

**The conglomerate  
resources of the Sherwood  
Sandstone Group of the  
country east of Stoke-on-  
Trent, Staffordshire**

Description of 1:25 000  
resource sheet SJ 94

D. P. Piper

The first twelve reports on the assessment of British sand and gravel resources appeared in the Report series of the Institute of Geological Sciences as a subseries. Report 13 and subsequent reports appear as Mineral Assessment Reports of the Institute.

Details of published reports appear at the end of this Report.

Any enquiries concerning this report may be addressed to Head, Industrial Minerals Assessment Unit, Institute of Geological Sciences, Keyworth, Nottingham NG12 5GG.

## PREFACE

National resources of many industrial minerals may seem so plentiful that stocktaking appears to be unnecessary, but the demand for minerals and for land for all purposes is intensifying and it has become apparent in recent years that assessments of the resources of these minerals should be undertaken. The publication of information about the quantity and quality of deposits over large areas is intended to provide a comprehensive factual background against which planning decisions about these resources can be made.

Sand and gravel, taken together as naturally occurring aggregate, was selected as the bulk mineral demanding the most urgent attention, initially in the south-east of England, where about half the national output is won and very few sources of alternative aggregates are available. Following a short feasibility project initiated in 1966 by the Ministry of Land and Natural Resources, the Industrial Minerals Assessment Unit (formerly the Mineral Assessment Unit) began systematic surveys in 1968. The work is now financed by the Department of the Environment and is undertaken with the cooperation of the Sand and Gravel Association of Great Britain.

This report is the second to describe the conglomerate resources within the Sherwood Sandstone Group (formerly the Bunter Pebble Beds) and follows a successful feasibility study begun in 1975. The Sherwood Sandstone Group rocks, which crop out over 17.3 km<sup>2</sup> of country east of Stoke-on-Trent, Staffordshire, have been assessed and the results are summarised in this report and shown on the accompanying 1:25 000 resource map SJ94. The survey was conducted by Mr D. P. Piper in 1979 and 1980 and is based on a geological survey at the 1:10 000 scale by Mr Piper and by Mr T. J. Charsley and Mr J. I. Chisholm of the Institute's North Wales, Cheshire and Lancashire Field Unit.

Mr J. D. Burnell, ISO FRICS, (Land Agent) was responsible for negotiating access to land for drilling and Mr K. E. Thornton and Mr G. Moore of the Photographic Department carried out the borehole photography. The ready cooperation of land owners and tenants and the assistance provided by local quarrying companies are gratefully acknowledged.

G. M. Brown

*Director*

Institute of Geological Sciences  
Exhibition Road,  
London SW7 2DE

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## CONTENTS

<b>Summary</b>	1
<b>Introduction</b>	1
<b>Description of the district</b>	3
General	3
Topography	3
Geology	4
The map	5
Results	6
Notes on resource blocks	8
<b>Appendix A:</b> Field and laboratory procedures	11
<b>Appendix B:</b> Classification and description of samples	11
<b>Appendix C:</b> Definition of mineral and categories of deposit	13
<b>Appendix D:</b> Statistical procedure	13
<b>Appendix E:</b> Explanation of the borehole records	14
<b>Appendix F:</b> Records of Industrial Minerals Assessment Unit boreholes	15
<b>Glossary</b>	22
<b>References</b>	22

## FIGURES

1	Sketch map showing the location of the resource sheet, SJ94	2
2	Sketch map of the resource sheet area showing settlements referred to in the text and resource block boundaries	3
3	Grading characteristics of 16 samples of conglomerate from natural and quarry sections within the district	7
4	Diagram to show the descriptive categories used in the classification of samples of the Sherwood Sandstone Group	12

## MAP

The conglomerate resources of the Sherwood Sandstone Group of the country east of Stoke-on-Trent, Staffordshire *in pocket*

## TABLES

1	Lithostratigraphic nomenclature for the Triassic rocks of this district (SJ94) and the adjacent Cheadle district (SK04)	4
2	Composition of the conglomerates (weight per cent)	6
3	Composition of the conglomerates (number per cent)	8
4	Mechanical properties of the conglomerates of Huntley Wood Quarry	8
5	Summary of results	9
6	Classification of gravel, sand and fines	12



# The conglomerate resources of the Sherwood Sandstone Group of the country east of Stoke-on-Trent, Staffordshire

Description of 1:25 000 resource sheet SJ 94

D. P. PIPER

## SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information and 6 boreholes drilled for the Industrial Minerals Assessment Unit, form the basis of the assessment of the conglomerate resources of the Sherwood Sandstone Group of the country east of Stoke-on-Trent, Staffordshire.

All deposits of the Sherwood Sandstone Group in the district which might be potentially workable for aggregate have been investigated and estimates of their volume have been inferred.

The 1:25 000 map is divided into five resource blocks containing between 0.3 and 5.6 km<sup>2</sup> of Sherwood Sandstone Group outcrop. For each block the geology of the deposits is described while data from boreholes and natural and quarry exposures are discussed. The geology, the position of the boreholes and the outlines of the resource blocks are shown on the accompanying map.

## INTRODUCTION

In recent years it has become apparent that more detailed information about the quality and quantity of bulk mineral deposits is required. Such information will add significantly to the factual background against which planning policies can be decided (Archer, 1969; Thurrell, 1971, 1981; Harris and others, 1974). The main objective of this survey is the provision of such data for the conglomerate resources of the Sherwood Sandstone Group, formerly known as the Bunter Pebble Beds, of the West Midlands.

This survey is concerned with the estimation of resources, which include deposits that may not be currently exploitable but have a foreseeable use, rather than reserves, which can only be assessed in the light of current economic conditions. Information is provided at the 'indicated level', "for which tonnage and grade are computed partly from specific measurements, samples or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout" (Bureau of Mines and Geological Surveys, 1948, p. 15). It follows that the whereabouts of reserves must still be established and their size and quality proved by the customary detailed exploration and evaluation undertaken by the extractive industry. The information provided by this survey should assist, however, in the selection of the best targets for further evaluation.

The conglomerate-rich members within the Sherwood Sandstone Group are prized as a source of aggregate for a wide variety of uses in the construction industry. Present-day working is concentrated in large workings, up to 50 m deep, in which the aggregate is won either by blasting or ripping methods. Working is confined to those parts of the deposit lying above the water table and average yields are in the order of  $120 \times 10^3$  to  $200 \times 10^3 \text{ m}^3 \text{ ha}^{-1}$  (Staffordshire County Council, 1966).

The assessment methods adopted for this survey were developed during a short feasibility study, which included an experimental drilling, logging and sampling exercise. They provide the most cost-effective method for a resource assessment on a regional scale (Piper and Rogers, 1980). The physical criteria and procedures are outlined in appendices at the back of this report.

This survey embodies data obtained from boreholes, quarry faces and natural exposures together with evidence from a recent geological resurvey at the 1:10 000 scale. Specially commissioned boreholes were drilled to investigate the resources to a depth of 60 m, although several of them were stopped or abandoned before this depth was reached.

The volume and other characteristics of the mineral (for definition of mineral see Appendix C) are assessed within resource blocks. It must be emphasised that the

*Note* National Grid references are given in square brackets. All fall within 100-km square SJ.

### *Bibliographic reference*

PIPER, D. P. 1982. The conglomerate resources of the Sherwood Sandstone Group of the country east of Stoke-on-Trent, Staffordshire: Description of 1:25 000 resource sheet SJ 94. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 91.

### *Author*

D. P. Piper, BA  
Institute of Geological Sciences  
Keyworth, Nottingham NG12 5GG

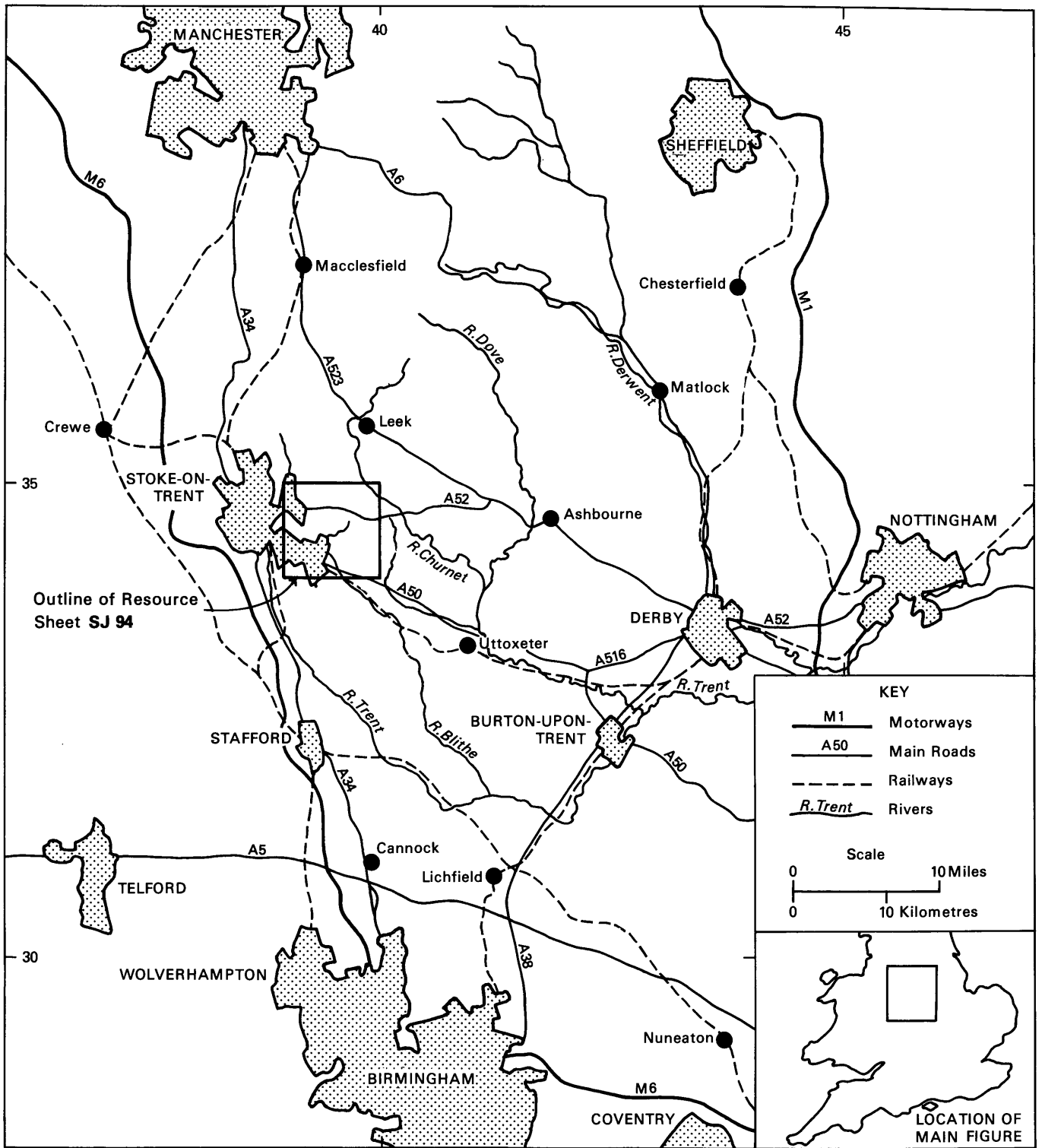


Figure 1 Sketch map showing the location of the resource sheet, SJ94

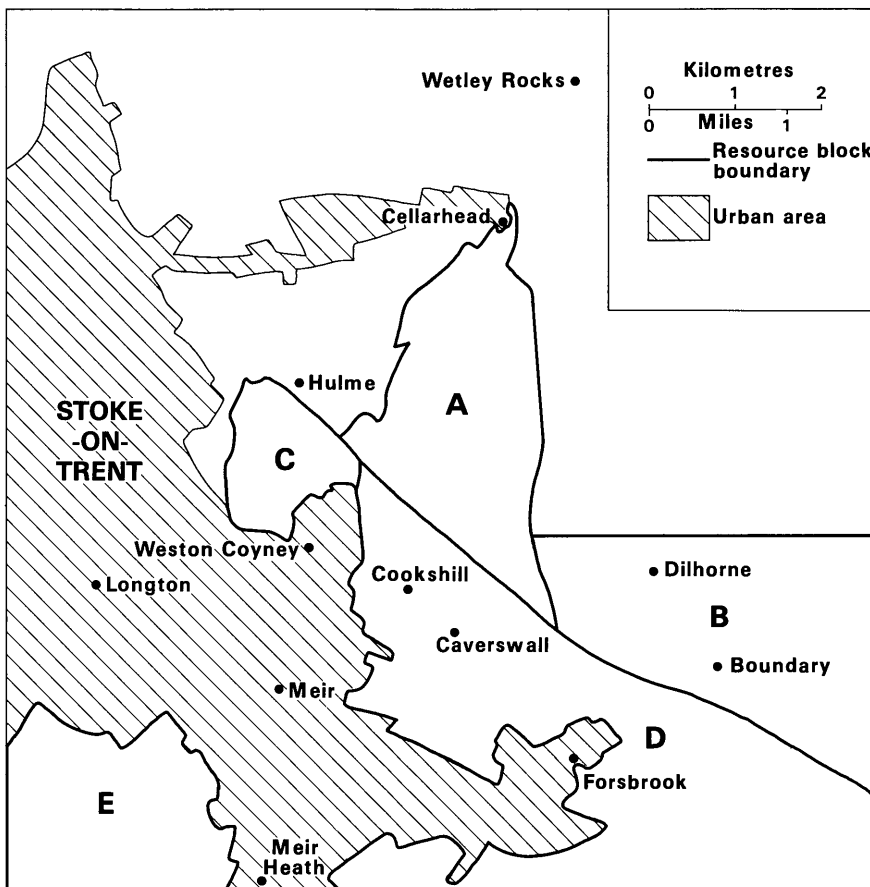


Figure 2 Sketch map of the resource sheet area showing settlements referred to in the text and resource block boundaries

results are presented for the block as a whole and valid conclusions cannot be drawn about the mineral in parts of the block except in the immediate vicinity of the sample points.

