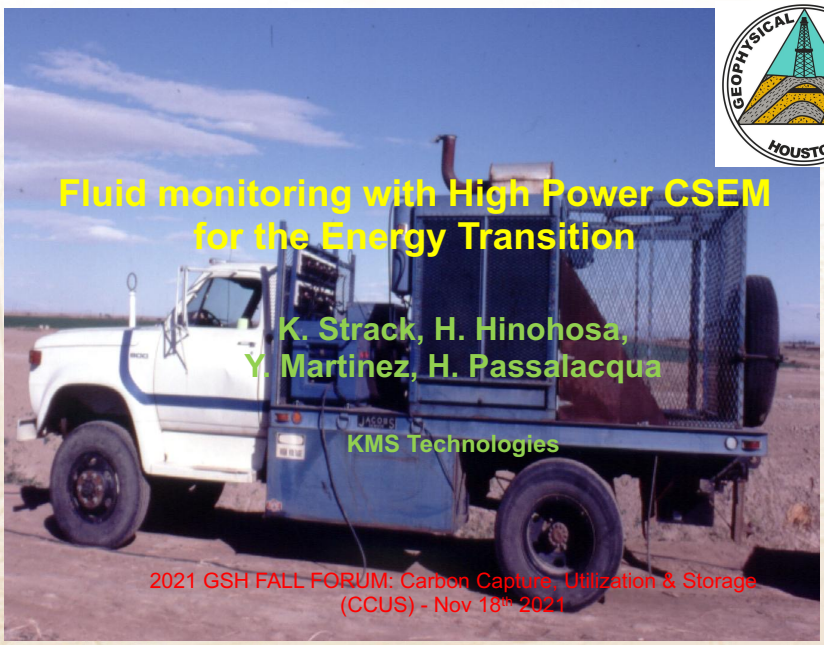

Fluid monitoring with High Power CSEM for the Energy Transition

K. Strack, H. Hinohosa,
Y. Martinez, H. Passalacqua

KMS Technologies

2021 GSH FALL FORUM: Carbon Capture, Utilization & Storage (CCUS) - Nov 18th 2021

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Setting the scene >> Technology >> Examples
Electromagnetics can immediately support Energy Transition

- **What are Energy Transition applications?**
  - **Support EV change over– battery material - mining**
  - **GREEN energy – geothermal**
  - **Reducing carbon footprint via CO_2 sequestration & EOR+**
- Others not shown here:
  - EOR → higher recovery factor → lower carbon footprint/barrel
  - Sub-basalt & subsalt imaging → lower environmental impact

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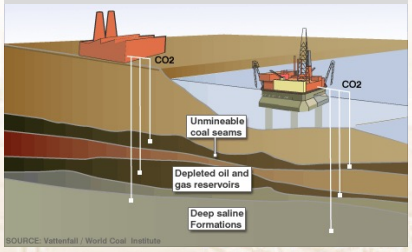
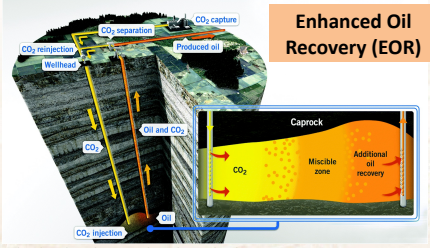
Setting the scene >> Technology >> Examples
Energy Transition: Lithium, Geothermal, & CO_2 storage in reservoirs

Carbon Capture Utilization, Storage (CCUS)



Enhanced Oil Recovery (EOR)



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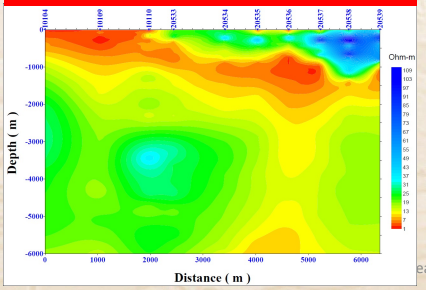
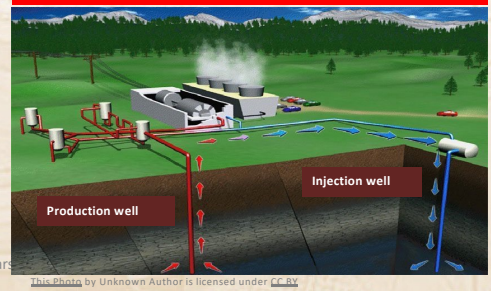
Geothermal Exploration



