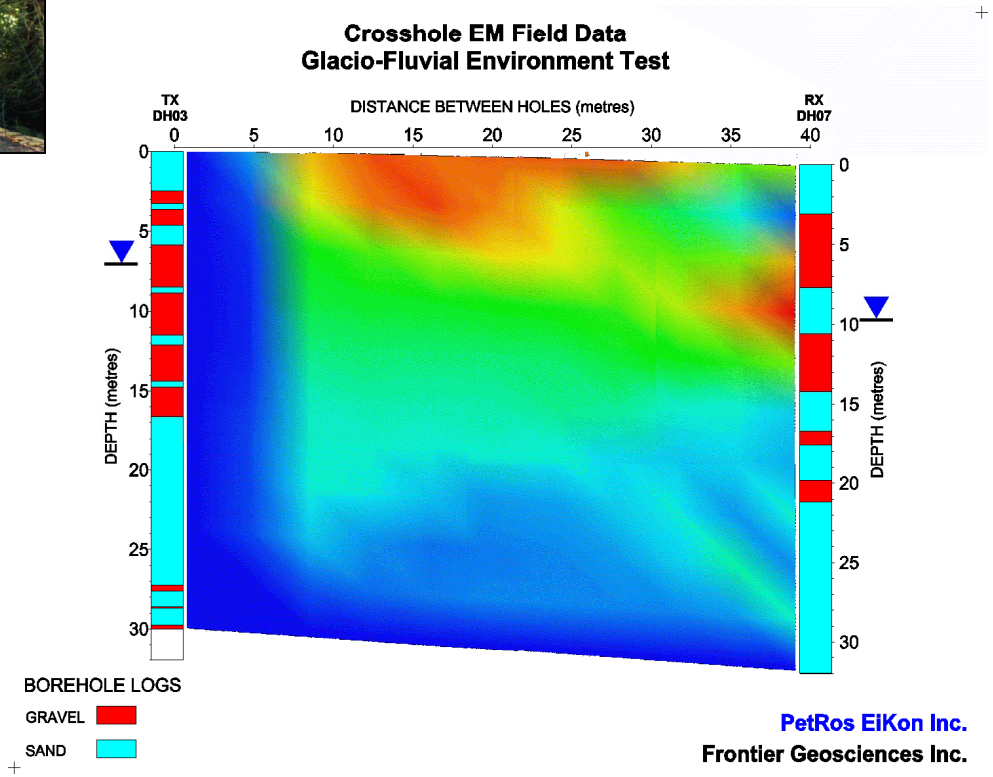
X-hole Tomography

A new frontier in Equipment and Software



PetRos EiKon Inc. **and**

Frontier Geosciences Inc.

X-hole Tomography

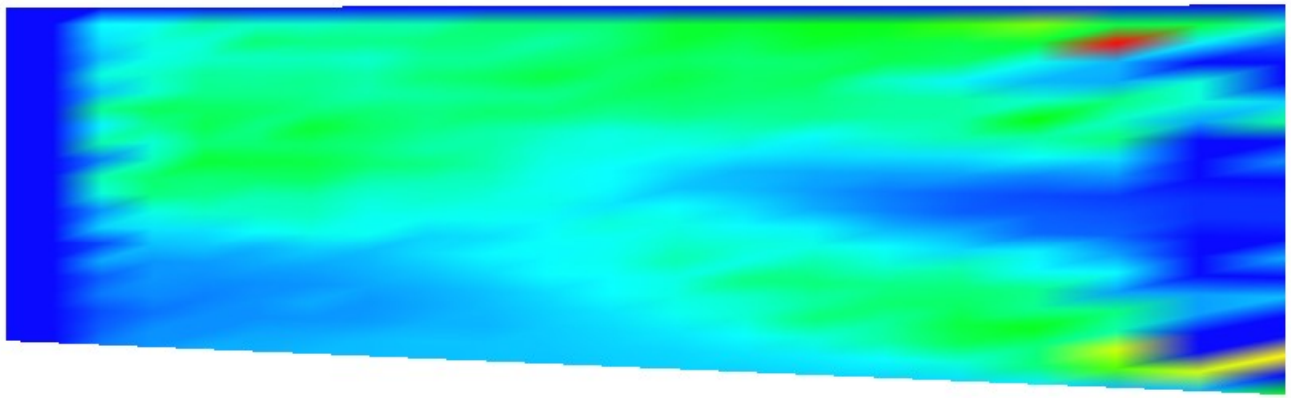
An Electrical Antennae Crosshole Instrumentation and Interpretation System

Crosshole Instrumentation

Interpretation Systems

Tomography

Imaging between holes

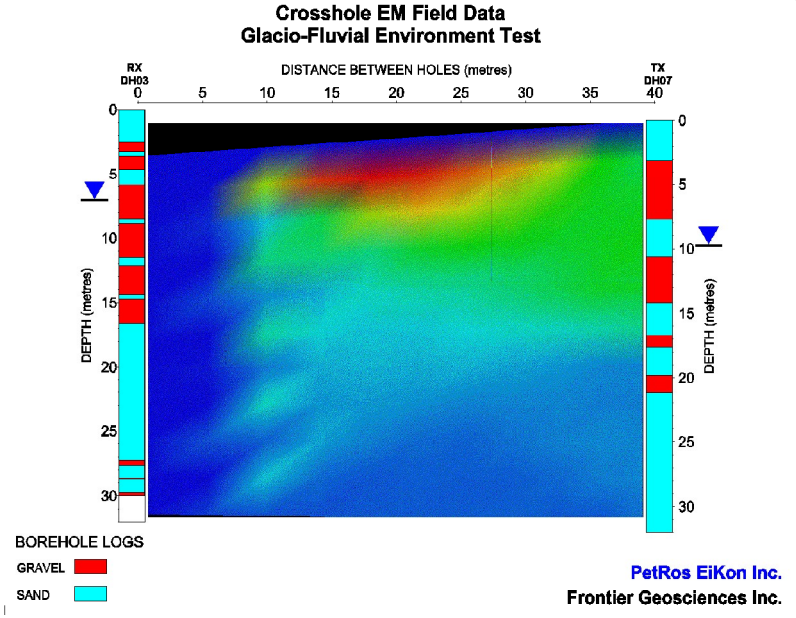


PetRos EiKon Inc *and* Frontier Geosciences Inc.

Overview of Development Program Objectives

Applications:

- Geotechnical
- Environmental
- Mine Development
- Oil Recovery Applications



subsurface structural investigations for

waste site and tailing applications,

ore delineation, reservoir characterization,

rock weaknesses, fluid and viscous boundary investigations

monitoring

Electrical Antennae

RIM Imaging Technologies

- electromagnetic waves in the radio-frequency band

Electric Field Transmitter and Receiver Antennae

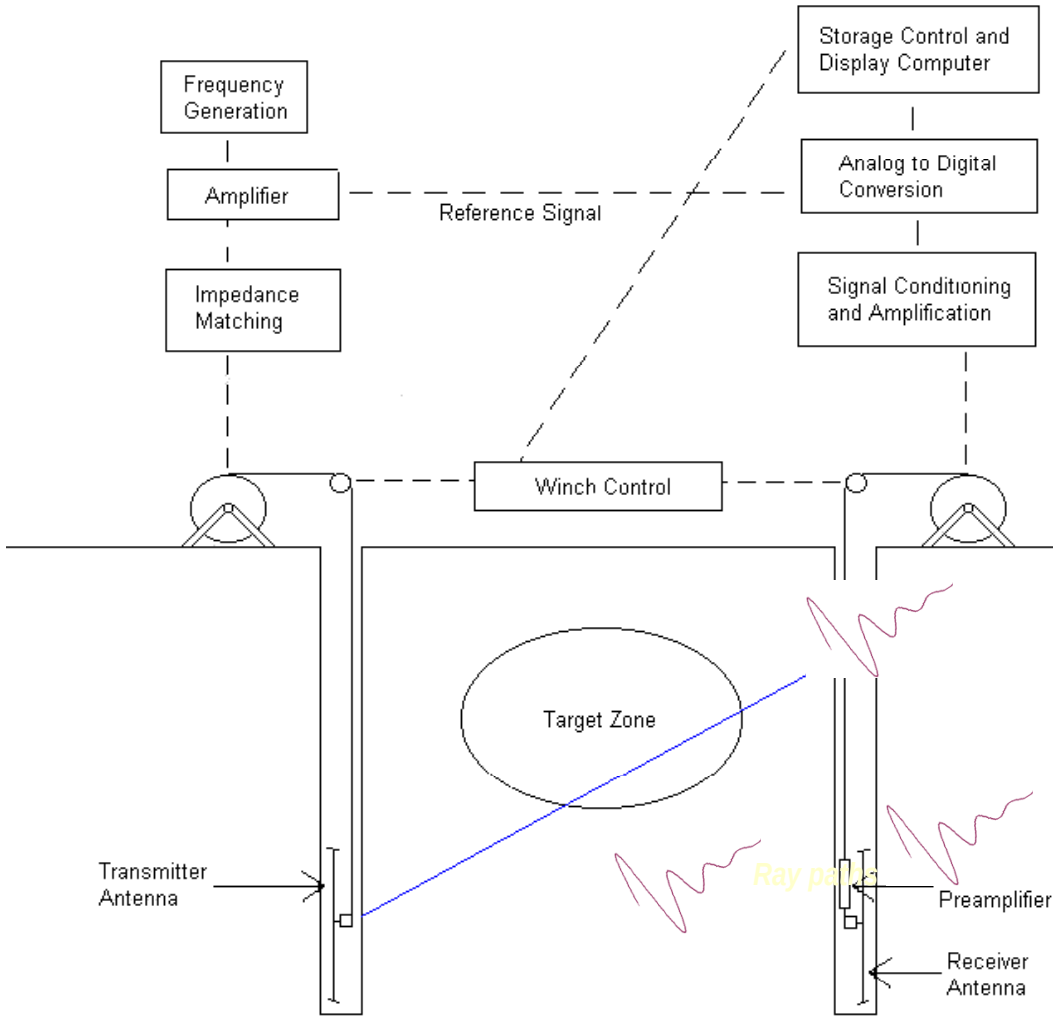
provides sensitivity advantages for a wide range of applications

