British Geological Survey

Department of the Environment, Transport and the Regions

Mineral Resource Information for Development Plans

Warwickshire: Resources and Constraints

TECHNICAL REPORT WF/99/2
Mineral Resources Series

Mineral Resource Information for Development Plans: Phase One Warwickshire: Resources and Constraints

A J Bloodworth, D G Cameron,
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This report accompanies the 1:100 000 scale map: Warwickshire Mineral Resources

Cover photograph
Judkins Quarry produced high-quality roadstone from Precambrian and Cambrian rocks of the Nuneaton Inlier until the mid-1990s. This quarry is now the site of a major landfill.
Photo: J Carney

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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 area of the Mineral Planning Authority of Warwickshire. The map also includes the former West Midlands Metropolitan County area covered by the Mineral Planning Authorities of Birmingham, Coventry, Dudley, Sandwell, Solihull, Walsall and Wolverhampton. This area is described in a separate report. The report and map 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 as a digitally-generated summary map. The map is produced at 1:100000 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 evaluation and planning, baseline data for environmental impact studies and environmental guidelines. It also enables a 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 map

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, hard rock (igneous rocks and sandstone), sand and gravel, brick clay, ironstone, hydrocarbons, cement 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 county area of Warwickshire and should be used in conjunction with the mineral resources map of the county which accompanies this report. The report and its associated map delineate and describe the mineral resources of current or potential economic interest in Warwickshire and relate these to national planning designations which may represent constraints on the extraction of minerals. The map also includes the former Metropolitan County of the West Midlands. The West Midlands is covered by a separate report. 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 resources map is at 1:100000 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 archaeological 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 information 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 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 mineral resources in their areas and of the reserves for which planning permissions have been granted.

The key elements of a minerals local plan or of 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 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 the protection of 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)

The maps 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 will exhibit physical and/or chemical properties and be present in sufficient quantity to be of intrinsic economic interest. Mineral resources are thus economic as well as physical entities.

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, therefore, a dynamic process which must take into account a range of factors. These include geological reinterpretation as additional data becomes available, 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, for example in terms of mineral to waste ratios, also change with location and time. Thus a mineral deposit with a high proportion of waste may be viable if located in close proximity to a major market, but uneconomic if located further away. The criteria used to delineate mineral resources are outlined in the relevant commodity section of the report. These criteria vary depending on the quality of the information available.

The map of Warwickshire and the West Midlands mainly 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 sand and gravel assessment studies have been undertaken by the British Geological Survey or other organisations, sufficient information may be available to define mineral resources at the **indicated resource level**. The sand and gravel resources around

Henley-in-Arden, Leamington Spa and Coventry fall into this category. The linework is based on the 1:25000 scale mineral assessment maps, where these are available.

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 the site must 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 map has been produced by the collation and interpretation of data principally held by the British Geological Survey. The geological lines are taken, with some generalisations, from available BGS 1:25000, 1:50000 scale and 1:63630 scale maps. These published maps are based on 1:10560 or 1:10000 scale surveys, which cover most of the county. 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 and where the permitted mineral reserve may have been depleted to a greater or lesser extent. Within the overall

site, there may be a number of individual planning permissions at various stages of development and restoration. All planning permissions data were obtained from Warwickshire 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 sites where the permission is still valid. Sites which have been restored have not been separately identified. However, information is available on the planning and operational status of each planning permission 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, overburden tips and landscaping, 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 Warwickshire County Council (Appendix 2).

ENVIRONMENTAL DESIGNATIONS

The map shows the extent of selected, nationally-designated planning constraints as defined for the purposes of this study. These are defined on a common national basis and therefore represent a consistent degree of constraint across the country. No interpretation should be made from the map with regard to the relative importance of the constraints, either in relation to mineral development proposals or in relation to each other. Users should consult policy guidelines issued by the relevant Government department, statutory agency or local authority.

The constraints shown on the map are:

- 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, the best and most versatile agricultural land, 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 has 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 proximity of Warwickshire to the major West Midlands conurbation has historically lead to a high demand for minerals from the county. That demand continues to this day, particularly for construction raw materials.

Coal extraction from the narrow crop of the Warwickshire Coalfield in the northern part of the county began in Roman times. Deep mining and the exploitation of the concealed coalfield to the south and west only began in the latter part of the 19th Century, reaching its peak between the wars. Extraction has declined in recent times, with only one deep mine and one opencast mine remaining in production. The prospects for oil and/or gas discovery within the county are considered to be low. As elsewhere in the West Midlands region, the Carboniferous Etruria Formation (which forms part of the succession in the Warwickshire Coalfield) is an important raw material for the manufacture of bricks.

Aggregates (in the form of sand and gravel and crushed-rock) now dominate minerals production in Warwickshire. Recent river terrace deposits from the valleys of the Tame and Avon are an important resource, as are some older Quaternary fluvial deposits which occur around Warwick and Coventry. Quaternary glacial sand and gravel deposits also represent a valuable resource, particularly in the east of the county around Rugby and in the north west around Coleshill.

The Precambrian – Lower Palaeozoic Nuneaton Inlier represents a regionally important resource of hard rock suitable for aggregate purposes. The outcrop area of the inlier is small, and much of the former resource is now worked-out or sterilised by urban development. The Precambrian volcanic rocks and overlying Cambrian sandstone were formerly an important source of high PSV roadstone for the Midlands and southern England. Roadstone and high specification aggregate are still produced from two quarries in Ordovician-age intrusions in the Cambrian shales which form the younger rocks of the inlier.

The Jurassic rocks in southern Warwickshire provide clay resources for the two large cement plants in the Rugby area (limestone in the form of chalk is imported from outside the county). The Marlstone Rock (formerly a source of iron ore) now constitutes a small, but locally important, source of Type 1 roadstone, fill and building stone.

