TECHNICAL REPORT WA/90/19

Geology and land-use planning: Morpeth–Bedlington–Ashington

Part 2 GEOLOGY

D J D Lawrence and I Jackson

BRITISH GEOLOGICAL SURVEY

TECHNICAL REPORT WA/90/19

Onshore Geology Series

Geology and land-use planning: Morpeth–Bedlington–Ashington

Part 2 GEOLOGY

1:10000 sheets NZ28NW, NW, SW, SE and NZ38NW, SW

Parts of 1:50000 geological sheets 9 (Rothbury), 10 (Newbiggin), 14 (Morpeth) and 15 (Tynemouth)

D J D Lawrence and I Jackson

This study was commissioned by the Department of the Environment, but the views expressed in it are not necessarily those of the Department

Maps and diagrams in this book use topography based on Ordnance Survey mapping

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PREFACE

This report, the second of two presenting the results of a survey of the geology of the Morpeth-Bedlington-Ashington district, describes the geology of the area in detail. A separate volume, Part I, reviews the geological factors relevant to land-use planning and development.

The district is covered by 1:10 000 sheets NZ 28 NW, NE, SW, SE and NZ 38 NW, SW and lies within 1:50 000 geological sheets 9 (Rothbury), 10 (Newbiggin), 14 (Morpeth) and 15 (Tynemouth). 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 between 1867 and 1879. A resurvey by G.A. Burnett, V.A. Eyles and A. Fowler between 1929 and 1950 was published on the New Meridian.

The present survey, which was funded jointly by the Department of the Environment and the British Geological Survey, revised the geological maps and prepared thematic maps designed for use by planners and developers. It was undertaken between 1986 and 1989 by I. Jackson (NZ 28 NE, SE, NZ 38 SW) and D.J.D. Lawrence (NZ 28 NW, SW, NZ 38 NW).

Mr P.J. Brand provided biostratigraphic contributions. Mr P.J. Robson advised on the establishment of the computerised borehole database and together with colleagues in the BGS Information and Central Services Unit and NERC Computing Services provided invaluable assistance in computer techniques. The programme managers were Dr. D.J. Fettes (BGS) and Mr. H. Mallett (DOE).

Uncoloured dyeline copies of the 1:10 000 geological sheets may be obtained through the BGS Maps Sales Department.

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January 1990

EXPLANATORY NOTES

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

Reports are also available for the following 1:25 000 sheets:

NZ15: Chopwell, Rowlands Gill, Consett and Stanley

NZ25: Kibblesworth, Birtley, Craghead and Chester-le-Street

NZ27: Cramlington, Killingworth and and Wide Open

NZ17E & 18E: Ponteland-Morpeth

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 28 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. 28 SE 58).

The word 'district' unqualified, in this account means the whole ground covered by NZ 28 NW, NE, SW, SE and NZ 38 NW and SW.

LIMITATIONS

This report and accompanying maps have been produced by the collation and interpretation of geological and related data from a wide variety of sources. However, the data are not comprehensive and do vary in quality. It is inevitable that this will be reflected in the documents presented; local features and conditions may not be represented and many boundaries may be approximate.

The maps of Coal Measures strata in Figures 8 to 74 have been computer-generated from digital data. Areas of working have been generalized from large scale mine plans, which should be consulted for detailed information (see Appendix). Seam isopachs are based on computer analysis of borehole data and refer to thickness of coal only, dirt bands are excluded. Interval and sandstone thickness diagrams are also generalized from computer analysis of borehole data. While providing an indication of geological conditions likely to be encountered, this report **cannot and should not** replace site-specific surveys aimed at evaluating potential resources or hazards.

The maps were constructed in May 1989, no information subsequent to that date has been taken into account.

CONFIDENTIALITY

Confidential data, chiefly British Coal Opencast Executive prospecting information, has been taken into account and used in a generalized way during the preparation of the geological maps and this report, but details of specific boreholes are not individually quoted.

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MAPS

1:10 000 scale standard geological maps (available separately)

NZ 28 NW Pegswood
NZ 28 NE Ashington
NZ 28 SW Nedderton
NZ 28 SE Bedlington
NZ 38 NW Newbiggin
NZ 38 SW Blyth

COVER PHOTOGRAPH

Hawk's Cliff, Newbiggin-by-the-Sea

Taken by Mr T Bain, BGS Photographic Unit

EXECUTIVE SUMMARY

INTRODUCTION

The Morpeth-Ashington-Bedlington area forms part of the Northumberland Coalfield. Coal mining and its decline has left a legacy of reclaimed and unreclaimed spoil heaps, uncharted old workings, subsidence and abandoned shafts. Large areas of variably restored opencast coal and brick clay workings are equally common. Resources of coal and industrial minerals remain, despite the long history of mining and quarrying.

The search for mineral resources, their subsequent extraction and, more recently, site investigations prior to development, have provided a wealth of geological information not available when the district was last surveyed. When set against this background the need for a comprehensive and up-to-date survey on the geological environment is readily apparent.

This study was therefore undertaken to examine and upgrade the geological database and associated datasets and present the results in a form to aid planners, engineers and geologists. Two sets of maps and accompanying reports have been prepared:

Part I (BGS Technical Report WA/90/14, published separately): A series of ten thematic maps at the 1:25 000 scale with an explanatory text (see Table 1).

Part II (this report): An explanatory text for a series of six geological maps at the 1:10 000 scale (available separately).

The study was funded jointly by the Department of the Environment and BGS. The work was carried out by BGS staff at the Newcastle upon Tyne office, with contributions from staff of the BGS Engineering Geology, Biostratigraphy and Hydrogeology Research Groups at Keyworth, Edinburgh and Wallingford.

OBJECTIVES

The detailed objectives of the full study were:

a) To complete, where necessary, new basic field geological mapping of the study area and produce revised maps at 1:10 000 scale.

b) To collect, evaluate and interpret available information on geology, geotechnical properties, ground conditions, geomorphology and hydrogeology.

c) To organise the information obtained into a database /archive.

d) To present basic data and interpretations for selected parts of the study areas as thematic maps and accompanying reports in a form easily understood by planners and others not trained in geology, mining, civil engineering or related disciplines (results published in Part I).

e) To identify the need for further investigations or specialist advice in relation to specific planning and development objectives and proposals (results published in Part I).

METHODOLOGY

The work involved the collation and interpretation of data from many different sources:- a specially commissioned 1:10 000 scale field geological survey, coal exploration boreholes, deep mine and opencast coal abandonment plans, site investigation boreholes and reports, existing geological maps and memoirs and other archival material held by third parties. Computerised databases of borehole and geotechnical information were also established.

Table 1 Presentation of results in 1:25 000 scale maps accompanying the complementary Part 1, Land Use Planning, Report

MAP	TITLE	DESCRIPTION
1	Solid geology	Major rock units named coals, faults
2	Drift geology	Recent and glacial (superficial) deposits
3	Rockhead elevation	Contours at 10m intervals on bedrock surface
4	Drift thickness	Thickness of superficial deposits contoured at 10m intervals
5	Shallow mining	Areas of known, probable and possible coal mining within 30m of surface
6	Made and disturbed ground	Differentiation of artificial deposits, location of landfill sites
7	Borehole and shaft sites	Location of shafts, boreholes, adits and trial pits
8	Engineering geology	Surface rocks and solis classified in geotechnical terms
9	Mineral and water resources (excluding coal)	Potential mineral deposits and sites of extraction
10	Geological factors for consideration in land–use planning	Significant elements from individual thematic maps presented together

PRESENTATION OF RESULTS

This report provides the first comprehensive description of the geology for much of the southern part of the district and is the first detailed account for over half a century of the geology in the northern part. The wealth of information available has been used to undertake a complete revision of the geological maps and seam-by-seam correlation within the district. The biostratigraphy has been compared with that of the adjacent Tynemouth district and, where necessary, palaeontological specimens have been re-examined.

Emphasis is placed on a description of the Upper Carboniferous stratigraphy, in particular the nature and distribution of the coal seams and their intervening strata. Information is displayed as a series of diagrams and isopach maps with descriptive text for each cyclic unit between pairs of vertically adjacent named coals. In the compilation of the report extensive use has been made of the computerised borehole database established for the project. All graphical vertical sections, coal distribution maps and interval thickness maps have been computer-generated.

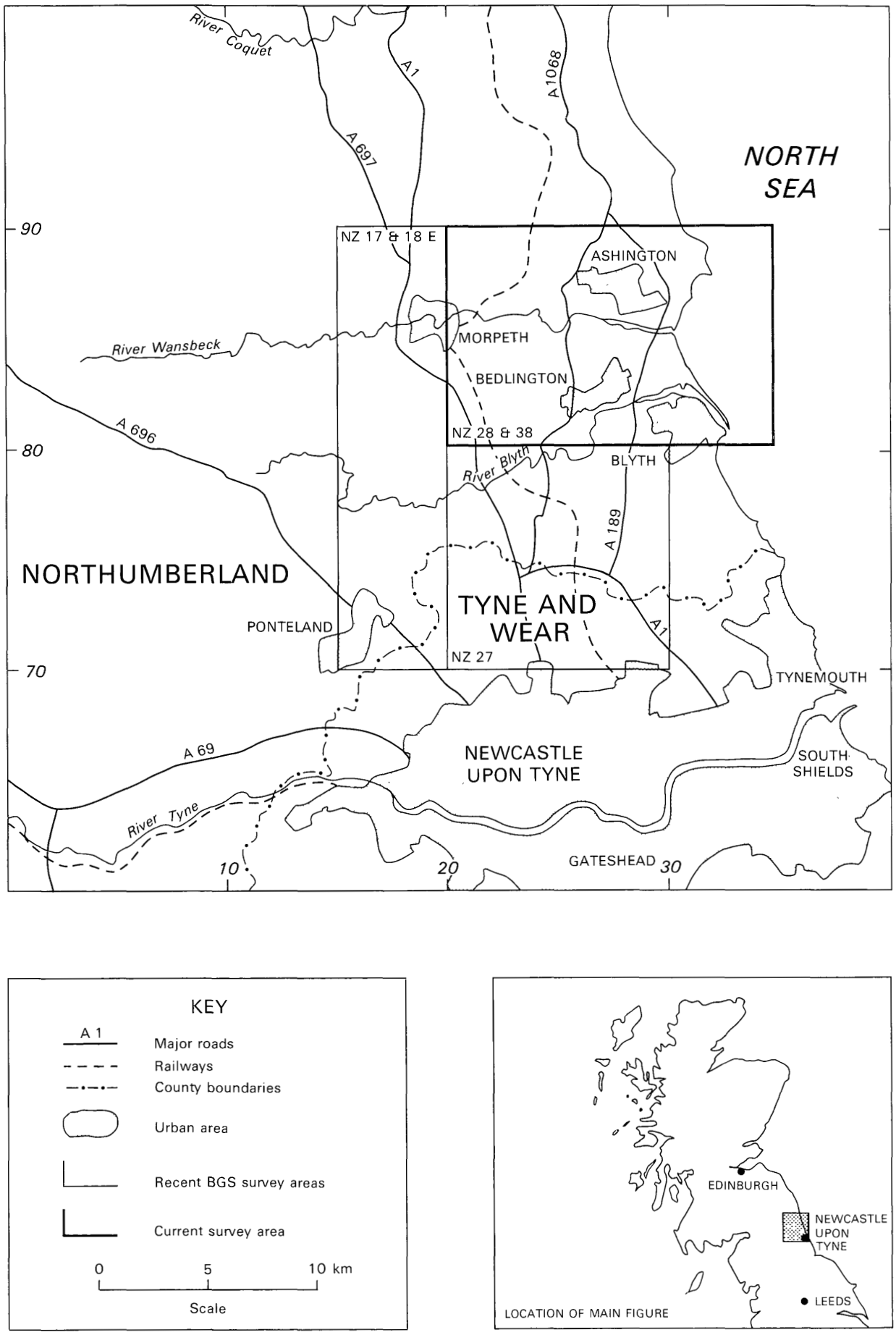


Figure 1. Location diagram

1 INTRODUCTION

OBJECTIVES

This report is the second of two describing the results of a research project funded jointly by the Department of the Environment and the British Geological Survey (Contract PECD 7/1/241). The objectives of the project were to provide an up-to-date geological database for the Morpeth-Bedlington Ashington area as a foundation for land-use and development, effective future geological research and the safeguarding of mineral resources. Part I (BGS Technical Report WA/90/14), available separately, describes the applications for land-use planning and development. The geological results, with particular emphasis on the stratigraphy of the Coal Measures, are presented here. The present study is the third DOE sponsored applied geological mapping project in south-east Northumberland, previous surveys have covered the Cramlington-Killingworth and Morpeth-Ponteland districts (see Figure 1). The British Geological Survey has undertaken these studies as part of the programme to maintain its coverage of 1:10 000 scale geological maps of the UK.

GEOGRAPHICAL SETTING

The area described lies to the north of Newcastle upon Tyne within the Blyth Valley, Castle Morpeth and Wansbeck districts of the County of Northumberland (Figure 1). The built-up areas of Blyth, Morpeth, Ashington, Bedlington, Newbiggin and Stakeford make up a significant proportion (c25%) of the land area, but in the main the district is rural. The east coast rail line and the A1 trunk road cross the district in the west.

Coal mining was for centuries the dominant industry and has left its mark on the landscape in the form of colliery buildings and terraces, shafts, pit heaps and the effects of subsidence. Although underground mining is now confined to one small private mine, opencast coal mining continues and Butterwell, currently one of the largest sites in Europe, is situated in the north-west of the district. With the exception of opencast mining and the large aluminium smelting and electricity generating plants at Lynemouth and Blyth respectively, industry in the district is now chiefly based on small light units in and around the urban areas.

Topographically, the east of the district is a featureless till plain relieved only by the incised valleys of the rivers Blyth and Wansbeck and the low sandstone hills upon which Bedlington and North Seaton stand. In the west the ground is more undulating and, south of Morpeth, rises to over 85 m above sea level. The rivers Blyth and Wansbeck, which drain the area, flow eastwards through gorges to meet the coast at Blyth and Cambois. At Cambois the coast is a dune-fringed sandy bay which separates the low rocky headlands of Newbiggin and Blyth.

DATA SOURCES AND METHODOLOGY

Several centuries of coal mining and, in recent decades, an extensive search for coal seams which could be worked opencast have provided a wealth of geological data for the district. In compiling this report and accompanying maps data from the following sources were collated and interpreted:

* a detailed geological field survey at 1:10 00
* deep mine coal boreholes and shaft records
* deep mine coal abandonment plans
* opencast coal prospecting boreholes
* opencast coal completion plans
* site investigation boreholes, trial pits and re
* existing geological maps
* aerial photographs
* Water Authority data
* Local Authority data
* geological reports and journals

The type, quantity, quality and limitations of each of these data sources are discussed in Part I.

Computerised databases of borehole and geotechnical information comprising more than 40 600 records (i.e. lines of data) were established. Their structure and value, both current and potential, are described in Appendices B and C to Part I. Computer-aided and conventional techniques were used to produce the 1:10 000 scale standard geological maps, the 1:25 000 scale thematic maps and the accompanying reports.

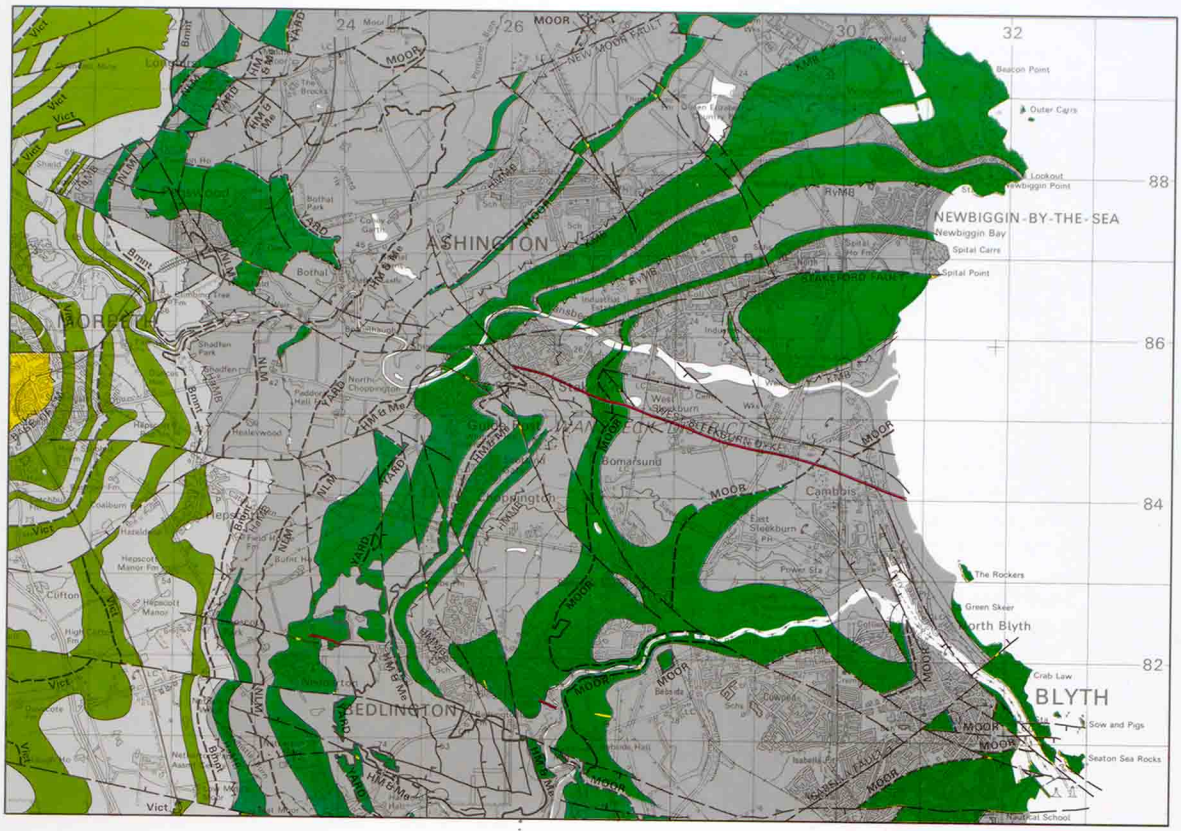
2 GEOLOGICAL SUMMARY

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 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 Tertiary times, 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 continued and most of the solid rocks in the district are now 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 subsequent Devensian glaciation which ended about 12 000 years ago, these deposits 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, along with alluvium and peat are still forming.



KEY

- Middle Coal Measures, undivided
- Sandstone in Middle Coal Measures
- Lower Coal Measures, undivided
- Sandstone in Lower Coal Measures
- Millstone Grit, undivided

- Coal seam
- Fault
- Marine Band
- Dolerite dyke

Opencast extraction is taken into account, but limits of workings are not shown

RyMB	Ryhope Marine Band
KMB	Kirkby's Marine Band
MOOR	Moorland
HMMB	High Main Marine Band
HM & Me	High Main and Metal
YARD	Yard
NLM	Northumberland Low Main
HaMB	Harvey Marine Band
Bmnt	Beaumont
Vict	Victoria
CM	Coal Measures

Scale

0 1 2 3 km

This figure is a simplified portrayal of 1:25 000 scale map 1 which should be consulted for detailed information

Figure 2. Solid geology

3 UPPER CARBONIFEROUS: GENERAL

INTRODUCTION

In the Morpeth-Bedlington-Ashington district there are some 760 m of Upper Carboniferous Strata proved in boreholes and surface exposures. These comprise 60 m of Millstone Grit, 210 m of Lower Coal Measures, and 490 m of Middle Coal Measures. The comprehensive geological description of the Tynemouth District by Land (1974), which includes some 20 km^2 in the south-east of this district, has provided a sound foundation for the description of the Upper Carboniferous geology in this report. However, borehole and mine plan information made available in the past 15 years has enabled substantial revision to be made even in the part of the district described by Land.

The remainder of the district was last surveyed in the period 1922 to 1926. A memoir was published for the northern half, on geological Sheets 9 and 10 (Fowler, 1936), but no memoir was prepared for Sheet 14. This report, therefore, provides the first comprehensive description of the geology for much of the district south of a line between Morpeth and North Seaton and is the first detailed account for over half a century of the geology to the north of this line a period during which the wealth of information from borehole, mine plan and surface and underground exposures has been used to undertake a complete revision of the geological map and seam-by-seam correlation within the district. The biostratigraphy has been compared with that of the Tynemouth District and other coalfields and where necessary palaentological samples have been re-examined.

CLASSIFICATION

The Upper Carboniferous sequence in this district is shown graphically in Figure 3. This classification is based on data from the whole coalfield and on comparison with other fields, because many horizons in this district have yielded a flora and fauna too restricted to be a reliable guide. Table 2 indicates the Westphalian faunal zones adopted throughout north-western Europe.

The boundaries of the divisions of the Carboniferous were originally based entirely on lithology and have been defined at different horizons by different authors. The historical background to the divisions of the Coal Measures used on geological survey maps of England and Wales is given by Stubblefield (1957). In the first edition of the one-inch geological maps on which this district lies, the Coal Measures were undivided. In the first resurvey they were divided into Lower, Middle (or Productive) and Upper Coal groups (Fowler, 1936, p.61). The boundaries of the Middle divisicn were taken at the Victoria (Choppington Brockwell) and Ashington coals. The base of the Coal Measures was taken as a purely arbitrary line within the coarse sandstone beneath the Victoria Seam and more or less parallel to the coal outcrop. In this survey the base of the Coal Measures and the Westphalian Series has been taken at an horizon believed to be equivalent to the Subcrenatum Marine Band (see Lawrence and Jackson, 1986).

DEPOSITIONAL SETTING

During Carboniferous times a major E-W trending structural unit, the Northumberland Trough, stretched across Britain from the North Sea to the Solway Firth. The trough lay between the Northern Pennine (Alston) block to the south and the Southern Uplands of Scotland ridge to the north. The district described in this report formed part of the Northumberland Basin at the eastern end of the trough, probably separated from the Solway Basin to the west by a basement high (see Johnson, 1984). Sedimentation into and within the basin was controlled by the relative rate of subsidence and tectonic evolution of the basin. Detailed consideration of the basin evolution is beyond the scope of this report, but the reader is referred to numerous papers which have been published in the 1970's and 1980's (e.g. Leeder, 1974, 1989; Johnson, 1984; Fielding, 1984, 1989; Collier, 1989; Kimbell et al., 1989).

Differential subsidence between the basin and adjacent blocks was most active during the Dinantian and progressively became reduced in the later Dinantian and Namurian (Johnson, 1984). Active rifting of the Northumberland Basin is thought to have ceased in the early Namurian (Collier, 1989). As the structural barriers between basins progressively lost their influence on

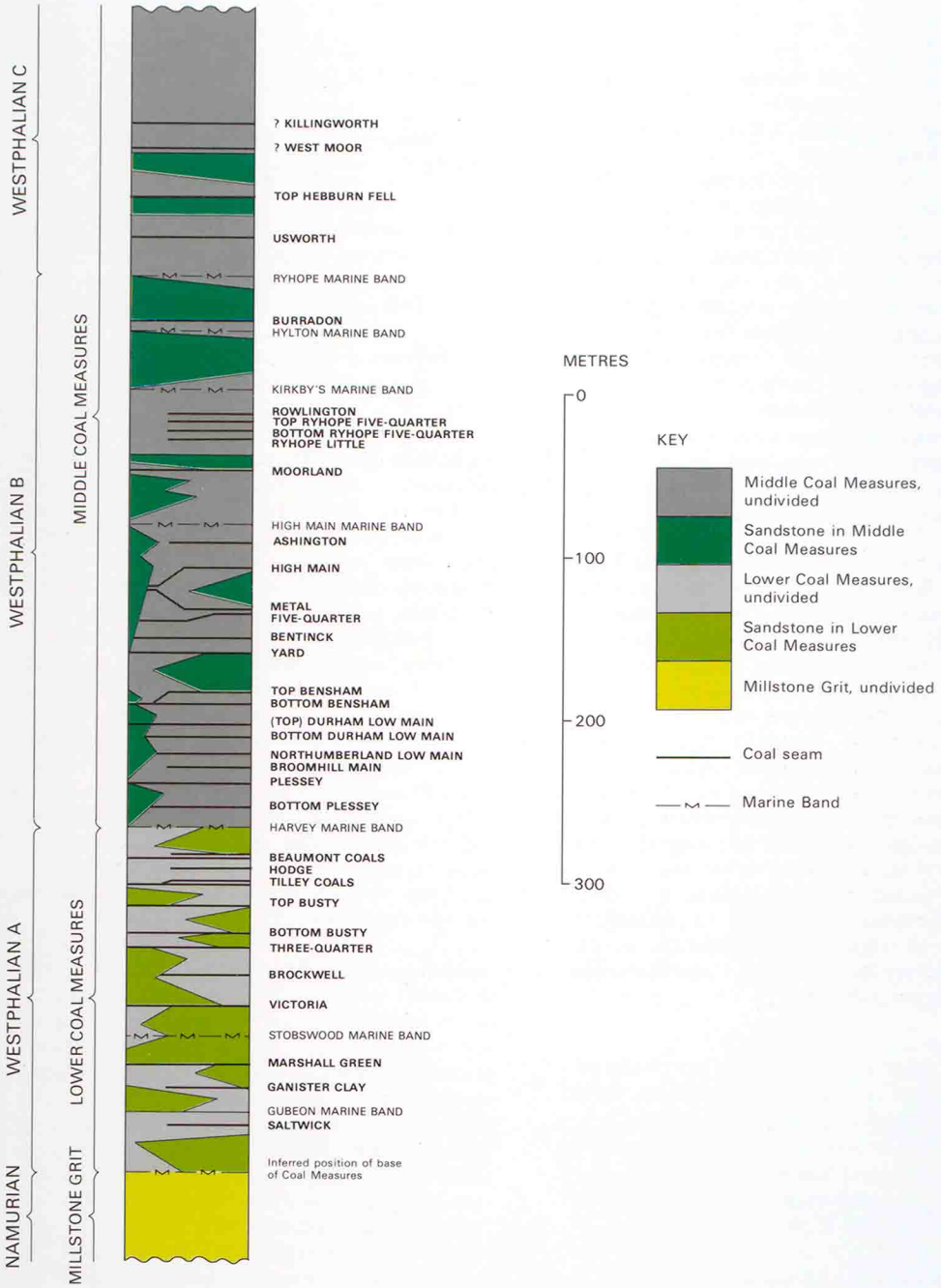


Figure 3. Generalized vertical section

sedimentation a flat lower deltaic plain environment extended from the Northumberland Basin, first northwards then southwards. By the end of the Namurian, the time of deposition of the oldest sediments represented in this district, subsidence of Trough and Block were almost equal. Epeirogenic (thermal) subsidence continued into the Westphalian with an increase in the rate of subsidence and deposition. In Westphalian times the district formed a small fragment of the Pennine depositional province (Calver, 1969, p. 234) and the regional environment of deposition changed from a lower delta plain, close to and below sea-level to an upper delta plain, still near to sea-level, but with more stable terrestrial conditions.

The rate of input of sediment almost kept pace with that of subsidence, but periodic variations in rate led to the establishment of the classic cyclic Coal Measures sequence. Steady influx of clastic sediment was sufficient to maintain a land surface on which forest-swamps were widely developed and thick peat deposits accumulated. Further subsidence, however, caused burial of the peat beds by mud and sand. As the land surface stabilised, more sediment was carried through the region in an established system of river channels rather than being deposited within the area (Johnson, 1984). Fielding (1984a) recognised a threefold hierarchy of depositional controls which operated across the Durham Coal Measures during Westphalian times:

(i) on the large scale, depositional geometry was controlled by patterns of major delta progradation and switching;

(ii) on the medium scale, by a combination of structurally and compactionally induced subsidence (see also Collier, 1989); and

(iii) on the small scale, by local sedimentary processes and subsidence patterns.

Fielding's observations for the Durham Coalfield in a series of papers (1982, 1984a, 1984b, 1986) can be applied to the Northumberland coalfield; a remarkably uniform thickness of Westphalian Coal Measures was laid down over the Northumberland Basin and Alston Block.

SEDIMENTOLOGY

The 'classical' Coal Measures cycle (or cyclothem) has the pattern (younging from 1 to 5):

5 Thick coal
4 Seatearth
3 Siltstone and sandstone
2 Barren mudstone
1 Fossiliferous mudstone

The following description of the constituent lithologies is taken largely from Land (1974, p.11).

Mudstones and siltstones. The bulk of the sediments are mudstones and silty mudstones. These are micaceous, generally barren of fossils apart from plant fragments, and show every gradation from finest mudstone through silty mudstone to fine sandstone. Ripple marks and small-scale cross-bedding are almost universal in siltstones and coarser rocks. A common rock is one composed of interlaminated mudstone and fine sandstone, the laminae generally varying in thickness between 0.05 and 25 mm and being laterally variable and impersistent. Bioturbation and compaction effects such as load-casting, micro-faulting and minor slumping are common. Ironstone nodules, generally flattened parallel with the bedding, are also common, particularly in the few feet above coal seams.

Sandstones. Sandstones are subarkosic, the dominant clastic component being quartz, orthoclase, microcline (commonly perthite), acid plagioclase, muscovite and biotite present in varying amounts. Rather poor sorting and angularity of grain are characteristic features. Common accessory minerals are zircon, garnet, rutile and tourmaline. The rocks are cemented by intergranular kaolinite, chlorite, fine-grained micas and quartz, or by secondary overgrowths leading to interlocking grains, and also in places by patchy calcite, baryte, or pyrite. This patchy cementation is commonest near faults and in coarser rocks.

Veinlets of carbonates and baryte with traces of iron, lead and zinc sulphides are common. Jones (1945) found no great change in mineralogy for samples throughout the Westphalian A and B. However, Haszeldine (1981) concluded that

Coal Measures divisions	Westphalian stages	Marker goniatite bands	Bivalve zones
MIDDLE COAL MEASURES	WESTPHALIAN C Ryhope Marine Band	*'Anthracoceras' hindi*	*Upper Anthracosia similis–Anthraconaia pulchra* Ryhope Marine Band
	WESTPHALIAN B Harvey Marine Band	*'Anthrococeratites' vanderbeckei*	*Lower Anthracosia similis–Anthraconaia pulchra* Bensham Seam *Anthraconaia modiolaris* Top Busty Seam
LOWER COAL MEASURES	WESTPHALIAN A	*Gastrioceras subcrenatum*	*Carbonicala communis* Ganister Clay Seam *Carbonicala lensisulcata*

Table 2 Zonal classification of the Westphalian

the Table Rocks and Seaton Sluice sandstones (see pages 67 and 71) could be separated petrographically and Fielding (1982) suggested that both sorting and diagenesis of sandstones were, in part, environmentally related. Geometrically the sandstones are either thin (generally less than 5 m) widespread sheets ('sheet sandstones') or thick (10 to 50 m) and of elongate, gently curving form in plan ('channel sandstones'). A single sandstone may be in both sheet and channel form in different areas. The sedimentology of these sandstones closely resembles that described by Potter (1962) in the Pennsylvanian of Illinois. Many of the sandstones below the Top Busty Seam are coarse- grained even when in thin sheets, but at higher levels it is generally only the channel sandstones which are coarse. Commonly the channel sandstones occupy washouts which may cut down many feet into underlying strata. Sandstones in washouts generally contain mudstone, ironstone and coal pebbles - many of the last, known colloquially as 'scares', are coalified logs and branches. Practically all sandstones, whatever their grade, are cross-bedded on various scales.

Seatearths. Underlying every coal seam is a seatearth, generally composed of mudstone and characterised by the presence of rootlets and lack of bedding. There is no apparent correlation between the thickness or character of a seatearth and that of the overlying coal. Seatearths are more persistent than their associated coals. In some localities and at some horizons, particularly in the lowest Coal Measures seatearth-sandstones occur, these are known as ganisters. At some levels, seatearths are noticeably brown or green in colour, in contrast to the more prevalent grey. Ironstone nodules are almost ubiquitous in seatearths, and sphaerosiderite is not uncommon.

Coals. The coals of this district are bituminous and show a general increase in rank both downwards and southwards from very weakly caking coals of British Coal (National Coal Board) class 802 to medium or, less commonly, strongly caking coals of class 502 (Jones, 1945). Most of the seams are split by seatearth or mudstone partings, and in places the top leaf of one seam may unite with the next higher seam, or seams.

Such a combination of the Metal and High Main seams gives rise to a maximum thickness (including dirt bands) of over 4 m on the southern edge of the district. Seams also show lateral thickness variations and may even die out. Fielding (1984a, 1984b, 1986) categorises and discusses coal seams splits and thickness variations within the adjacent Durham coalfields. The application of his observations to this district is considered together with the description of variation in individual coal seams in the detailed stratigraphic section of this report.

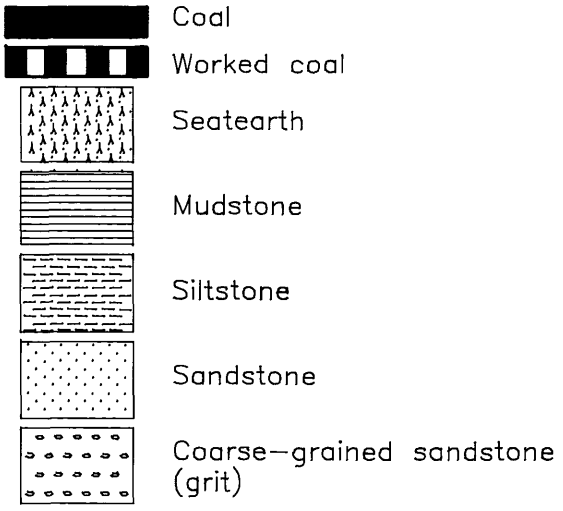
Along with other strata, coal seams are subject to washouts, generally infilled by channel sandstones, and to thermal metamorphism adjacent to igneous dykes (Jones and Cooper, 1970, pp. 59-63, pls. 4-7).

In addition to the usual bituminous coals, thin cannel coals occur at many horizons, particularly in the immediate roof of a normal seam. Cannels are rarely more than a few centimetres thick and are of limited areal extent; they are not associated with any underlying seatearth. They usually contain fish debris and *'Estheria'*.

Fielding (1984a) recognized 13 lithofacies within the Durham coalfield. His lithofacies consist of specific types, or combination of types, of the major constituent lithologies described above and are each given a detailed depositional interpretation (see Fielding 1984a, table 1).

GENERAL STRATIGRAPHY

Owing to the repetitive nature of the succession there is little, apart from local contained fossils, to distinguish one part from another. In describing the stratigraphy of the Coal Measures in this report, the strata between each pair of vertically adjacent, named coal seams or marine bands is considered as a unit. Each unit contains one or more cyclothems. Cyclothems are often incomplete and may show great lateral variation. Even within any one inter-seam interval it is likely that a series of borehole sections from throughout the district taken in isolation would not be readily correlated. Detailed correlation has been made by considering the whole suite of borehole and



Abbreviations at the side of section columns

B	Brachiopods
F	Fish
IR	Ironstone
L	Lingula
~	Mussels
Os	Ostracods
P	Plants

Figure 4 Key for Figures of Vertical Sections

shaft sections, placing particular reliance on the persistence of faunal bands and major coal seams and on the cyclic nature of the succession. Computer analysis of seam interval thickness has been used as an aid to correlation and was particularly valuable in identifying areas of apparent abnormality. Most coals over 1 m thick are confined to strata between the Harvey and High Main marine bands and two groups of strata are dominated by thick widespread sandstones - those between the subcrenatum Marine Band and the Victoria Seam and between the Kirkby's and Ryhope Marine Bands.

SEAM NOMENCLATURE

The evolution of seam correlation in the Northumberland and Durham coalfields since the original work by Buddle (1831a,b) is well described by Land (1974, p.15). Seam nomenclature suffers considerably from homonyms and synonyms, arising both from mis-correlation and from the plethora of local names introduced by private colliery companies. Land (1974, p.16) noted that "on a commercial basis: the value of a newly named seam could be enhanced by association with a name of good repute or by avoiding a name of low repute", hence the repeated use of the names Busty, Main and Yard in the district. Since the nationalisation of the mines British Coal (formerly the National Coal Board) has attempted to assign standard county names and, more recently, index letters to the seams. Traditionally Durham and Northumberland have each a separate set of names. The names used in this report are based largely on the Standard County series, with a few exceptions which are detailed in the text where they occur, as are instances in which this report departs from the nomenclature used by the Geological Survey in the Tynemouth district (Land 1974). The disposition of many of the colliery companies, the seam names they used and a comparison with the standard series and this report are shown in Figure 5 and Table 2.

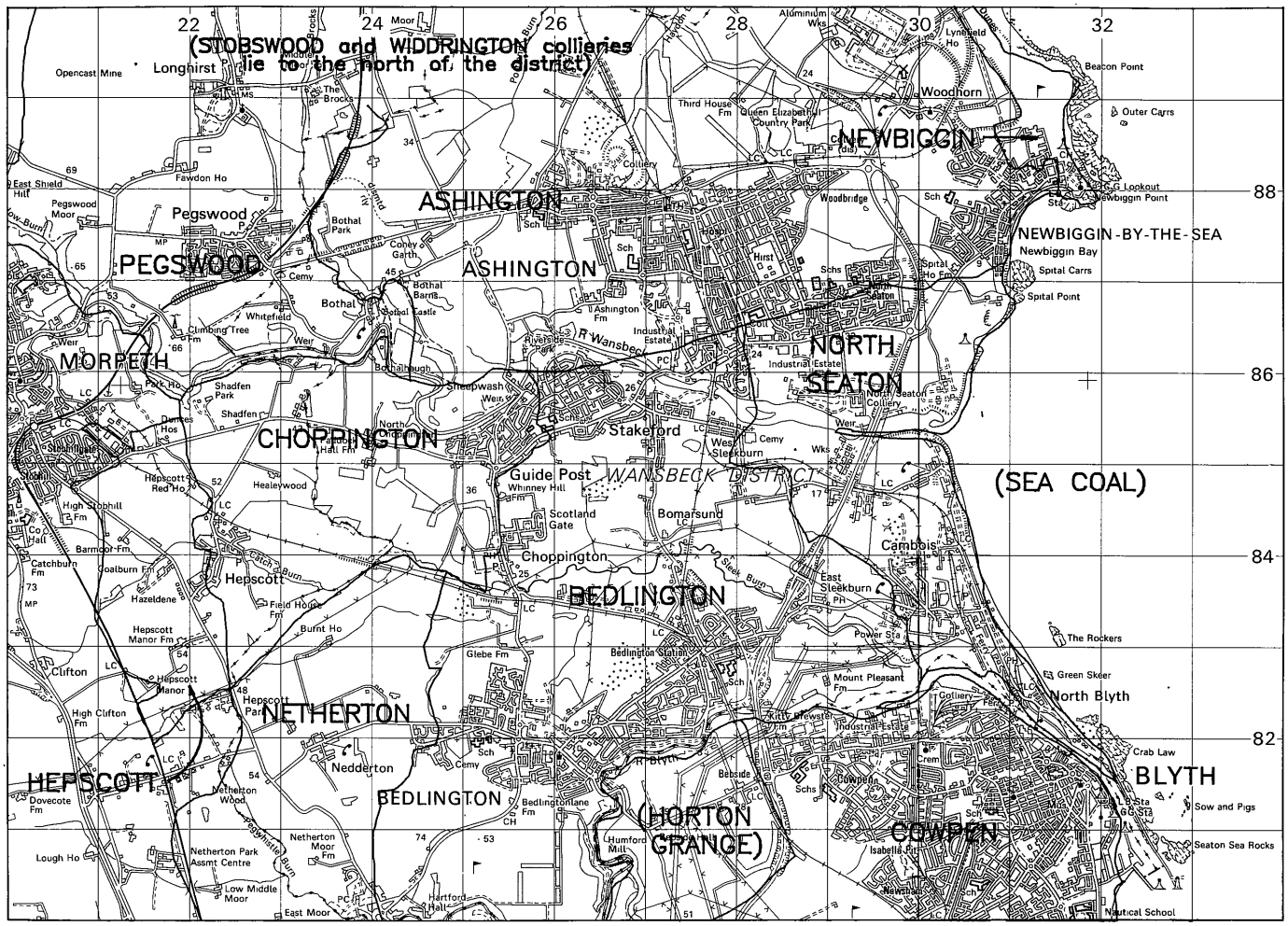


Figure 5 Distribution of colliery companies

Table 3A Coal seam nomenclature, Bensham and above

THIS SURVEY	INDEX LETTER	DURHAM COUNTY NAME	LOCAL COLLIERY NAME (WHERE DIFFERENT FROM THIS SURVEY)					
			ASHINGTON	NEWBIGGIN	NORTH SEATON	CHOPPINGTON	BEDLINGTON	CAMBOIS AND COWPEN
Moorland	DE1		Blackclose					
Ashington	DE2		High Main		High Main			
High Main	E		Top Main		New Main		Top Main [1]	Top Main [1]
Metal	F1		Middle Main		Top Main		Bottom Main	Bottom Main
Five-Quarter	F2		Bottom Main		Bottom Main	Grey		
Bentinck [2]	G1	Top Main				First Below Grey		
Yard	G(2)	Main						
Top Bensham	H1	Top Maudlin		Bensham	Bensham	Bensham	Upper Bensham	Bensham (Duke)
Bottom Bensham	H2	Bottom Maudlin		Stone		Stone	Bensham	Five-Quarter

NOTES: 1 The united High Main and Metal seams (E+F1) are also known as the Top Main
2 The Bentinck is also known as the Top Yard

Table 3B Coal seam nomenclature, Bensham and below

THIS SURVEY	INDEX LETTER	DURHAM COUNTY NAME	LOCAL COLLIERY NAME (WHERE DIFFERENT FROM THIS SURVEY)					
Bensham	H	Maudlin	Quarry					
Durham Low main	J	Five–Quarter	Band					Brass Thill (Little)
Northum–berland Low Main	K	Brass Thill						Hartley (Cowpen)
Broomhill *1* Main	K/L							
Plessey *2*	L							Low Low Main
Bottom *3* Plessey	M	Ruler (Cheeveley)						
Beaumont	N	Harvey				Top Busty	Harvey (Low Yard)	
Hodge	O							
Tilley *4*	P		Band	Yard			Top Busty	
Top Busty *5*	Q1		Harvey		Hepscott (Low Main)			
Bottom Busty	Q2			Top Main	Barmoor			
Three–Quarter	R		Top Busty	Bottom Main	Old Man (Splint)			
Stobswood New	R/S		Little Wonder		Bottom			
Brockwell	S		Bandy		Little			
Victoria *6*	T					Brockwell		
Marshall Green	U					Victoria		

NOTES:

1 ***The Broomhill main is the Hutton of the Tynemouth district (Land, 1974)***

2 ***The Plessey is also known as the Hutton in Northumberland mines***

3 ***The Bottom Plessey is the Cheeveley of the Tynemouth district (Land, 1974) and is known by that name at North Seaton Colliery***

4 ***The Tilley is also known as the Denton Low Main***

5 ***The Top Busty is also known as the Plessey, Low Main or Beaumont in the Morpeth area***

6 ***The Victoria is also known as the Bessie Grey in the Morpeth area***

4 MILLSTONE GRIT

STRATA BELOW THE SUBCRENATUM MARINE BAND

Millstone Grit strata are known from only 3 boreholes within the district (Figure 6). No details are available of the top 20 m or so of the sequence present beneath drift on the western edge of the district at Morpeth. The thickest Millstone Grit succession proved in the district, albeit only 62 m, is in the Ashington Colliery borehole (28 NE 58) and results from it passing through the Stakeford fault and recording the beds on its upthrow side. A grey shale unit which becomes calcareous and shelly near its base, about 16 m above the bottom of the bore, contains a fauna consisting of:-

Serpuloides sp., Rhabdomeson sp., Angiospirifer?, Composita sp., Crurithyris urii, Eomarginifera sp., Linoproductus sp., Orbiculoidea sp., orthotetoid, *Pugilis* cf. *scotica, Rugosochonetes hindi, Schizophoria sp.,* smooth spiriferid, *Euphemites sp., Glabrocingulum sp., Pterinopectinella sp.,* nautiloid (small nodes on shoulder, fine ornament), *Anthracoceras?, Reticuloceras?* This is consistent with an horizon at or about the Pisgah Hill Limestone (Whitehouse Limestone) identified in the adjacent Ponteland - Morpeth district (Lawrence and Jackson, 1986). In the Ashington Colliery borehole the sequence succeeding the 'Limestone' is recorded as follows:-

	m
Shale, grey to dark grey, with brachiopods, *planolites* and some slickensiding (Subcrenatum Marine Band equivalent)	1.2
Sandstone, grey hard, fine-grained, massive, (a typical ganister)	1.2
Shale, silty, micaceous with sandy bands	2.4
Shale, silty in places, dark grey with worm tubes, plant debris near top, brachiopods and lamellibranchs at base (lower marine band)	2.3
Shale, grey, silty with silty sandstone beds up to 0.6 m thick	8.5
Sandstone, pale, grey, massive, medium to course-grained, kaolinitic	6.7
Shale, sandy with rootlets	4.0
Sandstone, pale grey, fine-grained, massive	11.0
Shale, grey, coarse at top, calcareous with thin layers of shell fragments and shaly limestone at base (Pisgah Hill Limestone)	3.7

Some 37m higher in the same borehole there occurs the base of a pair of marine bands 6m apart.

The lower of the bands has a poorly preserved fauna comprising *Brochocarina?, Lingula mytilloides* and *Productus* cf. *carbonarius.* The upper band contained *Lingula sp. Productus carbonarius* and an orthotetid. The other two boreholes recording Millstone Grit Strata (Stannington Nos 1 and 2 boreholes, 28 SW 54 and 28SW 70, respectively), proved medium-grained, false-bedded sandstone beneath the presumed base of the Coal Measures, to a maximum thickness of 26 m in Stannington No.1. This sandstone was informally correlated with the '2nd Grit' of Durham by earlier workers.

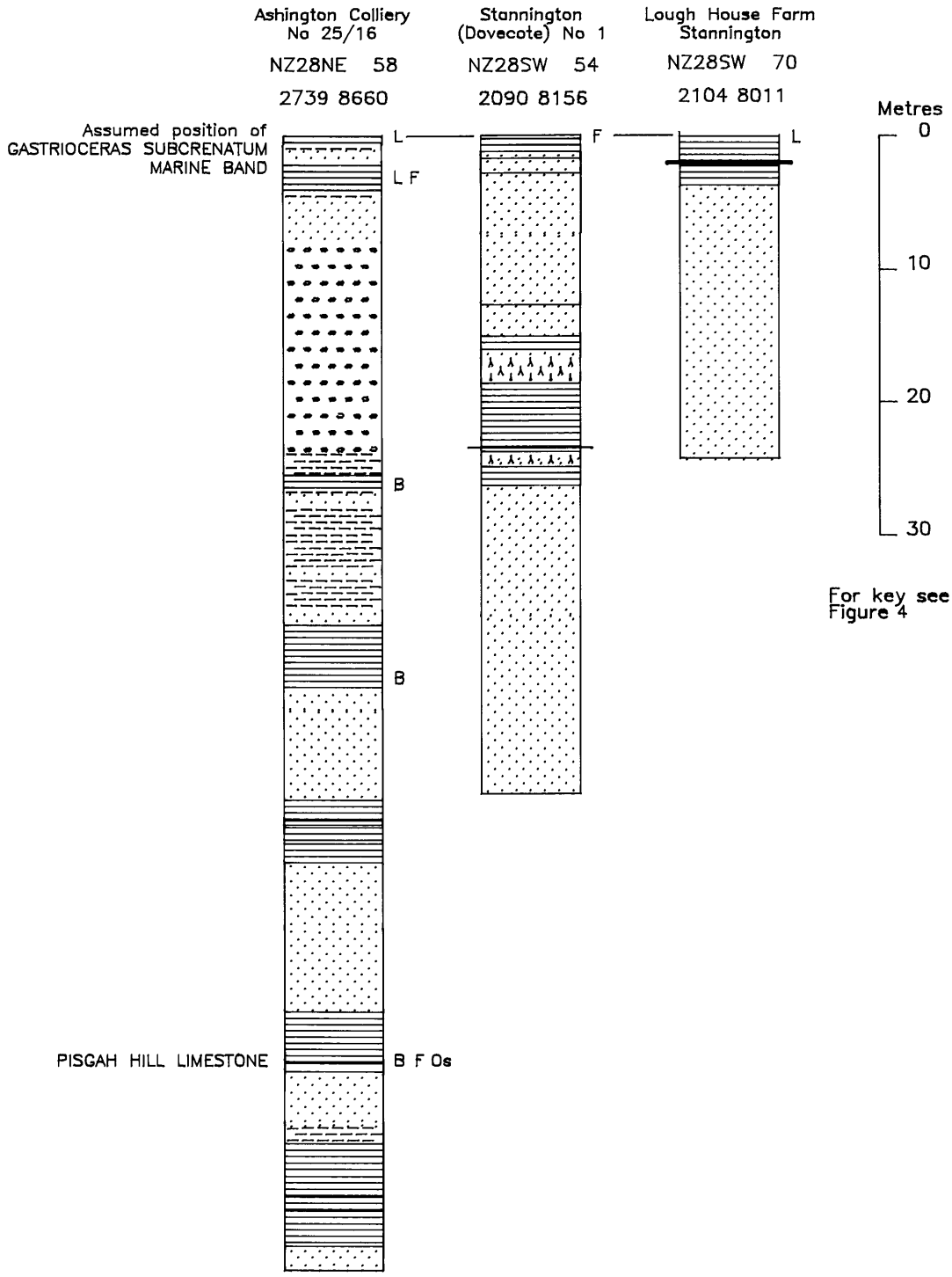


Figure 6 Millstone Grit sections

5 COAL MEASURES

BASE OF COAL MEASURES TO MARSHALL GREEN SEAM

Measures below the Marshall Green Seam have been recorded in thirteen boreholes within the district; only four of these reached the probable base of the Coal Measures. The general succession is illustrated in Figure 7, correlations are based on comparison with the recently surveyed and better known sequence in the Ponteland-Morpeth district to the west (Lawrence and Jackson, 1986).

The assumed equivalent of the **Subcrenatum Marine Band** occurred at a depth of 110 m in the Ashington Colliery borehole (28 NE 58) and yielded *Lingula mytilloides* and *orbiculoidea?*. This horizon corresponds with the 'Top Marine Band' of earlier workers.

The sandstone overlying the marine band is coarse-grained and pebbly towards its base in borehole 28 NE 58 and false-bedded with very coarse-grained layers in Stannington No. 2 borehole. It is possible that, locally, almost the entire interval between the base of the Coal Measures and the Marshall Green Seam is composed of sandstone (e.g. the Barrington Colliery borehole, 28 SE 29b), but generally there are two or three cycles topped by seatearths or thin coals. The lowest of these coal horizons has been correlated with the **Saltwick coal** and is present in the Bedlington 'D' Pit and Stannington No. 2 boreholes (28 SW 62 and 70) west of Bedlington, where it is up to 30 cm thick. The 7 cm coal near the base of borehole 28 SE 29b may also be equivalent to the Saltwick. The marine horizon overlying a thin coal-seatearth some 5 to 10 m above the Saltwick is the possible equivalent of the Gubeon Marine Band. In the Barmoor No. 9 borehole (28 SW 20) it contains *Lingula mytilloides* and the Ashington Colliery borehole (28 NE 56) yielded *Lingula mytilloides*, a productoid fragment and *Orbiculoidea?*.