Geothermal Energy Production



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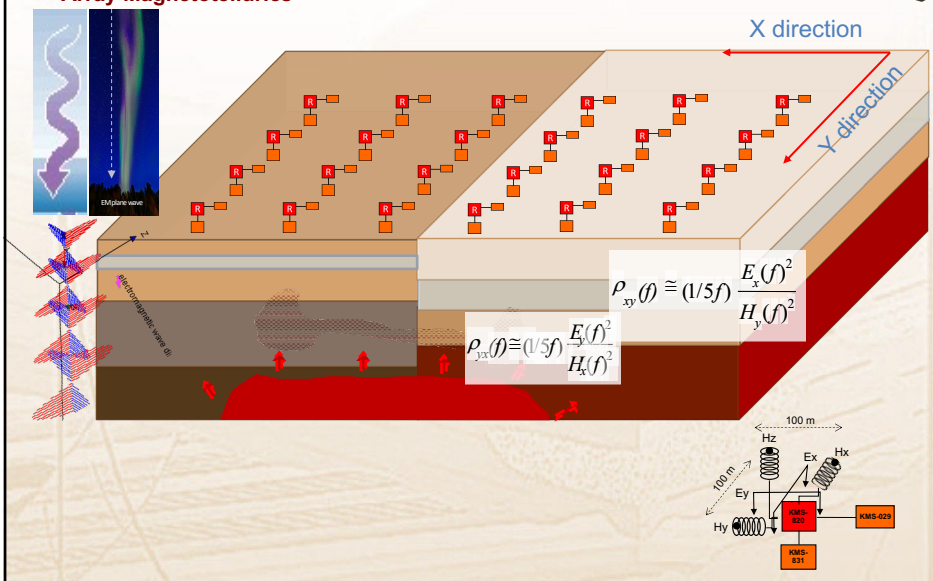
Setting the scene >> Technology >> Examples
Array Magnetotellurics



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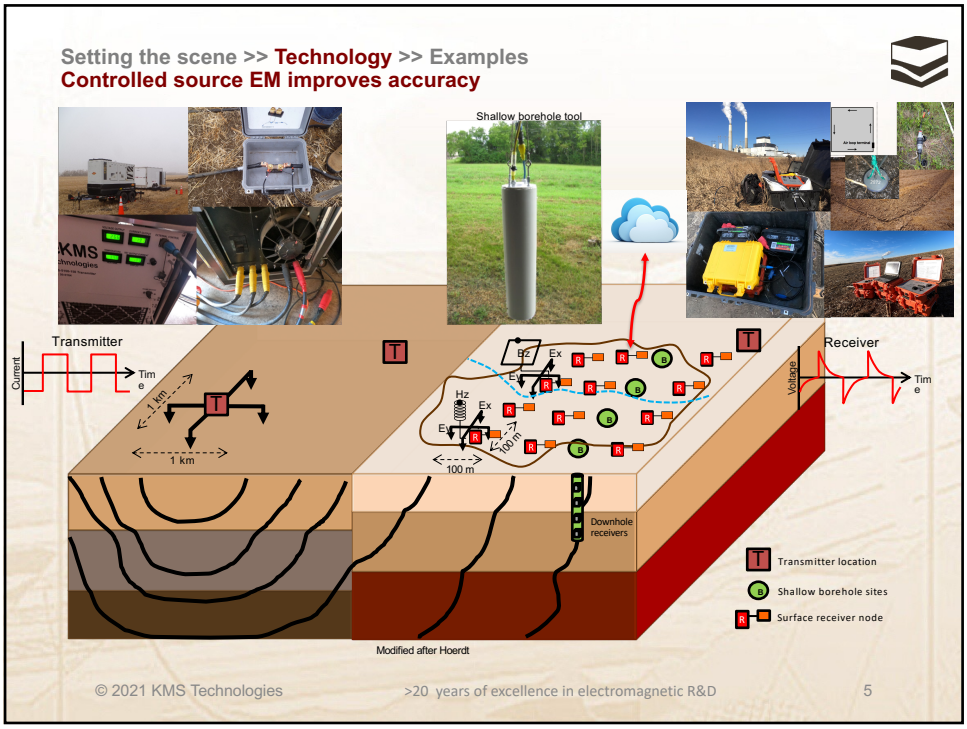
Setting the scene >> Technology >> Examples
Controlled source EM improves accuracy
Shallow borehole tool
Transmitter
Current
Time
1 km
1 km
Receiver
Voltage
Time
100 m
100 m
Hz
Ex
Ez
Downhole receivers
Transmitter location
Shallow borehole sites
Surface receiver node
Modified after Hoerdt
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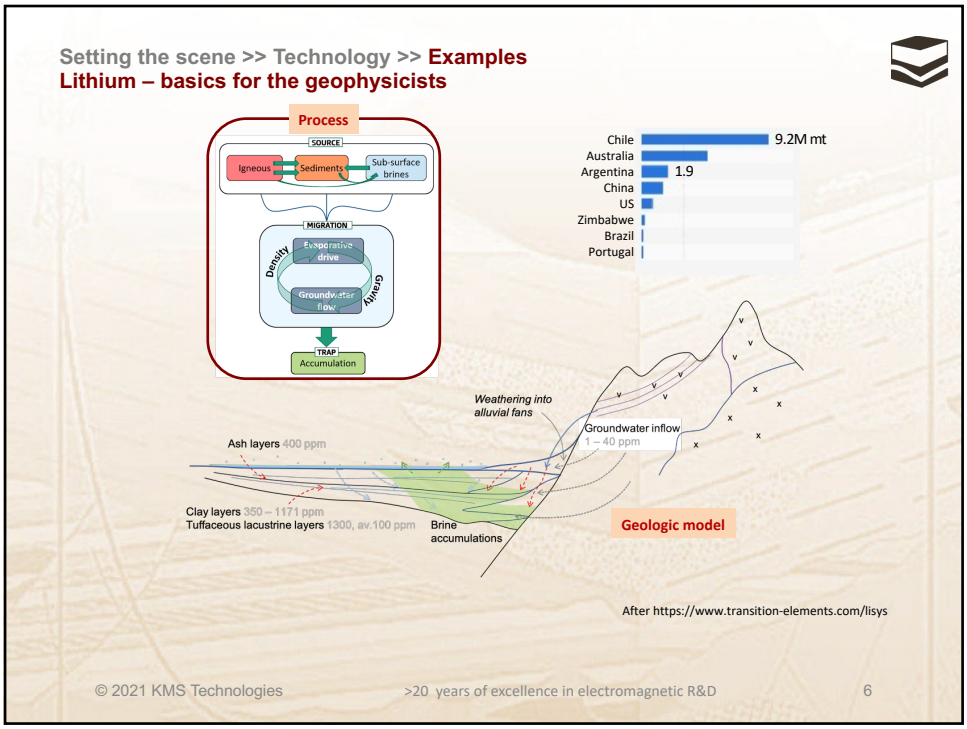
Setting the scene >> Technology >> Examples
Lithium – basics for the geophysicists
Process
SOURCE
Igneous
Sediments
Sub-surface brines
MIGRATION
Density
Evaporative drive
Groundwater flow
Gravity
TRAP
Accumulation
Chile 9.2M mt
Australia
Argentina 1.9
China
US
Zimbabwe
Brazil
Portugal
Weathering into alluvial fans
Groundwater inflow
1 – 40 ppm
Ash layers 400 ppm
Clay layers 350 – 1171 ppm
Tuffaceous lacustrine layers 1300, av.100 ppm
Brine accumulations
Geologic model
After https://www.transition-elements.com/lisys
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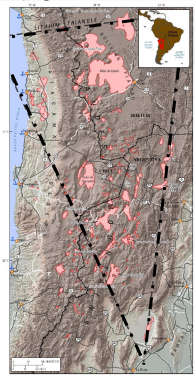
Setting the scene >> Technology >> **Examples**
Lithium exploration Argentina

