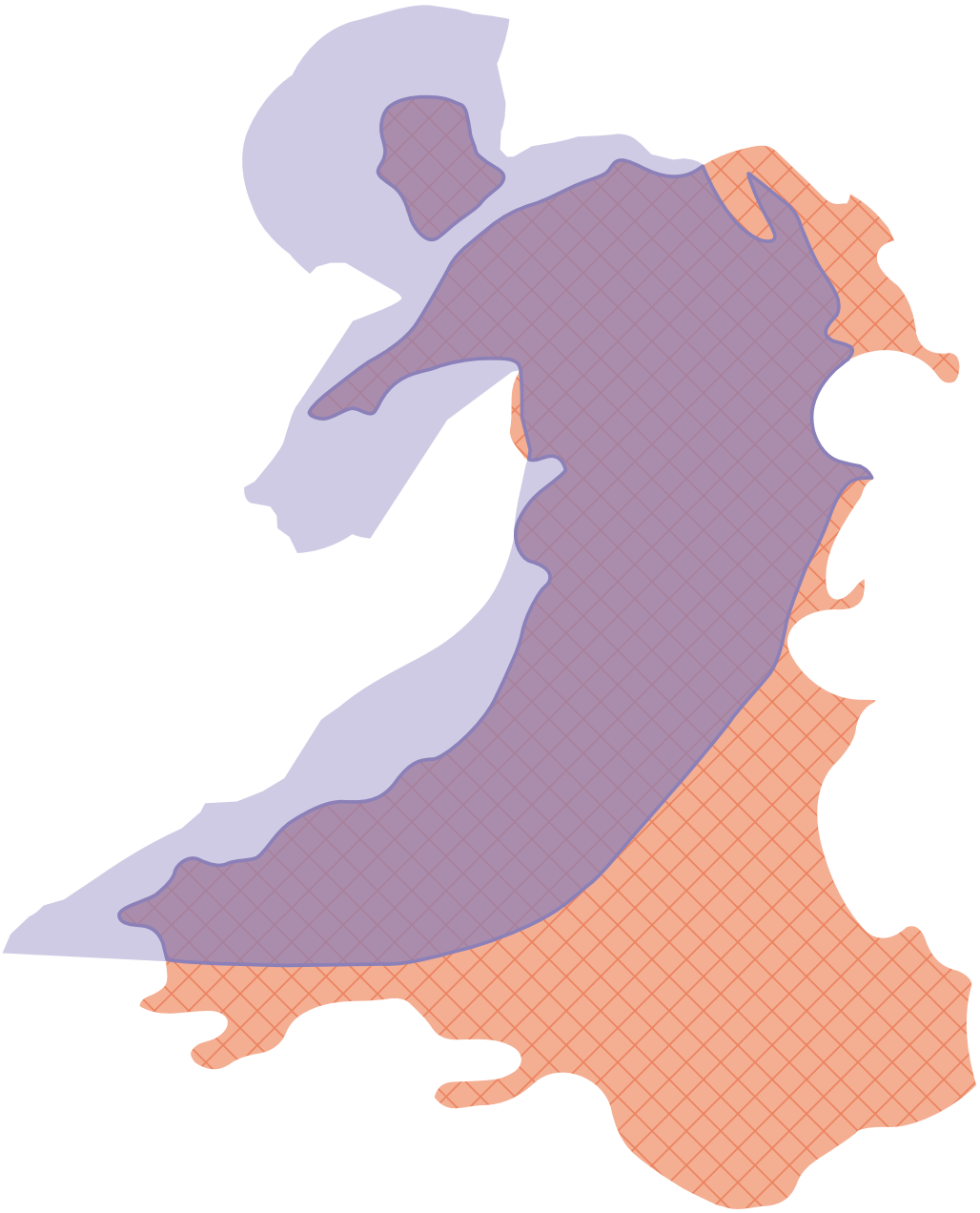
Radioactive Waste Management



Wales

SUBREGION 5

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, but the lack of information at depth makes it difficult to know where the potential host rocks have suitable thicknesses and properties.

Although rock can be seen at the surface over much of this subregion in sea cliffs, mountainous areas and man-made excavations such as quarries and road cuttings, there are very few deep boreholes or geophysical investigations to give us an understanding of the geology at depth.

