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Feasibility Study of Monitoring Delft Geothermal Project Using Land Controlled-Source Electromagnetic Method

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Delft geothermal project (DAPwell) is a planned geothermal well doublet, where relatively cold water is going to be injected through one well into a low enthalpy geothermal reservoir to produce hot water from the other well. The volume of the cold water around the injection well will increase over time and, in the end, result in a thermal breakthrough. Thus, it is essential to trace the time-lapse change in the volume of the cold water to monitor the DAPwell efficiently. The invaded reservoir volume by the cold water is associated with a decrease in the pore fluid temperature and salinity. This increases the electrical resistivity of the geothermal reservoir, where the cold front is located. Hence, estimating the time-lapse change in the electrical resistivity of the geothermal reservoir can be used to identify the distribution of the cold water. From a theoretical point of view, the controlled-source electromagnetic (CSEM) method can be used to get information about the change in the electrical resistivity within the geothermal reservoir. In this study, we investigate the feasibility of monitoring a geoelectric model of the DAPwell using land CSEM forward modelling. The optimal survey design is investigated as well as the influence of cold water volumetric changes on the time-lapse electric field response. The impact of measurements undesired effects on time-lapse CSEM response is analysed and then synthesized.

A subsurface model of the DAPwell is illuminated by a horizontal electric dipole source, which emits a sinusoidal field with several frequencies. Based on the numerical experiments, surface measurements do not pick up sufficient time-lapse signal to use them for field applications. On the other hand, the difference in the z-component of the electric field, determined along a depth section, allows for a successful detection of the electrical resistivity changes within the geothermal reservoir. The correlation between the spatial distribution of the cold water and the difference in time-lapse electric field responses is clarified. Finally, it is noticed that the difference in time-lapse signal is measurable in the presence of the different sources of noise.