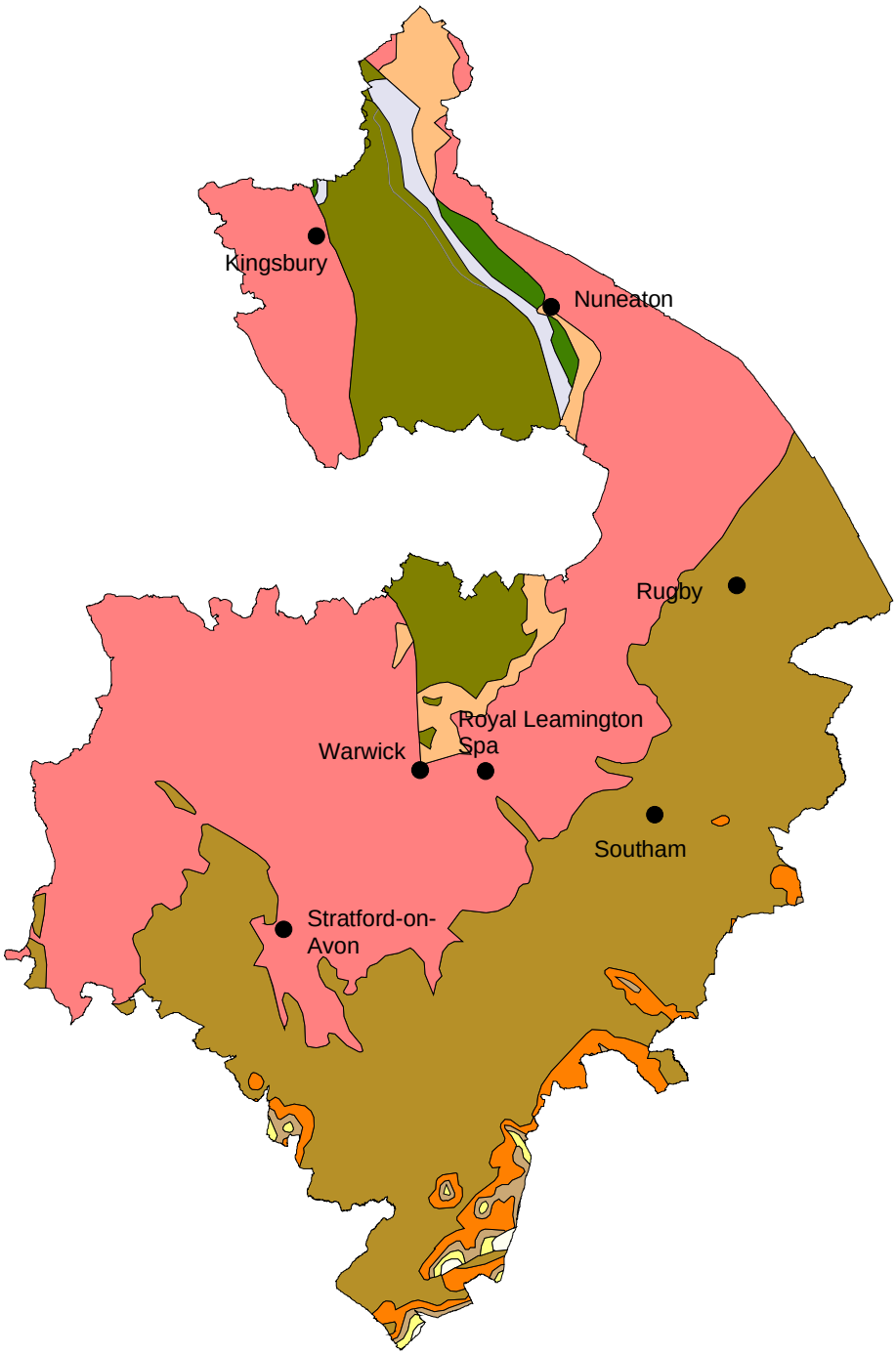

Figure 1 Simplified geological map of Warwickshire. Key relating mineral commodities to geology is shown on the next page.

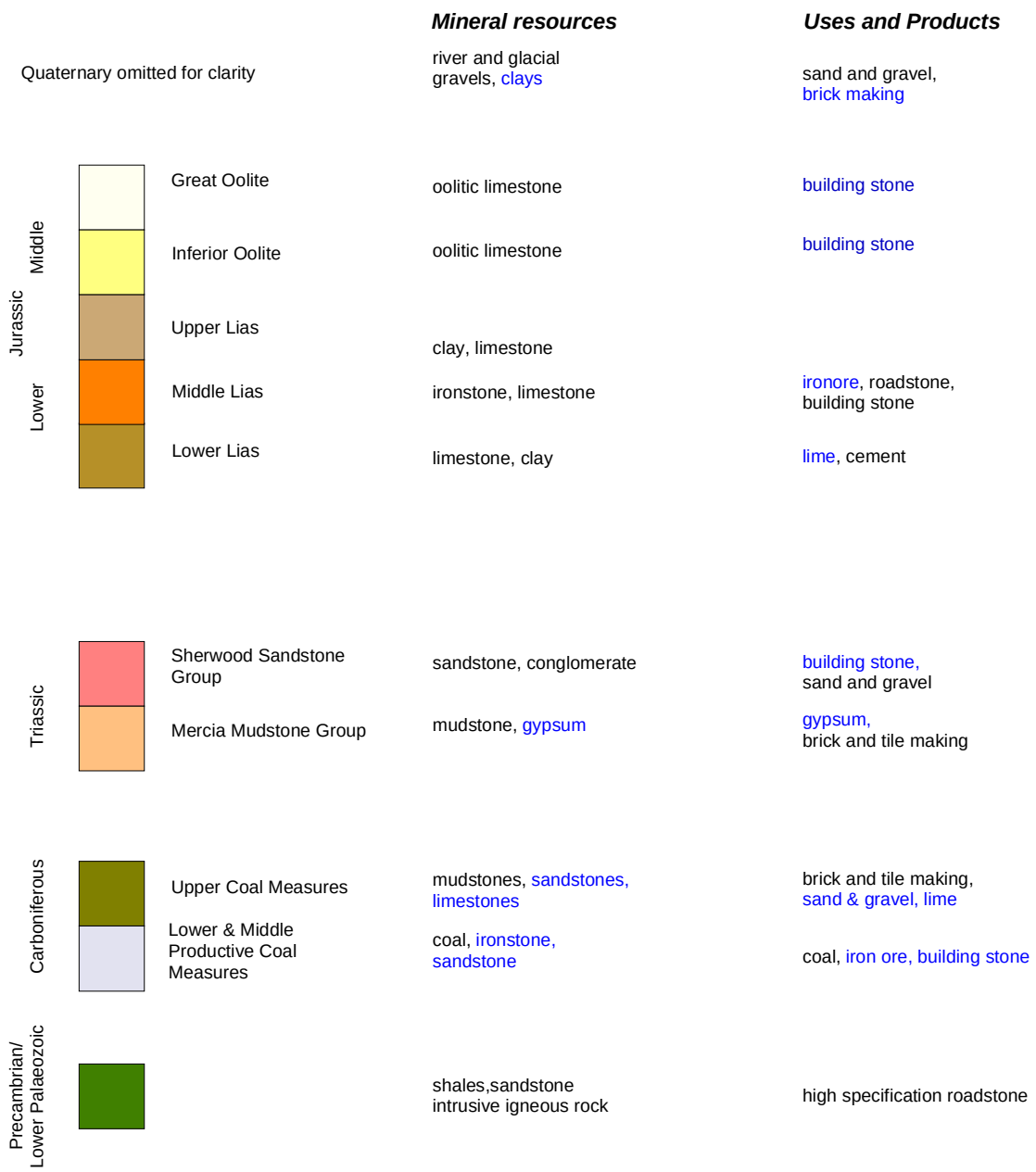

Figure 1 (continued) Key relating mineral commodities to geology. Materials no longer worked shown in blue.