There are slates and similar strong rocks under most of the subregion in which we may be able to site a GDF. They can be seen at the surface in Snowdonia and quarries such as Dinorwig near Llanberis and Penrhyn near Bethesda. These rocks are varied, folded and faulted and we would need to do more work to find out whether they have suitable properties and thicknesses.

Some of the subregion has been mined to depths below 100m for metal resources such as copper, lead and zinc, such as north of Dolgellau and Anglesey. 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.

Two areas in the inshore part 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.

Introduction

This subregion of the Wales region extends from Anglesey and Colwyn Bay in the north to St Davids and includes most of the intervening coastline as well as Snowdonia and the Cambrian Mountains. It includes part of the adjacent inshore area extending to 20km from the coast to the south of the Llŷn Peninsula and to the north and west of Anglesey.

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 is a very small area of Lower Strength Sedimentary Rocks (LSSR) and no Evaporites in the subregion. This subregion is dominated by basement rocks, ranging in age from Silurian (approx. 420 million years old) to Precambrian (older than approx. 540 million years old). A wide range of rock types in this subregion have potential to behave as HSR hosts, but they can largely be divided into 3 categories.

- Weakly metamorphosed sedimentary rocks range in age from Silurian to Cambrian (approx. 420 to 540 million years old) and mainly comprise thick sequences of mudrocks, siltstones and sandstones that have been folded and metamorphosed so that the mudrocks are now slates. Massive and uniform slates occurring within these rocks are potential HSR host rocks. Where the slates are interbedded with sandstones and siltstones every few metres or are intensely folded and/or steeply dipping, this is likely to complicate the search for a volume of rock with sufficiently uniform properties.
- Interbedded with the rocks of sedimentary origin are weakly metamorphosed igneous rocks. These include both pyroclastic rocks, including tuffs, occurring in Snowdonia, with smaller centres in Pembrokeshire and the Llŷn Peninsula. Many of these igneous bodies are relatively thin, heavily folded and interlayered with contrasting rock types, and so are less likely to be suitable host rocks for the development of a GDF. However the larger bodies, including the more massive lava flows and associated intrusive igneous rocks, do offer large volumes of potentially suitable and uniform host rock.
- The third component of the basement geology comprises Cambrian and Precambrian rocks (older than approx. 485 million years) of both igneous and sedimentary origin which are often more highly metamorphosed than the main sequence of Silurian to Cambrian rocks. These occur primarily on Anglesey but are also present on the adjacent mainland and in the St Davids Peninsula. Many of these mapped basement units are complex mixtures of contrasting rock types and are unlikely to be suitable as host rocks for this reason. However, there are some larger bodies, especially of highly metamorphosed igneous rocks, which may be suitable.

The Warwickshire Group mudstones occur within the depth range of interest in a very small area around Nolton Haven in Pembrokeshire. Although this rock type has been identified as a potential host rock by the BGS, 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.

A summary of the geological attributes of Wales 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 numerous major faults and pervasive folding of the basement rocks throughout this subregion (Figure 2). In parts of Gwynedd, such as the area around Llanberis and the Dinorwig, the intensity of the folding has led to the formation of slates in which the original sedimentary layering is almost completely obliterated. Faults play an important role in defining the boundaries of the subregion; in particular, the Welsh Borderland Fault System marks the south-eastern boundary of the subregion while other faults define the north-west margin of the subregion and juxtapose the basement rocks seen onshore from thick sequences of younger sedimentary rocks found off the coast in Cardigan Bay and the southern Irish Sea. 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].

In addition to the smaller scale folds seen in outcrops, the subregion contains a series of large scale fold structures, including the Central Wales Syncline and Tywi Anticline in central Wales and a further series of domes and synclines in North Wales (for example, Yr Wydffa occupies the core of a major syncline, visible from the east). This folding on various scales is likely to complicate the search for a volume of rock with sufficiently homogeneous properties.

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 main source of water across this subregion is surface storage; many of the rocks are of very low permeability, and there are few aquifers. The basement rocks do not normally provide a water source except where intensely fractured and weathered near the surface and there is little or no information about their hydrogeological properties at depth. In principle, groundwater may enter open fractures in basement rocks at outcrop and move through fractures in the rock, if they are connected, towards lower ground. However, it is impossible to predict how deep groundwater may circulate in the mountainous terrain without detailed information about the extent of such fractures, the depth to which they remain open and the degree to which they interconnect.

