

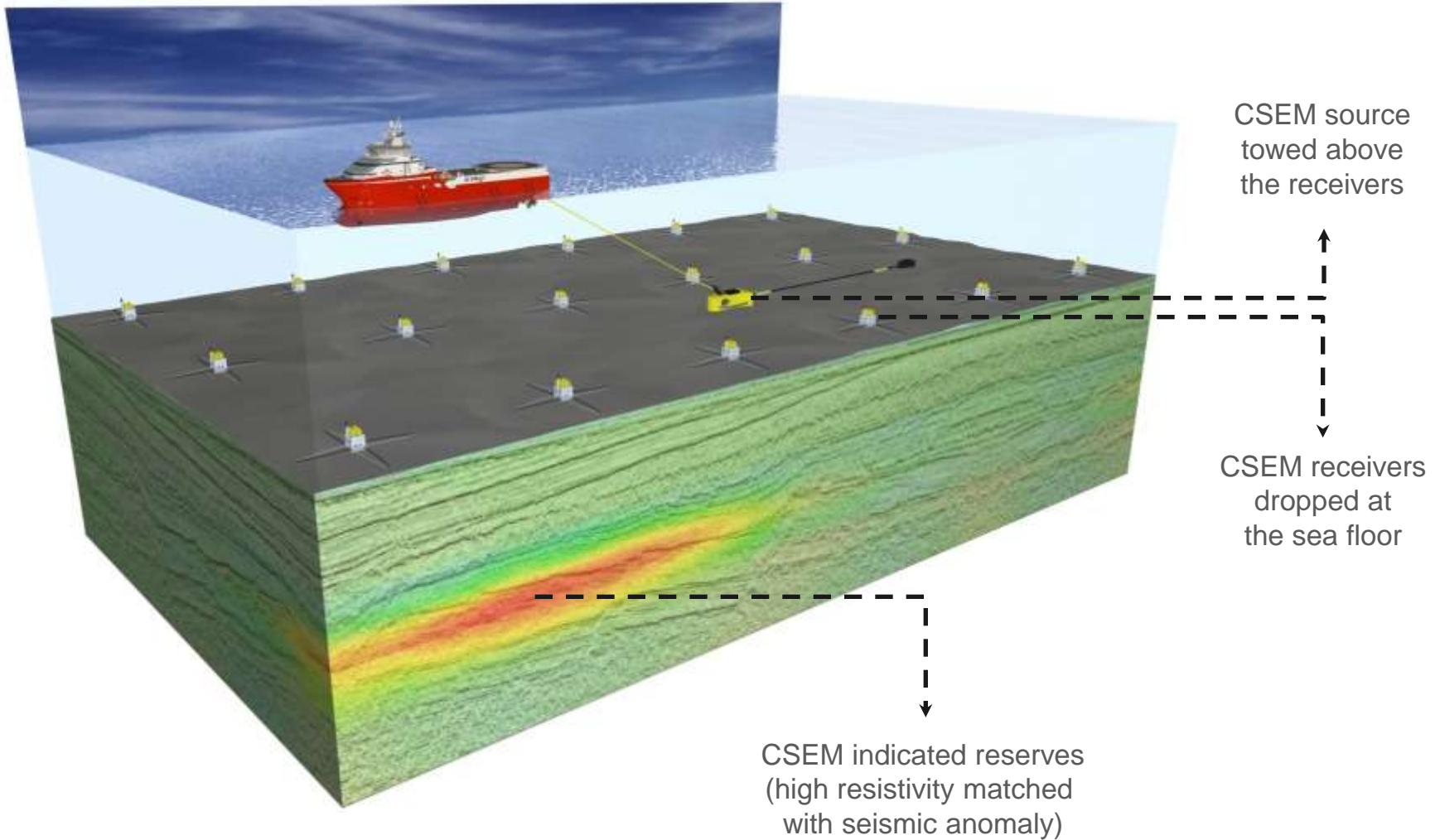
“Exploration experience with CSEM in deep water areas”

Svein Ellingsrud, Founder & Vice President, London May 26

SUBSURFACE STRUCTURES FLUID FILLED - WITH WHAT?



CSEM – RESISTIVITY MEASURED FROM THE SEA BED



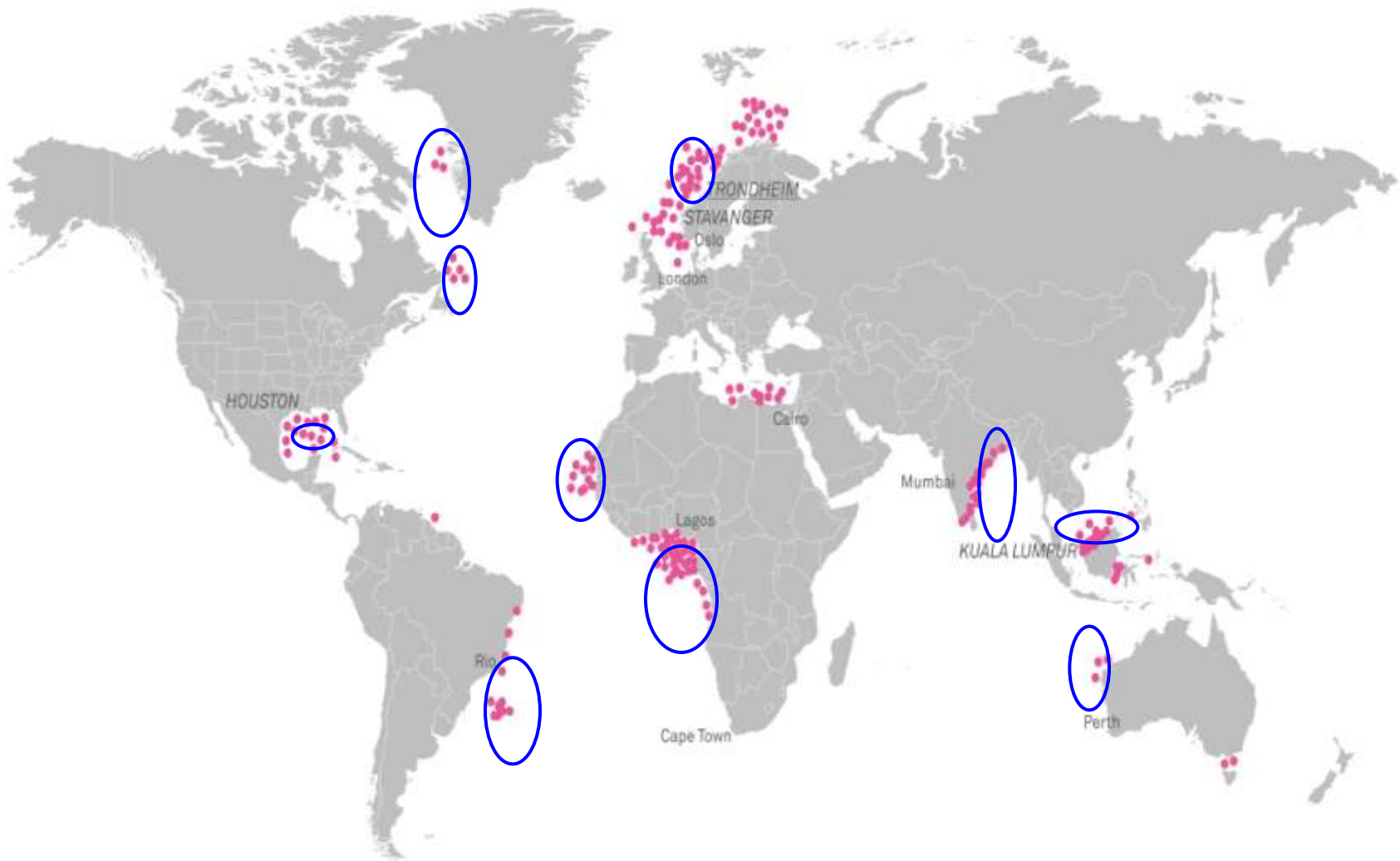
PURPOSE BUILT CSEM VESSELS



- BOA THALASSA and BOA GALATEA
 - Designed for optimum 3D data operations
 - Improved efficiency; 1000 km² per month
 - Large equipment space, up to 200 Receivers
 - Two complete source production lines
 - Sheltered operations, improved weather window
 - Cruising speed 16 knots
 - All equipment designed for **3500 m water depth**
 - Depth range 30 – 3500 m (NB also shallow water)
 - Full 3D operations down to 3500 m



