Examining the impact of steel cased wells on electromagnetic signals

Lindsey Heagy and Douglas Oldenburg

Electromagnetic methods are actively being explored for their potential to characterize induced fractures. Electrically conductive fluid and proppant may be used to introduce a physical property contrast that is associated with the stimulated region of a reservoir. This then serves as the target of the electromagnetic survey. A complicating factor is that the settings in which hydraulic fractures are being induced have steel-cased wells present. These wells introduce significant physical property contrasts because they have an electrical conductivity on the order of 5.5×10^6 S/m and a magnetic permeability in the range of 50 - 200 μ_0, which can vary along the length of the well. As such, the presence of the well will have a large impact on the electromagnetic fields and fluxes.

In many of the experiments being considered, an electrode is coupled to the steel casing, either at the top or at depth, and a return electrode is positioned some distance away from the well. Thus, if we are to use data from these experiments to characterize subsurface targets, we must understand how the casing affect the EM fields. In this presentation, we will focus our attention to examining the behaviour of currents, electric and magnetic fields for a variety of source configurations for both time and frequency domain experiments where the source is coupled to a vertical well. In particular, we will examine the impact of magnetic permeability and variations in permeability along the length of the well, as well as variations in casing thickness and the presence of gaps or flaws in the casing. In practice, a DC approximation of electric fields in a 0.5Hz - 1Hz frequency domain electromagnetic experiment is often taken so that the collected data can be inverted using a cheaper, DC simulation, rather than solving the full 3D electromagnetic problem. We will discuss the impacts this assumption has on the source-fields used to excite the target.

This numerical simulation study will consider vertical wells, focussing our attention to accurate numerical simulations of the steel casing. The numerical simulations are conducted using SimPEG, and open source software package for finite volume simulations and inversions (http://simpeg.xyz).