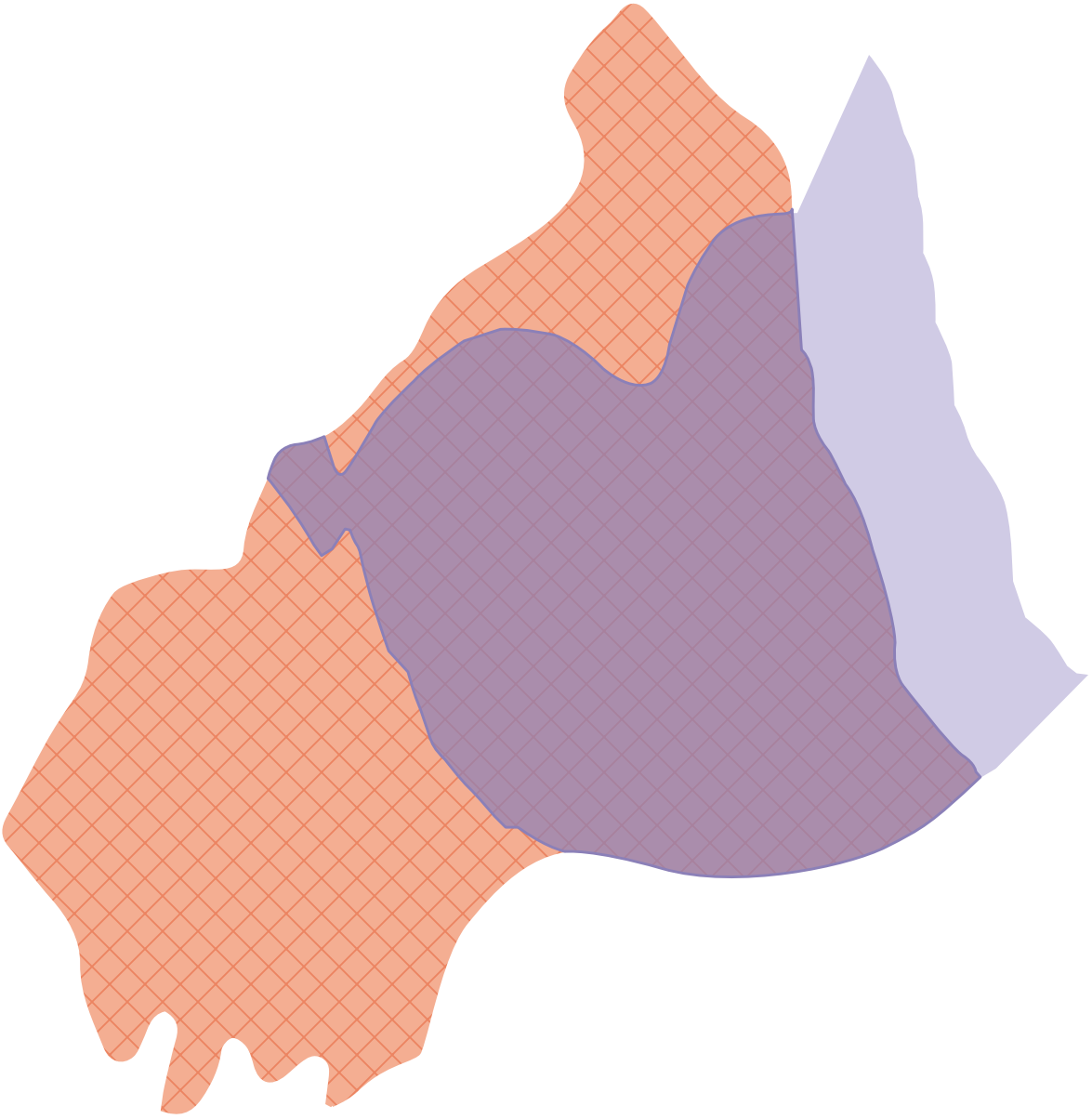
Radioactive Waste Management



Northern 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 parts of this subregion.

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

There are granites, volcanic lavas and similar strong rocks under the centre of the subregion centred on Weardale, in which we may be able to site a GDF. There are also layers of rock salt around Hartlepool and Teesside, in which we may be able to site a facility. We would need to do more work to find out whether these rocks have suitable properties and thicknesses in the depth range of interest for a GDF.

Some of the subregion has been mined to depths below 100m for coal resources, in the major Northumberland and Durham Coalfield and to the west near Hexham, Haltwhistle and Alston, and lead, fluorite and zinc, around Alston and Weardale. 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.

A small part of the south-east of this subregion has 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, and much of the near inshore in particular, are Coal Authority Licence Areas allowing companies to explore for coal. It is not known if 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 anhydrite, rock salt and potash, in the vicinity of Teesside, 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

This subregion extends from the Vale of Eden to the east coast, and is bounded to the north by the Scottish border and the Cheviot Hills. It includes the adjacent inshore area which extends to 20km from the coast.

Rock type

Figures 1a to 1c show where in the subregion there are likely to be Rock Types of Interest for the development of a GDF within the depth range of interest. There are 2 potential host rocks in this subregion:

- The Permian age (approx. 200 to 250 million years old) Zechstein Group of evaporite rocks are present in the depth range of interest around Hartlepool and Teesside. These are an extension of the geology seen in the northern part of the Eastern England region. They comprise limestone and evaporite minerals, including sulphate minerals as well as rock salt (halite) which is a potential Evaporite host rock. The Seal Sands borehole near Middlesbrough passed through a single bed of rock salt over 40m thick but there is no direct information about the wider extent, thickness and depth of the rock salt layer.
- Basement rocks (more than 420 million years old) occur in the depth range of interest under the central part of this subregion, centred on Weardale. They occur at the surface at the eastern margin of the Vale of Eden but are known mainly from boreholes and geophysical surveys. Skiddaw Group slates are probably the most widespread but the Borrowdale Volcanic Group is present in the west. Based upon their occurrence in the subregion 3 to the west where they are better known, these rocks are potential Higher Strength Rock (HSR) host. A large body of granite was first identified beneath the North Pennines by geophysical surveys and was subsequently confirmed in the Rookhope and Eastgate boreholes, south of Hexham. The granite sampled by drilling is known as the Weardale Granite. The top of the granite lies within the upper part of the depth range of interest, around 300m below NGS datum. The upper few metres are weathered, but deeper parts of the granite appear to be unaltered and have potential as a Higher Strength Rock (HSR) host.

