British Geological Survey

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Mineral Resource Information for Development Plans
Staffordshire: Resources and Constraints

D E Highley and D G Cameron

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Mineral Resource Information for Development Plans Staffordshire: Resources and Constraints

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This report accompanies the 1:100 000 scale maps:

Staffordshire Mineral resources (other than sand and gravel)
and
Staffordshire Sand and Gravel Resources

Cover Photograph
Cauldon limestone quarry at Waterhouses, 1977.(Blue Circle Industries) British Geological Survey Photographs. No. L2006.

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INTRODUCTION

This report has been prepared to be used in conjunction with the Mineral Resources Maps of Staffordshire. The principal aim of the report and its associated maps is to show the broad distribution of mineral resources of current or potential economic interest in Staffordshire and to relate these to selected, nationally-recognised planning constraints on extraction of minerals. The work is intended to assist in the consideration and preparation of development plan policies in respect of mineral extraction and the protection of important mineral resources.

Development plans set out the main considerations on which planning applications are determined, and they therefore form the essential framework of the planning system. The importance of the development plan system in planning decisions is emphasised by Section 54A of the Town and Country Planning Act 1990, which requires that planning applications and appeals be determined in accordance with the development plan, unless material considerations indicate otherwise. The planning system is therefore a plan-led system.

Development plan preparation must take account of Government guidance. This is primarily set out in Planning Policy Guidance notes (PPGs), Mineral Planning Guidance notes (MPGs) and Regional Planning Guidance notes (RPGs). These provide advice on a range of general and specific issues.

The 'development plan' includes structure plans, which contain strategic planning policies, and local plans, containing detailed policies and proposals, or unitary development plans, which combine both functions. In addition, relevant authorities must produce local plans on minerals and waste.

Information on mineral resources is required to assist the production of mineral local plans by the identification of important resources and the planning constraints which may affect such resources. This information is also necessary for the preparation of structure, local and unitary plans, both in relation to mineral development and the prevention of the sterilisation of important mineral resources.

Three major elements of information are presented and described:

- the geological distribution and importance of mineral resources
- the extent of mineral planning permissions and the location of current mineral workings
- the extent of selected planning constraints (national statutory designations)

The maps thus bring together a wide range of information, much of which is scattered and not always available in a consistent and convenient form. 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, the Coal Authority, the NRA, the Countryside Commission and English Nature), environmental interests and the general public.

Mineral resource classification

Mineral resources are natural concentrations of minerals which might now, or in the foreseeable future, be of economic value. However, the identification and delineation of mineral resources is imprecise as it is limited by the quantity and quality of data currently available and involves predicting what might or might not become economic to work in the future. The pattern of demand for minerals is continually evolving due to changing economic, technical and environmental factors. The economic potential of mineral resources is not static, therefore, but changes with time.

The maps of Staffordshire show the extent of **inferred resources**, that is, those mineral resources that can be defined from available geological information. They have neither been evaluated by drilling or other sampling methods, nor had their technical properties characterised on any systematic basis. The mineral resources shown on the maps take no account of the planning constraints that may limit their working.

That part of a **mineral resource** which has been fully evaluated and is commercially viable to work is called a **reserve** or **mineral reserve**. The relationship between **inferred resources** shown on the maps and evaluated and commercial deposits (**reserves**) is described in more detail in Appendix 3. In the context of land-use planning, however, the term **reserve** should strictly be limited to those minerals for which a valid planning permission for extraction exists (i.e. **permitted reserves**).

Mineral workings and planning permissions

The location and name of mineral workings, together with the main commodities produced, are shown on the maps and in Appendix 1. A distinction is made between surface and underground workings.

The extent of mineral planning permissions is shown on the Mineral Resources Maps. They cover active mineral workings, former mineral workings and, occasionally, unworked deposits. The planning permissions data were obtained from Staffordshire County Council, and this material has been verified by the County Council.

The present physical and legal status of individual permissions is not qualified on the maps or in the report. The areas shown may, therefore, include inactive sites, where the permission has expired due to the terms of the permission, i.e. a time limit, and inactive (dormant) sites where the permission still exists. Sites which have been restored have not been separately identified. A planning permission may extend beyond the mapped resource as it may make provision for operational land, including plant and overburden tips, or it may extend to an easily identified or ownership boundary. Information on the precise status and extent of individual planning permissions should be sought from the Mineral Planning Authority.

Environmental designations

The maps show the extent of selected, nationally-designated planning constraints as defined for the purposes of this survey. These constraints 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 maps 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:

- Areas of Outstanding Natural Beauty (AONB)
- National Nature Reserves (NNR)
- Sites of Special Scientific Interest (SSSI)
- Scheduled Monuments

In addition to the above, there may be other areas which have been designated internationally or nationally as requiring special consideration. Information within the area of the Peak District National Park falling within Staffordshire is not shown on the maps as a separate map and report has been prepared for the National Park.

Mineral development may also be constrained by other factors not shown on the maps, 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 Mineral Planning Authority (Appendix 2).

AONBs have been digitised from maps obtained from the Countryside Commission and English Nature provided digital data on SSSIs and NNRs. Information on the location of Scheduled Monuments has been obtained in digital form from English Heritage, and this has had to be edited and the grid references converted to a form that is suitable for use by BGS Cartographic Services.

MINERAL RESOURCES

Introduction.

The mineral resources of Staffordshire reflect the complex geological history of the area over the last 340 million years (Table 1). These events have produced a wide range of rock types of potential economic interest, mainly sedimentary, either exposed at the surface or found at relatively shallow depth beneath a cover of younger sedimentary rocks, including superficial (unconsolidated) deposits. These sediments were laid down under a variety of environmental and climatic conditions very different from those existing in the area today. Following deposition, the sediments were altered by hardening and compaction and now form the major part of the mineral resources of the county. The unconsolidated cover furnishes sand and gravel which make up the remainder of the resource.

Historically, rocks of Carboniferous age, particularly the Coal Measures found in the exposed coalfields and the outcrops of Carboniferous limestone, were of major economic importance. These rocks provided coal, iron (from ‘Blackband’ ironstones), lime and a wide variety of clays which laid the foundations of important local industries such as iron and steel, brick, and of course, the pottery industry.

During the last half of the 20th century, however, mineral production has changed, with a marked shift away from coal, iron and lime, to an increasing demand for raw materials for construction use. This is now the dominant sector of the mineral industry in the county. Carboniferous limestones are extensively worked for aggregates and cement manufacture. The Triassic Sherwood Sandstone is a major regional resource of sand and gravel for aggregate as, to a lesser extent, are the river gravels.

Table 1 Mineral resources of Staffordshire and their geological association

Age	Geological unit	Commodity/Use
Quaternary	River terrace gravels	Sand and gravel for aggregate
	Glaciofluvial gravels	Sand and gravel for aggregate
Triassic	Mercia Mudstone	Gypsum / anhydrite for cement manufacture
	Sherwood Sandstone	Sand and gravel for aggregate
		Sandstone for building stone
		Naturally-bonded moulding sand
Carboniferous	Barren Measures	Clay for tiles
	Etruria Formation	Clay for bricks and tiles
	Productive Coal Measures	Opencast and deep-mined coal
		Clay for bricks, *Fireclay, Oil, Iron*
	Millstone Grit	Sandstone for silica sand, Building sandstone Clay for cement manufacture,
	Milldale Limestones	Limestone for aggregate and cement
	Kevin Limestones	manufacture

Italics signify commodity no longer produced.

The Etruria Formation is a major source of brick clays and the county is also an important producer of silica sand and gypsum. Although the production of deep-mined coal has declined, the exposed coalfields remain a potential source of opencast coal. Exploration for hydrocarbons, including coalbed methane, continues. There are no significant peat resources in Staffordshire.

The most important mineral resources in the county today are, therefore, related to the supply of aggregates to the construction industry. Other resources, including coal, clay, gypsum and silica sand, will continue to be of importance, but it is the demand for aggregates which will be the driving force for mineral resource development in Staffordshire for the foreseeable future.

