Geological notes and local details for

Sheet NZ 27

Cramlington, Killingworth and Wide Open

(SE Northumberland)

Natural Environment Research Council

BRITISH GEOLOGICAL SURVEY

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Sheet NZ 27

Cramlington, Killingworth and Wide Open

(SE Northumberland)

Part of 1:50,000 Sheets 14 (Morpeth) and 15 (Tynemouth)

I. Jackson, D.J.D. Lawrence and D.V. Frost

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Geological notes and local details for
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SUMMARY

The geology, mineral resources and geotechnical problems of the Cramlington - Killingworth - Wide Open area (Sheet NZ 27) are described. Lower and Middle Coal Measures (Westphalian A, B and C), of fluvial and deltaic facies, are 650m thick, with 14 workable coals. Devensian glacial sediments up to 50m thick conceal the Coal Measures which are well known through numerous shafts, bores and mines. Coal has been mined extensively, but resources remain which could be worked opencast. Geotechnical problems result from subsidence over shallow coal workings and shafts, many of which are inadequately documented. Weak clays and silts in the glacial sequence may also cause foundation problems.

PREFACE

This account describes the geology of 1:25,000 sheet NZ 27 which lies within 1:50,000 geological sheets 14 (Morpeth) and 15 (Tynemouth). The resurvey was commissioned by Department of the Environment.

The area was first surveyed at the six-inch scale by H.H. Howell and W. Topley, and published on Northumberland Old Meridian County maps during the years 1867 to 1871. A re-survey by G.A. Burnett and V.A. Eyles in 1929-34 was published on the New Meridian. Revision of the eastern half of the area by D.H. Land during 1960-3 was published on National Grid sheets NZ 27 NE and SE. There is a memoir for the Tynemouth district (Land 1974) but not for the Morpeth district.

The present survey was made in 1983-4 by I. Jackson (NZ 27 NW and SW), D.V. Frost project leader (27 SE), and D.J.D. Lawrence (27 NE), with D.H. Land as programme manager.

G.M. Brown

Director, British Geological Survey

March 1985.

CONTENTS

LIST OF MAPS and FIGURES

MAPS at 1:10,000 scale For each of four themes there are four maps, for NZ 27 NW, NZ 27 NE, NZ 27 SW and NZ 27 SE respectively. The geological maps are overprinted on Ordnance Survey topographic bases.

MAPS at 1:25000 scale

FIGURES in the text

NOTE: It is emphasized that the maps in this report should not be used as a substitute for normal site investigation before any development.

INTRODUCTION

The area described in this report lies north of Newcastle upon Tyne and within the administrative counties of Tyne & Wear and Northumberland. It extends from Stannington and New Delaval in the north to Dinnington and Killingworth in the south (Fig. 1). The River Blyth flows eastwards across the northern margin of the area in a deeply incised valley; elsewhere relief is gently undulating from 30 to 78m above sea-level.

In the past, urban development was no more than a scatter of small villages usually sited on higher ground and built of locally quarried Coal Measures sandstone. Coal mining, first recorded in the 13th century, slowly changed the landscape. At first workings were only small scale near-crop bell pits and drifts. Production greatly increased after 1550 with an influx of capital and improved technology which included railways and borehole drilling. Before 1699 a railway ran from near Plessey Checks through New Delaval to the coast at Blyth. The oldest borehole record is of one near Killingworth Church drilled in 1694 to a depth of 65m. In the 19th century deep mines working large areas were developed, with a consequential expansion of settlements and population.

After 1960, when most of the mines became exhausted and the workforce moved, many of the rows of terraced miners' houses became derelict. In the 1970's an attempt was made to arrest the decline of the region with resettlement of people from central Newcastle and other urban areas to Killingworth and Cramlington new towns. New roads were made, old coal tips landscaped, opencast sites restored and built over, and new factory and trading estates developed. The remaining large areas of open countryside in the north and west include large country estates such as Blagdon and Seaton Delaval.

Note: the word 'area', unqualified, in this account means the whole ground covered by sheet NZ 27.

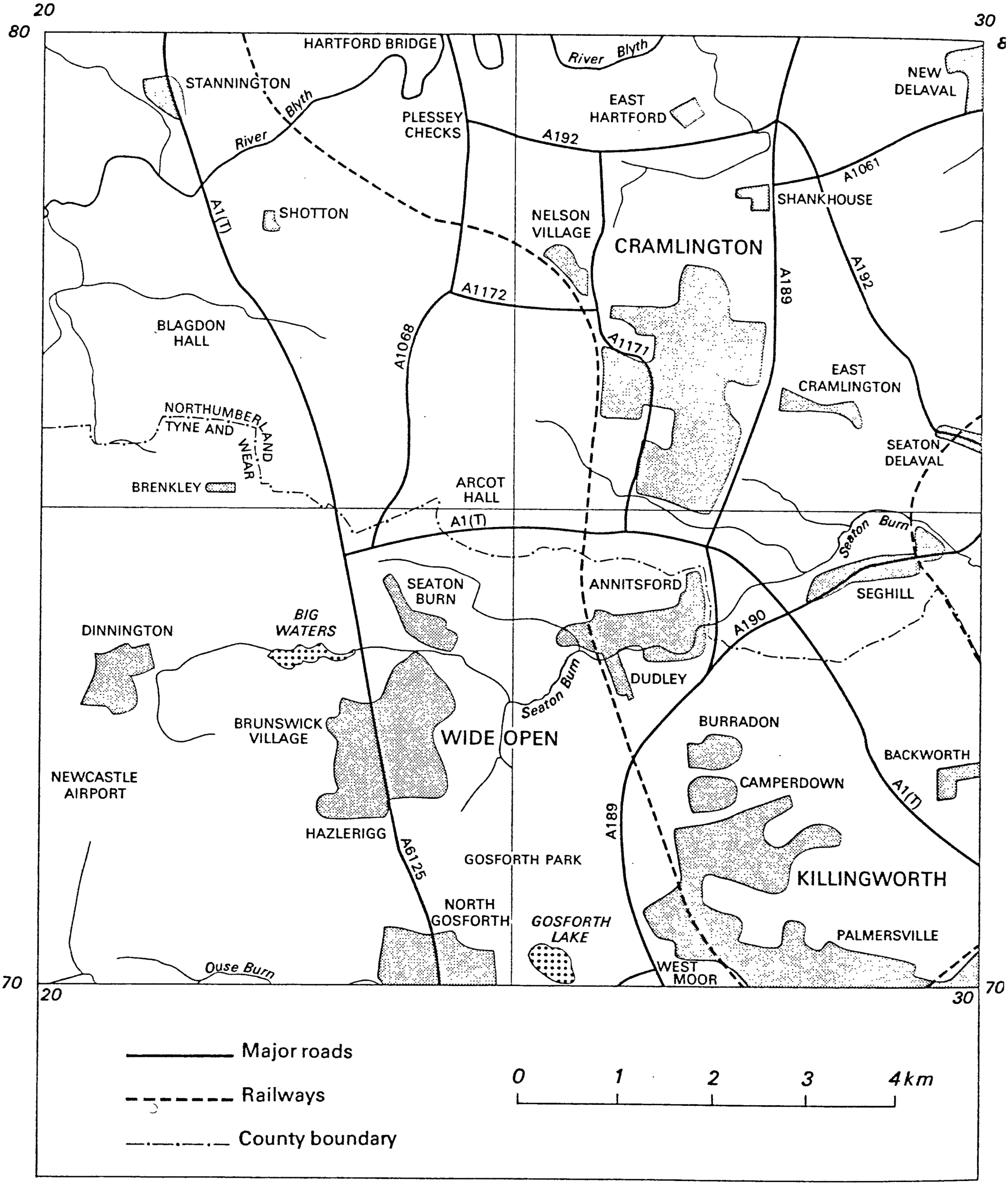

Fig. 1. Location map.

GEOLOGICAL HISTORY

Carboniferous rocks underlie the area and were deposited some 300 million years ago in the Northumberland Trough which was a region of relative subsidence with thick, rapid sedimentation between the Southern Uplands to the north and the Alston Block to the south. Pre-Carboniferous rocks are considered to be strongly folded Lower Palaeozoic strata although no borehole has penetrated the 5000m thick Carboniferous.

At the end of Carboniferous times folding and faulting were followed by deposition of younger strata, since removed by erosion, and apart from intrusion of Tertiary dykes together with further earth movements, the 'solid' geological history of the area was complete (Fig. 3).

However the landscape continued to be modified, particularly by the Quaternary Devensian glaciation which ended about 12,000 years ago. Most of the area is covered by glacial deposits or 'drift' (Fig. 5). Where these are thin or absent, resistant Coal Measures sandstones form topographic highs. The thickest drift, perhaps in excess of 50m, infills pre-glacial or glacial channels which cut into solid rock and descend eastwards to below sea level (Fig. 6 and 7).

Small streams, such as Seaton and Horton burns, meander eastwards in shallow valleys with thin alluvial deposits. Only the River Blyth and its tributaries cut down through the drift to expose rock.

COAL MEASURES GEOLOGY

Within the area there are about 650m of Lower and Middle Coal Measures (Fig. 2), resting conformably on older Namurian and Dinantian strata. All but the lowest 50m of the Coal Measures crop out. The Lower Coal Measures are of Westphalian A age; the Middle Coal Measures are Westphalian B (up to the Ryhope Marine Band) and Westphalian C.

