British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

OFFICE OF THE DEPUTY PRIME MINISTER

Mineral Resource Information in Support of National, Regional and Local Planning

Leicestershire and Rutland (comprising City of Leicester, Leicestershire and Rutland)

BGS Commissioned Research Report CR/02/24/N

D J Harrison, P J Henney, D G Cameron, N A Spencer, D J Evans, G K Lott, K A Linley and D E Highley,

Keyworth, Nottingham 2002

BRITISH GEOLOGICAL SURVEY
TECHNICAL REPORT CR/02/24/N

Mineral Resources Series

Mineral Resource Information for Development Plans: Leicestershire and Rutland (comprising City of Leicester, Leicestershire and Rutland)

D J Harrison, P J Henney, D G Cameron, N A Spencer, D J Evans, G K Lott, K A Linley and D E Highley,

This report accompanies the 1:100 000 scale map: Leicestershire and Rutland (comprising City of Leicester, Leicestershire and Rutland)

Cover Photograph

Bibliographical reference:
Harrison, D J, Henney, P J, Cameron, D G, Spencer, N A, Evans, D J, Lott, G K, Linley, K A and Highley, D E 2002. **Mineral Resource Information in Support of National, Regional and Local Planning: Leicestershire and Rutland (comprising City of Leicester, Leicestershire and Rutland)**. *BGS Commissioned Report CR/02/24/N.*

BRITISH GEOLOGICAL SURVEY

The full range of Survey publications is available from the BGS Sales Desk at the Survey headquarters, Keyworth, Nottingham. The more popular maps and books may be purchased from BGS-approved stockists and agents and over the counter at the Bookshop, Gallery 37, Natural History Museum (Earth Galleries), Cromwell Road, London. Sales desks are also located at the BGS London Information Office, and at Murchison House, Edinburgh. The London Information Office maintains a reference collection of BGS publications including maps for consultation. Some BGS books and reports may also be obtained from the Stationery Office Publications Centre or from the Stationery Office bookshops and agents.

The Survey publishes an annual catalogue of maps, which lists published material and contains index maps for several of the BGS series.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as its basic research projects. It also undertakes programmes of British technical aid in geology in developing countries as arranged by the Department for International Development and other agencies.

The British Geological Survey is a component body of the Natural Environment Research Council.

British Geological Survey Offices

Keyworth, Nottingham NG12 5GG
☎ 0115–936 3100 Fax 0115–936 3200
e-mail: sales @bgs.ac.uk www.bgs.ac.uk

BGS Internet Shop:
www.british-geological-survey.co.uk

Murchison House, West Mains Road,
Edinburgh EH9 3LA
☎ 0131–667 1000 Fax 0131–668 2683

London Information Office at the Natural History Museum (Earth Galleries),
Exhibition Road, South Kensington,
London SW7 2DE

☎ 020–7589 4090 Fax 020–7584 8270
☎ 020–7942 5344/45

Forde House, Park Five Business Centre,
Harrier Way, Sowton, Exeter, Devon EX2 7HU
☎ 01392–445271 Fax 01392–445371

Geological Survey of Northern Ireland, 20 College Gardens,
Belfast BT9 6BS
☎ 028–9066 6595 Fax 028–9066 2835

Maclean Building, Crowmarsh Gifford, Wallingford,
Oxfordshire OX10 8BB
☎ 01491–838800 Fax 01491–692345

Parent Body
Natural Environment Research Council
Polaris House, North Star Avenue,
Swindon, Wiltshire SN2 1EU
☎ 01793–411500 Fax 01793–411501

INTRODUCTION

This report is one of a series prepared by the British Geological Survey for various administrative areas in England for the Department for Transport, Local Government and the Region’s research project *Mineral Resource Information in Support of National, Regional and Local Planning.*

The accompanying map relates to the county of Leicestershire and Rutland 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 East Midlands 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 crushed-rock aggregate, sand and gravel, coal, brick clay, fireclay, hydrocarbons, gypsum, cement raw materials, building stone, and ironstone.

