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Geological notes and local details for 1:10 000 sheets.

Sheet SE 32 SE - Normanton

Part of 1:50 000 sheet 78 (Wakefield)

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LIMITATIONS

This report has been produced by collation and interpretation of, and interpolation from, geological, geotechnical and related data from a wide variety of sources. Details of these sources are contained in the report.

This report provides only a general description of the nature and extent of factors relevant to the planning of land use and development.

The data on which this report is based is not comprehensive and its quality is variable, and this report reflects the limitations of that data. No information made available after 1st January 1986 has been taken into account. For these reasons:-

> **This report provides only general indications of ground conditions and must not be relied upon as a source of detailed information about specific areas, or as substitute for site investigations or ground surveys. Users must satisfy themselves, by seeking appropriate professional advice and by carrying out ground surveys and site investigations if necessary, that ground conditions are suitable for any particular land use or development.**

EXECUTIVE SUMMARY

This report embodies the results of a study funded by the Department of the Environment in 1985/6. It aims to provide an up-to-date geological map and account of the solid and superficial geology, and to identify the implications for land-use planning. The study derives its information from two main sources:-

a) archival material comprising mine abandonment plans, opencast mining completion plans, quarry plans, borehole records, tip plans and data held by the BGS National Geoscience Data Centre.

b) a detailed field geological survey by the authors at a scale of 1:10 000.

The resurvey has considerably improved the geological mapping of the solid and superficial deposits. Several additional minor coal seams are delimited and a denuded terrace of the River Calder, lying above the previous highest terrace, is recorded. The Westphalian stratigraphy of the district is described in detail, in modern nomenclature. The generalised geological sequence is shown on the margin of the geological map and in figures 3, 7 and 13 of this report.

THEMATIC GEOLOGICAL MAPS

Some geological themes have particular implications for land-use planning. Special attention was paid during the resurvey to data relating to these themes.

The results are summarized in thematic geological maps covering:-

1. distribution of drift deposits
2. distribution of made ground
3. borehole locations
4. underground and opencast mining.

RELATIONSHIP BETWEEN GEOLOGY AND LAND-USE PLANNING

Of the geological factors which have implications for land-use planning, subsidence, particularly related to shallow mining and the location and extent of mineral resources are especially important.

Subsidence

Where coal was worked at depth, it is reasonable to assume that most of the subsidence occurred a short time after roof supports were withdrawn. But this is not necessarily true of shallow mining, which is common in parts of the district, especially as crop workings.

New Sharlston is the last active colliery in the district, although in the past, mines was much more numerous. Much of the district has been mined at depth, the principal worked seams being the Beeston, Middleton Eleven Yard, Middleton Main, Flockton, Haigh Moor, Warren House, Kent's Thick, Stanley Main, Abdy, Houghton Thin, Sharlston and Shafton (Figures 3,7 and 13).

In shallow workings, the earth pressures may not be sufficient to cause immediate collapse. The rate at which old workings collapse depends upon their depth, the type of extraction pattern, the geological structure and the age of the mining. In addition, new development or building can increase the surface loading and lead to catastrophic collapse. Since many shallow workings date from the earliest days of coal mining and are not shown on extant records or plans, they can be difficult to predict. In many cases, their presence is only proved by detailed site investigation. Numerous abandoned shafts are recorded in the district, but many more unrecorded ones probably exist.

Mineral Resrouces

In planning future developments, it is important to know where the mineral resources are, so that they are not built over before they can be worked. It may be possible to extract workable minerals in advance of development.

Much of the district is underlain by coal at shallow depth; amongst the most important seams are the Sharlston coals, which are regarded locally as prime opencast targets where they occur close to the surface. In addition, sand and gravel was formerly a significant resource in the Calder valley, although much of it has been extensively dug and little potentially workable sand and gravel remains.

Other Constraints on Land-Use Planning

Some of the drift deposits vary in lithology and thickness very rapidly. For example, the river terrace deposits may show differential compaction under load, and compressible beds may occur in buried channels. Head, which is generally too thin to map, may be present in substantial thicknesses locally and may be a hazard to foundations.

Made ground and fill may also constrain development. The varied chemical content and compaction of these materials can be hazardous. Backfilled quarries can give a problem, if they are not recognised during site investigation.

CONTENTS

FIGURES

INTRODUCTION

This report and the accompanying maps are a summary of the geology of 1:10,000 sheet SE 32 SE (Figure 1). It has been produced for the Department of the Environment as Phase 3 of a four-year programme to provide 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 around the rivers Aire and Calder, south-east of Leeds. The geological map is available as an uncoloured dye-line print from BGS, Keyworth.

The district 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 1875 and 1886 as six-inch Yorkshire county sheets 233,234, 248 and 249. The area was resurveyed by W Edwards, D.A. Wray and G.H. Mitchell between the years 1924-1935. A large amount of new information, especially from detailed site investigations for industrial and other developments, roads and mining, has since become available. The present 1:10 000 map incorporates the new data as part of a complete geological resurvey in 1985 by J.R.A. Giles and I.T. Williamson. Details of all the known shafts and boreholes are held in the files of the British Geological Survey. Mining records are held by British Coal and the Mines Records Office. Descriptions of the district, with details of sections that are now obscured, are provided by '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.

Accompanying the geological map and generalized vertical section, are Thematic Geological Maps illustrating particular facets of the geology relevant to the needs of planners and developers:

1. Distribution of Drift Deposits.
2. Distribution of Made Ground.
3. Borehole Locations.
4. Underground Mining.

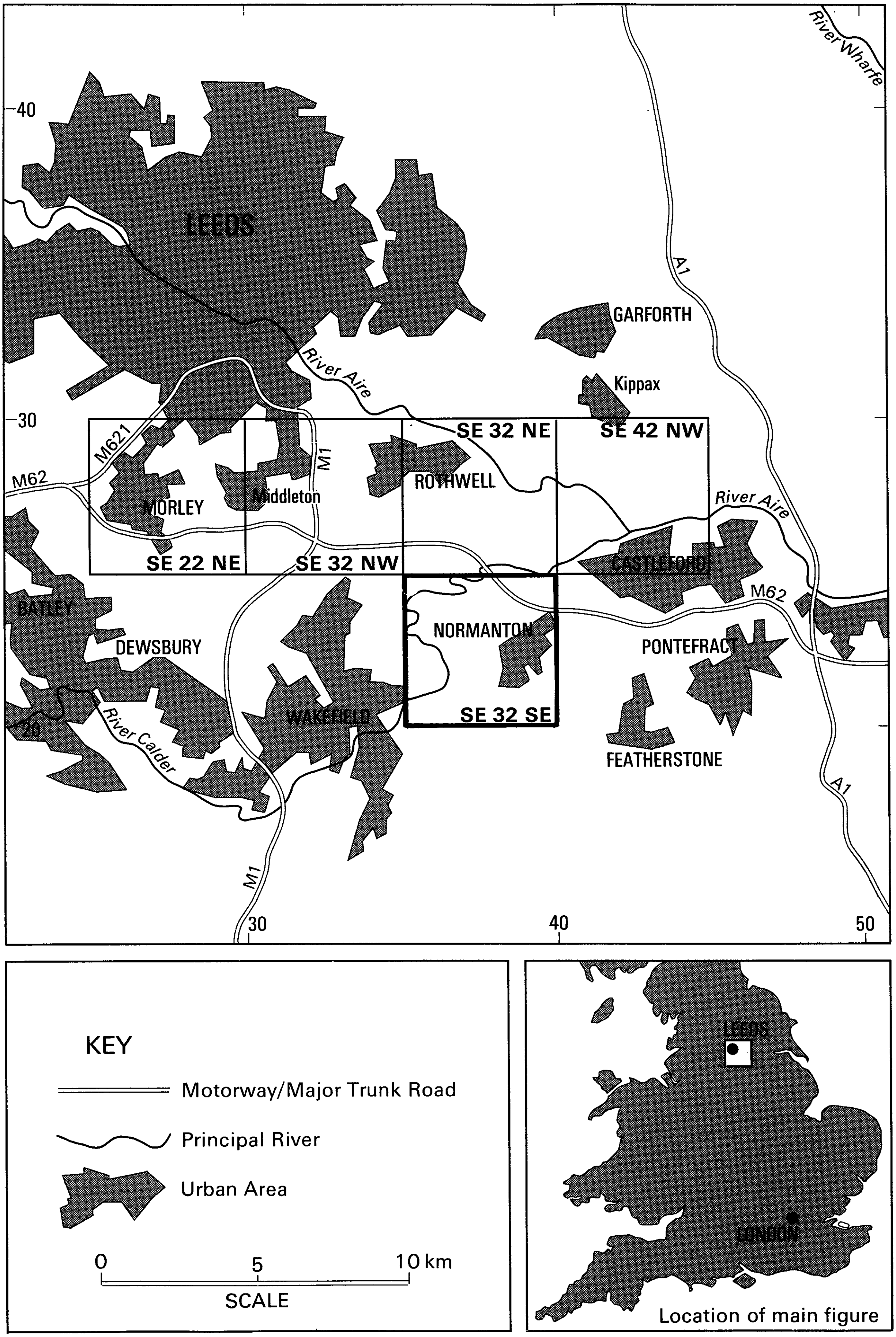

Figure 1 Sketch map showing location of district. Area of this report is shown with bold outline.

1. PHYSIOGRAPHY, POPULATION DISTRIBUTION, COMMUNICATIONS AND LAND USE

The district lies to the east of Wakefield, within the administrative area of the Wakefield District Council. The principle centres of population are Normanton and Altofts. Other scattered villages and hamlets are sited near former collieries. The valley of the meandering River Calder trends northwards across the western half of the district. The remainder of the ground is moderate, rolling relief, with a few bold escarpments formed by major sandstones such as the Oaks Rock and Warmfield Rock. The latter forms the highest point, 81m OD, at Plump Hill [3717 2091]. About half the area is rural, being devoted largely to arable farming with a little livestock rearing. Woodland is almost absent, except for isolated copses on the steepest slopes where they act as windbreaks. An area of landscaped parkland remains north of Heath Hall [3565 2034].

The district is crossed by the M62 motorway and the A655 Wakefield to Castleford road. Railway lines from Leeds, Wakefield and Barnsley converge at Goosehill Junction [3769 2215]. The canal of the Aire and Calder Navigation runs parallel to the River Calder along its valley.

Widespread coal mining since the late eighteenth century has left its mark on the landscape in the form of extensive waste tips, reclaimed opencast sites and numerous shafts. One mine, New Sharlston Colliery, is still working, and widespread opencast operations continue.

Sand and gravel, brickclay, ironstone and fireclay have been worked. Widespread dereliction of the Calder valley has been caused by sand and gravel extraction, followed by the tipping of domestic and colliery waste into the excavations. Some disused brickpits have also been backfilled with domestic and colliery waste.

2. COAL MEASURES (WESTPHALIAN)

2.1 GENERAL

The district is underlain by Coal Measures of Westphalian A,B and C age forming part of the West Yorkshire coalfield. About 175m of Westphalian C strata are exposed at the surface and a considerable thickness of Westphalian A and B strata, including numerous worked coals, lies at depth. The beds are mainly gently dipping and slightly folded; dips are commonly steeper near faults. To a large extent the solid rocks are obscured, by a mantle of soil, weathered and soliflucted Head, patches of thicker drift, urban development or waste tips. The few exposures which remain, are largely confined to disused quarries and other artificial sections. Details of the solid geology are taken mainly from archival material.

Sections of the boreholes and shafts used in the project are stored in the B.G.S. archives, and are indexed on 1:10 000 or 1:10 560 National Grid Maps of the Ordnance Survey. These archives may be examined on application to the National Geosciences Data Centre, British Geological Survey, Keyworth, Nottingham NG12 5GG.

The mine-plans examined during the resurvey are listed in Appendix A, as are details of their availability. Appendix B lists the BC Opencast information used in the project.

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 and in Figures 3, 7 and 13. Details of coal sections are given in Green, and others 1878 and Edwards and others, 1940, and have not been repeated in this report. Throughout, the term 'seam' means the combined thickness of coal and dirt partings, whereas 'leaf' refers to coal between dirt partings.

2.2 CLASSIFICATION

The Coal Measures in Yorkshire are subdivided into Westphalian A, B and C, in ascending order, on the basis of their fossils, with the boundaries at specific marine bands (Stubblefield and Trotter, 1957).

2.3 COAL MEASURES LITHOLOGIES

The most common lithologies are interbedded claystones, mudstones, silty mudstones and siltstones. They are generally barren of fossils except in discrete bands. Sedimentary structures comprise wave-ripple and lenticular bedding; bioturbation and soft-sediment deformation are also common. Ironstone nodules may be associated with these lithologies. The terms claystone and mudstone have been taken to be synonymous with the old mining terms bind, drub, blaes, metal and shale. Likewise, siltstone is synonymous with stone bind, fakey blaes and slaty stone.

The sandstones are normally fine-grained and are grey when fresh. However, oxidation of the contained iron causes weathered sandstones to be brown. Coarser grained lenses of intraformational breccias composed of angular mudstone and ironstone clasts, represent channel-lag deposits and occur in the thicker sandstones. The sandstone beds may be lenticular and less than 1 cm thick or many metres thick. The latter include named sandstones such as the Warmfield Rock and the Oaks Rock. The bedding varies from massive to flaggy. Sedimentary structures included flat lamination, wave-ripple bedding, trough cross-bedding, flaser and lenticular bedding. Bioturbation and soft-sediment deformation structures are also common. Fossil assemblages are dominated by plant material, particularly comminuted plant debris on the bedding surface of the more micaceous sandstones. The mining terms cank, freestone, galliard, post, rag and stone appear to be synonymous with sandstone.

The seatearths include all grades of sediment from claystone to sandstone, but generally they are unbedded and contain many rootlets. They normally lie directly beneath coals, but some are laterally more extensive than the associated seam. The equivalent old mining terms are clunch, earth, fireclay, ganister, spavin, stone clunch and stone spavin.

Coal, formally defined, is a readily combustible rock containing more than 50 per cent by weight, and more than 70 per cent volume, of carbonaceous material. Coal are laterally extensive, but can change their thickness or number of dirt partings, and can die out laterally. The coals of the district are bituminous, and generally increase in rank southwards (Wandless 1960).

Tonsteins are dense mudstones containing kaolinite aggregates and crystals and they usually less than 6 cm thick. Although rare, they are laterally extensive and commonly isochronous. They are generally considered to be kaolinised ash-fall tuffs or reworked volcanic detritus (Williamson, 1970).

Rare limestones are present, but they are thin and discontinuous. Eager and Rayner (1952) recorded a 0.15 m "shelly limestone" (probably an impure bio-sparite) from the former Westgate Brick Works [3140 2040]. Trueman (1954, pp 27) comments that, 'slabs of mussel bands contain so much carbonate of lime, with varying amounts of carbonate of iron (chalybite), that they form limestone-like masses'. Such limestone, locally called 'cank', are recorded in New Sharlston, Park Hill and St. John's No 2 collieries.

Ironstone, mainly in the form of impure siderite, is ubiquitous. It mostly occurs as nodules, bands and lenses of clay ironstone within mudstones. At certain horizons, such as the Black Bed Ironstone, sufficient concentrations of iron exist to have made the sideritic ironstone workable as an iron ore in the past.

Oolitic ironstones have also been recorded from the sequence. Dean (1935) records a variable oolitic ironstone, up to 0.25 m thick (Godwin, written communication), in the Robin Hood Quarry [3240 2720] at the horizon of the Swallow Wood coal.

2.4 PALAEOGEOGRAPHY AND SEDIMENTOLOGY

During the Upper Carboniferous, the district formed a small part of the Pennine depositional province, which was in turn part of the north-west European paralic belt. Generalised Westphalian palaeogeographical maps, based on Calver 1969 and Eames 1975, are published by Anderton and others (1979, Figs 11.18 and 11.23). Palaeomagnetic data for Westphalian coals is published by Noltimier and Ellwood (1977). Palaeomagnetic data for the Carboniferous is reviewed by Turner and Tarling (1975, pp 483-485) and Scotese and others (1979, pp 222, 229 and Figs 32 and 33). These suggest an equatorial palaeolatitude for much of the Carboniferous, including the Westphalian. Over a dozen plate-tectonic models have been proposed to account for the palaeomagnetic data, palaeogeography and phases of deformation in the Hercynides, and these are reviewed and discussed by Anderton and others. (1979, Ch. 12).

The main depositional environment was a fresh-water association of deltaic, fluvial and lacustrine sedimentation with sporadic marine incursions. Within the sediments of the Pennine depositional province, a number of facies have been identified (Fielding 1984 a and b; Haszeldine 1983, 1984; Haszeldine and Anderton, 1980; Scott, 1978), which can be grouped into several facies associations and interpreted in the terms of the main environments on the subaerial delta plain of the Mississippi (Coleman and Prior 1980). These environments are distributary channel fill, interdistributary bays, swamps and crevasse splays. A generalised diagram illustrating the relationships of the major depositational environments is shown in Figure 2. In addition to these, marine incursions have resulted in the formation of marine bands.