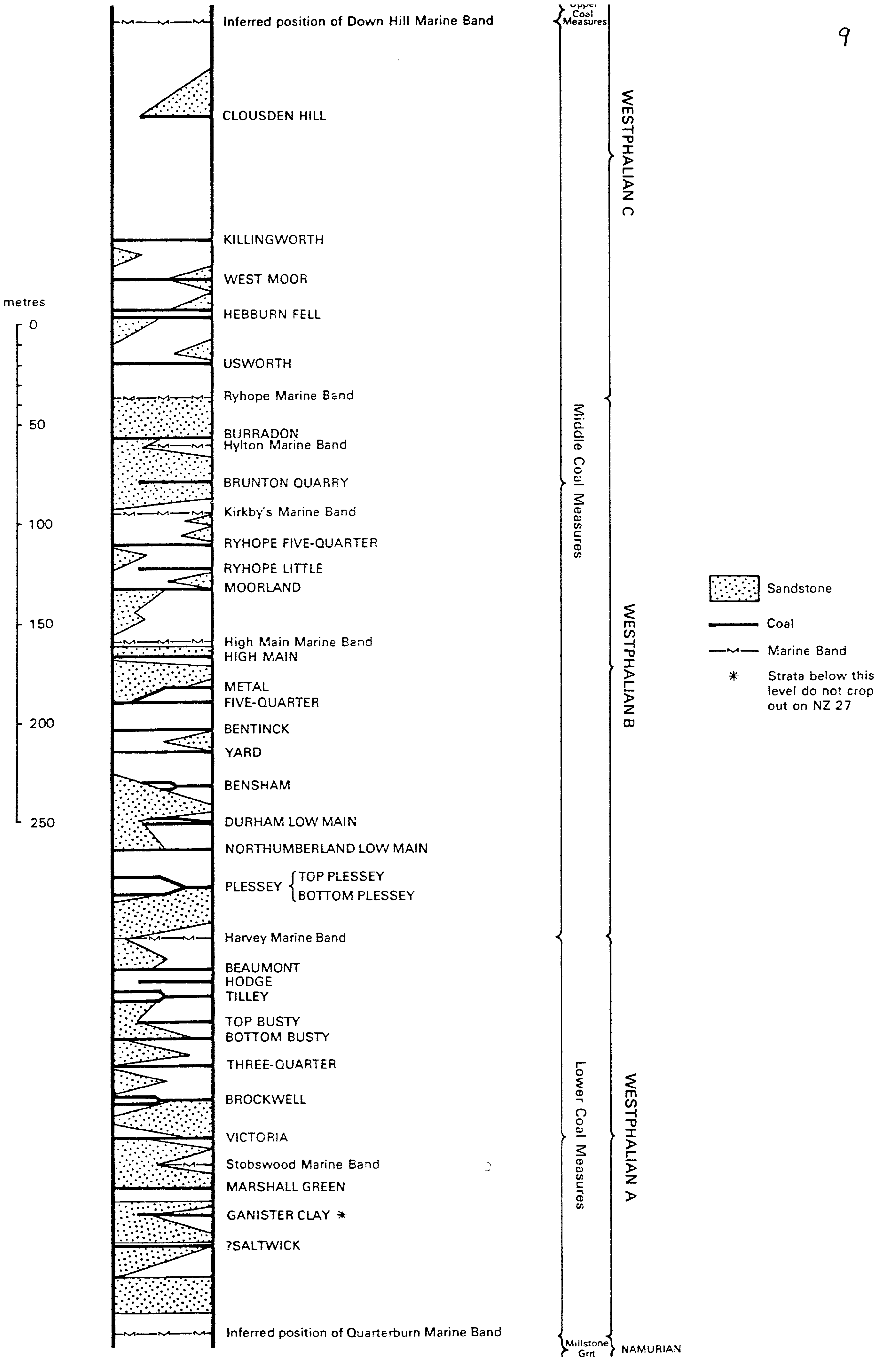

Fig. 2 Generalized vertical section

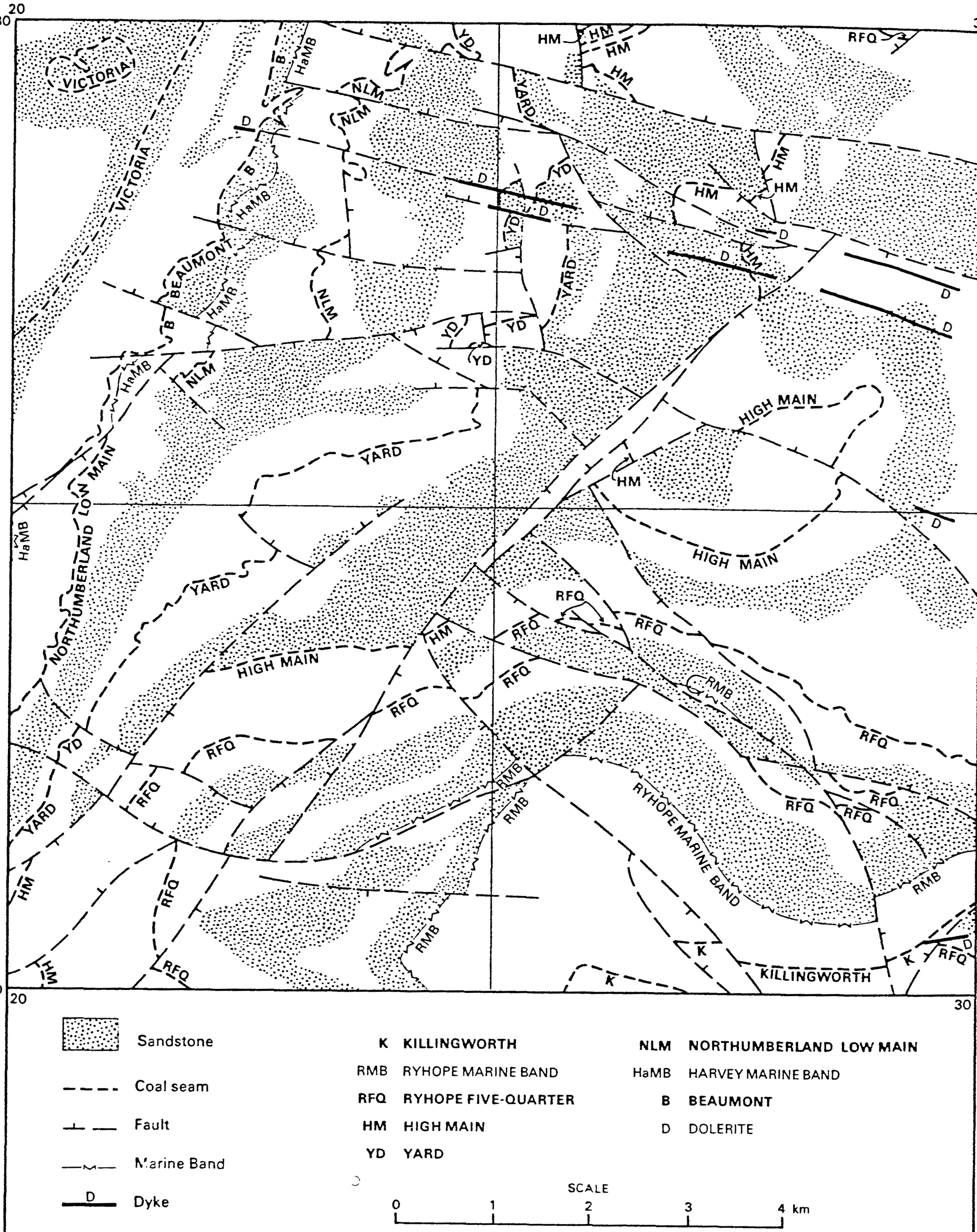

Fig. 3 Simplified geological map

Sedimentology

The Coal Measures rocks consist chiefly of mudstones with subordinate siltstones, sandstones, seatearths and coals in repetitive sequences or cycles, with the lithologies commonly in that upward order. Each cycle is generally between 10 and 30m thick, and the thicker ones usually contain thick sandstones. The depositional environment was fluvial flood-plain to upper deltaic with occasional marine incursions.

Coals About 3% of the measures are coal, which in this area is of bituminous rank. Of the 30 named seams, some 12 are thick enough to be mined. Lithologically, coals can be divided into bright (softs), dull (hards), banded (soft and hards), cannel, or dirty dependent upon their conditions of deposition and type of original flora. The seams are considered to have formed from vegetation which grew in situ, in swamps which were sufficiently de-oxygenated for the partial preservation of vegetable matter. Some seams are split by interdigitation of sediment, which may be on a regional scale or on a local scale, due to local subsidence and sedimentation. All seams vary in thickness and some thin out altogether, although their position may be indicated by the seatearth persisting. Many seams have 2 or 3 cm of cannel coal in their immediate roof.

Seatearths underlie all coal seams and grade from sandstone (ganister) to mudstone (fireclay). They are distinguished by the absence of bedding and the presence of rootlets. Once thought to be the soils in which coal forming forests grew, they are now believed to represent a sub-aqueous soil accumulation on which vegetation flourished without being preserved as coal. There is therefore no correlation between the thickness or character of the seatearth and that of the overlying coal. Fireclays and ganisters may or may not be usable as refractories.

Mudstones form over 50% of the Coal Measures sequence. Colloquial terms are shale, bind, metal and plate. Mudstones immediately above a coal seam, grey to pale grey in colour, generally contain fossil bivalves in 'mussel bands'. At five horizons, mudstones with marine fossils occur (marine bands), with foraminifera, fish scales, marine bivalves, Lingula sp. and in the Ryhope Marine Band, goniatites. Faunas were not studied in the present research.

By an increase in silt content mudstones grade into siltstones or pass by intercalation and interlamination of sandy beds (striped beds) into sandstone ('post' or 'hazel').

Sandstones and siltstones comprise up to 45% of the total sequence. They are in the form of thin (about 5m) but laterally widespread sheets (sheet sandstones) or thicker channel sandstones with a gently curving form in plan. Channel sandstones have erosive bases ('washouts') which cut down into underlying strata and may remove part of a coal seam. Practically all sandstones are cross-bedded on various scales and some show ripple marks and bioturbation.

Ironstones are most common in mudstones as nodules, lenses and 'bands', generally concentrated just above or below coals. Some nodules are septarian; those in seatearths may occupy cavities left by roots.

Structure

The Carboniferous rocks of the area were faulted and gently folded in the late-Carboniferous Hercynian movements, and later were gently tilted eastward with further smaller scale faulting in Tertiary times (Fig. 4). The larger faults may be reactivated earlier deep-seated fractures.

