British Geological Survey

Department of the Environment, Transport and the Regions

Mineral Resource Information for Development Plans

West Midlands: Resources and Constraints (Birmingham, Coventry, Dudley, Sandwell, Solihull, Walsall and Wolverhampton)

TECHNICAL REPORT WF/99/3
Mineral Resources Series

Mineral Resource Information for Development Plans: Phase One West Midlands: Resources and Constraints (Birmingham, Coventry, Dudley, Sandwell, Solihull, Walsall and Wolverhampton)

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This report accompanies the 1:100 000 scale map:
Warwickshire / West Midlands Mineral Resources

Cover Photograph
Aerial View of Aldridge, Walsall, showing clay workings in the Etruria Formation and associated Brick factories. Photograph courtesy of Ibstock Building Products Ltd, © Roger D Smith, ABIPP, Aerial Photography, Gosport, Hampshire.

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BRITISH GEOLOGICAL SURVEY

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

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SUMMARY

This report is one of a series prepared by the British Geological Survey for various administrative areas in England and Wales for Phase One of the Department of the Environment, Transport and the Regions Research Project *Mineral Resource Information for Development Plans*.

The report and accompanying map relate to the former Metropolitan County of the West Midlands and includes the Unitary Planning Authorities of Birmingham, Coventry, Dudley, Sandwell, Solihull, Walsall and Wolverhampton. They delineate and describe the mineral resources of current or potential, economic interest in the area and relate these to national planning designations which may represent constraints on the extraction of minerals. 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)

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 in combination with that for Warwickshire. The map is produced at 1:100 000 scale, which is convenient for overall display and allows for a legible topographic base on which to depict the information. In addition, as the data are held digitally using a Geographical Information System (GIS), easy revision, updating and customisation are possible, including presentation of subsets of the data at larger scales.

Basic mineral resource information is essential to support mineral exploration and development activities for resource management and land-use planning, as 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 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, by providing a knowledge base on the nature and extent of mineral resources and the environmental constraints which may affect their extraction. However, it is anticipated that the maps and report will also provide valuable data for a much wider audience, including the minerals industry, the Planning Inspectorate, the Environment Agency, the Countryside Commission, other

agencies and government bodies, environmental interests and the general public.

The mineral resource information has been produced by the collation and interpretation of data principally held by the British Geological Survey. The methodology for the collection and display of the data is described and a range of sources of information and further contacts is presented. The mineral resources covered are coal, crushed-rock aggregate, sand and gravel, brick clay, sandstone, silica sand and secondary aggregates.

INTRODUCTION

'..... it will become increasingly important to have reliable information about the nature, quantity and location of mineral resources as workable reserves in environmentally acceptable areas become scarcer.'

Sustainable Development: The UK Strategy.
The UK Government's response to the Rio Earth Summit.

This report is one of a series that has been prepared by the British Geological Survey for various administrative areas in England and Wales as part of the Department of the Environment Transport and the Regions research project *Mineral Resource Information for Development Plans*.

The report relates to the former Metropolitan County of the West Midlands and should be used in conjunction with the accompanying mineral resources map. The area includes the Unitary Authorities of Birmingham, Coventry, Dudley, Sandwell, Solihull, Walsall and Wolverhampton, which are also the respective Mineral Planing Authorities (MPAs). All references to the 'West Midlands' made in this report should be taken to include only the area covered by these seven unitary authorities. The report describes the mineral resources of current or potential economic interest in the West Midlands and these are delineated on the Mineral Resources Map which is combined with Warwickshire. The map and report relate these resources to national planning designations which may represent constraints on the extraction of minerals. 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, by providing 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.

All the data are held in digital form which can be readily revised on a regular basis. This also provides scope for producing customised maps of selected information, including the display of part of an administrative area in greater detail or a grouping of administrative areas to provide a broader picture. The mineral resource map is at 1:100 000 scale which is a convenient scale for overall display and to show the information on a legible topographic base. The report and map represents the situation at 1st November 1998.

Mineral resources are valuable national assets and their extraction and use makes a major contribution to wealth creation, the

infrastructure of our society and quality of life of individuals. However, minerals can only be worked where they occur and their extraction, particularly in the densely populated landmass of Britain, causes conflicts with other desirable aims of society, either by loss or change to valued landscapes, habitats or features of historical and archeological interest, or due to amenity impact.

Basic mineral resource information is essential to support mineral exploration and development activities. In the wider context of sustainable development, mineral resource data are required for resource management and land-use planning. These data also contribute to the baseline data needed for environmental impact studies and environmental guidelines. Moreover, knowledge of the extent and quality of mineral resources, and their rate of extraction, can help value them as national assets. This ensures that the capital they represent is managed properly and rates of depletion monitored.

MINERALS PLANNING

It is the function of the planning system through the development plan and individual decisions to achieve a balance between competing objectives. Achieving that balance requires adequate data on the relevant competing objectives, including the extent and details of mineral resources. As the development of workable resources in environmentally acceptable areas is becoming more difficult, it will be become increasingly important in the policy development process to have comparative and reliable data on the distribution and quality of such resources.

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/or waste. Development plans set out the main considerations on which planning applications are determined and 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 plans are produced through an extensive process of consultation with prospective developers and the general public. 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 Planning and Compensation Act 1991 introduced a mandatory requirement that all Mineral Planning Authorities (MPAs) in England and Wales prepare either a local plan or a unitary development plan, which set out the policies and proposals against which planning applications and appeals are determined. Mineral local plans are intended to provide a clear guide to mineral operators and the public where mineral extraction is likely in principle to be acceptable and where not. They cover a period of at least 10 years and are reviewed periodically to take account of new information and changing circumstances. MPAs are, therefore, required to undertake regular assessments of the existing resources in their areas and of the reserves for which planning permissions have been granted.

The key elements of a mineral local plan or the mineral policies of a unitary development plan are:

- to balance through its policies the essential need for minerals against protection of the environment and local amenity
- to make an appropriate provision for the supply of minerals and provide an effective framework within which the minerals industry may make planning applications
- to set out policies for the control of mineral working and associated development
- to identify areas of possible future mineral working
- to prevent unnecessary sterilisation of resources by the use of safeguarding policies, including defining mineral consultation areas

It follows from the above that information on the extent, quality and, if possible, quantity of mineral resources is an essential prerequisite for the production of mineral local plans, both in the context of identifying areas of future mineral working and the longer term objective of protecting important mineral resources against sterilisation. Such data should be available to all parties to assist them in their contribution to the development plan process, both to protect mineral resources from sterilisation and to provide for sufficient resources to meet the needs of society. This work is intended to assist that process.

Three major elements of information are presented and described:

- the geological distribution and importance of all mineral resources
- the extent of mineral planning permissions and the location of current mineral workings

- the extent of selected planning constraints (national statutory designations)

An additional and important objective is that the data should be capable of revision and update. 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. The data are held digitally using a Geographical Information System (GIS), which allows for easy revision, updating and customisation, including presentation of subsets of the data at larger scales. 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 Commission and English Nature), environmental interests and the general public.

MINERAL RESOURCE CLASSIFICATION

Mineral resources are natural concentrations of minerals, or bodies of rock, that are or may become of potential economic interest as a basis for the extraction of a commodity. They must have physical and/or chemical properties and be present in sufficient quantity to be of intrinsic economic interest.

The identification and delineation of mineral resources is inevitably somewhat imprecise as it is limited not only by the quantity and quality of data currently available but also involves predicting what might, or might not, become economic to work in the future. The assessment of mineral resources is thus a dynamic process which must take into account a range of factors. These include geological reinterpretation, as well as the continually evolving demand for minerals, or specific qualities of minerals, due to changing economic, technical and environmental factors. Consequently, areas that are of potential economic interest as sources of minerals may change with time. Criteria used to define resources, such as mineral to waste ratios, also change with location and time. Thus a mineral deposit with a high proportion of waste may be viable if it is located close to a major market, but uneconomic if situated further away. The criteria used to delineate resources are outlined in the relevant commodity section of the report. These criteria vary depending on the quality of information available.

The map of Warwickshire and the West Midlands principally shows the extent of **inferred mineral 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.

Where mineral assessment studies have been undertaken by the British Geological Survey, sufficient information may be available to define mineral resources at the **indicated resource level**. The sand and gravel resources of the West Midlands area partly fall into this category. The linework here is based on 1:25 000 scale mineral assessment maps. Mineral resources defined on the map delineate areas within which potentially workable minerals may occur. These areas are not of uniform potential, nor do they take account of planning constraints which 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. The individual merits of a site can then be judged against other land-use planning issues.

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 **measured, indicated** and **inferred resources** and evaluated commercial deposits (**reserves**) is described in more detail in Appendix 3. In the context of land-use planning, however, 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 mineral resources map has been produced by the collation and interpretation of data held by the British Geological Survey. The geological lines are taken, with some generalisations, from available BGS 1:25 000, 1:50 000 scale and 1:63 630 scale maps. These published maps are based on 1:10 560 or 1:10 000 scale surveys, which cover most of the area. In general, the more recent the survey the more detailed it is likely to be.

MINERAL WORKINGS AND PLANNING PERMISSIONS

The location and name of mineral workings that are currently active or temporarily inactive, together with the main mineral commodities produced, are shown on the map and in Appendix 1.

The extent of all known mineral planning permissions (other than coal) is also shown on the Mineral Resources Map. They include all permissions granted since 1st July 1948 and all IDO permissions, whatever their subsequent status in relation to legislation relating to the Planning and Compensation Act 1991 and the Environment Act 1995. Planning permissions cover active mineral workings, former mineral workings and, occasionally, unworked deposits. They represent areas where a commercial decision to work minerals has been taken in the past (they are, or were, mineral reserves) and

where the mineral resource may have been depleted to a greater or lesser extent. All planning permissions data were obtained from the various local authorities.

