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Geological notes and local details for 1:10 000 sheets.
Sheet SE 42 NW - Castleford
Part of 1:50 000 sheet 78 (Wakefield)
J. R. A. Giles

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BRITISH GEOLOGICAL SURVEY, KEYWORTH
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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 varity of sources. It has been derived from results contained in the maps and reports listed in Table 1 each of which give details of the various sources of the data.

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. Localised or anomalous features and conditions may not be represented, and any boundaries shown are only approximate. The dates of the geological mapping are shown in Table 1 and no information made available after these dates has been taken into account. For this reason:-

> 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.

CONTENTS

FIGURES

EXECUTIVE SUMMARY

This report embodies the result 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 superfical geology, and to identify and report on 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 and shaft records, tip plans and data held in the National Geoscience Data Centre at BGS Keyworth.

b) a detailed field geological survey by the author at the 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. A generalised geological sequence is shown on the margin of the geological map and in Figures 3, 6, 9 and 10 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 summarised in thematic geological maps covering:-

1. thickness of drift deposits
2. distribution of drift deposits
3. distribution of made ground
4. borehole locations
5. underground and opencast mining
6. sand and gravel resources
7. underground sand mining.

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.

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.

Subsidence

Although the effects of subsidence from coal and sand mining are considered separately below there are certain parts of the district where both coal and sand mining are within thirty metres of the surface.

Coal Mining

There are two active collieries in the district Allerton Bywater and Wheldale. Although, in the past, mines were much more numerous. Much of the district has been mined at depth, the principal seams worked being the Beeston, Middleton Main, Flockton Thick, Haigh Moor and Warren House (Figures 2, 6 and 12).

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 developments or buildings can increase the surface loading and lead to sudden 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, although many more unrecorded ones almost certainly exist.

Sand Mining

In certain parts of the district the Basal Permian Sand has been mined. This mining has usually taken the form of adits driven into the deposit from outcrop, the adits opened into pillar and stall mines which extended for distances of up to seven hundred metres. During the last two centuries numerous small mines may have exploited the reserves, however, only a few plans of the later and more extensive mines survive. Evidence of the existence of mines outside the areas of known mining is furnished by site investgation boreholes and archival sources. The rate at which old workings collapse depends upon the depth, type of extraction pattern, the geological conditions and the age of mining; it must not be assumed that all settlement from these mines has ceased. The mining of this deposit is generally at very shallow depth and there is a history of surface collapses due to void propagation from the abandoned workings to the surface in certain parts of the district.

Mineral Resources

In planning future developments, it is important to know where the mineral resources are, so that they are not sterilised by building. 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 Warren House, Kent's Thick and Meltonfield coals which are regarded as prime opencast targets where they occur close to the surface.

Sand and gravel forms a significant resource in the valleys of the Aire and Calder. It is currently being exploited north of Dunford House. Extensive resources of sand and gravel remain; though much has been sterlised by colliery waste tips.

In the east of the district the Lower Magnesian Limestone is exposed. It has been used in the past as building stone and is exploited at various localities in West Yorkshire for use as a aggregate. No extraction is currently taking place in the district.

Other Constraints on Land-use

Slope movements can cause further foundation problems. Certain slopes show clear evidence of cambering. The escarpment of the Lower Magnesian Limestone to the east of Ledston is clearly cambered and shows open joints aligned parallel to the edge of the escarpment. Slippage of strata and down-slope mass-movement of superficial deposits can also occur.

Some of the drift deposits may vary in lithology and thickness very rapidly. For example, the river terrace deposits may show differential compaction under loading, and compressible beds may occur in buried channels. Head, which is generally too thin to map, may be locally present in substantial thicknesses. It is a very variable deposit in composition, thickness and state of consolidation and as a result may be a hazard to foundations. Particular problems are caused by Head, which is of unknown thickness along the base of the Lower Magnesian Limestone escarpment, north of the River Aire. In places this may consist of several metres of poorly sorted silts and clays with sand and some gravel. If the toe of this deposit is excavated the sediment may be remobilise and move down slope.

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, particularly if they are not recognised during site investigations.

INTRODUCTION

This report and the accompanying maps are a summary of the geology of the 1:10 000 sheet SE 42 NW. It has been produced for the Department of the Environment, as Phase 4 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 the district 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 W. T. Aveline, A. H. Green, T. V. Holmes, R. Russell and J. C. Ward, the maps being published in 1876 as six-inch Yorkshire county sheets 219 and 234. The area was resurveyed by W. Edwards in 1931-32. 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 1986 by J. R. A. Giles. 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. Thickness of Drift Deposits.
2. Distribution of Drift Deposits.
3. Distribution of Made Ground.
4. Borehole Locations.
5. Underground and Opencast Mining.
6. Sand and Gravel Resources
7. Underground Sand Mining.

1. PHYSIOGRAPHY, POPULATION DISTRIBUTION, COMMUNICATIONS AND LAND USE

The district lies to the north of Castleford (Figure 1), across the boundary between the Leeds metropolitan District Council and the Wakefield metropolitan District Council. The major centre of population is the town of Castleford [4351 2572]. The villages of Allerton Bywater [4210 2755] and Great Preston [4050 2978] are sited near collieries, whilst the origin of Ledston [4318 2863] is related to the former Ledston estate.

The meandering rivers of the Aire and Calder dominate the district. Away from the rivers the ground rises towards the bold escarpments of the Lower Magnesian Limestone. The outlier of Lower Magnesian Limestone at Great Preston [4006 2997] forms the highest point in the district, 79 metres A.O.D. About sixty percent of the area is rural in character being largely devoted to arable farming with a little livestock rearing. Small isolated areas of woodland survive or are maintained such as Forest Plain [4438 2986]. An area of landscaped park survives at North Park [4361 2934] close to Ledston Hall [4357 2898].

The area is crossed by the A656 which follows the course of a Roman Road north of the River Aire. To the south of Castleford the M62 motorway skirts the edge of the district. Railway lines, that cross the south of the district, connect Castleford with Leeds, Wakefield and York. The Aire & Calder Navigation carries barges commonly loaded with oil or coal. The canal also carries a limit number of leisure craft.

Widespread coal mining since the end of the late eighteenth century has left its mark on the landscape in the form of extensive waste tips, reclaimed opencast sites and numerous shafts. Two mines, Allerton Bywater [4218 2781] and Wheldale [4393 2650], are still working. Brickclay, ironstone, fireclay and sandstone were also extracted from the Westphalian strata.

Numerous former quarries and mines in the Basal Permian Sand are also known, for example Wheldale Sand Mine [4493 2641]. Extensive former quarries in the Lower Magnesian Limestone are scattered along the escarpment, for example Crispin Quarry [4305 2960]. Gypsum was formerly quarried from the Permian Middle Marls at Plaster Pits [4457 2959].
Sand and gravel has been won from a number of small pits, scattered across the Quaternary sediments, mostly for local use. Sand and gravel is still actively quarried at Methley Mires sand and gravel quarry [4082 2643].

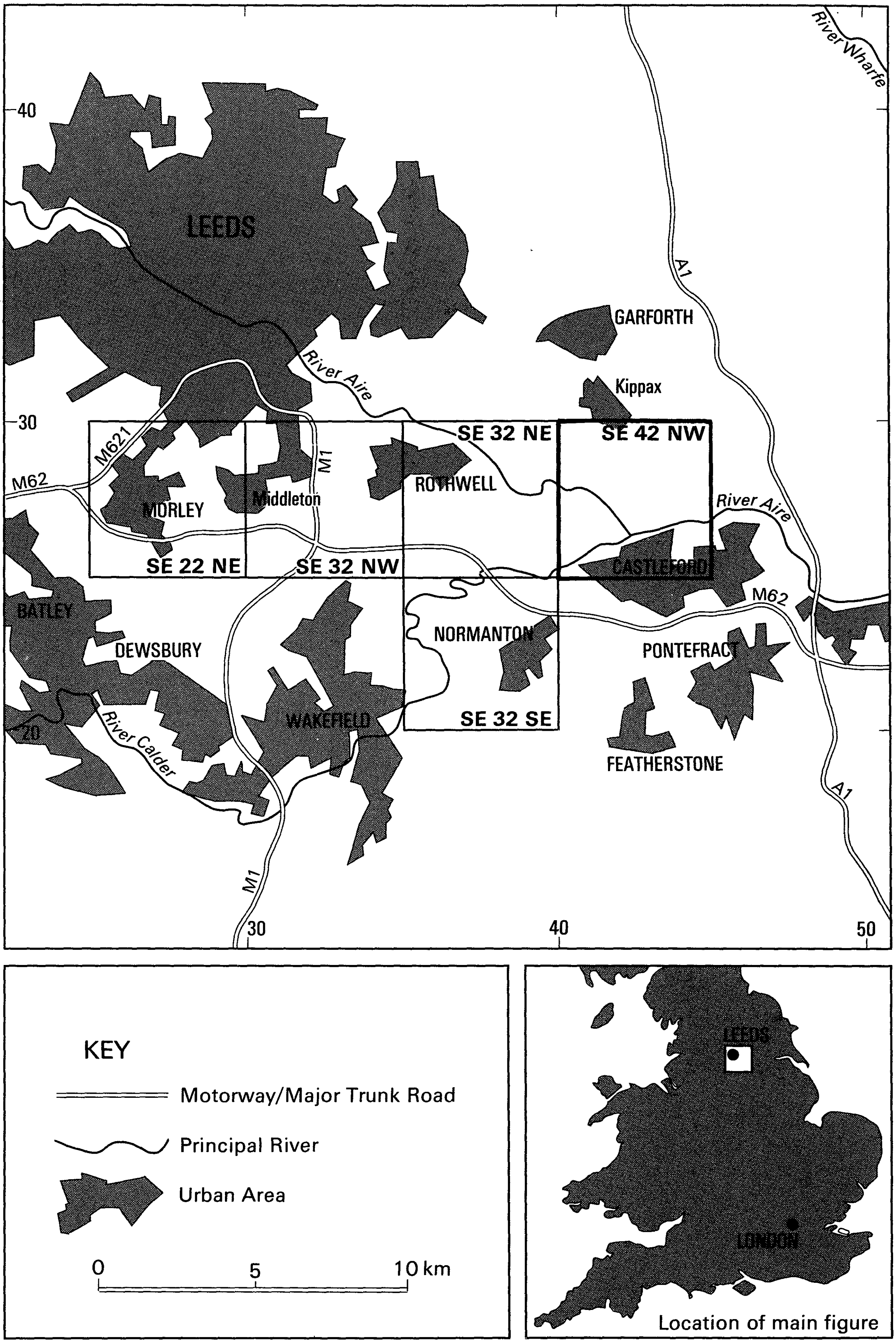

Figure 1 Sketch map showing location of district. Area of this report is shown with bold outline.

2. WESTPHALIAN

2.1 GENERAL

Much of the district is underlain by Coal Measures of Westphalian A, B and C age forming part of the West Yorkshire coalfield. About 50 metres of Westphalian C strata are exposed at the surface in the south-east of the district and a considerable thickness of Westphalian A and B strata, including numerous 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, drift deposits such as river terraces, urban developments or waste tips. The few exposures of the Westphalian which remain, are largely confined to disused quarries and other artificial sections. Details of the Westphalian sequences 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 index 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 Geoscience Data Centre (South), 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 British Coal 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, 6 and 9. 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 MEASURE LITHOLOGIES

The most common lithologies are interbeded 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 structures are also common. Ironstone nodules may be found in association with these lithologies. The terms claystone and mudstone have been taken to be synonymous with old mining terms bind, drub, blaes, metal and shale. Likewise, siltstone is synonymous with the 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 sandstone 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 one centimetre thick or many metres thick. The latter include named sandstones such as the Glass Houghton Rock. The bedding varies from massive to flaggy. Sedimentary structures include 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 old mining terms cank, freestone, galliard, post, rag and stone appear to be synonymous with sandstone.

The seatearths include all grades of sediments from claystone to sandstone, but generally they are unbedded and contain 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 percent by weight, and more than 70 per cent by volume, of carbonaceous material. Coals are normally laterally extensive, but can change their thickness or number of dirt partings, and die out. The coals of the district are bituminous, and generally increase in rank southwards (Wandlass, 1960).

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

Rare limestones are present, but they are thin and discontinuous. Eager and Rayner (1952) recorded a 0.15m " 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 limestones, locally called " cank", are recorded in Glass Houghton Colliery.

Ironstone, mainly in the form of impure siderite, is ubiquitous. It mostly occurs as nodules, bands and lenses of clay ironstone with 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 0.25m thick (Godwin, written communication), in the Robin Hood Quarry [3240 2720] at the horizon of the Swallow Wood coal.

2.4 PALAEO-GEOGRAPHY AND SEDIMENTOLOGY

During the Upper Carboniferous, the district formed a small part of the Pennine deposition 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 terms of the main environments on the subaerial delta plain of the Mississippi (Coleman and Prior 1980). These environments are distributary channel fill, interdistributary bay, swamps and crevasse splays. A generalised diagram illustrating the relationships of the major depositional 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, two kilometres or more wide, are interpreted as major distributary channels. The sandstones represent sand bars laid down at times of high and 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 deposits, normally less than one metre thick, of black, thinly laminated,

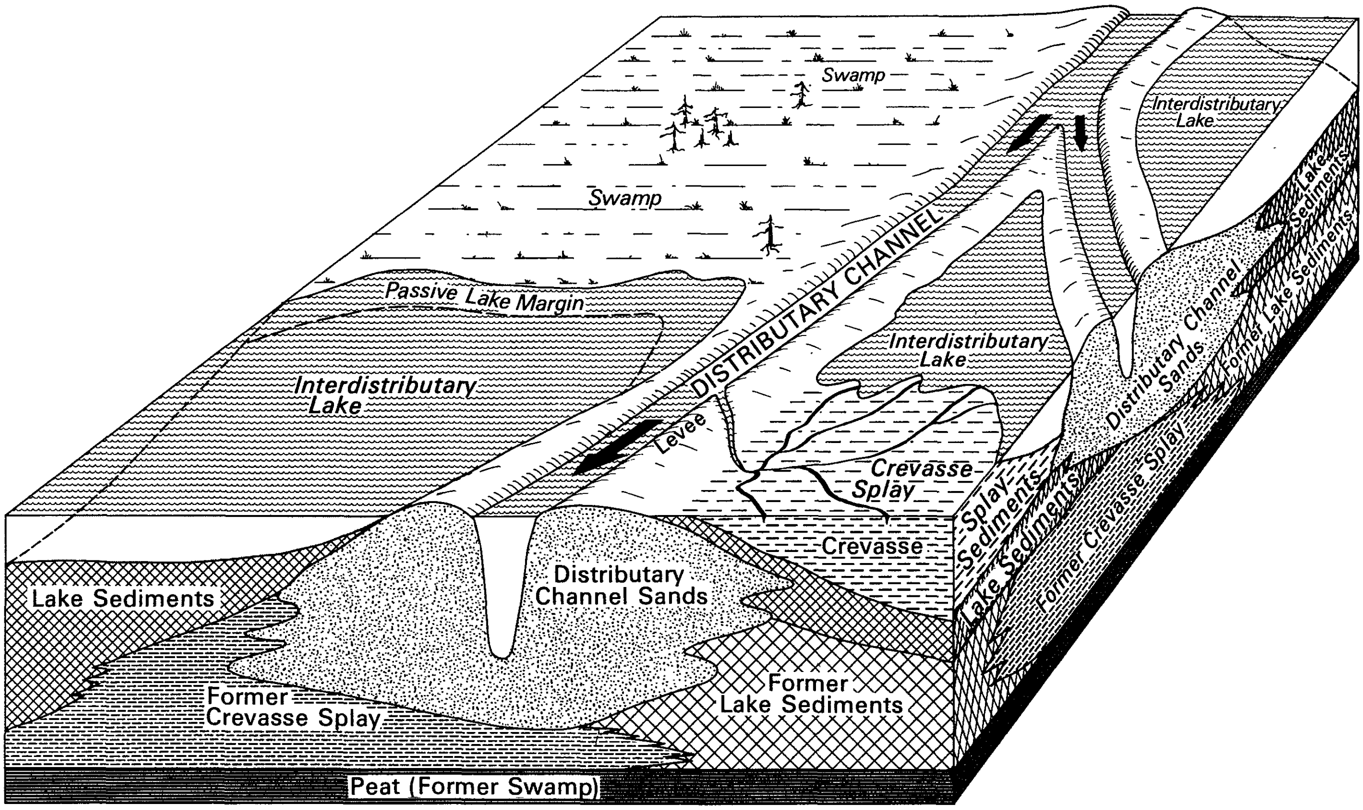

Figure 2 Generalised diagram illustrating the relationships of the major Westphalian depositional environment.

carbonaceous claystones; thin sporadic limestones are 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 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 proceeding two facies are frequently overlain by sheet-like spreads of massive laminated claystones containing non-marine bivalves, crustaceans and plant debris, commonly with numerous trace fossils. This facies represents an input of fine sediment into the lake, either as the most distal deposit 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 tend to become finer upwards. 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 seatearth 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 or alternatively a raised bog.

Crevasse Splays

This facies association comprise coarsening-upwards sequences from claystones, mudstones 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 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 splay. During a flood, the levee or banks of a major channel is breached allowing a minor channel and a distributary delta to form. The progressive encroachment of these small deltas and the succeeding delta-top channel sandstones, produces the coarsening-up sequence and changes in fossil assemblages. Fielding (1984 a) identifies three main facies in this association which he interpretes as proximal major crevasse splay channels, medial crevasse splay/minor delta and distal crevasse splay/minor delta.

