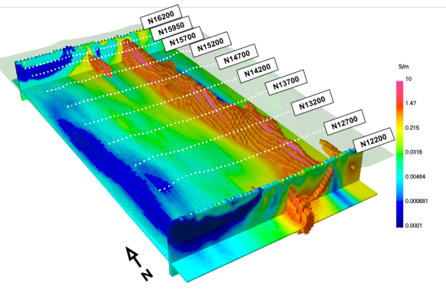
Summary and the Future

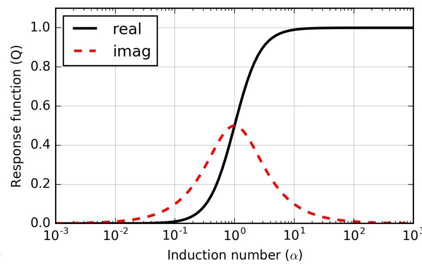
DISC
2017
Electromagnetics
Fundamentals and Applications

→

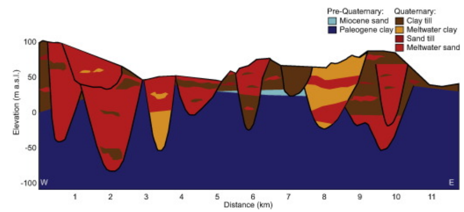
What have we covered?



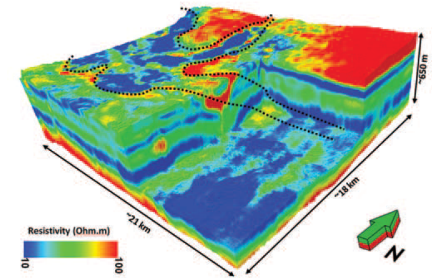
Mt. Isa, Australia: Mineral Exploration



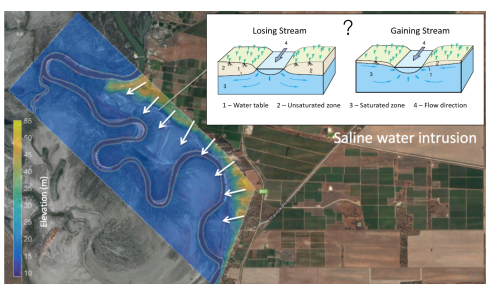
EM Fundamentals



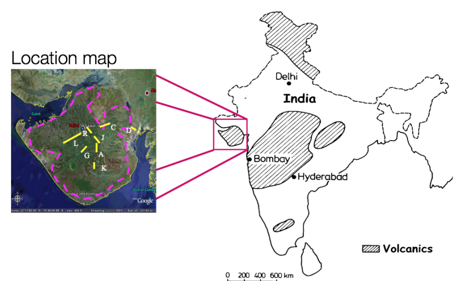
Kasted, Denmark: mapping paleochannels



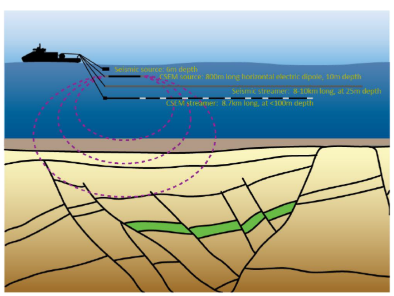
Wadi Sahba, Saudi Arabia: using EM to improve seismic imaging



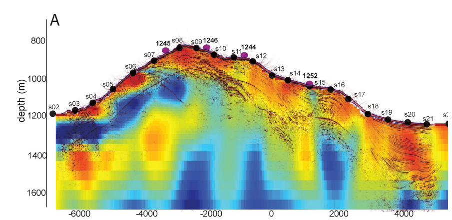
Bookpurnong, Australia: diagnosing river salinization



Deccan Traps, India: mapping sediment beneath basalt

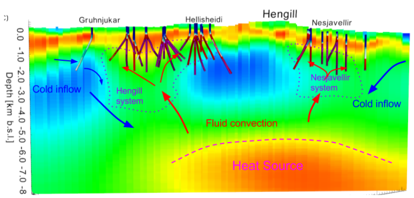


Barents Sea: Hydrocarbon de-risking

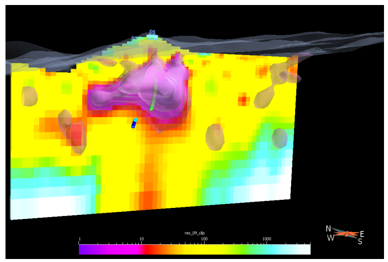


Oregon, USA: Methane Hydrates

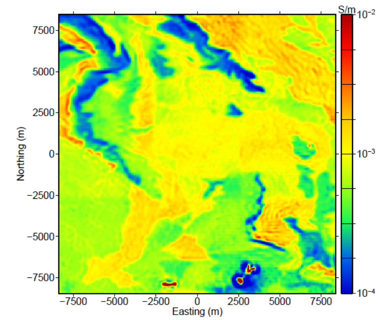
What have we covered?



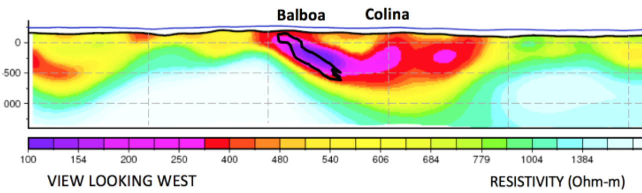
Iceland: characterizing geothermal systems



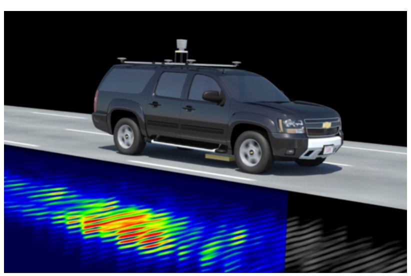
Santa Cecilia, Chile: Mineral Exploration



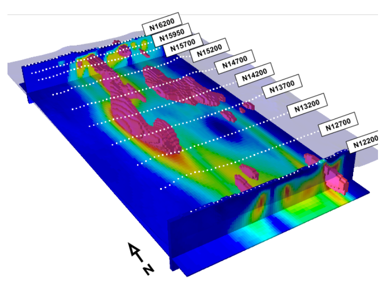
Noranda, Canada: Geologic Mapping



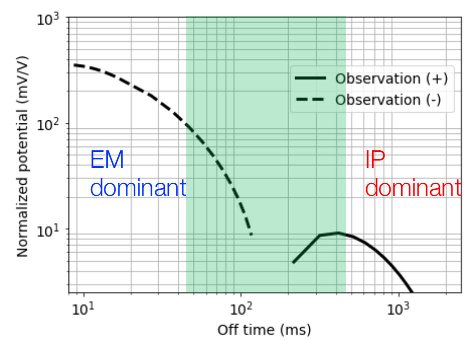
Balboa, Panama: Mineral Exploration



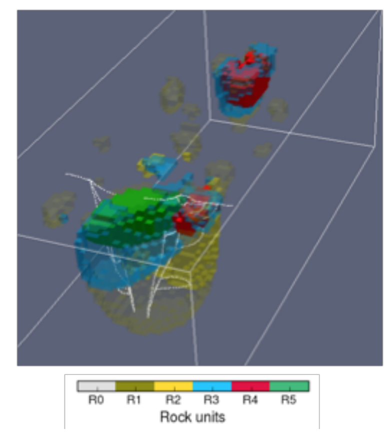
USA: Self-driving vehicles



Mt. Isa, Australia: Mineral Exploration



EM decoupling



TKC, Canada: Mineral Exploration

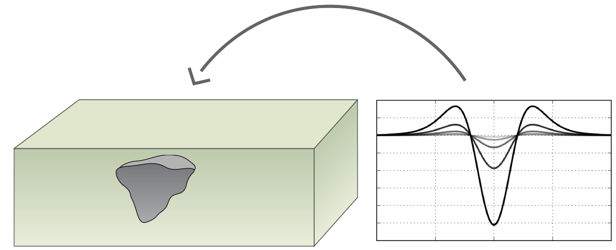
What does the future hold?

What does the future hold?

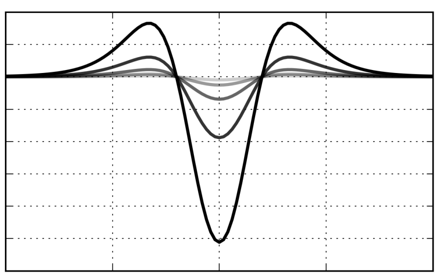
What does the future hold?