No account is taken in the assessment of such factors as roads, villages and high agricultural or landscape values which might prevent the conglomerate resource being exploited, although towns are excluded at the planning stage of the survey. The estimated total volume of mineral therefore bears no simple relationship to the amount of conglomerate that could be extracted in practice.

## DESCRIPTION OF THE DISTRICT

### GENERAL

The resource sheet represents an area of 100 km<sup>2</sup> to the east of the City of Stoke-on-Trent (Figure 1). During this century urban development has spread from the old industrial centres along the main roads which cross the district. Extensive building on the outcrop of the Sherwood Sandstone Group to the north and south of Meir (Figure 2) has served to eliminate a considerable area of conglomerate-bearing ground from this assessment.

Dairy farming and the pasturing of sheep and beef cattle form the principal agricultural activities in the district. Locally, the light sandy soils developed on the Sherwood Sandstone Group are suitable for the growing of arable crops and potatoes.

### TOPOGRAPHY

The landscape of the district is one of considerable diversity, closely related to the character of the underlying rocks.

In the north, resistant sandstones of Namurian age form the high, barren ground of Wetley Moor, which rises to 897 ft (273 m) above Ordnance Datum at [934 484]. A strong ridge of these rocks extends southwards from Wetley Rocks to Stansmore Hall [962 439], its crest rising to 922 ft (281 m) above Ordnance Datum at [961 464], the highest point in the district. To the east of this ridge the lower, gently sloping ground is underlain by folded and faulted rocks of Westphalian (Coal Measures) age. These rocks also underlie the western part of the district, where they are mantled by impermeable till, giving rise to an irregular ill-drained terrain lying between 420 ft and 650 ft (128–198 m) above Ordnance Datum.

The Sherwood Sandstone Group forms prominent escarpments where it overlies less resistant Carboniferous rocks, particularly south-eastwards from Dilhorne and between Meir Heath and Cellarhead. The sands and conglomerates of these features have been eroded to form a rounded undulating terrain, between 700 ft and 860 ft (213–262 m) above Ordnance Datum, which has been dissected by steep, dry valleys. Scarp slopes have also developed where these rocks are faulted against the younger, less resistant siltstones and mudstones, which form the lower ground around Caverswall and Forsbrook.

**Table 1** Lithostratigraphic nomenclature for the Triassic rocks of this district (SJ94) and the adjacent Cheadle district (SK04).

Cheadle District (after Rogers and others, 1980)		This District	
Group & Formation	Member	Group & Formation	Member
MERCIA MUDSTONE GROUP		MERCIA MUDSTONE GROUP	
Undivided		Undivided	
Denstone Formation		Denstone Formation	
SHERWOOD SANDSTONE GROUP		SHERWOOD SANDSTONE GROUP	
Hollington Formation			
		Hawksmoor Formation	
	Lodgedale Member		Hulme & Freehay Members
Hawksmoor Formation	Freehay Member		
Huntley Formation		Huntley Formation	

The district lies wholly within the catchment of the River Trent. The western part is drained by the Trent itself, while streams in the southern and central areas supply the rivers Blithe and Tean. In the north-east the River Churnet and its tributaries have cut deeply incised valleys through the Namurian and Westphalian rocks.

### GEOLOGY

The solid rocks exposed within the district belong to the Carboniferous and Triassic systems covered, in part, by thin deposits of Pleistocene and Recent age. The conglomerates being assessed occur within the lower part of the Triassic sequence and for this reason the other rocks are only discussed briefly.

#### Carboniferous rocks

The oldest rocks which crop out in the district are the mudstones and coarse-grained sandstones (grits) of Namurian age. They occur in the north and east and, in a general way, are overlain by progressively younger rocks to the south and south-east.

Coal-bearing rocks of Westphalian age occur in three synclines, in the east around Dilhorne, in the west around Longton and in the Shaffalong Syncline north of Cellarhead. In the first two areas the coal seams and interbedded ironstones and clays have been worked extensively both underground and in opencast operations. In the Shaffalong Syncline only the oldest seams are preserved and these have been exploited on a small scale where they crop out.

South of Longton the Coal Measures are overlain by the mudstones and sandstones of the Etruria, Newcastle and Keele formations; these are the youngest Carboniferous rocks in the district.

Towards the end of Carboniferous times the district was affected by severe earth movements followed by a period of intense subaerial erosion. The rocks were folded, faulted and uplifted and subsequently formed into a dissected landscape of considerable relief, upon which the Triassic rocks were laid down.

#### Triassic rocks

The strata which unconformably overlie the Carboniferous rocks were, until recently, assigned to the Bunter and Keuper series, terms widely used in Britain for over a century to subdivide the Triassic system. This nomenclature, which was based on incorrect chronostratigraphic correlations with the type sequence in Germany, is replaced in this report by a terminology suggested by a working party of the Geological Society of London (Warrington and others, 1980) and used in the report which describes the conglomerate resources of the Sherwood Sandstone Group around Cheadle (Rogers and others, 1982). The Triassic rocks are classified lithologically; the lower part of the sequence, in which sandstones predominate, forms the Sherwood Sandstone Group, while the upper part, in which the beds are predominantly argillaceous, is called the Mercia Mudstone Group. Both groups are subdivided where recent field mapping at the 1:10 000 scale has shown this to be possible (Table 1).

#### Sherwood Sandstone Group

The Sherwood Sandstone Group comprises at least 330 m of sandstones, pebbly sandstones and conglomerates with sporadic siltstone and mudstone beds. Within this district, the group is divisible into two lithostratigraphic formations, the basal Huntley Formation and the overlying Hawksmoor Formation.

*The Huntley Formation* is the name given to local developments of a basal conglomerate or breccia, which immediately overlies the irregular surface of Carboniferous rocks. The formation is characterised by an abundance of locally derived angular clasts and crops out at the base of the Triassic escarpment to the south-east of Boundary. The maximum recorded thickness for the formation, 24.4 m, was proved in borehole NE2 at Sheepwash pumping station.

*The Hawksmoor Formation* consists of pale red, red-brown or yellow, fine- to coarse-grained, cross-bedded sandstones and conglomerates with sporadic, thin micaceous siltstone and mudstone beds. The rocks are typically poorly cemented and friable at outcrop, though beds with a siliceous or calcareous cement do occur. Pebbly sandstones and conglomerates occur randomly throughout the formation but are more common in the lower part.

During the survey, individual conglomerate beds could be mapped only over very restricted areas, while correlation of their outcrops with beds recorded in boreholes proved possible only rarely. It proved practicable, however, to map out parts of the sequence in which gravels predominate and to assign them member status within the formation. Two such members were identified:



(1) *The Freehay Member* was defined first in the area south-east of Cheadle (Rogers and others, 1980). It persists into the eastern part of this district, where it caps the Triassic escarpment at Draycott Common Wood and Huntley Wood [99 41]. It consists of up to 35 m of conglomerate interbedded with impersistent thin beds and lenses of sandstone.

(2) Farther west, possible correlatives are included in the *Hulme Member*. In the Caverswall Common and Cresswell's Piece areas mapping indicates that sandstones are more common in this unit than in the Freehay Member and split the conglomerate into a series of distinct beds. Such an alternating sequence is well exposed in the disused quarries south of Hulme. A borehole for coal SW 17 [9480 4332] at Cookshill, penetrated 63.7 m of strata attributable to this member, in which sands and gravels were present in approximately equal proportions. Borehole SW 14 (9361 4349) in Weston Coyney, proved 60.5 m of Hulme Member but here the sequence is divided unequally into two conglomerate units separated by 10.7 m of sandstone. IMAU borehole NW 37, south-west of Hulme, penetrated a similar sequence.

The Freehay and Hulme members are thought to represent gravel spreads and bars laid down in the channels of a high-energy braided river system. In the east of the district, the principal channels, in which gravel was transported, remained active for long periods giving rise to the largely uninterrupted conglomerates of the Freehay Member. Farther west such gravelly channels were abandoned periodically and sands and muds accumulated in the more sluggish waterflow. In this area, the alternating sequence of conglomerates and sandstones characteristic of the Hulme Member was deposited.

Earlier workers (Hull, 1869; Barrow, 1903) regarded the conglomerates as the topmost part of the 'Bunter' and placed the overlying beds of sandstone in the 'Keuper'. In the Cheadle district these higher sandstones are locally quite distinct, being well cemented and interbedded with mudstones. In this district, however, the lithological differences between these sandstones and the underlying softer beds are lost, so that Gibson (1905) experienced considerable difficulty distinguishing 'Bunter' from 'Keuper' sands. In more recent surveys the distinctive sandstones of the Cheadle district are assigned to the Hollington Formation of the Sherwood Sandstone Group (Rogers and others, 1982), while in this district this formation is not recognised, all the sands being included in the Hawksmoor Formation.

#### *Mercia Mudstone Group*

The *Denstone Formation* is the basal formation of the group and consists of between 25 and 50 m of thinly bedded, red-brown siltstones interlayered with fine-grained sandstones and mudstones. It is characterised by the presence of ripple-marked surfaces, mica-covered bedding planes and scattered pseudomorphs after halite. The formation is lithologically similar to many units referred to the 'Waterstones' of the Midlands and Cheshire Basin (Hull, 1869; Gibson, 1925).

The overlying strata consist mainly of red mudstones with sporadic grey siltstones and fine-grained sandstones. These rocks were formerly known as the 'Keuper Marl' and are now assigned to the undivided part of the Mercia Mudstone Group.

#### *Geological structure*

The outcrop of Triassic rocks is divided into blocks by major normal faults, which trend to the north-west or north, some having throws of 100 m or more. They follow older fractures initiated by the earth movements at the end of the Carboniferous, some of which remained active during Permo-Triassic times, influencing the sedimentation of the Sherwood Sandstone Group. The sequence of strata within a faulted block may differ in detail from the sequences in adjacent blocks as a result of contemporaneous movement along these faults.

Minor faulting is common and can be seen in the faces of the gravel pits in the area. Such faults can rarely be traced away from the pits so that the accompanying map (in pocket) indicates only the more major dislocations.

Dips recorded in the Triassic rocks do not generally exceed 10 degrees and form a shallow syncline of northerly trend, plunging gently and broadening to the south. Rocks in the area around Forsbrook dip to the south-west, while farther west, around Meir they are inclined to the east or south-east. Differential movements between the faulted blocks of the district modify this picture considerably, giving rise to discordant dip directions and locally to more steeply inclined strata.

#### *Superficial deposits*

Deposits of Pleistocene and Recent age have been mapped during the recent survey, but they are not shown on the resource map. Where they rest on outcrops of the Sherwood Sandstone Group they are rarely more than 3 m thick.

Much of the lower ground, particularly in the west and south of the district, is covered by a thin sheet of stony till (boulder clay). It consists of stiff clay, sandy in places, with pebbles and clasts derived from local Carboniferous and Triassic rocks, together with erratics from north-west England and southern Scotland. (Gibson, 1925, p. 70). Patches of clayey soil and the scatter of erratic boulders over much of the higher ground suggest that this till was formerly more extensive.

Late-glacial moraines and small spreads of Glacial Sand and Gravel, which may be glacial outwash deposits, occur in some valleys.

Downwashed or soliflucted material, mapped as Head, partially fills many small valleys and forms a thin mantle on valley sides. It is particularly well developed in areas underlain by rocks of the Sherwood Sandstone Group, where pebbles are often spread well beyond the outcrops of conglomerate.

In the latter part of the Pleistocene, glacial meltwaters generally followed pre-existing valleys so that the alluvial valley-fills and terraces are mainly composite, including some Pleistocene material beneath more recent silts, sands and gravels.

#### *THE MAP*

The conglomerate resource map is folded into the pocket at the end of this report. The base map is the Ordnance Survey 1:25 000 Second Series. For cartographical reasons only geological data likely to have a bearing on the evaluation of conglomerate resources are shown on the map. These include faults and other structural information, together with geological bound-

aries for the Sherwood Sandstone Group, the Mercia Mudstone Group and their subdivisions. The limits of the superficial deposits and the geological boundaries within the Carboniferous rocks are not shown. Horizontal sections and a generalised vertical section at the margins of the map explain the stratigraphical relationships of the mapped deposits.

*Mineral resource information:* The Sherwood Sandstone Group outcrop is divided into resource blocks, whose boundaries are drawn to enclose geologically similar areas and to facilitate the assessment of the mineral-bearing ground. Within each block shades of brown indicate the categories of deposit into which the Sherwood Sandstone Group outcrop is subdivided (see Appendix C). Those parts of the outcrop within the limits of urban areas have not been assessed and are indicated by a brown stipple.

Rocks other than those of the Sherwood Sandstone Group, including sand and gravel which may occur within the drift deposits of the district, have not been assessed and are not identified on the resource map.

The boundaries between categories are drawn, as far as possible, along geological boundaries and thus the categories correspond to a large degree with the lithological units recognised during the recent geological resurvey. Where there is a transition from one category to another, which cannot be related to the geological lines and which could not be delineated accurately during the survey, inferred boundaries, shown by a distinctive zig-zag symbol, have been used. The symbol is intended to signify an approximate location within a likely zone of occurrence, rather than to represent the breadth of the zone, its size being limited only by cartographical considerations. For the purpose of measuring areas the centre line of the symbol is used.

*Borehole site data:* At the site of each borehole the lithologies penetrated are shown in a tablet. In IMAU boreholes the presence of mineral is indicated by grading boxes on the right-hand side of the log. Each box shows the mean grading of samples collected from the depth interval against which it is drawn.

## RESULTS

The data obtained from the laboratory investigations are reported in the following sections.

*Grading data:* A total of 16 bulk samples of conglomerate from natural and quarry sections were graded and the results are summarised in Figure 3. It can be seen that the particle-size distribution of the conglomerates is clearly bimodal with a gravel grade mode at +16 mm and a sand grade mode at +1/4 mm. The gravel grades (clasts greater than 4 mm) account for 67 per cent by weight of the mean grading, while the sand-sized particles are unevenly distributed with 22 per cent by weight in the +1/16–1/2 mm interval and only 6 per cent by weight in the +1/2–4 mm grades.

