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Mineral Safeguarding Areas for North York Moors National Park Authority

Minerals and Waste Programme

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BRITISH GEOLOGICAL SURVEY

MINERALS AND WASTE PROGRAMME

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Mineral Safeguarding Areas for North York Moors National Park Authority

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List of abbreviations

BGS	British Geological Survey
BRITPITS	BGS's database of mines and quarries
CYC	City of York Council
DIGMAP	BGS's digital onshore geology maps
DPD	Development Plan Documents
ESRI	Environmental Systems Research Institute (company which supplies the GIS software used in this project)
GIS	Geographical Information System
MPA	Mineral Planning Authority
MSA	Mineral Safeguarding Area
NERC	Natural Environmental Research Council
NPPF	National Planning Policy Framework
NYMNPA	North York Moors National Park Authority
NYCC	North Yorkshire County Council

Foreword

This British Geological Survey (BGS) report presents the results of an exercise that defines draft Mineral Safeguarding Areas for the North York Moors National Park Authority (NYMNPA). The exercise is based on published BGS mineral resource maps and expert geological knowledge. Resources that are proposed for safeguarding are described and presented, together with a justification for their inclusion. Consultation on the draft report and maps took place in autumn 2013 and has informed this final report.

The report (provided as hardcopy and in digital format) is supported by digital spatial information, formatted for use in a Geographical Information System (GIS) held by the NYMNPA.

Acknowledgements

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This report describes work carried out by the British Geological Survey (BGS) on behalf of the North York Moors National Park Authority to delineate draft Mineral Safeguarding Areas (MSAs), the results of which will be used to undertake a mineral consultation safeguarding exercise. The approach taken is in accordance with the methodology outlined in 'Mineral safeguarding in England: good practice advice' (Wrighton *et al*., 2011). National policy for minerals safeguarding, at the time of the study, is contained within the 'National Planning Policy Framework' that was published in March 2012.

The work undertaken in this study involved the production of maps showing the extent of mineral resources in the North York Moors National Park and the production of a recommended safeguarding methodology for each mineral resource informed by consultation. This report will be used to inform the establishment of MSAs through minerals planning policy, MSAs themselves are not finalised until relevant planning policy is adopted. Data depicted on the maps have been provided in digital format to the authority for use within a Geographical Information System.

1 Introduction

With increased pressure on land-use in the UK, there is a need to ensure mineral resources are not needlessly sterilised by other forms of development, restricting access for future generations. 'Mineral safeguarding' is the term that encompasses the process necessary to ensure that outcome.

There are two stages to the safeguarding process: (i) the identification of mineral resources and the definition of Mineral Safeguarding Areas (MSAs) where mineral sterilisation should be considered in the planning process; and (ii) the development of associated policies that guide the management of development proposals that are submitted in these areas. The North York Moors National Park Authority (NYMNPA) commissioned the BGS to delineate recommended MSAs to inform the Minerals and Waste Joint Plan (which they are producing with North Yorkshire County Council and the City of York Council). This work does not include the development of suitable policies that will guide development decisions in these areas. This will be undertaken by NYMNPA during their plan making process. MSAs are based on BGS geological linework, and amended where appropriate based on expert geological knowledge.

1.1 PLANNING CONTEXT

National policy for minerals safeguarding, at the time of the study, is contained within the 'National Planning Policy Framework' published in March 2012. Box 1 outlines the general policies for the safeguarding of minerals. The presence of mineral safeguarding areas gives no presumption for working and planning polices for the extraction of minerals apply regardless of the presence of MSAs. Mineral safeguarding areas indicated the presence of potential mineral resources and do not take into account any designations or policies which may have a bearing on the likelihood of extraction being acceptable.

Box 1 Key instructions in planning policy and available advice

National Policy

The *National Planning Policy Framework* (March 2012) outlines the national policy for safeguarding mineral resources. It requires Mineral Planning Authorities in England to define MSAs in their local plans and adopt appropriate policies.

'In preparing Local Plans, local planning authorities should: ...

...define Minerals Safeguarding Areas and adopt appropriate policies in order that known locations of specific minerals resources of local and national importance are not needlessly sterilised by non-mineral development, whilst not creating a presumption that resources defined will be worked; and define Minerals Consultation Areas based on these Minerals Safeguarding Areas...

... set out policies to encourage the prior extraction of minerals, where practicable and environmentally feasible, if it is necessary for non-mineral development to take place' [para 143].

'When determining planning applications, local planning authorities should: ...

... not normally permit other development proposals in mineral safeguarding areas where they might constrain potential future use for these purposes' [para 144].

'Minerals planning authorities should plan for a steady and adequate supply of industrial minerals by: ...

... encouraging safeguarding or stockpiling so that important minerals remain available for use' [para 146].

The definition of minerals of local and national importance is provided in Annex 2:

'Minerals which are necessary to meet society's needs, including aggregates, brickclay (especially Etruria Marl and fireclay), silica sand (including high grade silica sands), cement raw materials, gypsum, salt, fluorspar, shallow and deep-mined coal, oil and gas (including hydrocarbons), tungsten, kaolin, ball clay, potash and local minerals of importance to heritage assets and local distinctiveness.'

Key documents

'Mineral safeguarding in England: good practice advice' (Wrighton *et al*., 2011).

1.2 KEY DEFINITIONS

Box 2 provides some background to the terms used in the report.

Box 2 Mineral Safeguarding Areas

'Mineral resources are natural concentrations of minerals in or on the Earth's crust that are or may become of economic interest because they are present in such form, quality and quantity that there is the potential for eventual economic extraction. Mineral resources are thus defined by economic as well as physical parameters' [para 2.1.1].

'The definition of MSA boundaries requires up-to-date, factual information on the physical location of mineral resources and should be based principally on the best available mineral resource information at the time MSAs are defined. In the context of the plan making process, geology, unlike many other factors that influence planning, does not change with time' [para 4.1.1].

'There is no presumption that areas within a MSA will ultimately be allocated for extraction. If an application is submitted for mineral extraction within a MSA, the MSA designation itself does not provide any support for a grant of consent. If a MPA wishes to define future allocations for extraction then such areas must be identified as Areas of Search, Preferred Areas, and Specific Site allocations. Equally, there is no presumption that non-mineral development within a MSA is automatically precluded. MSAs alert those proposing sites for future development to the presence of valuable mineral resources which they otherwise might not have considered' [para 2.3.3].

'The MSAs indicate where local mineral safeguarding policies, formulated specifically to suit local circumstances, may apply. The process should ensure that minerals are not unnecessarily sterilised whilst allowing competing development to proceed if there is an overriding need for it. In those circumstances extraction of the mineral ahead of the development (prior extraction) should always be considered' [para 2.3.3].

Source: 'Mineral safeguarding in England: good practice advice' (Wrighton *et al*., 2011).

1.3 LIMITATIONS

The identification and delineation of mineral resources (the first step in the mineral safeguarding process) is imprecise as it is constrained by the quantity and quality of data currently available and involves predicting what may or may not become economic to work in the future. The pattern of demand for minerals is continually evolving due to changing economic, technical and environmental factors. The economic potential of a mineral resource is not static, but it changes with time.

Mineral resource maps that underpin the current work are derived from geological linework forming part of the national 1:50 000 scale digital geology coverage, DiGMapGB-50, from the BGS. This dataset is based on surveys performed at either 6-inch or 1:10 000 scales, and acquired at different times.

2 Methodology

Mineral resources and a recommended safeguarding methodology have been defined in the NYMNPA area in accordance with 'Mineral safeguarding in England: good practice advice' (Wrighton *et al.,* 2011). The document outlines a seven-step approach to creating an effective system for mineral safeguarding. The scope of work undertaken by BGS for NYMNPA is limited to steps 1 and 2. Steps 3-7, which include consultation on draft MSAs and drafting of the associated policies, are beyond the scope of this study. Consultation on the draft MSAs has been carried out by NYMNPA as part of the production of this report and the responses received have been taken into account in finalising the report. Consultation was undertaken with adjoining minerals planning authorities, representative bodies from the minerals sector, minerals operators (working both within the NYMNP and in adjoining areas) and English Heritage.

Box 3 Step by step approach to creating an effective safeguarding system for minerals	
Step 1	Identify the best geological and mineral resource information
Step 2	Decide which mineral resources to safeguard and the physical extent of MSAs
Step 3	Undertake consultation on draft MSAs
Step 4	Decide on the approach to safeguarding in the Core Strategy[1]
Step 5	Include development management policies in a DPD
Step 6	Include safeguarding in district level DPDs
Step 7	Include mineral assessments in the local list of information requirements

Source: *Mineral safeguarding in England: good practice advice* (Wrighton *et al*., 2011).

2.1 STEP 1: IDENTIFY THE BEST GEOLOGICAL AND MINERAL RESOURCE INFORMATION

The first step in the MSA process is to identify the most recent geological and mineral resource information. The mineral resources that are present in the NYMNPA area are shown in Appendix 1 whilst an overview of the geology of the area is provided in Appendix 2.

A review of mineral resource information held by BGS, including recent national updates, was used to select the resources found in the NYMNPA area. A recent national update undertaken by BGS to its mineral resource digital linework provided the most recent data for sand and gravel, limestone (both crushed rock aggregate and industrial use) and for brick clay in the NYMNPA area. Deep coal data was obtained from coal resource data published in 1999 and surface coal data was obtained from data produced by a project undertaken by the BGS for the Coal Authority (Jones *et al.*, 2006). Data on building stone resources were extracted from the BGS DiGMapGB-50 dataset and from the Strategic Stone Study database (http://www.bgs.ac.uk/mineralsuk/mines/stones/EH_project.html). The BGS database of mines and quarries, 'BRITPITS' was used to provide information on the location and current activity of quarries. All of the data were integrated within a GIS in order to undertake the process of defining MSAs. Table 1 summarises the data utilised during the study.

[1] This terminology reflects planning practice prior to the introduction of the NPPF in March 2012, these steps are not applicable in all situations, for example in single-tier planning authority areas or where a single plan is being produced. In some areas strategic policies may be adopted in a separate DPD to development management and site allocation policies, at the time of this study NYMNPA is producing a draft minerals and waste joint plan so there may be some deviation to the steps presented in current good practice advice.

Table 1: Available mineral resource information.

Resource	Data provider	Date of publication of dataset	Any more recent geological resource information	Comments
Sand and gravel	BGS	20/12/2012	No	
Limestone (crushed rock aggregate)	BGS	20/12/2012	No	
Limestone (industrial)	BGS	20/12/2012	No	
Sandstone (crushed rock aggregate)	Whilst sandstone is present it is not considered to be a crushed rock aggregate resource in NYMNP			
Igneous (crushed rock aggregate)	Whilst igneous rock is present it is not considered to be a crushed rock resource in NYMNP			
Chalk (crushed rock)	No resources in the study area			
Silica sand	No resources in the study area			
Brick clay	BGS	20/12/2012	No	
Building stone	BGS	15/04/2013	No	DigMapGB
Shallow coal	BGS on behalf of the Coal Authority	2006	No	
Deep coal	BGS on behalf of the Coal Authority	1999	No	
Potash / Salt	BGS	20/12/2012	No	
Gypsum / Anhydrite	Gypsum and anyhdrite are discussed due to safeguarding proposals put forward in the Tees Valley Joint Minerals and Waste Core Strategy			

2.2 STEP 2: DECIDE WHICH MINERAL RESOURCES TO SAFEGUARD AND THE PHYSICAL EXTENT OF MSAS

Paragraph 143 of the NPPF states that Mineral Planning Authorities are required to define mineral safeguarding areas in order that known locations of locally and national important minerals are not needlessly sterilised. To ensure this is undertaken, minerals of local and national importance that are at risk of sterilisation need to be delineated. As stated in Section 1.3, the pattern of demand for minerals is continually evolving due to changing economic, technical and environmental factors. Consequently areas that are of potential economic interest as sources of minerals may change with time. Using the best available data as identified in Step 1, and BGS mineral planning factsheets that have been prepared to inform the land use planning process[2], a list of mineral resources that are to be excluded from or included in the safeguarding process has

[2] These can be downloaded from www.bgs.ac.uk/mineralsuk/planning/mineralPlanningFactsheets.html

been made. Where mineral resources are identified for exclusion, a justification has been put forward. This list and justification can be seen in Appendix 3. Hydrocarbon resources have not been considered for MSAs as the location of surface infrastructure to access these resources is, to some degree, flexible so the resources are not as susceptible to the risks posed by sterilisation by other non-mineral development and the boundaries of these resources are poorly constrained.

In order to define the physical extent of MSAs, it has been decided that the mineral resource information identified in Step 1, and selected as part of Step 2, should be depicted on maps created for each mineral resource and used as a basis for consultation.

In the first instance, the full extent of each resource is included within the respective MSAs. This includes mineral resources in urban areas and in environmental designations in line with the mineral safeguarding good practice advice (Wrighton *et al*., 2011). In urban areas, the definition of MSAs will help to identify opportunities for prior extraction beneath large regeneration projects and brownfield sites. It is felt that justification for any other approach would be weak at this stage as it would diverge from the best practice advice. Policies can be used to control the amount of planning applications that would be considered on mineral safeguarding grounds. For example, householder development applications may be excluded from the assessment of mineral sterilisation, by inclusion in an exemption policy. Many of these considerations are likely to be considered during the consultation on policy and on the adoption of detailed mineral safeguarding boundaries that NYMNPA will undertake through the course of their plan preparation. Development is limited within environmental designations, meaning in these instances the mineral resource should be considered alongside all of the other planning factors.

Good practice advice raises the issue of sterilisation caused by development that is permitted on or close to the edges of the identified resource boundaries. This is because access to mineral resources is affected by consideration of the amenities of, and nuisance to, those that live and work close to the operation. In accordance with good practice a 'buffer' distance, i.e. the extension that should be applied to the mineral resource boundary in order to create an MSA and protect the identified 'edges' of the resource from sterilisation, should also be subject to consultation (Box 4). Buffer distances, shown in Table 2, put forward for consultation were based on those included in the Minerals Safeguarding Areas report produced for North Yorkshire County Council. No amendments were suggested to these through the consultation process.

Box 4 Buffering of MSA boundaries

'The boundaries of MSAs may be extended beyond the lateral extent of a mineral resource to avoid sterilisation by adjacent development.' [Case study 3, page 20]

Source: *Mineral safeguarding in England: good practice advice* (Wrighton *et al*., 2011).

Table 2: Buffer distances for consultation. Justifications for buffer distances are located in section 3

Category	Buffer
Sand and Gravel	250m
Brick clay	250m
Building stone	250m
Shallow coal	250m
Limestone	500m
Deep coal	700m
Potash / Salt	0m

3 Mineral Resources

This section provides a summary of the mineral resources in NYMNPA from an economic perspective. It provides a geological description of the resource, information regarding extraction activity and a rationale for delineation of MSAs.

3.1 SAND AND GRAVEL

Sand and gravel are defined on the basis of particle size as opposed to composition. Currently the term 'gravel' (or more correctly coarse aggregate) is used to describe material coarser than 4mm, with a maximum size of 80mm. 'Sand' (or fine aggregate) is described as material that is finer than 4mm, but coarser than 0.063mm. Material with a particle size of less than 0.063mm (i.e. clay and silt) is classed as 'fines'. Most sand and gravel is composed of particles that are rich in silica (quartz, quartzite and flint).

Superficial or 'drift' sand and gravel deposits occur in a variety of geological environments but are broadly divided into the following:

- River terrace deposits
- Sub-alluvial river terrace deposits
- Glacial sand and gravel

3.1.1 Geological description

The North York Moors have neither major river systems nor extensive thick glacial deposits that are prevalent in surrounding areas; as a result resources of sand and gravel are sparse. Sand and gravel resources are restricted to alluvial and sub-alluvial river terrace deposits in the east and south of the area and also glacial sand and gravel to the north east.

