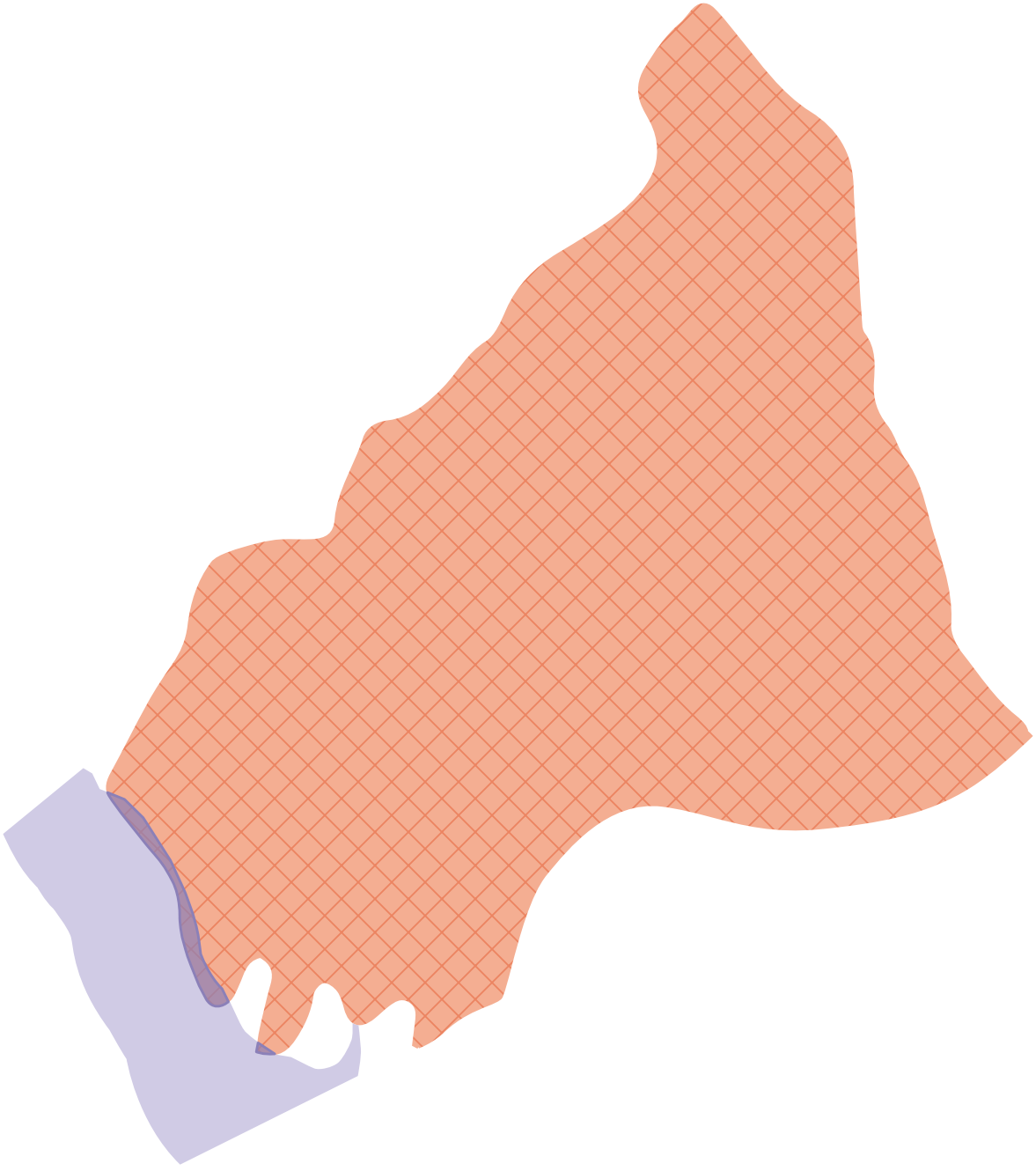
Radioactive Waste Management



Northern England

SUBREGION 4

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.

Most of the subregion is the inshore area which extends to 20km from the coast, but rock can be seen at the surface in the sea cliffs. Combined with some deep boreholes and numerous geophysical investigations, this gives us an understanding of the rocks present and their distribution.

There are clay-rich rock layers and layers of rock salt under most of subregion in which we may be able to site a GDF. There are also volcanic lavas and similar strong rocks around Egremont, 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 in the depth range of interest for a GDF.

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.

There are no known coal, oil, gas or metal resources in this subregion which means that it is unlikely that future generations may disturb a facility.

Parts of this area, particularly off the coast around Barrow-in-Furness, 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, off the coast to the south-west of Whitehaven, 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.

Introduction

This subregion is located largely in the inshore area extending to 20km from the coast from Morecambe Bay to St Bees Head.

Rock type

Figures 1a to 1d 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. The geology of this subregion is mainly known from geophysical surveys carried out as part of investigations near Sellafield in west Cumbria, and for inshore hydrocarbon exploration, and from deep boreholes in the Sellafield area and off the coast.

The Triassic Mercia Mudstone Group (approx. 200 to 250 million years old) is widespread off the coast in the depth range of interest and is dominated by mudstone. The mudstones also contain minor amounts of dolomite and dolomitic mudstone and gypsum and anhydrite occur in nodules and veins. The total thickness of the Mercia Mudstone Group increases rapidly to the south-west, from 230 to 2,250m. The 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) hosts where they are sufficiently thick. In this subregion the Mercia Mudstone Group also contains a series of 5 evaporite units containing rock salt (halite) layers. Off the coast, these rock salt layers may also be in excess of 100m thick and are potential Evaporite host rocks, although they are not always within the depth range of interest.