COAL

Warwickshire Coalfield

The Coal Measures of the Warwickshire Coalfield are preserved in a north-south trending syncline, that extends from Tamworth south to beyond Kenilworth. The coalfield is bounded to the west by the Western Boundary Fault System, to the north-east by outcrop and to the south-east by incrop below Triassic rocks. Because of the southward plunge of the syncline, the coal seams lie at increasing depth in that direction and are overlain by progressively younger Upper Carboniferous and Permian strata, comprising mainly of redbeds.

The outcrop of the exposed coalfield follows the northern and north-eastern perimeter of the syncline forming a narrow belt, typically no more than a kilometer wide. Within this belt, the coal-bearing strata are steeply inclined (8 to 50°) but dips moderate rapidly downdip. The succession is up to 190 m thick, and includes seven named coal seams in the Lower Coal Measures, and the important Thick Coal group of seams in the Middle Coal Measures (Figure 3). Over the central and southwestern part of the coalfield, the constituent leaves of the Thick Coal are either in contact or are separated by only thin dirt partings, giving a total seam thickness of up to 8.5 m. However, in the area of outcrop these seams split and are spread out over a vertical interval of between 25 and 35 m. A variable cover of glacial till conceals much of the southern part of the outcrop.

Coal extraction began during Roman times and continued, mainly as crop workings, until the 16th century. Deep mining and exploitation of the concealed coalfield really only began in the second half of the 19th Century. Output reached its highest level in 1939 when 5.8 million tonnes were produced from 20 mines. Since 1947, when the coal mining industry was nationalised, closures and mergers have progressively reduced the number of pits. With the closure of the Coventry Colliery in 1996 and the drift mine at Merevale more recently, Daw Mill is now the only operational deep mine in the coalfield. 1.8 million tonnes of deep mine coal was produced from the Warwickshire Coalfield in 1997/98 (Coal Authority, 1998).

The coals are generally high-volatile, low-rank bituminous coals (British Coal Rank, 902), with a moisture content that is generally quite high (over 10 per cent). *In situ* average sulphur values for the leaves of the Warwickshire Thick Coal are less than 4 per cent by weight (Fulton, 1987). The Two Yard seam in the upper part of the Warwickshire Thick Coal has an average *in situ* sulphur content of less than 1.5 per cent, although values in the northern and south-eastern parts of the coalfield rise to 2.5 per cent (National Coal Board, 1957). Average ash contents are less than 9 per cent by

weight (air dried basis) (Fulton, 1987). Coal quality deteriorates slowly towards the south-east, with ash and chlorine increasing and calorific value and rank decreasing from north-west to south-east (National Coal Board, 1957; 1985).

Opencast mining was undertaken along much of the length of the outcrop, mainly in the post-war period. The last remaining opencast coal site in the coalfield (at Dosthill near Tamworth) ceased coaling in July 1998. This site produced 72 000 tonnes of coal in 1997/98 (Coal Authority, 1998). Opencast coal production from 1985/86 to 1997/98 are given in Figure 2.

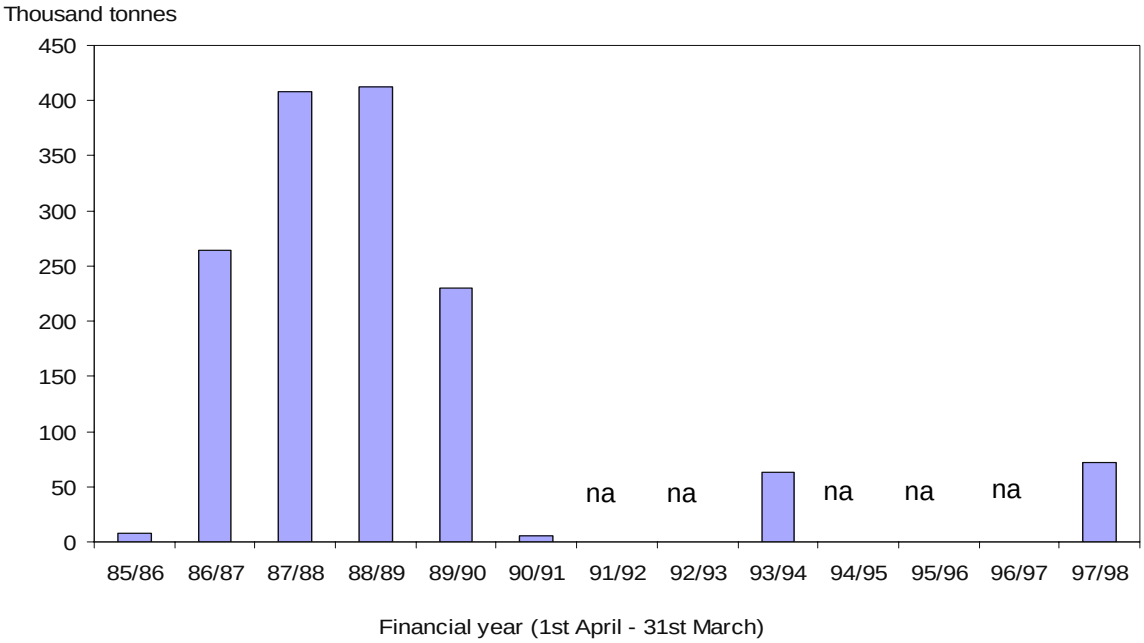

Figure 2 Opencast coal production from the Warwickshire Coalfield
na: data not available.

Source: Opencast coal mining statistics, County Planning Officers Society and The Coal Authority.

The opencast resource envelope is defined as the outcrop of the Lower and Middle Coal Measures. The overburden ratio increases rapidly downdip and is likely to preclude significant workings beneath younger cover rocks.

