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Mineral Resource Information in Support of National, Regional and Local Planning: South Yorkshire (comprising Metropolitan Boroughs of Barnsley, Doncaster and Rotherham and City of Sheffield)

Commissioned Report CR/04/173N

BRITISH GEOLOGICAL SURVEY

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Mineral Resource Information in Support of National, Regional and Local Planning: South Yorkshire (comprising Metropolitan Boroughs of Barnsley, Doncaster and Rotherham and City of Sheffield).

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This report accompanies the 1:100 000 scale map: South Yorkshire (comprising Metropolitan Boroughs of Barnsley, Doncaster and Rotherham and City of Sheffield).

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Front cover

Finningley Quarry, near Finningley, Doncaster.

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1 Introduction

This report is one of a series prepared by the British Geological Survey for various administrative areas in England for the Office of the Deputy Prime Minister's research project *Mineral Resource Information in Support of National, Regional and Local Planning.*

The accompanying map relates to South Yorkshire comprising the Metropolitan Boroughs of Barnsley, Doncaster and Rotherham and the City of Sheffield, and delineates the mineral resources of current, or potential, economic interest in the area and the sites where minerals are or have been worked. It also relates these to national planning designations, which may represent constraints on the extraction of minerals.

Three major elements of information are presented:

- the geological distribution and importance of mineral resources;
- the extent of mineral planning permissions and the location of current mineral workings; and
- the extent of selected, nationally-designated planning constraints.

This wide range of information, much of which is scattered and not always available in a consistent and convenient form, is presented on a digitally-generated summary map on the scale of 1:100 000. This scale is convenient for the overall display of the data and allows for a legible topographic base on which to depict the information. However, all the data are held digitally at larger scales using a Geographical Information System (GIS), which allows easy revision, updating and customisation of the information together with its possible integration with other datasets. The information will form part of a *Summary of the Mineral Resources of the Yorkshire and the Humber Region*.

The purpose of the work is to assist all interested parties involved in the preparation and review of development plans, both in relation to the extraction of minerals and the protection of mineral resources from sterilisation. It provides a knowledge base, in a consistent format, on the nature and extent of mineral resources and the environmental constraints, which may affect their extraction. An important objective is to provide baseline data for the long term. The results may also provide a starting point for discussions on specific planning proposals for mineral extraction or on proposals, which may sterilise resources.

It is anticipated that the map and report will also provide valuable background data for a much wider audience, including the different sectors of the minerals industry, other agencies and authorities (e.g. The Planning Inspectorate Agency, the Environment Agency, the Countryside Agency and English Nature), environmental interests and the general public.

Basic mineral resource information is essential to support mineral exploration and development activities, for resource management and land-use planning, and to establish baseline data for environmental impact studies and environmental

guidelines. It also enables a more sustainable pattern and standard of development to be achieved by valuing mineral resources as national assets.

The mineral resources covered are sand and gravel, crushed rock aggregate, brick clay, building stone, industrial dolomite, peat, coal and hydrocarbons.

1.1 Resources and Reserves

Mineral resources are natural concentrations of minerals or bodies of rock (or fluids such as oil and gas) that are, or may become, of potential interest as a basis for the economic extraction of a mineral product. They exhibit physical and/or chemical properties that make them suitable for specific uses and are present in sufficient quantity to be of intrinsic economic interest. Areas that are of potential economic interest as sources of minerals change with time as markets decline or expand, product specifications change, recovery technology is improved or more competitive sources become available.

That part of a mineral resource, which has been fully evaluated and is commercially viable to work is called a mineral reserve. In the context of land-use planning, the term mineral reserve should strictly be further limited to those minerals for which a valid planning permission for extraction exists (i.e. permitted reserves). Without a valid planning consent no mineral working can take place and consequently the inherent economic value of the mineral resource cannot be released and resulting wealth created. The ultimate fate of mineral reserves is to be either physically worked out or to be made non-viable by changing economic circumstances.

Mineral resources defined on the map delineate areas within which potentially workable mineral may occur. These areas are not of uniform potential and also take no account of planning constraints that may limit their working. The economic potential of individual sites can only be proved by a detailed evaluation programme. Such an investigation is also an essential precursor to submitting a planning application for mineral working. Extensive areas are shown as having no mineral resource potential, but some isolated mineral workings may occur in these areas. The presence of these operations generally reflects local or specific situations.

1.2 Environmental Designations

The map shows the extent of selected, nationally-designated planning constraints as defined for the purposes of this study. These are defined on a common national basis and therefore represent a consistent degree of constraint across the country. No interpretation should be made from the map with regard to the relative importance of the constraints, either in relation to mineral development proposals or in relation to each other. Users should consult policy guidelines issued by the relevant Government department, statutory agency or local authority.

The constraints shown on the map are:

- Part of the Peak District National Park;
- National nature conservation designations – National Nature Reserves (NNR) and Sites of Special Scientific Interest (SSSI);

- International nature designations – Special Areas of Conservation (SAC), Special Protection Areas (SPA) and Ramsar sites; and
- Scheduled Monuments.

Mineral development may also be constrained by many other factors not shown on the map, including local landscape designations, considerations relating to the protection of other resources, such as groundwater, and local amenity or environmental concerns, such as noise, traffic and visual impact. These have been excluded because the constraint is not defined on a national basis or the information is not generally available. The extent or degree of relevance of such constraints can be ascertained from the relevant statutory agency or the appropriate Mineral Planning Authority.

2 Sand and gravel

Sand and gravel are defined on the basis of particle size rather than composition. In current commercial practice, following the introduction of new European standards from 1st January 2004, the term 'gravel' (or more correctly coarse aggregate) is used for general and concrete applications to define particles between 4 and 80 mm, and the term 'sand' for material that is finer than 4 mm, but coarser than 0.063 mm. For use in asphalt 2 mm is now the break point between coarse and fine aggregate. Most commercial sand and gravel is composed of particles that are rich in silica (quartz, quartzite and flint), but other rock types may occur locally.

Between 1997 and 2004 annual production of sand and gravel in South Yorkshire (comprising Metropolitan Boroughs of Barnsley, Doncaster and Rotherham and City of Sheffield) has varied between 529,000 and 1,045,000 tonnes and permitted reserves were estimated at about 13.2 million tonnes at December 2003.

Sand and gravel resources occur in a variety of geological environments. In South Yorkshire these resources occur mainly within superficial deposits, subdivided into river sand and gravel, glaciofluvial sand and gravel, glaciolacustrine sand and gravel and blown sand with additional resources of bedrock sand and gravel.

