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BRITISH GEOLOGICAL SURVEY
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Geological notes and local details for 1:10 000 Sheets.

Sheet SE 32 NW — Rothwell

Part of 1:50 000 Sheets 78 (Wakefield)

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INTRODUCTION

This report is a summary of the geology of 1:10 000 sheet SE 32 NW. It has been produced, along with the accompanying maps, for the Department of the Environment, as Phase 1 of a four year programme providing up to date geological base maps and guidance on the main aspects and implications of the geology as they affect the future land-use planning and development of an area between the rivers Aire and Calder, southeast of Leeds. The geological map is available as an uncoloured dye-line print.

The area falls within the British Geological Survey 1:50 000 Sheet 78 (Wakefield). It was first surveyed at the six inches to the mile scale by A.H. Green, T.V. Holmes, R. Russell and J.C. Ward, the maps being published in 1874 and 1875 as six-inch Yorkshire county sheets 218 and 233. The area was resurveyed by W. Edwards, D.A. Wray and G.H. Mitchell between the years 1924-1935. A vast amount of new information, especially from detailed site investigations for industrial and other developments, roads and mining has become available since then. The present 1:10 000 map incorporates this in addition to a complete geological resurvey in 1983 by J.R.A. Giles and I.T. Williamson. Details of all known shaft and borehole sections are held in the files of the British Geological Survey (formerly Institute of Geological Sciences). Mining records are held by the NCB and the Mines Records Office. Descriptions of the area with details of old cuttings and sections that are now obscured are provided by two publications: 'The Geology of the Yorkshire Coalfield' (Green and others, 1878) and 'The Geology of the country around Wakefield' (Edwards and others, 1940), the latter describing the 1:50 000 Sheet 78.

To accompany the geological map and generalised vertical section, this report includes four Environmental Geology Maps illustrating individually, facets of the geology pertinent to the needs of planners and developers: these are 1. Distribution of Made Ground, 2. Distribution of Drift Deposits, 3. Borehole Locations, 4. Underground Mining.

1. PHYSIOGRAPHY, POPULATION DISTRIBUTION, COMMUNICATIONS AND LAND USE

The area is of mixed urban and rural aspect, lying south of the main Leeds conurbation within Leeds City Council and Wakefield Metropolitan District Council administrative areas.

Most of the ground is of moderate, rolling relief, with bolder ridges and escarpments (Figure 1) forming on the major sandstones. From the highest points at Middleton (130 m) and East Ardsley (140 m), the ground falls towards the River Aire in the north (25 m) and eastwards through Rothwell (35 m) and Lee Moor (70 m). Streams mostly flow north and east across the area to the River Aire. An exception to this is the compositely named stream Dolphin Beck-Bowling Beck-Lingwell Beck, flowing southeast along the Morley-Campsall fault belt (see Figures 1, 4 and 6) until it turns sharply northwards after its capture by Lee Moor Beck. All lie within substantial valleys and most can be considered as misfit streams, the main watershed being the high ground between Middleton and Rothwell.

The principal centres of population and industrial development are Middleton, Belle Isle and Rothwell in the north and Lofthouse and East Ardsley in the south. Smaller townships and villages, in part originally owing their existence to former collieries are Carlton, Ouzlewell Green, Robin Hood and Thorpe. In these areas land is largely given over to housing, light industrial development and recreation. Approximately half of the area is rural in character being devoted to mixed agriculture with comparatively little rearing of livestock. Wooded areas are few and today are only seen at Middleton Woods [3020 2900], Kiddaw Spring [3185 2745], Thorpe Wood [3015 2675] and Bushey Cliffe Wood [3430 2645]; only those at Middleton are of any maturity or age.

The area is crossed by two motorways, the M1 and M62, and in addition to a plethora of minor roads and tracks there are main links with Leeds, Wakefield and Pontefract. The Leeds-Pontefract-Castleford and Leeds-Wakefield railways also cross the area and the Aire-Calder Navigation Canal skirts the northern margin of the map.

Widespread coal mining since the late eighteenth century has left its mark upon the area in the form of extensive waste tips, reclaimed opencast sites and

numerous shafts. All working has now ceased but only recently so (December 1983) at Rothwell Haigh. Quarrying operations for sandstone, Brickclays, and sand and gravel, also no longer in progress, have also left prominent scars upon the landscape.

2. SOLID GEOLOGY

2.1 General

The area is composed of Upper Carboniferous (Westphalian A+B) rocks forming part of the West Yorkshire Coalfield. As elsewhere these comprise rhythmic alternations of sandstone, siltstone, mudstone, seatearth and coal. A considerable thickness of Westphalian A strata lies concealed beneath the area and together, due principally to the presence of numerous workable coals, these rocks have been important factors in the economy. Beds are mainly gently dipping and undulating but are commonly more steeply inclined near faults. To a large extent the solid rocks are obscured by either a mantle of soil, weathered and soliflucted clay (Head), patches of thicker drift deposits, urban development or waste tips. Consequently few exposures remain, these being largely confined to old quarries and other artificial sections. For these reasons, details of the solid geological sequences are taken mainly from archival material, itself of varied detail and quality.

Borehole and shaft sections form part of the British Geological Survey's archives and are indexed on six-inch National Grid Maps of the Ordnance Survey. Most of the mine plans are held by the Mines Records Office and the National Coal Board and details of the workings in a given seam may be examined by appointment at:

1. Mines Records and Mines Drainage Office
   Rawmarsh
   Rotherham
   South Yorkshire

2. NCB
   North Yorkshire Area HQ
   Allerton Bywater
   Castleford
   West Yorkshire

3. NCB Opencast Executive
   Yorkshire Area Office
   2 Windsor Road
   Shawcross
   Dewsbury

A generalised vertical section illustrating the sequence of solid rocks proved in the area is given on the margin of the 1:10 000 scale geological map; details of shaft and borehole sections in the vicinity are shown in Figures 2 and 3; and the horizontal cross sections (Figure 5) show the broad structure and relationships between the significant coals and sandstones. Little is known of the strata between the coals and major-named sandstones; details of coal sections are given in Green and others 1878, and Edwards and others 1940. It has not been felt necessary to repeat such details in this report.

2.2 Details

The lowest coal worked was the Better Bed. Only recorded at Middleton Broom Colliery, it was 0.18 m thick with no significant partings. To the west outside the area of interest it was proved to be of comparable thickness at Beeston No. 4 and West Ardsley Collieries. The seam is underlain by a seatearth clay, often referred to as a 'fireclay'. At Middleton Broom this ranged in thickness from 0.6 m to 1.5 m and was of sufficient quality to be extracted and used both as a source of brick and pottery clay and as a refractory material.

The Black Bed Coal (up to 0.8 m) was worked from Middleton Broom and Rothwell Haigh in the north of the area. The overlying 'black bed ironstones', in contrast to areas to the west, were apparently not extracted (Edwards and others 1940).

The Crow Coal (between 0.8 m and 1.0 m but including several partings and 'inferior' coal) was a good quality coal again worked principally from collieries in the northern part of the area.

The Beeston group of coals (up to 2.8 m) was of great economic importance in the Leeds area being recorded and worked from several collieries. Three leaves are consistently present. At Middleton Broom the Top (Top and Middle leaves) and Low Beeston seams and the parting between, measures 2.77 m. From there, in both easterly and south-westerly directions the seam splits more widely into the Top and Low Beeston Coals (Edwards and others 1940, pp 29-34), many colliery sections not recording strata below the Top Beeston. It can be assumed that the Top and Middle leaves are more or less worked out over virtually the entire area, excepting the Morley-Campsall fault belt.

The Blocking Coal (up to 1.8 m) was worked from Middleton and Lofthouse. Within 6 metres or so of the top of this seam, a thin coal, the Blocking Rider (up to 0.25 m) is commonly but not invariably present.

The Middleton Eleven-Yards Coal (up to 1.0 m) crops out in the far northwest corner of the area and was worked opencast at Lockwood [3020 2990]. There, several shafts and shallow workings were uncovered and it was estimated that some 50% of the valuable coal had already been extracted from the upper leaf. It was worked from Middleton Broom, Lofthouse, Rothwell Haigh and Newmarket Collieries.

The Wheatley Lime Coal (up to 1.2 m) is a seam of variable but generally poor quality. Northeastwards across the area from East Ardsley to Rothwell Haigh it separates from close to the base of the overlying Middleton Main Coal deteriorating rapidly in both quality and thickness.

The Middleton Main Coal (up to 2.0 m including dirt bands), commonly also referred to as the West Yorkshire Siltstone, crops out in and around the Lockwood opencast site north of Middleton Park. In the past it was a very important and valuable seam and has been extensively mined throughout the area; reserves are likely to be exhausted.