The Permian Cumbrian Coast Group (approx. 250 to 300 million years old) comprises mudstones with minor sandstones and evaporites. The mudstones are of variable thickness, but often exceed 100m, thinning onshore. These mudstones are comparable to those of the Mercia Mudstone Group, and may also have suitable properties to act as LSSR. They lie above an evaporite unit which contains mudstones, limestones and anhydrite together with halite beds which may be up to 100m thick and provide a potential Evaporite host rock off the coast, but are thinner onshore.

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.

Basement rocks occur beneath the younger sedimentary rock sequence along the coast, and are an extension of those described under subregion 3 of this region; they include rocks of the Ordovician Borrowdale Volcanic Group (approx. 445 to 485 million years old) which were studied in some detail as part of earlier investigations into the potential of the area around Sellafield in west Cumbria for geological disposal. These tuffs have been folded and metamorphosed to become slates which are potential HSR host rocks.

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 in this subregion, but the rocks have not been significantly affected by folding (Figure 2). The structure of this subregion is well-defined by geophysical surveys. The south-west margin of the Lake District in particular is affected by a series of faults forming the Lake District Boundary Fault. 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 in the onshore part of the subregion. There are several principal aquifers in the subregion including the Sherwood Sandstone and Appleby Groups where they occur onshore. However, most of this subregion is inshore where the water present in the pores of rocks beneath the seabed is saltwater rather than fresh and they are not therefore suitable for use as aquifers.

LSSR and Evaporite rocks occur above the basement and so provide a barrier to vertical movement between deep and shallow groundwater and the seabed even where they are not thick enough to host a GDF. Onshore, investigations of groundwater in the vicinity of Sellafield in west Cumbria established that freshwater was present in the Sherwood Sandstone Group; with increasing depth the water becomes more saline as a result of influx of seawater and brines from the thick sedimentary sequences beneath the Irish Sea. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2]. In the thin strip of the coastal plain, water in the basement rocks may not be separated from shallow groundwater by layers of clay-rich rocks or evaporites. However, since it is saline, and therefore of higher density than fresh water, it is unlikely that the deep saline water could rise and mix with shallow groundwater.

In some areas in the subregion, in the vicinity of the iron 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). 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

A number of Petroleum Exploration and Development Licences[3] are currently held in the subregion, particularly in the inshore near Barrow-in-Furness (Figure 4a). There are also Coal Authority Licence Areas in the northernmost inshore part of this subregion off Whitehaven (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.

There are 2 small areas of historical mining for iron ore along the eastern edge of the subregion, but the mining did not extend below 100m and therefore would not be of relevance to the safety of a GDF (Figure 4c).

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 Northern England subregion 4 where any of the 3 Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

