CSEM

Controlled source electromagnetic (EM) surveys have established themselves as a useful tool to complement seismic surveys in the drive to reveal the presence of commercial hydrocarbon reserves.

Recently, Canadian company Ocean Floor Geophysics has entered into the market by making a deal Norwegian company PGS, acquiring exclusive rights to their unique towed streamer CSEM technology.

“The idea of applying CSEM methods to hydrocarbon exploration was developed over twenty years ago,” said Matthew Kowalczyk of Oean Floor Geophysics."

When it started, however, the method was probably over- hyped as a panacea that would solve all exploration problems. This led to disappointment in the market, and some companies still will not use the technology because it failed to live up to its original promise , There are, however, still many users, who exploit the capability of the CSEM method to de-risk or high grade seismically identified prospects. “

Seismic systems essentially work by directing an acoustic source into the ground, and then measuring the returns.

Electromagnetic systems work on a similar principle: Electromagnetic energy is transmitted through the ground to an array of receivers, which measure the electric and/or magnetic field. By studying the recorded signals, the resistivity of the sub-surface can be determined.

This technique exploits the property of hydrocarbons as electric insulators. Hydrocarbon-filled reservoirs are normally more resistive than the surrounding water-filled sediment.

This contrast in resistivity can be detected using electromagnetic methods. The reason that the technique is useful is that resistivity measurements are complementary to other geophysical attributes, allowing sub-surface properties to be determined with greater certainty that when only a single data type is considered.

There are different ways that CSEM is deployed. The two most common in the marine environment are nodal surveys and the towed streamer approach.

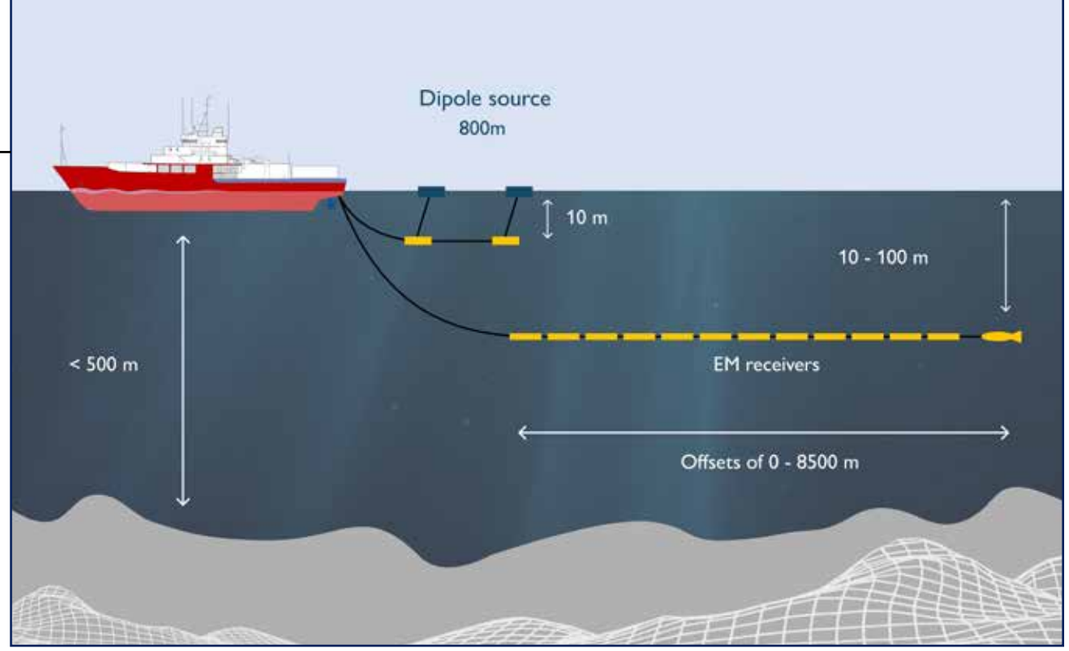
Nodal CSEM

In a nodal CSEM survey, receivers are pre-laid on the seabed and a dipole transmitter is towed over them.

The receivers measure up to three components of the electric and magnetic field at the seafloor, and are sensitive enough to measure field strengths that vary greatly in magnitude, from naturally occurring, magnetotelluric signals (EM signals generated in the Earth’s atmosphere and ionosphere) to the signals that are transmitted by the dipole source as part of the survey. For large surveys, these receivers have to remain autonomously operational for several weeks.

The EM source is an electric dipole towed close to the seabed, made up of two electrodes supported on a neutrally buoyant streamer, towed behind a deep-tow vehicle. The EM signal is formed by switching the polarity of a high current signal passed between the electrodes using a GPS synchronised time reference.

The frequency and source-receiver geometry is custom-designed based on the target geology. In order to reach deep targets, the EM source has to be particularly powerful,



Towed streamer array

typically with a peak output current of 1.25kA, although source currents up to 7kA have been used.

It is necessary to know the exact position of both the towed source and the receivers. This is accomplished using standard ultra-short baseline acoustic navigation systems.

Towed streamer CSEM

The second approach to CSEM uses a towed dipole source and an array of electric field receivers, which are both towed at relatively shallow depth behind a survey vessel. This is similar to a standard 2D seismic acquisition approach. In the system that OFG have acquired from PGS, the streamer is 8.5km long, with electric dipole receivers along its length.

The towed streamer CSEM approach is considerably more efficient than the nodal CSEM system: more data can be acquired within a fixed budget. The towed streamer CSEM system can also be deployed in tandem with a 2D seismic survey, allowing efficient collection of multiphysics data.

Since both source and receivers are towed at relatively shallow depths, however, the system is limited to water depths of about 400-500m or shallower. In deeper water the source is simply too far from the seafloor for a good signal to be achieved. In this setting, a hybrid deployment of nodal and towed streamer CSEM may be advantageous.

A further approach is deep water is to use a deep towed source, behind which are towed an array of 3-component electric field receivers, typically up to about 1km long. This approach has been used successfully by OFG for applications such as mapping and quantifying gas hydrate deposits in Japan.

“CSEM is a very powerful tool when combined with other geophysical methods,” said Kowalczyk. “Using multiphysics analysis approaches to combine CSEM and seismic data allows a robust interpretation of sub-surface properties.

"This is particularly important in settings where the interpretation of one data type in isolation is ambiguous, for example when determining whether the hydrocarbon saturation in a prospect is commercial or not, a problem that is notoriously hard to resolve using seismic alone."