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

Gloucestershire (comprising Gloucestershire and South Gloucestershire)

Commissioned Report CR/05/105N

BRITISH GEOLOGICAL SURVEY

COMMISSIONED REPORT CR/05/105N

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

Gloucestershire (comprising Gloucestershire and South Gloucestershire)

A J Benham, D J Harrison, A J Bloodworth, D G Cameron, N A Spencer, D J Evans, G K Lott, and D E Highley.

This report accompanies the 1:100 000 scale map: Gloucestershire (comprising Gloucestershire and South Gloucestershire)

Key words

Gloucestershire, Mineral Resources, Mineral Planning

Front cover

Daglingworth Quarry, near Cirencester, Gloucestershire

Bibliographical reference

BENHAM, A J, HARRISON, D J, BLOODWORTH, A J, CAMERON, D G, SPENCER, N A, EVANS, D J, LOTT, G K, AND HIGHLEY, D E, 2006. Mineral Resource Information in Support of National, Regional and Local Planning. Gloucestershire (comprising Gloucestershire and South Gloucestershire). *British Geological Survey Commissioned Report*, *CR/05/105N*. 16pp

Keyworth, Nottingham British Geological Survey 2006

BRITISH GEOLOGICAL SURVEY

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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 Gloucestershire, comprising Gloucestershire and South Gloucestershire, 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 South 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, bedrock sand, crushed rock aggregate, building stone, hydrocarbons, and coal.

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 conservation designations – Special Areas of Conservation (SAC), Special Protection Areas (SPA) and Ramsar sites
- Areas of Outstanding Natural Beauty (AONB) – parts of Wye Valley, Malvern Hills and Cotswolds
- Scheduled Monuments

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

2 Sand and gravel

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

The principal uses of sand are as fine aggregate in concrete, mortar and asphalt. The main use of gravel is as coarse aggregate in concrete. Substantial quantities of sand and gravel may also be used for construction fill.

Sand and gravel resources occur in a variety of geological environments. In Gloucestershire these resources fall into two categories: superficial or 'drift' deposits, subdivided into river terrace deposits, and sub-alluvial gravel deposits, and bedrock deposits. Superficial deposits are by far the most important and were assessed in parts of Gloucestershire by BGS in the 1970s and 1980s. Resources identified in these areas are identified separately on the map. Outside these areas, available data are more limited. Generally, only exposed sand and gravel are defined, although sub-alluvial resources of sand and gravel occurring beneath modern river floodplains may be extensive in some areas, and are marked on the map. Narrow spreads of sub-alluvial deposits (< 200 m width) are mainly excluded from the map. Their limited width is likely to preclude working of any sand and gravel present.

2.1 SUPERFICIAL DEPOSITS

Gloucestershire produced 0.7 million tonnes of sand and gravel in 2003, and had estimated permitted reserves of 9.41 million tonnes at the end of 2003 (South West Regional Aggregate Working Party). Recent sales figures are shown in Figure 1, which relates only to the county of Gloucestershire; there is no land-won sand and gravel production in South Gloucestershire.

