Presentation for

Application of a Portable Multi-Frequency Electromagnetic System in the Field of Environmental Engineering Exploration

June, 2018

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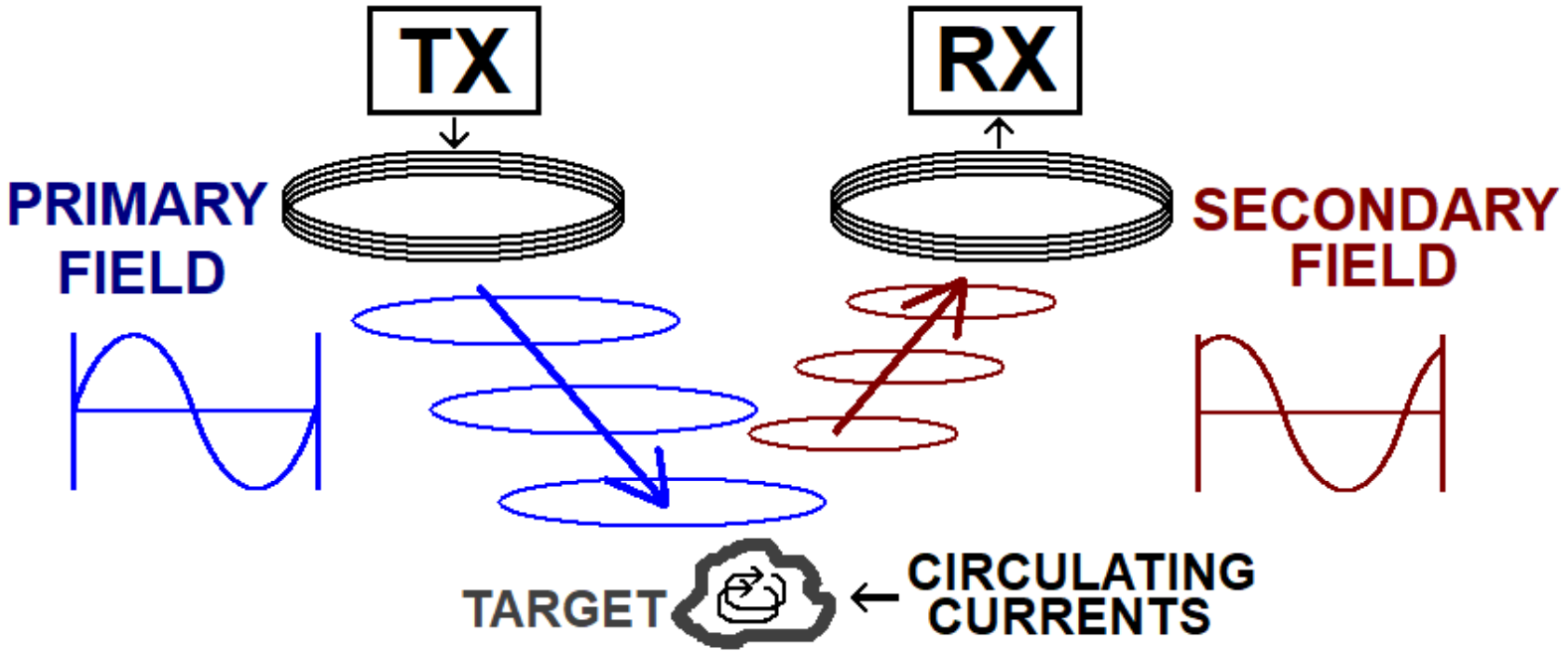
Introduction

This presentation will:

- Define some basics concepts related to EMI sensors
- Provide real-world examples of environmental investigation using a hand-held sensor.

What is ElectroMagnetic Induction ?



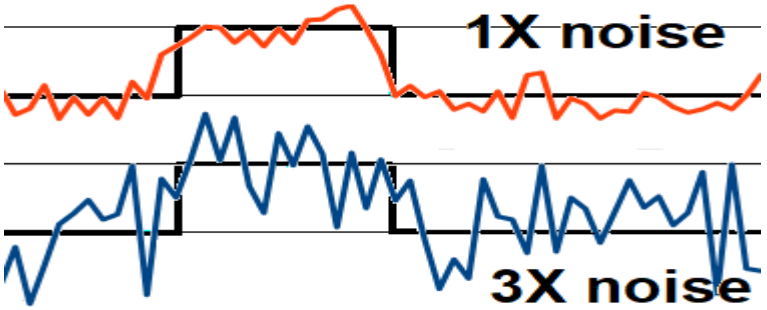
Note the phase difference between the TX and RX

- Can be used to characterize the target's electrical conductivity / magnetic susceptibility

How deep can we see ?