There are no significant clay-rich rock layers to provide hydraulic separation between deep and shallow groundwater. Mineral springs are present along the Welsh Borderland fault system, and probably result from water rising up through fractured rock in the fault zone, but there are no examples of thermal springs in this area which would be expected if there is rapid circulation to significant depths. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK [2].

[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

Deep exploration boreholes may influence the connectivity between shallow and deep groundwater which would also 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

Mining for lead, zinc, copper and gold has extended below 100m in a few small areas of the subregion (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.

There are two areas in the inshore part of the subregion with Oil and Gas Authority licenses, to the west of St Davids and to the south-west of the Llŷn Peninsula (Figure 4b), allowing companies to explore for these resources. 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.

Prospecting for copper, lead and zinc has taken place in the Parys Mountain area of Anglesey (A on Figure 4c) and for copper at Coed-y-Brenin, north of Dolgellau (B on Figure 4c) in recent times, but no further exploitation is in prospect. Areas of historical iron ore mining are also shown in Figure 4c but are 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 Wales subregion 5 where Higher Strength Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

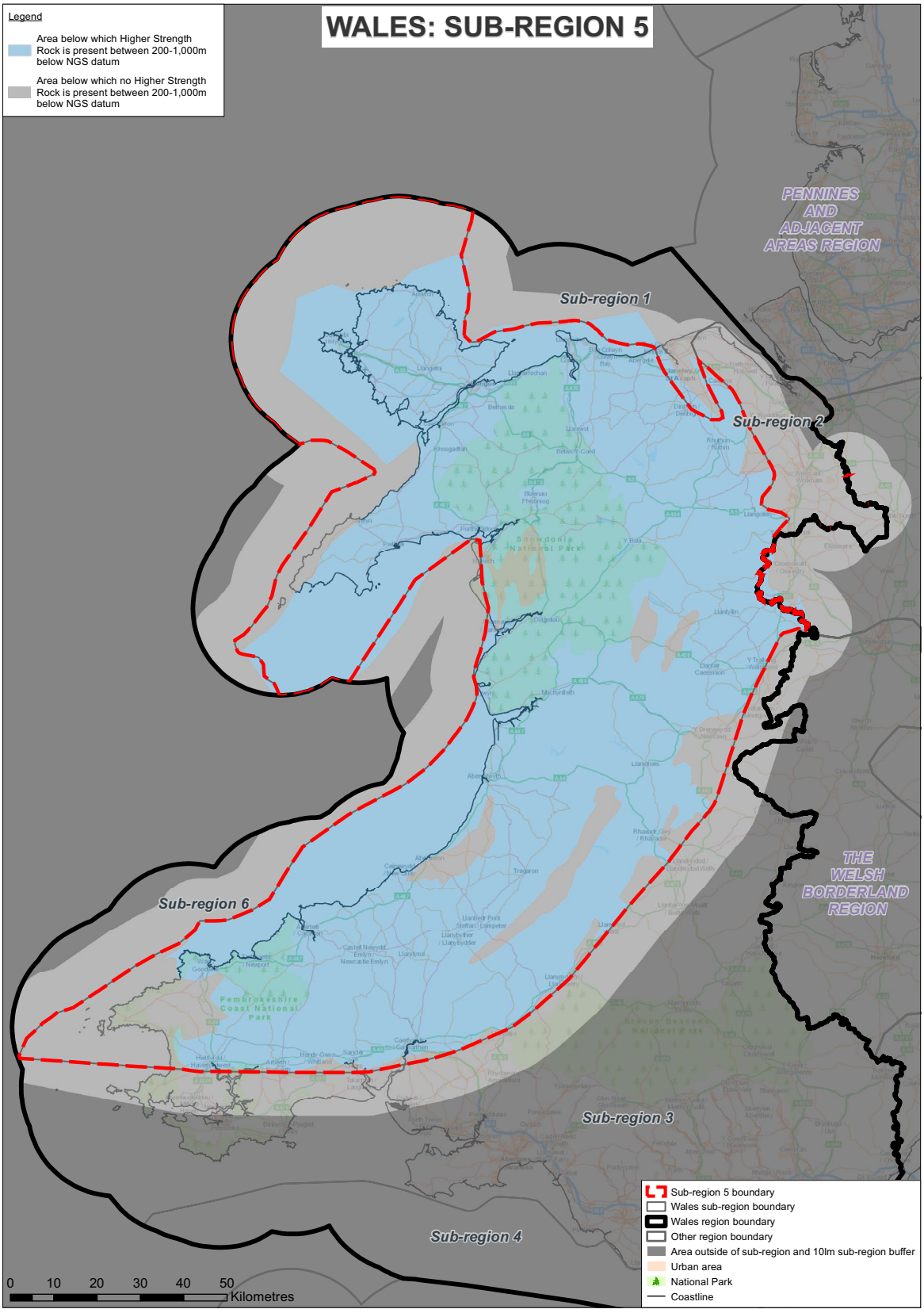


Figure 2 Major faults and areas of folding in Wales subregion 5.