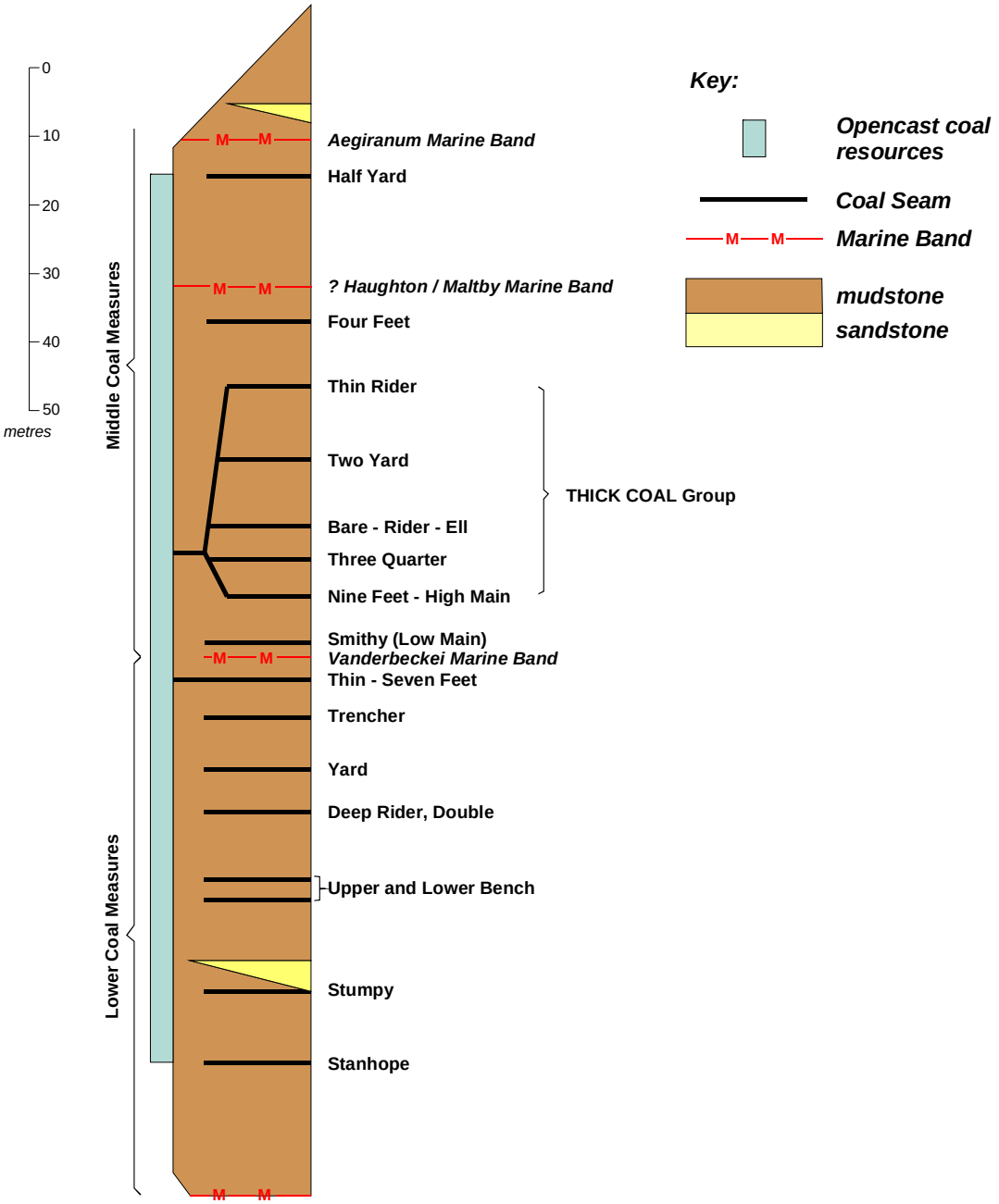

Figure 3 Generalized vertical section of the Coal Measures of the Warwickshire coalfield

Areas of 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 licenses 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 license area for coal extraction issued by the Coal Authority is shown. Licenses in Warwickshire consist of one underground and one opencast license. 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, the 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 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 physical properties of the fired brick, as well as its aesthetic qualities.

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 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. 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. Continuity of supply of consistent raw materials is of paramount importance.

The Etruria Formation forms part of the Carboniferous sequence that crops out in the north-west portion of the Warwickshire Coalfield and, as in neighbouring parts of Staffordshire and the West Midlands, has been worked extensively in the past. It 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. The top is an unconformable boundary with the overlying Halesowen Formation. The thickness ranges from 61 – 207 m. The relative proportions of disordered kaolinite, illite, quartz and iron oxides in the clay, and 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, 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. Brick clay working in Warwickshire is confined to a single site at Kingsbury in the north of the county. This site works Etruria Formation for the manufacture of facing bricks.

SAND AND GRAVEL

Warwickshire produced 1,208000 tonnes of sand and gravel in 1997. Production of sand and gravel in Warwickshire is shown in Figure 4. Sand and gravel resources occur as superficial or 'drift' deposits of Quaternary age, subdivided for practical purposes into 'glacial sand and gravel', and 'river sand and gravel'.

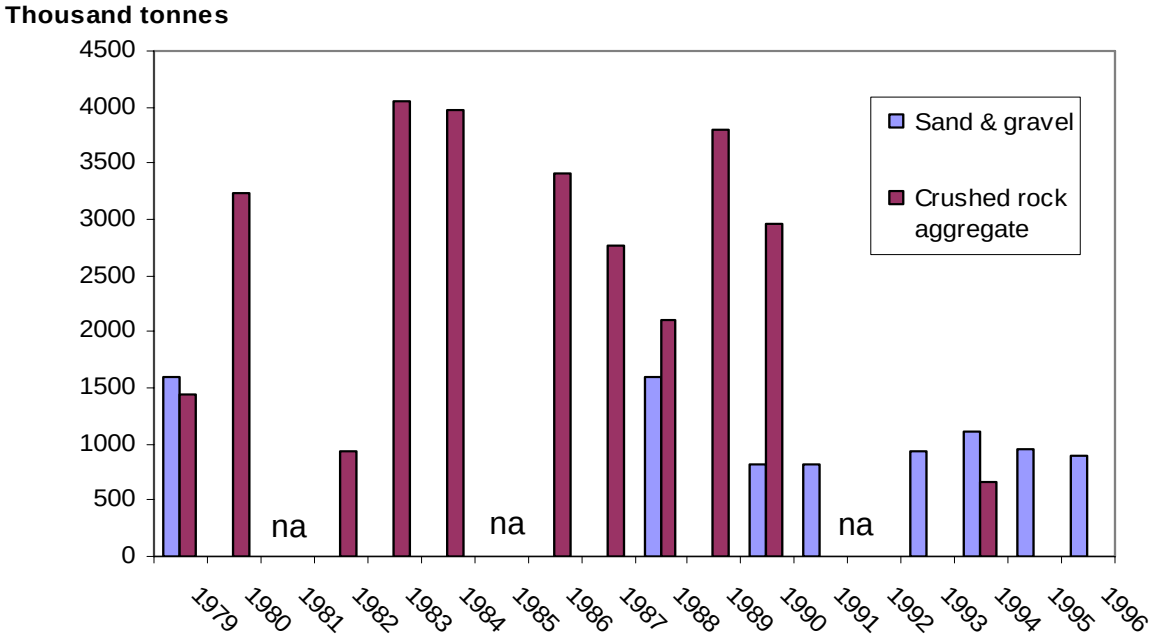

Figure 4 Output of sand and gravel and crushed-rock aggregate from Warwickshire
na: Data not available. Data has been suppressed in some years to maintain commercial confidentiality.