Problems

Inversion capabilities



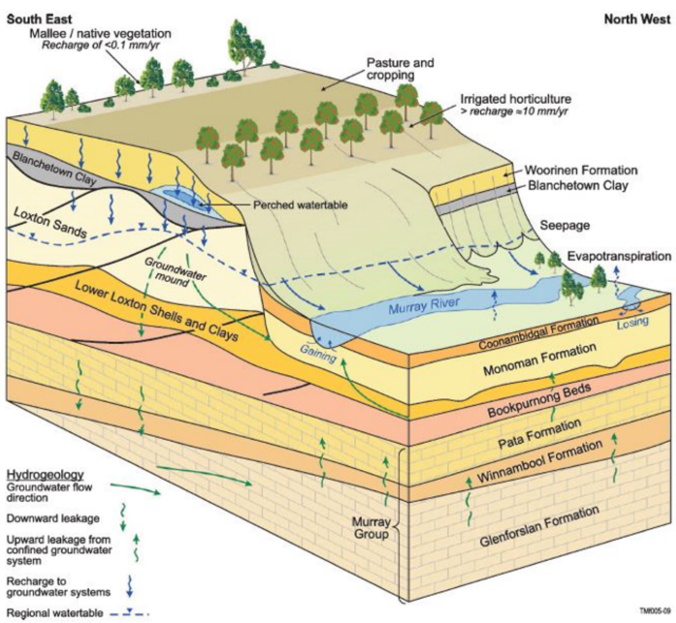
High quality data



Web tools to communicate

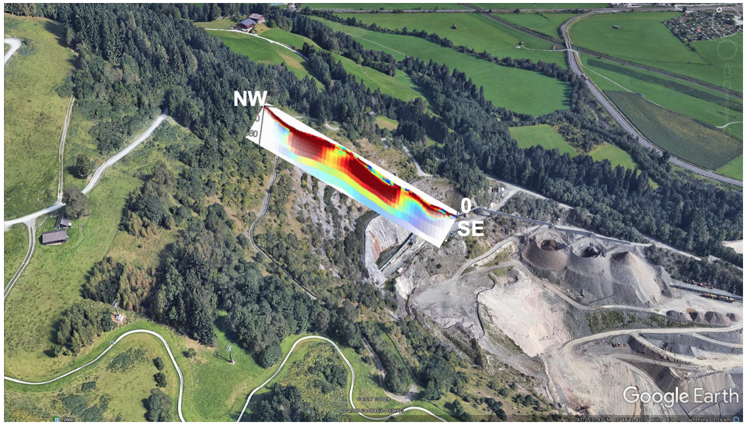
The Future: Monitoring

- Dam integrity
- Slope stability
- Aquifers
- Coal seam gas
- Enhanced oil recovery



Mt. Polly tailings dam collapse

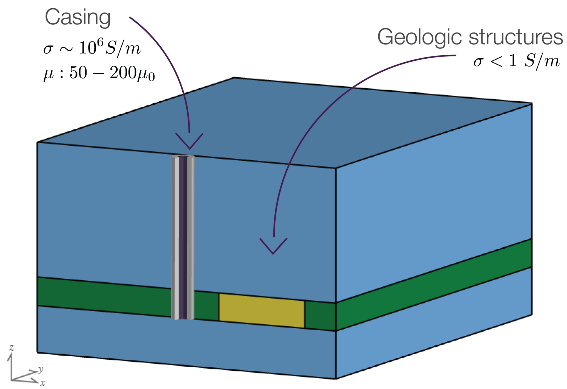
Water infiltration and slope stability

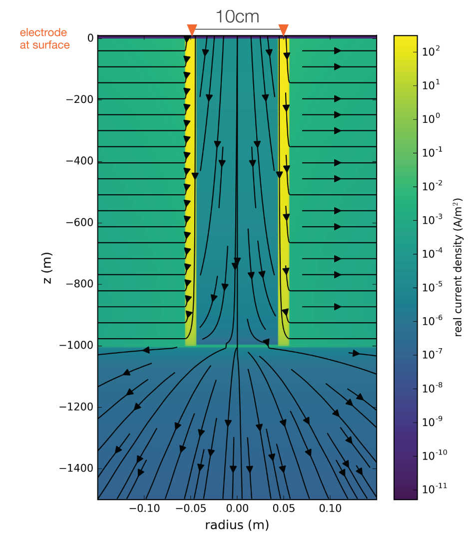


Florian Bleibinhaus

The Future: Large Contrasts

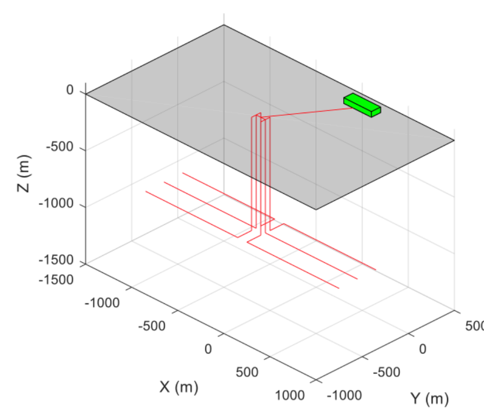
- Conductivity contrasts
- Permeability contrasts
- eg. Steel Casing
  - Mechanism for getting current to depth
  - Challenges:
    - Scales
    - Physical properties

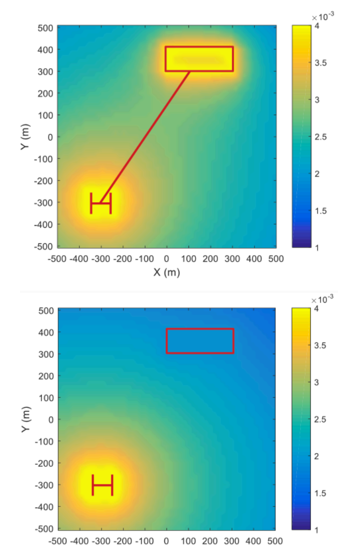




Corrosion

eg. Sudbury basin

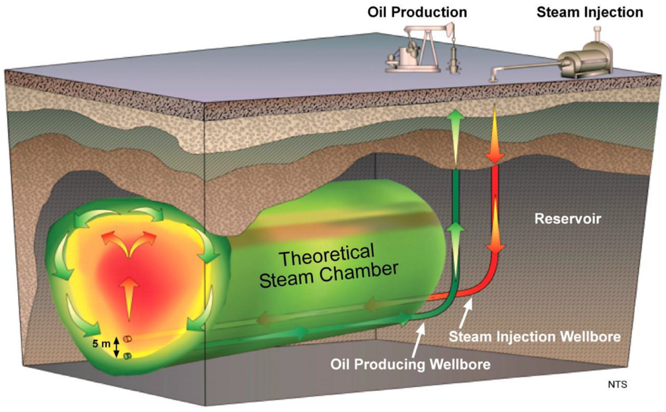


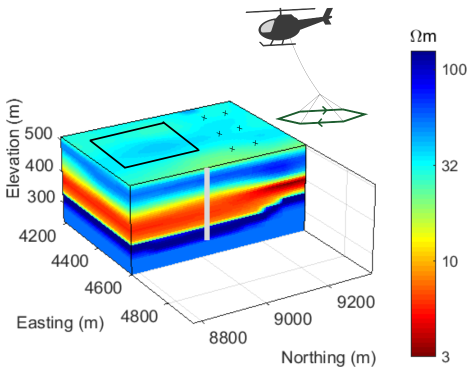


Monitoring: Choosing the appropriate survey

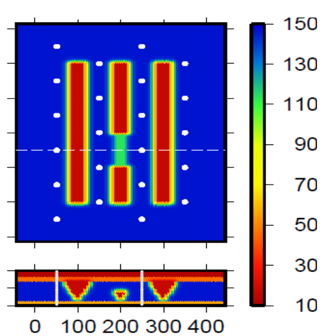
Different EM surveys needed to answer different questions

SAGD (Injection and monitoring steam flooding)

