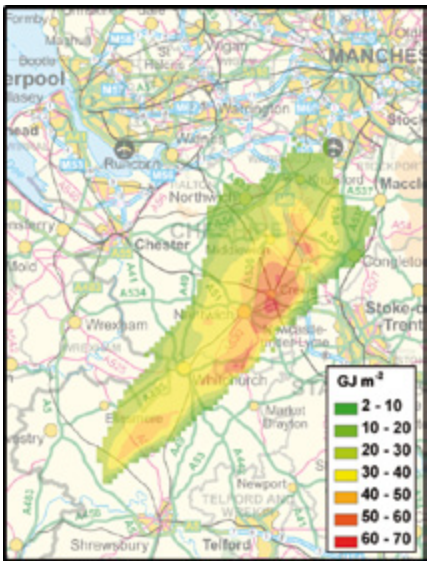
Abandoned coal mines allow us to tap into the Earth's natural heat. **Diarmad Campbell** and **colleagues**[1] explain how BGS can help achieve a low carbon future for the UK.

Future energy

Energy resources have been a major focus for BGS over our 175 year history. In the past, our geologists searched for coal to keep the UK supplied with energy crucial for economic development. Coal mining subsequently declined and by the 1980s we were studying abandoned mines to try and resolve problems of subsidence, flooding as the dewatering pumps were switched off, and contaminated water discharging into rivers. More recently we have returned to our geological maps and archives of coal mine plans with a new energy source in mind—geothermal energy.

Geothermal energy is heat stored in the ground. An example we are all familiar with is steaming geysers in active volcanic areas such as Iceland. In these places the ground is extremely hot and the heat energy resource is relatively easy to tap. In some cases steam can be used directly to drive electricity generating turbines. Even the UK has some areas where hot rocks are present at accessible depths, for example in Cornwall temperatures of 100°C are found at 2.6 kilometres depth. In the 1970s and 1980s the BGS investigated deep saline waters in sandstones in Northern Ireland and England to identify places where usable energy might be available. This work is being revisited and extended to provide resource estimations of use to local and regional planners who are interested in new applications such as agricultural heating.

Geothermal energy is very attractive as it is renewable, with the heat being replenished by heat from the centre of the Earth (or from the sun in very shallow systems). The carbon emissions resulting from these systems are typically lower than standard heating and cooling systems powered by gas or electricity. The UK is committed to reducing carbon emissions by 80 per cent by 2050 (compared to 1990 levels) to mitigate climate change. The BGS is helping to achieve this by giving estimates of the size of the geothermal resource in the UK and identifying the most suitable locations for such systems. Our geoscientists are following in the footsteps of their predecessors by seeking out energy resources to enable the people of the UK to sustain their quality of life in the future.



Geothermal resource (the heat 'in place'), of Permian sandstones in the Cheshire Basin. The resource is concentrated in the south-east of the basin against the main bounding fault and is centred on Crewe. The greatest resource is shown in red.

Technological advances now mean that we can also make use of a more widespread energy resource — geothermal sources of lower temperature. Ground source heat pumps (GSHPs) can be used to take heat energy out of the ground at almost any temperature. The heat may be removed by pumping groundwater out of the ground (open loop GSHP) or by circulating a fluid through pipes underground (closed loop GSHP). Either way the heat pump takes heat energy out of the liquid (making it colder) and can 'concentrate' that heat to provide water of useful temperatures for space heating of buildings. GSHPs can be used in reverse to cool buildings during the warmer months and the ground can even be used to store the heated water pumped in during the summer in order to retrieve that heat when needed in winter. This technology is widely used in other countries, such as Denmark, and is gaining popularity in the UK.

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Abandoned coal mines are a new focus because they commonly contain lots of voids which have filled up with groundwater (water held underground in holes and cracks in rocks) since mining ceased and dewatering pumps were switched off. This groundwater can be pumped out to feed GSHP systems. Our