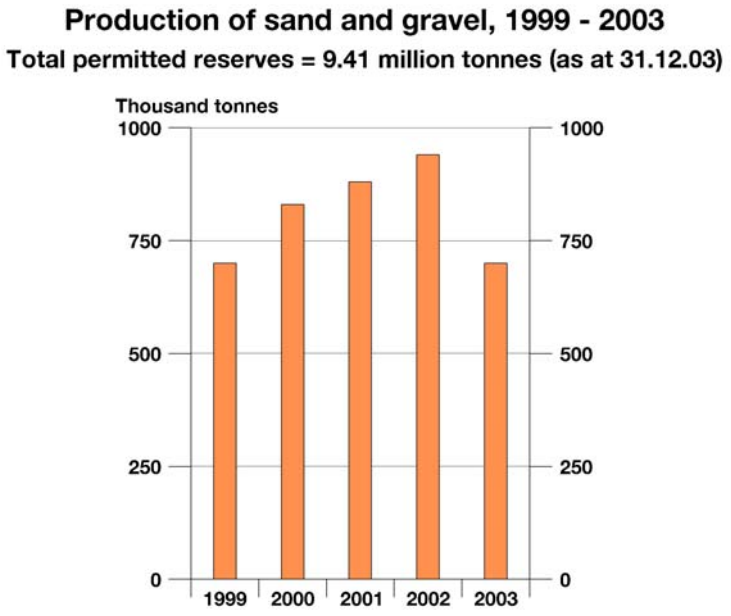

Figure 1. Gloucestershire: Production of sand and gravel 1999-2003.

Source: South West England Regional Aggregate Working Party reports

2.1.1 River Terrace Deposits

Most current sand and gravel workings in Gloucestershire are in river terrace deposits. These deposits represent the eroded remnants of formerly more extensive, relatively gravel-rich alluvial deposits laid down by rivers flowing at higher elevations than today. Individual river terraces may vary both in thickness and composition. River terraces occur at several levels in most of the major valleys in the county flanking the present floodplain, particularly associated with the River Thames, the River Severn, and the River Avon.

The older terraces are higher above the present course of the river and are generally dry in their upper parts. Younger terraces can be saturated at their bases. The deposits comprise sequences of sands and gravels with sheet-like morphology, sub-horizontal upper surfaces, and thicknesses of up to a few metres. The younger deposits are more laterally continuous since they have been less cut down by subsequent river erosion. An example of a wet-worked river terrace deposit can be seen in Plate 1.

Plate 1. River terrace gravel working at Horcott Quarry.

Compositionally, the river terrace gravels contain varying quantities of limestone, sandstone, quartzite, igneous rocks, flint, chert, and quartz together with sand and occasional silt and clay. There are significant compositional differences between the Severn and the Thames, with the important deposits of the Thames consisting mainly of oolitic limestone. The exact distribution of these deposits is complicated due to their gradational transition into Head and Alluvium and therefore thickness measurements are somewhat unreliable.

River terrace deposits represent an important resource in the county since they are generally clay-poor. They are currently extensively worked in the Thames Valley in southeast Gloucestershire, together with a few operations in the River Severn and River Avon areas near Gloucester. Extensive deposits of terrace deposits occur around and to the north of Cheltenham

and Gloucester. These were formerly used as a source of sand, but much is now sterilised by development. Terrace deposits also occur in the east of the county along the River Evenlode near Moreton-in-Marsh, however, these have a relatively high clay content and are too thin to be commercially exploited.

2.1.2 Sub alluvial gravel

These deposits are generally similar in composition to river terrace gravels, however they are saturated and would require wet working if they were exploited. The deposits are of very variable thickness, locally 5-10 m of deposits are present but they are commonly thinner.

Sub-alluvial gravel deposits are found along the northern bank of the River Thames where they are currently worked in some areas. Sub-alluvial gravels are also found at the confluence of the Rivers Severn and Avon near Gloucester. These are laterally extensive but relatively thin, and since some lie at, or just below, sea level, they are unlikely to be worked.

3 Bedrock sand deposits

3.1 BROMSGROVE SANDSTONE AND BRIDGNORTH SANDSTONE

The Triassic Bromsgrove Sandstone and the Permian Bridgnorth Sandstone formations crop out in the northwest of the county near Newent. These units have been quarried in the past and have provided building stones for local use but they are currently worked on a small-scale as a source of red building sand and red asphalt sand at Bromsberrow Heath, near Ledbury.

4 Crushed rock aggregate

A variety of hard rocks are, when crushed, suitable for use as aggregates. Their technical suitability for different applications depends on their physical characteristics, such as crushing strength and resistance to impact and abrasion. Higher quality aggregates are required for coating with bitumen for road surfacing, or for mixing with cement to produce concrete. For applications such as constructional fill and drainage media, with less demanding specifications, lower quality materials are acceptable. The area is an important source of crushed rock aggregate. Total production of crushed rock in 2003 was 4.57 million tonnes, of which 62 per cent was from South Gloucestershire. Total permitted reserves of crushed rock in Gloucestershire and South Gloucestershire at the end of 2003 were 27.85 million tonnes (South West England Regional Aggregates Working Party). Limestone is the most important source of crushed rock aggregate in the area.

