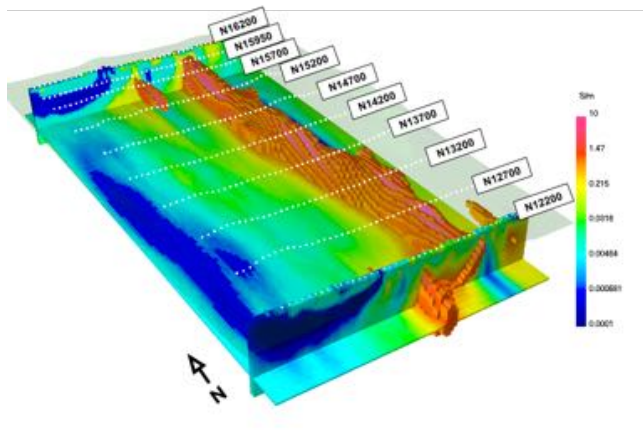


Summary and the Future

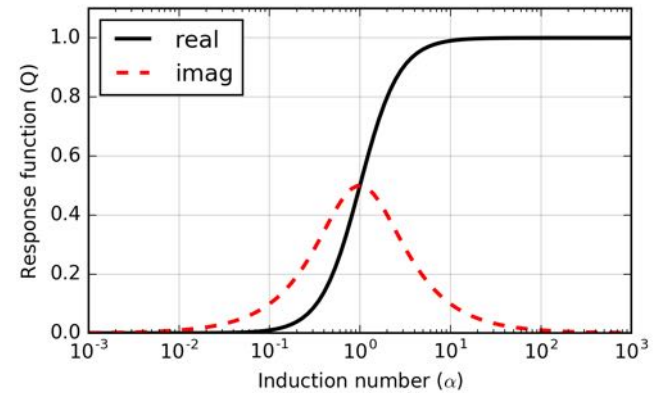


What have we covered?

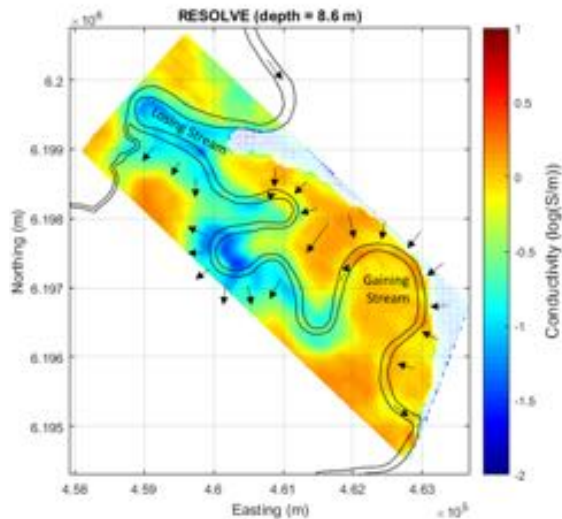
DC Resistivity



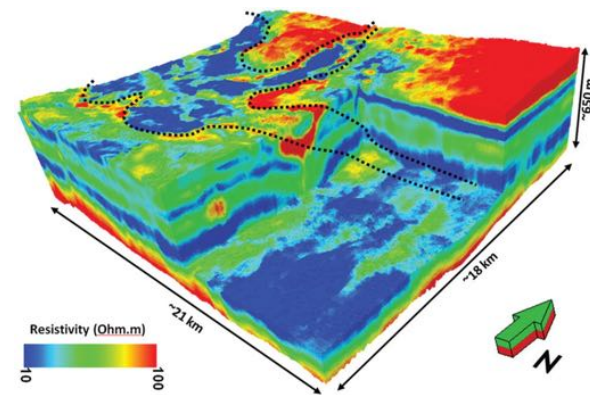
EM Fundamentals



Inductive Sources: Frequency

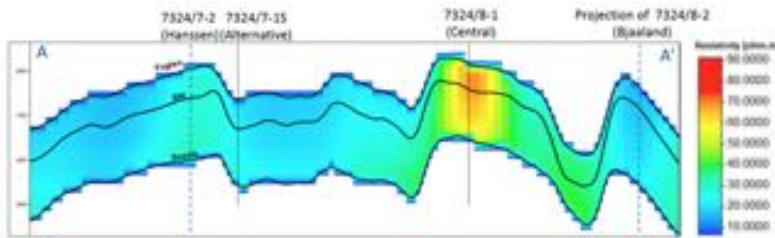


Inductive Sources: Time

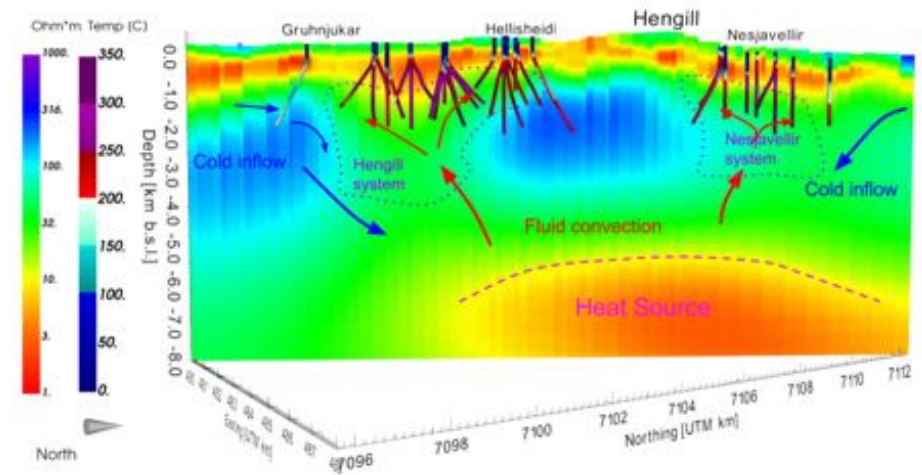


What have we covered?

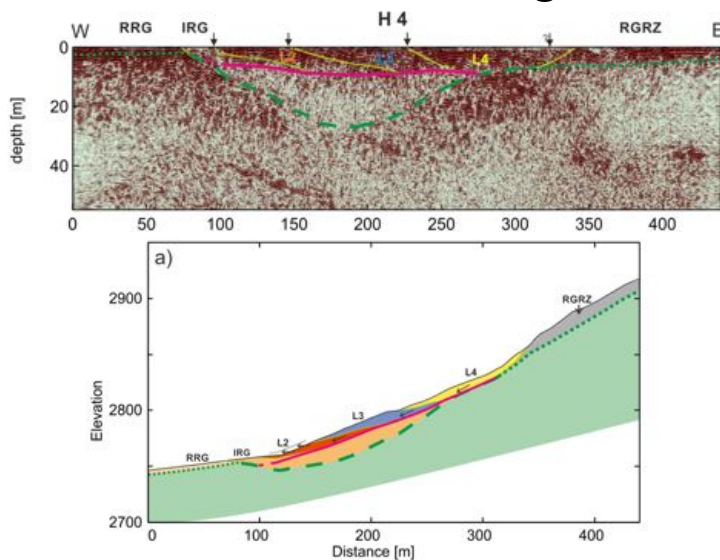
Grounded Sources



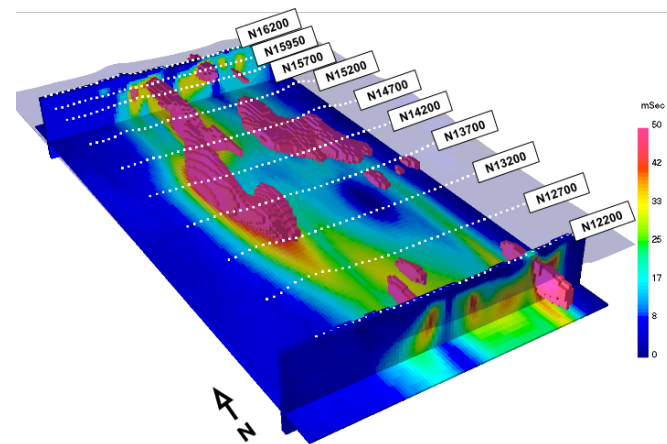
Natural Sources



Ground Penetrating Radar



Induced Polarization



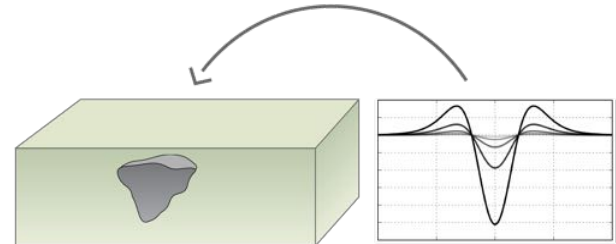
What does the future hold?

What does the future hold?

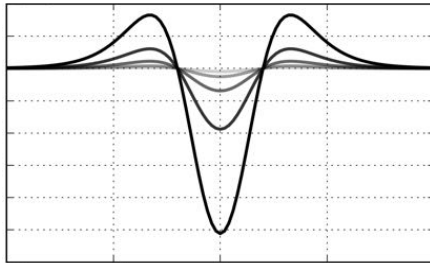
Problems



Inversion capabilities



High quality data

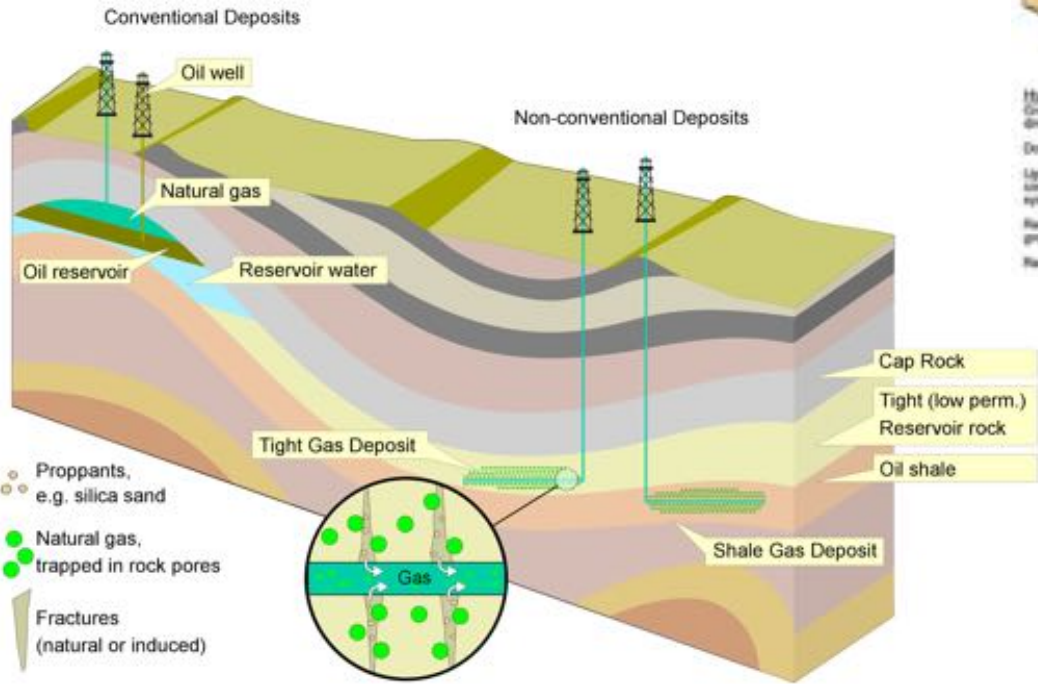
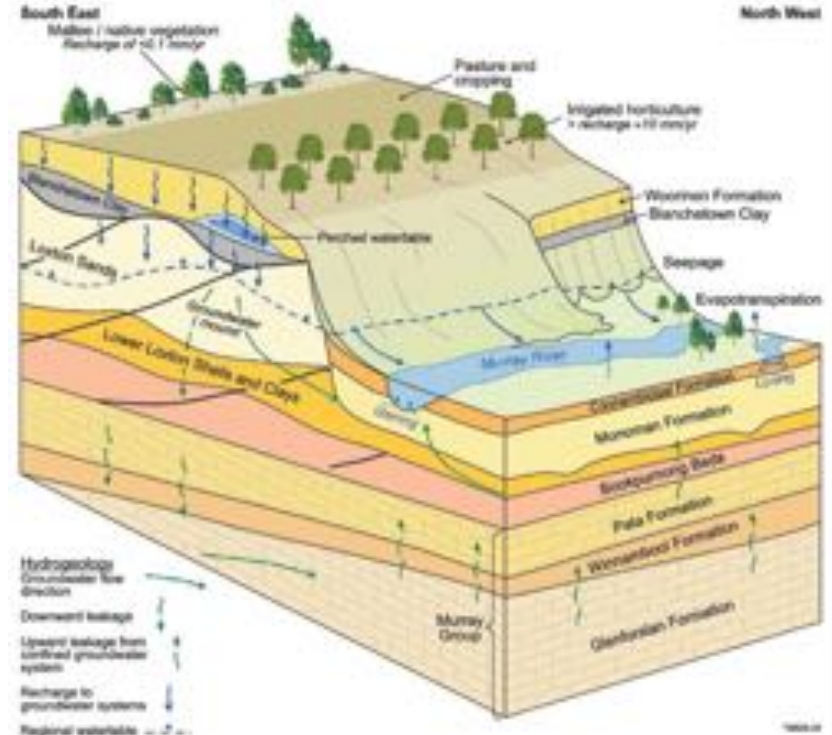


