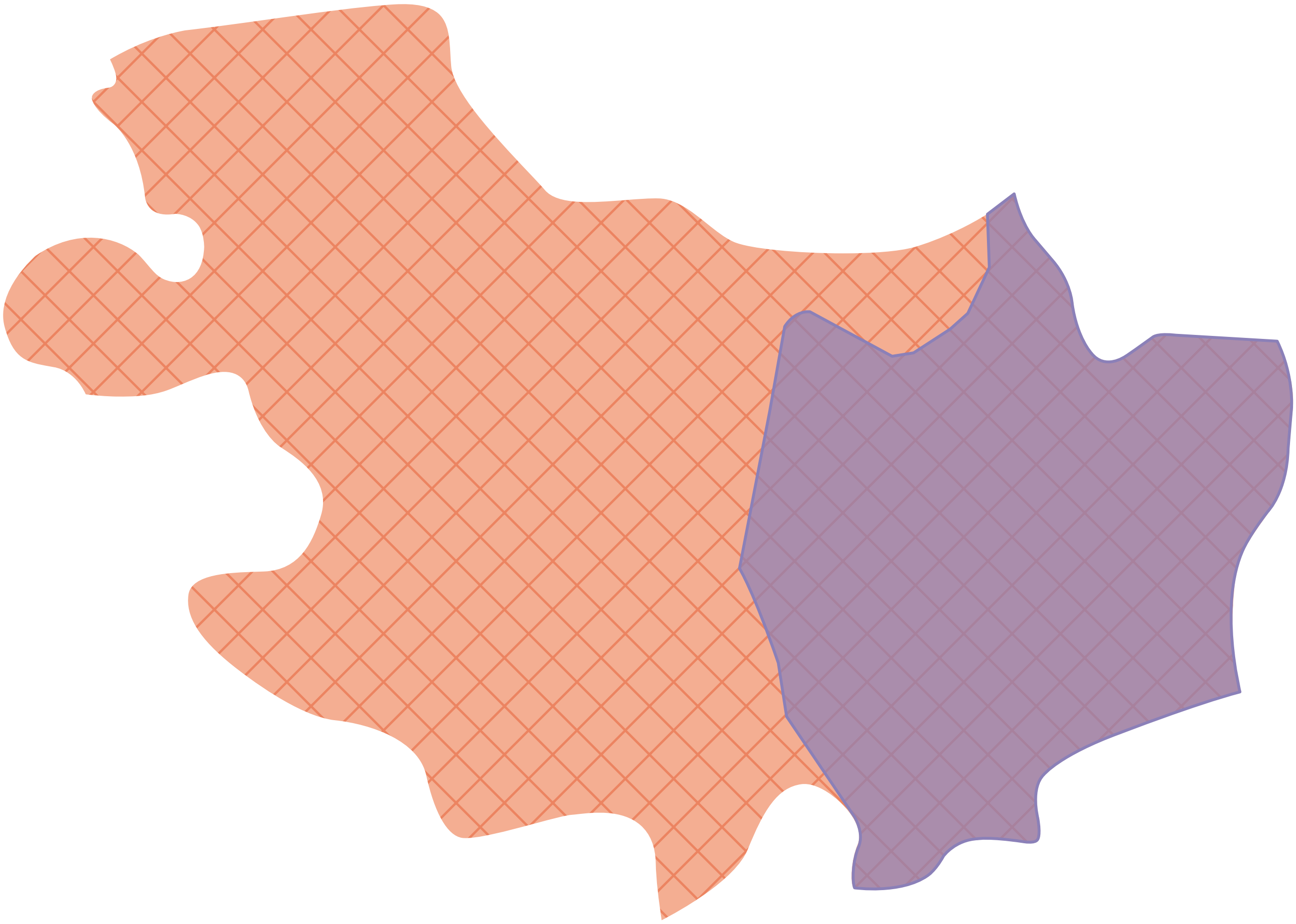


Central England

SUBREGION 3

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 most of this subregion.

Rock can only be seen at the surface in a few places in the subregion such as Charnwood Forest and in man-made excavations such as quarries or road cuttings. However, some deep boreholes and geophysical investigations give 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, under much of the subregion to the east of Coventry and Leicester. There are also granites and similar strong rocks under much of the central parts of the subregion, 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 around Coventry, Coalville and Melton Mowbray and there are known oil and gas resources to the north of Melton Mowbray. 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 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, west of Rugby and near Coalville, 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 have been mined for gypsum, near Barrow-upon-Soar, 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

The Central England subregion 3 extends east of Nottingham to Loughborough, Hinckley, Northampton and Stamford.