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 sites where the permission still exists. Sites which have been restored have not been separately identified. However, information on the planning and operational status of each planning permission may be available on the database which underpins the map. 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 appropriate Mineral Planning Authority (Appendix 2).

ENVIRONMENTAL DESIGNATIONS

The maps show 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:

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

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 appropriate 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. The areas shown as NNRs and SSSIs may also be subject to international designations reflecting their wider ecological importance. They may include Ramsar sites (wetlands of international importance as listed in accordance with the Ramsar Convention), or Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) as identified in accordance with EC Directives on wild birds and natural habitats, respectively.

MINERAL RESOURCES

OVERVIEW

The West Midlands covers the area stretching westwards from Coventry, through Birmingham to Wolverhampton and Dudley (the Black Country) and contains a high percentage of urban and industrial land. Whilst Coventry and Solihull have less old-style heavy industry, and a high proportion of green belt, Birmingham and the Black Country are overwhelmingly urbanised. The underlying rock types are predominantly sedimentary, with some igneous intrusive and volcanic bodies. The sedimentary rocks are predominantly sandstones, siltstones, mudstones and limestones, with coal, fireclay and ironstone seams. Dolerite bodies are relatively abundant in the western part of the area, associated locally with volcanic agglomerates and tuffs. A small outcrop of quartzite is exposed in the south west of Birmingham. Extensive superficial deposits of sand, gravel and clay, laid down by glacial and fluvial processes are widespread on the lower ground in the area. A simplified solid geology map, accompanied by a list of resources and commodities worked, is shown in Figure 1.

The economic prosperity of the Black Country was originally derived from the conjunction of coal, ironstone, fireclay and limestone resources in Carboniferous and underlying Silurian sediments. This area forms the southern part of the South Staffordshire Coalfield. Coal and ironstone have been extracted in this area since medieval times. Extraction reached a peak during the mid-19th Century, with numerous small mines in operation. Following the development of new iron producing processes in the nearby Coalbrookdale Coalfield during the Industrial Revolution, much of the Black Country was given over to ironmaking, with the products removed by canal and subsequently by rail. The southern part of the coalfield was also famed for the quality of its fireclay which was used to manufacture pots for melting glass as early as the 16th Century. Only intermittent opencast coal mining now continues in the south of the coalfield. The last deep mine for coal closed in 1968.

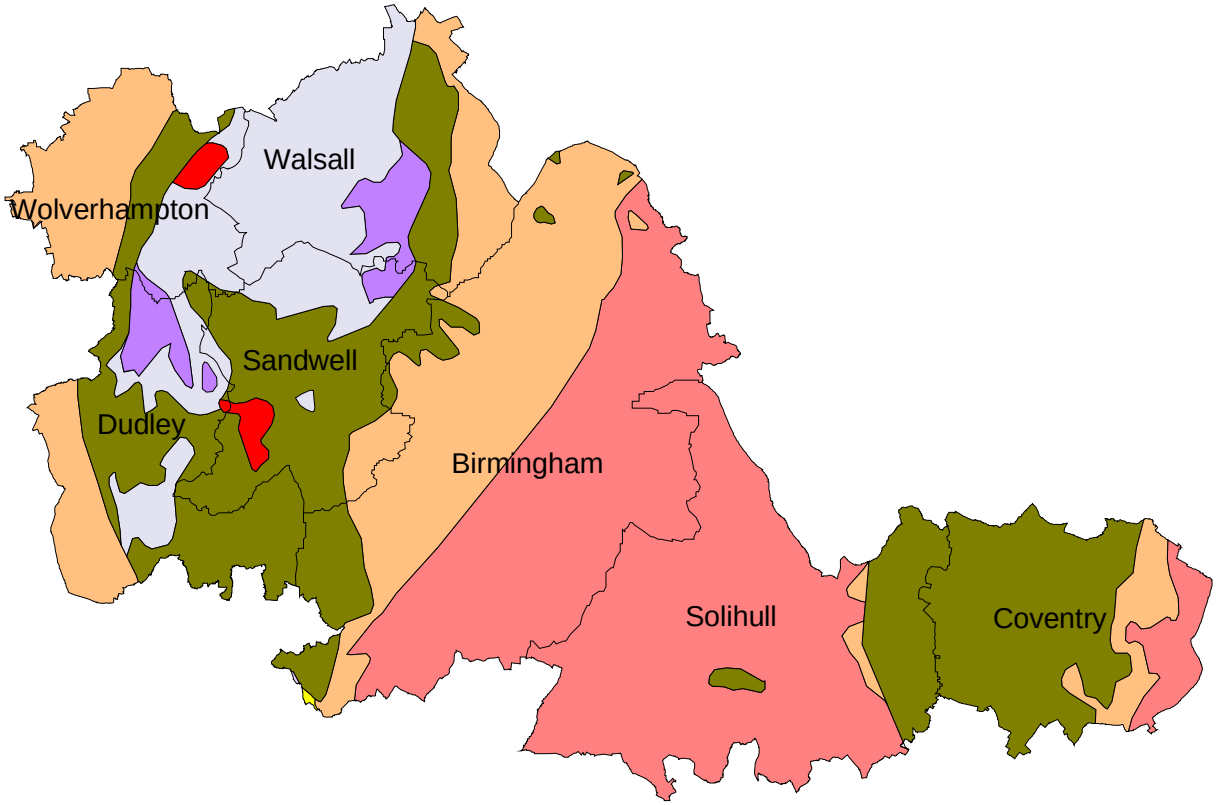
Silurian limestones were extensively worked in Dudley for use as a flux in ironmaking and for lime production. Some of the workings were underground and have led to areas of ground instability in the Dudley area. Lime was also produced from the thin *Spirorbis* limestones of Upper Carboniferous age. The Carboniferous dolerites to the west of Birmingham have been intensively worked for roadstone in the past and are still worked at the Rowley Hills Quarry complex. The Ordovician Lickey Quartzite south of Birmingham was formerly worked for rough building stone, as well as roadstone, but operations have now ceased.

Within the Birmingham area, small moulding sand and burnishing sand pits were formerly worked in the Triassic Sherwood Sandstone (formerly 'Pebble Beds' and 'Upper Mottled Sandstone'). Brick clay workings in the Triassic Mercia Mudstone and minor workings for cement in the Jurassic clays around Solihull were also formerly active. In Coventry, there were a few brick clay workings in the Mercia Mudstone and the Carboniferous Meriden Formation. Here, and in Solihull, the Upper Coal Measures are exposed, but deep coal mining in the concealed part of the Warwickshire Coalfield ceased with the closure of Coventry (Keresley) Colliery in 1996. There are no exposed or shallow coals in the Coventry area suitable for opencast operations.

Large-scale sand and gravel workings are found in the valley of the Blyth at Meriden, between Solihull and Coventry. Extensive resources occur in the Birmingham area of both glacial and river sand and gravels, but the former are sterilised by urban development. Pebble-bearing sandstones of the Sherwood Sandstone Group have been worked for sand and gravel in the eastern part of Walsall District

The West Midlands has relatively low potential for the discovery of oil and gas. Within the area, the Coal Measures have the highest potential as source rocks for gas. Despite this, extensive drilling for coal in the north has not revealed any significant oil and gas finds. No exploration wells, specifically targeted at oil and gas, have been drilled in the West Midlands. The South Staffordshire Coalfield also has low coalbed methane prospectivity, largely because it has been extensively mined. Despite this low potential, three areas within the West Midlands are licenced to coalbed methane companies.

Parts of the area have been recently surveyed by BGS as part of a thematic mapping programme and sets of maps published at 1:25 000 include mineral resources and geology. These special sheets cover Coventry (Old *et al.*, 1989), the Black Country (Powell *et al.*, 1992) and Wolverhampton (Bridge et al., 1996).



		Mineral Resources	***Uses and Products***
	Quaternary, omitted for clarity	glacial and river sand, gravel and clay	sand and gravel, brick making
Jurassic	Lower Lias	limestone, clay	lime, cement making
Triassic	Sherwood Sandstone Group	sandstone, conglomerate	sand, gravel, moulding sand, abrasives,
	Mercia Mudstone Group	mudstone	brick and tile making
Carboniferous	Upper Coal Measures	mudstone, coal, limestone, sandstone	brick and tile making, coal, lime, building stone
	Lower, Productive Coal Measures	coal, ironstone, sandstone	coal, building stone
	Dolerite intrusions	dolerite	roadstone
Silurian	Llandovery - Pridoli Barr, Wenlock, Aymestry limestones, Downton Castle Sandstone Formation	shale, limestone, sandstone	lime, aggregates, flux for iron making. silica rock for refractories, building stone
Ordovician	Lickey Quartzite	quartzite	building stone, roadstone

Figure 1 Simplified geological map of the former county of the West Midlands. Based on 1:625 000 Geological Survey Ten Mile Map, South Sheet (Solid) and 1:250 000 Mid-Wales and Marches Solid Geology. Commodities and their resources which are no longer worked are shown in blue text.

COAL

Coal-bearing strata, comprising the southern part of the South Staffordshire Coalfield, occurs at crop in Walsall, Dudley and Wolverhampton. Much of the coalfield lies in urban areas, the only open-ground in the north-west of Walsall forming part of the Green Belt. The concealed parts of the Warwickshire Coalfield occur in the east of the area around Coventry.