- weak resistivity contrasts
- permittivity variations
- IP effects and
- discrimination of magnetic structures

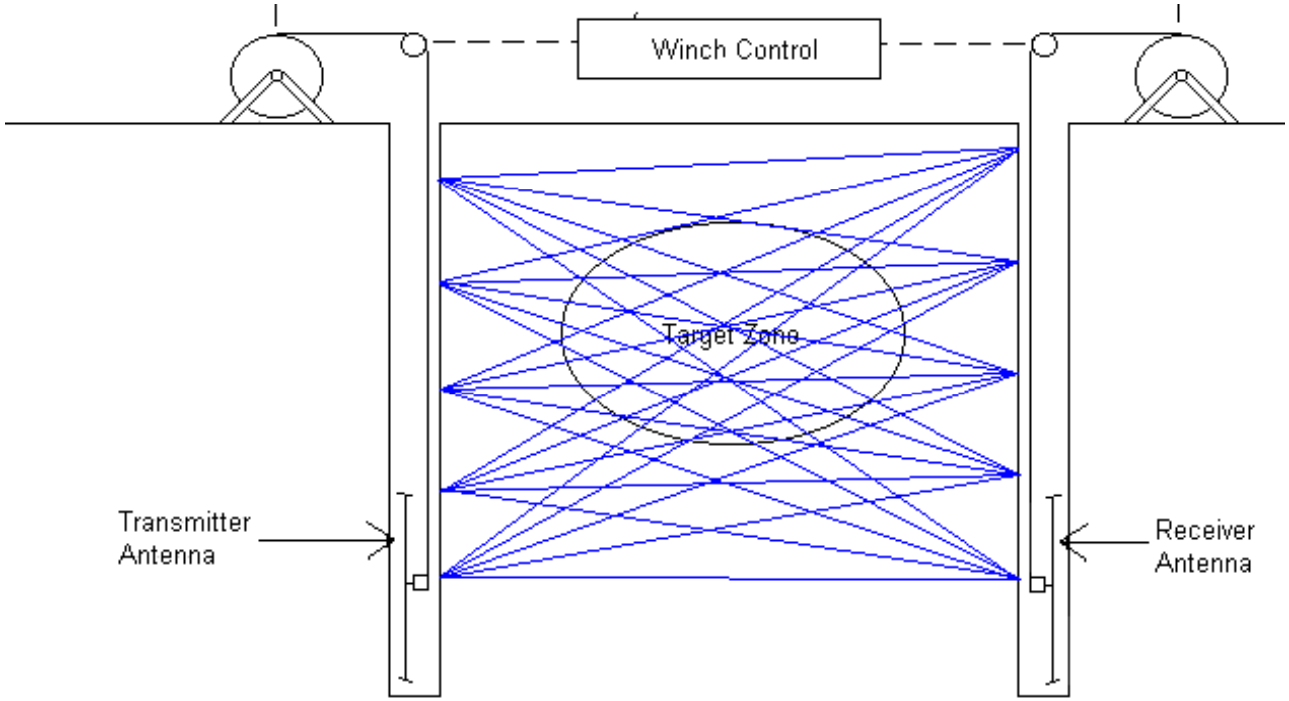
Low Frequency to reduce interference with near hole scattering

- lower frequencies enables minimization of scattering noise from near-hole fracturing