Sand and gravel

Sand and gravel resources are divided into two broad categories:

- Superficial or 'drift' deposits of Quaternary age, subdivided into glacial sand and gravel, and river gravels
- Bedrock or 'solid' deposits comprising conglomerates within the Triassic Sherwood Sandstone Group, formerly known as the 'Bunter Pebble Beds'

This division reflects the distinctly different forms of the deposits, their likely workable extent and yields, their particle size and need for processing, and thus their relative importance as aggregate

resources. Sand and gravel production in Staffordshire between 1973 and 1993 is shown in Figure 1.

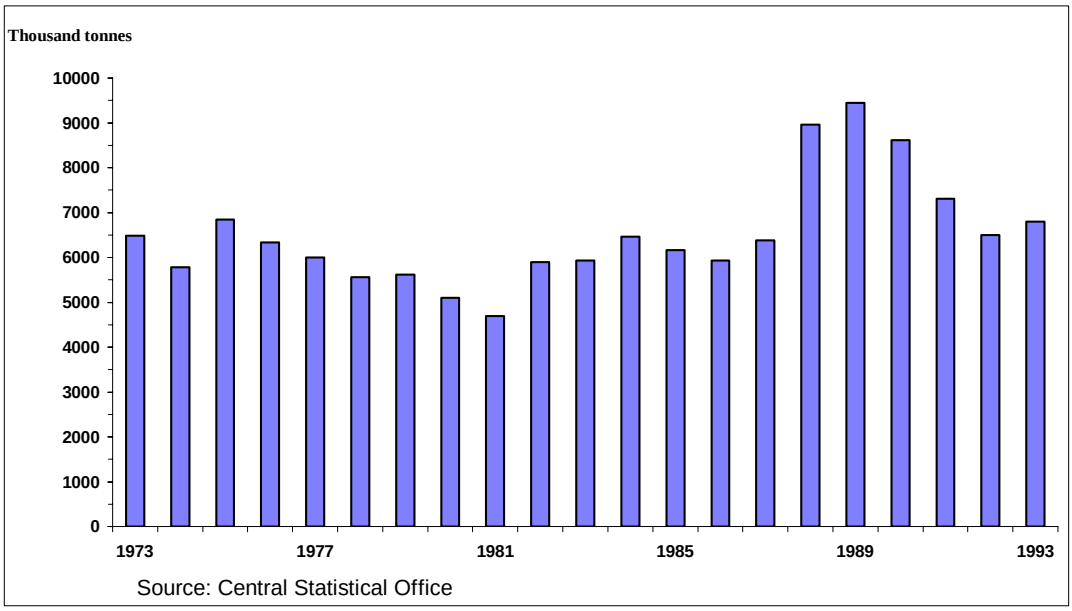

Figure 1 Sand and gravel production in Staffordshire, 1973–1993.

Superficial deposits
The separation of the superficial resources into two subdivisions reflects differences in the mode of occurrence of the deposits and, to some extent, their likely particle-size distribution.

River gravels include spreads of sand and gravel which occur beneath alluvium along the floors of the major river valleys, and in river terrace deposits flanking the valley sides (Figure 2). In Staffordshire they are mainly associated with the rivers Trent and Tame. In several of the river valleys in the county, terrace-like spreads of gravel occur at higher levels than the river terrace deposits and have been mapped as glacial, or glaciofluvial, sand and gravel. It seems likely that many of these have been deposited by river action and thus they are included with the river gravels. The deposits consist of a mixture of sand and gravel, in varying proportions, from which fine and coarse aggregate are produced by a process of washing and size separation, usually involving screening and hydrocyclone separation.

River gravels have been naturally processed by running water, which is an efficient mechanism for separating the different size fractions of the sediment being transported. As a result, beds of sand and gravel are likely to be relatively consistent in terms of particle-size and usually contain a lower proportion of 'fines' (silt and clay) than glacial deposits. Their particle-size distribution is, therefore, closer to user specifications. Nevertheless, beds of silt or clay may occur within these deposits.

The deposits only rarely exceed 10 m in thickness, with 4–8 m being typical for the River Trent gravels, but thinner elsewhere. The deposits are likely to be relatively consistent in thickness and composition locally, but different depositional conditions caused by such factors as changing valley shape and stream confluences can cause considerable variation.

The composition of the river gravels is likely to vary across the county. In the west and centre, the coarse fractions are likely to be dominated by quartzite pebbles derived from the Sherwood Sandstone Group; in the north they will contain a significant load of limestone fragments derived from the Carboniferous limestone uplands. Farther east, flint pebbles are incorporated from the erosion of glacial deposits.

Glacial deposits overlying, or in close proximity to, the outcrop of the Sherwood Sandstone Group are likely to have a smaller 'fines' fraction than deposits which have accumulated on, and incorporate, the mudstones of the Mercia Mudstone Group (formerly the 'Keuper Marl'). The coarse fraction of glacial deposits in the west and centre of the county is likely to consist largely of pebbles derived from the conglomerates of the Sherwood Sandstone Group, in which well-rounded pebbles and cobbles of quartzite predominate. Farther east, deposits may include a considerable proportion of flint derived from the Cretaceous Chalk.

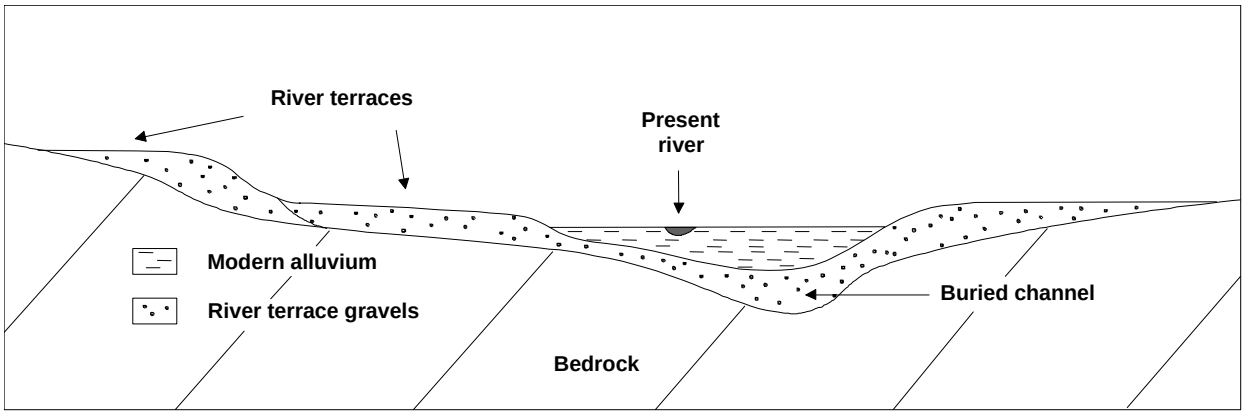

Figure 2 Sketch section across a river valley showing the relationship of alluvium to river terrace sand and gravel deposits

Glacial sand and gravel includes deposits laid down by a variety of glacial and glaciofluvial processes associated with icesheets, glaciers and, particularly, their meltwaters. They are also unconsolidated, but more variable than river gravels, less predictable in geographical extent and have a wider range of particle sizes, including a considerable proportion of 'fines', which may restrict their commercial potential. They may be extensive locally, and show considerable lateral variations in thickness and grading. In general, deposits are likely to be less than 10 m thick but may exceed this where they infill hollows and channels scoured into the underlying rock surface. Compositionally, they are likely to be locally derived from the mechanical erosion of the underlying rocks, but 'erratics' - derived from rock units outside the county and transported in by glacial action - are a feature of such deposits.

In several parts of the county, glacial sand and gravel is known to extend beneath, or to lie within, spreads of till (boulder clay). The extent, thickness and overburden ratios of such deposits are not known and are likely to be subject to considerable local variation. In places, however, such accumulations may represent additional resources and areas in which there is evidence to suggest that these may occur have been shown on the map. Glacial deposits have been worked in the past to provide construction sand and gravel, principally for local use. Small-scale production continues in the south–west of the county.

Bedrock deposits

Staffordshire is one of the few counties in England that has important resources of bedrock gravel consisting of loosely bound, sandy pebble beds (conglomerates) of Triassic age that are a major source of concrete aggregate. In extraction, the proportion of gravel to sand is of prime importance and where devoid of pebbles the formation is of limited value as an aggregate resource.