Web tools to
communicate



The Future: Monitoring

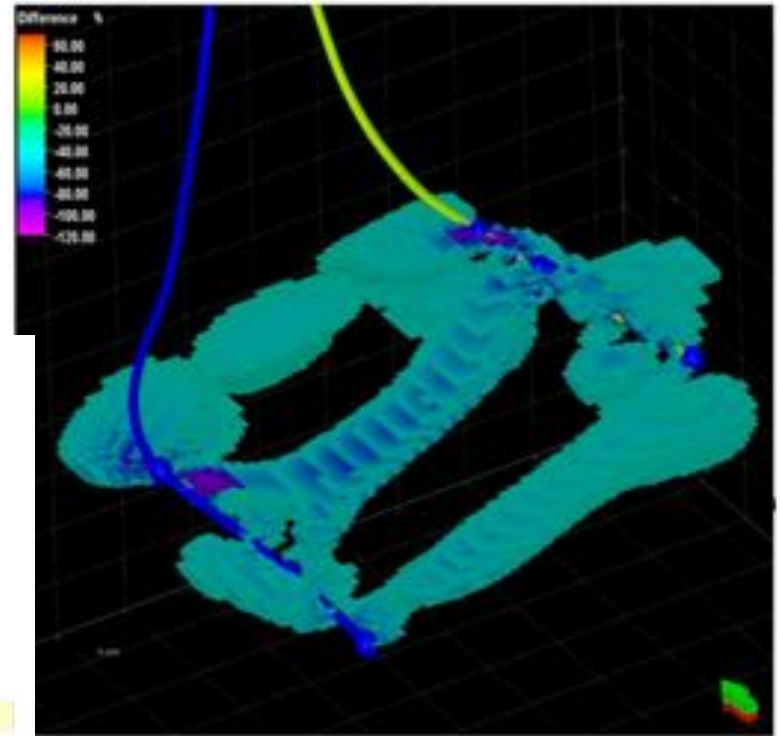
- Aquifers
- Enhanced oil recovery
- Hydraulic Fracturing
- CO₂ sequestration
- Coal seam gas