2.1 Superficial Deposits

Parts of the areas assessed for sand and gravel by BGS resource surveys are identified on the map. Resources shown here are taken from these maps where available. In these areas, the possible extent of sand and gravel concealed beneath other material is shown. These indicated resources were defined by overburden to mineral ratios. Outside these areas, available data are more limited. Generally, only exposed sand and gravel is defined, although sub-alluvial inferred resources of sand and gravel occurring beneath modern river flood plains may be extensive in some places. Narrow (< 200 m) spreads of sub-alluvial deposits are mainly excluded from the map. Their limited width is likely to preclude economic working of any sand and gravel present.

2.1.1 River sand and gravel (Terrace and sub-alluvial deposits)

Resources occur in both raised river terrace sequences flanking the modern floodplains and in floodplain terrace deposits associated with, and underlying, present day alluvium. This sequence of deposits is best developed along the River Don with a

succession of deposits formed, representing accumulations of sand and gravel in response to falling sea level in Pleistocene times. In the southwest, localised terrace deposits occur in the upper reaches of the Don between Sheffield and Rotherham but are predominantly sterilised by urban development. More extensive terrace deposits occur around Bentley at up to 12 m above OD. These deposits consist of sand, some of which is coarse-grained, thin beds of fine gravel in which most of the pebbles are of Carboniferous rocks, and thin clay beds. Coal particles are present in the sand fraction. The deposits pass laterally into glaciolacustrine silt and clay deposits.

East of Doncaster, fluvial deposits of sand and gravel form extensive flattish spreads, commonly referred to as Older River Gravels. These deposits consist of beds, lenses and layers of both pebble-free sand and well-sorted fine to medium gravel with a sand matrix. There is a wide variation in the composition of the sand and gravel, as shown in Figure 2. Variations in composition of the gravel fraction show that the more northerly deposits, around Dunsville and Holme Wood, were derived from the west, presumably via the Don, with the predominant composition of the pebbles being Carboniferous sandstone. In areas rich in Carboniferous-derived materials, coal detritus, usually in the form of coarse sand-sized particles can comprise up to 1 per cent of the deposit.

Figure 1. Finningley Quarry showing layers of both pebble-free sand and well-sorted fine to medium gravel in the working face.

The more southerly deposits (Figure 2) were derived from farther south, via the River Idle and to a lesser extent the Torne. The predominant composition of the pebbles in these deposits is Triassic quartzite. Near Misson and Finningley, the deposits have an average grading of about 28 per cent gravel, 59 per cent sand and 13 per cent fines. The pebbles are typically subrounded and comprise about 50 per cent quartzite, 25 per

cent quartz and 15 per cent sandstone, with minor amounts of limestone, mudstone, chert and igneous rock. Thin clay seams are present in the deposits but coal fragments are generally absent. The Older River Gravels are worked at several sites in the Doncaster district, primarily in the Finningley area and to the northeast of Doncaster for example, at Dunsville Quarry. At both Finningley and Austerfield Quarries, Older River Gravels, the original focus of extraction, have now been depleted. Current extraction at Finningley is from adjacent glaciofluvial deposits while extraction at Austerfield is now from the underlying Sherwood Sandstone Group.

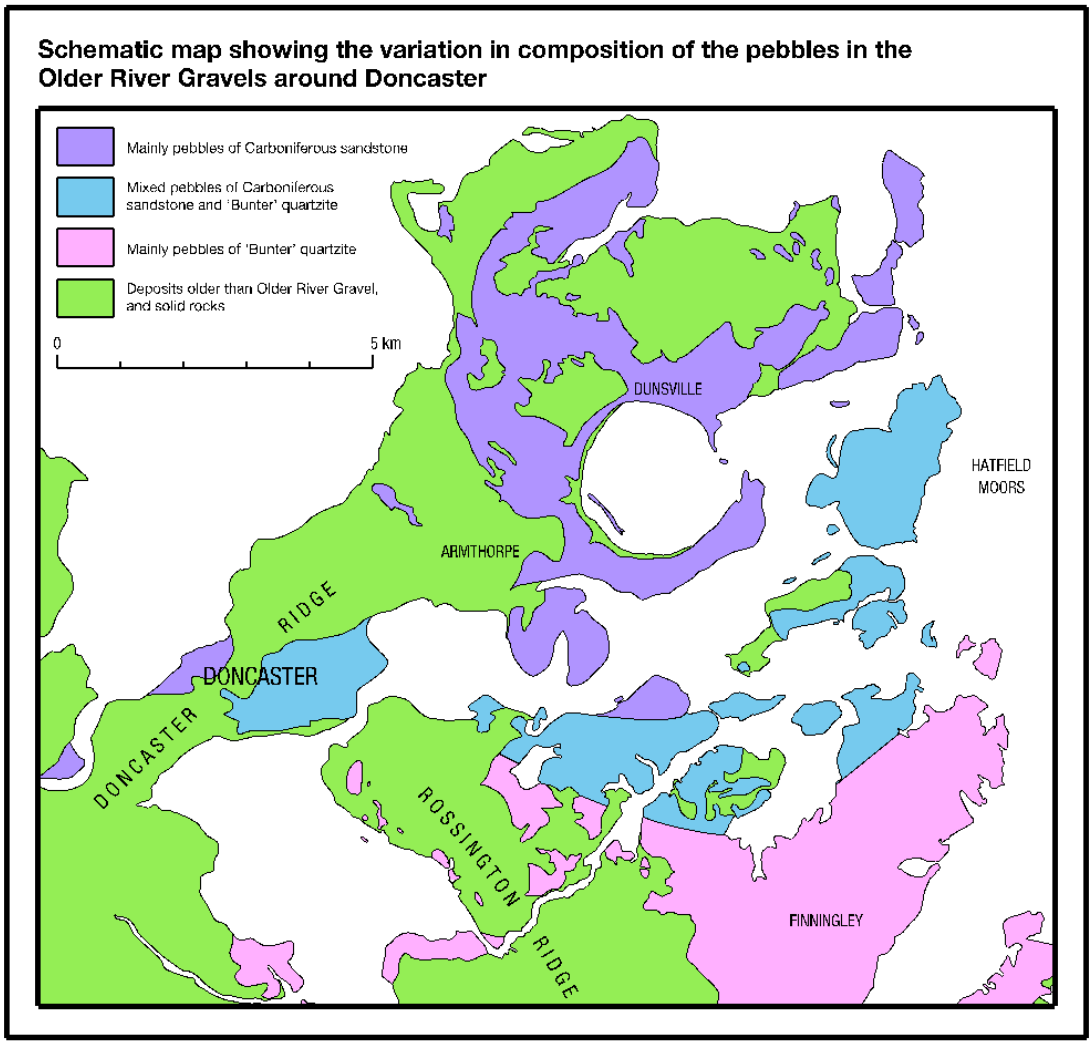

Figure 2. Schematic map showing the variation in composition of the pebbles in the Older River Gravels around Doncaster.

