First Results from the Scarborough Marine EM Survey

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Commercial Marine EM:

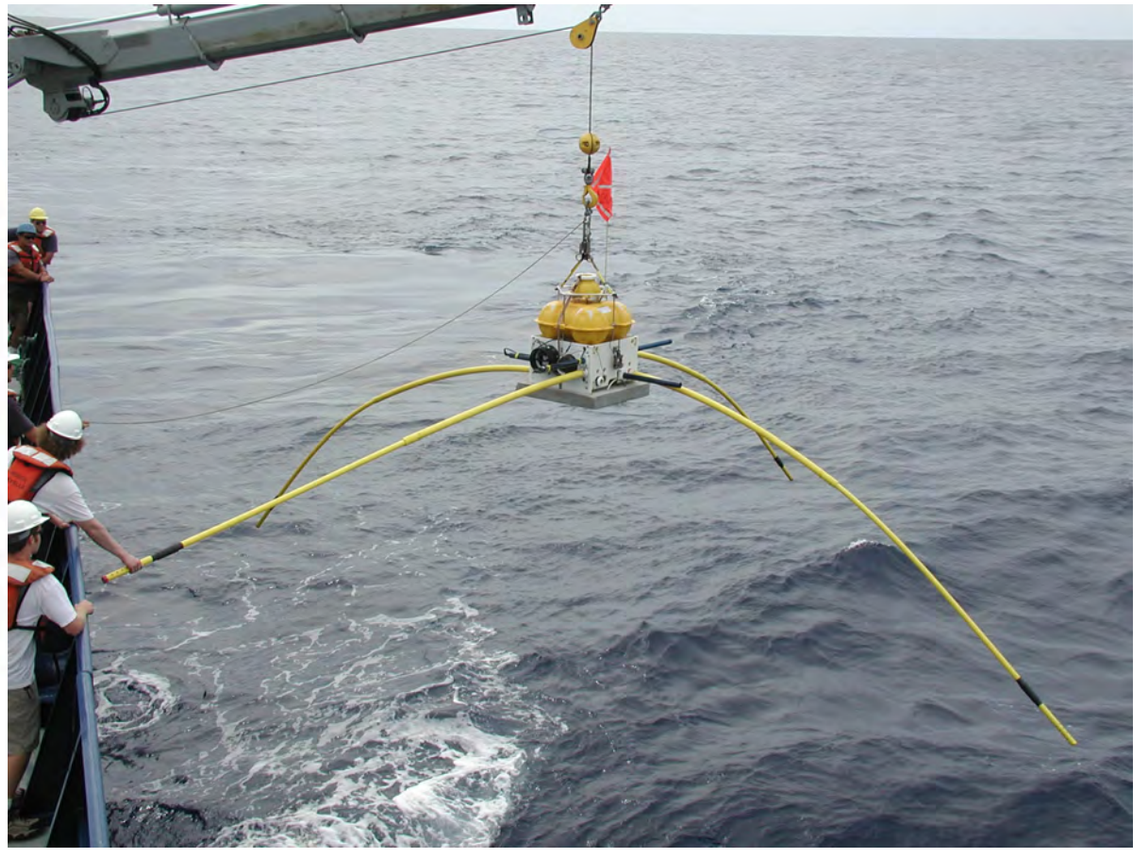
Marine MT being used for geological structure in seismic low-productivity areas (salt, sub-basalt, and carbonate)

Marine CSEM being used for pre-drill reservoir appraisal

- Instrumentation and practice little changed from academic precursors
- Many contractors are fighting for a relatively small market
- Processing and interpretation tools are wanting
- Navigation errors probably main limitation of data

The physics is sound - where do we go from here?

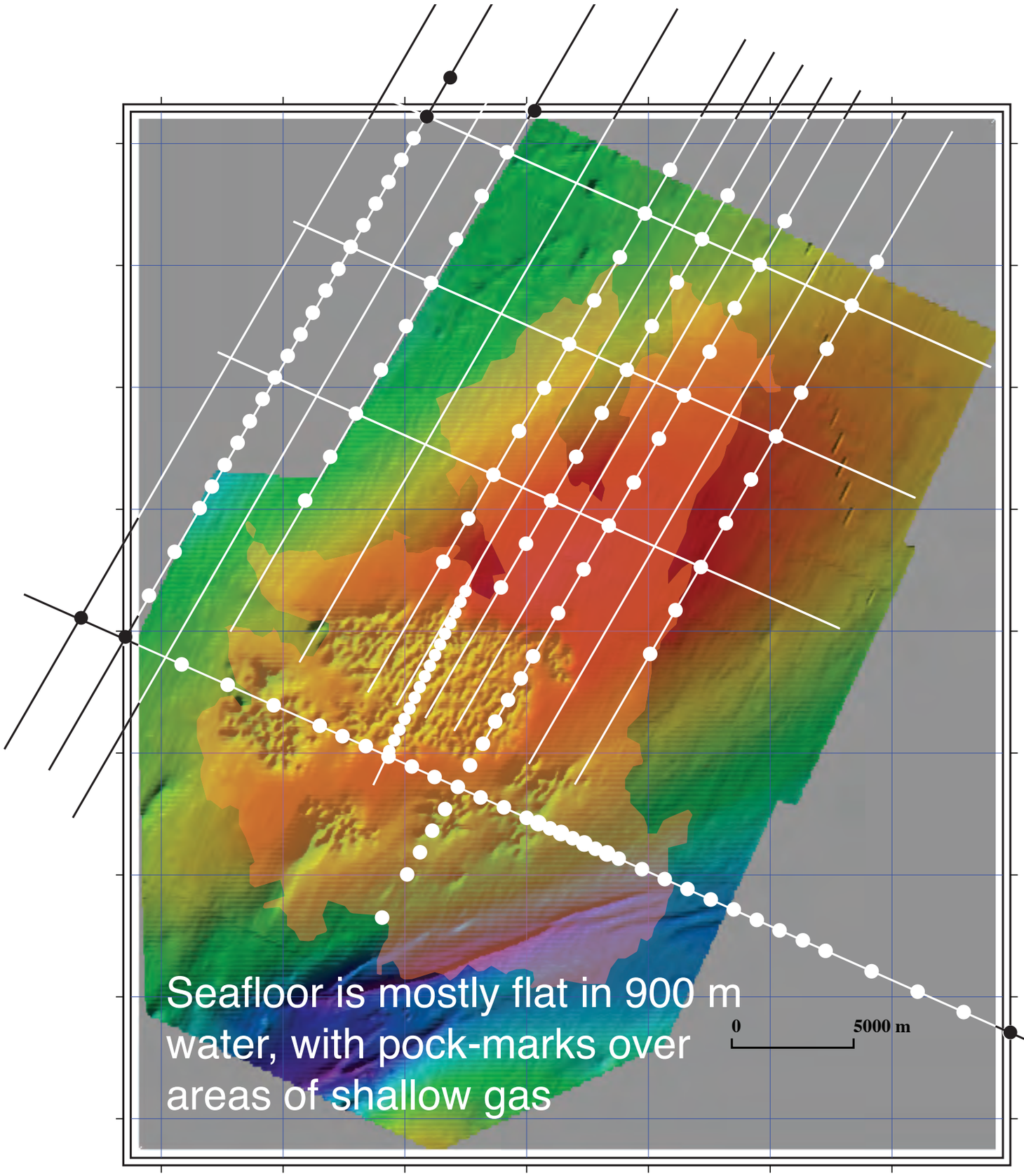
Need a high quality academic data set to drive the science.



NW Shelf Australia
May 22 - June 23 2009

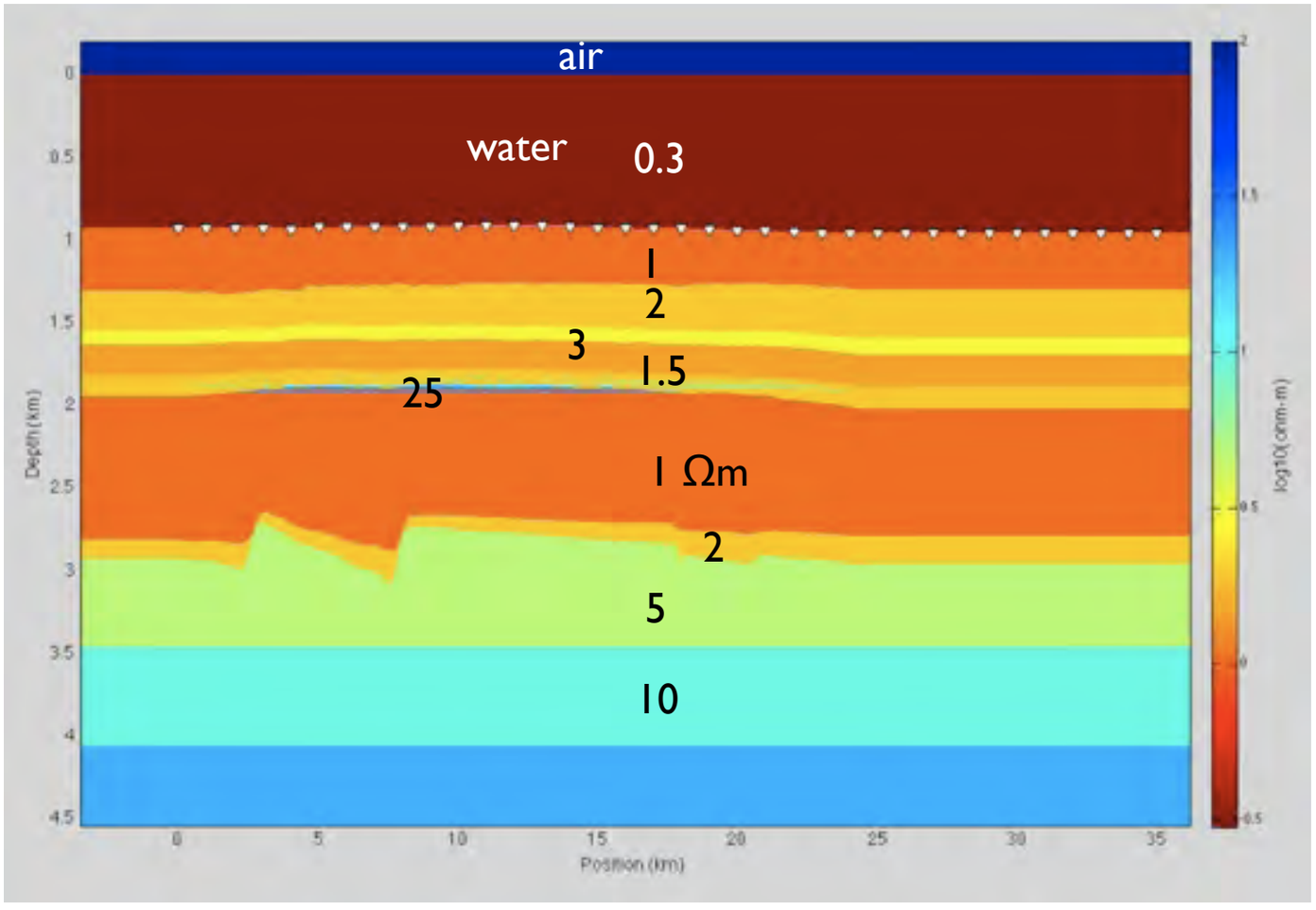
50 seafloor E/B receivers
2 deep-towed EM transmitters
2 long-wire receivers
2 3-axis towed receivers
250 m antenna (+ 100m spare)
160 concrete anchors
20 lbs Peet's coffee