Folding and faulting is shown on the 1:25000 scale structure contours map which shows contours at 30m intervals on the widely worked Yard and Bottom

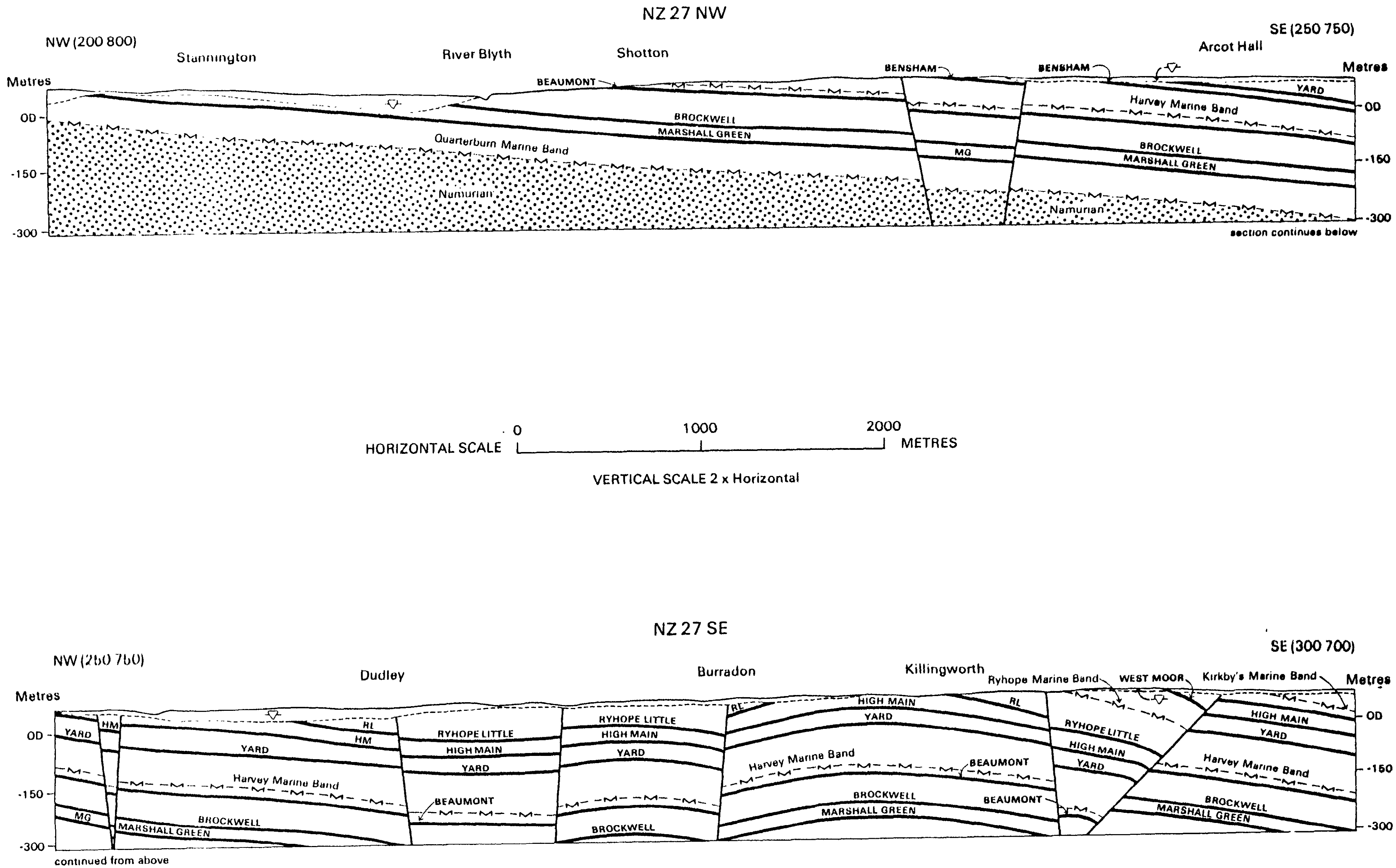

Fig.4. Horizontal section

Busty coals. The general structural pattern is of gently tilted strata intersected by a conjugate series of faults trending NE and NW. Dips average 3 to 4° to the S and SE. This overall pattern is interrupted by a shallow syncline near West Moor and a corresponding anticline near Seghill. Some correlation is suggested between lateral movement along the Ninety Fathom Fault and small folds to the north of the fault both here and in other areas.

The Hazlerigg-West Cramlington Fault, striking NE and bisecting the area, is one of the longest and most important dislocations. It is intersected at its SW end by the Havannah-Weetslade Fault and terminated to NE by the Hartley Station Fault. These faults, together with the Crimea, West Moor South, West Moor North and Burradon faults all have throws of the order of 30m. The majority of the faults are smaller. Some die out gradually as their throws reduce, while others are terminated abruptly by cross-faults. Most die out by splitting up into several fractures often with opposing throws, for example the Burradon Fault with a plexus of dislocations near Dudley. Faults with a throw of less than 3m are not shown on the structure contour map but are quite common, particularly in the area of very gentle dipping strata near Seghill. All faults hade up to 30°.

One of the largest and structurally significant faults of the Northumberland Coalfield is the Ninety-Fathom Fault or 'Dyke', which crosses the SE corner of the area. It has a vertical displacement down north of some 170m near Killingworth Moor and a hade of 45°. Most low-angle faults of this type show evidence of transcurrent movement. Mining information proves that the dip of the strata as they approach the downthrow side of the fault increases to 45° so that they meet the fault plane at right angles. On the upthrow side the strata are little disturbed.

Renewed earth movements in Tertiary times reactivated many faults, and intrusion of dykes occurred at this time. Some of these occupy fault planes whilst others are displaced by them.

Stratigraphy

Lower Coal Measures

Strata below the Marshall Green Coal are only poorly known from a small number of boreholes. The inferred position of the Quarterburn Marine band, marking the base of the Coal Measures, is 75m below the Marshall Green Coal. Intervening strata are largely sandstone with three thin coals tentatively correlated with the Bottom Saltwick, the Saltwick and the Ganister Clay coals.

The **Marshall Green Coal** is the lowest known to crop out in the area, and is 48 to 79cm thick. Strata above the Marshall Green are exposed in Catraw Burn west of Stannington. They are predominantly sandstones, coarse in places, and include a 2.5 m mudstone bed overlying the thin **Stobswood** coal; the mudstone contains fish debris indicative of the **Stobswood Marine Band** [207 795].

The **Victoria Coal** lies about 10m above the Stobswood seam. Near Stannington it forms an outlier which has been worked over a small area from drifts in Catraw Burn and from Church Pit, where the section shows 1.82m of coal including a parting. Elsewhere the seam is generally less than 50cm thick. Sandstone again dominates the measures, some 20m thick, between the Victoria and the Brockwell but two thin impersistent coals occur. In the roof of the lower one is a mussel band characterised by large <u>Carbonicola pseudorobusta</u> Trueman.

The **Brockwell** Coal commonly contains dirt partings which in the north and west split the seam into several leaves. It has been worked between Seghill and Backworth and SW of Dinnington. The maximum thickneses is 1.2m (inclusive of dirt bands). In places, for example near Burradon, it is washed out. From the Brockwell to the Three-Quarter, strata between 15 and 24m thick contain two thin impersistent coals and variable sandstones.

The **Three-Quarter Coal** has been worked near Backworth and south of the

Ninety Fathom Fault where it reaches 77cm in thickness, but elsewhere it is generally thinner and in places represented by cannel. There are 13 to 20m of strata up to the Bottom Busty. In the east, these are largely coarse sandstone.

The **Bottom Busty** Coal, average thickness 80cm, attains a maximum thickness of 1.14m in the west, has been opencasted south-west of Blagdon Hall and is currently being mined from Brenkley Colliery (the only working pit in the district). Strata between the Top and Bottom Busty, around 10m thick, include a thin coal and much sandstone.

The **Top Busty** Coal, also currently worked from Brenkley Pit, has been worked in the past between Seghill and Backworth. Its average thickness in these areas is 80 and 60cm respectively. It is subject to washouts. The overlying 10 to 20m of strata include some sandstone.

The **Tilley** Coal is banded nearly everywhere. Several thin seams may be present; in the west two leaves (with individual thicknesses of less than 74cm have been proved and the seam has been mined south of Seghill where it comprises 1.37m of alternating coal and dirt. In the interval of between 8 and 20m between the Tilley and the Beaumont seams are two thin impersistent coals, one of which is more persistent in the west and is correlated with the Hodge Coal.

The **Beaumont** Coal, which has an average thickness of about 1m, has been mined extensively and also opencasted in the north-west of the area. The 18m (average) of strata between the Beaumont and the Harvey Marine Band are mostly mudstone but with thick washout sandstones in places, which are exposed in the main road cutting at Shotton [221 774]. Immediately overlying the Beaumont is a thin fragmental clay rock followed by a mussel band with many ostracods at its base.

Middle Coal Measures

The **Harvey Marine Band,** which marks the base of the Middle Coal Measures, consists of 30 to 90 cm of very dark grey to black shale containing Lingula mytilloides J. Sowerby, fish scales and foraminifera. Overlying the marine band are mudstones with a mussel band at the base. Locally the bands are washed-out. In West Moor Borehole 27 SE/62 an intraformational conglomerate at the base of a thick sandstone rests directly on the marine shales. Sandstones up to 30m thick occupy most of the interval between the Harvey Marine Band and the overlying Plessey Coal.

The **Plessey** Coal takes its name from the eponymous locality [240 790] where it was first mined near crop and where it is over 1m thick. South-east of a line through Dinnington and Cramlington it is in two thin leaves and it is commonly washed-out. It is being opencasted W of Brenkley where it is 1.5m thick in two leaves. Measures between the Plessey and the Northumberland Low Main, some 20m in thickness, are variable in lithology but sporadically contain a thin coal or seatearth tentatively correlated with the Hutton Coal. Above the Plessey, though not in its immediate roof, is a prominent mussel band. The Plessey is not thick enough to be workable south of Cramlington, and the Hutton is similarly too thin north of the River Tyne; moreover in this intervening region of thin seams there are extensive sandstone washouts. Correlation is therefore not certain. Land (1974) thought that the two coals were at different horizons, but the Coal Board correlate them, and call the thin Cheeveley coal (which underlies the Plessey) the 'Plessey'.

The **Northumberland Low Main** has been worked over much of the area, some mining being prior to 1860. It approaches 2m in thickness, with only minor dirt bands, is of excellent quality with an ash content between 4 and 10% and low sulphur between 0.8 and 2.5%. A band of thick coal referred to as a 'swelly' trends northwards from near Backworth (Hurst 1860, Land 1974). While the swelly is certainly contemporaneous, because strata above and below are not affected, its origin is uncertain. Overlying measures up to the Durham Low Main coal are variable in both lithology and thickness, from 12 to 27m thick with sandstones prominent, and mussel bands in the mudstones.