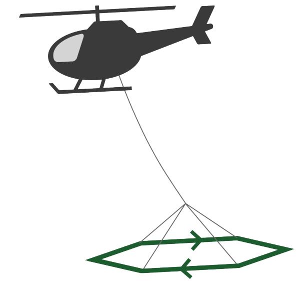


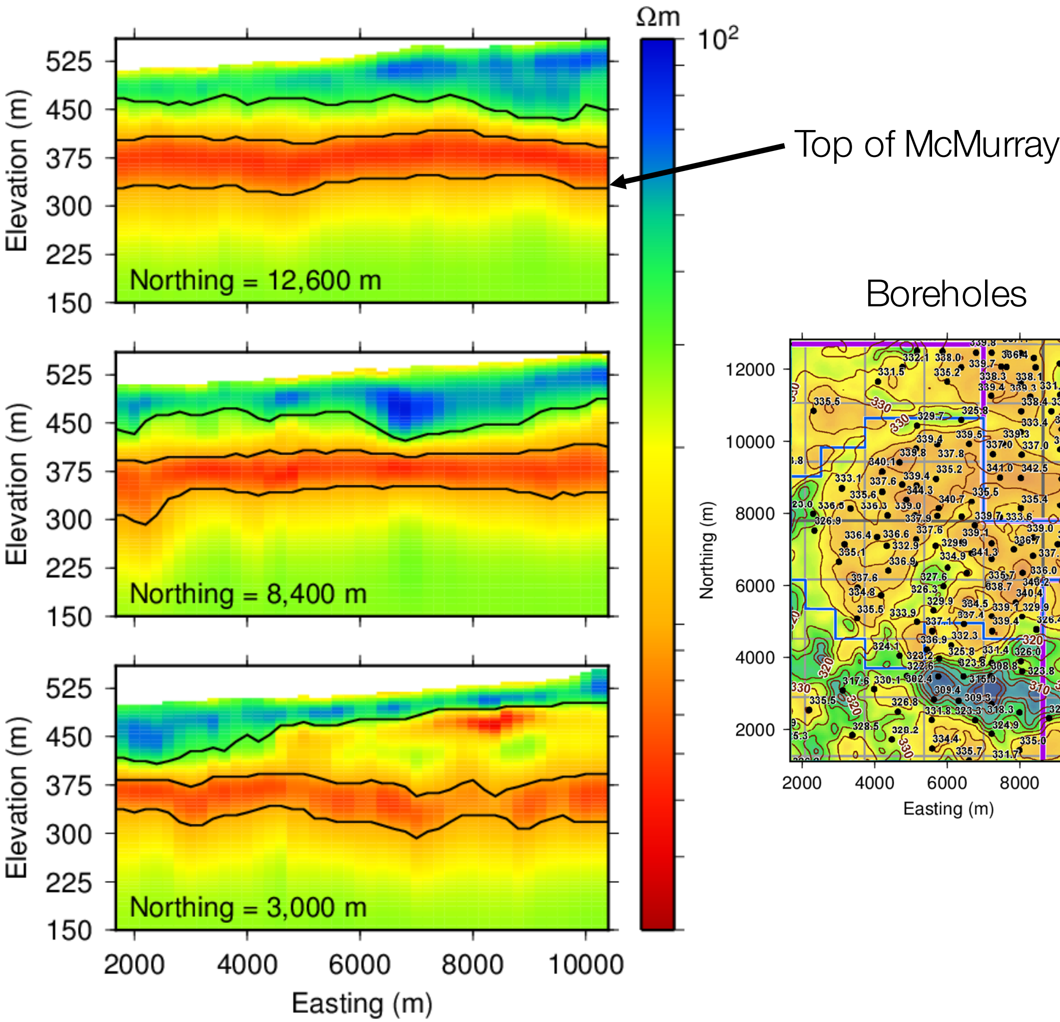


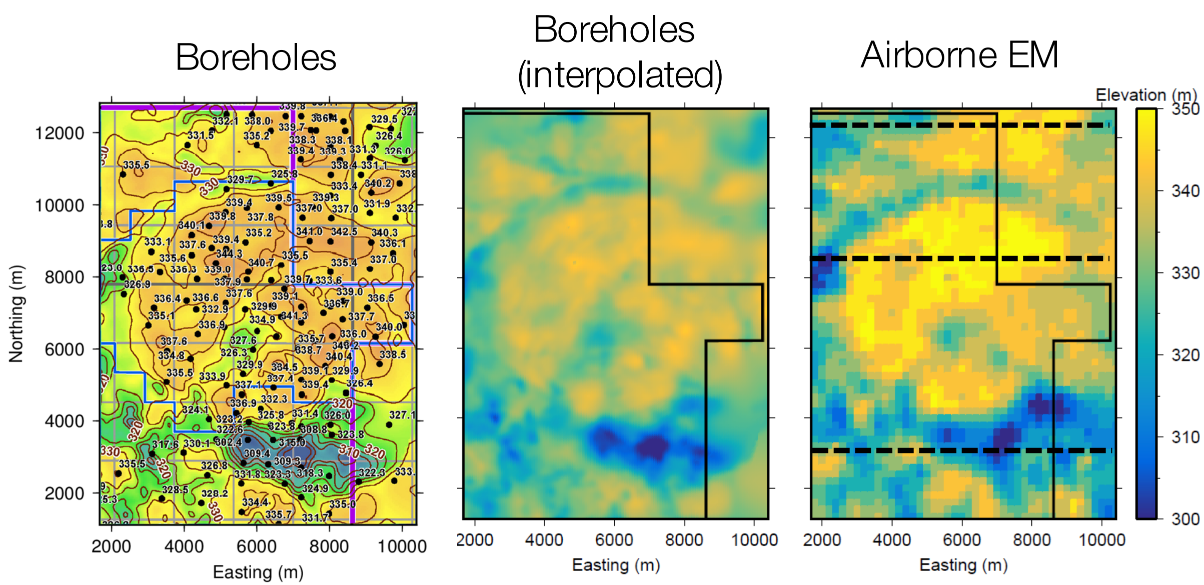
- Stage 1: Airborne reconnaissance survey
- Stage 2: Surface and borehole for pre-injection
- Stage 3: Monitoring array



Large scale reconnaissance (SAGD)

