Electromagnetic/microseismic array technology for reservoir monitoring & exploration

KMS Technologies

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Array technology
Outline

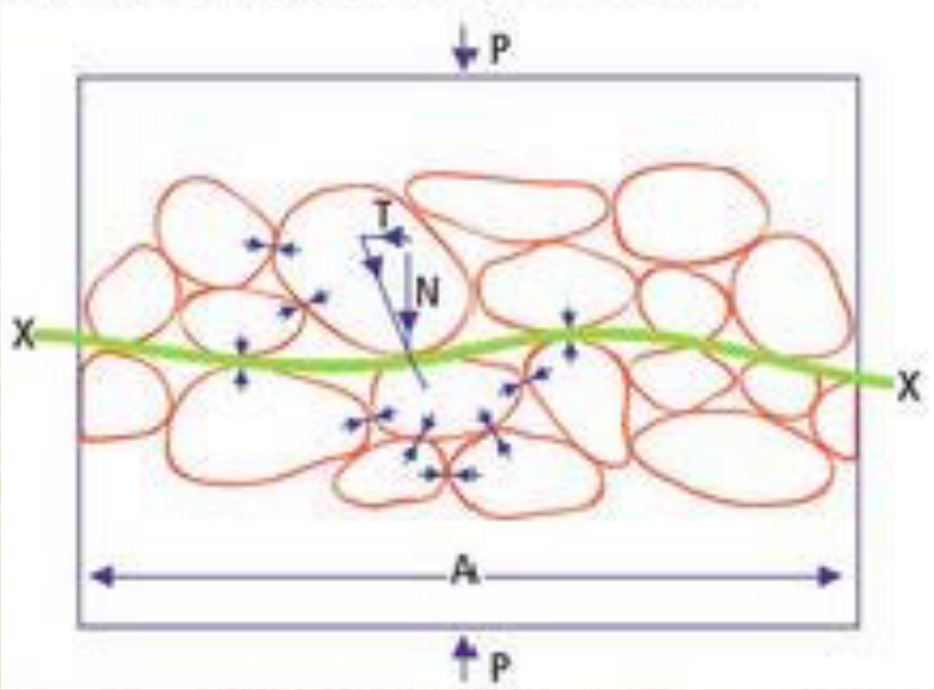
- Background
- Array multi-physics acquisition architecture
- Examples:
  - Monitoring
  - Geothermal
- Conclusion

History

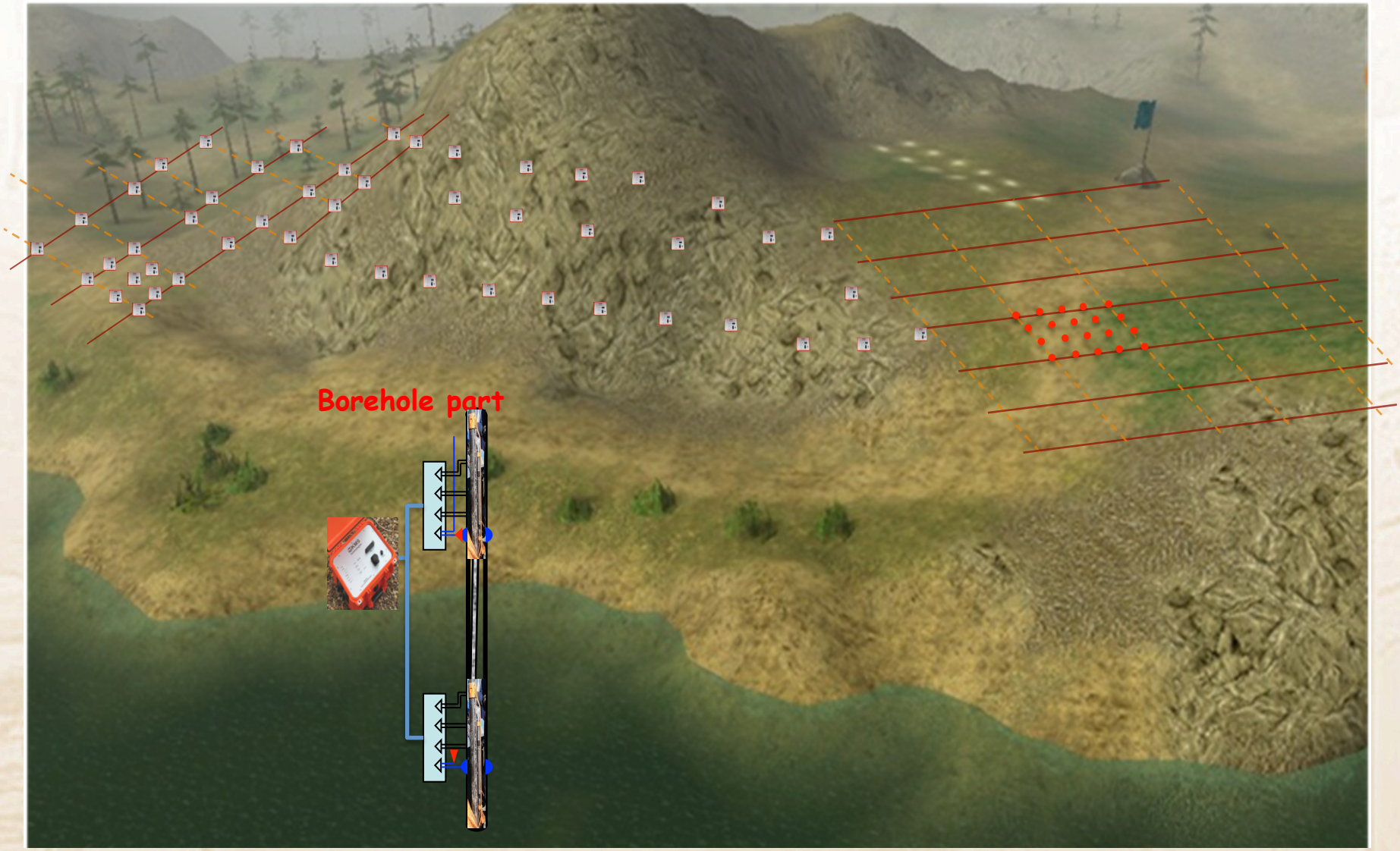
- 1980s - many EM methods standard for geothermal exploration
- >> 2010 - Only magnetotellurics remains as workhorse
- since 1990 - many routine microseismic recordings
- since 2010 - induced seismicity monitoring becomes common
- 2010 - new array technology microseismic/EM on the market
  applications in Thailand, Kenya, Iceland, Hungary etc.