Resources and Reserves

Mineral resources are natural concentrations of minerals, or bodies of rock that are, or may become, of potential economic interest as a basis for the extraction of a commodity. They will exhibit physical and/or chemical properties that make them suitable for specific uses and be 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 new uses are developed, 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 a 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 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.

CRUSHED ROCK AGGREGATE

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.

Leicestershire is a nationally important source of crushed rock aggregates.

Igneous rocks

Igneous rocks tend to produce strong aggregates with a degree of skid resistance and are hence suitable for many road-surfacing applications as well as for use in the lower parts of the road pavement.

A number of small outcrops of Precambrian/Cambrian igneous rocks occur in the Charnwood Forest and in south Leicestershire. The igneous rocks occur mainly as small intrusions of slightly metamorphosed diorite and granodiorite intruded into volcaniclastic and sedimentary rocks. Volcanic lavas of Precambrian age are also worked. They generally produce consistent, high strength, high durability aggregates suitable for roadstone and railway track ballast.

Leicestershire is the largest producer of igneous rock aggregates (around 15 million tonnes per year) in Britain due to the proximity of the outcrops to the main aggregates market in South-east England and the Midlands, and a regional lack of comparable hard rock raw materials. The igneous rocks are worked in several large quarries, such as Bardon, Croft, Mountsorrel and New Cliffe Hill. Several quarries are rail linked. Some quarries are limited in areal extent by rapidly thickening overburden of Mercia Mudstone and this has led to the development of deep quarries.

Limestone and dolomite

In north-west Leicestershire, Carboniferous limestones crop out in several small isolated inliers which locally form prominent hills above the surrounding Triassic rocks. The inliers, between Breedon and Thringstone, consist mainly of pinkish-yellow, bedded and massive dolomite (dolostone). The inliers at Breedon Hill and Cloud Hill are quarried on a substantial scale for aggregate materials which are suitable for most, except the most demanding, applications.

The Lincolnshire Limestone of Jurassic age occurs widely in the eastern half of Rutland. Most Jurassic limestones are soft, porous, thin and impersistent. However, the various limestone units making up the Lincolnshire Limestone form a relatively thick and persistent formation which is capable of producing lower quality aggregates, such as fill and sub-base roadstone. It is currently worked on a relatively small scale for aggregate production as well as for building stone and agricultural lime.

SAND AND GRAVEL

Sand and gravel are defined on the basis of particle size rather than composition. In current usage, the term 'gravel' is used for material that is coarser than 5 mm, with a maximum size of 40 mm, and the term 'sand' for material that is finer, but coarser than 0.075 mm. Most sand and gravel is composed of particles that are rich in silica (quartz, quartzite and flint), but other rock types, mainly limestone, may occur locally.

The principal uses of sand are as fine aggregate in concrete, mortar and asphalt. The main use of gravel is as coarse aggregate in concrete. Substantial quantities of sand and gravel may also be used for constructional fill. Some 1.5 million tonnes of sand and gravel were produced in Leicestershire in 2000.

Sub-alluvial & River Terrace deposits

The main sources of these materials in Leicestershire are Quaternary and Recent age deposits in the valleys of the Trent, Soar and Wreake where generally clean, well bedded sands and gravels rest on weathered bedrock although deposit quality can vary along the river valley. Resources occur in both raised river terrace sequences flanking the modern floodplains and in flood plain terrace deposits associated with, and underlying, present day alluvium. In the Trent Valley, workings have mainly centred upon the terrace deposits including, in the 19th century, the Allenton Sand and Gravel with the lower terrace and floodplain deposits, such as the Ambaston and Holme Pierrepoint Sand and Gravel being exploited as demand has risen. The latter deposits are extensively worked below the present water table in contrast to the dry workings in the upper terrace deposits. Thickness varies from between less than 1 m up to maximum values of around 10 m. The gravel content, which consists mainly of quartzite pebbles, is highly variable and medium grained sand generally forms at least 50 per cent of the deposits.

