

# Northern Ireland

## SUBREGION 1



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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 Petroleum Licences which was updated to include data to the end of June 2018.

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

Rock can be seen at the surface at some places in this subregion such as sea cliffs 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 [clay-rich rock](#) layers under most of the subregion including the north around Coleraine, Ballymoney and Ballycastle and south of Carnlough, Ballymena and Magherafelt, in which we may be able to site a GDF. There are also [volcanic lavas, slates and similar strong rocks](#) between Ballycastle and Cushendall, and layers of [rock salt](#), between Belfast and Larne, 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.

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.

One small area around Coalisland, County Tyrone was mined to depths below 100m for coal resources. In this area the mining is likely to have affected the way in which water moves through the rock. Also possible exploration in the future in this area means that it is more likely that future generations may [disturb a facility](#).

Parts of this area, north of Belfast, have [Petroleum 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 subregion which are mined for rock salt, in the south and east of County Antrim, 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 comprises the Antrim Plateau which covers most of County Antrim, eastern County Londonderry and the parts of Tyrone, Armagh and Down closest to Lough Neagh. It includes the adjacent [inshore](#) area which extends to 20km from the coast.



## Rock type

The surface geology of this subregion is dominated by the Antrim basalts, seen most famously at Giant's Causeway. However, even where they occur within the **depth range of interest**, they are not considered to be potential **Higher Strength Rocks** (HSR) because the tops and bottoms of individual **lava flows** are likely to be highly weathered and weak. **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 largely comprises a reasonably well-known and predictable sequence of **sedimentary** and volcanic **igneous** rocks throughout the depth range of interest. It includes 2 rock units containing **Lower Strength Sedimentary Rock** (LSSR) layers which may have potential to host a GDF:

- The Lias Group of Jurassic age (approx. 145 to 200 million years old) occurs within the depth range of interest in the Rathlin Basin (up to 250m thick) and north-east of Armagh in Lough Neagh Basin (up to 120m thick). Although the group is present in the Larne Basin, it is not within the depth range of interest. It contains the Waterloo Mudstone Formation which is predominantly mudstone with thin (<30cm thick) limestone interbeds. It is not known whether individual mudstones are thick enough to act as a host rock, but the Lias Group provides an effective **barrier to movement of groundwater** from depth towards the surface.
- The Mercia Mudstone Group of Triassic age (approx. 200 to 250 million years old) consists of up to 1,030m of reddish mudstones and siltstones with at least 200m present in the depth range of interest under much of this subregion. The thick, extensive mudstone units are known to act as a barrier to groundwater movement and have the potential to act as LSSR host rocks where they are sufficiently thick. Also sandstone beds up to 2.5m thick, known as 'skerries', occur in the upper parts and sandstone is common in the Lagavarra Formation at the base. These lithological variations would need to be understood to determine whether the Mercia Mudstone Group is suitable to host a GDF in any given location.

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.

In addition to these LSSR layers the Mercia Mudstone Group also contains up to 400m of rock salt (**halite**) under parts of south-east County Antrim between Larne and Belfast in the Larne Basin. In a borehole near Larne, 3 rock salt layers, the Larne, Carnduff and Ballyboley Halites, are present within the depth range of interest and are 178, 180 and 40m thick.

Younger **sills** are located between Limavady and Ballycastle, and between Armagh and Larne respectively. Sills have also been recorded within basins off the coast, and are particularly numerous in the Rathlin Basin located north of Coleraine and Ballycastle where they may reach thicknesses and depths sufficient to be considered as HSR layers. For example, a sill 220m thick was found in the Port More borehole west of Ballycastle, intruded into the Mercia Mudstone Group.



**Basement** rocks only occur in the depth range of interest in the north-east of this subregion between Ballycastle and Cushendall and comprise **metamorphosed** sandstones, mudstones, limestones and volcanics (the North East Antrim Inlier). There is little information on the nature of these rocks at depth and further information would be required to evaluate their potential as HSR host rocks.

A summary of the geological attributes of Northern Ireland 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** and **LSSR** layers have been affected by numerous **faults** (Figure 2). Although the **basement** rocks located in the Altmore **Anticline** dip fairly steeply, the younger sedimentary rocks are not significantly affected by **folding**. **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 <sup>1</sup>.

### 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 major aquifers are present in this subregion. The Cretaceous (66 to 145 million years ago) Ulster White Limestone (a form of chalk) and Hibernian Greensand act together as a single aquifer which is used for public water supply from boreholes and springs across this subregion. The top of the Ulster White Limestone is generally within 300m of ground surface underneath the Antrim Plateau, with the surface of the deepest portion found in the centre of the Lough Neagh Basin, where it reaches 800m below ground level. Under most of the Antrim Plateau it is confined underneath the younger less **permeable** Antrim Lava Group but boreholes have shown the aquifer to still be permeable and contain low salinity groundwater, for instance at Aughrimderg. **Karstic** conditions have developed in some places in the Ulster White Limestone, where concentration of groundwater flow has enlarged **fractures** by dissolution to form a network of major channels and caves, resulting in fast movement of groundwater near the surface. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK <sup>2</sup>.

The older Sherwood Sandstone Group and Enler Group are considered regionally important aquifer formations with potential for high productivity, and have been historically targeted for **potable** water supplies. The majority of exploitation and investigation of the Sherwood Sandstone and Enler Group aquifers has been focused on the Lagan and Enler Valleys, west of Belfast.

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<sup>1</sup> 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.