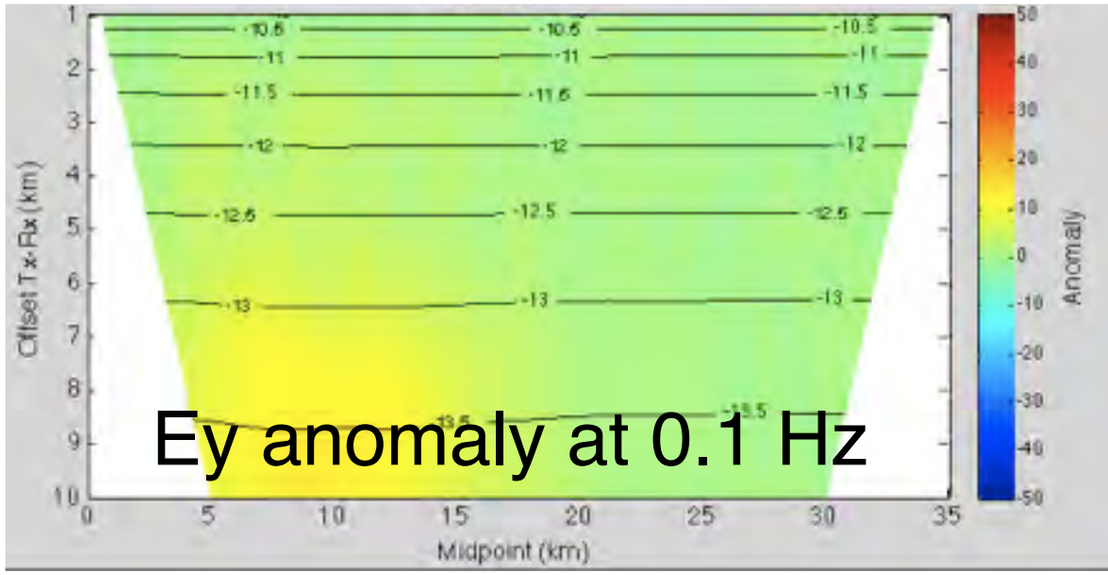
Scarborough gas field: The only academically collected data set since the first Statoil Girasoll survey in 2000. Funded by BHP-Billiton.

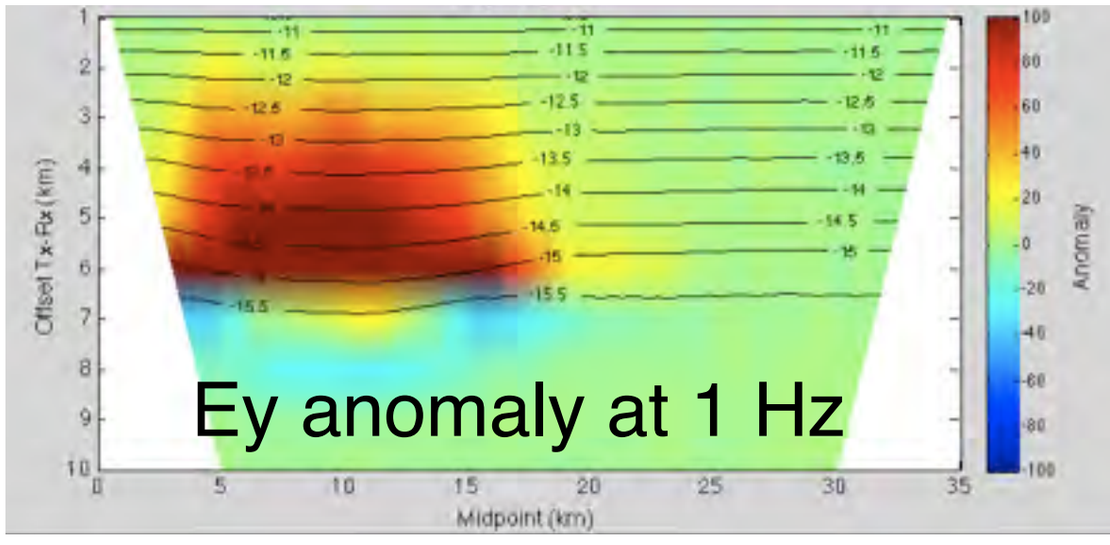


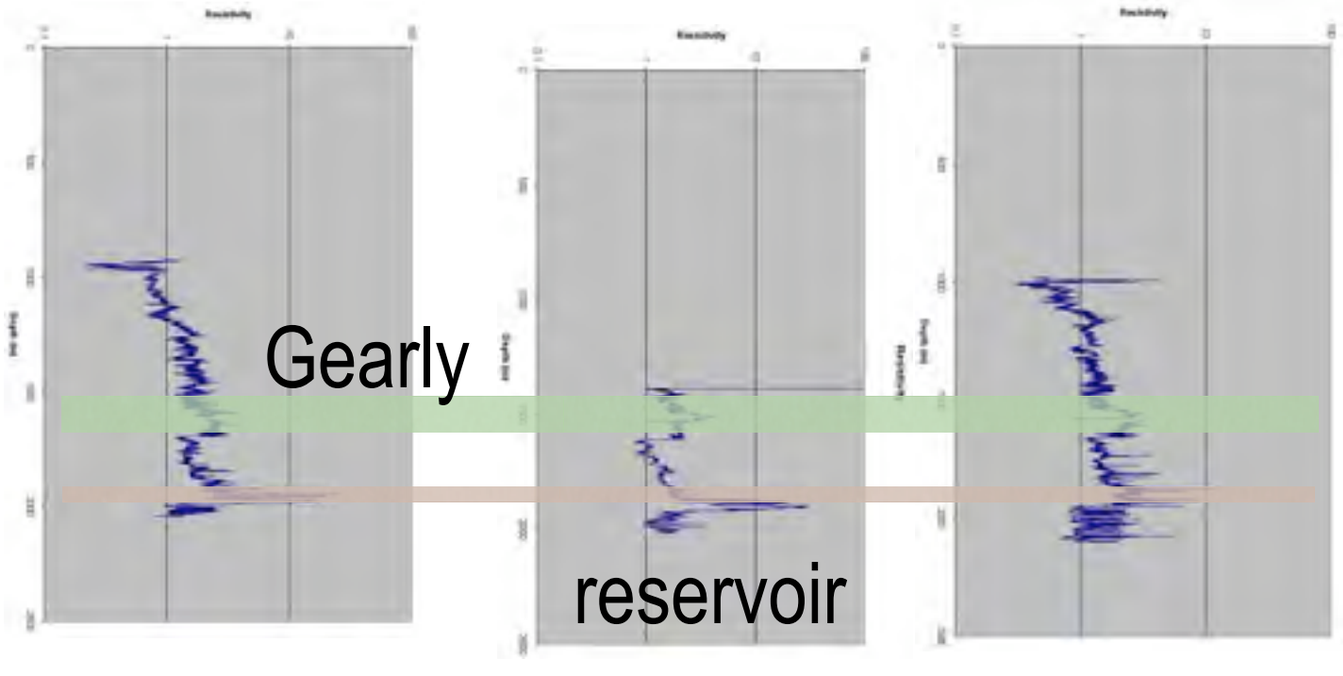
144 receiver deployments
12 days/300km CSEM tow
New instrument systems
New waveform

Pre-cruise MARE2DCSEM model study based on seismics and well logs shows little sensitivity to reservoir below 1 Hz:



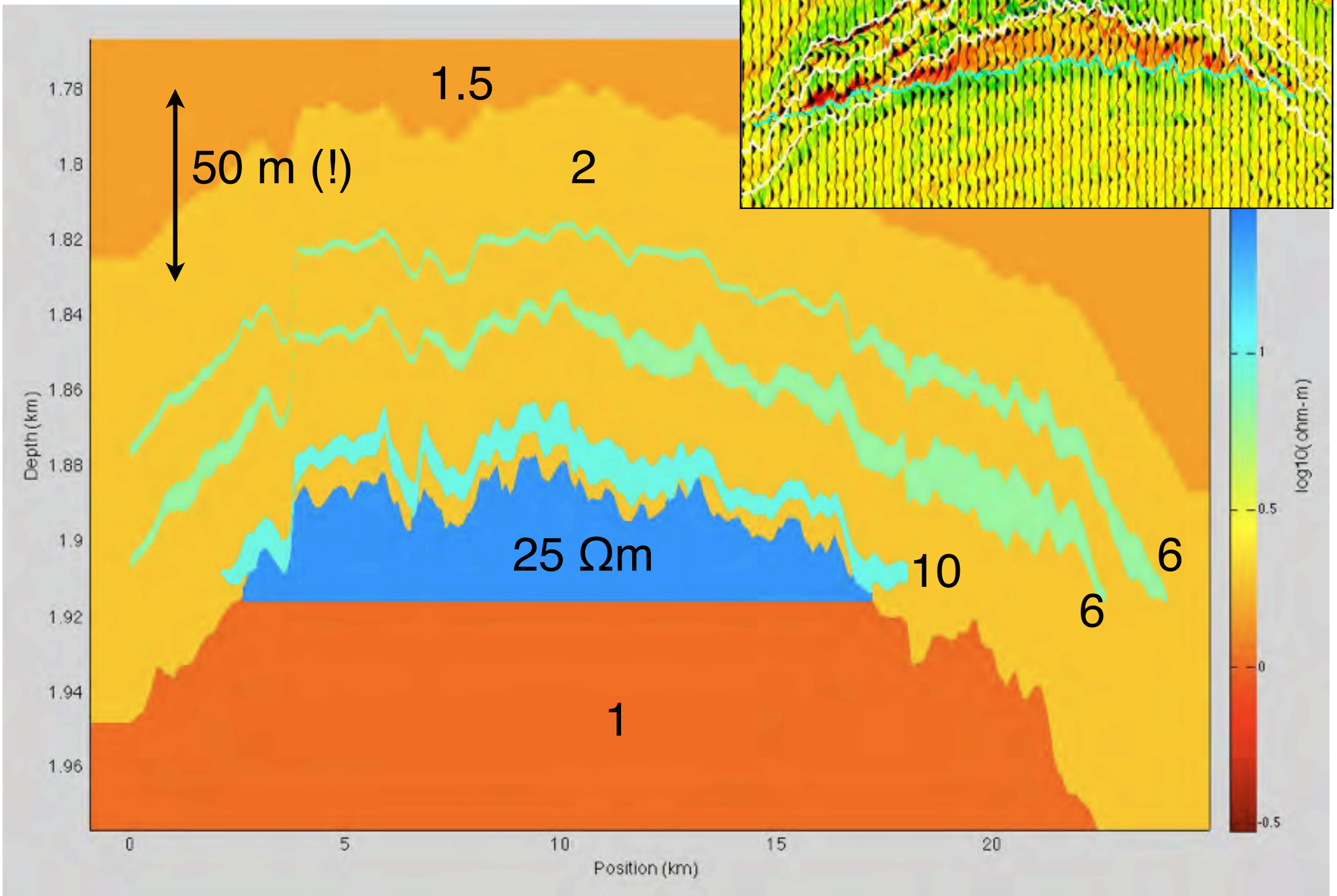




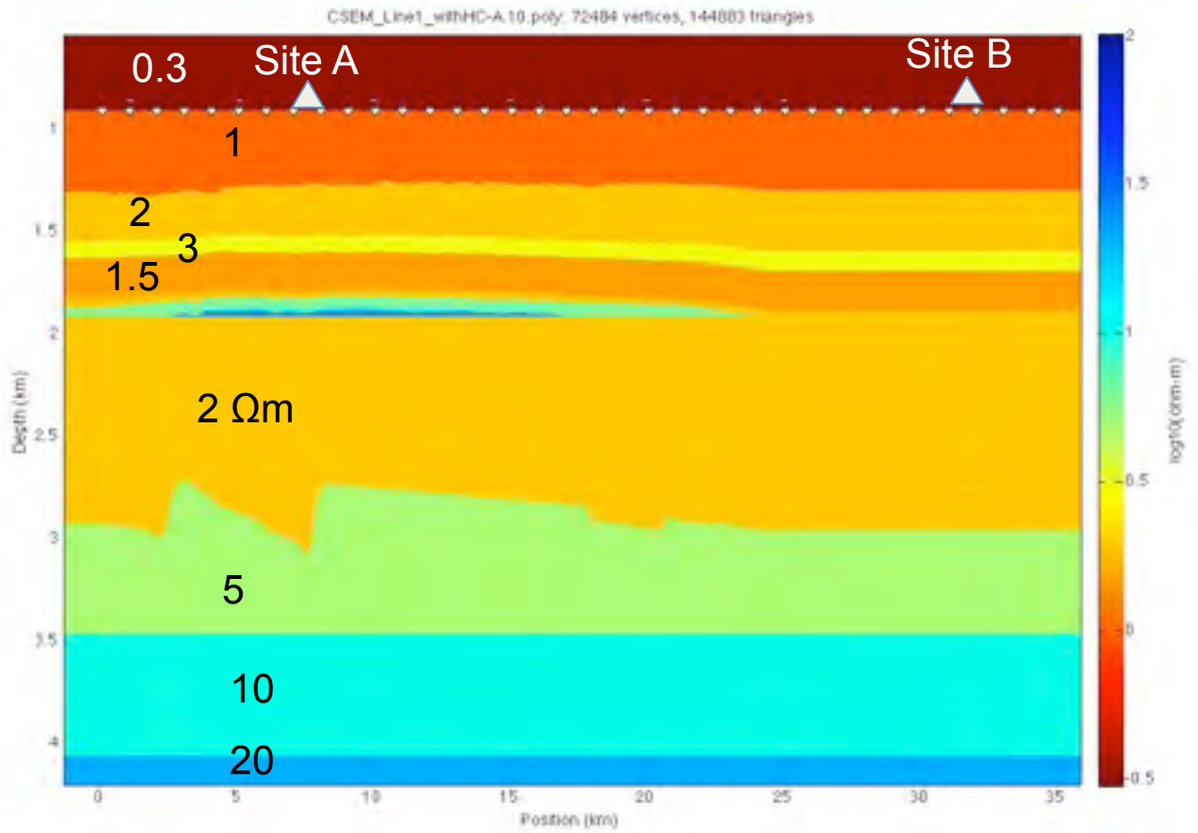


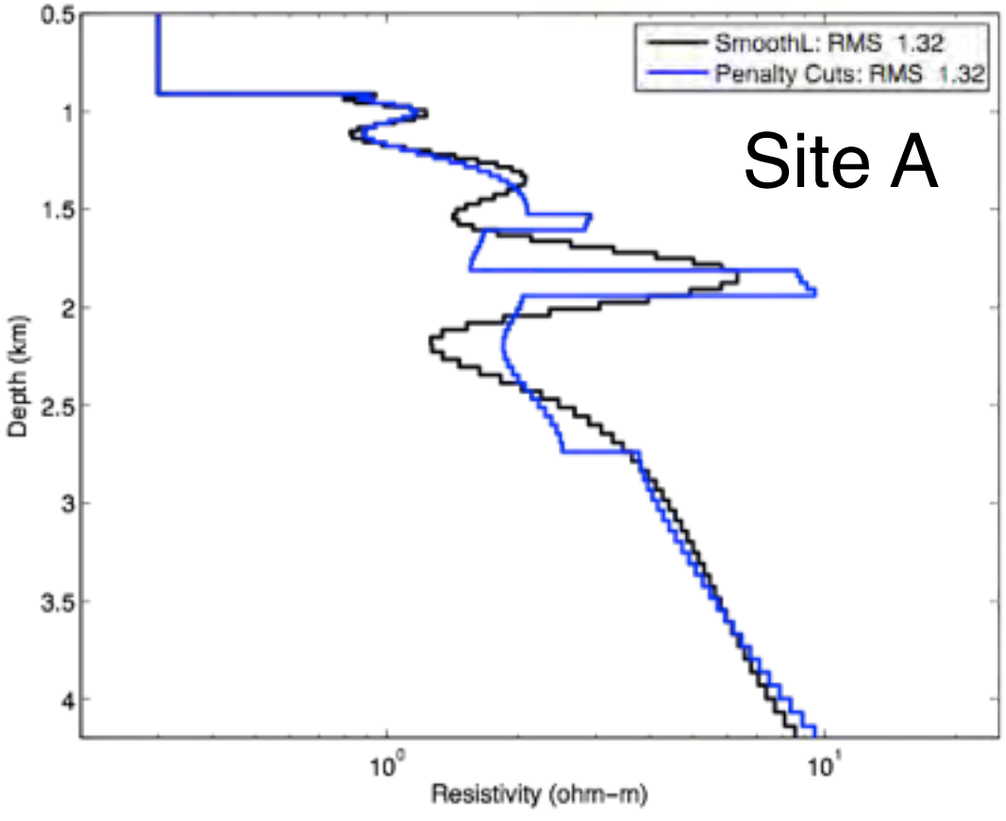
Well logs show overlying resistor (Gearly formation)

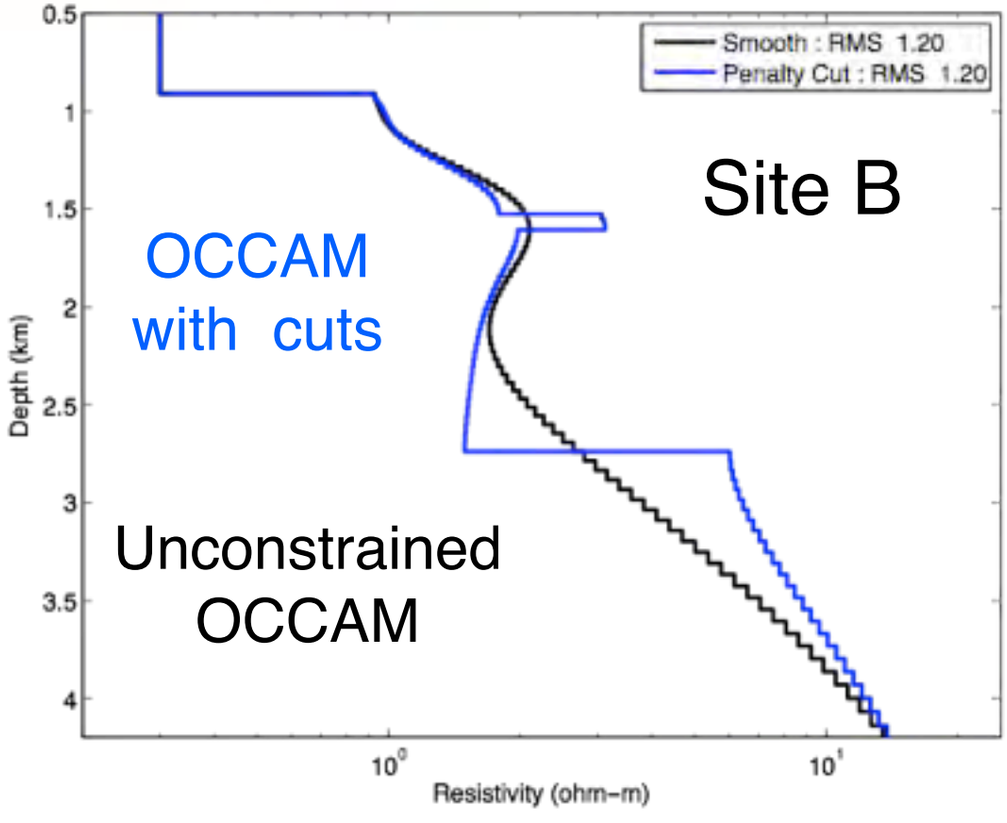
Close-up of reservoir



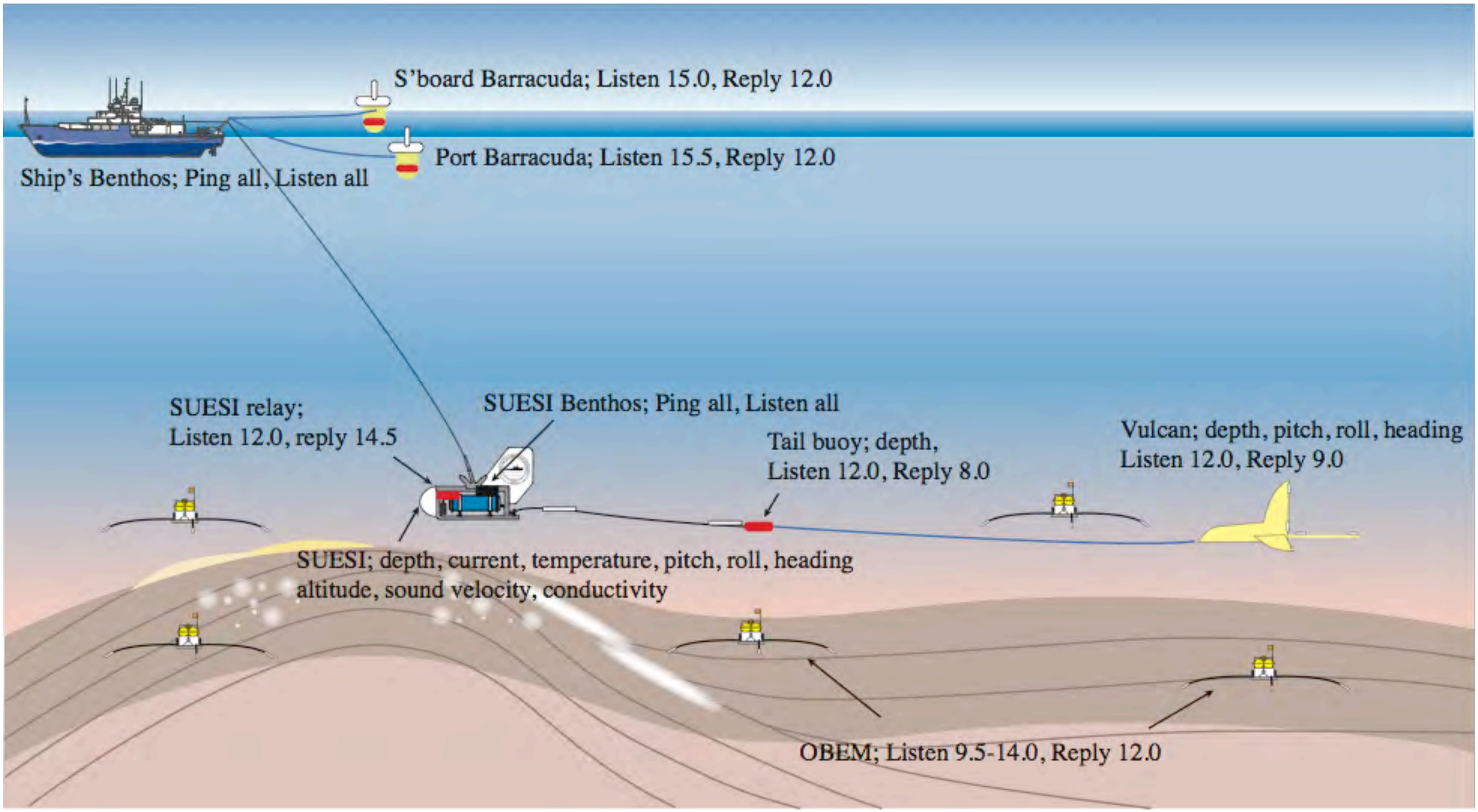
Ey, Ez and Bx at 0.1 and 1 Hz inverted with OCCAM1D after adding 1% random noise and omitting data below noise floor:



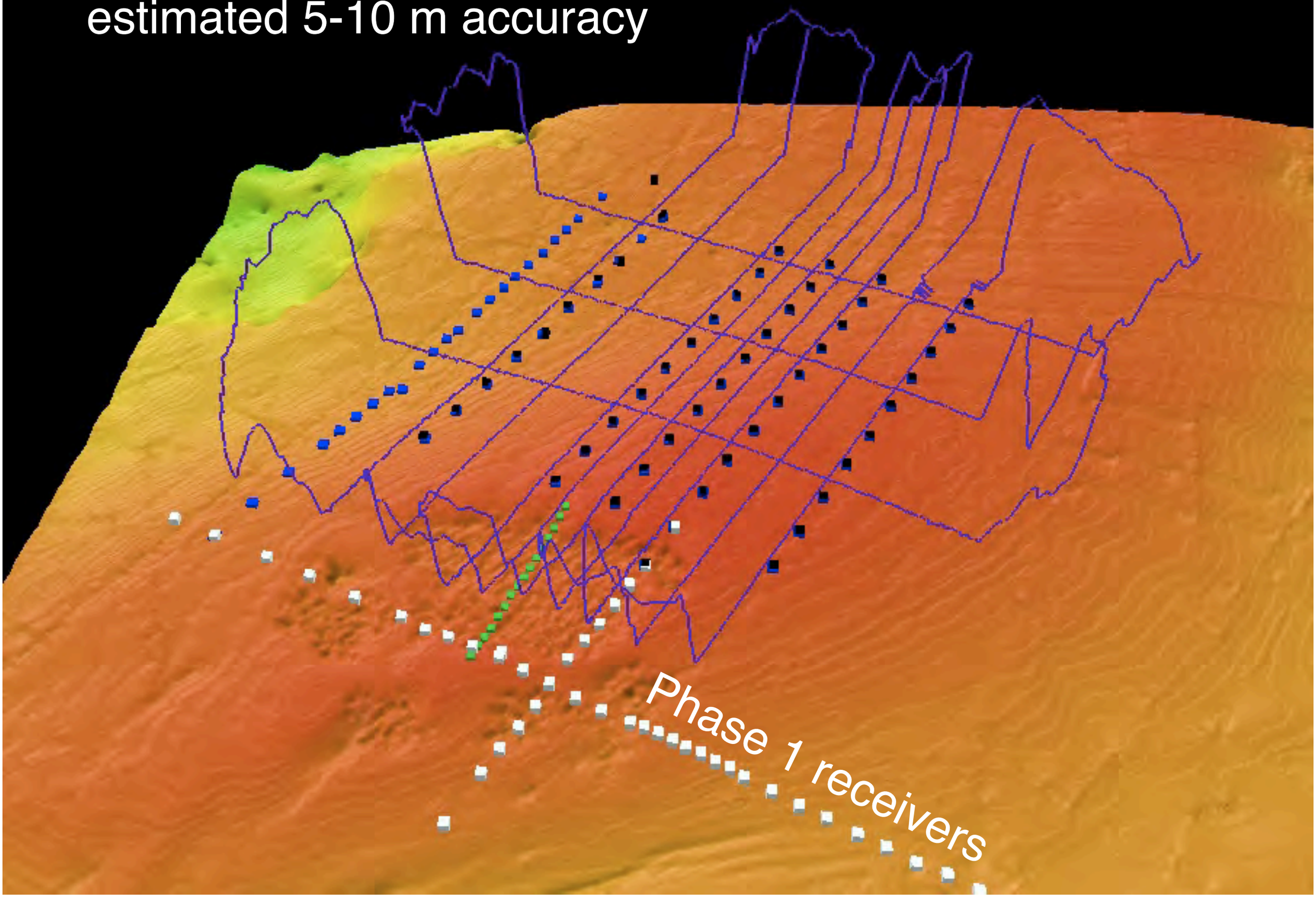




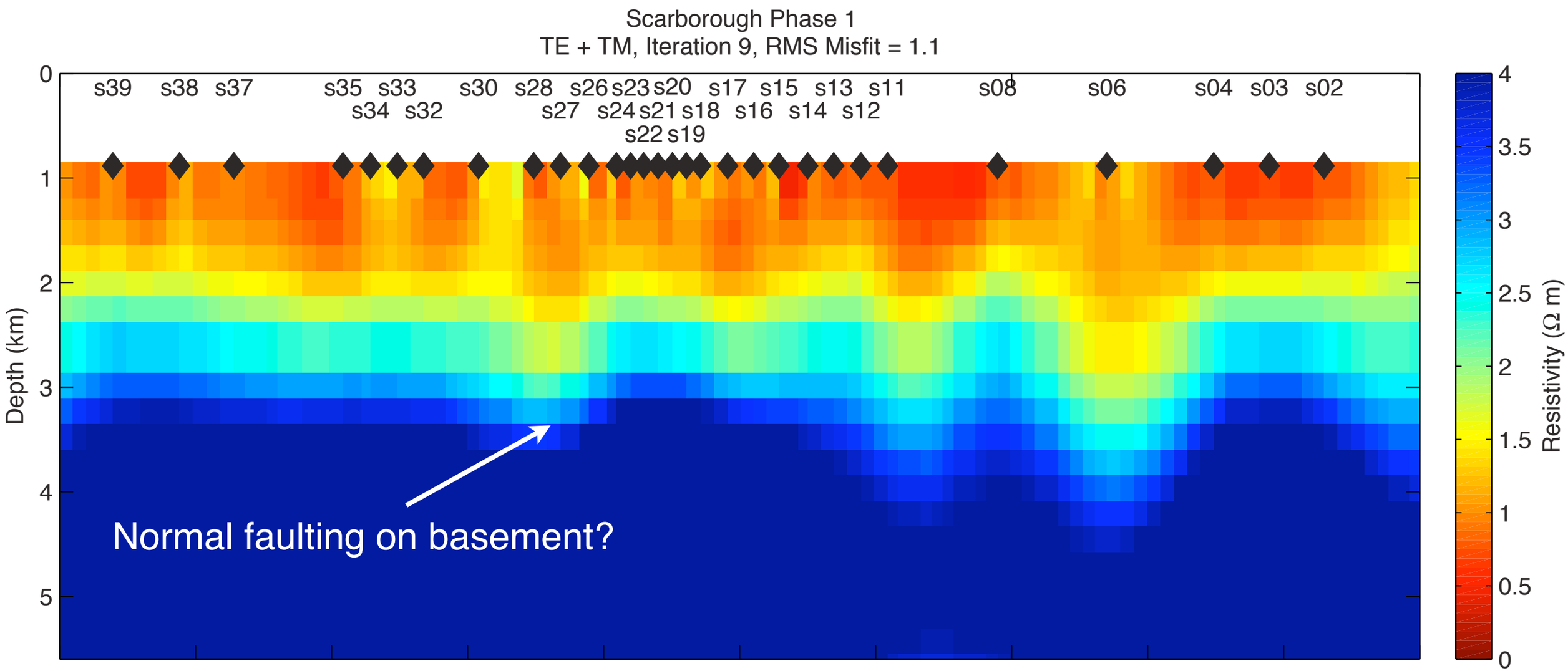
A new long baseline navigation solution was a critical part of the CSEM data acquisition:

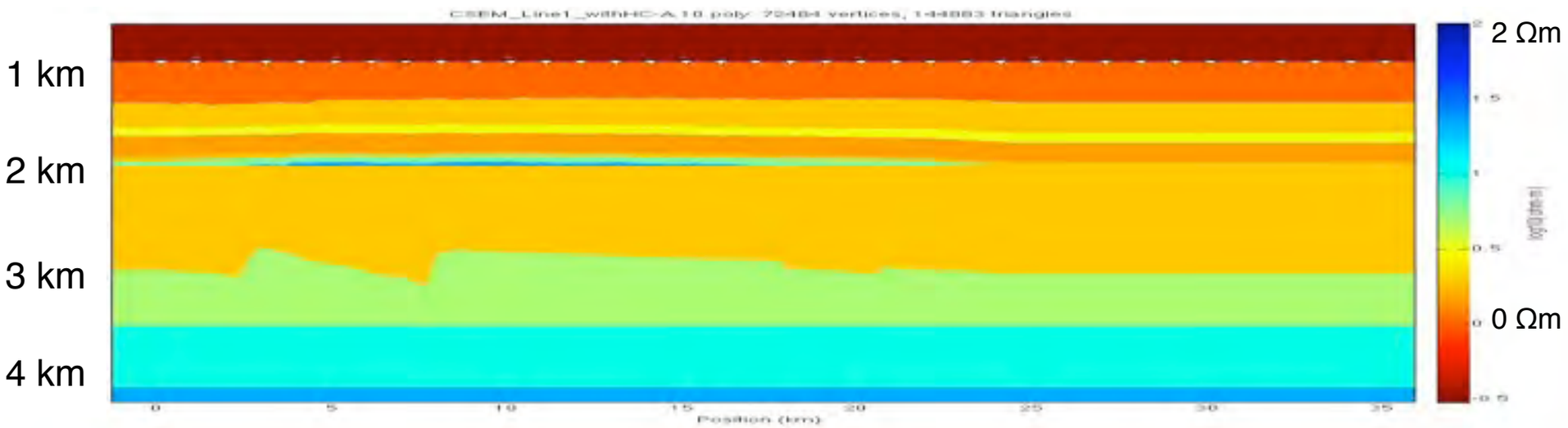


Phase 2 transmitter navigation:
estimated 5-10 m accuracy



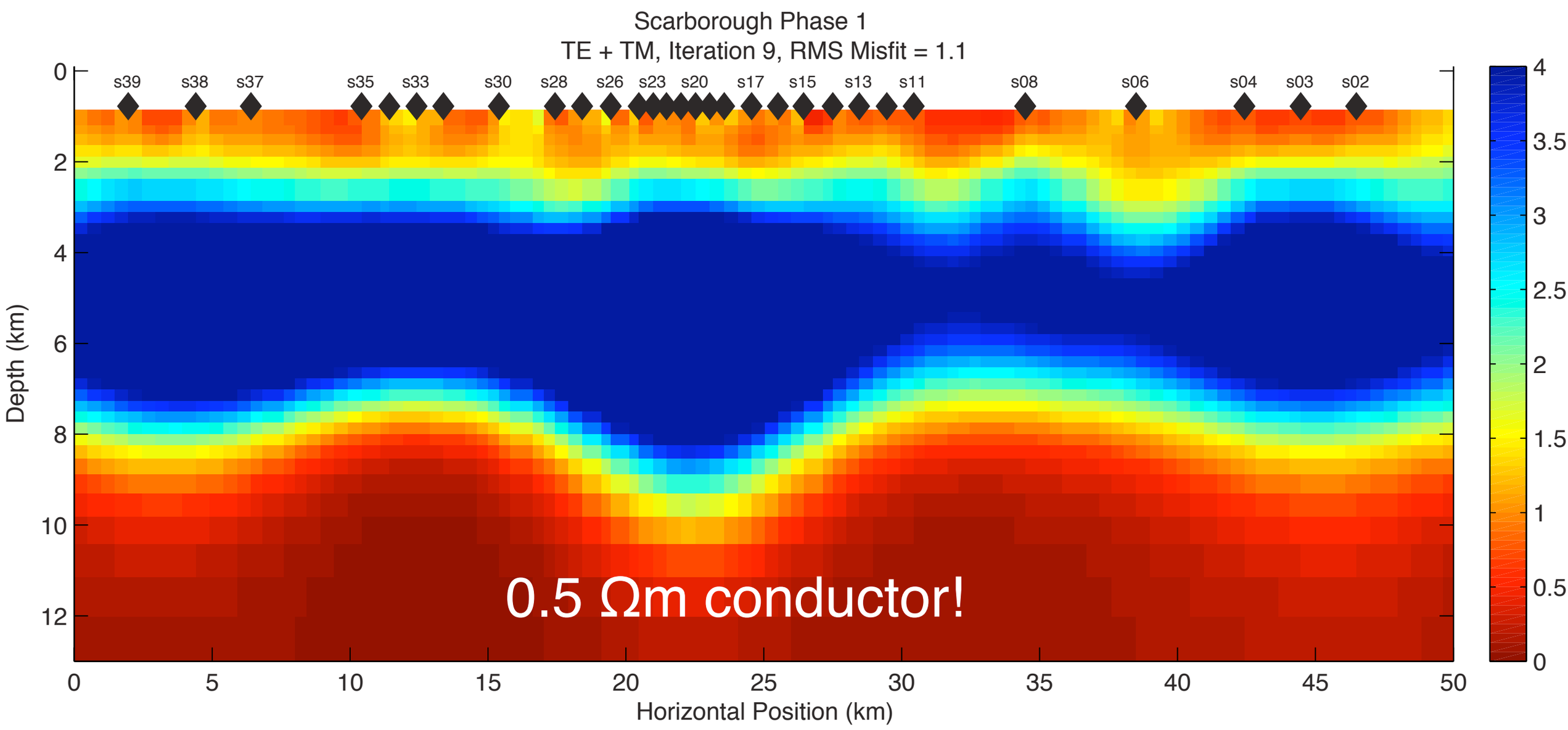
Phase 1 2D OCCAM MT inversion:





scale change

Phase 1 2D OCCAM MT inversion: Looking deeper



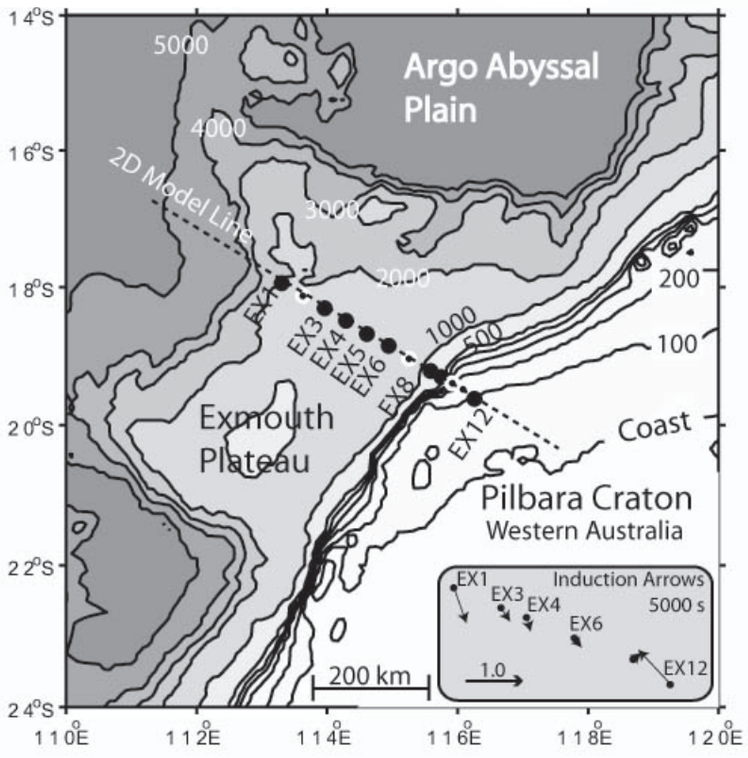
Can this be real?

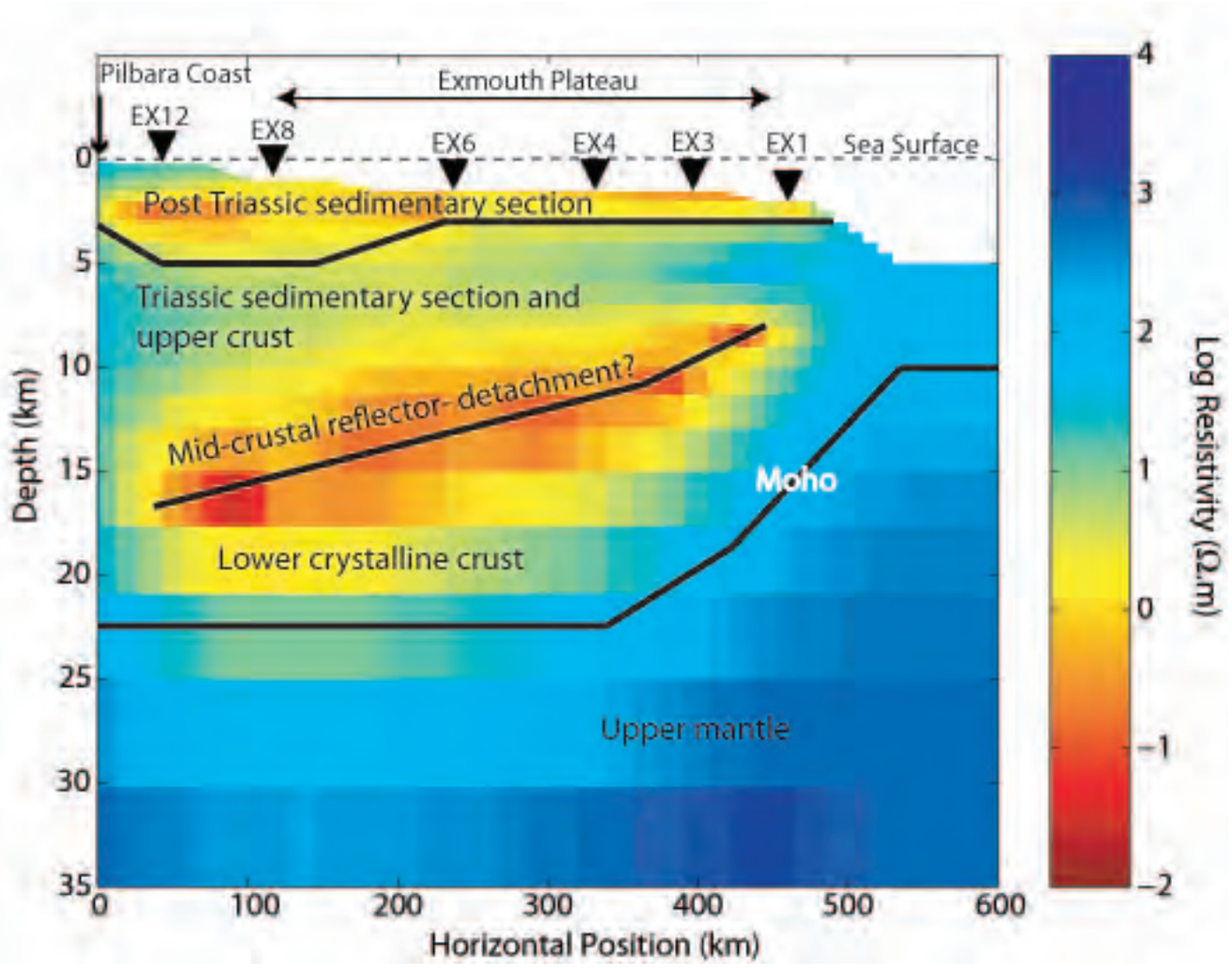
Yes! This feature has been seen before:

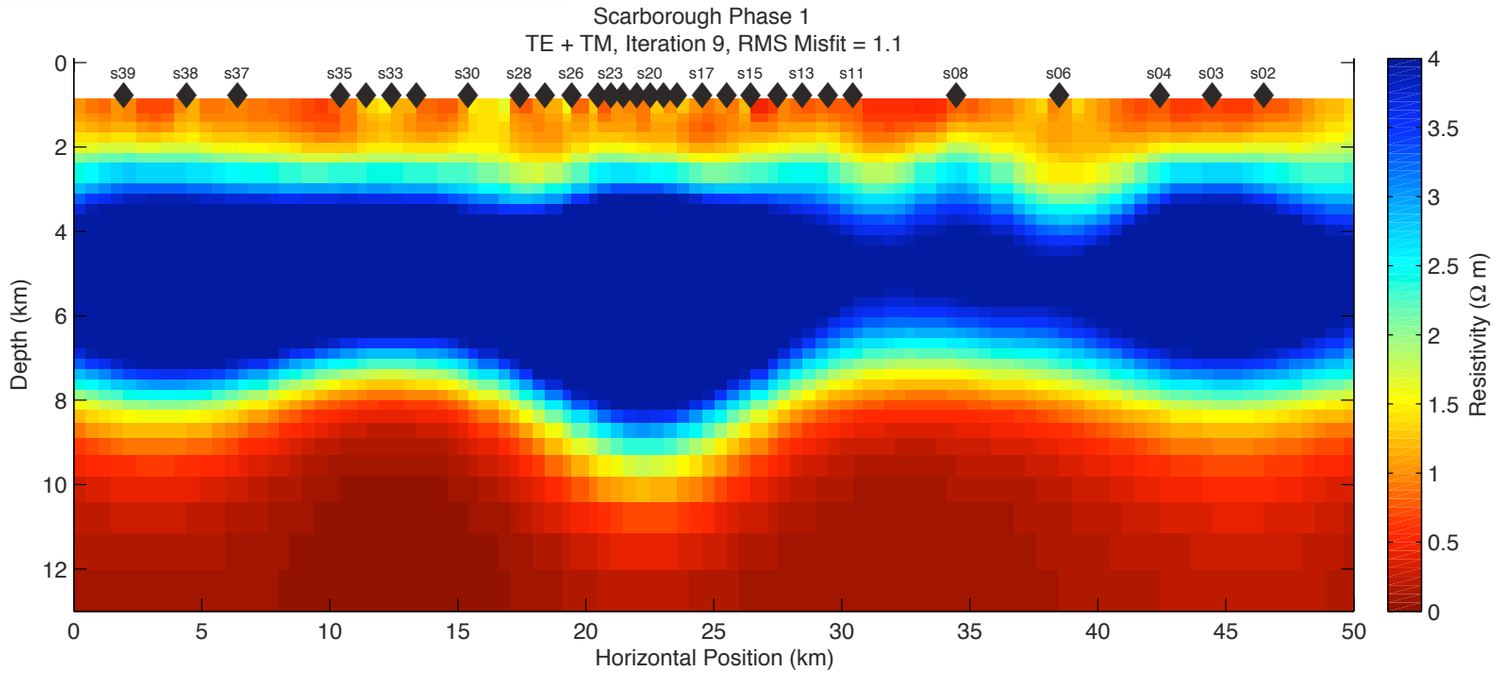
GEOPHYSICAL RESEARCH LETTERS, VOL. 32, L12305, doi:10.1029/2005GL022934, 2005