Rock type

Figures 1a to 1c 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 Lower Strength Sedimentary Rocks (LSSR) in this subregion belong to the Lias and Mercia Mudstone Groups of the younger sedimentary rocks.

The Lias Group is present in the depth range of interest near the eastern margin of the subregion and comprises mudstones with siltstone beds in the upper part and mudstone with limestone beds in the lower part. It is unlikely that individual mudstones are thick enough to act as a host rock, but the Lias Group provides an effective barrier to groundwater movement from depth towards the surface.

The Mercia Mudstone Group is predominantly low permeability in this region, comprising mudstone with some siltstone and occasional discontinuous sandstone beds. The thick, extensive mudstone units are known to act as a barrier to groundwater movement and may have the potential to act as LSSR host rocks.

Subsurface engineering in mudstones can be challenging because they are relatively weak. Where these mudstones occur in the lower part of the depth range of interest the constructability of a GDF would be considered during the siting process.

A wide range of rocks have been encountered in boreholes in the basement in this subregion. Their distribution is largely based upon geophysical survey data, so there is considerable uncertainty about how widespread they are. The Charnian Supergroup, one of the oldest rock units in England and Wales (over approx. 540 million years old), occurs at the surface in Charnwood Forest, north-west of Leicester, and comprises a variety of extrusive igneous rocks, including both lavas and pyroclastic sediments, together with bodies of andesite and dacite, igneous rocks that were intruded into them. Most Charnian rocks have undergone extensive metamorphic alteration of their original igneous minerals.

Ordovician igneous intrusions are quarried in the Charnwood Forest district, but are known to occur more widely. The Melton Mowbray Granodiorite near Leicester has been encountered in a single borehole at around 400m but is inferred from geophysical surveys to underlie a large area around Leicester. Geophysical data have also been used to deduce the presence of another intrusion near Loughborough although this has not been drilled. All of these intrusions are potential Higher Strength Rocks (HSR) .

The basement also includes sedimentary rocks of Ordovician and Cambrian age (approx. 445 to 540 million years old). It is unclear to what extent these rocks have been metamorphosed to become slaty and therefore it is not known whether they are potential HSR.

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 affecting the younger sedimentary, older sedimentary and basement rocks in this subregion (Figure 2). The boundaries of the subregion correspond approximately to bounding faults that juxtapose Carboniferous rocks to the north and west against the shallow basement block that characterises this subregion. 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 no major folding in this subregion.

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 in this subregion including the Sherwood Sandstone Group and younger Jurassic aquifers. In the north, Zechstein Group rocks underlying the Sherwood Sandstone Group can also be locally important as an aquifer.

Available information in this subregion suggests that at depths around 200m the groundwater in the Sherwood Sandstone Group tends to become too saline to be used for water supply. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2]. Near the margins of the subregion, where the Sherwood Sandstone is faulted against Carboniferous rocks, there is evidence for movement of groundwater between them. However, noble gas isotope studies carried out in the northern area indicate an age for Sherwood Sandstone groundwater of around 30,000 years, i.e. the aquifer here was last recharged before the last (Devensian) ice age. The numerous LSSR layers such as the Lias and Mercia Mudstone Group in this subregion are likely to act as barriers to vertical flow, even where these layers are not thick enough to host a GDF.

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 the far northern 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). There are no thermal springs in this subregion to suggest rapid flow of deep groundwater to the surface.

[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.

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

Resources

There are a small number of coal mines which extend below 100m (Figure 4a) and some small hydrocarbon fields in the 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 west of Rugby and near Coalville (Figure 4a) and a number of Petroleum Exploration and Development Licences are currently held in the north of the subregion (see Figure 4b). It is not known whether coal, oil or gas in these licence areas will be exploited, but they would need to be considered during the siting process.

Gypsum is mined near Barrow-upon-Soar at 170 m below NGS Datum (Figure 4c). 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, the presence of any excavations in these rocks would need to be considered in the siting of a GDF.

The full extent of the historic iron orefield around Corby and Kettering is also shown in Figure 4c but is not relevant to the siting of a GDF as the mines are shallower than 100m.

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.