Bedrock deposits of sand and gravel are mainly confined to the conglomerate members of the Sherwood Sandstone Group, although other units have been worked locally in the past. In general, the gravel fraction, comprising poorly-cemented beds of well-rounded quartzite pebbles and cobbles in a fine-grained sand matrix, is a very important resource of coarse aggregate for concrete, when processed by crushing and screening. Matrix sand is of only limited use, being too fine grained to meet most construction sand standards. However, when blended with coarse 'sand' derived from crushing the pebbles, it can be partly incorporated to meet specifications for concreting, building and asphalting sand. Pebble-free sand beds are generally regarded as waste, as are indurated sandstone beds and thin mudstones.

Conglomerate members in the Sherwood Sandstone Group may be in excess of 60 m thick, so that the volume of the aggregate available within a given area is likely to be considerably greater than for superficial deposits. The subdivision of the conglomerate resources on the accompanying resource map reflect the different levels of information available. The differing resource evaluations are illustrated in Figure 3.

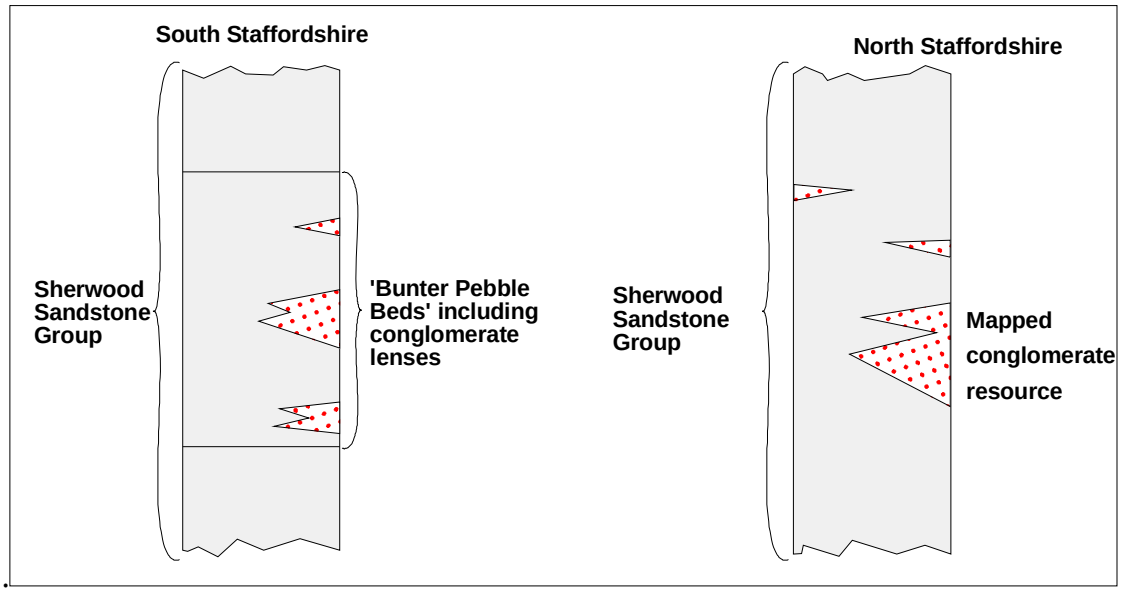

Figure 3 Sketch sections of the Sherwood Sandstone Group in North and South Staffordshire showing the difference in resource evaluation.

North of the heavy line on the Sand and Gravel Resource Map, the outcrop of the Sherwood Sandstone Group has been the subject of recent geological mapping and has been subdivided into two categories - i) exposed resources and ii) resources mostly beneath overburden (overburden to conglomerate ratio <1:2); the latter subdivision may include small areas of exposed resources outside areas mapped as conglomerate during recent geological surveying. Exposed resources were subdivided during these studies into two categories based on the estimated thickness of the deposits (>25 m and <25 m). These categories cannot be shown on the scale of the County Mineral Resources Map and readers are referred to the relevant mineral assessment reports for more detailed information.

South of the line, no mineral assessment studies have been undertaken and geological mapping generally pre-dates the 1980 revision of the lithostratigraphic subdivision of the Triassic. Conglomerate resources are defined within a broad division, the limits of which correspond to the mapped limits of the former 'Bunter Pebble Beds'. This unit includes conglomerate members equivalent to those mapped in the north but may also include considerable thicknesses of sparingly pebbly or pebble-free sandstone which might not be commercially viable to work.

Limestone

The accompanying map shows the distribution of limestone resources in Staffordshire. The limestones are of Carboniferous age and form the southern part of a much larger limestone outcrop in the Peak District and Derbyshire. Limestones of Carboniferous age are of considerable national importance and are quarried extensively in England and Wales for a range of construction and industrial uses. They are both the principal source of limestone and of crushed rock aggregate in Britain. Carboniferous limestones commonly occur in thick consistent beds that are easy to quarry. They usually produce strong, durable, low porosity aggregate materials. Limestone production in Staffordshire between 1973 and 1993 for all purposes, including cement manufacture, is shown in Figure 4, production for crushed rock aggregate is shown in Figure 5.

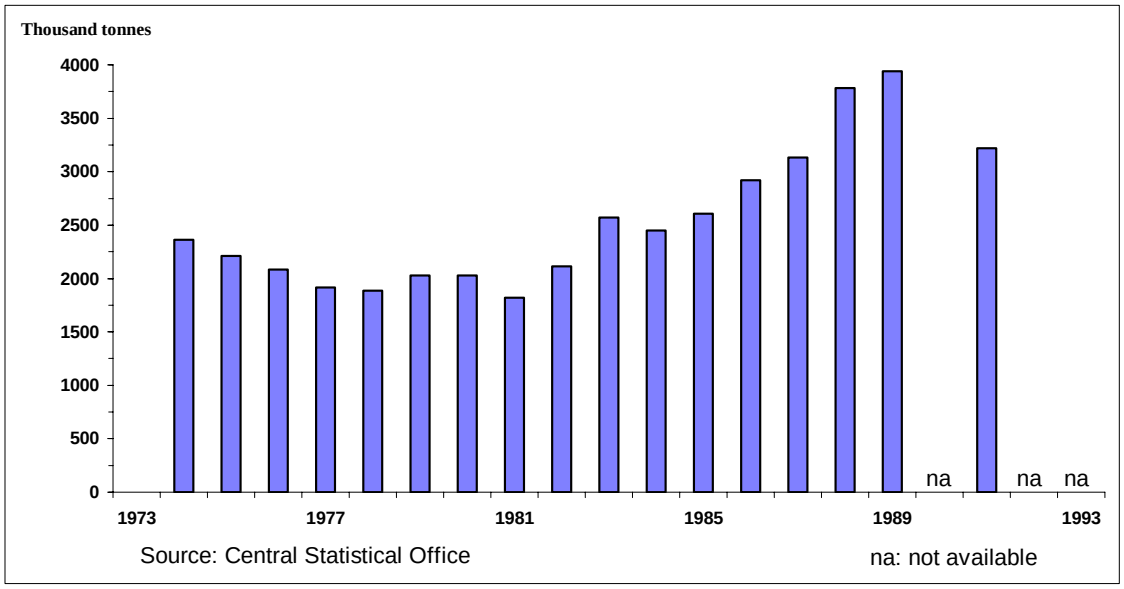

Figure 4 Total limestone production in Staffordshire, 1973–1993.

Limestone deposits in Staffordshire can be divided into two broad categories, depending on the environment in which they were deposited.

- Shelf limestones pale-coloured, massive, shallow-water limestones which are uniform over wide areas.
- Off-shelf limestones dark-coloured, well-bedded, deeper-water limestones which are more variable in character and contain shaly and cherty limestones.

This division reflects the resource potential of the limestones. The shelf limestones are a major source of aggregates and also of limestone for cement manufacture. In contrast, the off-shelf limestones are predominantly of low chemical purity and, therefore, of limited value for industrial uses.

