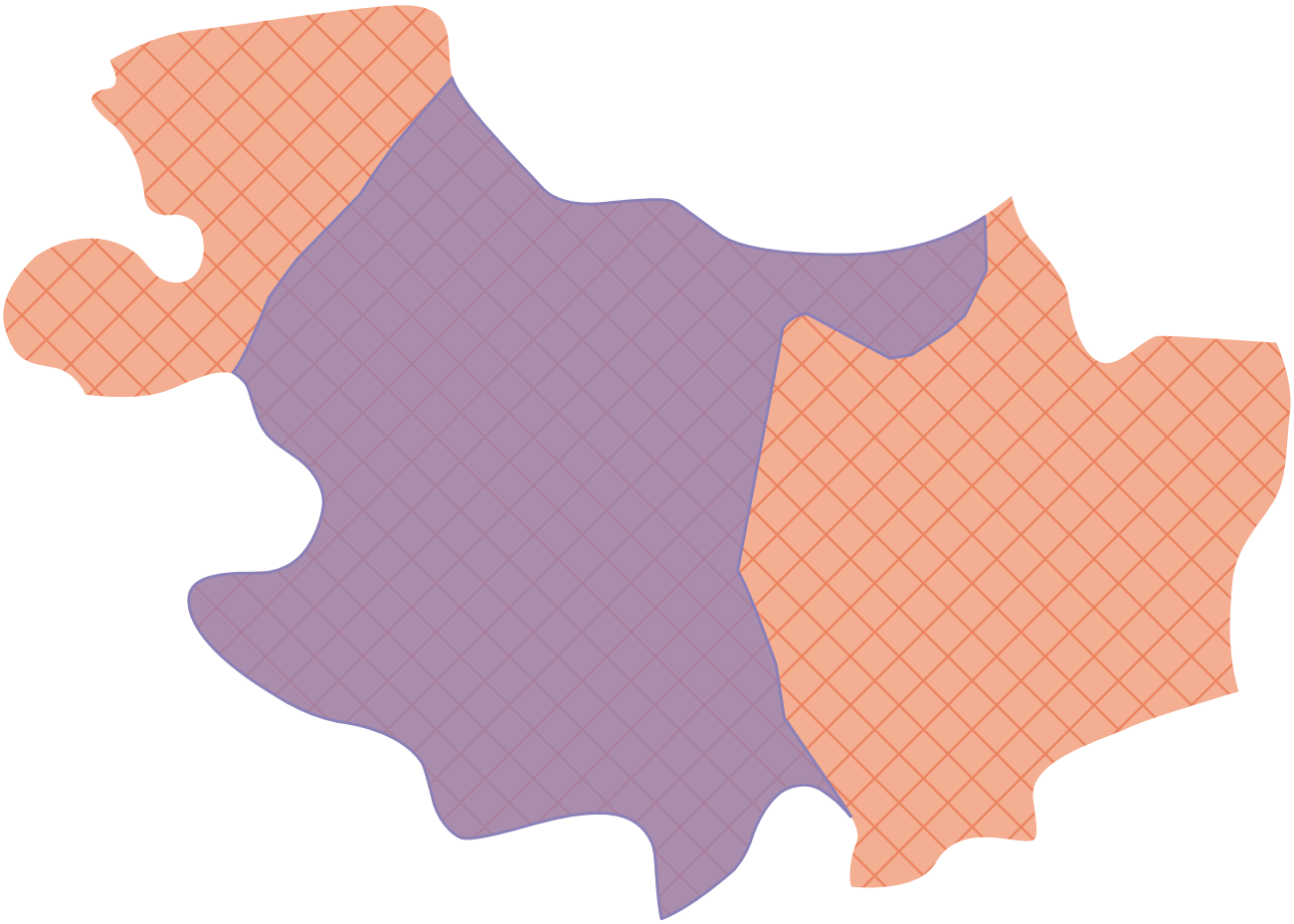
Radioactive Waste Management



Central England

SUBREGION 2

Contents

Clicking on words in green, such as sedimentary or lava will take the reader to a brief non-technical explanation of that word in the Glossary section. By clicking on the highlighted word in the Glossary, the reader will be taken back to the page they were on.

Clicking on words in blue, such as Higher Strength Rock or groundwater will take the reader to a brief talking head video or animation providing a non-technical explanation.

For the purposes of this work the BGS only used data which was publicly available at the end of February 2016. The one exception to this was the extent of Oil and Gas Authority licensing which was updated to include data to the end of June 2018.

Our work shows that we may find a suitable geological setting for a GDF in some of this subregion.

Rock can be seen at the surface in some of the subregion such as Cannock Chase and the Wrekin and in man-made excavations such as quarries or road cuttings. Combined with numerous deep boreholes and some geophysical investigations, this gives us an understanding of the rocks present and their distribution.

There are clay-rich rock layers, in which we may be able to site a GDF, in the west of the subregion, west of Stoke-on-Trent, Stafford and Wolverhampton and in the south-east of the subregion, east of Worcester and south of Birmingham and Lichfield. There may also be slates and similar strong rocks between Telford and Market Drayton in which we may be able to site a GDF. We would need to do more work to find out whether these rocks have suitable properties and thicknesses.

Even where individual clay-rich rock layers are found not to be thick enough to host a GDF they may support the siting of a GDF in deeper rocks as they could act as a barrier to groundwater flow from depth. This is important because movement of groundwater is one of the ways in which radioactive material could be carried back to the surface.