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

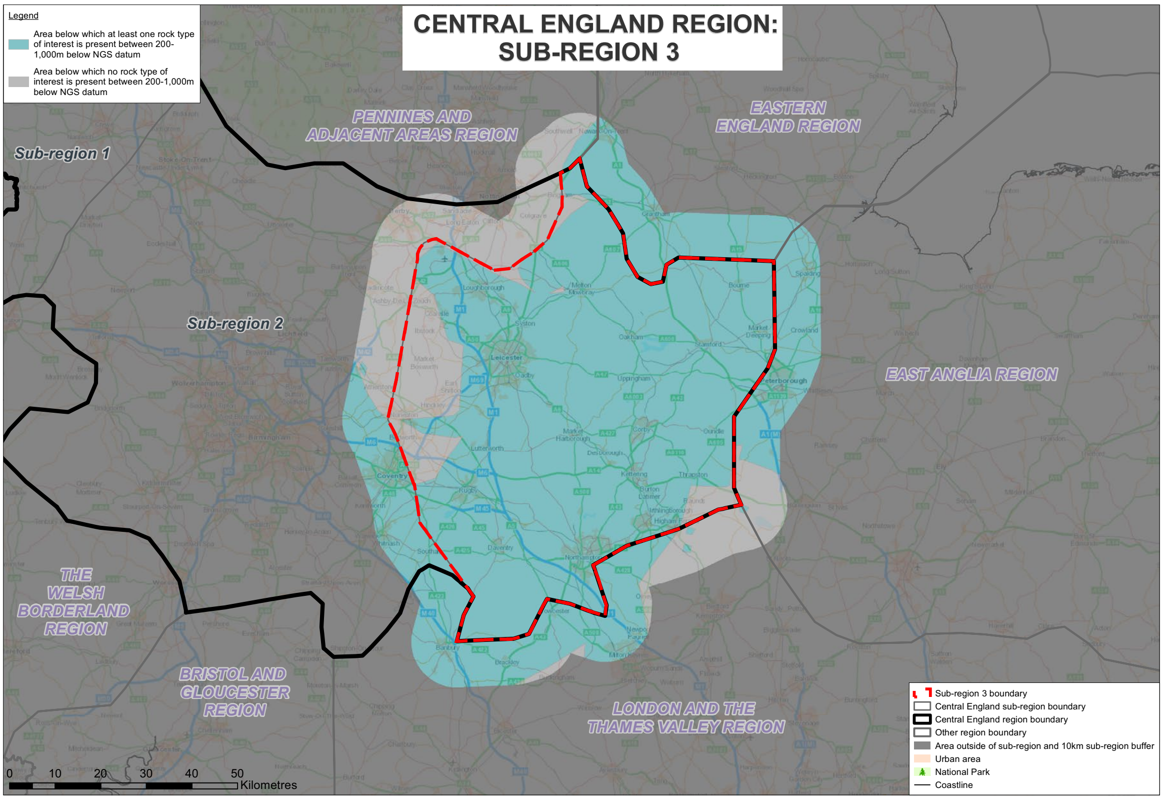


Figure 1b The areas of the Central England subregion 3 where Lower Strength Sedimentary Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