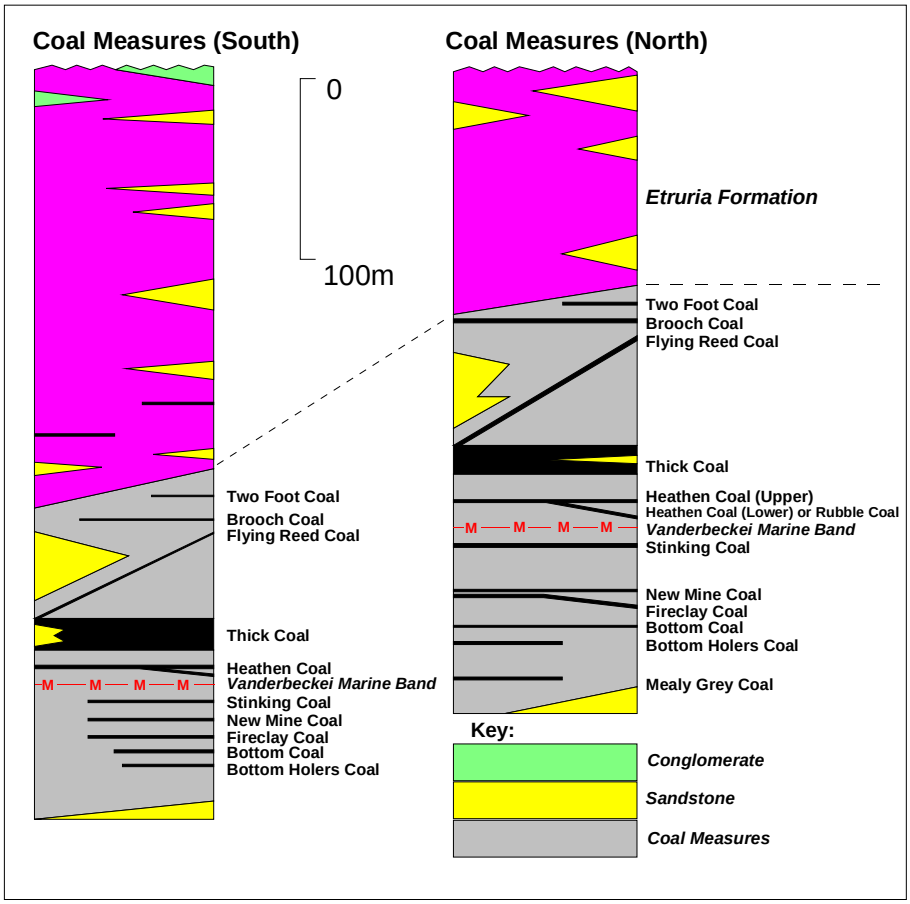


Figure 2 Generalized vertical section showing workable opencast coal seams in the Black Country, (Powell *et al.*, 1992)

Coal has been worked by deep mining and open pit operations in the South Staffordshire Coalfield since the Middle Ages, peak production being in the middle of the 19th Century. The principal seams worked are shown in Figure 2 and Table 1. The Thick Coal, up to 10 m thick, was the most extensively worked both by deep mining and at crop. The last deep mine (Baggeridge Colliery near Dudley) closed in 1968 and further deep mining is unlikely. Any future commercial interest will be confined to coal suitable for opencast extraction.

Coal Seam	thickness range (m) min	max
Two Foot	0.22	0.91
Brooch	0.30	1.82
Flying Reed	0.15	0.45
Thick	5.47	9.14
Upper Heathen	0.61	1.52
Lower Heathen (Rubble)	0.23	1.22
Stinking (Sulphur)	0.15	1.82
New Mine	0.45	3.96
Fireclay	0.45	2.74
Bottom Holers	0.30	3.65
Mealy Grey	0.70	0.70

Table 1 Approximate thicknesses of the principal coal seams in the South Staffordshire Coalfield. ***Source: (Powell et al., 1992)***

Large-scale opencast mining began in Britain during the Second World War, although by then, most of the resource in the West Midlands had been sterilised by urban and industrial development. However, redevelopment, following the closure of a number of major industrial sites, has allowed a programme of land reclamation and remedial work to be combined with opencast operations. Coals may therefore have been worked in smaller sites than elsewhere. The sites mostly worked the Thick Coal, which can often be recovered economically from old shallow pillar and stall workings. Seams above and below the Thick Coal have also been worked at a number of sites in the north of the area. Future operations can only occur in association with the redevelopment of fairly large industrial sites. Recent opencast coal production is shown in Figure 3. Current opencast activity is confined to the Walsall area.

The shallow coal resources shown on the accompanying Mineral Resources Map have been defined as including all seams from the Two Foot to the Mealy Grey Coal. Where either of these is absent or not mapped, the lower boundary is taken at the top of the basal sandstone of the Lower Coal Measures, and the upper limit is set at the base of the overlying red beds (Etruria Formation).

There are no shallow coal resources in Birmingham, Coventry or Solihull. The Thick Coal of the Warwickshire coalfield was formerly worked from Coventry Colliery (on the boundary with Warwickshire) until its closure in 1996. There was a proposal by British Coal to reach the unworked Thick Coal seams below Coventry and Solihull from a new colliery at Hawkhurst Moor in Solihull. This ‘South Warwickshire Prospect’ was never developed as the proposed new mine was refused planning permission.

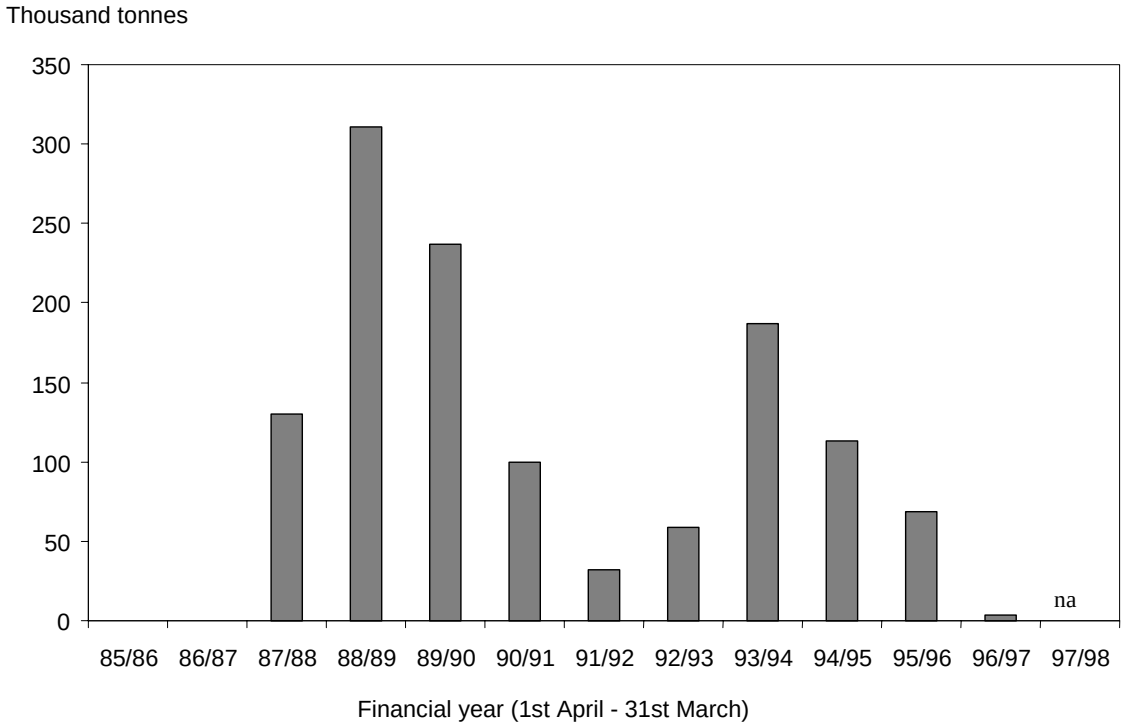


Figure 3 Opencast coal output in the West Midlands Metropolitan County
Source: Opencast coal mining statistics. County Planning Officers Society and the Coal Authority.

Areas of opencast coal extraction

The Coal Authority is a Non-Departmental Public Body which was established by the Coal Industry Act 1994. On 31st October 1994 it assumed responsibility for all the interests previously vested in British Coal in respect of unworked coal and coal mines and for the liabilities associated with past coal mining and unworked coal. The main functions of the Authority are to manage the coal resources under its control, encourage economically viable operations to work these resources, grant licences for coal exploration and extraction, provide effective management of subsidence damage claims, and provide information on past, present and proposed future coal mining activities.

For active sites, the extent of the licence area for coal extraction issued by the Coal Authority is normally shown on the Mineral Resources Map. However, at the time of writing, the current licence area of Ryder's Hayes was not available, therefore, the planning permission area is shown. Areas of extracted opencast coal are shown on the map, although these data may not be completely up-to-date. The Coal Authority's Mining Reports database contains information on past opencast coal mining activity, which is an aggregate of information derived from a number of sources. The areas shown on the map mainly reflect the limits of coal extraction. However, recent entries into the Mining Reports database principally reflect site

boundaries. More detailed information on specific sites may be obtained from the Coal Authority.

CLAY AND SHALE

Clay and shale are used mainly in the manufacture of structural clay products, such as facing and engineering bricks, pavers, clay roofing tiles and vitrified clay pipes. Brick manufacture is the largest tonnage use. Clays may also be used as a source of constructional fill and for lining and sealing landfill sites. The suitability of a clay for the manufacture of structural clay products depends principally on its behaviour during shaping, drying and, most importantly, firing. This behaviour will dictate the final technical and aesthetic properties of the fired brick.