The Lithium triangle (Puna Region)
(Argentina, Bolivia, Chile)



Hosts ~ 60% of the the world known (identified) resources of lithium reserves (USGS, 2020)

Figure source: https://www.sciencebase.gov/

Lithium geophysical prospecting
- Ultra low resistivities
- Low acoustic impedances
- Density Variations → **gravity**
- Puna Region: Extreme field conditions

Magnetotellurics : **Powerful** lithium prospecting technique

Courtesy of Proingeo SA

Proingeo s.a. TOPOGRAFIA GEOFISICA

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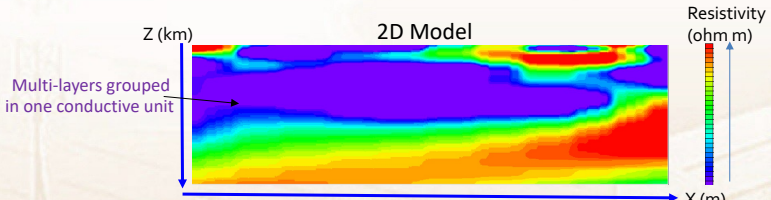
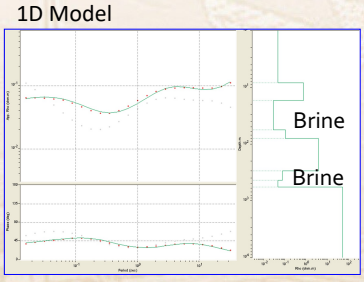
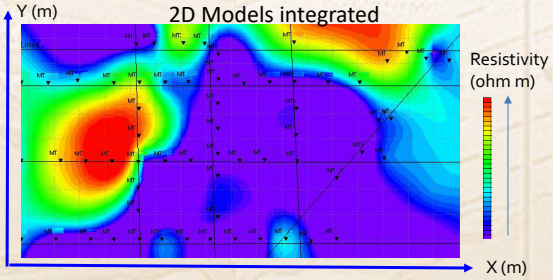
Setting the scene >> Technology >> **Examples**
Lithium exploration Argentina







Proingeo s.a. TOPOGRAFIA GEOFISICA A. Curcio, confidential report, Courtesy of PROINGEO SA

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Setting the scene >> Technology >> **Examples**
Geothermal: Hungary