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 (1967 and 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 0.5m per million years over time spans of at least 5000 years". Stach (1982, pp 17-18), in discussing the accumulation rates of coals. He concludes that "1 metres 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 in Tyne and Wear; " 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 10m thick sandstone at Seaton Sluice was deposited as part of one bar within a 1.9 kilometre wide low sinuosity river". Kirk (1983) likewise describes former channel bars producing sandstones up to 7m 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 metres 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 Pennines 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

Westphalian A

Measures between the Subcrenatum Marine Band and the Low Beeston

Little is known about this part of the sequence in this district. At crop to the north, the measures consist of the Ganister Coals, the Elland Flags and the measures between the Better Bed and Low Beeston coals, altogether some 270m to 290m in thickness.

Low Beeston Coal

This seam is proved in six shafts within the district. It has an average thickness of 1.34m and a range between 0.82m at Glass Houghton Colliery [4307 2438] to 1.70m at Methley Junction Colliery. The seam comprises either two or three leaves of coal separated by dirt partings.

Measures between the Low Beeston and Top Beeston

In this district these strata are very variable ranging from 0.40m at Methley Savile Colliery [3923 2730] to 12.81m at Methley Junction Colliery [3963 2565]. The measures are dominated by claystone and mudstone or, where thinner, mudstone-seatearth. At Methley Junction Colliery 9.45m of sandstone is recorded.

Top Beeston Coal

This seam is normally represented by two leaves of coal separated by a thin dirt parting with a mean thickness of 0.10m. The seam ranges in thickness from 0.86m at Ledston Luck Colliery [4293 3082] to 1.60m at Methley Savile Colliery. It has an overall mean thickness of 1.23 metres.

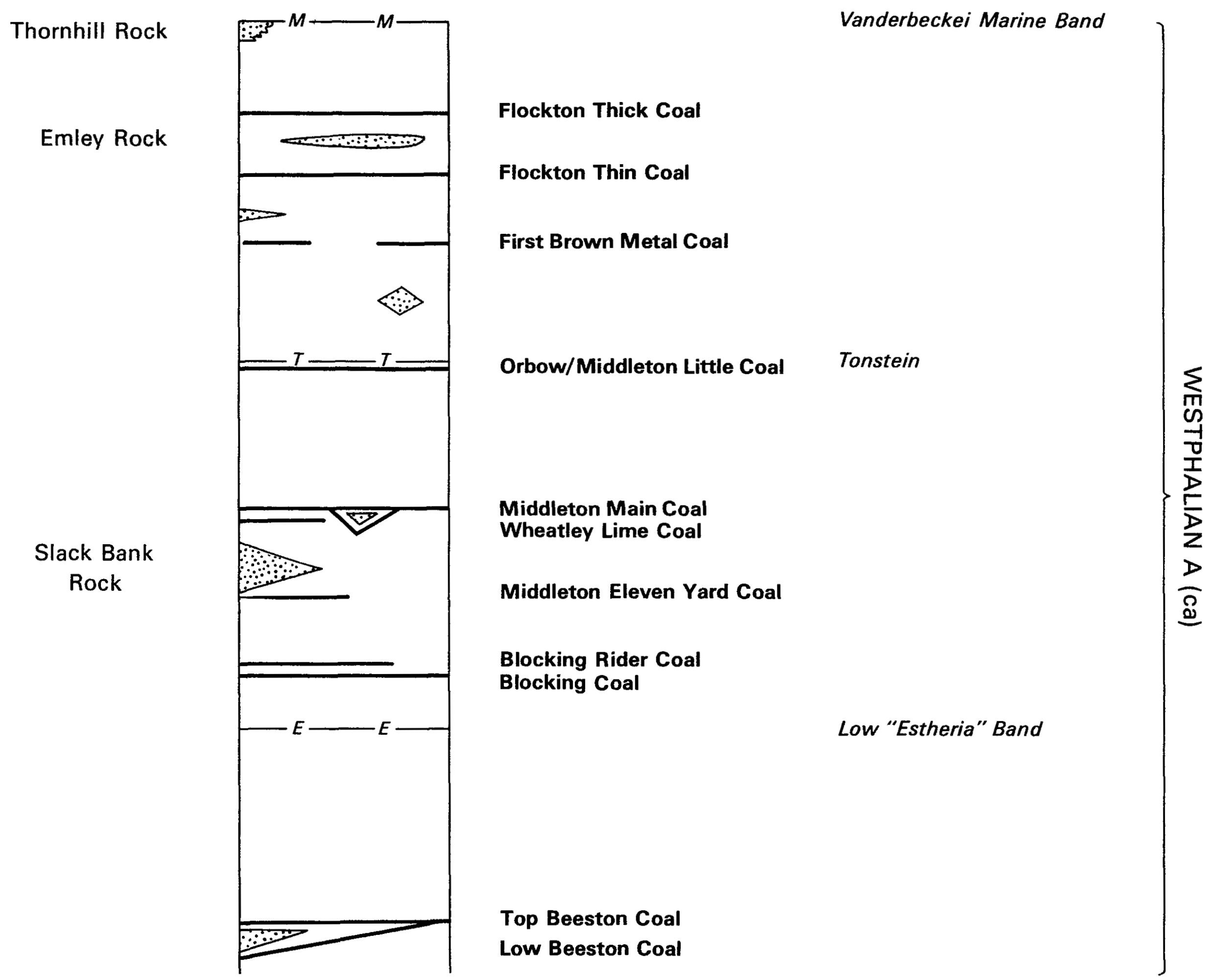

Figure 3 Generalised sequence of Westphalian A rocks of the Castleford District

The top leaf is the thicker and more persistent of the two leaves, having a mean thickness of 0.98m. The lower leaf is thinner or locally absent. It has a maximum thickness 0.44m at Methley Junction Colliery but is absent at Altofts [3894 2419], Methley Savile and Ledston Luck collieries.

The seam has been extensively worked throughout the district. Large ares of coal have been completely removed, except for pillars beneath rivers, canals, shafts and certain settlements.

Measures between the Top Beeston and Blocking

The mean thickness of these measures is 47.44m, with a range of between 37.37m at Ledsham Borehole [4555 2963] to 58.77m at Allerton Bywater Colliery [4215 2788]. The major lithologies are claystone and mudstone with subordinate siltstone and sporadic sandstones up to 6.63m thick. Three thin coals are normally recorded except at Glass Houghton Colliery where only two are proved. A coalfield-wide marker, the Low Estheria Band,is recorded in the Ledsham No. 1 Borehole, 10.36m below the Blocking Coal. Here the Low Estheria Band comprises of 1.30m of dark mudstone. The band is probably present elsewhere in the district, but it has not been identified in other sections.

Blocking Coal

The Blocking coal is normally represented by a single leaf with a mean thickness of 0.52m. It ranges in thickness from 0.35m (Ledsham Borehole) to 0.70m (Methley Savile Colliery). However, the seam may be split by one or two partings; these are normally thin but they may be up to 1.24m thick as at Altofts Colliery [3894 2419]. There does not appear to be a consistent pattern to the location or manner of the splits. There is no record of the seam having been worked in this district.

Measures between the Blocking and Middleton Eleven Yard

This sequence comprises a monotonous sequence of siltstone with subordinate claystone, mudstone and sporadic sandstones. The mean thickness of these measures is 14.59m. A thin coal, known locally as the Blocking Rider Seam, is commonly recorded. It has a mean thickness of 0.23m and comprises of a single leaf of coal. Where it is recorded the seam is found between 0.83m and 2.50m above the Blocking Seam. A second thin coal is also recorded at Victoria No 2 shaft [3979 2872] 12.62m above the Blocking Coal.

Middleton Eleven Yard Coal

The Middleton Eleven Yard Seam has been exploited in the west of the district from Whitwood [4059 2485] and Primrose Hill [3874 2973] collieries. However, the seam degenerates to the east and north before it disappears completely. Where present the seam has a mean thickness of 1.28m and has a maximum thickness of 2.00m, at Methley Savile Colliery.

Only a small area of this seam has been mined on the eastern edge of the district.

Measures between Middleton Eleven Yard and Middleton Main

These measures generally thin in a south to south-easterly direction from a maximum of 20.20m at Victoria No 2 Shaft to 6.17m at Glass Houghton Colliery.

In the west of the district, the Slack Bank Rock rests directly on the Middleton Eleven Yard Seam. The Slack Bank Rock has a maximum proved thickness 10.00m (Alofts Colliery). To the west of this district Giles and Williamson (1985: Fig. 3) showed that the Slack Bank Rock had the form of a major distributary channel. In the present district there is insufficient borehole and shaft information to be able to draw the same conclusion; however, the continuation of the distributary channel facies into the district is quite likely. Away from the sandstone lithofacies the dominant rock type is siltstone with subordinate claystone and mudstones. At Victoria No 2 Shaft two thin coals are recorded 7.26m and 8.23m above the Middleton Eleven Yard Seam.

To the west of the district an inferior coal seam known as the Wheatley Lime Coal is identified a short distance beneath the Middleton Main Coal (Williamson and Giles, 1984; Giles and Williamson, 1985). This seam has only been identified at one borehole in the district, where it is 0.65m and comprises six leaves of coal. It is separated from the Middleton Main Seam by 0.51m of mudstone.

Middleton Main Coal

This seam normally comprises two leaves separated by a dirt parting, normally less than one metre thick. However, the seam is sporadically split into as many as five leaves, as at Methley Mires No 2 Borehole [4164 2646]. In the centre of the district, the dirt parting between the two leaves that are normally present, becomes much thicker. At Fryston Colliery the "Silkstone Bottom Coal" and the "Silkstone Top Coal" are separated by 12.37m of strata, of which 10.85m are composed of sandstone. Elsewhere in the district the split is normally composed of mudstone and mudstone-seatearth.

The Middleton Main Seam is extensively worked in the north and south of the district except for pillars that remain beneath rivers, canals, shafts and selected buildings. In the central part of the district the seam has not been mined due to the presence of the thick parting between the two main leaves.

Measures between the Middleton Main and Middleton Little

These measures are dominantly composed of claystone and mudstone with lesser amounts of siltstone and sporadic thin sandstones. A number of thin coals have been recorded in these measures. For example three thin coals are noted 4.07m, 5.29m and 9.90m above the "Silkstone Top Coal" at Newton Ings Borehole [4483 2737]. A number of shell beds are also recorded as in Fryston Colliery Shaft where a "Mussel bed" is noted 8.61m above the "Silkstone Top Coal". The strata in this interval has a very variable thickness but on average the Middleton Main and Middleton Little coals are some twenty-seven metres apart.

Oxbow/Middleton Little Coal

In the region to the west the Middleton Little Coal and the overlying Third, Second, and First Brown Metal Coals are separate, distinct coal seams. Godwin and Calver (1974) demonstrated that the Middleton Little and the Third and Second Brown Metal coals unit to form a seam that Godwin and Calver named the Oxbow Coal. Giles and Williamson (1985: Fig 4) produced an isopach map showing the progressive thinning of the parting between the Middleton Little and Third Brown Metal Coal. In the Castleford district the Middleton Little, Third and Second Brown Metal coals remain united as the Oxbow Coal. This seam is also referred to as the Hard Band Seam in some records in the Castleford district. The combined seam has a mean thickness of 2.19m and a maximum thickness of 3.45m at Methley Savile Colliery. The seam normally comprises four leaves of coal separated by thin dirt partings. The upper two leaves (which represent the leaves of the lower two brown metal coals) are sporadically separated from the the rest of the seam by a thicker dirt parting.

A tonstein has been recorded by Salter (1964) in the Oxbow opencast site [3610 3000] at the level of the united Second and Third Brown Metal coals. Mr Goosens (pers comm) also records a tonstein at the level of the Second Brown Metal Coal in No. 1 drift at Allerton Bywater Colliery [4500 2920].

The seam has been worked from Allerton Bywater and Methley Junction collieries. No records exist of it having been worked elsewhere.

Measures between the Oxbow and the First Brown Metal

These measures vary greatly in thickness from 11.60m at Victoria No. 2 Shaft to 37.32m at Wheldale Colliery No. 12A Underground Borehole [4484 2806]; the variation is illustrated in figure 4. The dominant lithologies are claystone and mudstone with lesser amounts of siltstone. Locally, thick sandstones are recorded as at Methley Savile

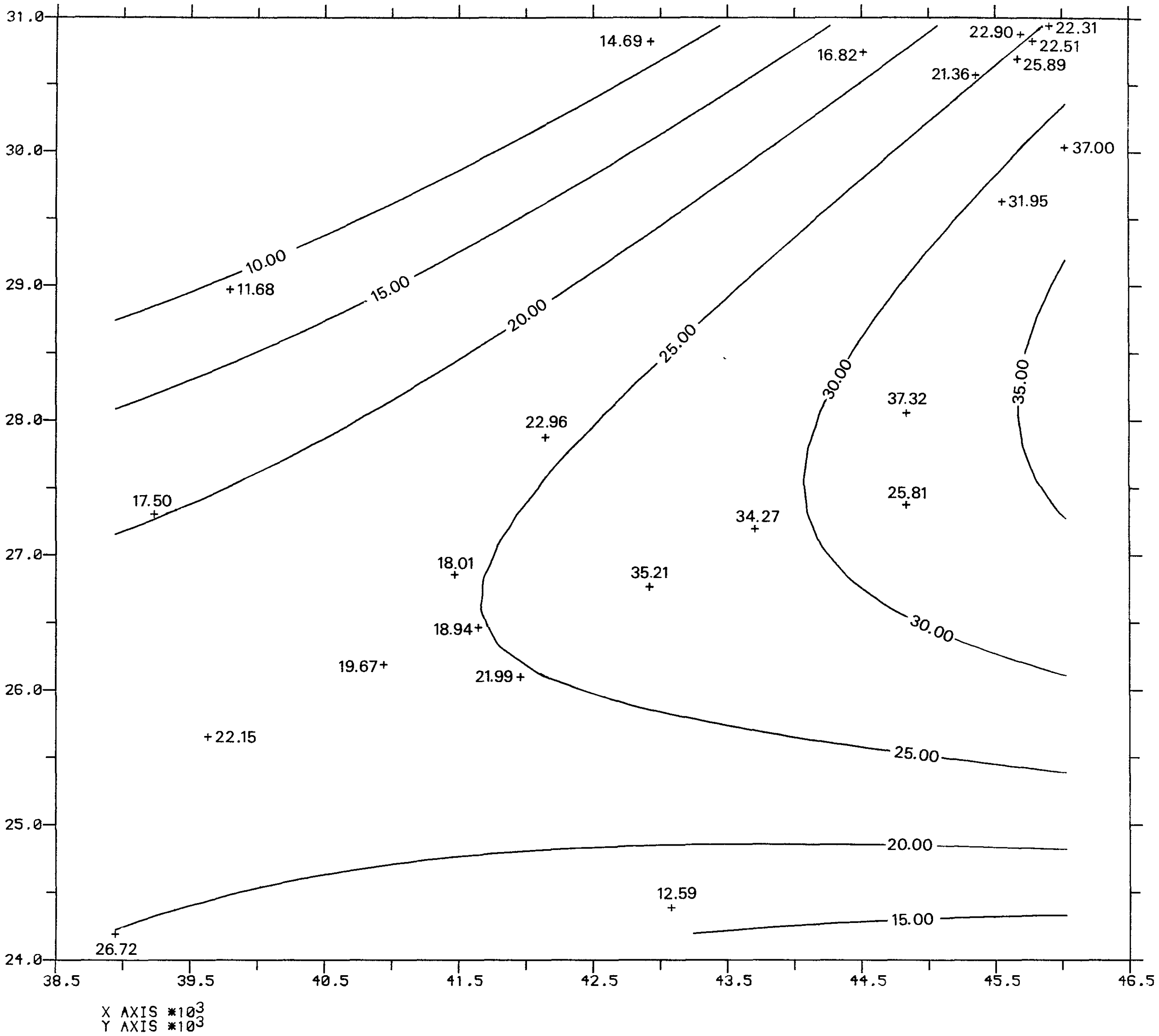

Figure 4 A computer generated 2nd order trend surface analysis of strata thickness between the Oxbow/Middleton Little Coal and the First Brown Metal Coal.

Colliery where 8.31m of sandstone are found interbedded with siltstone. Sporadic occurences of up to three thin coals are also recorded.

First Brown Metal Coal

This seam has a mean thickness 0.67m and a maximum thickness of 1.20m at Victoria No 2 Shaft. The seam normally has two leaves separated by a dirt parting up to 0.56m thick. The First Brown Metal Seam is locally absent, as at Allerton Bywater Colliery. There are no records of this seam having been worked in this district.

Strata between First Brown Metal and Flockton Thin

The strata are dominantly composed of claystone and mudstone; siltstone and a number of seatearths are also commonly present. One or two thin coals are normally present, as at Dunford House Borehole [4094 2619] where they are found 1.88m and 9.56m above the First Brown Metal Coal. Sandstone has been found in a number of sections, it is normally thin but at Methley Savile Colliery a sandstone 4.52m thick was recorded. These measures have a mean thickness of 13.08m and range in thickness from 8.84m at Ledsham No. 3 Borehole [4598 3087] to 17.60m at Victoria No. 2 Shaft. There is no apparent pattern to the change in thickness across this district.