Small brickworks mainly producing 'common' bricks from locally won raw materials were formerly a common feature in many industrial areas of Britain. However, in the last two or three decades there has been a major rationalisation of the brick industry which is now based on a small number of plants operated by a limited number of companies. With the demise of the 'common' brick, the main products are now high-quality facing bricks, engineering bricks and related products such as clay pavers. Modern brickmaking technology is highly-automated and requires a high capital investment. It is increasingly dependent, therefore, on raw materials with predictable and consistent firing characteristics in order to achieve high yields of saleable products and to reduce waste at the quarry and plant. Blending different clays to achieve improved durability and to provide a range of fired colours and aesthetic qualities is an increasingly common feature of the brick industry. Blending may become increasingly important as a method of reducing emission levels from kilns. Continuity of supply of consistent raw materials is of paramount importance.

In the West Midlands, the Carboniferous Etruria Formation, is the principal brick clay resource in the area, due to its low carbon and sulphur content, and to its firing properties. It crops out in Walsall, Dudley, Sandwell and, to a minor extent, in Wolverhampton. The extent of the Etruria Formation is shown on the accompanying Mineral Resources Map. A small part of the outcrop of the Etruria Formation is covered by variable thicknesses of superficial deposits. Large parts of the outcrop are now sterilised by urban development, although there are operational pits in Dudley and Walsall. Brick factories are situated at Aldridge, Walsall, Ketley and Dudley.

The Etruria Formation consists of a redbed sequence of mudstone and siltstone characterised by predominantly red colouration, variegated grey, brown and yellow. Sandstones and conglomerates, locally called ‘espleys’, are also present along with thin coals. The boundary with the underlying Coal Measures is difficult to define

since the transition is highly gradational and occurs lower down the sequence in the south of the area. The top is an unconformable boundary with the overlying Halesowen Formation. The thickness of the Etruria Formation ranges from 61–207 m. The relative proportions of disordered kaolinite, illite, quartz and iron oxides in the clay, together with the absence of impurities such as carbon, sulphur, soluble salts and (except locally) calcite make it suitable for the manufacture of high strength and low water absorption heavy clayware. These include 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, including blue.

Carboniferous clay-bearing formations overlying the Etruria Formation have been worked sporadically in the past and are still extracted at one location. At Midland Brickworks in Coventry, silty parts of the Keresley Member of the Carboniferous Meriden Formation (formerly the Coventry Sandstone) are worked for facing bricks. At Packington in Solihull, the Triassic Mercia Mudstone Group is worked for facing bricks. Till and glaciolacustrine clays were formerly worked on a small scale and blended with some of the above clays as raw material for bricks. Colliery and ironstone spoil have also been utilised for brick manufacture in the past in this area.

FIRECLAYS

Fireclays occur as seatearths, the fossil soils on which vegetation once grew, and underlie almost all coal seams. They are named after the overlying coal, and resources are almost entirely confined to coal-bearing strata. They consist of comparatively thin (usually <1.5 m), unbedded mudstones with rootlets. Fireclays may be sandy or silty, with variable amounts of carbonaceous matter and ironstone present as impurities. The term ‘fireclay’ is now used to describe seatearths which are of economic importance. Originally fireclays were valued as refractory raw materials, because of their relatively high alumina contents. Demand for fireclay for refractory use has, however, declined markedly since the late-1950s. This is mainly due to changing technology in the iron and steel industry where more severe operating conditions now require much higher quality refractories. However, some fireclays have relatively low iron contents compared with other brickmaking clays and they are now valued for the production of buff-coloured facing bricks and pavers. The close association of fireclay and coal means that they are usually recovered as a by-product of opencast coal operations. Despite this association, only a small proportion of opencast coal sites produce fireclays. This may be because of their variable quality, or for operational and planning reasons. Fireclay is usually stockpiled while coaling takes place before export to a brickworks. Restoration of opencast coal sites usually means that remaining

fireclay has to be returned to the void rather than being left as stocks.

The suitability of Coal Measure mudstones (which may also recovered from opencast coal sites) 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 rise to unacceptable emission levels. In general, carbon and sulphur levels should be less than 1.5 per cent and 0.2 per cent respectively, although the ease with which carbon burns out, and blending, may permit some tolerance in these figures.

In the South Staffordshire Coalfield, fireclays have their greatest development on the extreme southern margin of the coalfield, where the coal seams are replaced by fireclays. The area between Stourbridge and Gornal, west of Dudley, was formerly a very important fireclay mining district and several seams were worked. Fireclay was used for making pots for melting glass in the 16th Century, but the area gained prominence in the 19th Century when Stourbridge firebricks, widely used in gas retorts and coke ovens, had a worldwide reputation. Fireclay mining ceased many years ago and the area is now built over. Any future fireclay production in the West Midlands will be associated with opencast coal production.

SAND AND GRAVEL

- The West Midlands produced 575 000 tonnes of sand and gravel in 1997. Sand and gravel resources are divided into two broad categories:
- Superficial or ‘drift’ deposits of Quaternary age, subdivided for practical purposes into ‘glacial sand and gravel’, and ‘river sand and gravel’, and
- Bedrock or ‘solid’ deposits comprising pebbly sandstones within the Triassic Sherwood Sandstone Group.

The variability of sand and gravel deposits and their possible concealment beneath till (boulder clay) means that, in comparison with other bulk minerals, it is more difficult to infer the location and likely extent of potentially workable resources from geological maps. The properties which influence the economic potential of a sand and gravel deposit include:

- sand to gravel ratio
- proportion of fines and oversize material
- presence of deleterious rock types (such as coal or mudstone)
- thickness of deposit and overburden ratio
- position of the water table

- possible presence of unwanted interbedded material
- the ease with which material can be processed to produce a saleable product
- location relative to demand

As stated in the section on Mineral Resource Classification, the distribution of sand and gravel shown on the map can generally be considered as being at the inferred resource level. However, BGS sand and gravel assessment surveys in the Solihull area have upgraded the data in these areas to the level of 'indicated' resources. These areas are clearly delineated and include the category 'concealed glacial sand and gravel' which is not shown elsewhere on the map. Production of sand and gravel in the West Midlands is shown in Figure 4.

Superficial deposits

Superficial deposits comprise all those sediments laid down during the last two million years. For the purposes of this report, these materials have been divided up into two groups, 'river sand and gravel' and 'glacial sand and gravel'. Superficial sand and gravel deposits are widespread in the West Midlands area, although a very large proportion has been sterilised by urban and industrial development. The only significant workable resources within the area occur around Meriden, between Solihull and Coventry. Grading data for superficial sand and gravel in the Solihull area is given in Table 2.

River sand and gravel

Post-glacial river terrace and alluvial deposits are developed along the valleys of the rivers Tame, Rea and Blythe. River terrace deposits occur at various elevations above the present day level of the alluvial flood plain. They represent the eroded remnants of formerly more extensive, relatively gravel-rich alluvial deposits. Also included in the 'river sand and gravel category' are fluvio-glacial deposits. They are included in this category as they tend to occur beneath river terrace, as well as underlying flood plain deposits (alluvium) and may be undifferentiated on some older published maps. Sand and gravel quarrying operations based in river valleys will generally work both alluvial and underlying fluvio-glacial deposits where present.

River sand and gravel is only extracted from one site on the River Blythe, in Solihull, this material is being used for blending with glacial deposits extracted from another part of this site to increase the ratio of coarse aggregate.

Deposit type	*% Fines (<0.063 mm)*	*% Sand (0.063 – 4 mm)*	*% Gravel (>4 mm)*
Alluvium	5	27	68
River terrace deposits	9	58	33
Fluvio-glacial gravel	9	58	33
Glacial sand and gravel	12	63	25

Table 2 Mean grading data for superficial sand and gravel resources in the Solihull area. *Source*: Cannell, 1982.

Glacial sand and gravel

Deposits of glacial sand and gravel are ice-contact sediments, laid down by streams flowing on the top, within and beneath ice sheets. These deposits are commonly associated with till (boulder clay) and commonly occur as lenses either within or beneath till. They can be chaotic and/or grade directly into high-fines materials such as till. As a result of these factors, they are less predictable in geographic extent than river sand and gravel and may be more extensive than shown on geological maps. They generally show a more variable particle-size distribution, although sand-grade material tends to predominate. Their thickness can vary dramatically and they are difficult to predict without geophysical or borehole information. Lenses and intermittent beds of gravel may occur within the generally sandy deposits.

The pre-glacial Blythe valley near Solihull contains thick outwash deposits of glacial sand and gravel. A BGS sand and gravel resource assessment survey estimates an average thickness of 6.3 m, locally thickening to over 17 m (Cannell, 1982). Two sites in the Blythe valley are worked for glacial sand and gravel, one at Berkswell, the other at Cornet's End.

Bedrock deposits

Potential bedrock deposits of sand and gravel are confined to the pebbly sandstones and conglomerates of the Kidderminster Formation. This formation (formerly 'Bunter Pebble Beds') is part of the Triassic Sherwood Sandstone Group. In the adjacent county of Staffordshire, loosely bound, sandy pebble beds (conglomerates) within the Sherwood Sandstone are a very important source of aggregate. The underlying Permian Bridgnorth Sandstone and overlying Wildmoor and Bromsgrove sandstones, although worked in adjacent counties for less demanding aggregate uses, are not considered a resource in the West Midlands area.