The succeeding strata comprise sandstone locally exceeding 20 m in thickness and commonly with coarse-grained layers. Garnets were recorded from near the base and midway through the sandstone in the Netherton borehole (28 SW 44). The sandstone is overlain by the presumed equivalent of the **Ganister Clay Seam**. In the south of the district the seam is in two thin leaves, each less than 25 cm and separated by less than 3 cm of mudstone or seatearth-mudstone (e.g. Barmoor Farm No. 8 borehole, 28 SW 13). However, either of the coals may be locally washed out and the seam is probably represented by a mudstone parting in a borehole at Barrington Colliery (28 SE 29b). A horizon 5 m below the presumed Ganister Clay Seam in Bates No. 25 borehole (38 SW 36) contains *Curvirimula* cf. *trapeziforma*, but no comparable fauna has been recovered at this level elsewhere in the district. The 8 to 12 m of measures between the Ganister Clay Seam and overlying Marshall Green Seam are variably mudstone, siltstone and sandstone. Fish scales have been recorded from a dark grey mudstone some 5 m below the Marshall Green in the Barmoor Farm No. 8 borehole, which may be equivalent to the **Well Hill Marine Band** of the Ponteland-Morpeth district (Lawrence and Jackson, 1986).

Marshall Green Seam. The Marshall Green is the lowest major seam in the Coal Measures of the district. Known locally as the Choppington Victoria, it has been proved in boreholes throughout the district with a thickness ranging from 10 to 113 cm (borehole 28 NW 129) and a mean of 55 cm (Figure 8). It is a clean bright coal usually of high quality with ash content generally between 5% and 10% and a sulphur content of less than 0.1%. In the south of the district a dirt band of up to 10 cm is present towards the base of the seam and the seam is locally impoverished in the Newsham area. It is said to have been worked at the two old Cottingwood Pits [205 873] (Fowler, 1936) but the mine plan for the westernmost workings contains no details of levels and the depth of the shaft makes it more likely that the workings were in the Victoria (Choppington Brockwell) seam. There is no other record of the seam being mined within the district, although it was formerly worked to the south-west outside the district (Lawrence and Jackson, 1986).

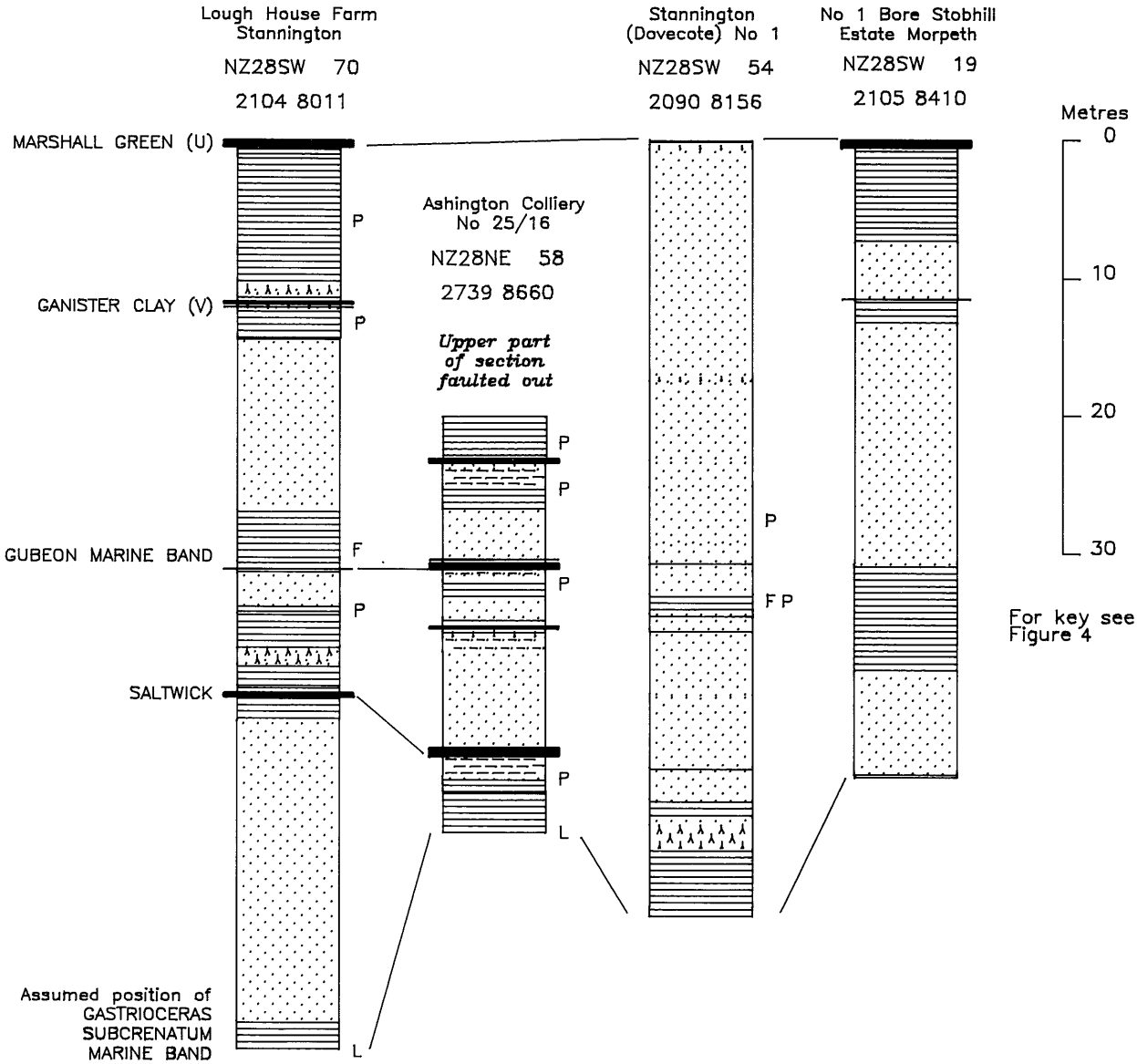
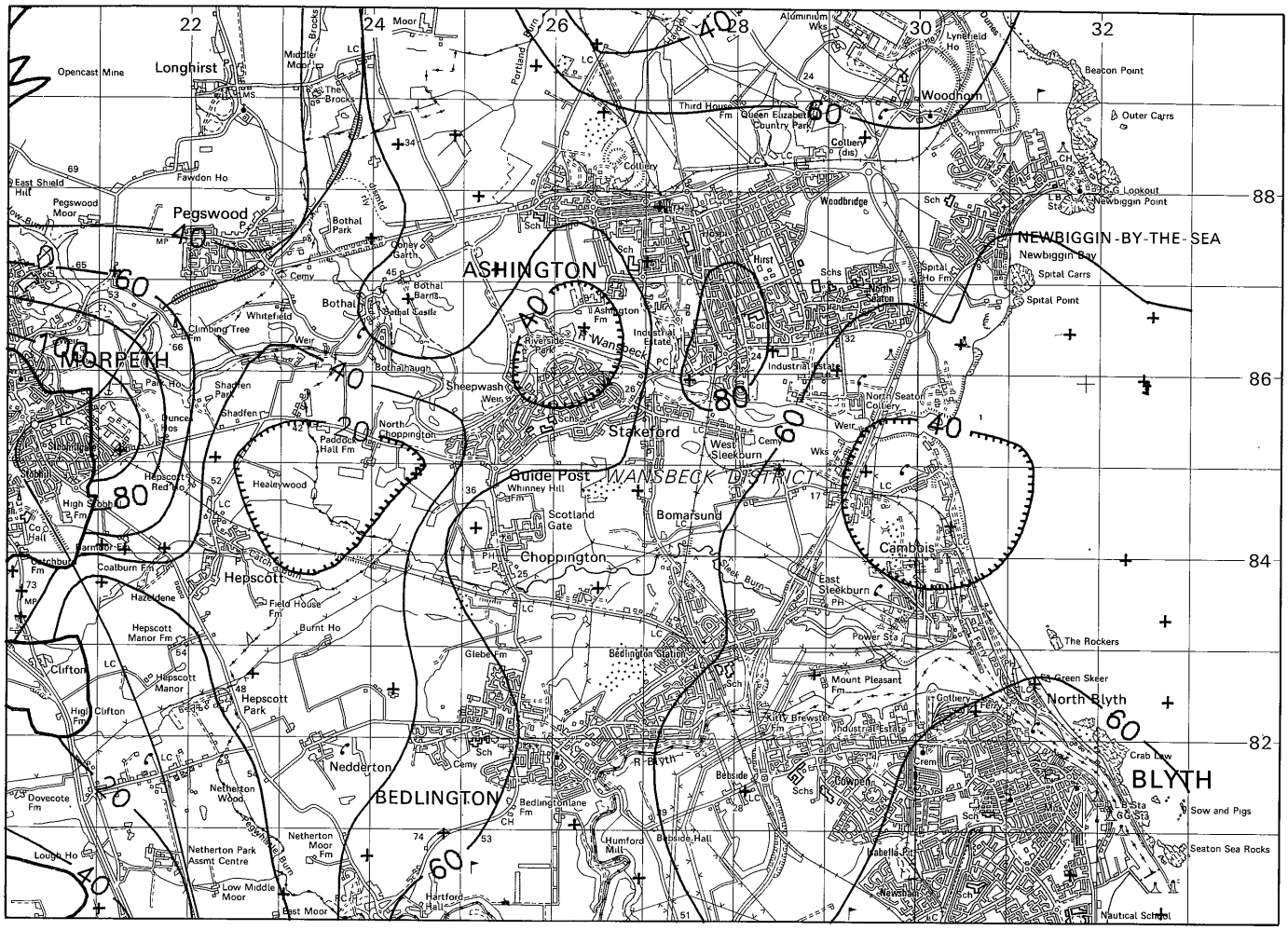


Figure 7 Base of Coal Measures to Marshall Green Seam



0 1 2 3km

Scale

—40— Isopach of Marshall Green Seam (cm) (ornamented on low side of line)

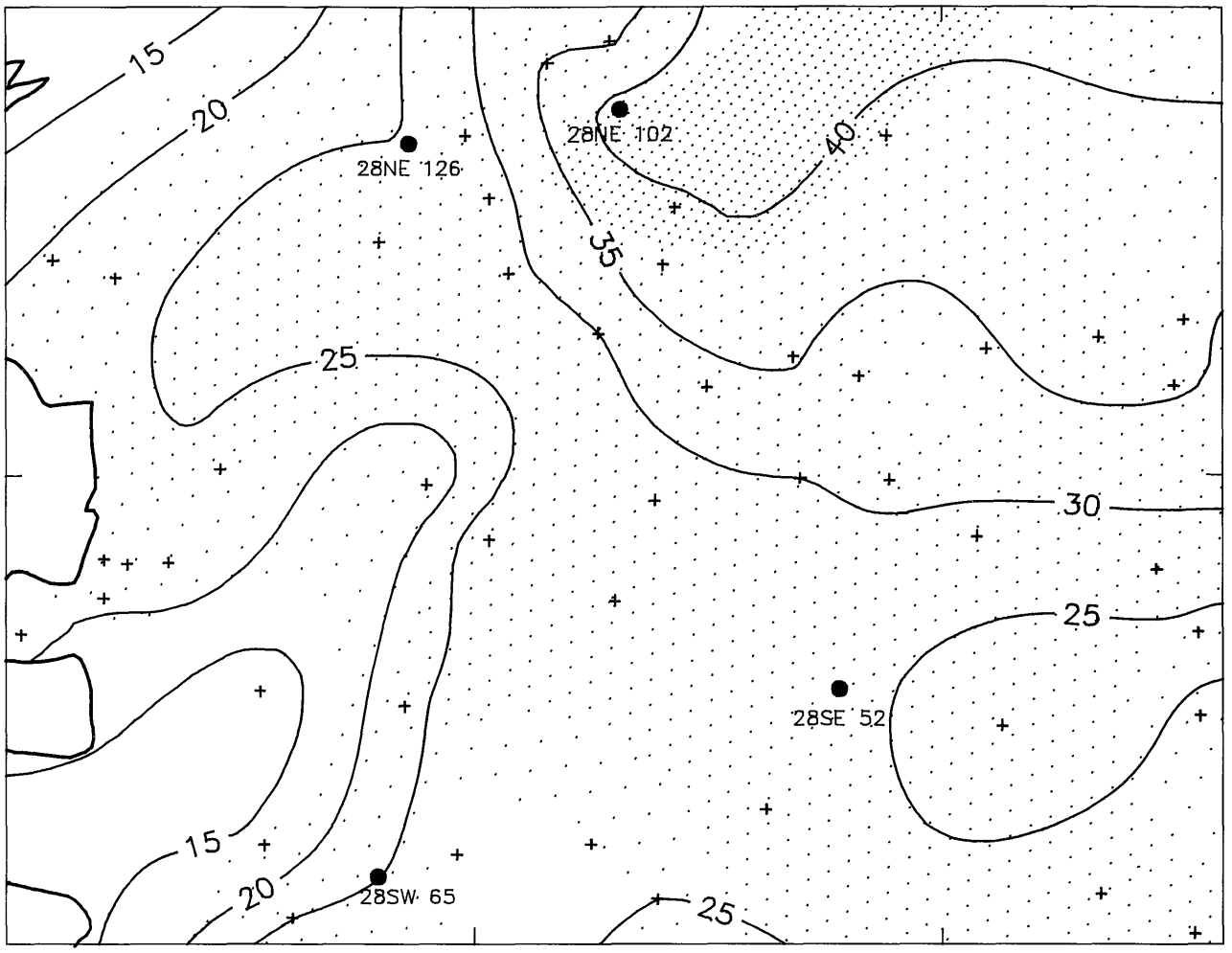
Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal

Style of working

Area of total extraction (goaf)

Figure 8 Marshall Green Seam (U), coal thickness and workings



15 Isopach of Marshall Green to Victoria interval

0 1 2 3km
Scale

Western limit of Marshall Green Seam at outcrop or fault

Sandstone above Marshall Green 5 to 10m thick

Sandstone above Marshall Green 10 to 15m thick

Sandstone above Marshall Green greater than 15m

\+ Bore or Shaft proving interval

● Section figured in report

Figure 9 Basal sandstone in Marshall Green to Victoria Interval

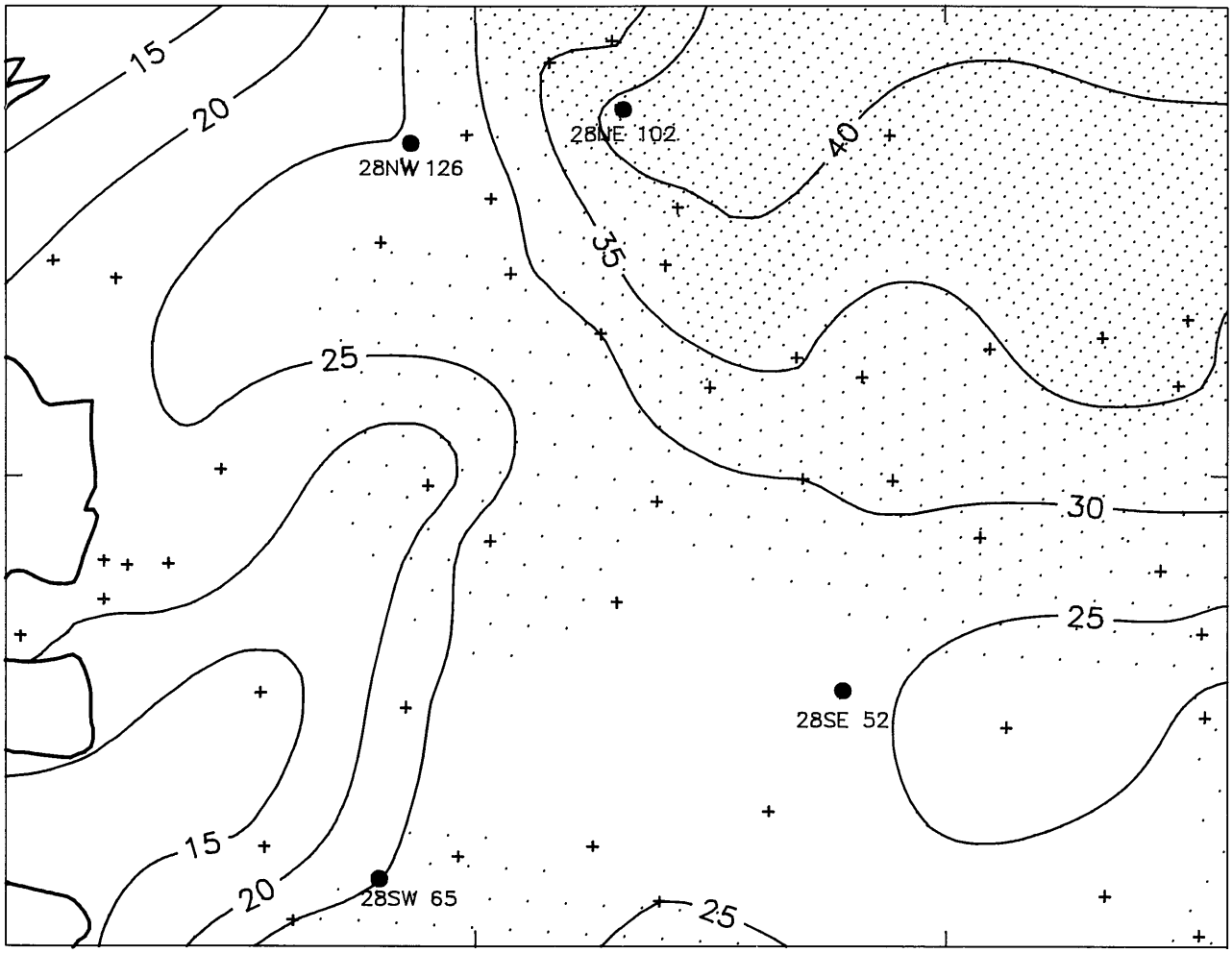


Figure 10 Sandstone above Stobswood Marine Band in Marshall Green Seam to Victoria Seam interval

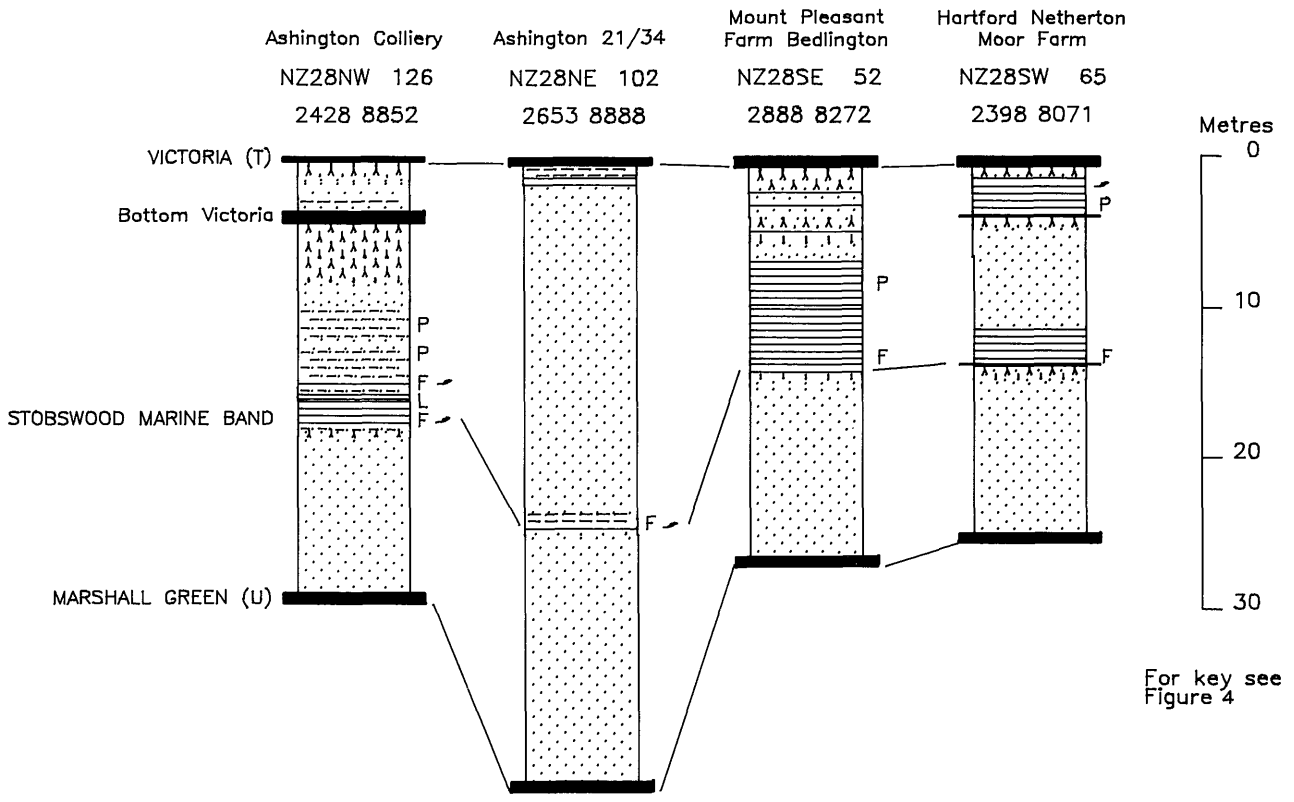


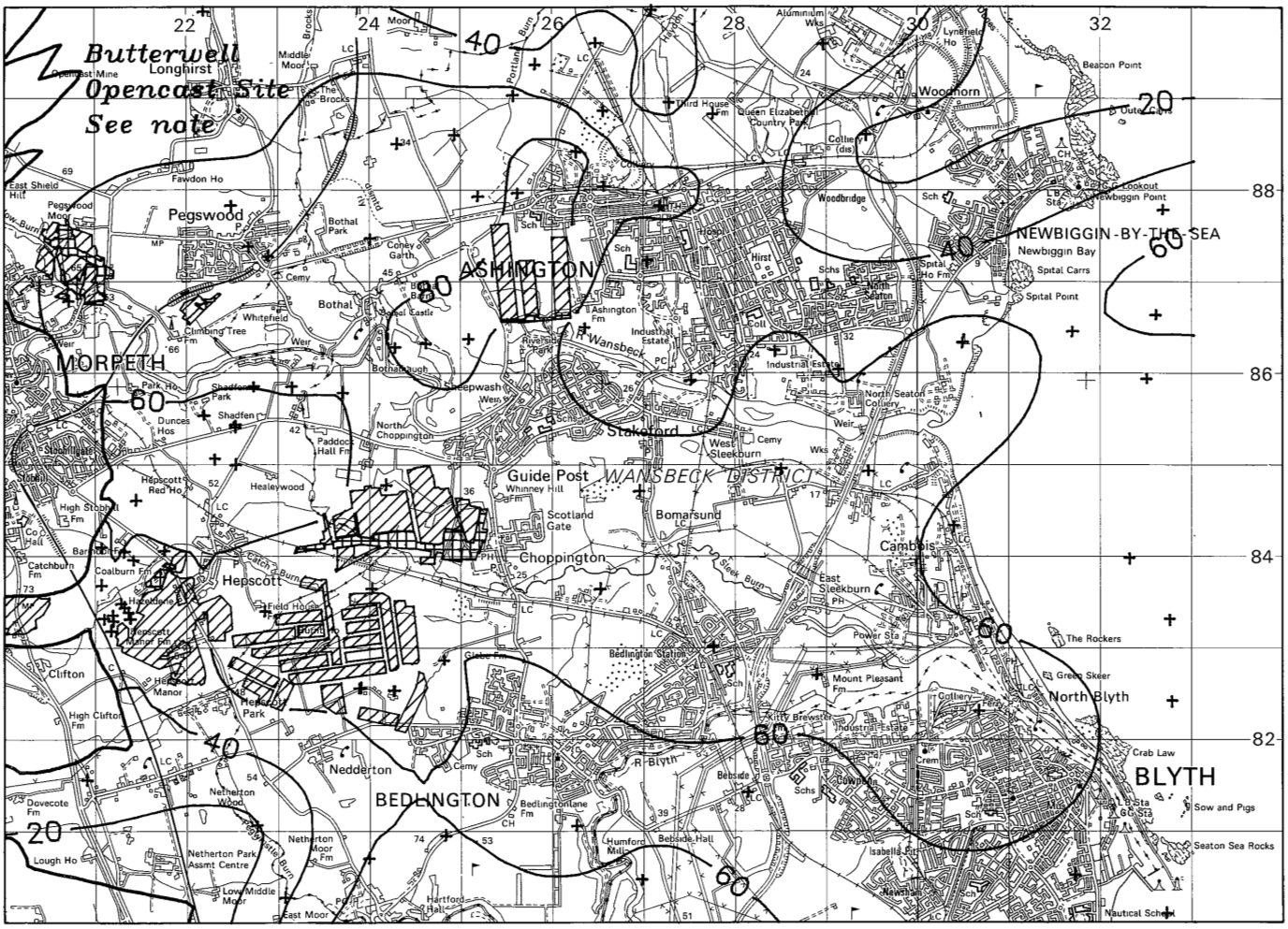
Figure 11 Marshall Green Seam to Victoria Seam interval

MARSHALL GREEN TO VICTORIA

Strata above the Marshall Green. Throughout most of the district the Marshall Green is immediately overlain by a coarse-grained, locally pebbly, sandstone. The sandstone is commonly cross-bedded in the lower and middle part, but becomes finer-grained upwards and is overlain, in places, by a seatearth-coal horizon immediately below the Stobswood Marine Band (Figures 9 and 10). The coal is variably developed up to a maximum thickness of 59 cm (28 SW 203) in the south-west of the district and was worked during the present Survey in the Glororum Opencast Site, 0.5 km to the west of the district at [193 823].

The thin **Stobswood Marine Band** is known to be present throughout much of the district. The band contains a fauna of fish debris and foraminifera, and *Planolites ophthalmoides* is commonly present in collections from overlying mudstones in the more north-easterly part of the area. *Lingula mytilloides* has been recovered only once in the boreholes examined, in Barmoor No 9 borehole (28 SW 20). Unless collections were made from a borehole, the exact position of the marine band is usually uncertain and its horizon has been estimated from the presence of a mudstone unit, up to 10 m thick, overlying the basal sandstone and commonly with scattered small mussels near its base. The marine band was identified in exposures at the Glororum Opencast Site (see above).

The interval between the Stobswood Marine Band and the Victoria Seam ranges in thickness from 10.9 to 24.8 m. Throughout much of the district it consists of sandstone in the lower part, with up to 10 m of argillaceous strata underlying the Victoria Seam. The sandstone increases in thickness to the north-east and north of Ashington the interval is largely composed of sandstone (e.g. 28 NE 102, Figure 11). However, around Bedlington the interval is largely mudstone with numerous plants and roots. A seatearth and thin coal commonly occur above the sandstone, but below the Victoria.



—40— Isopach of Victoria Seam (cm)

——— Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked areas)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 12 Victoria Seam (T), coal thickness and workings

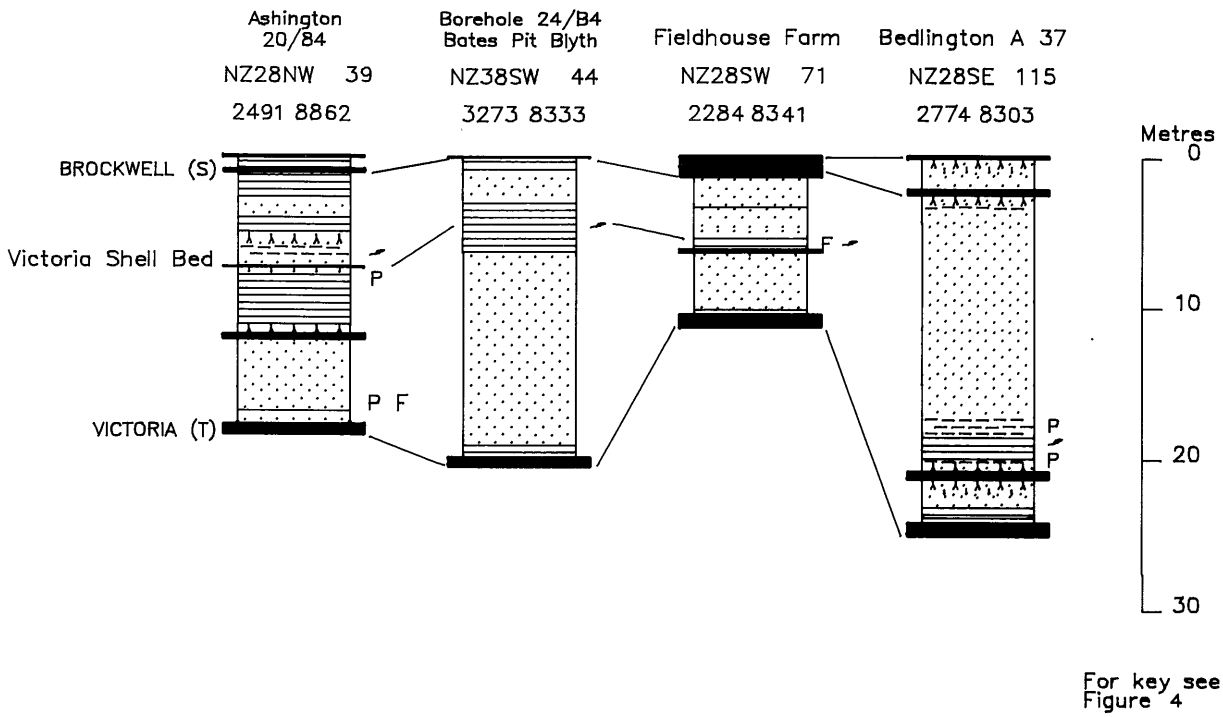


Figure 13 Victoria Seam to Brockwell Seam

Victoria Seam. The Victoria (Choppington Brockwell, or Bessie Grey) Seam has been mined in the west of the district the (Figure 12); the most recent deep workings were from Ashington Colliery in 1981. It is a persistent coal, usually clean and of good quality with a thickness (excluding dirt bands) ranging from 18 to 91 cm with a mean of 61 cm. Ash contents are generally between 3 and 8% and sulphur content between 0.7 and 1.2%. Fowler (1936) considered this seam to form the base of the 'Productive or Middle Coal Group'.

VICTORIA TO BROCKWELL

Strata between the Victoria and Brockwell Seams. The interval between the Victoria and Brockwell coals (Figures 13 and 14) ranges from 6.5 to 26.3 m. The succession comprises mainly sandstone in the west of the area and between Bedlington and Cambois, but with variable (often equal) proportions of mudstone and sandstone elsewhere. The interval commonly contains a thin coal or seatearth in the lower half and sometimes a second thin coal or seatearth in the upper half. Except locally in the western edge of the district around Hepscott, Morpeth and Pegswood and in the east at Cambois, the roof of the Victoria seam is mudstone. *Planolites ophthalmoides* (large form) was recovered from this roof mudstone in the Coneygarth borehole (28 NW 64) and it yielded fish debris in 3 boreholes in the east of the district at North Seaton Colliery, Ashington and Horton Grange. Elsewhere however no fauna has been recorded in the Victoria roof in contrast to the Tynemouth district to the south-east (Land, 1974). The presence of two thin seams above the Victoria is restricted to the area between Cambois and Ashington. The lower, thicker coal has been called the upper leaf of the Victoria (or Top Victoria) in several boreholes from Ashington Colliery and correlated with the median seam near Bothal where the Victoria-Brockwell interval is thinnest. The seam is of poor quality with high ash content and has not been mined. The thick sandstone towards the base of the interval is over 10 m thick in places and is commonly coarse and massive near its base.

At a variable interval above the Victoria, generally overlying the lower median coal, a

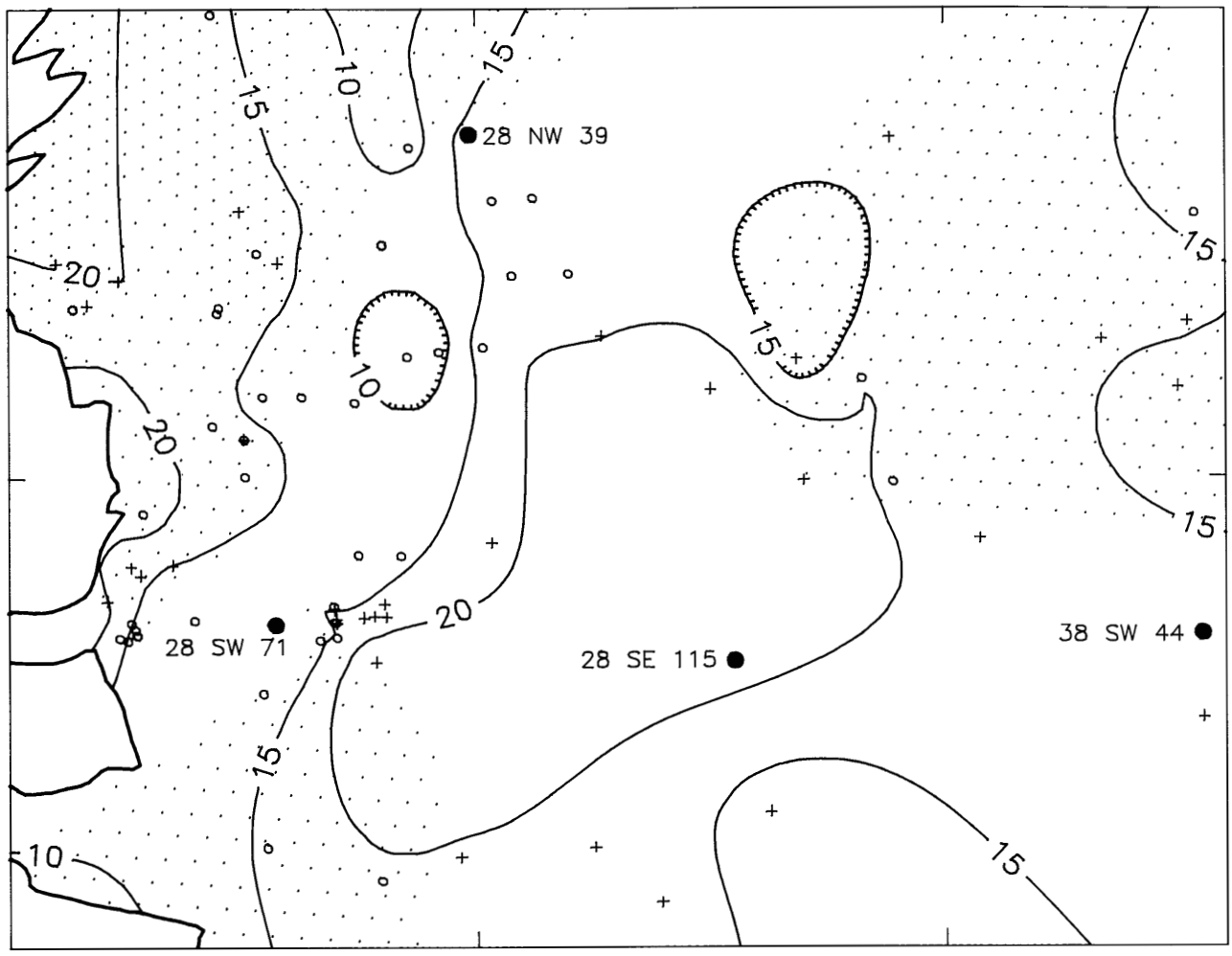
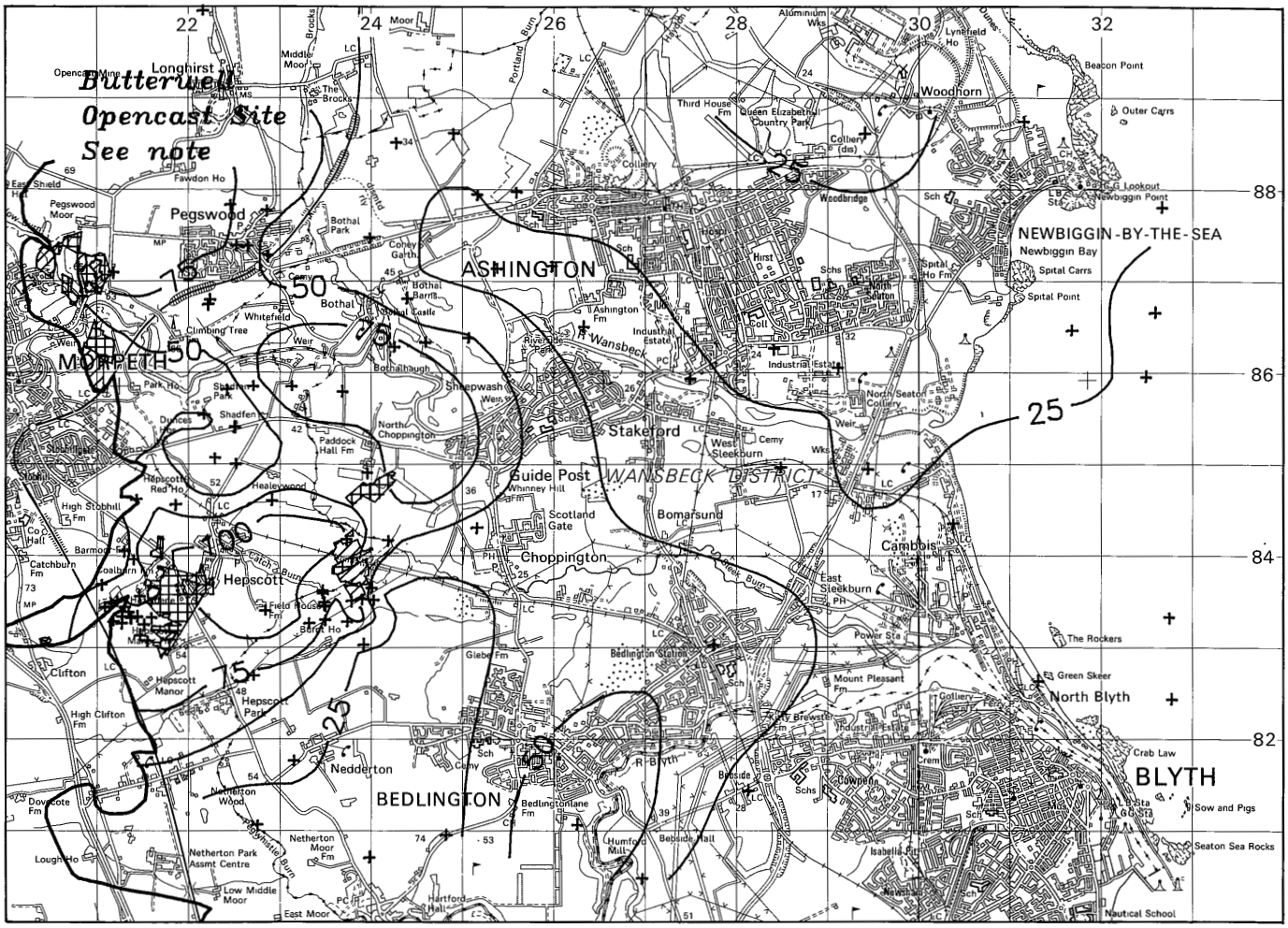


Figure 14 Victoria Seam to Brockwell Seam interval



—25— Isopach of Brockwell Seam (cm)

Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 15 Brockwell Seam (S), coal thickness and workings

geographically widespread, if faunally variable, musselband occurs. The poorest development of fauna in this band occurs in parts of 28 SE. The combined fauna from the horizon is:- *Carbonicola* aff. *bipennis*, *C. sp.* (*browni* group?) *C. cristagalli*, *C. pseudorobusta*, *C.* aff. *rhindii*, *C.* aff. *rhomboidalis*, *C.* cf. *robusta*, *C. robusta/pseudorobusta*, *C. robusta/rhomboidalis*, *Curvirimula* cf. *subovata*, *C.* cf. *trapeziforma*. The fauna is comparable to that obtained from other occurrences of the Victoria Shell Bed in Northumberland and also contains elements characteristic of the lower part of the Communis Zone in Scotland.

The musselband is generally succeeded by a sandstone which has its maximum thickness of over 10 m in the Choppington area, where it is overlain by the seatearth of the upper thin coal. The highest strata form a variable sequence of mudstones and silty mudstones with locally some thin coals or seatearths. It is possible that in some boreholes, thicker coals in this upper part of the sequence have been included by this and earlier Surveys in the Brockwell (or Bandy) sequence of coals.

Brockwell Seam. The Brockwell generally consists of a series of thin coals (hence the local name 'Bandy', where the underlying seam is known as the Choppington Brockwell). It is consequently difficult to assign the name consistently to one particular coal horizon and the Brockwell is used in places to describe a combination of thin coals over an interval of up to 5 m, but more usually less than 2 m. Figure 15 illustrates the total thickness of clean coal. Individual coals locally exceed 1 m in thickness in the south-west of the district (e.g. 122 cm in 28 SW 22), but are generally much thinner, and represent an inferior coal with the ash content commonly exceeding 11%. The seam was mined from Morpeth Moor Pit, where it was 90 cm thick and provided an excellent locomotive coal (Fowler, 1936) and from Hepscott Colliery as the 'Bottom Seam'. An analysis of the coal in a bore north-west of Hepscott showed 66 cm of good quality coal with an ash content of 5.7% and sulphur content of less than 1%.

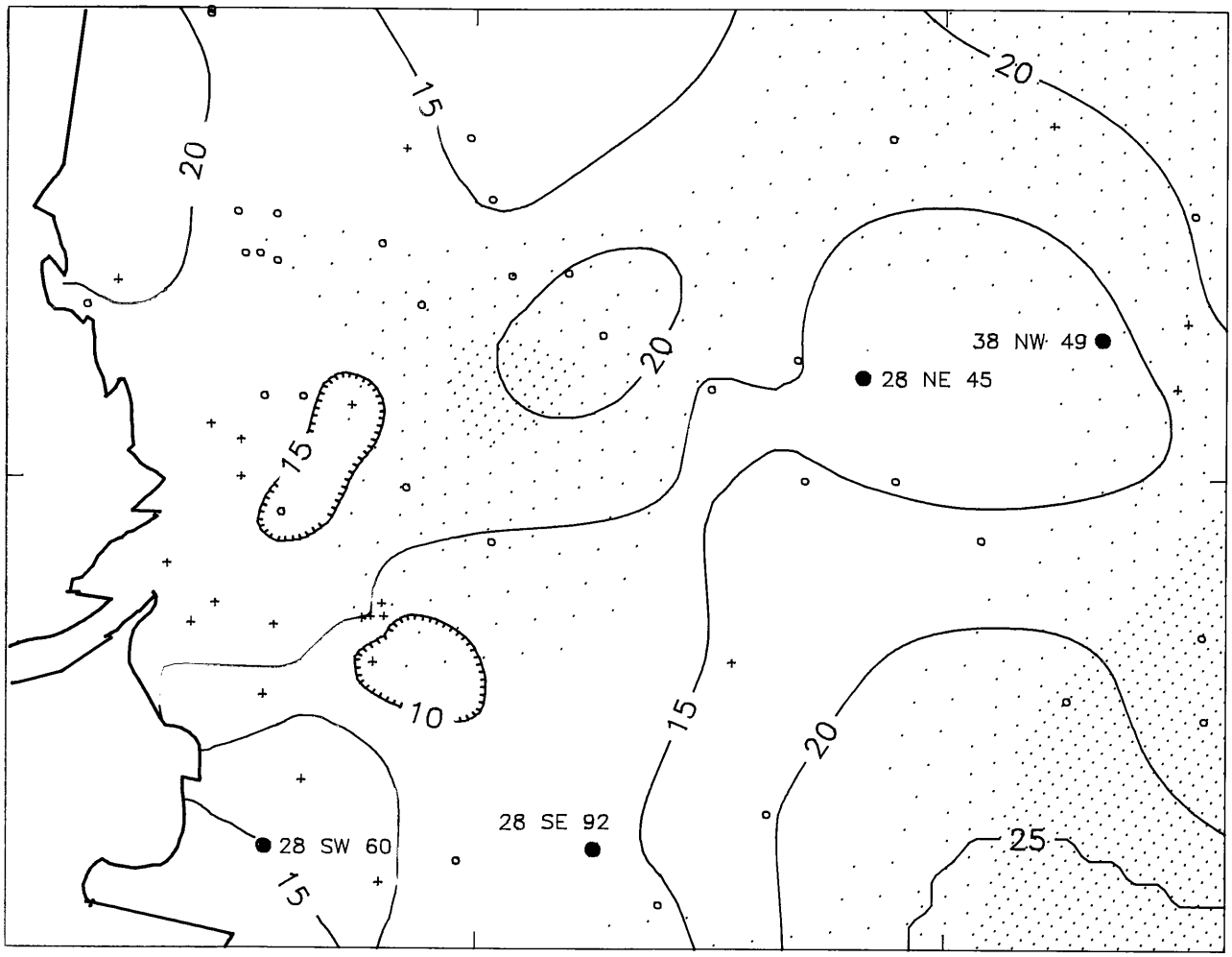
Most recently the Brockwell was mined until 1960 from Choppington B Colliery, where the seam, including dirt bands, was up to 1.4 m thick. The Brockwell is the lowest seam contractually worked in the Butterwell Opencast Site.

BROCKWELL TO THREE-QUARTER

The interval between the two seams ranges from 7 to 24 m, the greatest inverval generally occuring where the sandstone content is greatest. Except on Sheet 28 SW the intervening strata commonly include at least one intermediate thin coal or seatearth (Figures 16 and 17).

The strata comprising the interval vary throughout the district and it is difficult to identify a general pattern from available borehole information. Around Pegswood, Ashington, Netherton and south of Blyth the Brockwell has a sandstone roof. Elsewhere the roof is mudstone with a sparse fauna of mussels (e.g. boreholes 38 NW 31, 52 and 54a). The lithologically variable fine- to coarse-grained sandstone which forms or overlies the roof measures is over 5 m thick in places (see Figure 16), although in some the strata below the intermediate seam consists of mudstone and seatearth.

The thickest and most persistent intermediate seam, which probably represents the 'new seam' of Stobswood Colliery [237 948] 4 km north of the district (see Land, 1974, p. 29), is best developed in the north-west, where it reaches a maximum thickness of 53 cm. It can be traced throughout much of the district. The coal was mined from the Middle Drifts, east of the How Burn prior to 1927 as the Little Wonder (not the Little Wonder of Broomhill) where it was 43 cm thick including a dirt band, it is also worked under this name in the Butterwell Opencast Site. The beds in the upper part of the Brockwell to Three-Quarter interval form a variable sequence of mudstones with underlying sandstone in places, and up to three thin coal or seatearth horizons underlying the Three-Quarter Seam. Plants are relatively abundant in this upper part and fish have been recorded above the 'Stobswood New' at Cambois Colliery (38 NW 52).



0 1 2 3km
Scale

—40— Isopach of Brockwell to Three–Quarter interval (thickness in metres, ticks on low side of line)

Western limit of Brockwell Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval over 15m thick

BORE OR SHAFT PROVING INTERVAL:

+ Median coal absent

o Median coal present

● Section figured in this report

Figure 16 Brockwell Seam to Three–Quarter Seam interval

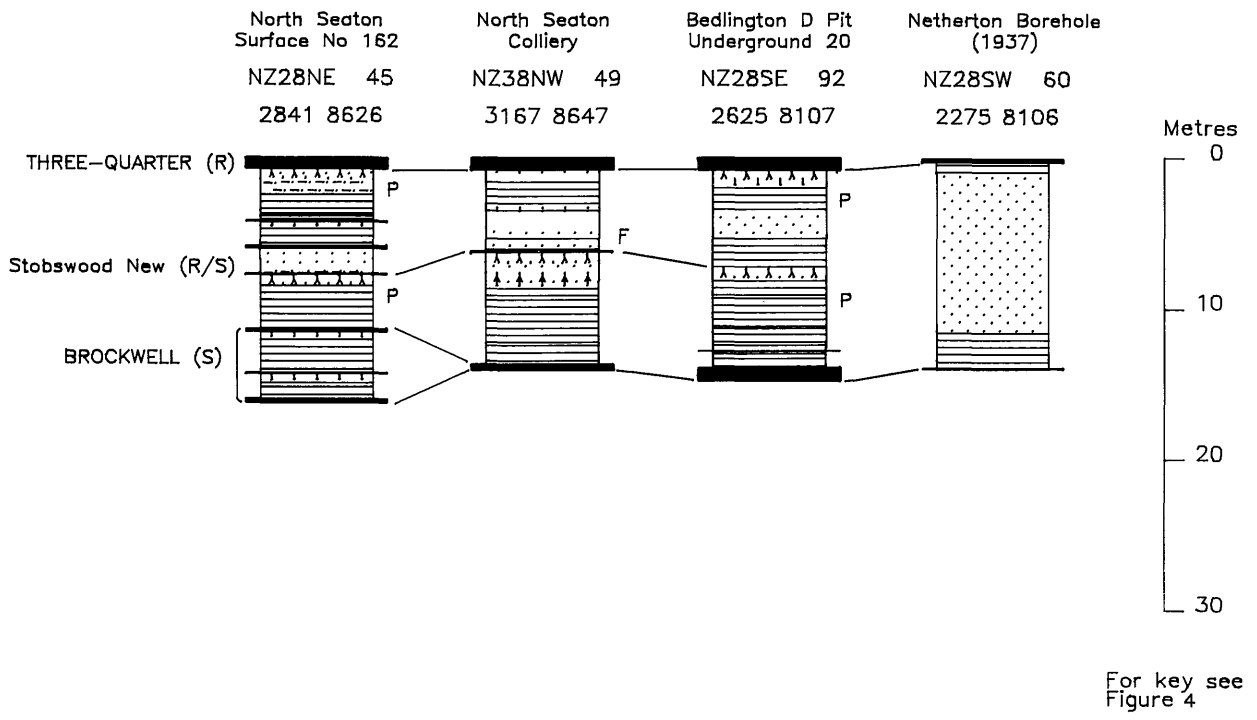


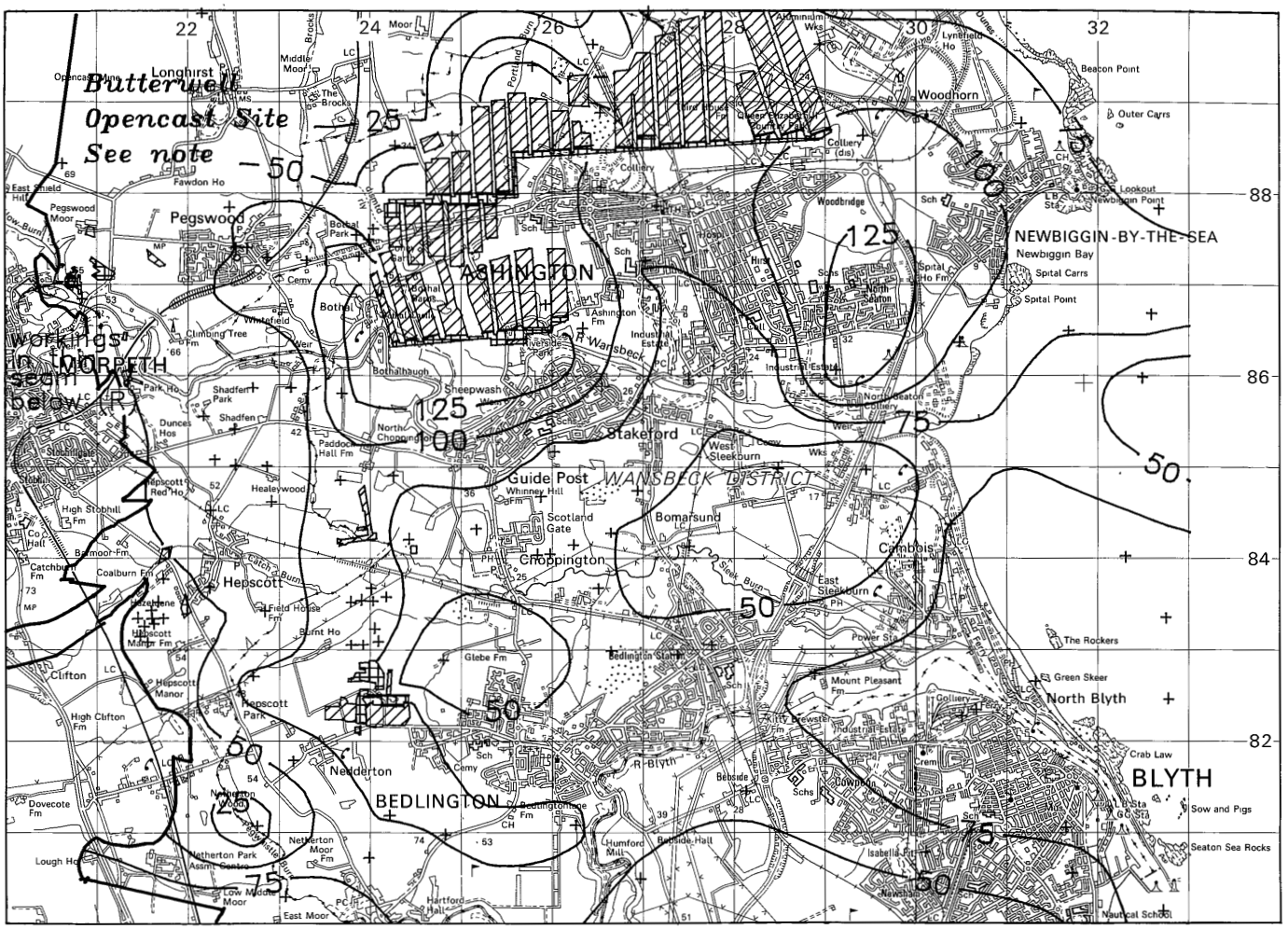
Figure 17 Brockwell Seam to Three-Quarter Seam

On Sheet 28 SW, a thin seam at the top of the interval has been considered to represent a lower leaf of the Three-Quarter, but it is possible that this might be more correctly correlated with the Stobswood New, which lies directly beneath the Three-Quarter.

