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

Norfolk

Commissioned Report CR/03/174N

BRITISH GEOLOGICAL SURVEY

COMMISSIONED REPORT CR/03/174N

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Key words

Norfolk, mineral resources, mineral planning.

Front cover

Front cover photo Leziate Beds orange sands, East Winch, near Middleton

Bibliographical reference

D J Harrison, P J Henney, D G Cameron, N A Spencer, E J Steadman, S F Hobbs, D J Evans, G K Lott, B S PMoorlock and D E Highley. 2004. Mineral Resource Information in Support of National, Regional and Local Planning. Norfolk. *British Geological Survey Commissioned Report, CR/03/174N*.

Keyworth, Nottingham British Geological Survey 2004

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

Published for the Office of the Deputy Prime Minister.

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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 the county of Norfolk 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 of England 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 maps 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, silica sand, crushed rock aggregate, hydrocarbons, building stone, chalk and peat.

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.

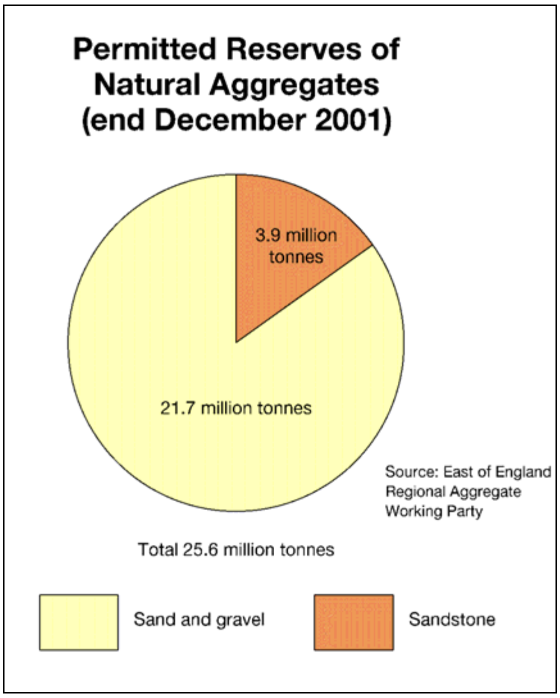
The constraints shown on the map are:

- National nature conservation designations - 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
- Scheduled Monuments
- Norfolk Broads (part)
- Norfolk Coast Area of Outstanding Natural Beauty (AONB).
- Heritage Coast

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 sand and gravel is composed of particles that are rich in silica (qaurtz, quartzite and flint), but other rock types may occur locally.



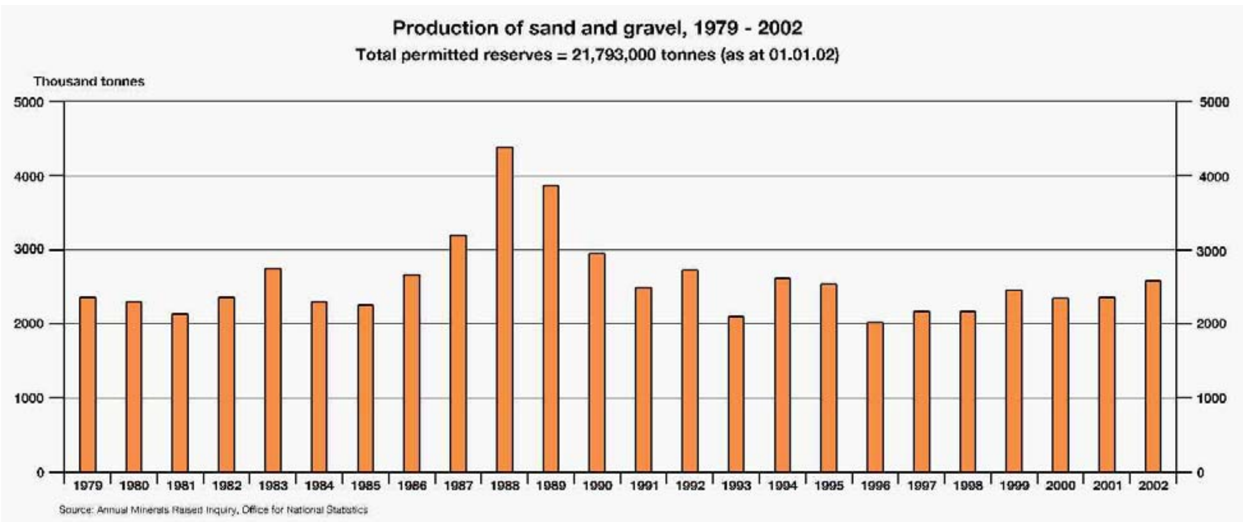


Figure 1. Permitted reserves of natural aggregates and production of sand and gravel in Norfolk.