Correct answer: it depends!

- Target size vs. depth
- Target conductivity/susceptibility
- Target contrast with soil
- Target size vs. sensor dimensions
- Motion noise
- Electrical noise
- Signal loss in soil
  - Depends on frequency
  - Depth discrimination possible



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The GEM-2 handheld sensor and applications

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The GEM-2 handheld sensor

- Frequency domain, up to 10 simultaneous frequencies (3-5 typical)
- Ultra-wide frequency range, from 25 Hz to 90+ kHz
  - Lowest frequencies response similar to magnetometer
  - Highest frequencies for low-conductivity targets

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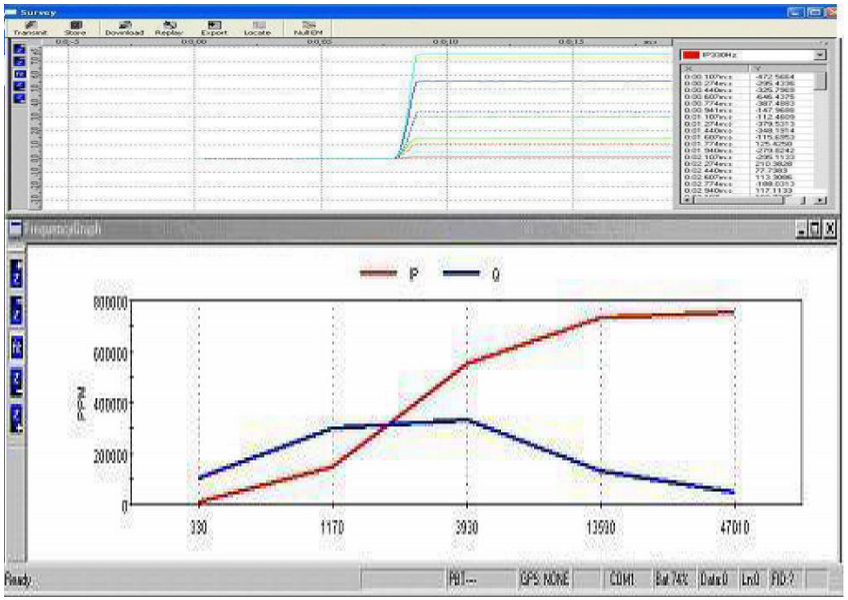
The GEM-2 handheld sensor (cont'd)



- Real-time displays
- up to 25/30 data points per second.
- GPS (optional) time & position in data stream.

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The GEM-2 handheld sensor (cont'd)

- Using the GEM-2 on a sled or cart may provide better data
  - Eliminates movements due to walking motion
  - Cart made of non-conductive materials
  - Economical even for a single survey

