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

Lancashire (comprising Lancashire and Boroughs of Blackpool and Blackburn with Darwen)

Commissioned Report CR/05/144N

BRITISH GEOLOGICAL SURVEY

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Cover illustration

Castle Cement Limited, Ribblesdale Works at night showing Kiln 7 Pre Heater Tower and the Wet Gas Scrubber. Photo Courtesy of Castle Cement Ltd

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This report accompanies the 1:100 000 scale map: Lancashire (comprising Lancashire and Boroughs of Blackpool and Blackburn with Darwen)

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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 Lancashire, comprising Lancashire and the Boroughs of Blackpool and Blackburn with Darwen, 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 North West 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, crushed rock aggregate, brick clay, building stone, silica sand, salt, metallic mineralization, 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:

- 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;
- Areas of Outstanding Natural Beauty (AONB) – Pendle Hill, Forest of Bowland (part) and Arnside and Silverdale (part); 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 sand and gravel is composed of particles that are rich in silica (quartz, quartzite and flint), but other rock types 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. Substantial quantities of sand and gravel may also be used as constructional fill.

Between 1998 and 2004 annual production of sand and gravel in Lancashire (comprising Blackpool and Blackburn with Darwen) has varied roughly between 350,000 and 1 million tonnes. Recent production is shown on the graph and permitted reserves are estimated at about 3.54 million tonnes. Marine dredged sand and gravel is landed at Heysham (95 550 tonnes in 2004).

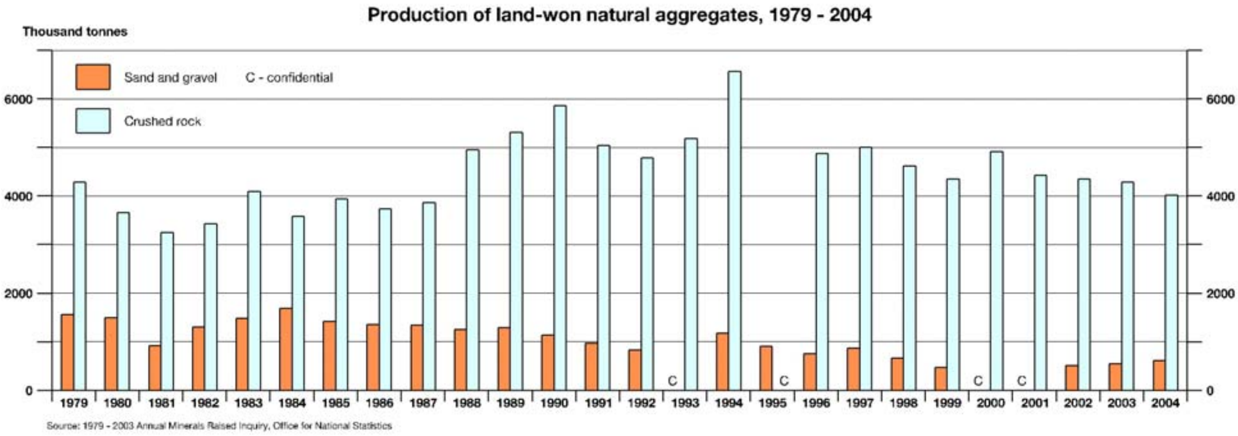

Figure 1. Production of sand and gravel in Lancashire, 1979-2004

Sand and gravel resources occur in a variety of geological environments. In Lancashire these resources occur mainly within superficial or 'drift' deposits, subdivided into river sand and gravel, glaciofluvial sand and gravel and blown sand. Sand is also produced from crushing bedrock deposits (see Sandstone).

Allott and Lomax (1990) gave a broad indication of the resources of sand and gravel in the region. Although the report was prepared before the most recently completed mapping in the region, it identifies several areas, particularly to the north of Lancaster where sand and gravel is likely to be present within the till sheet.

2.1 SUPERFICIAL DEPOSITS

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 are best developed along the Rivers Ribble, Hodder and Condon with a succession of deposits formed, representing accumulations of sand and gravel in response to falling sea level in

Pleistocene times. Less developed terrace deposits occur along the Rivers Darwen, Wyre and Wenning. The deposits typically consist of upwardly-fining and laterally graded spreads of gravel, sand, silt and clay.

In central Lancashire, terrace deposits occur along the River Ribble from south of Preston to Holden, north of Clitheroe. The distribution of terraces in the Ribble Valley relates to the blockage of the river by thick glacial drift in the Clitheroe district. South of Preston there is a wide alluvial flood plain, but upstream the valley is occupied largely by two river terraces, 1 m and 3 m above the flood plain. The terraces comprise mainly of gravel capped by sand and silt. Terrace deposits in the Preston area are predominantly sterilised by urban development. However, to the northeast of Preston, these deposits are worked at Brockholes, Samlesbury for asphalting sand, building sand and concreting aggregate. A similar development of fluviatile alluvium and terraces is found in the valley of the River Darwen, which joins the Ribble above Preston.

Northwest of Clitheroe, fluvial deposits of sand and gravel form localised terrace deposits in the upper reaches of the River Hodder between Whitewell and Slaidburn. At least three terraces have been identified, although only First and Second Terrace deposits have been widely mapped. Second Terrace occurrences are generally thin and patchy. Further more limited deposits occur in the lower Dunsop and Langden valleys.

