Natural Environment Research Council
BRITISH GEOLOGICAL SURVEY

GEOLOGY OF THE PONTELAND-MORPETH DISTRICT

1:10,000 sheets NZ 17 NE, SE and NZ 18 NE, SE
Parts of 1:50,000 Sheets 9 (Rothbury) and 14 (Morpeth)

D.J.D. Lawrence and I. Jackson

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Data used in preparing this report and associated maps is lodged at the Newcastle upon Tyne office of the British Geological Survey. Any enquiries concerning these documents should be directed to that office.

Similar reports are available for 1:25,000 sheets NZ15, NZ25, NZ26 and NZ27.

NOTES

All National Grid references in this report lie within the 100 km square NZ. Grid references are given to either eight figures (accurate to within 10 m), or six figures for more extensive locations.

Each borehole or shaft registered with BGS is identified by a four-element code (e.g. NZ 17 SE 58). The first two elements define the 10 km square (of the National Grid) in which the borehole is situated; the third element defines the quadrant of that square, and the fourth is the accession number of that borehole. In the text of the report the borehole/shaft is normally referred to by the last three elements alone (e.g. 17SE58).

The word 'district', unqualified, in this account means the whole ground covered by NZ17NE, SE and NZ18NE, SE.

PREFACE

This account describes the geology of the Ponteland-Morpeth district covered by 1:10,000 sheets NZ17NE, SE and NZ18NE, SE which lie within the 1:50,000 geological sheets 9 (Rothbury) and 14 (Morpeth). The district 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 1871 and 1879. A resurvey by G.A. Burnett, V.A. Eyles and A. Fowler between 1925 and 1949 was published on the New Meridian.

The present survey, which was commissioned and financed by the Department of the Environment, represents the second phase of a programme of work in south-east Northumberland. Its objectives are to provide up-to-date geological maps for the area and to identify and report on any particular implications for land use planning, development and redevelopment posed by the geology of the area, particularly with respect to superficial deposits, underground workings and mineral resources. Mapping was carried out in 1985-86 by D.J.D. Lawrence (NZ18NE and SE) and I. Jackson (NZ17NE and SE) with Mr D.H. Land as programme manager.

The ready cooperation of landowners and tenants during this resurvey and the assistance of British Coal Deep Mines and Opencast Executive and of Northumberland County Council are gratefully acknowledged.

G. Innes Lumsden
Director, British Geological Survey
October 1986

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Geology
Rockhead elevation
Drift thickness
Borehole and shaft sites*

1:25,000 scale
Structure contours
Shallow coal workings

*There are insufficient boreholes sited on NZ17NE to justify the preparation of a separate map showing boreholes and shafts for that sheet; all borehole and shaft sites are shown on the geological map.

NOTE: It is emphasized that the maps associated with this report should not be used as a substitute for site investigation.
The maps are available separately from the report.

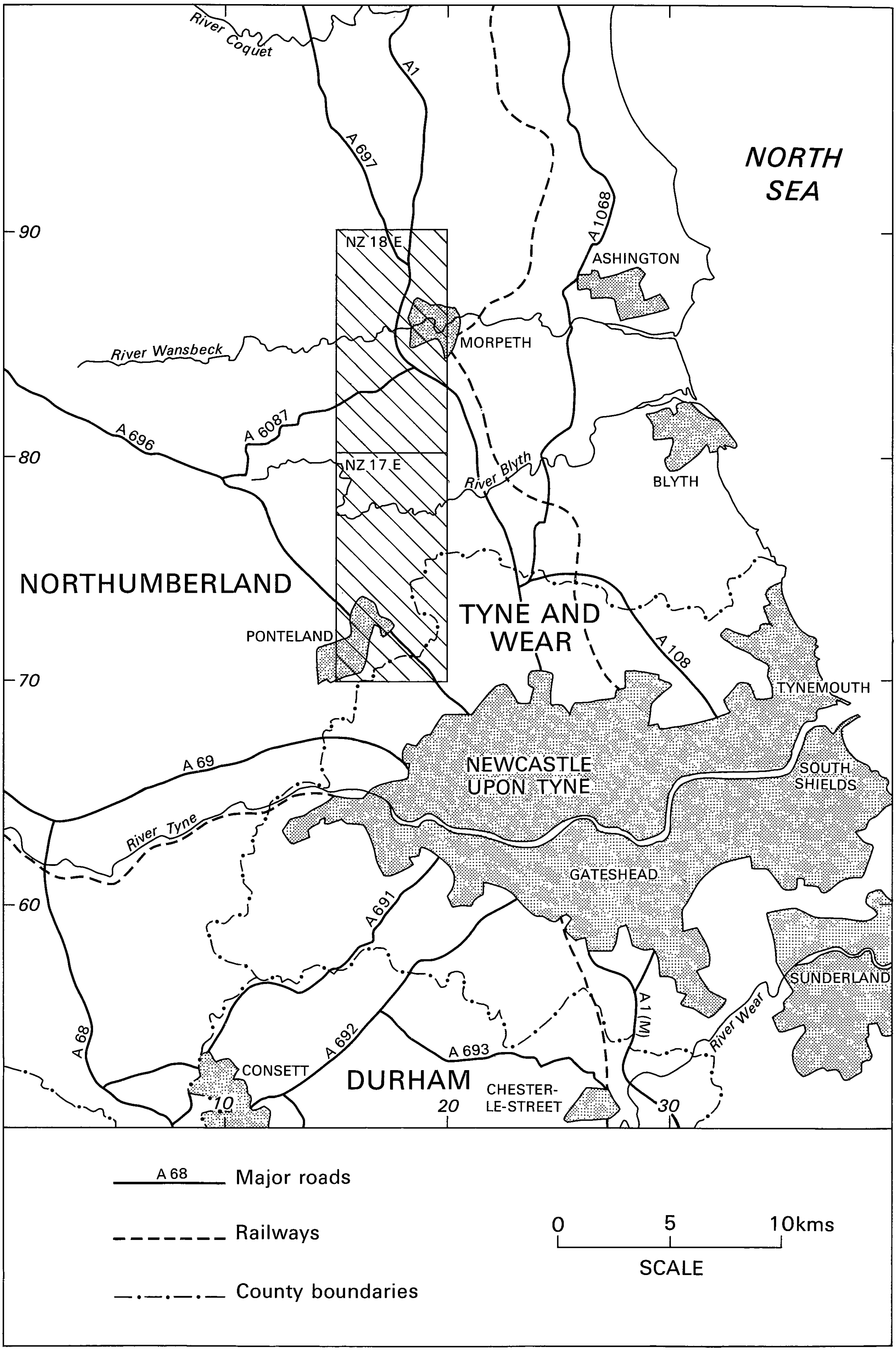


Figure 1. Sketch Map showing location of district

Geology of the Ponteland–Morpeth district

D.J.D. Lawrence and I. Jackson

SUMMARY

The geology, mineral resources and geotechnical characteristics of the Ponteland–Morpeth district (NZ17NE, SE and NZ18NE, SE) are described. Information on former workings in coal, sandstone and clays together with details of made ground are tabulated. An index of non-confidential boreholes and shafts is presented at Appendix A.

Millstone Grit and Lower and Middle Coal Measures (Namurian and Westphalian A and B) strata of fluvial, deltaic and marine origin crop out within the district with a total thickness of about 600 m. Although much of the Coal Measures sequence is well documented through numerous shafts, boreholes and mine workings, there is little data on the Millstone Grit and the basal Coal Measures in the south-west and, in that area, these are poorly understood. Eleven coal seams have been worked, but resources remain which could be extracted by opencast or small scale mining. Geotechnical problems may arise from subsidence over shallow coal workings and shafts, many of which are inadequately recorded. Foundation problems may also be caused by incompetent silts, clays and peats of glacial and recent origin.

INTRODUCTION

The district described in this report lies to the north of Newcastle upon Tyne, within the counties of Tyne and Wear and Northumberland (Figure 1) and includes in the north the market town of Morpeth, and in the south the dormitory settlements of Ponteland and Darras Hall. Outside these built-up areas, mixed pastoral and arable farming predominates. The A1 and A696 roads cross the district in the north and south respectively and Newcastle Airport, which serves the north-east region, is located to the south-east of Ponteland.

With the exception of the incised valleys of the Wansbeck and Font in the north, the district is of moderate relief. Expanses of flat ground below the 55 m contour in the Blyth and Pont valleys and at Prestwick Carr are overlooked by higher ground (up to 130 m above OD) at Saltwick, Berwick Hill and Callerton. The northern part of the district is drained by the easterly flowing River Wansbeck and its tributary the Font. To the south of Saltwick drainage is via the Blyth and Pont and in the extreme south the country is drained by the Ouse Burn.

The eastern part of the district lies within the Northumberland Coalfield and in this area, but particularly in the south-east, several coal seams have been extensively mined. South-west of Morpeth opencast workings were widespread. There is, however, no current coal extraction within the district.

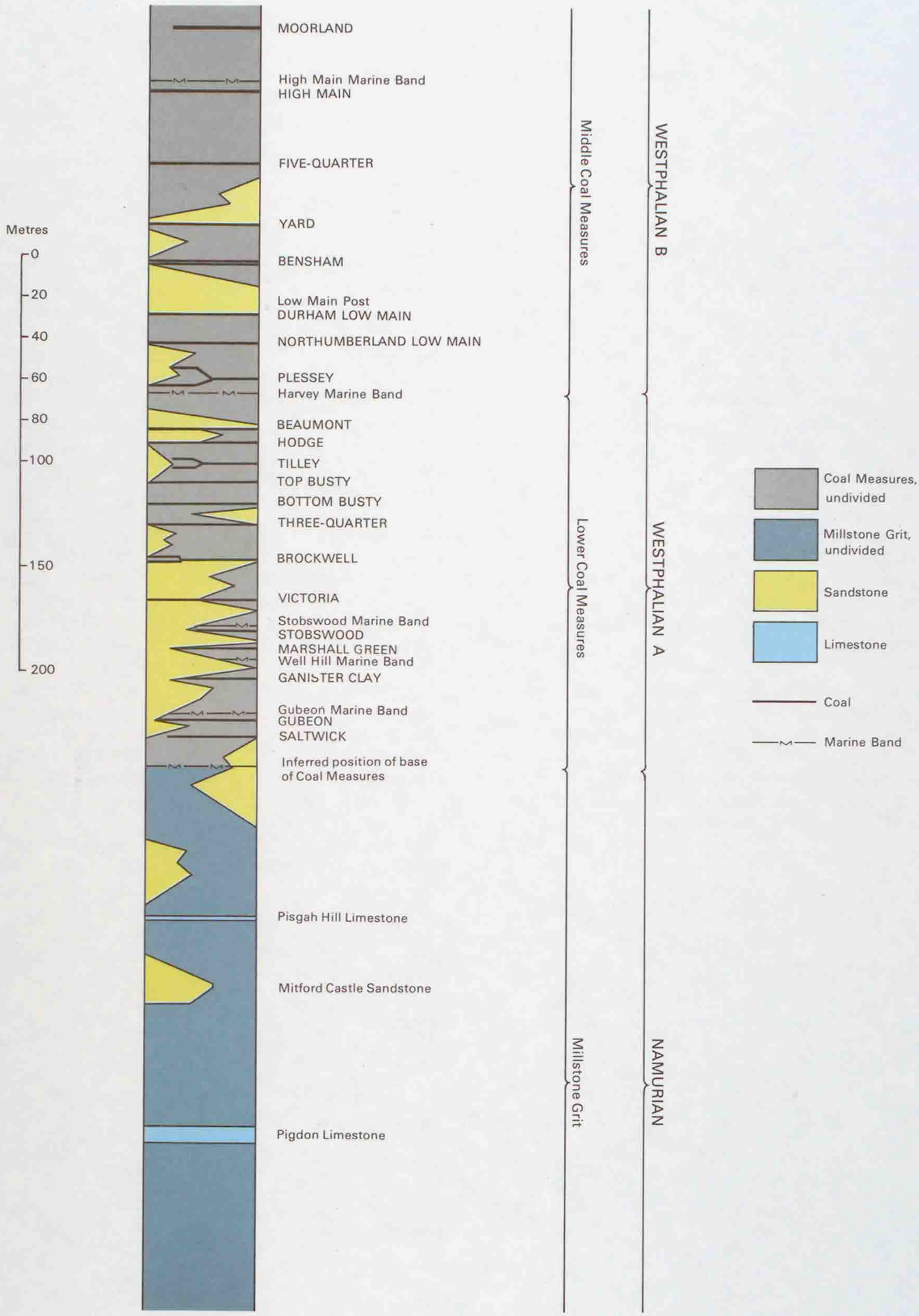


Figure 2 Generalized vertical section

GEOLOGICAL HISTORY

Apart from two minor igneous intrusions, the solid rocks which crop out in the district are of Upper Carboniferous age, deposited some 300 to 320 million years ago. Nothing is known of the pre-Carboniferous rocks, except that from outcrops in the Lake District and Scottish Southern Uplands it may be surmised that the pre-Carboniferous basement consists of strongly folded Lower Palaeozoic strata.

During Carboniferous times the district lay in the Northumberland Trough, a region of relative subsidence between the Southern Uplands to the north and the Alston Block to the south. Deltaic sedimentation into the trough was thick and rapid. Sediment was deposited in rhythmic sequences, mudstone and sandstone being predominant throughout, with marine limestones prominent in the lower part and coals significant in the upper part.

At the end of Carboniferous times folding and faulting associated with Hercynian (or Armorican) earth movements were followed by the deposition of younger strata, since removed by erosion. The 'solid' geological history of the district was effectively completed during the Tertiary, when igneous dykes were intruded and further earth movements led to the uplift and easterly tilting which marked the start of an erosional cycle.

Modification of the landscape continues to the present day and most of the solid rocks in the district are covered by superficial Quaternary deposits or 'drift'. Following the Tertiary uplift deep valleys, which decline eastwards to below sea-level, were cut into the solid rock throughout north-eastern England. Extensive drift deposits were laid down during the Devensian glaciation which ended about 12,000 years ago, these consist largely of till (boulder clay), but include laminated clay, sands and gravels. They are thickest where they infill 'buried valleys'. In geologically recent times rivers have deposited clays, silts, sands and gravels and have subsequently cut through earlier deposits to form a series of terraces. Present day river deposits, alluvium and peat are still forming.

UPPER CARBONIFEROUS GEOLOGY

In the Ponteland-Morpeth district the proved thickness of Upper Carboniferous rocks amounts to over 620 m, including 260 m of Millstone Grit (Namurian), 180 m of Lower Coal Measures (Westphalian A) and about 180 m of Middle Coal Measures (Westphalian B). From knowledge of adjacent districts it is likely that a further thickness of between 100 and 200 m of Millstone Grit lies at depth, with at least 500 m of Lower Carboniferous below.

The boundaries of the divisions of the Carboniferous were originally based entirely on lithology and were defined at different horizons by different authors. However, the generally accepted classification based on palaeontological boundaries has now been adopted throughout northwestern Europe, and is used here, as shown graphically in Figure 2. The base of the Westphalian Series is taken at a horizon believed to be equivalent to the Subcrenatum Marine Band. No attempt has been made to divide the underlying Namurian Series into its constituent stages.

The Millstone Grit is here taken as the strata between the base of the Great Limestone and the assumed equivalent of the Subcrenatum Marine Band, that is, it is the lithostratigraphical equivalent of the Namurian Series. In earlier surveys, their 'Millstone Grit' comprised some 150 m thickness of highest Namurian and Lower Westphalian, the rest of the Namurian being designated as 'Upper Limestone Group'.