GLOBAL EXPLORATION EXPERIENCE WITH CSEM



INTEGRATED EM SYSTEM

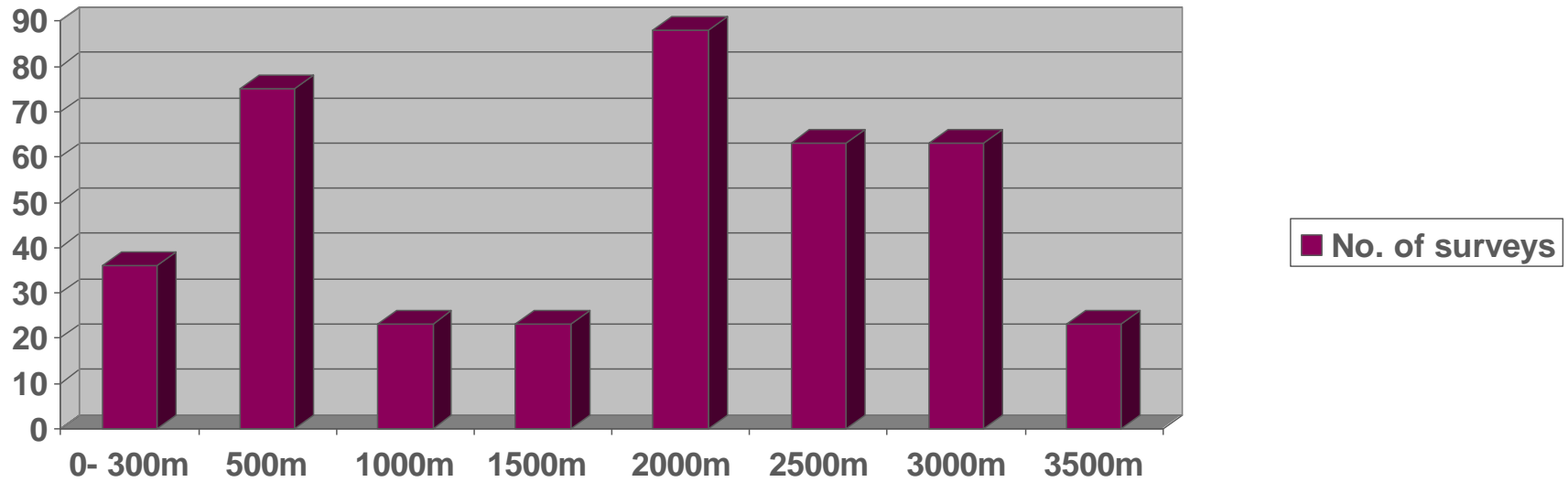


Experience in deep water areas



GLOBAL EXPLORATION EXPERIENCE WITH CSEM

No. of surveys as a function of water depth



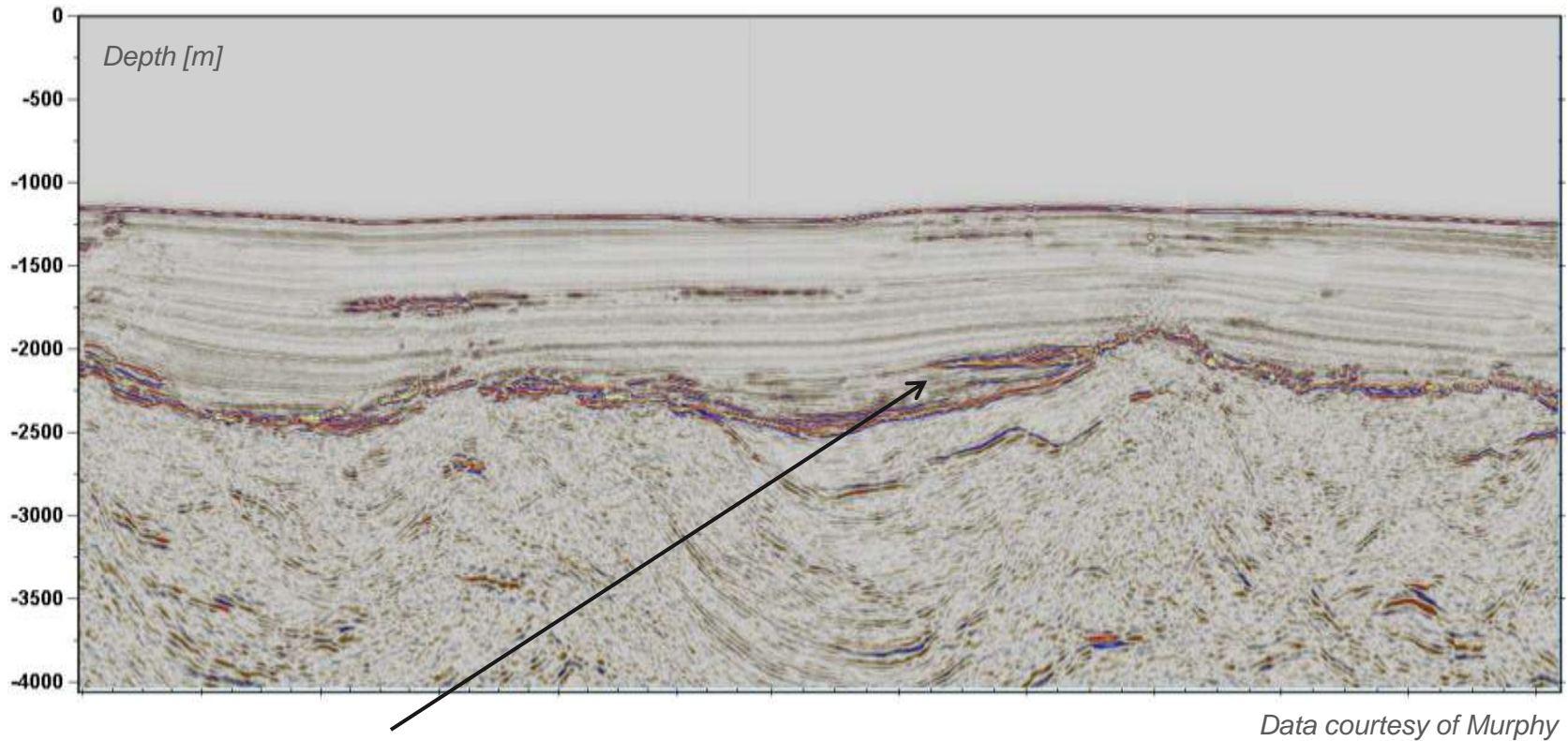
CSEM data has been acquired in water depth ranging from **44 – 3392 meter**

- 88 in the range of 1500 – 2000 m
- 63 in the range of 2000 – 2500 m
- 63 in the range of 2500 – 3000 m
- 23 in the range of 3000 – 3500 m



CASE STUDY - TESTING A SEISMIC PROSPECT, DISCOVERY

Murphy Rotan Case Study - Malaysia



Seismic flatspot indicates potential reservoir.

