ENHANCING MODEL RELIABILITY FROM TEM DATA
UTILIZING VARIOUS MULTIPLE DATA STRATEGIES

Ruizhong Jia and Ross Groom,

Petroseikon, Brampton, Ontario, Canada

TOPICS

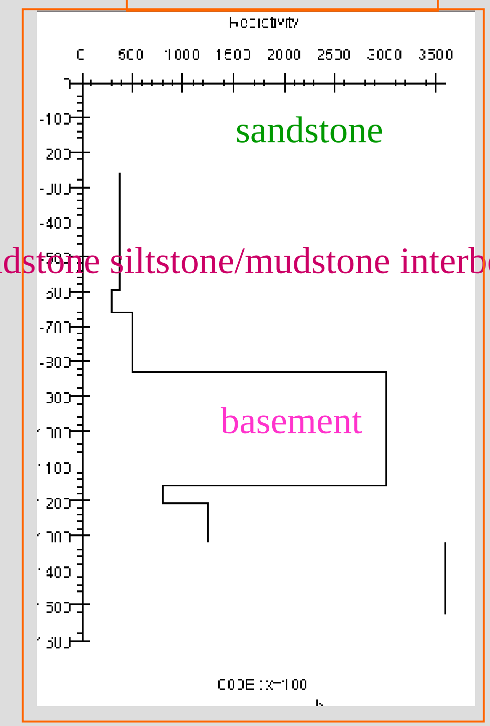
- **TEM inversion**
  - **what do we mean by TEM inversion**
  - **motivation**
  - **forward simulation criteria**
  - **inversion techniques**
- **Ground Example 1**
  - **well studied groundwater basin**
  - **multiple small loops, with multiple stations and multiple base frequencies**
  - **well data, other ground data, airborne data**
- **Ground Example 2**
  - **relatively immature uranium exploration environment**
  - **larger loops with multiple stations**
  - **vertical and horizontal components**
- **AEM Example**
  - **associated airborne data**

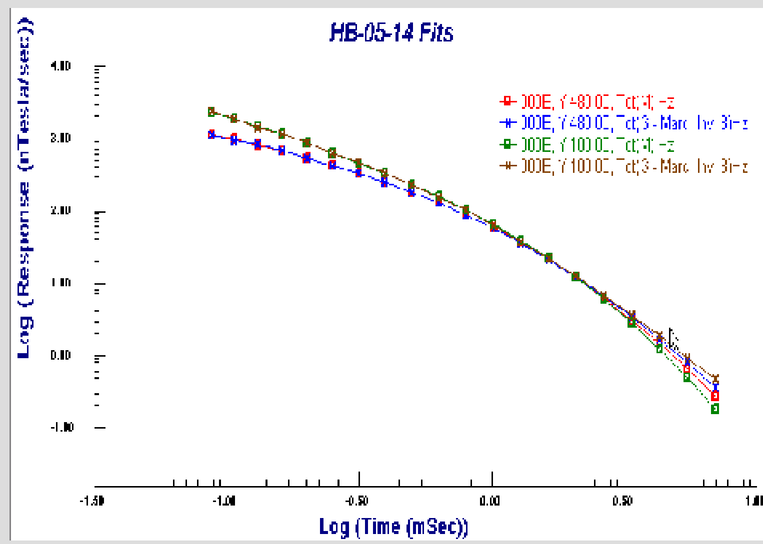
• **what do we mean by TEM inversion?**

determine by an automatic procedure of forward models at each datapoint (x,y) the resistivity as a function of depth - rho(z)

but with the objective to find as accurately as possible the depths where there are distinct variations in resistivity

Resistivity vs Depth



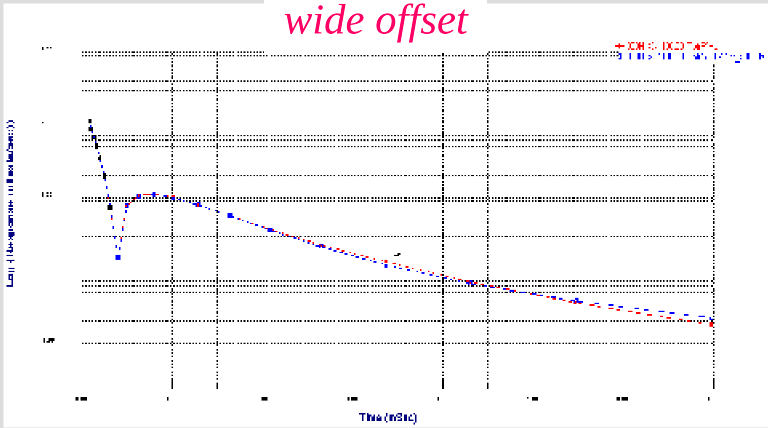


Petroseikon

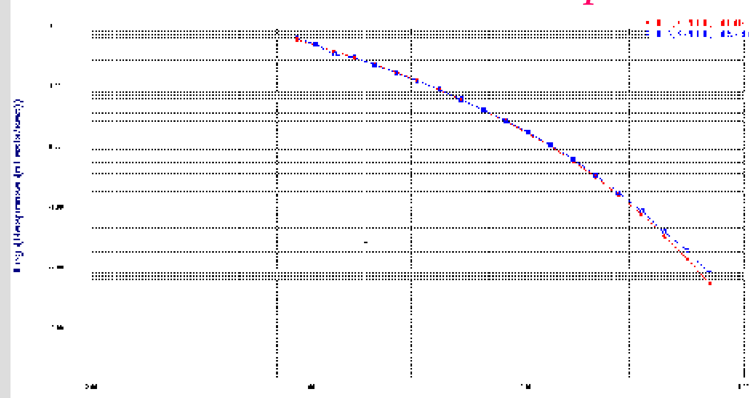
- **motivation?**

for several years, we have been "inverting"
 -moving loop - in-loop and slingram style
 -fixed loop - inside and outside loop
 -airborne - inside and outside TX
with Z and X coil orientations

wide offset



traditional inside loop



- lead us to the conclusion that inversion of one data element although having multiple time windows is not reliable due to "noise".