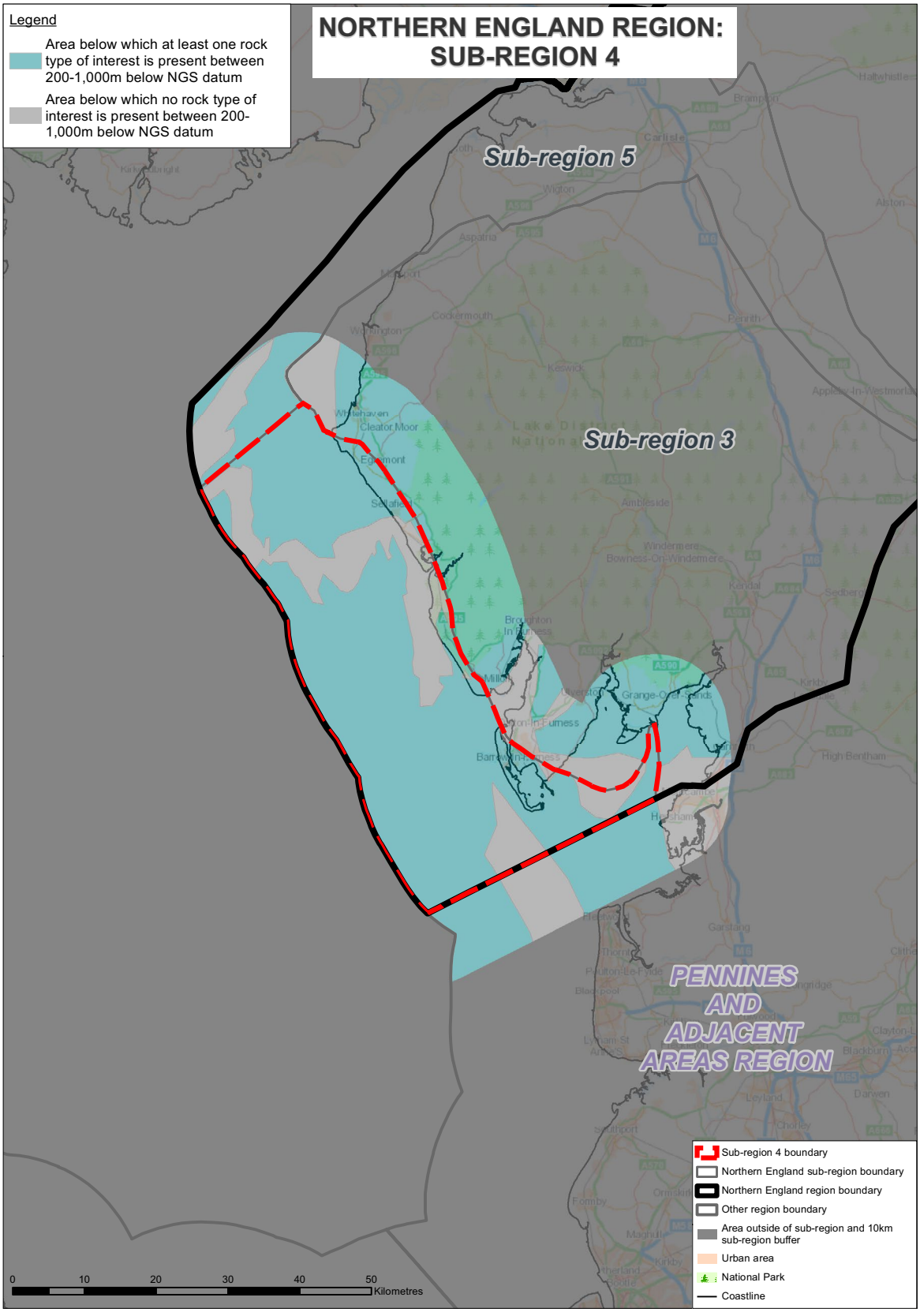


Figure 1b The areas of the Northern England subregion 4 where Lower Strength Sedimentary Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

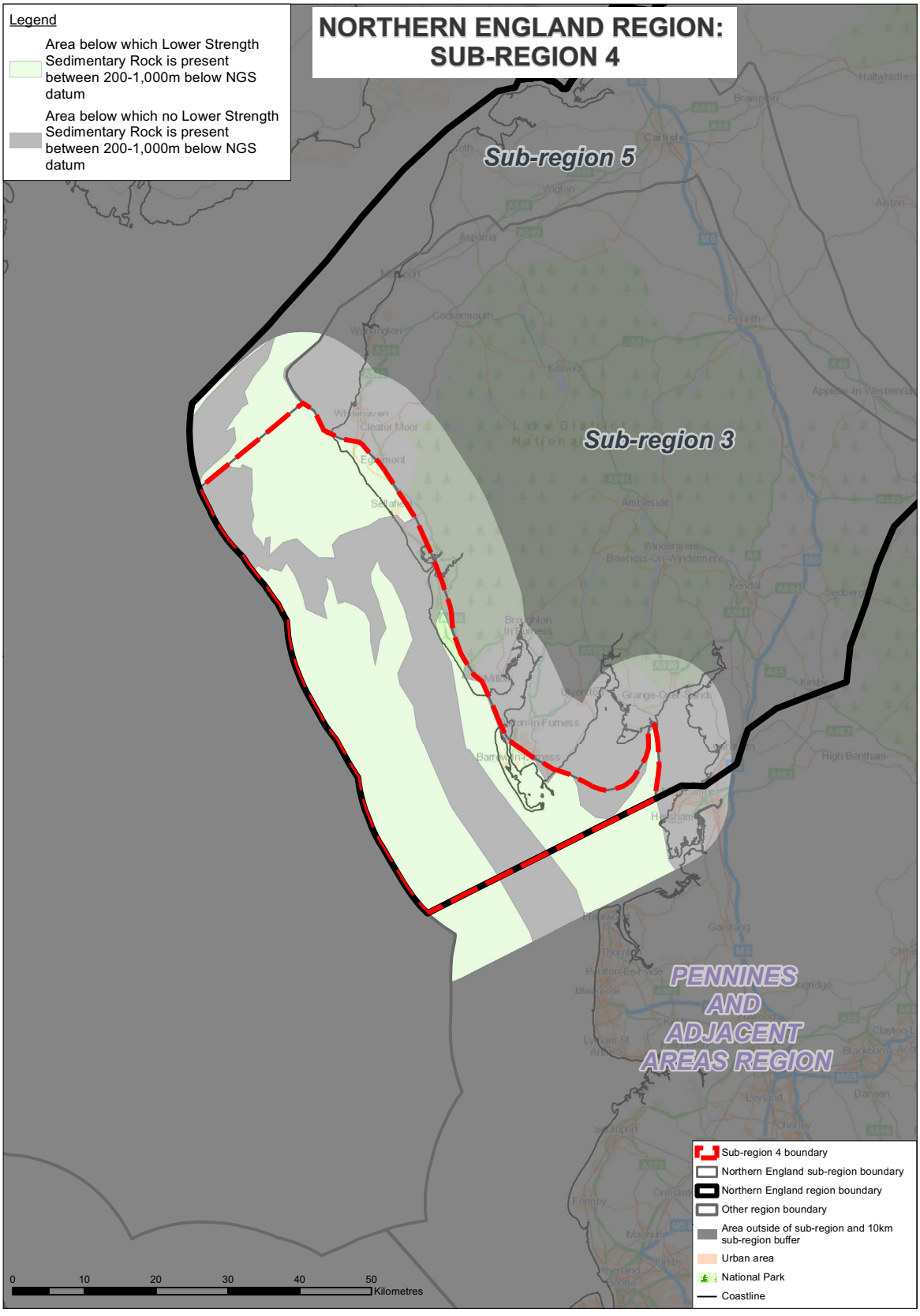


Figure 1c The areas of the Northern England subregion 4 where Higher Strength Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