The Whin Sill is a sheet-like layer of igneous rock which forms prominent outcrops along the Northumberland coast; further west, part of Hadrian's Wall is built on it, and across much of the subregion it occurs in the depth range of interest. Although the BGS have identified it as a potential HSR, we consider that it is unlikely to be suitable to host a GDF. This is firstly because it forms sheets which are typically only a few tens of metres thick, and so are unlikely to provide an adequate volume to host a GDF, and secondly because it is often cut by steep fractures which are likely to promote the vertical movement of water.

A summary of the geological attributes of the Northern 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 and some major folding in this subregion (Figure 2). The structure of this subregion is strongly influenced by faults, which form the boundaries to sedimentary basins and uplifted blocks of basement rocks. 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].

Folding has mainly affected the older, basement rocks but the Carboniferous rocks are also locally folded, including folding in south Durham, linked to faulting.

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. A number of principal aquifers are present within 400m of the surface in this subregion which are used for public water supply, including a range of Carboniferous rocks and Zechstein Group rocks in the south-east, which are particularly important. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2].

There are no clay-rich rock layers overlying the basement rocks in this subregion to provide hydraulic separation between deep and shallow groundwater. In the Northumberland and Durham Coalfield groundwater in the Pennine Coal Measures Group was probably separated from surface systems prior to mining, with evidence for deep groundwater flow along faults from the Weardale Granite to the west into the Carboniferous sandstones. There are no natural thermal springs to suggest rapid flow of deep groundwater to the surface. However, geothermal exploration in Weardale specifically targeted deep moving groundwater and at the Eastgate borehole warm water was encountered at 430m depth, flowing through the major mineral vein targeted by the drilling, and with a likely source at a depth of around 4km. The flow in the Weardale Granite basement was concentrated in one major fracture, and long lengths of the borehole did not experience any inflow of water. How frequent such permeable fractures are within this granite and whether they are connected to shallow groundwater systems is not known. There is evidence that mining has changed the original patterns of water movement in the Durham Coalfield. For example the water levels in the Zechstein Group limestones were found to be coupled to those in the underlying Pennine Coal Measures Group as water levels rose after mine closure.

In some areas in the subregion, in the vicinity of the coal and mineral mining areas, deep exploration boreholes may influence the connectivity between shallow and deep groundwater which would need to be considered during the siting process (Figure 3).

[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

The North Pennine region around Alston and Weardale was mined below 100m for lead, fluorite and zinc (Figure 4a). Coal was mined extensively below 100m in the major Northumberland and Durham Coalfield and to the east near Hexham, Haltwhistle and Alston (Figure 4b). The deepest mining was restricted to the coastal area and off the coast. 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 small part of the south-east of this subregion has Petroleum Exploration & Development Licences to allow companies to explore for oil and gas (Figure 4c). There are Coal Authority Licence Areas in the near inshore part of this subregion (Figure 4b) and zinc and lead resources have been identified recently at around 500m below NGS datum (A on Figure 4d). It is not known whether coal, minerals, oil or gas in these licence areas will be exploited, but they would need to be considered during the siting process.

Anhydrite, rock salt and potash have been mined below 100m (including solution mining) in the vicinity of Teesside (Figure 4d) and some of the caverns from which evaporite minerals have been mined are now used for toxic waste disposal. 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.

There has been some interest in exploiting geothermal heat in Weardale which would need to be considered during the siting process.

Areas of historical metal ore mining is also shown in Figure 4d but would not affect the siting of a GDF as these 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 Northern England subregion 2 where any of the 3 Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