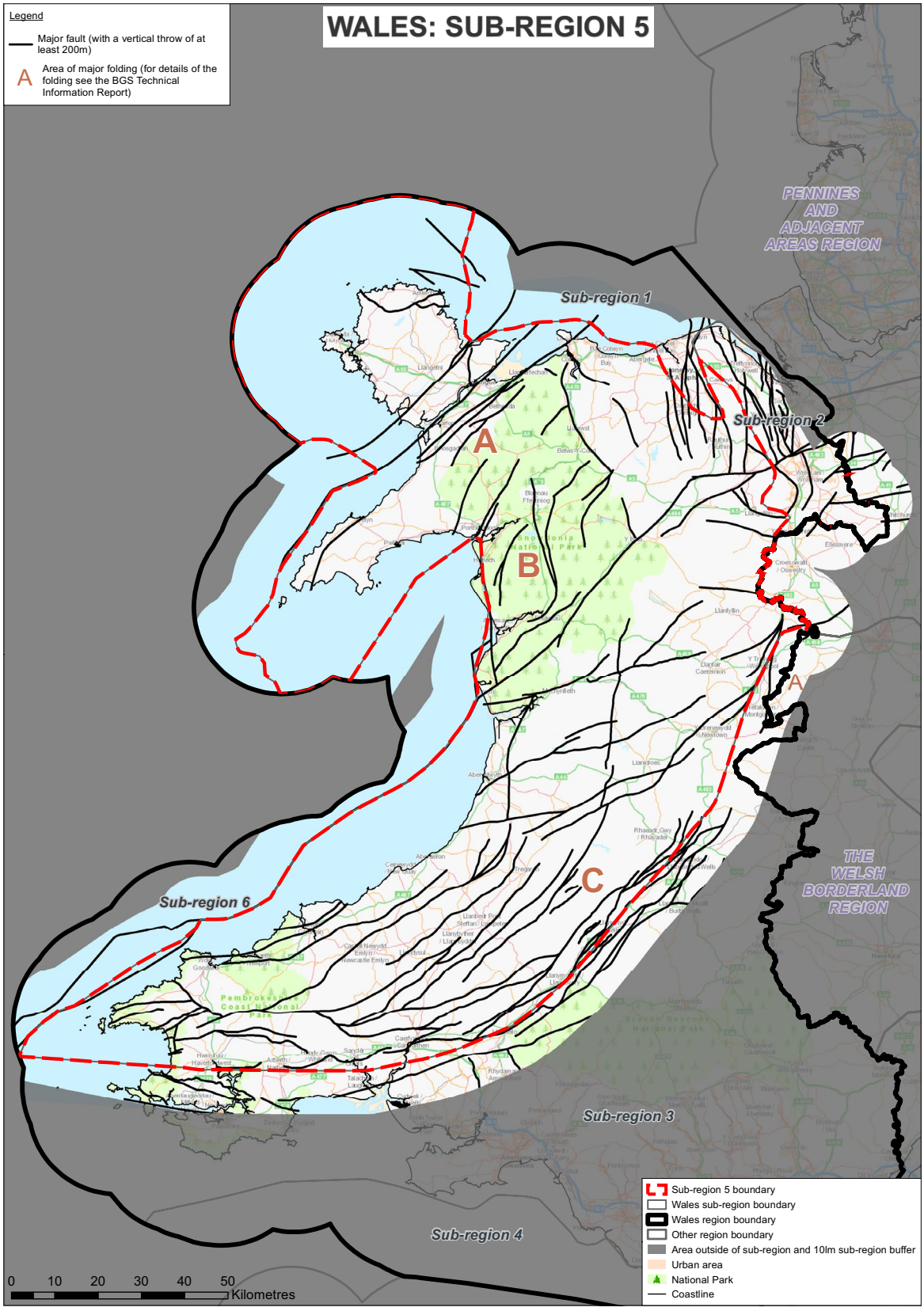


Figure 3 Areas of Wales subregion 5 with concentrations of deep exploration boreholes.