Status for geothermal applications

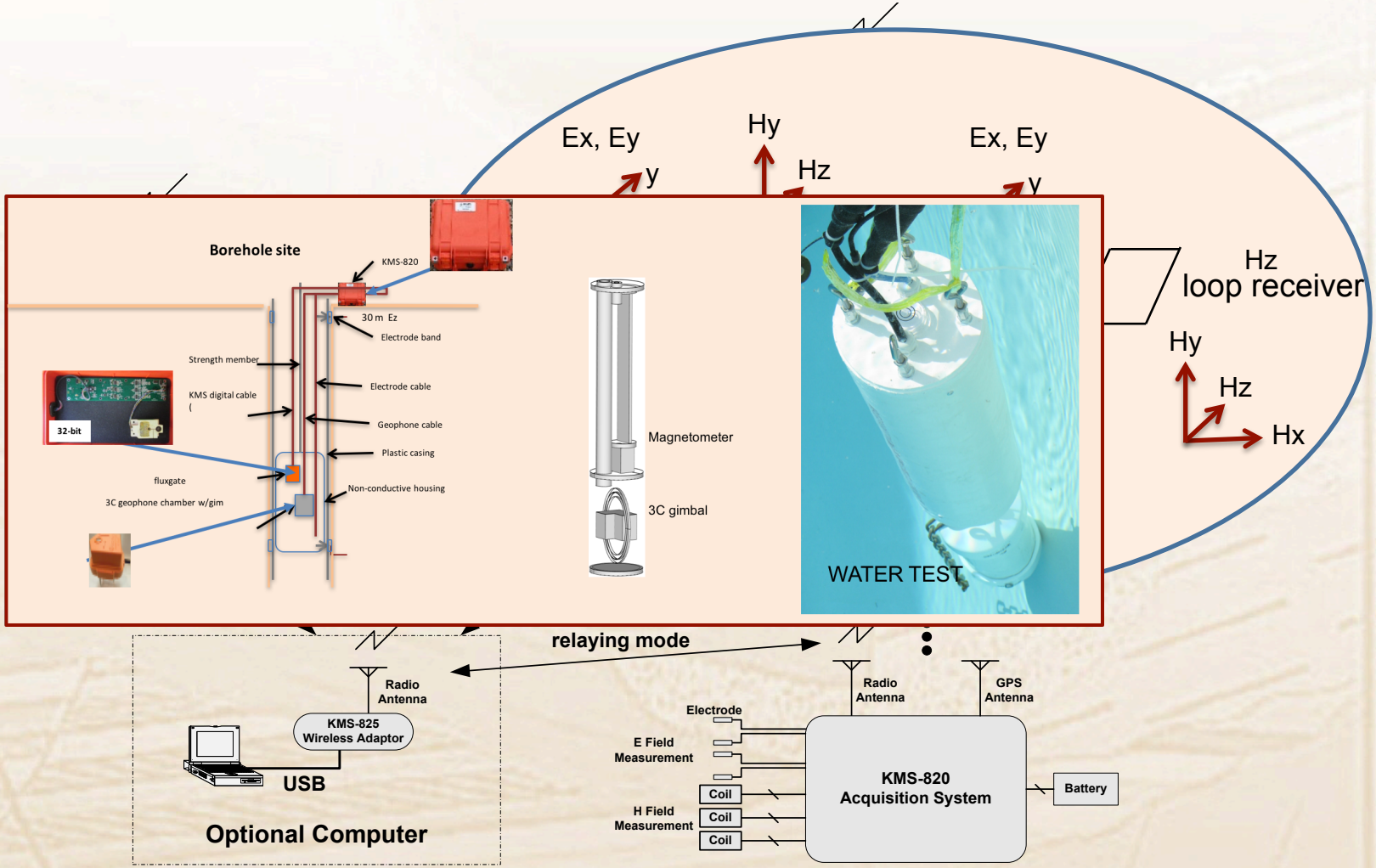
- Magnetotellurics is standard tool for geothermal exploration
- Combinations of multi-physics finds geothermal targets
- New array technology → more data, better quality, 3D Images
- WHY microseismics / EM?
  - Fluid movement
  - Induced seismicity monitoring



