Improved inversion of Induced Polarization and Transient Electromagnetic methods to characterize fractured media

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The characterization of aquifers located in fractured rocks requires the development of investigation techniques that permit to gain information with high spatial resolution and across broad spatial scales, considering the large subsurface heterogeneity imposed by fractures, their connectivity and extension. Hence, hydrogeological investigations have exploited the ability of geophysical methods to provide quasi-continuous information about subsurface properties. In particular, the Electrical Resistivity Tomography (ERT) and seismic methods are well-established methods used for the site characterization. Moreover, recent studies have also demonstrated an improved hydrogeological characterization by means of the Induced Polarization (IP) method, an extension of the ERT technique that provides information about the electrical conductivity and capacitive properties of the subsurface. Nevertheless, the uncertainty of the electrical methods increases with increasing the depth of investigation. To overcome this limitation and gain further information about changes in the electrical properties at depth, we here propose the application of Transient Electromagnetic (TEM) soundings, a technique well suited for deep investigations. Hence, variations in subsurface electrical properties can be solved in the shallow to intermediate depths through IP imaging, with deeper information resolved through TEM data. To evaluate our approach, we conducted combined geophysical investigations at three different study areas in Austria. The study areas represent different geometries, namely: (1) near Melk, representing a deep contact (> 50 m depth) between the Molasse formation and the Bohemian massif along the Diendorfer fault system (2) near Untersiebenbrunn, for an intermediate contact (> 20m depth) between flysch and the crystalline basement; and (3) the Rosalia study area, representing a shallow (<10 m depth) contact between soil and fractured gneiss. Our results show the possibility to gain detailed information about lithological changes in the different study areas, with an improved lithological interpretation of the electrical units following a cross-validation of the IP and TEM imaging results. Moreover, inversion of the IP data after inclusion of the TEM information permitted to improve the electrical images. Seismic measurements were also used to validate the contacts observed in the electrical images. Nevertheless, our results clearly demonstrated an improved hydrogeological characterization through the combined application of IP and TEM measurements.