SEDIMENTOLOGY

The Carboniferous succession is generally regarded as a sequence of cycles or cyclothems, each of which might be defined ideally as starting at the base with limestone and continuing upwards through marine mudstone, non-marine mudstone, siltstone, sandstone and seatearth, to coal. Each cycle of sediment began with an abrupt change in relative sea level giving marine or near-marine conditions. The water shallowed as sediments built up to water level and ended with the establishment of coal-forests on the newly formed land.

Cyclothems are rarely complete, and traced laterally either die out or split into two or more. The nature of the cycles changes progressively up the stratigraphical succession, the marine phase becoming less important and the coal-bearing phase more so.

Table 1. Upper Carboniferous cyclothems

Millstone Grit Cyclothem	Coal Measure Cyclothem
5 Thin Coal	5 Thick Coal
4 Seatearth	4 Seatearth
3 Siltstone & Sandstone	3 Siltstone and Sandstone
2 Mudstone	2 Barren mudstone
1 Limestone, shelly mudstone or calcareous sandstone	1 Fossiliferous mudstone

Coal. Coals are of bituminous rank and range in thickness from thin coal traces to 1.68 m. All seams vary in thickness and some thin out altogether, although their position may be indicated by the more persistent seatearth. Some seams are split by interdigitation of sediment; splits may be on either a regional or a local scale. In the Millstone Grit seams are generally thin and impersistent. Many seams have 2 or 3 cm of cannel coal in their immediate roof. Lithologically, coals can be divided into bright (softs), dull (hards), banded (softs and hards), cannel, or dirty dependent upon their conditions of deposition and type of original flora. All seams are autochtonous, i.e. formed from vegetation which grew *in situ*, in swamps which were sufficiently de-oxygenated for the partial preservation of vegetable matter. The thickness to which a coal seam developed and its liability to splitting was dependent upon the rate of subsidence of the growing vegetation surface.

Seatearth (fireclay, ganister). Underlying every coal seam is a seatearth, representing the soil accumulation on which vegetation flourished without becoming coal. There is no correlation between the thickness or character of a seatearth and that of the overlying coal. Seatearths are more persistent than their associated coals. They grade from sandstone (ganister) to mudstone (fireclay) and are distinguished from underlying strata by the presence of rootlets and absence, or total disruption, of bedding. Ganisters are most common near the base of the Lower Coal Measures.

Sandstone and **Siltstone** ('hazel', 'post', 'kingle', 'ramble'). About 45% of the total sequence is composed of sandstones and siltstones which are either thin (less than about 5 m) and in widespread sheets ('sheet sandstones'), or thick and of elongate, gently curving form in plan with erosive bases ('channel sandstones'). Washouts occur where such channel sandstones cut down into coal seams, the sandstone containing pebbles and fragments of mudstone and coal ('scares'). With the exception of channel sandstones, which always tend to have coarse bases, there is a general tendency for grain-size to decrease up the succession. Some of the Millstone Grit sandstones contain abundant quartz pebbles. Sandstones are usually pale grey to grey or cream at depth, but near the surface they weather to rusty brown or, less commonly, white. They are generally well cemented. In the Millstone Grit some of the coarse-grained sandstones are locally friable and others have calcareous cements.

Mudstone (shale, 'bind', 'metal', 'plate'). Mudstones form over 50% of the Coal Measures sequence and are only slightly less abundant within the Millstone Grit. They range in colour from pale grey to dark grey. Those at the base of cyclothems, particularly immediately above a coal seam, or associated with limestones, are commonly dark grey and fossiliferous, otherwise they are generally barren. In a coarsening upward sequence the mudstones become increasingly silty and grade into siltstones or pass by intercalation and interlamination of sandy beds (striped-beds) into fine-grained sandstone.

Ironstone ('whin'). Sideritic ironstone is common, developed either as nodules, generally flattened parallel to bedding, or as layers. In the metre or so above coal seams it typically forms laterally continuous beds up to about 10 cm in thickness. Ferruginous concretions are common in seatearths.

Limestone. Major limestones are grey in colour, dominantly fine-grained and fairly pure carbonates. The thinner, impersistent limestones are typically impure with varying

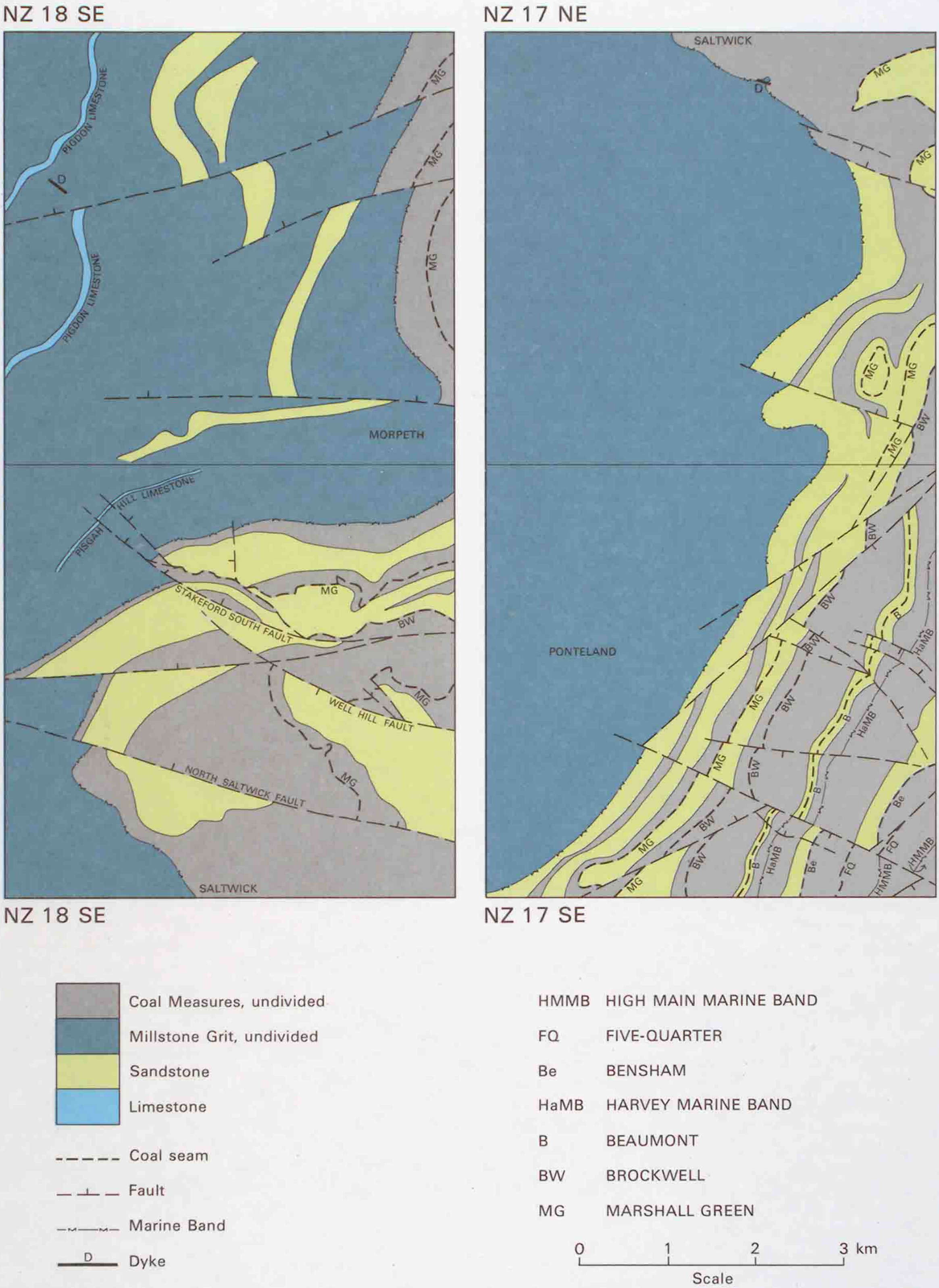


Figure 3. Simplified map of solid geology

proportions of mud, silt and sand. Silty and sandy limestones also tend to be ferruginous and locally show signs of bioturbation.

STRATIGRAPHY

In describing the stratigraphy of the Upper Carboniferous the strata between each pair of vertically adjacent named coals, limestones or marine bands are considered as a unit. In the Coal Measures these cyclic units, which may include several part cyclothems, are between 15 and 25 m thick, the variation being generally proportionate to the degree of development of sandstone. In the Millstone Grit, where named beds are less common, descriptive units may exceed 60 m in thickness.

Millstone Grit

The term Millstone Grit is used here to include all the strata between the base of the Coal Measures and the base of the Great Limestone (Johnson and others, 1962). Although the Millstone Grit crops out over more than half the district (Figure 3), this outcrop is confined to the upper 260 m of the series, the total thickness being between 350 and 450 m. The absence of borehole information or of stratigraphically useful exposures does not permit the subdivision of the Millstone Grit in the largely drift-covered area between Ponteland and Bellasis Farm [194 781], but the geology farther west suggests that no more than 200 m of strata are present. Details of the succession are taken from boreholes drilled mainly in the northern half of the district, the most important of which are illustrated in Figure 4. Major limestones have been given local names, and are correlated with the sequence established during recent BGS work farther south-west in the Northumberland basin (Holliday & Pattison, *in preparation*). These correlations are based on broad lithological similarities between successions, and will be subject to revision following detailed palaeontological study, which was beyond the scope of this survey.

The **Stanton Limestone**, the lowest limestone cropping out in the district, is recorded in the Morpeth Water Bore (18NE4), where it is 0.37 m thick, and is correlated with the Corbridge Limestone.

Measures between the Stanton Limestone and the Pigdon Limestone crop out in the north-west of the district, but are largely obscured by drift. The 65 m of strata recorded in the Morpeth Water Bore become sandier upwards. A 0.6 m thick limestone 10.3 m above the Stanton Limestone may represent its upper leaf. Coal partings were noted within sandstone about 40 m below the Pigdon Limestone.

The **Pigdon Limestone** crops out in the north-west of the district. No exposures were seen during the present survey, but it was formerly quarried south of the road at Pigdon [151 882] (Fowler, 1936). A maximum thickness of 8.5 m was recorded in the Morpeth Water Bore, where it is a rather impure, greyish, crinoidal limestone, shaly at the top and bottom. It is correlated with the Thornbrough Limestone.

Strata between the Pigdon Limestone and the Mitford Castle Sandstone range from 50 m to 60 m in thickness and show variable lithology (Figure 4). Three coal seams are developed in the upper half of the interval, the central one is 0.5 m thick in the Morpeth Water Bore, but elsewhere it and the others are less than 0.2 m thick. An impersistent limestone 3.1 m thick in the East Coldside bore (18SE24) may be equivalent to the Newton Limestone.

The **Mitford Castle Sandstone** is known from surface exposures and boreholes in the north of the district. Although probably of limited lateral extent, it is locally significant and has a maximum recorded thickness of 15 m in the East Coldside borehole. The sandstone can be examined in an old quarry at Mitford Castle [1700 8542]. The weathered, topmost 1.5 m exhibits large-scale trough cross-lamination, but the relatively unweathered lower 5 m of the section appears massive and structureless. It is very coarse-grained and feldspathic with abundant well-rounded quartz pebbles in the lower part. In exposures throughout the district the yellowish brown weathered surface of the sandstone is very friable. A 0.3 m thick limestone underlies the pebbly base of the sandstone in the RAF Tranwell borehole (18SE12), and may be equivalent to the Styford Limestone.

The interval between the Mitford Castle Sandstone and the Pisgah Hill Limestone, 30 m

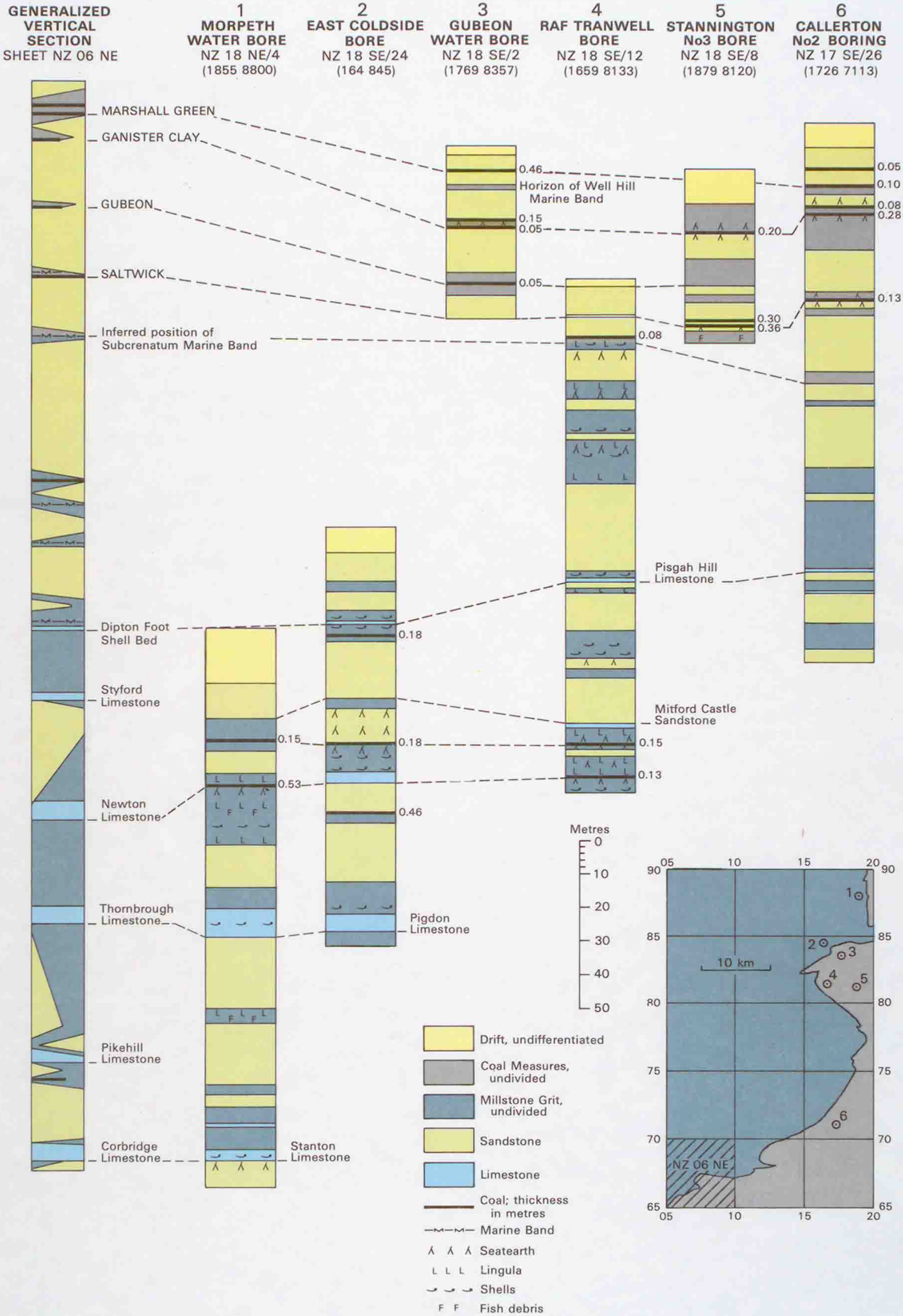


Figure 4. Comparative sections of the Millstone Grit and basal Coal Measures.

in the north of the district, comprises mainly mudstone, with some sandstone in the upper part. A fossiliferous mudstone up to 15 m thick, locally with *Lingula*, occurs in its lower part. Up to three thin coals are developed near the base, each seam generally less than 0.15 m in thickness, but locally ranging up to 0.3 m in the Broadlaw deep bore (18SE19). The upper part of the succession is variably sandstone or mudstone, with a Lingula band recorded near the top in several boreholes. The strata below the Pisgah Hill Limestone are very poorly known in the south of the district. A variable sequence of sandstone and mudstone is recorded in two boreholes at Callerton (17SE23 and 17SE26), the only records of the succession on sheets 17NE and SE.