Resources in modern alluvial sediments take the form of river terrace deposits, these extensive spreads of sand and gravel occur in both raised river terrace sequences, flanking modern floodplains, and underlying alluvium ('sub-alluvial terrace deposits'). River terrace sand and gravel resources are reasonably consistent over considerable distances, their composition reflecting, in general, the geology of the river catchment from which they were reworked. Generally, they are 'clean' deposits, with low fines content.

Only exposed river terraces are depicted on the 1:50 000 scale geological maps, although inferred[3] resources in sub-alluvial sand and gravel deposits, occurring beneath river floodplains, may be extensive in some places and have been identified from mineral resource map data used for this project. Where they underlie alluvium, these deposits will be water saturated and require wet-working, potentially making them less desirable as a resource. These deposits occur throughout the drainage network of the North York Moors, although areas are often small. The largest fluvial deposits can be found in the catchments of the Rivers Esk and Derwent.

Older sand and gravel deposits, derived from glacial sediments, can be found around the margins of the North York Moors National Park but only occur in significant thickness in the north east of the Park between Guisborough and Whitby. These resources consist of glaciofluvial deposits, the product of deposition by glacial meltwaters. They often display intricate relationships with

[3] An **'inferred mineral resource'** is that part of a mineral resource for which tonnage, grade and mineral content can be estimated with a low level of confidence. It is inferred from available geological evidence and assumed but not verified geological and/or grade continuity. This is opposed to an **'indicated mineral resource'** which is that part of a mineral resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a reasonable level of confidence. With the exception of the sub-alluvial river terrace deposits near Ingleby Arncliffe which are at the indicated level, the resources depicted on the maps within the NYMNPA area are inferred resources.

adjacent deposits of unsorted glacial till. Bodies of sand and gravel may occur as sheet- or fan-like layers above till deposits or as elongate, irregular lenses within the till sequence. Areas of wholly concealed, and thus possibly unknown, bodies of sand and gravel may occur under spreads of till and other drift deposits. Although these resources appear to be the most abundant sand and gravel deposits in the North York Moors National Park area they predominantly comprise clays and silts with thin interbeds of sand and gravels.

Clast composition of the gravels is variable between locally sourced Jurassic sandstones and heterogeneous compositions including Carboniferous sandstones and limestones as well as igneous material. The thickness of glacial deposits is also variable, they are thickest where they infill valleys in the north of the area, here they can occur as sequences of tills, sands and gravel over 30 metres thick. Thickness decreases rapidly in the higher areas and these deposits are absent over the majority of the upland moors of the National Park.

3.1.2 Extraction activity

Currently all aggregates produced in the north Yorkshire sub-region are from the North Yorkshire County Council and Yorkshire Dales National Park areas, with no production from the City of York and North York Moors National Park areas (NYCC *et al.*, 2013).

3.1.3 Rationale for MSA methodology

It is recommended that all sand and gravel resources are included on the safeguarding map (Figure A2). The original resource linework was not changed as a result of consultation and so has been used as the basis for defining MSAs

MSA buffer

Consistent with the approach utilised in North Yorkshire County Council's area, 250m is proposed as a buffer for sand and gravel resources. This should ensure that the identified boundaries of the resource area are effectively safeguarded from development permitted nearby.

3.2 LIMESTONE:

Limestone is a sedimentary rock consisting primarily of calcium carbonate (the calcified remains of marine organisms). Limestone with a high magnesium carbonate content is termed dolomite or dolostone. Limestone has a variety of uses – it can be crushed, ground or calcined (burnt to make lime) for a variety of constructional and industrial applications. Given most limestones are hard and durable the rock is useful as an aggregate, but it also has a variety of non-aggregate industrial uses that utilise its chemical properties (Harrison *et al.*, 2006). Limestone has also been extracted for building stone applications within the NYMNPA

3.2.1 Geological description

Limestones of Jurassic age are prevalent across the North York Moors. Limestones only form part of the Jurassic sequence, which also contains clays, siltstones and sandstones. The Jurassic limestones, which are generally soft, friable and porous, occur in units that are relatively thin and may be laterally impersistent. These limestones are generally only suitable for constructional fill uses. Certain limestone units, such as the Upper Jurassic Malton Oolite Member of the Coralline Oolite Formation that flanks the Vale of Pickering, are however sufficiently indurated to produce good quality aggregates. The Malton Oolite is an impure limestone with a high but variable silica content and is quarried to the south, in the adjacent planning authority area of North Yorkshire, for general-purpose crushed rock aggregate.

3.2.2 Extraction activity

There are currently no active limestone extraction sites in the North York Moors National Park. However, limestone is worked just south of the NYMNPA boundary at Newbridge Quarry (Figure A3) and in the east of the North Yorkshire County Council area (NYCC *et al*., 2013).

3.2.3 Rationale for MSA methodology

It is recommended that all limestone resources are included on the safeguarding map (Figure A3). All limestone resources were included on the resource maps for consultation. The limestone resources map was refined through consultation and the mineral safeguarding maps incorporate this information.

MSA buffer

Consistent with the approach utilised in North Yorkshire County Council's area, 500m is proposed as a buffer for limestone resources. This should ensure that the identified boundaries of the resource area are effectively safeguarded from development permitted nearby.

3.3 BRICK CLAY

'Brick clay' is the term used to describe clay in the manufacture of bricks, roof tiles, clay pipes and decorative pottery. These clays may sometimes be used in construction, such as in cement manufacture, as a source of fill and for lining and sealing landfill sites. The behaviour of clay during shaping, drying and firing dictates its suitability for the manufacture of bricks as it affects the properties of the fired brick such as strength, frost resistance and architectural appearance (Harrison *et al.*, 2006). Different clays are blended to achieve durability and provide a range of brick colours and textures.

3.3.1 Geological description

Clay and shale are a common lithology within the Jurassic rocks of the North York Moors National Park. The majority of formations that contain a clay component have been exploited for brick clay in the past. These vary from thick clay formations such as the Oxford Clay Formation, to heterogeneous beds of shale and thin sandstones from the Ravenscar Group. These clays have been used in a wide range of products, including pipes, flooring tiles and coarse pottery. However, this industry and local demand for brick clay have declined; as such these units can no longer be considered as a brick clay resource and therefore not shown on the map (Figure 1 and Figures A1 and A4).

More recent glaciolacustrine clays form brick clay resources within the North York Moors. These units are formed by the ponding of water into large lakes, formed behind glacial moraines. The lakes would have been a low energy environment allowing for the deposition of fine silts and clays. Glaciolacustrine deposits are exploited for brick clay further south where they are much better developed, for example at Alne and Littlethorpe, near Ripon. Within the North York Moors, a few small areas of glaciolacustrine deposits are present although they are not quite as thick or laterally persistent as the deposits further south.

3.3.2 Extraction activity

There are currently no active or inactive sites in the North York Moors National Park, although historically sites were worked throughout the Park.

3.3.3 Rationale for MSA methodology

The advice in 'Mineral safeguarding in England: good practice advice' (Wrighton *et al*., 2011) suggests that where a great number of geologically mapped subdivisions exist for geology in an area, it may be possible to reduce the extent of safeguarding areas for brick clay based on those formations that are actively worked. In the case study provided in the good practice advice, Nottinghamshire County Council identified specific formations that were currently worked by industry and consulted on the options for safeguarding.

There are no active brick clay sites in the North York Moors National Park; as such this approach cannot be taken. It is recommended that the whole of the glaciolacustrine brick clay resource is shown as a safeguarding area (Figure A4). The original resource linework was not changed as a result of consultation and so has been used as the basis for defining MSAs.

MSA buffer

Consistent with the approach utilised in North Yorkshire County Council's area, 250m is proposed as a buffer for sand and brick clay resources. This should ensure that the identified boundaries of the resource area are effectively safeguarded from development permitted nearby.

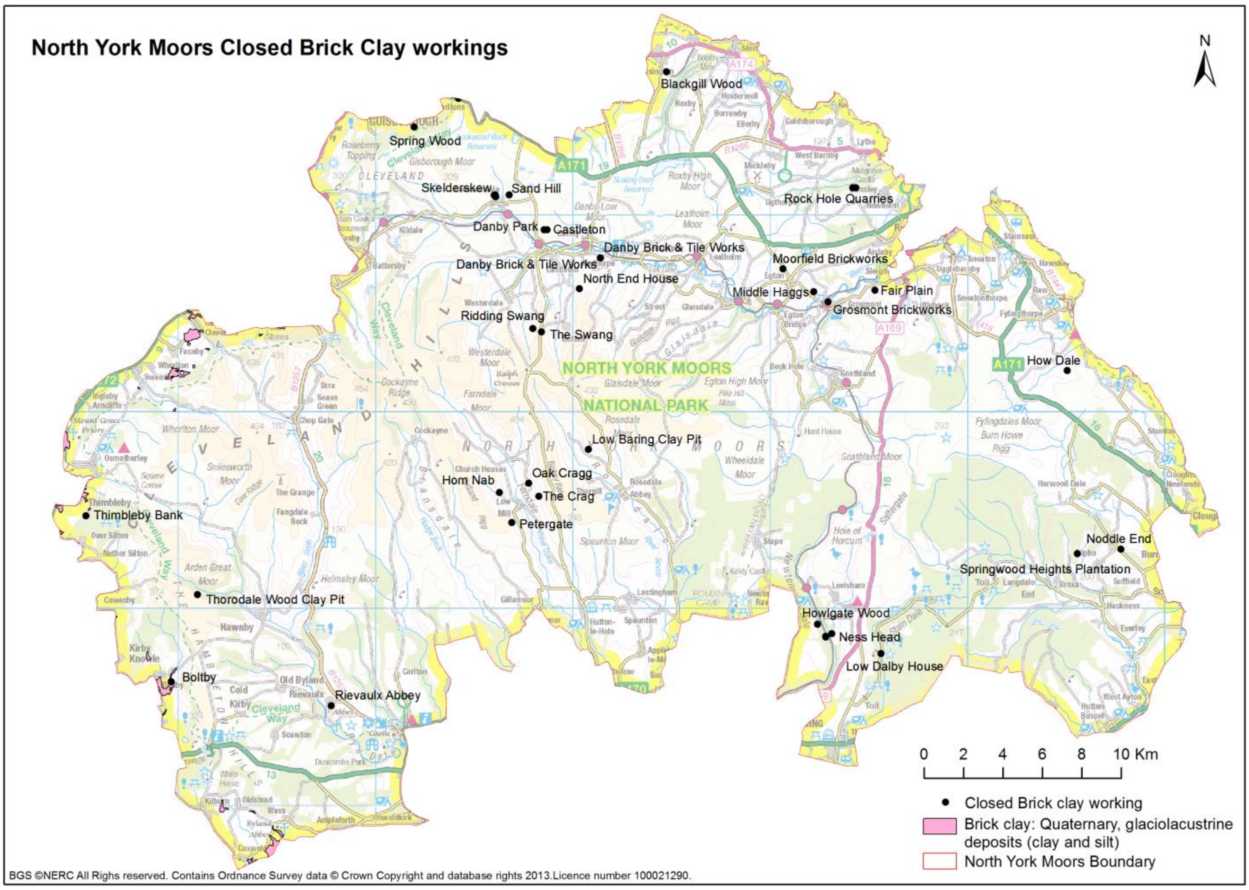


Figure 1: North York Moors National Park closed brick clay workings. (Note: the majority of historic sites worked Jurassic clay and shales from the Oxford Clay Formation and Ravenscar Group).

3.4 BUILDING STONES

Context

The bedrock geology of the National Park area (Figure A5a) is dominated by Middle Jurassic sedimentary rocks, which are assigned to the Ravenscar Group. There are in addition outcrops (associated with topographic incisions) of the underlying Lower Jurassic Lias Group succession and, in the south, an irregular, roughly E–W trending belt of Upper Jurassic strata (including the lithologically varied Corallian Group). Various stratigraphic units occurring within both the Ravenscar Group and the Corallian Group have been extensively quarried historically, and many of the individual workings are known to have produced building stone. Sandstones and limestones from these units comprise the building stone resource within the NYMNPA and the most important building stone types and their stratigraphical origins are summarised below.

‘Modern’ construction techniques combined with competition from alternative building materials such as brick, concrete, glass and steel – together with a general reduction in building following the wartime reconstruction efforts – has led to the closure of many stone quarries across the country (BGS, 2007). The North York Moors are no different in this respect, and the scaling back of quarrying operations has been such that building stone is actively produced at only two quarries (the Lowther’s Crag and Aislaby quarries), both of which are working Ravenscar Group sandstones of the Saltwick and/or Cloughton formations (Figure A5b). The continuing survival of the building stone industry is reliant on demand from both the ‘new-build’ and ‘conservation’ markets, and its ability to meet those demands.

The demand for building stone created by *ad hoc* conservation repair efforts and/or a will to preserve ‘local distinctiveness’ is unlikely to be such that that new individual quarries will be opened at any foreseeable stage in the future. This is especially true in the case of those building stones that have a limited geographical usage. The logical (and economically sound) solution to meeting the needs of such a transient market is to reopen former quarries on a temporary basis. This necessitates a slightly different, more focused, safeguarding strategy – one that involves not the safeguarding of entire outcrop areas of particular stratigraphic units but rather the safeguarding of specific former quarries deemed to be of potential future importance by the application of a suitable buffer zone. Within the NYMNP, the building stones best-suited to this ‘alternative’ safeguarding strategy can be usefully treated under two headings i.e. those lying within the Ravenscar Group and those within the Corallian Group (see Figure A5a).

3.4.1 Geological description

Ravenscar Group building stones:

Moor Grit

Moor Grit, a white or pale grey sandstone yielded by the Moor Grit Member of the Scalby Formation, has been worked historically at several localities within the NYMNP (Figure A5c). The Strategic Stone Study identifies one building (the Grade II-listed Royal Oak in Helmsley) that potentially utilised Moor Grit from ‘Old Fold’ – a quarry located on Helmsley Moor. ‘Old Fold’ was apparently also the source of blockstone used in road and railway bridge construction nearby. Levisham Station is identified as a Moor Grit building, while the village of Danby seemingly utilised stone from the ‘Southward Brow Quarries’ located immediately to the north. In the first instance, it is proposed that the former ‘Old Fold’ and ‘Southward Brow’ quarrying areas be safeguarded. Consideration should also be given to safeguarding the former quarries located to the north of Cloughton.

Long Nab Sandstone

Long Nab Sandstone, yielded by the Long Nab Member of the Scalby Formation (Figure A5d), is recorded within the fabric of the Grade II-listed Levisham Station. A quarry located close to Newtondale Halt (named ‘Sacredstone’) may have been the source of this sandstone, and potentially of other structures which sit along the North York Moors Railway. The ‘Sacredstone’ quarry should be considered for safeguarding.

Corallian Group building stones:

Corallian Group Calcareous Grits

The Lower Calcareous Grit, a yellow or buff coloured calcareous sandstone, and the stratigraphically higher but lithologically similar Birdsall Calcareous Grit, Middle Calcareous Grit and Upper Calcareous Grit have been quarried at various localities within the NYMNP (Figure A5e). Only a small number of these former quarries (such as ‘Shever Wood’ and

‘Hollins Wood’ near Helmsley) are confirmed building stone producers at the present time, however. Nonetheless, the Strategic Stone Study has found evidence of the widespread use of the various Corallian Group Calcareous Grits in the National Park e.g. Rievaulx Abbey, Byland Abbey and in the village of Lockton. Consideration should therefore be given to safeguarding former ‘Calcareous Grit’ quarries within the National Park (for example ‘Shever Wood’ and ‘Hollins Wood’), although the presence of these sandstones in neighbouring MPAs may diminish the case for widespread safeguarding. In a response to the consultation English Heritage commented that they considered it important that all Calcareous Grit quarries should be safeguarded.

