KMS Technologies – KJT Enterprises Inc.

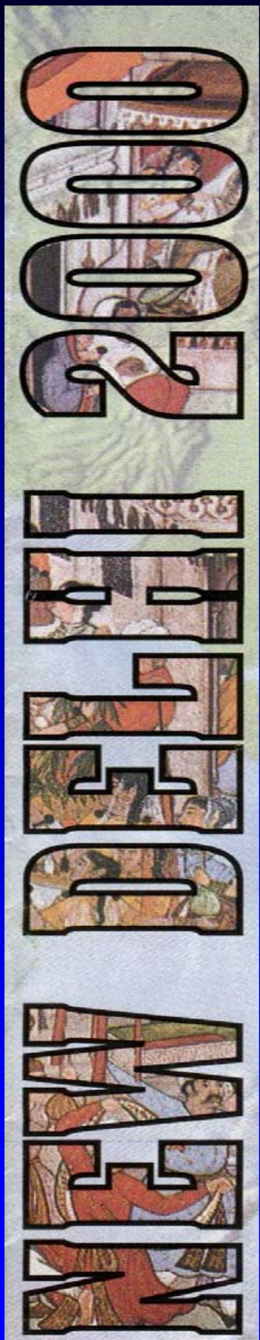
Presentation

Morrison, H. F., Wilt, M., Strack, K. – M.

2000

Borehole Electromagnetics Theory & Applications

Society of Petroleum Geophysicists/Society of Exploration Geophysicists
Conference & Exposition on Petroleum Geophysics, New Delhi



Borehole Electromagnetics Theory & Applications

H.F. Morrison[1], M. Wilt [2], K.-M. Strack [3]

Feb 2000

[1] University of California at Berkeley
[2] Electromagnetic Instruments Inc.
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Outline

- Importance of borehole EM
- The methods
- Cross well examples
- Summary

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Importance of borehole EM

- Resistivity dependence on Φ & S_w high
- Scaling to reservoir scales
- Signal comes from conductivity contrasts
- Crosswell seismic sensitivity & scale comparable
- Excellent for OWC detection
- Routine log measurement

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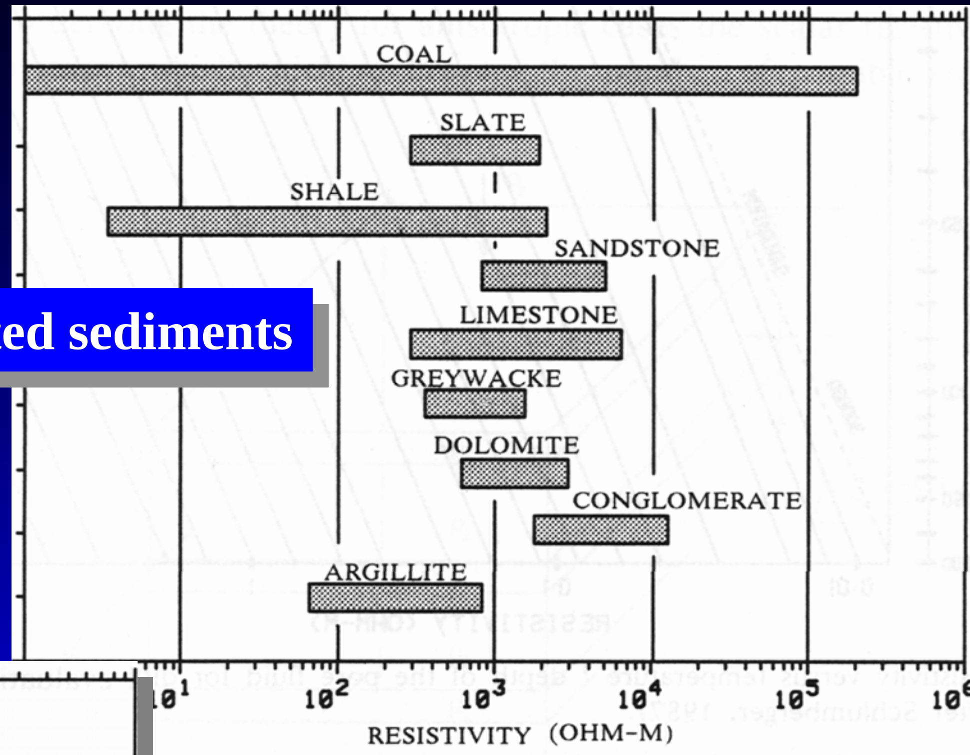
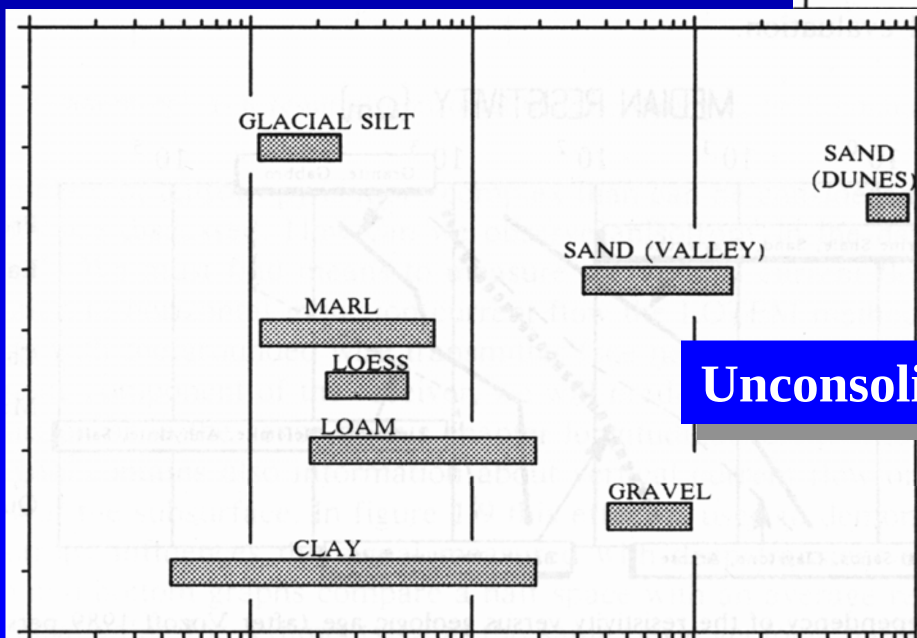
Resistivity Ranges

**Wide ranges =
fine parameter distinction**

Consolidated sediments



Unconsolidated sediments



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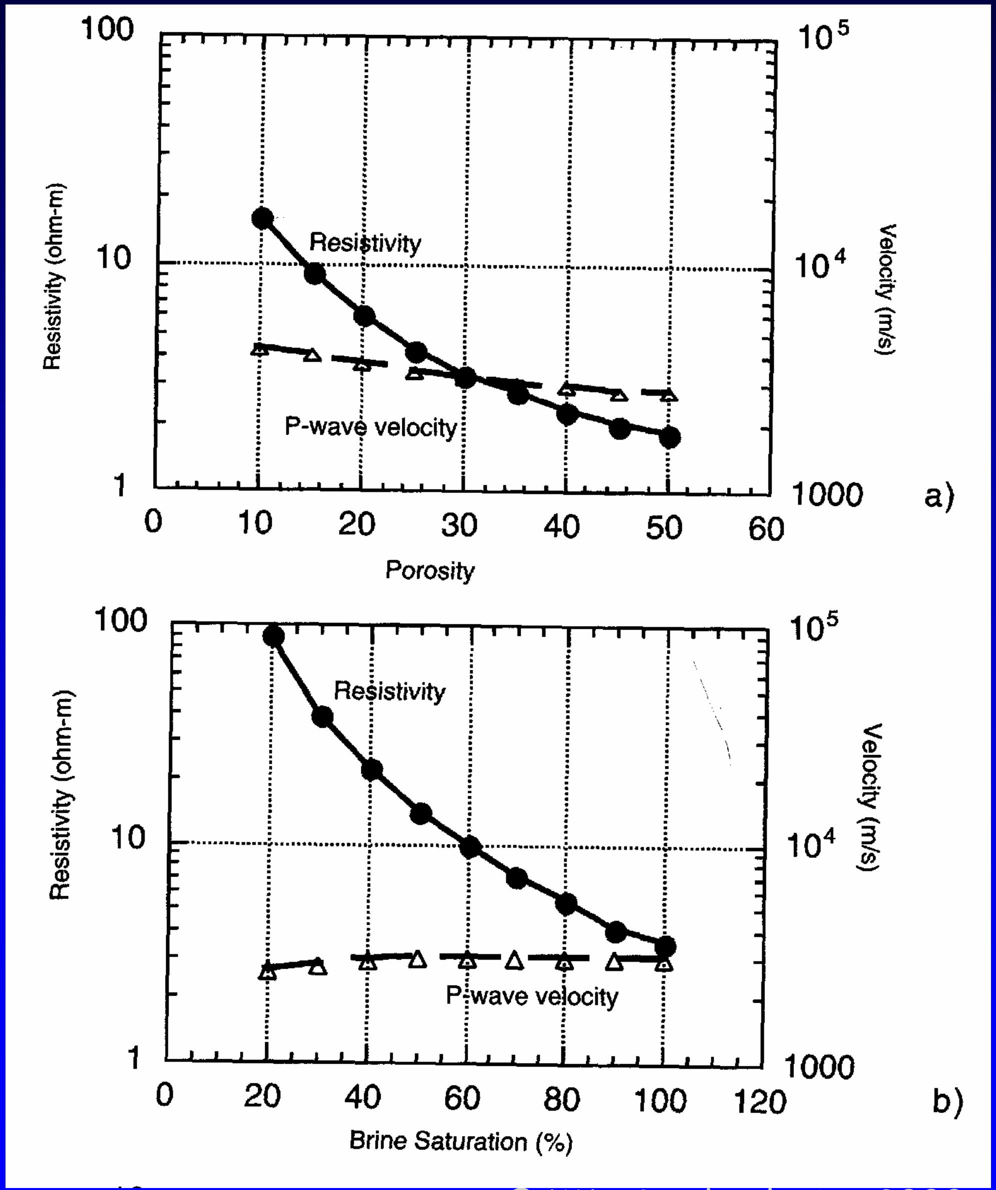
Resistivity & velocity versus porosity brine saturation temperature