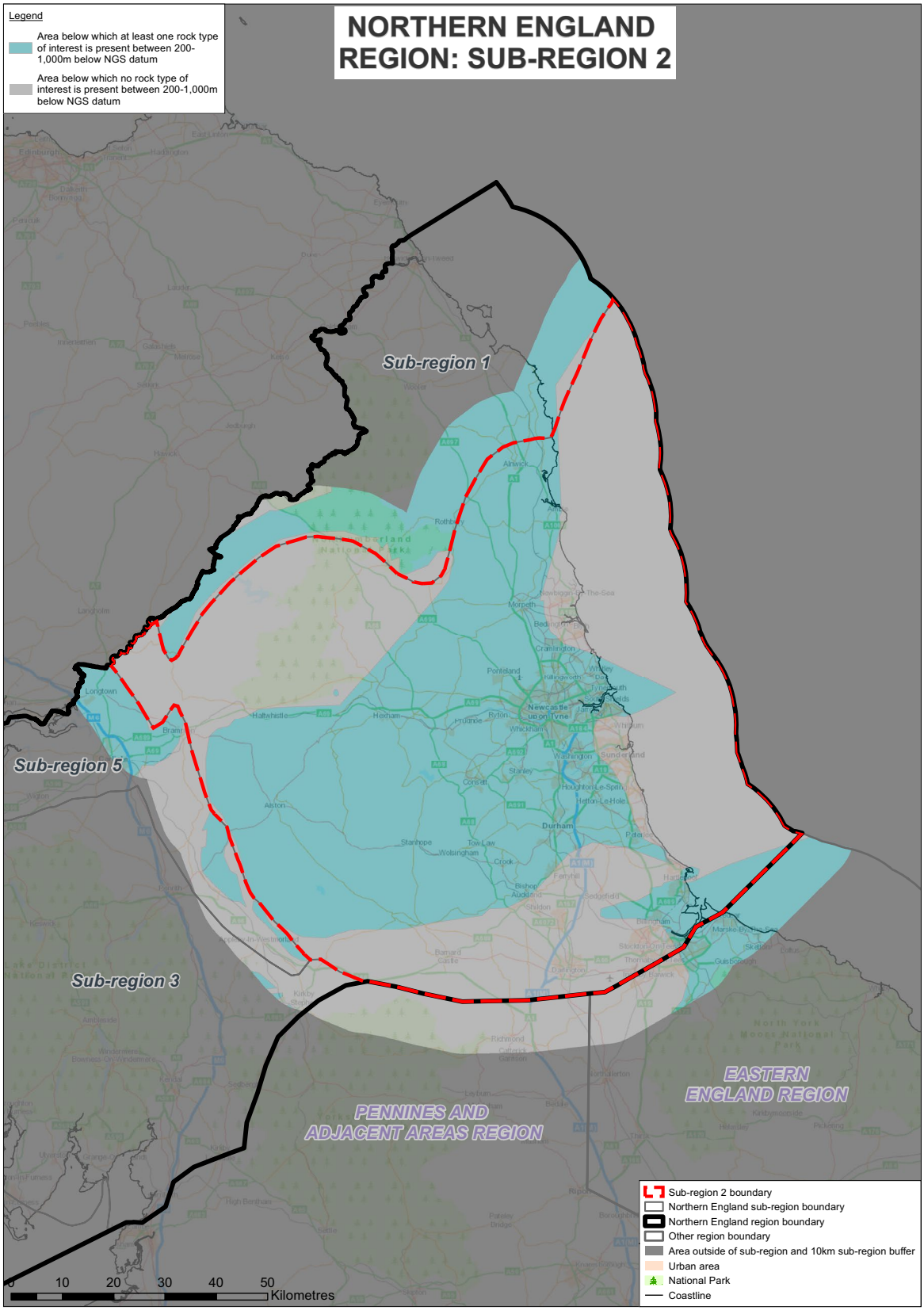


Figure 1b The areas of the Northern England subregion 2 where Higher Strength Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

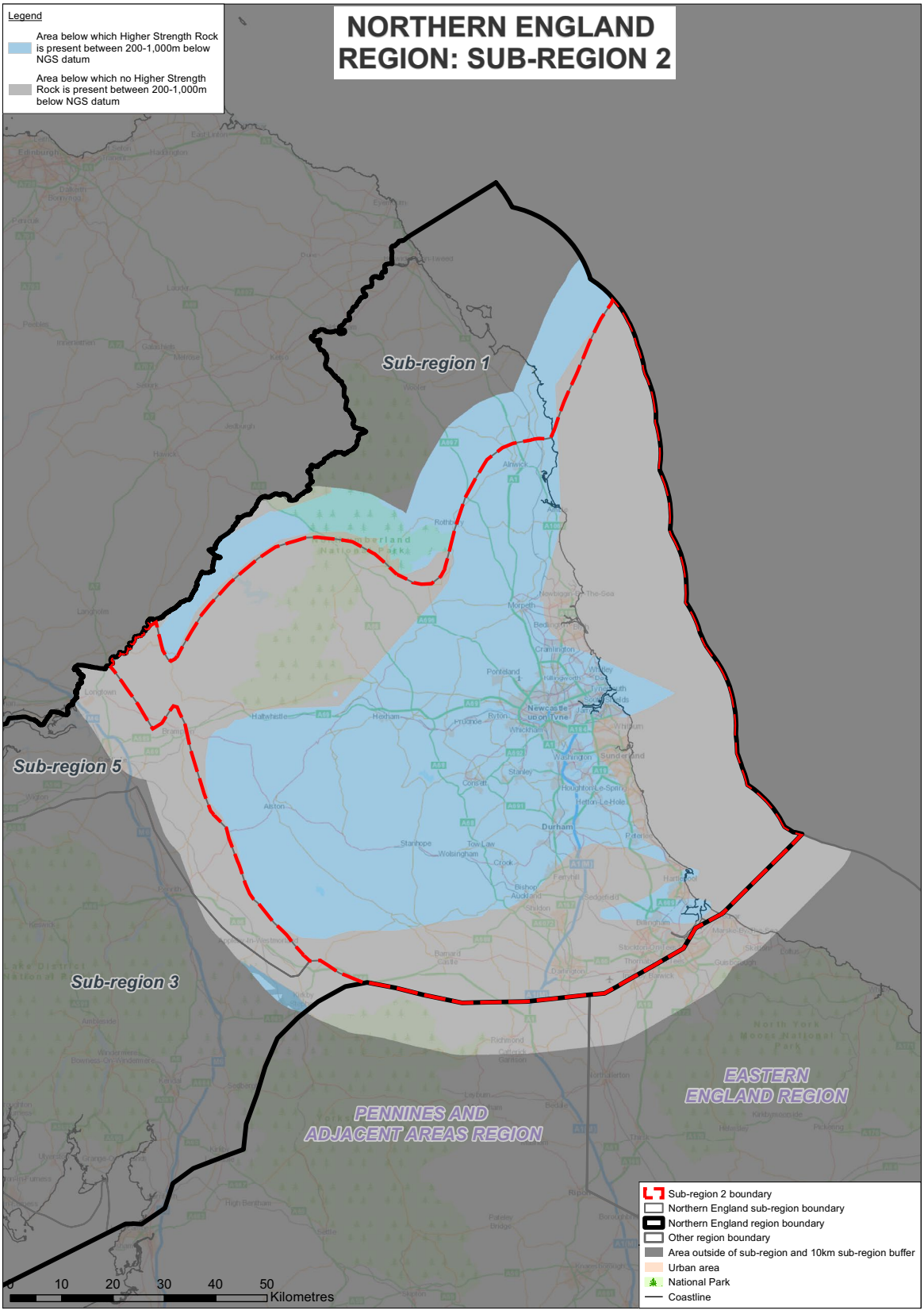


Figure 1c The areas of the Northern England subregion 2 where Evaporite Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