- **forward simulation criteria**

Reproduce Instrument Response

Current waveforms are periodic:

- ✓Transmitting Waveform is repeated many times and data are stacked
- ✓A discrete spectrum at harmonics of the base-frequency

✓Finite bandwidth – electronic implementation, linearity of coils , high frequency noise

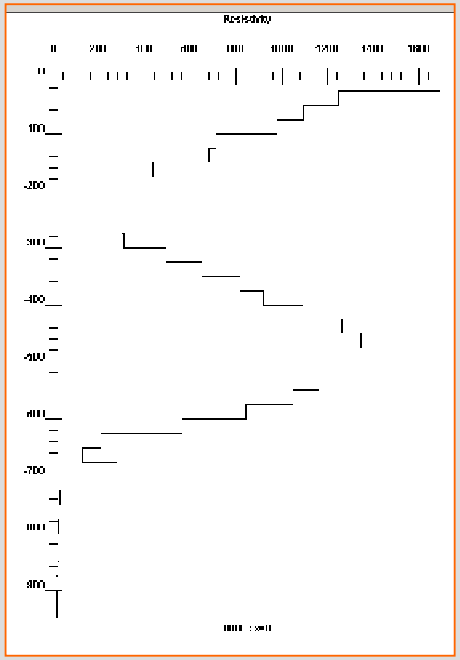
✓Correct loop geometry - no circular or square approximations

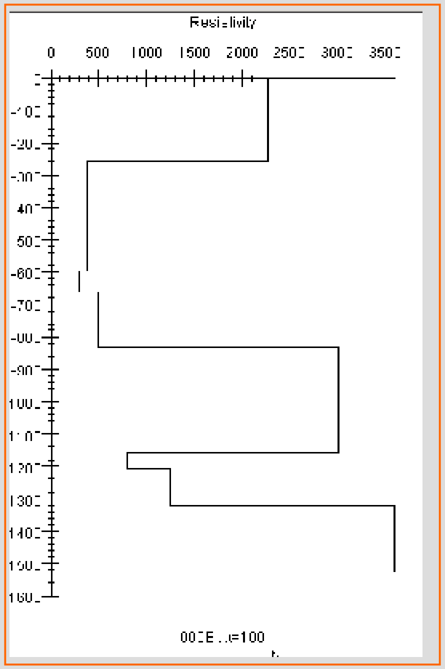
✓Utilization of variable current waveforms with different instruments

Petroseikon

• inversion techniques

- overparametrized (occam) vs underparametrized (marquardt)
- unconstrained and constrained resistivities, thicknesses and depths



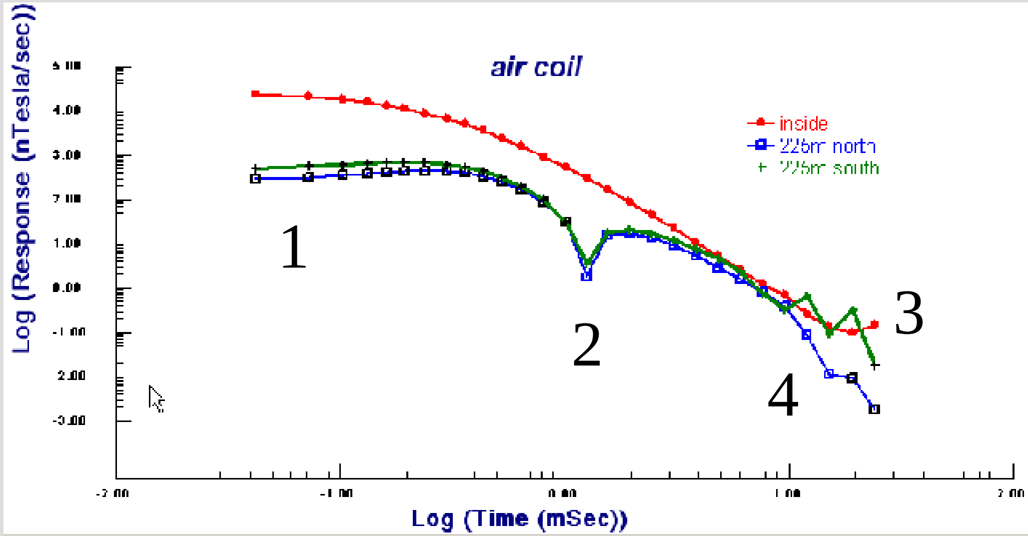


although smooth models are useful qualitatively
for some purposes they do not give adequate precision

Petroseikon

additional data components allows more complexity
in the discrete models and more certainty with the model

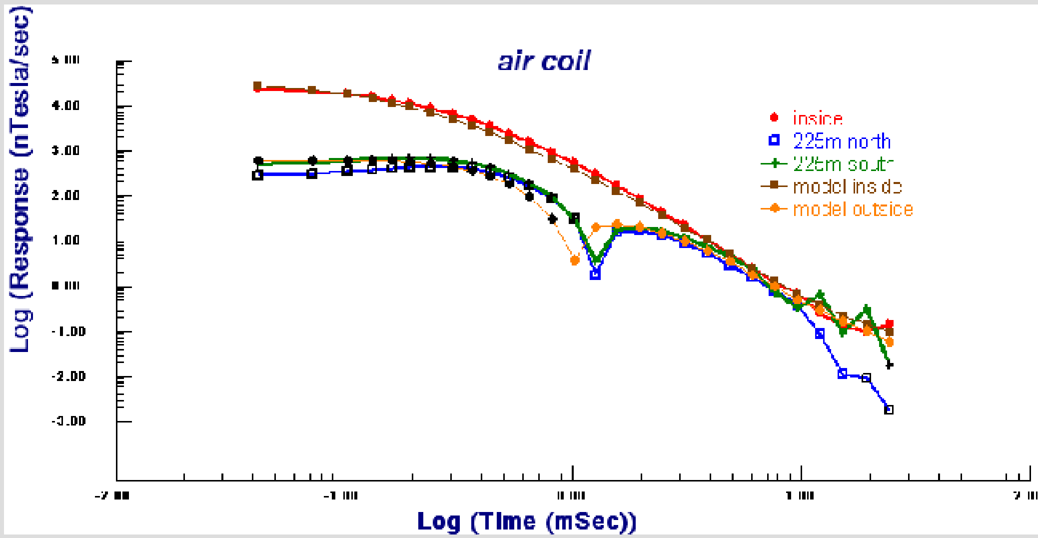
- **Ground Example 1 – data thanks to USGS WRD**
    - **well studied groundwater basin**
    - **2 outside and 1 inside loop measurement**



1. difference in early-time outside loop response
   - instrument, cultural, natural, or geological noise
2. common crossover time of currents
3. odd late time inloop response
4. noisy but still useful late time outside loop response

- **Ground Example 1**
  - **well studied groundwater basin**

without an inversion for multiple datapoints a trial and error procedure must use single station inversions and multiple station forward results iteratively

