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Supporting deployment of mine water geothermal in disused coalfields with high-resolution datasets from a highly instrumented geoenergy observatory

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Flooded disused mines have significant potential to supply clean heating and cooling and for seasonal storage in areas that could continue benefiting from the mines after closure. A proved technology, a more widespread deployment of mine water geothermal development is hampered by technical, socio-economical, and regulatory challenges. Among the technical challenges, the long-term system behaviour is an uncertain but fundamental element, regarding both the groundwater flow and heat distribution in the subsurface aquifer and the optimal performance of the geothermal installation and its components. A further development of mine water geothermal requires information and data from pilot, commercial and research installations to improve the knowledge about these complex systems, understand the interaction with the surrounding environment and learn from the experiences towards a more optimal design and construction of the geothermal infrastructure.

The UK Geoenergy Observatory (UKGEOS) in Glasgow was built between 2019 and 2023 as an at-scale research facility to study mine water geothermal. The observatory includes five boreholes drilled and screened into two levels of mine workings, four of them equipped with pumps and valves to allow for multiple configurations of abstraction and reinjection with operational pumping rates up to 12 l/s. The mine water boreholes are also equipped with hybrid fibre-optic cables for distributed temperature sensing (DTS) and electrical resistivity tomography (ERT) sensor arrays. The monitoring capabilities are complimented with an additional non-screened mine borehole, also equipped with DTS and ERT, and five environmental boreholes screened into the bedrock and the superficial aquifer to monitor the hydrogeological and thermal responses in the surrounding aquifers. The geothermal installation includes a sealed pipe between the abstraction/reinjection boreholes, three heat exchangers that can be used independently to test their performance, and a 200-kW heat pump/chiller. The system is equipped with sensors in the geothermal pipe circuit, the wellhead and downhole for high temporal resolution monitoring of hydraulic and thermal changes during the use of the Observatory and under natural conditions.

In this work we present results from some of the first geothermal tests performed in the Observatory in 2023. These include abstraction-reinjection in both heating and cooling modes with multiple configurations and variable flow rates and reinjection temperatures taking advantage of the capabilities of the Observatory. The datasets have been processed and examined with the support of numerical modelling. The analysis of hydraulic and thermal data from the multiple sensors in the mine and monitoring boreholes, the DTS and ERT, and the geothermal installation before and after heat exchange and reinjection have provided further insights about short- and long-term responses of the system. The observations show the different temporal and spatial scales of the hydraulic and thermal responses to the use of the geothermal infrastructure that constitute valuable information for the design of new geothermal installations in disused mines. The Observatory is now operative and open to academic and research projects aiming to understand better mine water systems.