The Middleton Little Coal (up to 1.1 m) crops out naturally within the area at Middleton Park and has been extensively worked both from shallow workings and at depth. There is a possibility that thin ironstones at this level have been worked in Park Wood, Middleton, adjacent to this area.

The Brown Metal Coals are three relatively persistent seams of variable quality, but generally inferior to most of the above mentioned coals. However, they have been of sufficient value to attract local interest in shallow crop-workings and bell pits throughout Middleton Park Woods. They have also been the subject of opencast operations along the northern part of the area. The maximum thickness of any of the seams is around 1 m but this generally includes considerable 'dirt' and the average is generally less than 0.5 m. Both First and Second Brown Metal coals have been sporadically worked from scattered shafts in the northwest of the area and from Middleton Broom Colliery. The thickness of strata separating the 2nd and 3rd Brown metals is very variable, being as much as 9 m or as little as 0.5 m at East View opencast site [3180 2995] . In some boreholes and shaft sections two or even one coals may represent the entire Brown Metals sequence. This characteristic variability and condensing of the sequence was also noted by Godwin and Calver (1974), who state that these coals (2nd and 3rd Brown Metals) unite north of Rothwell Haigh Fanny Pit and that the united seam rapidly approaches the Middleton Little A section exposed in Middleton Park Woods [3004 2892] showed the 1st Brown Metal to be only some 0.27 m thick. Six metres above this coal is a flaggy, fine-grained sandstone up to 4 m thick and forming a strong feature in the woods where it describes a gentle anticline next to the Middleton-Halton Trough. It can be traced towards Urn Farm 3157 2980 but apparently thins rapidly, dying out to the east.

The Flockton Thin or Adwalton Black Bed Coal (up to 4.2 m) crops out in the Middleton Park area, and below Belle Isle and Bell Hill. It has been worked opencast at Hunslet [3194 2980] and Bell Hill [3290 2995] and both shallow and deep mining has been extensively carried out in the past especially from Lofthouse.

The Emley Rock is a fine-grained sandstone present between the Flockton Coals. In Middleton Park Woods it produces a conspicuous feature forming most of the high ground and the first major escarpment in the Belle Isle area. It is variable in thickness and archival data show it to be present throughout the area at depth. At the time of the present survey (Autumn 1983) artificial sections at Rothwell Haigh [3403 2985] and Bell Hill [3268 2983] , [3217 2983] exposed the top two metres. Typical of the sandstones in this part of the sequence, it is pale brown, cross-bedded, fine- to medium-grained and sporadically micaceous and ferruginous.

The Flockton Thick or Adwalton Stone Coal (up to 2.2 m but including dirt partings) crops out from Middleton to Rothwell Haigh. Numerous dirt partings greatly detract from the value of this seam and it was only of local value before large scale opencast operations became feasible. Opencasting was carried out in several small sites collectively named Bell Hill. Shallow workings, presumably most for the uppermost leaf which is often a 'cannel' coal are recorded. The roof measures are commonly rich in shell debris and ironstone, the latter possibly being the equivalent of the Tankersley Ironstone which outside this area was formerly of some small economic significance. Artificial exposures were seen at Rothwell Haigh [3385 2978] , [3352 2973] and Bell Hill, the coal having a hard siliceous sandstone seatearth resting upon siltstones above the Emley Rock.

Above the Flockton Thick Coal and below the Thornhill Rock at least two coals are recorded but may not be universally present. The lower is a thin and discontinuous seam called the Smith Coal; there is virtually no information available on it. The upper, and more important, is the Joan Coal (up to 0.4 m). The Joan Coal is often ill-defined, if identified in borehole or shaft sections at all, and little is known about it in detail. The main interest in this part of the sequence comes from the presence of the Clay Cross or Vanderbeckii Marine Band in the roof measures or associated black shales of the Joan Coal. This marine band, although poorly known in the Leeds area is very important as

its base marks the boundary between Westphalian A (Lower Coal Measures) and Westphalian B (Middle Coal Measures). Its position relative to the Flockton Thick is variable and the crop of the Joan Coal indicated on the map is often conjectural. There is also a distinct possibility that it is missing in some areas, probably due to 'washouts' below the Thornhill Rock.

The Thornhill Rock is probably the single most conspicuous formation in the area, forming a prominent escarpment and dip slope covering nearly ten square kilometres. In this report we are using the name Thornhill Rock to refer to a formation of several lithologies including siltstone and mudstone, although as elsewhere the main rock type is a sandstone, sometimes up to 45 m thick. Eastwards from Rothwell there is a distinct facies change, with mudstones and coals increasingly common. The base of the formation is irregular and ill-defined appearing to be both diachronous and erosional with no sharp boundary. The lowest beds are thin, irregular, lensoid sandstones which appear to wedge out and in rapidly. Likewise, the top is ill-defined, not infrequently being represented by a shaly or silty facies. The bulk of the formation is a fine-grained sandstone with irregular and largely unpredictable intercalations or lenses of mudstone and iron-rich concretions. Borehole data reveal such 'shaly' facies in the Middleton [3095 2815], Robin Hood [3241 2722] and Clapgate Lane [3190 2855] areas; it has not been found practical to delineate these on the map. The coarse, massive sandstones usually recorded in boreholes and shaft sections appear at various heights above the Joan Coal (see above). These beds are responsible for the strong feature that marks the northern edge of the outcrop. Unweathered varieties known as 'blue stones' were formerly worked for building stone and ornamental purposes, the largest quarrying operation being at Robin Hood near Thorpe on the Hill [3175 2670]. Several small quarries existed locally at Rothwell [3445 2910], [3465 2900] between Rothwell Haigh and Robin Hood [3261 2852], [3259 2836], [3271 2833], [3246 2812], and Middleton [3020 2957], [3058 2981]. Most of the outcrop is represented by a long undulating dissected dip-slope. That sandstone is present at no great depth beneath the soil cover over most of this area is evidenced in numerous shallow bores and by the appearance of angular sandstone 'brash' in the fields.

The topmost beds of the formation are thinly-bedded often flaggy, cross-bedded sandstones passing up into siltstones and shales. Apart from the country

between Rothwell and Carlton the top of the Thornhill Rock appears to be faulted out near the Morley-Campsall Fault Belt. Small exposures of cross-bedded sandstone south of Thorpe Wood near Ardsley Junction [3020 2654] may represent the only outcrop of the Thornhill Rock within the fault belt.

Succeeding strata include several thin coals, one or more of which probably correlate with the Lidgett Coal of Wakefield.

The Haigh Moor Coal (up to 1.6 m not including dirt partings) is exposed in the southern part of the area where it was formerly worked opencast near Rothwell, Carlton and East Ardsley. It was also seen in the Robin Hood brick quarries. In detail it is a series of coals of variable thickness and value often divisible into the Top and Low Haigh Moor seams, the latter having at least two leaves. A thin coal, the Haigh Moor Rider (up to 0.4 m) occupies a position a few centimetres above the Top Haigh Moor but it is not everywhere present. The coal has probably been worked at shallow depth near its crop and was mined around East Ardsley, Lofthouse, Lee Moor and Thorpe on the Hill up to the margins of the Fault Belt. Within the fault belt it is known to be present at shallow depth near Ardsley Junction.

The Haigh Moor Rock is a major (up to 25 m thick), fine-grained, cross-bedded sandstone which forms the first strong feature above the Haigh Moor Coals south and west of Rothwell and at East Ardsley. Its base may in some instances approach, form the roof measures to or partly fill a washout in the Top Haigh Moor Coal (see for example Burnet and Everett 1914, Edwards 1937). It is present throughout the southern part of the area, being absent within the Fault Belt and dying out laterally between Rothwell and Bushy Cliffe Wood. The only section seen during the course of the survey was in a ditch northeast of Moor Knoll Lane, East Ardsley [3028 2602] .

The Swallow Wood Coal (up to 0.9 m) crops out above the Haigh Moor Rock between East Ardsley and Fall Bridge and was formerly seen in the railway cutting at the latter. It was also seen south of Carlton and at the Robin Hood Quarries where it was noted to be overlain by a conspicuous oolitic ironstone (Deans 1935). Boreholes sunk during the construction of the M62 Motorway recorded its presence and although not seen at present due to landscaping it is calculated to crop out in the motorway cutting at Thorpe.

It was worked at the Ouzlewell Green opencast site [3407 2625].

The Twenty-Seven Yards Coal (up to 0.3 m) crops out south of Rothwell towards Bushey Cliffe Wood southwest of Swithens Farm terminating against the Oulton Fault. It reappears at Robin Hood Quarries and is proved in the motorway cutting at Lingwell Gate Lane Bridge. It also crops out at East Ardsley.