Some of the subregion has been mined for coal to depths below 100m, such as the North and South Staffordshire, Leicester, South Derbyshire and Warwickshire Coalfields, and there are also known oil and gas resources north-east of Stoke-on-Trent. In these areas the mining and drilling is likely to have affected the way in which water moves through the rock. Also possible exploration in the future in these areas means that it is more likely that future generations may disturb a facility.

Parts of the north-west and north-east of the subregion have Petroleum Exploration & Development Licences to allow companies to explore for oil and gas. This exploration is currently at an early stage and it is not known whether oil or gas in these licence areas will be exploited. RWM will continue to monitor how this exploration programme progresses.

Parts of this area, such as to the north of Stoke-on-Trent, east of Warwick and around Telford, Cannock and Tamworth, are Coal Authority Licence Areas allowing companies to explore for coal. It is not known whether coal in these licence areas will be exploited. RWM will also continue to monitor how this exploration programme progresses.

Parts of the subregion which are mined for rock salt, around Stafford, Burton-on-Trent and Droitwich Spa, would also need to be taken into account in the siting of a GDF, although the nature of mining in evaporites does not affect the movement of groundwater in the surrounding rocks in the same way as other mining.

Introduction

Central England subregion 2 extends from Stoke-on-Trent in the north, to Telford in the west, south to Stratford-upon-Avon, and east to Coventry.

Rock type

Figures 1a to 1d show where in the region there are likely to be Rock Types of Interest for the development of a GDF within the depth range of interest. The Mercia Mudstone Group is dominated by mudstone, however it is only present in the depth range of interest between Stafford and Burton-on-Trent (where it also includes evaporite beds) and more locally near Whitchurch, Shropshire. Although the Mercia Mudstone Group is predominantly low permeability in this region, some discontinuous sandstone beds are present. Where the mudstone units in this group are thick and extensive, they are known to act as a barrier to groundwater movement and have the potential to act as Lower Strength Sedimentary Rock (LSSR) host rocks.

At the top of the older sedimentary rocks, the Warwickshire Group includes beds of mudstone, interlayered with sandstones and siltstones, which may behave as LSSR. They are present in the depth range of interest over a large part of the subregion. Mudstones are the predominant rock type but are unlikely to form a sufficiently thick and uniform body to act as a LSSR host rock. There is evidence however that they may provide hydraulic separation between deep and shallow groundwater systems. In the south of the region around Coventry and Warwick, thick sandstones are present.

The basement rocks, beneath the older sedimentary rock succession, are poorly known but include a range of Silurian, Ordovician and Cambrian sedimentary and igneous rocks (approx. 420 to 540 million years old), with some even older rocks also. These are similar to rocks occurring at the surface in Wales and the Welsh Borderland region and in some instances the mudrocks may have been folded and metamorphosed to be slaty and have potential as Higher Strength (HSR) host rocks. These rocks are present in the depth range of interest to the north of Telford, where they lie beneath LSSR of the Warwickshire Group.

The BGS have also identified a very small area of potential Evaporite rocks within the depth range of interest to the south of Uttoxeter.

A summary of the geological attributes of the Central England region can be found here, including a simplified rock column showing the oldest and deepest rocks at the bottom, with progressively younger rock units towards the top.

Rock structure

There are a number of major faults in this subregion which bound the sedimentary basins in which the younger and older sedimentary rocks were formed (Figure 2). Faults may act as barriers to or pathways for groundwater movement, depending upon their characteristics, and these would need to be considered during the siting of a GDF[1]. There is evidence that some of the faults in this subregion act as barriers to separate the groundwater within aquifers, such as the Sherwood Sandstone Group, into compartments.

The younger sedimentary sequence in this subregion has gentle dips and is not significantly folded. In some parts of the subregion, most notably in North Staffordshire, the older sedimentary rocks have been folded during the episode of deformation that broke them up into fault-bounded blocks. As a result they locally dip by as much as 30 degrees which is likely to complicate the search for a volume of rock with sufficiently uniform properties in these areas.

[1] Faults occur on a diverse range of scales, from centimetres to kilometres, and the subsurface is criss-crossed by networks of numerous individual faults. However our work includes only those faults identified by the BGS with throws (vertical offset) of 200m or more. This is because the data available to the BGS are not able to resolve all faults consistently, across all thirteen regions, with throws less than 200m. We recognize the potential importance of smaller scale faults to the integrity of a GDF and will need to survey them in detail as part of the site evaluation process.

Groundwater

There is very little information on groundwater in the depth range of interest for a GDF, 200 to 1,000m below NGS datum, although there is information on groundwater in aquifers above 200m. There are several principal aquifers within 400m of the surface in this subregion including the Sherwood Sandstone Group and the immediately underlying Permian Bridgnorth Sandstone. The Sherwood Sandstone Group occurs at the surface mainly in the Stafford district, although elsewhere it is often separated from the surface by rocks of the Mercia Mudstone Group and therefore not recharged from the surface. As a result, the water is often older with water that is too saline to be used for water supply at depths of more than a few hundred metres. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2]. In parts of the subregion, permeable layers within the Warwickshire Group are also exploited as an aquifer. In the south, near Warwick, it is over 1,000m thick and forms a multi-layered aquifer system with sandstone units that yield water separated by mudstone layers that are very low permeability.

The combination of sedimentary rock sequences in which high and low permeability layers alternate, and frequent faults which juxtapose rocks of different properties, means that groundwater is often compartmentalised. As a result, waters in different aquifers do not interact and nearby aquifers may therefore contain waters of contrasting composition.