4.1 LIMESTONE

Limestones are common rocks in Gloucestershire and range from Silurian to Jurassic in age; Carboniferous limestones are, however, the most important resource. Limestone aggregate is quarried predominantly from the steeply dipping Carboniferous limestones near Yate and Cromhall in South Gloucestershire and the saucer-shaped downfold in the Forest of Dean. However, significant quantities are also sourced from the Jurassic limestones of the Cotswolds.

Limestones of Carboniferous age have important commercial differences from those in the adjacent Mendip Hills. The Black Rock Limestone, for example, is replaced by dolomite, and other limestone units also become locally of low or variable chemical purity. Quarries near

Cromhall produce aggregate from the Black Rock Dolomite and the partially dolomitised Black Rock Limestone. The product has a high magnesium content and is significantly stronger than most Carboniferous limestones. At Wickwar, the Clifton Down Limestone is more siliceous (i.e. it is sandy) than in Somerset and this enables stone with a relatively high PSV (i.e. it is skid resistant) to be produced that can be used for road surfacing and concrete products (Plate 2).

Plate 2. Chipping Sodbury Quarry, near Wickwar, working Clifton Down Limestone.

The Black Rock Limestone also occurs near Chepstow and in the Forest of Dean where it forms an important resource; it is worked at the Drybrook and Stowfield quarries in the Forest of Dean. To the west in Monmouthshire the dolomite has been used as a metallurgical flux for ironmaking in South Wales, but in Gloucestershire it is mainly used for concrete aggregate, roadstone and for agricultural purposes. Thinner beds of Carboniferous limestone within the Avon Group are worked at Stowe Hill Quarry, near Lydney for aggregate use.

Jurassic limestone formations within the Inferior Oolite and Great Oolite groups are shown on the map to the east of the River Severn; the latter are the more extensive. The Inferior Oolite Group occurs over a more restricted area, although it thickens to reach a maximum of 100 m near Cheltenham. Most of the limestones within the Inferior Oolite are massive, coarse-grained, relatively soft and porous and contain little high-purity material. Their maximum thickness is less than 20 m. Limestones within the Inferior Oolite have been worked for many years on a small scale for building stone (e.g. ‘Guiting Stone’) or for low quality aggregates such as constructional fill.

The Great Oolite is worked mainly for aggregates and agricultural purposes with some used as a building stone. It includes a thin fissile stone known as “Stonesfield Slate”, formerly used for roofing but now worked for aggregate. The material is unusual among Jurassic limestones in that

it is reputed to be frost resistant and suitable for use in concrete and roadstone.

Limestones of Silurian age - the Woolhope, Wenlock and Aymestry limestones - crop out to the east of the Forest of Dean, near Longhope. Although Silurian limestones are worked for aggregate further north in Herefordshire and Shropshire, they are generally only suitable for low-grade applications such as fill since the limestones vary in thickness and quality and are occasionally argillaceous. They are not worked in Gloucestershire and are not considered a resource and are not shown on the map.