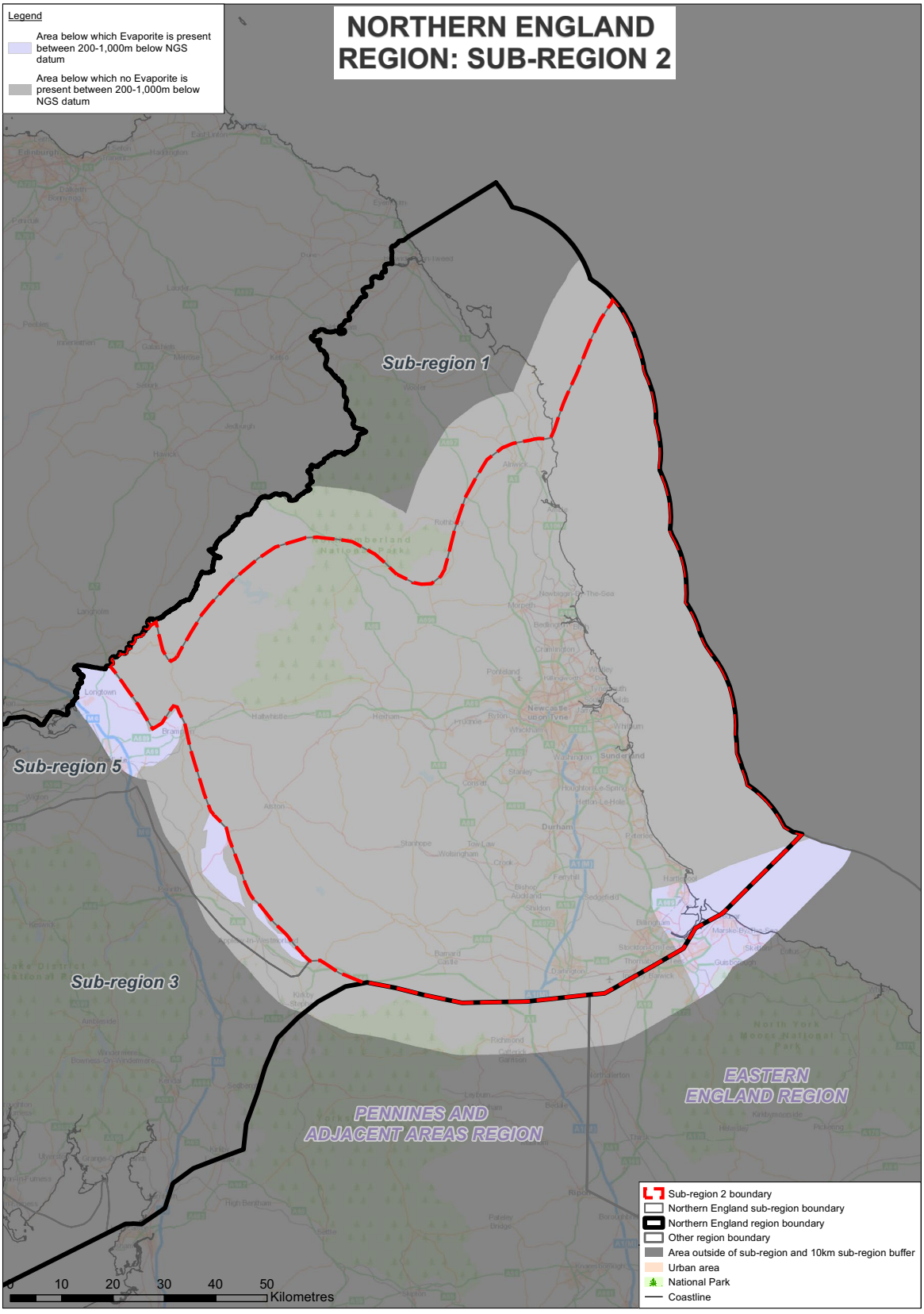


Figure 2 Major faulting and folding in the Northern England subregion 2.