Hambleton Oolite

Hambleton Oolite, a pale grey to white, fine-grained, ooidal limestone occurring within the Coralline Oolite Formation, has been worked in the past at several different quarries, mainly in the south-west of the National Park (where the bulk of the outcrop occurs; Figure A5f). The Strategic Stone Study links the ‘Griffe Bank’ and ‘Wass’ quarries with Rievaulx Abbey and Byland Abbey, respectively. Hambleton Oolite has also seen use in the villages of Levisham, Lockton, Cold Kirby, Old Byland and Scawton. The relevance of Hambleton Oolite both to buildings of historic importance and to the local definition of ‘sense of place’ provides a strong case for safeguarding former quarrying areas such as ‘Griffe Bank’, ‘Wass’ and ‘Boltby’.

Malton Oolite and Coral Rag

The Malton Oolite (a white to grey ooidal limestone) and the Coral Rag (a yellow-grey or pale grey, locally coarsely fossiliferous limestone) of the Coralline Oolite Formation have been worked historically in the south of the National Park (Figure A5g). Only a single building featuring either of these stone types was recorded during the course of the Strategic Stone Study, however. At the present time, there is little basis for safeguarding former Malton Oolite and Coral Rag quarrying areas within the NYMNP, especially if quarries lying within the lithologically ‘compatible’ Hambleton Oolite are subject to safeguarding.

<u>Building stones sourced from other stratigraphic units</u>:

Kellaways Rock and Hackness Rock

The Kellaways Rock and the Hackness Rock are relatively soft, ferruginous sandstones yielded by the Osgodby Formation (sitting stratigraphically between the Ravenscar Group and the Corallian Group). These have been worked at a number of sites in both the north and south of the NYMNP (Figure A5h). The ‘Penny Piece’ and ‘Hackness’ quarries have been identified as the source of building stone used for structures found in their surrounding areas. ‘Penny Piece’ is the source of the Kellaways Rock featuring in Rievaulx Abbey, while ‘Hackness’ is the eponymous source of the Hackness Rock used in the Rotunda Museum in Scarborough (lying within the adjacent North Yorkshire County Council MPA area) and York Museum. Owing to the relevance of Kellaways/Hackness Rock to “heritage assets”, consideration should be given to safeguarding one or both of the ‘Penny Piece’ and ‘Hackness’ quarrying areas.

3.4.2 Extraction activity

There are two active quarries within the NYMNP – the Lowther’s Crag and Aislaby quarries – both of which produce sandstones known as the ‘Aislaby Stone’ or ‘Saltwick Sandstone’ (the terms are effectively synonymous and are used interchangeably). Another quarry owned by the operator of the Aislaby Quarries (i.e. Carter’s Quarry, near Egton Bridge) is inactive at present. Lithologically, the generic ‘Saltwick Sandstone’ is a yellow or buff, medium- to coarse-grained sandstone deriving from the Saltwick and/or Cloughton formations of the Middle Jurassic Ravenscar Group. These two stratigraphic units (undifferentiated over large parts of the National Park; see Figure A5b) are geographically restricted to the North Yorks Moors, the Cleveland Hills and the Howardian Hills.

'Saltwick Sandstone' has been used in the villages of Robin Hood's Bay, Osmotherley, Boltby, Kirby Knowle, Danby, Egton, Fylingthorpe, Kilburn, Aislaby, Grossmont and Goathland. It has also been identified within the fabrics of numerous individual buildings including Mount Grace Priory (Osmotherley), Rievaulx Abbey, Byland Abbey, and both The Black Swan hotel and The Royal Oak public house in Helmsley. Furthermore, 'Saltwick Sandstone' has been 'exported' to London, and features in Covent Garden and in Waterloo and London bridges (English Heritage, 2012). Sandstones yielded by the Cloughton Formation (where actually differentiated) can be seen in and around Cloughton itself, and were used in the construction of Goathland Railway Station (English Heritage, 2012). These sandstones have also seen use as flagstones.

'Saltwick Sandstone' is currently economic to extract and has a 'live' market demonstrated by the presence of active workings. It has been quarried and used extensively as a building stone historically, not only in the NYMNP but in areas further afield, thereby indicating a local and wider significance. These considerations, along with the limited geographical extent of its outcrop, make many of the 74 active and historical building stone quarries occurring within the outcrop area of the Saltwick and Cloughton formations (Figure A5b) worthy of consideration for safeguarding.

3.4.3 Rationale for MSA methodology

The current national planning policy for minerals, and that having direct relevance to building stone resources, is contained within the *'National Planning Policy Framework'* (NPPF; see Box 6).

Box 6 Safeguarding building stone resources
'In preparing Local Plans, local planning authorities should: - *Define Mineral Safeguarding Areas and adopt appropriate policies in order that known locations of specific minerals resources of local and national importance are not needlessly sterilised by non-mineral development...'* The definition of minerals of local and national importance is provided in Annex 2: *'Minerals which are necessary to meet society's needs, including...local minerals of importance to heritage assets and local distinctiveness'.* The definition provided in Annex 2 for a heritage asset: *'A building, monument, site, place, area or landscape identified as having a degree of significance meriting consideration in planning decisions, because of its heritage interest. Heritage asset includes designated heritage assets and assets identified by the local planning authority (including local listing)'.*

When attempting to identify building stone resources that must be safeguarded in order to meet the needs of society, it is clear from national policy that particular significance should be attached to:

1) Those building stones that are of local, regional or even national importance from the point of view heritage assets and their preservation.
2) Those building stones that are key to defining a 'sense of place'.

English Heritage's Strategic Stone Study, carried out in conjunction with BGS, aims to establish and document patterns of building stone use across England and also pinpoint the quarry sources of the many building stones used historically, all with the intention of protecting and ensuring the long-term availability of the key building stone resources (Wrighton *et al*., 2011). The 'Strategic Stone Study' of the North York Moors was completed during the spring of 2012 as part of a more general study of North Yorkshire. The resultant findings are summarised in a document entitled *'A Building Stone Atlas of North Yorkshire East and York'* (English Heritage, 2012) and the data amassed can be interrogated by means of an online search tool and GIS interface (http://mapapps.bgs.ac.uk/buildingStone/BuildingStone.html). Although financial constraints have impacted on the amount and the detail of the information collected, clear patterns of building stone extraction within the park and their use both locally and further afield have been established.

Historical building stones that are of importance to heritage assets and to the definition of 'local distinctiveness'

Particular stratigraphic units that were quarried historically but are no longer worked may warrant safeguarding owing to their importance to conservation repair efforts. English Heritage advocate a 'like-for-like' replacement policy when effecting repairs to historical (especially listed) buildings and other structures, ideally entailing use of the 'original' stone from the original quarry source. The policy states: *'Wherever possible compatible materials should be used – stone that closely replicates the original in its appearance, chemical, physical and mineralogical properties, strength and durability'* (English Heritage, 2006). Building stones no longer in active production are also of importance to the preservation of 'local distinctiveness'. A desire to maintain the 'character' of stone-built towns and villages (very often having conservation area status) quite clearly has implications for new-build structures and extensions to existing structures within such settlements, creating a on-going (albeit unpredictable) need for the various building stone types used in the past.

MSA Buffer

The demand for building stone created by *ad hoc* conservation repair efforts and/or a will to preserve 'local distinctiveness' is unlikely to be such that that new individual quarries will be opened at any foreseeable stage in the future. This is especially true in the case of those building stones that have a limited geographical usage. The logical (and economically sound) solution to meeting the needs of such a transient market is to reopen former quarries on a temporary basis. This necessitates a slightly different, more focused, safeguarding strategy – one that involves not the safeguarding of entire outcrop areas of particular stratigraphic units but rather the safeguarding of specific former quarries deemed to be of potential future importance by the application of a suitable buffer zone. Within the NYMNP, the building stones best-suited to this 'alternative' safeguarding strategy can be usefully treated under two headings i.e. those lying within the Ravenscar Group and those within the Corallian Group (see Figure A5a). In the neighbouring authority of North Yorkshire a buffer distance of 250m was recommended around the location of former quarries, as a result of consultations and to reflect the method of working. This distance would therefore also be considered suitable for the North York Moors. Such a buffer is consistent with other minerals that are extracted without blasting, this distance may represent a maximum due to the generally low-key, low intensity method of working for building stone.

Summary/Conclusions

It is clear from the evidence provided by the Strategic Stone Study of North Yorkshire that the NYMNP area has extensive building stone resources. These have been widely exploited and used historically across the National Park, although individual building stone types tend to have only limited geographical spheres of influence (i.e. fairly close to their respective outcrops). Consideration of the patterns of building stone usage in our opinion warrants a comprehensive safeguarding of the active and former building stone quarries located within the outcrop of the Saltwick and Cloughton formations (Ravenscar Group), but a more selective safeguarding approach with respect to the quarry sources of the other historically important building stone types. This approach was supported by English Heritage during the consultation process undertaken by NYMNP. We stress, however, that our recommendations are based on a currently unrepresentative dataset.

3.5 COAL

Coal is a combustible rock that is formed through the alteration of dead plant material under the increasing temperatures and pressures experienced during burial. As a result of geological processes such as faulting and folding, coal seams can occur at varying depths from the surface, and can be of varying thicknesses.

Depending on its quality (physical and chemical properties), coal can be used as power station fuel to generate electricity, or if it is high enough quality, it can be used to fire blast furnaces for the metallurgical industries. Its quality is ranked by its Calorific Value (CV), which is the heat energy given off by the combustion of a unit quantity of fuel. This can vary from 15 MJ/kg for peat (low rank) to 35 MJ/kg for anthracite (high rank). Impurities such as chlorine and sulphur are detrimental in coal because they contribute to air pollution and also corrosion of power station infrastructure e.g. boiler pipes (BGS, 2011a).

Coal is extracted by surface or underground mining, depending on its proximity to the surface. However, where conditions and quality allow it may also be suitable for Coal Bed Methane (CBM) extraction or Underground Coal Gasification (UCG). CBM extraction exploits the gas that is adsorbed onto the coal surface during coal formation, usually via a series of boreholes. UCG involves the partial combustion of the coal seams in situ in order to drive off gases and produce heat (BGS, 2011a, BGS, 2011b).

Fireclays are commonly worked as a by-product of surface coal mining. They are mudstones that usually underlie a coal seam, and would have once been the soils on which the coal-forming plants and vegetation grew. Beds are primarily used for buff-coloured facing bricks and pavers (BGS, 2011a).

3.5.1 Geological description

The county of North Yorkshire includes the concealed East Pennine Coalfield. Coal-bearing strata are principally confined to the Pennine Lower and Middle Coal Measures (Upper Carboniferous). In general the coal-bearing horizons dip from west to east under the eastern edge of the North York Moors National Park. These horizons generally occur at depths greater than 1200m beneath the surface and represent the northern most extent of the East Pennine Coalfield. These deep coal seams are widespread and many are developed on a regional scale. However, there are lateral variations in thickness, composition and the number of dirt partings they contain. The seams are mainly bituminous and the calorific value and rank of the coals broadly increases eastward. Sulphur is an impurity associated with all Yorkshire coals, with the more easterly parts of the coalfield containing higher sulphur contents (Harrison *et al.*, 2006). There is some shallow coal in the centre of the North York Moors National Park. These are thin, discontinuous seams within alternating sequences of shales, mudstones and sandstones within the Jurassic Ravenscar Group.

The NYMNP also contains areas of shallow coal resource. These were delineated in the 2006 study carried out by BGS for the Coal Authority (report number CR/06/159N). They are based on a detailed examination of the stratigraphy to determine the vertical spacing, lateral continuity and thickness of coals. Of the categories outlined below only tertiary shallow coal resources are present in the NYMNP:

- Primary opencast coal resource areas are the main target for opencast coal extraction and comprise a relatively closely spaced succession of variable but generally thick coals.

- Secondary resource areas contain opencast coal resources, but in which the coals are generally thinner and less concentrated in vertical and lateral distribution.
- Tertiary opencast resource areas are locally present and typically inter-bedded with thick sandstones. They do form a resource but are not generally attractive for opencast mining. They often have high overburden ratios.
- Buried coals, overlain by up to 50m overburden, are usually down-dip of the main areas of mapped resource. They are covered by younger strata and are not ranked as primary, secondary or tertiary.

3.5.2 Extraction activity

Kellingley Colliery, near Knottingley, is now the only remaining deep coal mine in North Yorkshire. The deep coal resource is not exploited in the NYMNPA area. With regard to shallow coal, small areas of shallow coal are present in the NYMNP. Historically these coals have been worked by small-scale methods from around 1860 to 1900, the most extensive of these in the Rudland Rigg area.

3.5.3 Rationale for MSA methodology

DEEP COAL RESOURCES

During consultation about MSAs for the North Yorkshire County Council, the issue of subsidence was raised for minerals worked underground (Wrighton and Bide, 2011). Although subsidence from deep coal workings does not generally affect normal development, as pillars can be left to support the surface, sensitive surface development can affect the viability of deep workings. The example of a glass factory in Selby District was provided as support for this view, where risks to the operator from working underneath such sensitive development, even if pillars were left to support the surface, were considered too great to work the mineral. Although the affects of subsidence are not necessarily an issue for all surface development, it should be recognised that some sensitive surface developments will have the potential to sterilise mineral resources at depth. The deep coal may also be of significance if technologies allow their exploitation, such as for Underground Coal Gasification. The safeguarding of deep coal resources against sensitive development may provide the opportunity to discuss this form of gas extraction in the future, should the practice become economic in the UK onshore. Deep coal, therefore, is shown on the mineral safeguarding map (Figure A7).

SHALLOW COAL RESOURCES

Although not currently worked, the shallow coal resource areas shown on Figure A6 are considered to be a resource that should be safeguarded. This approach was supported by the Coal Authority through consultation conducted by NYMNP.

MSA buffers

The impact of subsidence on sensitive development, such as high precision factories, is negligible given current extraction techniques at a horizontal distance of 0.7 multiplied by the depth of working. As current depths of working do not generally exceed 1000m, a buffer of 700m should ensure that the safeguarding mechanism is robust for deep coal. This buffer distance was suggested during the consultation exercise undertaken for North Yorkshire County Council, so for consistency it is also proposed for NYMNPA.

In order to prevent the unnecessary sterilisation of the identified boundaries of the resource, a buffer of 250m is suggested for shallow coal resources. This is consistent with other buffers proposed for minerals that are not extracted by blasting.

3.6 POTASH AND SALT

Potash is a term used to encapsulate a variety of potassium-bearing mineral and refined products. Potassium bearing minerals that are of commercial interest are water-soluble. Sylvanite, which is mined in the UK, is a mixture of sylvine (potassium chloride, KCl) and halite (salt). Sylvine is a relatively scarce mineral, which occurs in beds up to a few metres thick. It is found in deposits that are formed by the extreme evaporation of seawater. Other potassium-bearing evaporite minerals found associated with sylvine are carnalite (hydrated potassium, magnesium chloride) and polyhalite (hydrated potassium magnesium, calcium sulphate).

Approximately 90% of UK potash production in the UK is used for fertilisers. Small quantities are also used by the chemical and pharmaceutical industries in goods such as soaps, the production of glass for television screens, drilling fluid additives, and as a flux in secondary aluminium smelting (BGS 2011c).

Salt (sodium chloride, NaCl), occurs as rock salt (halite) in beds ranging in thickness from a few centimetres up to several hundred metres. The purity of individual salt beds depends on the extent of mudstone interbedding.

