Deep electromagnetic imaging

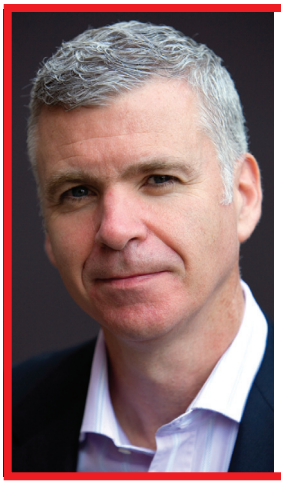
Ken Feather explains how the success of deep EM imaging has created a completely new service industry.

When can a new exploration technology be considered to have resulted in a fully fledged industry? Is the answer a measure of turnover? Is it when explorationists have to justify not using the technology? Perhaps it is when the 'big-three' seismic companies are compelled to add the technology to their portfolios?

Whatever your criterion, deep electromagnetic (EM) imaging, which uses EM energy to find hydrocarbons without drilling wells, has clearly become a major industry in its own right. Its much older sister industry, seismic surveying, has been the cornerstone for exploration decisions since modern-day oil exploration began. However, seismic techniques have limited ability to successfully predict the location of hydrocarbons when used in isolation, which is one reason why offshore exploration drilling hit rates are less than one in four.

The traditional exploration workflow relies on indirect evidence to locate hydrocarbons, and seismic methods are mainly sensitive to rock structures and not to the fluids within them. In contrast, EM methods are very sensitive to reservoir fluids and can indicate hydrocarbons directly. Naturally, the first popular use of EM imaging in the oil industry was to test, before drilling, whether the potential reservoir structures (prospects) identified from seismic data actually contained oil. This significantly reduced exploration drilling risks and avoided many costly dry wells.

More recently, new applications of EM imaging have extended its use to act like a divining rod to search for direct evidence of hydrocarbons before performing extensive seismic surveys or bidding for new acreage in licensing rounds. This is particularly valuable in frontier regions because it enables costly exploration resources to be targeted on the most promising areas, and it accelerates the delivery of higher-grade prospects and, ultimately, more discoveries. Applications beyond exploration are also being pursued. Scientists and engineers are developing methods and technology to use EM imaging for field appraisal, advancing field development plans and even reservoir monitoring on mature assets to help optimize production and recovery.



Ken Feather is VP Marketing at EMGS. He joined in 2005 after 17 years with Schlumberger, initially as a field engineer, and later in management positions within petrophysics, sales, new technology and marketing. Feather successfully introduced game-changing technology products and services, and the marketing and sales tools he developed have been adopted as best practices within Schlumberger. His speciality is marketing and brand strategy. He is a Chartered Engineer and a member of the Chartered Institute of Marketing and graduated from Salford University with a degree in Engineering.

Figure 1: An EMGS crew deploying a sensor during an EM-imaging survey. The sensors, which measure electric and magnetic fields, sink to the ocean floor with the aid of an eco-friendly anchor. Upon survey completion, the sensors are released and retrieved at surface and the anchors remain on the ocean floor and dissolve into natural materials after a few months. Multiple sensors are positioned in a grid or linear pattern at distances ranging from one to five km, depending on the survey's objective.

Fewer than 10 years have passed since the idea behind the technology was conceived, and it is only five years since the first commercial survey was performed, and yet the usually conservative exploration community has embraced EM imaging. During the latter half of 2007, interest in EM technology has intensified and has culminated in a frenzy of merger and acquisition activities, as smaller EM companies and the big-three seismic players have scrambled to catch up with the market leader and pioneer of the technique, Electromagnetic Geoservices (EMGS).

Invention and commercialisation

Offshore EM imaging, also known as seabed logging, is an unusual technology because the people who invented the technology continue to work at the forefront of its development and commercialisation. Terje Eidesmo and Svein Ellingsrud, who went on to found EMGS, first had the idea of using a powerful EM source to find offshore hydrocarbons in 1997 while working for Statoil. They performed modelling work and scaled experiments, and then, in 2000, ran the first full-scale field trial, work for which they were recently awarded the Society of Exploration Geophysicists' prestigious Virgil Kauffman Gold Medal.

In November 2002, EMGS conducted the world's first commercial offshore EM survey over Ormen Lange field in the North Sea. Since then, the company has performed over 300 surveys, logged more than 40,000 km of the ocean floor (greater than the Earth's circumference) and deployed over 11,000 seabed EM receivers (figure 1).

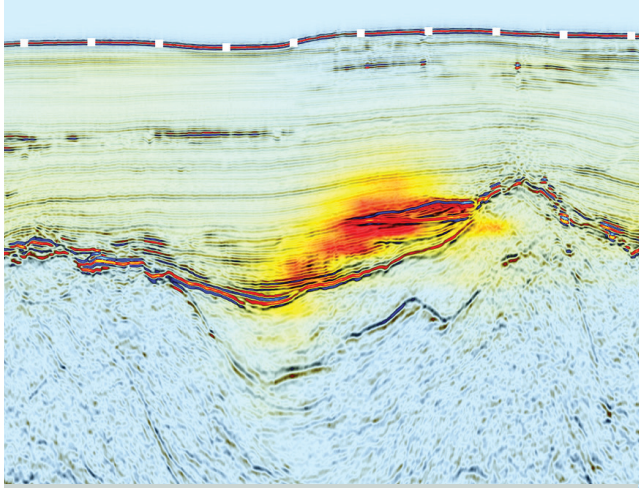


Figure 2: EM-imaging data integrated with seismic data shows which of the structures identified on a seismic image is likely to contain hydrocarbons and which can be discounted from further geophysical or drilling investigations. EM surveys measure resistivity; hydrocarbon-charged reservoirs typically have a much higher resistivity than the surrounding rock, as indicated by the red colour in the image above. (Data courtesy of Murphy Oil Corporation.)

