3D CSEM Exploration Performance in the Barents Sea

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Abstract

The Barents Sea in Norway has been explored for almost 35 years. Industry interest in the area has varied during these years. Today it is experiencing a peak in exploration due to recent oil discoveries and the opening of new areas in the east within the previously disputed zone between Russia and Norway. The exploration risk in the area relates to inefficient sealing and reservoir quality. A wide range of multiclient geophysical data is available in the area including conventional to high-resolution seismic, gravimetry, well data and 3D electromagnetic data. This paper describes the performance of 3D Controlled Source Electromagnetic data (CSEM) and how exploration is improved through integration of seismic and CSEM data. CSEM is a marine remote sensing technique indirectly sensitive to both hydrocarbon saturation and resource volumes. CSEM data responses are controlled by the resistivity distribution of the subsurface sediments. Resistivity varies with different rock types and is closely related to the total porosity of a formation. What makes 3D CSEM interesting for exploration is that resistivity varies with the composition of pore space fluid. Replacing brine in a sandstone reservoir with either gas or oil will significantly increase the resistivity at saturations higher than 50%. At high hydrocarbon saturation, sandstone has several orders of magnitude higher resistivity than water-filled or low hydrocarbon saturated sandstone. CSEM data can therefore identify interesting exploration targets and separate between low and high hydrocarbon saturation, the latter being a major challenge for seismic data. Altogether 50 000 km^2 of 3D CSEM data is available in the Barents Sea covering more than 30 wells. We show that CSEM data has very high prediction strength with respect to identifying significant oil and gas discoveries in the area. Our case examples demonstrate that integration of 3D CSEM and seismic data is necessary in order to enable risk reduction of seismically defined prospects. We show data examples from both dry and discovery wells, and illustrate how CSEM differentiates between non-commercial and commercial discoveries. We also demonstrate that adding CSEM data to the exploration workflow can generate new leads, which may eventually turn into prospects. Today, many oil companies apply an integrated workflow between seismic, CSEM and well data to improve exploration performance in the Barents Sea.