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Marine Transient EM Surveys

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SUMMARY

We describe transient electromagnetic (EM) surveys in water depths of about 100 m, where conventional Controlled Source EM (CSEM) has great problems with the air wave. Our proprietary method recovers the complete Earth impulse response, optimising signal strength with offset-dependent coded signals. Air wave removal is straightforward and our new method for removing magnetotelluric (MT) noise increases the low-frequency signal-to-noise ratio by about 20 dB. We demonstrate the techniques on real data from the North Sea.
Introduction

Resistivity is much more sensitive than acoustic impedance to brine saturation, and hydrocarbon-saturated rocks are much more resistive than brine-saturated. The search for hydrocarbons is enhanced, therefore, when conventional seismic methods are complemented by electromagnetic methods that measure the resistivity of sub-sea formations.

The proprietary transient EM method we describe (Wright et al., 2002; Ziolkowski et al., 2007), known as MTEM, has been designed to overcome many of the known problems of conventional CSEM. Unlike CSEM which works in deep water, MTEM works onshore, in transition zones, and in shallow water, as well as in deep water. Unlike CSEM, it has real-time quality control, and is designed to recover the full bandwidth of the Earth response at all offsets. Unlike CSEM, air wave removal is straightforward (Ziolkowski and Wright, 2007).

Method

The essence of the method is to measure both the transient source input current and the transient receiver output voltage response and then deconvolve to recover the full bandwidth Earth impulse response. Transient EM signal strength is maximised with a coded signal input and appropriate geometry and bandwidth. We have recently developed a method for removal of magnetotelluric (MT) noise which enables the signal-to-noise ratio to be increased by about 20 dB. This allows faster acquisition and deeper penetration.

Unconstrained inversion of the full bandwidth data recovers the depth information that cannot be recovered from CSEM data without a priori constraints.

Results of MT noise removal

We illustrate one step in the process. Figure 1 shows a common source gather of 250 s duration. Traces are at 200 m intervals with source-receiver offset ranging from 2,000 m on the far left to 7,200 m on the far right. The MT noise is well correlated across all the channels and the coded signal decreases in amplitude from left to right. Figure 2 shows the result of deconvolution. The upper traces are about 20 s long and still contain the MT noise. After MT noise removal the impulse responses are clearly visible, as shown on the lower traces.

Figure 1. Common source gather     Figure 2. MT noise removal after deconvolution

Conclusions

We will show step-by-step processing of multi-transient EM data from North Sea surveys, including unconstrained inversion of the data.

This method has obvious applications for the reduction of drilling risk for land and marine exploration for hydrocarbons, for monitoring production onshore and offshore, both in time-lapse surveys and by permanent monitoring, and for CO₂ sequestration, since CO₂ is resistive.

References