Flockton Thin Coal

This seam is very variable. In a little over half the available records the seam comprises one leaf with a mean thickness of 0.57m. In the majority of remaining records the seam consists of between two and seven leaves separated by thin dirt partings. There is no apparent pattern to the number of leaves into which this seam is split. For example, in two Wheldale Colliery Underground Boreholes 254m apart, the Flockton Thin Seam varies from a single leaf of coal 0.42m thick to a seam 1.19m thick with seven leaves of coal, separated by mudstone-seatearth partings. The seam has been worked in the north west of the district from Ledston Luck Colliery.

Measures between Flockton Thin and Flockton Thick

A monotonous sequence of mudstone is broken only by one thin coal that is recorded at a number of boreholes and shaft sections. For example a thin coal 0.08m thick was found 3.31m above the Flockton Thin Coal in the Angel Inn Borehole [4065 2812]. Thin sandstones are recorded in some boreholes as at Ledston Luck Colliery where 2.90m of "soft sandy rock" are noted. This may represent a part of the widespread

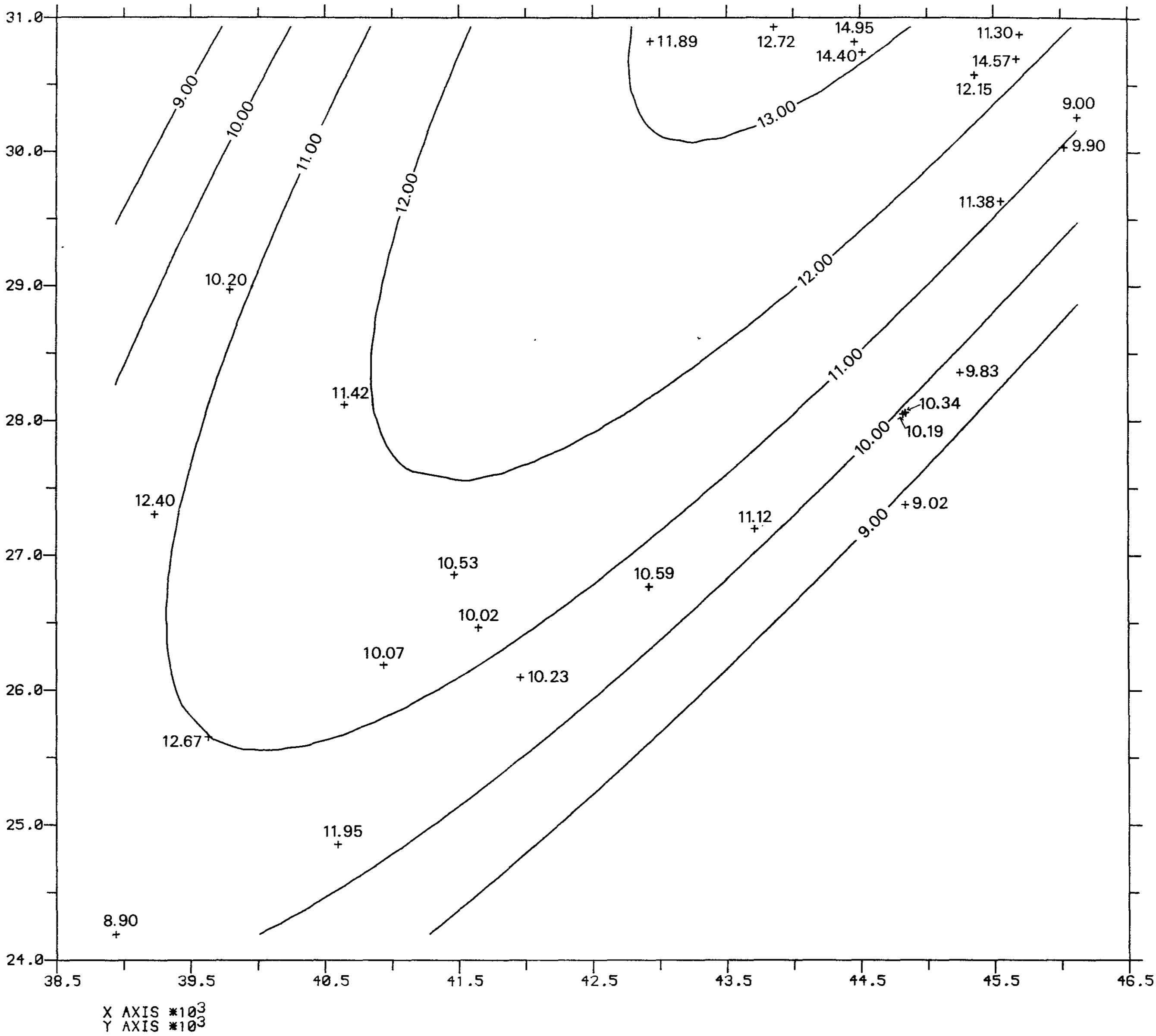

Figure 5 A computer generated 2nd order trend surface analysis of the strata between the Flockton Thin Coal and the Flockton Thick Coal.

sandstone known locally as the Emley Rock, which crops out to the south of Leeds and is recorded at depth near Normanton [3870 2275].

On average 11.09m of strata separate the two Flockton seams with a range for this district from 8.31m at Glass Houghton Colliery to 14.95m at Ledsham No.5 Borehole [4446 3081]. The variation in thickness across the district is illustrated by a second order trend surface analysis in figure 5.

Flockton Thick Coal

Borehole, shaft sections and mine abandonment plans (NE 807 and NE 842) show that the seam is represented in this district by two leaves of coal, separated by a dirt parting which is usually less than 0.30m thick. The seam as a whole has a mean thickness of 1.19m. Locally an additional dirt parting may split either the upper or low leaves of the seam, to produce a third leaf, as at Willow Grove 'A' Borehole [4147 2686]. Sporadically even more leaves may be present as at Ledston Luck Colliery where five of them have been proved. The seam has been extensively worked in the south of the district from Glass Houghton Colliery and in the north-west of the district from Ledston Luck Colliery.

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

The Vanderbeckei Marine Band has only been recorded in three boreholes in this district, these are the Newton Ings, Ledsham No 4 and New Road boreholes [4561 3004]. The mean thickness of these measures is some seventeen metres and they are dominantly composed of claystone and mudstone with subordinate siltstones and sandstones. A number of thin coals are also noted. One of these coals, usually found directly beneath the Vanderbeckei Marine Band is the Joan Coal.

Westphalian B

Vanderbeckei Marine Band

In this district the Vanderbeckei Marine Band is normally thin, ranging in thickness from 0.18m to 0.53m. The marine band in composed of dark coloured mudstone with abundant Lingula fossils.

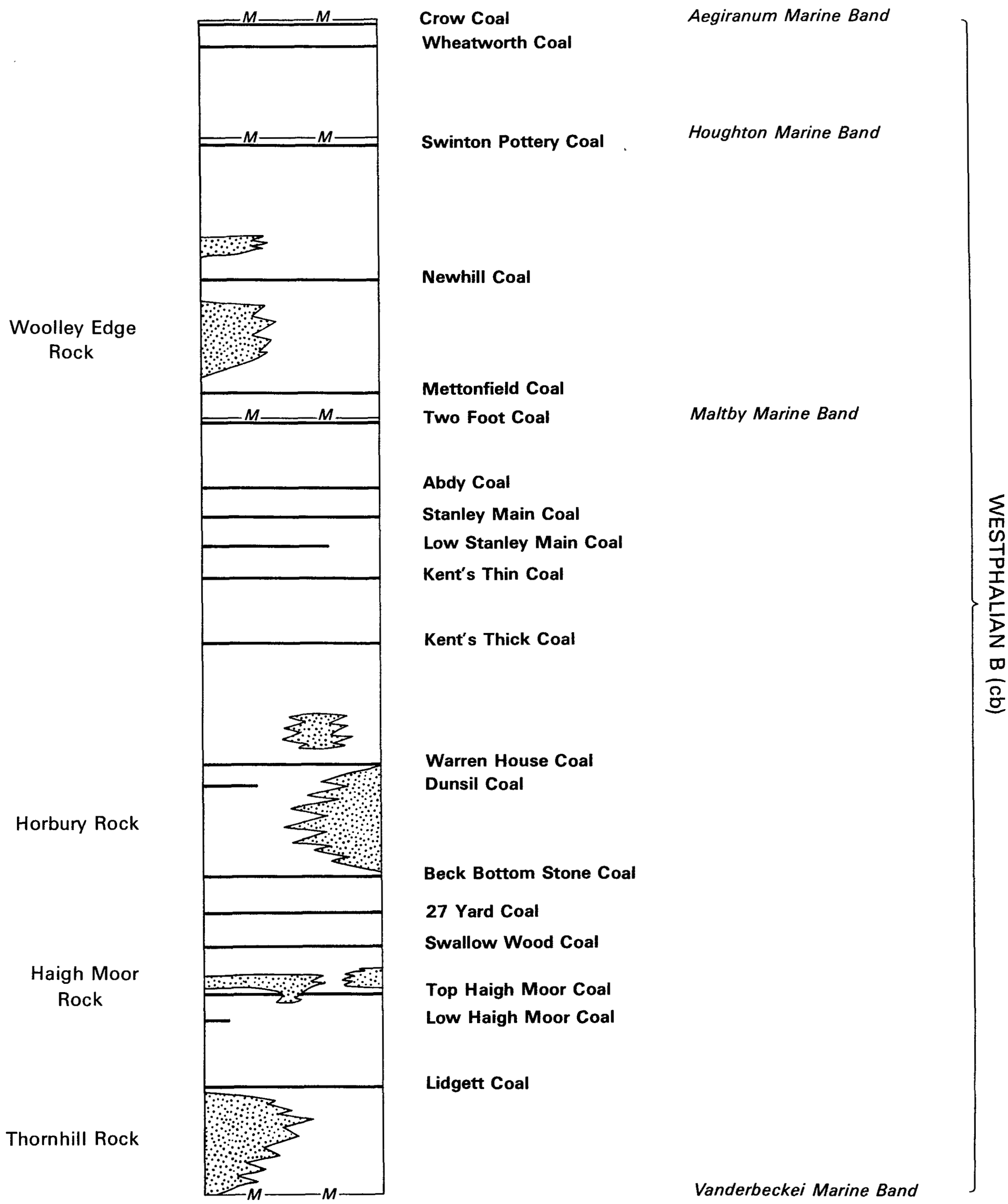

Figure 6 Generalised sequence of Westphalian B rocks of the Castleford District

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

As noted above the Vanderbeckei Marine Band is only recorded in three boreholes in the district. These show a remarkably uniform thickness of strata for this interval of between 31.80m and 32.3m.

The Thornhill Rock is present in about half the records proving these strata. It forms a massive sandstone up to a maximum thickness of 18.3m, closely associated with thick siltstones. These deposits can be interpreted as representing a major distributary channel facies with the associated siltstone dominated overbank flood facies. Sandstones of the Thornhill Rock are recorded from stratigraphically just below the Lidget Coal to below the level of the Vanderbeckei Marine Band. Individual sandstone bodies, which are normally less than eighteen metres thick, represent stratigraphically superimposed distributary channels.

Claystone, mudstone and siltstone are recorded in the other sections penetrating these strata. Sporadic thin coals are also noted, for example in Ledsham No 4 Borehole a thin coal is found 5.26m below the Lidget Seam.

Lidget Coal

The Lidget Coal is vary variable in this district. In a number of records it comprises a single leaf between 0.60m and 0.76m thick. Elsewhere the seam is split into between two and four leaves separated by dirt partings. Exceptionally as many as seven leaves may develop, as in the Spartal Lane Borehole [4326 2981]. The seam has not been mined in this district.

Measures between the Lidget and the Haigh Moor

Claystone, mudstone and siltstone are the dominant lithologies of these measures. Discontinuous sandstones, up to 4.88m thick, are locally present. Thin coals are recorded in most of the available sections. For example at Ledston Luck Colliery five thin coals, all less than 0.15m thick are noted.

The mean thickness of these measures is 27.77m with a range from 22.23m (Methley Junction Colliery) to 42.72m (Ledston Luck Colliery).

Haigh Moor Group of Coals

The Bottom or Low Haigh Moor Coal is only noted in two records in this district. At Altofts Colliery two leaves of

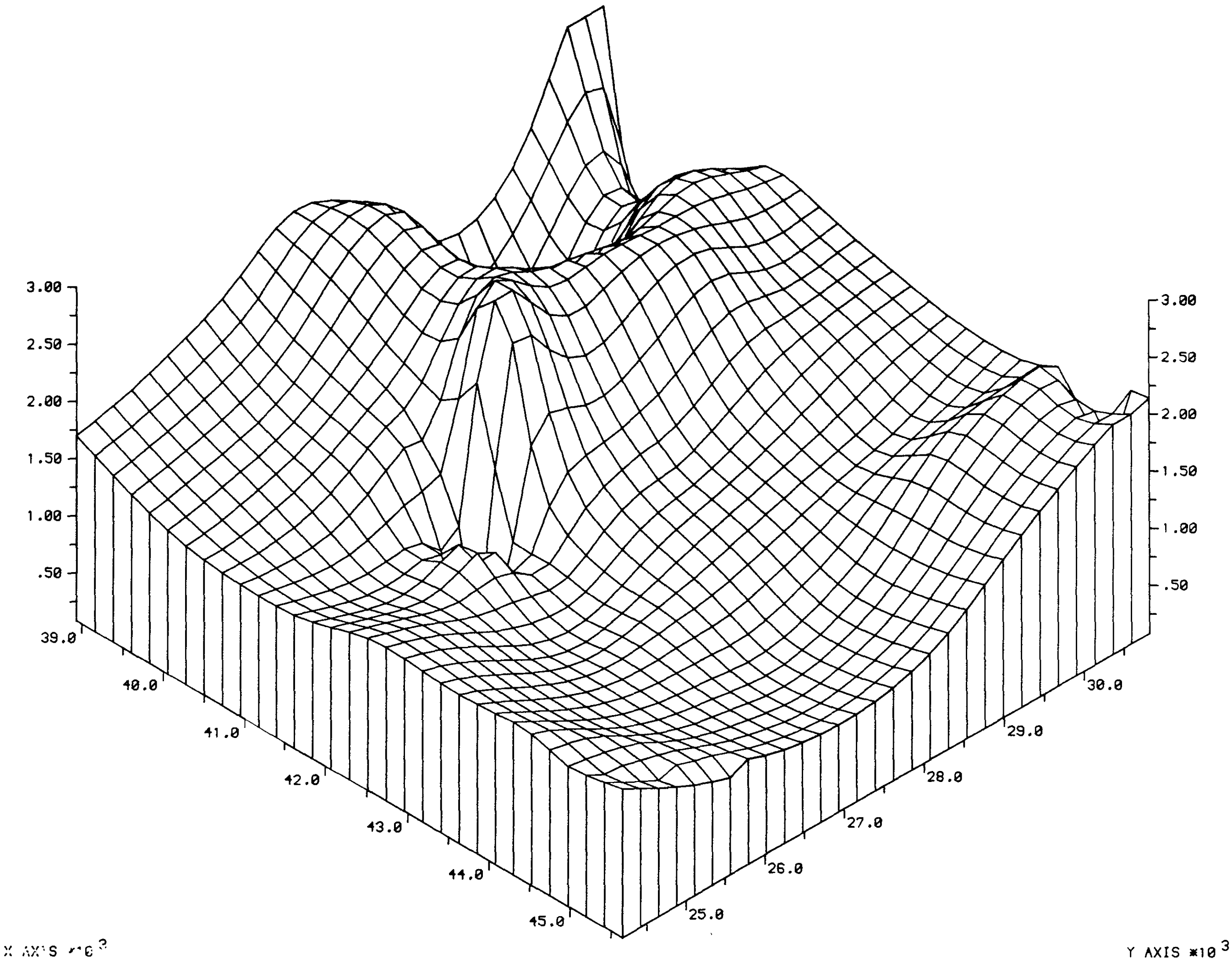

Figure 7 A computer generated isometric diagram illustrating the variation in thickness of the Top Haigh Moor Coal.

coal, the upper 0.38m and the lower 0.08m, are separated by 0.08m of dirt. Where as at Whitwood Colliery Bottom Haigh Moor Coal comprises a single leaf of coal 0.25m thick.

The measures between the Bottom Haigh Moor and Top Haigh Moor Coal are 7.56m and 9.60m thick at Whitwood and Altofts collieries, respectively. Both records note a sandstone which is 2.29m at Altofts Colliery and 3.30m thick at Whitwood Colliery.

The Top Haigh Moor Coal normally has two leaves of coal separated by a thin dirt parting. For example mine plan NE 403/C records a top leaf 1.14m thick and a bottom leaf 0.35m thick, separated by a dirt parting 0.08m thick. Similarly at the Owl Wood Opencast Site (Abandonment Plan NE 499) the top leaf was 1.21m thick whilst the bottom leaf was 0.53m thick, separated by 0.08m of dirt. The Top Haigh Moor Coal may also be split into three or even four leaves as at Hool Wood Colliery [4127 2868]. Locally the Top Haigh Moor Coal is washed-out by the overlying sediments as in Methley Mires No. 2 Borehole.

The mean thickness of the Top Haigh Moor Coal, measured from shaft and borehole records, is 1.60m with a maximum of 2.80m, recorded by a geophysical log of an uncored portion of the Willow Grove "A" Borehole. The variation in thickness is illustrated in figure 7.

