Seabed Logging – A Proven Tool for Offshore Exploration and Development*

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Introduction

Wellbore resistivity logs have provided evidence of the presence of hydrocarbons for almost 80 years. The theory is simple. In many geological settings, rocks saturated with hydrocarbons exhibit significantly higher electrical resistivities than those saturated with brine. Thus a kick on the resistivity log is always exciting news. Of course, there is one big problem with a wellbore resistivity log: you need to drill a well before you get this vital piece of information. Wouldn't it be very useful to get resistivity information before drilling a well? In the late 1990's, Terje Eidesmo and Svein Ellingsrud, two Statoil researchers, (Figure 1) were pondering this problem and their research led to the development of seabed logging. In this article, we will review the state of the art in seabed logging and discuss where and how it can be used.

History

In 2000, Statoil acquired data over a producing field and proved the concept of seabed logging. Two years later, this revolutionary technology was made available to the industry through the formation of EMGS. The company was led by Eidesmo and Ellingsrud, who were joined by Ståle Johansen, a longtime sponsor of the project within Statoil.

Today, EMGS is the leading provider of seabed logging and deep electromagnetic (EM) imaging services. The company has five vessels, with more due to enter service in 2008. Over 40 of the world' leading energy companies, including super-majors, nationals, and independents, have used EMGS to conduct more than 300 projects in water depths ranging from 50 to 3500 m.

How Does Seabed Logging Work?

A ship tows a horizontal electric dipole source close to the seabed to create a large electric field (Figure 2). As the electric field propagates through the subsurface, it is perturbed by any variations in the subsurface resistivity. The electric and magnetic fields are both measured and recorded by highly sensitive units distributed over the seabed. Once sufficient data has been recorded, an acoustic signal is sent to the receivers to trigger a release mechanism, and the recorders return to the surface for data analysis.

The recorded data is processed to remove noise, and compensate for environmental variations, such as water depth and background resistivity.

In many cases, this data can then be interpreted directly. Increasingly, however, the data is imaged using depth migration or inversion to facilitate easy integration with seismic and other subsurface data.

Why Is Seabed Logging So Exciting?

In its simplest form, an image of subsurface resistivity can indicate the presence or absence of hydrocarbons in a reservoir. Many experienced users of seabed logging are finding > 90% agreement between seabed-logging pore-fluid predictions and actual drilling experience. With normal wildcat frontier success rates below 20% and drilling costs at an all time high, seabed logging is rapidly becoming a key part of the offshore E&P workflow. In simple clastic sequences, seabed logging can deliver a near-perfect direct hydrocarbon indicator. In areas of more complex geology, seabed logging can provide useful independent data to confirm earth models derived from seismic data. However non-hydrocarbon-related resistive bodies (salt, volcanics, carbonates, gas hydrates, etc) may influence the data and need to be considered during modeling and interpretation.

The first step towards a successful seabed-logging project is to model the expected response of the reservoir with and without hydrocarbons in place to ensure that the difference in response will be detectable using the proposed acquisition and processing technology. Careful use of modelling can ensure that seabed logging is used in only places where it can be effective.

How Is Seabed Logging Applied?

Most seabed-logging projects have been used to confirm the presence of hydrocarbons in structures identified from seismic data before drilling. This application significantly reduces the drilling risk – especially for operators of expensive deepwater wells.

Over the last few years, an additional application has emerged called EM scanning. Scanning is characterized by the rapid deployment of wide-azimuth sensors in regular, sparse grid-like patterns over large areas. In this application, scanning is used to investigate large regions and detect resistive subsurface formations early in the exploration cycle. This new approach has been shown to accelerate prospect delivery and focus exploration efforts in the areas most likely to contain hydrocarbons (Figure 3). Scanning can even detect unconventional reservoirs that are not always easy to see on seismic data (such as stratigraphic traps). Because scanning is often applied over wide areas before lease sales, it is increasingly thought of as both a proprietary and a multiclient application.

Summary

Seabed logging is the first truly independent predrilling measurement of reservoir properties since the development of seismic technology early in the last century. It is a proven direct hydrocarbon indicator, which is now playing a key role in addressing the ever-growing challenges of meeting the world’s energy needs, and it has provided the catalyst for a completely new EM service industry.

Figure 1. Svein Ellingsrud and Terje Eidesmo, seabed logging inventors and founders of EMGS, sporting their Virgil Kauffman Gold Medals, awarded by the SEG in recognition of their pioneering work in applying controlled-source electromagnetics (CSEM) to the detection of hydrocarbons, which spawned an entirely new service industry.