Source: Geology of the country around Goole, Doncaster and the Isle of Axholme. Memoir of the British Geological Survey. 1994. Sheets 79 and 88.

Sub-alluvial gravels are encountered beneath the alluvium of the major valleys throughout the region. The extent of alluvium in this region has been modified in places by land management practices, including the construction of drainage channels and the deposition of Warp (silt and clay) during periods of artificially controlled flooding. The deposits are compositionally similar to the river terrace deposits, indeed some are their downstream equivalents where they pass below OD. They were mainly laid down during periods of deep downcutting during the ultimate, Devensian cold

phase when sea-levels fell to at least -100 m OD. The subsequent rise in sea level enabled silting up of these river channels producing thick overlying alluvial deposits (silty clays, peat). The deposits rest on an irregular channelled surface and are thus of very variable thickness. These deposits are always saturated and require wet working.

2.1.2 Glaciofluvial deposits

These are deposits mapped as the products of deposition by glacial meltwaters and are nowadays commonly labelled on BGS maps as glaciofluvial deposits, a more accurate description of their origin. The sequence of these deposits is complex with mappable units commonly exhibiting intricate relationships. Bodies of sand and gravel may occur as sheet-like layers or ridges on top of the sheet of till (boulder clay) or as elongate, irregular lenses within the till sequence. Areas of wholly concealed, and thus unknown, bodies of sand and gravel may occur under spreads of till and other drift deposits.

Glaciofluvial deposits occur in the east of the county, where they form elongate ridges and mounds capping the Doncaster and Rossington ridges and adjacent hills. These deposits have been described in detail in Mineral Assessment Reports Nos. 37 and 92 of the British Geological Survey and are shown on the map. The deposits comprise beds, lenses and layers of both pebble-free sand, and gravel with a sand matrix. They are fairly well sorted, though a few cobbles and small boulders are present. The deposits rest mainly on Sherwood Sandstone and transgress locally over clay, till and glacial channel deposits.

The glaciofluvial deposits near Rossington have an average grading of 24 per cent gravel, 65 per cent sand and 11 per cent fines, although the deposits vary laterally and vertically from pebble-free sand to sandy gravel. The pebbles are typically subrounded and comprise about 60 per cent quartzite, 20 per cent quartz and 15 per cent sandstone, with minor amounts of limestone, chert and igneous rock. The Rossington Ridge deposits are thought to be derived from the Sherwood Sandstone Group in Nottinghamshire and the northern Midlands. These deposits are worked at Finningley Quarry. The deposit contains around 6 per cent silt and clay, with an equal ratio of sand to gravel. The deposit is variable with pockets of silty material which are thought to represent small lake features. The pebbles in the gravel fraction comprise predominantly vein quartz and quartzite.

The more northerly Doncaster Ridge deposits differ in composition in their absence of pebbles of limestone, chert, and igneous rock. These deposits, almost exclusively covered by urban development, were derived from the Coal Measures to the west.

2.1.3 Glaciolacustrine deposits

During the Devensian glaciation, ice occupying the present coastal zone farther east blocked the eastward-draining valleys including the Humber Gap between Brough and Winterton and thus impounded ‘Lake Humber’ in the southern part of the Vale of York. Deposits associated with this glacial lake, termed glaciolacustrine deposits, occur in the easternmost part of South Yorkshire. These deposits occupy a wide irregular channel incised into Older River Gravels (see River sand and gravel) and Sherwood Sandstone, running from Doncaster Racecourse northeastwards towards Hatfield Woodhouse. They are present in the West Moor depression, in other low-lying localities towards the east (where they pass under the peat on Hatfield Moors)

and under the alluvium of the River Don in the northwest. These deposits are predominantly bedded fine-grained sands and laminated clays up to 5 m in thickness. They have a mean grading of 17 per cent fines and 83 per cent sand, although beds with low fines content are locally present. The sand fraction is predominantly fine-grained quartz; up to 35 per cent of medium-grained sand has been recorded but coarse-grained sand nowhere accounts for more than 1 per cent of these deposits.

2.1.4 Blown sand

These deposits are generally composed of fine- to medium-grained sand with a mean fines (<0.063 mm) content of around 8 per cent. The sand comprises sub-rounded to well-rounded quartz grains. These deposits are believed to be largely of late Quaternary age resulting from aeolian reworking of fluvial and glaciofluvial sands, particularly those associated with the Vale of York superficial deposits.

Blown sand deposits occur in the east of the county and are largely concealed beneath peat and alluvium. The most extensive blown sand deposits crop out on the flanks of Thorne Moor, Hatfield Moor and south of Finningley. Extensive deposits of sand, that rest in turn on glaciolacustrine silt and clay, also extend under the peat and alluvium of Thorne Moor and adjacent areas. This concealed sand varies from 0 to 3 m in thickness, with appreciable variations across short distances due to its undulating top. Blown sand is not worked in the area.

2.2 Bedrock Sand and Gravel

The sandstones and conglomerates of the Triassic, Sherwood Sandstone Group, in particular the Nottingham Castle Sandstone, has been worked at several sites in South Yorkshire, mainly as a minor component worked in the floor of sites working overlying superficial sand and gravel deposits. This material is mainly friable, loosely consolidated and easily worked. It is largely composed of a fine "clayey" sand with generally <2 per cent gravel and is generally more suitable for building sand and asphalting than the 'sharper' alluvial sands which are used for concreting. Where more gravel is present or conglomeratic horizons occur, the clasts are mainly rounded and sub-rounded quartz and quartzite pebbles with subordinate Carboniferous sandstone fragments. The Sherwood Sandstone Group is currently worked at Austerfield Quarry. The sand, which is dry screened, is predominantly used for mortar sand and asphalt sand and to a lesser extent for fill and pipe bedding sand.

3 Crushed rock aggregates

A variety of hard rocks are, when crushed, suitable for use as aggregates. Their technical suitability for different applications depends on their physical characteristics, such as crushing strength and resistance to impact and abrasion. Higher quality aggregates are required for coating with bitumen for road surfacing, or for mixing with cement to produce concrete. For applications such as constructional fill and drainage media, with less demanding specifications, lower quality materials are acceptable.

The only significant source of crushed rock aggregate in South Yorkshire is dolomite.

3.1 Dolomite

Dolomites (and subordinate limestones) of Permian age occupy a narrow outcrop of easterly dipping strata from north of Doncaster to Worksop. These Permian rocks – commonly known as the Magnesian Limestone – are highly variable lithologically and in their rock properties. They are relatively soft, with high porosity and are frequently too weak and friable to make high quality aggregate. Nevertheless, they are extensively quarried for low-grade applications, such as sub-base roadstone and fill, but some of the rocks are sufficiently sound, strong and durable to be used as concreting aggregate or coated roadstone. About 2.5 million tonnes of dolomite was produced as crushed rock aggregate in 2004 (Figure 3).

