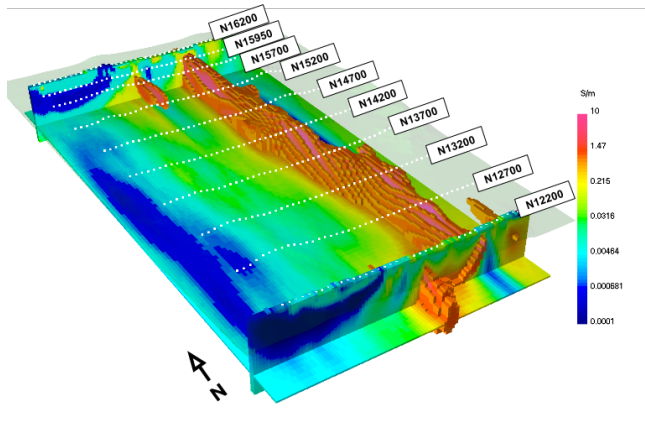


Summary and the Future

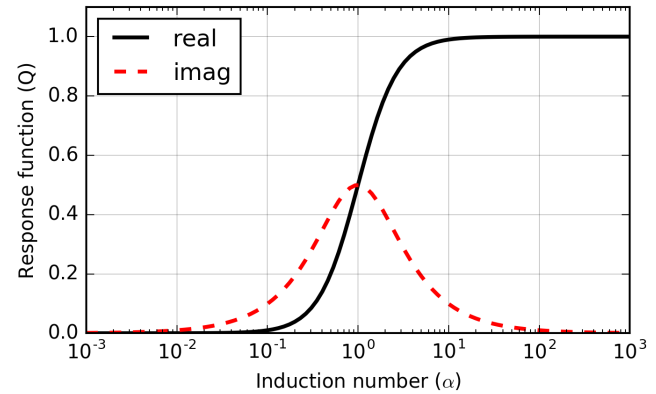


What have we covered?

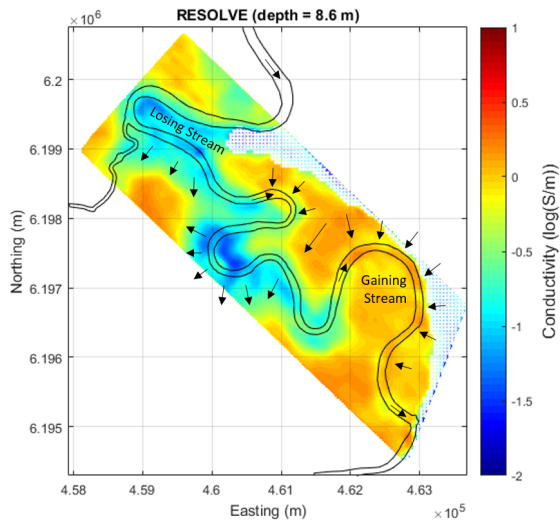
DC Resistivity



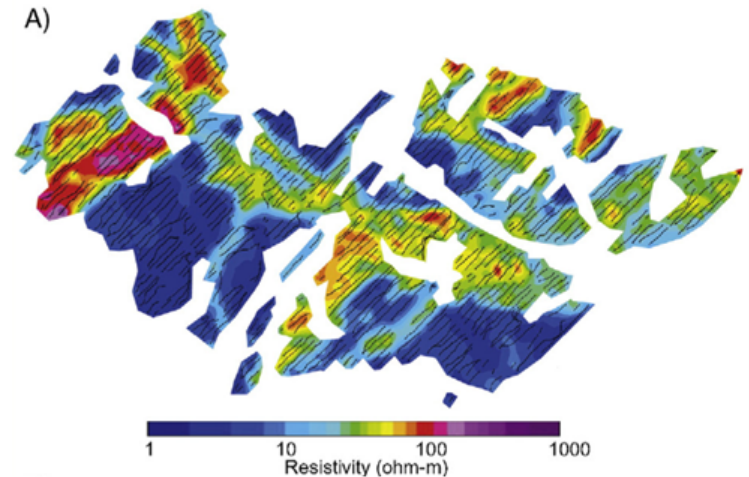
EM Fundamentals



Inductive Sources: Frequency

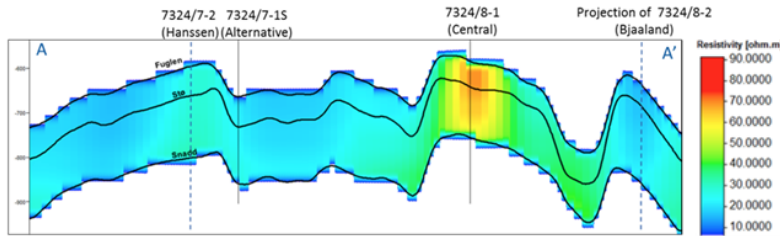


Inductive Sources: Time

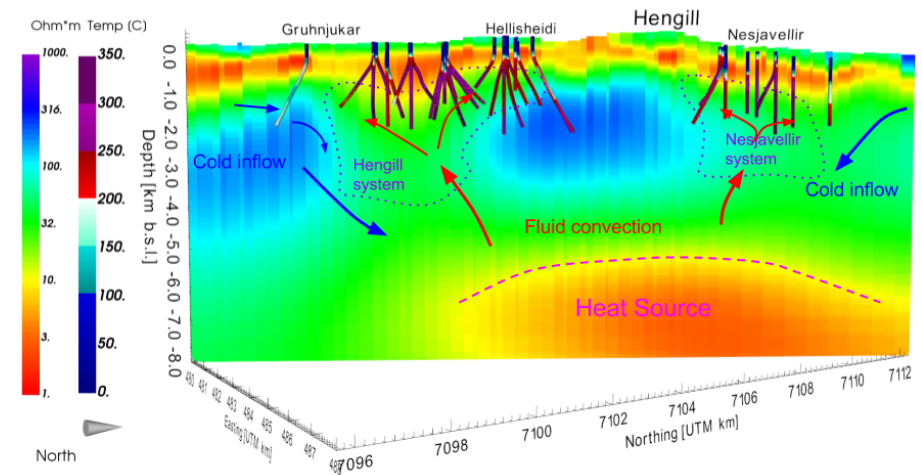


What have we covered?

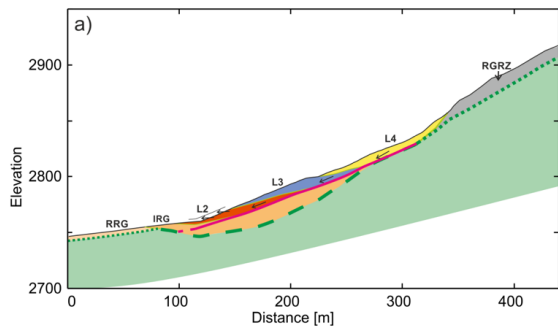
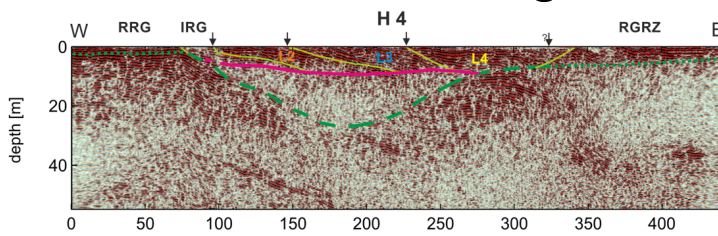
Grounded Sources



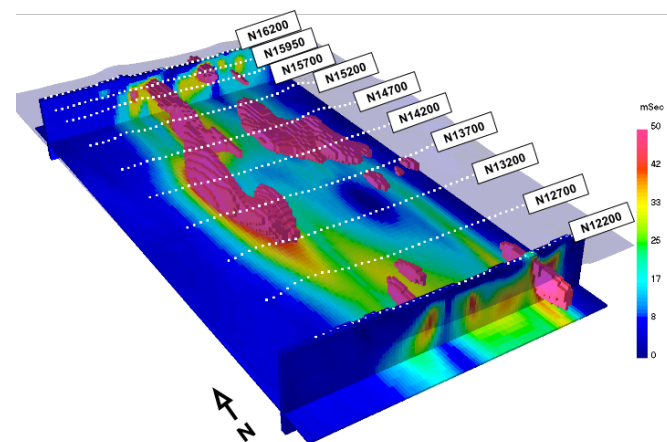
Natural Sources



Ground Penetrating Radar



Induced Polarization



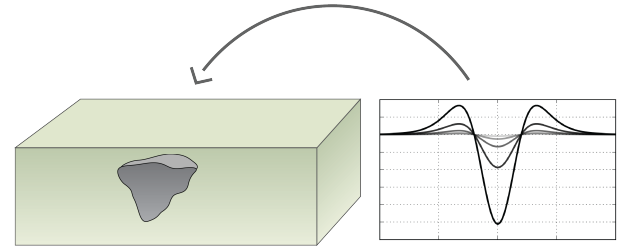
What does the future hold?

What does the future hold?