Crosshole EM Block Diagram

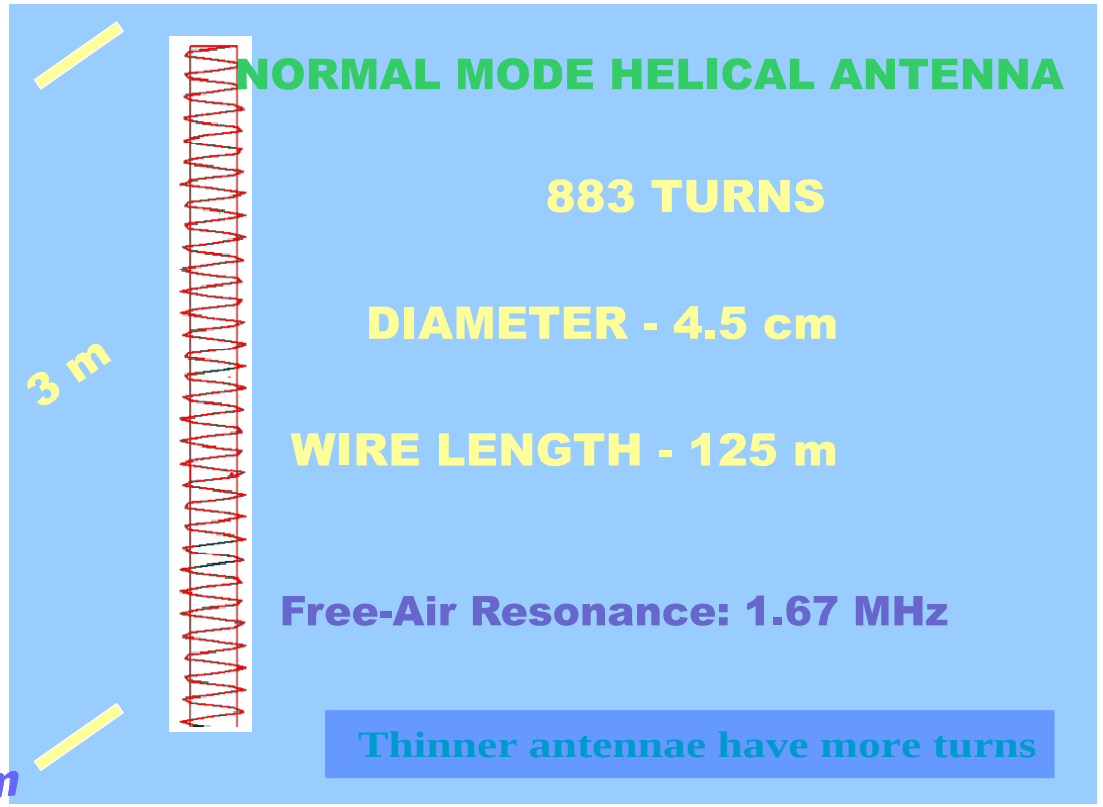


Cross Borehole Survey Panel

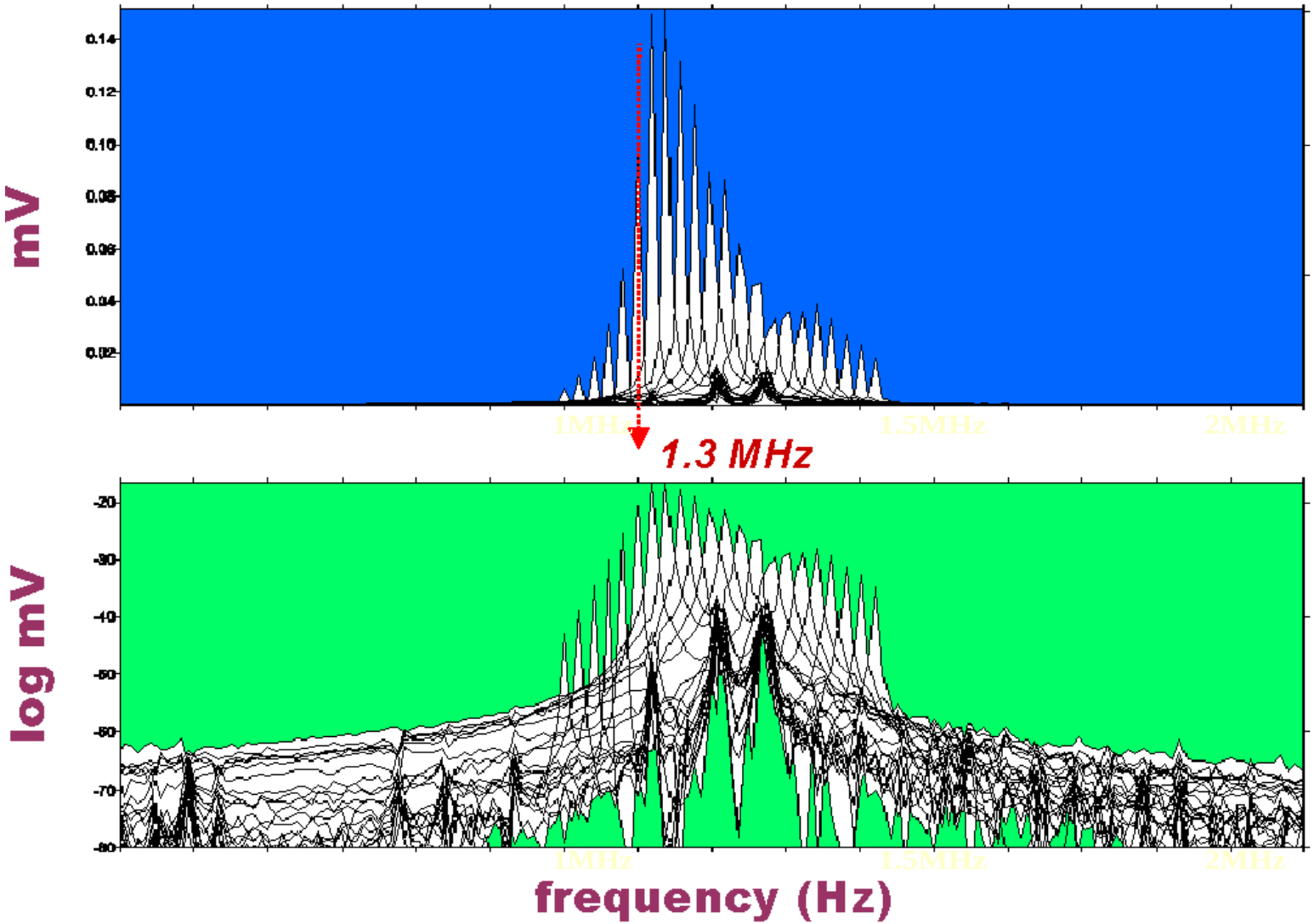


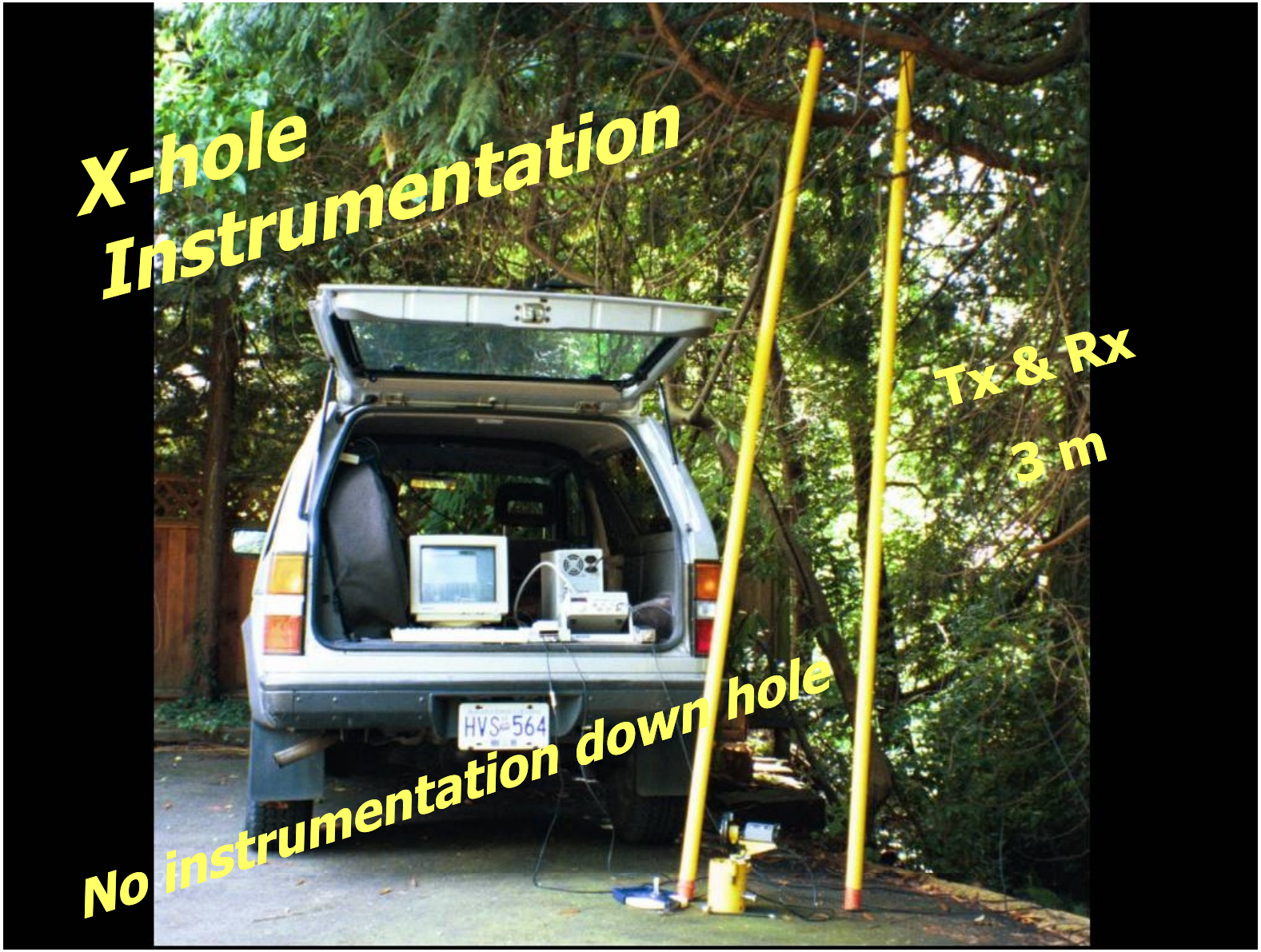
Normal Mode Helical Antennae

- *Small antennae (3m long, 4.-4.5 cm diameter) effective even for short, narrow holes*
- *Flexible for twisting holes*
- *Inexpensive design*
- *Depths greater than 600m*
- *Broad band resonance characteristics (100KHz - 1.5MHz)*
- *Collect multiple frequency data with a single antennae*