The Top Haigh Moor Coal has been extensively worked in the northern half of the district and in the south, beneath Castleford and Whitwood. To the north-west of the Methley Junction Fault old shallow working, for which no records exist, were proved during opencast prospecting.

Measure between the Haigh Moor and Warren House

These measures contain a number of thin named coals and two major sandstones. The mean thickness of the strata is 69.20m with a range of 47.31m (Hool Wood Colliery) to 85.67m (Dunford House Borehole).

The Top Haigh Moor Coal is normally overlain by the Haigh Moor Rock. This is a distributary channel sandstone body which, where present, is between 5.00m and 13.70m thick. The Haigh Moor Rock has an erosive base and in places cuts down through the Top Haigh Moor Coal causing the seam to be washed out as in Methley Mires No 2 borehole. The sandstone is not present in every record, for example at Allerton Bywater Colliery this stratigraphic interval is composed entirely claystone and mudstone.

Overlying the Haigh Moor Rock is a thin coal known as the Swallow Wood Coal. The Top Haigh Moor Coal and the Swallow Wood Coal are separated by an average of 14.29m of measures. The seam normally consists of a single leaf with a mean thickness 0.41m; however, a second leaf may locally develop as at Methley Mires No 1 Borehole . In two records, Allerton Bywater Colliery and Methley Mires No 2 Borehole, the Swallow Wood Coal is absent, the horizon being marked by a mudstone-seatearth. The Swallow Wood Coal was opencasted in part of the Owl Wood Site.

The strata between the Swallow Wood Coal and the overlying 27 Yard Coal has a mean thickness of 8.64m and a range from 5.10m (Methley Savile Colliery) to 14.79m (Altofts Colliery). The measures are almost entirely composed of claystone and mudstone with sporadic siltstones.

The 27 Yard Seam has a mean thickness 0.28m and a maximum recorded thickness of 0.45m. In the Owl Wood Opencast Site the 27 Yard Coal was 0.30m thick. The seam normally comprises a single leaf of coal but locally a second leaf may develop as in the Methley Mires No 2 Borehole.

Some 11.50m of strata separate the 27 Yard Coal from the succeeding Beck Bottom Stone Coal. The measures are composed of claystone and mudstone.

The Beck Bottom Stone Coal consists of a single leaf of coal between 0.20m and 0.80m thick, except for Allerton Bywater D5 Borehole [4240 2811] where the seam is split into two by 0.26m of mudstone-seatearth. The seam was opencasted as part of the Owl Wood Opencast Site. A small area of old workings was uncovered during the opencast operations.

The measures between the Beck Bottom Stone Coal and the Warren House Coal are very variable. They ranges in thickness from 15.60m (Victoria No 2 Shaft) to 46.77m (Glass Houghton Colliery), with an average thickness 34.89m. The Horbury Rock is recorded in Glass Houghton Colliery Shaft where it is 34.44m thick. This represents a major distributary channel sandstone. Thick sequences of siltstone are recorded at Altofts and Whitwood collieries; these are interpreted as over-bank flood or distal crevasse splay sediments related to the Horbury Rock distributary channel. Other boreholes and shafts penetrating these strata record a claystone and mudstone dominated sequence.

In the north-west of the district, in the area around Great Preston, a coal seam of limited areal extent is developed. It is referred to as the Dunsil Seam in the St Aidans Opencast Coal Mine, where it was extracted, but it probably does not correlate with the fully developed Dunsil seam of the Barnsley region. This seam is 0.88m thick in the St Aidans Opencast Coal Mine and some 0.80m thick in the Great Preston Opencast Coal Mine, where it was also worked. A limited area of old unrecorded mine workings was encountered in this seam during the mining at the St Aidans site. The Dunsil Seam is separated from the Warren House Coal by between six and seven metres of mudstone with sporadic thin sandstones.

Warren House Coal

This seam has a mean thickness of 1.53m and a range of 0.99m (Methley Mires No 1 Borehole) to 2.49m at (Area Headquarters Allerton Bywater No 2 B. H.), the variation in thickness is illustrated in figure 8. The seam is split a number of dirt partings, individually up to 0.35m thick, into between 2 and

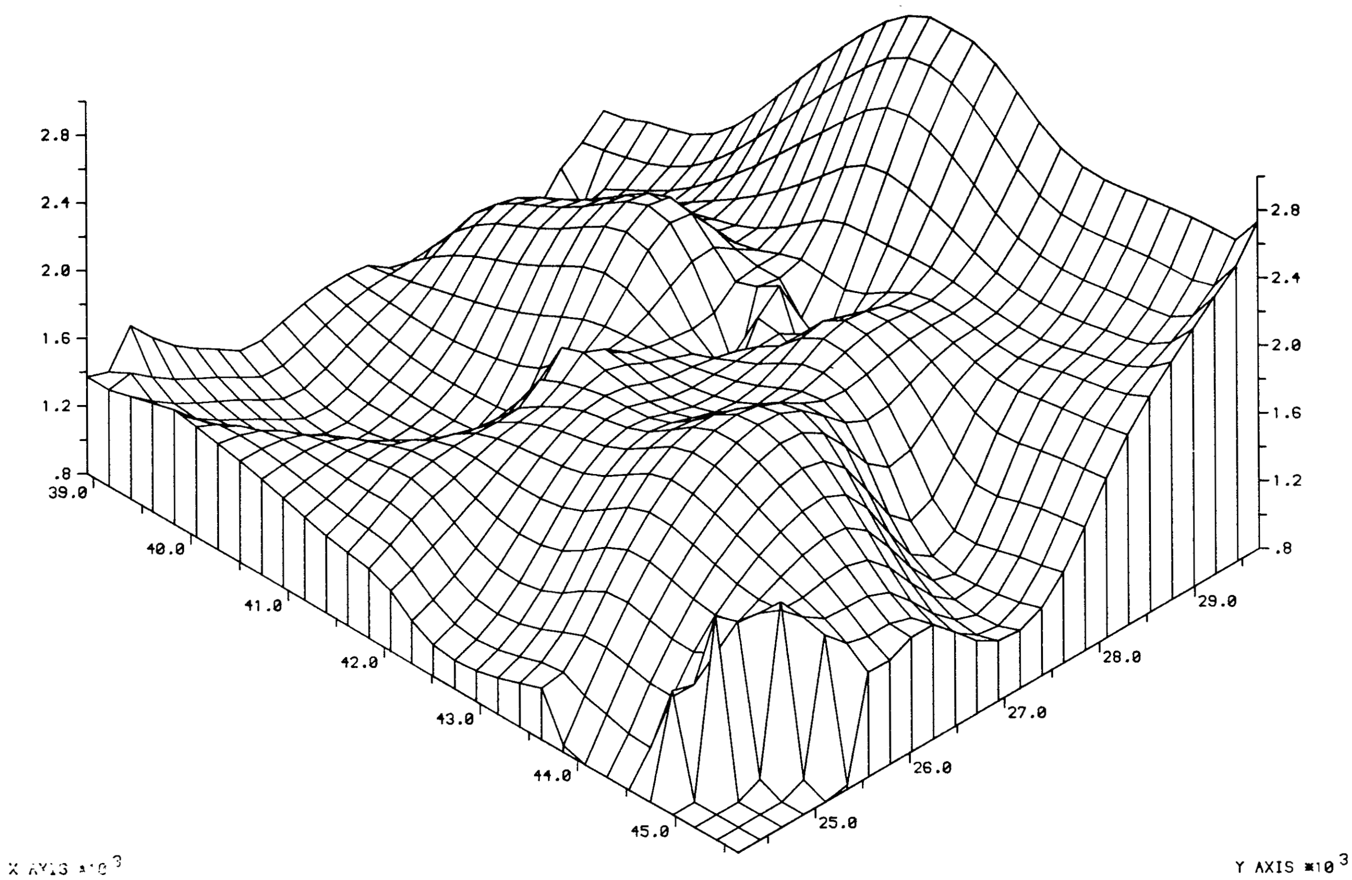

Figure 8 A computer generated isometric diagram illustrating the variation in thickness of the Warren House Coal.

9 leaves. A more major parting develops in the north-west of the district, splitting the seam into Top Warren House Coal and Low Warren House Coal; for example see Victoria No 2 Shaft where the parting is 0.43m. In the St Aidans Opencast Coal Mine the same parting comprised a metre of mudstone and seatearth.

The seam is exposed in the abandoned railway cutting to the north of the former Kippax Station [3054 2954]. It is very weathered and disturbed by various attempts mine the coal. At this exposure the Warren House Seam is 2.30m thick and divided into three leaves by two dirt partings 0.13m and 0.48m thick.

The seam has been extensively worked in both underground and opencast mines. Few mine plans exist for the underground mining in the north and west of the district but numerous shallow old workings have been encounted in boreholes and opencast mines. In the south of the district more extensive mine plans exist, mostly dating from the second half of the last century. Extensive opencast mining has taken place in the north of the district. The Warren House Coal has been extracted from the Watkinson Terrace Site [4045 2943], St Aidans Site [4005 2912], Owl Wood Site [4190 2926] and [4226 2900] and the Lowther North and Extension Site [4016 2833].

Strata between the Warren House and Kent's Thick

These strata are dominated by claystone and mudstone with siltstone and some thin ironstone beds. Sandstones are also found in many of the records from these measures. They are normally less than 6.27m thick but in the Barnsdale Road No 2 Borehole [4266 2703] 11.96m of light grey, fine to coarse grained sandstone is noted 3.86m above the Warren House Coal.

One or sometimes two thin coals are commonly recorded in these measures. For example in the Willow Grove "A" Borehole 0.08m of coal is found 27.86m above the Warren House Coal. Several thin coals are recorded at surface in the area around Great Preston, one of which was exposed during construction at Low Farm, Great Preston [4012 2948].

The strata between the Warren house and the Kent's thick seams has a mean thickness of 36.74m and ranges from 26.43m (Dunford House Borehole) to 57.81m (Wheldale Colliery [4415 2626]).

Kent's Thick Coal

The Kent's Thick Coal is very variable in its thickness and section. The seam can normally be described in terms of two generalised forms. In one form it comprises a one or two leaf seam with a mean thickness of some 0.60m and thin dirt partings. In the other form it consists of a two, or more rarely a multi-leaf seam, split by a thick dirt parting up to 1.22m thick (Willow Grove "A" Borehole). There does not appear to be a pattern to the distribution of the two main forms of this seam within the district.

The Kent's Thick Coal has been mined by the opencast method at the Lowther North and Extension Site. An extensive area of old unrecorded underground mine workings were discovered in this seam during the opencast operations.

Measures between the Kent's Thick and Kent's Thin

In borehole records a monotonous sequence of uniform claystone and mudstone is only alleviated by a single record of a sandstone, 4.11m thick, found in the Fryston Colliery Shaft. The strata have a mean thickness of 19.97m and a range from 17.40m (Methley Mires No 1 Borehole) to 23.23m (Newfield Farm Borehole [4488 2834]).

A sandstone, stratigraphically a short distance above the Kent's Thick Coal, forms a pronounced feature to the north-west of Owl Wood Farm [4124 2871]. This sandstone was formerly exposed in a cutting on the Kippax Branch Railway (Green et al 1878; Fig 105).

Opencast prospecting boreholes have proved the sub-drift crop of the Kent's Thick Coal to the north of Mickletown.

Kent's Thin Coal

A single leaf of coal with a mean thickness of 0.37m and a range of between 0.20m (Ledston Mill Borehole) and 0.78m (Beckfield House Borehole [4574 2792]) is the normal section of this seam. Locally the coal may be absent as at Methley Mires No 2 Borehole where the horizon of the seam is marked by 0.91m of black, carbonaceous mudstone. There are no records of this seam having been worked in this district.

Measures between the Kent's Thin and Stanley Main

In the majority of records for these measures the dominant lithologies are claystone and mudstone with some siltstone. Sporadic sandstones are locally recorded, as at Wheldale Colliery where 8.58m of sandstone are found directly beneath the Stanley Main Coal. The mean thickness of the strata between the Kent's Thin and Stanley Main coals is 18.48m with a range from between 9.91m (Altofts Colliery) to 36.46m at (Newton Ings Borehole).

A thin coal seam, known locally as the Low Stanley Main is commonly recorded in these measures. It normally comprises a single leaf of coal which has a mean thickness 0.57m and a maximum recorded thickness of 0.75m (Dunford House Borehole). The Low Stanley Main Coal is typically separated from the Stanley Main Coal by some 9.00m of siltstone with claystone and mudstone as at Newton Ings Borehole.

Stanley Main Coal

At St John's Colliery, Normanton [3742 2217] the Stanley Main Coal is 2.61m thick. Giles and Williamson (1986) described how the seam thins and splits into several thinner leaves in all directions from St John's Colliery. In the Castleford district the Stanley Main Coal is split by up to five dirt partings as at Methley Mires No 1 Borehole. The seam has a mean thickness in this district of 1.50m and a range between 1.20m (Mine Plan NE 966) and 2.39m (Alofts Colliery).

The seam, which is also locally called the Beamshaw Seam, has been worked to a limited extent in the south of the district.

Measures between the Stanley Main and Abdy

Claystone and mudstone are the major lithologies of these measures. Sporadic thin coals are noted in several records but these are only locally developed and probably do not correlate with each other. The strata have a mean thickness of 9.12m and a maximum recorded thickness of 15.54m (Altofts Colliery).

Abdy Coal

The Abdy Coal normally has two leaves of coal separated by a dirt parting up to 0.36m thick. The upper leaf is usually the thicker of the two with a maximum recorded thickness of 0.92m (Methley Mires No 2 Borehole). The seam has an overall mean thickness of 1.00m. Locally the seam may be split by further dirt partings into as many as four separate leaves, as in Newton Ings Borehole.

No records exist to suggest that this seam has been worked within this district.

Measures between the Abdy and Two Foot

Except for local developments of sandstone up to 5.49m thick, for example Ledston Mill Borehole, these measures are dominated by claystone and mudstone. These strata have a mean thickness of 19.94m and a range of between 15.29m (Wheldale Colliery) and 24.93m (Barnsdale Road No 1 Borehole [4266 2702]).

Two Foot Coal

The seam is represented by a single leaf of coal with an average thickness of 0.47m and a range of between 0.38m (Barnsdale Road No 1 Borehole) and 0.61m (Newton Abbey

Colliery [4500 2733]). At Wheldale Colliery the seam is represented by 0.05m of carbonaceous mudstone on a sandstone seatearth. There are no archival records to suggest that this seam has been worked in this district.

Measures between the Two Foot and Meltonfield

The Maltby Marine Band, where recorded in West Yorkshire, is found in the roof measures of the Two Foot Coal. Unfortunately, the marine band has not been recorded in any borehole or shaft in the district, even though it is probably present, though thin. Claystones and mudstones are once again the dominant lithology except for sporadic sandstones up to 5.31m thick. The mean thickness of the strata is 9.16m with a maximum recorded thickness 20.90m (Methley Mires No 2 Borehole).

Meltonfield Coal

The Meltonfield Coal is normally split into two leaves separated by some 2.00m of mudstone, as at Newton Lane Opencast site. The individual leaves are normally less than 0.50m thick. A typical section of this seam is recorded from the Barnsdale Road No 1 Borehole where the top leaf is 0.50m thick, the bottom leaf is 0.41m thick and the intervening mudstone is 1.76m thick.

No archival evidence exists of former underground mining. However, old mine workings were encountered at the Newton Lane Opencast Site, where bell pit workings were discovered in the top leaf of the seam and pillar and stall working were found in the bottom leaf.

Measures between the Meltonfield and Newhill

In the district around Normanton there is an extensive development of the Woolley Edge Rock. In this district the same stratigraphic level crops beneath the alluvium and terrace deposits of the Aire and Calder Valley. The boreholes and shafts that penetrate these measures show that they are composed of claystone, mudstone and siltstone with sporadic thin sandstones up to 1.22m thick. The only exception to this is Methley Mires No 2 Borehole. Geophysical logs of the upper uncored portion of the borehole show sandstone some 23.00m thick.

The measures range in thickness from 12.10m at the Pottery Street Borehole [4196 2610] to over 34.00m at Methley Mires No 2 Borehole.

Newhill Coal

The Newhill Seam was recorded at two adjacent locations [4154 2659] and [4162 2667], both in temporary drainage ditches in the floor of the sand and gravel quarry north of

Dunford House. The top and bottom of this seam was not exposed in the drainage ditch so a thickness could not be recorded. The coal, as would be expected, was very weathered. Green et al (1878; page 772) record that a coal was formerly exposed in the base of the cutting at Whitwood Junction [4081 2523]; this was probably the Newhill Coal. The seam crops out beneath the alluvium and river terrace deposits east of the Methley Junction Fault.

The Newhill Coal is recorded in a number of boreholes and shafts in the district. It normally has two leaves of coal separated by a dirt parting up to 0.60m thick. The thickness of the upper leaf is commonly about 0.40m whilst the thickness of the lower leaf is more variable reaching a maximum of 1.40m at the Barnsdale Road No 2 Borehole. There are no archival records to indicate that the seam has been mined underground, however, the seam is at shallow depth beneath Whitwood Mere area and it seems unlikely that it was not exploited at some time in the past.