The Beck Bottom Stone Coal (up to 0.3 m) is best seen today in the cutting on the M62 motorway west of the Lofthouse interchange and in the back wall of the Robin Hood Quarries. In its position near the base of the Horbury Rock it can be traced at East Ardsley, Lofthouse and Swithens Farm.

The strata between the Haigh Moor Rock and the Horbury Rock, in addition to the last three coals mentioned above, also contain two thin but mappable sandstones and a thin but localised and unnamed coal. The sandstones crop out between the Swallow Wood and Twenty-Seven Yards seams at Thorpe and Lofthouse and between the Twenty-Seven Yards and Beck Bottom Stone seams at East Ardsley respectively and the unnamed coal is recorded at the Dolphin opencast prospect [3240 2670].

Next to the Thornhill Rock, the Horbury Rock is the second most important major sandstone formation in the area. It forms the hill cappings at Swithens Farm and East Ardsley, and between Lofthouse and Coney Warren there is a long, gently undulating dip slope. It also forms the crest to the hills near Robin Hood Quarries dipping towards Thorpe Lane Farm. The complete thickness (up to 37 m at Lofthouse Colliery) is not seen, mainly due to faulting, but several exposures are recorded; the bottom few metres are represented at the Robin Hood Quarries by interbedded, thin sandstones and sandy shales, and in the motorway cutting west of the Lofthouse M1-M62 Interchange by massive wedge-bedded sandstones. Smaller exposures are also seen in the remains of an old quarry behind the Public House in East Ardsley [3080 3065] and beside the railway bridge under Long Thorpe Lane [3262 2623]. These show prominent cross-bedding in the sandstones and small amounts of interbedded mudstone and siltstone; both features seem to be characteristic of the formation as a whole. Isopachytes of the Horbury Rock show that it thins south and east from its outcrop (Edwards and others 1940) and appears to be virtually absent at Newmarket Spencer Pit [3504 2626].

The Warren House Coal (over 3 m including dirt partings) represents the Top Barnsley and Barnsley Rider seams in this area. It is recorded from Lofthouse and Newmarket Spencer Collieries and has been worked opencast at Ouzlewell Green and Coney Warren [3465 2613] . An average section at the latter site showed six leaves separated by dirt partings but in general the seam has a four-fold division into Top, Upper Middle, Lower Middle and Lower leaves. Shallow workings were located at Coney Warren during the opencast operations and it is very likely that they exist elsewhere. The Warren House generally everywhere overlies the Horbury Rock (see above); but if our assumptions are correct (based upon detailed field mapping and a reappraisal of the archival data), it is absent near East Ardsley, possibly having been 'washed out' by the sandstones above the Horbury Rock. The topmost beds of the Horbury Rock may also be missing. These sandstones alternating with thin, less competent, mudstones and siltstones are unique to the country southwest of the Morley-Campsall Fault Belt and in part correlate with the "Sandstone of Stubbs Wood" [3090 2510] as shown on the Primary Survey Map of 1874 and defined as such on the Revision Survey Map of 1935. Here we use the term the Stubbs Wood Formation. In turn they are overlain by a thin coal which may be the lateral equivalent of one of the Kents Coals. North of the fault belt, the strata above the Horbury Rock and below the equivalent of the Kents Coals are predominantly mudstones. These relations are shown diagrammatically in Figure 5.

The Methley Park Coal (up to 2.3 m) is a local name given to two seams at Methley Park [3800 2650] and southeast of this area, probably representing the coming together of the Kents Thick (up to 0.4 m) and Kents Thin (up to 0.3 m) Coals. The 'seam' was worked opencast at Coney Warren and obviously represents a substantial condensation of the sedimentary sequence in that area. Within the Morley-Campsall Fault Belt and southwards towards Lofthouse the coals are only known from boreholes and the thickness of the parting between the coals increases dramatically, the coals becoming known as the Kents Coals (figure 5). Only the Kents Thick probably crops out, around Lawns Lane [3180 2520] .

The youngest coal to crop out within the area is the Stanley Main Coal, caught up between and within the Morley-Campsall Fault Belt and a subsidiary fault south of Lofthouse. Old crop and opencast workings are known from the Lofthouse Park area [3385 2505] . These, and exploratory bores, proved it to be up to 4.5 metres thick but including several partings. Minor sandstones are seen above both the Methley Park Coal and Stanley Main Coal at Dungeon Lane Farm [3483 2650] and Lofthouse Park respectively.

3. STRUCTURE

The regional dip of strata is between 3° and 5° to the southeast. Minor rolls and flexures affect it and dips noticably steepen and change direction near some faults. Folding is common near major faults and within the Morley-Campsall Fault Belt. Apart from the regional dip the principal structural features of the area are a broad, open fold with a NW-SE trending axis and a complex zone of faulting (part of the Morley-Campsall Fault Belt) crossing the southern part of the area in a NW-SE direction. These features are summarised in Figures 5 and 6.

The northern part is dominated by NE-SW trending faults. Of these, the most significant are those defining the Middleton-Halton trough, a graben with boundary throws of 100 m and 64 m and overall southward down-throw. Associated with the southern boundary fault, which brings Thornhill Rock into contact with strata as low as the Middleton Little Coal, is a broad anticline with its axial trace parallel to the trough axis (see Figure 6). The Middleton-Bullerthorpe Lane Fault has a variable throw to the south ranging from around 0.5 m in the west to over 8 m in the east at Bell Hill. A graben is formed between this fault and the Bell Hill Fault which throws down to the northwest by about 4 m. The Rothwell Haigh Faults and the N-S fault near Lingwell CS School, Middleton, are comparatively minor structures with throws of less than 2 m.

The southern part is more structurally complex, faulting again being the principal feature. The Morley-Campsall fault belt is of considerable complexity and much of its structure is inferred from archival data, several interpretations being possible. Several major faults are associated with it.

On the northern side of the fault belt, a major off-shoot is the Thorpe-Ouzlewell Green Fault which, in common with all the larger faults, varies in throw along its length, downthrowing to the south by over 80 m in the west and only 12 m in the east where it is truncated by the Oulton Fault. The Carlton Fault, downthrowing to the south by about 35 m branches from it. This fault can be traced at surface eastwards as far as the restored opencast sites below Swithens Farm but has little effect on the strata, being only recorded at depth in the Middleton Main seam where its throw had diminished to only a metre or so. The Oulton Fault, previously mentioned, is a major NE-SW dislocation throwing down to the southeast by 70 m. Its hade is variable

along its length being near zero in the south where it is cut by the main fault belt, and about 20° at its northern end. Folded strata were recorded in the Ouzlewell Green opencast sites west of the fault.

South of the Morley-Campsall fault belt, the structure remains fairly complex being still much influenced by major faulting. A narrow NE-SW trending horst is defined by the East Ardsley and Ardsley-Lingwell Gate Faults. This structure almost brings the Horbury Rock into contact with the Stubbs Wood Formation indicating throws of around 12 m. Southeast of the Ardsley-Lingwell Gate Fault the strata are folded in a complex manner.

Within the fault belt, dips and strikes are highly variable and numerous cross faults further complicate the overall geometry. The lowest horizon exposed appears to be the Thornhill Rock, west of Ardsley Junction and the highest, the sandstones above the Stanley Main Coal, although these are no longer exposed. On former surveys, this structure was considered to be a graben in overall configuration but this was very much an oversimplification of the available data. Throws on boundary faults are very variable and are taken mainly from mine plans, but along most of its length the belt probably has an overall southward downthrow. At its narrowest point at Lingwell Bridge it is only 150 m across and this area is characterised at depth by a zone of intensely shattered rock. No single fault defines either the northern or southern margin of the belt along its length. Associated with the Thorpe Wood Fault a broad anticlinal structure is developed below Middleton and Thorpe on the Hill. Little can be seen of this structure at surface, the entire outcrop being predominantly of Thornhill Rock, but it is proved in underground coal workings.

Joint planes are also a common feature best displayed in the thicker sandstones; planes are mostly very steep or vertical and generally comprise two conjugate sets. These vary considerably in strike and no general synthesis or regional pattern can be discerned. Where open and forming notable fissures, such joints could present problems during development. For example, a vertical fissure some 15 cms wide by at least 2.75 m deep was recorded at Sharp Lane, Middleton, over a distance of 140 m running in a NW-SE direction. Where developed along strong escarpments, fissures could result in the cambering of strata. This is a possibility in the thicker sandstones but none has been proved. However, the likeliest occurrences are in the Thornhill Rock below Bell Hill and Rothwell Haigh and in the Horbury Rock at Swithens Farm and East Ardsley.