Three-Quarter Seam

The Three-Quarter (Pegswood Bottom Busty) Seam has been traced throughout the district (Figure 18). It ranges in thickness from 20 cm to over 130 cm and is of variable quality. Dirt bands are commonly present, either near the floor or the roof of the coal; ash content excluding dirt bands is between 5 and 12% and the sulphur is up to 2%. Locally the coal has a relatively high chlorine content.

The seam was worked near crop in the west of the district in the early part of this century both from drifts in the banks of the How Burn and River Wansbeck and from shafts at Morpeth Moor, Barmoor and Hepscott Collieries where it was sometimes termed the Little. More recently it has been worked at Netherton and until 1988 at Ashington Colliery where 60 to 70 cm of coal was general out of a total thickness of coal and dirt bands which in places exceeded 165 cm.



—25— Isopach of Three–Quarter Seam (cm)

Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal

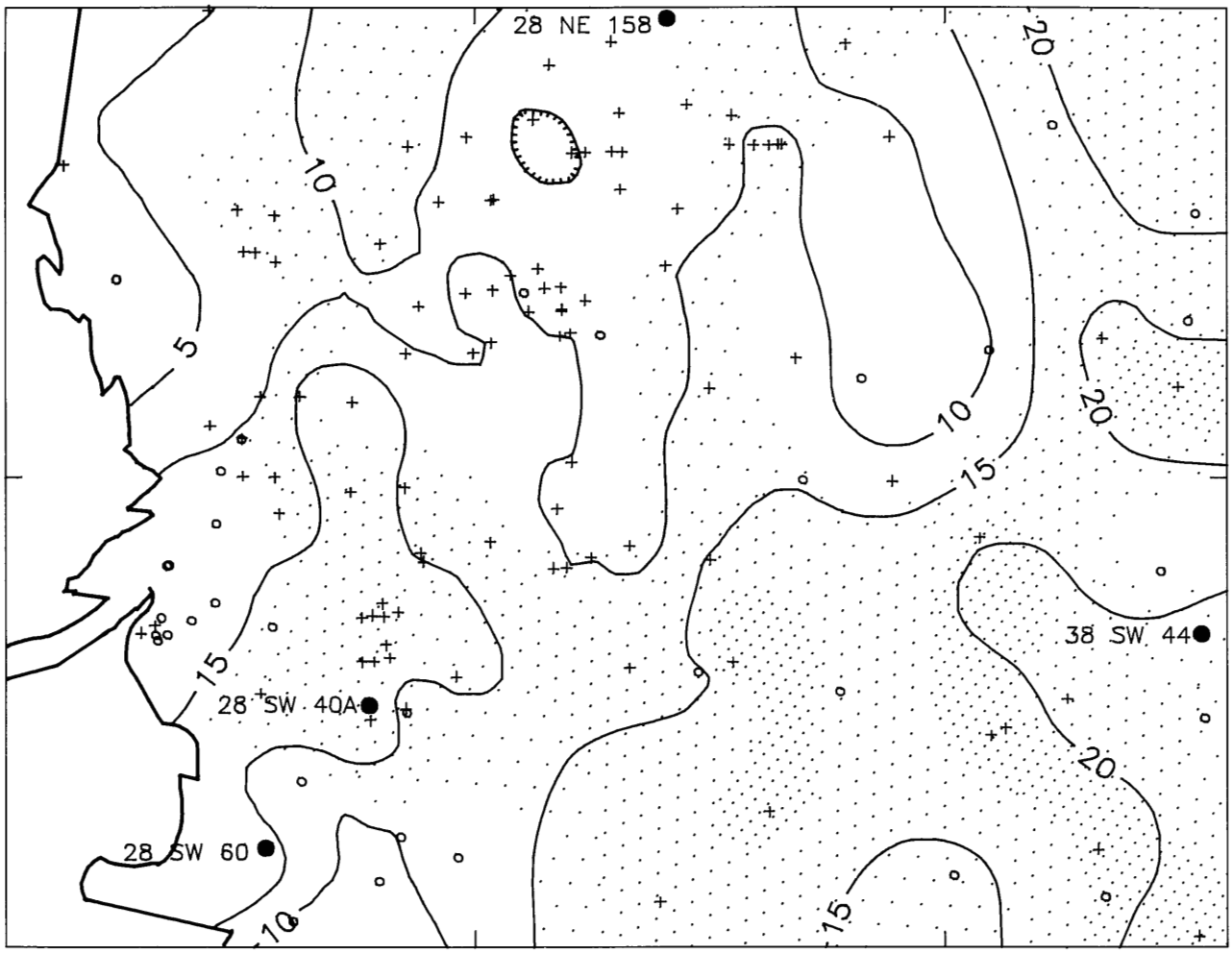
Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 18 Three–Quarter Seam (R), coal thickness and workings



—40— Isopach of Three–Quarter to Bottom Busty interval (thickness in metres, ticks on low side of line)

Western limit of Three–Quarter Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval over 15m thick

BORE OR SHAFT PROVING INTERVAL:

+ Median coal absent

∘ Median coal present

● Section figured in this report

Figure 19 Three–Quarter Seam to Bottom Busty Seam interval

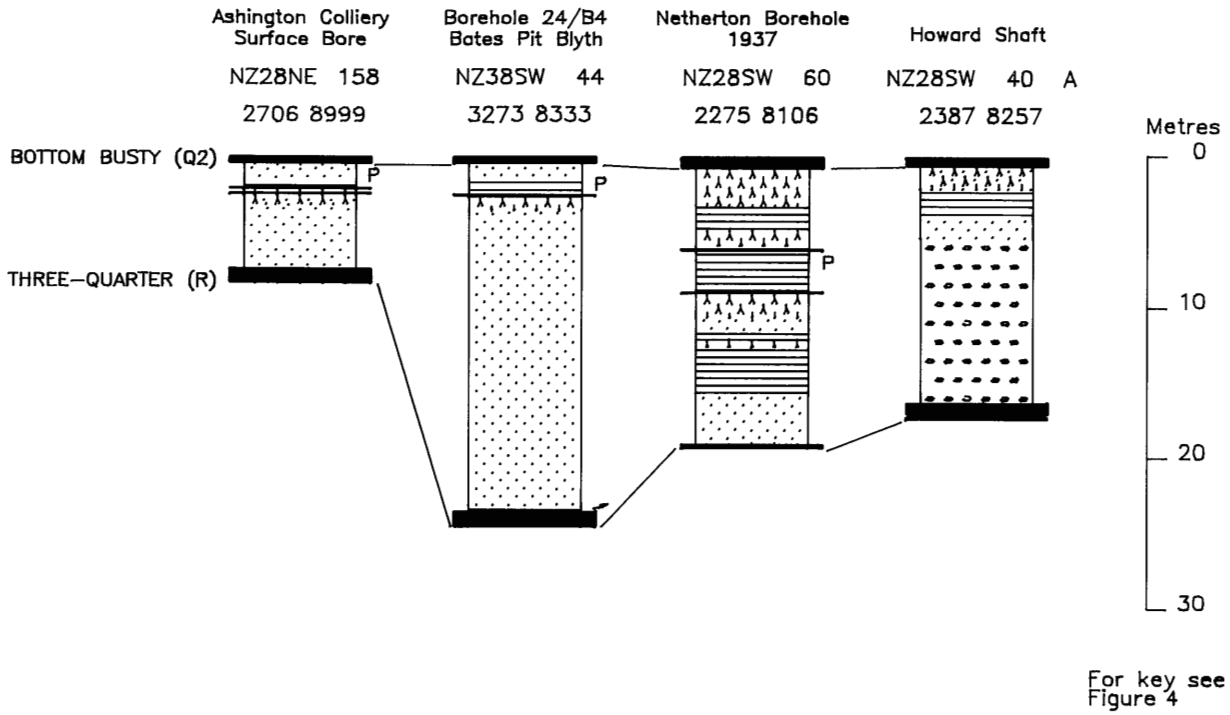


Figure 20 Three-Quarter Seam to Bottom Busty Seam

THREE-QUARTER TO BOTTOM BUSTY

This interval thickens south-eastwards from only 5 m in parts of the Butterwell opencast site to over 20 m at Blyth. It is dominated throughout much of the district by a thick sandstone which forms the roof of the Three-Quarter (Figures 19 and 20). Elsewhere the roof measures are mudstone, usually unfossiliferous, but in the south-east a fauna including *Carbonicola* cf. *martini*, *C.* cf. *oslancis*, *C.* aff. *pectorata*, *C.* cf. *rhomboidalis*, *Leaia sp.* and *Carbonita* has been recovered from various boreholes.

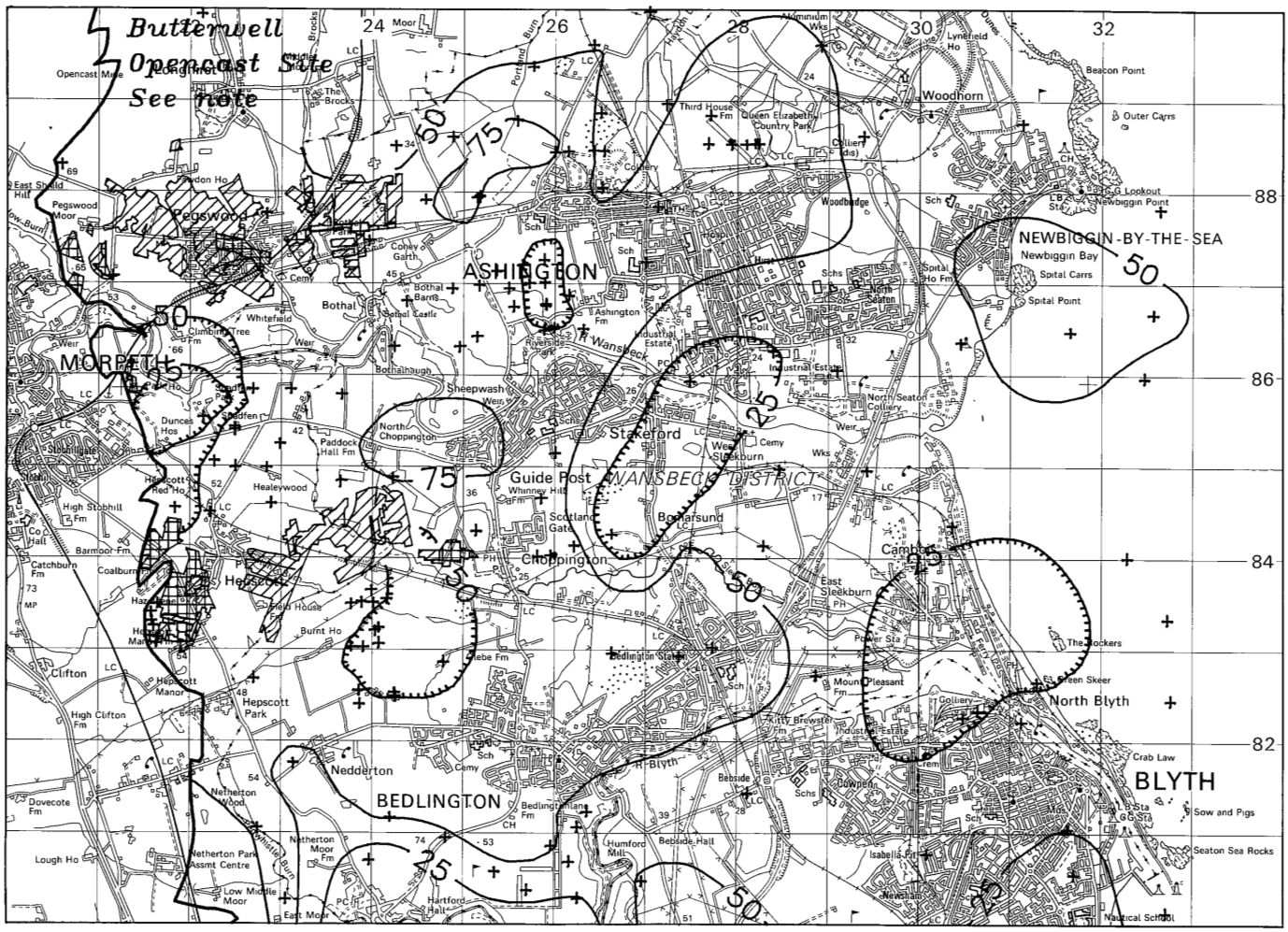
The thick sandstone mentioned above is variably fine- to coarse-grained and commonly cross-bedded. It is particularly coarse and locally conglomeratic towards its base (e.g. in borehole 28 SE 52). However, there is no record of the underlying Three-Quarter being washed out in the district. Around Netherton and at Ashington, where the interval is composed mainly of mudstone and siltstone, an intermediate seam is developed (Figure 20).

This seam, named the Hepscott Little in one borehole, is up to 56 cm thick with an average of 14 cm.

Bottom Busty Seam. The Bottom Busty Seam (Top Busty of Pegswood) has been mined in the west of the district (Figure 21). In the north of the district it was worked, near crop, at Morpeth Moor Colliery north of How Burn [208 870] where it was known as the Old Man.

It was also worked as the 'Top Seam' at Parkhouse Colliery [213 860] and as the 'Splint' in a drift from the Wansbeck [2133 8648]; it is likely that other local workings were also present along the banks of the Wansbeck. In the south it was worked, locally to crop, as the 'Splint' at Barmoor and Hepscott Collieries.

The seam has more recently been mined at greater depth from Pegswood and Choppington A and B Collieries, extraction ceasing in 1962. The coal at each Colliery was up to 76 cm thick, but thinned to only 45 cm at the eastern limit of the Choppington workings. Figure 21 illustrates the coal thickness across the district ranging from an average of 51 cm to a maximum of 95 cm. The quality of the coal decreases eastwards across the area; west of Ashington



0 1 2 3km
Scale

—40— Isopach of Bottom Busty Seam (cm) (ornamented on low side of line)

——— Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 21 Bottom Busty Seam (Q2), coal thickness and workings

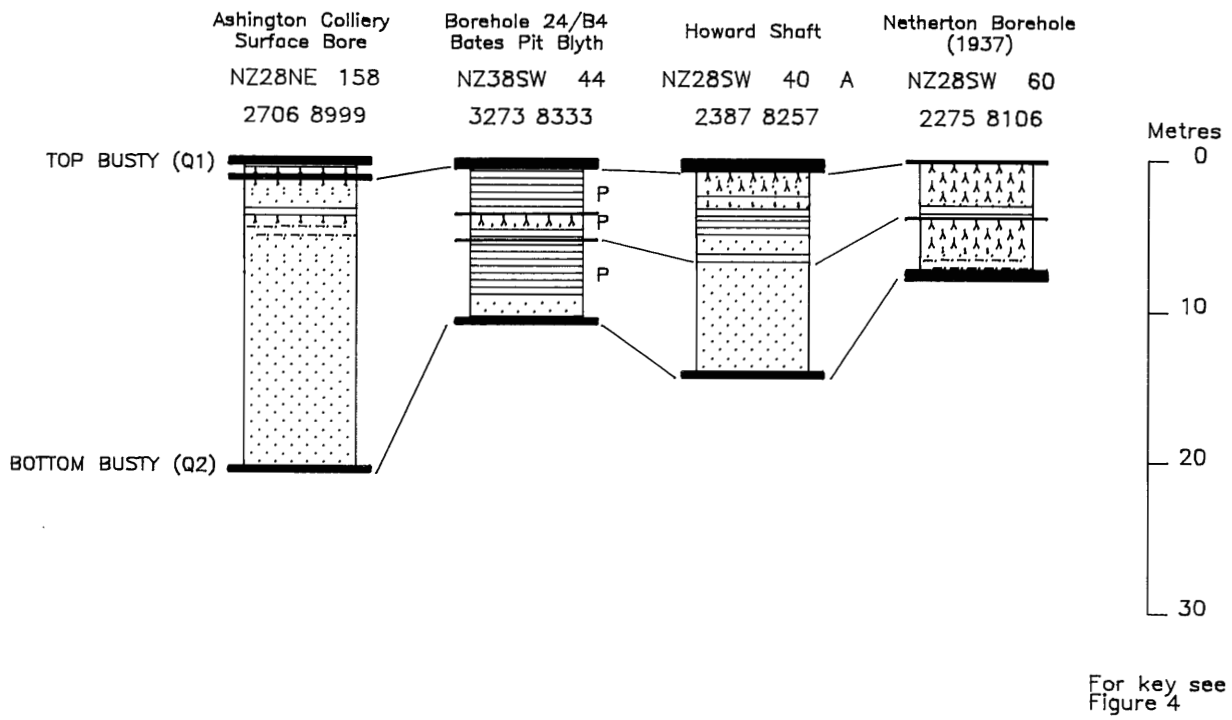


Figure 22 Bottom Busty Seam to Top Busty Seam

the seam is largely free from dirt with an ash content varying between 5 and 13%, in the east, however, the coal is generally either too banded or too thin to have been considered a workable proposition.

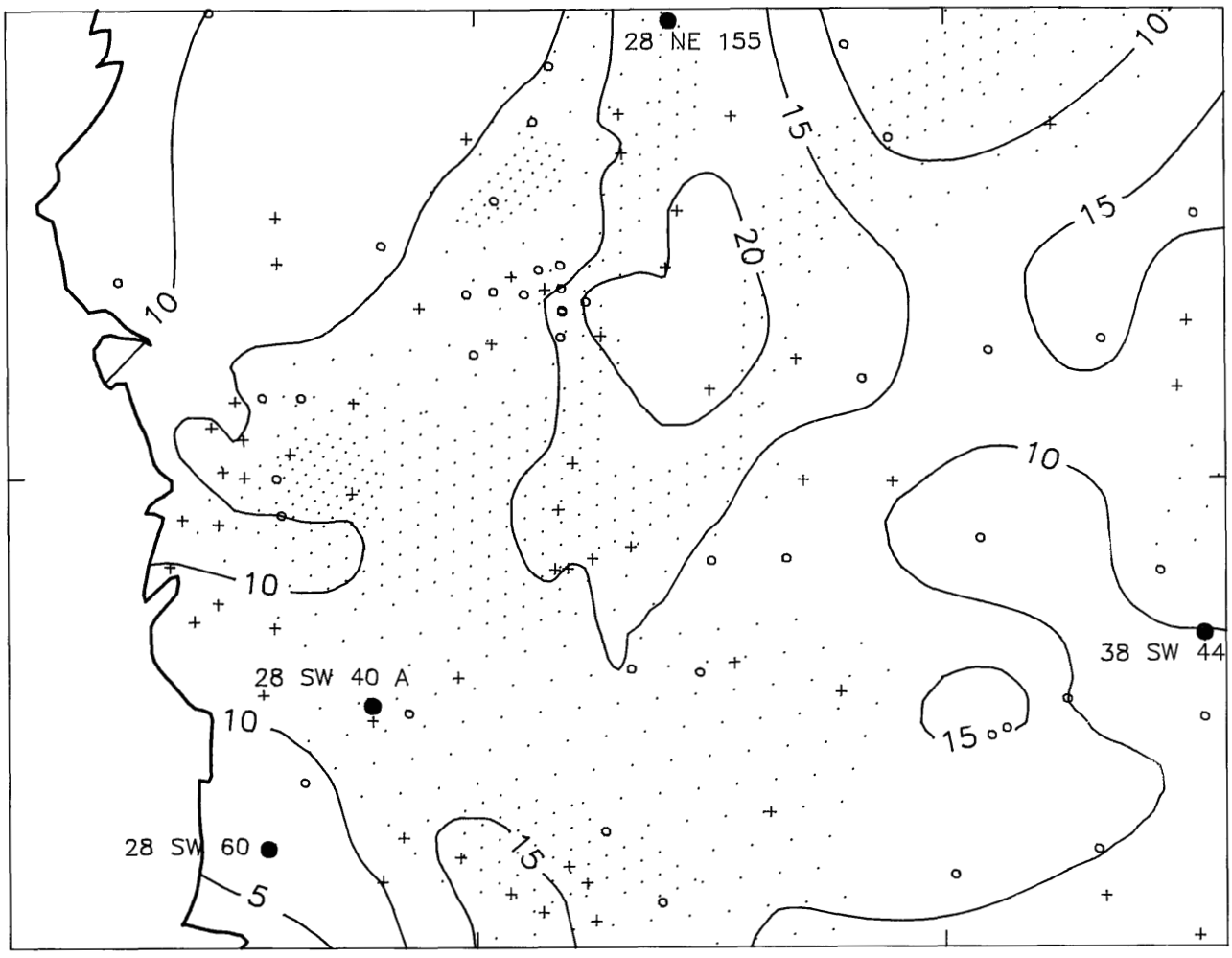
The Bottom Busty is washed out in borehole 28 SE 92, an underground borehole from Bedlington Doctor Pit.

BOTTOM BUSTY TO TOP BUSTY

In the centre of this district the interval is dominated by a thick sandstone (Figure 22). The sandstone is variably fine- to coarse-grained, generally kaolinitic and gritty near its base, where it is thickest. North of Ashington only a few metres of mudstone separate the sandstone from the seatearth of the Top Busty Coal. To the west of the major sandstone the interval is dominantly comprised of mudstone and siltstone with a thin intermediate coal developed locally. The seatearth and coal of this intermediate seam overlie the sandstone west of Ashington and are developed elsewhere as a parting within it (Figure 23). Locally, as in borehole 28 NW 39, a series of thin coals in the upper part of the interval form a continuous banded coal sequence below the main Top Busty. To the east of the main sandstone the succession is mainly mudstone, siltstone and fine-grained sandstone with one or two medium seatearths or coals generally about 10 cm in thickness.

The mudstones are rich in plant remains, Fowler (1936) lists a number of genera collected from the roof of the Bottom Busty in How Burn. Fish fragments have only been recorded from Ashington Colliery where they occur above a lower median seam in borehole 28 SW 64.

Top Busty Seam. The Top Busty (Pegswood Harvey, Widdrington Five-Quarter) Seam is of variable quality and structure. It has only been worked in the west (Figure 24), but is present throughout much of the district and has been explored extensively, including offshore from Newbiggin and Cambois where the coal is generally of good quality, but thin. The seam is up to 154 cm thick averaging 60 cm, and with an ash content in places as low as 3%, although more generally in the range 5 to 10%.



0 1 2 3km
Scale

—40— Isopach of Bottom Busty to Top Busty interval (thickness on metres)

Western limit of Bottom Busty Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval over 15m thick

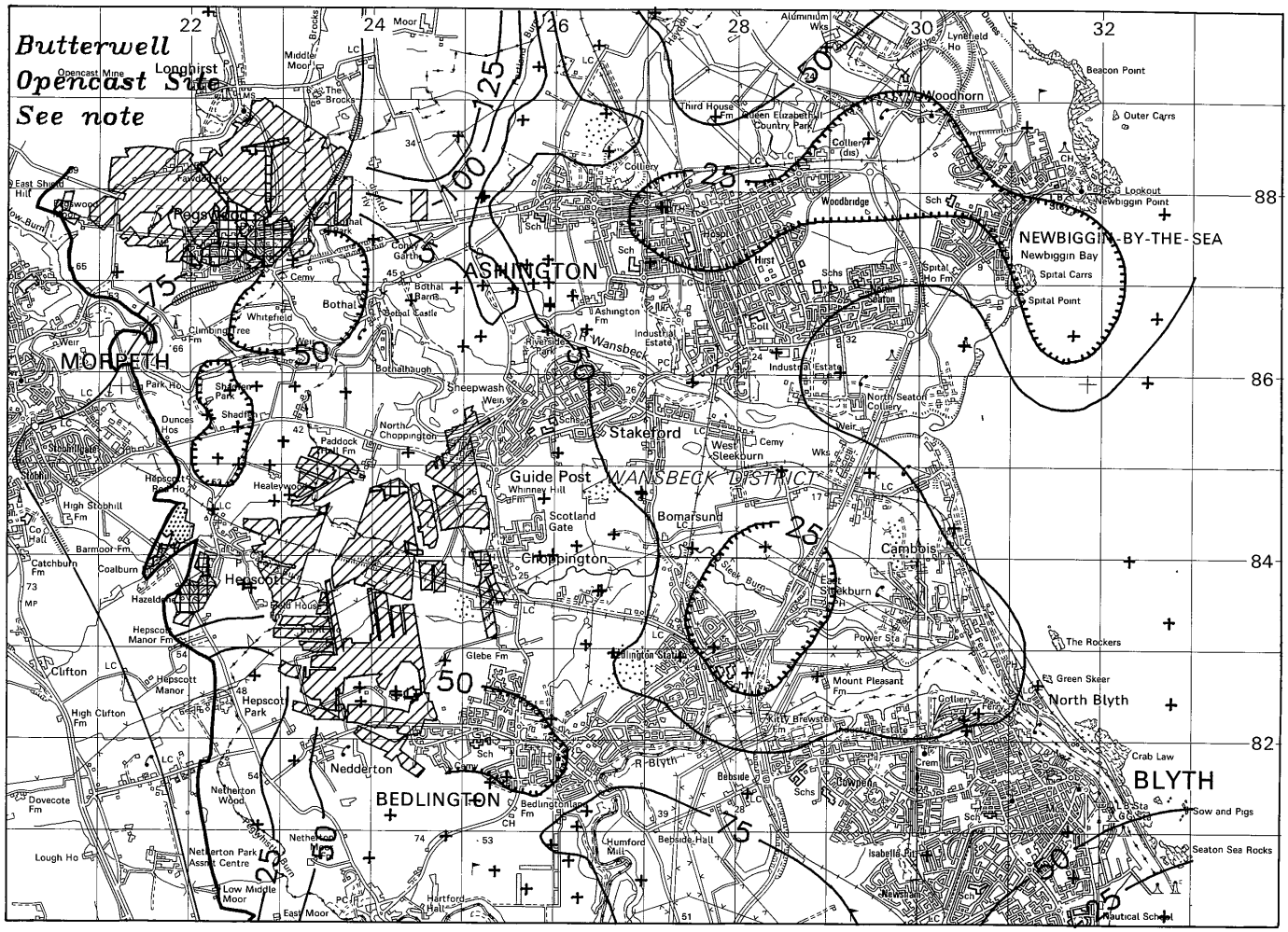
BORE OR SHAFT PROVING INTERVAL:

+ Median coal absent

∘ Median coal present

● Section figured in this report

Figure 23 Bottom Busty Seam to Top Busty Seam interval



—50— Isopach of Top Busty Seam (cm) (ornamented on low side of line)

Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

Style of working

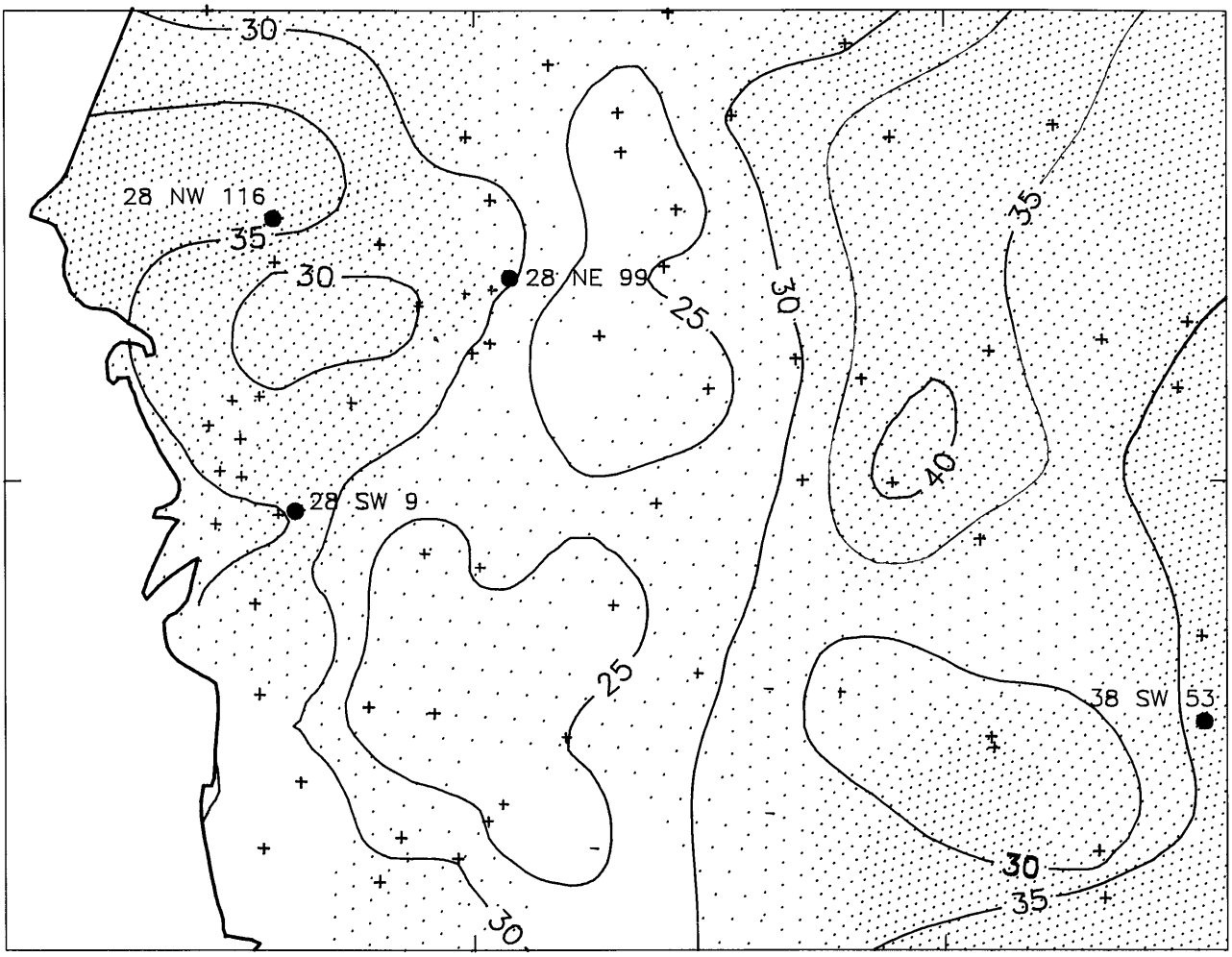
Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 24 Top Busty Seam (Q1), coal thickness and workings



0 1 2 3km
Scale

—40— Isopach of Top Busty to Beaumont interval (thickness in metres)

Western limit of Top Busty Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval 15 to 20m thick

Sandstone in interval over 20m thick

\+ Borehole or Shaft proving interval

● Section figured in this report

Figure 25 Top Busty Seam to Beaumont Seam interval

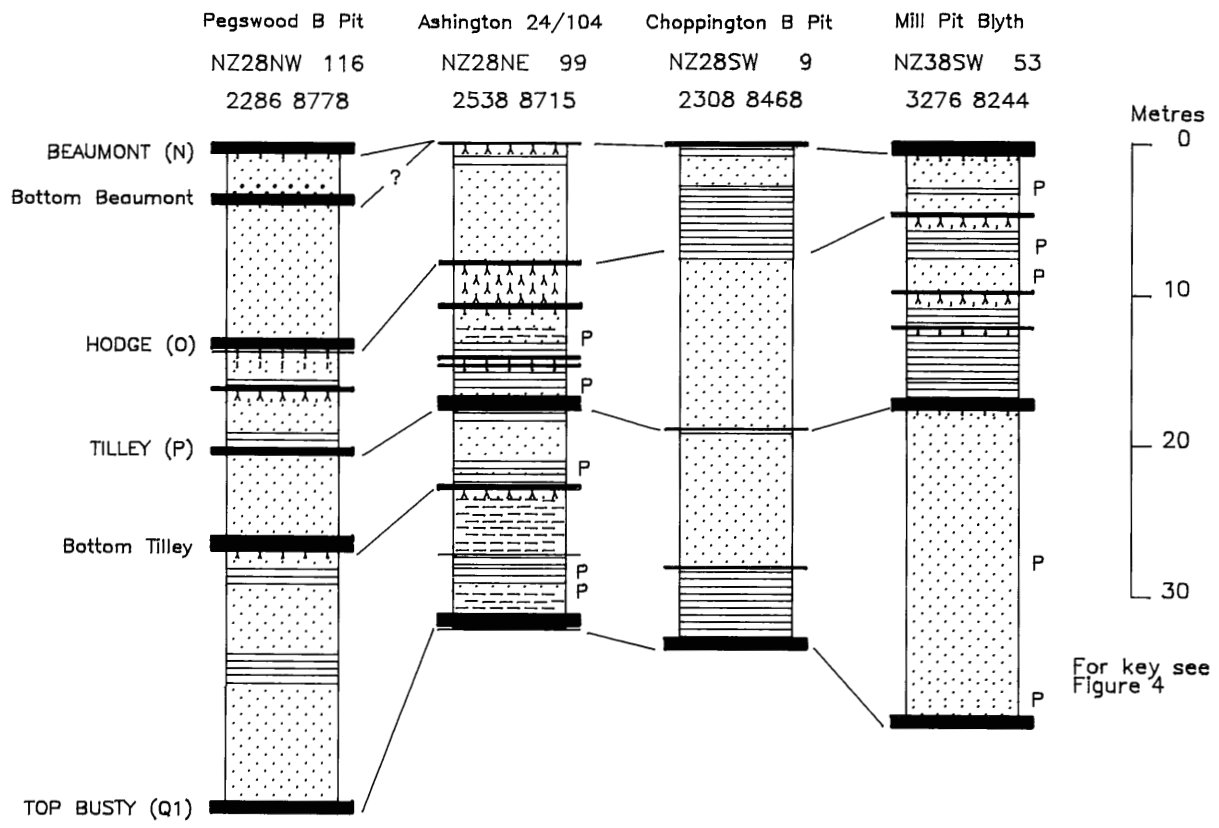


Figure 26 Top Busty Seam to Beaumont Seam

The outcrop of the Top Busty north of Morpeth is too far east for the coal to have been easily worked from the How Burn, as were lower seams (see Fowler, 1936), although it was worked very locally from How Burn Drift [2084 8685]. South of Morpeth it was mined, locally to crop, from Barmoor and Hepscott Collieries as the Barmoor and Hepscott seams respectively. The Top Busty was probably the seam extracted from the Catchburn Colliery drifts north of Clifton [2032 8310], the abandonment plan of 1921 listing the coal as 'probably Beaumont'.

The seam has been worked more extensively from Pegswood and the Choppington Collieries. At Choppington B the seam contained a dirt band of 5 to 10 cm near the base in a total thickness of up to 96 cm. There are extensive washouts in the seam offshore immediately to the east of the district and inland at the southern limit of the Pegswood workings [230 870], (see Fowler, 1936). The seam is also washed out locally in boreholes at Ashington.

TOP BUSTY TO BEAUMONT

The interval between these two major seams includes a number of coals which vary in position, thickness and quality throughout the district (Figures 25 and 26). The variation in the succession of strata makes it difficult to correlate these intermediate seams with certainty. The base of the Tilley (Widdrington Yard) group of coals has been identified at between 4 and 20 m above the Top Busty in different parts of the district and a seam identified as the Hodge is present at between 1.7 and 9.8 m below the Beaumont. There is some uncertainty in the Pegswood area where a seam informally termed the 'Bottom Beaumont' by British Coal is also present near the top of the interval.

0 1 2 3km
Scale

—40— Isopach of Top Busty to Tilley interval (thickness in metres, ticks on low side of line)

——— Western limit of Top Busty Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval over 15m thick

BORE OR SHAFT PROVING INTERVAL:

+ Median coal absent

o Median coal present

● Section figured in this report

Figure 27 Top Busty Seam to Tilley Seam interval

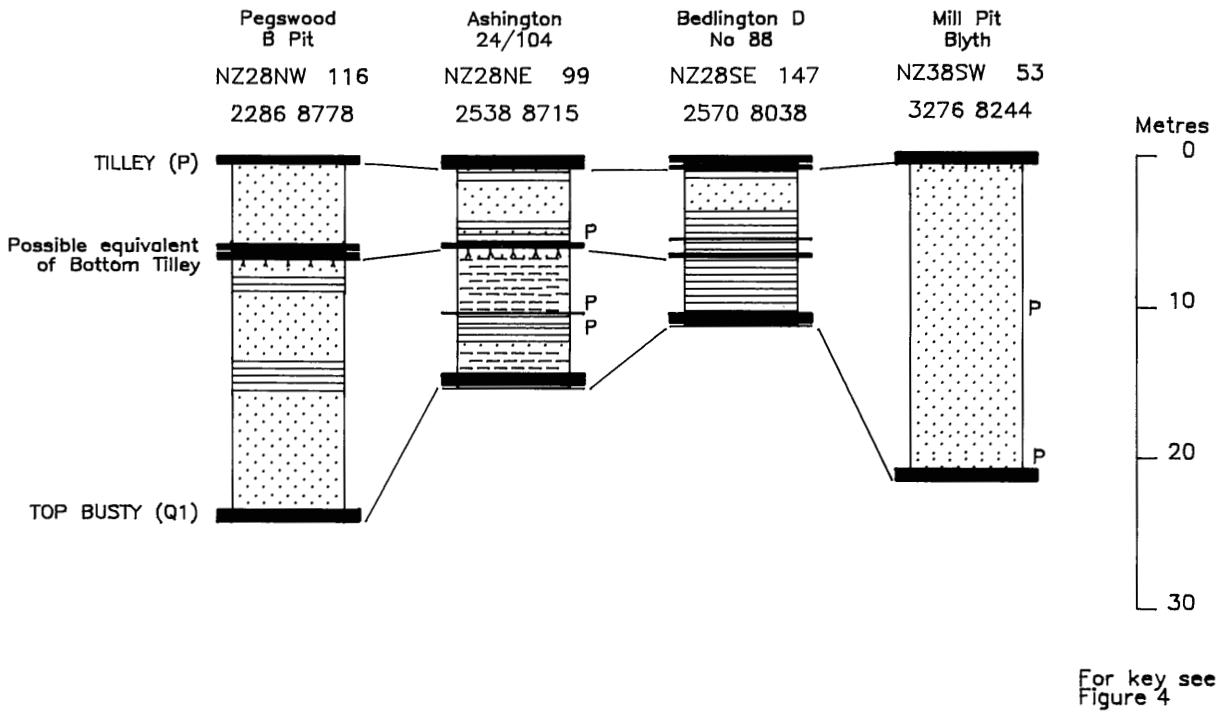


Figure 28 Top Busty Seam to Tilley Seam

Top Busty to Tilley. This interval is greatest north of Pegswood and east of Ashington and Blyth where a fine- to coarse-grained, cross-bedded, feldspathic sandstone dominates the interval and in places directly overlies and locally washes out the Top Busty (Figures 27 and 28). The roof measures of the Top Busty are mudstone in much of the district and these and succeeding mudstones, where sandstone is thin or absent, are rich in plant remains, a collection from the Pegswood Colliery is listed by Fowler (1936). *Carbonicola* fragments have been recorded from the Top Busty roof in the eastern part of the area. Mussel fragments have also been found in the roof mudstone of the higher of two intermediate thin coals which are developed intermittently in the central portion of the interval. In the Cambois/Blyth area and near Ashington a thin coal is present within 2 m of the Top Busty and has sometimes been included in the Busty Group by British Coal.

Tilley Seam. The name Tilley in this and other districts (see Jackson, Lawrence and Frost, 1985) has been applied to a group of coals rather than to one particular seam, partly owing to the difficulty of correlation where a series of coals of almost equal thickness is present. The Tilley, particularly where a thick top most seam is developed, is sometimes called the Denton Low Main but is also known in the district as the Widdrington Yard or Pegswood Band. The Tilley coals are least well developed in the south-west of the district being locally washed out near Hepscott in boreholes 28 SW 15 and 28 SW 38.

A Top Tilley and Bottom Tilley were recognised during the Survey of 27 NW (Jackson, Lawrence and Frost, 1985) and an upper and lower coal possibly equivalent to these are present locally in the district, particularly in the north-west, although the lower coal has not been formally named.

—50— Isopach of Tilley Seam (cm)
(ornamented on low side of line)

Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 29 Tilley Seam (P), coal thickness and workings

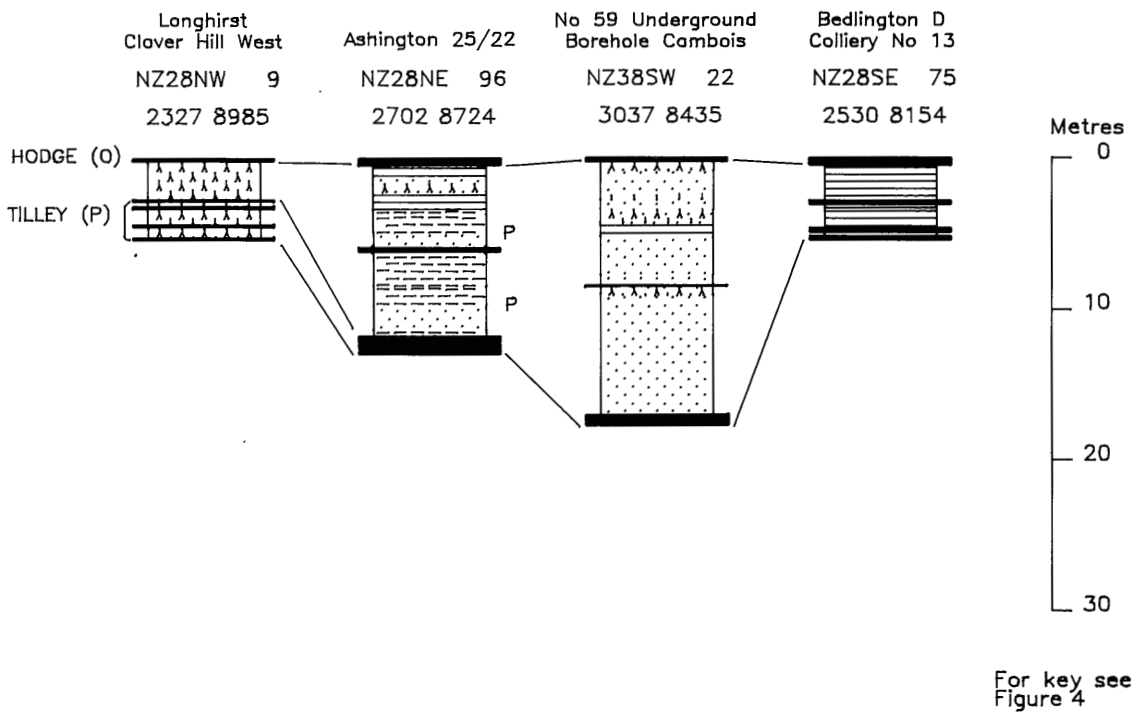
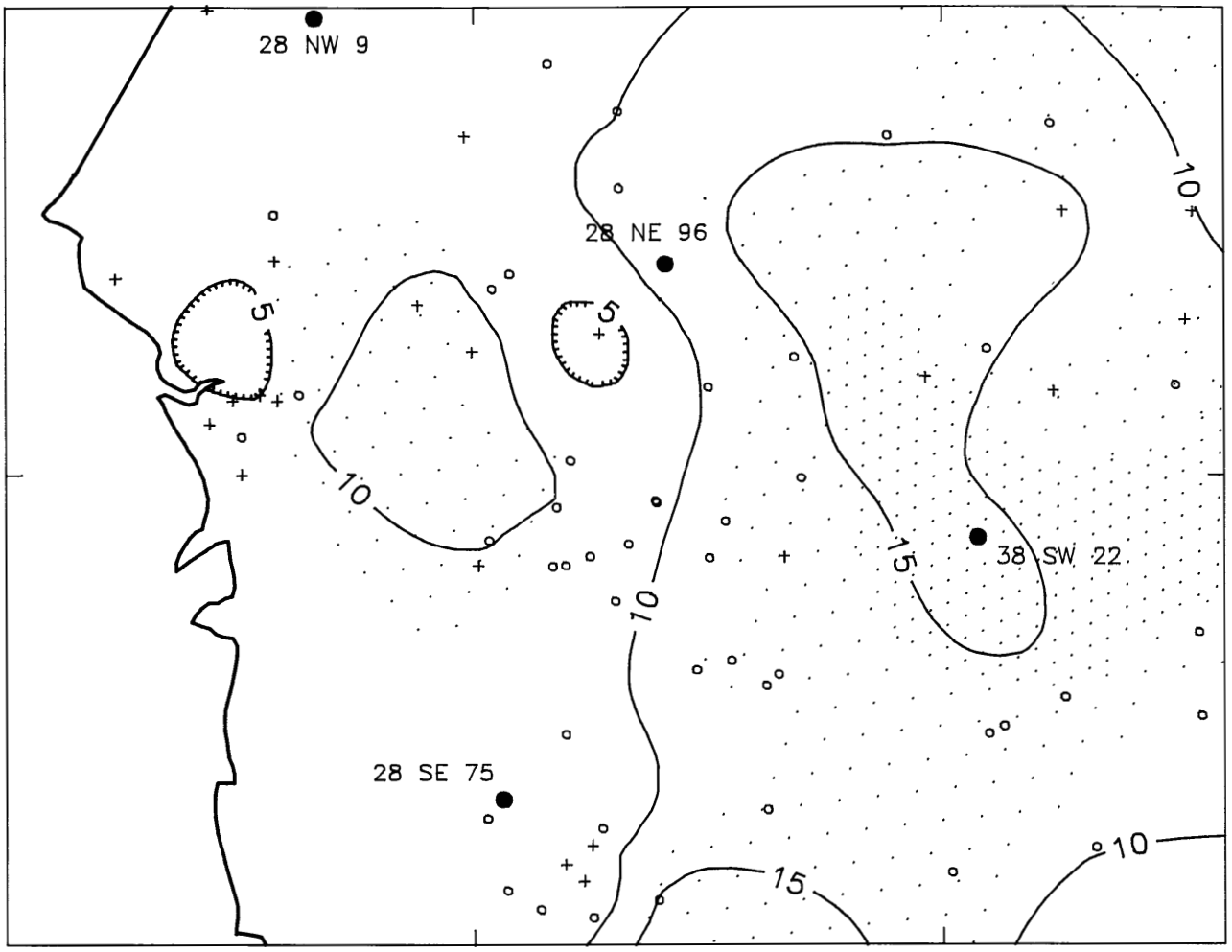


Figure 30 Tilley Seam to Hodge Seam

The Tilley was mined from Bedlington 'A' and, more recently, Ashington Collieries, in the central part of the district. Here the seam has its thickest development, up to 112 cm in 28 SE 12, and an average ash content of 10% (Figure 29). It is extracted as the Top and Bottom Widdrington Yard in Butterwell Opencast. Elsewhere the Tilley is a very variable seam, it is generally thin, or of inferior quality with one or more dirt bands, although the clean coal commonly has an ash content of less than 9% and locally thickens to 60 cm or more.

Tilley Seam to Hodge Seam. The apparent wide thickness variation in the interval between the Tilley and the Hodge (Figures 30 and 31) may in part reflect the difficulty of correlating the coals in this part of the succession.

In the east of the district the lower part of the interval contains a thick sandstone, commonly overlain by mudstones with seatearth. In many boreholes one or more thin coals are developed between the topmost Tilley and the Hodge. The roof of the Tilley varies from sandstone to mudstone, but although plants are noted from mudstones higher in the interval only one faunal record, of *Naiadites sp.* and *Carbonita humilis* in Cambois 55 borehole (38 NW 54), has been reported from the roof of the Tilley seam (as noted by Calver, *in* Land, 1974, p.38).



