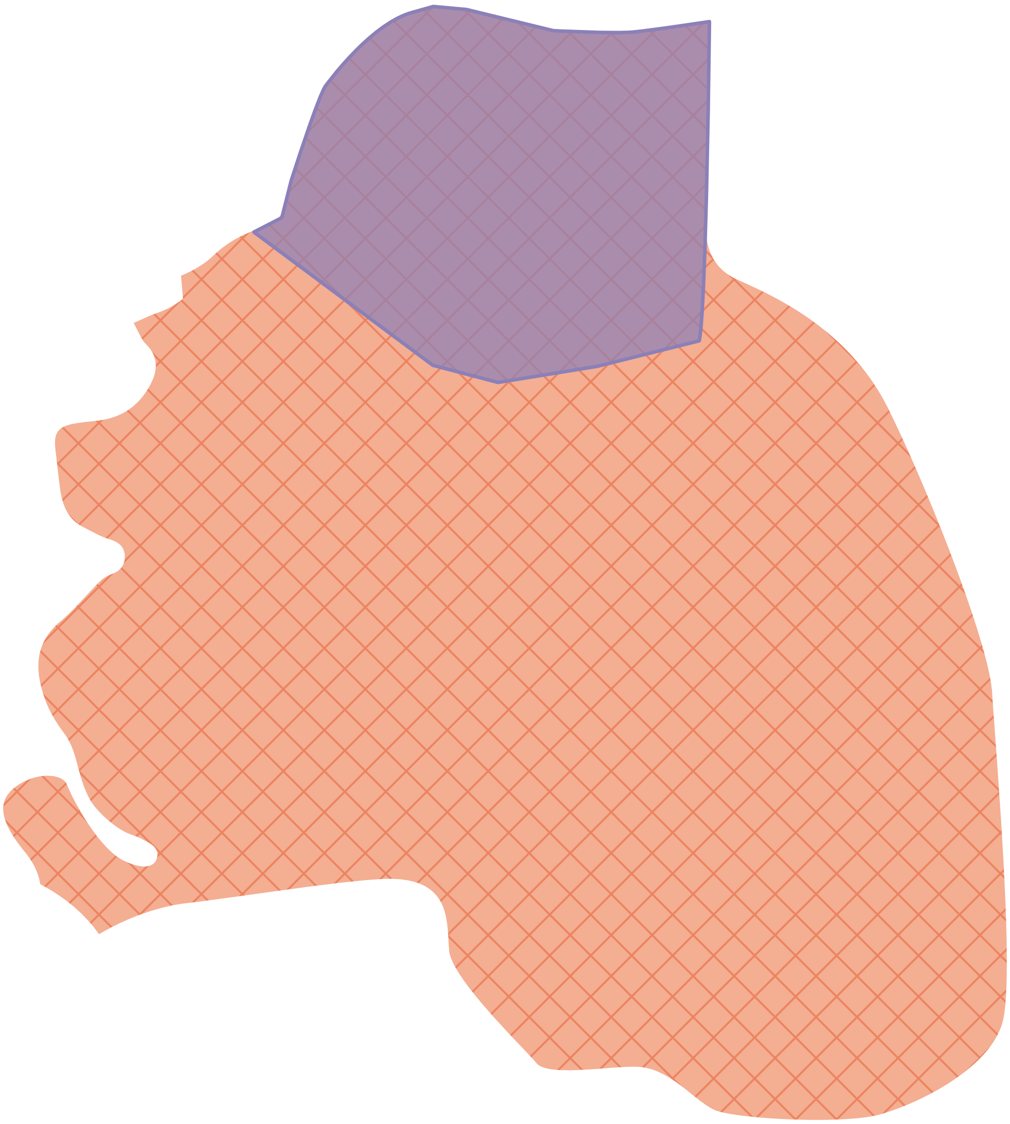
Radioactive Waste Management



Pennines and adjacent areas

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 some parts of this subregion, but the properties of the potential host rocks present may not be suitable.

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

There are granites, slates and similar strong rocks under part 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 in the depth range of interest for a GDF.