River terrace deposits occur along the River Condor, in particular around Galgate. Here, three terraces are developed at about 2 m, 4 m and 6 m respectively above the present floodplain, the lowest being the most extensive. The underlying deposits consist mostly of well-sorted sand and gravel up to 5 m thick. River terrace deposits have been worked on a small scale in the Galgate area.

Less developed terrace deposits occur along the River Wyre and River Lune. Along the River Wyre, south of Lancaster, two terraces have been mapped. The deposits beneath the first terrace have been worked to the south of Dolphinholme, where sections in gravel pits showed up to 4 m of gravel overlying 1.5 m of well-laminated sand and silt. Along the River Lune, sand and gravel up to 9.5 m thick has been recorded from boreholes put down on a terrace about 2 m above the present floodplain.

In the northern part of Lancashire, the drainage system is relatively immature with upland rivers and streams still actively downcutting. Terrace formation is extremely irregular in these upland areas, with innumerable, small, undifferentiated terraces occurring, underlain by 2 to 4 m of coarse imbricate bouldery gravels. These deposits are typically underlain by glaciofluvial deposits. West of High Bentham, localised terrace deposits occur at the confluence of the River Wenning and Hindburn.

2.1.2 Glaciofluvial sand and gravel

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. Only areas of exposed glaciofluvial sand and gravel are shown on the map.

Extensive resources of glaciofluvial sand and gravel have been mapped in the south of the county around Blackburn and Preston, the country east of Blackpool up to the M6 and in the north of the county around Lancaster. However, boreholes reveal that glaciofluvial deposits are more widespread than is suggested by mapping. The thickness of such deposits is variable but may be as high as 20 – 30 m. Large areas of these resources have been, however, sterilised by urban development.

Glaciofluvial sand and gravel is worked in two quarries: at Bradley Sandpit near Fulwood and at Lydiate Lane, Leyland. The quarries are producing general purpose building and concreting send from glaciofluvial deposits 4 m to 20 m thick. The deposits are naturally clean and can be processed by dry screening.

Figure 2. Bradley Sandpit near Fulwood, Lancashire. Working glaciofluvial sand and gravel.

2.1.3 Blown sand

Wind blown sands are of little importance as a source of aggregate because they are usually too fine-grained and uniform in size for use as concrete aggregate. Their narrow grain size is also an inhibiting factor for use in mortar.

Along the southwest coast of Blackpool and St Annes a large belt of blown sand between 2 and 5 km wide has developed, but the deposits are largely sterilised by urban development. Beach sand and some proto-dune blown sand is currently being won from the St Annes foreshore.

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.

Lancashire has important hard rock resources consisting of both limestones and sandstones of Carboniferous age. The limestones are the most important both in terms of output and quality. Carboniferous sandstones are generally only suitable for less demanding applications, but their proximity to major conurbations means that they are worked on a substantial scale.

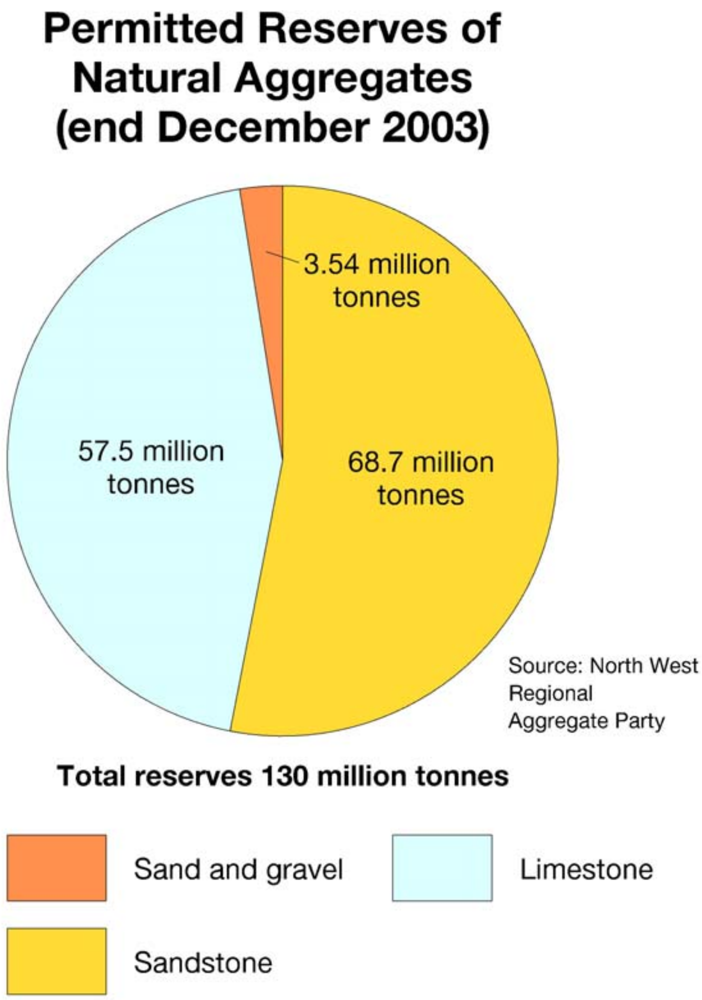

Figure 3. Permitted reserves of natural aggregate in Lancashire at end December 2003.

