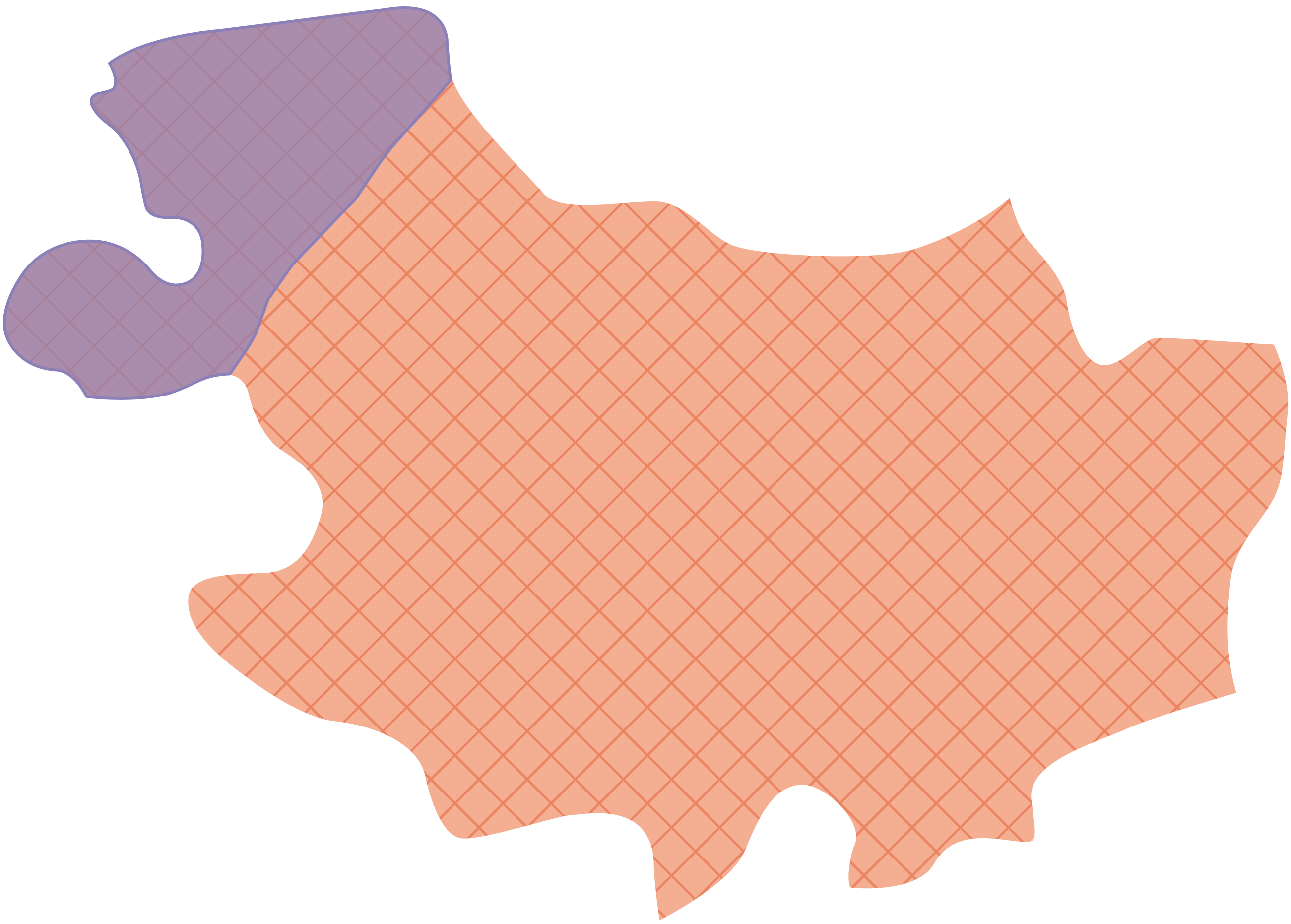


Central England

SUBREGION 1

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 much of this subregion.

Rock cannot generally be seen at the surface in this subregion, except in man-made excavations such as quarries or road cuttings. However, deep boreholes and geophysical investigations, particularly in the mining areas between Northwich and Crewe and around Oswestry, give us an understanding of the rocks present and their distribution.

There are clay-rich rock layers and rock salt layers under much of the central and eastern 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 contribute to the safety 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 around Oswestry has been mined for coal resources to depths below 100m. In these areas the mining 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 the Cheshire Basin which have been mined for rock salt 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 1 extends from Chester to Congleton in the north and close to Shrewsbury in the south.