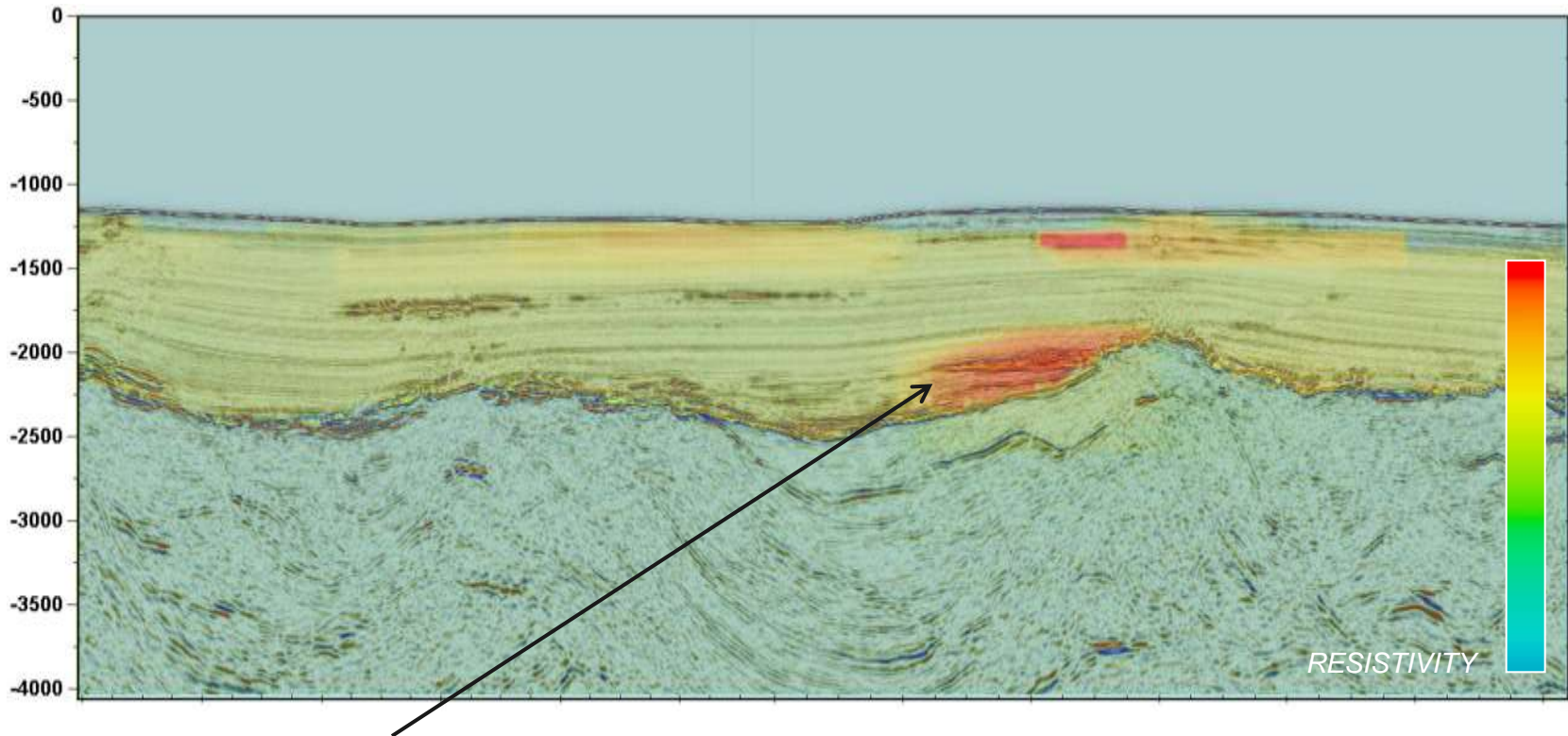


INTEGRATED EM SYSTEM



CASE STUDY - TESTING A SEISMIC PROSPECT, DISCOVERY

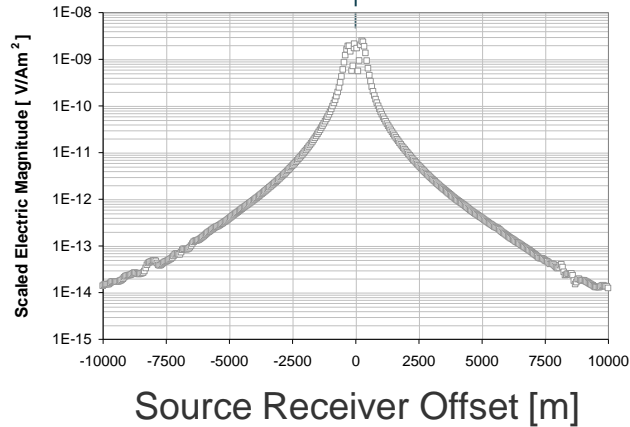
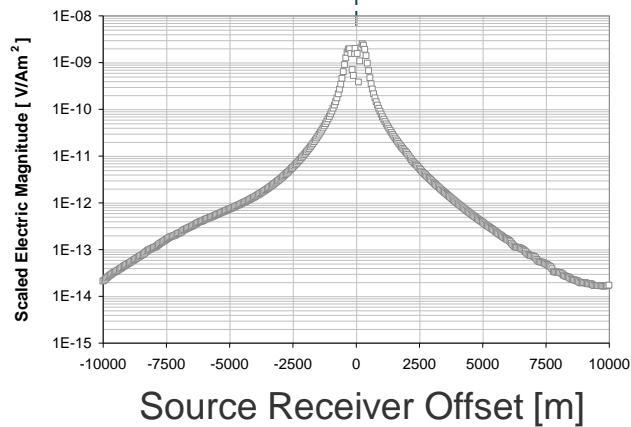
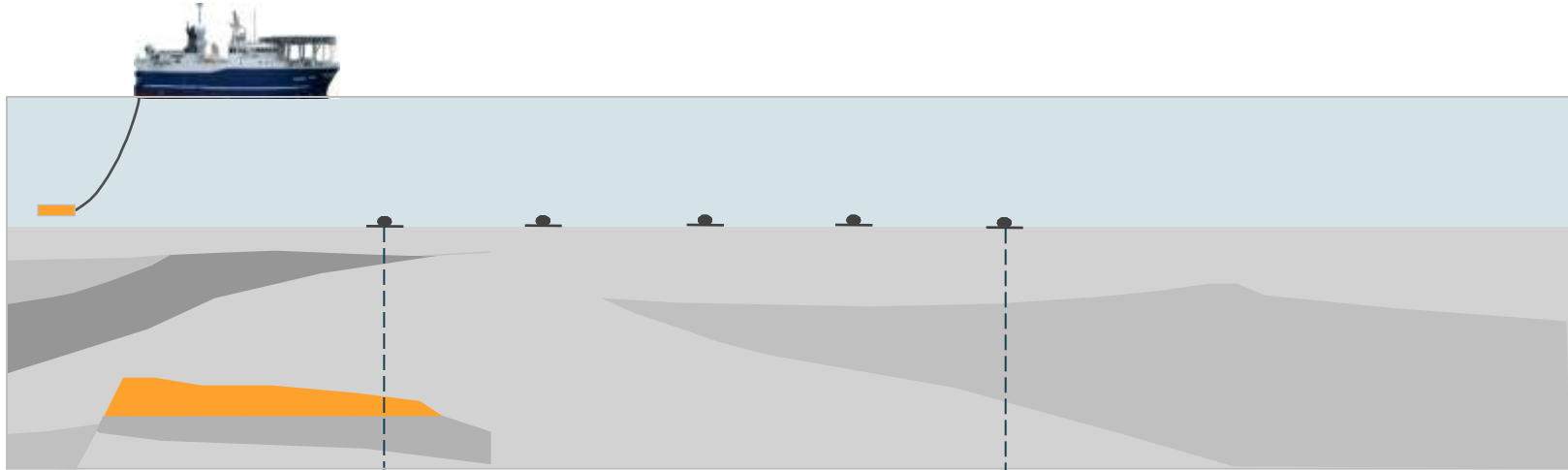
Rotan overlaid with EM measurements



An CSEM anomaly confirmed a seismic flatspot, both laterally and in depth. Therefore, the risk of drilling a low-saturation, non-commercial reservoir was reduced. The subsequent well encountered a good quality gas reservoir with a saturation of commercial potential.