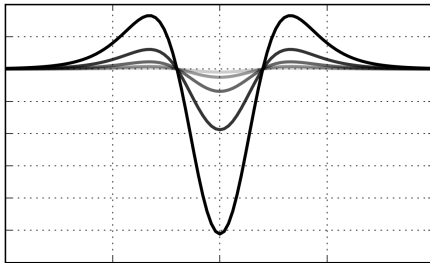
Problems



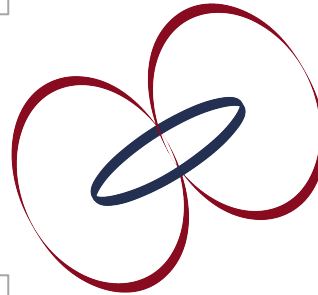
Inversion capabilities



High quality data

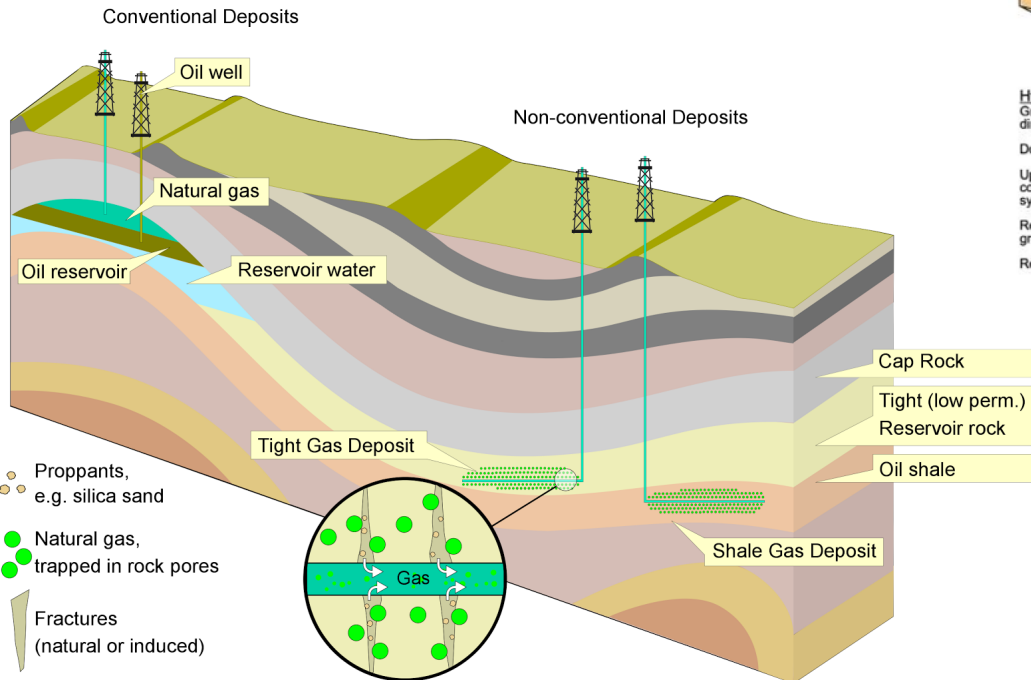
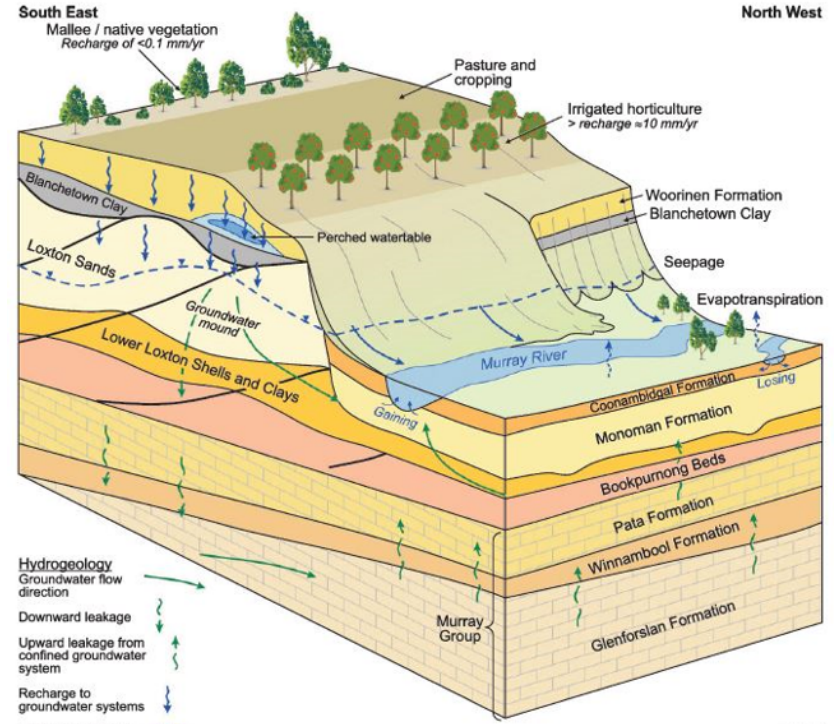