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 the most extensive rock unit occurring at the surface in the subregion and in places is present from the surface throughout the entire depth range of interest. The Mercia Mudstone Group is predominantly of very low permeability in this region, comprising mudstone and evaporites, although some discontinuous sandstone beds are present. The thick, extensive mudstone units are known to act as a barrier to groundwater movement and have the potential to act as Lower Strength Sedimentary Rocks (LSSR) host rocks.

The Lias Group is present in a small area around Prees and is known to extend to around 600m depth. It consists of interbedded mudstone, siltstone and sandstone. It is unlikely that individual mudstones are thick enough to act as a host rock, but the Lias Group provides an effective barrier to vertical movement separating deep and shallow groundwater.

The Mercia Mudstone Group also contains 2 major evaporite units that comprise bedded rock salt (halite) with mudstone interlayers. Individual salt layers locally exceed 30m in thickness and are a potential Evaporite host rock.

At the top of the older sedimentary sequence, the Warwickshire Group is dominated by mudstones which are interlayered with sandstones and siltstones, and which may behave as LSSR. Whilst mudstones are the predominant rock type they are unlikely to form a sufficiently thick and homogeneous body to act as a host rock, though they may provide hydraulic separation between deep and shallow groundwater systems.

There is also a very small area of basement rocks with the potential to act as Higher Strength host rocks along the south-western boundary of the subregion (Figure 1d).

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

The younger sedimentary rocks in this subregion are faulted and dip south-east, but are not significantly folded (Figure 2). Major faults are aligned north-east to south-west. and were active during deposition of Triassic sediments (approx. 200 to 250million years ago). 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].

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 present within 400m of the surface in this subregion including the Sherwood Sandstone Group which is widely used for public water supply, agriculture and industry. Groundwater movement is greater in the upper 100m of this aquifer, with much less groundwater movement through the deeper parts of the aquifer. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2].

The available information suggests that there is only limited groundwater flow below 400m and the deep groundwater in this subregion is saline. Stable isotope analyses have indicated groundwater ages of around 21,000 years old, resulting from recharge during the Pleistocene period. Mudstones in the Mercia Mudstone and Warwickshire Groups are likely to act as barriers to vertical flow between the various more permeable units described above. Where permeable sandstones are separated from the surface by these low permeability mudstones and evaporites, they are likely to contain old, saline groundwater. Groundwater is also divided into compartments by faults.

For parts 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

Coal has been mined extensively below 100m in the south-west of the subregion around Oswestry (Figure 4a). In these areas the mining 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.

A number of Petroleum Exploration and Development Licences are currently held in the north of the region (see Figure 4b). It is not known whether oil or gas in these licence areas will be exploited, but they would need to be considered during the siting process.

Rock salt has been extracted from the Cheshire Basin for many years, and many of the salt layers have been mined to depths of 200m (Figure 4c). In addition, solution mining by brine pumping has affected rocks to depths of around 500m. 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.