After Wilt & Alumbaugh , 1998

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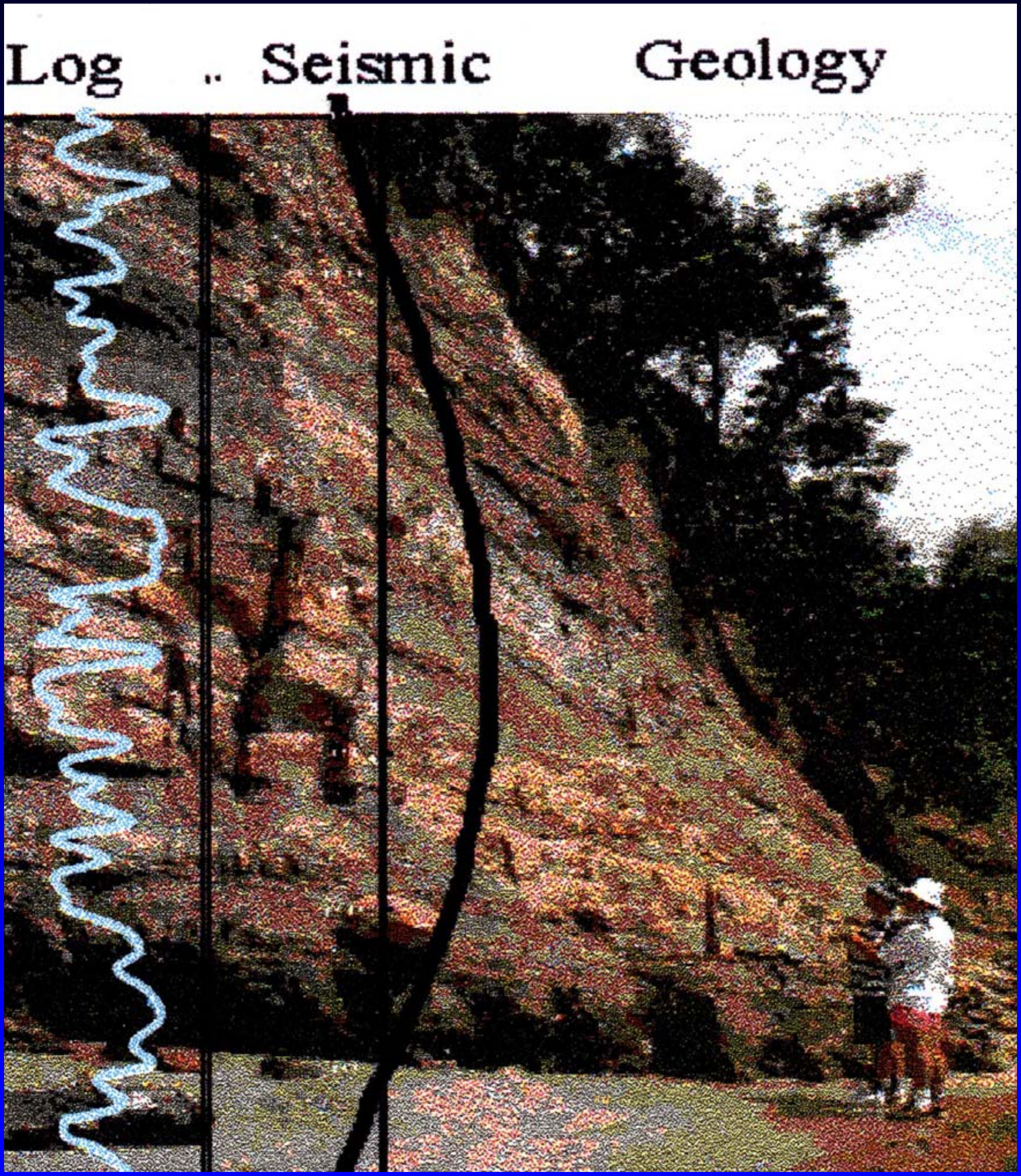
The scale issue



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The methods

- Classical borehole measurements
  - induction log — commercial
  - array induction — commercial
- Special applications
  - Deep Logging — R&D
  - Cross well — commercial trials
  - Single well — R&D

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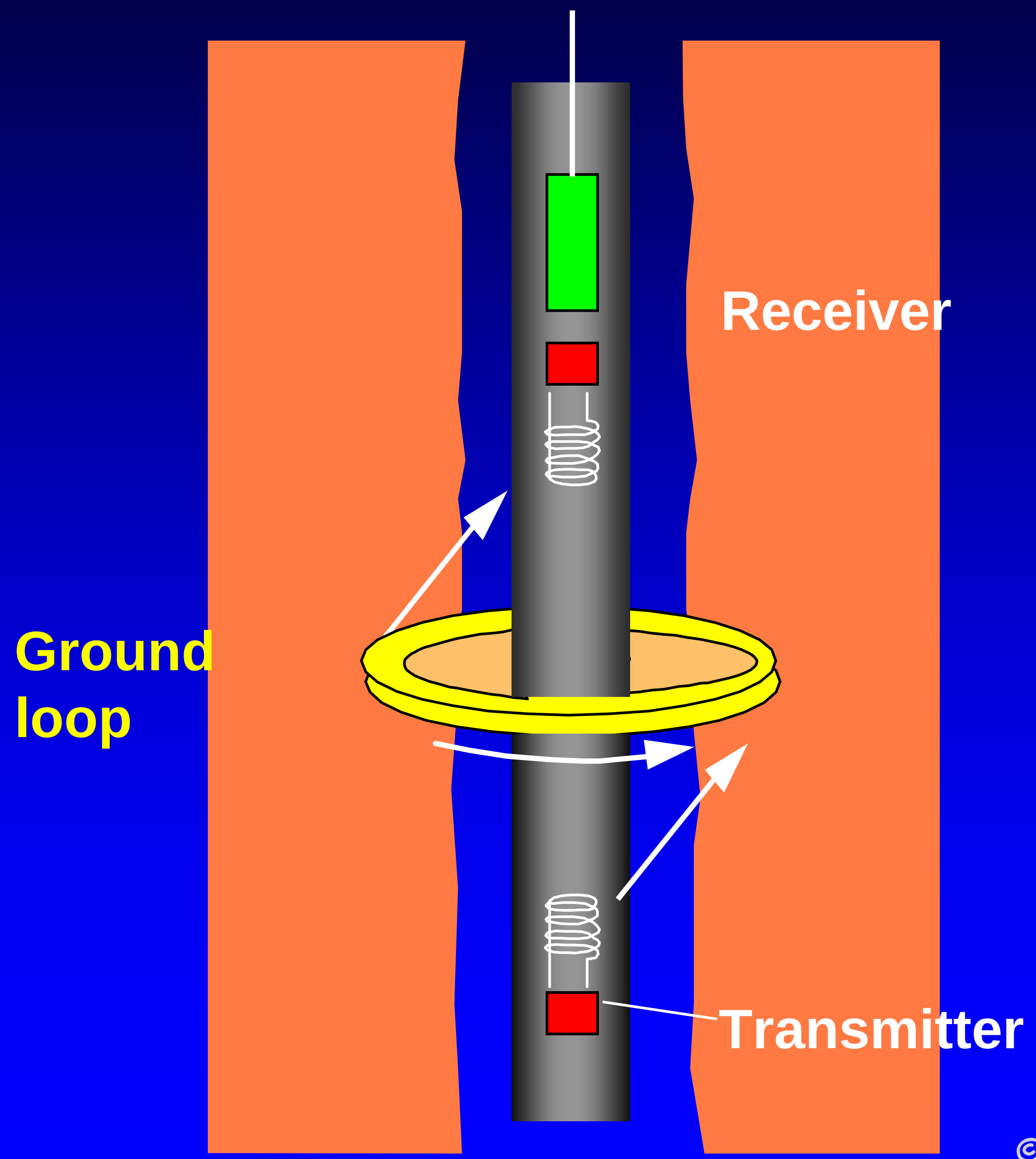
Induction log principle