3.6.1 Geological description

Potash and salt resources occur in rocks of late Permian age that underlie extensive areas and extend at depth from Teesside beneath much of north and east Yorkshire, and into north Lincolnshire[4]. The potash resource comprises the Fordon Evaporites and the Boulby Potash, which occurs at the top of the Boulby Halite Formation. The salt resource comprises several horizons, the most extensive, and the only one of economic importance, being the Boulby Halite. The Boulby potash underlies extensive parts of east Yorkshire but is currently only worked at the Boulby Mine in the North York Moors National Park. The Boulby Potash averages 7m in thickness but ranges from nil to over 20m. The bed consists of sylvinite (a mixture of sylvine and halite) with minor clay minerals and anhydrite, and traces of other minerals. The material mined is of high-grade by international standards with a mean KCl content of 34 per cent. However, grade varies both vertically and laterally (Harrison *et al,* 2006). The Boulby Halite achieves a total thickness of about 40m. It occurs about 8–10m below the Boulby Potash as a bed of pure and strong halite through which the mine's arterial roadways are driven to access current mining areas and to explore and develop new areas for potash production. The rock salt produced through driving these roadways is suitable for de-icing roads and substantial quantities are extracted for this purpose. Another potential potassium resource is polyhalite, polyhalite is found in the same sequence as the Boulby potash and in thick deposits from the Fordon Evaporites which underlies the Boulby Halite, which occurs in a broad swath across Yorkshire from the Tees to the Humber Estuary. Polyhalite is currently extracted, in relatively small quantities, from Boulby mine.. Sirius Mineral's York Potash project within NYMNP proposes extraction of principally polyhalite.

3.6.2 Extraction activity

The only place in the UK where large scale extraction of potash and salt currently takes place is at the Cleveland Potash owned, Boulby mine in NYMNP. Mining operations extend some 12.5 km, reaching 5 km offshore to the north where they are approximately 800m below the seabed.

York Potash Ltd is developing proposals for a new mine approximately two kilometres south of Sneaton village and four kilometres south of Whitby which would extract polyhalite. The extraction site is proposed to be located in NYMNP and it is proposed that material will be transported by pipeline, to a materials handling and port facilities at Teesside. Following the

[4] The limits of sylvinite, polyhalite and halite resources are based on D. B. Smith. 1989. The late Permian palaeogeography of north-east England: Proceedings of the Yorkshire Geological Society 47. P285-312.

withdrawl of an earlier application, it is expected that a revised planning application will be submitted to NYMNPA and North Yorkshire County Council in summer 2014. Separate applications for the pipeline and new and extended port facilities are expected to be submitted to the National Infrastructure Directorate at the Planning Inspectorate.

3.6.3 Rationale for MSA delineation

As they are industrials mineral the NPPF requires that Mineral Planning Authorities plan for a steady and adequate supply of potash and salt. Safeguarding areas for potash have been defined for NYMNPA (Figure A8). In consultations that were undertaken during the preparation of draft MSAs for NYCC, potash had not been included among the initial list of proposed minerals for safeguarding, due to the low risk of sterilisation of the mineral by surface development. It was felt that any surface infrastructure associated with any mine could be relatively flexible in terms of siting (in terms of operational considerations) and so minimise any conflicting impacts. The issue of subsidence, however, was raised during the consultation for minerals worked underground. Subsidence at surface can be up to 0.5m as a result of underground potash workings (BGS 2011c), which occurs uniformly and over large areas. Although not a threat to normal development, the siting of sensitive developments over areas of mineral resource is likely to lead to sterilisation of the mineral due to the risk of cost and reputation associated with any detrimental impacts (Wrighton and Bide, 2011).

Although the salt is produced as an ancillary product at Boulby, the salt resource is shown to occur over a larger area than the potash on the county map produced by BGS (Harrison *et al*., 2006). Nevertheless, it is not currently economic to extract salt without the potash, and is unlikely to be economic to extract on its own in the foreseeable future. It is proposed, therefore, that the safeguarding area for salt is combined with the potash and covers the same area as the potash.

MSA buffers

Potash and salt have not been buffered due to the nature of the deposit, which is large in area and deep underground. Unlike deep coal the extraction of these resources is not associated with significant subsidence effects on the surface. This is due to the potash/salt deposits occurring deeper then workable coal resources and the more ductile nature of these rocks, where voids left by mining are filled by the flow of rocks rather than collapse. The presence of the mineral resource linework as a safeguarding area should capture any sensitive development that has the potential to affect future access to the mineral.

3.7 GYPSUM AND ANHYDRITE

Gypsum ($CaSO_4.2H_2O$) and anhydrite ($CaSO_4$) are, respectively, the hydrated and anhydrous forms of calcium sulphate, which occur in beds up to a few metres thick. Anhydrite occurs at depth, becoming hydrated near surface and passing into gypsum. Anhydrite is thus much more extensive than gypsum, but in its pure form is not of economic importance because of its limited commercial application. Gypsum is soluble and often dissolves at outcrop, locally causing subsidence problems. Gypsum is used in the manufacture of plaster and plasterboard and mixed gypsum/anhydrite is used as a retarder in Portland cement.

3.7.1 Geological description

Anhydrite occurs within Permian rocks which underlie the North York Moors National Park. As these rocks do not occur near the surface, anhydrite has not been hydrated to from gypsum, as is the case where these rocks outcrop further west. The most extensive anhydrite formations at depth in the NYMNPA are the Billingham Anhydrite and Hartlepool Anhydrite which can be up to 7m thick.

3.7.2 Extraction activity

There has been no record of gypsum or anhydrite extraction from within the North York Moors National Park. Large scale extraction of anhydrite, from the Billingham Anhydrite Formation, occurred north of the park boundary between 1925 and 1971, primarily for the manufacture of ammonium sulphate and sulphuric acid. Anhydrite was also extracted from the Hartlepool Anhydrite Formation, in Hartlepool between 1924 and 1930.

3.7.3 Rationale for MSA methodology

Gypsum is safeguarded in the Tees Valley Joint Minerals and Waste Core Strategy which will be used to guide development decisions to the north of the area for which CYC, NYCC and NYMNPA are preparing a draft Minerals and Waste Joint Plan. The accompanying text states that *'whilst the extraction of these resources may not be currently viable for reasons of price, geology, quality and previous extractive work, this situation may change and they may be required at some point in the future'*.

Gypsum and anhydrite bearing units occur at depth under the NYMNPA area and as a result gypsum is unlikely to have formed and anhydrite is not considered to be an economic resource. Furthermore, gypsum and anhydrite are mined, in the main, through underground pillar and stall methods, although surface mining does occur where gypsum is close to the surface. There is a fairly low subsidence risk associated with the underground operations and impact at the surface is likely to be limited to the location of surface facilities of a mine (BGS, 2006b).

Based on evidence from published sources and the advice of experts in BGS, it is considered not necessary to safeguard gypsum and anhydrite in the NYMNPA area.

3.8 SUB-SURFACE MINEAL RESOURCES – CONFLICTING DEVLOPMENTS

Several classes of sub-surface mineral resources including coal, shale hydrocarbons, potash, salt and conventional hydrocarbons occur within the NYMNPA area. These resources can overly each other vertically and it is therefore possible that extraction of one resource could preclude development of another sub-surface mineral. For example an exploration well for hydrocarbons could sterilise a pillar of potash that is 100m in diameter, equally the presence of workings for potash could prohibit access to hydrocarbon resources. Consultation between parties with interests in these vertically-coincident resources should help to mitigate any sterilisation. The onus should be on the developer of a particular sub-surface resource to demonstrate the likely level of impact on access to, and extraction of, any other sub-surface resources. The horizontal and vertical extent of the 'zone of influence' associated with extraction will vary depending on the mineral, its geological context and the method of extraction used. When coupled with the higher level of geological uncertainty usually associated with mineral resources at depth, these factors mean that the application of standard buffer zones and separation distances around particular sub-surface resources is unlikely to be of any practical value.

4 Conclusions

This study has provided NYMNPA with a clearly defined and delineated set of recommended MSA maps and proposed safeguarding methodologies for each mineral resource present in the area. The project has followed recommendations and guidance, where possible, from 'Mineral Safeguarding in England: good practice advice' (Wrighton *et al*., 2011).

This work has addressed the first two steps involved in mineral safeguarding with step 3 being undertaken by the NYMNPA. The relevant remaining steps (4-7), will be addressed through the development of associated mineral safeguarding policies by the NYMNPA in the future.

Paper maps and Adobe PDF documents have been provided to NYMNPA showing the mineral resources within the MPA these will be used to inform the establishment of MSAs through minerals planning policies. The digital data has been supplied in the form of ESRI shapefiles for integration in a GIS.

Appendix 1 Maps

Published mineral resources map

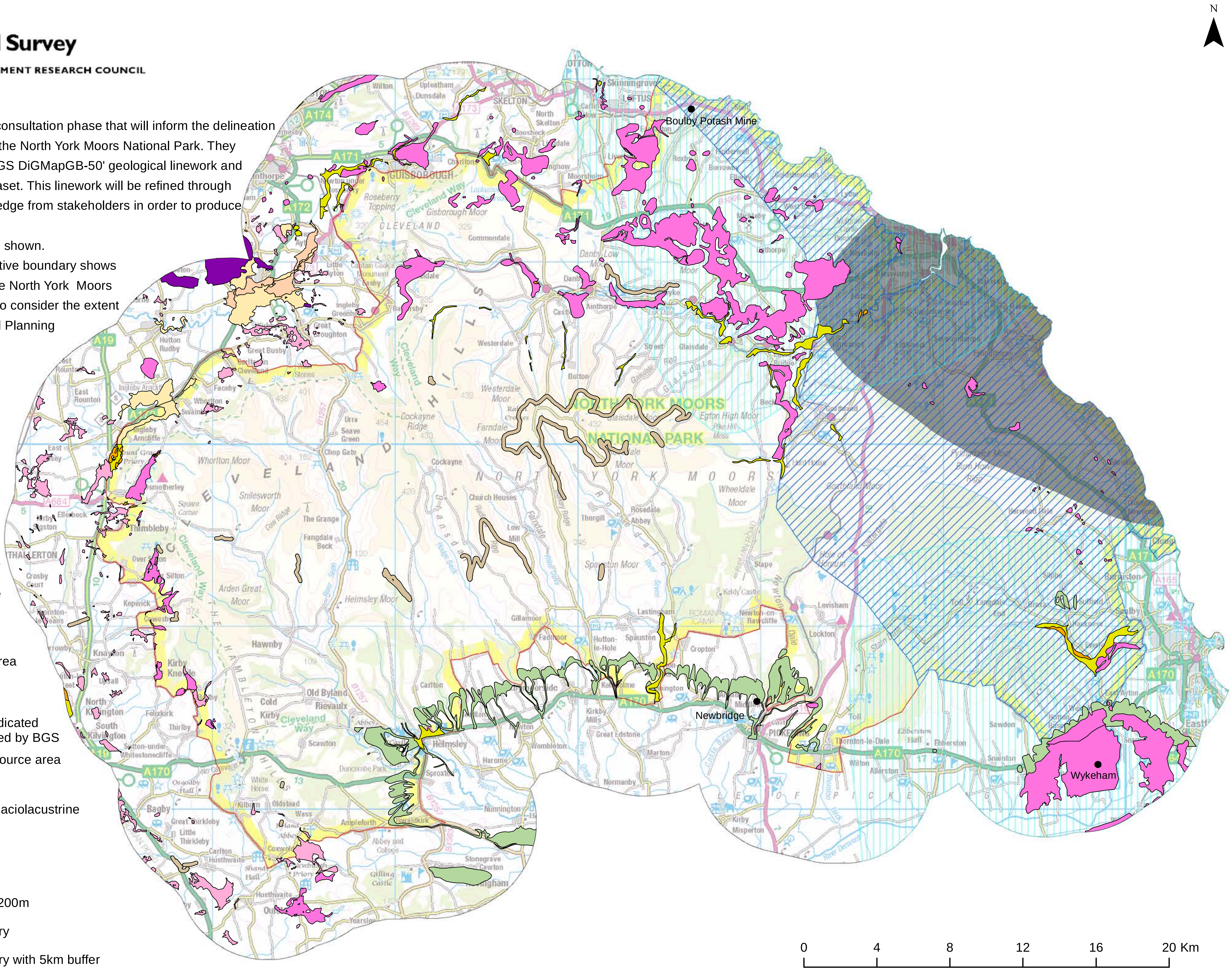
Consultation maps showing mineral resources

Consultation phase maps

These maps will form part of the consultation phase that will inform the delineation of Mineral Safeguarding Areas in the North York Moors National Park. They show geological units from the 'BGS DiGMapGB-50' geological linework and published Mineral Resources dataset. This linework will be refined through consultation to incorporate knowledge from stakeholders in order to produce Mineral Safeguarding Area Maps.

Active mineral extraction sites are shown.

The border around the administrative boundary shows mineral resources 5km beyond the North York Moors National Park boundary, in order to consider the extent of minerals straddling the Mineral Planning Authority boundary.



- Active Site
- Sub-alluvial River Terrace deposits
- Sub-alluvial River Terrace deposits
- River Terrace deposits
- River Terrace deposits - Indicated resources in area assessed by BGS
- Glaciofluvial deposits
- Glaciofluvial deposits - Indicated resources in area assessed by BGS
- Tertiary opencast coal resource area
- Limestone: Malton Oolite
- Brick clay - Quaternary, glaciolacustrine deposits (clay and silt)
- Potash\Salt
- Polyhalite
- Deep coal at more than 1200m
- North York Moors boundary
- North York Moors boundary with 5km buffer

Figure A1: North York Moors National Park: mineral resources, for clarity building stone resources are shown seperately (see Figures A5a-A5h)

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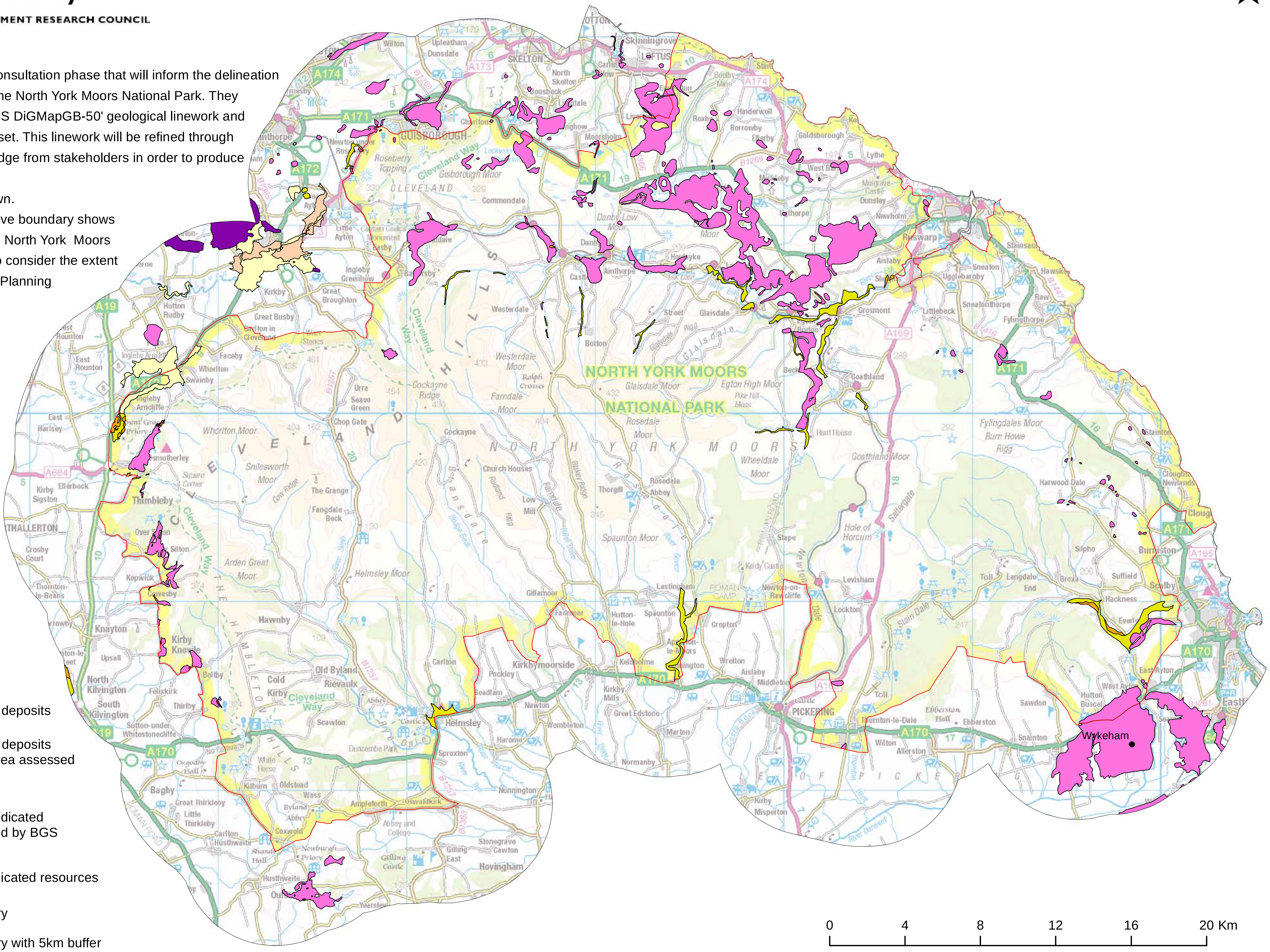
Consultation phase maps

These maps will form part of the consultation phase that will inform the delineation of Mineral Safeguarding Areas in the North York Moors National Park. They show geological units from the 'BGS DiGMapGB-50' geological linework and published Mineral Resources dataset. This linework will be refined through consultation to incorporate knowledge from stakeholders in order to produce Mineral Safeguarding Area Maps.