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

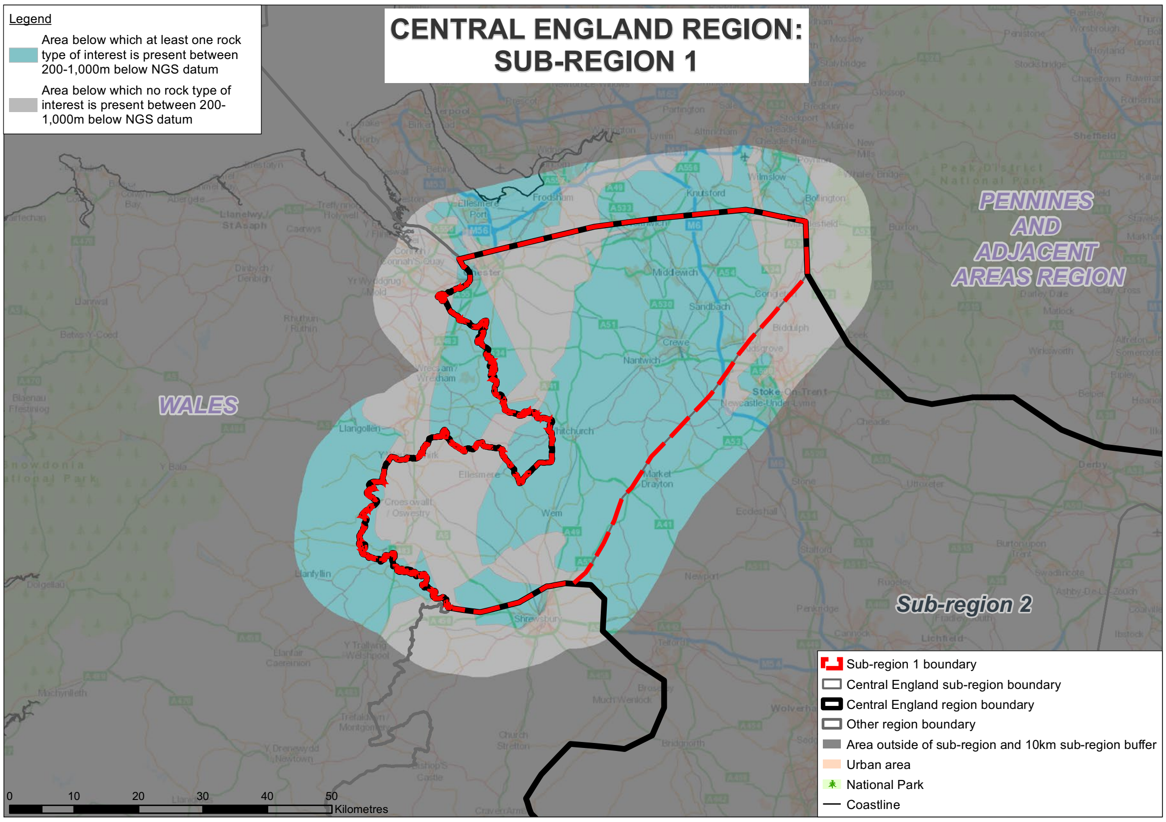


Figure 1b The areas of the Central England subregion 1 where Lower Strength Sedimentary Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

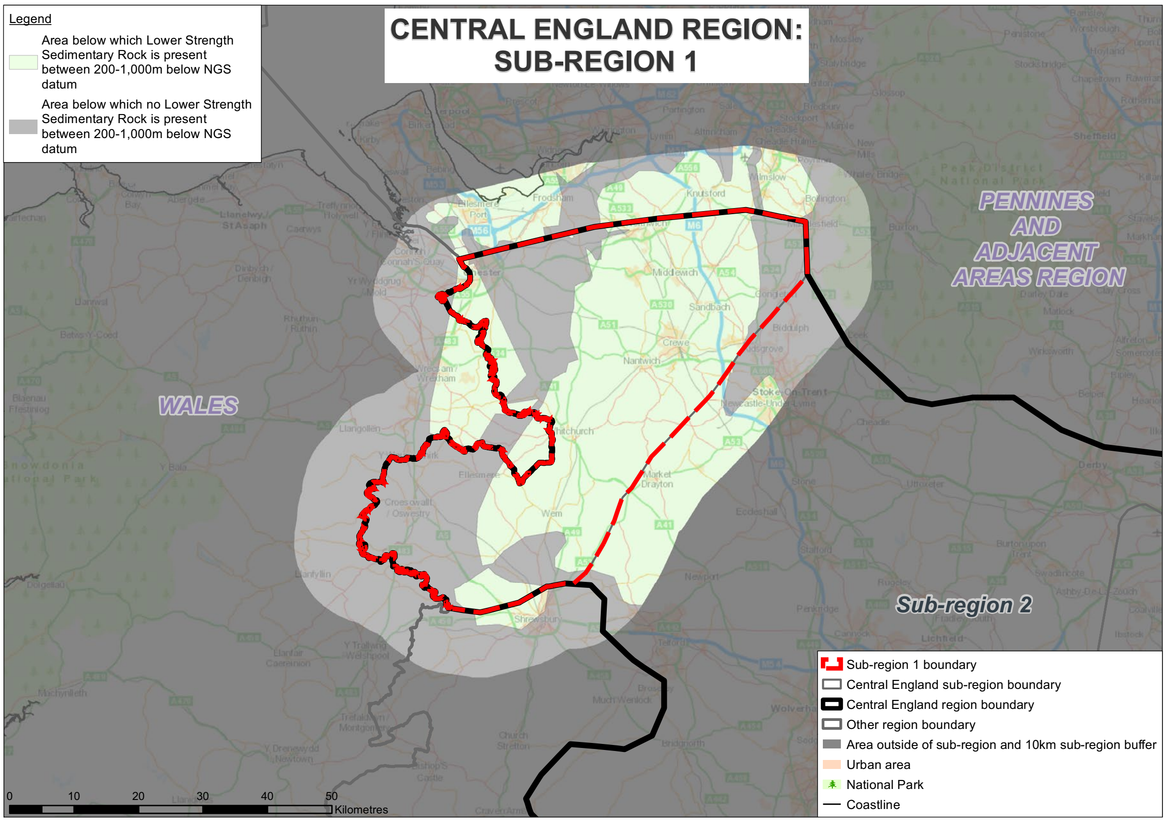


Figure 1c The areas of the Central England subregion 1 where Higher Strength Rocks of interest are present between 200 and 1,000 m below NGS datum.