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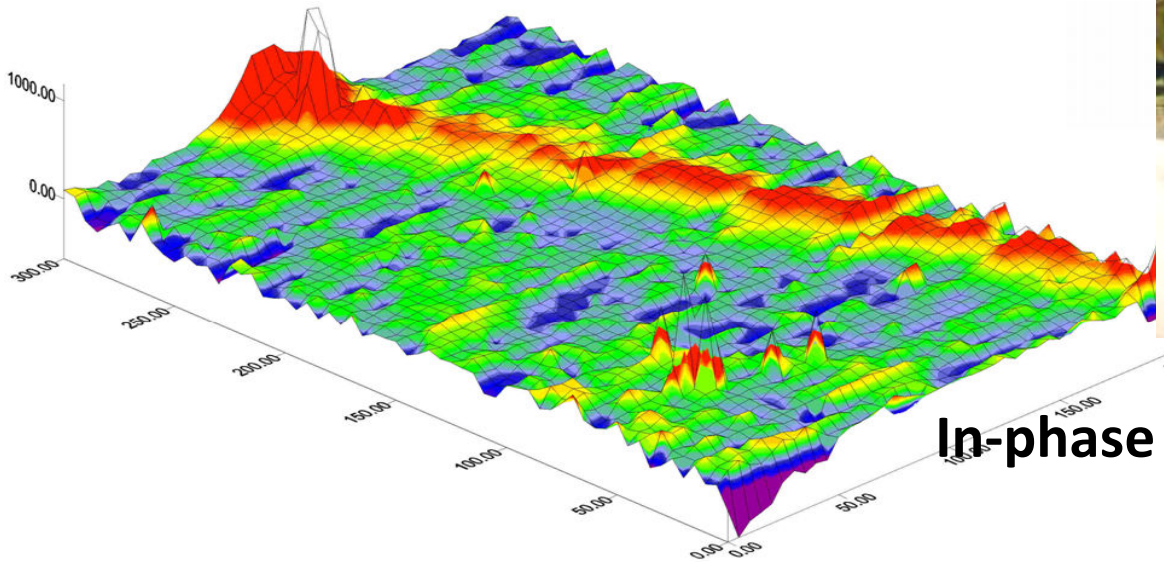
Application: Characterization of Underground Structures

Nevada nuclear test site: Locating a cloud chamber



In-phase data at 7,290 Hz

- One 30 cm. stainless steel pipe, 9 meters deep, clearly identified

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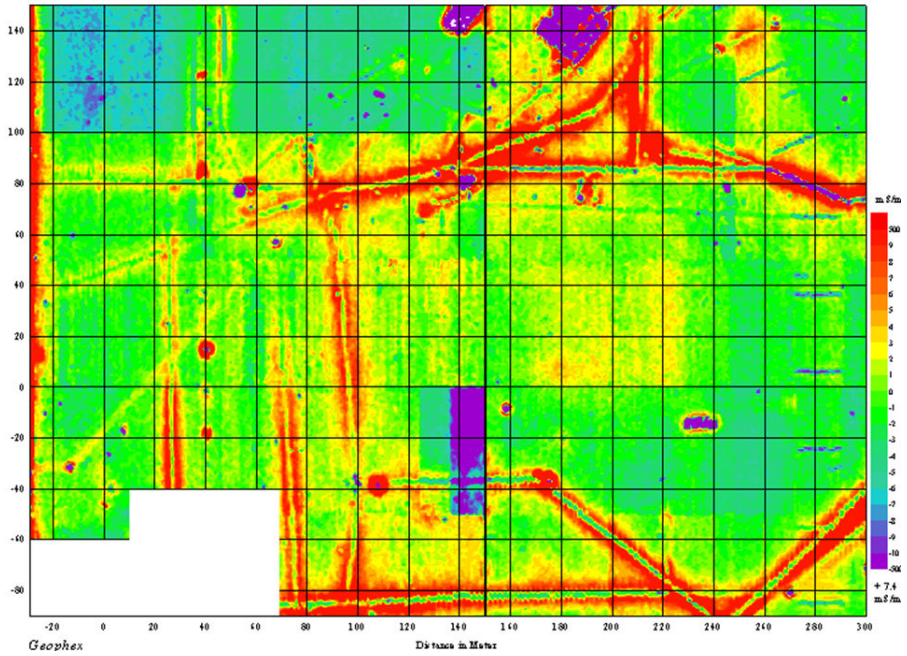
Tachigawa, Japan:
Surveying abandoned military airfield



- 6 hectare site, featureless tarmac
- Identified service tunnels, sewer lines and electrical utilities

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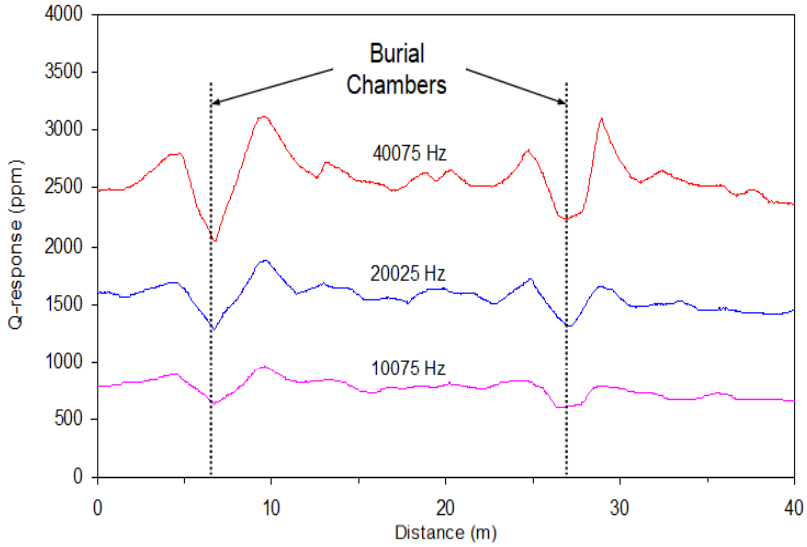
Xian, China: identifying burial chambers



