Analysis of 1D, 2D, and 3D Marine CSEM in COMSOL Multiphysics® Software

Edelson da C. Luz[1]
1. Universidade Federal do Pará, Belém, PA, Brasil

Introduction: The Marine Controlled Source ElectroMagnetic (marine CSEM) is a geophysical method used by the oil industry to investigate resistive targets in the sediments under the ocean floor. In this work we simulate marine CSEM data including 1D, 2.5D and 3D modeling.

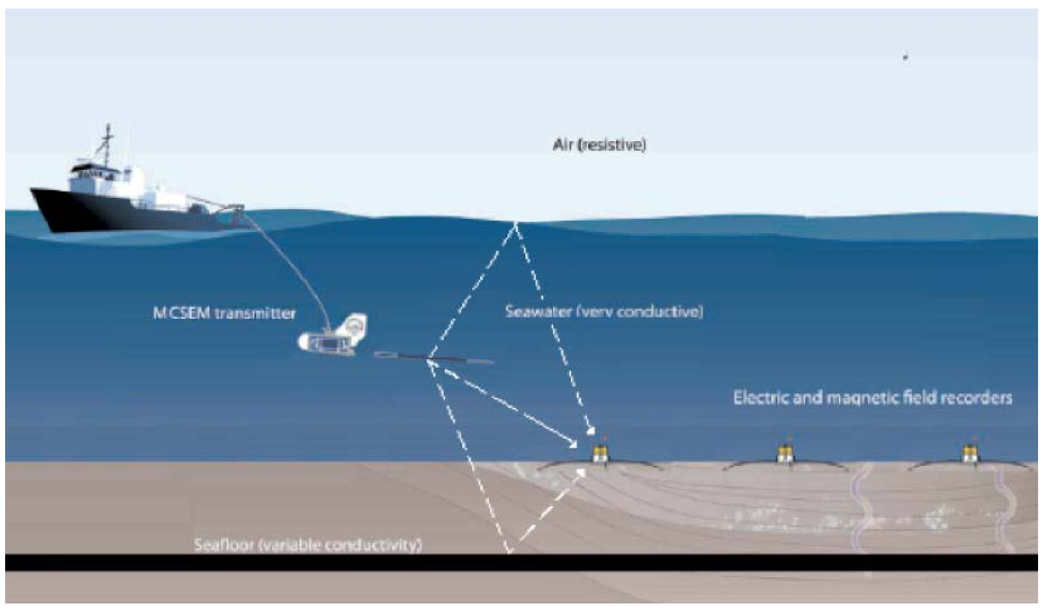

Figure 1. Illustration of the marine CSEM method. Adapted from Weitemeyer, Constable e Key (2006)

Computational Method: The source of the EM field is a horizontal electric dipole near the seabed. The field is calculated in the frequency domain, with the RF Module. Scattering boundary condition was used, with the boundaries located at more than five skin-depths from the source. A hydrocarbon reservoir is simulated by a resistive layer one thousand meters deep bellow the ocean floor. The finite element mesh was refined in the resistive layer and at the receiver positions.

Results: The 1D and 2D environments were simulated using a 3D mesh. In the 1D modeling all horizontal layers extend laterally to the outer boundaries of the mesh. Figure 2 shows results for 1D modeling using COMSOL, compared with those from Luz (2009), both for 1 Hz.

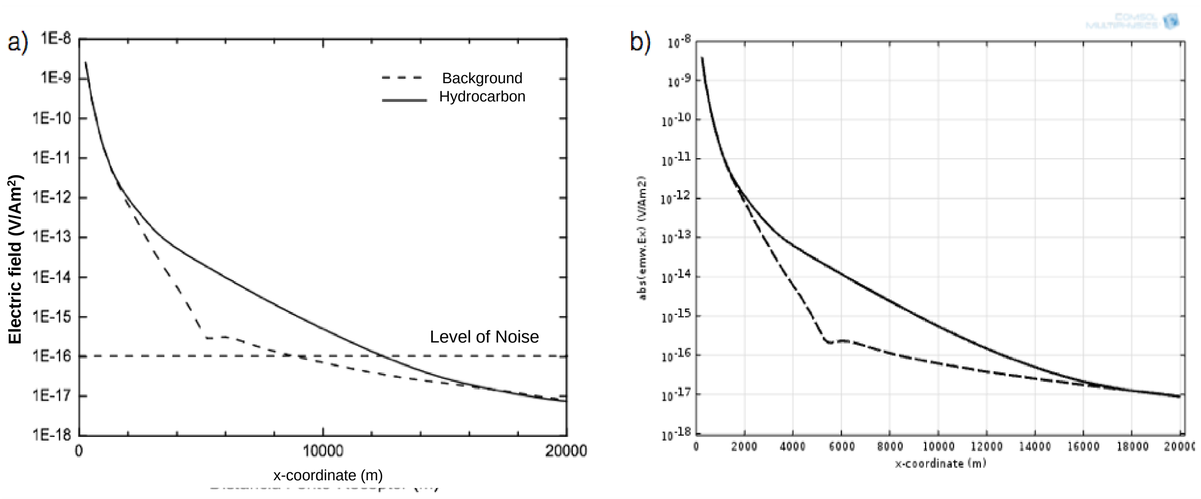

Figure 2. Results for MCSEM 1D. a) Luz (2009); b) Using COMSOL.