Source: Office for National Statistics Annual Minerals Raised Inquiry.

The variability of sand and gravel deposits means that, in comparison with other bulk minerals, it is more difficult to infer the location and the likely extent of potentially workable resources from geological maps. The criteria that 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
- location relative to demand

Information on the sand and gravel resources of substantial parts of the county is available in mineral assessment studies carried out by BGS and others. Reconnaissance studies have also been carried out in several areas and results are available as BGS Open File or Internal Reports. Additional data on the distribution of sand and gravel in Warwickshire are given in BGS maps and memoirs.

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. Surveys by the BGS Industrial Minerals Assessment Unit (Cannell, 1982; Crofts, 1982; Cannell and Crofts, 1984; Clarke and Moczarski, 1982) and others (Liverpool University, 1989) in various parts of the county have upgraded the data in these areas to the level of 'indicated' resources. These areas are clearly delineated and may include the category 'concealed glacial sand and gravel' which is not shown elsewhere on the map. It should be noted that the physical criteria used by BGS and Liverpool University to define indicated sand and gravel resources are somewhat different. The criteria used are set out in Table 1.

	BGS Mineral Assessment Reports	**University of Liverpool Report**
Deposit thickness	>1 m	>2.5 m
Overburden : sand & gravel ratio	3:1	1:1
Proportion of fines (<63μm)	<40 %	<10 %
Proximity of deposit to surface	25 m	25 m

Table 1 Physical criteria used by BGS and University of Liverpool surveys to define 'indicated' resources of sand and gravel in Warwickshire (Cannell, 1982; Liverpool University, 1989).

The distinction between river sand and gravel and glacial sand and gravel reflects differences in their mode of occurrence and to some extent in their quality (particle size distribution and lithology). 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 river 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 is therefore closer to user specifications. Nevertheless, beds of silt and clay may occur within these deposits. Glacial sand and gravel includes deposits laid down by a variety of glacial and glaciofluvial processes associated with icesheets and their meltwaters. They are 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.

River sand and gravel

This includes spreads of sand and gravel that occur beneath the alluvium along the floors of the major river valleys, as well as river terrace deposits flanking the valley sides. In Warwickshire they are mainly associated with the rivers Avon and Tame. The deposits consist of a mixture of sand and gravel, in varying proportions, from which coarse and fine aggregates are produced by a process of washing and size separation, usually involving sceening and hydrocyclone separation. In some areas in the east of the County, around Warwick and Coventry, terrace-like spreads of sand and gravel occur and have been mapped as glacial sand and gravel (the Hillmorton Sand and Gravel and the Baginton Sand and Gravel). However, it seems likely that both of these have been deposited by river action and thus they are included in this report (and on the map) with the river gravels. Grading data for river sand and gravel from Warwickshire are given in Table 2.

The Baginton Sand and Gravel is an older Quaternary deposit, around 10 m thick, which was laid down by river systems draining the pre-glacial land surface. The gravel component consists almost entirely of well rounded pebbles of quartzite and quartz derived from local Triassic rocks, although the more southerly deposits also contain Jurassic limestone clasts presumably derived from the nearby Cotswolds. The upper part of the unit is generally sandy, consisting mostly of fine to medium-grained, clean, well-sorted quartz sand. The Hillmorton Sand and Gravel is a localised fluvial channel-fill deposit near Rugby which consists mostly of fine to medium sand with lenses of flint and quartzite gravel. The deposits may be up to 50 m thick (Old *et al.,* 1987). Both the Baginton Sand and Gravel and the Hillmorton Sand and Gravel have been extensively worked in the past and large areas of the former have been worked out. Urban development around Rugby significantly constrains development of remaining deposits of the Hillmorton Sand and Gravel. The Baginton Sand and Gravel is extracted near Bubbenhall and there remains significant resources in the area between Warwick and Coventry.

Terrace sands and gravels are found in most of the river valleys, principally alongside parts of the Tame and Avon and their tributaries. Extensive extraction has occurred where the terrace gravels are located close to urban areas. Not all the spreads of river gravels shown on the accompanying map are likely to be of commercial value, some being too limited in extent, thickness or quality. Most of the larger terrace deposits, however, have been worked at some time and several pits are still active in the river gravels of the Tame (east of Birmingham) and in the River Avon gravels near Bidford-on-Avon and near Stretton-on-Dunsmore.

Individual terrace deposits only rarely exceed 6 m in thickness with 3 to 4 m being typical for the river terraces of the Avon and Tame, but thinner elsewhere. The terrace deposits are broadly lithologically similar and consist mainly of gravelly sands containing quartzite, quartz and flint pebbles with lenses of silt and clay. Up to five separate terraces have been mapped in the Avon valley (the second and third terraces are particularly important as sand and gravel resources) and two terraces are present alongside the Tame. Individual terrace 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 flood plains of all but the smallest valleys are covered by alluvial deposits. Their composition reflects local sources, although they generally comprise a layer of silty clay averaging around 3 to 5 m in thickness. Much of it is underlain by a layer of sandy gravel which may be workable in places.

Deposit type	**Fines %** **(<0.063mm)**	**Sand %** **(0.063-4 mm)**	**Gravel %** **(>4 mm)**
Alluvium (E of Solihull)[1]	5	27	68
River terrace (E of Solihull)[1]	9	58	33
Baginton Sand (SE of Coventry)[2]	12	63	25

Table 2 Mean grading data for river sand and gravel samples taken from the Solihull and Coventry areas([1]Crofts, 1982; [2]Cannel, 1982).

