Marine CSEM in time and frequency domain: some ways to enhance reservoir response.

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The efficiency, depth investigation and the spatial resolution of Controlled-Source Electromagnetic (CSEM) measurements in shallow and deep water environments are studied in both time- and frequency-domain.

I show that use of time-domain responses measured at very late time after the current-off can be more productive in shallow water and even on land. In a similar way, the use of very low frequencies ($f < 0.05$ Hz) in frequency domain measurements can overcome the airwave effect, allowing the technology to be used in shallow water.

In deep water the fundamental CSEM frequencies ($f = 0.25$ Hz and higher) still provide enhanced reservoir response and higher spatial resolution. However, the signal level is the biggest challenge at this frequency range: due to the stronger skin-effect, the signal may be prohibitively noisy, especially at longer offsets (> 5 km). The modeling shows that it is not as big problem in time domain.

The main barrier to adoption of CSEM method in oil industry is its relatively low spatial resolution and depth of investigation of both time and frequency-domain. A new Focused Source Electromagnetic (FSEM) method lifts this restriction, exploiting an idea of focusing the EM field in vertical direction, similar to the resistivity well logging tools like Laterolog. It removes the airwave effect in shallow water application. Both modeling and field examples demonstrate high spatial resolution and enhanced depth of investigation of FSEM.

The key tool for any interpretation in full 3D geometries is accurate and efficient 3D modeling software. I present a 3D finite-difference (FD) method of modeling EM responses based on iterative wide-band multi-frequency or multi-time Spectral Lanczos Decomposition Method. I show how it enables studying reservoir responses.