In the Wreake and Soar valleys, deposits generally occur as parallel, sheet-like spreads of sand and gravel rarely more than 5 m thick and often considerably thinner in places. The deposits generally comprise sand-rich, cross-bedded gravels deposited in braided channels. Several sets of terraces and associated deposits have been identified, attesting to the longevity and volume of sand and gravel deposition in these river systems. The most widespread deposits are those of the Syston Sand and Gravel and the Wanlip Sand and Gravel, contemporaneous with the Holme Pierrepoint deposits in the Trent Valley. The gravels within the deposits reflect the varied bedrock geology in their catchments but 'Bunter' quartzite pebbles and shattered flints are abundant, usually in similar proportions. Similar, but smaller areas, of sand and gravel are also associated with the River Sence and with the Rivers Avon and Welland along the southern border of the county.

Glaciofluvial deposits

These are deposits mapped as the products of deposition by glacial melt waters and are nowadays 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- or delta-like layers above till (boulder clay) deposits, 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. Such deposits may be more common in Leicestershire given the extensive areas of till mapped in this county. Glaciofluvial deposits are worked in Leicestershire but they are exploited only modestly due to the proximity of more readily worked river deposits. Data from several sites shows that the proportion of gravel varies from 50 to 5 per cent, with average gravel yields of 15 to 25 per cent. About 20 to 25 per cent of the deposits are silt-grade sediment which is removed by washing before sale. The gravel fraction consists mainly of hard 'Bunter' quartzite pebbles together with smaller proportions of porous sandstone. In some deposits boulders of igneous rocks are found, presumably from the nearby intrusions (e.g. Croft). Minor amounts of coal also occur and are floated off during washing. The gravel is generally sold for coarse concreting aggregate and the washed sands for asphalt, building or concreting sand. These deposits are potentially significant sources of sand and gravel, comparable to the deposits found in the Trent and Soar valleys.

Blown sand

This is generally composed of a fine- to medium-grained sand with a mean fines (<75 micron) content of around 8 per cent. The sand comprises subrounded to well rounded quartz grains. These deposits are believed to be largely of very late Devensian and earliest Flandrian age resulting from aeolian reworking of fluvial and glaciofluvial sands and unvegetated Triassic bedrock. Small patches are found in the Vale of Belvoir area, where it has been extracted on a small scale, and at Strathern. A more extensive tract occurs on the east side of the Devon Valley.

COAL

Coal-bearing rocks in Leicestershire are confined to Carboniferous strata of the Lower, Middle and Upper Coal Measures (Westphalian A, B and C). The main developments of these strata are in north-west Leicestershire, where they both crop out at the surface and are concealed beneath Triassic rocks, and in north-east Leicestershire where they are entirely concealed beneath younger strata.

In north-west Leicestershire the coal resources occur in the South Derbyshire and North-west Leicestershire coalfields, which are separated by the Ashby Anticline. The area to the west of the Boothorpe Fault, on the western flank of the Ashby Anticline, is known as the South Derbyshire Coalfield. To the east of the Boothorpe Fault the resource is contained within the North-west Leicestershire Coalfield, although this lies partly in South Derbyshire. Both coalfields formerly supported deep mining operations but all the mines have now closed. The exposed parts of the coalfields have supported extensive opencast mining operations and in the south, opencast working has extended beneath overlying Triassic rocks to access concealed coal-bearing strata. Opencast operations are now confined to the South Derbyshire Coalfield where some sites have also been important sources of fireclay (see text box).

The North-east Leicestershire (Vale of Belvoir) Coalfield is co-extensive with the South Yorkshire-Nottinghamshire Coalfield. However, in Leicestershire it has only been worked from the Asfordby mine near Melton Mowbray. The mine closed in 1997 after only about 2 years of operation, because of the complex geological problems encountered.

BRICK CLAY

'Brick clay' is the term used to describe clay and shale used predominantly in the manufacture of bricks and, to a lesser extent, roof tiles and clay pipes. These clays may sometimes be used 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 Leicestershire occur within the red mudstones of the Triassic Mercia Mudstone Group and within the Pottery Clays Formation (Coal Measures) of the South Derbyshire Coalfield. The former is used for brickmaking at five sites within the county and the latter is an important resource of fireclays (see text box). Mudstone within the Triassic Bromsgrove Sandstone Formation is also worked at Measham. The Jurassic Rutland Formation is also worked on a smaller scale at one site both for facing bricks and refractory bricks in the eastern part of the county.

