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Briefing note

CSEM: Is it a silver bullet for explorers?

Is controlled-source electromagnetics (CSEM) technology the new answer to solving the old problem of avoiding dry holes? Can it really define oil and gas deposits offshore below and help explorers to pinpoint the sweet spots for exploration and production wells?

CSEM is most useful in prospect identification, but may also add value in Exploration and Appraisal.

Professor Tim Minshull, a marine geophysicist within the Ocean and Earth Science department at the National Oceanography Centre, at the University of Southampton, believes it can.

"The technology was originally developed for any conductive features associated with molten rock under volcanoes beneath the ocean... You can also use it to look for fresh water sources offshore."

"There are ongoing developments in the application of CSEM to different targets, such as seabed mineral deposits, and in joint inversion of seismic and CSEM data... CSEM is [now] a fairly mature technology: it has progressed a lot in the last ten years. We did not have the computer power back then to generate 3D inversion images. Today, companies like Electromagnetic Geoservices (EMGS) provide 3D images, carrying out speculative surveys as well as proprietary ones. It is now quite a mature technology within the industry."

Professor Tim Minshull, marine geophysicist - University of Southampton

Progress

Progress on CSEM technology has been rapid. Three Statoil employees, Terje Eidesmo, Svein Ellingsrud, and Stale Johansen are credited with developing CSEM at Statoil's research centre in Trondheim, Norway, and after seabed logging trials in 1998, Statoil established EMGS as a spin-off in January 2002 with NOK 100 million (£7.85 million – US $12.27 million) turnover, to sell a seabed logging service.

Other companies such as Rock Solid Images and Petroleum Geo-Services (PGS) also provide CSEM and other survey technologies. PGS acquired their variant form of CSEM technology, known as MTEM, in 2007. It was invented by Anton Ziolkowski, Bruce Hobbs and David Wright in 2001 at the University of Edinburgh, where Professor Ziolkowski is now Professor of Petroleum Geoscience.

Service companies such as Schlumberger are also making use of the technology and adding to its commercial usefulness. In 2013 Schlumberger announced a plug-in application for its market-leading Petrel petroleum data analysis tool, to maximise the use of CSEM data with increased data quality control, editing and normalization. In Norway research continues into integration of geological data into efficient workflows extending right through to economics.

Commercially, CSEM is one of several non-seismic survey technologies at various stages of maturity which have at times been described as 'emerging', 'transformational' or 'disruptive', such as Full Tensor Gravimetry (FTG) or Atomic Dielectric Resonance, offered by Adrok in Edinburgh.

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> CSEM has been used most successfully in deep water, and research is now in progress to expand its use in shallow water and Onshore.

Developments in seismic technology

There are also developments in the well-established seismic technologies, such as the use of Sea bed nodes (OBN). In 2010, FairfieldNodal featured OBN at the Society of Exploration Geophysicists annual meeting as offering the ability to produce development quality surveys as contrasted to exploration quality surveys.

"Use of sea-bed Cables and/or Nodes has been fraught with difficulties, and drove one or more companies out of business (RXT for example)."

David Bamford - Finding Petroleum

For CSEM, several patents exist and there have been difficulties in resolving disputes over these.

Such problems may cloud the issue regarding any assessment of long-term technical potential. Even after the operational difficulties are solved (as David Bamford went on to say they have been, for OBN and CSEM), a sceptical approach can lead to slow adoption by the industry, at least until the added value is well established in case studies. In essence, the decision problem facing an Upstream company considering use of a technology such as CSEM resembles the sales problem facing the technology vendor; what is the Value of Information which the technology can offer, in a given context? How can we evaluate or demonstrate this, and how confident can we be in our results?

For users, the best use of these technologies depends on making an appropriate choice, depending on what geophysical problem they are trying to solve. CSEM is most useful in prospect identification, but may also add value in Exploration and Appraisal.

The key questions are:

- how can the new technology be integrated into the Exploration workflow?
- which technology is most appropriate for which geological context?
- how much value could the technology add compared to cost?

CSEM has been used most successfully in deep water, and research is now in progress to expand its use in shallow water and Onshore.

There is now quite a lot of experience in CSEM. EMGS for example has more than 700 surveys acquired worldwide and in water depths ranging from shallow (30 m) to ultra-deep (3500 m). They point out that full-azimuth 3D acquisition was introduced in 2007; it has been the standard way of acquisition since 2008. Wide azimuth 3D is very important when trying to image an earth which can be quite anisotropic.

The full-azimuth and multi-component data enables deployment of CSEM in complex geological settings, and robust imaging of reservoir geometries such as meandering channels becomes possible.

Key success factors for CSEM are the resolution available from the acquired data, and the interpretation of the data. Research in these areas continues to make excellent progress at the Scripps Institute in California and elsewhere. Southampton University used the technology a couple of times in 2012 and there are plans to deploy it next year for further mineral deposits research. At Edinburgh, Dr David Wright and Professor Ziolkowski are working on application of the MTEM method to land data - especially to look for shale gas and shale oil.