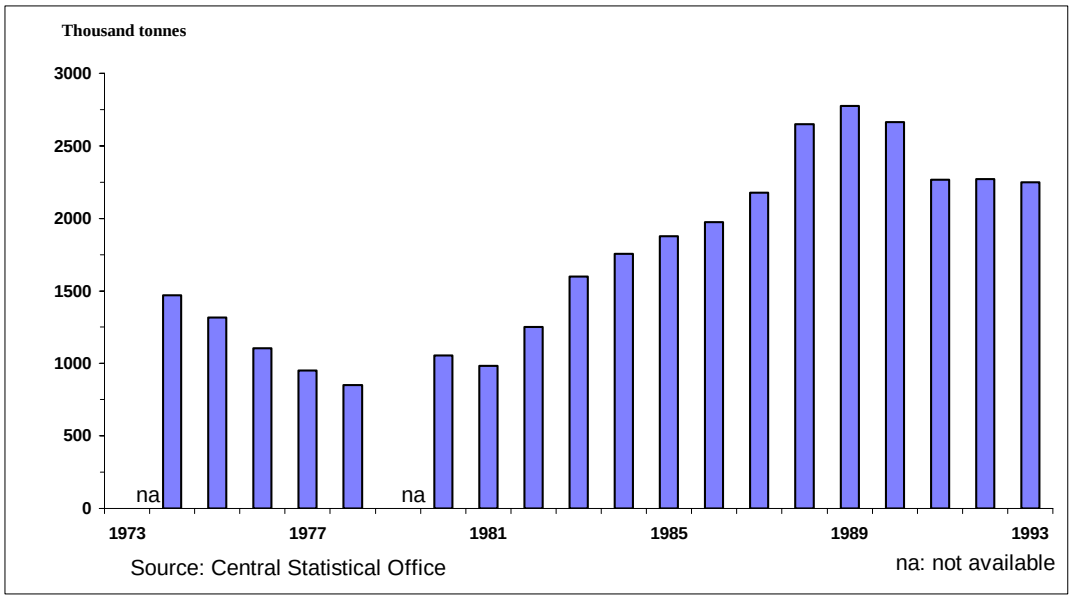

Figure 5 Limestone for crushed rock production in Staffordshire, 1973–1993.

Shelf Limestones

Two limestone formations are encountered at normal quarrying depths in Staffordshire and are known as the Kevin and Milldale limestones. The Kevin Limestones, which crop out in the south–west of the limestone area in the Weaver Hills, are stratigraphically and lithologically equivalent to the extensively quarried Bee Low Limestones of the Peak District and Derbyshire. The Kevin Limestones are around 200 m in thickness and comprise pale, thickly bedded limestones with widely spaced thin clay bands.

At the southern end of the Weaver Hills, the formation includes developments of massive reef limestone. The Kevin Limestones produce aggregates suitable for roadstone (except wearing course materials), concrete and for other general constructional purposes. They are quarried for aggregates at Kevin, Wredon and Wardlow quarries. These limestones are also of very high purity (>98 % $CaCO_3$) and the formation is notable for its chemical uniformity. Small variations in limestone chemistry occur in beds adjacent to the clay bands. They are not extracted for their chemical purity due to the limited demand for industrial limestone.

The overlying Milldale Limestones are about 470 m thick and are worked extensively around Caldon Low for cement manufacture and aggregates. The limestones are well bedded and darker in colour than the Kevin Limestones and chert and shaly beds occur sporadically throughout the sequence. The limestones are of variable and moderate purity (93.5 % to 98 % $CaCO_3$). The chief impurity is silica, although the limestones also contain disseminated clay and are typically stained red by iron oxides. The Milldale Limestones produce aggregates suitable for use in concrete and also as roadstone.

Off-Shelf Limestones

The shelf limestones become progressively more clay-rich as they pass north–eastwards into the off-shelf limestones, which are highly variable in thickness, structure and lithological character. The off-shelf limestones cover a large area which extends northwards into the Peak District National Park, where they form the limestone scenery of Dovedale and the Manifold valley. The off-shelf limestones do not support any active quarrying operations, largely because of their variable character and the proximity of better quality limestone in the shelf area.

The geology of the off-shelf limestones is relatively complex and the various limestone formations, known as the Milldale, Hopedale and Ecton limestones, show lateral variation in character. In general, the limestones are thin to thick-bedded, mid to dark grey in colour because of a high clay content, contain some beds of shale and chert and have been subjected to more intense folding. Massive, pale grey limestones of knoll-reef facies occur locally and are mainly of very high purity (>98 % $CaCO_3$) with only small amounts of silica and other impurities. The off-shelf limestones are otherwise impure or of low chemical purity but the thicker limestone units may have aggregate potential.

Coal

The coal resources of Staffordshire are mainly confined to the Potteries and Cannock coalfields, the Cheadle, Warwickshire and Shaffalong coalfields being of limited economic importance. Significant parts of the shallow coal resource area have been sterilised by urban development.

The Potteries Coalfield has an unusually thick coal-bearing sequence, but the seams exhibit high angles of dip almost everywhere. The area has had a long history of coal mining, much of the coal being consumed locally. With the decline in use of coal for domestic and industrial applications from about 1950, the major market became electricity generation, but this too has declined markedly in recent years with a consequent decline in the number of collieries. The last two British Coal deep mines, Silverdale and Trentham, which worked seams in the southern, concealed part of the coalfield where the seams are less geologically disturbed, closed in 1993. Both Trentham (renamed Hem Heath) and Silverdale were acquired by Coal Investments PLC in 1994 and have reopened. The exposed part of the Potteries Coalfield supports a number of small, licensed coal mines, although these too have declined in number in recent years.

The exposed coalfield has been, and continues to be, a potential source of opencast coal. Areas of shallow coal have been defined by the crop of the Two-foot Coal - the lowest coal of potential interest - in the north–west and east, a major fault in the west and the overlying Etruria Formation in the south. Two opencast sites, High Lane and Brown Lees, have recently completed coaling. Areas of former opencast coal extraction, dating back to the post-Second World War period, are shown on the map. The information has been derived from mineral consultation maps produced by British Coal Opencast. At currently active sites, the extent of the planning permission is shown, but elsewhere, only the worked area is defined. Except for more modern sites worked in the last 20 years or so, areas of former opencast coal extraction do not imply that the coal resource has been exhausted. The economics of opencast coal extraction have changed with time allowing coals with higher overburden ratios to be extracted. Consequently some areas have been worked on more than one occasion and some may well be worked again in the future. Saleable output of opencast coal in Staffordshire in recent years has been about 1 million tonnes per year.

In the Cheadle Coalfield, resources have been defined as the seams between the Woodhead Coal and the top of the preserved Coal Measures, which have provided the bulk of the coal extracted by both opencast and underground mining. Small-scale licensed mining continued until recently. Within Staffordshire, the coal resources of the Warwickshire Coalfield are mostly sterilised by urban development.

The Cannock Coalfield is bounded to the east and west by major faults which also partly define the limits of the opencast coal resource. The northern limit has been defined by overlying Triassic strata. The exposed coalfield is a potential source of opencast coal and currently supports one opencast operation, the recently opened Bleak House site. Parts of the coalfield, in the vicinity of Little Wyrley, are covered with thick sequences of superficial deposits which will preclude opencast mining under present economics. Shallow coal was formerly extensively worked by underground mining. The last British Coal deep mine, Littleton colliery, working the concealed north–western extension of the coalfield, closed in 1993.

Oil and gas

Conventional hydrocarbons

Hydrocarbon shows have been recorded in several boreholes in and immediately around Staffordshire, mainly in the Coal Measures and Millstone Grit (see inset map). Most of the shows are in two areas; the north–western side of the Potteries Coalfield and the area around Coalport just to the south–west of the county boundary. Additionally, oil shows have been recorded in Mear Hay colliery, Longton (5 barrels/day in 1874), Fair Lady, Hem Heath, Mossfield and Walsall Wood collieries. Oil sands (shows at the surface) are recorded in road cuttings at Burton and Dane [SJ 9007 6539]. However, to date, no economic accumulations of oil or gas have been discovered. The potential for the discovery of economic accumulations of conventional hydrocarbons is reduced because there appears to be a lack of significant volumes of mature source rocks.