Glacial sand and gravel

These deposits occur in several parts of the county, in association with spreads of till (boulder clay) and other glacial deposits. On the accompanying map they include the Wolston Sand and Gravel, the Dunsmore Gravel, the Anker Sand and Gravel, the Shawell Sand and Gravel, Glaciofluvial Deposits and deposits mapped as Glacial Sand and Gravel. These deposits are typically very variable in extent, thickness and lithology but such accumulations may represent valuable sand and gravel resources, such as in the Coleshill area where sand and gravel is extracted from several working pits. In general, glacial deposits are likely to be less than 10 m thick, but may locally exceed 20 m thickness where they infill hollows and channels scoured into the underlying bedrock. Grading data for glacial sand and gravel from Warwickshire are given in Table 3.

Deposit type	Fines % (<0.063mm)	Sand % (0.063-4 mm)	Gravel % (>4 mm)
Dunsmore Gravel (SE of Coventry)[1]	16	57	27
Wolston Sand and Gravel (SE of Coventry)[1]	22	76	2
Glacial sand and gravel (E of Solihull)[2]	12	63	25

Table 3 Mean grading data for glacial sand and gravel samples taken from the Solihull and Coventry areas ([1]Cannel, 1982; [2]Crofts, 1982).

The Wolston Sand and Gravel, Shawell Sand and Gravel, Anker Sand and Gravel and the Dunsmore Sand and Gravel in the east of the county are sheet-like deposits, commonly 3-4 m thick. Compositionally, they are mostly derived from erosion of local rocks, and generally contain quartzite, Triassic and Carboniferous sandstone, Jurassic limestone and Cretaceous Chalk and flint clasts in a matrix of reddish sand with clay layers.

HARD ROCK (IGNEOUS ROCK and SANDSTONE)

Rocks of Precambrian and Lower Palaeozoic age occur within a small inlier near Nuneaton and include some of the few sources of high strength, hard rock for crushed-rock aggregates in central England. Within the Nuneaton Inlier the rocks have a steep southwesterly regional dip of around 40° and form a narrow NW-SE elongated outcrop that extends for 18 km from Bedworth through Nuneaton to Atherstone. Hard rocks are located along the eastern margin of the outcrop near Nuneaton which is marked by a series of large roadstone quarries. These are mostly disused or are non-operational although they form valuable sites for landfill. However, two quarries (Griff and Mancetter) are currently operational, working Ordovician-age diorites hosted in the Cambrian Stockingford Shale Group mudstones for crushed rock aggregates. Aggregate properties of Nuneaton Inlier rocks are given in Table 4.

The Precambrian rocks of the area are divided into the Caldecote Volcanic Formation and a later complex of intrusive igneous rocks. Together, their outcrop covers a limited area of 3 km^2 between Nuneaton and Hartshill. They are the local representatives of Charnian rocks which occur in Charnwood Forest some 23 km to the north-east. The Caldecote Volcanic Formation consists of purplish grey, coarse- and fine-grained, massive or stratified, volcanic ashes (tuffs) and tuffaceous siltstones. They contain small intrusive stocks and dykes of fine to coarse-grained volcanic rocks (basalts, andesites and diorites). Many of the intrusive rocks are fractured and sheared and contain brecciated zones. They are commonly between 0.5 and 50 m thick, a variation which normally occurs along the length of a single body. Intrusive igneous rocks occupy around 25 per cent by volume of the total Precambrian outcrop.

Sedimentary rocks of Cambrian age crop out within the Nuneaton Inlier and the steeply-dipping succession is divided into two broad lithological divisions, sandstone and shale. The Hartshill Sandstone Formation rests unconformably on the eroded Precambrian basement and is overlain by the Stockingford Shale Group. The sandstones are exposed in a narrow belt 4 km by 0.5 km between Nuneaton and Hartshill. The Hartshill Sandstone Formation is 260 m thick and consists of hard, massively bedded, grey or reddish quartzitic sandstones with minor mudstone interbeds. It was formerly extensively worked in several large quarries near Nuneaton and, together with the underlying Precambrian rocks, they formed a valuable resource of road surfacing materials which is now virtually worked out or is constrained by development.

	PSV	AIV	ACV	AAV	Water absorption (%)
Diorite intrusion in Stockingford Shale (Ordovician)	59	10	11	6.8	0.9
Precambrian diorite	60	13	15	5.5	1.1
Hartshill Sandstone (Cambrian)	61	21	18	3.1	0.5

Table 4 Typical aggregate properties of rocks in the Nuneaton Inlier (BGS data)

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.

Both the sandstones and the overlying mudstones of the Stockingford Shale Group are intruded by igneous rocks of late Ordovician age. The intrusions occur as thin (1 – 5 m) sheets of a fine-grained type of rock, termed lamprophyre and thicker (up to 70 m), coarser-grained sills of diorite. Many intrusions form bold landform features, rising to over 150 m OD and can be traced for some considerable distance. The thicker intrusive bodies are quarried for roadstone and high-specification aggregate at Griff and Mancetter quarries.

IRONSTONE

The Banbury Ironstone Field is located mainly in Oxfordshire but extends into the southern part of Warwickshire where it was formerly worked. The ironstone is the Lower Jurassic Marlstone Rock Bed which consists of a sandy ferruginous limestone that has also undergone secondary enrichment due to oxidation. Workable ironstone was mainly oxidised and occurred under shallow or no overburden. The ironstone has an average Fe content of 25 per cent, with 10 per cent SiO_2, 13 per cent CaO and 0.25 per cent P. The bed is 3 to 4 m thick over most of the field, although locally thicker. The field was worked between 1860 and 1967 and most of the output was transported to South Wales for steelmaking.

The ironstone is no longer of economic significance as a source of iron ore, but it does represent a source of aggregate for use in less rigorous applications (for drainage and capping layers) and as Type 1 sub-base. As a result of the variation in properties within the Marlstone Rock, the acceptability of this material for these end-uses can only be confirmed on a site by site basis.

CEMENT RAW MATERIALS

Despite relatively poor-quality limestone resources, Warwickshire has a long history of cement manufacture dating back to the early part of the last century. Two large plants are currently operated by Rugby Cement at Southam and Rugby with clinker capacities of 405000 t/y and 375000 t/y, respectively. Smaller works were formerly active at several other locations. The Blue Lias occurs towards the base of the Jurassic strata in the county and originally forming the basis of the cement industry. It typically consists of an alternating sequence of dark grey mudstones and paler grey clayey limestone (cemenstones) some 0.1 to 0.2 m thick. The proportion of limestone within the succession is 30-35 per cent. The Blue Lias in bulk contains too high a ration of silica to lime for cement manufacture and formerly limestone was worked selectively. Later, limestone from the top of the underlying Langport Member of the Penarth Group was also worked. Latterly, these limestones proved unsuitable as raw materials for modern cement manufacture. A source of higher-purity lime was required and chalk from Totternhoe in Bedfordshire was originally brought in by rail. In

1965 the slurry pipeline from Kensworth quarry in Bedfordshire came into operation and is now the principal source of calcareous raw material for cement manufacture in the county.