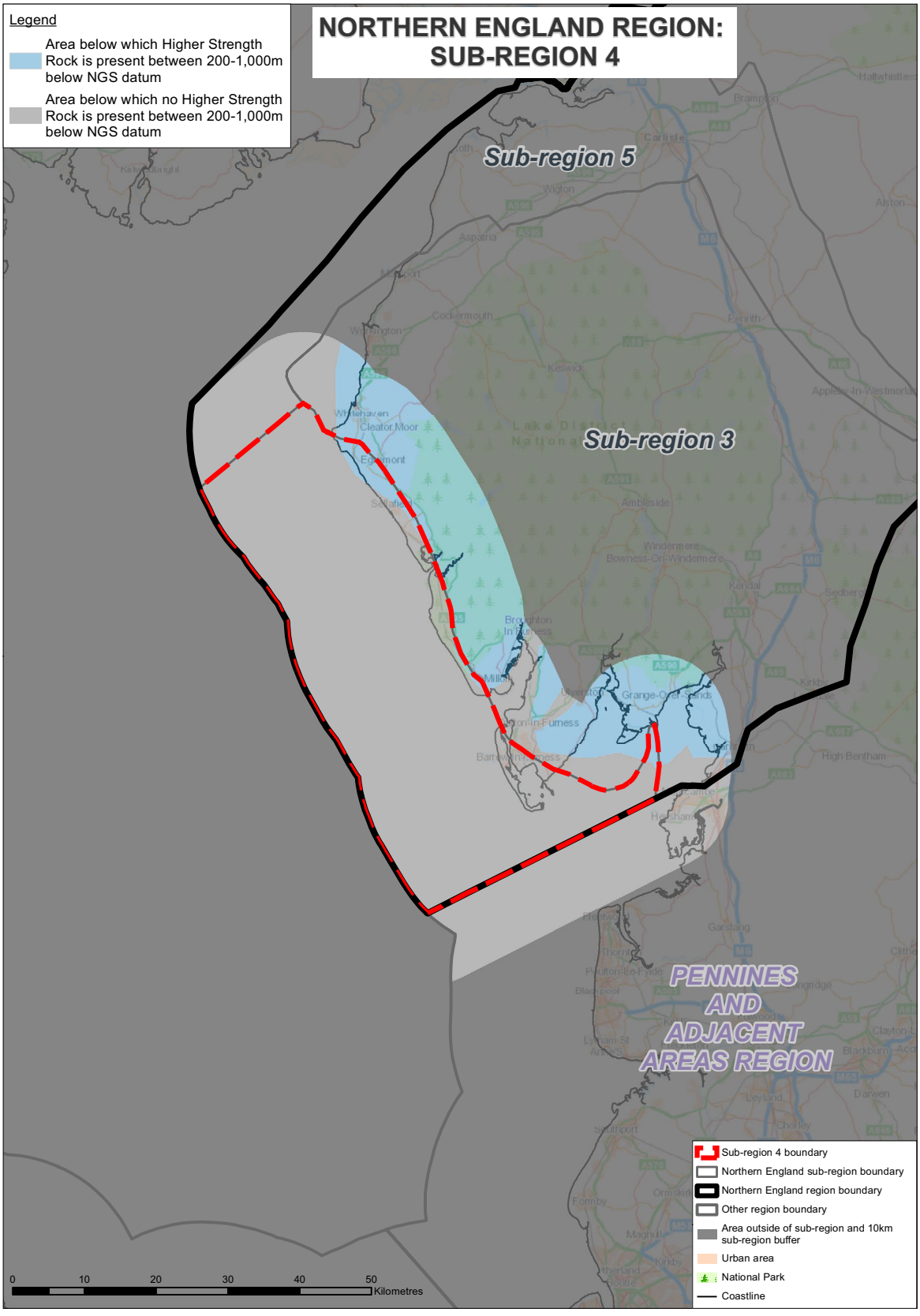


Figure 1d The areas of the Northern England subregion 4 where Evaporite Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