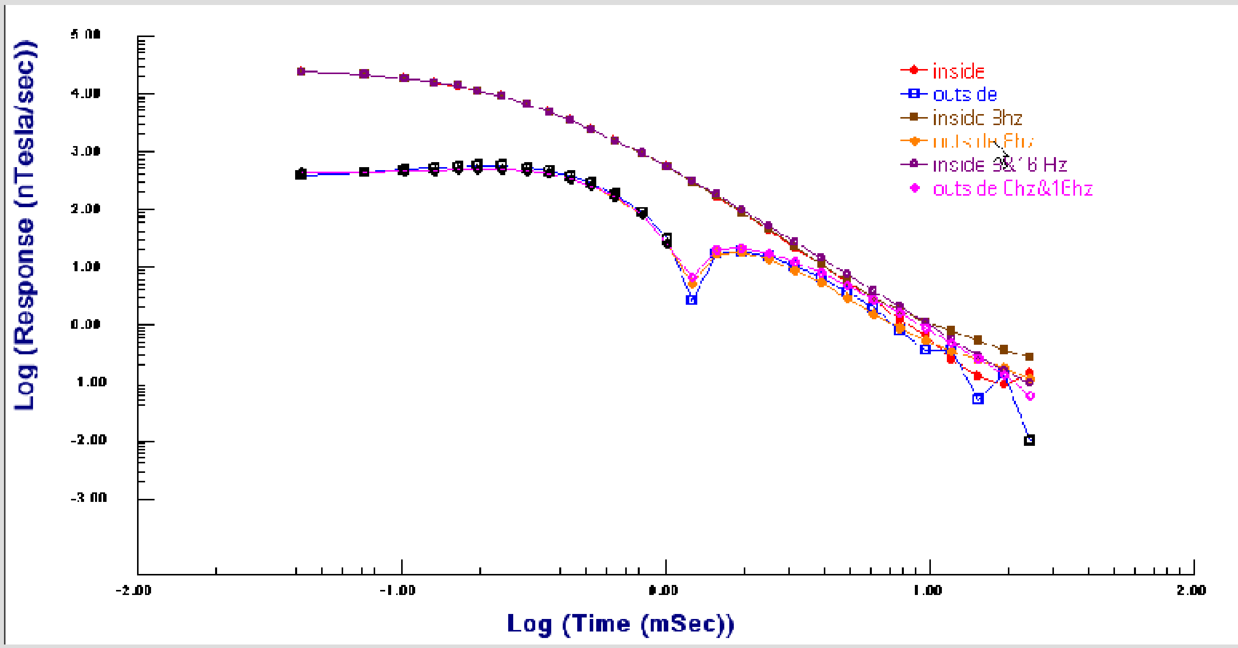


rho	dz
6.6	45
15	290
.8	

BUT, TOO TIME CONSUMING
and statistically uncertain

Petroseikon

- Ground Example 1
  - **use of stacked data and multiple data point inversions**



rho	Δz
4	3.6
5	36
15	

quicker and less labor oriented multiple data point inversions

model consistent with ground FEM data,
and well hole information to a limited depth

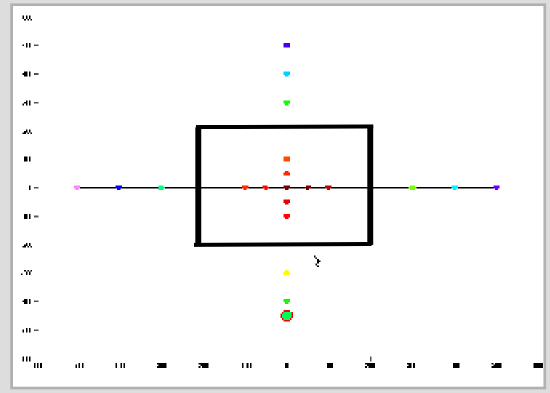
Petroseikon

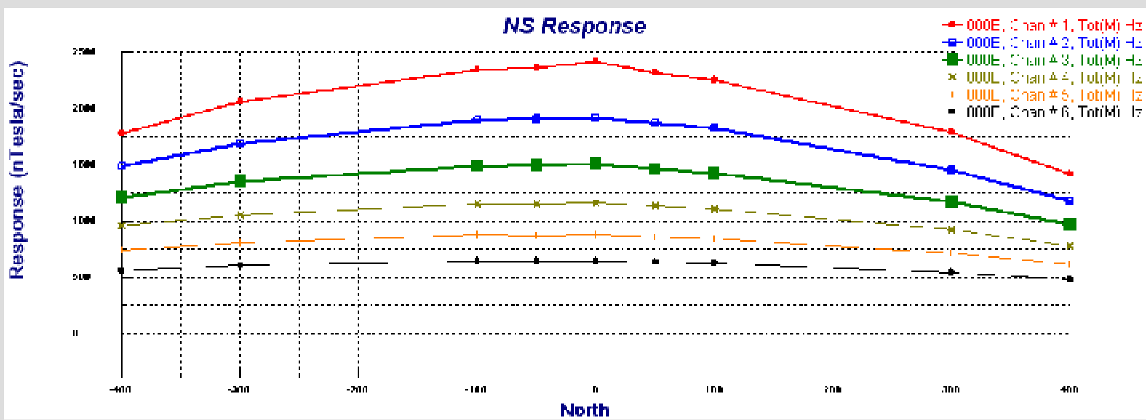
- Ground Example 2 – data thanks to **UNOR Inc**
  - **relatively immature uranium exploration**
  - **400x400 loop**

Survey Objective:

depth to basement through sedimentary sequence

22 measurements
11 NS, 11 EW

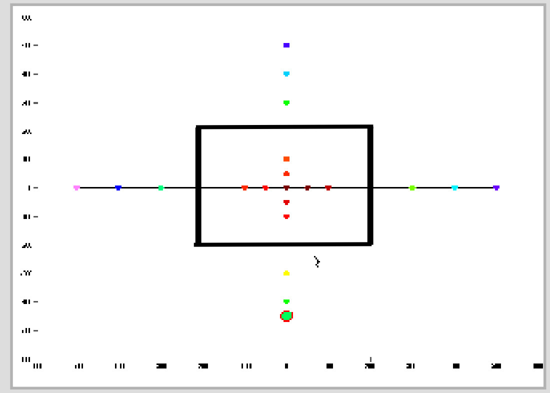


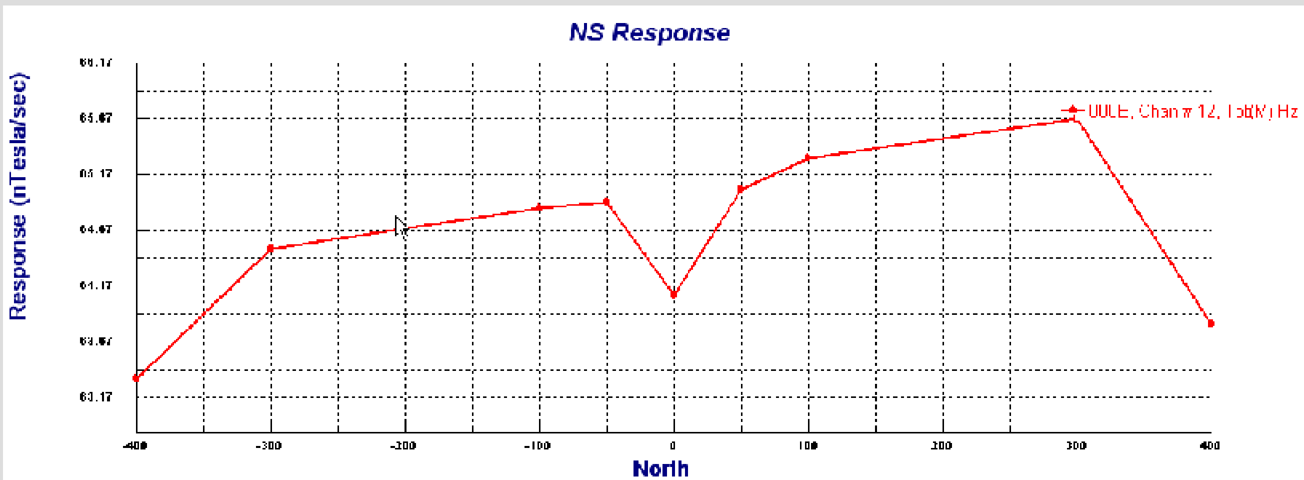


Hz data is relatively symmetric for NS and EW implying suitability of 1D model

Petroseikon

Ground Example 2



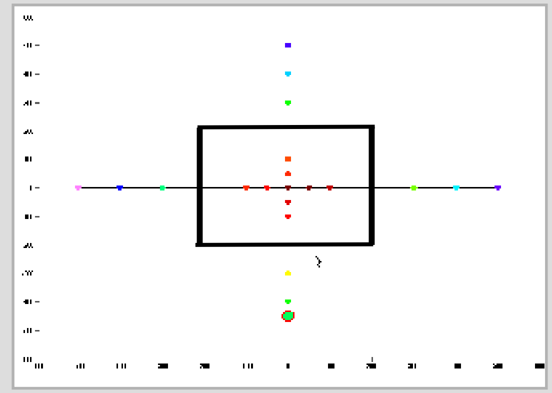


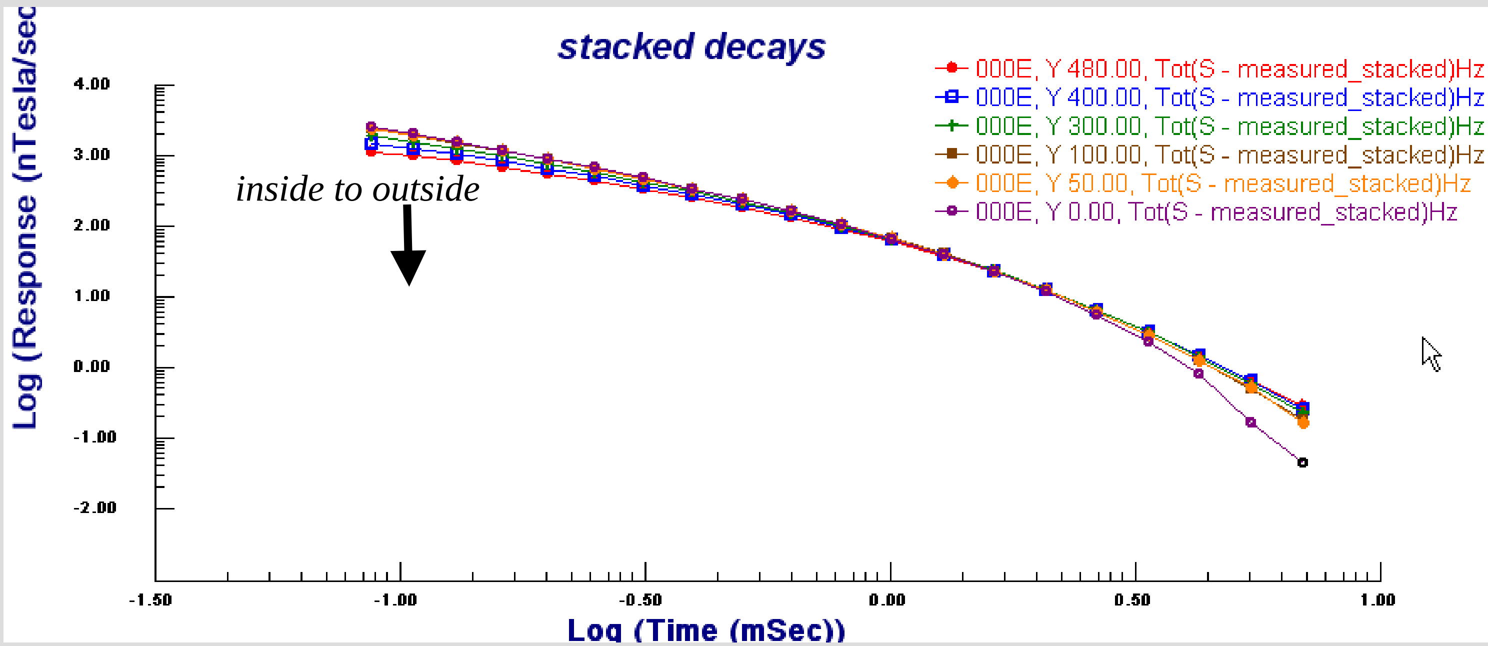
by Ch12, start to see switch in curvature inside the loop with characteristic too dropout at centre - “inside loop soundings can be dangerous”