A multi-frequency survey was conducted at a site known to include ancient burial chambers from the Qin dynasty

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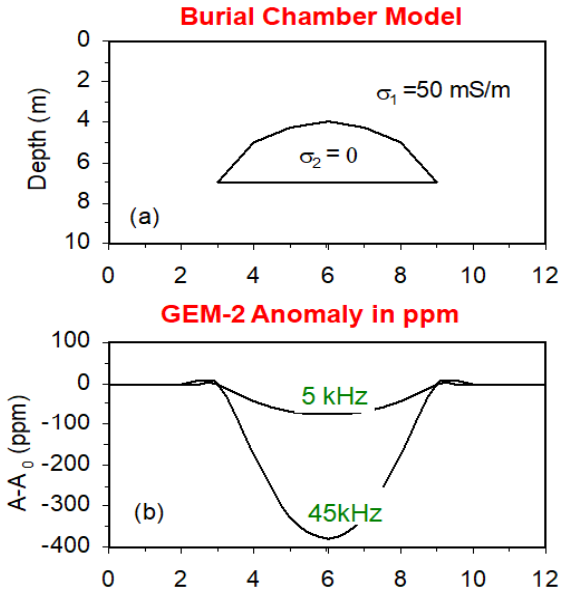
Xian, China (cont'd)



- Non-conductive underground voids identifiable by contrast with the surrounding conductive soil
- High frequency operation is important

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Application: Abandoned Landfills and Dump Sites

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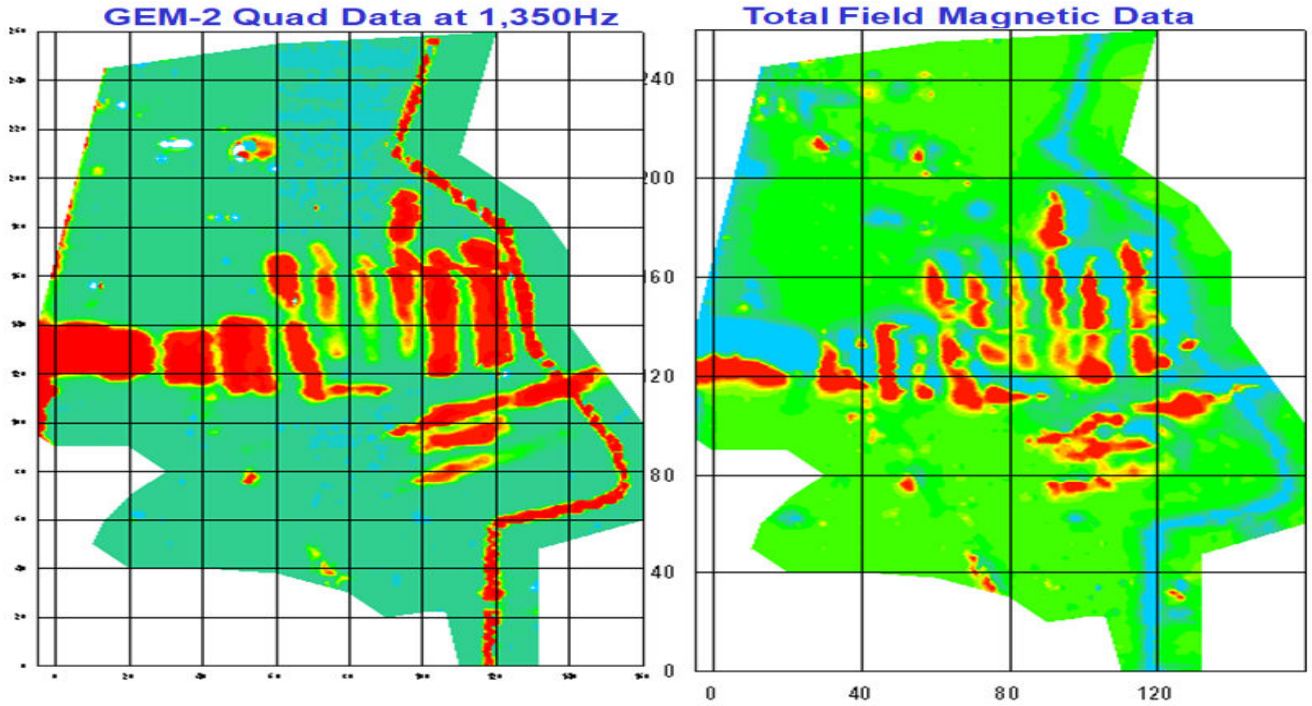
Tennessee, USA: Mapping a Nuclear waste site



