CSEM Ranking of Transform Margin Prospects*

Friedrich Roth[1], Lodve Berre[1], Stein Fanavoll[1], and Charles Thomas[1]

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[1]EMGS, Trondheim, Norway (lb@emgs.com)

Abstract

The Transform Margin play is a prolific HC play explored along the equatorial margins of Africa and South America. Significant discoveries include Jubilee (Ghana) and Liza (Guyana). The play consists of Late Cretaceous deep-water slope and basin floor channels and fans with structural/stratigraphic trapping. While prospects are typically well mapped with seismic and commonly exhibit seismic DHI's, their stratigraphic nature implies high risk and commercial drilling success rate has been declining recently, e.g. Fatala (Guinea). The highest risks typically are seal integrity and charge. De-risking with seismic DHI's is notoriously difficult due to the strong response from low saturation HC. As exemplified by the successful CSEM track record in Norway for both structural and stratigraphic plays, integration of resistivity from CSEM with seismic can de-risk seal and charge by distinguishing high from low saturation HC. Moreover, CSEM can reduce uncertainty in the prospect resources. Hence CSEM is a very valuable tool for de-risking AVO and seismic amplitude driven prospects, particularly in deep water where only large volumes are commercial. Existing CSEM data at the West African equatorial margin dates from the early years of commercializing CSEM technology (2002-2007). While some of these data proved the capability of CSEM to de-risk stratigraphic prospects (e.g. Fortuna in Eq. Guinea), the legacy data mostly failed to be of value due to immature products: the lack of imaging and non-existence of workflows to embed CSEM in prospect evaluation. These early shortcomings have now been overcome by tremendous technological advances and experience building from worldwide CSEM application. To illustrate the ability of modern CSEM to increase exploration performance for the Transform Margin play, we studied a drilling commitment for a hypothetical portfolio of four prospects in deep water Guinea. The setting is an analog to the Fatala prospect with high resource potential but significant uncertainty. We model the impact of CSEM information on the PoS and volume distribution of each prospect. Due to excellent CSEM sensitivity to the Late Cretaceous, only small volumes are undetectable

and thus a prospect without a resistive anomaly has very low probability of commercial success (Pc). We then simulate a drilling candidate selection and show that by downgrading prospects without a resistive anomaly the Pc of the first well is at least as high as drilling two wells without CSEM.

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CSEM Ranking of Transform Margin Prospects

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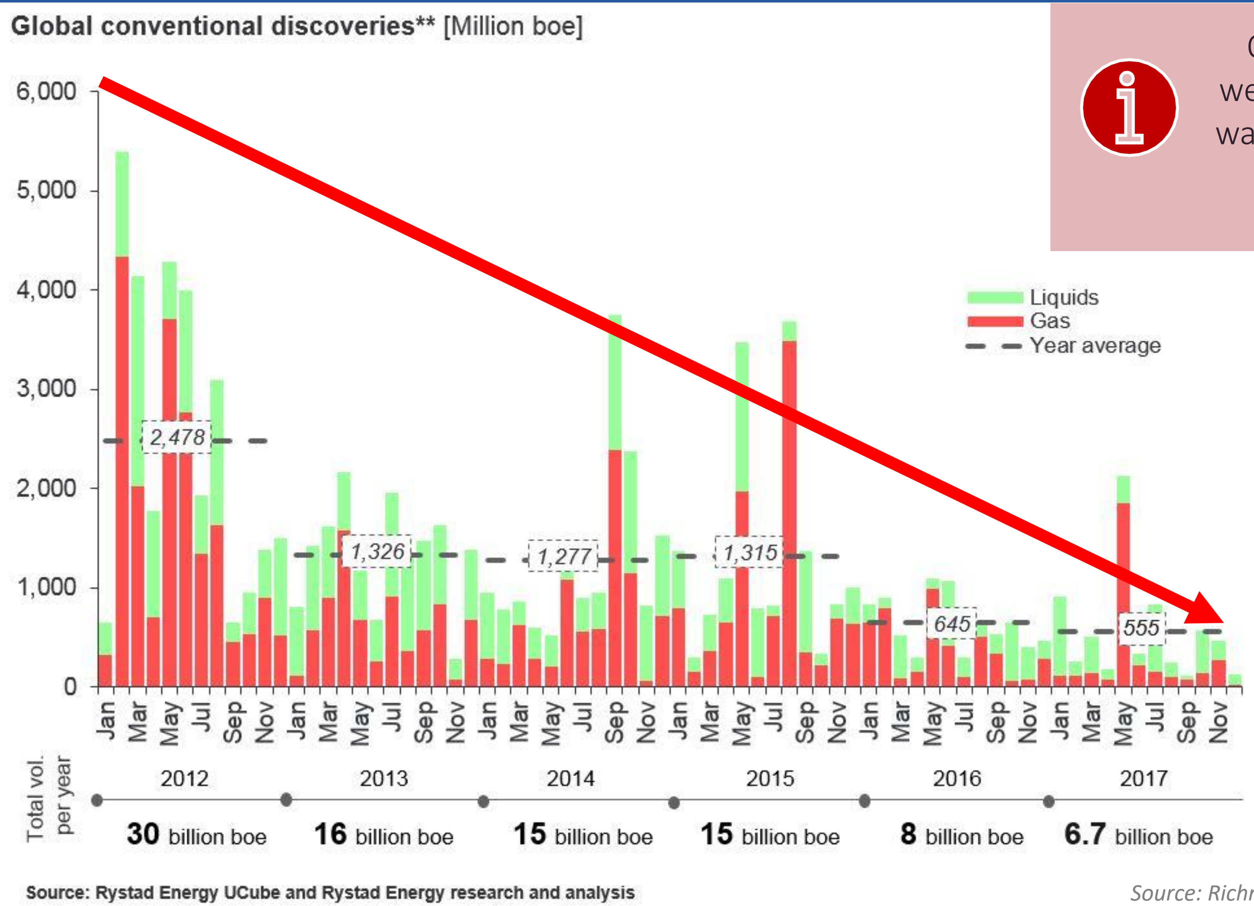
[1] EMGS, [2] Presenter

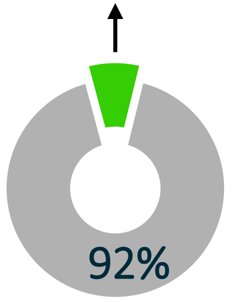
Outline

- Problem: Lack of exploration success on the Atlantic Transform Margin
- Reason: Seal and charge failure
- Solution: CSEM provides information on seal and charge
- Norwegian CSEM track record
- CSEM experience in Africa to date
- Guinea Synthetic Exploration Example

Exploration Success Rate is LOW



Only 8% of 110 frontier wells in the Atlantic Margin was considered commerical (from 2007-2015)

