[GC]Controlled-Source Electromagnetic (CSEM) Technology Helps Exploration Investment Decisions*

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Search and Discovery Article #41755 (2015)
Posted January 18, 2016

*Adapted from the Geophysical Corner column, prepared by the authors, in AAPG Explorer, November, 2015, and entitled “Additional Data Helps Investment Decisions”. Editor of Geophysical Corner is Satinder Chopra (schopra@arcis.com). Managing Editor of AAPG Explorer is Vern Stefanic.

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General Statement

The often-volatile outcome of exploration investment decisions is tightly linked to the level of uncertainty in the geological interpretation and associated value assessment. In order to evaluate subsurface opportunities, information is needed. This comes at a cost, affecting the profitability of the investment. Successful exploration companies carefully consider the type of information required to make their decisions, and how the information is to be utilized to minimize uncertainty. In this environment, the potential impact of new information has to be balanced against both its cost and the ease with which it can be embedded into existing decision-making processes.

CSEM Technology

Seismic methods provide information about the acoustic impedance contrasts between geological layers, allowing for structural definition of geological features and depositional systems analysis. Lateral changes in acoustic impedance and amplitude-versus-offset (AVO) effects provide constraints on lithology and fluid presence.

In contrast, controlled-source electromagnetic (CSEM) technology provides information on subsurface resistivity. In sedimentary basins, resistivity is driven primarily by the quantity of brine in the sediment. CSEM information also provides constraint on the area and anomalous transverse resistance (net thickness x resistivity contrast) of buried resistive layers. Hence, the use of CSEM-derived resistivity has the potential to improve our understanding of both fluid distribution and the size of resistive bodies (net rock volume) in a basin.

Conveniently, fluid assessment and net rock volume are two of the largest uncertainties in the conventional opportunity-evaluation workflow; hence, CSEM can potentially reduce some of the largest known uncertainties in exploratory prospectivity evaluation. Until recently, workflows designed for explorers to handle the CSEM information have been lacking. Instead, technical domain experts have tended to focus on integration approaches designed for lower-uncertainty environments. This is now changing as Baltar and Barker describe in their 2015 article “Prospectivity Evaluation with CSEM” for First Break magazine.

Impact on Investment Decisions

The authors had the good fortune of having access to a best-in-class CSEM dataset in order to analyze its realistic value potential today. The said dataset, from the Norwegian sector of the Barents Sea, covers 18 wells drilled in the period 1988-2015, with half from 2013-2014, and only one prior to 2007. When looking at economic considerations, three of the drilled prospects were arguably successful; all others turned up dry or well below a reasonable economic size. A quantitative evaluation of the covered prospects based on geological and seismic information leads to a portfolio without obvious clustering (Figure 1, left plot).

Baltar and Barker’s 2015 article outlined an interpretation workflow designed to integrate the CSEM information into a “seismic technology” portfolio such as this. The approach is based on a Bayesian update to the risk assessment (as widely used in industry for AVO, fluid seeps and other direct hydrocarbon indicators), extended into a coupled risk/volume update in order to account for, and leverage, the additional volumetric sensitivity of the CSEM information.

Resistivity volumes derived from CSEM data-driven processing (rather than a more complex product, integrated at the data level) are used as input in order to maximize transparency of information uncertainties and minimize the risk of interpretation bias. When trained explorers applied this workflow, the portfolio of opportunities now exhibits clear polarization and clustering (Figure 1, right plot).

What would happen if we could wind back time and optimize the drilling sequence based on this new portfolio evaluation (Figure 2)? Answer: The first three wells to be drilled would be commercial discoveries; any subsequent wells (which should not be drilled based on reasonable risk and volumetric hurdles) would be dry or technical discoveries. From an exploration efficiency perspective we are looking at drilling three instead of 18 wells with the same overall commercial success.

One could argue that this comparison is unfair, as the original sequence could never be optimized in this fashion due to license timing and well commitments. In order to address this argument and quantify the potential impact of consistent use of CSEM at a portfolio level, we have calculated the return on exploration investment (ROEI – defined as the net present value divided by the exploration and appraisal investments) for three alternative drilling sequences (actual, optimized without CSEM, and optimized with CSEM) and two oil price scenarios ($60 and $80 per barrel). Out of the three sequences, only the CSEM portfolio delivers a return above parity in both price scenarios (Figure 3).