<sup>2</sup> Water Framework Directive UK TAG. Defining and reporting on groundwater bodies, 2012.



The low permeability Mercia Mudstone and Lias Groups LSSR layers are likely to provide hydraulic separation between deep and shallow groundwater even where they are not thick enough to host a GDF.

There are some areas, such as around Belfast, Ballymoney, east of Carrickfergus and south of Antrim, where [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.

### Resources

One small shallow coalfield area around Coalisland, County Tyrone, was mined initially at the surface and subsequently underground ([Figure 4a](#)). Mining reached depths of around 270m below [NGS datum](#), but has ceased. In this area 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](#). This known resource would be taken into account in the siting of a GDF.

There are no conventional oil or gas fields in this subregion. However, a number of [Petroleum Licences](#) are currently held in the area north of Belfast ([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 (halite) was mined below 100m in the south and east of County Antrim, using both conventional extraction and [solution mining](#) ([Figure 4c](#)). There is currently 1 active salt mine at Kilroot near Carrickfergus, which has a maximum depth of around 400m and around 2km<sup>2</sup> of workings. 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 are 2 projects to develop [Compressed Air Energy Storage](#) (CAES) and natural gas storage caverns in a salt layer on Islandmagee near Larne, County Antrim. Seismic surveys and drilling results indicate that the layer is over 200m thick at depths of 1,400 to 1,800m below [NGS datum](#).

Although coal and iron ore were both mined in this subregion in the past this mining did not extend below 100m depth and therefore is not of relevance to the siting of a GDF.

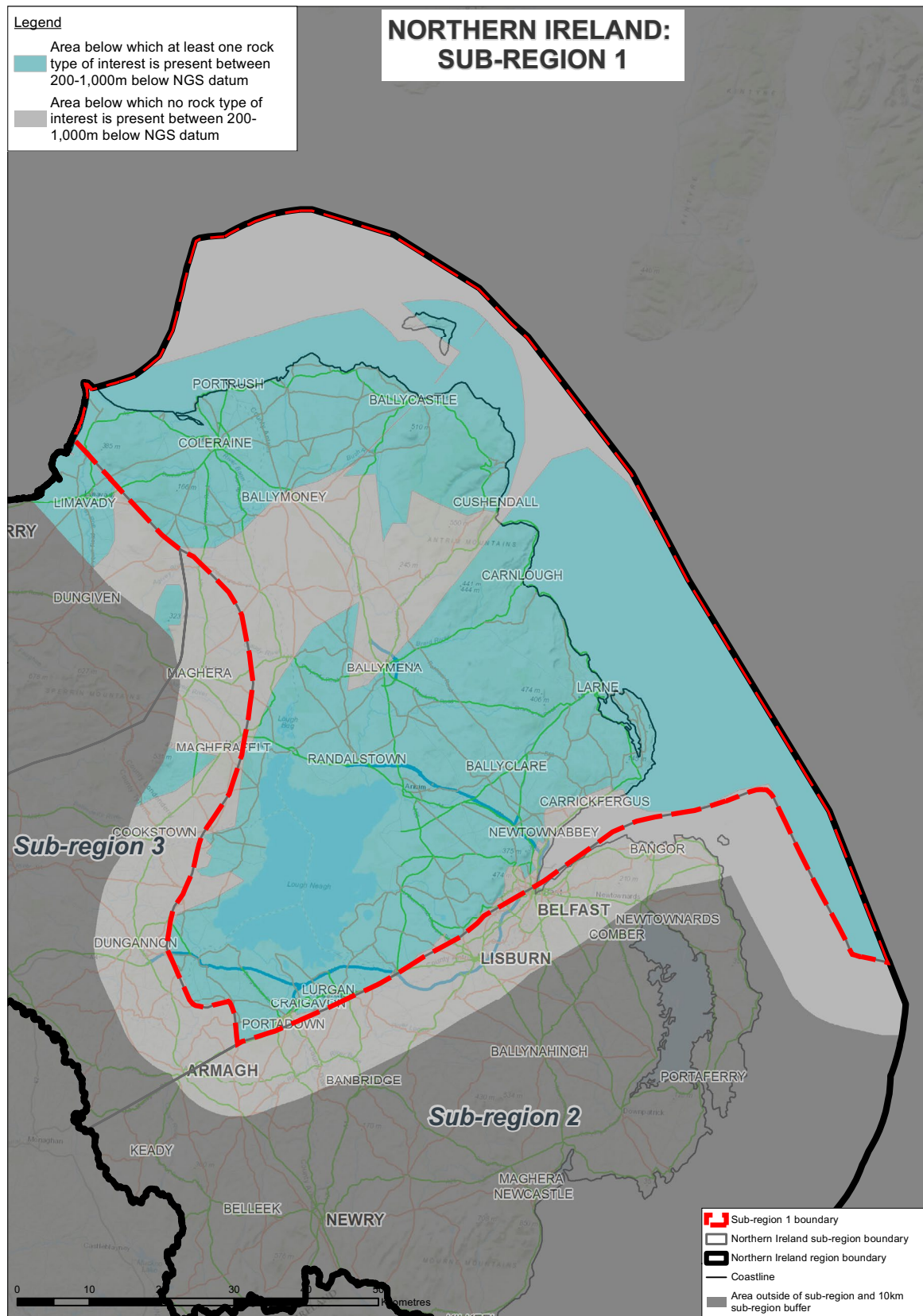
There is some potential for deep geothermal energy for direct heating applications in the sandstone layers currently being targeted for [hydrocarbon](#) exploration in the Rathlin, Larne and Lough Neagh sedimentary basins. These would need to be considered in the siting of a GDF.