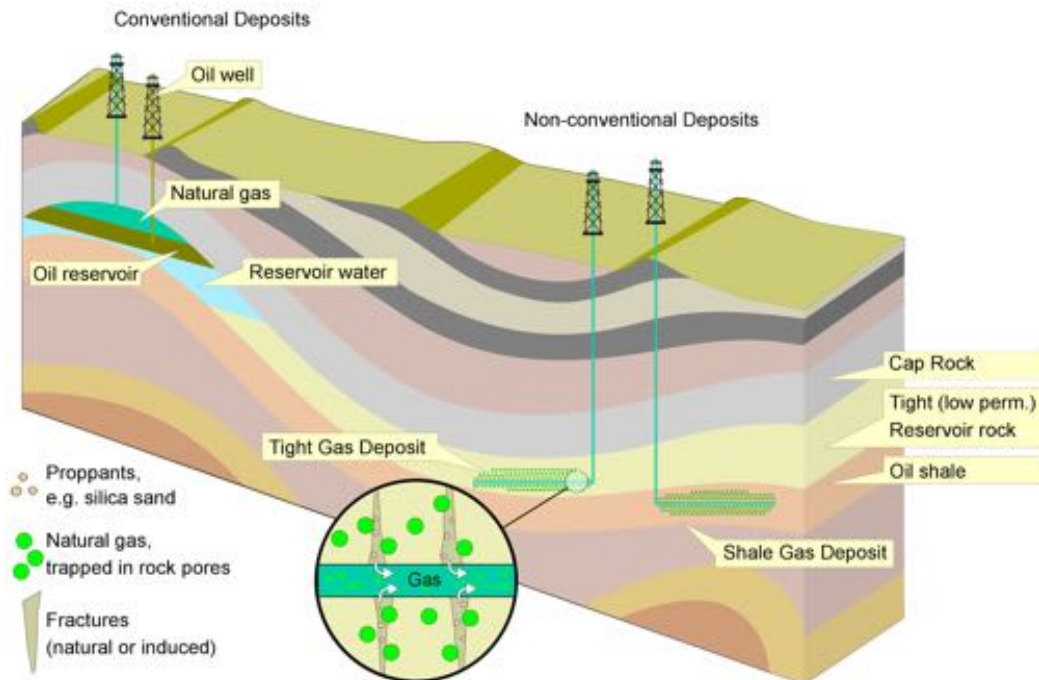
The Future: Monitoring

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

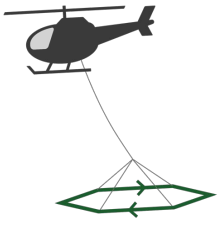
Resistivity isosurface – water flood



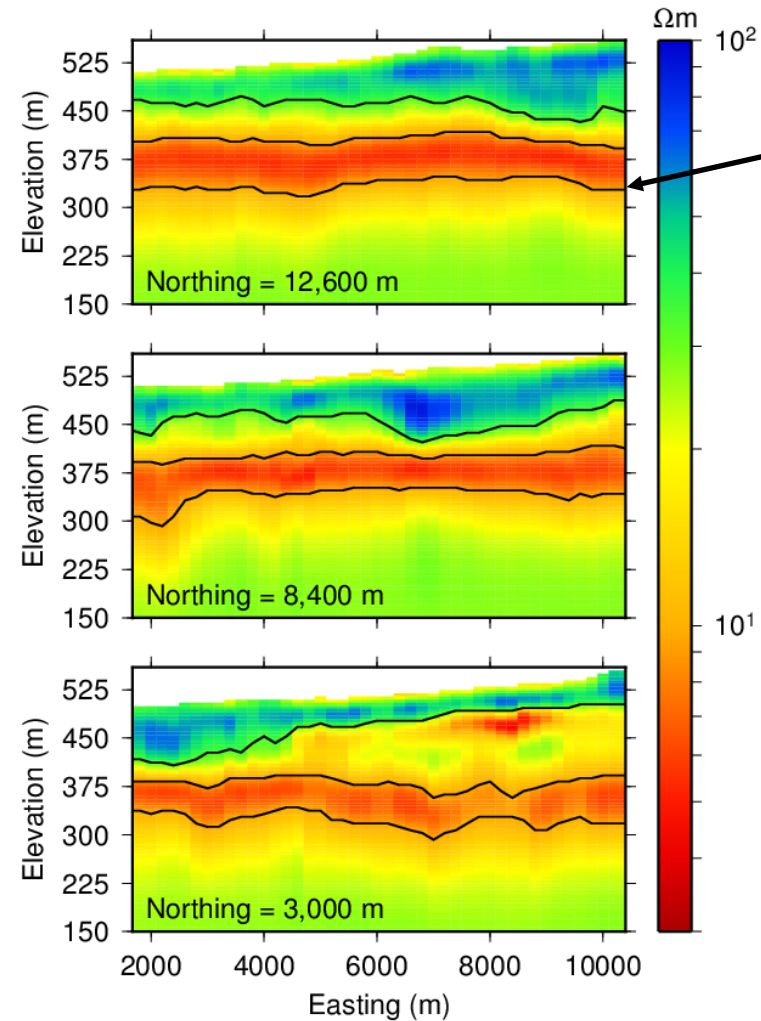
Saudi Arabia: Marsala et al., 2015



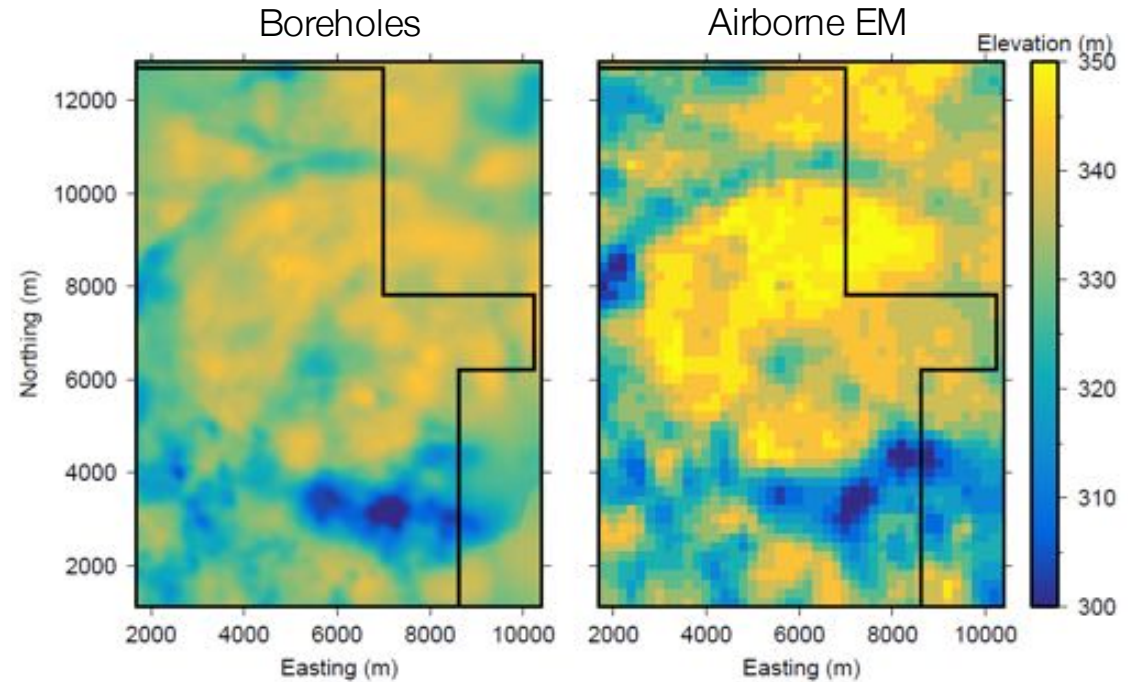
Multi-stage EM for monitoring



Large-scale: airborne

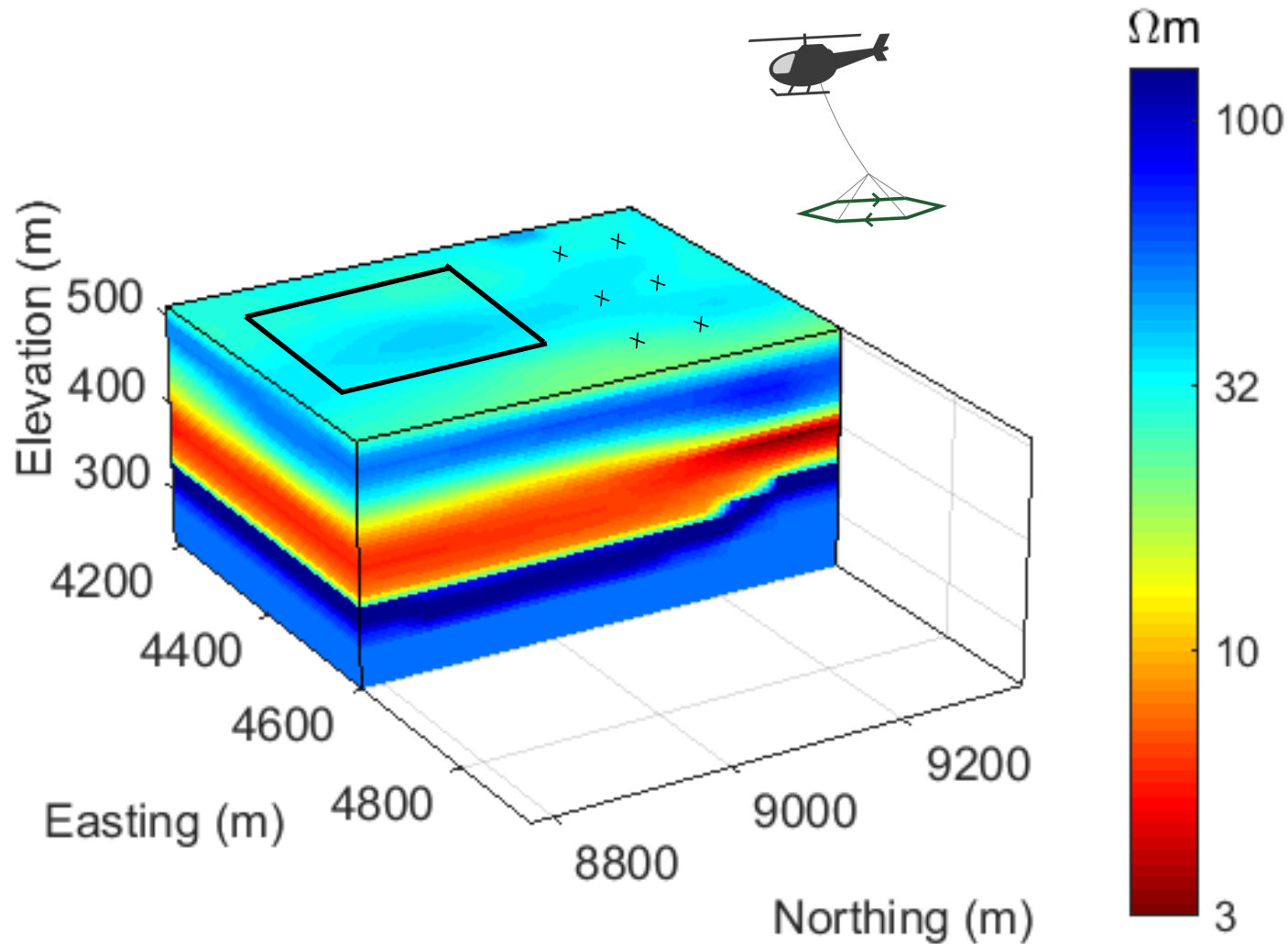


Top of McMurray



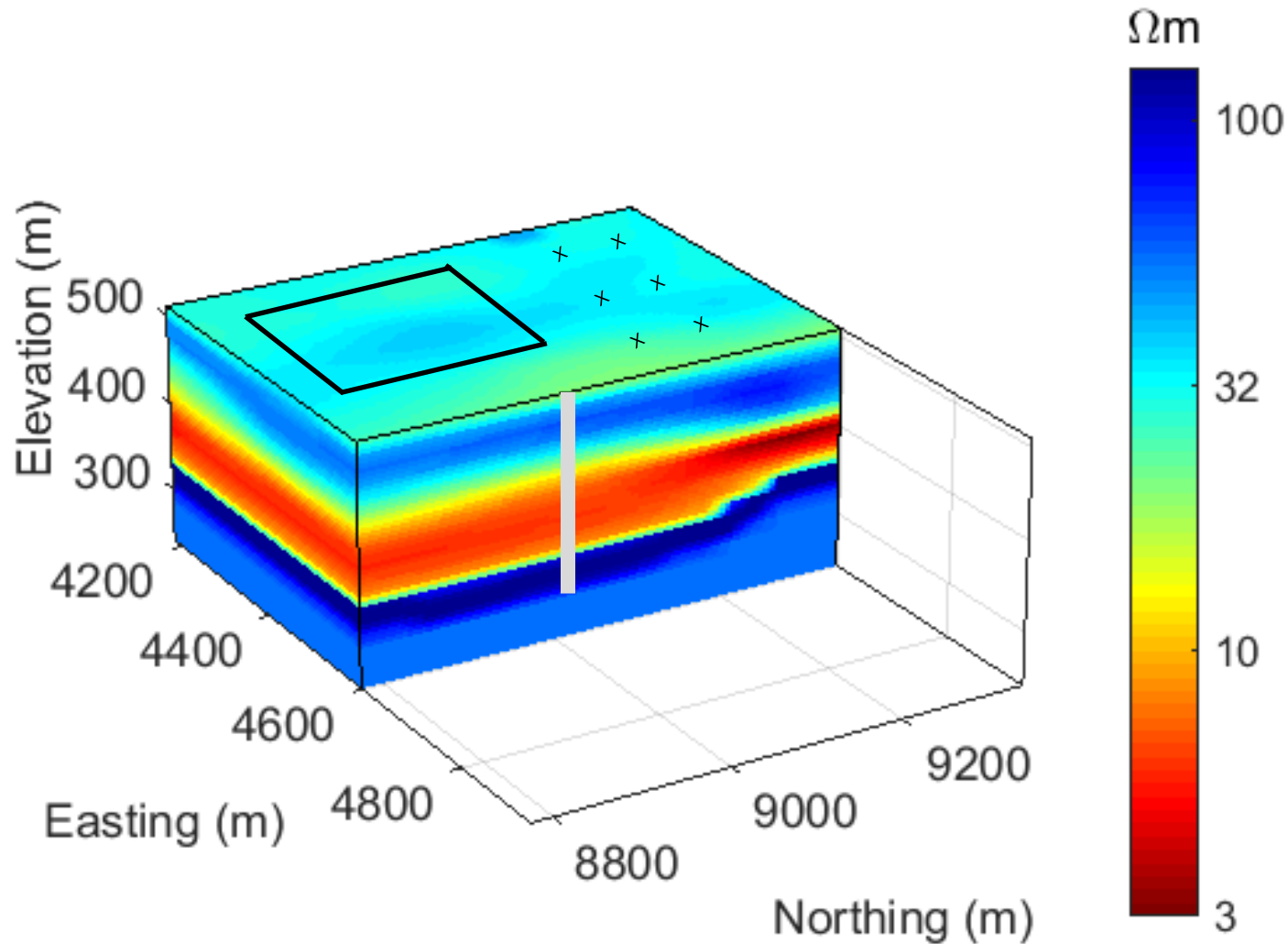
Multi-stage EM for monitoring

Local background: airborne + ground



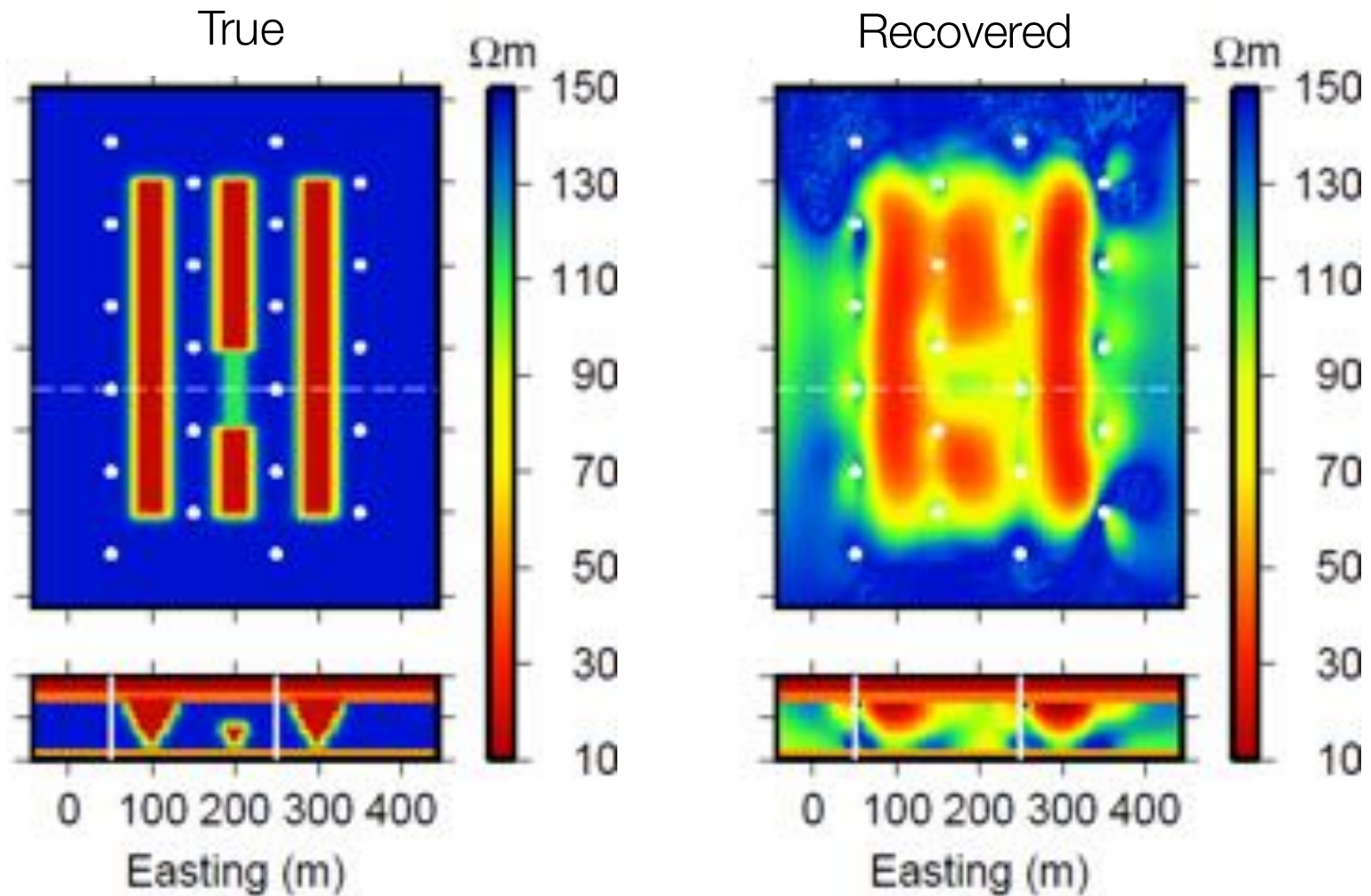