Distributary Channel Fill

Thick, cross bedded sandstones with sharp bases, deposited in elongate belts, 2 km or more wide, are interpreted as major distributary channels. The sandstones represents sand bars laid down at times of high or low water discharge. Thinly interbedded sandstones, siltstones and claystones, in elongate belts parallel to distributary channel deposits, are overbank flood deposits.

Interdistributary Bays

Interdistributary bays are dominated by fine-grained sediments. The main facies comprises sheet like deposits, normally less than one metre thick, of black, thinly laminated, carbonaceous claystones; the thin sporadic

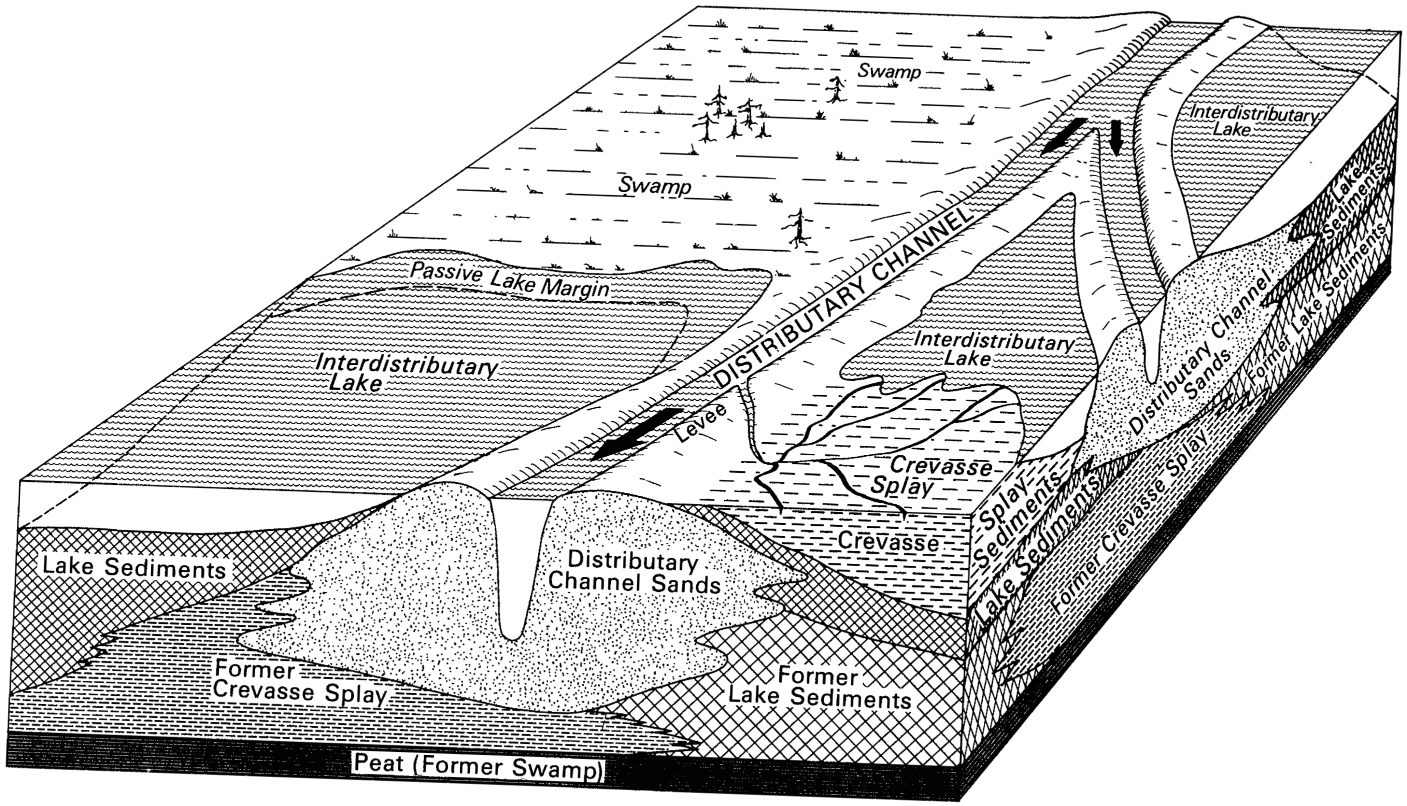

Figure 2 Generalised diagram illustrating the relationships of the major Westphalian depositional environment.

limestones are also closely associated with this facies. The fossils are non-marine bivalves, crustaceans, plant debris and fish debris. This facies association originated on the anoxic floors of the lakes isolated from the main sediment sources by swamps and distributary channel levees.

The anoxic lake floor deposits may pass laterally into massive or laminated claystones, commonly with rootlets, containing non-marine bivalves and plant debris, laid down in elongate, narrow belts parallel to coal seam splits. This facies represents a passive lake margin where the lake shallows into a swamp.

The preceding two facies are frequently overlain by sheet-like spreads of massive or laminated claystones containing non-marine bivalves, crustaceans and plant debris, commonly with numerous trace fossils. The facies represents and input of fine sediment into the lake, either as the most distal deposits of a crevasse splay or as overbank claystones from a distributary channel.

Swamps

There are two main facies to this association. Seatearths, which may vary in grain size from claystone to sandstone, generally tends to become finerupwards. Rootlets are diagnostic, plant debris and trace fossils are common and the facies has a sheet-like geometry. Seatearths are commonly found beneath coal, but not always. Buringh (1970) suggested that seatearths represent subaqueous azonal soils.

The second facies of this association is the coal itself. This forms a sheet-like body which may pass laterally into rooted claystones at the lake margin. It consists almost entirely of plant debris and is interpreted as representing a swamp.

Crevasse Splays

This facies association comprises coarsening-upward sequences from claystones and siltstones through to thin, channelled sandstones with erosive bases. As the coarseness increases upwards, the diversity of the fossils decreases from the varied assemblage of an anoxic lake floor to non-marine bivalves plus plant debris, and finally to just plant debris in the channel sandstones. The association is thought to represent the progressive filling of an interdistributary lake by one or more crevasse splays. During a flood, the levee or bank of a major distributory channel is breached allowing a minor channel and a distributory delta to form. The progressive encroachment of these small deltas and the succeeding delta-top channel sandstones, produces the coarsening-up sequences and changes in fossil assemblages. Fielding (1984a) identifies three main facies in this association which he interprets as proximal major crevasse splay channels, medial crevasse splays/minor deltas and distal crevasse splays/minor deltas.

Marine Bands

Dark grey to black, fissile, laminated claystones in extensive sheets dominate this facies. The marine faunas include bivalves, brachipods, crinoids, bryozoa, fish, goniatites and plant debris. Calver (1968 a and b) has described the faunal 'phases' of the marine bands, the possible spatial relationships of the marine communities, and how they relate to the other facies belts.

Rates of Sedimentation

Rates of sedimentation in the Coal Measures have been discussed by Broadhurst and others (1970, 1980), Stach (1982) and Haszeldine (1984), who conclude that the rates vary considerably from facies to facies. The slowest rates probably occur in the anoxic lake bottoms of the black mudstone facies. Haszeldine (1984, pp 812) comments "black mudstone layers represent rock accumulation rates of about 0.5 m/10^6 years over time spans of at least 5000 years". Stach (1982, pp 17-18), in discussing the accumulation rates for coals concludes that "1 metre of bituminous coal probably represents accumulation over approximately 6000 - 9000 years".

Sedimentation rates for the other main facies are probably much more rapid. The depositional rates of distributary channel fills can be envisaged, from Haszeldine's (1983) description of the palaeo-river which deposited the Seaton Sluice Sandstone; "Medial bars migrated westwards parallel to the river-channel axis and then accreted onto the northern bank as part of a large lateral bar. The whole 10-m thick sandstone at Seaton Sluice was deposited as part of one bar within a 1.9-km-wide low-sinuousity river". Kirk (1983) likewise describes former channel bars producing sandstones up to 7 m thick. In terms of geological time, such sandstones are deposited very quickly.

Broadhurst and others (1970) describe the sedimentation of overbank deposits, noting that upright tree trunks are preserved in the sediment. This indicates that many metres of sediment were deposited in a single, rapid event. An example of such a fossil tree was noted during the resurvey in the St Aidens Extension Opencast site [3858 2848] above the Warren House Coal.

Similarly, the rates of sedimentation by crevasse splays into interdistributary lakes are high. Modern Mississippian sedimentation rates of 10 to 50 years for 1 m of sediment have been recorded. Even allowing for compaction, this is geologically rapid.

Broadhurst and others (1980) have put forward a convincing case for seasonal sedimentation in some parts of the Westphalian sequence of the Pennine depositional province.

Cyclothems

The terms rhythms, cycles and cyclothems are frequently used in connection with Coal Measures deposits. The case for and against cycles has been discussed by Duff and Walton (1962), Duff and others (1967) and Westoll (1968). Repeated small-scale coarsening-upward cycles are certainly present in parts of the Westphalian, and are thought to represent crevasse splays prograding into interdistributary lakes during phases of nett subsidence.

2.5 STRATIGRAPHY

LOWER COAL MEASURES (Westphalian A)

Measures between the Subcrenatum Marine Band and the Better Bed.

Little is known about this part of the sequence in the district. At crop to the north, the measures consist of the Ganister Coals and the Elland Flags, together about 180 to 200 m thick. To the south in South Kirby No 1 Borehole [4546 1092], the equivalent beds are about 300 m thick.

Better Bed Coal

The lowest beds recorded in the district are the Better Bed Coal and its associated mudstone-seatearth; they were proved in Fox Pit, West Riding Collieries, as 0.90 m of mudstone-seatearth, overlain by 0.27 m of coal at 472.85 m depth. An extensive industry grew up to the south-east of Leeds extracting the Better Bed seatearth as a refractory clay. However, the proving at Fox Pit seems to have been uneconomic, as no records exist of it having been worked.

Measures between the Better Bed and Black Bed

The shaft at Fox Pit, which is the only record of these strata in the district, shows the Better and Black Bed coals to be 35m apart. The lowest beds are mudstone, with a few bands of siltstone, passing up into sandstones up to 4 m thick, interbedded with mudstone. The sequence probably correlates with the Thick Stone around Leeds.

Black Bed Coal

This is 0.55 m thick in the Fox Pit shaft and in St John's Colliery No.10 Underground Borehole [3633 2167], it is 0.43 m thick. The coal was worked from Fox Pit [3748 2445] and from Altofts Colliery [3894 2419] by across-measure drift from the Beeston Seam. Unfortunately, no record of this drift is preserved. The seam section, recorded on abandonment plans 9850 and NE 109, shows a single leaf of coal 0.53 m to 0.61 m thick.

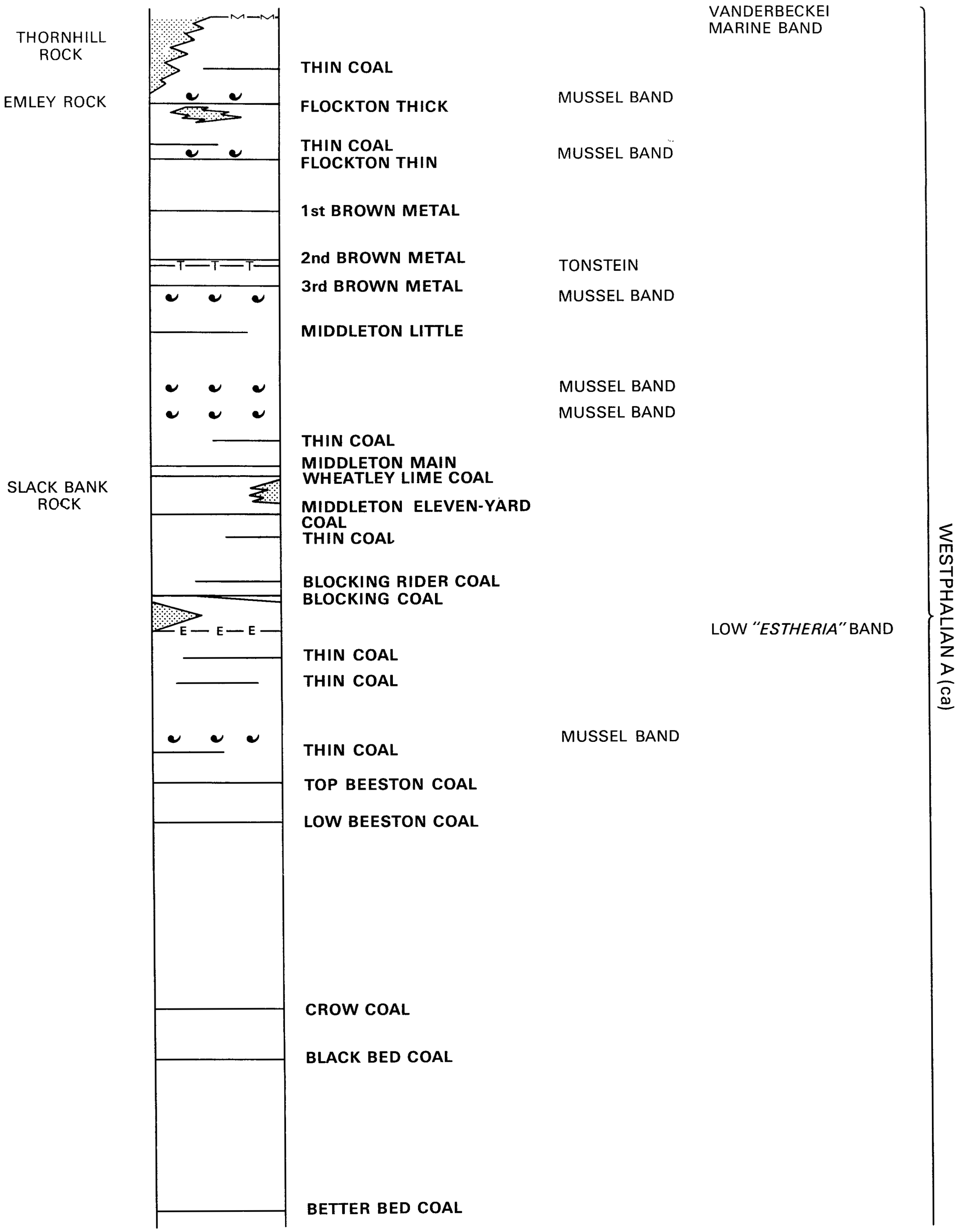

Figure 3 Generalised sequence of the Westphalian A rocks of the Normanton district

Measures between the Black Bed and Crow

The sequence is 12.92 m thick at Fox Pit, and 11.5 m thick in adjacent underground boreholes, St John's Colliery No 9 and 10 [3633 2167]. It consists mainly of mudstone with subordinate sandstone, and two thin coals are recorded in Fox Pit at 4.27 m and 8.35 m respectively above the Black Bed. Mudstone with ironstone, 1.06 m thick, is recorded about 0.50 m above the Black Bed in Fox Pit, and is probably the Black Bed Ironstone which contains up to 30% iron. Formerly, it was widely exploited at crop, but no records of its extraction have been found in this district.

Crow Coal

The coal is a single seam, 0.33 m thick in Fox Pit, and 0.4 m thick in St John's Colliery No 9 Underground Borehole. It has not been worked hereabouts.

Measures between the Crow and the Low Beeston

The succession is only recorded in the Fox Pit where it is 43.03 m thick.Mudstone and siltstone are the dominant lithologies with lesser amounts of sandstone.

Low Beeston Coal

The seam is proved in a number of shafts and underground boreholes and generally thins to the south-east. It has an average thickness of 1.86 m and ranges between 1.63 m and 2.14 m. It normally comprises 3 leaves, 0.14 to 0.16 thick separated by dirt partings up to 0.58 m thick.

Measures between the Low Beeston and Top Beeston

Mudstone and siltstone are the dominant lithologies in this sequence except at Methley Junction Colliery [3963 2565) where 9.45 m of sandstone is recorded. The strata vary in thickness from 6.68 m in Fox Pit to 12.95 m in St John's Colliery No 5 Underground Borehole [3570 2070].

Top Beeston Coal

The Top Beeston is normally represented by a single leaf of coal 0.69 m to 1.14 m thick, with a mean of 0.93 m. However, two dirt partings are recorded within the seam around [36 21], and they reach a maximum recorded thickness of 0.68 m in St John's Colliery No 8 Underground Borehole [3647 2098]. St John's Colliery No. 2 Underground Borehole [3666 1944] records a thin coal and 6.62 m of mudstone-seatearth and carbonaceous mudstone, at the horizon of the Top Beeston. The coal is extensively worked. In the north, large areas of the seam have been completely removed leaving only isolated pillars of coal, beneath rivers, canals, villages and shafts, although in the south, extraction has been less complete.