In South Yorkshire, the Permian sequence is made up of two carbonate rock units, separated by about 20 m of calcareous mudstone. The carbonate units are known as the Cadeby Formation (formerly Lower Magnesian Limestone) and the Brotherton Formation (formerly Upper Magnesian Limestone). The Cadeby Formation is around 50 m in thickness and consists of a varied sequence of dolomites and limestones. The Brotherton Formation is less than 20 m in thickness and is fairly homogeneous, consisting mostly of hard flaggy limestones and dolomites.

3.2 Sandstone

Most sandstone is too weak and porous to make good quality aggregate for roadstone and concrete, but may be suitable for fill or for the production of manufactured sand to produce reconstituted stone products.

Sandstones form substantial parts of the Upper Carboniferous sequence in South Yorkshire where they are interbedded with mudstones and coals. Where thick beds of sandstone are developed they have been widely extracted for building stone, although there is little current quarrying activity. There is no production of aggregate materials due, in part, to more readily available local supplies of crushed dolomite and natural sand and gravel.

For consistency with the map of West Yorkshire, where the sandstone is extensively worked, selected sandstone units within the Millstone Grit Group (Huddersfield White Rock, Midgeley Grit, Rough Rock and Rough Rock Flags) and the Pennine Coal Measures Group (Ackworth Rock and Greenmoor Rock) are shown.

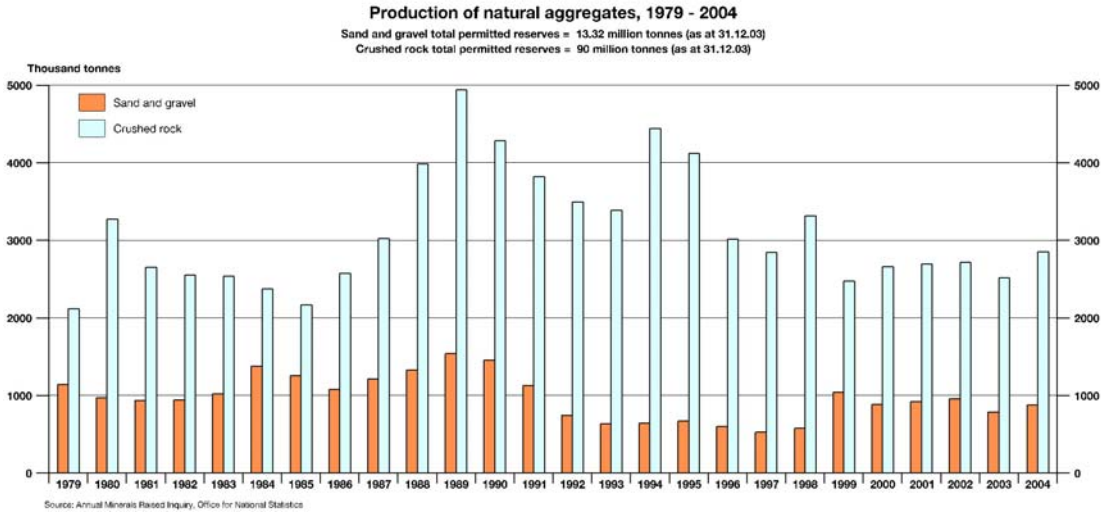

Figure 3. Production of natural aggregates in South Yorkshire, 1979 - 2004.

4 Industrial dolomite

Dolomite or dolostone is an important economic mineral because of its physical and chemical properties. It has a wide variety of applications but its primary use is in the construction industry. Dolomite is also important in certain industrial applications where its chemical properties are important. The principal uses of industrial dolomite are in steelmaking as a flux and for refractory use, and in glassmaking. For these applications, dolomite is required to be of high chemical purity. Dolomite for industrial purposes accounts for a relatively small and decreasing proportion of total dolomite output in Britain.

Dolomites with sufficiently low levels of impurities to be used in steelmaking and glassmaking are relatively scarce in Britain. The Permian, Cadeby Formation in the Cadeby, Sprotborough and Warmsworth area is, however, of higher purity and is extracted for glassmaking at Warmsworth and Cadeby quarries (Figure 4). The quality of the stone is variable and selective quarrying of specific horizons and subsequent blending is required to ensure that the stone meets the low iron requirements for glassmaking. Finely ground dolomite is also used for filler applications.

Figure 4. Warmsworth Quarry, Doncaster, producing industrial dolomite.

5 Brick Clay, including Fireclay

'Brick clay' is the term used to describe clay used predominantly in the manufacture of bricks and, to a lesser extent, roof tiles, clay pipes and decorative pottery. These clays may sometimes be used in cement manufacture, as a source of constructional fill and for lining and sealing landfill sites. The suitability of a clay for the manufacture of bricks depends principally on its behaviour during shaping, drying and firing. This will dictate the properties of the fired brick, such as strength and frost resistance and, importantly, its architectural appearance.

Most facing bricks, engineering bricks and related clay-based building products are manufactured in large automated factories. These represent a high capital investment and are increasingly dependent, therefore, on raw materials with predictable and consistent firing characteristics in order to achieve high yields of saleable products. Blending different clays to achieve improved durability and to provide a range of fired colours and textures is an increasingly common feature of the brick industry. Continuity of supply of consistent raw materials is of paramount importance.

The major brick clay resources in South Yorkshire occur within the mudstones of the Pennine Coal Measures and are interbedded with siltstones, sandstones, coal seams and seatearths. The mudstones are dark grey, with a variable carbon content. They are typically up to 5 m thick, but much thicker (20 to 30 m) in places. There are several large production units working Pennine Coal Measures mudstones concentrated around Barnsley and a further large works at Maltby. South Yorkshire also accounts for the bulk of UK production of vitrified clay drainage and sewerage pipes, with

manufacture concentrated in the Penistone area to the west of Barnsley. Historically, the industry was based on the extensive Lower Coal Measures fireclays which occur in the area. With the advent of improved firing technology in the mid to late 20th Century, the use of fireclays in these products declined sharply. The principal mineral raw material used in pipemaking is Lower Coal Measures mudstones derived from several sites close to the manufacturing centres at Hazelhead and Cawthorne.

Fireclays typically occur beneath coal seams and resources are confined to coal-bearing strata. The close association of fireclay and coal means that opencast coal sites are one of the few viable sources. Resources of fireclay are thus coincident with opencast coal resources and consequently the future supply of fireclay is largely dependent on the future of the opencast coal industry. Although originally valued as a refractory raw material, fireclay is now valued by the brick industry for its combination of good technical properties allied to its cream/buff-firing characteristics. However, not all fireclays are suitable for buff brick production because of the presence of impurities.