Conclusions

CSEM technology has grown from its initial research form into a commercial tool with at least one clear value proposition: Known exploration uncertainties can be reduced with the combination of regionally extensive 3-D CSEM information and appropriately trained explorers. Illustrated here with a dataset from the Barents Sea, the authors have witnessed similar performance in a range of settings globally. We have demonstrated the impact-potential on investment decisions, which has a corresponding effect on exploration capital efficiency. Harder to quantify is the additional value-potential through reductions in unknown exploration uncertainties, such as hitherto-overlooked play models and missed leads.

The biggest challenge now lies with oil companies, who face the prospect of adapting their exploration workflows and training their people to harness this potential. Arguably this would be the biggest step-change in the way exploration should be conducted in decades; and like any process change it may be hard to implement, but will undoubtedly be exciting. Nimbler companies will enjoy the improved capital efficiency. Others may find themselves playing catch-up with this maturing technology.

Reference Cited

Baltar, Daniel, and Neville D. Barker, 2015, Prospectivity evaluation with 3D CSEM: First Break, v. 33, p. 55-62.

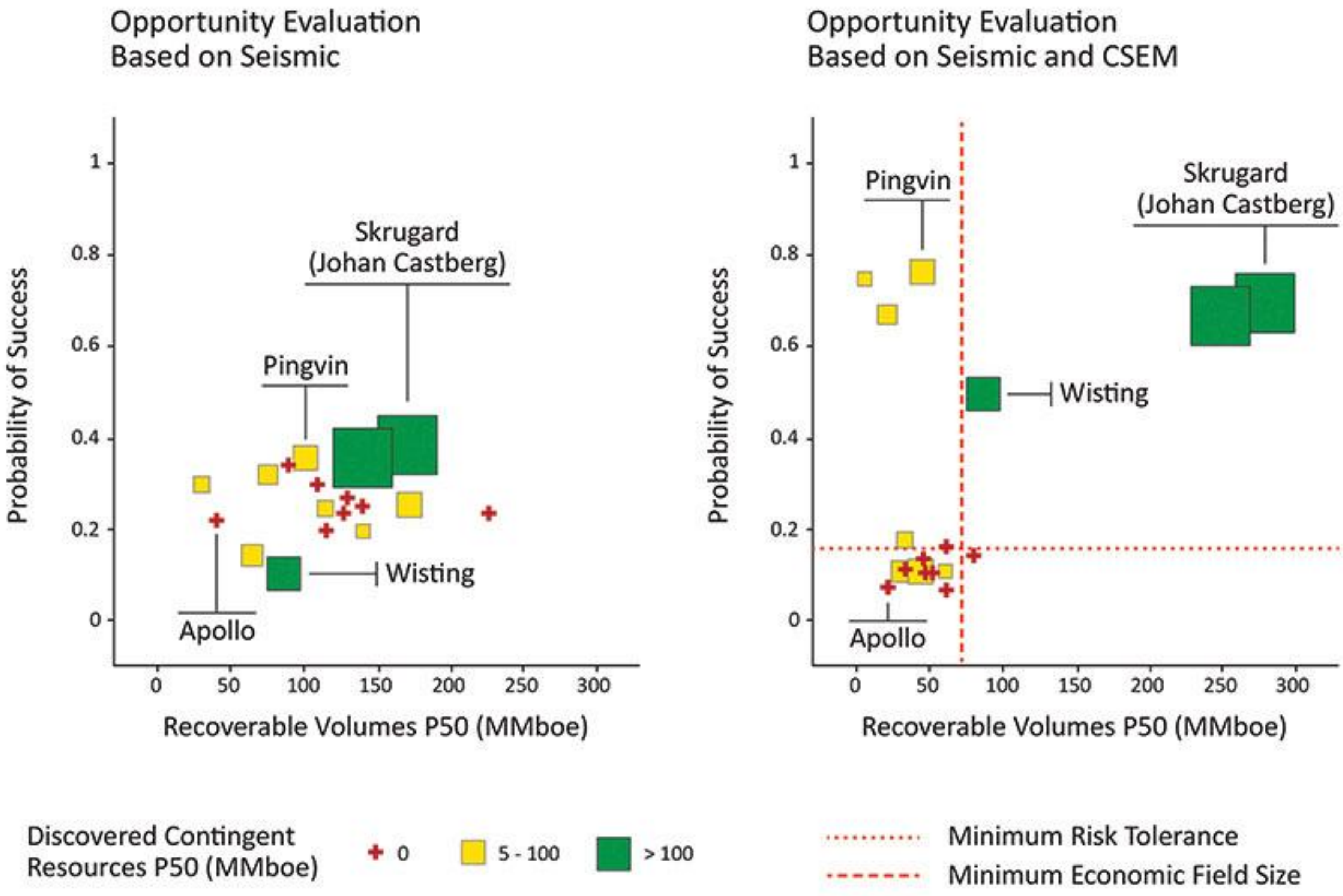

Figure 1. 18 Barents Sea prospect evaluations compared to well outcomes. Left: Reasonable PoS and P50 volume predictions made from publicly available seismic and geological information. Right: Updated predictions, taking the seismically-focused evaluation as a prior, and updating with 3-D CSEM information.