Objective: applicable for ALL exploration scenarios & monitoring



Architecture & hardware: original 2009 design UPDATE



Array receiver: Microseismics, magnetotellurics & Controlled Source EM

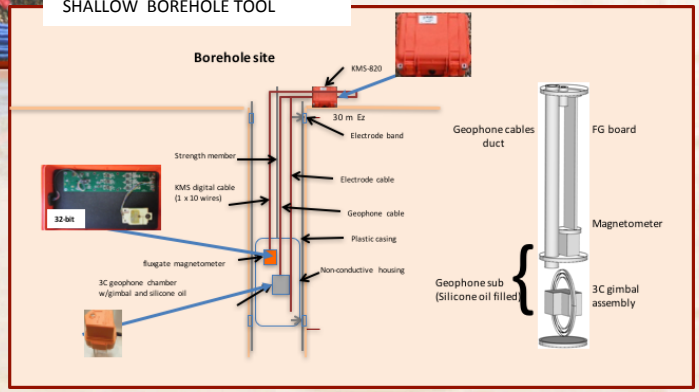
MARINE

Node
on deck

Combined seismic & EM node
For 2 months operation

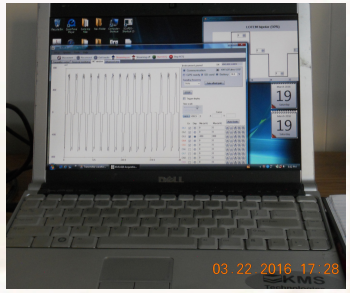
DEEP BOREHOLE

SHALLOW BOREHOLE TOOL

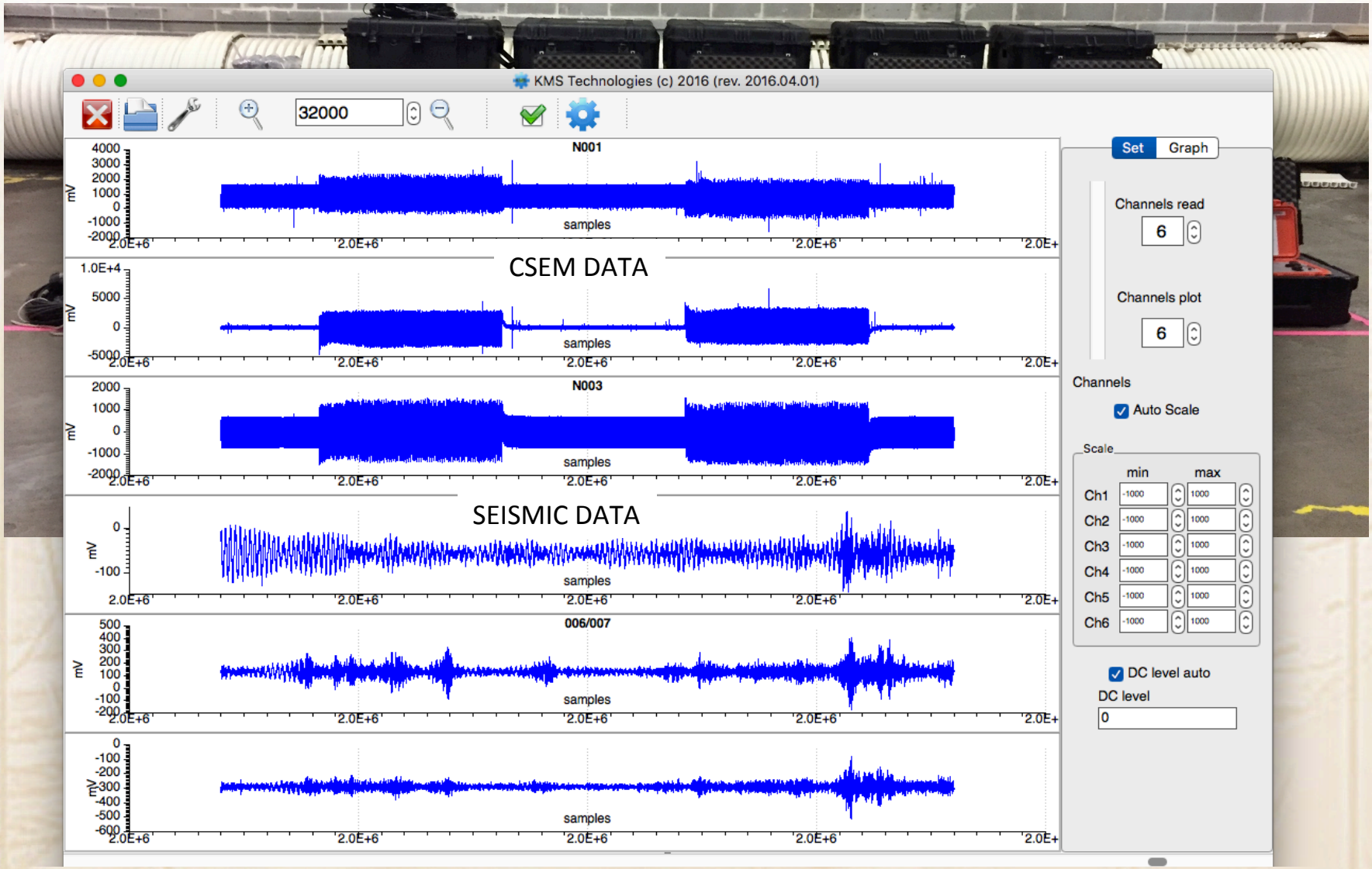


TRANSMITTER

KMS-5100 Transmitter – 100/150 KVA 2016

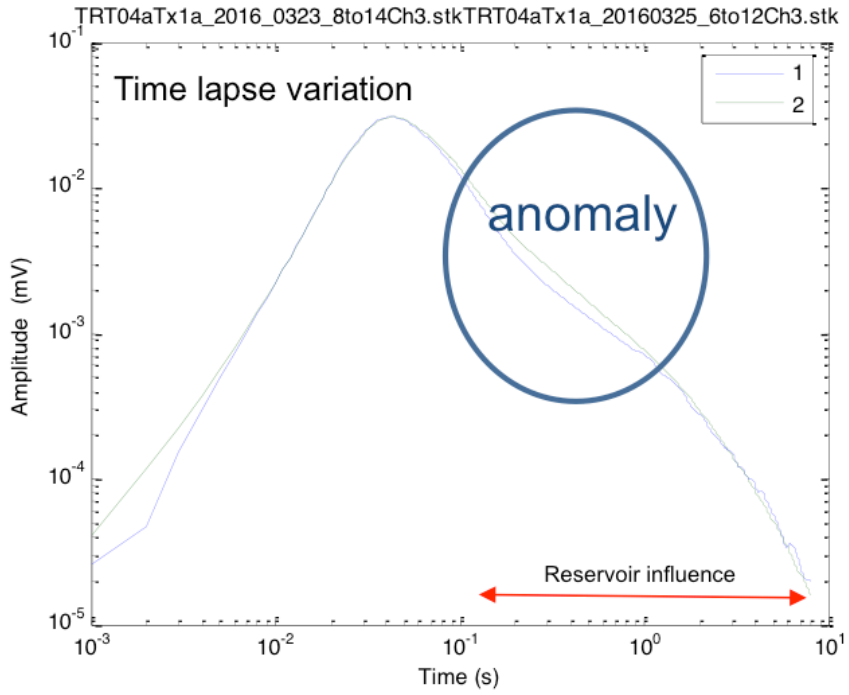


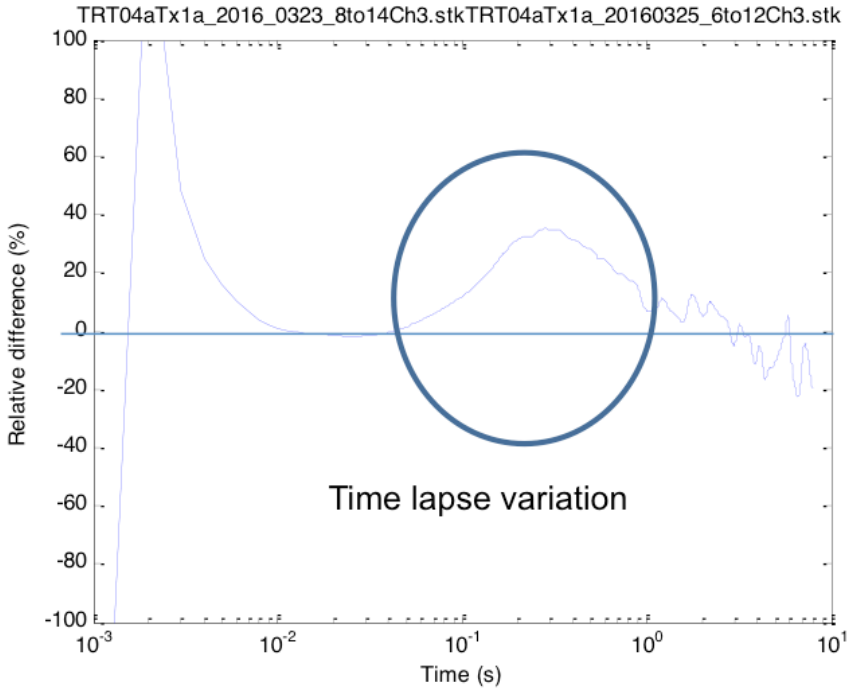
A 195 channel system for microseismic EM monitoring