These results are compared in Figure 3a with those for conglomerates in the Cheadle district (Rogers and others, 1982). The wider envelope shown for those suggests that they are more variable in character, although the much larger number of samples analysed during that survey may account, at least in part, for this difference. Samples collected during this survey contained fewer cobbles (+64 mm) and less material in the +32 mm grade and corroborated field observations

which indicated that these coarsest grades were less common in this district than farther east.

Grading information from borehole samples is not quoted in the same detail as that from natural and quarry section samples. The action of the drilling machine used in this survey breaks up the coarser particles of gravel so that individual grade proportions of the samples recovered from boreholes do not accurately reflect the natural grading of the deposit. It has been shown (Piper and Rogers, 1980) that reliable estimates of the gravel content of the deposit can be made by arbitrarily lowering the gravel/sand boundary from 4 mm to 1/2 mm. For this reason, grading data for the drilled bulk samples are not shown by individual grades but for the three fractions: fines (–1/16 mm), sand (+1/16–1/2 mm) and gravel (+1/2 mm).

Samples from a borehole are grouped to reflect changes in lithology with depth. In this survey, up to five subdivisions have been made to describe the mineral in a borehole. These lettered intervals are shown on the borehole logs in Appendix F. Mean gradings for each group of samples and for the total thickness of mineral in each borehole are given in that Appendix and shown graphically in the borehole tablets on the resource map.

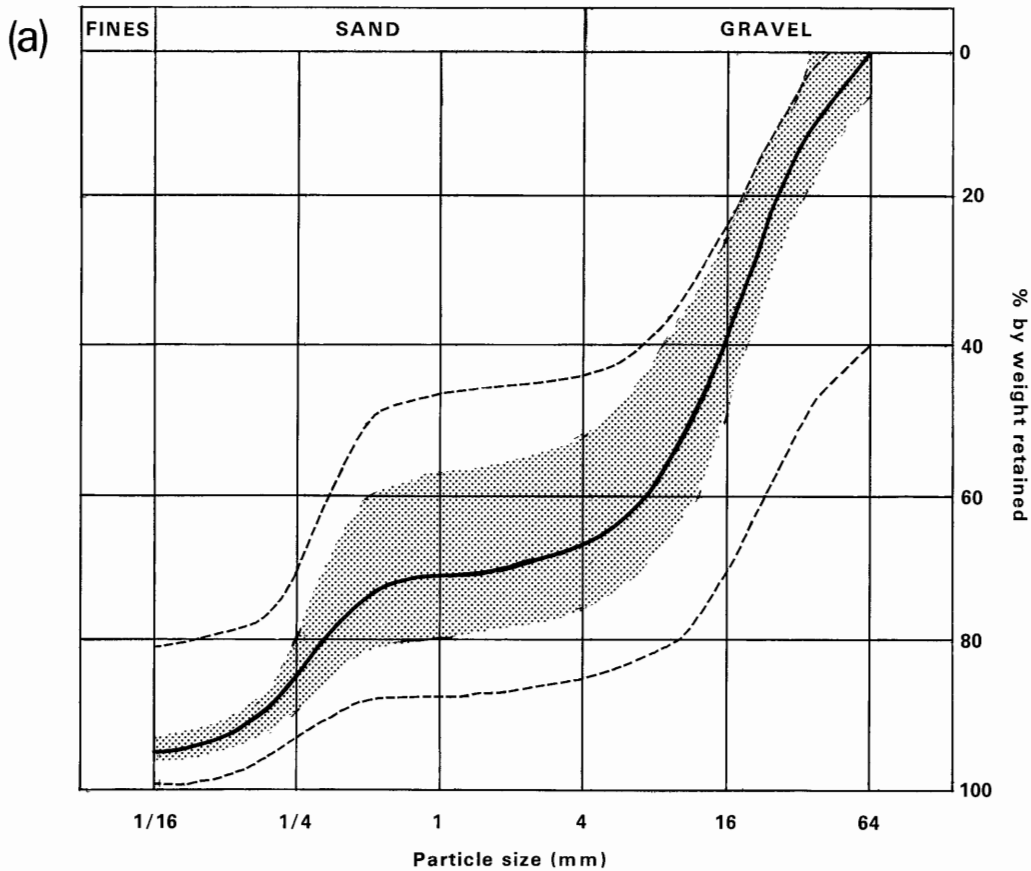
The mean gradings of mineral samples from IMAU boreholes in resource block A and within the sheet as a whole are given in Table 5.

*Composition of the conglomerates:* Pebble counts were performed on 14 conglomerate samples from natural and quarry sections. All gravel grades were analysed but the +32 mm and +64 mm grades contained insufficient material to be statistically representative. These grades have not been included in the calculations of the mean compositions. Eighteen samples of mineral from IMAU boreholes were also analysed for comparison. Only the fine gravel grades (+4–16 mm) of these could be counted, coarser clasts having been broken down during the drilling process. The weighted mean compositions, expressed in weight per cent, are given in Table 2, which shows that, with care in drilling and

**Table 2** Composition of the conglomerates (weight per cent)

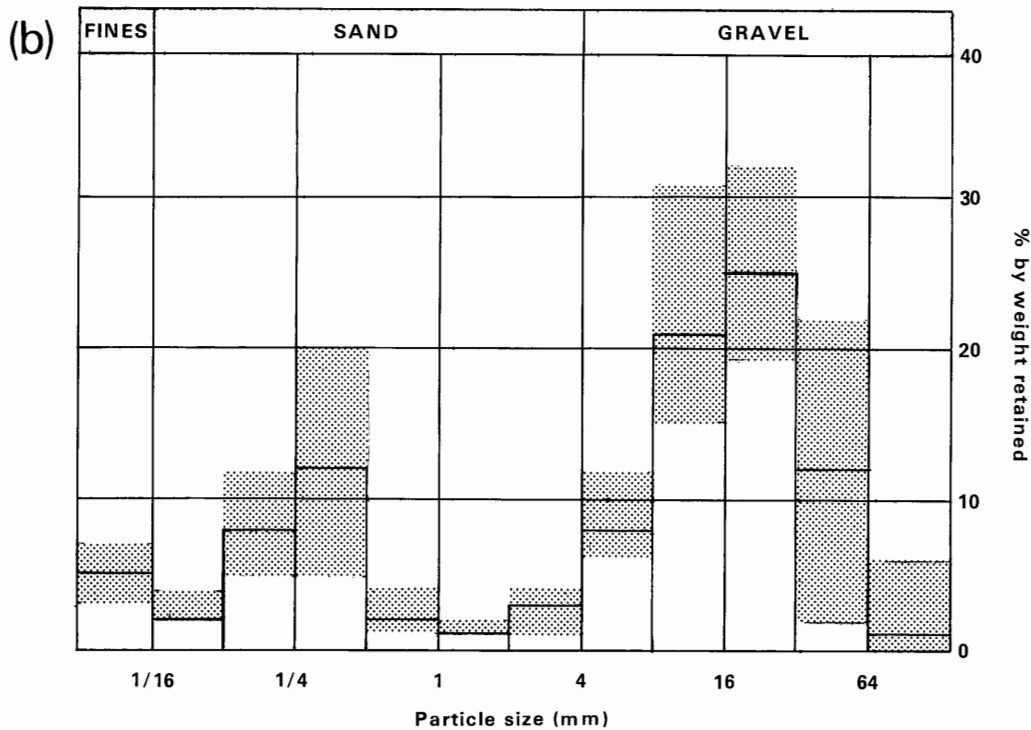
Lithology	Natural samples weight %	Drilled samples weight %
Quartzite	67	67
Quartz	23	23
Igneous	4	3
Metamorphic	trace	trace
Sandstone	2.5	3
Siltstone/Mudstone	1	1
Chert	2.5	2
Others	trace	1

collection, samples representative of the deposit can be obtained despite the destructive nature of the drilling method. Comparison with the mean compositions expressed in number per cent (Table 3) highlights the effect of the drilling process; the comminution of the quartzite pebbles which predominate in the coarse gravel grades, together with the destruction of clasts of more friable lithologies generally present only in the fine gravel grades, results in the over-representation of quartzites relative to other pebble types in the mean composition of the drilled samples.



**Figure 3** Grading characteristics of 16 samples of conglomerate from natural and quarry sections within the district.

- (a) – above – The continuous line represents the mean grading, the shaded area denotes the envelope within which the grading curves for individual samples fall. The broken lines represent the envelope limits for 59 conglomerate samples from the Cheadle district.
- (b) – below – The mean grading in the form of a histogram. The shaded areas represent the range of values obtained for each size interval.



**Table 3** Composition of the conglomerates (number per cent)

Lithology	Natural samples		Drilled samples	
	number	%	number	%
Quartzite	51		62	
Quartz	24		24	
Igneous	11		5	
Metamorphic	trace		trace	
Sandstone	5		3	
Siltstone/Mudstone	4		2	
Chert	5		3	
Others	trace		1	

It can be seen in Table 2 that, on average, 90 per cent by weight of the gravel grades is made up of quartzite and quartz pebbles. These predominate throughout the size range and are commonly the sole constituents of the coarse fractions. They are indurated, well rounded, equant, elongate or oblate and show little sign of chemical alteration or decomposition. Pressure solution pits, often surrounded by a rim of cemented sand grains, are common on the surfaces of pebbles, while many clasts split along well-developed fractures when removed from the supporting matrix. This latter phenomenon was particularly noticeable in the disused quarries at Normacot [924 423].

The remaining 10 per cent by weight is largely made up of igneous, sandstone and chert pebbles in approximately equal proportions. Many of the igneous pebbles are partially or thoroughly decomposed and together with the friable sandstone and chert pebbles, are likely to disintegrate during extractive processes.

Small, soft mudstone clasts likely to be deleterious in an aggregate mix are found in minor amounts throughout the district.

*Mechanical properties:* No mechanical tests have been carried out on samples collected during this survey but the data in Table 4 refer to the conglomerates of the Freehay Member at Huntley Wood Quarry [995 415] (written communication from Mr J. C. Ramsay, BCA Limited).

**Table 4** Mechanical properties of the conglomerates of Huntley Wood Quarry. (Data by permission BCA Limited)

	Gravel	Sand
Specific Gravity:		
Oven dry	2.58	2.60
Surface saturated	2.61	2.62
Apparent	2.66	2.65
Water Absorption	1.2%	0.8%
Aggregate Impact Value	17%	—
10% Fines	350 kN	—
Aggregate Abrasion Value	1.3%	—
Polished Stone Value	49	—

*Statistical results:* No statistical assessment of the volume of mineral in the district is attempted because there are too few sample points in each resource block for reliable calculations to be made. Inferred assessments are made, however, based on the evidence from the geological mapping of the district together with records from IMAU and commercial boreholes. A short description of the method used is given in Appendix D. The results for each resource block are given in Table 5.

#### NOTES ON RESOURCE BLOCKS

For assessment purposes the outcrop of the Sherwood Sandstone Group is subdivided into five structurally distinct resource blocks, outlined in Figure 2. Blocks A, B, C and E enclose outcrops of the lower part of the Sherwood Sandstone Group, including the potentially workable conglomerates of the Freehay and Hulme Members. Block D encloses outcrops of the sandy upper part of the Sherwood Sandstone Group and the mudstones and siltstones of the Mercia Mudstone Group. Where possible the resource block boundaries are drawn along the major faults which separate these blocks from each other and from older, Carboniferous, rocks which are not assessed. Blocks A and C are limited to the north and west by the base of the Sherwood Sandstone Group while blocks C, D and E are partially enclosed by the limits of the urban area.

#### Block A

This block encloses 5.6 km<sup>2</sup> of Sherwood Sandstone Group outcrop. Sandstones and pebbly sandstones of the Hawksmoor Formation crop out over 2.4 km<sup>2</sup> forming a prominent ridge which extends south-south-west from Cellarhead. These rocks are regarded as generally barren of mineral: they carry very little gravel indeed. Water boreholes NW9 and NE2 confirm the predominantly sandy nature of these rocks, although subordinate pebbly beds were proved in the latter. Field observations in the vicinity of Ridgefield Farm [953 469] suggested a local concentration of conglomerate beds but IMAU borehole NE38 nearby, proved only 'clayey' sandstone with pebbles to a depth of 30 m.

At Captain's Barn [949 455] the ridge is capped by the lowest conglomerates of the Hulme Member. IMAU borehole NW36 proved 10 m of 'clayey' sandy conglomerate overlying sandy beds of the Hawksmoor Formation. From the site of this borehole, the ground falls away eastwards into a tributary valley of the River Blithe; it is thought that the slope of the ground, about 6 degrees, approximates to the dip of the underlying rocks. On the eastern side of this small valley the Hulme Member crops out from Windycote [959 467] in the north, where it appears to be faulted against Carboniferous rocks, to the major fault which forms the south-western boundary of the block. In the vicinity of Windycote and in the woods at Cresswell's Piece [956 458] the rocks dip gently to the south-west. The lower part of the member only is preserved in these areas so that the sequence of conglomerates is generally less than 25 m thick. Farther south the Hulme Member is thicker, 37 m and 44 m being proved in IMAU

**Table 5** Summary of results

Block	Area		Inferred volume of mineral  × 10 <sup>6</sup> m <sup>3</sup>	Mean grading (percentages)		
	S.S.G.* km <sup>2</sup>	Mineral km <sup>2</sup>		Fines - 1/16 mm	Sand + 1/16-1/2 mm	Gravel + 1/2 mm
A	5.6	3.2	82	15	39	46
B	3.9	0.5	6	} not calculated		
C	1.9	1.3	20			
D	5.6	0.2	3			
E	0.3	0.2	5			
A to E	17.3	5.4	116		15	40

\* S.S.G. = Sherwood Sandstone Group

boreholes SE 35 and SE 36 respectively, without either reaching the bottom of the deposit. Consequently in an area of 1.5 km<sup>2</sup> around Hardiwick [957 444] the conglomerates are included in the category 'Exposed mineral generally greater than 25 m thick'. (See Appendix C.) An inferred boundary has been drawn between this area and the surrounding areas where the Hulme Member is thinner.