The **Durham Low Main** Coal has been worked opencast and in Seghill Colliery. During the recent miners' strike this coal was worked at crop SW of Hartford Bridge. A typical section of the seam is upper leaf of coal 53cm on dirt 28cm on coal 10cm on dirt 20cm on basal coal 25cm. Overlying strata, around 12m thick, are largely sandstone (the Table Rocks Sandstone or Low Main Post), which was quarried at Brenkley and Dinnington.

The **Bensham** Coal suffers extensive east-west washouts through Shankhouse. North of these it is split into Top and Bottom Bensham, about 6m apart and worked separately. South of the washouts it is worked as a single seam in the SE part of the area, where a typical section near Killingworth is coal 68cm on dirt 10cm on coal 50cm. In the west the seam contains several dirt bands and is subject to washouts. Mudstone overlying the Bensham carries a mussel band characterised by Anthraconaia pulchella Broadhurst. Measures between the Bensham and Yard coals average 20m in thickness, with the thick Seaton Sluice Sandstone in the northern part of the area. A thin coal up to 45cm thick occurs some 5m below the Yard Coal but has not been worked.

The **Yard** Coal is almost entirely worked out. It is remarkably consistent in its thickness, about 1m, and of excellent quality. The Yard-Five Quarter interval is about 20m thick and includes the **Bentinck** Coal, which is usually thin and variable but justified working in the recent miners strike at crop N of West Hartford. A mussel band occurs in its roof. Below the Bentinck, the strata are largely mudstone; above they are mostly sandstone.

The **Five-Quarter** Coal has been worked extensively. It increases in thickness from 70cm near Backworth to over 1m in the Seghill area where it closely approaches the overlying Metal Coal to form a seam up to 2.36m thick with a median dirt parting 50cm thick. The united seam is washed out over a wide area near Shankhouse and New Delaval. Strata between the Five Quarter and Metal Coals increase in thickness from a mere parting in the north to 12m in the south where they are largely sandstone.

The **Metal** Coal, about 1m thick, has been worked in the north and east, but in the south-west it is an impersistent seam up to 84cm thick. In the north it practically unites with the underlying Five-Quarter and suffers washouts. The Metal to High Main sequence consists mostly of sandstone, ranging in thickness from 10m south of Killingworth to over 45m at Acorn Bank. Quarries at Cramlington old village are in this sandstone.

The **High Main** Coal is the thickest seam worked in the area comprising some 2m of excellent quality coal which is now exhausted. It is poorly exposed in the Blyth valley near East Hartford where there are very early workings. South and east of Seghill poor quality, thin coals named Crow Coal occur close below the High Main proper. At Weetslade Colliery Lizzie Pit a bastard coal nearly 1m thick is present some 5m below the main seam. Around East Cramlington the High Main thins to about 0.5m. The interval between the High Main Coal and the High Main Marine Band varies from 18m of massive cross-bedded fine-grained sandstone (High Main Post) in the south and west near West Moor [265 705], to a metre of argillaceous strata at Burradon and farther north. A thin coal between 15 and 84cm thick underlies the marine band.

The **High Main Marine Band** is represented by less than a metre of black finely micaceous shale with Lingula sp. Except in the extreme south-east, it is either absent or unrecognised south of Shankhouse. Above the marine band is a thick, prolific mussel band. Between the marine band and the Moorland Coal, the strata are about 30m thick, and contain two thin impersistent coals. The upper part of this sequence is mostly sandstone, which is exposed in an old quarry [281 741] at Seghill and underlies the village.

The **Moorland** Coal is over 60cm thick in the north, but is of poor quality. It was recently worked opencast at Stickley Farm [281 775]. Strata between the Moorland and the Ryhope Little coals average 10m in thickness. Fish scales have been recorded in the roof of the Moorland. Sandstone is exposed in an old quarry [279 723] on the northern outskirts of Killingworth.

The **Ryhope Little** Coal reaches a maximum thickness of 84cm at Backworth

Colliery. It was worked opencast in 1970 to depths of 20m at Havelock Site south of Seghill. A typical coal section showed a 25cm upper leaf separated by 18cm of shale from a 61cm lower leaf. Locally the top leaf was washed out. Detailed correlation of coals about this level in the north-east is uncertain. Measures between the Ryhope Little and Ryhope Five-Quarter coals are some 11m thick and in places include a cannel up to 33cm thick.

The **Ryhope Five-Quarter** Coal is a complex seam with numerous dirt partings. In the West Moor Borehole the total thickness is 1.5m. Individual leaves of coal reach a maximum thickness of half a metre. There is evidence of surface workings on a small scale west of Backworth. Between the Ryhope Five-Quarter Coal and Kirkby's Marine Band there are some 12 to 20m of variable mudstones and sandstones with several thin unnamed unworked coals including a seam immediately underlying the marine shales.

Kirkby's Marine Band is characterised by an alternation of marine and non-marine phases. In West Moor Borehole the band is 3.6m thick with a non-marine parting of 0.36m. Strata between Kirkby's and Ryhope marine bands are some 60m thick, largely sandstone with the thin Brunton Quarry and Burradon coals and the Hylton Marine Band. The **Brunton Quarry** Coal, 18m above Kirkby's Marine Band, is thin and locally washed out by the overlying sandstone. The **Hylton Marine Band** is 30cm thick in West Moor Borehole and yielded foraminifera and <u>Lingula mytilloides</u>. About 4m higher is the **Burradon** Coal up to 25cm thick. Its name derives from the infilled quarry [2743 7307] west of Burradon House where the coal and overlying sandstone were exposed. This medium to coarse-grained sandstone, about 23m thick in its full development, is exposed in the main line railway cutting [262 727] S of Dudley, was quarried in Burradon House and East House Farm [289 712] quarries, and forms the ridge on which Killingworth old village stands.

The **Ryhope Marine Band** forms the base of Westphalian C strata. Its fauna includes foraminifera, <u>Dunbarella sp.</u>, <u>Posidonia sp.</u>, <u>'Anthracoceras' sp.</u> and <u>Lingula sp.</u> The marine mudstones also include a 13-cm bed of ankerite siltstone, or 'cank'. Some 17m of mudstones succeed the Ryhope Marine Band, and are overlain by the **Usworth** coal, which is 76cm thick near Killingworth. Overlying strata are mudstones and thin sandstones with carbonaceous horizons, totalling 23m in thickness, and capped by the **Hebburn Fell** Coal which is in two main leaves, an upper some 55cm thick separated by 4m from the lower 75cm thick leaf. Between the Hebburn Fell Coal and the 40-cm **Killingworth** Coal 36m higher, there are four coals including the 70cm thick **West Moor** Coal. Intervening strata are mudstones and sandstones. An estimated 100m of strata succeed the Killingworth Coal up to the inferred **Down Hill Marine Band,** which marks the base of the Upper Coal Measures and comprises the highest stratum mapped in the area. Nothing is known of these strata, except that they include a sandstone at least 10m thick which was formerly quarried at Clousden Hill [283 702] and which overlies the 50cm thick **Clousden Hill** Coal.

IGNEOUS DYKES

There are two classes of intrusive igneous dykes in Northumberland: a suite of quartz-dolerites associated with the Whin Sill and intruded some 295 million years ago in late Carboniferous times, and a suite of tholeiitic dolerite dykes of early Tertiary age (about 60 million years) emanating from the Mull volcano of W Scotland. In composition both types are similar but show textural differences in thin section.

Quartz dolerites A dyke trending just N of east is recorded on plans of the High Main Coal near High Farm [285 721] and is probably a quartz dolerite.

Tholeiitic dykes are narrow and occur in en echelon segments, discontinuous at any one level. The Tynemouth Dyke, about 1m wide, is recorded over a length of 650m in Beaumont workings at about -183m and again at -12m in Five-Quarter workings beneath Killingworth Moor. A very narrow segment of the Whitley Dyke some 100m long was proved in Yard workings [295 750] east of Seghill and also in Bensham workings nearby. The North and South Hartley dykes have been proved intermittently over an 8km length, at surface and in mining, running WNW north of Cramlington. On the north bank of the River Blyth [223 788] there is a small old quarry in the dyke.

QUATERNARY

Superficial Quaternary deposits include sediments of glacial origin present over almost the entire district and post-glacial alluvium and peat which are restricted to valleys and hollows (Fig 5).

Till (boulder clay) is the dominant glacial deposit; glacial sand and gravel is recorded in several boreholes and has been recognised at surface in a few scattered localities, whilst laminated silts and clays of glacial origin are present but have rarely been identified. The relationship between these glacial deposits is not known in detail. However, it is usually only within the buried valleys that thick complexes of sand, silt and clay occur. Where the drift is thin, till is generally the only deposit.

Rock-head

In this area, as in other glaciated lowland regions, the rockhead or bedrock surface has a more pronounced topography, or higher relief index, than the present surface (Fig. 6). Pre-existing valleys grade to below sea level and have been infilled by glacial drift. Boreholes prove three major buried valleys, two of which in the north decline N and E to levels below OD. The northern flank of a third valley, which lies beneath the Ouse Burn, occurs on the southern margin of the district.