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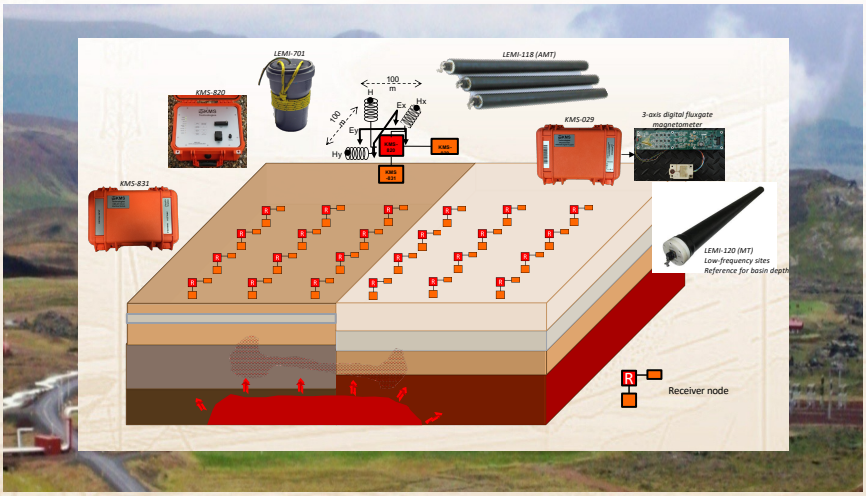
Setting the scene >> Technology >> **Examples**
Geothermal: Hungary



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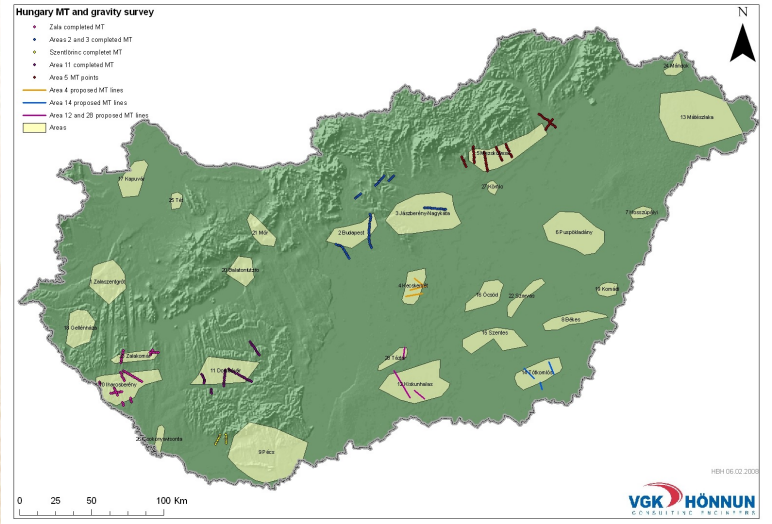
Setting the scene >> Technology >> **Examples**
Geothermal: Hungary map



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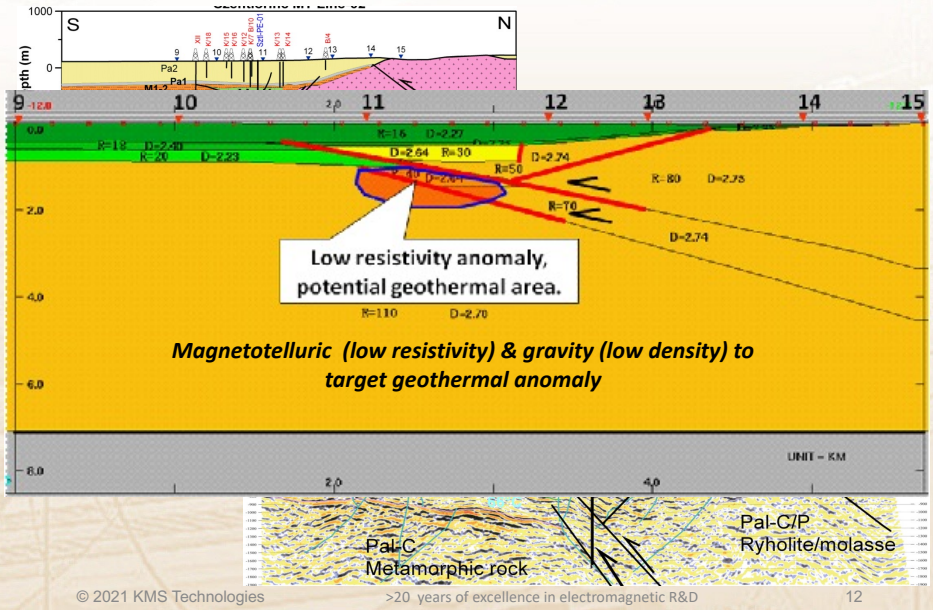
Setting the scene >> Technology >> **Examples**
Hungary: Integrated interpretation