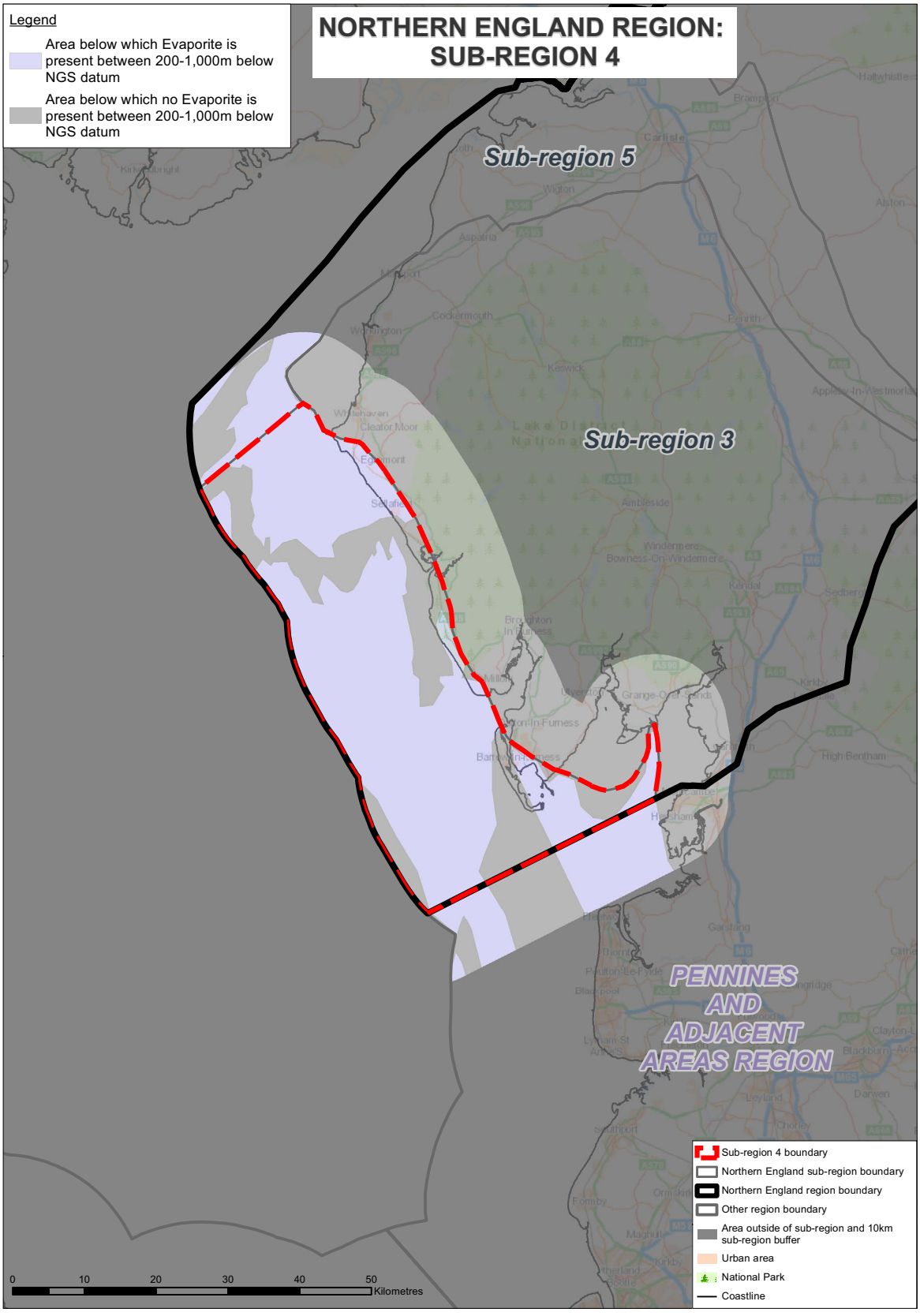


Figure 2 Major faulting and folding in the Northern England subregion 4.

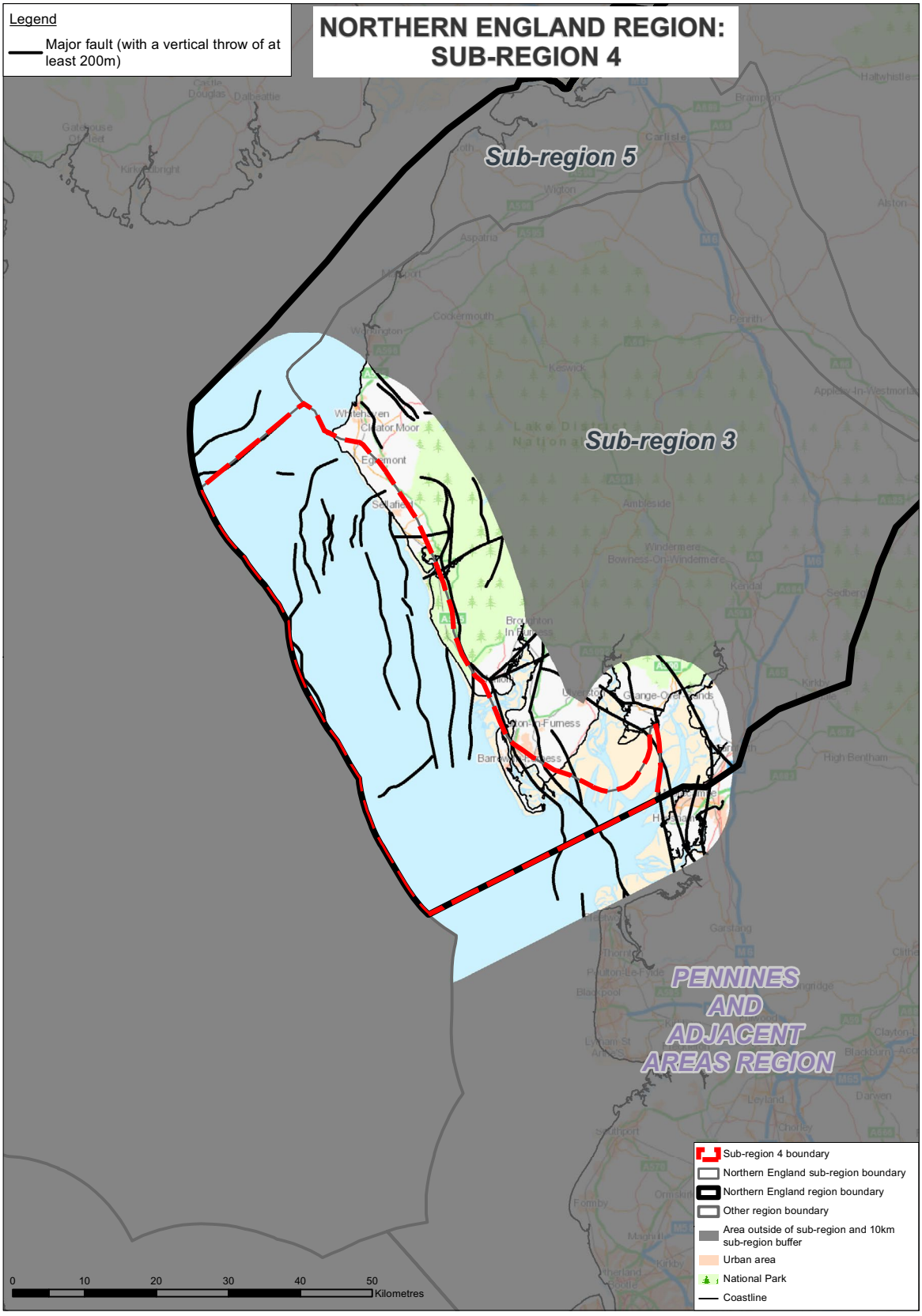


Figure 3 Areas in the Northern England subregion 4 with concentrations of deep exploration boreholes.