Approximately half the area of mineral is overlain by superficial deposits. Alluvial deposits and patches of Head may be more than 2 m thick but the more widespread mantle of till is commonly less thick.

The volume of mineral in the block is estimated to be 82 million m<sup>3</sup> which is the sum of 64 million m<sup>3</sup> for the 'Exposed mineral generally greater than 25 m thick' and 18 million m<sup>3</sup> for the 'Exposed mineral generally less than 25 m thick'. (See Appendix C.) A relatively small volume of mineral has already been extracted from the disused quarries in the block but this is thought to be an insignificant part of the total volume quoted.

The mean grading of mineral in the block (see Table 5) is calculated from data provided by IMAU boreholes NW 36, SE 35 and SE 36.

#### Block B

3.9 km<sup>2</sup> of Sherwood Sandstone Group rocks crop out in Block B, forming the outlier at Blakeleybank [964 434], the prominent escarpment south-east of Dilhorne and the hill north of The Green [998 429]. Within this area 3.4 km<sup>2</sup> is regarded as generally barren and only 0.5 km<sup>2</sup> contains potentially workable conglomerate resources.

The Huntley Formation crops out at the base of the escarpment and is proved by coal boreholes SE 11 and SE 19, in which these basal conglomerates and breccias are overlain by considerable thicknesses of Hawksmoor Formation sandstones with only a few pebbly beds. These sandstones are themselves overlain by the potentially workable conglomerates of the Freehay Member, which crop out over 0.5 km<sup>2</sup> in the south-east of the block. The outcrop is faulted so that up to 35 m of conglomerate is present to the east of the faults, while only a relatively thin sequence is preserved to the west. A considerable proportion, perhaps as much as half, of this potentially workable mineral has already been extracted from the workings at Huntley Wood [995 415], the only active quarry in the district. The mechanical properties of aggregate won from this quarry are given in Table 4, by kind permission of the owners, and no further tests have been carried out during this survey.

It should perhaps be re-emphasised that the estimated volume of mineral remaining, which is quoted in Table 5, bears no simple relationship to the amount which could be extracted in practice as no allowance has been made in the calculations for any restraints on the use of land for mineral working.

The small outcrop of the Freehay Member mapped as capping the hill north of The Green [998 429] was not confirmed by the drilling of borehole SE 19 and is not regarded as mineral-bearing.

#### Block C

The outcrop of the Hulme Member makes up the 1.3 km<sup>2</sup> of mineral-bearing ground in this block. The rocks are faulted but only the more important faults are shown on the resource map.

The conglomerates are well exposed in the disused quarries, which now form part of the Park Hall Country Park. The main quarrying activities were concentrated in the western part of the block so that little material remains unworked and much of that which does has been buried by recent landscaping operations.

Between grid-line (Eastings) 93 and the fault, which forms the eastern boundary of the Hulme Member outcrop, the sequence of conglomerates appears to be thicker than it is to the west and dips are generally to the east or north-east. IMAU borehole NW 37, south-west of Hulme, proved at least 36.5 m of mineral but the two principal conglomerate units are separated by approximately 8 m of sandstone interbedded with thin pebbly beds and mudstone. A similar sequence is interpreted from the quarry exposures in this part of the block. In the central quarry [931 449] the gravels exposed are assigned to the lower conglomerate unit and are overlain by a thick sandstone, which forms the upper part of the eastern face of the quarry. Commercial borehole records and recent mapping suggest that the outcrop of this sandstone extends to the north and south and that it dips below the gravels which are exposed further eastwards and which are thus thought to belong to the upper conglomerate unit.

The inferred boundaries between the categories of deposits within the block are drawn close to the approximate position of the top of the lower conglomerate unit: 0.5 km<sup>2</sup> is enclosed within the category 'Exposed mineral generally greater than 25 m thick' while a further 0.8 km<sup>2</sup> is classified as 'Exposed mineral generally less than 25 m thick'. (See Appendix C.) Approximately half of this latter area has been quarried so that the greater part (80 per cent) of the inferred volume of mineral remaining, which is quoted in Table 5, is contributed by the area enclosed within the thicker category.

The mean grading of mineral in the block is not calculated because there are too few sample points for reliable calculations to be made. The mean grading for the mineral in IMAU borehole NW37 is shown in Appendix F and indicates that gravel-size clasts make up 39 per cent by weight of the mineral recovered.

In the eastern part of the block the upper part of the Hawksmoor Formation crops out. Borehole SW16 penetrated nearly 81 m of sandstone with sporadic pebbly beds before passing into a 35 m-thick sequence of interbedded sands and conglomerates attributed to the Hulme Member. These conglomerates are too deeply buried to be considered potentially workable, so that the Hawksmoor Formation outcrop is classified as 'generally barren'.

#### *Block D*

This resource block is the largest in the district, with an area of 13.3 km<sup>2</sup> entirely underlain by a broad, shallow syncline of Triassic rocks. The Sherwood Sandstone Group crops out over an area of 5.6 km<sup>2</sup> on the flanks of the syncline overlain, in the centre of the block, by the siltstones and mudstones of the Mercia Mudstone Group.

Within the outcrop of the Sherwood Sandstone Group only the highest beds of the Hawksmoor Formation are exposed so that while conglomerate beds are known to be present at depth, (for example, coal borehole SW17 [9480 4332] at Cookshill) they are overlain by considerable thicknesses of sandstone and are thus not regarded as potentially workable. A small area of conglomerate has been mapped, however, in the vicinity of Draycott Hollow Farm [983 406] and represents the only conglomerate resource in the block. The outcrop is fault-bounded to the north and the beds dip away south-westwards beneath younger sandstones. No boreholes were drilled during this survey but down-dip from this area, and just beyond the southern edge of the district, water borehole SJ93 NE 1 at Cresswell pumping station [9736 3948] proved only about 16 m of conglomerate, overlying a further 56 m of sandstones and subordinate conglomerate beds at depth within the Hawksmoor Formation. The inferred volume of mineral in Table 5 is calculated using this figure of 16 m as the mean thickness of mineral over the 0.2 km<sup>2</sup> of the conglomerate outcrop.

The Sherwood Sandstone Group rocks in the area around Coneygreave [995 410] extend eastwards into the Cheadle district, where they are regarded as 'Mineral, generally greater than 25 m thick, beneath overburden' (Rogers and others, 1982). This classification is based on evidence from water borehole SK04 SW 1B at Tenford, which demonstrates the presence of conglomerates close to the surface. Within this district, however, old borehole records indicate that any conglomerates are deeply buried beneath sandstone so that the area around Coneygreave is interpreted as being 'generally barren'.

#### *Block E*

Block E includes 0.3 km<sup>2</sup> of Sherwood Sandstone Group rocks, which crops out at Cocknage Wood [916 404] on the western, downthrown side of a major fault. The basal sandstones of the Hawksmoor Formation, which rest unconformably on the sandstones and mudstones of the Carboniferous Keele Formation, are themselves overlain by the conglomerates of the Hulme Member, which cap the ridge. Towards the northern end of this ridge easterly dips in the order of 20 degrees are recorded but south of the fault at South Cocknage Farm [913 404] the crest of the ridge is broader and the dip much shallower. IMAU borehole SW48 passed into Carboniferous rocks at about 175 m above Ordnance Datum, which suggests that the base of the Sherwood Sandstone Group dips eastwards at about 6 degrees from its mapped position west of the borehole site.

Pebbles from the Hulme Member and from the underlying thin conglomerate beds within the Hawksmoor Formation are spread over the hillside so that it proved difficult to map the surface extent of the conglomerate body. A traverse across the slopes on the west side of the hill suggests the presence of a considerable thickness of gravel but borehole SW48 passed through only 12.5 m of potentially workable conglomerate.

The steeper dips at the northern end of the hill suggest that a thicker sequence of pebble beds is preserved here, so that while the two parts of the outcrop are of similar size, the more northerly contributes approximately 70 per cent of the inferred volume of mineral quoted in Table 5.

Till, mapped on the broader part of the ridge crest south of the fault, reaches a thickness of 3.5 m in borehole SW48 but elsewhere is thought to be thinner than this.

## APPENDIX A

### FIELD AND LABORATORY PROCEDURES

The procedures used in this resource assessment were developed from a successful experimental drilling, sampling and logging programme begun in 1975 and presented in detail by Piper and Rogers (1980).

Conglomerate members within the Sherwood Sandstone Group are identified by preliminary lithostratigraphic mapping. A pattern of boreholes is then drilled to provide reliable data about the nature and thickness of the deposit. This information is supplemented by data from pre-existing boreholes and natural and quarry sections. The cooperation of sand and gravel operators has enabled data from commercial boreholes to be incorporated in the calculations although they are held in confidence by the Institute and cannot be disclosed.

The drilling machine employed provides a continuous series of bulk samples, though the action of the down-the-hole hammer breaks up the coarser particles of gravel so that the samples recovered are not completely representative of the *in situ* grading of the deposit. On completion, the boreholes are logged photographically using a specially developed camera module. The colour photographs provide a reliable guide to the size of *in situ* pebbles. Geophysical logs are also used. A gamma-ray log is run in each borehole to measure the relative clay content of the strata, thereby picking out any mudstone beds. Below the water table, resistivity and spontaneous potential logs are used to highlight lithological changes and to verify the log produced from bulk samples. The black and white television system used to produce a videotape log of boreholes in the Cheadle district has not been used in this survey.

A new bulk sample is commenced at every 1 m depth because it proved impossible to detect lithological changes to any greater degree of accuracy. The samples are despatched to a laboratory for grading, while random checks on the accuracy of the results are carried out in the Institute's own laboratories. The grading procedure is based on British Standard 1377 (1967).

## APPENDIX B

### CLASSIFICATION AND DESCRIPTION OF SAMPLES

The particle-size distribution of borehole samples determined by the grading laboratory do not correspond with the *in situ* grading of the deposit because the coarser grades are comminuted during drilling. Lowering the gravel/sand boundary for the drilled samples from +4 mm to +½ mm has been shown (Piper and Rogers, 1980) largely to overcome this problem. In this report the mean grading for each group of borehole samples is tabulated on the borehole record sheets for the three grades: fines ( $-1/16$  mm), sand ( $+1/16-1/2$  mm) and gravel ( $+1/2$  mm). Natural and quarry face samples (which, of course, have not been comminuted) are graded in the usual way and the results for these samples are regarded as fully representative.

The classification and description of samples is a two-stage process: the absolute percentages of fines, sand and gravel are used to locate the sample within a field of the triangular diagram in Figure 4. The name of this field is used to describe the sample in the borehole log (see Appendix F). The term 'clayey' (as printed, with single quote marks) is used to describe all material passing  $1/16$  mm. It has no mineralogical significance and includes particles falling within the size range of silt.

Samples falling within the six conglomerate and sandy conglomerate fields are further described. The sand and gravel grades are qualified as in Table 6 and the rock types present are indicated. The relative proportions of the grades and rock types are indicated by the use of the words 'and' or 'with'. For example, 'quartzite and vein-quartz' indicates, very approximately equal proportions with neither constituent accounting for less than 25 per cent of the whole; 'quartzite with vein-quartz' indicates that quartzite is dominant and vein-quartz, the principal accessory rock type, comprises 5 to 25 per cent of the whole. Where rock types account for less than 5 per cent of the whole but are readily apparent, the phrase 'with some' is used as a prefix.

The terms used in the field to describe the degree of rounding of particles, which is concerned with the sharpness of the edges and corners of a clastic fragment and not its shape (after Pettijohn, 1975), are as follows:

Angular: showing little or no evidence of wear; sharp edges and corners.

Subangular: showing definite effects of wear. Fragments still have their original form but edges and corners begin to be rounded off.

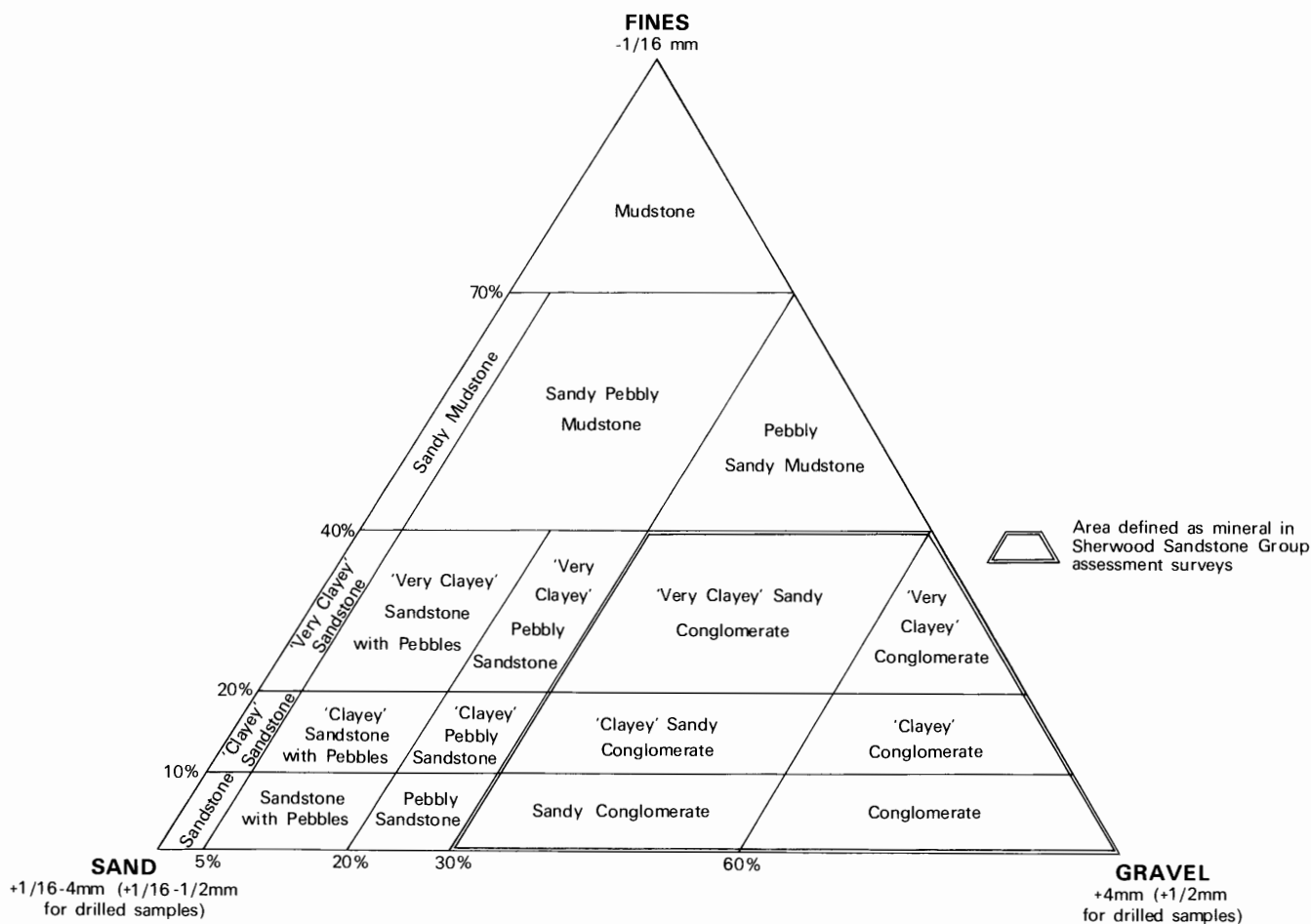
Subrounded: showing considerable wear. The edges and corners are rounded off to smooth curves. Original grain shape is still distinct.