The Mercia Mudstone Group is more familiar to the brick industry as the 'Keuper Marl'. The Group may be divided into a number of formations and current extraction by the brick industry is confined to the lower part of the Group. It has not been possible on the map to separately show the outcrop of the lower part of the Mercia Mudstone Group, but the resources are vast.

Red-brown mudstone and siltstones are worked as brick clays at three sites south of Coalville, and at Measham, Desford and Shepshed. Sandstone within the Mercia Mudstone is normally discarded during quarrying. The presence of small amounts of carbonate minerals within some horizons in the Mercia Mudstone produces bricks with a distinctive colour. This can form a good substrate for a range of applied facing finishes. Other horizons are also worked to produce bricks with a deeper red colour. There is a considerable variation in the carbonate content within the Mercia Mudstone sequence. At Ibstock, three horizons are quarried to produce bricks with fired colours between pale buff and red.

FIRECLAY

Fireclays occur as seatearths, or the fossil soils, that underlie most coal seams. Resources are, therefore, mainly confined to coal-bearing strata. The close association of fireclay and coal means that opencast coal sites provide one of the few viable sources of fireclay, from which they are produced as a low cost by-product. Fireclay resources are thus essentially coincident with shallow coal resources. The future of the opencast coal industry is crucial to the future supply of fireclay by making available clay that would not otherwise be economically recoverable.

Fireclays were originally valued as refractory raw materials due to their high alumina content but demand has fallen markedly since the late 1950s. Large tonnages were also used in the manufacture of vitrified clay pipes, particularly in Leicestershire. With a decline in this market, fireclays with low iron contents are now mainly valued for the production of buff-coloured facing bricks and pavers.

In north-west Leicestershire, fireclays of commercial value are almost entirely confined to the Pottery Clays Formation (Middle and Upper Coal Measures) of the South Derbyshire Coalfield. The formation is some 100 m thick and contains numerous thin, poor quality coals but a high concentration of unusually thick fireclays. Each coal seam and its associated fireclay have been numbered in descending order with the prefix ‘P’. The base of the Pottery Clays Formation is indicated by the P40 coal. The high concentration of relatively thick fireclays has meant that during the course of former and recent opencast coal operations, very large tonnages of fireclay have been produced and have had to be stockpiled for future use. The fireclays exhibit a wide range of compositions but blending has been employed on a large scale to produce more consistent qualities. For many years the area has been the most important source of fireclay in the UK supplying about 50 per cent of total output. Several millions of tonnes of fireclay are stockpiled at the former Donington Island opencast coal site and this constitutes an important source of fireclay for the future. Small quantities of fireclay have been produced in the Leicestershire Coalfield in the past.

In the eastern part of Rutland, greyish white and brown silty 'fireclays' up to 3 m thick occur within the Jurassic Rutland Formation (formerly Upper Estuarine Series) of the Great Oolite Group. They are worked in the extreme east of the county both for refractory applications and facing bricks. Quartz predominates in the clays which are highly siliceous. Although described as 'fireclays', they are more akin to ganisters because of their high silica content. The clays are utilised in monolithic refractories, used mainly in the automotive castings industry.

HYDROCARBONS

Conventional Oil and Gas

A number of exploration wells and the existence of a network of seismic reflection surveys, illustrates that the northern part of Leicestershire has been intensively explored for oil and gas since before the Second World War. This has led to a number of discovery wells and the development of two producing oilfields in the county (Plungar and Long Clawson). Long Clawson remains in production today. The total production of these fields is shown in the table below.