In the West Midlands, the Kidderminster Formation is generally less pebbly than further north, although it still contains 'shingle beds'

and 'scattered stones' (Eastwood *et al.,* 1925). In the Redditch area, it is characterised by a basal conglomerate up to 30 m thick, comprising 65 per cent quartzite and 25 per cent vein quartz (Old *et al.,* 1991). The main part of the formation is a weakly-cemented, massive red-brown to yellow-brown sandstone containing scattered pebbles and mudstone beds. Extensive parts of the outcrop are concealed beneath superficial deposits of variable thickness, including those containing glacial sand and gravel. Only exposed areas of the Kidderminster Formation are depicted on the mineral resources map. The Kidderminster Formation does not crop out in the Coventry area.

The lower, pebbly part of the formation was formerly worked in small pits at various locations. However, the two working pits in the Kidderminster Formation, at Aldridge, and Branton Hall Lane are both in Walsall, and both are in the sandier, upper, part of the formation. The Branton Hall Lane site produces a dry-screened red building sand (<5.5 mm), a <10 mm blinding sand (cable sand) and a >10 mm hoggin product. Aldridge produces dry-screened building sand.

SANDSTONE

Sandstones are accumulations of sand-sized particles composed predominantly of quartz, with variable amounts of feldspar and rock fragments set in a fine-grained matrix or cementing material. Many sandstones are very variable in quality and are often interbedded with mudstones or siltstones, or are weakly-cemented. Relatively few sandstones form resources of construction raw material.

The suitability of a sandstone for use as a building stone depends not only on strength and durability, but also on aesthetic qualities and textural consistency, and the size of the blocks that can be produced. Thinly-bedded sandstones may be suitable for the production of flagstones and roofing slates.

To the south of Birmingham, the Ordovician Lickey Quartzite has been used in the past as local walling material and rough hewn building stone (Old *et al.,* 1991). Triassic sandstones of the Kidderminster Formation (Sherwood Sandstone Group) were recently quarried at Highdown in neighbouring Staffordshire for building stone. Although the Bromsgrove Sandstone was also quarried on a limited scale for building stone, there are now no operational building stone quarries in the West Midlands. In Dudley, underground workings in the Silurian Gornal Sandstone (now known as the Downton Castle Sandstone Formation), produced a building stone then known as Gornal Stone.

SILICA SAND AND SILICA ROCK

The Triassic Wildmoor Sandstone of the Sherwood Sandstone Group was formerly extensively worked in Dudley both at crop and underground for naturally-bonded moulding sand. Working has now ceased in the West Midlands and much of the former quarry workings are built over. Silica rock, which was crushed for use in the manufacture of refractories, was obtained from the Silurian Gornal Sandstone (Downton Castle Sandstone Formation). There is no longer demand for silica refractories and naturally-bonded moulding sand is now of limited economic significance.

IGNEOUS ROCK

Igneous rocks are classified as either intrusive (formed from magma or molten rock solidified below the earth's surface), or extrusive (formed from lava and volcanic ash erupted at the earth's surface). In general, intrusive rocks tend to be of more consistent quality for aggregate production. Production of crushed rock aggregate (which equates with igneous rock production in the West Midlands) is shown in Figure 4.

Igneous rock production in the West Midlands makes a significant contribution to regional crushed rock aggregates supply. Igneous rocks are sometimes capable of producing high quality aggregates suitable for road surfacing as they can meet the required abrasion and polish resistance specifications. They are, however, not generally capable of producing premium grade road surfacing materials which are usually sourced from greywacke/gritstone quarries.

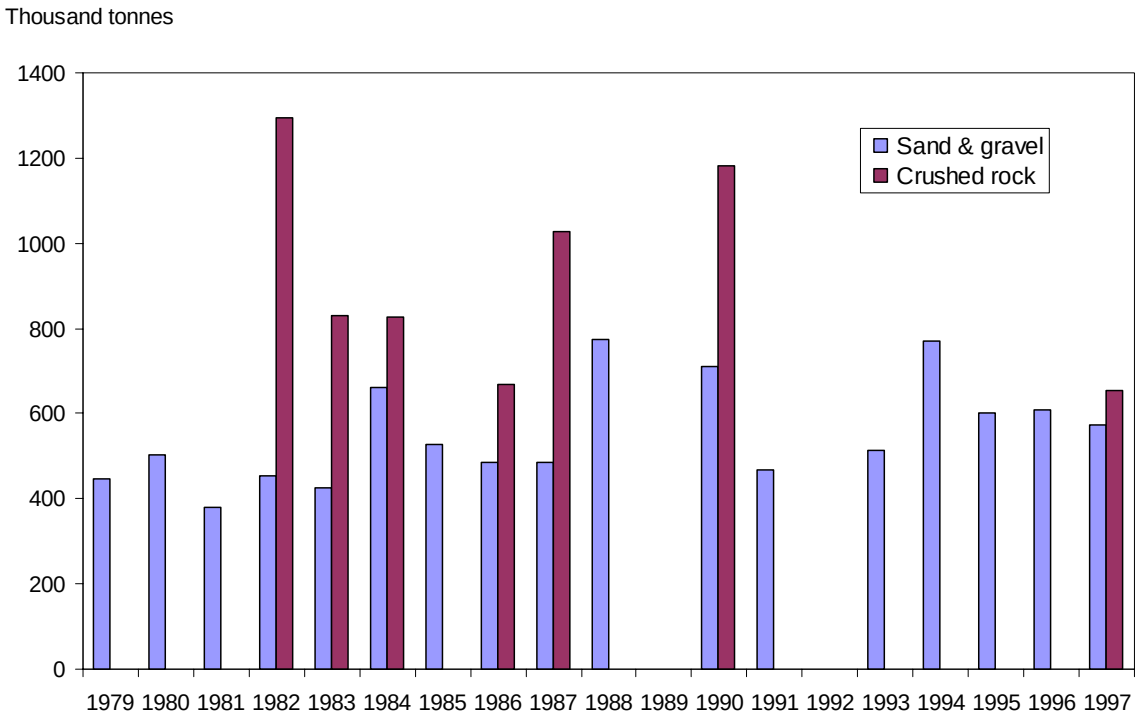


Figure 4 Production of crushed rock aggregate and sand & gravel within the West Midlands Metropolitan County. Data for missing years are not disclosed. *Source*: Annual Minerals Raised Inquiry.

Intrusive dolerites crop out at a number of locations in Sandwell and Wolverhampton, notably in the large Rowley Hills intrusion. Those outcrops which have not been worked already, are generally too small or are of unsuitable quality for aggregate production. Where there has been extensive working in the past, the voids have been filled in by domestic waste and are now built upon, or form public open spaces.

The Rowley Hills dolerite takes the form of a saucer-shaped intrusion or lopolith. Several large quarries worked this body in the past, although only two, Edwin Richards and Hailstone, have been operating in recent years (Figure 5). The two quarries were separated by a narrow spine of material occupied by a road. Closure of the road has allowed an amalgamation of these operations. The spine is now worked from the Edwin Richards side, whilst the Hailstone void is used as a landfill site.

Figure 5 Edwin Richards/ Hailstone dolerite quarry operated by Midland Quarry Products in the Rowley Regis Complex

The structure of the body limits the available resource. The current output from the complex is about 500 000 tonnes per year, and there are sufficient reserves for a further 10 years production at this rate. The majority of the output goes for coated roadstone and asphalt, with some unbound crushed rock used for Type 1 sub-base in road construction.

Rowley Regis Dolerite, Edwin Richards Quarry	
Aggregate Abrasion Value - AAV	4.4
Aggregate Crushing Value - ACV	14
Aggregate Impact Value - AIV	13
Polished stone value - PSV	50 - 52
Relative density	2.8
Water absorption (%)	1.2

Table 3 Aggregate properties of igneous rocks currently worked at Edwin Richards Quarry. *Source*: Midlands Quarry Products Ltd.

Definitions:

Aggregate Abrasion Value (AAV)

Resistance of an aggregate to abrasion as measured in the aggregate abrasion test. The smaller the value the more resistant the rock is to abrasion. Abrasion resistance is particularly important for road surfacing materials.

Aggregate Crushing Value (ACV)

Resistance of an aggregate to crushing when subjected to a crushing force as measured by the aggregate crushing test. The smaller the value, the more resistant the rock is to crushing.

Aggregate Impact Value (AIV)

Resistance of an aggregate to repeated impact as measured by the aggregate impact test. The smaller the value, the more resistant the rock is to impact.

Polished Stone Value (PSV)

Resistance of an aggregate to polishing as measured in the accelerated polishing test. A measurement of skid resistance on road surfaces. The larger the value the more resistant the rock is to polishing.

LIMESTONE

Limestones of Silurian age in the west of the area were worked extensively from the 17th to the early part of the 20th Century, primarily for lime and industrial uses. The deposits are of low quality, both in terms of chemical purity and aggregate properties, and are no longer considered a resource. However, limestones of comparable age are worked in adjacent counties and for consistency on a regional scale, their outcrop within the West Midlands is shown on the Mineral Resources Map.

The main workings were in the Much Wenlock and the Barr limestones. These materials were used for flux in ironmaking, agricultural lime and cement manufacture. These limestones were extensively worked at crop and underground, the latter causing severe land stability problems in some areas. Considerable grouting has been necessary in parts of Dudley to remediate this problem.