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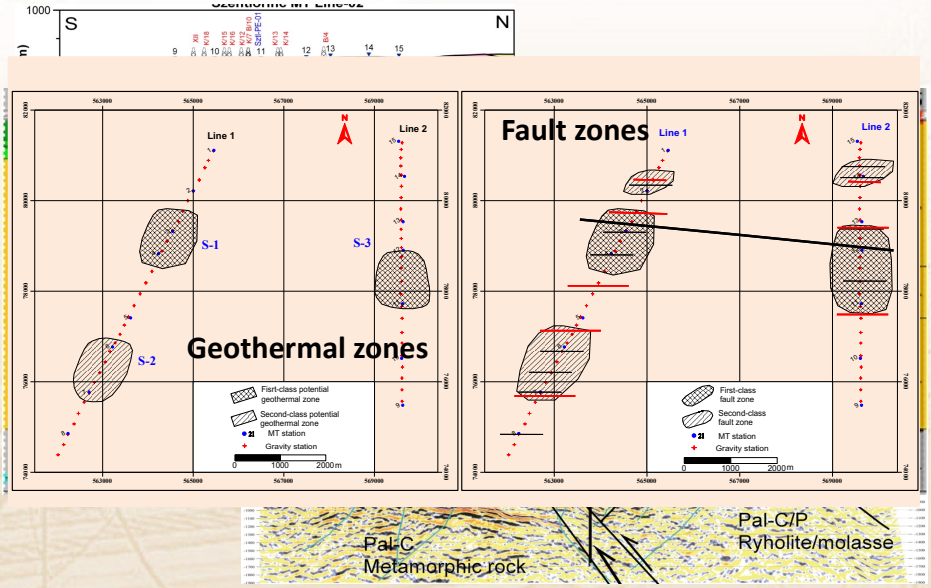
Setting the scene >> Technology >> **Examples**

Hungary: Integrated interpretation



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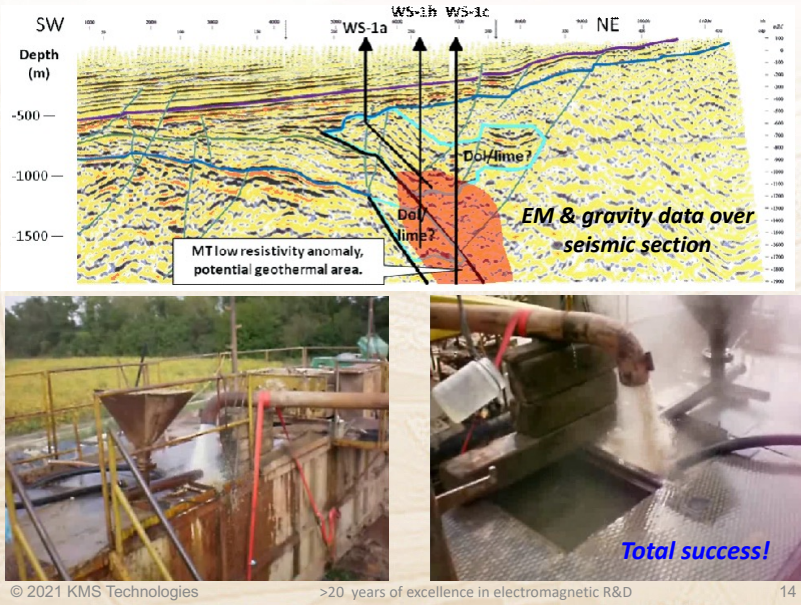
Setting the scene >> Technology >> **Examples**

Hungary: Drilling gives 3 MW



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Setting the scene >> Technology >> **Examples**
Carbon Capture, Utilization & Sequestration - CCUS

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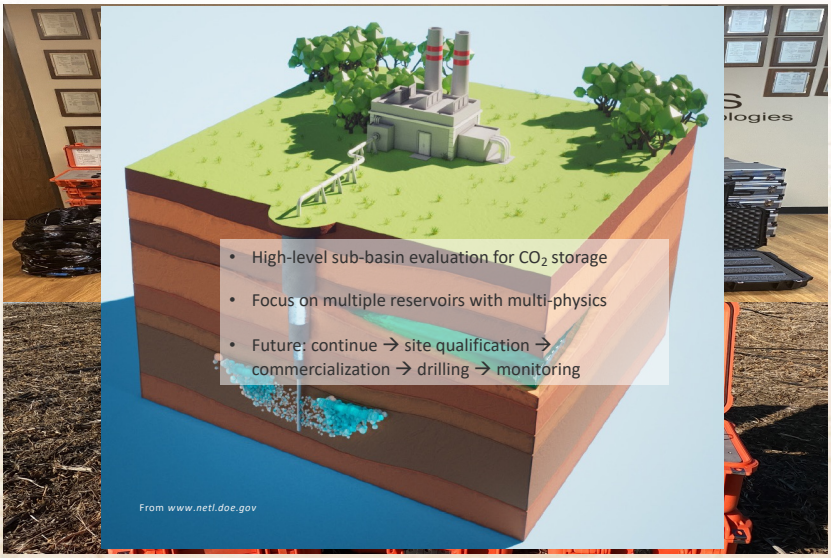
Setting the scene >> Technology >> **Examples**
Carbon Capture, Utilization & Sequestration - CCUS