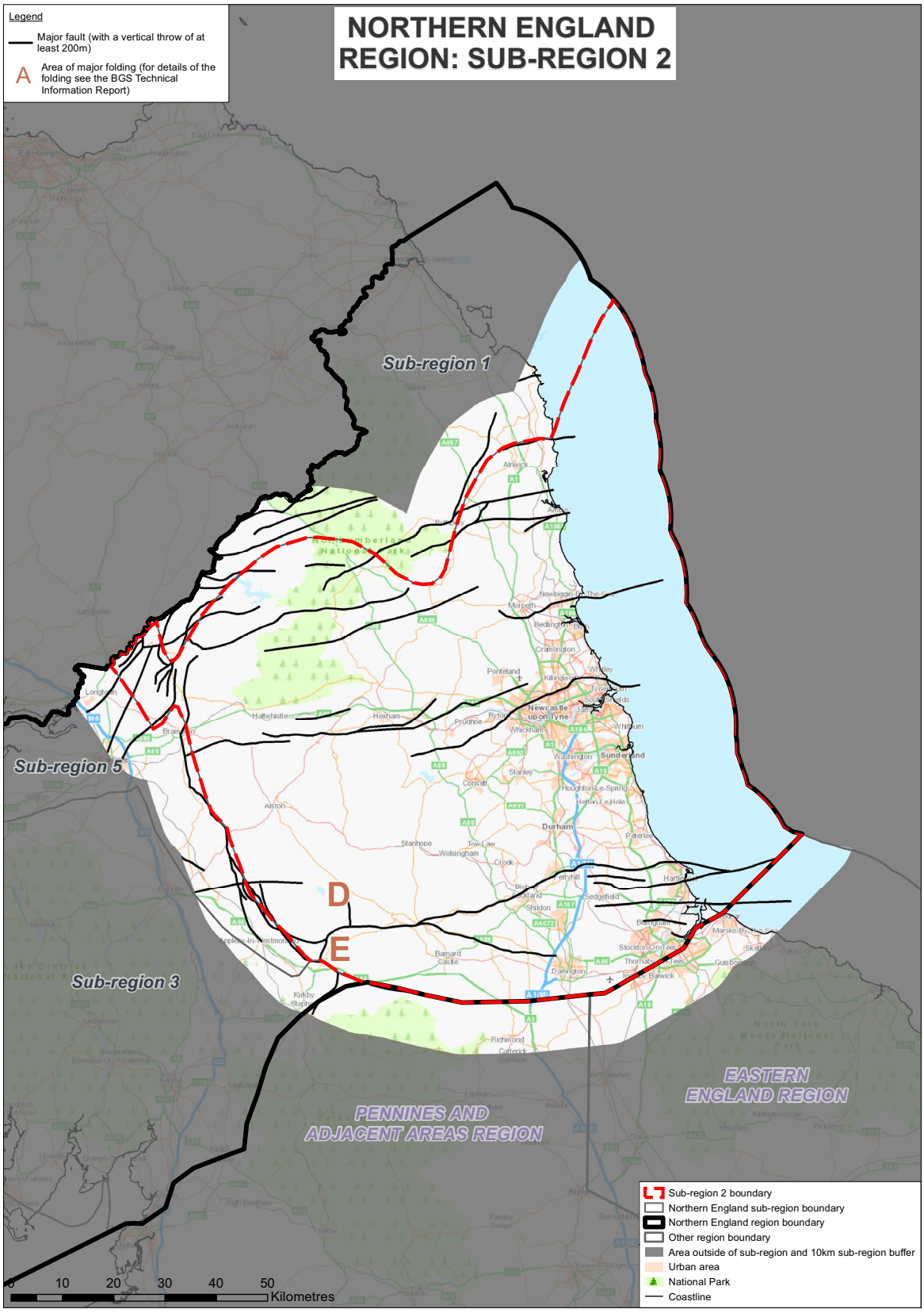


Figure 3 Areas in the Northern England subregion 2 with concentrations of deep exploration boreholes.

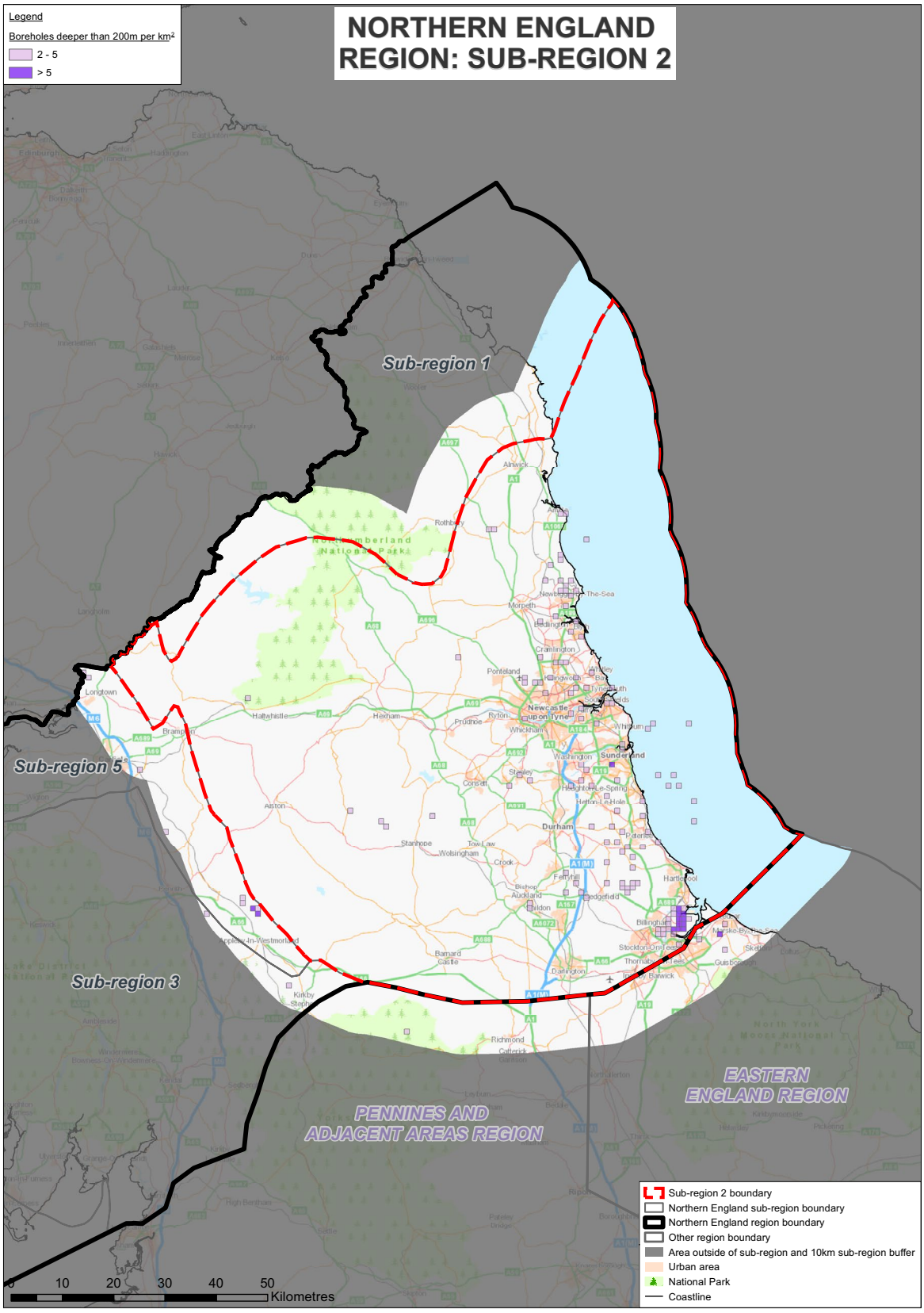


Figure 4a Areas of the Northern England subregion 2 with lead, fluorite and zinc mines present below 100m.