Coalbed methane potential

The prime requirements for coalbed methane prospects are unworked coal seams at depths of between 200 and 1500 m (low coal permeability and high drilling cost currently make deeper targets unattractive) and adequate levels of methane which generally increases with rank (degree of metamorphism). Coal occurs at depths of less than 1500 m throughout the area delineated on the inset map. However, there is insufficient information to accurately delineate those areas of coal less than 200 m deep. The Potteries Coalfield is the most prospective area of Staffordshire, having both the greatest total thickness of coal and the highest mean coalbed (coal seam) methane content. East Staffordshire coal seams have a lower methane content and only the most deeply buried coals in the south–east of the delineated area are likely to represent an attractive prospect at present. The methane data in the west Staffordshire area is unpublished, but at present the area is not considered to be so attractive as north Staffordshire, which is one of the best coalbed methane prospects in Britain.

Clay and shale

Staffordshire has the largest output of common clay and shale in Britain, production being some 0.9 million tonnes in 1993. The Etruria Formation is the principal clay resource in Staffordshire and one of the most important in Britain. It forms the basis of an extensive brick and tile industry in the Stoke-on-Trent area, in the area to the south of Cannock and near Tamworth. The bulk mineralogy of

the clay, i.e. the relative proportions of disordered kaolinite, illite, quartz and iron oxides, and the absence of impurities, such as carbon, sulphur, soluble salts and, except locally, calcite, makes it suitable for the manufacture of high strength and low water absorption heavy clayware, including high-quality facing and engineering bricks, pavers, and roofing and floor tiles. The characteristically high, but variable, iron content of the Etruria Formation allows the production of a wide range of fired colours. The extent of the Etruria Formation is shown on the accompanying Mineral Resource Map. The formation is known to be time-transgressive, being of different ages in different areas. For this reason alone it is unlikely that its mineralogical composition and suitability for brickmaking will be uniform across the whole outcrop.

Significant areas of the outcrop of the Etruria Formation are covered by variable thicknesses of superficial deposits, particularly in north–west Staffordshire. A major part of the resource, particularly in the Stoke-on-Trent area, has also been sterilised by urban development. Here the best quality clays occur in the lower and middle divisions of the formation. Remaining resources lie mainly in the upper part of the formation, where the clays are contaminated, in part, by calcareous pellets. Thus only a small part of the resource area shown is potentially available for extraction.

In the Potteries Coalfield, mudstones within the Coal Measures have in the past been extensively used in brick manufacture, and were until recently, at Birchenwood. Similarly, at Kingsley in the Cheadle Coalfield, Coal Measures mudstones were worked for brick manufacture but are now produced for industrial applications. Fireclays, which usually underlie coal seams, may exhibit relatively low iron contents compared with other clays and are used in the manufacture of buff-coloured facing bricks. Both fireclays and mudstones occur in association with opencast coal with which they may be worked. This is only rarely the case, however, mainly because of their variable quality, but also for operational and planning reasons.

Whilst a wide range of clays may be used in brick manufacture, modern brickmaking technology is highly dependent on raw materials with consistent and predictable firing characteristics. The suitability of Coal Measures mudstones and fireclays for brick manufacture depend in part on their carbon and sulphur contents. Both may lead to firing problems (black coring), and sulphur may also give unacceptable emission levels. In general, carbon and sulphur levels should be less than 1.5 % and 0.2 % respectively, although the ease with which carbon burns out, and blending, may permit some tolerance in these figures. Blending of different clays to give a range of fired colours and aesthetic qualities is an increasingly common feature of the brick industry.

Other clays occur extensively in Staffordshire and some, including the Triassic Mercia Mudstone Group, have been worked in the past. The suitability of the mudstone-bearing formations overlying the Etruria Formation, for example, the Halesowen, Newcastle, Keele and Radwood formations (Barren Measures), is largely unproven but considered to be inferior to the Etruria Formation. For this reason their distribution has not been shown on the main Mineral Resource Map, although the broad extent of all these formations and the Mercia Mudstone Group is shown on the inset map. The Radwood Formation is currently worked on a small scale at Willoughbridge for floor tile manufacture. The use of clays other than the Etruria Formation in brick manufacture is, therefore, a possible future development, particularly where these are of ‘red-bed’ type with possibly low carbon and sulphur contents. The increasing use of clay blends may also permit the wider use of alternative clays.

Clay is an essential raw material in cement-making, supplying the necessary silica, alumina and iron oxides for the manufacture of cement clinker. Normally it is extracted in close proximity to the cement plant. This is case at the Cauldon Cement Works, near Waterhouses, where mudstones within the Millstone Grit are extracted adjacent to the limestone resource.

Silica (industrial) sand

Silica sands are essential raw materials for the glass and foundry casting industries as well as in others such as ceramics and chemical manufacture and for other specialised uses. They are valued for their physical and/or chemical properties on which these industrial applications are based, and are defined by end-use as well as purity. Depending on end-use, processing is of varying degrees of complexity. The ease with which impurities such as iron-bearing contaminants can be reduced, together with the level of losses incurred in removing oversize and undersize fractions from a sand/sandstone, has a major bearing on its suitability as a silica sand resource.

Following considerable exploration and evaluation of the Millstone Grit during the late-1950s, the Rough Rock, which is the topmost sandstone unit of the Millstone Grit and up to 35 m thick, was found to be a suitable feedstock for the manufacture of colourless glass. The sandstone has a relatively high iron content, present mainly as iron oxide on the surface of the quartz grains and also as iron-bearing minerals. Hot sulphuric acid leaching removes most of the surface iron oxides and, together with spirals to remove heavy minerals, yields silica sand containing about 0.035 % Fe_2O_3 which is the required quality for glass and ceramics manufacture. The processing plant at Oakamoor, which came on stream in 1959, supplies the colourless glass container industry and the ceramics industry with a source of high quality silica sand. The sand has also a number of other applications in various manufacturing industries and in horticulture. A lower grade silica sand is also produced on a modest scale at the Hurst quarry near Biddulph by a simple crushing, washing and sizing process.

Resources of silica sand are difficult to define without a detailed evaluation of their properties and, most importantly, the ease with which they can be processed to acceptable quality. The resources identified on the map are the outcrops of the Rough Rock in proximity to the existing silica sand operations.

The Wildmoor Sandstone Formation in southern Staffordshire has been worked in the past as a source of naturally bonded moulding sand. This type of foundry sand is not as important as formerly and the formation has not been identified as an important silica sand resource. The only operation currently active in this formation is producing aggregates.

Gypsum/anhydrite

Gypsum ($CaSO_4.2H_2O$) and anhydrite ($CaSO_4$) are the naturally-occurring forms of calcium sulphate. These occur in the Triassic Mercia Mudstone Group in the Needwood Basin to the west of Burton-on-Trent. Commercial interest is confined to the Tutbury Gypsum, the inferred subsurface extent of which is shown on the map. The Tutbury Gypsum is currently worked at the Fauld mine, where it averages about 2.5 m in thickness, but formerly mining operations from outcrop extended as far west as Draycott. At Normanswood, farther to the west, a gypsum bed, probably at the horizon of the Tutbury Gypsum, was worked until the mine was abandoned in 1956.

Gypsum/anhydrite production at Fauld is for cement manufacture, but until 1989 the gypsum was also used for plaster manufacture. Anhydrite, which generally becomes more abundant in depth away from the zone of groundwater influence, also acts as a retarder in cement manufacture. Gypsum containing higher proportions of anhydrite than would have been acceptable for plaster manufacture may now be used. Minor quantities of alabaster block are also produced for ornamental purposes.

Salt

The inferred subsurface extent of salt is shown on the map. Two major salt formations, the Northwich Halite and the Wilkesley Halite, occur extensively in the Cheshire Basin and extend into the north–west of the county. The Northwich Halite is worked on a large scale in Cheshire by both rock salt mining and controlled brine pumping. In view of the very large salt resources in Cheshire, no requirement for producing salt in Staffordshire is currently anticipated.