Multi-stage EM for monitoring

Pre-injection: surface sources, borehole receivers



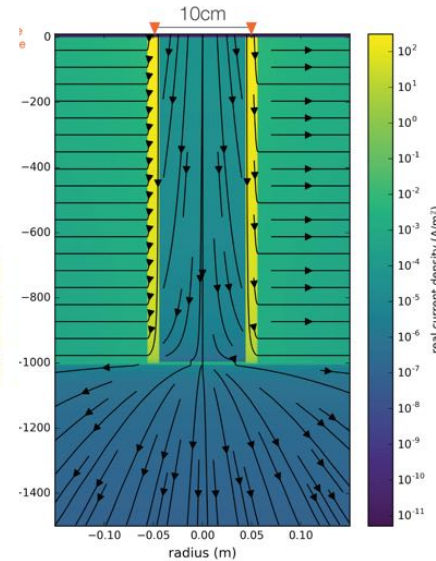
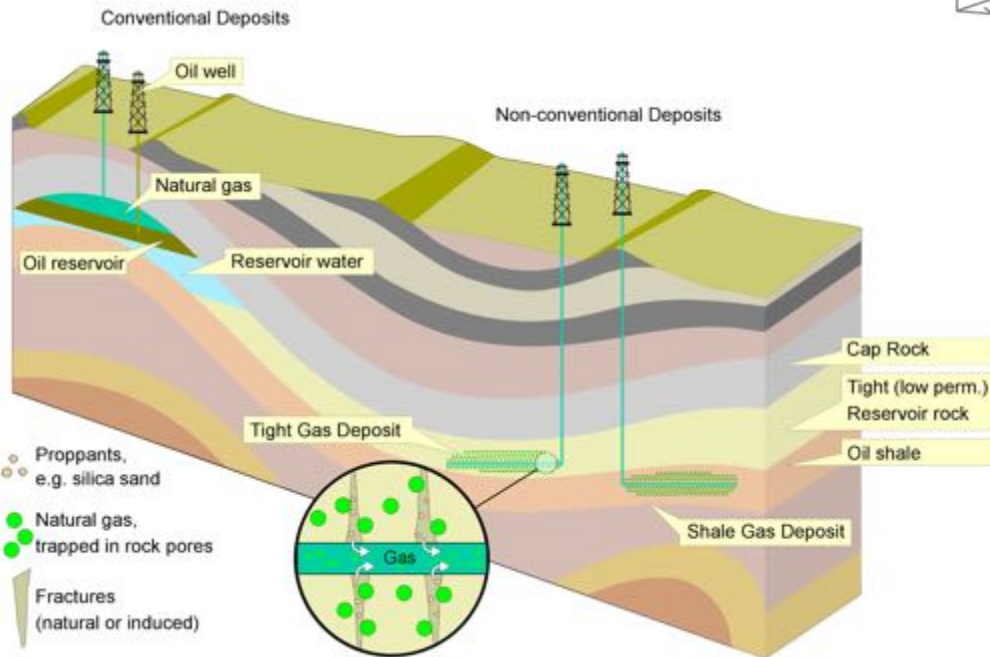
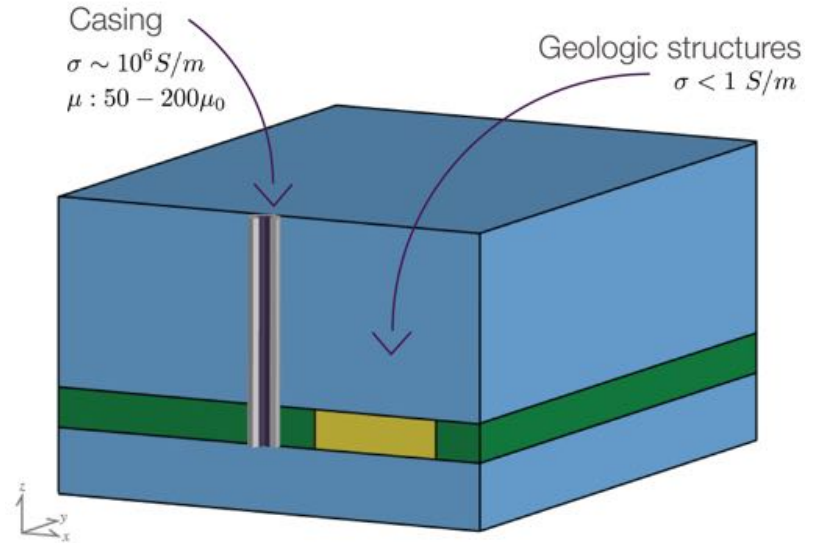
Multi-stage EM for monitoring

Post-injection: surface sources, borehole receivers



The Future: Monitoring

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

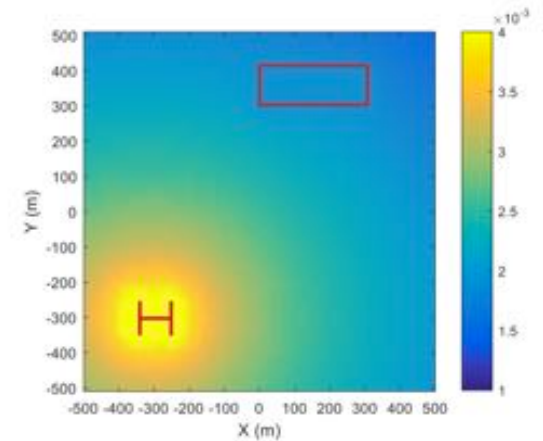
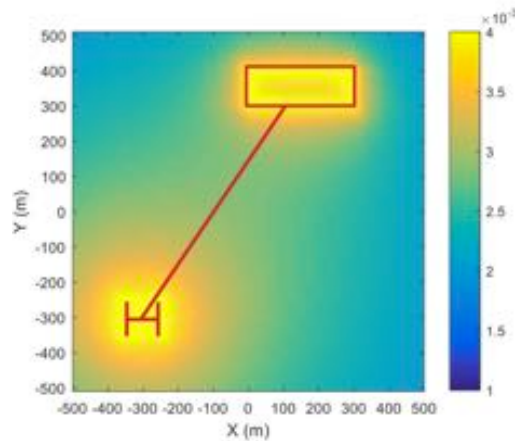
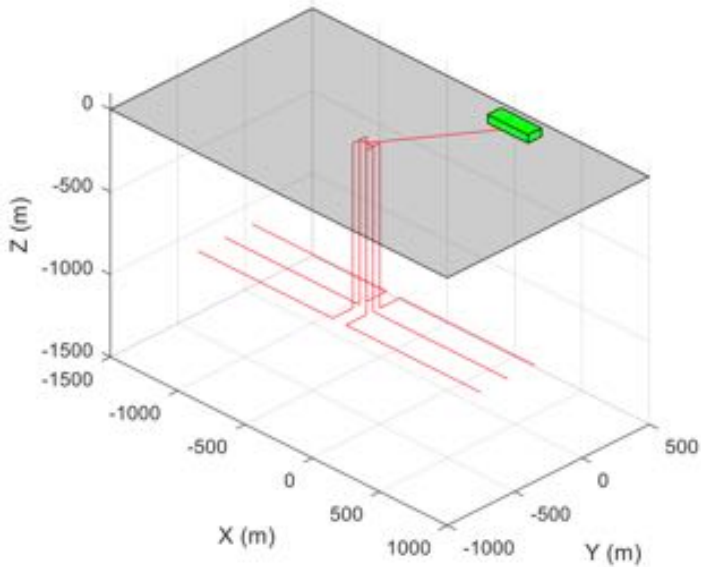
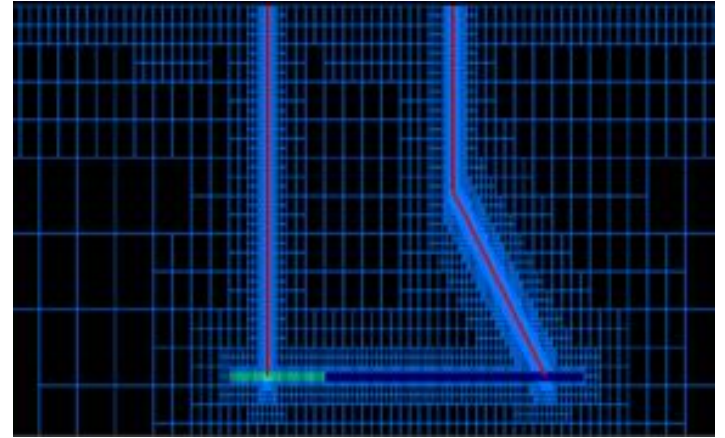
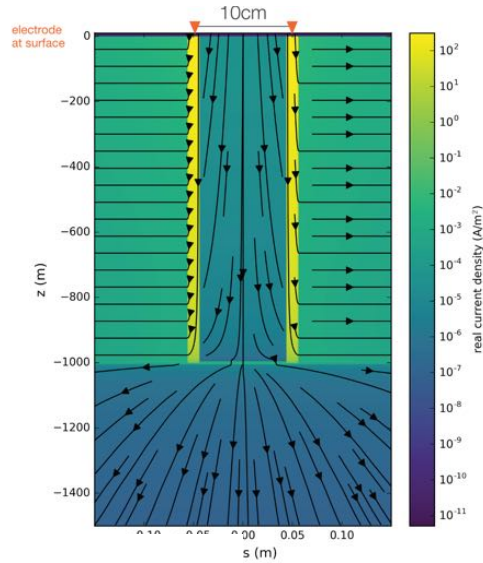