Web tools to
communicate



The Future: Monitoring

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

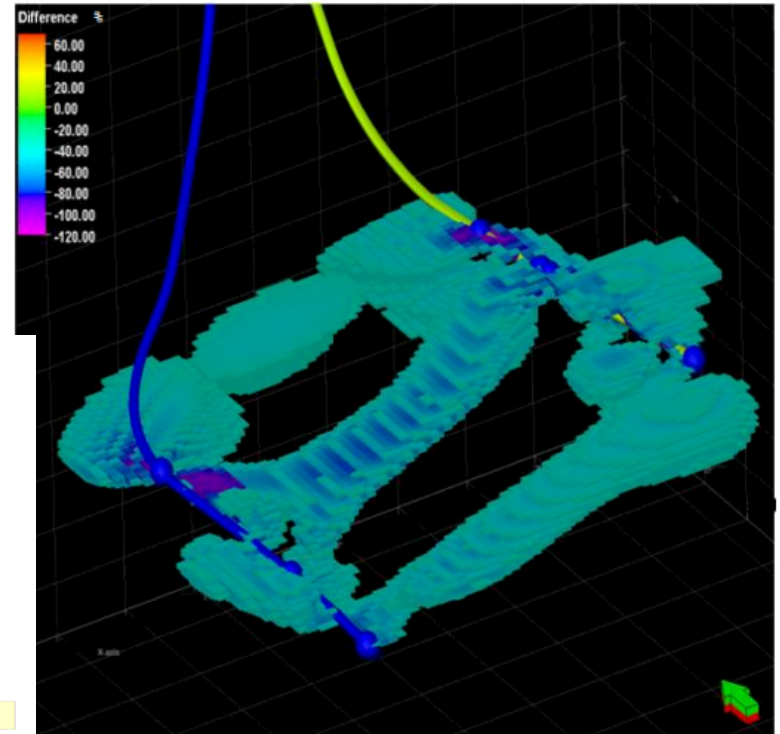


TM005-09

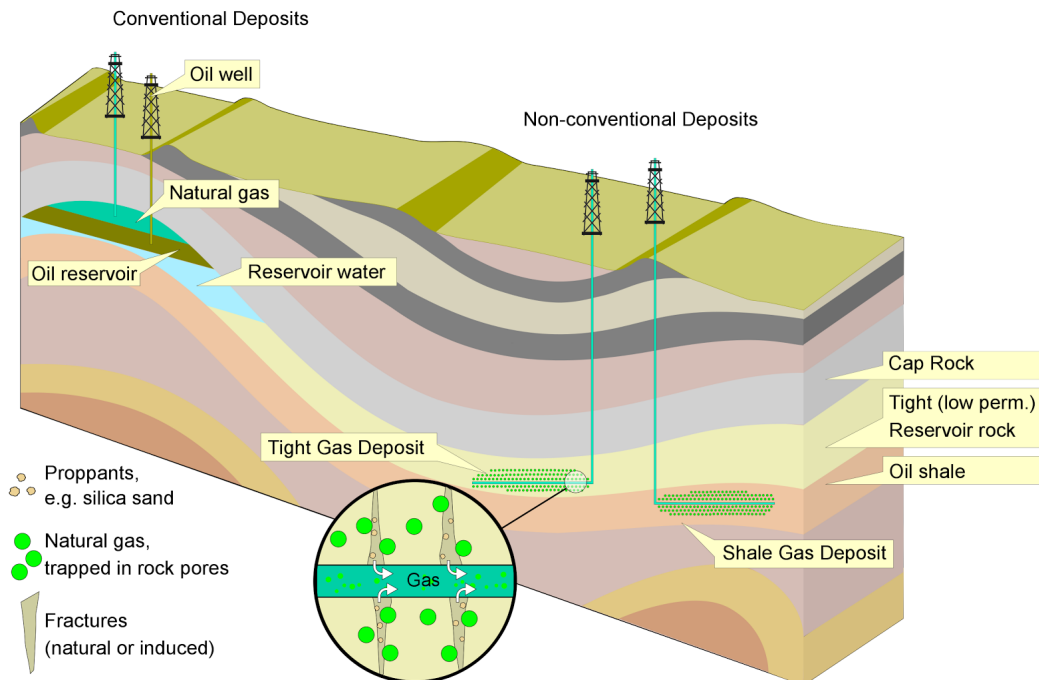
The Future: Monitoring

- Water flood
 - Cross-well EM
 - Image swept and missed regions of reservoir

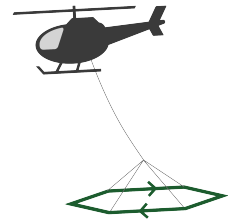
Resistivity isosurface – water flood



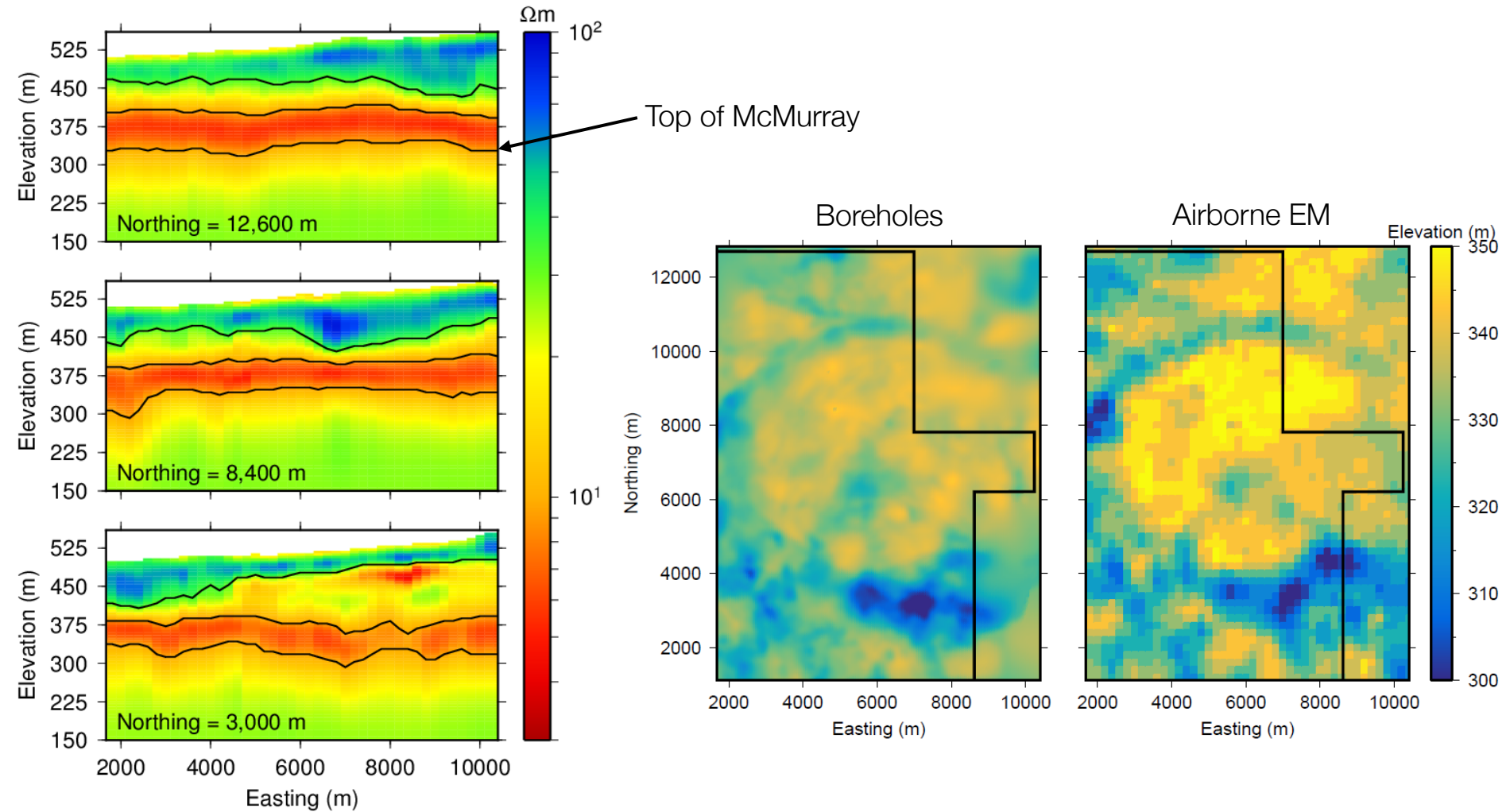
Saudi Arabia: Marsala et al., 2015



Multi-stage EM for monitoring

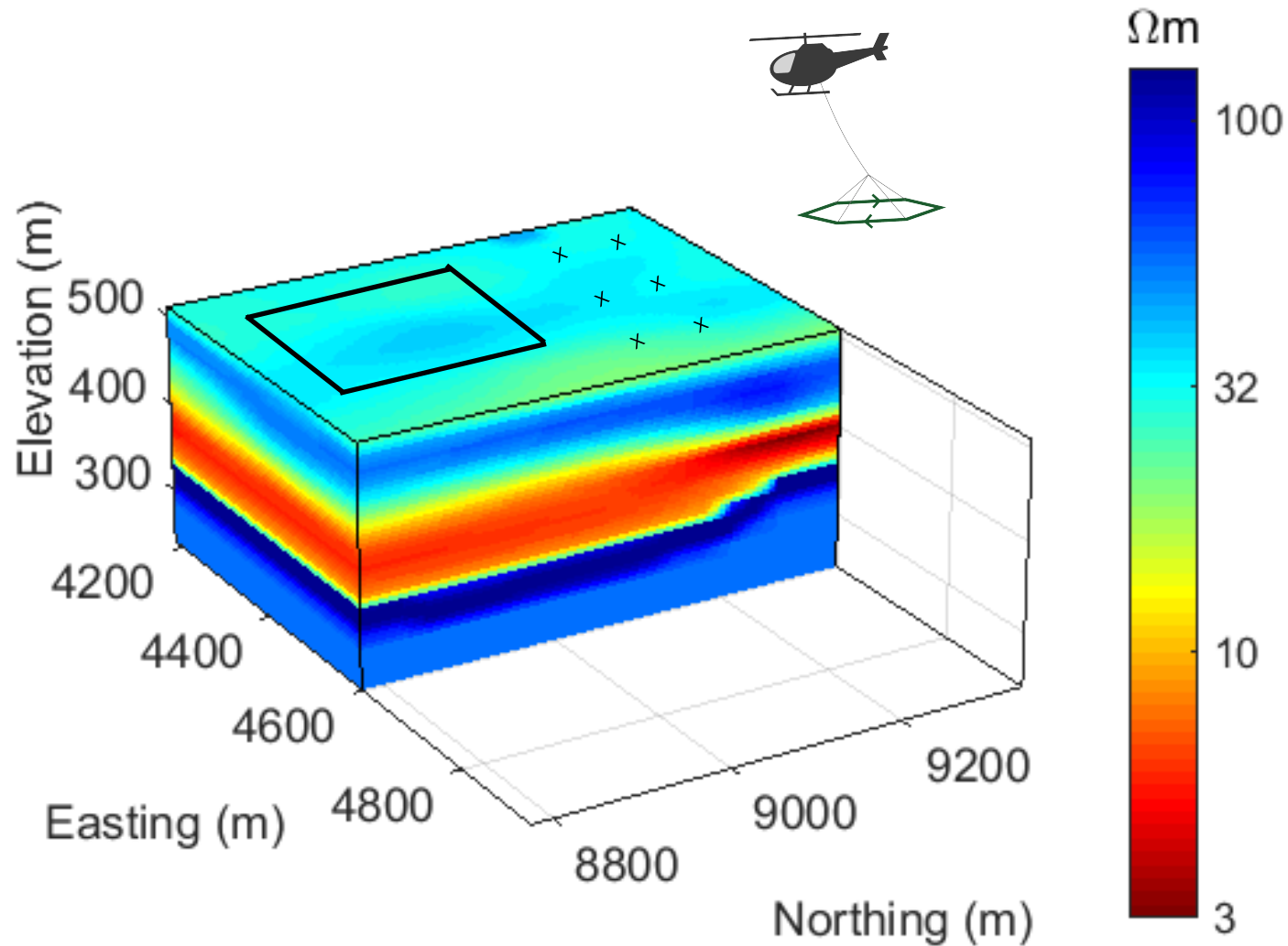


Large-scale: airborne



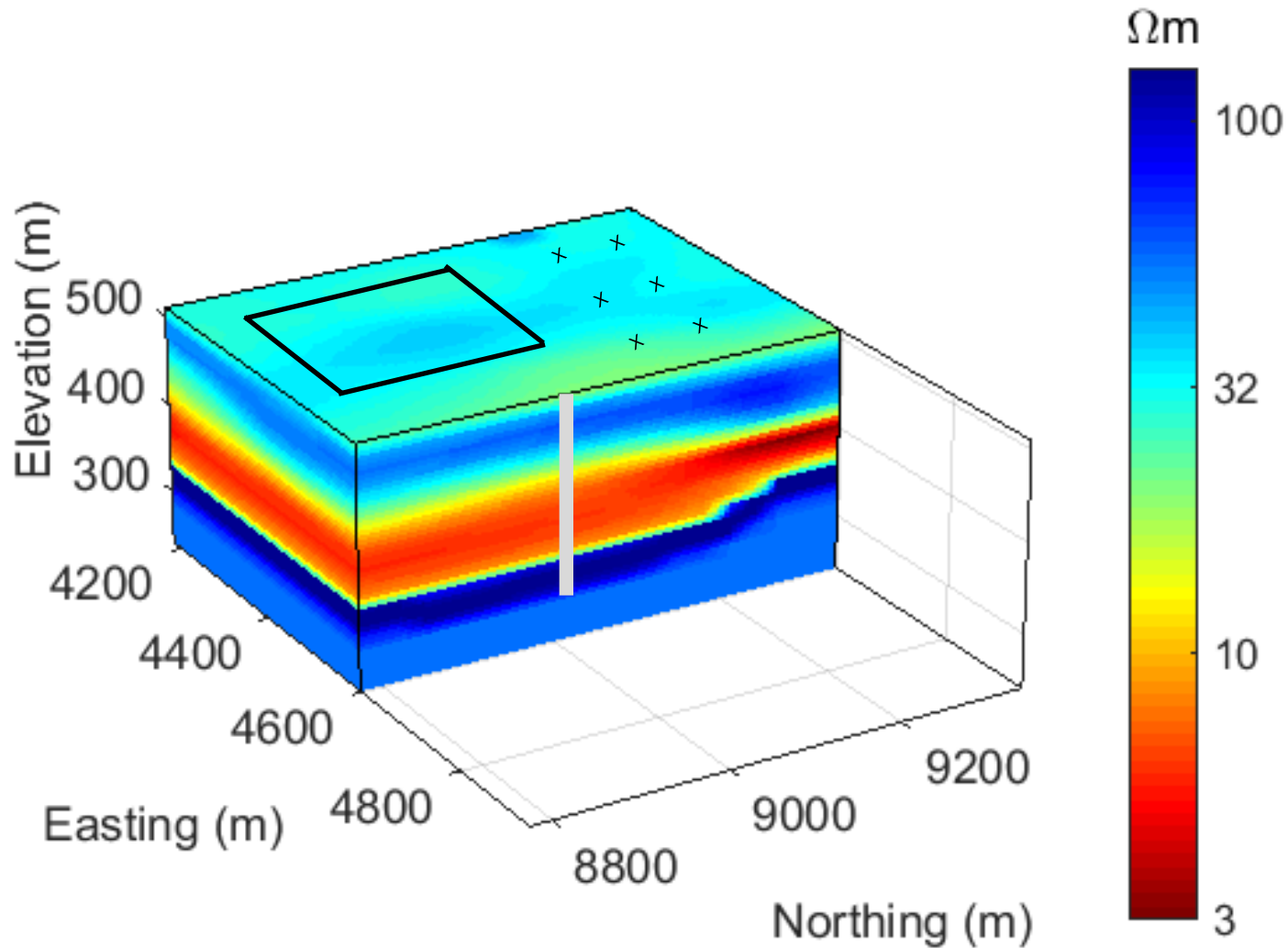
Multi-stage EM for monitoring

Local background: airborne + ground



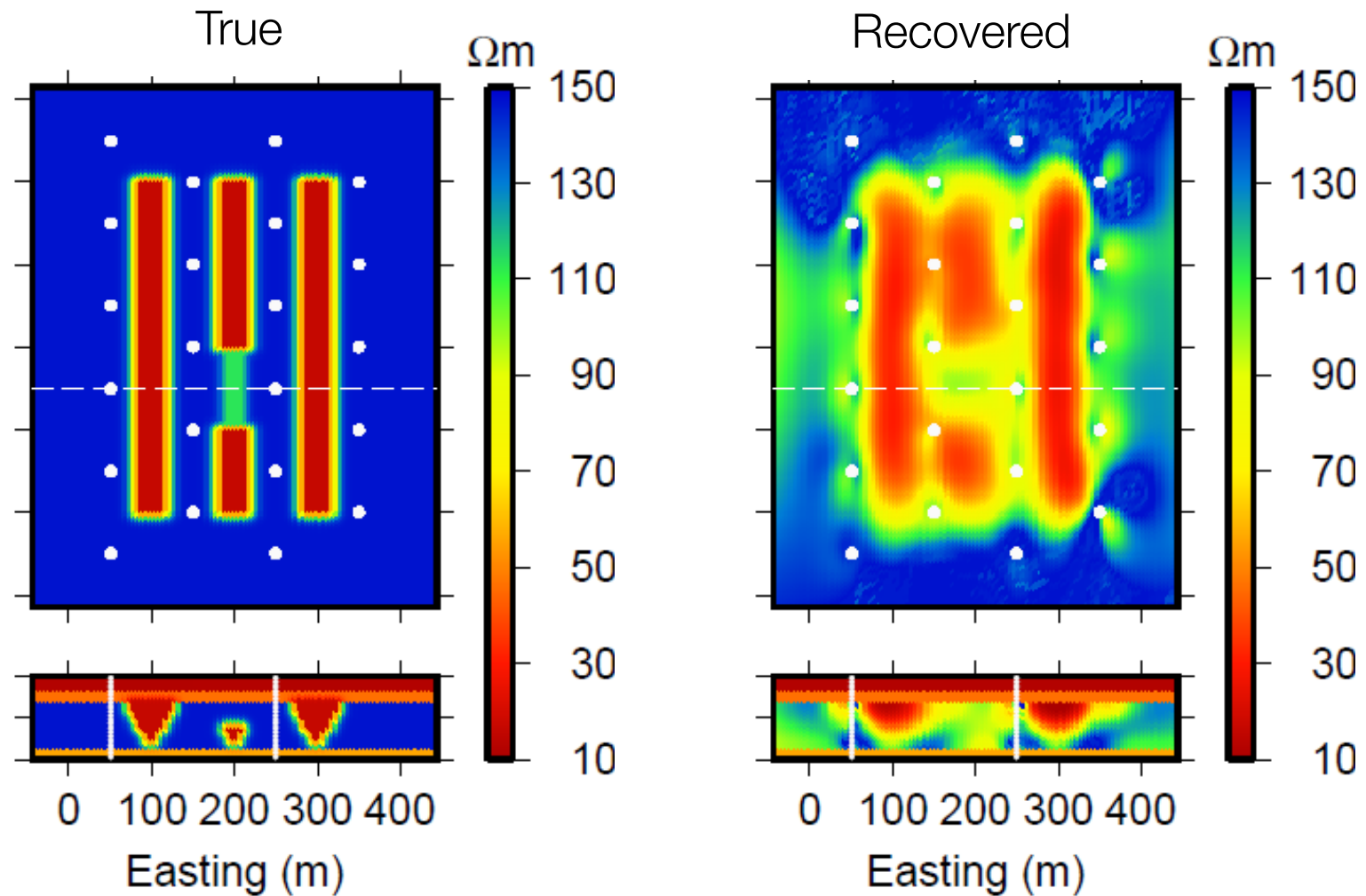