### 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.



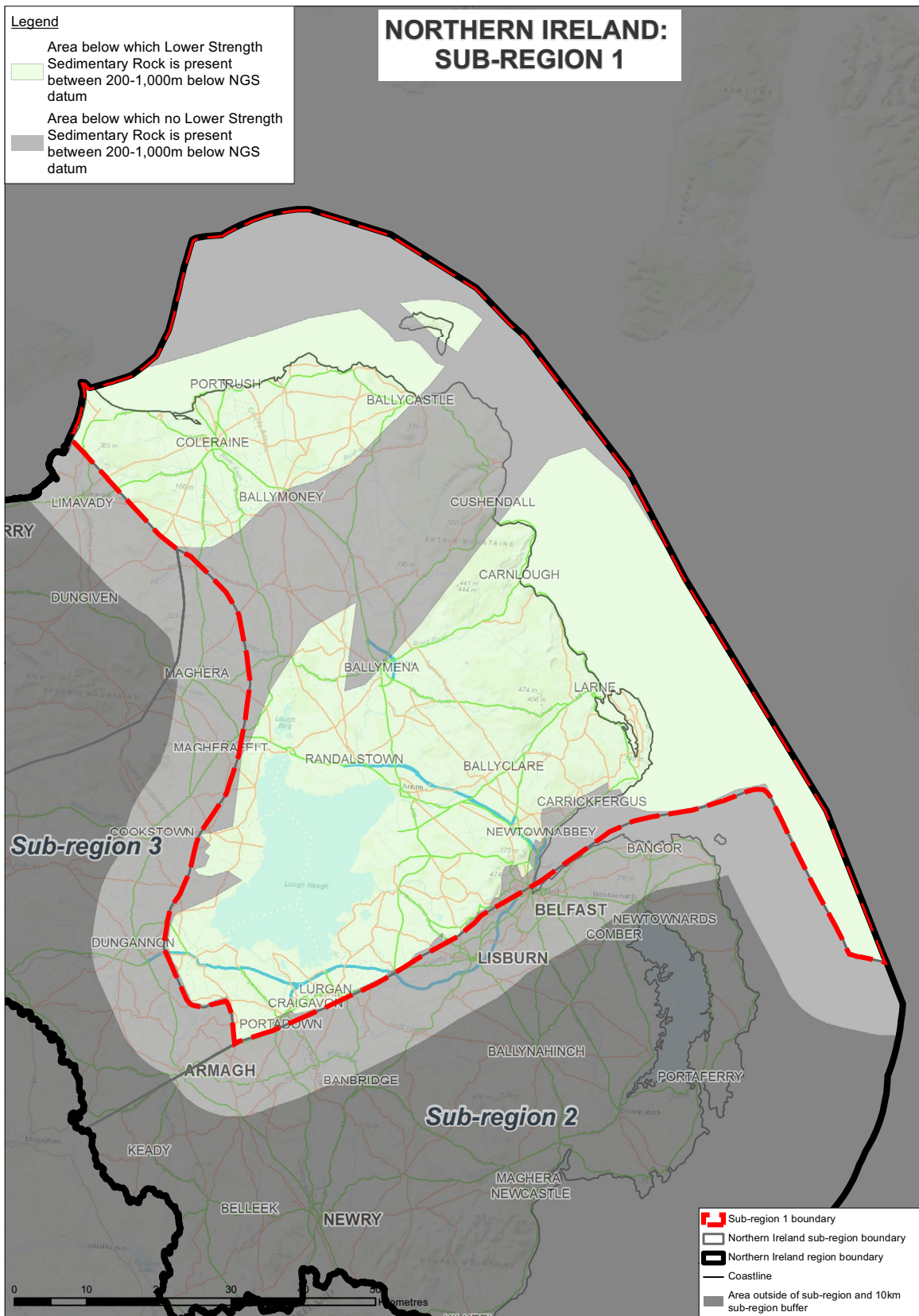
**Figure 1a** The areas of the Northern Ireland subregion 1 where any of the 3 Rock Types of Interest are present between 200 and 1,000 m below NGS datum.