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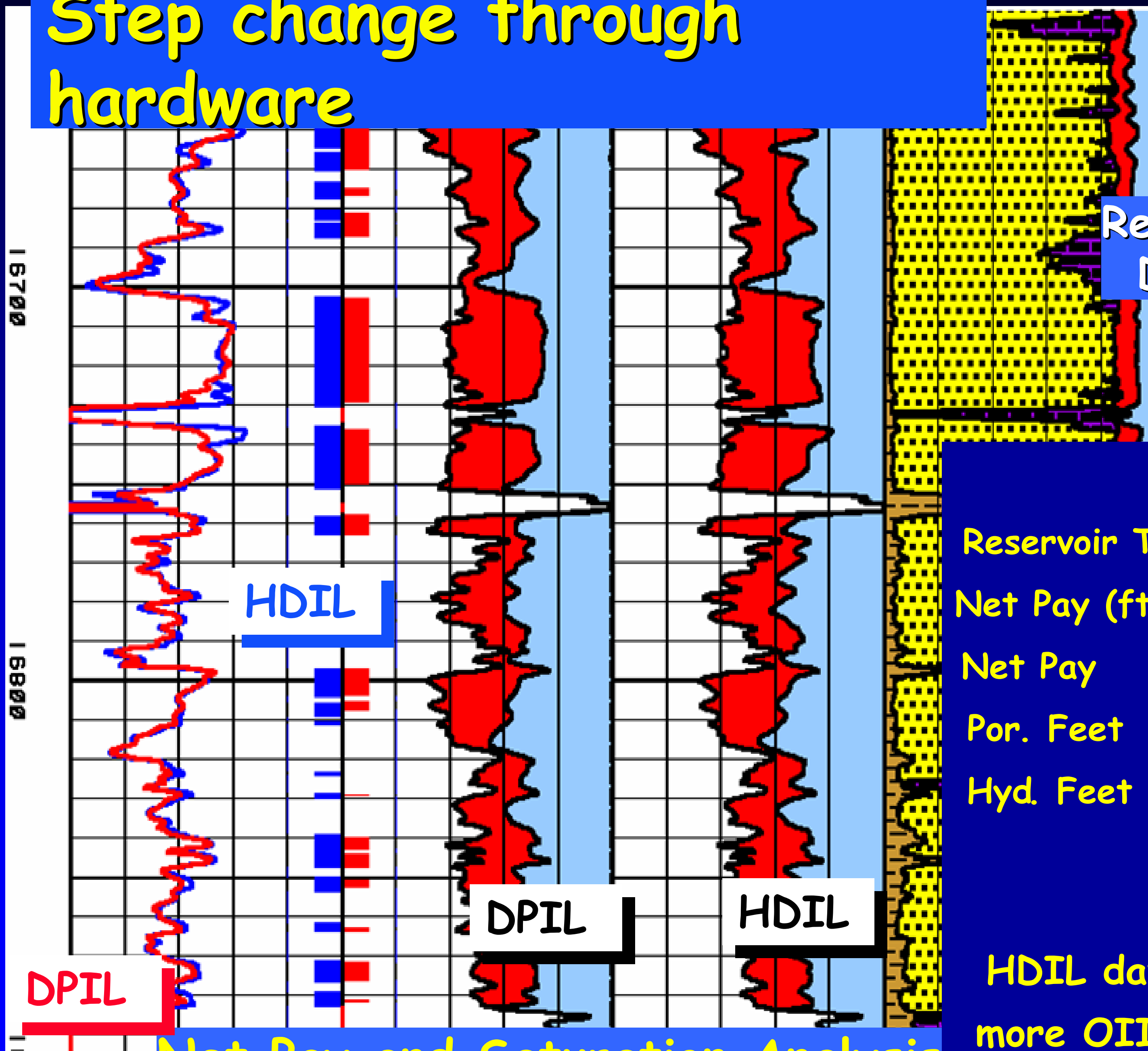
Step change through hardware



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Net Pay and Saturation Analysis

Reserves estimate DPIL vs. HDIL

	DPIL	HDIL
Reservoir Thickness:	270 ft	
Net Pay (ft)	103.6	130.1
Net Pay	38.4%	48.2%
Por. Feet	15.4 ft	18.9 ft
Hyd. Feet	7.4 ft	9.2 ft

HDIL data allowed 24% more OIIP be booked.

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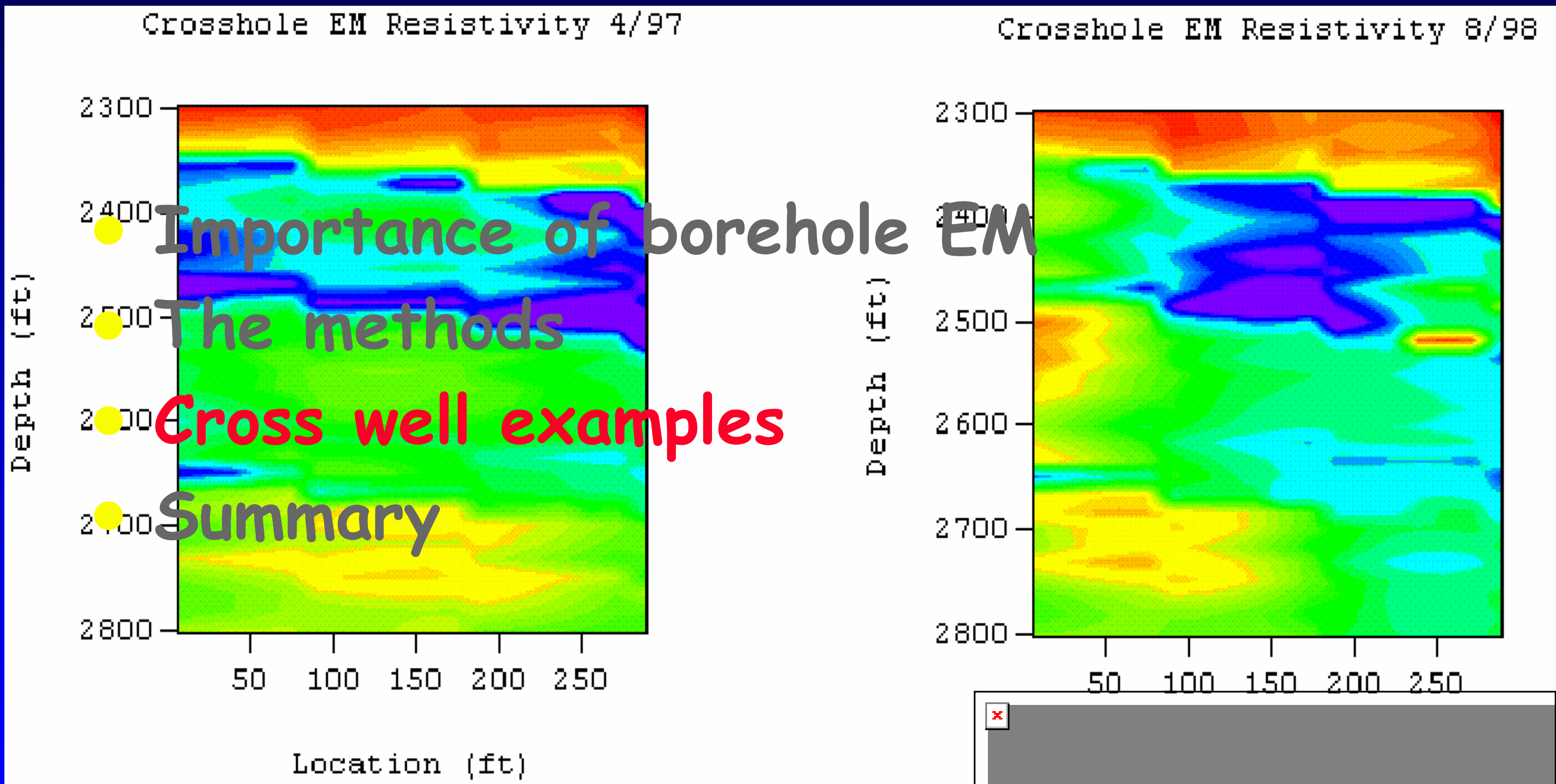

Cross-well time lapse measurements

Courtesy of EMI Inc.