Measures between the Top Beeston and Blocking.

The mean thickness of the measures is 43.50 m, with a range of 33.77 m at Snydale Colliery to 49.07 m at Altofts Colliery. The strata thin to the south-east. The major lithology is mudstone with siltstone and a few sandstones, the last reaching 6.63 m as a maximum. Three thin coals are commonly recorded, but they are laterally discontinuous; a persistent mussel band is recorded.

A marker across much of the coalfield, the Low *Estheria* Band, is recorded in St John's No 2 Underground Borehole, 7.50 m below the Blocking. It is probably present in other sections but has not been positively identified elsewhere.

Blocking Coal

The Blocking normally comprises one leaf of coal about 0.54 m thick and a range of between 0.46 m at Methley Junction Colliery and 0.74 m on Abandonment Plan NE 736. However, the seam splits in places into two leaves separated by up to 1.49 m of mudstone-seatearth. The composite seam reaches a maximum of 2.11 m at Whitwood Colliery. There does not appear to be a consistant pattern of splitting. A small panel of the seam has been worked to the south of St John's Colliery No. 2 shaft [3706 2171].

Measures between the Blocking and Middleton Eleven Yard

The measures are mainly mudstone with siltstone and a few sandstone beds.The mean thickness is 13.45 m, but the beds generally thin to the north-north-east. A thin coal, the Blocking Rider, is frequently recorded. It is about 0.15 m thick and lies about 2.50 m above the Blocking; another thin coal lies 11.60 m above the Blocking in Whitwood Colliery.

Middleton Eleven Yard Coal

This seam has been widely exploited, particularly in the west. It is about 0.87 m thick, with a range from 0.46 m at Whitwood Colliery to 1.50 m at Altofts Colliery. It seems to thin to the south-east and is locally split by a parting up to 0.84 m thick.

Measures between the Middleton Eleven Yard and the Middleton Main

Giles and Williamson (1985, Fig 3) show an isopach map for the Slack Bank Rock for the district to the north. Around Normanton, however, there is no sign of a similar major distributory channel facies sandstone. The dominant sediments are siltstone and sandstone with subordinate mudstone, which are interpreted as overbank flood deposits associated with proximal and medial crevasse splay.

The strata is on average 11.46 m thick with a range of 7.41 m at Whitwood Colliery to 19.09 m at St John's Colliery. There is a general thining eastward.

About 2.0 m below the Middleton Main is the Wheatley Lime Coal. This is an inferior seam between 0.61 m thick at New Sharlston Colliery [3838 2021] and 0.97 m thick at Fox Pit. It comprises two or three leaves of thin coal which may be up to 0.30 m thick, separated by dirt partings up to 0.36 m thick.

The beds between the Wheatley Lime and Middleton Main are mainly mudstone and mudstone-seatearth.

Middleton Main Coal

This seam, also known as the West Yorkshire Silkstone, is about 1.84 m thick. It is normally two leaves separated by a thin dirt parting up to 0.15 m thick. In places, the parting is absent or represented by an inferior coal. Mine plans show that the seam is split in places by a second dirt parting up to 0.79 m thick, which in Don Pedro Colliery [4036 2276] comprises mudstone-seatearth resting on siltstone. The Middleton Main is widely exploited and only isolated pillars remain.

Measures between Middleton Main and Middleton Little

These strata are largely mudstone and siltstone with discontinuous beds of sandstone. At least one thin coal is commonly recorded in sections, about 6 to 7 m above the Middleton Main and mussel bands or "shell beds" lie 12.98 m and 17.09 m above the Middleton Main at Altofts Colliery. The average thickness of the sequence is 30.18 m.

Middleton Little Coal

The Middleton Little unites with the 2nd and 3rd Brown Metal coals to form the Oxbow Coal (Godwin and Calver, 1974) in the district to the north, but these coals are several metres apart in the north of the present district. In the west, the Middleton Little is represented by a single coal between 0.38 m thick in St John's Colliery No. 2 shaft and 0.58 m thick in New Market Colliery. To the east of St John's Colliery, the seam splits into two leaves separated by up to 0.84 m of mudstone-seatearth. At New Sharlston Colliery, the Middleton Little has deteriorated to 0.84 m of carbonaceous mudstone and a thin coal. Further east at the Snydale and Don Pedro collieries, the Middleton Little is absent, the horizon consisting only of mudstone. The sequence of lateral changes may be interpreted in terms of different depositional facies. The single leaf of coal represents a swamp facies passing eastwards into a passive lake-margin facies represented by the split seam and carbonaceous mudstone. At Snydale and Don Pedro, interdistributory lake conditions, depositing mudstone, have replaced the swamp.

Measures between the Middleton Little and Flockton Thin

This succession is about 42.20 m thick and thins to both the north and west (Figure 4). The strata are mainly mudstone and mudstone-seatearth with at least 3 thin coals, the Brown Metals. In the district to the north, the lower two of these coals, the 2nd and 3rd Brown Metals, units with the Middleton Little to form the Oxbow Coal, but in this district the coals are quite separate. The 3rd Brown Metal is 3.75 m above the Middleton Little at Methley Junction Colliery and 17.95 m above it at Snydale Colliery. This divergence is illustrated in Figure 5.

Bottom Boat Borehole [3652 2479] records a mussel band with ostracods 5.89 m above the Middleton Little. A tonstein was recorded by Salter (1964) in the Oxbow opencast site [3610 3000] at the level of the combined Second and Third Brown Metal coals. Mr R. Goossens (pers. comm.) also records a tonstein at the level of the Second Brown Metal in No. 1 Drift at Allerton Bywater Colliery [4500 2920].

The three Brown Metals are normally thin and often of inferior quality. Splits develop locally and maybe complex; up to 7 thin seams have been recorded from these measures. The coals have not been worked.

Flockton Thin Coal

In the west, this is a single leaf of coal with a mean thickness of 0.63 m. In the east, the seam has two or more leaves separated by dirt partings up to 1.0 m thick. The seam thins to the south-west and splits in the east, so only in a small area in the north-west around Newmarket Colliery has it been worked.

Measures between Flockton Thin and Flockton Thick

These beds show a coarsening-upwards sequence from mudstone to siltstone or sandstone. The mudstone directly above the Flockton Thin commonly contains a mussel band as in the Bottom Boat Borehole. A thin coal is also commonly recorded at about this horizon; for example, 0.11 m of coal lies 3.10 m above the Flockton Thin in Altofts No 1 Borehole [3696 2361].

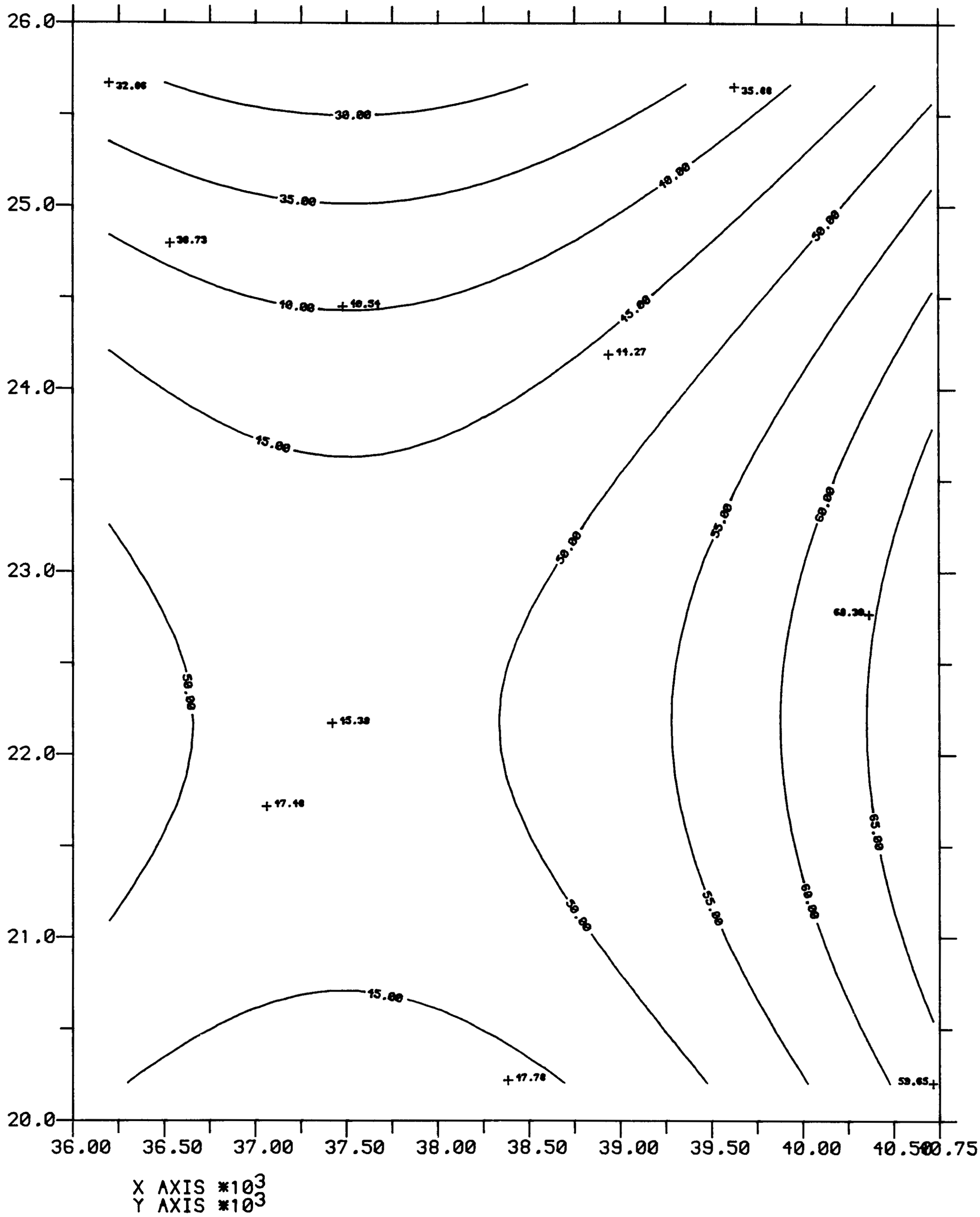

Figure 4 A computer generated 2nd order trend surface analysis of strata thickness between the Midddleton Little and Flockton Thin coals. (Correlation Coefficent = 0.97)

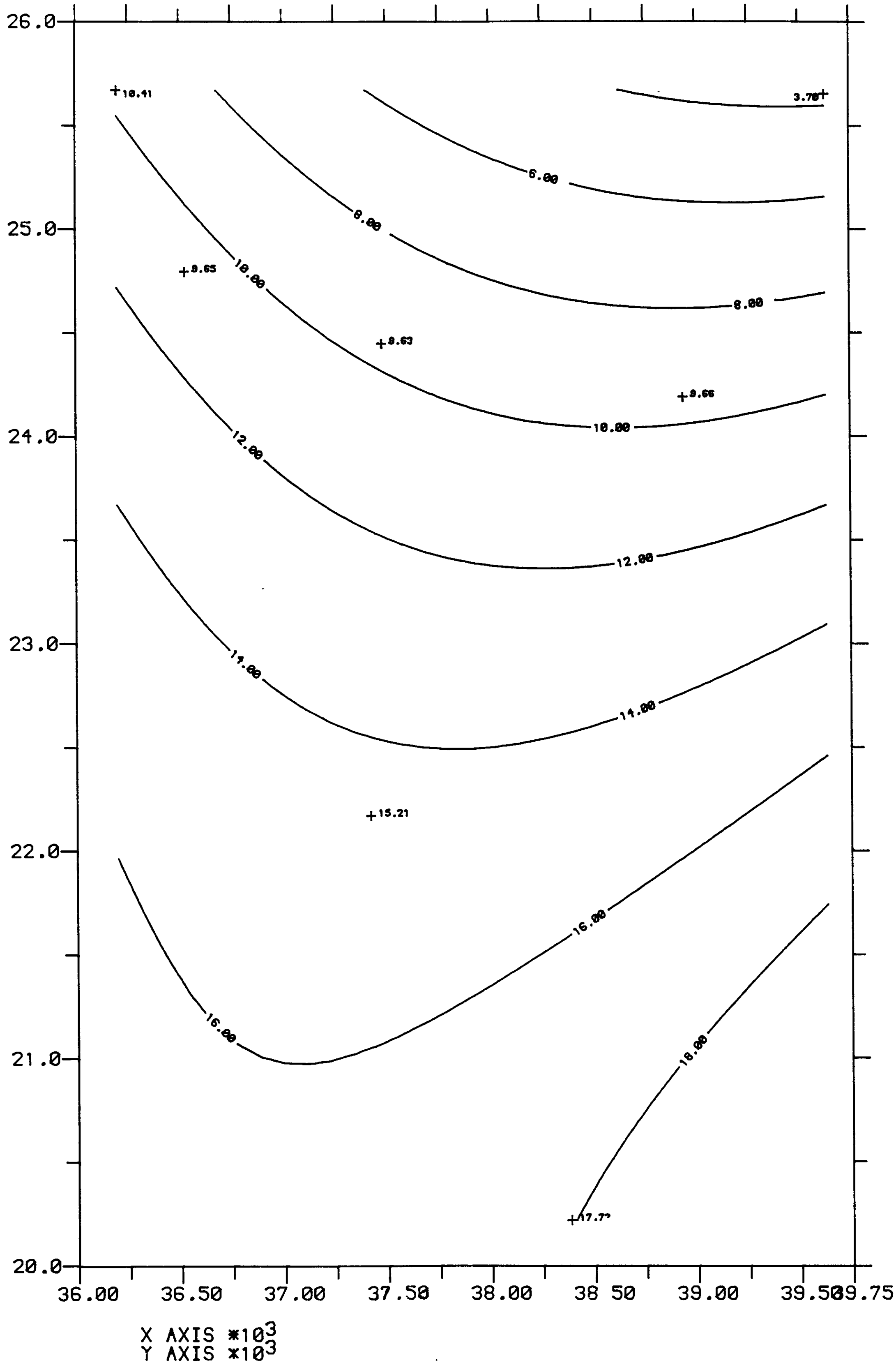

Figure 5 A computer generated 2nd order trend surface analysis of strata thickness between the Midddleton Little and 3rd Brown Metal coals. (Correlation Coefficent = 0.99)

A sandstone between 2.30 m and 4.00 m thick comes on above in most sections in the east of the district and correlates with the Emley Rock of the areas to the north and north-west. The sandstone represents a distributory channel facies whilst the siltstone into which it passes westwards represents either overbank flood facies or medial to distal crevasses splay facies.

The sequence thins markedly in the centre of the district to only 8.90 m at Altofts Colliery. The 2nd-order trend surface of this inter-seam interval (Figure 6) demonstrates the pronouced thinning.

Flockton Thick Coal

The seam is normally represented by two leaves separated by a dirt parting up to 0.67 m thick. The Flockton Thick at Birkwood Lock Borehole [3633 2384] is split by a parting of 3.40 m of mudstone and mustone-seatearth, into the Upper Flockton Thick, 0.36 m thick, and the Lower Flockton Thick, which is 1.38 m thick. The mean thickness of the full seam across the district is 1.38 m, and it has been worked in the north from the Newmarket and Whitwood collieries.

Measures between the Flockton Thick Coal and the Vanderbeckei (Clay Cross) Marine Band.

These measures are generally mudstone,and commonly include a mussel band in the roof of the Flockton Thick, and one or two thin coals. In the Birkwood Lock Borehole, geophysical logs indicate that about 34 m of Thornhill Rock rests almost directly on the Flockton Thick, and similar thick sandstonesare recorded in St John's No 2 Shaft and in several other boreholes and shafts in the west. The base of the Thornhill Rock is erosive and, in places, cuts down into the beds beneath the Vanderbeckei Marine Band.

At Fox Pit, the Joan Coal lies about 19 m above the Flockton Thick, and is represented by 3 thin leaves separated by dirt partings.