The **Pisgah Hill Limestone** is shown on 18SE where its outcrop is deduced from boreholes. Its position can be identified in the RAF Tranwell and Callerton No 2 bores, having a thickness of 0.53 m in the latter, but it has not been recorded on 18NE and is not exposed. The limestone is up to 0.28 m thick, locally crinoidal and commonly contains brachiopods. It passes laterally and vertically into calcareous mudstone or, less usually, calcareous sandstone (e.g. in Broadlaw deep bore) and is tentatively correlated with the Dipton Foot Shell Bed.

The sequence between the Pisgah Hill Limestone and the base of the Coal Measures comprises a series of minor cyclothems with several marine or quasi-marine horizons in the upper half. Some 70 m in thickness in the north the interval decreases to about 55 m in the south of the district. The lower half of the succession consists dominantly of sandstone, either in a single cycle with the sandstone up to 15 m in thickness at its top, or in two cycles locally with a *Lingula* band at the base of the upper cycle and with individual sandstones up to 10 m thick. Sandstone was formerly quarried for building stone at Mitford Steads [173 849] where it is micaceous and medium-grained.

In the upper half of the interval a 35 m thick sequence of alternating mudstones and sandstones, with a number of poorly developed seatearths, underlies the Coal Measures the base of which is taken at a marine band inferred to correlate with the Subcrenatum Marine Band. Individual mudstones or sandstones are usually less than 5 m thick. Four fossiliferous horizons, representing the marine bases of cycles, have been recognised in boreholes. These marine bands are variously mudstone, calcareous mudstone or limestone up to a maximum thickness of about 0.4 m. A poor, impersistent coal is developed beneath the lowest marine band, a mudstone, locally containing *Lingula* and brachiopods, which lies about 35 m beneath the inferred Subcrenatum Marine Band. The second horizon, 4 to 6 m higher, which varies from a 0.23 m thick calcareous mudstone to, less commonly, an argillaceous limestone up to 0.15 m in thickness, contains *Lingula*, productid brachiopods and sporadic fish fragments. The third horizon varies similarly and has its thickest development as a 0.38 m argillaceous limestone in the Saltwick area. The mudstone of the topmost marine horizon, about 15 m below the Coal Measures, is commonly reddened and associated with one or more poor, impersistent coals, but is generally the least well developed. In the Saltwick area up to 10 m of sandstone separates it from the overlying Coal Measures, but elsewhere two coals are present in the topmost 5 m or so. These coals are generally from 0.08 to 0.10 m, but apparently thicken locally and have an exceptional recorded thickness of 0.76 m in boreholes between Gubeon and Mitford Steads.

The cyclic nature of the strata precludes detailed correlation of isolated surface exposures in the Millstone Grit, but the fine- to coarse-grained, locally feldspathic sandstones formerly quarried in the Berwick Hill area [173 755] are probably above the Pisgah Hill Limestone.

Coal Measures

The 180 m thick succession of Lower Coal Measures forms an outcrop up to 4.4 km wide along the length of the district (Figure 3). The outcrop of the Middle Coal Measures is restricted to an area of about 3 km^2 in the southeast of the district, representing the lower 180 m or so of a sequence known to total 450 m farther east.

Strata between the base of the Coal Measures and the Brockwell seam are characterised by thick widespread sandstones, but higher in the succession, apart from contained fossils, there is little to distinguish one part of the sequence from another. Detailed palaeontological study was not undertaken in this survey, but significant faunal horizons known from adjacent areas are mentioned.

The thickest coals, consistently over 1 m thick, are almost wholly confined to the Middle Coal Measures, but a total of eleven seams have been mined throughout the succession from the Saltwick to the High Main. Coal seam names used in this district, which appear on the 1:10,000 scale geological maps, are those adopted in the Tynemouth memoir (Land, 1974). Correlation has been made with the standard nomenclature used by British Coal in Northumberland and Durham and the appropriate seam index letters are included in the generalized vertical sections on the relevant 1:10,000 scale geological maps. Local names applied to the coal seams are also shown on the sections, but are additionally quoted in the text; Table 2 lists the most significant variations.

Table 2. Coal seam nomenclature

This report	Local or County name	British Coal Index Letter
Five Quarter	Main	F
Durham Low Main	Five-Quarter	J
Northumberland Low Main	Brass Thill	K
Beaumont	Harvey	N
Brockwell	Bandy	S
Victoria	Brockwell	T
Marshall Green	Victoria	U

Lower Coal Measures. No goniatites have been found in the high Namurian or low Westphalian marine bands in Durham or Northumberland, but work in the Barnard Castle district (Mills and Hull, 1962) suggested that the local Quarterburn Marine Band represents the basal Westphalian Subcrenatum Marine Band. This band is poorly represented in this district, its probable equivalent occurring as a mudstone locally containing *Lingula*, brachiopods and fish fragments. In many boreholes its presence can only be inferred by lithological comparison. Therefore, rather than continue the name Quarterburn Marine Band into this district, the horizon at the inferred base of the Westphalian, marking the base of the Coal Measures, is described here as the presumed equivalent of the Subcrenatum Marine Band. Extensive borehole data on 18SE and the northern part of 17NE enables this horizon to be taken at a consistent level, but correlation with the southern margin of the district and farther south is tentative.

The assumed **Subcrenatum Marine Band** is not exposed in the district. In a discontinuous section through the horizon in Duddo Burn [180 794] the base of the Coal Measures has been taken above a thin coal overlying a sequence of interbedded sandstones and rooty siltstones. In the RAF Tranwell borehole the marine band consists of 0.9 m of medium grey blocky mudstone containing *Lingula* and brachiopods and underlain by a 1 m thick seatearth. The band also has been identified in a number of other bores in the central portion of the district, but in the south its position can only be surmised by overall lithological correlation. Up to 10 m of strata, consisting mainly of sandstone, separate the base of the measures from the overlying Saltwick seam.

The **Saltwick Seam** is the lowest one in the district to have been worked. East of Saltwick, from where the seam is named, it splits into two leaves separated by up to 1 m of sandy fireclay and was opencasted as the Top and Bottom Saltwick, each leaf being up to 36 cm in thickness. It was also mined on a limited scale at West Duddo in the 1890's. Elsewhere it occurs as a single seam up to 45 cm thick, but becomes impersistent northwards and is apparently absent north of the Stakeford South Fault.

The interval between the Saltwick and Ganister Clay seams, composed largely of sandstone, ranges in thickness from 35 m on 18SE to about 20 m near Bellasis Farm. The white-weathering, feldspathic, medium- to coarse-grained, locally pebbly sandstone has been worked in a number of small quarries throughout the district (see Table 5). An impersistent coal, the **Gubeon**, is developed about 10 m above the Saltwick on 18SE. It has a maximum thickness of 25 cm near its eponymous locality [172 833] and is overlain locally by a mudstone containing *Lingula* (the **Gubeon Marine Band**).

Throughout much of the district the **Ganister Clay Seam** is in two thin leaves each rarely more than 20 cm in thickness, generally separated by less than 3 cm of mudstone or seatearth-mudstone. Either of the seams may be locally washed out, and the coal is believed to be impoverished or absent to the west of Morpeth.

Mudstone is dominant between the Ganister Clay and Marshall Green seams, the interval ranging from only 6 m in the south of the district near High Callerton to about 20 m at Well Hill where a dark grey mudstone containing *Lingula* and fish fragments (the **Well Hill Marine Band**) occurs 4 m below the Marshall Green.

The **(Bottom) Marshall Green Seam** (Choppington Victoria) generally occurs as a single coal, locally washed out, up to 90 cm in thickness. It is separated from the overlying Stobswood Seam (Top Marshall Green) itself up to 60 cm thick, by between 3 and 10 m of strata comprising mainly sandstone throughout much of the district. The sandstone was formerly quarried at Bell's Hill [1934 7925] where it was yellowish white, coarse-grained and feldspathic. South of Tranwell on 18SE the interval is predominantly mudstone and up to four coals (including the Top and Bottom Marshall Green) are locally developed with a maximum total thickness of 1.5 m. Old workings are recorded at several localities (see Table 3) and it is likely that more than one seam was mined.

The Stobswood Seam is overlain by a thin mudstone bed, which in places contains fish debris indicative of the **Stobswood Marine Band**, and this in turn is overlain by up to 18 m of coarse-grained feldspathic sandstone, which has been quarried locally (Table 5).

The **Victoria Seam** (Choppington Brockwell), immediately underlain by a thin mudstone, has a maximum recorded thickness of 1.45 m, including a dirt parting, near Horton Grange [199 755]. Elsewhere the seam is between 18 and 66 cm thick. Sandstone again dominates the measures, some 20 m to 25 m thick, between the Victoria and the Brockwell. Up to three impersistent thin coals (the **Bottom Brockwell seams**) occur in the topmost 7 m of the interval, a mussel band characterised by large *Carbonicola pseudorobusta* being present in the roof of the lowest one.

The **Brockwell**, Splint or Bandy Seam commonly contains dirt partings and in places may be split into two. Where the seam is united the maximum thickness of coal is 1.3 m. The seam has been extensively worked in the south-east of the district between Prestwick and Woolsington. Overlying strata (approximately 18 m) contain two impersistent coals which do not exceed 15 cm in thickness.

The **Three-Quarter Seam**, which in places is represented by cannel, has a maximum proved thickness of 48 cm. The interval between the Three-Quarter and the Bottom Busty averages about 9 m in thickness and includes some sandstone.

The **Bottom Busty Seam** has been worked between Prestwick and Woolsington and also beneath the eastern margin of Prestwick Carr. The coal attains a thickness of 89 cm in boreholes but its mined thickness does not exceed 78 cm. Two thin coals (usually less than 20 cm) occur within 6 to 15 m of mudstone and siltstone which makes up the interval between the Top and Bottom Busty.

The **Top Busty Seam** which ranges between 30 and 71 cm in thickness, has been mined from small areas north of Moory Spot [200 734] and south of Callerton Station [192 701]. Thin coals are only rarely developed in the overlying measures which range between 6 and 14 m in thickness.

The **Tilley Seam** is commonly banded and may split into three leaves. The maximum thickness, inclusive of dirt bands, is 1.17 m. Mining of the seam northwards was terminated by a washout in the High Luddick area [183 706].

The **Hodge Seam** lies approximately 8 m above the Tilley seams. It has a mean thickness of about 40 cm and has not been worked within the district. The interval between the Hodge and Beaumont seams is usually less than 6 m and generally consists of sandstone.

The **Beaumont**, Harvey or Engine Seam is widely worked and maintains a thickness of about 1 m throughout much of the district. The succeeding 20 m of strata which separates the Beaumont from the Harvey Marine Band is dominated by sandstone in the lower part. Typically two thin coals, each less than 20 cm thick, lie approximately 9 and 13 m above the Beaumont.

Middle Coal Measures. The **Harvey Marine Band** is the local correlative of the Vanderbeckei Marine Band which marks the base of the Middle Coal Measures. It is identified only on the basis of lithology and relative position in the sequence. None of the boreholes which penetrate this part of the measures record any palaeontological detail. To the east (NZ27, Jackson and others, 1985) the marine band consists of 30-90 cm of very dark grey to black shale containing *Lingula mytilloides*, fish scales and foraminifera, and is overlain by a mudstone with a mussel band. There is little data on the interval between the Harvey Marine Band and the Northumberland Low Main, and sandstones of varying thickness and position make the correlation of this part of the sequence, especially the Plessey coal, difficult.

The **Plessey Seam** appears to split in the north into two leaves which may be separated by up to 10 m of sandstone and siltstone. However in Prestwick Opencast Site the interval between the two seams was only 1.4 m. Where the seams are united the thicknesses ranges up to 81 cm. Immediately east of the district near Brenkley [206 748] the Plessey seams are currently being worked opencast. Measures between the Plessey and the Northumberland Low Main, some 15 m in thickness, are of variable lithology but in places contain a thin (about 23 cm) coal and prominent mussel bands.

The **Northumberland Low Main** or Brass Thill Seam has an average thickness of 89 cm and has been widely worked. Extension and development of Newcastle Airport in the 1960's sterilized a large area of the seam. Workings in the south of the district, thought by British Coal to be in the Hutton Seam, are more probably, on the basis of the interval from the Beaumont workings, to be in the Northumberland Low Main. The overlying strata up to the Durham Low Main are chiefly of mudstone and siltstone with one or two mussel bands and a thin (3-23 cm), but persistent, coal lying about 4 m above the Northumberland Low Main.

The **Durham Low Main** or Northumberland Five-Quarter Seam does not usually exceed 50 cm in thickness. A small area of workings near Woolsington may be within this seam but the proximity of several large faults makes identification uncertain. A persistent sandstone, the Low Main Post, which ranges between 9 and 23 m in thickness, dominates the sequence between the Durham Low Main and the Bensham seam. Several boreholes record thin coals and seatearths above the sandstone.

The **Bensham** or Maudlin Seam is a split seam with up to four leaves. Individual leaves may exceed 1 m but commonly include several dirt bands; none of the leaves has been worked in this district. The mudstone immediately above the Bensham carries a mussel band which is elsewhere characterised by *Anthraconaia pulchella*. Approximately 20 m of mudstone and siltstone with subordinate sandstone separate the Bensham and Yard seams.

The **Yard Seam** attains a maximum thickness of only 40 cm within this district in contrast to areas in the east where the seam averages 1 m and has been largely worked out. The succession between the Yard Seam and the High Main Marine Band is recorded in only the Havannah, 1970, borehole (17SE58). This proved 28 m of alternating sandstone, mudstone and siltstone between the Yard and the Five-Quarter with three thin coals. The first and third of these are overlain by mudstone with mussel remains.

The **Five-Quarter** or Main Seam is 1.58 m thick in the above borehole; plans of the small area of Five-Quarter mined in this district record up to 1.68 m of coal. Old workings in the 'Grove' seam south of Callerton Station are thought to be in the Five-Quarter. The interval between the Five-Quarter and the High Main is 33.5 m and consists largely of siltstone with sandy partings. Fish scales were tentatively recognised within a mudstone 18 m above the Five-Quarter and two inferior coals 5 and 8 cm thick were also encountered below the High Main.

The small area of **High Main Coal** within this district has not been worked. Borehole 17SE58 proves 1.27 m of coal; this is overlain by 4 m of mudstone which includes a 25 cm coal with a mussel band in its roof.

The **High Main Marine Band** is represented by 1.5 m of dark grey broken mudstone containing fish scales and *Lingula sp.* Above the marine band 7 m of dark grey mudstone with ironstone bands includes many mussels.

The succession above this point has not been proved in any boreholes. The presence and position of the Moorland Seam and overlying beds is inferred on the basis of structure and rockhead contours only.