- Drums of various sizes buried in trenches
- Incomplete or incorrect site documents
- GEM-2 survey provides detail required for remediation

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North Carolina, USA: Investigating an abandoned town landfill

- Extent of the landfill was poorly understood
- First proposal was for cutting a series of exploratory trenches

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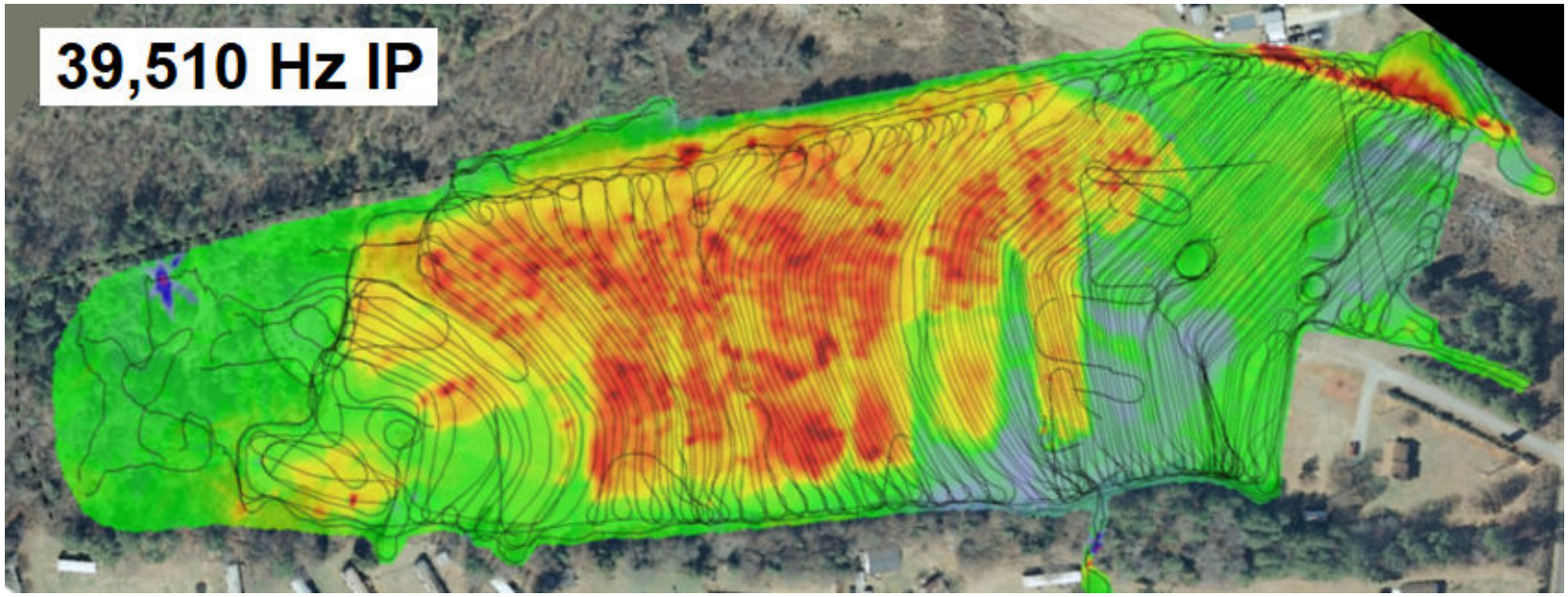
North Carolina landfill (cont'd)