Small quantities of fireclay are produced in the area for use in the blend of clays used in the manufacture of vitrified clay pipes.

6 Building stones

Historically the county has been a prolific source of Carboniferous building sandstones quarried from the Millstone Grit and Pennine Coal Measures groups. These sandstones were generally marketed under the generic name 'York Stone'. The sandstones were also the principal local source of millstones prior to the industrial revolution and, in the 19th Century, of grindstones for use in the Sheffield cutlery trade. Limestone from the late Permian has also been quarried for building use.

The oldest rocks that have been used for building are the quartzose sandstones of the Millstone Grit Group. They have been quarried for block stone, rubblestone, flagstone and roofing stone throughout the area of their outcrop. Extensive local quarrying of the many sandstones beds present in the Group has generally been associated with the development of the principal settlements in the area, notably in the area east of Barnsley and around Rotherham. The western outcrops of the Group were only quarried for local use, notably around Stocksbridge. The principal sandstone unit that has been worked commercially is the Rough Rock Formation, however, there is evidence of local quarrying from all sandstones in the Group.

The overlying Pennine Coal Measures Group has also been a prolific source of building sandstones, and all of the many sandstones that occur in the succession have been used for local building purposes, most notably around Barnsley, Mexborough, Sheffield and Rotherham. The sandstone from the Rotherham area has a distinctive red coloration and is known as Rotherham Red.

The magnesian limestones of the late Permian, Cadeby Formation crop out in a narrow, north-south strip across the area. These pale coloured dolostones have been

extensively quarried for local building along much of their outcrop, most notably around Brodsworth, Doncaster, Conisborough and Anston.
There is currently one active building sandstone quarry and four active building limestone quarries in the area, although the latter are principally sources of crushed rock aggregate.

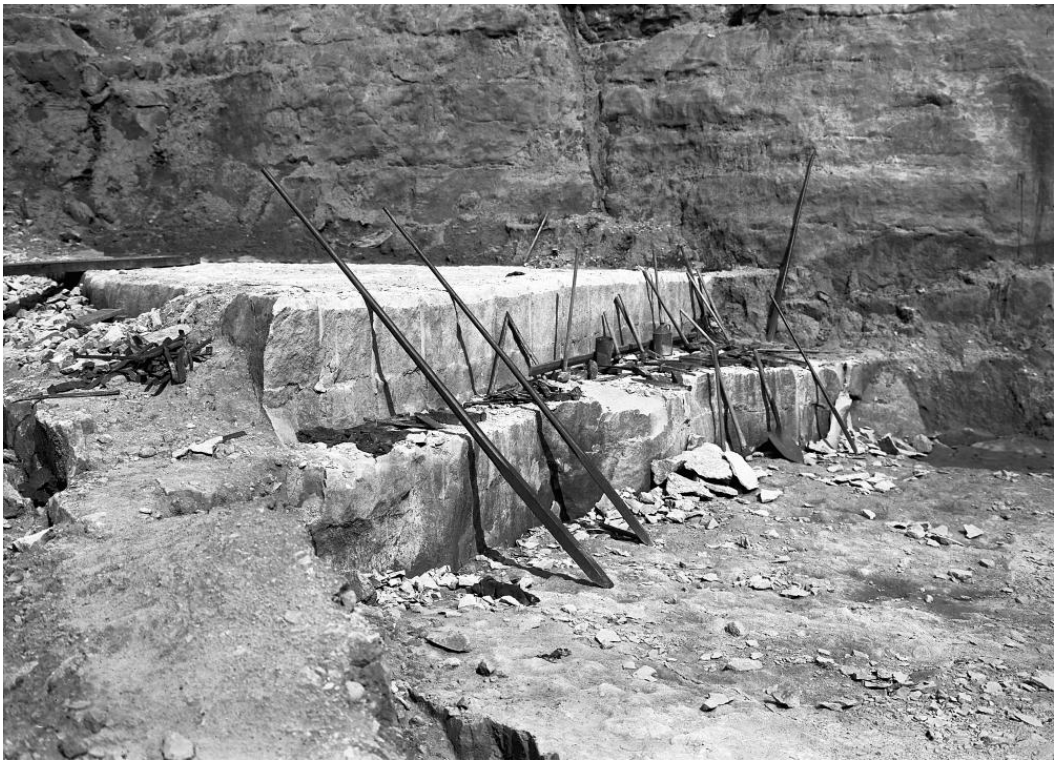

Figure 5. Permian dolomite worked at Turner's Quarry, Anston, Yorkshire, 1930.

The pale yellow, bioclastic, dolomitic limestones (or magnesian limestones) from the Anston area have been used extensively for local building. Anston Stone was selected for use as the principal freestone in the construction of the Palace of Westminster (new Houses of Parliament 1839-52) buildings in London.

7 Peat

Peat is an unconsolidated deposit of compressed plant remains in a water-saturated environment such as a bog or fen. Bogs occur in areas where inputs of water (almost exclusively from precipitation) have a low nutrient content and where rainfall is sufficient to maintain the ground surface in a waterlogged condition. The vegetation is characterised by acid-tolerant plant communities of which the moss genus *Sphagnum* is dominant. The two main types of bog are:

(i) raised bogs, characteristic of flat underlying topography and found on plains and broad valley floors; and
(ii) blanket bogs, which occur mainly in upland areas where conditions are suitably cool and wet, both of which occur in South Yorkshire.

Many lowland raised bogs have been designated as sites of international and national conservation importance. Peat is dug in England almost entirely (98 per cent) for horticultural purposes, either as a growing medium, or as a soil improver.
In South Yorkshire, extensive peat deposits occur in the extreme west and east of the county. In the west of the county, peat deposits occur on the Millstone Grit along the eastern side of the Pennines, from west of Penistone to Sheffield. The Millstone Grit outcrop in the upland Pennine areas gives rise to acid soils on which extensive upland blanket peat bogs contain peat up to several metres thick. These deposits almost exclusively occur within the Peak District National Park and South Pennine Moors conservation areas. They are not worked for horticultural purposes and are not shown on the map.

In the east of the county, peat deposits occur on Hatfield Moors and Thorne Moors, the latter including Crowle, Swinefleet and Goole moors. These deposits have been exploited for many years and the industry based on these resources is currently one of the largest in Great Britain. The peat is extracted by both a mechanised block cutting method and a surface milling technique, the latter accounting for an increasing proportion of the output. The peat is used for a variety of horticultural applications. The upper part of the deposit produces a light brown, open-textured peat which is of premium quality. A darker, more compact material from lower levels is of less value. These deposits occur within designated conservation areas (SSSI, SPA and SAC).