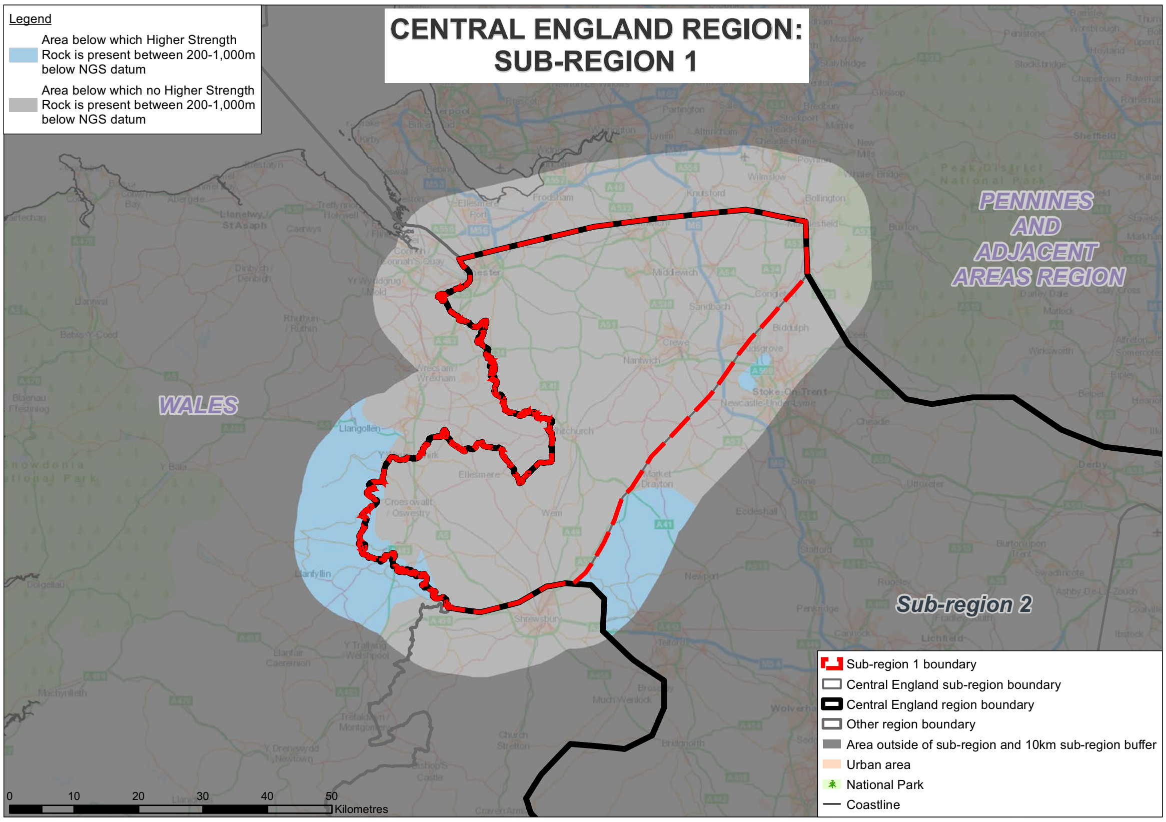


Figure 1d The areas of the Central England subregion 1 where Evaporite Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