Highest bedrock elevations, where the drift is also thin, usually coincide with the outcrops of more massive, relatively coarse-grained sandstones and generally form linear knolls (eg Brenkley, Killingworth and

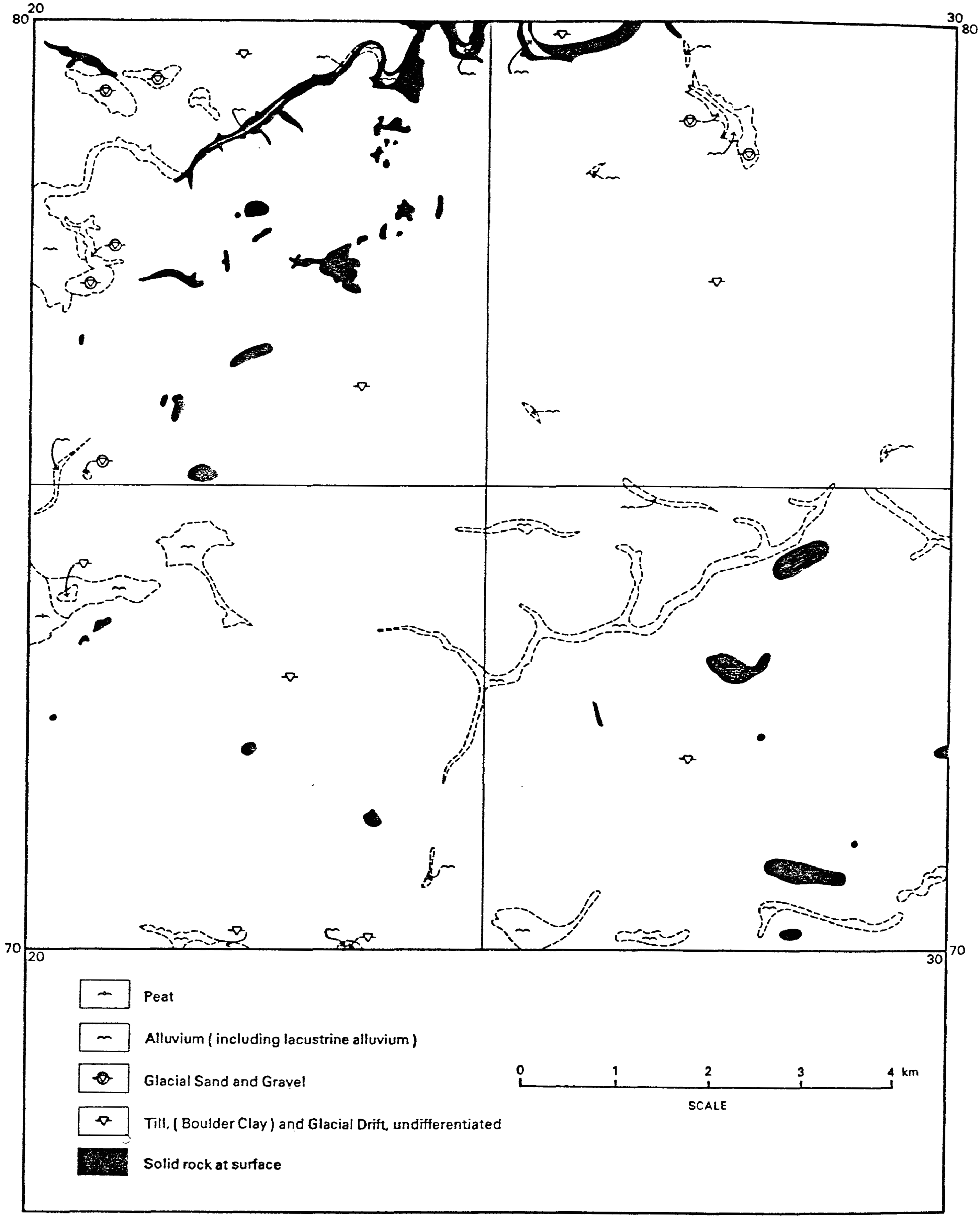

Fig. 5 Quaternary deposits

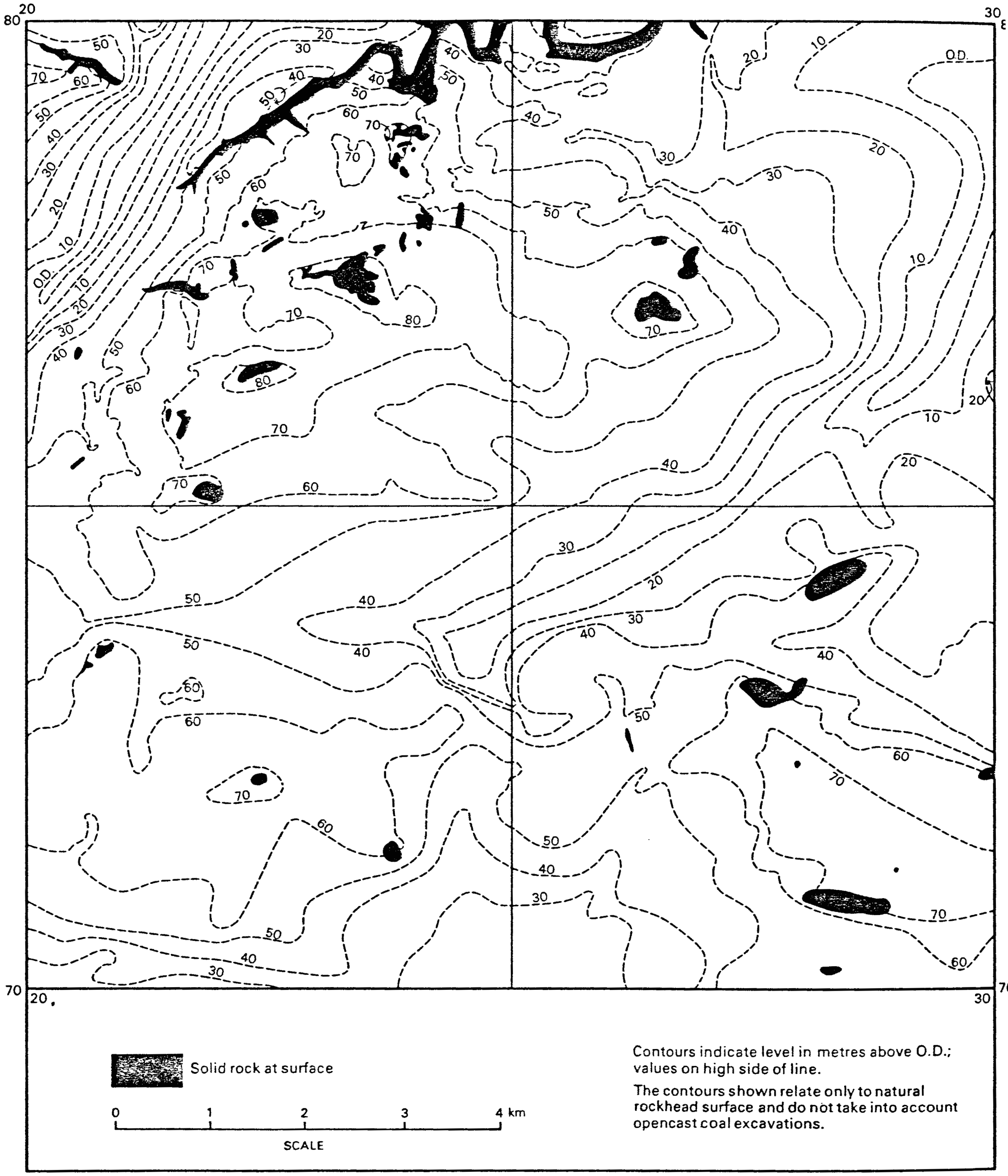

Fig. 6 Rockhead elevation

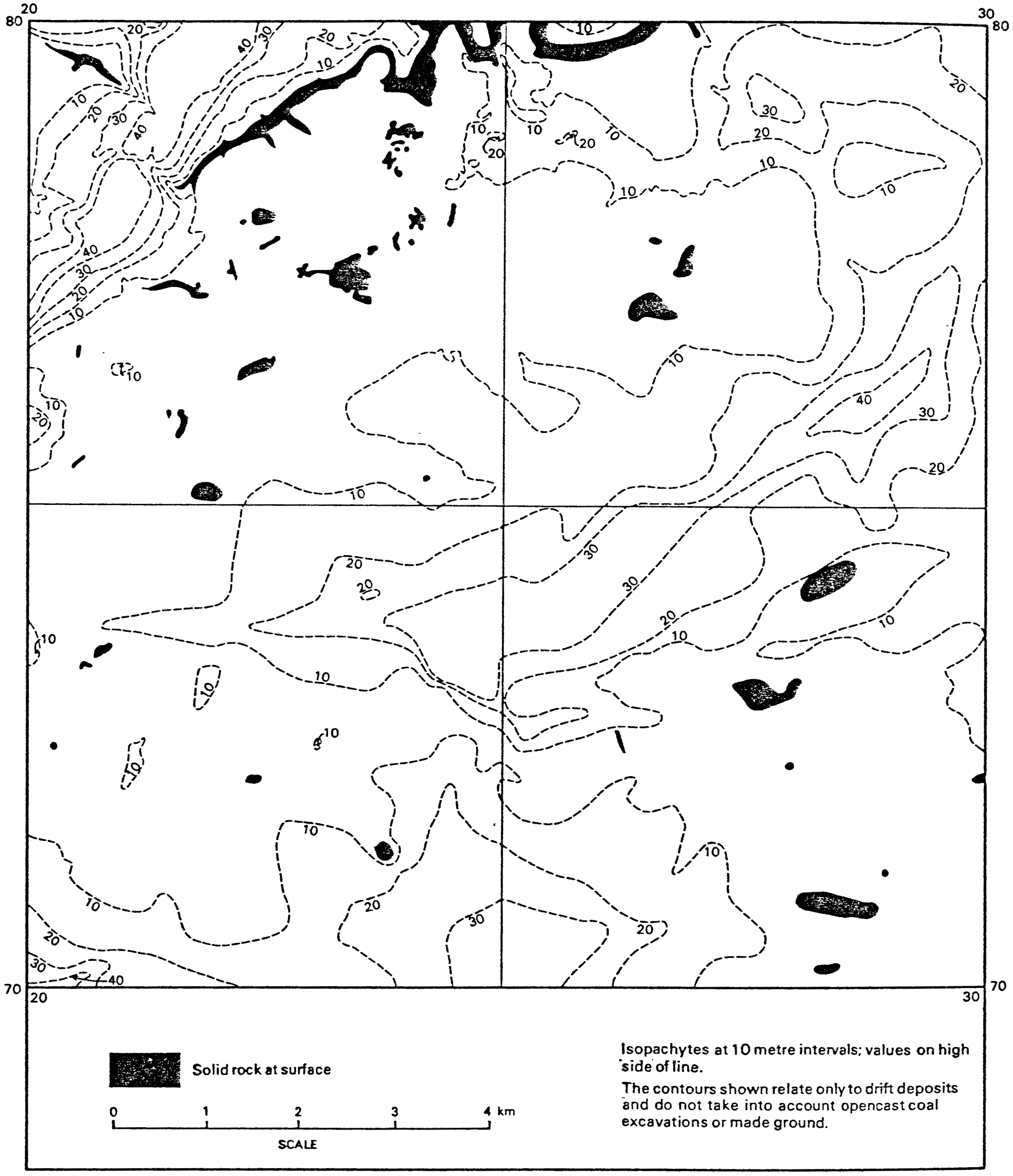

Fig. 7 Drift thickness contours

Shotton North Moor) rather than distinct ridges. Other than these, Coal Measures lithology appears to have little influence on rockhead relief.