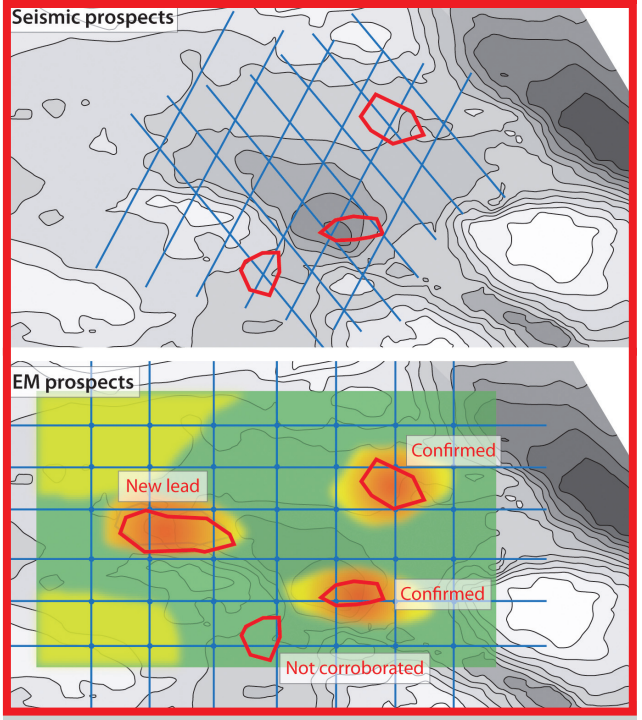


Figure 3: Three seismic-derived prospects are shown in this synthetic example (top) and three EM prospects are shown (bottom). The EM prospects confirm two of the seismic prospects, but not the third. A fourth prospect, which was not detected by the seismic survey, is revealed by the EM scan.

Unparalleled success

The reason for such rapid growth is simple: the technology works. Offshore exploration drilling success rates have historically been around one in four. By contrast, EMGS' surveys have correctly predicted the reservoir fluids in more than 90 percent of the cases where the company has drilling results.

Another reason for the technology's success is that EM data is independent of, but fits well with, seismic data. The first commercial depth migration of EM data, performed by EMGS in 2004, was a real milestone. It meant that EM data could be independently correlated with seismic and other geological information (Figure 2).

Unsurprisingly, given that EM surveying can directly test for the presence of commercial-scale offshore hydrocarbons and can help to avoid the drilling of dry wells, the technology has been rapidly adopted. Indeed, the big-three seismic companies are all climbing on board by acquiring or joining up with smaller EM-surveying companies. This scramble to catch up with market leader EMGS is a sure sign that the offshore EM-surveying industry has come of age.

Exploring with surgical precision

Scanning is a growing application for EM surveying that can rapidly identify leads in large areas, regardless of their seismic expressions (Figure 3). Scanning surveys enable costly exploration resources to be targeted on the most promising areas, and they accelerate the delivery of higher-grade prospects and, ultimately, more discoveries where there is oil to be found.

Scanning is particularly well suited to exploration in environmentally sensitive frontier regions. EM imaging has an inherently small environmental footprint; the source is harmless to sea mammals and the sensor anchors are made using a proprietary material that degrades to environmentally benign products (Figure 1). Similar to the way that medical scans enable surgeons to pinpoint problem areas before operating, EM scanning enables subsequent exploration investments and activities to be guided with almost surgical precision to prospective areas, thereby enhancing exploration efficiency.

The scale and effectiveness of scanning surveys are driving new multi-client business models and the development of new enabling modelling technologies. Scanning has been predicted to become the first-look method of choice for finding hydrocarbons in frontier areas; so, it is little wonder that the big-three seismic companies want a piece of the action.

A solid foundation

All the super-major and many of the independent and national oil companies have commissioned offshore EM surveys. This widespread adoption has been described as "...a remarkable achievement for a young technology, given the oil industry's notorious reluctance to embrace innovation" (Offshore Engineer, August 2007, p 22).

EMGS continues to work with government agencies, major resource holders and all the leading energy companies. It has offices across the world and operates the industry's largest survey fleet, with five vessels and two more purpose-built vessels planned for 2008. These vessels and EMGS' on- and offshore teams are helping operators to enhance their exploration performance by reducing the number of dry wells, enabling new discoveries and, ultimately, giving them a competitive edge. EM surveys can now be acquired in 3D, and the active research and development department at EMGS is constantly developing the survey equipment and the modelling and integration techniques.

In its Virgil Kaufmann Gold Medal award citation for the original inventors of the technique, the Society of Exploration Geophysicists stated: "This pioneering work spawned a new service industry," and that would certainly seem to be the case, judging by the evidence presented here.

It is an exciting time to be in the fast-moving EM industry. Who knows what the next decade will bring? ■

For more information, please visit emgs.com or email findinghydrocarbons@emgs.com.