Mining is likely to have changed the original patterns of water movement in parts of this subregion and shallow groundwater may circulate to much greater depths within the range of interest now than it did before mining. For a large part of this subregion deep exploration boreholes may influence the connectivity between shallow and deep groundwater which would need to be considered during the siting process (Figure 3). Although there are no thermal springs in the subregion, the presence of warm brines present at a depth of 61m at Droitwich Spa indicates the rapid vertical movement of groundwater from below the depth range of interest at this location.

[2] Water Framework Directive UK TAG. Defining and reporting on groundwater bodies, 2012.

Resources

Coal has been mined extensively below 100m in this subregion including the North and South Staffordshire and the Leicester and South Derbyshire Coalfields and the largely concealed Warwickshire Coalfield (Figure 4a). There are also some small hydrocarbon fields in the very north of the subregion (Figure 4b). In these areas the mining and drilling is likely to have affected the way in which water moves through the rock. Also possible exploration in the future in these areas means that it is more likely that future generations may disturb a facility. These known resources would be taken into account in the siting of a GDF.

In addition, there are Coal Authority Licence Areas north of Stoke on Trent, east of Warwick and around Telford, Cannock and Tamworth (Figure 4a), and a number of Petroleum Exploration and Development Licences[3] are currently held in the north-west and north-east of the subregion (Figure 4b). It is not known if coal, oil or gas in these licence areas will be exploited, but they would need to be considered during the siting process.

Rock salt (halite) has been extracted around Stafford, Burton-on-Trent and Droitwich Spa, mainly by solution mining (Figure 4c). Although the nature of mining in salt does not affect the movement of groundwater in the surrounding rocks in the same way as other mining, the presence of any excavations in these rocks would need to be considered in the siting of a GDF. There is potential to use brine cavities for gas storage, which would also need to be considered in the siting of a GDF.

Natural processes

Earthquakes and glaciations are unlikely to significantly affect the long-term safety of a GDF in the UK. Therefore, whilst a GDF would need to be sited and designed to take account of natural processes which may occur during its lifetime, they are not considered further as part of this screening exercise.

[3] This also includes other licences awarded by the Oil and Gas Authority to allow companies to explore for hydrocarbons.

Figure 1a The areas of the Central England subregion 2 where any of the 3 Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

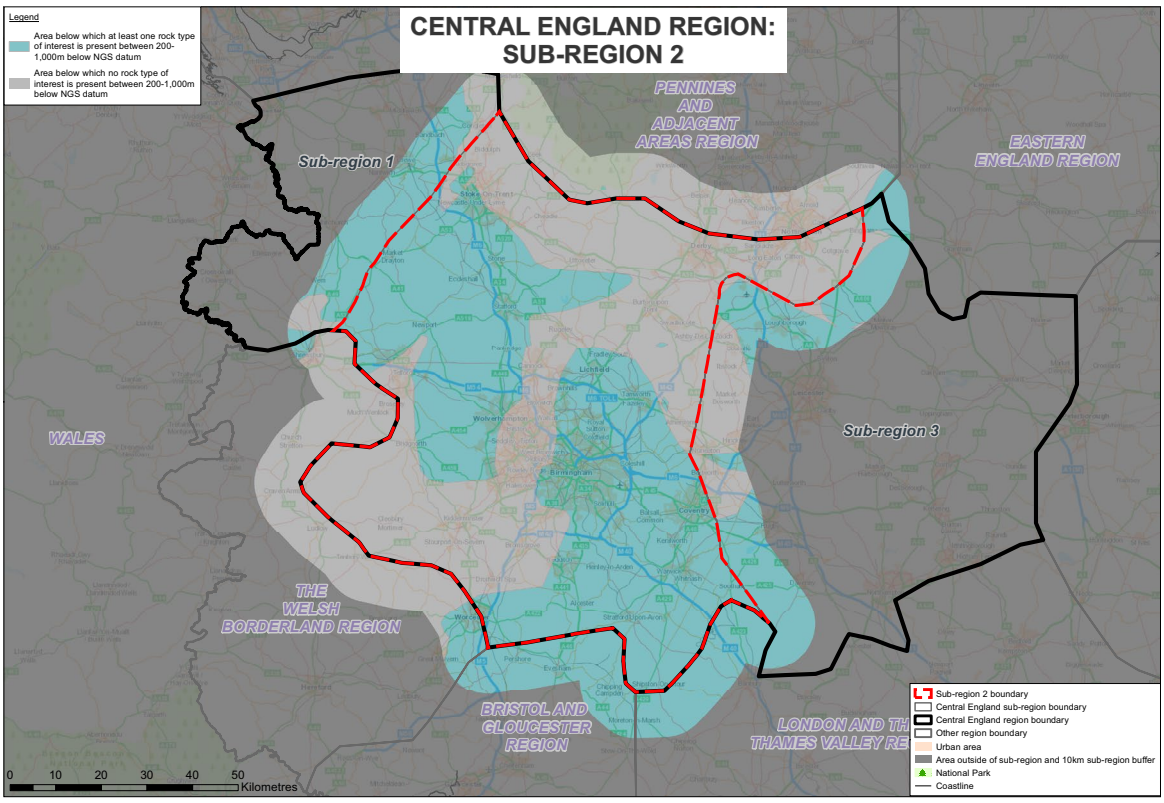


Figure 1b The areas of the Central England subregion 2 where Lower Strength Sedimentary Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