The most recent rockhead features are gorges cut since the last glaciation by the River Blyth and its tributaries Catraw Burn and Cascade Dene.

Quaternary deposits

Till comprises grey-brown and grey, sandy, silty and pebbly clays intercalated with thin lenses of sand, silt and gravel and overlain by about 2m of mottled orange, red-brown and pale grey silty, sandy clay with sporadic small pebbles. These deposits mantle almost the whole district. The maximum proved thickness of till is 46m but outside the buried valleys thicknesses of less than 10m are usual. Erratics are predominantly of Carboniferous rocks and include subrounded clasts of sandstone, siltstone, mudstone, ironstone, limestone and coal. A few far-travelled fragments of igneous and metamorphic rocks also occur. The erratics range in size from sand to boulders, with the latter increasing in abundance towards rockhead.

The grey and grey-brown till is largely an over-consolidated lodgement till deposited by a single phase of glaciation during the Devensian. The uppermost red-brown clays have been variously interpreted as upper lodgement till, ablation or flow till, a product of gelifluction (i.e. periglacial freeze/thaw mudflow) or, more recently, as a post-glacial weathering profile. It is likely that more than one process contributed.

Glacial Sand and Gravel within the glacial sequence is proved in a number of boreholes, but crops out over only about 1km^2 in the north-west at Stannington, W of Blagdon Hall and in the north-east at East Hartford. There are no working or disused sand and gravel quarries nor any significant natural exposures, thus the detailed lateral and vertical relationships are not known. Borehole records indicate that sand and gravel is largely confined to the buried valleys, in generally thin and laterally impersistent lenses, and not in a single correlatable unit.

Individual beds range up to a maximum proved thickness of 10.36m in a borehole near Horton Bridge [278 792]; but generally thicknesses do not exceed 3m. The deposits appear to be predominantly of sand-grade although many borehole records are of dubious quality.

Burnett & Eyles in the 1930's resurvey interpreted the intraformational sand and gravel as the Middle Sands of a tripartite Upper Boulder Clay-Middle Sands-Lower Boulder Clay sequence, implying a re-advance of the ice sheet following deposition of the sand and gravel. Later information from boreholes and opencast sites, and research into similar deposits elsewhere, has shown that the drift sequence is more complex and that much of the sand and gravel may have been deposited sub-glacially.

Laminated silt and clay. Although not recognised at outcrop, relatively stone-free, evenly bedded silts and clay are proved within the drift, particularly in boreholes in the West Moor and Dudley areas. The clays and silts occur within a complex of till, sand and gravel and attain a maximum proved thickness of 4.1m. Laminated clays may be more widespread but lack of detail in most borehole records precludes detailed assessment.

Alluvium. Thin deposits of clay, silt and fine sand fringe the rivers and streams and infill hollows and depressions. On the eastern margin of Prestwick Carr [203 738] fine alluvial peaty sands may have been redistributed by wind.

Peat occurs at Prestwick Carr and locally within alluvium.

MINERAL RESOURCES

Coal. The only current mining is at Brenkley colliery [222 743], where the Top and Bottom Busty seams are worked. Large-scale mining ceased with the closure of a succession of collieries in the 1950's and 1960's.

Substantial quantities of coal remain, particularly in areas of former pillar and stall working, in isolated patches cut off by faults or other geological structures, in barriers between takes (colliery working areas) and in thinner seams at significant depths beneath the surface. However, with the exception of Brenkley colliery, it is likely that no further deep mining will take place. Geological conditions and the extent of former workings will favour opencast extraction of remaining resources.

Opencast coal quarrying began in 1942, reaching a peak in the late 1940's, and restored opencast sites abound in the north and west (Fig 8). With the exception of the Bensham all the named seams from the Bottom Busty to the Ryhope Little have been worked. Only Brenkley opencast site [206 747] working the Plessey seam is currently active, but a small licensed site at Stickley Farm [281 775] working the Moorland and associated thin seams closed in 1984. Extensive areas have been prospected by the NCB Opencast Executive, although several prospects have already been sterilized by industrial or domestic development. In the eastern part of the area there may be potential for opencast working of small sites in the higher seams, for example the Ryhope Little which was worked in 1970 at Havelock [292 730].

Sandstone. The more massive and relatively coarser-grained sandstones have been worked for building stone from numerous small quarries throughout the area, but these are all now closed and most have been reclaimed or partially infilled. The quality of the stone may be judged from local buildings. Resources are vast, but no stone in this area has established a wide reputation.

Shale and mudstone. Thick mudstone and siltstone above the Plessey Seam west of Brenkley [204 747] were recently worked for brick-making. Resources of mudstone are very extensive, but there is no information on quality.

Metalliferous minerals. Veins with pyrite, galena, sphalerite, calcite, ankerite and baryte occur throughout the area but rarely exceed 2mm in width and so are of no commercial interest.

Intrusive igneous rocks. Tholeiitic dolerite south-east of Stannington was quarried [223 788] on a small scale in the past, probably for road metal. As the dyke is less than 2m wide, it is of no commercial interest today.

Sand and gravel. There is no commercial extraction of sand and gravel, though it was formerly dug on a small scale south of Middle Brunton East Farm [228 703]. Significant thicknesses of sand and gravel beneath relatively thin overburden have been proved in the Ouse Burn valley, near Horton Bridge and south-east of Stannington [217 787]. At the last-named locality the possibility of opening a borrow pit for sand for use during road construction has been investigated. Glacial sands and gravels show relatively rapid lateral and vertical changes in grade, but in this area sand predominates, though it is usually fine and with clayey and pebbly layers.

Glacial clays (chiefly till) have been worked for brick making in the past from small pits throughout the area. Recently clays have been worked on a larger scale at two sites, south-east of Burradon House [280 727] and between Seghill and Backworth [293 733].

Peat. There is no record of peat having been cut from that part of Prestwick Carr within the area.

Groundwater is not abstracted for public supply or industrial purposes, apart from mine dewatering. Ubiquitous old workings and the disturbance to the natural regime they cause, local undesirably high concentrations of iron and chlorides, the impermeable cover of boulder clay and the sealing effect of built-up areas all combine to make appreciable quantities of potable groundwater unobtainable. Large areas of backfilled opencast sites effectively seal off the underlying outcrop from surface recharge. Thus underground workings become dry after the same seam up-dip has been removed opencast.

Barium salts were formerly extracted from groundwater at Backworth Colliery, and relatively high concentrations of calcium, barium and chloride are also recorded by Anderson (1945) in groundwaters at other mines.

GEOLOGICAL IMPLICATIONS FOR LAND-USE PLANNING

Coal mining

East of the outcrop of the Beaumont Coal (Fig. 3), practically the whole area has been undermined by workings in one or more coal seams. Workings within 30m of the surface are shown in the shallow coal workings map. There are restricted areas of workings north-west of Brenkley in the Top and Bottom Busty and at Stannington in the Victoria. All the named coal seams from the High Main to Victoria (Fig. 2) except the Bentinck and Hodge have been exploited somewhere within the area and several of the thicker seams have been worked out almost completely. Local workings are known in the Ryhope Five Quarter west of Backworth but in general coals above the High Main have not been mined. Details of individual seams are given in the stratigraphical section of this report.

The earliest workings in the area for which plans are available date from about 1850 and were in the Northumberland Low Main, Yard and High Main seams. However, mining of these and other seams near outcrop in areas of thin drift was active at least as early as the mid-17th century, if not earlier. Early workings were by bell pits and pillar and stall workings; subsequently long-wall panel working was introduced, giving a high level of extraction. The major constraint of coal mining on planning and engineering arises from the possibility of subsidence, either associated with new workings, or as the result of collapse (or further collapse) of existing workings.

Current extraction and consequent subsidence are taking place only in the west in workings from Brenkley colliery. Subsidence associated with modern mining methods takes place contemporaneously with extraction of the coal, and although dramatic in the short term can generally be considered to have ceased a few years after working. The area of standing water east of Arcot Hall [251 753] and the marked NW-trending linear depressions W of Hoys Wood [223 756] NE of Brenkley are typical of subsidence features related to recent longwall mining in the Busty seams.

Delayed subsidence takes place by the upward migration of voids owing to collapse of pillars or of strata bridges following pillar and stall work, or less commonly by further compaction of the collapsed workings which result from longwall working or total extraction. Most of the mining in the deeper seams in the south and east of the district, which has taken place since about 1940, was by means of longwall working and is not considered to pose a serious subsidence problem. Shallow workings less than 30m or so below surface, particularly pillar and stall workings, are likely to cause the most damaging subsidence and may be longest delayed. With the exception of the Brenkley colliery area, practically all occurrences of pitfalls or other mining-related subsidence features fall within this 30m zone. Known or possible shallow workings are shown in the shallow coal workings map. The areas delineated are generalized and in considering particular sites it is useful to consult original documents. Workings known from mine plans can be anticipated and taken into account when planning, but areas of probable or possible working are much less predictable. Evidence for shallow mining in areas not recorded on plans is derived from boreholes, features such as pitfalls and the discovery of old workings in opencast or other excavations. Ancient unrecorded workings may occur in any areas where coal seams thick enough to be worked lie near the surface.

Areas of pitfalls, circular depressions commonly two to four metres in diameter which often form rectilinear patterns, resulting from the collapse of pillar and stall workings, were identified during the survey near the outcrops of the Northumberland Low Main, Yard, Metal and Five quarter seams and are noted on the geological maps. Typical examples can be seen near East Hartford [262 790] and east of Brenkley [229 752]. Some areas of pitfalls have been filled with ash or colliery waste, for example south-east of Dinnington [212 731]. Few definite examples of bell pits were observed but wherever coal is exposed or under very thin drift it should be assumed to have been worked.