0 1 2 3km
Scale

—40— Isopach of Tilley to Hodge interval (thickness in metres, ticks on low side of line)

Western limit of Tilley Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval over 10m thick

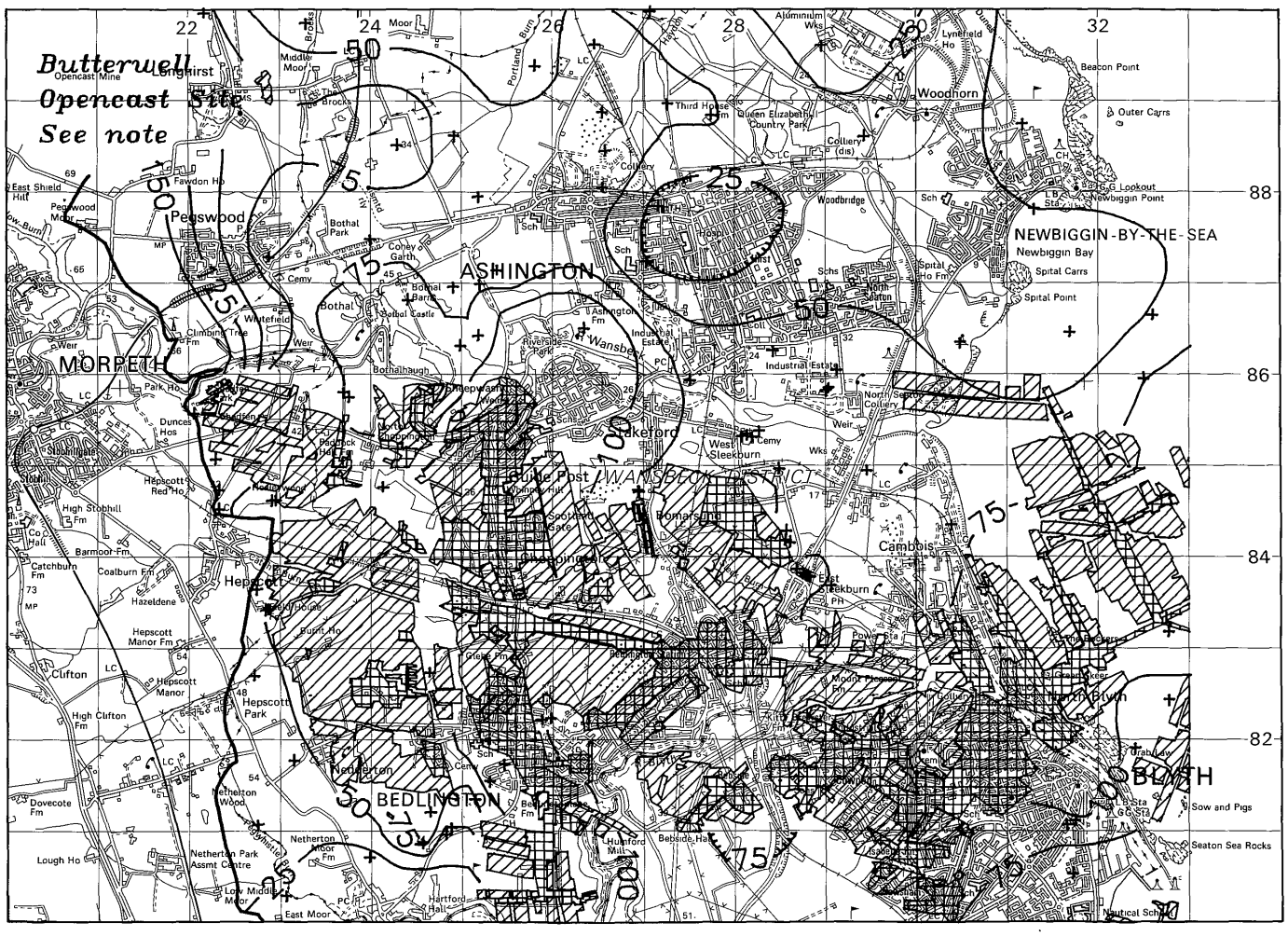
BORE OR SHAFT PROVING INTERVAL:

+ Median coal absent

∘ Median coal present

● Section figured in this report

Figure 31 Tilley Seam to Hodge Seam interval



0 1 2 3km
Scale

—50— Isopach of Beaumont Seam (cm) (ornamented on low side of line)

Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 32 Beaumont Seam (N), coal thickness and workings

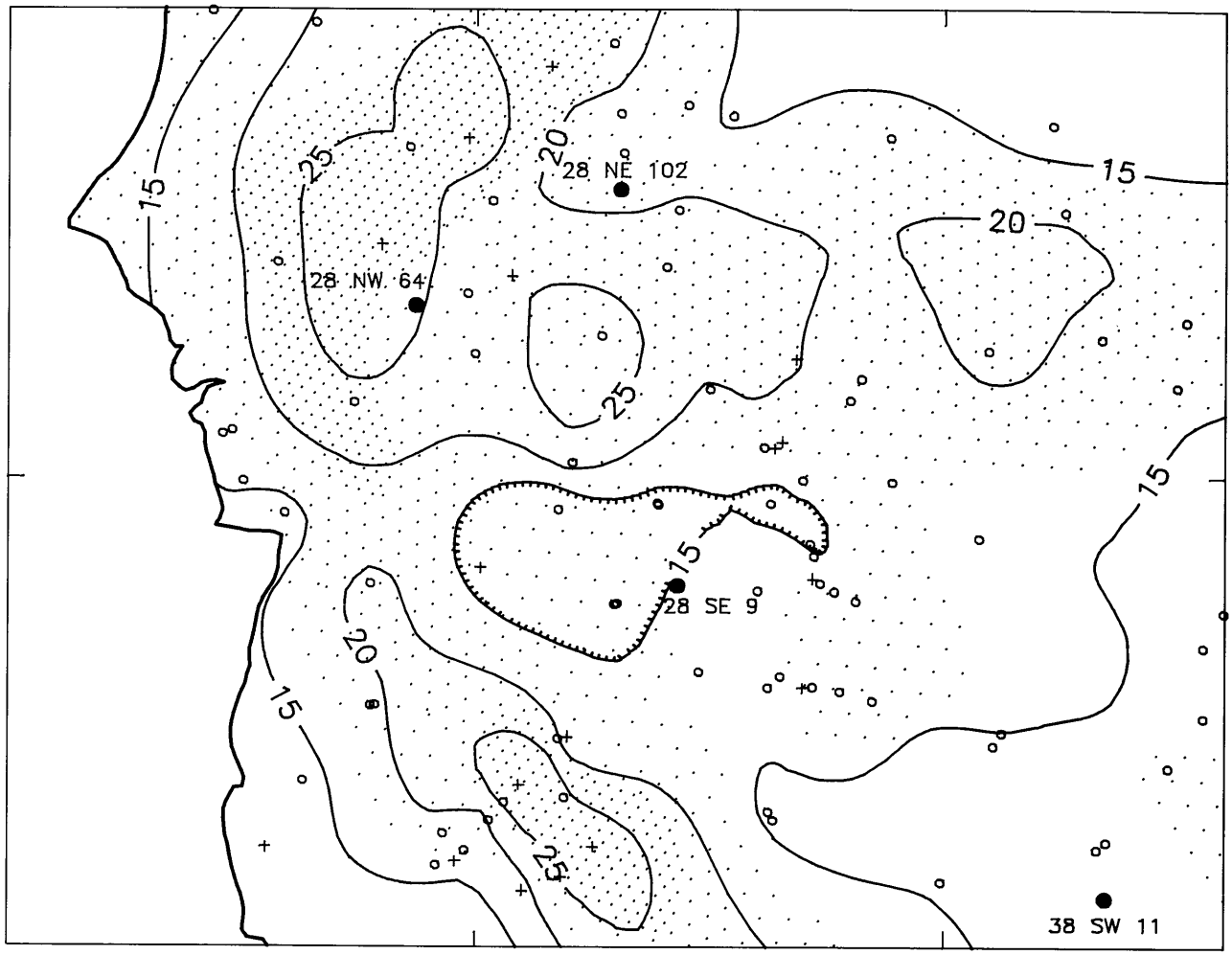
Hodge Seam to Beaumont Seam. A persistent seam which is present throughout the district from 1.7 to 10 m below the Beaumont has been correlated with the Hodge of areas to the south (Jackson, Lawrence and Frost, 1985). In boreholes and shafts locally it has sometimes been named the Stobswood Tilley or Tilley. The coal has not been mined and has a maximum thickness of 53 cm (in borehole 28 SE 147), with an average of 28 cm and is of good quality near Ashington. The Hodge to Beaumont interval is variably mudstone to fine-grained sandstone. The mudstones commonly contain abundant root horizons and ironstones are developed locally. In the north-west of the district an additional coal is present between the Hodge and the Beaumont, up to 91 cm thick, and has been termed the Bottom Beaumont by British Coal. Miospore analysis has been used by British Coal as an aid to identification of the Beaumont Seam at Ellington Colliery to the north of the district.

Beaumont Seam. The Beaumont, Harvey in Durham and some Northumberland mines, Choppington Top Busty locally, has been worked extensively in the southern half of the district, the workings being bounded to the north by the Stakeford fault. The seam is currently being mined under licence from Shadfen Park Drift [222 857] (Figure 32). It was mined, also almost to crop, from Choppington 'A' Colliery in the west and undersea from Bates Pit in the east. Local washouts are recorded on mine plans (e.g. at North Farm [2410 8528] and north-east of Bluehouse Wood [247 841]). The seam has been 'cindered' by Whin dyke intrusions at Netherton and east of Hepscott. In the area worked, the coal was commonly banded, with a total thickness of up to 130 cm. Elsewhere the seam is extremely variable both in thickness and structure, although the ash content of clean coal is generally under 10% and of sulphur less than 3%. Where both the Top and Bottom Beaumont coals have been identified it is the upper seam which is of better quality.

BEAUMONT SEAM TO HARVEY MARINE BAND

The interval between the Beaumont seam and the base of the Harvey Marine Band, which ranges from 10 to 25 m, is thickest in the west of the area where it is composed mainly of a SE-trending 'channel' sandstone (Figures 33 and 34). Variable strata make up the interval elsewhere, and the lower part is characterised in many places by a distinctive shell-bed containing a mussel-ostracod fauna, termed the Hopkins Band (see Land, 1974 for origin of the name). As noted by Land (1974, p.38) considerable variation exists in the distance separating the Beaumont Seam and this musselband; it occurs in the Beaumont roof where this is mudstone, but less commonly, can be separated from the Beaumont by up to 10 m of sandstone (e.g. in borehole 38 NW 47).

The Hopkins Band has not been recorded in all boreholes, although whether this is owing to its absence or to lack of observation is uncertain. Land (1974) describes in detail the faunal phases of the Hopkins Band; the combined fauna from the band in this area consists of:- *Anthraconaia sp., Anthracosia regularis, Naiadites* cf. *flexuosus, N.* aff. *quadratus, N. quadratus/flexuosus, Carbonita sp.* and *Geisina arcuata.* In one borehole (Bedlington F underground borehole, 28 SE 9) a further cycle above the Hopkins Band is present from which *Naiadites* aff. *quadratus* and *Geisina arcuata* have been obtained in the roof of a coal horizon 6 m above the Hopkins Band. The development of a coal - seatearth between the Beaumont and Harvey Marine Band is relatively common, locally three coal - seatearth horizons are present. The strata in the upper part of the interval generally comprise mudstones and siltstones with relatively abundant plant remains. Underlying the Harvey Marine Band are seatearths with one or two thin coals. In places in the east of the district these seatearths are noticeably green in colour; in other places they are brown. Sphaerosiderite or small pyrite aggregates have been recorded in some (e.g. boreholes 28 NE 102).



0 1 2 3km
Scale

—40— Isopach of Beaumont to Harvey Marine Band interval (thickness in metres, ticks on low side of line)

Western limit of Beaumont Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval over 15m thick

BORE OR SHAFT PROVING INTERVAL:

+ Median coal absent

o Median coal present

● Section figured in this report

Figure 33 Beaumont Seam to Harvey Marine Band interval

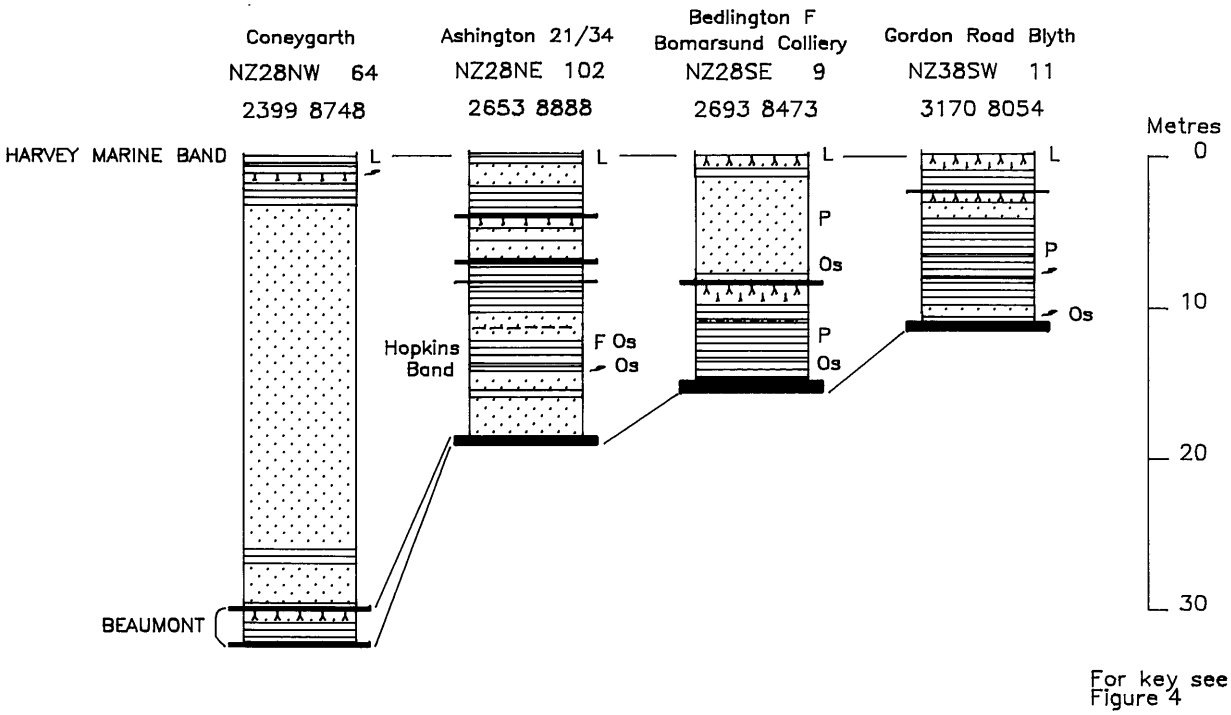


Figure 34 Beaumont Seam to Harvey Marine Band

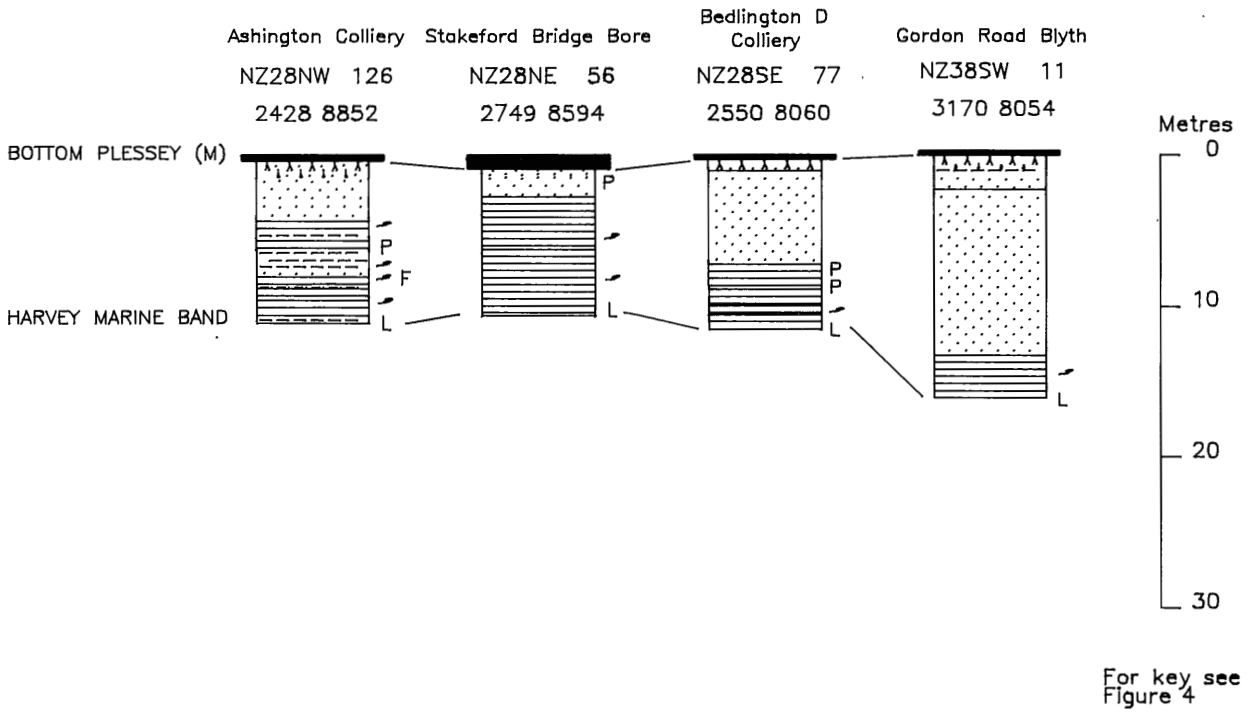


Figure 35 Harvey Marine Band to Bottom Plessey

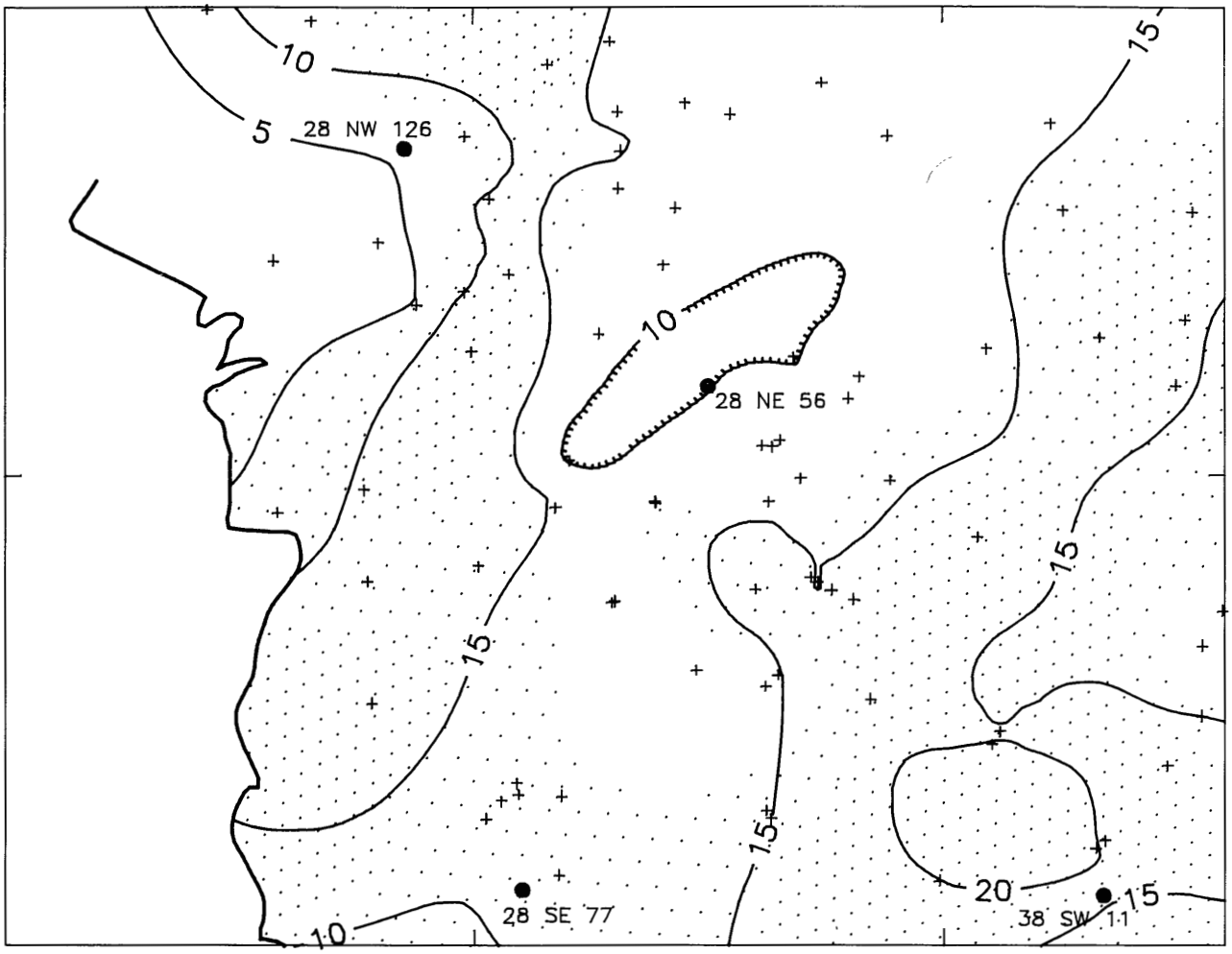
HARVEY MARINE BAND TO BOTTOM PLESSEY SEAM

The Harvey (Vanderbeckei) Marine Band, the base of which marks the base of the Middle Coal Measures, was first recorded in the Northumberland Coalfield by Hopkins (1934, p. 186) from Bates Pit [3062 8228] in the present district. The marine band consists of very dark grey to black shale, finely micaceous, in places slightly silty, and is generally between 30 and 100 cm thick. It has not been recorded in all boreholes, although in many cases this is probably due to collection failure rather than absence. The marine band is overlain by mudstones with an abundant fauna and in drawing Figures 33 to 36 the marine band has been taken at the base of these mudstones when it is not specifically recorded.

Only *Lingula mytilloides* has been recovered from the marine phase. The overlying non-marine strata contain a varied fauna including *Anthraconaia sp.* (aff. *modiolaris?*), *Anthracosia aquilina*, *A. aquilina/phrygiana*, *A.* cf. *disjuncta*, *A. ovum*, *A. ovum/aquilina*, *A. cf. phrygiana*, *A.* cf. *phrygiana* (short form), *A.* cf. *subrecta*, *Anthracosphaerium* cf. *affine*, *Naiadites* cf. *flexuosus*, *N. quadratus*, *N. quadratus/flexuosus*, *N. triangularis*.

The fossiliferous mudstones overlying the Harvey Marine Band are succeeded in much of the district by sandstone (Figures 35 and 36).

Bottom Plessey Seam. The Bottom Plessey or Ruler (Cheevely of Land, 1974) ranges in thickness from 6 to 96 cm, averaging 58 cm and is best developed in the north-east of the district where it was worked from Ashington, Woodhorn and Bates Collieries for twenty years up to 1980 (Figure 37). The Bottom Plessey is generally a good quality, clean coal with an ash content usually below 8%, the sulphur content is variable and ranges up to 2.5%; locally a thin dirt band is present. The seam is absent from an argillaceous part of the succession shown in boreholes near Choppington (28 NW 79,82,83, and 84), although it was probably not developed rather than worked out. The seam was



0 1 2 3km
Scale

—40— Isopach of Harvey Marine Band to Bottom Plessey Seam (thickness in metres, ticks on low side of line)

Western limit of Harvey Marine Band at outcrop or fault

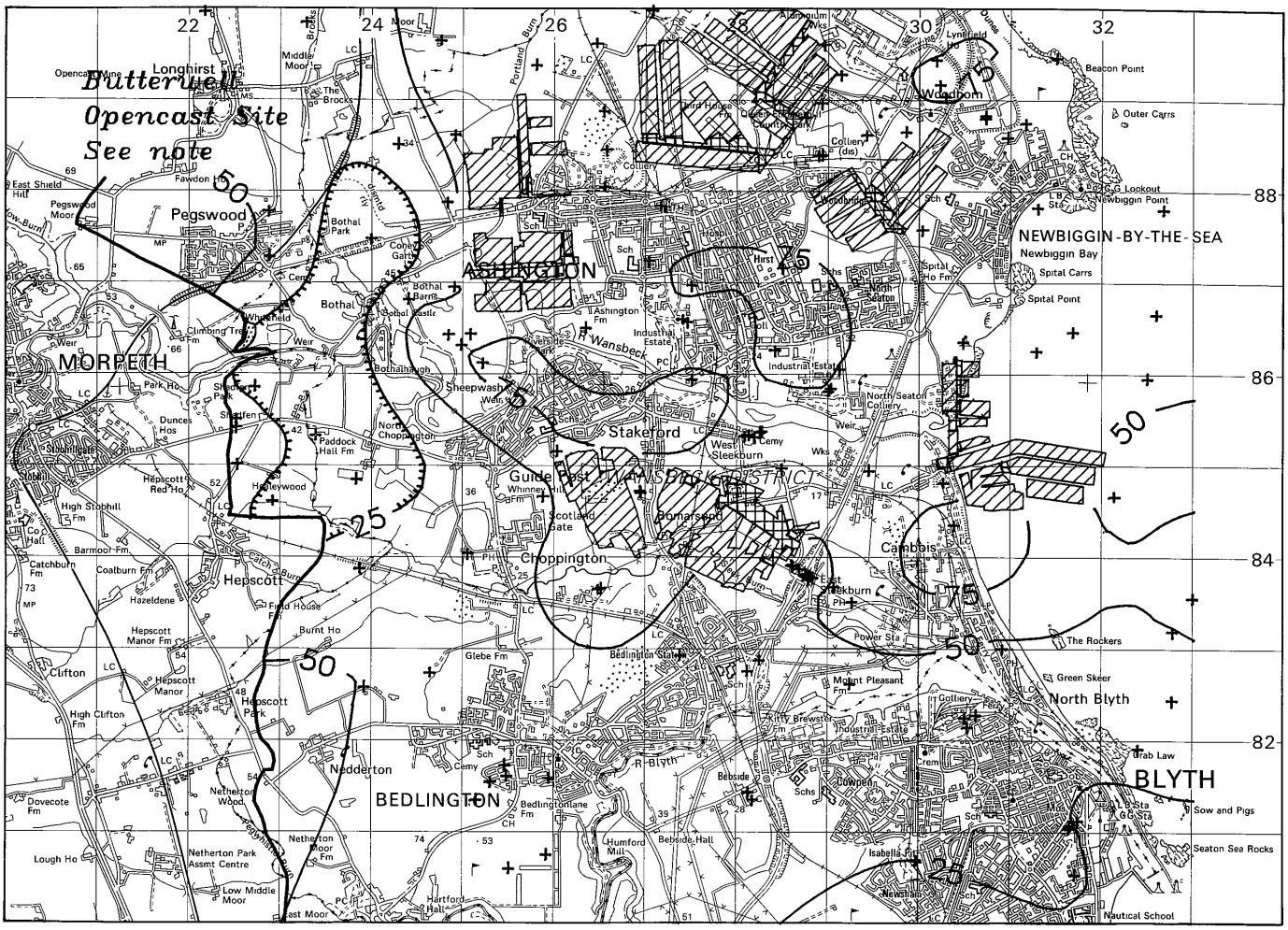
Sandstone in interval over 10m thick

Sandstone in interval 10 to 15m thick

\+ Bore or shaft proving interval

● Section figured in this report

Figure 36 Harvey Marine Band to Bottom Plessey Seam



0 1 2 3km
Scale

—40— Isopach of Bottom Plessey Seam (cm) (ornamented on low side of line)

Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 37 Bottom Plessey Seam (M), coal thickness and workings

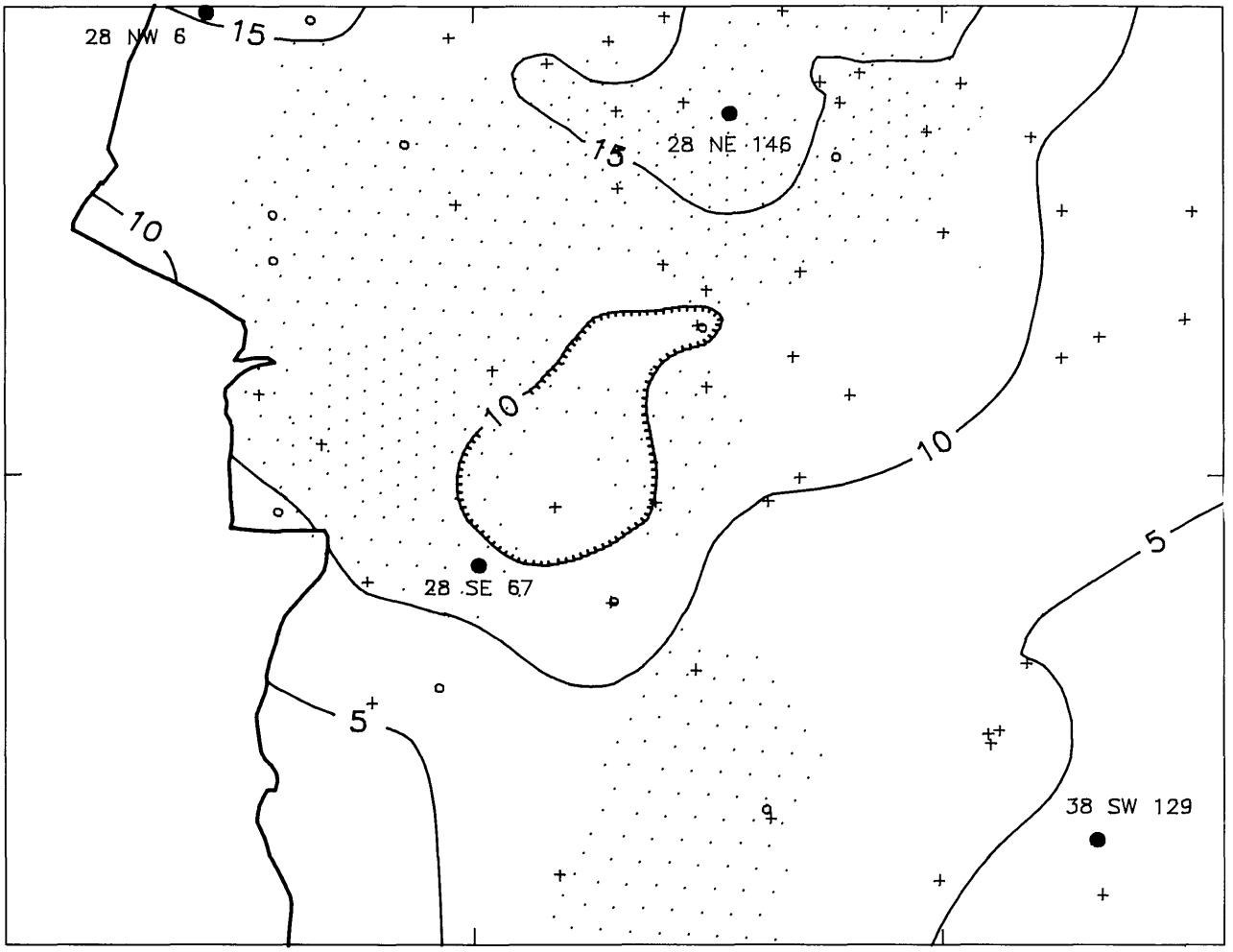


Figure 38 Bottom Plessey Seam to Plessey Seam interval

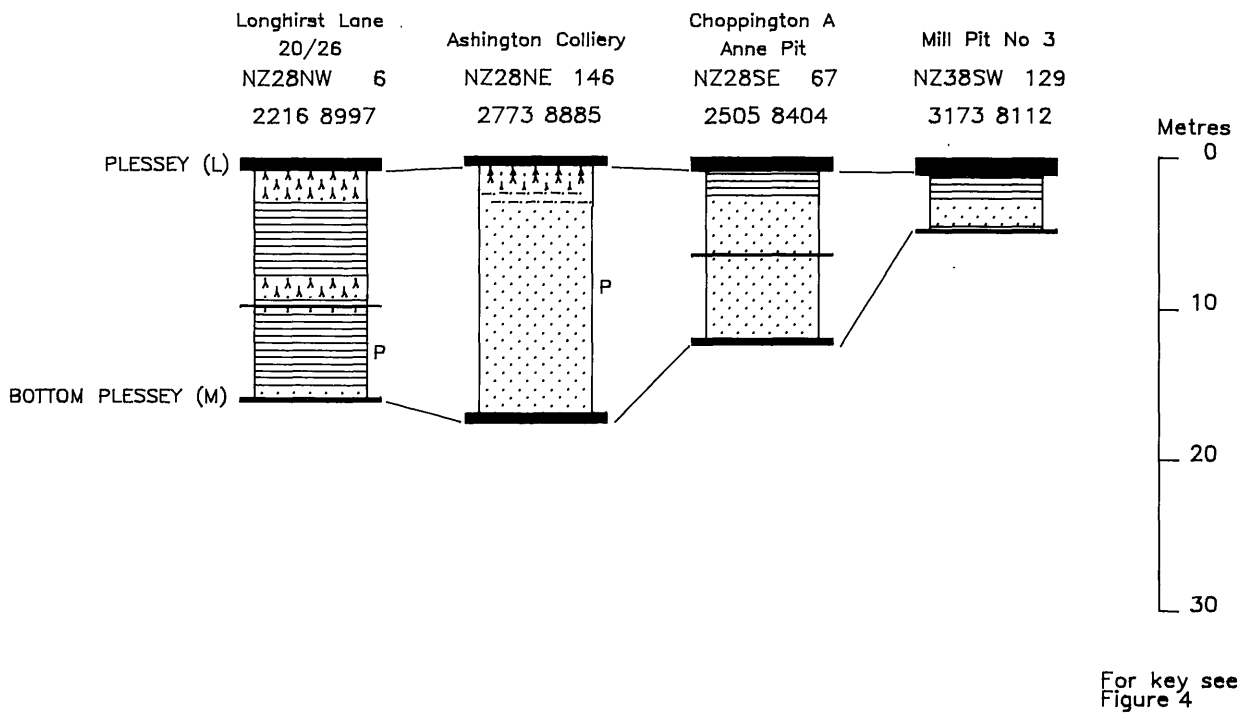


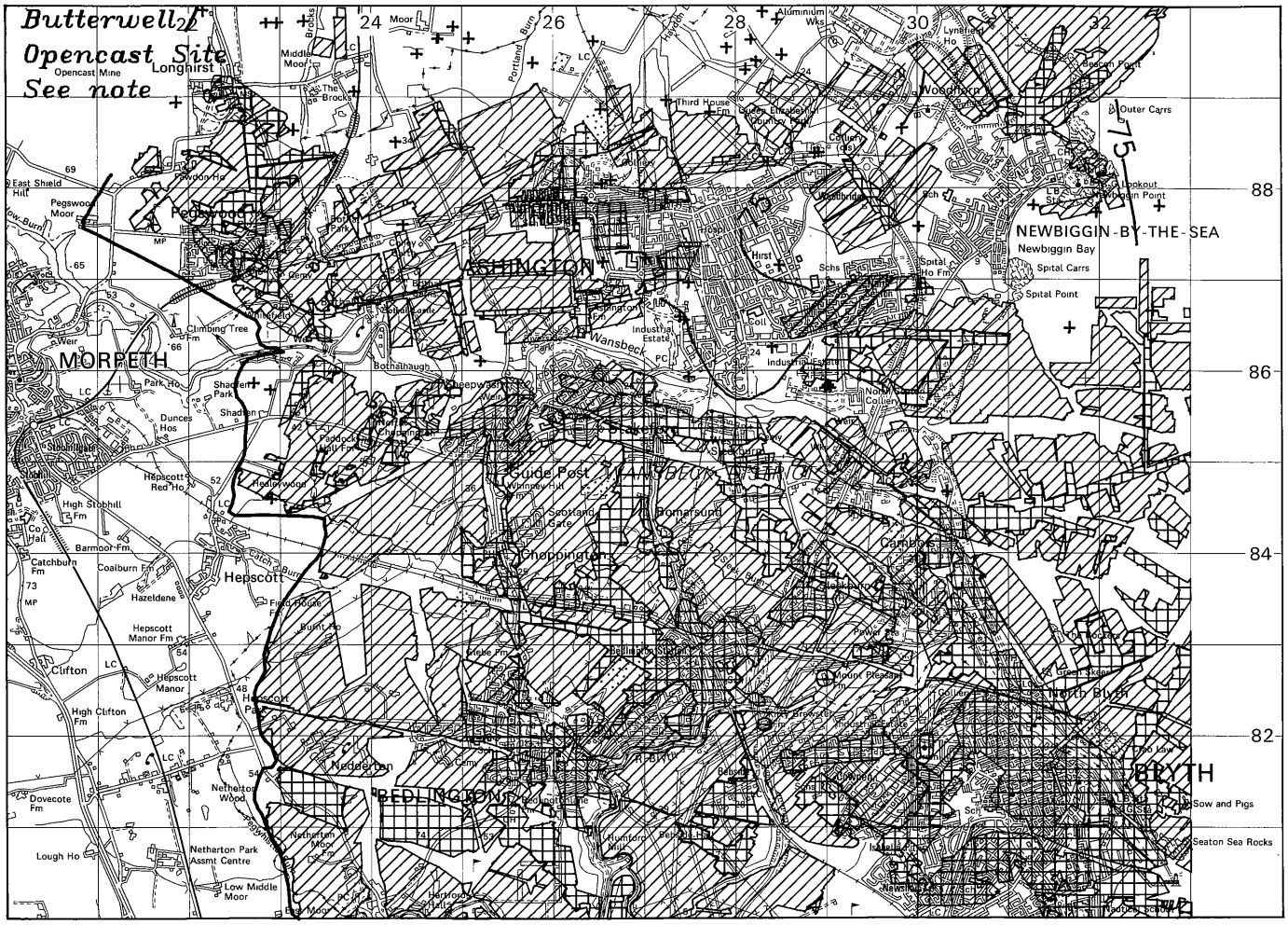
Figure 39 Bottom Plessey seam to Plessey Seam

worked opencast at Climbing Tree [226 864], where it was 50 cm thick, it is currently at the worked Butterwell Opencast Site.

BOTTOM PLESSEY TO PLESSEY

The strata above the Bottom Plessey include mudstones, siltstones and sandstones. To the south-east of the district, offshore from Cambois, the Plessey and Bottom Plessey come together and have been worked as a united seam. The interval between the two seams increases northwards to 17.1 m at Ashington (e.g. in borehole 28 NE 146) and between Ashington and Pegswood is composed mainly of sandstone (Figures 38 and 39). An additional coal-seatearth horizon is present in the centre of the interval where it has its thickest development, this coal was worked as the Middle Plessey (20 cm thick) in Climbing Tree opencast site [226 864].

Plessey Seam. The Plessey (Top Plessey) Seam has been wrought extensively throughout the district. It takes its name from a locality [240 790] known as Plessay or Plessy to the south of the district, where it was first mined near its outcrop (Land, 1974; Jackson, Lawrence and Frost, 1985). British Coal name the seam the Hutton (L) on mine plans (not the Hutton of Land, 1974, see below). The seam is generally of good quality without dirt bands, averaging 76 cm in thickness and with ash content usually 6 to 8%, but locally rising to 10%. Sulphur content is less than 1.5%. The seam is thickest in the south-east of the area where dirt bands are more common, but falls to less than 12 cm in the north (Figure 40).



—75— Isopach of Plessey Seam (cm)

Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

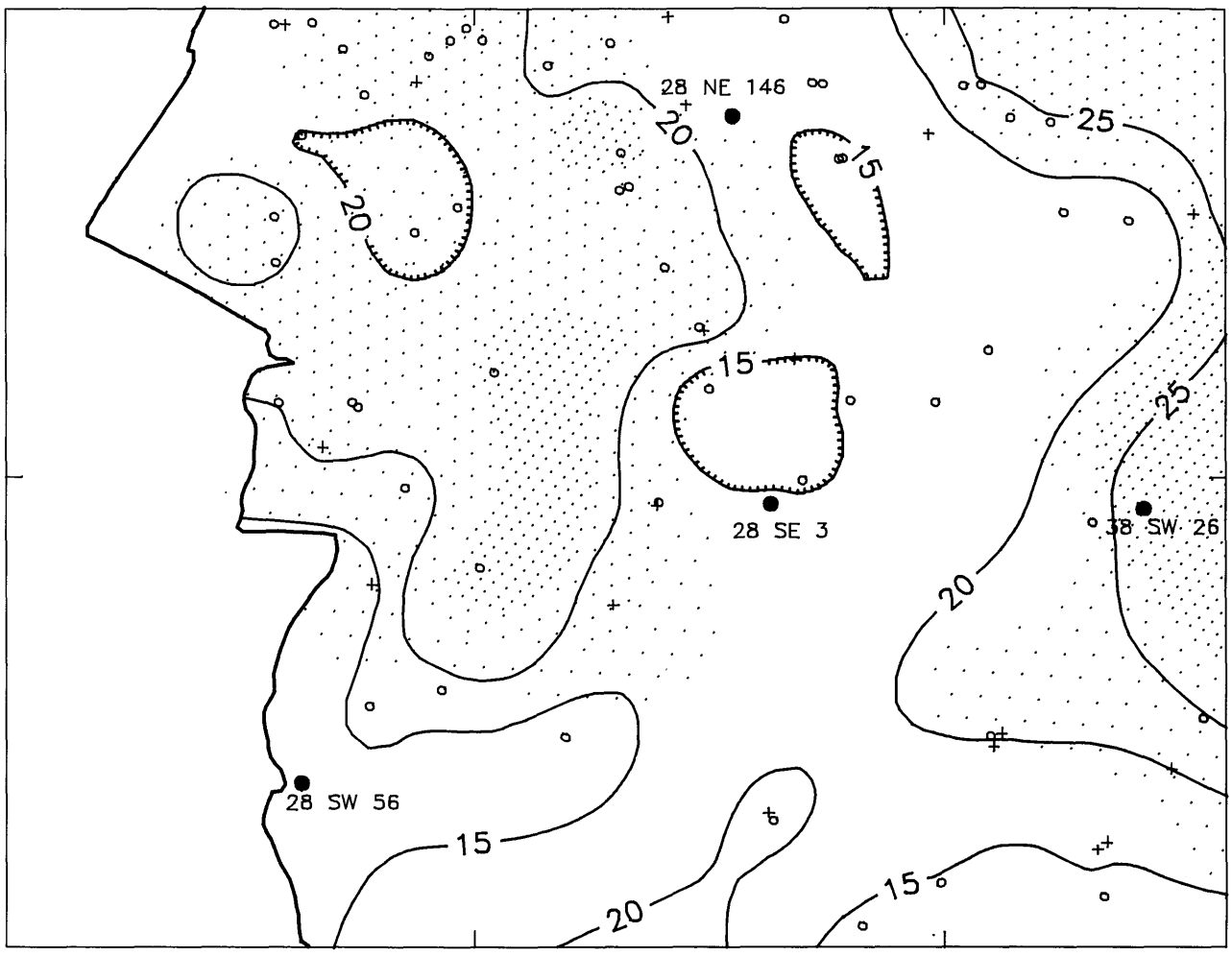
Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 40 Plessey Seam (L), coal thickness and workings



0 1 2 3km
Scale

—40— Isopach of Plessey to Northumberland Low Main interval (thickness in metres, ticks on low side of line)

Western limit of Plessey Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval over 15m thick

BORE OR SHAFT PROVING INTERVAL:

+ Median coal absent

o Median coal present

● Section figured in this report

Figure 41 Plessey Seam to Northumberland Low Main Seam interval

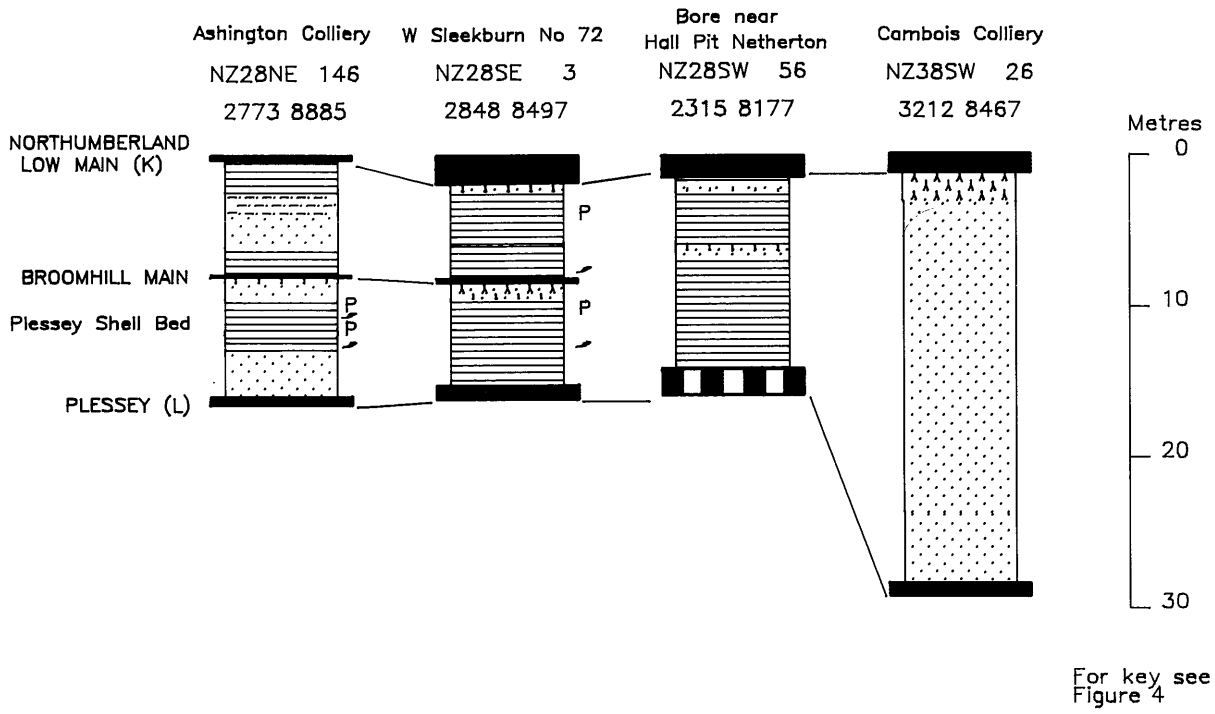
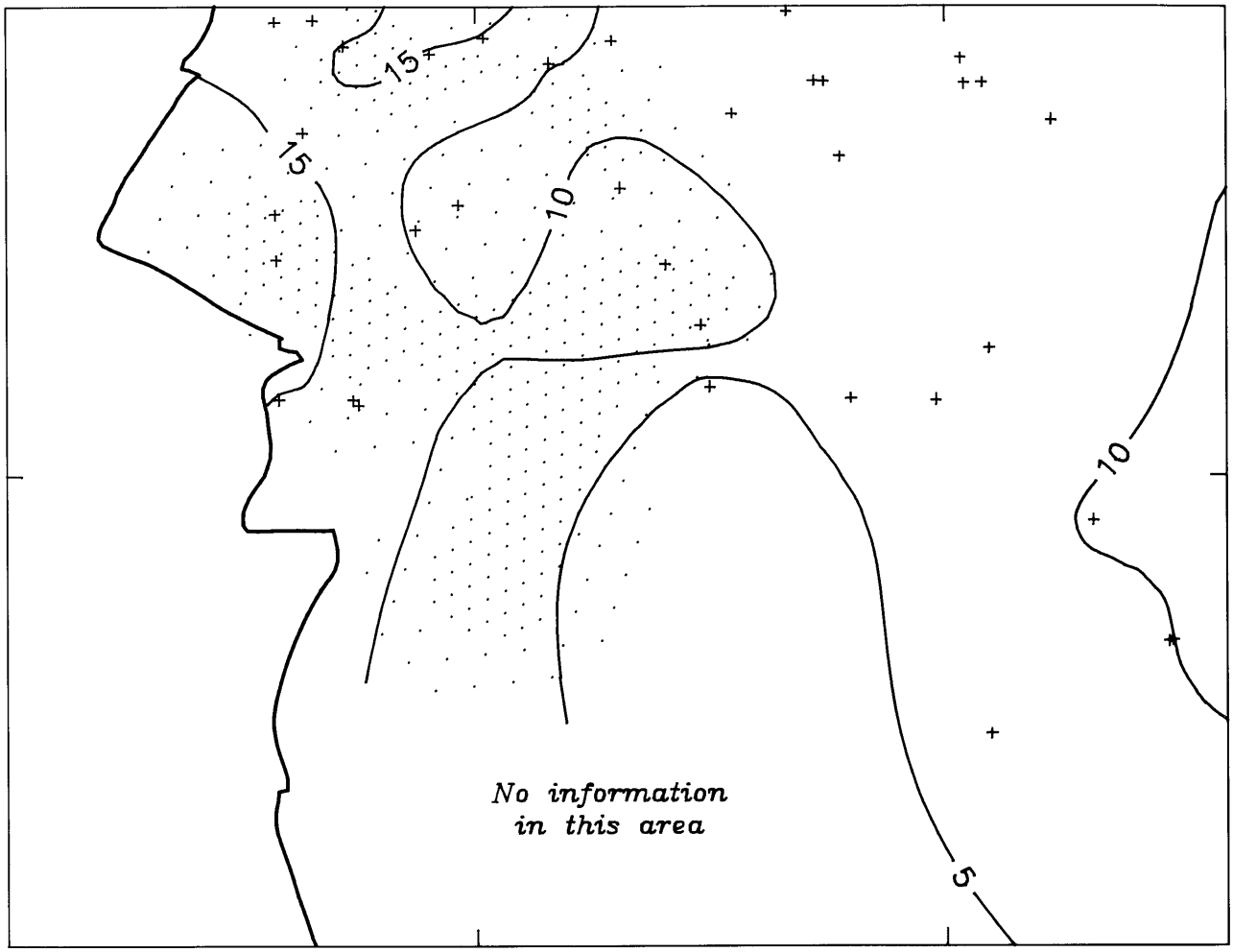


Figure 42 Plessey Seam to Northumberland Low Main Seam

PLESSEY TO NORTHUMBERLAND LOW MAIN

This interval (Figures 41 and 42) ranges from 13 m to 37 m and throughout much of the district is divided by an intermediate coal, here correlated with, and named, the Broomhill Main. This is equivalent to the Hutton of Land (1974, p. 30). The upper part of the interval is marked by presence of a thick sandstone in the north-west.

Plessey Seam to Broomhill Main Seam. This interval, ranging in thickness from 5 to 17 m is mainly comprised of mudstones and siltstones with thin sandstones developed locally and ranges in thickness from 5 to 17 m. Land (1974, p.48) noted that two fossiliferous horizons may occur above the Plessey Seam, the upper containing a prolific fauna and sometimes referred to as the 'Plessey Shell Bed'. The lower horizon contains *Anthracosia ovum* and *A. phrygiana*, whilst the upper contains a combined fauna consisting of:- *Anthraconaia* cf. *curtata*, *A. modiolaris*, *A.* cf. *salteri*, *Anthracosia aquilina*, *A. aquilina/phrygiana*, *A.* cf. *beaniana*, *A.* cf. *disjuncta*, *A. ovum*, *A. phrygiana*, *A.* cf. *phrygiana* (short form), *A.* cf. *retrotracta*, *Anthracosphaerium* cf. *turgidum*, *Naiadites quadratus*. A seatearth appears locally between these two mussel bands. In places a sandstone overlies the fossiliferous mudstones and locally at Choppington and Pegswood it occupies the entire interval. The thin seatearth of the Broomhill Main usually overlies the sandstone. Offshore from Cambois thin-bedded micaceous sandstone makes up the entire interval between the Plessey and Northumberland Low Main seams, although thin shale partings midway in the interval may represent the horizon of the Broomhill Main. Elsewhere (e.g. in borehole 38 NW 56 at North Seaton) a mudstone separates the upper and lower sandstones where seatearth or coal is not developed.



