The Importance of Electromagnetic (EM) Data –

Avoiding Dry Wells in the Barents Sea

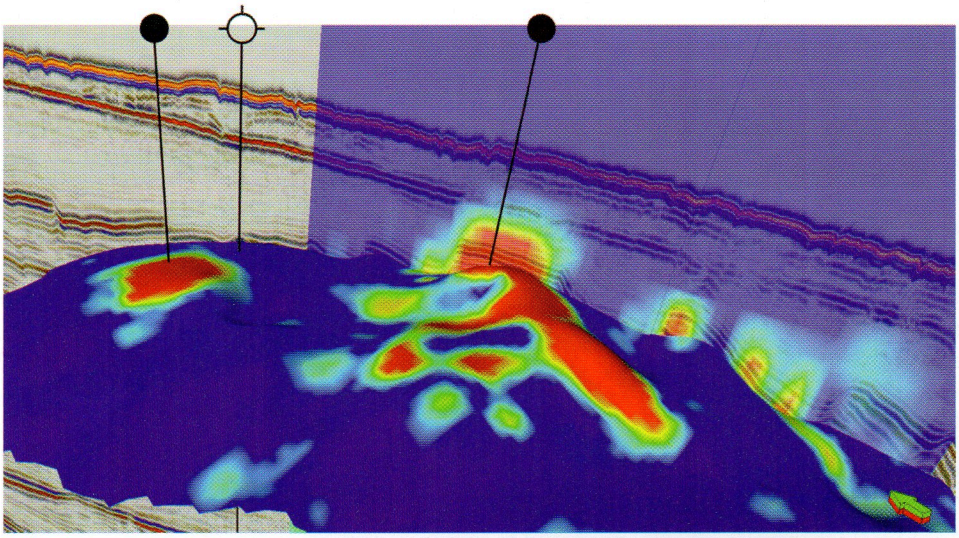
Much attention is currently focusing on the Barents Sea where the Norwegian Ministry of Petroleum and Energy is planning to offer 61 blocks under the country's 23rd licensing round later this year. Thirty-four of these blocks will be in the previously off-limits southeastern part of the Barents Sea, 20 in the southern Barents Sea and seven in the Norwegian Sea. Today, the region is a vast under-explored area, exhibiting a large variety of geological settings and offering significant hydrocarbon potential.

BY VINCENT VIEUGUE

Yet, the last few months have seen a number of disappointments in the Barents Sea with Statoil unable to find commercial quantities of hydrocarbons following the drilling of several wells. Statoil's drilling campaign in the Hoop area this year, for example – a frontier area of more than 15,000 square kilometres – resulted in just two small gas discoveries (Atlantis, 7325/1-1 and Mercury; 7324/9-1) and one dry well (Apollo, 7324/2-1), none of which could be deemed commercially viable.

Yet, while Statoil has experienced disappointments, this stands in contrast to other operators who have been drilling in the same Hoop area of the Barents Sea where successes include a major discovery at the Wisting Central structure in 2013 followed by another find in 2014 at the nearby Hanssen well.

Why the differing fortunes? One answer lies in the Electromagnetic (EM) data and the presence or absence of EM anomalies in these prospects. This article will show that there is clear evidence of a correlation between the size of the EM anomalies and size of the hydrocarbon discovery in geological provinces.



The Wisting and Hanssen oil discoveries are clearly associated with strong resistive anomalies (red areas) from the CSEM data. The well next to Hanssen going through a low resistive area (blue) is dry. Blending the resistive data with the seismic cross-section shows that the resistive anomaly confirms with the seismic structure defining Wisting. Also note how the resistive data delineates the two discoveries and defines the size of the reservoirs. The Hanssen discovery is much smaller than the Wisting discovery. Seismic data courtesy of TGS. CSEM data courtesy of EMGS.

Interpretation of EM Anomalies

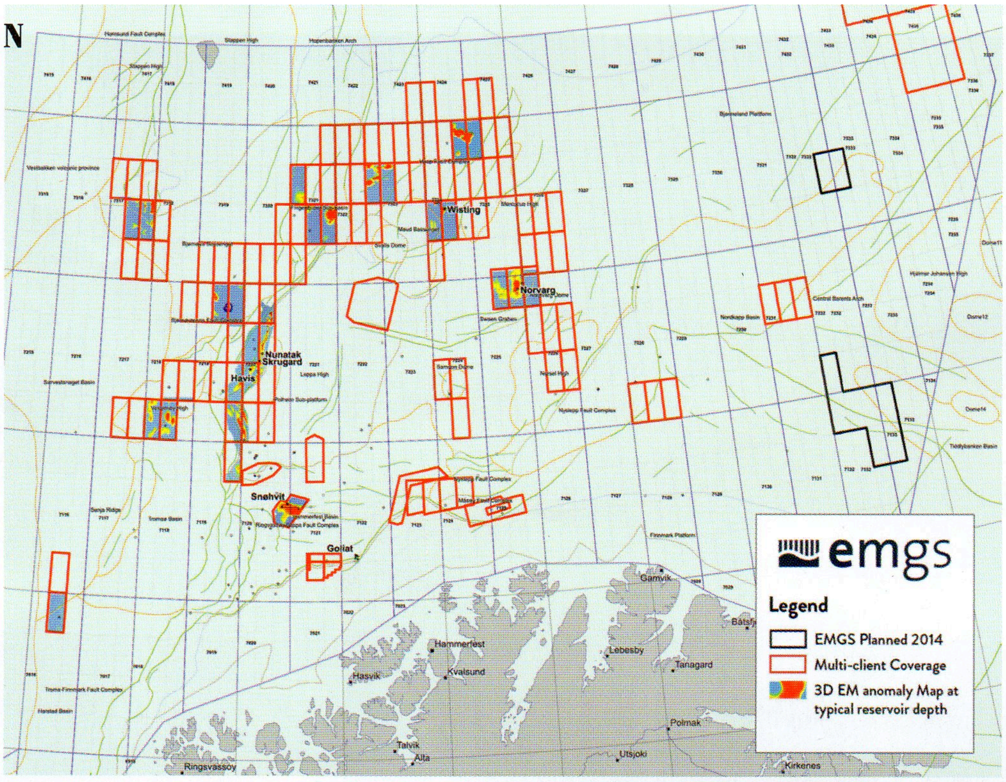
3D Controlled Source Electromagnetic (CSEM) data – in this case acquired and interpreted by the leader in this field, EMGS – maps resistive anomalies in the subsurface, where the larger the resistive body, the greater the response.