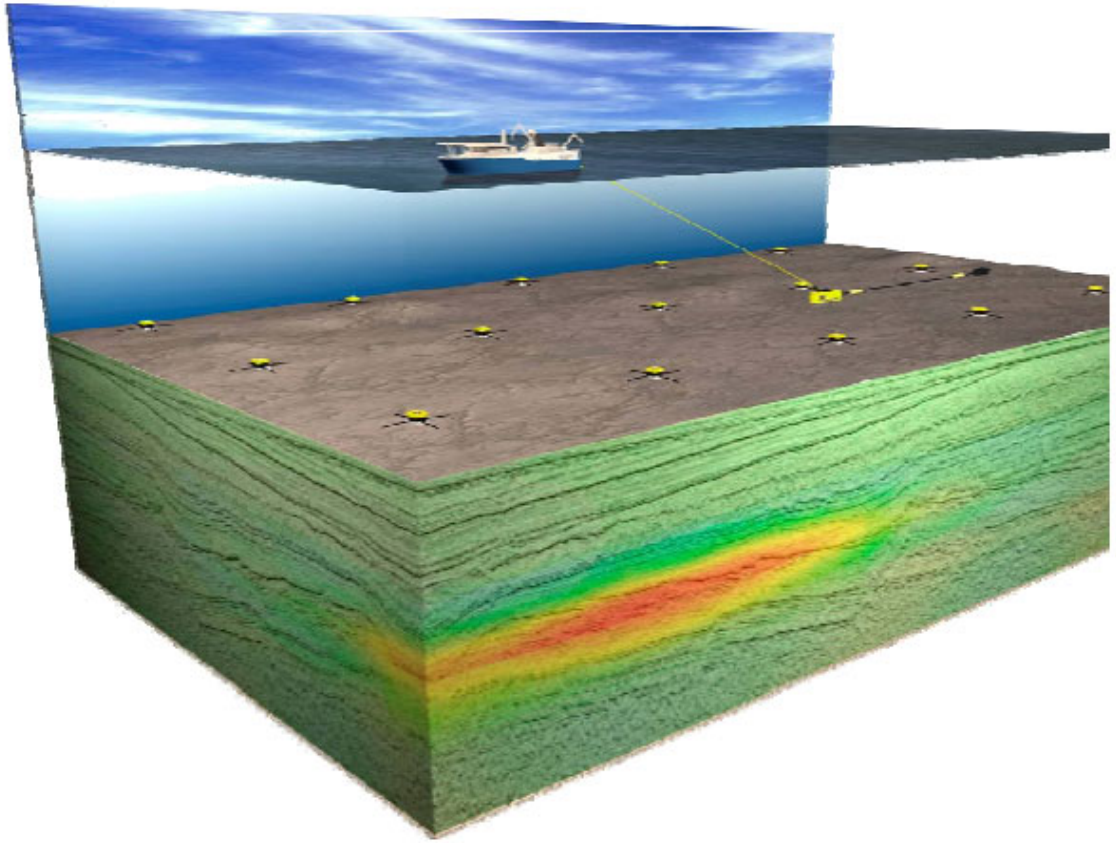

Figure 2. The acquisition of seabed-logging data.

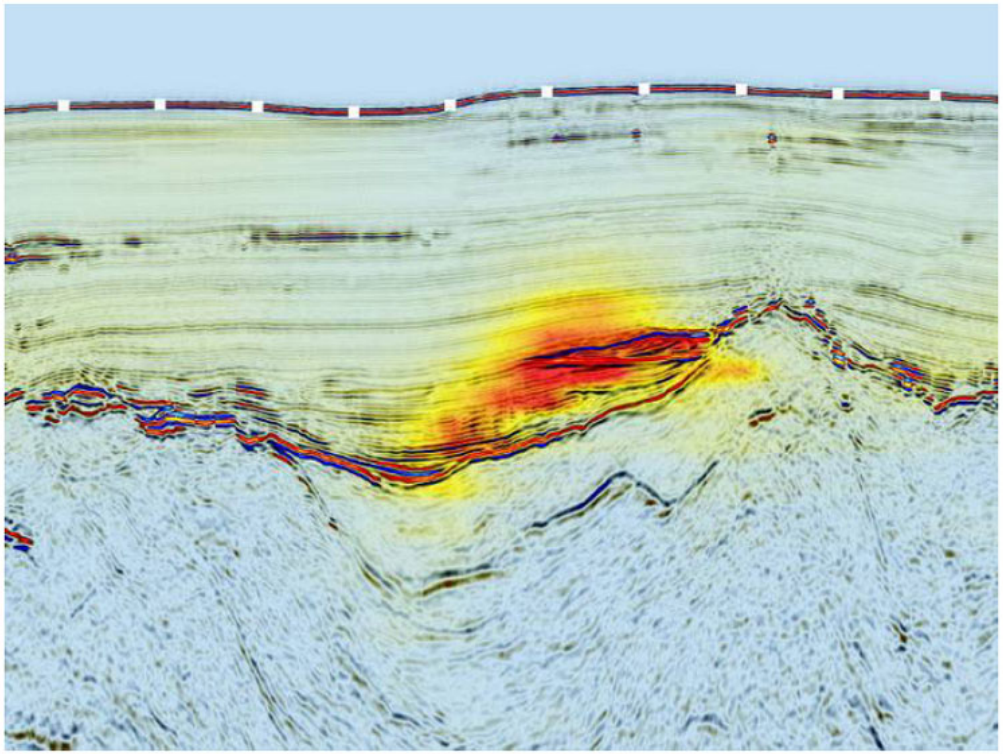

Figure 3. EM imaging data derived from seabed logging is integrated with seismic data and reveals which of the structures identified on this seismic image are likely to contain hydrocarbons and which can be downgraded in further geophysical or drilling investigations. (Data courtesy of Murphy Oil Corporation.)

Recommended Reading

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