EMGS explains that CSEM is a complement to seismic survey; it is not yet a standalone technology.

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> Ideally, joint inversions combining both CSEM and 3D seismic data can reinforce each other; indicating for example that a likely-looking formation shows low resistivity, typical of brine-saturated good porosity reservoir rock.

"It is never going to replace seismic, ... because it does not have the resolution of seismic data. It is the nature of the physics. CSEM is now an adjunct to seismic. One would not do a 3D CSEM survey without having done a 3D seismic survey first."

"Seismic data gives you an image of structure with resolution that can be tens of metres or less, whereas CSEM gives you a smoother image averaged over a kilometre or so. It is much smoother, but it is telling you the physical properties. 3D seismic gives you an image but CSEM can give you the resistivity - a property of the sub-surface that is sensitive to the fluids it contains, such as oil and gas."

Professor Tim Minshull, marine geophysicist - University of Southampton

Ideally, joint inversions combining both CSEM and 3D seismic data can reinforce each other; indicating for example that a likely-looking formation shows low resistivity, typical of brine-saturated good porosity reservoir rock. This would avoid the cost of drilling an exploratory well. Alternatively, similar rock will show high resistivity when filled with hydrocarbons, increasing the Probability of Success.

Unfortunately, interpretation is not always straightforward. High formation resistivity may also be associated with low porosity, low pore space connectivity or very low salinity brine. Conductive minerals or clay may show as low resistivity areas even in the presence of hydrocarbons. A good interpretation, with good estimates of probability and potential Value of Information should take account of all available information about the area geology and local experience.

In August 2011 EMGS acquired OHM Surveys Ltd, a company formed by Southampton University which helped to develop CSEM.

"EM technology significantly increases the exploration success rate compared to using seismic surveying techniques alone. The technology is not a replacement for seismic methods, but is complementary, providing greater certainty of discovery before drilling,"

EMGS

The same month EMGS also declared drilling results on the Norvarg prospect in the Barents Sea which proved gas. It is 250 kilometres from the Melkøye LNG plant which serves the Snøhvit gas field offshore northern Norway. After testing, it was estimated that the Total-operated find could contain between 10 and 50 billion standard cubic metres of gas (63-315 million barrels of recoverable oil equivalent). The Norvarg well encountered 400 metres of pay in one interval, Kobbe, and in a deeper Havert Formation, two further reservoir zones of 80 and 90 metres of gas were encountered.

One of the Norvarg exploration partners, Rocksource, used CSEM to pinpoint the reservoir prior to drilling.

"Prior to drilling we used our proprietary electromagnetic (EM) technology to de-risk the chance of finding hydrocarbons here. Norvarg was a challenging case with hydrocarbons at multiple levels which were successfully predicted. The positive production test in the Kobbe Formation improves the chance that these volumes will be developed and produced in the future."

Trygve Pedersen, chief executive - Rocksource

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> Enthusiasm for the technology continues, as exemplified by Repsol's recent collaboration with Rock Solid Images under a three-year agreement to develop both rock-physics modelling and CSEM interpretation and integration technologies.

So what exactly is CSEM?

Perhaps it is best left to one of the industry's proponent's to explain:

"[CSEM] relies on the difference in the electrical resistivity between oil - and water-bearing sediments beneath the seabed... Hydrocarbon saturated sediments display higher resistivity than water-filled sediments. This observation has been used for decades by the borehole logging community to confirm oil in place."

EMGS

EMGS says it has been able to apply this principle to the remote indication of hydrocarbons, by measuring subsurface resistivity from the seabed. Accordingly, the company says marine EM is a 'perfect partner' for seismic exploration techniques, by providing a structural picture of the subsurface.

Enthusiasm for the technology continues, as exemplified by Repsol's recent collaboration with Rock Solid Images under a three-year agreement to develop both rock-physics modelling and CSEM interpretation and integration technologies. Repsol and RSI will both own any resulting technology which is developed. Under the $11.5 million project, RSI says it will increase its research, development and Quantitative Interpretation groups substantially. A joint seismic and CSEM inversion system anchored within a rock-physics framework is a key deliverable.

"Both companies recognise the value of rock-physics based Quantitative Interpretation, and the additional value that CSEM data can bring to the exploration workflow. However, in order to unlock this value, there is a pressing need to develop sophisticated, robust and efficient interpretation tools and workflows; this project will specifically address this need."

Dr Lucy MacGregor, chief technology officer - RSI

In its 2015 first quarter results EMGS described further market opportunities in Asia where it expects to keep one survey vessel active in 2015, and perhaps more important opportunities as the Mexican continental shelf is opened up for international exploration after the Mexican government voted to end the monopoly held by state company Pemex, allowing foreign companies to explore there.

Please contact your Barnett Waddingham consultant if you would like to discuss any of the above topics in more detail. Alternatively contact us via the following:

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