0 1 2 3km
Scale

—40— Isopach of Broomhill Main to Northumberland Low Main Seam (thickness in metres)

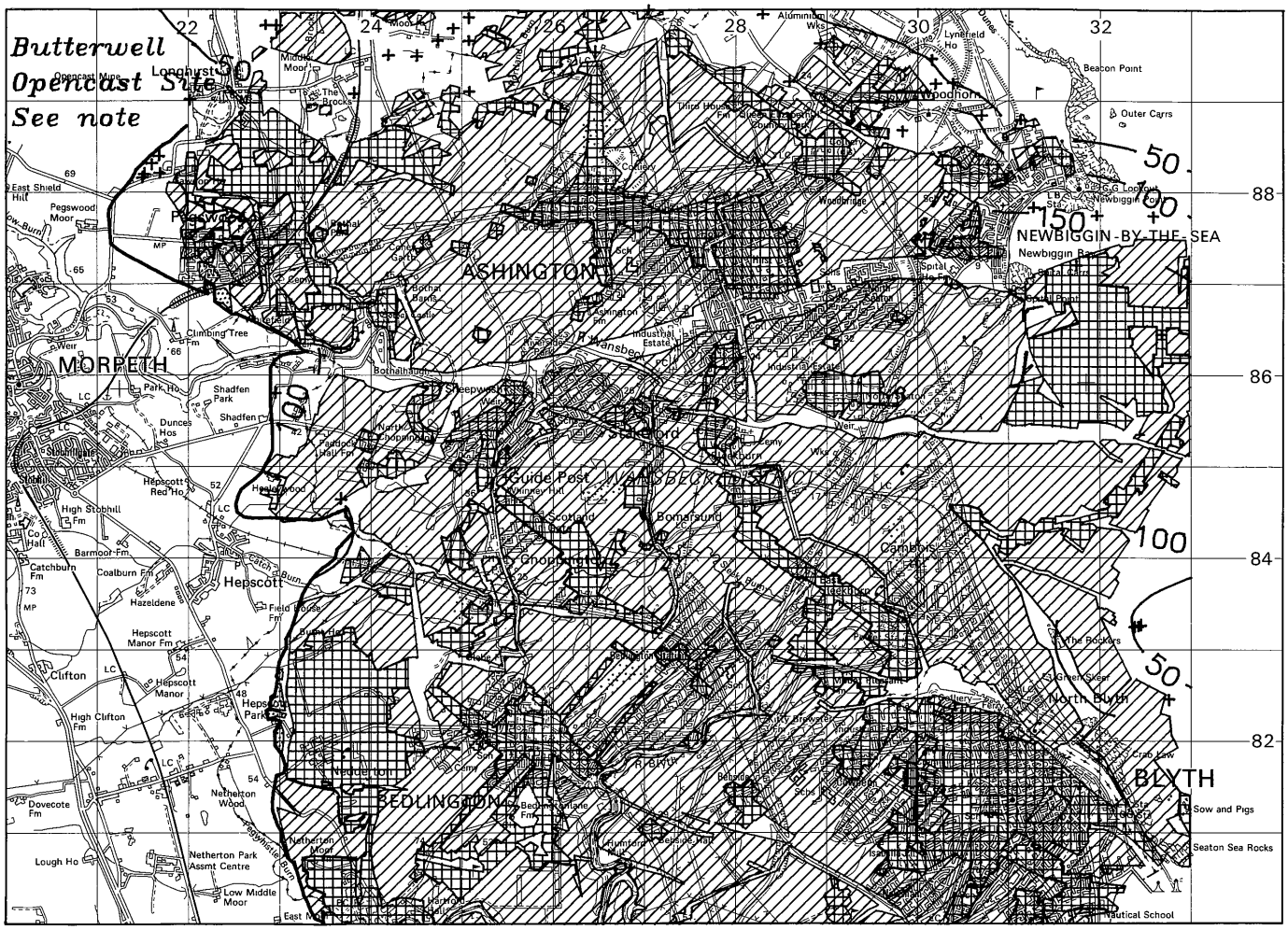
Western limit of Broomhill Main Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval over 10m thick

\+ Borehole or Shaft proving interval

Figure 43 Broomhill Main Seam to Northumberland Low Main Seam



0 1 2 3km

Scale

—50— Isopach of Northumberland Low Main Seam (cm)

Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 44 Northumberland Low Main Seam (K), coal thickness and workings

Broomhill Main Seam. The seam is washed out near Cambois and at Netherton, but otherwise can be traced throughout the district with an average thickness of 19 cm and a maximum of 92 cm. It is of much less importance than the equivalent Hutton Seam of the Tynemouth district to the south (Land, 1974) and has not been mined. The seam increases in thickness again north of Ashington and was worked as the Duke in the Widdrington - Broomhill area. It is currently extracted from the Butterwell Opencast Site.

Broomhill Main Seam to Northumberland Low Main Seam. The interval ranges from 4 to 20 m (Figure 43). It is composed dominantly of mudstone east of Ashington and Bedlington where the measures are thin and of sandstone between Ashington and Pegswood where the interval is thickest. Where mudstones are dominant they commonly contain abundant plant remains. A variable fauna has been recovered from the roof of the Broomhill Main Seam, mainly around North Seaton (Land, 1974, p.54). The fauna comprises:- *Anthraconaia sp.* (*salteri* group?) *A.* cf. *williamsoni, Anthracosia* cf. *aquilina, A.* cf. *beaniana, A.ovum/ phrygiana, A.phrygiana, A.subrecta, Anthracosphaerium exiguum, A. exiguum/turgidum, A.* cf. *turgidum, Naiadites productus/quadratus.*

The topmost part of the interval contains a seatearth and, unusually, one or two thin coals beneath the Northumberland Low Main.

Northumberland Low Main Seam. The Northumberland Low Main has been the most extensively worked seam in the district such that over a large part of the area resources are exhausted (Figure 44). It averages 120 cm and exceeds 2 m in thickness locally. The structure and quality of the seam vary and it commonly contains at least one thin dirt band. However, the quality is generally good and in at least one borehole (28 NW 27), where the ash content was less than 3%, has been described as superlative.

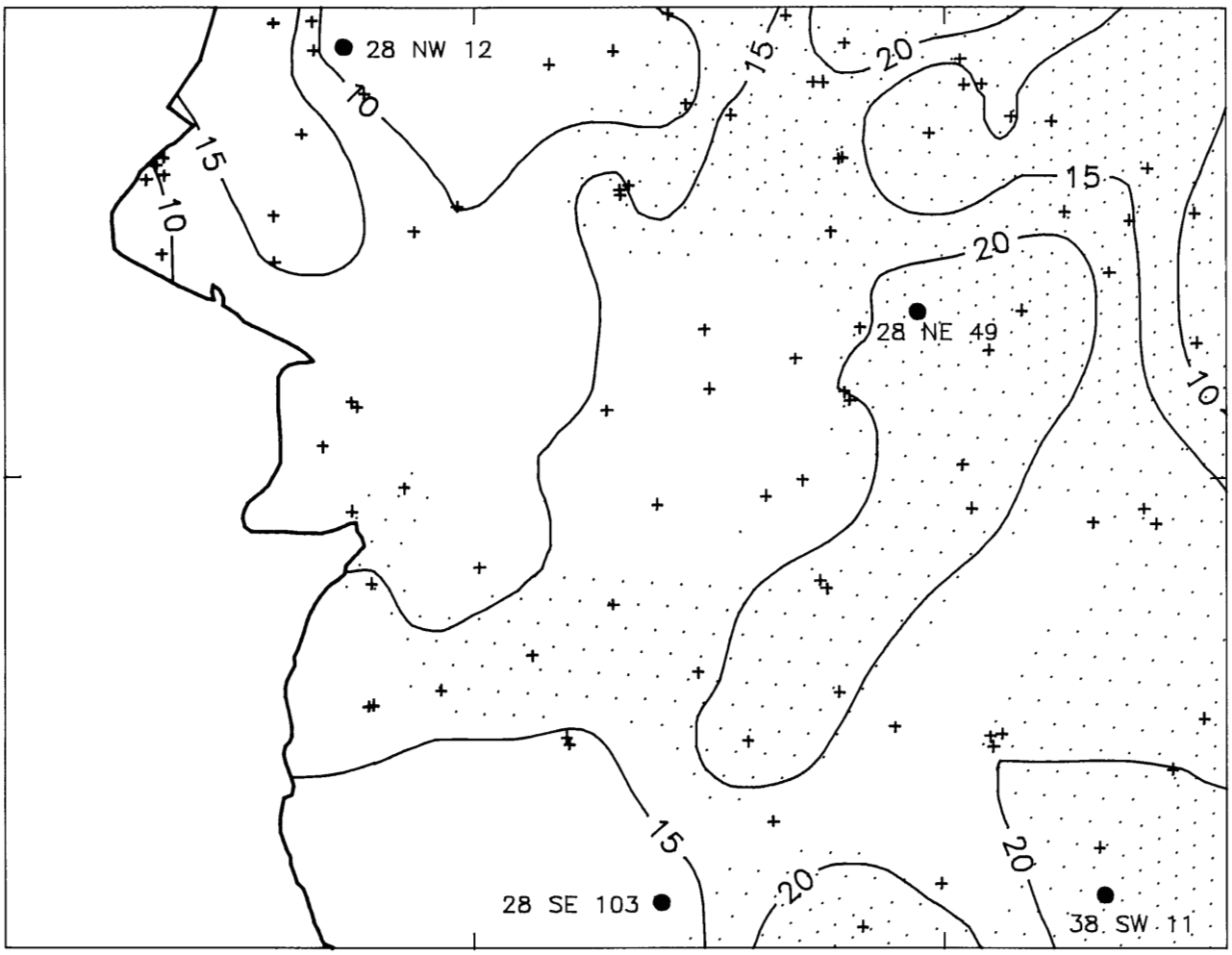
NORTHUMBERLAND LOW MAIN TO DURHAM LOW MAIN

The interval between the two 'Low Main' seams ranges from as little as 2 m up to 20 m, (Figures 45 and 46). Strata in this interval vary widely, in the north-west of the district the two seams are separated by only a few metres of mudstone, whereas in the east there are at least two intermediate cycles in which thin coals are developed.

In the west of the district the roof of the Northumberland Low Main is unfossiliferous, though in the Ashington No 2 underground borehole (28 NE 27) *Anthracosia phrygiana, Anthracosphaerium turgidum* and *Naiadites* cf. *productus* were collected. In the east the roof is generally black shale, canelly in many places. Fish debris occurs in the mudstone roof of a thin coal up to 2 m above the Northumberland Low Main in the Newbiggin area (e.g. borehole 38 NW 43a). At Newsham on the southern edge of the district [300 800] the canelly shale contains the noted "Newsham fauna", a varied fish and amphibian fauna first described by Atthey (1870); Land (1974) details the fauna and lists further references describing the occurrence. The shale or 'brat' roof of the seam was formerly extensively used in the production of bricks at Pegswood (Fowler, 1936, p. 139).

In the east a thin coal, known locally as the 'Cambois Little' occurs some 5 to 8 m above the Northumberland Low Main and is probably equivalent to the 'Whitley Seam' of Land (1974, p.61). Intermediate strata are largely grey mudstones with ironstone nodules and local sandstones. A prominent musselband commonly known as the Low Main Shell Bed (Trueman and Weir, 1951, p. 116) overlies the 'Cambois Little' coal or its presumed position where absent.

The combined fauna from the horizon is:- *Anthraconaia* cf. *irvinensis, A.* aff. *pulchella, A. sp.* (*salteri* group?), *A.* aff. *pulchella, A.* cf. *aquilina, A. aquilina/phrygiana, A.* aff. *barkeri, A. beaniana, A. carissima, A. disjuncta, A.* cf. *ovum, A. ovum/phrygiana, A. phrygiana, A. retrotracta, Anthracosphaerium affine, A.* cf. *exiguum, A.* cf. *turgidum, Naiadites* cf. *productus, N.* aff. *quadratus, N.* cf. *triangularis.*



—40— Isopach of Northumberland Low Main to (Top) Durham Low Main interval (thickness in metres)

Western limit of Northumberland Low Main Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval over 10m thick

\+ Borehole or Shaft proving interval

● Section figured in this report

Figure 45 Northumberland Low Main Seam to (Top) Durham Low Main Seam interval

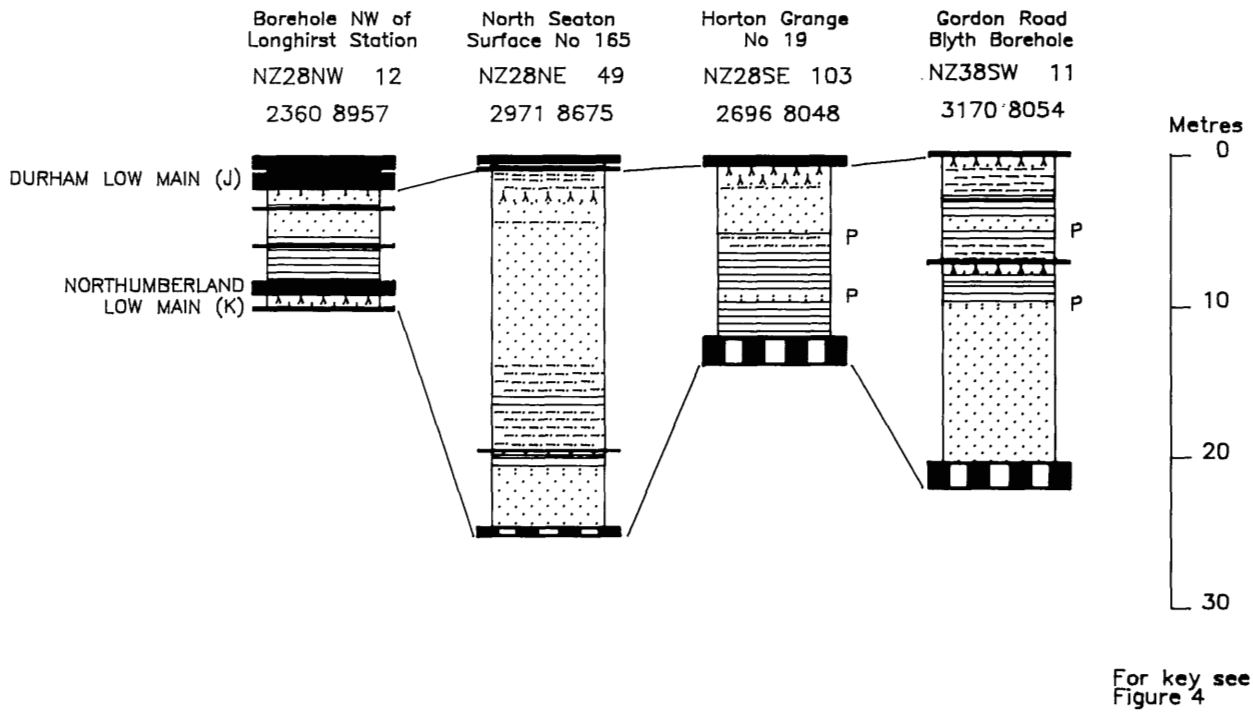


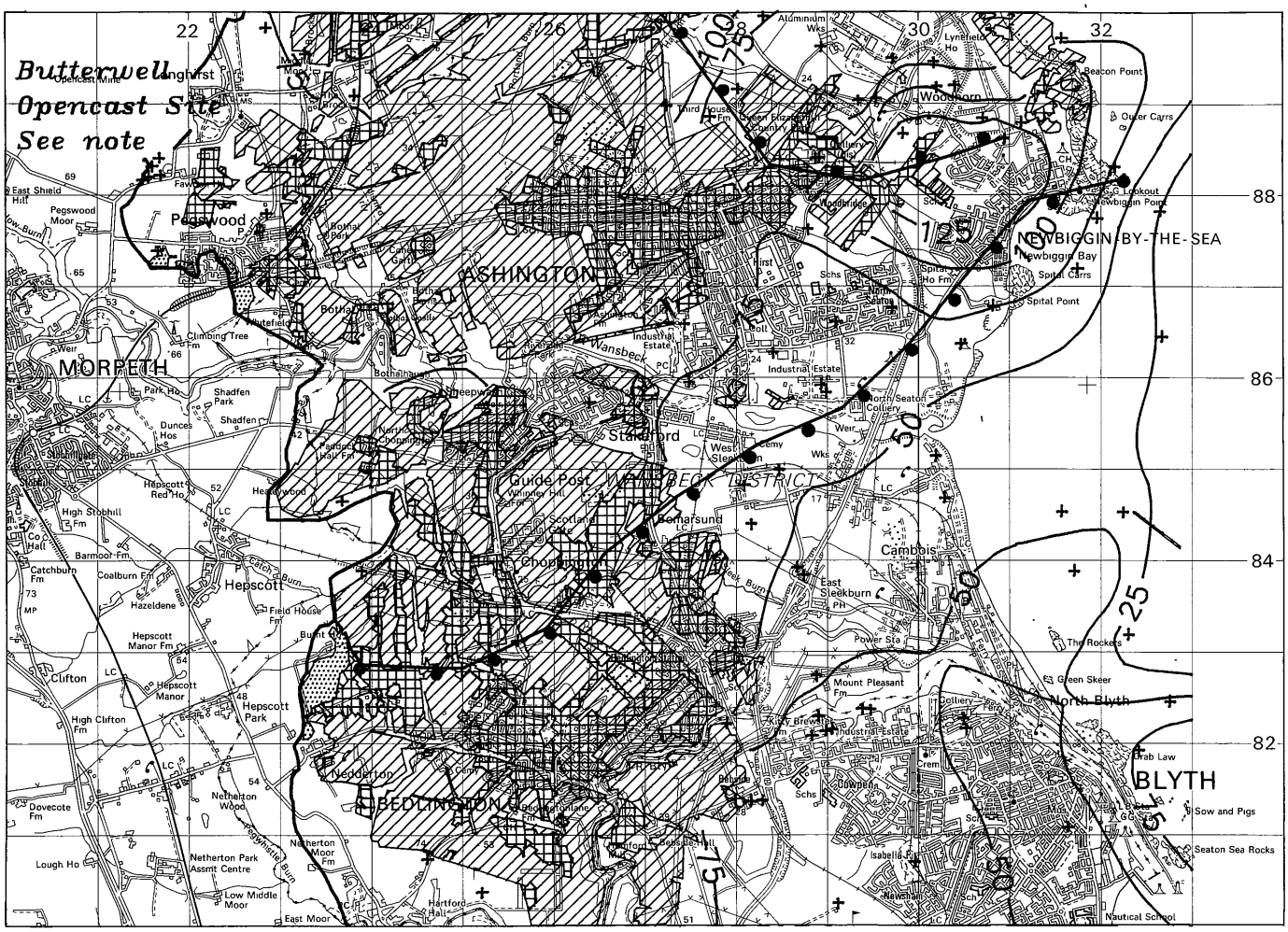
Figure 46 Northumberland Low Main Seam to Durham Low Main Seam interval

Notably the faunas from the iron rich developments differ from those occurring in more muddy sediments. *Anthraconaia* cf. *irvinensis* and *Anthracosia* aff. *barkeri* are confined to the ironstone developments, and the forms determined as *Anthraconaia* aff. *pulchella*, *A.* aff. *williamsoni* and *Anthracosia carissima* were collected from pale grey sediments not otherwise represented in the collections from this horizon.

The fossiliferous strata also include beds and nodules of shelly ironstone probably equivalent to the **Whitley Ironstone** of Land (1974, p.62). It was probably this ironstone which was mined from pits west of Netherton [233 823] to supply the Bedlington ironworks (see Part I, Section 4.4).

Silty mudstones and sandstone occur between the mussel band and the highest fossiliferous horizon in this interval which occurs above the Ellington seam of Land (1974, p.62) and contains a less varied fauna consisting of:- *Anthraconaia* cf. *cymbula*, *Anthracosia* cf. *caledonica*, *A.* aff. *disjuncta*, *A.* aff. *phrygiana*, *A.* cf. *simulans*, *Naiadites* cf. *productus*, *N. productus/quadratus*, *N. quadratus/flexuosus*.

There is some doubt as to the correlation of the Ellington seam in the present district (see below).



—50— Isopach of Durham Low Main and Top Durham Low Main Seams (cm)

Western limit of seam at outcrop or fault

Approximate line of split in seam (split on ornamented side of line)

\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

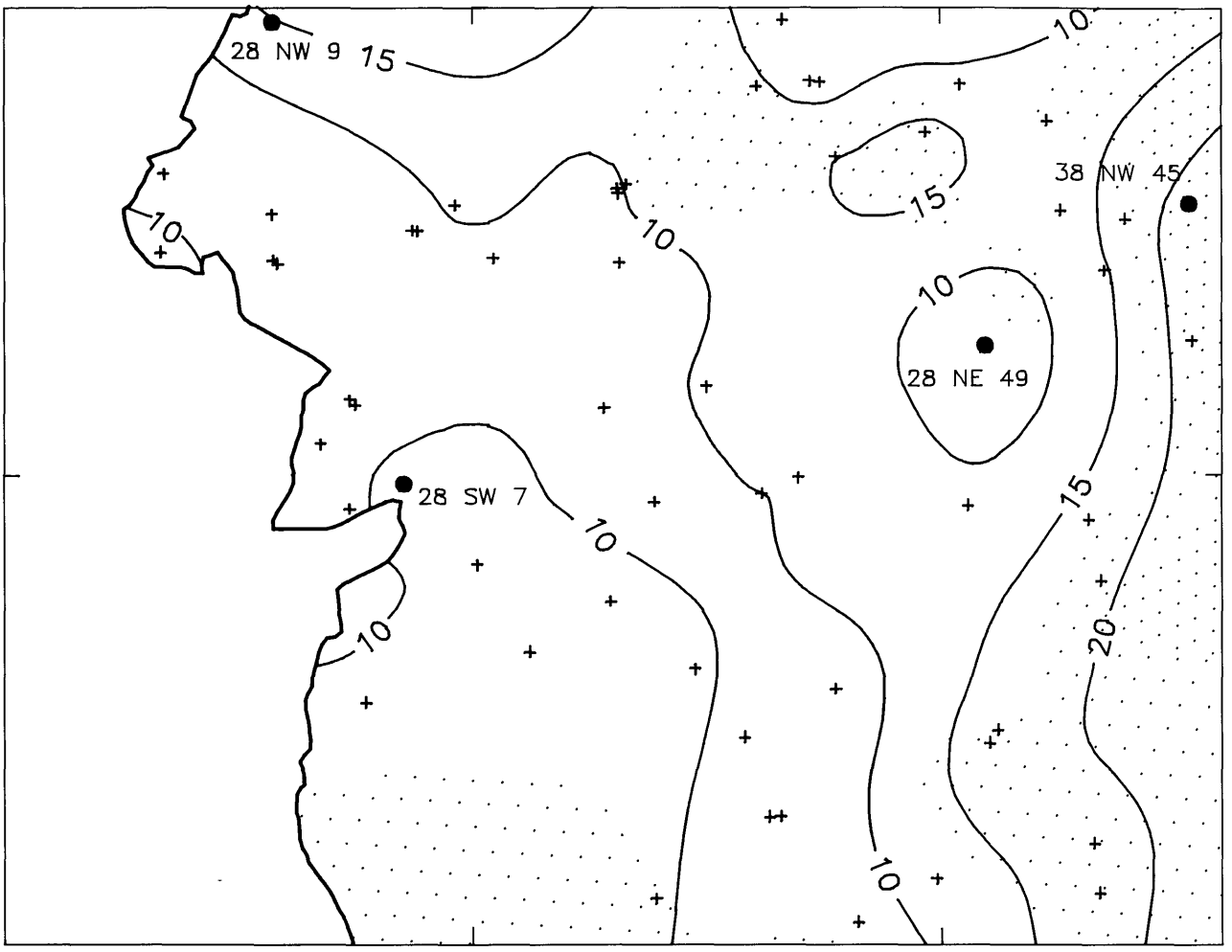
NOTE:
The seam has been worked opencast in the currently active Butterwell Site

Figure 47 Durham Low Main (J) and Top Durham Low Main (J1) seams, coal thickness and workings

Durham Low Main Seam. In Northumberland the Durham Low Main is generally known as the 'Five-Quarter'; the Durham name is used in this report in continuity with that used in the Tynemouth District by Land (1974) and to avoid confusion with 'Five-Quarter' where used higher in the succession. In a few instances locally around Netherton and Ashington the seam has been named the 'Six-Quarter'. The seam is banded almost throughout the district and commonly consists of Top and Bottom leaves of thicker coal, usually with intermediate thinner coals. In a few localities (e.g. near Pegswood) the seam occurs as a single, united seam up to 188 cm in thickness and in others as a group of coals of equal thickness. The large range in coal and inter-coal thickness variation makes correlation of individual coals very difficult. Where the top and bottom leaves of coal are sufficiently distinct, particularly in the north-east and south of the district, they have been identified as the Top and Bottom Durham Low Main coals respectively (Figure 47).

In the west of the district where the individual coals are less distinct. Analysis of the thickness of the various leaves and the interval between them and the Northumberland Low Main Seam suggests possible correlations. First that the Top Durham Low Main, the thicker and more persistent seam, is equivalent to much, if not all, of the succession represented by the banded Durham Low Main in the west. Second, that the Bottom Durham Low Main is an additional seam or split off the Durham Low Main, possibly equivalent to the **Ellington** of Land (1974, p.63). It is apparent that the relationship of the Ellington to the Durham Low Main will only be elucidated by a survey of the strata to the north of the district.

The (Top) Durham Low Main has been mined extensively in the central portion of the district and in workings west of Pegswood was known locally as the 'Band Coal'. It has also been opencasted near Pegswood and from Climbing Tree; in the latter the seam was 64 cm thick. At Howard opencast site [235 825] the top leaf of the Durham Low Main, which contained old pillar and stall mineworkings, ranged from 0.62 to 1.04 m in thickness with an impersistent thin mudstone parting. The lower leaf, 0.4 to 8.5 m below the upper, averaged 25 cm with a maximum thickness of 64 cm. The Bottom Durham Low Main has been mined only from Horton Grange Colliery in two small workings near Bebside.



0 1 2 3km
Scale

—40— Isopach of Durham Low Main Seam to Bensham Seam (thickness in metres)

Western limit of Durham Low Main Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval over 10m thick

Borehole or Shaft proving interval

Section figured in this report

Figure 48 (Top) Durham Low main Seam to (Bottom) Bensham Seam interval

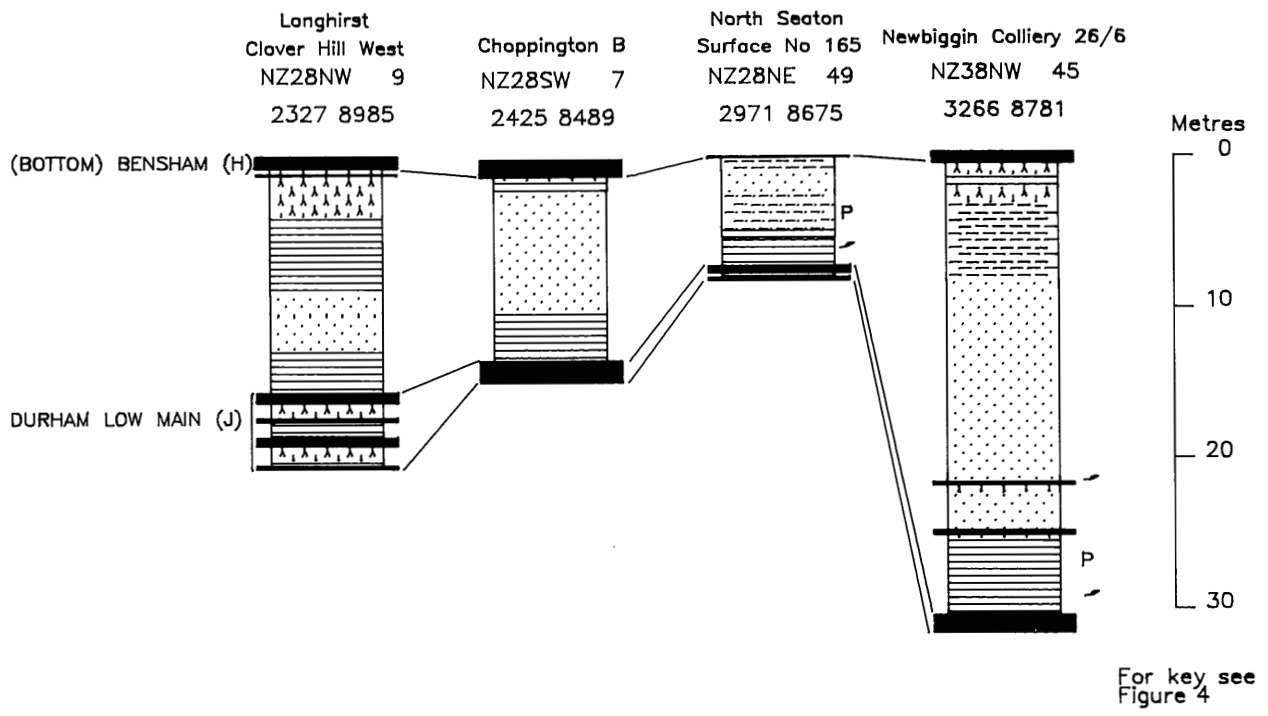


Figure 49 Durham Low Main Seam to Bensham Seam

DURHAM LOW MAIN TO BENSHAM

The Durham Low Main to Bensham interval ranges from 5 to 22 m (Figures 48 and 49). The roof measures of the (Top) Durham Low Main, where mudstone, contain a poor fauna of *Anthracosia* aff. *nitida*, *A. ovum*, *A. phrygiana*, *A.* cf. *phrygiana* (short form), *A.* aff. *retrotracta*, *Naiadites* cf. *productus*, *N. quadratus/productus*. A further mussel band 3 to 6 m higher in the sequence contains a poorly preserved fauna dominated by *Naiadites* cf. *productus*, although *Anthracosia sp.* may also be present. Unusually for the Northumberland coalfield, over much of the district the interval comprises mudstone and siltstone with only subordinate sandstone (Haszeldine, 1981, p.138). The thick medium- to coarse-grained sandstone in the east of the area is a continuation of the Table Rocks Sandstone (Lebour and Smythe, 1906) well exposed on the coast just south of the district (Land, 1974, p.66).

Bensham Seam. The Bensham (Maudlin of County Durham) has been worked extensively in the centre of the district to the east of its crop (Figure 50). In the end the Bensham, like the Durham Low Main, occurs as two distinct leaves identified as the Top and Bottom Bensham. In the rest, however, it is only a single, albeit commonly banded, unit. The Bottom Bensham is apparently the more persistent of the two seams. The Top Bensham probably represents a split from the lower seam, but is the thicker of the two in the east of the area. The (Bottom) Bensham seam is up to 170 cm thick, but is more commonly between 64 and 97 cm and tends to be of variably quality. The seam was extracted by opencast methods at a small site at Pegswood Moor and at Climbing Tree in the north, and at Howard Site in the south, although it was washed out extensively at Howard. The Top Bensham also has a maximum thickness of about 170 cm, but averages 70 cm. It has been worked in the south of the district from Bedlington 'D' and Horton Grange Collieries, and to a limited extent from pits near the coast (Figure 51). The seam was too thin to work in the region of a washout at Howard Opencast Site, but thickens to the south and was worked opencast to crop

—25— Isopach of Bensham and Bottom Bensham seams (cm)

0 1 2 3km
Scale

Western limit of seam at outcrop or fault

Approximate line of split in seam (split on ornamented side of line)

\+ Bore or shaft penetrating coal (outside worked area)

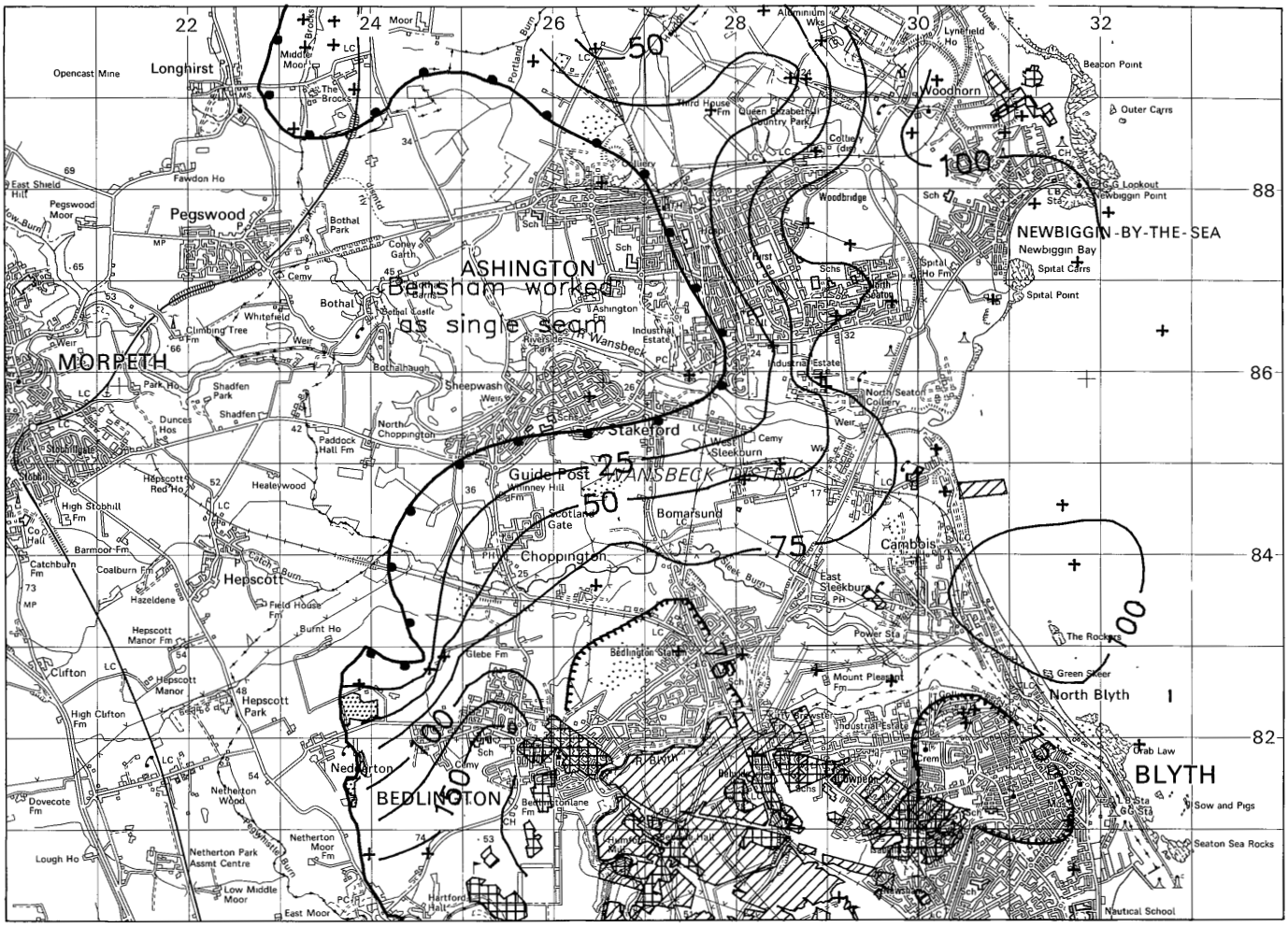
Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

Figure 50 Bensham (H) and Bottom Bensham (H2) seams, coal thickness and workings



50 Isopach of Top Bensham Seam (cm) (ornamented on low side of line)

Western limit of seam at outcrop or fault

Approximate line of split in seam (split on ornamented side of line)

Bore or shaft penetrating coal (outside worked area)

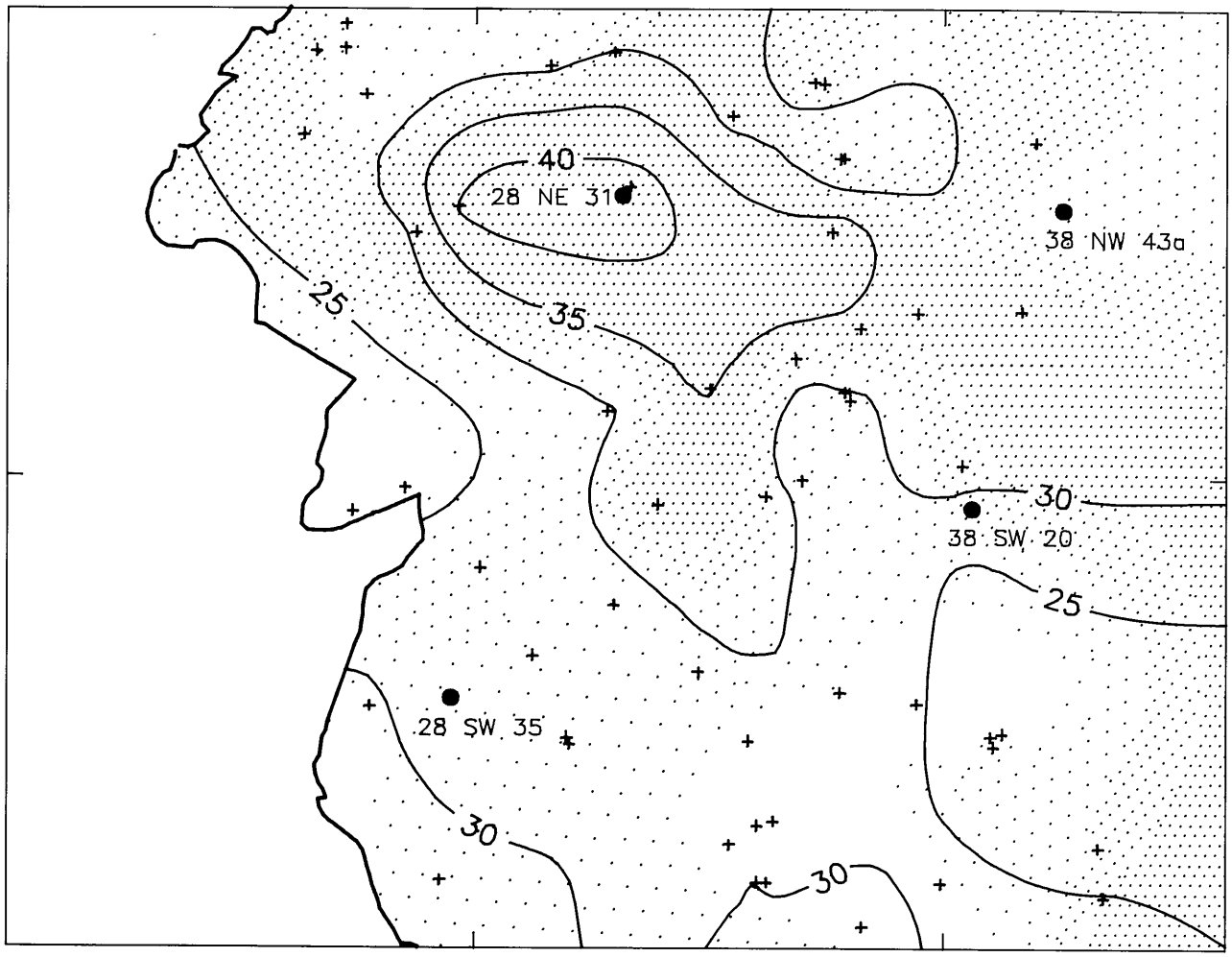
Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

Figure 51 Top Bensham Seam (H1), coal thickness and workings



0 1 2 3km
Scale

—40— Isopach of (Bottom) Bensham to Yard interval (thickness in metres)

Western limit of Bensham Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval 15 to 20 m thick

Sandstone in interval over 20m thick

\+ Bore or Shaft proving interval

● Section figured in this report

Figure 52 Bensham Seam to Yard Seam interval

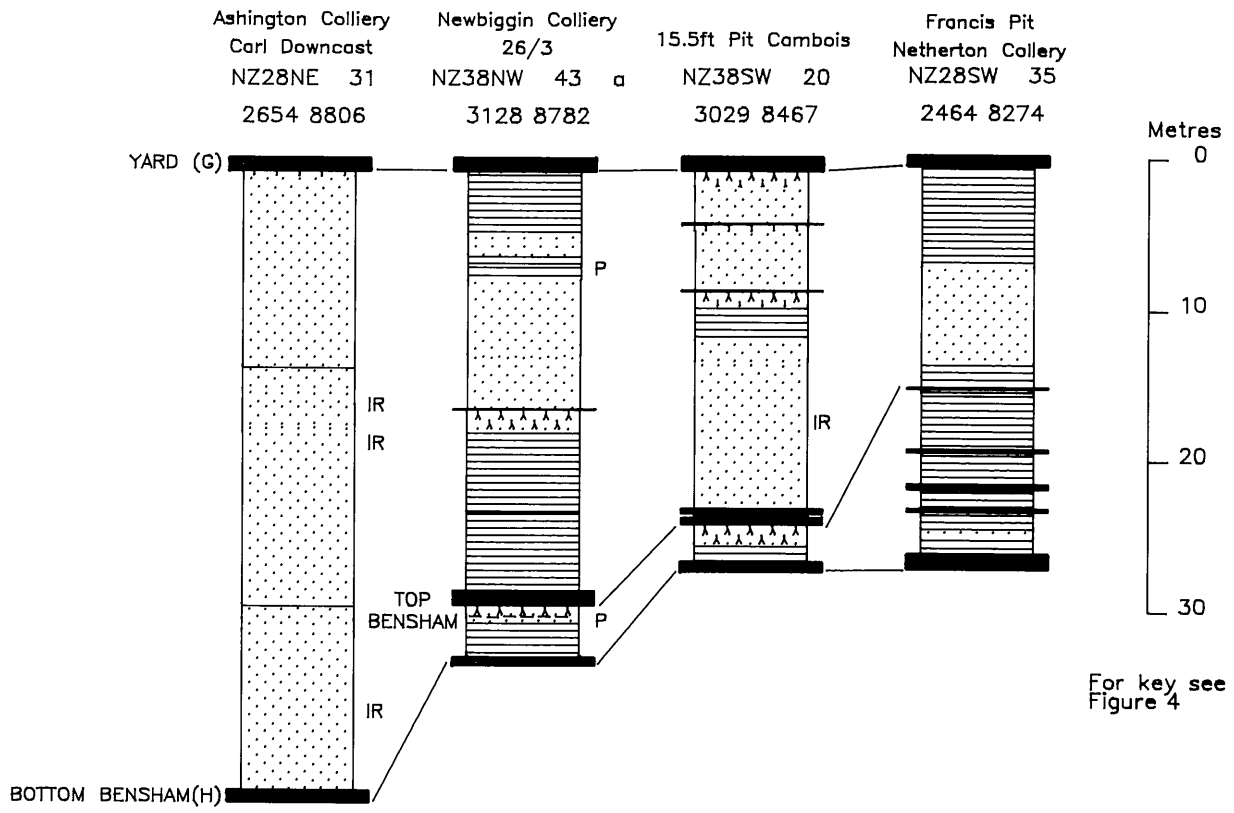


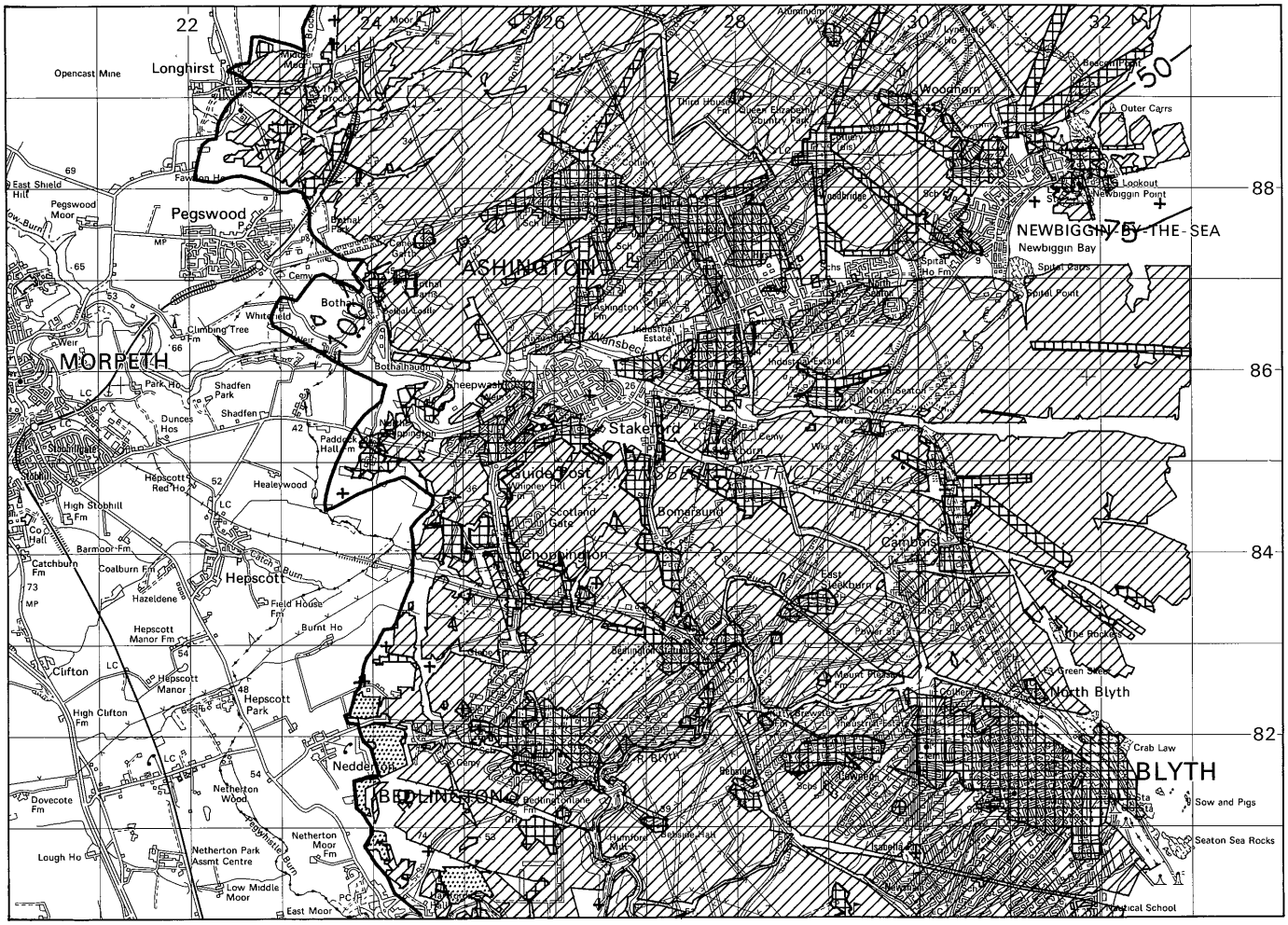
Figure 53 Bensham Seam to Yard Seam

at Howard House and Poland Sites. The seam generally is not of very good quality with an ash content commonly exceeding 10%.

BENSHAM TO YARD

Sandstone dominates the measures between the (Bottom) Bensham and the Yard, commonly making up over 60% of the succession. The interval ranges in thickness from 19 to 42 m, with a mean of 29 m (Figures 52 and 53).

The roof of the (Bottom) Bensham has yielded a fauna, during the present survey, of *Anthracosia* cf. *lateralis* and *A.* cf. *ovum*, and that of the Top Bensham *Anthraconaia pulchella, A.* aff. *varians, Anthracosia* cf. *caledonica, A.* cf. *carissima, A.* cf. *disjuncta, A.* cf. *nitida, A.* aff. *ovum, Anthracosphaerium* cf. *propinquum, Naiadites* cf. *obliquus*. This assemblage is very similar to that identified by Calver and listed by Land (1974, p.70). The sandstone comprises a main leaf which overlies the Top Bensham, where present, and a thinner, lower leaf, which is present between the Top and Bottom Bensham seams. The main leaf was named the Seaton Sluice Sandstone by Land (1974, p.72) and is equivalent to the 'Queen' Sandstone found further north in Northumberland. It locally cuts down through and washes out the Top Bensham It is generally fine- to coarse-grained with a coarse-grained and sometimes pebbly base. Land (1974) and Haszeldine (1981) describe the petrography of this and the underlying 'Table Rocks Sandstone'. In the Pegswood area the sandstone was quarried at several localities and the underlying Bensham seam was known as the 'Quarry Coal', probably because it lay beneath the thick quarried sandstone. Up to four thin intermediate coal or seatearth horizons are developed in the interval, but do not persist and cannot be correlated with any certainty. The faunas described from the upper part of the interval in the Tynemouth district (Land 1974, p.74) have not been recorded during this Survey.



