3D CSEM Inversion Including Induced Polarization Effect

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Abstract

In this study, the forward and inverse modeling of data from the Marine Controlled Source Electromagnetic Method (MCSEM) with the inclusion of the induced polarization effect will be presented. In some geological formations, above the hydrocarbon reservoir, a region with pronounced mineralization can be created and that is capable of generating considerable capacitive effects, due to the upward flow of fluids that are formed during the period of formation of the hydrocarbon reservoir, whether due to geological faults or other structural reasons. For a correct physical representation of this phenomenon in the modeling of MCSEM data, it is necessary to consider dispersive effects in the model, especially in the resistivity. One of the most used models for this purpose is the Cole-Cole model, which takes into account the dispersive effect of resistivity and depends on four parameters to represent the model's resistivity, there are: Resistivity at infinite frequency, chargeability, damping constant and of time. In the forward modeling, the vector finite element technique was used for the numerical solution of Maxwell's equations adapted to the problem. In the inverse modeling, the minimization of the nonlinear objective function was done with the Gauss-Newton method, together with the Marquardt strategy during the iterations. To stabilize the inverse problem, the Global Smoothness regularizer was used, which produced unique solutions for the problem. The study showed that the parameters of infinite resistivity and chargeability, of the Cole-Cole model, have sensitivities in the MCSEM data a few orders of magnitude greater than the other two parameters, which justified making the inversion only with those two, decreasing by two times the size of the normal equation that is solved in the inverse problem.