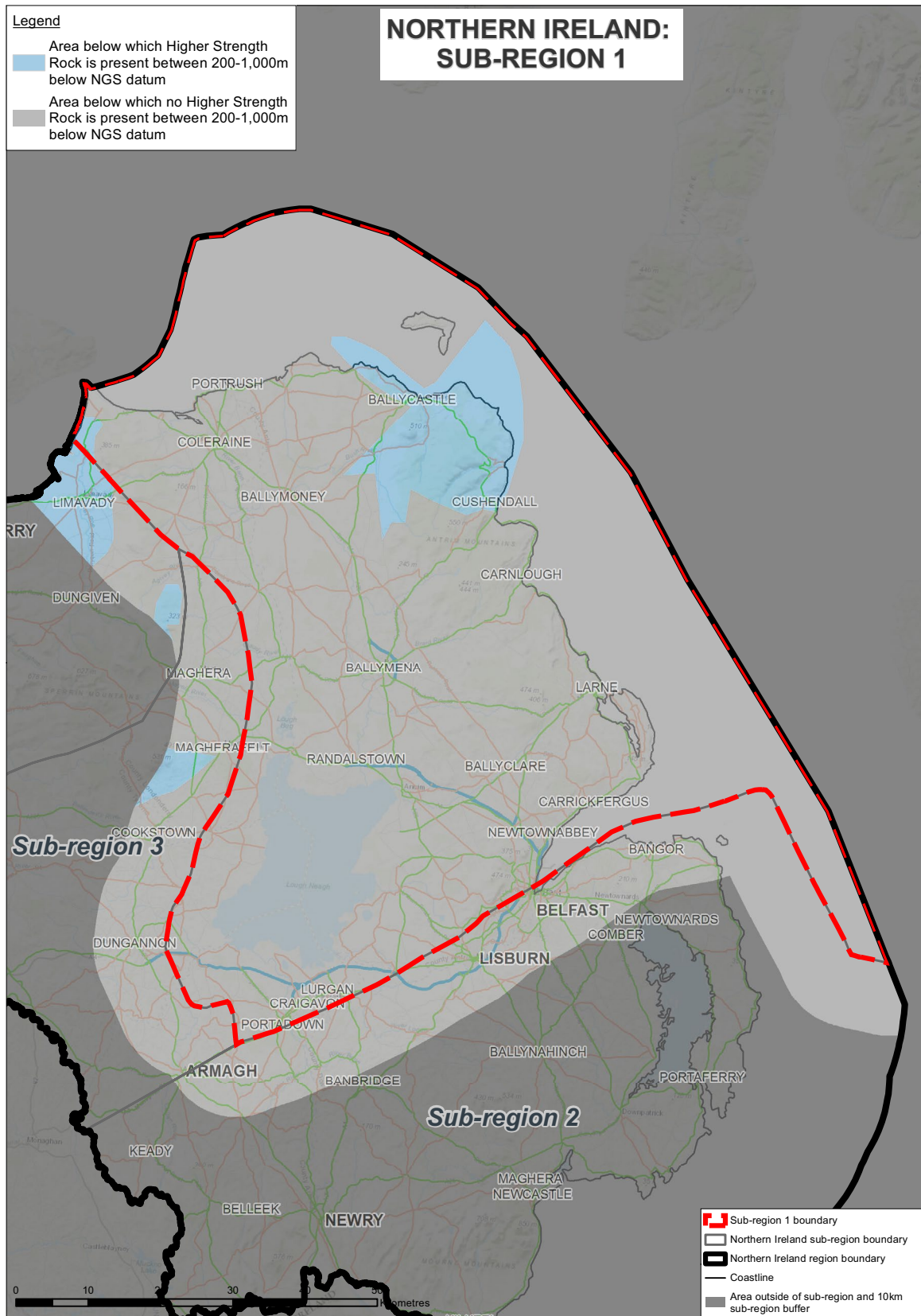
**Figure 1b** The areas of the Northern Ireland subregion 1 where Lower Strength Sedimentary Rock Types of Interest are present between 200 and 1,000 m below NGS datum.