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.

2.2 PRE-GLACIAL SAND AND GRAVEL

Pre-glacial fluvial and marine sand and gravel are present in the south and east of the county respectively. The fluvial sand and gravel, known as the Bytham Formation, were deposited by a pre-glacial river that flowed eastwards along a route very similar to that of the present day River Waveney; these deposits are thus restricted to this part of Norfolk, where they are almost entirely masked by overlying glaciofluvial deposits. The gravel fraction consists predominantly of sub-angular to well-rounded flint with up to about thirty per cent well-rounded quartz and quartzite clasts. The gravels are chalk-free. Lenses of fine- to coarse-grained sand and sandy gravel are also present. The gravels have been worked locally, often in combination with overlying glaciofluvial deposits, for example at Leet Hill, near Beccles. The Norwich Crag and the younger Wroxham Crag formation represent the marine formations. The former consists predominantly of fine- to medium-grained sand that is commonly ferruginous and locally shelly, although beds of silt and gravel may occur locally. The Wroxham Crag is predominantly a gravel with a similar composition to that of the Bytham Formation. The sands of the Norwich Crag are restricted to the south-eastern part of the county, whereas the gravels of the younger Wroxham Crag are well developed from Norwich northwards although generally, apart from in the deeper valleys and low-lying ground they are overlain by glaciofluvial deposits. The gravels have been worked in several small pits often in association with overlying glaciofluvial gravels.

2.3 GLACIOFLUVIAL SAND AND GRAVEL

Extensive outcrops and subcrops of glaciofluvial sand and gravel are present throughout the county. A feature of these deposits is their great variability in terms of thickness, particle size and composition. During the last one million years, Norfolk was over-ridden by ice sheets on several occasions. Some of the ice sheets covered most of the county, others impinged on the north or north-east of the county and did not extend far inland. In addition to producing extensive sheets of till (boulder clay), each ice sheet deposited outwash sand and gravel. In areas covered by two or more ice sheets this has commonly led to complex relationships with layers of till separating sand and gravel of differing age. In general, the most complex sequences occur in the north-east of the county, with the simplest relationships in the south and west.

In north Norfolk, a sand and gravel sequence, up to 40 m thick, caps the Cromer Ridge and provides a good source of aggregate. The gravels on the Cromer Ridge are comprised predominantly of fine to coarse, angular to well-rounded, flint with subordinate amounts of quartz, quartzite, and other far-travelled igneous and metamorphic rocks. The gravels are typically chalk-free. Similar, but much thinner, gravels extend westwards to just east of Hunstanton. These are much thinner, typically only several metres thick, commonly contain chalk, and are locally intermixed with chalky tills in a complex relationship. To the south of the Cromer Ridge, the glaciofluvial deposits in north-east Norfolk become finer grained and, from

North Walsham to the south of Great Yarmouth, are typically comprised of fine- to medium-grained chalky sands, with fine to coarse, poorly sorted gravels restricted to capping some of the small hills. Many of the small pits in north-east Norfolk have worked a combination of the glaciofluvial deposits and the underlying marine Wroxham Crag. Elsewhere in western and southern Norfolk, variable thicknesses of glaciofluvial sand and chalk-bearing flint gravel occur beneath the extensive tracts of Lowestoft Till (chalky boulder clay). These deposits crop out along many of the valleys where they have been worked for aggregate.

Figure 2 Fluvioglacial sand and gravel extraction, Feltwell Quarry, Thetford.

2.4 RIVER SAND AND GRAVEL (TERRACE AND SUB-ALLUVIAL DEPOSITS)

River Terrace Deposits, which postdate the glaciofluvial deposits, occur at several levels in most of the major valleys where they flank the present floodplain. The most extensive deposits occur in the valleys of the rivers Great and Little Ouse, Waveney, Nar, Wissey, Thet, Tas, Yare and Wensum.