4. DRIFT DEPOSITS

The drift deposits comprise Till, Glacial Sand and Gravel, Laminated Clay, River Terrace Deposit (undifferentiated), Alluvium, Peat and Head. Less than 10 per cent of the area is covered by mappable drift deposits with individual patches widely scattered. The main areas are around Rothwell and Lofthouse. The distribution of these is shown on the 1: 10 000 Geological Map and as a separate item on EGM 2.

4.1 Till

Stiff yellowish-brown to dark brown clay incorporating rounded to subangular stones commonly up to 0.5 m in diameter although boulders of 1.5 m have been recorded (Edwards et al 1940), caps the higher ground in Rothwell, north of Oulton Beck. From borehole logs and archival data on former sand and gravel pits in the area, this clay has a maximum thickness of around 4 m and generally overlies a substantial deposit of Glacial Sand and Gravel but may occasionally directly overlie bedrock. Only the uppermost portion of this sequence as seen at Rose Cottage Farm, near Rothwell Haigh, is still exposed. This shows just over a metre of sandy, weathered till resting upon gravel. Erratics within the till comprise various sandstones, grits, ironstones, cherts and quartz pebbles all thought to be of Carboniferous age but rarer erratics of Carboniferous and Permian limestones are also seen. Till is also recorded around the Lofthouse Interchange between the M1 and M62 motorways, where it was proved to be some 6.5 m thick. Smaller and thinner deposits of stony clay, thought to be Till, are found scattered across the area, commonly occupying minor hollows on the often ill-defined dip-slopes of the major sandstones such as the Thornhill Rock south of Belle Isle and the Horbury Rock at Swithens Farm south of Rothwell.

4.2 Glacial Sand and Gravel

Glacial Sand and Gravel is found only in the northern parts of the area where it covers much of the high ground between Oulton Beck and Rothwell Haigh. Although at present much of this deposit is sterilized by 'development', archival data indicate that up to 9.5 m of laminated and commonly cross-bedded sand and gravel were present and worked from various pits near Rose Cottage Farm, John O'Gaunts Inn and Haigh Cottage. The erratic content of the gravels is similar to that of the overlying Till, being mostly composed of Carboniferous sandstones with only a minor component of other rock types. No igneous

erratics are recorded. Details of former sections are provided by the memoir accompanying one-inch sheet (now reprinted at 1: 50 000 scale) 78 (Edwards and others 1940) and other publications (Hawkesworth, 1905, Gilligan, 1918). Minor patches, probably thin, are seen on the dip-slope of the Thornhill Rock. No detailed resource assessment has been carried out during the present survey.

4.3 Laminated Clay

A minor, but significant, deposit of contorted, laminated clay, was recorded below the Till but overlying the Glacial Sands, in the John O'Gaunts pits (Edwards et al, 1940) but was apparently absent in other sections near Rose Cottage. This deposit was not seen during the present survey and borehole data from Rothwell do not confirm its presence elsewhere. It appears therefore to be very localised in its occurrence, probably resulting from the minor ponding of sub-glacial streams rather than its being a widespread 'lacustrine' deposit. The alluvium associated with the River Aire is also known to be partly composed of laminated clay (Gilligan, 1918).

River Terrace Deposit (undifferentiated)

According to Edwards and others (1940) and Gilligan (1918) there are spreads of sand and gravel, commonly with thin beds of laminated clay, forming terraces at two levels along the margins of the River Aire and the River Calder. At Cinder Oven Bridge [3327 2998], although the ground is much altered by industrial development, it is possible that remnants of the upper terrace, lying some 2 to 3 metres above the alluvial plane of the River Aire, are present. The lines shown on the 1: 10 000 geological map are taken from the previous survey.

4.5 Alluvium

Narrow strips of Alluvium occur in the valleys of Oulton Beck, Lingwell Gate Beck, Bowling Beck, Lee Moor Beck, West Beck and Throstle Carr Beck. Although there are little or no data on its detailed composition or thickness it is a very variable deposit at surface, being predominantly a silty clay with thin ribbons of sand. Minor gravels and peaty clays are locally present. Thicknesses range from only a few centimetres to over 2 metres.

4.6 Peat

Deposits of Peat are commonly associated with Alluvium. A small deposit is found south of the M62 motorway at Ardsley Junction in the valley of Dolphin

Beck-Bowling Beck. Less significant patches, also associated with the present drainage system, are seen along Dolphin Beck south of Thorpe Wood, West Beck to the west of Carlton where the beck is culverted beneath the former railway, and in the streams flowing north through Middleton Woods. There are no data on thickness.

4.7 Head

Head is the term applied to deposits formed initially by the slow downslope movement of material under periglacial conditions of alternate freezing and thawing but which are probably still forming today under the action of present-day weathering and plant growth. Many of the valley deposits in the area come under this heading and comprise an often bewildering admixture of soft clay, sands and angular rock fragments, extending over all rock types in the substratum. It may be present over much of the ground and commonly is a yellow sandy clay lacking in cohesion and stability. Its tendency to be thicker in hollows and against obstructions on slopes is a natural consequence of this. It is generally less than 2 m thick but may exceed this in some of the main valleys. It has not been found possible to indicate its overall distribution on the map due to its thinness and lack of distinguishing characteristics. It should be assumed to be present everywhere unless proved otherwise.

5. MADE GROUND

Made Ground, constructed from a variety of sources and materials, covers a considerable part of the area. Due to the inherent variability of such deposits, detailed and careful site investigationsare necessary where development is to be sited on them, so as to determine thickness, compressibility and chemical content. Six main categories are distinguished and recorded thicknesses are extremely variable.

(i) Landscaped Ground
(ii) Made Ground; undifferentiated
(iii) Back-filled Quarries; nature of fill unknown
(iv) Back-filled opencast coal workings
(v) Colliery waste tips
(vi) General refuse tips

5.1 Landscaped Ground

This category covers ground such as recent housing developments, schools, industrial estates and recreational areas where the original ground surface is likely to have been modified by earth moving operations. Such areas may or may not be covered by significant Made Ground (generally > 1.5 m) and it is virtually impossible to determine the distribution of any deposit present without a comprehensive investigation.

5.2 Made Ground, undifferentiated

This category includes major road and motorway embankments, railway embankments and other general constructional areas. Within any development area such deposits may be widespread. Detailed site investigation will be needed to determine the presence and extent of such deposits as it was not always found practical to delineate them on the map, (EGM 1).

This material has proved unstable in one locality; a small area of landslipping is located about 1 km east of Ardsley East, adjacent to the sewage works and has resulted from the erosion of the artificially steeped slope of the made ground embankment by Bowling Beck.

5.3 Back-filled Quarries

Excavations of various depth and size for sandstone,clays for brickmaking and sand and gravel are scattered across the area and often there is no surface indication of their former extent and in a few cases, their very existence.

In most instances archival material has supplied the details. In general no information on the nature or state of compaction of the fill material is available.

5.4 Back-filled opencast coal workings

There are a dozen former opencast coal pits in the area, as designated by the NCB Opencast Executive; their distribution is shown on the accompanying environmental map. Such sites are effectively landscaped and restored.

5.5 Colliery Waste Tips

These tips are a conspicuous feature of parts of the area. They generally consist of inert materials but there may also be a considerable proportion of coal. The larger tips may be landscaped and redeveloped.

5.6 General Refuse Tips

Domestic and industrial refuse contains a wide admixture of materials which may, upon burial, involve problems of instability and the possible emission of gas. Such problems are exemplified by the Middleton Broom Landfill site. Archival data have proved inadequate in providing the total distribution of waste tips and it is inevitable that not all have been located.

6. ECONOMIC GEOLOGY

Most of the common lithologies have been of some economic significance in the past. They are coal, ironstone, fireclay, shale, sandstone, sand and gravel.

6.1 Coal

All coal production in the area has ceased, but only recently (1983) at Rothwell Haigh Colliery, and no further deep mining is envisaged at present as reserves are largely exhausted. The entire area, apart from major pillars under settlements and within the Morley-Campsall Fault Belt, has been undermined. Numerous shafts, disused workings, at crop, at shallow depth and at considerable depth and several waste tips are the industry's legacy to the area and are of importance in considering any future development.

As previously mentioned (Section 5.4) opencast mining has been important and extensive, chiefly in the north and east. There are no working sites at present but several areas have been explored. Future extraction is probably not feasible due to quality and structural considerations as well as to the fact that large areas are 'sterilised' by development. Sites of any future extraction would therefore be of small extent.