3.1 LIMESTONE

Lancashire is an important source of limestone and in 2004 4.68 million tonnes were quarried in the county. Most (about 3 million tonnes) is consumed in the construction industry as aggregate or fill for local and regional needs. Significant amounts of limestone are also produced for cement manufacture at Clitheroe.

The Carboniferous Limestone is a major source of limestone aggregate and it these rocks which comprise the present and future resources of limestone in Lancashire. The Carboniferous limestones of Lancashire occur in two distinct areas, each containing rocks of distinctive character and thickness.

In the northwest of the county, Carboniferous limestones crop out around Carnforth. These limestones, which form part of the larger resource area of south Cumbria, are shallow water, 'shelf' limestones that are mostly thick-bedded, pale grey, consistent deposits. They are structurally simple and can be quarried extensively and economically. Currently three quarries work these limestones for aggregates and have good motorway access, distributing aggregate materials to north Lancashire and Merseyside. The limestones in this area are mostly of high purity. Notable high purity (>97% $CaCO_3$) units are the Park Limestone and Urswick Limestone formations; both contain substantial thicknesses of high purity limestone and form a potential resource of industrial grade limestone. The Urswick Limestone is the most actively quarried unit; extraction is for crushed rock aggregate production.

Carboniferous limestones in the Clitheroe area were deposited in a different sedimentary environment (of deeper water sedimentation) from the limestones in the Carnforth area. The limestone sequence is much thicker and is significantly different in lithology. Dark grey, shaly limestones interbedded with mudstones predominate. The limestones are very variable in character, are folded and steeply dipping. Partial replacement of the limestones by silica and dolomite is a common feature. The limestones are also mostly concealed beneath superficial (drift) deposits. Most of the limestones are impure or are of low and variable chemical purity. Knoll-reef limestones, however, are developed around Clitheroe and these form relatively consistent deposits of high purity limestone. The knoll-reefs range in thickness from less than 30 m to over 600 m and are formed of massive, mid-grey, fine-grained limestone.

Figure 4. A view of Lanehead Quarry and the Ribblesdale Cement Works, from the nearby village of Chatburn. Quarry is working the Carboniferous Chatburn Limestone. Photo Courtesy of Castle Cement Ltd

The most important limestone unit in the Clitheroe area is the Chatburn Limestone which consists of over 200 m of dark grey, well bedded limestone with muddy partings but relatively few thick mudstones. They are relatively well exposed and are extracted in a large shared quarry at Clitheroe for aggregate (Tarmac Ltd North West) and cement production (Castle Cement). The large cement plant, utilises the natural mix of limestone and mudstone. Some local deposits of higher purity knoll-reef limestone are used to optimise the mix. The cement plant has a clinker capacity of 0.75 million tonnes per year. It is therefore a major consumer of limestone raw material with, approximately, 1.6 tonnes of dry raw material being required for each tonne of clinker produced. Aggregates from this site are used for roadstone (as it is a naturally dark coloured stone) and there are two asphalt plants within the quarry. Output is around 1 million tonnes per year and all products are transported by road to markets within Lancashire as far as Liverpool.

3.2 SANDSTONE

The Carboniferous sandstones of the Millstone Grit and Pennine Coal Measures groups (particularly the Lower Coal Measures) of Lancashire have traditionally been extensively used as a source of building stone and, today, both disused and working quarries are a common feature of the landscape. However, the main use of the sandstone is for relatively low-grade aggregate; sales of sandstone aggregate were about 1.2 million tonnes in 2004.

Carboniferous sandstones consist of sand-sized particles, with minor pebbles, composed dominantly of quartz, but also with some feldspar, which are cemented by silica, to a greater or lesser extent. The sandstones are typically buff-coloured, although locally grey, and vary from fine- to coarse-grained.

Most of the sandstones are too weak and porous to make good quality aggregate for roadstone and concrete, but maybe suitable for fill and for the production of manufactured sand to produce reconstituted stone products. The Haslingden Flags (Millstone Grit) are unusual in that they are much stronger than most other local sandstones, and are capable of producing crushed rock aggregates for concrete and roadstone.

There are currently around 12 working sandstone quarries in Lancashire and together with several quarries in adjacent areas of Greater Manchester, they form one of the largest concentrations of sandstone quarries in Britain. Most quarries produce blockstone or a range of masonry products and some produce crushed sandstone aggregate generally for less demanding specifications, although three quarries working the Haslingden Flags also produce roadstone. Some quarries crush and process significant amounts of sandstone to produce manufactured sand for aggregate use (both coarse sand, 3 – 6 mm, for concrete products and fine sand, <3 mm, for building sand) as there is a regional shortage of natural sand.

There are many sandstone units within the Carboniferous, but the Upper and Lower Haslingden Flags, the Fletcher Bank Grit (all Millstone Grit), the Ousel Nest Grit and the Old Lawrence Rock (Lower Coal Measures) are the most extensively worked of the sandstones.

Figure 5. Hanson Aggregates: Brinscall Quarry, Chorley, Lancashire; Carboniferous, Fletcher Bank Grit is worked for crushed rock aggregates. Photo courtesy of Hanson Aggregates.