Salt was produced from brine springs in Staffordshire at least as early as the 17th century and in 1893 an industry was established at Stafford Common following the discovery of rock salt in boreholes in 1891. Production of salt in Stafford by natural brine pumping ceased in 1970 because of subsidence problems. To the east, brine wells have been recorded at Weston-on-Trent and Shirleywich but the production of salt ceased there in 1901. The subsurface extent of the Stafford Halite Formation is imprecisely known but it appears to be of low quality and very thin at the margins.

Sandstone

Most of the thicker sandstone units within the Millstone Grit and the Coal Measures have been used as local sources of building stone, mostly on a small-scale, but in places larger quarries, now abandoned, have been developed. One small quarry at Hollins, near Biddulph still produces building stone. The extent of the Millstone Grit is shown on the inset map.

The Triassic Hollington Formation consists mainly of cross-bedded, red-brown and yellow sandstones which are locally well-cemented and provide a valuable and attractive source of building stone. The number of disused quarries testifies to its usefulness in the past and there are currently three small working quarries in the Uttoxeter area producing building stones; Hollington, Greatgate Quarry and Tearne.

At Gillow Heath, north–west of Biddulph, a band of compact, quartzitic siltstone, known as whetstone, was formerly worked for grinding and polishing uses. A similar material has been mined near Mow Cop and to the east of Biddulph. These operations were last worked in the 1970s, but a large planning permission for the underground extraction of whetstone remains.

MINERAL RESOURCES AND ENVIRONMENTAL DESIGNATIONS

The character of the landscape reflects the nature and structure of the underlying rocks, the erosive forces to which they have been subjected and the soil and vegetation that they support. It is constantly changing due, in the longer term, to geomorphological processes, and in the shorter term, to economic and social pressures. Mineral extraction can produce irrevocable, but not necessarily harmful, change to a locality over a relatively short timescale. In order to ensure that such changes are both sustainable and non-injurious to the environment, the most important landscapes and habitats, such as National Parks and SSSIs, are given a greater

degree of protection from mineral working. The necessity for mineral extraction in such areas has to be justified by a most rigorous examination of the merits of the proposal. This examination should consider the public interest in the development of the resources and the social desirability of employment, as well as the need to protect the environment. There is no prohibition on working minerals in such areas.

The resolution of conflicts between mineral resource development and other considerations is undertaken through the development plan framework and a balanced appraisal of the various issues associated with particular developments. The Mineral Resources Maps of Staffordshire provide a synthesis of available information which can be revised and updated as additional information becomes available. It is hoped that they will assist local and national Government, the minerals industry and other interests in the consideration and production of policies included in development plans.

The Cannock Chase AONB coincides with a major part of the area where the conglomerate resources of the Triassic Sherwood Sandstone occur. Several large sand and gravel quarries working these bedrock deposits also occur within the AONB. A small area of shallow coal resources extends into the AONB.

There are a large number of SSSIs in Staffordshire and some of the most extensive are within the AONB and overlie the conglomerate resources. Other SSSIs are widely scattered but include sites located over the limestone resource in the north–east of the county.

There is a greater concentration of Scheduled Monuments over the limestone in the north–east of the county. Elsewhere, Scheduled Monuments are scattered except for a concentration on the river gravels at the confluence of the rivers Trent and Tame, north of Lichfield.

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- Planning Policy Guidance Notes
- Minerals Planning Guidance Notes
- Regional Planning Guidance Notes and Circulars

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a) British Geological Survey 1:50 000 or 1:63 360* scale New Series geological map sheets

110	Macclesfield	(1968)	
111	Buxton	(1978)	
123	Stoke-on-Trent	(1993)	
124	Ashbourne	(1983)	
139	Stafford	(1927)	
140	Burton-upon-Trent	(1982)	
141	Loughborough	(1950)	reprinted (1976)
153	Wolverhampton	(1929)*	reprinted (1968)
154	Lichfield	(1926)*	reprinted (1954)
155	Coalville	(1982)	
167	Dudley	(1939)	reprinted (1975)

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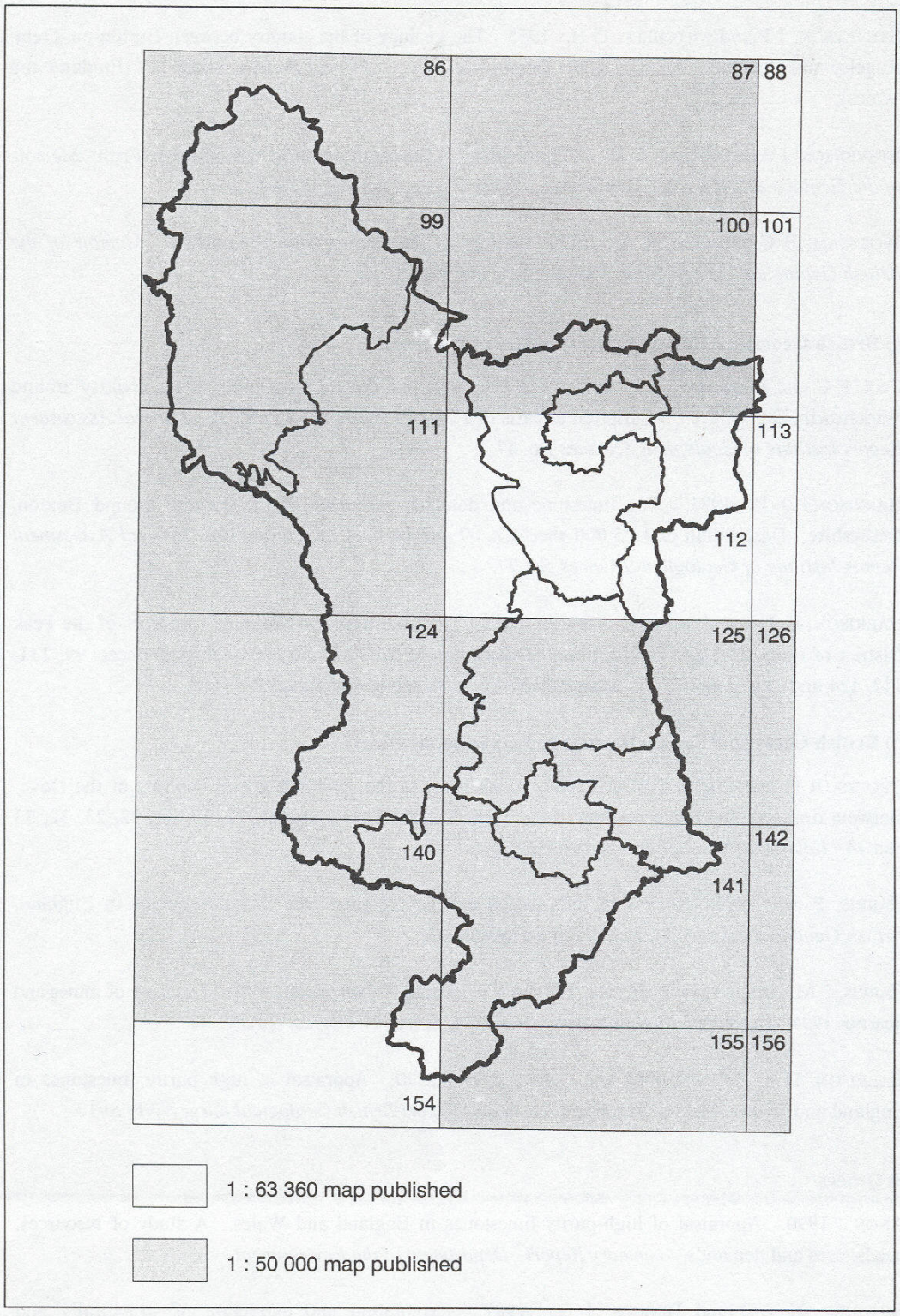

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APPENDIX 1 MINERAL WORKINGS IN STAFFORDSHIRE (1994)