Name of field	Field Type (oil or gas)	Operator at time of discovery	Current operator	Discovery date	Production started	Production ceased	Total production to 2000 (tonnes)
Plungar	Oil	BP		1953	1954	1980	43,788
Long Clawson	Oil	Pentex	Pentex	Mar-86	Dec-90	Still producing	95,000
Total Production							**138,788**

Exploration to date indicates that the best potential for the discovery of oilfields lies in northern parts of the county. In recent years exploration in the East Midlands has been dominated by operators such as ROC Oil (UK) Ltd (formerly Candecca), who developed a large acreage position across the region. This has led to areas in the north-east of the county being currently licensed for oil and gas exploration, with most licence blocks straddling either the Nottinghamshire and/or Lincolnshire county boundaries (see inset map). With the exception of the Long Clawson oil discovery in 1986, there has been only limited success as a result of this exploration phase. The most notable is the oil discovery of the Belvoir No.1 well, also in 1986. There appears to be very limited oil and gas prospectivity over the majority of the county to the south of northing 200,000.

North-eastern and western parts of Leicestershire are underlain by Coal Measures. The Vale of Belvoir prospect found in north-east Leicestershire contains concealed, north-eastwards-dipping Lower-Middle Coal Measures at depths of between 200 and 800 m. They have been worked only around Asfordby, where igneous rocks complicated workings. In the west of the county, Lower-Middle Coal Measures are found in two synclines and an intervening anticline at depths between 0 and 240 m. Eighteen or more coal seams 0.3-4 m thick have been extensively worked. Coal rank in both areas is high volatile bituminous, with seam gas content in Leicestershire between 0.5-0.6 m^3 methane/tonne.

Coal Mine Methane

Coal mine methane is mine gas drained from operational mines. Asfordby was the only mine in the Vale of Belvoir Coalfield, but closed in 1997. Mining ceased in the Leicestershire area of the Leicestershire and South Derbyshire coalfields in the mid-late 1980s. There is thus no current potential for coal mine methane.

Abandoned Mine Methane

The artificial voids left in abandoned coal mines form excellent potential reservoirs for coal mine gas and have high levels of permeability. Prospects in the Vale of Belvoir Coalfield are perceived as poor due to very low initial seam gas content, and the limited extent of workings. Prospects for the Leicestershire and South Derbyshire coalfields are ranked as very poor due to low seam gas content and the likely flooding of the main workings.

Coalbed Methane

The term coalbed methane is used here to refer to the extraction of methane via boreholes from coal seams other than in abandoned or active coal mines. Thus it includes the extraction from unmined areas, or coal seams above or below abandoned or working mines. The levels of coalbed methane in the coal seams of Leicestershire are relatively low (0.5-1.0 m^3 methane/tonne). In the USA, most coalbed methane production is from coals containing 7 or more m^3 methane/tonne. Thus coalbed methane development from virgin coal seams in Leicestershire is not economic at the present times, a point illustrated by the fact that no coalbed methane wells have been drilled in the county to date. Future coalbed methane potential will depend upon extremely favourable changes in the economic situation.

GYPSUM/ANHYDRITE

Gypsum ($CaSO_4.2H_2O$) and anhydrite ($CaSO_4$) are forms of calcium sulphate. They are worked from natural deposits, but may also be derived as by-products of certain industrial processes, notable flue gas desulphurisation (FGD). The amount of natural gypsum extracted in Britain has declined appreciably in recent years due to the availability of substantial amounts of high quality synthetic gypsum obtained from FGD plants at coal-fired power stations. Gypsum has many applications but is used principally in the production of plaster and plasterboard. A mixture of gypsum/anhydrite is used as a retarder in cement manufacture.

Natural Gypsum

Gypsum and anhydrite occur as beds, or nodular masses, up to a few metres thick. Gypsum is formed by the hydration of anhydrite at or near the surface but passes into anhydrite generally at depths of more than 100 m. Gypsum occurs in the Triassic Mercia Mudstone Group in north Leicestershire, east of Loughborough and is currently being mined underground at Barrow-upon-Soar. The mineral is extracted from the Tutbury Gypsum in the Cropwell Bishop Formation near the top of the Group. The Tutbury Gypsum is around 4 m thick in the Barrow-upon-Soar mine, although only some 2.5 m is extracted, and occurs at a depth of between 60 and 150 m. The seam thins to the east to less than 2 m thick. Extraction is by pillar and stall mining, using continuous cutting machines. Mine output is of the order of 0.7 Mt/y. The gypsum contains small, but variable amounts of mudstone and a homogeniser is used to maintain consistency. The only product manufactured at the Barrow works is bagged building plaster. The small amount of mudstone in the gypsum helps to improve the workability of the plaster. Desulphogypsum is unsuitable for the manufacture of bagged plasters because it lacks workability.