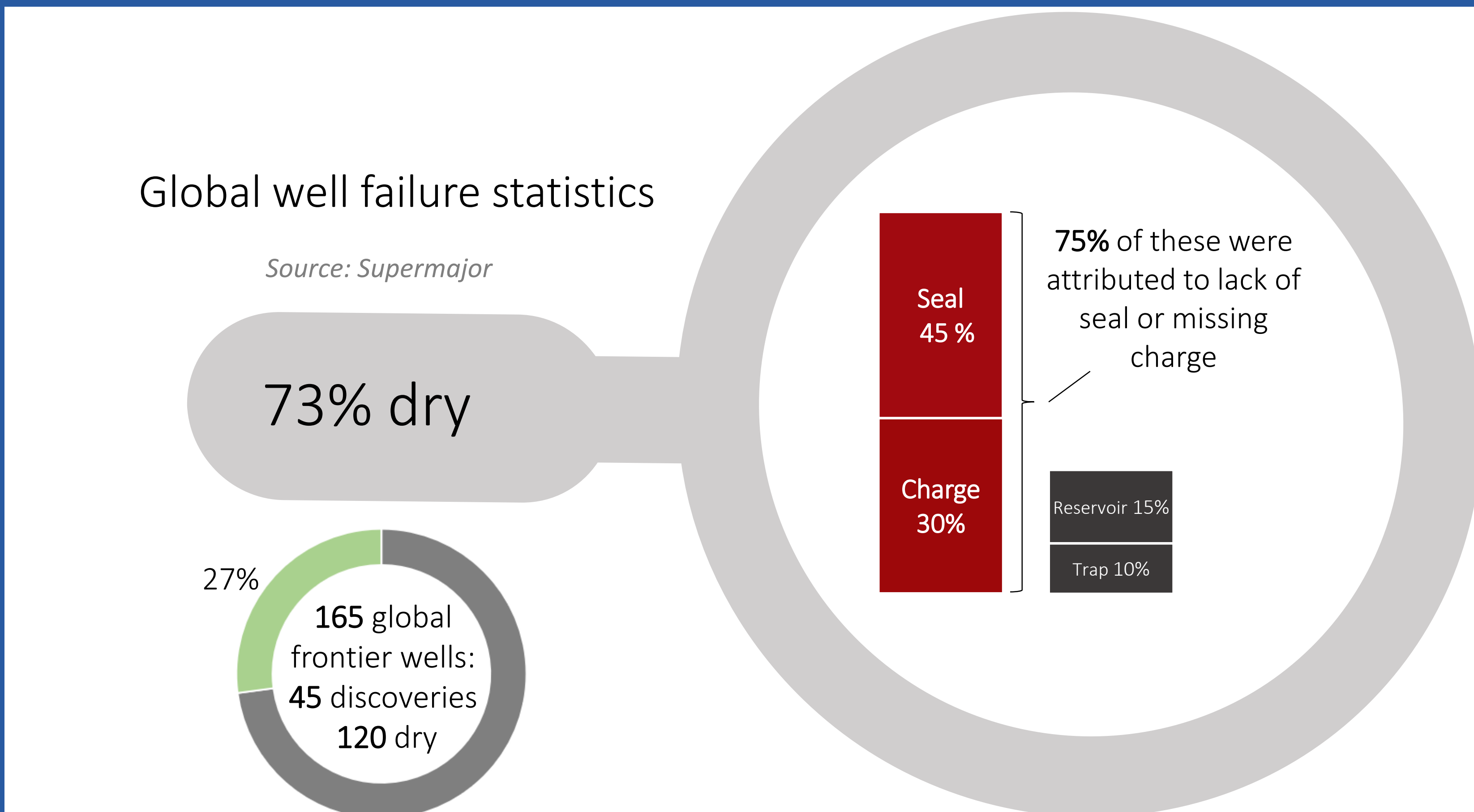


were non-commercial or dry

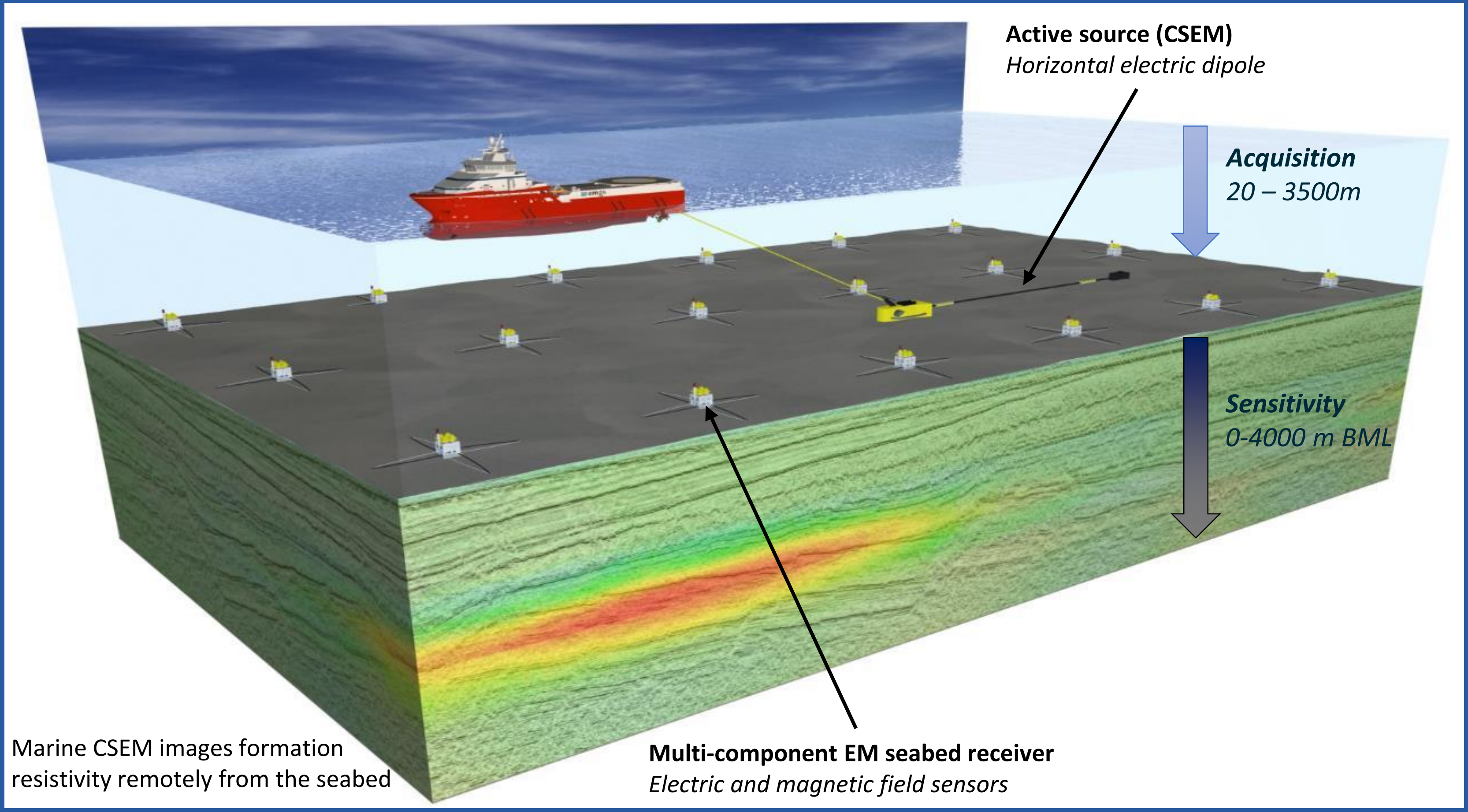
Atlantic margin

Source: Richmond Energy Partners / Westwood Group

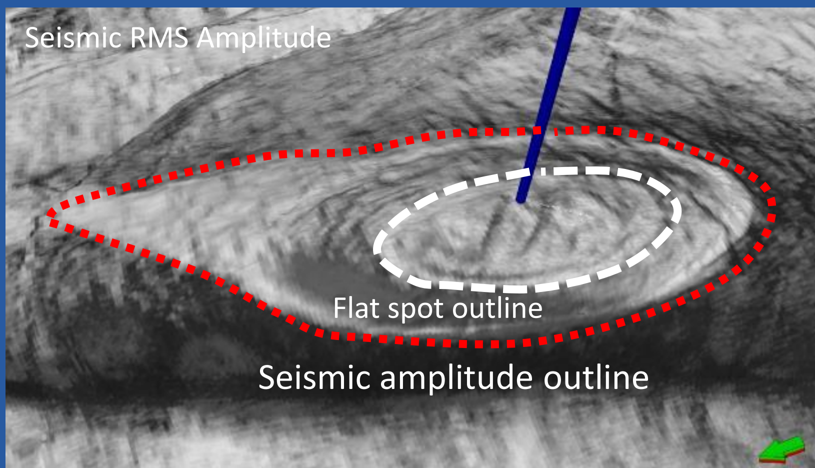
Why Is The Success Rate Low?

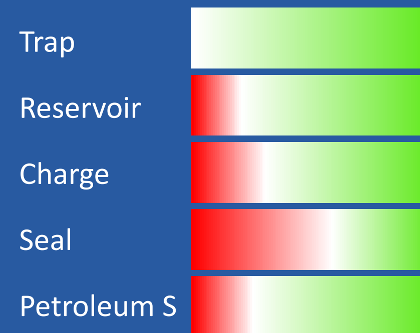


Marine 3D CSEM In A Nutshell



CSEM Sensitive to Seal & Charge





Source: Alcocer et al., 2013-04, First Break vol. 31

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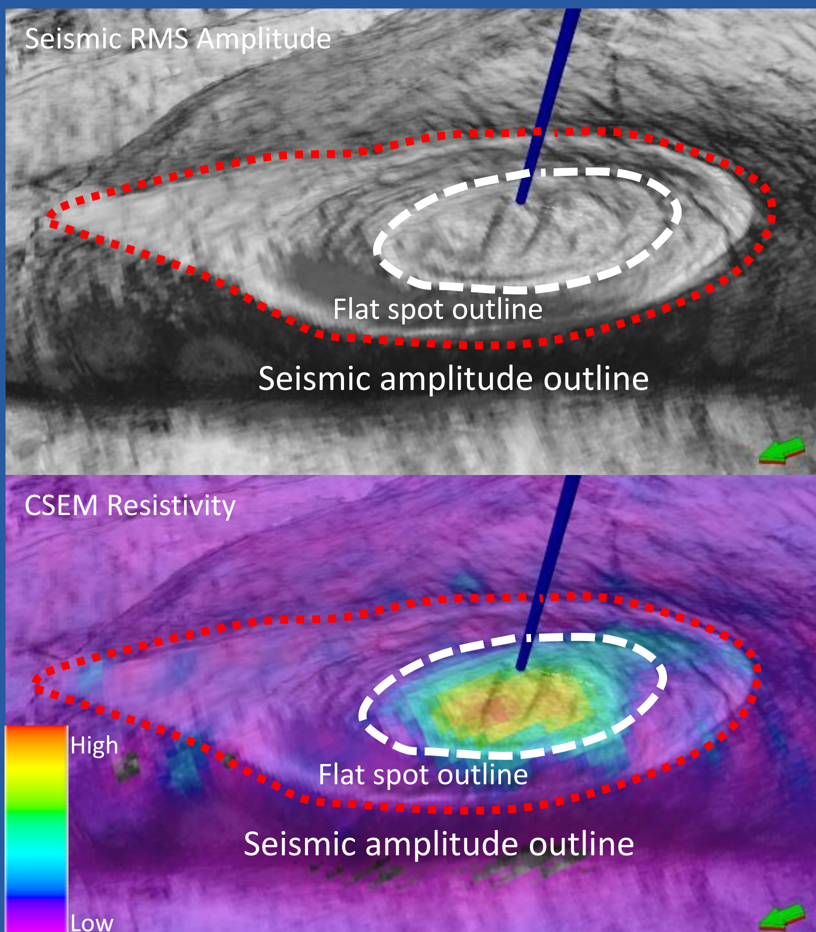

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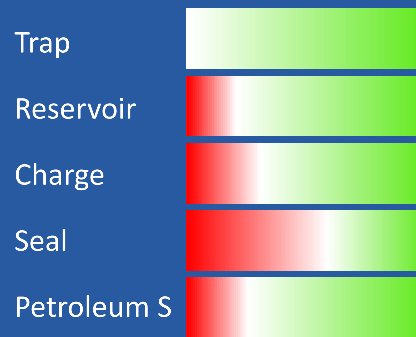

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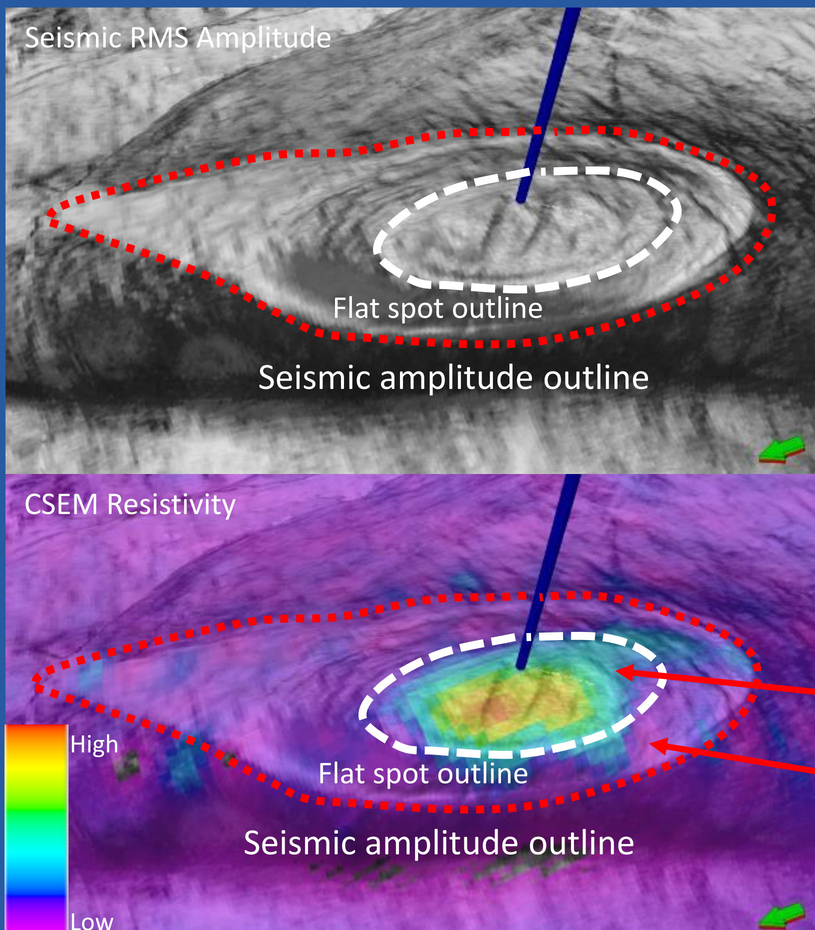
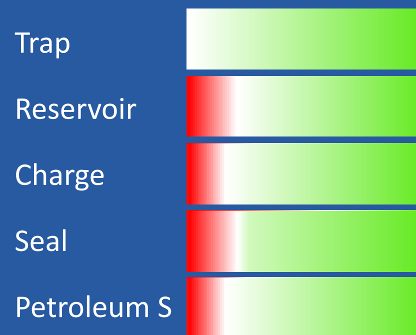
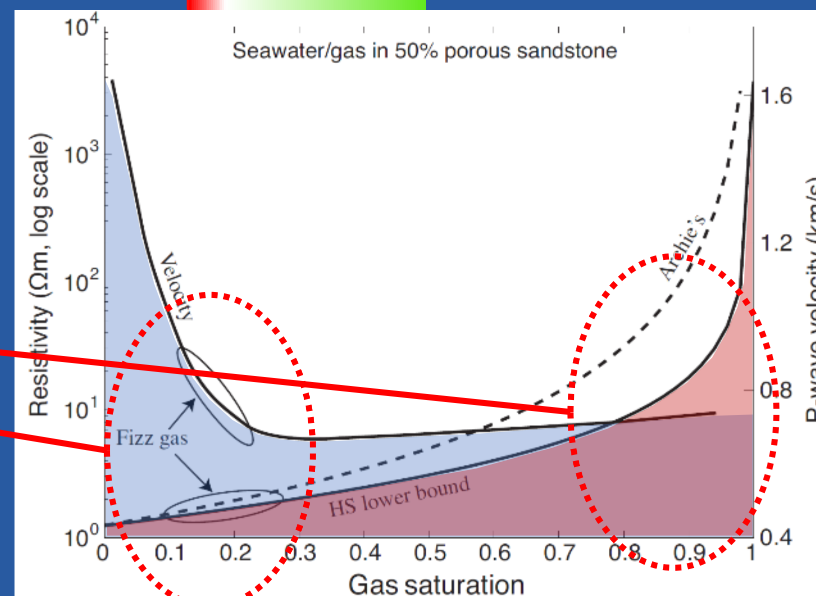
CSEM Sensitive to Seal & Charge