Petroseikon

• Ground Example 2

stack data at equivalent distances from centre – 6 data





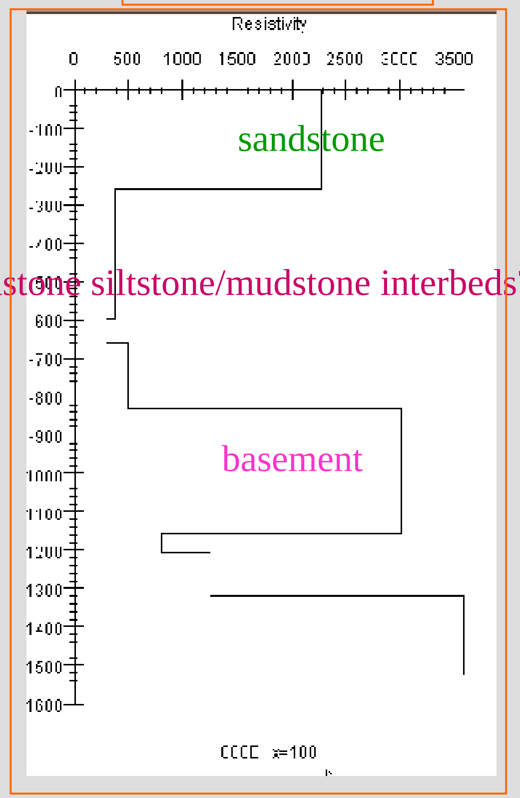
Petroseikon

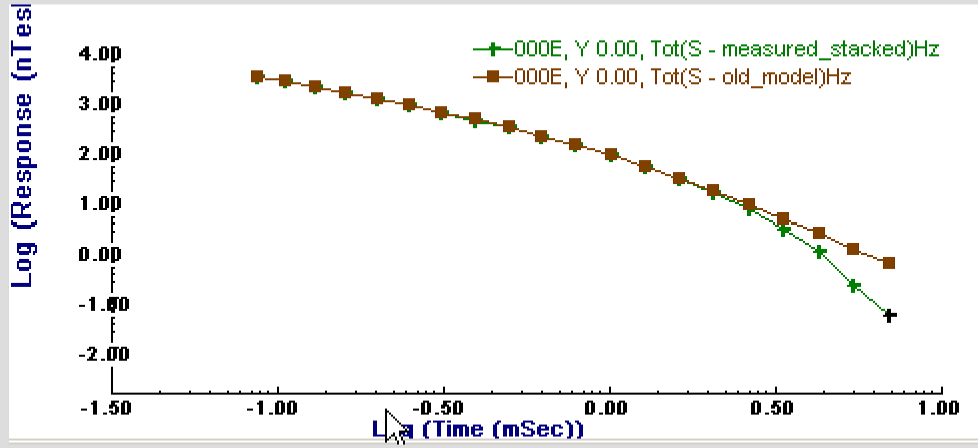
• Ground Example 2

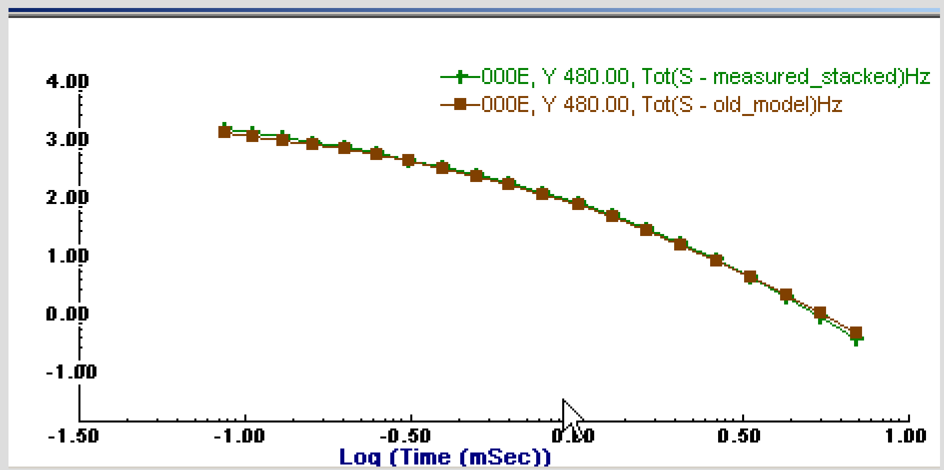
initial model fits

repeated manual iteration

Resistivity vs Depth

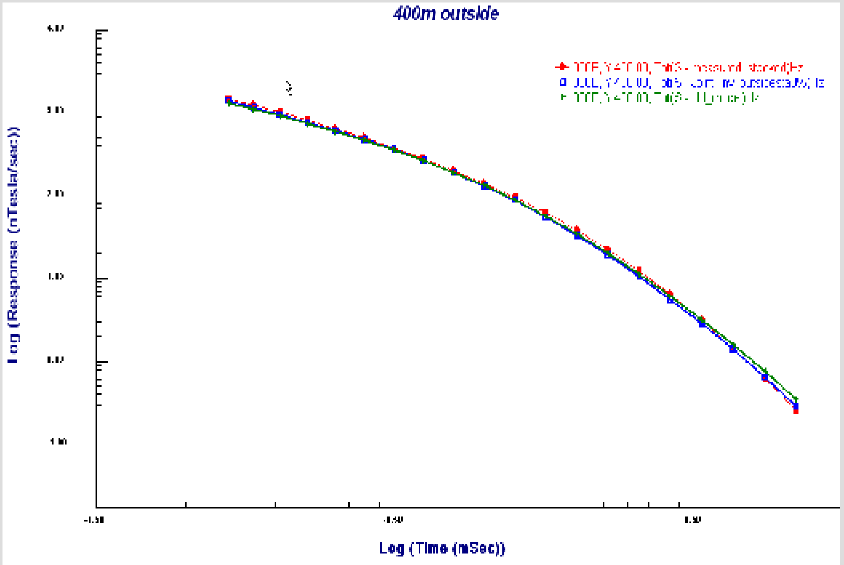






Petroseikon