IGNEOUS DYKES

There are only two examples of intrusive igneous rocks known from the district:

A NE-SW trending whin dyke was formerly recorded at Pigdon [1550 8824]. It is no longer exposed, but its trend indicates that it belongs to the late-Carboniferous or early Permian Whin Sill suite. Farther south, heavily weathered grey-green dolerite is exposed in Duddo Burn [1815 7946] as a near vertical dyke trending WNW-ESE and may be intruded along a small fault. From its trend it is probably a continuation of the Tertiary Hartley Dyke.

STRUCTURE

The general structural pattern in the Carboniferous rocks of the district is of gently tilted strata intersected by a conjugate series of faults trending approximately NE and NW. This overall pattern is interrupted by a shallow, but areally extensive syncline in the Tranwell-Saltwick area (see 1:25,000 structure contour map).

The Strata were faulted and folded in the late-Carboniferous Hercynian orogeny and later were gently tilted eastwards in Tertiary times. In common with much of the Northumberland coalfield, they show a general easterly or south-easterly dip. There is, however, local variation illustrated by the outcrop pattern as shown on the geological map (Figure 3) and depicted in detail on the 1:25,000 scale structure contour map, which is contoured at 25 m intervals on the base of the Coal Measures.

In the far north of the district the Millstone Grit strata dip consistently ESE at between 3° and 5°. The increase in dip to about 8° within the Coal Measures outcrop in the north-east of the district near Hebron is illustrated in the horizontal section (Figure 5). Farther south near Mitford the direction of dip in the Millstone Grit veers towards the south-east, or locally the south, into a relatively flat-lying, faulted, synclinal basin centred near North Saltwick. A series of open minor flexures are present within the syncline, the strata near Saltwick dipping at less than 1°. A minor E-W trending anticline south of Bell's Hill [195 789] marks the approximate southern limit of the gently folded strata. Around Prestwick the dip is consistently south-east, increasing to 10°, the maximum in the district, south of the airport. The dip of the Millstone Grit on sheets 17NE and SE is surmised, from the known geology farther west, to be very gentle, probably less than 5° to the east or south-east and possibly with minor open folds.

A conjugate set of faults cuts the Coal Measures, occurring within 30° north or south of a generally east-west trend. All are normal and most have throws of 25 m or less. Those in the north of the district have northerly downthrows and cause significant displacement of the Coal Measures outcrop. The Stakeford South Fault is the largest in the district, with a northerly downthrow of 70 m or so. North of Gubeon the plexus of faults associated with it cause significant displacement and rotation of strata within individual fault blocks, for example dips of 8° to the SSW were recorded in the Gubeon opencast site. The two major NE-SW trending faults near Prestwick Carr are a continuation from the adjacent district to the east. Within the Coal Measures some of the faults are terminated abruptly by crossfaults, while others die out gradually as their throws reduce or by splitting up into several fractures often with opposing throws. Delineation of faults within the Millstone Grit is less certain, particularly in the south of the district where the rocks are largely obscured by drift. Renewed earth movements in Tertiary times reactivated many faults, and intrusion of dykes occurred at this time.

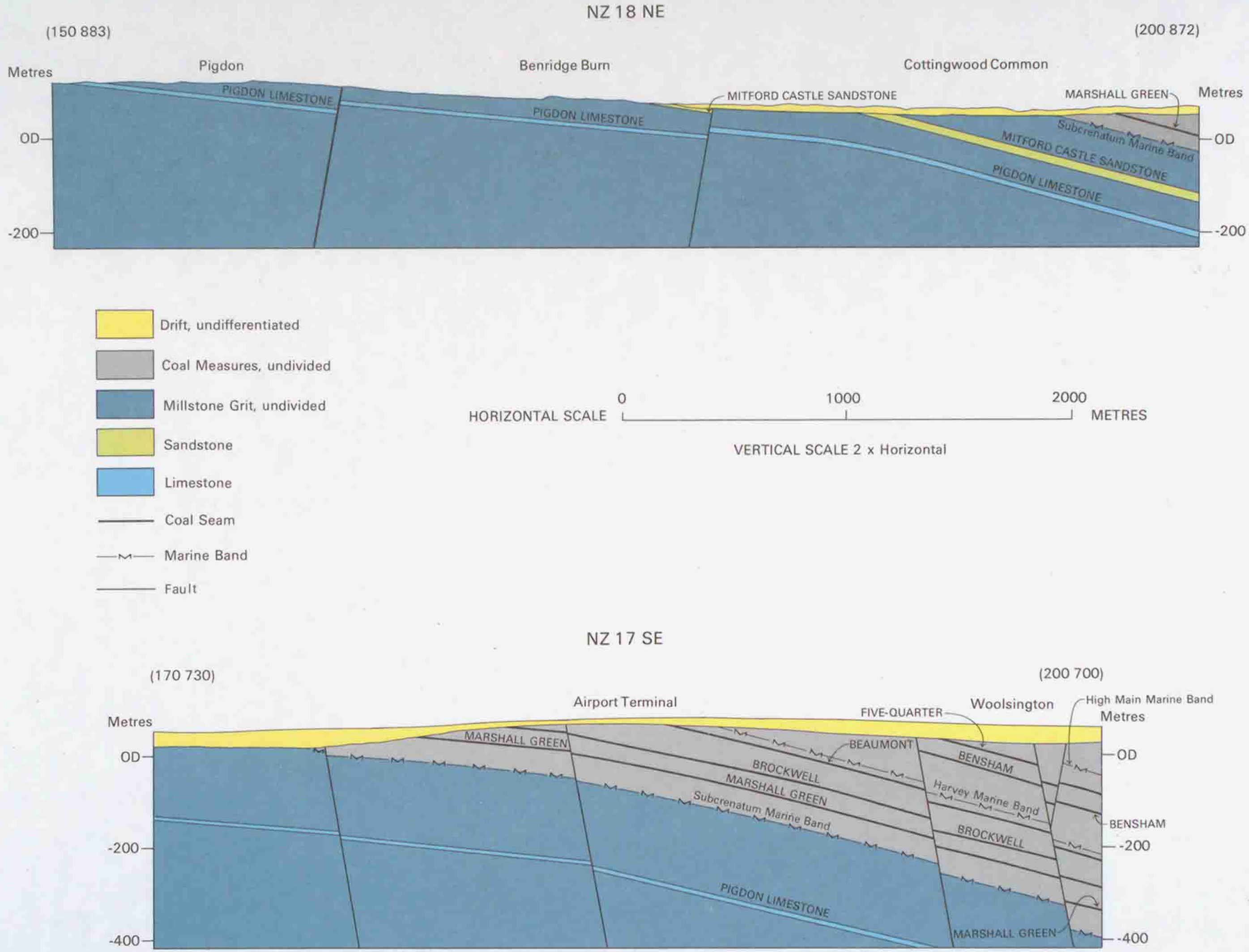


Figure 5 Horizontal Section

QUATERNARY

Quaternary (drift or superficial) deposits mantle almost the entire district (Figure 7). It is only on the higher ground and in a few river valleys, where erosion has removed these deposits, that solid rocks are exposed. Till (boulder clay) predominates, but water-deposited sands, gravels, silts and clays associated with the glacial and immediate post-glacial period are common within buried valleys. Glacial sediments within these valleys may exceed 60 m in thickness and their mutual relationships may be complex. This contrasts with those interfluvial areas of thin drift where till is generally the only deposit. Glacial drainage channels, typically with a 'U' shaped cross-section, occur near Shilvington [157 812] and around High Callerton [156 704]. Their form has been modified by solifluction, gullying and the accumulation of alluvium on the channel floor. Post-glacial river terraces flank the rivers Pont, Wansbeck and Font and recent alluvium and peat overlie glacial deposits in valleys and other areas of low ground.

ROCKHEAD

Rockhead elevations within the district are illustrated in Figure 6. In common with other glaciated lowland areas the rockhead or bedrock surface has an appreciably greater relief than the present day surface. Pre-existing (?pre-glacial) valleys coincident with or marginally offset from the present day valleys of the Wansbeck, Catraw Burn, Blyth and Ouse Burn have been infilled with glacial drift. Additionally there is a large buried valley to the north and east of Ponteland which runs beneath Prestwick Carr and then declines northwards to join the buried valley of the Blyth in the vicinity of Ewe Hill [197 767]. Whereas the eastern sections of all of these features are reasonably well fixed and can be shown to descend to levels near to, or below OD, there is only limited evidence for the extent or depth of their upstream (western) parts.

QUATERNARY DEPOSITS

Till (boulder clay) is present over most of the district and usually consists of a stiff, grey and grey-brown silty, sandy and stony clay overlain by approximately 2 m of mottled orange-brown and pale grey silty sandy clay with sporadic pebbles. Thin lenses of sand, gravel and laminated, stone-free silt and clay are commonly included in the till. The maximum proved thickness of till, 40.7 m, occurs within the buried valley of the proto-Ouse Burn; although it is thought that thicknesses in excess of 60 m may be present in the Morpeth area.

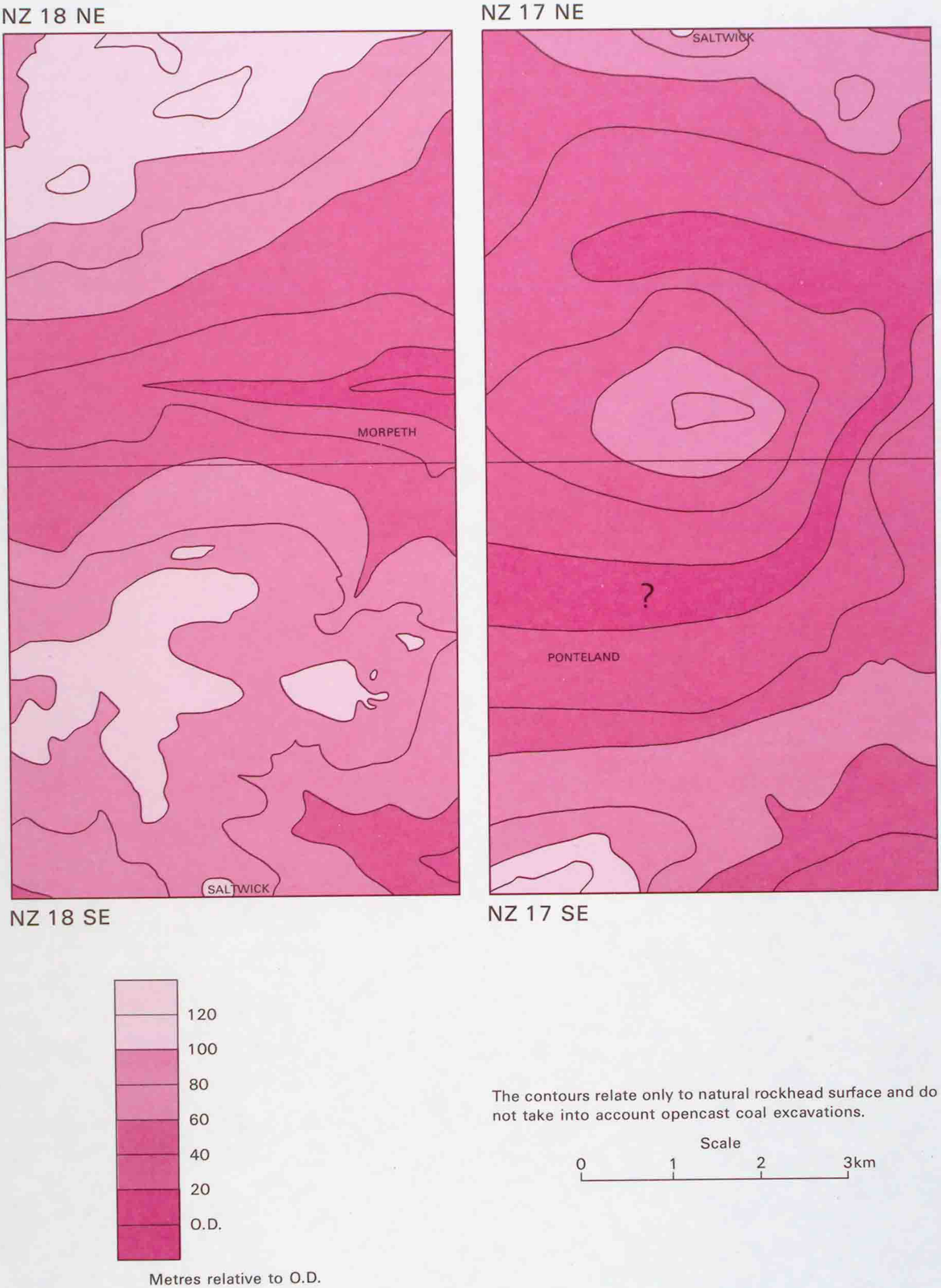
Sub-rounded Carboniferous sandstone is the predominant erratic type, although limestone is ubiquitous in the west of the district and ironstone and siltstone are common. Clasts of far-travelled igneous and metamorphic rocks are also present. Erratics range in size from a few millimetres to large boulders, with the latter increasing in abundance towards rockhead. However, some erratics may be exceptionally large: the excavation of the Tranwell opencast coal site encountered an erratic which was more than 270 m long. A section in one face of the excavation recorded:-

till	about 2 m
sandstone	4.6 m
shale	15 cm
coal	14 cm
till	about 6 m

resting on shale overlying the Victoria seam.

The identification of such large bodies of detached bedrock prior to excavation is a difficult task but their possible existence should always be considered.

The stiff grey and grey-brown stony clays, which form the major part of the till, are interpreted as overconsolidated lodgement till deposited by a single phase of glaciation during the late Devensian. Sections in lodgement till may be seen in river cliffs of the Font, Wansbeck, Blyth and Pont. Several boreholes record deformation till, comprising angular clasts of bedrock in a clayey silt or sand matrix, at the base of the glacial sequence. The origin of the uppermost mottled orange-brown sporadically stony clays is unclear and they have been variously interpreted as upper lodgement tills, ablation and flow tills, the product of gelifluction or, more recently, as a post-glacial weathering profile. It seems likely that more than one process is involved. These upper clays are significantly weaker than the underlying stiff grey till (see geotechnical properties, p.28).



The contours relate only to natural rockhead surface and do not take into account opencast coal excavations.

Figure 6. Rockhead elevation

In the west between Kirkley Hall [150 772] and Shilvington [158 810], a ridge rising 5-10 m above the country to the east has been mapped as moraine. Previous surveys considered the feature to be composed of sand and gravel. However, other than a small disused sand pit to the north-west of Thorneyford [1535 7789] and a possible local increase in the stone content of the drift, there is little superficial evidence of a change in lithology.

Glacial Sand and Gravel is extensively exposed along the valleys of the Font and Wansbeck and other smaller, scattered outcrops have been mapped throughout the district, for example south and west of Morpeth [193 842], at Prestwick Carr [180 744] and east of Ponteland [174 733]. A number of boreholes and trial pits also encounter sand and gravel, usually associated with the glacial sequence within the buried valleys.

In the Font and Wansbeck valleys sand and gravel is recorded within till along the valley sides and also appears to form a surface deposit on higher ground between the two rivers west of Mitford [167 858] (surface elevation 60-65 m OD). Up to 7 m of sand and gravel has been noted lying with a relatively sharp but uneven base on till. For the most part the sediments comprise fine- to medium-grained sand with silty and clayey interbeds and with lenses and layers of pebble and cobble gravel up to 2 m thick. In several exposures gravel forms the base of the deposit, a feature often marked by a spring line.