Corrosion



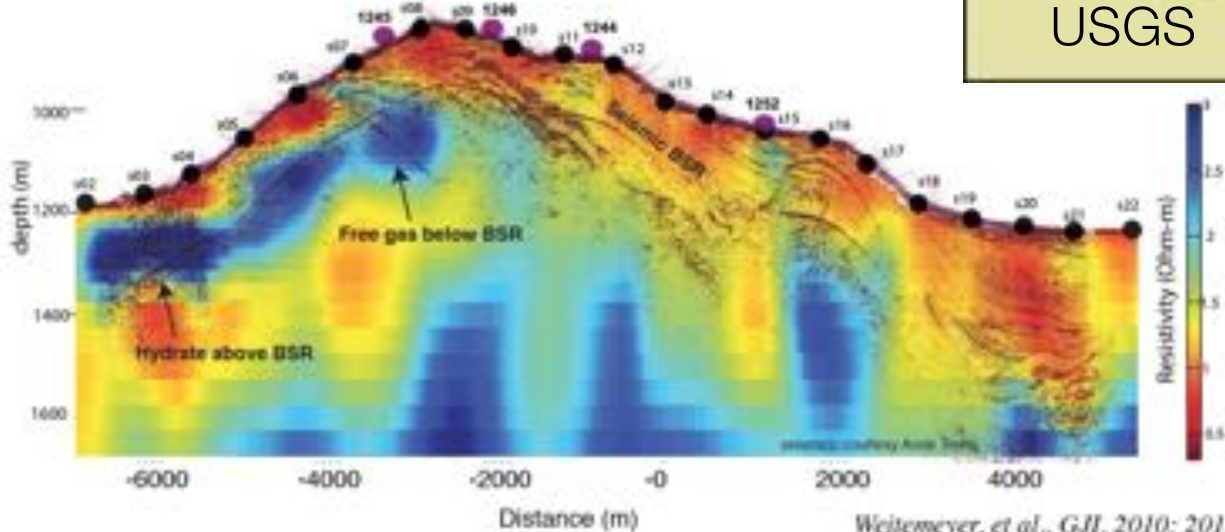
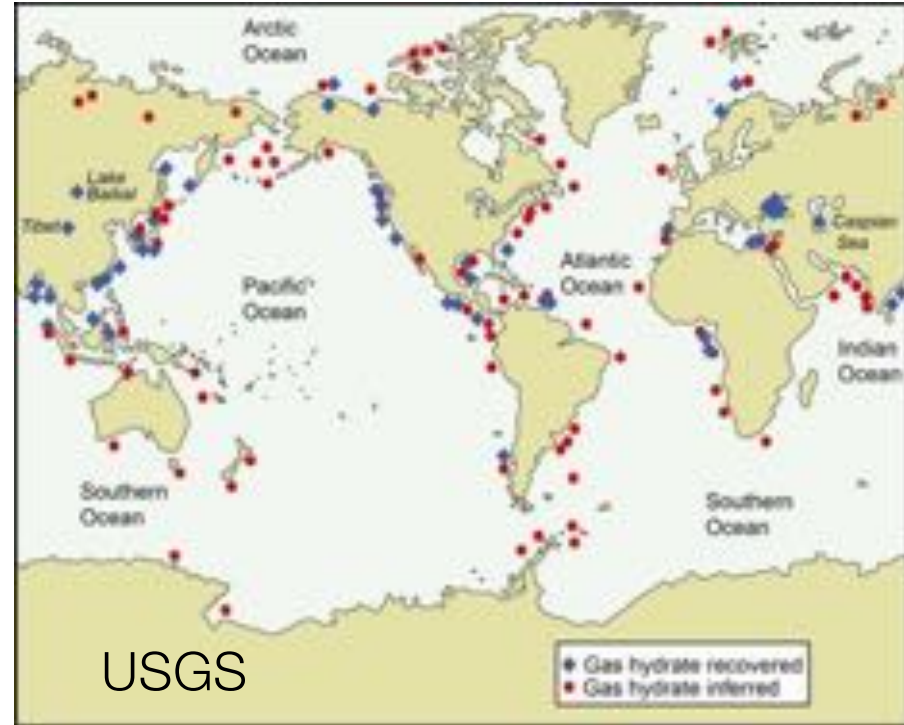
The Future: Monitoring

- Steel Casing



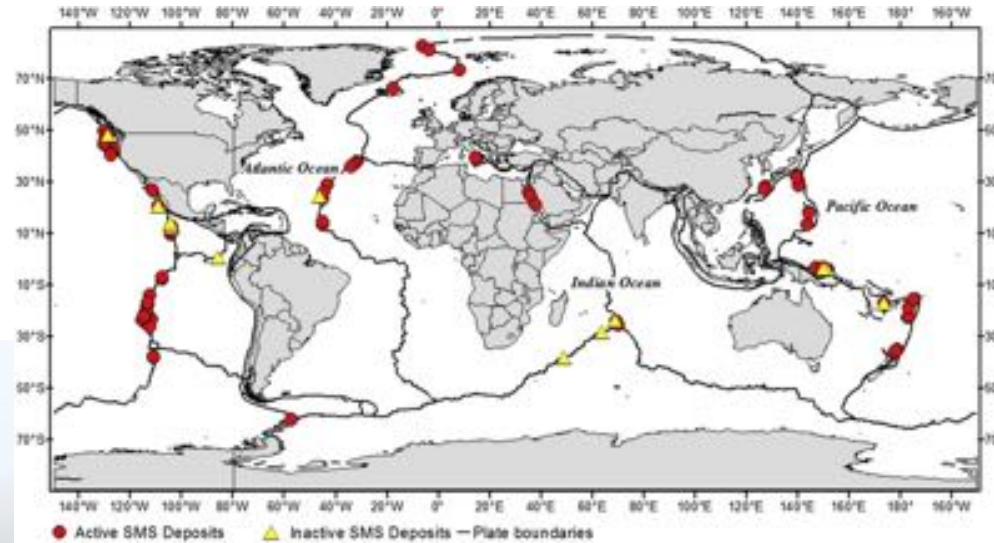
The Future: Marine EM

- Gas hydrates
 - Resistivity is diagnostic

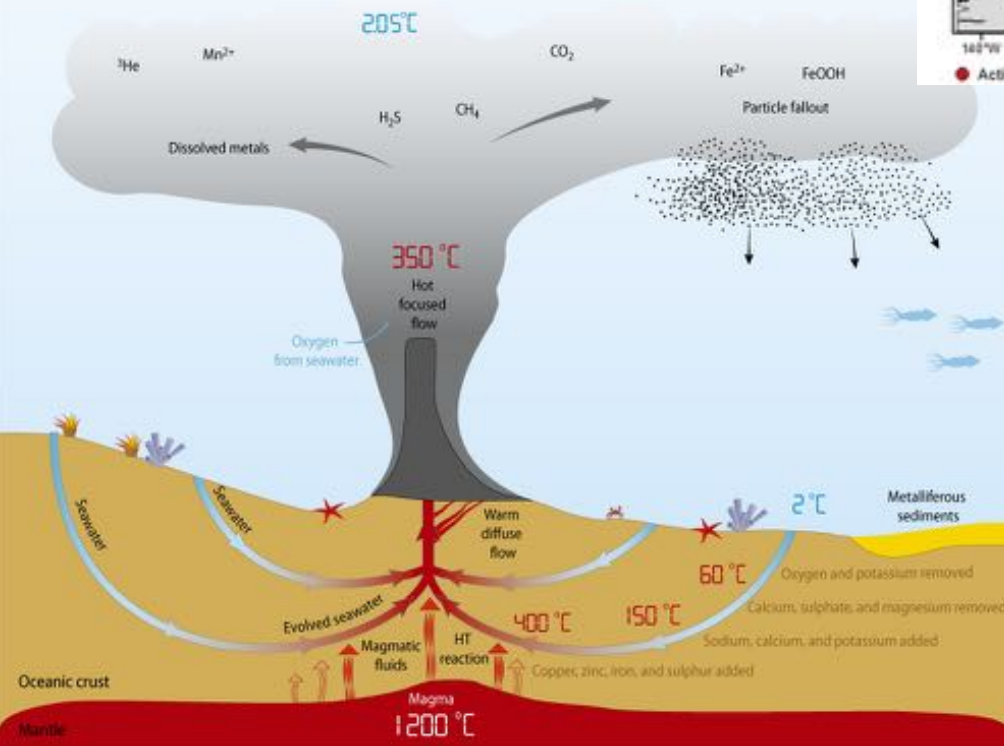


The Future: Marine EM

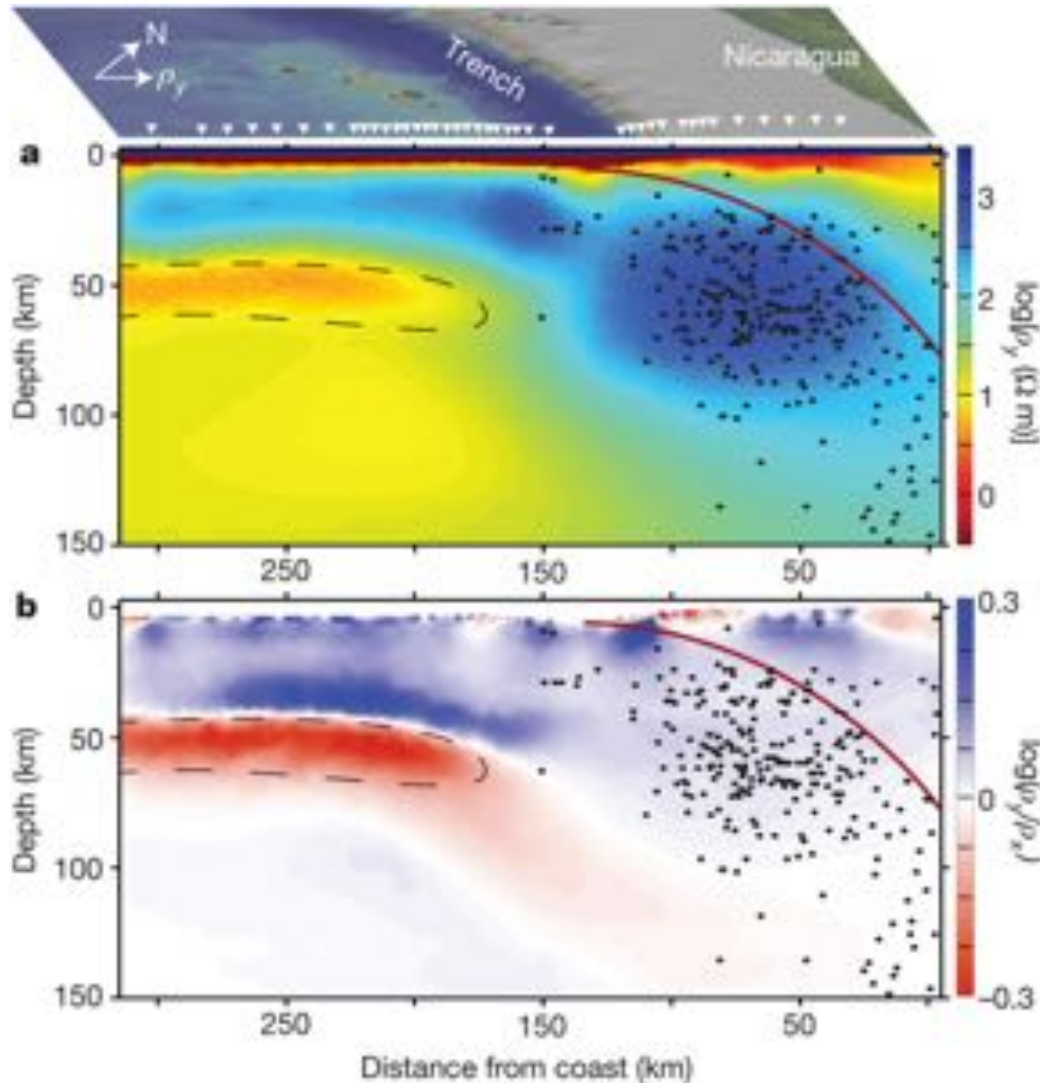
- Submarine massive sulfides
 - Conductive relative to background