Some of the subregion has been mined for lead, fluorite, zinc and barite resources to depths below 100m, in North Swaledale and west of Pateley Bridge in particular. 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.

Introduction

The Pennines and adjacent areas subregion 1 is the most northerly part of the Pennines and adjacent areas region which includes the Yorkshire Dales National Park.

Rock type

Figure 1 shows where in the subregion there are likely to be Higher Strength Rocks (HSR) within the depth range of interest, there are no Lower Strength Sedimentary Rocks (LSSR) or Evaporites in the subregion. The following 4 subdivisions of the basement rocks are identified, all with the potential to act as HSR.

- Windermere Group rocks occur locally at the surface in this subregion but are not encountered in any boreholes and so their extent at depth is not well known. Based on information for the Northern England region, the Windermere Group is likely to include thick slates (metamorphosed mudstones) with the potential to act as a HSR host rock.
- Dent Group rocks have been identified as potential HSR in the Craven area, to the north of the Craven Fault system where the mudstones become slaty in the depth range of interest.
- Interbedded sandstones and siltstones of the Ingleton Group have also been intensely folded and metamorphosed such that they have become slaty. Surface exposures are dominated by thin layers of sandstone and siltstone with contrasting properties.
- The Wensleydale Granite is a potential HSR host rock, but does not occur at the surface and consequently is only poorly understood. It has only been penetrated by the Raydale borehole that drilled down to approximately 500m depth, the deepest 100m sampling the top of the Wensleydale Granite. The borehole demonstrated that this upper part of the granite is extensively fractured and weathered, and would not be of sufficiently low permeability to act as a host rock. At greater depths however, it is likely to be less weathered and is a potential HSR host rock. Although geophysical investigations provide a good indication of the lateral extent of the granite, there is some uncertainty over what volume is present within the depth range of interest.

The basement rocks are overlain by older sedimentary rocks of Carboniferous age (approx. 300 to 360 million years old), which are generally not Rock Types of Interest. This is because the dominant rock type in the depth range of interest is limestone, with associated sandstones and mudrocks. The BGS have identified a small area of Warwickshire Group as a potential LSSR to the south-east of Kirkby Lonsdale. We consider that it is unlikely that they would be suitable to host a GDF in this location because of their limited volume and unsuitable physical properties. They may, however, contribute to the safety of a GDF in deeper rocks as they could act as a barrier to groundwater flow from depth.

A summary of the geological attributes of the Pennines and adjacent areas 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 basement rocks which contain the potential HSR hosts in this subregion are strongly folded (Figure 2). Often, where the layers have contrasting mechanical properties, the folding is accompanied by small scale faulting that may impact groundwater movement. Most of the older sedimentary rocks and the Wensleydale Granite are relatively unfolded with few major faults. However the southern margin of the subregion is bounded in part by the North Craven Fault, a major fault system with associated folding. Variably and steeply dipping rock layers are likely to complicate the search for a volume of rock with sufficiently uniform properties in these areas. Faults may act as barriers to or pathways for groundwater movement, depending upon their characteristics, and the siting of a GDF would need to take account of them[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. The Carboniferous Limestone aquifer is a principal aquifer within 400m of the surface in this subregion and is used for public water supply. Over geological timescales, weakly acid groundwater has dissolved the limestone leading to enlargement of natural fracture systems and the formation of a connected network of fissures and caves, known as karst. They can be long and wide meaning that groundwater flow is often high-volume, rapid and unpredictable.

There are no low permeability clay-rich rock layers in this subregion to provide hydraulic separation between the shallower karstic aquifer and the groundwater in the underlying basement rocks.

Mining is likely to have changed the original patterns of water movement and shallow groundwater may now circulate to greater depths within the depth range of interest than it did before mining.

There are a number of locations in this subregion where concentrations of 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.

Resources

There are abandoned lead, fluorite, zinc and barite mines in this subregion, some of which penetrated to around 200m below NGS datum in North Swaledale (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.