Other, smaller, outcrops of glacial sand and gravel are not so well exposed and are only tentatively delineated. They appear to consist chiefly of sand, with the notable exception of a sinuous, esker-like, feature within Prestwick Carr [180 744] which has been quarried for sand and gravel.

Individual beds of sand and gravel within boreholes and trial pits range up to a maximum proved thickness of 9.9 m west of Morpeth [1765 8561] but generally thicknesses do not exceed 2 m. The quality of the drift logging in many records makes an accurate assessment of composition of the deposits impossible; however, sand-grade material appears dominant. Sandstone is the main rock-type within the gravels but other lithologies including limestone are also present; coal grains occur in the sand fraction.

Although detailed lateral and vertical relationships of the glacial deposits are not known, borehole records indicate that sand and gravel is largely confined to the buried valleys where it occurs as thin and laterally impersistent lenses and not in a single correlatable unit.

It seems probable that the sediments were deposited in transient streams and water bodies, subglacially and subaerially during the glaciation and deglaciation of the region.

Glacial Lake Deposits. Silt and clay, usually laminated, stone-free and with intercalated very fine-grained sand lenses and partings, is exposed in the valleys of the Blyth and Pont. These sediments are also recorded in boreholes and trial pits which penetrate the upper part of the glacial sequence in the Ponteland area. Other, apparently less extensive, occurrences of laminated silt and clay have been noted in cliff sections of the River Font [165 860], at Scotch Gill [1823 8610], west of Broad Law [155 799] and in site investigation boreholes west of Morpeth.

The widespread deposits of the Blyth and Pont valleys crop out below the 53 m (175ft) contour between Kirkley Mill [165 767] and Bellasis Farm [194 781]. Up to 1.8 m of finely laminated silt and clay with sand laminae overlies till in natural exposures along the river courses. Laminated silt and clay proved during site investigation work in the Ponteland area appears to be closely associated with sand and gravel in the glacial sequence; thicknesses of individual beds do not normally exceed 2 m.

Laminated silt and clay may be more widespread than indicated above, but lack of boreholes in certain areas and lack of detail in those boreholes which do exist preclude detailed definition. Most of the sediments were probably deposited in subglacial and subaerial lacustrine environments in glacial and late-glacial times.

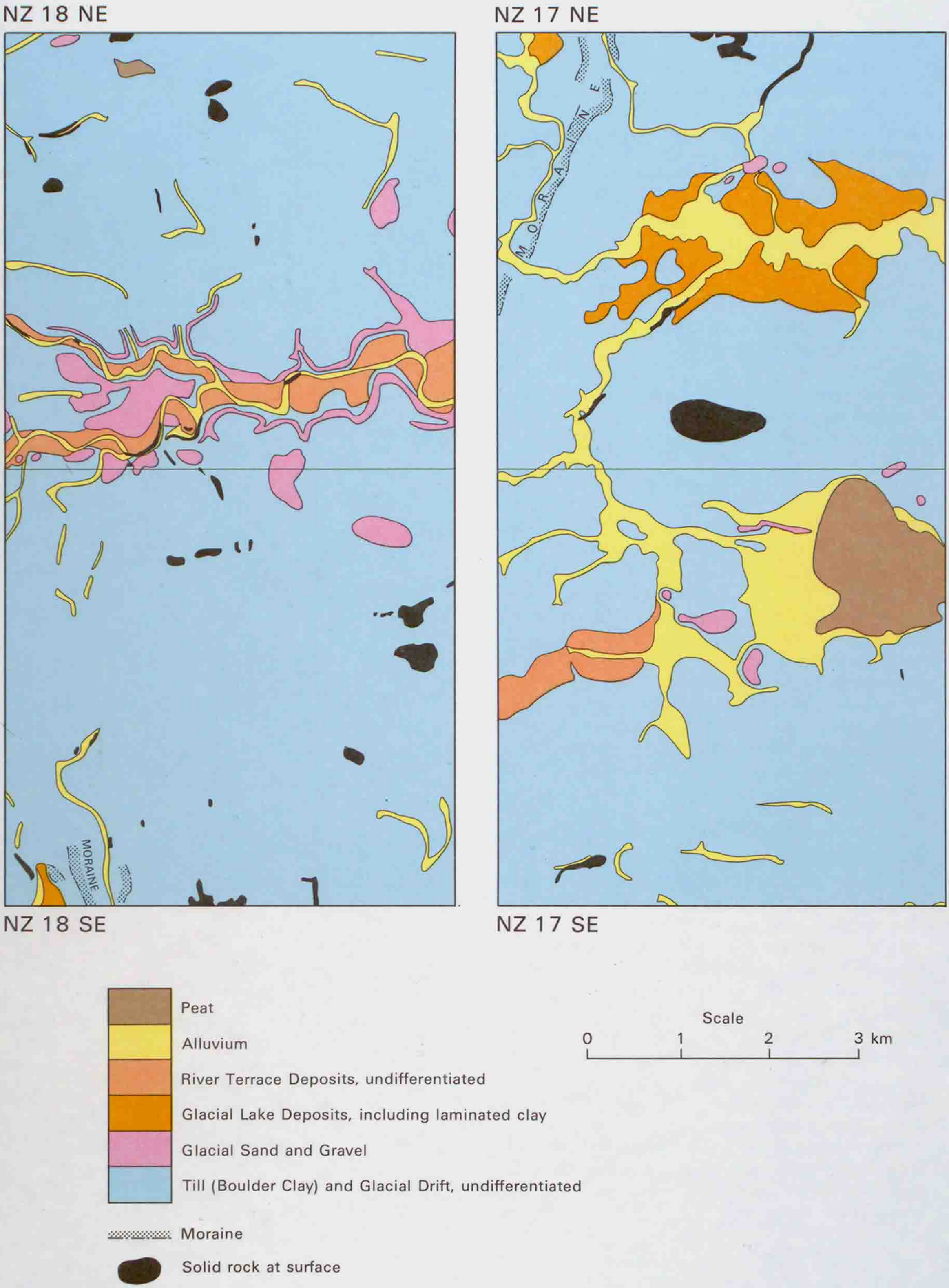


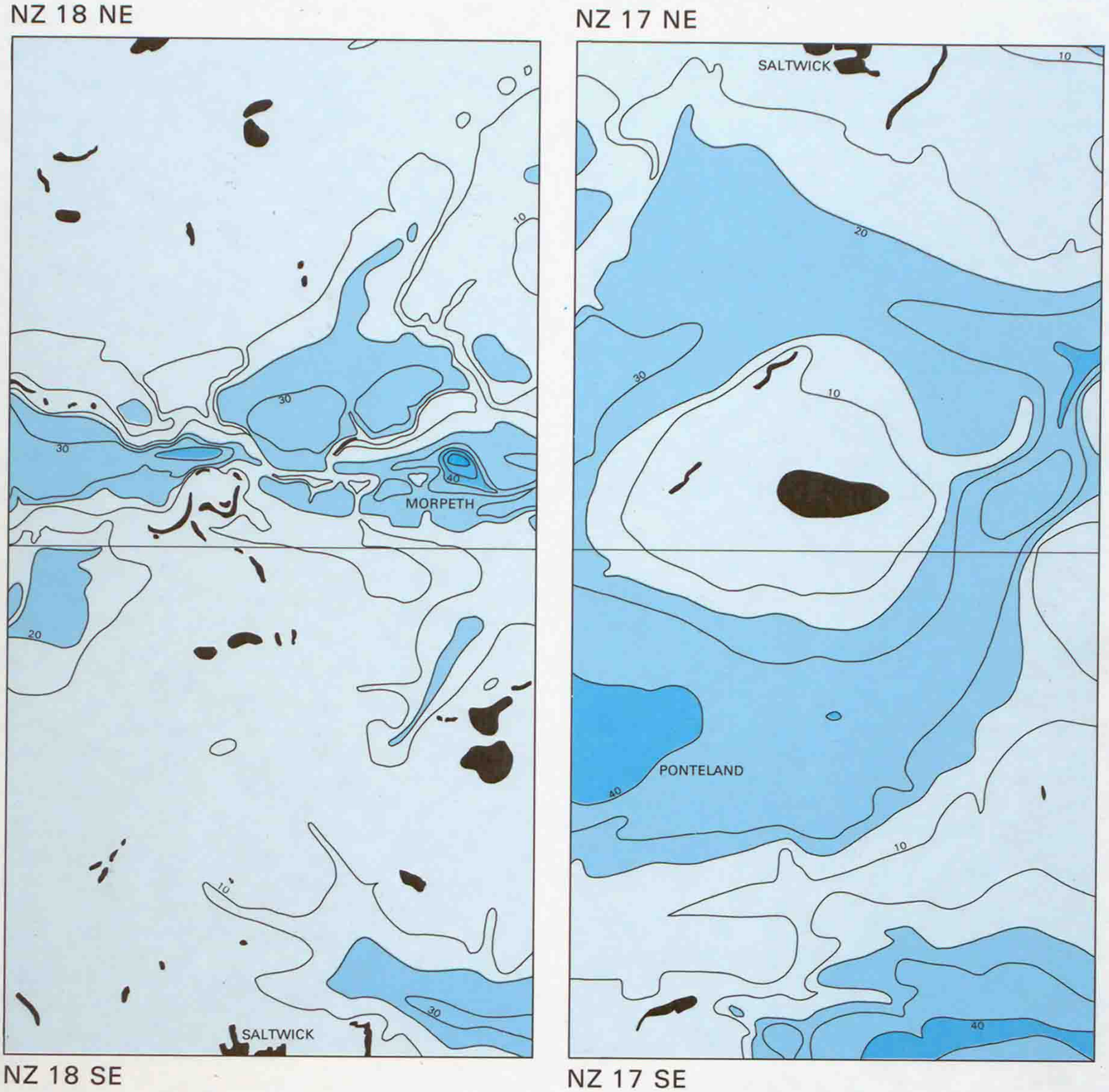
Figure 7. Quaternary deposits

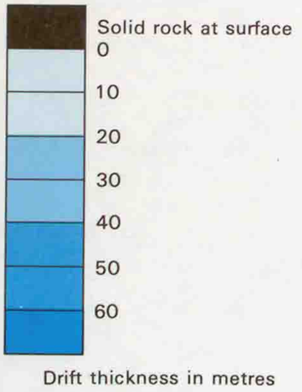
River Terrace Deposits are developed along the rivers Wansbeck, Font and Pont. A discontinuous veneer of sand and gravel overlying laminated clay which flanks the River Blyth probably also represents terrace deposits. Terrace surfaces lie between 3 and 10 m above present river level. A number of individual terraces are identifiable but their lateral correlation has not been established. In the Wansbeck and Font valleys the terraces comprise sand up to 2 m thick overlying a layer of pebble and cobble gravel which in turn rests on till. Sections in the Pont terraces are rare but south of West Houses [1510 7227] in excess of 1.3 m of gravel in a fine sand matrix was seen to rest on till. A series of site investigation boreholes drilled through terrace deposits at Ponteland [163 727] encountered between 1.4 and 2.0 m of gravel and sand overlain by up to 1.2 m of sandy clay with gravel. Isolated flat-topped features about 17 m above river level north-east of Buck Haughs [164 862] and west of Newminster Abbey [187 858] probably represent remanie terraces.

Alluvium. Tracts of alluvium flank many river and stream courses in the district; alluvium of lacustrine origin floors Prestwick Carr and adjacent low ground near Ponteland. The fluvial deposits do not usually exceed 3 m in thickness and consist of laterally variable clay, silt and fine sand, often including peat and organic sediments and with a gravelly unit at the base. A typical section in the Blyth Valley [1820 7756] records 0.6 m of silt, overlying 0.9 m of sandy silt on fine silty sand.

The lacustrine alluvium of Prestwick Carr is overlain by peat in the east. In this area alluvial sediments comprise sand with pebbly, silty and clayey partings and may reach thicknesses in excess of 8 m. The lake within which this alluvium was deposited existed until comparatively recent times (the Carr was drained in 1856). The settlements of Eland and Ponteland undoubtedly owe their names to their physiographic situation.

Peat occurs west of Lough House [164 896], but most extensively in the eastern part of Prestwick Carr where it reaches a maximum proved thickness of 2.7 m. Organic clay and peat is also recorded as lenses and pockets within alluvium.





The contours relate only to drift deposits and do not take into account opencast coal excavations or made ground.

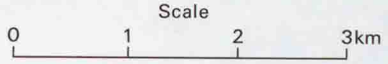


Figure 8. Drift thickness contours

Table 4. Former opencast coal sites

Site	Grid Reference	Date coaling completed	Coal seams worked	Coal recovered Mg (tonne)
Gubeon	170 838	1957	Bottom Marshall Green	13,510
Tranwell	180 835	1957	Bottom Marshall Green }	68,631
Tranwell	182 833	1957	Victoria }	
Glororum	190 824	1957	Marshall Green	6,282
Saltwick	175 800	1958	Top and Bottom Saltwick	115,816
Prestwick*	200 731	1949	Top and Bottom Plessey	132,658

*Site extends beyond district boundary.

MINERAL RESOURCES

Coal. There is no current mining or opencast working of coal in the district. The last colliery with a take within the district was the Havannah mine which closed in 1977 (see Table 3). Table 4 lists former opencast sites. Although substantial quantities of deep coal remain unworked further large-scale mining appears unlikely. Taking geological factors in isolation there is considerable potential for opencast working or small-scale mining. In many areas coal remains intact, or has been mined by the pillar and stall method which may leave more than 50% of the coal in place.

Sandstone, both within the Millstone Grit and the Coal Measures, was formerly quarried on a small scale at many localities, usually for building stone (Table 5). Most quarries in the area have now been reinstated or partially infilled. Resources of sandstone of varying hue and grain-size are considerable.

Limestone was formerly quarried at Pigdon [151 982], but there is no other record of its extraction within the district.

Mudstone and siltstone are common throughout the sequence and resources are very extensive. Although there is no direct information on quality, siltstones and mudstones above the Plessey seam were recently worked for brick-making just east of the district at Brenkley [204 747].

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

Igneous rocks. Two dykes occur within the district, but as both are quite narrow, probably less than 2 m, neither can be considered as a workable resource.

Sand and gravel occurs within glacial and river terrace deposits and alluvium. The thickest and most extensive deposits are those of glacial origin flanking the Wansbeck and Font valleys where the sand and gravel has a maximum recorded thickness of 9.9 m, and overburden, usually till, ranges up to about 8 m. Although glacial sand and gravel shows rapid vertical and lateral changes of grade, fine- to medium-grained sand is dominant in this area. River Terrace Deposits comprised of sand and gravel occur in the Wansbeck, Font and Pont valleys. Up to 2.3 m has been proved; overburden does not usually exceed 1 m. Alluvial sand and gravel occurs within a very variable sequence of silts and clays. Very fine-grained clayey sands predominate with gravel usually only present in the basal layers. Sand and silt deposits are concealed beneath the peat of Prestwick Carr. Individual beds reach 4.2 m, but the sand is probably very fine-grained and the percentage of the silt/clay grade fraction is unknown.