8 Coal

South Yorkshire lies predominantly within the East Pennine Coalfield. The coal-bearing strata of the Pennine Lower and Middle Coal Measures (Upper Carboniferous) generally dip to the east or south. Coal seams crop out at the surface in the west and become concealed by younger rocks, down to depths of 1200 m below OD, east of Rotherham. Coal seams are numerous and many are developed at a regional scale. They vary laterally in both thickness and composition, chiefly by variation in the number of dirt partings present within the seams. Twenty-two coal seams are recognised in the Pennine Lower Coal Measures and nine in the Pennine Middle Coal Measures. The seams are mainly bituminous and the calorific value and rank of the coals broadly increases eastwards. Sulphur is an impurity associated with all Yorkshire coals, with the most easterly parts of the coalfield recorded as moderately high in sulphur.

Although UK domestic production of coal has declined in recent years, South Yorkshire remains an important coal-mining region in the UK with five opencast coal sites and two deep coal mines in recent operation. In the last five years, from 1999 to 2004, total coal production in South Yorkshire decreased from 3.5 Mt to 2.8 Mt (Figure 6). Recent opencast coal production was from the Ferry Moor, Low Barugh and Woodhead sites in Barnsley and from the Orgreave site in Rotherham. Total opencast coal production in 2005 was 0.44 Mt but at the end of 2005 only the Orgreave site was in operation, although this was near completion.

Two underground coal mines are currently in operation: Rossington in Doncaster and Maltby in Rotherham, although is due to close in 2006 and be placed on a care and

maintenance basis. Total underground production in South Yorkshire in 2005 was 2.6 Mt. Underground production in Yorkshire has been concentrated in the Barnsley seam complex, a thick, relatively undivided seam with lower values of sulphur (1.01 per cent). However, in the extreme northeast of the county, the Barnsley seam is split by mudstone partings and is less productive. At the former Hatfield Colliery, substantial workings have occurred in the Hatfield High Hazel seam; the mine is currently mothballed.

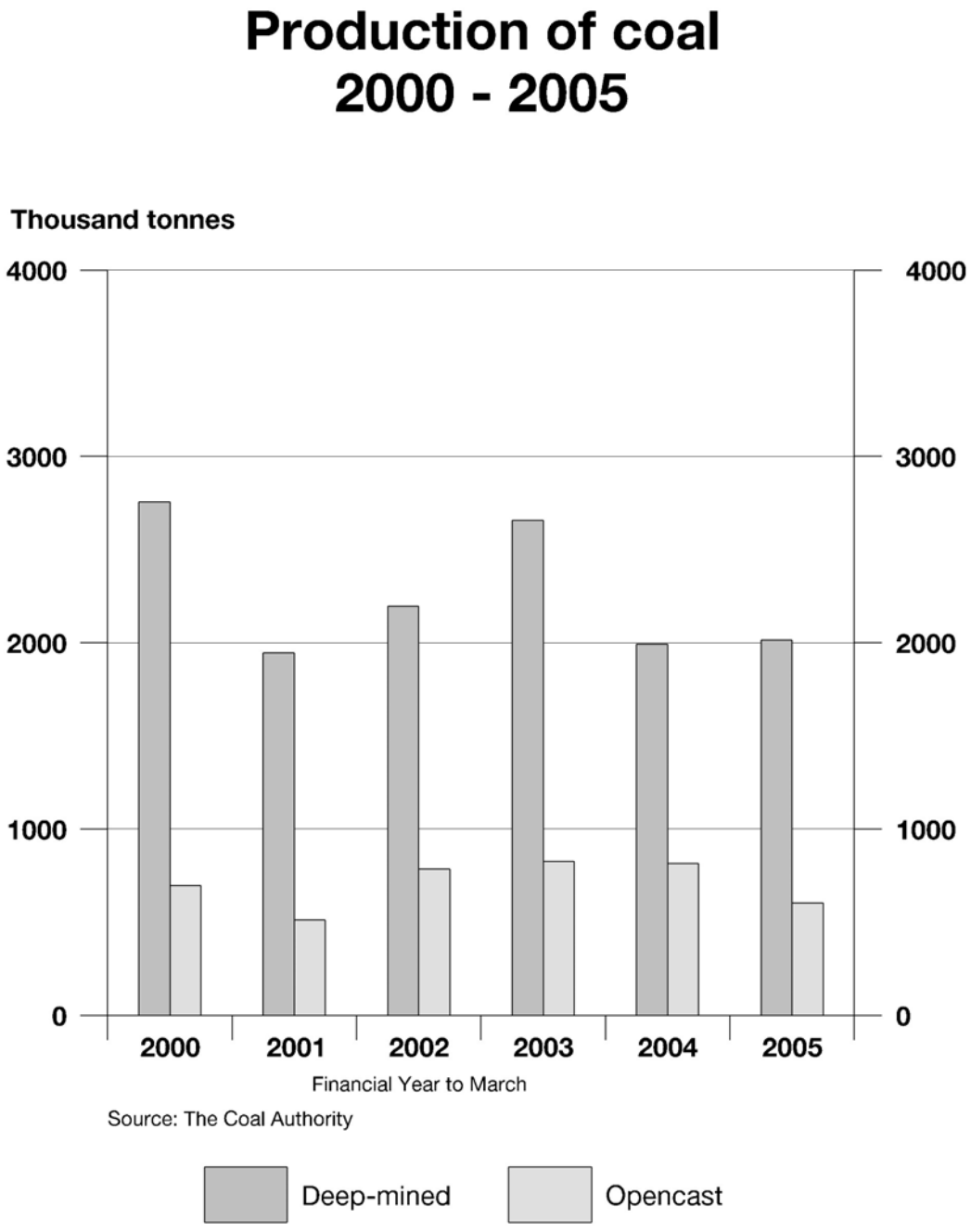

Figure 6. Production of coal 1999 – 2005 in South Yorkshire

9 Hydrocarbons

9.1 Conventional Oil and Gas

Upper Carboniferous (Namurian and Westphalian) strata occur at outcrop or at depth over most of South Yorkshire. Pennine Coal Measures (Westphalian) strata constitute part of the major East Pennine Coalfield, which is divided into important regions, the majority of which have been heavily mined.

Permian and Triassic strata crop out over the eastern half of the county providing, in addition to Carboniferous sequences, potential reservoir rocks for hydrocarbons generated from the Carboniferous rocks.

