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Using electrical anisotropy for sub-scale structural characterization of sediments: an experimental validation study

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Knowledge of subsurface heterogeneity is important for a correct representation of flow and transport in subsurface hydrological systems. Recently, Winchen et. al. (2009) presented a numerical study in which the anisotropy in effective complex resistivity of 2D bimodal facies distributions was successfully used to estimate the volume fraction of the two facies, the Cole-Cole parameter describing the electrical response of each facies, and the correlation length ratio that provides important information on the spatial arrangement of the facies. Power-law mixing model was used to predict electrical response, and parameters were inverted by fitting to simulated electrical effective complex resistivity data for two perpendicular directions. The objective of this work was to experimentally validate the findings of the numerical study of Winchen et al. (2009) using a 2D measurement cell. In their numerical study, the effective complex resistivity was determined from the simulated current flow in response to an applied potential gradient. This is not experimentally feasible. Instead, we now determined the effective spectral electrical properties from a superpositioning of a set of current injections and voltage measurements. Two materials were selected and the spectral electrical properties were measured with SIP in the frequency range from 10-2 to 10+4 Hz. In a first step, numerical studies were performed that validated the superpositioning method to determine the effective electrical properties and confirmed that the inverse estimation of the correlation length ratio is feasible for the two selected materials. In a second step, the two materials were spatially arranged in the 2D measurement cell following a bimodal facies distribution generated by SISIM. The effective spectral complex resistivity was determined by superpositioning of measurements made with a laboratory EIT system and used again to estimate volume fraction, correlation length ratio, and Cole-Cole parameters describing both materials. A reasonable agreement between the known and inversely determined properties was found.

References

Winchen T., A. Kemna, H. Vereecken, and Johan A. Huisman, 2009, Characterization of bimodal facies distributions using effective anisotropic complex resistivity: A 2D numerical study based on Cole-Cole models: Geophysics, 74, 19-22.