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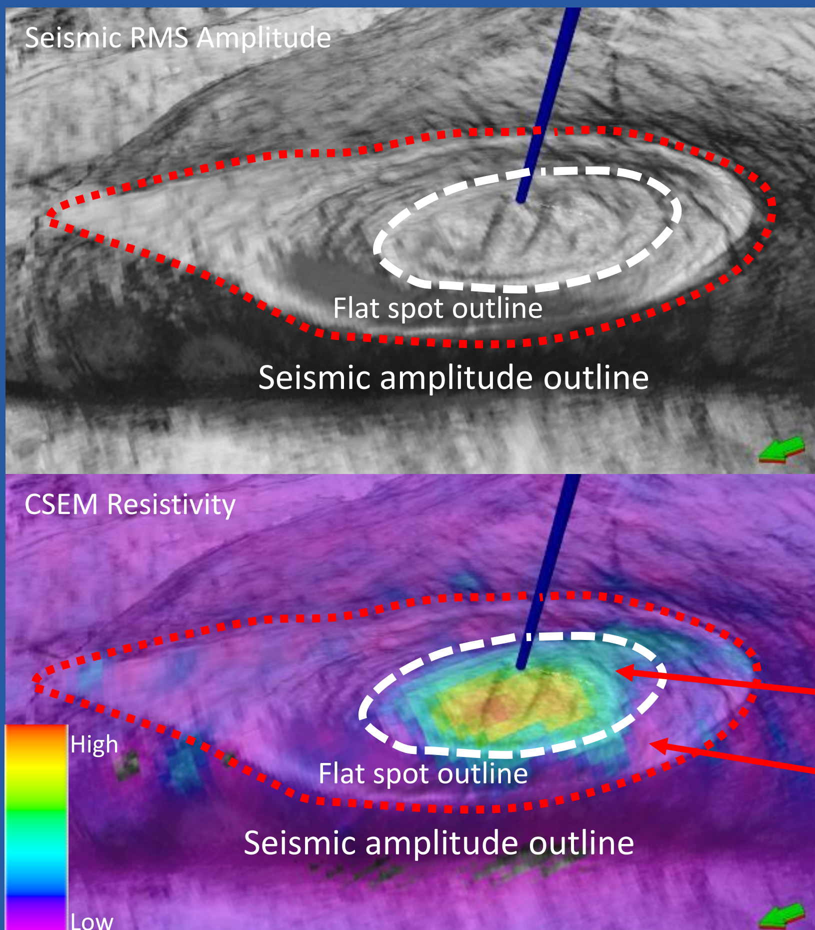
Source: Constable, 2010, Geophysics

CSEM Sensitive to Seal & Charge



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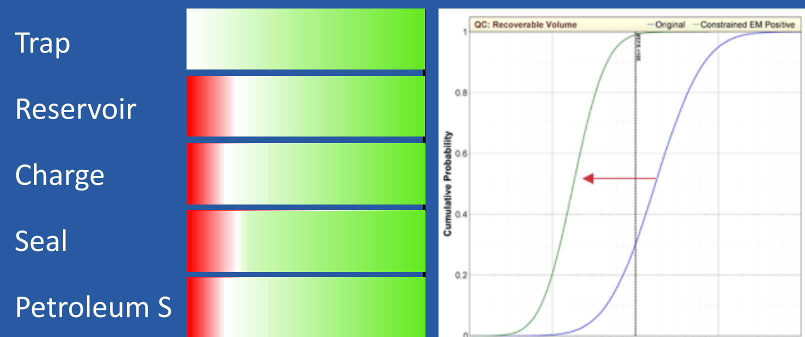

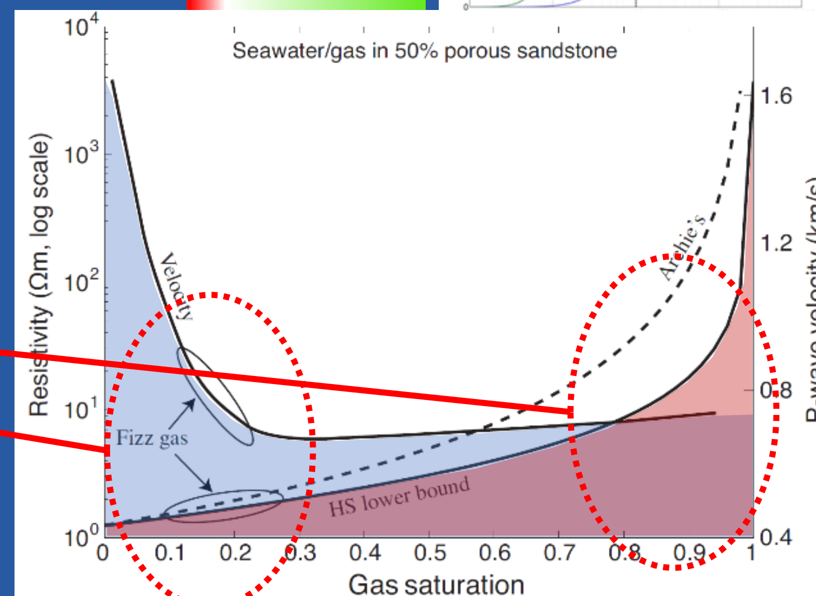

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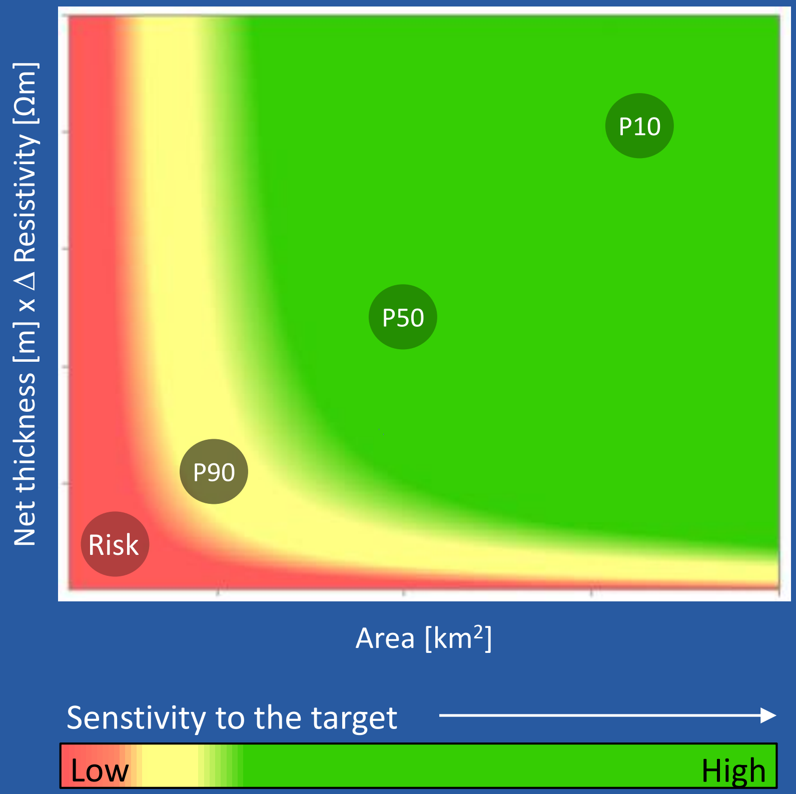
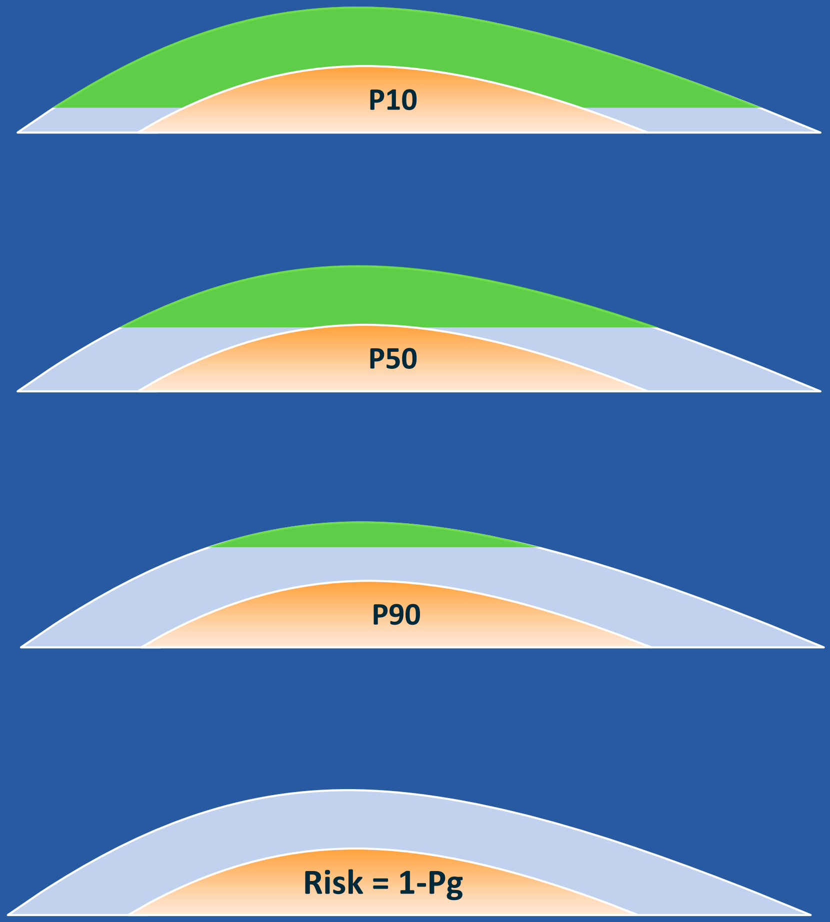
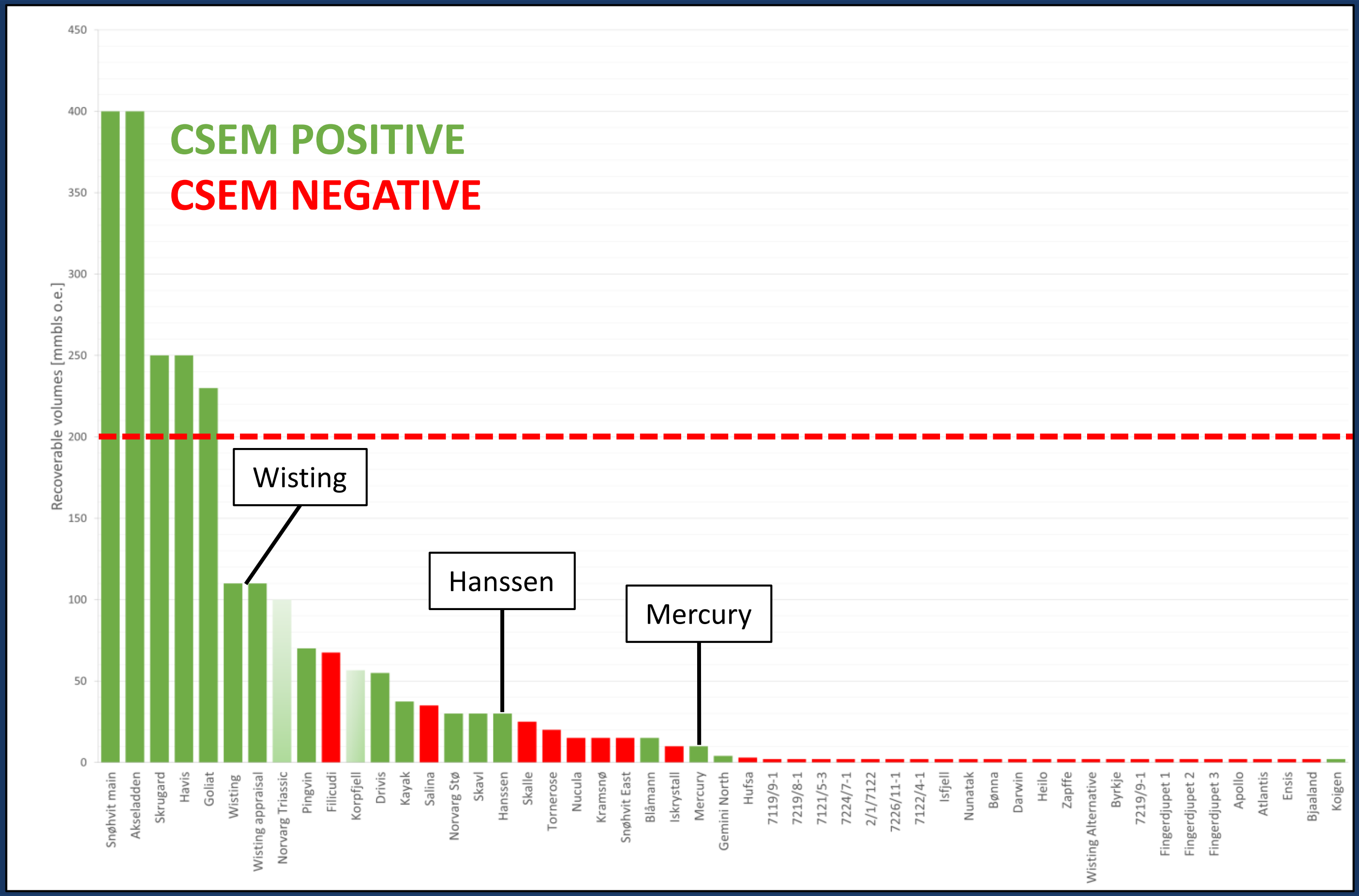
CSEM In Exploration Perspective