Measures between the Newhill and Swinton Pottery

In this district there is only a limited amount of shaft and borehole information on which to base a description of these strata which have a thickness of approximately forty metres. These measures are exposed in the area of Whitwood Mere. A pronounced feature forming sandstone forms a low hill at Whitwood Junction. The railway cutting [3760 2200] exposes a typical fine-grained, thinly bedded, sandstone. At Glass Houghton Colliery a sandstone 4.57m thick is recorded 8.66m above the Newhill Coal. This would correlate reasonably well with the sandstone exposed at Whitwood Junction. Between this sandstone and the Swinton Pottery Coal the strata is dominated by mudstone with two thin coals in the upper part of the sequence. Directly beneath the Swinton Pottery Coal there is a thick mudstone-seatearth which has been widely exploited as a pottery clay. It was quarried, along with the overlying coal, near Whitwood Mere, at the former Mere Pottery [4180 2547]. Green et al (1878; page 446) note two sections from this quarry which record some 0.90m of "fireclay".

Swinton Pottery Coal

The Swinton Pottery Coal crops out in the south of the district near Whitwood Mere. In the former quarry associated with the Mere Pottery Green et al (1878; page 446) recorded 0.33m of coal. In the shaft of Wheldale Colliery the Swinton Pottery Coal is a single leaf 0.48m thick. In the Fryston Drift Borehole No 3 [4563 2679] the seam is in a single leaf only 0.12m thick.

Measures between the Swinton Pottery and Wheatworth

The Houghton Marine Band is found in the roof of the Swinton Pottery Coal over much of this region. However, it has not been positively identified in the Castleford district.

Claystone and mudstone once again are the dominant lithology forming s sequence some thirty metres thick. At Wheldale Colliery two thin coals are recorded at 12.14m and 21.49m above the Swinton Pottery Coal. They are both less than 0.20m thick. An exposure of the upper of these two coals was formerly seen in the quarries of Red Hill Brickworks [4353 2577] and [4264 2567] where it was between 0.10m and 0.15m thick.

Wheatworth Coal

The Wheatworth Coal was formerly seen at exposures on Smawthorne Lane [4284 2518] and Pontefract Road [4328 2546] in Castleford. At Glass Houghton Colliery the Wheatworth Seam is 0.91 m thick, including two thin dirt partings. In site investigation boreholes in the Castleford area it has a maximum recorded thickness of 1.24m.

The seam has been widely worked in the Castleford area although few records exist to indicate the nature and extent of the mining. Mine Abandonment Plan NE 466 records "old working" east of Castleford beneath Healdfield Lane [4405 2592]. Old workings were also encountered in a site investigation to the West of Pontefract Road. Old shafts to the Wheatworth and an underground level in the Wheatworth are shown on Primary Geological Survey Map Yorkshire 234 (1876), in the Red Hills area of Castleford.

Measures between the Wheatworth Coal and Aegiranum (Mansfield) Marine Band

These measures are some 9.00m thick. They are composed of claystone and mudstone except where a sandstone is developed. The sandstone, only a few metres stratigraphically above the Wheatworth Coal, forms an impersistent feature. This feature is best developed south of Smawthorne Lane where it forms a distinct crest-line that crosses Smawthorne Grove and Smawthorne Avenue. Site investigation borehole to the west of Pontefract Road show that the sandstone is up to seven metres thick. The crest becomes less pronounced where it crosses the Recreation Ground [4292 2506] and then dies gradually eastwards, until it disappears west of the Civic Centre [4344 2559]. A thin sandstone at the same stratigraphic level forms a thin and indistinct feature to the south of Wheldale Colliery.

Directly beneath the Aegiranum Marine Band a thin coal is widely developed in the region. It is locally named the Crow Coal and at Glass Houghton Colliery is 0.15m thick.

Westphalian C

Aegiranum (Mansfield) Marine Band

The Aegiranum Marine Band was formerly exposed at the Red Hill Brickworks quarry. At this locality Edwards (1932) describes a 0.22m of "dull black shale with goniatites" which overlies the thin Crow Coal. At Glass Houghton Colliery the Crow Coal is overlain by 0.36m of "black shale" in the inferred position of the Aegiranum Marine Band.

Measures between the Aegiranum (Mansfield) Marine Band and the Houghton Thin Coal

These measures are some 10.00m to 12.00m thick and are composed entirely of mudstone. The strata crops out to the south of Castleford Civic Centre but is not exposed in the district. No boreholes or shaft records are available.

Houghton Thin Coal

In the Red Hills area of Castleford, to the south-east of the town centre, there are many old shafts, which formerly provided access to the Houghton Thin Coal, recorded on the Primary Geological Survey Map, Yorkshire 234 (1876). A record of the old Red Hill Colliery [4435 2515] shows that the Houghton Thin Coal is 0.51m thick. This seam appears to have been extensively worked but very little archival information is available which describes the extent and style of mining.

Measures between the Houghton Thin and Sharlston Yard

To the west in the Normanton District at Warmfield [3740 2100] a thick sandstone, known as the Warmfield Rock, is found at this stratigraphic level. In the Castleford district the sandstone is much thinner and less persistent. A thin sandstone forms a clear feature though Queen's Park [4383 2556]. Along strike and to the south-east of Close Road [4362 2507], a sandstone with a pronounced crest-line forms a good feature. Apart from these two feature forming sandstones the rest of the strata is likely to be composed of claystone and mudstone with some siltstone. The estimated thickness of these measures, in this district, is some 25.00m.

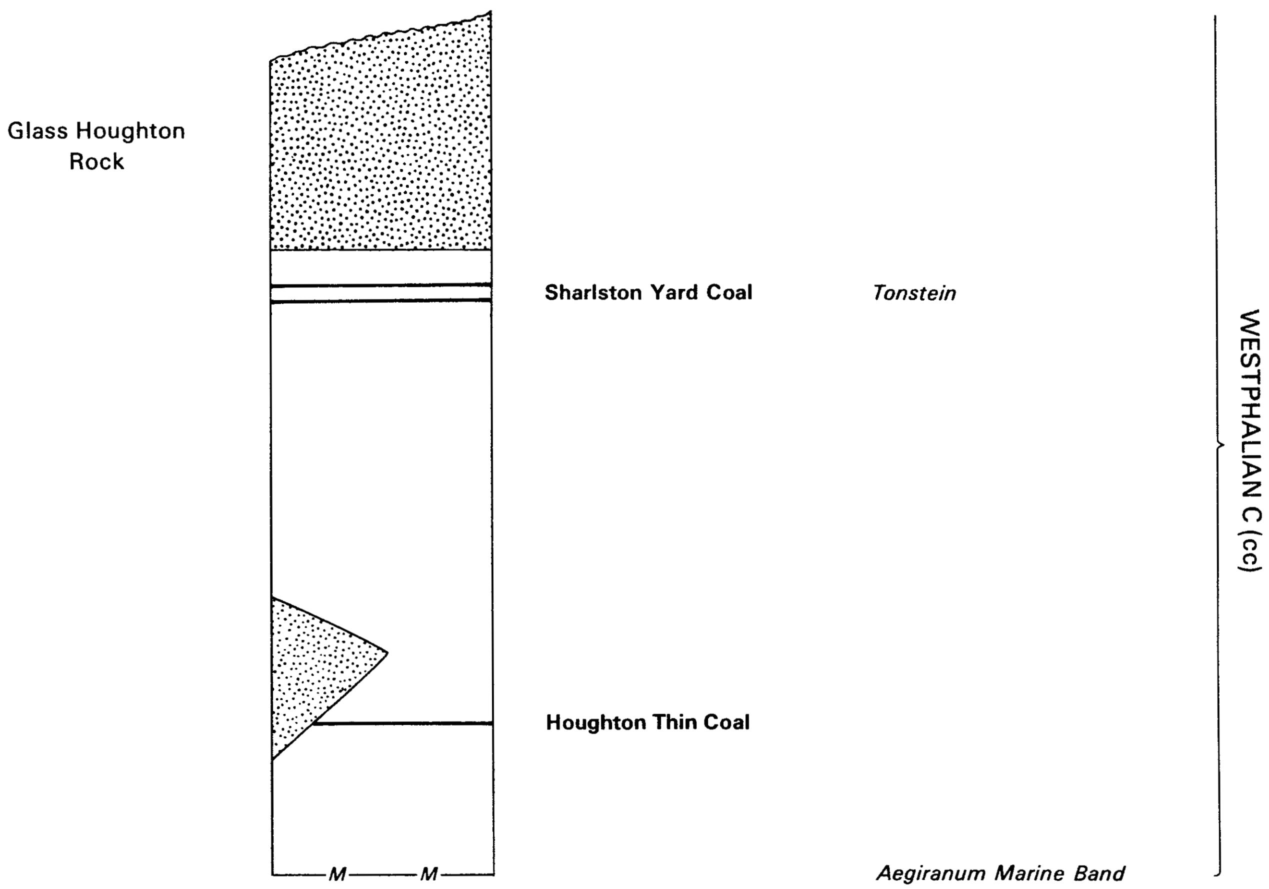

Figure 9 Generalised sequence of Westphalian C rocks of the Castleford District

Sharlston Yard Coal

This coal was formerly exposed in the side of Ferrybridge Road [4397 2535]. The Sharlston Yard comprises two separate leaves of coal seperate by several metres of mudstone and mudstone-seatearth. In this district no boreholes, shafts sections or archival descriptions of the seams are available, consequently, no detailed description is possible.

It is not known if the seams have been mined. There are no records to indicate that it has been mined but the possibility of past mining should be considered.

Measures above the Sharlston Yard

Only the measures immediately above the Sharlston Yard Coal are exposed in the district. A few metres of claystone and mudstone separate the seam from the Glass Houghton Rock. The Glass Houghton Rock is exposed in a road cuttings on Queen's Park Drive and Redhill Road [4409 2539]. It is a fine-grained, thickly bedded sandstone with pronounced large-scale trough cross-bedding. A total of some 12.00m of this sandstone are exposed beneath the basal Permian unconformity.

3. PERMIAN

3.1 GENERAL

Permian rocks form a bold escarpment in the east of the district where they unconformably overlie rocks of Upper Carboniferous (Westphalian B and C) age. A total of some 55 metres of Permian strata crop out in the district. The beds have a gentle regional dip of two to three degrees to the east-north-east, except where the strata are affected by faults. Part of the exposed area is mantled by drift deposits such as remanie till and head.

Those borehole and shaft sections that have been located are curated 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 Manager, National Geoscience Data Centre (South), British Geological Survey, Keyworth, Nottingham NG12 5GG.

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. In addition figure 10 illustrates the sequence of Permian strata. Many details of the Permian rocks of the region are published in Edwards and others 1940.

3.2 CLASSIFICATION AND CORRELATION

The correlation of the British Permian was reviewed by Smith and others 1974. The correlation presents special difficulties because of the variability of the sediments and the lack of a normal marine sequence. The nature and rate of sedimentation in each major basin of deposition was probably governed by local factors and was therefore unique. Marine sequences are available in the British Upper Permian and some of the carbonate members within these sequences yield abundant and diagnostic faunas. Such faunas allow accurate within basin correlation. The faunal evidence is reviewed by Pattison, Smith and Warrington 1973.

A classification for the the Permian rocks of the British Isles was proposed by Smith and others 1974. Smith (1974a) described in detail the application of this proposed British classification to the Yorkshire region. The classification for Central Yorkshire, described by Smith (1974a), has been followed in mapping the Castleford District. Subsequently Smith and others 1986 have published a revised nomenclature for the Upper Permian strata of eastern England.

3.3 PALAEO-GEOGRAPHY

Between the youngest Carboniferous and oldest Permian deposits of the district there was a period of widespread uplift. The earth movements which caused the uplift probably occured in the late Westphalian and possibly the Stephanian stages of the Carboniferous. By the latter part

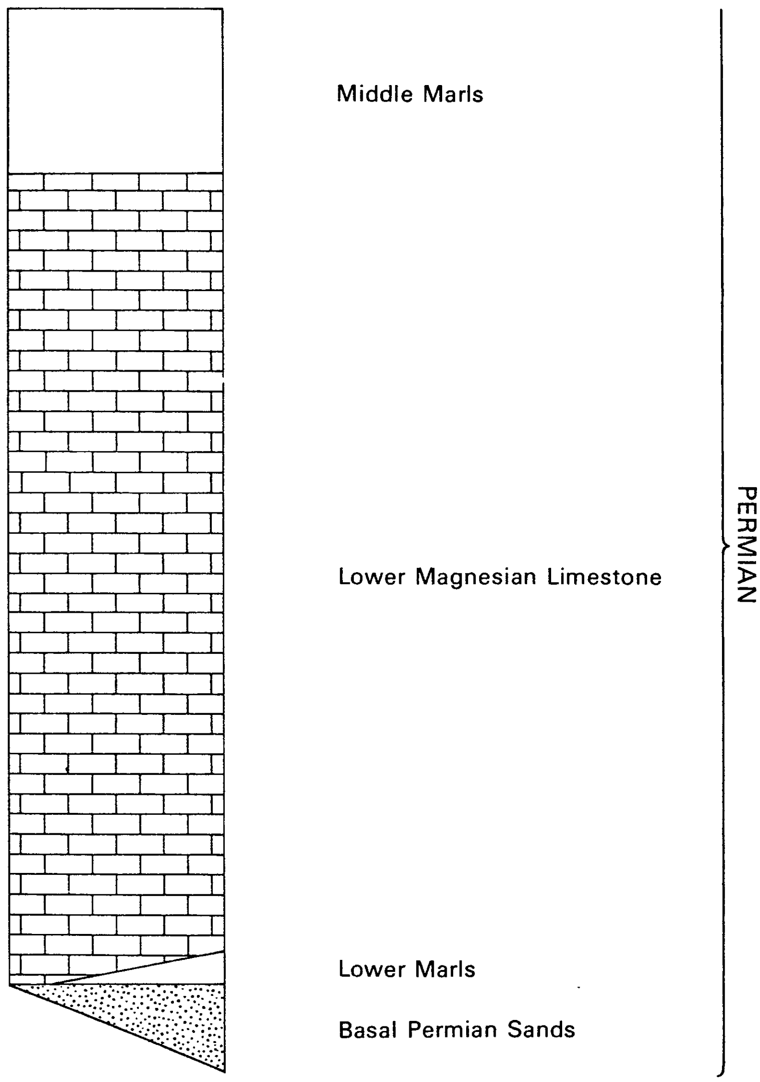

Figure 10 Generalised sequence of Permian rocks of the Castleford District

of the Lower Permian subaerial erosion had reduced many areas to a gently rolling peneplain. Smith (1974a) comments that the sub-Permian surface is almost plane where it cuts across Coal Measures and that such area may at times have been below the contemporary sea-level. The enviroment during this extended period of subaerial erosion was that of a semi-arid desert.

At the start of the Upper Permian there was a major marine transgression. The Zechstein Sea, an epicontinental sea, flooded much of eastern England including the Castleford district. Smith (1970) describes the palaeogeography of the British Zechstein in terms of a series of five sedimentary cycles, EZ1 - EZ5. Each cycle commences with a shelf carbonate deposit which grades up into evaporites. Only strata of the lowest cycle EZ1 are found exposed in Castleford district.

Studies of the palaeo-latitude for the Permian show that the British Isles were more or less equatorial. Van der Voo and French (1974) have published reconstructions of the palaeo-latitude for both the Early and Late Permian.

3.4 STRATIGRAPHY

Basal Permian Sands

These sediments are described by Edwards and others (1940), Pryor (1971) and reviewed by Smith (1974a). The Basal Permian Sands are though to be, at least in part, of Lower Permian age. However, no diagnostic fossils have been found to confirm this speculation. During Lower Permian times the region was subjected to extensive sub-aerial erosion in a semi-arid environment. Products of the erosion were transported, primarily by wind, and deposited in the low lying areas either as a sand sheet or in the form of dunes. The sands may have been subsequently reworked during the marine transgression which formed the Zechstein Sea, consequently the final mode of deposition may have been shallow marine (Pryor 1971).

In the Castleford district the Basal Permian Sands form an almost continuous deposit which rests unconformably upon the underlying Westphalian rocks. Pryor (1971, Fig. 3) describes the Basal Permian Sands of the "Leeds Area", which from his text includes exposures at Kippax, as a subgreywacke in terms of Folk (1954). Smith (1974a) describes the sands as moderately sorted with angular to well-rounded grains, the coarser of which are commonly frosted. They are composed mainly of quartz with up to 20 percent rock fragments and 10 percent feldspar. A small suite of heavy minerals is also present.

The maximum recorded thickness of Basal Permian Sands encountered in a borehole in this district was 5.41m. The sands may be locally absent as 4 percent of the boreholes did not encounter the Basal Permian Sands at the expected stratigraphic position, for example Ledsham No 1 Borehole. In several other boreholes the Basal Permian Sands were very thin, for example in the Ledsham No 21 Borehole [4544 3076] the sands were only 0.03m thick. Boreholes records show that the Basal Permian Sands have a mean thickness of 2.30m.

The Basal Permian Sands are exposed at a number of localities in the district. The best exposures are in the road-cuttings in which Queens Park Drive and Red Hill Road cross the Permian escarpment [4409 2539]. Here some 1.90m of soft, very pale orange, thickly bedded sandstone rests directly on the Glass Houghton Rock of Westphalian age. A similar section is seen in the back garden of a private house [4468 2638], totals only 0.50m. In Kippax Park [4235 2935] a further exposure of Basal Permian Sands was recorded. At the time of the survey the base of the exposure was covered in debris but 1.00m of very pale orange, fine- to medium-grained, friable sandstone was visible. Exposures were formerly more numerous, many of which are recorded in Edwards and others (1940, page 132).