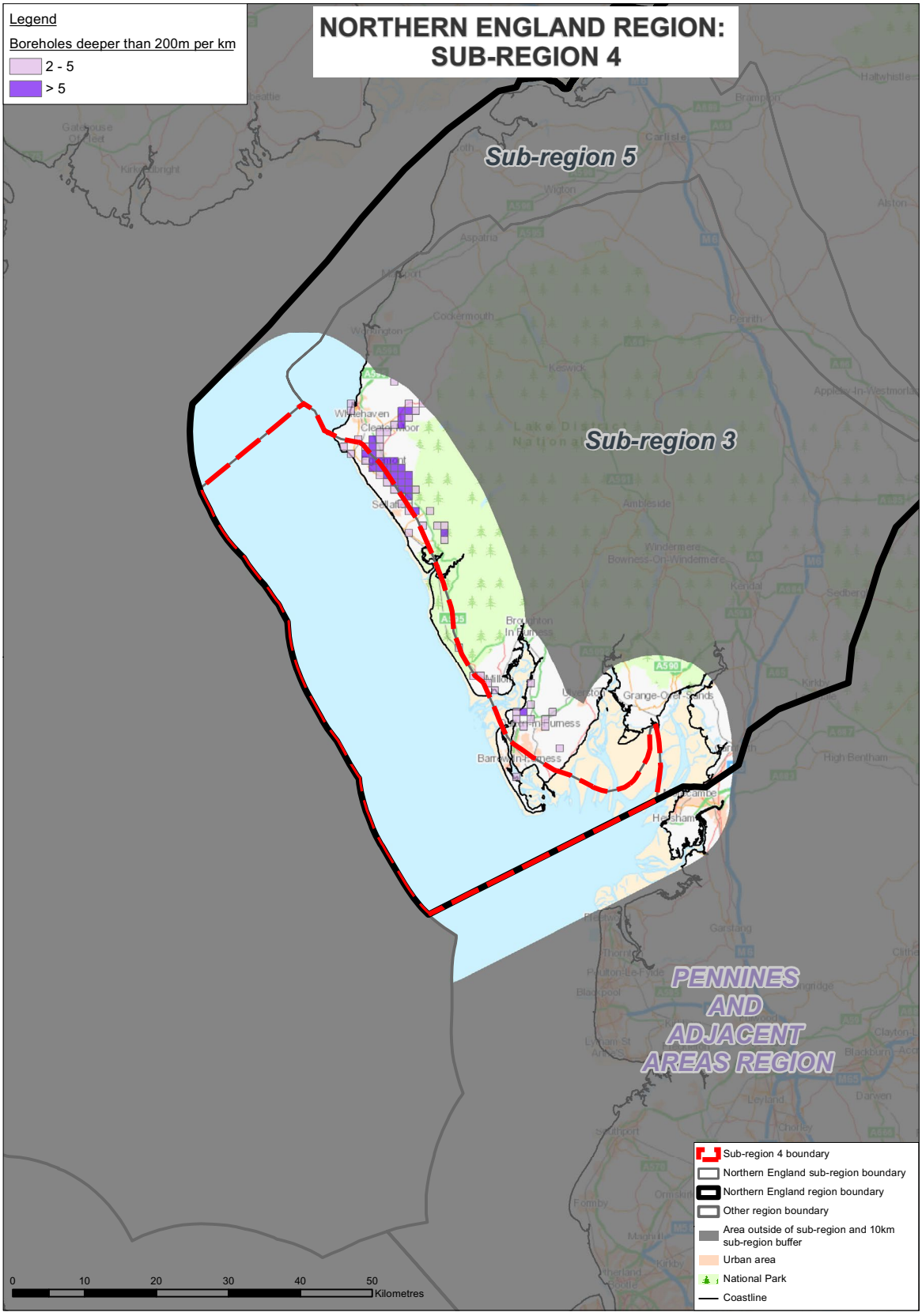


Figure 4a Areas of the Northern England subregion 4 with Petroleum Exploration and Development Licences.