Rounded: original faces almost completely destroyed, but some comparatively flat surfaces may still remain. All original edges and corners have been smoothed off to rather broad curves. Original shape is still distinct.

Well-rounded: no original faces, edges or corners remain. The entire surface consists of broad curves; flat areas are absent. The original shape is suggested by the present form of the grain.

**Table 6** Classification of gravel, sand and fines

Size limits	Grain size description	Qualification	Primary classification
64 mm -	Cobble		
16 mm -	Pebble	Coarse	Gravel
4 mm -		Fine	
1 mm -		Coarse	
¼ mm -	Sand	Medium	Sand
1/16 mm -		Fine	
	Fines (silt and clay)		Fines



**Figure 4** Diagram to show the descriptive categories used in the classification of samples of the Sherwood Sandstone Group



## APPENDIX C

### DEFINITION OF MINERAL AND CATEGORIES OF DEPOSIT

#### DEFINITION OF MINERAL

The statistical assessment of the aggregate resource is based on that part of the deposit which is defined as potentially workable and called mineral. The following criteria are used in this report to define mineral:

- a The deposit should average at least 5 m in thickness.
- b The ratio of overburden to conglomerate should be no more than 1:2.
- c The gravel (+4 mm) content of the deposit should be not less than 30 per cent by weight of the whole.
- d The proportion of fines ( $-\frac{1}{16}$  mm) should not exceed 40 per cent by weight.
- e The deposit must lie within about 60 m of the surface, this being taken as the likely maximum working depth under most circumstances.

It follows from the second and fifth criteria that boreholes are drilled no deeper than 20 m if no mineral deposit has been encountered.

Beds of sandstone or other deposits lying between the surface and the top of the mineral deposit are regarded as overburden. Sandstone partings within the conglomerate sequence are regarded as mineral and included in the calculations of its thickness and overall grading.

#### CATEGORIES OF DEPOSIT

The resource map is divided into five categories of deposit each distinctively coloured. The following categories are used:

- a Exposed mineral generally greater than 25 m thick
- b Exposed mineral generally less than 25 m thick
- c Sherwood Sandstone Group rocks generally barren
- d Sherwood Sandstone Group rocks not assessed
- e Rocks other than the Sherwood Sandstone Group

The mineral is identified as exposed where the overburden, commonly consisting only of soil, subsoil and thin superficial deposits, averages less than 2 m in thickness.

## APPENDIX D

### STATISTICAL PROCEDURE

The statistical procedure recommended (Piper and Rogers, 1980) for the estimation of conglomerate resources is similar to that adopted by the Industrial Minerals Assessment Unit for its surveys of sand and gravel resources. However, the resource blocks in this district are too small and the number of sample points too few for the volume of mineral to be calculated in this way. For this reason the volumes of mineral quoted in Table 5 are inferred from the available data in the manner described below.

An interpretation of the geology and structure is made from mapping evidence together with data from IMAU and commercial boreholes. 'Contours' of mineral thickness are drawn in each mineral-bearing area. The area enclosed within each 'contour' interval is measured and its mean thickness is estimated. The volume of mineral in each interval is calculated as the product of the area and the estimated thickness; individual volumes are then summed and rounded to give the inferred volume of mineral of each mineral-bearing area which is quoted in Table 5.

Where mineral is present in more than one category of deposit a separate calculation is made for each. These figures are combined in the Summary of Results but may be discussed more fully in Notes on Resource Blocks.

Where quarrying has significantly reduced the estimated total volume of mineral in the block, the volume which is quoted in the Summary of Results is the estimated volume remaining at the time of survey. The volume of mineral already extracted is calculated in much the same way as the other estimates of volume.

An overall mean thickness of mineral in each resource block is not produced by this method of estimating resources but may be calculated by dividing the total volume of mineral in the block by its area. Confidence limits at the 95 per cent probability level cannot be quoted.

**APPENDIX E**

**EXPLANATION OF THE BOREHOLE RECORDS**

**Annotated example**

**SJ 94 NW 37<sup>1</sup> 9319 4551<sup>2</sup>**

Block C

**South-west of Hulme<sup>3</sup>**

Surface level +233.0 m<sup>4</sup>  
 Rest-water level +197.5 m<sup>5</sup>  
 Down-the-hole hammer, with air-flush<sup>6</sup>  
 225 mm diameter  
 March 1980

<sup>7</sup>Overburden 0.5 m  
 Mineral 36.5 m+

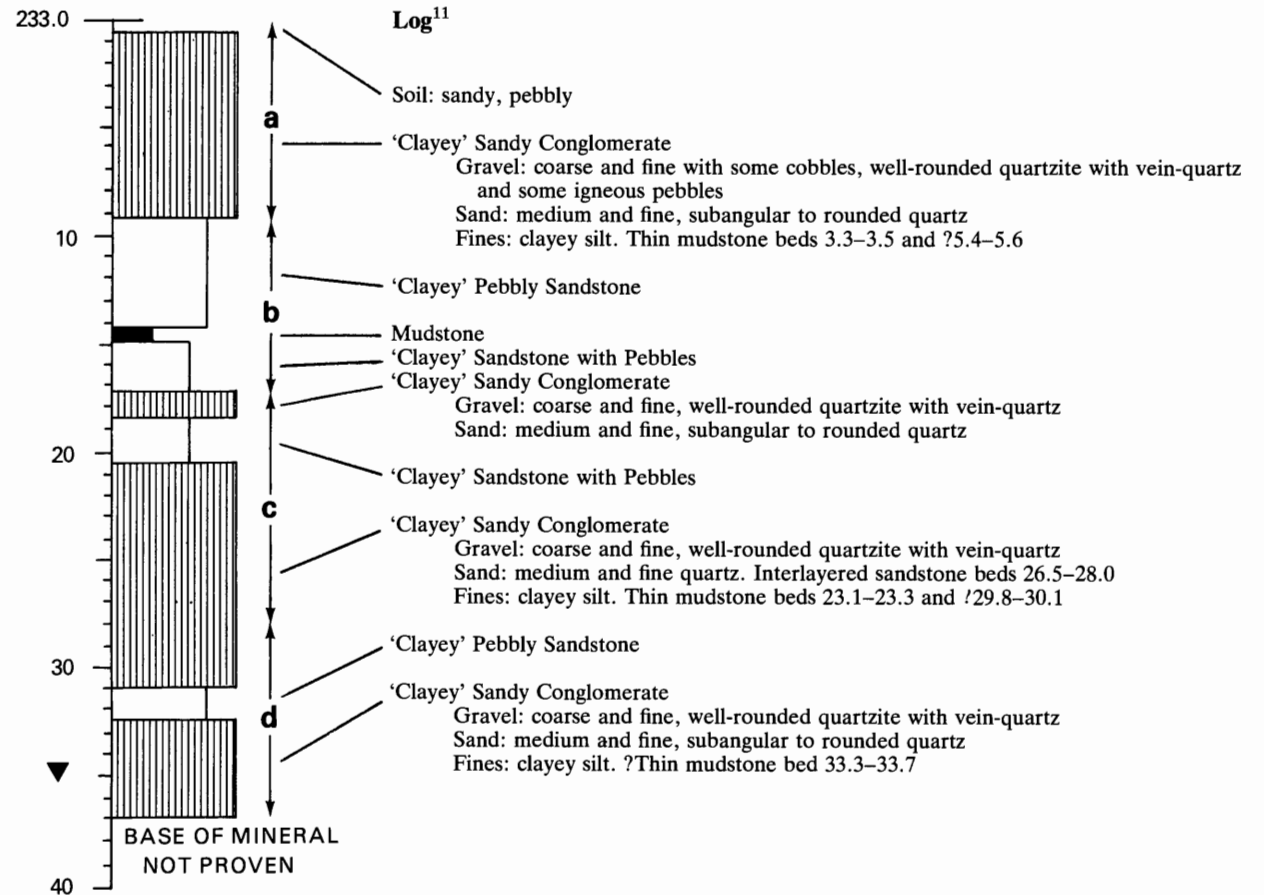
**Grading**

<sup>8</sup> Mineral sample	Depth below surface (m)	<sup>9</sup> percentages		
		Fines -1/16 mm	Sand +1/16-1/2 mm	Gravel +1/2 mm
<b>a</b>	0.5-9.2	11	31	58
<b>b</b>	9.2-17.3	17	63	20
<b>c</b>	17.3-28.0	14	43	43
<b>d</b>	28.0-37.0	16	52	32
Mean for deposit	0.5-37.0	14	47	39

<sup>10</sup>**Composition of gravel fraction\***

Depth below surface (m)	percentages by weight							
	Qtzt	Qtz	Ign	Mm	Sst	S/M	Ch	Oth
2.0-3.0	54	31	7	trace	3	2	3	trace
7.0-8.0	68	21	4	1	3	1	2	—
23.0-24.0	76	17	3	—	2	trace	2	trace
32.5-37.0	78	16	1	trace	2	1	1	trace
Mean for deposit	72	20	3	trace	2	1	2	trace

\* +4-16 mm fraction only counted



The numbered paragraphs below correspond with the annotations given on the specimen record:

### 1 Borehole Registration Number

Each Industrial Minerals Assessment Unit (IMAU) borehole is identified by a Registration Number consisting of two statements:

- 1 The number of the 1:25 000 sheet on which the borehole lies, for example SJ94.
- 2 The quarter of the 1:25 000 sheet on which the borehole lies and its number in a series for that quarter, for example NW 37.

Thus the full registration number is SJ94 NW 37, which is abbreviated to NW 37 in the text.

### 2 National Grid reference

Unless otherwise stated all National Grid references in this publication lie within the 100-km grid square SJ. Grid references are given to eight figures, accurate to within 10 m, for borehole sites. (In the text, six-figure grid references are used for more approximate locations).

### 3 Location

The position of the borehole is generally referred to the nearest named locality on the 1:25 000 base map. The resource block in which the borehole lies is also given.

### 4 Surface level

The surface level at the borehole site is given in metres above Ordnance Datum.

### 5 Rest-water level

If groundwater was present in the borehole, its level 24 hours after the cessation of drilling is given in metres above Ordnance Datum. The position of the rest-water level is indicated on the graphical log by an inverted solid triangle.

### 6 Type of drill and date of drilling

All the boreholes in this survey were drilled with a truck-mounted Dando 250 rotary-percussion rig with a down-the-hole hammer using compressed air to flush out the drilled material. The diameter of the borehole and the month and year of its completion are stated.

### 7 Overburden and mineral

Mineral is that part of a deposit which satisfies the arbitrary definition of potentially workable material given in Appendix C. Overburden is waste material which occurs between the ground surface and the top of the mineral deposit.

### 8 Sample intervals and depths

Individual samples are grouped into lettered intervals, which reflect the changing lithologies within the mineral deposit. The upper and lower limits of each interval are quoted in metres below the surface. The intervals are indicated on the graphic log of the borehole by double-ended arrows and the appropriate letters.

### 9 Grading data

The mean grading of the bulk samples within each lettered interval is expressed in weight per cent for the three grades fines ( $-1/16$  mm), sand ( $+1/16-1/2$  mm) and gravel ( $+1/2$  mm). The mean gradings are weighted by the appropriate thickness for each sample and are used to calculate the weighted mean grading for the total thickness of mineral in the borehole.

### 10 Composition

Details of the composition of selected samples are given. The weighted mean of the samples is also quoted.

### 11 Lithology

The borehole log is shown graphically in such a way that conglomerates and sandy conglomerates are emphasised by wider bars which are ruled, whereas sandier deposits are indicated by narrower bars left unornamented. The bars are drawn schematically so that, in a general way, the widths of the bars indicate the relative gravel content of the deposits. For cartographic reasons the 'clay' content is omitted although mudstones are shown by narrow solid bars.

Each bar is accompanied by a brief description of the deposit based on the scheme of descriptive categories (Figure 4) while conglomerates and sandy conglomerates are further described in terms of their grading characteristics and rock types.

All rocks shown on the borehole logs in this report belong to the Sherwood Sandstone Group.

## APPENDIX F

### RECORDS OF INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLES

Borehole registration number	Grid reference*	Page
SJ94 NW 36	9499 4566	16
NW 37	9319 4551	17
NE 38	9538 4707	18
SW 48	9168 4003	19
SE 35	9568 4486	20
SE 36	9586 4358	21

36 other records held by the Institute have been used in the assessment of resources.