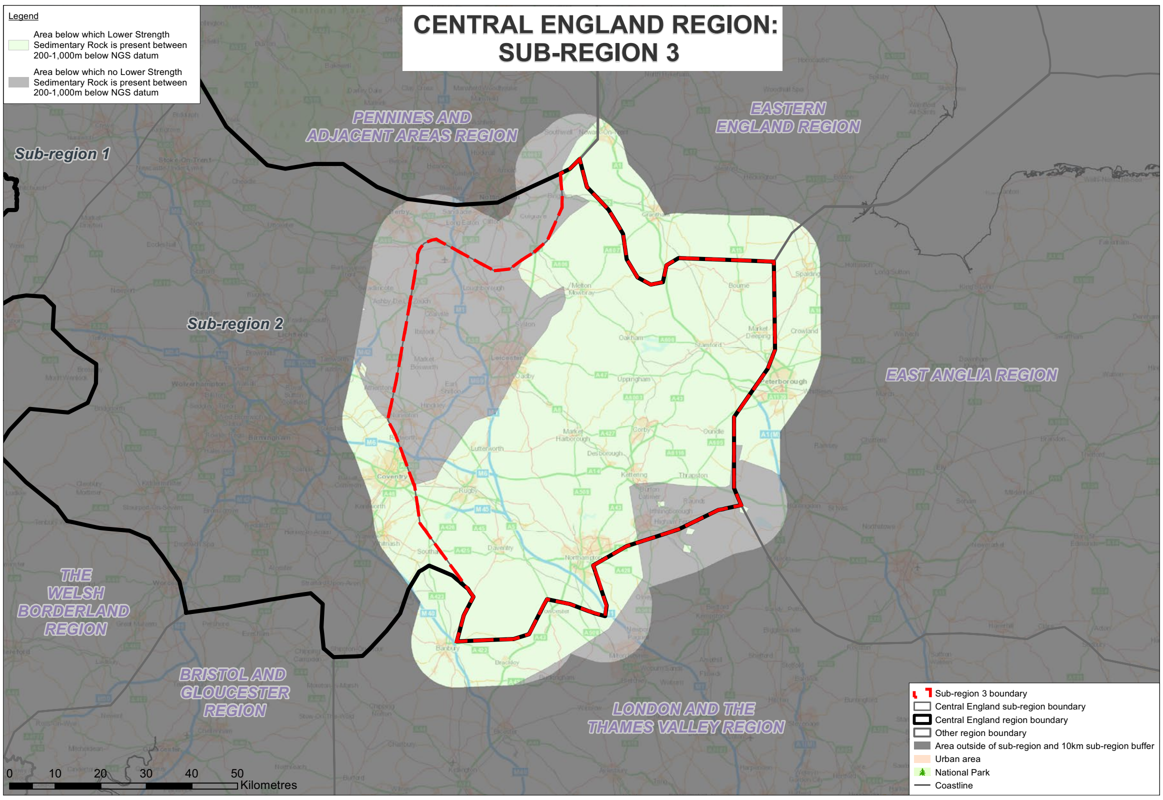


Figure 1c The areas of the Central England subregion 3 where Higher Strength Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

