Effects of borehole design on complex electrical resistivity measurements

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Abstract

Recent studies have shown that electrical resistivity measurement in boreholes can be influenced by the borehole design and the aquifer properties. It was found that large boreholes and aquifers with a large formation factor are particularly prone to erroneous resistivity measurements. However, effects of the borehole casing have not been considered yet. Within the context of the 4DEIT project, we have developed a broadband borehole Electrical Impedance Tomography (EIT) measurement system that enables complex electrical resistivity measurements of unprecedented accuracy. To support the interpretation of these borehole EIT measurements, the aim of this study is to investigate the effect of PVC borehole casing and the complex nature of the electrical conductivity on the EIT measurements. In order to do so, we used a 2D axisymmetrical finite element model that solves the Poisson equation. The borehole is located at the rotational axis and the 2D coordinates are the radius of the cylinder and the depth along the borehole. The finite element discretization consists of triangular elements which are smaller near the borehole. To get realistic values for the complex resistivity, we analyzed spectral induced polarization measurements made on aquifer material from the Krauthausen test site using Debye decomposition. The resulting complex resistivity values were implemented in our model together with an effective representation of the borehole casing that considers the resistivity of PVC and the slotted fraction. This model was then used to investigate the effect of borehole diameters, effective properties of the borehole casing, and the formation factor on the complex resistivity. To validate the simulations, we performed measurements in a water column. For this, a symmetrical rain barrel filled with tap water was used. It was concluded that the properties of the borehole casing have a large impact on the apparent resistivity when two current electrodes are situated in the same borehole.