Multi-stage EM for monitoring

Pre-injection: surface sources, borehole receivers



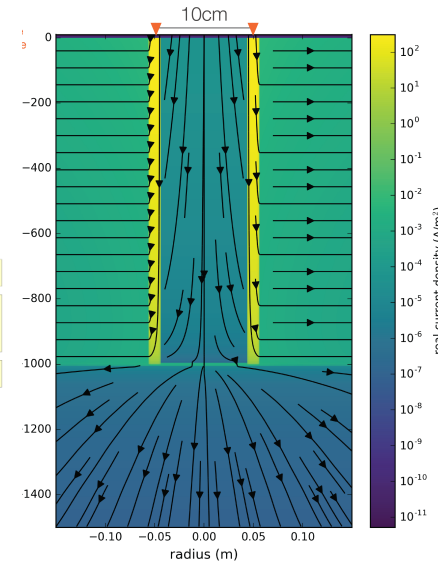
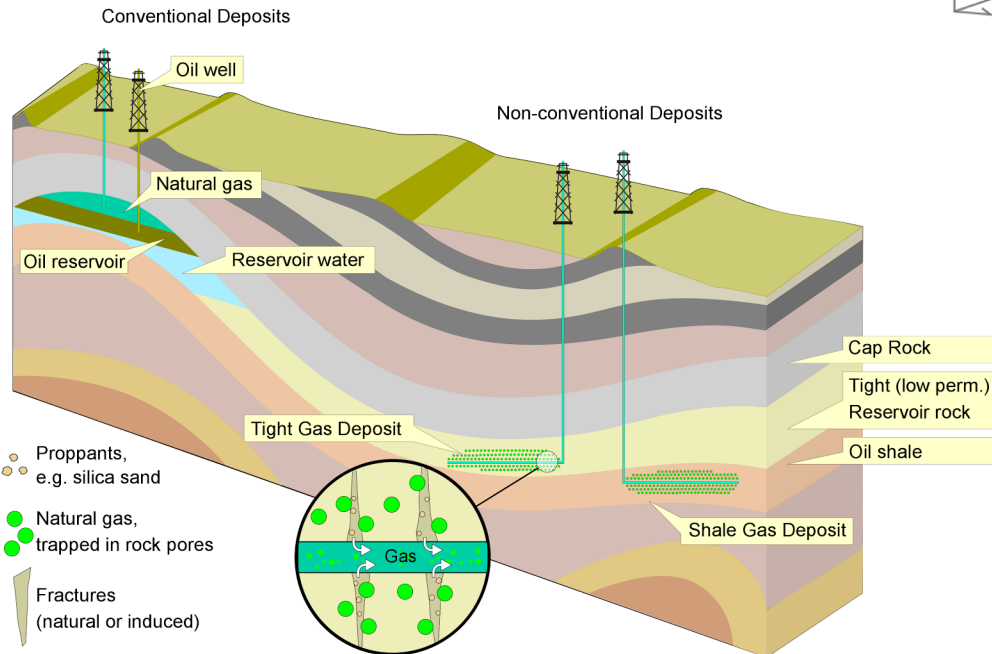
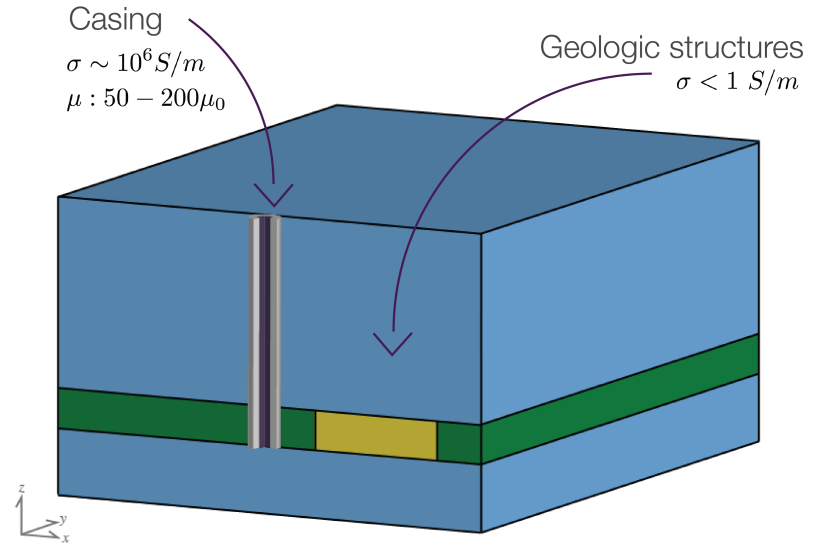
Multi-stage EM for monitoring

Post-injection: surface sources, borehole receivers



The Future: Monitoring

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

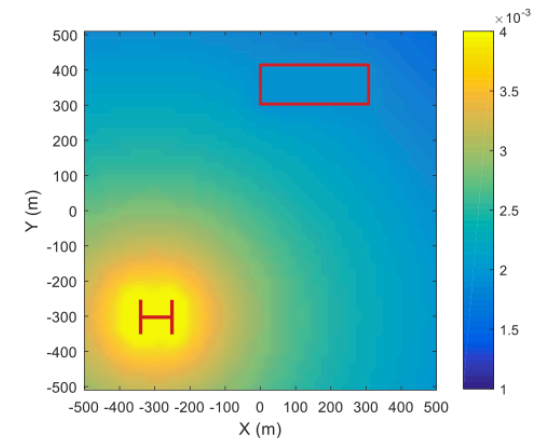
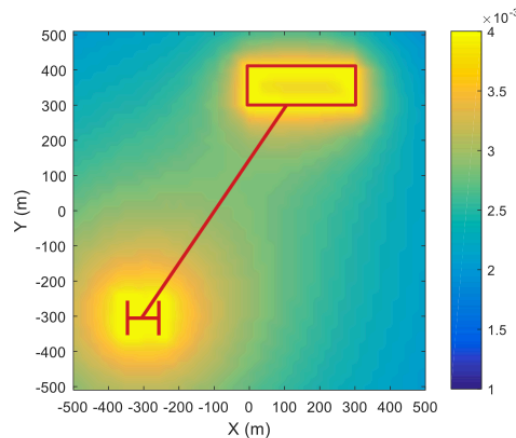
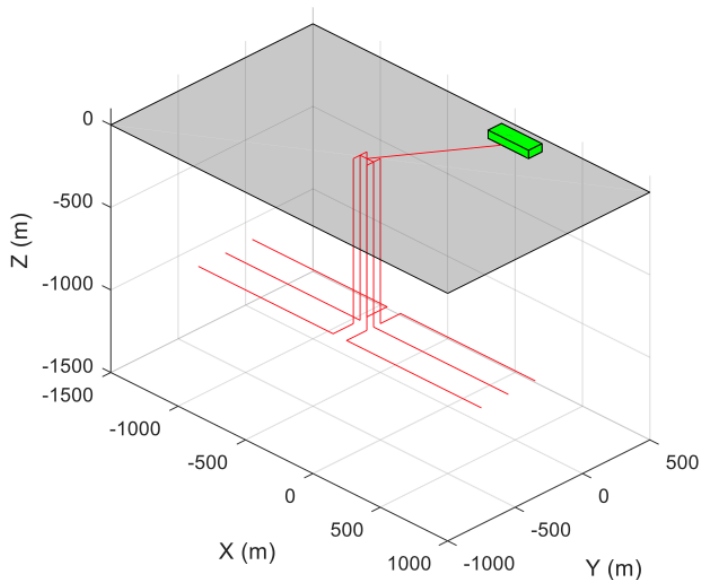
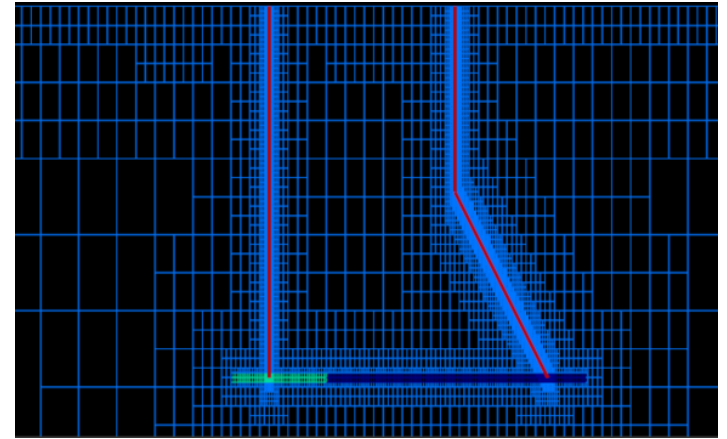
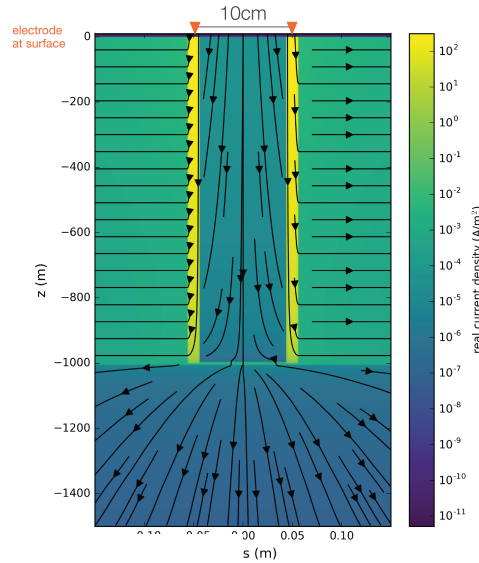


Corrosion



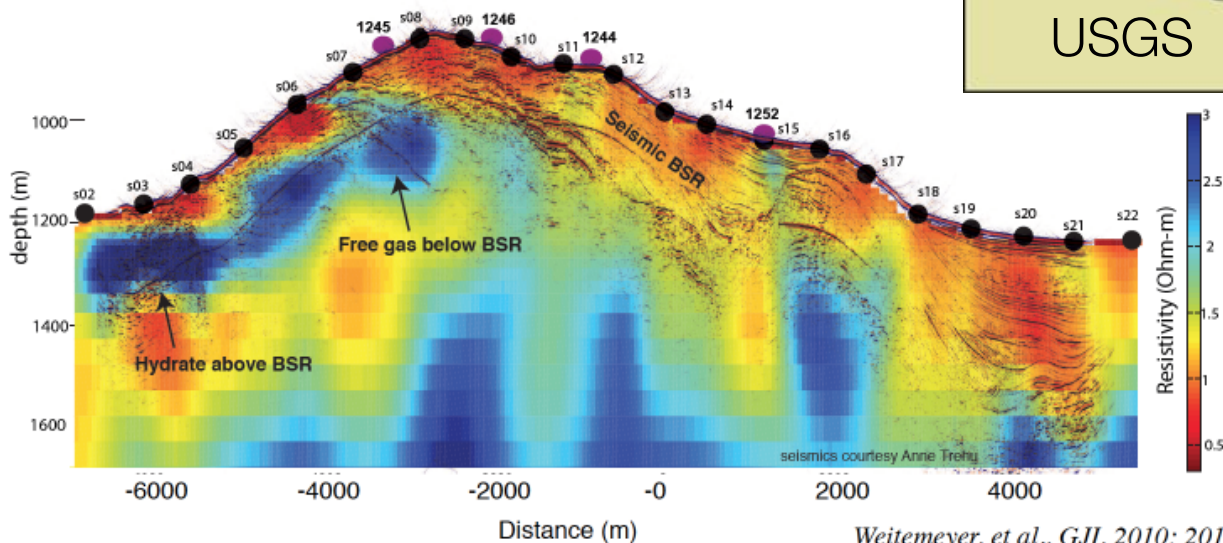
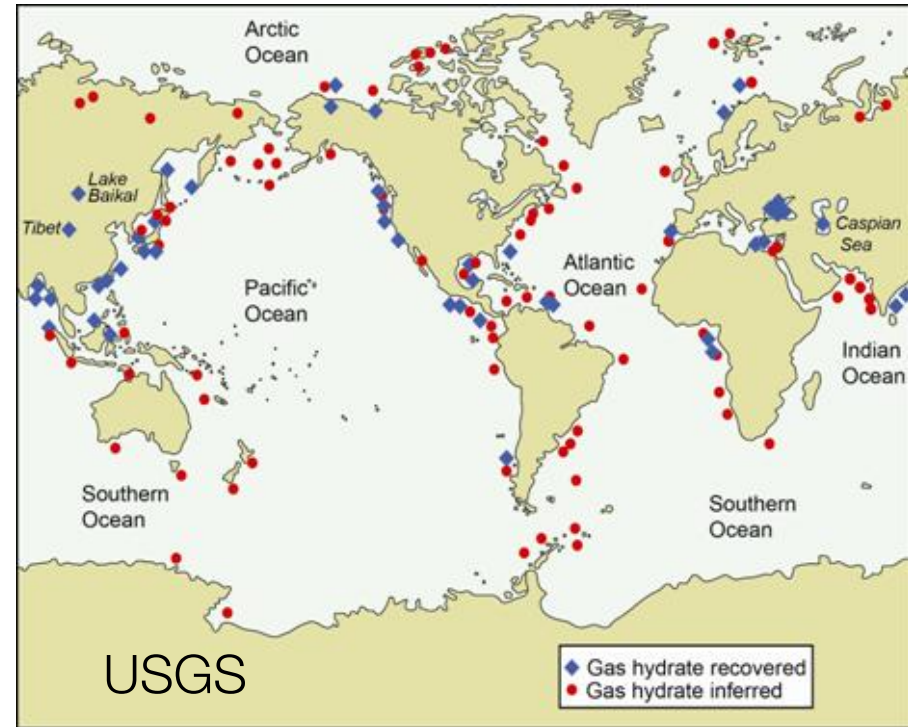
The Future: Monitoring