The most important deposit was the Silurian **Much Wenlock** or **Dudley Limestone**. This is divided into the Upper Quarried Limestone (10 m) and Lower Quarried Limestone (13 m) separated by the unworked Nodular (Limestone) Member (35 m). The Upper and Lower Quarried limestones are strong blue-grey, thin to medium bedded fossiliferous limestones with thin mudstone partings. The Nodular Limestone is a thinly bedded clayey limestone with calcareous mudstones, containing irregular reef patches or ‘crog balls’. Underground mining was carried out using pillar and stall methods, or, where steeply dipping strata were encountered, in horizontal, unsupported, chambers. Although some mines were up to 260 m deep, most were between 20 and 70 m in depth. Others mines were extensions of existing coal workings. Some 19 million tonnes or 7 million m^3 of limestone were extracted, mainly between 1750 and 1900. The limestone is exhausted at outcrop and the mines are no longer economic to work. The limestone was also formerly used as a building stone and could be worked on a small scale in

restoration projects. The underlying Barr (Woolhope) Limestone was worked for lime in the Walsall area, as was the overlying Aymestry (Sedgley) Limestone

Thin **Spirorbis** limestones within the Carboniferous Halesowen Group were worked in the past for lime, as were Jurassic **Blue Lias** limestones which crop out to the south of Birmingham. These deposits are no longer of any economic significance.

HYDROCARBONS

The hydrocarbon potential of the West Midlands is discussed in conjunction with Warwickshire.

Conventional oil and gas

Warwickshire and West Midlands have a relatively low potential for the discovery of oil and gas. Within the area, the Coal Measures have the highest potential as source rocks for gas. Despite this, extensive drilling for coal in the north has not revealed any significant oil and gas finds. The best prospects for oil and gas are likely to be in south-west Warwickshire, where seismic survey data indicate that Coal Measures could be concealed at depth in the area around Barford and Stratford-on-Avon.

The Coal Measures rest on Lower Palaeozoic strata that have no source potential. Younger potential source rocks (such as Lower Jurassic strata found in south Warwickshire) have not been buried to a sufficient depth to generate oil or gas.

No exploration wells specifically targeted at oil and gas have been drilled in Warwickshire or the West Midlands.

Coalbed methane

The area includes parts of the South Staffordshire and Warwickshire coalfields, as well as a large area of concealed Coal Measures (see map). An area with no productive Coal Measures at depth occurs between the South Staffordshire and Warwickshire coalfields. In the absence of borehole information, the presence of methane-bearing Coal Measures in south-west Warwickshire remains a matter for speculation.

With average measured methane values of 1.7 m^3/tonne (Creedy, 1991), the exposed part of the Warwickshire Coalfield can probably be ruled out as a coalbed methane prospect, since these values are too low to be of commercial interest. Although the large area of concealed productive Coal Measures south of the Warwickshire Coalfield may have some potential for methane, indications are that the gas content of any coals in this area will also be too low for commercial exploitation. This is because the Oxfordshire Coalfield

(which lies immediately to the south) has an average methane content of only 0.4 m^3/tonne.

There are no released measured methane values for the coals of the South Staffordshire Coalfield. However, the South Staffordshire Coalfield has low methane prospectivity, largely because it has been extensively mined.

Despite this low potential, three areas within Warwickshire and West Midlands are licenced to coalbed methane companies; EXL 283 to Octagon and EXL 208 and 209 to Evergreen Resources Ltd.

SECONDARY AGGREGATES

The term 'secondary aggregates' is used to describe a range of materials which may be used as alternatives to primary aggregates (subject to considerations of quality and contamination), but which arise as wastes from a variety of activities. These may be considered under three main headings:

Naturally-occurring materials arising from mineral extraction and processing operations, such as colliery spoil, overburden and quarry/processing waste

Materials arising from industrial processes, such as slags and ash, which may be of variable composition

Construction and demolition wastes which may be either in a natural or manufactured state and include asphalt planings, road sub-base, concrete rubble and masonry. These material are excluded from this study as their arisings are highly variable in location, type and duration.

Utilising the aggregate potential of such materials may have the advantage of both reducing the demand for primary aggregates and thus land for extraction, and the problems of disposing of waste. In general, however, many secondary aggregates are only suitable for less demanding aggregate applications, and their production and use may not always be environmentally or economically desirable. There are now very limited resources of secondary aggregates in the West Midlands area.

Colliery spoil

Colliery spoil, or minestone is the waste from mining and processing coal, consisting mainly of mudstone and siltstone. In the West Midlands, most former tips have been reclaimed/restored and are not now available as a source of secondary aggregate.

Slags

There are no steelworks currently producing the volume of slag that could be regarded as an economic secondary resource. Where these have been tipped previously, the material has now either been removed or flattened as in the case of minestone.

MINERAL RESOURCES AND PLANNING CONSTRAINTS

Landscape character 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. This character is constantly changing due to economic and social pressures in the short-term and to geomorphological processes in the long-term. Within the West Midlands area, widespread urbanisation has had a major impact on the original character of the landscape. Mineral extraction may cause irrevocable, but not necessarily harmful, change to a locality over a relatively short timescale. In order to ensure that such changes are sustainable and do not harm the environment the most valuable landscapes and habitats (National Parks, AONB, SSSIs etc.) are given a greater degree of protection from mineral working. The need for mineral workings in such areas has to be justified by a most rigorous examination of the merits of the proposal. This examination considers the wider public interest in the development of the resource and social and economic issues, as well as the need to protect the environment.

Mineral extraction in areas designated as SPAs of SACs may be acceptable if there are no alternatives and if there are imperative reasons of overriding public interest which support the development. For certain priority SACs development can only be considered to be acceptable if there are overriding reasons of public health or safety or due to beneficial environmental consequences. Whilst the requirement to assess the acceptability of mineral working in such designated areas is therefore stringent, there is no total 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 the development control system with a balanced appraisal of the issues raised. The Mineral Resource Map of Warwickshire and the West Midlands provide a syntheses of available information which can be revised and updated as additional data becomes available. Additional constraint information can be incorporated as required. It is hoped that these maps and the associated report will assist local and national government, the minerals industry and other interests in the consideration and production of policies in development plans.

Widespread urbanisation of the area means that there are few areas with landscape designations. The largest is Sutton Park SSSI and NNR, followed by the Dudley NNR, with a few other sites in Solihull and Coventry. The Dudley site, Wren’s Nest, is also a geological SSSI, covering the former limestone workings and the resource here is largely worked out.

SELECTED BIBLIOGRAPHY

For further information on national planning policy, users should consult the following :

- Planning Policy Guidance
- Mineral Planning Guidance Notes
- Regional Planning Guidance Notes

published by the HMSO for the Department of the Environment, Transport and the Regions.

Information from the following documents and maps was used in the compilation of the map

a) British Geological Survey 1:25 000*, 1:50 000 and 1:63 360# geological map sheets

Sheet	Name	Edition	Published
SO98, Part SO88, SP08	Geology of the Black Country – 2A Bedrock geology (South)	S	1992 *
SO99, part SO89, SP09	Geology of the Black Country – 2B Bedrock geology (North)	S	1992 *
SO98, part SO88, SP08	Geology of the Black Country – 3A Distribution and thickness of superficial (drift) deposits (South)	D	1992 *
SO99, part SO89, SP09	Geology of the Black Country – 3B Distribution and thickness of superficial (drift) deposits (North)	D	1992 *
SO98, part SO88, SP08	Geology of the Black Country – 5A Surface mineral resources and quarrying (South)	S&D	1992 *
SO99, part SO89, SP09	Geology of the Black Country – 5A Surface mineral resources and quarrying (North)	S&D	1992 *
SP27/37	Geology of the Coventry Area – 1 Bedrock geology	S	1990 *
SP28/38	Geology of the Coventry Area – 2 Bedrock geology	S	1990 *
SP27/37	Geology of the Coventry Area – 3 Drift thickness and lithology	S	1990 *
SP28/38	Geology of the Coventry Area – 4 Drift thickness and lithology	D	1990 *
SP27/37	Geology of the Coventry Area – 5 Sand and gravel resources	D	1990 *

Sheet	Name	Edition	Published
SP28/38	Geology of the Coventry Area – 6 Sand and gravel resources	D	1990 *
-	Wolverhampton Urban Geochemical Survey – Solid Geology	S	1996 *
-	Wolverhampton Urban Geochemical Survey – Drift Geology	D	1996 *
153	Wolverhampton	S	1929 #
153	Wolverhampton	S&D	1929 # 1993 F
154	Lichfield	SwD	1926 #
154	Lichfield	S&D	1922 #
167	Dudley	S&D	1975
168	Birmingham	S&D	1996
168	Birmingham	SwD	1924 # 1992 F
169	Coventry	SwD	1994
169	Coventry	S&D	1994
183	Redditch	S&D	1989
184	Warwick	S&D	1984
	S Solid edition D Drift edition S+D Solid and Drift combined SwD as above with uncoloured drift sheet	P – Provisional edition F – 1:50000 scale Facsimile of 1:63 360	

S = Solid; D = Drift; S&D = Drift with Solid outcrops; SwD = Solid outcrops with drift linework only;

1994 = date of publication of 1:50 000 scale sheet; 1926 # = date of publication of 1:63 360 scale sheet; 1990 * = date of publication of 1:25 000 scale sheet; F Facsimile of earlier 1:63 360 map.

b) British Geological Survey Sheet Memoirs

BARROW, G, GIBSON, W, CANTRILL, T C, DIXON, E E L and CUNNINGTON, C H. 1919. Geology of the country around Lichfield. *Memoirs of the Geological Survey of Great Britain*. Sheet 154 (England & Wales).

HAMBLIN, R J O and COPPACK, B C. 1955. Telford and the Coalbrookdale Coalfield. *Memoirs of the Geological Survey of Great Britain.* Sheet 152 and 153 (parts) (England & Wales).

WHITEHEAD, T H, ROBERTSON, T, POCOCK, R W and DIXON, E E L. 1928. The country between Wolverhampton and Oakengates. *Memoirs of the Geological Survey of Great Britain*. Sheet 153 (England & Wales).

WHITEHEAD, T H, and POCOCK, R W. 1947. Dudley and Bridgnorth. *Memoirs of the Geological Survey of Great Britain*. Sheet 167. (England and Wales).