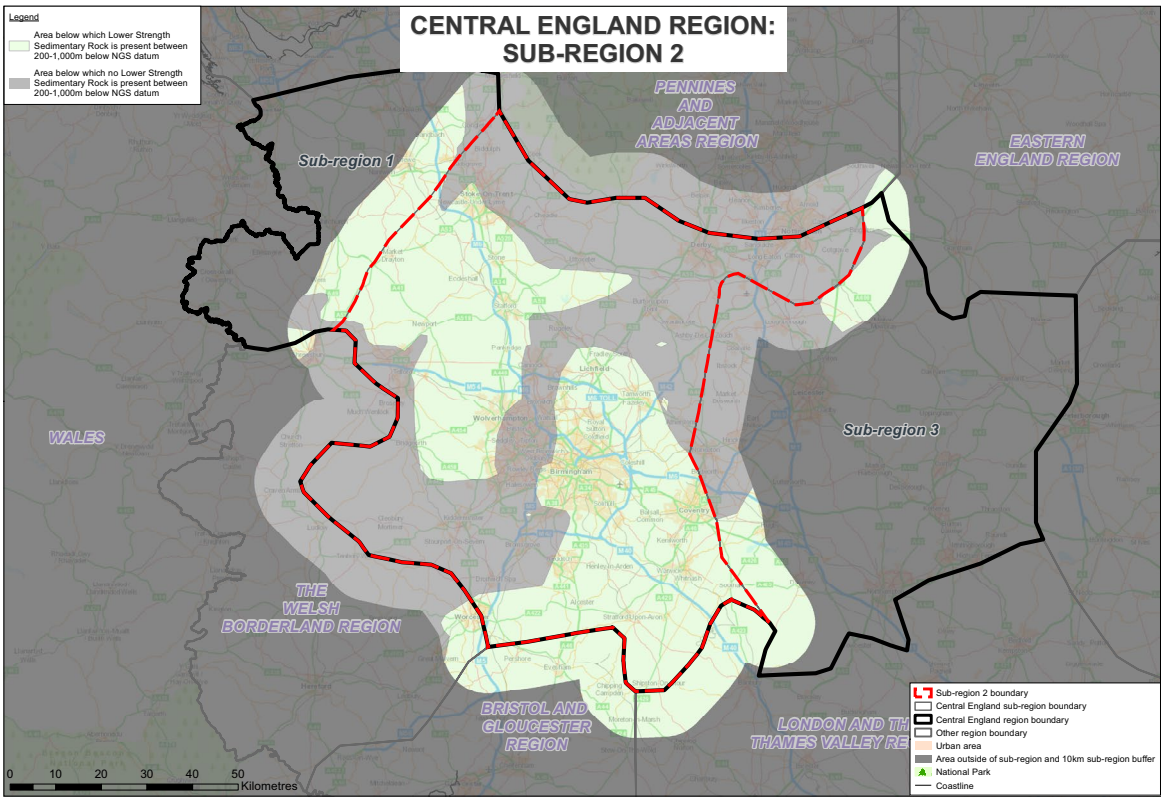


Figure 1c The areas of the Central England subregion 2 where Higher Strength Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

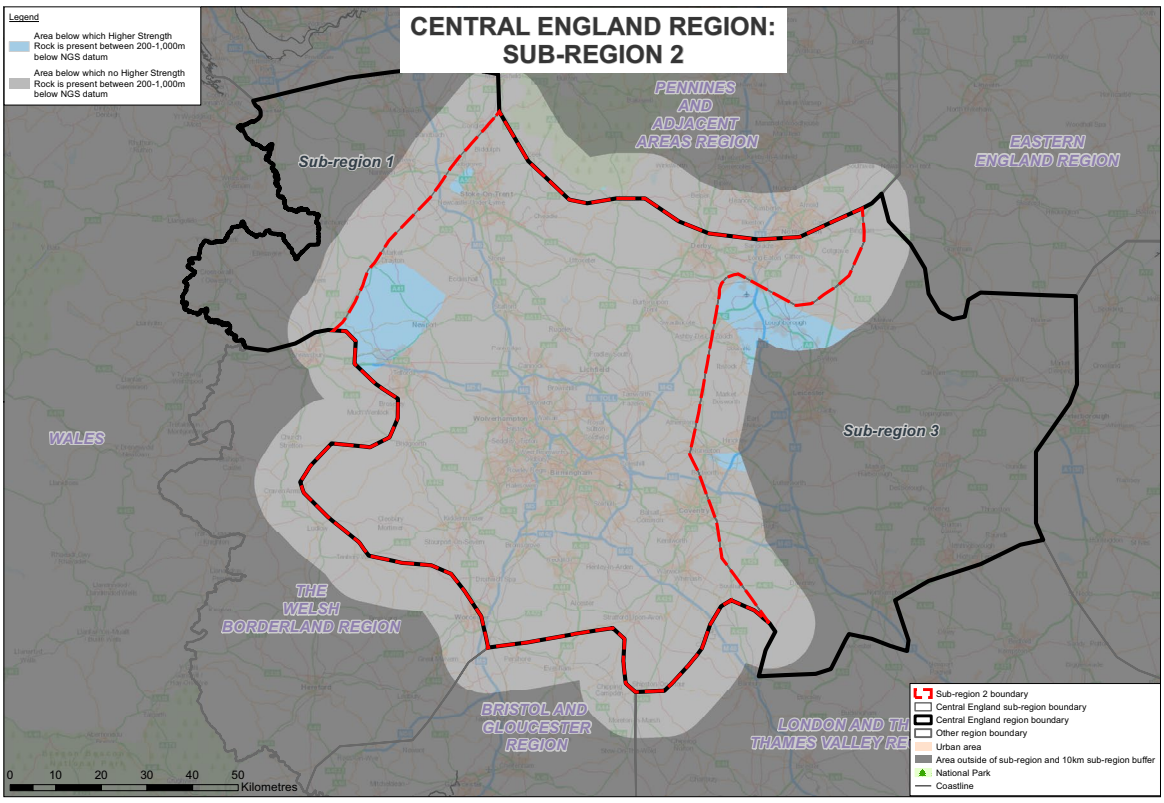


Figure 1d The areas of the Central England subregion 2 where Evaporite Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