Prediction Strength – Norway



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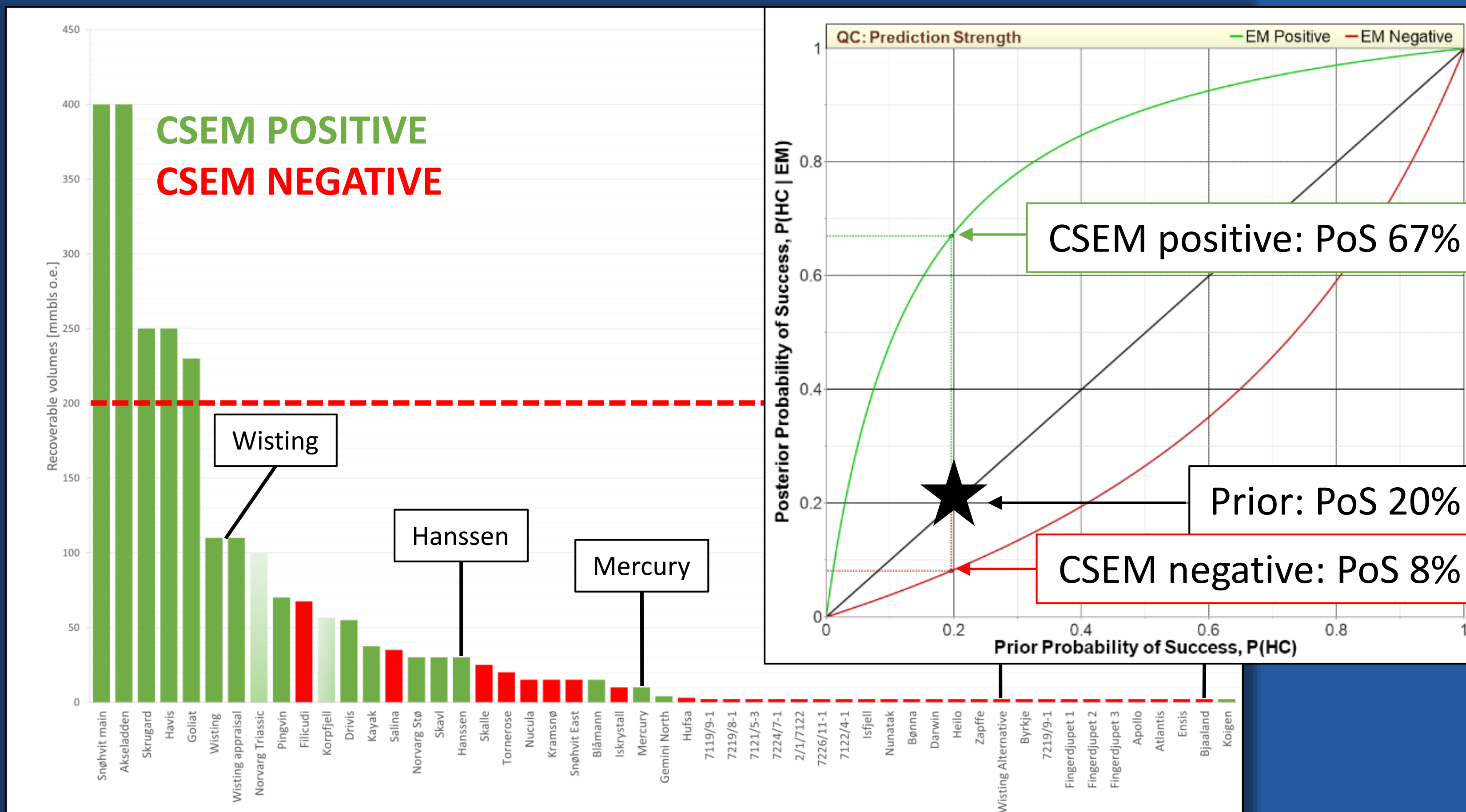

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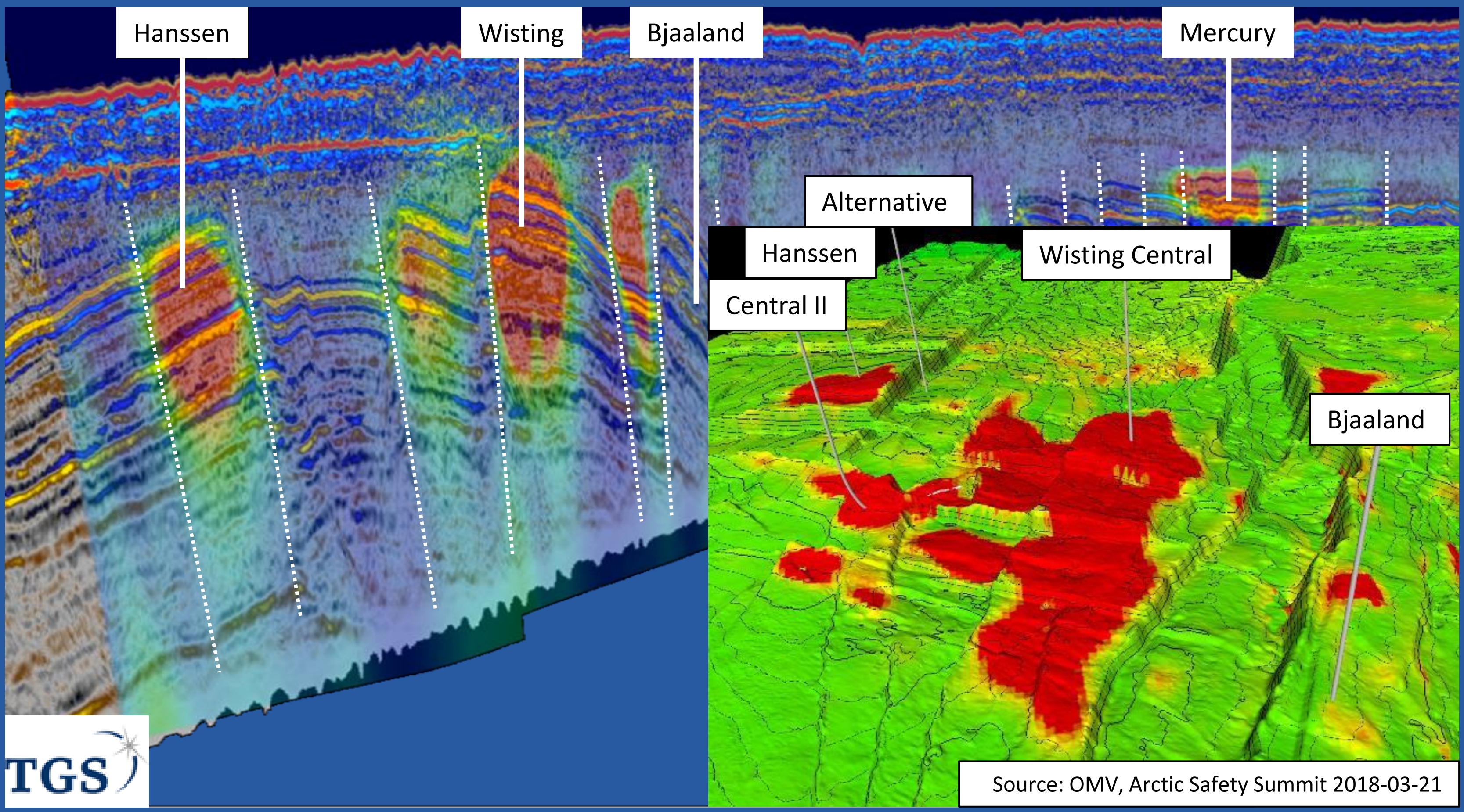
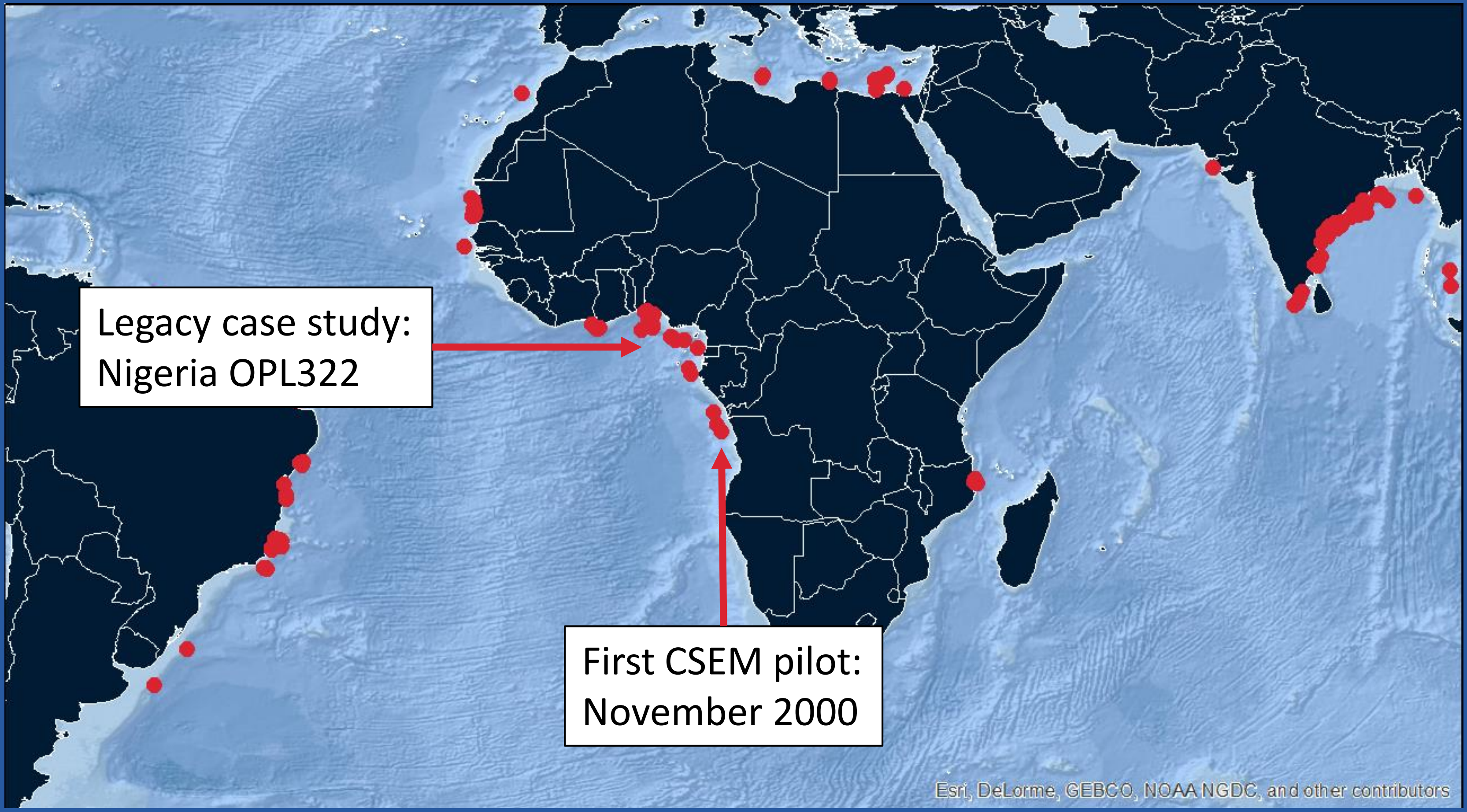
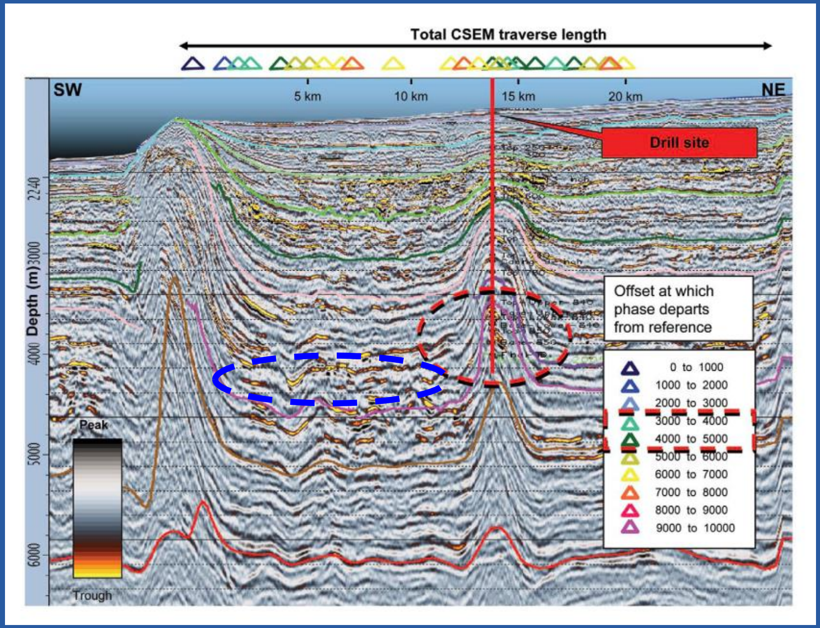