Table 3. Former collieries with a take within the district

Colliery	Approximate Grid Reference of mine entrance	Seam worked	1*	2*
Gubeon	171 837	Marshall Green (un-named on plan)	U	1908
Gubeon (Drift)	176 836	Marshall Green (worked as Brockwell)	U	1929
Tranwell	189 836	Marshall Green	U	1913
Tranwell	190 835	Marshall Green (worked as Victoria)	U	1926
		Victoria (worked as Brockwell)	T	1926
West Clifton	199 832	Victoria (worked as Brockwell)	T	1947
Glororum	191 824	Marshall Green (un-named on plan)	U	1899
		Marshall Green (worked as Beaumont)	U	1929
Dovecote Moor	193 813	Marshall Green (worked as Top seam)	U	1905
(Stanfield Pit)		Marshall Green (worked as Busty)	U	1908
		Marshall Green	U	1936?
Dovecote 'B' Pit	198 812	Marshall Green (worked as Busty)	U	1917
(Stannington Coal Company)		Marshall	U	1922
(Dovecote Colliery)		Marshall Green (worked as Brockwell)	U	1924
		Marshall Green	U	1924
West Duddo	181 797	Saltwick	W	1897
East Walbottle	200 734	Beaumont	N	1966
		Top Busty	Q1	1920
		Bottom Busty	Q2	1945
Havannah	215 718	Northumberland Low Main	K	1962
		Beaumont	N	1971
		Bottom Busty	Q2	1970
		Brockwell	S	1975
Hazlerigg	228 718	Five-Quarter	F	1942
Prestwick	184 712	Beaumont	N	1937
		Bottom Busty	Q2	1964
		Brockwell	S	1903+1963
Pawley Letch	183 702	Northumberland Low Main (worked as Hutton)	K	1925
		Beaumont	N	1836
North Walbottle	178 674	?Durham Low Main (worked as K)	J	1929
		Northumberland Low Main (worked as Hutton)	K	1962
		Beaumont	N	1944
		Tilley	P	1968
		Top Busty	Q1	1966
		Bottom Busty	Q2	1962
		Brockwell	S	1966
Callerton Drift	161 697	Marshall Green	U	1960

1* = British Coal index letter. 2* = Date last worked.

Note. Plans record ancient workings in Five-Quarter (F), Bottom Busty (Q2) and Brockwell (S) at Woolsington and Prestwick.

Table 5. Former sandstone quarries

Site	Grid Reference	Lithology	Stratigraphic Position
Quarry Hill	172 891	Yellow-brown, coarse-grained	Millstone Grit
East Benridge	1772 8762	Yellow-brown, feldspathic, pebbly	Mitford Castle Sandstone
Mitford Castle	169 854	Yellow-brown, feldspathic, pebbly	Mitford Castle Sandstone
Mitford Steads	173 849	Yellowish, medium-grained	Millstone Grit
Cock Hill	1759 8402	White, coarse	below Ganister Clay
Catchburn	1962 8345	White, coarse	above Victoria
Tranwell Farm	1876 8337	Coarse, feldspathic	between Stobswood & Victoria
Crag Plantation	1966 8303	White, coarse	below Ganister Clay
North Whitehouse	189 817	Feldspathic, coarse	between Stobswood & Victoria
North Saltwick	173 811	White, coarse, locally pebbly	above Saltwick
Watch Hill	159 819	Coarse, feldspathic	below Gubeon
West Duddo	1823 7962	White, feldspathic	between Saltwick & Top Saltwick
Bells Hill	1934 7925	Coarse, feldspathic, yellow and white	between Marshall Green & Stobswood
Bellasis Farm	1923 7843	Coarse, feldspathic	below Saltwick
Berwick Hill	1718 7544	Yellowish, fine-grained, shaley	Millstone Grit
Berwick Hill	1743 7561	Yellow, feldspathic, coarse	Millstone Grit
Berwick Hill	175 756	Yellowish, flaggy, micaceous	Millstone Grit
Kirk Hill	1662 7518	Coarse, gritty with quartz pebbles	Millstone Grit
High Callerton	1598 7046	Medium with coarse, pebbly, ironstained	below Ganister Clay

There is currently no extraction of sand and gravel within the district, though it was formerly dug north-west of Thorneyford [1535 7789] and north of Morpeth [1988 8663]. Areas of terrace and glacial sand and gravel have already been sterilised by development at Morpeth [195 864] and Darras Hall [162 727].

Glacial clays. Till and glacial lake deposits have been worked for brick and tile manufacture at a number of localities. These pits, listed in Table 6, are all small excavations and probably supplied a local market. Resources of glacial clay are considerable.

Peat. Extensive peat deposits form the eastern part of Prestwick Carr. Thicknesses of up to 2.7 m have been proved and the peat has been cut in the past at [1945 7532].

Groundwater. There is little data on the hydrogeology of the district. In the areas from which coal has been mined or quarried the natural drainage pattern and water table has been severely modified. Incompletely collapsed workings, and shafts and opencast sites significantly influence local groundwater flow. Localised perched water tables are probably present within Quaternary sands and gravels but their limited supply potential is difficult to assess. The groundwater regime should always be considered when planning landfill sites; observation holes will be needed for this.

Table 6. Former clay pits worked for brick and tile making

Site	Grid Reference	Deposit worked
Hare Wood	176 900	Till
Cottingwood Common	1945 8697	Till
Cottingwood Common	1950 8689	Till
St George's Hospital	1985 8696	Till
King's School, Morpeth	197 867	Till
Spital Hill	176 865	Till
Tranwell Airfield	1650 8176	Till
Kirkley Mill	164 768	Glacial Lake Deposits
Berwickhill Bridge	171 744	Till
Limestone Lane	151 731	Till
Prestwick Pit Houses	181 716	Till

GEOLOGICAL IMPLICATIONS FOR LAND-USE PLANNING

COAL MINING

There is no direct evidence, but it is probable that mining of several seams, near outcrop and in areas of thin drift, began in this district before the 18th century. It is likely that, at first, the coal was worked from small adits into a valley side or from bell pits, which were usually less than 12 m deep and about 20 m wide. Later, deeper seams were extracted by the pillar and stall method with extraction rates of 40–50%. Panel working, introduced in some mines at the beginning of the 19th century, increased extraction considerably, sometimes reworking areas of pillar and stall. This method was later replaced by longwall working, a system with the highest recovery ratio.

The above brief history of mining methods is central to an understanding of the potential problems which abandoned mine-workings may pose the planner, developer or civil engineer. Possibly the most serious hazard which old workings present is that prior to 1900 few mines were documented and those plans which do exist are likely to be inaccurate. Although after 1872 accurate plans were to be lodged with the Mines Record Office these often showed only the extent of the mining and did not record levels or geological information. Similarly the positions of many of the associated shafts, adits and bell pits are unknown or poorly recorded and, since they were commonly only capped at surface, these may remain open below.

Areas of pillar and stall working cause particular difficulties:

* Up to 60% of the coal may remain in place, consequently site investigation may fail to identify mined areas, as only a proportion of site investigation boreholes are likely to encounter mine workings.

* Packing of workings with rock was not necessary, and where roof measures have subsided to rest on the seatearth with slight disturbance, the only evidence in borehole cores may be a little powdered coal on a stained, slightly weathered and perhaps rusty seatearth.

* Collapse of pillars often results in cavities and breccia pipes in the strata above caused by bed separation and upward migration of the voids.

* Sandstone roofs may resist collapse and delay subsidence for a considerable time.

In contrast longwall workings do not normally cause concern:

* The method is usually restricted to the deeper seams.

* The workings are comprehensively surveyed and documented.

* Although subsidence may be substantial it is generally assumed to be largely contemporaneous with the extraction of coal and to have finished within a few years of working.

Coal mining in this district has now ceased. Up to 11 coal seams are known to have been worked in the past by most of the methods described above (Table 3). Almost all that part of the district south-east of the outcrop of the Brockwell coal on 17SE has been undermined (Figure 3), and certain areas have been undermined several times. The Beaumont, Bottom Busty and Brockwell seams in particular were widely worked. There is no record of mining on 18NE and only restricted workings in the Saltwick seam on 17NE.

There are however a number of isolated mines in the Victoria and Marshall Green coals on 18SE and shafts indicate that other workings may be present.

Known or possible workings are shown on the shallow coal workings map. The areas delineated are generalized and in considering particular sites it is **essential to consult the original documents** (held by British Coal) **from which information has been abstracted**. 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 not recorded on plans is derived from boreholes, from features such as pitfalls and from the discovery of old workings in opencast or other excavations. **Ancient, unrecorded, workings may occur at shallow depths in any area where a coal thick enough to be worked lies near the surface**.

Pitfalls (roughly circular depressions up to 4 m in diameter which often form rectilinear patterns) resulting from the collapse of pillar and stall workings were identified near the outcrop of the Beaumont seam to the north of the airport [189 719] and above the Victoria seam at Tranwell [191 833]. Extensive areas of near-crop pillar and stall working are common in both the Beaumont and Brockwell seams. It is in such areas of pillar and stall working at depths of less than 30 m that collapse of strata into existing voids is most likely.

Mine shafts, particularly prevalent in the Prestwick area, are shown on both the geological map and the borehole and shaft map. The sites of all shafts and adits known to BGS and British Coal have been plotted, **but others may exist**.

GEOTECHNICAL PROPERTIES

The description of the geotechnical characteristics of the deposits of the adjacent sheet NZ27 (Jackson and others, 1985) is equally applicable to this district and is repeated here with minor modification.

Areas in which the drift thickness is less than 5 m, where foundations or trenches for services may encounter solid, are delineated on the 1:10,000 drift thickness maps (see Figure 8).

Mudstones and siltstones are the dominant lithologies in 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 m are generally weathered. Trenching is relatively easy but tunnelling at depths of 12 m 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 3 m. 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. 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 large boulders, erratics (see p.18) and potentially waterbearing sand and gravel bodies.

The orange-brown and grey stony clays forming the uppermost 1 to 2 m 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. It 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; sub-vertical joints are a major source of weakness in such situations and also lead to instability on natural slopes, in particular 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 have 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 proves difficult in places.

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 occur where slopes have been oversteepened and undercut by the rivers Blyth, Font and Wansbeck. 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**. The distribution of made ground is illustrated in Figure 9 and Table 7 details each site. The recognition and delineation of made ground is important because of its differing foundation properties, because of the contrast in foundation conditions in passing from made to natural ground, and because of the effect on the drainage of the 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. The fill of these old excavations will be highly variable and may include domestic and agricultural waste; compaction of the fill leading to possible differential settlement of any structure built across the edges of the excavations may necessitate special precautions. 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 occur chiefly south-west of Morpeth and, in comparison with sites elsewhere in the region, are small in area. 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.

Table 7. Made Ground

Site No	Locality	Grid Reference	Area (ha)	*	Excavation (If any)	Composition of fill
1	Hare Wood	176 900	<0.25	R	Site of tile works	?
2	Hebron	19 89	54.00	U		Overburden and waste dump from Butterwell Opencast Site
3	Cottingwood Common	194 871	0.50	R		?
4	Cottingwood Common	194 869	<0.25	R	Site of clay pits	?
5	Kings School, Morpeth	199 869	1.00	R		Redistributed till
6	Morpeth	195 855	0.50	R		Domestic refuse and till
7	Gubeon	169 838	2.50	R	Gubeon Opencast Coal Site	Overburden and waste
8	Tranwell Farm	178 835	9.00	R	Tranwell Opencast Coal Site	Overburden and waste
9	Tranwell Cottages	189 836	0.50	U		Colliery waste
10	Tranwell Farm	182 833	2.00	R	Tranwell Opencast Coal Site	Overburden and waste
11	Crag Plantation Hepscott	199 831	1.00	U		Colliery waste (West Clifton)
12	Glororum	190 824	1.00	R	Glororum Opencast Coal Site	Overburden and waste
13	Watch Hill	158 819	<0.25	U	Sandstone quarry	Partially infilled with quarry waste
14	Tranwell Airfield	165 817	0.50	R	Site of clay pit	?
15	Tranwell Airfield	165 816	0.50	U		?
16	Saltwick	175 800	27.00	R	Saltwick Opencast Coal Site	Overburden and waste
17	West Duddo	1823 7962	<0.25	R	Sandstone quarry	?
18	Bell's Hill	1934 7925	<0.25	R	Sandstone quarry	?
19	Bellasis Farm	1923 7843	<0.25	R	Sandstone quarry	?
20	Kirkley Mill	164 768	0.75	P	Site of clay pits	?
21	Berwick Hill	1718 7544	<0.25	R	Sandstone quarry	?
22	Berwick Hill	1743 7561	<0.25	R	Sandstone	?
23	Berwick Hill	175 756	<0.25	R	Sandstone quarry	
24	Kirk Hill	1662 7518	<0.25	U	Sandstone quarry	Partially infilled with domestic and agricultural waste
25	Limestone Lane	151 731	3.00	R	Site of brick and tile works	?(building rubble noted at surface)
26	Moory Spot Cottages	200 734	1.25	U		Colliery waste (Robert Pit)
27	Moory Spot	200 731	0.50	R	Prestwick Opencast Coal Site	Overburden and waste
28	Prestwick Pit Houses	183 713	4.25	U		Colliery waste (Prestwick Pit)
29	Low Luddick	183 702	<0.25	U		Colliery waste (Pawley Letch Pit)

*. R = restored; U = unrestored; P = partially restored.

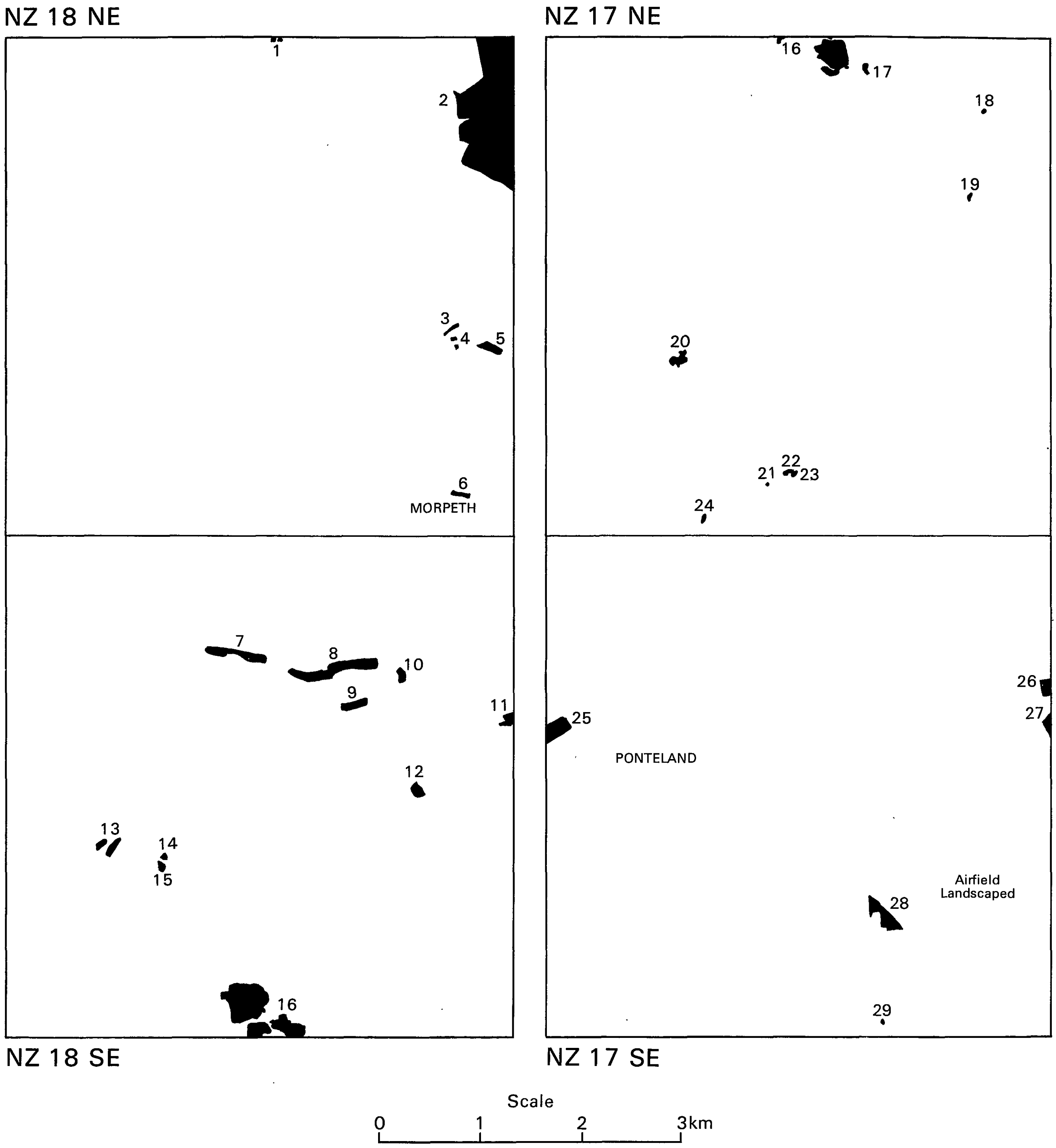


Figure 9. Made ground (for explanation see table 7)

CONCLUSIONS

1. Geological data (boreholes, shafts, mine plans) is far from evenly distributed (c.f. the Millstone Grit crop north of Ponteland with the Coal Measures between Prestwick and Woolsington). The accuracy and reliability of the geological boundaries in an area is dependent upon the density and quality of information in that area.