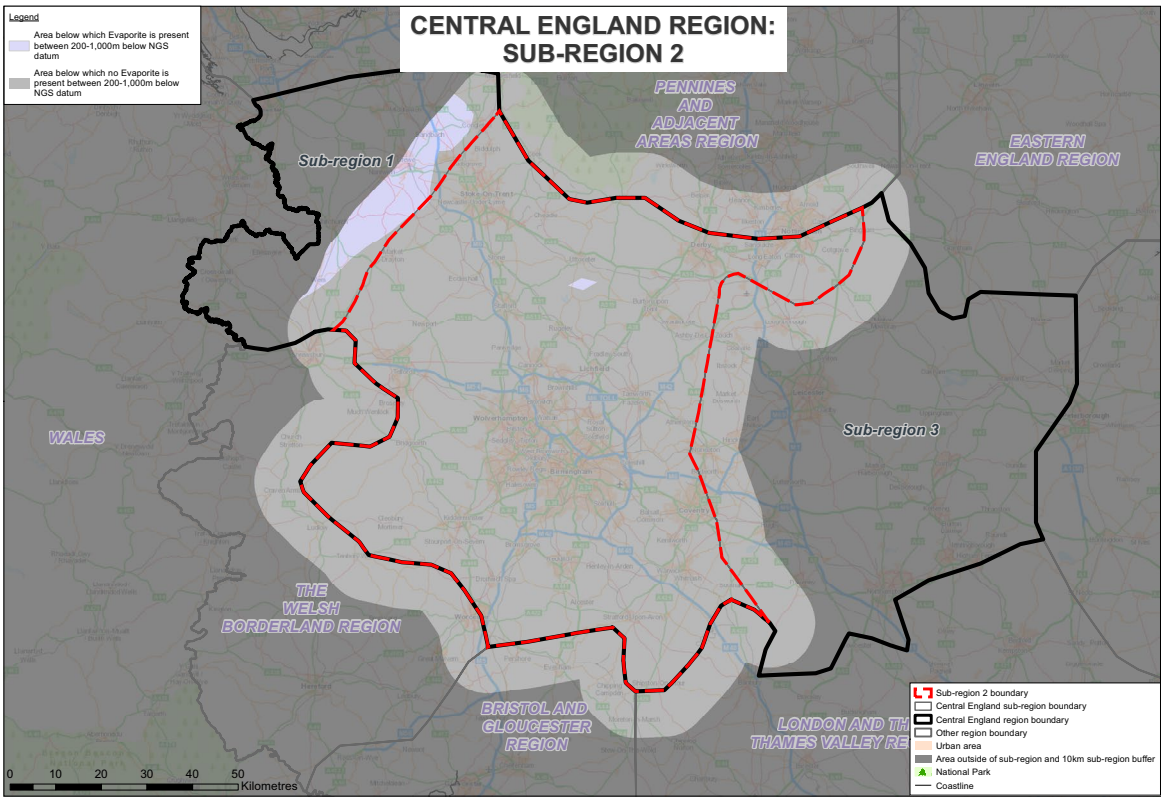


Figure 2 Location of major faults in the Central England subregion 2.