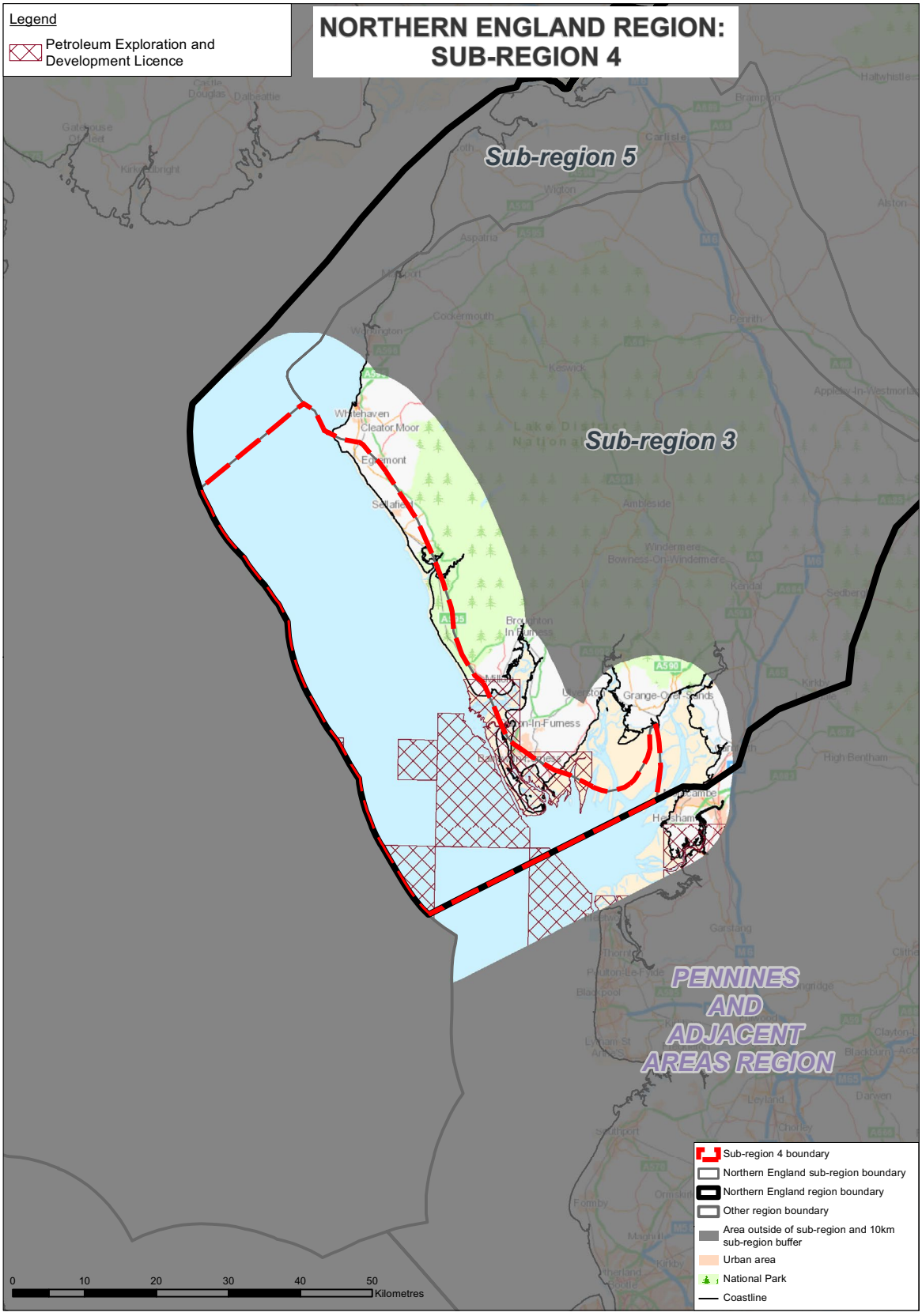


Figure 4b Areas of the Northern England subregion 4 with Coal Authority Licence Areas.