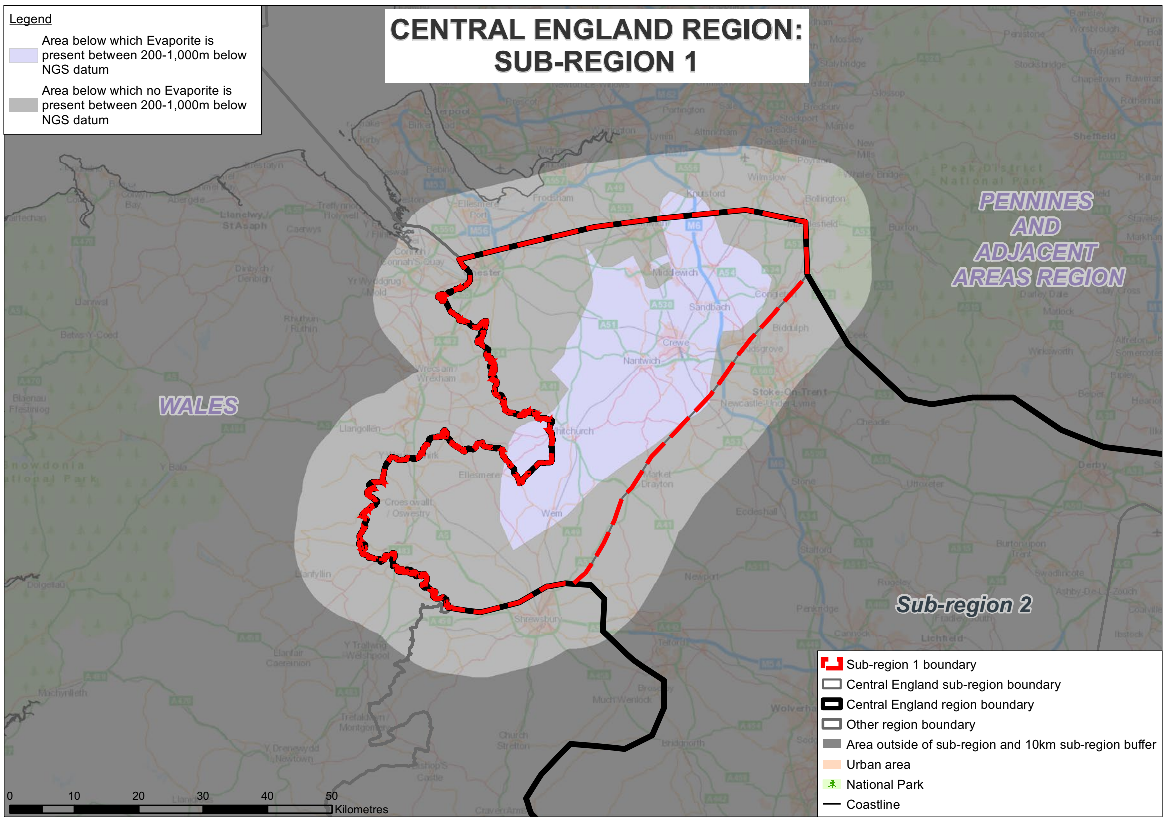


Figure 2 Location of major faults in the Central England subregion 1.

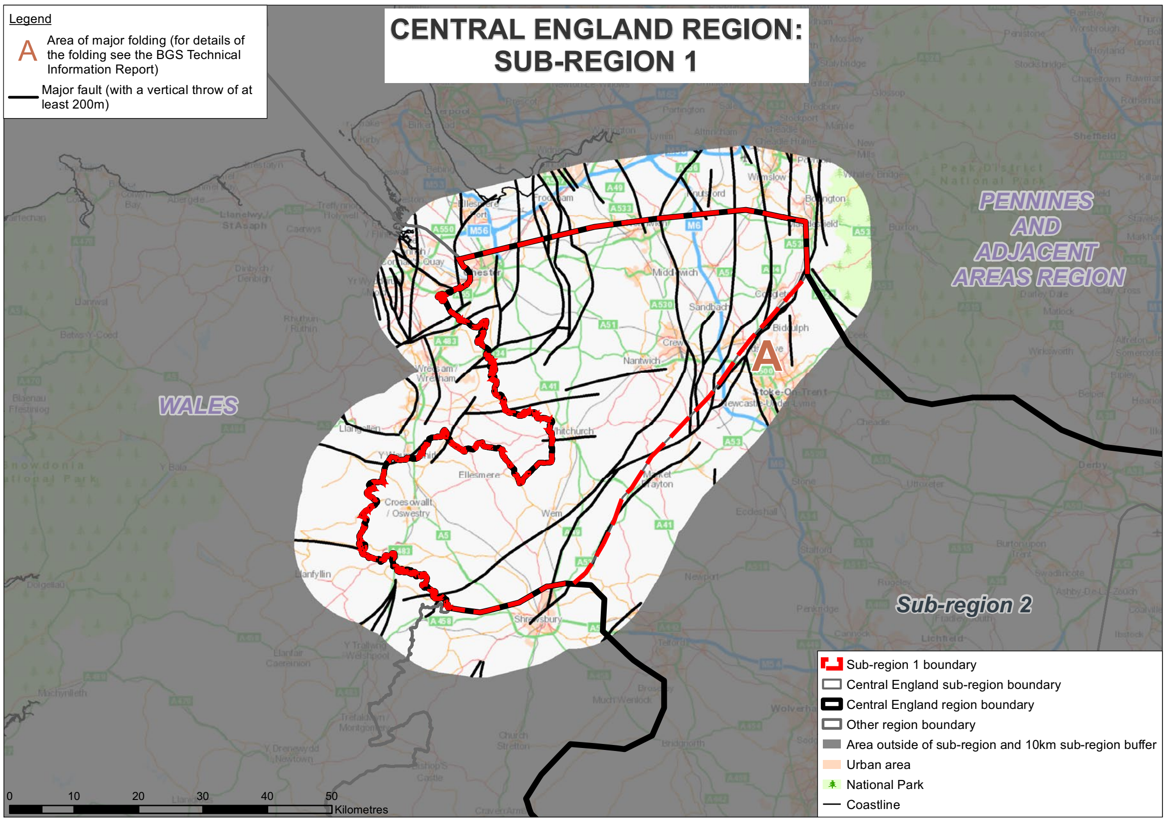


Figure 3 Areas in the Central England subregion 1 with concentrations of deep exploration boreholes.