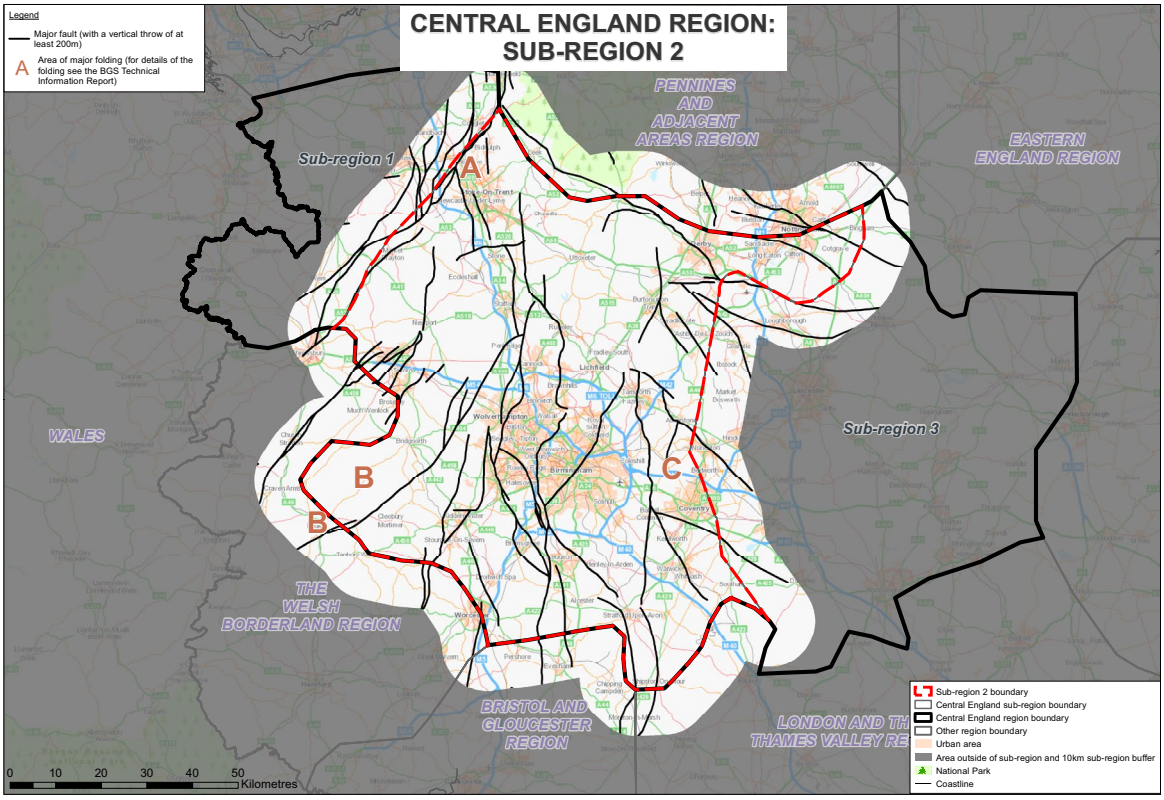


Figure 3 Areas in the Central England subregion 2 with concentrations of deep exploration boreholes.

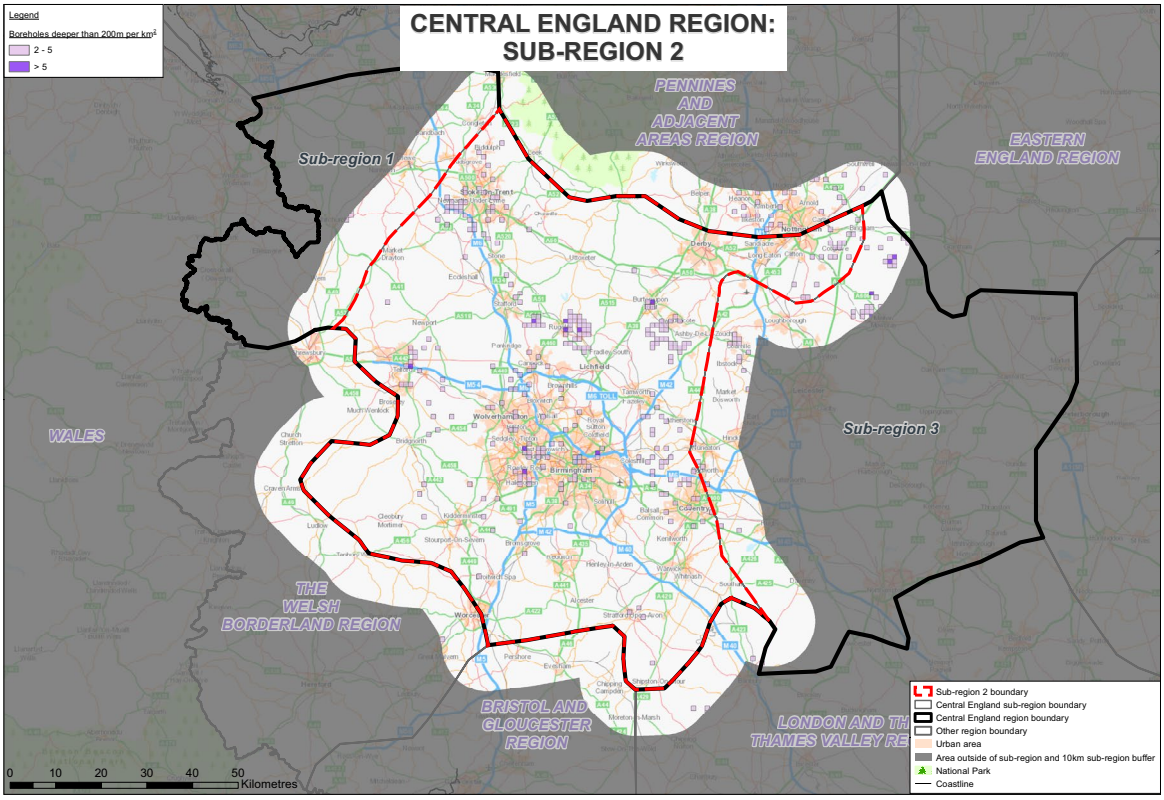


Figure 4a Areas of the Central England subregion 2 with coal mines more than 100m deep and Coal Authority Licence Areas.