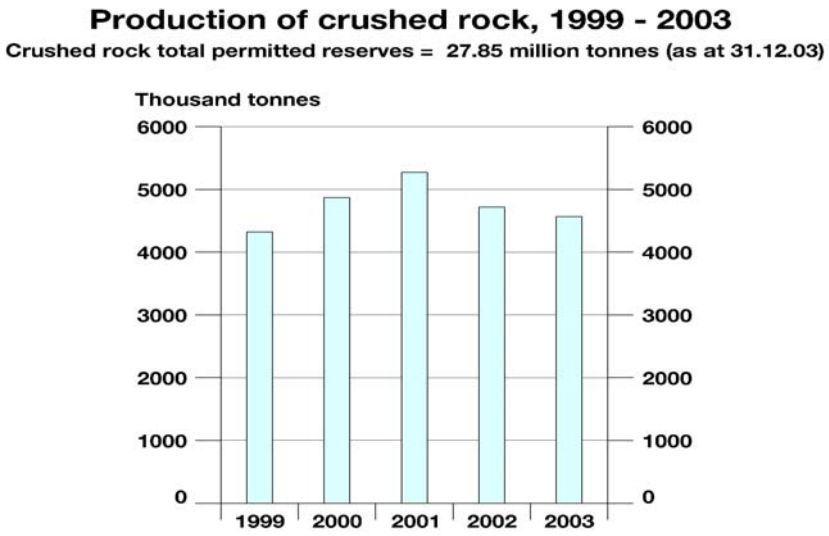

Figure 2. Gloucestershire: Production of crushed rock, 1999-2003.

Source: South West England Regional Aggregate Working Party

4.2 SANDSTONE

Several formations in Gloucestershire are currently worked, or have the potential to be worked, for sandstone for use as a building stone, or in certain cases as aggregate.

The Carboniferous Cromhall Sandstone Formation (formerly the Drybrook Sandstone) is quarried at the Quartzite Quarry in South Gloucestershire near Charfield. The rock has a high strength and resistance to polishing and is used as a roadstone throughout southern England.

4.3 IGNEOUS ROCK

A very small part of the Precambrian Malvern Complex crops out in northern Gloucestershire and extends over the county boundary into Herefordshire and Worcestershire. The complex is composed mainly of intrusive igneous rocks, which are a potential source of good quality aggregate. These rocks were worked outside the county until the 1980s and are shown to provide continuity across the regional boundary.

5 Building stone

A wide range of rock types is used as a source of building stone. The suitability of particular rock types depends not only on aesthetic qualities, such as colour and textural consistency but also on factors such as strength and durability, and commercial considerations such as the size of block or slab that can be extracted. A continuing supply of building stone from a variety of sources is important for new build and conservation work. Building stone operations range from

small sites supplying local markets, to larger concerns that trade across Britain and sometimes overseas.

Historically the area has produced and used a wide range of stones for building purposes and these are summarised below. Many different rock units are still of importance today with Jurassic limestones being the most important source of building stone, which is worked at many quarries in the Cotswolds. Devonian and Carboniferous sandstones (Pennant Sandstone Formation) are worked on a small scale in the Forest of Dean area. However, almost all crushed rock aggregate quarries produce, or have the capacity to produce, building stone as and ancillary product.

The oldest rocks, in the west of the area, are the metasedimentary, sedimentary and associated intrusive igneous rocks of the Cambrian to Silurian inliers of Tortworth, May Hill and the southern Malvern Hills. Each area was extensively quarried for a variety of materials including building stone. Downton Castle Sandstone was quarried at Clifford Mesne and around Gorsley.

The purple-red and green sandstones of the overlying Devonian Brownstones Formation was quarried around the Forest of Dean near Mitcheldean, Soudley and Blakeney. The distinctive Quartz Conglomerate Formation was once an important source of millstones for the cider and milling industries and was used locally for building at Tintern.

The Carboniferous limestones and Pennant sandstones of the Carboniferous of the Forest of Dean include some of the oldest and most extensive building stone quarries / mines in the area at Bixhead and Bixslade. The Permian age Haffield breccia was also worked locally for building stone. Today building stone is often provided from the larger aggregate quarries in the Forest of Dean.

Red and green coloured sandstones of the Triassic age Sherwood Sandstone Group were worked on a small scale near Huntley, Byfords Farm and Newent. The Arden Sandstone ‘skerry’ from the overlying Mercia Mudstone Group was quarried for local building purposes along parts of its outcrop as at Corse House Farm.

Grey limestones of the Lower Jurassic, Blue Lias Formation (Lias Group) were extensively quarried along much of its outcrop for lime and local building stone e.g. Hasfield, Ashleworth.

The ferruginous limestones of the Marlstone Rock Formation were used locally close to the outcrop as at Cam, Alderton, Langley Hill and Burhill.