4 Brick Clay

‘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 bricks such as strength and frost resistance and, importantly, its architectural appearance, such as colour and texture.

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 and consistent raw materials is of paramount importance.

Brick clay has been worked extensively in the past, mostly from Carboniferous mudstones (chiefly from the Pennine Coal Measures but also the Millstone Grit). Today the Pennine Coal Measures remain the principal brick clay resource and are shown as coincident with shallow coal and unproductive Coal Measures on the map. Resources of brick clay are extensive in Lancashire and there are several large production units for facing and engineering bricks extracting mudstones from the Lower Coal Measures and Millstone Grit. The suitability of Carboniferous mudstones depends, in part, on their carbon and sulphur contents. Both may lead to firing problems and sulphur may also give unacceptable emission levels, although blending of clays may reduce these problems. The Accrington Mudstone (Lower Coal Measures) of Lancashire is higher in illite and consistently lower in carbon than other Coal Measure mudstones and is the principal brick clay resource. Similar greenish-grey mudstones occur at the level of the Haslingden Flags (Millstone Grit) and also form a valuable resource. The location of brick pits is principally the result of proximity to the centre of demand and ease of accessibility, rather than on factors simply of resource quality. As both the Coal Measures and Millstone Grit consist predominantly of interbedded sandstones and mudstones, several sandstone quarries are sources of brick clay and vice versa.

5 Building Stone

Historically, Lancashire has a very long tradition of using locally quarried stone for building purposes. The oldest rocks of the county are the limestones of the Lower Carboniferous succession and these have been quarried locally along much of their outcrop, notably around Carnforth and Clitheroe.

Many of the overlying Carboniferous (Namurian) sandstone units have also been quarried in the past for building stone, for example, the Pendle Grit (Ogden Reservoir); Warley Wise Grit (Sabden Reservoir); Kinderscout Grit (Walshaw Dean and Longdendale reservoirs). The sandstone of the Pendle Grit Formation was extensively quarried for building around Preston for example at Longridge Fell and Mellor. The town hall at Preston is built of Longridge Stone. The Ellel Crag sandstone, one of several sandstones used extensively in Lancaster and the surrounding villages and towns, also known as Galgate Stone, is still worked. The Rough Rock was worked to small extent on Scout Moor for buildings stone. In recent years, the Fletcher Bank Grit was used for the construction and restoration of Manchester Cathedral. Extensive stone quarrying industries developed in several areas notably along the Tame, Rossendale and Longdendale valleys where houses, factories bridges, and reservoirs are characteristically constructed of local stones.

The Haslingden Flags (Lower and Upper) were quarried and mined in several areas around Chorley and, most extensively, along the Rossendale Valley from Whitworth and Bacup through Rawtenstall, Haslingden to Pickup Bank. Many of the local towns and villages were built and roofed using block stone and flagstone from these sandstones. The Moorcock Sandstone was quarried extensively at Caton Moor for flagstone. The numerous small pits in the Ward's Stone Sandstone on the fells around Clougha supplied fissile sandstone for roofing to Lancaster and surrounding towns and villages.

In the southern part of the county the numerous sandstones of the Pennine Coal Measures Group have also been extensively exploited in the past throughout their outcrop area. The fissile sandstones of the Dyneley Knowle (at Appley Bridge, Billinge and Stalybridge) and Upholland flags provided paving and roofing slates for local use e.g. in St. Helen's, Wigan, Bolton, Darwen, Accrington, Burnley etc.

The more massive beds of these Lower Coal Measure sandstone units have also been locally worked for building stone e.g. Crutchman (Milnrow) and Old Lawrence Rock (Stalybridge), Ousel Nest (Bolton) and Tim Bobbin (Burnley) sandstones. The growth of the former industrial towns of Skelmersdale, Chorley, Blackburn, Accrington, Burnley and Nelson, at the heart of the coalfield area, formerly supported a very active local building stone industry.

The red and yellow sandstones of the Triassic Sherwood Sandstone Group succession cropping out in southwest of the county have been worked at a number of localities for local building stone including Halsall, Melling, Clieves, Downholland and Altcar. Currently there are 11 active building sandstone quarries in the county all working sandstones from the Carboniferous succession.

6 Silica Sand

Silica (industrial) sands contain a high proportion of silica (SiO_2) in the form of quartz and are used for purposes other than as construction aggregates. They are essential raw materials for the glass and foundry castings industries, but also have a wide range of other industrial applications, including in ceramics and chemicals manufacture, for water filtration media, and in sports and horticultural applications. 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 a combination of chemical and physical properties. These include a high silica content in the form of quartz and, more importantly, low levels of impurities, particularly clay, iron oxides and refractory minerals such as chromite. Silica sands typically have a narrow grain size distribution, generally in the range 0.5 mm to 0.1 mm, although coarser grades are required for some applications. For most applications, silica sands have to conform to very closely defined specifications and consistency in quality is of critical importance. Particular uses often require different combinations of properties. Consequently, different qualities of silica sand are usually not interchangeable in use. Silica sands command a higher price than construction sands. This allows them to serve a wider geographical market, including exports.