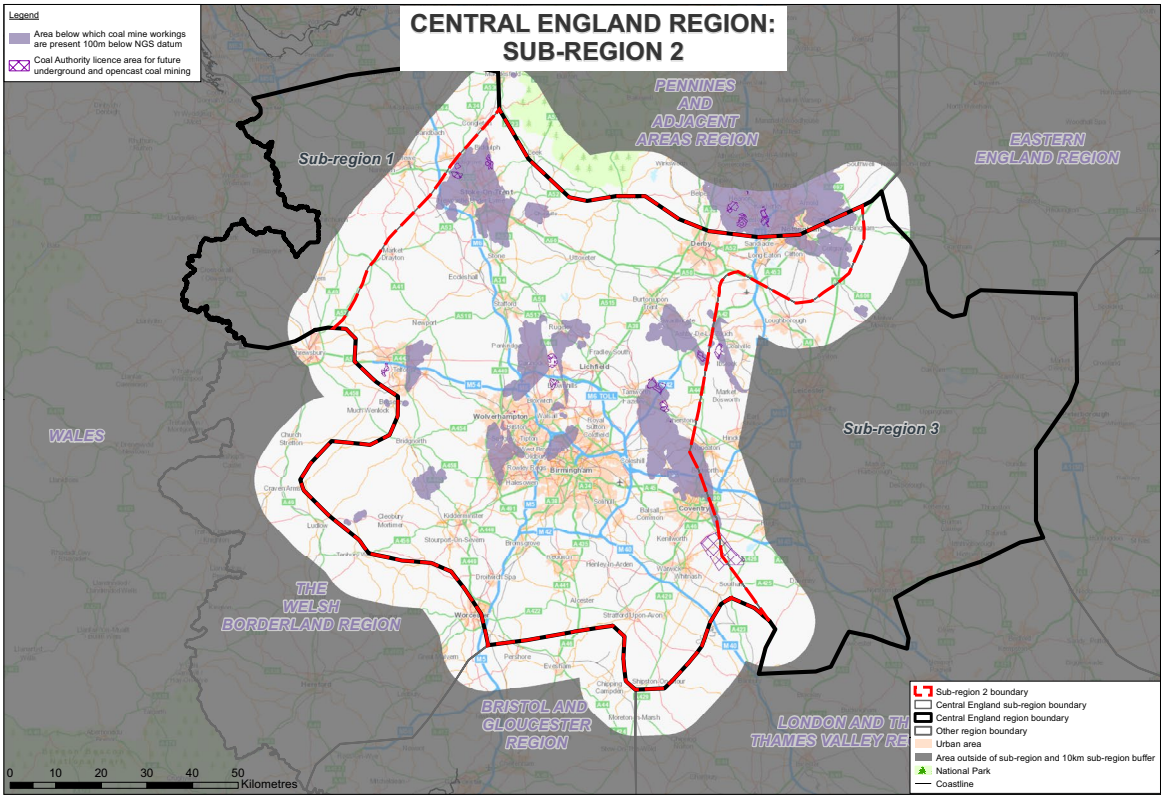


Figure 4b Areas of the Central England subregion 2 with oil and gas fields and Petroleum Exploration and Development Licences.

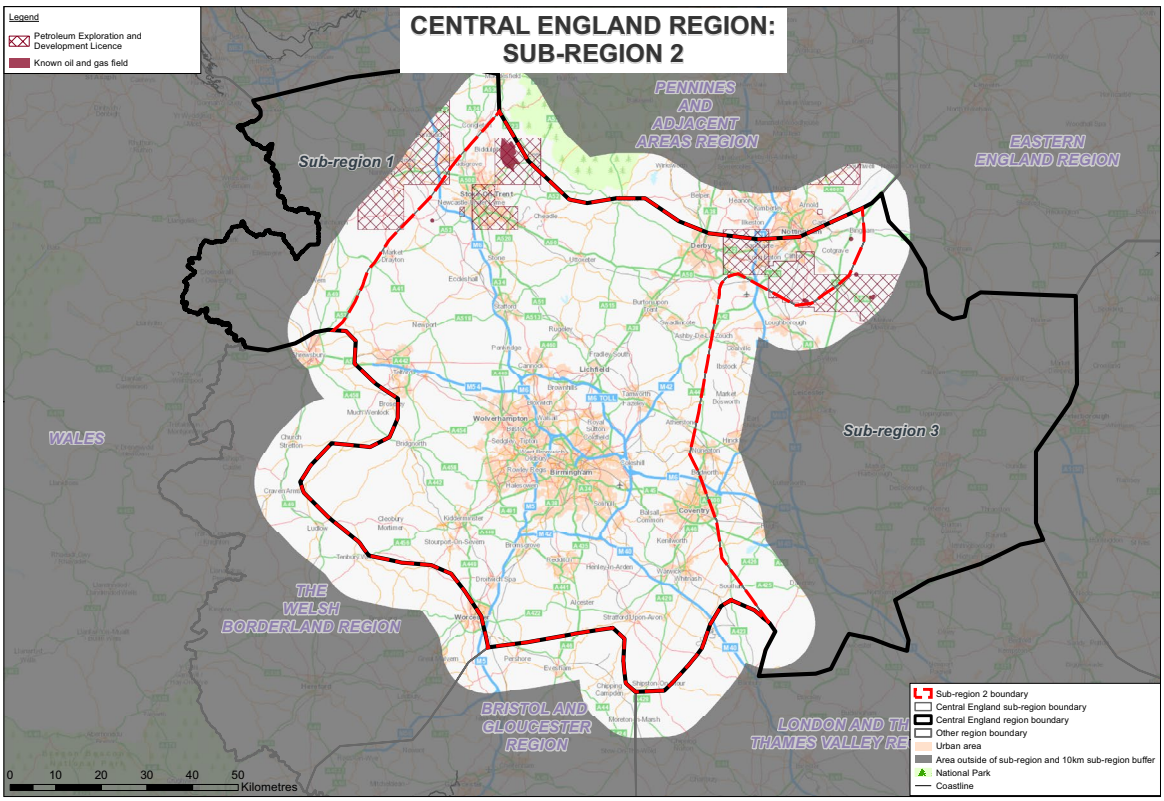
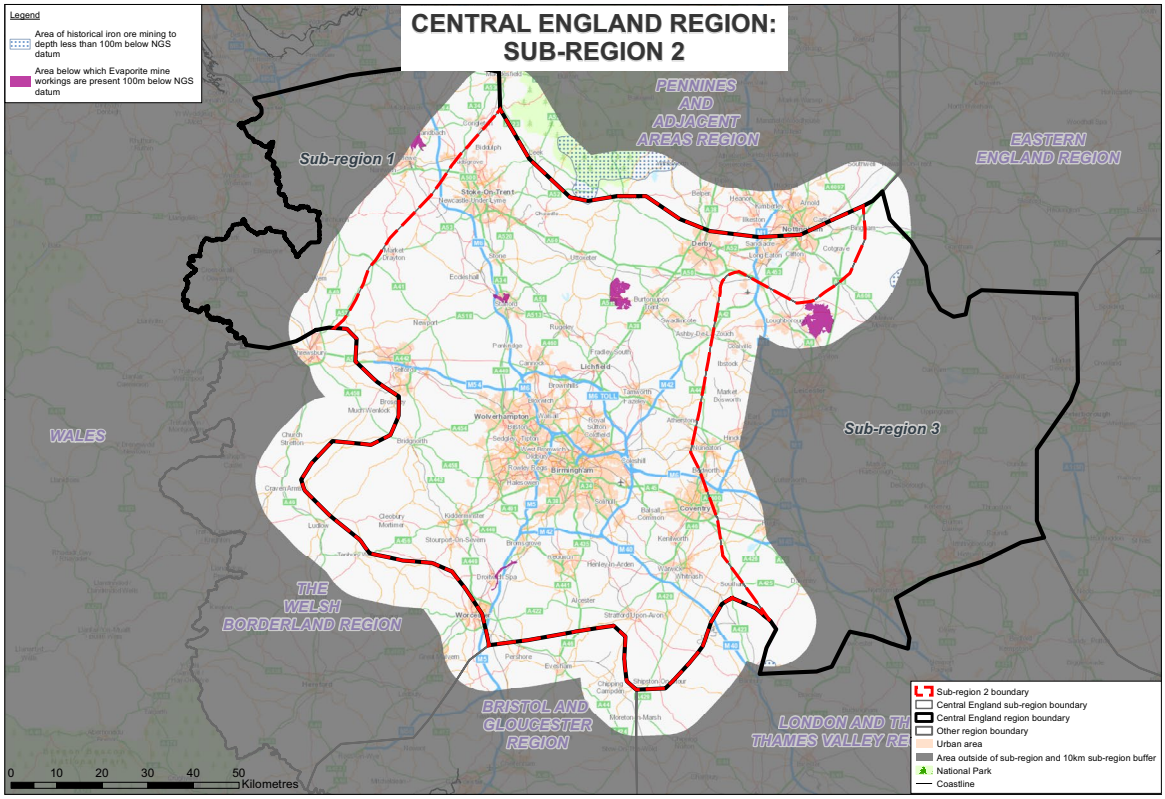