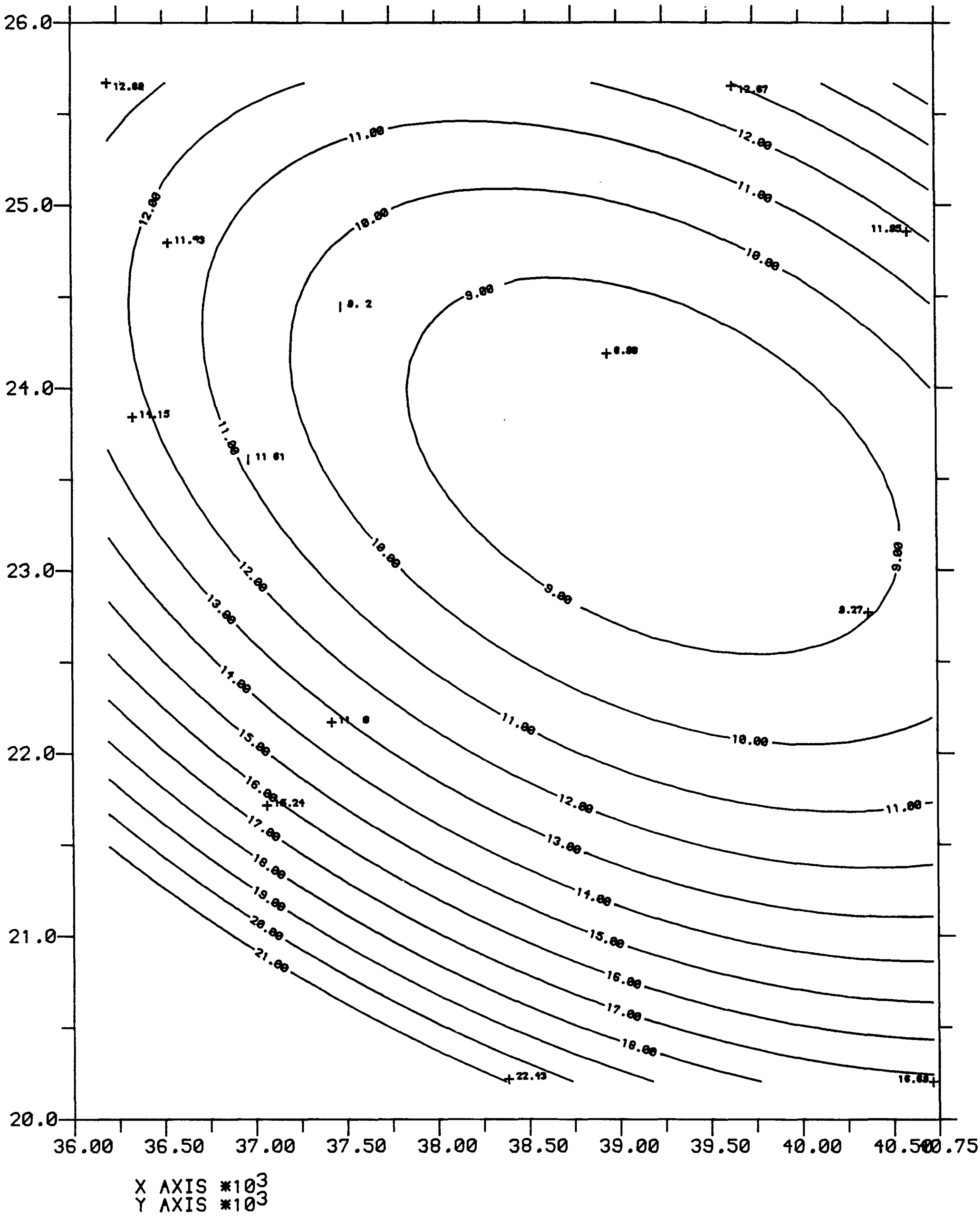

Figure 6 A computer generated 2nd order trend surface analysis of strata thickness between the Flockton Thin and Flockton Thick coals. (Correlation Coefficent = 0.96)

MIDDLE COAL MEASURES (Westphalian B)

Vanderbeckei (Clay Cross) Marine Band

The Marine Band has not been postively identified in the district, but is probably the 1.17 m of dark mudstone above the Joan Coal at Fox Pit. Similar beds of dark mudstone above inferior, thin Joan coals are also recorded in the Altofts and New Sharlston collieries.

Measures between the Vanderbeckei (Clay Cross) Marine Band and the Lidget Coal.

The estimated thickness of this succession is about 40m. The Thornhill Rock is recorded in about half the provings. It is a massive sandstone up to 22 m thick and closely associated with thick siltstones. The deposits are interpreted as a major distributory channel facies associated with a siltstone-dominated overbank flood facies. Sandstones of the Thornhill Rock occur from stratigraphically just below the Lidgett to just above the Flockton Thick, a mean stratigraphical thickness of 63.44 m. The individual sandstones, normally not more than 22.00 m thick, represent stratigraphically superimposed distributory channels.

Mudstones and siltstones are recorded in the other sections penetrating this succession, with a few thin coals, for example at New Sharlston Colliery, where a thin coal lies 13.19 m below the Lidget.

Lidget Coal

This is generally a single seam 0.61 m to 0.93 m thick, which thins towards the centre of the district and thickens markedly southwards where it splits into 2 or rarely 3 leaves, separated by up to 0.20m of carbonaceous mudstone. The seam, including dirt partings, reaches its maximum in Park Hill Colliery No 55 Underground Borehole [3709 2140] where it is 1.29 m thick. A small area of the Lidget has been worked from New Sharlston Colliery (Mine Plan NE 682).

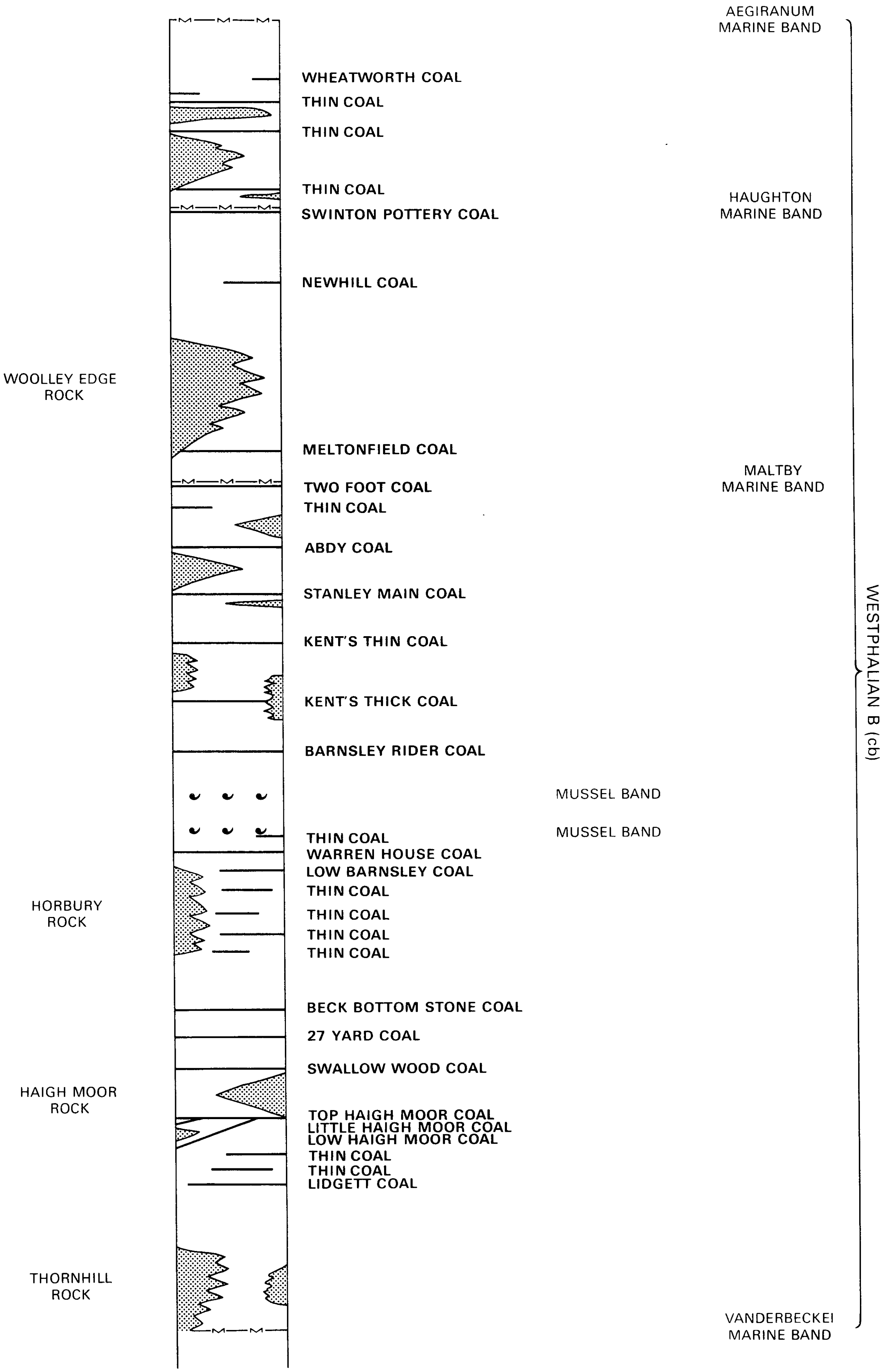

Figure 7 Generalised sequence of the Westphalian B rocks of the Normanton district

Measures between the Lidget and Haigh Moor.

This sequence contains mudstones and siltstones with discontinuous, thin coals. For example, at Altofts Colliery, thin coals lie 4.29 m and 12.10 m below the Low Haigh Moor. Locally, thicker sandstones may develop, as at Fox Pit where 11.27 m of sandstone directly overlie the Lidget. The mean thickness of the sequence is 18.01 m with a range of 14.68 m at St John's Colliery to 22.23 m at Methley Junction Colliery; the sequence is thinest in the centre of the district.

The Haigh Moor Coals

In the south, at New Sharlston Colliery, this group of coals is represented by a seam 3.02 m thick, comprising 3 leaves of coal up to 1.29 m thick, separated by dirt parting up to 0.84 m thick. Northwards, the lower two leaves separate from the upper to form a distinct seam.

The lower two leaves constitute the Low or Bottom Haigh Moor. Although it is commonly represented by 2 leaves, it may have up to 4 leaves. The seam, including partings, is generally about 1.19 m thick. A 2nd-order trend surface (Figure 8) suggests that the Low Haigh Moor thickens to the west.

In the south of the district, the Low and Top Haigh Moor seams are separated by as little as 0.30 m of carbonaceous mudstone or mudstone-seatearth. Northwards across the district, the parting thickens intomudstone with siltstone. Where the parting thickens to more than 7 m sandstone, up to 3.30m thick, is persistently recorded. A 2nd-order trend surface analysis (Figure 9) illustrates the development of the parting.

The Top Haigh Moor consists of a single leaf of coal, up to 1,29 m thick, where it is combined with the Low Haigh Moor, As the split between the Low and Top Haigh Moor develops, another leaf, the Little Haigh Moor, develops beneath the Top Haigh Moor. The Little Haigh Moor reaches a maximum thickness of 0.43 m in Bottom Boat Pit [3589 2488] and lies 0.46 m below the Top Haigh Moor.

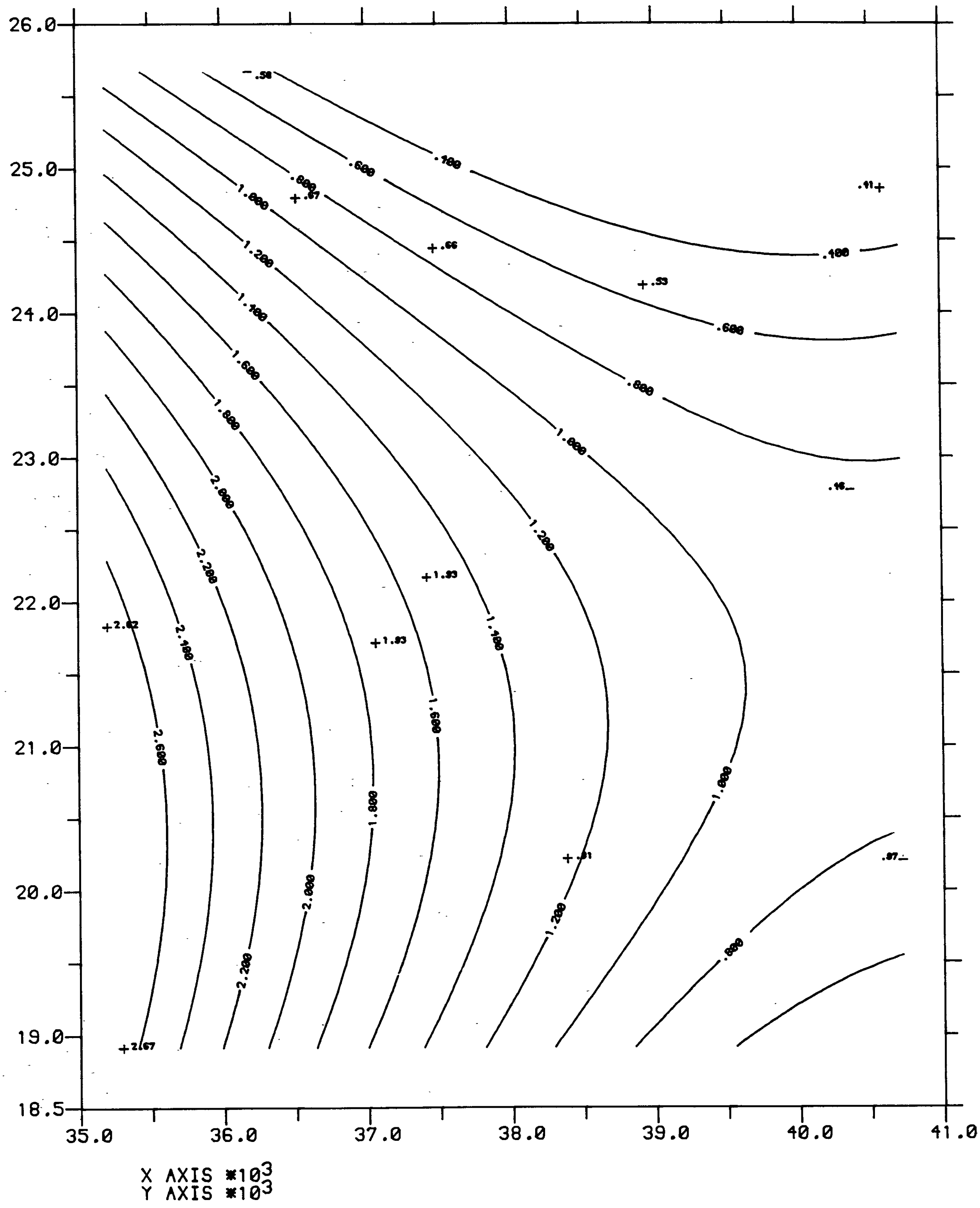

Figure 8 A computer generated 2nd order trend surface analysis of seam thickness for the Low Haigh Moor Coal. (Correlation Coefficent = 0.96)

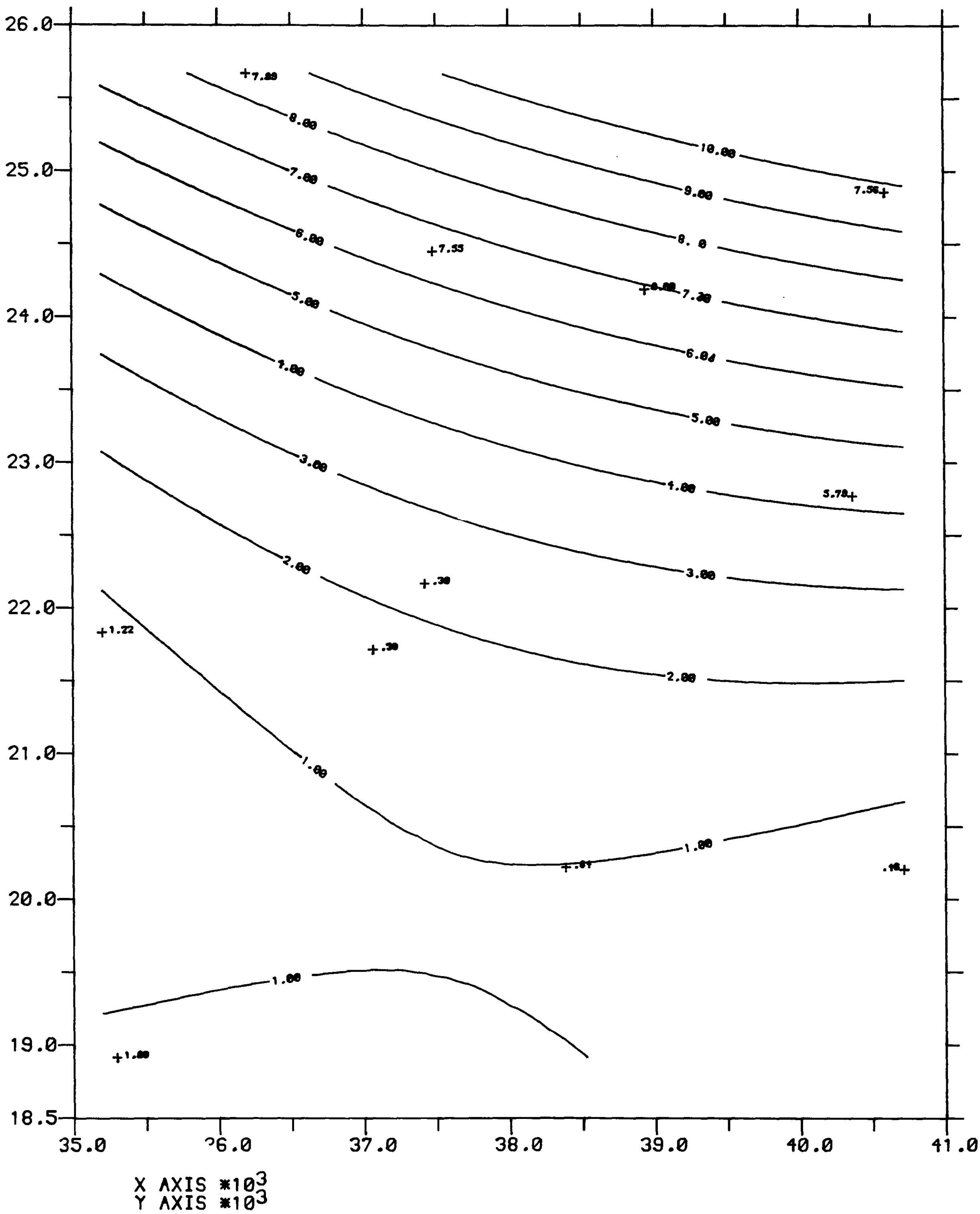

Figure 9 A computer generated 2nd order trend surface analysis of strata thickness between the Low Haigh Moor and Top Haigh Moor coals. (Correlation Coefficent = 0.91)

The Top and Little Haigh Moor seams have been extensively worked across the district. A compilation of Haigh Moor mine plans suggest that they were not worked beneath Normanton, although there may be old workings, predating the Mining Acts, which are not recorded on any plans.