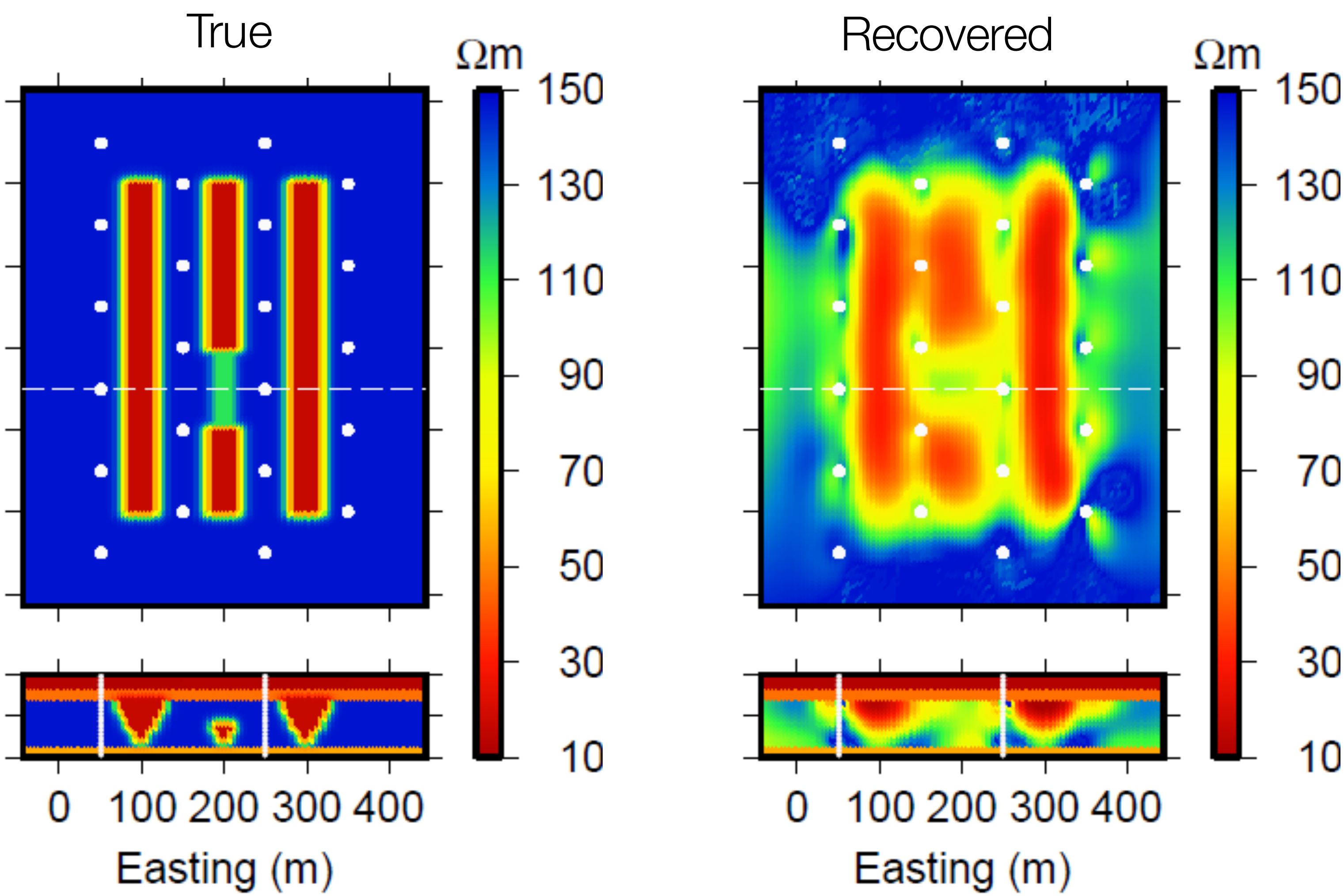






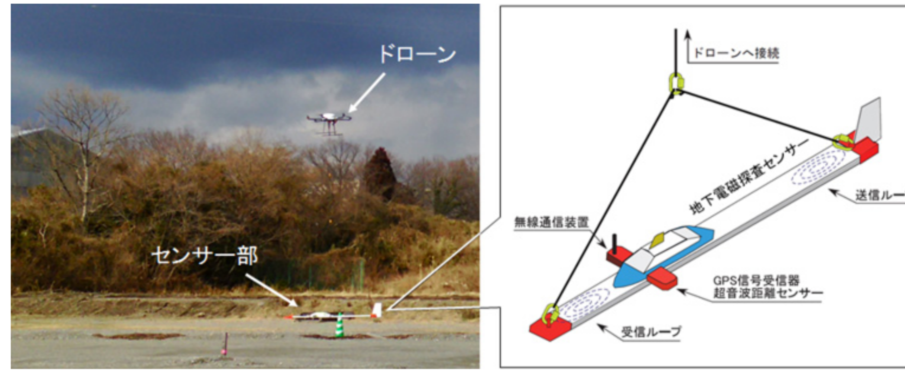
Multi-stage EM for monitoring

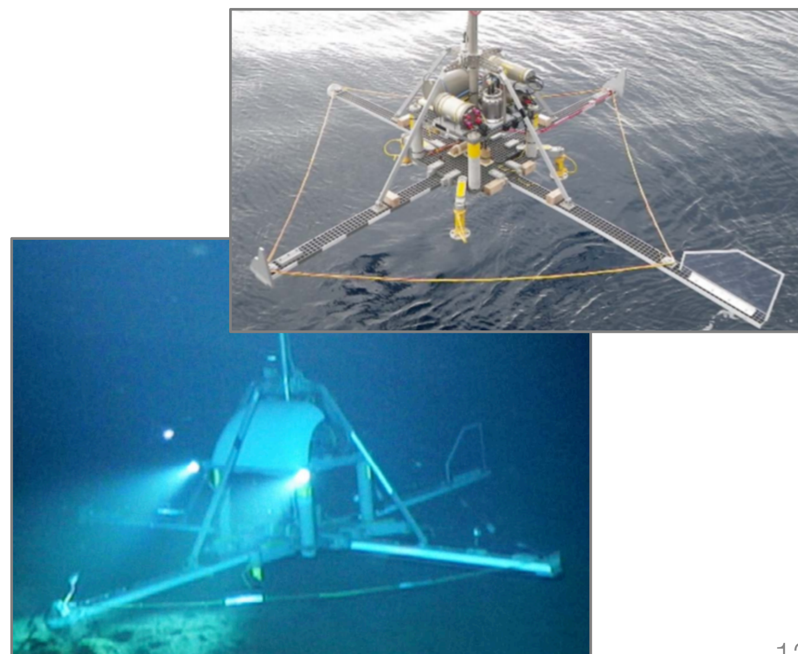
Post-injection: surface sources, borehole receivers



The Future: High Quality Data

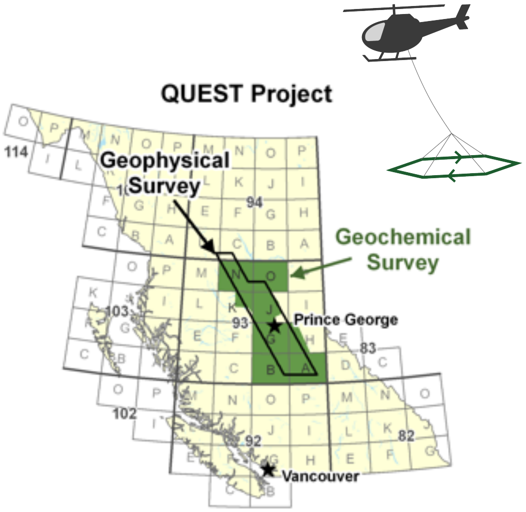
- Improved instrumentation
  - Lower noise
  - More power
  - Better control on transmitters and receivers
    - Current waveform
    - Filtering parameters
    - Position and orientation
    - Higher sampling rates
    - …
- Data collection
  - Drones
  - AUVs
  - ROVs
- Mathematical modelling requires that we know all the details.



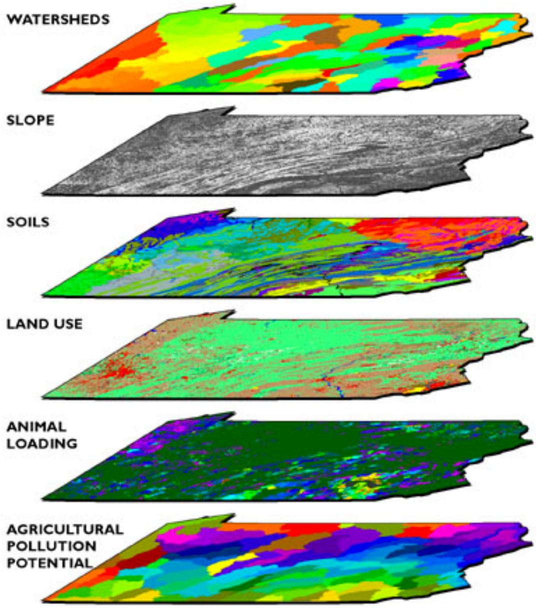


The Future: Lots of Data

- Big data
  - Multicomponent receivers
  - Many transmitters, receivers
  - High sampling rates
  - Large areas



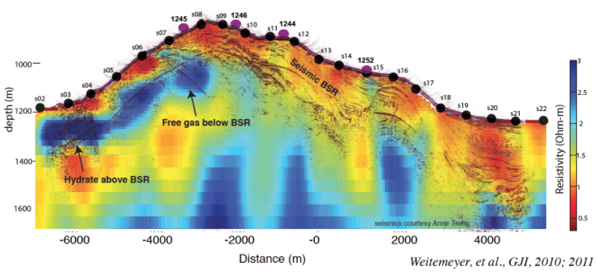
- Multiple types of data
  - geophysical surveys
  - Physical properties
  - Geochemistry
  - Geology
  - …