The oolitic and shelly limestones of the Middle Jurassic Inferior Oolite and Great Oolite groups are the most characteristic and important building stones of the county. Quarries are numerous across the outcrop. Some of the better-known quarries are associated with specific towns and villages including, in the Inferior Oolite Group, those at Cleeve Cloud, Coscombe, Guiting, Bourton on the Hill, Longborough, Stanway, Painswick, Nailsworth, Leckhampton, Whittington, Westington and Rodborough. In the Great Oolite Group important quarries operated at Minchinhampton, but the succession was better known as a source of Cotswold roofing slates, with quarries at Througham, Brockhill, Sevenhampton, Naunton and Kineton. The shelly limestones of the Forest Marble Formation were also extensively worked for heavier roofing slates at Tetbury. The extent of Jurassic limestones is shown on the map.

Currently there are five sandstone quarries operating in the area – Copse Stone and Wilderness quarries working the Devonian Brownstones Formation and Barnhill, Minetrain and Birch Hill working the Carboniferous Pennant Sandstone Formation in the Forest of Dean. The extent of these formations is not shown on the map because their suitability for use as building stone may be localised due to factors such as bed thickness and extent, and discontinuities and degree of cementation.

6 Hydrocarbons

6.1 CONVENTIONAL OIL AND GAS

Gloucestershire lies to the north of the Variscan Front, where Variscan Basement lies at shallow depths and across which thin and variable Permian and overlying Mesozoic sequences were deposited. This impacts on the quality and extent of potential reservoir and source rocks across the area. Any source rocks present within this succession will be neither thick enough nor likely to have been buried deep enough for the generation of hydrocarbons.

Palaeozoic strata lie concealed beneath the Permian and Mesozoic cover across the area. Sequences of Westphalian Carboniferous-Devonian age, representing the western margins of the Oxfordshire-Berkshire Coalfield, occur in a N-S belt up to 7 km inside the county's eastern boundary. Westwards, the subcrop is progressively older Palaeozoic-Precambrian rocks adjacent to the major Malvern Fault line and with little or no hydrocarbon potential.

British Gas drilled a series of boreholes for exploration and also the potential for gas storage in the period 1961-2 at Stow-on-the-Wold in the east of the county (see Table below). Further exploration wells were drilled at various points around the county between 1975 and 1989. Six exploration wells were drilled within the area of Coal Measures subcrop, the most recent being Ash Farm (BP) in 1981. All wells have proved dry and were abandoned, although Leighbrook, drilled by Altana in 1989, was plugged and abandoned with minor gas shows.

Currently, PEDL087 is the only active hydrocarbon exploration or production licence in the county reflecting limited hydrocarbon prospectivity in the county. High-risk plays, requiring Westphalian (Coal Measures) gas sources may exist in the east of the county. The minor gas shows in the Leighbrook No.1 well drilled in the north and centre of the county are enigmatic and difficult to explain.

Table 1. Hydrocarbon exploration wells in Gloucestershire

Well	Drilling date	Original operator	Current licence area and operator	Status
Ash Farm 1	1981	BP Exploration UK Ltd	Open acreage	Plugged and abandoned dry
Guiting Power	1979	Bearcat Exploration (UK) Ltd	Open acreage	P&A dry
Leighbrook 1	1989	Altana	Open acreage	P&A minor gas shows
Sherbourne 1	1975	Shell UK Exploration UK Ltd	Open acreage	P&A dry
Stow-on-the-Wold 1	1961	BP & Gas Council	Open acreage	P&A dry
Stow-on-the-Wold 2	1962	Gas Council	Open acreage	Gas storage evaluation
Stow-on-the-Wold 3	1962	Gas Council	Open acreage	Gas storage evaluation

Stow-on-the-Wold 4	1962	Gas Council	Open acreage	Gas storage evaluation
Windrush 1	No details	No details	Open acreage	No details