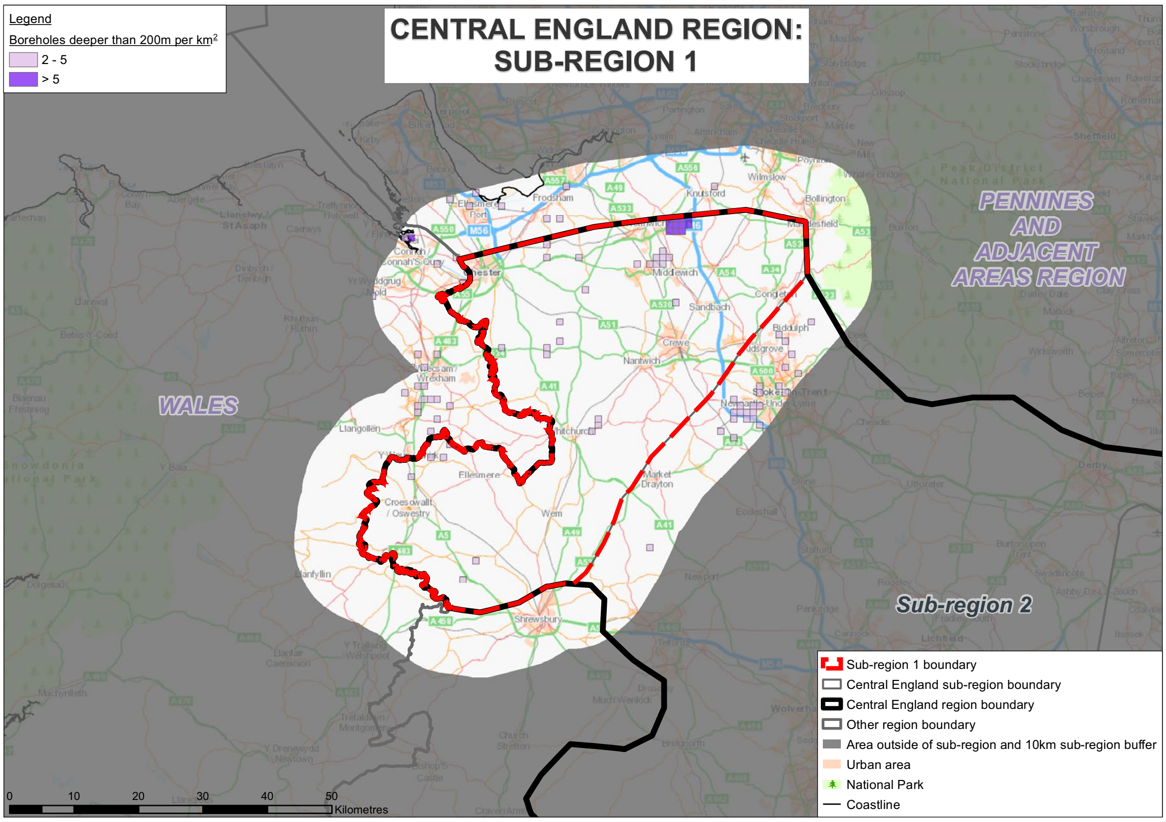


Figure 4a Areas of the Central England subregion 1 with coal mines more than 100m deep.