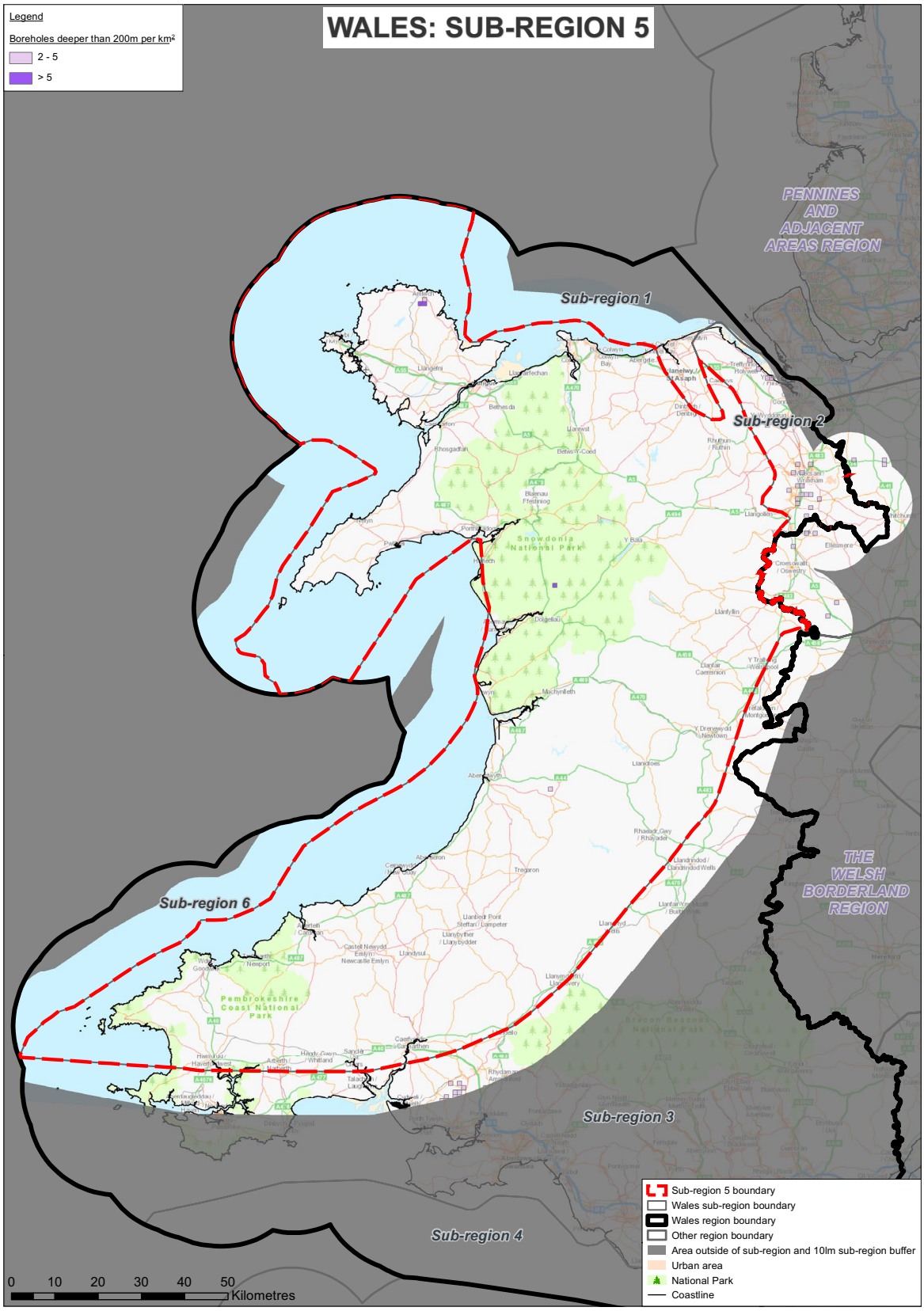


Figure 4a Areas of Wales subregion 5 with metal mines present below 100m.