- High-level sub-basin evaluation for CO_2 storage
- Focus on multiple reservoirs with multi-physics
- Future: continue → site qualification → commercialization → drilling → monitoring

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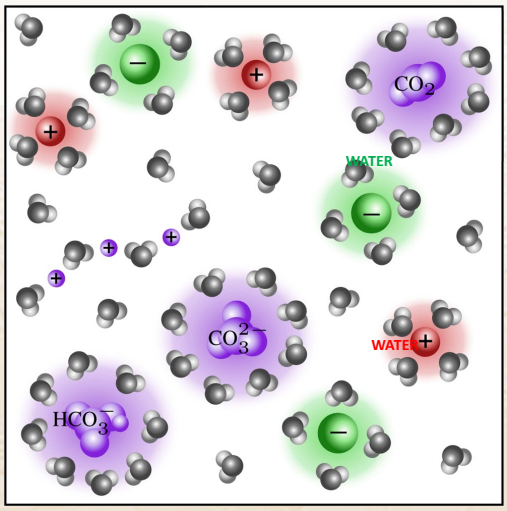
Setting the scene >> Technology >> **Examples**

CCUS: CO2 influence on resistivity

- @ normal brine salinity → fluids are more resistive (6 -50 times)
- @ low salinity (≤ 5,000 ppm) → more conductive



After Boerner et al., 2015

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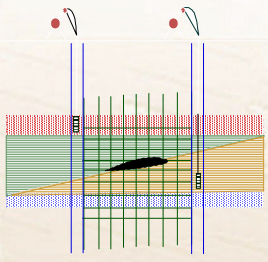
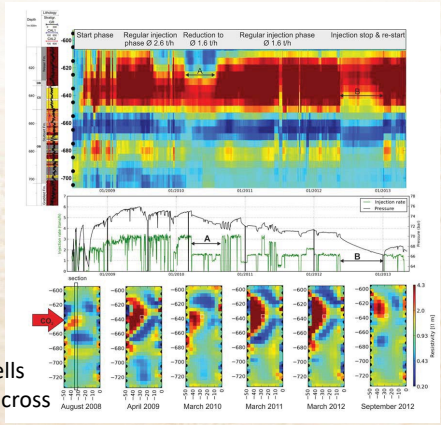
Setting the scene >> Technology >> **Examples**

CCUS: ERT example Ketsin: Cross well tomography





Tomography principle

- Moved transmitter/receiver in 2 wells
- Plot resistance where straight path cross
- Plot in color

After Schmitt-Hattenbergera et al., 2014

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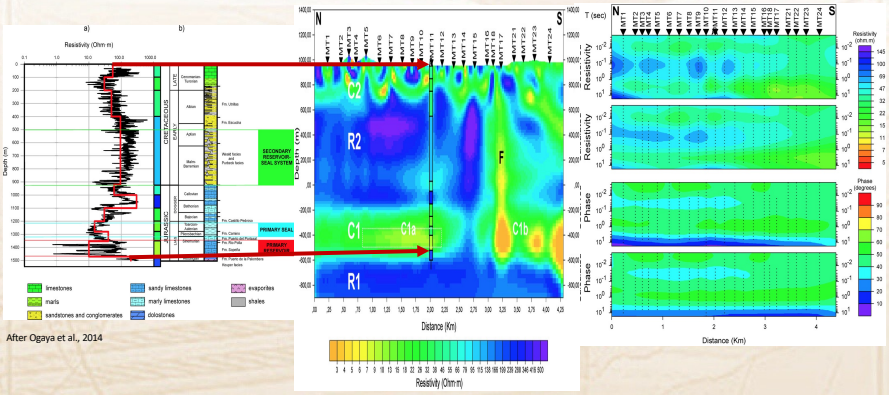
Background & physics >> **Methods** >> example >> issues & path forward

CCUS: Magnetotellurics

- LLNL, 2018, report: ERT and MT equally good for SHALLOW CO2 reservoirs
- LBL, 2017, weak response need to get in a borehole
- Ogaya, 2014, concludes MT can see a weak effect but CSEM should be used, time lapse pending



After Ogaya et al., 2014

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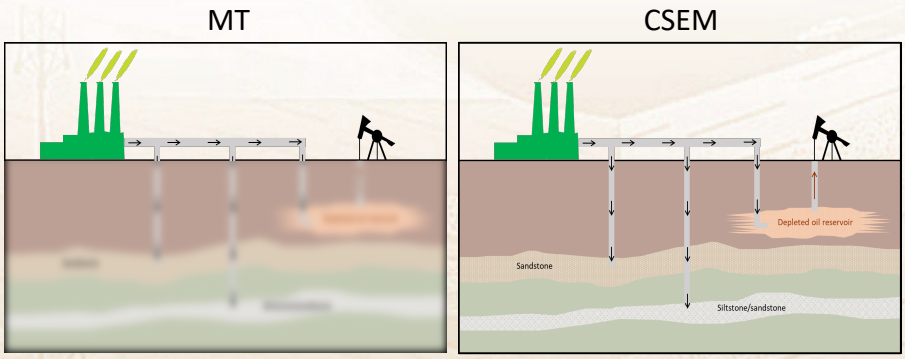
Setting the scene >> Technology >> **Examples**