0 1 2 3km

Scale

—50— Isopach of Yard Seam (cm)

Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

Figure 54 Yard Seam (G), coal thickness and workings

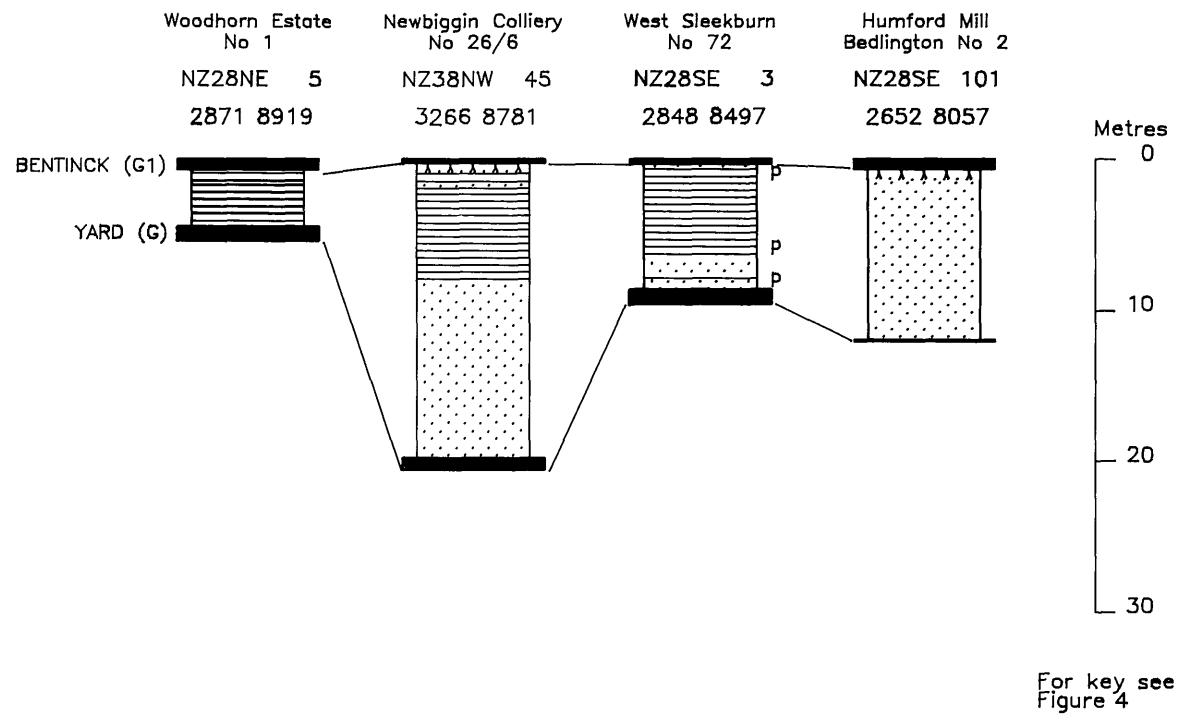
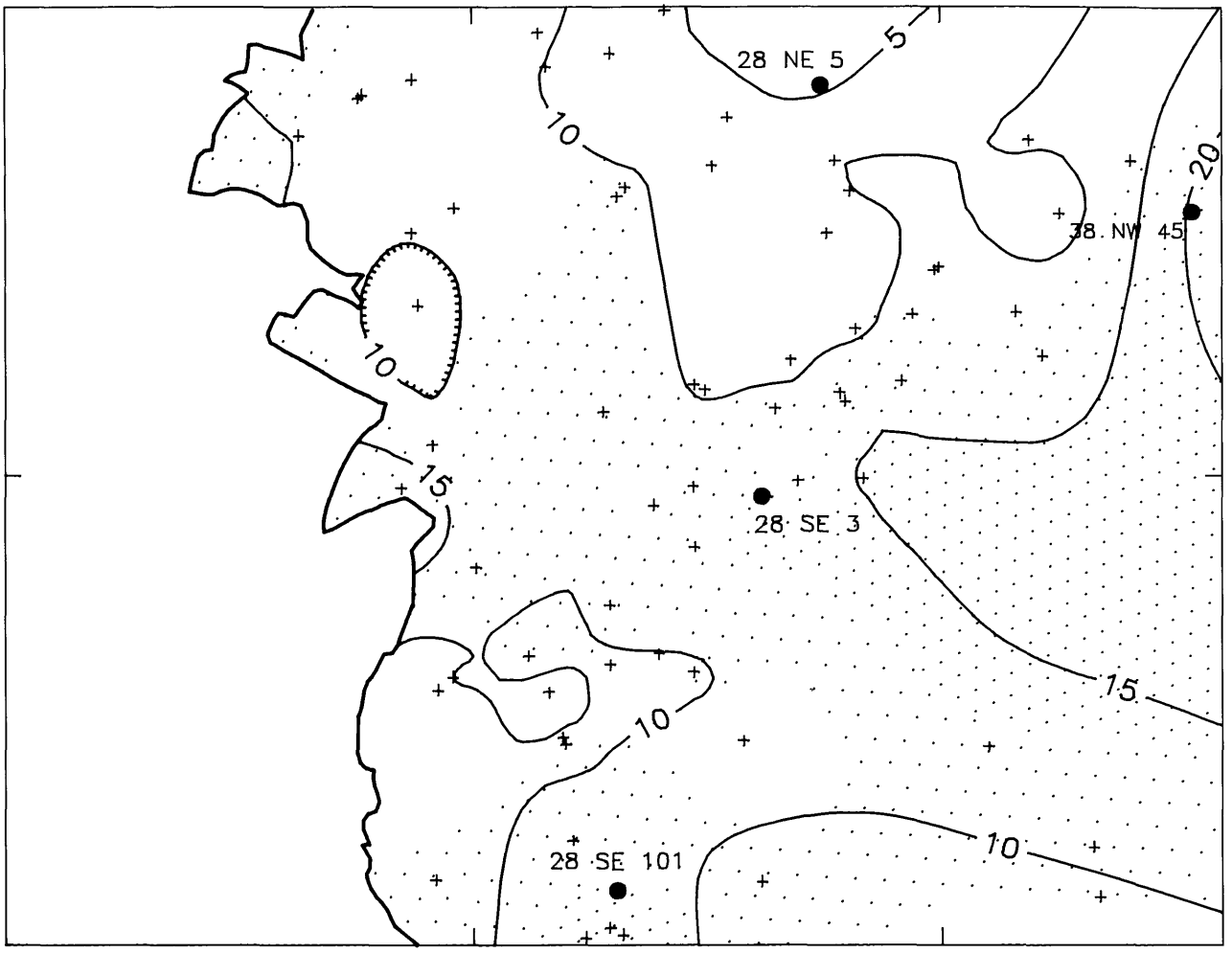


Figure 55 Yard Seam to Bentinck Seam interval

Yard Seam. The Yard has been mined to crop over practically the entire district with much of the working prior to nationalisation in 1947 (Figure 54). Fowler (1936, p.73) notes, "it (the Yard) is a hot coal, burns very freely and brightly, leaves little ash and that brown and heavy; these features make it in great demand as a house coal, perhaps indeed the best in the Coal Measures". Even in 1936 the Yard was largely wrought out around Ashington. Today the epithets used to describe the Yard coal quality include "very good", "exceptionally good", and "usual superlative quality". The ash content is generally less than 4% and sulphur content below 1.7%, however, the coal is commonly only weakly caking. The seam is usually between 74 and 96 cm thick and free from dirt bands, although a thin dirt band has been recorded near the top of the seam. The Yard was most recently worked, in the 1950's and 1960's, in a series of opencast sites on 28 SW (e.g. Howard, Howard House, Poland and Red House) where an area of coal remained between the seam outcrop and the limit of deep mining; old pillar and stall workings were encountered in several of these sites.

YARD TO BENTINCK

The Yard to Bentinck interval is generally between 9 and 12 m, but ranges from a maximum of 20 m to only 3 m north of Woodhorn (Figures 55 and 56). Over most of the area the Bentinck has a mudstone roof, the combined fauna from which consists of:- *Anthraconaia sp. (*aff. *varians?), Anthracosia* cf. *aquilina.* Trueman and Weir non Sowerby, *A.* aff. *caledonica, Anthracosphaerium sp., Naiadites* cf. *obliquus, N. productus.* In a very few boreholes sandstone overlies the seam and around Bedlington makes up the entire interval. The interval is thickest where the sandstone is best developed. In the Humford Mill No. 2 Borehole (28 SE 101) over 10 m of light grey fine-grained sandstone were recorded; elsewhere the sandstone is fine- to medium-grained and in places cross-bedded. Shaly strata with thin ironstone bands and nodules are usually present towards the top of the interval above the sandstone and in a few places a thin shaly unit is developed within the topmost part of the sandstone. A thin coal



0 1 2 3km
Scale

—40— Isopach of Yard to Bentinck interval (thickness in metres, ticks on low side of line)

Western limit of Yard Seam at outcrop or fault

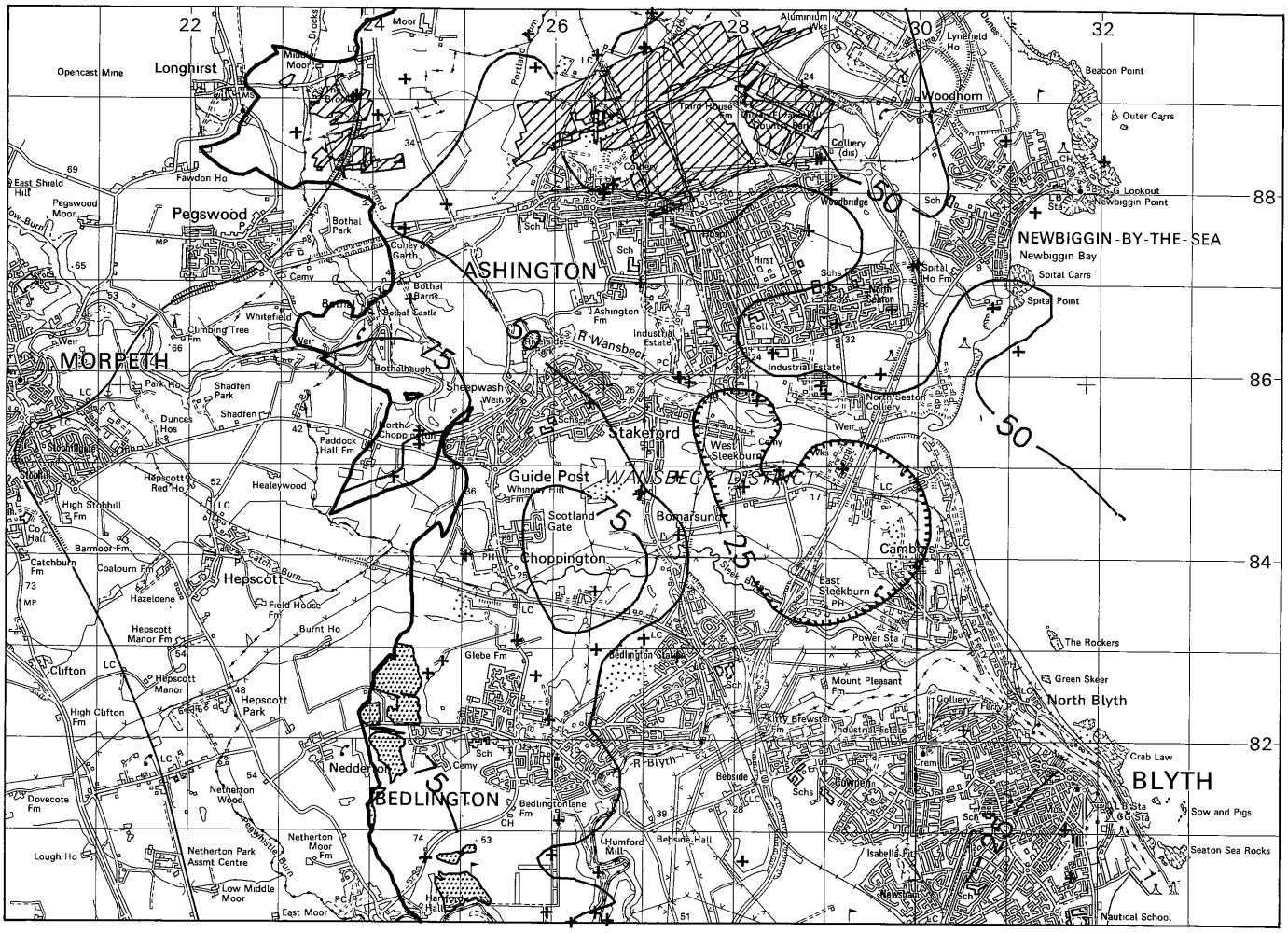
Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

\+ Bore or Shaft proving interval

● Section figured in this report

Figure 56 Yard Seam to Bentinck Seam interval



—50— Isopach of Bentinck Seam (cm) (ornamented on low side of line)

0 1 2 3km
Scale

Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

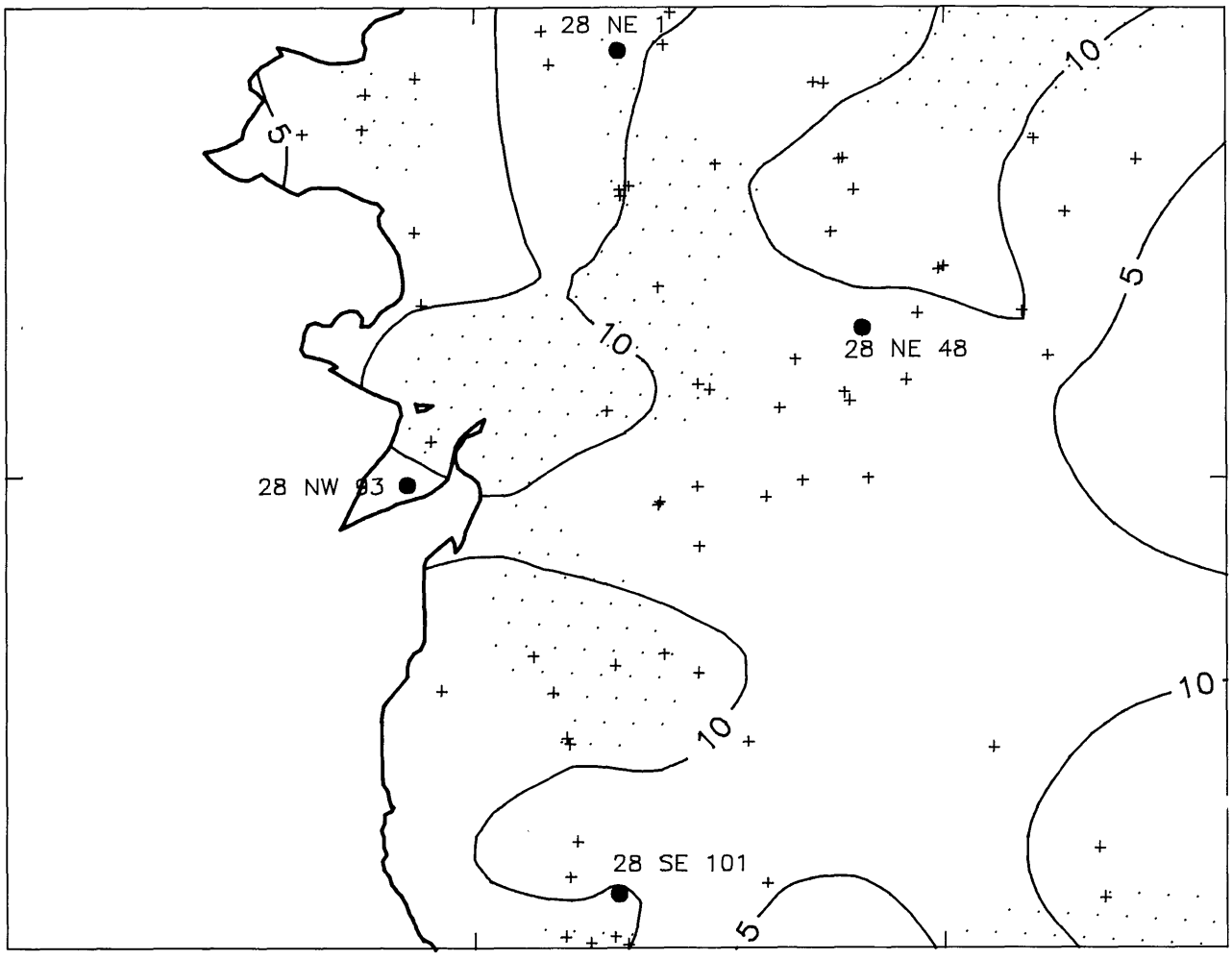
Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

Figure 57 Bentinck Seam (G1), coal thickness and workings



0 1 2 3km
Scale

—40— Isopach of Bentinck to Five–Quarter interval (thickness in metres)

Western limit of Bentinck Seam at outcrop or fault

Sandstone in interval over 5m thick

\+ Borehole or Shaft proving interval

● Section figured in this report

Figure 58 Bentinck Seam to Five–Quarter Seam interval

seatearth occurs near the base of the shaly unit in the area between Choppington and Bedlington.

Bentinck Seam. The Bentinck (Top Yard) Seam has been mined from Pegswood, Ashington and Woodhorn Collieries towards the northern edge of the district. It has a maximum recorded thickness of 112 cm in a borehole at Barrington Colliery (28 SE 29), but is usually less than 70 cm and over much of the district is less than 40 cm (Figure 57). Both thickness and quality deteriorate towards the south-east and at Bedlington the seam is impoverished and of a poor nature. In addition to the mineworkings in the north the seam has been worked opencast near crop in the south-west; at Howard Opencast Site it ranged from 54 to 81 cm thick.

RELATIONS OF COAL SEAMS BETWEEN THE BENTINCK SEAM AND THE HIGH MAIN MARINE BAND

The nature of this part of the succession has been well summarised by Land (1974, p.76); the introductory notes which follow have been adapted from his summary.

Between the Bentinck Seam and the High Main Marine Band there are five coal seams with complex relationships. In stratigraphical order, they are:

High Main Marine Band
High Main Marine Band Seam
Ashington Seam
High Main Seam
Metal Seam
Five-Quarter Seam
Bentinck Seam

In different areas, different pairs or triplets of these seams come together, either to coalesce or to be separated by a parting so thin that they may be mined together. The Ashington and the three seams below are subject to extensive washouts.

Stratigraphical variation is particularly marked in a N-S direction between Bebside and Bedlington Station: the Metal and Five-Quarter diverge northwards, as do the High Main and High Main Marine Band seams. The High Main and Metal converge in the same direction, while the Ashington Seam appears above the High Main and approaches the High Main Marine Band Seam. The High Main, Metal and Five-Quarter all converge south of Bedlington, where in the Church Lane Borehole [2608 8112] the three are represented by 6 m of coal in 12 leaves within 10 m of strata. These seams also come together east of Lynemouth to the north of the district.

Local nomenclature is as complex as the stratigraphy, 'Metal' and 'Five-Quarter' are essentially north Durham names: in Northumberland these seams are generally known as 'Top Main' and 'Bottom Main' respectively. North of the River Wansbeck the Ashington Seam takes on the name 'High Main' and the High Main becomes known as 'Top Main' or 'New Main' (see Table 3).

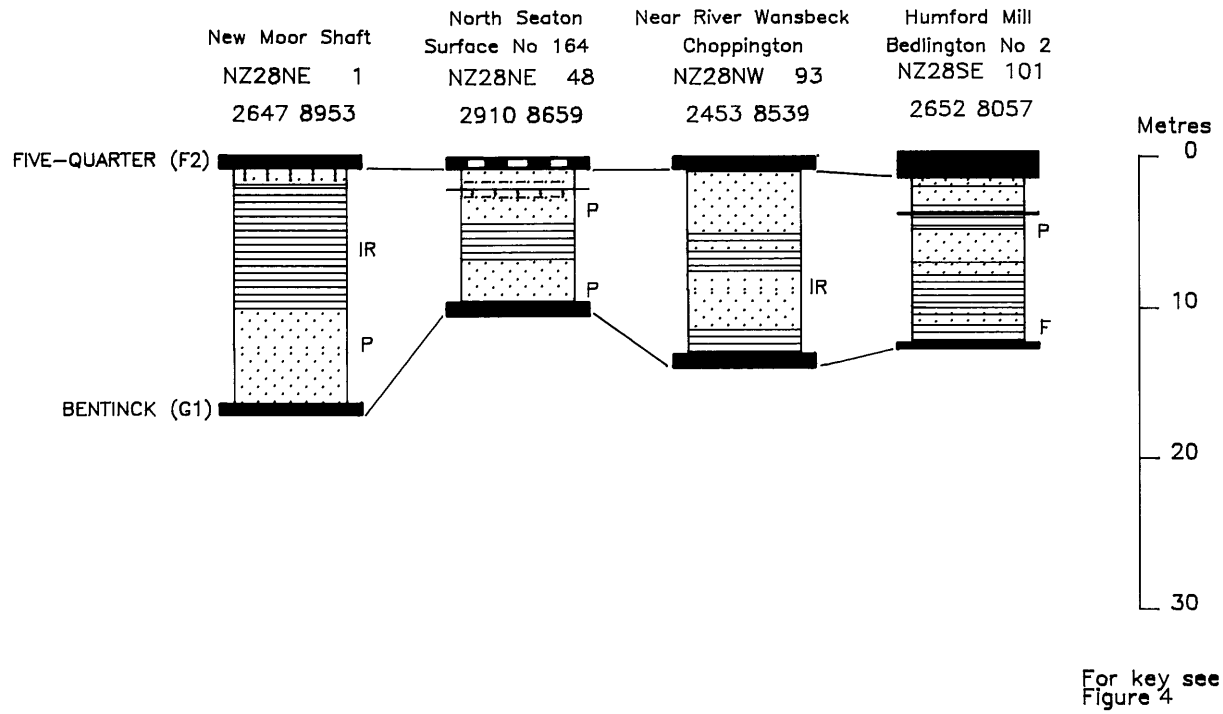
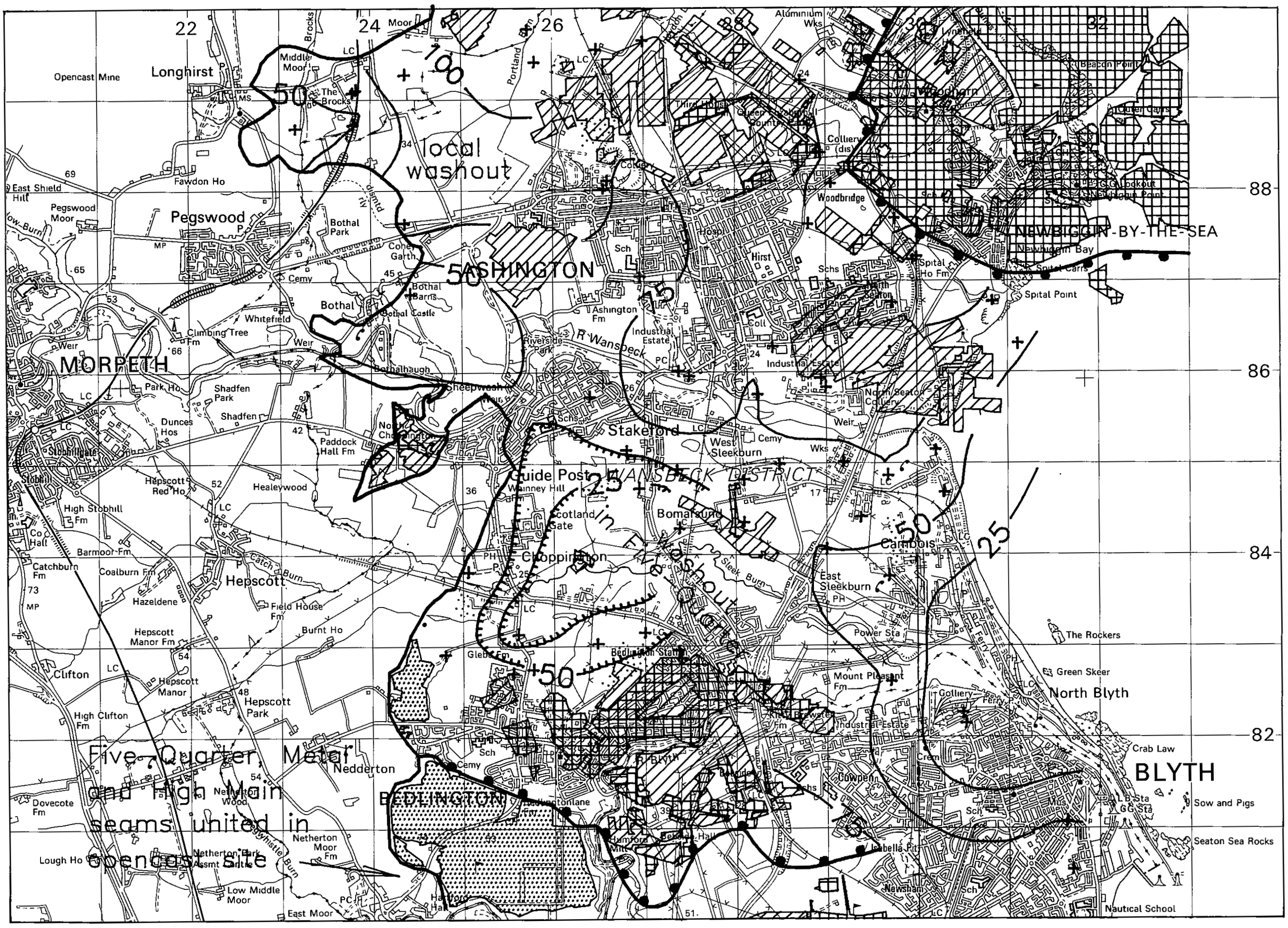


Figure 59 Bentinck Seam to Five-Quarter Seam

BENTINCK TO FIVE-QUARTER

This interval is generally between 8 and 11 m thick, but ranges from 5 to 16 m (Figures 58 and 59). There is no distinct relation in interval thickness variation between the top of the Bentinck Seam and the base of the Five-Quarter Seam, according to whether the latter is separated from, or united with, the overlying Metal Seam. Where thickest, the interval contains a sandstone, but over much of the district it is dominated by mudstones and siltstones. In the east of the district dark shales overlying the Bentinck Seam commonly contain fish debris and are succeeded by mudstones with a mussel band.

Five-Quarter Seam. The Five-Quarter has been mined both as a separate seam and together with the overlying Metal Seam. Where worked opencast in part of the Acorn Bank site it was combined with both the Metal and High Main Seams. In the north of the area in which it was mined as a single seam the Five-Quarter was commonly up to 1 m thick with a dirt band of up to about 8cm at, or just above, the centre of the seam. The mined thickness of the coal decreases south towards Bedlington (Figure 60). The top part of the seam is probably eroded towards the extensive washouts which are recorded between Bomarsund and Bedlington Station and between Humford Mill and New Delaval.



—40— Isopach of Five-Quarter Seam (cm) (ornamented on low side of line)

Western limit of seam at outcrop or fault

Approximate line of convergence of seams (united on unornamented side of line)

\+ Bore or shaft penetrating coal (outside worked area)

0 1 2 3km

Scale

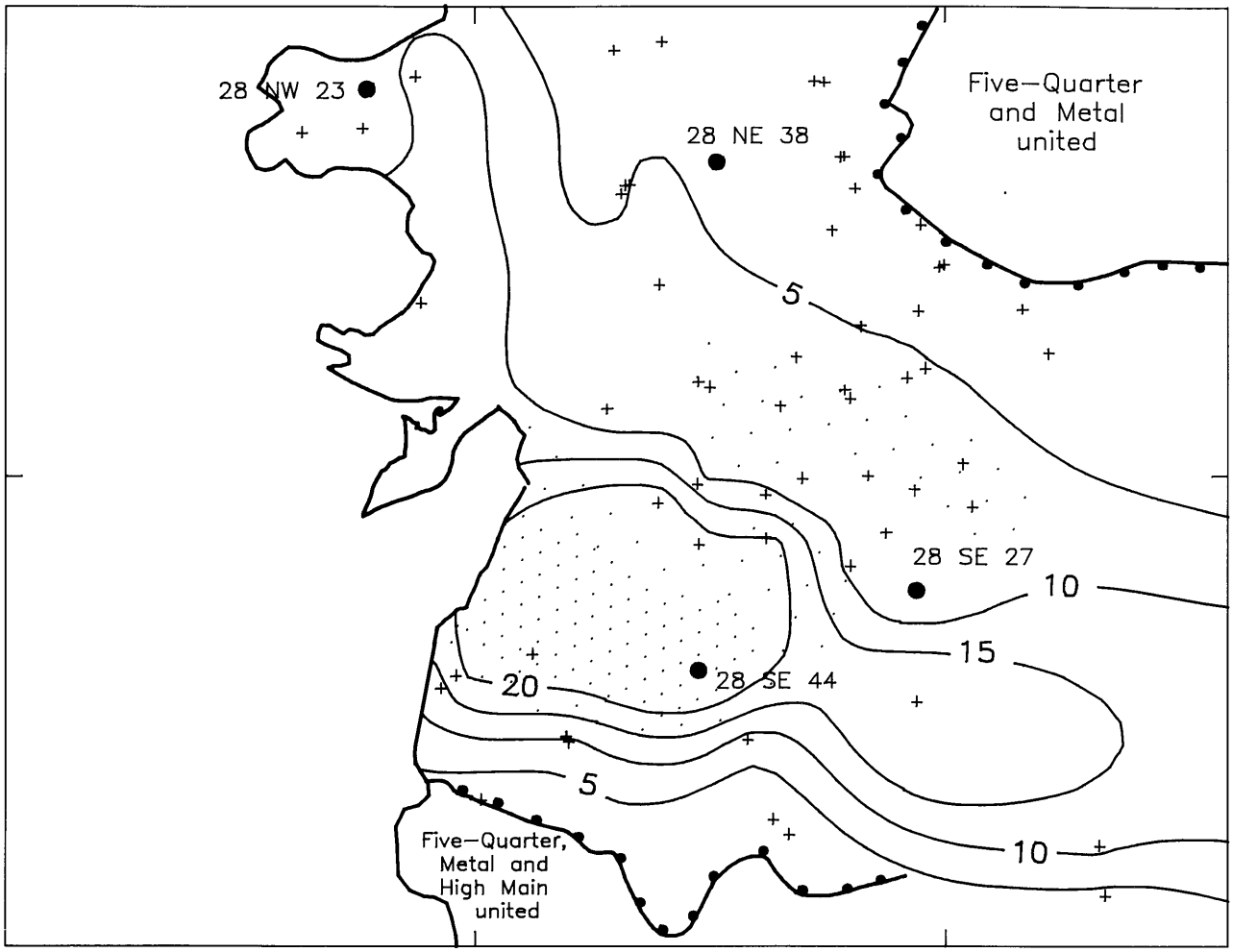
Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

Figure 60 Five-Quarter (F2) and united Metal and Five-Quarter seams (F2+F1), coal thickness and workings



0 1 2 3km
Scale

—40— Isopach of Five–Quarter to Metal interval (thickness in metres)

Western limit of Five–Quarter Seam at outcrop or fault

Approximate line of convergence of seams (united on unornamented side of line)

Sandstone in interval 5 to 10m thick

Sandstone in interval over 10m thick

\+ Bore or Shaft proving interval

● Section figured in this report

Figure 61 Five–Quarter Seam to Metal Seam interval

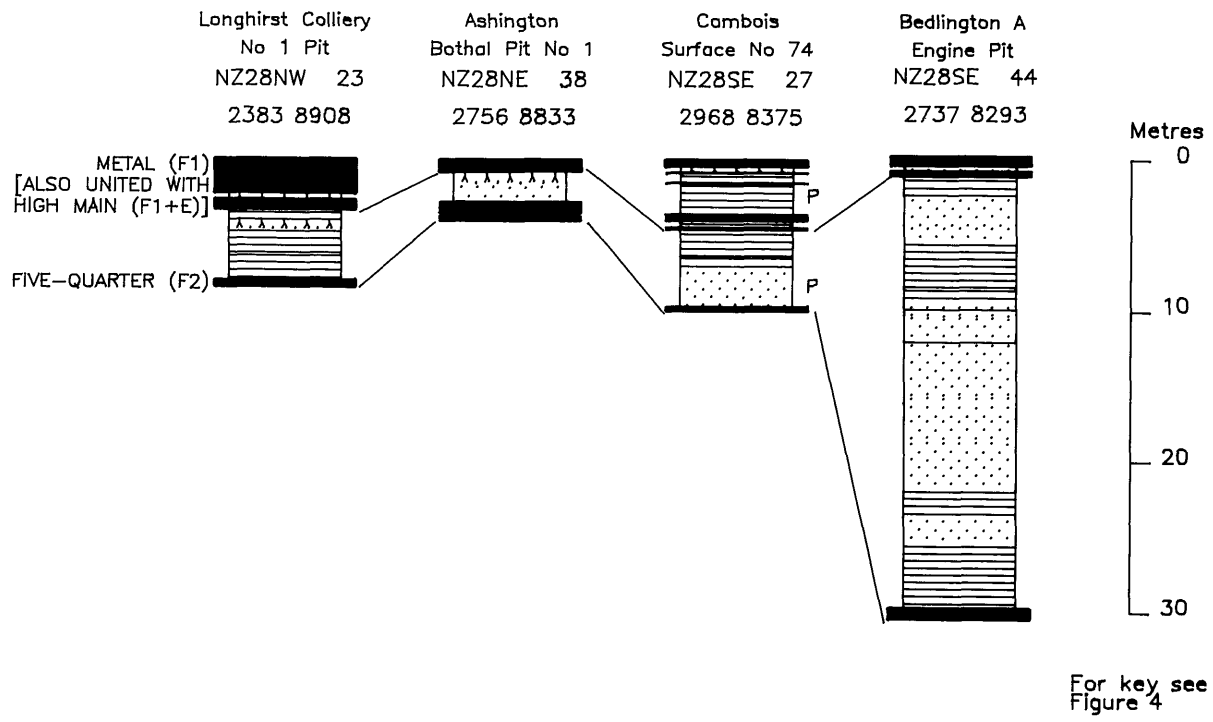


Figure 62 Five-Quarter Seam to Metal Seam

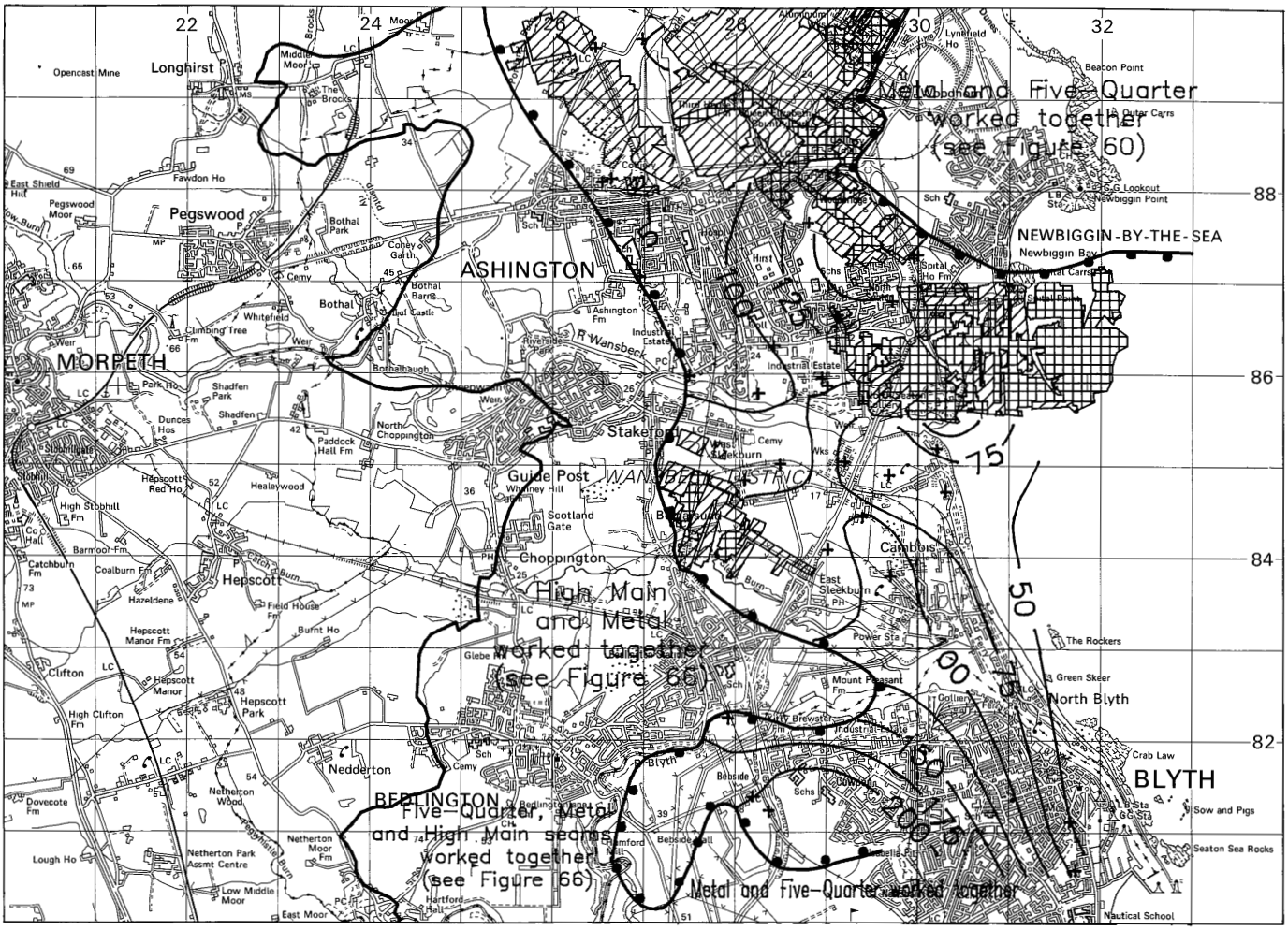
FIVE-QUARTER TO METAL

The Five-Quarter and Metal Seams are united or nearly so, in the extreme north-east and south of the district, but diverge elsewhere such that the axis of maximum interval thickness is aligned approximately WSW-ESE between Choppington and North Blyth (Figure 61). Over 28m of measures separate the Five-Quarter Seam from the Metal where is is combined with the High Main Seam in the Engine Pit of Bedlington 'A' Colliery (28 SE 44) (Figure 62). A fine- to medium-grained sandstone up to 17 m in thickness makes up almost half the interval, accounting for part of the increase in interval thickness in the Bedlington, Hepscott area.

Metal and combined **Metal/Five-Quarter and High Main/Metal** seams The Metal occurs as a distinct and separate coal over only a relatively limited area (Figure 63). Over much of the district it is separated by less than a metre, commonly of seatearth and mudstone, from the underlying Five-Quarter or overlying High Main Seams. The seam thins towards a washout aligned approximately NE-SW between East Sleekburn and Cambois and is absent in boreholes from Bates Pit (e.g. No. 3 New Shaft, 38 SW 24).

In workings from Ashington, North Seaton and Newbiggin Collieries the seam consisted of two leaves separated by a dirt band of up to 10 cm, the total thickness worked increasing from less than 1 m north of Ashington to over 1.5 m at Newbiggin. South of the river Wansbeck the number and thickness of dirt bands increases and consequently also the total thickness of workings. Up to 3.5 m of coal and bands has been worked towards the southern limit of the Bedlington 'D' colliery 'take', but this thickness may include part, or all, of the underlying Five-Quarter.

The **Metal** and **Five-Quarter** are known to have been worked together, commonly under the name of the 'Main' in extensive workings from Newbiggin Colliery, both inland and offshore, where the total thickness of coal and bands generally exceeds 2 m and in places reaches 2.7 m. The two seams have also been worked



—40— Isopach of Metal Seam (cm)

0 1 2 3km
Scale

Western limit of united Metal and High main seams at outcrop or fault

Approximate line of seam convergence (seams united on unornamented side of line)

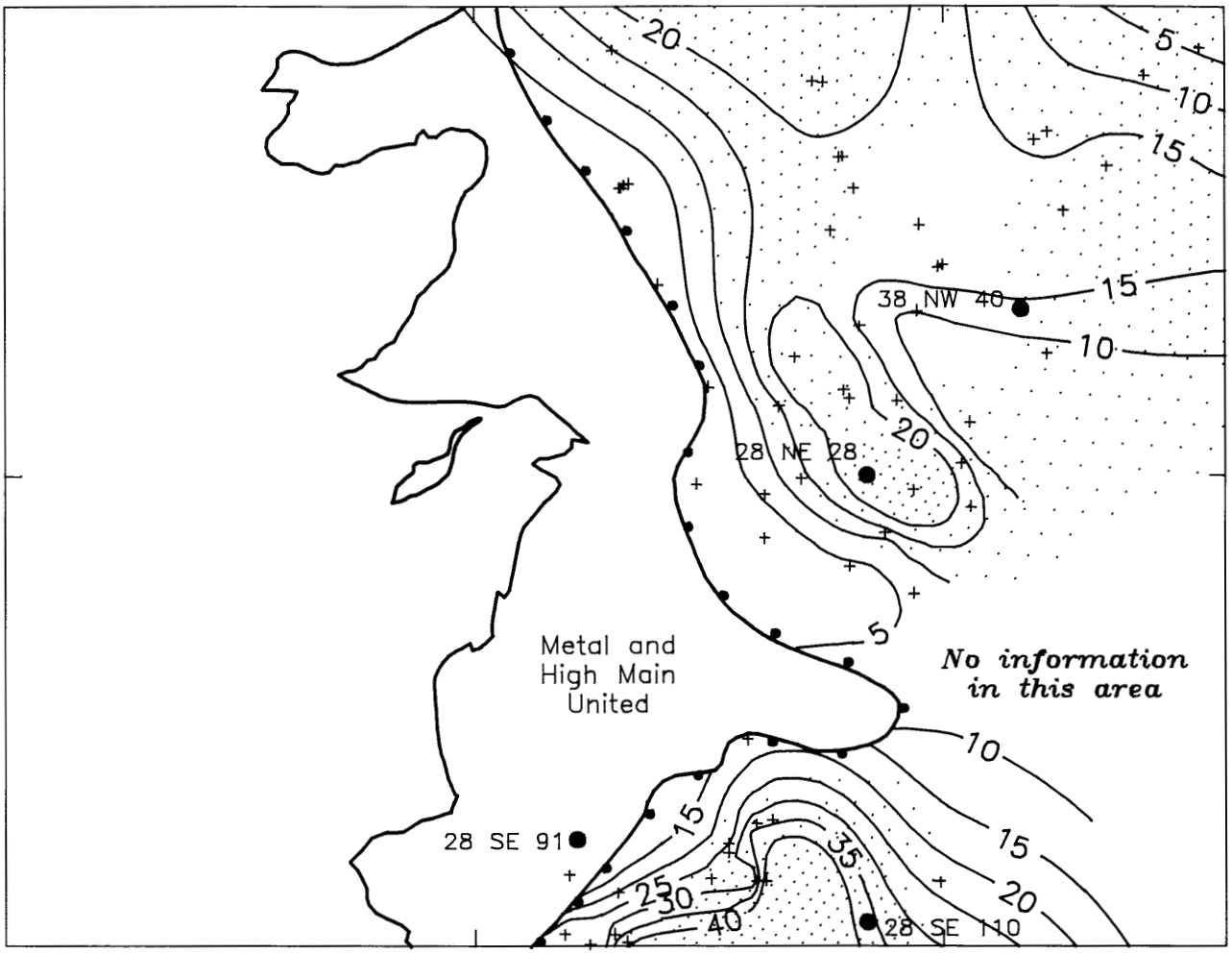
\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Figure 63 Metal Seam (F1), coal thickness and workings



—40— Isopach of Metal to High Main interval (thickness in metres)

0 1 2 3km
Scale

Western limit of united Metal and High Main seams at outcrop or in fault

Approximate line of seam convergence (seams united on unornamented side of line)

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval over 15m thick

\+ Borehole or Shaft proving interval

● Section figured in this report

Figure 64 Metal Seam to High Main Seam interval

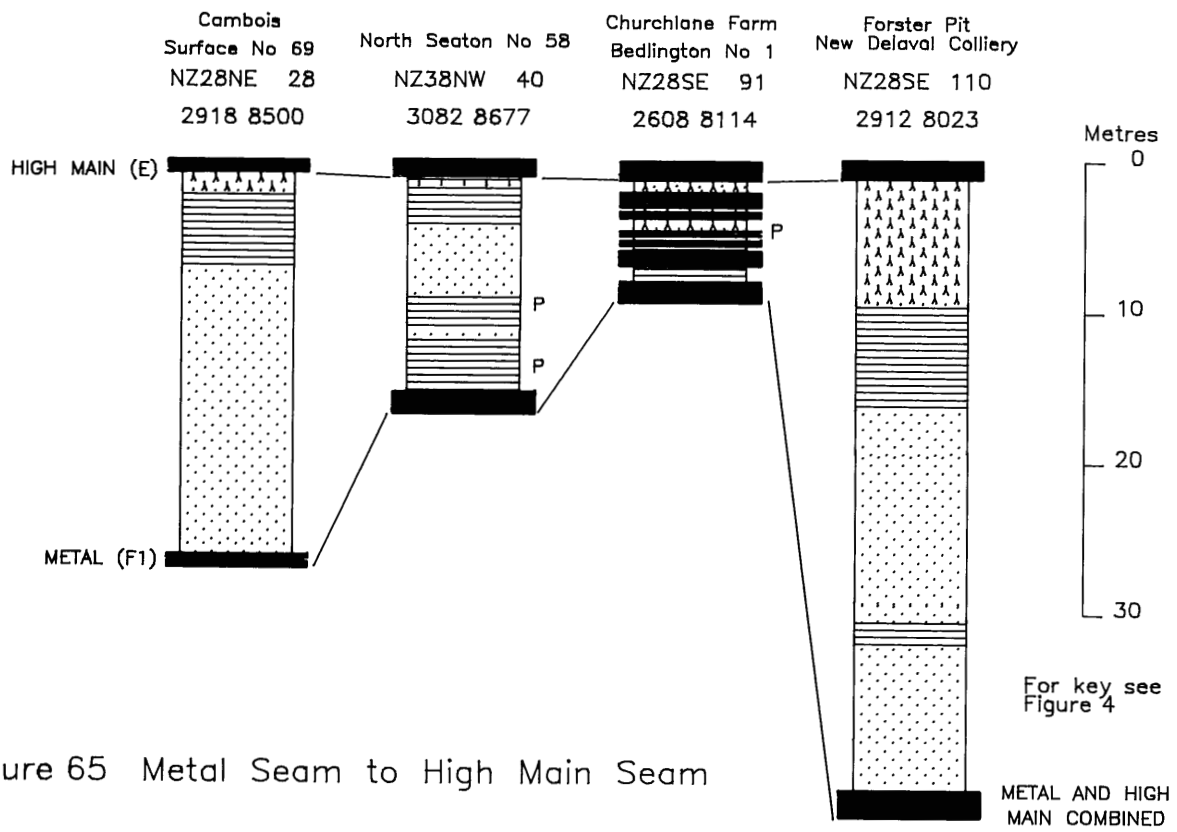


Figure 65 Metal Seam to High Main Seam

together from New Delaval on the southern edge of the district (Land, 1974, p.85).

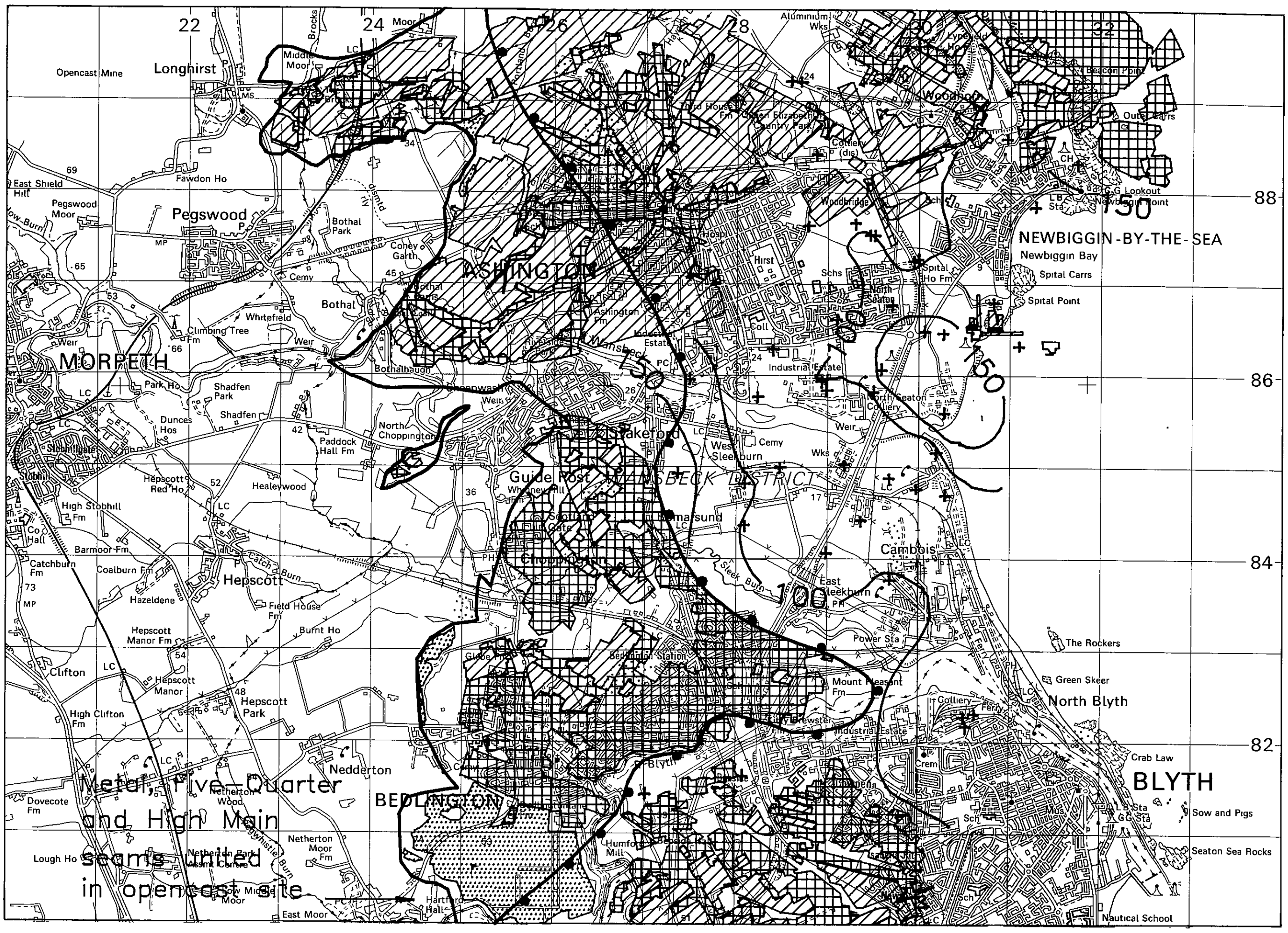
METAL TO HIGH MAIN

Over much of the district the Metal and High Main seams are united or nearly so (see above). The maximum recorded separation of over 40 m occurs in the very south of the district west of Newsham at Forster Pit, New Delaval Colliery (28 SE 110). The separation also exceeds 20 m in a zone from Cambois to Ashington and northwards (Figure 64). As is usual in this part of the Middle Coal Measures succession, the increase in interval thickness corresponds to an increase in the amount of sandstone present. In an air shaft at Richard Pit (28 SE 111a) a 28 m thick sandstone unit which succeeds the combined Metal and Fivequarter Seam makes up over 85% of the interval and is overlain by a locally thick seatearth of the High Main Seam (Figure 65). *Anthraconaia* cf. *pulchella* and *Naiadites* cf. *productus* have been recorded from the roof measures of the Metal Seam within the district.

North of the Stakeford Fault the High Main Seam has been worked from Ashington, Woodhorn and Newbiggin collieries. The thickness of 'coal and bands' extracted ranges from 0.8 to 1.2 m, with the coal thickness generally decreasing to the east (Figure 66).

South of the Stakeford Fault on the southern edge of the district, where the High Main Seam was worked beneath Bebside from Horton Grange and Bebside collieries, it showed wide variation in nature and thickness. In boreholes at Acorn Bank Farm (28 SE 108 and 28 SE 112) the total thickness was over 2 m; the 85 cm top coal was the best quality with an ash content of approximately 7.5%, but a sulphur content of over 3% and the lower coals were of rather poor quality. The seam was worked out at the north-eastern limit of working near Cowpen [292 818].