CSEM Experience In Africa To Date



CSEM Experience In Africa To Date

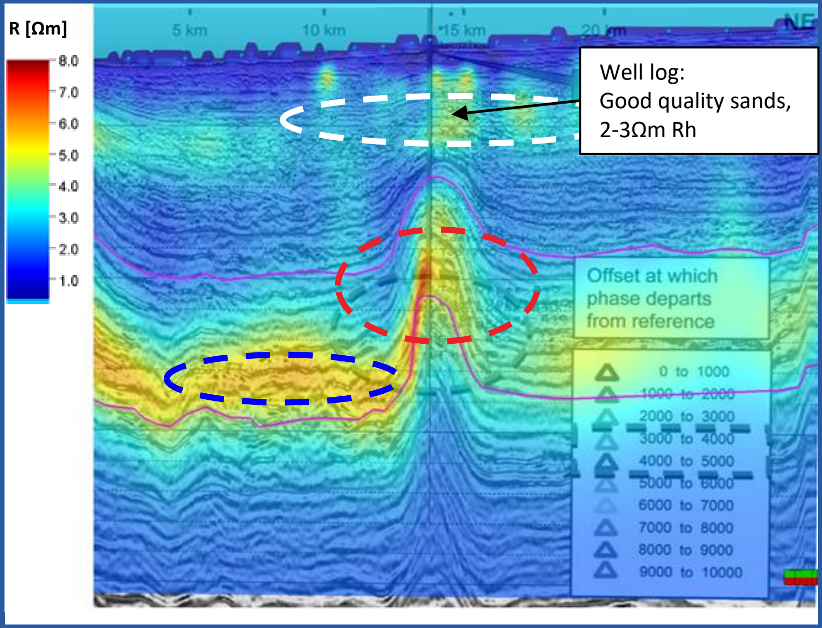
2006 Attribute Analysis



Source: Moser et al, The Leading Edge (2006-08) Pp. 977-982

2006 attribute analysis correctly predicted discovery at crest of structure.

2018 Unconstrained Inversion

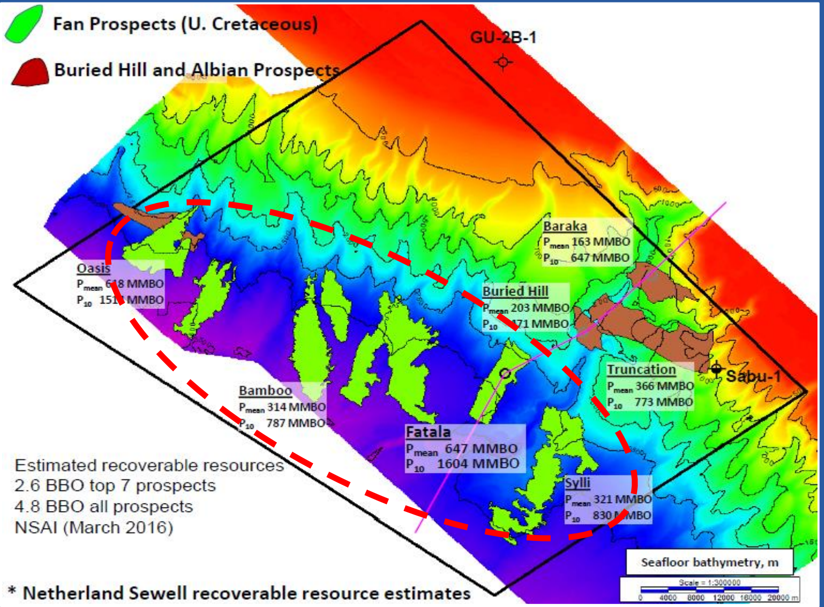


CSEM Courtesy of HARVEX

2018 inversion identifies discovery at crest of structure and potential upside down-dip.

Portfolio Modelling Example

- 1 well drilling campaign
- Target: Upper Cretaceous turbidite fan play
- 4 prospect portfolio
- Volumes:
  - P10 & PMean from public information
  - P90 from Swanson's rule
  - Lognormal volume distribution
- MEFS = 200 MMbbl
- PoS: 28% for all prospects
- Pe: 19% for Fatala
- CSEM false positive risk: 20%

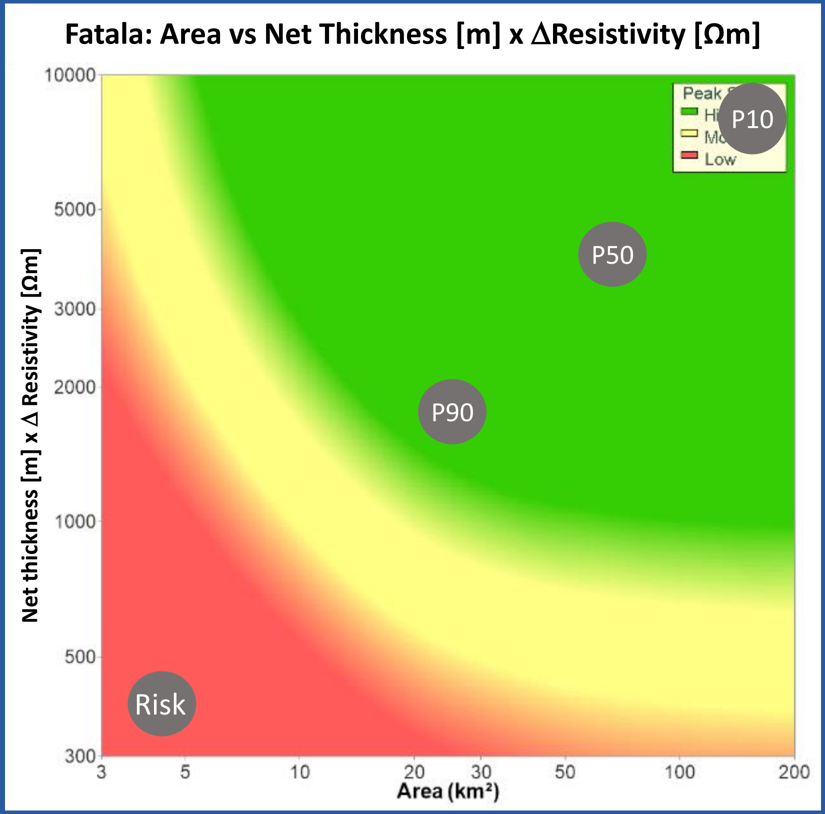


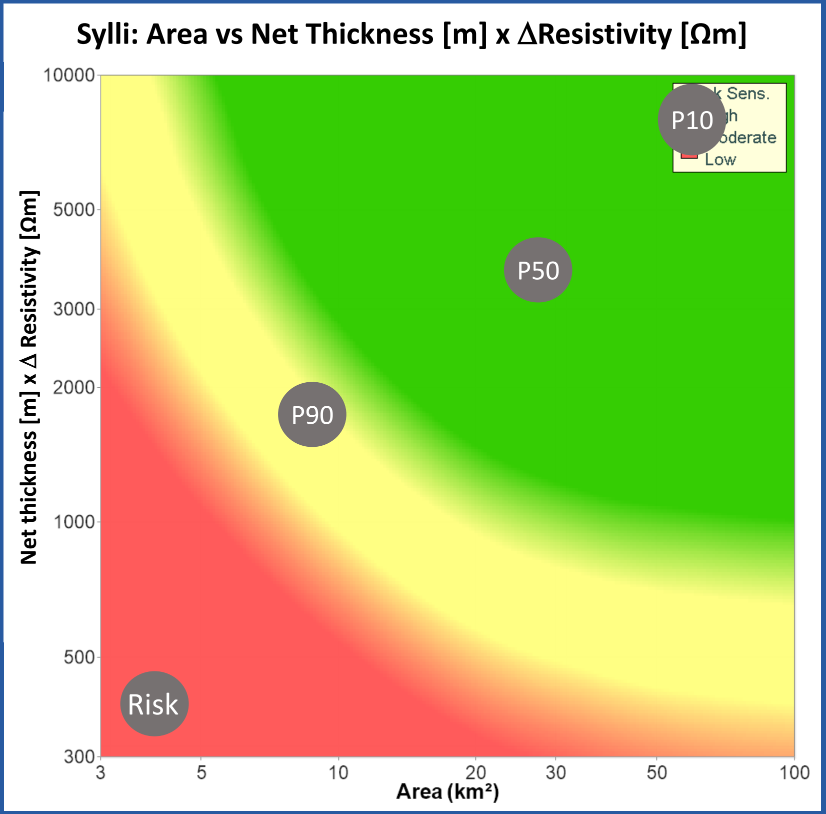
Seismically derived ranking based on volumes