The full extent of the historic North Pennine Orefield, which exploited these mineral deposits in the Carboniferous Limestone Supergroup, is also shown in Figure 4b 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 1 The areas of the Pennines and adjacent areas subregion 1 where Higher Strength Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

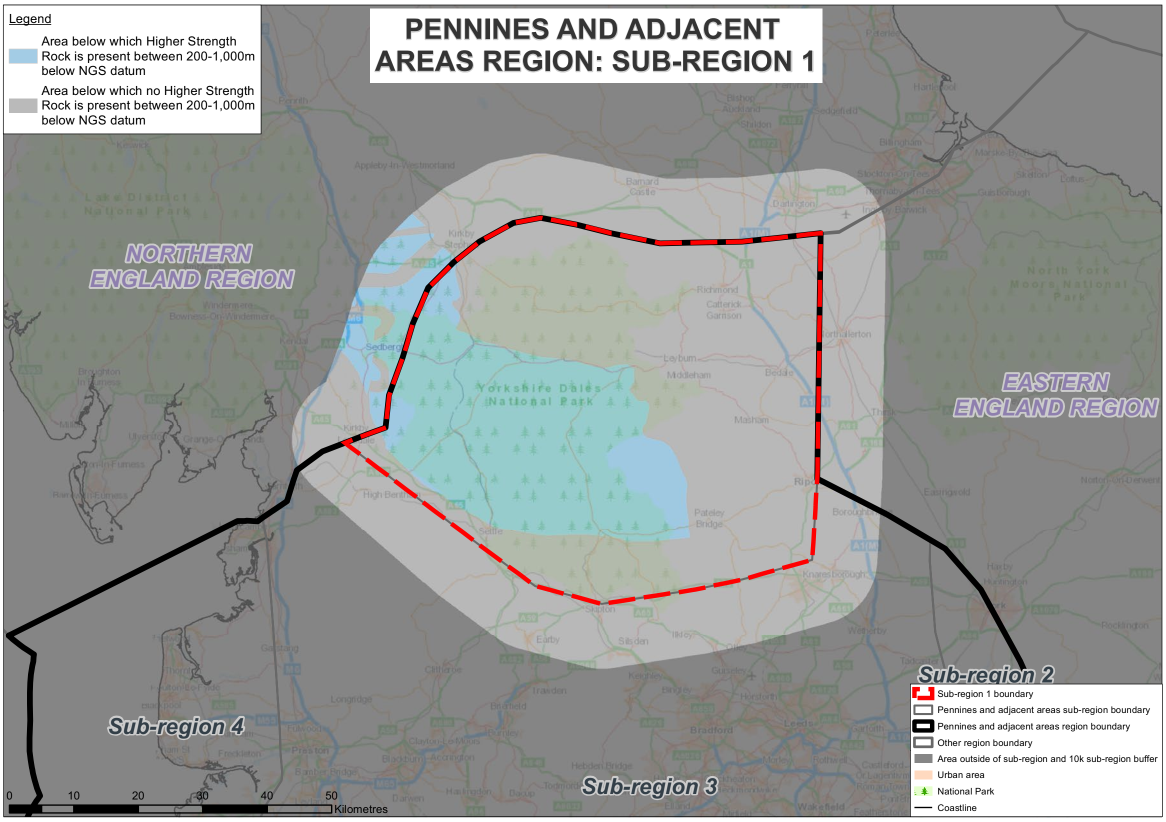


Figure 2 Location of major faults in the Pennines and adjacent areas subregion 1.