EASTWOOD, T, WHITEHEAD, T H and ROBERTSON, T. 1925. Geology of the Country around Birmingham, *Memoirs of the Geological Survey of Great Britain.* Sheet 168 (England and Wales).

BRIDGE, D McC, CARNEY, J, LAWLEY, R S and RUSHTON, A W A. 1998. Geology of the country around Coventry. *Memoirs of the Geological Survey of Great Britain.* Sheet 169 (England and Wales).

OLD, R A, HAMBLIN, R J O, AMBROSE, K and WARRINGTON, G. 1991. Geology of the country around Redditch. *Memoirs of the British Geological Survey*. Sheet 183 (England and Wales).

OLD, R A, SUMBLER, M G, and AMBROSE, K. 1987. Geology of the country around Warwick. *Memoirs of the British Geological Survey*. Sheet 184 (England and Wales).

c) British Geological Survey Reports and other publications

BRIDGE, D McC, BROWN, M J and HOOKER, P J. 1996. Wolverhampton Urban Geochemical Survey: an integrated geoscientific case study. *British Geological Survey Technical Report* WE 95/49.

CANNELL, B. 1982. The sand and gravel resources of the country east of Solihull, Warwickshire: description of parts of 1:25 000 sheets SP 17, 18, 27 and 28. Mineral Assessment Report, Institute of Geological Sciences, No 115.

CROFTS, R G. 1982. The sand and gravel resources of the country between Coventry and Rugby, Warwickshire: description of parts of 1:25 000 sheets SP 47 and part of SP 37. Mineral Assessment Report, Institute of Geological Sciences, No 125.

CANNELL, B and CROFTS, R G. 1982. The sand and gravel resources of the country around Henley-in-Arden, Warwickshire: description of parts of 1:25 000 sheets SP 15, 17, 25, 26 and 27. Mineral Assessment Report, Institute of Geological Sciences, No 142.

CREEDY, D P. 1983. Seam gas-content database aids firedamp prediction. *The Mining Engineer,* **143**, August, 79-82.

CREEDY, D P. 1988. Geological controls on the formation and distribution of gas in British Coal Measures strata. *International Journal of Coal Geology*, **10**, 1-31.

CREEDY, D P. 1991. An introduction to geological aspects of methane occurrence and control in British deep coal mines. *Quarterly Journal of Engineering Geology*, **24**, 209-220.

DEPARTMENT OF THE ENVIRONMENT. 1983. Limestone Mines in the West Midlands: the legacy of mines long abandoned. London, *HMSO*.

DEPARTMENT OF THE ENVIRONMENT, 1996. Survey of Land for Mineral Workings in England, 1994, Volume 2, Survey Tables. London, *HMSO*.

GLOVER, B W, HOLLOWAY & YOUNG, S R. 1993. An evaluation of coalbed methane potential in Britain. *British Geological Survey Technical Report WA/93/24.*

HARRISON, D J, HUDSON, J H and CANNELL, B. 1991. Appraisal of high-purity limestones in England and Wales. A report for the Department of the Environment; Part 1 Resources. *British Geological Survey Technical Report* WF/90/10.

OLD, R A, BRIDGE, D McC and REES, J G. 1990. Geology of the Coventry area. Description of 1:25 000 sheets SP27/37 and 28/38 (excluding SP38 NE). *British Geological Survey Technical Report* WA/89/29.

OVE ARUP & PARTNERS (Arup Geotechnics). 1990. Review of Mining Instability in Great Britain; a report for the Department of the Environment. Regional Report West Midlands, Volume 1/iv.

POWELL, J H, GLOVER, B W and WATERS, C N. 1992. A geological background for planning and development in the 'Black Country'. *British Geological Survey Technical Report* WA/92/33.

SELLEY, R C. 1992. Petroleum seepages and impregnations in Great Britain. *Marine and Petroleum Geology*, **9**, 226-244.

SMITH, N J P, CHADWICK, R A, WARRINGTON, G, KIRBY, G A & JONES, D G. 1995. The hydrocarbon prospectivity of the Cheshire basin and surrounding areas. *British Geological Survey Technical Report No. WA/94/95C.*

WALSALL UNITARY DEVELOPMENT PLAN. *1995*

WEST MIDLANDS REGIONAL AGGREGATES WORKING PARTY. 1995. ANNUAL REPORT.

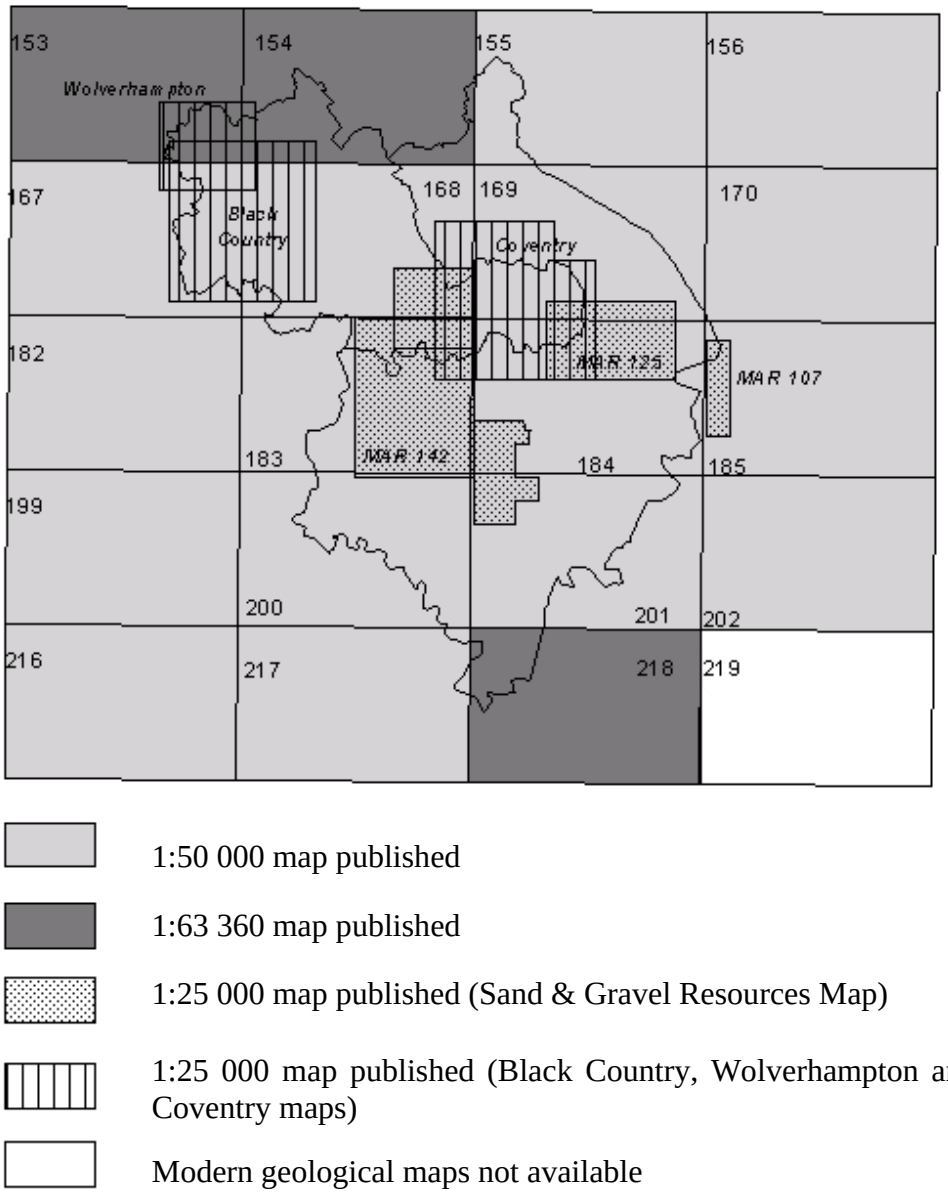


Figure 6 Availability of British Geological Survey 1:50 000 or 1:63 360 scale New Series geological map coverage of Warwickshire and the West Midlands. Also shows 1: 25 000 Mineral Assessment Report areas and Thematic map coverage.