Mine shafts are present throughout the area and are particularly numerous between Cramlington and the River Blyth. The sites of all shafts and adits known to the National Coal Board are shown on the geological maps, but others may also exist. The positions of many old shafts are very poorly documented and, as they were commonly only capped at surface level and remain open below, still present a hazard. The condition of shafts and adits needs investigation, in consultation with the NCB, before any development takes place.

Geotechnical properties

Areas in which the drift thickness is less than 5m, where foundations or trenches for services may encounter solid, are delineated on the 1:10 000 drift thickness overlays.

Mudstones and siltstones together comprise the bulk of the Coal Measures, but they are generally covered by thick drift. Their clay minerals are stable, but mudstones weather rapidly on exposure; even when covered by a substantial thickness of drift, the topmost 1 to 3 metres are generally weathered. Trenching is relatively easy but tunnelling at depths of 12m or less presents substantial support problems. Explosives are not generally required in surface excavations.

Sandstones. Excavation and tunnelling in sandstones presents few support problems but generally requires explosives for depths below 2 to 3m. Some of the coarser-grained sandstones are gritty and highly abrasive and some sandstones are quartz-cemented and extremely tough. Ganister, a variety of sandstone seatearth found beneath some coals, is a particularly tough rock. Joint blocks that have been weakened by subsidence over old coal workings may require support in deep excavations and the presence of deep open joints may necessitate special precautions.

Seatearths contain readily-weathered clay minerals which with the abundant random internal polished ('listric') surfaces make them unstable both in excavations and under load.

Till or boulder clay which mantles much of the area is a tough over-consolidated lodgement till. Typical undrained shear strengths are in the range 100-350 kN/m^2 and it is generally regarded as a good foundation material which presents few problems in trenching, tunnelling and in excavations except for its toughness and the presence of boulders and potentially waterbearing sand and gravel bodies.

The reddish-brown and brown stony clays forming the uppermost 1 to 2m of the glacial sequence however possess quite different geotechnical properties and are inherently weaker than the subjacent sediments. They are characterised by increased natural moisture content, increased plasticity, increased drained brittleness and a reduction in undisturbed undrained shear strength. The last named is locally increased where the clays are dry or where secondary effects have led to unusual compaction, but lower parts of the deposits are commonly soft and plastic where in contact with underlying water-bearing strata. The reversed strength gradient thus induced must be taken fully into account in foundation design, but is an especial hazard in open excavations which are reasonably stable where the clays are dry but dangerously unstable where lower parts of the profile are wet; the sub-vertical joints are a major source of weakness in such situations and also lead to instability on natural slopes especially where superficial stony clay overlies plastic laminated clay.

Other types of till (flow and ablation) may be present but their distribution and geotechnical properties are difficult to predict.

Laminated Silt and Clay, though subordinate in amount within the glacial sequence, are significant because of their engineering characteristics. Below the water table they are generally weak, with a shear strength commonly ranging from 25 to 70 kN/m^2. Under vertical load the clays are prone to strong compression and ductile flow, and foundations need to be specially designed: slab foundations or piling to rock or into strong till is generally necessary for heavy structures. Laminated clay and silt has a low safe angle of rest and excavations need close support; tunnelling and shaft sinking are moderately hazardous where these deposits are dry but call for extreme care where they are water-bearing and therefore highly prone to fluidization and ductile flow. Digging main sewer trenches in these deposits proved difficult in places.

Glacial Sand and Gravel. Water-bearing sands and gravels encountered within till sequences may be a problem but elsewhere sand and gravel, where dry or confined, can support considerable loads.

Alluvium, Lacustrine Alluvium and Peat. Alluvium is generally thin and where sandy will pose few civil engineering difficulties. However, silt, peat and organic clays, which are generally present, give rise to foundation problems.

Landslips have been recorded where slopes have been oversteepened and undercut by the River Blyth, especially where thick drift deposits infill the buried valley south of Stannington. Slipping is a potential hazard wherever slopes cut into interbedded clays, silts and sands are oversteepened either artificially or naturally. Lubrication of potential slip planes by groundwater will give rise to gravitational and rotational slips.

Made ground and backfilled opencast cover about 10% of the area (Fig 8). Colliery spoil makes up most of the made ground and several old spoil heaps are still obviously distinct artificial mounds. However, during reclamation the spoil is commonly redistributed over a wider area, dressed with soil and planted with grass or trees. In such landscaped areas the extent and thickness of made ground is difficult to fix precisely; for example landscaping of the spoil heap north of Seghill 289 752 , involved removing topsoil from approximately 0.5km of the neighbouring fields, spreading colliery waste and then re-soiling -- in the absence of other information the new surface of the fields might be readily taken as the natural one. The proportion of made ground composed of domestic or industrial refuse is small. Much of the industrial refuse comes from demolition of old buildings, and tips are usually less than three metres thick. The only extensive area of domestic waste is south-east of Seghill 296 741 . It is important to identify and map made ground because of its different foundation properties, because of the

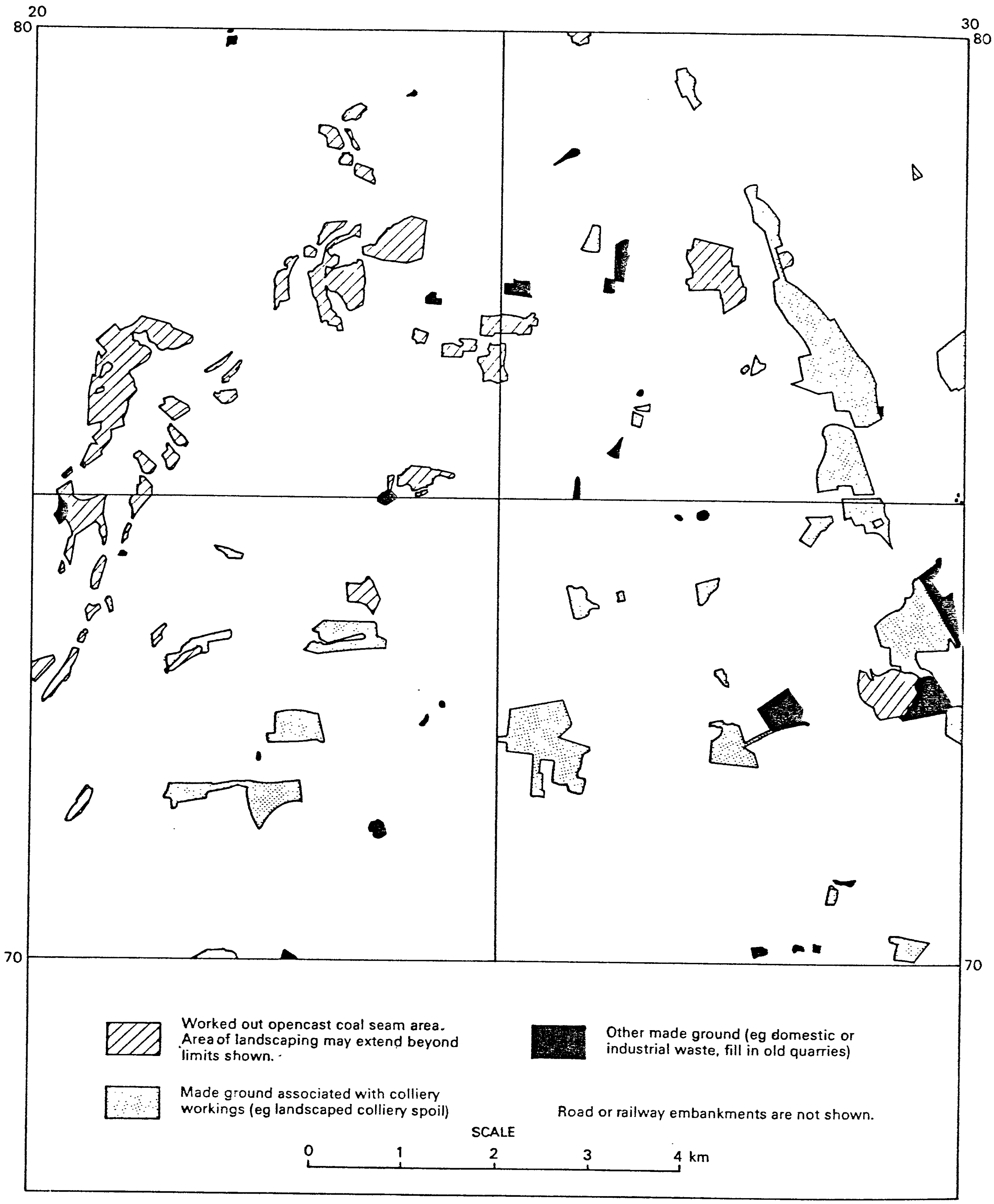

Fig.8 Made ground

contrast in foundation conditions in passing from made to natural ground, and because of the effect on the drainage of an area. Domestic refuse, in particular, will contain both compressible and methane-generating components.

In addition to made ground spread on the surface, waste has been tipped into abandoned clay pits and sandstone quarries. Old clay pits occur throughout the area, and though generally less than 10m in depth, can be quite extensive, as in the recently worked pit south-east of Burradon House [280 727]. Sandstone quarries are generally small in area, but can exceed 10m in depth. The fill of these old excavations will be highly variable and may include domestic waste; compaction of the fill leading to differential settlement of any structure built across the edges of the excavations is a particular hazard. Known pits and quarries are shown on the geological maps, but there may be others, for example small sandstone quarries in areas where rock is exposed or has only very thin drift cover.

Backfilled opencast coal sites are extensive and numerous in the western part of the area with a few sites in the east; one of the largest sites, Delhi [208 760], worked seven seams over an area of 47 hectares to a maximum depth of 40m. Dates of the completion of coaling are given for each site on the geological maps. Opencast quarries are filled with the overburden which was originally taken from them. Although settlement and compaction of the fill must be expected in the years immediately following restoration, the position and former depth of the excavations is well known and because of this they can be taken into account in planning and implementation of engineering works. In the east two sites, Shankhouse [272 774], and Cramlington [249 768] have been built over with housing estates.