6.2 Ironstone

Several collieries record bands and nodules of ironstone in the mudstones above the Black Bed Coal, at the level of the Middleton Little Coal and above the Flockton Thick Coal. Collieries working the Black Bed Coal are likely to have, in addition, worked the overlying ironstones. This is certainly the case throughout most of the Yorkshire Coalfield but the ironstones were apparently not worked at Middleton (Edwards and others, 1940). The presence of shallow pits and old crop workings in Middleton Park Woods may indicate that ironstone was extracted along with the Middleton Little Coal. There is no record of the shelly sideritic ironstones above the Flockton Thin Coal having been worked in the area.

6.3 Fireclay

The fireclay beneath the Better Bed Coal was the principal stratum worked south of Leeds, generally along with the coal. The chief site of industry built around its extraction and use as a refractory was at Middleton Broom colliery in the northwest.

6.4 Shale

In general, the shaly beds of the Coal Measures vary widely in their properties but several horizons produced useful material for the brick making industry. Brick making was carried out at Middleton Broom and at Robin Hood, working strata at the levels of the Brown Metal Coals and those below the Horbury Rock respectively. Where appropriate, local siltstones and finer-grained sandstones were also used. This industry has now ceased.

6.5 Sandstone

The only sandstone of any economic importance is the Thornhill Rock, the lower unweathered parts of which are a source of good quality building stone. It is no longer worked in the area but was formerly quarried extensively at Thorpe on the Hill and in several places along the Leeds-Wakefield road. These workings are now back-filled. Their approximate former extent is shown on the map. Small quarries are also recorded in Middleton Park Woods, at Kiddaw Spring and in several other locations across the outcrop but the sandstone recovered was presumably only used locally for constructing roads and walls. The Thornhill Rock has a very extensive outcrop, but much is sterilized by development. Although all extraction has ceased the potential resources are high, the main constraints at present being economic rather than geological.

Other, but less significant sandstones such as the Emley Rock and the Horbury Rock have been worked locally but are inferior in quality to the Thornhill Rock.

6.6 Sand and Gravel

A thick deposit (maximum 9 m) of glacial sand and gravel caps the high ground in the northeast of the area with scattered minor occurrences elsewhere. It was formerly worked from several pits at Rothwell Haigh and put to a variety of uses, including, in the late 17th and early 18th centuries, a local glass industry (Smith, 1974). A considerable thickness probably remains but is now almost entirely sterilized by housing developments.

7. GEOLOGY: CONSTRAINTS ON PLANNING

The principal geological constraint upon planning and engineering is subsidence, whether it be due to undermining, differential compaction of strata and Made Ground, or to faulting. Much of the area covered by Sheet SE 32 NW is likely to be affected by at least one of these factors. The distribution of faults is shown in Figure 6, and that of Made Ground and Old Workings on Environmental Geology Maps (EGMs) 1 and 4 respectively.

There are currently no working collieries in the area, but where an area has been extensively undermined, either at shallow depth or at deeper levels, there is a possibility of subsidence for some time after the date of mining. The rate at which workings tend to collapse depends upon the method of extraction, the geological conditions and the spread of ages of mining; it cannot be assumed that all settlement has ceased. Shallow mining and crop workings are known in several parts of the area such as Middleton Woods, Belle Isle, the Bushey Cliffe Wood area and East Ardsley. In Middleton Woods there are numerous excellent examples of bell-pits and shallow crop-workings in the Brown Metal Coals. In the East Ardsley area the Haigh Moor Rock forms a strong roof to the Haigh Moor Coal and old workings by the pillar and stall method may still be open. These specific examples show that in all 'coalfield' areas it is essential to carry out a careful examination of all available mining records and a detailed site investigation prior to any development. The extent of mining in the past is evident from the vast number of abandoned shafts. Locating these should be given high priority during site investigation. In some cases several shafts are shown closely grouped on the geological map, as for example at Perserance Cottage, Rothwell [3317 2885]. Such occurrences should be treated with care, for it is not clear from the original data whether the shafts positions represent individual shafts or the same shaft incorrectly located on other archival documents.

The widespread distribution of Made Ground and Fill may present problems for the Planning Authorities because of the varied chemical content and degree of compaction of the materials used. Potential development sites either wholly or partly on such deposits should be investigated fully giving consideration to the problem of subsidence due to differential compaction of foundations.

Similar considerations apply to sites crossed by faults or underlain by more than one type of rock. Movement along faults, in response to either regional

or local (generally mining-induced) tectonics can cause subsidence. Such movements are infrequent, but the possibility should be borne in mind when siting developments in areas crossed by major faults, such as the Morley-Campsall fault belt. Slope instability also causes foundation problems. Slippage of strata and the down-slope mass-movement of superficial deposits can occur when embankments and cuttings are over-steepened. Landslips are not at present widespread in the Rothwell area. However, a small slip has occurred in Made Ground about 1 km east of East Ardsley along the margin of the valley of Bowling Beck near the sewage works [3148 2593]. Similar ground, where streams are eroding the base of colliery or other waste tips, requires particular care when developments are planned.

In assessing the future needs of the area in general, consideration should be given to siting major developments where they will not sterilize resources. A case in point is the Sand and Gravel deposits in and around Rothwell, which are already largely sterilized by housing.

8. ENVIRONMENTAL GEOLOGY MAPS

Four environmental geology maps have been produced to illustrate various aspects of the geology in a readily assessable form for use in present and future planning and development. The maps cover: (i) Distribution of Made Ground; (ii) Distribution of Drift Deposits; (iii) Borehole Locations; and (iv) Underground Mining.

MAP 1 Distribution of Made Ground

Six categories of Made Ground are distinguished on this map. The categories are (i) Landscaped Ground (ii) Made Ground, undifferentiated (iii) Back-filled Quarries (iv) Back-filled Opencast Coal Workings (v) Colliery Waste Tips (vi) General Refuse Tips. They are discussed in Section 5.

MAP 2 Distribution of Drift Deposits

Recent Alluvial deposits and Glacial deposits are depicted on this map. In addition, Head (soliflucted material) and downwash are widespread, mantling much of the solid sequences, but because they are thin and lacking in distinguishing characteristics it is not possible to delimit them accurately and most have not been shown. The deposits are discussed in more detail in Section 4 of this report.

MAP 3 Borehole Locations

The locations of all known boreholes or of areas where shallow drilling has been particularly intensive are shown on this map, where the records of such holes form part of the British Geological Survey's archives. However, it is recognised that many locations have been omitted. Additionally, due to confidentiality, it has not been found possible to include the holes drilled by the National Coal Board during exploration for the numerous opencast sites.

MAP 4 Underground Mining

Coal has been extracted in this area since the late eighteenth century, but all mining has now ceased. Records and large-scale plans of abandoned mines held by the National Coal Board have been examined and provide some information on the extent of disused workings. However, many of the older workings have no known plans. Their presence must be inferred from boreholes, old shafts and tips, and from archival information. Old coal workings are present at

depths ranging from immediately subsurface to over 300 m. An arbitary depth of 30 m has been chosen to separate shallow and deep workings.

On the environmental map, three categories of ground are shown: (i) Areas where coal is known, or inferred, to have been worked less than 30 metres below rockhead; (ii) Areas where coal is known, or inferred, to have been worked at depths greater than 30 metres below rockhead; and (iii) Areas where no workings are known. Particular care is required when developments are planned in areas where the thicker coals (Middleton Main, Haigh Moor, Stanley Main) are close to the surface, as old pillar and stall workings may stand open for many years, possibly collapsing only after changes in groundwater conditions or after overloading at critical points such as roadway intersections.

The map also shows positions of mineshafts, though it is unlikely that all have been located. Also shown are worked-out opencast sites and the former brickpit at Robin Hood from which the Haigh Moor coals were opencasted. The information given on the underground mining map is generalised. For detailed information on former shafts and mining subsidence problems, reference should be made to the National Coal Board (see page 4).