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APPENDIX 1 MINERAL WORKINGS IN BIRMINGHAM, COVENTRY, DUDLEY, SANDWELL, SOLIHULL, WALSALL AND WOLVERHAMPTON (1998)

OPERATOR	NAME OF WORKING	COMMODITY
Coventry		
Websters Hemming & Sons	Midland Brickworks	Common Clay & Shale
Dudley		
Baggeridge Brick	Oak Farm	Common Clay & Shale
Hinton, Perry & Davenhill Ltd	Ketley	Common Clay & Shale
Ibstock Building Products Ltd	Stallings Lane	Common Clay & Shale
Redland Property Holdings Ltd	Tansey Green	Common Clay & Shale
Sandwell		
Midland Quarry Products Ltd	Edwin Richards / Hailstone Complex (Rowley Regis)	Igneous Rock
Solihull		
BFI Packington Ltd	Arden Brickworks	Common Clay & Shale
RMC - Western Aggregates	Berkswell 1	Sand and Gravel
Tilcon (South) Ltd	Meriden 1	Sand and Gravel
Walsall		
Bliss Sand & Gravel Co Ltd	Branton Hill Lane	Sand and Gravel
Chelwood Brick Ltd	Barnett and Beddows	Common Clay & Shale
Chelwood Brick Ltd	Sandown	Common Clay & Shale
Ibstock Building Products Ltd	Atlas	Common Clay & Shale
Parkhill Estates	Ryders Mere	Coal, Opencast
Parkhill Reclamation	Highfields South	Common Clay & Shale
RMC - Western Aggregates	Aldridge	Sand and Gravel

APPENDIX 2 CONTACT ADDRESSES FOR FURTHER ENQUIRIES

Birmingham City Council Dept of Planning and Architecture Broad Street Birmingham B1 2NA Tel: 0121 235 4041 Fax: 0121 236 0599	Coventry City Council City Development Direcorate Planning Services Tower Block, Much Park Street Coventry CV1 2PY Tel: 01203 831 225 Fax: 01203 831 296
Dudley MBC Planning & Leisure Dept 3 St James's Road Dudley DY1 1HZ Tel: 01384 818181 Fax: 01384 452141	Sandwell MBC Environment & Development Services Dept Wigmore, Pennyhill Lane West Bromwich B71 3RZ Tel: 0121 569 4040 Fax: 0121 569 4072
Solihull MBC Environmental & Technical Services Dept PO Box 19, Council House Solihull B91 3QT Tel: 0121 704 6000 Fax: 0121 704 6404	Walsall MBC Engineering & Town Planning Dept Civic Centre Darwall Street Walsall WS1 1DG Tel: 01922 652 502 Fax: 01922 23234
Wolverhampton MBC Dept of Technical Services Civic Centre St Peter's Square Wolverhampton WV1 1RP Tel: 01902 27811 Fax: 01902 315403	Countryside Agency John Dower House Crescent Place Cheltenham Gloucestershire GL50 3RA Tel: 01242 521381 Fax: 01242 584270
English Nature Northminster House Northminster Peterborough PE1 1UA Tel: 01733 455000 Fax: 01733 455103	English Heritage Fortress House Savile Row London SW1X 1AB Tel: 0207 973 3000 Fax: 0207 973 3001

The Secretary Regional Aggregate Working Party Development and Waste Regulation Department of Planning, Transport and Economic Strategy Warwickshire County Council Shire Hall Warwickshire CV34 4SX Tel: 01926 410410 Fax: 01926 412641	The Environment Agency Midlands Region Sapphire East 550 Streetsbrook Road Solihull West Midlands B91 1QT Tel: 0121 711 2324 Fax: 0121 711 5824
The Coal Authority 200 Lichfield Lane Mansfield Nottinghamshire NG18 4RG Tel: 01623 427162 Fax: 01623 427316	The Department of the Environment, Transport and the Regions Eland House Bressenden Place London SW1E 5DU Tel: 0171 890 3000 Fax: 0171 890 3859

APPENDIX 3 METHODOLOGY

The British Geological Survey (BGS) was commissioned in 1993 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 developed a methodology for the collection and display of data in a consistent and comparable format for four Mineral Planning Authority (MPA) areas - Bedfordshire, Derbyshire, Staffordshire and the Peak District National Park. The concept developed by the BGS for the trial study is now being extended to some twenty mineral planning authorities in England and Wales through a further phase of the project which started in 1996.

The main element of the trial study was the production of maps, with accompanying interpretative reports, for each MPA area. All mineral resource and planning constraint information has been collated 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 taken digitally from hard copy maps, mainly with scales between 1:50 000 and 1:10 000. Other material was obtained in a variety of digital formats which have had to be converted for use by the Intergraph Microstation System. The structure of the information will allow the data to be transferred in digital form to the BGS MINGOL (MINerals GIS On-Line) system. MINGOL is being developed to provide a decision-support system for the rapid solution of minerals-related problems to aid corporate and public mineral resource management. It applies a state-of-the art GIS to relate the nature and distribution of mineral resources to other information such as planning and environmental constraints, and mineral exploration, borehole and commodity statistics datasets.

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 or areas on request.

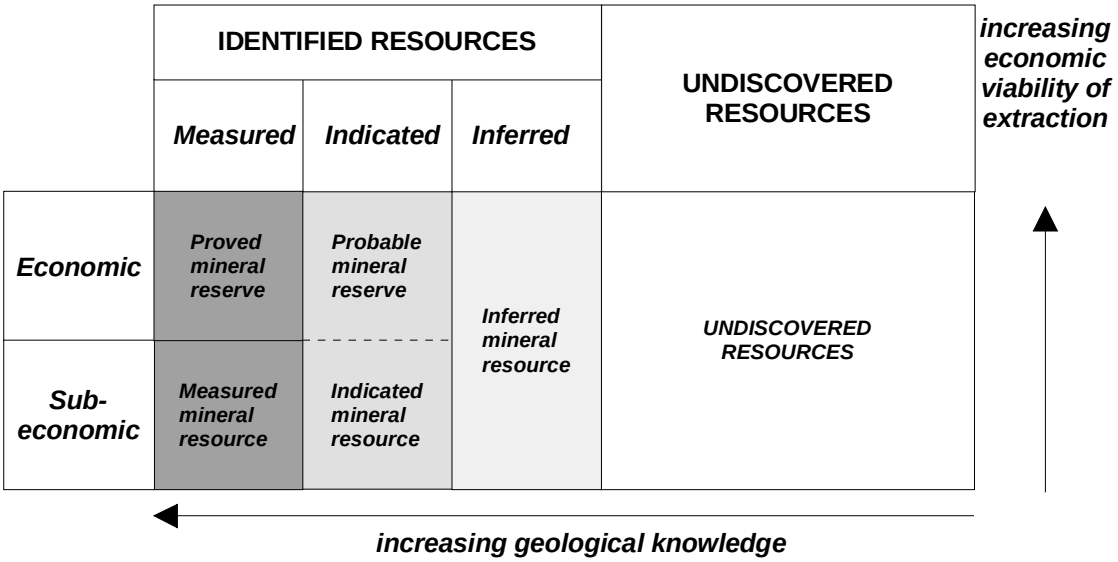

Figure 1 Classification of resources

Based on McKelvey, 1972

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 demand, mineral prices and costs of extraction may change with time, so mineral resources may become reserves and vice versa.

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 mineral resource information has been produced by the collation and interpretation of data principally 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, in the **inferred resource** category (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. Inferred resources may be converted into indicated and measured resources with increasing degrees of investigation and assessment. However, where mineral resource studies (including drilling and testing) have been carried out, sufficient information is available to define the resource at the **indicated** level. Sand and gravel assessment studies have been carried out in parts of the West Midlands.

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 revenues generated by its sale and, ultimately, the viability of the deposit. This activity is an essential precursor to submitting a planning application for mineral extraction. That part of a resource that is both 'measured' and 'economic', i.e. that has been fully evaluated and is commercially viable to work, is called a **reserve** or **mineral reserve**. It is customary to distinguish **proved** and **probable reserves**, which correspond to the economic parts of measured and indicated resources respectively (Figure 1).

In the context of land-use planning, however, the term **reserve** should strictly be further limited to those minerals for which a valid planning permission for extraction exists, i.e. **permitted reserves**. The extent of mineral planning permissions (other than coal) is shown on the Mineral Resources Map. These cover both active mineral workings and inactive mineral workings. Some mineral planning permissions may have been worked out and some may have remained unworked. 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 not depicted on the map.

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:

- 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 the West Midlands are shown on the map. The information is derived from the British Geological Survey's Mines and Quarries Database, updated as appropriate from local authority records. Letters (e.g. **Sg** = sand and gravel) are used to show the main mineral commodity produced.

The extent of the planning permissions shown on the Mineral Resources Map cover active mineral workings, former mineral workings and, occasionally, unworked deposits. 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. However, information on the planning and operational status of each planning permission may be available on the database which underpins the map. Under the provisions of the 1995 Environment Act, after 1 November 1997, sites that are classified as dormant may no longer be worked until full modern planning conditions have been approved by the Mineral Planning Authority. A 'dormant site' is defined as a site where no mineral development has taken place to any substantial extent in the period 23 February 1982 and ending 6 June 1995. Information on the precise status and extent of individual planning permissions should be sought from the various Mineral Planning Authorities (Appendix 2).

Most planning permissions appear on a mapped mineral resource area and thus the underlying resource colour identifies the mineral type. Planning permissions may fall outside resource areas for the following reasons:

- 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:

The latest data available for the total areas of planning permissions in the West Midlands County, collected for the Department of Environment Minerals Survey of 1994, is shown in Table 1. This information is updated at intervals.

Authority	Commodity	Total permitted area (ha)	No. of sites	% area
Birmingham				
Workings	-	0	0	-
Total		**0**	**0**	**-**
Coventry				
Workings	-	0	0	-
Total		**0**	**0**	**-**
Dudley				
Surface workings	Clay/shale	95	7	96.94
	Sandstone	3	2	3.06
Total		**98**	**9**	**100**
Sandwell				
Surface workings	Coal (opencast)	38	1	34.55
	Igneous rock	72	3	65.45
Total		**110**	**4**	**100**
Solihull				
Surface workings	Clay/shale	40	1	25.64
	Sand and gravel (construction)	116	4	74.36
Total		**156**	**5**	**100**
Underground workings	Coal (under GDO)	58	1	100
Total		**58**	**1**	**100**
Walsall				
Surface workings	Clay/shale	199	10	78.35
	Coal (opencast)	32	1	12.6
	Sand and gravel (construction)	23	2	9.06
Total		**254**	**13**	**100**
Underground workings	Clay/shale	15	1	100
Total		**15**	**1**	**100**
Wolverhampton				
Surface workings	Coal (opencast)	45	1	100
Total		**45**	**1**	**100**

Table 1 Areas of planning permissions for mineral workings by Mineral Planning Authority (as at 1.4.94). Source: Department of the Environment, 1996 Survey of Land for Mineral Workings in England, 1994.