Portland cement clinker is manufactured by heating an intimately homogenised and controlled mixture of calcareous and clayey raw materials to partial fusion. Small amounts of iron oxide and sand may be added to optimise the mix. These raw materials supply the lime, silica, alumina and iron oxide necessary for the formation of the calcium silicate and smaller quantities of calcium aluminates that constitute cement clinker. The clinker is cooled and then finely ground typically with 5 per cent of gypsum/anhydrite. The gypsum/anhydrite is introduced to control the initial rate of reaction with water and allow concrete to be placed and compacted before hardening commences. Limestone, or chalk, provides lime for the production of cement clinker and typically accounts for 80-90 per cent of the raw mix. Clay or shale accounts for some 10-15 per cent and provides most of the silica, alumina and iron oxide. Cement making is highly capital-intensive and cement plants are normally located close to the main limestone raw material. The Warwickshire industry is unusual in being remote from its limestone source.

Blue Lias clay continues to be supplied for cement manufacture from the Southam quarry. Limestone within the underlying Langport Member is also exposed in the base of the quarry. Some of this material is used for building stone whilst the remainder also goes for cement manufacture. The limestone beds within the Blue Lias are too thin to be regarded as a limestone resource and are not, therefore, shown on the main map.

A new cement plant involving a capital investment of some £120 million is currently being built at Rugby and will have a capacity of 1.35 million tonnes a year. The plant will replace the existing plant at Rugby, as well as those at Southam and Chinnor in Oxfordshire when it comes into production in 1999. The new plant will be supplied with chalk from Kensworth in Bedfordshire by slurry pipeline and clay will be trucked in from Southam. Reserves of clay at this site are sufficient for about 40 years. No production of clay is envisaged at Rugby although some reserves remain. Both works currently rely on Southam clay.

HYDROCARBONS

Conventional oil and gas

Warwickshire and the 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 gas and oil have been drilled in Warwickshire or the West Midlands.

Coalbed methane

The area includes part of the Warwickshire coalfield, 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 imply 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.

Despite this low potential, three areas within the Warwickshire and West Midlands are licensed 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. The 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, 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 very limited resources of secondary aggregates in Warwickshire.

Other materials

Spoil from former colliery tips consists mainly of mudstone and siltstone. In Warwickshire, these have largely been reclaimed/restored and are not available as a source of secondary aggregate.

MINERAL RESOURCES AND PLANNING CONSTRAINTS

The landscape character of Warwickshire 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. Mineral extraction can 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 the social and economic issues as well as the need to protect the environment.

Mineral extraction in areas designated as SPAs or 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 or 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 provides a synthesis 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.

A major part of the Warwickshire/ West Midlands area is urbanised. This development both dominates as a land use and reduces the extent to which land may be available for mineral extraction, or may be covered by national planning designations. However, a number of Scheduled Ancient Monuments and SSSIs are scattered throughout these urban areas, in some cases reflecting the industrial and mining heritage of this locality.

Outside the urban area, landscape and land-use are considerably influenced by the underlying geology. This can create areas which are valued for landscape and nature conservation purposes although they are not, with the exception of a small section of the Cotswolds AONB in the south of Warwickshire, of national importance.

Due to the need to contain the growth of the urban area, much of the immediate surrounding open countryside is designated as Green Belt. In this area, the purpose of planning policy is to maintain openness. The extraction of minerals need not be incompatible with the purposes of that designation. Other local 'green area' designations may have been made by local planning authorities. The boundaries of the Green Belt, green areas, local landscape designations and local conservation designations are not shown on the accompanying map but may be found on relevant local plans published by the local planning authorities.

Other local and site specific factors may preclude or affect mineral extraction operations. High-grade agricultural land may be a constraint if the land cannot be restored to at least the same grade following extraction. Such factors represent technical constraints rather than fundamental policy constraints and can only be considered on a site by site basis. They have therefore been excluded from the map.

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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
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*
SP28/38	Geology of the Coventry Area – 6 Sand and gravel resources	D	1990*
154	Lichfield	SwD	1926#
155	Coalville	SwD	1982
168	Birmingham	S+D	1996
169	Coventry	SwD	1994
169	Coventry	S+D	1994
170	Market Harborough	S+D	1969 (1997F)
183	Redditch	S+D	1989
184	Warwick	S+D	1984
185	Northampton	S+D	1980
200	Stratford-upon-Avon	S+D	1974
201	Banbury	S+D	1982
217	Moreton-in-Marsh	S+D	1981
218	Chipping Norton	S+D	1968#
	F – 1:50000 scale facsimile of 1:63 360 S+D Solid and Drift combined SwD as above with uncoloured drift sheet		

b) British Geological Survey Sheet Memoirs

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*****Available only from BGS

c) British Geological Survey Reports and other publications

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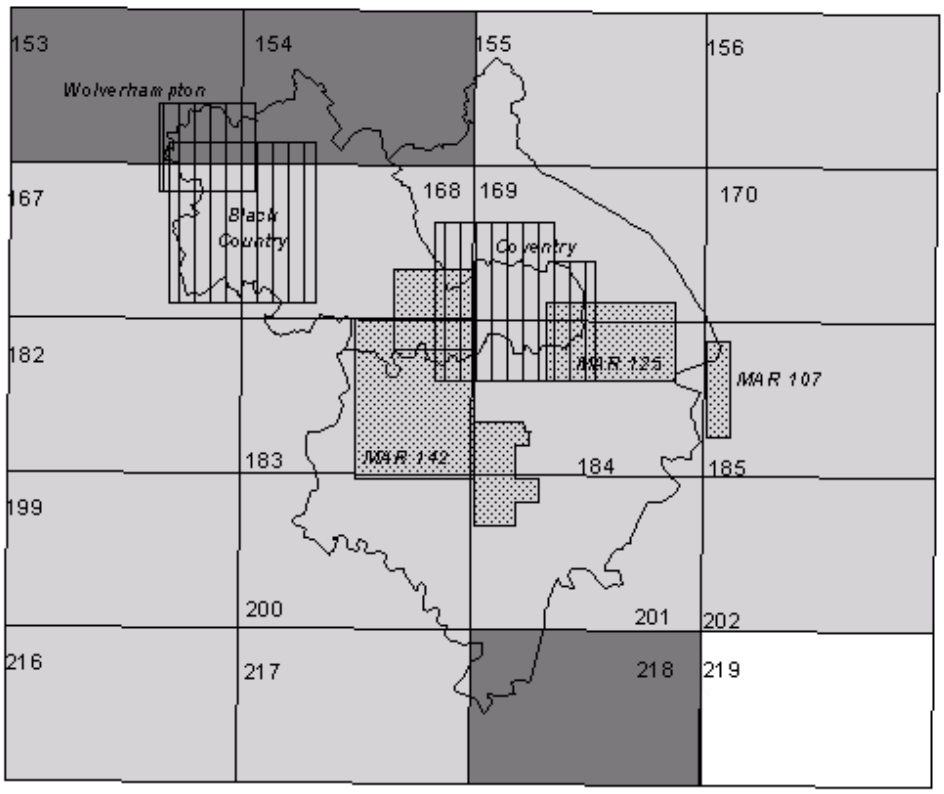