Pit Name	Location	Operator	Commodity
Silverdale Mine	Newcastle-under-Lyme	Coal Investments PLC	Coal
Hem Heath Mine	Trentham	Coal Investments PLC	Coal
Apedale Mine	Newcastle-under-Lyme	Aurora Mining	Coal
Little Sherriff Mine	Newcastle-under-Lyme	Apedale Hall Colliery Co. Ltd	Coal
Haying Wood Mine	Newcastle-under-Lyme	J A Knight, (Coppice) Ltd	Coal
Chatterley Whitfield Mine	Stoke-on-Trent	R P Minesearch	Coal
Bleak House	Cannock	Wimpey Mining / BC Opencast	Coal
Kingsley	Cheadle	Redland Bricks Ltd	Common Clay and Shale
Fenton Manor	Stoke-on-Trent	Redland Bricks Ltd	Common Clay and Shale
Lightwood	Longton	Daniel Platt Ltd	Common Clay and Shale
Bradwell Wood East	Newcastle-under-Lyme	P R Powell	Common Clay and Shale
Bradwell Wood West	Newcastle-under-Lyme	P R Powell	Common Clay and Shale
Knutton	Newcastle-under-Lyme	Redland Bricks Ltd	Common Clay and Shale
Walleys	Newcastle-under-Lyme	Redland Bricks Ltd	Common Clay and Shale
Chatterley	Newcastle-under-Lyme	J Kimberley and Sons Ltd	Common Clay and Shale
Rufus (Bradwell Wood)	Newcastle-under-Lyme	Redland Bricks Ltd	Common Clay and Shale
Keele	Newcastle-under-Lyme	Redland Bricks Ltd	Common Clay and Shale
Willoughbridge	Market Drayton	Willoughbridge Plant Co. Ltd	Common Clay and Shale
Essington	Essington	Redland Bricks Ltd	Common Clay and Shale
Redhurst	Essington	Greenways Landfill / Tarmac Brick and Tile	Common Clay and Shale
Cheslyn Hay / Rosemary Tileries and Shale		Cheslyn Hay	Redland Bricks Ltd Common Clay
Campions Wood	Cheslyn Hay	Berrickbridge Ltd	Common Clay and Shale
Campions Wood	Cheslyn Hay	Tarmac Brick and Tile	Common Clay and Shale
Himley Wood	Dudley	Baggeridge Brick	Common Clay and Shale
Holly Bank Gorse	Essington	Marley Building Materials Ltd	Common Clay and Shale
Wilnecote / Hockley	Dosthill	Tilcon-Mortar & Special Products	Common Clay and Shale
Fauld Mine	Tutbury	British Gypsum Ltd	Gypsum / anhydrite
Cauldon	Waterhouses	Blue Circle Industries	Limestone / Common Clay and Shale
Caldon Low	Waterhouses	Tarmac-Western	Limestone
Wardlow	Waterhouses	Tarmac-Western	Limestone
Wredon	Waterhouses	Alfred McAlpine Quarry Products	Limestone
Kevin	Waterhouses	Tilcon-Western	Limestone
Huntley Wood	Cheadle	ARC-Central	Sand and Gravel
Elford	Lichfield	ARC-Central	Sand and Gravel
Manor Park	Kings Bromley	ARC-Central	Sand and Gravel
Hints	Tamworth	Tilcon-Western	Sand and Gravel
Shire Oak	Aldridge	Tarmac-Western	Sand and Gravel
Weeford	Lichfield	RMC-Western Aggregates	Sand and Gravel
Wharf Lane	Brownhills	Stubbers Green Ash Co.	Sand and Gravel
Newbold	Barton-under-Needwood	Douglas Concrete and Aggregate Ltd	Sand and Gravel
Trysull / Church Lane	Wombourne	Tilcon-Western	Sand and Gravel
Stewpony	Kinver	Biffa Waste Services Ltd	Sand and Gravel

Pit Name	Location	Operator	Commodity
Upper Whittimere Farm	Wombourne	T A Bishop & Son	Sand and Gravel
Enville Road	Wall Heath	F G Davis & Sons (Contractors) Ltd	Sand and Gravel
Trentham / Lordsley	Willoughbridge	ARC-Central	Sand and Gravel
Middleton Hall	Tamworth	ARC-Central	Sand and Gravel
Saredon	Shareshill	Biffa Waste Services Ltd	Sand and Gravel
Hilton Park	Featherstone	ARC-Central	Sand and Gravel
Anglesey	Brownhills	Blakemore	Sand and Gravel
Freehay	Cheadle	ARC-Central	Sand and Gravel
Pottal Pool	Penkridge	ARC-Central	Sand and Gravel
Weeford (Moneymore)	Lichfield	ARC-Central	Sand and Gravel
Huntington / Shoal Hill	Cannock	ARC-Central	Sand and Gravel
Almington	Market Drayton	ARC-Central	Sand and Gravel
Seisdon	Wombourne	Tarmac-Western	Sand and Gravel
Windmill Hill / Manor Farm	Essington	Tarmac-Western	Sand and Gravel
Hopwas / Packington Hill	Tamworth	RMC-Western Aggregates	Sand and Gravel
Croxden	Cheadle	Tarmac-Western	Sand and Gravel
Cranebrook	Lichfield	Yates Bros. (Norton Canes) Ltd	Sand and Gravel
Eccleshall / Baden Hill	Stone	Redland Aggregates	Sand and Gravel
Rugeley	Rugeley	RMC-Western Aggregates	Sand and Gravel
Barton Pit	Lichfield	ARC-Central	Sand and Gravel
Alrewas	Lichfield	Redland Aggregates	Sand and Gravel
Blackhills	Wombourne	F G Davis & Sons (Contractors) Ltd	Sand and Gravel
Hinksford Road	Swindon	F G Davis & Sons (Contractors) Ltd	Sand and Gravel
Greatgate Quarry	Great Gate	J Oldham and Co. (Stonemasons) Ltd	Sandstone
Hollington Red	Hollington	Staffordshire Stone (Hollington) Ltd	Sandstone
Tearne	Hollington	J Oldham and Co. (Stonemasons) Ltd	Sandstone
Hollins	Horton	G W Barnacle	Sandstone
Oakamoor	Cheadle	Hepworth Minerals and Chemicals Ltd	Silica Sand
Hurst	Biddulph	HSS (Sands and Engineering) Ltd	Silica Sand

As at 31.12.94

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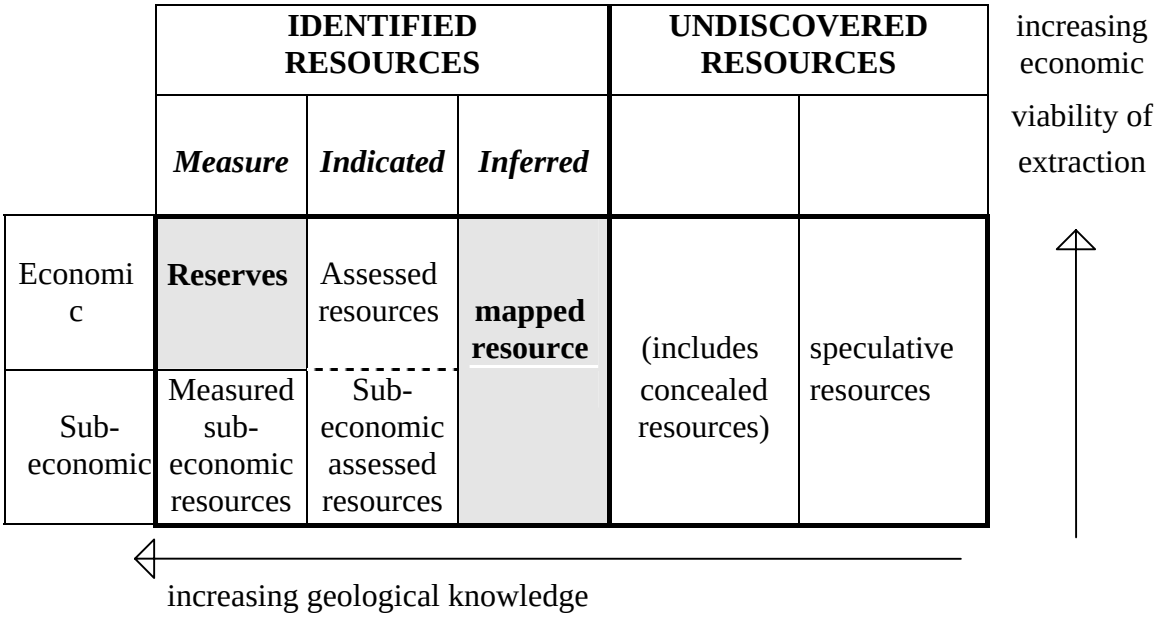
APPENDIX 3 METHODOLOGY

The British Geological Survey (BGS) was commissioned by the Department of the Environment to prepare, on a trial basis, a set of concise statements mainly in map form, to show the broad distribution of mineral resources in selected counties and to relate these to selected, nationally designated planning constraints. The trial study has developed a methodology for the collection and display of data in a consistent and comparable format based on four Mineral Planning Authority (MPA) areas - Bedfordshire, Derbyshire, Staffordshire and the Peak District National Park.