Silica sand processing is of varying degrees of complexity and depends on the nature of the raw material and the end use of the sand. It typically requires a high capital investment in plant. Processing is aimed at modifying both the physical and chemical properties of the sand to meet user specifications. 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 from a sand, has a major bearing on its potential use. Within the UK, deposits of silica sand occur in only limited areas and quantities, and the special characteristics of silica sand extraction, in particular the cost of processing, means that the industry has a restricted distribution.

Large parts of the west Lancashire Plain are covered by extensive deposits of wind-blown sand known as the Shirdley Hill Sand Formation. The sands, which are up to 3 m thick, are younger than the glacial deposits and lie immediately beneath a cover of topsoil. They account for some of the most productive agricultural land in Lancashire. The sands are fine-grained, yellow and grey and characteristically uniform in both composition and grain-size distribution, reflecting their wind blown origin. The sand deposits were of considerable economic importance in the past as a source of glass sand, particularly after the development of St Helens as a major glassmaking centre. The sands have been extensively worked in the Ormskirk/Rainford area for the production of coloured container glass and, more importantly, flat glass. Most of the sand particles fall in the range 500 µm to 125 µm, which is ideal for glass making but unsuitable for construction use. For flat glass manufacture only the top 0.5 to 1 m of lower iron sand was worked directly beneath topsoil. This sand typically contains 97% SiO_2 and 0.1–0.12% Fe_2O_3, the latter component being the most critical for glassmaking. However, the thinness of the deposits, the large areas required and the consequent high working costs led to their gradual replacement by Chelford Sand from the Cheshire Basin. Extraction for flat glass manufacture ceased in 1977. Because the deposits are so thin and such large areas of land would be required to maintain production, it is unlikely that the Shirdley Hill Sand will be used as a source of glass sand in the future. In addition, current market trends are for lower iron glass, which would be difficult to achieve using the Shirdley Hill Sand. Consequently they are not shown as a resource on the main map. The sands have, however, been worked for horticultural use. The extent of the Shirdley Hill Sand and their historic planning permissions are shown on the inset map.

7 Salt

Salt (sodium chloride, NaCl), occurs in nature in the solid form as rock salt (halite) or in solution as brine. Rock salt occurs in beds, commonly associated with mudstone, ranging from a few centimetres up to several hundred metres in thickness. The purity of individual salt beds depends on the extent of mudstone interbedding. Salt-bearing strata do not crop out at the surface in the UK because of dissolution by groundwater. The boundary at which salt dissolution is taking place is called the 'wet-rockhead.' Where salt-bearing strata are too deep to be affected by groundwater, the normal contact between the salt and overlying rock is known a 'dry-rockhead.' Brine occurs naturally at the wet-rockhead but may also be produced artificially by injecting water into the salt bed and pumping out the resultant salt solution. This may contain up to 25–26% NaCl when fully saturated.

In the UK rock salt is extracted by underground mining, for use principally in de-icing road, and by controlled brine pumping for use as a chemical feedstock and in the manufacture of white salt. Natural or 'wild' brine pumping has, in the past, resulted in accelerated subsidence over wide areas. Modern, controlled methods of brine extraction, which were developed at Preesall, do not cause subsidence and almost all brine is now produced by this method. At Preesall, however, subsidence did occur as the method was being developed.

Salt resources in Lancashire occur at Preesall within the Triassic, Mercia Mudstone Group in a small area to the east of Fleetwood. The principal salt-bearing unit is the Preesall Halite Formation, which is preserved in a fault-bounded graben and is continuous with the salt resources that occur beneath Walney Island in Cumbria. The complete sequence of the Preesall Halite Formation, proved by boreholes to be up to 289 m thick on the western edge of the former brinefield, is only present in the area of the dry-rockhead. The extent of the wet-rockhead and dry-rockhead is shown on the map.

Salt was produced at Preesall between 1889 and 1993. Extraction was initially by brine pumping using an early form of controlled brine pumping in which cavities are created in the salt bed. Soon after rock salt mining was introduced but was abandoned in the early 1930s. The brine was used in salt manufacture and as a chemical feedstock. In later years it was only used in the manufacture of chlorine and caustic soda by the electrochemical process at the Hillhouse works in Fleetwood. However, this plant closed in 1993 removing the need for brine. With a large and well, established salt industry in Cheshire, it is highly unlikely that production will resume at Preesall.

Salt-bearing strata are, however, ideally suited for the creation of storage cavities, notably for natural gas but also other materials. Proposals have been made to create an underground natural gas storage facility to the east of the Wyre Estuary. Twenty cavities are proposed to be developed by solution mining at depths of up to 350 m. The resulting brine will be discharged into the sea. (see also Hydrocarbons).

8 Metallic mineralisation

The Lower Carboniferous Craven Basin, which extends over an area approximately 60 km by 30 km from Lancashire into North Yorkshire, has potential for base-metal mineral deposits. BGS and industry have carried out mineral exploration in the area over the past 35 years. Significant Zn/Pb mineralisation has been found in the Slaidburn area, north of Clitheroe in Lancashire, and northeast of Settle in North Yorkshire. BP Minerals and Cominco drilled a number of holes in the late 1970s and early 1980s and found both stratiform and replacement mineralisation within carbonate rocks of Tournaisian and lower Dinantian age (Lower Carboniferous).