	Pmean	P10	PoS	Pe
Fatala	647 MMBO	1604 MMBO	28%	19%
Oasis	618 MMBO	1514 MMBO	28%	19%
Sylli	321 MMBO	830 MMBO	28%	13%
Bamboo	314 MMBO	787 MMBO	28%	12%

Source: Hyperdynamics, Oil Capital Conference, London 2016-09-21

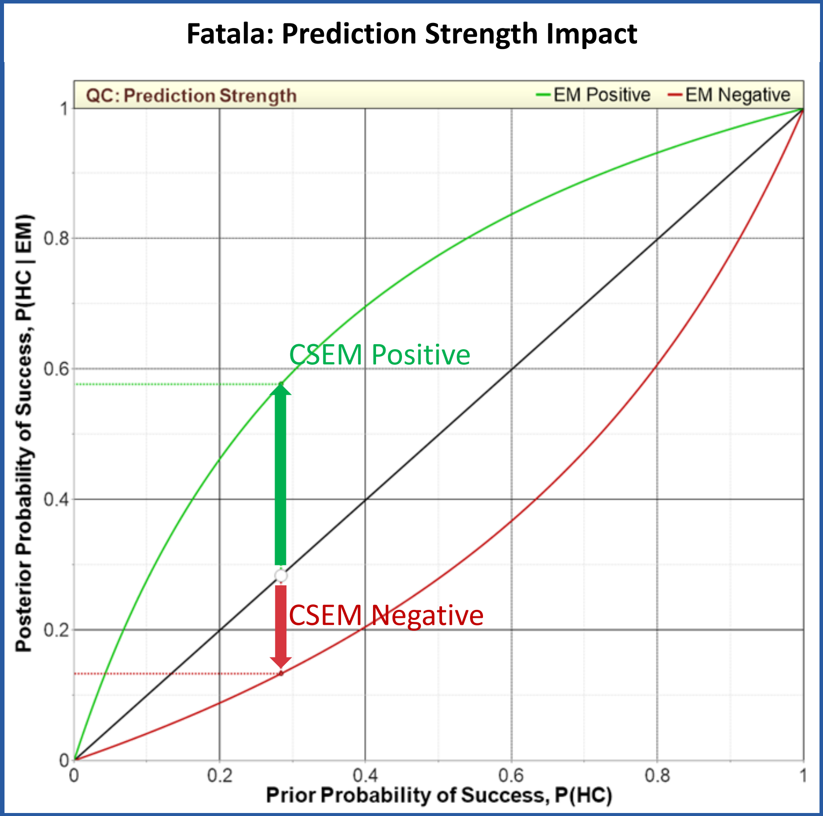
Portfolio Modelling Example

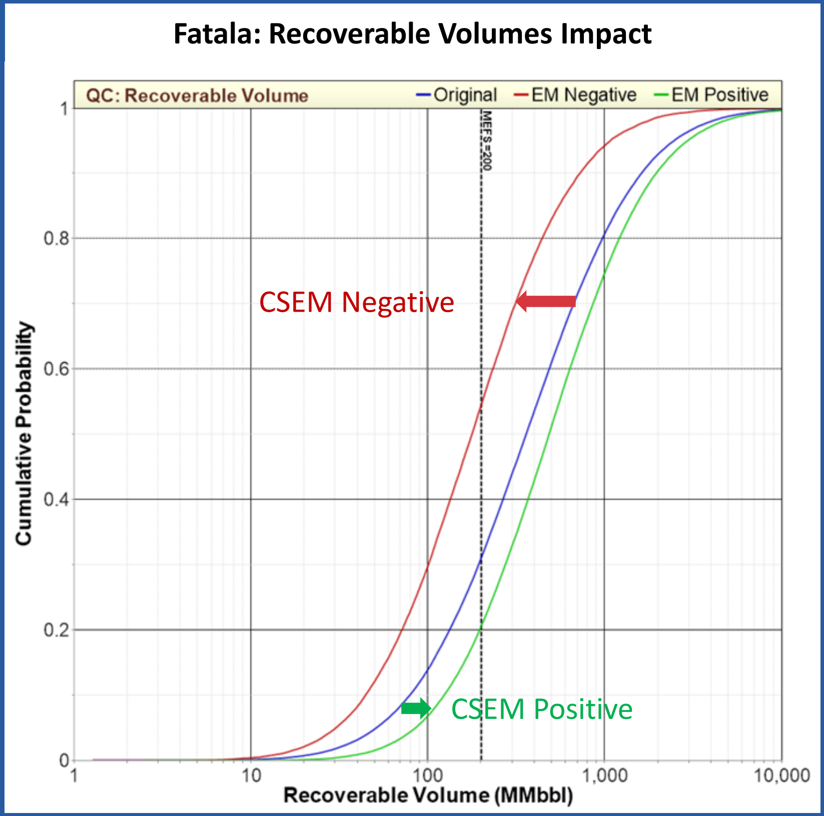




Technical Reference: Baltar, D. and N. Barker, [2015], Prospectivity Evaluation with CSEM, First Break 33(9), 33-41.

Portfolio Modelling Example





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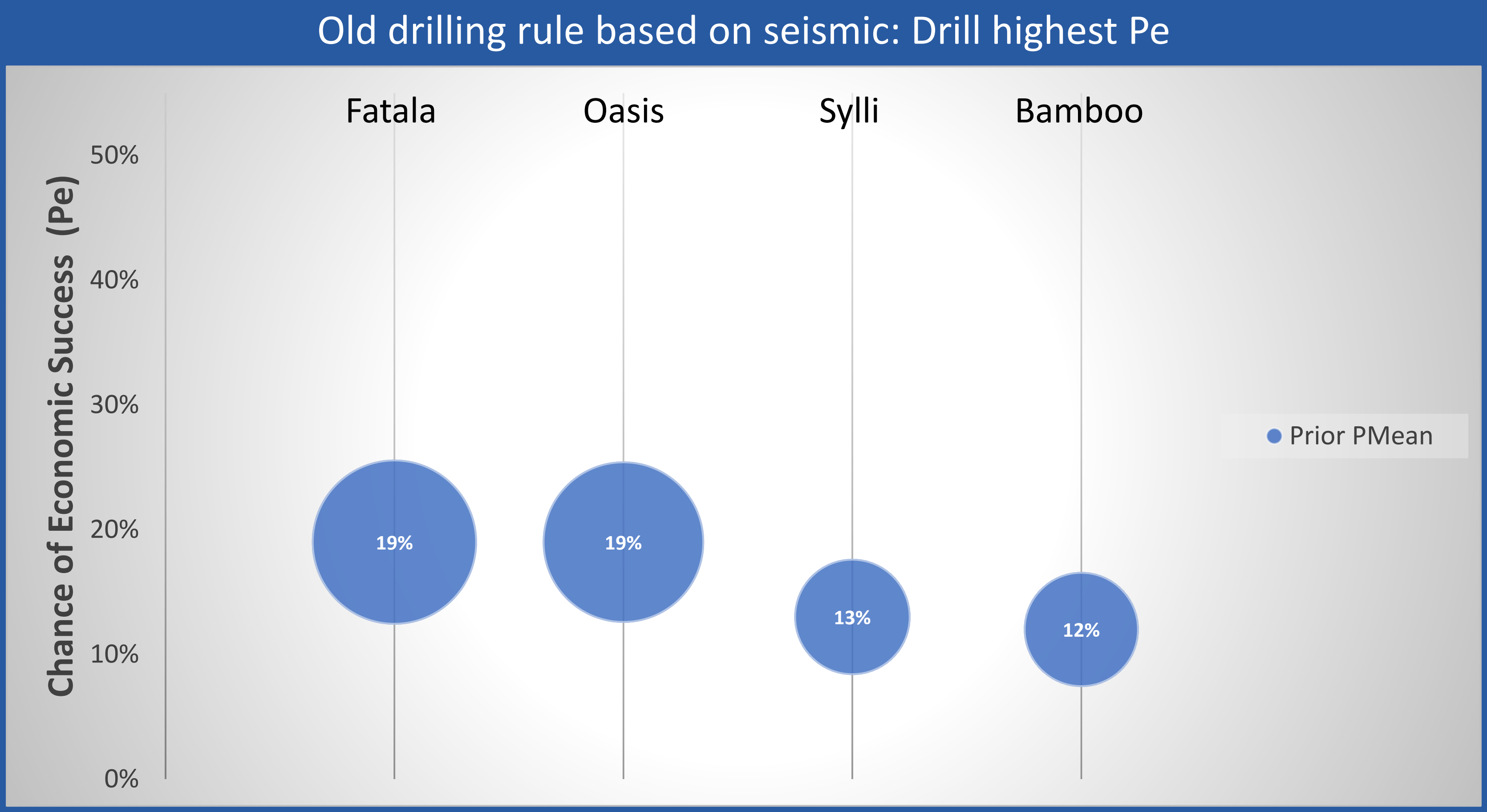
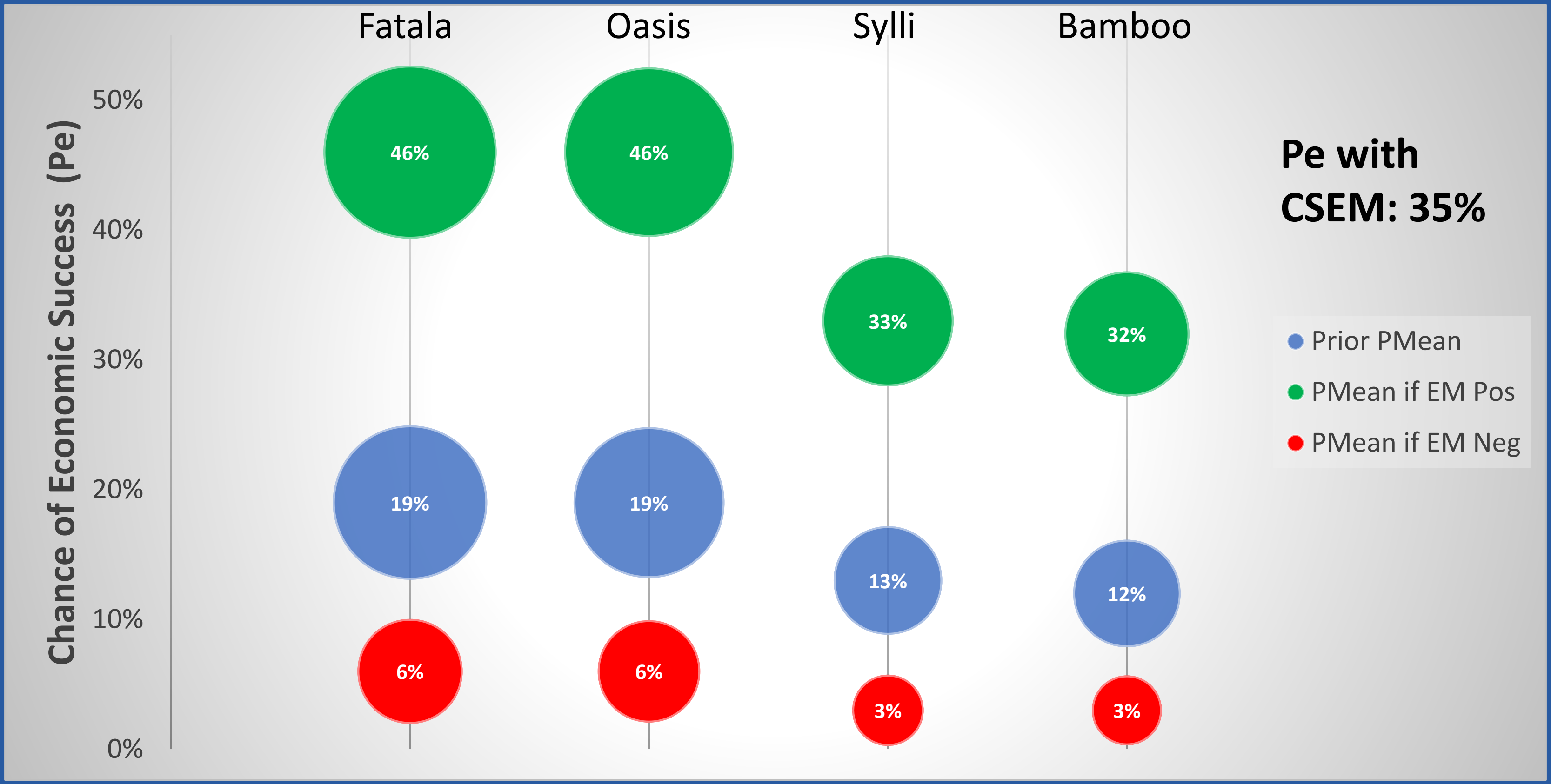