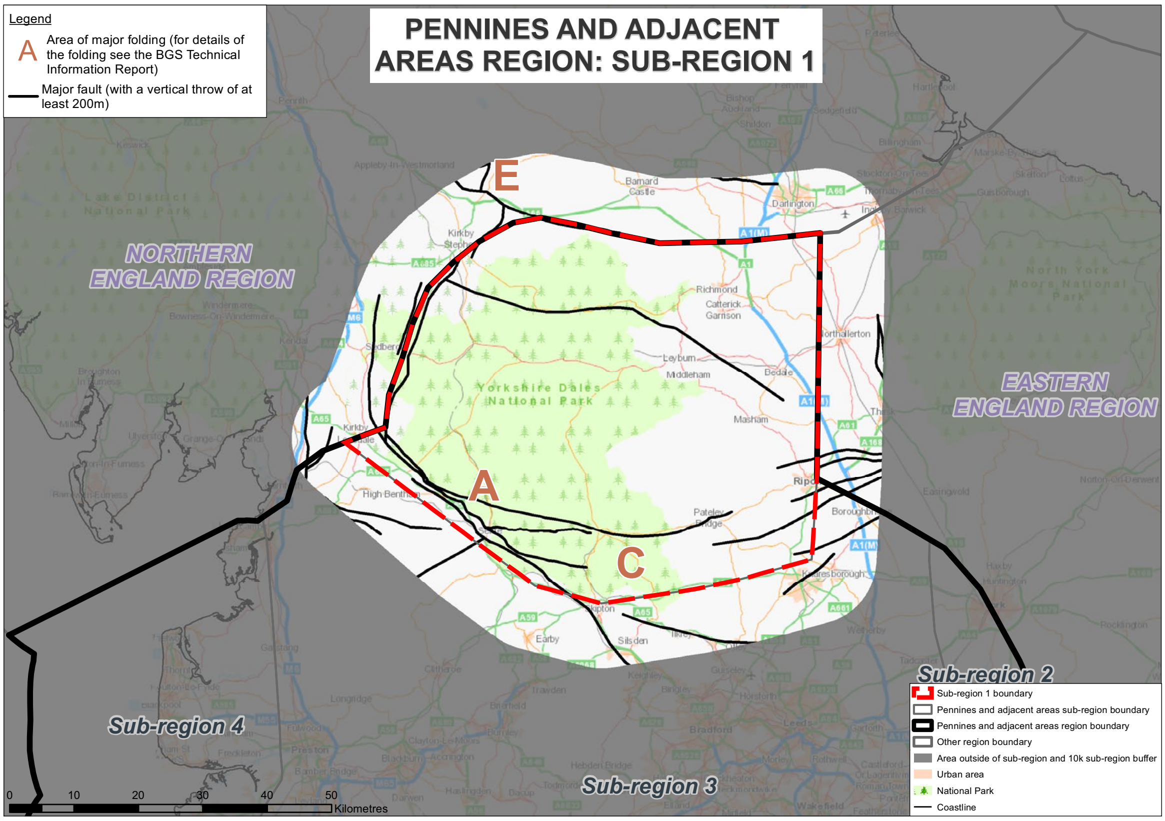


Figure 3 Areas in the London and the Thames Valley subregion 1 with concentrations of deep exploration boreholes.