Controlled source EM improves accuracy II



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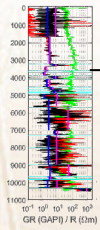
Setting the scene >> Technology >> **Examples**
Electromagnetic methods in the CO_2 project



Input data
well-logs, geology,
seismic horizons;
additional surveillance

Rock physics
Determine reservoir
parameter variations

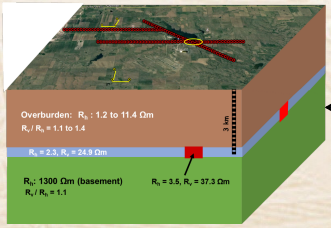
Feasibility
Link data with
variations

Field noise
measurements

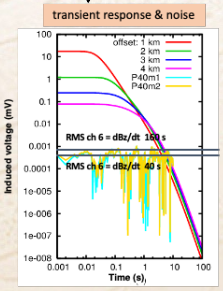
Define pilot
→ 2-3 monitoring cycles
→ BASELINE

Evaluate / decide

Baseline survey



transient response & noise



After Barajas-Olalde, 2021 SEG expanded abstract

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Setting the scene >> Technology >> **Examples**
CSEM Acquisition options

- 24 hours operation for CSEM (versus Standard: Night – MT &. Day CSEM)
  - More routine less operational problems
  - Generator stays warm
  - Electrode pit remain stable
  - High production rate
  - Q/A via Cloud enabled receivers

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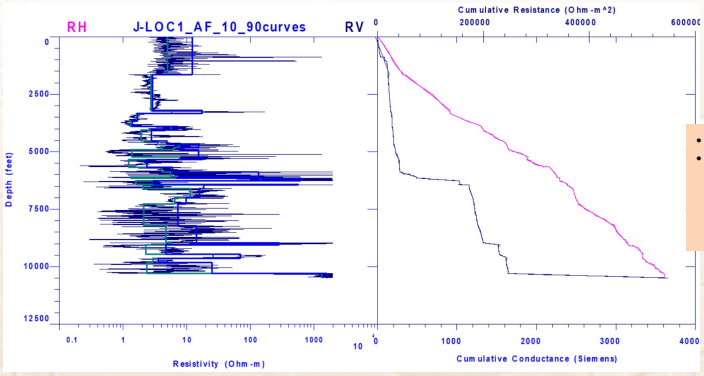
Setting the scene >> Technology >> Examples
Build anisotropic model from composite logs



- 31 layers
- Use
  - Rv for CSEM – E field
  - Rh for CSEM – H field
  - Rh for MT

After Barajas-Olalde, 2021 SEG expanded abstract

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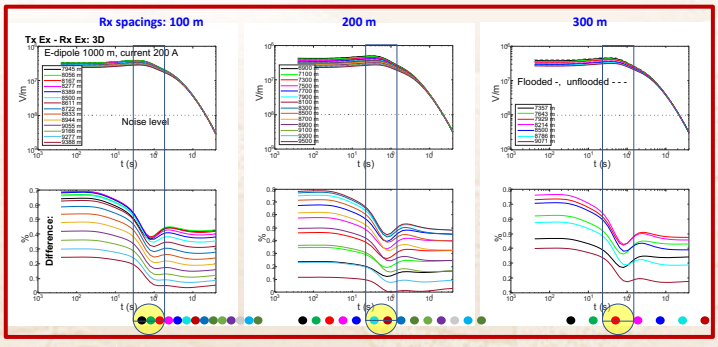
Setting the scene >> Technology >> Examples
3D models Ex – station spacing target reservoir



RESULT: select 200 m

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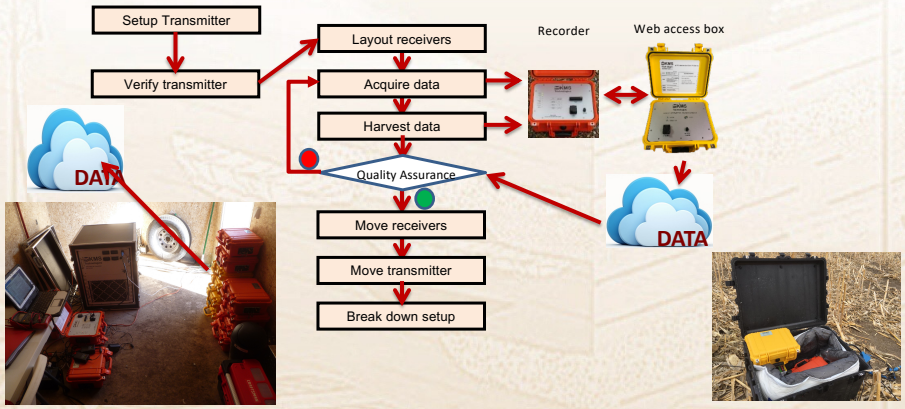
Setting the scene >> Technology >> **Examples**