Subsurface resistivity and the integrated interpretation of EM anomalies is being used today to improve play and prospect evaluation, with the establishing of a clear correlation between the response of the EM measurements and the fluid content of the reservoir. Furthermore, the CSEM signal is driven by the size (area and thickness) of the resistive body – two important parameters that tend to be associated with the highest uncertainties in reserves estimation.

Nowhere is this correlation being better demonstrated than in the Barents Sea where EMGS has to date acquired 40,000 square kilometres of 3D EM data and where Jonny Hesthammer, Managing Director of Atlantic Petroleum Norway and Professor at the University of Bergen, is using the well-known correlation between the size of the EM anomalies and the volume of hydrocarbons in the reservoir in his pre-well predictions. This correlation has then been backed up by subsequent drilling results.

Exceptionally Good Correlation

In the Hanssen-well (7324/7-2) for example, drilled in June 2014, an EM anomaly was coincident with the discovery and resembled the nearby Wisting discovery. The Hanssen structure was located seven kilometres northwest of the Wisting Central oil discovery and 315 kilometres from Hammersfest in Northern Norway.



Successes in the Hoop area of the Barents Sea include a major discovery at the Wisting Central structure in 2013 followed by another find in 2014 at the nearby Hanssen well

According to Hesthammer, "The results are startling, I have looked at EMGS's inverted multi-client EM data from the Hoop area and there is simply an exceptionally good correlation between the strength and extent of observed EM anomalies and the volumes of hydrocarbons. For example, the largest EM anomaly in the area is related to the Wisting Central Structure with estimates of 132 million barrels of oil equivalent (boe) and the second largest anomaly relates to the Hanssen discovery where 18 to 56 million boe were detected. This anomaly is approximately a quarter of the size of Wisting, which fits perfectly with the size of proven reserves."

He continues: "We also must not forget that the Wisting Alternative structure was deliberately drilled outside the EM anomaly associated with the Hanssen discovery. Here, the well targeting hydrocarbons in the Kobbe formation was dry which was again in agreement with the EM data."

Observed Anomaly Correlation

So what happened in the case of the Atlantis, Mercury and Apollo wells drilled by Statoil?

In the case of the Mercury well, there was an apparent EM anomaly associated with the prospect but the strength of the anomaly was only a third of that of the Hanssen prospect and subsequently delivered much smaller volumes at 6-12 million boe. "Again a fabulously good correlation between the observed anomaly and the discovery of the amount of hydrocarbons in the area," Hesthammer says.

In regard to the Apollo and Atlantis wells further north, the wells were drilled in an area with significantly higher background resistivity than observed for the wells further south. Yet again, the EM data remains compelling according to Hesthammer: "Apollo was drilled just outside a distinct resistive lineament and is therefore not linked to any clear EM anomaly. It should therefore be no surprise that this well was dry. For the Atlantis well, however, the picture is more nuanced. There is no obvious anomaly associated with this prospect either, but EM data revealed slightly elevated resistivity, which fits nicely with the observation of small amounts of gas in the well."

The results of Hanssen and Mercury also show that 3D EM is sensitive to small targets with hydrocarbon columns in some cases down to ten metres (32 feet).

Lessons Learned

So what can we learn from these results and the correlation between EM anomalies and hydrocarbons?

"The data from the Hoop area is some of the most persuasive I have seen in terms of evidence that EM technology works", concludes Hesthammer.

Yet, the question remains whether lessons will be learned and whether EM data will be used to its maximum potential in future drilling decisions. How many dry wells will there be (all subsidised by the Norwegian government), for example, before a traditionally conservative industry accepts the correlation between 3D EM anomalies and discoveries and makes CSEM surveys an active part of the prospect evaluation workflow?

In the harsh and sensitive environment of the Barents Sea, EMGS and the EM data generated are playing a crucial role in influencing lease decisions and reducing the occurrence of expensive dry hole and non-commercial discoveries.

In such an area of geological complexity and where seismic data can struggle on its own, the integration of EM data into the exploration workflow allows for a better classification of prospects through the downgrading or upgrading of the probability of finding hydrocarbons, thereby improving the success rates of operators that incorporate the data into their decisions-making. As can be seen in this article, such information is often vindicated once drilling takes place. ■

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