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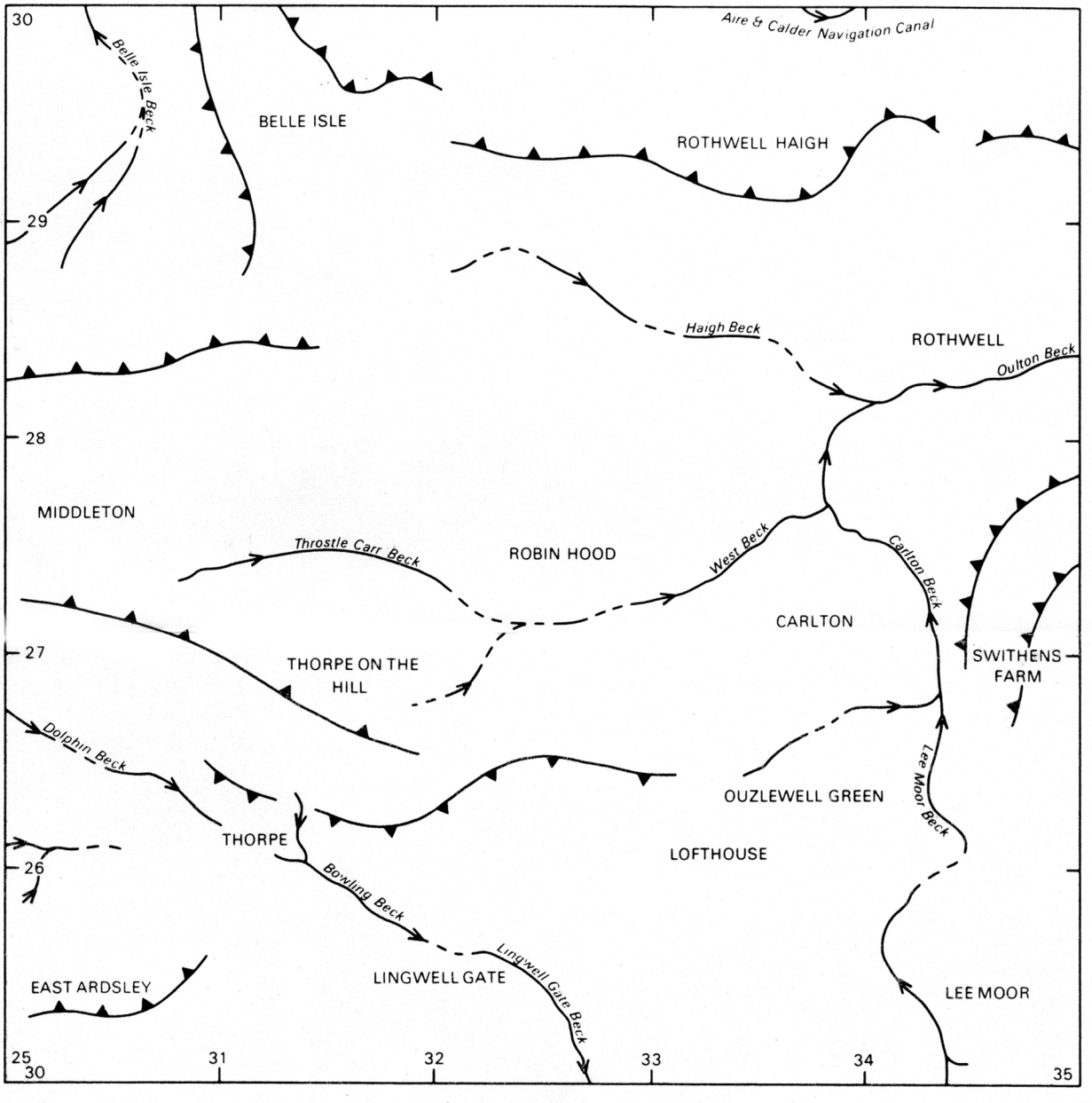


FIGURE 1. Outline map of the area showing main locations referred to in the text, main drainage system and prominent escarpments

Drainage

Escarpments

WA/DM/84/001

VERTICAL SCALE
(metres)

50
40
30
20
10
0

SE 32 NW

KEY

Sandstone
Siltstone and mudstone
Coal
Coal (worked out)
Seatearth
Ironstone (shown diagrammatically)

1 MIDDLETON NEW COLLIERY
2 MIDDLETON BROOM COLLIERY
3 NEW HALL COLLIERY
4 STOURTON VILLA (bore)
5 COUSINS PIT ROTHWELL HAIGH COLLIERY
6 BYE PIT ROTHWELL HAIGH COLLIERY
7 BEESTON PIT ROTHWELL HAIGH COLLIERY
8 UPCAST PIT WEBSTERS FARM ROTHWELL HAIGH COLLIERY
9 FANNY PIT ROTHWELL HAIGH COLLIERY
10 PARK PIT WATERLOO MAIN COLLIERY
11 DAM PIT WATERLOO MAIN COLLIERY

NO DETAILS

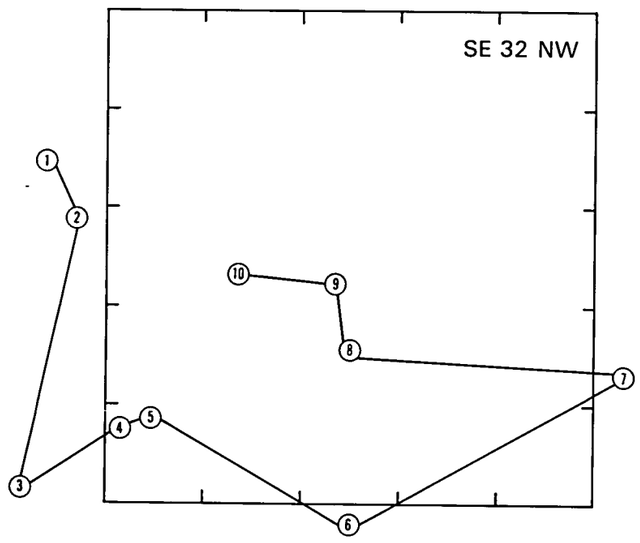
Flockton Thick
Flockton Thin
1st Brown Metal
2nd & 3rd Brown Metals
Middleton Little
Middleton Main
Wheatley Lime
Middleton Eleven Yards
Blocking
Beeston
Crow
Black Bed
Better Bed

1st Brown Metal Coal
2nd Brown Metal
3rd Brown Metal
Middleton Little Coal
Middleton Main
Middleton Eleven Yards
Rider
Blocking
Blocking Coal
Beeston
Beeston Coal
Crow
Crow Coal
Black Bed

Rothwell Report
SE 32 NW
WA/DM/84/001

FIGURE 2. REPRESENTATIVE VERTICAL SECTIONS OF STRATA : NORTHERN PORTION (Vertical Scale 1:1000)

VERTICAL SCALE
(metres)
50
40
30
20
10
0



KEY
Sandstone
Siltstone and mudstone
Coal
Coal (worked out)
Seatearth
Ironstone (shown diagrammatically)

① BEESTON MANOR NO 2 PIT
② WEST PIT MIDDLETON COLLIERY
③ RED PIT ARDSLEY
④ FAN SHAFT EAST ARDSLEY COLLIERY
⑤ PUMPING PIT EAST ARDSLEY COLLIERY
⑥ LOFTHOUSE COLLIERY
⑦ SPENCER PIT NEWMARKET COLLIERY
⑧ DOLPHIN A 26 (bore)
⑨ JANE PIT ROBIN HOOD COLLIERY
⑩ CASTLE PIT ~~ROBIN HOOD~~ COLLIERY

Kents Thin
Kents Thick Coal
Methley Park Coal
Warren House
Beck Bottom Stone
Twenty Seven Yards
Swallow Wood
Rider
Haigh Moor
Joan Coal
Joan
Smith
Flockton Thick
Flockton Thin
1st Brown Metal
2nd Brown Metal
3rd Brown Metal
1st,2nd and 3rd Brown Metals
Middleton Little
Middleton Main
Middleton Main Coal
Middleton Main Wheatley Lime
Middleton Eleven Yards
Middleton Eleven Yards Coal
Blocking
Blocking Coal
Beeston

FIGURE 3. REPRESENTATIVE VERTICAL SECTIONS OF STRATA: SOUTHERN PORTION
(Vertical Strata 1:1000)

