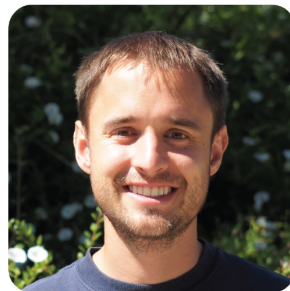
Sarah



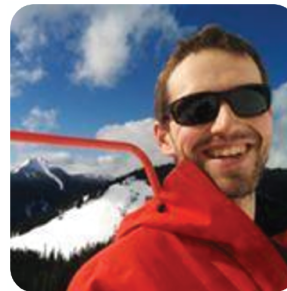
Dom



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

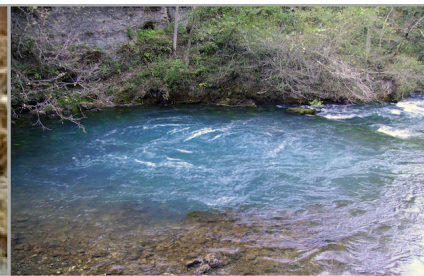
<http://disc2017.geosci.xyz>



minerals



contaminants



water



geothermal



geotechnical



slope stability



hydrocarbons



unexploded ordnance

Thank You!

<http://disc2017.geosci.xyz>



minerals



contaminants



water



geothermal



geotechnical



slope stability



hydrocarbons



unexploded ordnance