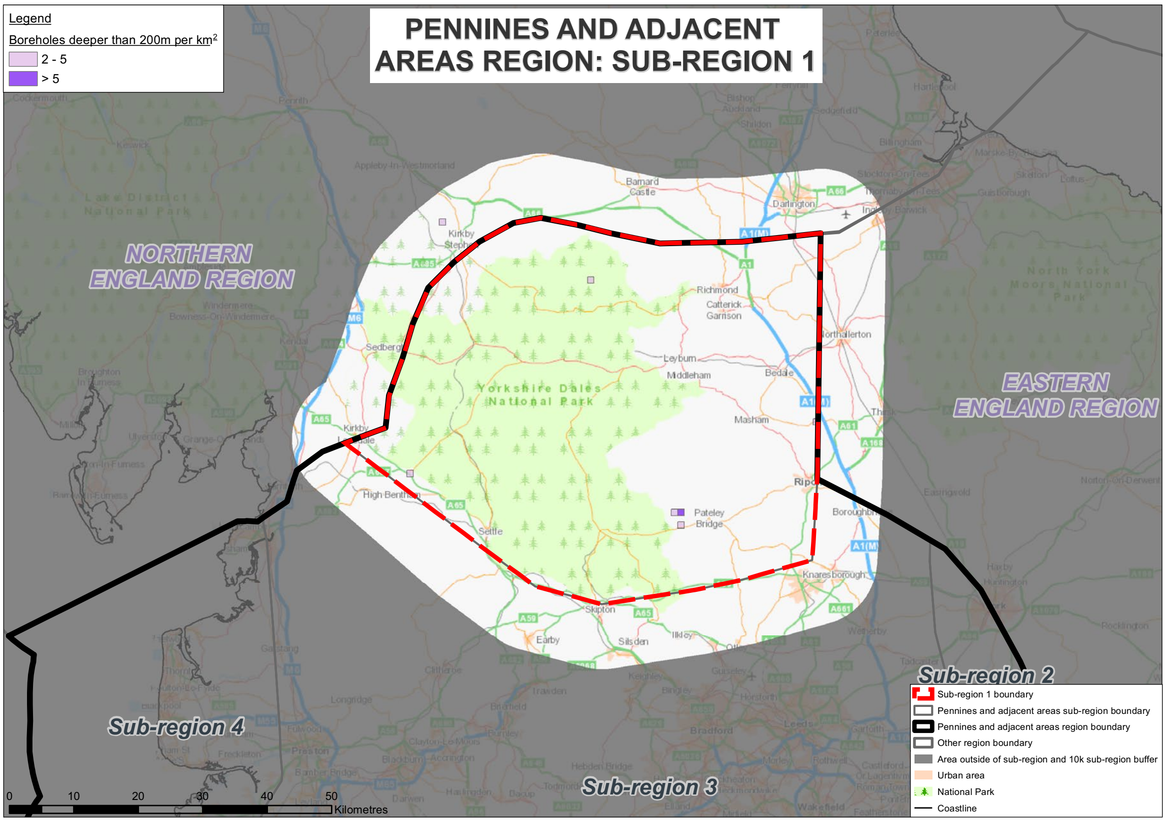


Figure 4a Areas of the Pennines and adjacent areas subregion 1 with mines present below 100m.