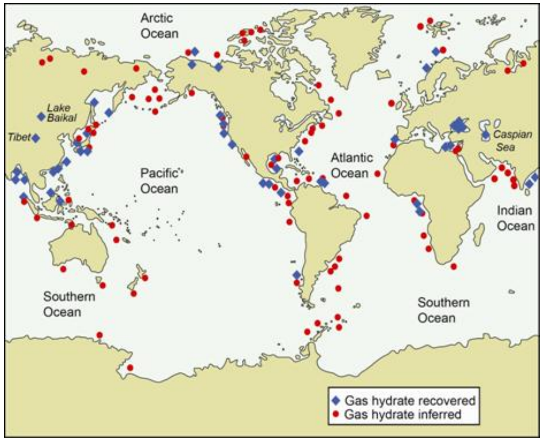


- Machine learning

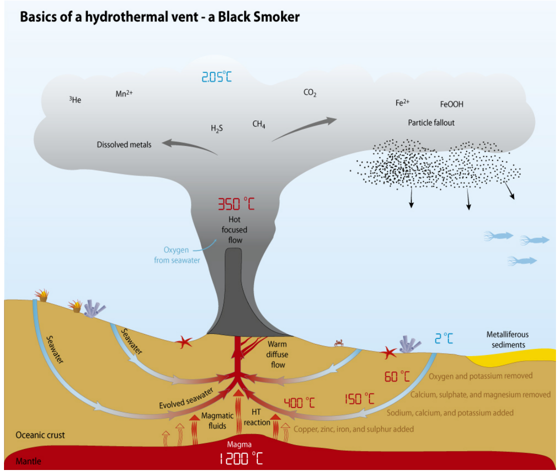
The Future: Marine EM

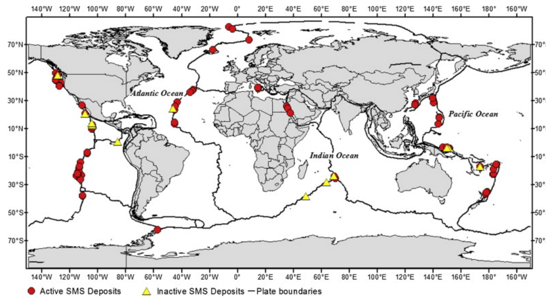
Gas hydrates



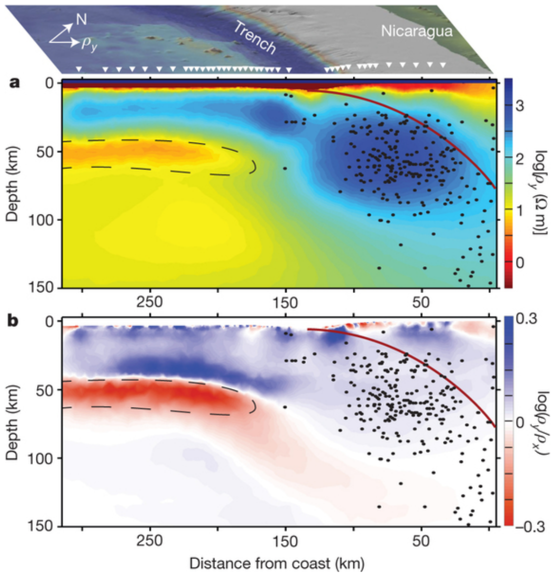


Seafloor massive sulfides





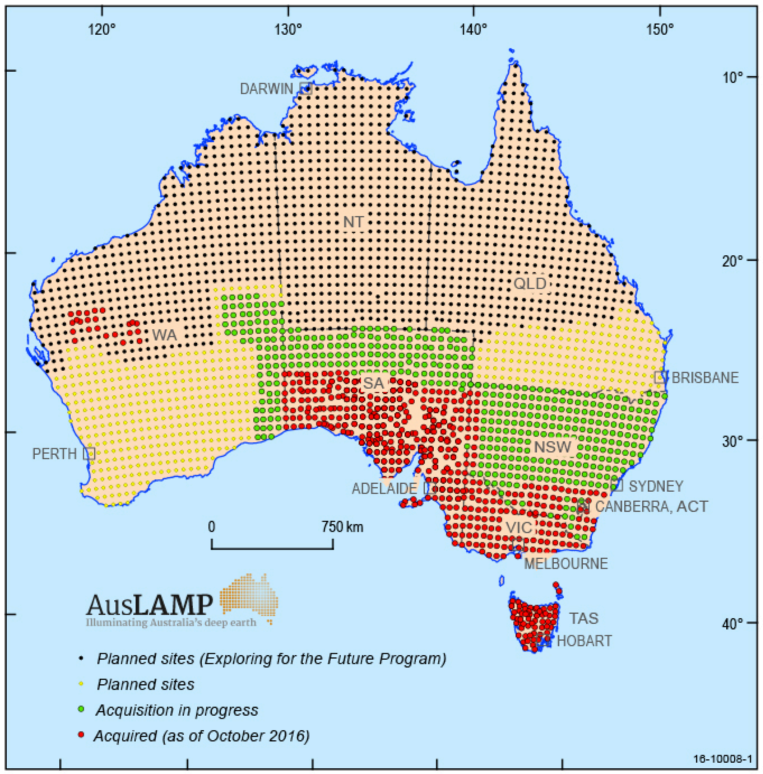
Tectonic studies, natural hazards



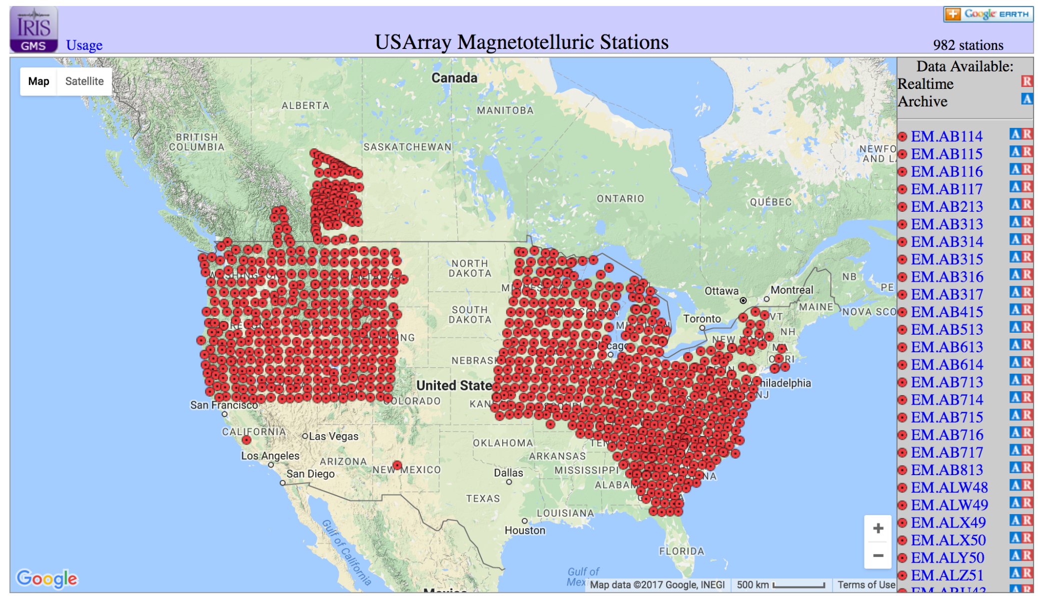
Naif et al., 2013

The Future: Large Scale EM

AusLamp

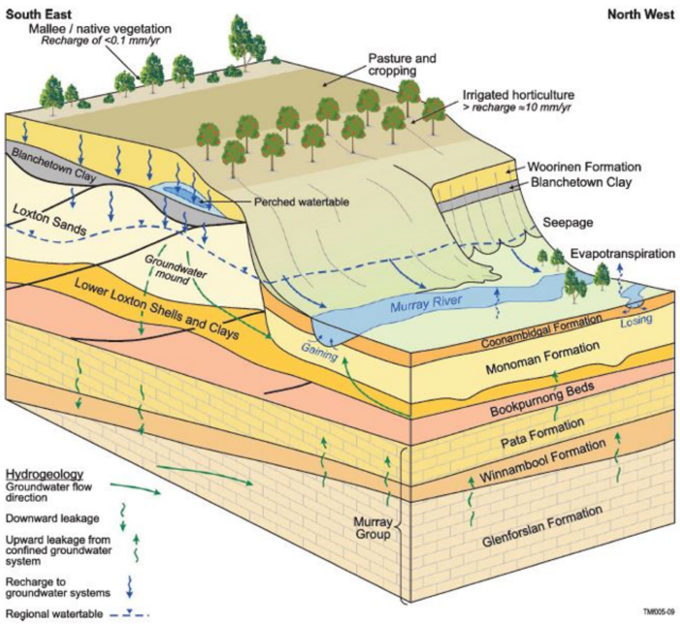


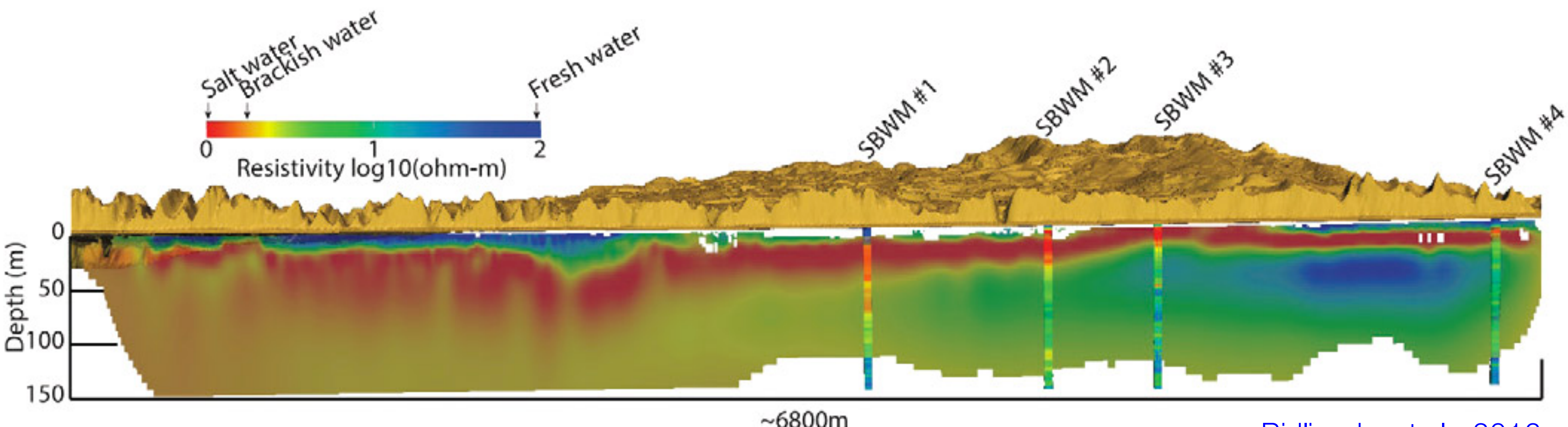
Earth scope



The Future: Water

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



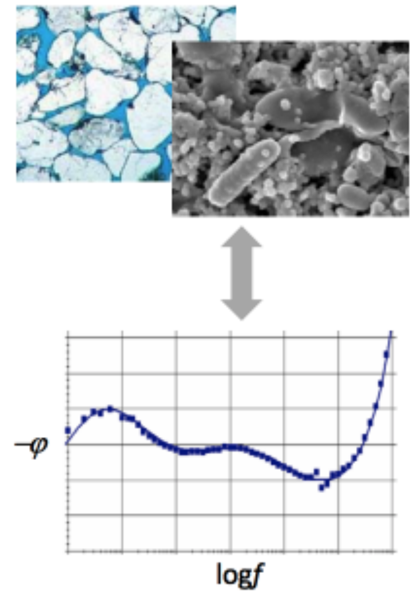


Pidlisecky et al., 2016

The Future: Physical Properties

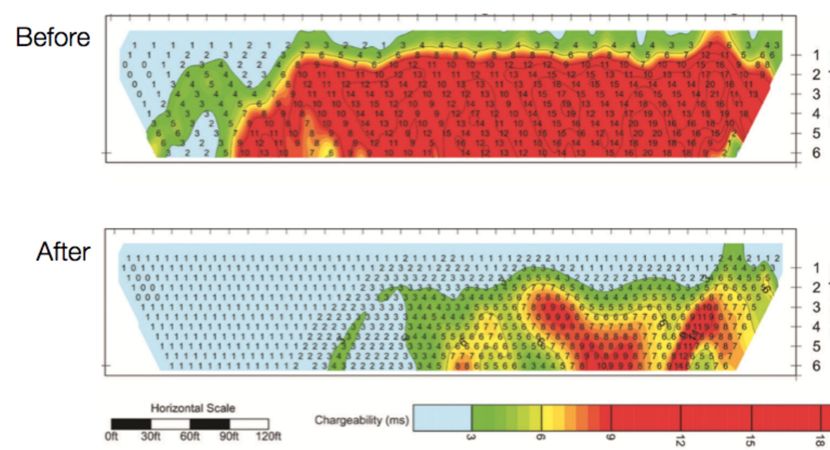
Dispersive Conductivity (IP)