Basics of a hydrothermal vent - a Black Smoker



The Future: Marine EM



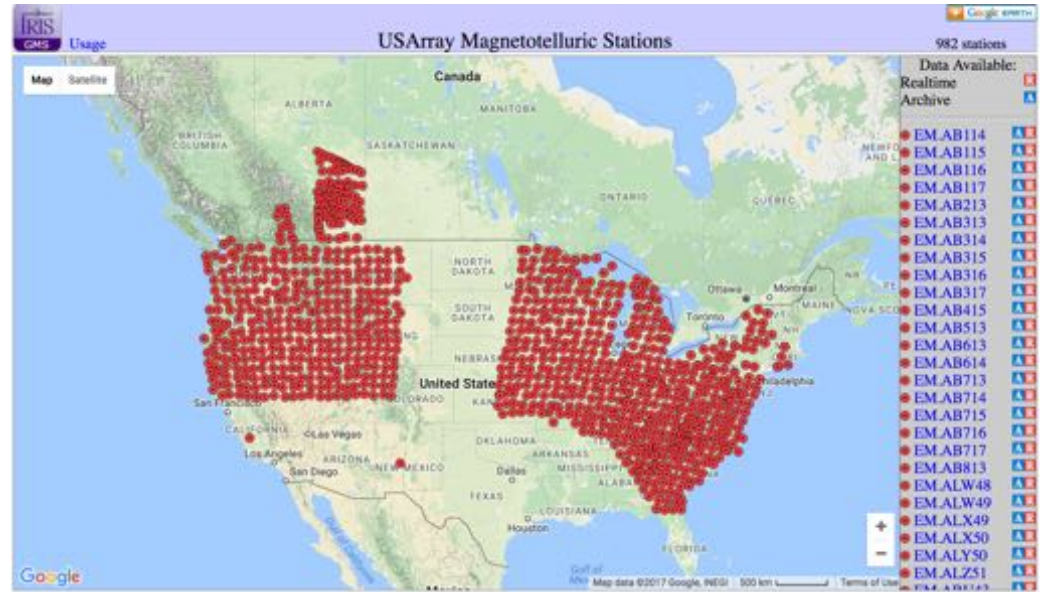
- Tectonic studies
- Natural Hazard
- Large anisotropy
 - indicative of melt-rich channel

The Future: Large Scale MT

AusLamp

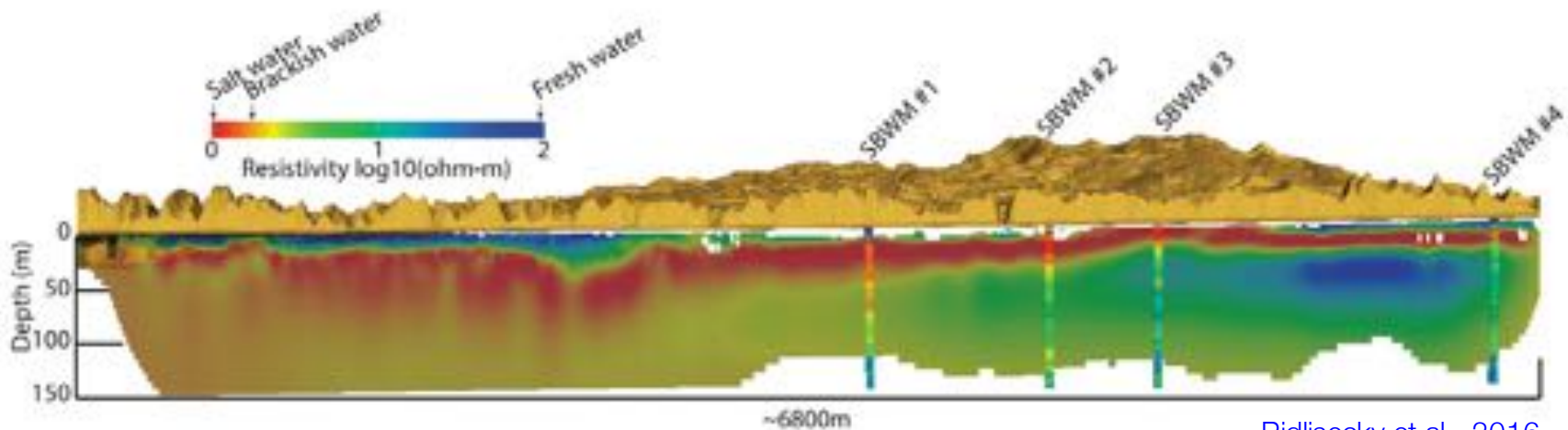
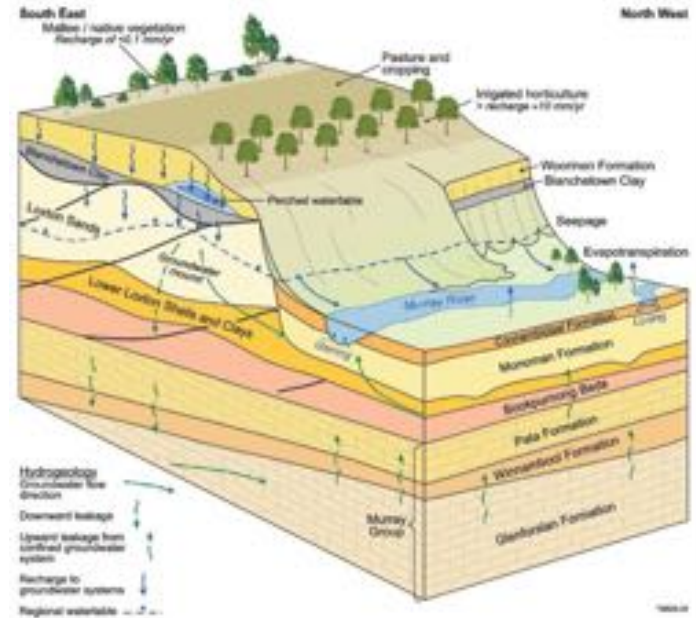