\* All fall within SJ94

**SJ94NW 36 9499 4566**  
**Captain's Barn Farm**

Surface level +236.4 m  
 Water not struck  
 Down-the-hole hammer, with air-flush  
 225 mm diameter  
 March 1980

Overburden Nil  
 Mineral 10.0 m

**Block A 236.4**

**Grading**

Mineral sample	Depth below surface (m)	percentages		
		Fines - 1/16 mm	Sand + 1/16 - 1/2 mm	Gravel + 1/2 mm
<b>a</b>	0-10.0	14	42	44
Mean for deposit	0-10.0	14	42	44

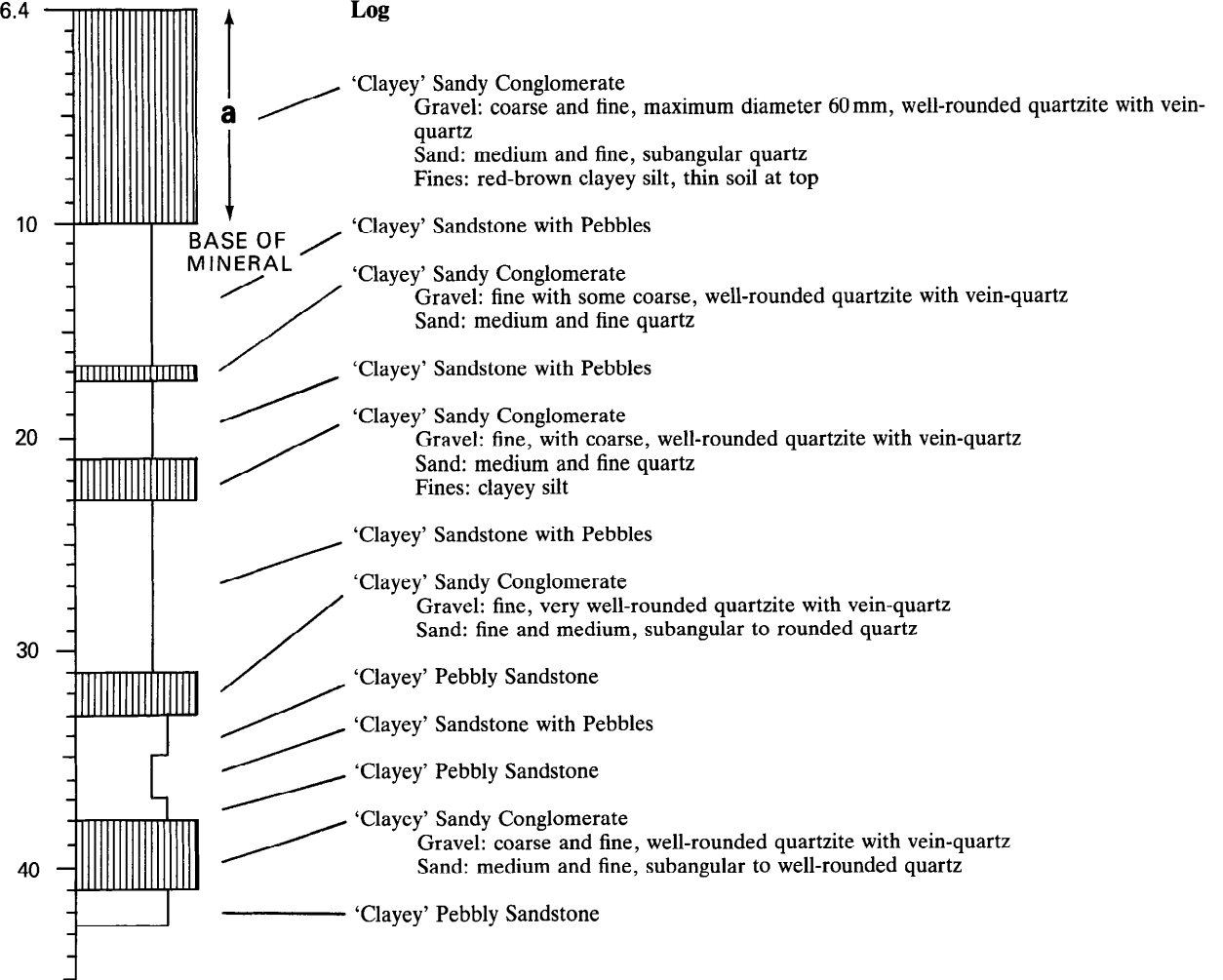
**Composition of gravel fraction\***

Depth below surface (m)	percentages by weight							
	Qtzt	Qtz	Ign	Mm	Sst	S/M	Ch	Oth
4.0-5.0	61	23	3	—	5	3	5	—
7.0-8.0	65	29	2	—	1	1	2	—
9.0-10.0	70	24	1	—	2	trace	2	1
Mean for deposit	66	25	2	—	3	1	3	trace

\* +4-16 mm fraction only counted

Qtzt = Quartzite                      Sst = Sandstone  
 Qtz = Quartz                            SM = Siltstone/Mudstone  
 Ign = Igneous                           Ch = Chert  
 Mm = Metamorphic                    Oth = Others

**Log**



**SJ94NW 37 9319 4551**  
**South-west of Hulme**

Surface level +233.0 m  
 Rest-water level +197.5 m  
 Down-the-hole hammer, with air-flush  
 225 mm diameter  
 March 1980

Overburden 0.5 m  
 Mineral 36.5 m+

**Grading**

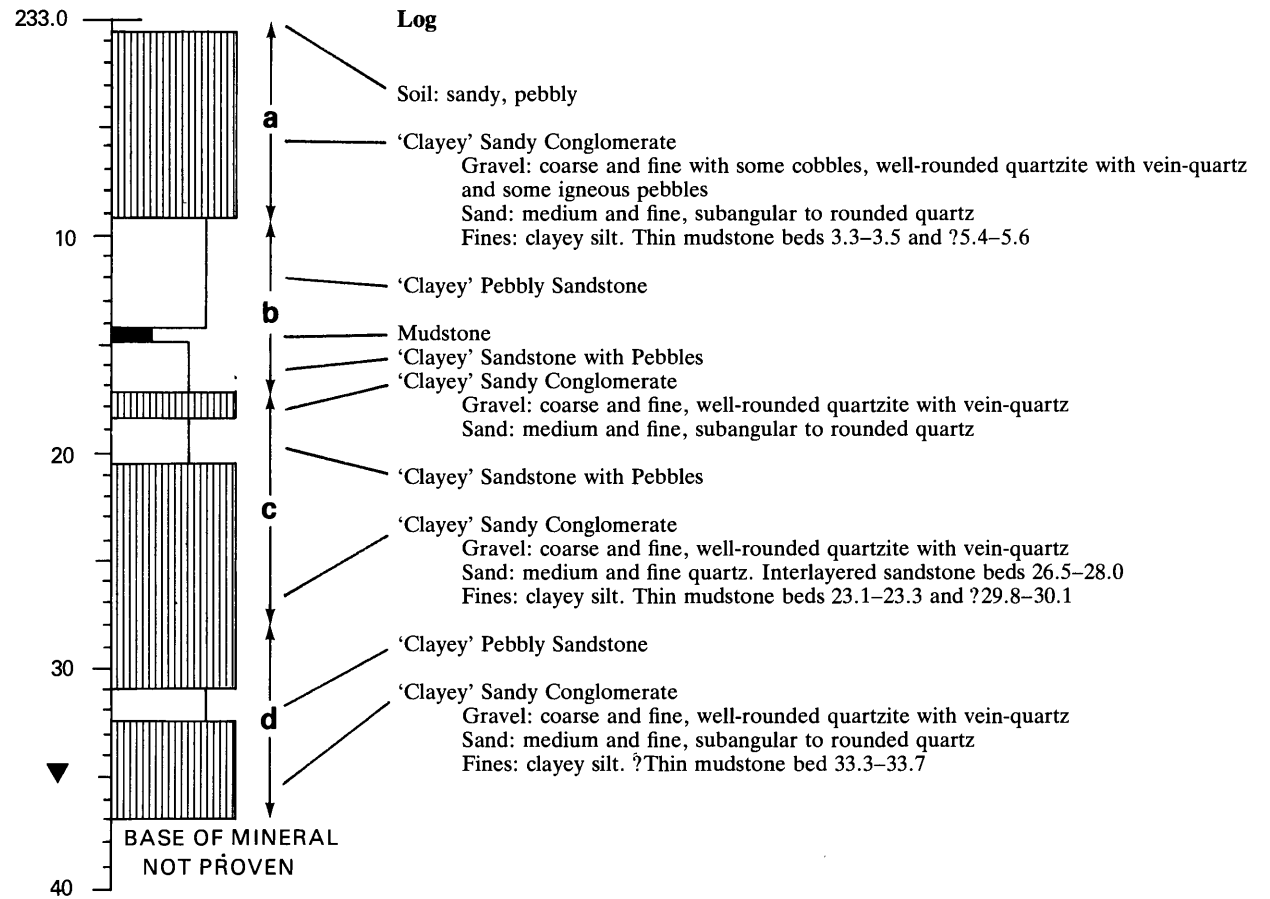
Mineral sample	Depth below surface (m)	percentages		
		Fines -1/16 mm	Sand +1/16-1/2 mm	Gravel +1/2 mm
<b>a</b>	0.5-9.2	11	31	58
<b>b</b>	9.2-17.3	17	63	20
<b>c</b>	17.3-28.0	14	43	43
<b>d</b>	28.0-37.0	16	52	32
Mean for deposit	0.5-37.0	14	47	39

**Composition of gravel fraction\***

Depth below surface (m)	percentages by weight							
	Qtzt	Qtz	Ign	Mm	Sst	S/M	Ch	Oth
2.0-3.0	54	31	7	trace	3	2	3	trace
7.0-8.0	68	21	4	1	3	1	2	—
23.0-24.0	76	17	3	—	2	trace	2	trace
32.5-37.0	78	16	1	trace	2	1	1	trace
Mean for deposit	72	20	3	trace	2	1	2	trace

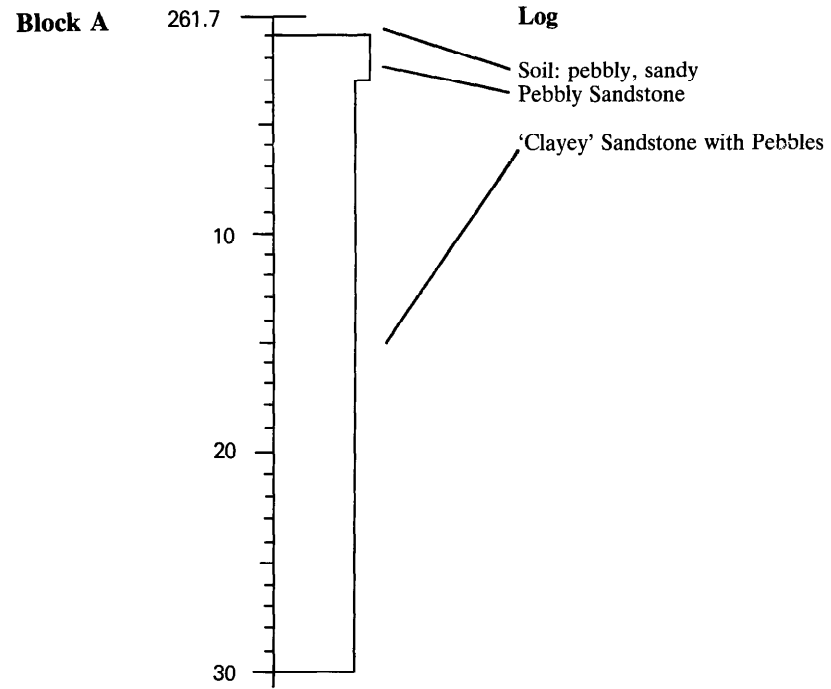
\* +4-16 mm fraction only counted

**Block C**



**SJ 94 NE 38 9538 4707**  
**Ridgefield Farm**

Surface level +261.7 m  
Water not struck  
Down-the-hole hammer, with air-flush  
225 mm diameter  
March 1980



**SJ 94 SW 48 9168 4003**  
**South of Cocknage Wood**

Surface level +227.2 m  
 Rest water level +183.4 m  
 Down-the-hole hammer, with air-flush  
 225 mm diameter  
 March 1980