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

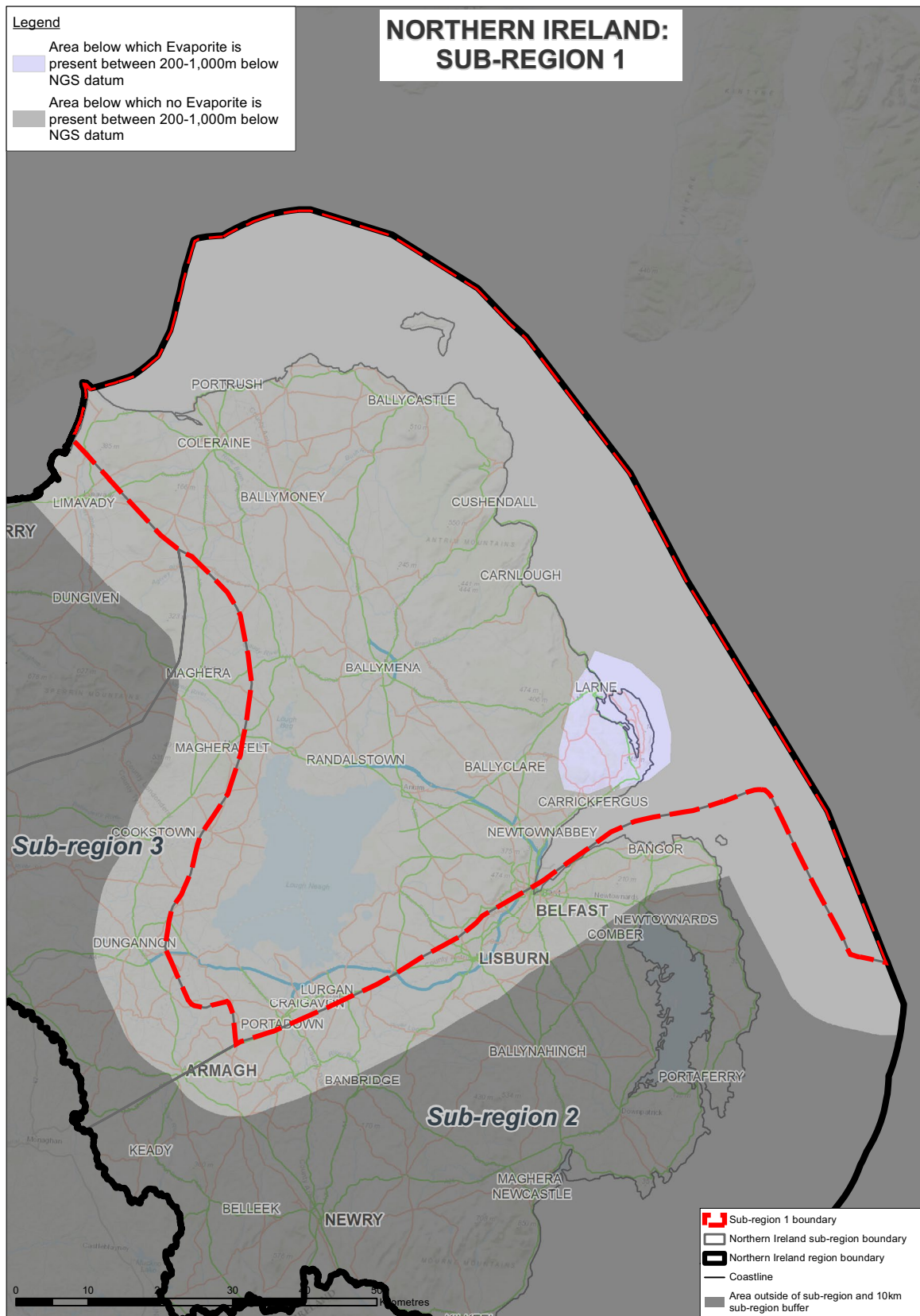
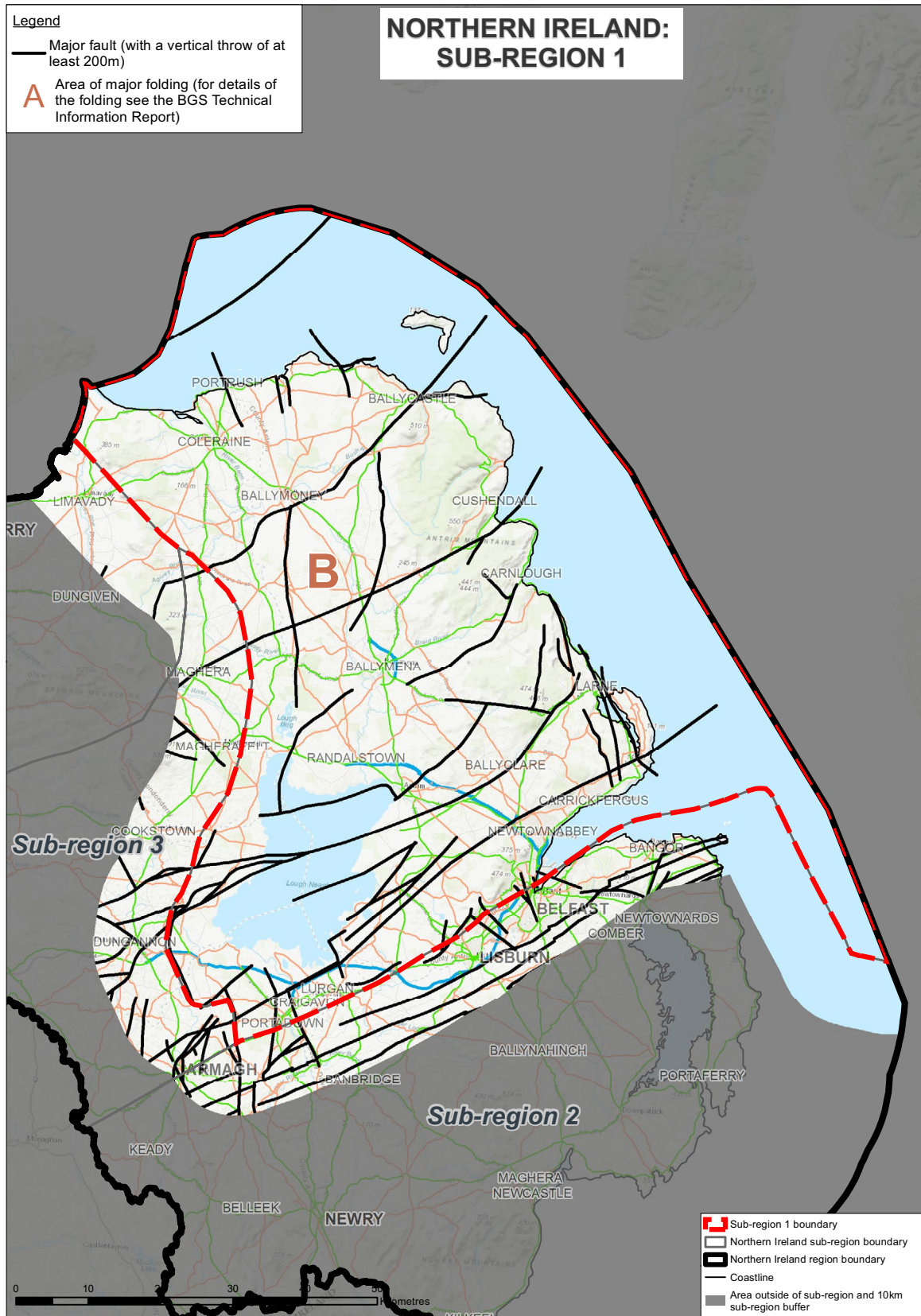