1:50 000 map published

1:63 360 map published

1:25 000 map published (Sand & Gravel Resources Map)

1:25 000 map published (Black Country, Wolverhampton and Coventry maps)

Modern geological maps not available

Figure 5 Availability of British Geological Survey 1:50 000 or 1:63 360 scale New Series geological map coverage of Warwickshire

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APPENDIX 1 MINERAL WORKINGS IN WARWICKSHIRE (1997)

OPERATOR	NAME OF WORKING	COMMODITY
Court Plant Hire	Avon Hill	Limestone
G A Stephens	Barn Cottage Farm	Sand & Gravel
Smiths Concrete	Bubbenhall	Sand & Gravel
RMC - Western Aggregates	Coleshill	Sand & Gravel
Bruntingthorpe Gravels Ltd	Copston Lane	Sand & Gravel
RJB Mining (UK) Ltd	Daw Mill Colliery	Coal, Deep
Onyx Land Technologies Ltd	Dosthill	Coal, Opencast
Land Fill Development Co Ltd	Dunton	Sand & Gravel
Hornton Quarries Ltd	Edge Hill	Limestone
Pioneer Aggregates	Griff	Igneous & Metamorphic Rock
Mr Aston	Highwood Farm	Sand & Gravel
Baggeridge Brick	Kingsbury	Common Clay & Shale
Ideal Aggregates Ltd	Linghall	Sand & Gravel
Tilcon (South) Ltd	Mancetter	Igneous & Metamorphic Rock
RMC - Western Aggregates	Marsh Farm	Sand & Gravel
Hanson Aggregates - Central	Middleton Hall	Sand & Gravel
John Hutsby	Oakham Farm	Limestone
Rugby Cement	Southam Cement	Common Clay & Shale

APPENDIX 2 CONTACT ADDRESSES FOR FURTHER ENQUIRIES

Warwickshire County Council Shire Hall Warwick Warwickshire CV34 4RR Tel 01926 410410	Stratford on Avon District Council Elizabeth House Church Street Stratford-upon-Avon CV37 6HX Tel 01789 267575
Nuneaton and Bedworth Borough Council The Town Hall Coton Road Nuneaton Warwickshire CV11 5AA Tel 01203 376376	Rugby Borough Council The Town Hall Rugby Warwickshire CV21 2LB Tel 01788 533533
North Warwickshire Borough Council The Council House South Street Atherstone Warwickshire CV9 1BD Tel 01827 715341	Warwick District Council The Town Hall Leamington Spa Warwickshire CV32 4AT Tel: 01926 450000
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	Environment Agency Regional Office Sapphire East 550 Streetsbrook Road Solihull West Midlands B91 1QT Tel: 0121 711 2324 Fax: 0121 711 5824

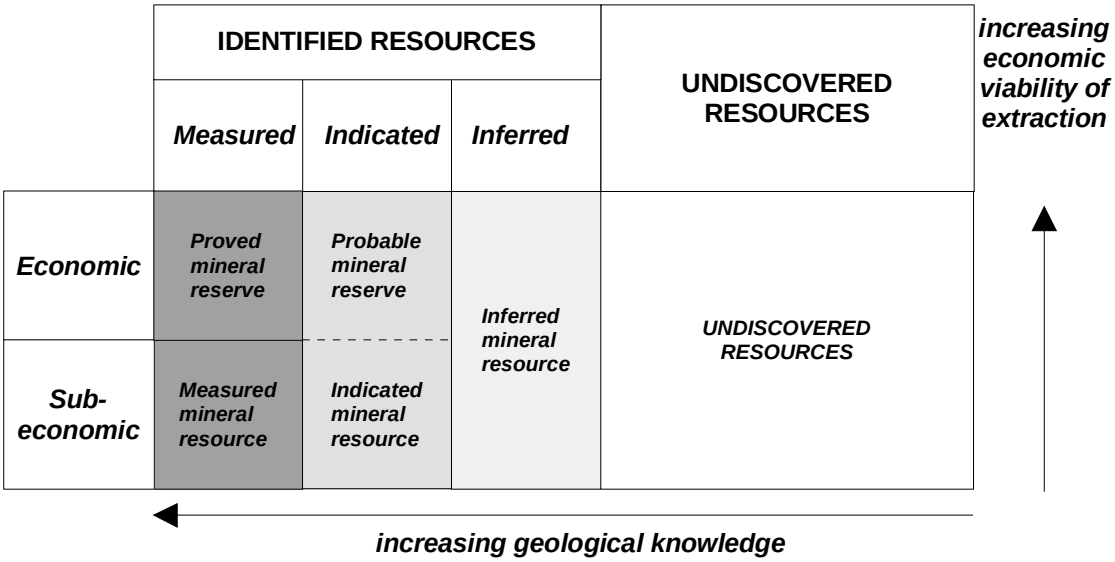
APPENDIX 3 METHODOLOGY

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 Warwickshire.

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 many 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 Warwickshire and 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 mineral planning 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 in 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 182 and ending 6 June 1995. Information on the precise status and extent of individual planning permissions should be sought from Warwickshire County Council.

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 Warwickshire, collected for the Department of Environment Minerals Survey of 1994, is shown in Table 1. This information is updated at intervals.

Table 1 Areas of planning permissions for mineral workings in Warwickshire (as at 1.4.94)

	Commodity	Total permitted area (ha)	No. of sites	%
Surface workings	Clay/shale	39	1	3.75
	Ironstone	20	2	1.93
	Igneous rock	219	4	21.1
	Limestone/dolomite	157	2	15.12
	Sand and gravel (construction)	603	11	58.09
	Total	**1038**	**20**	**100**

Source: *Department of the Environment. 1996. Survey of Land for Mineral Workings in England 1994.*