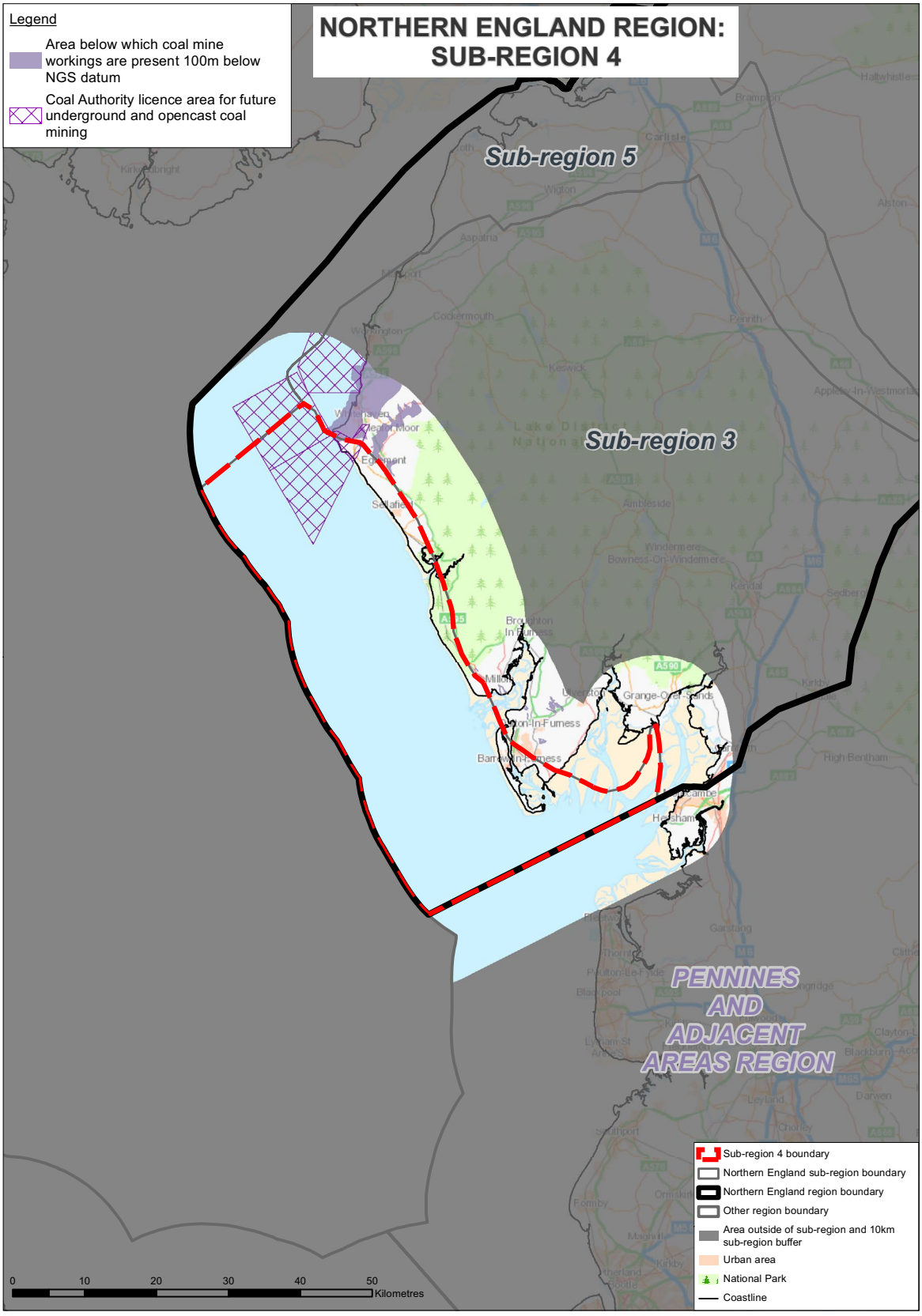
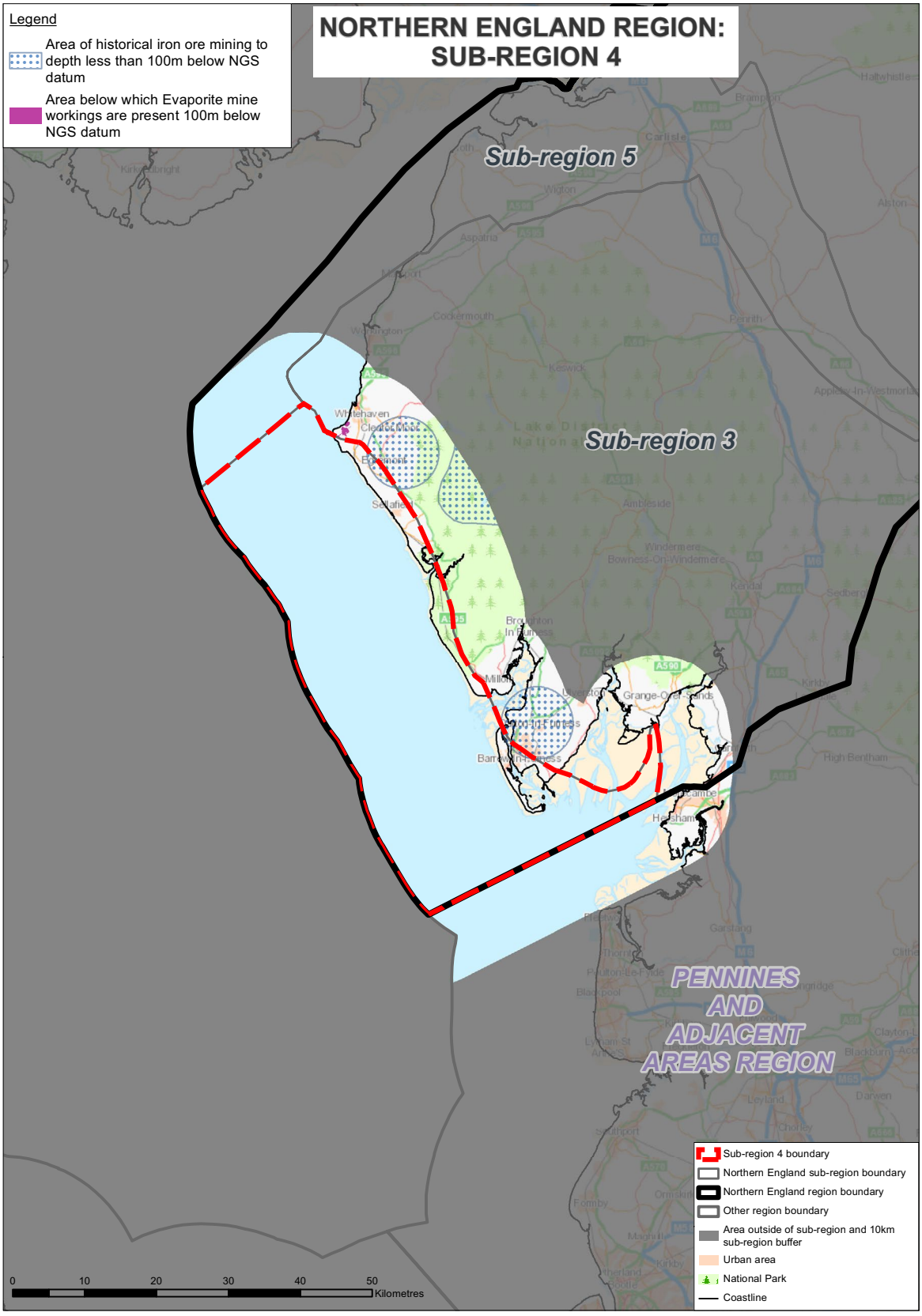


Figure 4c Areas of the Northern England subregion 4 with historical iron ore mines less than 100m deep.



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.

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

Dolomite
Magnesium carbonate mineral which often is found in limestones.

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.

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.

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.

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

Nodules
Small, often irregular mineral precipitations found within sedimentary rocks. They usually have a contrasting composition to the rock in which they are found e.g. flint nodules in chalk.

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).

Tuff
Fine-grained rock formed from compacted ash ejected during explosive volcanic eruptions.

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

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