The Heat Beneath Our Feet: Modelling Mine Energy Systems

Durham University, Department of Earth Sciences

In partnership with The Coal Authority

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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 and application as well as collaboration with local and national institutes. The student will become part of a vibrant research community at Durham University.

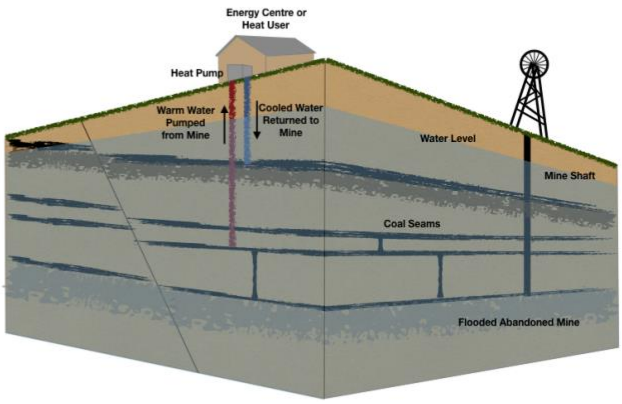

Figure 1) Schematic representation of a minewater heat pump system.

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). 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

Numerical modelling of mine water flow and heat exchange between the subsurface and mine water will be used to assess whether and under which conditions a mine system can provide long-term heat supply. Model reliability depends on the accuracy of local mine data, appropriate modelling software, and model calibration with experimental data. We will apply those models to prospective production sites. The project therefore has the following objectives: 1) Data collection. Mine data collection is achieved through collaboration with the Coal Authority and local former mining communities. Collaboration with the BGS and the UKGEOS Glasgow Research centre will provide geological and hydrological data. Links with industrial partners (in county Durham and Heerlen, the Netherlands) will provide data from operating minewater pumping sites. 2) Code development. Our bespoke mine geothermal model (Fig.2) will be combined with a BGS hydrogeological model to look at the local heat exchange (Rodríguez & Díaz, 2009) between mines and circulating minewater. 3) Model application will provide optimization strategies for prospected geothermal sites in the UK and elsewhere.

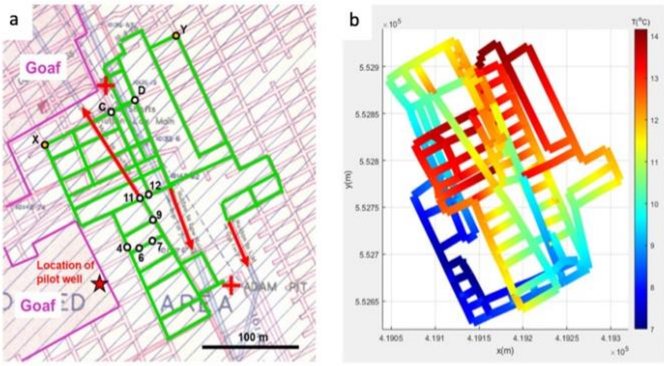

Figure 2a) Project example: Part of the mine plan under the Louisa Centre, Stanley, County Durham, UK. b) Modelling of the long-term mine water heating for this mine system through abstraction from the Hutton coal seam, and re-injection into a shallower seam.

Timeline

Year 1: Training in numerical modelling & data; knowledge exchange with regional institutes, county councils and Coal Authority; developing & testing of models; 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 postgraduate 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).