Figure 2 Location of major faults in the Northern Ireland subregion 1





**Figure 3** Areas in the Northern Ireland subregion 1 with concentrations of deep exploration boreholes.

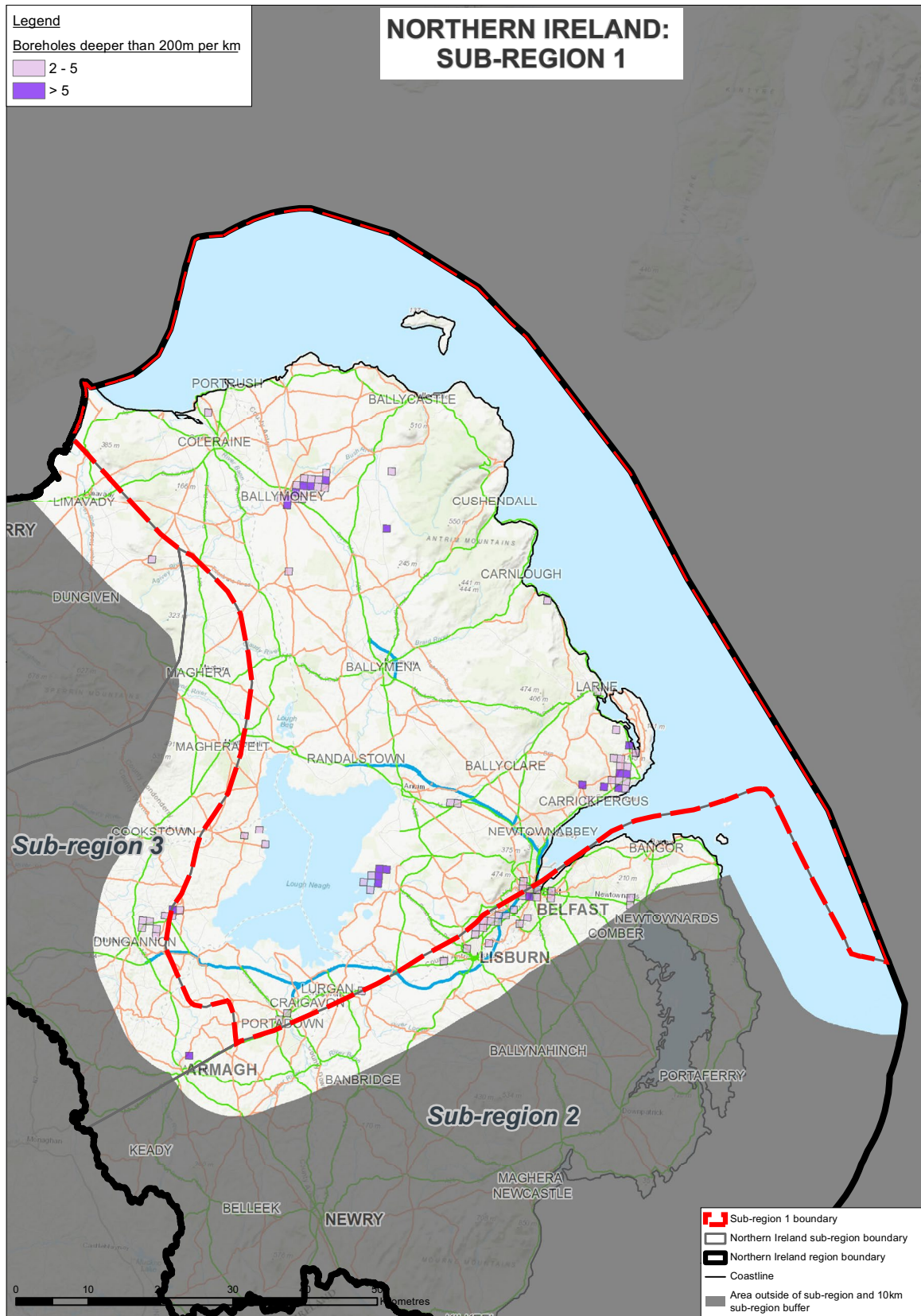






Figure 4a Areas of the Northern Ireland subregion 1 with coal mines present below 100m.