Active sand and gravel site is shown.

The border around the administrative boundary shows mineral resources 5km beyond the North York Moors National Park boundary, in order to consider the extent of minerals straddling the Mineral Planning Authority boundary.



- Active Site
- Sub-alluvial River Terrace deposits
- Sub-alluvial River Terrace deposits - Indicated resources in area assessed by BGS
- River Terrace deposits
- River Terrace deposits - Indicated resources in area assessed by BGS
- Glaciofluvial deposits
- Glaciofluvial deposits - Indicated resources in area assessed by BGS
- North York Moors boundary
- North York Moors boundary with 5km buffer

Figure A2: North York Moors National Park: sand and gravel resources

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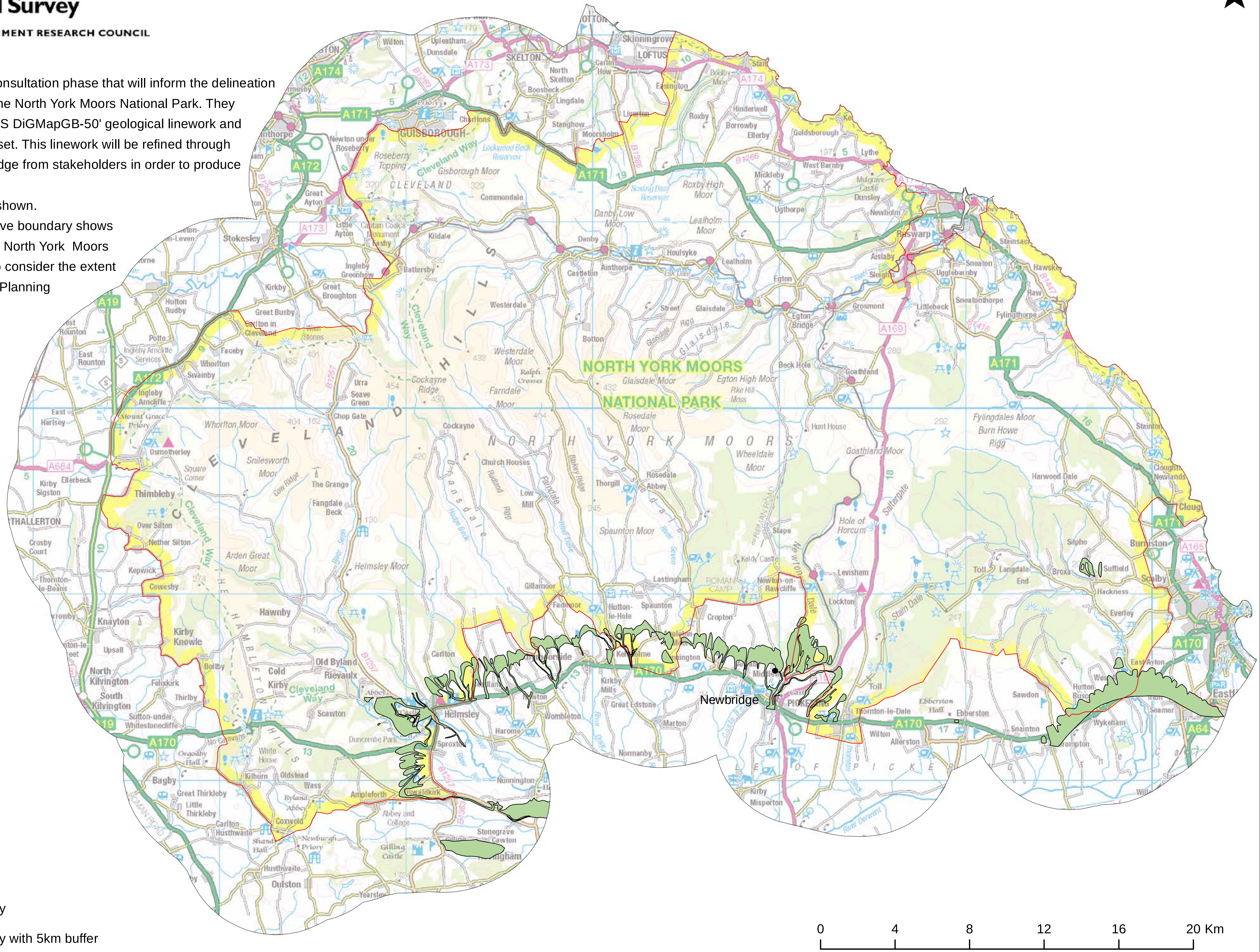
Consultation phase maps

These maps will form part of the consultation phase that will inform the delineation of Mineral Safeguarding Areas in the North York Moors National Park. They show geological units from the 'BGS DiGMapGB-50' geological linework and published Mineral Resources dataset. This linework will be refined through consultation to incorporate knowledge from stakeholders in order to produce Mineral Safeguarding Area Maps.

Active limestone extraction site is shown.

The border around the administrative boundary shows mineral resources 5km beyond the North York Moors National Park boundary, in order to consider the extent of minerals straddling the Mineral Planning Authority boundary.



Active Site

Limestone

North York Moors boundary

North York Moors boundary with 5km buffer

Figure A3: North York Moors National Park: Limestone resources

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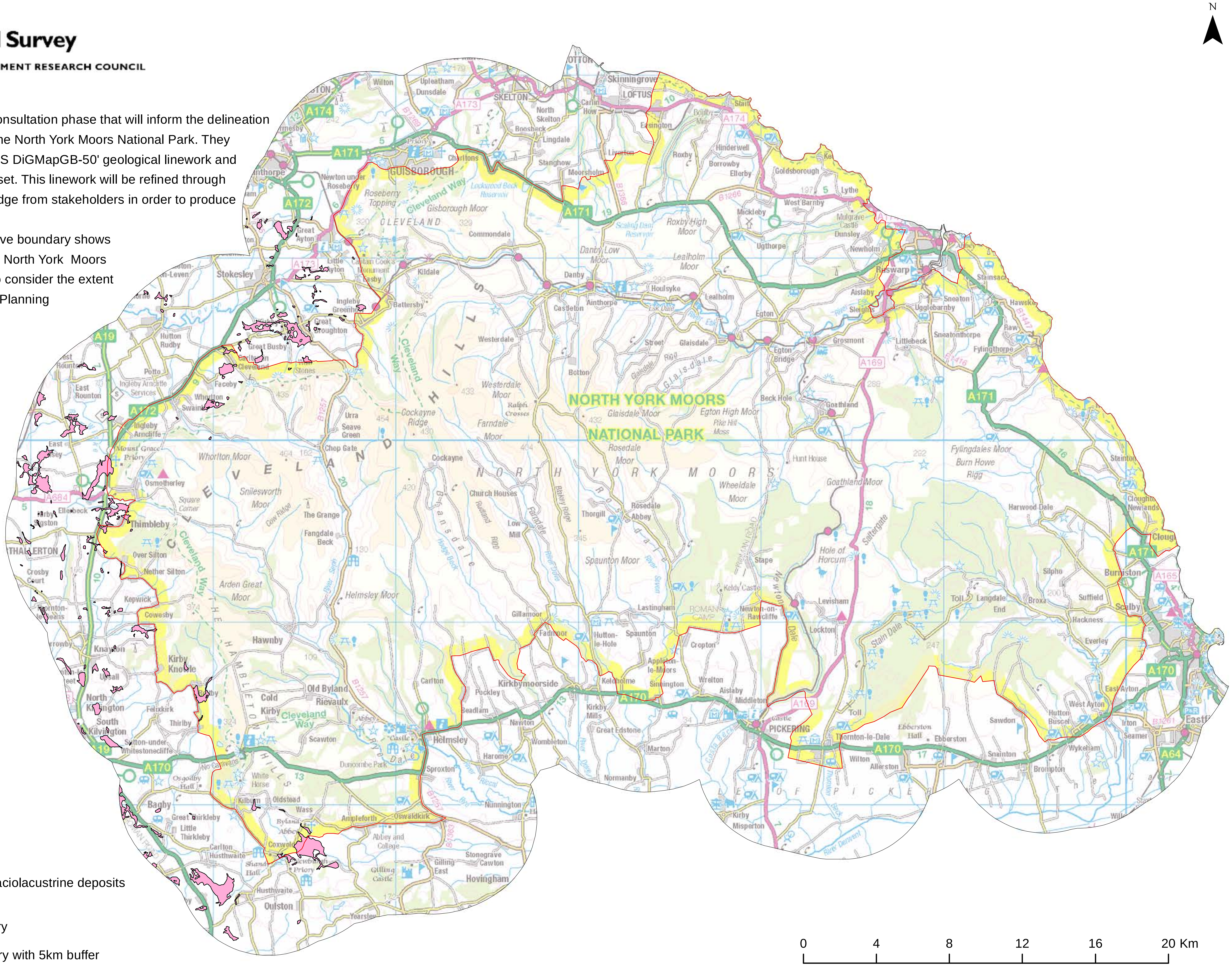
Consultation phase maps

These maps will form part of the consultation phase that will inform the delineation of Mineral Safeguarding Areas in the North York Moors National Park. They show geological units from the 'BGS DiGMapGB-50' geological linework and published Mineral Resources dataset. This linework will be refined through consultation to incorporate knowledge from stakeholders in order to produce Mineral Safeguarding Area Maps.

The border around the administrative boundary shows mineral resources 5km beyond the North York Moors National Park boundary, in order to consider the extent of minerals straddling the Mineral Planning Authority boundary.



Brick clay: Quaternary, glaciolacustrine deposits (clay and silt)