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Crosswell examples

- The MAIL tool et al.
- Cross well example
- New multi-component tool

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Crosswell examples

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Single Hole Systems of EMI

- MFT250 - mining
  - Single sensor 3 component HF tool
- MAIL Tool - geothermal
  - Multiple sensor 3 component tool
- VEMP Tool - mining
  - 3 component surface to borehole system
- Geo-Bilt (2000- 2001)

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Raising the MAIL Tool in Japan

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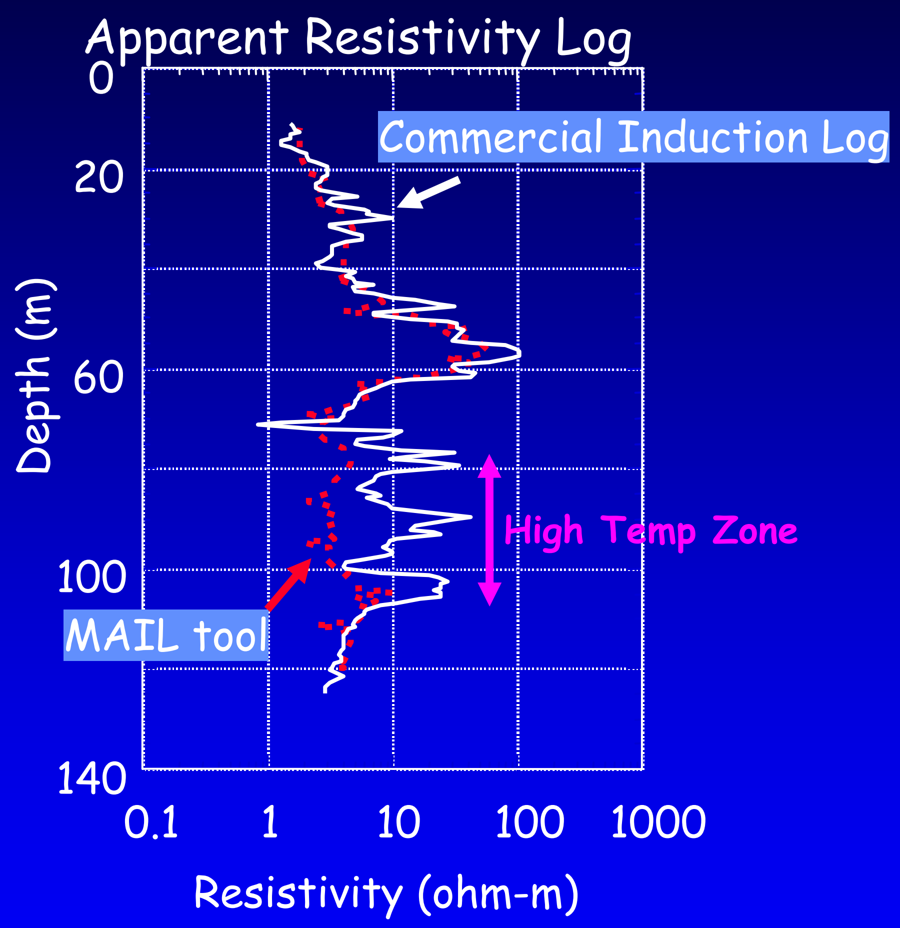
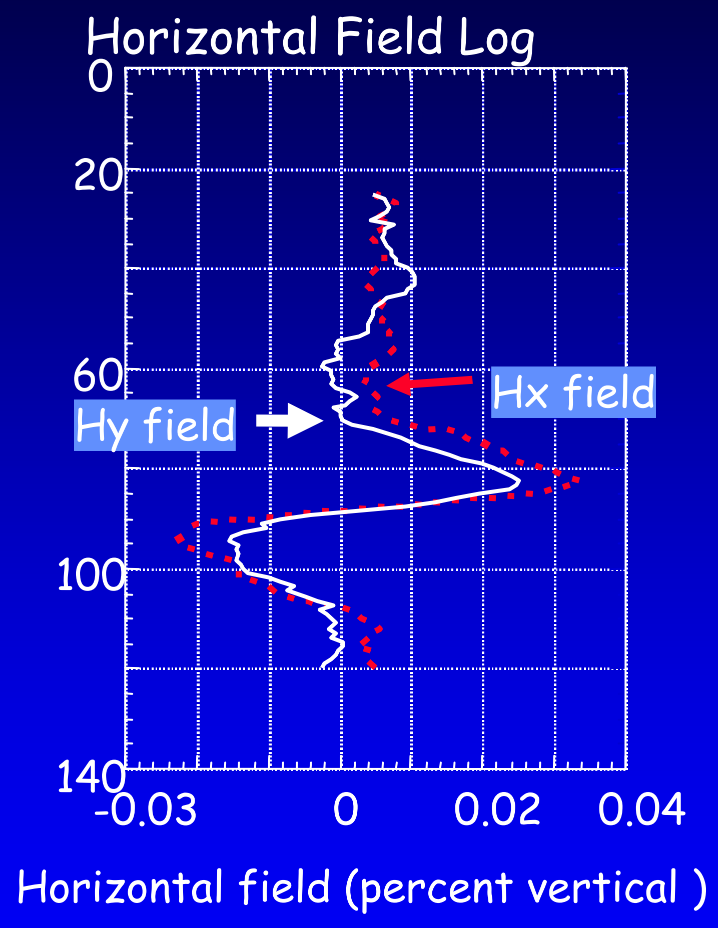
MAIL results: well DRL61w (0 on section)





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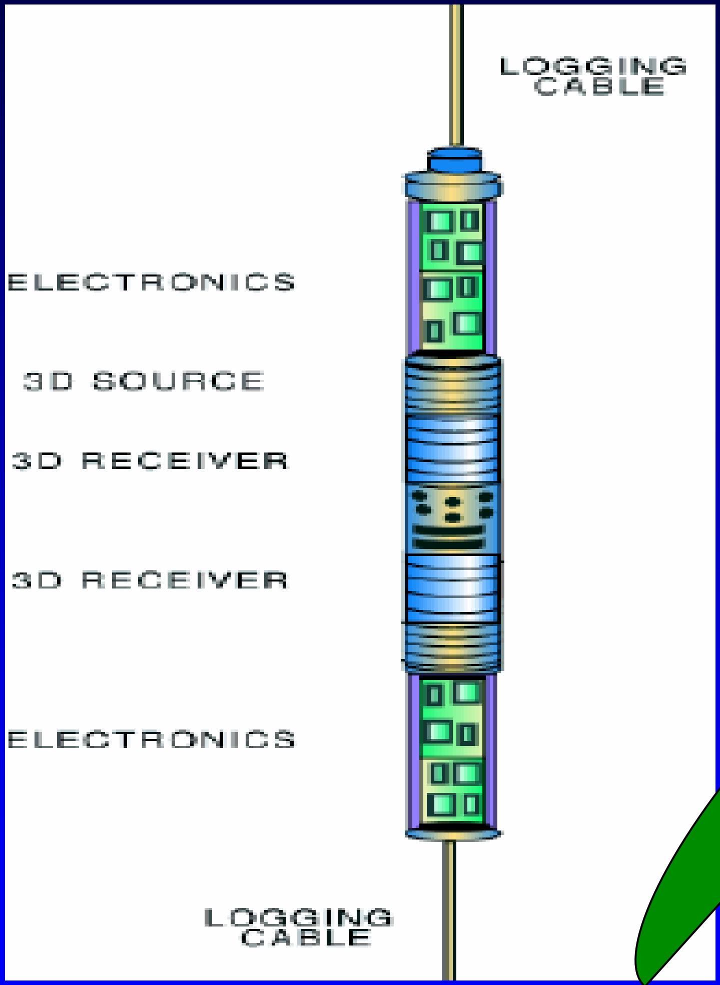
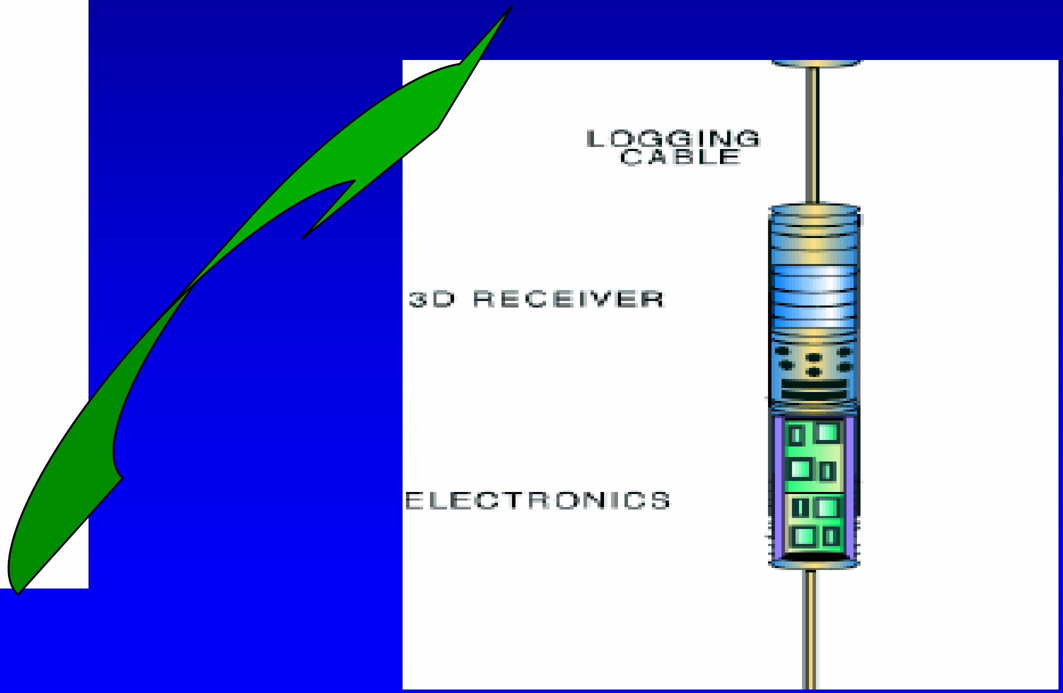
Geo-Bilt building blocks