The deposits generally comprise sequences of sands and gravels, commonly 3-8 m in thickness with a sheet-like geometry. The basal contact is gently scalloped, but locally the deposits may infill deep channels. The composition of the gravels reflects their derivation from upslope glaciofluvial gravels and also from the reworking of the Norwich Crag and Wroxham Crag formations where present. Where glaciofluvial input is dominant the gravel clasts tend to be angular to subangular with small quantities of rounded quartz and quartzite. Where input from the Wroxham Crag has been significant, the gravels contain a greater proportion of rounded clasts of flint, quartz and quartzite.

The River Terrace Deposits are generally dry in their upper part and saturated at lower levels, particularly in the lowermost terrace, and where the sand and gravel overlies impermeable deposits such as till.

Gravels occur beneath the silty alluvium and peat in many of the major valleys. The gravels were laid down during former cold periods when the rivers were graded to a lower base level than at present. In places, mapped River Terrace Deposits on the lower flanks of valleys can be demonstrated to extend beneath the alluvial deposits. The most extensive deposits of Sub-alluvial Gravels occur in the Waveney valley near Great Yarmouth where they have a proven maximum thickness of 11 m. The deposits comprise fine to coarse, predominantly flint gravels with subordinate sand. Because of their location, the Sub-alluvial Gravels are always saturated and require wet working.

Figure 3 River Wissey terrace sand and gravel deposit, Lynford, near Thetford.

2.5 BLOWN SAND

Impressive dunes of blown sand, some more than 12 m high, are a common feature along the coast of Norfolk, particularly in the Great Yarmouth, Winterton on Sea and Hunstanton areas. In places several rows of coast-parallel dunes are present with the most seaward row still receiving sand from the adjacent sandy beaches. The older and bigger dunes along the north Norfolk coast, which are now stabilised by vegetation, probably originated during the late Pleistocene and formed from extensive areas of glaciofluvial outwash sands that were exposed along the coast at that time. The blown sand is composed of clean, well-sorted fine- to medium-grained sand comprised of sub-rounded to well-rounded quartz grains.

2.6 BEACH SAND AND GRAVEL

Extensive areas of shoreface and storm beach sand and gravel are present around the Norfolk coast. On many of the modern beaches the distribution of sand and gravel is ephemeral, and may differ greatly before and after a storm event. The North Norfolk coast is characterised by several long, gravelly, storm beach spits, such as at Blakeney and Scolt Head. A further storm beach extends for some 11 km southwards from Hunsanton. The beach and storm beach gravels are composed predominantly of sub-rounded to well-rounded flints, generally less than 150 mm in diameter, with minor quantities of quartz and quartzite and, locally other less durable rock-types, for example, chalk, Carstone and Red Chalk occur in the deposits south of Hunstanton.

Figure 4 Red Chalk outcrop overlying Lower Chalk and underlying sandstone (carstone), Hunstanton.

3 Silica sand

Norfolk is one of the most important sources of silica sand in Britain accounting for over 10 per cent of total output and a much larger proportion of glass sand production.

Silica (industrial) sands contain a high proportion of silica in the form of quartz and are marketed for purposes other than for direct application in the construction industry. They are essential raw materials for the glass and foundry casting industries, but also have a wide range of other industrial and horticultural uses, including ceramics and chemicals manufacture, and for water filtration. They are produced from both loosely consolidated sand deposits and by crushing weakly cemented sandstones. Unlike construction sands, which are used for their physical properties alone, silica sands are valued for both their chemical and physical properties and it is on a combination of these properties that their industrial applications are based. These include a high silica content in the form of quartz and, more importantly, an absence of deleterious impurities, such as clay, iron oxides and chromite, and typically a narrow grain-size distribution (generally in the range 0.5 to 0.1 mm). For most applications silica sands have to conform to very closely defined specifications, specific uses demanding different combinations of properties. Consequently different grades of silica sand are usually not interchangeable in use.

Depending on the end use of a silica sand, processing is of varying degrees of complexity and often requires a high capital investment in plant. A critical factor in defining a sand or sandstone deposit as a silica sand resource is the ease with which contaminants, such as iron-bearing impurities and clay can be removed, together with the level of losses incurred in removing oversize and undersize fractions to obtain the desired size distribution. Resources of silica sand occur in only limited areas and the special characteristics of silica sand extraction and, in particular, the cost of processing means that the industry has a restricted distribution. Silica sands command a higher price than construction sand, which allows them to serve a wider geographical market.