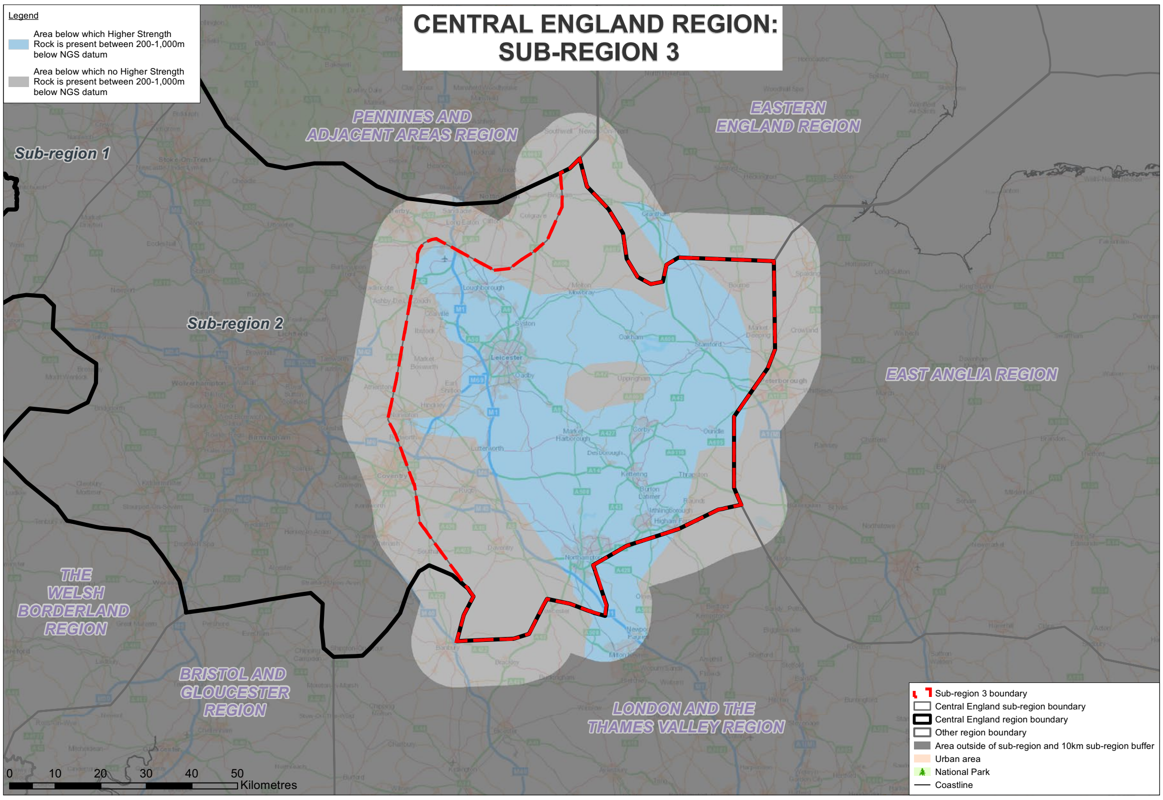


Figure 2 Location of major faults in the Central England subregion 3.

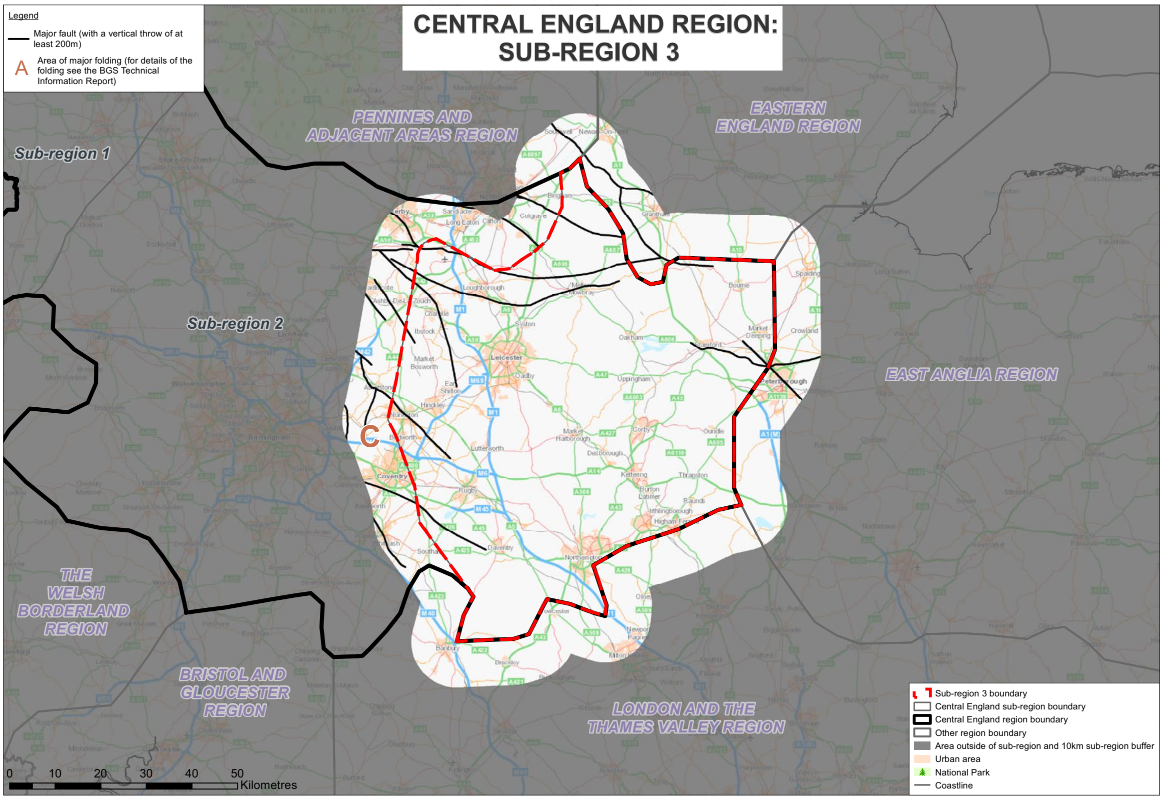


Figure 3 Areas in the Central England subregion 3 with concentrations of deep exploration boreholes.