The mineralisation displays similarities in its geological setting to the major, currently worked Zn/Pb sulphide deposits in rocks of the same age in the Irish Midlands; Navan, Galmoy and Lisheen. The Craven Basin is thus still regarded as prospective for base metal mineralisation.

9 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, almost exclusively from precipitation, have a low nutrient content and where rainfall is sufficient to maintain the ground surface in a water logged 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. Many lowland raised bogs have been designated as sites of international and national conservation areas. Peat is dug in England mainly from raised lowland bogs, almost entirely (98%) for horticultural purposes, either as a growing medium, or as a soil improver.

In Lancashire, extensive lowland bogs have been mapped in the extreme southwest and west of the county. Many of the peat deposits have been worked extensively in the past and today a large percentage of these areas have been “reclaimed” to agricultural land. Due to the unavailability of up to date linework defining the extent of the reclamation, the entire resource as mapped is shown on the map. Today, peat is worked at Simonswood Moss, northwest of Kirkby. Areas of upland blanket peat are not shown.

10 Coal

Southwest and southeast Lancashire lie within the South Lancashire and Burnley (Wigan Basin) coalfields respectively. The northwestern limits of the South Lancashire Coalfield crop out in the south of the county in the Chorley to Ormskirk area. Pennine Lower to Middle Coal Measures dip to the south, where they eventually become concealed beneath the Permo-Triassic of the Cheshire Basin. In excess of 30 named coal seams occur within the South Lancashire Coalfield, the most important of which occur in the middle and upper parts of the Pennine Lower Coal Measures and throughout the Pennine Middle Coal Measures, with a number of seams in excess of 2 m in thickness. Coals from the Pennine Upper Coal Measures are generally thin, the exception being the Worsley Four Foot, which can be up to 1.6 m in thickness. Within Lancashire, the Lower Coal Measures predominantly occur. Although the county was formerly an important coal mining area there are no significant current mining operations, opencast or underground. There has been no opencast coal extraction since the early 1990s. Very small sale underground mining is carried out intermittently at Hill Top Colliery near Bacup. The future potential for opencast working is limited by the lack of thick seams in the basal part of the Lower Coal Measures, the overlying thick drift deposits and the extensive urban development.

Within the Burnley Coalfield, the main coal bearing interval occurs within the Lower Coal Measures (Upper Carboniferous) and can be up to 650 m in thickness. The seams occur from surface and are overlain by thick superficial drift deposits, particularly in the west. The seams are often of excellent quality but are relatively thin. The most important seams are the Burnley Four Foot, Ardley, and Lower and Upper Mountain seams. The Burnley Coalfield which has been extensively worked in the past, is not currently worked. The last deep mine, Hapton Valley Colliery, was closed in 1982. The potential for future underground coal mining is low due to extensive mining in the past and the lack of good, thick seams. Although large areas of shallow coal has been sterilised by urban development and thick overburden occurs in parts, some potential for future opencast sites remains in the east of the county.

Significant parts of the Burnley Coalfield and parts of the South Lancashire Coalfield are now considered to be unproductive. These areas are shown on the main map as a brick clay resource and on the inset map for hydrocarbons. Locally, however, small opencast prospecting may exist within these areas.

A further small area of unprospective coalfield occurs in the northeast of the county, part of the Ingleton Coalfield. This coalfield has limited extent and little coal remains and is not shown on the main map.

11 Hydrocarbon

11.1 CONVENTIONAL OIL AND GAS

Urban development dominates the southern area of the county, with other large urban areas around Preston, Blackpool and Lancaster. The southern urbanisation is associated with the outcrop of Westphalian (Pennine Coal Measures) strata in the Burnley and northwestern parts of the important South Lancashire Coalfield. Much of this area has been heavily mined. Parts of the small Ingleton Coalfield crop out in the northern reaches of the county.

Elsewhere, Dinantian and Namurian strata are at crop over the eastern half of the county area, whilst Permo-Triassic strata crop out over the western half and represent the onshore continuation of the East Irish Sea Basin. Within this basin, hydrocarbons, mainly gas, have been discovered offshore in the Morecombe, Douglas, Lennox. Millom, Hamilton (including East and North), Bains, Calder, Dalton, Ormond South and Crossans fields. Oil has also been produced from the Douglas and Lennox fields.

Onshore, there are many known occurrences of oil and gas. Gas is encountered in the coalfields, and oil seeps have been recorded in the Formby area since 1637. A tragic example of gas generation is provided by the explosion at the Abbeystead water pumping station in May 1984. A build-up of methane gas that had collected in the tunnels and underground valve house was ignited and the ensuing explosion and fire killed 18 people and badly injuring many more. The gas is likely to have originated from the Namurian shales.

The region has attracted interest from oil companies. In 1939, D'Arcy Exploration (later to become BP) drilled 45 shallow wells and proved the existence of the small Formby Oilfield, straddling the western county boundary and extending into Merseyside (Table 1). The oilfield proved almost unique, being sealed by glacial boulder clay and produced 71,557 barrels of oil until it was shut down in 1965 (Table 1). Much work has gone into trying to identify the origin of the oil, with most observers believing it represents a deeper and breached Carboniferous trap: hydrocarbons have been generated from the underlying Carboniferous (Silesian) source rocks.