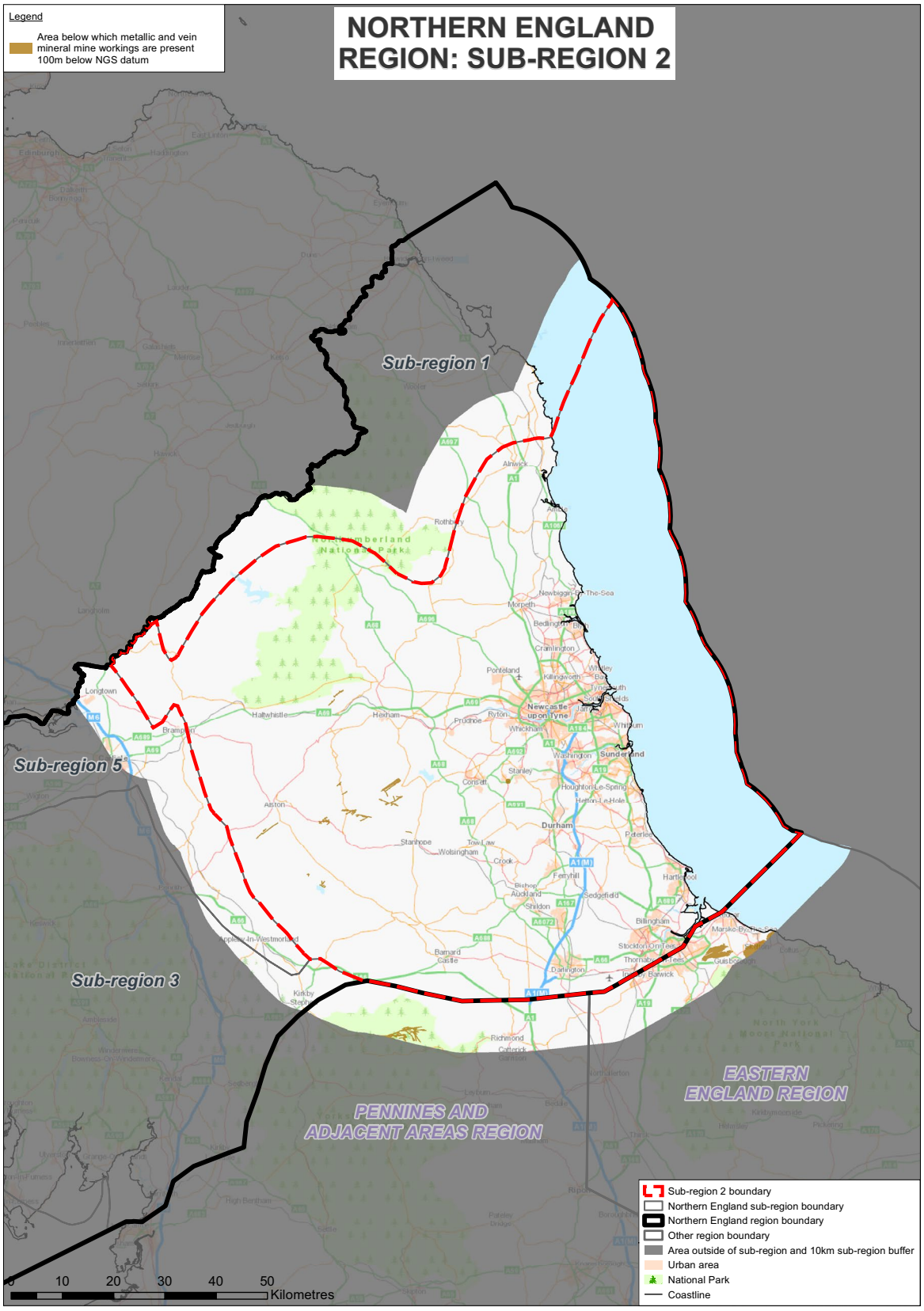


Figure 4b Areas of the Northern England subregion 2 with coal mines more than 100m deep and Coal Authority Licence Areas.