WA/DM/84/001

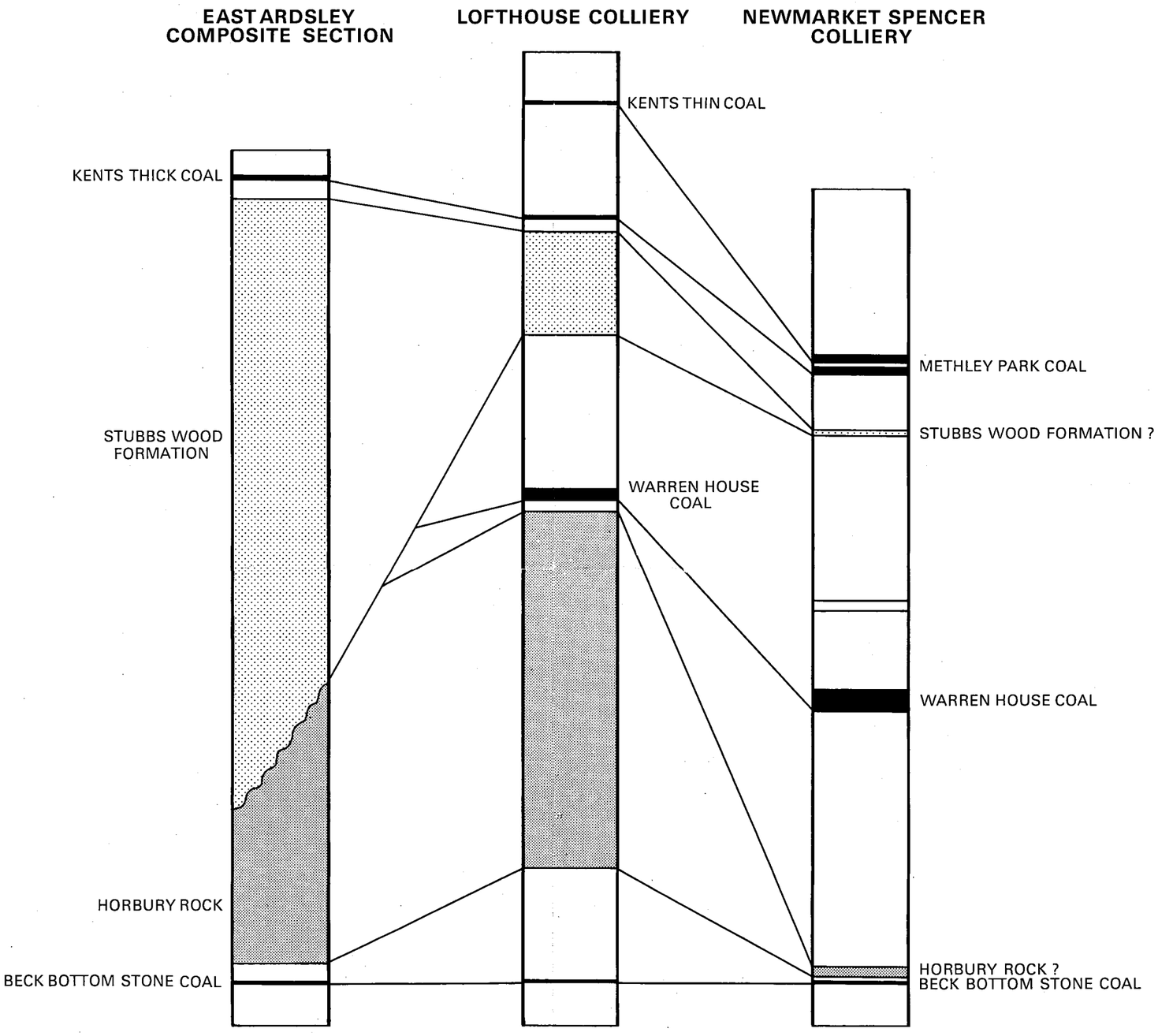
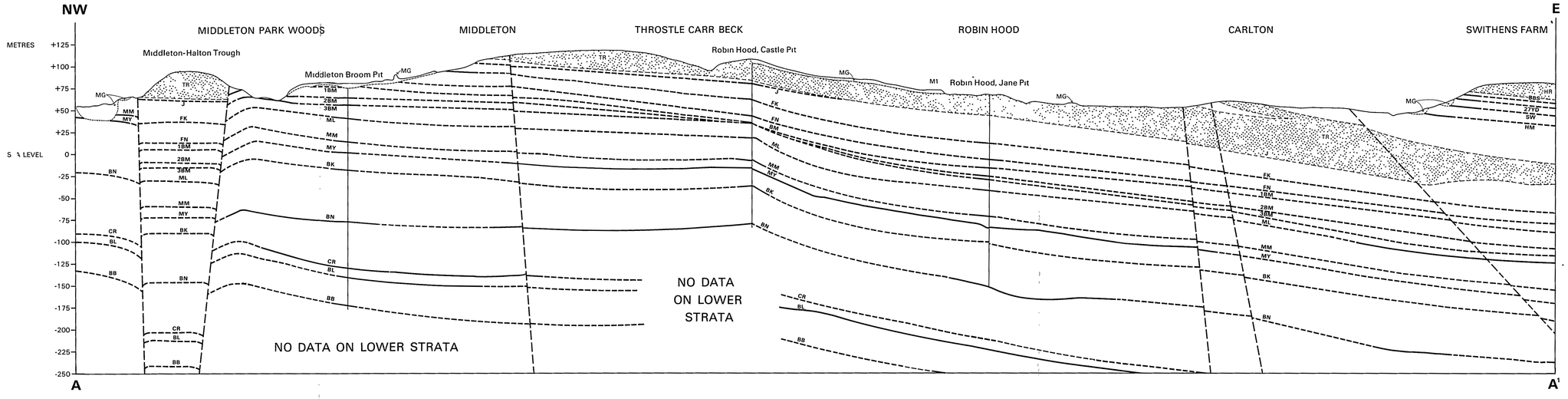
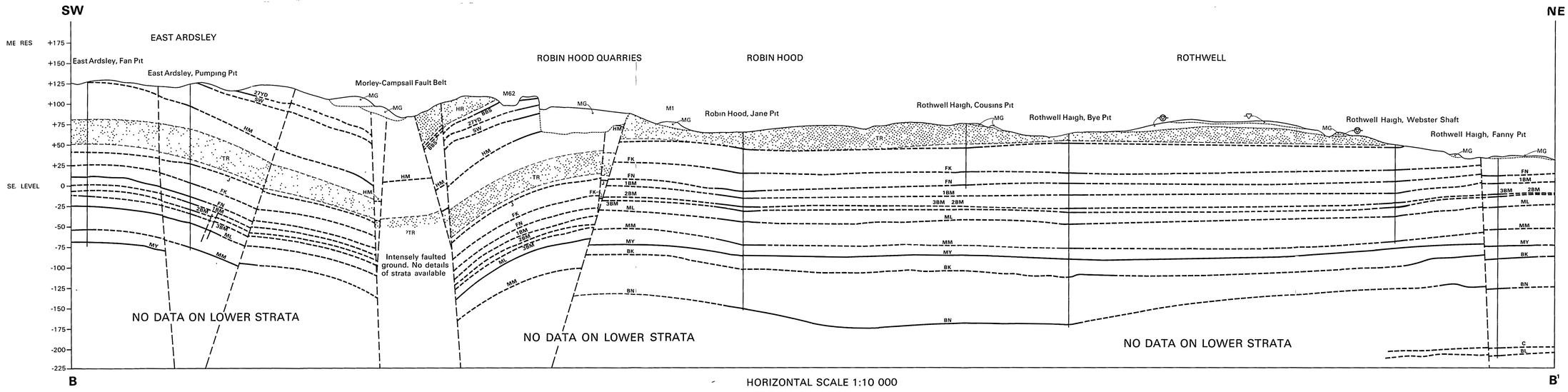


FIGURE 4: DIAGRAMMATIC VERTICAL SECTIONS SHOWING THE POSSIBLE RELATIONSHIP BETWEEN STUBBS WOOD FORMATION AND THE HORBURY ROCK, THE RAPID FACIES CHANGE ACROSS THE AREA AND THE 'WASHOUT' IN THE WARREN HOUSE COAL.





HORIZONTAL SCALE 1:10 000
VERTICAL EXAGGERATION x 4

British Geological Survey

(Figure 5)

Generalised Horizontal Sections

SHEET SE 32 NW

(Rothwell)

Based on a 1 10 000 geological survey by J R A Giles and I T Williamson, 1983
J J Chisholm and I C Burgess, Programme Managers
G M Brown, DSc , F R S , Director, British Geological Survey

Production of this map was supported by the Department of the Environment

MG Made Ground

Glacial Sand and Gravel

Till

Major Sandstones (TR-Thornhill Rock, HR-Horbury Rock)

Geological Boundary, Drift and limits of Made Ground

Geological Boundary, Solid

MM Coal seams For details of abbreviations see Generalised Vertical Section on 1 10 000 Geological Map