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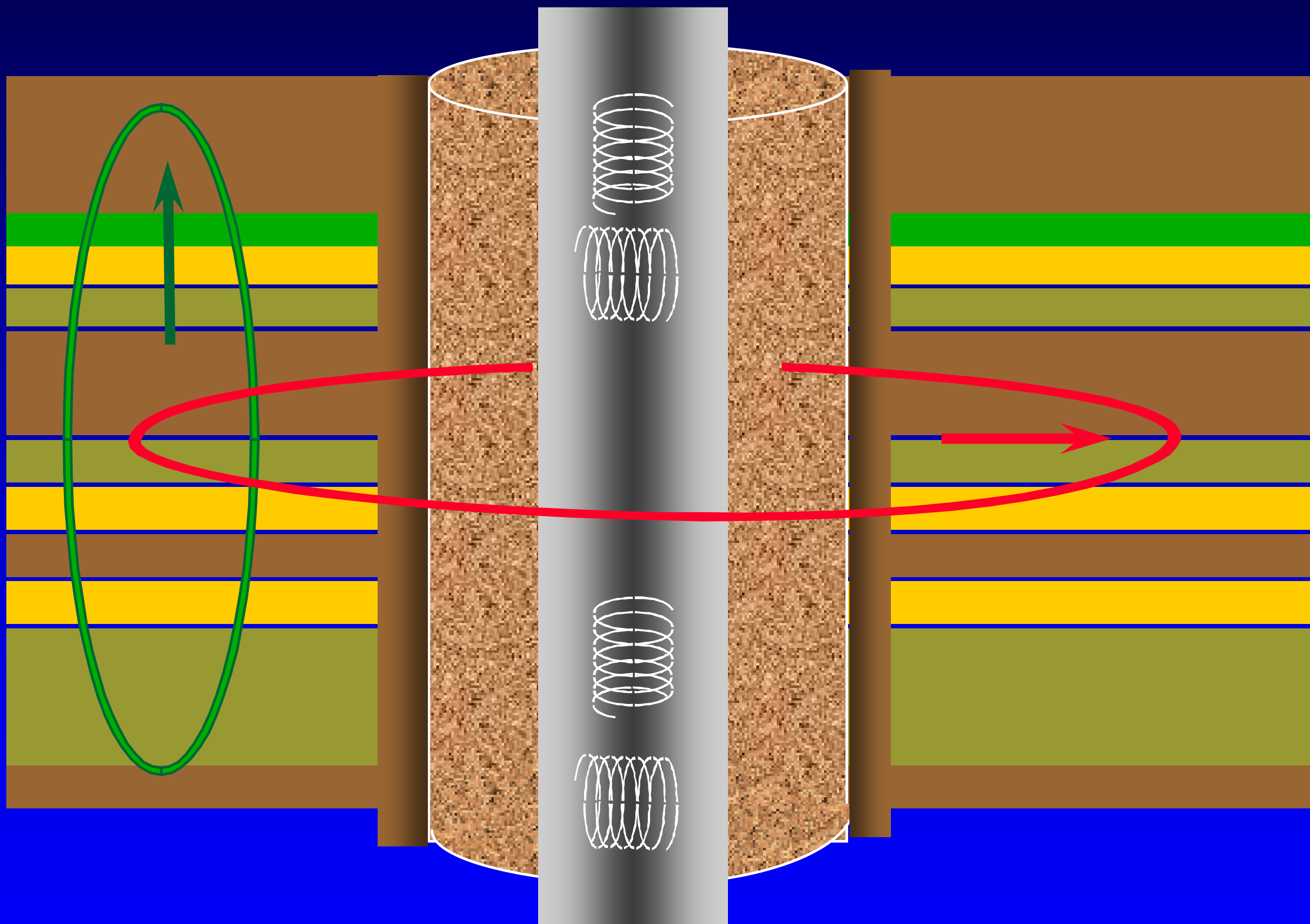
Geo-Bilt tool physics



MAIL needs dipping beds or anisotropy

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Crosshole EM

- 1990: LLNL,LBL, and EMI, developed first low frequency crosswell EM System
- Designed to be a 2-D to 3-D extension of EM induction logs; complementary to crosswell seismic logging

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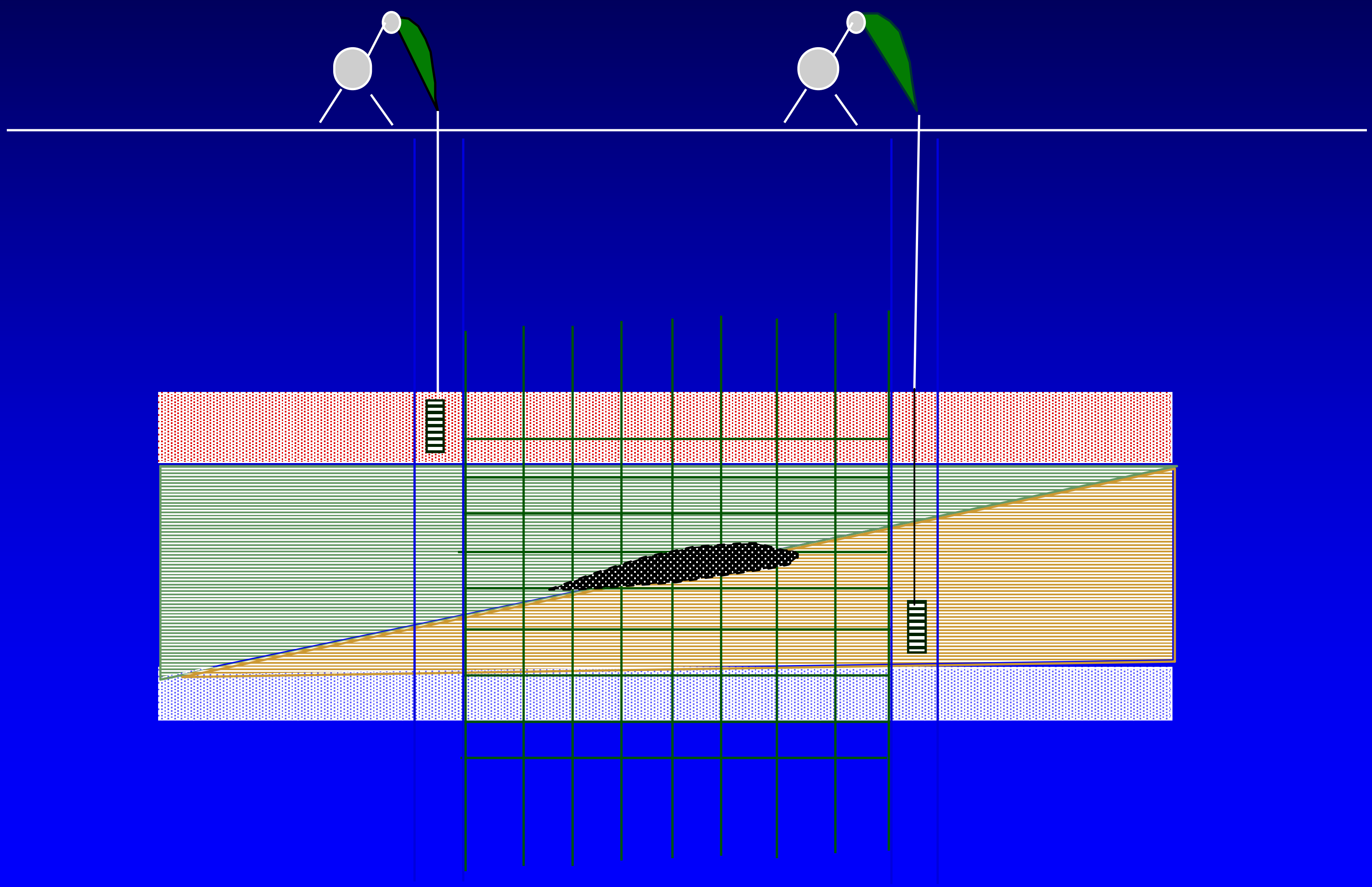
Conductivity tomography