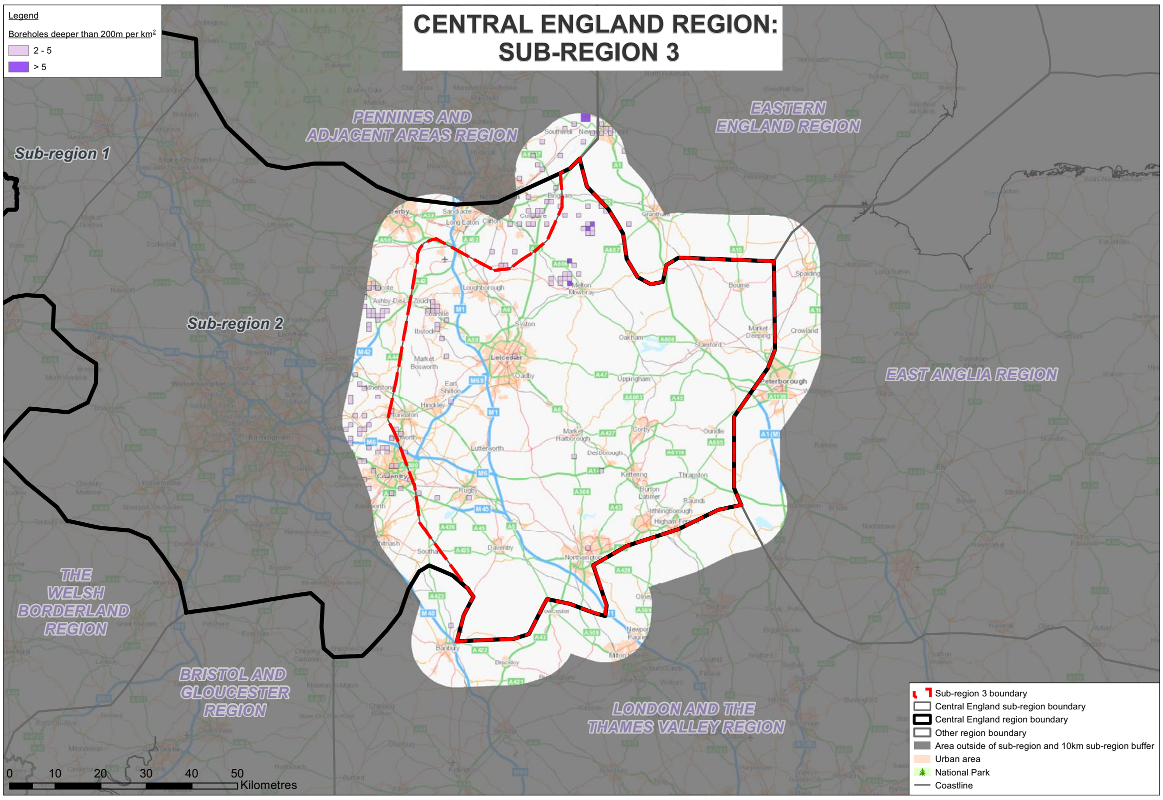


Figure 4a Areas of the Central England subregion 3 with coal mines more than 100m deep and Coal Authority Licence Areas.