Reservoir Monitoring: Example layout & water flood time lapse result

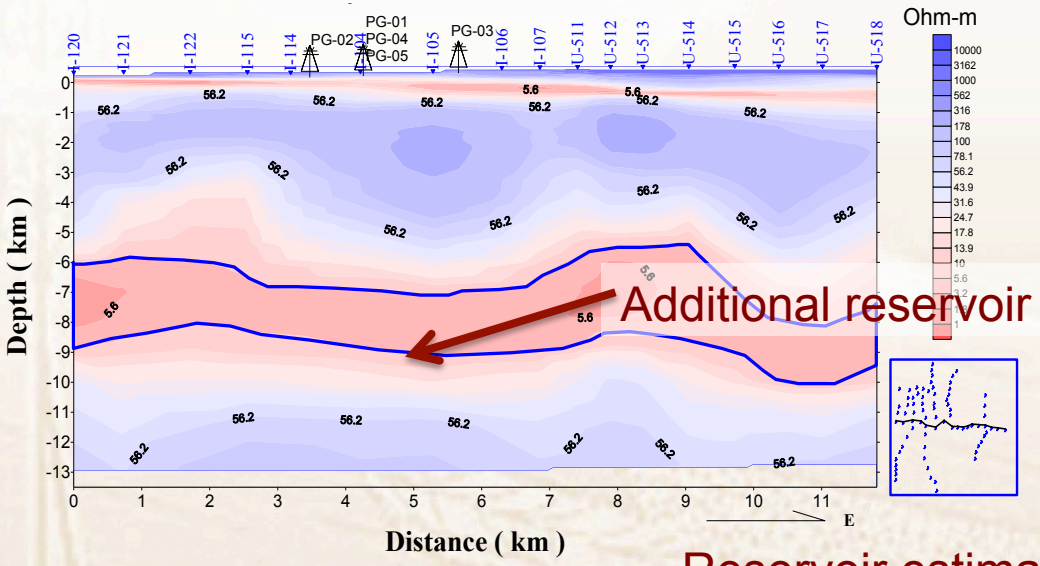
Magnetic field SHOULD see the injected water.

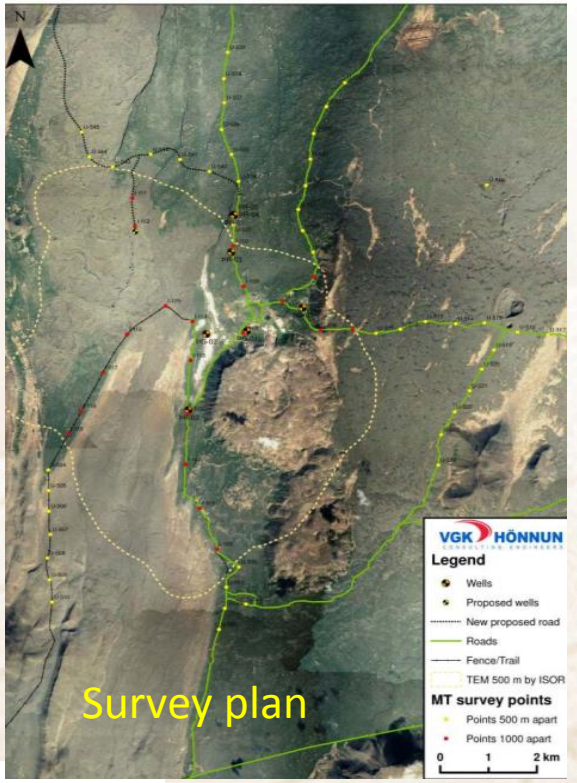




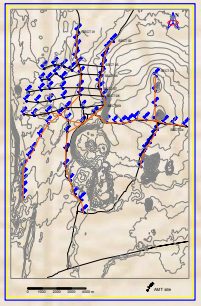
Shallow Borehole Tool – KMS-888
includes 3C seismic, 3C magnetic & 3C electric sensors