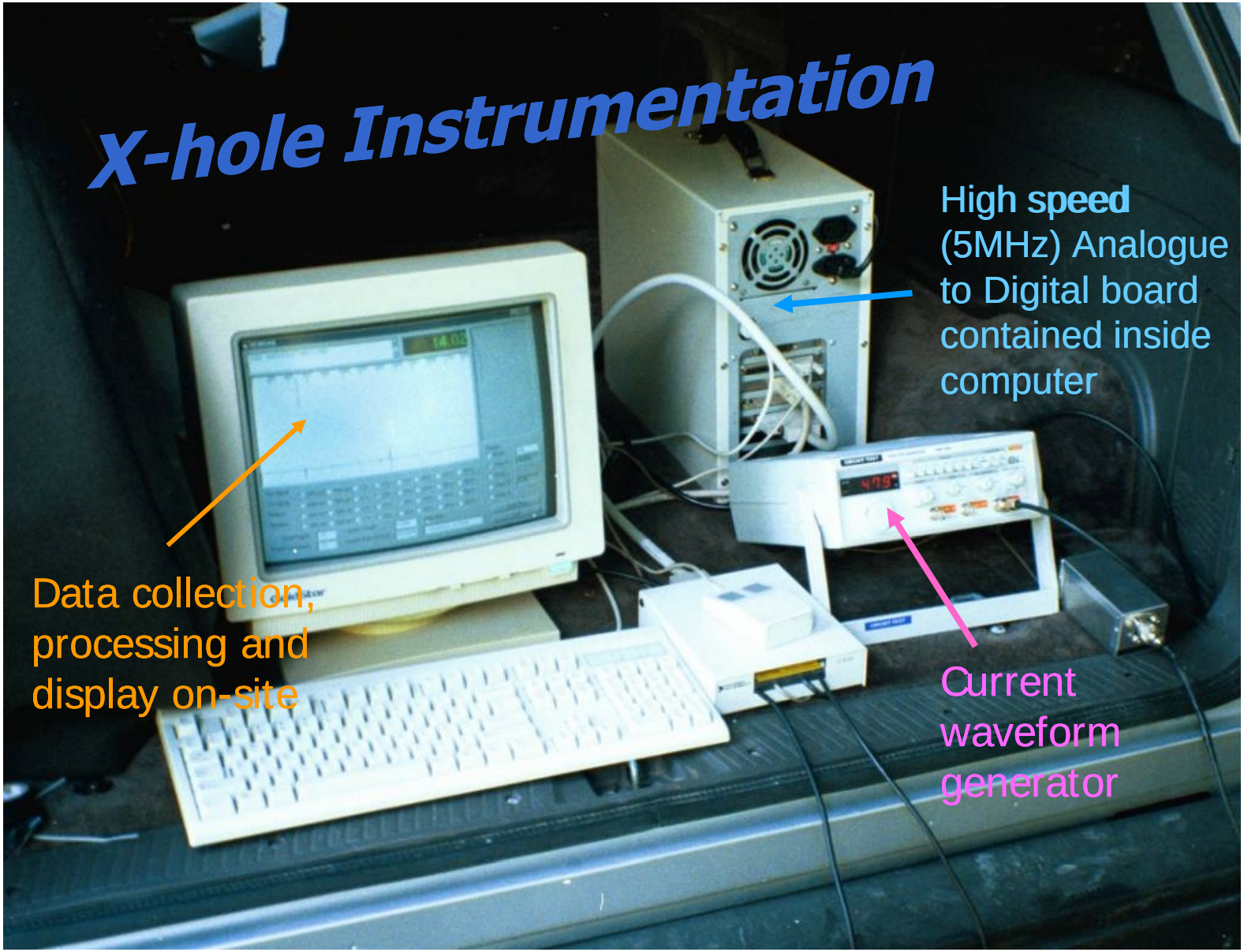


Free Air Resonance Test




X-hole
Instrumentation
Tx & Rx
3 m
No instrumentation down hole

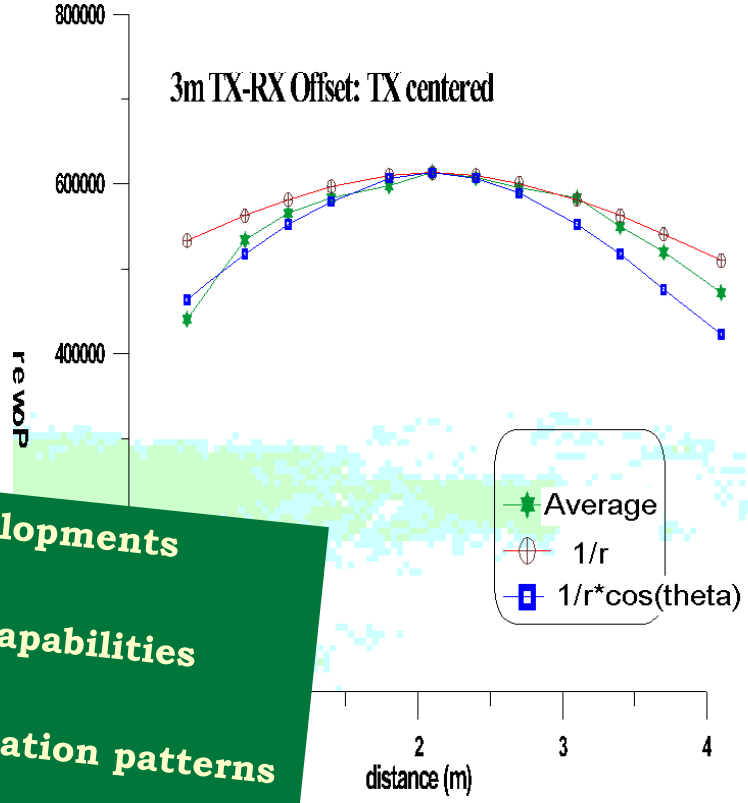
X-hole Instrumentation

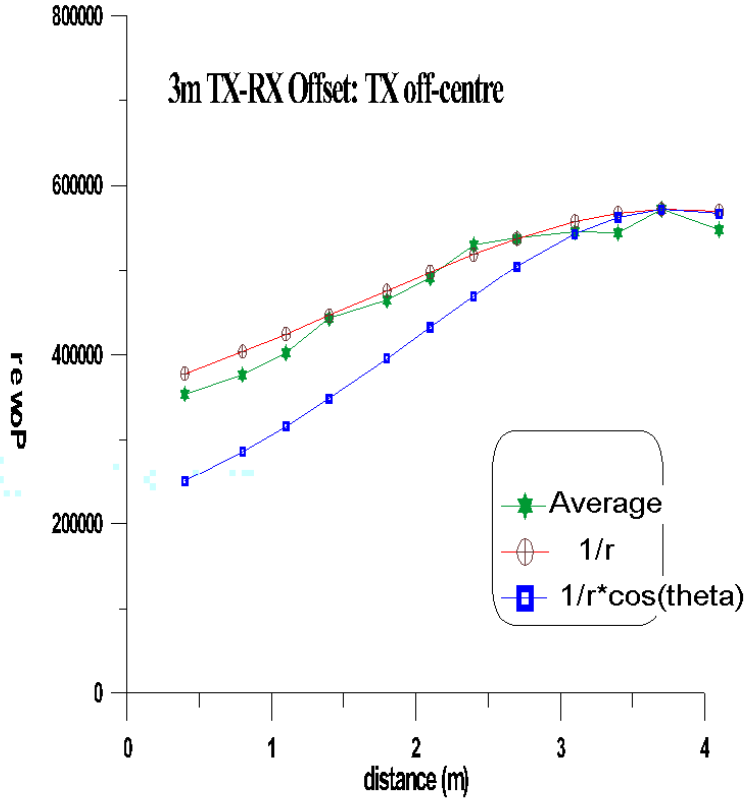


Data Collection
Rapid Surveying Technique

- Log data as antennae moves virtually in free-fall
- Monitor reflected voltage from antennae as a function of Tx position in ground
- Collect data at 0.94 m intervals with automated triggers
- 1 Data sample every second
- Log up to 600 m in 15 min
- Log a 35 m deep Xhole panel with a single frequency in less than an hour

NMHA FreeSpace Radiation Pattern





Project Developments include Simulation Capabilities for both antennae radiation patterns and scattering effects

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IN-FIELD SPECTRA CAPTURE

Digital Signal Analyzer Software

analyze noise characteristics and power

Tune dial to an optimum frequency

View Spectra on Computer Screen

Select a radiating frequency within a quite zone of the broad resonating band

Test Survey Results:

1. Glacio-Fluvial Environment Test
2. Earthen Dam Test
3. Mine Setting Test
4. Municipal Landfill Test Site

Glacio-Fluvial Environment Test

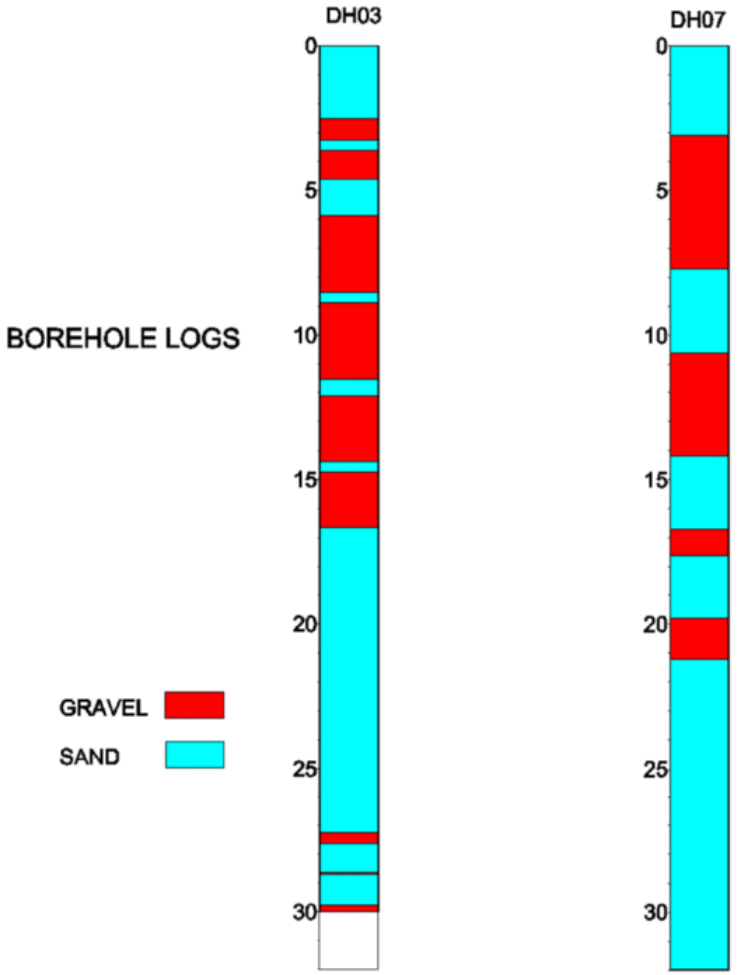
Tests performed in shallow monitoring holes within glacio-fluvial fill outside a large water-reservior earthen dam

- One reverse panel of data collected (first with the TX in one hole and the Rx in the other and then reversing the configuration)

Results:

- revealed structure
- indicated several scattering characteristics of the system
- normal mode helical antenna have broad band efficiency in the key range of frequencies when operated in earth materials
- the resonant frequency of the antenna is lowered and made considerably broader when the antennae are operated in earth materials
- provides a wide operating spectra,;the lower range of which are frequencies thought to be most sensitive for dam safety and environmental investigations involving overburden and placer granular materials

Glacio-Fluvial Test



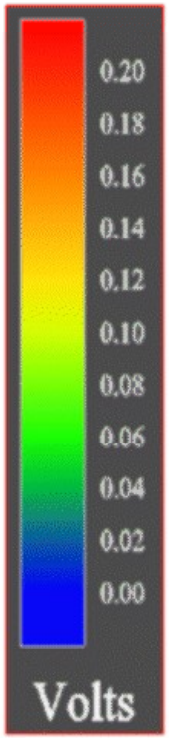
- Relatively low frequency (500 KHz) gives greater sensitivity in this weak contrast environment
- Short antennae design (3m) enables use in shallow applications (20 m holes). Other commercially available RIM antennae are 10x longer for low frequencies and 2x longer for high frequencies
- Low frequency reduces attenuation allowing for larger hole separations