Measures between the Haigh Moor coals and the Warren House.

There are several named, thin or discontinuous coals and two major sandstones in this interval, which is about 72.22 m thick but varies from 56.90 m in Don Pedro Colliery to 106.35 m in Park Hill Colliery.

The Top Haigh Moor is generally overlain by mudstone, commonly with bands of ironstone, and thin sandstones and siltstones. At Nelson Colliery,the thin Haigh Moor Rider coal, lies 0.91 m above the Top Haigh Moor. The Haigh Moor Rock, a variable and discontinuous sandstone, is recorded in the Altofts, Park Hill, Don Pedro and Snydale collierie; it ranges in thickness from 7.44 m to 24.38 m. Overlying it is the Swallow Wood, which is a thin but persistent seam recorded in all but one of the local sections. Generally, it is up to 0.25 m thick but 2 or 3 leaves separated by dirt parting up to 0.64 m thick can also occur.

About 8.48 m separate the Swallow Wood and 27 Yard coals. The latter seam is also thin and persistent occuring in all the local sections. It varies from a single leaf of coal 0.05 m thick to 3 leaves totalling 0.79 m.

Above the 27 Yard, the most common lithology is mudstone with smalleramounts of siltstone and a few impersistent sandstones less than 2.0 m thick. The beds range from 3.99 m in Altofts Colliery to 11.54 m in St John's Colliery, and are overlain by the Beck Bottom Stone Coal. This is again persistent and is usually a single leaf of coal up to 0.25 m thick. At Park Hill and in St John's No 2 shaft, the Beck Bottom is represented by 2 leaves separated by a dirt parting up to 0.15 m thick.

The strata between the Beck Bottom and the Warren House are very variable. In the north and west there is a thick sandstone, the Horbury Rock, in this interval. Williamson and Giles (1984) and Giles and Williamson (1985) noted that its distribution was controlled by major syn-depositional faults, but these are not apparent in this district. The Horbury Rock is 24.3 m thick in Park Hill Colliery. At Altofts, Don Pedro, Oakenshaw and Whitwood collieries, a thick sequence of siltstone with thin bands of sandstones is present, probably representing overbank flood and crevass splay deposits associated with the Horbury Rock distributory channel.

Elsewhere, the sequence is dominated by mudstone with up to 5 impersistent coals. The most extensive of these is the Low Barnsley which is recorded at St John's 1 and 2, New Sharlston and Snydale collieries and in Park Hill Colliery No 55 Underground Borehole. It has also been worked from Park Hill Colliery in an area just south of Warmfield [3762 2080]. It normally comprises a two-leaf seam with a mean thickness of 1.26 m including a dirt parting up to 0.15 m thick. Boreholes and shaft sections suggest that the Low Barnsley lies between 3.51 m (St Jonh's Colliery) and 9.56 m (New Sharlston Colliery) below the Warren House, although mine plans in the Warmfield area show that the Low Barnsley is separated from the Warren House by about 20 m of strata.

There is a general eastwards thinning of the measures between the Beck Bottom Stone and the Warren House. Thickness varies from 15.09 m in Don Pedro Colliery to 67.46 m in Park Hill Colliery.

Warren House Coal

The seam has a mean thickness of 1.76 m and a range from 0.94 m in Parkhill Colliery No 1 Underground Borehole [3668 2092] to 2.22 m in Welbeck Lane Borehole [3585 2159]. An isometric diagram, Figure 10, illustrates the variation in the overall seam thickness. The seam is split into 3 to 8 leaves by a number of dirt partings, individually up to 1.02 m thick.

The upper leaves of the Warren House Coal locally combine to form a single leaf, up to 1.22 m thick with 2 or 3 thinner leaves beneath. In this form, the combined upper leaves have been worked from Altoft Colliery. Two small panels have also been worked from Park Hill Colliery, where the seam comprises 4 to 6 leaves.

The seam has been prospected to evaluate its opencast potential in the north-west, where the boreholes show that the Warren House contains many thin, dirt partings.

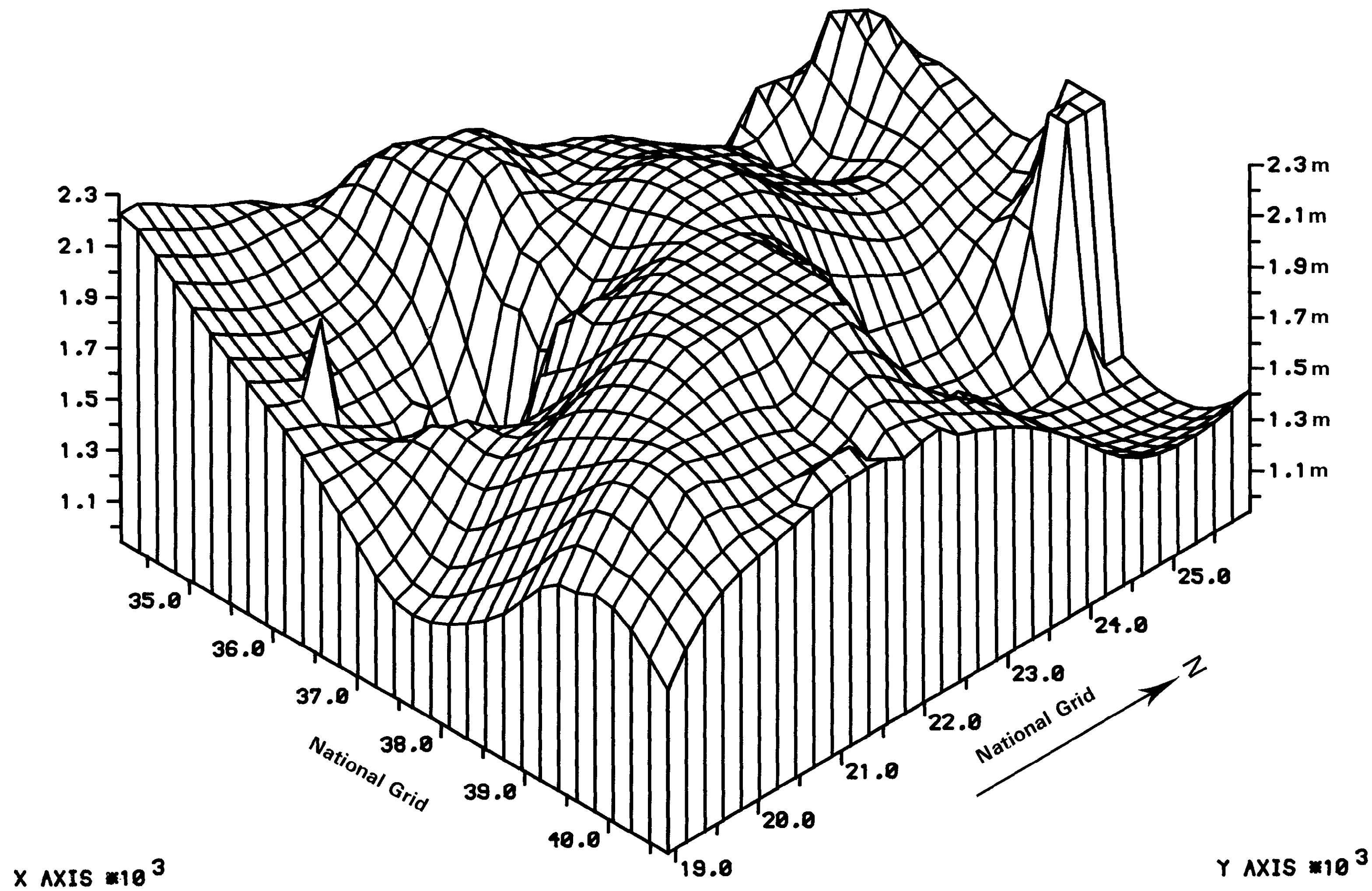

Figure 10 A computer generated isometric diagram, viewed from the south-east, illustrating the variation in the thickness of the Warren House Coal. Vertical scale in metres.

Measures between the Warren House and Kent's Thick

These strata are dominated by mudstone, with siltstone, sporadic ironstones and sandstones up to 3.00 m thick. Several mussel bands have been identified in the Kirthorpe Lane [3544 2278] and Ward Land boreholes [3561 2045]. A thin coal, the Barnsley Rider, is logged in a majority of local sections. For example 0.20 m of inferior coal lies 26.27 m above the Warren House Coal in the Ward Lane Borehole. On the other hand, a thin, impersistent coal, lying only about 6 m above the Warren House Coal, at the opencast prospect east of Bottom Boat is probably not the Barnsley Rider. At Whitwood Colliery, 13.03 m of sandstone washes out the Kent's Thick Coal and some underlying measures.

The mean thickness of the succession is 41.02 m, with a range of 34.66 m in the Kirkthorpe Lane Borehole to 51.70 m in St John's Colliery, and a general thinning to the north-north-east.

Kent's Thick Coal

In the north the Kent's Thick is either absent or represented only by a sequence of thin coals and mudstone-seatearths as at Altofts Colliery, or by sandstone, as at Whitwood Colliery where it is 13 m thick. In the south the seam is normally a single leaf of coal, although 2 or 3 leaves may be present in places.

Where it is not split, the Kent's Thick has been mined, for example, in the Park Hill and New Sharlston collieries; here, mine plans show that the seam reached a maximum thickness of 1.47 m.

Measures between Kent's Thick and Kent's Thin

The mean thickness of these beds is 16.15 m with a range of 12.42 m atAltofts Colliery to 18.71 m in Park Hill Colliery.

Mudstone is the dominant lithology with subordinate siltstone and a few bands of ironstone. Sandstones are locally present, as at Park Hill Colliery where there is 10.27 m of sandstone.

Kent's Thin Coal

This is normally a single leaf of coal, between 0.33 m thick at Altofts Colliery and 0.66 m thick at Park Hill Colliery. Locally a split develops which separates the seam into two leaves with 0.08 m of carbonaceous mudstone. The Kent's Thin crops out on the south side of the Calder valley north of Altofts [3719 2371], although there are no sections and its exact outcrop is not known with certainty.

Measures between Kent's Thin and Stanley Main

The sequence is dominated by mudstone with lesser amounts of siltstone, and a thin sandstone 1.32 m thick is recorded at Park Hill Colliery. A similar sandstone forms a feature on the side of the Calder valley north of Altofts and near Birkwood Farm [3608 2368]. A thin coal is recorded 2.07 m below the Stanley Main in the Ward Lane Borehole.

The mean thickness of these strata is 13.38 m with a range from 9.91 m at Altofts Colliery to 18.40 m in the Wakefield Power Station Borehole [3445 2020], which suggests a progressive south-westwards thickening.

Stanley Main Coal

The seam is thickest around Normanton. It is normally 3 leaves of coal. At St John's Colliery lowest the "Main Coal" (1.09 m) is overlain by 0.19 m of Alum Shale, whilst the middle leaf is the "Lime Coal" (0.56 m) overlain by 0.22 m of dirt. The upper most "Black Band Coal" is 0.61 m thick. The seam deteriorates away from Normanton. Northwards it thins, and to the south it splits into the Bottom and Top Beamshaw Coals. To the east and west it splits into several thin leaves. The seam has a mean thickness for the district of 2.57 m. It thickens southwest-wards (Figure 11) as the dirt parting between the "Main" and "Lime" coals develops, andthe seam reaches a maximum of 5.02 m at Oakenshaw Colliery; 54% of this is dirt partings.

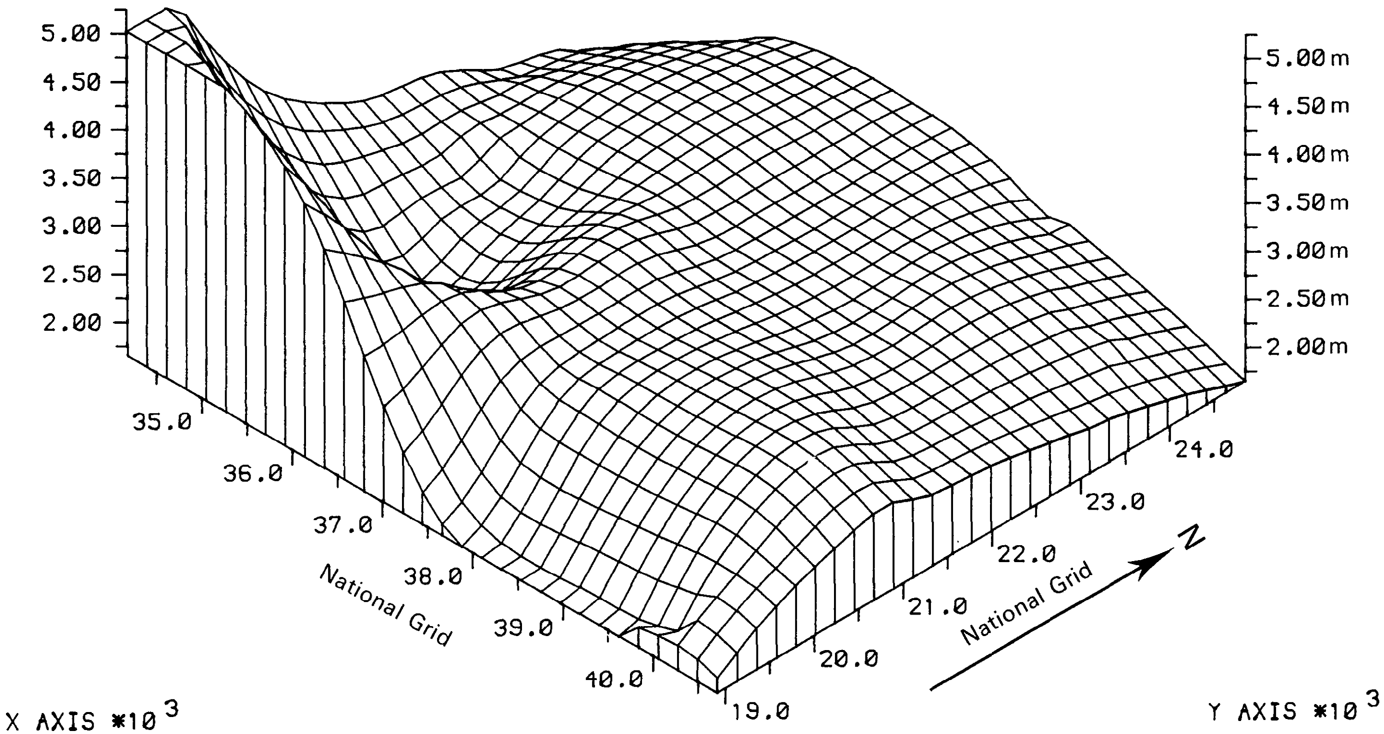

Figure 11 A computer generated isometric diagram, viewed from the south-east, illustrating the variation in thickness of the Stanley Main Coal. Vertical scale in metres.

Around Normanton, the seam has been extensively worked since before proper mining records began. South of the Methley Junction Fault, the seam has been almost completely mined except from pillars protecting buildings and mine shafts. North of the Fault, the Stanley Main crops out just north of Altofts. Numerous boreholes for opencast and site investigations show that the seam has been worked from adits and bell pits. Two small opencast sites, Birkwood Clump and Birkwood Common, extracted the Stanley Main during the 1940's and 1950's, but further extraction was inhibited by extensive old workings. Red soils above the Stanley Main crop suggest that an underground fire occurred in the disused workings at some time in the past.