6.2 ABANDONED MINE GAS DRAINAGE (AMM) AND COAL BED METHANE (CBM) POTENTIAL

The Oxfordshire-Berkshire Coalfield covers an area of some 3327 km^2, and lies at depths of between 300 and 1500 m. It contains mainly thin, high volatile bituminous coals preserved in synclines with an intervening anticline. The average gas seam content is 0.4 m^3 CH_4 per tonne. No coal has been mined. The small Forest of Dean Coalfield covers an area of just 88 km^2 and contains Upper Coal Measures up to 610 m thick. Nineteen seams are present. Coal rank is high, volatile bituminous, non-caking and although the total coal thickness is low (9.75 m), the area has been heavily worked. No data exist for the gas content, but gas was absent in most mines, although most areas are now flooded. The small coalfield at Newent provides no potential within the county.

The gas content of the seams in the Bristol and Somerset Coalfield is not known but believed to be low.

6.2.1 Abandoned Mine Gas Methane (AMM)

The prospects for AMM are negligible because of the low gas levels, flooding and the lack of extensive workings.

6.2.2 Coalbed Methane (CBM)

CBM refers to methane extracted via boreholes from coal seams other than in abandoned or active coal mines. It includes extraction from coal seams above or below abandoned or working mines. There is little potential for CBM in the county due to the low gas levels encountered.

7 Coal

Shallow coal resources in Gloucestershire occur within two areas; the Forest of Dean Coalfield and part of the Bristol-Somerset Coalfield.

7.1 FOREST OF DEAN COALFIELD

The Forest of Dean Coalfield, located east of Monmouth, covers an area of approximately 88 km^2 and was one of the earliest regions in Britain where coal and iron were worked. The Forest has always been Crown property and the rights to work coal in the area have been vested in the local inhabitants who can qualify as Freeminers. Only people born within the Forest of Dean area and who have already worked in a coal mine may qualify as Freeminers; the number of Freeminers within the coalfield continues to fall.

The unusual feature of this coalfield is that is almost completely exposed at surface. It occurs in a raised asymmetrical syncline with a steeper eastern limb that crops in the area of Staple Edge and the Soudley Valley. The coal-bearing strata are divided into three formations; the Trenchard

Formation, the Pennant Sandstone Formation, and the Grovesend Formation.

The late-Carboniferous age Trenchard Formation reaches up to 120 m thick in the north of the coalfield and forms the lowest division of the 'Upper Coal Measures', resting with angular unconformity on older strata beneath. The formation consists mainly of sandstones, mudstones and conglomerates with occasional coal seams. In the northeast of the Forest it consists of fine-grained mudstones, progressing to coarser sandstones in the southwest.

The late-Carboniferous age Pennant Sandstone Formation is also mainly sandstone but contains the economically most important coal seam in the area, the Coleford High Delf Seam. At least two other workable coal seams occur in this formation, and these are interpreted as being deltaic deposits with the main palaeocurrents indicating that rivers were flowing from a southeasterly direction.

The late-Carboniferous age Grovesend Formation has fine-grained sediments at its base but also includes as many as eight thin coal seams. The upper division of the formation is again composed of sandstones with some horizons of finer grained, shaley material.

Freemining in the Forest of Dean has been in steady decline since the privatisation of the coal industry in 1994. There is only one drift mine (Monument Mine) intermittently producing small amounts of coal (274 tonnes in 2004). There was no recorded production in 2005. Coal has also been produced by opencast mining in the past with approximately 0.75 Mt produced since World War Two, although opencast mining ceased in 1985. Historically many deep coal mines operated in the Forest of Dean, however, the last of these mines closed around the late 1960s and early 1970s.

The small Newent Coalfield is of no economic significance.

7.2 BRISTOL-SOMERSET COALFIELD

The Bristol-Somerset Coalfield is mostly concealed beneath a variable Permian to Mesozoic cover. Part of this coalfield occurs in South Gloucestershire, and this has previously been exploited where the Coal Measures are exposed at or near surface and there has also been some deep mining up to the 1960s. The coalfield is structurally complex and the seams are generally thin and uneconomic to work. Prospecting areas for opencast coal have been identified in the past but it is unlikely that any significant future production will occur in this area. Small quantities of coal have been produced at the Cattybrook Quarry, near Almondsbury wher Coal Maeasures mudstones are extracted for brickmaking. The extent of the coalfield is only shown on the inset map.