Faults

Broken lines denote uncertainty

For position of sections see 1 10 000 Geological Map

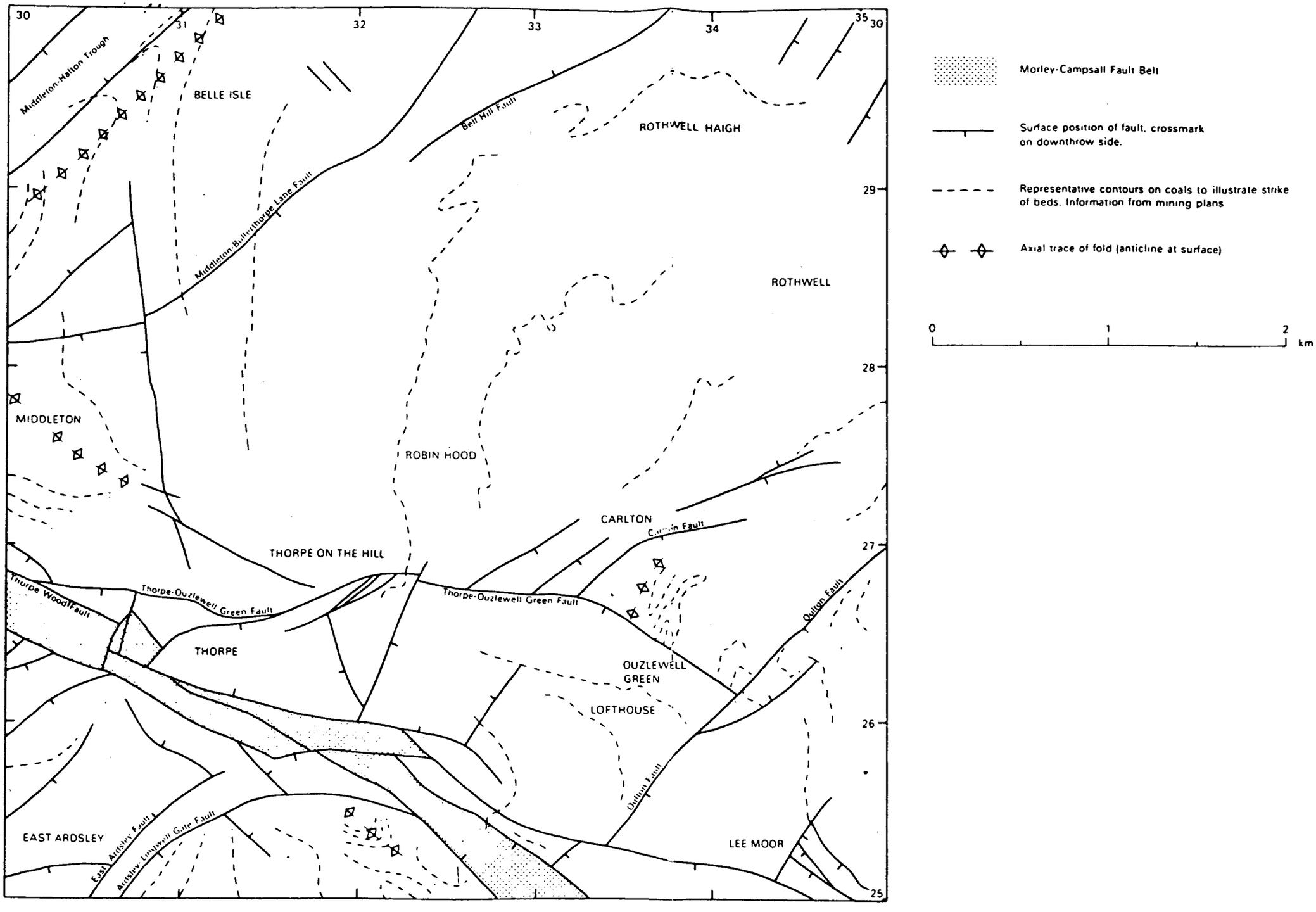


FIGURE 6. Principal Structural Features (SE 32 NW)

HEIGHTS IN METRES

ORDNANCE SURVEY

SHEET SE 32 NW

BRITISH GEOLOGICAL SURVEY

Environmental Geology Maps
(Rothwell)

SCALE 1:10 000

SHEET SE 32 NW

MAP 1: DISTRIBUTION OF MADE GROUND

Based on a 1:10 000 geological survey by J.R.A.Giles and I.T.Williamson.
1983, J.I.Chisholm and I.C.Burgess, Programme Managers.
G.M.Brown, D.Sc., F.R.S., Director, British Geological Survey.

Production of this map was supported by the Department of the Environment.

Landscaped ground

Made ground, Undifferentiated

Backfilled quarries, nature of fill unknown

Backfilled opencast coal workings

Colliery waste tips

General refuse tips

Outlines of old quarries, now backfilled, and of many areas of made ground, are derived from documentary sources. It is not claimed that all such quarries and deposits have been located, or that the limits shown are accurate.

The 'Landscaped ground' category comprises areas such as industrial estates, where the original topography has been extensively remodelled by earth-moving and tipping. Made ground is widespread, but its full extent cannot be determined.

A geological account accompanies this map:

Williamson, I.T. and Giles, J.R.A., 1984. Geological notes and local details for 1:10 000 sheets: Sheet SE 32 NW (Rothwell). (Keyworth; British Geological Survey).

Any enquires regarding this map should be directed to:

British Geological Survey,
Nicker Hill,
Keyworth,
Nottingham NG12 5GG.

THIS MAP IS TO BE USED ONLY FOR PRELIMINARY STUDIES AND IS NOT INTENDED AS A SUBSTITUTE FOR ON-SITE INVESTIGATION.

THIS MAP GIVES AN INTERPRETATION OF DATA AVAILABLE AT THE LAST DATE OF SURVEY, ADDITIONAL INFORMATION IS AVAILABLE IN B.G.S. FILES.

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SE 32 NW

HEIGHTS IN METRES

ORDNANCE SURVEY

SHEET SE 32 NW

WA/DM/84/001

BRITISH GEOLOGICAL SURVEY

Environmental Geology Maps
(Rothwell)

SCALE 1:10 000

SHEET SE 32 NW

MAP 2: DISTRIBUTION OF DRIFT DEPOSITS

Based on a 1:10 000 geological survey by J.R.A.Giles and I.T.Williamson. 1983. J.I.Chisholm and I.C.Burgess, Programme Managers. G.M.Brown, D.Sc., F.R.S., Director, British Geological Survey.

Production of this map was supported by the Department of the Environment.

- Head*
- Peat
- Alluvium
- River Terrace, Undifferentiated
- Till
- Glacial Sand and Gravel

*Much of the area is covered by a widespread, but normally thin, deposit of sandy clay which includes head and deposits of associated origin. It has been possible to delineate only the thicker and more persistent of these deposits.

See accompanying report for details.

A geological account accompanies this map:

Williamson, I.T. and Giles, J.R.A., 1984. Geological notes and local details for 1:10 000 sheets: Sheet SE 32 NW (Rothwell). (Keyworth; British Geological Survey).

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HEIGHTS IN METRES

ORDNANCE SURVEY

SHEET SE 32 NW

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BRITISH GEOLOGICAL SURVEY

Environmental Geology Maps (Rothwell)

SCALE 1:10 000

SHEET SE 32 NW

MAP 3: **BOREHOLE LOCATIONS**

Based on a 1:10 000 geological survey by J.R.A.Giles and I.T.Williamson, 1983. J.I.Chisholm and I.C.Burgess, Programme Managers. G.M.Brown, D.Sc., F.R.S., Director, British Geological Survey.

Production of this map was supported by the Department of the Environment.

- ⊙ Borehole
- ⊙U Underground borehole
- NCB Opencast exploration area

A geological account accompanies this map:

Williamson, I.T. and Giles, J.R.A., 1984. Geological notes and local details for 1:10 000 sheets: Sheet SE 32 NW (Rothwell). (Keyworth; British Geological Survey).

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BRITISH GEOLOGICAL SURVEY

Environmental Geology Maps
(Rothwell)

SCALE 1:10 000

SHEET SE 32 NW

MAP 4: UNDERGROUND AND OPENCAST MINING

Based on a 1:10 000 geological survey by J.R.A.Giles and I.T.Williamson.
1983, J.I.Chisholm and I.C.Burgess, Programme Managers.
G.M.Brown, D.Sc., F.R.S., Director, British Geological Survey.

Production of this map was supported by the Department of the Environment.

- Workings known or inferred at 0 to 30m* depth below rockhead.
- Workings known or inferred at depths greater than 30m below rockhead
- Worked-out opencast coal sites
- No record of mining
- ⊖ Mine shaft
- ⌖ Mine shaft, abandoned
- Adit or mine mouth, abandoned, showing direction of entry

Whilst every effort has been made to trace the sites of mine shafts, it is not claimed that all have been located. For information on exact positions and conditions of shafts, application should be made to the National Coal Board.

All boundaries are generalized and therefore imprecise. For detailed information the large-scale abandonment plans of the relevant seams should be examined. For such information and for information on present and future mining, underground or opencast, application should be made to the National Coal Board.

*Old coal workings are present at depths ranging from immediately sub-surface to over 300m. An arbitrary depth of 30m below rockhead has been chosen to separate shallow and deep workings. For information on the conditions of old workings, application should be made to the National Coal Board.

Shallow workings may be present beneath worked out opencast coal sites.

A geological account accompanies this map:

Williamson, I.T. and Giles, J.R.A., 1984. Geological notes and local details for 1:10 000 sheets: Sheet SE 32 NW (Rothwell). (Keyworth; British Geological Survey).

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