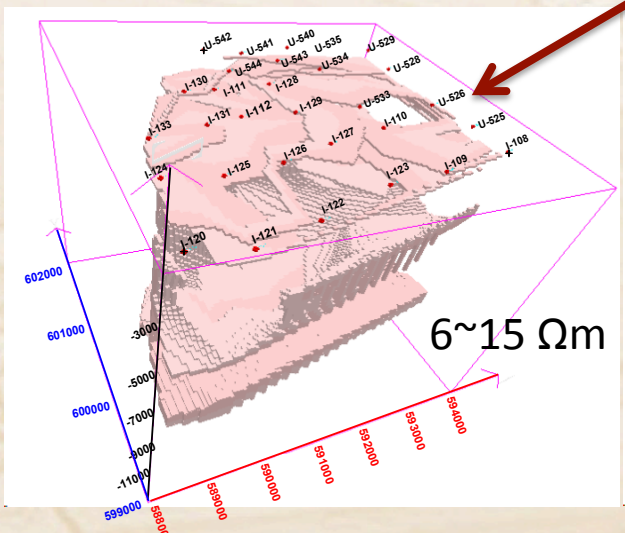
Iceland: additional reservoir & reservoir estimates

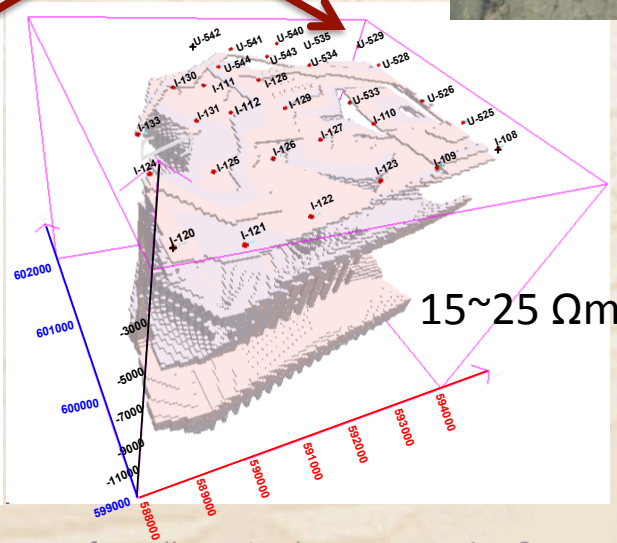




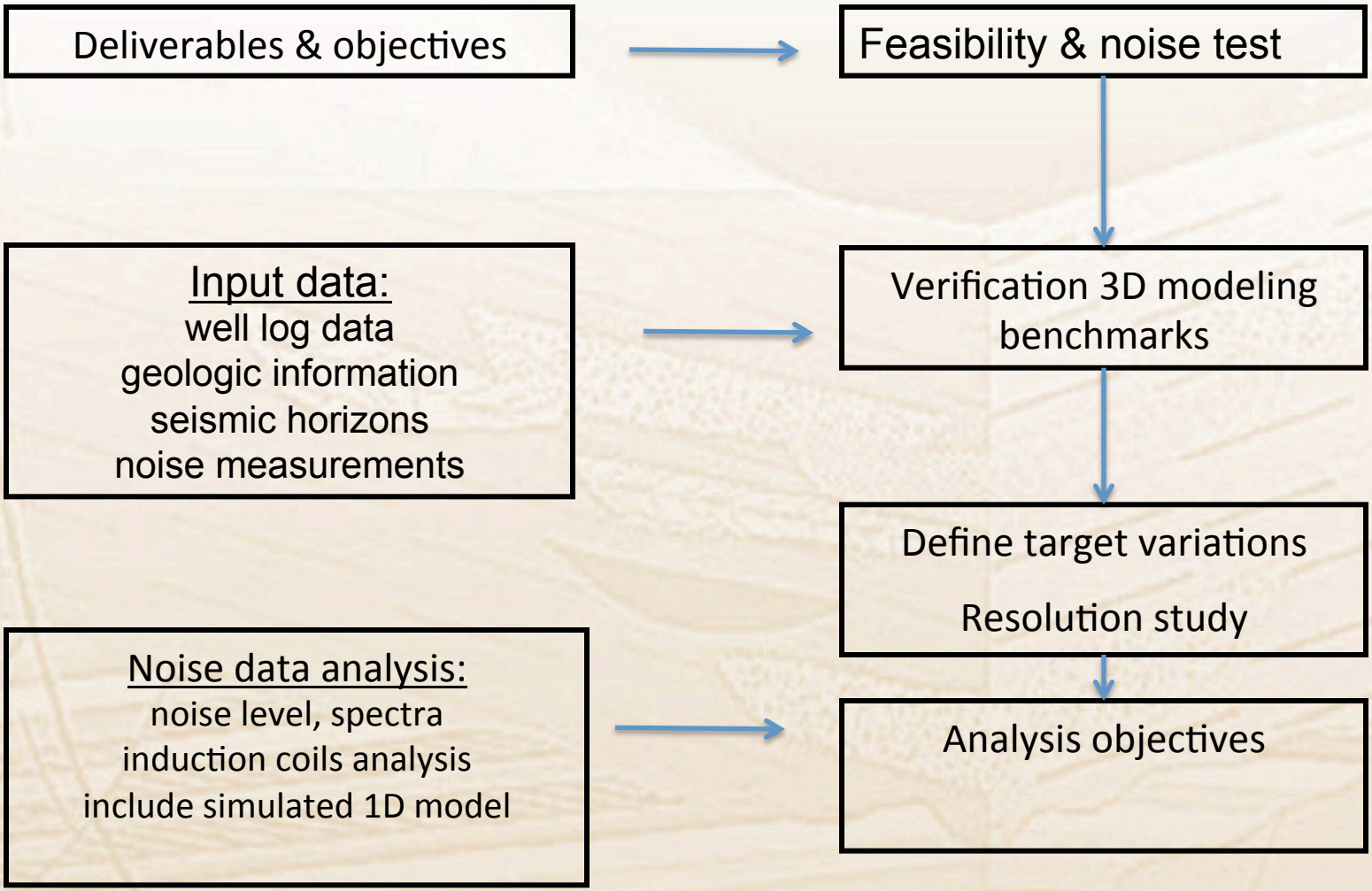
Reservoir estimates