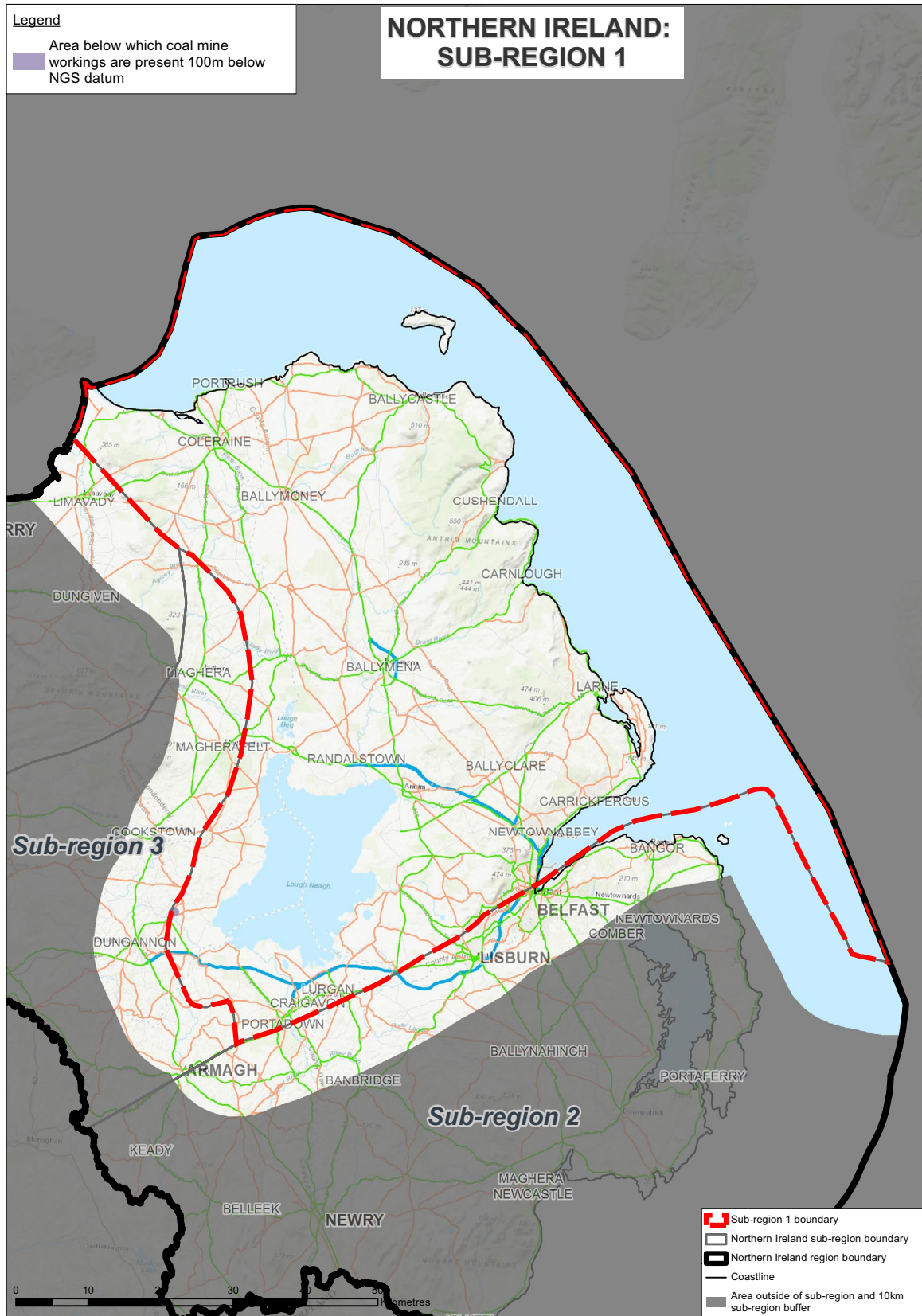




Figure 4b Areas of the Northern Ireland subregion 1 with Petroleum Exploration and Development Licences.