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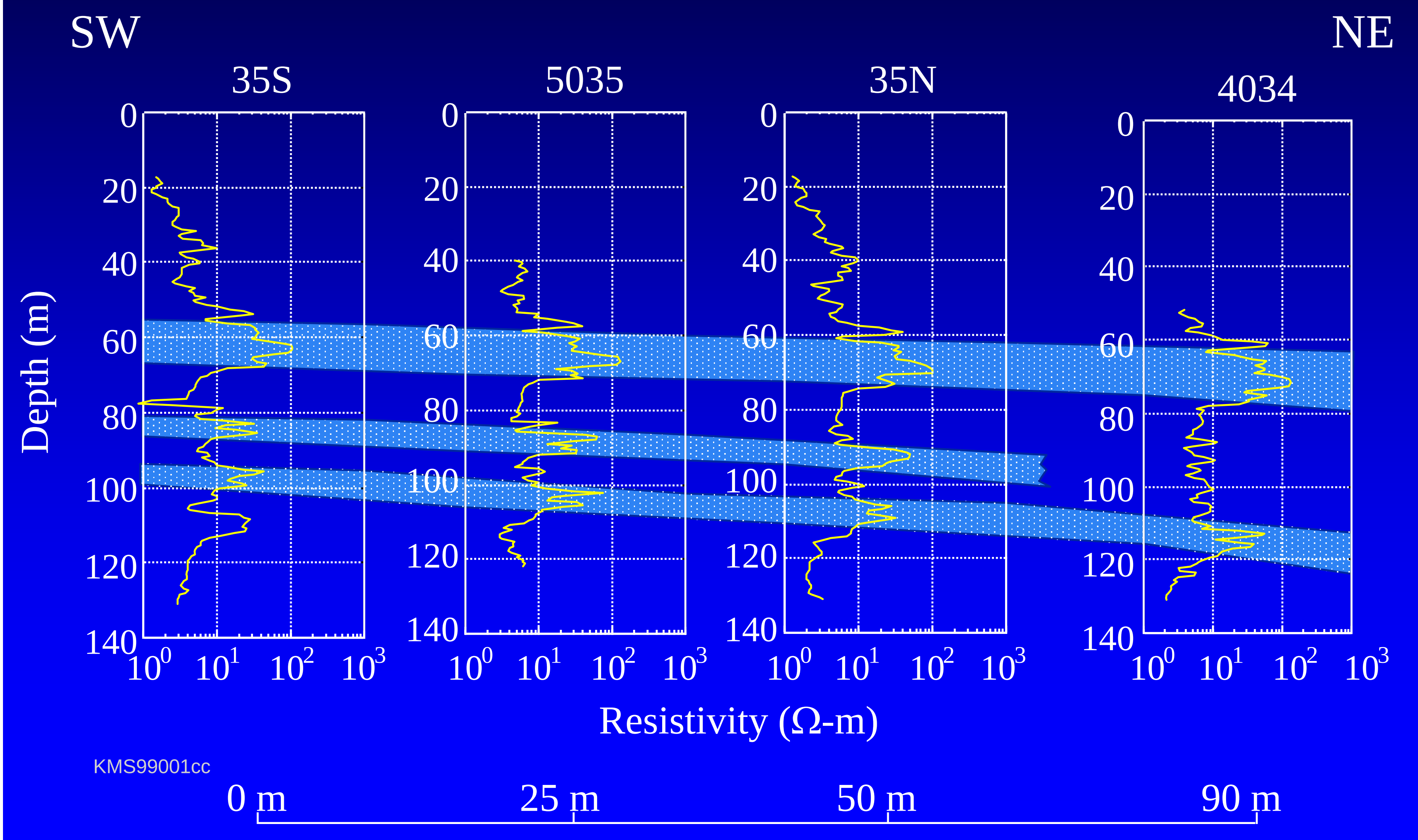
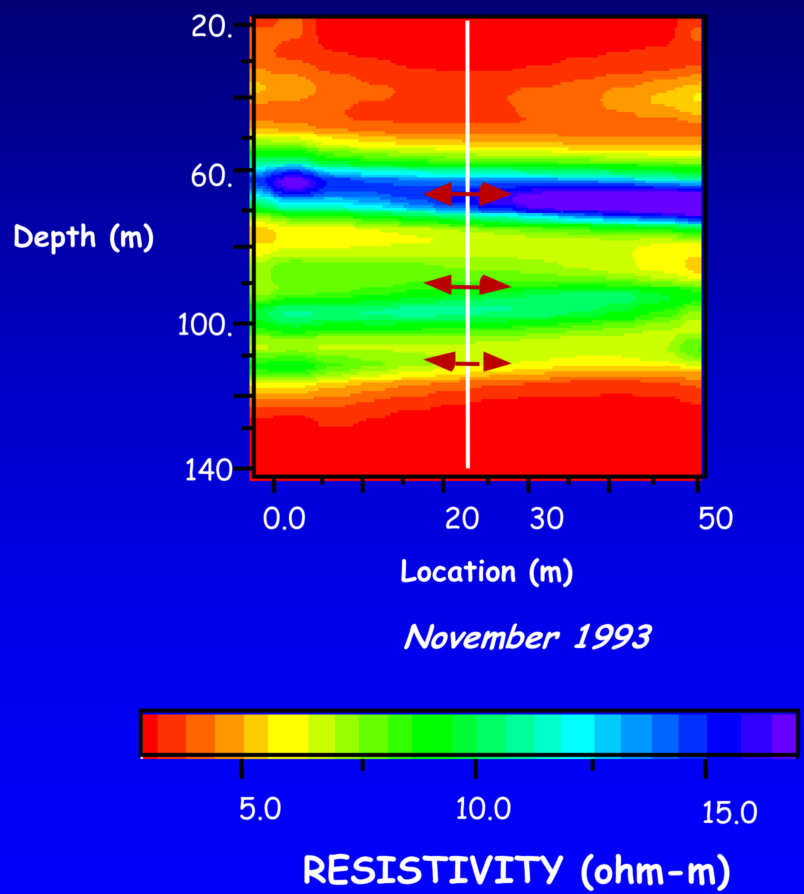
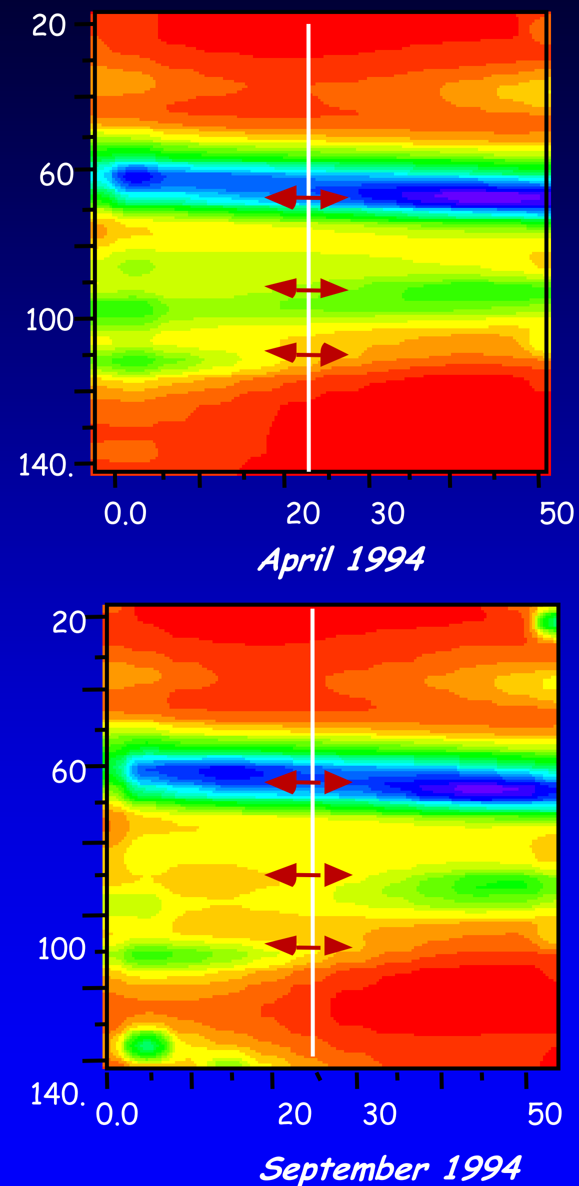
Model from Induction Logs