The Basal Permian Sand were extensively mined. This mining is discussed in more detail in part 8.1 of this report and depicted on TGM 7.

Lower Marls

A number of boreholes record a thin calcareous mudstone that rests directly on the Basal Permian Sands and is in turn overlain by the Lower Magnesian Limestone. The maximum recorded thickness in this district was reported from Ledsham No 16 Borehole [4427 3038] where 2.58m of grey calcareous mudstones are interbedded with thin, very muddy limestones. These "marls" are not exposed in the district. Smith (1974a) notes that the Lower Marls also commonly contain numerous fragments of comminuted plant debris. The environment of deposition is reviewed by Smith (1974a) who suggests that the Lower Marls were deposited on a restricted marine shelf environment in only a few metres of water.

Lower Magnesian Limestone

The Lower Magnesian Limestone (Cadeby Formation, Smith and others (1986)) forms a bold escarpment in the east of the district. It is widely exposed and recorded in numerous boreholes, only a few of which penetrate the full thickness. The sedimentology of the strata in Yorkshire has been described by Smith (1974 a and b) and Harwood (1981). The diagenetic history of the limestone was studied by Harwood (1986) and Kaldi (1986). Smith (1974a) suggests that the Lower Magnesian Limestone was formed on a broad open self in which peloid and skeletal grainstones and packstones were deposited in no more than a few metres of water. In deeper water bryozoan-algal patch reefs (Smith 1981), with flanking peloid-pisoid grainstones and packstones were formed. Harwood (1986) notes that much of the original detail has been obliterated by three types of dolomitization.

A minor discontinuity, the Hampole Discontinuity (Smith 1968), represents an extensive emergence of the shelf sediments during a fall in sea-level. Smith (1968) divides the Lower Magnesian Limestone into Lower Subdivision (Wetherby Member, Smith and others 1986)) and the Upper Subdivision (Sprotbrough Member, Smith and others (1986)) at the Hampole Discontinuity. The Hampole Discontinuity has not been identified in the Castleford district in either boreholes or exposures.

In the Castleford district only three boreholes penetrate the full thickness of the Lower Magnesian Limestone. These are:-

Borehole Name	Thickness
Sheepcote Wood No 1A Borehole	37.21m
Ledsham No 16 Borehole	45.65m
Ledsham No 35 Borehole	55.14m

The Lower Magnesian Limestone described in borehole and shafts and seen at exposure in the district has been extensively recrystallised during dolomitisation and little original fabric survives. Harwood (1986) comments that primary limestones only exist where early calcite cementation protected the sediment from subsequent dolomitization. An example of such a remnant is recorded at Queen's Park Drive [4409 2539] where 7.50m of thickly-bedded, medium-grained biosparite is exposed. Local recrystalisation has occured at this locality but much of the extensive exposure still displays the primary fabric.

Other exposures of Lower Magnesian Limestone in the district are recorded at:-

Kippax Park	[4235 2935]
Home Farm	[4263 2952]
Old Quarry	[4315 2949]
Crispin Quarry	[4316 2956]
Crispin Plantation	[4333 2940]
Ledston Hall	[4343 2907]
Newton Farm	[4492 2793]
Priory Cottage	[4453 2796]
Wheldon Road	[4468 2638]

At each of these exposure the Lower Magnesian Limestone has been extensively dolomitized and many of them display numerous vughs. Where the base is exposed as at Kippax Park and Wheldon Road, the limestones which directly overlie the Basal Permian Sands are normally very sandy for up to 1.90m.

Middle Marls

A greyish red soil colour is indicative of the presence of Middle Marls (Edlington Formation, Smith and others 1986)) in a small area around Park Farm [4416 2951] and to the north of Forest Plain [4440 2991]. Edwards (1940, pp 135) records a section at Plaster Pits [4458 2959] where 6.0m of stiff red marl with pure-white massive gypsum was formerly exposed. At Park Farm an old well, mentioned on Primary Geological Survey Map Yorkshire 219 (1876), records 9.14m of "red clay" overlying limestone.

The environment of deposition is discussed by Smith (1974a). He suggest that the Middle Marls were laid down on a broad coastal plain fringing an extensive shallow sea to the east.

4. STRUCTURE

The dip of the strata is normally less than three degrees, though minor rolls and flexures noticably steepen the dip near faults where folding is also present. There is no overall direction of dip across the district; the direction varying from fault-block to fault-block. The direction and value of dip also changes vertically, especially where the dip is so low that the effects of differential compaction of the sediments become significant.

The major fault set is north-east trending (see figure 11). This set includes the Methley Savile, Methley Junction and Whitwood faults as well as numerous minor faults. The major faults throw down to the south-east, with throws of up to one hundred and twenty metres. However, the throws decrease rapidly and eventually the faults die out laterally. The Methley Junction fault, for example, has a throw of one hundred and eighteen metres at Low Common [4020 2600]. Yet some five kilometres to the north east the Methley Junction Fault dies out. A similar pattern is followed by the Whitwood Fault. Many faults in this region form en echelon pairs. As one fault dies out another fault develops with the same trend but off set from the first fault by a distance of about one kilometre. This, however, does not appear to happen in this particular district.

The major faults are probably most correctly represented by a narrow zone of sub-parallel fractures. At several localities in the region faults have been investigated by site investigations or exposed during quarrying or opencast coal mining. At each of these localities the faults consisted of at least two sub-parallel fractures. These faults are also probably multiple fractures elsewhere along their lengths.

A second fault set is recorded, with minor throws which are normally less than two metres. These faults have a north-west trend and are much more limited vertically and laterally than the major faults. Because of their impersistence and inherent variability, these minor faults have not been projected to the surface unless they are proved independently, for example in an opencast prospect.

Folding is usually in the form of broad open structures. The only significant folding in the district is an anticline north-west of the Methley Savile Fault. The anticline plunges to the north-west and the axial surface dips to the north-east. The extent and style of folding is clearly seen when the mine plans from this area are studied.

There is a marked angular unconformity between Westphalian and Permian strata. Some of the major faults, which have large throws in the Westphalian, either do not fault the Permian or have only small throws of one or two metres. An example of this is the Methley Junction Fault which has a throw of some twenty-five metres, in the Westphalian, west of Ledston, whilst the throw is less than two metres in the Permian. This suggest that whilst there was extensive faulting and folding in the district during the late-Westphalian there has been much less activity since.

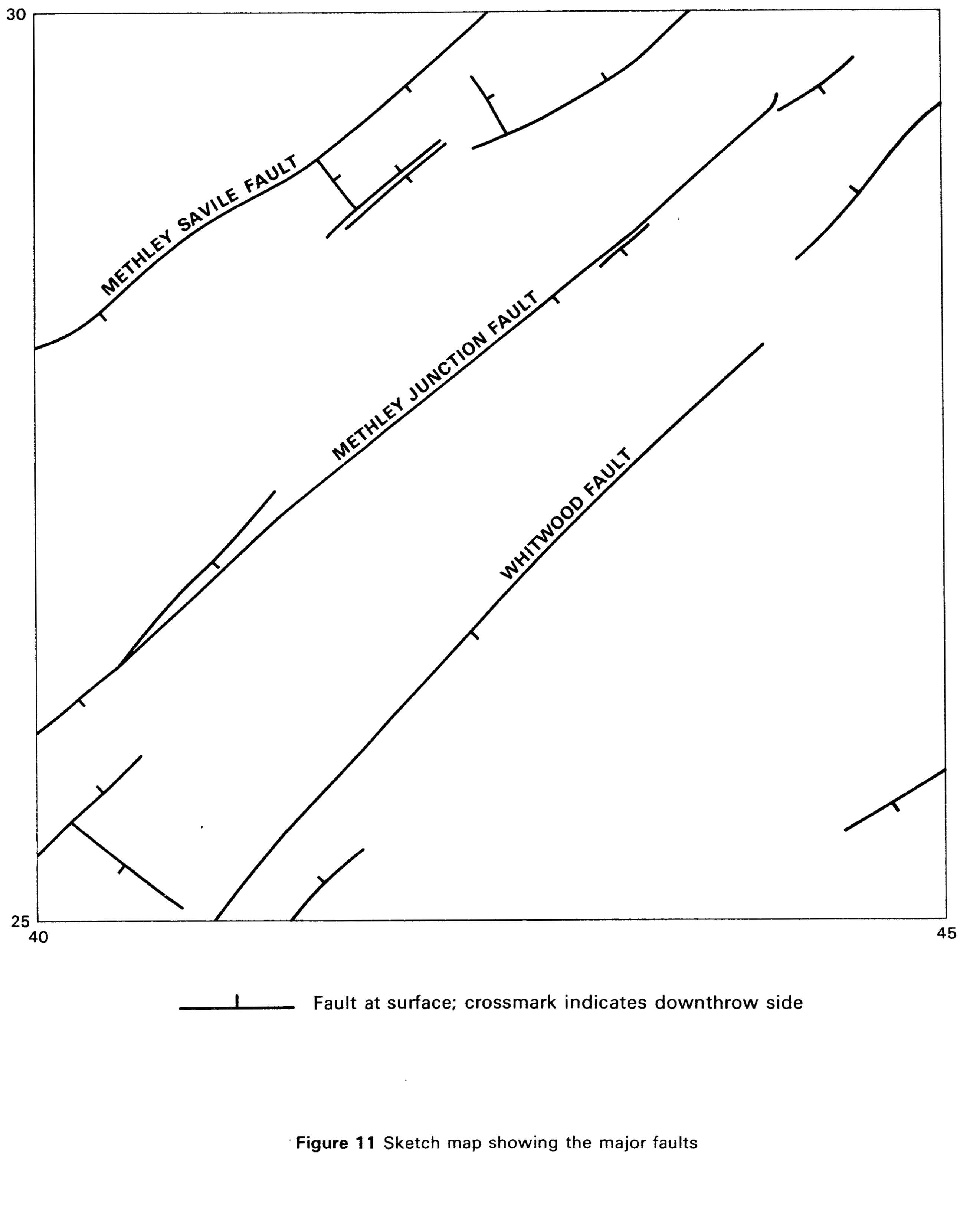

Figure 11 Sketch map showing the major faults

Locally the Permian is faulted and folded. For example to the east of Park Farm there is a north-east to south-west trending fault which throws down to the north-west. This has a throw of between ten and twenty metres in the Permian and causes the Permian strata to be folded into a monocline on the downthrow side.

Joint planes are common and are best seen in the thicker sandstones of the Westphalian and the limestones of the Permian. They are mostly very steep or vertical, and generally comprise two or more conjugate sets at any one locality. Regionally, however, these 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 noticable fissures. Such fissures has been noted where sites have been cleared prior to development.

Cambering has been recorded at some localities where competent beds such as sandstones or limestone cap hills or form pronounced breaks in slope. For example where the Lower Magnesian Limestone forms a pronounced escarpment to the east of Ledston there are clear signs of cambering including open joints in the limestone, which are aligned parallel to the edge of the escarpment.

5. DRIFT GEOLOGY

The Quaternary drift deposits comprise Till, River Terrace Deposits, Alluvium, and Head. Some 50 percent of the area is covered by mappable drift deposits with individual patches widely scattered. The main areas of drift are located in the Aire/Calder valley. Thematic Geological Map (TGM) 2 shows the distribution of drift deposits and TGM 1 gives isopachytes of drift thickness across the area.

5.1 REGIONAL SETTING

During the Quaternary, 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 decalcified. They are preserved as denuded remnants of the interfluves.

Ipswichian deposits of the last inter-glacial are poorly recorded. Bones of two adults and one juvenile Hippopotamus were found in the terrace deposits of the 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 moraines at York and Esrick 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 Castleford 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, existed in the Vale of York. Its initial level of Lake Humber, was at about 30 A.O.D. (Edwards, 1936), and this is marked by isolated patched of shore-line gravels along the edge of the Pennines and along the York-Esrick Moraines. The level of Lake Humber subsequently dropped to between 7 and 8 A.O.D.

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

5.2 TILL

The till is confined to isolated patches in the north-east of the district around Park Farm. Only very poor sections were available during the resurvey but the deposit was generally a pale reddish brown, pebbly clay. The clasts are dominantly composed of magnesian limestone with lesser amounts of Carboniferous limestone and sandstone and sporadic occurences of coal.

5.3 RIVER TERRACE DEPOSITS

Much of the drift covered area comprises the fluvial deposits of the rivers Aire and Calder. Two main river terraces have been mapped, but at Ledston another, higher, sand and gravel deposit of uncertain origin has been recorded; this has been classified as "Terrace Deposits, undifferentiated" on the accompanying map. The First and Second terraces are equivalents to those originally recognised by Green et al. (1878) and by Edwards et al. (1940). As a consequence of the complexities of the fluvial, fluvio-glacial and fluvio-lacustrine depositional enviroments the terrace deposits show rapid lithological variation both vertically and horizontally; they range from laminated clays through silts and sands to coarse gravel.

Gaunt et al. (1970) reported a radiocarbon date from a mammoth tusk found in a silt at the base of the terrace gravels at the Oxbow Opencast site, to the west of the present district. This yields a date of 38,600 +1720 to -1420 years B.P. The deposition of the second and first terrace is later than this date.

River Terrace Deposits, Undifferentiated

At the south end of the village of Ledston, opencast coal prospecting related to the Newton Lane Opencast Coal Mine recorded a small area of sand and gravel. Boreholes showed that the deposit, which consisted dominantly of sand with lesser amounts of gravel, was up to 4.26m thick. The surface of the deposit occurs between 20m and 30m A.O.D., which places it above the level of the second terrace deposits. Although its origin is unclear it is probably related to the deposits that Edwards (1936) attributed to the high level strand line of Lake Humber.

Second River Terrace Deposits

Deposits representing this terrace are widespread at the confluence of the rivers Aire and Calder, to the east of Mickletown. The terrace surface, which was originally essentially flat, is now gently rolling, illustrating the effects of subsidence on the area over many years.

There are at present no exposures of the this terrace in the district. However, borehole evidence from a number of sources suggests that the deposit varies from a "very clayey" pebbly sand to a sandy gravel. The gravel fraction is dominantly composed of Carboniferous sandstones with lesser amounts of ironstone, shale, limestone and traces of igneous rocks and quartz pebbles. Giles and Williamson (1985) reported that, in individual samples, ironstone could reach twelve percent of the gravel fraction. The sand and gravel is normally overlain by relatively thin deposits of silt and clay beneath soil. Sporadic beds of clay are recorded in the boreholes within the sand and gravel, but these are normally thin and discontinuous. The sand and gravel normally rests directly on the bedrock even where channels are incised into bedrock.

Despite complications caused by subsidence the terrace can be traced over a considerable area attaining a maximum height of some five metres above the level of the alluvium. However, some of this height difference may be attributable to varying degrees of subsidence, at different localities.

First River Terrace Deposits

This terrace is far less extensive than the second terrace, being confined to small area to the north of Mickletown and isolated remnants south of Allerton Bywater and to the west of Newton Farm [4470 2793]. Although a number of boreholes record the thicknesses of the deposit only one describes the nature of the sediment. This single record descibes the sand and gravel as a "clayey" pebbly sand. The composition of the gravel fraction is essentially the same as the gravel fraction of the second terrace. Subsidence has affected this terrace, flooding a considerable percentage of the deposit to the north of Mickletown.

First River Terrace Deposits are found along the course of the Sheffield Beck and its north-westwards extension, Kippax Beck. Much of this deposit has been either removed as overburden during opencast coal mining or has been covered by various deposits of made ground. At some time prior to the publication of the first Ordnance Survey 1:10560 map in 1850 the course of Sheffield Beck, east of Brigshaw Lane, has been diverted to the south onto the first terrace. Just to the north of the "Playing Fields" on Brigshaw Lane [4122 2926] there is a small exposure of this deposit. It comprises a sequence of "clayey" sand and "clayey" pebbly sand. The dominant gravel component is ironstone.

5.4 ALLUVIUM

Alluvial deposits occur along the margins of the present water courses of both the River Aire and River Calder forming spreads hundreds of metres wide. They were formed comparatively recently by progressive deposition from meandering rivers. The alluvium is being quarried for sand and gravel north and west of Dunford House. A typical section of the quarry face shows that the alluvium is composed of sandy gravel which may be locally "clayey". Borehole evidence from the surrounding area largely confirms this generality. Some ninety percent of the gravel fraction is composed of sub-rounded to well-rounded Carboniferous sandstone. The remaining ten percent is divided between ironstone, quartz, coal and sporadic volcanic and igneous clasts. The deposit is crudely bedded and widespread imbrication of tabular clasts was noted. The imbrication locally picks out tabular cross bedding, with sets less than a thirty centimetres thick. Occasionally tree trunks have been recovered from the gravel.

The floodplain of the River Calder, to the west of the confluence with the River Aire shows a number of abandoned meanders. These may well have been artificially created when the river was straightened to improve it as a navigable waterway. Other, older and entirely natural abandoned meanders have been located in boreholes and in the quarry near Dunford House. One section of the quarry shows a sequence of silty clays with interbedded peat. The peat is rich in woody material and contains identifiable fragments of Betula. The silty clay and peats represent the progressive infilling of a cut-off meander channel.

The alluvium has also been effected by subsidence. Large areas of alluvium have been flooded to form permanent shallow lakes known locally as "Ings"; for example Newton Ings [4440 2742].