Rifting of a passive margin and development of a lower-crustal detachment zone: Evidence from marine magnetotellurics

Graham Heinson
Antony White
F. E. M. Lilley

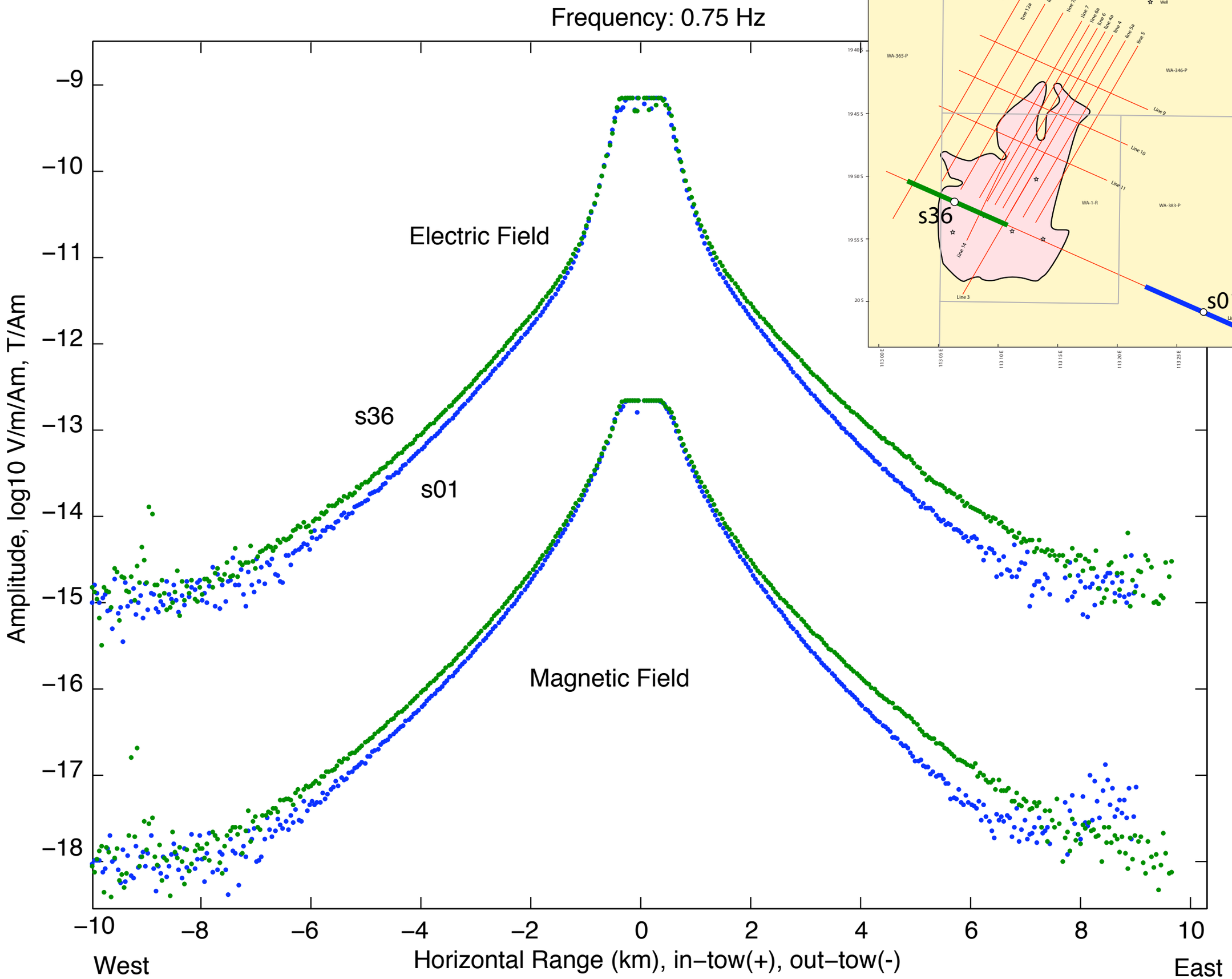


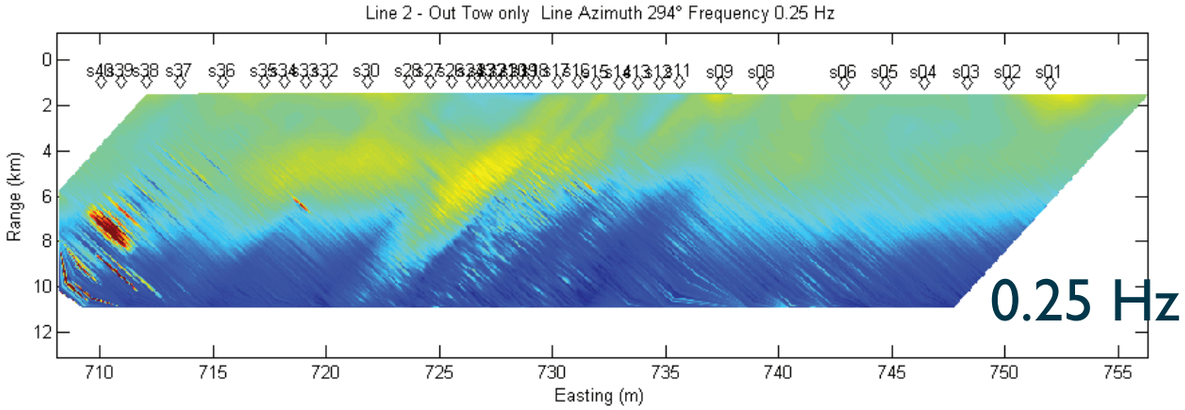


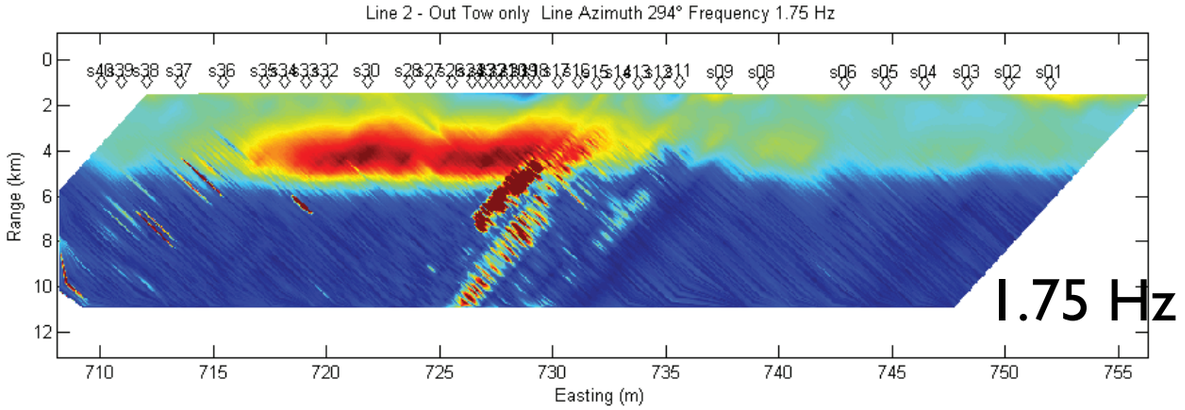


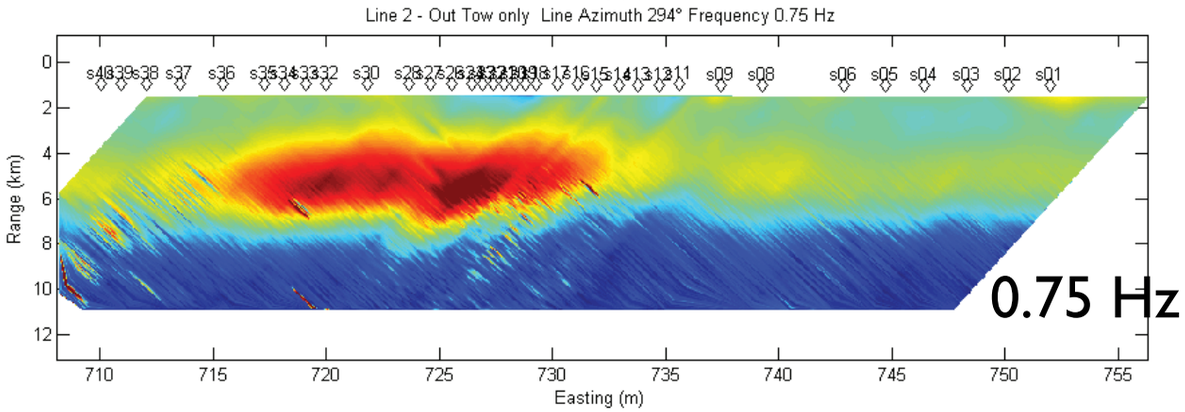
scale change

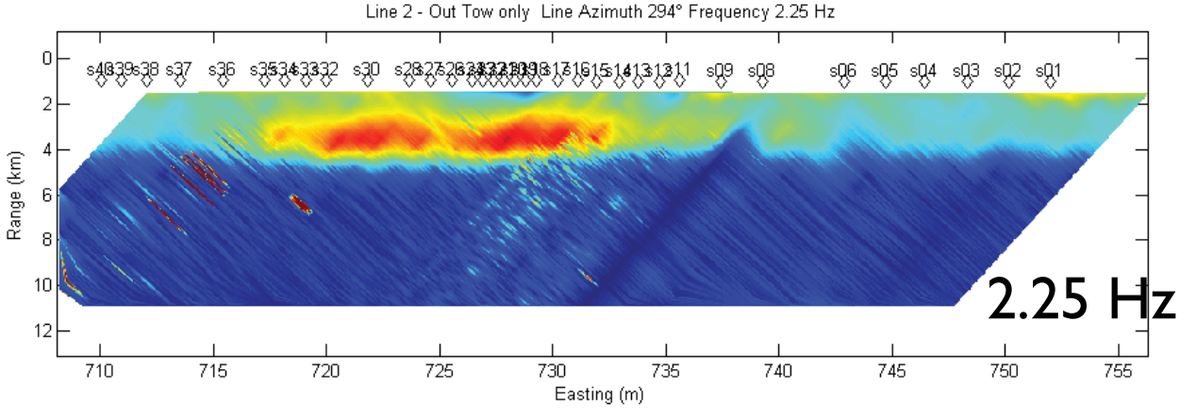
CSEM Ey/Bx data on/off reservoir:

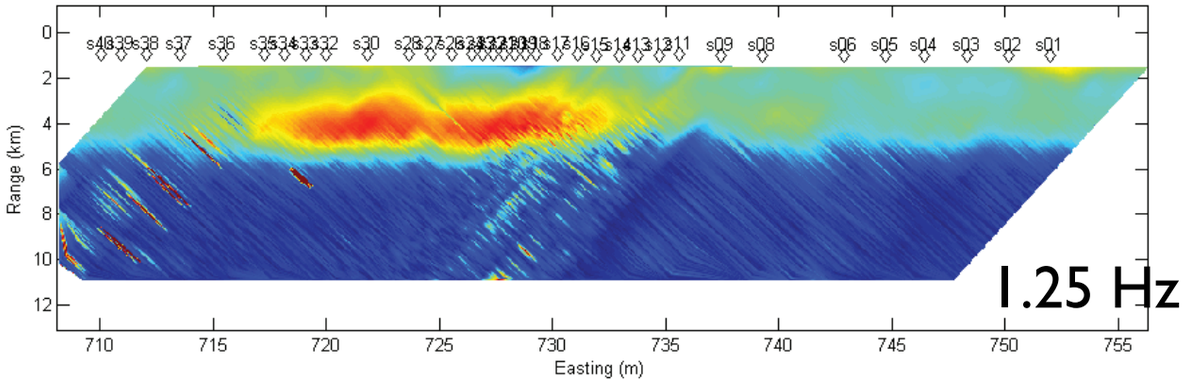


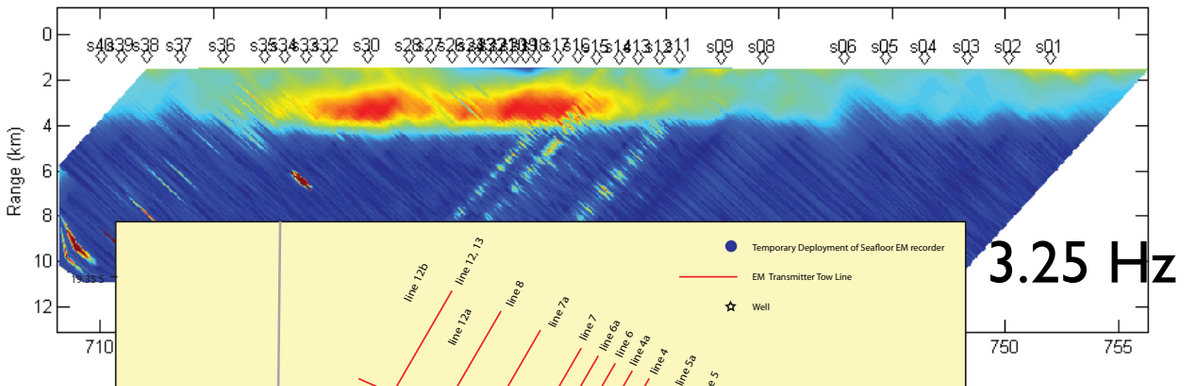




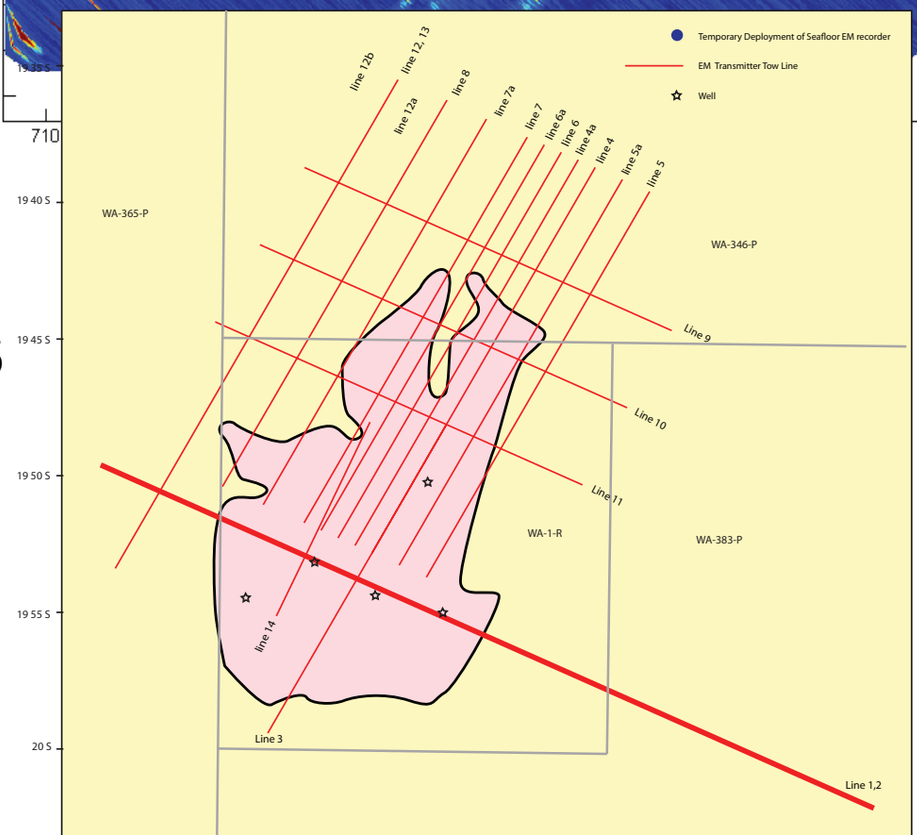




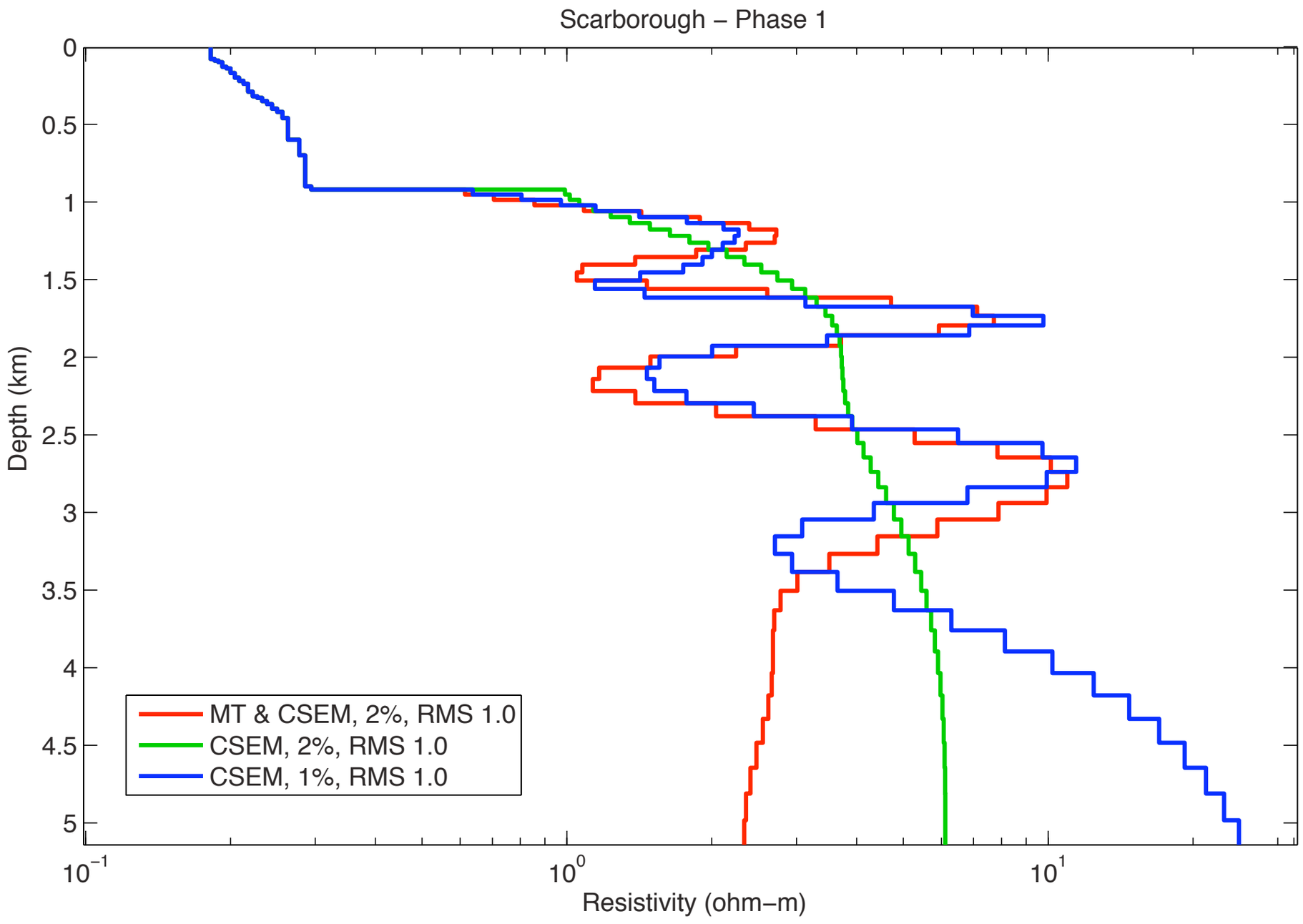




Line 1 anomaly pseudosections (red = x2 referenced to 1 Ωm layer underlain by 2 Ωm)