CSEM. acquisition workflow



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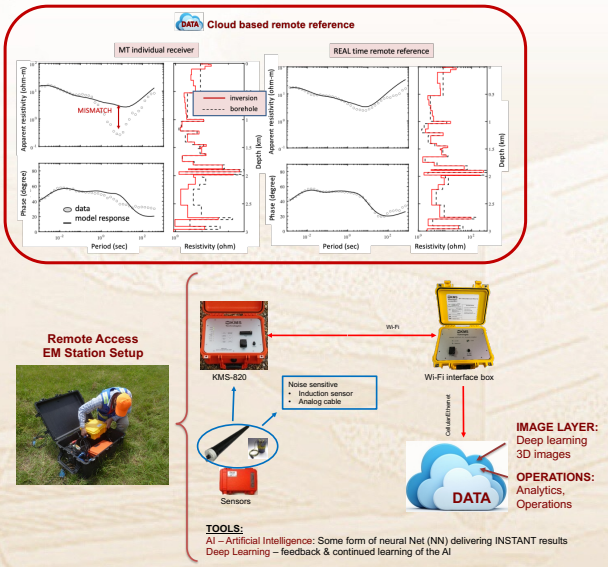
Setting the scene >> Technology >> **Examples**

MT QA via Cloud: Quality Assurance RR (1400 miles) & 3D model



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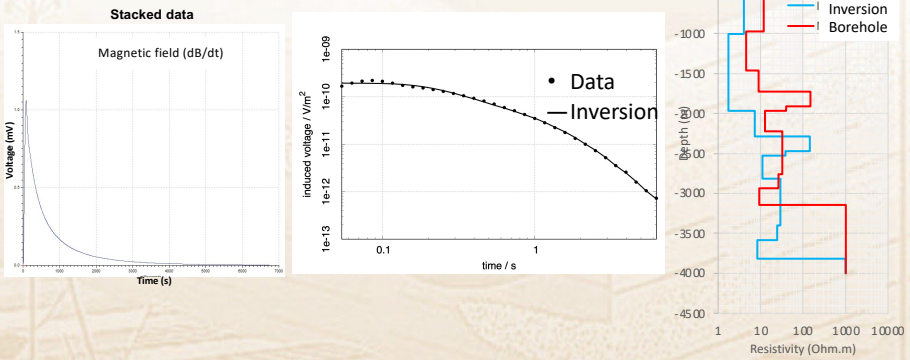
Setting the scene >> Technology >> **Examples**

CSEM Quality Assurance – Hz: Compare site inversion with anisotropic log



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Setting the scene >> Technology >> **Examples**

Summary

- CSEM is well suited for fluid imaging
- Depth 1 to km requires high power Tx
- High contrast (Lithium) no problem
- Geothermal: use in exploration & production
- CCUS: monitoring & with seismic for seal integrity

- **MUST: Calibrate – calibrate - calibrate**

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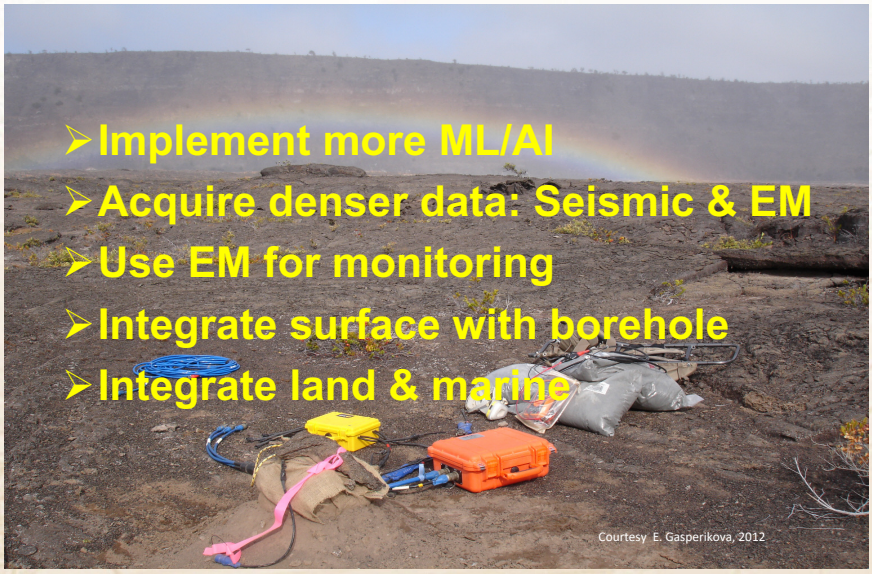
Setting the scene >> Technology >> **Examples**

FUTURE:



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