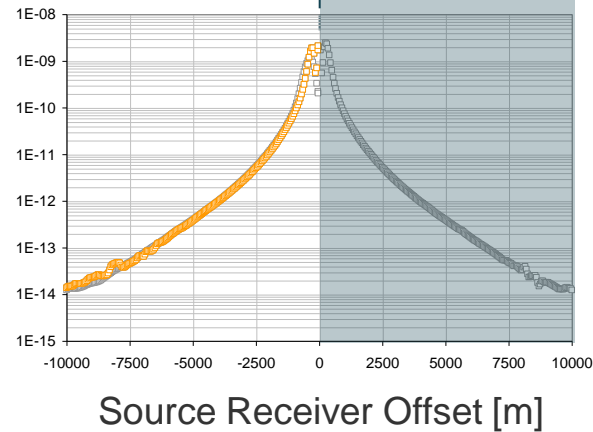
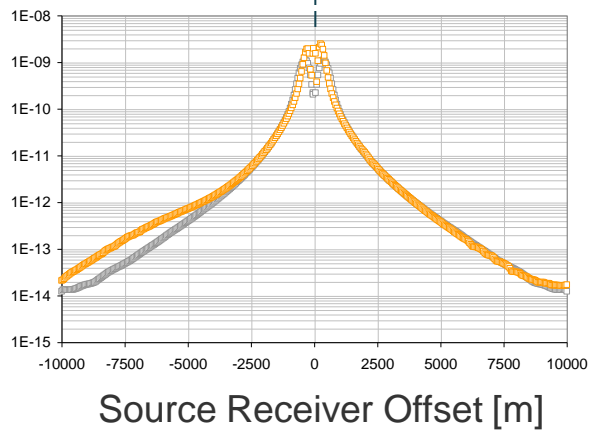
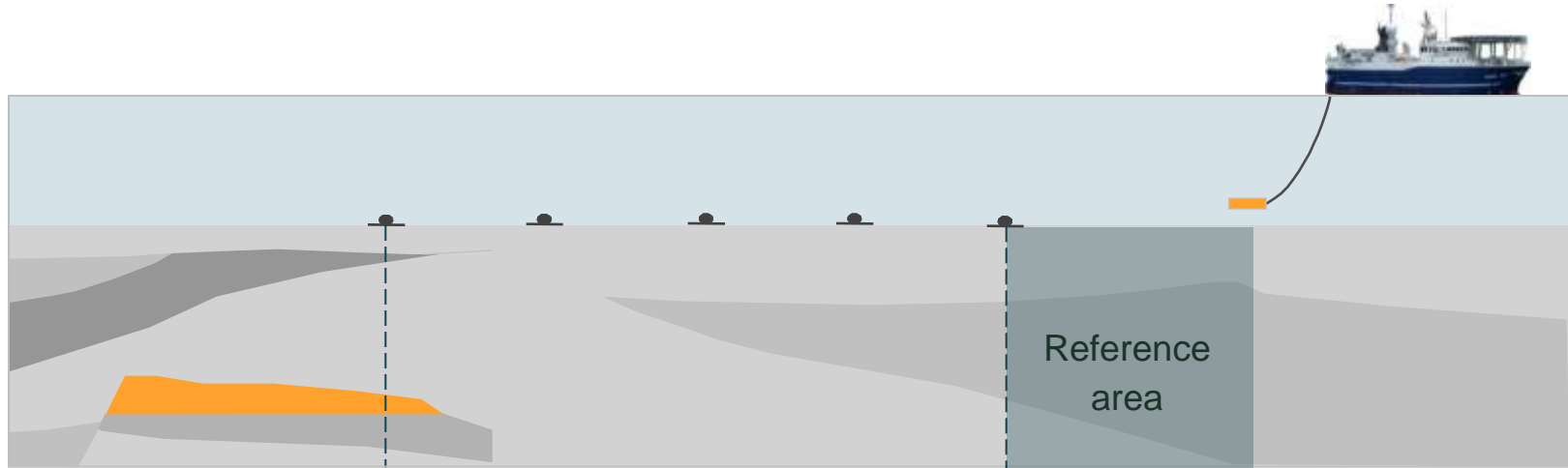
EXPLAINING NORMALIZED MAGNITUDE VERSUS OFFSET



Magnitude versus Offset
(MvO)



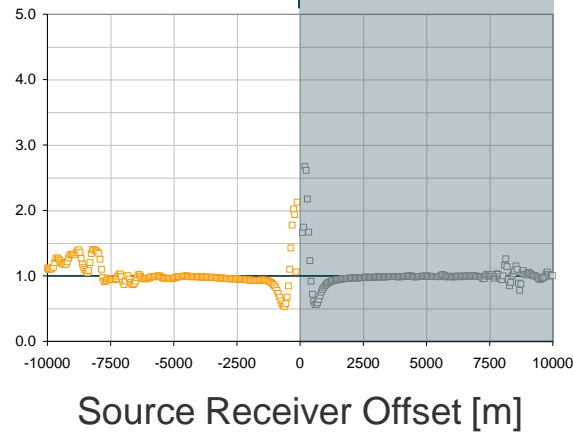
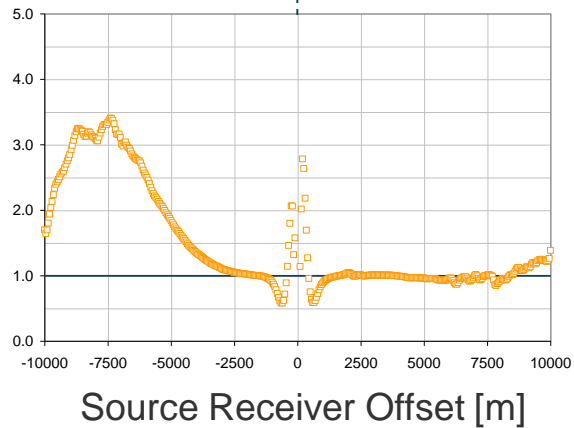
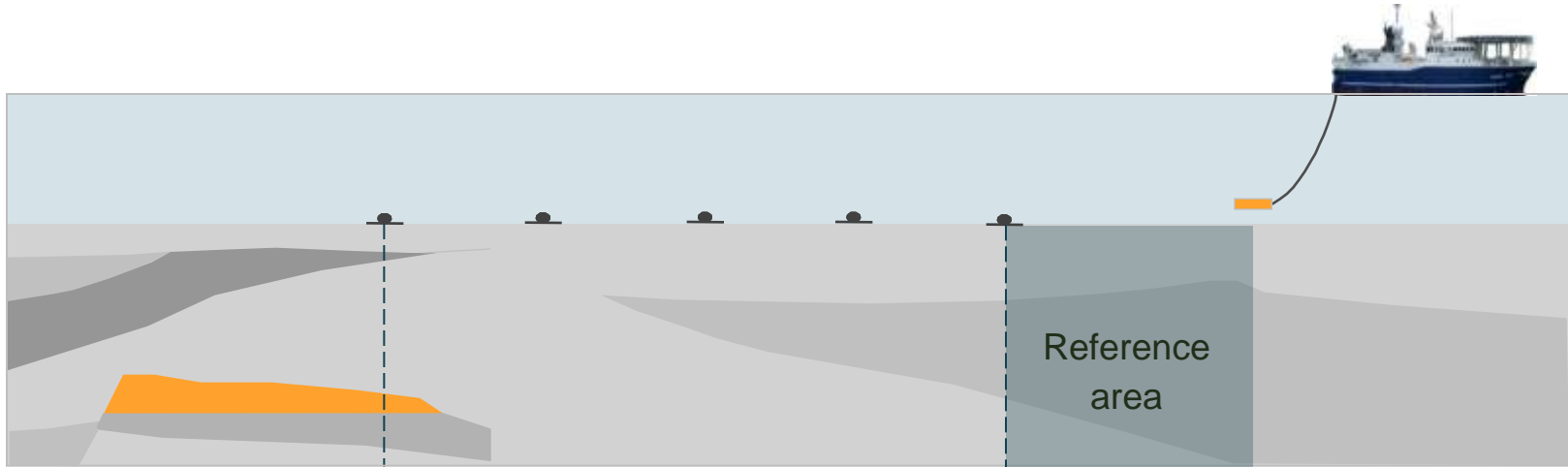
EXPLAINING NORMALIZED MAGNITUDE VERSUS OFFSET