Silica sand production in Norfolk is based on the Leziate Beds of Lower Cretaceous age at Leziate to the east of King's Lynn, which have been extensively exploited since before the Second World War. The Leziate Beds are the uppermost division of the Sandringham Sands Formation and crop out from the Wash, to the west of Hunstanton, southwards to Ryston near Downham Market in south-west Norfolk. They have a maximum thickness of 30 m in the Leziate – Middleton area and consist of loosely consolidated, mostly clean grey and white, fine–grained, well-sorted quartz sands. Subordinate bands of mudstone and silt may occur.

Resources of silica sand are difficult to define without a detailed evaluation of their properties and, most importantly, the ease with which they can be processed to a marketable quality. The outcrop of the Leziate Beds is shown on the map, which includes material covered by thin superficial deposits. Resources also occur beneath the overlying Carstone, both in isolated outliers, such as at Middleton, and to the east where the Leziate Beds dip beneath the Carstone.

Silica sand is quarried at two sites in the Leziate area. The most important is Wicken quarry, which supplies sand both for the manufacture of colourless glass containers and flat glass. Mintlyn quarry produces a fine foundry sand for resin coating, for use mainly in metal casting. In order to produce to high purity silica sand suitable for the manufacture of colourless glass the sands at Leziate are processed by sizing, attrition scrubbing, and either a cold or hot sulphuric acid leaching to remove iron oxides coating the individual quartz grains. Froth flotation can be used to remove heavy minerals if required. The hot acid leach yields a higher quality glass sand containing less than 0.035 per cent Fe_2O_3, which is suitable for use in the manufacture of colourless glass containers. Sand with a somewhat higher iron content can be used in the production of flat glass and is produced by a cold acid leach. The processing plant at King's Lynn is rail linked.

Figure 4 Leziate Beds orange sands, East Winch, near Middleton.

4 Chalk

Chalk is a relatively soft, fine-grained, white limestone consisting mostly of the debris of planktonic algae. The Chalk is of Upper Cretaceous age and occurs extensively in eastern and southern England where it forms an important resource of ‘limestone raw materials’. The Chalk is the dominant bedrock in Norfolk.

The White Chalk Subgroup (formerly known as the ‘Middle and Upper Chalk’) occurs extensively in central parts of the county, although much of the outcrop is concealed by a thick cover of superficial deposits. This part of the sequence is predominantly white coloured, with layers of flint. It is generally of high purity (93-98 per cent $CaCO_3$), in contrast to the underlying Grey Chalk Subgroup (‘Lower Chalk’) which is mainly of lower purity (<93 per cent $CaCO_3$) due to the numerous calcareous mudstone bands.

The Chalk has been worked in many parts of the county, primarily for agricultural purposes, although harder beds and the numerous flints have also been used for building stone. Chalk is currently extracted at only three sites, and on a relatively small scale, for the production of agricultural lime.

5 Crushed rock aggregate

A variety of hard rocks are 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 material is acceptable. Norfolk has limited resources of rock suitable for crushed rock aggregate.

5.1 SANDSTONE

In north-west Norfolk the Carstone of Lower Cretaceous age forms a local resource of crushed rock aggregate. The Carstone is a thickly bedded or massive, iron-rich sandstone which is commonly pebbly and medium-grained. It is dark greenish grey in colour but weathers to a rusty brown. In the northern part of its outcrop, around Hunstanton, it is 19 m thick, but becomes thinner and more clay-rich southwards from Sandringham.

The Carstone has been extensively quarried in the past for building stone, but in recent years extraction has been for relatively low-grade crushed rock aggregates. South of the River Nar, the formation becomes less massive and has not been worked. Currently, relatively low quality sandstone aggregates, such as fill materials, are produced in several quarries around Middleton, Sandringham and Snettisham. Some of the quarries also produce construction sand (mortar and asphalt sand) from the soft, silty, lower beds of the Carstone and from the underlying Leziate Member.

6 Peat

Peat is an unconsolidated deposit of plant remains formed in a water-saturated environment such as a bog or fen. Peat occurs extensively in the Fenland area of south-west Norfolk, in the Broadland area of east Norfolk, and also along the larger river valleys in the east of the county.