CONCLUSIONS

1. Extensive coal mining places restraints on planning or development, especially in areas where coal has been mined at shallow depth. Subsidence associated with the collapse of old workings is likely to be greatest over areas of ancient pillar and stall workings, many of which are unrecorded. There are numerous shafts, many of which are poorly documented. Many shafts are not filled and may be poorly sealed.
2. Subsidence must be anticipated above present and future workings from Brenkley colliery.
3. The till which covers much of the area generally provides good foundation conditions, however the complex drift deposits of the buried valleys have more variable and relatively weaker engineering properties. Steep slopes in thicker and more complex drift will fail if overloaded or over-steepened.
4. Made ground, particularly that filling old quarries, poses problems of uneven settlement, especially for structures across the margins. Backfilled opencast coal sites are numerous but their position and former depth is usually well documented.
5. The area contains substantial resources of coal which could be extracted by opencast methods.
6. Resources of sand and gravel are restricted to three localities: in the Ouse Burn valley, near Horton Bridge and south-east of Stannington. The material is predominantly of fine grade. Its potential for use as fill during road construction has been investigated south-east of Stannington.
7. Sandstone has been quarried locally for building stone, and there are ample resources.
8. Apart perhaps for areas of near-crop coal which might be exploited opencast, there is no reason to recommend any measures to prevent sterilization of mineral resources.

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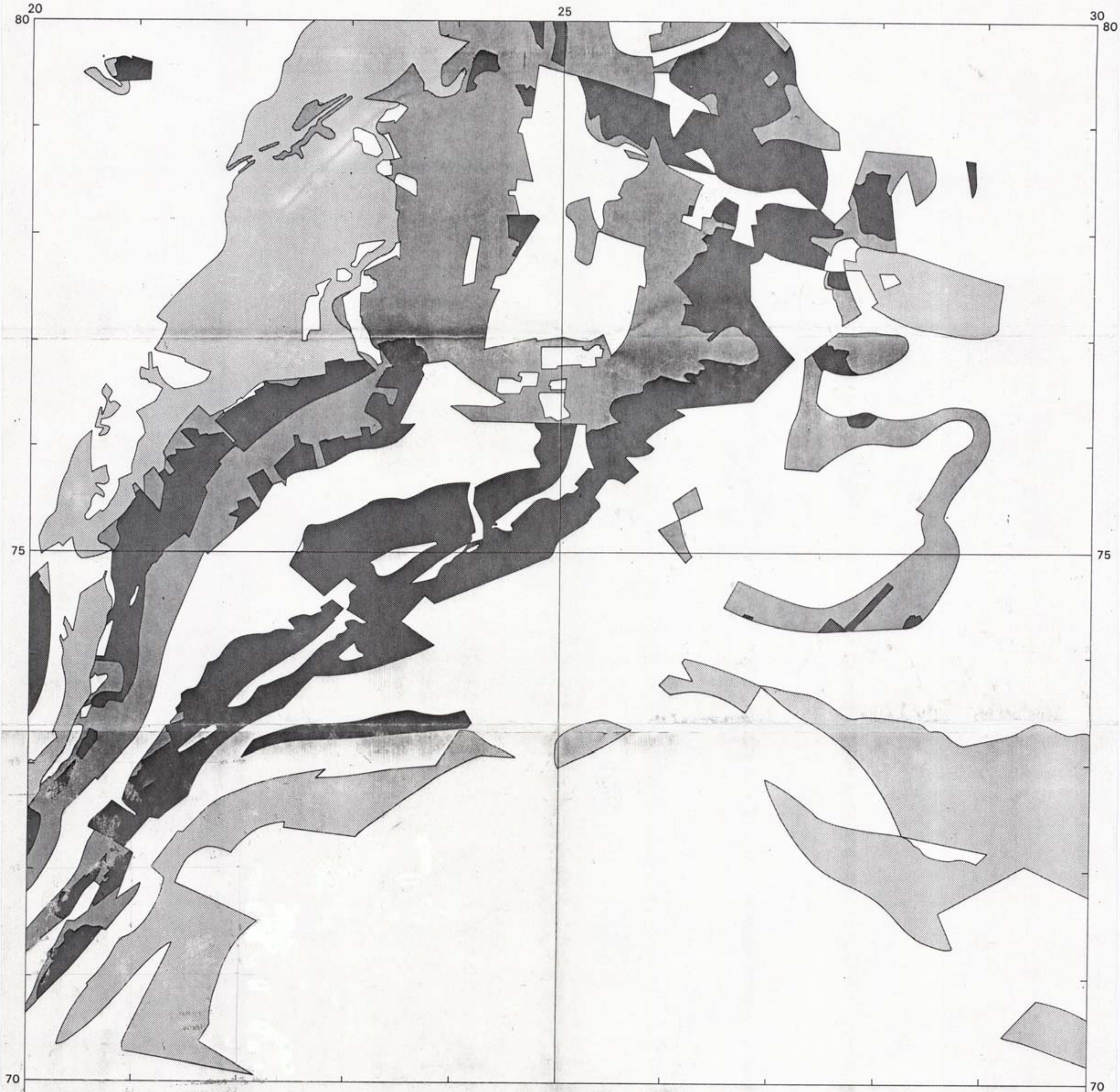


MINE WORKINGS WITHIN 30 METRES OF GROUND SURFACE

- Workings recorded on plans
- Some evidence for mining from surface features or borehole data, no plans available
- Local workings possible (eg from bell pits)
- Workings absent within 30m of surface (includes areas where old workings have been removed during opencast excavations)

SCALE 1:25 000

0 1 2 3

kilometres

This map should be read in conjunction with the accompanying geological report: Jackson, I., Lawrence, D.J.D. and Frost, D.V. 1985. 'Geological notes and local details for Sheet NZ 27, (Cramlington, Killingworth and Wide Open)'.

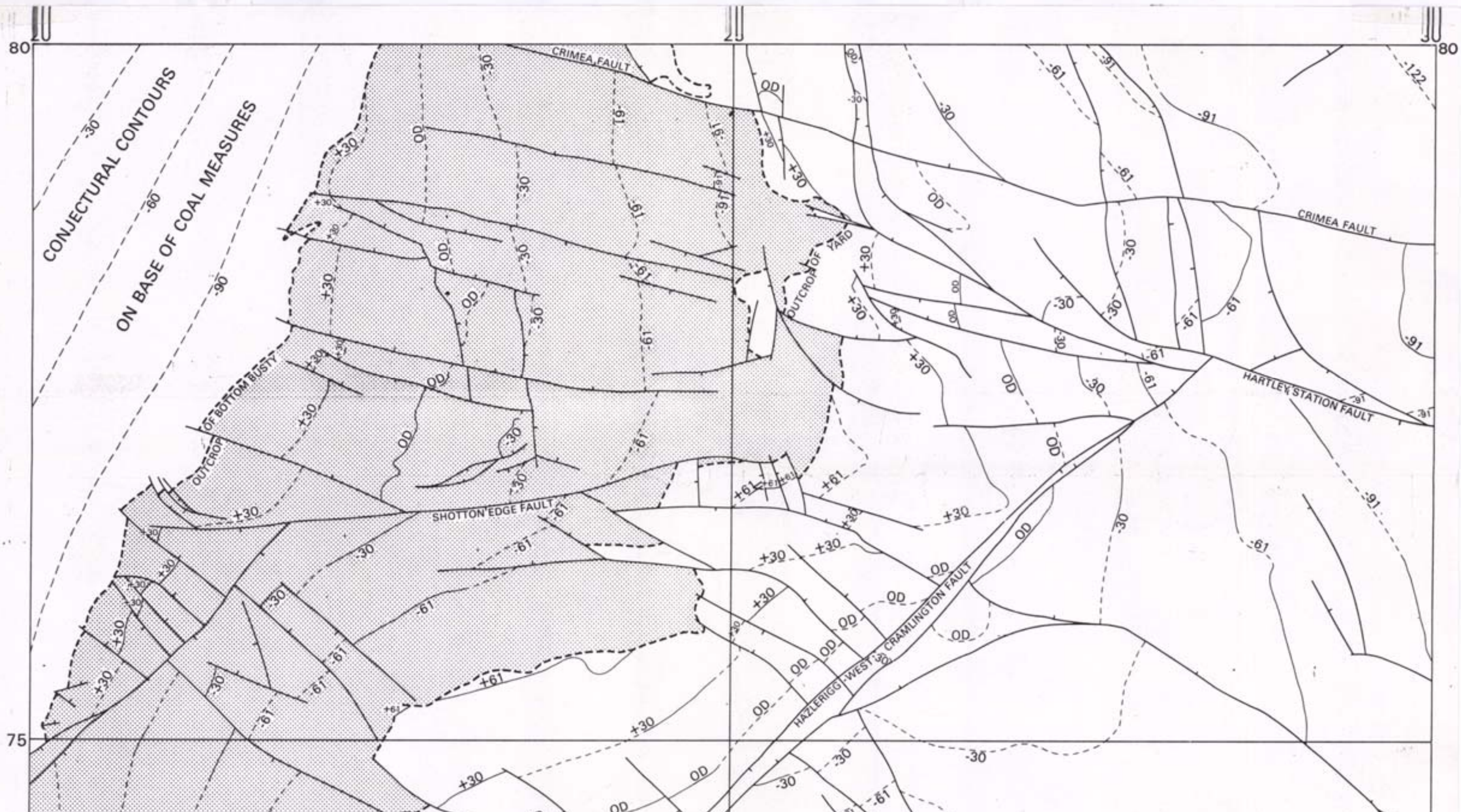
Any enquiries regarding this map should be directed to:

British Geological Survey,
Windsor Court,
Windsor Terrace,
Newcastle upon Tyne, NE2 4HE

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

THIS MAP GIVES AN INTERPRETATION OF DATA AVAILABLE AT THE LAST DATE OF SURVEY. ADDITIONAL INFORMATION IS AVAILABLE IN BGS FILES.

SHALLOW COAL WORKINGS



Coal outcrop

Fault, crossmark indicates downthrow side Many minor faults omitted

-91 Contour in seam, broken line denotes uncertainty. Figures for levels above datum given on the high side of the line and those for levels below datum on the low side. All figures in metres

0 1 2 3

KILOMETRES

Area contoured on base of Bottom Busty seam

The interval from Base of Coal Measures to Bottom Busty is about 150m; from Bottom Busty to Yard is about 147m.

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STRUCTURE CONTOURS