Magnitude versus Offset
(MvO)



EXPLAINING NORMALIZED MAGNITUDE VERSUS OFFSET



Normalized Magnitude
versus Offset
(NMvO)

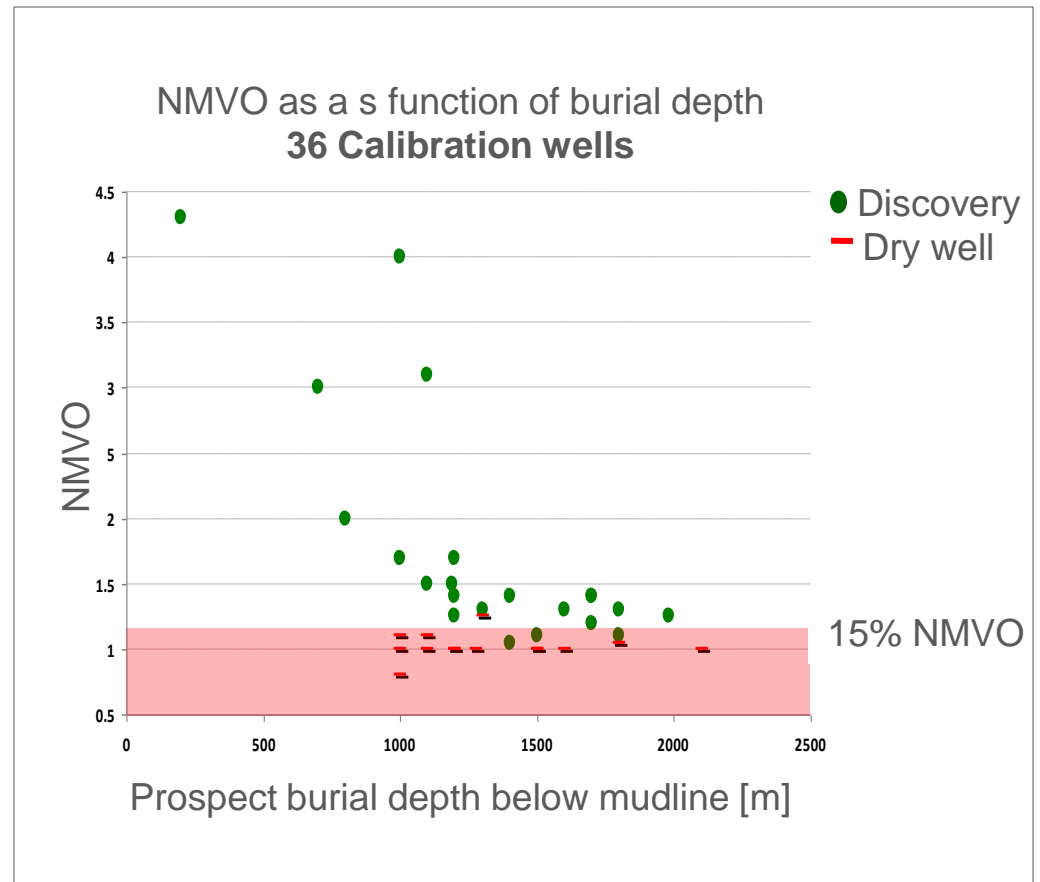


WHAT DOES THE DRILL BIT SAY?

The results

Calibration wells

- Overall “exploration success” 61%
 - Discoveries significant anomalies 95%
 - Discoveries no significant anomaly 19%
 - Dry wells with significant anomaly 1
 - Dry wells no significant anomalies 13
-
- Very large correlation

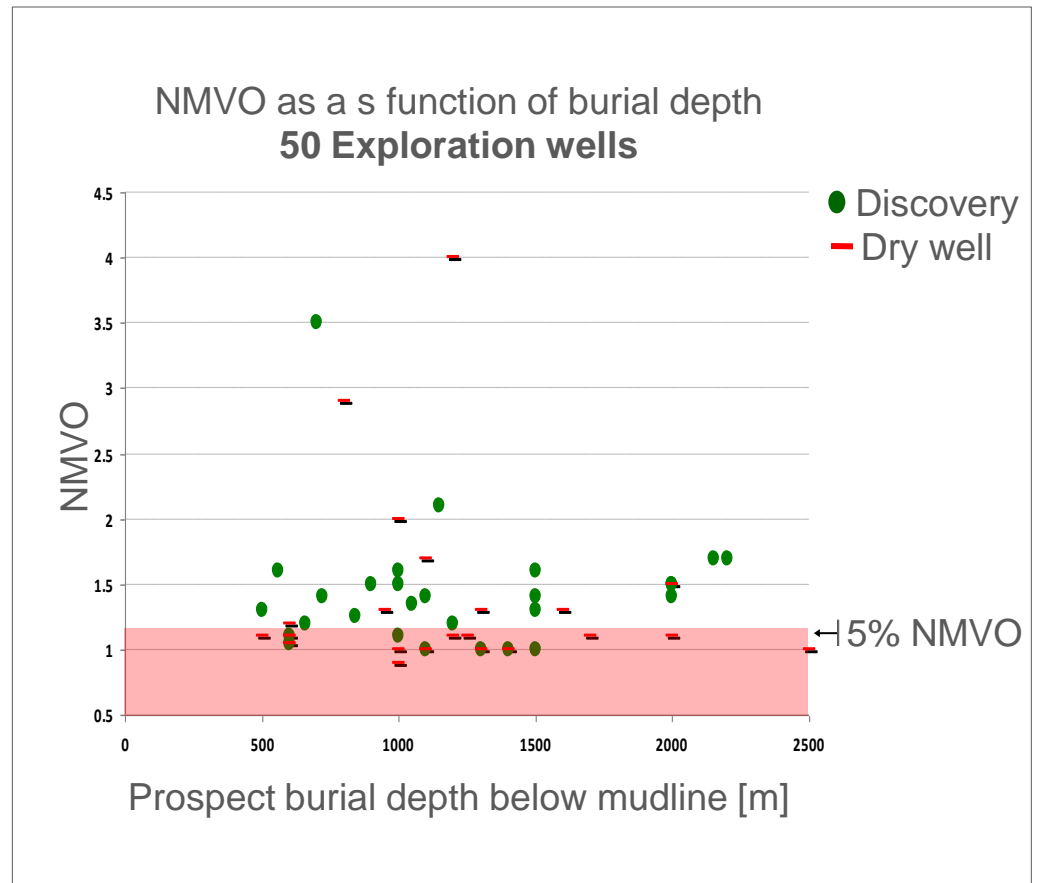


WHAT DOES THE DRILL BIT SAY?