The Alum Shale recorded at St John's and at Park Hill Colliery was formerly mined separately; once processed, it is a valuable mordant for use in the dyeing industry.

Measures between the Stanley Main and Abdy

A pronounced feature is formed by a sandstone above the Stanley Main at Altofts. Boreholes in this area show that it is up to 7.20 m thick and that it either rests directly on the Stanley Main or just above it. Deep boreholes and shafts across the district show that the sandstone persists, and has a maximum recorded thickness of 12.80 m, at St John's Colliery. Southwards, the sandstone is replaced by siltstone with sandstone bands. The mean overall thickness of the measures is 13.24 m.

Abdy Coal

The Abdy is on average 0.86 m thick ranging from 0.60 m in the Wakefield Power Station Borehole to 1.41 m Park Hill Colliery. The seam is normally in one leaf but a dirt parting, up to 0.36 m thick is very common. The coal has been worked from Park Hill and New Sharlston collieries.

Measures between the Abdy and Two Foot

Mudstone is the main lithology of these measures with local beds of sandstone up to 6.53 m thick. The mean thickness of the strata is 16.85 m, with a range from 9.22 m at Snydale Colliery to 23.77 m at Stanley Ferry Pit. The northward thickening of the measures is illustrated in Figure 12. A thin coal, known locally as the Crow Coal, is present in the west, as a single bed 0.29 m thick. It is on average 6.43 m below the Two Foot Coal and possibly unites with the Two Foot Coal in the east of the district.

Two Foot Coal

This seam is represented by a single leaf of coal with an average thickness of 0.64 m. At Park Hill Colliery, a thin parting develops within the seam splitting it into two leaves. This seam has not been worked, as far as is known worked within the district.

Measures between the Two Foot and Meltonfield

The Maltby Marine Band has been identified in the roof of the Two Foot Coal in the Welbeck Lane Borehole. It comprises 0.58 m of black, slightly silty, mudstone with *Lingula*. Although not recorded in other sections, it is probably present throughout the district. Mudstone with sporadic siltstone and thin sandstone overlies the Maltby Marine Band. The average thickness of these measures is 9.56 m with a range of 7.19 m (Stanley Ferry Pit) to 14.30 m (St John's Colliery).

Meltonfield Coal

This seam is normally represented by a single leaf of coal, but it may be split by a usually thin dirt parting. At Don Pedro Colliery this dirt parting is exceptionally thick, comprising 3.35 m of mudstone. The seam, excluding the Don Pedro Colliery record, has a mean thickness of 0.66 m and is not recorded as having been being worked in this district. The Meltonfield is washed out by the Woolley Edge Rock in the shafts of St John's No. 2 Colliery and Altofts Colliery.

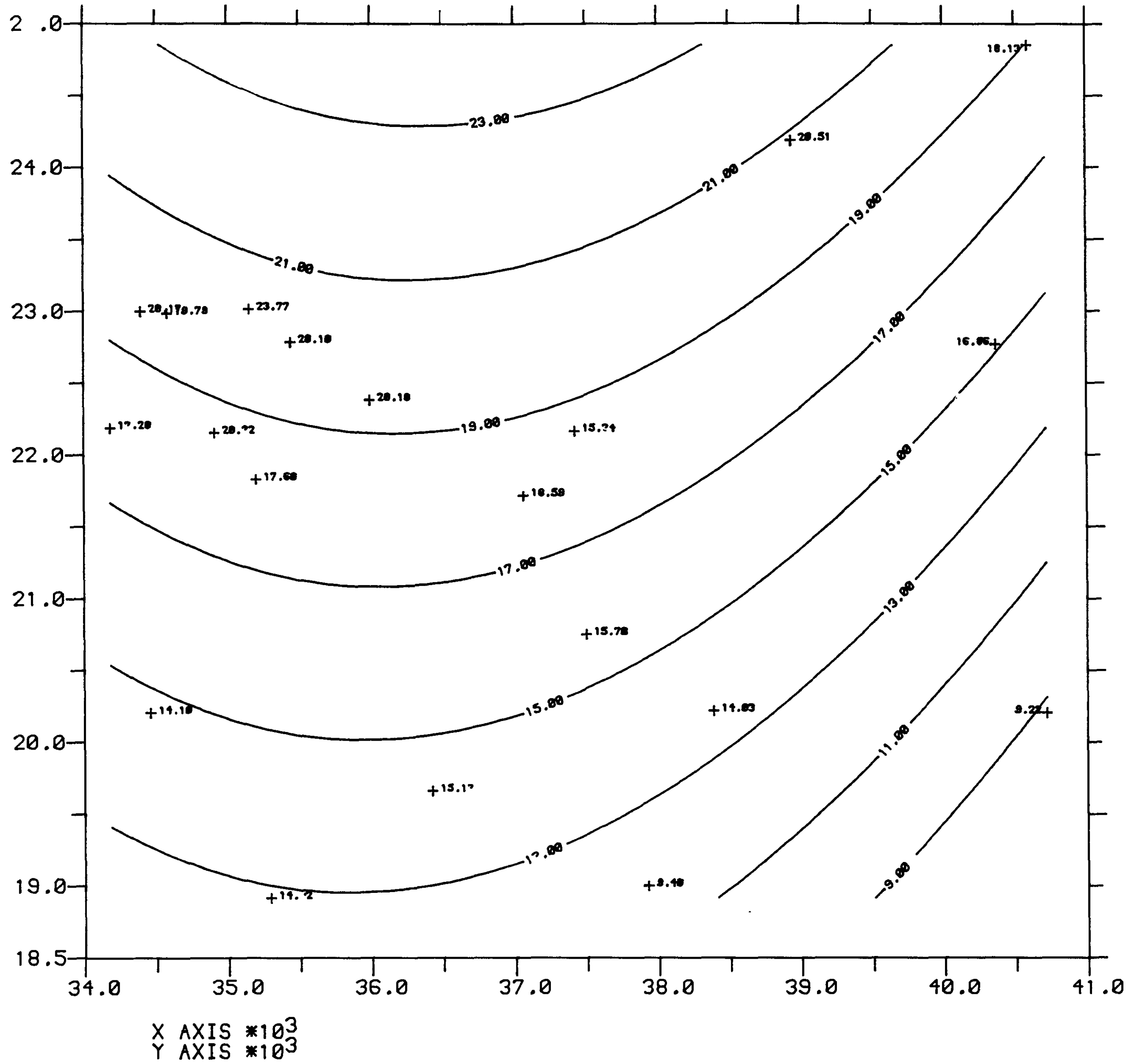

Figure 12 A computer generated 2nd order trend surface analysis of strata thickness between the Abdy and Two Foot coals. (Correlation Coefficent = 0.87)

Measures between the Meltonfield and Newhill

The Woolley Edge Rock is generally the thickest sandstone in the sequence but is laterally discontinuous in places. It is exposed to the east of Normanton, where it forms a relatively low-lying area now occupied by the Normanton Industrial Estate. Numerous site investigation boreholes confirm its presence.

At Goosehill Junction [3760 2216], a railway cutting records an excellent section of the Woolley Edge Rock, showing a sandstone channel cut into sandy mustones. Four facies can be identified. The first, at the base of the section, is an intraformational breccia composed of generally flattened clasts of mudstone, siltstone and ironstone in a fine-grained sandstone matrix. Within the breccia are large, angular, rotated blocks of silty, sandy mudstone, often showing trace fossils such as bivalve escape tubes. These blocks are up to about a cubic metre in size. The facies is interpreted as a bank-slump deposit, formed when the sides of a major distributory channel become over-steepened by rapid incision or by channel migration. Examples of this have been described from the Brahmaputra River by Coleman (1969: p163).

Above this, a second facies consists of thickly bedded, slabby, fine-grained, trough cross-bedded sandstone with sporadic lenses of small intraformational clasts. Its base is sharply erosive and cuts down into the underlying facies. The maximum thickness of the facies is 1.4 m and it contains up to 5 trough cross-bedded units vertically above each other. It yielded a few palaeocurrent measurements ranging between 290° and 358°. The facies is interpreted as representing preserved dunes that were migrating along the base of the channel.

The third facies consists of about 8m of lenticular beds of sandstone, each between 2 and 3m thick and several tens of metres long. Internally, the sandstones are cross-laminated and flaser-bedded with sporadic, isolated, intraformational clasts. The sandstones resemble the "type A sand units" of Kirk (1983) and are interpreted as representing large sand bars migrating along the palaeoriver.

The fourth facies, at the top of the cutting, consists of thinly-bedded, flaggy, fine-grained, micaceous, laminated sandstones which are interbedded and interdigitated with thinly-bedded, laminated, sandy mudstones. They are thought to represent the final stages of abandoned channel-fill. The whole sequence of deposits at the Goosehill Junction represents the progressive infilling of a major distributary channel.

In boreholes, the Woolley Edge Rock reach substantial thicknesses; for example, up to 29.60 m of sandstone is recorded in the Wakefield Power Station Borehole. Sandstones of the Woolley Edge Rock are recorded over a vertical distance of some 45 m; from the Meltonfield Coal, which is washed out in places, to just below the Newhill coal. A similar process as described for the Thornhill Rock is also thought to be operating here.

Newhill Coal

This seam is absent over much of the district. It is only recorded in the Snydale, Don Pedro, Heath Common and Oakenshaw collieries in the south and east. The seam is normally composed of a single leaf of coal with a mean thickness of 0.84 m. At Heath Common Colliery the seam is split by a single dirt parting, 0.64 m thick.

Measures between the Newhill and Swinton Pottery

These strata have an average thickness of about 20 m. Sections recorded in BGS archives from Normanton Quarries [3910 2216] and Normanton Brick Quarries [3800 2215] show that the sequence is dominately mudstones and siltstones with thin sandstones. Shaft sections from Snydale, Don Pedro and Oakenshaw collieries confirm this. A local development of sandstone forms the bold feature on which the original settlement of Normanton was built. This sandstone, which is probably never more than 3m thick, is faulted to the south of the old town and thins rapidly in this direction; it cannot be traced as far as the Normanton Brick Quarries.

The Clowne Marine Band should occur in the roof of the Newhill Coal buthas not so far been identified in West Yorkshire.

Swinton Pottery Coal

The Swinton Pottery Coal is commonly represented by 2 leaves separated by a dirt parting up to 0.18m thick, although it can also occur as 1 or 3 leaves, the latter having dirt partings up to 0.30m thick. The seam is absent at New Sharlston Colliery. The coal crops out in the railway cutting just south of Normanton Station [3800 2261] and in brick pits [3793 2265 and 3737 2257], where it is a single leaf between 0.20m and 0.30m thick. It has been removed at the brick pits and was "mined" in the railway cutting during the 1984 Miner's strike. The mudstone-seatearth beneath the coal has a good reputation as a pottery clay and formerly was widely worked for this purpose in West Yorkshire.

Measures between the Swinton Pottery Coal and the Aegiranum (Mansfield) Marine Band

The Houghton Marine Band lies immediately above the Swinton Pottery Coal. Dr N Riley (Pers Comm) examined the railway cutting immediately south of Normanton Station and noted that the fauna in the strata above the Swinton Pottery Coal had a marine aspect. Dark grey and black mudstones are recorded above the Swinton Pottery Coal in the brick pits east of Normanton, but no fossils have been found in this section.

The sandstone overlying the Houghton Marine Band is between 0.90 m and 2.00 m thick in the brick pits east of Normanton, where it is fine-grained, cross-bedded, micacous and carbonacous. Even though it is so thin, the sandstone forms a pronounced feature between the brick pits and to the south of Normanton. In the brick pit at [3793 2265], this sandstone is overlain by 1.20 m of grey mudstone which is in turn succeeded by 1.20 m of massive, fine-grained, flaggy sandstone which thins rapidly westwards and cannot be traced as far as Ruddings Wood [3725 2272].

North of Ruddings Wood, the lowest beds of the Oaks Rock form a bold hill which is fault-bounded to the north. At Heath [3557 2004], the Oaks Rock is in two leaves separated by 7m to 8 m of mudstone. The lower leaf is some 15 m thick and forms a steep bluff on which Heath Village stands, above the River Calder. The lower leaf thins rapidly northwards and cannot be traced north of Kirkthorpe [3630 2108]. At Low Wood Quarry [3554 2043], the Oaks Rock is a fine-grained, planar cross-bedded sandstone. Palaeocurrent directions are consistently to the north-west.

The lower leaf of the Oaks Rock has thin coals above and below it. Near the boathouse [3583 2078], several small exposures of a thin coal, 0.10 m thick resting on a mudstone seatearth, are recorded beneath the Oaks Rock. BGS archives record the former exposure of a thin coal in Kirkthorpe Lane, [3624 2098], between the two leaves of the Oaks Rock. In a railway cutting [3687 2033] the same coal 0.15 m thick and contains a 0.03 m dirt parting; it is overlain by 2.40 m of mudstone which in turn is overlain by the upper leaf of the Oaks Rock.

The last is thinner but more persistent than the lower leaf of the Oaks Rock. It forms a pronounced bluff above the River Calder at Kirkthorpe. The feature continues southwards to the limit of the map and northwards until it is lost beneath the colliery waste from St John's Colliery and the drift deposits of the Calder valley. In a railway cutting east of Church Field [3660 2093] the upper leaf of the Oaks Rock varies in thickness up to a maximum of 2.90 m. There are two distinct facies present; the lower has an erosive base and is shaped like a channel, some 50 m wide and 1.40 m deep at its maximum. Internally, it is a fine-grained, massive, cross-laminated, flaser-bedded sandstone. The upper facies is a more extensive sheet of fine-grained, medium-bedded and trough cross-bedded sandstone.

The Oaks Rock is recorded in all the borehole penetrating these measures. A geophysical log of the Welbeck Lane Borehole records 31.20 m of sandstone, the maximum recorded thickness in the district. Many of the sections also record 3 persistent thin coals.

Opencast prospecting around Gled Hill [3633 2050] consistently recorded one and, sporadically, two thin coals above the upper leaf of the Oaks Rock. In the railway cutting east of Church Field, a 0.3 m coal is recorded 2.40 m above the Oaks Rock.

East of the district, the Snydale and Don Pedro collieries record the Wheatworth Coal. It is worked near Glass Houghton but is worthless at the above collieries and disappears completely a short distance westwards.

The succession between the top of the Oaks Rock and the Aegiranum Marine Band is dominantly mudstone with thin sandstones. One of these sandstone caps the three prominent hills north-east of Heath and must lie close to the horizon of the Sutton Marine Band but the latter has not been recorded in the district.

UPPER COAL MEASURES (Westphalian C)

Aegiranum (Mansfield) Marine Band

In the railway cutting beneath Kirkthorpe Lane Bridge [3695 2101], a section through the Aegiranum Marine Band reads:

Mudstone, dark grey, fisside, fossiliferous	to 1.10 m+
Silstone ankeritic, fossiliferous, lenticular	to 0.41 m
Mudstone, dark grey, fossiliferous	to 0.36 m
Coal, inferior	to 0.08 m
Mudstone, seatearth	to 0.80 m

The the Aegiranum Marine Band has also been identified in the shafts at Stanley Ferry, New Sharlston and Snydale collieries.

Measures between the Aegirnaum Marine Band and the Houghton Thin Coal

These measures are recorded in the shafts of New Sharlston and Stanley Ferry collieries where they are 31.85 m and 24.4 m thick, respectively. In both sections the strata comprises mudstone passing upwards into siltstone. These beds form a steep featureless scarp-slope beneath the Warmfield Rock west of Warmfield.