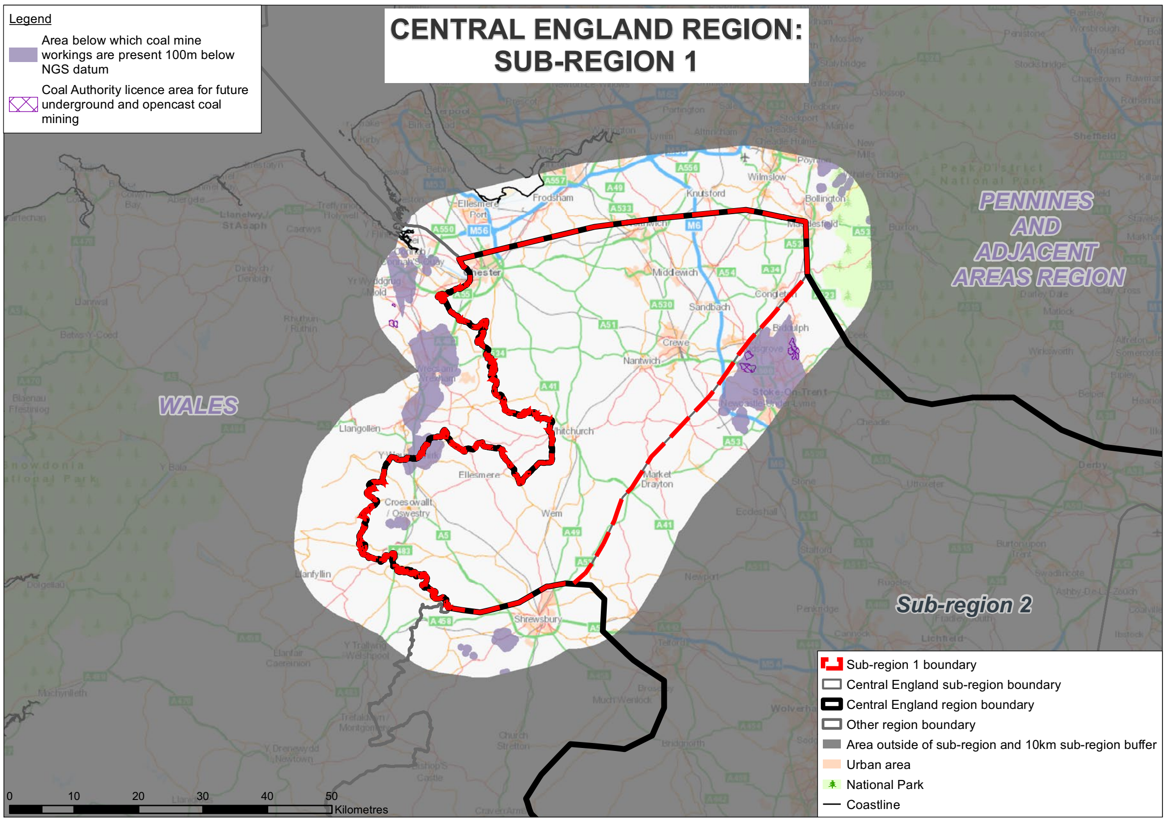


Figure 4b Areas of the Central England subregion 1 with Petroleum Exploration and Development Licences.