- Steel Casing



The Future: Marine EM

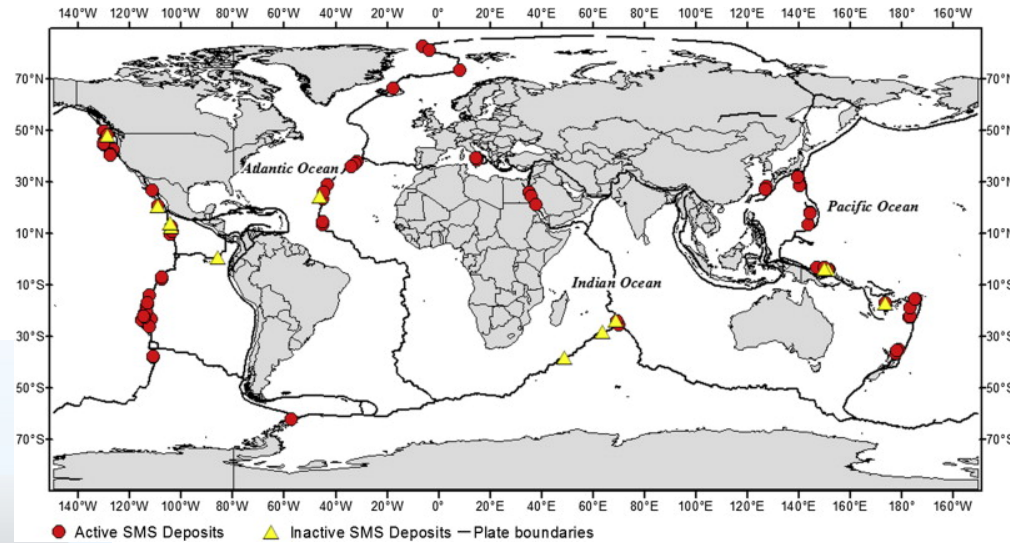
- Gas hydrates
 - Resistivity is diagnostic



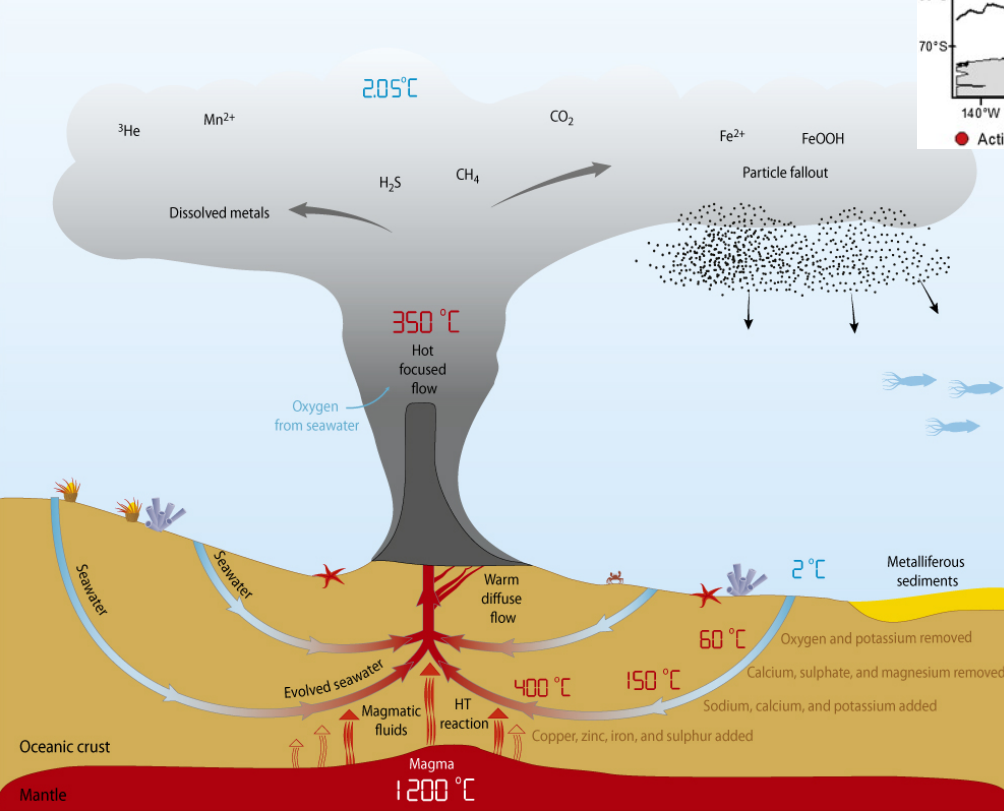
Weitemeyer, et al., GJI, 2010; 2011

The Future: Marine EM

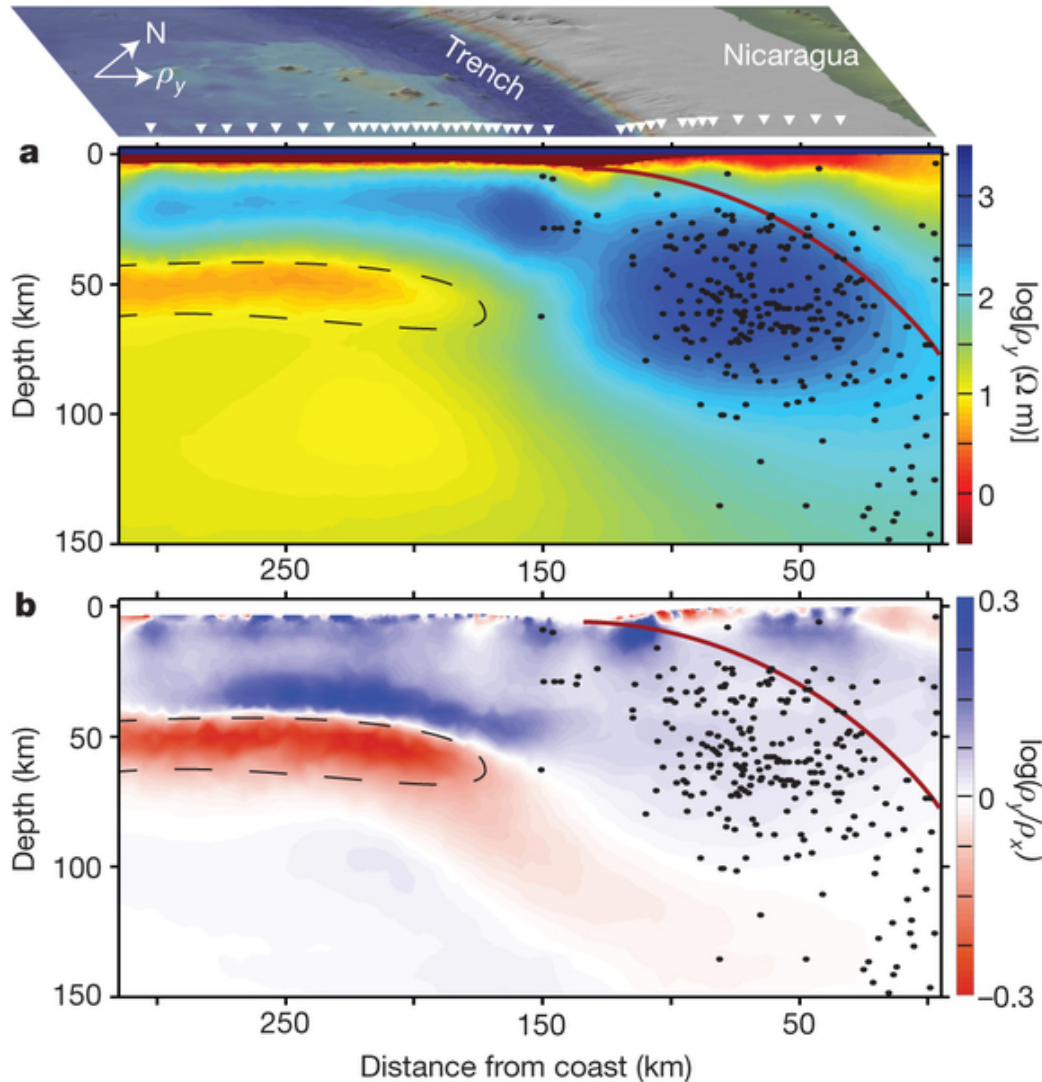
- Submarine massive sulfides
 - Conductive relative to background



