Mine-Water Heat, Coal Mines, Temperature Profiles, Numerical Modelling, OpenGeoSys, Dawdon-Horden Coalfield

Heat demand for domestic and industrial space heating represents more than 30% of the energy consumption in the UK. Most of this energy is currently supplied by natural gas, contributing up to 19% of the carbon footprint of the country in 2017. To reach Net-Zero carbon emissions by 2050, the UK Government is looking at new approaches to decarbonize residential heating. Among them, using mine-water from abandoned legacy mine workings as a new low-carbon heat source has been of growing interests. Using open-loop ground-source heat pump systems, heat energy can be harnessed from the 12-20°C water stored in the large underground voids inherited from past mining activities. Although the temperature of the water is expected to increase with depth according to local geothermal gradient, temperature measurements in former mine shafts in the UK revealed the lack of correlation between the depth of the measurements and the mine-water temperature. The aim of this study is therefore to assess the key parameters controlling the temperature profiles in mine-shafts to understand if those can be used to calibrate mine models aiming at assessing their long-term geothermal potential. We use the finite-element modelling software OpenGeoSys to simulate groundwater flow and heat transfers in a 2D porous media representing a mine of simple geometry. We first analyse the effects of a 500-day pumping period followed by mine-water recovery on the temperature distribution in a pumping shaft for different hydraulic boundary conditions, assuming a constant geothermal flux of 0.085 W/m². We then investigate the effects of the material properties, the mine geometry and pumping scenario on the modelled temperature profiles. Time-series of energy change in the system are also calculated to get insights into the relationships between the observed mine-water temperature and the actual heat potential of the mine. Results indicate that the hydraulic conductivity of the worked coal seams intersected by the shaft and the nature of the hydraulic recharge governs the observed temperature profile. During pumping, the average temperature in the shaft depends on the pumping depth and on the temperature of the mine-water flowing into the shaft at the seam insets, as predicted by the undisturbed geothermal gradient. Heat convection in the highly-permeable mining voids during prolonged dewatering periods is however suggested to disturb the rock temperature and alter the initial geothermal gradient around the shaft over the long-term. Although mine-water in the shaft re-equilibrates with the surrounding rock within ~20 years following the cessation of pumping, the nature of the hydraulic recharge during water rebound also tend to control the mechanisms of heat recovery and the residual temperature anomaly in the shaft. Further analysis is being undertaken to assess the thermal footprint of long-term mining on the observed temperature distribution in flooded coal mines, considering more realistic mine geometry and dewatering history.