Geophysical Research Abstracts
Vol. 17, EGU2015-10385, 2015
EGU General Assembly 2015

Effect of borehole design on electrical impedance tomography measurements

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Electrical Impedance Tomography (EIT) is a sophisticated non-invasive tool to investigate the subsurface in engineering and environmental studies. To increase the depth of investigation, EIT measurements can be made in boreholes. However, the presence of the borehole may affect EIT measurements. Here, we aim to investigate the effect of different borehole components on EIT measurements using 2,5-D and 3D finite element modeling and unstructured meshes. To investigate the effect of different borehole components on EIT measurements, a variety of scenarios were designed. In particular, the effect of the water-filled borehole, the PVC casing, and the gravel filter were investigated relative to complex resistivity simulations for a homogenous medium with chain and electrode modules. It was found that the results of the complex resistivity simulations were best understood using the sensitivity distribution of the electrode configuration under consideration. In all simulations, the sensitivity in the vicinity of the borehole was predominantly negative. Therefore, the introduction of the water-filled borehole caused an increase in the real part of the impedance, and a decrease (more negative) in the imaginary part of the simulated impedance. The PVC casing mostly enhanced the effect of the water-filled borehole described above, although this effect was less clear for some electrode configuration. The effect of the gravel filter mostly reduced the effect of the water-filled borehole with PVC casing. For EIT measurements in a single borehole, the highest simulated phase error was 12% for a Wenner configuration with electrode spacing of 0.33 m. This error decreased with increasing electrode spacing. In the case of cross-well configurations, the error in the phase shit was as high as 6%. Here, it was found that the highest errors occur when both current electrodes are located in the same borehole. These results indicated that cross-well measurements are less affected by the presence of the borehole than measurements in a single borehole.