The results

Exploration wells

- Overall exploration success 56%
- Discoveries significant anomalies 70%
- Discoveries no significant anomaly 35%
- Dry wells with significant anomaly: 9
- Dry wells no significant anomalies: 13
- Significantly higher exploration success with significant CSEM anomaly
- Results discussed in: Fanavoll et al, First Break volume 28, May 2010

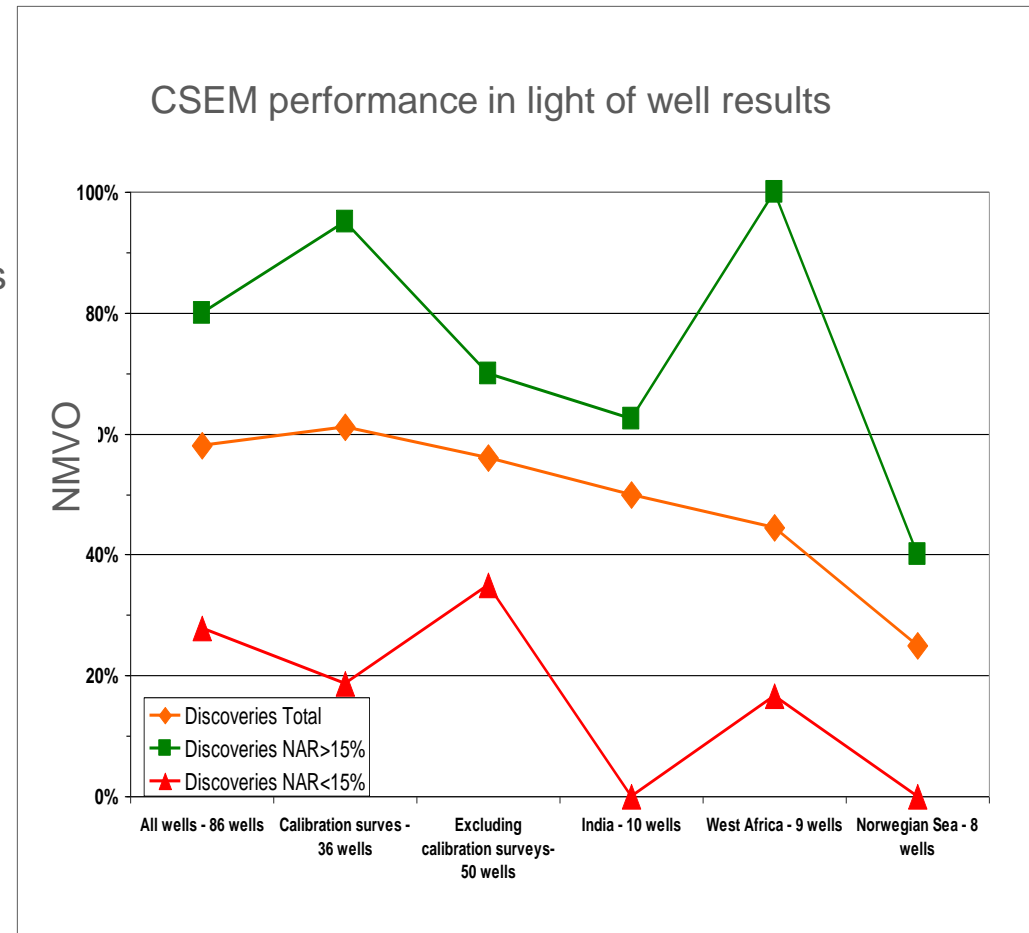


WHAT DOES THE DRILL BIT SAY?

The results

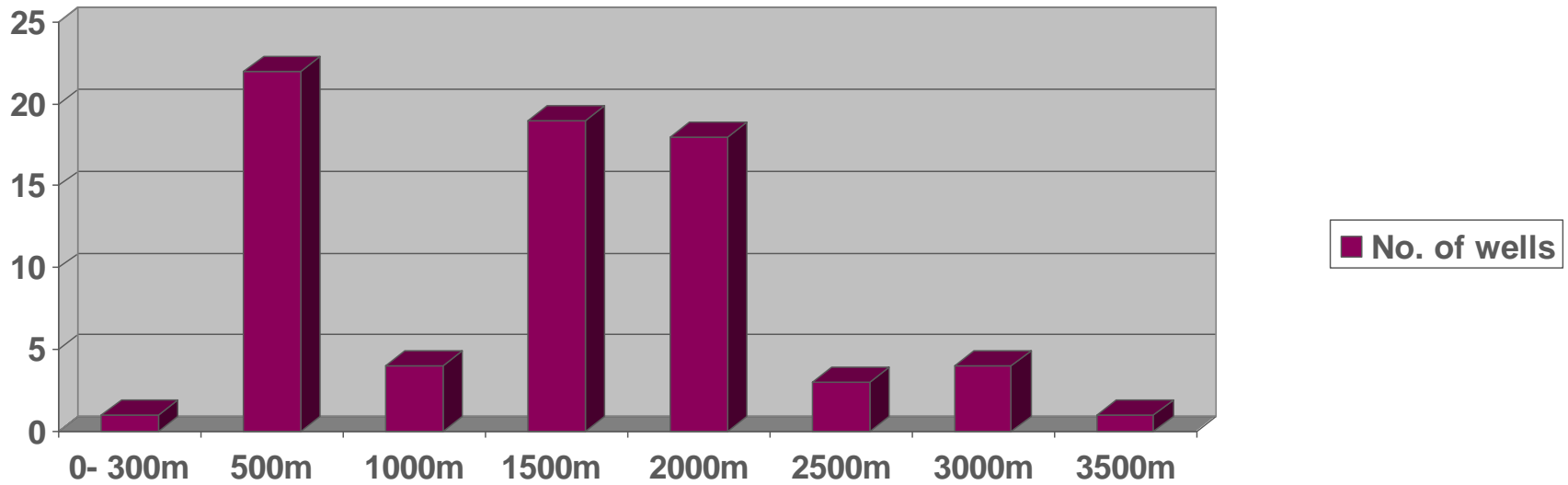
Function of regions with more than 9 wells

- Regional exploration successes vary
- All regions show higher exploration success



GLOBAL EXPLORATION EXPERIENCE WITH CSEM

No. of calibration/exploration wells as a function of water depth (total 80)