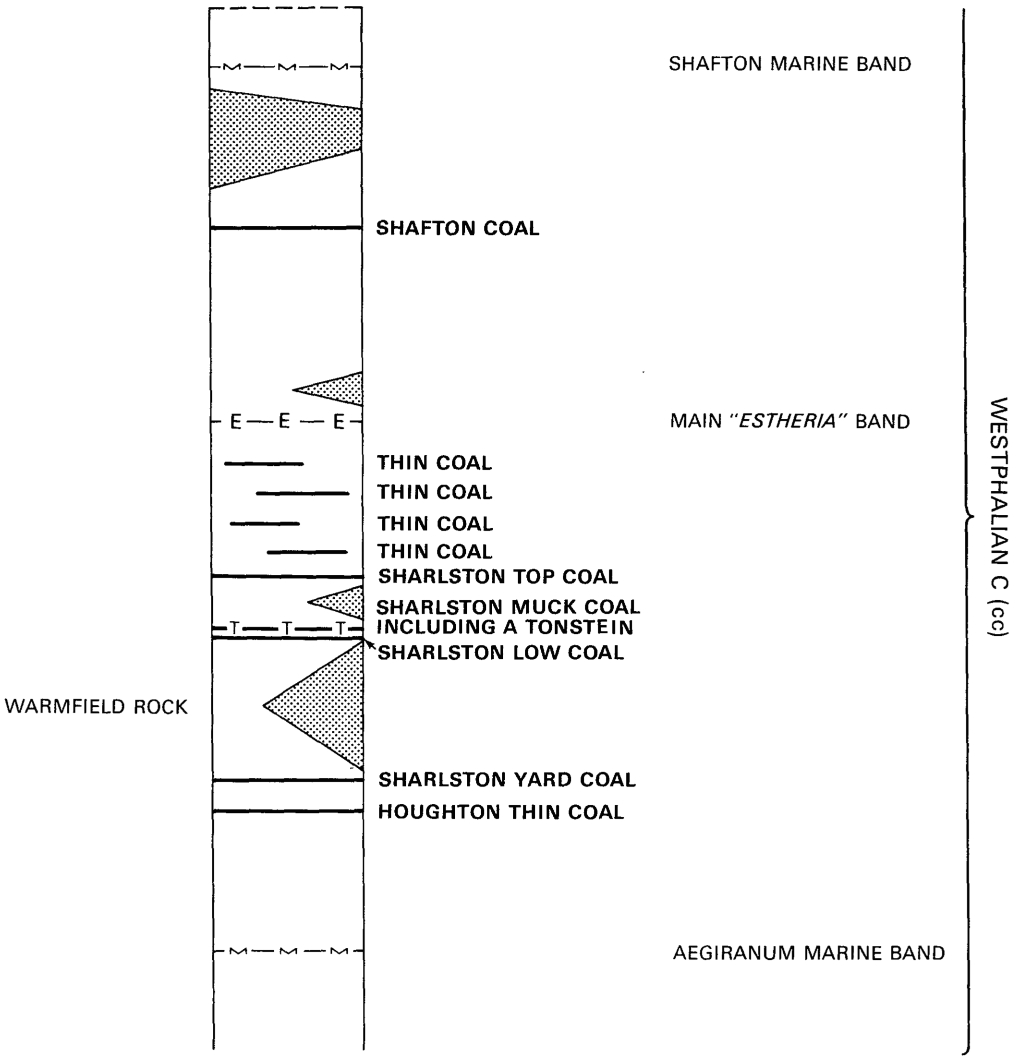

Figure 13 Generalised sequence of the Westphalian C rocks of the Normanton district

Houghton Thin Coal

At New Sharlston Colliery the seam is 0.41 m thick. At Stanley Ferry Colliery, it comprises two leaves separated by 0.38 m of mudstone-seatearth. The Houghton Thin crops in the steep scarp-slope formed by the Warmfield Rock, west of Warmfield. It was worked opencast here in the Gap Lane Site, the seam comprising a single leaf of coal 0.38 m thick. At the Snydale Opencast Site the seam was between 0.23 m and 0.89 m thick with a thin cannel coal forming an upper leaf. Old unrecorded workings in the coal were uncovered during excavations at the site.

Measures between the Houghton Thin Coal and the Sharlston group of coals

The strata between the Houghton Thin and the Sharlston Yard, the lowest seam in the Sharlston group of Coals, varies from 3.05 m to 8.53 m. At New Sharlston Colliery and in Gap Lane Opencast Site, these beds were mudstones and siltstones, whilst at Snydale Opencast Site several sandstones were also recorded from these measures.

The Sharlston group of coals

There are 4 main seams, the Sharlston Top, Sharlston Muck, Sharlston Low and Sharlston Yard.

At New Sharlston Colliery these seams occur within 43.30 m of strata. The measures crop out largely along the Morley-Campsall Fault Belt and in the south-east of the district, where the Coals represent a major reserve of coal recoverable by opencast mining.

The Sharlston Yard is normally represented by a single leaf of coal 0.50m to 1.00 m thick. Locally a thin, inferior, lower leaf may develop which is separated from the upper leaf by between 0.05 m and 0.23 m of mudstone. No abandonment plans exist of the seam having been wanted but disused workings were discovered in both Gap Lane and Snydale opencast sites.

A mean thickness of 27.93 of strata separates the Sharlston Yard and Sharlston Low coals. These measures are dominated by the Warmfield Rock, a fine-grained, medium bedded, flaggy sandstone up to 30.30 m thick. The most common sedimentary structure in the sandstone is through cross-bedding. The rock is thickest near Warmfield and thins markedly westwards until it dies out west of Goosehill Bridge [37725 2162]. It also thins eastwards, but still forms some pronounced dip-and-scarp slope north of New Sharlston Colliery, although it is absent in the colliery shaft, where it is replaced by 25.96 m of mudstone. The Warmfield Rock probably represents a major distributary channel sandstone.

The Sharlston Low is between 0.81 m and 1.13 m thick, and normally consists of a single leaf of coal but at Snydale Opencast site an inferior, pyritic coal upto 0.18 m thick is recorded in the roof measures. The seam is exposed in a railway cutting near Goosehill Bridge, the detailed section being recorded in Green and others (1886). The Sharlston Low was worked locally prior to the statutary lodgement of mine abandonment plans, so many disused workings are unrecorded, especially along the outcrop. Such workings were encountered in the Gap Lane II Opencast Site and in Sharlston No 3 Borehole [3880 2004].

The Sharlston Low and Muck coals almost join within the present district. West of Goosehill Bridge, a mudstone parting of as little as 0.15m separates the two seams. At the Gap Lane II Opencast Site near Warmfield, the parting between the two seams is less than 1 m thick, whilst at Syndale Opencast Site the seams are separated by up to 3.40 m of mudstone.

The Sharlston Muck is a variable seam, up to 1.68 m thick, in the Sharlston No 5 Borehole [3853 1992]. A more typical sequence is represented by the secton at Gap Lane II Opencast Site:-

Coal	0.05m
Ironstone	0.03m
Coal	0.30m
Mudstone	0.08m
Coal	0.37m

In the Pineapple Prospect, west of Warmfield, borehole record a well developed tonstein with the coal, which is also visible in the section at Goosehill Bridge. The seam has also been mined extensively along its outcrop but, like the Sharlston Low no plans survive; disused workings were recorded from Gap Lane II Opencast Site and Sharlston No 4 Borehole [3833 1964].

The measures between the Sharlston Muck and Sharlston Top range from 4.57 m to 16.76 m mudstones and siltstones are the dominant lithologies but subordinate sandstones may be present, for example, at Goosehill cutting, 3.40 m of sandstone is recorded above the Sharlston Muck. Sharlston Colliery Drift Proving Borehole No 1 [3827 2003] also records two thin coals above the Sharlston Muck.

The Sharlston Top is very variable. At New Sharlston Colliery it is a single leaf 1.02 m thick, whilst at Gap Lane II Opencast Site it is split into 3 leaves up to 0.46 m thick and separated by mudstone partings up to 0.17 m thick. The seam varies from 0.46 m thick in Sharlston No 4 Borehole to 1.10 m thick at Sharlston Colliery Drift Proving Borehole No 1. Disused workings are proved in many boreholes that penetrate this seam and were exposed during operations at Snydale and Gap Lane II opencast sites.

Measures between the Sharlston group of coals and the Shafton

These measures have an average thickness of 68.80 m and are dominantly mudstone. A series of thin, discontinuous coals are recorded immediately above the Sharlston Top and about 30 m higher in the sequence is the Estheria Band; this has been consistently recorded in opencast prospecting boreholes and is normally less than 1.50 m thick. Above the Estheria Band is a sandstone up to 5.50 m thick, which forms a pronounced linear ridge north-east of Warmfield.

Shafton Coal

The seam is normally represented by a single leaf up to 1.35 m thick with an average thickness of 1.13 m. Locally the seam is split into two leaves by a dirt parting about 0.15 m thick. Opencast prospecting boreholes suggest that it has been locally worked close to crop but no abandonment plans of these disused workings exist.

Measures above the Shafton Coal

A pronounced feature aligned across Woodhouse Common [3820 2114] and to Woodhouse Grange [3774 2152] is formed by a substantial but un-named sandstone up to 24.70 m thick. It thins appreciably towards New Sharlston where is is only about 10 m thick. The sandstone is separated from the underlying Shafton Coal by as little as 2.50 m of mudstone. Above the sandstone is a sequence of mudstones which contain the 0.70 m thick Shafton Marine Band lying about 31.00 m above the Shafton.

3. STRUCTURE

The dip of the beds is generally less than five degrees though local flexures near to faults noticeably steepen the dip. There is no consistent direction of dip across the district since the direction varies from fault-block to fault-block. The direction of dip also changes vertically through the sequence where the dip is low and the effects of differential compaction of the sediments becomes significant.

The major NE-trending faults of the Oulton area (Giles and Williamson 1985) continue into the north of the present district (figure 14). The main normal faults, such as the Methley Junction Fault, have throws of up to 105 m. A second set of normal faults, with trends between E and ESE, has smaller throws.

The centre of the district is structurally more complex. Faulting is again the principal feature. The Morley-Campsall Fault Belt is of considerable complexity and much of the detail is deduced from archival data, some of which is open to several interpretations. Within the Fault Belt, dips and strike are highly variable and there are numerous cross faults. Former surveys suggested that the structure was a down-faulted trough but this has proved to be an oversimplification of the available data. The throws of the boundary faults are very variable, and are taken mainly from mine-plans, supplemented by data from opencast exploration; along most of its length the Belt probably has an overall throw down to the south.

On the north side of the Fault Belt, major fault branches have variable throws; for example, the Normanton Station Fault throws about 75 m near Normanton Station but only 5 m at Normanton Golf Course, where it is terminates against a cross fault. Other faults behave similarly, showing an initial branch with large throws away from the Fault Belt followed by a change in trend to become sub-parallel to the Fault Belt, wich coincides with a progressive decrease in throw.

South of the Morley-Campsall Fault Belt, the pattern of major NE-trending normal faults is re-established, together with a minor set of NW-trending normal faults.

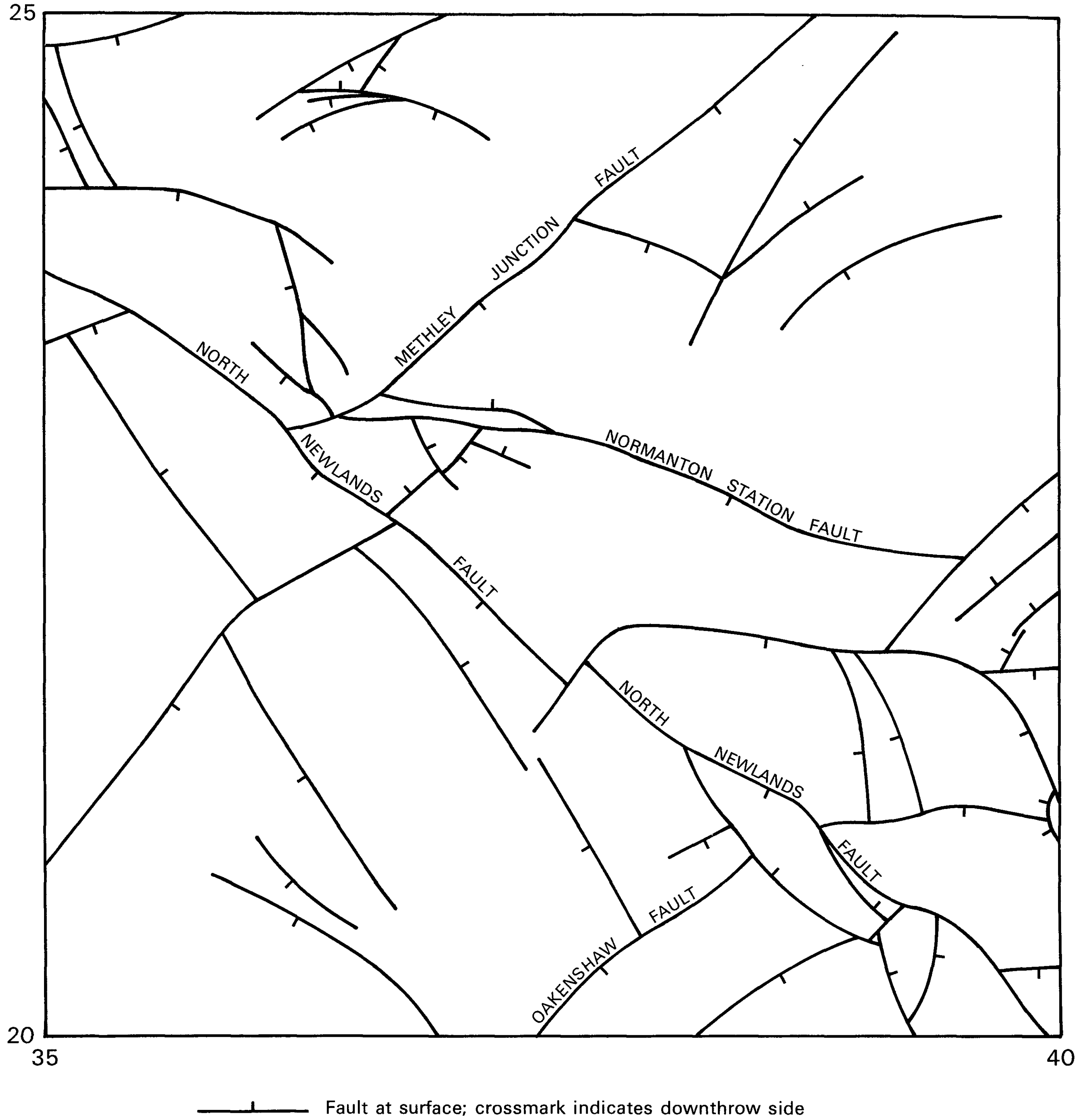

Figure 14 Sketch map of the major faults

Folding is usually in the form of broad open structures. For example, in the fault-bounded block north of the Morley-Campsall Fault Belt and east of the Methley Junction Fault, a broad, gentle anticline is developed. It can be particularly well seen on the Beeston Seam mine plans. A broad, open and plunging anticline can be detected on the Stanley Main plans between the Morley-Campsall Fault Belt and the Oakenshaw Fault.

Joint planes are common and are best seen in the thicker sandstones. They are mostly very steep or vertical, and generally comprise two conjugate sets. Regionally, however, they vary considerably in trend and no general pattern can be discerned from the sparse data available. The joints near the surface may open where undermined, causing noticeable fissures. This has been noted when sites have been been cleared of topsoil prior to development.

Cambering of limited extent has been recorded at some localities where sandstones cap hills or form pronounced breaks in slopes.

4. DRIFT GEOLOGY

The Quaternary drift deposits comprise Till, River Terrace Deposits, Alluvium, Peat, Head and Blown Sand. About 20 to 25% of the area is covered by mappable drift deposits, mainly located in the Calder valley. Scattered, isolated patches of till, alluvium and head are spread over the rest of the district. Thematic Geological Map (TGM) 1 shows the distribution of the drift deposits.

4.1 REGIONAL SETTING

During the Quaternary times, West Yorkshire was affected by several cold episodes. Prior to the Ipswichian the region was covered by ice on at least one occasion. Deposits relating to pre-Ipswichian glaciation show no constructional features and are usually extensively weathered and decalcified. They are preserved as eroded remnants on the interfluves.

Ipswichian deposits dating from the last interglacial are poorly recorded. Bones of two adults and one juvenile Hippopotamus were found in the Terrace Deposits of the River Aire (Denny 1854), although the precise location of these finds is not accurately known.

In the most recent glaciation, during the Dimlington Stadial (Rose 1985), ice advanced down the Vale of York, briefly as far south as Doncaster but the more northerly moraines at York and Escrick represent a more persistent southern limit to the advance. Ice also accumulated on the Pennines producing substantial valley glaciers which flowed down the main Pennine dales.

It is probable that the Normanton district was free of ice for much of the Devensian, as the major ice-sheets terminated to the north and west of the district. Fluvio-glacial deposits were laid down under peri-glacial conditions in the major dales during the advance and subsequent retreat of the ice. At the time of maximum glaciation and for a period during the retreat, a substantial pro-glacial lake, Lake Humber, covered much of the Vale of York. Its initial level was at about 30 m A.O.D. (Edwards 1936), and this is marked by isolated patches of shore-line gravels along the edge of the Pennines and along the York-Escrick Moraine. The level of Lake Humber subsequently dropped to between 7 and 8m A.O.D.

Following the climatic amelioration at the end of the Devensian, Lake Humber was drained and meandering river systems developed in the major dales, re-sorting and re-depositing the fluvio-glacial deposits.

4.2 TILL

Till is confined to isolated thin patches in the east of the district. No good sections of the till have been observed during the resurvey, so it is difficult to identify with certainty. Near Ashfield [3870 2329], a stoney clay was ploughed in the fields. On Normanton Golf Course [3960 2233], the bedrock features are masked by a drift deposit, shown in shallow drainage ditches to be stony. In conjunction with its topographical position, this evidence suggests that it is till.

