Outline

• Challenges to exploration performance and value creation
• Impact of CSEM in exploration uncertainty
• Performance of CSEM in prospect evaluation
• Challenges to the application of CSEM and value realization
Value of exploration

\[ V_{\text{exp}} = NPV_e \, P_e - (1 - P_e) \, C_{\text{exp}} \]

- **Gains term**
- **Losses term**

**Vexp** is Value of Exploration  
**NPVe** is the average Net Present Value of an economic success  
**Pe** is the probability of an economic success  
**Cexp** is the Cost of Exploration

• Pe is the main Value of Exploration driver
Evaluation workflow

UNCERTAINTY ↔ Pe

Volume estimation

Area
Net thickness
Porosity
Saturation
Rf
FVF

PoS

Trap
Reservoir
Charge
Seal

Pe
A better exploration outcome

Typical exploration failures: most failures are due to the fluid component
PORTFOLIO VS PROSPECT

**Prediction Performance**

Gulf of Mexico, Amplitude Supported Plays

- Prediction capability limited on an individual prospect basis
- Large fields have been systematically under predicted (Mars Basin)
- Small fields have been systematically over predicted (creaming effect)
VOLUME ESTIMATION UNCERTAINTY

RV = NRV Φ Shc Rf / FVF

The net rock volume is the main source of recoverable volume uncertainty.
Decision making under uncertainty

Pe ~ 5-50%

Can EM do something to improve this?

Area
Net thickness
Porosity
Saturation
Rf
FVF

Volume estimation

Trap
Reservoir
Charge
Seal

PoS

Pe
3D EM TECHNOLOGY

What EM does:
Image subsurface resistivity

Acquisition
Water depth
20 – 3500m

CSEM Measurement
Sensitivity
0 – 3500m
CSEM SENSITIVITY FOR A SPECIFIC TARGET

The larger the resistive body, the larger the EM signal.
Decision making under uncertainty

- Trap
- Reservoir
- Charge
- Seal

CSEM result

Integration with seismic & well log data
CSEM sensitivity
Rock property uncertainties
CSEM uncertainties

Area
- Net thickness
- Porosity
- Saturation
- Rf
- FVF

Volume estimation

PoS

Pe
Barents Sea example

Courtesy: Det Norske
Volume prediction with CSEM

- Prediction capability limited on an individual prospect basis
- Large fields have been systematically under predicted (Mars Basin)
- Small fields have been systematically over predicted (creaming effect)

Do we need exploration to optimize EP portfolios? IQPC Portfolio Optimization in Oil and Gas, Houston, TX, February 2004.

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Exploration Portfolio before 3D CSEM

Note: only CSEM feasible prospects included in this portfolio
Exploration portfolio after 3D CSEM

Note: only CSEM feasible prospects included in this portfolio
Exploration portfolio after 3D CSEM

Note: only CSEM feasible prospects included in this portfolio
Exploration portfolio after 3D CSEM

Note: only CSEM feasible prospects included in this portfolio
Portfolio before and after 3D EM

- 14 wells drilled
- 1 economic success
- 3 mid-sized discoveries
- 10 dry wells / technical success
- Pe no EM = 7%
- Pe with EM = 33 %
Decision making under uncertainty

Pe ~ 5-50%

Can EM do something to improve this?

Yes, evidence from Brazil, Mexico, and the Barents Sea prove this is the case.
Challenges to CSEM adoption and application

- Data
  - Information
    - Evaluation
      - Decision

- Workflows
  - Interpreters

2002
2008
2012
Conclusion

- Pe is the main Value of Exploration driver

- Fluid presence and net rock volume evaluation uncertainties prevent Pe improvement

- Resistivity derived from CSEM allows for a significant reduction of the main uncertainties and increase of Pe

- Needs to be adopted systematically
  - Workflows must be adapted
  - Interpreters have to be trained

- The exploration workflow will need to change to adapt to the new tool

- EMGS offers an integral CSEM solution for hydrocarbon exploration