Steel Casing Effect on Land CSEM Monitoring

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Abstract

The potential of electromagnetic methods for CO_2 or gas reservoir monitoring has intensified the development of deep controlled-source electromagnetic (CSEM) techniques on land. In many applications, the deep source is located near the steel casing of the borehole, resulting in the currents that diffuse through it and produce a measurable perturbation in the surface measurements. This effect has to be taken into consideration when analyzing the responses of land CSEM surveys. However, a realistic and accurate simulation of the casing effect is a significant numerical challenge. While some numerical schemes utilize the symmetry of the casing and can efficiently model simple geometric structures, full three-dimensional simulations are required in complex geological settings or in presence of heterogeneous conductivities in the casing. Due to the huge conductivity contrast near the thin walls of the casing, its modeling requires a spatial discretization that allows for accurate results at very different scales (from centimeters to tens of meters). In addition, mixing highly conductive elements of steel casing with relatively resistive subsurface and insulating air in one model makes the resulting system matrix very ill conditioned. In this report, we present the results of a set of numerical simulations for a realistic case. It corresponds to a CO_2 reservoir on a deep saline aquifer (1300-1500m deep). As a source, we consider an electrical vertical dipole located at 1520m, at the end of a vertical steel casing 1500m long. The presented results include electrical responses at the surface and inside the borehole. Different scenarios of pre- and post- CO_2 injection are considered to address key practical questions, as how is the behavior of the distorting casing fields? Which is the offset distance where the casing effect dominates? Which is the minimum of CO_2 amount required to obtain a significant change in the responses at the surface? Good agreement between the responses of the different scenarios demonstrates the feasibility of simulating casing effects in complex geological areas.