4.3 RIVER TERRACE DEPOSITS

Two terraces fringe the alluvium of the River Calder and are equivalent to those originally recognised by Green and others (1878) and Edwards and others (1940). They were laid down in complex fluvial and fluvial-lacustrine environments and therefore show rapid lithological variation both vertically and horizontally, ranging from laminated clays through silts and sands to coarse gravel.

Second River Terrace Deposits

Only small isolated areas of this deposit are preserved. The most widespread is north of Altofts around [3700 2400] where a rolling terrace feature with sandy to pebbly soil is preserved. Ditches across the terrace suggest that it is here less than 1 m thick. A similar terrace feature is developed west of Lady Gordon's Bridge [3676 2138]. Here, a dissected and undulating terrace has a sandy soil with sporadic pebbles which contrasts markedly with the heavy, mudstone-derived soils of the surrounding fields.

First River Terrace Deposit

This terrace forms a broad feature [355 220] to the east of the former Park Hill Colliery. Most of the thicker parts of the deposit have been exploited for sand and gravel and the resulting pits backfilled or left derelict. Prospecting boreholes, drilled prior to the extraction of the sand and gravel, indicated that it was up to 9.8 m thick. The deposit is dominantly sandy gravel but with varying proportions of sand and gravel. It is normally clean but sporadically 'clayey'. Thin, discontinuous bands of clay and silt were also recorded.

A thin ribbon of the First Terrace Deposit is also preserved north of Altofts. Little is known about the terrace here except that Fox Pit records 5.4 m of "sand" at the top of the shaft.

4.4 ALLUVIUM

The alluvium is the most extensive of the drift deposits and forms a broad spread up, to 1.4 km wide, in the valley of the River Calder. The deposit was formed comparatively recently by progressive deposition from the meandering river. No sections through the alluvium were available for examination during the re-survey but numerous prospecting and site investigation boreholes show that the deposit is up to 12.2 m thick. At the surface, the deposits are varied, ranging from gravel to fine silts and clays. At depth, they are more consistently gravel with cobbles and sporadic boulders up to 0.7 m in diameter.

Parts of the river may have been artifically straightened and constrained by artificial banks and the construction of the railway near Kirkthorpe truncated a meander which is now partly silted.

Small strips of alluvium occur along Choke Churl Beck (3953 2465) and an unnamed stream [380 216] north of Woodhouse Grange.

4.5 PEAT

An area of wet low-lying alluvium north of Park Hill Colliery is covered by thin peat as is a smaller area of alluvium east of Birkwood Bridge [3589 2395]. No data is available on the thickness of these deposits.

4.6 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. Some of these deposits are probably still moving today under the action of present-day weathering and plant growth. Many of the deposits in the local valleys come under this heading and comprise mixtures of soft clay, sands and angular rock fragments, including all rock types in the substratum. Head may be present over much of the ground and commonly is a yellow, sandy clay lacking in cohesion and stability. It tends to be thicker in hollows and to have accumulated against obstructions on slopes. A substantial polymict deposit thought to be mainly head has been mapped [388 235] near Ashfield. The head is generally less than 2 m thick, but may exceed this in some of the main valleys. It is not possible to indicate its complete distribution due to its thinness and its lack of distinguishing characteristics. It should be assumed to be present everywhere unless proved otherwise during site investigation.

4.7 BLOWN SAND

A small area of recent blown sand has been deposited [3553 2070] where sand, derived from power station waste deposits, has been blown against a pre-existing embankment.

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 investigations are necessary where they are to be built on so as to determine their thickness, compressibility and chemical content. Six main categories are distinguished below; recorded thicknesses are extremely variable.

5.1 LANDSCAPED GROUND

This category covers the ground beneath 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 Made Ground more than 1.5 m thick, which has been taken as the arbitrary limit for mapped deposits, and it is virtually impossible to determine accurately the thickness of such deposits 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. There thickness is generally more easily estimated and within a development area, such deposits can be widespread.

5.3 BACK-FILLED QUARRIES

Excavations of sandstone, of clays for brickmaking and of sand and gravel are scattered across the area. Many have been back-filled so that commonly there is little surface indication of their former extent. In most instances, archival records have supplied the details of the former pit or quarry but there is generally little information on the nature or state of compaction of the fill.

5.4 BACK-FILLED OPENCAST COAL SITES

There are numerous former opencast coal sites in the district, as shown on the accompanying Thematic map. Such sites are effectively landscaped and restored.

5.5 COLLIERY WASTE TIPS

These tips are a conspicuous feature of parts of the district especially along the Calder valley. They generally consist of pyrite mudstone and sandstone but there may also be a considrable proportion of coal.

5.6 GENERAL REFUSE TIPS

Domestic and industrial refuse contains a wide admixture of materials which may, upon burial, produce problems of instability and the possible emission of methane. Archival data have proved inadequate in indicating the positions of all waste-tips and it is likely that not all have been located.

6. ECONOMIC GEOLOGY

6.1 COAL

Coal is still raised in the district at New Sharlston Colliery. No opencast coal production is currently active but several sites have been prospected for possible future production. Almost the entire district has been subject to underground mining for coal, except for pillars protecting settlements, canals, rivers and shafts. Numerous shafts, backfilled opencast coal sites, shallow mines, deep mines and several large waste tips are a legacy that the coal industry has bequeathed to the district. Opencast mining has been extensive in the past. Many of the sites exploited the Sharlston coals; prospecting of this group of coals is continuing and further production from them cannot be excluded. Recent improvements in methods of excavation has lead to the prospecting of deeper coals which it is now feasible to work.

6.2 MINESTONE

Extensive areas of colliery spoil lie adjacent to the sites of several former collieries. Some of this spoil is now regarded as a resource of 'minestone', which can be processed to meet specifications for a wide variety of uses such as fill for embankments or river and sea defences, land reclamation and brick-making. Minestone was extracted from West Riding Colliery Tip [3933 2472] in the financial year 1983/84, but since transport costs constitute so large a proportion of the total costs, the market is dependant upon local demand.

6.3 FIRECLAY

Some mudstone-seatearths are exploited for fireclay. In particular, the seatearth of the Better Bed Coal was extensively worked to the south-east of Leeds. However, it has been proved at only one shaft in this district, and has not been worked. The mudstone-seatearth of the Swinton Pottery Coal has been worked for refractory clay at St John's Field [3725 2252].

6.4 IRONSTONE

Many sections in shafts and boreholes record bands and lenses of ironstone. Collieries to the south of Leeds which worked the Black Bed Coal commonly also extracted the overlying ironstone-rich strata. In this district little Black Bed Coal was worked, and apparently none of the overlying ironstones. Thick bands of ironstone are known above the Middleton Main and Flockton Thick, but again there is no evidence of their having been worked.

6.5 MUDSTONE AND CLAYSTONE

The mudstones and claystones of the Coal Measures have very variable physical properties. However, several horizons have been worked as brick-clays. For example, several pits have worked the strata above and below the Swinton Pottery Coal for most of this century. Several smaller brick-pits have been opened in the strata above the Sharlston Top, but none of these is currently active.

6.6 SANDSTONE

No economically important sandstone crops out in the area. Most of the sandstones of any thickness have been exploited in the past for building stone. Most of these pits are small and the stone is inferior. For example, a minor quarry in the Warmfield Rock [3725 2122] seems to have supplied stone for local walls and farm buildings.

6.7 SAND AND GRAVEL

Much of the potentially workable sand and gravel has already been extracted. This was in the first Terrace Deposits of the Calder and their extension beneath alluvium. The little that remains is mainly covered by colliery spoil tips.

6.8 HYDROCARBONS

Speculative structure contour maps based on shaft, borehole and mine-plan data indicate several anticlinal closures in the district. To the east, stratigraphically below the Productive Coal Measures, some Westphalian and Namurian sandstones are known reservoir rocks.

7. RELATIONSHIPS BETWEEN GEOLOGY AND LAND-USE PLANNING

The two principal geological factors which have implications for land-use planning are subsidence (mainly related to shallow mining) and the extent of mineral resources. To illustrate the controlling factors, TGM 1,2 and 4 show the distribution of drift deposits, made ground and underground mining respectively and Figure 14 shows the position of the major faults.

7.1 SUBSIDENCE

New Sharlston Colliery is the last working colliery in the district but in the recent past, mines were much more numerous. Much of the district has been mined at depth, the principal seams being the Beeston, Middleton Eleven Yard, Middleton Main, Flockton, Haigh Moor, Warren House, Kent's Thick, Stanley Main, Abdy, Houghton Thin, Sharlston and Shafton.

Shallow mining and crop workings are known from several parts of the district, such as at Altofts where the Stanley Main was worked, and at Warmfield Common where the Sharlston coals were exploited. Many of the opencast sites and prospects recorded evidence of shallow much earlier mining in the Stanley Main, Sharlston and Shafton coals. On this basis, shallow mining is likely to have occurred wherever these seams lie within 30 m of the surface. Where mining has taken place, subsidence is likely for some time after the date of mining, depending upon the depth of the workings, type of extraction pattern, the geological conditions and the age of mining; it cannot be assumed that all settlement has ceased, particularly where pillar-and-stall workings are involved. Within the areas where shallow mining is likely, detailed site investigations are necessary prior to any development.

Numerous abandoned shafts are recorded in the district, but there may also be many unrecorded ones. In some cases, several shafts are shown closely grouped on the geological map. Such occurences may represent the same shaft differently locating on two or more archival documents. The exact location of shafts should be given high priority during site investigations, since some may only be capped; others may have been filled, but compaction of the fill has left a void beneath a surface capping. In each case there is a potential hazard to construction.

The possibility of localized subsidence along faults which intercept a mining wave should also be borne in mind. Natural movement along faults can cause subsidence but such movements are extremely rare. It is much more common for subsidence to be concentrated along a fault when coal extraction has occurred on one side of it. Such subsidence tends to be most intense when workings approach the fault from the upthrow side. A good example of this type of subsidence can be seen south of Normanton Golf Course [3960 2233]. These effects must be considered when developments are planned in faulted areas where mining is active.

Differential compaction may occur where different parts of a site are underlain by different rocks. This can arise from the original sequence of the rocks or where differing lithologies are thrown together by faults. The hazard may also arise when part of the site rests on bedrock and the remainder lies on poorly compacted fill.

7.2 MINERAL RESOURCES

In planning the development of a district, consideration should be given to siting major constructions where they will not prohibit the future exploitation of mineral resources, if possible, workable minerals should be extracted in advance of development.

Some parts of the present district are underlain by coal at shallow depth, the most important seams being the Warren House, Houghton Thin, Sharlston and Shafton. Few records exist of the extent of former mining in these seams. Throughout much of the district, they are regarded as prime targets for extraction by opencast methods. Currently, opencast coal prospecting is taking place and it is likely that new opencast sites may be proposed.

7.3 OTHER CONSTRAINTS ON LAND-USE PLANNING.

Slope movements can cause foundation problems. Certain slopes show evidence of cambering, especially where a competent sandstone forms a distinct break in slope on a hillside otherwise underlain by mudstone.

In these circumstances, blocks of the coherent rock can become detached from the outcrop and slide down the slope. Similar cambering of both solid and superficial deposits can occur when slopes are cut into or artifically over-steepened; in extreme cases, mass movement of rock can occur.

A small natural landslip is recorded west of Gled Hill [3634 2050], but local experience suggests that most landslips occur within made ground deposits.

8. THEMATIC GEOLOGY MAPS

Four thematic 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.

MAP 1 DISTRIBUTION OF DRIFT DEPOSITS

Fluvial and Glacial deposits shown. Head and downwash are also widespread, mantling much of the solid rocks, but because the occurences are thin and lacking in distinguishing characteristics, it is not possible to delimit them accurately and few are shown on the map. The deposits are discussed in more detail in Section 4 of this report.

MAP 2 DISTRIBUTION OF MADE GROUND

Six categories of Made Ground are distinguished. 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 3 BOREHOLE LOCATIONS

The locations of all known boreholes and of those areas where shallow drilling has been particularly intensive are shown; the records of the holes form part of the British Geological Survey's archives. However, it is recognised that not all past boreholes have been recorded.

MAP 4 UNDERGROUND AND OPENCAST MINING

Coal has been extracted in this area since at least, the late eighteenth century. Records and large-scale plans of abandoned mines held by British Coal have been examined and provide much information on the extent of disused workings. However, many of the older workings, comprising numerous bell-pits and pillar-and-stall workings, have no known plans. Their presence can be inferred only from boreholes, old shafts and tips, and from archival information. Disused coal workings are present at depths ranging from immediately subsurface to over 600 m. An arbitary depth of 30 m has been chosen to separate shallow and deep workings.

Four categories of ground are shown on Map 4. (i) areas where coal is known or inferred to have been worked less than 30 m below rockhead; (ii) areas where coal is known or inferred to have been worked at depths greater than 30 m below rockhead; (iii) areas where coal has been worked by the opencast method and (iv) areas where no workings are known. Particular care is required when developments are planned in areas where the thicker coals (Haigh Moor, Warren House, Methley Park, Stanley Main) are close to the surface, as old pillar-and-stall workings may stand for many years, possibly collapsing only after changes in groundwater conditions or after loading at critical points such as underground roadway intersections.

The map also shows the positions of mineshafts, though it is unlikely that all have been located. Both former and active opencast sites are shown, but the information given on the map is generalised. For detailed information on former shafts and mining subsidence problems, reference should be made to British Coal.

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APPENDIX A

MINE ABONDONMENT PLANS EXAMINED IN THE PREPARATION OF THESE MAPS AND REPORT.

A. <u>OFFICIAL CATALOGUE</u>

821	NE 109	NE 682
1621	NE 237	NE 682
1651	NE 265	NE 701
2080	NE 312	NE 726
3410	NE 313	NE 727
4150	NE 314	NE 728
4493	NE 317	NE 729
4521	NE 379	NE 730
4724	NE 395	NE 731
4807	NE 403	NE 735
4821	NE 423	NE 736
5513	NE 426	NE 795
5777	NE 436	NE 796
5936	NE 437	NE 833
7164	NE 438	NE 834
7993	NE 468	NE 843
8483	NE 496	NE 859
9352	NE 571	NE 864
9850	NE 572	NE 867
10445	NE 623	NE 889
11998	NE 642	NE 913
12435	NE 644	NE 914
12436	NE 645	NE 923
13090	NE 678	NE 925
14277	NE 679	
14369	NE 681	

B PRIVATE CATALOGUE

CT 17	FGB 802	M 483
CT 60	FGB 804	M 485
CT 61	FGB 811	
CT 68	FGB 839	
CT 69	FGB 841	
FGB 73	FGB 905	
FGB 118	FGB 906	
FGB 126	FGB 907	
FGB 129	FGB 927	
FGB 130	FGB 928	
FGB 212	FGB 968	
FGB 253	GCR 37	
FGB 254	GCR 44	
FGB 255	GCR 45	
FGB 286	GCR 46	
FGB 299	GCR 48	
FGB 300	GCR 70	
FGB 301	GCR 71	
FGB 304	GCR 73	
FGB 305	GCR 74	
FGB 322	GCR 80	
FGB 323	GCR 86	
FGB 324	GCR 84	
FGB 401	GCR 90	
FGB 440	GCR 93	
FGB 444	GCR 130	
FGB 477	M 251	
FGB 478	M 261	
FGB 611	M 265	
FGB 719	M 279	
FGB 720	M 297	
FGB 761	M 311	
FGB 762	M 313	
FGB 765	M 384	
FGB 780	M 385	

All the above plans may be examined by appointment with:-

Mines Records and Mines Drainage Office
Westfield House
Westfield Road
Rawmarsh
Rotherham
South Yorkshire

Additional information concerning mining and shaft locations is available from:-

British Coal
North Yorkshire Area HQ
Allerton Bywater
Castleford
West Yorkshire

APPENDIX B

BRITISH COAL OPENCAST RECORDS EXAMINED IN THE PREPARATION OF THESE MAPS AND REPORTS.

No	Site
092	Roman Station Farm*
201	Sharlston Common
205	Woodhouse
217	Snydale*
337	Red Lane*
338	Deanfield
505	Danhead Wood with Huntwick & Victoria
695	Birkwood Clump
721	Gap Lane I and II*
776	Willow Garth
872	Penbank
881	Loscoe
911	Wain
947	Pineapple
949	St John's
968	Rowley
Unnumbered	Altofts
Unnumbered	Birkwood Common*
Unnumbered	Hill Top Farm*

Copies of these records may be examined at the discretion of:-

British Coal Opencast Executive
Yorkshire Area HQ
Rothwell Colliery
Rothwell
Leeds
LS26 0JZ

In addition the completion plans of those sites marked by an asterisk can be examined by appointment with:-

Mines Records and Mines Drainage Office
Rawmarsh
Rotherham
South Yorkshire