Earth scope



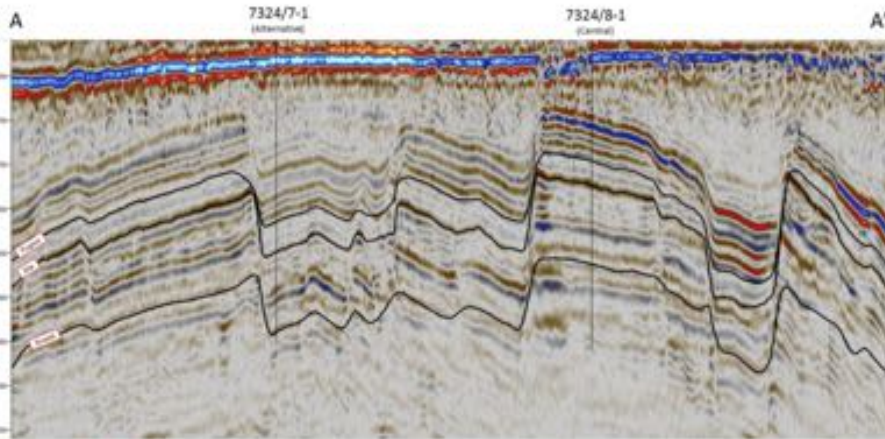
The Future: Water

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

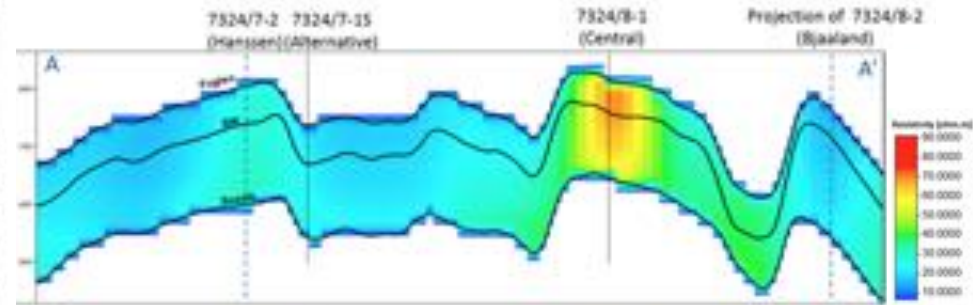


The Future: Data Integration & Multi-physics

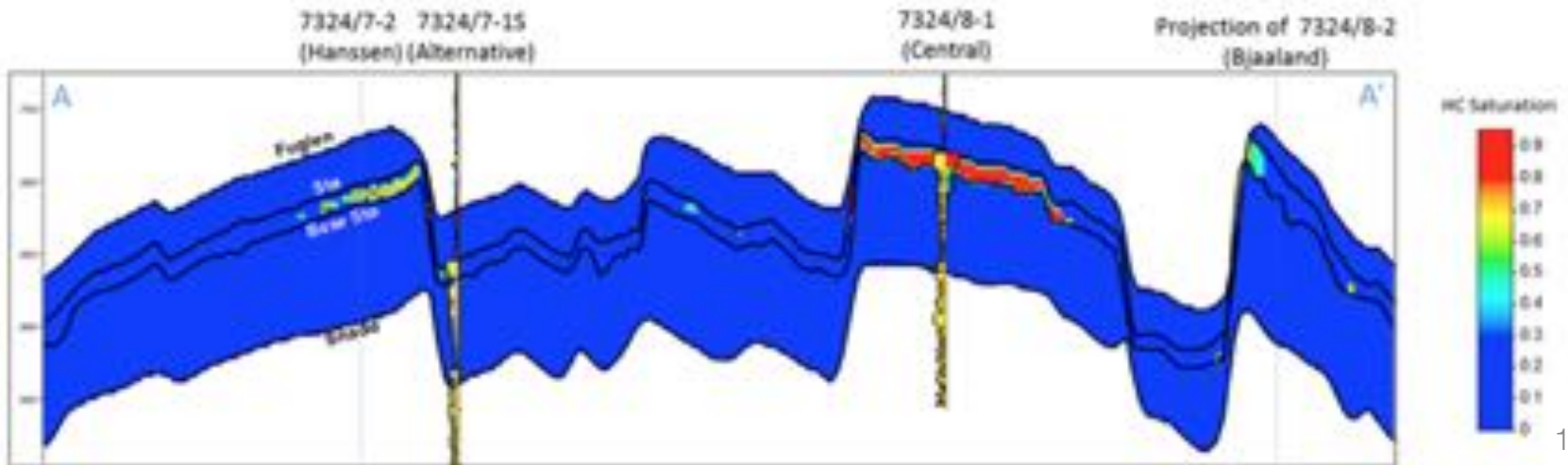
Seismic



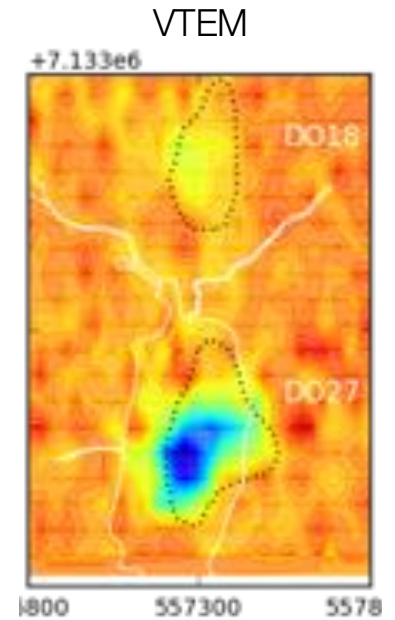
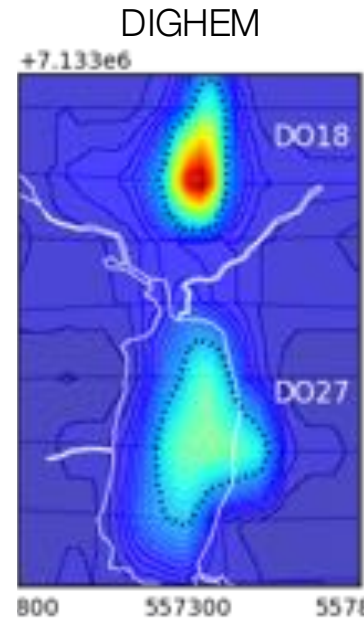
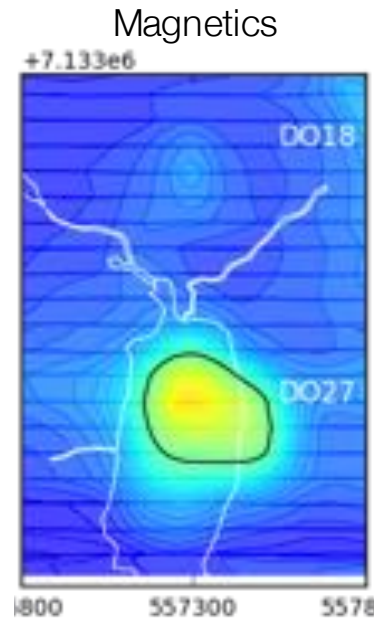
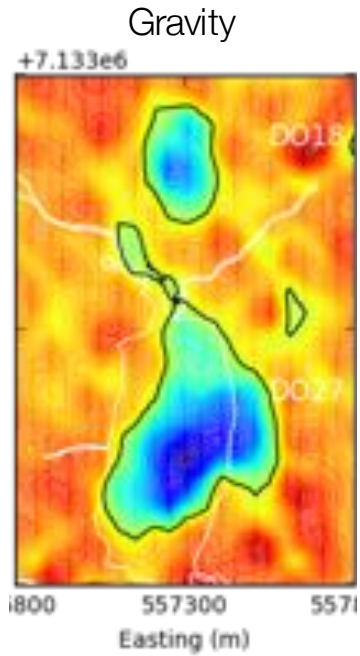
EM



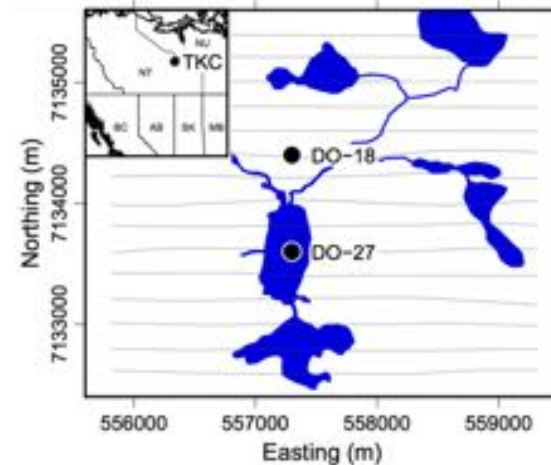
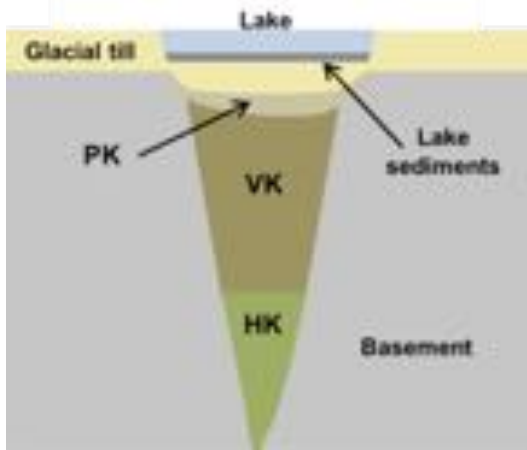
Final hydrocarbon saturation model