The **Metal** and **High Main** seams come close together over much of the western and central parts of the district. North of the Stakeford Fault they were worked together at depth from Longhirst Colliery in the fault-bounded area between the Brocks and Potland Burn. To the south of this



—100— Isopach of High Main Seam (cm)

Western limit of seam at outcrop or fault

Approximate line of seam convergence (seams united on unornamented side of line)

\+ Bore or shaft penetrating coal (outside worked area)

Scale: 0 1 2 3km

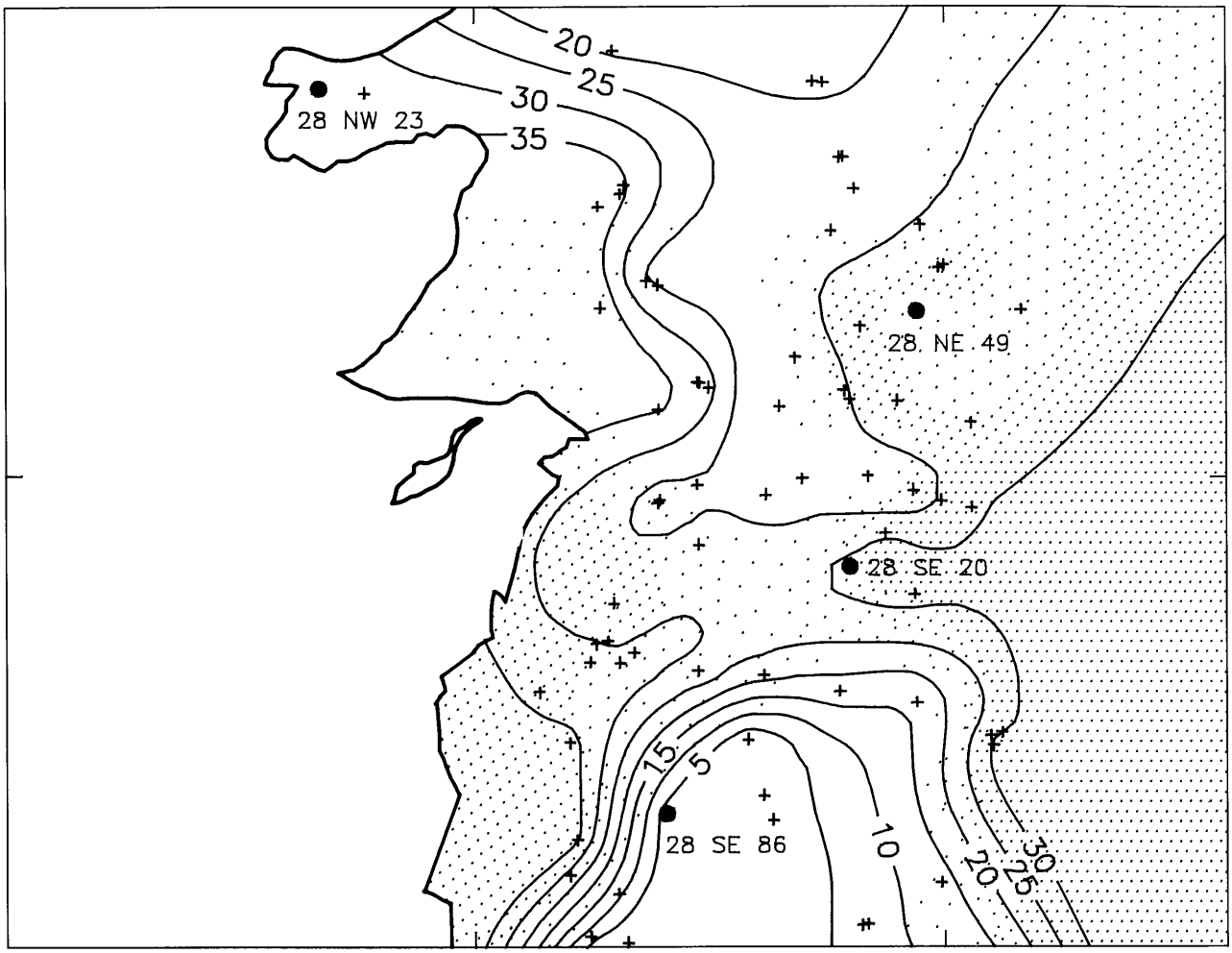
Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

Figure 66 High Main (E) and united Metal and High Main (E+F1) seams, coal thickness and workings



0 1 2 3km
Scale

—40— Isopach of High Main Seam to High Main Marine Band interval (thickness in metres)

Western limit of High Main Seam at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval 15 to 20 m thick

Sandstone in interval over 20 m thick

\+ Bore or Shaft proving interval

● Section figured in this report

Figure 67 High Main Seam to High Main Marine Band interval

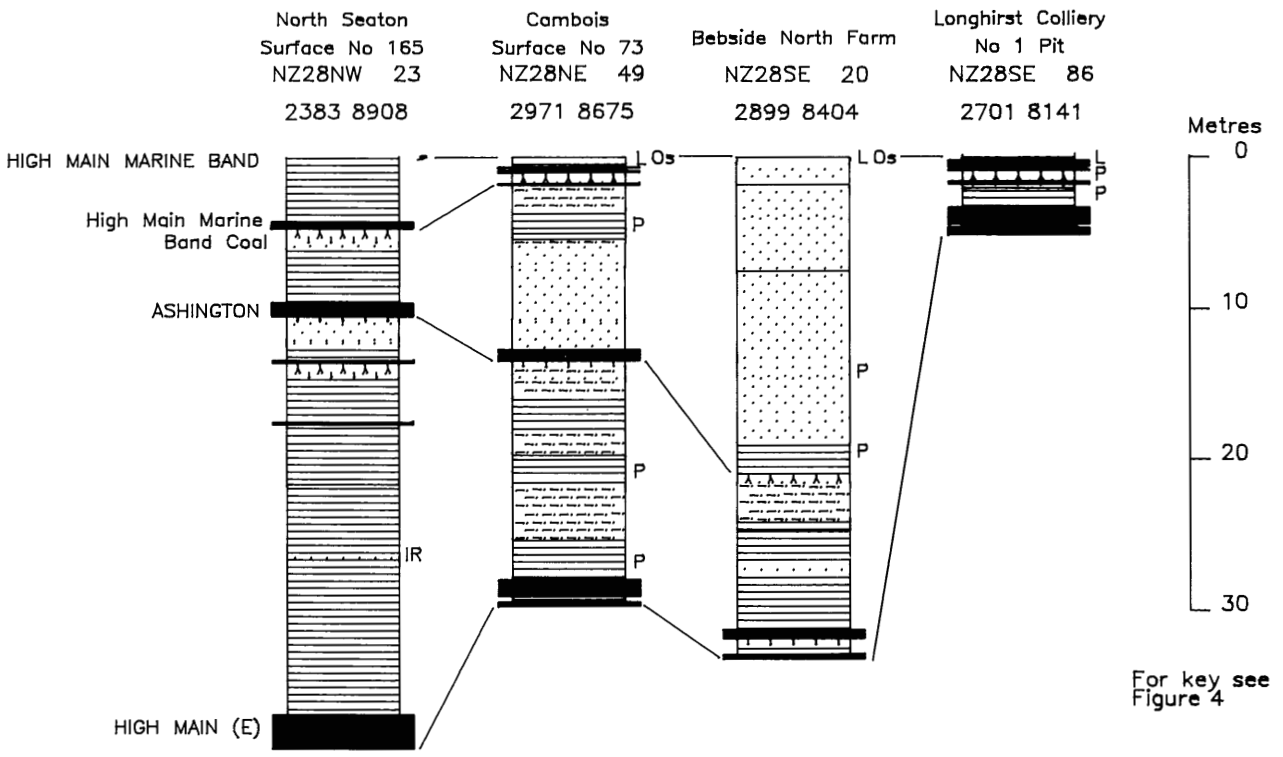


Figure 68 High Main Seam to High Main Marine Band

fault-trough the seams have been mined to crop in workings from Coney Garth and Bothal Banks. They were also worked opencast in the Abyssinia sites. Coal thicknesses of between 1.2 m and 4.2 m, sometimes including bands, are recorded on mine plans. The zone of combined working extends less than 2 km eastwards from the outcrop. The thicker High Main Seam has been worked separately in most of the workings from Ashington Colliery with the exception of an area bounding the Stakeford Fault.

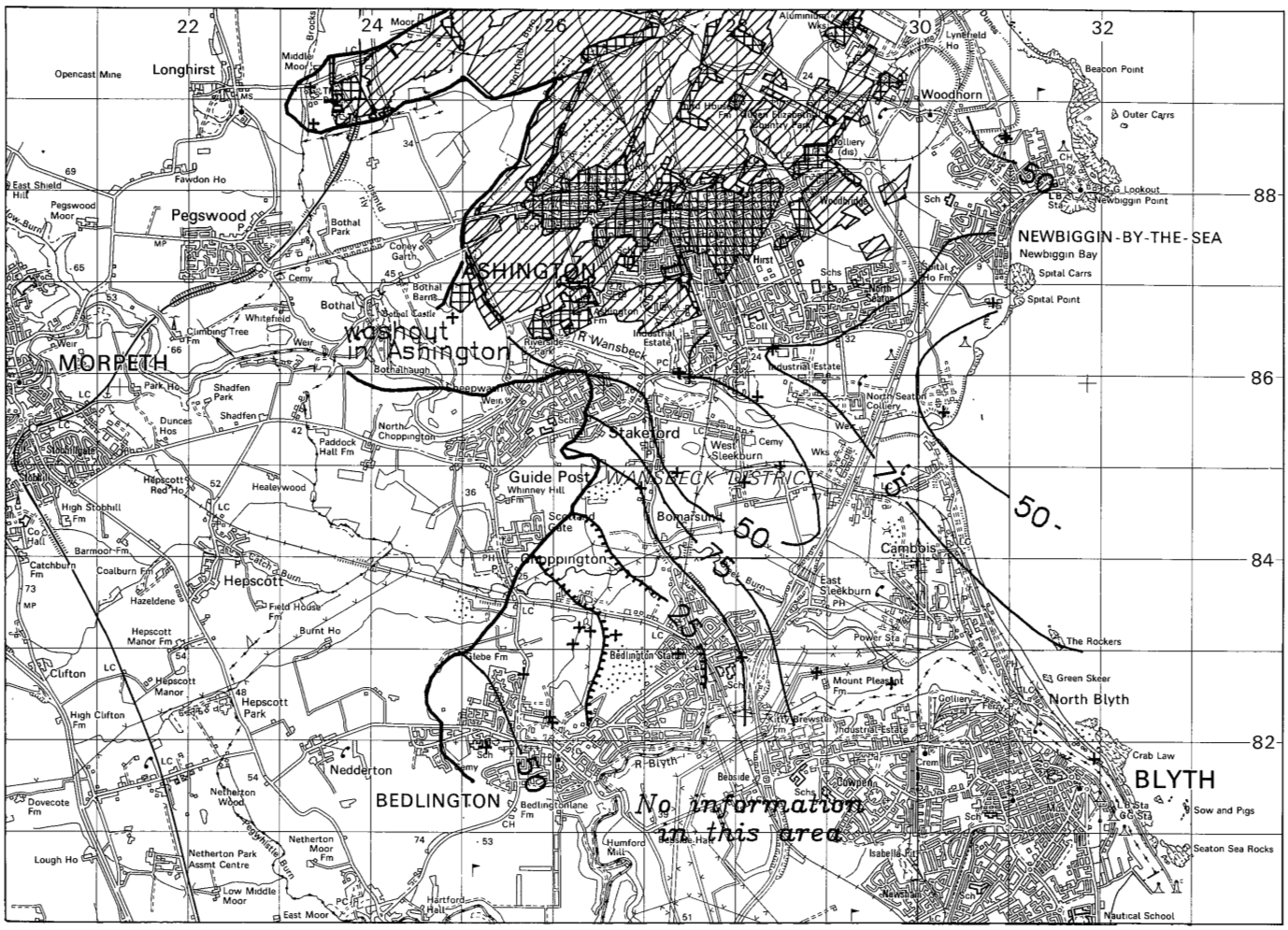
South of the Stakeford Fault the Metal and High Main have generally been worked together over an area extending from Choppington to East Sleekburn and Horton Grange, although locally, where less than 1 m of coal is recorded on plans, it is likely that only one major leaf of coal was worked.

The thickness, structure and quality of the individual coals which make up these composite seams are extremely varied. However, at least one workable coal is usually present even when the composite seam is highly banded; the ash content of such individual coals can be less than 6% contrasting with overall values greater than 20% for the total thickness.

HIGH MAIN SEAM TO HIGH MAIN MARINE BAND

In the south of the district between Hartford, Bebside and Newsham only a few metres of mudstone and coal-seatearth separates the High Main Seam from the High Main Marine Band (e.g., the borehole at Bebside North Farm, 28 SE 86). At Ashington, in the Ashington Furnace Shaft (28 NE 77), the separation has increased to almost 40 m, although it is again reduced to less than 25 m between Ashington and Woodhorn (Figures 67 and 68). The intervening measures are predominantly sandstone where the interval is thickest. The base of the Ashington Seam lies between 5.5 and 21.2 m above the High Main Seam.

The Ashington Seam has been identified in boreholes over much of the district north of a line from Bedlington Station to North Blyth (Figure 69). However it was also



—50— Isopach of Ashington Seam (cm) (ornamented on low side of line)

Western limit of seam at outcrop or fault

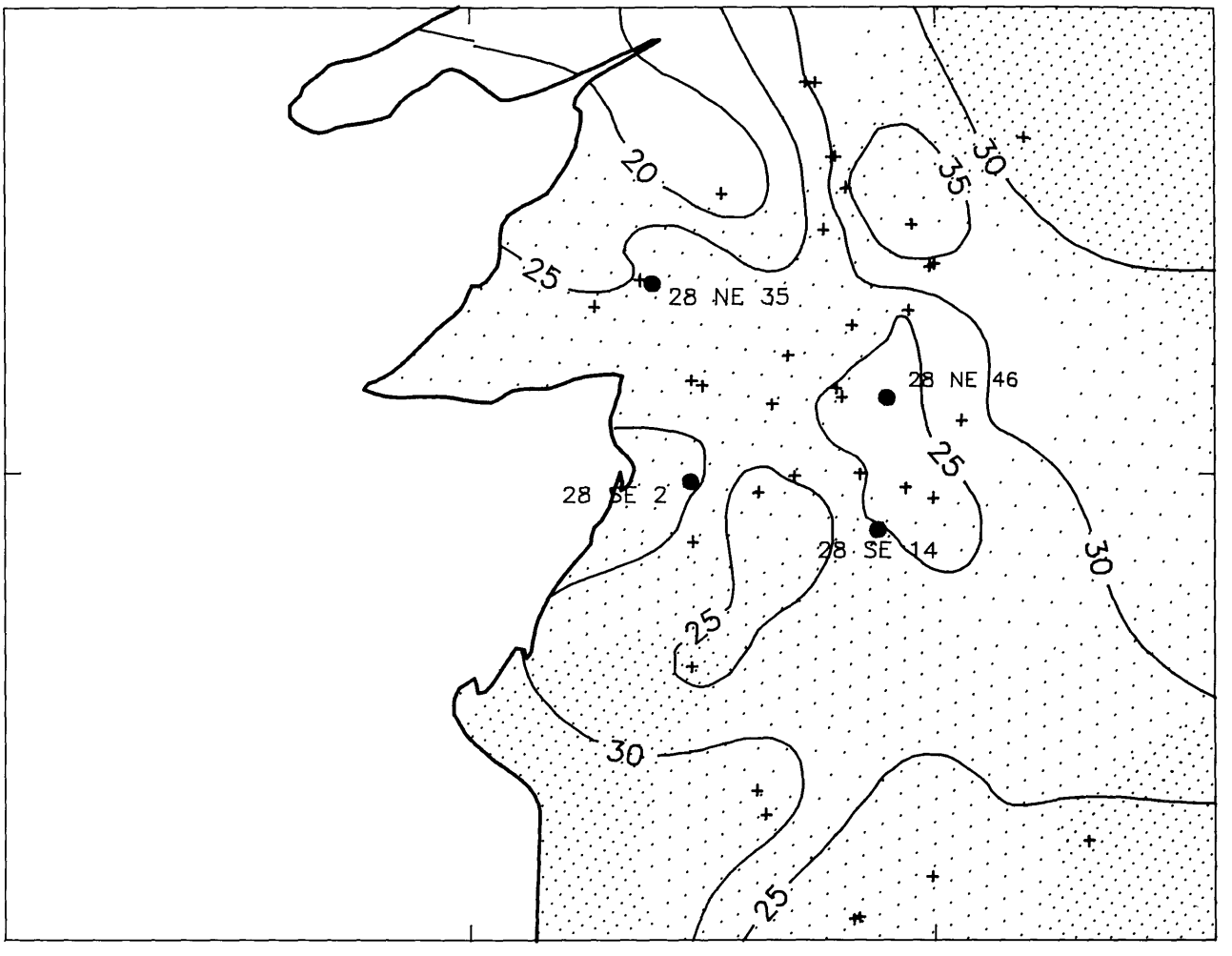
\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Figure 69 Ashington Seam (DE2), coal thickness and workings



0 1 2 3km
Scale

—40— Isopach of High Main Marine Band to Moorland Seam (thickness in metres)

Western limit of High Main Marine Band at outcrop or fault

Sandstone in interval 5 to 10m thick

Sandstone in interval 10 to 15m thick

Sandstone in interval over 15m thick

\+ Borehole or Shaft proving interval

● Section figured in this report

Figure 70 High Main Marine Band to Moorland Seam interval

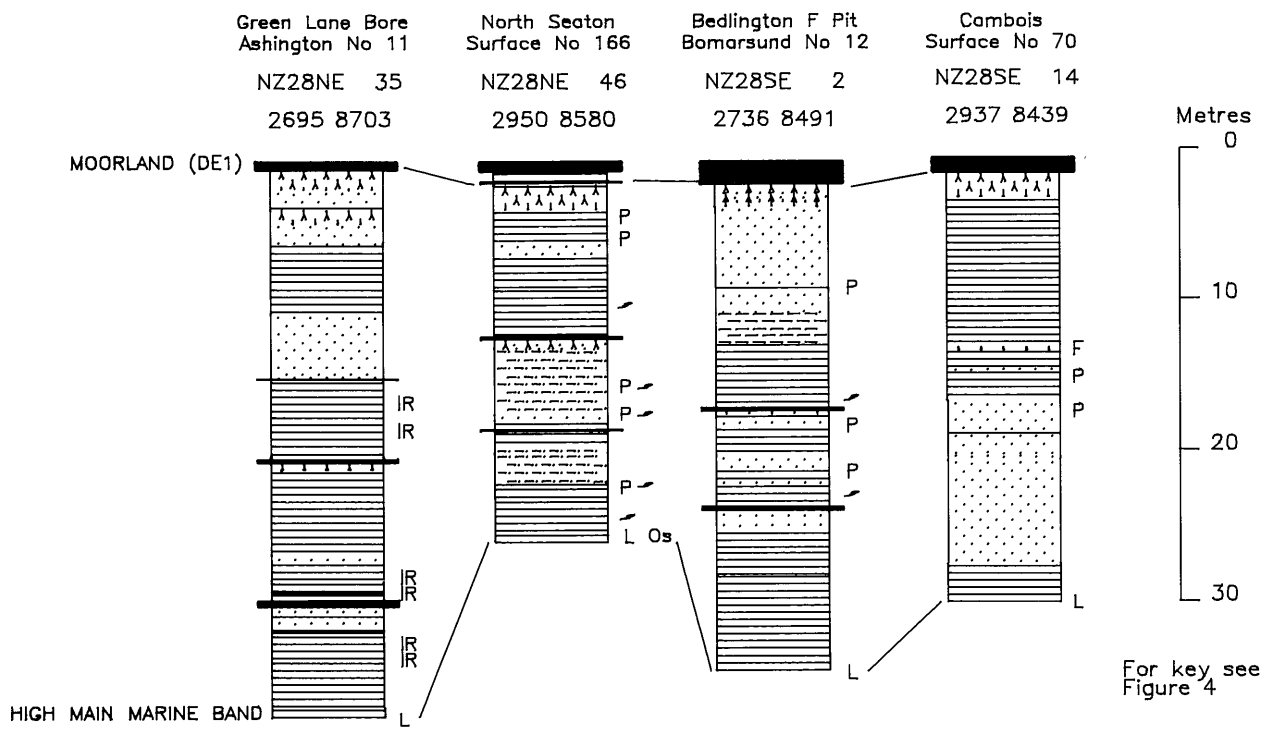


Figure 71 High Main Marine Band to Moorland Seam

present in the Acorn Bank Opencast Site and is probably the coal which was encountered in borings at Blyth Harbour, which suggests that the Ashington Seam is present in the south of the district. Known variously as the Top High Main, Upper High Main and High Main (see Table 3), it has been mined only in the north of the district. At Longhirst colliery in the north-west and Woodhorn colliery it was worked as a seam up to 140 cm thick but locally with a dirt band of over 20 cm.

HIGH MAIN MARINE BAND TO MOORLAND SEAM

Where the High Main Marine Band has been formally identified the interval between it and the Moorland Seam ranges between 26.4 and 36.6 m (Figures 70 and 71). However, if boreholes in which the position of the marine band is conjectural are included, a much wider range is evident. Within the interval two impersistent coals are usually present, although between North Seaton and Woodhorn three coals have been recorded.

The High Main Marine Band took its name (Anderson, 1958) from the subjacent named coal, despite the fact that in places this is over 30 m below. It was first named (*op.cit.*) the 'High Main Lingula Band'. The marine band comprises about 0.6 m of black finely micaceous mudstone. The marine portion of the band occurs towards the base of the cycle and may show interdigitation of non-marine strata, as, for example, in the North Seaton borehole (28 NE 49). Normally only *Lingula mytilloides* is present in the marine band, but *Myalina compressa* occurs in association in North Seaton 166 borehole (28 NE 46). In addition the ostracods, *Geisina arcuata* or *Holinella sp.*, may be present together with examples of *Planolites ophthalmoides*. However, the marine portion has not always been recognised. In the Ashington Green Lane borehole (28 NE 35) no marine fossils were recovered, although the position of the band is recognisable from the large and varied non-marine fauna in the upper part of the cycle. This prolific mussel band - the High Main Shell Bed - includes the following fauna:- *Anthraconaia cymbula, A. librata, A. rubida A.* cf. *varians, Anthracosia acutella, A. aquilina* Trueman and Weir *non* Sowerby, *A.* cf. *aquilinoides, A. atra,*

A. concinna, A. fulva, A. lateralis, A. cf. *planitumida, A.* cf. *simulans, Anthracosphaerium* cf. *propinquum, A. radiatum, A.* cf. *truemani, A.* cf. *turgidum, Naiadites alatus, N.* cf. *daviesi, N. obliquus, N.* cf. *productus.*

Above the shell bed the sediment coarsens and locally passes up into sandstone. The lower of the two thin coals may commonly be absent or represented by its seatearth. The cycle above the lower coal commences with a fossiliferous mudstone and concludes with siltstone, silty mudstone and sandstone. The mudstone contains the following fauna:- *Anthraconaia* aff. *lanceolata, Anthracosia* cf. *planitumida, Naiadites* cf. *obliquus, N.* cf. *productus* and *Euestheria sp.* The upper thin coal seam is equally impersistent and when the strata are not washed out by the overlying sandstone is succeeded by mudstones containing *Anthraconaia sp., Anthracosia* cf. *carissima, Anthracosphaerium sp., Naiadites angustus, N.* cf. *obliquus* and *Euestheria sp.*

In the southern part of the district a sandstone, up to approximately 20 m thick, is commonly present in the uppermost part of the interval and almost everywhere the Moorland Coal is underlain by a substantial seatearth.

Rocks within the interval are exposed discontinuously in the incised valley of the River Blyth between Acorn Bank [266 800] and Mount Pleasant [291 825]. Although the marine band itself was not located during the field survey the High Main Shell Bed was noted south of Humford Mill, at [2652 8007].

The upper thin coal and succeeding sandstone crops out on the western side of the Blyth Valley below Church Lane [2645 8072] where the following sequence was formerly exposed:

Massive yellow sandstone	3.70+
Soft grey fireclay	0.15
Grey shales with mussels	0.04
Clay band ironstone	0.05
Grey shales	0.15
Coal	0.15-0.20
Fireclay	0.31
Sandy shales	

The thick sandstone which has been quarried on both banks [2635 8095] and [2662 8081] is a massive, yellow rock up to 5 m thick. Further exposures occur to the south of Bedlington at [2658 8169] and at Mount Pleasant Farm [2890 8247].

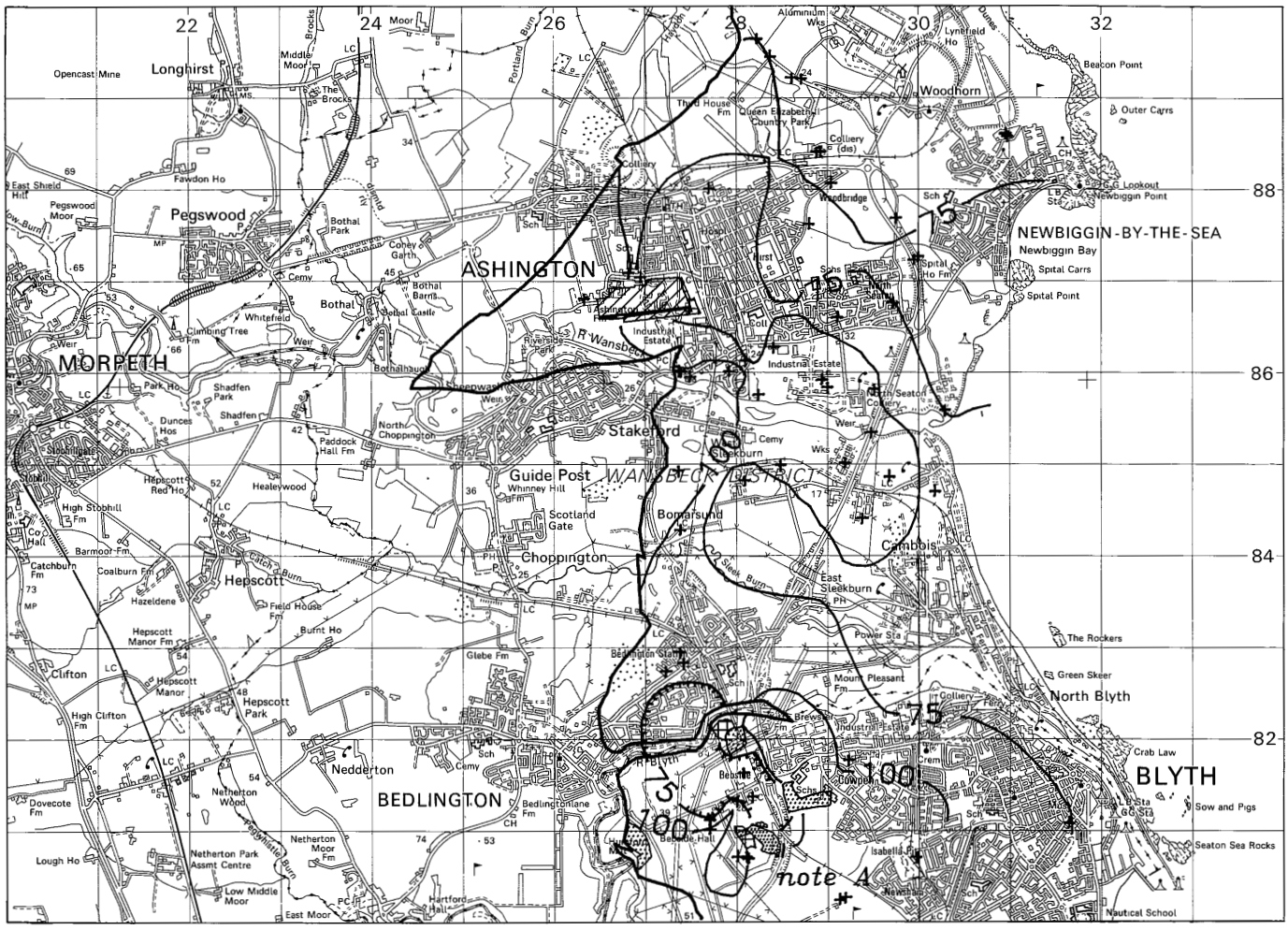
Moorland Seam. The Moorland Seam is named from Bedlington Moor Land, near the present Bedlington Station, where the coal was mined at least as early as the 18th century. Another area of ancient workings occurs at Blackclose [277 860], to the south of Ashington, from which comes an alternative name for the seam. One of the earliest records of local mining in England is near Blyth, where, in 1236, the Moorland Seam was worked along and near its outcrop westwards through Cowpen to Bebside.

Whilst the full recorded range of the Moorland Seam is 0.23 to 1.80 it is generally between 0.75 and 1.25 m thick and is commonly split by dirt bands into at least two seams. This splitting appears to be more pronounced in the north where three seams separated by almost 3 m of strata have been encountered. Its shallow depth made it an attractive proposition for early miners and old workings have been noted at Blackclose, Bebside, Blyth and Bedlington. Within this district however, only three mine plans recording probable Moorland workings (at Ashington, Bebside and Horton Grange, see Appendix) have been traced (Figure 72). Its shallow depth and also the need to stabilise the old workings, has resulted in opencast workings at a number of locations.

MOORLAND TO RYHOPE LITTLE

Borehole and opencast site evidence indicates that strata between the Moorland Seam and the Ryhope Little Seam show considerable local variation (Figures 73 and 74). Because of this it is probable that some of the correlations and thin coal crop positions speculatively defined during this re-survey may be incorrect.

To the east and south of Bedlington the interval between these seams varies between 11.40 and 18.88 m and usually includes a thin intermediate coal (or its seatearth) about 10 m above the Moorland Seam. A second thin coal may also be present in places. Near its crop the Moorland is succeeded by sandstone, but further east it is overlain by argillaceous rocks. In this



—75— Isopach of Moorland Seam (cm) (ornamented on low side of line)

——— Western limit of seam at outcrop or fault

\+ Bore or shaft penetrating coal (outside worked area)

Style of working

Area of total extraction (goaf)

Area of pillar and stall workings

Area of opencast workings

note A

There are opencast workings in the Ryhope Little and Ryhope Five-Quarter seams at Hathery Lane, Bebside

Figure 72 Moorland Seam (DE1), coal thickness and workings

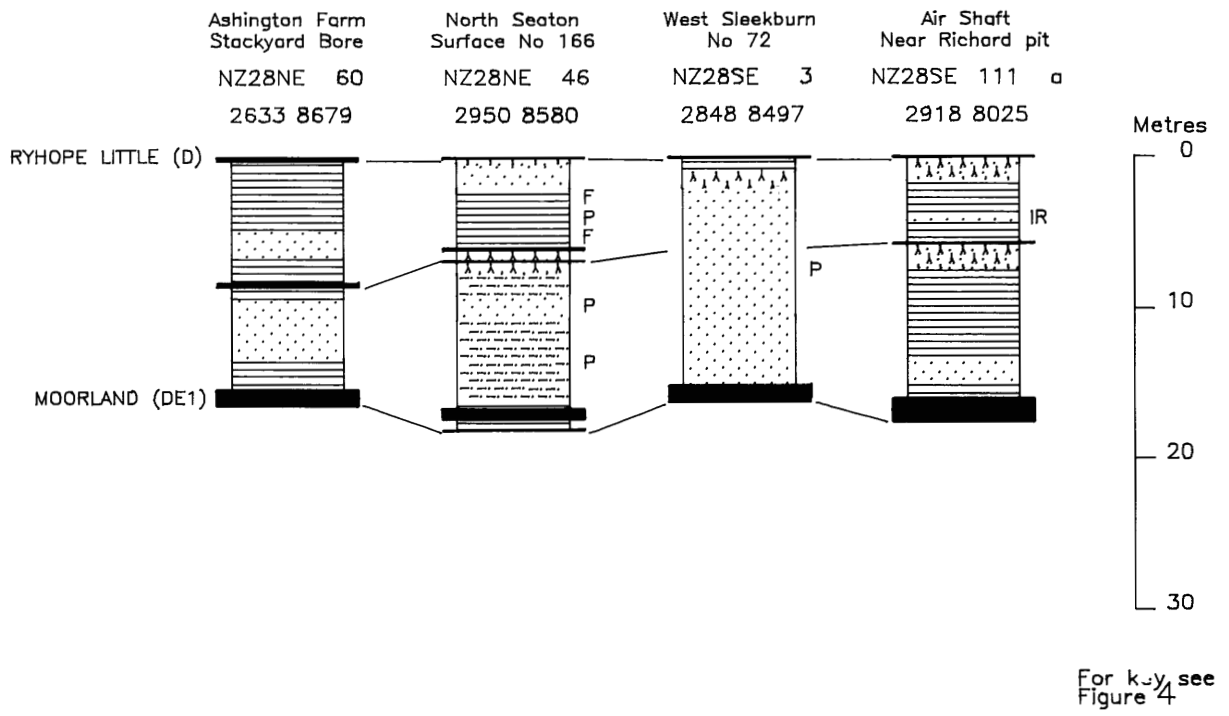


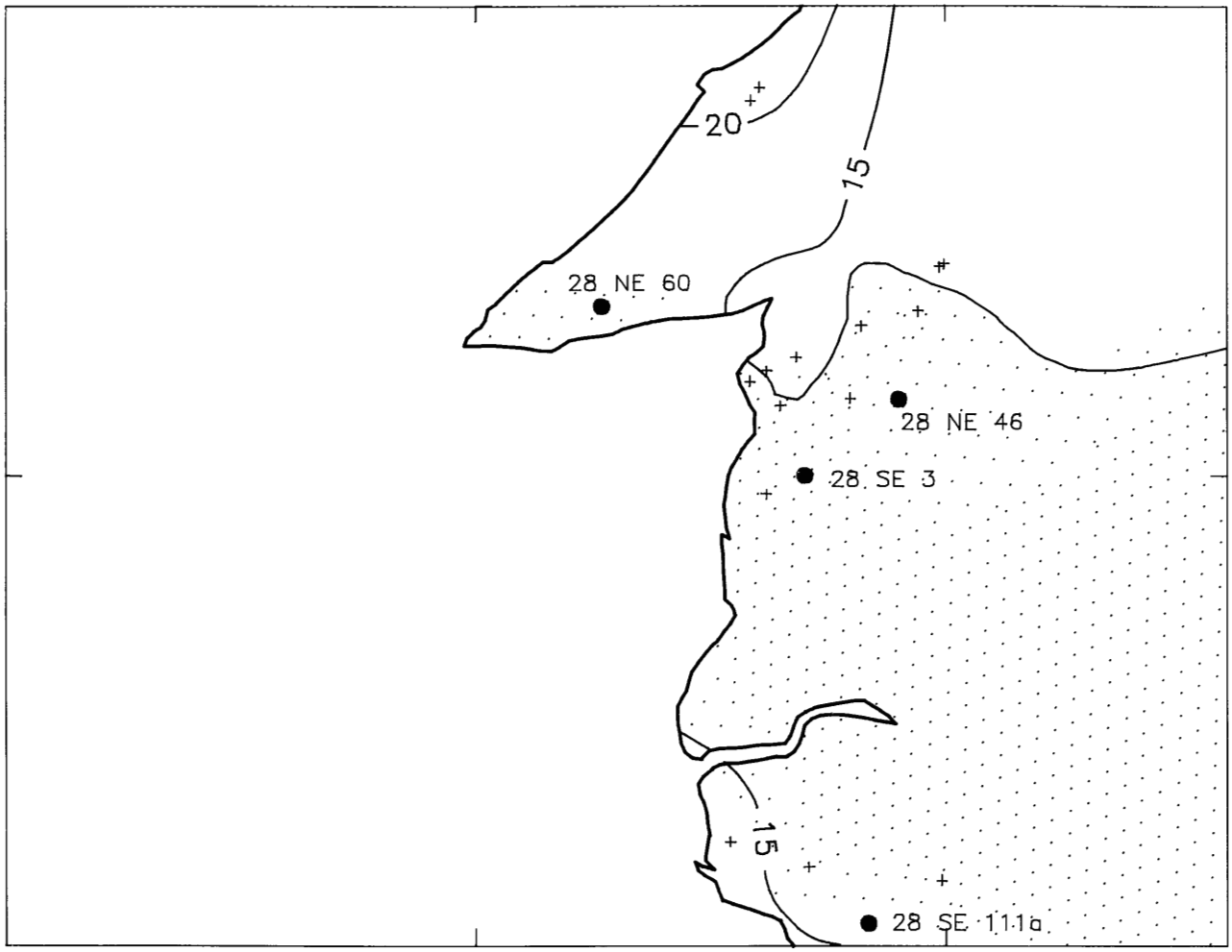
Figure 73 Moorland Seam to Ryhope Little Seam

district no fauna has been recovered from the roof of the Moorland Coal. In a roadside cutting on Bebside Bank [277 820] two coals were formerly visible, their outcrops marked by collapsed adits. The lower seam, probably the Moorland, was noted to be about 0.6 m thick and was separated from the higher (probably the intermediate seam) by about 3.7 m of sandstone.

Within the shallow syncline between Bomarsund and North Seaton the interval between the Moorland and the Ryhope Little ranges from 12.60 to 23.01 m, with a persistent intermediate coal commonly split into two thin leaves. In many places a thick sandstone succeeds the Moorland but the rocks above the intermediate coal are finer-grained and variable in lithology.

To the north of the Stakeford Fault the interval maintains its variability and whereas in the region of Third House Farm [280 890] about 21 m of strata are present, west of Newbiggin thicknesses of 11 m are more usual, although the intermediate coal is still commonly present.

Ryhope Little Seam. The Ryhope Little Seam is the lowest of at least five thin coals which occur in close proximity in this part of the sequence. However, in many of the boreholes any of these coals may be poorly developed or absent, and between clusters of boreholes therefore, the correlations are conjectural. The Ryhope Little Seam is rarely split by dirt and borehole data from the district produces a simple mean thickness of 0.36 m, although exceptionally, 1.29 m was recorded during the sinking of West Sleekburn Colliery Shaft (28 SE 11). The seam is consistently absent from boreholes to the north and east of Woodhorn. Small areas of the Ryhope Little were extracted during opencast operations at Bebside in the late 1960's, but there is no record of any mining of the seam.



0 1 2 3km
Scale

—40— Isopach of Moorland to Ryhope Little interval (thickness in metres)

Western limit of Moorland Seam at outcrop or in fault

Sandstone in interval 5 to 10m thick

Sandstone in interval over 10m thick

\+ Borehole or Shaft proving interval

● Section figured in this report

Figure 74 Moorland Seam to Ryhope Little Seam interval

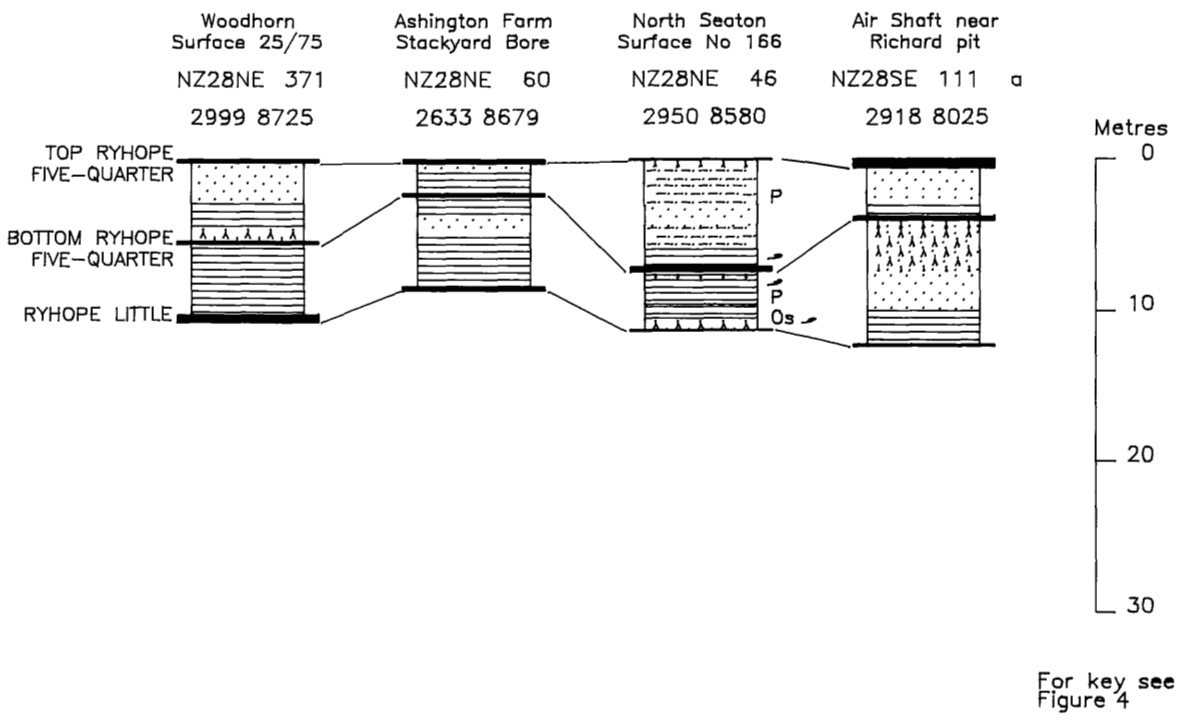


Figure 75 Ryhope Little Seam to Top Ryhope Five-Quarter Seam

RYHOPE LITTLE TO RYHOPE FIVE-QUARTER

Immediately to the north of the Stakeford Fault the Ryhope Little to Ryhope Five-Quarter interval is approximately 5.5 m and is chiefly mudstone. To the south of the Fault in the North Seaton area the interval is more variable ranging from 2.21 to 8.76 m, and includes a sandstone which reaches 5 m in thickness at Blackclose. The Ryhope Little Marine Band has been recognised only in borehole 38 NW 40 where *Lingula Mytilloides* was recorded; the Ryhope Little Seam was, however, absent. Although the marine band was not encountered elsewhere, in other boreholes, a restricted fauna in which ostracods are locally abundant has been noted in mudstones a metre or so above the coal. Between Cowpen and Newsham the interval ranges between 3.33 and 8.36 m and several boreholes record an intermediate thin coal (Figure 75).

Ryhope Five-Quarter Seam. The Ryhope Five-Quarter appears to be split into two distinct seams throughout this district. North of the Stakeford Fault the separation is between 1.9 and 7.4 m with the Bottom Ryhope Five-Quarter and Top Ryhope Five-Quarter coal averaging respectively, 0.21 and 0.25 m in thickness respectively. Around North Seaton the interval is about 5 m and includes, at the base, a mudstone containing mussels. Where the coals are developed the bottom seam is between 8 and 40 cm in thickness and the top seam between 5 and 31 cm. From the limited evidence available in the Cowpen - Newsham area the inter-seam interval is also about 5 m and is dominated by sandstone. The Bottom Ryhope Five-Quarter ranges between 33 and 68 cm in thickness and the Top Ryhope Five-Quarter between 8 and 53 cm.

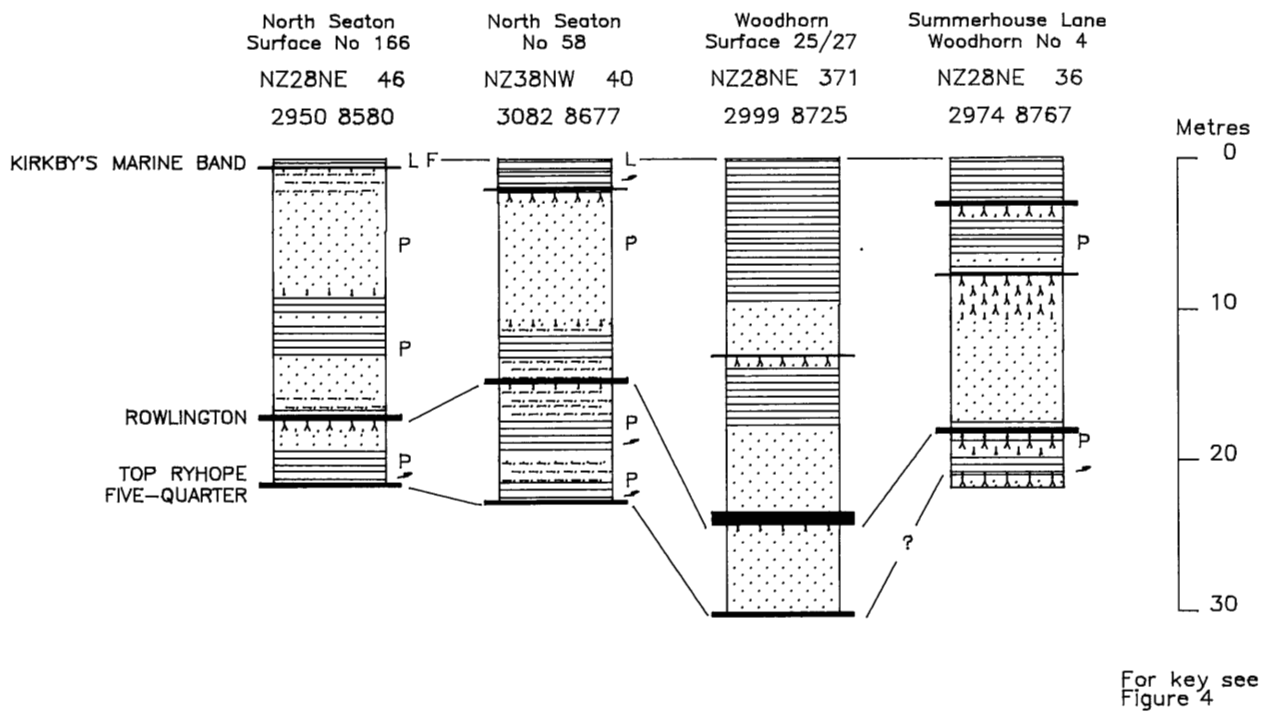


Figure 76 Top Ryhope Five–Quarter to Kirkby's Marine Band

RYHOPE FIVE-QUARTER TO ROWLINGTON

The Rowlington Seam was named by Land (1974) from its outcrop in Rowlington Dean south of Ashington [2818 8593]. There, a 15 cm thick coal was seen to be overlain by shale with ironstone nodules and underlain by seatearth and sandstone with shale partings. In this part of the district the interval between the Top Ryhope Five-Quarter and the Rowlington is between 3.5 and 6.1 m and comprises fossiliferous mudstones overlain by sandstones (Figure 76). The mudstones contain *Anthraconaia* cf. *cymbula*, *Anthracosia* cf. *acutella*, *A.* cf. *aquilina* Trueman and Weir *non* Sowerby, *A.* cf. *aquilinoides*, *A. atra*, *A.* cf. *concinna*, *A.* cf. *elliptica*, *A. fulva*, *A.* cf. *planitumida*, *A.* cf. *simulans*, *Naiadites* cf. *alatus*, *N. angustus*, *N.* cf. *daviesi* and *N* cf. *obliquus*; additionally fish remains were obtained from borehole 28 NE 46. The Rowlington Seam is absent from boreholes in the Ashington Farm area [260 870] but has been proved further east where the interval between it and the Top Ryhope Five-Quarter ranges from 3.3 to 7.8 m. In the south of the district the shaft record for Isabella Pit [2996 8069] notes 2.49 m of 'blue metal' (mudstone) above the Top Ryhope Five-Quarter.

Rowlington Seam. North of the Stakeford Fault the coal is generally between 33 and 76 cm thick but an old (1868) borehole west of Woodhorn (28 NE 5) encountered a coal 0.91 m thick which has been tentatively correlated with the Rowlington Seam. In the North Seaton area thicknesses average about 0.2 m.

ROWLINGTON TO KIRKBY'S MARINE BAND

In the area to the north of the Stakeford Fault the Kirby's Marine Band has been identified with certainty in only one borehole (28 NE 36). Throughout the rest of this area the marine band's position is conjectural and based on the presence of a thin coal which usually underlies it. The interval between the Rowlington Seam and the Marine Band is about 17 m and includes an intermediate, thin and impersistent coal some 10 m above the Rowlington. Below the intermediate seam sandstone is dominant and above the seam the lithologies are variable (Figure 76).

South of the Stakeford Fault the highest strata in the interval are exposed on the coast at Hawks Cliff, [307 863] to [305 858]. The full interval was intersected by four boreholes in the North Seaton area (although in only two was the Kirkby's Marine Band formally identified). The intermediate coal is recorded in only one of the boreholes, but its seatearth is present 4 to 8 m above the Rowlington Seam in the others. Variable strata below the coal contrast with 5 to 8 m of sandstone above.

At Hawks Cliff a sequence, dipping north-westwards at c.10°, was recorded by Land (1974). This section is now covered by storm beach deposits and slumping of the overlying boulder clay. The full sequence is

	m
Kirkby's Marine Band	-
Coal, very shaly at top and bottom	0.46
Seatearth-mudstone, pale grey; ganister partings	0.61
Sandstone, fairly massive fine-grained, somewhat ferruginous; roots at the top; plant impressions abundant at one or two horizons; small scale cross bedding directed south-south-west seen to	1.83

KIRKBY'S MARINE BAND TO RYHOPE MARINE BAND

Kirkby's Marine Band was named by Armstrong and Price (1954, p.978) from its discovery by Kirkby (1860, p.412) who recognized the alternation of marine and non-marine phases characteristic of the band in this coalfield. However, only one borehole in the district (38NW 40) illustrated this alternation, elsewhere only one or no marine phase was recovered. The marine fauna consits of *Planolites ophthalmoides* and *Lingula mytilloides* and the combined non-marine fauna of:- *Anthraconaia sp.* (cf. *cymbula*?), *Anthracosia acutella*, *A.* cf. *aquilina* Trueman and Weir *non* Sowerby, *A.* cf. *aquilinoides*, *A. atra*, *A.* cf. *concinna*, *A. fulva*, *Curvirimula sp.*, *Naiadites* cf. *alatus*. The presence of *Curvirimula sp.* is of interest as this genus, in the Middle Coal Measures, seems to be associated with the presence of marine conditions.

The only exposure of Kirkby's Marine Band is the coastal section at Hawks Cliff, however, the fauna recovered was not prolific. Land (1974) detailed the fossils collected and described the full section, namely:

	m
North Seaton Sandstone; sandstone, medium-grained sparingly micaceous, gritty and pebbly towards base; plant fragments at least	7.62
Shale, black, cannelly towards base	0.46
	0.76
Coal; shaly at top; parting near base	0.38
Seatearth, sandy, except at top	0.31
	1.22
Sandstone, cross-bedded, fine grained, micaceous about	6.1
Silty shale and shaly sandstone	1.83
Shale, dark grey; a few ironstone bands; represents upper leaf of Kirkby's Marine Band but no fossils found	1.07
Shale, grey, micaceous; mussels including *Anthracosia atra*, *A.* cf. *acutella* and *A.sp.* intermediate between *atra* and *lateralis*	0.91
Kirkby's Marine Band, lower leaf; mudstone, mudstone; dark grey, micaceous; *Lingula* cf. *elongata*	0.08
Coal, shaly at top and bottom	0.46

[This section is the same as that described by Fowler (1936, p.78) in which his "Blue shale with Carbonicola shells" represents Kirkby's Marine Band and its included mussel band.]

The full sequence between the Kirkby's Marine Band and the Ryhope Marine Band is found only to the north of the Stakeford Fault. Four boreholes have shown the interval to range between 58.9 and 68.7 m in thickness, but to be lithologically consistent, predominantly comprising sandstone with a median mudstone (probably the Hylton Marine Band position) and an overlying coal - the **Burradon Seam** (Figure 77). In the Hawks Cliff section south of the fault 38 cm shaley coal and associated seatearth and mudstone are recorded 8 m above the Kirkby's Marine Band (see section above and also cover photograph). This coal is possibly a correlative of the thin seam recorded in borehole 28 NE 60 and exposed in Wellhead Dean [2600 8644].