North York Moors boundary

North York Moors Boundary with 5km buffer

Figure A4: North York Moors National Park: Brick Clay resources

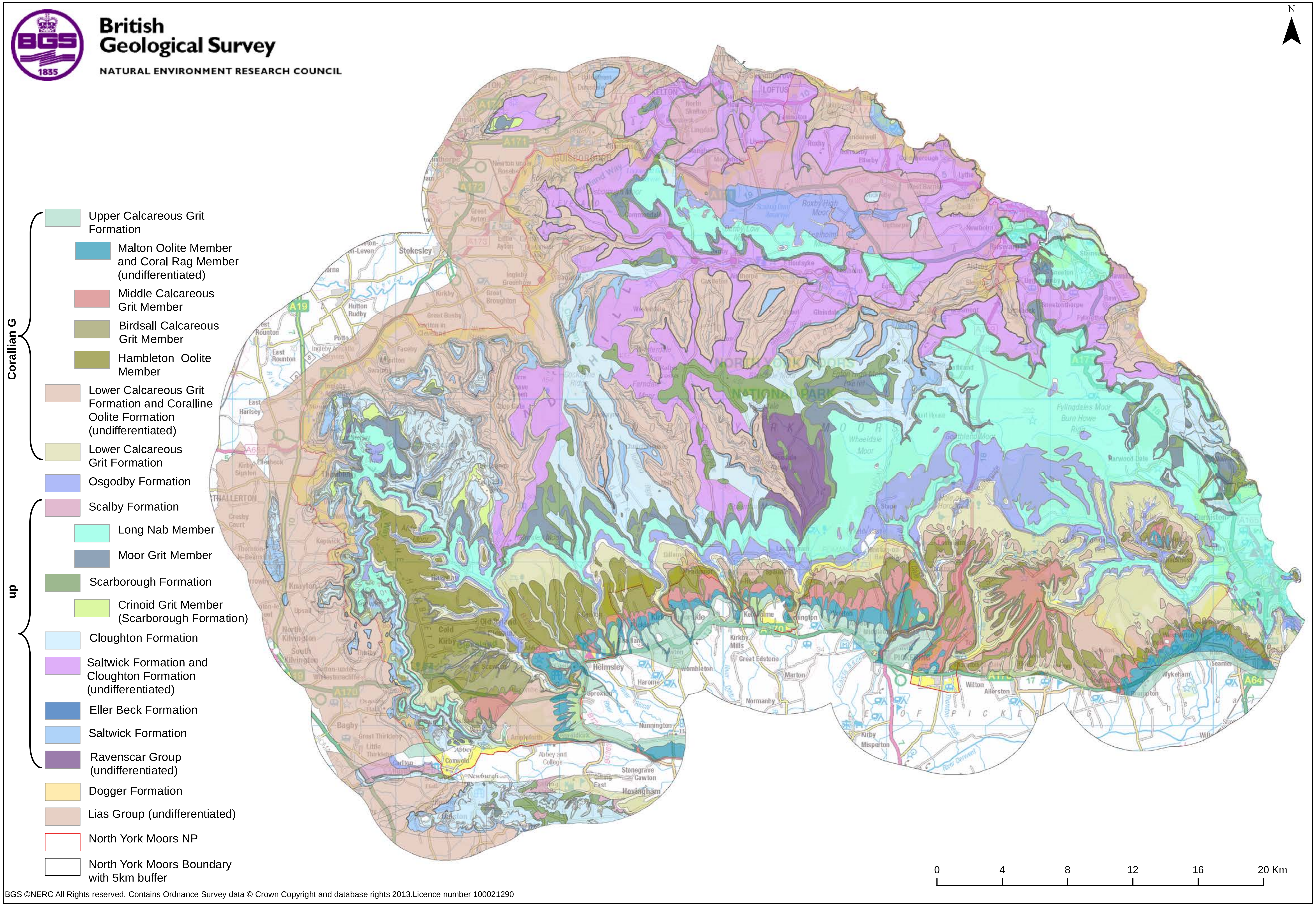


Figure A5a: North York Moors National Park: Building stone bedrock stratigraphy

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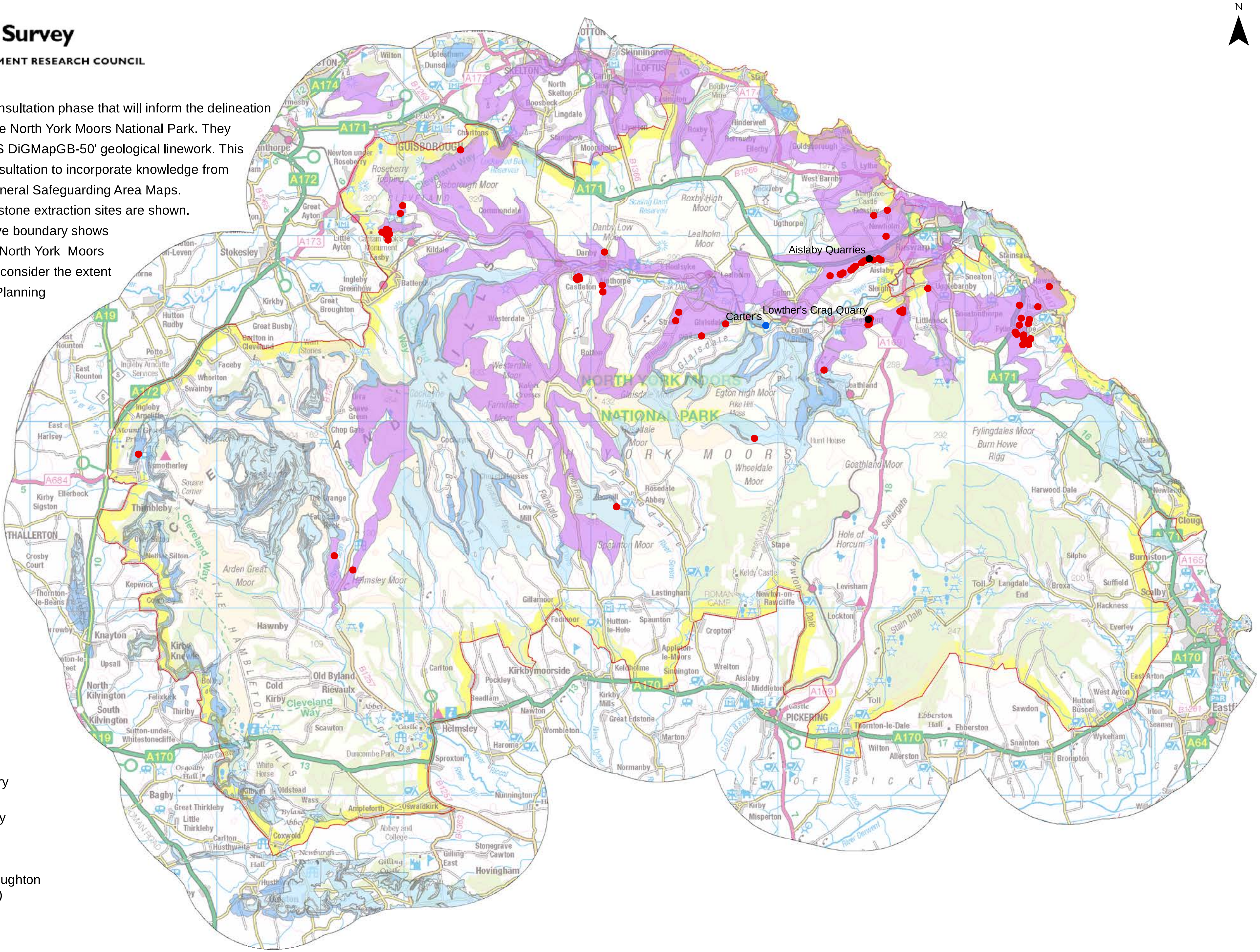

- Active building stone quarry
- Inactive building stone quarry
- Former building stone quarry
- Cloughton Formation
- Saltwick Formation and Cloughton Formation (undifferentiated)
- Saltwick Formation
- North York Moors NP
- North York Moors Boundary with 5km buffer

Figure A5b: North York Moors National Park: Building stones Saltwick and Cloughton formations (Ravenscar Group).

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Former building stone quarry

Moor Grit Member

North York Moors NP

North York Moors Boundary with 5km buffer

0 3.5 7 10.5 14 17.5 Km

Figure A5c: North York Moors National Park: Building stones Moor Grit Member (Scalby Formation, Ravenscar Group).

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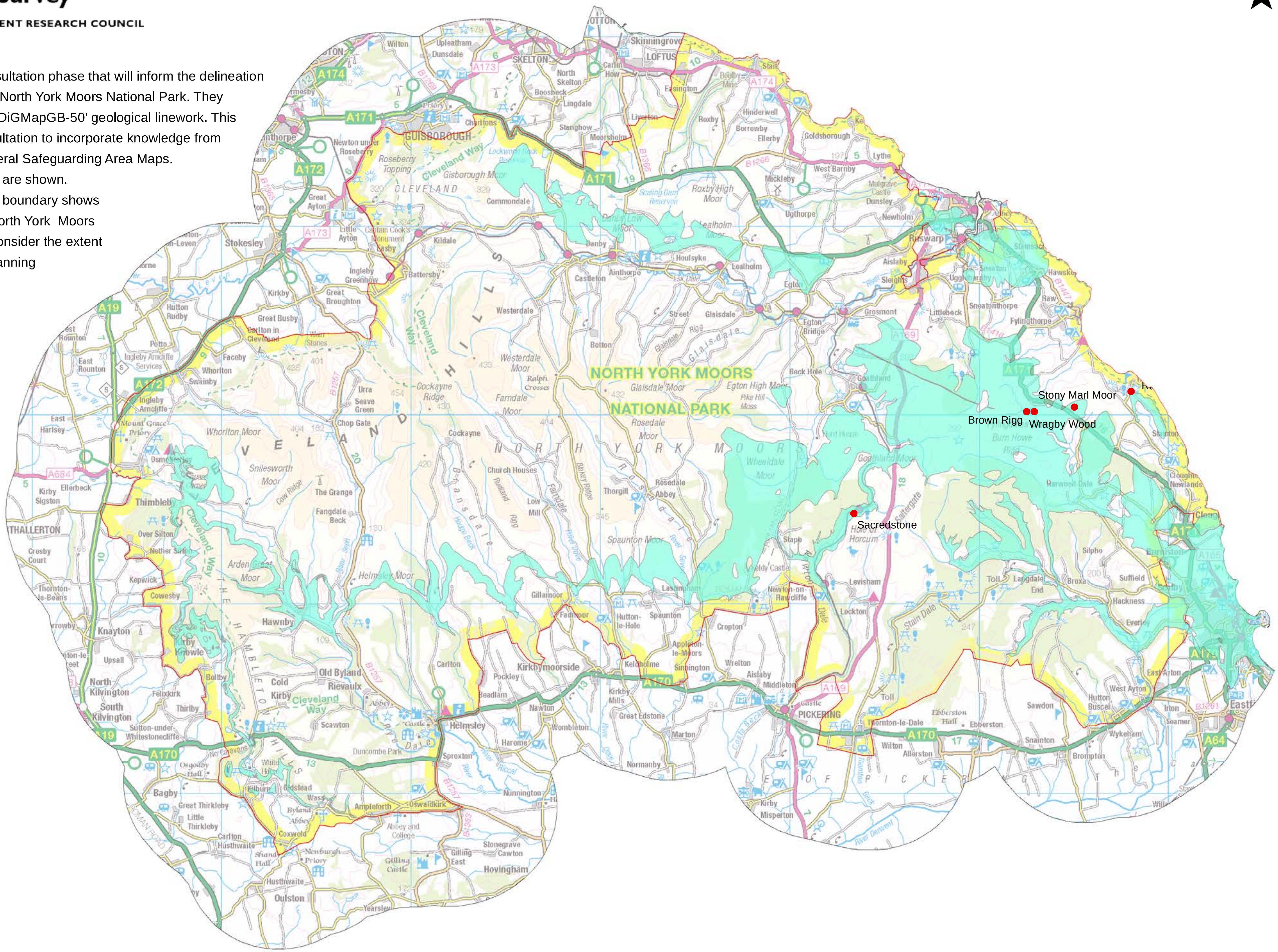

- Former building stone quarry
- Long Nab Member
- North York Moors NP
- North York Moors Boundary with 5km buffer

0 4 8 12 16 20 Km

Figure A5d: North York Moors National Park: Building stones Long Nab Member (Scalby Formation, Ravenscar Group)

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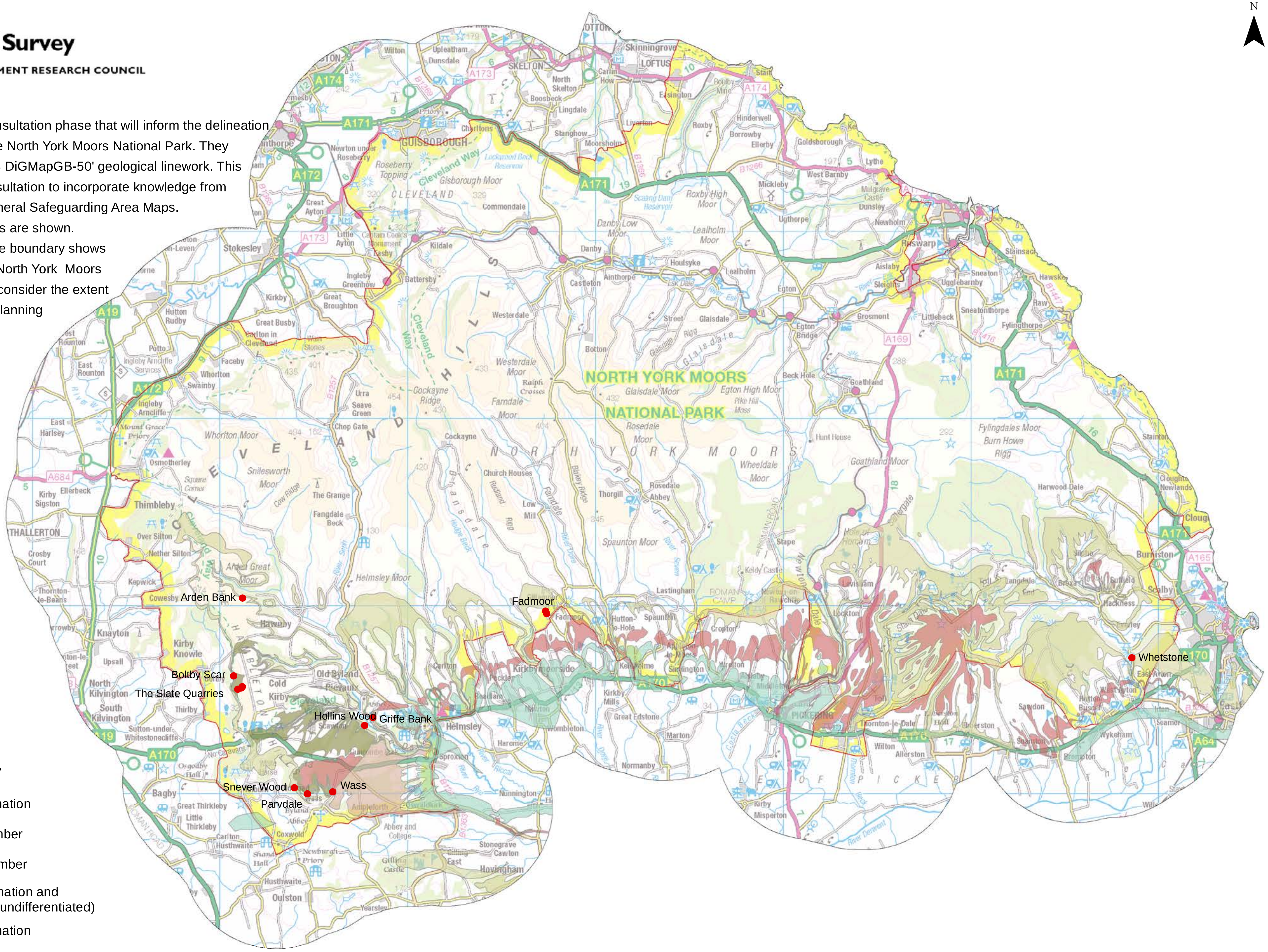

- Former buiding stone quarry
- Upper Calcareous Grit Formation
- Middle Calcareous Grit Member
- Birdsall Calcareous Grit Member
- Lower Calcareous Grit Formation and Coralline Oolite Formation (undifferentiated)
- Lower Calcareous Grit Formation
- North York Moors Boundary with 5km buffer
- North York Moors NP

Figure A5e: North York Moors National Park: Building stones Corallian Group 'Calcareous Grit' units.

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- Former building stone quarry
- Hambleton Oolite Member
- North York Moors NP
- North York Moors Boundary with 5km buffer

Figure A5f: North York Moors National Park: Building stones Hambleton Oolite Member (Coralline Oolite Formation, Corallian Group).

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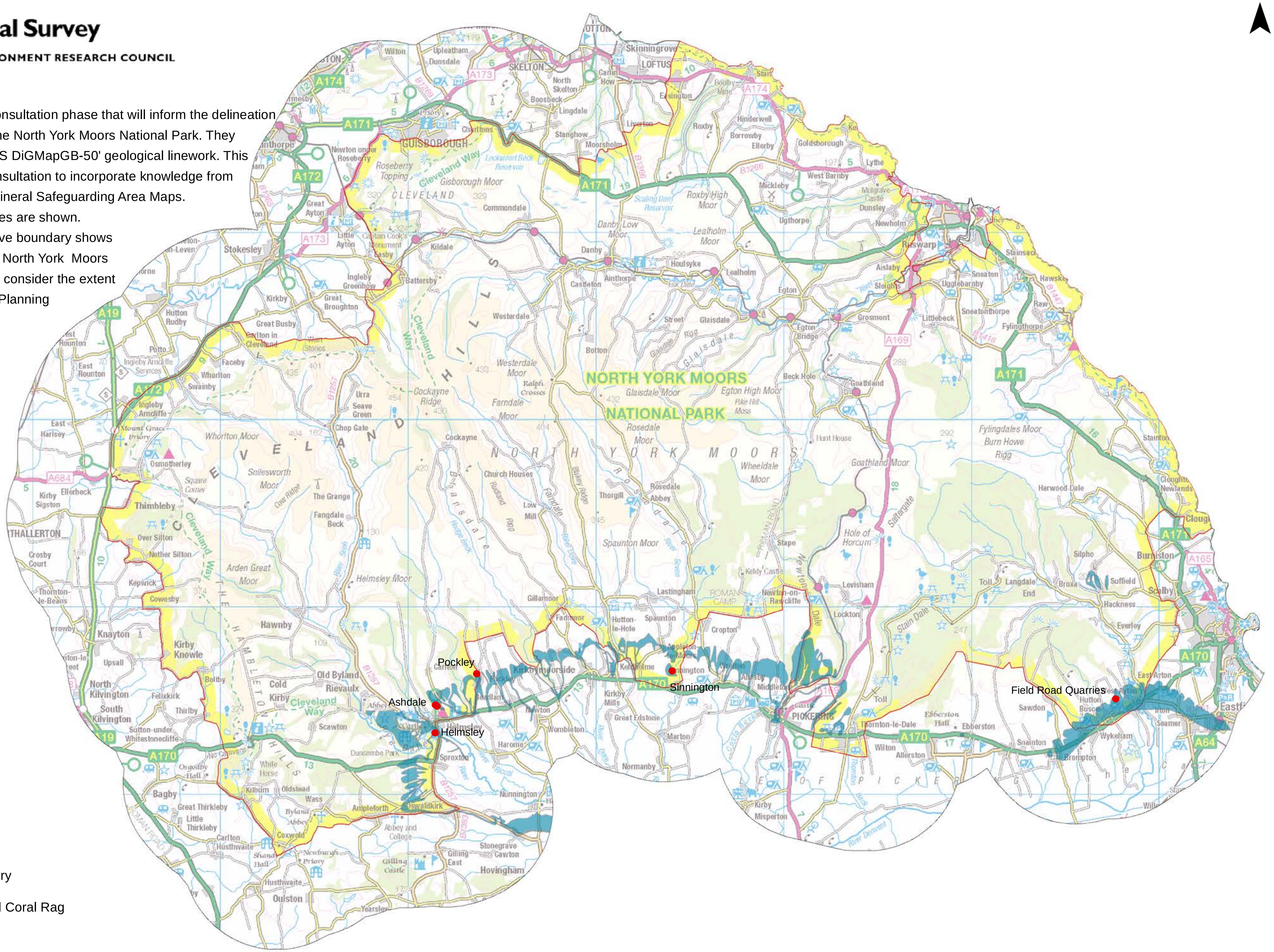

- Former buiding stone quarry
- Malton Oolite Member and Coral Rag Member (undifferentiated)
- North York Moors NP
- North York Moors Boundary with 5km buffer

0 4 8 12 16 20 Km

Figure A5g: North York Moors National Park: Building stones Malton Oolite and Coral Rag members (Coralline Oolite Formation, Corallian Group).