Basics of a hydrothermal vent - a Black Smoker



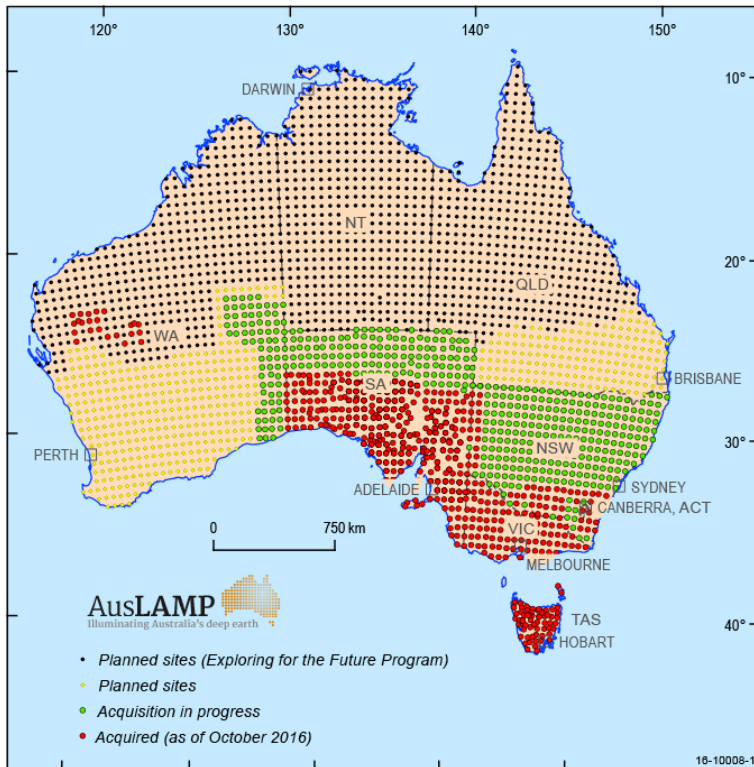
The Future: Marine EM



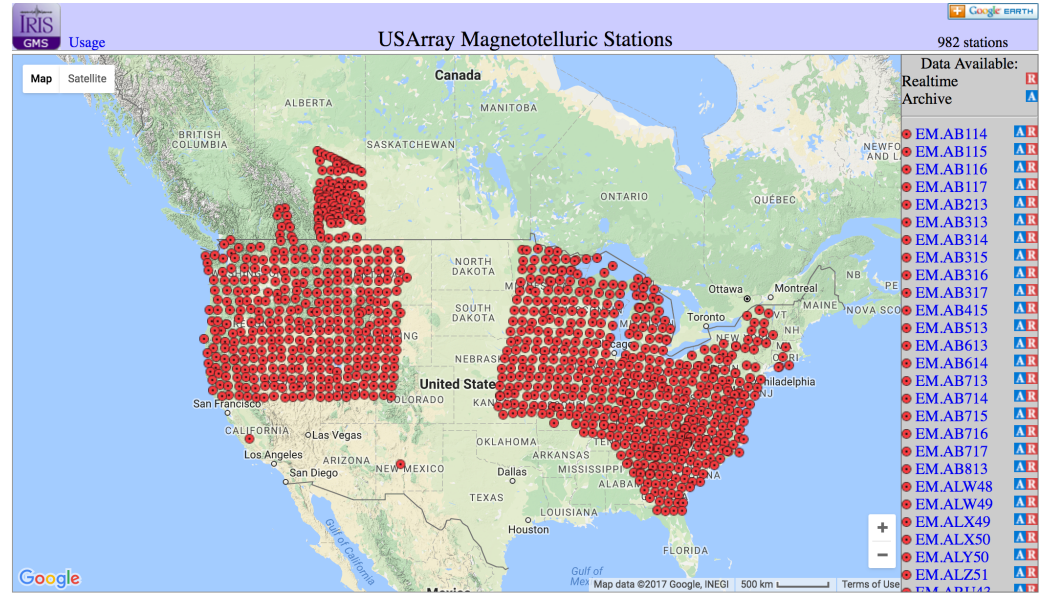
- Tectonic studies
- Large anisotropy
 - indicative of melt-rich channel

The Future: Large Scale MT

AusLamp

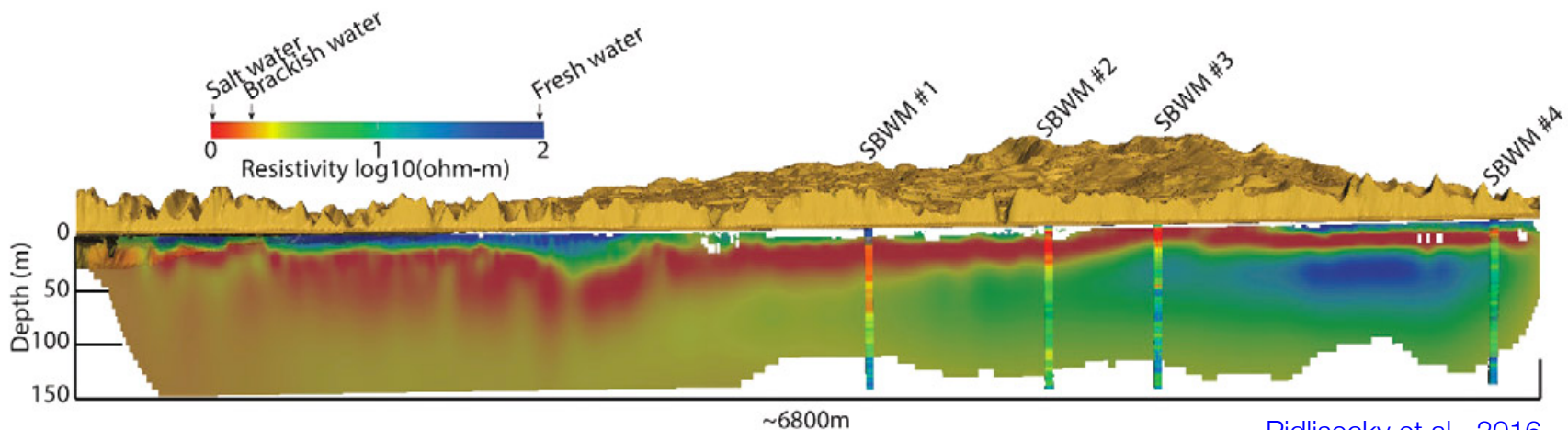
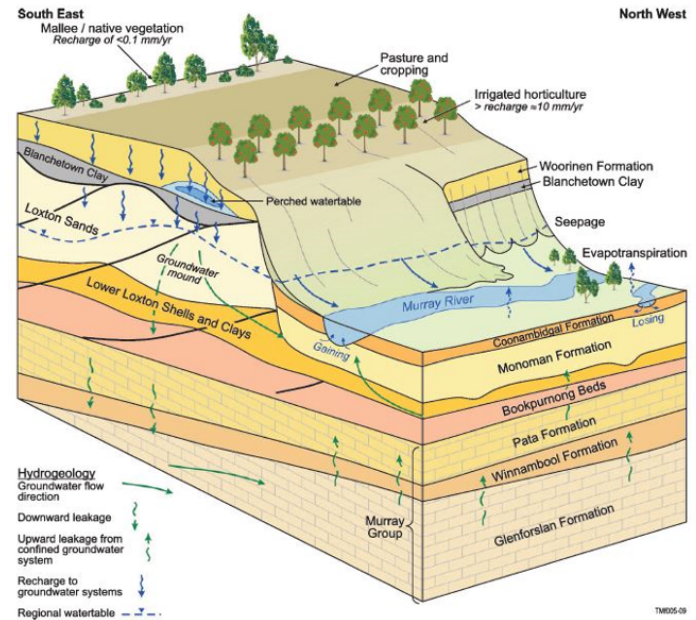


Earth scope



The Future: Water

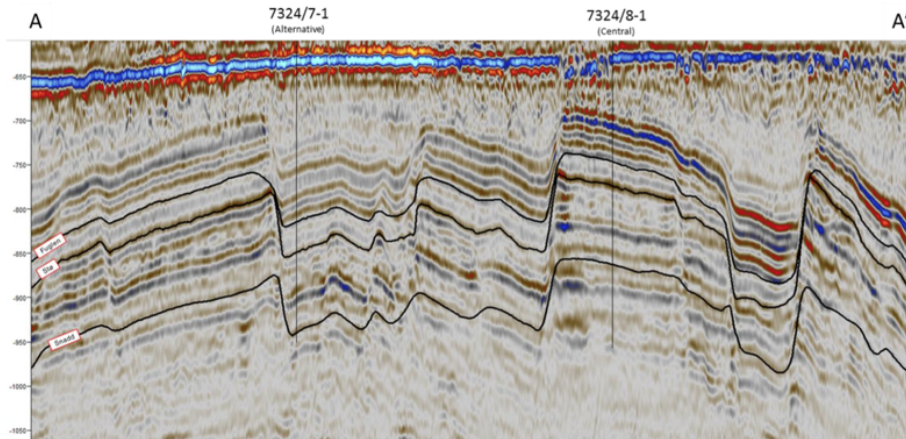
- Finding and delineating water
- Aquifer monitoring and management
- Salt water intrusions
- Pollutants