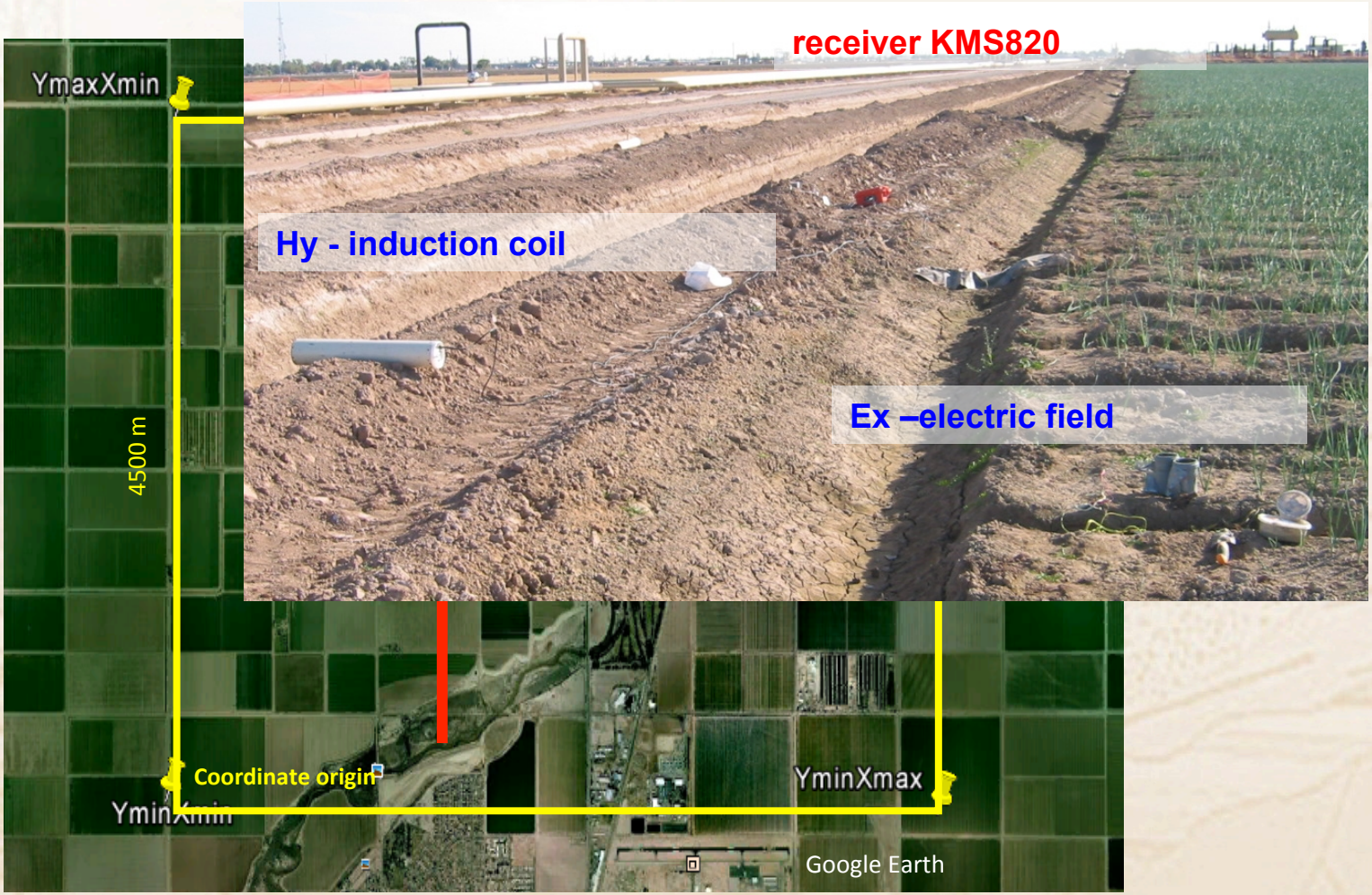




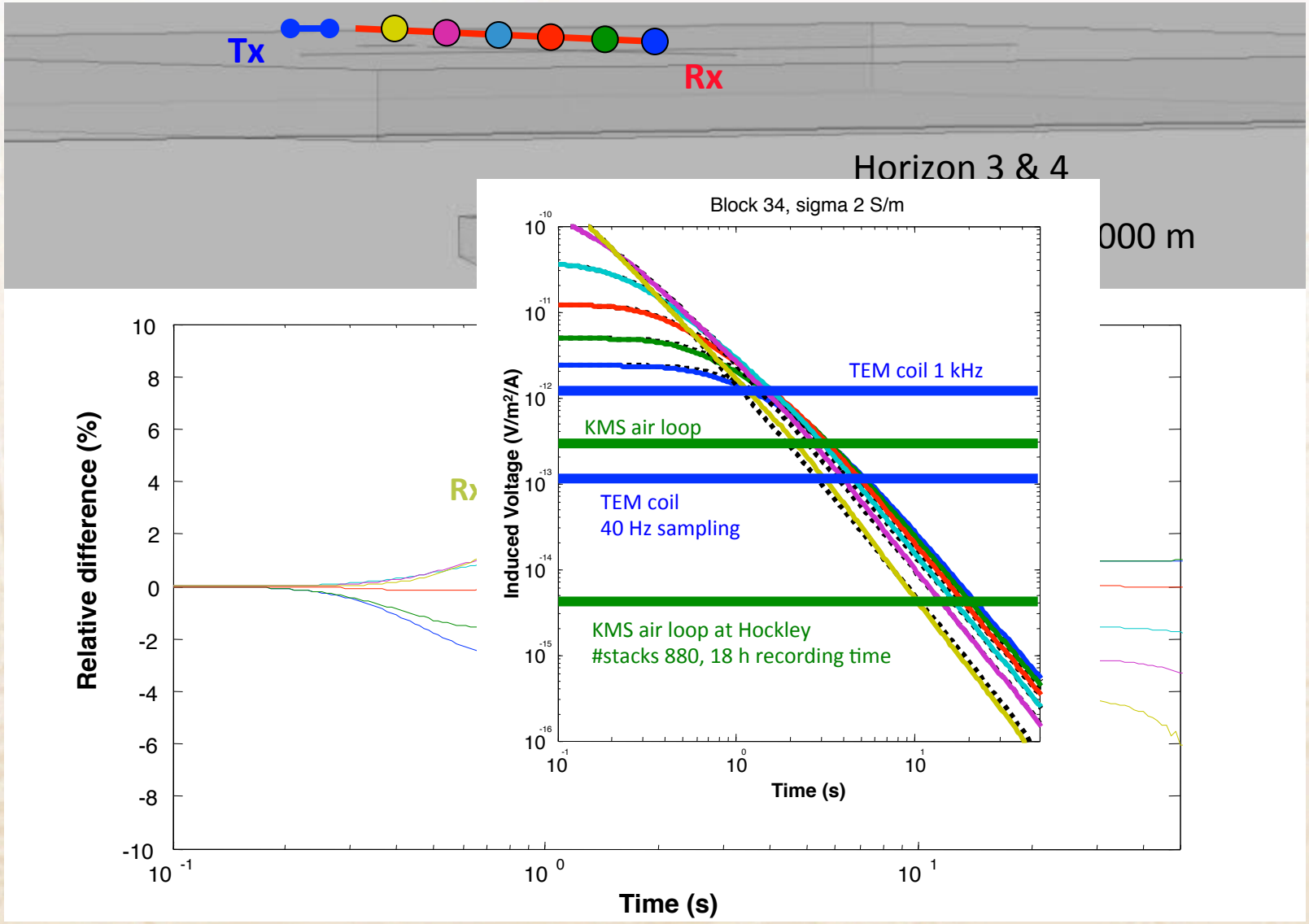
Monitoring project overall Workflow



California: Area with seismic horizons



3D reservoir: relative difference, SMALL block



- Microseismic/EM technology has matured over the past 30 years
- Revisiting CSEM is worth while
- Monitoring offers a great opportunity to combine microseismics/electromagnetics
- Sufficient examples exits to go to larger demonstrations