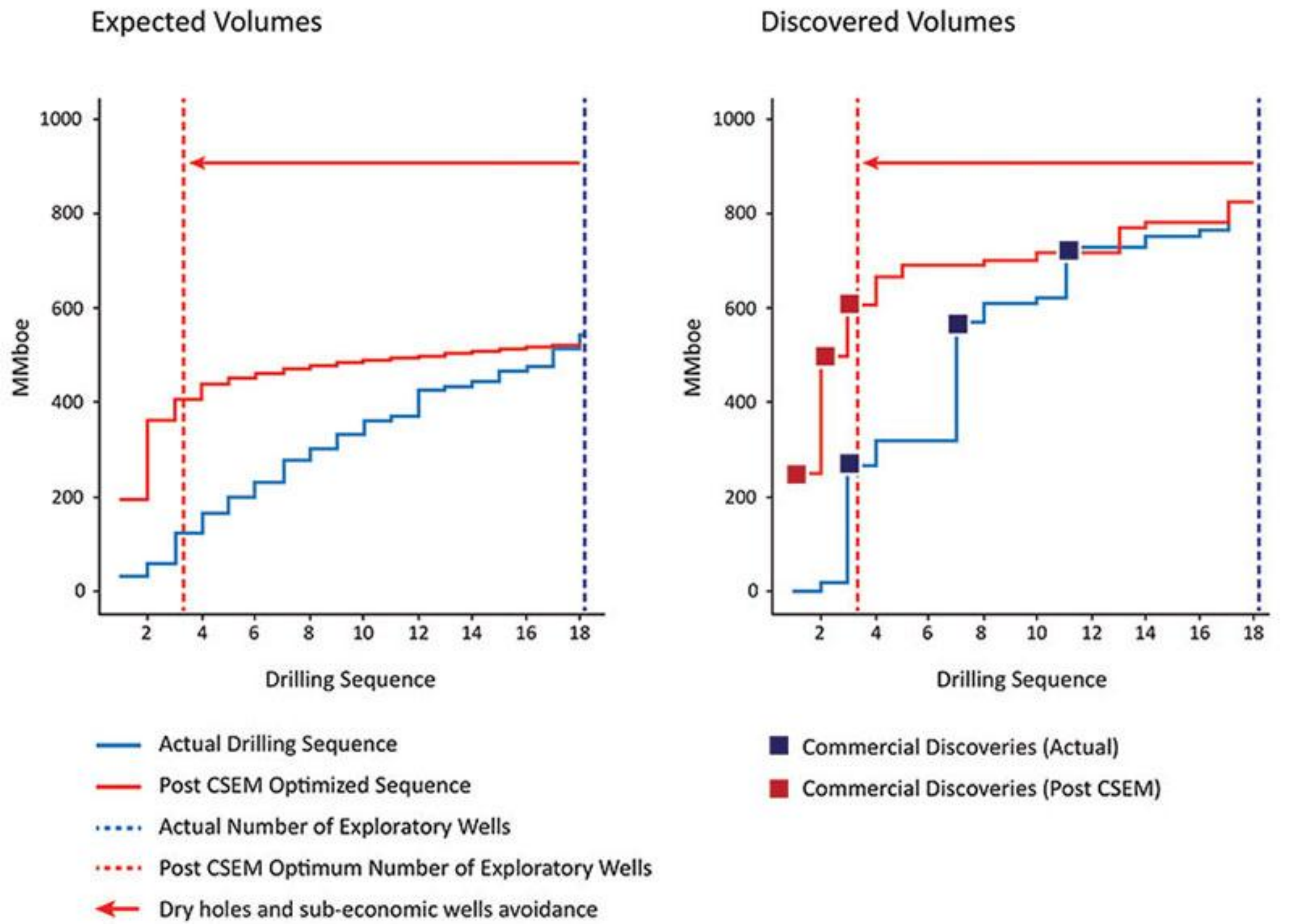

Figure 2. Impact of CSEM on drilling sequence and number of exploratory wells, optimized based on decreasing expected hydrocarbon volumes (left). Impact of optimized drilling sequence on actual commercial discoveries (right): A three out of three success rate for the post-CSEM sequence; three out of 18 for the actual drilling sequence.