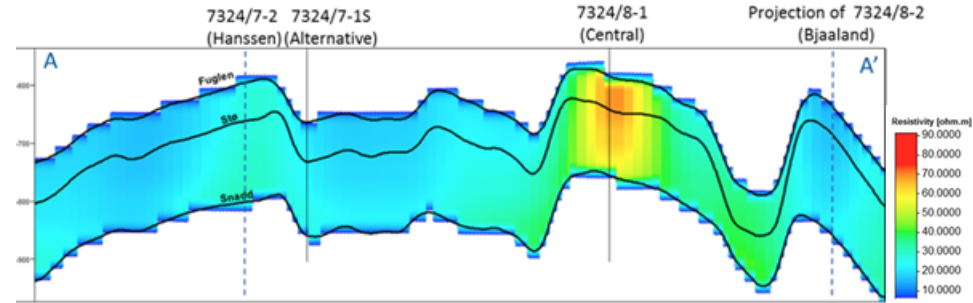
Pidlisecky et al., 2016

The Future: Data Integration & Multi-physics

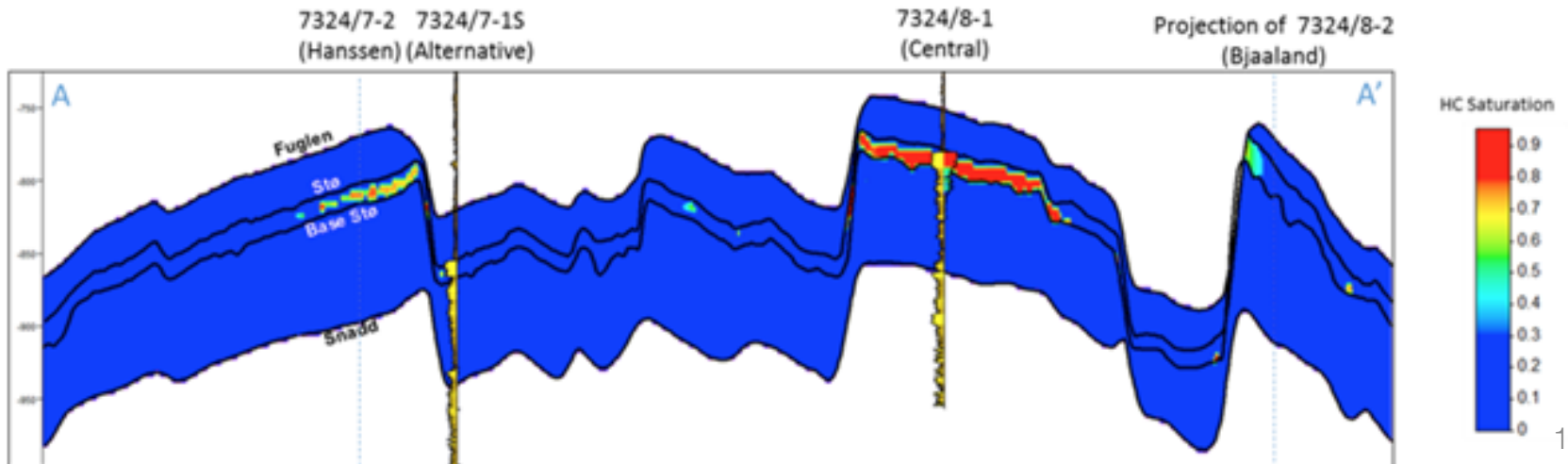
Seismic



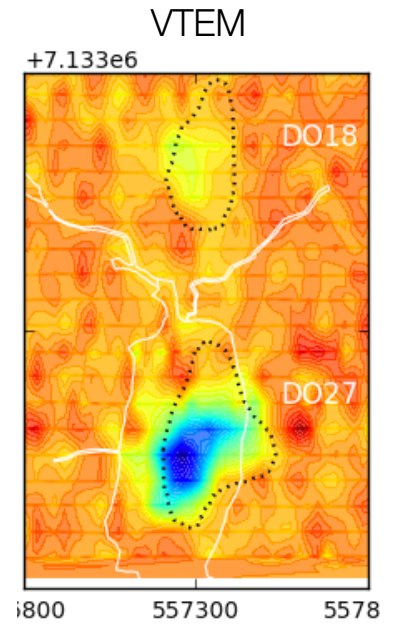
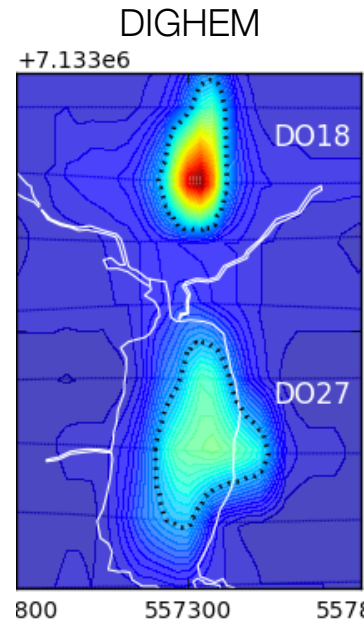
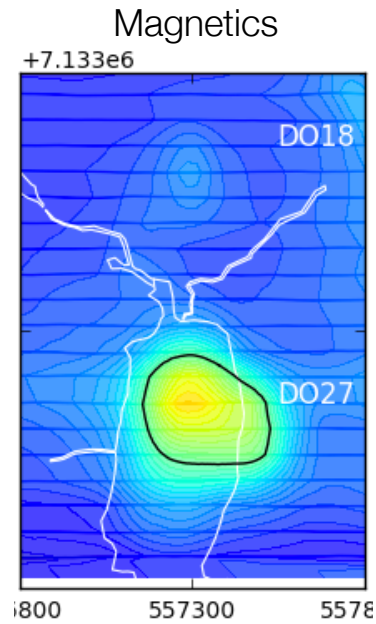
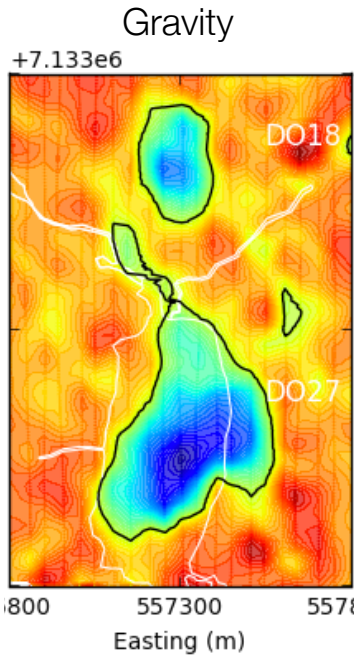
EM



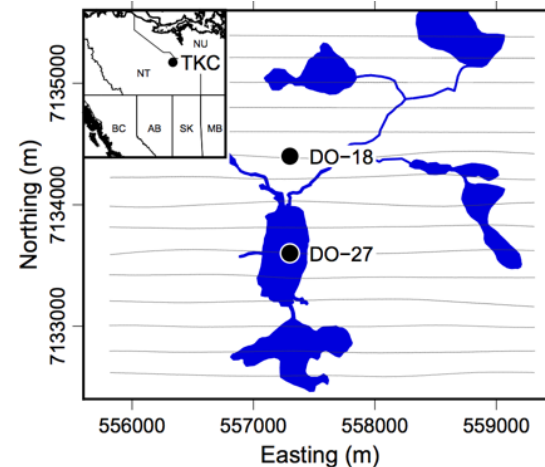
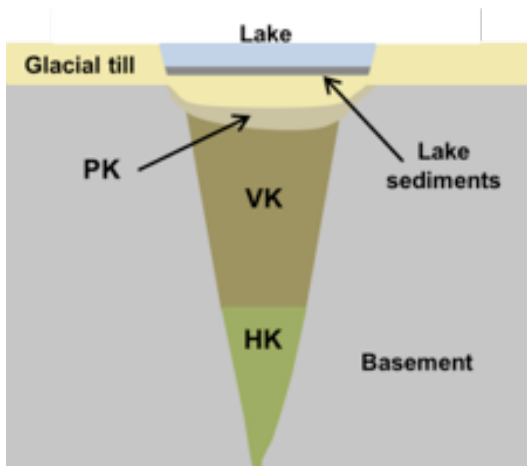
Final hydrocarbon saturation model



The Future: Data Integration & Multi-physics

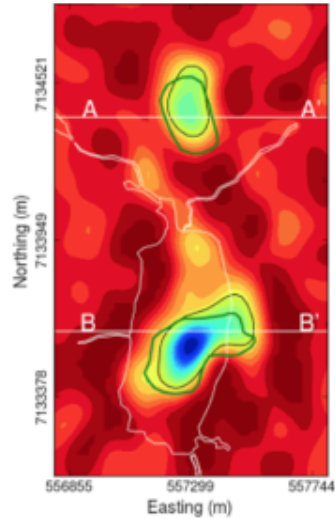


Kimberlite Model

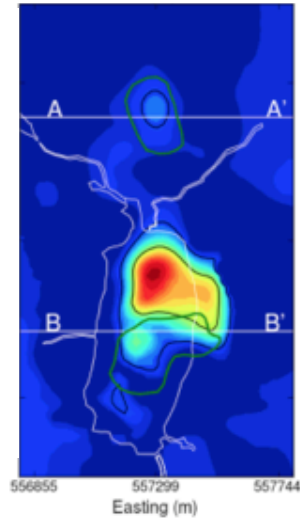


The Future: Data Integration & Multi-physics

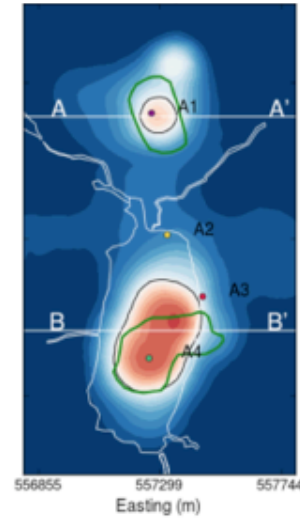
Density



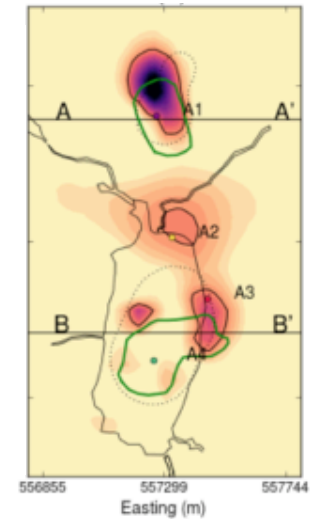
Susceptibility



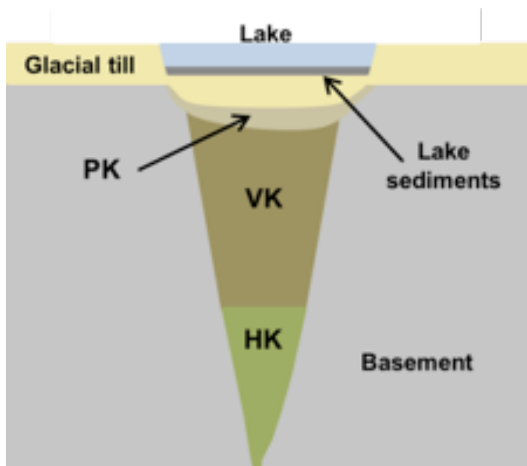
Conductivity



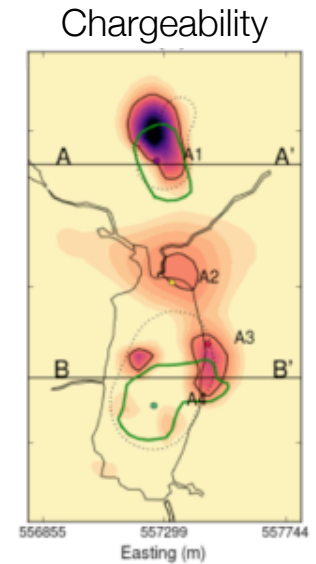
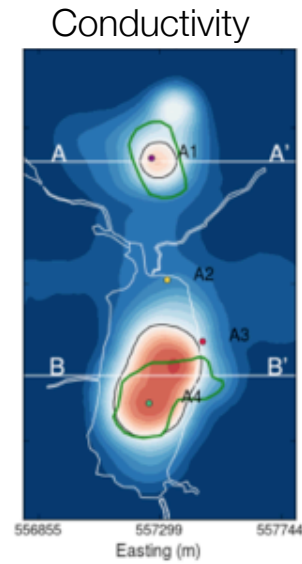
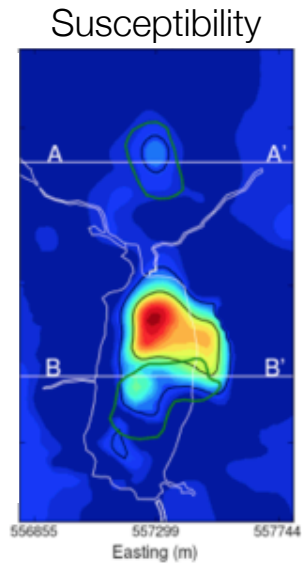
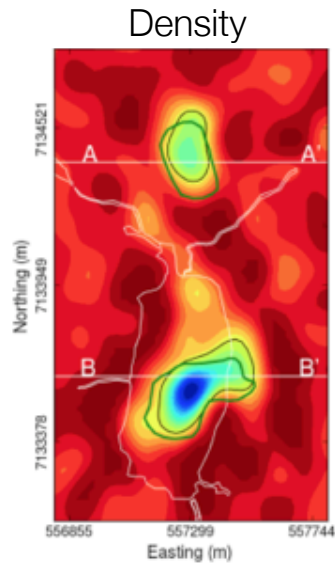
Chargeability



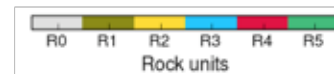
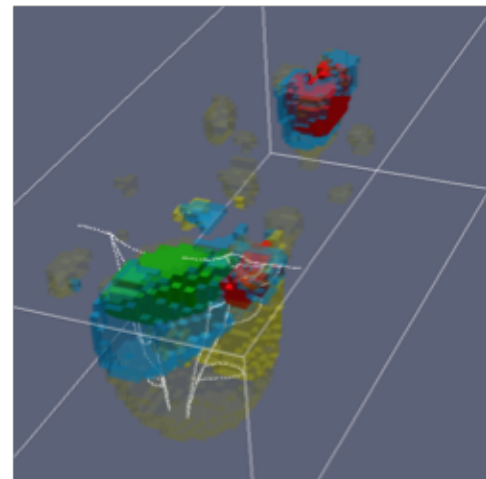
Kimberlite Model



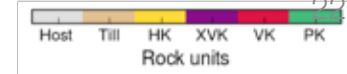
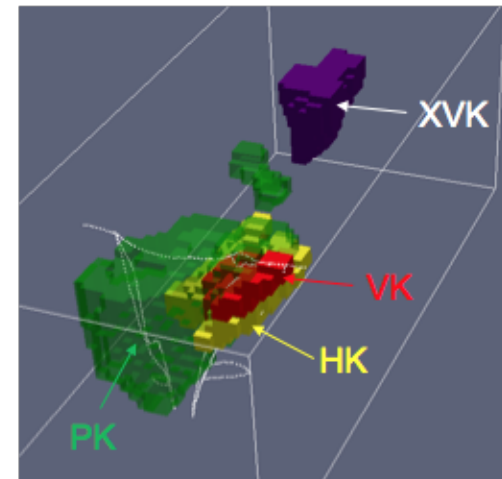
The Future: Data Integration & Multi-physics



