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Industry Adoption and Use of the CSEM Technology

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SUMMARY

After more than ten years of acquisition of EM data, it is widely accepted that the technology has a significant potential for improving exploration efficiency. However, despite the fact that there is a convincing track record of EM results correlating with well results and some oil companies incorporating EM technology into their workflows, adoption of the technology in the industry overall has not come a long way.
This paper discuss some of the challenges faced by the petroleum industry in the interpretation of EM data, as well as necessary improvements of the technolgy in order to enhance the value of incorporating EM data into decision workflows. the current use of EM is illustrated by two examples, one unsuccessful and one successful

Introduction

After more than ten years of acquisition of EM data, it is widely accepted that the technology has a significant potential for improving exploration efficiency. However, despite the fact that there is a convincing track record of EM results correlating with well results and some oil companies incorporating EM technology into their workflows, adoption of the technology in the industry overall has not come a long way.

The reasons for this may be many, and demonstrate that further development and understanding of the technology is needed in order to make it generally accepted as an exploration tool:

- License partnership: In a license where some partners want to use EM, and some do not, the drilling location may not be optimal from purely an EM standpoint. E.g. for a large number of licenses in the Barents Sea (offshore Norway), only some of the partners have acquired access to EM data (see Table 1).
- Interpretation errors are commonly referred to as 'technology failures', even though the result of the EM measurement can be shown to concur with the well result. Terms as 'false negatives' and 'false positives' are frequently used in situations where the interpretation has proven to be erroneous. Interpretation by its nature relies on experience with data, workflows and tools for taking EM results into the prospect evaluation process and decision making.
- Lack of knowledge and understanding of uncertainties in the interpretation of EM data are also challenges. Although some oil companies have developed workflows for including CSEM results in their decisions, there are few individuals in the industry who have worked with multiple CSEM surveys. This may in part be due to the fact that there is currently little or no formal training or education related to the interpretation of EM data.
  An inversion result is only one model which explains the data satisfactorily. It is therefore important to evaluate the possible outcome of inversion results in terms of viable geologic models. Future development of hardware and software will certainly limit the range of outcomes, but will not remove the need for a broader understanding in the industry on how to handle the uncertainties related to interpretation of CSEM data.
- Timing of the results; often the consideration of the use of EM come too late to affect decisions. The earlier the data is acquired in the exploration cycle, the more value it has, as the uncertainties are largest in early exploration phase, especially in frontier exploration.

Table 1 *Overview of number of licenses in the Barents Sea where multi-client 3D EM data is available. Out of 24 licenses, there are 19 where at least one partner has licensed the EM data, but only 5 of these where all partners have. To date, only one drilling decision was made where EM played an important role.*

Total # of licenses with available EM data	1 or more partner with licensed EM data	All partners with licensed EM data	# of licenses where EM was used in decisions
24	19	5	1

Case examples

To illustrate the challenges and potential value of optimal handling of EM results, we will review two case examples from the Barents Sea; both examples relate to wells drilled in 2013.

1. The first example is from the south-west Barents Sea, where the 'Darwin' well (PL531) was drilled. Several interesting observations are apparent from EM, but interpretation is challenging, and the risk is high because there is no confirmed play model in the area. The selected well location, however, implies that the well was aiming for a target with no significant EM response as the location is outside the main EM anomaly, and consequently, the outcome of the well was

limited by the minimum size which the EM measurement would have been sensitive to. The result of this drilling was a dry well.

2. The second example is from the northeastern Barents Sea; the Wisting well in PL537. A shallow target is identified from seismic amplitudes, associated with a strong EM anomaly (Figure 1) which is an indication that a resistive volume is present, and consequently, a significantly increased Probability of Success (POS) may be inferred. This observation was a decisive factor for one of the partners in the license application process. The result of drilling was a discovery with a 60 meter column of light oil.

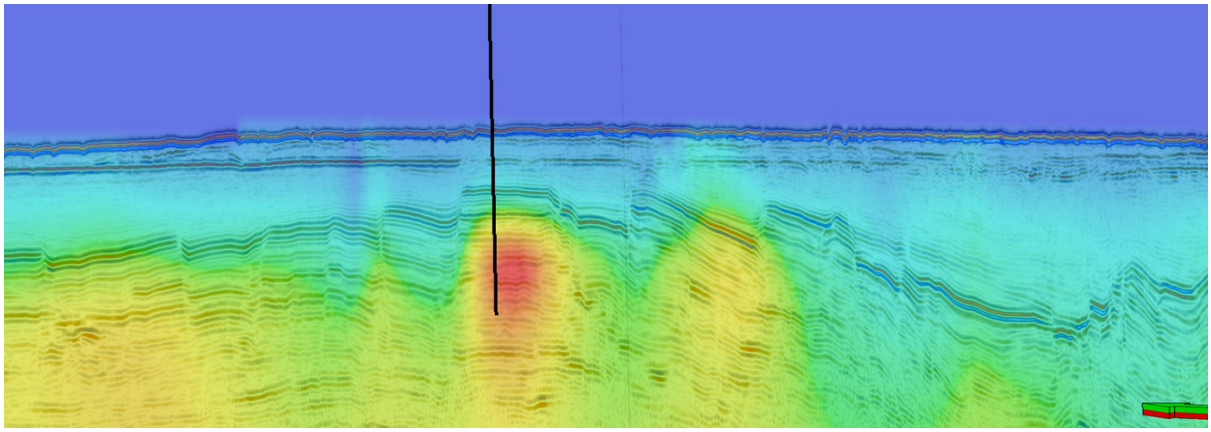

Figure 1 *Seismic section overlain by vertical resistivity (Rv) from 3D inversion. The presence of a strong anomaly clearly indicates that a significant hydrocarbon volume is preserved. Black solid line shows the location of the discovery well.*

Discussion

In order to increase the adoption of EM in exploration for oil and gas, we have pointed to a number of focus points, which are essential in order to understand and interpret the EM results. First, we need to increase the confidence in the CSEM measurement itself. This will require a better understanding of how the inversion result is controlled by regularization parameters and 3D inversion start models. Then the EM results must be included in the standard exploration workflow, and being allowed to influence POS and drilling decisions. Key issues are quantification of interpretation uncertainties and definition of possible geologic models within the range of outcomes of the CSEM imaging. One has to recognize that there is always a geologic model which explains what we see in CSEM data and that sometimes it is not straightforward to determine such a model.

We believe that the challenges we have discussed here demonstrate that further technology development and increased understanding of the value and limitations of this technology is necessary in order for it to be fully accepted as an exploration tool.