7.3 OXFORDSHIRE-BERKSHIRE COALFIELD

The east of the county contains the western margin of the wholly concealed Oxfordshire-Berkshire Coalfield. The strata mainly comprise Upper Coal Measures and the coal seams are comparatively thin and are not of current economic interest.

8 Brick clay

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

frost resistance and, importantly, its architectural appearance.

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

There are three brickworks in Gloucestershire (Broadmoor, Hawkwell Green and Wellacre) and one in South Gloucestershire (Cattybrook) that currently work brick clay and produce bricks and related products for building purposes. Cattybrook brickworks, near Almondsbury is also supplied with brick clay from the Shortwood Quarry, near Pucklechurch. The clay worked at Broadmoor and Hawkwell Green in the Forest of Dean is from the Cinderford Member of the Carboniferous Grovesend Formation, whilst the Wellacre site, near Blockley, produces clay from part of the Jurassic, Charmouth Mudstone Formation. In South Gloucestershire the Cattybrook site works Carboniferous South Wales Lower and Middle Coal Measures mudstones and fireclays, whilst the Shortwood Quarry works mudstones in the Farrington and Barren Red members of the Carboniferous Grovesend Formation. Both red and buff-firing bricks are produced at Cattybrook. Because of the variable nature of these clays they are not shown on the map.

9 Other minerals

9.1 EVAPORITE MINERALS

Celestite (strontium sulphate, $SrSO_4$) is the main source of strontium. The only deposits that were of commercial importance in the UK occur in South Gloucestershire and in the Bristol area. The most recent workings were at Yate, where production ceased in 1991 due to the exhaustion of reserves.

Nodular and disseminated celestite occurs as the 'Severnside Evaporite Bed' near the top of the Triassic Mercia Mudstone Group, at the unconformity of the Mercia Mudstone with the underlying Palaeozoic rocks (mainly Coal Measures). Celestite also occurs in veins and as infillings of redistributed celestite both in the Mercia Mudstone and underlying rocks. Further working of celestite in the area is unlikely and these resources are not shown on the map. The extent of former planning permissions are shown. (For further information see 'The celestite resources in the area north-east of Bristol'. *Mineral Assessment Report, Institute of Geological Sciences,* No. 25, 1976).

9.2 IRON ORE

Irregular bodies of limonite and hematite occur in limestones of Lower Carboniferous age in the Forest of Dean and have been mined at outcrop and at depth where the limestones dip beneath the Coal Measures on the flanks of the basin. The iron ores represent metasomatic replacement deposits in limestone and dolomite, the most important unit containing these deposits being the Gully Oolite Formation. The iron ores were worked from Roman times until the 1940s; recorded output between 1842 and 1940 being about 4.8 million tonnes of ore. Resources are effectively exhausted and the deposits are no longer of economic significance as a source of iron ore. However, very minor amounts of ochre (pigment) are sometimes recovered from old workings, which are now show caves.

10 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 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 reflects 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.