**Block E 227.2**

Overburden 3.5 m  
 Mineral 12.5 m

**Grading**

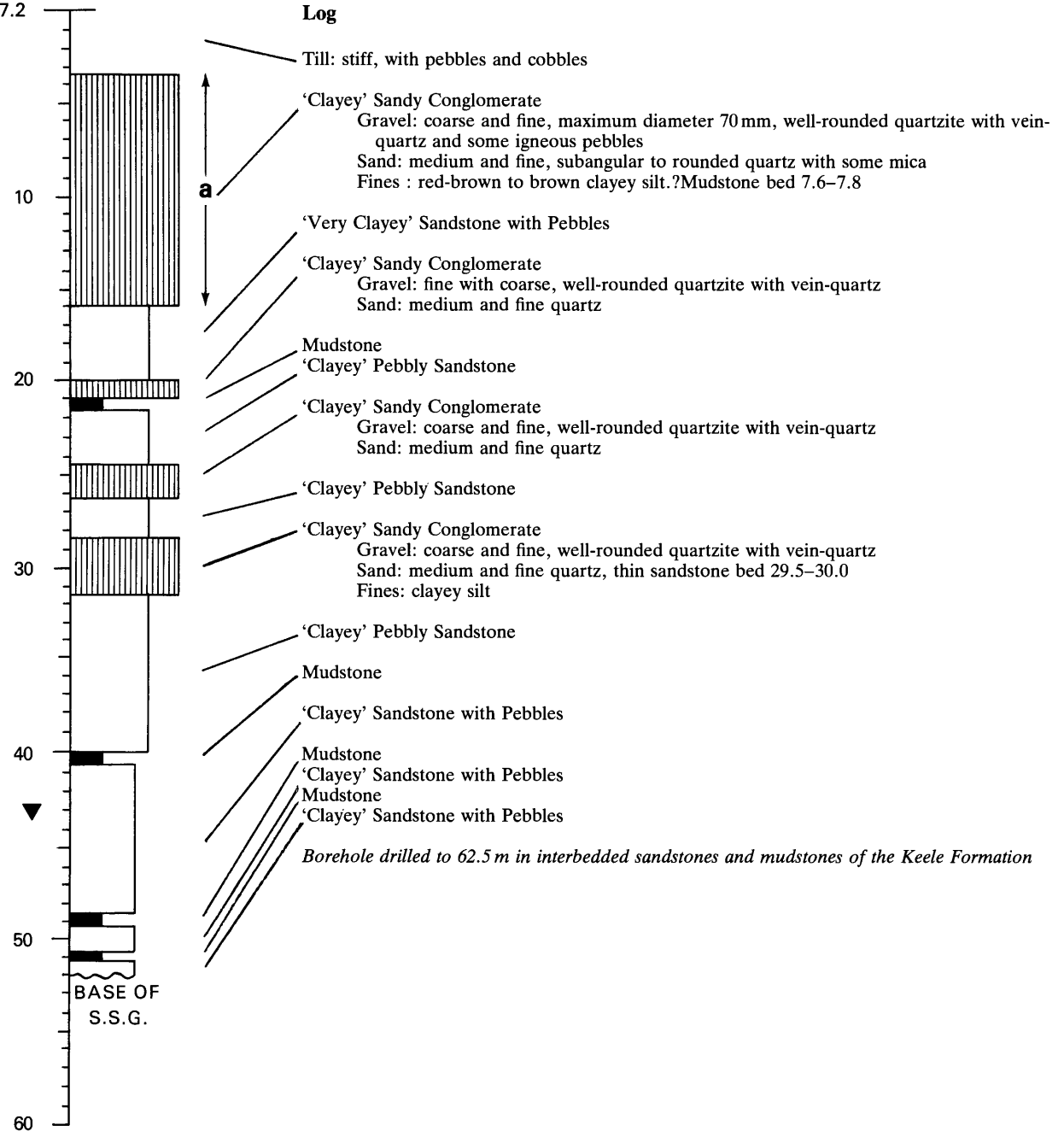
Mineral sample	Depth below surface (m)	percentages		
		Fines -1/16 mm	Sand +1/16-1/2 mm	Gravel +1/2 mm
<b>a</b>	3.5-16.0	14	27	59
Mean for deposit	3.5-16.0	14	27	59

**Composition of gravel fraction\***

Depth below surface (m)	percentages by weight							
	Qtzt	Qtz	Ign	Mm	Sst	S/M	Ch	Oth
10.0-11.0	60	25	7	—	4	1	3	trace
13.0-14.0	78	17	1	—	2	trace	2	trace
Mean for deposit	69	21	4	—	3	1	2	trace

\* +4-16 mm fraction only counted

**Log**



**SJ 94 SE 35 9568 4486**  
**Wardhill**

Surface level +243.1 m  
 Rest-water level c. +220 m  
 Down-the-hole hammer, with air-flush  
 225 mm diameter  
 March 1980

Overburden 2.0 m  
 Mineral 37.0 m +

**Block A** 243.1

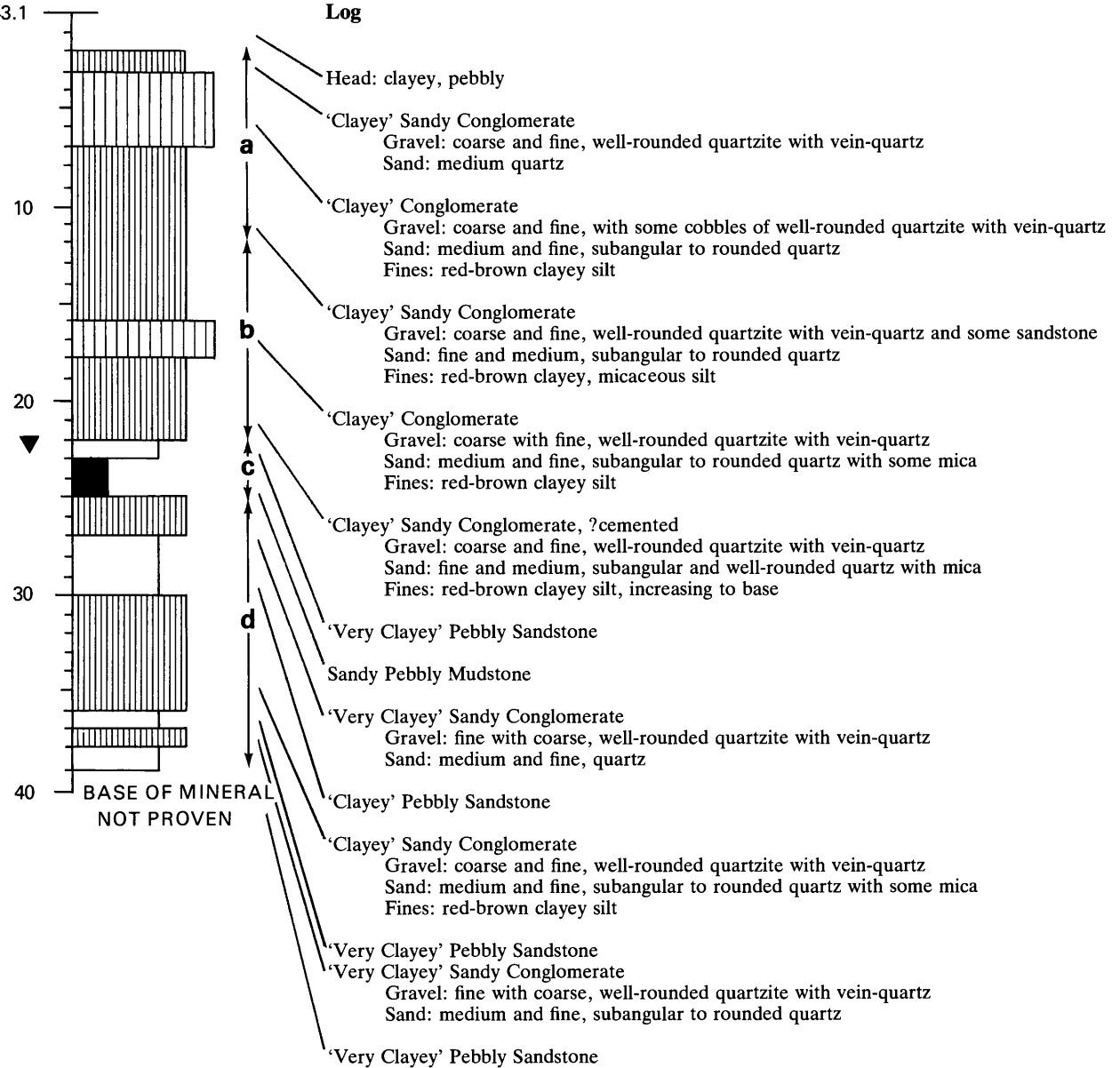
**Grading**

Mineral sample	Depth below surface (m)	percentages		
		Fines -1/16 mm	Sand +1/16-1/2 mm	Gravel +1/2 mm
<b>a</b>	2.0-12.0	13	31	56
<b>b</b>	12.0-22.0	14	34	52
<b>c</b>	22.0-25.0	40	33	27
<b>d</b>	25.0-39.0	22	45	33
Mean for deposit	2.0-39.0	19	37	44

**Composition of gravel fraction\***

Depth below surface (m)	percentages by weight							
	Qtzt	Qtz	Ign	Mm	Sst	S/M	Ch	Oth
5.0-6.0	65	23	4	1	3	1	2	1
11.0-12.0	63	24	2	—	5	2	3	1
17.0-18.0	76	17	3	—	2	trace	2	—
32.5-34.0	69	24	3	—	1	1	1	1
Mean for deposit	69	21	3	trace	3	1	2	1

\* +4-16 mm fraction only counted





**SJ 94 SE 36 9586 4358**  
**West of Blakeybank**

Surface level +239.4 m  
 Rest-water level +212.1 m  
 Down-the-hole hammer, with air-flush  
 225 mm diameter  
 March 1980

Overburden 3.0 m  
 Mineral 44.0 m +

**Grading**

Mineral sample	Depth below surface (m)	percentages		
		Fines - 1/16 mm	Sand + 1/16-1/2 mm	Gravel + 1/2 mm
<b>a</b>	3.0-13.0	13	38	49
<b>b</b>	13.0-23.5	12	33	55
<b>c</b>	23.5-26.8	20	55	25
<b>d</b>	26.8-37.0	14	41	45
<b>e</b>	37.0-47.0	† 8	43	49
Mean for deposit	3.0-47.0	12	40	48

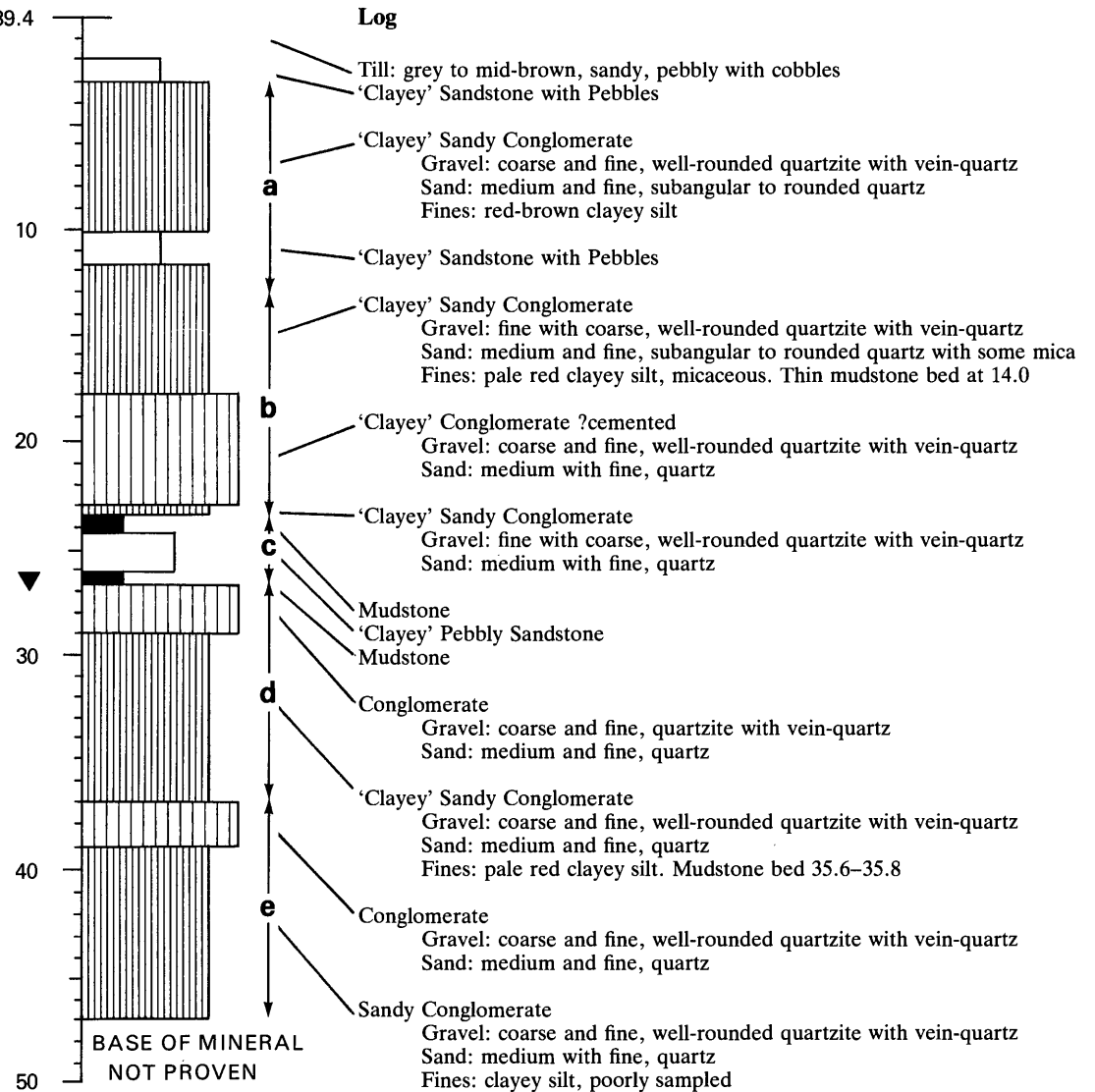
† Samples taken below the water table with some fines loss

**Composition of gravel fraction\***

Depth below surface (m)	percentages by weight							
	Qtzt	Qtz	Ign	Mm	Sst	S/M	Ch	Oth
4.0-5.0	63	25	3	—	2	3	3	1
15.0-16.0	71	22	2	trace	2	1	2	trace
22.0-23.0	76	18	1	—	2	1	1	1
32.0-37.0	67	23	3	trace	3	1	3	trace
44.0-46.0	61	26	3	—	5	1	3	1
Mean for deposit	66	23	3	—	3	1	3	1

\* +4-16 mm fraction only counted

**Block A 239.4**



## GLOSSARY

- Argillaceous** Fine-grained, consisting predominantly of silt and clay. Refers particularly to sedimentary rocks.
- Alluvial** Refers to sediments transported by a river and deposited along its course.
- Chronostratigraphy** The study of stratified rock units, their subdivisions and correlation based on the time of their deposition.
- Conglomerate** A coarse-grained sedimentary rock composed of rounded clasts (pebbles, cobbles, boulders) set in a finer-grained matrix of sand, silt or clay and commonly consolidated by a natural cement.
- Cross-bedded** Refers to a series of beds deposited at an angle to the original depositional surface as a result of wind or water building the loose grains into ripples, dunes, bars, etc.
- Down-the-hole hammer** A hard-rock drill whose compressed air-powered piston immediately follows the drill bit and causes it to batter the strata to be penetrated. The system is automatic and not directly controlled from the surface.
- Erratic** A term usually applied to a large pebble, cobble or boulder transported from its source by a glacier. The matching of an erratic to its source is a useful method of determining the direction of ice movement.
- Escarpment** A more or less continuous inland cliff or steep slope (the scarp) formed by the erosion of inclined strata and generally marking the outcrop of a resistant rock layer occurring in a series of softer strata. The feature may also be produced as the direct result of a fault.
- Formation** The primary unit in lithostratigraphy consisting of a succession of strata useful for mapping or description. Formations may be combined into groups or subdivided into members.
- Halite** The mineral form of sodium chloride (NaCl) – ‘common salt’ – usually deposited from solution by the evaporation of the solvent, water.
- Impermeable** A term applied to a rock which does not allow water to pass through it easily.
- Indurated** Applied to a compact rock hardened by the action of pressure, cementation and/or heat.
- Moraine** A mound or ridge of unsorted and (usually) unconsolidated rock debris transported by a glacier and deposited as the ice melts.
- Outlier** An area or group of rocks surrounded by older rocks.
- Pseudomorph** One mineral occurring in the crystal form of another mineral which it has replaced.
- Quartzite** A very hard sandstone consisting principally of quartz grains that have been completely and solidly cemented with secondary silica so that the original pore spaces are entirely filled. The rock, being now hard and homogeneous, will tend to fracture across and through the original grains rather than round them.
- Solifluction** (or Solifluxion) A slow downhill movement of a mass of soil and loose rock as a result of the alternate freezing and thawing of the water contained within it.
- Syncline** A trough fold, the core of which contains stratigraphically younger rocks.
- Till** Unsorted and unstratified rock debris of all sizes brought together by glacier ice and subsequently deposited.
- Unconformable** Describes strata which do not succeed the underlying rocks in immediate order of age. It indicates a substantial break or gap in the geological record.