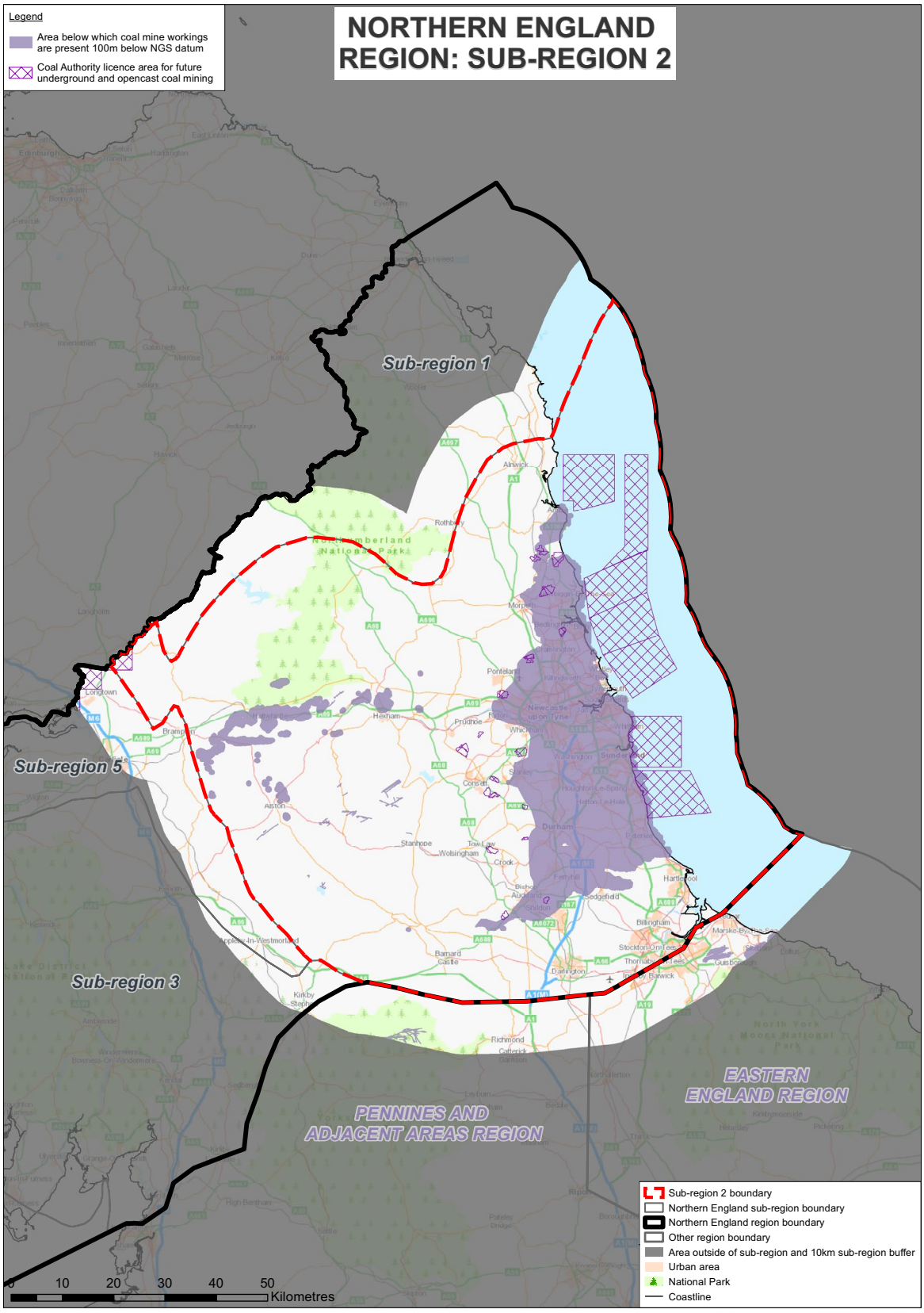


Figure 4c Areas of the Northern England subregion 2 with Petroleum Exploration and Development Licences.