The result shown in Figure 3 reproduces that of the 2D model presented by Abubakar (2006). In the 2D model the resistive body extends to the domain boundaries only on the *y* axis and on the negative *x* axis. The COMSOL response using the mesh of Figure 3-b shows excellent agreement with the result of Abubakar (2006).

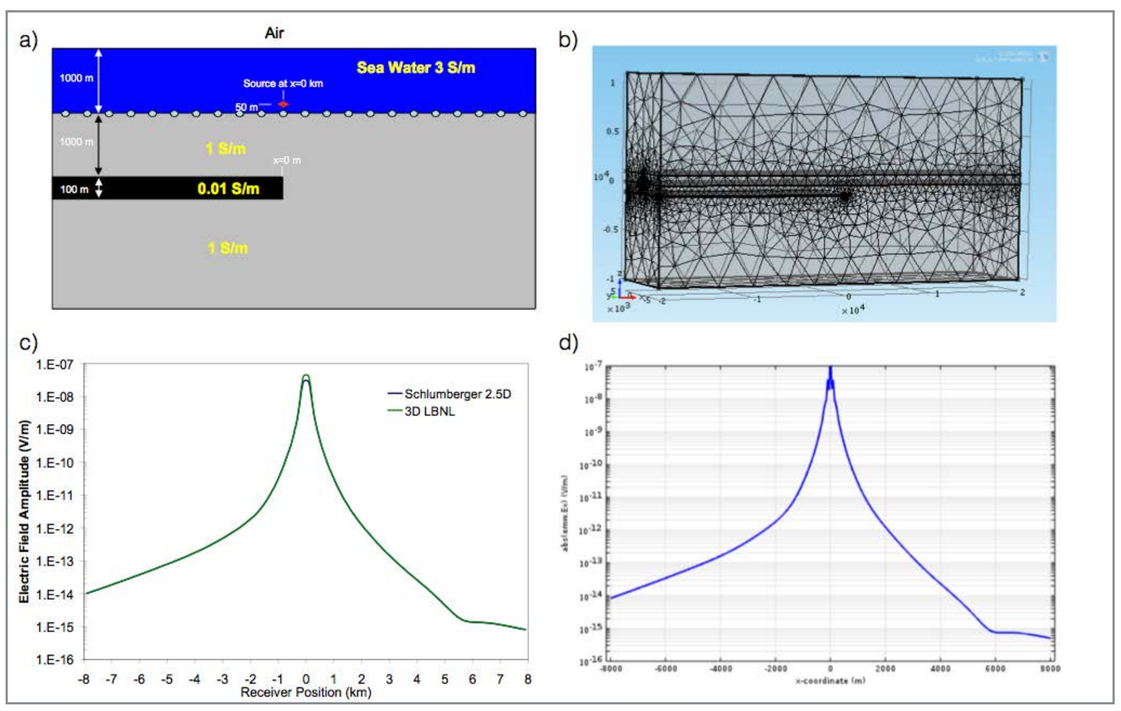

Figure 3. 2D study with 0.635 Hz . a) model from Abubakar (2006). b) mesh generated by COMSOL. c) results from Abubakar (2006). d) results using COMSOL.

The longest time to generate the results was less than one minute, for the 1D model, running on a MacBook Pro laptop computer with 8GB of RAM and I7 quad-core processor.

Conclusions: The results obtained with COMSOL Multiphysics software show themselves as a promising tool for the studies of electromagnetic methods in prospecting of hydrocarbons, providing satisfactory results that can be obtained in very short times, independently if analysis is performed in 1D, 2D or 3D.

References:

Abubakar, A.; Habashy, T,; Druskin, V.; Alumbaugh, D.; Zerelli, A. and Knizhnerman L. Two-and-Half-Dimensional Forward and Inverse Modeling for Marine CSEM Problems. SEG/New Orleans 2006 Annual Meeting

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Weitemeyer, K.; Constable, S.; Key, K. Marine EM techniques for gas-hydrate detection and hazrd mitigation. The Leading Edge, v. 25, p. 629-632, (2006).