Figure 4c Areas of Central England subregion 2 with evaporite mines more than 100m deep.



Glossary

Aquifers
Aquifers are rocks that contain freshwater in pores and/or fractures and whose porosity and permeability are sufficiently high to make the extraction of groundwater possible.

Brine
Water that is either saturated with dissolved salts, or contains a large amount of dissolved salt. An example of a brine is seawater.

Dip
The angle, or slope of a plane, such as sedimentary layering, measured relative to the horizontal.

Evaporite
The generic term for rock created by the evaporation of water from a salt-bearing solution, such as seawater, to form a solid crystalline structure. Gypsum, anhydrite and halite are all types of evaporite.

Fault
A fracture in the earth's crust across which the rock layers each side of it have been offset relative to one another.

Gas storage
Underground facilities where gas can be pumped and stored under pressure. These can be within man-made caverns in salt deposits or by pumping gas into depleted oil and gas reservoirs. The gas can then be extracted again when demand is high.

Halite
A sodium chloride evaporite mineral that forms when salty water dissolves. Also known as rock salt, or just 'salt'.

Hydrocarbon
A compound of hydrogen and carbon. Hydrocarbons are the chief components of oil and natural gas.

Igneous
One of three main rock types (the others being sedimentary and metamorphic), consisting of hard, dense rocks made up of interlocking crystals. They form due to cooling of magma deep within the crust beneath volcanoes, or as lavas erupted at the surface.

Metamorphosed
A rock that has undergone change due to the action of temperature and pressure.

Principal aquifers
An aquifer classified by the Environment Agency as: "rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage." They represent the most important aquifers in terms of water supply or base flow.

Saline
Containing salt (e.g. seawater is saline).

Glossary

Sedimentary

A type of rock resulting from the consolidation of material that has accumulated in layers to form gravel, sandstone, mudstone and limestone. The layers may be built up by movement from erosion (e.g. by rivers, the sea or wind) or by chemical precipitation. Generally, the material that accumulates has originated from the weathering of other rocks. Sedimentary rocks constitute one of the three main classes of rocks identified by geologists, the others being igneous and metamorphic.

Slaty

Distinctive way in which slate rocks split into very fine sheets.

Solution mining

A technique to extract soluble minerals out of the ground by pumping liquids into a deposit, dissolving the target minerals, returning the water to surface and reprecipitating the mineral. Solution mining for rock salt is carried out in the UK and for other commercially valuable minerals around the world.

Radioactive Waste Management

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