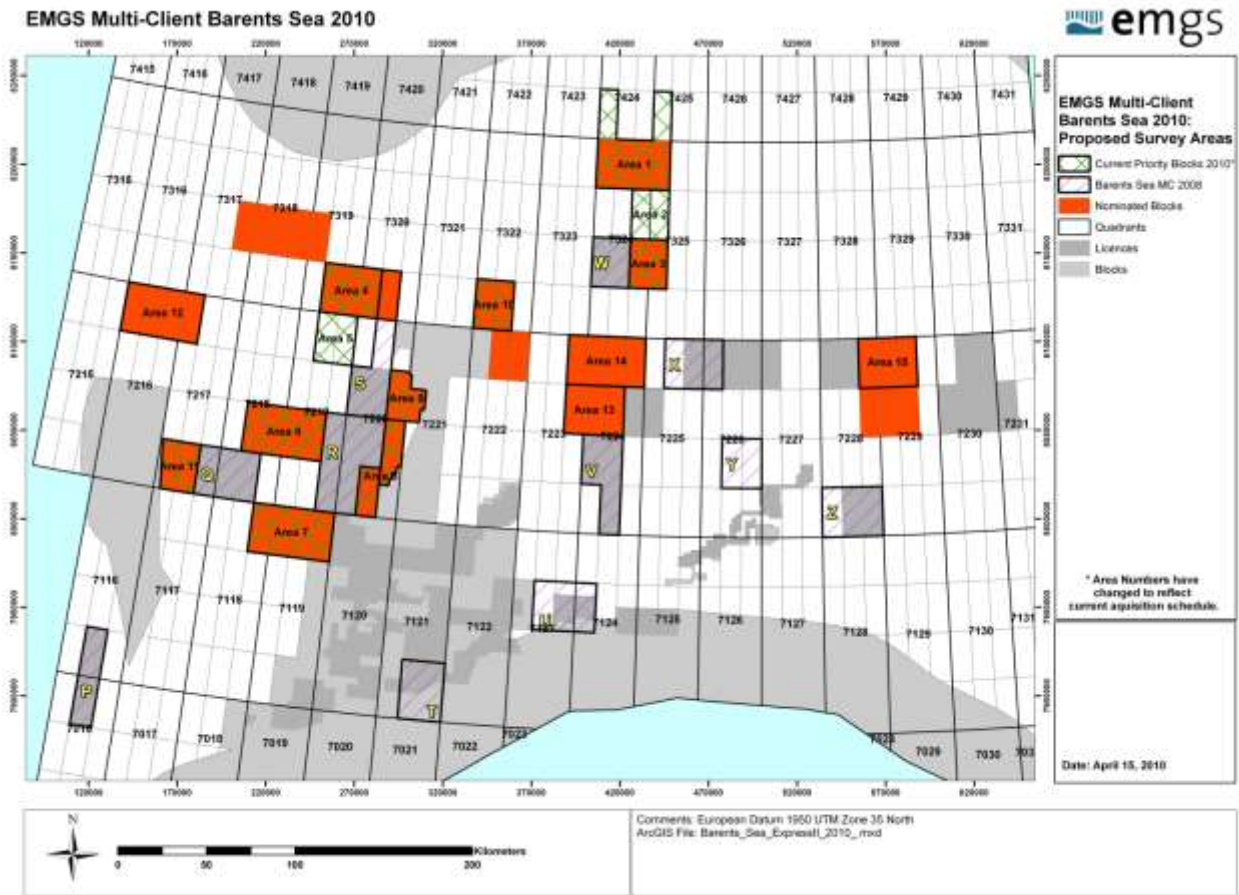


CSEM data has been acquired in water depth ranging from 44 – 3392 meter

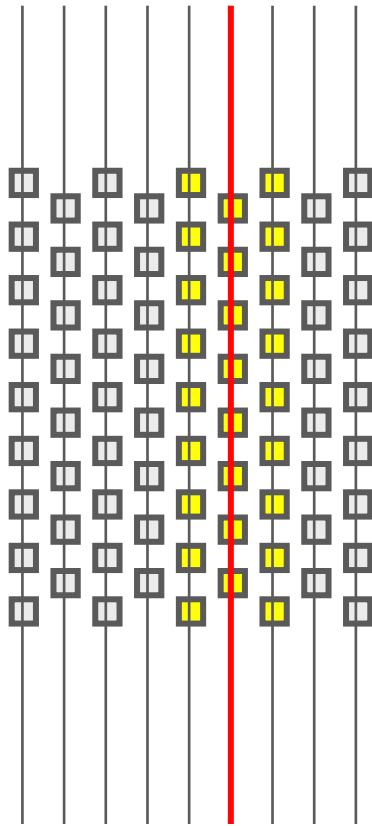
- 19 in the range of 1000 – 1500 m
- 18 in the range of 1500 – 2000 m
- 3 in the range of 2000 – 2500 m
- 4 in the range of 2500 – 3000 m



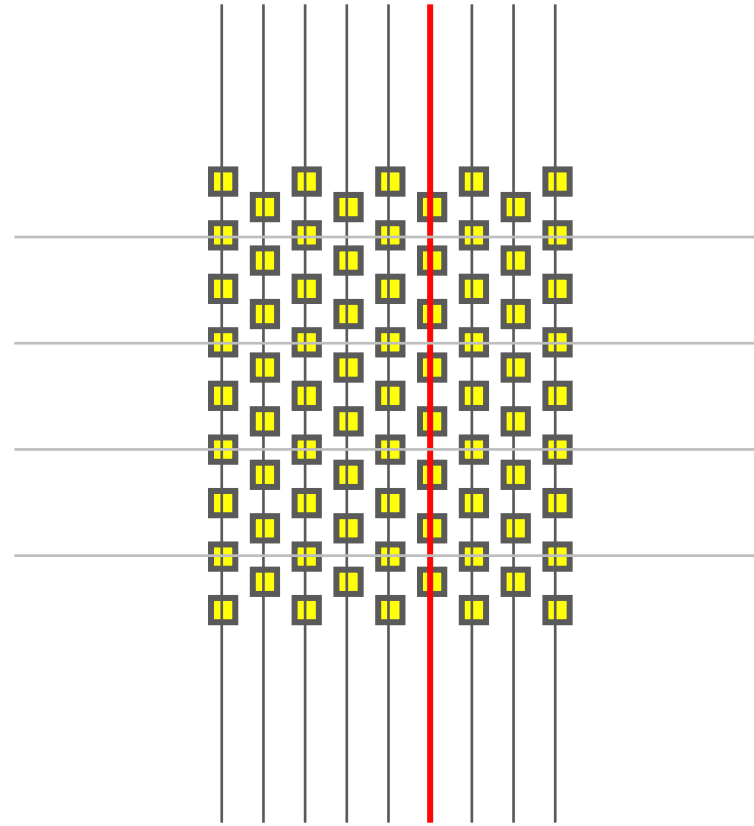
EXAMPLE OF MULTICLIENT CAMPAIGNS – LARGE AREAS BARENTS SEA 2008 AND 2010



STRATEGY FOR DATA DENSITY IN LARGER AREAS – INCREASED DATA DENSITY



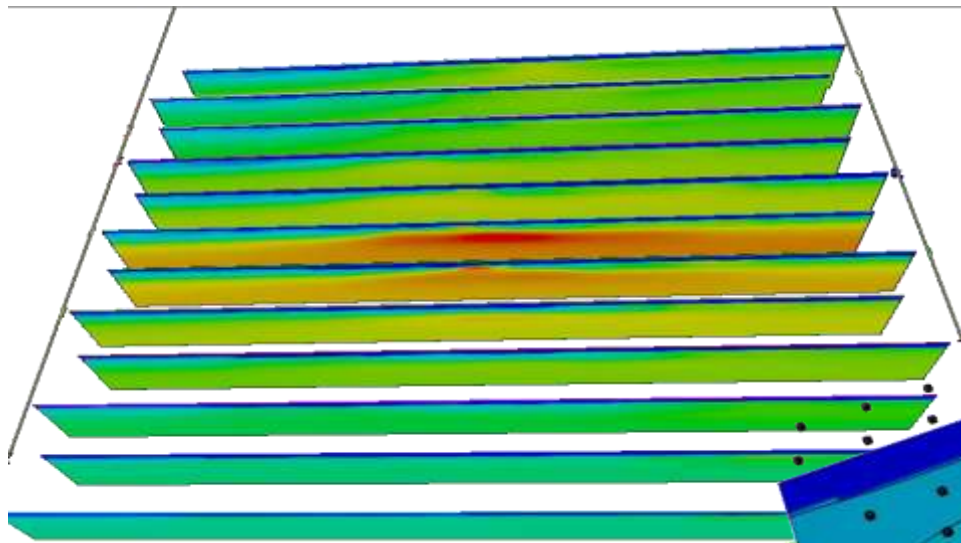
- 2008** • 3km x 3km sampling
• 3 lines live