Time lapse view of steam flood





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Single well water flood 3D modeling example

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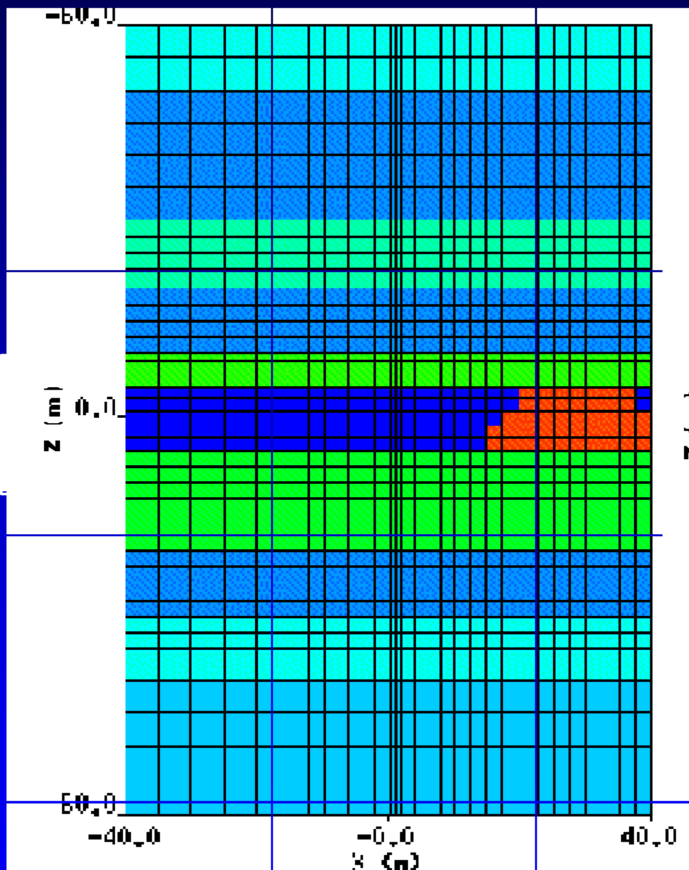
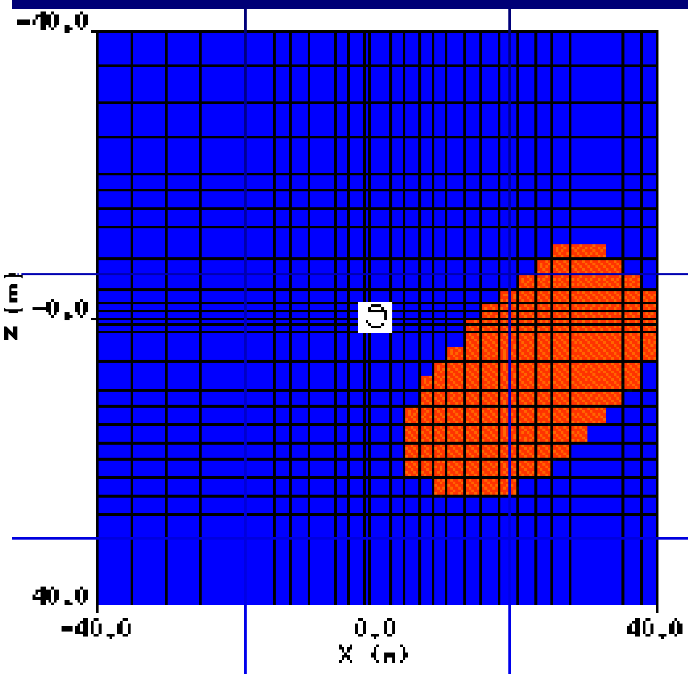
Water Flood Model (Alumbaugh & Wilt)

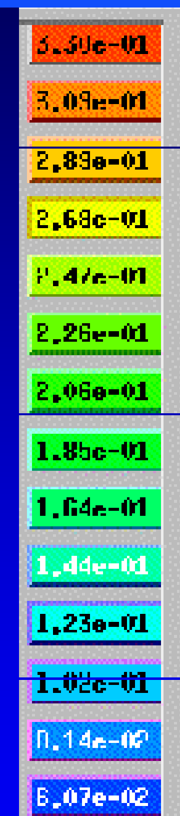
X-Z Cross Section at Y=0



X-Y Cross Section at Z=0



Conductivity (S/m)



21 VMD Source Pos. - Three Frequencies/Decade from 1KHz to 100KHz

Forward Model Mesh = 64 x 61 x 66

Inversion Model Mesh = 45 x 45 x 53 : Imaging Region = 30 x 30 x 40

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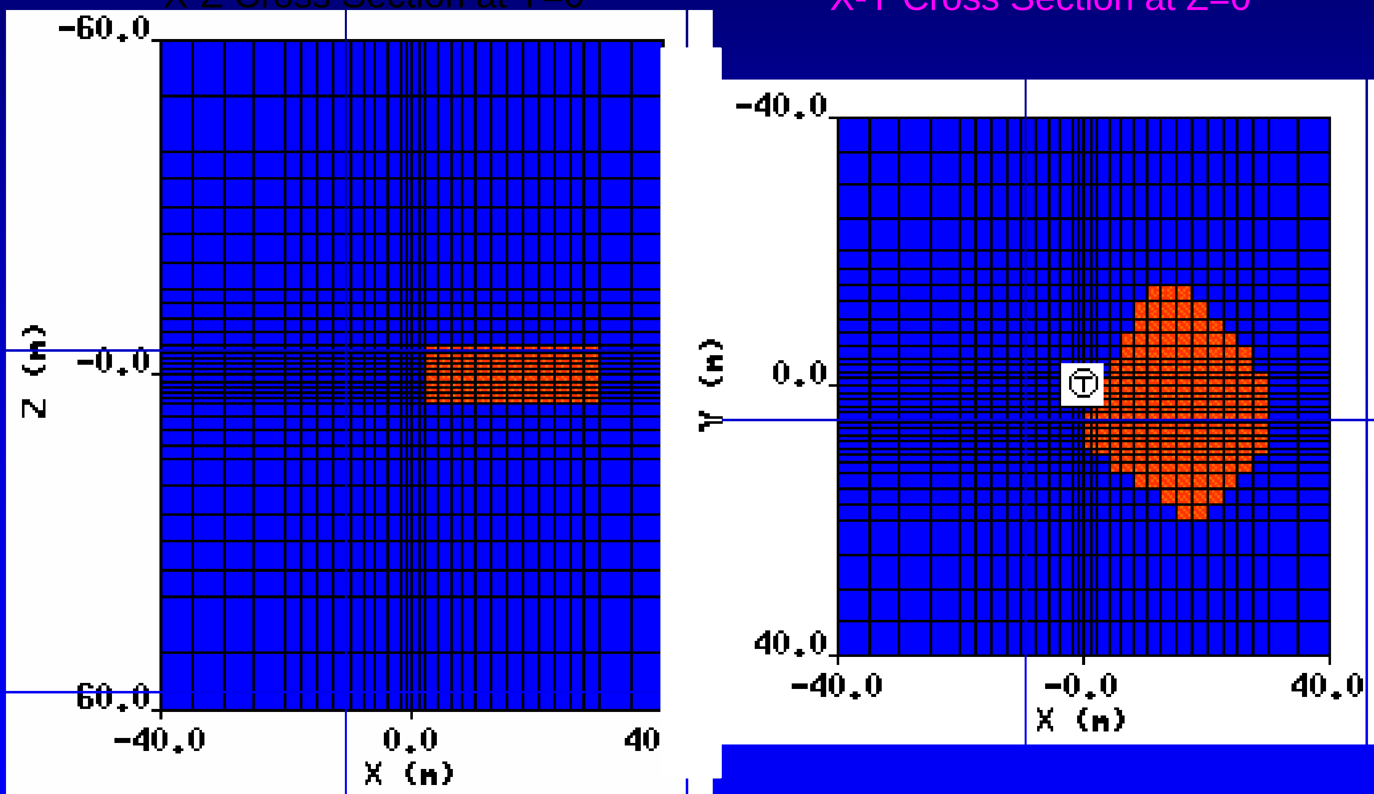
Initial 3D model (Alumbaugh & Wilt)

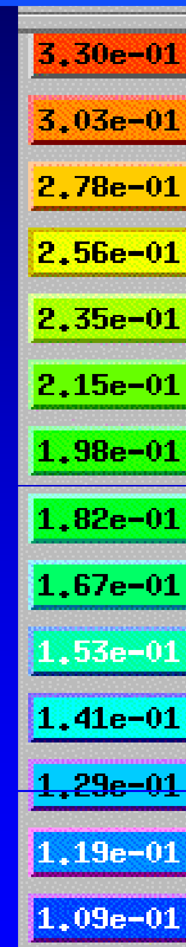
Model 1 as shown
Model 2 flipped across the XY planes.

