The Heat Beneath Our Feet: Modelling Mine Energy Systems

Durham University, Department of Earth Sciences

In partnership with The Coal Authority

Supervisory Team

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Summary

Mine geothermal energy is a viable, low-carbon heat source to warm our houses. Before installation of such mine geothermal system, it is essential to investigate the potential of local mines using predictive numerical water circulation models. This PhD project aims to investigate mine geothermal systems using numerical models to enable generic recommendations and advise on the potential productivity and risks of specific sites. The project will involve code development as well as collaboration with local and national institutes. The student will become part of a vibrant research community at Durham University, with interaction with research groups within the department of Earth Sciences, the Durham Energy Institute (DEI), and Advanced Research Computing (ARC) community across the University.

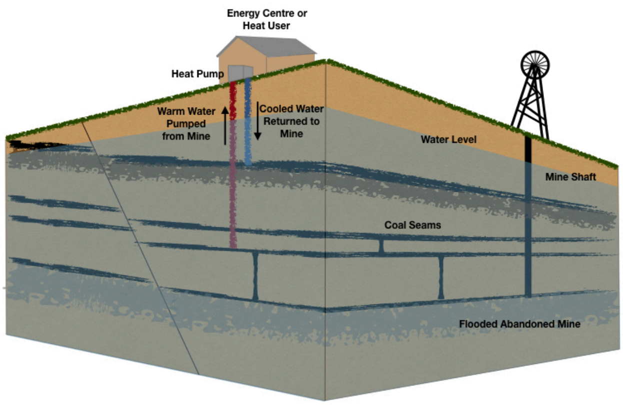

Figure 1) Schematic representation of a minewater heat pump system.

Background

Over half of UK energy demand is used to produce heat, most of this comes from burning gas and most is consumed by the domestic sector. In the past, coal mining directly provided the energy to heat our homes. While coal energy is phased out to decarbonise our energy supply, the water within flooded abandoned mines provide a huge source (2.2 million GWh) of geothermal heat for the future, enough to meet the UK's heating demand for more than a century. The mine water is only lukewarm (12-20°C), but by using a heat pump, temperatures can be increased to a more comfortable 40-50°C (Bailey et al, 2016). Heat pumps need electricity, but for every kW of electrical input, the mine water heat output is 3-4 kW, making this an efficient energy source. Research has shown that our abandoned mines could meet our heat demands for a century or more and will deliver economic opportunities to former mining areas (Fig.1).
After extracting its heat, the mine water is returned to the subsurface to avoid surface water contamination, and the right location(s) for re-injection of the water is crucial for the thermal evolution of the mine system. In addition, mine water could interact with nearby (drinking water) aquifers, so a proper understanding of the hydrogeological behaviour of the mine system is required. Therefore, numerical modelling of mine water and surrounding groundwater flow and associated heat exchange is an essential first stage for the successful deployment of these geothermal mine systems (Loredo et al, 2016).

Methodology

This student will investigate the exchange of heat (Rodríguez & Díaz, 2009) and chemicals between mine water and the regional subsurface by developing novel and bespoke software to integrate existing and user-written thermal and chemical hydrogeological numerical models (Fig. 2). For access to mine plan data, model calibration against real systems, and incorporation of the significant local expertise, this project plans significant collaboration with the Coal Authority, the NERC Geoenergy Observatory

(Glasgow), and local county councils. Project outcomes include optimization strategies for prospected geothermal sites in the UK and elsewhere (e.g. Stanley, South Tyneside, and Blyth Port), and calculation of the effective geothermal heat capacity for onshore and North Sea near offshore asset opportunities. The onshore abandoned mine models will be further developed to address dual porosity systems in conventional former onshore/nearshore petroleum reservoirs (Beatrice in the Moray Firth; Hewett in the Southern Gas Basin).

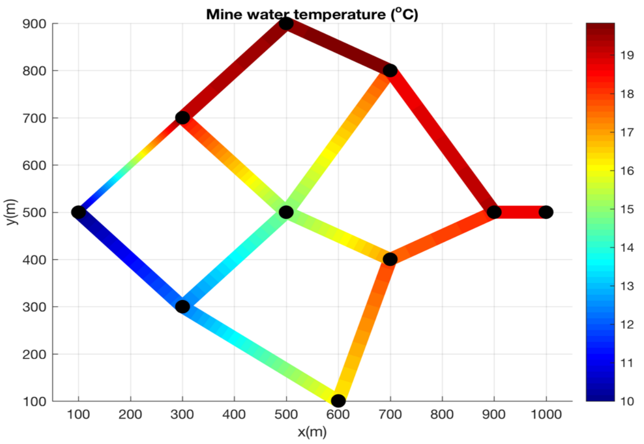

Figure 2) Synthetic example of a mine water temperature and flow calculation.

Timeline

Year 1: Training in numerical modelling, data, and knowledge exchange with regional institutes, county councils and the Coal Authority; setting up and testing of numerical models; training in project specific and transferable skills.

Year 2: Code development; application to targeted test sites; industrial secondment to enhance skill set and future employability; academic publication writing.

Year 3: Collect scientific results that will be written up in the form of several scientific publications; these will be combined with further chapters to integrate into a first draft of the PhD thesis.

Year 4: project completion: finalizing thesis and submission of scientific manuscripts.

Training & Skills

The student will become part of the GeoNetZero CDT, which offers a multidisciplinary package of training focused around meeting the specific needs and requirements of each of our students who benefit from the combined strengths and expertise that is available across our partner organizations.

The student will benefit from a vibrant research culture in the department of Earth Sciences, in which ~70 PhD students work on various geoscience projects. In particular, Geoenergy, Environmental Science, and Computational Geoscience form major research clusters in the department of Earth Sciences, and have dedicated group meetings and seminars. The student may join the Centre for Doctoral Training in Energy for additional training activities (e.g. lectures, site visits), while the Durham Energy Institute (DEI) provides opportunities to engage in networking with other energy researchers and professionals involved with industry, policy and governance, as well as with outreach events, competitions and public lectures.

Training opportunities: data management of high-performance computing systems; numerical modelling (programming, code development, model setup, and usage); general and transferable skills.

The student is expected to attend national and international conferences to disseminate research results and to spend time away from Durham to integrate all project partners at the partner institutes.

An industrial secondment will provide valuable research experience in a commercial environment. The skills acquired through academic training and research can be applied in a different environment, while this secondment will also provide a direct link into industry, as an essential network component.

References & Further Reading

- Bailey et al. (2016). Heat recovery potential of mine water treatment systems in Great Britain, Int. J. Coal Geol., Volume 164, 77-84, https://doi.org/10.1016/j.coal.2016.03.007.
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Further Information

For further information on the PhD project, the department of Earth Sciences or doing a PhD in Durham, please feel free to contact Jeroen van Hunen (jeroen.van-hunen@durham.ac.uk)