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On the use of hydration heat for quality management of borehole heat exchanger grouting

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The ongoing energy transition from conventional, fossil fuel based energy generation, over to renewable energy sources led to an increase in geothermal energy use. Different systems for extracting heat from the subsurface are in use, whereas a commonly used system is the borehole heat exchanger (BHE). A BHE generally consist of a closed loop pipe system through which a heat exchanging fluid is circulated. The BHE is surrounded by grouting. The grouting, focus of this work, has two main objectives to fulfill: Firstly, to thermally couple the subsurface and the BHE pipes; and, secondly, to protect the pipes and to prevent the heat exchanging fluid from entering the subsurface in case of BHE mechanical failure. Therefore, to provide proper functionality, efficiency, and safety of a BHE, it has to be guaranteed that the grouting does not have defects.
The hardening reaction (hydration) of the grouting is exothermic, whereas the grouting is mostly a variant of (thermally enhanced) cement. The hydration temperature depends on the type of grout as well as the possible dilutions (resulting in defects) of the grouting material by water, air or drilling debris, and the thermal transport potential of the subsurface. Therefore the quality of the grouting can be investigated by temperature measurements during the hardening process.
To validate this further, tests on field and laboratory scale were conducted. For laboratory testing, different columns were built in which different defects of BHE grouting and pipes were simulated. For defect simulation isolation and mixing with drilling debris were chosen, representing inclusions of water and/or air during cement casting as well as partial collapse of the borehole. The temperature changes during installation and hardening of the grouting are measured by fiber-optic distributed temperature sensing (DTS). This allows for temporal and spatial high resolution, continuous temperature measurements at the interface of pipe to grout material. To increase inherent spatial resolution of the DTS device, for laboratory scale experiments, wrapping the fiber around the pipe is used.