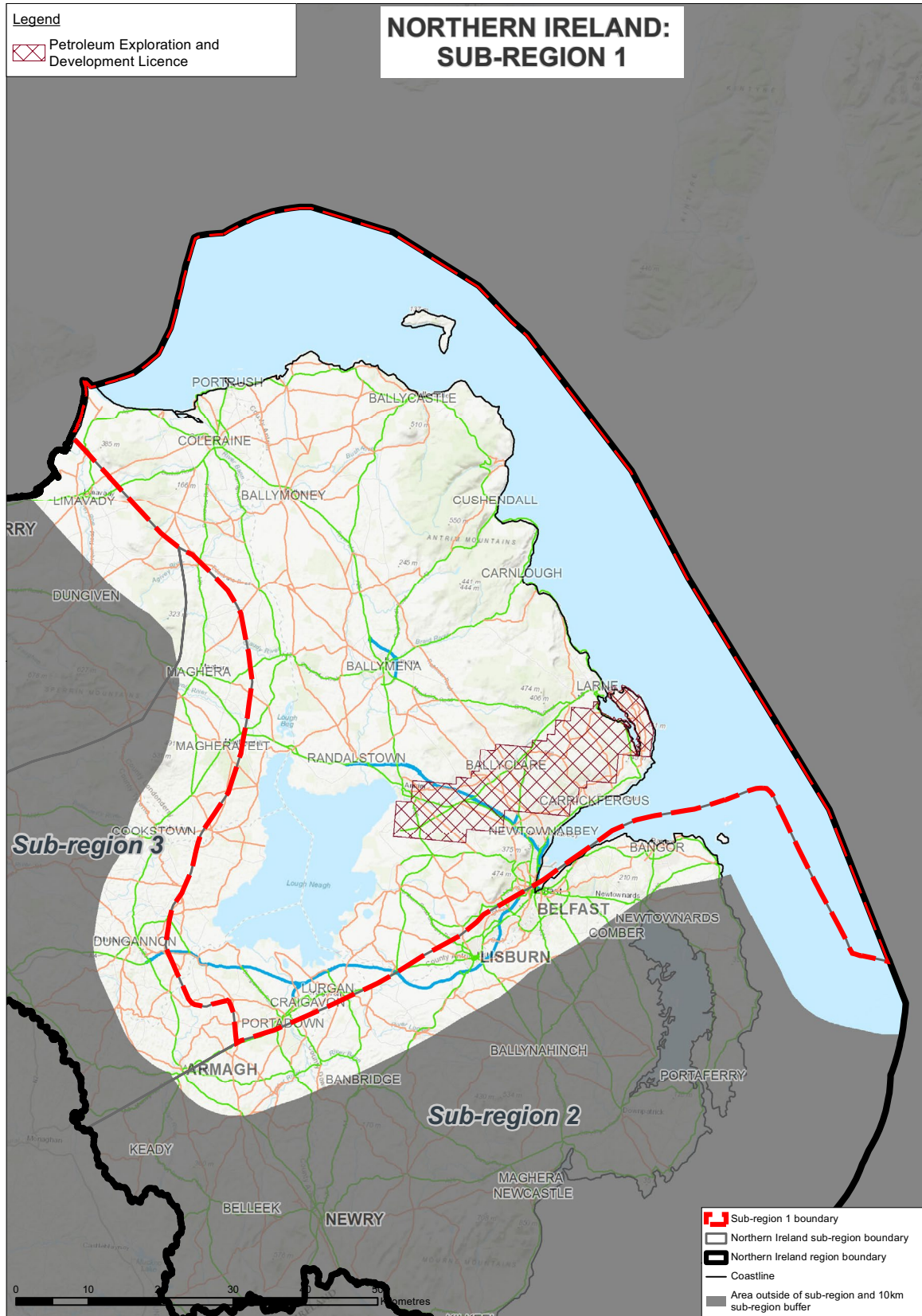
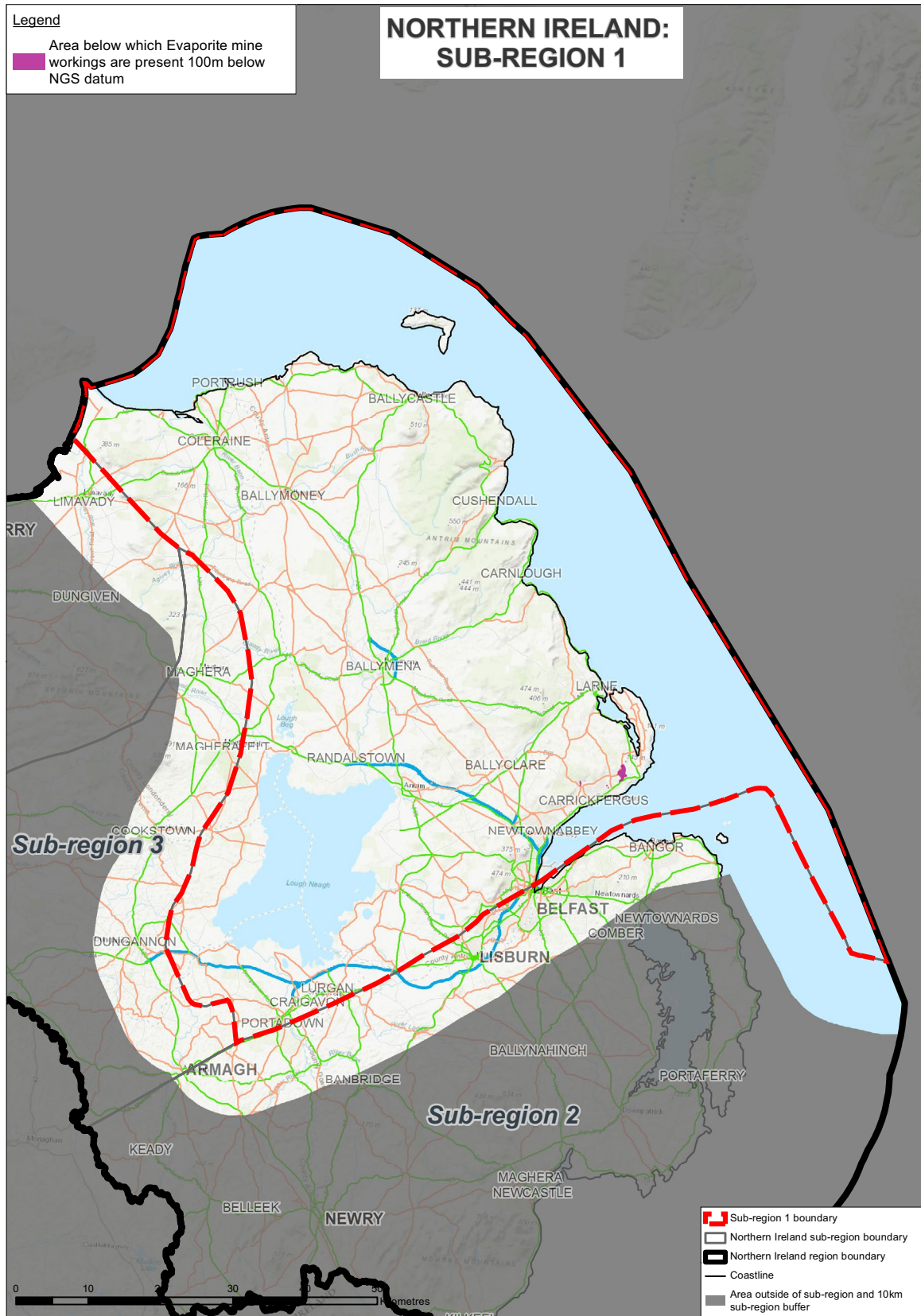






Figure 4c Areas of the Northern Ireland subregion 1 with evaporite mines present below 100m





## Glossary

### Anticline

A type of fold where the rock layers are buckled to form a dome-shaped structure.

### 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.

### Compressed air energy storage

Compressed air energy storage (CAES) is a process whereby air is stored under high pressure which can then be released at times of high electricity demand. In large scale CAES facilities abandoned mine caverns are pumped with air when electricity demand is low. The air in these caverns is then depressurised later and the heat and depressurisation generates electricity through a conventional turbine.

### Dip

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

### Fracture

A crack in rock. Fractures can provide a pathway for fluids, such as groundwater or gas, to move in otherwise impermeable rock.

### 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.

### Karst

A distinctive type of landscape consisting of deep cracks and caves in limestones. Karst forms due to the action of mildly acidic groundwater dissolving the limestone.

### Lava flow

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

### Metamorphosed

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

### Potable

Water that is of drinkable quality.



### 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.

### Sill

Horizontal or sub-horizontal planar sheet of igneous rock intruded as hot magma along cracks and fractures in the earth's crust.

### 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.



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