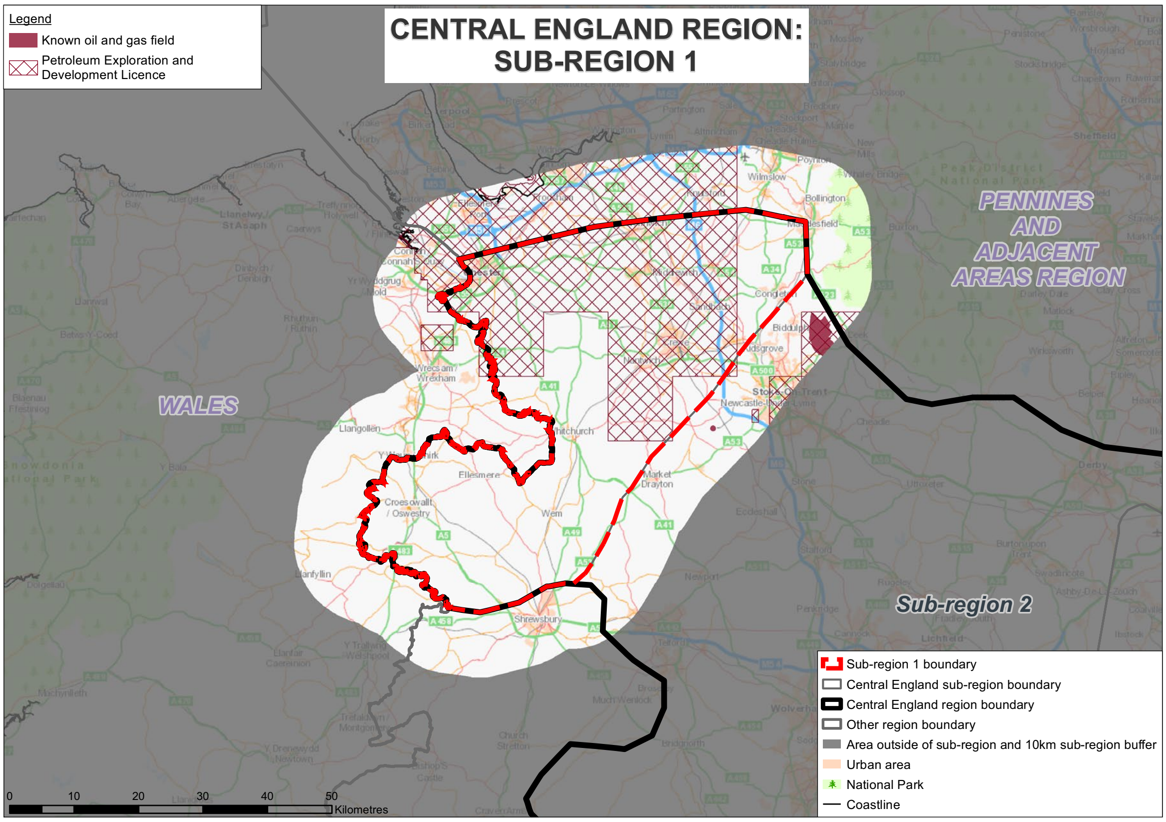
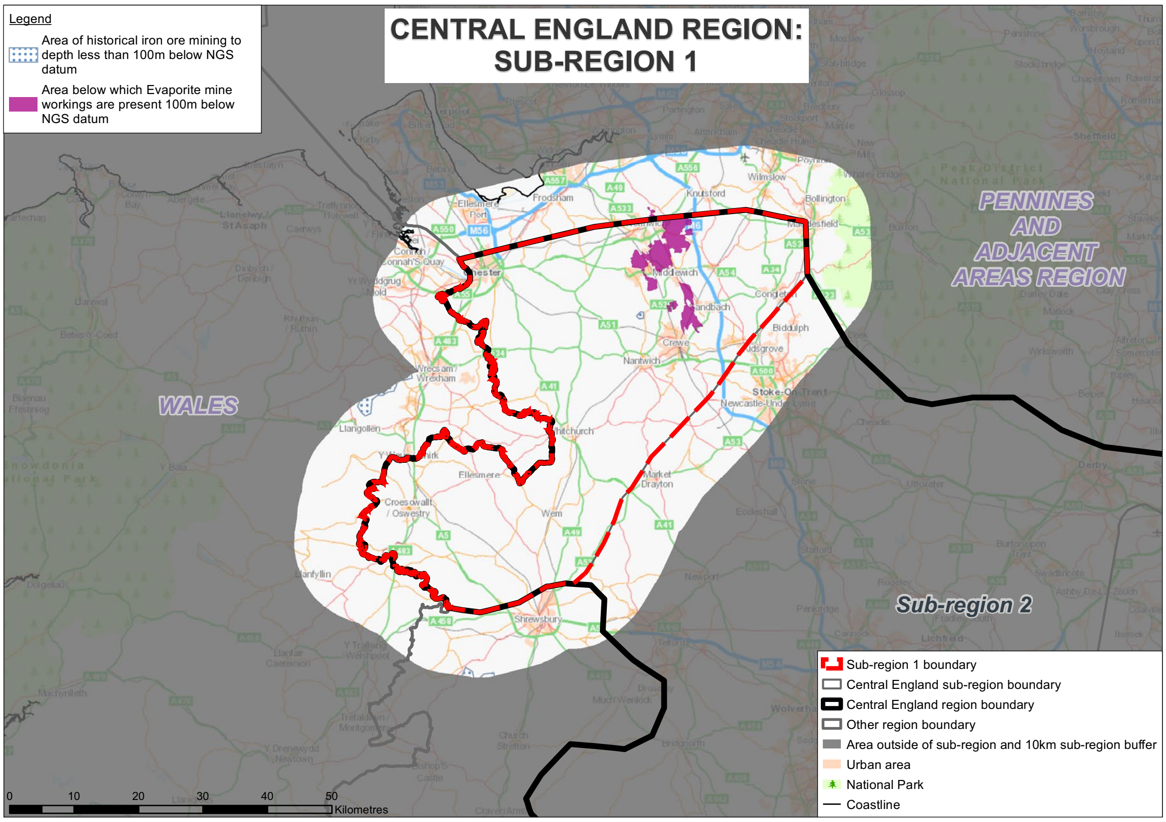


Figure 4c Areas of Central England subregion 1 with evaporite mines more than 100m deep.



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.

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.

Faults
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'.

Pleistocene
The Pleistocene describes the period of geological time between c.2.5 million years ago and 11,700 years ago. It represents the time period spanning the world's most recent period of repeated glaciations. This period is sometimes referred to as "the Ice Age" however, "ice age" can refer to several periods throughout geological history.

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).

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.

Stable isotope analyses
Stable isotope analysis is an analytical technique which measures the relative abundances of non-radioactive (therefore "stable") isotopes, allowing inferences to be made about ancient environments in which rocks were deposited. For example, by measuring the relative abundance of Oxygen-16 and Oxygen-18 in calcium carbonate in fossils it is possible to infer the temperature of the ocean at the time they were alive.

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