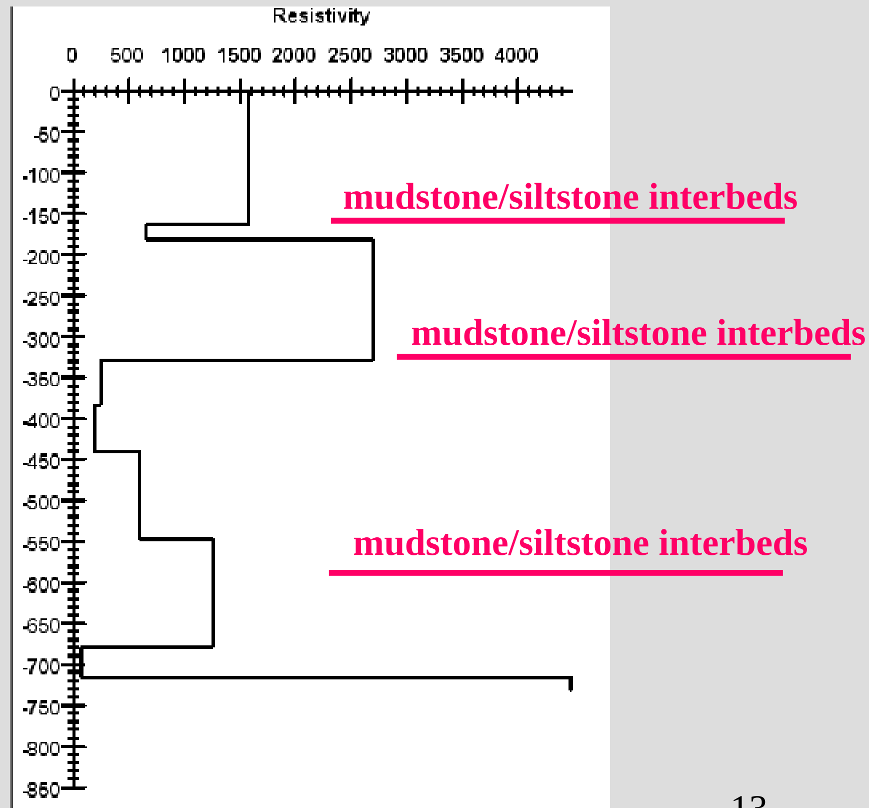
Ground Example 2



6 pt inversion – inside/outside

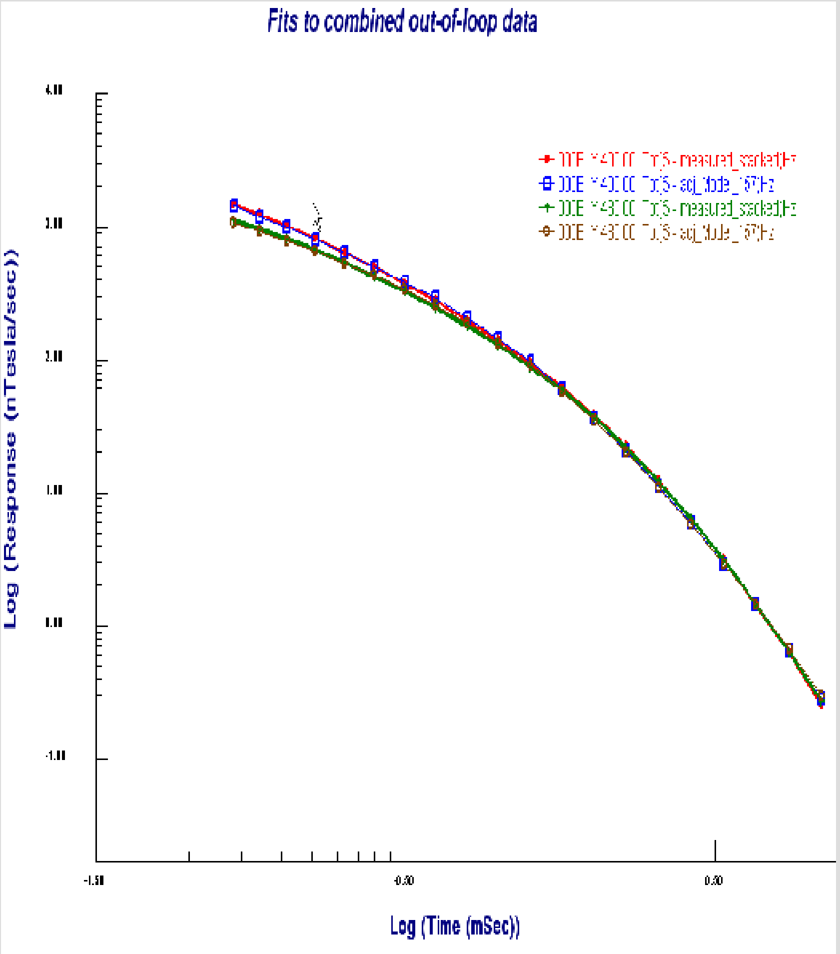
somewhat better late and early time

but quicker from a manpower perspective

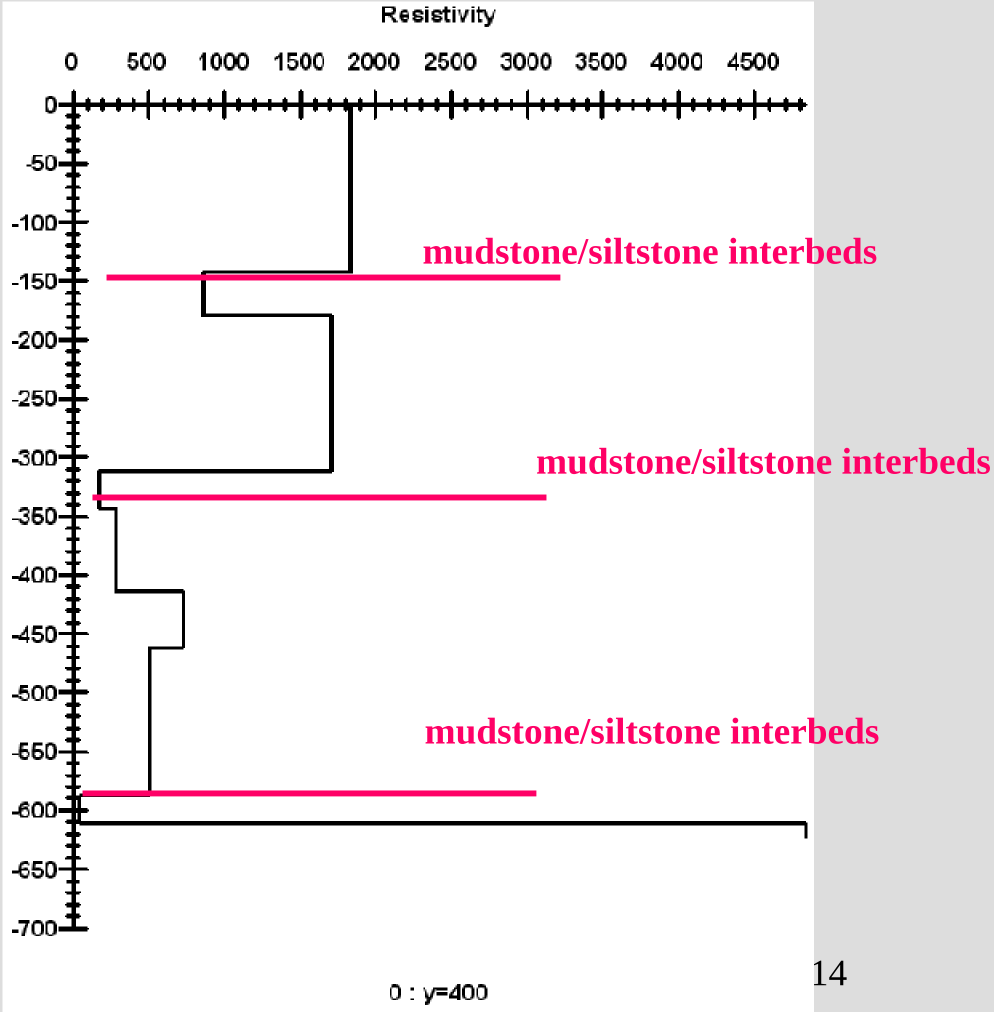


Petroseikon

• Ground Example 2



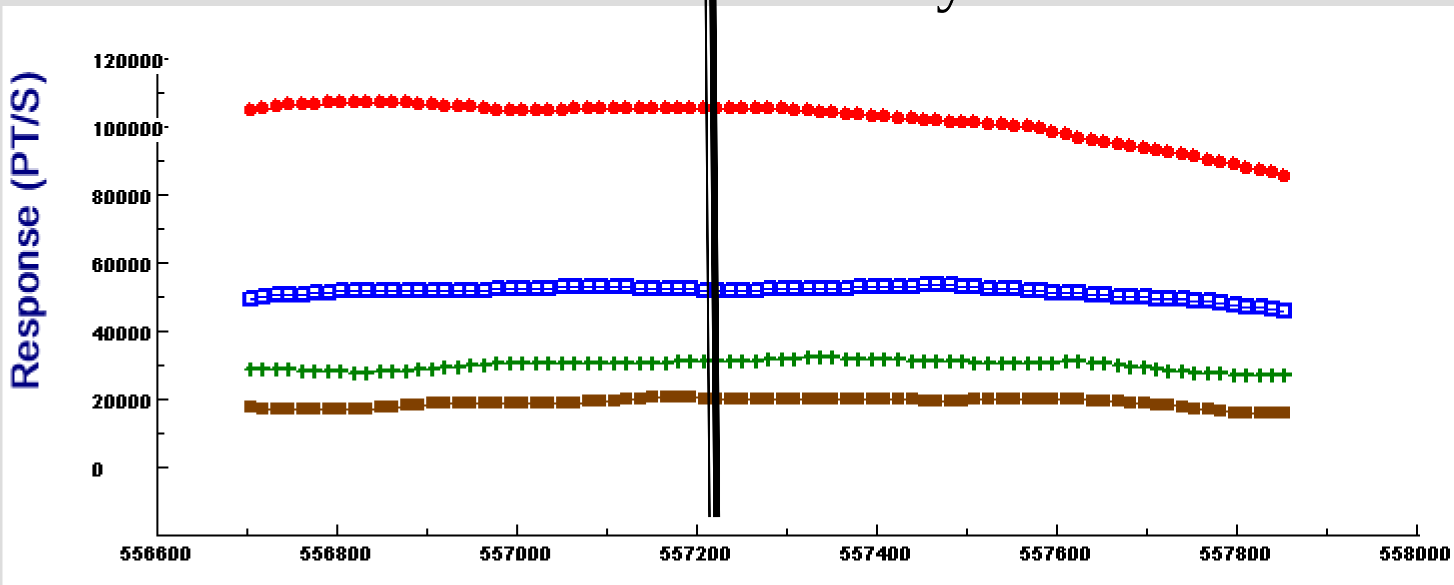
better mid-time fits
with only outside loop