2. Most of the district has not been affected by coal mining. Undermined areas are restricted to the south-east and isolated areas south-west of Morpeth.

3. The till which covers much of the district 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 thick and variable drift sediments will fail if overloaded or oversteepened.

4. Made ground is of limited extent. There are only six opencast sites; positions and depths of these are well documented.

5. Considerable resources of coal remain within the Coal Measures in the south-east and central parts of the district.

6. Potential resources of sand and gravel occur in the Wansbeck and Font valleys. There is insufficient data for an adequate assessment of their extent, thickness and quality to be made.

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Appendix A : Index of non-confidential boreholes and shafts (including trial pits and adits).

BGS Borehole Registration				Grid Reference East/North		Date Drilling Completed	Surface/ U.ground	Surface Level	Drift Thick.	Borehole Depth
NZ17NE	1			1974	7937	Jul 1946	S	76.20	4.83	45.72
NZ17NE	2		*	1807	7971		S	78.33	1.52	5.94
NZ17NE	3			195	781	1865	S	50.00	1.07	109.73
NZ17NE	4			191	755	1912	S	70.00	46.63	61.57
NZ17NE	5	A		1560	7728	Jul 1963	S	49.62	22.86	25.91
NZ17NE	5	B		1559	7727	Jul 1963	S	51.00	10.66	10.66
NZ17SE	1			1606	7024	Feb 1956	S	121.77	1.88	24.69
NZ17SE	2			1607	7006	1902	S	122.00	3.05	42.27
NZ17SE	3			1603	7001	Aug 1952	S	122.00	3.81	39.62
NZ17SE	4			1977	7360	1936	S	53.00	14.22	34.70
NZ17SE	5			1977	7341	1936	S	53.00	9.98	18.29
NZ17SE	6			1998	7341		S		0.00	64.31
NZ17SE	6	A		1998	7341	Dec 1919	U		0.00	35.38
NZ17SE	6	B		1998	7341	Dec 1919	U		0.00	37.08
NZ17SE	6	C		1998	7341	Jan 1920	U		0.00	4.47
NZ17SE	6	D	*	1998	7341		S	53.00	11.45	119.23
NZ17SE	6	E		1998	7341	Mar 1920	U		0.00	39.70
NZ17SE	7			1901	7331	Jun 1909	S	52.00	13.66	40.23
NZ17SE	8			1898	7331	Jul 1909	S	52.00	13.31	15.44
NZ17SE	9			1879	7315	Apr 1952	S	53.00	25.40	30.48
NZ17SE	10			1977	7315	1913	S	56.00	4.19	18.29
NZ17SE	11			1972	7298	Jan 1892	S	60.00	5.43	121.92
NZ17SE	12			1920	7284	Jul 1924	S	55.00	6.76	60.35
NZ17SE	13			1908	7283	Jun 1913	S	60.00	8.99	52.90
NZ17SE	14			1864	7277	Apr 1952	S	54.00	12.98	15.57
NZ17SE	15			1922	7271	Jun 1913	S	61.00	8.05	28.80
NZ17SE	16			1958	7271	Sep 1937	S	60.00	1.37	20.73
NZ17SE	17			1883	7263		S	60.00	10.11	32.61
NZ17SE	18			1894	7260	May 1913	S	60.00	10.06	40.23
NZ17SE	19			1896	7252	Oct 1952	S	63.00	14.17	91.44
NZ17SE	20			1963	7248	Oct 1937	S	66.00	6.10	45.26
NZ17SE	21			1965	7238	1962	U		0.00	60.96
NZ17SE	22		*	1844	7205		S	71.00	13.72	65.18
NZ17SE	23			1758	7172	1909	S	76.00	7.01	145.64
NZ17SE	24			1987	7122	Apr 1953	S	70.00	19.35	84.25
NZ17SE	25			1852	7110	Aug 1937	S	83.00	19.40	28.17
NZ17SE	26			1726	7113	1902	S	83.00	7.62	162.61
NZ17SE	27			1817	7094	Apr 1926	U		0.00	17.98
NZ17SE	28			1834	7082	Feb 1926	S	92.00	35.05	68.20
NZ17SE	29			1763	7053	Jun 1960	S	88.15	15.90	81.08
NZ17SE	30			1722	7043	Oct 1952	S	97.54	13.72	62.64
NZ17SE	31			1880	7036	Jul 1952	S	80.00	38.76	61.87
NZ17SE	32			1963	7035		U		0.00	46.67
NZ17SE	33		*	1827	7021	1830	S	81.00	34.90	146.24
NZ17SE	34			1834	7014	1828	S	79.00	40.69	90.88
NZ17SE	35			1897	7011	Sep 1902	S	71.00	41.89	256.03
NZ17SE	36			1905	7028	Mar 1964	S	74.57	40.39	119.05
NZ17SE	37			1798	7054	Feb 1965	S	86.04	16.92	20.42
NZ17SE	38			1827	7058	Aug 1965	S	91.44	25.15	83.34
NZ17SE	39			1812	7058	Aug 1965	S	88.53	23.01	60.35
NZ17SE	40			1940	7362	Jul 1966	S	51.91	17.58	56.87
NZ17SE	41			1902	7293					
NZ17SE	42			1921	7339					
NZ17SE	43			1921	7339	Jun 1966	S	52.06	14.33	49.88
NZ17SE	44			1902	7293	Jun 1966	S	58.67	14.94	34.14
NZ17SE	45			1907	7192	Mar 1968	U	-2.04	0.00	37.77
NZ17SE	46			1955	7221	Apr 1968	U	-35.36	0.00	36.98
NZ17SE	47			1957	7196	Jun 1968	U	-49.56	0.00	39.14
NZ17SE	48			1889	7274	Oct 1968	S	60.75	1.83	37.31
NZ17SE	49			1927	7246	Nov 1968	S	67.33		70.87
NZ17SE	50			1914	7268	Jun 1969	S	62.15	3.66	58.88
NZ17SE	51			1923	7268	May 1969	S	59.44		62.61
NZ17SE	52			1951	7178	Aug 1969	U	-50.94	0.00	37.95
NZ17SE	53			1952	7181	Sep 1969	U	-50.94	0.00	31.55
NZ17SE	54			1873	7276	Sep 1969	S	56.17	13.26	26.14
NZ17SE	55			1866	7276	Oct 1969	S	54.74	12.90	19.30
NZ17SE	56			1890	7203	Mar 1970	S	71.62	7.92	36.93
NZ17SE	57			1900	7278	Feb 1970	S	59.86	16.76	52.81
NZ17SE	58			1996	7019	Dec 1970	S	64.50	39.27	174.12
NZ17SE	59	1		1627	7272	Mar 1976	S	58.00	12.00	12.00

* Denotes a shaft

BGS Borehole Registration			Grid Reference East/North		Date Drilling Completed	Surface/ U.ground	Surface Level	Drift Thick.	Borehole Depth
NZ17SE	59	2	1631	7269	Mar 1976	S	59.00	6.00	6.00
NZ17SE	59	3	1623	7270	Mar 1976	S	60.50	6.00	6.00
NZ17SE	59	4	1620	7272	Mar 1976	S	59.50	6.00	6.00
NZ17SE	59	5	1630	7271	Mar 1976	S	57.50	6.00	6.00
NZ17SE	60	a	1606	7182	Dec 1982	S	73.95	10.10	10.10
NZ17SE	60	b	1602	7205	Dec 1982	S	68.56	10.80	10.80
NZ17SE	60	c	1596	7209	Dec 1982	S	66.62	10.70	10.70
NZ17SE	60	d	1587	7217	Dec 1982	S	69.80	11.10	11.10
NZ17SE	60	e	1581	7239	Dec 1982	S	69.27	12.20	12.20
NZ17SE	60	f	1579	7248	Dec 1982	S	61.52	10.50	10.50
NZ17SE	61	a	1512	7378	Apr 1980	S	63.08	3.20	3.20
NZ17SE	61	b	1534	7378	Apr 1980	S	63.44	2.40	2.40
NZ17SE	61	c	1552	7382	Apr 1980	S	61.03	3.20	3.20
NZ17SE	61	d	1574	7382	Apr 1980	S	58.40	3.80	3.80
NZ17SE	61	e	1593	7384	Apr 1980	S	58.53	3.20	3.20
NZ17SE	61	f	1609	7381	Apr 1980	S	59.07	3.20	3.20
NZ17SE	61	g	1627	7377	Apr 1980	S	56.89	3.60	3.60
NZ17SE	61	h	1648	7370	Apr 1980	S	62.75	3.95	3.95
NZ17SE	61	i	1658	7364	Apr 1980	S	62.72	4.00	4.00
NZ17SE	61	j	1673	7353	Apr 1980	S	55.75	4.00	4.00
NZ17SE	61	k	1677	7348	Apr 1980	S	55.08	4.00	4.00
NZ17SE	61	l	1690	7334	Apr 1980	S	54.44	3.20	3.20
NZ17SE	61	m	1698	7328	Apr 1980	S	54.12	3.20	3.20
NZ17SE	61	n	1708	7315	Apr 1980	S	55.00	2.30	2.30
NZ17SE	61	o	1722	7298	Apr 1980	S	54.47	2.50	2.50
NZ17SE	61	p	1730	7292	Apr 1980	S	54.40	2.80	2.80
NZ17SE	61	q	1740	7280	Apr 1980	S	56.21	3.80	3.80
NZ17SE	61	r	1747	7274	Apr 1980	S	57.46	3.80	3.80
NZ17SE	61	s	1752	7267	Apr 1980	S	57.63	3.90	3.90
NZ17SE	61	t	1759	7260	Apr 1980	S	57.08	3.50	3.50
NZ17SE	61	u	1771	7243	May 1980	S	56.74	2.80	2.80
NZ17SE	61	v	1782	7226	May 1980	S	56.00	2.70	2.70
NZ17SE	61	w	1789	7214	May 1980	S	62.20	3.70	3.70
NZ17SE	61	x	1798	7200	May 1980	S	67.93	3.30	3.30
NZ17SE	61	y	1807	7184	Apr 1980	S	73.50	3.40	3.40
NZ17SE	62	a	1642	7385	Jul 1980	S	60.72	3.40	3.40
NZ17SE	62	b	1652	7386	Jul 1980	S	60.38	3.65	3.65
NZ17SE	62	c	1668	7388	Jul 1980	S	55.84	3.80	3.80
NZ17SE	62	d	1683	7389	Jul 1980	S	54.43	4.00	4.00
NZ17SE	62	e	1699	7389	Jul 1980	S	53.47	4.00	4.00
NZ17SE	62	f	1713	7390	Jul 1980	S	57.54	3.80	3.80
NZ17SE	62	g	1728	7390	Jul 1980	S	58.43	3.80	3.80
NZ17SE	62	h	1738	7389	Jul 1980	S	57.28	3.20	3.20
NZ17SE	62	i	1748	7389	Jul 1980	S	55.59	3.70	3.70
NZ17SE	62	j	1764	7385	Jul 1980	S	53.89	2.70	2.70
NZ17SE	62	k	1771	7377	Jul 1980	S	53.42	3.50	3.50
NZ17SE	62	l	1778	7365	Jul 1980	S	53.19	3.20	3.20
NZ17SE	62	m	1781	7350	Jul 1980	S	53.20	2.40	2.40
NZ17SE	62	n	1782	7333	Jul 1980	S	53.20	2.70	2.70
NZ17SE	62	o	1785	7305	Jul 1980	S	53.32	3.80	3.80
NZ17SE	62	p	1787	7290	Jul 1980	S	56.98	2.90	2.90
NZ17SE	62	q	1788	7279	Jul 1980	S	57.01	2.40	2.40
NZ17SE	62	r	1789	7270	Jul 1980	S	57.64	3.20	3.20
NZ17SE	62	s	1791	7261	Jul 1980	S	56.25	2.40	2.40
NZ17SE	62	t	1791	7250	Jul 1980	S	55.61	3.80	3.80
NZ17SE	62	u	1793	7240	Jul 1980	S	59.72	3.50	3.50
NZ17SE	62	v	1794	7230	Jul 1980	S	59.94	3.20	3.20
NZ17SE	62	w	1795	7220	Jul 1980	S	62.30	3.50	3.50
NZ17SE	63	a	1948	7298	Jul 1972	S	56.00	1.98	1.98
NZ17SE	63	b	1945	7295	Jul 1972	S	56.00	1.19	1.19
NZ17SE	63	c	1943	7291	Jul 1972	S	56.00	1.98	1.98
NZ17SE	63	d	1937	7284	Jul 1972	S	59.00	2.29	2.29
NZ17SE	63	e	1933	7281	Jul 1972	S	60.00	2.69	2.69
NZ17SE	63	f	1927	7276	Jul 1972	S	58.00	2.90	2.90
NZ17SE	63	g	1924	7273	Jul 1972	S	58.00	2.90	2.90
NZ17SE	64	C1	1639	7174	Oct 1980	S	70.04	3.20	3.20
NZ17SE	64	C2	1648	7177	Oct 1980	S	70.59	2.90	2.90
NZ17SE	64	C3	1658	7180	Oct 1980	S	69.45	3.20	3.20
NZ17SE	64	C4	1668	7182	Oct 1980	S	68.64	3.70	3.70
NZ17SE	64	C5	1675	7183	Oct 1980	S	67.47	3.70	3.70