Reflecting the potential of the Namurian shales as source rocks, there have been quite intensive periods of oil exploration across much of the county. At one time or another, exploration licences have covered much of the county and there has been extensive acquisition of seismic reflection data and drilling of a number of exploration wells (Table 2). Exploration wells to date, however, show little or no success (Table 2), with the exception of Elswick and Thistleton wells, drilled over the Permo-Triassic crop. British Gas drilled Thistleton 1 in 1988, which encountered gas shows. Elswick 1 was subsequently drilled in 1990 and encountered commercial quantities of gas in Permo-Triassic reservoirs (Table 1). The gasfield was developed in 1996 and to date, has produced 11,722,000 m^3 of gas. The produced gas is used for power generation on site and supplied to local industries.

Only four licences were held in late 2004. One was by Warwick (EXL 269-1) who operate the Elswick Gasfield. These licences reflect the fact that the hydrocarbon prospectivity of the county is not presently perceived as great, with perhaps the best prospects appearing to be in the west of the county, adjacent to the producing East Irish Sea Basin. The absence of Mesozoic strata across much of the eastern half of the county means that the potential for oil and gas fields must rely on similar conditions occurring to those in the East Midlands oil province. That is, an intra-Carboniferous play and accumulations that have been little disturbed since their formation and charging.

Noteworthy is the Kirkham well, drilled in 1970 as a test for the underground storage of gas by the NW Gas Board. This is a topic gaining much significance due to the fact that by around 2004, and despite our North Sea reserves, the UK became a net importer of gas. Further such gas storage projects are now going through planning application and public enquiry stages, including one by Canatxx around the River Wyre.

Table 1. Oil and gas fields in Lancashire

Name of field	Field Type (oil or gas)	Operator at time of discovery	Current operator	Discovery date	Production started	Status at 2005	Total production (tonnes/barrels or Ksm^3)
Formby	Oil	D'Arcy Exploration Company Ltd.	Currently open acreage	1939	1939	Shut down (1965)	10,195/71,557
Elswick	Gas	British Gas	Warwick	1990	1996	Still producing	12,723

Source: DTI

Table 2. Hydrocarbon exploration wells in Lancashire

Exploration wells	Drilling date	Original operator	Status
Bickerstaffe 1	1944	D'Arcy Exploration Company Ltd	Plugged &Abandoned, dry
Boulsworth 1	1963	Conoco	P&A dry
Hesketh 1	1990	British Gas	P&A dry
Holme Chapel 1	1974	Quintana Petroleum Corporation	P&A dry
Roddlesworth 1	1988	Amoco	P&A dry
Scarisbrick 1	1939	D'Arcy Exploration Company Ltd	P&A dry
Swinden	1978	Cluff Oil & IGS	P&A dry
Thistleton 1	1988	British Gas	P&A gas shows
Upholland 1	1956	BP Exploration Company Ltd	P&A dry
Upholland G1	1944	D'Arcy Exploration Company Ltd	P&A dry
Whitmoor 1	1967	Place Oil & Gas Company Ltd	P&A dry

11.2 ABANDONED MINE METHANE DRAINAGE (AMM) AND COALBED METHANE (CBM) POTENTIAL

Three coalfields exist within the county and Pennine Coal Measures crop out over much of the southeastern part of the county. The Burnley coalfield comprises Lower Coal Measures preserved in an asymmetrical syncline and covering an area of approximately 315 km^2. Two main coal-bearing intervals exist, containing medium-low volatile coals with most coals being thin and extensively worked. No seam gas data are available for the Burnley coalfield. The last mine (Hapton Valley) closed in 1982 and mine workings are thus expected to be flooded.

The northwestern limits of the South Lancashire coalfield crop out in the south of the county in the Chorley to Ormskirk area. Lower to Middle Coal Measures dip to the south, where they eventually become concealed beneath the Permo-Triassic of the Cheshire Basin. Elsewhere in the coalfield the succession is up to 880m thick, with 33 named coals present, attaining a maximum seam thickness of >3 m and producing 20-25 m total thickness. Coals are high to medium, volatile bituminous types and yield a seam gas content of up to 9.5 m^3 , with an average of 8.2 m^3 CH_4 per tonne.

Coal Measures of the small Ingleton Coalfield, formed by a partially concealed syncline, are found in the northeast of the county. There is little remaining coal and those seams present are truncated by an intra-Coal Measures unconformity, limiting their extent. Hereabouts, up to 6 seams may have been mined in shallow workings only a few hundred metres deep. No gas or rank data are available and the coal is largely worked out.

In the USA, most coalbed methane production is from coals containing 7 or more m^3 CH_4 per tonne. Gas content of the coals in the South Lancashire coalfield is thus above the economic threshold in America, however, the coalfield in the county has been heavily worked. CBM development from virgin coal seams in any of the coalfields is thus probably not a prospect. AMM and CBM potential in the county are not perceived as good, given the intense coal mining in the area and now long abandoned and likely flooded mines. These conclusions are supported by the fact that, unlike to the south within the South Lancashire Coalfield, there are presently no hydrocarbon extraction or development licences for CBM or AMM extraction, except in the southwest of the county.

11.3 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 any rights of access, and the licensees must obtain any consent under current legislation, including planning permissions. 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.

12 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 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.