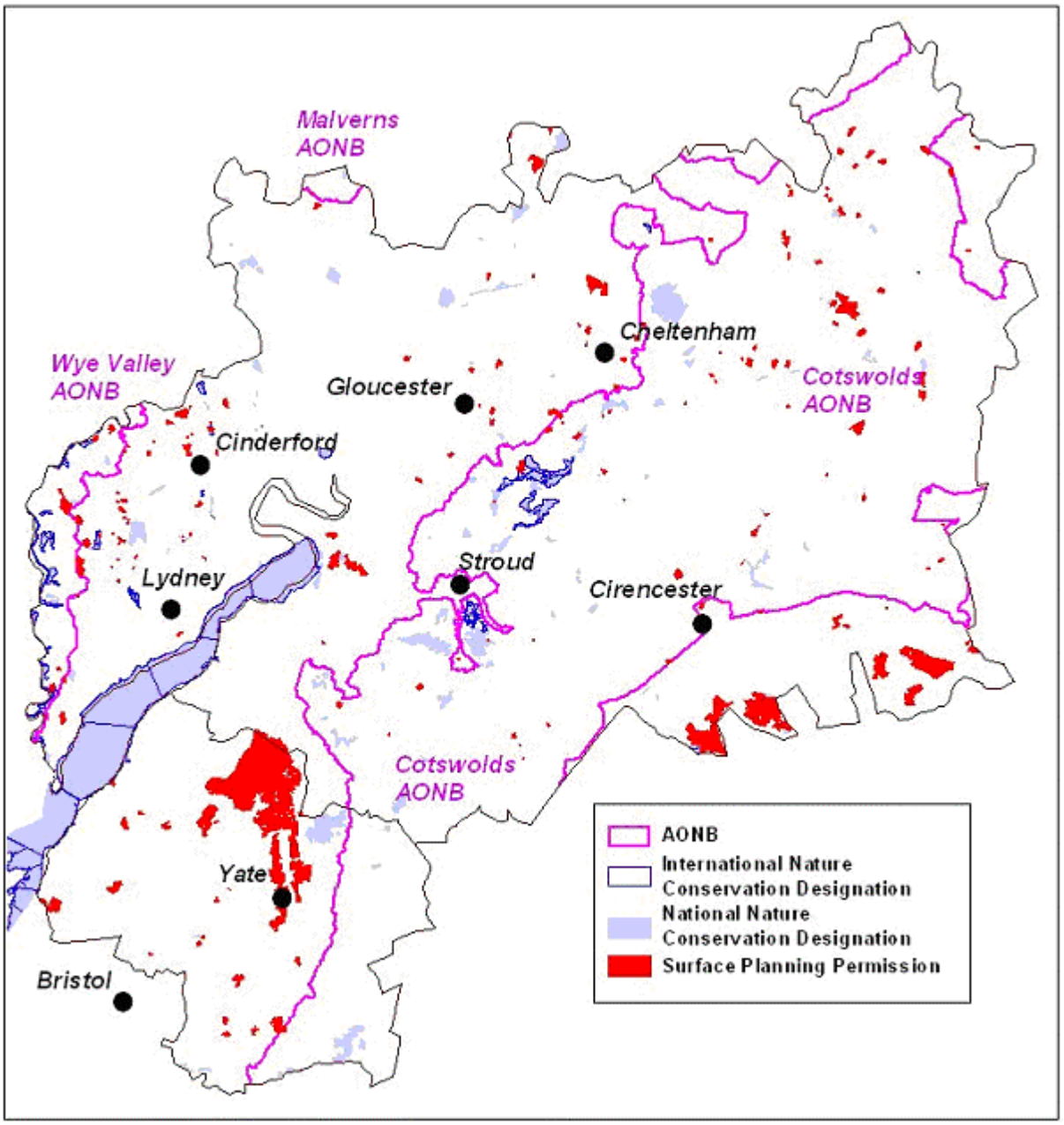

Figure 3. Surface planning permissions and landscape and nature conservation designations in Gloucestershire

11 Planning permissions for the extraction of minerals

The extent of all known extant, and non-extant planning permissions for the extraction of minerals is shown on the map, irrespective of their current planning or operational status. Digital data was supplied by Gloucestershire County Council and other polygons were digitised by BGS from other documents supplied by Gloucestershire and South Gloucestershire 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 listed below. Any queries regarding the sites shown should be directed to the relevant authority. 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

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 Stationery Office, © Crown copyright.

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CONSTRAINT INFORMATION

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:

English Nature

Digital SSSI and NNR boundaries © English Nature 2000.

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 scheduled since that date are not accounted for. © Copyright English Heritage.

Contact address: English Heritage, 23 Savile Row, London, WS1 2ET, Tel: 020 7973 3132, Web page: www.english-heritage.org.uk/

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/

Published for the Office of the Deputy Prime Minister.