- Ice / water, permafrost
- Organic materials
- Bioremediation
- Hydraulic permeability
- Characterizing materials based on spectral IP response



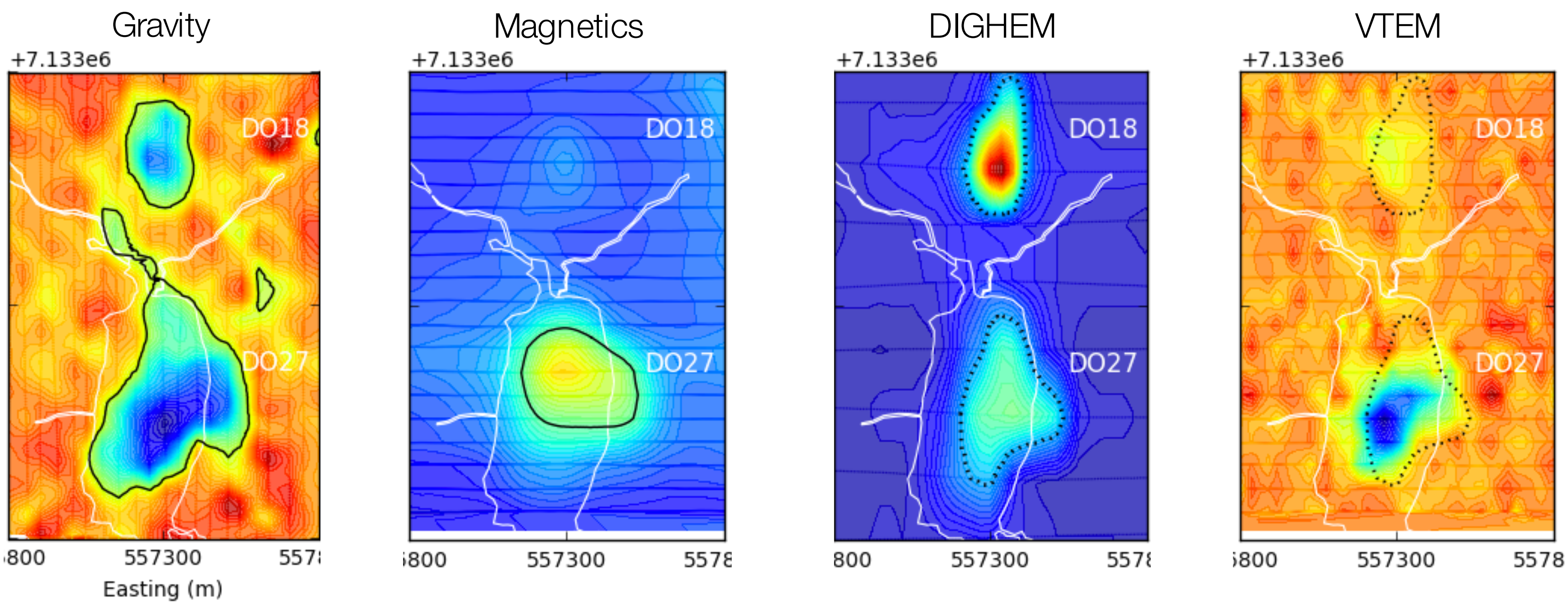
Dispersive Magnetic Permeability (Viscous Remanent Magnetization)

- Soils
- Bioremediation (?)

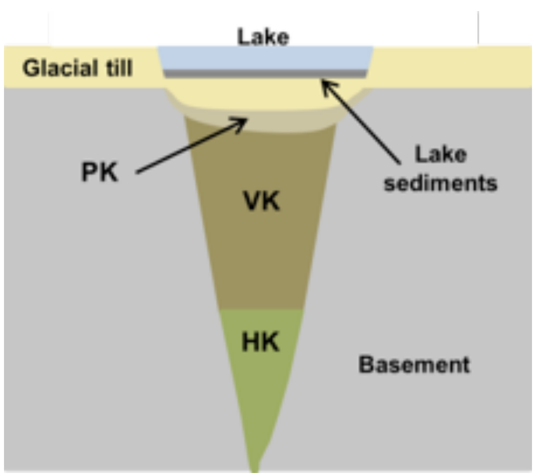


Numerical Modelling

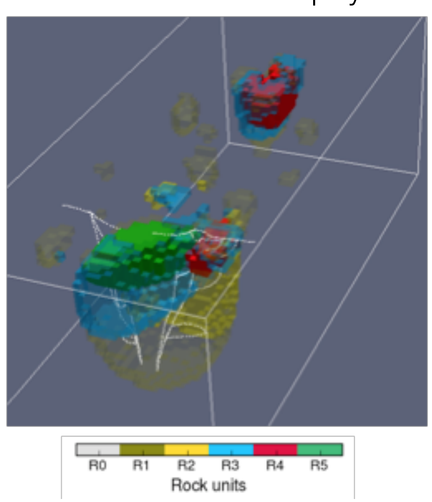
The Future: Data Integration & Multi-physics



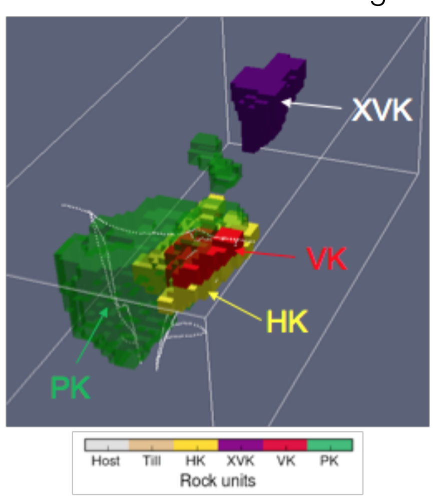
Kimberlite Model



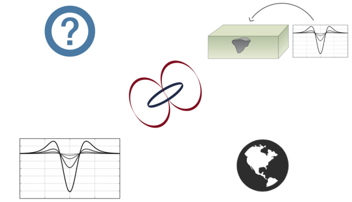
Rock Model from Geophysics



Rock Model from Drilling



The Future: Modelling and Inversion



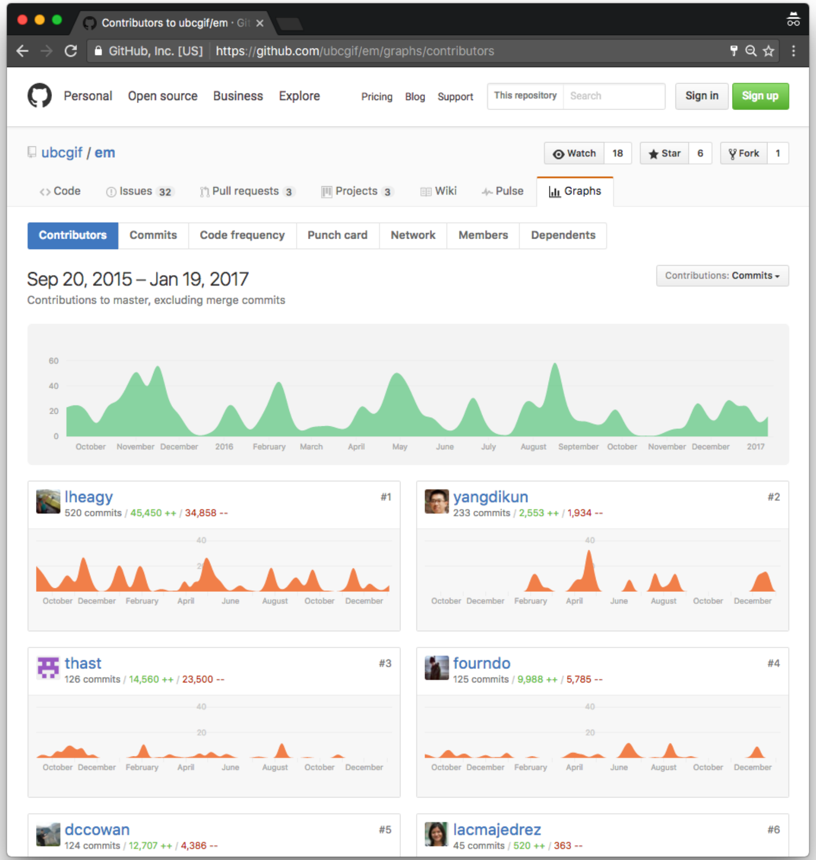
- HPC, Cloud computing
- Collaborative development
- Open source

simpeg

Simulation and Parameter Estimation in Geophysics
http://simpeg.xyz

pyGIMLi

Geophysical Inversion & Modelling Library



Github	Travis CI	Jupyter	Creative Commons	Python
versioning, collaborating	testing, deploy	interactive computing	licensing, reuse	computation