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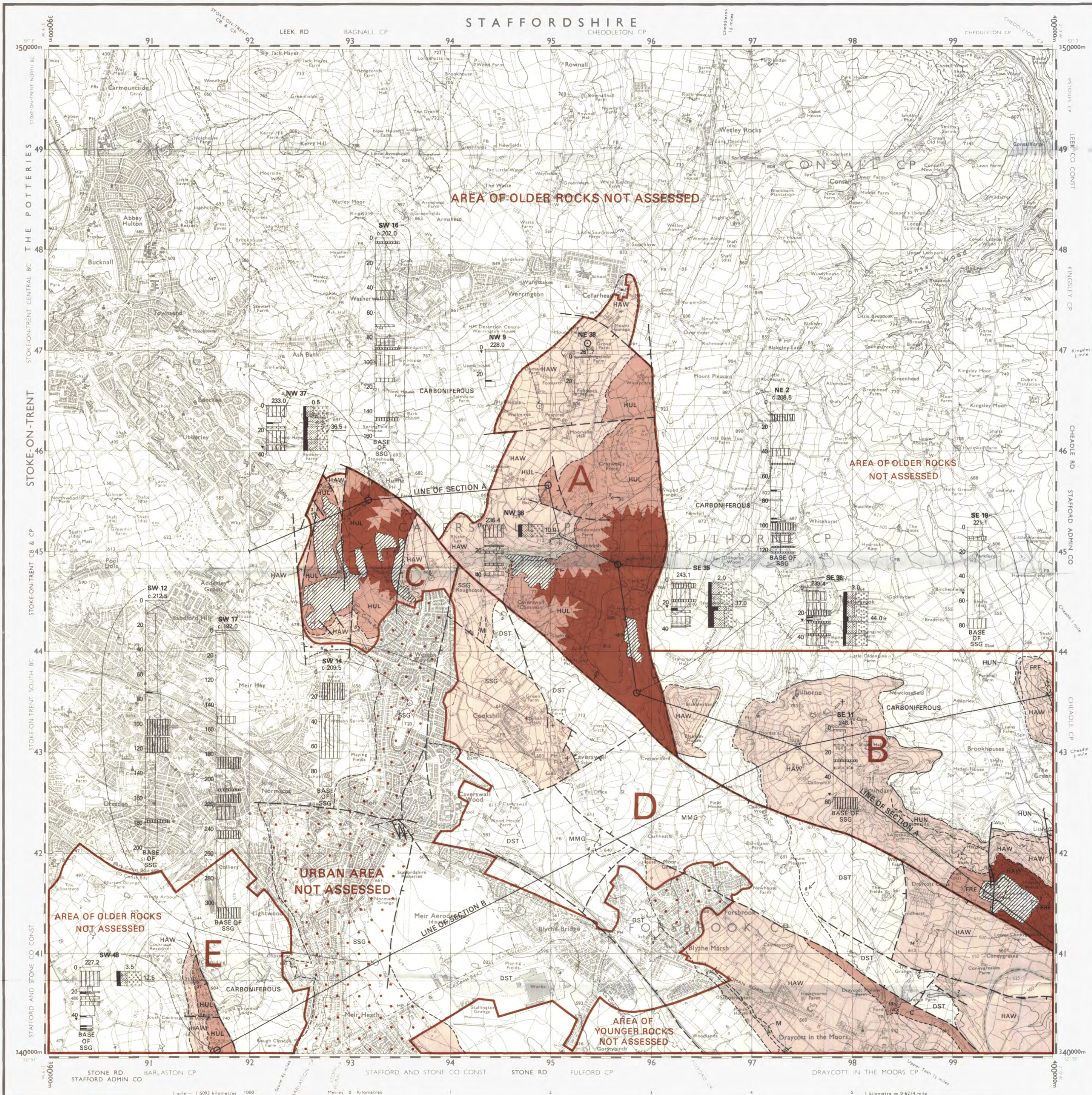
THE CONGLOMERATE RESOURCES OF THE SHERWOOD SANDSTONE GROUP  
OF THE COUNTRY EAST OF STOKE-ON-TRENT, STAFFORDSHIRE

91

This map should be read in conjunction with the accompanying Report which contains details of the assessment of resources.

ORDNANCE SURVEY  
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SHEET SJ 94



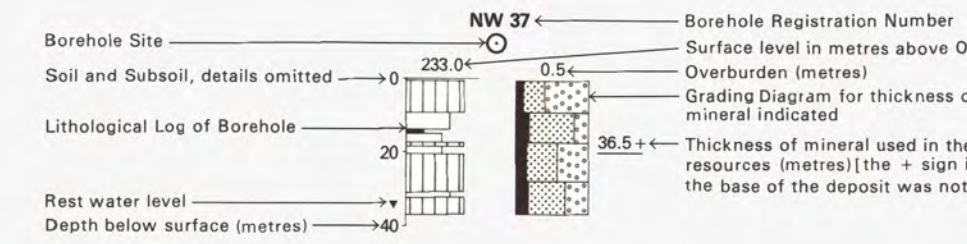
EXPLANATION OF SYMBOLS AND ABBREVIATIONS

- CATEGORIES OF DEPOSITS**
- Exposed mineral, generally greater than 25m thick. CAT-CON 1
  - Exposed mineral, generally less than 25m thick. CAT-CON 2
  - Sherwood Sandstone Group rocks, generally barren. CAT-CON 3
  - Sherwood Sandstone Group rocks, not assessed. CAT-CON 4
  - Rocks other than the Sherwood Sandstone Group. CAT-CON 5
  - Areas worked for conglomerate. WG-12

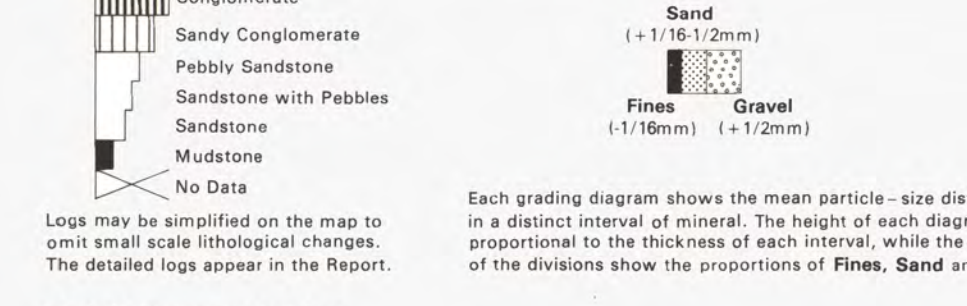
BOREHOLE DATA

- SITE LOCATIONS**
- Industrial Minerals Assessment Unit (I.M.A.U.) Boreholes
  - Other Boreholes

I.M.A.U. BOREHOLES



Lithological Log



**Borehole Registration Number**  
Each I.M.A.U. borehole is identified by a Registration Number, e.g. NW 37. The letters refer to the quarter sheet and the figures to the I.G.S. serial number for that quarter. The unique designation for borehole NW 37 is SJ 94 NW 37.

**OTHER BOREHOLES**  
The layout of information is the same as for I.M.A.U. boreholes, although data available may not be as comprehensive. They are registered in the same series.

**RESOURCE BLOCKS**  
For the purposes of assessment, the Sherwood Sandstone Group outcrop is divided into Resource Blocks (see Report). Each is designated by a letter.

**BOUNDARY LINES**

- Resource Block boundary
- Inferred boundary between categories of deposits
- Geological boundary
- x Fault at surface, crossmark indicates downthrow side
- Broken lines denote uncertainty

**STRUCTURAL SYMBOLS**

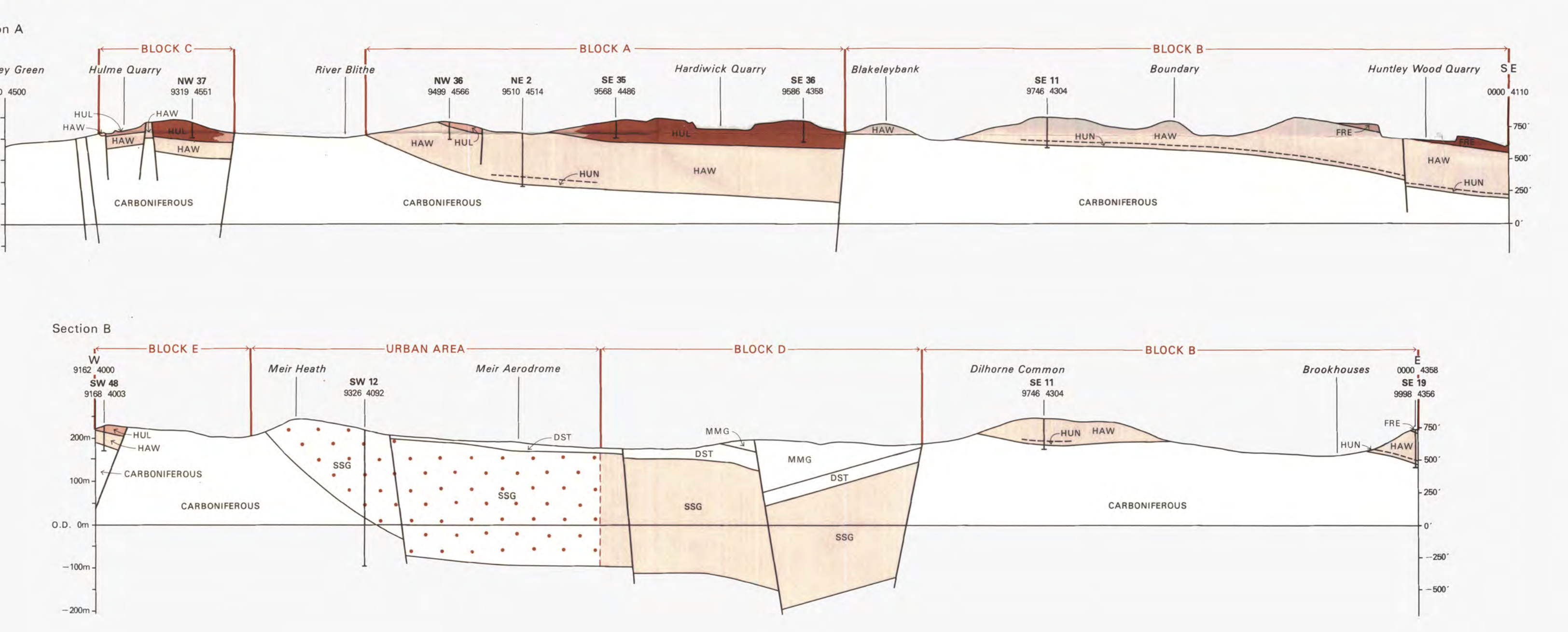
- Horizontal strata
- Gently inclined strata
- Inclined strata, dip in degrees

SJ 85	SJ 96	SK 06
123	SJ 94	124
SJ 83	SJ 83	SK 03

Diagram showing the relationship between Ordnance Survey 1:25,000 sheets and 1:50,000 New Series geological sheets (23 Stoke-on-Trent and 261 Abbotsbury)

The representation on this map of a Road, Track or footpath, is no evidence of the existence of a right of way.  
Geological lines from original surveys by G. Barrow, W. Gibson, C. B. Wedd and C. E. DeRance 1896-1901.  
Western part resurveyed by W. B. Evans and A. A. Wilson 1961-62 with additions by T. J. Charsley, J. I. Chisholm and D. P. Piper 1974-1980. Eastern part resurveyed by T. J. Charsley, J. I. Chisholm and D. P. Piper 1975-1979.  
J. V. Stephens, B. J. Taylor, W. B. Evans and I. P. Stevenson, District Geologists.  
Conglomerate resource survey by D. P. Piper 1974-1980.  
R. G. Thurrell, Head, Industrial Minerals Assessment Unit.  
1:25,000 Conglomerate Resource Sheet published 1982.  
G. M. Brown, D.Sc., F.R.S., Director, Institute of Geological Sciences.  
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**HORIZONTAL SECTIONS**  
Horizontal Scale 1:25 000  
Vertical Scale 3x horizontal scale



**GENERALIZED VERTICAL SECTION AND EXPLANATION OF STRATIGRAPHICAL SYMBOLS**