X-Z Cross Section at Y=0

X-Y Cross Section at Z=0



Conductivity (S/m)



Forward Model Mesh = 64 x 61 x 66

21 VMD Source Pos. - Three Frequencies/Decade from 2.1KHz to 210KHz

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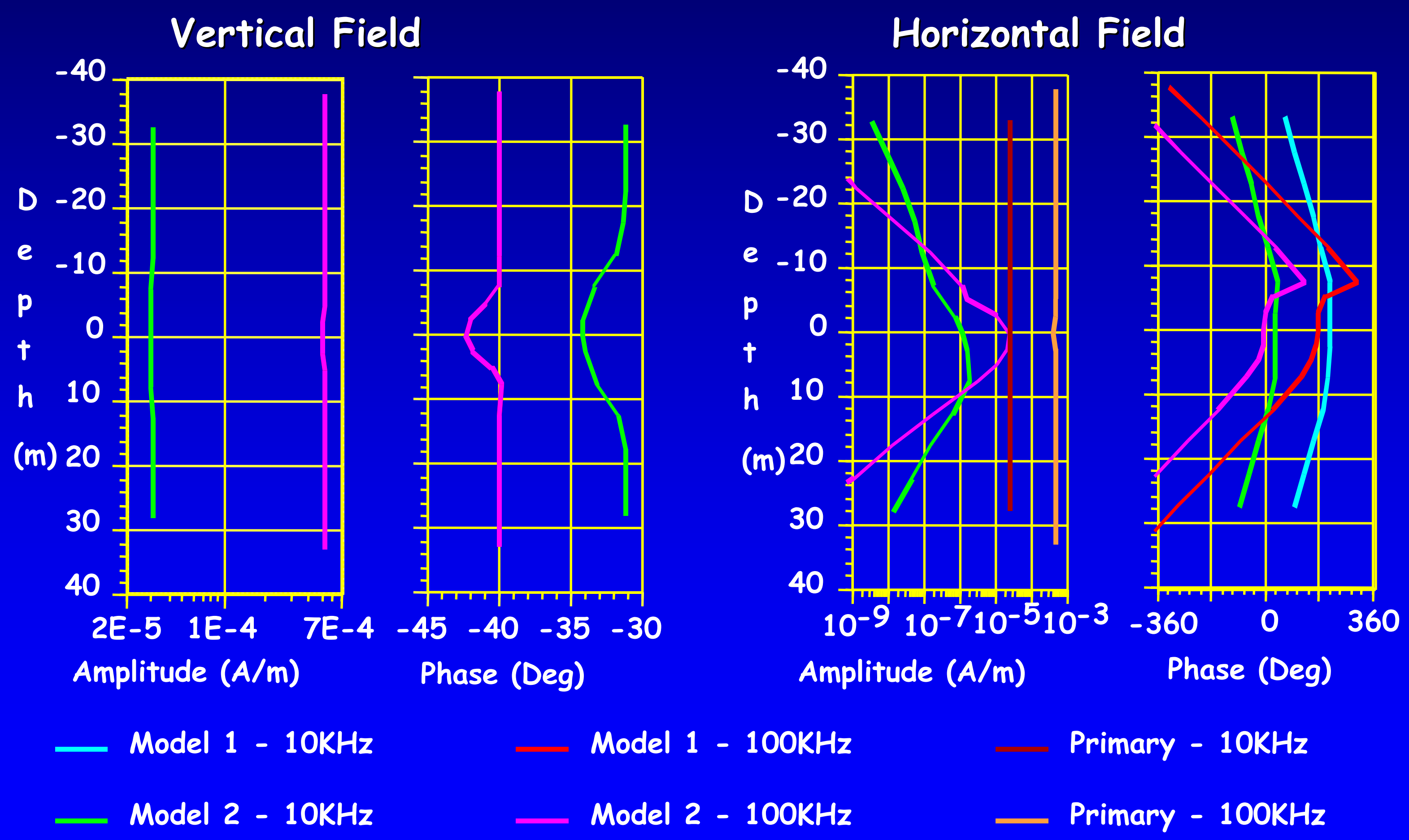
Forward Modeling Results

Tx-Rx Separation : 10KHz=16m 100KHz=6m **(Alumbaugh & Wilt)**



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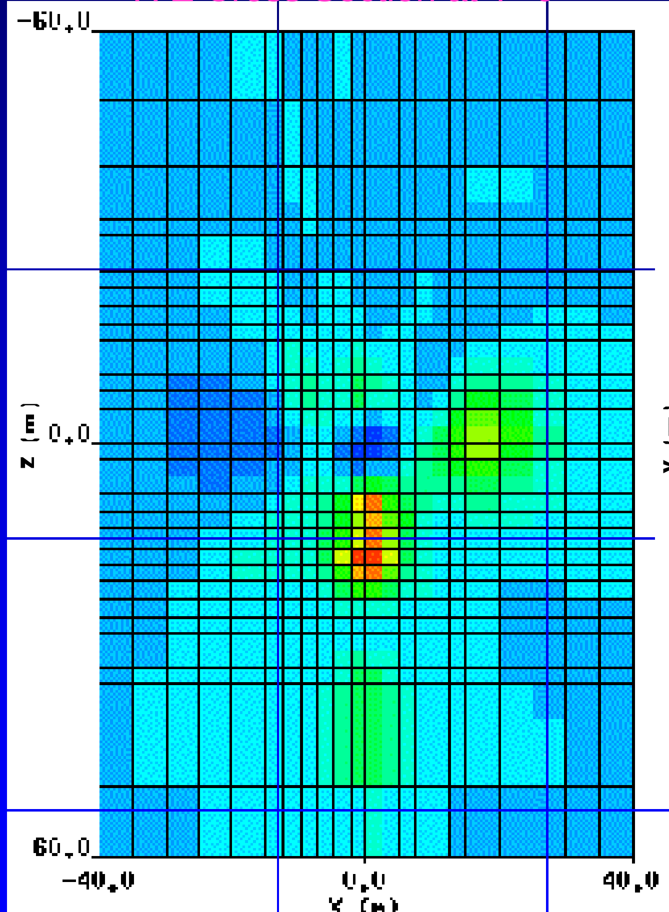
3D image results (Alumbaugh & Wilt)

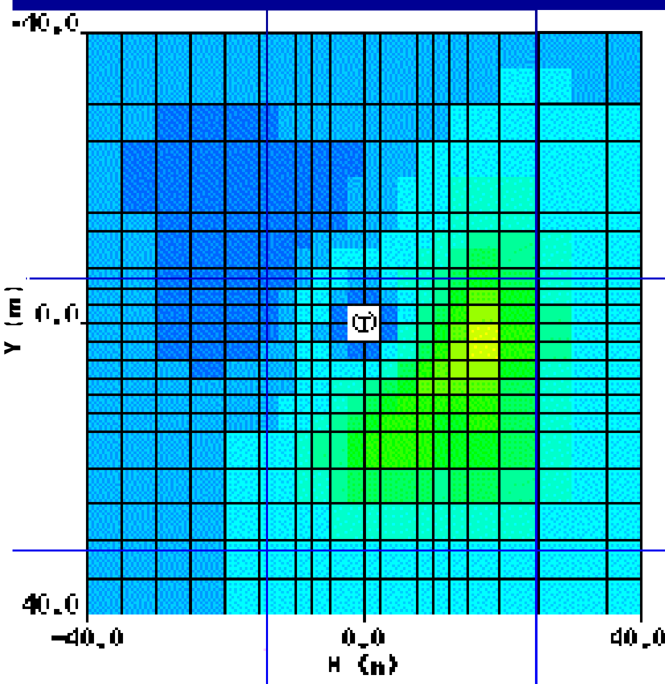
Horizontal Fields Only, Induction Number=3

Whole Space Starting Model - Data Noise=0.2%

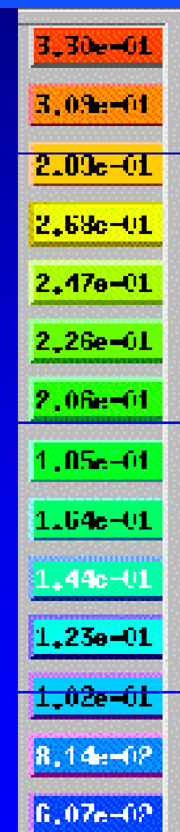
X-Z Cross Section at Y=0



X-Y Cross Section at Z=0



Conductivity (S/m)



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Status cross, single well

- All tools frequency domain (TD in mining)
- Cross well:
  - open hole < 500-750 m — commercial trial
  - one casing < 500 m — commercial trial
  - both wells cased — in test phase
  - single well — R&D phase

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