The sandstone between this coal and the Hylton Marine Band, forming the upper part of Hawks Cliff, (see section above), has been named the **North Seaton Sandstone** by Fowler (1936). It has been quarried at North Seaton Colliery [294 856] and near the coast [308 867]. It is probably the equivalent of the Woodhorn Sandstone which is exposed on the coast around Beacon Point [317 894] and has been quarried at Woodhorn Village [299 890] and also south of Ashington Farm [262 865]. In the quarry at Woodhorn over 21 m of brown, fine-grained, sparingly micaceous sandstone was formerly worked for facing and grindstones (Fowler, 1936).

The mudstone which lies midway in the interval and which is underlain by a thin coal in only one borehole (28 NE 36), has produced no fauna within this district. Hence, the position of the Hylton Marine Band within this mudstone is speculatively assigned. Approximately 4 m of mudstones and sandstones separate the marine band horizon from the **Burradon Seam** which was encountered during a recent site investigation for a new hospital near Ashington [291 880] and proved to be about 45 cm thick. The Burradon Seam has also been equated with shaley coal exposed in the base of the small quarry north of Stakeford [2602 8630].

The sandstone between the Burradon coal and the Ryhope Marine Band ranges between 25.5 and 28.2 m in thickness and is exposed on the coast at Newbiggin [317 879] and on both banks of the River Wansbeck, north of Stakeford at [2640 8635] and [2605 8630]. At Newbiggin and on the north bank of the Wansbeck coarse-grained, pebbly lenses and beds are common within the sandstone.

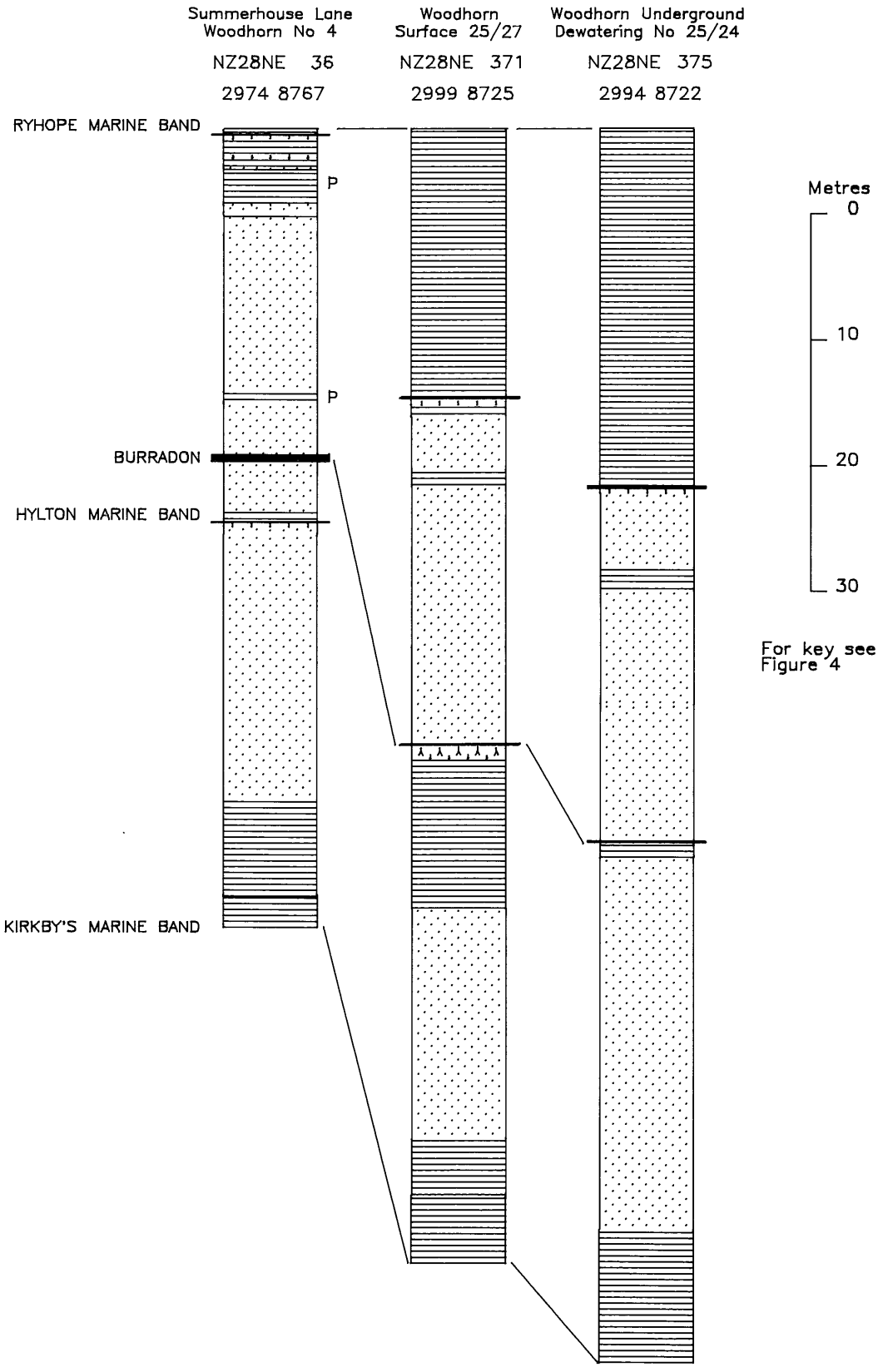


Figure 77 Kirkby's Marine Band to Ryhope Marine Band

STRATA ABOVE THE RYHOPE MARINE BAND

The **Ryhope Marine Band** was named by Armstrong and Price (1954) from its discovery in specimens from Ryhope by Tonks (1939). It had been informally named by Burnett (1947) as the 'Ashington Marine Bed' from its presence in borehole 28 NE 36, the "Summerhouse Lane borehole". The extensive collection made from this borehole has been reviewed and the revised fauna is as follows:- *Serpuloides sp., Cancrinella* cf. *craigmarkensis, Lingula mytilloides, Productus?, Strobeus sp., Edmondia sp.* (aff. *punctatella?), Pernopecten carboniferus, Posidonia sulcata,* orthocone, *Metacoceras?, Donetzoceras?,* goniatite *Gen* and *sp. nov.* (Duncan *in* Currie et al., 1937), *Euestheria sp.* A varied assemblage of conodonts is also present including at least one association of elements. The biostratigraphic detail is discussed by Land (1974).

In this district approximately 160 m of strata may occur above the Ryhope Marine Band but there is no direct evidence for the uppermost 80 m, and their presence is inferred on structural grounds. Above the Marine Band information is available from only four boreholes and limited exposure of higher beds at Spital Carrs [312 872] adjacent to the Stakeford Fault.

The boreholes are close together and record very similar sequences, with up to 7 coals (see Figure 78); four of these have been tentatively correlated with seams named in the south of the coalfield. The lowest seam, the Usworth, is up to 76 cm thick and lies 25 m above the Ryhope Marine Band. The intervening rocks are mudstones. Above the Usworth 12 m of mudstone, with a pair of impersistent thin coals, is capped by 6 m of sandstone underlying the Hebburn Fell Seam. This coal is in two leaves up to 1.37 and 2.06 m thick and separated by 5 m of mudstone.

The highest coal proved in boreholes 28 NE 106, 371 and 375, is equated with the West Moor Seam a coal described from a borehole at the eponymous locality (27 SE 62) more than 15 km to the south. The West Moor Coal has a mean thickness of 40 cm and lies about 28 m above the Top Hebburn Fell Seam. A thin intermediate seam occurs 8 m above the Top Hebburn Fell Coal within or at the top of a mudstone sequence which in turn is overlain by sandstone. Temporary trench sections down dip (i.e. south) of these boreholes at [2964 8700] and [3016 8717] noted during the 1929 - 50 survey, record a higher coal (or coals?) 46 to 61 cm thick which may be the **Killingworth Seam.**

Seam contours from mine plans of deeper coals worked immediately north of the Stakeford Fault show a progressive increase in dip as the fault is approached and the depiction of the highest measures at surface in this area is a projection based on cumulative interval thicknesses.

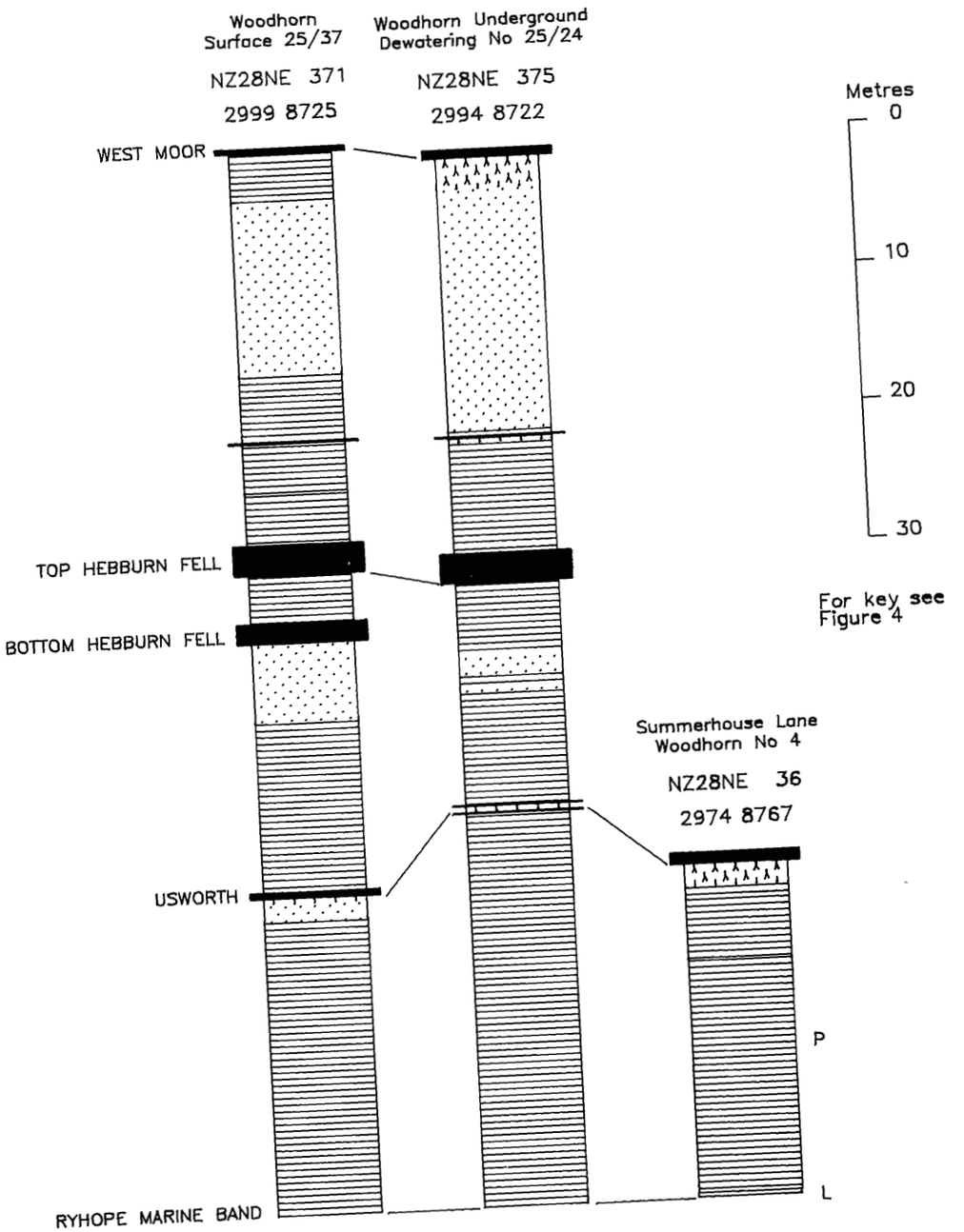


Figure 78 Strata above the Ryhope Marine Band

6 IGNEOUS ROCKS

Four WNW-trending tholeiitic dolerite dykes cross the district (Figure 79). They are part of the dyke-swarm from the Tertiary volcano of Mull in western Scotland, some 200 miles away. Petrographically the tholeiitic dolerites are olivine-free or olivine-poor plagioclase-augite rocks, with the feldspar and pyroxene generally in ophitic relationship and having an intersertal texture with a glassy mesostasis, which is usually devitrified of micro-crystalline. Land (1974) discusses the detailed petrography of the dykes, the easternmost expressions of which are seen on geological Sheet 15, and lists the literature pertaining to them.

The dykes in the district are the North Seaton, the West Sleekburn, the Barrington-North Blyth and the Netherton-south Blyth. With the exception of the West Sleekburn Dyke, which is 6 to 21 m wide, continuous and nearly vertical, the dykes are generally less than 5 m wide, are laterally discontinuous at any given stratigraphical level, and are vertically discontinuous at any given point along their length. They thus appear as a series of sections in echelon, corrected by narrow cross feeders (Land, 1974, figure 80). Records of the dykes are usually confined to mine workings with a limited number of former exposures on the coast, or in quarries inland.

The **North Seaton Dyke**, is known only from colliery workings. It was first described by Land (1974).

The **West Sleekburn Dyke** is much the thickest and most continuous dyke in the district, but is nowhere exposed. It is proved in mine-workings in the Yard and Plessey seams only as far west as Guide Post. The dykes formerly seen at Bothal Mill [2653 8613] and said to have been quarried west of Climbing Tree [2614 8127], the latter with a width of over 4 m, probably represent a continuation of the West Sleekburn dyke.

The **Barrington-North Blyth Dyke** was formerly exposed on the coast at Blyth North Beach [3185 8221] where it was 1.2 m wide (Land, 1974, p. 119), but is now covered by shingle. It is usually less than 3 m thick, but can be identified on mine plans from the coast west to Hepscott, as a series of discontinuous lines displaced by faults. West of Choppington it is present as two parallel intrusions, some 20 m apart.

The Netherton-South Blyth Dyke is generally narrow, but attains a width of 9 m in places and may have been quarried south of Bedlington at [2644 8147]. It is recorded on mine plans as far west as Nedderton and was proved in the Howard House opencast site.

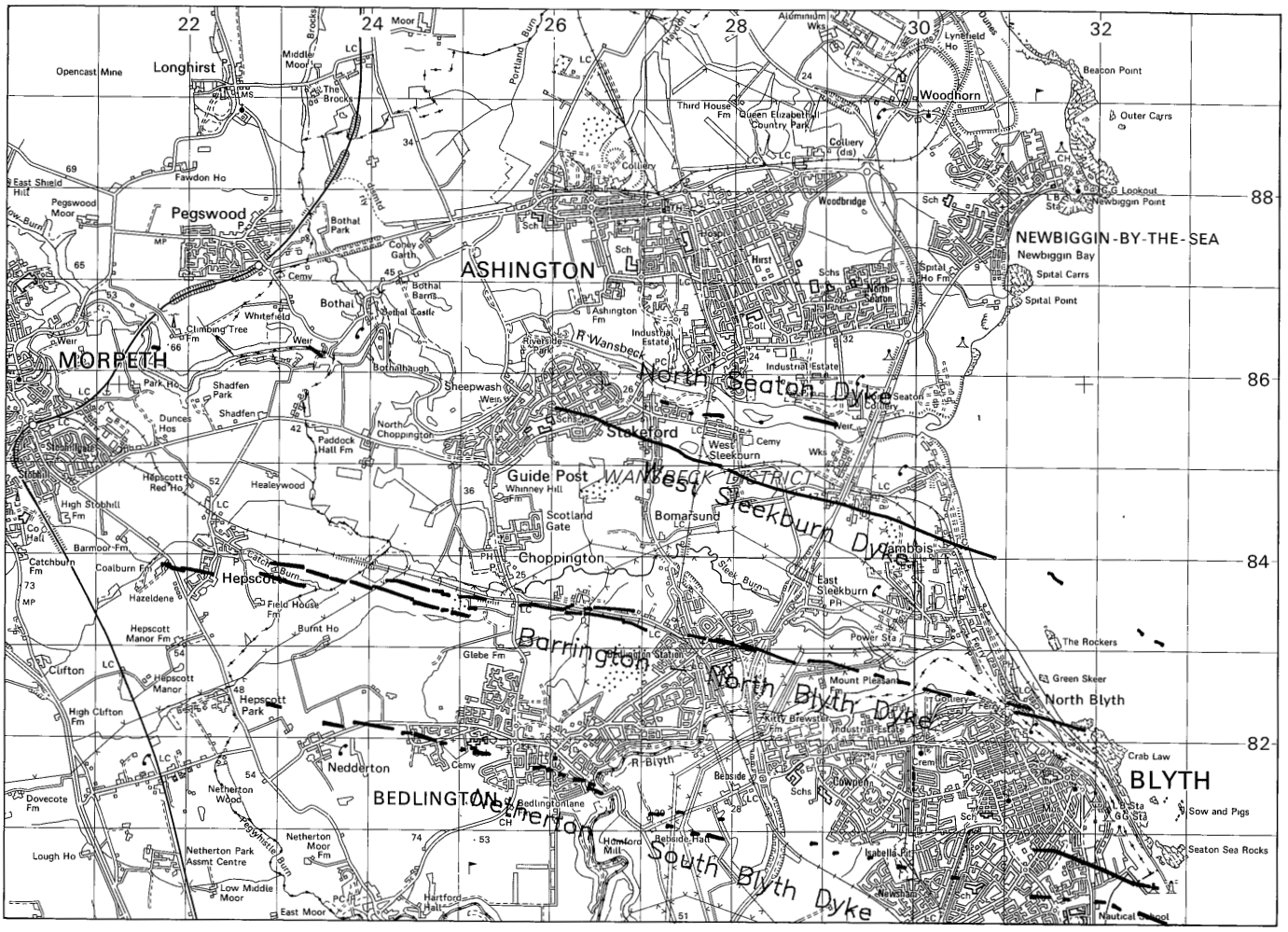


Figure 79 Tholeiite dykes

7 STRUCTURE

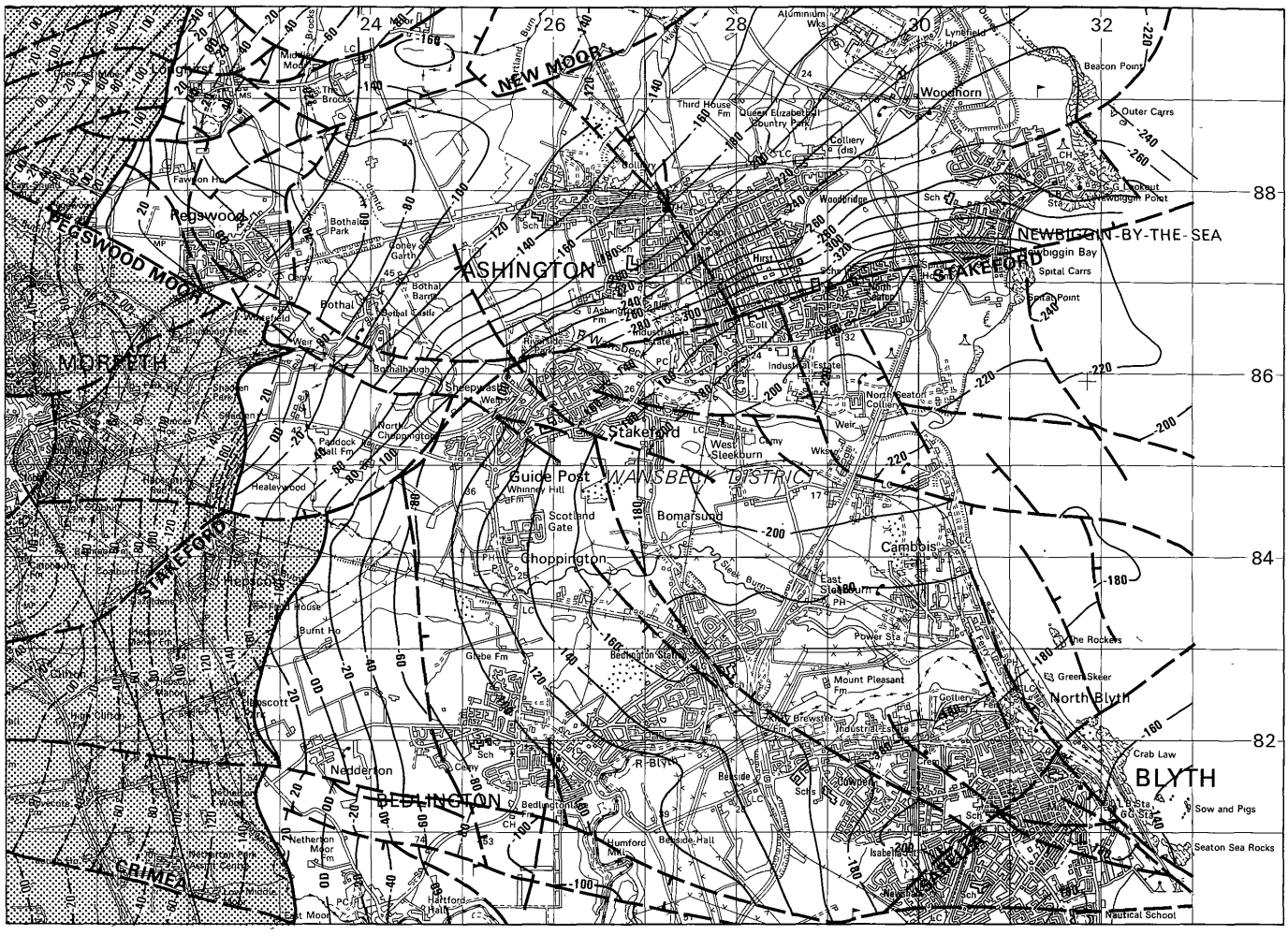
During much of Westphalian times compaction - induced subsidence was the major control on the pattern of facies distribution. It is probable that this was accompanied periodically by syn-depositional extensional fault movements (Fielding, 1986; Collier, 1989). The strata were subsequently faulted and gently folded during the Hercynian movements and tilted gently eastwards with further faulting in Tertiary times.

The major fault within the district is the ENE-trending Stakeford Fault, which shows a maximum northerly downthrow of some 200 m in the Yard Seam (Figure 80).

The faults in the north-west part of the district show similar large vertical displacements. These intrabasinal faults form part of a suite of major normal faults which lie within the Northumberland Basin and exhibit net extensional displacements. The faults have the same ENE-WSW trend as the Stublick and Ninety-Fathom faults at the southern margin of the basin (Frost and Holliday, 1980; Collier, 1989). Information available from mine plans shows the Stakeford Fault to hade at approximately 45°. As the fault is approached on its downthrow or north side the dip of bedding increases to 45° so that the strata meet the fault plane at right angles. On the upthrow side the strata are little disturbed (Figure 79). Collier (1989) discusses this phenomenon of hanging wall rollover, identified by the old Northumberland miners on plans as "beds dip to a riser", in association with the Ninety Fathom Fault (see Land 1974, p.126) and develops from it a model in which fault displacement is terminated at a decollement surface within the Carboniferous basin fill.

A second suite of NNW-trending normal faults generally have smaller displacements (<30 m) and steeper dips (averaging 70°; calculated from mine plans).

The larger displacement of up to 70 m along the Crimea Fault (Jackson, Lawrence and Frost, 1985) is explained in terms of differential folding either side of the fault (Land, 1974, p.125). Many of these faults die out by splitting into several fractures with throws of a few metres. Faults of less than 3 m (10 feet on old plans) are not shown in Figure 79 or on the 1:10 000 scale geological maps, but are plentiful.



Crop of Plessey Seam

Coal Measure strata below Plessey Seam

Approximate position of base of Coal Measures

-80 Contours on base of Coal Measures

-80 Contours on Plessey Seam

} Contour relative to Ordnance Datum, interval at 20m

Fault, crossmark on downthrow side; major faults are named

Scale

0 1 2 3

kilometres

Figure 80. Structure Contours

8 QUATERNARY

Almost all of the district is covered by drift deposits, solid rocks are exposed only within incised river valleys, on the coast and as isolated low sandstone hills (Figure 81). The drift deposits are chiefly of glacial origin and date from the last, late Devensian, glaciation approximately 12 000 - 18 000 years ago. Till (boulder clay) predominates but water-deposited sands, gravels, silt and clays are common within buried valleys where sediment relationships may be complex and thicknesses may exceed 60 m. Post-glacial and recent river terraces, and alluvium flank the river and streams while sand dunes and beach deposits fringe the coast.

ROCKHEAD

The Rockhead surface illustrated in Figure 82 has been constructed using data from over 1 500 boreholes coupled with limited exposure evidence. The information reveals an erosional surface which has a more pronounced topography than the incised till plain which forms the present-day land surface, with valleys declining to depths more than 20 m below current sea level. The dominant feature is a valley system which enters the district from the west and south-west, unites at Hepscott [225 842] and reaches the present coast near Cambois [304 851]. Borehole evidence indicates that there is another channel trending N-S beneath Newbiggin and also shows that the south-eastern part of the district lies on the northern flank of a major drift-filled valley running north-eastwards from Cramlington.

Although a continuously graded profile has been assumed in the construction of the rockhead contours, it is possible that each of the valleys may have been overdeepened by the action of the ice or sub-glacial meltwater.

The most recent modifications to the rockhead surface are the gorges which result from incision by the rivers Blyth and Wansbeck and their tributaries in the post-glacial period.

TILL

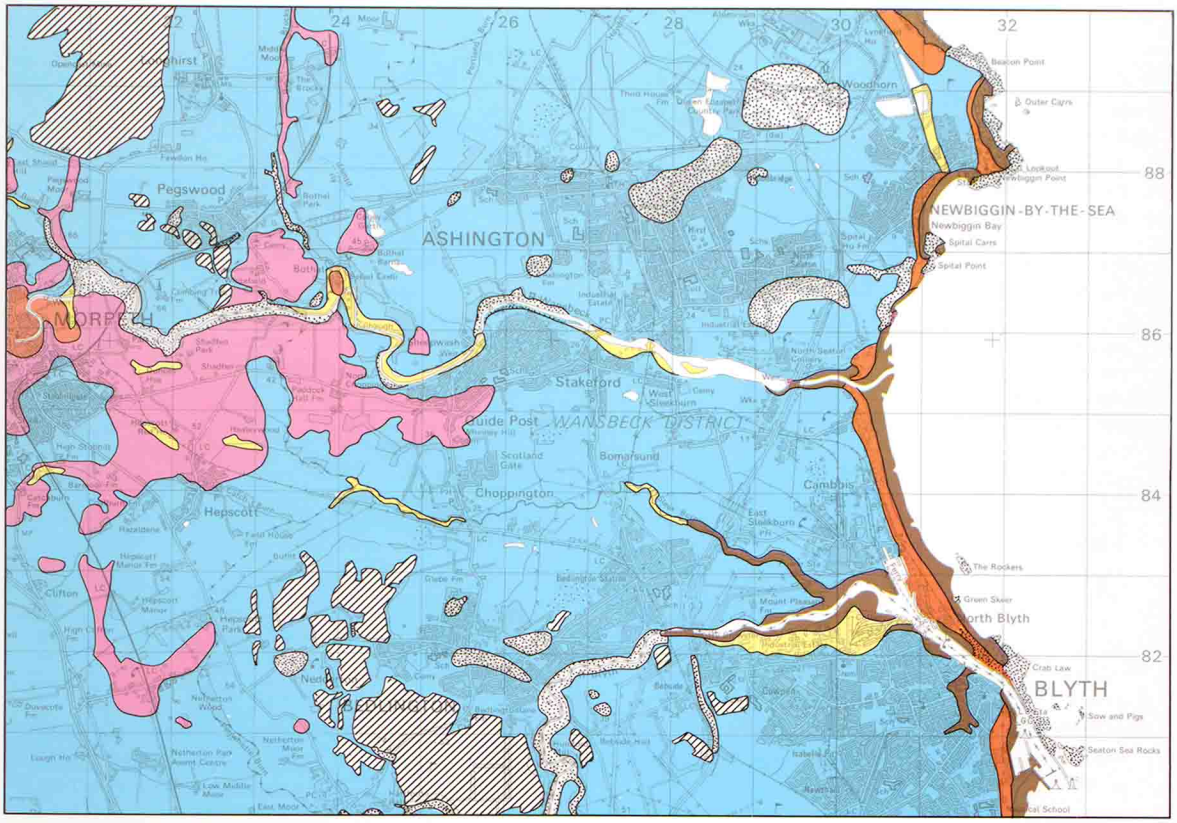
Till (boulder clay) is the most widespread glacial deposit and the one which attains the greatest thickness. There are many small sections in the deposit but few of any great thickness or lateral continuity and consequently much of the information about till and its relationship with other glacial sediments and rockhead, is obtained from borehole data. However, only in recent years (with the advent of standard site investigation techniques) has the logging of superficial deposits in boreholes provided sufficient detail to significantly enhance the analysis of the drift sequence.

The thickest till sequences are those encountered within buried valleys; up to 60 m has been proved and it is thought that thicknesses in excess of this may be present in the Stobhill and Stannington areas. Where it is unweathered, till comprises a stiff, grey to grey-brown, silty, sand stony clay; near surface, however, a distinct upper layer, mottled orange-brown and grey and only sporadically stony, is generally present. Thin sand lenses and partings of sand, gravel, silt and clay are common throughout. Erratics are mostly of local Carboniferous origin, chiefly subrounded sandstones with subordinate, siltstone, mudstone, ironstone, limestone and coal. A few far-travelled igneous and metamorphic rocks from southern Scotland and the Lake District also occur. Erratics vary in size from a few millimetres to large boulders and some may be exceptionally large. A probable 'raft' of solid sandstone within a thick till sequence occurs north of Stannington [212 802]. Boreholes and temporary exposures record up to 6 m of flaggy sandstone with variable dip, near the top of a drift sequence believed to be over 30 m thick.

The grey and grey-brown till is largely an overconsolidated lodgement till, thought to be deposited by a single phase of glaciation during the late-Devensian. The upper, mottled layer has been variously interpreted as upper lodgement, ablation or flow till, a product of gelifluction or more recently (Eyles and Sladen, 1981) as a post-glacial weathering profile. It is likely that more than one process was involved.

LAMINATED SILT AND CLAY

These deposits have not been differentiated at surface, but boreholes and clay pit workings indicate extensive deposits in the



KEY

- Blown Sand
- Alluvium
- Marine Beach and Tidal Flat
- River Terrace Deposits, undifferentiated
- Glacial Sand and Gravel
- Till (boulder clay) and glacial drift, undifferentiated

0 1 2 3km
Scale

This figure is a simplified portrayal of 1:25 000 scale map 2 which should be consulted for detailed information

- Solid rock at surface
- Worked-out opencast coal seam area

Areas of made ground outlined for clarity

Figure 81. Drift geology

Choppington and Cambois areas and to the north-east of Morpeth; all associated with areas of thicker drift within buried valleys. There are other, less extensive deposits, but lack of detail in borehole logs precludes a more accurate assessment.

Up to 18 m of laminated clay and silt has been encountered in the Choppington area but thicknesses of less than two metres are more usual. Borehole logs generally describe a laminated, virtually stone-free silty clay with intercalated fine sand partings; sections in working brick pits recorded by previous surveys give a fuller account:-

Foggos Brickworks, Choppington [248 836], 1929: "..... fully 15 feet of finely laminated blue-grey clay (weathering through dark to light brown) is exposed. There are laminae of sand and the clay itself is, to a varying degree, sandy, though where purest very fine-grained and plastic. Interbanding with sand is irregular. There are said to be 40 feet of this clay, but the base is not exposed. Occassionally it is gravelly, and some large boulders occur ..... ".

In several sections a "little reddish (upper) boulder clay on top of the brick clays" was also noted. It is probable that much of the laminated silt and clay was deposited in a lacustrine environments (both subaerial and subglacial) in glacial and late-glacial times.

ALLUVIUM

Alluvium occurs as narrow, discontinuous tracts flanking rivers and streams and also filling small flats and hollows. It varies considerably in thickness and composition. In the Wansbeck Valley between Bothal [240 865] and Sheepwash [256 857] it appears to consist of sand and gravel, elsewhere composite and laterally variable deposits of sand, silt, clay and gravel are recorded. Thin lenses of peat and organic-rich sediments are commonly associated with alluvial deposits.

MARINE AND ESTUARINE ALLUVIUM

These deposits have been mapped below the Normal Tidal Limit in the Blyth, Wansbeck and Sleekburn Valleys. Like alluvium the sediments usually form discontinuous narrow spreads but a more extensive tract occurs on the south bank of the Blyth estuary [290 823]. At this locality the deposit comprises 0.6 m of sand pebbly soil on 0.4 m of sub-angular to sub-rounded sandstone gravel. Alluvial sediments also occur beneath thin (0.5 m) tidal flat deposits in the Wansbeck estuary. Site investigation boreholes drilled prior to the construction of the North Seaton road bridge prove a consistent sequence of sand and gravel lying on sand which in turn rests on organic silt; the average cumulative thickness being about 13 m.

MARINE BEACH AND TIDAL FLAT DEPOSITS

Within the bays, beach deposits generally comprise sand but around the headlands shingle is more common. A small storm beach of cobbles and boulders was noted north of the mouth of the River Wansbeck [305 857]. The tidal flats in both estuaries are generally covered with a veneer of mud.

BLOWN SAND

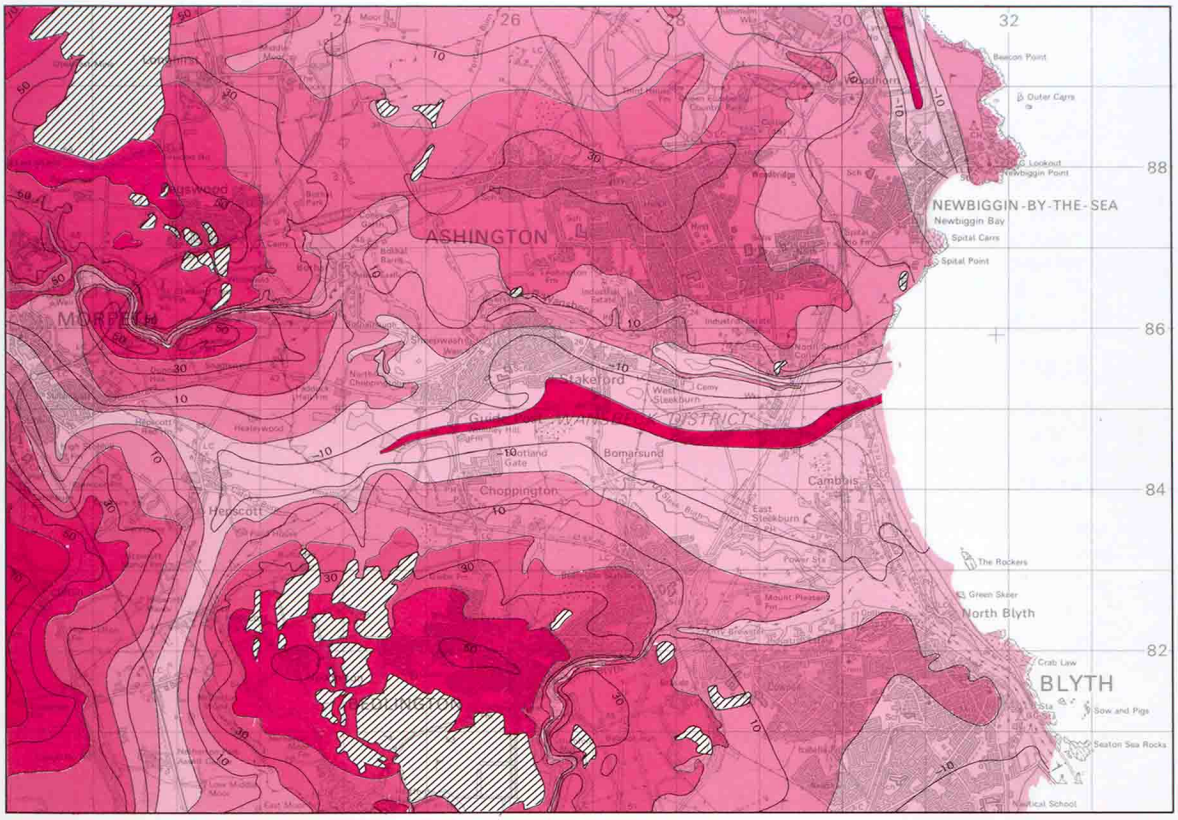
Dunes fringe the bays although in the Cambois area they are less prominent than formerly because of development and subsequent landscaping. To the south, at North Blyth, up to 7.16 m of sand has been proved in site investigation boreholes. However, all the dune deposits thin rapidly inland to no more than an indistinct veneer.

PEAT

Beneath the coastal dunes there are generally a few centimetres of peat which has been dated as Atlantic (pollen zone VIIA) by Raistrick and Blackburn (1932). Up to 5 cm of peat are visible beneath blown sand on North Seaton Links, near [3045 8525], and up to 0.3 m of sandy peat occurs in a similar setting below the dunes at North Blyth [313 828] to [318 820].

MADE GROUND

Previous surveys did not map made ground although it was described briefly in the Tynemouth Memoir (Land, 1974). The current Survey has attempted to delineate all areas of made ground except the ubiquitous thin spread within urban areas and the readily apparent fill of road and rail embankments. In this district made ground may be broadly sub-divided into backfilled opencast coal-seam areas, colliery spoil and



KEY

80
70
60
50
40
30
20
10
OD
−10
−20
<−20

Metres relative to OD.

Worked-out opencast coal and quarry sites.

The contours relate to natural rockhead surface only.

0 1 2 3km

Scale

This figure is a simplified portrayal of 1:25 000 scale map 3 which should be consulted for detailed information

Figure 82. Rockhead elevation

miscellaneous wastes (including domestic, industrial, agricultural, quarry and building waste). Because of the difficult foundation conditions it can pose and the potential problems of methane-generation and leachate migration, the distribution and composition of Made Ground is a significant factor in development decisions and it is therefore considered in detail in Part I - the Land-use Planning Report.

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APPENDIX:LIST OF BRITISH COAL MINE ABANDONMENT PLANS IN SURVEY AREA (BY COLLIERY)

COLLIERY	SEAM NAME ON ON PLAN	DATE OF ABANDONMENT	BRITISH COAL CATALOGUE NUMBER
ASHINGTON	Plessey	1937	12107
	Plessey	1969	NC611
	Plessey	1969	NC626
	Yard	1946	14133
	Bensham	1965	NC538
	Bottom Main	1966	NC556
	Five Quarter	1966	NC567
	Low Main	1966	NC568
	High Main	1968	NC595
	High Main	1969	NC612
	Top Yard	1969	NC625
	Tilley	1971	NC647
	Bottom Busty	1974	NC673
	Bottom Busty	1979	NC673
	Victoria	1981	NC725
	Three Quarter	1988	NC747
	Blackclose	1968	NC594
	Middle Main	1969	NC624
BARMOOR	Barmoor	1911	5741
	Barmoor (or Low Main)	1939	NC716
	Splint	1911	5741
	Splint (or Plessey)		NC716
	Bottom	1911	5741
	Brockwell	1963	NC490
	Little (or Three Quarter)	1930	NC716
	Bandy	1939	NC716
	Brockwell (or Victoria)	1930	NC716
BARRINGTON	Harvey	1938	12398
	High Main		NC133
BATES	Main	1984	NC735
	Bottom Plessey	1983	NC736
	Harvey	1982	NC737
	Plessey	1985	NC740
	Three Quarter	1986	NC741
BEDLINGTON A	Yard	1953	NC158
	Yard	1966	NC565
	Bensham	1954	NC175
	Low Main	1954	NC184
	Lower Main (or Main)	1957	NC275
	Top Busty (or Denton Low Main)	1958	NC300
	Beaumont	1968	NC606
	Top Main	1971	NC644

	Denton Low Main	1971	NC650
	Plessey	1961	NC476
	Five Quarter	1964	NC524
	Bensham	1963	NC492
	Plessey	1965	NC529
BEDLINGTON D	Five Quarter	1953	NC90
(OR DOCTOR)	Yard	1953	NC146
	Low Main	1954	NC181
	Top Main (High Main)	1960	NC386
	Lower Main	1960	NC387
	Plessey	1961	NC476
	Plessey	1965	NC529
	Upper Bensham	1963	NC491
	Bensham	1963	NC492
	Beaumont	1968	NC607
BEDLINGTON E	Five Quarter	1952	NC42
(OR WEST SLEEKBURN	Yard	1959	NC335
OR THE WINNING)	Yard	1962	NC335
	Plessey	1960	NC388
	Bensham	1962	NC457
	Low Main	1962	NC458
	Upper Bensham	1943	13647
	Main	1952	NC43
	Top Main	1955	NC238
	Top Main	1962	NC456
	Bottom Plessey	1962	NC459
	Harvey (or Low Yard or Beaumont)	1962	NC460
BEDLINGTON F	Five Quarter	1956	NC294
(OR BOMARSUND)	Five Quarter	1956	NC322
	Low Main	1959	NC322
	Yard	1962	NC433
	Bensham	1964	NC525
	Bensham	1959	NC322
	Bensham	1962	NC457
	Top Main (High Main)	1965	NC537
	Bottom Plessey	1965	NC540
	Plessey	1959	NC322
	Plessey	1961	NC410
	Harvey	1938	12398
	Harvey	1953	NC89
	Harvey	1963	NC493
	Beaumont	1968	NC607
	Blake	1949	14936
	Five Quarter	1956	NC322
BESSIE GREY NEW	Hutton	1937	12068
BOTHAL PARK	High Main	1952	NC7
	Main	1952	NC7
	Yard	1961	NC443

	Five Quarter	1961	NC444
	Low Main	1961	NC445
	Bensham	1961	NC446
CAMBOIS	Low Main	1925	8568
	Low Main	1968	8568
	Five Quarter (Brass Thill, Little)		
	Plessey	1968	NC627
	Bottom Plessey	1968	NC628
	Yard	1962	NC503
	Unnamed (?Low Main)		NC64
	Besham	1953	NC81
CATCHBURN	Unnamed	1908	5532
	Busty	1917	6794
	Probably Beaumont	1921	7353
CHOPPINGTON A	Low Main	1934	11223
	Low Main	1942	13120
	Yard	1939	12545
	Bensham	1939	12546
	Bensham	1959	NC345
	Plessey	1939	12547
	Plessey	1962	NC473
	Five Quarter	1944	13570
	Five Quarter	1964	NC522
	Top Busty	1966	NC547
	Beaumont	1966	NC555
	Five Quarter	1956	NC264
	Five Quarter	1959	NC345
	Denton Low Main	1945	13824
	Three Quarter	1953	NC147
	Three Quarter	1956	NC315
	Three Quarter	1957	NC316
	Three Quarter	1963	NC527
	Top Busty	1956	NC315
	Top Busty	1966	NC545
	One Foot Ten Inches	1956	NC315
	Harvey	1956	NC315
	Bandy	1957	NC316
	Brockwell	1956	NC315
	Brockwell	1957	NC316
	Beaumont	1957	NC316
	Beaumont/Harvey	1965	NC543
	Beaumont/Harvey	1966	NC555
	Lower Busty	1957	NC316
	Lower Busty	1959	NC349
	Lower Busty	1961	NC526
CHOPPINGTON B (HIGH)	Yard	1935	11470
	Yard	1952	11470
	Bensham	1939	12548
	Bensham	1959	NC345

	Low Main	1949	14937
	Low Main (or Brass Thill)		NC724
	High Main	1952	NC10
	Plessey	1952	NC31
	Plessey	1962	NC473
	Top Busty	1952	NC32
	Top Busty	1966	NC547
	Lower Busty	1959	NC349
	Top Main	1953	NC88
	Bandy	1966	NC546
	Five Quarter	1959	NC345
	Five Quarter	1964	NC522
	Bensham	1959	NC345
	Beaumont	1965	NC543
CHOPPINGTON NORTH	Three Feet		13915
	Six and a Half Feet		13915
CLIFTON	Beaumont	1899	3984
CLIFTON WEST	Brockwell	1947	14248
	Victoria	1947	14248
	Beaumont	1929	9848
COTTINGWOOD WEST	Victoria	1918	6846
	Brockwell	1918	6846
COWPEN	Yard (High Main)		R.361
	Low Main		R.361
	Low Main	1904	8567
	Low Main	1939	8567
	Main		R.361
	Yard	1928	9900
	Yard	1942	9900
	Unnamed		R.361
	High Main	1939	12630
	Plessey	1942	13157
	Bensham	1941	13336
	Five Quarter	1941	13336
	Beaumont	1946	14063
EWART HILL	High Main	1954	NC694
	Grey (Main F)	1954	NC694
HARTFORD	Five Quarter	1939	12554
	Five Quarter	1961	NC402
	Low Main	1939	12554
	Yard	1940	12649
	Plessey	1946	14170
	Yard	1961	NC399
	Bensham	1961	NC404
	High Main	1961	NC400

HEPSCOTT	Low Main		
	Barmoor	1911	5741
	Barmoor	1924	8815
	Splint	1911	5741
	Splint	1924	8815
	Bottom	1911	5741
	Little	1924	8815
BEBSIDE	Hartley		R.387A
(HORTON GRANGE)	Yard		R.387A
	Yard	1945	13948
	Bensham	1945	85648
	Bensham	1961	NC398
	Low Main	1925	8564
	Yard	1925	8564
	Yard	1945	13948
	Harvey	1925	8564
	Stone	1925	8564
	Stone (Bottom Benshaw)		NC450
	Main	1925	8564
	Plessey	1925	8564
	High Main	1906	8565
	High Main	1942	13348
	Top Main	1960	NC370
	Bottom Main	1960	NC370
	Top Five Quarter (Top Brass Thill)	1957	NC304
	Top Five Quarter (Top Brass Thill)	1962	NC304
	Five Quarter	1925	8564
	Moorland	1942	13348
	Lower Main	1961	NC398
N69NW HOWBURN	Little Wonder	1921	7377
	Little Wonder	1922	7695
	Bandy	1922	7695
	Nineteen Inch	1929	9871
	Twenty One Inch	1929	9871
	Harvey	1929	9871
ISABELLA (COWPEN	Yard (High Main)		R.361
ISABELLA)	Low Main		R.361
	Low Main	1904	8567
	Main		R.361
	Unnamed		R.361
	Yard	1928	9900
	Yard	1942	9900
	Plessey	1942	13157
	Bensham	1962	NC478
	High Main	1966	NC548
	Five Quarter (Stone Coal)	1966	NC549
	Plessey	1966	NC550

LILLY	Top (Splint)	1926	8591
LONGHIRST	High Main	1896	3472
	High Main	1904	4736
	Main	1896	3472
	Grey (Main)	1904	4736
	Yard	1896	3472
	Yard	1904	4736
	Five Quarter	1961	NC448
LONGHIRST DRIFT	Diamond	1965	NC528
	Low Main (Brass Thill)	1967	NC590
	Middle Main	1969	NC613
	Bentinck	1969	NC614
	Plessey	1969	NC615
	Top Beaumont (Top Harvey)	1969	NC616
	Top Busty	1969	NC617
LONGHIRST GRANGE	Plessey	1901	4304
	Denton Low Main	1953	NC107
	Low Main	1954	NC220
	Low Main	1908	8569
	Plessey	1969	NC630
	Bottom Plessey	1969	NC630
MORPETH BANKS	Unnamed		R.389D
MORPETH MOOR	Old Man	1909	5331
	Old Man	1917	6741
	Brockwell	1917	6741
	Little	1917	6741
	Low Main	1917	6741
	Bandy	1917	6741
NETHERTON (OR HARTLEY WEST)	Unnamed		R.357D
	Yard		R.357D
	Yard	1956	NC263 (or 294?)
	Five Quarter	<1879	1063
	Five Quarter (Top Low Main)	1910	NC711
	Low Main	<1879	1063
	Main		11324
	Plessey	1964	NC509
	Top Busty	1970	NC634
	Bottom Busty	1974	NC665
	Bensham	<1879	1063
	Stone	1942	13349
	Beaumont	1966	NC551
	Three Quarter	1974	NC666
	Victoria	1974	NC667

NETHERTON HALL	Five Quarters	1892	3087
	Low Main	1943	11723
	Plessey	1943	13573
	Low Main	1936	11723
NEWBIGGIN	Plessey	1950	NC2
	Plessey	1967	NC588
	New Main (Diamond)	1954	NC203
	Main	1966	NC572
	Yard	1948	NC586
	Yard	1958	nc323
	Bensham	1932	10809
	Bensham	1967	NC587
	Bottom Plessey	1964	NC589
	Low Main	1933	11041
	Low Main	1938	12319
	Low Main	1953	NC104
	Low Main	1958	NC323
	Five Quarter	1933	11041
	Five Quarter	1949	14950
	Five Quarter	1958	NC323
	High Main	1953	NC103
	Unnamed	1953	NC103
	Low Main	1953	NC157
NEWSHAM (DELAVAL NEW)	Low Main	1893	8566
	Bensham	1930	10397
	Bensham	1955	NC246
	Beaumont	1930	10397
	Plessey	1930	10397
	Stone	1930	10397
	Stone	1938	10397
	Low Main	1930	10397
	Low Main	1938	10397
	YardMain	1930	10397
	YardMain	1938	10397
	Main	1955	NC244
	High Main	1955	NC245
NORTH SEATON	New Main (Diamond)	1960	NC382
	Low Main	1960	NC383
	Five Quarter	1960	NC383
	Yard	1941	NC406
	Bottom Main	1960	NC407
	Five Quarter (Brass Thill)	1961	NC408
	Top Main	1961	NC409
	Five Quarter	1964	NC522
	Plessey	1962	NC473
	Beaumont	1966	NC555
	Low Main	1919	8570
	Plessey	1949	14453

PARK HOUSE	Bandy	1902	4341
	Little	1912	5954
	Top (Old Man)	1912	5954
	Splint	1931	10434
PEGSWOOD	Five Quarter	1930	10272
	Five Quarter	1944	13766
	Five Quarter	1969	NC618
	Five Quarter	1969	NC611
	Bensham	1930	10272
	Bensham	1964	NC537
	Beaumont	1942	13121
	Brockwell	1949	1494
	Yard (Low Main)		NC92
	Bentinck	1954	NC251
	Bottom Busty	1966	NC584
	Bottom Plessey	1968	NC605
	Low Main	1969	NC619
	Three Quarter	1956	NC731
	Pegswood Harvey	1969	NC620
	Plessey	1968	NC604
WOODHORN	Low Main	1953	NC157
	Yard	1966	NC566
	Main	1968	NC602
	Main	1968	NC602
	High Main	1970	NC643
	Plessey	1981	NC717
	Low Main	1958	NC323
	Yard	1958	NC323
	Yard	1966	NC566
	Five Quarter	1958	NC323
	High Main	1937	12113
	Plessey	1937	12113
	Diamond	1939	12429
	Bottom Main	1968	NC603
	Ashington	1970	NC642
	Top Yard	1970	NC645
	Hutton	1970	NC646
	Hutton	1977	NC646