The main element of the trial study was the production of maps, with accompanying concise reports, for each MPA area. All mineral resource and planning constraint information has been captured digitally on a PC-based system using Intergraph Microstation to produce a cartographic database. Data has been captured as a series of files, structured on separate levels so that they can be viewed either independently or in various combinations, as required. Most of the information has been captured digitally from hard copy maps mainly with scales of 1:25 000, 1:50 000 and 1:63 360. The BGS 1:250 000 digital geological dataset has been used in places. Other material was obtained in a variety of digital formats which have had to be converted for use by the Intergraph Microstation System.

As the data are held digitally, map output can be on any scale but 1:100 000 has been found to be a convenient size to summarise the information for individual MPAs. This provides a legible topographic base which enables both the broad implications of the information, and sufficiently accurate detail, to be shown. The particular advantage of holding all the information in digital form is that it is comparatively easy to update and revise as additional information becomes available, and also provides scope for producing customised maps of selected information on request. Any future changes in administrative boundaries (e.g. post-local government reorganisation) can be easily accommodated.

Figure 1 Classification of resources



Based on McKelvey, 1972 and Harris, 1993

Classification of reserves and resources

The diagram, Figure 1, is a representation of a conventional method for classifying mineral reserves and resources, based on a system introduced the US Bureau of Mines and the US Geological Survey and adapted by the British Geological Survey. In this conceptual diagram the vertical dimension of the diagram represents the economic viability of the resource and consists simply of two categories, **economic** and **sub-economic**, depending on whether or not it is commercially viable under prevailing economic circumstances. As the costs of extraction and the prices obtained for the mineral may change with time, the division between the two categories is not fixed. This has been well illustrated in recent years in the coal industry where coal reserves in operational mines have moved into the sub-economic category as a direct consequence of these mines being closed. The horizontal dimension represents degrees of geological knowledge about the resource, from mere speculation about its existence (right-hand side) to thorough assessment and sampling on a systematic basis (left-hand side).

In the present study the County Mineral Resource Maps have been produced by the collation and interpretation of data held by the British Geological Survey. Since the mineral resource data presented are not comprehensive and the quality is variable, the boundaries shown are approximate. Most of the mineral resource information presented is, therefore, at the **inferred resource** level (Figure 1), that is to say those resources that can be defined from available geological information and which may have some economic potential. They have neither been evaluated by drilling or other sampling methods, nor had their technical properties characterised on any systematic basis. However, where mineral assessment studies, including drilling and testing, have been carried out, sufficient information may be available to define the extent and quality of the deposits at the **indicated resource** level (Figure 1). The conglomerate resources of the Sherwood Sandstone Group of north Staffordshire and the Carboniferous limestone resources have been assessed at the indicated resource level.

A mineral resource is not confirmed as economic until it is proved by a relatively expensive evaluation programme. This usually involves a detailed measurement of the material available for extraction together with an evaluation of the quality of the material, its market suitability, the revenue its sale will generate and, ultimately, the viability of the deposit. That part of a resource that is both ‘measured’ and ‘economic’, i.e. it has been fully evaluated and is commercially viable to work, is called a **reserve** or **mineral reserve**.

In the context of land-use planning, however, the term **reserve** should strictly be limited to those minerals for which a valid planning permission for extraction exists, i.e. **permitted reserves**. The extent of mineral planning permissions is shown on the Mineral Resources Maps. These cover active mineral workings and also inactive (dormant) mineral permissions. Some mineral planning permissions may have remained unworked, and others may have become uneconomic prior to being worked out. In most cases the areas involved are likely to have been worked to some extent in the past, and may now be restored. In addition, parts of the resource areas may have been fully evaluated by the minerals industry, but either have not been subject to a planning application or have been refused permission for extraction. These areas are **unpermitted reserves**.

A **landbank** is a stock of planning permissions and is commonly quoted for aggregates. It is composed of the sum of all **permitted reserves** at active and inactive sites at a given point of time, and for a given area, with the following provisos (DOE, MPG6):

it includes the estimated quantity of reserves with valid planning permission at dormant or currently non-working sites;

it includes all reserves with valid planning permission irrespective of the size of the reserves and production capacity of particular sites;

it does not include estimated quantities of material allocated in development plans but not having the benefit of planning permission; and

it does not include any estimate for the contribution that could be made by marine dredged, imported or secondary materials.

It is important to recognise, however, that some of the permitted reserves contained within landbanks have not been fully evaluated with the degree of precision normally associated with the strict use of the term **reserves**, indeed some may not have been evaluated at all.

Mineral workings and planning permissions

The locations and names of mineral workings in Staffordshire are shown on the maps. The information is derived from the British Geological Survey's Mines and Quarries Database, updated as appropriate from Staffordshire County Council's records. Letters (e.g. **Lst** = limestone) are used to show the main mineral commodity produced.

The requirement to define past mineral workings presented an initial difficulty, in that no comprehensive and up-to-date source of information was identified. Following discussions with the MPAs and with DoE's agreement, it was agreed to show the extent of mineral planning permissions which will reflect most activity post-1946. For Staffordshire, the County Council kindly made available index maps from which the planning permissions were digitised. Planning permissions for re-working old mine tips are not included.

The extent of the planning permissions shown on the Mineral Resources Map cover active mineral workings, former mineral workings and, occasionally, unworked deposits. A distinction is made between surface and underground permissions. The present physical and legal status of the planning permissions is not qualified on the map. The areas shown may, therefore, included inactive sites, where the permission has expired due to the terms of the permission, i.e. a time limit, and inactive (dormant) sites where the permission still exists. Sites which have been restored are not separately identified. Information on the precise status and extent of individual planning permissions should be sought from Staffordshire County Council.

Most planning permissions appear on a mapped mineral resource area and thus the underlying resource colour identifies the mineral type. This is not the case in the following circumstances:

- where a planning permission for one mineral overlies another resource area, e.g. the underground permission for whetstone occurs almost entirely over a coal resource area.
- where no resource has been mapped

Planning permissions fall outside resource areas for the following reasons:

- some old permissions may be for minerals which are no longer of economic importance and no resource has, therefore, been mapped, e.g. planning permissions for the extraction of naturally bonded moulding sand.
- permissions shown partly off resource areas may extend to ownership, or other easily defined boundaries, or to include ground for ancillary facilities such as processing plants, roads and overburden tipping.
- isolated workings occurring outside defined resource areas may reflect very local or specific situations not applicable to the full extent of the underlying rock type: shale working adjacent to the Cauldon cement works is an example.

The latest data available for the total areas of planning permissions in Staffordshire, collected for the Department of Environment Minerals Survey of 1988, is shown in Table 1. This information is updated at intervals.

Table 1 Areas of planning permissions for mineral workings in Staffordshire, 1988

	Commodity	**Total (hectares)**	**%**
Surface Workings	Clay/Shale	474	14.6
	Coal (opencast)	674	20.87
	Gypsum/Anhydrite	12	0.37
	Limestone/Dolomite	244	7.55
	Sand & Gravel (Construction)	1682	52.07
	Sand (Industrial/Silica)	93	2.88
	Sandstone	4	0.12
	Other Minerals	47	1.46
Total		**3230**	**100**
Underground workings	Coal (under GDO)	26317	72.9
	Coal (specific plan. permissions)	7748	21.47
	Gypsum/Anhydrite	2028	5.62
Total		**36093**	**100**

From: Department of the Environment, Survey of Land for Mineral Workings in England, 1988