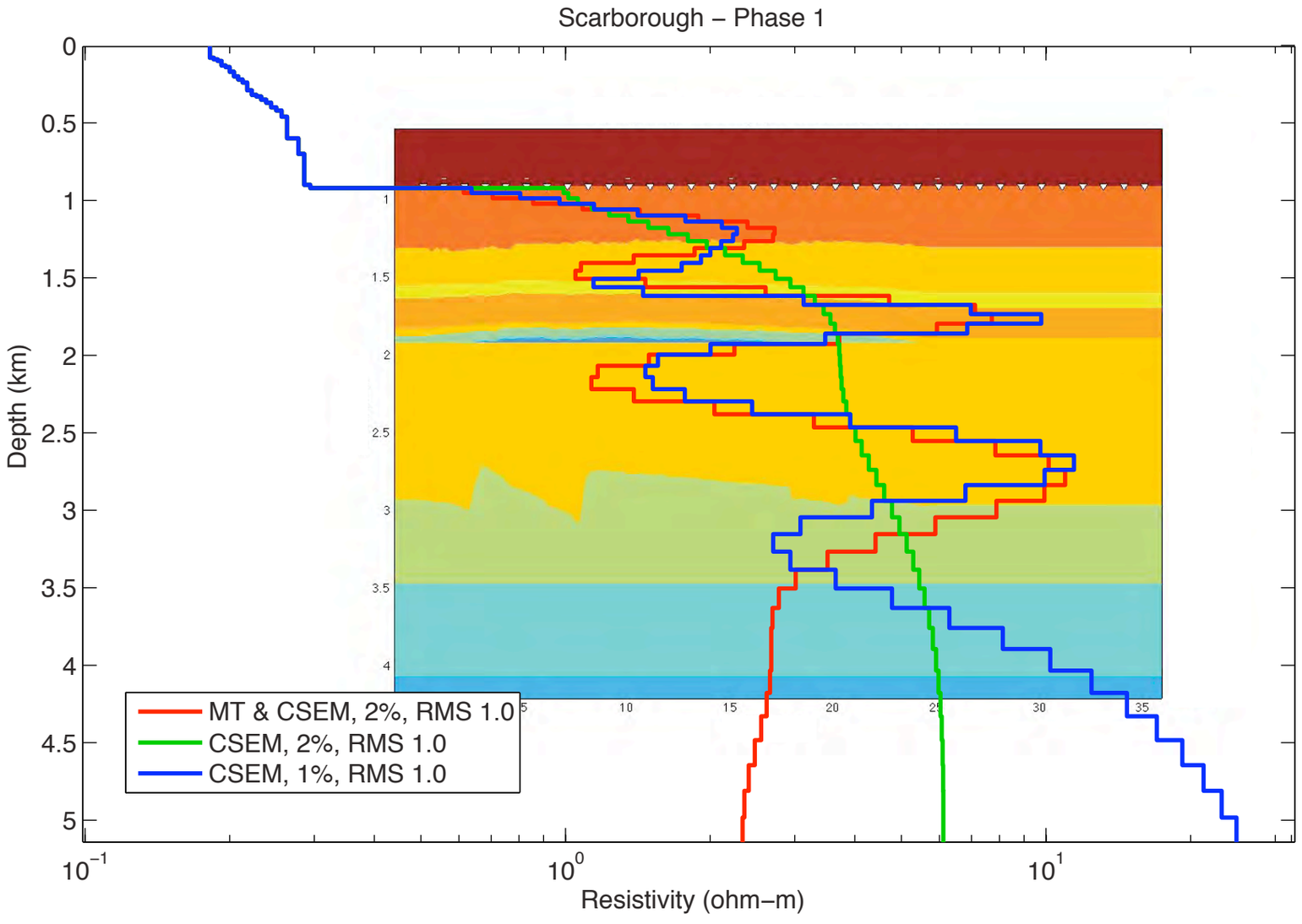


1D OCCAM inversions of one site, Ey amplitudes (seven frequencies 0.25 - 16.75 Hz) + MT

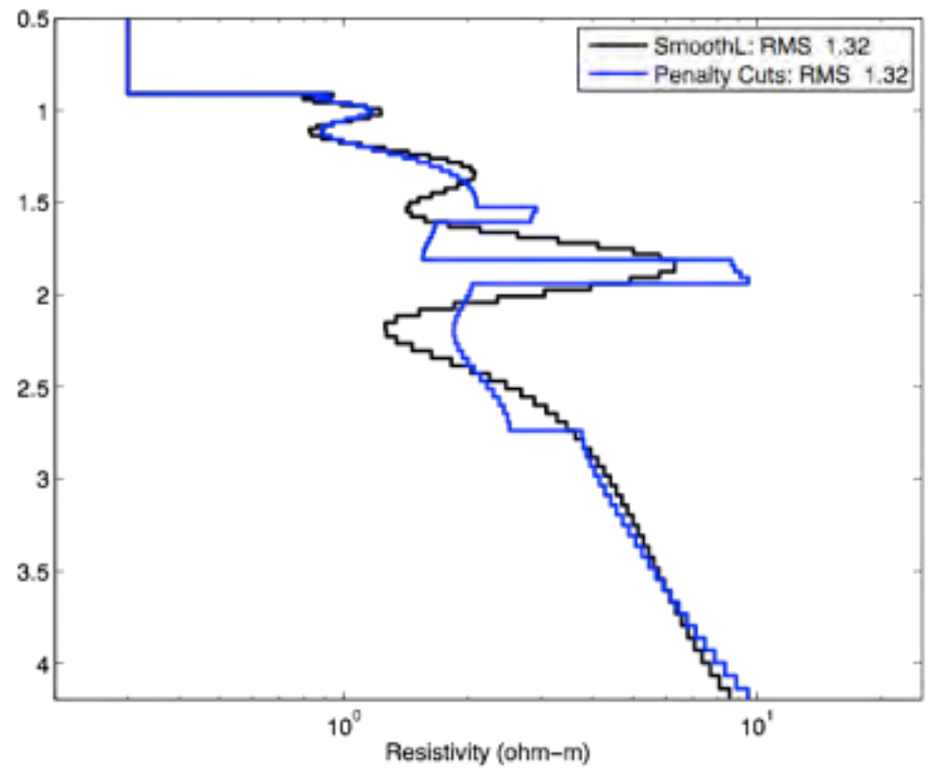


For 2% error floor, MT helps find the reservoir, but with a 1% error floor, CSEM amplitudes give a similar model.

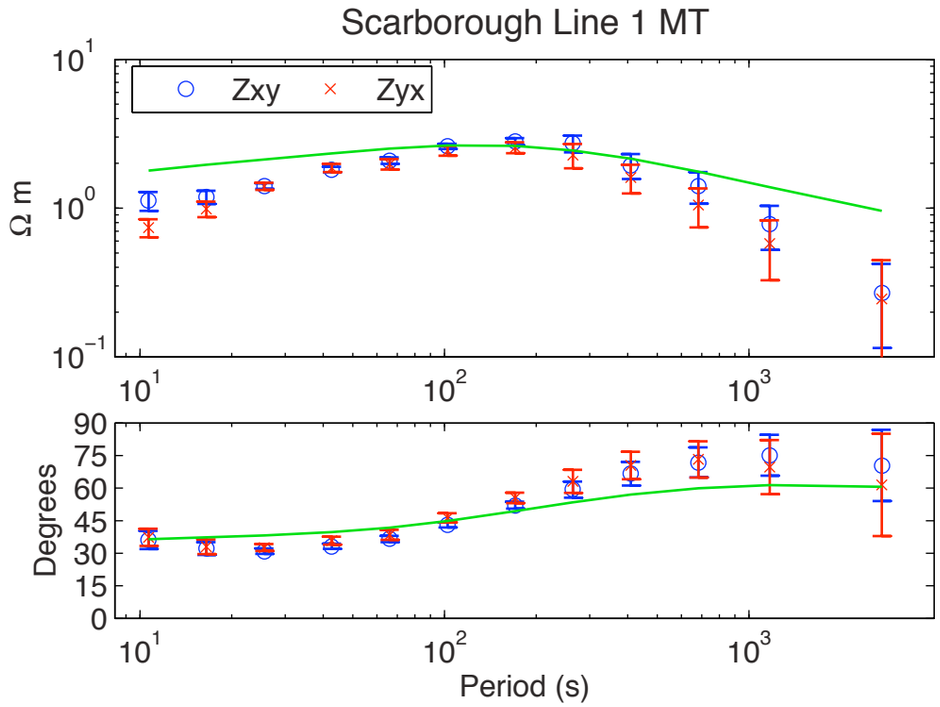
Agreement with pre-cruise design study is good. Reservoir response is shallow, but perhaps smeared with Gearly, and we have yet to include phase, magnetics, etc.

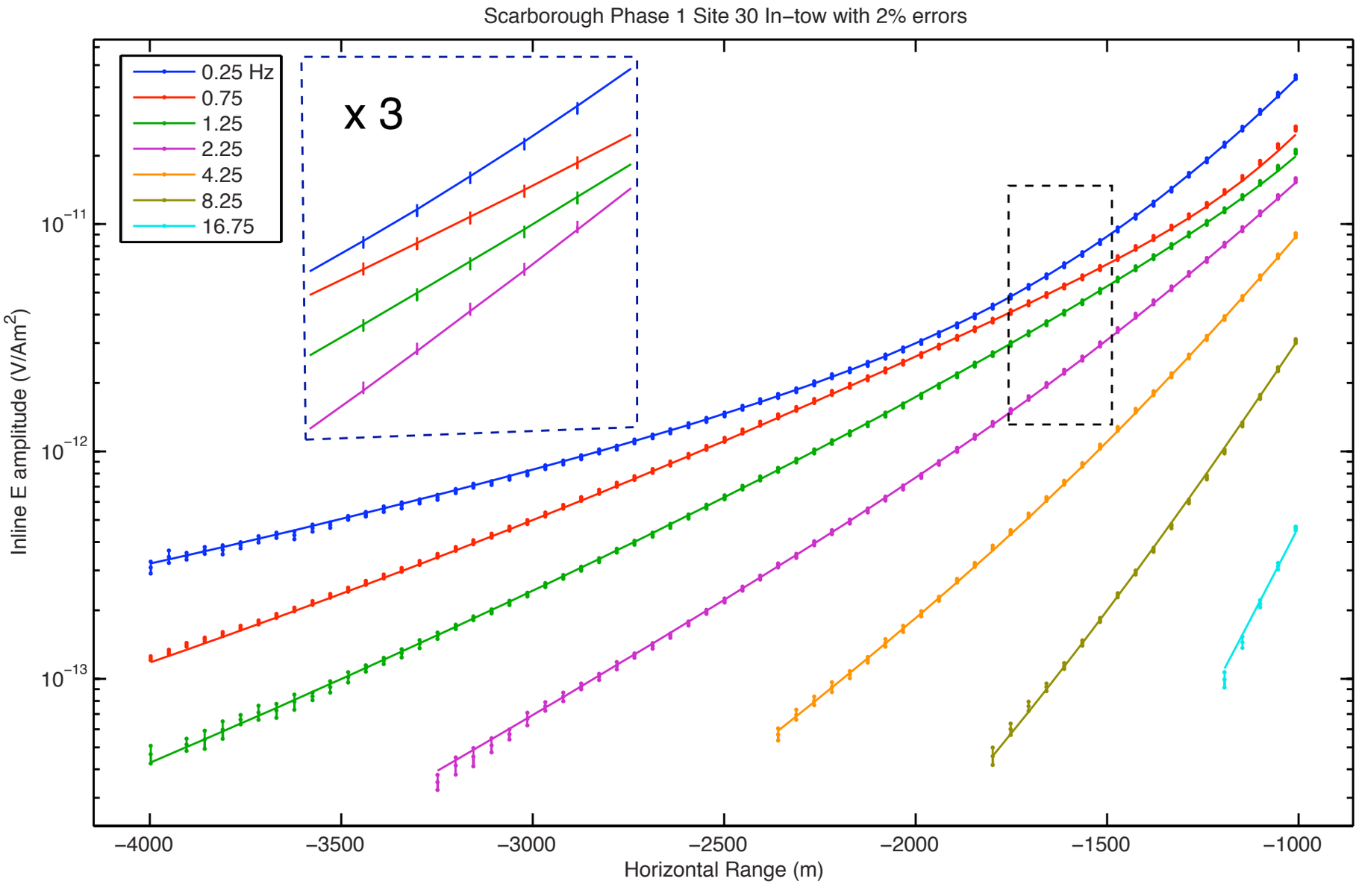


Pre-cruise



Data fits for 2% error floor: MT data are being neglected because they are only 8% of the total data, but fits to CSEM amplitudes across more than 1 decade of frequency are excellent.





IN CONCLUSION:

We have collected 144 sites of very high quality CSEM data over a well-documented gas reservoir.

These data will be extremely useful to drive the development of 1D, 2D, and 3D inversion/interpretation.

Data will be publicly released as we publish our work.

http://marineemlab.ucsd.edu

Scarborough funding: BHP Billiton