5.5 HEAD

Head is the term applied to deposits formed initially by the slow downslope movement of material under periglacial conditions of alternate freezing and thawing but which are still probably forming today under the action of present-day weathering and plant growth. Deposits at the foot of pronounced escarpments, such as the Permian escarpment in the east of the district, come under this heading. They comprise a bewildering mixture of soft clay, sands and angular rock fragments. A similar deposit is also found in the bottom of dry valleys on the surface of the Permian limestone. One such deposit has been separately mapped in Horselock Dale [4480 2911].

Head may also be present over much of the Westphalian strata where it is commonly a yellow sandy clay lacking in cohesion and stability. It tends to be thicker in hollows and against obstructions or slopes.

The head is generally less than two metres thick, but may exceed this thickness at the base of the Permian escarpment. It is not possible to indicate its complete distribution due to its thinness and its lack of distinguishing characteristics. Head should be assumed to be present everywhere unless proved otherwise.

6. 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 development is to be sited on them, so as to determine their thickness, compressibility and chemical content. Nine main categories are distinguished below; recorded thicknesses are extremely variable.

6.1 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 significant made ground more than 1.5m, which has been taken as the arbitary limit for mapped deposits, and it is virtually impossible to determine the distribution of any deposit present without a comprehensive investigation.

6.2 MADE GROUND, UNDIFFERENTIATED

This category includes major road and railway embankments, and other general constructional areas. There thickness is generally more easily estimated and within any development area, such deposits can be widespread.

6.3 BACK-FILLED QUARRIES

Excavations for sandstone, clays for brickmaking, limestone and sand and gravel are scattered across the district. Many have been back-filled so that commonly there is no surface indications of their former extent. In most instances archival material has 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.

6.4 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.

6.5 COLLIERY WASTE TIPS

These tips are a conspicuous feature of the district. They generally consist of inert material but there may be a considerable proportion of coal. Some of the larger tips have been landscaped and redeveloped, such as Whitwood Golf Course in the south west of the district. This material may be locally unstable, as small areas of landslipping from coal tips have been noted from the region.

6.6 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 gas. Archival data have proved inadequate in indicating the position of all waste-tips and it islikely that not all have been located.

6.7 ACTIVE OPENCAST COAL WORKINGS, WASTE TIPS

The St Aidans Extension Opencast Site is working at the time of publication, and mounds of discard and spoil surrounding the site consist of all strata types encountered in the sequence down to the Dunsil Seam. Some alluvial deposits may also be incorporated into the tips. By the nature of opencast operations some of these tips may only be temporary whilst others may become more permanent features of the landscape.

6.8 COAL STOCKPILES

Although these are not necessarily permanent features of the landscape stockyards by collieries may exist for tens of years. Such stockyards are commonly levelled and surfaced prior to use and these "foundations" may not removed when the site is no longer used for its original purpose.

6.9 SAND AND GRAVEL STOCKPILES

These stockpiles are fairly short lived features and are normally placed directly on unprepared ground. After use the sites of the former stockpiles are landscaped with the general restoration of the sand and gravel quarry and its immediate surroundings.

7. ECONOMIC GEOLOGY

7.1 COAL

The production of coal still continues in the area two deep mines. The larger of these is Allerton Bywater colliery which still has substantial reserves of coal. Wheldale Colliery on in the south-east of the district has smaller reserves. Opencast coal mining is also active in the region at the St. Aidian Extension site [3870 2860], immediately to the west of this district, and at Cornwall site [4470 2360], to the south of Castleford.

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 very extensive in the past. Many sites have exploited the Warren House Coal by removing thin overburden, but other seams have also been worked by this method. Recent improvements in the methods and scale of excavations means that it is now feasible to work deeper seams, beneath considerable thicknesses of overburden. Although there is no active prospecting in the district, at present, the possibility of further prospecting and extraction cannot be excluded.

7.2 MINESTONE

Extensive areas of colliery spoil lie adjacent to the sites of active and former collieries. Some of this spoil is now regared as a resource of "minestone", which can be processed to meet specifications for a wide variety of uses such as embankments, river and sea defences, land reclamation and brick-making.

7.3 FIRECLAY

Mudstone seatearth can be exploited as a fireclay. The seatearth of the Swinton Pottery Coal has been widely used as a refactory material as well as a pottery clay. An extensive abandoned quarry is located in the Whitwood Mere area of Castleford. A thin, unnamed, coal seam between the Swinton Pottery and Wheatwood coals also has a number of quarries along it crop from which the seatearth was extracted. Other older quarries may have existed but have now been backfilled.

7.4 IRONSTONE

Ironstones are associated with a number of coal seams, and have been widely exploited within this region. Of particular importance were the ironstones associated with the Black Bed, Middleton Main and Flockton Thick coals. However, there is no evidence to suggest that these ironstones, or any other locally developed ironstones, have been exploited in this district.

7.5 MUDSTONE AND CLAY

The mudstones and claystones of the Westphalian have very variable physical properties. However, several horizons have been used as raw-material for brick-making. A number of former brick-pits are known from the measures above and below the Wheatworth Coal in the area around Castleford. For example the Healdfield Brick Works [4388 2594].

7.6 SANDSTONE

No economically important sandstone crop out on the area. However, most of the sandstones of any thickness have been exploited for local building materials. The quarries made for this purpose were generally only small and had short lives, and many of them where probably unrecorded.

7.7 BASAL PERMIAN SANDS

This material was widely exploited, wherever it occured in this district. It was formerly used as a moulding sand for casting iron, glass making and as a building sand. It was either quarried, in conjunction with the overlying Lower Magnesian Limestone or mined by adits from surface. The mining commenced before there was any statutory requirement to record the nature and extent of underground workings. Hence there are only mine plans for the more recent mines such as the Wheldale Sand Mine [4491 2640] and the Ledston Sand Mine [4294 2949]. The material has been extensively exploited but is no longer used as its is not of sufficient quality for modern industrial processes.

7.8 LOWER MAGNESIAN LIMESTONE

The limestone of this district has been used for two main purposes. Firstly it has been widely exploited for agricultural lime, particularly on the outliers of limestone at Pannel Hill [4289 2910] and at Great Preston [4010 2985]. Secondly the limestone has been used as a local building stone. Many quarries are known from area around Ledston, for example Crispin Quarry [4328 2938]. No active limestone quarries are working in this district at present but extensive modern limestone quarries are working the Lower Magnesian Limestone to the west and north of the district.

7.9 MIDDLE MARL

The small area of Middle Marl at Park Farm [4418 2952] has been quarried for the gypsum that is found within the mudstone. The gypsum was probably quarried for local use.

7.10 SAND AND GRAVEL

Potentially workable sand and gravel is present within the district. The major resource is the terrace and alluvial deposits of the rivers Aire and Calder. These deposits are described above, and an assessment of the sand and gravel resources of the district is given below and in TGM 6.

7.11 HYDROCARBONS

Speculative contour maps of the geological structures of the district, based on shafts, boreholes and mine-plan data, indicate several upfolds or anticlines of the kind which sometimes serve as traps for oil or gas. Sesimic surveys have recently been conducted to investigate these structures in detail and to identify further potential hydrocarbon traps at depth. To date, no hydrocarbon prospecting boreholes have been drilled hereabouts but to the east, Westphalian and Namurian sandstones, lying stratigraphically below the Coal Measures, are known to be reservoir rocks with respect to hydrocarbons.

8. 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, 3, 5 and 7 show the distribution of drift deposits, made ground, underground coal mining and underground sand mining respectively. Figure 11 shows the position of major faults and TGM 6 shows the distribution of mineral resources.

8.1 SUBSIDENCE

Although the effects of subsidence from coal and sand mining are considered separately below there are certain parts of the district where both coal and sand mining have been carried out within thirty metres of the surface.

Coal Mining

There are two active collieries in the district. These are Allerton Bywater and Wheldale collieries. However, in the past mines were much more numerous. Much of the district has been mined at depth, the principal seams being the Beeston, Middleton Main, Flockton Thick, Haigh Moor and Warren House.

Shallow mining and crop workings are known from several parts of the district. For example numerous bell pits were noted by Edwards along the crop of the Meltonfield Coal south of Ledston, during the First Resurvey. The extent of the bell pit mining in this area was subsequently demonstrated when that same area was opencasted by British Coal. Many other opencast sites and prospects encountered evidence of shallow mining. In Castleford site investigation boreholes encountered shallow mining in the Wheatworth Seam. Other seams which are encountered close to the surface may also have been worked at shallow depth. Where mining has taken place there is a possibility of subsidence for some time after the date of mining. The rate at which old workings collapse depends upon the type of extraction pattern, the geological conditions and the age of the mining; it cannot be assumed that all settlement has ceased, particularly where pillar and stall workings are involved. Due to the extent of inferred shallow mining in the district, detailed site investigations are desirable prior to any development.

Numerous abandoned shafts are recorded in the district, but many more unrecorded ones probably exist. In some cases several shafts are shown closely grouped on the geological map. Such occurences may represent the same shaft differently located on two or more archival documents. The exact location of shafts should be given high priority during site investigations. This can be particularly important in areas where shafts pass through significant thicknesses of unconsolidated deposits.

The possibility of localized extreme subsidence along faults which cross the sites of potential developments should also be borne in mind. Natural movements along faults, in response to either regional or local factors can cause subsidence but such movements are extremely rare. It is more common for subsidence to follow faults when coal extraction has been limited by the fault. Such subsidence tend to be most intense when workings approach the fault from the upthrow side. These effects should be considered when planning developments which straddle faults.

Differential compaction may occur on sites which are underlain by more than one lithology; whether this is due to the original sedimentation or differing lithologies thrown together by faults. This may become significant if the site is excessively loaded during development.

Sand Mining

In certain parts of the district the Basal Permian Sands have been mined. This mining has usually taken the form of adits driven into the deposit from outcrop. The adits opened into pillar and stall mines which extended for distances of up to seven hundred metres. Throughout the district the mining of this deposit is thought to be within thirty metres of the surface. The sand mining was active for nearly two hundred years from the late seventeenth century to the middle years of this century. During that time numerous small mines may have exploited the reserves, however, only a few plans of the later and more extensive mines survive. Evidence of the existence of mines outside the areas of known mining is furnished by site investgation boreholes and archival sources.

The rate at which old workings collapse depends upon the type of extraction pattern, the geological conditions and the age of mining; it must not be assumed that all settlement has ceased even with the most ancient workings. There is a history of void propagation from the abandoned workings to the surface in certain parts of the district. North of Pannel Hill at the old Ledston Sand Mine numerous voids have propagated to the surface causing many circular collapse craters in the woodland. In the Redhills area of Castleford voids have been encountered during various site investigations.

Void propagation from shallow sand mines is controlled by a number of factors. These include the size and spacing of the pillars left during mining and the strength of the roof rock, which in turn is controled by the joint spacing and the thickness of the beds in the magnesian limestone. The ground water conditions are also an important control. As the Lower Magnesian Limestone forms a pronounced escarpment the Basal Permian Sand is normally above the water table over much of the district. Locally perched water tables may develop which allow water to gather in old sand workings and weaken the pillars which support the roof. Any engineering operation which could cause local perched water tables, such as the use of a grout curtain, should carefully consider the implications on the local ground water conditions.

8.2 MINERAL RESOURCES

In planning the future of this district consideration should be given to siting major developments where they will not sterilize mineral resources, and the possibility of extraction of workable minerals in advance of development.

Much of the district is underlain by coal at shallow depth; the most important shallow seams being the Warren House, Kent's Thick and Meltonfield coals. Few records exist as to the extent of former mining in these seams. Throughout this district these seams are regarded as prime opencast targets where they occur close to the surface. The Warren House Seam has already been extensively worked. No current opencast prospecting is taking place in the district but it is likely that areas will be prospected in the future.

Sand and gravel forms a significant resource in the valleys of the Aire and Calder. It is currently being exploited north of Dunford House. Extensive resources of sand and gravel remain; even though much has been sterilised by colliery waste tips. Details of the sand and gravel resources are presented below and on TGM 6.

In the east of the district the Lower Magnesian Limestone is exposed. It has been used in the past as building stone and is exploited at various localities in West Yorkshire as an aggregate. No extraction is currently taking place in the district.

8.3 OTHER CONSTRAINTS ON LAND-USE PLANNING

Slope movements can cause foundation problems. Certain slopes show clear evidence of cambering. The escarpment of the Lower Magnesian Limestone to the east of Ledston is clearly cambered and shows open joints aligned parallel to the edge of the escarpment. Down-slope mass-movement of superficial deposits can also occur. A particular danger is the deposit of Head of unknown thickness along the base of the Lower Magnesian Limestone escarpment, north of the River Aire. In places this may consist of several metres of poorly sorted silts and clays with sand and some gravel. If the toe of this deposit is excavated, for example in a road cutting, the sediment may become remobilised and move down slope. Only one landslip has been recorded, in this district, at Wheldale [4448 2629] just to the east of the colliery.

The drift deposits may also constrain development. These deposits can change in lithology and thickness very rapidly, as do, for example, the river terrace deposits. In consequence the degree of compaction under load can vary equally rapidly and is difficult to quantify in advance. The drift deposits may conceal buried channels such as the one to the south of Mickletown (see TGM 2), giving further problems of prediction. Head, which is largely unmappable, covers much of the areas mapped as exposed solid. It is normally thin but may mask rockhead depressions. Head is particularly thick along the base of the Lower Magnesian Limestone escarpment (see above). As a consequence of the variable nature of head and the other drift deposits a careful investigation should be made of them before development commences.

The possibility of localised extreme subsidence along faults which cross sites should be borne in mind. Natural movement along faults, in response to either regional or local factors, can cause subsidence but such movements are extremely rare. It is much more common for susidence to follow faults when coal extraction has been limited by the faults. Such subsidences tend to be most intense when workings approach the fault from the upthrow side. These effects should be carefully considered when developments are planned which straddle faults. Several case histories of site investigations to locate fault positions in this district are held in the NGDC. These show that the faults are not single fractures but normally consist of a series of sub-parallel fractures. These form a complex fault zone which may be many tens of metres wide.

Faults may also juxapose lithologies of different geotechnical properties. If excessively high loads are placed across a such a fault during development differential compaction of the strata may occur. In addition the rocks that have been faulted may be internally fractured and consequently weaker than the same strata in an area uneffected by faults.

Made ground and fill may also constrain development. The varied chemical content and compaction of these materials must be carefully investigated before development. Backfilled, unlocated quarries are probably present in the sandstone, mudstone, limestone and the sand and gravel. Consideration should be given to investigating for these as part of a full site investigation.

9. THEMATIC GEOLOGY MAPS

Seven 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 THICKNESS OF DRIFT DEPOSITS

The thickness of the Quaternary deposits is shown on this thematic map, the thickness contour (isopachyte) interval being 2m. The contouring has been done by hand and is based on the total archival information available at 31. 3. 87. Additional information may modify the present information.

The glacial deposits are normally thin and are assumed to be less than two metres thick.

The fluvial deposits fill channels incised into bedrock. They generally contain between eight and twelve metres of sediment but a closed depression occurs in the channel floor, south of Mickletown, which is filled with over fourteen metres of sediment. The major rockhead channel follows the course of the River Calder while the present course of the River Aire bears little relationship to any rockhead channels.

The overdeepening of the rockhead channels may have a sub-glacial origin.

MAP 2 DISTRIBUTION OF DRIFT DEPOSITS

Fluvial and Glacial deposits are depicted on the map. Head and downwash are also widespread, mantling much of the solid rock, 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. Thicker deposits of downwash and soliflucted material are probably present along the base of the Permian escarpment. Because of a total lack of sections or boreholes through this material it has not been possible to determine the nature or extent of the deposit. The deposits are discussed in more detail in Section 5.

MAP 3 DISTRIBUTION OF MADE GROUND

Nine categories of Made Ground are distinguished on this thematic map. The categories are:-

1. Landscaped ground

2. Made ground, undifferentiated

3. Backfilled quarries, nature of fill unknown

4. Backfilled opencast coal workings

5. Colliery waste tips

6. General refuse tips

7. Waste tips associated with active opencast coal workings

8. Coal stockpiles

9. Sand and gravel stockpiles

Each of these categories is discussed more fully in Section 6 of this report.

MAP 4 BOREHOLE LOCATIONS

The locations of all known boreholes are shown on this thematic map. The records of these boreholes form part of the British Geological Survey's National Geoscience Data Centre (NGDC). Each borehole registered with the NGDC is identified by a four-element alphanumeric descriptor (e.g. SE 42 NW 41). The first two elements define the 10-km square (of the National grid) in which the borehole is situated; the third element defines a quadrant of that square, and the fourth is the accession number of the borehole. On the thematic map only the last element is required to uniquely define an individual borehole. Where a recorded section from a colliery shaft is known it is treated in the same way as a borehole, for example the record of Allerton Bywater Colliery Shaft is registered as SE 42 NW 15.

British Coal opencast exploration boreholes are so numerous in this district that they are registered in a separate series. It is impractical to show individual boreholes on the scale of 1:10-000 so only general areas which have been prospected are shown.

MAP 5 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 many bell pits and pillar and stall workings, have no known plans. Their presence can inferred only from boreholes, old shafts and tips, and from archival information. Old coal workings are present at depths ranging from immediately subsurface to over 300m. An arbitrary depth of 30m has been chosen to separate shallow and deep mining.