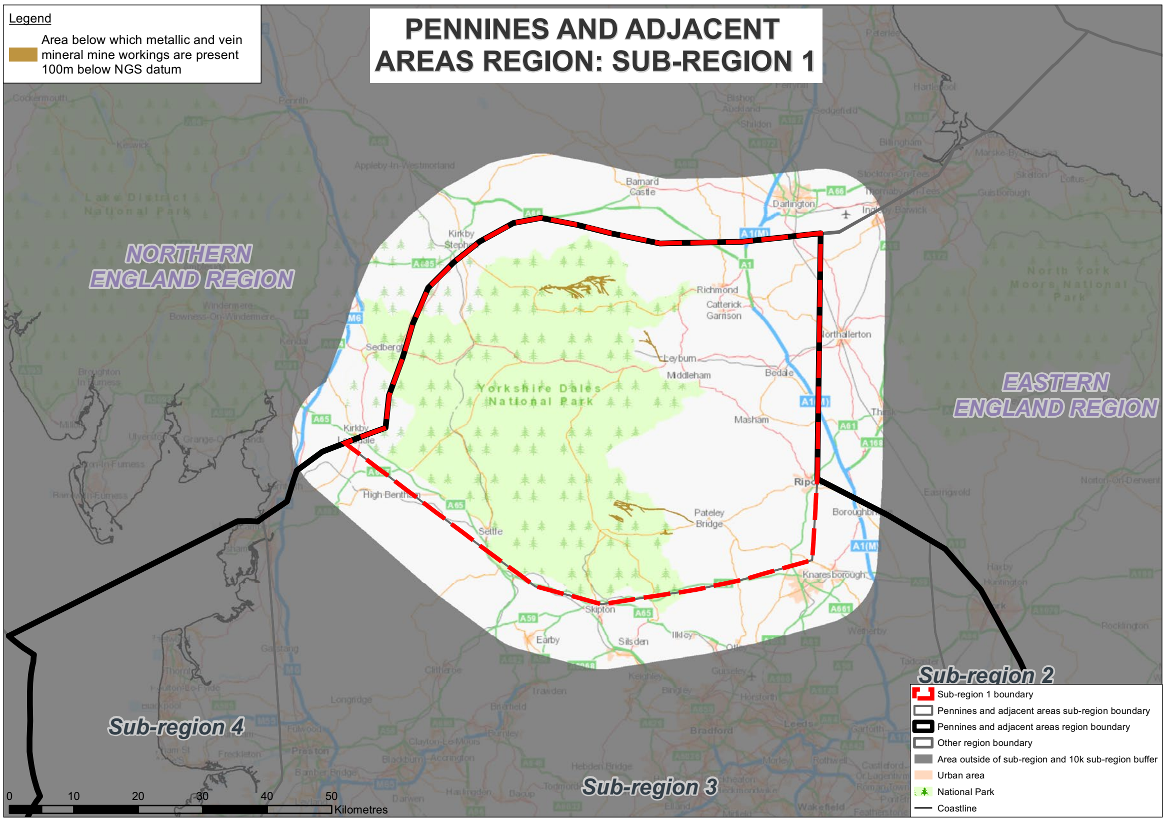
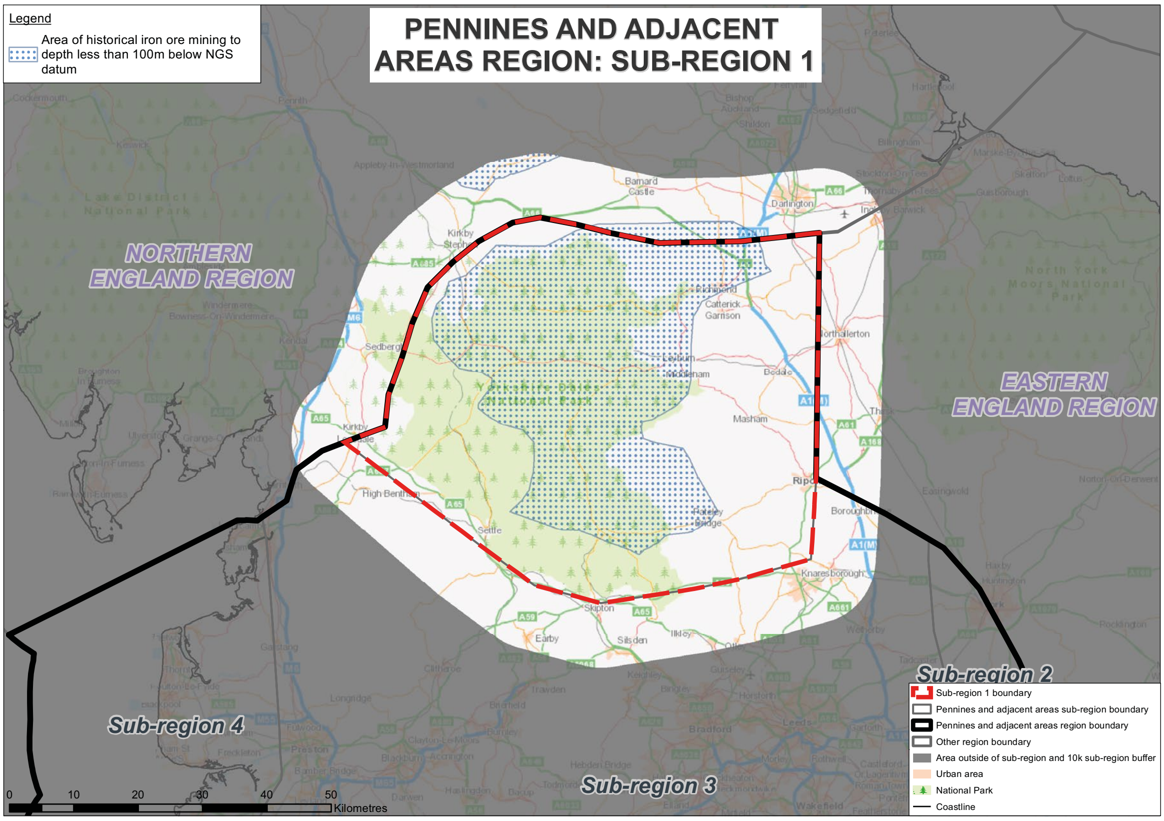


Figure 4b Areas of the Pennines and adjacent areas subregion 1 with historical mines less than 100m deep.



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.

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

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

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.

Metamorphosed
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.

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.

Radioactive Waste Management

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