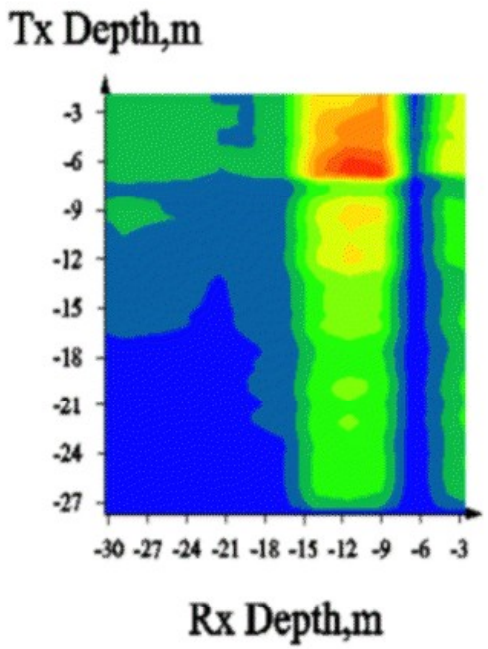
Crosshole EM Field Data

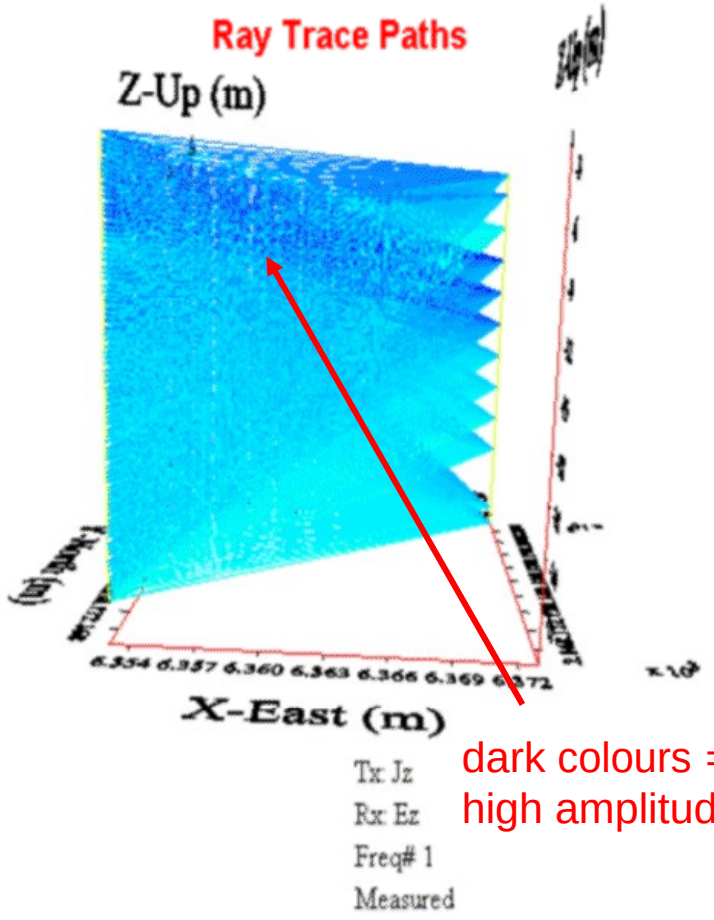
hole 07 **TX in hole DH07**

Ray Trace Paths weighted by amplitude

Data Display as a function ofTx vs Rx Position







dark colours = high amplitude

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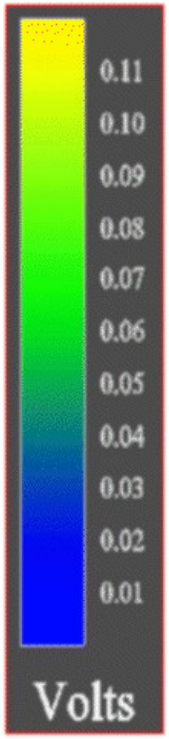
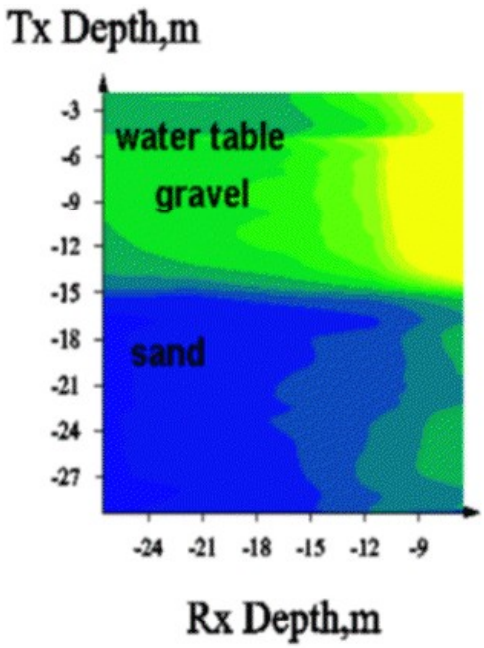
Crosshole EM Field Data

Hole 03

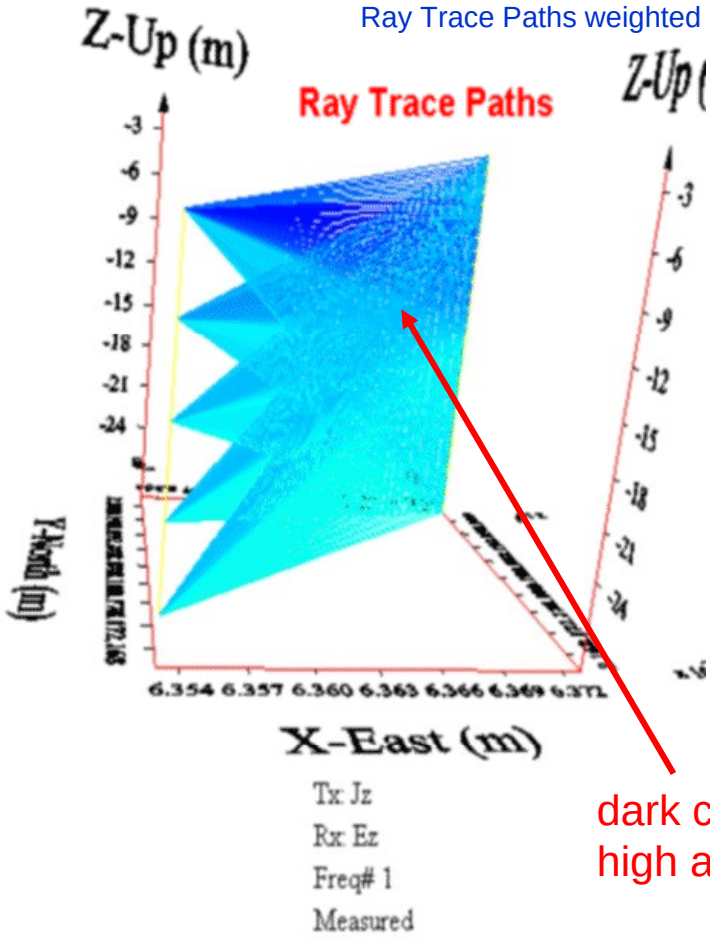
TX in hole DH03

Data Display as a function of Tx vs Rx Position





Ray Trace Paths weighted by amplitude



dark colours = high amplitude

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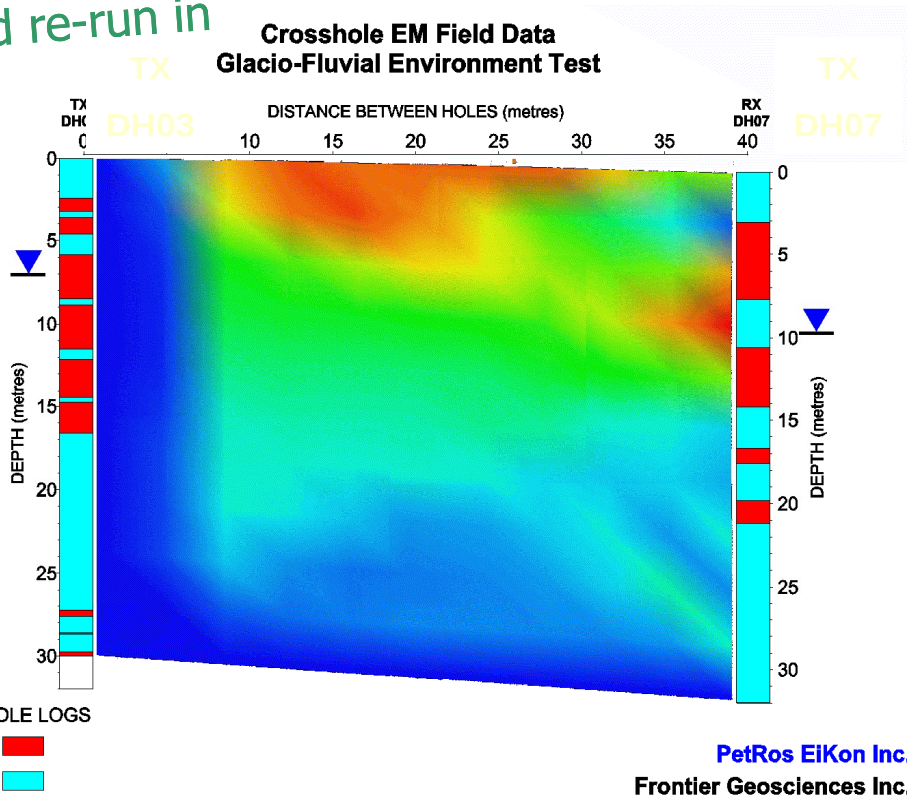
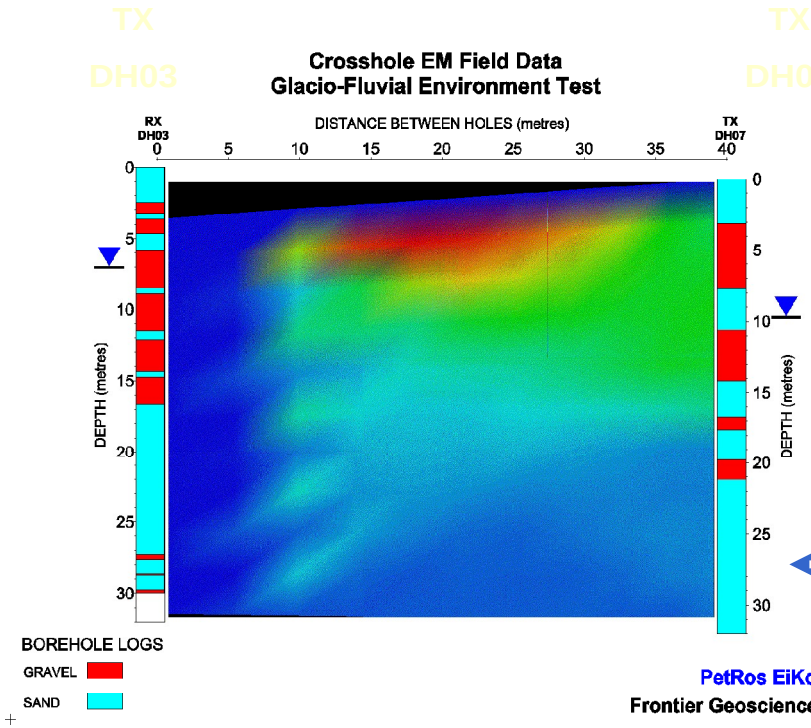
Reciprocal Surveying

Tx-Rx antennae reversed and re-run in the second panel

Panel1:

11 Tx positions used





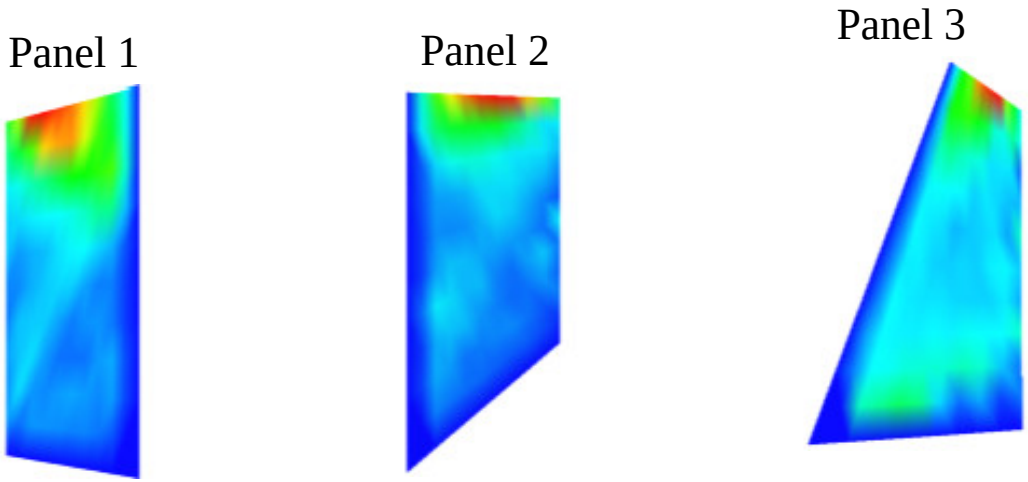
Panel 2

Reduced Resolution

Only 5 Tx positions used

500 KHz frequency used

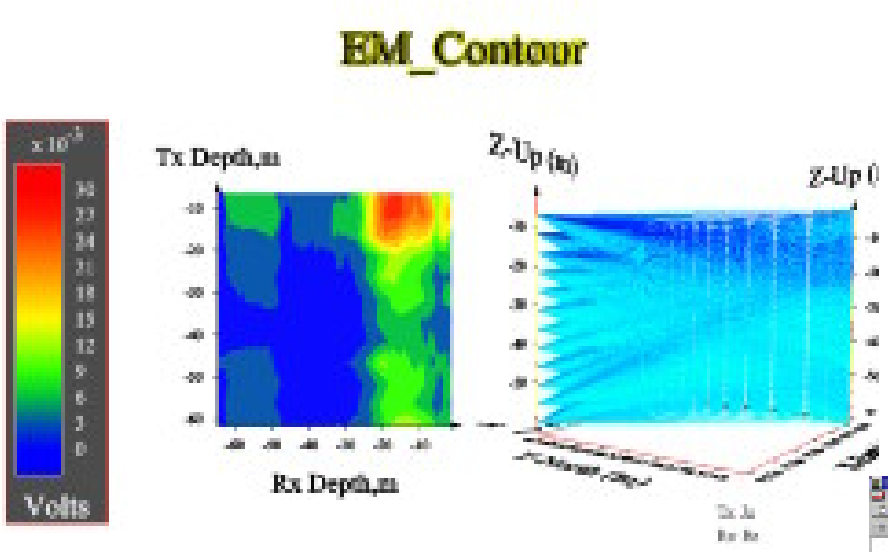
Earthen Dam Test Site



large earth filled dam

- sinkhole was discovered in the dam crest
- a broad range of geophysical approaches, including seismic, electromagnetic, resistivity, magnetics and ground penetrating radar methods failed to characterize the sinkhole due to difficulty in access, dam site surface conditions, culture and impedance contrasts.
- Borehole based geophysics proved to be the most diagnostic technique
- The essential objective is to image changes in the 'core', which consists of medium to fine grained material that has been rendered very dense during placement. The core is encased in very coarse (.5 m plus) shell materials for protection.

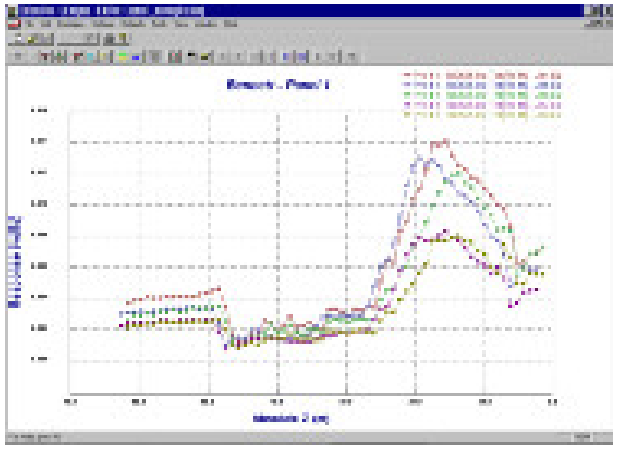
Earthen Dam Test Site



Panel 1 - Contour Plot Tx vs R

- test crosshole EM surveys were carried out in three borehole pairs. Two of these were in sections through a sinkhole and one was in undisturbed core material.

- The surveys in the sinkhole area show a lower attenuation shallow zone that is interpreted to be the coarse shell material in place, and shell materials that collapsed into the sinkhole during a 1996 event.
- the water table is clearly seen in this data

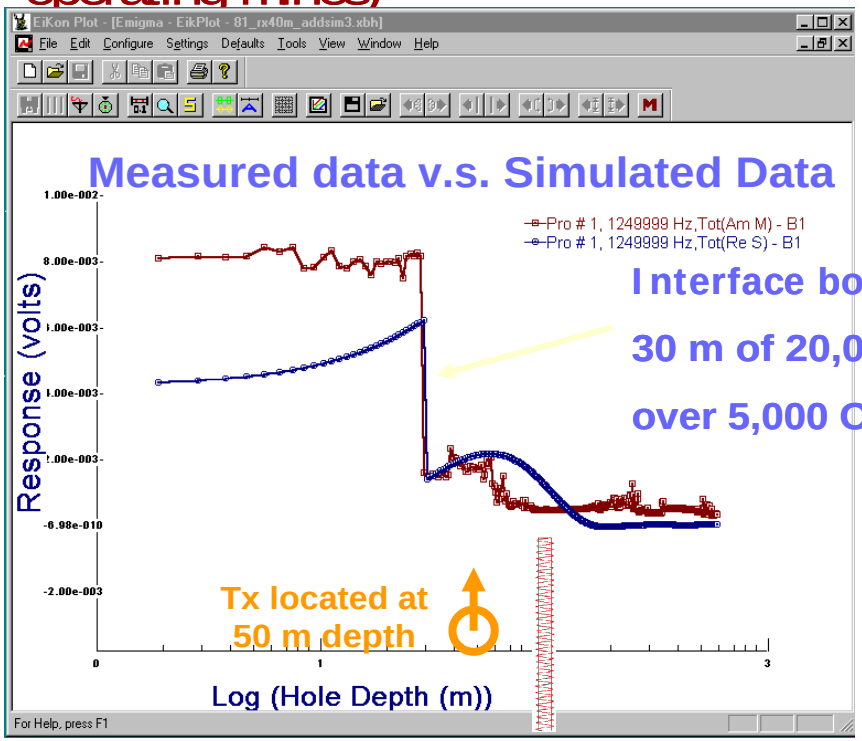


Panel 1 - X-hole data in volts

Mine Test Site – Sudbury, Canada

Instrumentation performed well with:

- **Electrically Resistive** Environment
- Strong wideband cultural noise present (holes located close and between two operating mines)
- Cold weather conditions (-20C)
- Deep holes (600m)
- Tx, Rx offsets greater than 600m



Mine Site Data

Xhole data (red)

Simulated data (blue)

Landfill Test Site – Waterloo, Canada

contains suspected leachate plumes with the potential to threaten municipal and private water sources and local wildlife

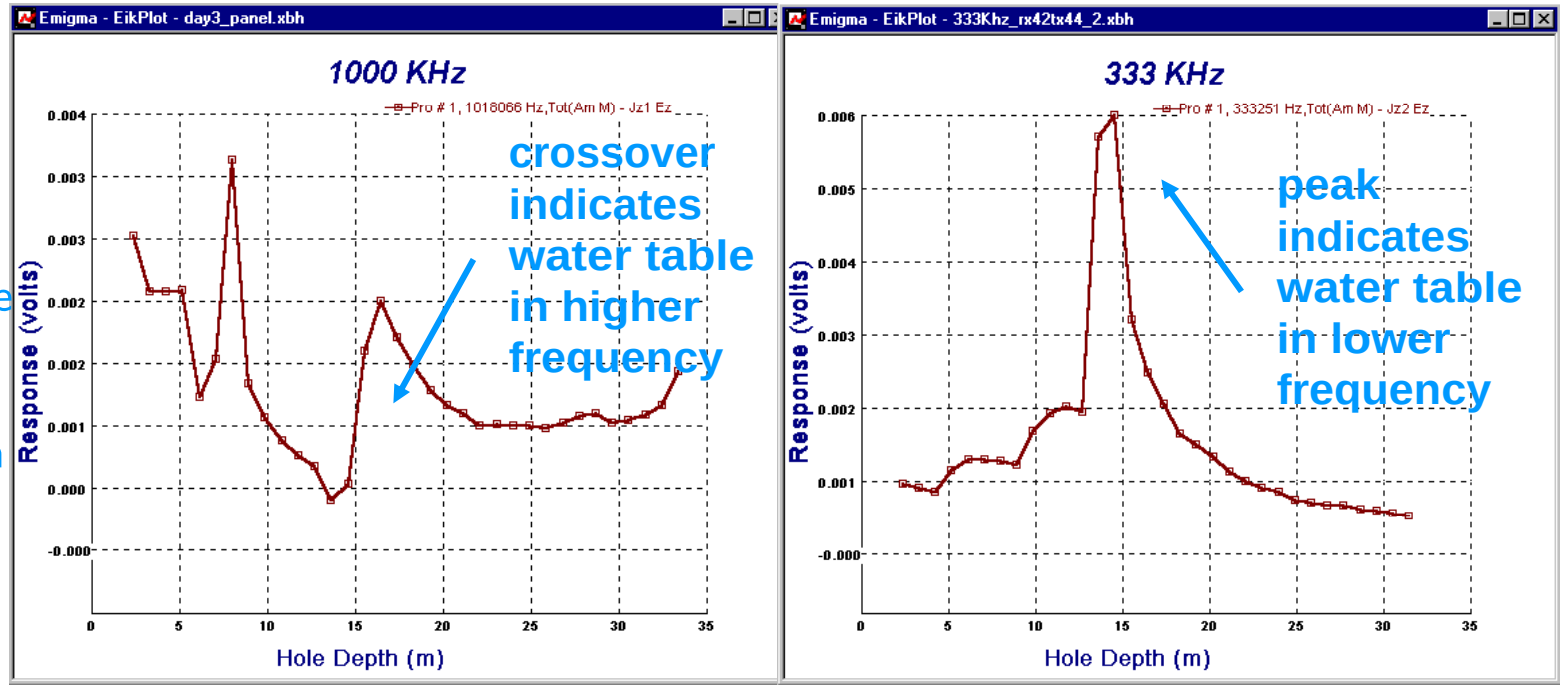
Multiple frequency tests - 333, 600, 750 and 1000 KHz

Instrumentation performed well with:

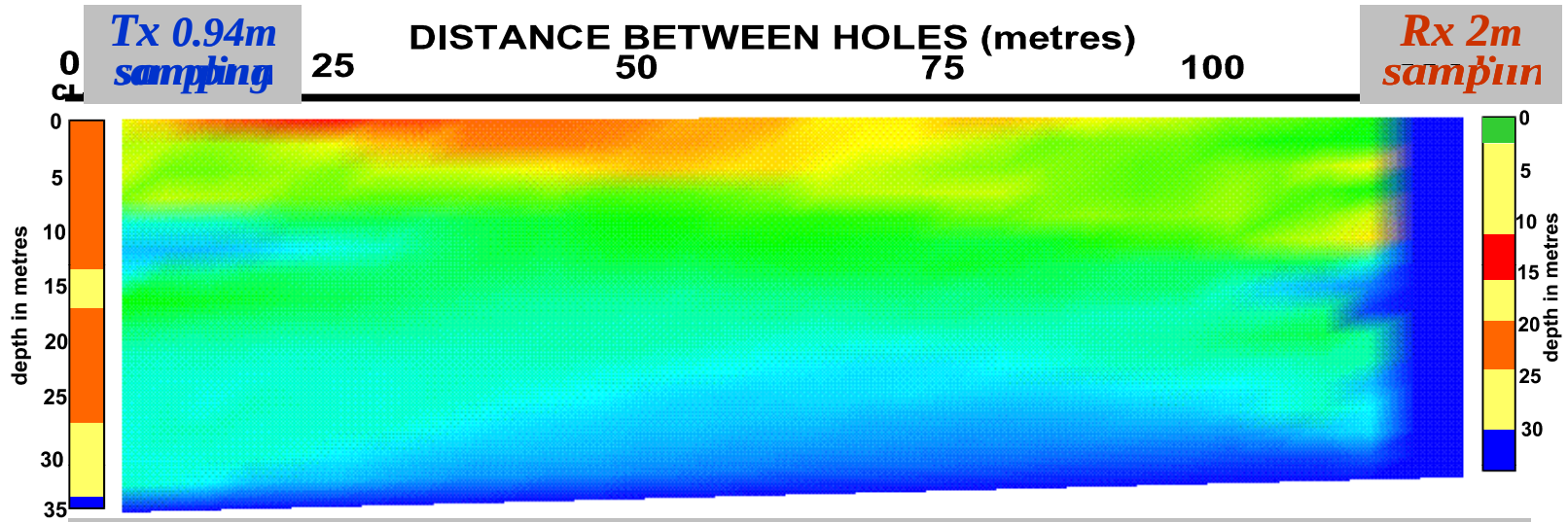
- wide Tx, Rx separations (100m) in conducting soil, till and bedrock
- strong cultural noise present (commercial arc-welding plant within .5 km of site, power lines, buildings, truck traffic)