* Denotes a shaft

BGS Borehole Registration	Grid Reference East/North		Date Drilling Completed	Surface/ U.ground	Surface Level	Drift Thick.	Borehole Depth
NZ17SE 64 C6	1687	7185	Oct 1980	S	65.95	4.20	4.20
NZ17SE 64 C7	1694	7186	Oct 1980	S	64.19	4.10	4.10
NZ17SE 64 C8	1701	7187	Oct 1980	S	60.24	4.10	4.10
NZ17SE 64 C9	1709	7188	Oct 1980	S	60.37	3.20	3.20
NZ17SE 64 C10	1719	7190	Oct 1980	S	65.03	3.90	3.90
NZ17SE 64 C11	1726	7192	Oct 1980	S	67.31	3.20	3.20
NZ17SE 64 C12	1734	7195	Oct 1980	S	67.67	3.20	3.20
NZ17SE 64 C13	1741	7196	Oct 1980	S	67.36	3.20	3.20
NZ17SE 64 C14	1752	7200	Oct 1980	S	66.17	3.20	3.20
NZ17SE 64 C15	1761	7203	Oct 1980	S	65.30	3.20	3.20
NZ17SE 65	1997	7338					
NZ17SE 66	1892	7312		U			
NZ17SE 67	* 1855	7256		S			9.14
NZ17SE 68	1930	7247		S			
NZ17SE 69	* 1927	7245		S			
NZ17SE 70	* 1925	7243		S			
NZ17SE 71	* 1850	7245		S			16.45
NZ17SE 72	* 1840	7223		S			14.63
NZ17SE 73	* 1865	7215		S			36.58
NZ17SE 74	* 1824	7205		S			
NZ17SE 75	* 1843	7204		S			32.92
NZ17SE 76	* 1830	7198		S			
NZ17SE 77	* 1824	7197		S			
NZ17SE 78	* 1821	7192		S			
NZ17SE 79	* 1837	7189		S			
NZ17SE 80	* 1817	7181		S			
NZ17SE 81	* 1821	7176		S			
NZ17SE 82	* 1827	7177		S			
NZ17SE 83	* 1807	7169		S			
NZ17SE 84	* 1821	7166		S			
NZ17SE 85	* 1843	7165		S			47.55
NZ17SE 86	* 1841	7162		S			23.77
NZ17SE 87	* 1826	7151		S			42.06
NZ17SE 88	* 1822	7151		S			
NZ17SE 89	* 1791	7182		S			
NZ17SE 90	* 1795	7148		S			
NZ17SE 91	* 1809	7140		S			
NZ17SE 92	* 1846	7142		S			62.18
NZ17SE 93	* 1800	7128		S			29.26
NZ17SE 94	* 1826	7127		S			
NZ17SE 95	* 1842	7127		S			
NZ17SE 96	* 1838	7121		S			
NZ17SE 97	* 1837	7119		S			
NZ17SE 98	* 1836	7062		S			
NZ17SE 99	* 1827	7033		S			
NZ17SE 100	* 1794	7022		S			
NZ17SE 101	1801	7023		S			
NZ17SE 102	* 1753	7220		S	6.30	31.00	31.00
NZ17SE 103	* 1858	7004		S			
NZ17SE 104	180	700	Nov 1985	S			
NZ18NE 1	1682	8950	May 1974	S	120.00	1.14	44.81
NZ18NE 2	1673	8781	Mar 1912	S	87.78		33.83
NZ18NE 3	1834	8740	1938	S	70.00	20.12	52.58
NZ18NE 4	1873	8799	1932	S	79.00	18.46	165.71
NZ18NE 5	1820	8864	1897	S	95.00	5.38	27.53
NZ18NE 6 C	1787	8509	Oct 1959	S	70.29	4.88	4.88
NZ18NE 6 13	1785	8513	Oct 1959	S	68.85	11.28	11.28
NZ18NE 6 14	1777	8525	Nov 1959	S	66.60	11.89	11.89
NZ18NE 6 15	1768	8545	Dec 1959	S	62.97	14.02	14.02
NZ18NE 6 16	1769	8621	Oct 1959	S	67.52	13.72	13.72
NZ18NE 6 17	1783	8656	Oct 1959	S	69.22	9.75	9.75
NZ18NE 6 18	1791	8675	Oct 1959	S	69.34	6.40	6.40
NZ18NE 6 19	1801	8696	Nov 1959	S	64.06	6.10	6.10
NZ18NE 6 20	1807	8706	Nov 1959	S	68.98	3.05	3.05
NZ18NE 6 21	1814	8722	Nov 1959	S	72.34	4.27	4.27
NZ18NE 6 22	1818	8738	Nov 1959	S	70.37	6.71	6.71
NZ18NE 6 23	1821	8777	Dec 1959	S	76.87	3.66	3.66
NZ18NE 6 24	1822	8816	Dec 1959	S	84.73	6.10	6.10
NZ18NE 6 25	1820	8829	Dec 1959	S	90.16	3.05	3.05
NZ18NE 6 26	1821	8838	Dec 1959	S	90.57	3.05	3.05

* Denotes a shaft

BGS Borehole Registration			Grid Reference East/North		Date Drilling Completed	Surface/ U.ground	Surface Level	Drift Thick.	Borehole Depth
NZ18NE	6	27	1822	8853	Dec 1959	S	92.14	6.17	6.60
NZ18NE	6	28	1821	8860	Dec 1959	S	93.57	2.90	2.90
NZ18NE	6	W8	1762	8580	Dec 1959	S	36.94	26.37	36.58
NZ18NE	6	12B	1792	8502	Oct 1959	S	70.29	5.49	5.49
NZ18NE	6	12D	178	851	Oct 1959	S	68.72	7.62	7.62
NZ18NE	6	14A	1767	8545	Dec 1959	S	64.34	6.10	6.10
NZ18NE	6	15A	1767	8551	Dec 1959	S	63.58	7.77	7.77
NZ18NE	6	15B	1762	8597	Oct 1959	S	51.32	3.20	3.20
NZ18NE	6	15C	1765	8609	Jan 1960	S	63.45	7.62	7.62
NZ18NE	6	15D	1768	8606	Oct 1959	S	60.35	3.78	3.78
NZ18NE	6	15E	1765	8613	Jan 1960	S	65.61	8.53	8.53
NZ18NE	6	16A	1770	8625	Oct 1959	S	67.97	15.24	15.24
NZ18NE	6	16B	1772	8630	Oct 1959	S	68.64	7.62	7.62
NZ18NE	6	16C	1774	8634	Oct 1959	S	69.04	9.91	9.91
NZ18NE	6	16D	1776	8640	Oct 1959	S	69.16	9.91	9.91
NZ18NE	6	W16	1765	8561	Nov 1959	S	58.42	30.78	
NZ18NE	7		196	862		S	35.00		
NZ18NE	8		1741	8940	Jul 1982	S	125.00	2.00	50.00
NZ18NE	9	a	1923	8668	Mar 1976	S	61.00	3.60	3.60
NZ18NE	9	b	1927	8668	Mar 1976	S	61.97	4.10	4.10
NZ18NE	9	c	1931	8668	Mar 1976	S	58.86	3.50	3.50
NZ18NE	9	d	1936	8667	Mar 1976	S	53.20	3.20	3.20
NZ18NE	9	e	1926	8663	Mar 1976	S	62.53	3.90	3.90
NZ18NE	9	f	1931	8663	Mar 1976	S	59.83	4.00	4.00
NZ18NE	9	g	1935	8663	Mar 1976	S	54.87	3.50	3.50
NZ18NE	9	h	1940	8663	Mar 1976	S	49.67	3.30	3.30
NZ18NE	9	i	1927	8670	Mar 1976	S	60.09	4.00	4.00
NZ18NE	9	j	1933	8665	Mar 1976	S	57.82	3.50	3.50
NZ18NE	10	a	1818	8750	Jan 1966	S	72.94	12.34	12.34
NZ18NE	10	b	1820	8749	Jan 1966	S	73.28	9.30	9.30
NZ18NE	10	c	1820	8751	Jan 1966	S	72.94	9.14	9.14
NZ18NE	10	d	1818	8753	Jan 1966	S	72.91	9.14	9.14
NZ18NE	11	a	1821	8851	Jan 1966	S	92.33	5.64	6.10
NZ18NE	11	b	1821	8854	Jan 1966	S	92.02	5.80	6.10
NZ18NE	11	c	1824	8850	Jan 1966	S	91.66	7.24	7.62
NZ18NE	11	d	1824	8852	Jan 1966	S	91.47	6.10	6.40
NZ18NE	12	a	1761	8579	Feb 1966	S	36.67	17.91	17.91
NZ18NE	12	b	1763	8578	Feb 1966	S	36.79	6.01	6.01
NZ18NE	12	c	1761	8576	Feb 1966	S	36.33	12.57	12.57
NZ18NE	12	d	1763	8576	Feb 1966	S	36.45	6.55	6.55
NZ18NE	12	e	1762	8572	Mar 1966	S	33.13	13.11	13.11
NZ18NE	12	f	1764	8573	Mar 1966	S	32.64	9.30	9.30
NZ18NE	12	g	1762	8570	Mar 1966	S	32.67	3.05	3.05
NZ18NE	12	h	1764	8571	Mar 1966	S	31.88	2.06	2.06
NZ18NE	12	i	1765	8567	Apr 1966	S	33.22	9.60	9.60
NZ18NE	12	j	1764	8566	Mar 1966	S	34.14	6.55	6.55
NZ18NE	12	k	1763	8567	Mar 1966	S	33.56	6.55	6.55
NZ18NE	12	l	1762	8563	Mar 1966	S	48.37	6.55	6.55
NZ18NE	12	m	1763	8564	Jun 1966	S	48.37	6.55	6.55
NZ18NE	12	n	1764	8564	Mar 1966	S	50.11	6.55	6.55
NZ18NE	12	o	1765	8564	Mar 1966	S	49.96	1.12	1.12
NZ18NE	12	p	1764	8565	Mar 1966	S	46.45	6.55	6.55
NZ18NE	13	A	1792	8877	1970	S	104.55	1.63	1.63
NZ18NE	13	B	1785	8883	1970	S	108.20	1.60	1.60
NZ18NE	13	C	1780	8890	1970	S	112.78	2.44	2.44
NZ18NE	13	D	1776	8896	1970	S	116.43	2.74	2.74
NZ18NE	13	E	1770	8906	1970	S	117.65	2.67	2.67
NZ18NE	13	F	1765	8914	1970	S	119.79	2.74	2.74
NZ18NE	13	G	1760	8925	1970	S	123.75	1.82	1.82
NZ18NE	13	H	176	893	1970	S	124.97	1.83	1.83
NZ18NE	13	I	175	894	1970	S	123.75	1.68	1.68
NZ18NE	13	J	175	895	1970	S	120.70	1.47	1.47
NZ18NE	13	K	175	896	1970	S	116.74	1.60	1.60
NZ18NE	13	L	174	897	1970	S	115.52	1.68	1.68
NZ18NE	13	M	174	898	1970	S	113.40	1.60	1.60
NZ18NE	14		1976	8594		S	60.00	29.87	49.38
NZ18NE	15		1996	8588		S	60.00	31.62	38.02
NZ18SE	1		1770	8356	Apr 1929	S	107.00	2.89	48.76
NZ18SE	2		1769	8358	Oct 1934	S	106.37	2.97	52.27
NZ18SE	3		1768	8249		S	107.00	9.14	16.23

* Denotes a shaft

BGS Borehole Registration			Grid Reference East/North		Date Drilling Completed	Surface/ U.ground	Surface Level	Drift Thick.	Borehole Depth
NZ18SE	4		1766	8229		S	100.00	5.79	13.92
NZ18SE	5		1786	8244	Jun 1939	S	107.00	6.55	33.53
NZ18SE	6		1798	8247	Jul 1939	S	104.00	2.54	36.90
NZ18SE	7		1883	8121	May 1928	S	80.00	10.06	10.06
NZ18SE	8		1880	8123	Nov 1940	S	81.00	10.36	53.34
NZ18SE	9		1879	8119	Jun 1926	S	80.00	11.27	49.68
NZ18SE	10		1720	8095	Sep 1825	S	93.00	1.90	82.37
NZ18SE	11		1719	8047	Sep 1763	S	93.00	9.14	53.39
NZ18SE	12		1659	8134	Mar 1960	S	103.94	2.13	152.40
NZ18SE	13		1813	8288		S	90.00	1.83	81.68
NZ18SE	14		1948	8496	1875	S	61.00	11.33	110.03
NZ18SE	15		1959	8348	Jun 1946	S	70.99	2.44	28.96
NZ18SE	16		1977	8365	1946	S	66.90	1.83	19.81
NZ18SE	17	a *	1926	8131	1899	S	78.00	2.83	19.40
NZ18SE	17	b *	1927	8135	1899	S	78.00	2.03	20.85
NZ18SE	18	*	1983	8124		S	72.24	5.64	25.76
NZ18SE	19		1612	8062		S	78.58	6.20	126.64
NZ18SE	20	*	1980	8123		S			
NZ18SE	21		1660	8184	1959	S	104.62	2.44	85.90
NZ18SE	22	*	1992	8313	1986	S	74.00	4.06	39.42
NZ18SE	23	a	1862	8412	Mar 1966	S	79.80	6.40	6.40
NZ18SE	23	b	186	841	Mar 1966	S	79.16	6.40	6.40
NZ18SE	23	c	1881	8393	Mar 1966	S	79.70	2.89	3.50
NZ18SE	23	d	1881	8395	Mar 1966	S	79.37	4.11	4.57
NZ18SE	24		164	845	1967	S	74.00	7.32	124.51
NZ18SE	25		1795	8498	Oct 1959	S	70.71	6.10	6.10
NZ18SE	26		1799	8493	Oct 1959	S	70.87	6.72	6.72
NZ18SE	27		1801	8490	Oct 1959	S	71.01	3.05	3.05
NZ18SE	28		1813	8475	Oct 1959	S	68.15	6.10	6.10
NZ18SE	29		1819	8468	Nov 1959	S	71.63	6.10	6.10
NZ18SE	30		1824	8460	Sep 1959	S	71.87	6.40	6.40
NZ18SE	31		1849	8427	Sep 1959	S	78.76	4.77	5.79
NZ18SE	32		1883	8392	Sep 1959	S	78.74	2.44	2.44
NZ18SE	33		1914	8366	Sep 1959	S	89.83	10.67	10.67
NZ18SE	34		1931	8351	Sep 1959	S	84.43	5.64	5.64
NZ18SE	35		1940	8344	Sep 1959	S	75.11	0.23	1.52
NZ18SE	36		1966	8322	Sep 1959	S	83.45	0.46	1.22
NZ18SE	37		1979	8310	Sep 1959	S	77.92	5.49	5.49
NZ18SE	38		1985	8313	Sep 1959	S	76.20	1.52	1.52
NZ18SE	39	*	1705	8377		S			
NZ18SE	40	*	1715	8377		S			
NZ18SE	41	*	1719	8373		S			
NZ18SE	42	*	1756	8374		S			
NZ18SE	43	*	1890	8359		S			
NZ18SE	44	*	1910	8341		S			19.20
NZ18SE	45	*	1877	8337		S			19.20
NZ18SE	46	*	1911	8326		S			
NZ18SE	47	*	1920	8256		S			
NZ18SE	48	*	1902	8235		S			
NZ18SE	49	*	1920	8231		S			
NZ18SE	50	*	1825	8180		S			
NZ18SE	51	*	1893	8098		S		15.85	23.77

* Denotes a shaft

This appendix represents a selective retrieval from the BGS Newcastle Borehole and Shaft Index, currently accessed through a Mimer relational database management system, running on the VAX 8600 at BGS Keyworth. Other data stored against each record includes site name, purpose, client and drilling contractor, reliability and drilling method.

NOTES