CEMENT RAW MATERIALS

Rutland is an important cement-producing county and a large plant located at Ketton has a capacity of 1.3 million tonnes a year of cement clinker and accounts for some 10 per cent of GB capacity. Cement manufacture started at Ketton in 1929.

Portland cement clinker is manufactured by heating an intimately homogenised and controlled mixture of calcareous and clayey raw materials to partial fusion (typically at 1400°-1500°C). Small amounts of iron oxide and sand (silica) may be added to optimise the mix. These raw materials supply the lime, silica, alumina and iron oxide necessary for the formation of the calcium silicates and smaller quantities of calcium aluminates that constitute cement clinker. The clinker is cooled and then finely ground, typically with 5 per cent gypsum/anhydrite, to form the final cement. Gypsum/anhydrite is introduced to control the initial rate of reaction with water and to allow concrete to be placed and compacted before hardening commences. Limestone, or chalk, provides lime for the production of cement clinker and typically accounts for 80-90 per cent of the raw mix. Mudstone accounts for some 10-15 per cent and provides most of the silica, alumina and iron oxide.

Cement making is highly capital intensive and cement plants are normally located in close proximity to the main raw materials, i.e. limestone. The large cement plant at Ketton is based on Jurassic limestone (Lincolnshire Limestone) and the overlying mudstone (Rutland Formation).

IRONSTONE

The Jurassic Marlstone Rock Formation consists principally of an iron-rich, fossiliferous limestone which weathers to a deep rusty-brown colour. It is relatively resistant to erosion and in areas where the formation has a relatively high iron content, it has been worked as a source of ironstone. It has also been worked on a small scale for building stone and lime. Relatively large-scale iron ore extraction took place from around 1880 into the 1950s. Nowadays most of the former shallow quarries have been returned to agriculture. The ironstone bed is around 4 m in thickness. The ore was of a variable quality with an iron content of around 25-40 per cent.

Technological and economic changes within the UK iron and steel industry has led to the demise of the Marlstone Rock Formation as a source of iron ore, because of its low iron content and level of impurities. For this reason it is not shown as a resource on the map. However, there remain a large number of planning permissions granted for the extraction of ironstone and overlying minerals within the county.

A second iron-bearing horizon is the Middle Jurassic Northampton Sand Formation. This was extensively worked for ironstone further south in Northamptonshire. In Leicestershire the iron content only averages 20 per cent, which is far below the 30 to 50 per cent typical of the workable ironstone in other parts of the Midlands.

BUILDING STONE

Historically the counties of Leicestershire and Rutland have produced and used a wide range of indigenous stones for building purposes. Former sources of building stone in the counties include: –

Leicestershire

The varied volcaniclastic lithologies of the Precambrian (Charnian) of the Charnwood area; the igneous intrusive bodies at Mountsorrel (granodiorite), Markfield, Groby and Croft; the Cambrian metamorphic slates of the Swithland quarries; the dolomitised Carboniferous limestones of Breedon; the Carboniferous sandstones of the coalfield area; the Triassic sandstone (Sherwood Sandstone Group) of Castle Donnington; the Triassic sandstones (Mercia Mudstone Group) of Dane Hills, Leicester; the Lower Jurassic limestones of Barrow-upon-Soar and elsewhere along the outcrop; the Lower Jurassic sandstones of the Dynham Formation and ironstones of the Marlstone Rock Formation; the Lincolnshire Limestone Formation. None of these sources are currently exploited for building stone in the county.