In the Fenland area, peat occurs at two main levels, a Lower Peat, and an Upper Peat commonly referred to on BGS maps as the Nordelph Peat. The bulk of the Lower Peat, which can be up to several metres thick, formed between 5400 and 4700 years BP, with isolated pockets preserved in deep channels and hollows which may date back to between 7000 and 9000 years BP. The Lower Peat is commonly separated from the Upper Peat by a series of inter-tidal silts. Radio-carbon dates indicate that formation of the Upper Peat commenced in about 4000 years BP and continued to form in places until the fens were drained in medieval times about 1500 year BP.

In the Broadland area, up to three layers of peat may be present, an impersistent Lower Peat up to about 2 m thick, an extensive Middle Peat generally between 2 and 4 m thick, and an Upper Peat generally confined to the marsh margins. Radio-carbon dates suggest that the Middle Peat in Broadland formed between about 5000 and 2000 BP years ago with the Upper Peat forming more recently than 1600 years BP. In places estuarine silts separate the peats, but towards the margins of the marshland the silts may be absent and the peats merge into a single combined unit. The peat was worked extensively for fuel between the 12th and 15th centuries; the workings now being flooded and forming the broads.

Many of the peatland areas in Norfolk have been given national or international conservation status. About 98 per cent of the peat extracted in the UK is used as a growing media by amateur gardeners and professional horticulturists.

7 Building stone

The Cretaceous formations of Norfolk have yielded a range of building stones. However, none of the quarries produced good freestone and a considerable volume of Middle Jurassic Lincolnshire Limestone (Barnack, Ancaster, etc) and some Caen Stone (Middle Jurassic limestone from Normandy) was imported into the county from medieval times onwards.

The Lower Cretaceous strata were the most important source of building stone, providing yellow-brown, ferruginous sandstones from the Carstone Formation, and Dersingham Member of the Sandringham Sands Formation, which were used extensively in buildings along their outcrop. In addition, some of the sands in the Leziate Member of the Sandringham Sands Formation in the Castle Acre area of north-west Norfolk have been cemented with a silica cement; these have been used locally for building stone.

Red chalk rubblestone from the Hunstanton (Red Chalk) Formation was occasionally used locally for building in the Old Hunstanton area. In contrast, the Upper Cretaceous white chalks were quarried across much of the outcrop e.g. Marham and Northwold for blockstone or 'clunch', as well as for flint, the most common local building stone.

Quartz-cemented and iron-cemented gravels and sands from the Quaternary have provided a very local source of building stone. Pebbles of flint, and other more exotic lithologies, derived from glaciofluvial outwash deposits and modern beaches, have also been used extensively for building purposes.

Currently, only the Carstone Formation is being quarried for building stone, on a small scale at Snettisham.

8. Hydrocarbons

8.1 CONVENTIONAL OIL AND GAS

To the north of the Variscan Front in southern Britain, the county of Norfolk occupies a tract of land beneath which Palaeozoic basement, forming part of the northern flank of the ancient London-Brabant Massif (LBM), lies at relatively shallow depths. Thin Mesozoic and Cainozoic rocks rest with (often) marked angularity upon the basement rocks. At crop they range from the Kimmeridge Clay Formation (Jurassic) in the west of the county, to Chalk and Cainozoic ('Tertiary') in the east. None of the potential Mesozoic source rocks found in the Southern North Sea are thick enough or have, in the onshore area, been buried to sufficient depths to generate hydrocarbons. In the east of the county, to the east and north of Norwich, boreholes have proved both Carboniferous Dinantian Limestone and strata of Westphalian (Coal Measures) age to subcrop the Mesozoic cover rocks. Representing a sandstones and mudstone sequence up to 60 m thick, no coals were recorded and the Westphalian has been assigned a C-D age.