South Yorkshire lies towards the northwestern end of two major Carboniferous basins: the Gainsborough Trough and Edale Gulf. Within these areas source rocks were deposited which have since produced significant quantities of oil and gas, forming a series of important oil and gas fields to the southeast that make up the East Midlands Oil Province. Within the county, seismic reflection data indicate that the main prospective areas have, to date, been in central and eastern areas of the county, influenced to a large extent by coal mining activities and urban development. Several exploration wells have been drilled in the county between 1940 and 1983 (Tables 1 and 2). All were plugged as dry and abandoned with the exception of two wells. Trumfleet 1 proved a major gas discovery but was only developed in 1998. To the southeast, Hatfield 1 followed as a gas discovery in 1981 and proved to be the discovery well for the series of wells that confirmed the two related Hatfield West and Hatfield Moors gas fields (Table 2), which were developed in the mid 1980s. Trumfleet was still producing in late 2005, whilst the role of the Hatfield gasfields had changed to that of gas storage facilities, gas being injected into the reservoir during periods of low demand and then pumped out during peak demand.

The pattern of exploration to date thus indicates that the hydrocarbon potential of the county is perhaps relatively poor, due to the previous exploration and the level of coal mining activity. As seen in the Hatfield fields, depleted oil and gas fields could be increasingly used for gas storage. The majority of the exploration licences held in the county relate to the extraction of methane (see below).

Well name	Date Drilled	Operator at time of drilling	Well Status
Anston	1983	BP Development Ltd	Plugged & abandoned, dry
Askern	1957	BP Exploration Company Ltd	Plugged & abandoned, dry
Blaxton Common	1982	Taylor Woodrow Energy Ltd	Plugged & abandoned, dry
Hatfield 1	1981	BP Development Company Ltd	Shut-in as gas well
Kiveton Park	1940	BP Development Ltd	Plugged & abandoned, dry
Moss	1979	NCB/BP Exploration Company Ltd	Plugged & abandoned, dry
Tickhill	1958	BP Exploration Company Ltd	Plugged & abandoned, dry
Trumfleet 1	1956	BP Exploration Company Ltd	Shut-in as gas well. Well No.5 proved oil.
Warmsworth	1982	RTZ Oil & Gas Ltd	Plugged & abandoned, dry

Table 1. South Yorkshire exploration wells.

Name of field	Field Type (oil or gas)	Operator at time of discovery	Operator of licence block, late 2005	Discovery date	Production started	Current status
Hatfield Moors	gas	Taylor Woodrow Energy Ltd	Edinburgh Oil & Gas plc	1983	1986	Field use converted to gas storage facility at end 2000
Hatfield West	gas	Taylor Woodrow Energy Ltd	Edinburgh Oil & Gas plc	1983	1986	Field use converted to gas storage facility at end 2000
Trumfleet	gas	BP Exploration Company Ltd	Warwick Energy	1956-1965	1998	Still producing late 2005

Table 2. South Yorkshire gas fields.

9.2 Abandoned Mine Methane (AMM), Coal Mine Methane (CMM) and Coal Bed Methane (CBM) Potential

Pennine Lower to Middle Coal Measures forming part of the Yorkshire Coalfield crop out or are below the Permian cover in much of the county. These Coal Measures are generally simple eastwards dipping and locally folded. They continue eastwards beneath the Permian cover rocks in the east of the county, being continuous with the concealed Eastern England Coalfield.

The Pennine Coal Measures in the county have been very heavily worked, with thicker seams almost totally worked out. By 2005 of the 50 plus pits operating in 1978, all but the Rossington and Maltby pits in the area had closed. The coal across the county is a high volatile bituminous coal with a seam gas content of between 4.1 and 6.1 m^3 CH_4 per tonne.

In the USA, most CBM production is from coals containing 7 or more m^3 CH_4 per tonne. The lower gas content of the coal in the county, combined with the fact that the coalfield has been heavily worked suggests that CBM development from virgin coal seams in South Yorkshire is probably not economic at present. However, the gas seam content in the South Yorkshire region is 6.1 m^3 CH_4 per tonne and is therefore perhaps only just marginal. Future CBM potential and prospectivity will be dependent on areas of undisturbed coal, which in the county will probably be limited to the east.

Initially AMM and CMM potential in the county appears good, given the intense coal mining in the area. During 2005 Alkane Energy held two licences (PEDLs 37 and 108), Stratagas one (PEDL92) and Octagon four (PEDLs 60, 11, 43 and 66) that covered some part of the county. These permit the extraction of gas from abandoned coal mines with schemes at Wheldale (near Castleford) and at Monk Bretton (near Barnsley) and at Shirebrook and Markham in the North Derbyshire, although all but Monk Bretton are outside the county. The gas produced is commonly used on site for power generation or supplied direct to local consumers. However, the potential for water entering and flooding areas of the mines, that are often interconnected, could impact greatly on any prospects identified in the county. Water is currently pumped from the Barnsley area to protect Maltby Colliery.

Prospects for AMM in the county are thus thought to be good if the mines are not flooded. The schemes operated by Alkane Energy have, however, seen rapid declines in the volumes of gas extracted and concerns in 2003 over the classification and tax regimes of the resource have led to doubts over the economic viability of this resource. Coal Mine Methane is recovered from existing operating mines.

A potential future area for development in coalfield areas is Underground Coal Gasification. This is very much an unproven, new technology, which is under review and test in a number of countries. Again, the level of mining across the county and the depth of the coals might rule against this being a realistic potential resource in South Yorkshire.

9.3 Licensing

The Department of Trade and Industry grants licences for exclusive rights to explore and exploit oil and gas onshore within Great Britain. The rights granted by landward licences do not include rights of access, and the licensees must obtain any consent under current legislation, including planning permission. Licensees wishing to enter or drill through coal seams for coalbed methane and abandoned mine methane must also seek the permission of the Coal Authority.

10 Aims and limitations

The purpose of the maps in this series is to show the broad distribution of those mineral resources which are or may be of current or potential economic interest and to relate these to selected, nationally-recognised planning designations. The maps are intended to assist in the consideration and preparation of development plan policies in respect of mineral extraction and the protection of important mineral resources against sterilisation. They bring together a wide range of information, much of which is scattered and not always available in a convenient form.

The maps have been produced by the collation and interpretation of mineral resource data principally held by the British Geological Survey. Information on the extent of mineral planning permissions has been obtained from the relevant Mineral Planning Authority (MPA). Some of these permissions may have lapsed or expired. The status of individual areas can be ascertained from the appropriate MPA. Location information on national planning designations has been obtained from the appropriate statutory body (Countryside Agency, English Nature and English Heritage). For further information the relevant body should be contacted.

The mineral resource data presented are based on the best available information, but are not comprehensive and their quality is variable. The inferred boundaries shown are, therefore, approximate. Mineral resources defined on the map delineate areas within which potentially workable minerals may occur. These areas are not of uniform potential and also take no account of planning constraints that may limit their working. The economic potential of specific sites can only be proved by a detailed evaluation programme. Such an investigation is an essential precursor to submitting a planning application for mineral working. Extensive areas are shown as having no mineral resource potential, but some isolated mineral workings may occur in these areas. The presence of these operations generally reflect very local or specific situations.