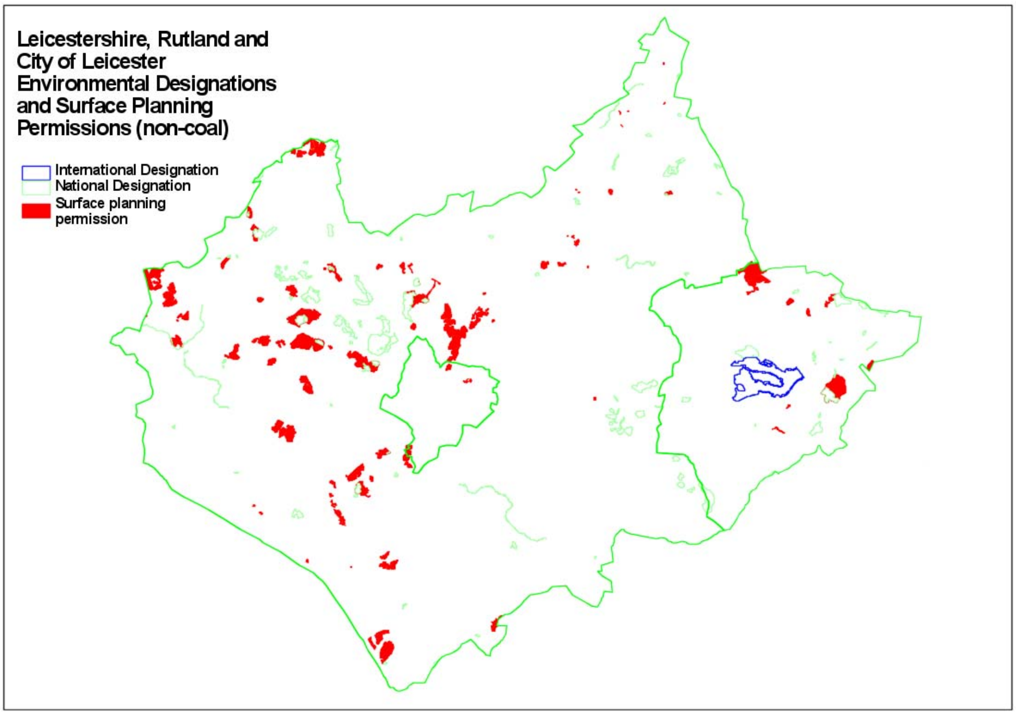
Rutland

The county has in the past been a major source of ironstone and limestones from the Lower and Middle Jurassic successions for local building purposes. Although the ironstone quarries have long since ceased to operate the Middle Jurassic Lincolnshire Limestone is still extensively exploited for building stone. Quarries are in operation at Ketton and Clipsham, the latter stone is produced from a number of quarries spanning the Rutland/Lincolnshire border.

PLANNING PERMISSIONS FOR MINERAL EXTRACTION

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 digitally supplied by Leicestershire County Council or digitised by BGS from documents supplied by Leicestershire County Council (covering Leicestershire and Rutland) and Leicester City Council. Any queries regarding the sites shown should be directed to these authorities and Rutland County Council 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 may have been depleted to a greater or lesser extent. Their current planning status is not qualified on the map but is available in the underlying database.



Contact addresses:

Leicestershire County Council, Planning & Transportation Department, County Hall, Glenfield, Leicester, LE3 8RJ, Tel: 0116 265 7127, Fax: 0116 265 7965, Webpage: www.leics.gov.uk

Leicester City Council, Environment & Development Department, New Walk Centre, Welford Place, Leicester, LE1 6ZG, Tel: 0116 252 7220, Fax: 0116 255 6385, Webpage: www.leicester.gov.uk/intro.html

Rutland County Council, Planning Department, Environmental Services, Council Offices, Catmose, Oakham, LE15 6HP, Tel: 01572 722577, Fax: 01572 758373, Webpage: www.rutnet.co.uk/rcc

Contact address:

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

Positions of Scheduled Monuments at 15th August 2001 as supplied by English Heritage.

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, WS1 2ET, Tel: 020 7973 3132, Web page: www.english-heritage.org.uk

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

Coal Licence Areas © The Coal Authority 2001.

Contact address:

The Coal Authority, 200 Lichfield Lane, Mansfield, Nottinghamshire, NG18 4RG,

Tel: 01623 427162, Fax: 01623 638338

Published for the Department for Transport, Local Government and the Regions