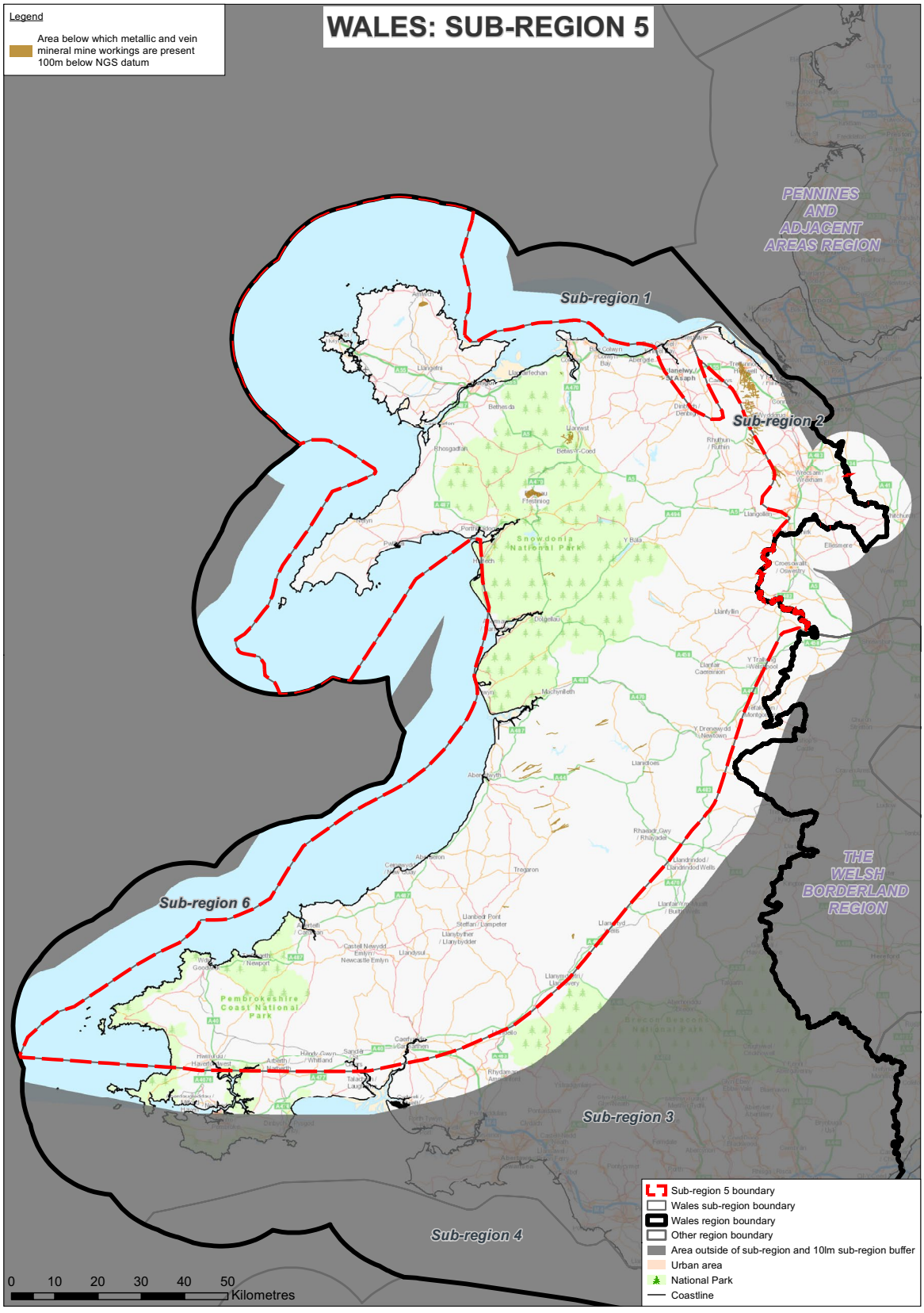


Figure 4b Areas of Wales subregion 5 with Petroleum Exploration and Development Licences.