Exploration for both gas and oil has occurred offshore in the southern North Sea where, sourced from Namurian shales and the Coal Measures, large gas fields such as Hewitt and Leman have been discovered within 25-50 km to the east of the coastline. Turning to the onshore, there have been brief periods of hydrocarbon exploration in the county. D'Arcy Exploration Company Limited drilled the first hydrocarbon exploration well at North Creake in 1945 (Table 1). It proved dry and was subsequently plugged and abandoned with no further testing. There followed a series of wells drilled in the late 1960s and early 1970s, with the last exploration well being by Trafalgar House Oil & Gas Limited at West Somerton in 1987. Seismic reflection data were acquired both during the late 1960s, accompanying the early phase of drilling, and the early and late 1980s. They occur in a strip of land upto 20 km wide around the northern and northeastern coastline. A group of three exploration wells were drilled at Ellingham, Rocklands and Breckles in the south central part of the county. They proved subcropping strata of Devonian age that may be connected to the south with that proved in the Four Ashes No.1 borehole in north Suffolk.

To date, hydrocarbon exploration in the county has proved unsuccessful with no oil or gas shows recorded in those wells drilled. Although initially appearing to offer little or no conventional hydrocarbon potential, the award to Roc Oil in the 11^{th} Onshore Licencing Round (2003) of PEDL127 (covering northern parts of the county), shows renewed interest in the prospects along the northern coastline area. The absence of suitable shale or coal source rocks proven in the county suggests that any plays will be reliant upon models that involve long distance migration of hydrocarbons from out of the southern North Sea and the presence of stratigraphic traps at the base of, or perhaps within, the thin Mesozoic rocks on the northern flank of the LBM.

Of related interest, the county has one of the main gas storage facilities at Bacton, which in 1999, accounted for some 19 per cent of gas supplied into the UK, coming mainly from the southern North Sea gasfields. Further storage facilities, perhaps using underground (geological) sites, might become important in the future.

8.2 COAL BED METHANE (CBM) POTENTIAL

Strata of Precambrian and Lower Palaeozoic age form the majority of the pre- Mesozoic basement to the county of Norfolk. Beneath the Wash to the north, strata of Namurian and Westphalian A-B age subcrop the cover rocks. Onshore there has only been a thin Westphalian C-D succession with no coals recorded.

Cainozoic strata of Palaeocene and Eocene age crop out and rest unconformably upon the Chalk in the east of the county, reaching a maximum thickness of some 115 m immediately offshore from Great Yarmouth (Arthurton et al., 1994). They comprise interbedded sandstones, siltstones and mudstones deposited in open marine to shallow brackish conditions near the margins of the then slowly subsiding southern North Sea basin. There are no references to the occurrence of lignite in these successions.

The county of Norfolk is therefore thought to have little or no CBM development potential.

Table 1. Hydrocarbon exploration and oil shale wells drilled in Norfolk.

Name	**Date**	**Company**	**Status**
Breckles No.1	Dec 1969	Norris Oil Company Ltd	Plugged & Abandoned, dry
East Ruston No.1	June 1971	Hamilton Brothers	Plugged & Abandoned, dry
Ellingham No.1	Dec 1964	Superior Oil	Plugged & Abandoned, dry
Hunstanton No.1	Jan 1969	Place Oil & Gas Company (UK) Ltd	Plugged & Abandoned, dry
Lexham No.1	Oct 1971	Norris Oil Company Ltd	Plugged & Abandoned, dry
North Creake No.1	May 1945	D'Arcy Exploration Company Ltd	Plugged & Abandoned, dry
North Runcton	1974	IGS/DEn oil shale project	Plugged & Abandoned, dry
Rocklands No.1	Nov 1969	Norris Oil Company Ltd	Plugged & Abandoned, dry
Saxthorpe No.1	Oct 1970	Duntex Petroleum Corporation	Plugged & Abandoned, dry

Somerton No.1	Jan 1969	Continental Oil Company of England Ltd	Plugged & Abandoned, dry
South Creake No.1	Aug 1969	BP Petroleum Development Ltd	Plugged & Abandoned, dry
West Somerton No.1	Oct 1987	Trafalgar House Oil & Gas Ltd	Plugged & Abandoned, dry
Wiggenhall No.1	Jan 1971	Texaco Production Services Ltd	Plugged & Abandoned, dry

9 Aims and limitations

The purpose of the maps in this series is to show the broad distribution of those mineral resources which 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 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 Norfolk County Council. 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.

9.1 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 digitised by BGS from Plotting Sheets and other documents supplied by Norfolk County Council and any queries regarding the sites shown should be directed to these authority at the address 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.