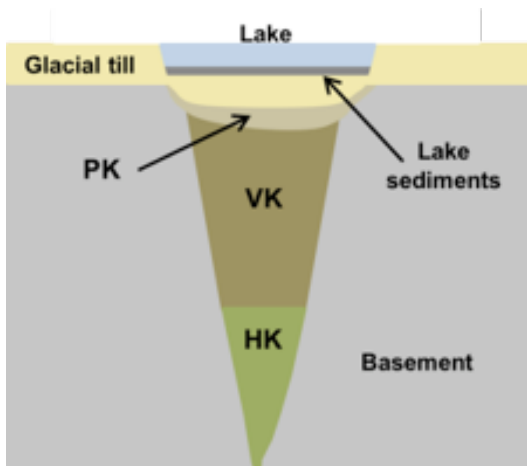
Rock Model from Geophysics



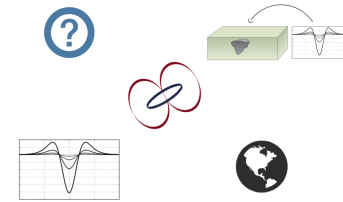
Rock Model from Drilling



Kimberlite Model



The Future: Modelling and Inversion

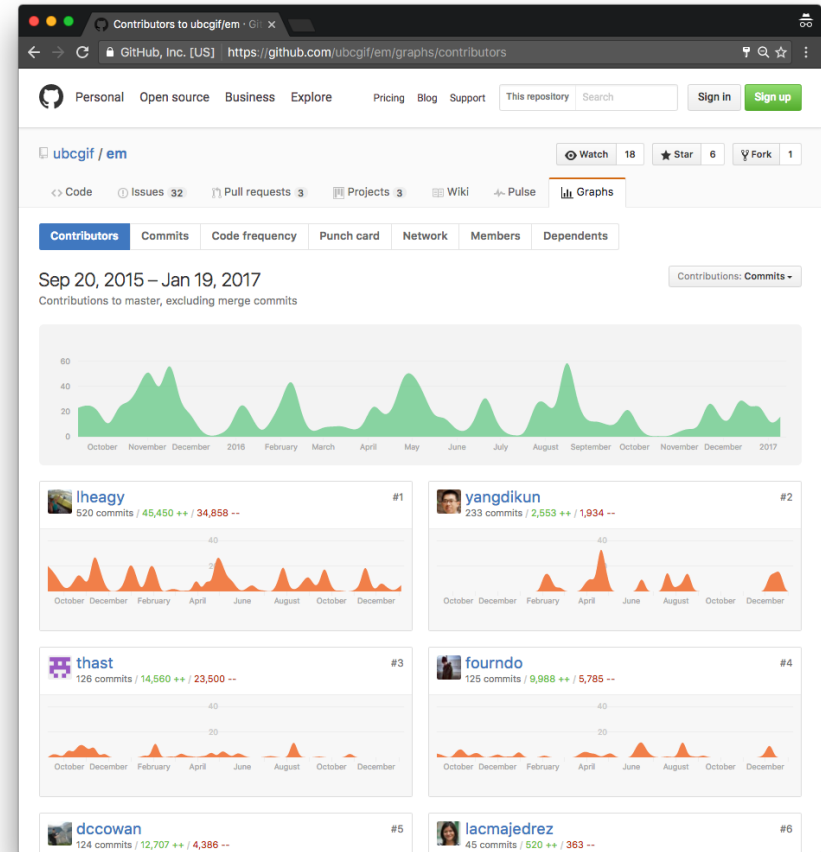


- HPC, Cloud computing
- Collaborative development
- Open source



Simulation and Parameter Estimation in Geophysics

<http://simpeg.xyz>



Github

versioning, collaborating



Travis CI

testing, deploy



Jupyter

interactive computing



Creative Commons

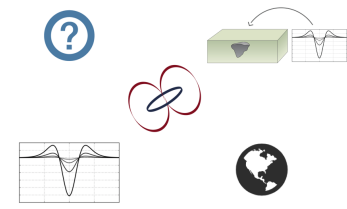
licensing, reuse



Python

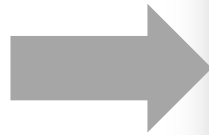
computation

The Future: Modelling and Inversion



- Interactive computing
- Visualization

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



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

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
```

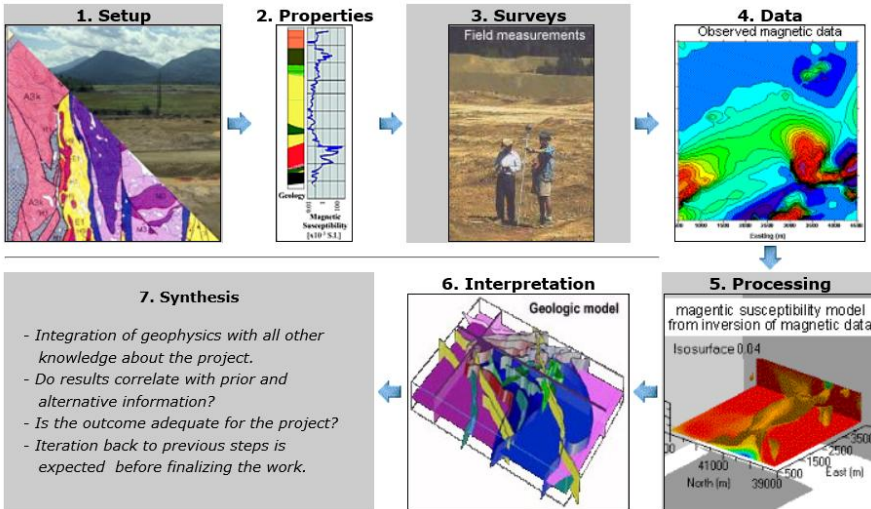
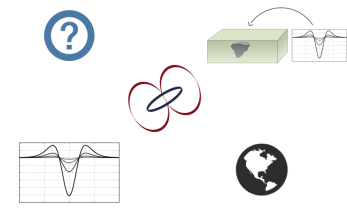
The widget interface includes the following controls:

- 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:

- 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. A color bar on the right indicates the magnitude of the magnetic field in A/m, ranging from $10^{-6.8}$ to $10^{-6.2}$.
- EM data at Rx hole:** A 1D plot showing the A-B profile of the magnetic field. The vertical axis is labeled "A-B profile (m)" and ranges from -40 to 40. The horizontal axis is labeled "|H|-field field (A/m)".

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

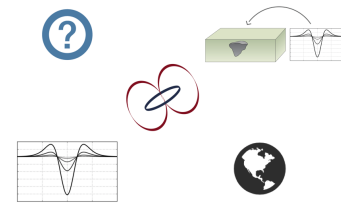
Bookpurnong

- 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

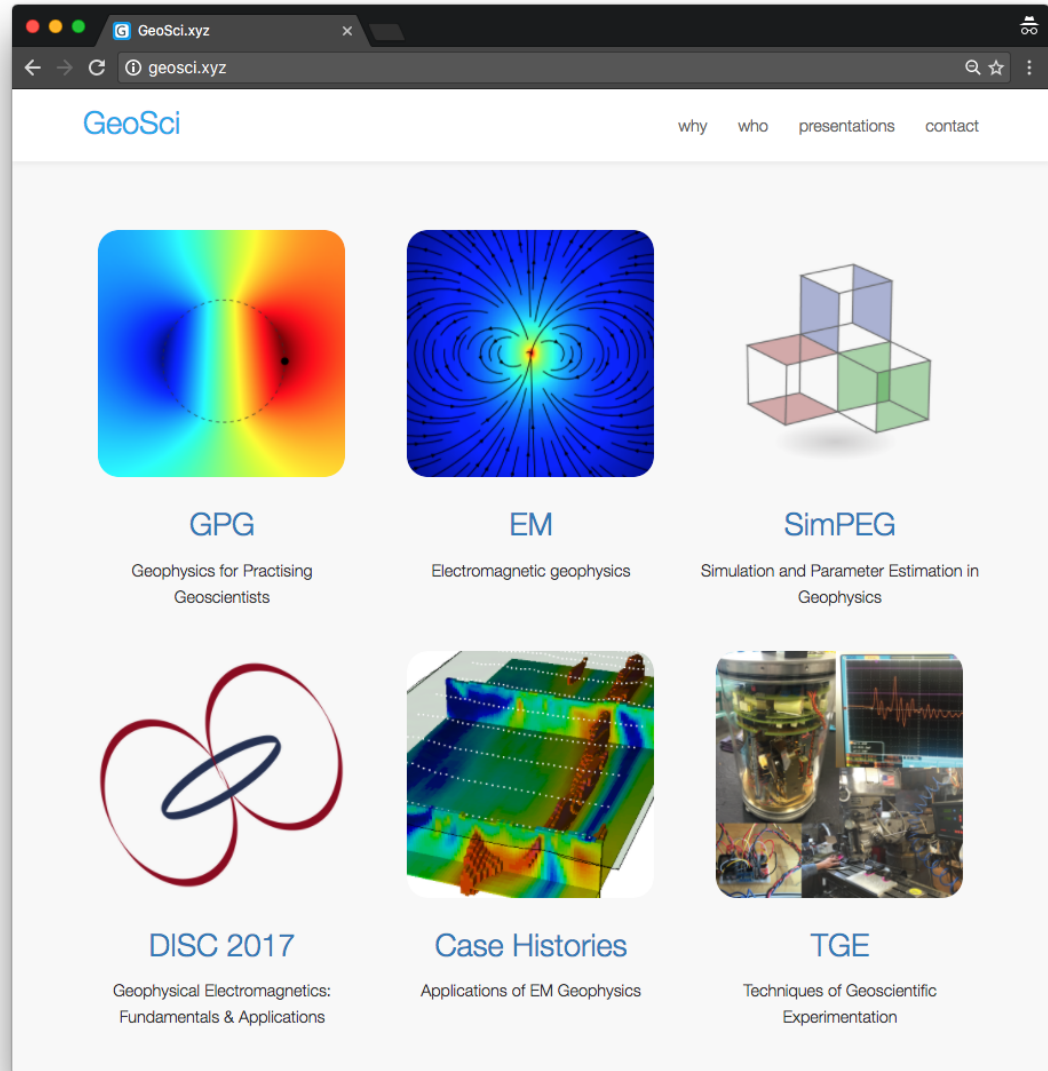
- GeoSci

<http://geosci.xyz>

- Web-textbooks
- Software
- Apps

- Apps:

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



GIF DISC Team



doug



lindsey



seogi

UBC GIF Team



Thibaut



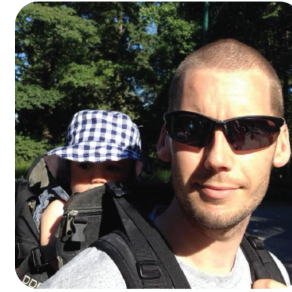
Patrick



Rowan



Devin



Kris



Sarah



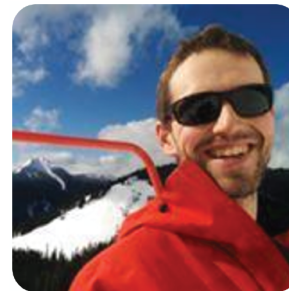
Dom



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

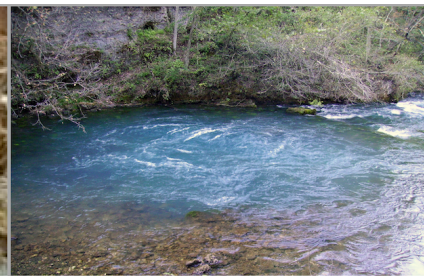
<http://disc2017.geosci.xyz>



minerals



contaminants



water



geothermal



geotechnical



slope stability



hydrocarbons



unexploded ordnance

Thank You!

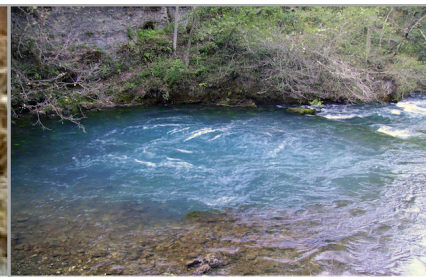
<http://disc2017.geosci.xyz>



minerals



contaminants



water



geothermal



geotechnical



slope stability



hydrocarbons



unexploded ordnance