- EM survey identified the extents of the landfill
- Used as a basis for further investigation

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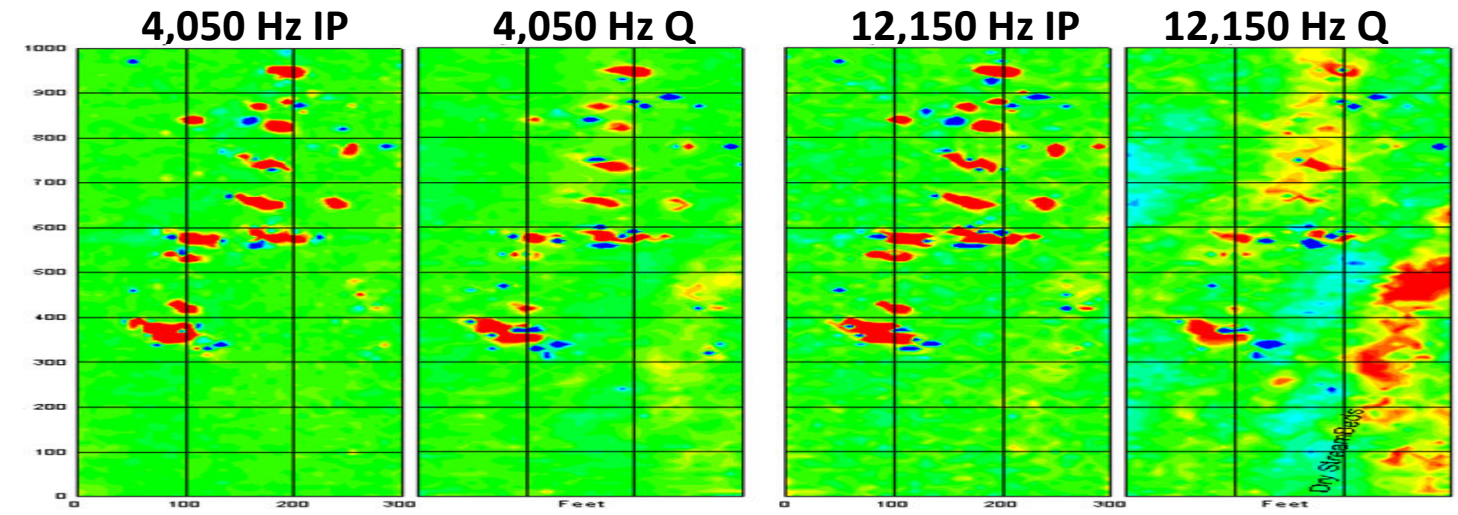
Thartar, Iraq: Investigating a suspected cache



- Reports of hidden nuclear processing equipment
- 3 hectare site surveyed and excavated in a single day

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Application: Other Environmental Investigations

Alberta, Canada: Pipeline leakage

- Oil production often requires the pipeline transport of ‘produced water’, water containing salt (‘brine’)
- Any leakage can damage farmland, requiring expensive remediation
- Early detection is crucial.

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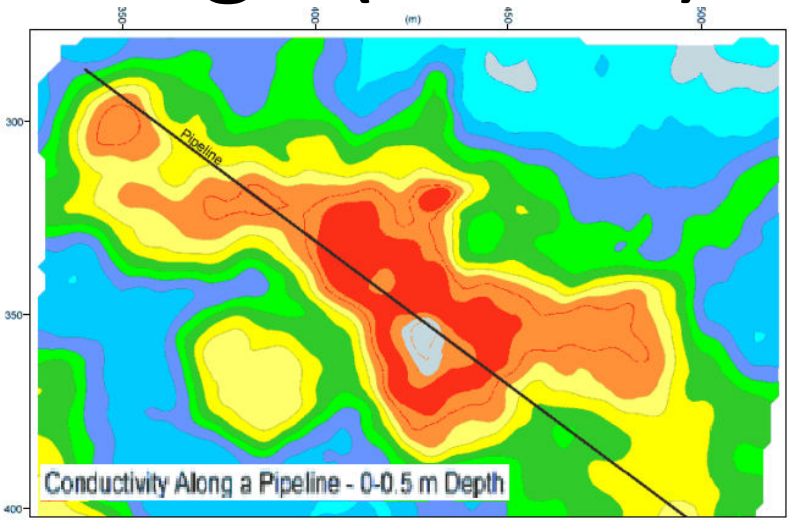
Canada: Pipeline leakage (cont'd)