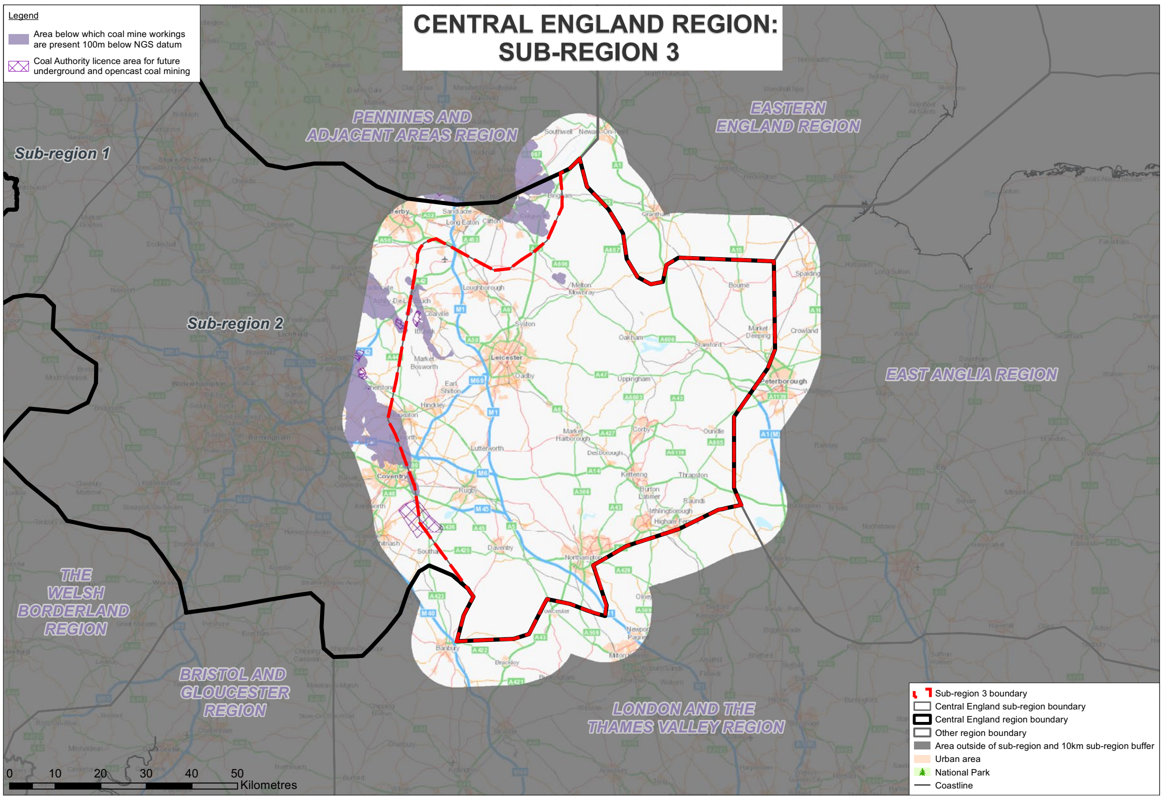


Figure 4b Areas of the Central England subregion 3 with oil and gas fields and Petroleum Exploration and Development Licences.