APPENDIX 1

CONTACT ADDRESS:

Norfolk County Council, Planning & Transportation Department, County Hall, Martineau Lane, Norwich NR1 2SG, Tel: 01603 222222, Fax: 01603 223219, Web page: www.norfolk.gov.uk

TOPOGRAPHIC BASE

Topography reproduced from the OS map by British Geological Survey with the permission of Ordnance Survey on behalf of The Controller of Her Majesty's Stationary Office, © Crown copyright.

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

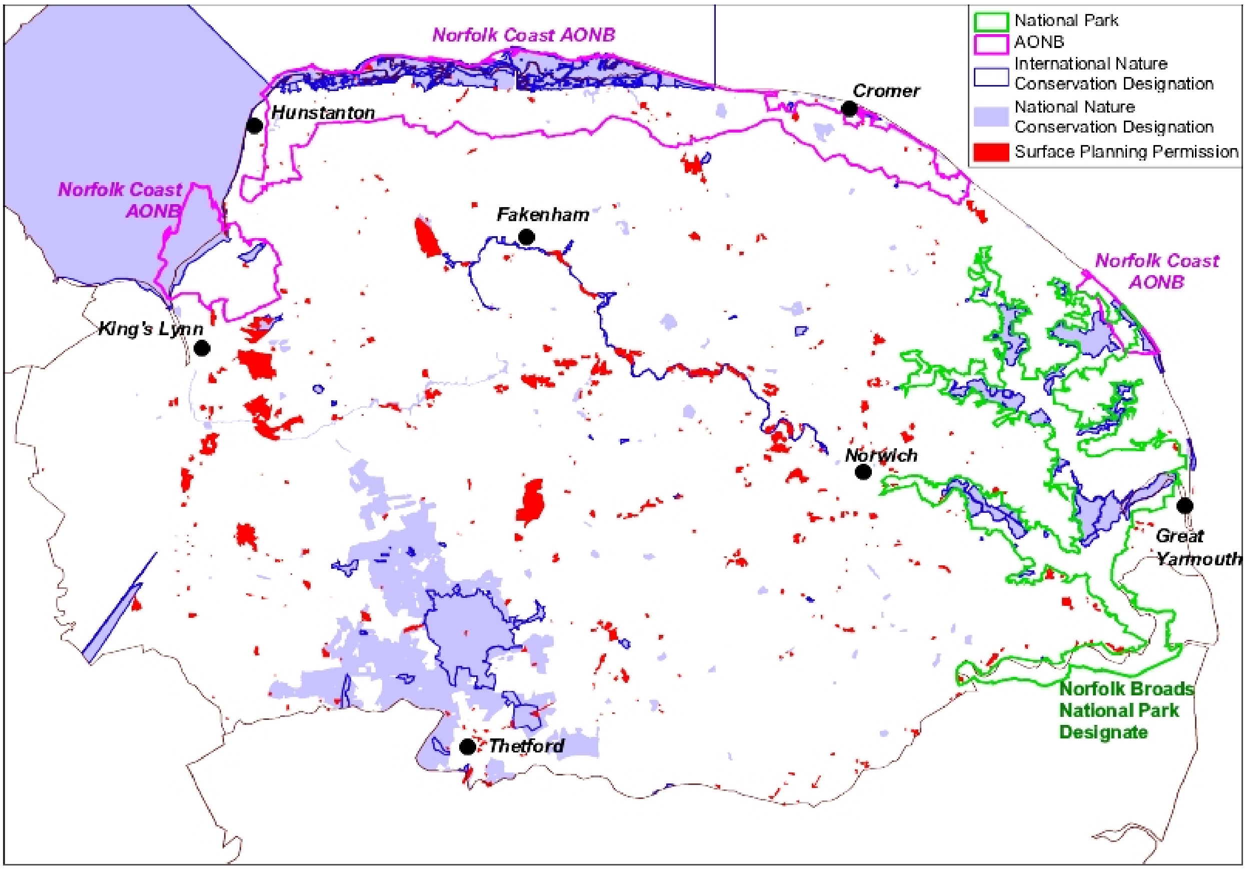


Figure 5 Constraints and designations in Norfolk.

English Nature – Digital SSSI, NNR, SPA, SAC and Ramsar boundaries © English Nature 2003.

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

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 schedlued 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

Countryside Agency – Digital AONB boundaries © Countryside Commission 1986.

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