Petroseikon

- **AEM Example**
  - **associated airborne data**

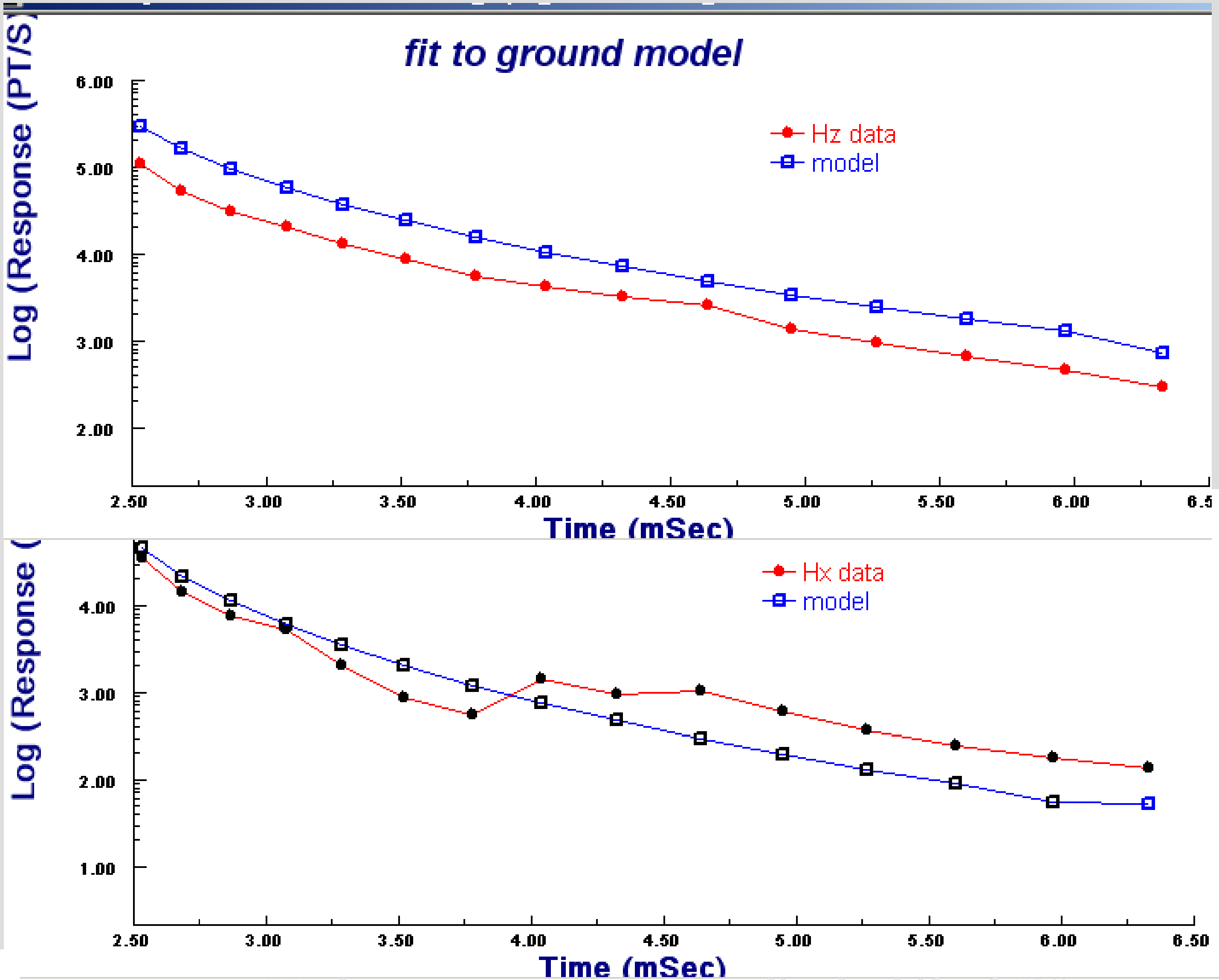
4 early offtime channels



<u>smooth spatial response</u>

thus we would expect a slowly varying 1D model to be reasonably appropriate

• AEM Example

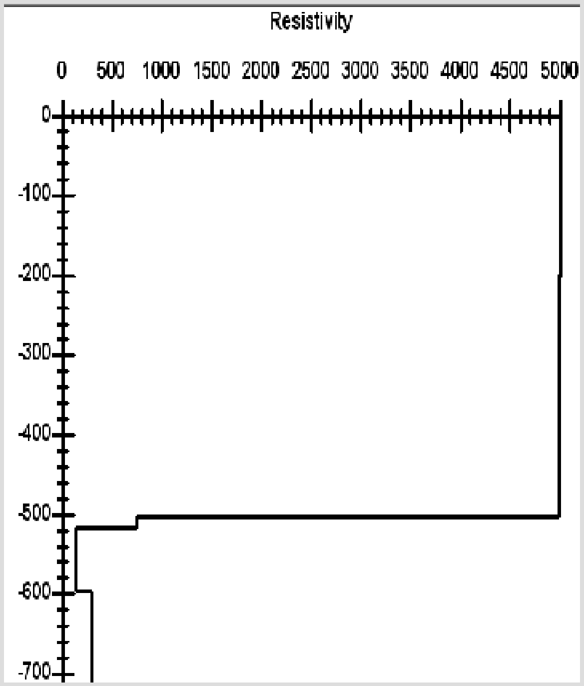


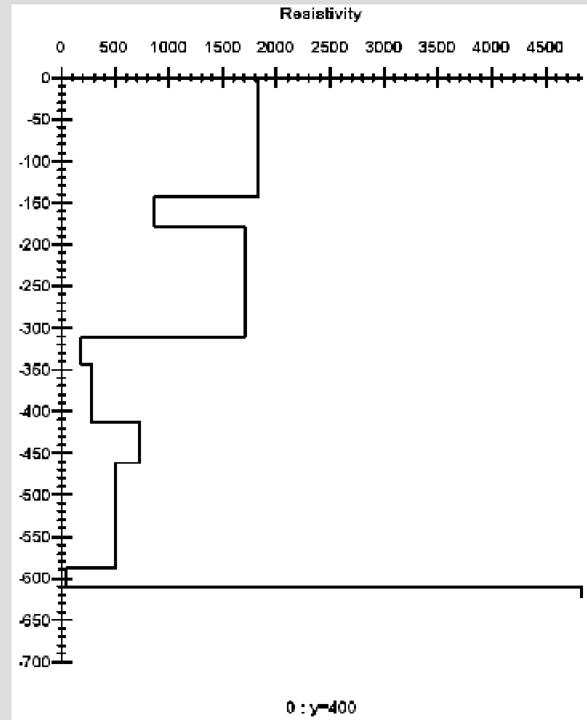
Petroseikon

Hz decays correctly but amplitude shift of “3”
Hx approximately correct within data limits

- **AEM Example**

Joint Hz (15 chn) and Hx (5) chns