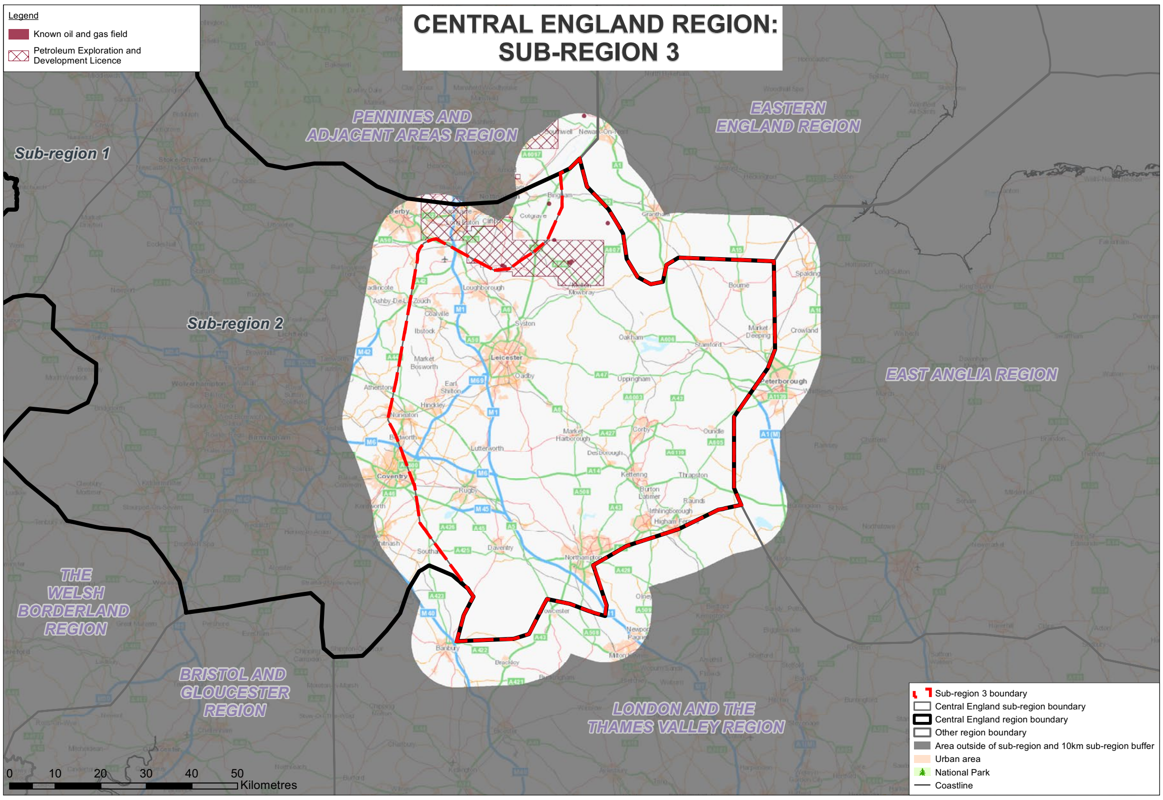
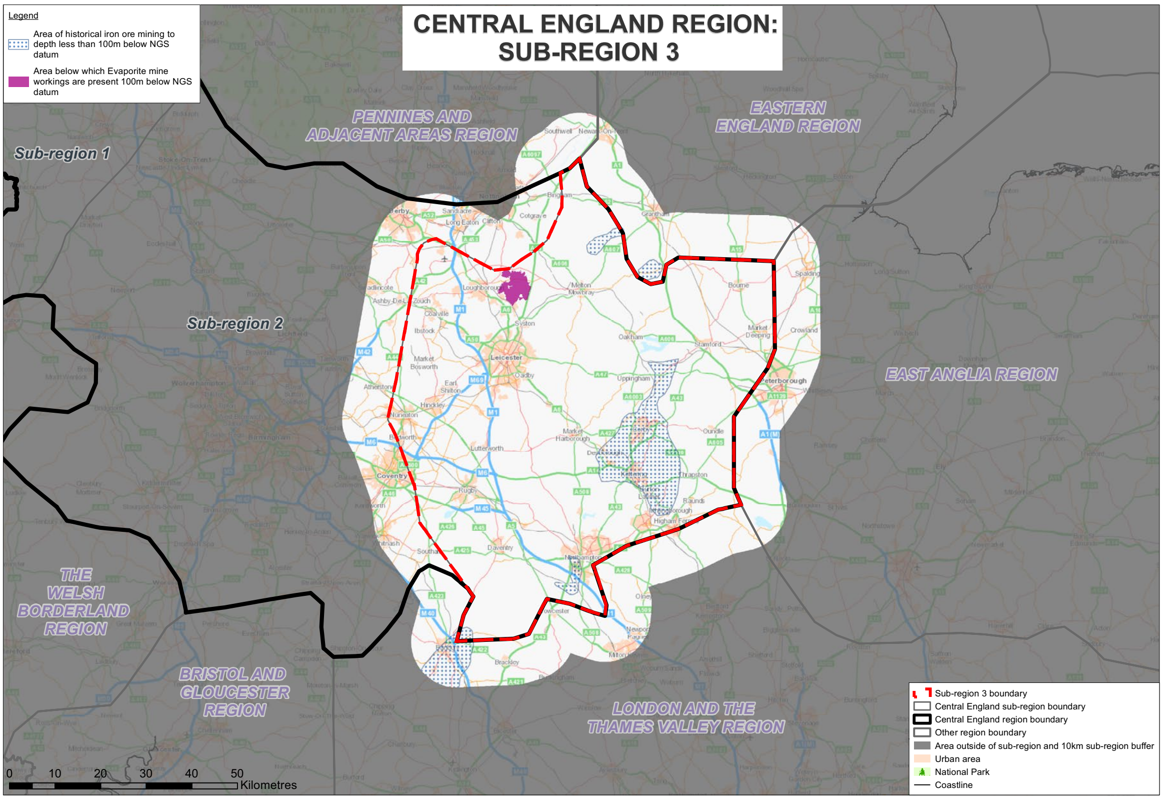


Figure 4c Areas of the Central England subregion 3 with historical evaporite mines more than 100m below NGS Datum and iron ore mining less than 100m below NGS datum.



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.

Devensian
The most recent glacial period, popularly known as the last Ice Age, which occurred from c.110,000 to 12,000 years ago.

Extrusive igneous
Rocks that have formed from ancient volcanic eruptions, mainly lava but also pyroclastic material ejected into the air during explosive eruptions.

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

Granodiorite
Darker coloured granite richer in iron and magnesium than normal granite.

Gypsum
A calcium sulphate mineral that forms from the evaporation of salty seas. It contains water and occurs at shallower depths and lower temperatures than anhydrite.

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.

Lavas
A mass of flowing or solidified lava. After cooling and solidification, lava flows often form distinctive topographical features.

Metamorphic
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.

Pyroclastic
Deposits of solid material erupted explosively from a volcano, ranging in size from large blocks and boulders to very fine ash. The citizens of Pompeii were buried beneath thick clouds of hot pyroclastic material in 79AD.

Glossary

Saline

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

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.

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