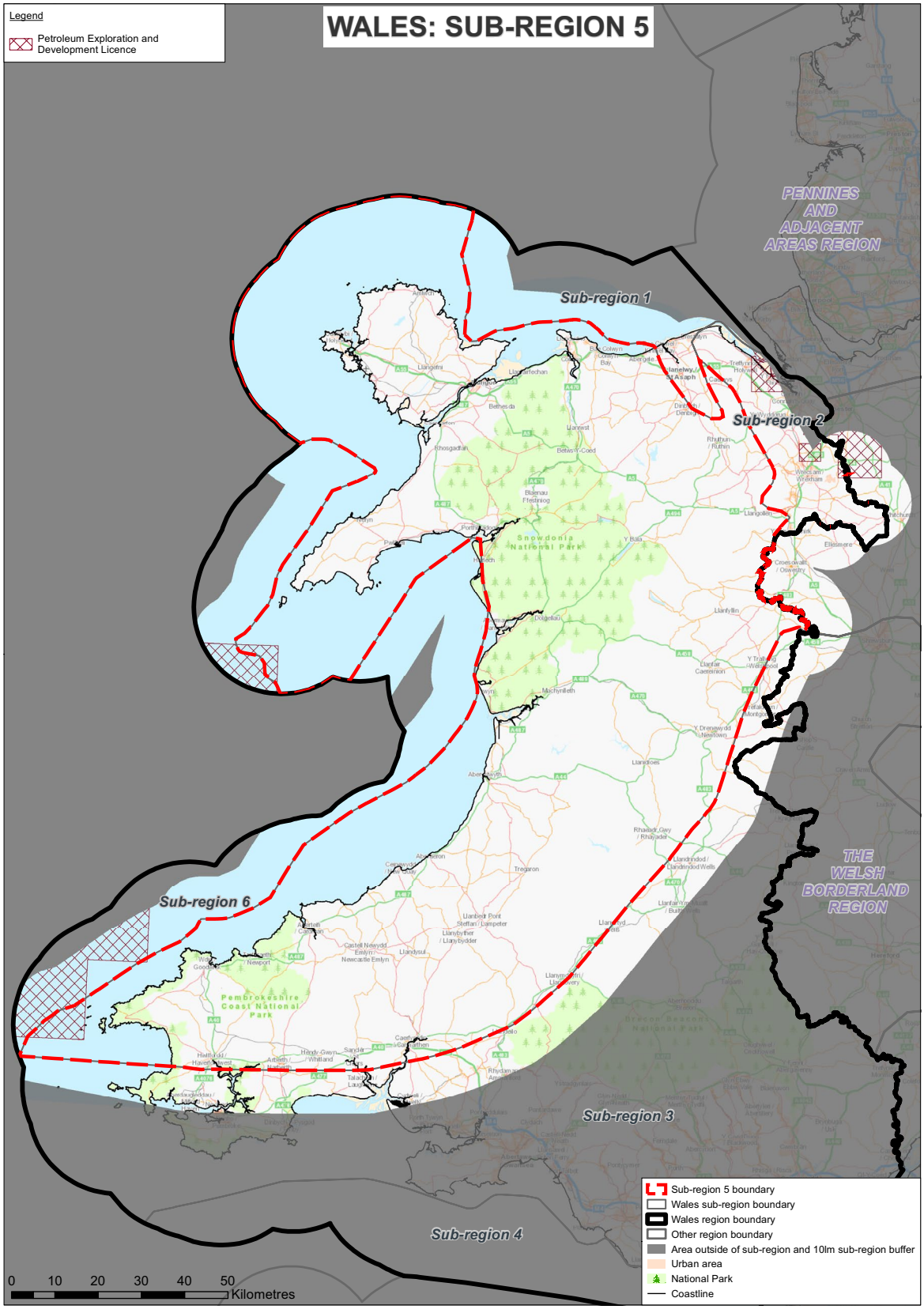
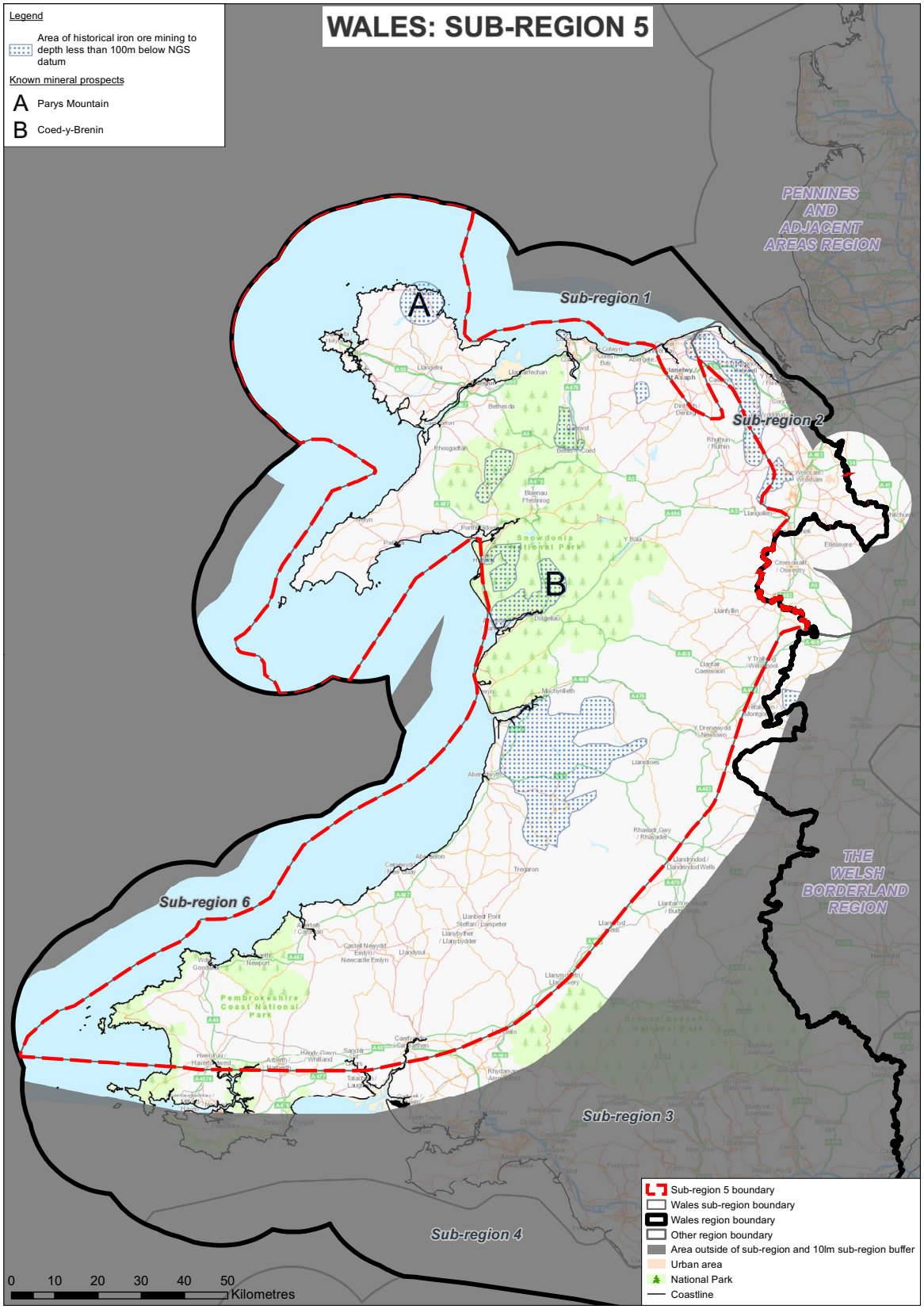


Figure 4c Areas of Wales subregion 5 with historical mining less than 100m deep and known mineral deposits.



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.

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.

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.

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.

Outcrop
A visible exposure of bedrock on the surface.

Pyroclastic
Deposits of solid material erupted explosively from a volcano, ranging in size from large blocks and boulders to very fine ash. The citizens of Pompeii were buried beneath thick clouds of hot pyroclastic material in 79AD.

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.

Syncline
A folded rock structure where the rocks are buckled to form a basin-shaped feature.

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

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