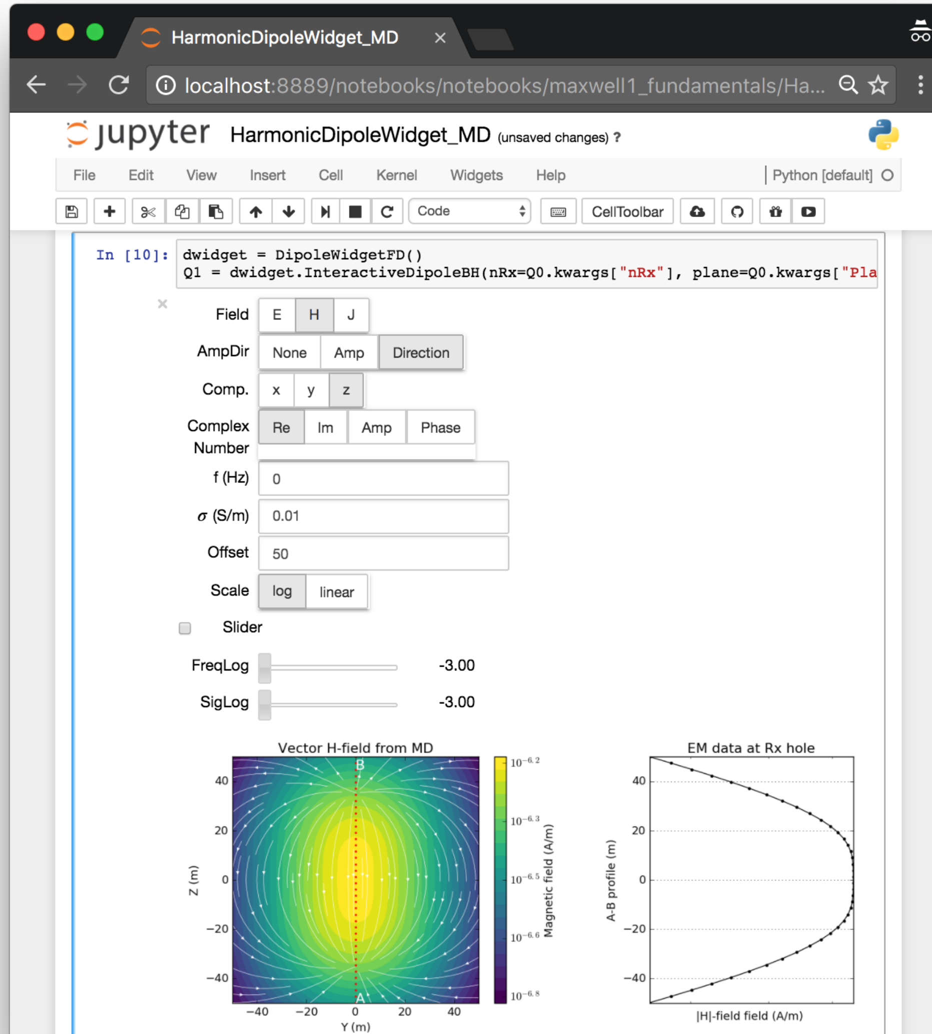
The Future: Modelling and Inversion

- Interactive computing
- Visualization

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

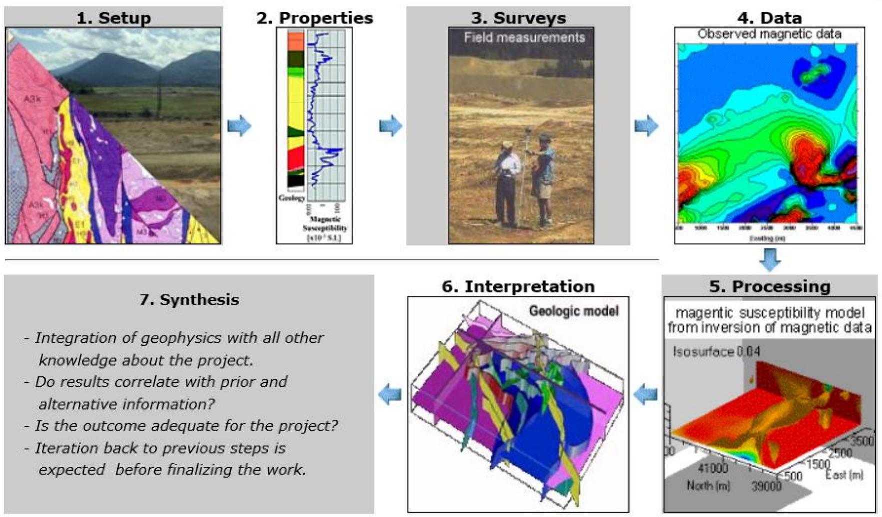
$$\nabla \times \mathbf{h} = \mathbf{j} + \frac{\partial \mathbf{d}}{\partial t}$$