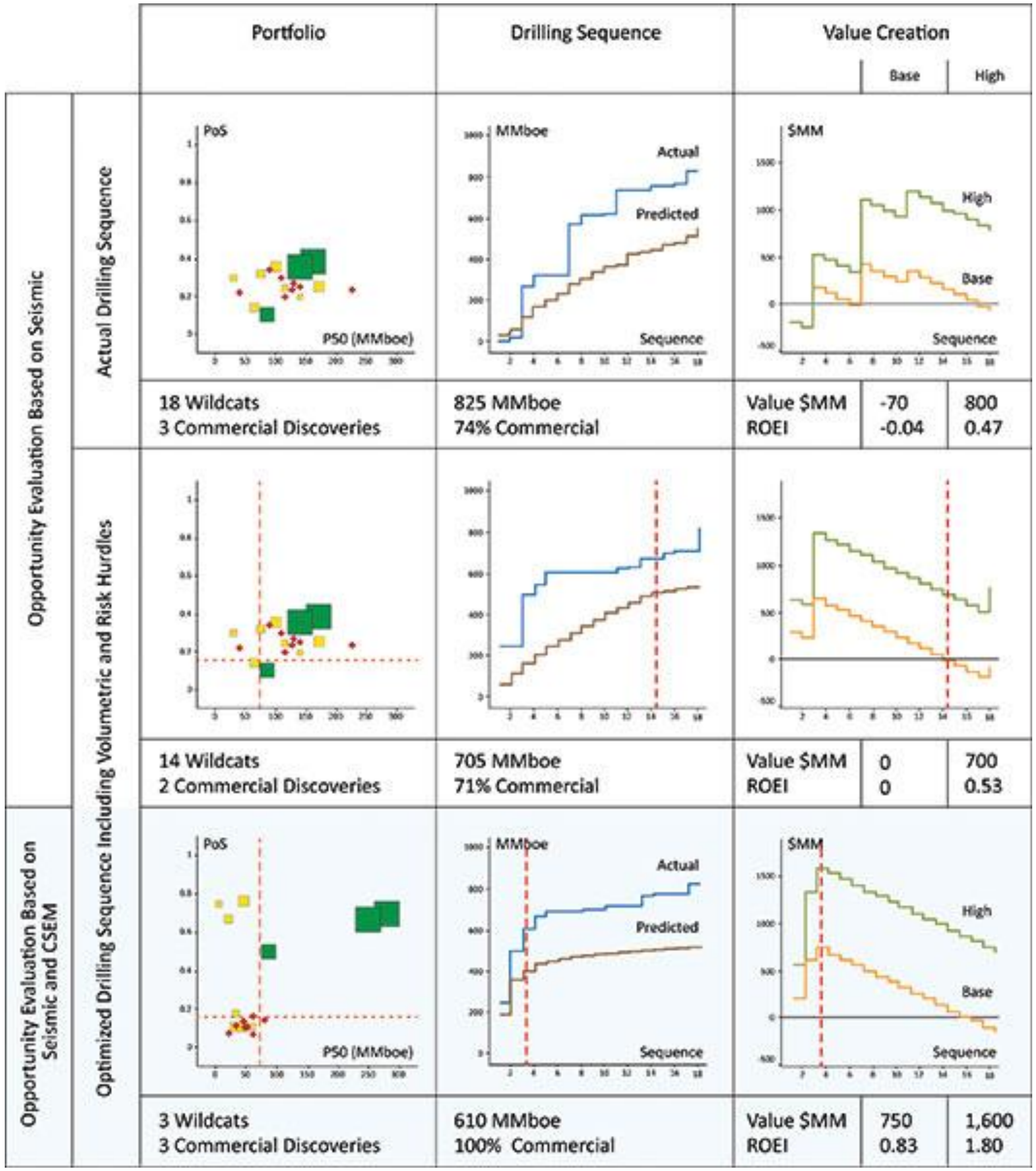

Figure 3. Summary of the impact of CSEM-enabled investment decisions. The original drilling sequence of 18 exploratory wells delivered three commercial discoveries, with a negative Return on Exploration Investment (ROEI) based on a $60/boe world. A drilling sequence based on volumes and risks updated with CSEM information would have delivered three exploratory wells for three commercial discoveries, for an ROEI of 0.83 also based on a $60/boe world.