♦ Moving Tx configuration in the same hole for 2 frequencies

♦ Receiver position at 3.0 m



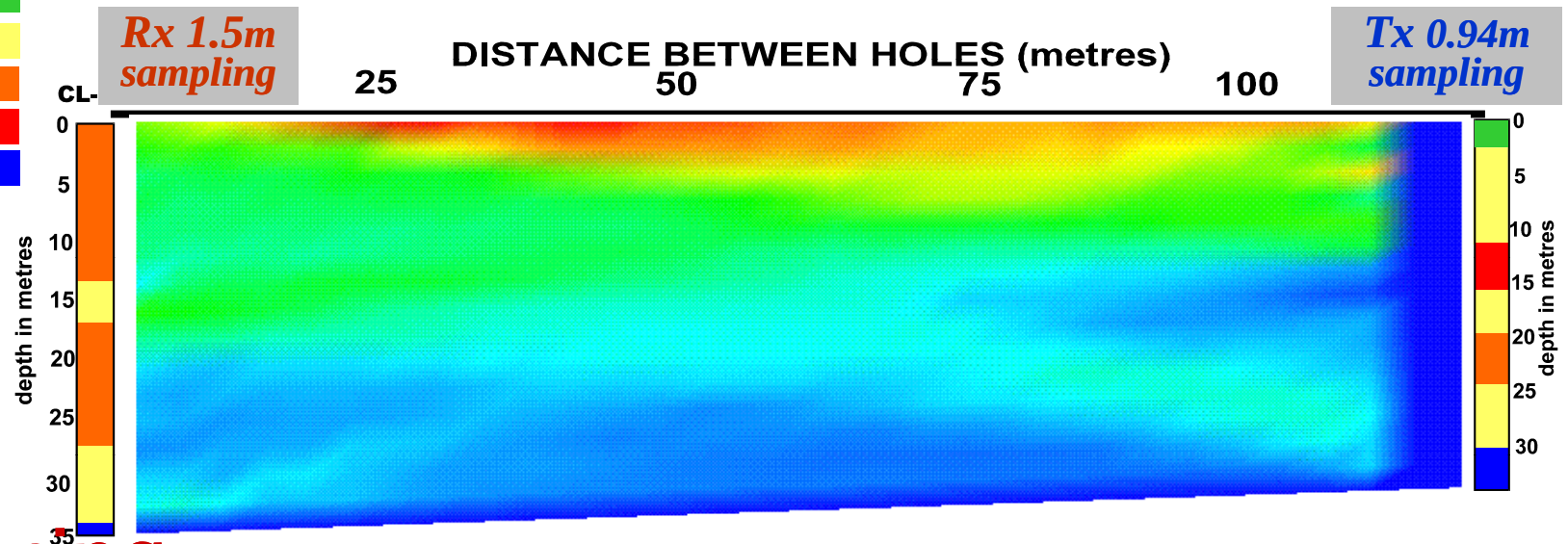
Landfill Test Site – Waterloo, Canada



Reverse Pattern Sampling for the same frequency - 1 MHz

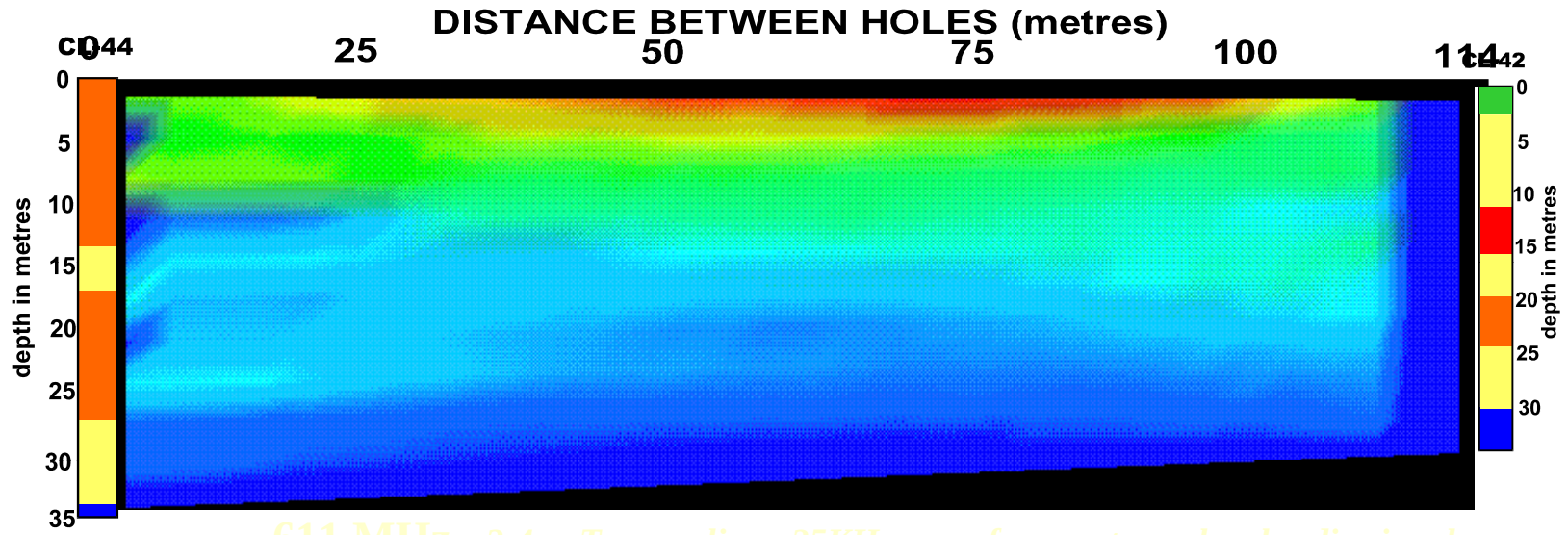
borehole log legend

FILL
SAND
SILTY SAND
SILT
BEDROCK



Raytracing

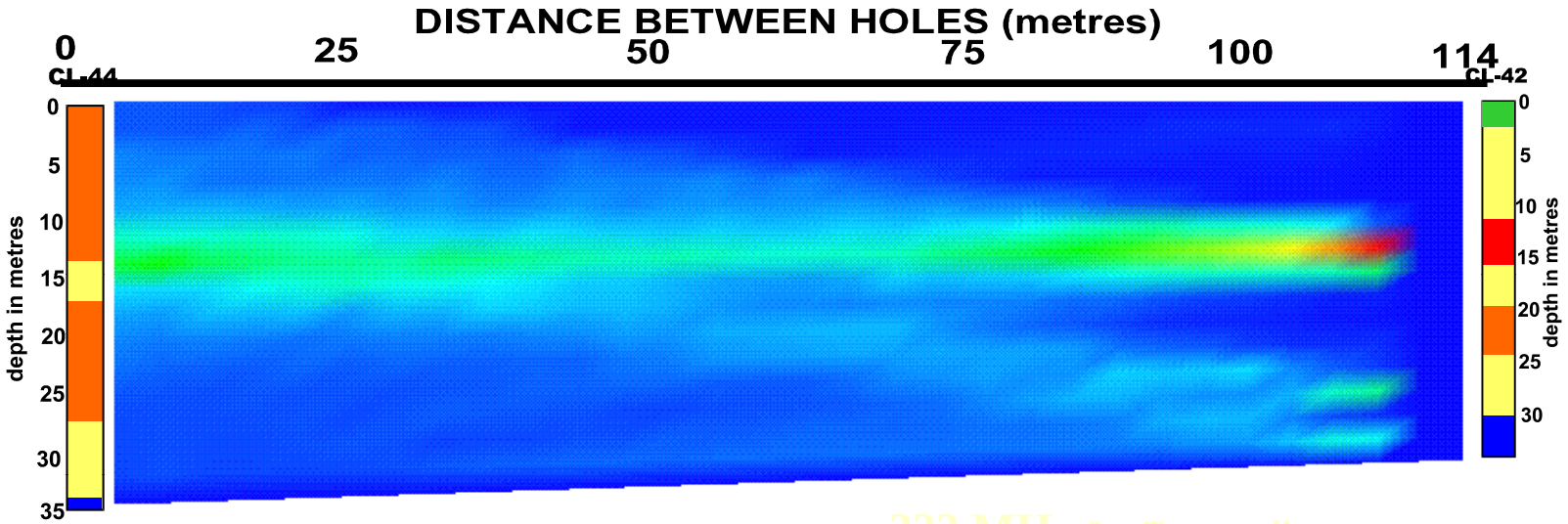
Landfill Test Site – Waterloo, Canada



borehole log legend

.611 MHz *2-4 m Tx sampling 25KHz away from a strong local radio signal*

FILL
SAND
SILTY SAND
SILT
BEDROCK

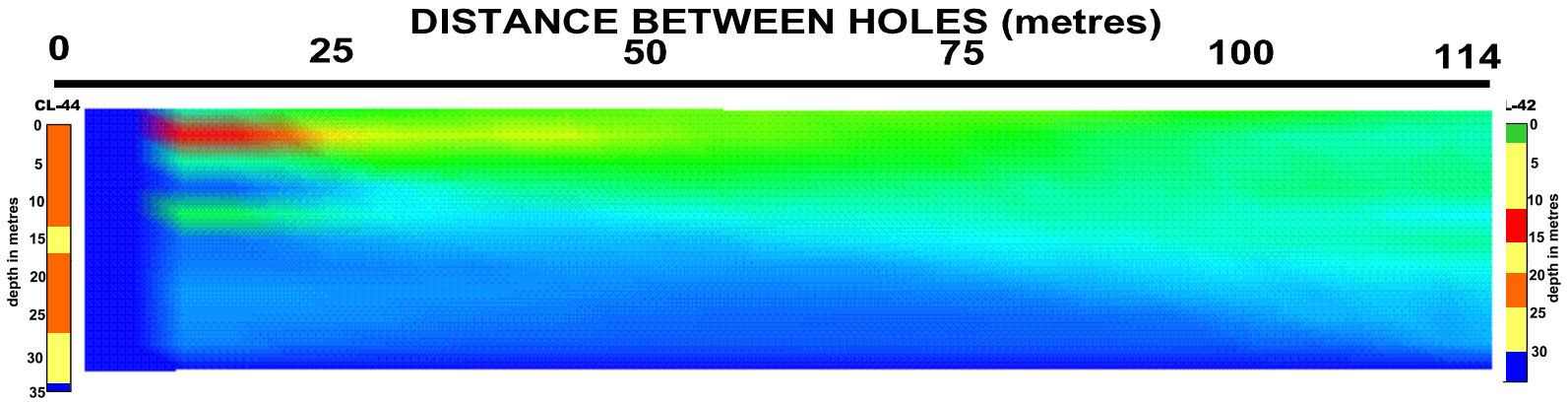


.333 MHz *2m Tx sampling*

Raytracing

Landfill Test Site – Waterloo, Canada

borehole log legend



.750 MHz *2m Tx sampling*

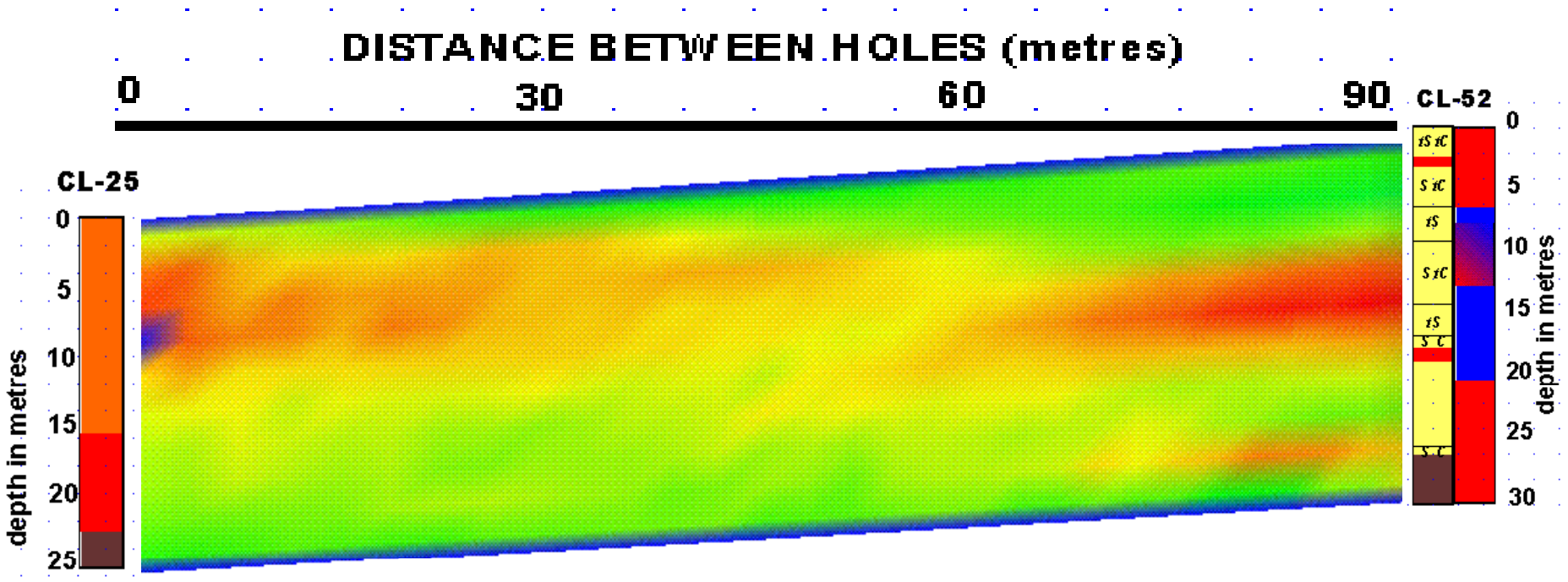
Landfill Test Site – Waterloo, Canada

borehole log legend

FILL
SAND + GRAVEL
SILTY SAND
SILT
BEDROCK

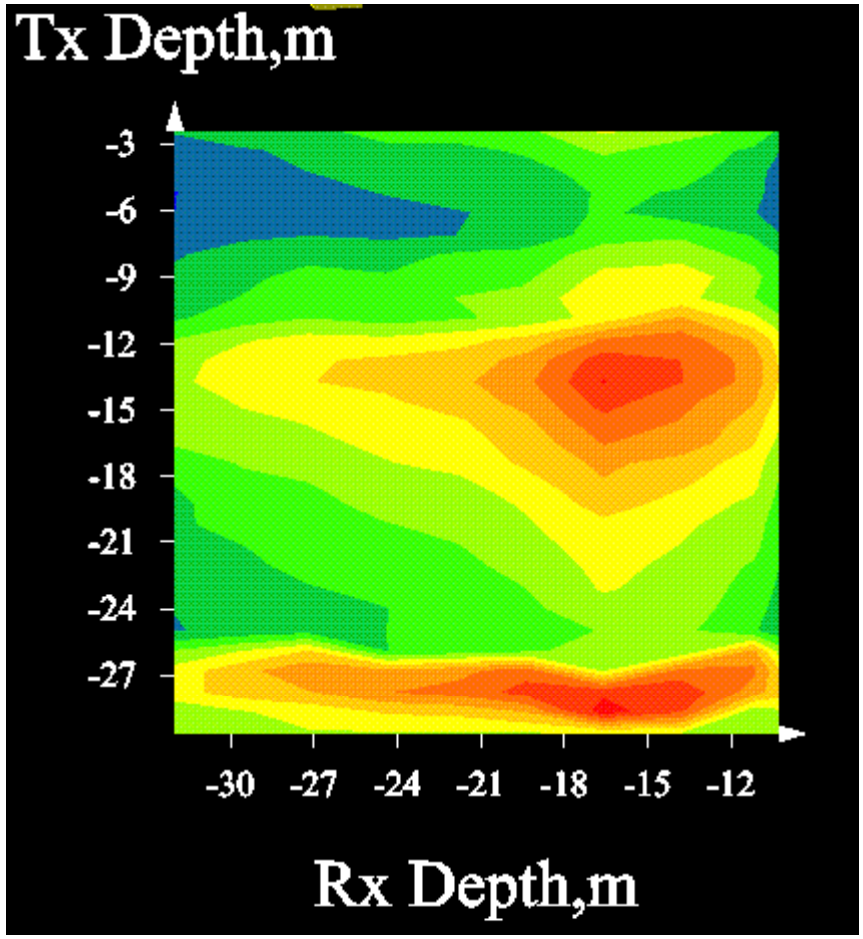
S Silt
tS Trace Silt
C Clay
tC Clay

CONDUCTIVITY HIGH
CONDUCTIVITY LOW
INTERMITTENT H + L



.151 MHz 0.94 *Tx sampling*

Contour tx position vs rx



Conclusions:

- NMHA can operate between low KHz and low MHz using compact broadband antennae

-Rapid data collection with sufficient redundancy for noise estimates

Present Research Focus

- Relationship between freespace resonance and broadband underground

- Radiation pattern in lossy medium for more effective tomography and inversion techniques

Status: 2000

-5 test areas studied

-more than 12 panels of data have been collected

-initial development extremely successful

-excellent data repeatability

-interpretable multi-frequency data

-developed signal-to-noise estimation procedures to ensure data quality

-reliable field procedures developed

-dependable pre-commercialization equipment

-all necessary software now available

READY to study scattering processes which are not clearly understood in RIM technology

Test Sites Required:

- Additional test sites are sought for

- Environmental detection applications and Mine applications

Major Objectives:

-1 Secure additional test sites

-2 Collect more than 4 pairings of data in order to image the subsurface in 3D

Minor Objectives:

-1 Survey holes with greater than 25 m offsets to test the equipment's distance limitations

-2 Survey a site with cultural noise to determine equipment's noise tolerance

Contact Us

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