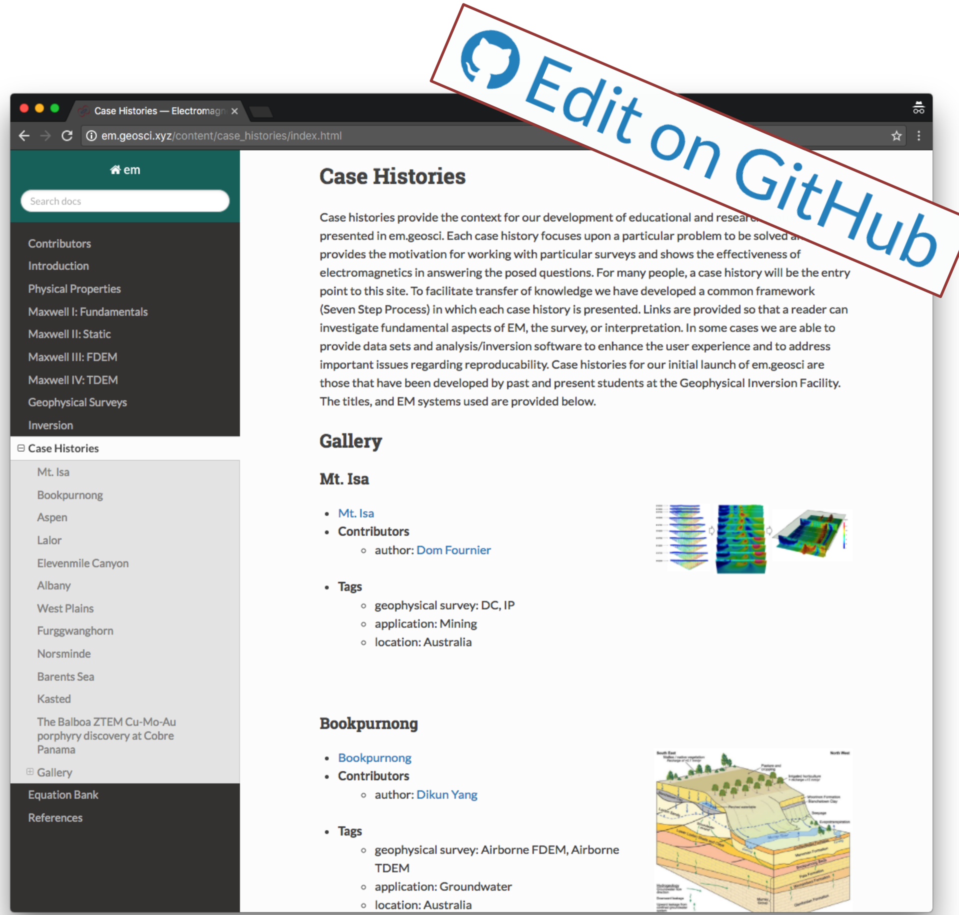
simpeg



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

The Future: Collaboration





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

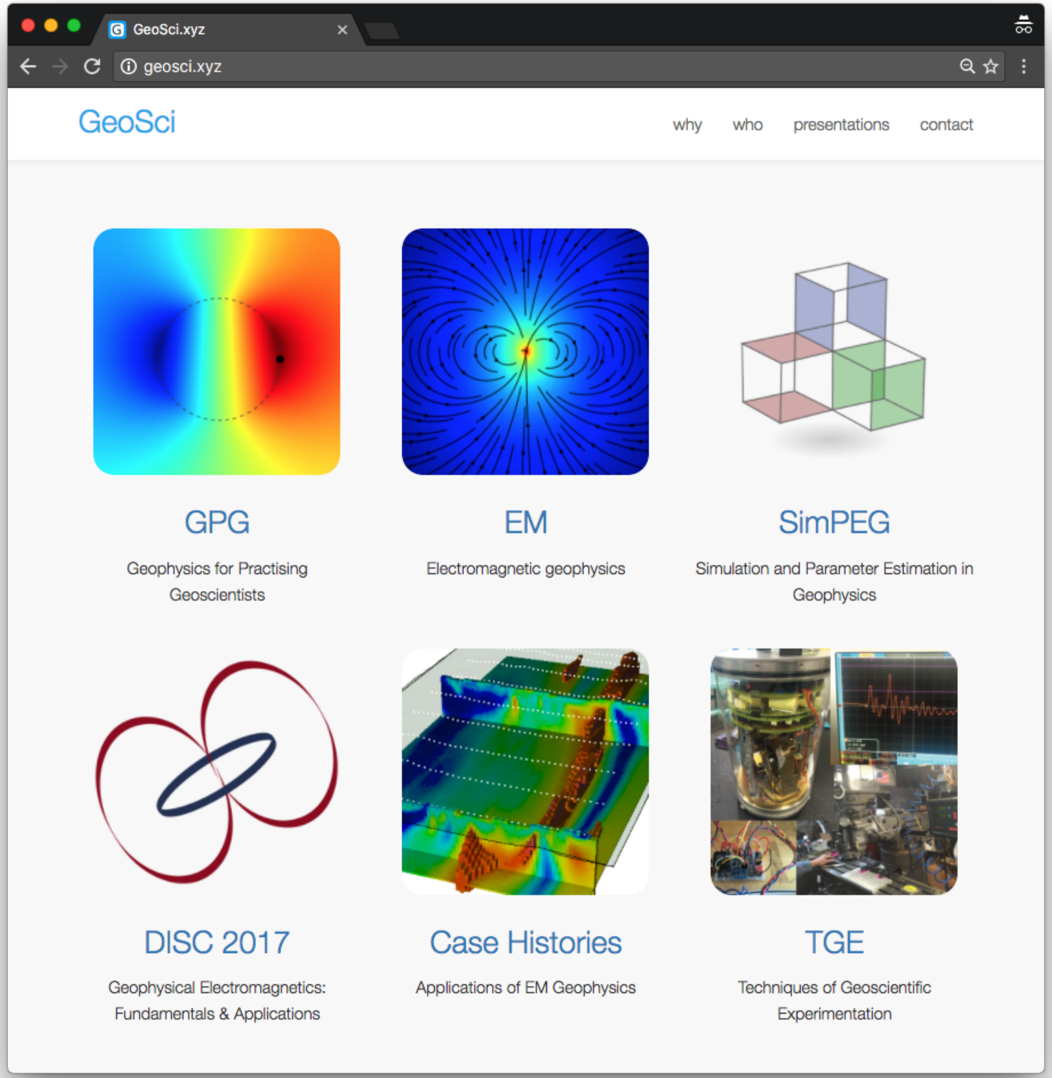
- GeoSci

  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

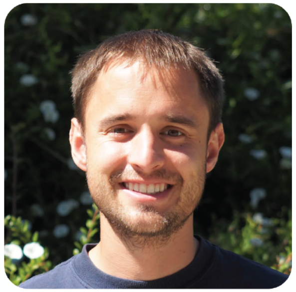

Devin


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


minerals


contaminants


water


geothermal


geotechnical

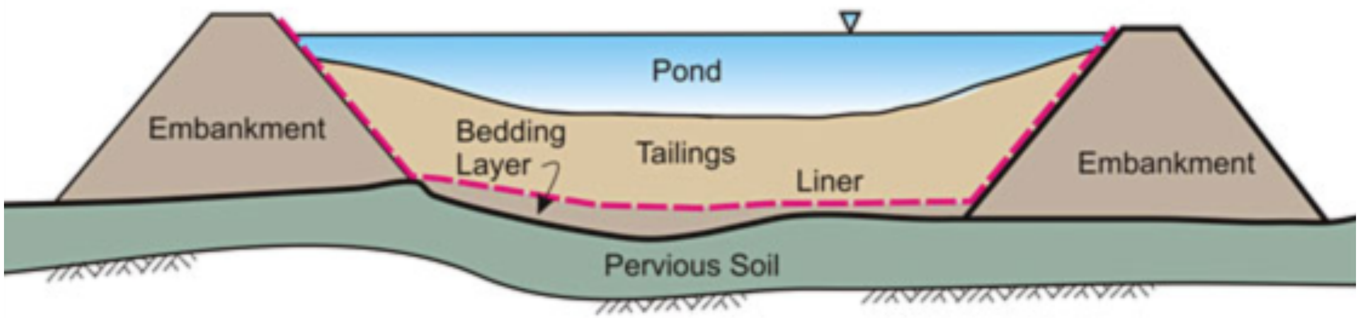

slope stability


hydrocarbons


unexploded ordnance

The Future: Monitoring

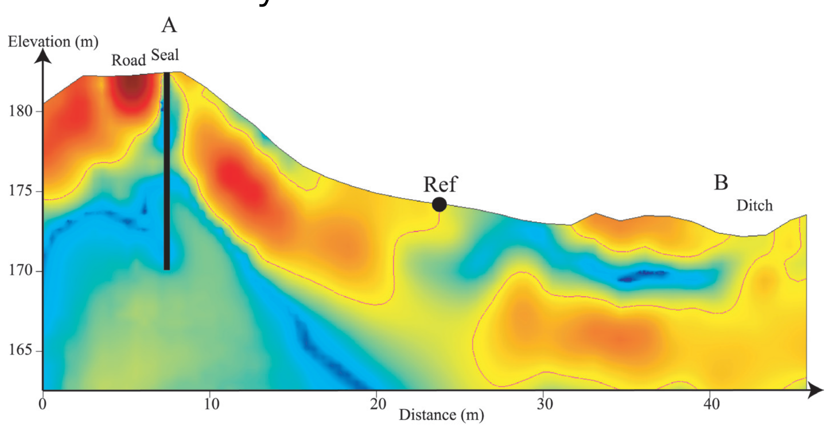
- Tailings Dam: How do we monitor?



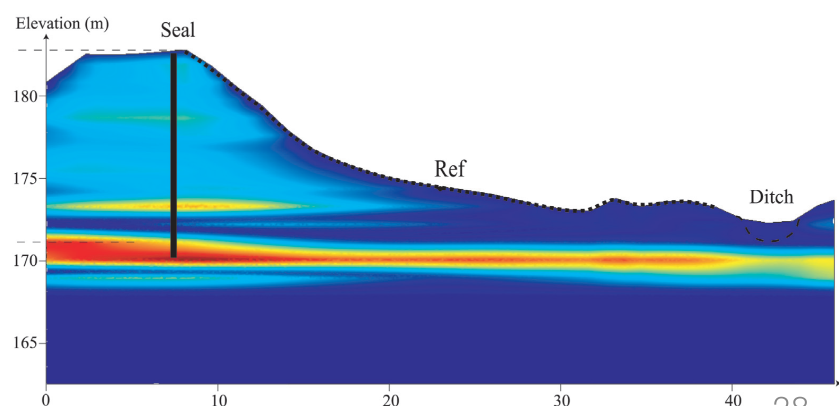
From the GARD Guide

- Self-potential and DC for monitoring Dam integrity

Conductivity

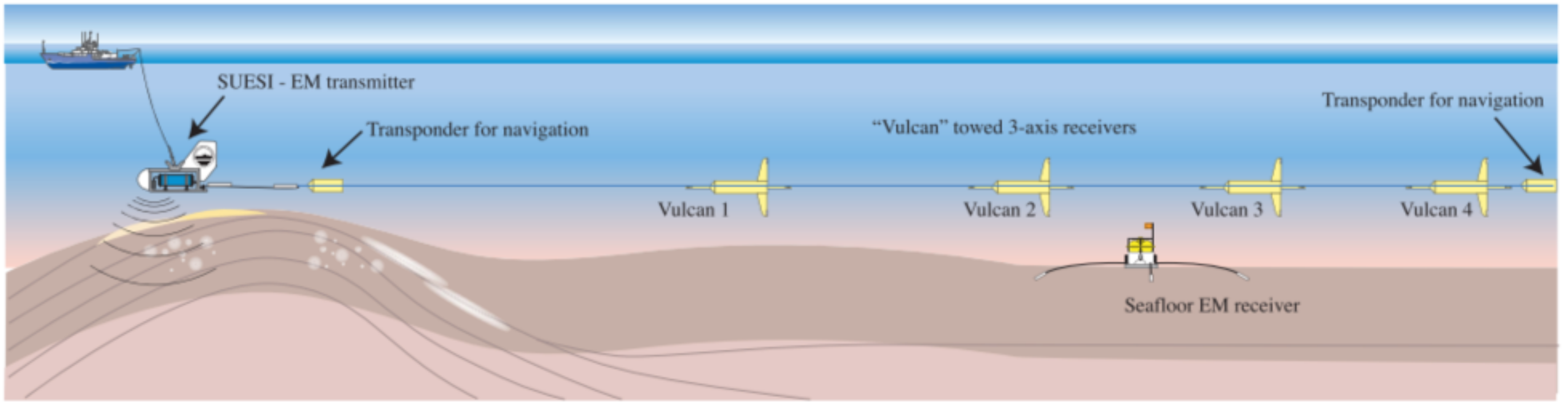


Streaming current



The Future: Marine EM

- Grounded source:
  - E.g. Vulcan system (towed + ocean bottom receivers)



Constable et al., 2016

- Inductive source:
  - E.g. Waseda Univ. (towed coincident loop; similar to AEM)