The information given on the thematic map is generalised. Four categories of ground are shown on the thematic map:

1. areas where coal is known or inferred to have been worked less than 30 m below rockhead;

2. areas where coal is known or inferred to have been worked at depth greater than 30m below rockhead;

3. areas that are the sites of former opencast coal mining;

4. areas where no workings are known or inferred.

The thematic map also shows the position of mineshafts, though it is unlikely that all have been located.

Particular care is required when developments are planned in areas where the thicker or more valuable coals (Haigh Moor, Warren House, Wheatworth and Houghton Thin seams) are close to the surface, as old pillar and stall workings may stand open for many years. Such pillar and stall workings may eventually collapse if there is a change in groundwater conditions or after loading at critical points such as roadway intersections.

In this district there is evidence that the Meltonfield and possibly the Newhill seams were worked at shallow depth in places, for example the abandonment plan for the Newton Lane opencast site records numerous bell pits in the upper leaf of the Meltonfield coal. As result of the gentle dip and subdued rockhead topography these two seams are generally within 30m of rockhead over a large area of the Aire/Calder valley. However, it seams unreasonable to categorise the whole area of the Aire/Calder valley, in this district, as being undermined at shallow depth. Therefore only the are to the west of the Whitwood Fault is demarcated as an area where shallow mining is known or inferred to have occurred within 30m of rockhead.

For detailed information on the location of former shafts, details of coal mining and any related subsidence problems, reference should be made to British Coal.

MAP 6 SAND AND GRAVEL RESOURCES

The river terraces and alluvial deposits of the district are known to contain sand and gravel. To illustrate the resource potential, thematic map 6, shows a resource block where data are available to give an estimate of the quality and quantity of the resource block. In conjunction with this map Chapter 10 of this report gives a fuller description and details of the resources and methodology used in assessing them.

MAP 7 UNDERGROUND SAND MINING

The Basal Permian Sand has been mined as a foundry sand, glass sand and building sand at various times since the late seventeenth century or earlier. Extensive mining continued into the present century with the largest known in the district, Wheldale Sand Mine [4490 2640], which is estimated to have some thirty two kilometres of tunnels extending to seven hundred metres from the mine mouths.

The thematic map shows the surface position of the Basal Permian Sand and divides the area underlain by Permian deposits into:-

1. those areas under which Basal Permian Sand is not likely to have been mined

2. those areas under which Basal Permian Sand has possibly been mined

The boundaries between the two areas is taken 700m from the crop of the Basal Permian Sand, since this is the extent of the largest local mine, the Wheldale Sand Mine.

This cautionary zone is further divided into three:-

1. Proven sand mining

   Areas where mine plans exist to show the extent and style of the sand mining

2. Suspected sand mining

   Areas where archival evidence suggests that mining was formally carried out but the documents do not indicate the extent or style of mining. Such records comprise a variety of information about former mining activities and include, for example, boreholes that encounter voids in the Basal Permian Sand, old trade directories which give some indication of the activities of former mining companies, official returns from companies which indicate how many men they employed underground, etc.

3. Possible sand mining

   This category includes all other areas within the 700m cautionary zone in which mining is not known or suspected. In the Airedale area of Castleford the 700m zone terminates against a fault which throws down the Basal Permian Sand to depths below which mining is unlikely.

10. CONSTRUCTIONAL MATERIALS

10.1 LIMESTONE RESOURCES

The limestone of this district has been used for two main purposes. Firstly it has been widely exploited for agricultural lime, particularly on the outliers of limestone at Pannel Hill [4289 2910] and at Great Preston [4010 2985]. Secondly the limestone has been used as a local building stone. Many quarries are known from area around Ledston, as for example Crispin Quarry [4328 2938]. No active limestone quarries are working in this district at present but there are extensive modern limestone quarries the Lower Magnesian Limestone to the east and north of the district. These quarries are producing crushed rock aggregate.

The distribution of the Lower Magnesian Limestone is illustrated in Figure 12. It is largely confined to the east of the district except for the outlier at Great Preston in the north-west. Very little is known about the Lower Magnesian Limestone in this district and the thickness has only been proved in four boreholes. No commercial resource surveys are known from this district; hence no data are available concerning changes in thickness or variations in mechanical and physical properties of the rock.

With the limited data available it is not practical to attempt even an indicative assessment of the resource (Bureau of Mines and Geological Survey, 1980).

10.2 SAND AND GRAVEL RESOURCE ASSESSMENT

As part of the present project, the local sand and gravel deposits have been the subject of a resource assessment, as described below. This is concerned with the estimation of resources, which include deposits that are not currently exploitable but have a foreseeable use, rather than reserves, which can only be assessed in the light of current, locally prevailing, economic considerations. Clearly, neither the economic nor the social factors used to decide whether a deposit may be workable in the future can be predicted; they are likely to change with time. Deposits not currently economically workable may be exploited as demand increases, as higher-grade alternative material becomes scarce, or as improved processing techniques are applied to them. The improved knowledge of the main physical properties of the resource and their variability, which this survey seeks to provide, will add significantly to the factual background against which planning policies can be decided (Archer, 1969; Thurrell, 1971, 1981; Harris and others, 1974).

The survey provides information at the "indicated" level. "Indicated" assessments "are computed partly from specific measurements, samples or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and

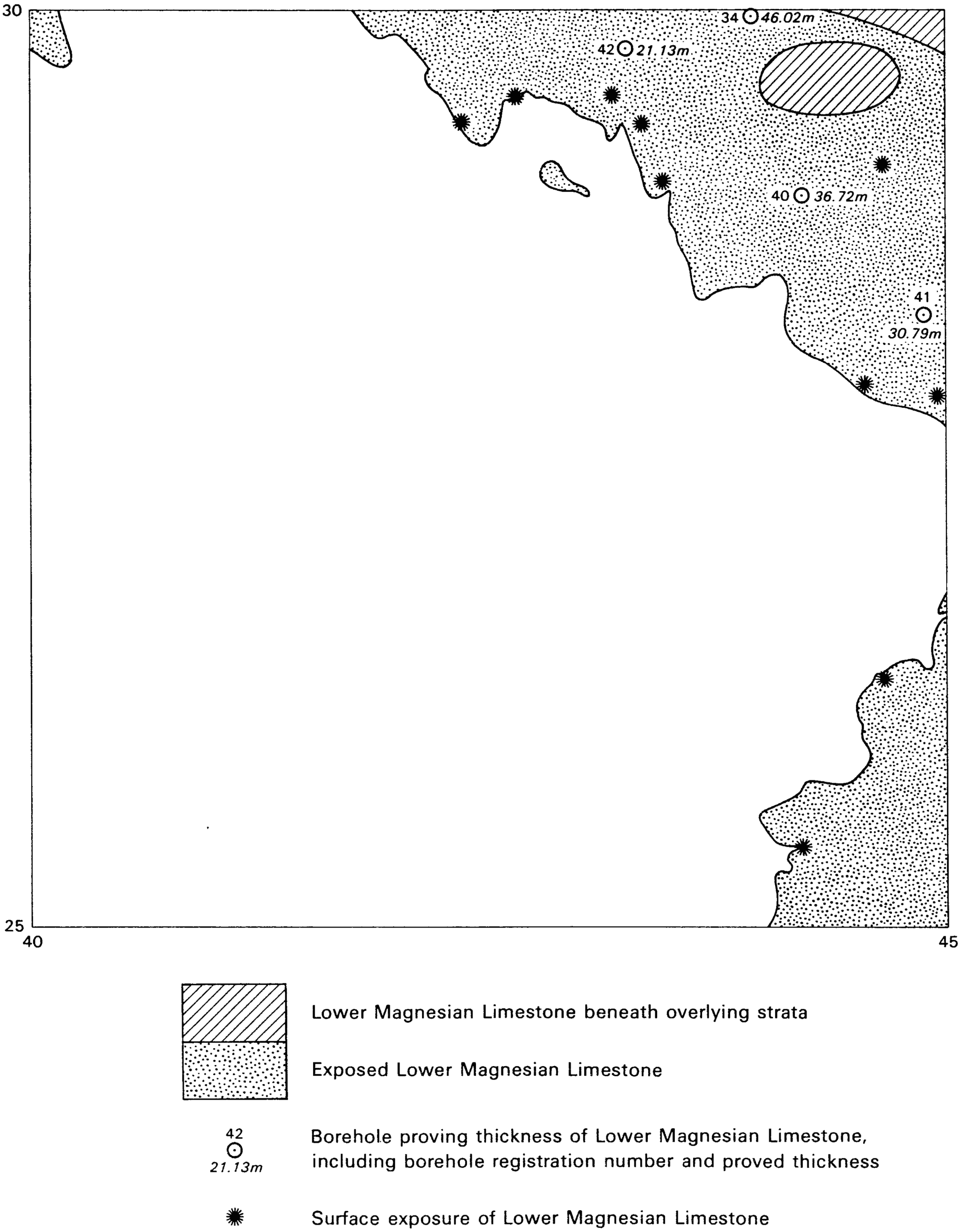

Figure 12 Sketch map showing the distribution of the Lower Magnesian Limestone and related data in the Castleford District

sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout". (Bureau of Mines and Geological Survey, 1980).

It follows that the whereabouts of reserves must still be established and their size and quality proved by the customary detailed exploration and evaluation undertaken by industry. However, the information provided by this survey should assist in the selection of possible sites suitable, in geological terms, for further investigation. The following arbitrary physical criteria have been adopted:

1. The deposit should average at least 1m in thickness.

2. The ratio of overburden to sand and gravel should be no more than 3:1.

3. The proportion of fines (particles passing a 0.625mm B. S. sieve) should not exceed 40 percent.

4. The deposit should lie within 25m of the surface, this being taken as the likely maximum working depth under most circumstances. It follows from the second criterion that boreholes are drilled no deeper than 18 m if no sand and gravel has been proved.

A deposit of sand and gravel that broadly meets these criteria is regarded as "potentially workable" and is described and assessed as "mineral" in this report.

Pre-Pleistocene rocks, which are usually consolidated and devoid of potentially workable sand and gravel, are referred to as "bedrock". Permian Basal Sand is the only exception. This material was extensively mined for sand. However, the resource have been extensively exploited in the past and little potentially workable mineral remains. "Waste" is any material other than bedrock or mineral; "overburden" is waste that occurs between the surface and an underlying body of mineral.

For the particular needs of assessing sand and gravel resources, a grain-size classification based on the geometric scale 1/16mm, 1/4mm, 1mm, 4mm, 16mm, 64mm has been adopted. The boundaries between fines (that is, the clay and silt fractions) and sand, and sand and gravel grade material, are placed at 1/16mm and 4mm respectively (Giles, 1982, Appendix C).

The volume and other characteristics of the mineral are assessed within resource blocks, each of which, ideally contains approximately ten square kilometres of sand and gravel. No account is taken of any factors, for example roads, villages or land of high agricultural or landscape value, which might stand in the way of sand and gravel being exploited, although towns are excluded. The estimated total volume therefore bears no simple relationship to the amount that could be extracted in practice.

It must be emphasised that the assessment applies to the resource block as a whole; valid conclusions cannot be drawn about mineral in parts of a block, except in the immediate vicinity of the actual sample points.

The geology of the solid and drift deposits are described in section 2,3, and 5 of this report.

Composition of the Sand and Gravel Resources

The unconsolidated aggregate resources of the district consist of entirely of fluvial sand and gravel. Details of boreholes and gradings from these deposits are largely confidential, but the information has been collated and interpreted and is presented below in general terms.The available grading data is of variable quality and age, in addition it is unevenly distributed. For this reason quantitative descriptions, eg mean values and ranges, are not presented here. The grading information is only discussed in qualitative terms.

Fluvial Sand and Gravel

River Terrace Deposits (Undifferentiated), Second River Terrace Deposit, First River Terrace Deposit and Alluvium are considered under this heading. The potentially workable fluvial deposits range from 'very clayey' pebbly sand to gravel. The mean value would probably lie in the 'clayey' pebbly sand class. Sections in the sand and gravel quarry north of Dunford House show that the sand fraction is composed of fine to coarse grained, subangular to rounded, equant quartz grains with coarse grained, subangular to well-rounded lithic grains. The gravel fraction is dominated by fine and coarse grained, equant and tabular sandstone with minor amounts of chert, ironstone, coal, quartz and igneous clasts. Aggregate impact values for this material are presented by Giles and Williamson (1985, p42).

The Map

The sand and gravel resource map forms Thematic Geology Map 6 which accompanies this report. Site-specific data is not shown on TGM 6 as the majority of it is confidential and the small fraction that is in the public domain could be given undue weight if presented out of the context of the whole body of data. The non-confidential data may be examined by application to The Manager, National Geoscience Data Centre (South), British Geological Survey, Keyworth, Nottingham.

Mineral Resource Information

The mineral-bearing ground in this district consist of a single resource block (Giles, 1982, Appendix A). Within this resource block the mineral is shown as a continuous (or almost continuous) spread beneath overburden.

Areas where bedrock crops out, where boreholes indicate absence of sand and gravel beneath cover or where sand and gravel beneath cover is interpreted to be not potentially workable are unornamented on the map. In such cases it has been assumed that mineral is absent except in infrequent and relatively minor patches that can neither be outlined nor assessed quantitatively in the context of this survey. Areas of unassessed sand and gravel, for examples in built-up areas, are indicated by a stipple.

The area of mineral-bearing ground is measured, where possible, from the mapped geological boundary lines. The whole of the area is considered as mineral-bearing, even though it may include small areas where sand and gravel is not present or is not potentially workable.

Results

The statistical results are summarised in Table 1. The statistical methods used are outlined in Giles (1982, Appendix B).

Accuracy of Results

For the resource block (block A), assessed at the indicative level, the accuracy of the results at the 95 percent probability level (that is, on average nineteen out of every twenty sets of limits constructed in this way contain the true value for the volume of mineral) is 15 percent. However, the true volume is more likely to be nearer the figure estimated than either of the limits. Moreover, it is probable that roughly the same percentage limits would apply for the statistical estimate of mineral volume within a very much smaller parcel of ground (say 100 hectares) containing similar sand and gravel deposits, if the results from the same number of sample points were used in the calculation. Thus, if closer limits are needed for a quotation of reserves, data from more sample points would be required, even if the area were quite small. It must be emphasised that the quoted volume of mineral has no simple relationship to the amount that could be extracted in practice, as no allowance has been made in the calculation for any restraints (such as existing buildings and roads) on the use of the land for mineral workings.

Notes on the Resource Block

Block A

Geological criteria have been used to designate the boundary of the resource block. The block is composed entirely of fluvial sand and gravel of the various river terrace deposits and alluvium. The assessment of the block was made using information from BGS archives. This included site investgation boreholes, several resource surveys of the deposits by commercial concerns and selected British Coal Opencast exploration boreholes. A total of 71 boreholes were used.

One large quarry currently exploits the resources. Other much smaller quarries may have extracted small volumes of sand and gravel for primarily local use; however, no records exist of their former extent or depth. British Coal Opencast Sites have removed significant areas of sand and gravel during excavations for coal, for example at the Lowther North and Extension Site [4030 2820]. In addition large areas of this resource block are underlain by potential opencast coal resources, several areas of which have been prospected in the past.

Several large colliery spoil tips rest on alluvium. These areas have been excluded from the resource block and have not been assessed. However, parts of these colliery spoil tips may be resources in their own right (see Section 7.2, Minestone).

The mean overburden thickness is 2.47m with a range of between 0.15m and 6.70m. Waste partings are recorded in a number of boreholes and these range in thickness from 0.15m to 2.89m and are normally composed of soft clay or silts. The sand and gravel has a mean thickness of 5.09m and a range of between 0.30m and 14.63m. Several boreholes in the

resource block record peat, silt and clay instead of sand and gravel.

The volume of potentially workable sand and gravel resources

in this block is 43.3 million metres 3 + 15 percent.

APPENDIX A

MINE ABANDONMENT PLANS EXAMINED IN THE PREPARATION OF THESE MAPS AND REPORTS.

1182	NE 1	FGB 496
2140	NE 4	FGB 497
3136	NE 170	FGB 499
3367	NE 348	FGB 800
3368	NE 383	GCR 193
3727	NE 401	M 184
4204	NE 402	M 227
4465	NE 403	M 686
4657	NE 437	MWK 2
7330	NE 438	MWK 6
7331	NE 466	OC 247
7366	NE 471	
8539	NE 499	
8540	NE 505	
9354	NE 506	
9898	NE 509	
10356	NE 644	
10410	NE 645	
11650	NE 646	
12301	NE 647	
12353	NE 720	
14436	NE 741	
14463	NE 807	
	NE 811	
	NE 842	
	NE 869	
	NE 898	
	NE 966	

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 cocerning 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.

Number	Site Name
181	St Aidans *
253	Great Preston *
448	Billywood
520/520A	Watkinson Terrace *
551	Pannel Hill
577	Mickletown
637A	Owl Wood 1 *
637A/738A	Owl Wood 2 (Brigshaw) *
637A	Owl Wood 3 (Longdike Lane) *
637A	Owl Wood 4 (Longdike Lane, Haigh Moor Area) *
637A	Owl Wood 5 *
637A	Owl Wood 6 *
637A	Owl Wood Extension *
706	Bowers Row
730/730A	Newton Lane *
829/829A	Lowther North and Extension *
No number	Healdfield Brickworks *

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

British Coal Opencast Executive
Yorkshire Area HQ
Rothwell Colliery
Rothwell
Leeds

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

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

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