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The effect of filter cake deposition on the hydraulic conductivity of boreholes

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Efficient construction and operation of borehole heat exchangers (BHEs) are essential in its contribution to the energy transition. In practice, implementation of BHE at larger scale requires low construction costs and high production rates. This requires small diameter drillings to reduce drilling and backfilling material costs, in which achieving a proper backfilling is a challenge. At present, there is an urgent need to improve the available techniques with more effectively and efficiently backfill methods for BHEs. In current Dutch practice, sealing (to prevent short-circuit flow between penetrated aquifers) is achieved by using either clay or grouts as backfilling materials, both have their pro's and con's. In optimisation of applying backfilling materials and methods, the filter cake, formed during the drilling procedure, also has a sealing capacity and is overlooked in addressing the sealing of the borehole.

In this study the effect of filter cake formation on sealing capacity in unconsolidated sediments is quantified. Filter cake formation in unconsolidated porous formations (aquifers) is a complex process, which is affected by pressure differences between the borehole and the aquifer, aquifer characteristics (e.g. grain size distribution, porosity and permeability) and drilling mud/fluid properties.

A laboratory configuration is designed to stimulate different scenarios during the construction of a BHE. Consequently, the effectiveness, in terms of hydraulic conductivity, of the formed filter cake is determined by falling head tests.

Uniform aquifers with the smallest grain size tested (D50 = 0.22 mm) show a two order of magnitude reduction in hydraulic conductivity, as a direct result of filter cake formation. In contrast, filter cake formation is absent in uniform more coarse sands (D50 ≥ 0.65 mm). This demonstrates that filter cake deposition is highly variable with the grain size of the aquifer penetrated. Moreover, the experiments performed indicate that the deposition of a filter cake is not limited by additive concentrations in the drilling fluid or the duration of drilling fluid exposure to the formation.

This preliminary study creates the foundation for further research, since the experiments

demonstrate the potential of filter cakes to significantly contribute to the sealing capacity within a borehole.