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The Use and Adoption of Offshore Electromagnetic Surveying as a Fundamental Geophysical Toolbox – Informed Decision Making During the E&P Cycle.

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Summary

The marine controlled-source electromagnetic (CSEM) surveying method has rapidly gained acceptance as an exploration tool for detecting and delineating hydrocarbon reservoirs. Whereas seismic surveys can detect the structures that may contain hydrocarbons with great accuracy, distinguishing hydrocarbon fluids from water within these structures is more problematic – as a result, less than a third of exploration wells result in a commercial discovery. This paper discusses how and where in the exploration cycle CSEM techniques can be applied to de-risk drilling.

Introduction

During the commercial development of the technology, CSEM was applied as an exploration tool to de-risk prospects in deep water clastic environments (such as offshore West Africa). In recent years the limitations previously associated with the CSEM technique have being addressed by heavy investment in research and development in the field. Significant step changes in the technology include:

- Shallow water CSEM surveying: addressing the "airwave" problem enabling work in water depths as shallow as 50m to be undertaken as a matter of course (MacGregor et al 2006).
- Integration of CSEM with other geophysical datasets, such as seismic:
  - Co-rendering CSEM and seismic results
  - Determining reservoir properties from the integration of CSEM, seismic and well log data
- Using the joint power of CSEM and Magnetotelluric (MT) data to image beneath massive resistors such as flood basalt flows and diapiric salt.

CSEM and MT technology can be utilised at many stages during the exploration workflow increase knowledge of the subsurface. Examples of the application of the technology are:

- Basin architecture & sub-basalt mapping (CSEM & MMT) to identify areas with the prerequisites for hydrocarbon prospectivity.
- Regional resistivity mapping to screen large areas for regions of high resistivity, and focus further work programs.
- Ranking of mature prospect portfolios to identify the optimum target for drilling.
- Detailed Prospect Delineation (edge field detection)
- Near Field Exploration
- Reservoir monitoring by combining time-lapse CSEM, Seismic and well log information.

CSEM Theory

The CSEM method uses a high-powered horizontal electric dipole to transmit a low-frequency electromagnetic signal through the seafloor to an array of multi-component electromagnetic receivers. By studying the received signal as the source is towed through the array, the bulk electrical resistivity of the seafloor can be determined at scales of a few tens of meters to depths of several kilometres. CSEM is very sensitive to thin resistive layers such as accumulations of hydrocarbons. MT signal is generated naturally in the earth's ionosphere and is sensitive to bulk background structure.

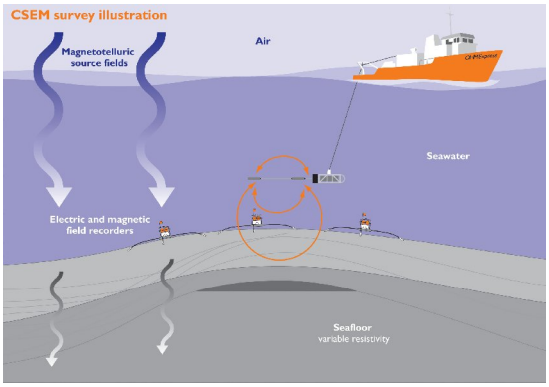

Figure 1: A schematic of the CSEM and MT acquisition method, and equipment.

Examples

Up to date short case features are presented in this paper, highlighting the areas outlined above, discussing how CSEM is making a real and defined difference to oil and gas exploration.

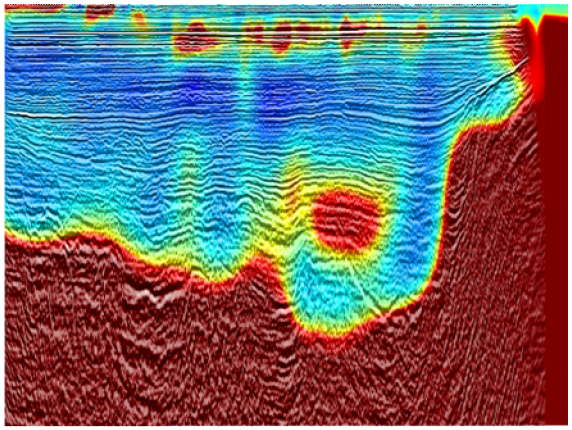

Figure 2: An example CSEM inversion result co-rendered with 2D seismic data (Macgregor et al 2007).

Conclusions

Offshore electromagnetic surveys can add value at all stages of the exploration process. Recent development of the technology has pushed back the perceived frontiers for CSEM to be able to be routinely applied in shallow water environments. The integration of electromagnetic, seismic and well log data significantly enhance the interpretation of each dataset.

References

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MacGregor, L.M, Andreis D., Tomlinson J. and Barker N., 2006, Controlled-source electromagnetic imaging on the Nuggets-1 reservoir, The Leading Edge, Volume 25, Issue 8, pp. 984-992 (August 2006)