PROJECT TITLE: Assessing the geothermal resource available from abandoned coal mines

University of Bristol Research Theme(s): Climate/Environment, Digital/Data

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Project keywords: geothermal; abandoned coal mines; coupled modelling; geophysical monitoring

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**Figure 1: Schematic illustrating the typical design for an abandoned mine geothermal system**

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**Project Background:**
The decarbonisation of domestic and commercial heating remains a major challenge for the UK’s net-zero strategy. The use of abandoned coal mines as a source of low enthalpy geothermal heat provides an attractive opportunity to provide a source of low-carbon heating to urban homes and businesses in Bristol and across the UK. Because the development of the coal industry spawned the development of many of our towns and cities, over one quarter of the UK’s housing stock overlies abandoned mines (Adams et al., 2019). The Coal Authority estimates that flooded coal mines in the UK may contain 2.2 million GWh of heat. Hot water from abandoned mines is typically extracted through borehole doublets, with hot water being extracted, passed through a heat exchanger, and re-injected into a different part of the mine. Abandoned mines present a complex system from a hydrogeological perspective, with different spaces and materials through which flow can occur, including voids (mine shafts and roadways); goaf (rubble material generated by collapse of mined spaces) and back-filled material; and fault/fracture pathways through the intact rock. The design and placement of production and re-injection wells must account for these uncertain subsurface conditions. Flow pathways from injector to producer must be of adequate length such that re-injected cooled water does not quickly re-circulate to the producer, but with sufficient permeability to avoid increases in pressure at the injector, which could lead to unwanted environmental consequences such as fluid leakage to the surface, or ground deformation.

**Project Aims and Methods:**
In this project, the student will conduct a multi-disciplinary study to address key uncertainties that have so far limited the development of abandoned mine geothermal projects. The objectives of the proposed research are:

- To analyse geophysical measurements, combined with thermal and hydrogeological observations, in order to image, map and quantify the flow of fluid and heat through an abandoned mine system as geothermal heat is extracted.
To develop coupled hydrothermal models to simulate the flow of heat and fluids through abandoned mine systems. These models will be verified and calibrated with geophysical observations.

To use calibrated numerical models for sensitivity analysis and scenario-testing – what geological and operational factors will be conducive to generating high returns of geothermal heat that are sustainable over a long period, and what factors might pose the greatest challenges for successful abandoned mine geothermal developments?

The student will analyse geophysical data collected at the UKGEOS pilot project in Glasgow, Scotland. At this site, geothermal injection/production doublets have already been drilled into an abandoned coal mine system. These wells have been instrumented with a suite of geophysical instruments, including fibre-optic cables suitable for use as a Distributed Acoustic Sensing (DAS) arrays for passive and active seismic monitoring; and continuous electrical resistivity tomography (ERT) systems. The student will use ParaGeo (Crook et al., 2018), a coupled thermal/hydro/mechanical simulation toolkit to develop numerical simulations of heat production and fluid flow. Once calibrated, these models will be used to evaluate the potential resource, and to investigate how extraction and re-injection wells might be sited to optimise heat production and minimise environmental impacts.

Most interest in disused coal mine geothermal heat has so far been in the north of England and in Scotland. However, abandoned mines are found across the UK, including under the city of Bristol. To date, little effort has been made to quantify the potential for abandoned mine geothermal heat underneath Bristol. Therefore, as a final component of the proposed research, the student will take the modelling work and learnings made at the UKGEOS Glasgow site, and use this knowledge to investigate the potential for low carbon heating for the city of Bristol.

Candidate requirements: This project requires a student with an undergraduate degree in geophysics, geology, physics, engineering, or a related discipline. Some experience in the use of coupled models to simulate subsurface flow/geomechanics would be beneficial but not essential. Some programming experience is also desirable.

Project partners (if any): British Geological Survey (BGS)

Training: Training will be provided in the use of ParaGeo to simulate coupled subsurface processes. Training will also be provided in the analysis and inversion of geophysical datasets. You will have the opportunity to visit the UKGEOS Glasgow site, a state-of-the-art facility for monitoring disused mine systems.

Background reading and references:

Useful links
http://www.bristol.ac.uk/earthsciences/courses/postgraduate/

How to apply to the University of Bristol:
http://www.bristol.ac.uk/study/postgraduate/apply/

The application deadline is Monday 14 February, 2022 at 2359 GMT.

Interviews will take place during the period 10 March – 18 March 2022.

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