- Salt water is MORE conductive than surrounding soil
- A sled-based survey can quickly cover large areas and detect minor leaks
- Much cheaper than other sampling methods, the survey can be repeated on a regular basis
- Note: Other chemicals can also be found if they are LESS conductive than surrounding soil

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Utah, USA: Comparing waste lagoons

Sled-mounted GEM-2

- Industrial hog farm
- Site has both clay-lined and membrane-lined hog waste lagoons

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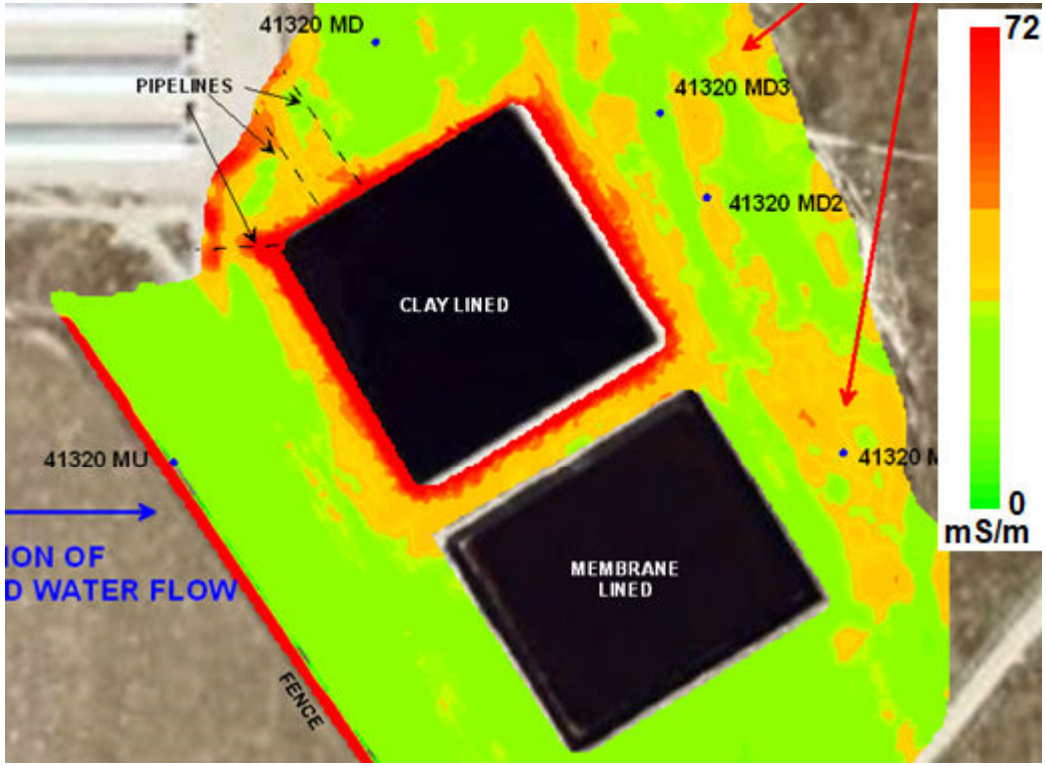
Utah, USA: Waste lagoons (cont'd)



- Hog waste is more conductive than surrounding soil
- Clay-lined lagoon is obviously porous and causing downstream contamination

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Antarctica: Measuring ice shelf thickness

- Studies by Alfred Wegener Institute of Germany
- Possible because ice much less conductive than seawater
- GEM-2 multi-frequency operation enables depth sounding

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End of Presentation

Geophex Ltd. would like to thank:

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Our representative in China, HengDa Century(Beijing) Geophysics Technology Co., Ltd, for sponsoring our trip

You! For attending.