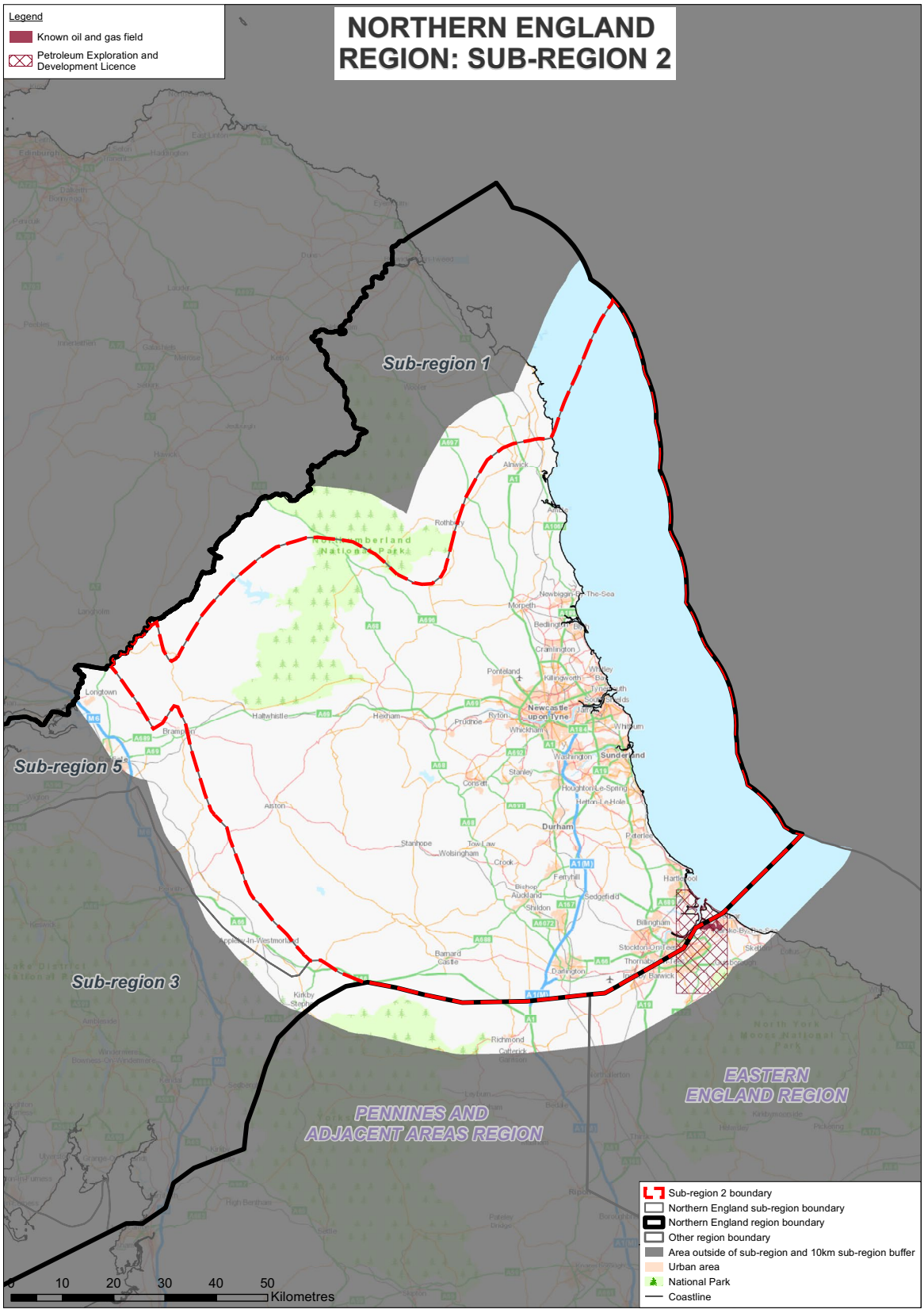
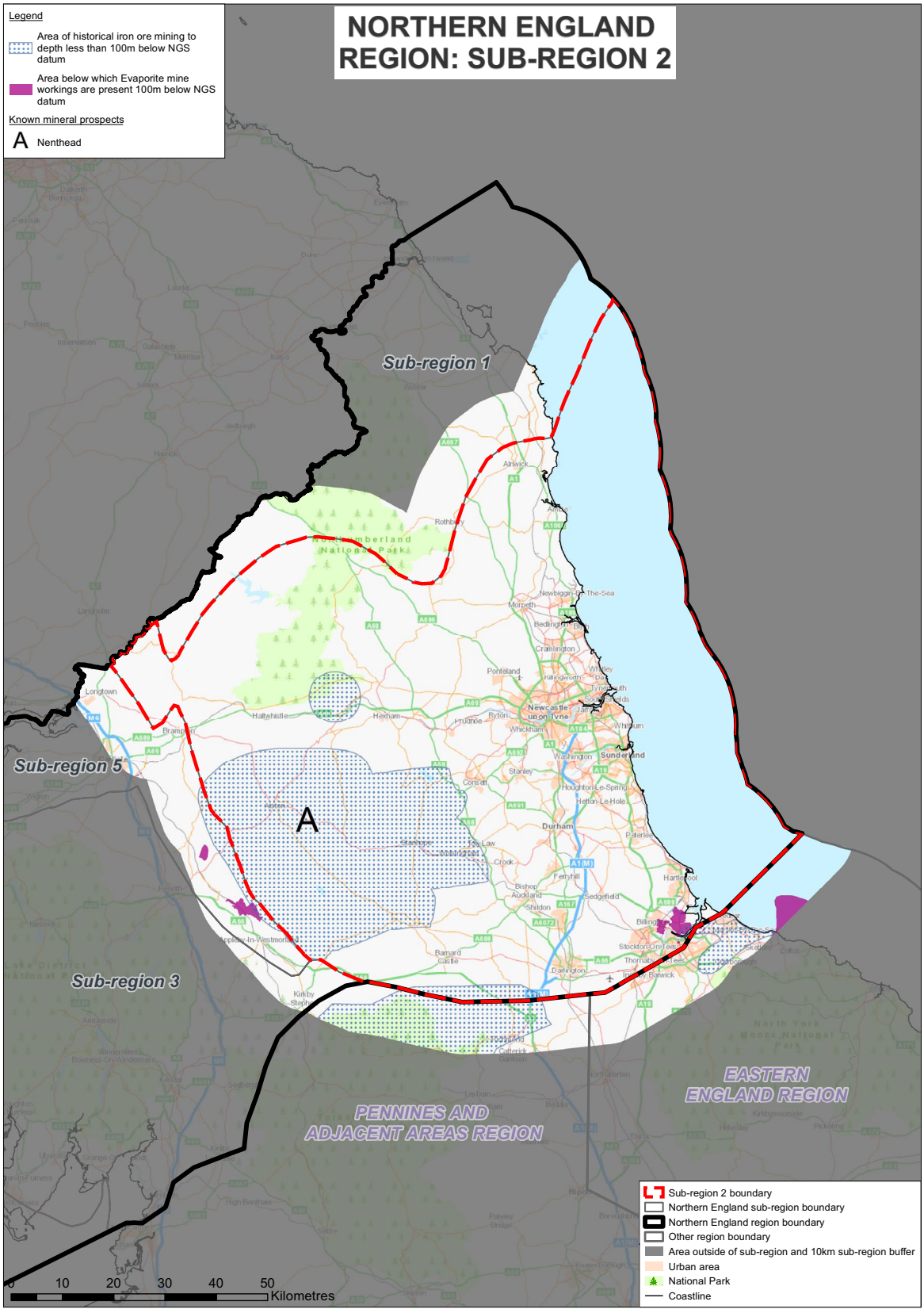


Figure 4d Areas of the Northern England subregion 2 with historical iron ore mines less than 100m deep, known mineral prospects and evaporite mines present below 100m.



Glossary

Anhydrite
A calcium sulphate mineral that forms from the evaporation of salty seas. It contains no water and occurs at greater depths and higher temperatures than gypsum.

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.

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.

Fracture
A crack or discontinuity in rock. These cracks can provide a way for fluids, such as groundwater or gas to move in otherwise impermeable rock.

Granites
Pale-coloured, coarse crystalline igneous rock rich in silica, sodium, calcium and potassium.

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

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.

Outcrop
A visible exposure of bedrock on the surface.

Potash
The collective term for potassium-bearing evaporite minerals. Potash is mined in the UK for use in fertilizer.

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.

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.

Vein
Sheet-like accumulations of minerals that have been intruded into fractured rock. Commonly they are made up of quartz or calcite crystals but can also contain small concentrations of precious metals.

Radioactive Waste Management

Building 587
Curie Avenue
Harwell Oxford
Didcot OX11 0RH

T 03000 660100
www.gov.uk/rwm