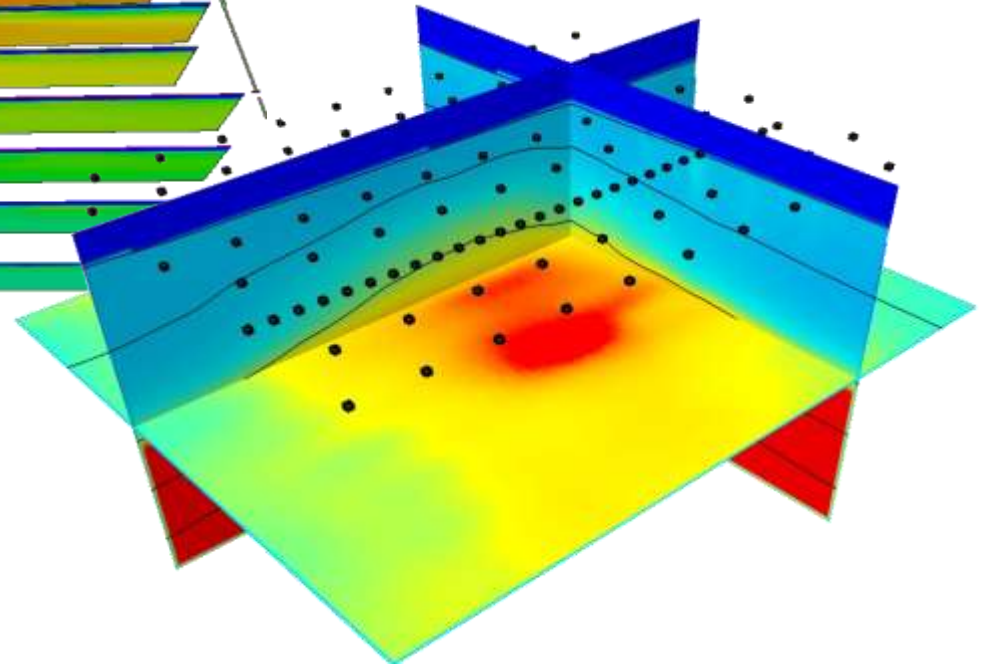
- 2010** • 3km x 3km sampling
• All lines live
• *Full azimuth (with orthogonal lines)*



ANISOTROPIC INVERSION IN BOTH 2.5D AND 3D



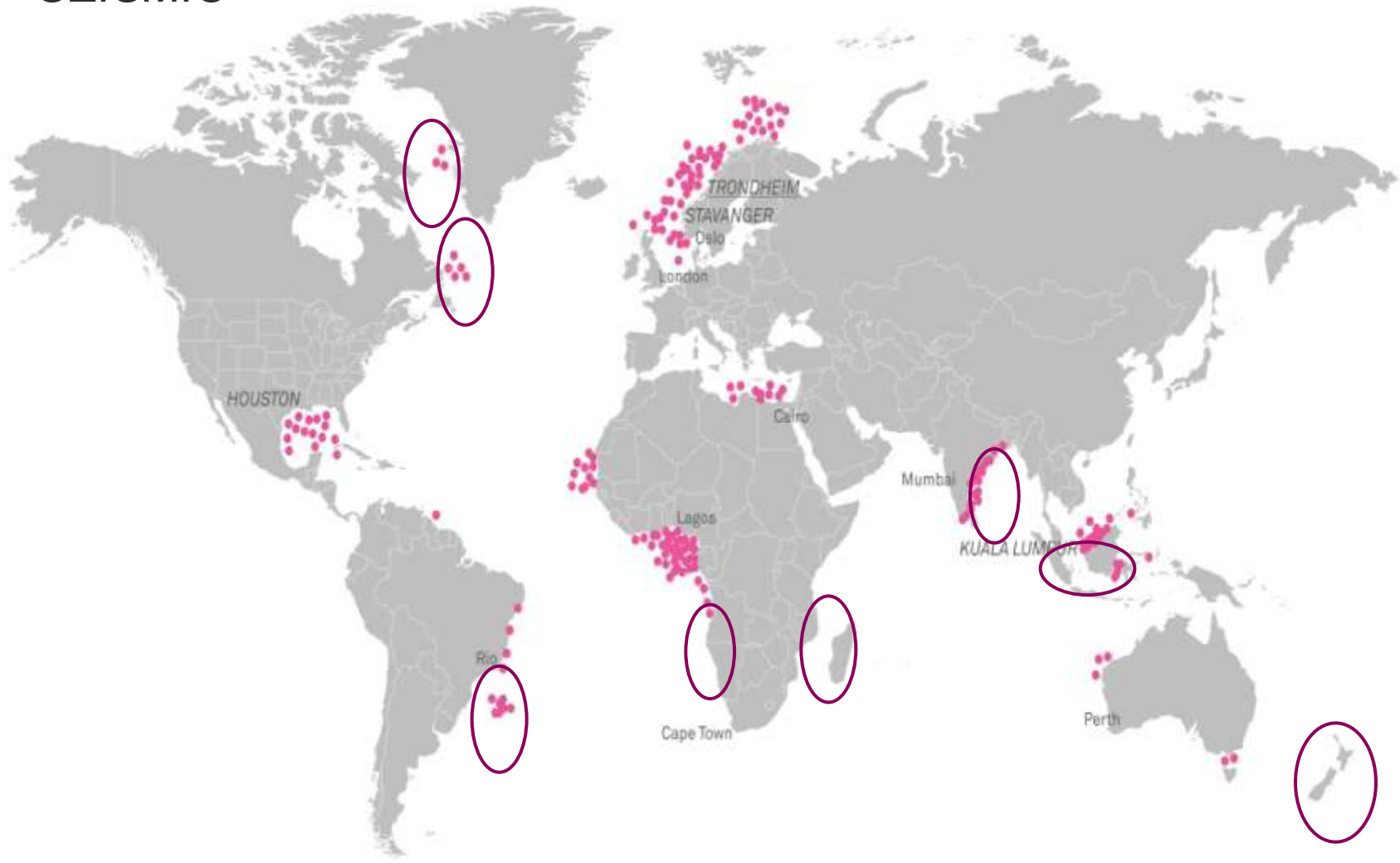
2.5D Anisotropic inversion
SEGY resistivity-depth profiles



3D Anisotropic inversion
SEGY resistivity-depth volumes



LARGE SCALE CSEM ACQUISITION CAN BE DONE AFTER 2D SEISMIC



 Emerging deep water areas



INTEGRATED EM SYSTEM



CONCLUSIONS

- CSEM has been used extensively for hydrocarbon exploration in deep water areas
 - ***Depth range 44 – 3392 m***
- CSEM has been "calibrated" with 86 wells.
 - ***Higher exploration success in all regions***
- 3D CSEM grids can be acquired efficiently in large deep water areas
 - ***Before or after 3D seismic***
- Currently large multi client campaign in the Barents Sea
 - ***Same strategy can be used to explore emerging deep water areas***