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Geophex Family Photo Album

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EM instruments on sleds & carts

- Sleds are often more stable than wheeled carts, for better data
- May be temporarily built, for a single survey

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EM instruments on vehicles

- Examples for tunnel detection, mine clearance and humanitarian demining

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Airborne EM instruments

- Used for shallow geology and groundwater exploration

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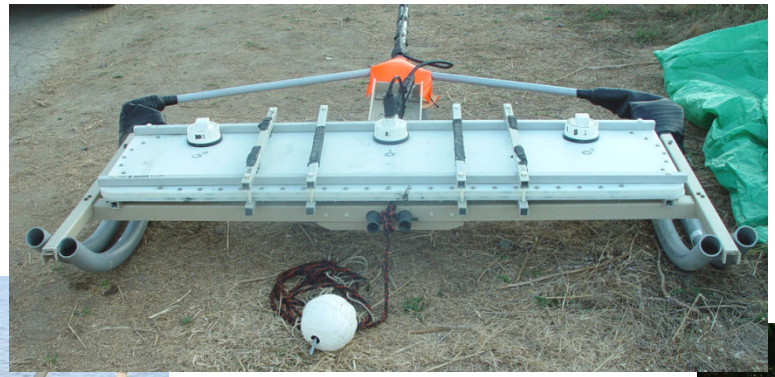
Surface and shallow water EM instruments

- Cleanup of underwater dumps, underwater salvage



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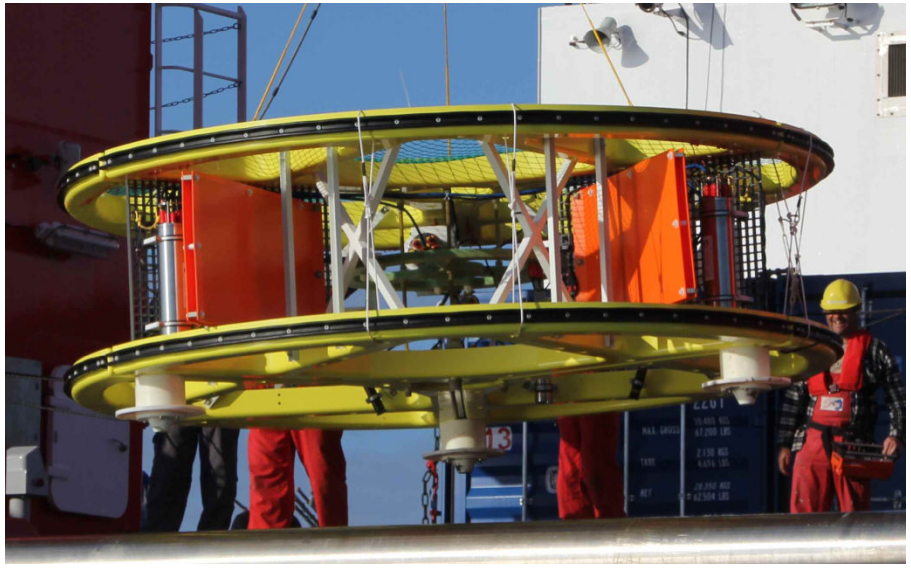
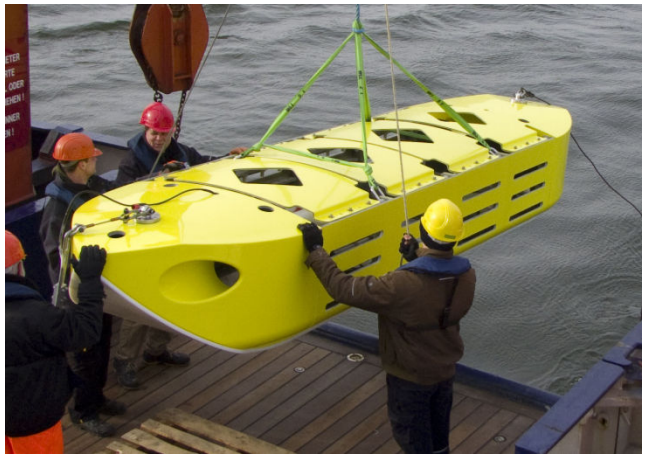
Deep sea EM instruments

- Study of sediment flows, mineral exploration





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EM instruments on robotic vehicles

- For exploration of hazardous or inaccessible locations

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