The Future: Data Integration & Multi-physics

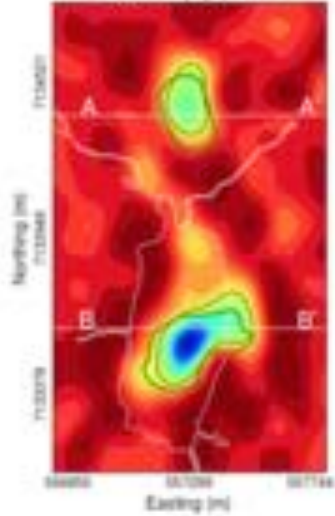


Kimberlite Model

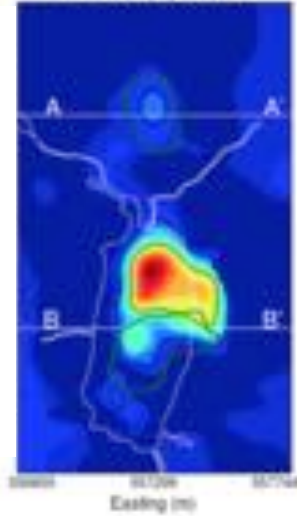


The Future: Data Integration & Multi-physics

Density



Susceptibility



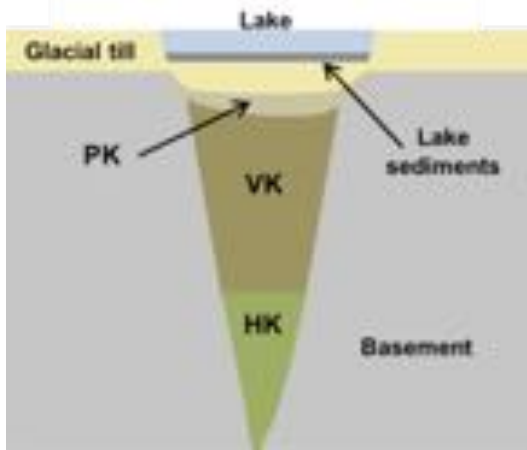
Conductivity



Chargeability

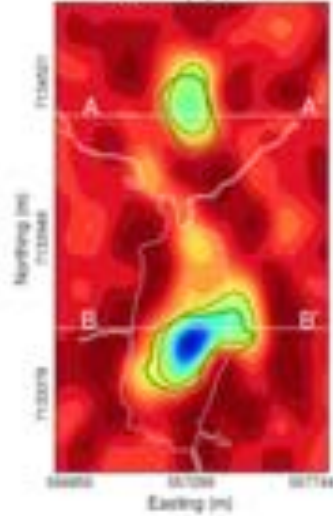


Kimberlite Model

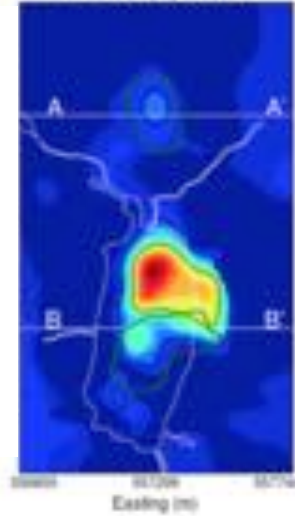


The Future: Data Integration & Multi-physics

Density



Susceptibility



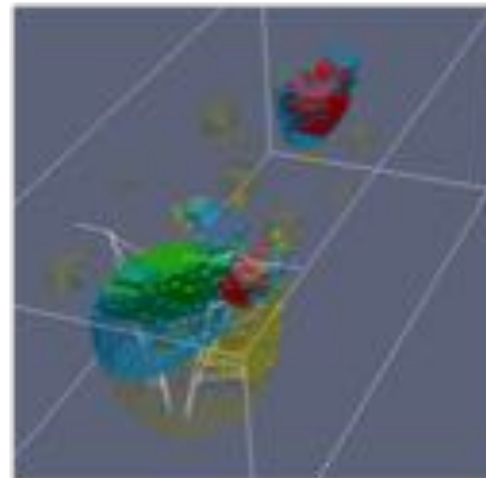
Conductivity



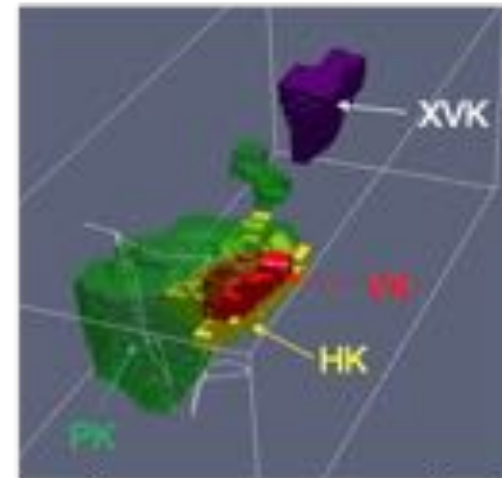
Chargeability



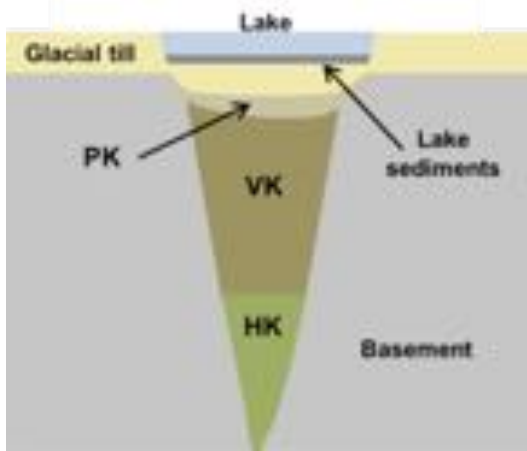
Rock Model from Geophysics



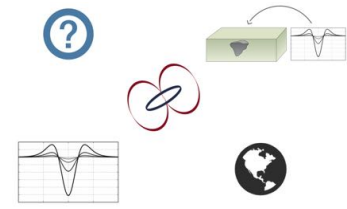
Rock Model from Drilling



Kimberlite Model



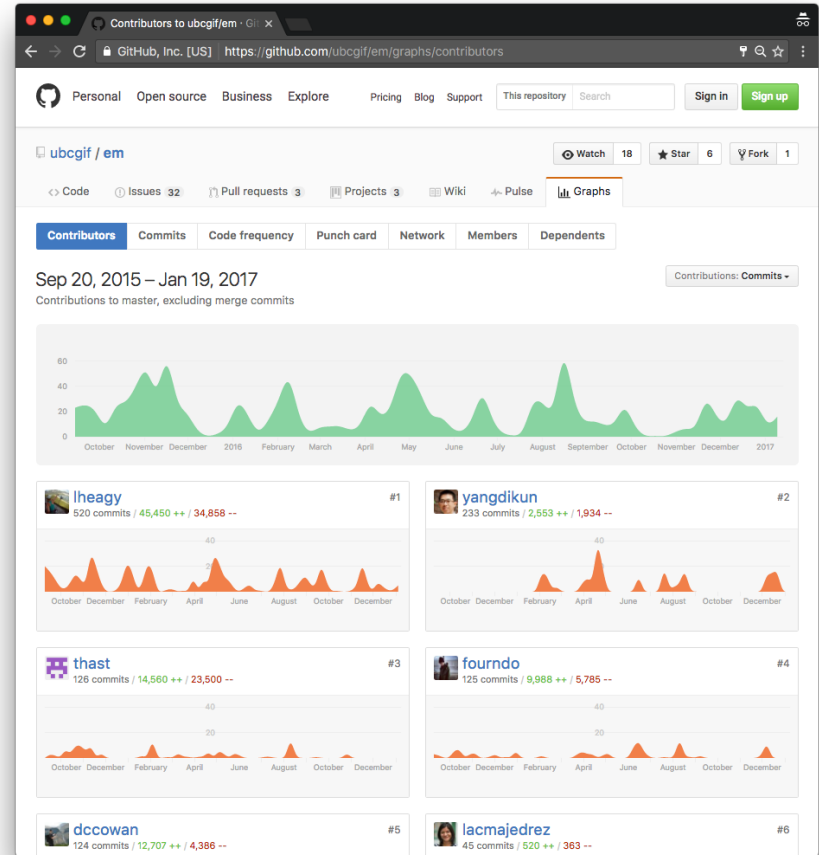
The Future: Modelling and Inversion



- 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

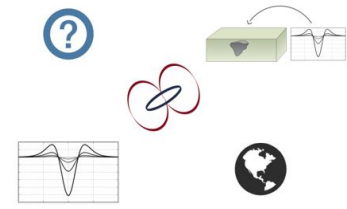


Creative Commons
licensing, reuse



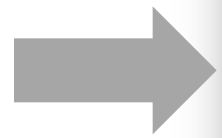
Python
computation

The Future: Modelling and Inversion

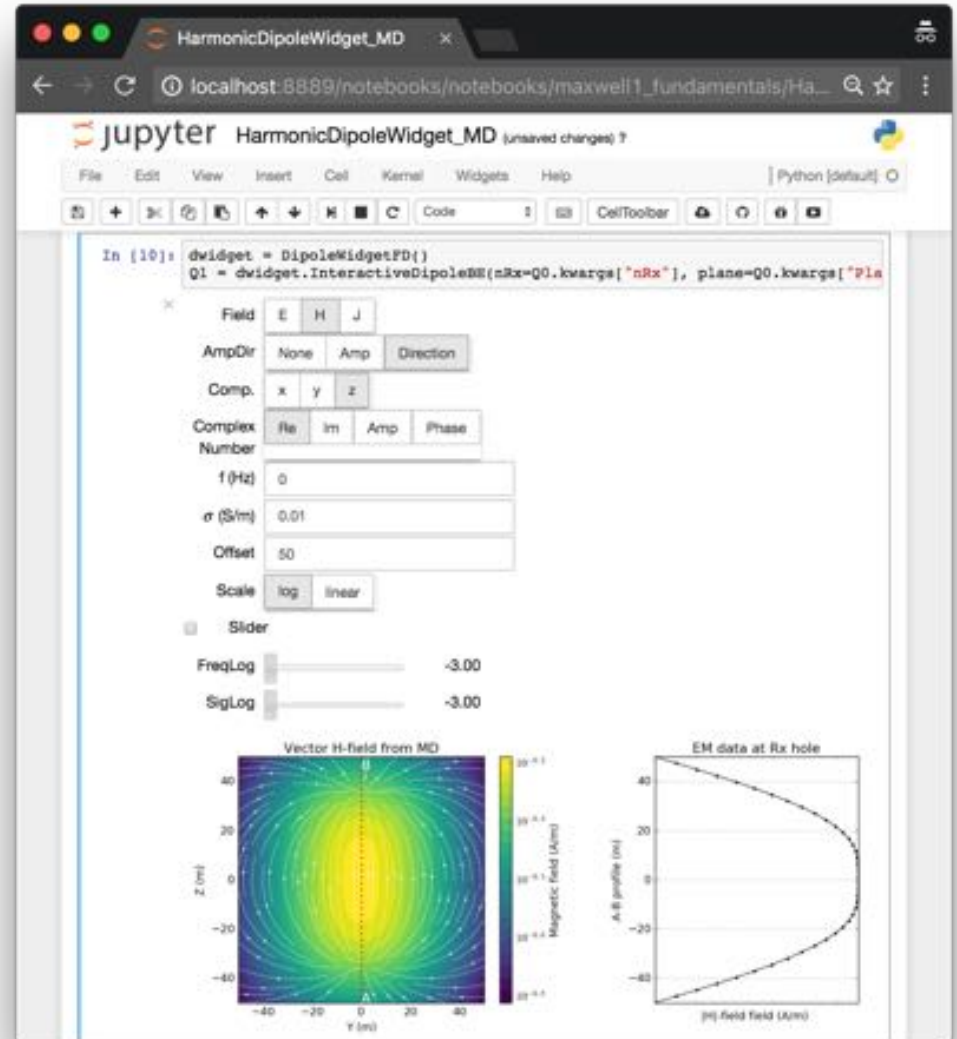


- Interactive computing
- Visualization

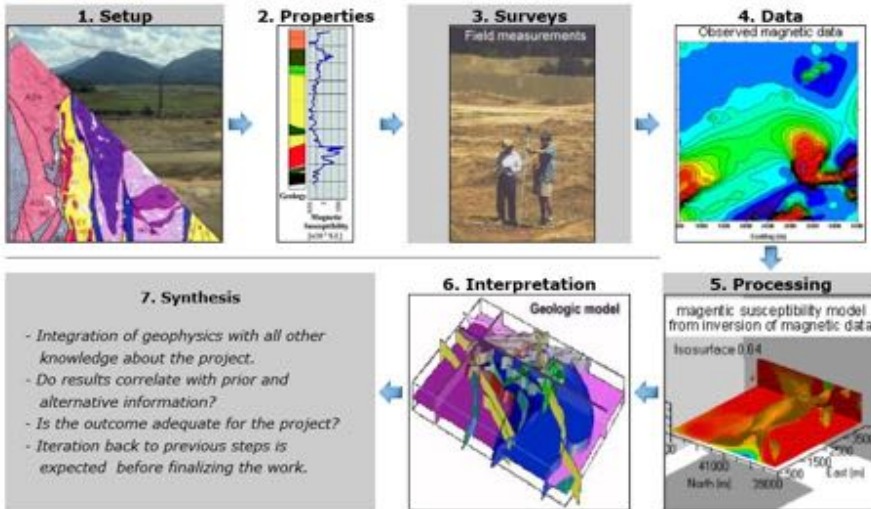
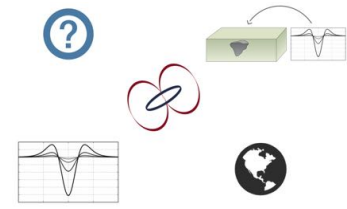
$$\nabla \times \mathbf{e} = - \frac{\partial \mathbf{b}}{\partial t}$$



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



The Future: Collaboration



<http://slack.geosci.xyz>

Case Histories — Electromagnetics

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 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

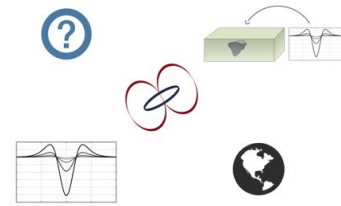
Mt. Isa

- **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

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

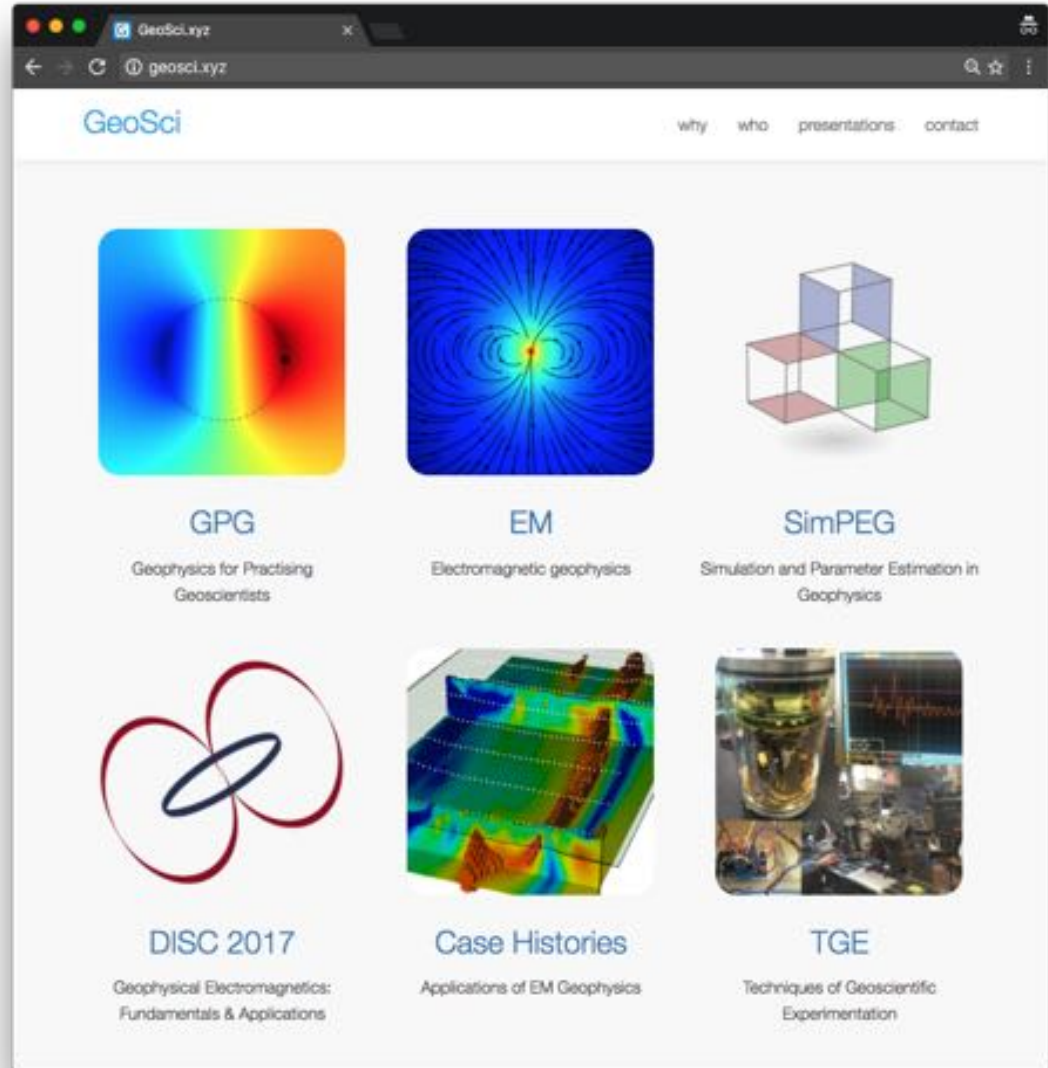
- GeoSci

<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>



minerals



contaminants



water



geothermal



geotechnical



slope stability



hydrocarbons



unexploded ordnance