13 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 digitised by BGS from Plotting Sheets and other documents supplied by Lancashire County Council, Blackpool and Blackburn with Darwen Borough Councils. In addition, planning permission information was digitally acquired from Ministry of Housing and Local Government maps for the area and incorporated in the data. This data has been checked and amended by the local Authorities shown below. Any queries regarding the sites shown should be directed to these authorities. The polygons cover active, former and restored mineral workings and, occasionally, unworked deposits.

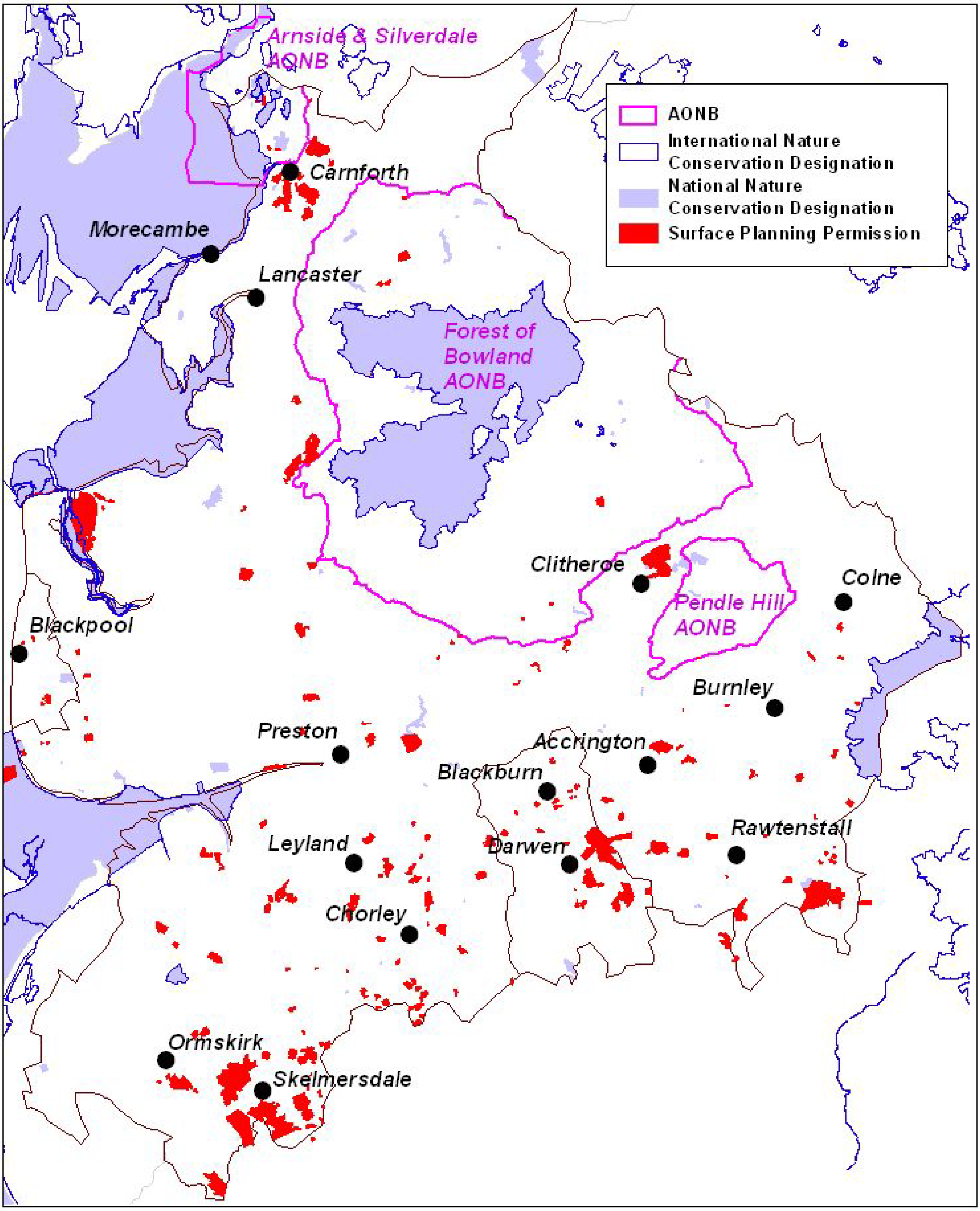

Figure 6. Surface planning permissions and national environmental designations in Lancashire

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.

13.1 CONTACT ADDRESSES:

Lancashire County Council, Environmental Directorate, PO Box 9, Guild House, Cross Street, Preston PR1 8RD, Tel: 01772 264468, Fax: 01772 264201, web address: www.lancashire.gov.uk

Blackburn with Darwen Borough Council, Technical Services Department, Town Hall, Blackburn BB1 7DY, Tel: 01254 585585, Fax: 01254 674683, web address: www.blackburn.gov.uk

Blackpool Borough Council, Technical Services Department, PO Box 117, Westgate House, Squires Gate Lane, Blackpool FY4 2TS, Tel: 01253 476240, Fax: 01253 476201, web address: www.blackpool.gov.uk

14 Appendix

14.1 TOPOGRAPHIC BASE

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14.2 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.

14.2.1 English Nature

Digital SSSI, NNR, SAC, SPA and RAMSAR boundaries © English Nature 2006

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

14.2.2 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

14.2.3 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

14.2.4 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