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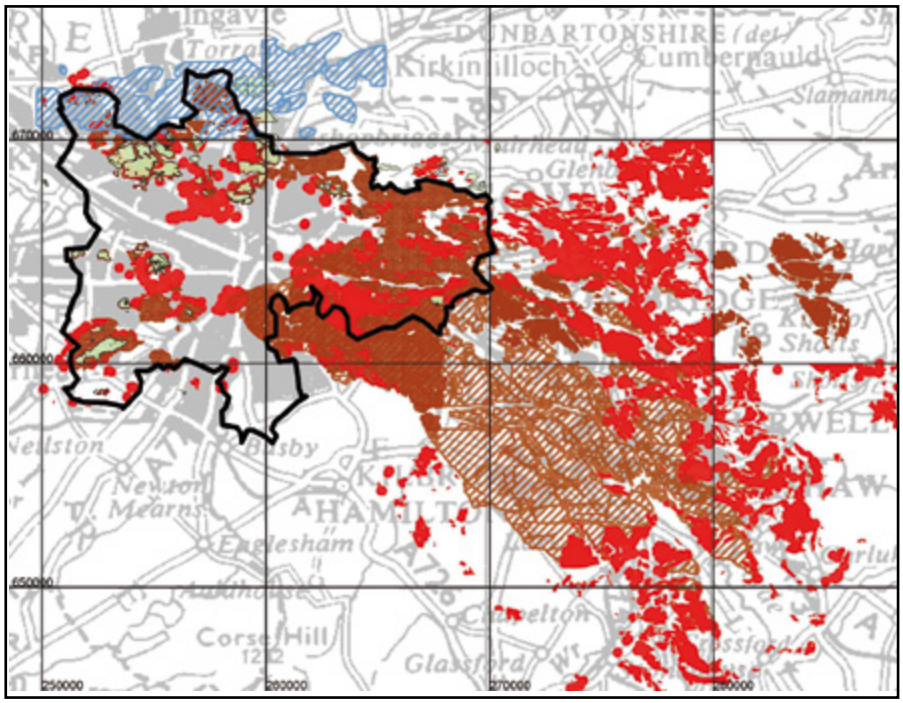

Extent of mining (areas in red and brown), based on various sources, and of a buried valley (blue) beneath Glasgow (outlined in black) and nearby towns.

records of abandoned mines date back to 1839 — an amazing resource of great value to the nation.

For example, the ground that much of Glasgow is built on contains a network of abandoned mines that once employed hundreds of people to extract coal, ironstone and other minerals. Most of the mines were collapsed soon after the coal had been extracted, but these rubbly collapsed layers can still store and transmit significant volumes of groundwater. Larger voids remain in the form of old shafts and roadways as many of these are still propped open. As part of a large multidisciplinary initiative, the Clyde Urban Super Project (CUSP), the BGS is assessing ground source heat resources beneath the Glasgow area. For this, detailed 3D geological models have been developed of the complex deposits and rocks beneath much of the city and adjoining areas. The models integrate a lot of disparate information held in various formats by the BGS and other organisations and provide an excellent platform for interpreting the groundwater systems associated with mine workings. Thermal modelling of the mine waters on a variety of scales (local to conurbation) can be undertaken. The uncertainty inherent in individual model layers is also routinely quantified using the recently developed BGS confidence calculator.

We are working with local authority and private sector partners, for example under the Sustainable Glasgow initiative, to develop strategies to exploit these resources. GSHP systems fed by mine waters could contribute to the heating and cooling demands of houses and offices built as part of large regeneration projects. Our assistance will help to ensure that such projects are successful. Our work provides the basis for local authority decision-makers, private energy-providers, and developers, in conjunction with the Coal Authority and others, to commit to long-term low-carbon energy strategies utilising ground source heat, especially in urban areas. It can also underpin the rapid expansion in ground source heat installations that is likely to occur as a result of long-term financial support to be provided under the forthcoming Renewable Heat Incentive scheme, to be introduced in April 2011.

Our proud history of seeking out energy resources continues as we help to provide the UK with the low carbon energy needed for a healthy and prosperous future.

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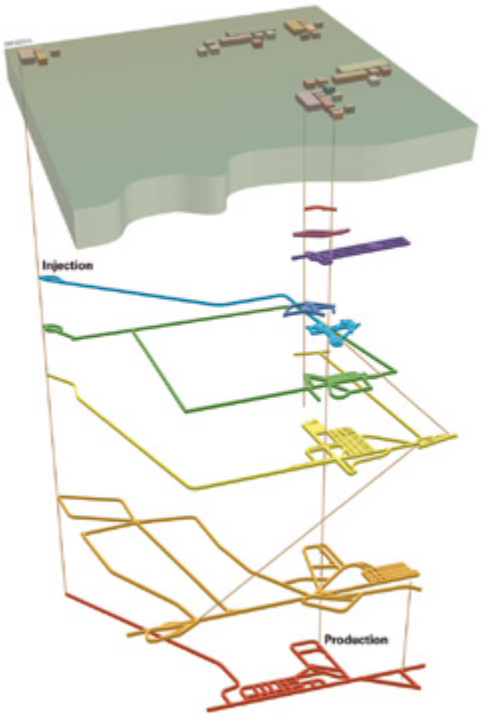

A 3D representation of a minewater-related ground source heat reservoir, at Heerlen in the Southern Netherlands (modified after Mine Water Project 2008; see www.minewaterproject.info).