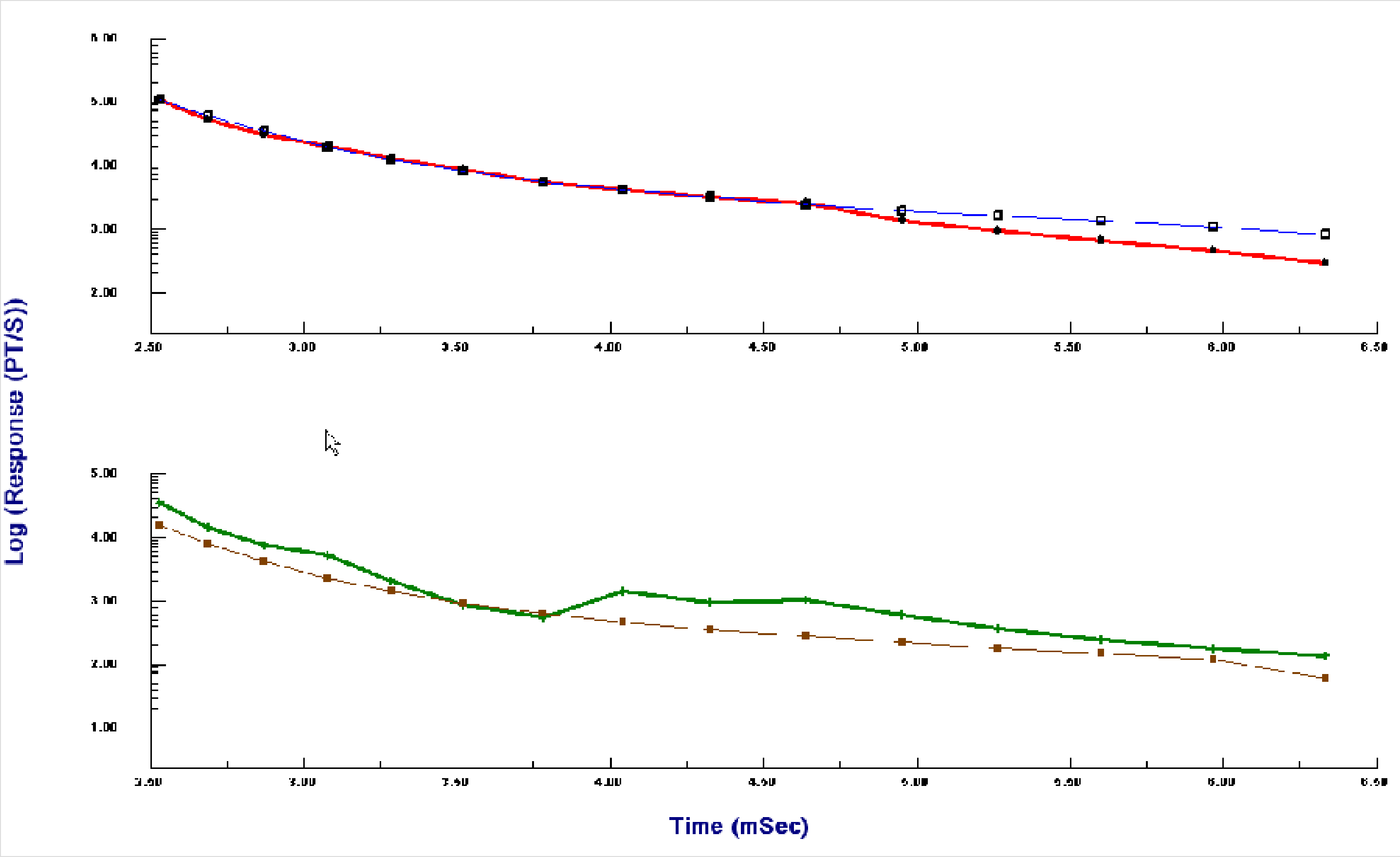




Ground data model

• AEM Example

Joint Hz (15 chn) and Hx (5) chns



Comments

- **multiple common distance outside loop measurements allow:**

a) checking of geology from 1D inversion interpretation

b) allows checking of data accuracy and system effects

c) stacking of stations to help minimize lateral effects and improve signal to noise

d) multiple station inversions to provide more reliable models

-calibration of airborne data with ground data for more reliable inversion results