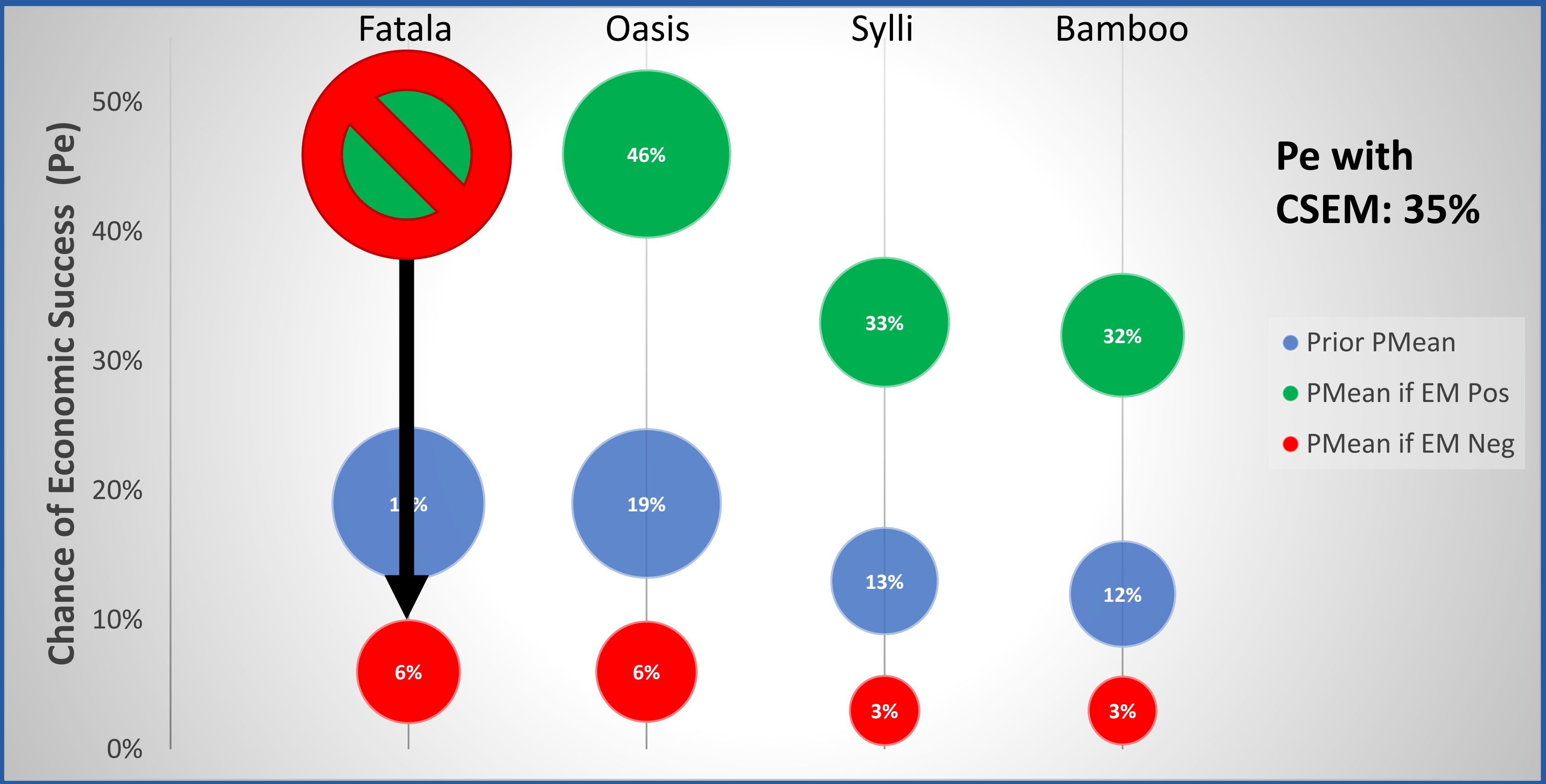
Portfolio Modelling Example

New drilling rule: Drill highest Pe from CSEM



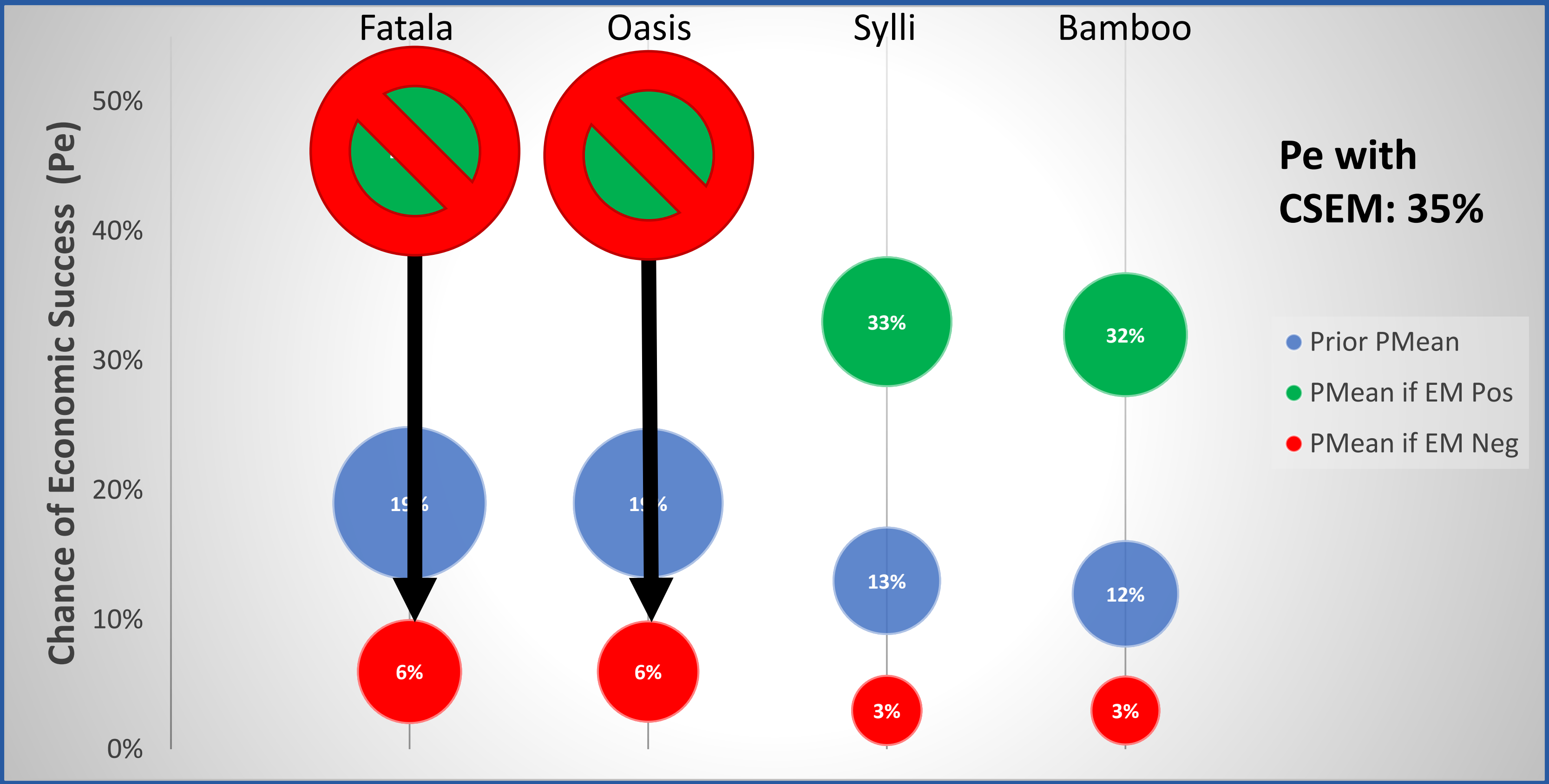
Portfolio Modelling Example

If Fatala is CSEM negative, Pe drops to 6% – drill Oasis instead



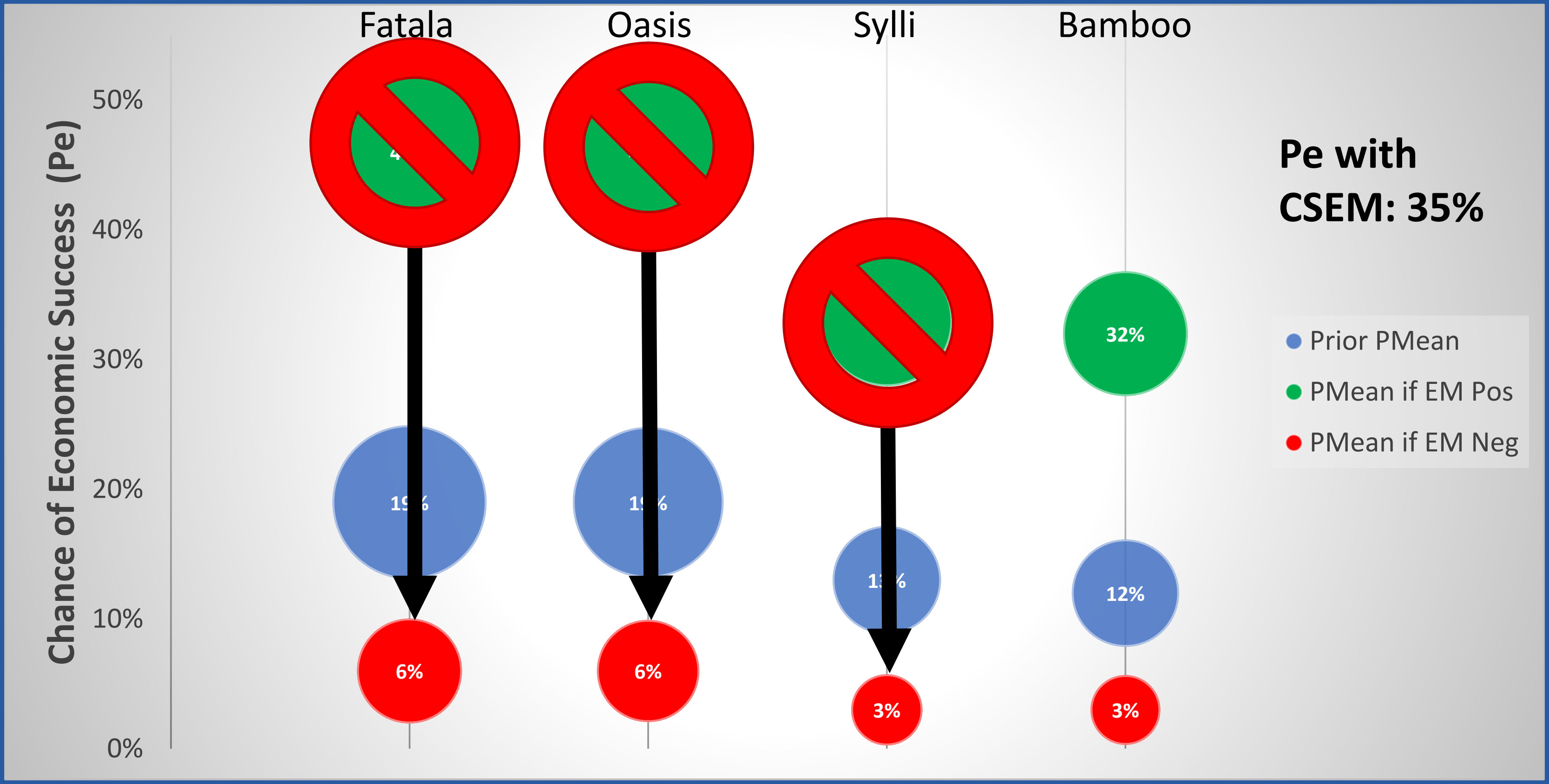
Portfolio Modelling Example

If Oasis is CSEM negative, Pe drops to 6% – drill Sylli instead



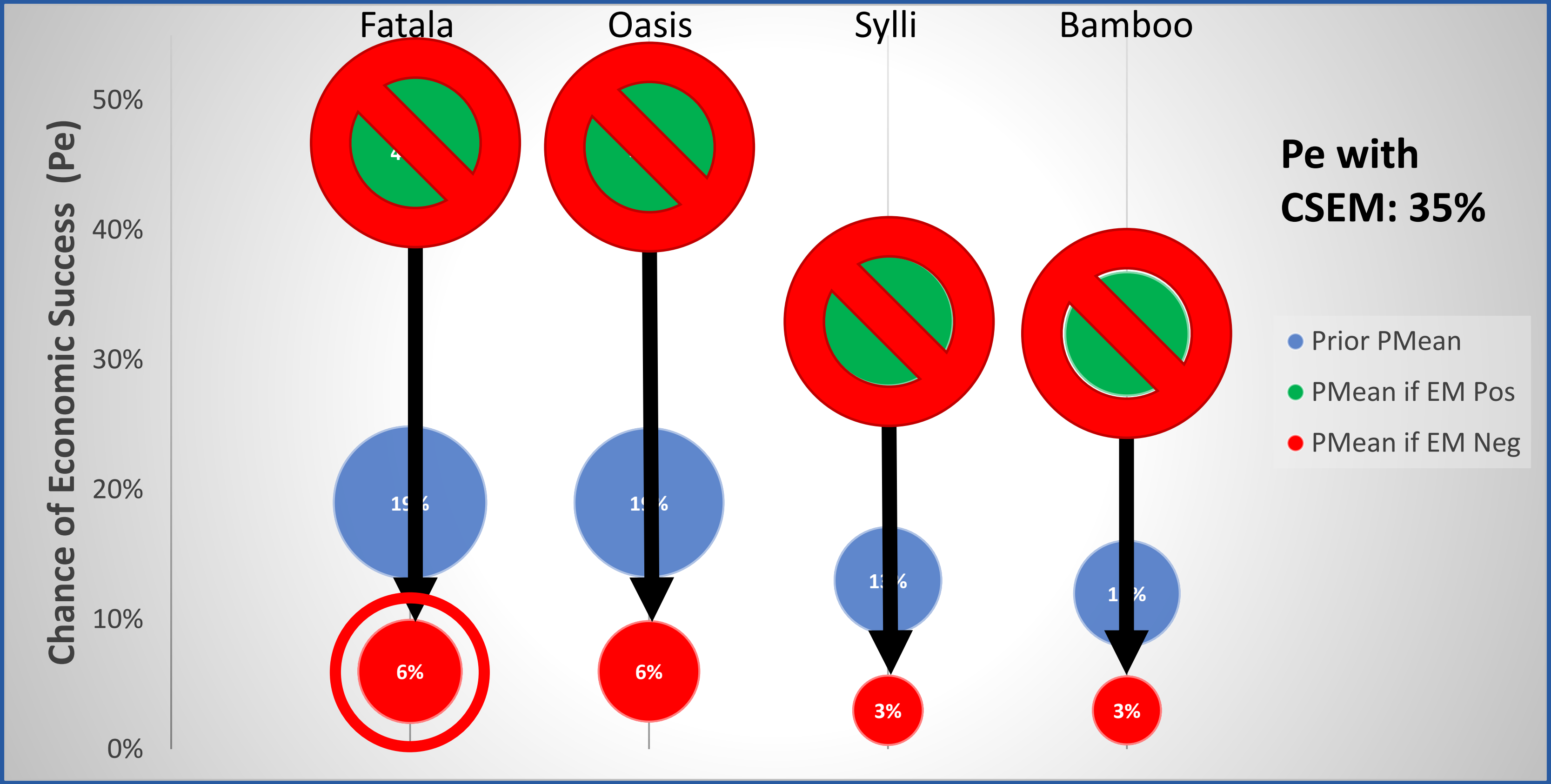
Portfolio Modelling Example

If Sylli is CSEM negative, Pe drops to 3% – drill Bamboo instead



Portfolio Modelling Example

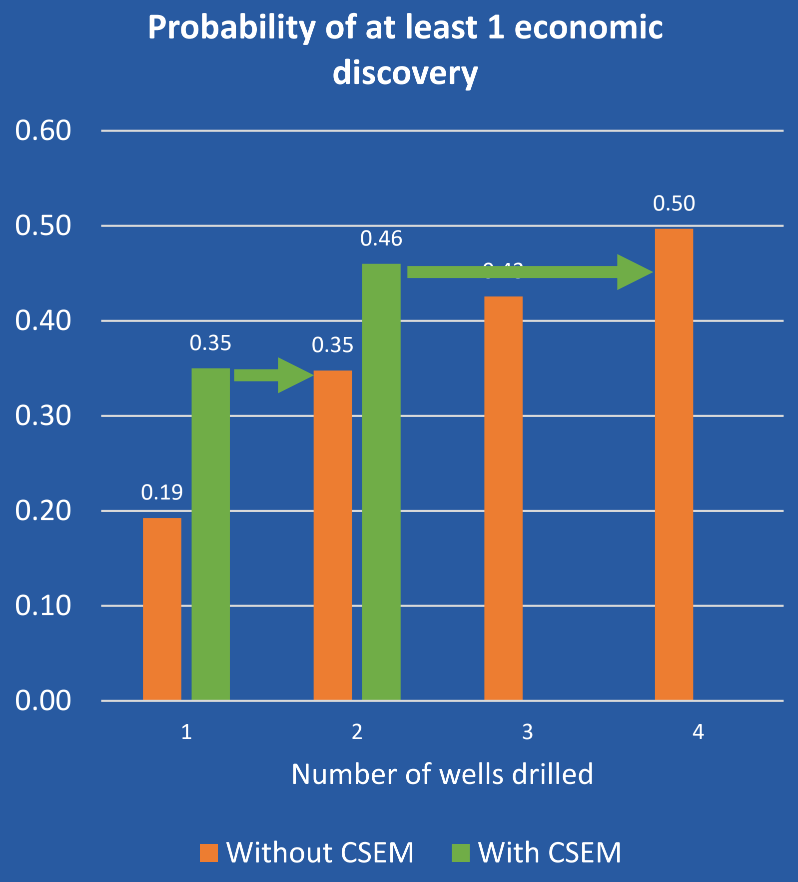
If Bamboo is CSEM negative, Pe drops to 3% – drill Fatala instead…



Portfolio Modelling Example

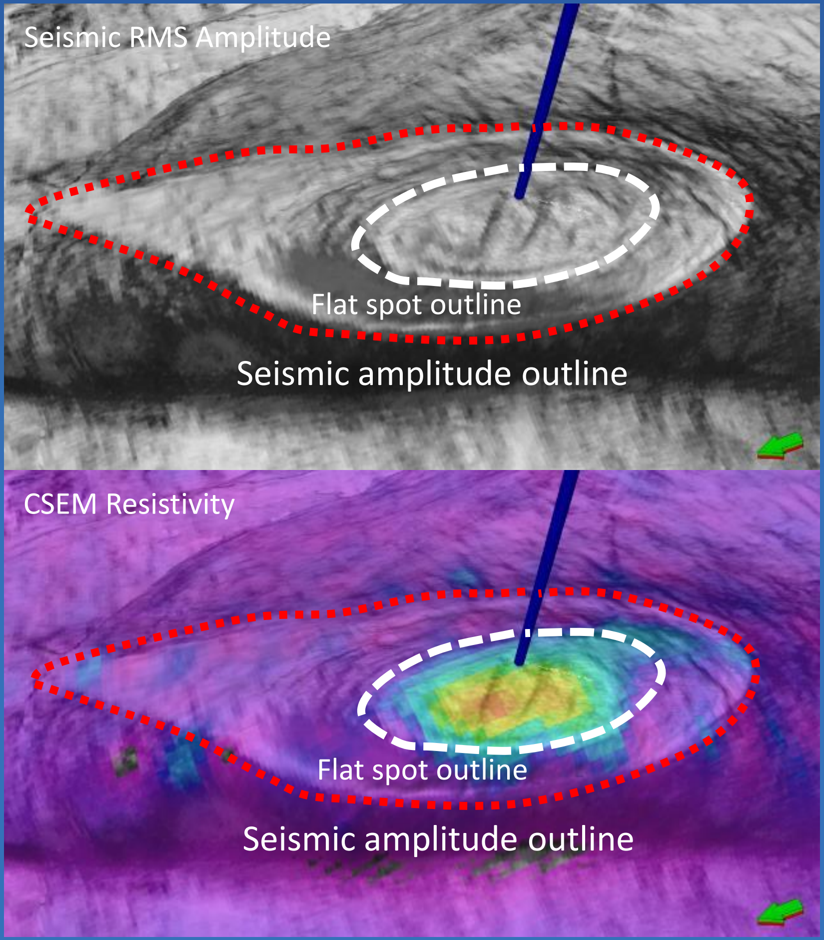
Strong sensitivity to the Upper Cretaceous interval makes the chance of an economic discovery essentially zero with a CSEM negative observation

- ***1 well commitment:***
  - CSEM increases probability of economic discovery (Pe) from 19% to 35% - as good as drilling 2 wells!
  - Expected value of the Upper Cretaceous portfolio doubled
- ***2 well commitment:***
  - CSEM increases Pe from 35% to 46% - almost as good as drilling 4 wells
  - ~1.4x increase in expected value of the Upper Cretaceous portfolio
- Binary CSEM interpretation assumed – performance will increase with EMGS standard intergrated interpretation efforts



Conclusions

- The stratigraphic nature of the Transform Margin play implies high risk
- The highest risks typically are seal integrity and charge
- De-risking with seismic DHI's is notoriously difficult due to the strong response from low saturation hydrocarbons
- CSEM has improved – now is the time to implement in workflows!
- Integrating CSEM with seismic DHIs can de-risk seal and charge by distinguishing between high and low saturations
- Thus CSEM will help rank your prospect portfolio and significantly increase your chance of economic success
- CSEM enables success in the critical early exploration phase



Source: Alcocer et al., 2013-04, First Break vol. 31