The maps are intended for general consideration of mineral issues and not as a source of detailed information on specific sites. The maps should not be used to determine individual planning applications or in taking other decisions on the acquisition or use of a particular piece of land, although they may give useful background information which sets a specific proposal within context.

11 Planning permission for the extraction of minerals

The extent of all known extant and former planning permissions for mineral working is shown on the map, irrespective of their current planning or operational status. The polygons were supplied as digital files by Rotherham Metropolitan Borough Council and were also digitised by BGS from Plotting Sheets and other documents supplied by Barnsley Metropolitan Borough Council, Doncaster Metropolitan Borough Council and Sheffield City Council. In addition, planning permission information was digitally acquired from Ministry of Housing and Local Government maps for the area and incorporated in the data. These data have been checked and amended by the local authorities shown below. Any queries regarding the sites shown should be directed to these authorities at the addresses shown below. The polygons cover active, former and restored mineral workings and, occasionally, unworked deposits.

Planning permissions represent areas where a commercial decision to work mineral has been made, a successful application has been dealt with through the provisions of the Town and Country Planning legislation and the permitted reserve will have been depleted to a greater or lesser extent. The current planning status is not qualified on the map but is available in the underlying database.

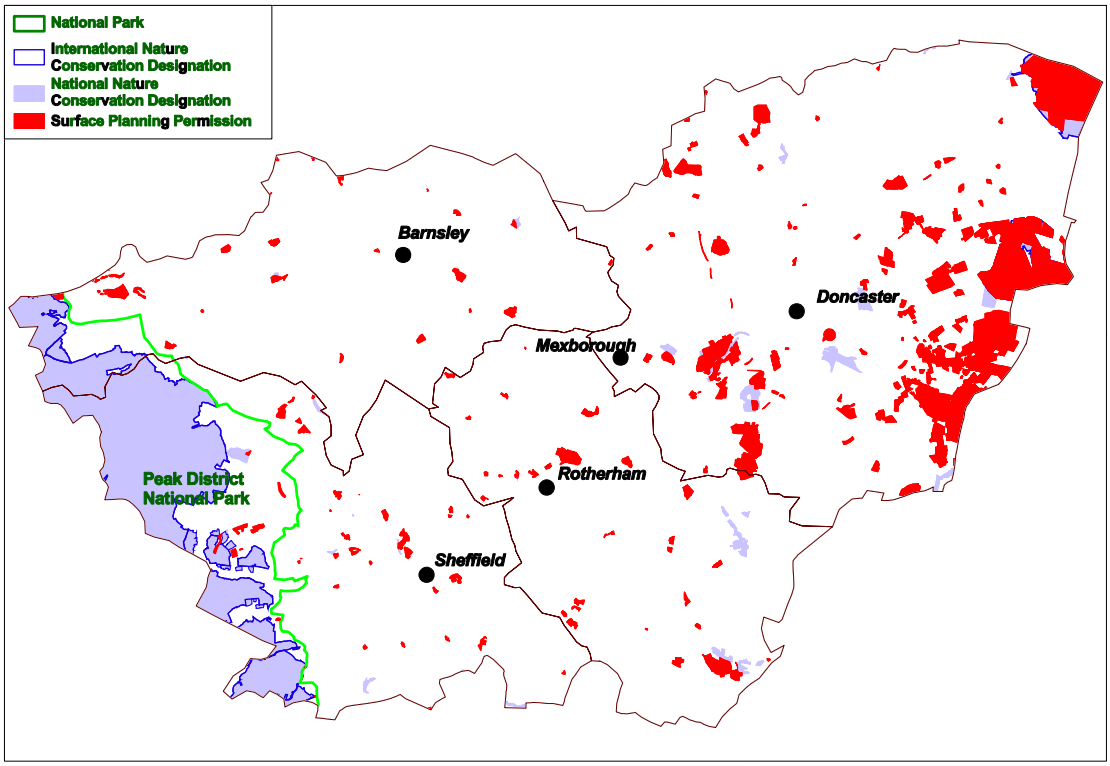

Figure 7. Surface planning permissions and national environmental designations in South Yorkshire.

Contact addresses:

Barnsley Metropolitan Borough Council, Planning Services Department, Central Offices, Kendray Street, Barnsley S70 2TN, Tel: 01226 7707700, Fax: 01226 772697, web address: www.barnsley.gov.uk
Doncaster Metropolitan Borough Council, Directorate of Planning & Design Services, 2nd Floor, Danum House, St. Sepulchre Gate, Doncaster DN1 1UB, Tel: 01302 734444, Fax: 01302 734949, web address: www.doncaster.gov.uk

Rotherham Metropolitan Borough Council, Planning Services, Bailey House, Rawmarsh Road, Rotherham S60 1QT, Tel: 01709 382121, Fax: 01709 823865, web address: www.rotherham.gov.uk

Sheffield City Council, Planning, Transport & Highways Department, Town Hall Extension, Sheffield S1 2HH, Tel: 0114 272 6444, Fax: 0114 273 5002, web address: www.sheffield.gov.uk

12 Appendix

12.1 Topographic Base

12.2 Constraint Information

Constraint information published on the accompanying map has been provided from the various agencies listed below; any enquires on the information should be addressed to the relevant agency.

12.2.1 English Nature

Digital SSSI, NNR, SAC, SPA and RAMSAR boundaries © English Nature 2004

Contact address: English Nature, Northminster House, Northminster, Peterborough PE1 1UA. Tel: 01733 455000. Fax: 01733 455103. Web page: www.english-nature.org.uk

12.2.2 English Heritage

Positions of scheduled monuments at 25th September 2003.

The majority of monuments are plotted using a centred NGR symbol. Consequently the actual area and/or length of a monument protected by the legal constraints of

scheduling cannot be represented here. Monuments scheduled since that date are not accounted for. © Copyright English Heritage.

Contact address: English Heritage, 23 Savile Row, London W1S 2ET. Tel: 0207 973 3132. Web page: www.english-heritage.org.uk

12.2.3 Countryside Agency

Digital AONB boundaries © Countryside Commission 1986 (now Countryside Agency).

Contact address: Countryside Agency, John Dower House, Crescent Place, Cheltenham, Gloucestershire GL50 3RA. Tel: 01242 521381. Fax: 01242 584270. Web page: www.countryside.gov.uk

12.2.4 The Coal Authority

Coal Licence Areas © The Coal Authority 2006

Contact address: The Coal Authority, 200 Lichfield Lane, Mansfield, Nottinghamshire NG18 4RG. Tel: 01623 427162. Fax: 01623 638338