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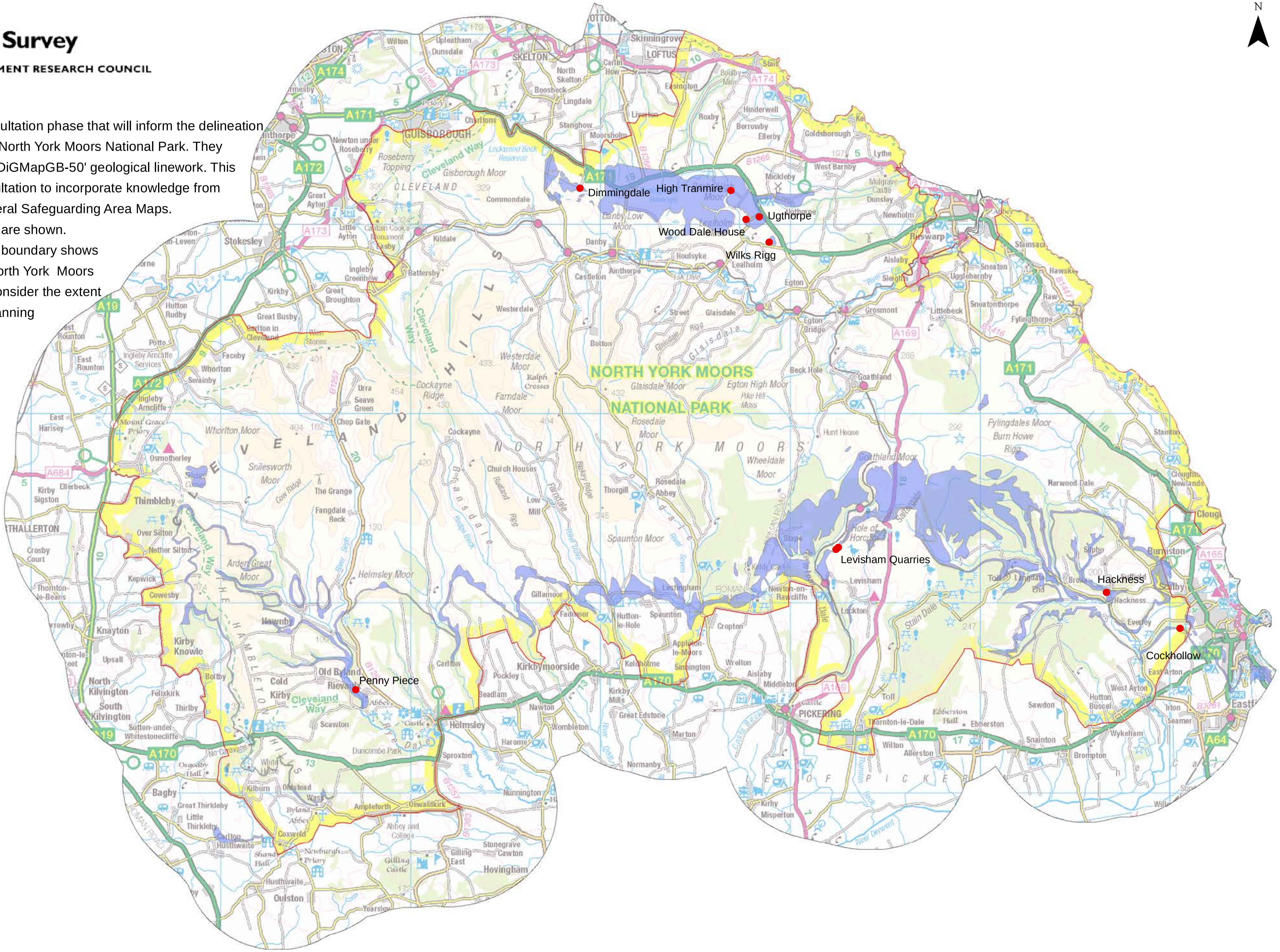

Former building stone quarry
Osgodby Formation
North York Moors NP
North York Moors Boundary with 5km buffer

0 4 8 12 16 20 Km

Figure A5h: North York Moors National Park: Building stones Osgodby Formation.

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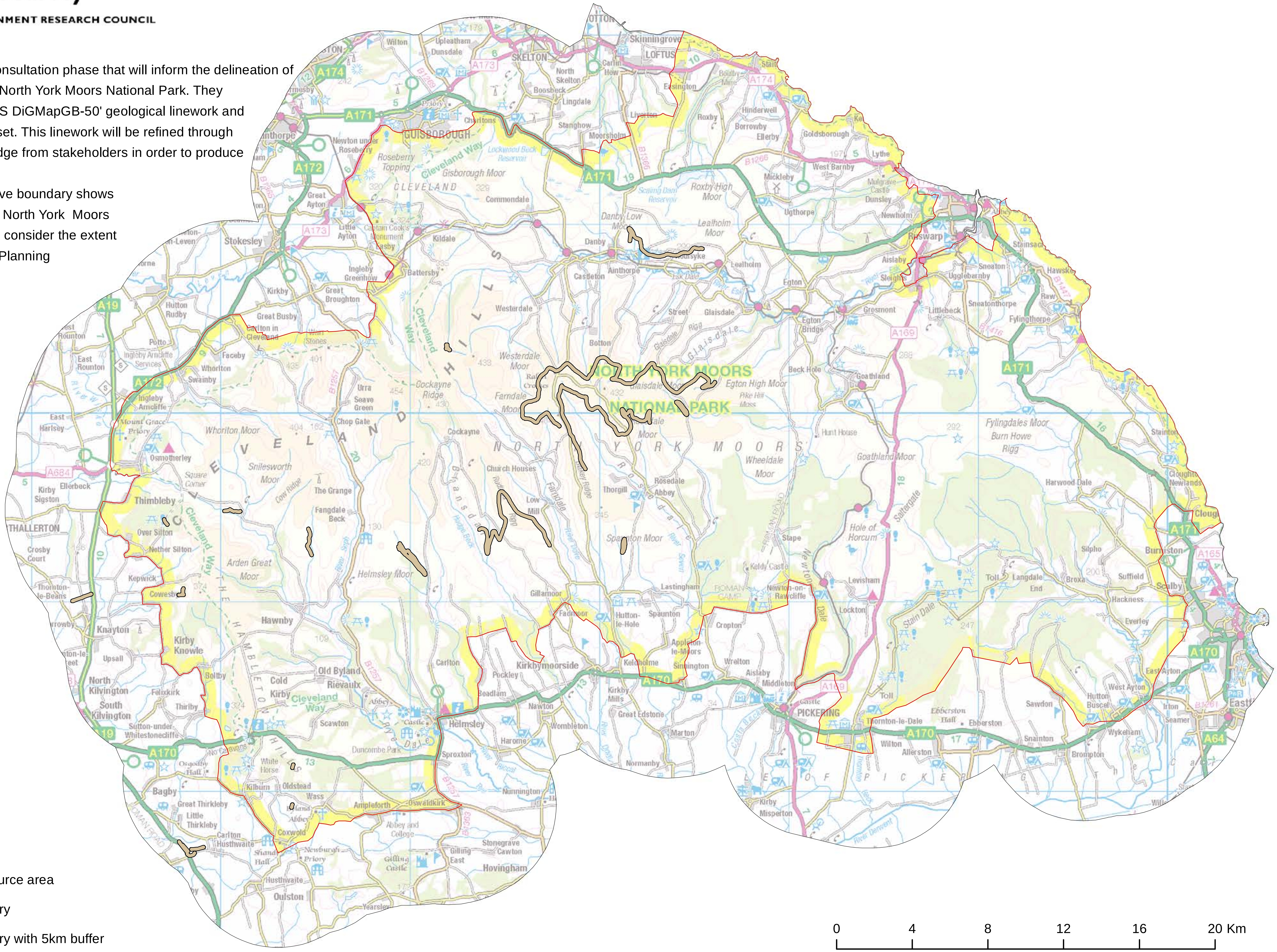

Tertiary shallow coal resource area

North York Moors boundary

North York Moors boundary with 5km buffer

Figure A6: North York Moors National Park: Shallow coal resources

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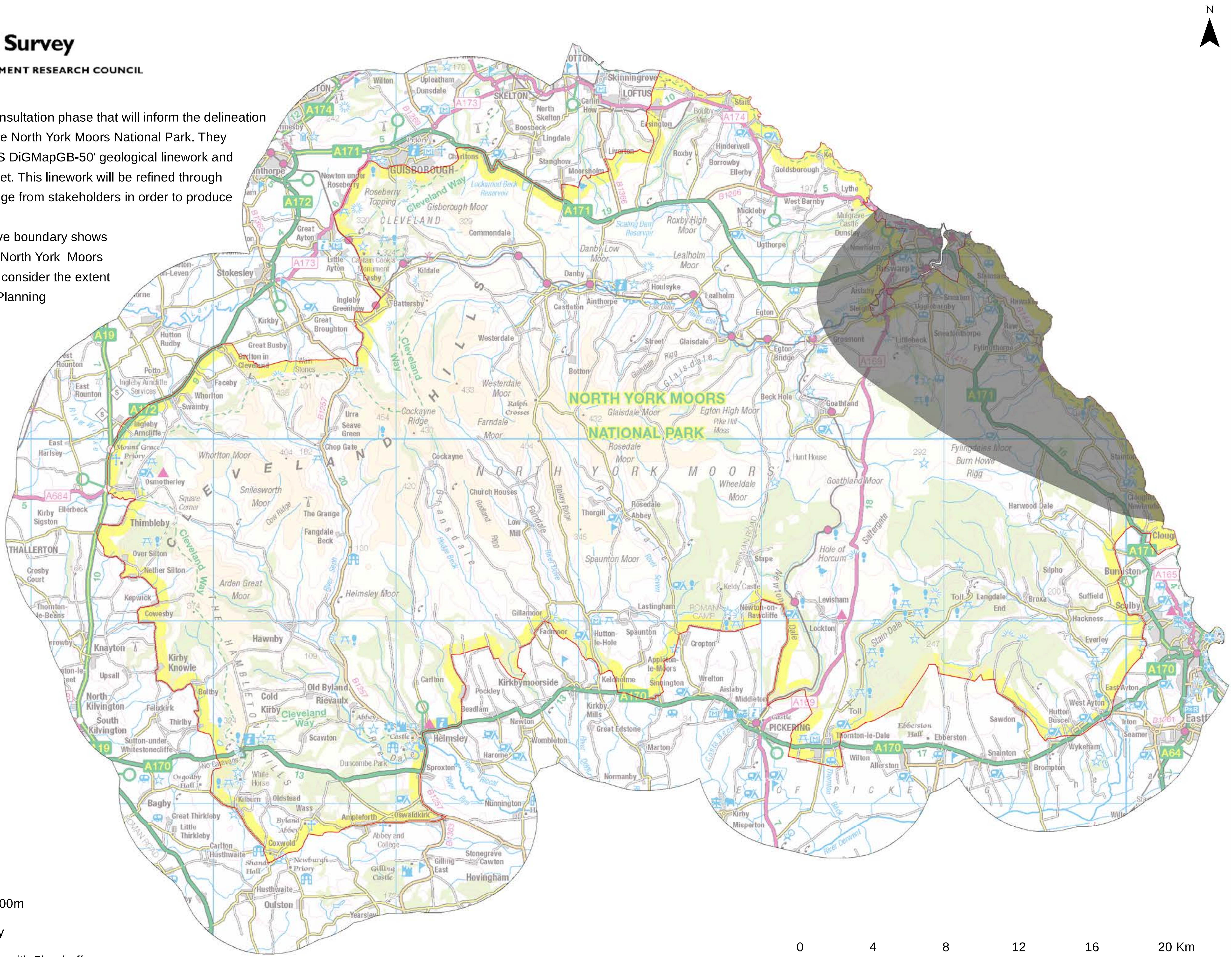

Deep coal at more than 1200m

North York Moors boundary

North York Moors boundary with 5km buffer

Figure A7: North York Moors National Park: Deep coal resources

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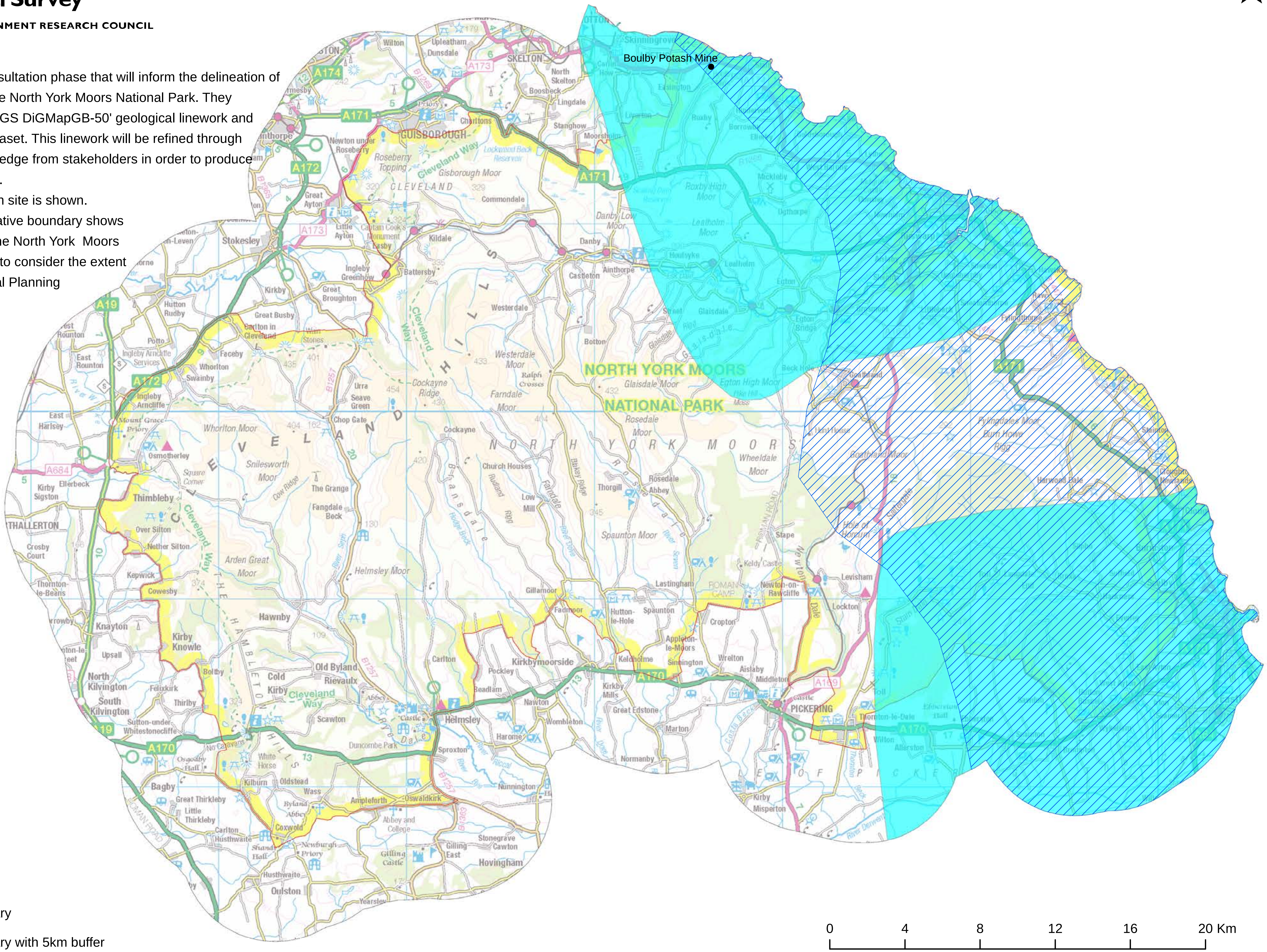
Active sylvinite and salt extraction site is shown.

The border around the administrative boundary shows mineral resources 5km beyond the North York Moors National Park boundary, in order to consider the extent of minerals straddling the Mineral Planning Authority boundary.



- Active Site
- Polyhalite
- Sylvinite and salt
- North York Moors boundary
- North York Moors boundary with 5km buffer

Figure A8: North York Moors National Park: Sylvinite, salt and polyhalite resources

Appendix 2 Geological overview

Overview of Geology

This area is typified by moorland plateaus with expanses of bedrock outcropping in these upland areas, except where there is a capping of peat on the hilltops. In contrast, the bedrock of the deeply incised valleys is commonly concealed beneath superficial deposits that are typically fluvial or glacial in origin.

Bedrock

Bedrock strata at the surface are restricted to the Jurassic, with the youngest Late Jurassic rocks occurring in the south of the park and the oldest Early Jurassic rocks occurring in the north (Figure 2).

The Jurassic rocks of the North York Moors have been formed by both clastic and carbonate sedimentation in a topographic low known as the Cleveland basin. Clastic sediments were sourced from the erosion of rocks from topographic highs to the south east and north west. The style of deposition of these sediments was principally defined by the sea level during the Jurassic, which fluctuated considerably. The oldest rocks in the park are shales, limestones and occasional sandstones of the Lias Group, which is generally exposed in the base of valleys. These sediments were deposited in a marine environment on a large shallow shelf with low topography, the alteration between shales, limestones, muds and sandstones is due to both fluctuations in sea level and differing rates of sediment input into the basin causing cyclical sediment deposition. This sequence contains deposits of jet, alum and ironstone which were extensively mined during the 19^{th} and 20^{th} centuries. These sediments are overlain by sandstones, siltstones and mudstones of the Ravenscar Group, which was deposited in a terrestrial environment during a time of major sea level regression. When the sea level was lowest the area was covered by a major braided river system fed from surrounding upland areas, this formed deposits of coarse-grained, hard sandstone which now form the upland areas of the North York Moors National Park. Sea levels rose once again during the Late Jurassic to deposit the Oxford Clay Formation and Corallian Group, a series of clays and siliclastic rocks forming lowland areas flanking the higher moors. These units pass into the Ancholme Group to the east, a thick succession of marine clays that occur in the far south of the North York Moors National Park.

Beneath the Jurassic rocks there is the Triassic sequence of mudstones and sandstones underlain by the Permian strata which include evaporites including salt, potash and polyhalite. Coal bearing strata are present at considerable depths beneath these.

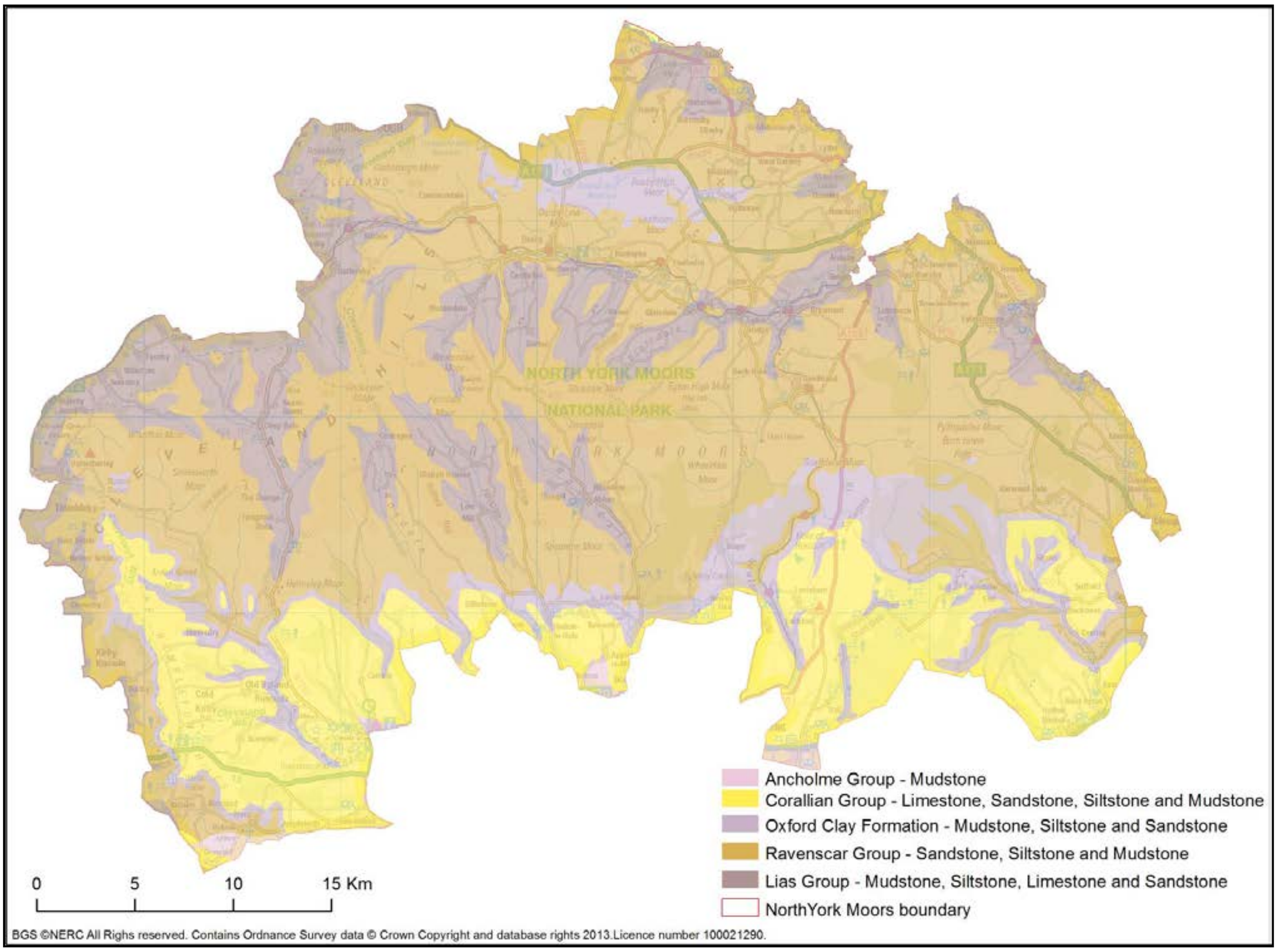


Figure 2: Simplified bedrock geology for North Yorkshire.

Superficial deposits

Superficial deposits in the national park fall into three broad categories: glacial deposits, fluvial deposits and organic deposits. The latter comprises the peat that caps some of the upland areas; it does not contain any sand and gravel and so will not be discussed further in this account. The most extensive areas of superficial deposits are described below and are shown in Figure 3.

Due to the predominantly upland nature of much of the North York Moors National Park and the fact that much of this area was not covered by ice during the last major glaciations superficial deposits are neither prevalent nor thick in this area. Glacial deposits only occur in the low-lying areas and were deposited as the ice from the Vale of York and North Sea encroached on the lower lying flanks of the hills.

During the Devensian glaciations, which reached its zenith about 20,000 years ago, a tongue of ice from the Devensian ice sheet advanced southwards along the Vale of York. Simultaneously, another lobe of the same ice sheet advanced from what is now the North Sea into the eastern end of the Vale of Pickering: its maximum westward limit marked by a terminal moraine. As the ice advanced it overrode remnants of older superficial deposits and its own sand and gravel outwash that was deposited by meltwater issuing from the ice, before reaching a stand-still during which the moraines were formed. In doing so it deposited a thick and widespread layer of till, consisting essentially of stiff, gravelly boulder clay, over the pre-existing landscape.

Sheet-like bodies of sand and gravel deposited in front of an ice-sheet by meltwater are termed 'sandur' (pl. sandar). Sand and gravel deposited near the ice sheet as sandar, in meltwater channels, in contact with the ice sheet as eskers or within moraines are known collectively as glaciofluvial deposits. These types of deposits are most common in the north of the area, between Guisborough and Whitby and in the valley of the River Esk. The build up of large moraines caused water to pond in large glacial lakes extending north from the Vale of York, which extended into the east of the North York Moors National park on the edge of the Hambleton Hills. Fine sediment was deposited in these lakes to form sequences of fine sands clays and silts, these sediments are known as glaciolacustrine deposits.

Fluvial deposits are not extensive in the North York Moors National Park due to the absence of major river systems in this predominantly upland area. The largest fluvial deposits can be found in the catchments of the Rivers Esk and Derwent. In the middle and lower reaches of rivers floodplain deposits typically comprise silt and clay, sometimes with thin basal gravel. Alluvium may overlie part of the lowest (youngest) river terrace deposits. River terrace deposits, comprise mainly sand and gravel, typically as a low 'staircase' of elongate tabular bodies that represent remnants of sand and gravel floodplain deposits left behind as fast-flowing rivers cut down to successively lower levels in response to uplift and climate change during Pleistocene times.

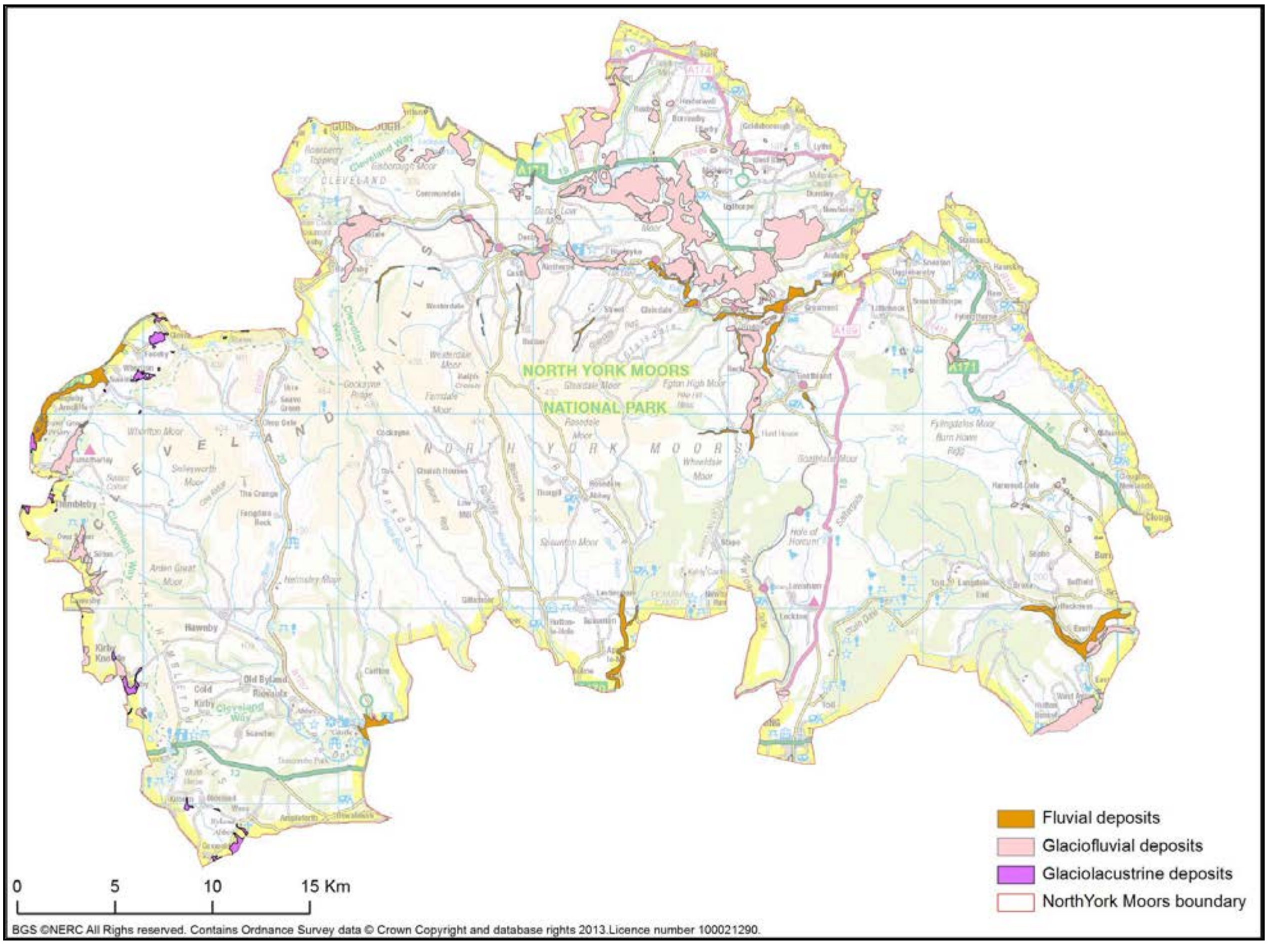


Figure 3: Superficial deposits in the North York Moors National Park.

Appendix 3 Economic minerals – decisions on safeguarding

	Safeguard?	Justification if not safeguarded
Sand and Gravel	Y	
Limestone (crushed rock aggregate and industrial)	Y	
Sandstone (crushed rock aggregate)	N	There are no resources of this type present.
Igneous rock (crushed rock aggregate)	N	There are no resources of this type present.
Chalk	N	There are no resources of this type present.
Silica sand	N	There are no resources of this type present.
Brick clay	Y	
Building stone	Y	
Shallow coal (within 50m of the surface)	Y	
Deep coal	Y (sensitive developments only)	
Potash /polyhalite/ salt	Y (sensitive developments only)	
Gypsum / anhydrite	N	Extraction of anhydrite has taken place north of the NYMNPA, but resources only occur at depth and only anhydrite is likely to be present within the NYMNPA. Consultation may reveal further information.
Hydrocarbons (conventional oil and gas, abandoned mine methane, coal mine methane	N	The location of surface infrastructure to access these resources is to some degree flexible, so the resources are not as susceptible to the risks posed by sterilisation by other non-mineral development. Underground Coal Gasification may cause subsidence at surface, but there are currently no operations of this type in

potential)		the UK onshore[5]. The extent of the burn area is unpredictable so boundaries would be hard to define[6].
Shale hydrocarbons	N	This is an emerging technology that takes place deep underground. The surface impacts associated with hydraulic fracturing of the shales are felt by few people and structural damage at the surface is unlikely[7]. The location of surface infrastructure to access these resources is to some degree flexible, so the resources are not as susceptible to the risks posed by sterilisation by other non-mineral development.

[5] http://coal.decc.gov.uk/en/coal/cms/publications/mining/gasification/gasification.aspx; http://www.bbc.co.uk/news/uk-wales-16567883

[6] Wrighton, C E and Bide, T P. 2011. *Mineral Safeguarding Areas for North Yorkshire County Council*. British Geological Survey Commissioned Report, CR/11/132. 48pp.

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